Appendix A: Factors influencing erosion and quantifying streambank erosion

Factors influencing bank stability

Bank stability is dependent upon the ratio between resistive (F_R) and driving forces (F_D); ratios less than one indicate bank failure (Amiri-Tokaldany et al., 2003; Osman & Thorne, 1988). Traditionally, F_D and F_R are modeled using Figure 19 (Osman & Thorne, 1988). It is assumed (1) the failure plane passes through the toe of the bank, (2) the bank is constructed of homogenous materials, and (3) the effects of soil water pressure in the saturated and unsaturated portions of the bank as well as the hydrostatic confining pressure of the water in the channel are negligible. According to Osman & Thorne (1988), bank stability is proportional to the soil's cohesion (c') and angle of friction (ϕ'). Bank stability decreases with increasing bank angle and height and soil specific weight (γ_s). Equation 19 and Equation 20 describe F_D and F_R, respectively.

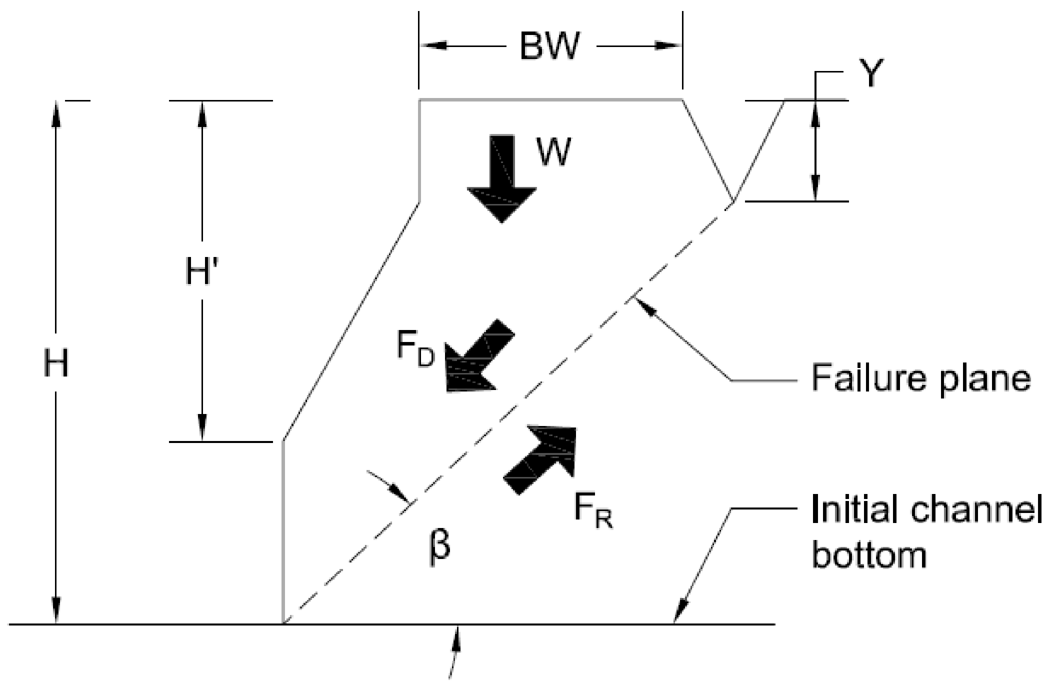


Figure 1. Traditional bank stability analysis where H = initial bank height; H' = bank height after failure; BW = location of tension crack or magnitude of bank retreat; Y = depth of tension crack; β = bank angle after failure; W = weight of failure block; F_D = driving forces; F_R = resisting forces (Osman & Thorne, 1988)

$$F_D = \frac{\gamma}{2}\left(\frac{H^2-y^2}{\tan\beta} - \frac{H'^2}{\tan i}\right)\sin\beta \qquad \text{Equation 1}$$

Where:
F_D = forces driving bank failure (lbf)
γ = soil specific unit weight (lb/ft^3)
H = initial bank height (ft)
y = depth of tension crack (ft)
β = bank failure plane angle (°)
H' = bank height after failure (ft)
i = initial bank angle (°)

$$F_R = \frac{(H-y)c'}{\sin\beta} + W\cos\beta\tan\phi \qquad \text{Equation 2}$$

Where:
F_R = forces resisting bank failure (lbf)
H = initial bank height (ft)
y = depth of tension crack (ft)
c' = soil effective cohesion (lb/ft^2)
β = bank failure plane angle (°)
W = weight of failure block (lb)
ϕ' = soil angle of friction (°)

Research by Amiri-Tokaldany et al. (2003), Fox et al. (2007), and Simon et al. (2000) indicates the effects of the bank's soil water pressure and the channel's hydrostatic confining pressure are not negligible. Simon et al. (2000) found an increase in negative pore pressure can increase apparent c' and a decrease in positive pore pressure can increase the soil's ϕ'. Fox et al. (2007) determined seepage can cause significant bank erosion and suggests different types of seepage exist: intermittent low flow, persistent high flow, and buried. Intermittent low flow seepage occurs after storm events, and buried seepage forms from sloughed bank material.

Amiri-Tokaldany et al. (2003) developed a new bank stability analysis (Figure 1.2) to account for the effects of soil water pressure and channel hydrostatic confining pressure. However, the revised bank stability analysis does not account for vegetation and only considers planar types of failure. Additionally, the method assumes the water pressure in the channel adjacent to the bank is in equilibrium. Equation 21 and Equation 22 describe the revised F_D and F_R, respectively.

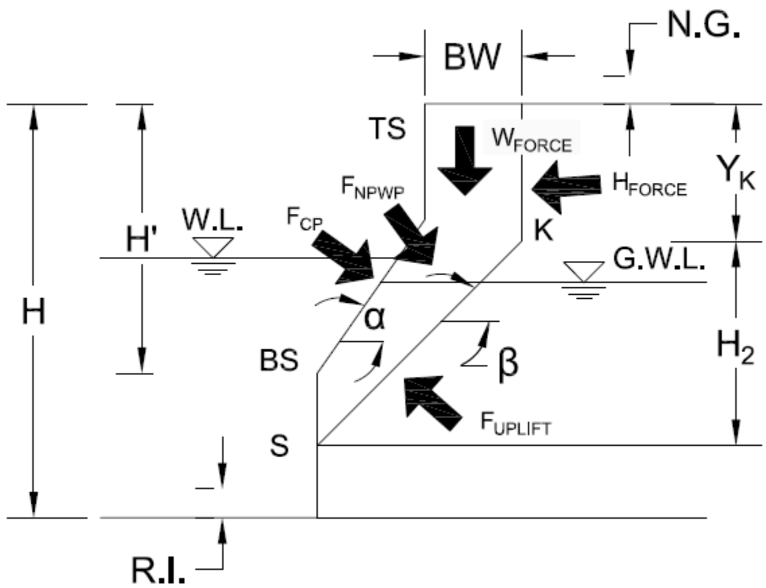


Figure 2. Revised bank stability analysis where H = initial bank height; W.L. = level of water in channel; R.I. = elevation of channel bed; BW = location of tension crack or magnitude of bank retreat; N.G. = natural ground level; G.W.L. = groundwater level; W_{FORCE} = weight of unit width of failure block; F_{NPWP} = force due to negative pore pressure acting on unit width of failure block; F_{CP} = hydrostatic confining pressure acting on unit width of failure block; F_{UPLIFT} = uplift force due to positive pore water pressuring acting on unit width of failure block; H_{FORCE} = hydrostatic force exerted by water present in tension crack on unit width of failure block; α and β = angles of bank before and after bank failure, respectively; Y_K = depth of tension crack; TS, BS, S, K, H', and H_2 define geometry of bank (Amiri-Tokaldany et al., 2003)

$$F_D = W_{force} \sin\beta - F_{cp} \sin i + H_{force} \cos\beta \qquad \text{Equation 3}$$

Where:

F_D = forces driving bank failure (lbf)
W_{force} = weight of unit width of failure block (lb/ft)
β = bank failure plane angle (°)
F_{cp} = hydrostatic confining pressure acting on unit width of failure block (lb/ft)
i = angle between hydrostatic confining pressure and normal to failure plane (°)
H_{force} = hydrostatic force exerted in tension crack on failure block (lb/ft)

$$F_R = \bar{C}L + F_{npwp} + (W_{force}\cos\beta + F_{cp}\cos i - F_{uplift} - H_{force}\sin\beta) * \tan\bar{\phi} \qquad \text{Equation 4}$$

Where:

F_R = forces resisting bank failure (lbf)
$\bar{C}$ = average cohesion plane (lb/ft^2)
L = length of failure plane (ft)
F_{npwp} = force due to negative pore pressure acting on unit width of failure block (lb/ft)
W_{force} = weight of unit width of failure block (lb/ft)
β = bank failure plane angle (°)
F_{cp} = hydrostatic confining pressure acting on unit width of failure block (lb/ft)
i = angle between hydrostatic confining pressure and normal to failure plane (°)
F_{uplift} = uplift force due to positive pore water pressuring acting on failure block (lb/ft)
H_{force} = hydrostatic force exerted in tension crack on failure block (lb/ft)
$\bar{\phi}$ = friction angle averaged across individual bank soil layers (°)

Quantifying streambank erosion using form-based models

Streambank erosion can be quantified using repeated surveys of permanent cross-sections and erosion bank pins (Beck et al., 2018; Hancock & Lowry, 2015; Harden et al., 2009; Luffman et al., 2015; Myers et al., 2019; Palmer et al., 2014; Zaimes et al., 2021; Zaimes & Schultz, 2015). Form- or processed-based models can also quantify streambank erosion. One of the most common form-based models is the Bank Erosion Hazard Index (BEHI) developed by Rosgen (2001).This method consists of seven metrics and requires bank height and angle, root depth and density, and surface protection measurements to assess the bank's erodibility. This method also requires a known bankfull height. Bankfull refers to stable channel conditions that effectively move sediment loads and interact with the floodplain (Doll et al., 2002; Leopold & Maddock, 1953; Metcalf et al., 2009; Sweet & Geratz, 2003; Wolman & Miller, 1960). Bankfull indicators include the uppermost scour line, back of a point bar, and the upper break in bank slope (Harman, 2000). Bankfull dimensions can also be identified using regional curves that relate hydraulic geometry to the watershed area (Doll et al., 2002; Harman et al., 1999, 2014; Metcalf et al., 2009; Sweet & Geratz, 2003).

BEHI uses the field measurements, ratio between the bank height and bankfull height, and three adjustments to calculate a score or rating for the streambank. The adjustments account for streambank material, stratification, and location within the channel (e.g., pool, riffle, meander). The rating is converted into an erosion risk index that was developed from field observations of streambank instability (Table 12). Rosgen (2001) defines the erosion indices as: very low (< 9.5), low (10-19.5), moderate (20-29.5), high (30-39.5), very high (40-45), or extreme (> 45). Refer to Rosgen (2001) for details regarding each metric and the field observations used to develop the erosion indices.

Table 1. BEHI ratings (Rosgen, 2001)

Category	Bank height/bankfull height	Root depth/bank height	Root density (%)	Bank angle (°)	Surface protection (%)	Total
Very low						
Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80	-
Score	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	5-9.5
Low						
Value	1.11-1.19	0.89-0.50	79-55	21-60	79-55	-
Score	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	10-19.5
Moderate						
Value	1.2-1.59	0.49-0.30	54-30	61-80	54-30	-
Score	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	20-29.5
High						
Value	1.60-2.9	0.29-0.15	29-15	81-90	29-15	-
Score	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	30-39.5
Very high						
Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10	-
Score	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	40-45
Extreme						
Value	> 2.8	< 0.05	< 5	< 119	< 10	-
Score	10	10	10	10	10	46-50

The Bank Assessment for Nonpoint Consequences of Sediment (BANCS) combines BEHI scores with near bank stress (NBS) ratings to estimate an annual ε using pre-determined erodibility curves that are based on field collected data (Bigham et al., 2018; Rosgen, 2009). NBS accounts for the shear stress (τ) applied along the streambank and is described by six categories ranging from very low to extreme (Table 13). NBS ratings are estimated using seven methods listed in order of increasing difficulty:

1. Observing the presence of transverse/central bars or channel pattern changes,
2. Calculating the radius of curvature-to-bankfull width ratio,
3. Identifying the pool slope-to-average water surface slope ratio,
4. Quantifying the pool slope-to-riffle slope ratio,
5. Calculating near-bank maximum depth-to-bankfull mean depth ratio,
6. Determining the near-bank τ-to bankfull τ ratio, and
7. Quantifying the vertical velocity profiles across the channel perpendicular to the assessed bank.

Table 2. Summary of NBS ratings for each method (Rosgen, 2009)

NBS rating	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7
Very low	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	2.21-3.00	0.20-0.40	0.40-0.60	1.00-1.50	0.80-1.05	0.50-1.00
Moderate	2.01-2.20	0.41-0.60	0.61-0.80	1.51-1.80	1.06-1.14	1.01-1.60
High	1.81-2.00	0.61-0.80	0.81-1.00	1.81-2.50	1.15-1.19	1.61-2.00
Very high	1.50-1.80	0.81-1.00	1.01-1.20	2.51-3.00	1.20-1.60	2.01-2.40
Extreme	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Several studies have evaluated how well BEHI, NBS, and BANCS assessments predict streambank instability. Allmanová et al. (2021) compared measured erosion rates (ε) to BEHI and NBS assessments for 18 sites along the Kubrica Stream in Slovakia. The ε and BEHI assessments had a correlation coefficient (R) of 0.47; the R between ε and NBS indices was 0.65. Two erosion prediction curves were developed for moderate and high BEHI scores using one years' worth of flow data. The models' coefficient of determination (R^2) was 0.47 and 0.55, respectively. Allmanová et al. (2021) indicated the models' performance could improve if the parameters for the NBS rating methods were less ambiguous.

Allmanová et al. (2019) evaluated how well BEHI and NBS assessments explain measured ε for 18 sites along the Lomnická stream in Slovakia. BEHI scores had a strong relationship with the ε (R^2 = 0.72), and NBS had a moderately strong relationship (R^2 = 0.53). However, the erosion curves developed from the BEHI data had a poor relationship with the ε (R^2 = 0.004 to 0.15). Allmanová et al. (2019) concluded BEHI assessments are a good predictor of channel erodibility but the BANCS model is a poor predictor of annual ε. Harmel et al. (1999) had similar conclusions for monitored banks along the Upper Illinois River in the Ozark Highlands ecoregion of Oklahoma and Arkansas.

To improve BANCS predictability, Sass & Keane (2012) adapted the BEHI data for three streams in northeast Kansas. The BEHI scores were adjusted to account for the presence of woody riparian vegetation along the streams. The root depth to bank height ratio and root density were combined into one predictor: presence of woody vegetation. This adjustment increased the R^2 values for the high-very high BEHI curve from 0.77 to 0.84 and from 0.75 to 0.88 for the moderate BEHI curve. Sass & Keane (2012) reported future studies will focus on adjusting the bank material predictor to improve model performance.

Bigham et al. (2018) conducted a review of studies that developed erosion prediction curves using the BANCS method and noted subjectivity was a concern among the studies. To address this concern, Bigham et al. (2018) collaborated with 10 fluvial geomorphologists to evaluate six study banks twice within a two-month period and completed a sensitivity and uncertainty analysis to determine which BANCS variables influence the ratings. The experts assigned the same BEHI scores between 17 and 50% of time and NBS ratings between 33 and 100% of the time. The most sensitive BEHI parameter was the study bank height, and the bank material adjustment contributed the most uncertainty to the BEHI scores. With regards to NBS, the method used to rate the applied τ was the most sensitive and subjective parameter. Bigham et al. (2018) recommended accurately identifying bank material (e.g., particle size analysis), using the central tendency of multiple assessments to finalize BEHI/NBS scores, and evaluating NBS using more than one method to reduce subjectivity and improve model performance.

A channel evolution model (CEM) is a form-based model that describes a stream's stage of degradation and can be used to evaluate watershed management strategies and stream restoration projects (Figure 21) (Biedenharn et al., 2004; Booth & Fischenich, 2015; Cluer & Thorne, 2014; Hawley et al., 2020; Lammers et al., 2020; Watson et al., 2002; Williams et al., 2022). The main stages of the archetypal CEM developed by Schumm et al. (1984) include:

1. Stage I: stable;
2. Stage II: incising (degradation);
3. Stage III: incision exceeds the critical bank height for bank failure and widening occurs (mass wasting);
4. Stage IV: aggradation to the point bank failures cease but a new floodplain has not been built;
5. Stage V: quasi-equilibrium has been reached, and the channel is connected to new the floodplain.

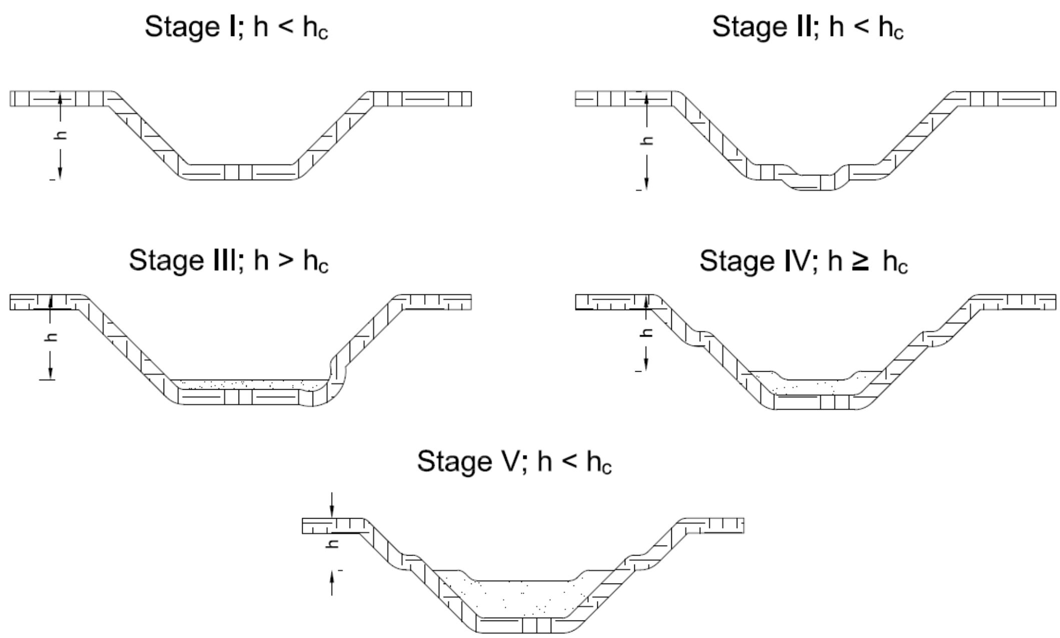


Figure 3. Proposed channel evolution model by (Schumm et al., 1984); h refers to bank height and h_c refers to critical bank height

Watson et al. (2002) quantified the CEM developed by Schumm et al. (1984) using a measure of bank stability (N_g) and sediment continuity (N_h). N_g is the ratio between the existing bank height (h) and critical bank height at the same angle (h_c); a bank is stable when this ratio less than one. N_h is the ratio of the channel's sediment transport capacity to the target sediment supply. Continuity, aggradation, and degradation occur when N_h equals one, is less than one, and is greater than one, respectively (Table 14).

Table 3. Quantifying the channel evolution model using bank and hydraulic stability ratios (Watson et al., 2002)

Channel evolution model stage	**Bank stability (N_g)**	**Hydraulic stability (N_h)**
I	< 1	1
II	< 1	> 1
III	> 1	> 1
IV	> 1	< 1
V	< 1	1

Hawley et al. (2012) and Simon & Hupp (1987) modified the archetypal CEM for streams located in semiarid climates and western Tennessee, respectively. The CEM for Tennessee streams quantifies the failure types, bank surfaces present, and approximate bank angles for each stage of the regional CEM (Table 15,Figure 22) (Simon & Hupp, 1987). Rosgen (1994) expanded the work of Schumm et al. (1984) and classified streams based on the dominant slope range, cross-sectional shape, channel bed material, entrenchment, sinuosity, and width to depth ratio. Rosgen (1994) also described how streams evolve among the proposed eight classifications.

Table 4. Western Tennessee streams channel evolution model (Simon & Hupp, 1987)

Channel evolution model stage/name	**Bed level adjustment**	**Active widening**	**Failure types**	**Bank surfaces present; approximate bank angles (°)**
I; Pre-modified	Pre-modified	No	N/A	N/A; 20-30
II; Constructed	N/A	Human disturbance	N/A	N/A; 18-34
III; Degradation	Migrating degradation	No	N/A	N/A; 20-30
IV; Threshold	Migrating degradation	Yes	Slab rotational pop-out	Vertical face; 70-90 Upper bank; 25-50
V; Aggradation	Secondary aggradation	Yes	Slab rotational pop-out; low-angle slides	Vertical face; 70-90 Upper bank; 25-40 Slough line; 20-25
VI; Re-stabilization	Downstream-imposed aggradation	No	Low-angle slides; pop-out	Vertical face; 70-90 Upper bank; 25-35 Slough line; 15-20

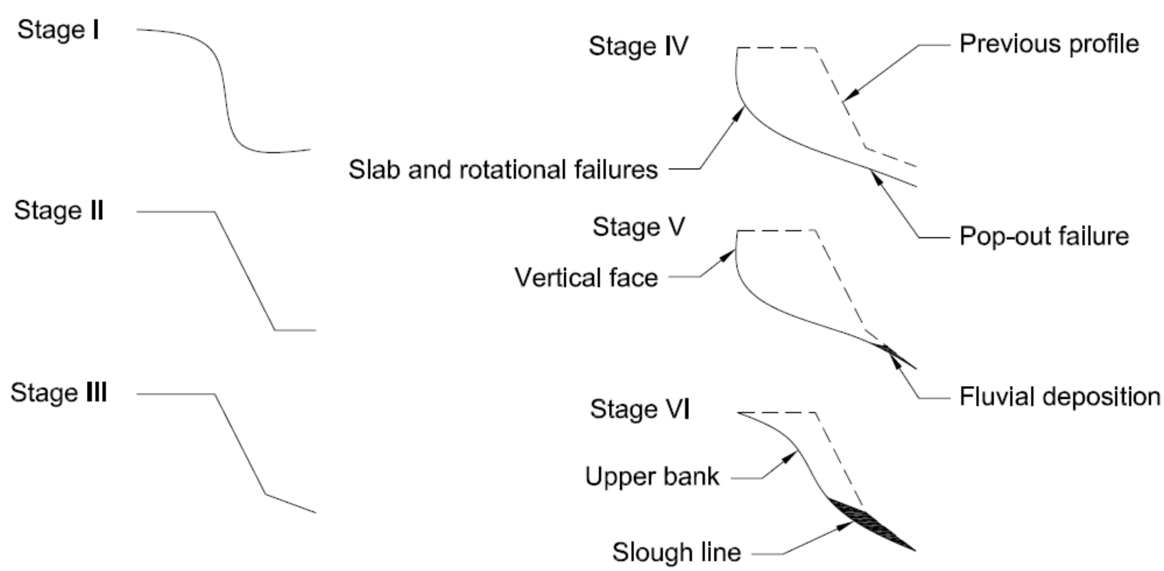


Figure 4. Modified channel evolution model (Simon & Hupp, 1987)

Quantifying streambank erosion using process-based models

Process-based models identify streambank erosion by simulating sediment transport or the entrainment and movement of soil particles through suspension (suspended load) or rolling, sliding, and saltation (bedload) (Prosser & Rustomji, 2000; Vericat & Batalla, 2010). Saltation refers to particles that skip or periodically lose contact with the channel bed. Sediment transport capacity refers to the maximum amount of sediment a flow can carry, and erosion occurs when the total sediment load is less than the flow's transport capacity (Aksoy & Kavvas, 2005; Huang et al., 1999; Prosser & Rustomji, 2000). One of the more popular and commonly used one (1D) and two-dimensional (2D) models is the Hydrologic Engineering Center-River Analysis System (HEC-RAS) software (Damte et al., 2021; Haghiabi & Zaredehdasht, 2012; Sathya et al., 2021). In addition to sediment transport, HEC-RAS is used quite frequently to design and evaluate stream restoration projects (Doll et al., 2020a, 2020b; Marois & Mitsch, 2017; Moore et al., 2014; Violin et al., 2011). The United States Army Corps of Engineers (USACE) maintains this publicly-available software and provides guidance for building, running, and troubleshooting models.

To account for lateral retreat, HEC-RAS is often coupled with the Bank Stability and Toe Erosion (BSTEM) model developed by the United States Department of Agriculture- Agricultural Research Service (USDA-ARS) National Sedimentation Laboratory (Langendoen & Simon, 2008; Pollen-Bankhead & Simon, 2009; Simon et al., 2000, 2011; Simon & Collison, 2002). BSTEM uses flow parameters and bank geometry and geotechnical characteristics to model bank instability. Vegetative characteristics (e.g., root tensile strength, type) can also be simulated but these data are not required. Appendix K includes an overview of the HEC-RAS and BSTEM analyses.

Klavon et al. (2017) provided a comprehensive review of studies using BSTEM to evaluate streambank stability techniques, the causes of bank instability, and the sensitivity to geotechnical parameters (e.g., soil water pore pressure) and roots. Based on these studies' findings, Klavon et al. (2017) reported the model (1) works well for streams in the central United States, (2) can identify the most effective stability techniques and common failure modes, and (3) assists with sediment load calculations. However, the model lacks the ability to account for the influences of vegetation and subaerial processes, and results from simulations using default BSTEM parameters should be used with caution.

Quantifying soil erodibility parameters

In-situ or laboratory-scale jet erosion tests (JETs) quantify the critical shear stress (τ_c) and the erodibility coefficient (k_d) used in BSTEM (Al-Madhhachi et al., 2013b; Daly et al., 2013; Khanal et al., 2016; Khanal & Fox, 2017; Lindow et al., 2009; Pollen-Bankhead & Simon, 2010; Smith et al., 2021). Hanson (1990) initially developed the JET apparatus, and modifications have improved performance and usability (Hanson & Cook, 2004). The JET apparatus consists of a deflection plate, jet submergence tank, point gauge, nozzle, jet tube, adjustable head tank, lid and hoses (Figure 23) (Hanson & Cook, 2004).

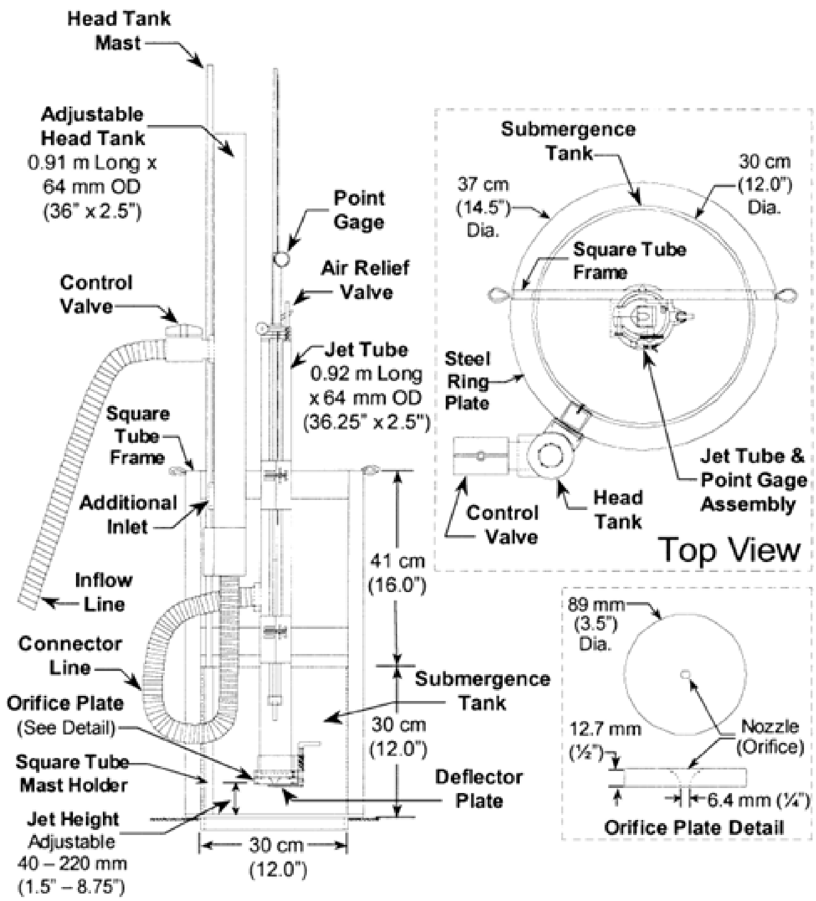


Figure 5. Schematic of full-sized JET (Hanson & Cook, 2004)

The mini-JET is a smaller version of the full-sized JET and uses a rotatable plate with a depth gauge and nozzle, submergence tank, foundation ring, valve, hoses, pressure gauge, adjustable head tank, and inlet and outlet water hoses (Figure 24 and Figure 25). Al-Madhhachi et al. (2013b) compared the full-sized and mini-JET using two soil types and found the mini-JET provides comparable results to the full-sized JET.

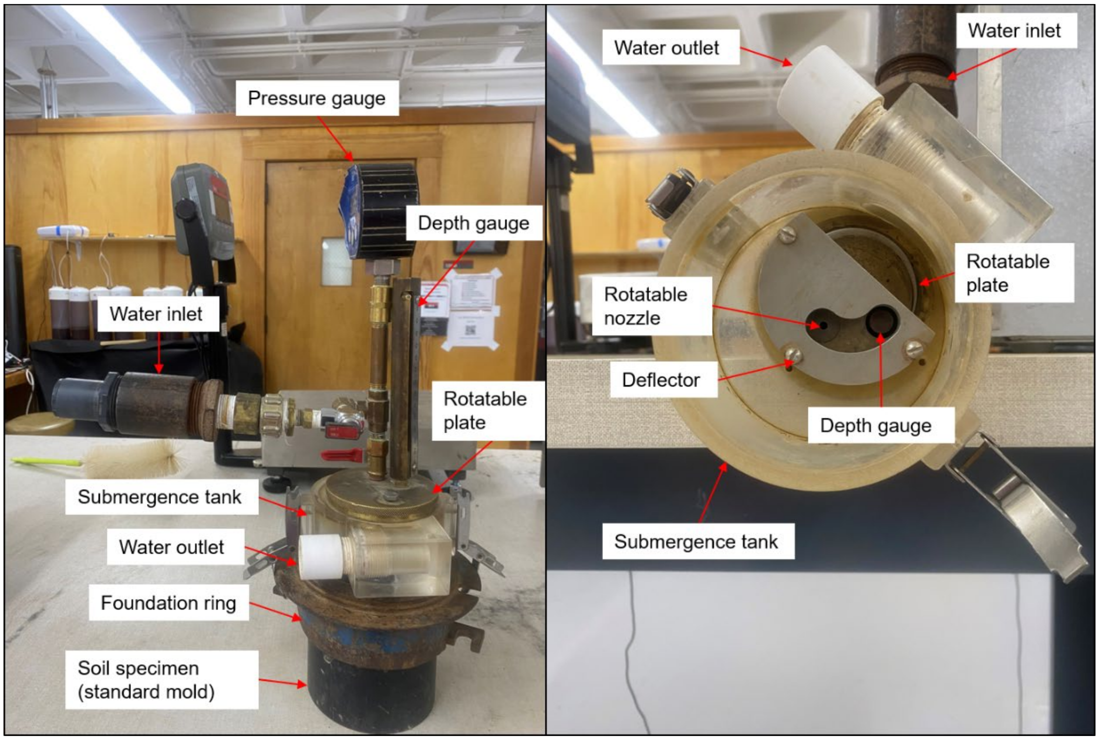


Figure 6. Side view (left) and bottom view (right) of mini-JET

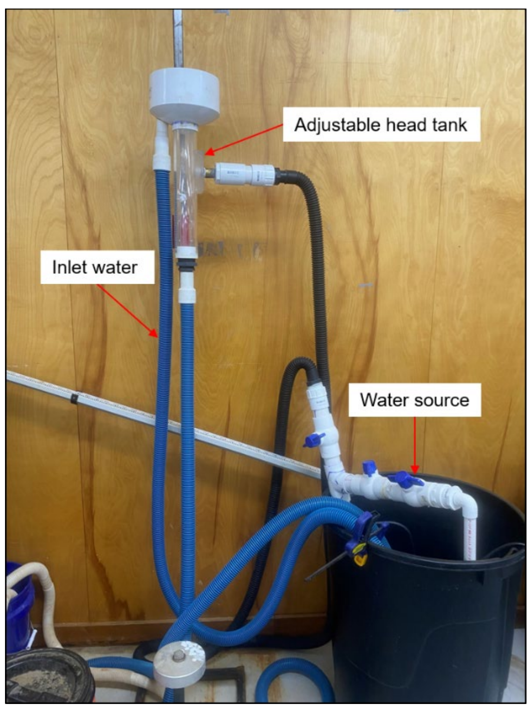
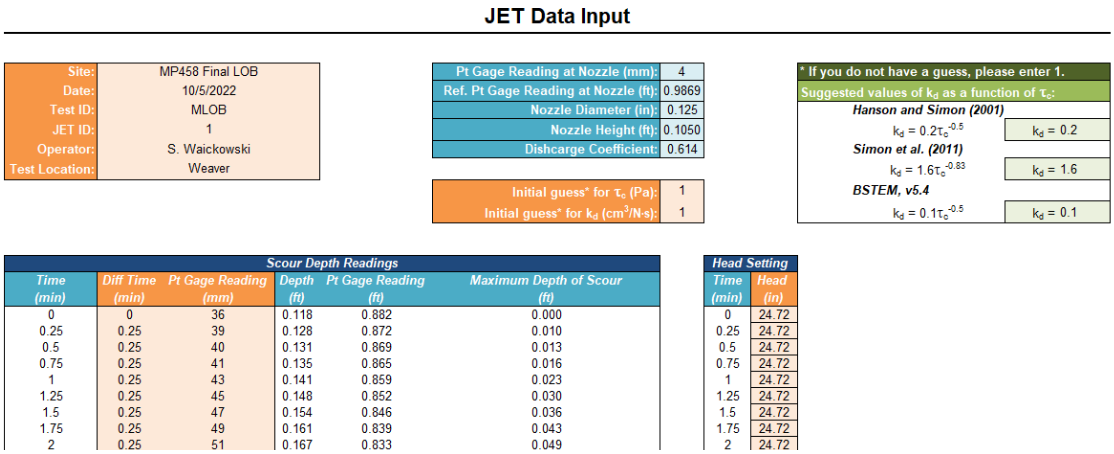


Figure 7. Mini-JET adjustable head tank and water supply

Both devices shoot a small jet of water into the soil at a constant pressure head, which causes the material to erode and create a scour hole (Al-Madhhachi et al., 2013b). Depth measurements are taken at different intervals and used to solve for τ_c and k_d in the JET

Spreadsheet Tool version 2.1 (Figure 26) (Daly et al., 2013). The time intervals for the scour hole readings are subjective. Khanal et al. (2016) recommends the initial and final time intervals are at least 30 and 300 seconds, respectively. The initial pressure head is also subjective and requires iteration until a reasonable ε and total scour depth under the expected range of applied shear stresses (τ_a) is achieved. Fox et al. (2022) used raw data from 187 mini-JET experiments to develop guidance for selecting an initial pressure head. Fox et al. (2022) found the minimum pressure head needed to achieve 1 in of scour for a 60-minute test is 1, 8, 18, and 98 in for highly erodible, more erodible, erodible, and moderately resistant soils, respectively. For a 90-minute test, the minimum pressure head is 0.59, 6, 12, and 69 in for highly erodible, more erodible, erodible, and moderately resistant soils, respectively.


JET Data Input

Site:	MP458 Final LOB
Date:	10/5/2022
Test ID:	MLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1050
Dishcarge Coefficient:	0.614

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess, please enter 1.	
Suggested values of k_d as a function of τ_c:	
Hanson and Simon (2001)	
$k_d = 0.2\tau_c^{-0.5}$	$k_d = 0.2$
Simon et al. (2011)	
$k_d = 1.6\tau_c^{-0.83}$	$k_d = 1.6$
BSTEM, v5.4	
$k_d = 0.1\tau_c^{-0.5}$	$k_d = 0.1$

Scour Depth Readings					
Time (min)	*Diff Time (min)*	*Pt Gage Reading (mm)*	*Depth (ft)*	*Pt Gage Reading (ft)*	*Maximum Depth of Scour (ft)*
0	0	36	0.118	0.882	0.000
0.25	0.25	39	0.128	0.872	0.010
0.5	0.25	40	0.131	0.869	0.013
0.75	0.25	41	0.135	0.865	0.016
1	0.25	43	0.141	0.859	0.023
1.25	0.25	45	0.148	0.852	0.030
1.5	0.25	47	0.154	0.846	0.036
1.75	0.25	49	0.161	0.839	0.043
2	0.25	51	0.167	0.833	0.049

Head Setting	
Time (min)	*Head (in)*
0	24.72
0.25	24.72
0.5	24.72
0.75	24.72
1	24.72
1.25	24.72
1.5	24.72
1.75	24.72
2	24.72

Figure 8. Example of JET data input sheet (Daly et al., 2013)

The JET Spreadsheet Tool version 2.1 created by Daly et al. (2013) processes the JET specifications, gauge readings, head settings, and scour reading times to identify the soil's erodibility parameters. The tool includes three solution techniques: Blaisdell, Scour Depth, and Iterative Solutions. The Blaisdell method is a linear excess τ model and is based on the analytical work of Blaisdell et al. (1981), Hanson et al. (2002), Hanson & Cook (1997, 2004), and Stein & Nett (1997) (Equation 23 through Equation 34). It is assumed the scour depth changes (δJ/δt) are the ε represented as a function of the maximum τ (Equation 23). The Blaisdell method also assumes the soil's τ_c (Equation 24) occurs when the scour rate is equal to zero at the equilibrium scour depth (J_e) or when erosion is no longer occurring (Equation 27). To optimize the calculations, Blaisdell et al. (1981) developed a hyperbolic function to predict J_e, which is calculated using the scour depth readings, time intervals, and the Solver tool in Microsoft Excel (Equation 28). The scour depth readings, time intervals, dimensional time function developed by Stein & Nett (1997), Excel Solver, and an initial estimate of τ_c are used to fit Equation 29 to solve for k_d. The additional parameters included in Equation 29 are calculated using Equation 30 through Equation 34.

$$\frac{\delta J}{\delta t} = k_d \left[\frac{\tau_o J_p^2}{J^2} - \tau_c \right] \text{ for } J \geq J_p \qquad \text{Equation 5}$$

Where:
$\delta J/\delta t$ = scour rate (i/min)
k_d = erodibility coefficient ($in^3/lb*s$)
τ_o = maximum shear stress (lb)
J_p = potential core length from jet origin (in)
J = scour depth (in)
τ_c = critical shear stress (lb/in^2)

$$\tau_c = \tau_o \left(\frac{J_p}{J_e} \right)^2 \qquad \text{Equation 6}$$

Where:
τ_c = critical shear stress (lb/in^2)
τ_o = maximum shear stress (lb/in^2)
J_p = potential core length from jet origin (in)
J_e = equilibrium scour depth (in)

$$\tau_o = C_f * \rho_w * U_o^2 \qquad \text{Equation 7}$$

Where:
τ_o = maximum shear stress (lb/in^2)
C_f = coefficient of friction (0.00416)
ρ_w = density of water (62.4 lb/ft^3) at temperature during test
U_o = jet velocity at the orifice (in/s)

$$J_p = C_d * d_o \qquad \text{Equation 8}$$

Where:
J_p = potential core length from jet origin (in)
C_d = diffusion constant (6.3)
d_o = jet nozzle diameter (in)

$$J_e = d_o 10^{\log\left(\frac{J_e}{d_o}\right)} \qquad \text{Equation 9}$$

Where:
J_e = equilibrium scour depth (in)
d_o = jet nozzle diameter (in)

$$A_1^2 = \left[\left(\log\left(\frac{J}{d_o}\right) - \log\left(\frac{U_o t}{d_o}\right)\right) - \log\frac{J_e}{d_o}\right]^2 - \log\left(\frac{U_o t}{d_o}\right)^2 \qquad \text{Equation 10}$$

Where:
A_1 = hyperbola's semi-transfer and semi-conjugate value
J = scour depth (in)
d_o = jet nozzle diameter (in)
U_o = jet velocity at the orifice (in/s)
t = time (s)
J_e = equilibrium scour depth (in)

$$T^* - T_p^* = -J^* + 0.5\ln\left(\frac{1+J^*}{1-J^*}\right) + J_p^* - 0.5\ln\left(\frac{1+J_p^*}{1-J_p^*}\right) \qquad \text{Equation 11}$$

Where:
T^* = dimensional time of scour depth to J_e (s/s)
T_p^* = dimensional time from jet nozzle to initial soil surface (s/s)
J^* = dimensional scour depth to J_e (in/in)
J_p^* = dimensional potential core length to J_e (in/in)

$$T^* = \frac{t}{\quad_r} \qquad \text{Equation 12}$$

Where:
T^* = dimensional time of scour depth to J_e (s/s)
t = time of scour depth reading (s)
T_r = reference time to reach equilibrium scour depth (s)

$$T_r = \frac{J_e}{k_d \tau_c} \qquad \text{Equation 13}$$

Where:
T_r = reference time to reach equilibrium scour depth (s)
J_e = equilibrium scour depth (cm)
k_d = erodibility coefficient (in^3/lbf*s)
τ_c = critical shear stress (lb/in^2)

$$T_p^* = \frac{T_p}{T_r}$$ Equation 14

Where:
T_p^* = dimensional time from jet nozzle to initial soil surface (s/s)
T_p = time from jet nozzle to initial soil surface (s)
T_r = reference time to reach equilibrium scour depth (s)

$$J^* = \frac{J}{J_e}$$ Equation 15

Where:
J^* = dimensional scour depth to J_e (in/in)
J = scour depth (in)
J_e = equilibrium scour depth (in)

$$J_p^* = \frac{J_p}{J_e}$$ Equation 16

Where:
J_p^* = dimensional scour depth to J_e (in)
J_p = dimensional potential core length (in)
J_e = equilibrium scour depth (in)

The Scour Depth method is based on the work of Al-Madhhachi et al. (2013a, 2014), Daly et al. (2013), and Wilson (1993a, 1993b). This non-linear method uses the excess τ equation (Equation 35) and the Excel solver to fit τ_c and k_d to the scour depths observed at each time interval. The generalized reduced gradient method is used to minimize the sum of the squared errors (SSE) between the observed scour depth and solutions for Equation 35. The Iterative Solutions method developed by Simon et al. (2010) uses the basis of dimensionless time (T*) (Equation 30) and scour depth (J*) (Equation 33) to solve for τ_c and k_d simultaneously. The model fits the data by minimizing the root mean square errors (RMSEs) between the observed and predicted time measurements that are estimated using Equation 29. The initial guesses for τ_c and k_d are derived from the Blaisdell method.

$\varepsilon = 100 * k_d * (\tau_o - \tau_c)^a$ Equation 17

Where:

ε = erosion rate (in/s)

k_d = erodibility coefficient (in^3/lbf*s)

τ_o = maximum shear stress (lb/in^2)

τ_c = critical shear stress (lb/in^2)

a = exponent typically assumed to be 1

Existing literature provides conflicting recommendations for which technique to use to solve for τ_c and k_d. Daly et al. (2013, 2015) and Simon et al. (2010) reported the Blaisdell method underestimates τ_c and suggested the Scour Depth method should be used instead. Karamigolbaghi et al. (2017) compared the results from 155 JET tests conducted throughout the United States and found the Scour Depth and Iterative Solutions methods may calculate physically unrealistic erodibility parameters. However, Karamigolbaghi et al. (2017) also concluded that the Iterative Solutions and Scour Depth techniques provide stronger regression equations between τ_c and k_d (R^2 values between 0.63 and 0.71) compared to the Blaisdell method (R^2 value of 0.43). Mahalder et al. (2018) compared the erodibility parameters derived by the three techniques using data collected from 21 sites across Tennessee. The results indicated the Blaisdell method was more consistent, and they recommended τ_c and k_d should be derived using this technique. However, all of these studies acknowledged JET results are influenced by soil texture, w, and bulk density (ρ_b) as well as JET operational procedures.

Appendix B: Hydrologic equations

The duration of flow associated with the 1-yr and 10-yr, 24-hr storms were calculated using Equation 36 through Equation 40 (Malcom, 1989; USDA-NRCS, 2004). The velocities associated with the peak discharges were calculated using Equation 41 through Equation 48 (Saatci, 1990), and the Manning's roughness coefficient (n) used in these equations was calculated using Equation 49 through Equation 54 (Camp, 1946).

$$S = \left(\frac{1000}{CN} - 10\right) \quad \text{Equation 1}$$

$$Q^{*} = \left(\frac{(P-0.2S)^2}{P+0.8S}\right) \quad \text{Equation 2}$$

$$V = 3630 * Q^{*} A \quad \text{Equation 3}$$

$$T_p = \frac{V}{1.39 Q_p} \quad \text{Equation 4}$$

$$Q = \begin{cases} \frac{Q_p}{2}\left[1 - \cos\left(\frac{\pi t}{T_p}\right)\right], & 0 \le t \le 1.25 T_p \\ 4.34 Q_p e^{-1.3\left(\frac{t}{T_p}\right)}, & t > 1.25 T_p \end{cases} \quad \text{Equation 5}$$

Where:
Q = discharge (ft^3/s)
Q_p = peak discharge (ft^3/s)
t = time (s)
T_p = time to peak (s)
V = runoff volume (ft^3)
Q^{*} = runoff depth (in)
A = watershed area (ac)
P = precipitation (in)
S = maximum potential retention (in)
CN = curve number (unitless)

$$\theta = 2\cos^{-1}\left(\frac{r-h}{r}\right) \qquad \text{Equation 6}$$

Partially full pipe flow- less than half full

$$A = \frac{r^2(\theta - \sin\theta)}{2} \qquad \text{Equation 7}$$

$$P = r\theta \qquad \text{Equation 8}$$

$$R_h = {}^{A}\!/_{P} \qquad \text{Equation 9}$$

$$V = \frac{\frac{AR_h^{2/3}S^{1/2}}{n}}{\frac{r^2(\theta - \sin\theta)}{2}} \qquad \text{Equation 10}$$

Partially full pipe flow- more than half full

$$A = \pi r^2 - \frac{r^2(\theta - \sin\theta)}{2} \qquad \text{Equation 11}$$

$$P = 2\pi r - r\theta \qquad \text{Equation 12}$$

$$V = \frac{\frac{AR_h^{2/3}S^{1/2}}{n}}{\pi r^2 - \frac{r^2(\theta - \sin\theta)}{2}} \qquad \text{Equation 13}$$

Where:

V = velocity (ft/s)

A = cross-sectional area of flow normal to the flow direction (ft^2)

R_h = hydraulic radius (ft)

S = pipe slope (ft/ft)

n = Manning's roughness coefficient ($s/ft^{1/3}$)

r = pipe radius (ft)

θ = angle projected from center of pipe to flow depth (radians)

h = flow depth (ft)

$0 \le {}^{h}/_{D} \le 0.03$	$n/n_{full} = 1 + \frac{h/D}{0.30}$	Equation 14
$0.03 \le {}^{h}/_{D} \le 0.10$	$n/n_{full} = 1.1 + (h/D - 0.03)(12/7)$	Equation 15
$0.10 \le {}^{h}/_{D} \le 0.20$	$n/n_{full} = 1.22 + 0.60(h/D - 0.10)$	Equation 16
$0.20 \le {}^{h}/_{D} \le 0.30$	1.29	Equation 17
$0.30 \le {}^{h}/_{D} \le 0.50$	$n/n_{full} = 1.29 - 0.20(h/D - 0.30)$	Equation 18
$0.50 \le {}^{h}/_{D} \le 1.0$	$n/n_{full} = 1.29 - 0.50(h/D - 0.50)$	Equation 19

Where:
n = Manning's roughness coefficient for pipe flow ($s/ft^{1/3}$)
n_{full} = Manning's roughness coefficient for full pipe flow ($s/ft^{1/3}$)
h = Water level (ft)
D = Pipe diameter (ft)

Appendix C: Predictor variables and responses for decision tree and PCR analyses for occurrence of erosion

Table 1. Predictor variables and responses for occurrence of erosion analyses

Site	PD[a]	WA[b]	IA[c]	OA[d]	CN[e]	Qp_1[f]	Qp_{10}[g]	D_1[h]	D_{10}[i]	V_1[j]	V_{10}[k]	R[l]	DE[m]	A[n]	B[o]	C[p]	D[q]	q_u[r]	n[s]	ρ_b[t]	S[u]	C[v]	RE
DE162	3.5	2	0	0	77	2.52	7.00	2.70	2.93	1.99	2.63	22	6	0	100	0	0	1.88	0.06	58	38	13	F
MP024	3.5	37	4	35	58	6.24	65.76	7.33	4.57	2.67	5.16	211	4	28	72	0	0	0.63	0.10	74	75	10	F
MP078	2	0	0	0	90	0.79	1.60	1.90	2.20	1.57	1.91	1073	28	0	0	100	0	0.88	0.08	67	75	7	F
MP120	4	21	0	21	80	32.76	83.72	4.00	4.30	4.18	5.51	229	0	0	69	31	0	0.88	0.10	59	65	12	T
MP138	1.5	12	3	8	76	11.10	32.77	4.67	4.93	3.23	4.03	329	28	0	36	64	0	2.50	0.10	78	75	15	F
MP142	2	0	0	0	55	0.02	0.52	3.20	1.83	0.58	1.40	185	6	0	100	0	0	2.50	0.06	74	61	18	T
MP143	3	101	6	97	73	80.47	258.22	5.87	5.97	5.46	6.40	8	3	14	78	4	3	0.50	0.10	74	73	10	T
MP152	3	3	0	2	73	3.10	9.42	2.60	2.93	2.23	3.01	1154	17	0	24	47	29	1.50	0.06	74	75	9	T
MP219	3	35	1	30	69	25.27	90.76	5.73	5.73	3.46	4.98	678	16	0	41	0	59	0.75	0.06	72	37	17	F
MP225	3.5	11	1	0	57	1.26	13.80	12.63	7.73	1.73	3.30	1844	27	0	99	0	1	2.75	0.10	71	27	11	F
MP227	2	1	0	0	55	0.09	1.47	4.17	2.47	0.99	2.16	1154	36	0	100	0	0	1.00	0.04	97	38	14	F
MP228	2	0	0	0	55	0.03	0.44	3.00	2.07	0.42	0.85	2261	9	0	100	0	0	1.50	0.06	73	36	18	T
MP229	2.5	0	0	0	77	0.51	1.32	1.97	2.33	0.54	0.70	2446	7	0	0	0	100	0.50	0.06	51	22	16	T
MP257	1.5	16	1	16	43	0.01	1.79	3.07	11.40	0.34	1.43	1070	28	55	45	0	0	1.38	0.10	63	40	19	T
MP292	4	45	6	42	61	2.43	43.64	11.30	4.73	2.05	4.55	283	40	1	99	0	0	2.25	0.10	74	61	12	T
MP311	2	0	0	0	58	0.11	0.83	2.10	1.90	0.88	1.52	214	4	0	100	0	0	0.88	0.06	42	33	15	F
MP318	1.5	4	0	4	56	1.02	9.84	4.10	3.03	1.71	3.14	953	25	0	100	0	0	1.00	0.10	65	69	12	T
MP319	1.5	112	5	106	53	1.23	81.91	30.70	6.57	1.79	4.03	294	9	18	82	0	0	1.00	0.06	64	67	11	T
MP356	2	7	4	5	93	14.01	27.04	4.97	5.47	3.51	3.51	461	18	0	30	0	70	0.38	0.06	51	55	7	T

MP359	2	7	4	7	92	21.69	42.01	3.33	3.73	3.83	4.88	246	4	0	0	0	100	0.75	0.06	90	56	11	F
MP360	2	2	1	2	89	6.58	13.57	2.90	3.23	2.83	3.50	387	6	0	0	0	100	0.63	0.06	94	70	7	T
MP361	2	1	0	1	90	3.75	7.41	2.40	2.73	2.40	2.93	199	11	0	0	0	100	0.38	0.06	100	63	9	F
MP415	2.5	1	0	1	60	0.35	2.12	2.27	2.17	1.04	1.69	1532	57	0	90	0	10	0.38	0.03	70	19	12	F
MP416	2	4	0	3	59	1.01	8.47	4.40	3.30	1.77	3.20	1772	63	0	100	0	0	1.13	0.03	75	9	22	F
MP425	2.5	11	1	9	81	19.23	47.42	3.77	4.10	2.70	3.34	2180	31	0	12	0	88	1.00	0.08	98	70	13	F
MP426	2.5	18	0	17	84	14.52	33.51	9.20	10.10	2.49	3.07	2481	32	0	0	11	89	1.63	0.06	76	47	9	F
MP427	2.5	0	0	0	86	1.24	2.65	2.03	2.37	1.75	2.16	3251	25	0	0	0	100	0.75	0.06	78	57	12	T
Site	**PD**[a]	**WA**[b]	**IA**[c]	**OA**[d]	**CN**[e]	**Qp_1**[f]	**Qp_{10}**[g]	**D_1**[h]	**D_{10}**[i]	**V_1**[j]	**V_{10}**[k]	**R**[l]	**DE**[m]	**A**[n]	**B**[o]	**C**[p]	**D**[q]	**q_u**[r]	**n**[s]	**ρ_b**[t]	**S**[u]	**C**[v]	**RE**
MP433	3	15	0	15	61	5.43	33.89	4.47	3.70	2.59	4.37	4544	56	0	100	0	0	0.50	0.10	83	62	10	F
MP458	3.5	8	1	6	46	0.02	3.61	12.67	5.03	0.50	2.30	1090	14	61	39	0	0	1.50	0.10	90	69	16	T
MP459	3.5	17	4	15	53	0.36	16.96	26.37	6.90	1.23	3.51	289	15	71	30	0	0	1.00	0.10	86	83	7	F
MP465	1.5	3	0	2	73	4.04	12.14	2.70	3.07	2.54	3.32	388	20	0	100	0	0	NA	0.03	72	54	16	T
MP467	3	1	0	0	82	1.84	4.40	2.13	2.47	1.92	2.45	317	16	0	0	100	0	1.88	0.08	83	74	3	F
MP469	2.5	3	1	0	89	8.97	18.75	3.17	3.53	3.02	3.76	1269	23	0	0	0	100	1.00	0.06	76	78	8	F
MP472	1.25	37	15	33	85	74.06	171.64	4.87	5.33	3.57	3.57	165	2	0	39	48	14	0.88	0.10	61	72	11	F
MP495	2	2	1	0	90	5.72	11.66	2.87	3.23	1.94	2.39	3316	1	0	0	0	100	0.88	0.06	79	54	17	T
MP507	1.5	0	0	0	77	0.56	1.47	1.77	2.07	1.46	1.89	661	7	0	0	0	100	0.75	0.04	74	64	5	T
MP508	2.5	2	0	1	85	5.30	12.14	3.27	3.63	2.60	3.30	1162	30	0	0	1	99	0.73	0.06	96	62	10	F
MP508A	1.25	0	0	0	77	0.46	1.21	1.67	2.00	1.00	1.30	66	0	0	0	0	100	0.25	0.04	84	48	16	F
MP508C	1	0	0	0	77	0.48	1.26	1.70	2.03	1.43	1.89	393	19	0	0	0	100	0.21	0.04	81	53	9	T
MP508D	1.5	1	0	1	77	1.65	4.35	2.07	2.40	2.05	2.64	433	19	0	0	0	100	0.16	0.05	78	51	13	F
MP511	3	1	0	1	77	1.47	3.92	2.33	2.67	1.81	2.38	163	2	0	0	0	100	0.24	0.04	77	55	10	F

MP525	4	38	1	38	71	37.61	128.56	4.33	4.50	4.36	5.99	104	4	0	46	51	3	0.88	0.10	66	83	8	F
MP558	1	1	1	0	92	4.43	8.79	2.97	3.37	2.67	3.08	440	0	0	31	0	69	1.00	0.06	70	55	14	T
MP559	1	2	0	0	82	0.90	2.18	10.63	12.13	1.71	2.22	704	26	0	28	0	72	1.00	0.10	70	55	14	T
MP573	3.5	31	1	30	67	16.24	66.65	5.47	5.30	2.89	4.31	1824	21	0	26	66	8	2.13	0.08	97	40	9	F
MP578	2.5	12	6	10	87	33.07	72.23	3.83	4.23	4.28	5.66	58	0	6	50	0	44	0.88	0.10	71	74	7	F
MP591	4	1	0	1	82	2.46	5.84	2.50	2.83	1.72	2.17	3605	6	0	0	8	92	2.25	0.10	71	32	16	F
MP615	2.5	11	1	9	48	0.05	7.05	20.57	4.50	0.71	2.82	122	13	54	46	0	0	0.75	0.06	52	76	3	F
MP785	2	8	2	8	67	14.18	45.17	3.13	3.47	NA	NA	73	2	0	100	0	0	NA	0.10	NA	NA	NA	T
MP814	4	29	15	25	90	62.68	128.28	5.27	5.77	3.62	4.28	311	11	0	0	0	100	0.75	0.06	83	50	23	F
MP840	2.5	5	2	4	76	7.45	20.48	2.87	3.23	2.86	3.85	2001	28	1	66	0	34	0.63	0.06	53	58	6	F
OUT2104	1.5	2	0	0	83	1.24	2.91	8.87	10.10	1.80	2.30	1072	17	0	0	65	35	1.50	0.06	74	75	9	T
OUT2106	1	2	1	0	91	4.68	9.38	2.80	3.17	2.76	3.08	1125	17	0	0	89	11	1.50	0.06	74	75	9	T
OUT2111	2	0	0	0	70	0.53	1.69	2.07	2.40	1.21	1.67	458	18	0	57	0	43	0.63	0.06	69	18	20	F
POW162	2	0	0	0	74	0.37	1.05	1.67	2.00	1.22	1.62	868	20	0	100	0	0	2.38	0.06	73	38	17	F
W10	2	1	1	0	89	2.64	5.47	2.73	3.10	2.24	2.77	2965	74	0	0	100	0	0.75	0.06	75	57	18	T
W11	2	5	0	5	80	9.17	23.46	3.13	3.47	3.12	3.90	3045	5	0	0	74	26	0.75	0.04	96	59	21	T
Site	**PD**[a]	**WA**[b]	**IA**[c]	**OA**[d]	**CN**[e]	**Q_{p1}**[f]	**Q_{p10}**[g]	**D_1**[h]	**D_{10}**[i]	**V_1**[j]	**V_{10}**[k]	**R**[l]	**DE**[m]	**A**[n]	**B**[o]	**C**[p]	**D**[q]	**q_u**[r]	**n**[s]	**ρ_b**[t]	**S**[u]	**C**[v]	**RE**
W13	1.5	8	5	8	92	24.97	48.15	3.60	4.00	2.24	2.77	242	8	0	0	0	100	0.75	0.06	75	62	10	F
W18	1	9	1	0	86	19.39	43.81	3.73	4.13	3.08	3.08	1483	34	0	0	0	100	2.75	0.06	84	69	16	F
W19C	3	3	2	0	94	7.60	14.49	4.03	4.50	2.83	3.40	945	4	0	0	0	100	1.88	0.06	77	72	12	F

Note RE refers to the response where T = True (1, erosion stopped before reaching outfall location) and F = False (0, erosion extended to the outfall); [a] Pipe diameter (ft), [b] Watershed area (ac), [c] Impervious area (ac), [d] Offsite-area (ac), [e] Composite curve number, [f] Peak discharge for 1-yr, 24-hr storm event (ft^3/s), [g] Peak discharge for 10-yr, 24-hr storm event (ft^3/s), [h] Duration of 1-yr, 24-hr storm event (hr), [i] Duration of 10-yr, 24-hr storm event (hr), [j] Maximum velocity 1-yr, 24-hr storm: Permissible velocity, [k] Maximum velocity 10-yr, 24-hr storm event: Permissible velocity, [l] Radial distance of pipe outlet from stream (ft), [m] Departure (ft), [n] Downslope hydrologic soil group (HSG) A soils (%), [o] Downslope HSG B soils (%), [p] Downslope HSG C soils (%), [q] Downslope HSG D soils (%), [r] Median approximate unconfined compressive strength of channel banks immediately downslope of pipe outlet (lb/ft^2), [s] Median Manning's n coefficient for channel banks immediately downslope of pipe outlet ($s/ft^{1/3}$), [t] Median bulk density of channel banks immediately downslope of pipe outlet (lb/ft^3), [u] Median percentage of sand content in channel banks immediately downslope of pipe outlet (%), [v] Median percentage of clay content in channel banks immediately downslope of pipe outlet (%)

Appendix D: Predictor variables and responses for magnitude of erosion analyses

Table 1. Predictor variables and responses for magnitude of erosion (cross-sectional dimensions) analyses

Site	PT[a]	Qu[b]	MN[c]	PD[d]	WA[e]	OA[f]	IA[g]	R[h]	A[i]	B[j]	C[k]	D[l]	CN[m]	V_1[n]	V_{10}[o]	DI[p]	DE[q]	Qp1[r]	Qp10[s]	D_1[t]	D_{10}[u]	W	AR	DP
DE162	995	1.88	0.06	3.5	2	0	0	22	0	100	0	0	77	1.99	2.63	2.52	7.00	3	3	0	6	12	10	8
MP024	2086	0.63	0.10	3.5	37	35	4	211	28	72	0	0	58	2.67	5.16	6.24	65.76	7	5	0	4	2	1	4
MP078	1031	0.88	0.08	2	0	0	0	1073	0	0	100	0	90	1.57	1.91	0.79	1.60	2	2	0	28	9	6	8
MP120	2124	0.88	0.10	4	21	21	0	229	0	69	31	0	80	4.18	5.51	32.76	83.72	4	4	0	0	0	0	0
MP138	2069	2.50	0.10	1.5	12	8	3	329	0	36	64	0	76	3.23	4.03	11.10	32.77	5	5	0	28	6	3	5
MP142	2121	2.50	0.06	2	0	0	0	185	0	100	0	0	55	0.58	1.40	0.02	0.52	3	2	0	6	14	9	7
MP143	2126	0.50	0.10	3	101	97	6	8	14	78	4	3	73	5.46	6.40	80.47	258.22	6	6	0	3	0	0	0
MP152/ OUT2104/ OUT2106	2105	1.50	0.06	3	6	2	1	1118	0	10	64	27	81	2.23	3.01	2.85	7.16	5	5	0	17	15	13	8
MP152/ OUT2104/ OUT2106	2108	1.25	0.06	3	6	2	1	1118	0	10	64	27	81	2.23	3.01	2.85	7.16	5	5	283	12	7	4	6
MP152/ OUT2104/ OUT2106	2110	1.25	0.08	3	6	2	1	1118	0	10	64	27	81	2.23	3.01	2.85	7.16	5	5	542	4	17	35	20
MP152/ OUT2104/ OUT2106	2111	1.50	0.10	3	6	2	1	1118	0	10	64	27	81	2.23	3.01	2.85	7.16	5	5	573	5	8	3	4
MP219	482	0.75	0.06	3	35	30	1	678	0	41	0	59	69	3.46	4.98	25.27	90.76	6	6	0	16	2	0	3
MP225	1044	2.75	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	0	27	3	2	9
MP225	1045	1.75	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	342	21	3	1	5
MP225	1046	1.25	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	543	18	4	3	8
MP225	1047	1.13	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	839	12	2	1	3
MP225	1048	1.50	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	1453	3	3	1	5
MP227	502	1.00	0.04	2	1	0	0	1154	0	100	0	0	55	0.99	2.16	0.09	1.47	4	2	0	36	13	7	9
MP227	2043	1.88	0.10	2	1	0	0	1154	0	100	0	0	55	0.99	2.16	0.09	1.47	4	2	1016	2	13	28	22
MP227	2045	3.63	0.06	2	1	0	0	1154	0	100	0	0	55	0.99	2.16	0.09	1.47	4	2	347	21	15	12	11
MP228	628	1.50	0.06	2	0	0	0	2261	0	100	0	0	55	0.42	0.85	0.03	0.44	3	2	0	9	27	29	14
MP229	506	0.50	0.06	2.5	0	0	0	2446	0	0	0	10	77	0.54	0.70	0.51	1.32	2	2	0	7	26	32	6

												0												
MP257	2059	1.38	0.10	1.5	16	16	1	1070	55	45	0	0	43	0.34	1.43	0.01	1.79	3	11	0	28	8	3	3
MP257	2061	1.50	0.10	1.5	16	16	1	1070	55	45	0	0	43	0.34	1.43	0.01	1.79	3	11	109	24	14	9	5
MP257	2062	1.63	0.10	1.5	16	16	1	1070	55	45	0	0	43	0.34	1.43	0.01	1.79	3	11	346	20	4	1	3
MP292	2083	2.25	0.10	4	45	42	6	283	1	99	0	0	61	2.05	4.55	2.43	43.64	11	5	0	40	0	0	0
MP311	999	0.88	0.06	2	0	0	0	214	0	100	0	0	58	0.88	1.52	0.11	0.83	2	2	686	4	10	9	11
MP311	1000	0.88	0.06	2	0	0	0	214	0	100	0	0	58	0.88	1.52	0.11	0.83	2	2	902	2	19	24	17
MP318	2084	1.00	0.10	1.5	4	4	0	953	0	100	0	0	56	1.71	3.14	1.02	9.84	4	3	0	25	3	24	10
MP319	2082	1.00	0.06	1.5	112	106	5	294	18	82	0	0	53	1.79	4.03	1.23	81.91	31	7	0	9	1	1	2
MP356	2046	0.38	0.06	2	7	5	4	461	0	30	0	70	93	3.51	3.51	14.01	27.04	5	5	0	18	6	2	5
Site	**PT**[a]	**Qu**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**W**	**AR**	**DP**
MP359	1006	0.75	0.06	2	7	7	4	246	0	0	0	100	92	3.83	4.88	21.69	42.01	3	4	0	4	8	8	11
MP360	1008	0.63	0.06	2	2	2	1	387	0	0	0	100	89	2.83	3.50	6.58	13.57	3	3	0	6	6	4	6
MP361	1003	0.38	0.06	2	1	1	0	199	0	0	0	100	90	2.40	2.93	3.75	7.41	2	3	0	11	15	37	36
MP415	1018	0.38	0.03	2.5	1	1	0	1532	0	90	0	10	60	1.04	1.69	0.35	2.12	2	2	0	57	10	12	13
MP415/MP416	1019	1.25	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	182	55	6	4	8
MP415/MP416	1020	1.25	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	168	52	12	19	15
MP415 /MP416	1021	1.25	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	502	45	8	5	6
MP415/MP416	1022	1.00	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	1044	33	11	6	5
MP415/MP416	1023	0.88	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	1568	21	9	10	11
MP415/MP416	1024	1.13	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	2168	11	16	28	18
MP415/MP416	1026	0.75	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	1331	26	18	33	15
MP416	1017	1.13	0.03	2	4	3	0	1772	0	100	0	0	59	1.77	3.20	1.01	8.47	4	3	0	63	3	2	7
MP425	1033	1.00	0.08	2.5	11	9	1	2180	0	12	0	88	81	2.70	3.34	19.23	47.42	4	4	0	31	5	5	11
MP425/MP426	1034	0.88	0.10	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	352	18	3	2	5
MP425/MP426	1035	1.13	0.10	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	441	16	2	1	3

MP425/MP426	1036	0.88	0.08	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	676	12	3	1	3
MP425/MP426	1037	1.75	0.08	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	790	11	3	1	2
MP425/MP426	1039	1.50	0.06	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	971	6	2	1	4
MP426	1041	1.63	0.06	2.5	18	17	0	2481	0	0	11	89	84	2.49	3.07	14.52	33.51	9	10	0	32	2	0	2
MP426	1042	1.00	0.06	2.5	18	17	0	2481	0	0	11	89	84	2.49	3.07	14.52	33.51	9	10	269	21	2	1	2
MP427	185	0.75	0.06	2.5	0	0	0	3251	0	0	0	100	86	1.75	2.16	1.24	2.65	2	2	0	25	0	0	0
MP433	1010	0.50	0.10	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	0	56	3	1	3
MP433	1011	0.50	0.10	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	241	35	3	2	8
MP433	1012	0.50	0.06	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	298	31	3	3	13
MP433	1013	0.50	0.08	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	556	24	6	4	6
MP433	1014	1.00	0.08	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	775	18	2	0	2
MP433	1015	1.00	0.08	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	1186	1	3	1	2
MP458	989	1.50	0.10	3.5	8	6	1	1090	61	39	0	0	46	0.50	2.30	0.02	3.61	13	5	0	14	16	15	10
MP458	990	1.25	0.10	3.5	8	6	1	1090	61	39	0	0	46	0.50	2.30	0.02	3.61	13	5	150	12	7	8	11
MP458	991	0.75	0.06	3.5	8	6	1	1090	61	39	0	0	46	0.50	2.30	0.02	3.61	13	5	297	6	7	11	17
MP459	2065	1.00	0.10	3.5	17	15	4	289	71	30	0	0	53	1.23	3.51	0.36	16.96	26	7	0	15	12	2	12
MP459	2067	NA	0.08	3.5	17	15	4	289	71	30	0	0	53	1.23	3.51	0.36	16.96	26	7	114	14	4	2	5
MP465	2096	NA	0.03	1.5	3	2	0	388	0	100	0	0	73	2.54	3.32	4.04	12.14	3	3	0	20	2	5	5
Site	**PT**[a]	**Qu**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V1**[n]	**V10**[o]	**DI**[p]	**DE**[q]	**Qp1**[r]	**Qp10**[s]	**D1**[t]	**D10**[u]	**W**	**AR**	**DP**
MP467	1054	1.88	0.08	3	1	0	0	317	0	0	100	0	82	1.92	2.45	1.84	4.40	2	2	0	16	13	15	19
MP467	1057	0.63	0.06	3	1	0	0	317	0	0	100	0	82	1.92	2.45	1.84	4.40	2	2	206	10	9	7	8
MP469	1062	1.00	0.06	2.5	3	0	1	1269	0	0	0	100	89	3.02	3.76	8.97	18.75	3	4	273	23	4	1	3
MP469/W18	1063	0.50	0.06	2.5	12	0	1	1426	0	0	0	100	87	3.06	3.26	16.60	37.11	4	4	595	7	5	1	3
MP472	2093	0.88	0.10	1.25	37	33	15	165	0	39	48	14	85	3.57	3.57	74.06	171.64	5	5	0	2	0	0	0
MP495	984	0.88	0.06	2	2	0	1	3316	0	0	0	100	90	1.94	2.39	5.72	11.66	3	3	0	1	12	7	6
MP507	997	0.75	0.04	1.5	0	0	0	661	0	0	0	100	77	1.46	1.89	0.56	1.47	2	2	0	27	56	57	9
MP508	962	0.73	0.06	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	0	30	25	27	18
MP508	963	2.13	0.06	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	136	27	12	10	12
MP50	96	1.	0.	2.	2	1	0	11	0	0	1	9	85	2.	3.	5.3	12.	3	4	31	2	7	3	7

8	4	13	06	5				62				9		60	30	0	14			6	5			
MP508	965	1.00	0.06	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	1048	15	5	4	9
MP508	966	1.50	0.08	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	1244	13	20	27	18
MP508	967	1.38	0.08	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	1497	9	18	28	21
MP508	968	0.88	0.10	2.5	3	2	0	979	0	0	1	99	83	2.46	3.14	4.38	10.18	3	3	1362	5	26	67	37
MP508	972	0.75	0.06	3	4	2	0	811	0	0	1	99	81	2.33	2.98	3.79	8.90	3	3	745	0	18	22	12
MP508A	970	0.25	0.04	1.25	0	0	0	66	0	0	0	100	77	1.00	1.30	0.46	1.21	2	2	0	0	69	160	30
MP508C	974	0.21	0.04	1	0	0	0	393	0	0	0	100	77	1.43	1.89	0.48	1.26	2	2	0	19	55	61	12
MP508D	976	0.16	0.05	1.5	1	1	0	433	0	0	0	100	77	2.05	2.64	1.65	4.35	2	2	0	19	47	66	17
MP511	973	0.24	0.04	3	1	1	0	163	0	0	0	100	77	1.81	2.38	1.47	3.92	2	3	0	2	47	67	28
MP511	969	1.13	0.08	3	1	1	0	163	0	0	0	100	77	1.81	2.38	1.47	3.92	2	3	150	1	31	73	30
MP525	2088	0.88	0.10	4	38	38	1	104	0	46	51	3	71	4.36	5.99	37.61	128.56	4	5	0	4	3	8	5
MP558	2080	1.00	0.06	1	1	0	1	440	0	31	0	69	92	2.67	3.08	4.43	8.79	3	3	0	0	0	0	0
MP559	2079	1.00	0.10	1	2	0	0	704	0	28	0	72	82	1.71	2.22	0.90	2.18	11	12	0	26	3	15	9
MP573	2074	2.13	0.08	3.5	31	30	1	1824	0	26	66	8	67	2.89	4.31	16.24	66.65	5	5	0	21	4	3	7
MP578	2076	0.88	0.10	2.5	12	10	6	58	6	50	0	44	87	4.28	5.66	33.07	72.23	4	4	0	0	3	23	9
MP591	2071	2.25	0.10	4	1	1	0	3605	0	0	8	92	82	1.72	2.17	2.46	5.84	3	3	0	6	26	11	13
MP591	2072	1.50	0.10	4	1	1	0	3605	0	0	8	92	82	1.72	2.17	2.46	5.84	3	3	347	3	20	11	11
MP615	993	0.75	0.06	2.5	11	9	1	122	54	46	0	0	48	0.71	2.82	0.05	7.05	21	5	0	13	21	34	17
MP785	2102	NA	0.10	2	8	8	2	73	0	100	0	0	67	NA	NA	14.18	45.17	3	3	0	2	0	0	0
MP814	982	0.75	0.06	4	29	25	15	311	0	0	0	100	90	3.62	4.28	62.68	128.28	5	6	0	11	3	4	2
MP840	609	0.63	0.06	2.5	5	4	2	2001	1	66	0	34	76	2.86	3.85	7.45	20.48	3	3	0	28	9	10	15
MP840	979	1.75	0.06	2.5	5	4	2	2001	1	66	0	34	76	2.86	3.85	7.45	20.48	3	3	319	22	10	11	11
MP840	980	0.75	0.06	2.5	5	4	2	2001	1	66	0	34	76	2.86	3.85	7.45	20.48	3	3	471	12	9	4	5
OUT2111	474	0.63	0.06	2	0	0	0	458	0	57	0	43	70	1.21	1.67	0.53	1.69	2	2	0	18	30	18	8
POW162	996	2.38	0.06	2	0	0	0	868	0	100	0	0	74	1.22	1.62	0.37	1.05	2	2	0	20	21	8	4
POW162	998	NA	0.06	2	0	0	0	868	0	100	0	0	74	1.22	1.62	0.37	1.05	2	2	599	6	17	18	12
W10	959	0.75	0.06	2	1	0	1	2965	0	0	100	0	89	2.24	2.77	2.64	5.47	3	3	0	74	14	11	10
W10	1027	1.88	0.06	2	1	0	1	2965	0	0	100	0	89	2.24	2.77	2.64	5.47	3	3	788	43	7	3	5
Site	**PT**[a]	**Qu**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**W**	**AR**	**DP**
W10	1028	0.88	0.06	2	1	0	1	2965	0	0	100	0	89	2.24	2.77	2.64	5.47	3	3	1236	34	14	23	20
W10	1029	1.13	0.06	2	1	0	1	2965	0	0	100	0	89	2.24	2.77	2.64	5.47	3	3	1951	15	19	22	14

W11	957	0.75	0.04	2	5	5	0	3045	0	0	74	26	80	3.12	3.90	9.17	23.46	3	3	0	5	10	3	4
W13	1004	0.75	0.06	1.5	8	8	5	242	0	0	0	100	92	2.24	2.77	24.97	48.15	4	4	0	8	3	3	12
W13	1005	1.00	0.06	1.5	8	8	5	242	0	0	0	100	92	2.24	2.77	24.97	48.15	4	4	51	0	6	5	9
W18	1059	2.75	0.06	1	9	0	1	1483	0	0	0	100	86	3.08	3.08	19.39	43.81	4	4	0	34	2	0	3
W19C	1065	1.88	0.06	3	3	0	2	945	0	0	0	100	94	2.83	3.40	7.60	14.49	4	5	708	4	5	4	8

Note W refers to Width at top of bank (TOB): Bankfull (BKFUL) width for cross-section (ft/ft), AR refers to $Area_{TOB}$: $Area_{BKFUL}$ for cross-section (ft^2/ft^2), and DP Maximum $Depth_{TOB}$: $Depth_{BKFUL}$ for cross-section (ft/ft); [a] Point number, [b] Median approximate unconfined compressive strength of channel banks (lb/ft^2), [c] Median Manning's roughness coefficient of channel banks ($s/ft^{1/3}$), [d] Pipe diameter (ft), [e] Pipe outlet watershed area (ac), [f] Pipe outlet offsite area within watershed (ac), [g] Pipe outlet impervious area within watershed (ac), [h] Radial distance of pipe outlet to stream (ft), [I] Downslope hydrologic soil group (HSG) A soils (%), [j] Downslope HSG B soils (%), [k] Downslope HSG C soils (%), [l] Downslope HSG D soils (%), [m] Composite curve number (CN) for pipe outlet watershed, [n] Maximum velocity for 1-yr, 24-hr storm event: Permissible velocity, [o] Maximum velocity for 10-yr, 24-hr storm event: Permissible velocity, [p] Distance from pipe outlet to cross-section (ft), [q] Estimated elevation difference between cross-section and outfall (ft), [r] Peak discharge for 1-yr, 24-hr storm event for pipe outlet watershed (ft^3/s), [s] Peak discharge for 10-yr, 24-hr storm event for pipe outlet watershed (ft^3/s), [t] Duration of 1-yr, 24-hr storm event for pipe outlet watershed (hr), [u] Duration of 10-yr, 24-hr storm event for pipe outlet watershed (hr)

Table 2. Summary of predictor variables and responses for magnitude of erosion (volume of eroded soil) analyses

Site	PD[a]	WA[b]	IA[c]	OA[d]	CN[e]	Qp_1[f]	Qp_{10}[g]	D_1[h]	D_{10}[i]	V_1[j]	V_{10}[k]	R[l]	DE[m]	A[n]	B[o]	C[p]	D[q]	q_u[r]	n[s]	ρ_b[t]	S[u]	C[v]	V
DE162	3.5	2	0	0	77	3	7	3	3	2	3	22	0	100	0	0	2	0.06	58	38	13	6	0.15
MP024	3.5	37	4	35	58	6	66	7	5	3	5	211	28	72	0	0	1	0.1	74	75	10	4	0.3
MP078	2	0	0	0	90	1	2	2	2	2	2	1073	0	0	100	0	1	0.08	67	75	7	28	0.14
MP120	4	21	0	21	80	33	84	4	4	4	6	229	0	69	31	0	1	0.1	59	65	12	0	0
MP138	1.5	12	3	8	76	11	33	5	5	3	4	329	0	36	64	0	3	0.1	78	75	15	28	0.28
MP142	2	0	0	0	55	0	1	3	2	1	1	185	0	100	0	0	3	0.06	74	61	18	6	0
MP143	3	101	6	97	73	80	258	6	6	5	6	8	14	78	4	3	1	0.1	74	73	10	3	0
MP152	3	3	0	2	73	3	9	3	3	2	3	1154	0	24	47	29	2	0.06	74	75	9	17	0.19
MP219	3	35	1	30	69	25	91	6	6	3	5	678	0	41	0	59	1	0.06	72	37	17	16	0.48
MP225	3.5	11	1	0	57	1	14	13	8	2	3	1844	0	99	0	1	3	0.1	71	27	11	27	0.28
MP227	2	1	0	0	55	0	1	4	2	1	2	1154	0	100	0	0	1	0.04	97	38	14	36	0.48
MP228	2	0	0	0	55	0	0	3	2	0	1	2261	0	100	0	0	2	0.06	73	36	18	9	0.34
MP229	2.5	0	0	0	77	1	1	2	2	1	1	2446	0	0	0	100	1	0.06	51	22	16	7	0
MP257	1.5	16	1	16	43	0	2	3	11	0	1	1070	55	45	0	0	1	0.1	63	40	19	28	0.67
MP292	4	45	6	42	61	2	44	11	5	2	5	283	1	99	0	0	2	0.1	74	61	12	40	0
MP311	2	0	0	0	58	0	1	2	2	1	2	214	0	100	0	0	1	0.06	42	33	15	4	0.06
MP318	1.5	4	0	4	56	1	10	4	3	2	3	953	0	100	0	0	1	0.1	65	69	12	25	0.37
MP319	1.5	112	5	106	53	1	82	31	7	2	4	294	18	82	0	0	1	0.06	64	67	11	9	0
MP356	2	7	4	5	93	14	27	5	5	4	4	461	0	30	0	70	0	0.06	51	55	7	18	0.23
MP359	2	7	4	7	92	22	42	3	4	4	5	246	0	0	0	100	1	0.06	90	56	11	4	0.22
MP360	2	2	1	2	89	7	14	3	3	3	4	387	0	0	0	100	1	0.06	94	70	7	6	0.09
MP361	2	1	0	1	90	4	7	2	3	2	3	199	0	0	0	100	0	0.06	100	63	9	11	1.39
MP415	2.5	1	0	1	60	0	2	2	2	1	2	1532	0	90	0	10	0	0.03	70	19	12	58	0.08
MP416	2	4	0	3	59	1	8	4	3	2	3	1772	0	100	0	0	1	0.03	75	9	22	63	0.38
MP42	2.	11	1	9	81	19	47	4	4	3	3	21	0	1	0	8	1	0.	9	7	1	3	0.

5	5											80		2		8		08	8	0	3	1	18
MP426	2.5	18	0	17	84	15	34	9	10	2	3	2481	0	0	11	89	2	0.06	76	47	9	32	0.09
MP427	2.5	0	0	0	86	1	3	2	2	2	2	3251	0	0	0	100	1	0.06	78	57	12	25	0
MP433	3	15	0	15	61	5	34	4	4	3	4	4544	0	100	0	0	1	0.1	83	62	10	56	0.06
MP458	3.5	8	1	6	46	0	4	13	5	1	2	1090	61	39	0	0	2	0.1	90	69	16	14	0.32
MP459	3.5	17	4	15	53	0	17	26	7	1	4	289	71	30	0	0	1	0.1	86	83	7	15	0.46
MP465	1.5	3	0	2	73	4	12	3	3	3	3	388	0	100	0	0	NA	0.03	72	54	16	20	0
MP467	3	1	0	0	82	2	4	2	2	2	2	317	0	0	100	0	2	0.08	83	74	3	16	0.61
MP469	2.5	3	1	0	89	9	19	3	4	3	4	1269	0	0	0	100	1	0.06	76	78	8	23	0.03
MP472	1.25	37	15	33	85	74	172	5	5	4	4	165	0	39	48	14	1	0.1	61	72	11	2	0.16
MP495	2	2	1	0	90	6	12	3	3	2	2	3316	0	0	0	100	1	0.06	79	54	17	2	0.22
MP507	1.5	0	0	0	77	1	1	2	2	1	2	661	0	0	0	100	1	0.04	74	64	5	7	0.14
MP508	2.5	2	0	1	85	5	12	3	4	3	3	1162	0	0	1	99	1	0.06	96	62	10	30	1.23
Site	**PD[a]**	**WA[b]**	**IA[c]**	**OA[d]**	**CN[e]**	**Qp_1[f]**	**Qp_{10}[g]**	**D_1[h]**	**D_{10}[i]**	**V_1[j]**	**V_{10}[k]**	**R[l]**	**DE[m]**	**A[n]**	**B[o]**	**C[p]**	**D[q]**	**q_u[r]**	**n[s]**	**ρ_b[t]**	**Su[u]**	**Cv[v]**	**V**
MP508A	1.25	0	0	0	77	0	1	2	2	1	1	66	0	0	0	100	0	0.04	84	48	16	0	0.4
MP508C	1	0	0	0	77	0	1	2	2	1	2	393	0	0	0	100	0	0.04	81	53	9	20	0
MP508D	1.5	1	0	1	77	2	4	2	2	2	3	433	0	0	0	100	0	0.05	78	51	13	19	0.46
MP511	3	1	0	1	77	1	4	2	3	2	2	163	0	0	0	100	0	0.04	77	55	10	2	0.36
MP525	4	38	1	38	71	38	129	4	5	4	6	104	0	46	51	3	1	0.1	66	83	8	5	0.71
MP558	1	1	1	0	92	4	9	3	3	3	3	440	0	31	0	69	1	0.06	70	55	14	0	0
MP559	1	2	0	0	82	1	2	11	12	2	2	704	0	28	0	72	1	0.1	70	55	14	26	0
MP573	3.5	31	1	30	67	16	67	5	5	3	4	1824	0	26	66	8	2	0.08	97	40	9	21	0.59
MP578	2.5	12	6	10	87	33	72	4	4	4	6	58	6	50	0	44	1	0.1	71	74	7	0	1.05
MP591	4	1	0	1	82	2	6	3	3	2	2	3605	0	0	8	92	2	0.1	71	32	16	6	0.08
MP615	2.5	11	1	9	48	0	7	21	5	1	3	122	54	46	0	0	1	0.06	52	76	3	13	2.69
MP785	2	8	2	8	67	14	45	3	3	NA	NA	73	0	100	0	0	NA	0.1	NA	NA	NA	2	0
MP814	4	29	15	25	90	63	128	5	6	4	4	311	0	0	0	100	1	0.06	83	50	23	11	1.16
MP84	2.	5	2	4	76	7	20	3	3	3	4	20	1	6	0	3	1	0.	5	5	6	2	0.

0	5											01		6		4		06	3	8		8	44
OUT2104	1.5	2	0	0	84	1	3	9	10	2	2	1072	0	0	65	35	2	0.06	74	75	9	17	0.15
OUT2106	1	2	1	0	91	5	9	3	3	3	3	1125	0	0	89	11	2	0.06	74	75	9	17	0.11
OUT2111	2	0	0	0	70	1	2	2	2	1	2	458	0	57	0	43	1	0.06	69	18	20	18	0.01
POW162	2	0	0	0	74	0	1	2	2	1	2	868	0	100	0	0	2	0.06	73	38	17	20	0.09
W10	2	1	1	0	89	3	5	3	3	2	3	2965	0	0	100	0	1	0.06	75	57	18	74	0.38
W11	2	5	0	5	80	9	23	3	3	3	4	3045	0	0	74	26	1	0.04	96	59	21	5	0.31
W13	1.5	8	5	8	92	25	48	4	4	2	3	242	0	0	0	100	1	0.06	75	62	10	8	0.22
W18	1	9	1	0	86	19	44	4	4	3	3	1483	0	0	0	100	3	0.06	84	69	16	34	0.08
W19C	3	3	2	0	94	8	14	4	5	3	3	945	0	0	0	100	2	0.06	77	72	12	4	0.04

Note V refers to the estimated volume of eroded soil per channel length (yd^3/ft); [a] Pipe diameter (ft), [b] Watershed area (ac), [c] Impervious area (ac), [d] Offsite-area (ac), [e] Composite curve number, [f] Peak discharge for 1-yr, 24-hr storm event (ft^3/s), [g] Peak discharge for 10-yr, 24-hr storm event (ft^3/s), [h] Duration of 1-yr, 24-hr storm event (hr), [i] Duration of 10-yr, 24-hr storm event, [j] Maximum velocity 1-yr, 24-hr storm: Permissible velocity, [k] Maximum velocity 10-yr, 24-hr storm event: Permissible velocity, [l] Radial distance of pipe outlet from stream (ft), [m] Departure (ft), [n] Downslope hydrologic soil group (HSG) A soils (%), [o] Downslope HSG B soils (%), [p] Downslope HSG C soils (%), [q] Downslope HSG D soils (%), [r] Median approximate unconfined compressive strength of channel banks immediately downslope of pipe outlet (ton/ft^2), [s] Median Manning's n coefficient for channel banks immediately downslope of pipe outlet ($s/ft^{1/3}$), [t] Median bulk density of channel banks immediately downslope of pipe outlet (lb/ft^3), [u] Median percentage of sand content in channel banks immediately downslope of pipe outlet (%), [v] Median percentage of clay content in channel banks immediately downslope of pipe outlet (%)

Appendix D: Predictor variables and responses for magnitude of erosion analyses

Table 1. Predictor variables and responses for magnitude of erosion (cross-sectional dimensions) analyses

Site	PT[a]	Qu[b]	MN[c]	PD[d]	WA[e]	OA[f]	IA[g]	R[h]	A[i]	B[j]	C[k]	D[l]	CN[m]	V_1[n]	V_{10}[o]	DI[p]	DE[q]	Q_{p1}[r]	Q_{p10}[s]	D_1[t]	D_{10}[u]	W	AR	DP
DE162	995	1.88	0.06	3.5	2	0	0	22	0	100	0	0	77	1.99	2.63	2.52	7.00	3	3	0	6	12	10	8
MP024	2086	0.63	0.10	3.5	37	35	4	211	28	72	0	0	58	2.67	5.16	6.24	65.76	7	5	0	4	2	1	4
MP078	1031	0.88	0.08	2	0	0	0	1073	0	0	100	0	90	1.57	1.91	0.79	1.60	2	2	0	28	9	6	8
MP120	2124	0.88	0.10	4	21	21	0	229	0	69	31	0	80	4.18	5.51	32.76	83.72	4	4	0	0	0	0	0
MP138	2069	2.50	0.10	1.5	12	8	3	329	0	36	64	0	76	3.23	4.03	11.10	32.77	5	5	0	28	6	3	5
MP142	2121	2.50	0.06	2	0	0	0	185	0	100	0	0	55	0.58	1.40	0.02	0.52	3	2	0	6	14	9	7
MP143	2126	0.50	0.10	3	101	97	6	8	14	78	4	3	73	5.46	6.40	80.47	258.22	6	6	0	3	0	0	0
MP152/ OUT2104/ OUT2106	2105	1.50	0.06	3	6	2	1	1118	0	10	64	27	81	2.23	3.01	2.85	7.16	5	5	0	17	15	13	8
MP152/ OUT2104/ OUT2106	2108	1.25	0.06	3	6	2	1	1118	0	10	64	27	81	2.23	3.01	2.85	7.16	5	5	283	12	7	4	6
MP152/ OUT2104/ OUT2106	2110	1.25	0.08	3	6	2	1	1118	0	10	64	27	81	2.23	3.01	2.85	7.16	5	5	542	4	17	35	20
MP152/ OUT2104/ OUT2106	2111	1.50	0.10	3	6	2	1	1118	0	10	64	27	81	2.23	3.01	2.85	7.16	5	5	573	5	8	3	4
MP219	482	0.75	0.06	3	35	30	1	678	0	41	0	59	69	3.46	4.98	25.27	90.76	6	6	0	16	2	0	3
MP225	1044	2.75	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	0	27	3	2	9
MP225	1045	1.75	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	342	21	3	1	5
MP225	1046	1.25	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	543	18	4	3	8
MP225	1047	1.13	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	839	12	2	1	3
MP225	1048	1.50	0.10	3.5	11	0	1	1844	0	99	0	1	57	1.73	3.30	1.26	13.80	13	8	1453	3	3	1	5
MP227	502	1.00	0.04	2	1	0	0	1154	0	100	0	0	55	0.99	2.16	0.09	1.47	4	2	0	36	13	7	9
MP227	2043	1.88	0.10	2	1	0	0	1154	0	100	0	0	55	0.99	2.16	0.09	1.47	4	2	1016	2	13	28	22
MP227	2045	3.63	0.06	2	1	0	0	1154	0	100	0	0	55	0.99	2.16	0.09	1.47	4	2	347	21	15	12	11
MP228	628	1.50	0.06	2	0	0	0	2261	0	100	0	0	55	0.42	0.85	0.03	0.44	3	2	0	9	27	29	14
MP229	506	0.50	0.06	2.5	0	0	0	2446	0	0	0	10	77	0.54	0.70	0.51	1.32	2	2	0	7	26	32	6

												0												
MP257	2059	1.38	0.10	1.5	16	16	1	1070	55	45	0	0	43	0.34	1.43	0.01	1.79	3	11	0	28	8	3	3
MP257	2061	1.50	0.10	1.5	16	16	1	1070	55	45	0	0	43	0.34	1.43	0.01	1.79	3	11	109	24	14	9	5
MP257	2062	1.63	0.10	1.5	16	16	1	1070	55	45	0	0	43	0.34	1.43	0.01	1.79	3	11	346	20	4	1	3
MP292	2083	2.25	0.10	4	45	42	6	283	1	99	0	0	61	2.05	4.55	2.43	43.64	11	5	0	40	0	0	0
MP311	999	0.88	0.06	2	0	0	0	214	0	100	0	0	58	0.88	1.52	0.11	0.83	2	2	686	4	10	9	11
MP311	1000	0.88	0.06	2	0	0	0	214	0	100	0	0	58	0.88	1.52	0.11	0.83	2	2	902	2	19	24	17
MP318	2084	1.00	0.10	1.5	4	4	0	953	0	100	0	0	56	1.71	3.14	1.02	9.84	4	3	0	25	3	24	10
MP319	2082	1.00	0.06	1.5	112	106	5	294	18	82	0	0	53	1.79	4.03	1.23	81.91	31	7	0	9	1	1	2
MP356	2046	0.38	0.06	2	7	5	4	461	0	30	0	70	93	3.51	3.51	14.01	27.04	5	5	0	18	6	2	5
Site	**PT**[a]	**Qu**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**W**	**AR**	**DP**
MP359	1006	0.75	0.06	2	7	7	4	246	0	0	0	100	92	3.83	4.88	21.69	42.01	3	4	0	4	8	8	11
MP360	1008	0.63	0.06	2	2	2	1	387	0	0	0	100	89	2.83	3.50	6.58	13.57	3	3	0	6	6	4	6
MP361	1003	0.38	0.06	2	1	1	0	199	0	0	0	100	90	2.40	2.93	3.75	7.41	2	3	0	11	15	37	36
MP415	1018	0.38	0.03	2.5	1	1	0	1532	0	90	0	10	60	1.04	1.69	0.35	2.12	2	2	0	57	10	12	13
MP415/MP416	1019	1.25	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	182	55	6	4	8
MP415/MP416	1020	1.25	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	168	52	12	19	15
MP415 /MP416	1021	1.25	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	502	45	8	5	6
MP415/MP416	1022	1.00	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	1044	33	11	6	5
MP415/MP416	1023	0.88	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	1568	21	9	10	11
MP415/MP416	1024	1.13	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	2168	11	16	28	18
MP415/MP416	1026	0.75	0.06	2	5	4	0	1735	0	99	0	1	59	1.77	3.20	0.91	7.51	4	3	1331	26	18	33	15
MP416	1017	1.13	0.03	2	4	3	0	1772	0	100	0	0	59	1.77	3.20	1.01	8.47	4	3	0	63	3	2	7
MP425	1033	1.00	0.08	2.5	11	9	1	2180	0	12	0	88	81	2.70	3.34	19.23	47.42	4	4	0	31	5	5	11
MP425/MP426	1034	0.88	0.10	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	352	18	3	2	5
MP425/MP426	1035	1.13	0.10	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	441	16	2	1	3

MP425/MP426	1036	0.88	0.08	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	676	12	3	1	3
MP425/MP426	1037	1.75	0.08	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	790	11	3	1	2
MP425/MP426	1039	1.50	0.06	2.5	28	26	1	2368	0	5	7	89	83	2.57	3.17	16.29	38.75	7	8	971	6	2	1	4
MP426	1041	1.63	0.06	2.5	18	17	0	2481	0	0	11	89	84	2.49	3.07	14.52	33.51	9	10	0	32	2	0	2
MP426	1042	1.00	0.06	2.5	18	17	0	2481	0	0	11	89	84	2.49	3.07	14.52	33.51	9	10	269	21	2	1	2
MP427	185	0.75	0.06	2.5	0	0	0	3251	0	0	0	100	86	1.75	2.16	1.24	2.65	2	2	0	25	0	0	0
MP433	1010	0.50	0.10	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	0	56	3	1	3
MP433	1011	0.50	0.10	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	241	35	3	2	8
MP433	1012	0.50	0.06	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	298	31	3	3	13
MP433	1013	0.50	0.08	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	556	24	6	4	6
MP433	1014	1.00	0.08	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	775	18	2	0	2
MP433	1015	1.00	0.08	3	15	15	0	4544	0	100	0	0	61	2.59	4.37	5.43	33.89	4	4	1186	1	3	1	2
MP458	989	1.50	0.10	3.5	8	6	1	1090	61	39	0	0	46	0.50	2.30	0.02	3.61	13	5	0	14	16	15	10
MP458	990	1.25	0.10	3.5	8	6	1	1090	61	39	0	0	46	0.50	2.30	0.02	3.61	13	5	150	12	7	8	11
MP458	991	0.75	0.06	3.5	8	6	1	1090	61	39	0	0	46	0.50	2.30	0.02	3.61	13	5	297	6	7	11	17
MP459	2065	1.00	0.10	3.5	17	15	4	289	71	30	0	0	53	1.23	3.51	0.36	16.96	26	7	0	15	12	2	12
MP459	2067	NA	0.08	3.5	17	15	4	289	71	30	0	0	53	1.23	3.51	0.36	16.96	26	7	114	14	4	2	5
MP465	2096	NA	0.03	1.5	3	2	0	388	0	100	0	0	73	2.54	3.32	4.04	12.14	3	3	0	20	2	5	5
Site	**PT**[a]	**Qu**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**W**	**AR**	**DP**
MP467	1054	1.88	0.08	3	1	0	0	317	0	0	100	0	82	1.92	2.45	1.84	4.40	2	2	0	16	13	15	19
MP467	1057	0.63	0.06	3	1	0	0	317	0	0	100	0	82	1.92	2.45	1.84	4.40	2	2	206	10	9	7	8
MP469	1062	1.00	0.06	2.5	3	0	1	1269	0	0	0	100	89	3.02	3.76	8.97	18.75	3	4	273	23	4	1	3
MP469/W18	1063	0.50	0.06	2.5	12	0	1	1426	0	0	0	100	87	3.06	3.26	16.60	37.11	4	4	595	7	5	1	3
MP472	2093	0.88	0.10	1.25	37	33	15	165	0	39	48	14	85	3.57	3.57	74.06	171.64	5	5	0	2	0	0	0
MP495	984	0.88	0.06	2	2	0	1	3316	0	0	0	100	90	1.94	2.39	5.72	11.66	3	3	0	1	12	7	6
MP507	997	0.75	0.04	1.5	0	0	0	661	0	0	0	100	77	1.46	1.89	0.56	1.47	2	2	0	27	56	57	9
MP508	962	0.73	0.06	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	0	30	25	27	18
MP508	963	2.13	0.06	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	136	27	12	10	12
MP50	96	1.	0.	2.	2	1	0	11	0	0	1	9	85	2.	3.	5.3	12.	3	4	31	2	7	3	7

8	4	13	06	5				62				9		60	30	0	14			6	5			
MP508	965	1.00	0.06	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	1048	15	5	4	9
MP508	966	1.50	0.08	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	1244	13	20	27	18
MP508	967	1.38	0.08	2.5	2	1	0	1162	0	0	1	99	85	2.60	3.30	5.30	12.14	3	4	1497	9	18	28	21
MP508	968	0.88	0.10	2.5	3	2	0	979	0	0	1	99	83	2.46	3.14	4.38	10.18	3	3	1362	5	26	67	37
MP508	972	0.75	0.06	3	4	2	0	811	0	0	1	99	81	2.33	2.98	3.79	8.90	3	3	745	0	18	22	12
MP508A	970	0.25	0.04	1.25	0	0	0	66	0	0	0	100	77	1.00	1.30	0.46	1.21	2	2	0	0	69	160	30
MP508C	974	0.21	0.04	1	0	0	0	393	0	0	0	100	77	1.43	1.89	0.48	1.26	2	2	0	19	55	61	12
MP508D	976	0.16	0.05	1.5	1	1	0	433	0	0	0	100	77	2.05	2.64	1.65	4.35	2	2	0	19	47	66	17
MP511	973	0.24	0.04	3	1	1	0	163	0	0	0	100	77	1.81	2.38	1.47	3.92	2	3	0	2	47	67	28
MP511	969	1.13	0.08	3	1	1	0	163	0	0	0	100	77	1.81	2.38	1.47	3.92	2	3	150	1	31	73	30
MP525	2088	0.88	0.10	4	38	38	1	104	0	46	51	3	71	4.36	5.99	37.61	128.56	4	5	0	4	3	8	5
MP558	2080	1.00	0.06	1	1	0	1	440	0	31	0	69	92	2.67	3.08	4.43	8.79	3	3	0	0	0	0	0
MP559	2079	1.00	0.10	1	2	0	0	704	0	28	0	72	82	1.71	2.22	0.90	2.18	11	12	0	26	3	15	9
MP573	2074	2.13	0.08	3.5	31	30	1	1824	0	26	66	8	67	2.89	4.31	16.24	66.65	5	5	0	21	4	3	7
MP578	2076	0.88	0.10	2.5	12	10	6	58	6	50	0	44	87	4.28	5.66	33.07	72.23	4	4	0	0	3	23	9
MP591	2071	2.25	0.10	4	1	1	0	3605	0	0	8	92	82	1.72	2.17	2.46	5.84	3	3	0	6	26	11	13
MP591	2072	1.50	0.10	4	1	1	0	3605	0	0	8	92	82	1.72	2.17	2.46	5.84	3	3	347	3	20	11	11
MP615	993	0.75	0.06	2.5	11	9	1	122	54	46	0	0	48	0.71	2.82	0.05	7.05	21	5	0	13	21	34	17
MP785	2102	NA	0.10	2	8	8	2	73	0	100	0	0	67	NA	NA	14.18	45.17	3	3	0	2	0	0	0
MP814	982	0.75	0.06	4	29	25	15	311	0	0	0	100	90	3.62	4.28	62.68	128.28	5	6	0	11	3	4	2
MP840	609	0.63	0.06	2.5	5	4	2	2001	1	66	0	34	76	2.86	3.85	7.45	20.48	3	3	0	28	9	10	15
MP840	979	1.75	0.06	2.5	5	4	2	2001	1	66	0	34	76	2.86	3.85	7.45	20.48	3	3	319	22	10	11	11
MP840	980	0.75	0.06	2.5	5	4	2	2001	1	66	0	34	76	2.86	3.85	7.45	20.48	3	3	471	12	9	4	5
OUT2111	474	0.63	0.06	2	0	0	0	458	0	57	0	43	70	1.21	1.67	0.53	1.69	2	2	0	18	30	18	8
POW162	996	2.38	0.06	2	0	0	0	868	0	100	0	0	74	1.22	1.62	0.37	1.05	2	2	0	20	21	8	4
POW162	998	NA	0.06	2	0	0	0	868	0	100	0	0	74	1.22	1.62	0.37	1.05	2	2	599	6	17	18	12
W10	959	0.75	0.06	2	1	0	1	2965	0	0	100	0	89	2.24	2.77	2.64	5.47	3	3	0	74	14	11	10
W10	1027	1.88	0.06	2	1	0	1	2965	0	0	100	0	89	2.24	2.77	2.64	5.47	3	3	788	43	7	3	5
Site	**PT**[a]	**Q_u**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**W**	**AR**	**DP**
W10	1028	0.88	0.06	2	1	0	1	2965	0	0	100	0	89	2.24	2.77	2.64	5.47	3	3	1236	34	14	23	20
W10	1029	1.13	0.06	2	1	0	1	2965	0	0	100	0	89	2.24	2.77	2.64	5.47	3	3	1951	15	19	22	14

W11	957	0.75	0.04	2	5	5	0	3045	0	0	74	26	80	3.12	3.90	9.17	23.46	3	3	0	5	10	3	4
W13	1004	0.75	0.06	1.5	8	8	5	242	0	0	0	100	92	2.24	2.77	24.97	48.15	4	4	0	8	3	3	12
W13	1005	1.00	0.06	1.5	8	8	5	242	0	0	0	100	92	2.24	2.77	24.97	48.15	4	4	51	0	6	5	9
W18	1059	2.75	0.06	1	9	0	1	1483	0	0	0	100	86	3.08	3.08	19.39	43.81	4	4	0	34	2	0	3
W19C	1065	1.88	0.06	3	3	0	2	945	0	0	0	100	94	2.83	3.40	7.60	14.49	4	5	708	4	5	4	8

Note W refers to Width at top of bank (TOB): Bankfull (BKFUL) width for cross-section (ft/ft), AR refers to $Area_{TOB}$: $Area_{BKFUL}$ for cross-section (ft^2/ft^2), and DP Maximum $Depth_{TOB}$: $Depth_{BKFUL}$ for cross-section (ft/ft); [a] Point number, [b] Median approximate unconfined compressive strength of channel banks (lb/ft^2), [c] Median Manning's roughness coefficient of channel banks ($s/ft^{1/3}$), [d] Pipe diameter (ft), [e] Pipe outlet watershed area (ac), [f] Pipe outlet offsite area within watershed (ac), [g] Pipe outlet impervious area within watershed (ac), [h] Radial distance of pipe outlet to stream (ft), [l] Downslope hydrologic soil group (HSG) A soils (%), [j] Downslope HSG B soils (%), [k] Downslope HSG C soils (%), [l] Downslope HSG D soils (%), [m] Composite curve number (CN) for pipe outlet watershed, [n] Maximum velocity for 1-yr, 24-hr storm event: Permissible velocity, [o] Maximum velocity for 10-yr, 24-hr storm event: Permissible velocity, [p] Distance from pipe outlet to cross-section (ft), [q] Estimated elevation difference between cross-section and outfall (ft), [r] Peak discharge for 1-yr, 24-hr storm event for pipe outlet watershed (ft^3/s), [s] Peak discharge for 10-yr, 24-hr storm event for pipe outlet watershed (ft^3/s), [t] Duration of 1-yr, 24-hr storm event for pipe outlet watershed (hr), [u] Duration of 10-yr, 24-hr storm event for pipe outlet watershed (hr)

Table 2. Summary of predictor variables and responses for magnitude of erosion (volume of eroded soil) analyses

Site	PD[a]	WA[b]	IA[c]	OA[d]	CN[e]	Qp_1[f]	Qp_{10}[g]	D_1[h]	D_{10}[i]	V_1[j]	V_{10}[k]	R[l]	DE[m]	A[n]	B[o]	C[p]	D[q]	q_u[r]	n[s]	ρ_b[t]	S[u]	Cv[v]	V
DE162	3.5	2	0	0	77	3	7	3	3	2	3	22	0	100	0	0	2	0.06	58	38	13	6	0.15
MP024	3.5	37	4	35	58	6	66	7	5	3	5	211	28	72	0	0	1	0.1	74	75	10	4	0.3
MP078	2	0	0	0	90	1	2	2	2	2	2	1073	0	0	100	0	1	0.08	67	75	7	28	0.14
MP120	4	21	0	21	80	33	84	4	4	4	6	229	0	69	31	0	1	0.1	59	65	12	0	0
MP138	1.5	12	3	8	76	11	33	5	5	3	4	329	0	36	64	0	3	0.1	78	75	15	28	0.28
MP142	2	0	0	0	55	0	1	3	2	1	1	185	0	100	0	0	3	0.06	74	61	18	6	0
MP143	3	101	6	97	73	80	258	6	6	5	6	8	14	78	4	3	1	0.1	74	73	10	3	0
MP152	3	3	0	2	73	3	9	3	3	2	3	1154	0	24	47	29	2	0.06	74	75	9	17	0.19
MP219	3	35	1	30	69	25	91	6	6	3	5	678	0	41	0	59	1	0.06	72	37	17	16	0.48
MP225	3.5	11	1	0	57	1	14	13	8	2	3	1844	0	99	0	1	3	0.1	71	27	11	27	0.28
MP227	2	1	0	0	55	0	1	4	2	1	2	1154	0	100	0	0	1	0.04	97	38	14	36	0.48
MP228	2	0	0	0	55	0	0	3	2	0	1	2261	0	100	0	0	2	0.06	73	36	18	9	0.34
MP229	2.5	0	0	0	77	1	1	2	2	1	1	2446	0	0	0	100	1	0.06	51	22	16	7	0
MP257	1.5	16	1	16	43	0	2	3	11	0	1	1070	55	45	0	0	1	0.1	63	40	19	28	0.67
MP292	4	45	6	42	61	2	44	11	5	2	5	283	1	99	0	0	2	0.1	74	61	12	40	0
MP311	2	0	0	0	58	0	1	2	2	1	2	214	0	100	0	0	1	0.06	42	33	15	4	0.06
MP318	1.5	4	0	4	56	1	10	4	3	2	3	953	0	100	0	0	1	0.1	65	69	12	25	0.37
MP319	1.5	112	5	106	53	1	82	31	7	2	4	294	18	82	0	0	1	0.06	64	67	11	9	0
MP356	2	7	4	5	93	14	27	5	5	4	4	461	0	30	0	70	0	0.06	51	55	7	18	0.23
MP359	2	7	4	7	92	22	42	3	4	4	5	246	0	0	0	100	1	0.06	90	56	11	4	0.22
MP360	2	2	1	2	89	7	14	3	3	3	4	387	0	0	0	100	1	0.06	94	70	7	6	0.09
MP361	2	1	0	1	90	4	7	2	3	2	3	199	0	0	0	100	0	0.06	100	63	9	11	1.39
MP415	2.5	1	0	1	60	0	2	2	2	1	2	1532	0	90	0	10	0	0.03	70	19	12	58	0.08
MP416	2	4	0	3	59	1	8	4	3	2	3	1772	0	100	0	0	1	0.03	75	9	22	63	0.38
MP42	2.	11	1	9	81	19	47	4	4	3	3	21	0	1	0	8	1	0.	9	7	1	3	0.

5	5											80		2		8		08	8	0	3	1	18
MP426	2.5	18	0	17	84	15	34	9	10	2	3	2481	0	0	11	89	2	0.06	76	47	9	32	0.09
MP427	2.5	0	0	0	86	1	3	2	2	2	2	3251	0	0	0	100	1	0.06	78	57	12	25	0
MP433	3	15	0	15	61	5	34	4	4	3	4	4544	0	100	0	0	1	0.1	83	62	10	56	0.06
MP458	3.5	8	1	6	46	0	4	13	5	1	2	1090	61	39	0	0	2	0.1	90	69	16	14	0.32
MP459	3.5	17	4	15	53	0	17	26	7	1	4	289	71	30	0	0	1	0.1	86	83	7	15	0.46
MP465	1.5	3	0	2	73	4	12	3	3	3	3	388	0	100	0	0	NA	0.03	72	54	16	20	0
MP467	3	1	0	0	82	2	4	2	2	2	2	317	0	0	100	0	2	0.08	83	74	3	16	0.61
MP469	2.5	3	1	0	89	9	19	3	4	3	4	1269	0	0	0	100	1	0.06	76	78	8	23	0.03
MP472	1.25	37	15	33	85	74	172	5	5	4	4	165	0	39	48	14	1	0.1	61	72	11	2	0.16
MP495	2	2	1	0	90	6	12	3	3	2	2	3316	0	0	0	100	1	0.06	79	54	17	2	0.22
MP507	1.5	0	0	0	77	1	1	2	2	1	2	661	0	0	0	100	1	0.04	74	64	5	7	0.14
MP508	2.5	2	0	1	85	5	12	3	4	3	3	1162	0	0	1	99	1	0.06	96	62	10	30	1.23
Site	**PD[a]**	**WA[b]**	**IA[c]**	**OA[d]**	**CN[e]**	**Qp_1[f]**	**Qp_{10}[g]**	**D_1[h]**	**D_{10}[i]**	**V_1[j]**	**V_{10}[k]**	**R[l]**	**DE[m]**	**A[n]**	**B[o]**	**C[p]**	**D[q]**	**q_u[r]**	**n[s]**	**ρ_b[t]**	**S[u]**	**C[v]**	**V**
MP508A	1.25	0	0	0	77	0	1	2	2	1	1	66	0	0	0	100	0	0.04	84	48	16	0	0.4
MP508C	1	0	0	0	77	0	1	2	2	1	2	393	0	0	0	100	0	0.04	81	53	9	20	0
MP508D	1.5	1	0	1	77	2	4	2	2	2	3	433	0	0	0	100	0	0.05	78	51	13	19	0.46
MP511	3	1	0	1	77	1	4	2	3	2	2	163	0	0	0	100	0	0.04	77	55	10	2	0.36
MP525	4	38	1	38	71	38	129	4	5	4	6	104	0	46	51	3	1	0.1	66	83	8	5	0.71
MP558	1	1	1	0	92	4	9	3	3	3	3	440	0	31	0	69	1	0.06	70	55	14	0	0
MP559	1	2	0	0	82	1	2	11	12	2	2	704	0	28	0	72	1	0.1	70	55	14	26	0
MP573	3.5	31	1	30	67	16	67	5	5	3	4	1824	0	26	66	8	2	0.08	97	40	9	21	0.59
MP578	2.5	12	6	10	87	33	72	4	4	4	6	58	6	50	0	44	1	0.1	71	74	7	0	1.05
MP591	4	1	0	1	82	2	6	3	3	2	2	3605	0	0	8	92	2	0.1	71	32	16	6	0.08
MP615	2.5	11	1	9	48	0	7	21	5	1	3	122	54	46	0	0	1	0.06	52	76	3	13	2.69
MP785	2	8	2	8	67	14	45	3	3	NA	NA	73	0	100	0	0	NA	0.1	NA	NA	NA	2	0
MP814	4	29	15	25	90	63	128	5	6	4	4	311	0	0	0	100	1	0.06	83	50	23	11	1.16
MP84	2.	5	2	4	76	7	20	3	3	3	4	20	1	6	0	3	1	0.	5	5	6	2	0.

0	5											01		6		4		06	3	8		8	44
OUT2 104	1.5	2	0	0	84	1	3	9	10	2	2	1072	0	0	65	35	2	0.06	74	75	9	17	0.15
OUT2 106	1	2	1	0	91	5	9	3	3	3	3	1125	0	0	89	11	2	0.06	74	75	9	17	0.11
OUT2 111	2	0	0	0	70	1	2	2	2	1	2	458	0	57	0	43	1	0.06	69	18	20	18	0.01
POW 162	2	0	0	0	74	0	1	2	2	1	2	868	0	100	0	0	2	0.06	73	38	17	20	0.09
W10	2	1	1	0	89	3	5	3	3	2	3	2965	0	0	100	0	1	0.06	75	57	18	74	0.38
W11	2	5	0	5	80	9	23	3	3	3	4	3045	0	0	74	26	1	0.04	96	59	21	5	0.31
W13	1.5	8	5	8	92	25	48	4	4	2	3	242	0	0	0	100	1	0.06	75	62	10	8	0.22
W18	1	9	1	0	86	19	44	4	4	3	3	1483	0	0	0	100	3	0.06	84	69	16	34	0.08
W19 C	3	3	2	0	94	8	14	4	5	3	3	945	0	0	0	100	2	0.06	77	72	12	4	0.04

Note V refers to the estimated volume of eroded soil per channel length (yd^3/ft); [a] Pipe diameter (ft), [b] Watershed area (ac), [c] Impervious area (ac), [d] Offsite-area (ac), [e] Composite curve number, [f] Peak discharge for 1-yr, 24-hr storm event (ft^3/s), [g] Peak discharge for 10-yr, 24-hr storm event (ft^3/s), [h] Duration of 1-yr, 24-hr storm event (hr), [i] Duration of 10-yr, 24-hr storm event, [j] Maximum velocity 1-yr, 24-hr storm: Permissible velocity, [k] Maximum velocity 10-yr, 24-hr storm event: Permissible velocity, [l] Radial distance of pipe outlet from stream (ft), [m] Departure (ft), [n] Downslope hydrologic soil group (HSG) A soils (%), [o] Downslope HSG B soils (%), [p] Downslope HSG C soils (%), [q] Downslope HSG D soils (%), [r] Median approximate unconfined compressive strength of channel banks immediately downslope of pipe outlet (ton/ft^2), [s] Median Manning's n coefficient for channel banks immediately downslope of pipe outlet ($s/ft^{1/3}$), [t] Median bulk density of channel banks immediately downslope of pipe outlet (lb/ft^3), [u] Median percentage of sand content in channel banks immediately downslope of pipe outlet (%), [v] Median percentage of clay content in channel banks immediately downslope of pipe outlet (%)

Appendix E: Raw data from site assessments and desktop analyses

Table 1. Approximate unconfined compressive strength measurements for site assessments

Site	Point number	Assessment	Left bank			Right bank		
			Median (ton/ft^2)	Average (ton/ft^2)	Layer	Median (ton/ft^2)	Average (ton/ft^2)	Layer
DE162	995	Outlet	3.00	2.35	1	1.75	1.75	1
DE162 (DE162/MP311/ POW162 Outfall)	1001	Intermediate	0.75	0.65	1	0.50	0.65	1
MP024	2086	Outlet	0.75	0.65	1	0.50	0.55	1
MP024	2087	Outfall	0.50	0.70	1	0.75	0.95	1
MP078	1031	Outlet	0.75	0.80	1	1.25	1.10	1
MP078	1032	Culvert/Final	0.75	0.85	1	1.00	0.90	1
MP120	2126	Outlet	0.75	0.85	1	1.25	1.05	
MP138	2069	Outlet	1.75	2.30	1	2.75	2.55	1
MP138	2070	Outfall	1.25	1.40	1	1.00	1.25	1
MP142	2121	Outlet	2.25	2.25	1	2.50	2.85	1
MP143	2126	Outlet	0.50	0.95	1	0.50	0.60	1
MP152/OUT2104 /OUT2106	2105	Outlet	2.00	2.05	1	1.25	1.25	1
MP152/OUT2104/ OUT2106	2108	Intermediate	1.50	1.75	1	1.00	1.05	1
MP152/OUT2104/ OUT2106	2110	NA	1.25	1.25	1	1.25	1.35	1
MP152/OUT2104/ OUT2106	2111	NA	1.75	1.55	1	1.50	1.25	1
MP152/OUT2104/ OUT2106	2113	Final	1.50	2.00	1	1.00	1.00	1
MP219	482	Outlet	0.75	0.95	1	0.50	0.55	1
MP225	1044	Outlet	2.50	2.25	1	3.25	2.75	1
MP225	1045	NA	1.75	1.60	1	2.00	1.75	1
MP225	1046	NA	1.25	1.10	1	1.75	1.45	1
MP225	1047	NA	1.50	1.35	1	1.00	1.05	1

Site	Point number	Assessment	Left bank			Right bank		
			Median (ton/ft^2)	Average (ton/ft^2)	Layer	Median (ton/ft^2)	Average (ton/ft^2)	Layer
MP225	1051	Outfall	1.25	1.75	1	2.00	2.40	1
MP225	1050 (1048)	Intermediate	1.50	1.40	1	1.25	1.40	1
MP227	503	Outlet	1.00	1.00	1	0.75	1.10	1
MP227	1052	Outfall	2.00	1.90	1	1.75	2.10	1
MP227	2043	NA	2.25	1.90	1	1.50	1.95	1
MP227	2045	Intermediate	4.00	4.10	1	2.75	2.65	1
MP228	628	Outlet	1.88	1.88	1	0.88	0.88	1
MP229 (OUT111)	506	Outlet	0.75	0.75	1	0.50	0.60	1
MP257	2059	Outlet	1.00	1.05	1	2.25	2.15	1
MP257	2061	Intermediate	1.50	1.40	1	1.25	1.60	1
MP257	2062	NA	1.50	1.70	1	1.75	1.65	1
MP257	2063	Final	2.25	2.55	1	2.75	2.80	1
MP292	2083	Outlet	2.25	-	-	-	-	-
MP311	999	Outlet	0.75	0.85	1	1.00	0.90	1
MP311	1000	Intermediate	0.75	0.75	1	0.75	0.75	1
MP318	2084	Outlet	1.00	1.25	1	1.00	1.20	1
MP319	2082	Outlet	1.00	0.85	1	1.25	1.10	1
MP356	2046	Outlet	0.25	0.45	1	1.00	0.85	1
MP356	2057	Final	0.50	0.65	1	1.00	1.05	1
MP359	1006	Outlet	0.50	0.65	1	0.75	0.75	1
MP359/W13	1007	Outfall	0.50	0.55	1	0.50	0.80	1
MP360	1008	Outlet	0.50	0.65	1	1.00	1.15	1
MP360	1009	Final	0.75	1.15	1	0.50	0.50	1
MP361	1002	Outfall	0.75	0.80	1	0.50	0.70	1
MP361	1003	Outlet	0.25	0.30	1	0.50	0.55	1
MP415	1018	Outlet	0.75	0.65	1	0.25	0.30	1
MP415/MP416	1019	NA	1.75	1.80	1	1.25	1.20	1
Site	**Point number**	**Assessment**	**Left bank**			**Right bank**		
			Median	**Average**	**Layer**	**Median**	**Average**	**Layer**

			(ton/ft²)	(ton/ft²)		(ton/ft²)	(ton/ft²)	
MP415/MP416	1020	NA	1.25	1.30	1	1.25	1.40	1
MP415/MP416	1021	NA	1.25	1.90	1	1.25	1.20	1
MP415/MP416	1022	NA	1.25	1.30	1	1.00	1.00	1
MP415/MP416	1023	NA	0.75	0.85	1	1.00	1.00	1
MP415/MP416	1024	NA	1.00	1.55	1	1.25	1.35	1
MP415/MP416	1025	Outfall	0.75	0.80	1	1.00	1.00	1
MP415/MP416	1026	Intermediate	1.25	1.10	1	0.50	0.55	1
MP416	1017	Outlet	1.00	1.15	1	2.00	1.60	1
MP425	1033	Outlet	1.25	1.85	1	1.25	1.55	1
MP425	1033	Outlet	0.75	0.65	2	-	-	-
MP425/MP426	1034	NA	0.50	0.65	1	1.25	1.15	1
MP425/MP426	1035	NA	1.00	0.95	1	1.50	1.25	1
MP425/MP426	1036	NA	0.50	0.70	1	1.00	1.05	1
MP425/MP426	1037	NA	1.75	2.00	1	1.75	1.75	1
MP425/MP426	1039	NA	1.50	1.50	1	1.25	1.15	1
MP425/MP426	1040	Intermediate/Outfall	0.25	0.35	1	0.25	0.35	1
MP426	1042	NA	1.00	0.95	1	1.50	1.40	1
MP426 (OUT215)	1041	Outlet	1.75	1.95	1	0.75	1.15	1
MP427 (OUT1521)	185	Outlet	0.75	0.70	1	0.25	0.50	1
MP433	1010	Outlet	0.25	0.45	1	0.50	0.60	1
MP433	1011	Intermediate	0.50	0.45	1	0.50	0.50	1
MP433	1012	NA	0.50	0.70	1	1.00	1.05	1
MP433	1013	NA	0.50	0.45	1	1.00	0.90	1
MP433	1014	NA	1.50	1.40	1	1.00	0.90	1
MP433	1015	NA	1.00	1.45	1	1.00	0.95	1
MP433	1016	Culvert/Final	0.75	0.75	1	0.50	0.45	1
MP458	990	NA	1.50	1.60	1	1.00	1.15	1
Site	**Point number**	**Assessment**	**Left bank**			**Right bank**		
			Median (ton/ft²)	**Average (ton/ft²)**	**Layer**	**Median (ton/ft²)**	**Average (ton/ft²)**	**Layer**
MP458	989	Outlet	1.50	1.55	1	1.50	1.20	1

MP458	991	Intermediate	0.75	0.95	1	1.25	1.15	1
MP458	991	Intermediate	0.50	0.55	2	0.50	0.60	2
MP458	992	Final	1.00	1.10	1	0.27	0.26	1
MP459	2065	Outlet	1.00	0.85	1	1.00	1.00	1
MP459	2066	Outfall	0.75	0.80	1	0.25	0.45	1
MP459	2067	Intermediate	-	-	-	-	-	-
MP465	2096	Outlet	NA	NA	-	NA	NA	-
MP467	1054	Outlet	2.00	2.10	1	1.75	1.75	1
MP467	1056	Outfall	2.00	1.40	1	1.25	1.50	1
MP467	1057	NA	0.50	0.45	1	1.50	1.75	1
MP469 (W19*)	1062	Outlet	0.50	0.45	1	2.25	2.40	1
MP469 (W19*)	1063	NA	0.50	0.60	1	0.50	0.60	1
MP472	2093	Outlet	0.75	0.80	1	1.00	1.00	1
MP495 (FID10)	984	Outlet	1.00	1.00	1	0.75	1.00	1
MP495 (FID10)	985	Culvert/Intermediate	0.75	0.96	1	0.75	0.70	1
MP508	962	Outlet	1.50	1.65	1	0.16	0.17	1
MP508	963	NA	2.75	2.70	1	2.00	1.85	1
MP508	964	NA	1.25	1.20	1	1.00	1.00	1
MP508	965	NA	0.50	0.70	1	1.00	1.20	1
MP508	966	NA	1.25	1.35	1	2.25	1.95	1
MP508	967	NA	1.50	1.50	1	1.25	1.15	1
MP508	968	NA	0.50	0.65	1	1.25	1.25	1
MP511 (MP508B)	969	NA	1.25	1.20	1	0.75	0.95	1
MP508	971	Outfall	0.23	0.22	1	0.25	0.24	1
MP508	972	NA	0.75	0.55	1	0.75	0.75	1
MP508A	970	Outlet	0.20	0.21	1	0.25	0.24	1
Site	**Point number**	**Assessment**	**Left bank**			**Right bank**		
			Median (ton/ft^2)	**Average (ton/ft^2)**	**Layer**	**Median (ton/ft^2)**	**Average (ton/ft^2)**	**Layer**
MP508C	974	Outlet	0.23	0.21	1	0.19	0.19	1
MP508D	976	Outlet	0.17	0.15	1	0.16	0.15	1
MP507 (MP508E)	973	Outlet	0.75	0.70	1	-	-	-

MP511 (MP508B)	973	Outlet	0.25	0.25	1	0.22	0.23	1
MP525	2088	Outlet	1.25	1.50	1	0.50	0.65	1
MP525	2090	Outfall	0.50	0.55	1	0.50	0.90	1
MP558	2080	Outlet	-	-	-	-	-	-
MP559	2079	Outlet	1.00	1.15	1	0.50	0.65	1
MP573	2074	Outlet	2.25	2.30	1	2.00	2.70	1
MP573	2075	Final	2.50	2.40	1	3.25	2.90	1
MP578	2076	Outlet	0.50	0.60	1	1.50	1.30	1
MP591	2071	Outlet	2.00	2.30	1	2.50	2.15	1
MP591	2072	Intermediate	1.50	1.55	1	1.50	1.75	1
MP591	2073	Final	2.75	2.45	1	1.00	1.65	1
MP615	993	Outlet	1.00	0.90	1	0.75	0.75	1
MP615	994	Outfall	1.25	1.60	1	0.50	0.85	1
MP785	2102	Outlet	-	-	-	-	-	-
MP814 (Site3&4)	982	Outlet	0.75	0.75	1	0.75	0.70	1
MP814 (Site3&4)	983	Outfall	0.25	0.30	1	0.50	0.50	1
MP840	609	Outlet	0.75	0.85	1	0.50	0.50	1
MP840	979	NA	1.75	1.70	1	1.50	1.80	1
MP840	980	NA	0.50	0.70	1	0.75	0.75	1
MP840	981	Outfall	0.50	0.50	1	0.25	0.35	1
OUT2111	474	Outlet	0.75	0.90	1	0.25	0.35	1
POW162	996	Outlet	2.25	2.00	1	2.50	2.55	1
POW162	998	NA	-	-	-	-	-	-
W10	959	Outlet	0.75	0.70	1	0.75	0.75	1
Site	**Point number**	**Assessment**	**Left bank**			**Right bank**		
			Median (ton/ft^2)	**Average (ton/ft^2)**	**Layer**	**Median (ton/ft^2)**	**Average (ton/ft^2)**	**Layer**
W10	1027	NA	0.75	0.70	1	1.25	1.25	1
W10	1028	NA	2	2.25	1	0.75	0.95	1
W10	1029	Intermediate	1	1.15	1	0.75	0.95	1
W10	1030	Outfall	1.25	1.40	1	0.20	0.21	1
W11	957	Outlet	0.75	0.80	1	0.75	1.35	1

W13	1004	Outlet	0.75	0.75	1	0.75	0.80	1
W13	1005	NA	0.75	0.65	1	1.25	1.40	1
W18	1059	Outlet	0.75	0.70	1	3.25	3.10	1
W18/MP469 (W19*)/ W19C	1066	Outfall	2.00	2.45	1	0.75	0.80	1
W19C	1065	Outlet	0.75	1.10	1	2.00	1.75	1

Table 2. Summary of Manning's roughness coefficients for site assessments (Brunner, 2022)

Site	Assessment	Point number	Left bank	Channel	Right bank
DE162	Outlet	995	0.06	0.03	0.06
DE162 (DE162/MP311/ POW162 Outfall	Intermediate	1001	0.06	0.03	0.06
MP024	Outlet	2086	0.10	0.04	0.10
MP024	Outfall	2087	0.10	0.03	0.10
MP078	Outlet	1031	0.10	0.04	0.06
MP078	Culvert/Final	1032	0.10	0.03	0.06
MP120	Outlet	2124	0.10	0.10	0.10
MP138	Outlet	2069	0.10	0.03	0.10
MP138	Outfall	2070	0.03	0.03	0.03
MP142	Outlet	2121	0.06	0.03	0.06
MP143 (MP117)	Outlet	2126	0.10	0.10	0.10
MP152/OUT2104/ OUT2106	Outlet	2105	0.06	0.03	0.06
MP152/OUT2104/ OUT2106	Intermediate	2108	0.06	0.03	0.06
MP152/OUT2104/ OUT2106	NA	2110	0.06	0.03	0.10
MP152/OUT2104/ OUT2106	NA	2111	0.10	0.03	0.10
MP152/OUT2104/ OUT2106	Final	2113	0.10	0.03	0.10
MP219	Outlet	482	0.06	0.04	0.06
MP225	Outlet	1044	0.10	0.05	0.10
MP225	NA	1045	0.10	0.05	0.10
MP225	NA	1046	0.10	0.05	0.10
MP225	NA	1047	0.10	0.05	0.10
MP225	Outfall	1051	0.10	0.04	0.10
MP225	Intermediate	1050 (1048)	0.10	0.04	0.10
MP227	Outlet	502	0.04	0.03	0.04
MP227	Outfall	1052	0.10	0.03	0.10
MP227	NA	2043	0.10	0.04	0.10
MP227	Intermediate	2045	0.06	0.04	0.06
MP228	Outlet	628	0.06	0.04	0.06
MP229 (OUT111)	Outlet	506	0.06	0.03	0.06
MP257	Outlet	2059	0.10	0.03	0.10
MP257	Intermediate	2061	0.10	0.03	0.10
MP257	NA	2062	0.10	0.03	0.10
MP257	Final	2063	0.10	0.03	0.10
Site	**Assessment**	**Point number**	**Left bank**	**Channel**	**Right bank**

MP292	Outlet	2083	0.10	0.10	0.10
MP311	Outlet	999	0.06	0.03	0.06
MP311	Intermediate	1000	0.06	0.03	0.06
MP318	Outlet	2084	0.10	0.04	0.10
MP318	Intermediate/Final	2085	0.10	0.04	0.10
MP319	Outlet	2082	0.06	0.03	0.06
MP356	Outlet	2046	0.06	0.04	0.06
MP356	Final	2057	0.06	0.03	0.10
MP359	Outlet	1006	0.06	0.04	0.06
MP359/W13	Outfall	1007	0.06	0.03	0.06
MP360	Outlet	1008	0.06	0.03	0.06
MP360	Final	1009	0.06	0.03	0.06
MP361	Outfall	1002	0.06	0.04	0.06
MP361	Outlet	1003	0.06	0.04	0.06
MP415	Outlet	1018	0.03	0.04	0.03
MP415/416	NA	1019	0.06	0.04	0.06
MP415/416	NA	1020	0.06	0.04	0.06
MP415/416	NA	1021	0.06	0.03	0.06
MP415/416	NA	1022	0.06	0.03	0.06
MP415/416	NA	1023	0.06	0.03	0.06
MP415/416	NA	1024	0.06	0.03	0.06
MP415/416	Outfall	1025	0.06	0.03	0.06
MP415/416	Intermediate	1026	0.06	0.03	0.06
MP416	Outlet	1017	0.03	0.04	0.03
MP425	Outlet	1033	0.06	0.04	0.10
MP425	NA	1034	0.10	0.03	0.10
MP425	NA	1035	0.10	0.03	0.10
MP425	NA	1036	0.06	0.03	0.10
MP425	NA	1037	0.06	0.03	0.10
MP425	NA	1039	0.06	0.03	0.06
MP425/426/427	Intermediate/Outfall	1040	0.06	0.03	0.06
MP426 (OUT215)	Outlet	1041	0.06	0.04	0.06
MP426 (OUT215)	NA	1042	0.06	0.03	0.06
MP427 (OUT1521)	Outlet	185	0.07	0.03	0.05
MP433	Outlet	1010	0.10	0.04	0.10
MP433	Intermediate	1011	0.10	0.03	0.10
MP433	NA	1012	0.06	0.03	0.06
MP433	NA	1013	0.10	0.03	0.06
MP433	NA	1014	0.10	0.03	0.06
Site	**Assessment**	**Point number**	**Left bank**	**Channel**	**Right bank**
MP433	NA	1015	0.10	0.03	0.06
MP433	Culvert/Final	1016	0.06	0.03	0.06

MP458	Outlet	989	0.10	0.03	0.10
MP458	NA	990	0.10	0.03	0.10
MP458	Intermediate	991	0.06	0.03	0.06
MP458	Final	992	0.06	0.03	0.06
MP458	Outfall	NA	0.06	0.03	0.06
MP459	Outlet	2065	0.10	0.04	0.10
MP459	Outfall	2066	0.10	0.04	0.10
MP459	Intermediate	2067	0.10	0.04	0.06
MP465	Outlet	2096	0.03	0.04	0.03
MP467	Outlet	1054	0.10	0.04	0.06
MP467	Outfall	1056	0.06	0.03	0.10
MP467	NA	1057	0.06	0.03	0.06
MP469 (W19*)	Outlet	1062	0.06	0.03	0.06
MP469 (W19*)	NA	1063	0.06	0.03	0.06
MP472	Outfall	2091	0.10	0.03	0.10
MP472	Outlet	2093	0.10	0.03	0.10
MP495 (FID10)	Outlet	984	0.06	0.04	0.06
MP495 (FID10)	Culvert/Intermediate	985	0.06	0.03	0.06
MP507 (MP508E)	Outlet	997	0.04	0.03	0.04
MP508	Outlet	962	0.06	0.03	0.06
MP508	NA	963	0.06	0.03	0.06
MP508	NA	964	0.06	0.03	0.06
MP508	NA	965	0.06	0.03	0.06
MP508	NA	966	0.10	0.03	0.06
MP508	NA	967	0.10	0.03	0.06
MP508	NA	968	0.10	0.03	0.10
MP511 (MP508B)	NA	969	0.10	0.03	0.06
MP508	Outfall	971	0.06	0.03	0.06
MP511 (MP508B)	NA	972	0.06	0.03	0.06
MP508A	Outlet	970	0.04	0.03	0.04
MP508C	Outlet	974	0.04	0.03	0.04
MP508D	Outlet	976	0.04	0.03	0.06
MP511 (MP508B)	Outlet	973	0.04	0.04	0.04
MP525	Outlet	2088	0.10	0.03	0.10
MP525	Outfall	2090	0.10	0.03	0.10
MP558	Outlet	2080	0.06	0.06	0.06
MP559	Outlet	2079	0.10	0.04	0.10
Site	**Assessment**	**Point number**	**Left bank**	**Channel**	**Right bank**
MP573	Outlet	2074	0.10	0.03	0.06
MP573	Final	2075	0.10	0.03	0.06
MP578	Outlet	2076	0.10	0.04	0.10
MP591	Outlet	2071	0.10	0.04	0.10

MP591	Intermediate	2072	0.10	0.03	0.10
MP591	Final	2073	0.10	0.04	0.10
MP615	Outlet	993	0.06	0.04	0.06
MP615	Outfall	994	0.06	0.04	0.06
MP785	Outlet	2102	0.10	0.10	0.10
MP814 (Site3&4)	Outlet	982	0.06	0.04	0.06
MP814 (Site3&4)	Outfall	983	0.06	0.04	0.06
MP840	Outlet	609	0.06	0.04	0.06
MP840	NA	979	0.06	0.04	0.06
MP840	NA	980	0.06	0.04	0.06
MP840	Outfall	981	0.06	0.03	0.06
OUT2111	Outlet	474	0.06	0.03	0.06
POW162	Outlet	996	0.06	0.04	0.06
POW162	NA	998	0.06	0.04	0.06
W10	Outlet	959	0.06	0.04	0.06
W10	NA	1027	0.06	0.04	0.06
W10	NA	1028	0.06	0.03	0.06
W10	Intermediate	1029	0.06	0.03	0.06
W10	Outfall	1030	0.06	0.03	0.06
W11	Outlet	957	0.04	0.04	0.04
W13	Outlet	1004	0.06	0.03	0.06
W13	NA	1005	0.06	0.03	0.06
W18	Outlet	1059	0.06	0.03	0.06
W18/MP469 (W19*)/W19C	Outfall	1066	0.06	0.03	0.06
W19C	Outlet	1065	0.06	0.03	0.06

Table 3. Summary of bulk density measurements for site assessments

Site	Point number	Assessment	Left bank					Right bank				
			Pre-oven weight (g)	Dry weight (g)	Volume (cm^3)	Bulk density (lb/ft^3)	Layer	Pre-oven weight (g)	Dry weight (g)	Volume (cm^3)	Bulk density (lb/ft^3)	Layer
DE162	995	Outlet	165.5	123.0	148.03	52	1	145.0	117.0	113.87	64	1
DE162 (DE162/MP311/ POW162) Outfall	1001	Intermediate	175.5	124.5	187.88	41	1	299.0	226.0	176.50	80	1
MP024	2086	Outlet	270.5	239.0	187.88	79	1	232.5	204.5	187.88	68	1
MP024	2087	Outfall	260.5	166.5	187.88	55	1	219.5	182.0	187.88	60	1
MP078	1031	Outlet	282.0	187.5	187.88	62	1	298.0	213.0	185.04	72	1
MP078	1032	Culvert/Final	295.0	226.0	187.88	75	1	312.0	244.0	187.88	81	1
MP120	2126	Outlet	272.5	209.0	187.88	69	1	206.5	143.5	187.88	48	1
MP138	2069	Outlet	303.5	217.0	187.88	72	1	298.0	253.0	187.88	84	1
MP138	2070	Outfall	242.4	177.1	187.88	59	1	247.8	177.6	182.19	61	1
MP142	212	Outlet	251.0	224.5	170.80	82	1	227.50	199.00	187.88	66	1
MP143	2126	Outlet	307.5	229.0	187.88	76	1	201.0	158.0	136.64	72	1
MP152/OUT2104/ OUT2106	2105	Outlet	265.4	234.5	187.88	78	1	280.8	211.8	187.88	70	1
MP152/OUT2104/ OUT2106	2108	Intermediate	287.7	226.3	187.88	75	1	305.6	222.6	187.88	74	1
MP152/OUT2104/ OUT2106	2113	Final	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MP219	482	Outlet	296.5	218.0	187.88	72	1	301.0	218.0	187.88	72	1
MP225	1044	Outlet	240.5	202.0	187.88	67	1	263.5	224.5	187.88	75	1
MP225	1048	Intermediate	326.0	240.5	190.73	79	1	293.5	201.5	187.88	67	1
MP225	1052	Outfall	331.5	261.0	187.88	87	1	362.5	298.5	187.88	99	1
MP227	503	Outlet	336.5	290.0	187.88	96	1	354.5	295.5	187.88	98	1
MP227	1052	Outfall	330.0	264.5	182.19	91	1	319.0	261.5	187.88	87	1
MP227	2045	Intermediate	276.0	245.0	187.88	81	1	277.5	250.0	187.88	83	1
MP228	628	Outlet	248.0	229.0	187.88	76	1	235.5	212.5	187.88	71	1
Site	**Point number**	**Assessment**	**Left bank**					**Right bank**				
			Pre-oven weight (g)	Dry weight (g)	Volume (cm^3)	Bulk density (lb/ft^3)	Layer	Pre-oven weight (g)	Dry weight (g)	Volume (cm^3)	Bulk density (lb/ft^3)	Layer

MP229 (OUT111)	506	Outlet	189.5	118.5	125.26	59	1	230.0	126.5	182.19	43	1
MP257	2059	Outlet	259.0	186.5	187.88	62	1	257.5	193.5	187.88	64	1
MP257	2061	Intermediate	326.5	280.0	187.88	93	1	272.5	218.5	187.88	73	1
MP257	2063	Final	246.5	202.5	187.88	67	1	236.5	197.0	170.80	72	1
MP292	2083	Outlet	277.3	223.8	187.88	74	1	NA	NA	NA	NA	NA
MP311	1000	Intermediate	279.5	193.0	187.88	64	1	259.5	184.5	187.88	61	1
MP311	999	Outlet	224.5	153.5	187.88	51	1	185.0	84.5	159.42	33	1
MP318	2084	Outlet	245.1	175.2	170.80	64	1	240.5	182.7	170.80	67	1
MP318	2085	Intermediate/ Final	288.0	219.5	187.88	73	1	320.5	246.5	187.88	82	1
MP319	2082	Outlet	235.5	165.5	170.80	60	1	294.5	202.5	187.88	67	1
MP356	2046	Outlet	276.5	172.0	187.88	57	1	207.5	120.0	170.80	44	1
MP356	2057	Final	292.5	205.5	187.88	68	1	323.5	263.5	187.88	88	1
MP359	1006	Outlet	309.0	245.0	170.80	90	1	336.5	270.5	187.88	90	1
MP359/W13	1007	Outfall	291.5	214.0	182.19	73	1	310.0	239.5	187.88	80	1
MP360	1008	Outlet	325.0	275.5	187.88	92	1	342.5	287.5	187.88	96	1
MP360	1009	Final	358.5	300.0	187.88	100	1	341.5	294.0	187.88	98	1
MP361	1002	Outfall	285.0	220.0	187.88	73	1	306.0	237.5	190.73	78	1
MP361	1003	Outlet	367.5	333.5	187.88	111	1	312.0	273.0	190.73	89	1
MP415	1017	Outlet	290.0	215.5	187.88	72	1	223.5	167.0	153.72	68	1
MP415/MP416	1025	Outfall	241.5	185.0	187.88	61	1	288.0	218.0	187.88	72	1
MP415/MP416	1026	Intermediate	381.0	304.0	187.88	101	1	285.0	211.0	176.50	75	1
MP416	1018	Outlet	314.0	225.0	187.88	75	1	279.5	219.0	182.19	75	1
MP425	1033	Outlet	333.5	292.5	187.88	97	1	327.5	296.5	187.88	99	1
MP425	1033	Outlet	346.0	284.0	187.88	94	2	175.0	154.5	165.11	58	2
MP425/426/427	1040	Intermediate/ Outfall	295.5	210.0	187.88	70	1	228.5	167.5	142.34	73	1
MP426 (OUT215)	1041	Outlet	301.5	221.5	187.88	74	1	315.5	246.5	187.88	82	1
MP427 (OUT1521)	185	Outlet	326.0	251.0	187.88	59	1	321.5	246.0	187.88	43	1
Site	**Point number**	**Assessment**	**Left bank**					**Right bank**				
			Pre-oven weight (g)	Dry weight (g)	Volume (cm^3)	Bulk density (lb/ft^3)	Layer	Pre-oven weight (g)	Dry weight (g)	Volume (cm^3)	Bulk density (lb/ft^3)	Layer
MP433	1010	Outlet	302.0	252.5	170.80	92	1	327.5	265.0	187.88	88	1

MP433	1011	Intermediate	339.5	277.0	187.88	92	1	343.0	258.0	176.50	91	1
MP433	1016	Culvert/Final	269.5	186.5	170.80	68	1	291.0	212.5	187.88	71	1
MP458	989	Outlet	NA	224.0	187.88	74	1	NA	294.5	187.88	98	1
MP458	991	Intermediate	NA	192.5	187.88	64	1	NA	214.0	187.88	71	1
MP458	991	Intermediate	NA	226.5	187.88	75	2	NA	233.5	187.88	78	2
MP458	992	Final	286.0	210.0	187.88	70	1	328.0	240.5	187.88	80	1
MP459	2065	Outlet	299.5	238.5	187.88	79	1	277.0	208.0	187.88	69	1
MP459	2066	Outfall	298.0	219.0	187.88	73	1	313.0	240.5	187.88	80	1
MP459	2067	Intermediate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MP465	2096	Outlet	256.4	207.3	187.88	69	1	285.7	227.6	187.88	76	1
MP467	1054	Outlet	281.5	257.0	187.88	85	1	273.0	243.5	187.88	81	1
MP467	1056	Outfall	229.0	211.0	187.88	70	1	233.5	210.0	187.88	70	1
MP469 (W19*)	1062	Outlet	281.0	205.0	182.19	70	1	217.0	179.0	136.64	82	1
MP472	2091	Outfall	242.5	184.0	187.88	61	1	218.0	187.5	187.88	62	1
MP472	2093	Outlet	270.0	176.2	187.88	59	1	267.1	189.0	187.88	63	1
MP495 (FID10)	984	Outlet	NA	212.0	187.88	70	1	NA	260.5	187.88	87	1
MP495 (FID10)	985	Culvert/ intermediate	NA	180.5	187.88	60	1	NA	183.0	187.88	61	1
MP507 (MP508E)	997	Outlet	301.0	258.5	187.88	86	1	234.5	186.5	187.88	62	1
MP508	962	Outlet	NA	310.5	187.88	103	1	NA	268.0	187.88	89	1
MP508	971	Outfall	NA	210.5	187.88	70	1	NA	244.5	187.88	81	1
MP508A	970	Outlet	NA	298.0	187.88	99	1	NA	231.0	212.10	68	1
MP508C	974	Outlet	NA	234.0	187.88	78	1	NA	251.5	187.88	84	1
MP508D	976	Outlet	NA	220.0	187.88	73	1	NA	249.0	187.88	83	1
MP511 (MP508B)	973	Outlet	NA	231.0	187.88	77	1	NA	232.0	187.88	77	1
MP525	2088	Outlet	242.0	188.5	187.88	63	1	290.0	207.0	187.88	69	1
MP525	2090	Outfall	269.5	186.0	187.88	62	1	291.0	194.0	187.88	64	1
Site	**Point number**	**Assessment**	**Left bank**					**Right bank**				
			Pre-oven weight (g)	Dry weight (g)	Volume (cm^3)	Bulk density (lb/ft^3)	Layer	Pre-oven weight (g)	Dry weight (g)	Volume (cm^3)	Bulk density (lb/ft^3)	Layer
MP558	2080	Outlet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MP559	2079	Outlet	296.5	226.5	187.88	75	1	276.0	193.0	187.88	64	1
MP573	2074	Outlet	330.0	291.5	187.88	97	1	350.5	309.0	199.27	97	1

MP573	2075	Final	277.1	218.6	187.88	73	1	286.0	239.0	187.88	79	1
MP578	2076	Outlet	168.0	119.5	142.34	52	1	324.5	268.0	187.88	89	1
MP591	2071	Outlet	194.6	152.4	125.26	76	1	232.0	199.0	187.88	66	1
MP591	2072	Intermediate	196.7	154.3	165.11	58	1	281.8	201.4	187.88	67	1
MP591	2073	Final	240.5	149.0	153.72	61	1	270.0	224.0	187.88	74	1
MP615	993	Outlet	156.0	110.0	159.42	43	1	280.5	182.0	187.88	60	1
MP615	994	Outfall	268.0	185.5	187.88	62	1	287.5	211.0	187.88	70	1
MP785	2102	Outlet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MP814 (Site3&4)	982	Outlet	316.5	244.0	187.88	81	1	310.0	257.0	187.88	85	1
MP814 (Site3&4)	983	Outfall	298.5	220.5	187.88	73	1	330.5	251.0	187.88	83	1
MP840	609	Outlet	242.5	142.0	187.88	47	1	280.5	179.0	187.88	59	1
MP840	981	Outfall	323.5	258.5	187.88	86	1	295.0	229.0	187.88	76	1
OUT2111	474	Outlet	253.0	158.5	187.88	53	1	337.0	256.0	187.88	85	1
POW162	996	Outlet	271.5	213.0	187.88	71	1	199.5	169.5	142.34	74	1
W10	959	Outlet	250.0	234.5	187.88	78	1	242.5	219.0	187.88	73	1
W10	1029	Intermediate	306.0	230.0	187.88	76	1	252.0	187.0	170.80	68	1
W10	1030	Outfall	278.0	192.0	176.50	68	1	309.5	215.0	176.50	76	1
W11	957	Outlet	292.0	281.5	159.42	110	1	244.5	224.0	170.80	82	1
W13	1004	Outlet	266.0	182.0	187.88	60	1	341.5	269.5	187.88	90	1
W18	1059	Outlet	261.0	220.0	170.80	80	1	296.0	266.0	187.88	88	1
W18/MP469 (W19*)/ W19C	1066	Outfall	322.0	237.0	187.88	79	1	338.0	261.5	187.88	87	1
W19C	1065	Outlet	257.0	232.5	187.88	77	1	260.5	230.5	187.88	77	1

Table 4. Summary of soil texture data for site assessments

Site	Point number	Assessment	Left bank					Channel				Right bank				
			% Clay	% Sand	% Silt	Soil Texture	Layer	% Clay	% Sand	% Silt	Soil Texture	% Clay	% Sand	% Silt	Soil Texture	Layer
DE162	995	Outlet	13.1	36.1	50.8	Silt loam	1	18.4	66.1	15.5	Sandy loam	12.4	39.2	48.4	Loam	1
DE162 (DE162/ MP311/ POW162) Outfall	1001	Intermediate	21.6	18.7	59.7	Silt loam	1	17.6	67.4	15.0	Sandy loam	19.5	28.6	51.9	Silt loam	1
MP024	2086	Outlet	12.7	72.3	15.0	Sandy loam	1	4.2	90.9	4.9	Sand	8.2	78.5	13.3	Loamy sand	1
MP024	2087	Outfall	8.5	77.0	14.5	Sandy loam	1	0.7	97.0	2.3	Sand	8.7	73.8	17.5	Sandy loam	1
MP078	1031	Outlet	5.2	80.6	14.2	Loamy sand	1	-	-	-	-	9.2	69.2	21.6	Sandy loam	1
MP078	1032	Culvert/ Final	14.3	52.1	33.6	Sandy loam	1	11.4	79.1	9.5	Sandy loam	16.4	59.2	24.4	Sandy loam	1
MP120	2126	Outlet	13.8	64.1	22.1	Sandy loam	1	4.0	93.2	2.8	Sand	11.0	66.6	22.4	Sandy loam	1
MP138	2069	Outlet	12.8	75.0	12.2	Sandy loam	1	3.7	96.3	0.0	Sand	17.6	74.0	8.4	Sandy loam	1
MP138	2070	Outfall	14.2	46.9	38.9	Loam	1	9.5	57.5	33.0	Sandy loam	12.0	52.2	35.8	Sandy loam	1
MP142	2121	Outlet	24.7	52.1	23.2	Sandy clay loam	1	15.9	69.8	14.3	Sandy loam	11.1	69.8	19.1	Sandy loam	1
MP143	2126	Outlet	11.6	68.0	20.4	Sandy loam	1	21.7	24.3	54.0	Silt loam	8.1	77.6	14.3	Sandy loam	1
MP152/OUT2104/ OUT2106	2105	Outlet	8.0	79.0	13.0	Loamy sand	1	3.7	94.2	2.1	Sand	9.4	70.8	19.8	Sandy loam	1
MP152/OUT2104/ OUT2106	2108	Intermediate	14.4	47.9	37.7	Loam	1	7.8	92.2	0.0	Sand	17.1	57.1	25.8	Sandy loam	1
MP152/OUT2104/ OUT2106	2113	Final	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP219	482	Outlet	17.1	51.1	31.8	Loam	1	13.0	73.4	13.6	Sandy loam	16.7	23.3	60.0	Silt loam	1
MP225	1044	Outlet	13.3	21.4	65.3	Silt loam	1	24.9	42.9	32.2	Loam	8.7	33.1	58.2	Silt loam	1
MP225	1048	Intermediate	16.7	18.7	64.6	Silt loam	1	9.2	42.4	48.4	Loam	7.4	41.8	50.8	Silt loam	1
MP225	1051	Outfall	14.3	23.0	62.7	Silt loam	1	11.6	35.5	52.9	Silt loam	9.0	29.3	61.7	Silt loam	1
Site	**Point**	**Assessment**	**Left bank**					**Channel**				**Right bank**				

	number		% Clay	% Sand	% Silt	Soil Texture	Layer	% Clay	% Sand	% Silt	Soil Texture	% Clay	% Sand	% Silt	Soil Texture	Layer
MP227	503	Outlet	15.3	44.6	40.1	Loam	1	12.0	51.7	36.3	Loam	12.1	30.6	57.3	Silt loam	1
MP227	1052	Outfall	11.4	46.8	41.8	Loam	1	13.2	40.8	46.0	Loam	15.9	38.9	45.2	Loam	1
MP227	2045	Intermediate	8.7	33.3	58.0	Silt loam	1	10.9	24.9	64.2	Silt loam	11.7	36.0	52.3	Silt loam	1
MP228	628	Outlet	15.6	28.7	55.7	Silt loam	1	17.3	36.8	45.9	Loam	20.7	42.2	37.1	Loam	1
MP229 (OUT111)	506	Outlet	18.0	17.6	64.4	Silt loam	1	16.3	35.4	48.3	Loam	14.1	25.6	60.3	Silt loam	1
MP257	2059	Outlet	20.6	38.4	41.0	Loam	1	10.6	54.2	35.2	Sandy loam	18.1	42.4	39.5	Loam	1
MP257	2061	Intermediate	11.4	59.9	28.7	Sandy loam	1	9.4	55.6	35.0	Sandy loam	13.2	49.4	37.4	Loam	1
MP292	2083	Outlet	8.0	61.0	31.0	Sandy loam	1	4.2	84.0	11.8	Loamy sand	16.1	60.9	23.0	Sandy loam	1
MP311	1000	Intermediate	13.4	13.3	73.3	Silt loam	1	6.8	71.6	21.6	Sandy loam	20.8	20.0	59.2	Silt loam	1
MP311	999	Outlet	15.9	37.5	46.6	Loam	1	5.1	71.0	23.9	Sandy loam	15.0	29.0	56.0	Silt loam	1
MP318	2084	Outlet	14.7	62.2	23.1	Sandy loam	1	11.5	74.9	13.6	Sandy loam	8.9	75.2	15.9	Sandy loam	1
MP318	2085	Intermediate/ Final	7.8	76.9	15.3	Sandy loam	1	4.6	86.1	9.3	Loamy sand	10.8	58.0	31.2	Sandy loam	1
MP319	2082	Outlet	11.1	69.4	19.5	Sandy loam	1	10.8	62.1	27.1	Sandy loam	11.0	65.2	23.8	Sandy loam	1
MP356	2046	Outlet	6.1	58.2	35.7	Sandy loam	1	6.7	78.2	15.1	Loamy sand	8.5	51.2	40.3	Loam	1
MP356	2057	Final	6.8	64.0	29.2	Sandy loam	1	7.6	65.4	27.0	Sandy loam	6.1	61.0	32.9	Sandy loam	1
MP359	1006	Outlet	8.6	59.4	32.0	Sandy loam	1	-	-	-	-	12.7	52.8	34.5	Sandy loam	1
MP359/W13	1007	Outfall	7.6	74.6	17.8	Sandy loam	1	3.8	81.7	14.5	Loamy sand	11.9	67.7	20.4	Sandy loam	1
MP360	1008	Outlet	7.8	69.6	22.6	Sandy loam	1	4.2	87.0	8.8	Loamy sand	5.7	70.6	23.7	Sandy loam	1
MP360	1009	Final	22.3	47.1	30.6	Loam	1	10.6	77.6	11.8	Sandy loam	9.0	64.8	26.2	Sandy loam	1
MP361	1002	Outfall	5.1	58.0	36.9	Sandy loam	1	12.0	84.1	3.9	Loamy sand	8.0	58.0	34.0	Sandy loam	1
MP361	1003	Outlet	6.4	60.8	32.8	Sandy loam	1	5.4	91.0	3.6	Sand	11.9	65.0	23.1	Sandy loam	1
MP415	1018	Outlet	13.5	19.0	67.5	Silt loam	1	14.4	25.4	60.2	Silt loam	11.4	18.7	69.9	Silt loam	1
Site	**Point number**	**Assessment**	**Left bank**					**Channel**				**Right bank**				
			% Clay	**% Sand**	**% Silt**	**Soil Texture**	**Layer**	**% Clay**	**% Sand**	**% Silt**	**Soil Texture**	**% Clay**	**% Sand**	**% Silt**	**Soil Texture**	**Layer**

MP415/ MP416	1025	Outfall	13.4	16.5	70.1	Silt loam	1	3.3	69.1	27.6	Sandy loam	10.2	30.5	59.3	Silt loam	1
MP415/ MP416	1026	Intermediate	11.3	15.7	73.0	Silt loam	1	12.9	51.3	35.8	Loam	14.2	26.5	59.3	Silt loam	1
MP416	1017	Outlet	23.4	5.7	70.9	Silt loam	1	10.9	31.5	57.6	Silt loam	21.1	11.8	67.1	Silt loam	1
MP425	1033	Outlet	19.5	49.7	30.8	Loam	1	5.9	86.4	7.7	Loamy sand	6.4	83.9	9.7	Loamy sand	1
MP425	1033	Outlet	9.0	69.6	21.4	Sandy loam	2	-	-	-	-	-	-	-	-	-
MP425/426/427	1040	Intermediate/ Outfall	5.8	80.2	14.0	Loamy sand	1	5.2	94.2	0.6	Sand	5.2	88.0	6.8	Sand	1
MP426 (OUT215)	1041	Outlet	8.6	44.4	47.0	Loam	1	12.1	38.5	49.4	Loam	9.5	50.0	40.5	Loam	1
MP427 (OUT1521)	185	Outlet	14.1	50.9	35.0	Loam	1	16.1	28.9	55.0	Silt loam	9.9	63.1	27.0	Sandy loam	1
MP433	1010	Outlet	9.8	54.1	36.1	Sandy loam	1	14.3	46.3	39.4	Loam	9.2	68.8	22.0	Sandy loam	1
MP433	1011	Intermediate	4.0	86.9	9.1	Loamy sand	1	7.3	84.3	8.4	Loamy sand	4.5	75.0	20.5	Loamy sand	1
MP433	1016	Final	9.1	85.3	5.6	Loamy sand	1	2.6	95.5	1.9	Sand	3.0	96.2	0.8	Sand	1
MP458	989	Outlet	11.8	72.5	15.7	Sandy loam	1	7.0	89.5	3.5	Sand	20.6	65.7	13.7	Sandy clay loam	1
MP458	991	Intermediate	48.6	19.3	32.1	Clay	1	47.3	15.7	37.0	Clay	16.2	55.2	28.6	Sandy loam	1
MP458	991	Intermediate	28.1	54.7	17.2	Sandy clay loam	2	-	-	-	-	32.6	34.9	32.5	Clay loam	2
MP458	992	Final	6.9	73.5	19.6	Sandy loam	1	0.5	91.0	8.5	Sand	6.1	77.4	16.5	Loamy sand	1
MP458	NA	Outfall	5.0	62.3	32.7	Sandy loam	1	3.9	81.7	14.4	Loamy sand	0.9	77.3	21.8	Loamy sand	1
MP459	2065	Outlet	9.6	73.8	16.6	Sandy loam	1	3.9	84.2	11.9	Loamy sand	3.8	92.4	3.8	Sand	1
MP459	2066	Outfall	4.7	89.8	5.5	Sand	1	9.4	74.4	16.2	Sandy loam	9.4	83.2	7.4	Loamy sand	1
MP465	2096	Outlet	16.0	55.9	28.1	Sandy loam	1	20.9	60.2	18.9	Sandy clay loam	15.2	51.8	33.0	Loam	1
MP467	1054	Outlet	5.9	72.4	21.7	Sandy loam	1	3.3	76.7	20.0	Loamy sand	0.6	75.3	24.1	Loamy sand	1
Site	**Point number**	**Assessment**	**Left bank**					**Channel**				**Right bank**				
			% Clay	**% Sand**	**% Silt**	**Soil Texture**	**Layer**	**% Clay**	**% Sand**	**% Silt**	**Soil Texture**	**% Clay**	**% Sand**	**% Silt**	**Soil Texture**	**Layer**
MP467	1056	Outfall	4.1	66.6	29.3	Sandy loam	1	1.5	98.5	0.0	Sand	9.4	42.9	47.7	Loam	1

MP469 (W19*)	1062	Outlet	9.4	75.8	14.9	Sandy loam	1	3.0	95.3	1.7	Sand	6.9	79.7	13.4	Loamy sand	1
MP472	2091	Outfall	13.2	68.5	18.3	Sandy loam	1	7.5	84.4	8.1	Loamy sand	10.3	67.2	22.5	Sandy loam	1
MP472	2093	Outlet	11.4	69.0	19.6	Sandy loam	1	10.5	72.4	17.1	Sandy loam	9.8	74.8	15.4	Sandy loam	1
MP495 (FID10)	984	Outlet	20.2	56.3	23.5	Sandy clay loam	1	24.2	48.9	26.9	Sandy clay loam	13.6	51.3	35.1	Loam	1
MP495 (FID10)	985	Culvert/ Intermediate	27.5	24.5	48.0	Clay loam	1	12.1	77.8	10.1	Sandy loam	10.6	35.2	54.2	Silt loam	1
MP507 (MP508E)	977	Outlet	4.9	68.6	26.5	Sandy loam	1	35.3	19.2	45.5	Silty Clay loam	4.9	59.0	36.1	Sandy loam	1
MP508	962	Outlet	9.9	64.2	25.9	Sandy loam	1	14.0	61.1	24.9	Sandy loam	10.1	58.9	31.0	Sandy loam	1
MP508	971	Outfall	7.0	72.0	21.0	Sandy loam	1	0.5	85.7	13.8	Sand	10.5	64.4	25.1	Sandy loam	1
MP508A	970	Outlet	16.6	45.8	37.6	Loam	1	8.1	80.9	11.0	Loamy sand	14.6	50.4	35.0	Loam	1
MP508C	974	Outlet	7.6	62.2	30.2	Sandy loam	1	14.7	33.7	51.6	Silt loam	10.6	44.5	44.9	Loam	1
MP508D	976	Outlet	9.7	72.3	18.0	Sandy loam	1	15.8	22.4	61.8	Silt loam	17.0	30.0	53.0	Silt loam	1
MP511 (MP508B)	973	Outlet	8.7	46.7	44.6	Loam	1	4.9	69.9	25.2	Sandy loam	12.2	63.7	24.1	Sandy loam	1
MP525	2088	Outlet	8.6	82.0	9.4	Loamy sand	1	4.7	90.0	5.3	Sand	8.1	83.1	8.8	Loamy sand	1
MP525	2090	Outfall	16.7	44.1	39.2	Loam	1	3.6	93.4	3.0	Sand	16.9	60.2	22.9	Sandy loam	1
MP558	2080	Outlet	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP559	2079	Outlet	17.0	53.5	29.5	Sandy loam	1	15.5	56.1	28.4	Sandy loam	10.9	56.8	32.3	Sandy loam	1
MP573	2074	Outlet	9.0	40.1	50.9	Silt loam	1	19.7	44.6	35.7	Loam	8.9	39.2	51.9	Silt loam	1
MP573	2075	Final	10.7	35.6	53.7	Silt loam	1	7.4	84.7	7.9	Loamy sand	9.4	22.4	68.2	Silt loam	1
MP578	2076	Outlet	5.4	74.7	19.9	Sandy loam	1	8.9	75.4	15.7	Sandy loam	8.7	72.7	18.6	Sandy loam	1
Site	**Point number**	**Assessment**	**Left bank**					**Channel**				**Right bank**				
			% Clay	**% Sand**	**% Silt**	**Soil Texture**	**Layer**	**% Clay**	**% Sand**	**% Silt**	**Soil Texture**	**% Clay**	**% Sand**	**% Silt**	**Soil Texture**	**Layer**
MP591	2071	Outlet	12.6	31.4	56.0	Silt loam	1	8.0	63.2	28.8	Sandy loam	20.1	31.8	48.1	Loam	
MP591	2072	Intermediate	12.4	45.8	41.8	Loam	1	14.0	47.8	38.2	Loam	17.3	18.4	64.3	Silt loam	1

MP591	2073	Final	17.4	28.3	54.3	Silt loam	1	-	-	-	-	14.7	20.9	64.4	Silt loam	1
MP615	993	Outlet	4.8	72.2	23.0	Sandy loam	1	4.1	83.9	12.0	Loamy sand	0.7	79.0	20.3	Loamy sand	1
MP615	994	Outfall	7.5	67.7	24.8	Sandy loam	1	3.8	82.2	14.0	Loamy sand	5.7	66.8	27.5	Sandy loam	1
MP785	2102	Outlet	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP814 (Site3&4)	982	Outfall	22.0	31.1	46.9	Loam	1	24.4	70.0	5.6	Sandy clay loam	7.8	75.9	16.3	Sandy loam	1
MP814 (Site3&4)	983	Outlet	18.2	46.4	35.4	Loam	1	-	-	-	-	28.5	53.5	18.0	Sandy clay loam	1
MP840	609	Outlet	8.8	50.6	40.6	Loam	1	0.6	90.7	8.7	Sand	3.4	66.0	30.6	Sandy loam	1
MP840	981	Outfall	1.5	72.4	26.1	Loamy sand	1	3.2	90.1	6.7	Sand	3.8	84.8	11.4	Loamy sand	1
OUT2111	474	Outlet	20.9	10.9	68.2	Silt loam	1	24.5	16.3	59.2	Silt loam	19.3	24.8	55.9	Silt loam	1
POW162	996	Outlet	19.7	29.0	51.3	Silt loam	1	10.1	63.6	26.3	Sandy loam	13.7	46.8	39.5	Loam	1
W10	959	Outlet	20.6	49.3	30.1	Loam	1	0.6	77.8	21.6	Loamy sand	16.1	64.1	19.8	Sandy loam	1
W10	1029	Intermediate	5.0	76.5	18.5	Loamy sand	1	3.5	93.1	3.4	Sand	9.8	59.2	31.0	Sandy loam	1
W10	1030	Outfall	0.0	93.0	7.0	Sand	1	3.1	91.9	5.0	Sand	4.1	93.0	2.9	Sand	1
W11	157	Outlet	12.6	66.1	21.3	Sandy loam	1	0.6	91.4	8.0	Sand	29.1	52.5	18.4	Sandy clay loam	1
W13	1004	Outlet	8.9	68.8	22.3	Sandy loam	1	5.3	80.2	14.5	Loamy sand	11.6	54.2	34.2	Sandy loam	1
W18	1059	Outlet	21.4	59.9	18.7	Sandy clay loam	1	11.0	83.5	5.5	Loamy sand	10.2	77.9	11.9	Sandy loam	1
W18/MP469 (W19*)/W19C	1065	Outfall	6.1	90.6	3.3	Sand	1	2.0	95.8	2.2	Sand	8.1	72.0	19.9	Sandy loam	1
W19C	1066	Outlet	9.7	80.8	9.5	Loamy sand	1	2.7	97.3	0.0	Sand	14.4	64.0	21.6	Sandy loam	1

Table 5. Summary of confining layer data for site assessments

Site	**Assessment**	**Point number**	**Depth to confining layer (ft)**
DE162	Outlet	995	0.00
DE162 (DE162/MP311/POW162 Outfall)	Intermediate	1001	0.65
MP024	Outlet	2086	0.00
MP024	Outfall	2087	3.77
MP078	Outlet	1031	0.00
MP078	Culvert/Final	1032	1.30
MP120	Outlet	2124	NA
MP138	Outlet	2069	2.70
MP138	Outfall	2070	0.50
MP142	Outlet	2121	3.30
MP143	Outlet	2126	NA
MP152/OUT2106/OUT2014	Outlet	2105	3.80
MP152/OUT2106/OUT2014	Intermediate	2108	3.80
MP152/OUT2106/OUT2014	Final	2113	NA
MP219	Outlet	482	0.00
MP225	Outlet	1044	1.88
MP225	Intermediate	1050	1.75
MP225	Outfall	1051	1.50
MP227	Outlet	502	0.00
MP227	Outfall	1052	0.83
MP227	Intermediate	2045	0.30
MP228	Outlet	628	0.00
MP229 (OUT111)	Outlet	506	3.00
MP257	Outlet	2059	2.90
MP257	Intermediate	2061	3.35
MP257	Final	2063	0.00
MP292	Outlet	2083	NA
MP311	Outlet	999	0.52
MP311	Intermediate	1000	1.25
MP318	Outlet	2084	1.85
MP318	Intermediate/Final	2085	0.60
MP319	Outlet	2082	2.10
MP356	Outlet	2046	0.00
MP356	Final	2057	2.75
Site	**Assessment**	**Point number**	**Depth to confining layer (ft)**

MP359	Outlet	1006	3.51
MP359/W13	Outfall	1007	4.20
MP360	Outlet	1008	3.85
MP360	Final	1009	2.65
MP361	Outfall	1002	3.30
MP361	Outlet	1003	2.87
MP415	Outlet	1018	2.85
MP415/MP416	Outfall	1025	0.00
MP415/MP416	Intermediate	1026	0.00
MP416	Outlet	1017	2.80
MP425	Outlet	1033	0.00
MP425/MP426/MP427	Intermediate/Outfall	1040	1.25
MP426	Outlet	1041	4.40
MP427	Outlet	185	3.70
MP433	Outlet	1010	2.85
MP433	Intermediate	1011	2.80
MP433	Culvert/Final	1016	2.87
MP458	Outlet	989	2.00
MP458	Intermediate	991	1.00
MP458	Final	992	1.65
MP459	Outlet	2065	0.70
MP459	Outfall	2066	0.00
MP459	Intermediate	2067	0.00
MP465	Outlet	2096	0.00
MP467	Outlet	1054	1.80
MP467	Outfall	1056	3.81
MP469 (W19*)	Outlet	1062	3.40
MP472	Outfall	2091	0.45
MP472	Outlet	2093	NA
MP495 (FID10)	Outlet	984	2.20
MP495 (FID10)	Culvert/Intermediate	985	1.20
MP508	Outlet	962	0.40
MP508	Outfall	971	0.90
MP508A	Outlet	970	0.00
MP508C	Outlet	974	0.70
MP508D	Outlet	976	0.80
MP508E	Outlet	973	0.00
MP511 (MP508B)	Outlet	973	0.00
MP525	Outlet	2088	0.60
Site	**Assessment**	**Point number**	**Depth to confining layer (ft)**
MP525	Outfall	2090	3.80
MP558	Outlet	2080	NA

MP559	Outlet	2079	1.60
MP573	Outlet	2074	0.00
MP573	Final	2075	0.00
MP578	Outlet	2076	0.00
MP591	Outlet	2071	0.00
MP591	Intermediate	2072	1.00
MP591	Final	2073	0.00
MP615	Outlet	993	0.40
MP615	Outfall	994	0.00
MP785	Outlet	2102	NA
MP814	Outlet	982	0.00
MP814	Outfall	983	0.00
MP840	Outlet	609	0.00
MP840	Outfall	981	4.60
OUT2104	Outlet	2104	NA
OUT2106	Outlet	2106	NA
OUT2111	Outlet	474	2.65
OUT2111	Outlet	474	2.65
POW162	Outlet	996	0.00
W10	Outlet	959	4.30
W10	Intermediate	1029	1.50
W10	Outfall	1030	4.30
W11	Outlet	957	0.00
W13	Outlet	1004	4.20
W18	Outlet	1059	0.00
W18/MP469 (W19*)/W19C	Outfall	1066	0.00
W19C	Outlet	1065	0.00

Table 6. Summary of Bank Erosion Hazard Index (BEHI) data for site assessments

Site	Point number	Cross-section	Bank	BEHI score	BEHI category	Study bank height (ft)	Bankfull height (ft)	Root depth (ft)	Root density (%)	Bank angle (°)	Surface protection (%)
DE162	995	Outlet	LOB	35.6	High	2.6	0.2	2.6	10	32	10
DE162	995	Outlet	ROB	20.6	Moderate	1.4	0.2	1.4	95	16	95
DE162 (DE162/MP311/ POW162) Outfall	1001	Intermediate	LOB	34.1	High	2.4	0.2	2.4	10	42	10
DE162 (DE162/MP311/ POW162) Outfall	1001	Intermediate	ROB	34.2	High	3.6	0.2	3.6	5	62	40
MP024	2086	Outlet	LOB	26.9	Moderate	2.4	0.6	2.4	35	25	100
MP024	2086	Outlet	ROB	40.6	Very High	3.8	0.6	3.8	5	32	5
MP024	2087	Outfall	LOB	50.4	Extreme	1.7	0.6	0.0	0	44	5
MP024	2087	Outfall	ROB	48.7	Extreme	2.6	0.6	0.0	0	34	5
MP078	1031	Outlet	LOB	40.8	Very High	1.4	0.1	1.4	5	35	5
MP078	1031	Outlet	ROB	34.2	High	2.7	0.1	2.7	35	22	10
MP078	1032	Culvert/ End	LOB	29.1	Moderate	3.5	0.1	3.5	35	19	35
MP078	1032	Culvert/ End	ROB	38.1	High	2.5	0.1	2.5	5	41	15
MP120	2124	Outlet	NA	NA	NA	NA	0.5	NA	NA	NA	NA
MP138	2069	Outlet	LOB	36.2	High	2.4	0.4	2.4	10	23	35
MP138	2069	Outlet	ROB	38.5	High	2.2	0.4	2.2	5	29	5
MP138	2070	Outfall	LOB	45.6	Extreme	0.9	0.4	0.0	0	28	0
MP138	2070	Outfall	ROB	48.3	Extreme	0.8	0.4	0.0	0	53	0
MP142	2121	Outlet	LOB	37.8	High	0.8	0.1	0.8	5	16	5
MP142	2121	Outlet	ROB	38.0	High	1.1	0.1	1.1	5	29	10
MP143	2126	Outlet	NA	NA	NA	NA	0.8	NA	NA	NA	NA
MP152/OUT2104/ OUT2106	2105	Outlet	LOB	44.2	Very High	2.4	0.2	1.0	5	25	5
MP152/OUT2104/ OUT2106	2105	Outlet	ROB	37.8	High	2.4	0.2	2.4	5	15	5
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**

MP152/OUT2104/ OUT2106	2108	Intermediate	LOB	35.2	High	2.6	0.2	2.6	5	14	10
MP152/OUT2104/ OUT2106	2108	Intermediate	ROB	31.8	High	1.4	0.2	1.4	10	15	60
MP152/OUT2104/ OUT2106	2110	NA	LOB	28.4	Moderate	2.4	0.2	2.4	10	38	70
MP152/OUT2104/ OUT2106	2110	NA	ROB	27.0	Moderate	3.6	0.2	3.6	35	42	80
MP152/OUT2104/ OUT2106	2111	NA	LOB	32.5	High	2.4	0.6	2.4	5	10	90
MP152/OUT2104/ OUT2106	2111	NA	ROB	40.1	Very High	3.8	0.6	3.8	0	15	100
MP152/OUT2104/ OUT2106	2113	Final	LOB	43.2	Very High	1.7	0.6	0.0	0	23	90
MP152/OUT2104/ OUT2106	2113	Final	ROB	50.2	Extreme	2.6	0.6	0.0	0	23	5
MP219	482	Outlet	LOB	29.4	Moderate	1.4	0.1	1.4	50	39	50
MP219	482	Outlet	ROB	29.8	Moderate	2.7	0.1	2.7	35	67	35
MP225	1044	Outlet	LOB	31.4	High	3.5	0.1	3.5	20	35	20
MP225	1044	Outlet	ROB	29.4	Moderate	2.5	0.1	2.5	35	45	45
MP225	1045	NA	LOB	27.3	Moderate	NA	0.5	NA	35	14	50
MP225	1045	NA	ROB	37.0	High	2.4	0.4	2.4	5	35	5
MP225	1046	NA	LOB	25.9	Moderate	2.2	0.4	2.2	35	26	90
MP225	1046	NA	ROB	28.4	Moderate	0.9	0.4	0.0	35	35	90
MP225	1047	NA	LOB	35.2	High	0.8	0.4	0.0	10	33	15
MP225	1047	NA	ROB	35.8	High	0.8	0.1	0.8	5	15	5
MP225	1051	Outfall	LOB	23.6	Moderate	1.1	0.1	1.1	35	29	95
MP225	1051	Outfall	ROB	25.7	Moderate	NA	0.8	NA	35	31	95
MP225	1050 (1048)	Intermediate	LOB	23.2	Moderate	2.4	0.2	1.0	35	22	95
MP225	1050 (1048)	Intermediate	ROB	29.9	Moderate	2.4	0.2	2.4	5	28	80
MP227	502	Outlet	LOB	25.0	Moderate	2.6	0.2	2.6	90	75	90
MP227	502	Outlet	ROB	24.7	Moderate	1.4	0.2	1.4	80	62	80
MP227	2043	NA	LOB	25.9	Moderate	2.4	0.2	2.4	35	35	95
MP227	2043	NA	ROB	47.4	Extreme	3.6	0.2	3.6	5	133	5
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**
MP227	2045	Intermediate	LOB	34.7	High	2.6	0.2	2.6	10	24	15
MP227	2045	Intermediate	ROB	35.8	High	1.4	0.2	1.4	5	16	5

MP227	1052 (1044)	Outfall	LOB	26.8	Moderate	2.4	0.2	2.4	35	23	80
MP227	1052 (1044)	Outfall	ROB	26.7	Moderate	3.6	0.2	3.6	35	32	80
MP228	628	Outlet	LOB	38.3	High	2.4	0.6	2.4	0	26	100
MP228	628	Outlet	ROB	38.8	High	3.8	0.6	3.8	0	35	100
MP229 (OUT111)	506	Outlet	LOB	44.7	Very High	1.7	0.6	0.0	0	13	0
MP229 (OUT111)	506	Outlet	ROB	31.5	High	2.6	0.6	0.0	15	9	15
MP257	2059	Outlet	LOB	29.2	Moderate	1.4	0.1	1.4	35	22	35
MP257	2059	Outlet	ROB	29.3	Moderate	2.7	0.1	2.7	35	24	35
MP257	2061	Intermediate	LOB	37.2	High	3.5	0.1	3.5	10	24	10
MP257	2061	Intermediate	ROB	36.5	High	2.5	0.1	2.5	5	29	5
MP257	2062	NA	LOB	34.5	High	NA	0.5	NA	5	39	10
MP257	2062	NA	ROB	36.5	High	2.4	0.4	2.4	5	30	5
MP257	2063	Final	LOB	40.3	Very High	2.2	0.4	2.2	5	45	5
MP257	2063	Final	ROB	36.9	High	0.9	0.4	0.0	5	37	5
MP292	2083	Outlet	NA	NA	NA	0.8	0.4	0.0	NA	NA	NA
MP311	999	Outlet	LOB	30.4	High	0.8	0.1	0.8	35	90	75
MP311	999	Outlet	ROB	28.7	Moderate	1.1	0.1	1.1	35	71	50
MP311	1000	Intermediate	LOB	24.3	Moderate	NA	0.8	NA	35	23	80
MP311	1000	Intermediate	ROB	24.3	Moderate	2.4	0.2	1.0	35	24	80
MP318	2084	Outlet	LOB	29.2	Moderate	2.4	0.2	2.4	35	22	35
MP318	2084	Outlet	ROB	25.9	Moderate	1.7	0.2	1.7	35	35	95
MP319	2082	Outlet	LOB	46.4	Extreme	1.2	0.2	1.2	0	12	5
MP319	2082	Outlet	ROB	32.9	High	4.4	0.2	4.4	35	16	35
MP356	2046	Outlet	LOB	27.6	Moderate	4.0	0.2	2.0	35	20	90
MP356	2046	Outlet	ROB	40.0	High	2.4	0.2	2.4	10	70	10
MP356	2057	Final	LOB	49.5	Extreme	1.7	0.2	1.7	0	29	0
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**
MP356	2057	Final	ROB	37.3	High	2.3	0.3	2.3	10	26	10
MP359	1006	Outlet	LOB	45.0	Very High	3.8	0.3	3.8	10	158	10
MP359	1006	Outlet	ROB	39.4	High	3.6	0.3	3.6	5	47	5
MP359/W13	1007	Outfall	LOB	22.9	Moderate	4.1	0.3	4.1	95	23	95

MP359/W13	1007	Outfall	ROB	26.6	Moderate	1.8	0.3	1.8	35	10	95
MP360	1008	Outlet	LOB	26.3	Moderate	1.7	0.2	1.7	35	3	95
MP360	1008	Outlet	ROB	37.3	High	1.8	0.2	1.8	5	16	10
MP360	1009	Final	LOB	27.3	Moderate	2.1	0.2	2.1	35	53	90
MP360	1009	Final	ROB	46.0	Extreme	1.4	0.2	1.4	5	166	5
MP361	1002	Outfall	LOB	30.3	High	7.8	0.2	7.8	35	34	50
MP361	1002	Outfall	ROB	36.5	High	7.2	0.2	7.2	5	24	20
MP361	1003	Outlet	LOB	31.2	High	14.4	0.2	14.4	35	22	35
MP361	1003	Outlet	ROB	36.3	High	8.0	0.2	8.0	15	40	20
MP415	1018	Outlet	LOB	31.7	High	2.7	0.2	2.7	15	14	15
MP415	1018	Outlet	ROB	30.4	High	3.1	0.2	3.1	15	27	30
MP415/MP416	1019	NA	LOB	29.7	Moderate	2.4	0.2	2.4	35	32	35
MP415/MP416	1019	NA	ROB	29.3	Moderate	3.4	0.2	3.4	35	23	35
MP415/MP416	1020	NA	LOB	26.4	Moderate	2.7	0.2	2.7	35	45	95
MP415/MP416	1020	NA	ROB	38.5	High	3.8	0.2	1.8	25	142	85
MP415/MP416	1021	NA	LOB	27.9	Moderate	2.1	0.2	2.1	35	25	50
MP415/MP416	1021	NA	ROB	26.2	Moderate	1.6	0.2	1.6	35	41	95
MP415/MP416	1022	NA	LOB	30.0	Moderate	0.9	0.2	0.9	35	82	90
MP415/MP416	1022	NA	ROB	25.2	Moderate	2.1	0.2	2.1	35	22	60
MP415/MP416	1023	NA	LOB	28.8	Moderate	2.2	0.2	2.2	5	16	50
MP415/MP416	1023	NA	ROB	47.4	Extreme	1.2	0.2	0.0	0	47	5
MP415/MP416	1024	NA	LOB	23.9	Moderate	3.7	0.2	3.7	35	36	95
MP415/MP416	1024	NA	ROB	39.7	High	3.4	0.2	2.4	5	82	10
MP415/MP416	1025	Outfall	LOB	26.8	Moderate	4.9	0.2	3.0	35	53	100
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**
MP415/MP416	1025	Outfall	ROB	47.7	Extreme	3.3	0.2	1.3	5	140	10
MP415/MP416	1026	Intermediate	LOB	23.9	Moderate	3.3	0.2	3.3	35	45	100
MP415/MP416	1026	Intermediate	ROB	40.7	Very High	2.9	0.2	2.9	20	137	20
MP416	1017	Outlet	LOB	53.0	Extreme	2.3	0.2	0.0	0	167	0
MP416	1017	Outlet	ROB	51.0	Extreme	2.2	0.2	0.0	0	90	0
MP425	1033	Outlet	LOB	36.1	High	4.7	0.4	4.7	5	64	25

MP425	1033	Outlet	ROB	37.6	High	4.5	0.4	4.5	35	40	5
MP425	1034	NA	LOB	28.3	Moderate	2.6	0.4	2.6	35	14	100
MP425	1034	NA	ROB	24.5	Moderate	2.1	0.4	2.1	35	18	100
MP425	1035	NA	LOB	33.7	High	2.7	0.4	2.7	35	32	35
MP425	1035	NA	ROB	40.7	Very High	1.6	0.4	1.6	5	33	5
MP425	1036	NA	LOB	35.7	High	1.3	0.4	0.6	35	28	50
MP425	1036	NA	ROB	28.7	Moderate	4.2	0.4	4.2	35	22	70
MP425	1037	NA	LOB	37.4	High	0.9	0.4	0.2	5	22	50
MP425	1037	NA	ROB	43.0	Very High	1.0	0.4	0.2	5	22	5
MP425	1039	NA	LOB	31.9	High	1.9	0.4	1.9	35	25	50
MP425	1039	NA	ROB	29.3	Moderate	1.6	0.4	1.6	35	23	95
MP425	1040	Intermediate/ Outfall	LOB	29.4	Moderate	3.2	0.4	3.2	35	26	95
MP425	1040	Intermediate/ Outfall	ROB	28.8	Moderate	2.3	0.4	2.3	35	23	100
MP426	1041	Outlet	LOB	36.0	High	1.9	0.4	1.9	5	30	10
MP426	1041	Outlet	ROB	32.4	High	1.1	0.4	1.1	5	29	50
MP426	1042	NA	LOB	39.7	High	1.9	0.4	0.6	35	24	5
MP426	1042	NA	ROB	43.0	Very High	1.0	0.4	0.2	5	32	10
MP433	1010	Outlet	LOB	27.6	Moderate	6.0	0.5	6.0	35	39	100
MP433	1010	Outlet	ROB	27.5	Moderate	5.5	0.5	5.5	35	38	100
MP433	1011	Intermediate	LOB	39.6	High	4.4	0.5	3.4	35	152	75
MP433	1011	Intermediate	ROB	29.7	Moderate	4.6	0.5	4.6	35	41	100
MP433	1012	NA	LOB	36.8	High	7.9	0.5	7.9	95	149	35
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**
MP433	1012	NA	ROB	42.5	Very High	6.5	0.5	4.9	35	132	35
MP433	1013	NA	LOB	41.0	Very High	3.5	0.5	1.4	35	33	10
MP433	1013	NA	ROB	34.4	High	9.8	0.5	7.7	35	24	35
MP433	1014	NA	LOB	31.1	High	4.3	0.5	4.3	35	20	35
MP433	1014	NA	ROB	33.2	High	10.7	0.5	10.7	35	22	35
MP433	1015	NA	LOB	36.2	High	3.5	0.5	3.5	35	22	10
MP433	1015	NA	ROB	36.0	High	3.8	0.5	3.8	35	17	10

MP433	1016	Final	LOB	36.9	High	4.1	0.5	4.1	35	25	5
MP433	1016	Final	ROB	33.4	High	3.3	0.5	3.3	35	26	35
MP458	989	Outlet	LOB	32.9	High	4.2	0.4	4.2	10	27	50
MP458	989	Outlet	ROB	31.2	High	3.8	0.4	3.8	35	21	35
MP458	990	NA	LOB	30.3	High	4.6	0.4	4.6	15	45	15
MP458	990	NA	ROB	27.7	Moderate	3.8	0.4	3.8	20	74	50
MP458	991	Intermediate	LOB	36.8	High	7.3	0.4	5.3	5	55	10
MP458	991	Intermediate	ROB	39.3	High	6.4	0.4	6.4	5	45	5
MP458	992	Final	LOB	32.6	High	5.5	0.4	5.5	35	50	35
MP458	992	Final	ROB	33.8	High	5.4	0.4	5.4	35	34	35
MP459	2065	Outlet	LOB	30.2	High	6.5	0.5	6.5	35	22	45
MP459	2065	Outlet	ROB	51.5	Extreme	4.2	0.5	0.0	0	29	0
MP459	2066	Outfall	LOB	28.9	Moderate	2.0	0.5	2.0	35	25	100
MP459	2066	Outfall	ROB	59.0	Extreme	1.9	0.5	0.0	0	170	0
MP459	2067	Intermediate	LOB	0.0	Very Low	6.2	0.5	6.2	35	19	100
MP459	2067	Intermediate	ROB	0.0	Very Low	3.7	0.5	0.0	0	10	100
MP465	2096	Outlet	NA	NA	NA	NA	0.2	NA	NA	NA	NA
MP467	1054	Outlet	LOB	41.0	Very High	4.4	0.2	3.0	35	144	35
MP467	1054	Outlet	ROB	41.6	Very High	3.3	0.2	2.9	35	144	35
MP467	1056	Outfall	LOB	39.8	High	5.1	0.2	5.1	5	55	5
MP467	1056	Outfall	ROB	26.9	Moderate	4.4	0.2	4.4	35	56	95
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**
MP467	1057	NA	LOB	51.3	Extreme	2.0	0.2	0.0	0	25	0
MP467	1057	NA	ROB	40.5	Very High	1.8	0.2	1.2	35	153	75
MP469 (W19*)	1062	Outlet	LOB	41.2	Very High	1.2	0.3	1.2	5	44	5
MP469 (W19*)	1062	Outlet	ROB	30.0	Moderate	0.9	0.3	0.9	50	11	50
MP469 (W19*)	1063	NA	LOB	50.9	Extreme	0.9	0.3	0.0	0	17	0
MP469 (W19*)	1063	NA	ROB	51.2	Extreme	1.2	0.3	0.0	0	23	0
MP472	2091	Outfall	LOB	38.1	High	5.3	0.5	1.0	35	30	35
MP472	2091	Outfall	ROB	32.0	High	5.8	0.5	5.8	35	37	35

MP495 (FID10)	984	Outlet	LOB	27.2	Moderate	1.2	0.2	1.2	35	22	95
MP495 (FID10)	984	Outlet	ROB	0.0	Very Low	3.5	0.2	3.5	35	20	95
MP495 (FID10)	985	Culvert/ Immediate	LOB	34.4	High	1.5	0.2	1.5	5	27	5
MP495 (FID10)	985	Culvert /Immediate	ROB	36.5	High	1.6	0.2	1.6	5	30	5
MP507 (MP508E)	997	Outlet	LOB	28.6	Moderate	2.2	0.1	2.2	35	10	35
MP507 (MP508E)	997	Outlet	ROB	29.1	Moderate	2.1	0.1	2.1	35	20	35
MP508	962	Outlet	LOB	28.1	Moderate	4.6	0.1	4.6	35	40	95
MP508	962	Outlet	ROB	28.6	Moderate	5.2	0.1	5.2	35	25	75
MP508	963	NA	LOB	35.5	High	2.7	0.1	2.0	15	50	15
MP508	963	NA	ROB	24.3	Moderate	3.1	0.1	2.1	90	37	90
MP508	964	NA	LOB	32.1	High	2.0	0.1	2.0	35	85	35
MP508	964	NA	ROB	21.2	Moderate	2.0	0.1	2.0	75	21	75
MP508	965	NA	LOB	45.4	Extreme	2.4	0.1	1.2	5	165	5
MP508	965	NA	ROB	37.1	High	2.2	0.1	2.2	35	151	35
MP508	966	NA	LOB	28.2	Moderate	5.1	0.1	4.1	35	23	35
MP508	966	NA	ROB	27.3	Moderate	4.3	0.1	4.3	35	14	50
MP508	967	NA	LOB	34.3	High	5.8	0.1	3.8	35	41	35
MP508	967	NA	ROB	30.8	High	5.2	0.1	5.2	50	28	50
MP508	968	NA	LOB	33.1	High	6.4	0.1	6.4	35	65	5
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**
MP508	968	NA	ROB	36.9	High	5.6	0.1	5.6	15	37	15
MP508	971	Outfall	LOB	32.9	High	2.4	0.1	2.4	35	55	35
MP508	971	Outfall	ROB	35.0	High	1.9	0.1	1.9	35	79	35
MP508_Outfall	972	NA	LOB	29.8	Moderate	5.1	0.1	5.1	35	33	60
MP508_Outfall	972	NA	ROB	34.3	High	2.4	0.1	1.4	50	72	50
MP508A	970	Outlet	LOB	20.8	Moderate	4.7	0.1	4.7	95	21	95
MP508A	970	Outlet	ROB	21.1	Moderate	5.3	0.1	5.3	95	26	95
MP508C	974	Outlet	LOB	22.0	Moderate	1.2	0.1	1.2	95	5	95
MP508C	974	Outlet	ROB	26.7	Moderate	4.5	0.1	4.5	35	16	65
MP508D	976	Outlet	LOB	27.8	Moderate	4.3	0.1	4.3	35	24	50

MP508D	976	Outlet	ROB	29.2	Moderate	3.8	0.1	3.8	35	22	35
MP511 (MP508B)	969	NA	LOB	43.4	Very High	5.2	0.1	1.0	5	40	5
MP511 (MP508B)	969	NA	ROB	50.9	Extreme	6.2	0.1	1.0	5	92	5
MP511 (MP508B)	973	Outlet	LOB	29.9	Moderate	5.9	0.1	5.9	35	35	35
MP511 (MP508B)	973	Outlet	ROB	34.8	High	6.5	0.1	6.5	35	43	15
MP525	2088	Outlet	LOB	30.6	High	2.9	0.5	2.9	95	73	50
MP525	2088	Outlet	ROB	33.6	High	3.7	0.5	3.7	35	20	30
MP525	2090	Outfall	LOB	48.5	Extreme	5.6	0.5	0.0	0	50	0
MP525	2090	Outfall	ROB	49.2	Extreme	4.5	0.5	0.0	0	24	0
MP558	2080	Outlet	NA	NA	NA	NA	0.2	NA	NA	NA	NA
MP559	2079	Outlet	LOB	28.5	Moderate	3.7	0.2	3.7	35	23	75
MP559	2079	Outlet	ROB	27.3	Moderate	3.7	0.2	3.7	35	24	95
MP573	2074	Outlet	LOB	36.2	High	4.4	0.6	4.4	5	23	5
MP573	2074	Outlet	ROB	36.2	High	3.9	0.6	3.9	5	24	5
MP573	2075	Final	LOB	43.0	Very High	2.8	0.6	2.8	10	135	10
MP573	2075	Final	ROB	36.7	High	3.2	0.6	1.2	5	55	35
MP578	2076	Outlet	LOB	0.0	Very Low	2.5	0.3	0.0	0	39	100
MP578	2076	Outlet	ROB	0.0	Very Low	4.6	0.3	4.6	35	47	35
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**
MP591	2071	Outlet	LOB	19.5	Low	4.9	0.2	4.9	100	9	100
MP591	2071	Outlet	ROB	20.4	Moderate	4.3	0.2	4.3	100	28	100
MP591	2072	Intermediate	LOB	25.1	Moderate	2.1	0.2	2.1	35	9	90
MP591	2072	Intermediate	ROB	24.7	Moderate	1.6	0.2	1.6	35	61	100
MP591	2073	Final	LOB	26.4	Moderate	1.6	0.2	1.6	35	56	100
MP591	2073	Final	ROB	22.7	Moderate	2.0	0.2	2.0	35	22	100
MP615	993	Outlet	LOB	30.1	High	14.5	0.4	14.5	55	31	35
MP615	993	Outlet	ROB	31.0	High	7.9	0.4	7.9	35	32	75
MP615	994	Outfall	LOB	31.2	High	4.2	0.4	4.2	35	22	35
MP615	994	Outfall	ROB	0.0	Very Low	7.2	0.4	7.2	35	32	95
MP785	2102	Outlet	NA	NA	NA	NA	0.3	NA	NA	NA	NA
MP814 (Site3&4)	982	Outlet	LOB	32.8	High	5.5	0.6	5.5	70	150	50

MP814 (Site3&4)	982	Outlet	ROB	39.1	High	6.7	0.6	6.7	35	147	35
MP814 (Site3&4)	983	Outfall	LOB	32.0	High	7.0	0.6	7.0	35	69	35
MP814 (Site3&4)	983	Outfall	ROB	44.0	Very High	3.9	0.6	3.9	10	140	35
MP840	609	Outlet	LOB	37.1	High	7.0	0.3	7.0	35	125	35
MP840	609	Outlet	ROB	31.4	High	3.8	0.3	3.8	35	73	80
MP840	979	NA	LOB	43.0	Very High	3.6	0.3	3.6	50	123	5
MP840	979	NA	ROB	26.2	Moderate	3.4	0.3	3.4	35	51	100
MP840	980	NA	LOB	37.1	High	2.2	0.3	2.2	35	162	95
MP840	980	NA	ROB	28.9	Moderate	1.9	0.3	1.9	35	26	100
MP840	981	Outfall	LOB	29.6	Moderate	2.3	0.3	2.3	60	60	50
MP840	981	Outfall	ROB	34.5	High	1.9	0.3	1.9	35	47	35
OUT2111	474	Outlet	LOB	26.9	Moderate	1.3	0.1	1.3	35	15	35
OUT2111	474	Outlet	ROB	43.7	Very High	1.2	0.1	0.0	0	23	10
POW162	996	Outlet	LOB	0.0	Very Low	1.8	0.1	1.8	35	6	100
POW162	996	Outlet	ROB	0.0	Very Low	3.4	0.1	3.4	35	7	95
POW162	998	NA	LOB	0.0	Very Low	1.6	0.1	1.6	35	35	100
Site	**Point number**	**Cross-section**	**Bank**	**BEHI score**	**BEHI category**	**Study bank height (ft)**	**Bankfull height (ft)**	**Root depth (ft)**	**Root density (%)**	**Bank angle (°)**	**Surface protection (%)**
POW162	998	NA	ROB	0.0	Very Low	2.8	0.1	2.8	35	36	100
W10	959	Outlet	LOB	47.5	Extreme	2.6	0.2	0.0	0	29	0
W10	959	Outlet	ROB	45.0	Very High	2.6	0.2	0.0	0	30	35
W10	1027	NA	LOB	37.0	High	4.8	0.2	4.8	15	39	30
W10	1027	NA	ROB	39.9	High	1.8	0.2	1.8	5	18	5
W10	1028	NA	LOB	31.8	High	4.2	0.2	4.2	35	24	50
W10	1028	NA	ROB	33.7	High	3.9	0.2	3.9	35	32	35
W10	1029	Intermediate	LOB	31.3	High	2.3	0.2	2.3	90	85	75
W10	1029	Intermediate	ROB	32.8	High	2.5	0.2	2.5	95	167	95
W10	1030	Outfall	LOB	29.1	Moderate	0.9	0.2	0.9	35	30	100
W10	1030	Outfall	ROB	28.4	Moderate	0.9	0.2	0.9	35	15	100
W11	957	Outlet	LOB	0.0	Very Low	2.2	0.3	0.0	0	34	100
W11	957	Outlet	ROB	0.0	Very Low	2.3	0.3	0.0	0	21	100

W13	1004	Outlet	LOB	46.0	Extreme	4.6	0.3	4.6	5	135	5
W13	1004	Outlet	ROB	39.1	High	4.2	0.3	4.2	35	167	35
W13	1005	NA	LOB	33.8	High	4.0	0.3	4.0	35	33	35
W13	1005	NA	ROB	32.8	High	3.2	0.3	3.2	35	34	45
W18	1059	Outlet	LOB	31.4	High	4.2	0.4	4.2	35	26	35
W18	1059	Outlet	ROB	33.1	High	5.1	0.4	5.1	35	20	35
W18/MP469 (W19*)/ W19C	1066	Outfall	LOB	34.0	High	1.2	0.3	1.2	35	37	35
W18/MP469 (W19*) /W19C	1066	Outfall	ROB	30.9	High	1.2	0.3	1.2	35	46	50
W19C	1065	Outlet	LOB	41.1	Very High	2.1	0.3	2.1	35	154	35
W19C	1065	Outlet	ROB	33.3	High	1.9	0.3	1.9	35	62	35

Table 7. Summary of percentage of downslope hydrologic soil group (HSG) data for site assessments

Site	Average water storage 0-10 in	Average water storage 0-20 in	Average water storage 0-39 in	Average water storage 0-59 in	HSG A	HSG B	HSG C	HSG D	HSG A/D	HSG B/D	HSG C/D	Ur	W
DE162	4.00	8.00	16.00	22.56	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MP024	4.61	9.22	18.06	25.06	0.00	0.21	0.79	0.00	0.00	0.00	0.00	0.00	0.00
MP078	1.44	2.37	4.75	7.52	0.00	0.01	0.26	0.00	0.00	0.03	0.00	0.70	0.00
MP120	4.71	9.33	17.98	25.81	0.00	0.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00
MP138	3.15	6.54	12.63	17.85	0.00	0.23	0.77	0.00	0.00	0.00	0.00	0.00	0.00
MP142	3.98	8.03	15.95	23.00	0.49	0.11	0.31	0.00	0.00	0.09	0.00	0.00	0.00
MP143	4.76	9.42	18.16	26.06	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
MP152	3.34	6.75	12.52	18.08	0.00	0.30	0.41	0.18	0.00	0.11	0.00	0.00	0.00
MP219	4.24	8.12	15.35	19.07	0.00	0.23	0.00	0.00	0.00	0.08	0.68	0.00	0.00
MP225	4.21	8.23	14.99	17.54	0.00	0.81	0.00	0.15	0.00	0.00	0.03	0.00	0.00
MP227	4.09	7.93	14.02	16.42	0.00	0.61	0.00	0.37	0.00	0.02	0.00	0.00	0.00
MP228	3.84	7.63	12.57	13.94	0.00	0.16	0.00	0.78	0.00	0.02	0.03	0.00	0.01
MP229	3.83	7.61	12.47	13.73	0.00	0.15	0.00	0.80	0.00	0.01	0.03	0.00	0.01
MP257	3.72	7.64	14.94	21.47	0.30	0.54	0.02	0.00	0.00	0.14	0.00	0.00	0.00
MP292	3.76	7.38	13.99	20.02	0.56	0.27	0.17	0.00	0.00	0.00	0.00	0.00	0.00
MP311	4.23	8.73	17.28	25.47	0.00	0.33	0.00	0.00	0.00	0.67	0.00	0.00	0.00
MP318	3.76	7.74	15.37	21.35	0.17	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MP319	3.47	6.95	13.56	20.23	0.60	0.04	0.00	0.00	0.36	0.00	0.00	0.00	0.00
MP356	3.87	7.23	10.49	12.41	0.00	0.00	0.00	0.76	0.00	0.24	0.00	0.00	0.00
MP359	1.90	3.90	7.19	8.93	0.00	0.36	0.00	0.00	0.00	0.18	0.00	0.46	0.00
MP360	1.75	3.54	6.69	8.73	0.00	0.23	0.00	0.00	0.00	0.20	0.04	0.53	0.00
MP361	1.45	3.05	5.28	5.86	0.00	0.45	0.00	0.00	0.00	0.01	0.03	0.51	0.00
MP415	4.02	7.94	15.13	19.63	0.00	0.88	0.06	0.05	0.00	0.00	0.00	0.00	0.00
MP416	4.05	8.01	15.30	19.92	0.00	0.90	0.04	0.04	0.00	0.02	0.00	0.00	0.00
MP425	3.06	6.62	13.33	19.22	0.00	0.35	0.32	0.33	0.00	0.00	0.00	0.00	0.01
MP426	3.05	6.61	13.33	19.23	0.00	0.33	0.30	0.35	0.00	0.00	0.00	0.00	0.01
Site	**Average water storage 0-10 in**	**Average water storage 0-20 in**	**Average water storage 0-39 in**	**Average water storage 0-59 in**	**HSG A**	**HSG B**	**HSG C**	**HSG D**	**HSG A/D**	**HSG B/D**	**HSG C/D**	**Ur**	**W**

MP427	3.15	6.77	13.55	19.48	0.00	0.39	0.33	0.26	0.00	0.01	0.00	0.00	0.01
MP433	3.35	7.22	13.99	19.79	0.00	0.94	0.04	0.02	0.00	0.02	0.00	0.00	0.00
MP458	3.15	6.07	12.10	18.92	0.44	0.36	0.00	0.00	0.00	0.20	0.00	0.00	0.00
MP459	3.04	5.78	11.99	17.00	0.01	0.91	0.00	0.00	0.00	0.08	0.00	0.00	0.00
MP465	3.93	7.16	14.08	21.17	0.00	0.69	0.11	0.00	0.00	0.20	0.00	0.00	0.00
MP467	3.61	6.73	12.41	15.60	0.00	0.00	0.48	0.44	0.00	0.09	0.00	0.00	0.00
MP469	1.36	2.30	3.77	4.45	0.00	0.00	0.10	0.24	0.00	0.00	0.00	0.62	0.04
MP472	4.16	8.05	15.99	21.51	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.52	0.00
MP495	2.58	4.99	10.09	13.67	0.00	0.00	0.22	0.51	0.00	0.02	0.00	0.25	0.01
MP507	3.38	6.93	13.87	19.81	0.00	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.02
MP508	3.40	7.07	14.11	19.60	0.00	0.00	0.00	0.76	0.00	0.00	0.23	0.00	0.01
MP508A	4.15	8.51	16.77	25.16	0.00	0.00	0.00	0.31	0.00	0.69	0.00	0.00	0.00
MP508C	3.78	7.65	14.68	17.95	0.00	0.00	0.00	0.99	0.00	0.01	0.00	0.00	0.00
MP508D	3.74	7.60	14.64	18.07	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
MP511	3.84	7.62	15.03	22.47	0.00	0.00	0.00	0.78	0.00	0.22	0.00	0.00	0.00
MP525	4.76	9.42	18.16	26.06	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
MP558	3.60	7.24	14.01	20.04	0.00	0.43	0.00	0.00	0.57	0.00	0.00	0.00	0.00
MP559	3.78	7.61	14.66	20.50	0.00	0.63	0.02	0.00	0.34	0.00	0.00	0.00	0.00
MP573	4.16	7.73	14.12	17.46	0.00	0.37	0.51	0.00	0.00	0.02	0.11	0.00	0.00
MP578	2.88	5.68	11.04	16.07	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MP591	3.96	6.66	10.10	11.34	0.00	0.05	0.44	0.08	0.00	0.00	0.43	0.00	0.00
MP615	4.20	8.21	16.73	23.98	0.00	0.32	0.00	0.00	0.00	0.68	0.00	0.00	0.00
MP785	3.15	5.73	9.04	10.83	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MP814	0.46	0.90	1.82	2.62	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.91	0.00
MP840	2.26	4.28	8.86	13.04	0.13	0.65	0.00	0.00	0.00	0.00	0.00	0.12	0.10
OUT2104	3.34	6.74	12.39	17.83	0.00	0.30	0.39	0.20	0.00	0.12	0.00	0.00	0.00
OUT2106	3.32	6.63	12.20	17.62	0.00	0.28	0.46	0.19	0.00	0.07	0.00	0.00	0.00
OUT2111	4.26	8.24	15.59	19.71	0.00	0.15	0.00	0.00	0.00	0.19	0.66	0.00	0.00
Site	**Average water storage 0-10 in**	**Average water storage 0-20 in**	**Average water storage 0-39 in**	**Average water storage 0-59 in**	**HSG A**	**HSG B**	**HSG C**	**HSG D**	**HSG A/D**	**HSG B/D**	**HSG C/D**	**Ur**	**W**
POW162	4.28	8.46	16.54	23.02	0.00	0.87	0.00	0.00	0.00	0.13	0.00	0.00	0.00

W10	3.46	6.44	11.93	14.78	0.00	0.00	0.65	0.34	0.00	0.02	0.00	0.00	0.00
W11	3.45	6.42	11.89	14.72	0.00	0.00	0.63	0.34	0.00	0.02	0.00	0.00	0.01
W13	2.12	4.34	8.05	10.13	0.00	0.37	0.00	0.00	0.00	0.22	0.00	0.41	0.00
W18	1.75	3.12	5.62	7.10	0.00	0.00	0.12	0.35	0.00	0.00	0.00	0.52	0.02
W19C	1.75	3.00	5.06	6.13	0.00	0.00	0.15	0.30	0.00	0.00	0.00	0.48	0.07

Note Ur and W refer to urban soils and water, respectively

Table 8. Summary of watershed characteristics and downslope data for site assessments

Site	County	Pipe diameter (ft)	Pipe material	Offsite watershed area (ac)	Watershed area (ac)	Impervious area (ac)	Outlet elevation (ft)	Outfall elevation (ft)	Overall departure(ft)	Channel length (ft)	Distance from outlet to outfall (ft)	Buffer radius (ft)
DE162	Chatham	3.5	RCP	0.3	1.5	0.4	471	465	6	699	699	22
MP024	Catawba	3.5	CMP	35.5	37.0	3.8	899	895	4	209	209	211
MP078	Wake	2	RCP	0.2	0.2	0.1	385	357	28	701	701	1073
MP120	Forsyth	4	RCP	20.6	20.6	0.0	815	815	0	0	224	229
MP138	Forsyth	1.5	RCP	7.7	11.8	2.5	900	873	28	677	677	329
MP142	Forsyth	2	RCP	0.3	0.3	0.0	827	820	6	0	230	185
MP143	Forsyth	3	RCP	97.4	101.2	6.3	814	811	3	0	94	8
MP152	Forsyth	3	RCP	1.8	2.5	0.4	729	712	17	774	1185	1154
MP219	Chatham	3	RCP	30.1	35.4	1.3	668	651	16	817	817	678
MP225	Chatham	3.5	RCP	0.0	11.0	0.5	639	612	27	1750	1750	1844
MP227	Chatham	2	RCP	0.0	0.9	0.0	643	607	36	1452	1452	1154
MP228	Chatham	2	RCP	0.2	0.3	0.0	574	565	9	187	472	2261
MP229 (OUT111)	Chatham	2.5	RCP	0.3	0.3	0.0	572	565	7	0	306	2445
MP257	Guilford	1.5	RCP	15.7	15.8	0.6	881	853	28	883	1065	1070
MP292	Buncombe	4	CMP	41.6	44.7	6.0	2130	2090	40	0	322	283
MP311	Chatham	2	RCP	0.3	0.3	0.0	469	465	4	784	784	214
MP318	McDowell	1.5	CMP	4.2	4.2	0.1	1281	1256	25	440	1044	953
MP319	Buncombe	1.5	CMP	106.0	112.3	5.0	2255	2246	9	0	271	294
MP356	Guilford	2	RCP	5.3	6.5	4.3	717	699	18	225	561	461
MP359	Wake	2	RCP	6.7	6.7	3.7	354	350	4	265	265	246
MP360	Wake	2	RCP	1.9	2.3	0.7	357	351	6	221	421	387
MP361	Wake	2	RCP	1.1	1.1	0.5	344	333	11	137	137	199
MP415	Chatham	2.5	RCP	0.7	0.8	0.1	435	378	57	2742	2742	1532
MP416	Chatham	2	RCP	3.3	4.3	0.4	441	378	63	2827	2827	1772
MP425	Chatham	2.5	RCP	8.9	10.6	1.4	449	418	31	1278	1278	2180
MP426	Chatham	2.5	RCP	17.0	17.6	0.3	450	418	32	1250	1250	2481
MP427	Chatham	2.5	RCP	0.0	0.4	0.1	443	418	25	0	860	3251
Site	**County**	**Pipe diameter (ft)**	**Pipe material**	**Offsite watershed area (ac)**	**Watershed area (ac)**	**Impervious area (ac)**	**Outlet elevation (ft)**	**Outfall elevation (ft)**	**Overall departure(ft)**	**Channel length (ft)**	**Distance from outlet to outfall (ft)**	**Buffer radius (ft)**
MP433	Chatham	3	RCP	15.1	15.1	0.0	527	471	56	7431	7431	4544
MP458	Wake	3.5	RCP	6.1	8.5	0.9	362	349	14	2450	2551	1090
MP459	Wake	3.5	RCP	15.4	17.2	4.4	344	329	15	237	237	289
MP465	Caldwell	1.5	RCP	2.4	2.8	0.4	1061	1041	20	0	421	388
MP467	Wake	3	RCP	0.2	0.8	0.3	216	199	16	592	592	317
MP469	Wake	2.5	RCP	0.0	3.2	1.1	276	253	23	649	649	1269

MP472	Caldwell	1.25	CMP	33.2	37.3	15.3	1095	1093	2	60	60	165
MP495	Wake	2	RCP	0.0	1.8	0.8	291	289	1	99	NA	3316
MP507	Chatham	1.5	RCP	0.3	0.3	0.0	237	230	7	56	2912	661
MP508	Chatham	2.5	RCP	0.7	2.5	0.5	240	210	30	3326	3326	1162
MP508A	Chatham	1.25	RCP	0.2	0.2	0.0	210	210	0	189	189	66
MP508C	Chatham	1	RCP	0.2	0.2	0.0	229	210	19	0	2063	393
MP508D	Chatham	1.5	RCP	0.8	0.8	0.0	229	210	19	2179	2179	433
MP511	Chatham	3	RCP	0.8	0.8	0.0	212	210	2	956	956	163
MP525	Caldwell	4	CMP	37.7	37.8	1.2	1152	1148	4	73	73	104
MP558	McDowell	1	CMP	0.0	1.3	0.8	1234	1234	0	0	89	440
MP559	McDowell	1	CMP	0.0	1.7	0.2	1259	1234	26	0	619	704
MP573	Carrabus	3.5	RCP	30.2	30.7	0.5	581	560	21	2189	2189	1824
MP578	McDowell	2.5	RCP	10.5	12.0	6.3	1232	1232	0	11	11	58
MP591	Carrabus	4	RCP	1.1	1.1	0.3	505	498	6	3758	3758	3605
MP615	Wake	2.5	RCP	9.2	10.8	1.3	354	341	13	281	281	122
MP785	Watauga	2	CMP	8.2	8.2	2.2	3353	3351	2	0	63	73
MP814	Wake	4	RCP	24.6	29.4	15.4	407	396	11	230	230	311
MP840	Wake	2.5	RCP	4.1	4.7	1.8	373	345	28	1222	1222	2001
OUT2104	Forsyth	1.5	CMP	0.0	2.1	0.3	729	712	17	839	1249	1072
OUT2106	Forsyth	1	CMP	0.0	1.5	0.9	729	712	17	858	1268	1125
OUT2111	Chatham	2	RCP	0.1	0.5	0.1	669	651	18	785	785	458
POW162	Chatham	2	RCP	0.0	0.2	0.0	485	465	20	1414	1414	868
Site	**County**	**Pipe diameter (ft)**	**Pipe material**	**Offsite watershed area (ac)**	**Watershed area (ac)**	**Impervious area (ac)**	**Outlet elevation (ft)**	**Outfall elevation (ft)**	**Overall departure(ft)**	**Channel length (ft)**	**Distance from outlet to outfall (ft)**	**Buffer radius (ft)**
W10	Wake	2	RCP	0.0	0.9	0.5	331	257	74	3066	3177	2965
W11	Wake	2	RCP	5.0	5.1	0.4	340	334	5	379	3827	3045
W13	Wake	1.5	RCP	7.5	8.0	4.6	358	350	8	291	291	242
W18	Wake	1	RCP	0.0	8.7	1.1	287	253	34	954	954	1483
W19C	Wake	3	RCP	0.0	2.8	2.0	256	253	4	212	212	945

Note RCP and CMP refer to reinforced concrete pipe and corrugated metal pipe, respectively

Table 9. Summary of hydrologic characteristics for site assessments

Site	Flow path (ft)	Slope (ft/ft)	T_c (min)	CN	Q_p_1-yr (ft^3/s)	V_1-yr (ft/s)	Q_p_10-yr (ft^3/s)	V_10-yr (ft/s)	V_1/P	V_10/P	Duration 1-yr (hr)	Duration 10-yr (hr)
DE162	1060	0.02	7.0	77	2.52	5.96	7.00	7.88	1.99	2.63	2.70	2.93
MP024	2770	0.04	12.2	58	6.24	6.68	65.76	12.90	2.67	5.16	7.33	4.57
MP078	300	0.08	1.7	90	0.79	3.92	1.60	4.77	1.57	1.91	1.90	2.20
MP120	2543	0.04	11.3	80	32.76	10.45	83.72	13.78	4.18	5.51	4.00	4.30
MP138	2728	0.02	16.7	76	11.10	8.08	32.77	10.07	3.23	4.03	4.67	4.93
MP142	226	0.09	1.3	55	0.02	1.45	0.52	3.50	0.58	1.40	3.20	1.83
MP143	3864	0.02	19.2	73	80.47	13.64	258.22	15.99	5.46	6.40	5.87	5.97
MP152	687	0.05	3.7	73	3.10	5.57	9.42	7.52	2.23	3.01	2.60	2.93
MP219	2525	0.02	16.1	69	25.27	10.37	90.76	14.94	3.46	4.98	5.73	5.73
MP225	3240	0.02	19.4	57	1.26	5.20	13.80	9.90	1.73	3.30	12.63	7.73
MP227	431	0.02	3.5	55	0.09	2.98	1.47	6.47	0.99	2.16	4.17	2.47
MP228	387	0.02	3.4	55	0.03	1.27	0.44	2.56	0.42	0.85	3.00	2.07
MP229 (OUT111)	438	0.03	3.4	77	0.51	1.62	1.32	2.11	0.54	0.70	1.97	2.33
MP257	2441	0.02	13.6	43	0.01	1.20	1.79	5.00	0.34	1.43	3.07	11.40
MP292	4039	0.07	12.8	61	2.43	5.13	43.64	11.39	2.05	4.55	11.30	4.73
MP311	314	0.02	3.0	58	0.11	2.63	0.83	4.55	0.88	1.52	2.10	1.90
MP318	960	0.10	3.7	56	1.02	4.28	9.84	7.86	1.71	3.14	4.10	3.03
MP319	6272	0.15	13.5	53	1.23	4.49	81.91	10.07	1.79	4.03	30.70	6.57
MP356	3791	0.02	20.7	93	14.01	8.79	27.04	8.79	3.51	3.51	4.97	5.47
MP359	1253	0.04	6.5	92	21.69	9.58	42.01	12.20	3.83	4.88	3.33	3.73
MP360	591	0.03	4.4	89	6.58	7.08	13.57	8.75	2.83	3.50	2.90	3.23
MP361	563	0.07	2.9	90	3.75	6.01	7.41	7.34	2.40	2.93	2.40	2.73
MP415	396	0.05	2.5	60	0.35	3.13	2.12	5.08	1.04	1.69	2.27	2.17
MP416	907	0.02	6.8	59	1.01	5.32	8.47	9.61	1.77	3.20	4.40	3.30
MP425	1407	0.02	10.0	81	19.23	9.46	47.42	11.69	2.70	3.34	3.77	4.10
MP426	1823	0.01	13.1	84	14.52	8.71	33.51	10.74	2.49	3.07	9.20	10.10
MP427	368	0.03	2.8	86	1.24	4.37	2.65	5.39	1.75	2.16	2.03	2.37
Site	Flow path (ft)	Slope (ft/ft)	T_c (min)	CN	Q_p_1-yr (ft^3/s)	V_1-yr (ft/s)	Q_p_10-yr (ft^3/s)	V_10-yr (ft/s)	V_1/P	V_10/P	Duration 1-yr (hr)	Duration 10-yr (hr)
MP433	1960	0.04	9.2	61	5.43	6.48	33.89	10.93	2.59	4.37	4.47	3.70
MP458	1427	0.04	7.6	46	0.02	1.25	3.61	5.74	0.50	2.30	12.67	5.03

MP459	2669	0.03	12.6	53	0.36	3.06	16.96	8.77	1.23	3.51	26.37	6.90
MP465	732	0.04	4.4	73	4.04	6.35	12.14	8.31	2.54	3.32	2.70	3.07
MP467	429	0.02	3.7	82	1.84	4.81	4.40	6.13	1.92	2.45	2.13	2.47
MP469	1360	0.03	7.5	89	8.97	7.55	18.75	9.39	3.02	3.76	3.17	3.53
MP472	2721	0.03	13.5	85	74.06	8.92	171.64	8.92	3.57	3.57	4.87	5.33
MP495	909	0.03	5.9	90	5.72	6.79	11.66	8.38	1.94	2.39	2.87	3.23
MP507	170	0.07	1.1	77	0.56	3.64	1.47	4.72	1.46	1.89	1.77	2.07
MP508	1677	0.01	12.3	85	5.30	6.49	12.14	8.26	2.60	3.30	3.27	3.63
MP508A	352	0.05	2.3	77	0.46	3.49	1.21	4.55	1.00	1.30	1.67	2.00
MP508C	274	0.04	2.0	77	0.48	3.57	1.26	4.73	1.43	1.89	1.70	2.03
MP508D	421	0.03	3.1	77	1.65	5.12	4.35	6.61	2.05	2.64	2.07	2.40
MP511	660	0.02	4.9	77	1.47	4.54	3.92	5.94	1.81	2.38	2.33	2.67
MP525	2944	0.06	11.1	71	37.61	10.89	128.56	14.97	4.36	5.99	4.33	4.50
MP558	901	0.01	8.1	92	4.43	6.68	8.79	7.69	2.67	3.08	2.97	3.37
MP559	1228	0.01	10.5	82	0.90	4.28	2.18	5.54	1.71	2.22	10.63	12.13
MP573	2520	0.02	15.2	67	16.24	8.66	66.65	12.94	2.89	4.31	5.47	5.30
MP578	1603	0.04	7.7	87	33.07	10.70	72.23	14.16	4.28	5.66	3.83	4.23
MP591	597	0.02	4.6	82	2.46	5.15	5.84	6.50	1.72	2.17	2.50	2.83
MP615	1414	0.04	7.0	48	0.05	1.76	7.05	7.05	0.71	2.82	20.57	4.50
MP785	1603	0.16	4.7	67	14.18	8.82	45.17	12.20	-	-	3.13	3.47
MP814	3416	0.02	18.1	90	62.68	12.67	128.28	14.97	3.62	4.28	5.27	5.77
MP840	1029	0.07	4.7	76	7.45	7.16	20.48	9.63	2.86	3.85	2.87	3.23
OUT2104	923	0.02	6.8	83	1.24	4.50	2.91	5.76	1.80	2.30	8.87	10.10
OUT2106	679	0.02	5.6	91	4.68	6.90	9.38	7.69	2.76	3.08	2.80	3.17
OUT2111	496	0.02	4.0	70	0.53	3.63	1.69	5.00	1.21	1.67	2.07	2.40
POW162	242	0.02	2.4	74	0.37	3.67	1.05	4.85	1.22	1.62	1.67	2.00
Site	**Flow path (ft)**	**Slope (ft/ft)**	**T_c (min)**	**CN**	**Q_p_1-yr (ft^3/s)**	**V_1-yr (ft/s)**	**Q_p_10-yr (ft^3/s)**	**V_10-yr (ft/s)**	**V_1/P**	**V_10/P**	**Duration 1-yr (hr)**	**Duration 10-yr (hr)**
W10	689	0.01	8.7	89	2.64	5.60	5.47	6.94	2.24	2.77	2.73	3.10
W11	1375	0.02	8.8	80	9.17	7.81	23.46	9.75	3.12	3.90	3.13	3.47
W13	1525	0.02	9.4	92	24.97	5.60	48.15	6.94	2.24	2.77	3.60	4.00
W18	1796	0.02	10.4	86	19.39	7.69	43.81	7.69	3.08	3.08	3.73	4.13
W19C	1784	0.01	13.8	94	7.60	7.06	14.49	8.51	2.83	3.40	4.03	4.50

Note T_c, CN, Q_p, V, P, and Duration refers to the time concentration, composite curve number, peak velocity, permissible velocity, and duration of runoff respectively

Table 10. Summary of cross-sectional dimensions, slope ratios, channel evolution stage, distance, and elevation from cross-section to outfall characteristics for site assessments

Site	Point number	Cross-section	$Width_{TOB}$ (ft)	$Area_{TOB}$ (ft^2)	$Depth_{TOB}$ (ft)	Volume (yd^3)	$Slope_{LAND}$ (ft/ft)	$Slope_{INT}$ (ft/ft)	Stage	Distance (ft)	$Departure_{OUT}$ (ft)[a]
DE162	995	Outlet	11.0	11.1	1.7	105	0.021	0.025	2	0	6
DE162 (DE162/MP311/POW162) Outfall	1001	Intermediate	8.6	14.4	2.6	0	-	-	-	222	-
MP024	2086	Outlet	6.8	8.2	2.3	62	0.023	0.019	4	0	4
MP024	2087	Outfall	8.2	7.9	1.8	0	0.023	-	-	209	-
MP078	1031	Outlet	3.4	1.7	0.9	96	0.038	0.040	3	0	28
MP078	1032	Culvert/End	6.0	5.7	2.6	0	-	-	-	701	-
MP138	2069	Outlet	12.0	14.7	2.1	188	0.046	0.044	4	0	28
MP138	2070	Outfall	4.0	1.4	0.8	0	-	-	-	630	-
MP142	2121	Outlet	6.0	3.4	1.0	14	0.032	0.027	4	0	6
MP152/OUT2104/OUT2016	2108	Intermediate	6.0	4.5	1.3	218	0.023	0.030	3	283	12
MP152/OUT2104/OUT2106	2105	Outlet	13.7	14.6	1.8	100	0.023	0.017	4	0	17
MP152/OUT2104/OUT2106	2110	NA	15.0	41.0	4.5	26	0.023	0.000	5	542	4
MP152/OUT2104/OUT2106	2111	NA	7.0	3.4	0.8	24	0.023	0.027	3	573	5
MP152/OUT2104/OUT2106	2113	Final	5.5	3.2	1.0	0	-	-	-	774	-
MP219	482	Outlet	7.0	4.8	1.6	145	0.023	0.021	5	0	16
MP225	1044	Outlet	6.6	10.5	3.5	103	0.016	0.016	3	0	27
MP225	1045	NA	5.2	5.7	2.0	76	0.016	0.017	3	342	21
MP225	1046	NA	8.8	14.7	3.3	94	0.016	0.019	2	543	18
MP225	1047	NA	3.8	2.4	1.2	102	0.016	0.015	4	839	12
Site	Point number	Cross-section	$Width_{TOB}$ (ft)	$Area_{TOB}$ (ft^2)	$Depth_{TOB}$ (ft)	Volume (yd^3)	$Slope_{LAND}$ (ft/ft)	$Slope_{INT}$ (ft/ft)	Stage	Distance (ft)	$Departure_{OUT}$ (ft)[a]
MP225	1048/1050	Intermediate	7.0	6.6	1.9	122	0.016	0.011	5	1453	3
MP225	1051/1052	Outfall	10.0	16.6	2.7	0	-	-	-	1736	-
MP227	502	Outlet	9.0	5.0	1.7	92	0.026	0.042	2	0	36
MP227	1052	Outfall	6.6	7.4	2.6	0	0.026	-	-	1447	-
MP227	2043	NA	9.3	21.4	4.0	230	0.026	0.004	4	1016	2
MP227	2045	Intermediate	10.0	9.3	2.0	381	0.026	0.029	3	347	21
MP228	628	Outlet	11.0	9.2	1.7	64	0.027	0.021	4	0	9
MP229 (OUT111)	506	Outlet	11.0	4.0	0.8	0	0.025	0.022	4	0	7
MP257	2059	Outlet	18.9	17.0	1.2	145	0.028	0.032	2	0	28

MP257	2061	Intermediate	34.0	54.4	2.1	271	0.028	0.017	4	109	24
MP257	2062	NA	8.8	7.3	1.5	174	0.028	0.031	3	346	20
MP257	2063	Final	8.4	10.2	2.1	0	0.028	0.019	-	883	4
MP311	999	Outlet	4.4	3.3	1.5	50	0.009	0.009	5	686	4
MP311	1000	Intermediate	9.0	9.1	2.3	4	0.009	0.162	2	902	2
MP318	2084	Outlet	9.2	14.1	2.4	162	0.069	0.057	5	0	25
MP318	2085	Intermediate/ Final	6.8	5.8	1.6	0	0.069	-	-	440	-
MP319	2082	Outlet	7.0	4.2	1.1	21	0.040	0.031	4	0	9
MP356	2046	Outlet	9.6	7.8	1.6	51	0.043	0.055	3	0	18
MP356	2057	Final	6.6	4.5	1.2	0	0.043	-	-	225	11
MP359	1006	Outlet	13.0	25.7	3.9	30	0.019	0.011	4	0	4
MP359/ W13	1007	Outfall	8.0	8.2	1.8	65	0.019	-	-	244	-
MP360	1008	Outlet	6.4	6.3	1.5	19	0.057	0.057	4	0	6
MP360	1009	Final	4.2	3.3	1.4	0	0.057	-	-	106	-
MP361	1002	Outfall	18.6	45.5	6.6	0	0.113	-	-	131	-
MP361	1003	Outlet	11.6	33.3	7.0	191	0.113	0.085	4	0	11
MP415	1018	Outlet	6.7	8.7	2.3	38	0.021	0.033	3	0	57
MP415/ MP416	1019	NA	8.0	8.9	2.3	21	0.022	0.061	2	182	55
MP415/MP416	1020	NA	7.7	13.5	2.6	107	0.021	0.022	3	168	52
Site	**Point number**	**Cross-section**	**$Width_{TOB}$ (ft)**	**$Area_{TOB}$ (ft^2)**	**$Depth_{TOB}$ (ft)**	**Volume (yd^3)**	**$Slope_{LAND}$ (ft/ft)**	**$Slope_{INT}$ (ft/ft)**	**Stage**	**Distance (ft)**	**$Departure_{OUT}$ (ft)[a]**
MP415/ MP416	1021	NA	5.0	3.7	1.1	82	0.021	0.021	2	502	45
MP415/416	1022	NA	7.2	4.4	0.8	149	0.021	0.026	2	1044	33
MP415/ MP4166	1023	NA	6.2	7.3	1.9	304	0.021	0.016	4	1568	21
MP415/ MP416	1024	NA	10.4	20.1	3.2	426	0.021	0.020	4	2168	11
MP415/ MP416	1025	Outfall	8.8	20.0	3.4	0	0.021	-	-	2742	-
MP415/ MP416	1026	Intermediate	12.0	23.6	2.7	136	0.021	0.020	4	1331	26
MP416	1017	Outlet	4.1	5.3	2.1	48	0.022	0.046	3	0	63
MP425	1033	Outlet	9.3	22.8	4.3	183	0.028	0.035	3	0	31
MP425/ MP426	1034	NA	6.5	7.3	1.8	17	0.028	0.020	5	352	18
MP425/ MP426	1035	NA	5.0	3.0	1.4	31	0.028	0.017	4	441	16
MP425/ MP426	1036	NA	5.9	4.1	1.1	14	0.028	0.014	4	676	12
MP425/ MP426	1037	NA	5.9	2.7	0.9	0	0.028	0.026	4	790	11
MP425/ MP426	1039	NA	4.5	2.6	1.5	55	0.028	0.029	3	971	6
MP425/ MP426	1040	Intermediate/ Outfall	9.0	11.3	2.3	0	0.028	-	-	1185	-
MP426	1041	Outlet	3.9	1.7	0.8	26	0.026	0.041	3	0	32
MP426	1042	NA	6.0	3.6	1.0	17	0.026	0.030	3	269	21

MP433	1010	Outlet	6.5	4.6	1.3	82	0.046	0.085	2	0	56
MP433	1011	Intermediate	8.0	13.9	3.8	31	0.046	0.072	3	241	35
MP433	1012	NA	7.3	16.0	6.1	188	0.046	0.029	4	298	31
MP433	1013	NA	14.0	23.4	2.5	106	0.046	0.027	4	556	24
MP433	1014	NA	4.5	2.6	1.0	59	0.046	0.039	4	775	18
MP433	1015	NA	6.0	5.1	1.1	9	0.046	0.022	4	1186	1
MP433	1016	Culvert/ End	4.4	3.5	1.2	0	0.046	-	-	1244	-
MP458	989	Outlet	29.0	57.6	3.8	242	0.023	0.008	4	0	14
MP458	990	NA	13.0	29.7	4.1	199	0.023	0.045	2	150	12
Site	**Point number**	**Cross-section**	**$Width_{TOB}$ (ft)**	**$Area_{TOB}$ (ft^2)**	**$Depth_{TOB}$ (ft)**	**Volume (yd^3)**	**$Slope_{LAND}$ (ft/ft)**	**$Slope_{INT}$ (ft/ft)**	**Stage**	**Distance (ft)**	**$Departure_{OUT}$ (ft)[a]**
MP458	991	Intermediate	13.4	43.0	6.6	333	0.023	0.026	3	297	6
MP458	992	Final	15.4	35.7	5.0	0	0.023	-	-	526	-
MP459	2065	Outlet	31.0	14.6	5.6	64	0.079	0.001	4	0	15
MP459	2066	Outfall	5.8	6.1	1.9	0	0.079	-	-	228	-
MP459	2067	Intermediate	10.0	15.6	2.5	46	0.079	0.127	2	114	14
MP465	2096	Outlet	4.0	2.3	1.0	0	-	-	5	0	-
MP467	1054	Outlet	8.5	10.5	3.3	58	0.028	0.029	3	0	16
MP467	1056	Outfall	13.0	42.4	4.7	0	0.028	-	-	552	-
MP467	1057	NA	5.6	4.6	1.4	302	0.028	0.030	3	206	10
MP469 (W19*)	1062	Outlet	4.3	1.8	0.8	25	0.044	0.049	3	273	23
MP469 (W19*)/ W18	1063	NA	5.6	2.4	0.9	22	0.044	0.033	4	595	7
MP472	2091	Outfall	6.6	8.6	2.4	0	-	-	-	60	-
MP472	2093	Outlet	0.0	0.0	0.0	10	0.032	0.032	5	0	2
MP495 (FID10)	984	Outlet	11.3	8.9	1.4	22	0.023	0.015	5	0	1
MP495 (FID10)	985	End	7.0	3.0	0.9	0	0.023	-	-	99	-
MP507 (MP508E)	997	Outlet	24.0	19.5	1.2	8	0.025	0.019	5	0	27
MP508	962	Outlet	27.0	44.2	4.5	151	0.009	0.022	2	0	30
MP508	963	NA	13.0	15.7	2.9	70	0.009	0.010	2	136	27
MP508	964	NA	8.0	5.2	1.9	157	0.009	0.014	2	316	25
MP508	965	NA	5.4	6.3	2.2	180	0.009	0.011	3	1048	15
MP508	966	NA	22.0	43.4	4.4	417	0.009	0.014	2	1244	13
MP508	967	NA	20.0	45.6	5.3	1776	0.009	0.004	4	1497	9
MP508	968	NA	18.0	50.2	6.5	748	0.009	0.011	3	1362	5
MP508	971	Outfall	11.0	11.9	2.0	0	0.009	-	-	509	0
MP508_Outfall	972	NA	12.5	16.5	2.2	279	0.009	0.000	4	745	0
MP508A	970	Outlet	27.0	47.2	3.6	61	0.005	0.000	5	0	0
MP508C	974	Outlet	22.0	18.5	1.4	0	0.035	0.028	5	0	19
Site	**Point number**	**Cross-section**	**$Width_{TOB}$ (ft)**	**$Area_{TOB}$ (ft^2)**	**$Depth_{TOB}$ (ft)**	**Volume (yd^3)**	**$Slope_{LAND}$ (ft/ft)**	**$Slope_{INT}$ (ft/ft)**	**Stage**	**Distance (ft)**	**$Departure_{OUT}$ (ft)[a]**

MP508D	976	Outlet	32.0	49.4	3.0	801	0.009	0.011	2	0	19
MP511 (MP508B)	969	NA	21.0	55.0	5.4	0	0.005	0.004	4	150	1
MP511 (MP508B)	973	Outlet	32.0	50.2	5.0	292	0.005	0.013	3	0	2
MP525	2088	Outlet	17.0	23.8	2.4	51	0.037	0.061	3	0	4
MP525	2090	Outfall	7.7	14.3	3.1	0	0.037	-	-	73	-
MP559	2079	Outlet	5.6	4.5	1.7	52	0.047	0.041	5	0	26
MP573	2074	Outlet	13.0	25.6	4.0	1289	0.017	0.016	4	0	21
MP573	2075	Final	12.0	26.8	3.9	0	0.017	-	-	1329	-
MP578	2076	Outlet	14.8	28.3	3.0	12	0.000	0.000	5	0	-
MP591	2071	Outlet	20.0	10.2	2.6	132	0.013	0.011	5	0	6
MP591	2072	Intermediate	15.0	10.2	2.2	155	0.013	0.007	5	347	3
MP591	2073	Final	16.0	12.6	2.1	0	0.013	-	-	713	-
MP615	993	Outlet	44.0	161.6	6.9	756	0.086	0.060	4	0	13
MP615	994	Outfall	20.0	34.0	3.6	0	0.086	-	-	209	-
MP814 (Site3&4)	982	Outlet	11.0	40.8	4.9	267	0.054	0.051	4	0	11
MP814 (Site3&4)	983	Outfall	12.0	35.9	4.5	0	0.054	-	-	188	-
MP840	609	Outlet	13.0	27.2	4.6	223	0.031	0.017	4	0	28
MP840	979	NA	14.0	28.5	3.3	107	0.031	0.065	3	319	22
MP840	980	NA	13.0	9.5	1.7	203	0.031	0.023	4	471	12
MP840	981	Outfall	9.0	10.6	2.1	0	0.031	-	-	1018	-
OUT2111	474	Outlet	16.0	8.6	1.2	251	0.023	0.022	4	0	18
POW162	996	Outlet	8.0	2.5	0.5	84	0.021	0.023	2	0	20
POW162	998	NA	6.7	5.1	1.4	14	0.021	0.031	2	599	6
W10	959	Outlet	10.0	9.1	1.8	169	0.028	0.039	3	0	74
W10	1027	NA	4.7	2.5	0.9	179	0.028	0.019	4	788	43
W10	1028	NA	10.3	19.1	3.7	492	0.028	0.027	4	1236	34
W10	1029	Intermediate	14.0	18.0	2.6	315	0.028	0.019	4	1951	15
Site	**Point number**	**Cross-section**	**Width $_{TOB}$ (ft)**	**Area$_{TOB}$ (ft^2)**	**Depth $_{TOB}$ (ft)**	**Volume (yd^3)**	**Slope$_{LAND}$ (ft/ft)**	**Slope$_{INT}$ (ft/ft)**	**Stage**	**Distance (ft)**	**Departure$_{OUT}$ (ft)[a]**
W10	1030	Outfall	9.0	3.5	0.9	20	0.028	-	-	2740	-
W11	957	Outlet	15.0	8.3	1.4	116	0.020	0.014	5	0	5
W13	1004	Outlet	6.2	12.9	4.3	29	0.035	0.163	3	0	8
W13	1005	NA	11.0	18.4	3.2	-	0.035	0.000	4	51	0
W18	1059	Outlet	3.0	1.7	1.0	18	0.044	0.041	4	0	34
W18/MP469 (W19*)/ W19C	1066	Outfall	8.9	7.4	1.3	0	0.044	-	-	848	-
W19C	1065	Outlet	6.1	8.0	2.0	40	0.044	0.025	4	708	4

[a] Departure$_{OUT}$ refers to the estimated elevation difference between the cross-section and outfall

Note TOB, volume, LAND, INT, OUT refer to the top of bank, estimated volume of eroded soil, estimated slope of the land along the flow path prior to pipe installation, and
estimated slope of the channel bed between two cross-sections at the time of assessment, respectively

Appendix F: Hydrologic, hydraulic, and water quality data for monitored sites

Table 1. Summary of MP458 hydrologic and runoff data

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
1	-	1.08	7/2/2021 6:14	7/2/2021 8:56	2.70	2.10	0.40	Summer	9.79	50039	6.53
2	1.13	0.17	7/3/2021 12:00	7/3/2021 14:28	2.48	-	-	Summer	0.00	0	-
3	4.73	2.31	7/8/2021 7:57	7/8/2021 17:12	9.26	-	-	Summer	79.34	350047	-
4	1.01	0.10	7/9/2021 17:23	7/9/2021 17:38	0.25	-	-	Summer	-	-	-
5	9.15	0.79	7/18/2021 21:16	7/19/2021 15:16	18.00	1.68	0.04	Summer	6.71	29639	5.47
6	9.00	0.44	7/28/2021 15:12	7/28/2021 15:54	0.70	2.82	0.63	Summer	0.00	0	-
7	6.03	0.13	8/3/2021 16:33	8/3/2021 19:32	2.99	-	-	Summer	0.00	0	-
8	11.69	0.17	8/15/2021 12:02	8/16/2021 0:44	12.71	-	-	Summer	53.63	209541	11.27
9	0.71	0.27	8/16/2021 17:50	8/16/2021 23:13	5.38	-	-	Summer	14.33	61969	5.23
10	2.95	0.21	8/19/2021 21:55	8/20/2021 0:08	2.23	-	-	Summer	0.00	0	-
11	0.61	0.43	8/20/2021 14:49	8/20/2021 15:57	1.13	-	-	Summer	0.00	0	-
12	-	0.28	-	9/2/2021 0:00	-	-	-	Summer	0.00	0	-
13	7.45	1.56	9/9/2021 10:44	9/9/2021 13:28	2.73	3.72	0.57	Summer	15.60	86617	7.03
14	-	1.74	-	9/10/2021 0:00	-	-	-	Summer	0.00	0	-
15	-	0.57	-	9/22/2021 0:00	-	-	-	Fall	0.00	0	-
Storm event	**Antecedent dry period**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity**	**Average intensity**	**Season**	**Peak flow**	**Runoff volume**	**Runoff duration**

	(days)					(in/hr)	(in/hr)		(ft^3/s)	(ft^3)	(hr)
16	-	0.46	-	9/23/2021 0:00	-	-	-	Fall	7.91	32723	5.37
17	-	0.60	-	9/30/2021 0:00	-	-	-	Fall	0.00	0	-
18	9.07	1.65	10/9/2021 1:44	10/9/2021 15:14	13.50	1.26	0.12	Fall	19.01	215039	10.23
19	7.03	0.39	10/16/2021 15:54	10/16/2021 16:24	0.50	1.74	0.78	Fall	6.79	23331	3.93
20	8.78	0.44	10/25/2021 11:10	10/25/2021 12:02	0.87	1.74	0.51	Fall	2.55	8682	1.87
21	0.40	0.91	10/25/2021 21:38	10/25/2021 22:26	0.80	4.56	1.14	Fall	55.44	156501	4.60
22	2.85	0.77	10/28/2021 18:46	10/29/2021 6:36	11.83	1.14	0.07	Fall	22.24	156442	12.53
23	24.03	0.35	11/22/2021 7:24	11/22/2021 13:30	6.10	0.30	0.06	Fall	-	-	-
24	3.58	0.11	11/26/2021 3:20	11/26/2021 5:48	2.47	0.18	0.04	Fall	-	-	-
25	12.01	0.37	12/8/2021 5:58	12/8/2021 9:16	3.30	0.42	0.11	Fall	0.00	0	-
26	3.48	0.50	12/11/2021 20:50	12/12/2021 2:08	5.30	2.28	0.09	Fall	4.48	17442	2.77
27	6.97	0.99	12/19/2021 1:18	12/19/2021 16:22	15.07	0.30	0.07	Fall	10.04	137290	10.40
28	1.97	0.57	12/21/2021 15:42	12/22/2021 2:32	10.83	0.42	0.05	Fall	6.24	65580	6.90
29	7.78	0.20	12/29/2021 21:08	12/30/2021 3:44	6.60	0.42	0.03	Winter	0.00	0	-
30	2.65	0.19	1/1/2022 19:22	1/1/2022 19:42	0.33	1.20	0.57	Winter	2.50	15864	4.17
31	0.52	0.41	1/2/2022 8:12	1/2/2022 9:20	1.13	1.38	0.36	Winter	9.23	55849	4.63
32	0.48	2.82	1/2/2022 20:46	1/3/2022 14:54	18.13	1.20	0.16	Winter	49.39	1006925	26.20
Storm event	**Antecedent dry period (days)**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity (in/hr)**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**
33	6.24	0.45	1/9/2022	1/10/2022	3.73	0.60	0.12	Winter	13.55	103395	6.90

			20:38	0:22							
34	6.48	1.54	1/16/2022 11:56	1/17/2022 1:32	13.60	0.72	0.11	Winter	25.45	442347	11.40
35	3.44	0.51	1/20/2022 12:06	1/20/2022 22:42	10.60	0.18	0.05	Winter	5.96	87829	7.00
36	1.62	0.22	1/22/2022 13:30	1/22/2022 17:14	3.73	0.24	0.06	Winter	-	-	-
37	12.66	0.23	2/4/2022 9:08	2/4/2022 11:06	1.97	0.60	0.12	Winter	0.00	0	-
38	2.72	0.91	2/7/2022 4:28	2/7/2022 23:04	18.60	0.30	0.05	Winter	9.23	108931	8.60
39	10.18	0.41	2/18/2022 3:18	2/18/2022 8:44	5.43	0.72	0.08	Winter	-	-	-
40	9.06	0.19	2/27/2022 10:10	2/27/2022 16:26	6.27	0.12	0.03	Winter	-	-	-
41	8.24	0.10	3/7/2022 22:08	3/8/2022 1:22	3.23	0.42	0.03	Winter	-	-	-
42	0.82	0.37	3/8/2022 20:58	3/9/2022 12:48	15.83	0.30	0.02	Winter	-	-	-
43	2.31	0.18	3/11/2022 20:16	3/11/2022 23:08	2.87	0.24	0.06	Winter	-	-	-
44	0.26	1.11	3/12/2022 5:20	3/12/2022 9:52	4.53	0.96	0.24	Winter	-	-	-
45	4.31	2.08	3/16/2022 17:18	3/17/2022 11:18	18.00	1.80	0.12	Winter	32.01	462114	24.17
46	6.74	0.84	3/24/2022 5:06	3/24/2022 14:04	8.97	1.50	0.09	Spring	9.10	91479	13.40
47	6.94	1.17	3/31/2022 12:38	3/31/2022 16:58	4.33	1.56	0.27	Spring	26.99	127930	8.10
48	5.04	0.44	4/5/2022 17:54	4/6/2022 0:16	6.37	1.14	0.07	Spring	3.74	23814	10.20
49	2.32	0.12	4/8/2022 7:56	4/8/2022 10:46	2.83	0.72	0.04	Spring	18.14	177044	25.23
Storm event	**Antecedent dry period (days)**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity (in/hr)**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**
50	9.89	1.26	4/18/2022 8:04	4/18/2022 14:56	6.87	1.14	0.18	Spring	15.35	153436	8.03
51	8.05	0.14	4/26/2022	4/26/2022	1.87	0.54	0.08	Spring	0.00	0	-

			16:10	18:02							
52	5.03	0.21	5/1/2022 18:48	5/2/2022 2:54	8.10	0.96	0.03	Spring	0.00	0	-
53	4.63	0.17	5/6/2022 17:54	5/6/2022 23:34	5.67	0.48	0.03	Spring	0.00	0	-
54	5.72	0.10	5/12/2022 16:58	5/12/2022 21:44	4.77	0.30	0.02	Spring	0.00	0	-
55	0.92	0.16	5/13/2022 19:48	5/13/2022 20:52	1.07	0.60	0.15	Spring	0.00	0	-
56	2.88	0.29	5/16/2022 17:52	5/16/2022 18:34	0.70	2.22	0.41	Spring	0.43	4059	3.73
57	6.91	1.78	5/23/2022 16:28	5/24/2022 0:36	8.13	4.44	0.22	Spring	-	-	-
58	3.39	1.01	5/27/2022 10:00	5/27/2022 18:42	8.70	4.20	0.12	Spring	0.98	16491	9.77
59	0.33	0.11	5/28/2022 2:32	5/28/2022 2:48	0.27	0.54	0.41	Spring	16.62	58792	4.17
60	11.69	0.46	6/8/2022 19:22	6/9/2022 2:02	6.67	2.16	0.07	Spring	0.00	0	-
61	7.66	0.28	6/16/2022 17:54	6/16/2022 18:40	0.77	1.92	0.37	Spring	0.59	3073	2.47
62	1.01	0.27	6/17/2022 18:54	6/17/2022 19:56	1.03	1.38	0.26	Spring	0.00	0	-
63	5.10	0.34	6/22/2022 22:18	6/23/2022 2:40	4.37	0.60	0.08	Summer	0.00	0	-
64	4.56	0.59	6/27/2022 16:06	6/27/2022 18:10	2.07	2.88	0.29	Summer	18.52	35406	3.40
65	1.37	0.72	6/29/2022 3:04	6/29/2022 11:38	8.57	3.72	0.08	Summer	0.00	0	-
66	7.33	0.98	7/6/2022 19:34	7/6/2022 21:00	1.43	2.52	0.68	Summer	0.00	0	-
Storm event	**Antecedent dry period (days)**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity (in/hr)**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**
67	0.84	0.15	7/7/2022 17:08	7/7/2022 19:10	2.03	0.60	0.07	Summer	0.00	0	-
68	0.92	0.40	7/8/2022 17:12	7/8/2022 22:50	5.63	1.08	0.07	Summer	30.42	127256	4.53
69	0.79	2.99	7/9/2022	7/9/2022	2.63	3.96	1.14	Summer	-	-	-

			17:52	20:30							

Table 2. Summary of MP458 TSS data

Storm event	Sampled volume (ft^3)	Percentage of hydrograph (%)	TSS (mg/L)
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	18235	62	11.65
6	-	-	-
7	-	-	-
8	-	-	15.63
9	-	-	-
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	12.81
14	-	-	-
15	-	-	-
16	27990	86	-
17	-	-	-
18	-	-	-
19	18223	78	8.91
20	-	-	-
21	-	-	-
22	46882	30	13.43
23	-	-	-
24	-	-	-
25	-	-	-
26	-	-	20.32
27	-	-	-
28	-	-	-
29	-	-	-
30	-	-	-
31	-	-	-
32	-	-	-
33	-	-	-
34	-	-	-
35	-	-	-
36	-	-	-
37	-	-	-
38	45888	42	16.88
39	-	-	-
Storm event	**Sampled volume (ft^3)**	**Percentage of hydrograph (%)**	**TSS (mg/L)**

40	-	-	-
41	-	-	-
42	-	-	-
43	-	-	-
44	-	-	-
45	-	-	-
46	-	-	-
47	48963	38	25.72
48	20288	85	8.21
49	-	-	-
50	-	-	-
51	-	-	-
52	-	-	-
53	-	-	-
54	-	-	-
55	-	-	-
56	1057.82	26	21.39
57	-	-	-
58	-	-	-
59	-	-	-
60	-	-	-
61	-	-	-
62	-	-	-
63	-	-	-
64	32791	93	11.47
65	-	-	-
66	-	-	-
67	-	-	-
68	-	-	-
69	-	-	-
70	-	-	-

Table 3. Summary of MP458 maximum velocities and potential maximum erosion rates from 1D steady analyses

Storm event	Maximum velocity (ft/s)	Permissible velocity exceeded	Velocity ratio	τ_a (lb/ft^2)	τ_a_Qp/τ_a	τ_a:τ_c	ε (in/s)
1	10.09	Yes	4.04	0.51	Less Qp	181	6.04E-03
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	9.09	Yes	3.64	0.51	Qp greater	181	6.04E-03
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	20.35	Yes	8.14	0.51	Less Qp	181	6.04E-03
9	11.17	Yes	4.47	0.26	Qp greater	92	3.03E-03
10	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
13	11.42	Yes	4.57	0.51	Less Qp	181	6.04E-03
14	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-
16	9.52	Yes	3.81	0.51	Less Qp	181	6.04E-03
17	-	-	-	-	-	-	-
18	12.03	Yes	4.81	0.31	Less Qp	110	3.63E-03
19	9.13	Yes	3.65	0.51	Less Qp	181	6.04E-03
20	7.00	Yes	2.80	0.12	Qp greater	43	1.34E-03
21	16.44	Yes	6.58	0.52	Less Qp	184	6.16E-03
22	12.59	Yes	5.03	0.34	Qp greater	121	3.99E-03
23	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-
26	8.12	Yes	3.25	0.15	Qp greater	53	1.70E-03
Storm event	**Maximum velocity**	**Permissible velocity**	**Velocity ratio**	τ_a **(lb/ft^2)**	τ_a**_Qp/**τ_a	τ_a:τ_c	**ε (in/s)**

	(ft/s)	**exceeded**					
27	10.16	Yes	4.06	0.22	Less Qp	78	2.55E-03
28	8.91	Yes	3.57	0.17	Qp greater	60	1.95E-03
29	-	-	-	-	-	-	-
30	6.96	Yes	2.79	0.51	Less Qp	181	6.04E-03
31	9.93	Yes	3.97	0.51	Less Qp	181	6.04E-03
32	15.89	Yes	6.36	0.51	Less Qp	181	6.04E-03
33	11.00	Yes	4.40	0.26	Qp greater	92	3.03E-03
34	13.09	Yes	5.24	0.36	Less Qp	128	4.23E-03
35	8.80	Yes	3.52	0.43	Less Qp	153	5.08E-03
36	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-
38	9.93	Yes	3.97	0.43	Less Qp	153	5.08E-03
39	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-
45	13.98	Yes	5.59	0.40	Less Qp	142	4.72E-03
46	9.89	Yes	3.96	0.21	Qp greater	74	2.43E-03
47	13.31	Yes	5.32	0.37	Less Qp	131	4.36E-03
48	7.73	Yes	3.09	0.61	Less Qp	216	7.25E-03
49	11.86	Yes	4.74	0.61	Less Qp	216	7.25E-03
50	11.37	Yes	4.55	0.27	Qp greater	96	3.15E-03
51	-	-	-	-	-	-	-
52	-	-	-	-	-	-	-
53	-	-	-	-	-	-	-
Storm event	**Maximum velocity (ft/s)**	**Permissible velocity exceeded**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**$\tau_a:\tau_c$**	**ε (in/s)**
54	-	-	-	-	-	-	-

55	-	-	-	-	-	-	-
56	4.27	Yes	1.71	0.51	Less Qp	181	6.04E-03
57	-	-	-	-	-	-	-
58	5.40	Yes	2.16	0.64	Less Qp	227	7.61E-03
59	11.58	Yes	4.63	0.64	Less Qp	227	7.61E-03
60	-	-	-	-	-	-	-
61	4.69	Yes	1.87	0.51	Less Qp	181	6.04E-03
62	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-
64	11.94	Yes	4.77	0.51	Less Qp	181	6.04E-03
65	-	-	-	-	-	-	-
66	-	-	-	-	-	-	-
67	-	-	-	-	-	-	-
68	13.77	Yes	5.51	0.39	Less Qp	138	4.60E-03
69	-	-	-	-	-	-	-
70	14.81	Yes	5.92	0.51	Less Qp	181	6.04E-03

Note τ_a, Q_p, τ_c, and ε refer to applied shear stress, peak discharge, critical shear stress, and erosion rate, respectively

Table 4. Summary of MP459 hydrologic and runoff data

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
1	-	1.08	7/2/2021 6:14	7/2/2021 8:56	2.70	2.10	0.40	Summer	0.51	908	1.40
2	1.13	0.17	7/3/2021 12:00	7/3/2021 14:28	2.48	-	-	Summer	0.00	0	0.00
3	4.73	2.31	7/8/2021 7:57	7/8/2021 17:12	9.26	-	-	Summer	39.66	141966	7.17
4	1.01	0.10	7/9/2021 17:23	7/9/2021 17:38	0.25	-	-	Summer	0.00	0	0.00
5	9.15	0.79	7/18/2021 21:16	7/19/2021 15:16	18.00	1.68	0.04	Summer	0.00	0	0.00
6	9.00	0.44	7/28/2021 15:12	7/28/2021 15:54	0.70	2.82	0.63	Summer	0.00	0	0.00
7	6.03	0.13	8/3/2021 16:33	8/3/2021 19:32	2.99	-	-	Summer	0.00	0	0.00
8	11.69	0.17	8/15/2021 12:02	8/16/2021 0:44	12.71	-	-	Summer	-	-	-
9	0.71	0.27	8/16/2021 17:50	8/16/2021 23:13	5.38	-	-	Summer	-	-	-
10	2.95	0.21	8/19/2021 21:55	8/20/2021 0:08	2.23	-	-	Summer	-	-	-
11	0.61	0.43	8/20/2021 14:49	8/20/2021 15:57	1.13	-	-	Summer	0.00	0	0.00
12	-	0.28	-	9/2/2021 0:00	-	-	-	Summer	0.00	0	0.00
13	7.45	1.56	9/9/2021 10:44	9/9/2021 13:28	2.73	3.72	0.57	Summer	0.25	198	0.43
14	-	1.74	-	9/10/2021 0:00	-	-	-	Summer	0.00	0	0.00
15	-	0.57	-	9/22/2021 0:00	-	-	-	Fall	0.00	0	0.00
16	-	0.46	-	9/23/2021 0:00	-	-	-	Fall	0.00	0	0.00

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
17	-	0.60	-	9/30/2021 0:00	-	-	-	Fall	0.00	0	0.00
18	9.07	1.65	10/9/2021 1:44	10/9/2021 15:14	13.50	1.26	0.12	Fall	10.39	105175	11.77
19	7.03	0.39	10/16/2021 15:54	10/16/2021 16:24	0.50	1.74	0.78	Fall	0.00	0	0.00
20	8.78	0.44	10/25/2021 11:10	10/25/2021 12:02	0.87	1.74	0.51	Fall	1.99	10047	4.83
21	0.40	0.91	10/25/2021 21:38	10/25/2021 22:26	0.80	4.56	1.14	Fall	43.68	109227	5.73
22	2.85	0.77	10/28/2021 18:46	10/29/2021 6:36	11.83	1.14	0.07	Fall	-	-	-
23	24.03	0.35	11/22/2021 7:24	11/22/2021 13:30	6.10	0.30	0.06	Fall	0.19	3601	7.23
24	3.58	0.11	11/26/2021 3:20	11/26/2021 5:48	2.47	0.18	0.04	Fall	0.00	0	0.00
25	0.66	0.37	12/8/2021 5:58	12/8/2021 9:16	3.30	0.42	0.11	Fall	0.17	1158	2.40
26	3.48	0.50	12/11/2021 20:50	12/12/2021 2:08	5.30	2.28	0.09	Fall	1.84	11968	5.20
27	6.97	0.99	12/19/2021 1:18	12/19/2021 16:22	15.07	0.30	0.07	Fall	3.83	45955	12.60
28	1.97	0.57	12/21/2021 15:42	12/22/2021 2:32	10.83	0.42	0.05	Fall	1.21	16727	11.70
29	7.78	0.20	12/29/2021 21:08	12/30/2021 3:44	6.60	0.42	0.03	Winter	0.00	0	0.00
30	2.65	0.19	1/1/2022 19:22	1/1/2022 19:42	0.33	1.20	0.57	Winter	0.47	4790	4.70
31	0.52	0.41	1/2/2022 8:12	1/2/2022 9:20	1.13	1.38	0.36	Winter	2.65	16357	6.57
32	0.48	2.82	1/2/2022 20:46	1/3/2022 14:54	18.13	1.20	0.16	Winter	80.63	720399	23.00
33	6.24	0.45	1/9/2022 20:38	1/10/2022 0:22	3.73	0.60	0.12	Winter	5.54	32566	5.83

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
35	3.44	0.51	1/20/2022 12:06	1/20/2022 22:42	10.60	0.18	0.05	Winter	1.99	19225	6.93
36	1.62	0.22	1/22/2022 13:30	1/22/2022 17:14	3.73	0.24	0.06	Winter	0.19	3049	5.40
37	12.66	0.23	2/4/2022 9:08	2/4/2022 11:06	1.97	0.60	0.12	Winter	0.19	960	1.67
38	2.72	0.91	2/7/2022 4:28	2/7/2022 23:04	18.60	0.30	0.05	Winter	3.98	34227	11.57
39	10.18	0.41	2/18/2022 3:18	2/18/2022 8:44	5.43	0.72	0.08	Winter	0.31	1240	1.40
40	9.06	0.19	2/27/2022 10:10	2/27/2022 16:26	6.27	0.12	0.03	Winter	0.17	4848	9.17
41	8.24	0.10	3/7/2022 22:08	3/8/2022 1:22	3.23	0.42	0.03	Winter	0.00	0	0.00
42	0.82	0.37	3/8/2022 20:58	3/9/2022 12:48	15.83	0.30	0.02	Winter	1.48	20855	20.27
43	2.31	0.18	3/11/2022 20:16	3/11/2022 23:08	2.87	0.24	0.06	Winter	0.00	0	0.00
44	0.26	1.11	3/12/2022 5:20	3/12/2022 9:52	4.53	0.96	0.24	Winter	28.17	152088	8.40
45	4.31	2.08	3/16/2022 17:18	3/17/2022 11:18	18.00	1.80	0.12	Winter	30.03	257930	22.13
46	6.74	0.84	3/24/2022 5:06	3/24/2022 14:04	8.97	1.50	0.09	Spring	6.23	33390	11.60
47	6.94	1.17	3/31/2022 12:38	3/31/2022 16:58	4.33	1.56	0.27	Spring	21.33	66768	7.73
48	5.04	0.44	4/5/2022 17:54	4/6/2022 0:16	6.37	1.14	0.07	Spring	1.26	6425	5.90
49	2.32	0.12	4/8/2022 7:56	4/8/2022 10:46	2.83	0.72	0.04	Spring	6.72	29004	4.37
50	9.89	1.26	4/18/2022 8:04	4/18/2022 14:56	6.87	1.14	0.18	Spring	11.07	91904	9.50
51	8.05	0.14	4/26/2022 16:10	4/26/2022 18:02	1.87	0.54	0.08	Spring	0.00	0	0.00

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
52	5.03	0.21	5/1/2022 18:48	5/2/2022 2:54	8.10	0.96	0.03	Spring	0.23	1309	2.33
53	4.63	0.17	5/6/2022 17:54	5/6/2022 23:34	5.67	0.48	0.03	Spring	0.34	2271	3.23
54	5.72	0.10	5/12/2022 16:58	5/12/2022 21:44	4.77	0.30	0.02	Spring	0.00	0	0.00
55	0.92	0.16	5/13/2022 19:48	5/13/2022 20:52	1.07	0.60	0.15	Spring	0.00	0	0.00
56	2.88	0.29	5/16/2022 17:52	5/16/2022 18:34	0.70	2.22	0.41	Spring	0.39	2977	3.87
57	6.91	1.78	5/23/2022 16:28	5/24/2022 0:36	8.13	4.44	0.22	Spring	61.96	173427	12.17
58	3.39	1.01	5/27/2022 10:00	5/27/2022 18:42	8.70	4.20	0.12	Spring	0.17	2377	8.60
59	0.33	0.11	5/28/2022 2:32	5/28/2022 2:48	0.27	0.54	0.41	Spring	11.71	29381	4.13
60	11.69	0.46	6/8/2022 19:22	6/9/2022 2:02	6.67	2.16	0.07	Spring	0.00	0	0.00
61	7.66	0.28	6/16/2022 17:54	6/16/2022 18:40	0.77	1.92	0.37	Spring	2.29	4879	4.37
62	1.01	0.27	6/17/2022 18:54	6/17/2022 19:56	1.03	1.38	0.26	Spring	0.00	0	0.00
63	5.10	0.34	6/22/2022 22:18	6/23/2022 2:40	4.37	0.60	0.08	Summer	0.17	2016	6.13
64	4.56	0.59	6/27/2022 16:06	6/27/2022 18:10	2.07	2.88	0.29	Summer	4.76	15506	5.73
65	1.37	0.72	6/29/2022 3:04	6/29/2022 11:38	8.57	3.72	0.08	Summer	0.14	1491	5.10
66	7.33	0.98	7/6/2022 19:34	7/6/2022 21:00	1.43	2.52	0.68	Summer	0.00	0	0.00
67	0.84	0.15	7/7/2022 17:08	7/7/2022 19:10	2.03	0.60	0.07	Summer	0.12	668	2.67
68	0.92	0.40	7/8/2022 17:12	7/8/2022 22:50	5.63	1.08	0.07	Summer	39.77	111730	3.90

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
69	0.79	2.99	7/9/2022 17:52	7/9/2022 20:30	2.63	3.96	1.14	Summer	0.00	0	0.00
70	0.29	0.43	7/10/2022 3:32	7/10/2022 17:06	13.57	0.42	0.03	Summer	0.00	0	0.00

Table 5. Summary of MP459 TSS data

Storm event	Sampled volume (ft^3)	Percentage of hydrograph (%)	TSS (mg/L)
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	-	-	-
6	-	-	-
7	-	-	-
8	-	-	-
9	-	-	-
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
16	-	-	-
17	-	-	-
18	-	-	-
19	-	-	-
20	-	-	-
21	-	-	-
22	-	-	-
23	-	-	-
24	-	-	-
25			-
26	-	-	-
27	-	-	-
28	-	-	-
29	-	-	-
30	-	-	-
31	-	-	-
32	-	-	-
33	-	-	-
34	-	-	-
35	-	-	-
36	-	-	-
37	-	-	-
38	-	-	-
39	32185	94	14.79
Storm event	**Sampled volume (ft^3)**	**Percentage of hydrograph (%)**	**TSS (mg/L)**

40	-	-	-
41	1554	32	4.87
42	-	-	-
43	-	-	-
44	-	-	-
45	-	-	-
46	-	-	-
47	29605	89	62.27
48	35828	54	106.85
49	2322	36	21.15
50	-	-	-
51	27663	30	15.09
52	-	-	-
53	-	-	-
54	-	-	-
55	-	-	-
56	-	-	-
57	-	-	-
58	27108	16	92.56
59	-	-	-
60	26840	91	83.56
61	-	-	-
62	-	-	-
63	-	-	-
64	-	-	-
65	12376	80	22.42
66	-	-	-
67	-	-	-
68	-	-	-
69	-	-	7.92
70	-	-	-

Table 6. MP459 maximum velocities and potential maximum erosion rates from 1D steady analyses

Storm event	Maximum velocity (ft/s)	Permissible velocity exceeded	Velocity ratio	τ_a (lb/ft^2)	τ_a_Qp/τ_a	$\tau_a:\tau_c$	ε (in/s)
1	0.99	No	0.39	0.14	Less Qp	7.75	3.38E-04
2	-	-	-	-	-	-	-
3	3.74	Yes	1.50	0.50	Qp greater	27.68	1.34E-03
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
13	0.75	No	0.30	0.04	Qp greater	2.21	6.08E-05
14	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-
18	2.46	No	0.98	0.25	Qp greater	13.84	6.43E-04
19	-	-	-	-	-	-	-
20	1.40	No	0.56	0.12	Qp greater	6.64	2.82E-04
21	3.88	Yes	1.55	0.52	Qp greater	28.78	1.39E-03
22	-	-	-	-	-	-	-
23	0.65	No	0.26	0.04	Qp greater	2.21	6.08E-05
24	-	-	-	-	-	-	-
25	0.62	No	0.25	-	-	-	-
26	1.37	No	0.55	0.12	Qp greater	6.64	2.82E-04
Storm event	**Maximum velocity**	**Permissible velocity**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**$\tau_a:\tau_c$**	**ε (in/s)**

	(ft/s)	exceeded					
27	1.74	No	0.70	0.16	Qp greater	8.86	3.93E-04
28	1.26	No	0.50	0.10	Qp greater	5.54	2.27E-04
29	-	-	-	-	-	-	-
30	0.95	No	0.38	0.06	Qp greater	3.32	1.16E-04
31	1.52	No	0.61	0.14	Qp greater	7.75	3.38E-04
32	4.92	Yes	1.97	0.79	Qp greater	43.73	2.14E-03
33	2.01	No	0.80	0.19	Qp greater	10.52	4.76E-04
34	3.00	Yes	1.20	0.35	Qp greater	19.37	9.20E-04
35	1.40	No	0.56	0.12	Qp greater	6.64	2.82E-04
36	0.65	No	0.26	-	-	-	-
37	0.66	No	0.26	-	-	-	-
38	1.77	No	0.71	0.16	Qp greater	8.86	3.93E-04
39	0.80	No	0.32	-	-	-	-
40	0.64	No	0.25	-	-	-	-
41	-	-	-	-	-	-	-
42	1.31	No	0.52	0.11	Qp greater	6.09	2.55E-04
43	-	-	-	-	-	-	-
44	3.32	Yes	1.33	0.40	Qp greater	22.14	1.06E-03
45	3.39	Yes	1.36	0.42	Qp greater	23.25	1.11E-03
46	2.08	No	0.83	0.20	Qp greater	11.07	5.04E-04
47	3.04	Yes	1.21	0.35	Qp greater	19.37	9.20E-04
48	1.27	No	0.51	0.10	Qp greater	5.54	2.27E-04
49	2.12	No	0.85	0.21	Qp greater	11.62	5.32E-04
50	2.50	No	1.00	0.26	Qp greater	14.39	6.70E-04
51	-	-	-	-	-	-	-
52	0.73	No	0.29	-	-	-	-
53	0.83	No	0.33	0.05	Qp greater	2.77	8.85E-05
Storm event	**Maximum velocity (ft/s)**	**Permissible velocity exceeded**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**τ_a:τ_c**	**ε (in/s)**
54	-	-	-	-	-	-	-

55	-	-	-	-	-	-	-
56	0.88	No	0.35	0.06	Qp greater	3.32	1.16E-04
57	4.43	Yes	1.77	0.66	Qp greater	36.53	1.78E-03
58	0.62	No	0.25	-	-	-	-
59	2.54	Yes	1.02	0.27	Qp greater	14.95	6.98E-04
60	-	-	-	-	-	-	-
61	1.46	No	0.58	0.13	Qp greater	7.20	3.10E-04
62	-	-	-	-	-	-	-
63	0.62	No	0.25	0.04	Less Qp	2.21	6.08E-05
64	1.92	No	0.77	0.18	Qp greater	9.96	4.49E-04
65	0.59	No	0.23	-	-	-	-
66	-	-	-	-	-	-	-
67	0.56	No	0.22	-	-	-	-
68	3.74	Yes	1.50	0.50	Qp greater	27.68	1.34E-03
69	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-

Note τ_a, Q_p, τ_c, and ε refer to applied shear stress, peak discharge, critical shear stress, and erosion rate, respectively

Table 7. MP459 discharge rating curve

Discharge (ft^3/s)	Water surface elevation (ft)
0	93.40
0.25	93.57
0.5	93.62
1	93.70
5	94.04
10	94.28
15	94.46
20	94.61
25	94.73
30	94.84
35	94.93
40	95.02
45	95.10
50	95.17
55	95.23
60	95.29
65	95.35
70	95.41
75	95.46
80	95.51
85	95.55
90	95.60
95	95.65
100	95.70
110	95.77
120	95.86

Table 8. MP459 velocity rating curve

Velocity (ft/s)	**Discharge (ft^3/s)**
0.45	0.05
0.75	0.25
0.98	0.5
1.22	1
1.96	5
2.43	10
2.75	15
2.98	20
3.19	25
3.39	30
3.58	35
3.75	40
3.92	45
4.08	50
4.23	55
4.38	60
4.52	65
4.65	70
4.77	75
4.9	80
5.02	85
5.13	90
5.21	95
5.3	100
5.51	110
5.66	120
0.45	0.05

Table 9. Summary of MP467 hydrologic and runoff data

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
1	-	1.08	7/2/2021 6:14	7/2/2021 8:56	2.70	2.10	0.40	Summer	13.88	41207	1.73
2	5.91	4.24	7/8/2021 6:52	7/8/2021 16:32	9.67	3.78	0.44	Summer	38.00	340346	7.20
3	10.20	0.79	7/18/2021 21:16	7/19/2021 15:16	18.00	1.68	0.04	Summer	0.00	0	0.00
4	9.00	0.44	7/28/2021 15:12	7/28/2021 15:54	0.70	2.82	0.63	Summer	0.00	0	0.00
5	5.96	0.15	8/3/2021 14:56	8/3/2021 19:36	4.67	0.12	0.03	Summer	0.00	0	0.00
6	3.33	0.90	8/7/2021 3:28	8/7/2021 11:04	7.60	2.22	0.12	Summer	0.00	0	0.00
7	2.96	0.22	8/10/2021 10:10	8/10/2021 13:18	3.13	1.20	0.07	Summer	7.75	13651	0.83
8	3.98	2.42	8/14/2021 12:46	8/14/2021 18:32	5.77	4.50	0.42	Summer	43.00	140200	2.43
9	0.85	2.57	8/15/2021 14:54	8/16/2021 1:08	10.23	8.34	0.25	Summer	43.57	84228	2.00
10	3.91	0.14	8/19/2021 22:58	8/20/2021 0:14	1.27	0.30	0.11	Summer	0.00	0	0.00
11	0.61	0.25	8/20/2021 14:50	8/20/2021 21:14	6.40	1.98	0.04	Summer	6.18	11042	0.80
12	2.71	0.82	8/23/2021 14:22	8/23/2021 14:58	0.60	3.96	1.37	Summer	0.00	0	0.00
13	16.83	0.43	9/9/2021 11:00	9/9/2021 14:00	5.00	-	-	Summer	5.84	19723	1.33
14	13.42	0.19	9/23/2021 0:00	9/23/2021 2:00	3.00	-	-	Fall	11.13	23840	1.30
15	7.00	0.30	9/30/2021 2:00	9/30/2021 4:00	3.00	-	-	Fall	5.53	11679	0.87
16	8.91	2.79	10/9/2021 1:46	10/9/2021 21:24	19.63	2.82	0.14	Fall	26.15	345513	22.07
Storm event	**Antecedent dry**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min**	**Average intensity**	**Season**	**Peak flow**	**Runoff volume**	**Runoff duration**

	period (days)					intensity (in/hr)	(in/hr)		(ft^3/s)	(ft^3)	(hr)
17	6.78	0.26	10/16/2021 16:14	10/16/2021 16:36	0.37	1.50	0.71	Fall	0.00	0	0.00
18	9.21	1.66	10/25/2021 21:38	10/26/2021 0:42	3.07	4.20	0.54	Fall	44.43	131639	2.70
19	2.75	0.77	10/28/2021 18:46	10/29/2021 6:36	11.83	1.14	0.07	Fall	6.29	96036	10.40
20	27.87	0.13	11/26/2021 3:34	11/26/2021 6:04	2.50	0.24	0.05	Fall	0.00	0	0.00
21	12.00	0.37	12/8/2021 5:58	12/8/2021 9:16	3.30	0.42	0.11	Fall	0.00	0	0.00
22	3.48	0.50	12/11/2021 20:50	12/12/2021 2:08	5.30	2.28	0.09	Fall	6.29	26952	1.93
23	6.97	0.99	12/19/2021 1:18	12/19/2021 16:22	15.07	0.30	0.07	Fall	8.26	125555	7.27
24	1.97	0.57	12/21/2021 15:42	12/22/2021 2:32	10.83	0.42	0.05	Fall	5.84	56190	4.27
25	7.78	0.20	12/29/2021 21:08	12/30/2021 3:44	6.60	0.42	0.03	Winter	0.00	0	0.00
26	2.65	0.19	1/1/2022 19:22	1/1/2022 19:42	0.33	1.20	0.57	Winter	0.00	0	0.00
27	0.52	0.41	1/2/2022 8:12	1/2/2022 9:20	1.13	1.38	0.36	Winter	8.90	63146	3.90
28	0.48	2.82	1/2/2022 20:46	1/3/2022 14:54	18.13	1.20	0.16	Winter	28.06	492676	15.30
29	6.24	0.45	1/9/2022 20:38	1/10/2022 0:22	3.73	0.60	0.12	Winter	4.23	66212	6.17
30	6.48	1.54	1/16/2022 11:56	1/17/2022 1:32	13.60	0.72	0.11	Winter	13.82	210354	8.57
31	3.44	0.51	1/20/2022 12:06	1/20/2022 22:42	10.60	0.18	0.05	Winter	4.33	81824	9.47
32	1.62	0.22	1/22/2022 13:30	1/22/2022 17:14	3.73	0.24	0.06	Winter	0.00	0	0.00
33	12.66	0.23	2/4/2022 9:08	2/4/2022 11:06	1.97	0.60	0.12	Winter	0.00	0	0.00
Storm event	**Antecedent dry period**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**

Storm event	Antecedent dry (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min (in/hr)	Average intensity	Season	Peak flow	Runoff volume	Runoff duration
34	2.72	0.91	2/7/2022 4:28	2/7/2022 23:04	18.60	0.30	0.05	Winter	6.05	129541	10.23
35	10.18	0.41	2/18/2022 3:18	2/18/2022 8:44	5.43	0.72	0.08	Winter	3.28	36384	5.33
36	9.06	0.19	2/27/2022 10:10	2/27/2022 16:26	6.27	0.12	0.03	Winter	0.00	0	0.00
37	8.24	0.10	3/7/2022 22:08	3/8/2022 1:22	3.23	0.42	0.03	Winter	0.00	0	0.00
38	0.82	0.37	3/8/2022 20:58	3/9/2022 12:48	15.83	0.30	0.02	Winter	0.00	0	0.00
39	2.31	0.18	3/11/2022 20:16	3/11/2022 23:08	2.87	0.24	0.06	Winter	0.00	0	0.00
40	0.26	1.11	3/12/2022 5:20	3/12/2022 9:52	4.53	0.96	0.24	Winter	16.52	129318	5.03
41	4.31	2.08	3/16/2022 17:18	3/17/2022 11:18	18.00	1.80	0.12	Winter	24.89	310115	19.17
42	6.74	0.84	3/24/2022 5:06	3/24/2022 14:04	8.97	1.50	0.09	Spring	6.29	72450	9.53
43	6.94	1.17	3/31/2022 12:38	3/31/2022 16:58	4.33	1.56	0.27	Spring	21.47	88114	4.20
44	5.04	0.44	4/5/2022 17:54	4/6/2022 0:16	6.37	1.14	0.07	Spring	0.00	0	0.00
45	2.32	0.12	4/8/2022 7:56	4/8/2022 10:46	2.83	0.72	0.04	Spring	0.00	0	0.00
46	9.89	1.26	4/18/2022 8:04	4/18/2022 14:56	6.87	1.14	0.18	Spring	8.01	78858	4.83
47	8.05	0.14	4/26/2022 16:10	4/26/2022 18:02	1.87	0.54	0.08	Spring	0.00	0	0.00
48	5.03	0.21	5/1/2022 18:48	5/2/2022 2:54	8.10	0.96	0.03	Spring	0.00	0	0.00
49	4.63	0.17	5/6/2022 17:54	5/6/2022 23:34	5.67	0.48	0.03	Spring	0.00	0	0.00

	period (days)					**intensity (in/hr)**	**(in/hr)**		**(ft^3/s)**	**(ft^3)**	**(hr)**
50	5.72	0.10	5/12/2022 16:58	5/12/2022 21:44	4.77	0.30	0.02	Spring	0.00	0	0.00
51	0.92	0.16	5/13/2022 19:48	5/13/2022 20:52	1.07	0.60	0.15	Spring	0.00	0	0.00
52	2.88	0.29	5/16/2022 17:52	5/16/2022 18:34	0.70	2.22	0.41	Spring	0.00	0	0.00
53	6.91	1.78	5/23/2022 16:28	5/24/2022 0:36	8.13	4.44	0.22	Spring	26.55	117488	9.87
54	3.39	1.01	5/27/2022 10:00	5/27/2022 18:42	8.70	4.20	0.12	Spring	16.20	52403	2.60
55	0.33	0.11	5/28/2022 2:32	5/28/2022 2:48	0.27	0.54	0.41	Spring	0.00	0	0.00
56	11.69	0.46	6/8/2022 19:22	6/9/2022 2:02	6.67	2.16	0.07	Spring	0.00	0	0.00
57	7.66	0.28	6/16/2022 17:54	6/16/2022 18:40	0.77	1.92	0.37	Spring	0.00	0	0.00
58	1.01	0.27	6/17/2022 18:54	6/17/2022 19:56	1.03	1.38	0.26	Spring	0.00	0	0.00
59	5.10	0.34	6/22/2022 22:18	6/23/2022 2:40	4.37	0.60	0.08	Summer	0.00	0	0.00
60	4.56	0.59	6/27/2022 16:06	6/27/2022 18:10	2.07	2.88	0.29	Summer	0.00	0	0.00
61	1.37	0.72	6/29/2022 3:04	6/29/2022 11:38	8.57	3.72	0.08	Summer	8.45	20735	1.50
62	7.33	0.98	7/6/2022 19:34	7/6/2022 21:00	1.43	2.52	0.68	Summer	35.51	148624	3.67
63	0.84	0.15	7/7/2022 17:08	7/7/2022 19:10	2.03	0.60	0.07	Summer	0.00	0	0.00
64	0.92	0.40	7/8/2022 17:12	7/8/2022 22:50	5.63	1.08	0.07	Summer	0.00	0	0.00
65	0.79	2.99	7/9/2022 17:52	7/9/2022 20:30	2.63	3.96	1.14	Summer	83.18	326199	4.73
Storm event	**Antecedent dry period (days)**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity (in/hr)**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**

66	0.29	0.43	7/10/2022 3:32	7/10/2022 17:06	13.57	0.42	0.03	Summer	4.58	24910	2.20
67	5.04	0.20	7/15/2022 18:00	7/15/2022 18:38	0.63	0.78	0.32	Summer	0.00	0	0.00
68	7.83	0.11	7/23/2022 14:28	7/23/2022 14:48	0.33	0.54	0.33	Summer	0.00	0	0.00
69	1.04	0.56	7/24/2022 15:46	7/24/2022 17:24	1.63	1.26	0.34	Summer	0.00	0	0.00
70	1.19	1.26	7/25/2022 21:54	7/26/2022 16:52	18.97	3.00	0.07	Summer	10.98	22429	1.03
71	0.89	0.12	7/27/2022 14:08	7/27/2022 21:04	6.93	0.90	0.02	Summer	0.00	0	0.00
72	0.79	0.15	7/28/2022 15:58	7/28/2022 20:34	4.60	1.08	0.03	Summer	0.00	0	0.00
73	2.72	0.62	7/31/2022 13:46	8/1/2022 8:06	18.33	1.56	0.03	Summer	0.00	0	0.00

Table 10. Summary of MP467 TSS data

Storm event	Sampled volume (ft^3)	Percentage of hydrograph (%)	TSS (mg/L)
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	-	-	-
6	-	-	-
7	-	-	-
8	140200	100	107.18
9	-	-	-
10	-	-	98.72
11	-	-	-
12	-	-	-
13	-	-	114.08
14	-	-	-
15	6237	53	88.33
16	-	-	-
17	-	-	-
18	-	-	-
19	75910	79	47.5
20	-	-	-
21	-	-	-
22	-	-	162.33
23	-	-	-
24	-	-	-
25	-	-	-
26	-	-	-
27	-	-	-
28	-	-	-
29	-	-	-
30	-	-	-
31	-	-	-
32	-	-	-
33	-	-	-
34	47481	37	55.52
35	-	-	-
36	-	-	-
37	-	-	-
38	-	-	-
39	-	-	-
Storm event	**Sampled volume (ft^3)**	**Percentage of hydrograph (%)**	**TSS (mg/L)**

40	-	-	-
41	-	-	-
42	43091	59	132.84
43	37411	42	328.98
44	-	-	-
45	-	-	-
46	29886	38	74.55
47	-	-	-
48	-	-	-
49	-	-	-
50	-	-	-
51	-	-	-
52	-	-	-
53	55523	47	339.15
54	28552	54	162.85
55	-	-	-
56	-	-	-
57	-	-	-
58	-	-	-
59	-	-	-
60	-	-	-
61	14595	70	205.08
62	-	-	-
63	-	-	-
64	-	-	-
65	-	-	-
66	-	-	-
67	-	-	-
68	-	-	-
69	-	-	-
70	19494	87	228.07
71	-	-	-
72	-	-	-
73	-	-	-

Table 11. Summary of MP467 maximum velocities and potential maximum erosion rates from 1D steady analyses

Storm event	**Maximum velocity (ft/s)**	**Permissible velocity exceeded**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**τ_a:τ_c**	**ε (in/s)**
1	2.88	Yes	1.15	0.31	Qp greater	42.41	$7.77*10^{-3}$
2	3.71	Yes	1.48	0.46	Qp greater	62.93	$1.16*10^{-2}$
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	2.47	No	0.99	0.25	Qp greater	34.20	$6.23*10^{-3}$
8	3.81	Yes	1.53	0.48	Qp greater	65.67	$1.21*10^{-2}$
9	3.82	Yes	1.53	0.71	Less Qp	97.13	$1.80*10^{-2}$
10	2.31	No	0.92	-	-	-	-
11	-	-	-	0.22	Qp greater	30.10	$5.46*10^{-3}$
12	-	-	-	-	-	-	-
13	2.27	No	0.91	0.22	Qp greater	30.10	$5.46*10^{-3}$
14	2.72	Yes	1.09	0.29	Qp greater	39.67	$7.26*10^{-3}$
15	2.23	No	0.89	0.21	Qp greater	28.73	$5.21*10^{-3}$
16	3.40	Yes	1.36	0.40	Qp greater	54.72	$1.01*10^{-2}$
17	-	-	-	-	-	-	-
18	3.84	Yes	1.54	0.48	Qp greater	65.67	$1.21*10^{-2}$
19	2.32	No	0.93	0.23	Qp greater	31.46	$5.72*10^{-3}$
20	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-
22	2.32	No	0.93	0.23	Qp greater	31.46	$5.72*10^{-3}$
23	2.51	Yes	1.00	0.26	Qp greater	35.57	$6.49*10^{-3}$
24	2.27	No	0.91	0.22	Qp greater	30.10	$5.46*10^{-3}$
25	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-
Storm event	**Maximum velocity**	**Permissible velocity**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**τ_a:τ_c**	**ε (in/s)**

	(ft/s)	**exceeded**					
27	2.56	Yes	1.02	0.26	Qp greater	35.57	$6.49*10^{-3}$
28	3.46	Yes	1.38	0.41	Qp greater	56.09	$1.03*10^{-2}$
29	2.06	No	0.82	0.19	Qp greater	25.99	$4.69*10^{-3}$
30	2.88	Yes	1.15	0.31	Qp greater	42.41	$7.77*10^{-3}$
31	2.07	No	0.83	0.19	Qp greater	25.99	$4.69*10^{-3}$
32	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-
34	2.30	No	0.92	0.22	Qp greater	30.10	$5.46*10^{-3}$
35	1.91	No	0.76	0.17	Qp greater	23.26	$4.18*10^{-3}$
36	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-
40	3.02	Yes	1.21	0.34	Qp greater	46.51	$8.54*10^{-3}$
41	3.36	Yes	1.34	0.40	Qp greater	54.72	$1.01*10^{-2}$
42	2.32	No	0.93	0.23	Qp greater	31.46	$5.72*10^{-3}$
43	3.24	Yes	1.30	0.37	Qp greater	50.62	$9.32*10^{-3}$
44	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-
46	2.49	No	1.00	0.25	Qp greater	34.20	$6.23*10^{-3}$
47	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-
51	-	-	-	-	-	-	-
52	-	-	-	-	-	-	-
53	3.42	Yes	1.37	0.41	Qp greater	56.09	$1.03*10^{-2}$
Storm event	**Maximum velocity (ft/s)**	**Permissible velocity exceeded**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**τ_a:τ_c**	**ε (in/s)**
54	3.01	Yes	1.20	0.33	Qp greater	45.15	$8.29*10^{-3}$

55	-	-	-	-	-	-	-
56	-	-	-	-	-	-	-
57	-	-	-	-	-	-	-
58	-	-	-	-	-	-	-
59	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-
61	2.53	Yes	1.01	0.26	Qp greater	35.57	$6.49*10^{-3}$
62	3.65	Yes	1.46	0.45	Qp greater	61.56	$1.14*10^{-2}$
63	-	-	-	-	-	-	-
64	-	-	-	-	-	-	-
65	4.22	Yes	1.69	0.54	Less Qp	73.87	$1.37*10^{-2}$
66	2.11	No	0.84	0.20	Qp greater	27.36	$4.95*10^{-3}$
67	-	-	-	-	-	-	-
68	-	-	-	-	-	-	-
69	-	-	-	-	-	-	-
70	2.71	Yes	1.09	0.29	Qp greater	39.67	$7.26*10^{-3}$
71	-	-	-	-	-	-	-
72	-	-	-	-	-	-	-
73	-	-	-	-	-	-	-

Note τ_a, Q_p, τ_c, and ε refer to applied shear stress, peak discharge, critical shear stress, and erosion rate, respectively

Table 12. MP467 discharge rating curve

Discharge (ft^3/s)	Water surface elevation (ft)
0	97.21
0.5	97.40
1	97.50
1.5	97.58
2	97.65
2.5	97.71
3	97.77
3.5	97.82
4	97.87
4.5	97.92
5	97.96
5.5	98.01
6	98.05
6.5	98.09
7	98.13
7.5	98.17
8	98.20
8.5	98.24
9	98.27
9.5	98.31
10	98.34
12	98.46
14	98.58
16	98.68
18	98.78
20	98.88
22	98.97
24	99.05
26	99.14
28	99.22
30	99.29
40	99.64
50	99.94
60	100.22
70	100.48
80	100.71
90	100.93
100	101.13
120	101.48
140	101.65

Table 13. MP467 velocity rating curve

Velocity (ft/s)	Discharge (ft^3/s)
0	0
0.31	0.01
1.01	0.5
1.28	1
1.5	1.5
1.63	2
1.76	2.5
1.86	3
1.95	3.5
2.02	4
2.1	4.5
2.17	5
2.23	5.5
2.29	6
2.34	6.5
2.39	7
2.44	7.5
2.49	8
2.53	8.5
2.57	9
2.61	9.5
2.65	10
2.78	12
2.89	14
3	16
3.09	18
3.18	20
3.26	22
3.33	24
3.4	26
3.46	28
3.52	30
3.76	40
3.94	50
4.08	60
4.16	70
4.2	80
4.25	90
4.3	100
4.41	120
4.78	140

Table 14. Summary of MP495 hydrologic and runoff data

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
1	-	1.08	7/2/2021 6:14	7/2/2021 8:56	2.70	2.10	0.40	Summer	2.93	16953	2.70
2	5.91	4.24	7/8/2021 6:52	7/8/2021 16:32	9.67	3.78	0.44	Summer	5.64	65866	9.67
3	10.20	0.79	7/18/2021 21:16	7/19/2021 15:16	18.00	1.68	0.04	Summer	1.78	12134	18.00
4	9.00	0.44	7/28/2021 15:12	7/28/2021 15:54	0.70	2.82	0.63	Summer	0.25	121	0.70
5	5.96	0.15	8/3/2021 14:56	8/3/2021 19:36	4.67	0.12	0.03	Summer	0.00	0	4.67
6	3.33	0.90	8/7/2021 3:28	8/7/2021 11:04	7.60	2.22	0.12	Summer	2.64	11531	7.60
7	2.96	0.22	8/10/2021 10:10	8/10/2021 13:18	3.13	1.20	0.07	Summer	0.00	0	3.13
8	3.98	2.42	8/14/2021 12:46	8/14/2021 18:32	5.77	4.50	0.42	Summer	4.62	25731	5.77
9	0.85	2.57	8/15/2021 14:54	8/16/2021 1:08	10.23	8.34	0.25	Summer	13.25	52040	10.23
10	3.91	0.14	8/19/2021 22:58	8/20/2021 0:14	1.27	0.30	0.11	Summer	0.00	0	1.27
11	0.61	0.25	8/20/2021 14:50	8/20/2021 21:14	6.40	1.98	0.04	Summer	1.36	4902	6.40
12	2.71	0.82	8/23/2021 14:22	8/23/2021 14:58	0.60	3.96	1.37	Summer	2.73	18071	0.60
13	-	2.86	10/9/2021 1:50	10/9/2021 21:14	19.40	1.92	0.15	Fall	2.99	83606	19.40
14	6.79	0.13	10/16/2021 16:12	10/16/2021 17:14	1.03	0.36	0.13	Fall	0.00	0.00	1.03
15	9.18	1.49	10/25/2021 21:40	10/25/2021 23:14	1.57	3.78	0.95	Fall	2.50	22264	1.57
16	2.80	0.54	10/28/2021 18:20	10/29/2021 6:30	12.17	0.54	0.04	Fall	1.47	28280	12.17
Storm event	**Antecedent dry**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min**	**Average intensity**	**Season**	**Peak flow**	**Runoff volume**	**Runoff duration**

	period (days)					intensity (in/hr)	(in/hr)		(ft^3/s)	(ft^3)	(hr)
17	6.21	0.11	11/4/2021 11:30	11/4/2021 16:22	4.87	0.12	0.02	Fall	0.00	0.00	4.87
18	17.64	0.54	11/22/2021 7:38	11/22/2021 14:36	6.97	0.72	0.08	Fall	1.70	16887	5.90
19	3.54	0.13	11/26/2021 3:38	11/26/2021 7:58	4.33	0.24	0.03	Fall	0.00	0.00	0.00
20	11.90	0.51	12/8/2021 5:32	12/8/2021 13:22	7.83	0.84	0.07	Fall	2.89	26991	5.73
21	3.32	0.22	12/11/2021 20:56	12/12/2021 0:30	3.57	1.20	0.06	Fall	2.04	7432	2.33
22	6.99	0.93	12/19/2021 0:16	12/19/2021 18:34	18.30	0.42	0.05	Fall	4.09	87073	14.30
23	1.87	0.60	12/21/2021 15:24	12/22/2021 2:12	10.80	0.60	0.06	Fall	3.68	53054	8.43
24	7.97	0.21	12/30/2021 1:34	12/30/2021 3:26	1.87	0.30	0.11	Winter	1.62	7682	3.57
25	3.20	0.36	1/2/2022 8:16	1/2/2022 9:14	0.97	1.20	0.37	Winter	3.30	24162	4.93
26	0.45	2.58	1/2/2022 20:00	1/3/2022 14:46	18.77	1.20	0.14	Winter	3.42	123207	20.90
27	6.25	0.40	1/9/2022 20:42	1/10/2022 0:10	3.47	0.48	0.12	Winter	1.50	16869	5.20
28	6.49	1.46	1/16/2022 12:00	1/17/2022 0:28	12.47	0.72	0.12	Winter	2.79	68242	11.10
29	3.48	0.57	1/20/2022 12:00	1/20/2022 22:52	10.87	0.18	0.05	Winter	1.87	42370	11.27
30	1.65	0.24	1/22/2022 14:30	1/22/2022 17:40	3.17	0.18	0.08	Winter	0.68	9862	7.20
31	12.65	0.18	2/4/2022 9:16	2/4/2022 14:14	4.97	0.54	0.04	Winter	0.27	413	0.50
32	2.72	0.88	2/7/2022 7:32	2/7/2022 23:18	15.77	0.30	0.06	Winter	2.45	65259	13.00
33	10.17	0.34	2/18/2022 3:20	2/18/2022 6:16	2.93	0.84	0.12	Winter	1.26	11031	6.03
Storm event	**Antecedent dry period**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**

	(days)					(in/hr)					
34	9.14	0.19	2/27/2022 9:42	2/27/2022 16:06	6.40	0.12	0.03	Winter	0.52	2271	2.03
35	9.18	0.38	3/8/2022 20:26	3/9/2022 14:08	17.70	0.30	0.02	Winter	0.84	12728	9.47
36	2.26	0.16	3/11/2022 20:24	3/11/2022 23:28	3.07	0.24	0.05	Winter	0.93	9108	5.57
37	0.27	1.01	3/12/2022 5:54	3/12/2022 10:12	4.30	1.08	0.23	Winter	3.09	53109	15.90
38	4.31	1.51	3/16/2022 17:42	3/17/2022 11:04	17.37	1.32	0.09	Winter	2.93	93204	18.17
39	6.70	0.46	3/24/2022 3:50	3/24/2022 14:54	11.07	1.14	0.04	Spring	1.36	21970	9.00
40	6.89	1.16	3/31/2022 12:12	3/31/2022 17:34	5.37	1.74	0.22	Spring	2.93	34180	7.43
41	5.01	0.47	4/5/2022 17:54	4/6/2022 0:16	6.37	0.60	0.07	Spring	1.67	17705	8.73
42	2.27	0.21	4/8/2022 6:48	4/8/2022 11:00	4.20	0.60	0.05	Spring	1.29	8066	6.07
43	9.88	1.31	4/18/2022 8:02	4/18/2022 14:56	6.90	1.44	0.19	Spring	3.15	42203	13.87
44	13.16	0.17	5/1/2022 18:52	5/1/2022 21:10	2.30	0.54	0.07	Spring	0.00	0	0
45	4.86	0.30	5/6/2022 17:46	5/6/2022 23:50	6.07	1.86	0.05	Spring	0.00	0	0
46	0.68	0.20	5/7/2022 16:06	5/7/2022 19:20	3.23	1.20	0.06	Spring	0.08	100	0.97
47	15.90	0.55	5/23/2022 16:50	5/24/2022 6:20	13.50	1.86	0.04	Spring	3.42	30836	12.80
48	3.17	0.21	5/27/2022 10:30	5/27/2022 11:40	1.17	0.96	0.18	Spring	2.64	621638	7.43
49	0.26	0.20	5/27/2022 17:50	5/28/2022 3:04	9.23	0.84	0.02	Spring	3.04	30909	12.43
Storm event	**Antecedent dry**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min**	**Average intensity**	**Season**	**Peak flow**	**Runoff volume**	**Runoff duration**

	period (days)					intensity (in/hr)	(in/hr)		(ft^3/s)	(ft^3)	(hr)
50	11.68	0.26	6/8/2022 19:24	6/9/2022 1:36	6.20	1.56	0.04	Spring	0.00	0	0.00
51	7.68	0.48	6/16/2022 17:58	6/16/2022 18:54	0.93	2.28	0.51	Spring	0.96	1463	3.13
52	6.14	0.26	6/22/2022 22:22	6/23/2022 2:46	4.40	0.42	0.06	Summer	0.00	0	0.00
53	4.56	0.50	6/27/2022 16:14	6/27/2022 18:12	1.97	2.04	0.25	Summer	0.00	0	0.00
54	1.36	0.38	6/29/2022 2:56	6/29/2022 9:04	6.13	0.84	0.06	Summer	1.32	5542	5.17
55	6.44	0.47	7/5/2022 19:36	7/5/2022 20:02	0.43	4.26	1.08	Summer	1.05	1568	1.03
56	0.97	1.25	7/6/2022 19:22	7/6/2022 21:22	2.00	3.24	0.63	Summer	2.93	24192	8.10
57	0.83	1.12	7/7/2022 17:14	7/7/2022 19:12	1.97	5.64	0.57	Summer	3.04	27825	7.33
58	0.93	2.03	7/8/2022 17:28	7/9/2022 3:06	9.63	4.20	0.21	Summer	8.74	44227	7.63
59	0.64	1.40	7/9/2022 18:28	7/9/2022 23:14	4.77	3.30	0.29	Summer	3.09	45429	10.80
60	0.26	0.78	7/10/2022 5:26	7/10/2022 20:24	14.97	0.78	0.05	Summer	2.89	73549	18.40
61	4.90	0.20	7/15/2022 18:00	7/15/2022 18:38	0.63	0.78	0.32	Summer	0.04	282	3.57
62	7.83	0.11	7/23/2022 14:28	7/23/2022 14:48	0.33	0.54	0.33	Summer	0.00	0	0.00
63	1.04	0.56	7/24/2022 15:46	7/24/2022 17:24	1.63	1.26	0.34	Summer	1.74	6757	3.83
64	1.19	1.26	7/25/2022 21:54	7/26/2022 16:52	18.97	3.00	0.07	Summer	2.84	24352	7.83
65	0.89	0.12	7/27/2022 14:08	7/27/2022 21:04	6.93	0.90	0.02	Summer	0.00	0	0.00
Storm event	**Antecedent dry period (days)**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity (in/hr)**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**

66	0.79	0.15	7/28/2022 15:58	7/28/2022 20:34	4.60	1.08	0.03	Summer	0.30	447	0.80
67	2.72	0.62	7/31/2022 13:46	8/1/202 8:06	18.33	1.56	0.03	Summer	1.43	22893	13.47

Table 15. Summary of MP495 TSS data

Storm event	Sampled volume (ft^3)	Percentage of hydrograph (%)	TSS (mg/L)
1	16613	98	18.59
2	-	-	-
3	8566	71	18.13
4	-	-	-
5	-	-	-
6	-	-	8.50
7	-	-	-
8	19736	77	33.01
9	-	-	-
10	-	-	-
11	-	-	13.59
12	17816	99	37.99
13	-	-	-
14	-	-	-
15	-	-	15.06
16	-	-	7.79
17	-	-	-
18	16498	98	8.76
19	-	-	-
20	-	-	5.34
21	-	-	7.30
22	-	-	-
23	-	-	-
24	-	-	-
25	-	-	-
26	-	-	-
27	-	-	-
28	-	-	-
29	-	-	-
30	-	-	-
31	-	-	-
32	19955	31	8.40
33	-	-	11.16
34	-	-	-
35	-	-	-
36	-	-	-
37	-	-	-
38	-	-	-
39	20462	93	11.76
Storm event	Sampled volume (ft^3)	Percentage of hydrograph (%)	TSS (mg/L)

40	19870	58	17.68
41	16318	92	12.33
42	-	-	-
43	19621	46	9.32
44	-	-	-
45	-	-	-
46	-	-	-
47	20297	66	27.32
48	21846	4	24.80
49	-	-	-
50	-	-	-
51	-	-	-
52	-	-	-
53	-	-	-
54	3335	60	15.74
55	-	-	-
56	-	-	-
57	-	-	-
58	-	-	-
59	-	-	-
60	-	-	-
61	-	-	-
62	-	-	-
63	4567	68	15.32
64	19443	80	18.21
65	-	-	-
66	-	-	-
67	22443	98	8.33

Table 16. Summary of MP495 maximum velocities and potential maximum erosion rates from 1D steady analyses

Storm event	Maximum velocity (ft/s)	Permissible velocity exceeded	Velocity ratio	τ_a (lb/ft^2)	τ_a_Qp/τ_a	$\tau_a:\tau_c$	ε (in/s)
1	7.42	Yes	2.12	0.40	Less Qp	26.79	6.24E-03
2	8.88	Yes	2.54	0.52	Qp greater	34.82	8.18E-03
3	6.48	Yes	1.85	0.41	Less Qp	27.46	6.40E-03
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	7.22	Yes	2.06	0.38	Qp greater	25.45	5.91E-03
7	-	-	-	-	-	-	-
8	8.38	Yes	2.39	0.47	Qp greater	31.47	7.37E-03
9	11.41	Yes	3.26	0.67	Qp greater	44.87	1.06E-02
10	-	-	-	-	-	-	-
11	6.01	Yes	1.72	0.31	Qp greater	20.76	4.78E-03
12	7.28	Yes	2.08	0.37	Qp greater	24.78	5.75E-03
13	7.46	Yes	2.13	0.40	Less Qp	26.79	6.24E-03
14	-	-	-	-	-	-	-
15	7.11	Yes	2.03	0.37	Qp greater	24.78	5.75E-03
16	6.15	Yes	1.76	0.31	Qp greater	20.76	4.78E-03
17	-	-	-	-	-	-	-
18	6.41	Yes	1.83	0.34	Qp greater	22.77	5.26E-03
19	-	-	-	-	-	-	-
20	7.39	Yes	2.11	0.34	Qp greater	22.77	5.26E-03
21	6.73	Yes	1.92	0.35	Qp greater	23.44	5.43E-03
22	8.09	Yes	2.31	0.44	Qp greater	29.47	6.88E-03
23	7.86	Yes	2.24	0.42	Qp greater	28.13	6.56E-03
24	6.32	Yes	1.81	-	-	-	-
25	-	-	-	0.42	Less Qp	28.13	6.56E-03
26	-	-	-	0.41	Qp greater	27.46	6.40E-03
Storm event	**Maximum velocity**	**Permissible velocity**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**$\tau_a:\tau_c$**	**ε (in/s)**

	(ft/s)	exceeded					
27	-	-	-	0.32	Qp greater	21.43	4.94E-03
28	-	-	-	0.39	Qp greater	26.12	6.07E-03
29	-	-	-	0.35	Qp greater	23.44	5.43E-03
30	-	-	-	0.28	Less Qp	18.75	4.29E-03
31	-	-	-	-	-	-	-
32	7.07	Yes	2.02	0.37	Qp greater	24.78	5.75E-03
33	5.89	Yes	1.68	0.31	Less Qp	20.76	4.78E-03
34	4.64	Yes	1.33	0.28	Qp greater	18.75	4.29E-03
35	5.26	Yes	1.50	0.31	Less Qp	20.76	4.78E-03
36	5.41	Yes	1.55	0.31	Less Qp	20.76	4.78E-03
37	7.52	Yes	2.15	0.40	Qp greater	26.79	6.24E-03
38	7.42	Yes	2.12	0.40	Less Qp	26.79	6.24E-03
39	6.01	Yes	1.72	0.31	Qp greater	20.76	4.78E-03
40	7.42	Yes	2.12	0.39	Qp greater	26.12	6.07E-03
41	6.37	Yes	1.82	0.34	Qp greater	22.77	5.26E-03
42	5.93	Yes	1.69	0.31	Qp greater	20.76	4.78E-03
43	7.56	Yes	2.16	0.40	Qp greater	26.79	6.24E-03
44	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-
46	2.75	No	0.79	0.17	Less Qp	11.38	2.51E-03
47	7.72	Yes	2.21	0.25	Qp greater	16.74	3.81E-03
48	-	-	-	0.38	Qp greater	25.45	5.91E-03
49	7.49	Yes	2.14	-	-	-	-
50	-	-	-	-	-	-	-
51	5.46	Yes	1.56	0.30	Less Qp	20.09	4.62E-03
52	-	-	-	-	-	-	-
53	-	-	-	-	-	-	-
Storm event	**Maximum velocity (ft/s)**	**Permissible velocity exceeded**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**τ_a:τ_c**	**ε (in/s)**
54	5.97	Yes	1.71	0.31	Qp greater	20.76	4.78E-03

55	5.60	Yes	1.60	0.29	Less Qp	19.42	4.45E-03
56	7.42	Yes	2.12	0.39	Qp greater	26.12	6.07E-03
57	7.49	Yes	2.14	0.39	Qp greater	26.12	6.07E-03
58	10.08	Yes	2.88	0.59	Qp greater	39.51	9.31E-03
59	7.52	Yes	2.15	0.40	Qp greater	26.79	6.24E-03
60	7.39	Yes	2.11	0.40	Qp greater	26.79	6.24E-03
61	2.22	No	0.63	0.15	Less Qp	10.05	2.19E-03
62	-	-	-	-	-	-	-
63	6.45	Yes	1.84	0.34	Qp greater	22.77	5.26E-03
64	7.35	Yes	2.10	0.40	Qp greater	26.79	6.24E-03
65	-	-	-	-	-	-	-
66	4.01	Yes	1.15	0.23	Less Qp	15.40	3.48E-03
67	6.11	Yes	1.75	-	-	-	-

Note τ_a, Q_p, τ_c, and ε refer to applied shear stress, peak discharge, critical shear stress, and erosion rate, respectively

Table 17. Summary of MP495 maximum velocities and potential maximum erosion rates from 1D unsteady analyses

Storm event	τ_a (lb/ft^2)	τ_a:τ_c	ε (in/s)
1	6.40	428.59	0.10
2	7.57	506.94	0.12
3	4.73	316.75	0.08
4	-	-	-
5	-	-	-
6	6.14	411.18	0.10
7	-	-	-
8	7.02	470.11	0.11
9	-	-	-
10	-	-	-
11	4.66	312.07	0.08
12	6.23	417.20	0.10
13	6.45	431.94	0.10
14	-	-	-
15	5.97	399.79	0.10
16	4.47	299.34	0.07
17	-	-	-
18	4.66	312.07	0.08
19	-	-	-
20	6.36	425.91	0.10
21	5.25	351.58	0.08
22	6.95	465.42	0.11
23	6.82	456.71	0.11
24	-	-	-
25	6.63	443.99	0.11
26	6.69	448.01	0.11
27	4.41	295.32	0.07
28	6.28	420.55	0.10
29	4.91	328.81	0.08
30	4.66	312.07	0.08
31	-	-	-
32	5.91	395.77	0.10
33	4.66	312.07	0.08
34	4.66	312.07	0.08
35	4.66	312.07	0.08
36	4.66	312.07	0.08
37	6.52	436.62	0.11
38	6.40	428.59	0.10
Storm event	τ_a (lb/ft^2)	τ_a:τ_c	ε (in/s)

39	4.66	312.07	0.08
40	6.04	404.48	0.10
41	4.66	312.07	0.08
42	4.66	312.07	0.08
43	6.55	438.63	0.11
44	-	-	-
45	-	-	-
46	-	-	-
47	6.70	448.68	0.11
48	6.14	411.18	0.10
49	-	-	-
50	-	-	-
51	4.65	311.40	0.08
52	-	-	-
53	-	-	-
54	4.66	312.07	0.08
55	4.65	311.40	0.08
56	6.41	429.26	0.10
57	6.49	434.61	0.10
58	10.49	702.48	0.17
59	6.52	436.62	0.11
60	6.36	425.91	0.10
61	-	-	-
62	-	-	-
63	4.66	312.07	0.08
64	6.33	423.90	0.10
65	-	-	-
66	-	-	-
67	-	-	-

Note τ_a, τ_c, and ε refer to applied shear stress, critical shear stress, and erosion rate, respectively

Table 18. Summary of MP814 hydrologic and runoff data

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
1	-	0.83	7/2/2021 7:14	7/2/2021 9:22	2.13	1.56	0.39	Summer	13.54	42464	3.37
2	0.61	0.20	7/2/2021 23:54	7/3/2021 5:16	5.37	0.60	0.04	Summer	12.51	25175	2.67
3	5.13	3.55	7/8/2021 8:28	7/8/2021 17:58	9.50	1.80	0.37	Summer	18.06	314863	15.87
4	29.70	0.45	8/7/2021 10:40	8/7/2021 11:26	0.77	3.42	0.59	Summer	12.89	10449	1.33
5	1.28	0.68	8/8/2021 18:10	8/8/2021 22:00	3.83	3.84	0.18	Summer	18.75	24439	1.97
6	7.83	0.46	8/16/2021 18:00	8/17/2021 3:50	9.83	2.34	0.05	Summer	9.22	12297	2.00
7	2.82	0.64	8/19/2021 23:30	8/20/2021 4:20	4.83	2.70	0.13	Summer	13.38	26052	3.50
8	0.45	0.66	8/20/2021 15:12	8/20/2021 16:50	1.63	4.14	0.40	Summer	18.25	27420	1.80
9	11.97	0.26	9/1/2021 16:00	9/1/2021 23:00	0.29	-	-	Summer	1.38	3206	4.33
10	6.86	0.43	9/8/2021 19:32	9/8/2021 20:00	0.47	2.94	0.92	Summer	13.75	9503	1.43
11	0.61	1.56	9/9/2021 10:44	9/9/2021 13:28	2.73	3.72	0.57	Summer	19.97	61748	4.00
12	12.40	1.30	9/21/2021 23:10	9/22/2021 15:26	16.27	4.14	0.08	Summer	18.67	72099	23.80
13	16.51	5.42	10/9/2021 3:36	10/9/2021 16:36	13.00	5.28	0.42	Fall	42.57	470186	14.00
14	6.98	0.15	10/16/2021 16:06	10/16/2021 16:42	0.60	0.78	0.25	Fall	7.88	11511	1.20
15	8.76	0.69	10/25/2021 10:52	10/25/2021 11:52	1.00	2.04	0.69	Fall	15.54	50690	10.93
16	0.42	0.78	10/25/2021 21:54	10/26/2021 2:12	4.30	4.26	0.18	Fall	23.58	64313	3.60
Storm event	**Antecedent dry**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min**	**Average intensity**	**Season**	**Peak flow**	**Runoff volume**	**Runoff duration**

	period (days)					intensity (in/hr)	(in/hr)		(ft^3/s)	(ft^3)	(hr)
17	2.85	0.83	10/28/2021 22:32	10/29/2021 7:44	9.20	3.12	0.09	Fall	19.06	53767	8.40
18	24.01	0.27	11/22/2021 8:02	11/22/2021 14:02	6.00	0.18	0.05	Fall	0.81	10939	6.77
19	19.28	0.37	12/11/2021 20:40	12/11/2021 21:22	0.70	2.58	0.53	Fall	15.62	13394	1.80
20	7.34	0.73	12/19/2021 5:36	12/19/2021 15:48	10.20	0.30	0.07	Fall	2.79	43902	11.97
21	2.09	0.20	12/21/2021 17:56	12/22/2021 3:16	9.33	0.12	0.02	Fall	0.85	13970	9.10
22	11.20	0.38	1/2/2022 8:08	1/2/2022 10:02	1.90	1.32	0.20	Winter	9.09	18016	1.97
23	0.48	3.55	1/2/2022 21:38	1/4/2022 4:02	30.40	1.92	0.12	Winter	26.39	400408	21.20
24	5.71	0.30	1/9/2022 21:02	1/10/2022 1:50	4.80	0.30	0.06	Winter	2.46	17480	3.87
25	6.56	1.17	1/16/2022 15:10	1/17/2022 22:00	30.83	0.30	0.04	Winter	5.93	78647	8.30
26	2.71	0.25	1/20/2022 15:00	1/20/2022 19:28	4.47	0.30	0.06	Winter	-	-	-
27	17.62	0.28	2/7/2022 10:26	2/8/2022 1:08	14.70	0.30	0.02	Winter	2.18	45119	19.20
28	10.10	0.17	2/18/2022 3:32	2/18/2022 5:06	1.57	0.42	0.11	Winter	2.51	19645	6.57
29	18.68	0.31	3/8/2022 21:22	3/9/2022 12:52	15.50	0.24	0.02	Winter	1.71	41071	17.97
30	2.39	1.08	3/11/2022 22:14	3/12/2022 9:40	11.43	1.08	0.09	Winter	10.34	107503	16.00
31	4.31	1.41	3/16/2022 17:12	3/17/2022 10:34	17.37	0.84	0.08	Winter	9.77	199378	20.60
32	6.82	0.59	3/24/2022 6:18	3/24/2022 13:22	7.07	1.68	0.08	Spring	5.88	24183	9.97
33	6.96	1.06	3/31/2022 12:26	3/31/2022 16:42	4.27	2.04	0.25	Spring	-	-	-
Storm event	**Antecedent dry period**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**

	(days)					(in/hr)					
34	5.07	0.26	4/5/2022 18:22	4/5/2022 21:40	3.30	0.54	0.08	Spring	4.49	39278	14.43
35	1.74	0.54	4/7/2022 15:32	4/7/2022 16:28	0.93	2.28	0.58	Spring	19.46	49780	5.53
36	10.66	1.01	4/18/2022 8:12	4/18/2022 15:10	6.97	0.60	0.14	Spring	8.32	75636	9.07
37	19.01	0.97	5/7/2022 15:28	5/7/2022 19:40	4.20	5.64	0.23	Spring	18.83	51836	9.30
38	6.72	0.76	5/14/2022 12:58	5/14/2022 13:54	0.93	3.12	0.81	Spring	13.72	51338	8.20
39	2.21	0.10	5/16/2022 19:00	5/16/2022 19:00	1.00	-	-	Spring	1.38	1499	1.20
40	6.88	2.12	5/23/2022 16:08	5/24/2022 5:02	12.90	4.26	0.16	Spring	-	-	-
41	3.51	0.21	5/27/2022 17:16	5/27/2022 17:50	0.57	0.90	0.37	Spring	-	-	-
42	0.35	0.45	5/28/2022 2:18	5/28/2022 11:12	8.90	2.70	0.05	Spring	-	-	-
43	11.32	0.14	6/8/2022 18:54	6/8/2022 22:08	3.23	0.24	0.04	Spring	-	-	-
44	14.14	0.12	6/23/2022 1:34	6/23/2022 3:42	2.13	0.42	0.06	Summer	2.17	9216	4.43
45	4.53	0.59	6/27/2022 16:30	6/27/2022 19:30	3.00	3.18	0.20	Summer	14.80	21990	2.87
46	1.39	0.57	6/29/2022 4:50	6/29/2022 9:42	4.87	3.30	0.12	Summer	14.07	17991	4.90
47	8.38	-	7/7/2022 18:42	7/7/2022 20:32	-	-	-	Summer	5.05	7875	1.83
48	0.98	0.13	7/8/2022 20:04	7/9/2022 0:58	4.90	0.18	0.03	Summer	3.77	8935	2.10
49	1.57	0.16	7/10/2022 14:34	7/10/2022 16:40	2.10	0.30	0.08	Summer	4.57	14109	3.43
Storm event	**Antecedent dry**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min**	**Average intensity**	**Season**	**Peak flow**	**Runoff volume**	**Runoff duration**

	period (days)					intensity (in/hr)	(in/hr)		(ft^3/s)	(ft^3)	(hr)
50	-	-	-	7/13/2022 0:00	-	-	-	Summer	0.24	721	1.37
51	-	-	-	7/15/2022 0:00	-	-	-	Summer	0.16	391	1.13
52	-	-	-	7/21/2022 0:00	-	-	-	Summer	5.75	2419	0.83
53	-	-	-	7/23/2022 0:00	-	-	-	Summer	0.30	689	1.57
54	-	-	-	7/24/2022 0:00	-	-	-	Summer	0.97	988	1.03
55	2.63	0.17	7/26/2022 15:04	7/26/2022 16:06	1.03	0.78	0.16	Summer	3.34	4136	1.13
56	1.17	0.92	7/27/2022 20:10	7/27/2022 22:28	2.30	2.88	0.40	Summer	16.67	36067	7.43
57	3.57	0.39	7/31/2022 12:06	8/1/2022 9:12	21.10	1.56	0.02	Summer	7.63	33159	12.53

Table 19. Summary of MP814 TSS data

Storm event	Sampled volume (ft^3)	Percentage of hydrograph (%)	TSS (mg/L)
1	-	-	-
2	-	-	-
3	73580	23	13.19
4	-	-	-
5	-	-	-
6	-	-	-
7	-	-	-
8	-	-	213.15
9	-	-	37.80
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	4114	36	167.43
15	50624	100	36.23
16	-	-	-
17	47341	88	65.09
18	9372	86	19.43
19	-	-	47.94
20	-	-	-
21	-	-	-
22	-	-	-
23	-	-	-
24	-	-	-
25	-	-	-
26	-	-	-
27	-	-	-
28	13500	69	18.94
29	-	-	-
30	-	-	-
31	-	-	-
32	-	-	-
33	-	-	-
34	39127	100	15.61
35	-	-	-
36	-	-	-
37	51836	100	66.49
38	41431	81	90.04
39	600	40	18.75
Storm event	**Sampled volume (ft^3)**	**Percentage of hydrograph (%)**	**TSS (mg/L)**

40	-	-	-
41	-	-	-
42	-	-	-
43	-	-	-
44	-	-	-
45	-	-	-
46	-	-	-
47	-	-	-
48	-	-	-
49	-	-	-
50	-	-	-
51	-	-	-
52	-	-	-
53	-	-	-
54	-	-	-
55	2111	51	140.00
56	-	-	-
57	31049	94	161.52

Table 20. Summary of MP814 maximum velocities and potential maximum erosion rates from 1D steady analyses

Storm event	Maximum velocity (ft/s)	Permissible velocity exceeded	Velocity ratio	τ_a (lb/ft^2)	τ_a_Qp/τ_a	τ_a:τ_c	ε (in/s)
1	7.37	Yes	2.10	0.33	Qp greater	10.50	1.13E-02
2	7.22	Yes	2.06	0.57	Less Qp	18.13	2.04E-02
3	7.99	Yes	2.28	0.57	Less Qp	18.13	2.04E-02
4	7.28	Yes	2.08	0.50	Less Qp	15.91	1.77E-02
5	8.07	Yes	2.31	0.52	Less Qp	16.54	1.85E-02
6	6.66	Yes	1.90	0.51	Less Qp	16.23	1.81E-02
7	7.35	Yes	2.10	0.54	Less Qp	17.18	1.93E-02
8	8.01	Yes	2.29	0.56	Less Qp	17.82	2.00E-02
9	3.99	Yes	1.14	0.37	Qp greater	11.77	1.28E-02
10	7.39	Yes	2.11	0.53	Less Qp	16.86	1.89E-02
11	8.22	Yes	2.35	0.57	Less Qp	18.13	2.04E-02
12	8.06	Yes	2.30	0.53	Less Qp	16.86	1.89E-02
13	10.26	Yes	2.93	0.56	Less Qp	17.82	2.00E-02
14	6.39	Yes	1.83	0.55	Less Qp	17.50	1.96E-02
15	7.64	Yes	2.18	0.40	Less Qp	12.73	1.40E-02
16	8.62	Yes	2.46	0.57	Less Qp	18.13	2.04E-02
17	8.11	Yes	2.32	0.56	Less Qp	17.82	2.00E-02
18	3.44	No	0.98	0.32	Less Qp	10.18	1.09E-02
19	7.65	Yes	2.19	0.55	Less Qp	17.50	1.96E-02
20	4.80	Yes	1.37	0.49	Qp greater	15.59	1.74E-02
21	3.49	No	1.00	0.32	Less Qp	10.18	1.09E-02
22	6.64	Yes	1.90	0.53	Less Qp	16.86	1.89E-02
23	8.91	Yes	2.54	0.57	Less Qp	18.13	2.04E-02
24	4.65	Yes	1.33	0.45	Qp greater	14.32	1.58E-02
25	5.91	Yes	1.69	0.57	Less Qp	18.13	2.04E-02
26	-	-	-	-	-	-	-
Storm event	**Maximum velocity**	**Permissible velocity**	**Velocity ratio**	τ_a **(lb/ft^2)**	τ_a**_Qp/**τ_a	τ_a:τ_c	**ε (in/s)**

	(ft/s)	**exceeded**					
27	4.51	Yes	1.29	0.44	Qp greater	14.00	1.55E-02
28	4.68	Yes	1.34	0.48	Qp greater	15.27	1.70E-02
29	4.23	Yes	1.21	0.39	Qp greater	12.41	1.36E-02
30	6.87	Yes	1.96	0.55	Less Qp	17.50	1.96E-02
31	6.77	Yes	1.93	0.56	Less Qp	17.82	2.00E-02
32	5.90	Yes	1.68	0.57	Less Qp	18.13	2.04E-02
33	-	-	-	-	-	-	-
34	5.47	Yes	1.56	0.57	Less Qp	18.13	2.04E-02
35	8.16	Yes	2.33	0.53	Less Qp	16.86	1.89E-02
36	6.48	Yes	1.85	0.57	Less Qp	18.13	2.04E-02
37	8.08	Yes	2.31	0.52	Less Qp	16.54	1.85E-02
38	7.39	Yes	2.11	0.53	Less Qp	16.86	1.89E-02
39	3.99	Yes	1.14	0.37	Qp greater	11.77	1.28E-02
40	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-
44	4.50	Yes	-	-	-	-	4.50
45	7.54	Yes	-	-	-	-	7.54
46	7.43	Yes	0.52	Less Qp	16.54	1.85E-02	7.43
47	5.65	Yes	0.52	Less Qp	16.54	1.85E-02	5.65
48	5.21	Yes	0.55	Qp greater	17.50	1.96E-02	5.21
49	5.49	Yes	0.53	Less Qp	16.86	1.89E-02	5.49
50	2.43	No	0.26	Less Qp	8.27	8.65E-03	2.43
51	2.17	No	0.22	Less Qp	7.00	7.14E-03	2.17
52	5.86	Yes	0.52	Less Qp	16.54	1.85E-02	5.86
53	2.59	No	0.26	Qp greater	8.27	8.65E-03	2.59
Storm event	**Maximum velocity (ft/s)**	**Permissible velocity exceeded**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**τ_a:τ_c**	**ε (in/s)**
54	3.63	Yes	0.32	Qp greater	10.18	1.09E-02	3.63

55	5.03	Yes	0.52	Less Qp	16.54	1.85E-02	5.03
56	7.80	Yes	0.57	Less Qp	18.13	2.04E-02	7.80
57	6.33	Yes	0.52	Less Qp	16.54	1.85E-02	6.33

Note τ_a, Q_p, τ_c, and ε refer to applied shear stress, peak discharge, critical shear stress, and erosion rate, respectively

Table 21. Summary of MP814 maximum velocities and potential maximum erosion rates from 1D unsteady analyses

Storm event	τ_a (lb/ft^2)	τ_a:τ_c	ε (in/s)
1	1.14	36.27	0.04
2	0.54	17.18	0.02
3	-	-	-
4	-	-	-
5	-	-	-
6	-	-	-
7	-	-	-
8	-	-	-
9	-	-	-
10	-	-	-
11	0.57	18.13	0.02
12	-	-	-
13	0.66	21.00	0.02
14	-	-	-
15	-	-	-
16	0.28	8.91	0.01
17	-	-	-
18	-	-	-
19	-	-	-
20	-	-	-
21	-	-	-
22	-	-	-
23	-	-	-
24	-	-	-
25	-	-	-
26	-	-	-
27	-	-	-
28	-	-	-
29	-	-	-
30	-	-	-
31	-	-	-
32	-	-	-
33	-	-	-
34	-	-	-
35	-	-	-
36	-	-	-
37	-	-	-
38	-	-	-
Storm event	**τ_a (lb/ft^2)**	**τ_a:τ_c**	**ε (in/s)**

39	-	-	-
40	-	-	-
41	-	-	-
42	-	-	-
43	-	-	-
44	-	-	-
45	-	-	-
46	-	-	-
47	-	-	-
48	-	-	-
49	-	-	-
50	-	-	-
51	-	-	-
52	-	-	-
53	-	-	-
54	-	-	-
55	-	-	-
56	-	-	-
57	-	-	-

Note τ_a, τ_c, and ε refer to applied shear stress, critical shear stress, and erosion rate, respectively

Table 22. Summary of MP840 hydrologic and runoff data

Storm event	Antecedent dry period (days)	Depth (in)	Storm start	Storm end	Duration (hr)	Max. 5-min intensity (in/hr)	Average intensity (in/hr)	Season	Peak flow (ft^3/s)	Runoff volume (ft^3)	Runoff duration (hr)
1	-	0.83	7/2/2021 7:14	7/2/2021 9:22	2.13	1.56	0.39	Summer	3.34	6188	1.47
2	0.61	0.20	7/2/2021 23:54	7/3/2021 5:16	5.37	0.60	0.04	Summer	1.08	2377	4.23
3	0.28	0.10	7/3/2021 12:00	7/3/2021 12:40	0.68	-	-	Summer	0.00	0	-
4	4.81	3.15	7/8/2021 8:09	7/8/2021 19:41	11.54	-	-	Summer	-	-	-
5	0.84	0.30	7/9/2021 15:52	7/9/2021 18:53	3.01	-	-	Summer	-	-	-
6	9.09	0.68	7/18/2021 21:00	7/19/2021 17:00	0.83	-	-	Summer	1.43	4189	20.73
7	18.74	0.45	8/7/2021 10:40	8/7/2021 11:26	0.77	3.42	0.59	Summer	-	-	-
8	1.28	0.68	8/8/2021 18:10	8/8/2021 22:00	3.83	3.84	0.18	Summer	-	-	-
9	7.83	0.46	8/16/2021 18:00	8/17/2021 3:50	9.83	2.34	0.05	Summer	-	-	-
10	2.82	0.64	8/19/2021 23:30	8/20/2021 4:20	4.83	2.70	0.13	Summer	-	-	-
11	0.45	0.66	8/20/2021 15:12	8/20/2021 16:50	1.63	4.14	0.40	Summer	-	-	-
12	19.11	0.43	9/8/2021 19:32	9/8/2021 20:00	0.47	2.94	0.92	Summer	0.54	443	0.33
13	0.61	1.56	9/9/2021 10:44	9/9/2021 13:28	2.73	3.72	0.57	Summer	7.12	10079	2.67
14	12.40	1.30	9/21/2021 23:10	9/22/2021 15:26	16.27	4.14	0.08	Summer	1.43	5887	16.70
15	12.11	0.12	10/4/2021 18:00	10/4/2021 23:00	0.21	-	-	Fall	0.38	1334	4.23
16	4.20	3.68	10/9/2021 3:46	10/9/2021 15:00	11.24	-	-	Fall	-	-	-
Storm event	**Antecedent dry**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min**	**Average intensity**	**Season**	**Peak flow**	**Runoff volume**	**Runoff duration**

	period (days)					**intensity (in/hr)**	**(in/hr)**		**(ft^3/s)**	**(ft^3)**	**(hr)**
17	7.05	0.13	10/16/2021 16:07	10/16/2021 16:17	0.17	-	-	Fall	0.72	1425	1.00
18	8.77	0.19	10/25/2021 10:43	10/25/2021 11:30	0.78	-	-	Fall	-	-	-
19	0.41	0.99	10/25/2021 21:26	10/26/2021 2:22	4.93	-	-	Fall	-	-	-
20	2.71	0.70	10/28/2021 19:25	10/29/2021 6:13	10.80	-	-	Fall	-	-	-
21	24.08	0.27	11/22/2021 8:02	11/22/2021 14:02	6.00	0.18	0.05	Fall	1.75	18887	7.33
22	15.62	0.44	12/8/2021 4:52	12/8/2021 7:57	3.08	-	-	Fall	1.12	9222	3.90
23	3.49	0.10	12/11/2021 19:49	12/11/2021 22:28	2.65	-	-	Fall	1.51	7973	4.60
24	7.07	0.70	12/19/2021 0:13	12/19/2021 16:36	16.38	-	-	Fall	0.49	9960	14.33
25	1.95	0.20	12/21/2021 15:23	12/22/2021 1:13	9.84	-	-	Fall	0.74	9789	9.67
26	7.96	0.13	12/30/2021 0:22	12/30/2021 3:32	3.16	-	-	Winter	0.64	4171	3.23
27	3.19	0.38	1/2/2022 8:08	1/2/2022 10:02	1.90	1.32	0.20	Winter	1.08	8636	6.13
28	0.50	0.53	1/2/2022 22:06	1/3/2022 7:40	9.56	-	-	Winter	1.18	11776	9.63
29	6.56	0.30	1/9/2022 21:02	1/10/2022 1:50	4.80	0.30	0.06	Winter	6.31	37663	7.33
30	6.56	1.17	1/16/2022 15:10	1/17/2022 22:00	30.83	0.30	0.04	Winter	81.94	195489	14.67
31	2.71	0.25	1/20/2022 15:00	1/20/2022 19:28	4.47	0.30	0.06	Winter	2.52	37578	15.77
32	14.52	0.19	2/4/2022 7:53	2/4/2022 9:43	1.83	0.42	0.10	Winter	-	-	-
33	2.89	0.36	2/7/2022 7:03	2/7/2022 21:51	14.80	0.24	0.02	Winter	-	-	-
Storm event	**Antecedent dry period**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min intensity**	**Average intensity (in/hr)**	**Season**	**Peak flow (ft^3/s)**	**Runoff volume (ft^3)**	**Runoff duration (hr)**

	(days)					**(in/hr)**					
34	10.18	0.37	2/18/2022 2:10	2/18/2022 5:52	3.70	0.54	0.10	Winter	1.36	5463	3.93
35	9.16	0.17	2/27/2022 9:36	2/27/2022 15:01	5.42	0.12	0.03	Winter	0.52	943	0.80
36	9.19	0.33	3/8/2022 19:35	3/9/2022 13:04	17.48	0.18	0.02	Winter	0.52	10958	16.57
37	2.67	0.83	3/12/2022 5:05	3/12/2022 8:28	3.38	0.42	0.25	Winter	0.61	4964	6.03
38	4.30	0.32	3/16/2022 15:45	3/17/2022 8:56	17.18	0.66	0.02	Winter	0.98	28865	20.50
39	6.83	1.03	3/24/2022 4:48	3/24/2022 13:17	8.48	0.84	0.12	Spring	1.12	7319	11.00
40	6.93	0.92	3/31/2022 11:33	3/31/2022 16:46	5.22	0.96	0.18	Spring	-	-	-
41	5.04	0.30	4/5/2022 7:48	4/5/2022 20:16	2.47	0.42	0.12	Spring	0.41	2516	5.00
42	12.48	0.97	4/18/2022 7:53	4/18/2022 14:40	6.78	0.42	0.14	Spring	0.34	3804	9.27
43	18.10	0.12	5/6/2022 16:59	5/6/2022 21:04	4.08	0.42	0.03	Spring	0.00	0	-
44	0.51	0.63	5/7/2022 9:23	5/7/2022 18:45	9.37	0.72	0.07	Spring	0.45	3356	4.07
45	5.12	0.11	5/12/2022 21:39	5/12/2022 22:33	0.90	0.54	0.12	Spring	-	-	-
46	1.54	0.13	5/14/2022 11:27	5/14/2022 13:56	2.48	0.18	0.05	Spring	-	-	-
47	2.18	0.25	5/16/2022 18:17	5/16/2022 18:48	0.52	0.84	0.48	Spring	-	-	-
48	3.23	0.31	5/20/2022 0:24	5/20/2022 5:51	5.45	0.60	0.06	Spring	-	-	-
49	3.43	1.64	5/23/2022 16:09	5/24/2022 5:14	13.08	2.82	0.13	Spring	-	-	-
Storm event	**Antecedent dry**	**Depth (in)**	**Storm start**	**Storm end**	**Duration (hr)**	**Max. 5-min**	**Average intensity**	**Season**	**Peak flow**	**Runoff volume**	**Runoff duration**

	period (days)					intensity (in/hr)	(in/hr)		(ft^3/s)	(ft^3)	(hr)
50	3.21	0.14	5/27/2022 10:17	5/27/2022 10:38	0.35	0.72	0.40	Spring	0.00	0	-
51	0.26	0.82	5/27/2022 16:57	5/27/2022 18:14	1.28	1.74	0.64	Spring	-	-	-
52	12.03	0.20	6/8/2022 18:55	6/8/2022 22:02	3.12	0.48	0.06	Spring	0.16	945	4.63
53	8.87	0.18	6/17/2022 18:49	6/18/2022 0:09	5.33	0.48	0.03	Spring	-	-	-
54	4.95	0.13	6/22/2022 23:00	6/23/2022 3:28	4.47	0.24	0.03	Summer	1.40	6447	5.50
55	4.55	0.12	6/27/2022 16:36	6/27/2022 17:47	1.18	0.24	0.10	Summer	0.58	2381	3.17
56	1.45	0.54	6/29/2022 4:39	6/29/2022 8:53	4.23	1.26	0.13	Summer	0.24	1090	5.37
57	4.66	0.50	7/4/2022 0:37	7/4/2022 5:50	5.22	1.02	0.10	Summer	-	-	-
58	3.53	0.56	7/7/2022 18:27	7/8/2022 1:02	6.58	1.98	0.09	Summer	-	-	-
59	1.74	0.39	7/9/2022 18:46	7/9/2022 23:08	4.37	0.54	0.09	Summer	0.15	701	2.80
60	0.33	0.28	7/10/2022 7:09	7/10/2022 17:53	10.73	0.30	0.03	Summer	0.16	1572	11.70
61	12.85	0.25	7/23/2022 14:19	7/23/2022 15:40	1.35	0.42	0.19	Summer	0.29	861	2.87
62	2.97	0.13	7/26/2022 14:58	7/26/2022 16:07	1.15	0.42	0.11	Summer	0.16	488	4.33
63	5.17	0.45	7/31/2022 20:14	7/31/2022 23:32	3.30	2.10	0.14	Summer	0.13	633	4.97

Table 23. Summary of MP840 TSS data

Storm event	Sampled volume (ft^3)	Percentage of hydrograph (%)	TSS (mg/L)
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	-	-	
6	1805	43	25.89
7	-	-	-
8	-	-	-
9	-	-	-
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	474	36	13.15
16	-	-	-
17	877	62	26.94
18	-	-	-
19	-	-	-
20	-	-	-
21	18281	97	11.12
22	-	-	-
23	-	-	8.86
24	-	-	-
25	-	-	-
26	-	-	-
27	-	-	-
28	-	-	-
29	-	-	-
30	-	-	-
31	-	-	-
32	-	-	-
33	-	-	-
34	5280	97	64.22
35	442	47	27.59
36	-	-	-
37	-	-	-
38	-	-	-
39	5328	73	26.86
Storm event	**Sampled volume (ft^3)**	**Percentage of hydrograph (%)**	**TSS (mg/L)**

40	-	-	-
41	-	-	-
42	-	-	-
43	-	-	-
44	2258	67	15.68
45	-	-	-
46	-	-	-
47	-	-	-
48	-	-	-
49	-	-	-
50	-	-	-
51	-	-	-
52	-	-	-
53	-	-	-
54	-	-	-
55	-	-	-
56	-	-	-
57	-	-	-
58	-	-	-
59	-	-	-
60	-	-	-
61	-	-	-
62	-	-	-
63	-	-	-

Table 24. Summary of MP840 maximum velocities and potential maximum erosion rates from 1D steady analyses

Storm event	Maximum velocity (ft/s)	Permissible velocity exceeded	Velocity ratio	τ_a (lb/ft^2)	τ_a_Qp/τ_a	τ_a:τ_c	ε (in/s)
1	7.26	Yes	2.90	0.65	Qp greater	76.85	1.84E-02
2	5.33	Yes	2.13	0.38	Qp greater	44.93	1.06E-02
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	5.73	Yes	2.29	0.46	Qp greater	54.38	1.29E-02
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-
12	4.43	Yes	1.77	-	-	-	-
13	8.87	Yes	3.55	0.79	Qp greater	93.40	2.24E-02
14	5.73	Yes	2.29	0.46	Qp greater	54.38	1.29E-02
15	4.04	Yes	1.61	0.24	Qp greater	28.37	6.63E-03
16	-	-	-	-	-	-	-
17	4.79	Yes	1.92	0.30	Qp greater	35.47	8.35E-03
18	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-
21	6.07	Yes	2.43	0.52	Qp greater	61.48	1.46E-02
22	5.38	Yes	2.15	0.39	Qp greater	46.11	1.09E-02
23	5.82	Yes	2.33	0.46	Qp greater	54.38	1.29E-02
24	4.31	Yes	1.73	0.24	Less Qp	28.37	6.63E-03
25	4.83	Yes	1.93	0.30	Qp greater	35.47	8.35E-03
26	4.64	Yes	1.85	0.27	Qp greater	31.92	7.49E-03
Storm event	Maximum velocity (ft/s)	Permissible velocity exceeded	Velocity ratio	τ_a (lb/ft^2)	τ_a_Qp/τ_a	τ_a:τ_c	ε (in/s)
27	5.33	Yes	2.13	0.42	Less Qp	49.65	1.18E-02
28	5.46	Yes	2.18	0.40	Qp greater	47.29	1.12E-02
29	8.58	Yes	3.43	0.78	Qp greater	92.22	2.21E-02
30	18.41	Yes	7.36	1.57	Less Qp	185.61	4.47E-02
31	6.72	Yes	2.69	0.60	Qp greater	70.94	1.69E-02
32	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-
34	5.66	Yes	2.27	0.44	Qp greater	52.02	1.24E-02
35	4.38	Yes	1.75	0.24	Qp greater	28.37	6.63E-03
36	4.38	Yes	1.75	0.24	Qp greater	28.37	6.63E-03

37	4.59	Yes	1.84	0.26	Qp greater	30.74	7.20E-03
38	5.20	Yes	2.08	0.35	Qp greater	41.38	9.78E-03
39	5.38	Yes	2.15	0.39	Qp greater	46.11	1.09E-02
40	-	-	-	-	-	-	-
41	4.11	Yes	1.64	0.24	Less Qp	28.37	6.63E-03
42	3.91	Yes	1.56	0.19	Less Qp	22.46	5.20E-03
43	-	-	-	-	-	-	-
44	4.21	Yes	1.68	0.24	Less Qp	28.37	6.63E-03
45	-	-	-	-	-	-	-
46	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-
51	-	-	-	-	-	-	-
52	3.17	Yes	1.27	-	-	-	-
53	-	-	-	-	-	-	-
Storm event	**Maximum velocity (ft/s)**	**Permissible velocity exceeded**	**Velocity ratio**	**τ_a (lb/ft^2)**	**τ_a_Qp/τ_a**	**τ_a:τ_c**	**ε (in/s)**
54	5.70	Yes	2.28	0.45	Qp greater	53.20	1.26E-02
55	4.53	Yes	1.81	0.26	Qp greater	30.74	7.20E-03
56	3.54	Yes	1.41	0.18	Qp greater	21.28	4.91E-03
57	-	-	-	-	-	-	-
58	-	-	-	-	-	-	-
59	3.10	Yes	1.24	0.11	Qp greater	13.00	2.91E-03
60	3.17	Yes	1.27	-	-	-	-
61	3.74	Yes	1.49	0.19	Less Qp	22.46	5.20E-03
62	3.17	Yes	1.27	0.11	Qp greater	13.00	2.91E-03
63	2.94	Yes	1.18	0.11	Qp greater	13.00	2.91E-03

Note τ_a, Q_p, τ_c, and ε refer to applied shear stress, peak discharge, critical shear stress, and erosion rate, respectively

Appendix G: JET test data for monitored sites

JET Data Input

Site:	MP458 Outlet LOB
Date:	10/5/2022
Test ID:	KLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0984
Dishcarge Coefficient:	0.627

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, please enter 1.

Suggested values of k_d as a function of τ_c:

Hanson and Simon (2001)

$k_d = 0.2\tau_c^{-0.5}$ | k

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$ | k

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$ | k

Scour Depth Readings						Head Setting	
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)	Time (min)	Head (in)
0	0	34	0.112	0.888	0.000	0	24.72
0.25	0.25	34	0.112	0.888	0.000	0.25	24.72
0.5	0.25	37	0.121	0.879	0.010	0.5	24.72
0.75	0.25	38	0.125	0.875	0.013	0.75	24.72
1	0.25	42	0.138	0.862	0.026	1	24.72
1.25	0.25	42	0.138	0.862	0.026	1.25	24.72
1.5	0.25	43	0.141	0.859	0.030	1.5	24.72
1.75	0.25	44	0.144	0.856	0.033	1.75	24.72
2	0.25	44	0.144	0.856	0.033	2	24.72
2.25	0.25	45	0.148	0.852	0.036	2.25	24.72
2.5	0.25	46	0.151	0.849	0.039	2.5	24.72
2.75	0.25	47	0.154	0.846	0.043	2.75	24.72
3	0.25	48	0.157	0.843	0.046	3	24.72
3.25	0.25	48	0.157	0.843	0.046	3.25	24.72
3.5	0.25	48	0.157	0.843	0.046	3.5	24.72
4	0.5	50	0.164	0.836	0.052	4	24.72
4.5	0.5	50	0.164	0.836	0.052	4.5	24.72
5	0.5	51	0.167	0.833	0.056	5	24.72
5.5	0.5	52	0.171	0.829	0.059	5.5	24.72
6	0.5	52	0.171	0.829	0.059	6	24.72
6.5	0.5	53	0.174	0.826	0.062	6.5	24.72
7	0.5	53	0.174	0.826	0.062	7	24.72
7.5	0.5	53	0.174	0.826	0.062	7.5	24.72
8.5	1	53	0.174	0.826	0.062	8.5	24.72
9.5	1	54	0.177	0.823	0.066	9.5	24.72
10.5	1	54	0.177	0.823	0.066	10.5	24.72
11.5	1	55	0.180	0.820	0.069	11.5	24.72
12.5	1	55	0.180	0.820	0.069	12.5	24.72
13.5	1	56	0.184	0.816	0.072	13.5	24.72
14.5	1	57	0.187	0.813	0.075	14.5	24.72
15.5	1	57	0.187	0.813	0.075	15.5	24.72
16.5	1	57	0.187	0.813	0.075	16.5	24.72
18.5	2	58	0.190	0.810	0.079	18.5	24.72
20.5	2	59	0.194	0.806	0.082	20.5	24.72
22.5	2	59	0.194	0.806	0.082	22.5	24.72
27.5	5	60	0.197	0.803	0.085	27.5	24.72

Figure 1. Summary of MP458 outlet left bank raw data

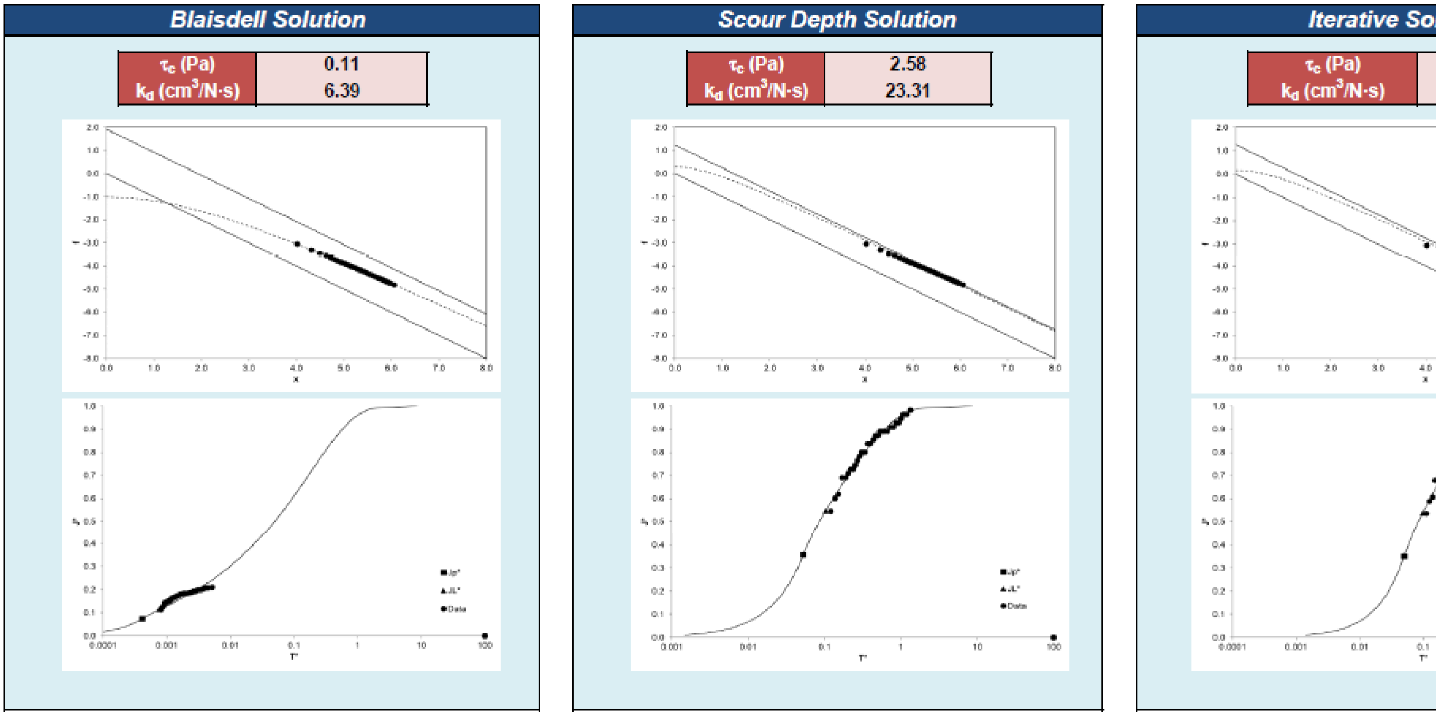


Figure 2. Summary of MP458 outlet left bank erodibility parameters

JET Data Input

Site:	MP458 Outlet ROB
Date:	10/5/2022
Test ID:	KROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0951
Dishcarge Coefficient:	0.62

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, pleas

Suggested values of k_d as a funct

Hanson and Simon (200

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	33	0.108	0.892	0.000
0.25	0.25	34	0.112	0.888	0.003
0.5	0.25	35	0.115	0.885	0.007
0.75	0.25	36	0.118	0.882	0.010
1	0.25	37	0.121	0.879	0.013
1.25	0.25	38	0.125	0.875	0.016
1.5	0.25	38	0.125	0.875	0.016
1.75	0.25	39	0.128	0.872	0.020
2	0.25	39	0.128	0.872	0.020
2.25	0.25	40	0.131	0.869	0.023
2.5	0.25	41	0.135	0.865	0.026
2.75	0.25	42	0.138	0.862	0.030
3	0.25	43	0.141	0.859	0.033
3.25	0.25	44	0.144	0.856	0.036
3.5	0.25	44	0.144	0.856	0.036
3.75	0.25	46	0.151	0.849	0.043
4	0.25	46	0.151	0.849	0.043
4.25	0.25	46	0.151	0.849	0.043
4.75	0.5	46	0.151	0.849	0.043
5.25	0.5	47	0.154	0.846	0.046
5.75	0.5	48	0.157	0.843	0.049
6.25	0.5	48	0.157	0.843	0.049
6.75	0.5	49	0.161	0.839	0.052
7.25	0.5	49	0.161	0.839	0.052
7.75	0.5	49	0.161	0.839	0.052
8.75	1	50	0.164	0.836	0.056
9.75	1	50	0.164	0.836	0.056
10.75	1	50	0.164	0.836	0.056
12.75	2	52	0.171	0.829	0.062
14.75	2	52	0.171	0.829	0.062

Head Setting	
Time (min)	Head (in)
0	24.72
0.25	24.72
0.5	24.72
0.75	24.72
1	24.72
1.25	24.72
1.5	24.72
1.75	24.72
2	24.72
2.25	24.72
2.5	24.72
2.75	24.72
3	24.72
3.25	24.72
3.5	24.72
3.75	24.72
4	24.72
4.25	24.72
4.75	24.72
5.25	24.72
5.75	24.72
6.25	24.72
6.75	24.72
7.25	24.72
7.75	24.72
8.75	24.72
9.75	24.72
10.75	24.72
12.75	24.72
14.75	24.72

Figure 3. Summary of MP458 outlet right bank raw data

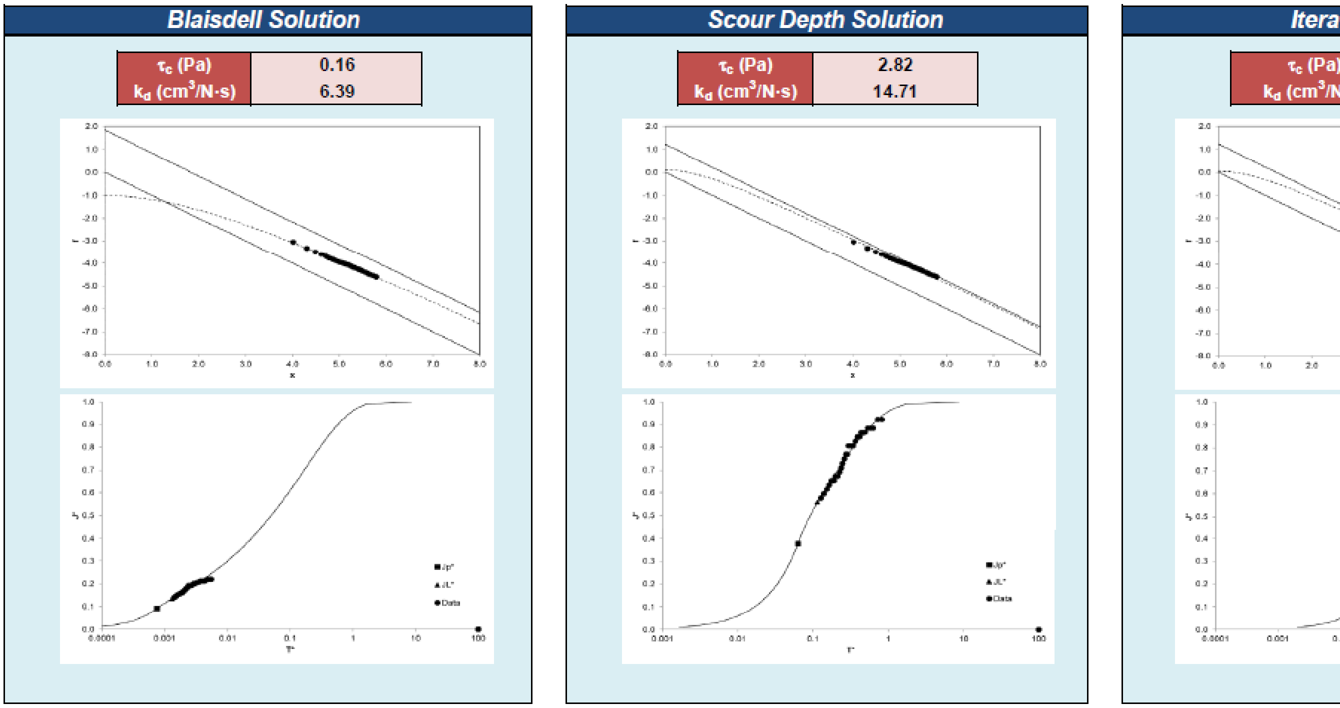


Figure 4. Summary of MP458 outlet right bank erodibility parameters

JET Data Input

Site:	MP458 Intermediate LOB
Date:	10/5/2022
Test ID:	LLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1115
Dishcarge Coefficient:	0.62

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess
Suggested values of k_d as a
Hanson and Simo
$k_d = 0.2\tau_c^{-0}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	38	0.125	0.875	0.000
0.25	0.25	38	0.125	0.875	0.000
0.5	0.25	39	0.128	0.872	0.003
0.75	0.25	40	0.131	0.869	0.007
1	0.25	41	0.135	0.865	0.010
1.25	0.25	42	0.138	0.862	0.013
1.5	0.25	43	0.141	0.859	0.016
1.75	0.25	44	0.144	0.856	0.020
2	0.25	44	0.144	0.856	0.020
2.25	0.25	45	0.148	0.852	0.023
2.5	0.25	46	0.151	0.849	0.026
2.75	0.25	46	0.151	0.849	0.026
3	0.25	47	0.154	0.846	0.030
3.25	0.25	47	0.154	0.846	0.030
3.5	0.25	47	0.154	0.846	0.030
4	0.5	48	0.157	0.843	0.033
4.5	0.5	48	0.157	0.843	0.033
5	0.5	49	0.161	0.839	0.036
5.5	0.5	50	0.164	0.836	0.039
6	0.5	50	0.164	0.836	0.039
6.5	0.5	50	0.164	0.836	0.039
7.5	1	50	0.164	0.836	0.039
8.5	1	52	0.171	0.829	0.046
9.5	1	53	0.174	0.826	0.049
10.5	1	53	0.174	0.826	0.049
11.5	1	53	0.174	0.826	0.049
13.5	2	53	0.174	0.826	0.049
15.5	2	53	0.174	0.826	0.049
20.5	5	54	0.177	0.823	0.052
25.5	5	54	0.177	0.823	0.052

Head Setting	
Time (min)	Head (in)
0	66.48
0.25	66.48
0.5	66.48
0.75	66.48
1	66.48
1.25	66.48
1.5	66.48
1.75	66.48
2	66.48
2.25	66.48
2.5	66.48
2.75	66.48
3	66.48
3.25	66.48
3.5	66.48
4	66.48
4.5	66.48
5	66.48
5.5	66.48
6	66.48
6.5	66.48
7.5	66.48
8.5	66.48
9.5	66.48
10.5	66.48
11.5	66.48
13.5	66.48
15.5	66.48
20.5	66.48
25.5	66.48

Figure 5. Summary of MP458 intermediate left bank raw data

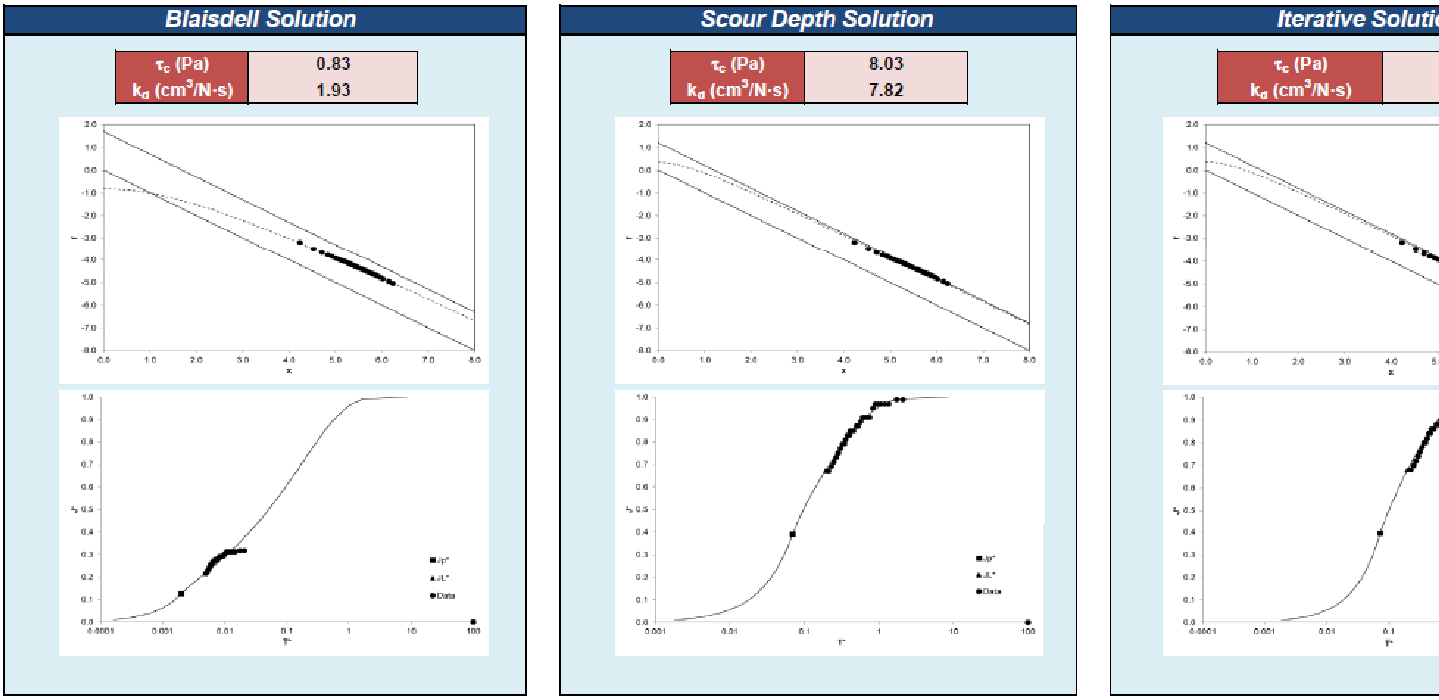


Figure 6. Summary of MP458 intermediate left bank erodibility parameters

JET Data Input

Site:	MP458 Intermediate ROB
Date:	10/5/2022
Test ID:	LROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1214
Dishcarge Coefficient:	0.609

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, please e
Suggested values of k_d as a function
Hanson and Simon (2001)
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	41	0.135	0.865	0.000
0.25	0.25	44	0.144	0.856	0.010
0.5	0.25	46	0.151	0.849	0.016
0.75	0.25	46	0.151	0.849	0.016
1	0.25	47	0.154	0.846	0.020
1.25	0.25	48	0.157	0.843	0.023
1.5	0.25	49	0.161	0.839	0.026
1.75	0.25	51	0.167	0.833	0.033
2	0.25	53	0.174	0.826	0.039
2.25	0.25	56	0.184	0.816	0.049
2.5	0.25	60	0.197	0.803	0.062
2.75	0.25	67	0.220	0.780	0.085
3	0.25	68	0.223	0.777	0.089
3.25	0.25	69	0.226	0.774	0.092
3.5	0.25	70	0.230	0.770	0.095
3.75	0.25	72	0.236	0.764	0.102
4	0.25	72	0.236	0.764	0.102
4.25	0.25	74	0.243	0.757	0.108
4.5	0.25	77	0.253	0.747	0.118
4.75	0.25	80	0.262	0.738	0.128
5	0.25	80	0.262	0.738	0.128
5.25	0.25	80	0.262	0.738	0.128
5.75	0.5	82	0.269	0.731	0.135
6.25	0.5	82	0.269	0.731	0.135
6.75	0.5	84	0.276	0.724	0.141
7.25	0.5	85	0.279	0.721	0.144
7.75	0.5	85	0.279	0.721	0.144
8.25	0.5	85	0.279	0.721	0.144
9.25	1	86	0.282	0.718	0.148
10.25	1	87	0.285	0.715	0.151
11.25	1	88	0.289	0.711	0.154
12.25	1	88	0.289	0.711	0.154
13.25	1	88	0.289	0.711	0.154
15.25	2	90	0.295	0.705	0.161
17.25	2	90	0.295	0.705	0.161

Head Setting	
Time (min)	Head (in)
0	66.48
0.25	66.48
0.5	66.48
0.75	66.48
1	66.48
1.25	66.48
1.5	66.48
1.75	66.48
2	66.48
2.25	66.48
2.5	24.48
2.75	24.48
3	24.48
3.25	24.48
3.5	24.48
3.75	24.48
4	24.48
4.25	24.48
4.5	24.48
4.75	24.48
5	24.48
5.25	24.48
5.75	24.48
6.25	24.48
6.75	24.48
7.25	24.48
7.75	24.48
8.25	24.48
9.25	24.48
10.25	24.48
11.25	24.48
12.25	24.48
13.25	24.48
15.25	24.48
17.25	24.48

Figure 7. Summary of MP458 intermediate right bank raw data

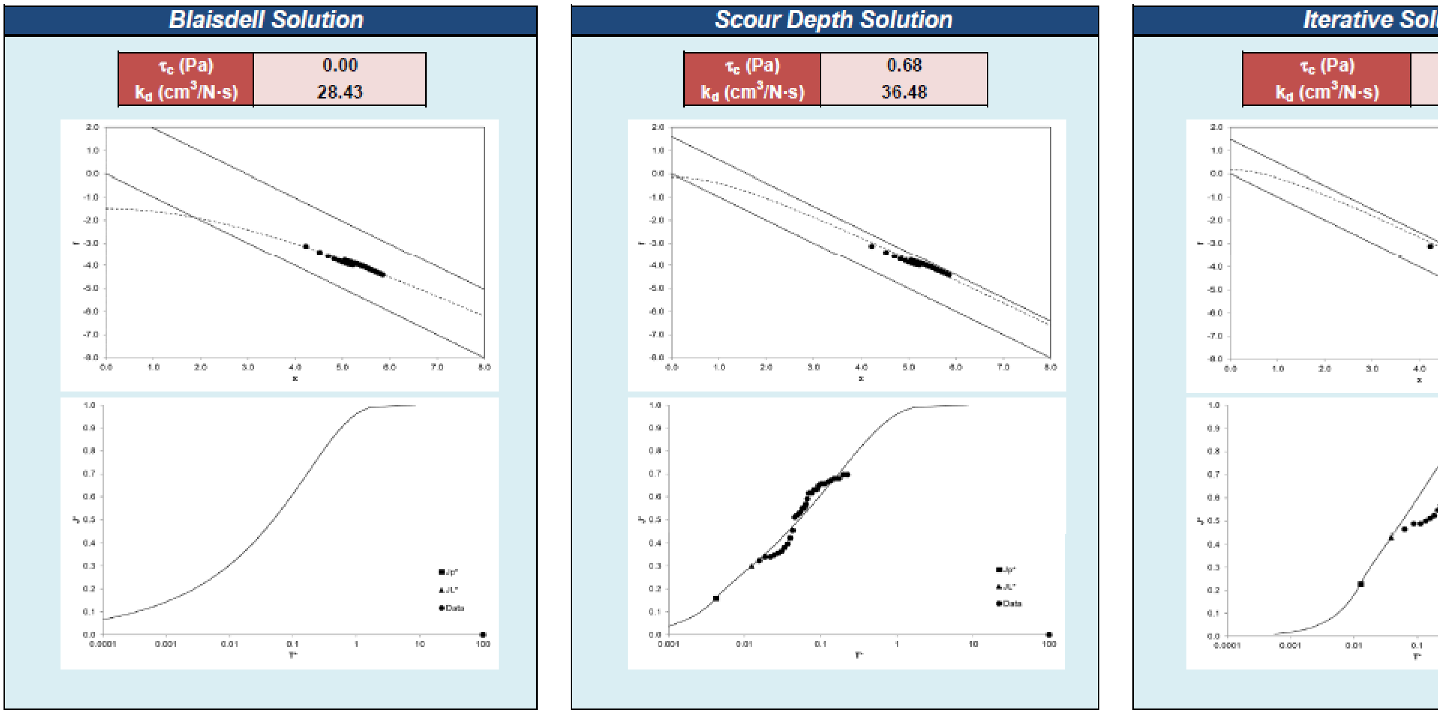


Figure 8. Summary of MP458 intermediate right bank erodibility parameters

JET Data Input

Site:	MP458 Final LOB
Date:	10/5/2022
Test ID:	MLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1050
Dishcarge Coefficient:	0.614

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess,
Suggested values of k_d as a
Hanson and Simon
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings							Head Setting	
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)		Time (min)	Head (in)
0	0	36	0.118	0.882	0.000		0	24.72
0.25	0.25	39	0.128	0.872	0.010		0.25	24.72
0.5	0.25	40	0.131	0.869	0.013		0.5	24.72
0.75	0.25	41	0.135	0.865	0.016		0.75	24.72
1	0.25	43	0.141	0.859	0.023		1	24.72
1.25	0.25	45	0.148	0.852	0.030		1.25	24.72
1.5	0.25	47	0.154	0.846	0.036		1.5	24.72
1.75	0.25	49	0.161	0.839	0.043		1.75	24.72
2	0.25	51	0.167	0.833	0.049		2	24.72
2.25	0.25	52	0.171	0.829	0.052		2.25	24.72
2.5	0.25	53	0.174	0.826	0.056		2.5	24.72
2.75	0.25	56	0.184	0.816	0.066		2.75	24.72
3	0.25	58	0.190	0.810	0.072		3	24.72
3.25	0.25	59	0.194	0.806	0.075		3.25	24.72
3.5	0.25	60	0.197	0.803	0.079		3.5	24.72
3.75	0.25	62	0.203	0.797	0.085		3.75	24.72
4	0.25	63	0.207	0.793	0.089		4	24.72
4.25	0.25	64	0.210	0.790	0.092		4.25	24.72
4.5	0.25	66	0.217	0.783	0.098		4.5	24.72
4.75	0.25	68	0.223	0.777	0.105		4.75	24.72
5	0.25	68	0.223	0.777	0.105		5	24.72
5.25	0.25	70	0.230	0.770	0.112		5.25	24.72
5.5	0.25	71	0.233	0.767	0.115		5.5	24.72
5.75	0.25	72	0.236	0.764	0.118		5.75	24.72
6	0.25	73	0.240	0.760	0.121		6	24.72
6.25	0.25	75	0.246	0.754	0.128		6.25	24.72
6.5	0.25	75	0.246	0.754	0.128		6.5	24.72
6.75	0.25	75	0.246	0.754	0.128		6.75	24.72

Figure 9. Summary of MP458 final left bank raw data

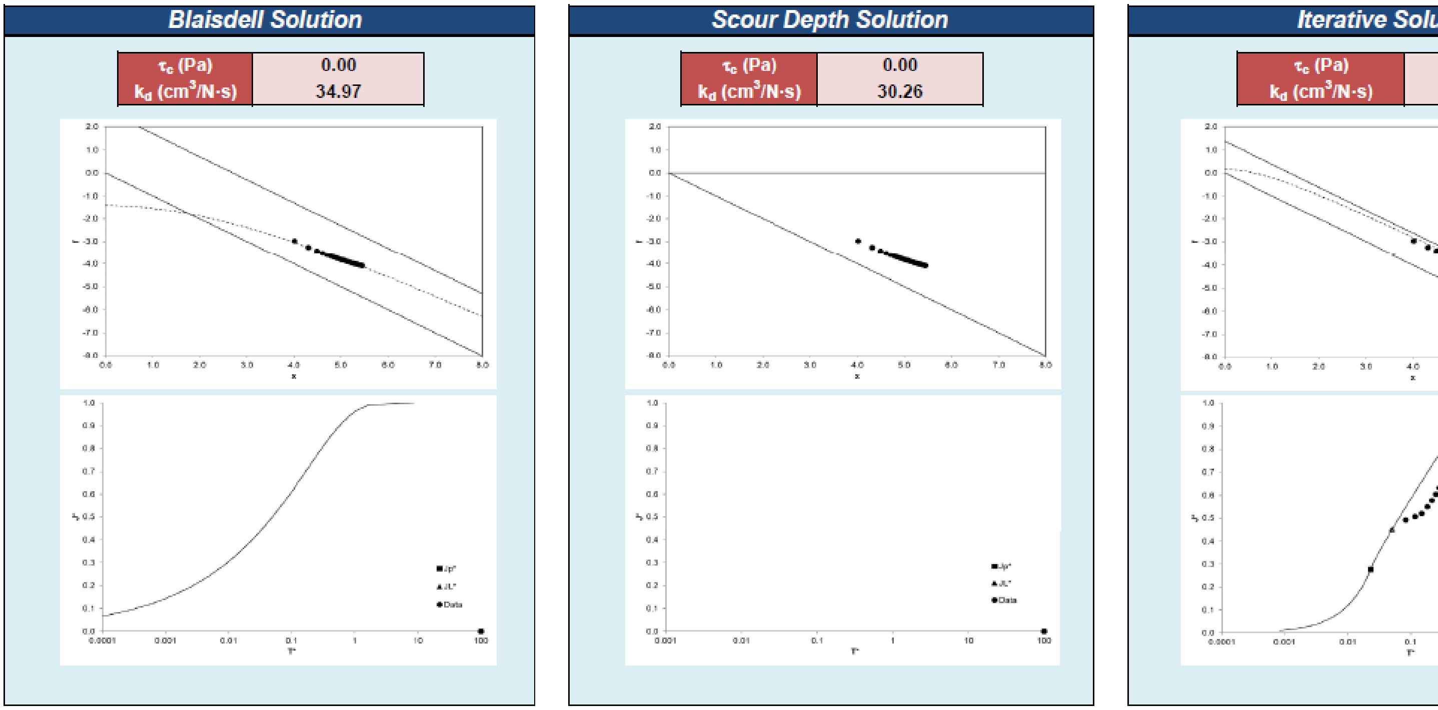


Figure 10. Summary of MP458 final left bank erodibility parameters

JET Data Input

Site:	MP459 Outlet LOB
Date:	9/5/2022
Test ID:	GLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1083
Dishcarge Coefficient:	0.635

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, plea

Suggested values of k_d as a func

Hanson and Simon (200

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	37	0.121	0.879	0.000
0.25	0.25	38	0.125	0.875	0.003
0.5	0.25	39	0.128	0.872	0.007
0.75	0.25	40	0.131	0.869	0.010
1	0.25	40	0.131	0.869	0.010
1.25	0.25	41	0.135	0.865	0.013
1.5	0.25	41	0.135	0.865	0.013
1.75	0.25	43	0.141	0.859	0.020
2	0.25	42	0.138	0.862	0.016
2.25	0.25	43	0.141	0.859	0.020
2.5	0.25	43	0.141	0.859	0.020
2.75	0.25	43	0.141	0.859	0.020
3.25	0.5	43	0.141	0.859	0.020
3.75	0.5	44	0.144	0.856	0.023
4.25	0.5	45	0.148	0.852	0.026
4.75	0.5	46	0.151	0.849	0.030
5.25	0.5	46	0.151	0.849	0.030
5.75	0.5	47	0.154	0.846	0.033
6.25	0.5	48	0.157	0.843	0.036
6.75	0.5	49	0.161	0.839	0.039
7.25	0.5	49	0.161	0.839	0.039
7.75	0.5	50	0.164	0.836	0.043
8.25	0.5	50	0.164	0.836	0.043
8.75	0.5	51	0.167	0.833	0.046
9.25	0.5	51	0.167	0.833	0.046
9.75	0.5	51	0.167	0.833	0.046
10.75	1	51	0.167	0.833	0.046
11.75	1	51	0.167	0.833	0.046
12.75	1	51	0.167	0.833	0.046
14.75	2	52	0.171	0.829	0.049
16.75	2	52	0.171	0.829	0.049
18.75	2	52	0.171	0.829	0.049
23.75	5	52	0.171	0.829	0.049
28.75	5	52	0.171	0.829	0.049

Head Setting	
Time (min)	Head (in)
0	72.48
0.25	72.48
0.5	72.48
0.75	72.48
1	72.48
1.25	72.48
1.5	72.48
1.75	72.48
2	72.48
2.25	72.48
2.5	72.48
2.75	72.48
3.25	72.48
3.75	72.48
4.25	72.48
4.75	72.48
5.25	72.48
5.75	72.48
6.25	72.48
6.75	72.48
7.25	72.48
7.75	72.48
8.25	72.48
8.75	72.48
9.25	72.48
9.75	72.48
10.75	72.48
11.75	72.48
12.75	72.48
14.75	72.48
16.75	72.48
18.75	72.48
23.75	72.48
28.75	72.48

Figure 11. Summary of MP459 outlet left bank raw data

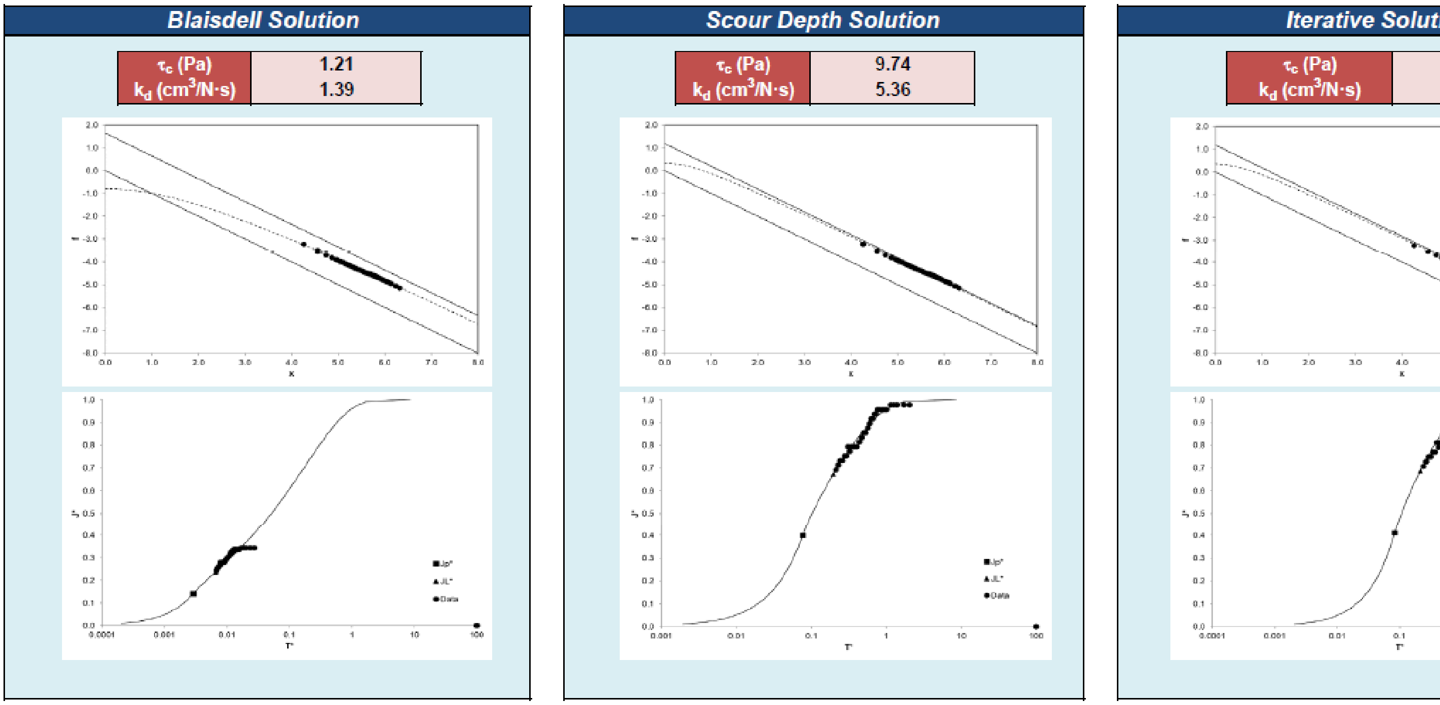


Figure 12. Summary of MP459 outlet left bank erodibility parameters

JET Data Input

Site:	MP459 Outlet ROB
Date:	9/5/2022
Test ID:	GROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0787
Dishcarge Coefficient:	0.62

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

*** If you do not have a guess,**

Suggested values of k_d as a

Hanson and Simon

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.8}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	***Diff Time (min)***	***Pt Gage Reading (mm)***	***Depth (ft)***	***Pt Gage Reading (ft)***	***Maximum Depth of Scour (ft)***
0	0	28	0.092	0.908	0.000
0.25	0.25	30	0.098	0.902	0.007
0.5	0.25	30	0.098	0.902	0.007
0.75	0.25	30	0.098	0.902	0.007
1.25	0.5	31	0.102	0.898	0.010
1.75	0.5	34	0.112	0.888	0.020
2.25	0.5	35	0.115	0.885	0.023
2.75	0.5	35	0.115	0.885	0.023
3.25	0.5	36	0.118	0.882	0.026
3.75	0.5	37	0.121	0.879	0.030
4.25	0.5	38	0.125	0.875	0.033
4.75	0.5	40	0.131	0.869	0.039
5.25	0.5	41	0.135	0.865	0.043
5.75	0.5	42	0.138	0.862	0.046
6.25	0.5	42	0.138	0.862	0.046
6.75	0.5	42	0.138	0.862	0.046
7.75	1	43	0.141	0.859	0.049
8.75	1	45	0.148	0.852	0.056
9.75	1	45	0.148	0.852	0.056
10.75	1	45	0.148	0.852	0.056

Head Setting	
Time (min)	***Head (in)***
0	72.48
0.25	72.48
0.5	72.48
0.75	72.48
1.25	72.48
1.75	72.48
2.25	72.48
2.75	72.48
3.25	72.48
3.75	72.48
4.25	72.48
4.75	72.48
5.25	72.48
5.75	72.48
6.25	72.48
6.75	72.48
7.75	72.48
8.75	72.48
9.75	72.48
10.75	72.48

Figure 13. Summary of MP459 outlet right bank raw data

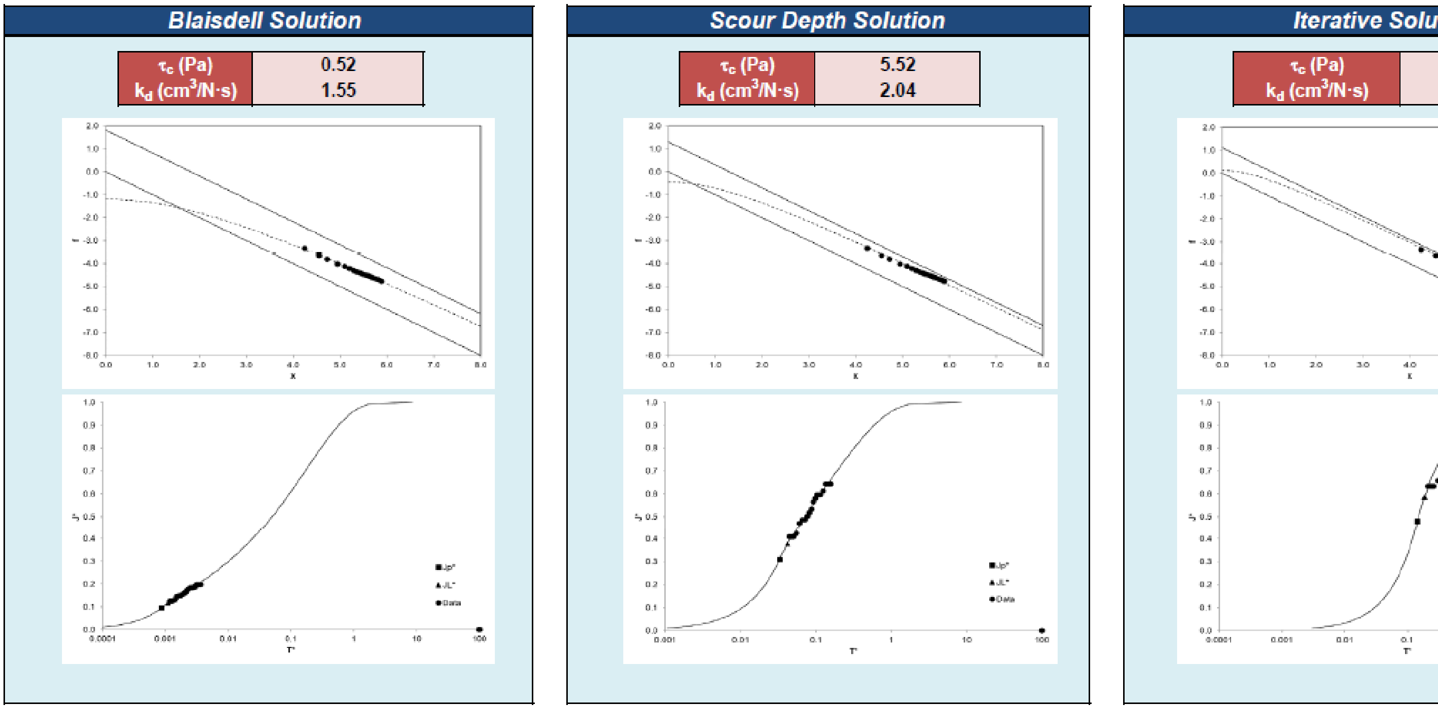


Figure 14. Summary of MP459 outlet right bank erodibility parameters

JET Data Input

Site:	MP459 Outfall LOB
Date:	9/10/2022
Test ID:	HLOB Trial B
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0984
Dishcarge Coefficient:	0.606

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess, ple
Suggested values of k_d as a fun
Hanson and Simon (20
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	*Diff Time (min)*	*Pt Gage Reading (mm)*	*Depth (ft)*	*Pt Gage Reading (ft)*	*Maximum Depth of Scour (ft)*
0	0	34	0.112	0.888	0.000
0.25	0.25	34	0.112	0.888	0.000
0.5	0.25	35	0.115	0.885	0.003
0.75	0.25	35	0.115	0.885	0.003
1	0.25	35	0.115	0.885	0.003
1.5	0.5	36	0.118	0.882	0.007
2	0.5	37	0.121	0.879	0.010
2.5	0.5	37	0.121	0.879	0.010
3	0.5	37	0.121	0.879	0.010
4	1	38	0.125	0.875	0.013
5	1	38	0.125	0.875	0.013
6	1	39	0.128	0.872	0.016
7	1	40	0.131	0.869	0.020
8	1	40	0.131	0.869	0.020
9	1	40	0.131	0.869	0.020
11	2	41	0.135	0.865	0.023
13	2	41	0.135	0.865	0.023
15	2	41	0.135	0.865	0.023
20	5	42	0.138	0.862	0.026
25	5	42	0.138	0.862	0.026
30	5	42	0.138	0.862	0.026

Head Setting	
Time (min)	*Head (in)*
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.5	24.48
2	24.48
2.5	24.48
3	24.48
4	24.48
5	24.48
6	24.48
7	24.48
8	24.48
9	24.48
11	24.48
13	24.48
15	24.48
20	24.48
25	24.48
30	24.48

Figure 15. Summary of MP459 outfall left bank raw data

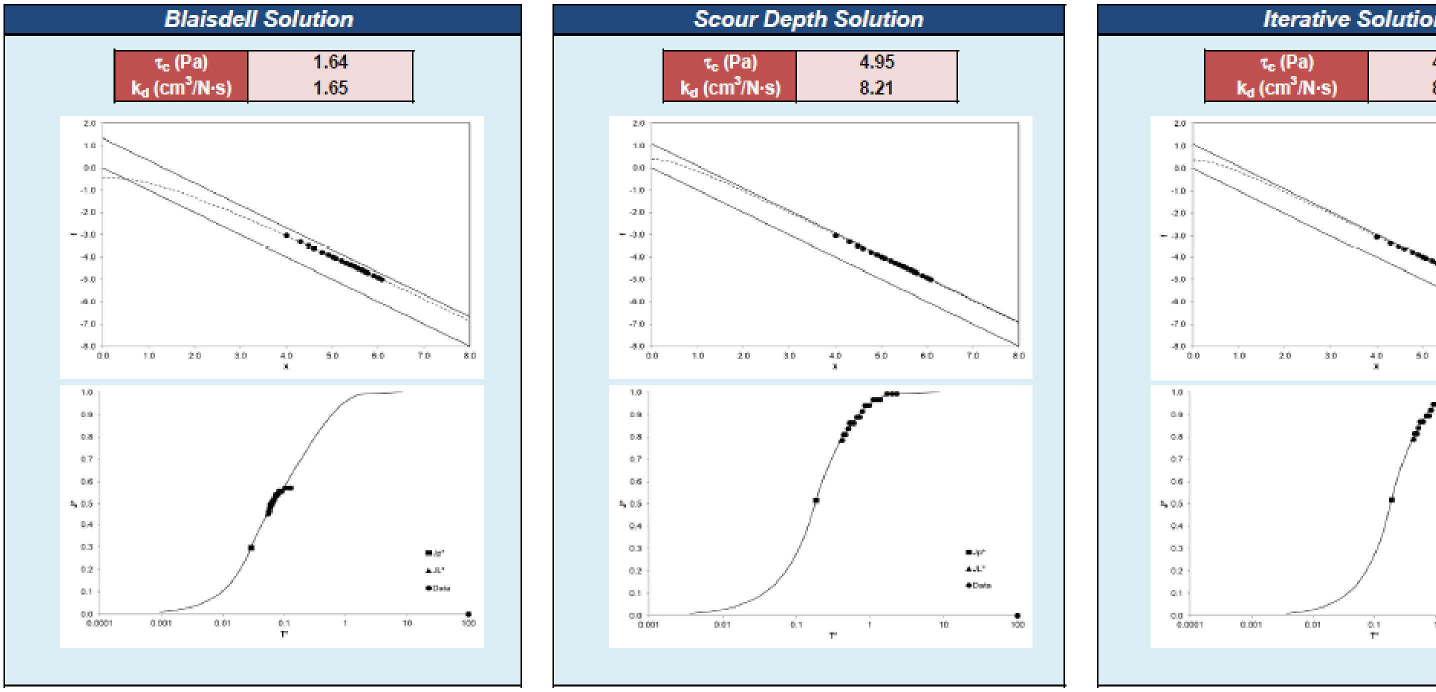


Figure 16. Summary of MP459 outfall left bank erodibility parameters

JET Data Input

Site:	MP459 Outfall ROB
Date:	9/10/2022
Test ID:	HROB Trial B
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1017
Dishcarge Coefficient:	0.609

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess,
Suggested values of k_d as a

Hanson and Simon
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.8}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	*Diff Time (min)*	*Pt Gage Reading (mm)*	*Depth (ft)*	*Pt Gage Reading (ft)*	*Maximum Depth of Scour (ft)*
0	0	35	0.115	0.885	0.000
0.25	0.25	36	0.118	0.882	0.003
0.5	0.25	37	0.121	0.879	0.007
0.75	0.25	37	0.121	0.879	0.007
1	0.25	38	0.125	0.875	0.010
1.25	0.25	38	0.125	0.875	0.010
1.5	0.25	39	0.128	0.872	0.013
1.75	0.25	40	0.131	0.869	0.016
2	0.25	40	0.131	0.869	0.016
2.25	0.25	40	0.131	0.869	0.016
2.75	0.5	41	0.135	0.865	0.020
3.25	0.5	42	0.138	0.862	0.023
3.75	0.5	43	0.141	0.859	0.026
4.25	0.5	43	0.141	0.859	0.026
4.75	0.5	43	0.141	0.859	0.026
5.75	1	44	0.144	0.856	0.030
6.75	1	45	0.148	0.852	0.033
7.75	1	46	0.151	0.849	0.036
8.75	1	47	0.154	0.846	0.039
9.75	1	48	0.157	0.843	0.043
10.75	1	50	0.164	0.836	0.049
11.75	1	51	0.167	0.833	0.052
12.75	1	52	0.171	0.829	0.056
13.75	1	54	0.177	0.823	0.062
14.75	1	54	0.177	0.823	0.062
15.75	1	54	0.177	0.823	0.062
17.75	2	56	0.184	0.816	0.069
19.75	2	56	0.184	0.816	0.069
21.75	2	58	0.190	0.810	0.075
23.75	2	58	0.190	0.810	0.075
25.75	2	58	0.190	0.810	0.075
30.75	5	58	0.190	0.810	0.075

Head Setting	
Time (min)	*Head (in)*
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.25	24.48
1.5	24.48
1.75	24.48
2	24.48
2.25	24.48
2.75	24.48
3.25	24.48
3.75	24.48
4.25	24.48
4.75	24.48
5.75	24.48
6.75	24.48
7.75	24.48
8.75	24.48
9.75	24.48
10.75	24.48
11.75	24.48
12.75	24.48
13.75	24.48
14.75	24.48
15.75	24.48
17.75	24.48
19.75	24.48
21.75	24.48
23.75	24.48
25.75	24.48
30.75	24.48

Figure 17. Summary of MP459 outfall right bank raw data

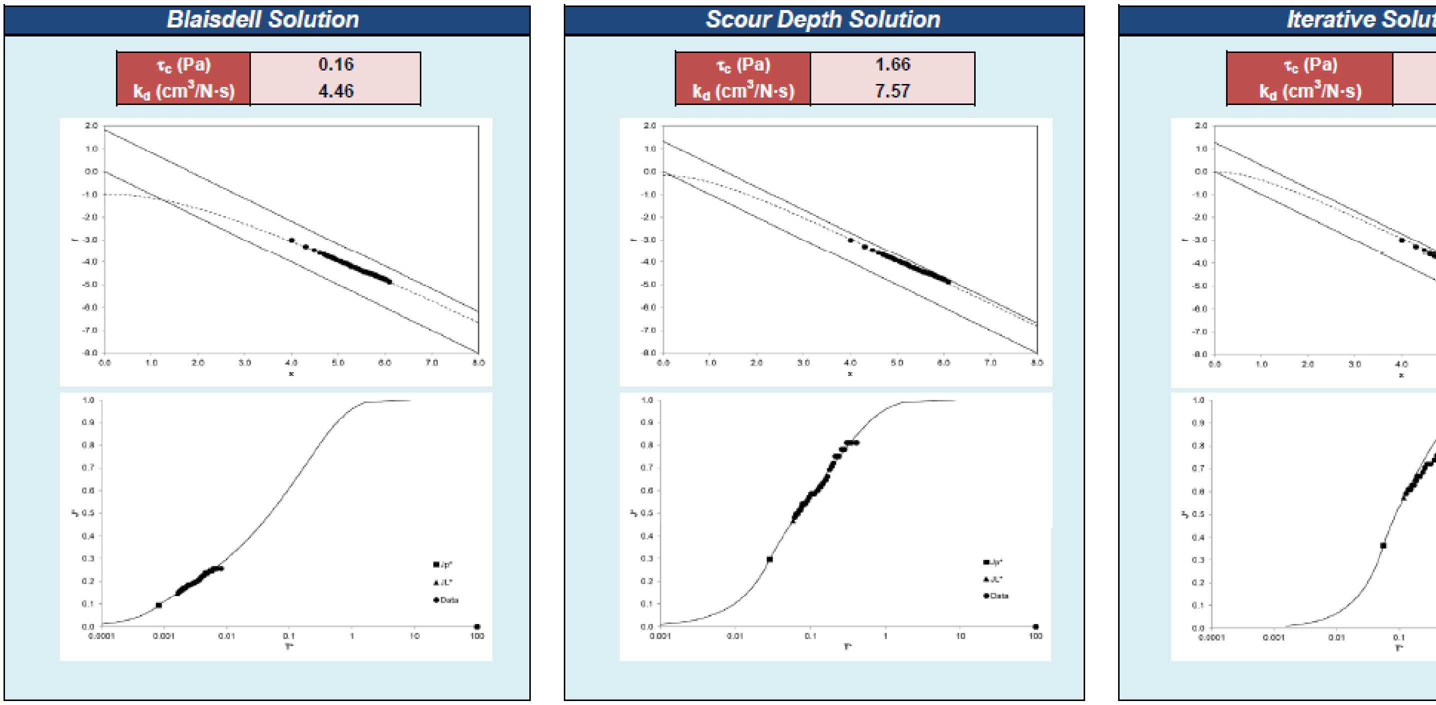


Figure 18. Summary of MP459 outfall right bank erodibility parameters

JET Data Input

Site:	MP467 Outlet LOB
Date:	9/10/2022
Test ID:	ELOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1181
Dishcarge Coefficient:	0.606

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm³/N-s):	1

* If you do not have a guess, plea

Suggested values of k_d as a func

Hanson and Simon (200

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	40	0.131	0.869	0.000
0.25	0.25	44	0.144	0.856	0.013
0.5	0.25	48	0.157	0.843	0.026
0.75	0.25	50	0.164	0.836	0.033
1	0.25	52	0.171	0.829	0.039
1.25	0.25	53	0.174	0.826	0.043
1.5	0.25	54	0.177	0.823	0.046
1.75	0.25	55	0.180	0.820	0.049
2	0.25	58	0.190	0.810	0.059
2.25	0.25	60	0.197	0.803	0.066
2.5	0.25	61	0.200	0.800	0.069
2.75	0.25	64	0.210	0.790	0.079
3	0.25	64	0.210	0.790	0.079
3.25	0.25	64	0.210	0.790	0.079
3.75	0.5	67	0.220	0.780	0.089
4.25	0.5	67	0.220	0.780	0.089
4.75	0.5	69	0.226	0.774	0.095
5.25	0.5	69	0.226	0.774	0.095
5.75	0.5	69	0.226	0.774	0.095
6.75	1	70	0.230	0.770	0.098
7.75	1	72	0.236	0.764	0.105
8.75	1	73	0.240	0.760	0.108
9.75	1	75	0.246	0.754	0.115
10.75	1	76	0.249	0.751	0.118
11.75	1	78	0.256	0.744	0.125
12.75	1	80	0.262	0.738	0.131
13.75	1	81	0.266	0.734	0.135
14.75	1	81	0.266	0.734	0.135
15.75	1	81	0.266	0.734	0.135
17.75	2	81	0.266	0.734	0.135
19.75	2	82	0.269	0.731	0.138
24.75	5	83	0.272	0.728	0.141

Head Setting	
Time (min)	Head (in)
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.25	24.48
1.5	24.48
1.75	24.48
2	24.48
2.25	24.48
2.5	24.48
2.75	24.48
3	24.48
3.25	24.48
3.75	24.48
4.25	24.48
4.75	24.48
5.25	24.48
5.75	24.48
6.75	24.48
7.75	24.48
8.75	24.48
9.75	24.48
10.75	24.48
11.75	24.48
12.75	24.48
13.75	24.48
14.75	24.48
15.75	24.48
17.75	24.48
19.75	24.48
24.75	24.48

Figure 19. Summary of MP467 outlet left bank raw data

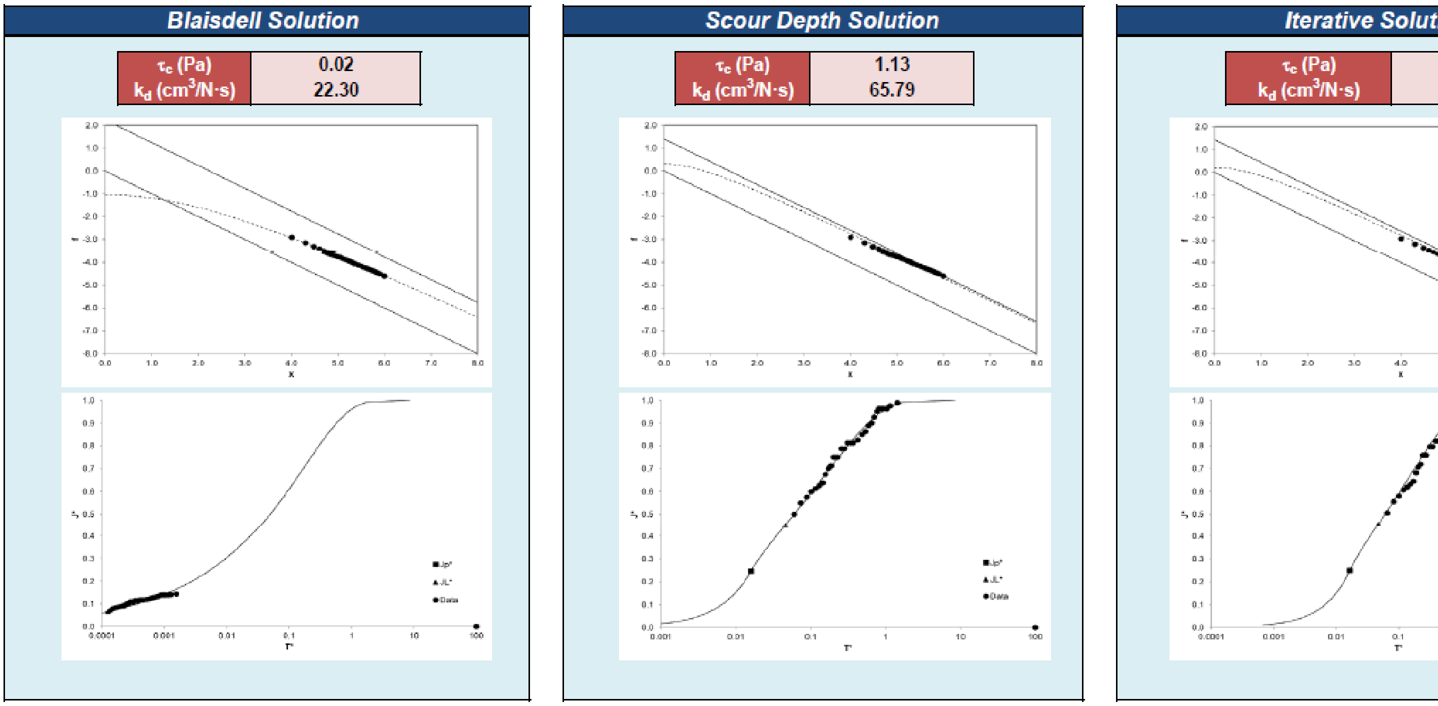


Figure 20. Summary of MP467 outlet left bank erodibility parameters

JET Data Input

Site:	MP467 Outlet ROB
Date:	9/11/2022
Test ID:	EROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0787
Dishcarge Coefficient:	0.635

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess, ple

Suggested values of k_d as a func

Hanson and Simon (20

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	28	0.092	0.908	0.000
0.25	0.25	35	0.115	0.885	0.023
0.5	0.25	37	0.121	0.879	0.030
0.75	0.25	38	0.125	0.875	0.033
1	0.25	39	0.128	0.872	0.036
1.25	0.25	40	0.131	0.869	0.039
1.5	0.25	40	0.131	0.869	0.039
1.75	0.25	41	0.135	0.865	0.043
2	0.25	42	0.138	0.862	0.046
2.25	0.25	42	0.138	0.862	0.046
2.5	0.25	43	0.141	0.859	0.049
2.75	0.25	43	0.141	0.859	0.049
3	0.25	43	0.141	0.859	0.049
3.5	0.5	43	0.141	0.859	0.049
4	0.5	44	0.144	0.856	0.052
4.5	0.5	44	0.144	0.856	0.052
5	0.5	44	0.144	0.856	0.052
6	1	45	0.148	0.852	0.056
7	1	45	0.148	0.852	0.056
8	1	46	0.151	0.849	0.059
9	1	46	0.151	0.849	0.059
10	1	46	0.151	0.849	0.059
12	2	47	0.154	0.846	0.062
14	2	47	0.154	0.846	0.062
16	2	48	0.157	0.843	0.066
18	2	49	0.161	0.839	0.069
20	2	49	0.161	0.839	0.069
22	2	49	0.161	0.839	0.069
27	5	49	0.161	0.839	0.069

Head Setting	
Time (min)	Head (in)
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.25	24.48
1.5	24.48
1.75	24.48
2	24.48
2.25	24.48
2.5	24.48
2.75	24.48
3	24.48
3.5	24.48
4	24.48
4.5	24.48
5	24.48
6	24.48
7	24.48
8	24.48
9	24.48
10	24.48
12	24.48
14	24.48
16	24.48
18	24.48
20	24.48
22	24.48
27	24.48

Figure 21. Summary of MP467 outlet right bank raw data

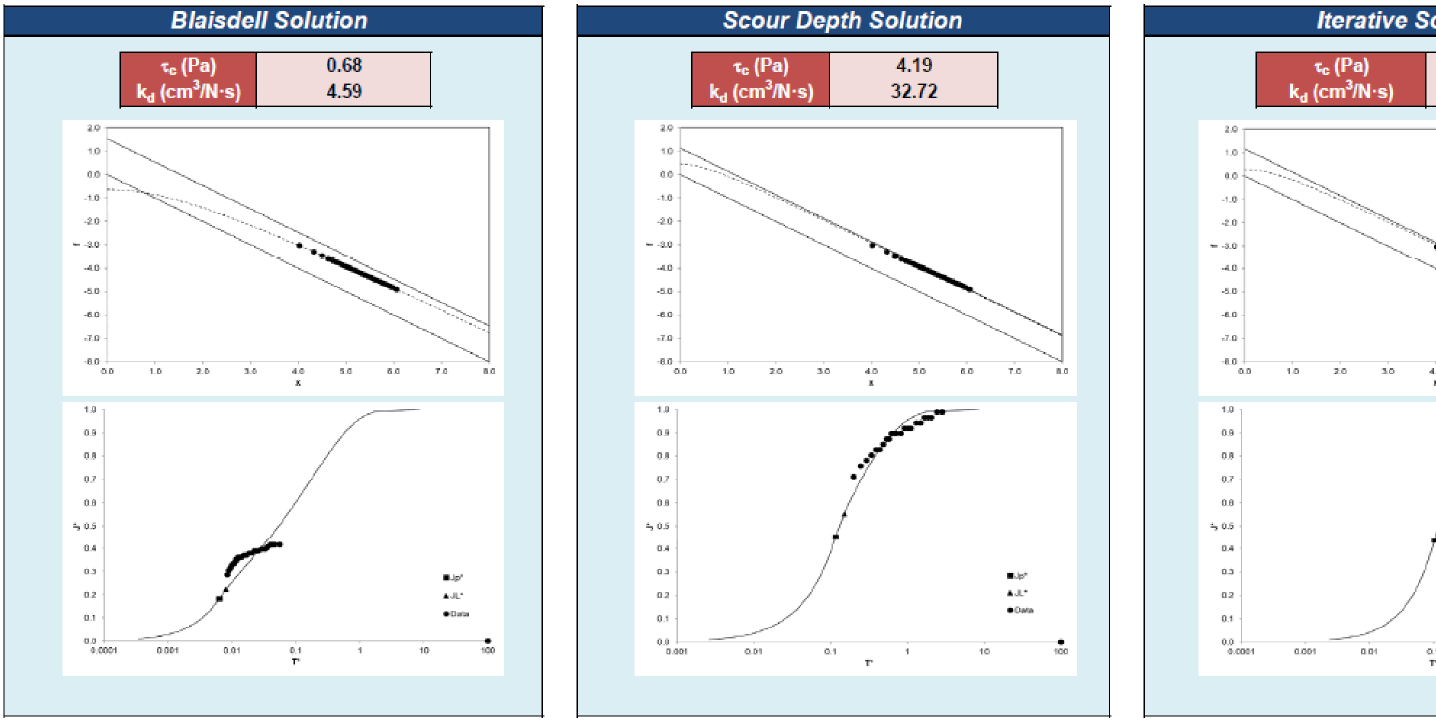


Figure 22. Summary of MP467 outlet right bank erodibility parameters

JET Data Input

Site:	MP467 Outfall LOB
Date:	9/11/2022
Test ID:	FLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1247
Dishcarge Coefficient:	0.627

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm³/N·s):	1

* If you do not have a guess

Suggested values of k_d as a

Hanson and Simon

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.8}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	42	0.138	0.862	0.000
0.25	0.25	47	0.154	0.846	0.016
0.5	0.25	48	0.157	0.843	0.020
0.75	0.25	49	0.161	0.839	0.023
1	0.25	49	0.161	0.839	0.023
1.25	0.25	49	0.161	0.839	0.023
1.75	0.5	50	0.164	0.836	0.026
2.25	0.5	50	0.164	0.836	0.026
2.75	0.5	50	0.164	0.836	0.026
3.75	1	51	0.167	0.833	0.030
4.75	1	51	0.167	0.833	0.030
5.75	1	51	0.167	0.833	0.030
7.75	2	52	0.171	0.829	0.033
9.75	2	52	0.171	0.829	0.033
11.75	2	52	0.171	0.829	0.033
16.75	5	53	0.174	0.826	0.036
21.75	5	54	0.177	0.823	0.039
26.75	5	54	0.177	0.823	0.039
31.75	5	54	0.177	0.823	0.039

Head Setting	
Time (min)	Head (in)
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.25	24.48
1.75	24.48
2.25	24.48
2.75	24.48
3.75	24.48
4.75	24.48
5.75	24.48
7.75	24.48
9.75	24.48
11.75	24.48
16.75	24.48
21.75	24.48
26.75	24.48
31.75	24.48

Figure 23. Summary of MP467 outfall left bank raw data

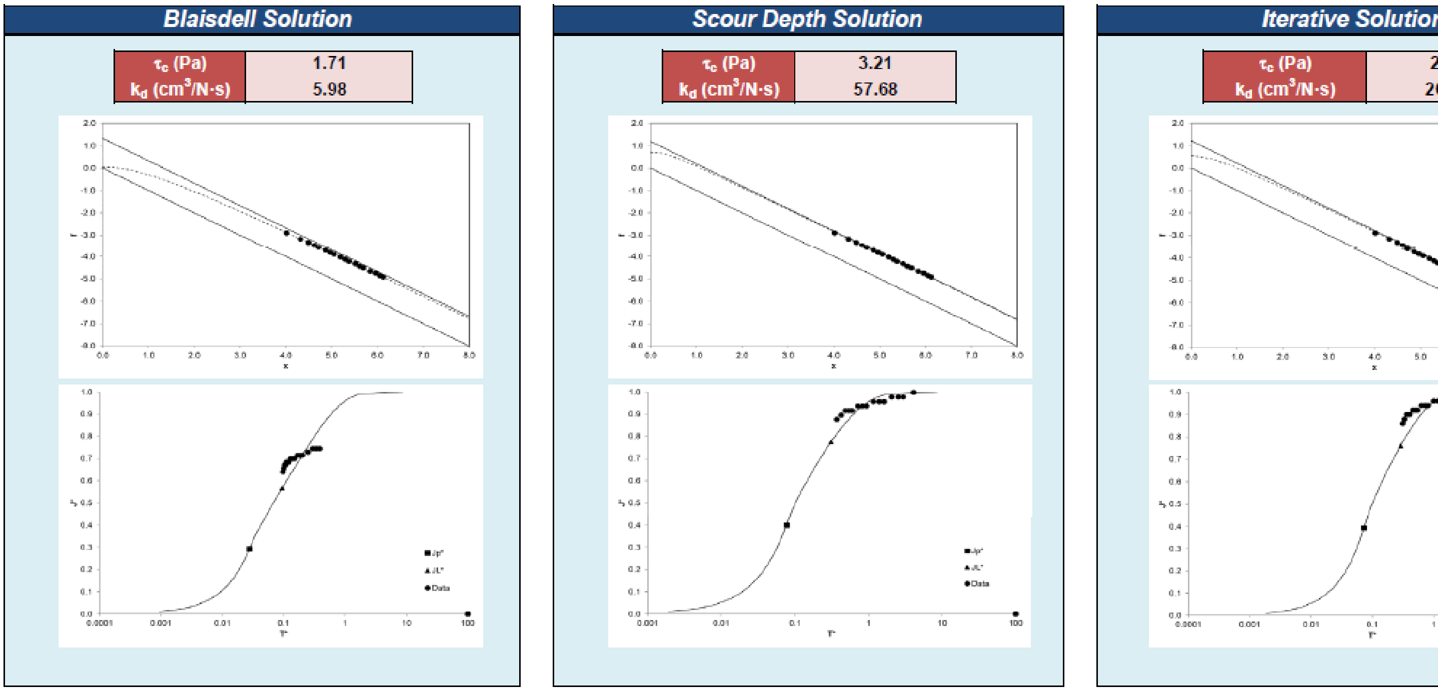


Figure 24. Summary of MP467 outfall left bank erodibility parameters

JET Data Input

Site:	MP467 Outfall ROB
Date:	9/11/2022
Test ID:	FROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0984
Dishcarge Coefficient:	0.627

Initial guess* for τ_o (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess,
Suggested values of k_d as a f
Hanson and Simon
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	34	0.112	0.888	0.000
0.25	0.25	36	0.118	0.882	0.007
0.5	0.25	37	0.121	0.879	0.010
0.75	0.25	37	0.121	0.879	0.010
1	0.25	37	0.121	0.879	0.010
1.5	0.5	38	0.125	0.875	0.013
2	0.5	39	0.128	0.872	0.016
2.5	0.5	39	0.128	0.872	0.016
3	0.5	39	0.128	0.872	0.016
4	1	40	0.131	0.869	0.020
5	1	40	0.131	0.869	0.020
6	1	41	0.135	0.865	0.023
7	1	41	0.135	0.865	0.023
8	1	42	0.138	0.862	0.026
9	1	42	0.138	0.862	0.026
10	1	43	0.141	0.859	0.030
11	1	44	0.144	0.856	0.033
12	1	44	0.144	0.856	0.033
13	1	45	0.148	0.852	0.036
14	1	46	0.151	0.849	0.039
15	1	46	0.151	0.849	0.039
16	1	46	0.151	0.849	0.039
18	2	47	0.154	0.846	0.043
20	2	47	0.154	0.846	0.043
22	2	47	0.154	0.846	0.043

Head Setting	
Time (min)	Head (in)
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.5	24.48
2	24.48
2.5	24.48
3	24.48
4	24.48
5	24.48
6	24.48
7	24.48
8	24.48
9	24.48
10	24.48
11	24.48
12	24.48
13	24.48
14	24.48
15	24.48
16	24.48
18	24.48
20	24.48
22	24.48

Figure 25. Summary of MP467 outfall right bank raw data

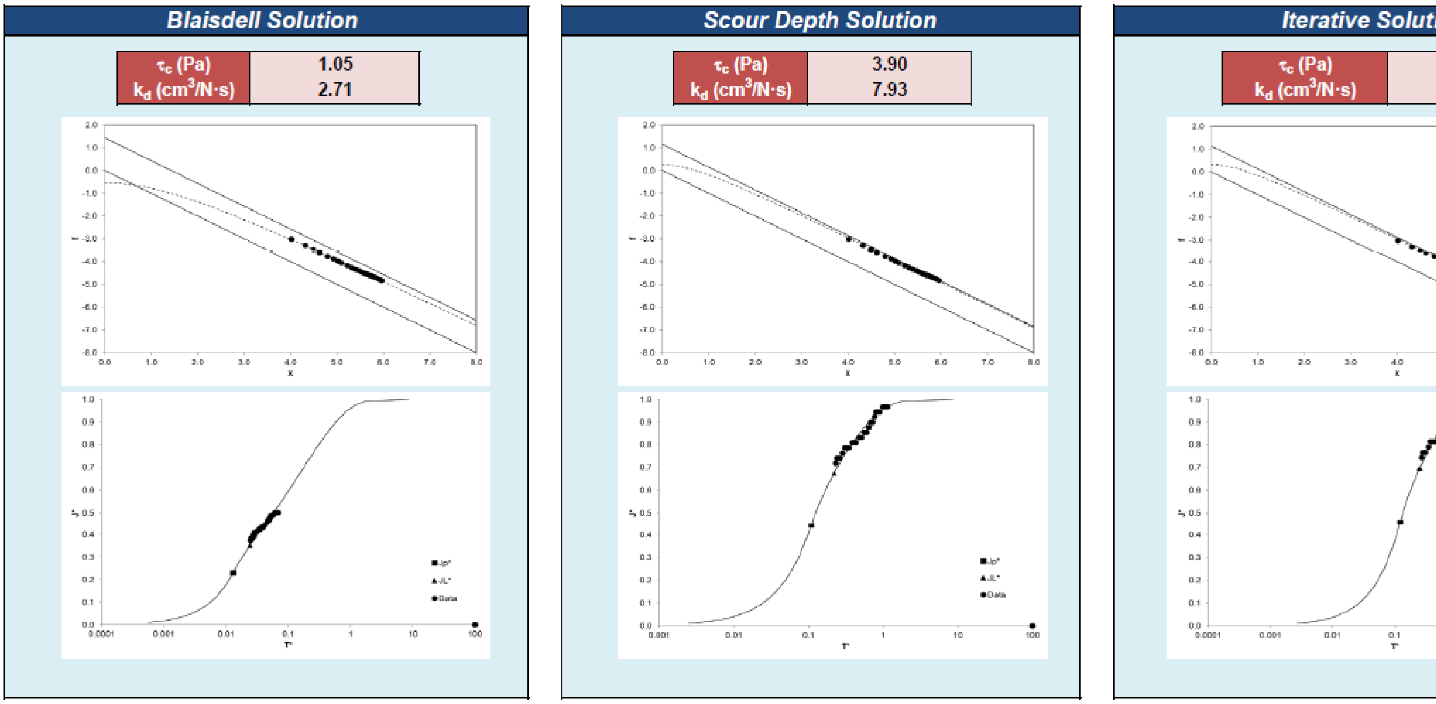


Figure 26. Summary of MP467 outfall right bank erodibility parameters

JET Data Input

Site:	MP495 Outlet LOB
Date:	9/11/2022
Test ID:	CLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0820
Dishcarge Coefficient:	0.627

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess, ple
Suggested values of k_d as a fun
Hanson and Simon (20
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	*Diff Time (min)*	*Pt Gage Reading (mm)*	*Depth (ft)*	*Pt Gage Reading (ft)*	*Maximum Depth of Scour (ft)*
0	0	29	0.095	0.905	0.000
0.25	0.25	31	0.102	0.898	0.007
0.5	0.25	36	0.118	0.882	0.023
0.75	0.25	36	0.118	0.882	0.023
1	0.25	36	0.118	0.882	0.023
1.5	0.5	36	0.118	0.882	0.023
2	0.5	36	0.118	0.882	0.023
2.5	0.5	39	0.128	0.872	0.033
3	0.5	40	0.131	0.869	0.036
3.5	0.5	40	0.131	0.869	0.036
4	0.5	41	0.135	0.865	0.039
4.5	0.5	41	0.135	0.865	0.039
5	0.5	41	0.135	0.865	0.039
6	1	42	0.138	0.862	0.043
7	1	42	0.138	0.862	0.043
8	1	42	0.138	0.862	0.043
10	2	42	0.138	0.862	0.043
12	2	42	0.138	0.862	0.043
17	5	42	0.138	0.862	0.043

Head Setting	
Time (min)	*Head (in)*
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.5	24.48
2	24.48
2.5	36.24
3	36.24
3.5	36.24
4	36.24
4.5	36.24
5	36.24
6	36.24
7	36.24
8	36.24
10	36.24
12	36.24
17	36.24

Figure 27. Summary of MP495 outlet left bank raw data

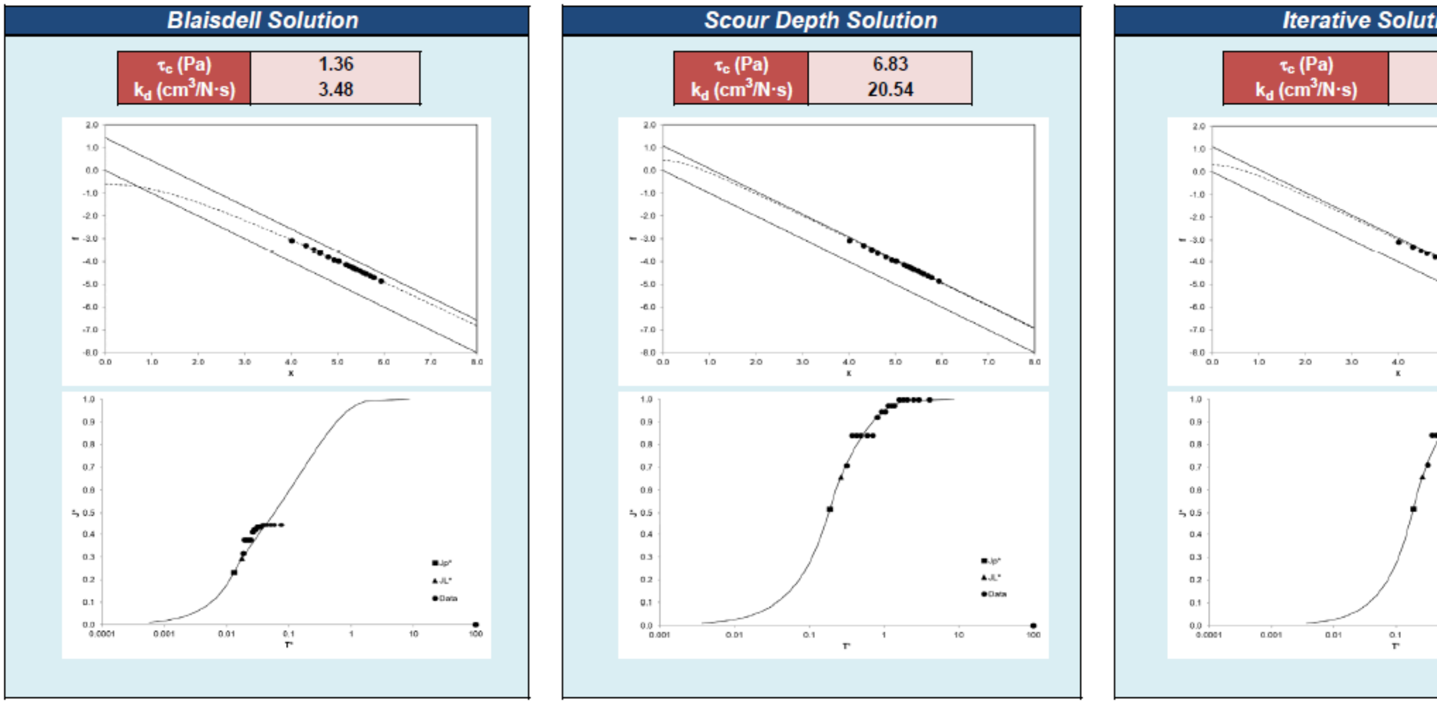


Figure 28. Summary of MP495 outlet left bank erodibility parameters

JET Data Input

Site:	MP495 Outlet ROB
Date:	9/11/2022
Test ID:	CROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1115
Dishcarge Coefficient:	0.62

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, p
Suggested values of k_d as a f

Hanson and Simon (
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings						Head Setting	
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)	Time (min)	Head (in)
0	0	38	0.125	0.875	0.000	0	36.24
0.25	0.25	42	0.138	0.862	0.013	0.25	36.24
0.5	0.25	48	0.157	0.843	0.033	0.5	36.24
0.75	0.25	51	0.167	0.833	0.043	0.75	24.72
1	0.25	51	0.167	0.833	0.043	1	24.72
1.25	0.25	51	0.167	0.833	0.043	1.25	24.72
1.75	0.5	52	0.171	0.829	0.046	1.75	24.72
2.25	0.5	53	0.174	0.826	0.049	2.25	24.72
2.75	0.5	55	0.180	0.820	0.056	2.75	24.72
3.25	0.5	56	0.184	0.816	0.059	3.25	24.72
3.75	0.5	58	0.190	0.810	0.066	3.75	24.72
4.25	0.5	60	0.197	0.803	0.072	4.25	24.72
4.75	0.5	61	0.200	0.800	0.075	4.75	24.72
5.25	0.5	62	0.203	0.797	0.079	5.25	24.72
5.75	0.5	63	0.207	0.793	0.082	5.75	24.72
6.25	0.5	65	0.213	0.787	0.089	6.25	24.72
6.75	0.5	66	0.217	0.783	0.092	6.75	24.72
7.25	0.5	66	0.217	0.783	0.092	7.25	24.72
7.75	0.5	66	0.217	0.783	0.092	7.75	24.72
8.75	1	66	0.217	0.783	0.092	8.75	24.72
9.75	1	67	0.220	0.780	0.095	9.75	24.72
10.75	1	68	0.223	0.777	0.098	10.75	24.72
11.75	1	70	0.230	0.770	0.105	11.75	24.72
12.75	1	71	0.233	0.767	0.108	12.75	24.72
13.75	1	71	0.233	0.767	0.108	13.75	24.72
14.75	1	71	0.233	0.767	0.108	14.75	24.72
16.75	2	72	0.236	0.764	0.112	16.75	24.72
18.75	2	72	0.236	0.764	0.112	18.75	24.72
20.75	2	72	0.236	0.764	0.112	20.75	24.72
25.75	5	72	0.236	0.764	0.112	25.75	24.72

Figure 29. Summary of MP495 outlet right bank raw data

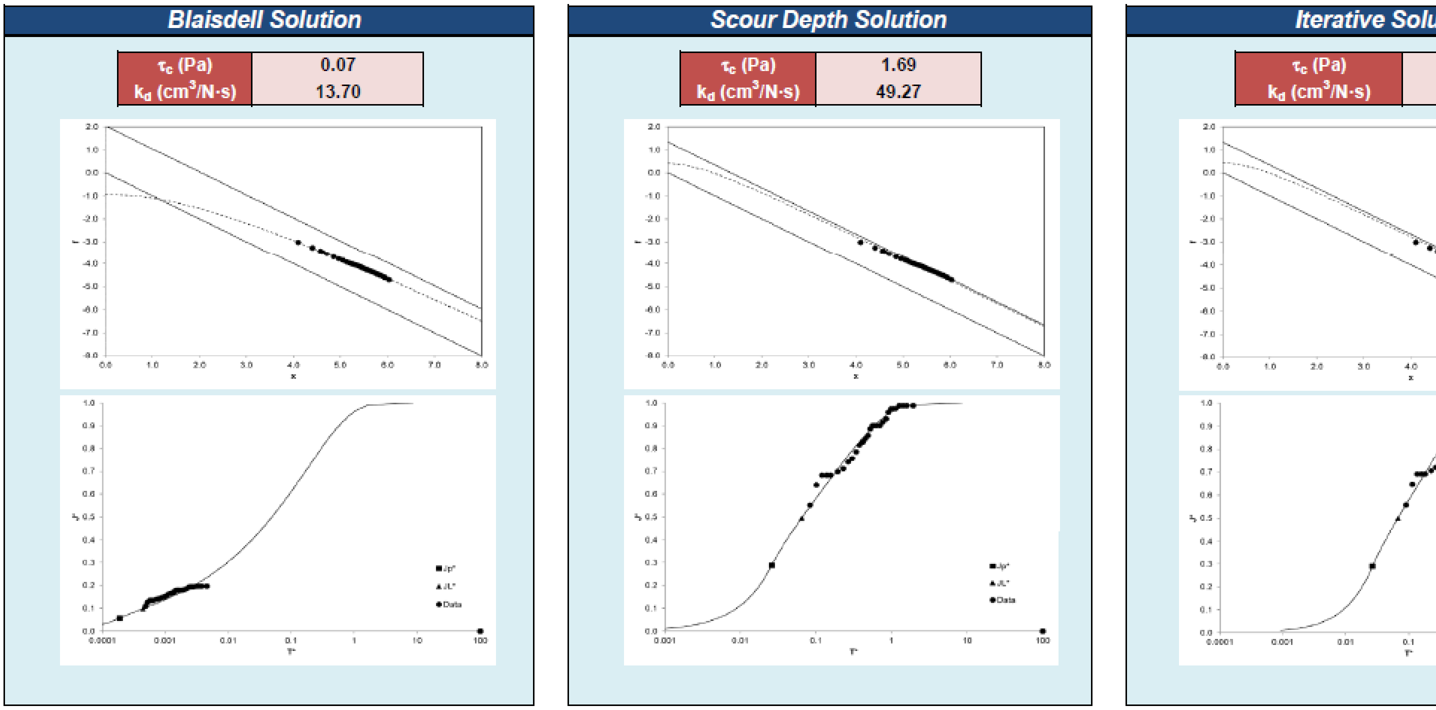


Figure 30. Summary of MP495 outlet right bank erodibility parameters

JET Data Input

Site:	MP495 Outfall LOB
Date:	9/11/2022
Test ID:	DLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1083
Dishcarge Coefficient:	0.62

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess, pl
Suggested values of k_d as a fu
Hanson and Simon (2
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	37	0.121	0.879	0.000
0.25	0.25	37	0.121	0.879	0.000
0.5	0.25	37	0.121	0.879	0.000
0.75	0.25	38	0.125	0.875	0.003
1	0.25	39	0.128	0.872	0.007
1.25	0.25	41	0.135	0.865	0.013
1.5	0.25	41	0.135	0.865	0.013
1.75	0.25	42	0.138	0.862	0.016
2	0.25	42	0.138	0.862	0.016
2.25	0.25	42	0.138	0.862	0.016
2.75	0.5	43	0.141	0.859	0.020
3.25	0.5	43	0.141	0.859	0.020
3.75	0.5	43	0.141	0.859	0.020
4.75	1	43	0.141	0.859	0.020
5.75	1	44	0.144	0.856	0.023
6.75	1	44	0.144	0.856	0.023
7.75	1	44	0.144	0.856	0.023
9.75	2	45	0.148	0.852	0.026
11.75	2	45	0.148	0.852	0.026
13.75	2	45	0.148	0.852	0.026
18.75	5	46	0.151	0.849	0.030
23.75	5	46	0.151	0.849	0.030

Head Setting	
Time (min)	Head (in)
0	24.72
0.25	24.72
0.5	24.72
0.75	24.72
1	24.72
1.25	24.72
1.5	24.72
1.75	24.72
2	24.72
2.25	24.72
2.75	24.72
3.25	24.72
3.75	24.72
4.75	24.72
5.75	24.72
6.75	24.72
7.75	24.72
9.75	24.72
11.75	24.72
13.75	24.72
18.75	24.72
23.75	24.72

Figure 31. Summary of MP495 outfall left bank raw data

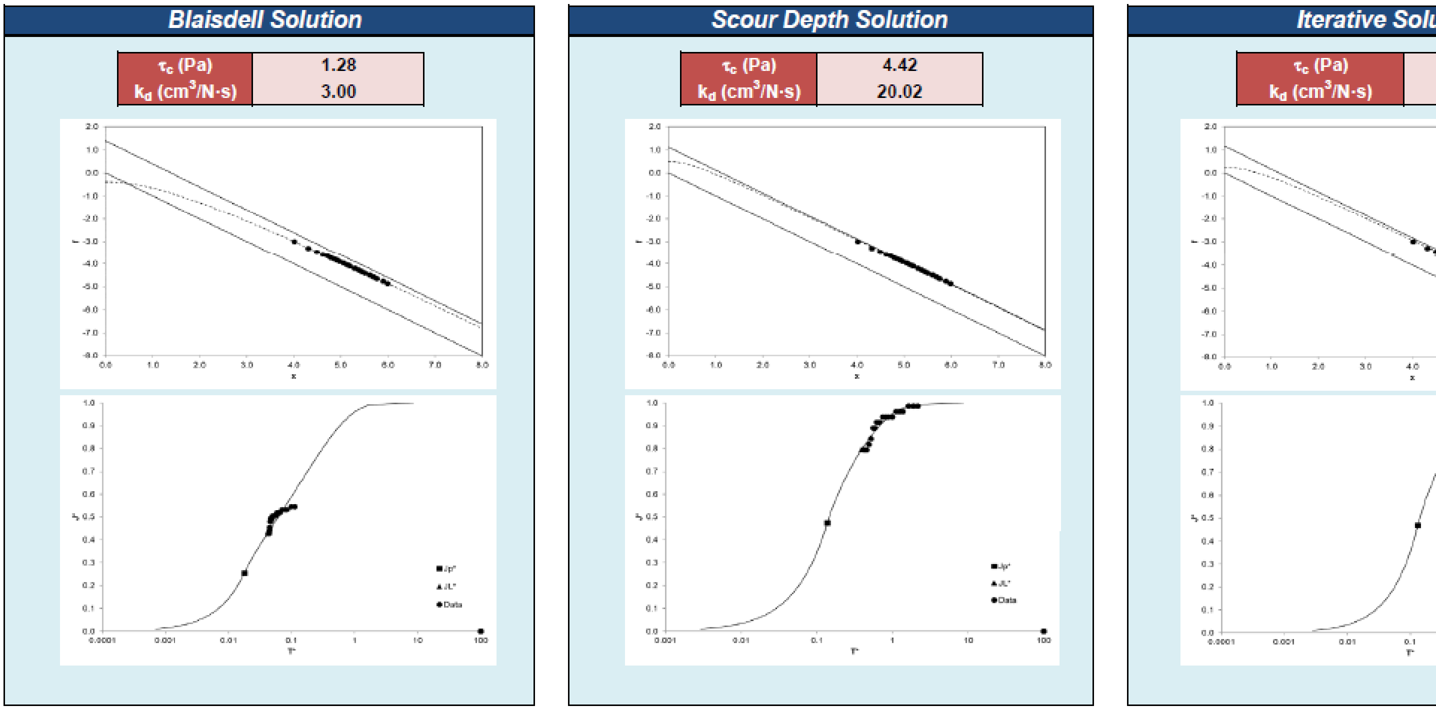


Figure 32. Summary of MP495 outfall left bank erodibility parameters

JET Data Input

Site:	MP495 Outfall ROB
Date:	9/11/2022
Test ID:	DROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0755
Dishcarge Coefficient:	0.614

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess, please
Suggested values of k_d as a functio
Hanson and Simon (2001)
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	27	0.089	0.911	0.000
0.25	0.25	31	0.102	0.898	0.013
0.5	0.25	32	0.105	0.895	0.016
0.75	0.25	32	0.105	0.895	0.016
1	0.25	33	0.108	0.892	0.020
1.25	0.25	33	0.108	0.892	0.020
1.5	0.25	34	0.112	0.888	0.023
1.75	0.25	35	0.115	0.885	0.026
2	0.25	35	0.115	0.885	0.026
2.25	0.25	35	0.115	0.885	0.026
2.75	0.5	36	0.118	0.882	0.030
3.25	0.5	36	0.118	0.882	0.030
3.75	0.5	37	0.121	0.879	0.033
4.25	0.5	37	0.121	0.879	0.033
4.75	0.5	38	0.125	0.875	0.036
5.25	0.5	38	0.125	0.875	0.036
5.75	0.5	38	0.125	0.875	0.036
6.75	1	40	0.131	0.869	0.043
7.75	1	40	0.131	0.869	0.043
8.75	1	40	0.131	0.869	0.043
10.75	2	41	0.135	0.865	0.046
12.75	2	41	0.135	0.865	0.046
14.75	2	41	0.135	0.865	0.046
19.75	5	42	0.138	0.862	0.049
24.75	5	42	0.138	0.862	0.049

Head Setting	
Time (min)	Head (in)
0	24.72
0.25	24.72
0.5	24.72
0.75	24.72
1	24.72
1.25	24.72
1.5	24.72
1.75	24.72
2	24.72
2.25	24.72
2.75	24.72
3.25	24.72
3.75	24.72
4.25	24.72
4.75	24.72
5.25	24.72
5.75	24.72
6.75	24.72
7.75	24.72
8.75	24.72
10.75	24.72
12.75	24.72
14.75	24.72
19.75	24.72
24.75	24.72

Figure 33. Summary of MP495 outfall right bank raw data

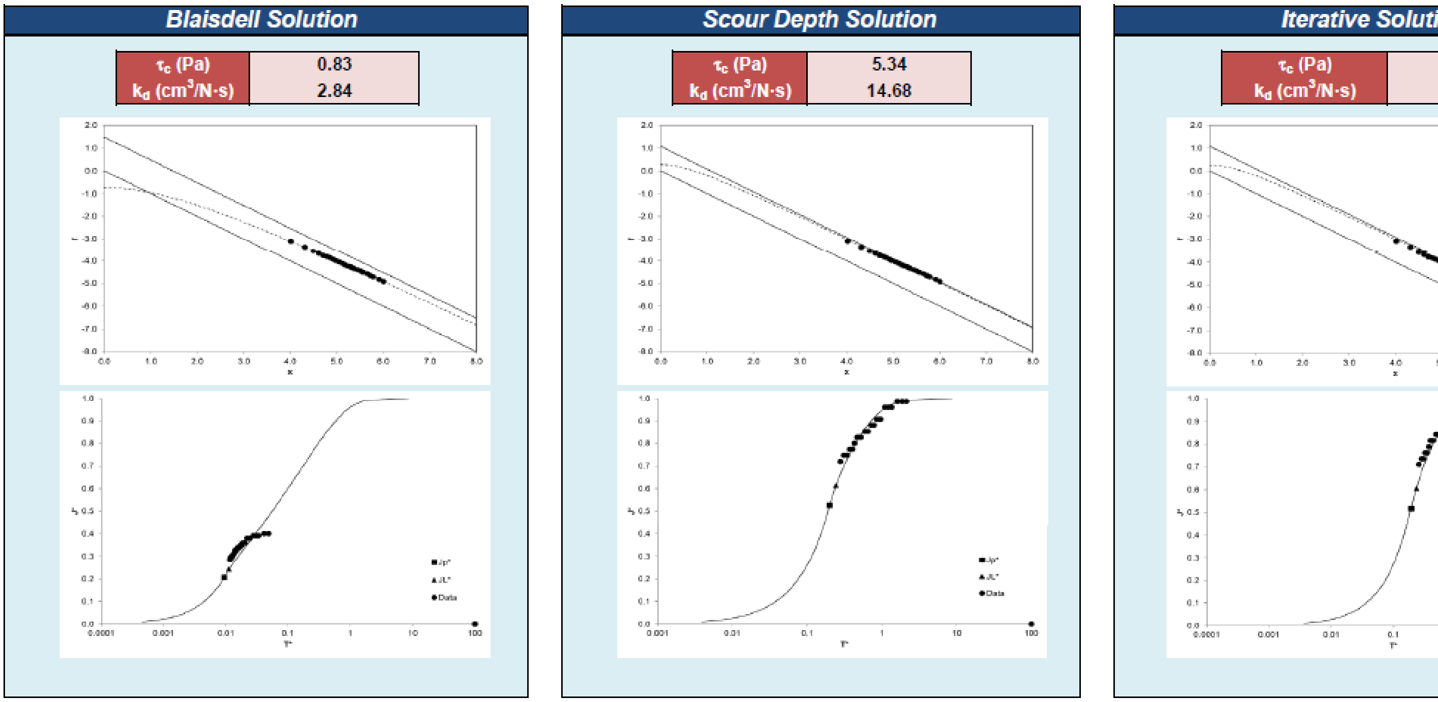


Figure 34. Summary of MP495 outfall right bank erodibility parameters

JET Data Input

Site:	MP814 Outlet LOB
Date:	9/10/2022
Test ID:	ILOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1148
Dishcarge Coefficient:	0.627

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, pl

Suggested values of k_d as a fu

Hanson and Simon (2

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	*Diff Time (min)*	*Pt Gage Reading (mm)*	*Depth (ft)*	*Pt Gage Reading (ft)*	*Maximum Depth of Scour (ft)*
0	0	39	0.128	0.872	0.000
0.25	0.25	41	0.135	0.865	0.007
0.5	0.25	43	0.141	0.859	0.013
0.75	0.25	43	0.141	0.859	0.013
1	0.25	44	0.144	0.856	0.016
1.25	0.25	45	0.148	0.852	0.020
1.5	0.25	46	0.151	0.849	0.023
1.75	0.25	47	0.154	0.846	0.026
2	0.25	47	0.154	0.846	0.026
2.25	0.25	47	0.154	0.846	0.026
2.75	0.5	48	0.157	0.843	0.030
3.25	0.5	48	0.157	0.843	0.030
3.75	0.5	49	0.161	0.839	0.033
4.25	0.5	50	0.164	0.836	0.036
4.75	0.5	51	0.167	0.833	0.039
5.25	0.5	51	0.167	0.833	0.039
5.75	0.5	52	0.171	0.829	0.043
6.25	0.5	52	0.171	0.829	0.043
6.75	0.5	52	0.171	0.829	0.043

Head Setting	
Time (min)	*Head (in)*
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.25	24.48
1.5	24.48
1.75	24.48
2	24.48
2.25	24.48
2.75	24.48
3.25	24.48
3.75	24.48
4.25	24.48
4.75	24.48
5.25	24.48
5.75	24.48
6.25	24.48
6.75	24.48

Figure 35. Summary of MP814 outlet left bank raw data

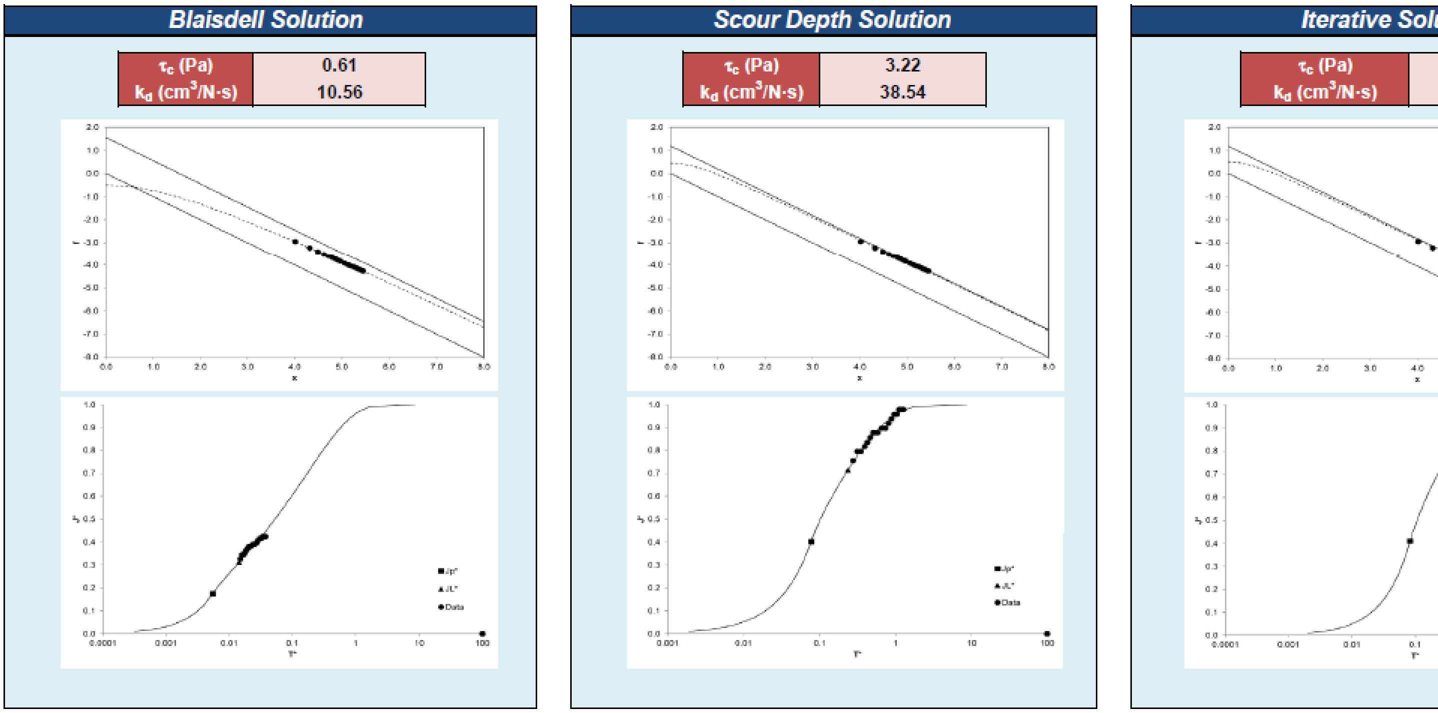


Figure 36. Summary of MP814 outlet left bank erodibility parameters

JET Data Input

Site:	MP814 Outlet ROB
Date:	9/10/2022
Test ID:	IROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.0919
Dishcarge Coefficient:	0.606

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, ple

Suggested values of k_d as a fun

Hanson and Simon (20

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	32	0.105	0.895	0.000
0.25	0.25	44	0.144	0.856	0.039
0.5	0.25	44	0.144	0.856	0.039
0.75	0.25	44	0.144	0.856	0.039
1.25	0.5	44	0.144	0.856	0.039
1.75	0.5	44	0.144	0.856	0.039
2.25	0.5	45	0.148	0.852	0.043
2.75	0.5	46	0.151	0.849	0.046
3.25	0.5	47	0.154	0.846	0.049
3.75	0.5	47	0.154	0.846	0.049
4.25	0.5	47	0.154	0.846	0.049

Head Setting	
Time (min)	Head (in)
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1.25	24.48
1.75	24.48
2.25	24.48
2.75	24.48
3.25	24.48
3.75	24.48
4.25	24.48

Figure 37. Summary of MP814 outlet right bank raw data

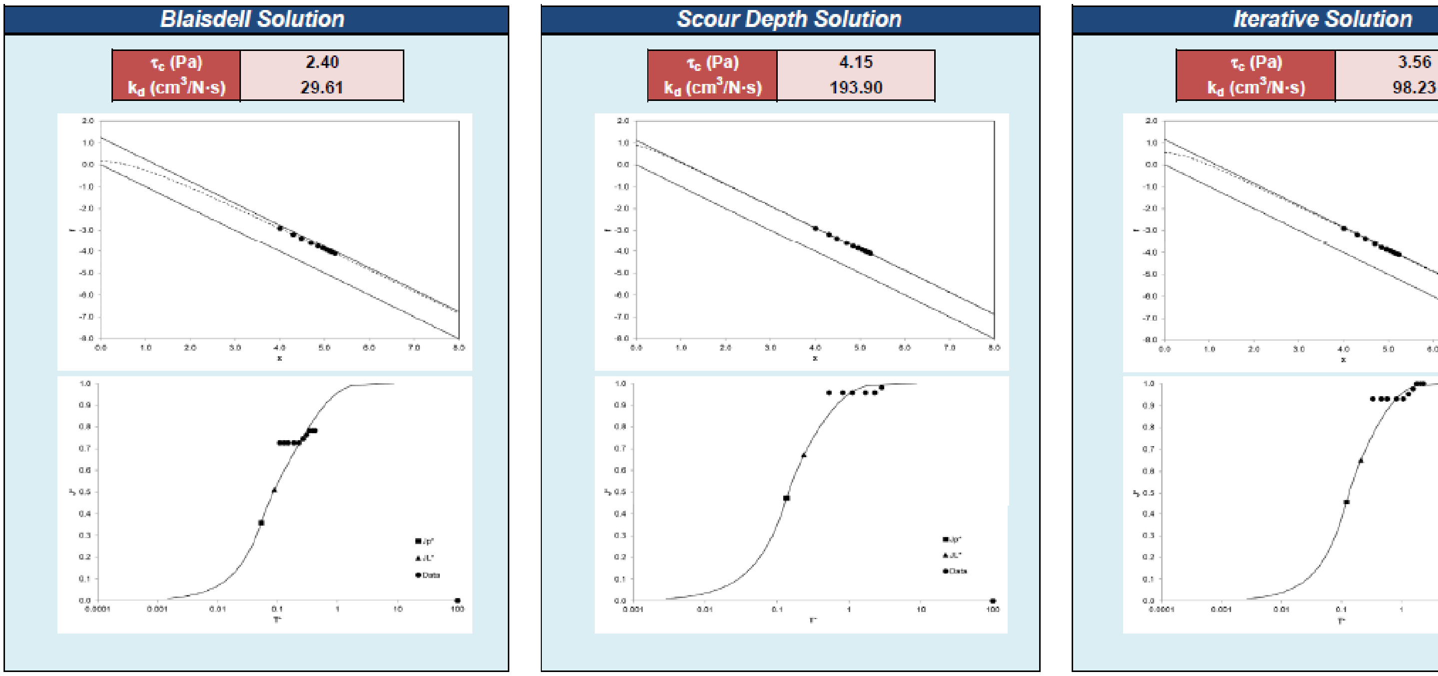


Figure 38. Summary of MP814 outlet right bank erodibility parameters

JET Data Input

Site:	MP814 Outfall LOB
Date:	9/10/2022
Test ID:	JLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1280
Dishcarge Coefficient:	0.627

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess,
Suggested values of k_d as a f
Hanson and Simon
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	*Diff Time (min)*	*Pt Gage Reading (mm)*	*Depth (ft)*	*Pt Gage Reading (ft)*	*Maximum Depth of Scour (ft)*
0	0	43	0.141	0.859	0.000
0.25	0.25	47	0.154	0.846	0.013
0.5	0.25	47	0.154	0.846	0.013
0.75	0.25	48	0.157	0.843	0.016
1	0.25	48	0.157	0.843	0.016
1.25	0.25	48	0.157	0.843	0.016
1.5	0.25	48	0.157	0.843	0.016
2	0.5	48	0.157	0.843	0.016
2.5	0.5	50	0.164	0.836	0.023
3	0.5	50	0.164	0.836	0.023
3.5	0.5	51	0.167	0.833	0.026
4	0.5	51	0.167	0.833	0.026

Head Setting	
Time (min)	*Head (in)*
0	72.48
0.25	72.48
0.5	72.48
0.75	72.48
1	72.48
1.25	72.48
1.5	72.48
2	72.48
2.5	72.48
3	72.48
3.5	72.48
4	72.48

Figure 39. Summary of MP814 outfall left bank raw data

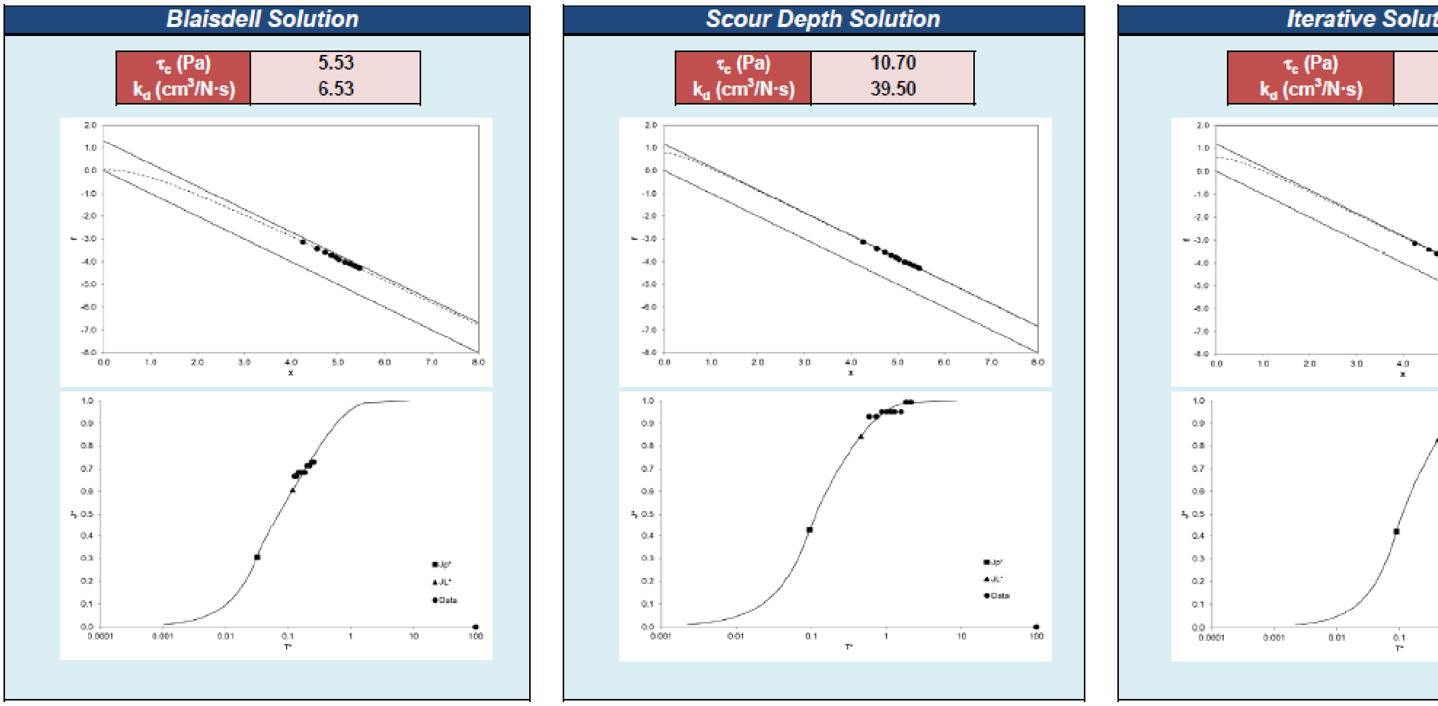


Figure 40. Summary of MP814 outfall left bank erodibility parameters

JET Data Input

Site:	MP814 Outfall ROB
Date:	9/10/2022
Test ID:	JROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1115
Dishcarge Coefficient:	0.627

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess, pl

Suggested values of k_d as a fu

Hanson and Simon (2

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	38	0.125	0.875	0.000
0.25	0.25	42	0.138	0.862	0.013
0.5	0.25	43	0.141	0.859	0.016
0.75	0.25	45	0.148	0.852	0.023
1	0.25	47	0.154	0.846	0.030
1.25	0.25	49	0.161	0.839	0.036
1.5	0.25	52	0.171	0.829	0.046
1.75	0.25	52	0.171	0.829	0.046
2	0.25	53	0.174	0.826	0.049
2.25	0.25	56	0.184	0.816	0.059
2.5	0.25	57	0.187	0.813	0.062
2.75	0.25	57	0.187	0.813	0.062
3	0.25	57	0.187	0.813	0.062
3.5	0.5	58	0.190	0.810	0.066
4	0.5	58	0.190	0.810	0.066
4.5	0.5	60	0.197	0.803	0.072
5	0.5	61	0.200	0.800	0.075
5.5	0.5	62	0.203	0.797	0.079
6	0.5	62	0.203	0.797	0.079
6.5	0.5	62	0.203	0.797	0.079
7.5	1	62	0.203	0.797	0.079
8.5	1	64	0.210	0.790	0.085
9.5	1	64	0.210	0.790	0.085
10.5	1	64	0.210	0.790	0.085
12.5	2	65	0.213	0.787	0.089
14.5	2	66	0.217	0.783	0.092
16.5	2	68	0.223	0.777	0.098
18.5	2	68	0.223	0.777	0.098
20.5	2	68	0.223	0.777	0.098
25.5	5	69	0.226	0.774	0.102
30.5	5	69	0.226	0.774	0.102

Head Setting	
Time (min)	Head (in)
0	24.48
0.25	24.48
0.5	24.48
0.75	24.48
1	24.48
1.25	24.48
1.5	24.48
1.75	24.48
2	24.48
2.25	24.48
2.5	24.48
2.75	24.48
3	24.48
3.5	24.48
4	24.48
4.5	24.48
5	24.48
5.5	24.48
6	24.48
6.5	24.48
7.5	24.48
8.5	24.48
9.5	24.48
10.5	24.48
12.5	24.48
14.5	24.48
16.5	24.48
18.5	24.48
20.5	24.48
25.5	24.48
30.5	24.48

Figure 41. Summary of MP814 outfall right bank raw data

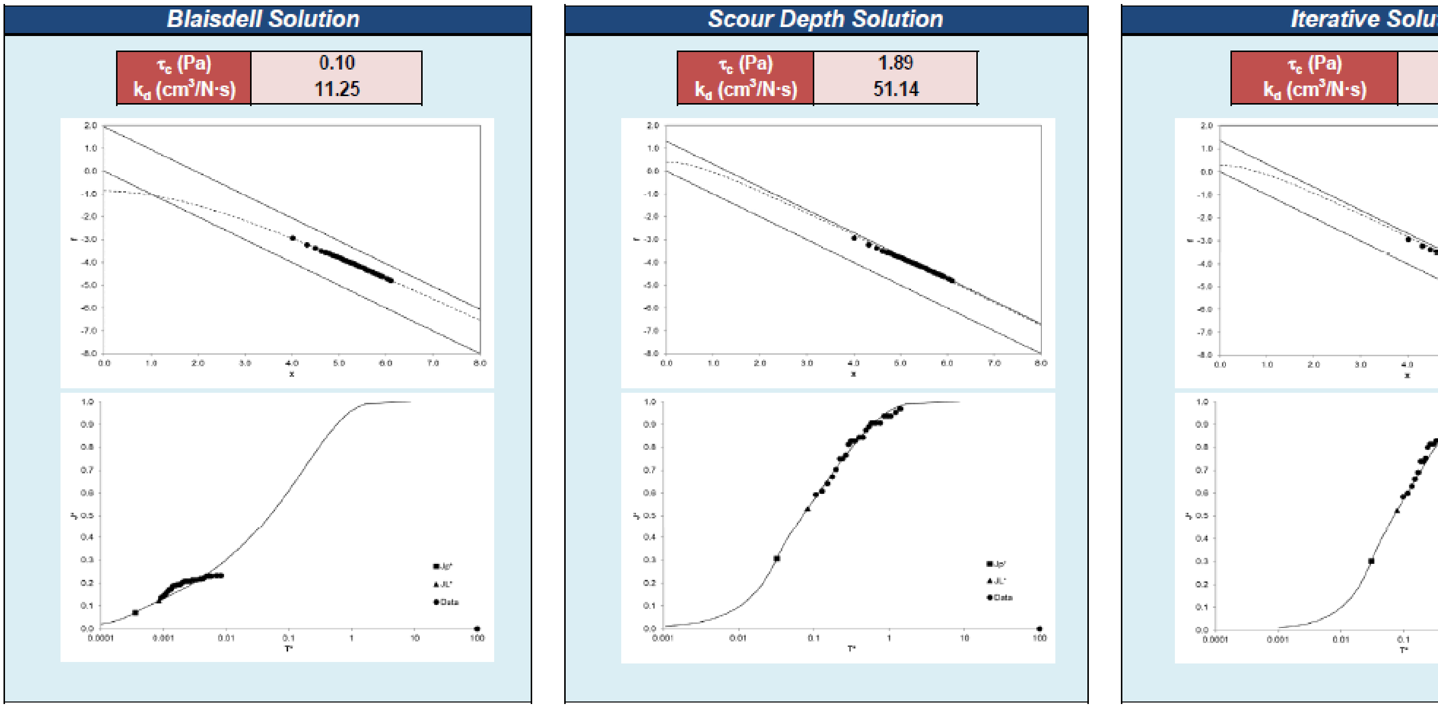


Figure 42. Summary of MP814 outfall right bank erodibility parameters

JET Data Input

Site:	MP840 Outlet LOB
Date:	8/26/2022
Test ID:	ALOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1280
Dishcarge Coefficient:	0.614

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, pl

Suggested values of k_d as a fu

Hanson and Simon (2

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	43	0.141	0.859	0.000
0.25	0.25	46	0.151	0.849	0.010
0.5	0.25	55	0.180	0.820	0.039
0.75	0.25	55	0.180	0.820	0.039
1	0.25	56	0.184	0.816	0.043
1.25	0.25	58	0.190	0.810	0.049
1.5	0.25	59	0.194	0.806	0.052
1.75	0.25	60	0.197	0.803	0.056
2	0.25	60	0.197	0.803	0.056
2.25	0.25	60	0.197	0.803	0.056

Head Setting	
Time (min)	Head (in)
0	72.48
0.25	72.48
0.5	72.48
0.75	72.48
1	72.48
1.25	72.48
1.5	72.48
1.75	72.48
2	72.48
2.25	72.48

Figure 43. Summary of MP840 outlet left bank raw data

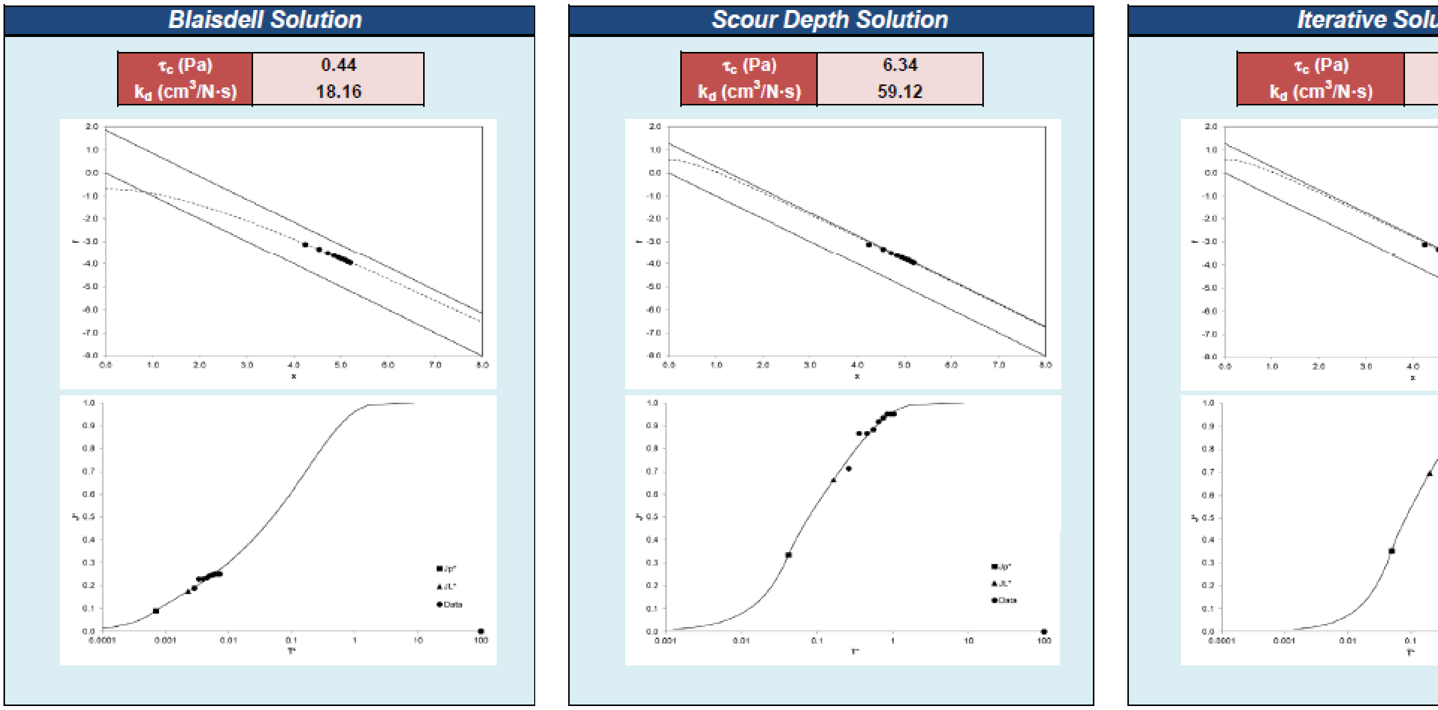


Figure 44. Summary of MP840 outlet left bank erodibility parameters

JET Data Input

Site:	MP840 Outlet ROB
Date:	9/5/2022
Test ID:	AROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1214
Dishcarge Coefficient:	0.635

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess,
Suggested values of k_d as a f
Hanson and Simon
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.83}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	41	0.135	0.865	0.000
0.25	0.25	49	0.161	0.839	0.026
0.5	0.25	50	0.164	0.836	0.030
0.75	0.25	51	0.167	0.833	0.033
1	0.25	54	0.177	0.823	0.043
1.25	0.25	55	0.180	0.820	0.046
1.5	0.25	57	0.187	0.813	0.052
1.75	0.25	59	0.194	0.806	0.059
2	0.25	60	0.197	0.803	0.062
2.25	0.25	61	0.200	0.800	0.066
2.5	0.25	61	0.200	0.800	0.066
2.75	0.25	63	0.207	0.793	0.072
3	0.25	64	0.210	0.790	0.075
3.25	0.25	64	0.210	0.790	0.075
3.5	0.25	64	0.210	0.790	0.075
4	0.5	65	0.213	0.787	0.079
4.5	0.5	65	0.213	0.787	0.079
5	0.5	65	0.213	0.787	0.079

Head Setting	
Time (min)	Head (in)
0	72.48
0.25	72.48
0.5	72.48
0.75	72.48
1	72.48
1.25	72.48
1.5	72.48
1.75	72.48
2	72.48
2.25	72.48
2.5	72.48
2.75	72.48
3	72.48
3.25	72.48
3.5	72.48
4	72.48
4.5	72.48
5	72.48

Figure 45. Summary of MP840 outlet right bank raw data

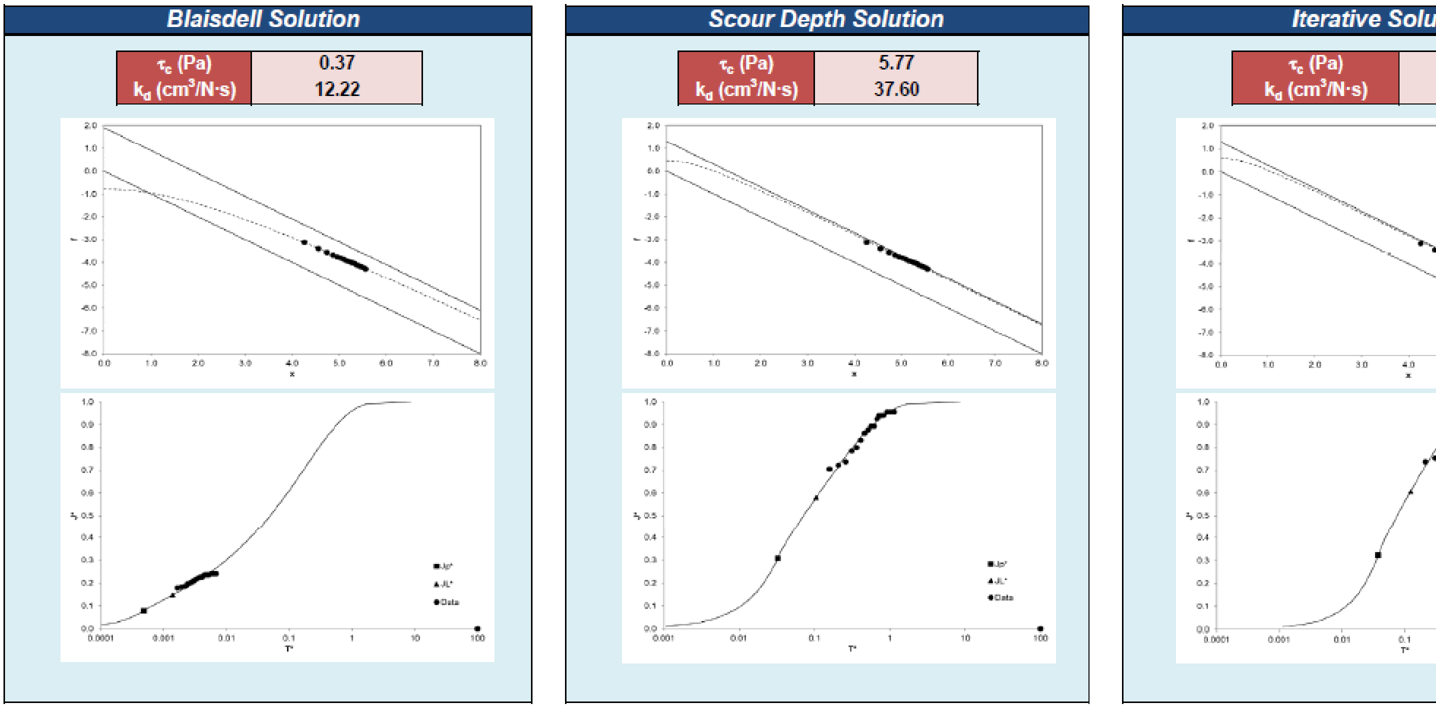


Figure 46. Summary of MP840 outlet right bank erodibility parameters

JET Data Input

Site:	MP840 Outfall LOB
Date:	8/31/2022
Test ID:	Trial B BLOB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1115
Dishcarge Coefficient:	0.609

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N-s):	1

* If you do not have a guess, plea

Suggested values of k_d as a func

Hanson and Simon (200

$k_d = 0.2\tau_c^{-0.5}$

Simon et al. (2011)

$k_d = 1.6\tau_c^{-0.83}$

BSTEM, v5.4

$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	38	0.125	0.875	0.000
0.25	0.25	48	0.157	0.843	0.033
0.5	0.25	54	0.177	0.823	0.052
0.75	0.25	56	0.184	0.816	0.059
1	0.25	58	0.190	0.810	0.066
1.25	0.25	61	0.200	0.800	0.075
1.5	0.25	62	0.203	0.797	0.079
1.75	0.25	64	0.210	0.790	0.085
2	0.25	65	0.213	0.787	0.089
2.25	0.25	68	0.223	0.777	0.098
2.5	0.25	68	0.223	0.777	0.098
2.75	0.25	70	0.230	0.770	0.105
3	0.25	72	0.236	0.764	0.112
3.25	0.25	73	0.240	0.760	0.115
3.5	0.25	73	0.240	0.760	0.115
3.75	0.25	75	0.246	0.754	0.121
4	0.25	76	0.249	0.751	0.125
4.25	0.25	78	0.256	0.744	0.131
4.5	0.25	78	0.256	0.744	0.131
4.75	0.25	78	0.256	0.744	0.131
5.25	0.5	78	0.256	0.744	0.131
5.75	0.5	79	0.259	0.741	0.135
6.25	0.5	80	0.262	0.738	0.138
6.75	0.5	80	0.262	0.738	0.138
7.25	0.5	81	0.266	0.734	0.141
7.75	0.5	82	0.269	0.731	0.144
8.25	0.5	83	0.272	0.728	0.148
8.75	0.5	83	0.272	0.728	0.148
9.25	0.5	83	0.272	0.728	0.148
10.25	1	85	0.279	0.721	0.154
11.25	1	85	0.279	0.721	0.154
12.25	1	85	0.279	0.721	0.154
14.25	2	85	0.279	0.721	0.154
16.25	2	85	0.279	0.721	0.154
21.25	5	85	0.279	0.721	0.154

Head Setting	
Time (min)	Head (in)
0	72.48
0.25	72.48
0.5	72.48
0.75	72.48
1	72.48
1.25	72.48
1.5	72.48
1.75	72.48
2	72.48
2.25	72.48
2.5	72.48
2.75	72.48
3	72.48
3.25	72.48
3.5	72.48
3.75	72.48
4	72.48
4.25	72.48
4.5	72.48
4.75	72.48
5.25	72.48
5.75	72.48
6.25	72.48
6.75	72.48
7.25	72.48
7.75	72.48
8.25	72.48
8.75	72.48
9.25	72.48
10.25	72.48
11.25	72.48
12.25	72.48
14.25	72.48
16.25	72.48
21.25	72.48

Figure 47. Summary of MP840 outfall left bank raw data

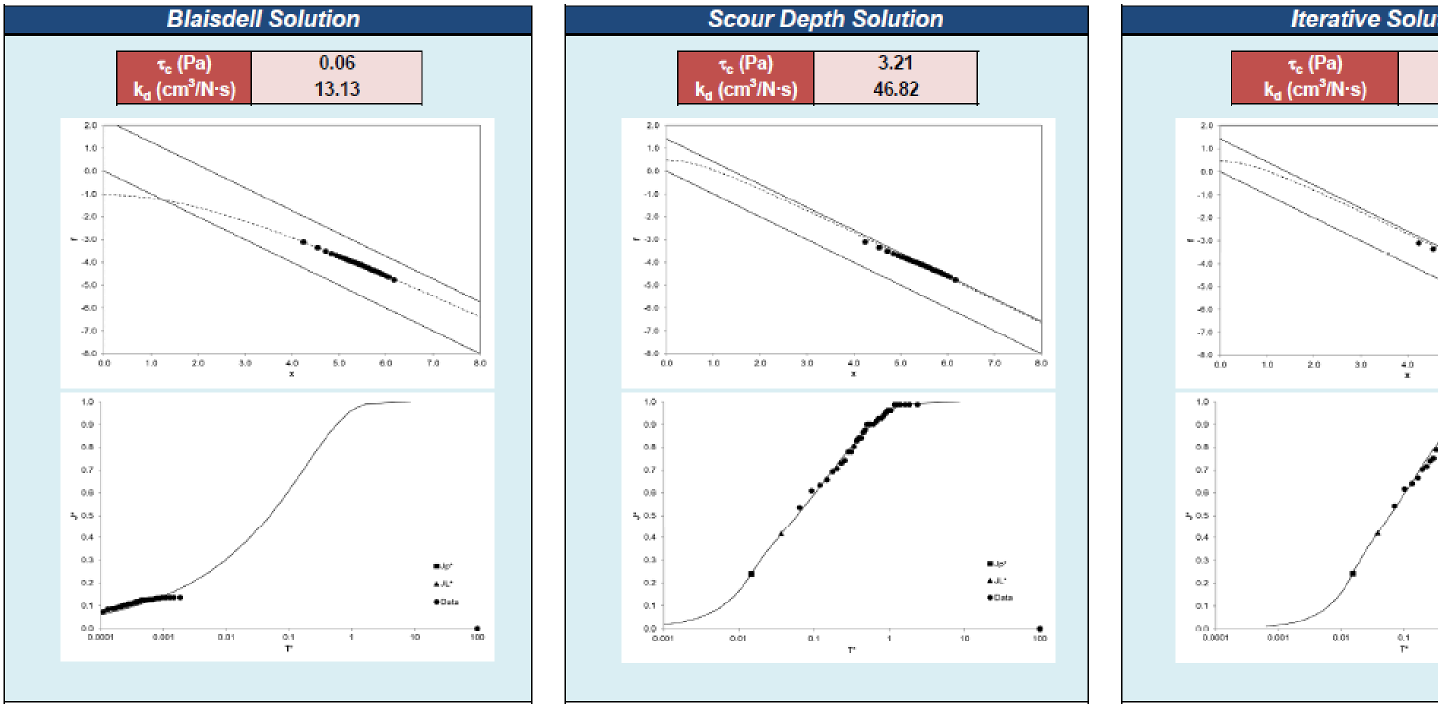


Figure 48. Summary of MP840 outfall left bank erodibility parameters

JET Data Input

Site:	MP840 Outfall ROB
Date:	9/1/2022
Test ID:	BROB
JET ID:	1
Operator:	S. Waickowski
Test Location:	Weaver

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1017
Dishcarge Coefficient:	0.635

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d (cm^3/N·s):	1

* If you do not have a guess,
Suggested values of k_d as a

Hanson and Simon
$k_d = 0.2\tau_c^{-0.5}$
Simon et al. (2011)
$k_d = 1.6\tau_c^{-0.8}$
BSTEM, v5.4
$k_d = 0.1\tau_c^{-0.5}$

Scour Depth Readings					
Time (min)	Diff Time (min)	Pt Gage Reading (mm)	Depth (ft)	Pt Gage Reading (ft)	Maximum Depth of Scour (ft)
0	0	35	0.115	0.885	0.000
0.25	0.25	46	0.151	0.849	0.036
0.5	0.25	49	0.161	0.839	0.046
0.75	0.25	51	0.167	0.833	0.052
1	0.25	54	0.177	0.823	0.062
1.25	0.25	57	0.187	0.813	0.072
1.5	0.25	58	0.190	0.810	0.075
1.75	0.25	59	0.194	0.806	0.079
2	0.25	60	0.197	0.803	0.082
2.25	0.25	61	0.200	0.800	0.085
2.5	0.25	63	0.207	0.793	0.092
2.75	0.25	64	0.210	0.790	0.095
3	0.25	65	0.213	0.787	0.098
3.25	0.25	67	0.220	0.780	0.105
3.5	0.25	68	0.223	0.777	0.108
3.75	0.25	69	0.226	0.774	0.112
4	0.25	69	0.226	0.774	0.112
4.25	0.25	69	0.226	0.774	0.112
4.75	0.5	70	0.230	0.770	0.115
5.25	0.5	70	0.230	0.770	0.115
5.75	0.5	70	0.230	0.770	0.115

Head Setting	
Time (min)	Head (in)
0	72.48
0.25	72.48
0.5	72.48
0.75	72.48
1	72.48
1.25	72.48
1.5	72.48
1.75	72.48
2	72.48
2.25	72.48
2.5	72.48
2.75	72.48
3	72.48
3.25	72.48
3.5	72.48
3.75	72.48
4	72.48
4.25	72.48
4.75	72.48
5.25	72.48
5.75	72.48

Figure 49. Summary of MP840 outfall right bank raw data

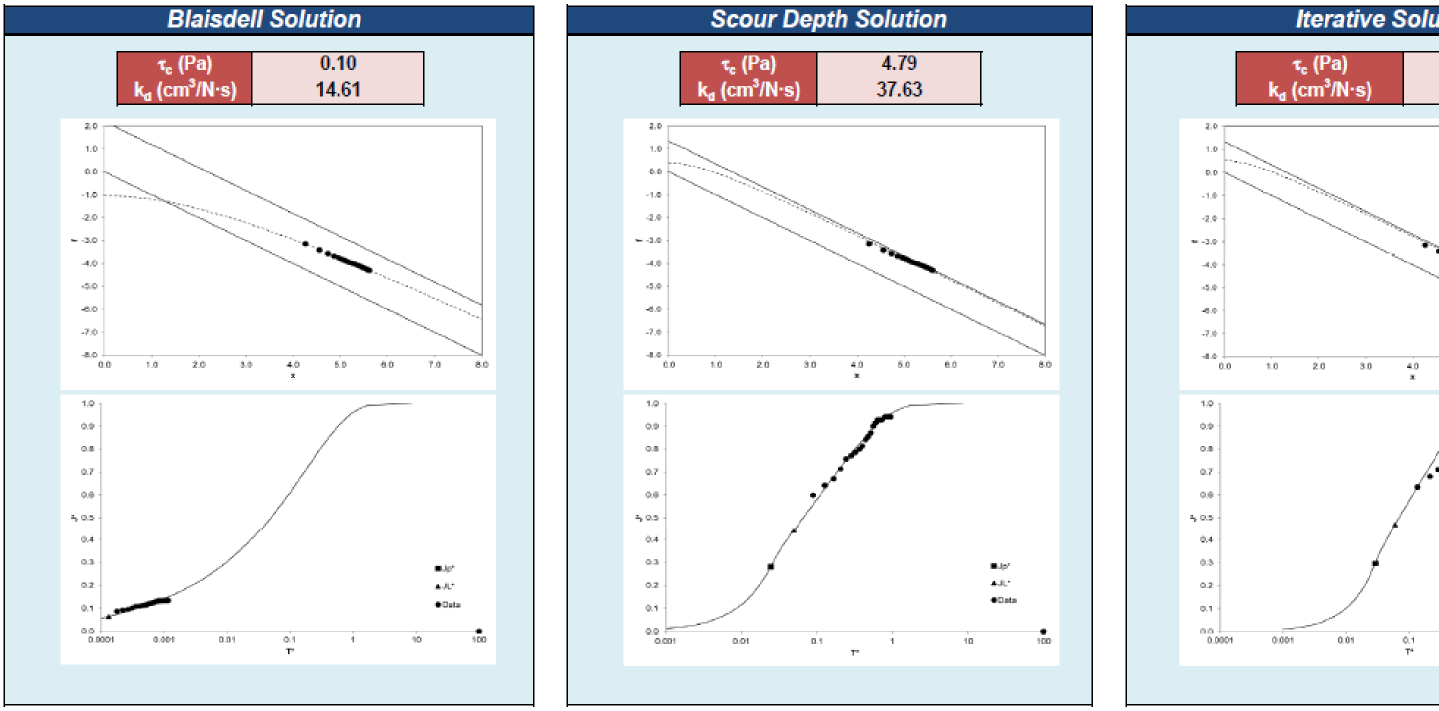


Figure 50. Summary of MP840 outfall right bank erodibility parameters

Appendix H: Soil gradation results for monitored sites

Table 1. MP458 outlet channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.81	552.29	86.48	21.61	78.39
1.68	#12	579.12	600.7	21.58	5.39	72.99
0.5	#35	400.16	493.28	93.12	23.27	49.72
0.25	#60	483.75	538.24	54.49	13.62	36.10
0.125	#120	344.43	437.45	93.02	23.25	12.85
0.0625	#230	340.16	376.26	36.1	9.02	3.83
	Pan	367.92	383.12	15.2	3.80	0.03

d_{50} = 0.51 mm

Table 2. MP458 outlet left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.83	495.76	29.93	8.06	91.94
1.68	#12	579.1	590.25	11.15	3.00	88.93
0.5	#35	400.44	460.57	60.13	16.20	72.74
0.25	#60	483.75	527.93	44.18	11.90	60.84
0.125	#120	344.34	458.01	113.67	30.62	30.22
0.0625	#230	340.1	419.42	79.32	21.37	8.85
	Pan	367.94	401.21	33.27	8.96	-0.11

Table 3. MP458 outlet right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.82	596.25	130.43	30.90	69.10
1.68	#12	579.11	616.16	37.05	8.78	60.32
0.5	#35	400.27	543.53	143.26	33.94	26.38
0.25	#60	483.74	520.84	37.1	8.79	17.59
0.125	#120	344.35	384.48	40.13	9.51	8.08
0.0625	#230	340.1	363.77	23.67	5.61	2.47
	Pan	367.94	378.72	10.78	2.55	-0.08

Table 4. MP458 intermediate channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.81	572.39	106.58	22.40	77.60
1.68	#12	579.1	602.83	23.73	4.99	72.61
0.5	#35	400.06	516.63	116.57	24.50	48.11
0.25	#60	483.77	532.37	48.6	10.22	37.89
0.125	#120	344.35	421.64	77.29	16.25	21.65
0.0625	#230	340.09	395.1	55.01	11.56	10.08
	Pan	367.94	411.81	43.87	9.22	0.86

d_{50} = 0.59 mm

Table 5. MP458 intermediate left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.83	561.22	95.39	34.69	65.31
1.68	#12	579.14	600.38	21.24	7.73	57.58
0.5	#35	401.32	488.67	87.35	31.77	25.81
0.25	#60	483.79	508.72	24.93	9.07	16.74
0.125	#120	344.39	365.48	21.09	7.67	9.07
0.0625	#230	340.1	356.26	16.16	5.88	3.19
	Pan	367.96	376.79	8.83	3.21	-0.02

Table 6. MP458 intermediate right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.83	537.54	71.71	33.63	66.37
1.68	#12	579.03	593.42	14.39	6.75	59.62
0.5	#35	400.67	447.74	47.07	22.07	37.55
0.25	#60	483.8	502.05	18.25	8.56	28.99
0.125	#120	344.35	368.94	24.59	11.53	17.46
0.0625	#230	340.12	364.18	24.06	11.28	6.18
	Pan	367.94	382.19	14.25	6.68	-0.50

Table 7. MP458 final channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.78	603.73	137.95	12.85	87.15
1.68	#12	579.08	616.75	37.67	3.51	83.64
0.5	#35	400.09	723.03	322.94	30.08	53.56
0.25	#60	483.72	730.56	246.84	22.99	30.57
0.125	#120	344.35	574.08	229.73	21.40	9.18
0.0625	#230	340.09	412.72	72.63	6.76	2.41
	Pan	367.93	393.32	25.39	2.36	0.05

d_{50} = 0.36 mm

Table 8. MP458 final left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.9	562.11	96.21	24.06	75.94
1.68	#12	579.18	602.09	22.91	5.73	70.21
0.5	#35	402.08	484.62	82.54	20.64	49.57
0.25	#60	483.79	539.9	56.11	14.03	35.54
0.125	#120	344.39	423.66	79.27	19.82	15.72
0.0625	#230	340.14	387.2	47.06	11.77	3.95
	Pan	367.95	384.29	16.34	4.09	-0.13

Table 9. MP458 final right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.81	560.61	94.8	31.57	68.43
1.68	#12	579.09	602.88	23.79	7.92	60.51
0.5	#35	400.94	485.39	84.45	28.12	32.39
0.25	#60	483.75	506.62	22.87	7.61	24.78
0.125	#120	344.35	375.38	31.03	10.33	14.45
0.0625	#230	340.11	369.99	29.88	9.95	4.50
	Pan	367.94	382.34	14.4	4.79	-0.30

Table 10. MP459 outlet channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
4.76	#4	0	0	0	0	100
2	#10	465.95	786.94	320.99	39.29	60.71
1.68	#12	579.42	637.51	58.09	7.11	53.60
0.5	#35	403.34	712.32	308.98	37.82	15.79
0.25	#60	483.81	565.83	82.02	10.04	5.75
0.125	#120	344.36	374.37	30.01	3.67	2.08
0.0625	#230	340.1	351.95	11.85	1.45	0.63
	Pan	368.01	373.56	5.55	0.68	-0.05

d_{50} = 1.57 mm

Table 11. MP459 outlet left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.97	611.72	145.75	28.39	71.61
1.68	#12	579.42	609.7	30.28	5.90	65.71
0.5	#35	402.99	544	141.01	27.46	38.25
0.25	#60	483.78	552.93	69.15	13.47	24.78
0.125	#120	344.42	416.63	72.21	14.06	10.72
0.0625	#230	340.24	382.69	42.45	8.27	2.45
	Pan	368	381.52	13.52	2.63	-0.18

Table 12. MP459 outlet right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.76	570.32	104.56	32.29	67.71
1.68	#12	579.09	600.97	21.88	6.76	60.96
0.5	#35	400.03	493.6	93.57	28.89	32.06
0.25	#60	483.73	516.93	33.2	10.25	21.81
0.125	#120	344.34	376.65	32.31	9.98	11.83
0.0625	#230	340.09	368.43	28.34	8.75	3.08
	Pan	367.92	377.89	9.97	3.08	0.00

Table 13. MP459 outfall channel bed gradation

Sieve diameter (mm)	**Sieve**	**Sieve weight (g)**	**Sieve + soil retained (g)**	**Soil retained (g)**	**Soil retained (%)**	**Soil passing (%)**
2	#10	465.99	689.97	223.98	28.43	71.57
1.68	#12	579.5	639.23	59.73	7.58	63.98
0.5	#35	403.18	762.64	359.46	45.63	18.35
0.25	#60	483.8	571.87	88.07	11.18	7.17
0.125	#120	344.4	373.73	29.33	3.72	3.45
0.0625	#230	340.14	359.37	19.23	2.44	1.01
	Pan	368.02	376.41	8.39	1.07	-0.06

d_{50} = 1.32 mm

Table 14. MP459 outfall left bank gradation

Sieve diameter (mm)	**Sieve**	**Sieve weight (g)**	**Sieve + soil retained (g)**	**Soil retained (g)**	**Soil retained (%)**	**Soil passing (%)**
2	#10	466.02	502.13	36.11	7.75	92.25
1.68	#12	579.4	591.32	11.92	2.56	89.69
0.5	#35	402.91	517.35	114.44	24.56	65.14
0.25	#60	483.83	566.67	82.84	17.77	47.36
0.125	#120	344.49	458.01	113.52	24.36	23.01
0.0625	#230	340.2	420.71	80.51	17.27	5.73
	Pan	368	394.68	26.68	5.72	0.01

Table 15. MP459 right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	466	504.66	38.66	10.42	89.58
1.68	#12	579.29	592.13	12.84	3.46	86.12
0.5	#35	402.67	453.61	50.94	13.73	72.39
0.25	#60	483.78	505.31	21.53	5.80	66.59
0.125	#120	344.37	422.36	77.99	21.02	45.57
0.0625	#230	340.12	467.96	127.84	34.45	11.12
	Pan	367.98	409.24	41.26	11.12	0.00

Table 16. MP467 outlet channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	466.1	556.05	89.95	13.32	86.68
1.68	#12	579.41	622.22	42.81	6.34	80.34
0.5	#35	403.46	778.54	375.08	55.54	24.80
0.25	#60	483.82	562.95	79.13	11.72	13.08
0.125	#120	344.36	382.63	38.27	5.67	7.41
0.0625	#230	340.09	363.56	23.47	3.48	3.94
	Pan	368.04	394.94	26.9	3.98	-0.05

d_{50} = 1.04 mm

Table 17. MP467 outlet left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.95	497.27	31.32	8.53	91.47
1.68	#12	579.26	590.5	11.24	3.06	88.41
0.5	#35	402.68	513.45	110.77	30.18	58.23
0.25	#60	483.79	555.02	71.23	19.41	38.82
0.125	#120	344.41	415.57	71.16	19.39	19.44
0.0625	#230	340.12	389.44	49.32	13.44	6.00
	Pan	367.97	390.37	22.4	6.10	-0.10

Table 18. P467 outlet right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.96	544.67	78.71	13.12	86.88
1.68	#12	579.3	604.26	24.96	4.16	82.71
0.5	#35	402.61	637.1	234.49	39.10	43.61
0.25	#60	483.78	586.85	103.07	17.19	26.43
0.125	#120	344.55	433.42	88.87	14.82	11.61
0.0625	#230	340.14	382.13	41.99	7.00	4.61
	Pan	367.98	395.96	27.98	4.67	-0.06

Table 19. MP467 outfall channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.95	586.8	120.85	13.32	86.68
1.68	#12	579.37	648.55	69.18	7.63	79.05
0.5	#35	403.41	1026.57	623.16	68.69	10.36
0.25	#60	483.83	557.41	73.58	8.11	2.25
0.125	#120	344.4	356.27	11.87	1.31	0.94
0.0625	#230	340.15	344.44	4.29	0.47	0.47
	Pan	368.05	372.05	4	0.44	0.03

d_{50} = 1.18 mm

Table 20. MP467 outfall left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.96	554.45	88.49	16.97	83.03
1.68	#12	579.31	605.43	26.12	5.01	78.02
0.5	#35	402.6	601.58	198.98	38.16	39.85
0.25	#60	488.8	567.81	79.01	15.15	24.70
0.125	#120	344.39	400.35	55.96	10.73	13.97
0.0625	#230	340.13	380.99	40.86	7.84	6.13
	Pan	367.97	395.04	27.07	5.19	0.94

Table 21. MP467 outfall right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.95	485.1	19.15	2.61	97.39
1.68	#12	579.29	587.38	8.09	1.10	96.29
0.5	#35	402.66	561.14	158.48	21.59	74.69
0.25	#60	483.79	740.31	256.52	34.95	39.74
0.125	#120	344.39	533.02	188.63	25.70	14.04
0.0625	#230	340.12	407.79	67.67	9.22	4.82
	Pan	367.97	403.31	35.34	4.82	0.00

Table 22. MP495 outlet channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	466.09	542.91	76.82	8.47	91.53
1.68	#12	579.43	633.85	54.42	6.00	85.52
0.5	#35	403.46	1011.55	608.09	67.07	18.45
0.25	#60	483.84	559.89	76.05	8.39	10.06
0.125	#120	344.37	403.67	59.3	6.54	3.52
0.0625	#230	340.13	355.92	15.79	1.74	1.78
	Pan	368.08	383.77	15.69	1.73	0.05

d_{50} = 1.06 mm

Table 23. MP495 outlet left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.89	505.02	39.13	5.75	94.25
1.68	#12	579.19	604.38	25.19	3.70	90.55
0.5	#35	402.37	682.89	280.52	41.21	49.34
0.25	#60	483.81	585.49	101.68	14.94	34.40
0.125	#120	344.4	445.81	101.41	14.90	19.50
0.0625	#230	340.12	410.48	70.36	10.34	9.17
	Pan	367.94	430.49	62.55	9.19	-0.02

Table 24. MP495 outlet right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	466.01	489.61	23.6	4.26	95.74
1.68	#12	579.27	599.32	20.05	3.62	92.12
0.5	#35	402.62	712.41	309.79	55.93	36.19
0.25	#60	483.85	575.88	92.03	16.62	19.57
0.125	#120	344.47	393.95	49.48	8.93	10.64
0.0625	#230	340.17	370.76	30.59	5.52	5.12
	Pan	368.03	396.13	28.1	5.07	0.05

Table 25. MP495 outfall channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.98	543.27	77.29	15.26	84.74
1.68	#12	579.43	604.7	25.27	4.99	79.76
0.5	#35	403.51	646.98	243.47	48.06	31.70
0.25	#60	483.78	575.74	91.96	18.15	13.55
0.125	#120	344.42	386	41.58	8.21	5.34
0.0625	#230	340.13	357.33	17.2	3.39	1.95
	Pan	368.04	377.97	9.93	1.96	-0.01

d_{50} = 0.95 mm

Table 26. MP495 outfall left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.91	586.86	120.95	34.99	65.01
1.68	#12	579.16	604.96	25.8	7.46	57.54
0.5	#35	402.5	540.92	138.42	40.05	17.50
0.25	#60	483.79	514.1	30.31	8.77	8.73
0.125	#120	344.38	355.03	10.65	3.08	5.64
0.0625	#230	340.12	352.2	12.08	3.49	2.15
	Pan	367.97	375.58	7.61	2.20	-0.05

Table 27. MP495 outfall right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.88	582.83	116.95	32.02	67.98
1.68	#12	579.21	606.45	27.24	7.46	60.53
0.5	#35	402.49	548.24	145.75	39.90	20.63
0.25	#60	483.82	522.25	38.43	10.52	10.11
0.125	#120	344.41	362.61	18.2	4.98	5.12
0.0625	#230	340.13	352.73	12.6	3.45	1.68
	Pan	367.97	374.67	6.7	1.83	-0.16

Table 28. MP814 outlet channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.99	692.08	226.09	22.98	77.02
1.68	#12	579.38	638.29	58.91	5.99	71.03
0.5	#35	403.08	816.65	413.57	42.03	29.00
0.25	#60	483.78	641.22	157.44	16.00	13.00
0.125	#120	344.43	421.8	77.37	7.86	5.13
0.0625	#230	340.15	375.87	35.72	3.63	1.50
	Pan	368.03	382.29	14.26	1.45	0.05

d_{50} = 1.09 mm

Table 29. MP814 outlet left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.89	545.14	79.25	23.20	76.80
1.68	#12	579.21	600.48	21.27	6.23	70.57
0.5	#35	402.26	509.62	107.36	31.43	39.14
0.25	#60	483.78	525.11	41.33	12.10	27.04
0.125	#120	344.4	391.02	46.62	13.65	13.39
0.0625	#230	340.1	375.83	35.73	10.46	2.93
	Pan	367.95	378.76	10.81	3.16	-0.23

Table 30. MP814 outlet right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.95	611.33	145.38	17.46	82.54
1.68	#12	579.27	655.06	75.79	9.10	73.43
0.5	#35	402.34	882.66	480.32	57.69	15.74
0.25	#60	483.8	568.11	84.31	10.13	5.62
0.125	#120	344.37	371.7	27.33	3.28	2.33
0.0625	#230	340.12	354.19	14.07	1.69	0.64
	Pan	367.94	374.32	6.38	0.77	-0.12

Table 31. MP814 outfall channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	466.19	555.86	89.67	11.49	88.51
1.68	#12	579.48	605.66	26.18	3.36	85.15
0.5	#35	403.71	688.75	285.04	36.53	48.62
0.25	#60	483.83	699.56	215.73	27.65	20.98
0.125	#120	344.37	446.62	102.25	13.10	7.87
0.0625	#230	340.13	383.52	43.39	5.56	2.31
	Pan	368.05	385.66	17.61	2.26	0.05

d_{50} = 0.54 mm

Table 32. MP814 outfall left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.86	527.48	61.62	21.95	78.05
1.68	#12	579.21	596.72	17.51	6.24	71.82
0.5	#35	402.42	467.97	65.55	23.35	48.47
0.25	#60	483.78	519.77	35.99	12.82	35.65
0.125	#120	344.37	388.91	44.54	15.86	19.79
0.0625	#230	340.12	375.3	35.18	12.53	7.26
	Pan	367.95	388.8	20.85	7.43	-0.17

Table 33. MP814 outfall right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.84	507.11	41.27	8.24	91.76
1.68	#12	579.17	595.1	15.93	3.18	88.58
0.5	#35	402.15	578.21	176.06	35.14	53.45
0.25	#60	483.75	609.53	125.78	25.10	28.34
0.125	#120	344.36	432.42	88.06	17.57	10.77
0.0625	#230	340.09	378.12	38.03	7.59	3.18
	Pan	367.94	384.4	16.46	3.29	-0.11

Table 34. MP840 outlet channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	466.71	589.24	122.53	19.93	80.07
1.68	#12	579.45	614.65	35.2	5.72	74.35
0.5	#35	403.48	739.69	336.21	54.68	19.67
0.25	#60	483.78	561.84	78.06	12.69	6.98
0.125	#120	344.38	375.82	31.44	5.11	1.87
0.0625	#230	340.12	348.25	8.13	1.32	0.54
	Pan	368.1	371.28	3.18	0.52	0.03

d_{50} = 1.15 mm

Table 35. MP840 outlet left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.9	523.48	57.58	20.32	79.68
1.68	#12	579.23	597.44	18.21	6.43	73.26
0.5	#35	402.18	488.47	86.29	30.45	42.81
0.25	#60	483.77	517.99	34.22	12.07	30.74
0.125	#120	344.37	382.24	37.87	13.36	17.37
0.0625	#230	340.11	370.68	30.57	10.79	6.59
	Pan	367.94	387.43	19.49	6.88	-0.29

Table 36. MP840 outlet right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.86	514.22	48.36	12.05	87.95
1.68	#12	579.14	596.85	17.71	4.41	83.53
0.5	#35	402.11	547.44	145.33	36.22	47.31
0.25	#60	483.77	544	60.23	15.01	32.30
0.125	#120	344.45	415.45	71	17.70	14.61
0.0625	#230	340.15	385.18	45.03	11.22	3.38
	Pan	367.94	381.62	13.68	3.41	-0.03

Table 37. MP840 outfall channel bed gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	466.15	488.02	21.87	2.46	97.54
1.68	#12	579.62	586.38	6.76	0.76	96.77
0.5	#35	403.77	668.23	264.46	29.79	66.98
0.25	#60	483.76	759.26	275.5	31.04	35.94
0.125	#120	344.36	578.35	233.99	26.36	9.58
0.0625	#230	340.14	409.93	69.79	7.86	1.72
	Pan	368.07	383.03	14.96	1.69	0.03

d_{50} = 0.36 mm

Table 38. MP840 outfall left bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.9	547.19	81.29	22.77	77.23
1.68	#12	579.17	599.86	20.69	5.79	71.44
0.5	#35	402.1	473.43	71.33	19.98	51.46
0.25	#60	483.77	518.77	35	9.80	41.66
0.125	#120	344.41	423.26	78.85	22.08	19.57
0.0625	#230	340.15	390.04	49.89	13.97	5.60
	Pan	367.9	388.34	20.44	5.72	-0.12

Table 39. MP840 outfall right bank gradation

Sieve diameter (mm)	Sieve	Sieve weight (g)	Sieve + soil retained (g)	Soil retained (g)	Soil retained (%)	Soil passing (%)
2	#10	465.92	499.44	33.52	14.05	85.95
1.68	#12	579.21	588.73	9.52	3.99	81.95
0.5	#35	402.17	437.16	34.99	14.67	67.28
0.25	#60	483.82	510.53	26.71	11.20	56.08
0.125	#120	344.38	418.13	73.75	30.92	25.16
0.0625	#230	340.11	384.55	44.44	18.63	6.53
	Pan	367.95	383.58	15.63	6.55	-0.03

Appendix I: HEC-RAS geometric files

MP458

```
Geom Title=MP458_Rebuild
Program Version=6.20
Viewing Rectangle= 4768.4091985679 , 5143.6973747306 , 5122.63505834318 ,
4975.03510733877

River Reach=MP458          ,MP458
Reach XY= 8
        4788.46        4983.2        4844.06        5035.56
        4874.71        5046.5        4912.55        5050.15
        4953.27        5030.31        4996.67        5017.45
        5066.41        5046.16        5130.23        5111.76
Rch Text X Y=4873.9025,5015.34
Reverse River Text= 0

Type RM Length L Ch R = 1 ,403.9   ,108.77,107.91,102.99
XS GIS Cut Line=3
4772.088494412634999.395740546614788.637883135634983.36722610861
4795.746685502994976.48216568195
Node Last Edited Time=Oct/05/2022 17:08:58
#Sta/Elev= 7
      0  106.59   12.34  105.91   14.99  104.45   17.33  103.18   22.93  102.07
   29.12  103.67   32.94  104.44
#Mann= 3 ,0,0
      0     .06       0   14.99     .05       0   32.94     .06       0
Bank Sta=14.99,32.94
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=102.57,0.2, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,295.99  ,43.69,39.14,32.2
XS GIS Cut Line=3
       4867.385       5059.3484873.990375125635046.23875811369
4881.34723602484 5031.6380931677
Node Last Edited Time=Oct/05/2022 17:12:11
#Sta/Elev= 10
      0  103.26    8.25  102.89    8.77  102.55    9.67  101.98   10.35  101.81
   12.03  100.94    18.7  101.61   20.14  102.02   22.08  102.56   31.03     103
#Mann= 3 ,0,0
      0     .06       0    8.77     .05       0   22.08     .06       0
Bank Sta=8.77,22.08
XS Rating Curve= 0 ,0
```

XS HTab Starting El and Incr=100.94,0.12, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,256.85 ,46.74,44.91,43.14
XS GIS Cut Line=3
4917.96404548632 5061.93106846384912.87567976499 5049.99335315714
4905.93312177713 5033.70555363599
Node Last Edited Time=Oct/05/2022 17:15:20
#Sta/Elev= 14
0 100 4.46 98.85 9.56 98.31 10.18 94.57 11.37 94.37
12.49 94.5 13.16 94.49 15.54 94.81 16.55 96.99 17.4 98.3
18.18 99.39 22.32 101.66 26.33 102 30.68 102.07
#Mann= 3 ,0,0
0 .06 0 9.56 .05 0 17.4 .06 0
Bank Sta=9.56,17.4
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=94.87,0.36, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,211.94 ,39.46,45.49,50.6
XS GIS Cut Line=3
4968.89515490006 5050.72682169412 4953.24282003669 5030.32319341858
4943.24 5017.284
Node Last Edited Time=Oct/05/2022 17:19:09
#Sta/Elev= 14
0 99.63 4.41 99.61 18.89 99.26 18.9 99.26 21.94 94.81
24.27 92.92 25.31 92.87 26.01 92.89 26.92 93.2 28.09 94.71
31.94 99.13 33.21 100.592 33.33 100.73 42.15 101.11
#Mann= 3 ,0,0
0 .06 0 18.89 .05 0 31.94 .06 0
Bank Sta=18.89,31.94
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=93.37,0.39, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,166.45 ,70.93,75.69,80.04
XS GIS Cut Line=3
4993.32988081541 5044.06330928126 4996.85286738068 5017.53090709225
4998.93211668602 5001.87161410365
Node Last Edited Time=Oct/05/2022 17:22:13
#Sta/Elev= 14
0 99.4 19.43 99.17 19.84 99.16 22.07 96.81 23.91 94.9
24.28 94.53 24.97 92.94 26.15 93 27.25 93.05 28.89 93.37

```
   31.22   95.29    32.3   96.74   35.78   97.16   42.56   99.46
#Mann= 3 ,0,0
       0     .06       0   22.07     .05       0    32.3     .06       0
Bank Sta=22.07,32.3
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=93.44,0.3, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,90.76   ,89.68,90.76,91.94
XS GIS Cut Line=3
        5052.939        5063.5115066.738589122025046.49679359172
5077.843295679515032.80524322728
Node Last Edited Time=Oct/05/2022 17:25:23
#Sta/Elev= 12
       0   97.66   12.92   97.57   13.24   97.25    13.7    96.8   14.08   96.37
   17.28   92.93   24.13   91.76   25.93   92.78   27.16   93.72   31.72   97.25
   31.74   97.25   39.54   97.21
#Mann= 3 ,0,0
       0     .06       0   13.24     .05       0   31.74     .06       0
Bank Sta=13.24,31.74
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=92.26,0.27, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,0       ,,,
XS GIS Cut Line=3
        5120.034        5121.1885130.031839218035111.55229405862
5140.018078885875101.92776751833
Node Last Edited Time=Oct/05/2022 17:27:50
#Sta/Elev= 11
       0   95.14    9.13   93.84   10.64   92.53   12.06    91.2   12.91    90.2
    13.4   89.12   16.56   88.98   17.37   88.95   17.38   88.95   19.09   92.49
   27.75   95.17
#Mann= 3 ,0,0
       0     .06       0   10.64     .05       0   19.09     .06       0
Bank Sta=10.64,19.09
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=89.45,0.29, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

LCMann Time=Dec/30/1899 00:00:00
LCMann Region Time=Dec/30/1899 00:00:00
LCMann Table=0
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Chan Stop Cuts=-1

Use User Specified Reach Order=0
GIS Units=Feet
GIS DTM Type=
GIS DTM=
GIS Stream Layer=
GIS Cross Section Layer=
GIS Map Projection=
GIS Projection Zone=
GIS Datum=
GIS Vertical Datum=
GIS Data Extents=,,,

GIS Ratio Cuts To Invert=-1
GIS Limit At Bridges=0
Composite Channel Slope=5

MP459

```
Geom Title=MP459-Geom
Program Version=6.20
Viewing Rectangle= 5001.73135107755 , 5195.25226385072 , 5042.65046 ,
4854.20954

River Reach=MP459          ,CH CL
Reach XY= 6
        5015.23        5017.9       5054.89       4997.36
        5088.31        4951.9       5121.17        4899.3
        5156.24       4893.62        5189.04       4874.32
Rch Text X Y=5058.6825,4982.005
Reverse River Text= 0

Type RM Length L Ch R = 1 ,226.46  ,41.49,41.83,44.95
XS GIS Cut Line=5
       5034.015       5040.8035022.320277752245025.03762380381
5017.428357991325016.76727498639       5017.233       5016.437
5003.628614928275003.35638939463
Node Last Edited Time=Sep/30/2022 16:22:31
#Sta/Elev= 17
      0   101.3    5.96  100.24   15.06   98.63   15.29   98.58   19.63   96.87
   23.72   95.25   27.02   93.52   27.03   93.52   29.24   93.42   29.62    93.4
   32.11   94.05   35.42   95.31   35.43   95.31   44.76   98.62      45   98.71
   45.11   98.71   48.49   99.24
#Mann= 3 ,0,0
      0     .1      0   15.06    .035      0   44.76     .1      0
Bank Sta=15.06,44.76
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=93.9,0.37, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,184.63  ,63.94,57.82,50.85
XS GIS Cut Line=3
       5064.689        5012.885054.568193973724997.52302315736
5041.542552528714977.75834497734
Node Last Edited Time=Sep/30/2022 16:39:39
#Sta/Elev= 16
      0   98.51    2.94   97.62    5.51   96.84    8.37   95.71   11.31   94.59
   14.32   94.49   16.78   93.87   18.28   92.92   18.39   92.89   19.13   92.74
   24.07   93.96   26.71   94.52   27.91   95.03   32.58   96.95   35.22   97.22
   42.06   97.78
#Mann= 3 ,0,0
      0     .1      0   14.32    .035      0   26.71     .1      0
```

```
Bank Sta=14.32,26.71
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=93.24,0.26, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,126.81  ,52.4,58.46,60.46
XS GIS Cut Line=3
       5103.362       4960.6855088.855682315074951.02197910566
5076.438282949654942.75043893072
Node Last Edited Time=Sep/30/2022 16:39:40
#Sta/Elev= 15
       0    95.6    1.39   95.48    4.65    95.2     6.7   94.19    8.01   93.73
   10.56   92.85   10.63   92.82   12.64   91.88   17.19   89.56   17.43   89.65
   28.67   93.74   28.79   93.74   28.95   93.77   30.94   94.15   32.35    94.4
#Mann= 3 ,0,0
       0      .1       0    8.01    .035       0   28.95     .06       0
Bank Sta=8.01,28.95
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=90.06,0.28, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,68.35   ,33.87,38.76,35.79
XS GIS Cut Line=3
       5137.987       4921.7875119.834337125654901.44370053936
       5110.103       4890.538
Node Last Edited Time=Sep/30/2022 16:39:31
#Sta/Elev= 14
       0   91.66     .88   91.51    6.15   90.61    6.17   90.61    7.13   90.24
   13.52   87.56   13.91   87.57   27.26   87.27   29.35   87.22   29.57   87.26
   32.18   90.31   33.76   92.18   34.16   92.66   41.88   94.79
#Mann= 3 ,0,0
       0      .1       0    6.15    .035       0   32.18      .1       0
Bank Sta=6.15,32.18
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=87.72,0.35, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,29.59   ,26.84,29.59,53.05
XS GIS Cut Line=3
       5166.121       4902.6635156.856387001434893.26323969953
5146.809380306544883.06967255497
Node Last Edited Time=Sep/30/2022 16:39:28
#Sta/Elev= 12
```

```
     0   89.55    1.68   89.01    6.17   87.57    8.18   86.58   10.18   85.51
  11.09   84.82   13.13    83.1    13.2   83.12   18.59   84.83   22.99   84.99
  23.88   85.33   27.51   86.69
#Mann= 3 ,0,0
     0      .1       0   11.09    .035       0   18.59      .1       0
Bank Sta=11.09,18.59
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=83.6,0.3, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,0       ,,,
XS GIS Cut Line=2
5187.03540260796 4886.2160180492       5193.355       4856.057
Node Last Edited Time=Sep/30/2022 16:39:26
#Sta/Elev= 9
     0   81.56    7.12   81.71    8.34   80.57    9.23   80.52   11.57   80.39
  13.41   80.26    13.9   81.03   17.36   81.79   30.81    82.4
#Mann= 3 ,0,0
     0      .1       0    7.12    .035       0   17.36      .1       0
Bank Sta=7.12,17.36
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=80.26,0.11, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

LCMann Time=Dec/30/1899 00:00:00
LCMann Region Time=Dec/30/1899 00:00:00
LCMann Table=0
Chan Stop Cuts=-1

Use User Specified Reach Order=0
GIS Units=Feet
GIS DTM Type=
GIS DTM=
GIS Stream Layer=
GIS Cross Section Layer=
GIS Map Projection=
GIS Projection Zone=
GIS Datum=
GIS Vertical Datum=
GIS Data Extents=,,,

GIS Ratio Cuts To Invert=-1
GIS Limit At Bridges=0
Composite Channel Slope=5
```

MP467

```
Geom Title=MP467Geo_Rebuild_Edit
Program Version=6.20
Viewing Rectangle= 0 , 1 , 1 , 0

River Reach=MP467           ,MP467
Reach XY= 2
0.413754227733940.086809470124010.405862457722660.97519729425028
Rch Text X Y=0.4117813,0.3089064
Reverse River Text= 0

Type RM Length L Ch R = 1 ,626.35  ,42.11,19.84,22.09
Node Last Edited Time=Sep/30/2022 10:59:48
#Sta/Elev= 15
       0     105    1.48     104     2.7     103     3.9  101.81    4.03  101.81
    5.31  101.31    5.98  101.02   10.15   97.42   10.75   97.87   11.86   98.64
   13.98  100.43   14.19  100.92   14.85  101.66   15.76  102.82   21.69     105
#Mann= 3 ,0,0
       0      .1       0    5.98     .05       0   14.19      .1       0
Bank Sta=5.98,14.19
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=97.92,0.19, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,606.51  ,3.03,17.22,20.86
Node Last Edited Time=Sep/30/2022 11:00:46
#Sta/Elev= 15
       0     102     .43   101.5    8.08  101.23    8.16   101.2    9.34  100.76
   10.91  100.17   11.57   99.27   11.91   97.16   14.01   97.25   14.46   97.26
   14.47   97.27   18.43  100.13   19.17  100.73      20  100.88      21     102
#Mann= 3 ,0,0
       0      .1       0    9.34     .05       0   19.17      .1       0
Bank Sta=9.34,19.17
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=97.66,0.18, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,589.29  ,559.36,12.7,30.85
Node Last Edited Time=Sep/30/2022 11:01:18
#Sta/Elev= 14
       0     101    1.93   100.7    3.75   100.7    9.32  100.62    9.45  100.47
    9.75  100.16   12.76   96.94   12.82   96.94   14.63   97.09   15.29    98.9
   15.65  100.17   21.27  100.47   23.07  100.57      25     101
```

```
#Mann= 3 ,0,0
       0      .1       0    9.75     .05       0   15.65      .1       0
Bank Sta=9.75,15.65
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=97.44,0.16, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,576.59  ,540.32,31.24,6.24
Node Last Edited Time=Sep/30/2022 11:01:34
#Sta/Elev= 15
       0  100.85    2.39  100.72    4.61   100.9    7.04   100.5    7.66   99.08
    8.54   97.01    9.16   96.42   11.65   96.79   12.09   96.87   12.22   98.47
   12.73   99.08   19.57  100.36   20.07  100.36   20.27  100.36   24.76     101
#Mann= 3 ,0,0
       0      .1       0    7.04     .05       0   19.57      .1       0
Bank Sta=7.04,19.57
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=96.92,0.2, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,545.35  ,38.5,42.06,62.04
Node Last Edited Time=Sep/30/2022 11:02:11
#Sta/Elev= 13
       0  100.56    3.75   99.57    9.26   98.03    9.74   97.55   11.28   95.22
   12.37   94.99   12.41   94.99   16.26   99.59   20.96   99.64   21.64   99.65
   21.66   99.65   21.72   99.65   28.12     101
#Mann= 3 ,0,0
       0      .1       0    3.75     .05       0   16.26      .1       0
Bank Sta=3.75,16.26
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=95.49,0.25, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,503.28  ,142.2,138.06,131.59
Node Last Edited Time=Sep/29/2022 14:15:54
#Sta/Elev= 12
       0      99    8.09   98.95     8.7   98.76   14.02    95.5   15.86   95.38
   16.15   95.39   16.16   95.39   18.13   98.76   20.87   98.97   25.46   99.27
   25.75   99.27   31.19   99.13
#Mann= 3 ,0,0
       0      .1       0     8.7     .05       0   18.13      .1       0
Bank Sta=8.7,18.13
XS Rating Curve= 0 ,0
```

```
XS HTab Starting El and Incr=95.88,0.17, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,365.13  ,42.14,41.28,42.82
Node Last Edited Time=Sep/29/2022 14:15:58
#Sta/Elev= 12
       0   94.94     2.2   94.97    2.59   94.97    5.15   93.31    5.67      93
     5.7      93    9.46   93.67   12.36   94.92   12.46   94.93   24.01   94.68
   25.81   94.56   28.11   94.57
#Mann= 3 ,0,0
       0      .1       0    2.59     .05       0   12.46      .1       0
Bank Sta=2.59,12.46
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=93,0.1, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,323.86  ,40.04,48.78,53.64
Node Last Edited Time=Sep/30/2022 11:03:02
#Sta/Elev= 15
       0      94     2.1    93.5   12.16   93.42   12.69   92.88   15.17   89.04
   15.38   89.03   15.76   89.41   20.88   92.87    20.9   92.87   25.79   93.63
      26   93.64   31.16   93.81   32.53   93.75   34.41   93.77   35.63   93.82
#Mann= 3 ,0,0
       0      .1       0   12.69     .05       0   20.88      .1       0
Bank Sta=12.69,20.88
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=89.53,0.21, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,275.08  ,48.72,48.52,50.66
Node Last Edited Time=Sep/29/2022 14:16:06
#Sta/Elev= 12
       0   92.42   10.01   92.82    10.1   92.81   10.18   92.73    14.1    91.3
   17.02   91.22   20.53   90.31   21.24   88.95   21.56   89.69   22.03   91.44
   23.19   91.54   31.32   92.68
#Mann= 3 ,0,0
       0      .1       0   17.02     .05       0   22.03      .1       0
Bank Sta=17.02,22.03
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=89.45,0.17, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1
```

```
Type RM Length L Ch R = 1 ,226.56  ,48.82,41.6,33.02
Node Last Edited Time=Sep/29/2022 14:16:10
#Sta/Elev= 12
       0   91.24    7.69   91.35    7.83   91.35   13.49   90.93   14.93   86.92
   16.49   86.53   19.68    90.3   20.02   90.45   20.23   90.95   31.13   91.23
   31.32   91.24   38.57   91.41
#Mann= 3 ,0,0
       0      .1       0   13.49     .05       0   20.23      .1       0
Bank Sta=13.49,20.23
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=87.03,0.22, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,184.97  ,57.22,40.72,26.88
Node Last Edited Time=Sep/29/2022 14:16:14
#Sta/Elev= 13
       0   90.39    4.34   90.37    5.82   90.35    8.61      87    9.12    86.4
    9.39   86.39   12.57    86.2   13.65   88.91    14.4   89.95   14.43   89.96
   26.48   90.48   26.55   90.48   31.18   90.41
#Mann= 3 ,0,0
       0      .1       0    5.82     .05       0   14.43      .1       0
Bank Sta=5.82,14.43
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=86.7,0.19, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,144.24  ,12.76,29.74,47.4
Node Last Edited Time=Sep/29/2022 14:16:18
#Sta/Elev= 13
       0   89.35    8.87   89.47    9.73   89.14   15.58   88.08   18.06   85.81
   23.38   86.24   24.86   86.49   26.41   88.07   27.18   88.88   33.76   89.46
   33.97   89.47   43.52   89.93   45.41   89.94
#Mann= 3 ,0,0
       0      .1       0   15.58     .05       0   26.41      .1       0
Bank Sta=15.58,26.41
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=86.31,0.18, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,114.50  ,89.08,81.88,89.2
Node Last Edited Time=Sep/29/2022 14:16:22
#Sta/Elev= 13
       0   89.17   14.39   89.03   14.51   89.03   19.97      89   23.71   88.85
```

```
  23.72   88.85   23.73   88.85   28.25   86.04   30.67   85.25   31.46    85.3
   31.8   85.95   35.81   88.71   42.12   88.83
#Mann= 3 ,0,0
      0      .1       0   23.71     .05       0   35.81      .1       0
Bank Sta=23.71,35.81
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=85.75,0.17, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,32.64   ,45.98,32.64,6.74
Node Last Edited Time=Sep/29/2022 14:16:26
#Sta/Elev= 13
      0   88.19    10.1   88.01   10.15   88.01   15.07   87.98   17.64   85.18
  17.72   85.08    23.8   83.84   24.73   83.86   25.95   84.08   26.54   84.29
  29.07   85.91   31.45    88.2   38.24   88.26
#Mann= 3 ,0,0
      0      .1       0   15.07     .05       0   31.45      .1       0
Bank Sta=15.07,31.45
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=84.34,0.2, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,0       ,0,0,0
Node Last Edited Time=Sep/29/2022 14:16:30
#Sta/Elev= 9
      0   87.42    3.71   87.65    4.71   87.66   11.78   82.43   14.35   83.19
  15.47   83.52   16.42    85.9   18.96   87.73   29.88   87.61
#Mann= 3 ,0,0
      0      .1       0    4.71     .05       0   18.96      .1       0
Bank Sta=4.71,18.96
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=82.93,0.24, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

LCMann Time=Dec/30/1899 00:00:00
LCMann Region Time=Dec/30/1899 00:00:00
LCMann Table=0
Chan Stop Cuts=-1

Use User Specified Reach Order=0
GIS Ratio Cuts To Invert=-1
GIS Limit At Bridges=0
Composite Channel Slope=5
```

MP495

```
Geom Title=MP495-Geom_Edit
Program Version=6.31
Viewing Rectangle= 4975.95984588161 , 5076.30012599571 , 5028.41679668746 ,
4970.29452398146

River Reach=MP495           ,MP495
Reach XY= 7
        4983.43         5023.48         4986.04         5020.99
        4997.64         5010.36          5011.6          5005.3
        5037.69         4992.53         5056.68         4984.39
        5072.44          4979.5
Rch Text X Y=5005.6825,5012.485
Reverse River Text= 0

Type RM Length L Ch R = 1 ,99.13   ,3.43,3.47,3.57
XS GIS Cut Line=3
4988.073466931635027.846970484464983.620284335435023.30306634167
4976.943574118025016.49033621849
Node Last Edited Time=Oct/21/2022 12:15:47
#Sta/Elev= 19
       0  100.59     .15  100.59    1.11  100.37     1.7  100.24    3.94   99.64
    5.01   99.46    5.16   99.44    6.36   99.55    6.49   99.56    7.37   99.62
    8.79   99.81    8.88   99.93    9.97  100.26   11.62  100.61   11.83  100.65
   14.36  101.13   15.02  101.21   15.42  101.26    15.9  101.33
#Mann= 3 ,0,0
       0     .05       0     .15    .035       0   11.62     .05       0
Bank Sta=0.15,11.62
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=99.44,0.09, 21
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,95.66   ,15.15,15.76,16.64
XS GIS Cut Line=3
4990.336288095655025.287210280214986.134870728935020.90464937836
4979.509777777785013.99391645075
Node Last Edited Time=Oct/21/2022 12:16:08
#Sta/Elev= 16
       0  100.61     .43  100.63     .55  100.62    2.38  100.47    5.22   98.43
    5.25   98.42    6.07   98.55    7.83   98.72    8.32   99.35    8.33   99.35
   11.97  100.53    12.9  100.82   13.02  100.88   15.14  101.11   15.56  101.15
   15.64  101.15
#Mann= 3 ,0,0
       0     .05       0    2.38    .035       0   11.97     .05       0
```

```
Bank Sta=2.38,11.97
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=98.42,0.14, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,79.9    ,12.96,14.58,16.44
XS GIS Cut Line=3
5004.042180051155018.34196060151  4997.7778012425010.30443622169
4992.312174891875003.29175286098
Node Last Edited Time=Jun/27/2022 09:11:38
#Sta/Elev= 22
       0  100.18    1.46  100.42    3.28   100.3    4.63  100.21    5.11   100.2
    6.69   99.45    6.82   99.43    6.98   99.34     9.4    98.1   10.19   98.11
   10.36   98.12   10.56   98.43   10.64   98.54    11.1    98.6   12.59   99.05
   14.15   99.38    14.3   99.43   15.93  100.28   16.48  100.54    16.6  100.55
   18.24  100.52   19.08  100.51
#Mann= 3 ,0,0
       0     .05       0    5.11    .035       0   15.93     .05       0
Bank Sta=5.11,15.93
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=98.1,0.12, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,65.33   ,29.76,29.28,28.68
XS GIS Cut Line=3
5014.368770875525011.637708813775011.480386169865005.34587420143
5007.421957184884996.50530531549
Node Last Edited Time=Oct/21/2022 12:16:28
#Sta/Elev= 17
       0   99.72    1.63   99.67    2.09   99.65    4.25   99.07    5.04    98.9
    5.61   98.35    6.13   98.08    6.14   98.08    6.92   98.18    7.16   98.21
    8.78   98.17    9.39   98.49    13.6   99.72   14.35   99.89   14.39    99.9
   15.88   99.99   16.65  100.03
#Mann= 3 ,0,0
       0     .05       0    2.09    .035       0    13.6     .05       0
Bank Sta=2.09,13.6
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=98.08,0.1, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,36.06   ,19.6,20.55,21.8
XS GIS Cut Line=3
 5042.02395078315000.235634284915037.772641489094992.49526751297
```

```
 5033.72776491954985.13075318798
Node Last Edited Time=Jun/27/2022 09:13:35
#Sta/Elev= 22
       0   99.24     .06   99.23    1.79   98.88     2.6   98.71    4.91   98.21
    5.23   98.15    6.45   97.85    6.96   97.53    8.74   97.23    8.83   97.25
     9.2   97.35    9.47   97.59    9.73      98    9.78   98.13   10.83   98.29
   10.84   98.29   10.91   98.31   12.44   99.39   15.34   99.58   15.47   99.59
   16.53   99.69   17.23   99.76
#Mann= 3 ,0,0
       0     .05       0    5.23     .03       0    9.78     .05       0
Bank Sta=5.23,9.78
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=97.23,0.13, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,15.5    ,14.72,15.52,16.24
XS GIS Cut Line=3
5060.964538540914996.165803405845056.669588932954984.39017868042
5053.497993477144975.69449624464
Node Last Edited Time=Oct/21/2022 12:16:58
#Sta/Elev= 20
       0   98.82      .1   98.83    1.33   98.81    2.44   98.77    4.43   98.72
    7.13   98.23    8.39   98.01    8.93    97.9     9.6   97.79   10.98   97.52
   12.43   96.81   12.48   96.77   12.53   96.77   12.57   96.77   13.45   97.03
   15.46   97.74   19.32   98.46   19.53   98.49   21.01   98.67   21.79   98.78
#Mann= 3 ,0,0
       0     .05       0     9.6     .03       0   15.46     .05       0
Bank Sta=9.6,15.46
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=96.77,0.1, 21
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,0      ,,,
XS GIS Cut Line=3
 5075.31639775934993.870035386725071.476800029014979.80035153819
5069.038177321854970.86435018446
Node Last Edited Time=Oct/21/2022 12:17:08
#Sta/Elev= 12
       0    98.3    2.58   98.17   10.98   97.72   12.89   97.41   13.44   97.09
   14.48   97.02   14.58   97.08    15.2   97.41   16.94   97.74   18.39      98
   23.49    98.3   23.85   98.34
#Mann= 3 ,0,0
       0     .05       0   10.98     .03       0   16.94     .05       0
Bank Sta=10.98,16.94
```

XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=97.02,0.07, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

LCMann Time=Dec/30/1899 00:00:00
LCMann Region Time=Dec/30/1899 00:00:00
LCMann Table=0
Chan Stop Cuts=-1

Use User Specified Reach Order=0
GIS Units=Feet
GIS DTM Type=
GIS DTM=
GIS Stream Layer=
GIS Cross Section Layer=
GIS Map Projection=
GIS Projection Zone=
GIS Datum=
GIS Vertical Datum=
GIS Data Extents=,,,

GIS Ratio Cuts To Invert=-1
GIS Limit At Bridges=0
Composite Channel Slope=5

MP814

Geom Title=MP814
Program Version=6.20
Viewing Rectangle= 4952.38467062038 , 5001.17855386396 , 5062.66212122334 , 4880.64552355225

River Reach=MP814 ,HEC-RAS
Reach XY= 11

4984.23	4882.43	4983.36	4915.9
4972.32	4942.02	4979.11	4956.55
4974.92	4969.52	4972.36	4986.5
4968.62	5002.96	4966.32	5016.01
4971.78	5035.44	4977.47	5045.
4984.93	5053.01		

Rch Text X Y=4984.405,4925.075
Reverse River Text= 0

Type RM Length L Ch R = 1 ,175.23 ,27.19,29.45,31.39
XS GIS Cut Line=3
4970.225772777354885.42858065898 4984.12082751764886.55949294506
4998.994989496964887.77009433109
Node Last Edited Time=Oct/10/2022 09:36:41
#Sta/Elev= 16

0	100.68	2.65	99.49	8.51	98.17	9.55	97.83	10.27	95.21
10.75	94.73	12.92	94.61	13.34	94.4	13.94	94.32	15.44	94.11
16.39	94.3	17.04	95.05	20.81	97.7	25.06	100.71	26	101.14
28.86	101.78								

#Mann= 3 ,0,0

0	.06	0	9.55	.035	0	20.81	.06	0

Bank Sta=9.55,20.81
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=94.61,0.36, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,145.78 ,30.12,28.9,24.68
XS GIS Cut Line=3
4963.250216874654910.659484956514983.320137003384915.99376783124
5000.700182459614920.61312247961
Node Last Edited Time=Oct/10/2022 09:36:30
#Sta/Elev= 19

0	100.37	8.05	100.02	8.89	99.8	11.2	99.11	15.54	97.76
18.9	95.09	19.23	94.76	19.25	94.76	20.09	94.33	20.21	93.7
20.77	93.55	22.27	93.12	22.42	93.23	23.43	95.72	24.44	97.64
25.2	99.09	31.77	100.87	32.19	100.94	38.75	101.64		

```
#Mann= 3 ,0,0
       0     .06       0   15.54    .035       0   24.44     .06       0
Bank Sta=15.54,24.44
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=93.62,0.4, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,116.88  ,14.2,15.84,14.18
XS GIS Cut Line=3
 4958.43227225824942.034323775554972.592374377444942.60177424129
4996.218266370334943.54855579003
Node Last Edited Time=Oct/10/2022 09:36:52
#Sta/Elev= 15
       0    98.4    6.92   98.95    9.03   98.96    9.36   98.99   10.84   96.63
   11.82   95.02   12.32   94.57   13.35   92.36   14.17   92.31   15.68   92.21
   15.82   92.23   17.76   96.59   25.16   98.59   32.71  101.03   37.82  101.03
#Mann= 3 ,0,0
       0     .06       0   10.84    .035       0   17.76     .06       0
Bank Sta=10.84,17.76
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=92.71,0.42, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,101.04  ,10.65,12.89,14.23
XS GIS Cut Line=3
4957.453759708334956.052229177864978.970152326654956.97276646724
4998.016511062334957.78762812896
Node Last Edited Time=Oct/10/2022 09:37:01
#Sta/Elev= 26
       0   98.06    4.93   98.43    5.16   98.45     5.4   98.47    9.51   98.76
   11.45    98.9   11.47   98.86   12.08   98.31   18.18   92.35    18.2   92.36
   21.08    91.7    21.1   91.68   21.13   91.68   21.54   91.83   23.71   92.68
   24.24   93.15   25.78   95.07   27.49   98.38   28.26   98.93      31  100.79
   31.93  101.09   31.95  101.09   32.64  101.08   39.86   100.6    40.2   100.6
    40.6  100.64
#Mann= 3 ,0,0
       0     .06       0   11.45    .035       0   28.26     .06       0
Bank Sta=11.45,28.26
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=92.18,0.45, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,88.15   ,17.48,16.85,16.26
```

```
XS GIS Cut Line=3
4955.401043010194965.725232869394975.007630904834969.24415742829
4995.851534135264972.98515118892
Node Last Edited Time=Oct/10/2022 09:37:07
#Sta/Elev= 27
      0   97.74    4.12   98.03    6.56   98.41    6.58   98.41   10.32   98.62
  13.17   98.39   13.38    98.4   14.66   97.58   16.05   96.76   16.18   96.72
  17.31   94.84   17.59   92.86   18.77   92.53   19.85   92.24   19.92   92.24
  21.94   92.36   22.58    92.4   22.59   92.41   24.32   96.65   24.75    97.6
  26.28   97.99   29.29   98.75   29.35   98.77   33.22   99.94   35.85  100.48
  40.44  100.16    41.1   100.2
#Mann= 3 ,0,0
      0     .06       0   16.18    .035       0   24.32     .06       0
Bank Sta=16.18,24.32
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=92.74,0.4, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,71.3    ,18.34,18.43,18.51
XS GIS Cut Line=3
4953.45339147632  4983.3670788174972.45079345138 4985.8959470904
4997.75018645022 4989.2637145554
Node Last Edited Time=Oct/10/2022 09:37:19
#Sta/Elev= 21
      0   97.27    1.12   97.35    6.89   98.27    7.53   98.33   11.22    98.4
  14.03   97.68   14.42   97.56    16.6   94.68   19.16   94.11   21.54   93.58
  22.89   94.77   22.94   94.77   24.08   97.33    24.1   97.39   24.16   97.41
  27.94   98.25   31.52   99.23   33.61   99.86   39.38   99.72   39.92   99.73
  44.69  100.04
#Mann= 3 ,0,0
      0     .06       0   14.42    .035       0    24.1     .06       0
Bank Sta=14.42,24.1
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=94.08,0.31, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,52.87   ,14.52,13,10.38
XS GIS Cut Line=3
4952.863042024735001.689014483054968.454434010575003.88033512479
4992.847337146485007.30868021433
Node Last Edited Time=Oct/10/2022 09:37:37
#Sta/Elev= 18
      0   97.07    3.38   97.48    3.92    97.5    7.82   97.76    8.52   96.81
   9.71   94.98   10.11   94.64   11.83   93.69   15.74   93.22   16.51   93.13
```

```
  16.89   93.12   21.58   92.77   23.07   96.94   26.04   97.85   30.98   99.32
  32.65   99.76   33.12   99.79   40.38   99.94
#Mann= 3 ,0,0
      0     .06       0    8.52    .035       0   23.07     .06       0
Bank Sta=8.52,23.07
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=93.27,0.33, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,39.87   ,24.26,20.15,11.57
XS GIS Cut Line=4
4953.254692999255016.684920816444966.507512223735016.66712592816
4979.115069674325016.650197448824980.895066849035016.64780740257
Node Last Edited Time=Oct/10/2022 09:37:49
#Sta/Elev= 18
      0   96.82    2.78   97.22    4.59   97.47    4.78   97.44    5.21   97.38
   8.62   95.51     9.1   94.76    9.57   93.85   10.03   93.42   11.73    93.1
  13.25   92.66   14.15    92.4   17.03   92.48    17.1   92.48   17.44   92.64
  24.08   95.45   25.86   96.16   27.64   97.18
#Mann= 3 ,0,0
      0     .06       0    8.62    .035       0   24.08     .06       0
Bank Sta=8.62,24.08
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=92.9,0.23, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,19.72   ,12.44,10.88,8.35
XS GIS Cut Line=3
4964.49196579596 5040.45491927484972.115735245345036.00565730878
4991.411730861845024.74443804407
Node Last Edited Time=Oct/10/2022 09:38:04
#Sta/Elev= 17
      0   97.71    1.22   98.96    1.71   99.07    1.73   99.07    2.29   96.14
   4.14    92.8    5.57    92.3    8.83   92.25    9.32   92.23   12.77   92.25
  12.85   92.29   15.22   95.69   17.02   96.17    17.4   96.25   24.03   97.48
  24.34   97.54   31.17   98.81
#Mann= 3 ,0,0
      0     .06       0    2.29    .035       0   15.22     .06       0
Bank Sta=2.29,15.22
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=92.73,0.32, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1
```

```
Type RM Length L Ch R = 1 ,8.84    ,3.53,8.84,9.04
XS GIS Cut Line=3
4969.213755821585052.453599094894977.748755974185045.29868682132
4990.528843304465034.58510720072
Node Last Edited Time=Sep/02/2022 13:58:53
#Sta/Elev= 25
      0   96.44     .33   96.37    2.37   96.22    5.87   95.52    6.23   95.43
   6.88   95.03    7.23   94.74    7.24   94.73    7.25   94.73    7.43   91.84
   8.19   91.24   10.13   91.27   11.14   91.08   12.07   90.91   12.99   91.12
  13.59   91.25   15.76   92.05   16.38   92.82   17.82   94.63   18.13   94.68
  19.01   94.91   25.94   96.39   26.28   96.37   27.12   96.44   27.81   96.66
#Mann= 3 ,0,0
      0     .06       0    7.23    .035       0   17.82     .06       0
Bank Sta=7.23,17.82
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=91.41,0.28, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,0      ,,,
XS GIS Cut Line=3
4973.042989058645060.877644775584983.775622098135051.76509108563
 4996.69369135595040.79699041093
Node Last Edited Time=Sep/02/2022 13:58:55
#Sta/Elev= 18
      0   97.14    2.22   96.67    3.75      96    5.08   94.04    7.53   93.73
   10.2   90.92   10.53   90.48   11.47   89.83   14.08   91.07   14.71   91.37
  16.97   93.64   18.27   94.83   19.47   94.73   22.58   95.23    22.7   95.27
  23.66   95.47   26.48   95.27   31.03   95.67
#Mann= 3 ,0,0
      0     .06       0    7.53    .035       0   16.97     .06       0
Bank Sta=7.53,16.97
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=90.33,0.5, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

LCMann Time=Dec/30/1899 00:00:00
LCMann Region Time=Dec/30/1899 00:00:00
LCMann Table=0
Chan Stop Cuts=-1

Use User Specified Reach Order=0
GIS Units=Feet
GIS DTM Type=
GIS DTM=
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GIS Stream Layer=
GIS Cross Section Layer=
GIS Map Projection=
GIS Projection Zone=
GIS Datum=
GIS Vertical Datum=
GIS Data Extents=,,,

GIS Ratio Cuts To Invert=-1
GIS Limit At Bridges=0
Composite Channel Slope=5

MP840

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Geom Title=MP840Geom_Rebuild_Edit
Program Version=6.31
Viewing Rectangle= 0 , 1 , 1 , 0

River Reach=MP840          ,MP840
Reach XY= 2
0.487034949267190.009019165727170.480270574971820.97181510710259
Rch Text X Y=0.4853439,0.2497182
Reverse River Text= 0

Type RM Length L Ch R = 1 ,820.51  ,13.75,20.76,22.59
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 11
    5.56  105.31    6.47  105.14    7.11   105.1   14.54   103.3   16.55  101.93
    18.5  100.63   22.84   97.78   25.25   96.82   27.63   100.6   32.51  100.82
   35.63  101.04
#Mann= 3 ,0,0
    5.56     .06       0    18.5    .035       0   27.63     .06       0
Bank Sta=18.5,27.63
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=97.32,0.4, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,799.75  ,48.99,46.83,47.17
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 15
       0  103.64   11.89  101.15   12.28  101.13    18.8  100.63   24.38   100.2
   30.84  100.36   32.81   99.92    33.6    98.6   34.04   96.36   36.77   96.66
   37.31   96.96   38.85   99.68   42.48  100.45   42.52  100.46      54  103.64
#Mann= 3 ,0,0
       0     .06       0   32.81    .035       0   38.85     .06       0
Bank Sta=32.81,38.85
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=96.86,0.34, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,752.92  ,24.34,18.92,12.38
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 15
   22.22   98.06   26.05   98.27   26.23   98.08   26.46   98.03   30.89    96.2
   33.66   94.82   33.69   94.81   35.54   94.75   35.76   94.84   38.57   96.27
   41.52   98.48    47.4   99.35   51.06   99.76   53.63  100.34   64.21   99.48
```

```
#Mann= 3 ,0,0
  22.22     .06       0   26.05    .035       0   41.52     .06       0
Bank Sta=26.05,41.52
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=95.25,0.25, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,734     ,48.79,48.24,46.56
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 11
       0   97.02   16.55   97.02   16.57   97.03   19.23   94.52   20.18   94.39
   22.32   94.32   23.82   94.34   27.51   96.39   28.23   96.77   44.92  100.35
   49.71  100.03
#Mann= 3 ,0,0
       0     .06       0   16.55    .035       0   28.23     .06       0
Bank Sta=16.55,28.23
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=94.82,0.28, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,685.76  ,95.03,109.94,112.83
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 14
       0   97.29    6.87   98.32    8.91   98.28   34.61   95.63   36.39   91.58
   39.82    91.8   39.83   91.77   39.88   91.77   44.59   95.54   45.32   96.12
   49.52   98.03   49.53   98.03   49.54   98.03   63.58   98.88
#Mann= 3 ,0,0
       0     .06       0   34.61    .035       0   44.59     .06       0
Bank Sta=34.61,44.59
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=92.08,0.31, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,575.82  ,46.07,40.51,35.7
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 10
       0   94.21   10.68   95.11   25.59   91.12   31.55   88.06   32.39   87.93
   43.63   89.48    50.7   91.18   51.07   91.18   51.69   91.13   66.48      89
#Mann= 3 ,0,0
       0     .06       0   25.59    .035       0    50.7     .06       0
Bank Sta=25.59,50.7
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=88.43,0.43, 20
```

```
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,535.31  ,56.13,55.17,54.93
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 16
   13.98   90.89   14.02   90.87   15.24    89.4   15.96    88.5   17.28   87.63
   20.24   87.17   22.83   86.85   24.64   86.89   25.68   87.02    26.7   87.09
   28.52   89.06   28.68   89.32   28.88    89.4   40.34   89.85    49.7   89.54
   55.42   88.64
#Mann= 3 ,0,0
   13.98     .06       0   15.24    .035       0   28.88     .06       0
Bank Sta=15.24,28.88
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=87.35,0.18, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,480.14  ,42.41,42.56,42.46
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 11
   18.67   89.95    24.9   86.86   24.95   86.79   26.91   85.15   30.55   85.39
   31.38    85.5   33.94   85.84   44.65   86.76   45.87   86.77    47.7   86.62
   51.62   86.67
#Mann= 3 ,0,0
   18.67     .06       0   24.95    .035       0   44.65     .06       0
Bank Sta=24.95,44.65
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=85.65,0.21, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,437.58  ,24.27,20.69,15.38
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 15
   12.39   89.38   12.58   89.28   15.98   86.44   16.71   86.14   19.43   85.43
   20.29   85.19   22.54   84.89   24.52   84.63   26.43   84.24   26.56   84.21
   26.65   84.19   26.66   84.19   28.83   85.45   36.28    85.4   46.05   85.24
#Mann= 3 ,0,0
   12.39     .06       0   19.43    .035       0   28.83     .06       0
Bank Sta=19.43,28.83
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=84.69,0.23, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1
```

```
Type RM Length L Ch R = 1 ,416.89  ,28.09,24.82,24.27
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 9
   10.82   86.23   15.26    84.4   16.73   83.78   22.65   84.45   25.06   84.56
   26.53    84.6   27.47   84.71   29.86   84.79   38.47   85.05
#Mann= 3 ,0,0
   10.82     .06       0   15.26    .035       0   22.65     .06       0
Bank Sta=15.26,22.65
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=83.78,0.12, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,392.07  ,3.19,16.55,20.6
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 11
       0   84.46    2.05   84.48   13.14   82.84   13.97   82.69   15.69   83.09
   16.35   83.22    22.4   84.12   23.89   84.45   23.95   84.45      24   84.45
    29.6   84.59
#Mann= 3 ,0,0
       0     .06       0    2.05    .035       0   23.89     .06       0
Bank Sta=2.05,23.89
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=82.69,0.09, 21
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,375.52  ,22.58,19.87,20.2
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 17
       0   83.98    1.38   84.06    4.81   84.19   11.28   84.15   13.39   83.82
   14.18   83.72   17.77   82.86      20   82.32   21.41   82.77   21.91   82.96
   21.95   82.96   24.95   83.86   29.16   84.01   30.45   84.06   30.52   84.06
   30.57   84.06   41.04   84.19
#Mann= 3 ,0,0
       0     .06       0   13.39    .035       0   24.95     .06       0
Bank Sta=13.39,24.95
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=82.32,0.09, 21
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,355.65  ,28.01,23.95,19.81
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 15
       0   84.96     .55   84.91    2.46   85.36   15.98   83.73   18.05   83.53
```

19.74 83.23 20.49 82.78 20.83 82.73 25.17 82.44 26.81 82.25
27.22 82.35 29.99 82.67 34.38 83.6 34.48 83.61 44.24 83.26
#Mann= 3 ,0,0
0 .06 0 18.05 .035 0 34.38 .06 0
Bank Sta=18.05,34.38
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=82.75,0.13, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,331.70 ,9.3,13.77,16.72
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 17
0 83.27 7.64 85.02 7.93 84.96 10.88 83.98 14.88 82.66
14.92 82.67 18.5 81.32 18.8 81.24 19.02 81.11 21.25 80.95
21.28 80.95 21.37 81 23.67 82.27 25.43 82.77 33.56 83.09
35.31 83.08 37.34 83.17
#Mann= 3 ,0,0
0 .06 0 14.92 .035 0 25.43 .06 0
Bank Sta=14.92,25.43
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=81.45,0.18, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,317.93 ,29.16,27.93,26.74
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 22
0 82.97 5.1 84.11 9.71 82.76 10.09 82.61 13.68 82.37
16.13 81.42 16.6 81.23 16.61 81.23 16.62 81.23 17.65 81.07
20.62 80.24 20.68 80.23 20.71 80.23 24.17 80.48 25.28 81.37
25.32 81.4 27.19 81.51 28.21 81.58 28.28 81.58 28.31 81.58
37.66 82.76 41.67 82.91
#Mann= 3 ,0,0
0 .06 0 16.13 .035 0 25.32 .06 0
Bank Sta=16.13,25.32
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=80.73,0.17, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,290 ,31.36,29.91,29
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 21
4.4 82.66 11.22 81.96 11.24 81.96 15.15 81.59 15.21 81.58
17.08 80.88 17.09 80.88 19.09 80.29 22.03 79.89 22.06 79.9

```
   24.7    79.7   25.32   79.66   26.13   80.17   26.58   80.76   28.29   81.22
  29.16   81.56   30.11   81.87   30.16   81.89   35.09   82.19   37.03   82.12
  45.78    81.7
#Mann= 3 ,0,0
    4.4     .06       0   15.15     .03       0   29.16     .06       0
Bank Sta=15.15,29.16
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=79.66,0.15, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,260.09  ,68.98,65.63,63.7
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 16
   7.74   81.12    9.41   81.19    9.43   81.19    9.44   81.19   12.28   80.54
   15.6   80.15   16.28   80.01    18.3   78.87   20.49   78.53   21.07   78.86
  23.14      80   25.42    81.2   25.95    81.5   27.91   82.04   28.67   82.21
  39.46   81.82
#Mann= 3 ,0,0
   7.74     .06       0   16.28     .03       0   23.14     .06       0
Bank Sta=16.28,23.14
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=79.03,0.16, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,194.46  ,36.3,33.84,30.1
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 12
      0   79.52   10.45   79.11   18.77   79.19      23   77.82    23.7   77.98
   26.5   78.41   29.93    78.8   31.77   78.93   32.88   79.19   35.14   79.68
   40.8   80.59   48.11   80.81
#Mann= 3 ,0,0
      0     .06       0   18.77     .03       0   32.88     .06       0
Bank Sta=18.77,32.88
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=77.82,0.15, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,160.62  ,85.35,92.92999,104.13
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 9
      0   78.75    7.21   78.88    7.79   78.89   12.13   78.57   16.66    77.7
  17.45   77.48   19.59   77.74   20.34   78.07    23.9   81.04
#Mann= 3 ,0,0
```

```
       0     .06       0   16.66     .03       0   19.59     .06       0
Bank Sta=16.66,19.59
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=77.98,0.15, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,67.69   ,23.67,21.6,15.74
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 15
       0   77.23    9.78   76.92    9.92   76.92    9.93   76.92   16.91   76.83
   21.93   76.26   22.16   76.06   23.13    75.2   24.69   74.98   27.87    74.9
   29.45   75.44   30.01   76.05   33.74   76.56   33.79   76.55   54.14   75.97
#Mann= 3 ,0,0
       0     .06       0   22.16     .03       0   30.01     .06       0
Bank Sta=22.16,30.01
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=74.9,0.12, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,46.09   ,46.72,46.09,45.01
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 19
    5.79   80.62     6.1    80.6    7.19   80.45    9.18   79.07   11.53   78.02
   12.97   76.93   13.23   76.21   13.63   75.06   15.52   74.01   15.84   73.96
   17.02   73.85   20.61   74.65   21.28   74.88   22.04   75.09   23.13   76.28
   24.07   76.32   27.55   76.33   28.79   76.31   33.48   76.26
#Mann= 3 ,0,0
    5.79     .06       0   13.23     .03       0   23.13     .06       0
Bank Sta=13.23,23.13
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=74.35,0.31, 20
XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

Type RM Length L Ch R = 1 ,0       ,0,0,0
Node Last Edited Time=Oct/02/2022 10:18:55
#Sta/Elev= 9
    7.36   75.42   12.57   75.49   14.21   74.58   16.23   74.03   16.48   73.93
   17.81   74.55   20.34   75.69   20.93   75.73   21.58   75.55
#Mann= 3 ,0,0
    7.36     .06       0   14.21     .03       0   17.81     .06       0
Bank Sta=14.21,17.81
XS Rating Curve= 0 ,0
XS HTab Starting El and Incr=73.93,0.09, 20
```

XS HTab Horizontal Distribution= 5 , 5 , 5
Exp/Cntr=0.3,0.1

LCMann Time=Dec/30/1899 00:00:00
LCMann Region Time=Dec/30/1899 00:00:00
LCMann Table=0
Chan Stop Cuts=-1

Use User Specified Reach Order=0
GIS Ratio Cuts To Invert=-1
GIS Limit At Bridges=0
Composite Channel Slope=5

Appendix J: Proposed channel evolution model for channels downslope of pipe outlets

Introduction

Channel evolution models (CEMs) are routinely used for the development, implementation, and evaluation of watershed management strategies and stream restoration projects (Booth & Fischenich, 2015; Cluer & Thorne, 2014; Hawley et al., 2020; Williams et al., 2022). Lammers et al. (2020) combined hydrologic model simulations with a CEM that predicts evolution over the course of multiple years to evaluate how well watershed scale stormwater control measures (SCMs) and stream restoration projects reduce pollutant loads in Colorado's Big Dry Creek watershed. The results indicated the strategic implementation of SCMs and stream restoration projects can reduce channel instability and pollutant loads. Biedenharn et al. (2004) used the CEM to optimize resources allocated for rehabilitating eroded streams within the Hickahala Creek watershed in Mississippi. Post-retrofit, the CEM was used to evaluate the effectiveness of the restoration projects; over time, less aggradation has occurred at the restored sites. In recent years the use of regenerative stormwater conveyances (RSCs) to stabilize eroding gullies at pipe outlets has increased (Cizek et al., 2017, 2018; Koryto et al., 2017; Thompson et al., 2020). RSCs employ an extensive design of media, boulders, and cobbles to stabilize banks and convey runoff. Typically, rip-rap or in extreme cases concrete is used to stabilize eroding channels downslope of pipe outlets (Figure 86).

Figure 1. Example of rip-rap lining eroding channel downslope of pipe outlet

The gullies downslope of pipe outlets function as ephemeral streams and serve as a source of excess sediment for adjacent streams (Bennett et al., 2000; Valentin et al., 2003). However, these gullies lack the bankfull and floodplain characteristics needed to use the stability identification methods proposed by Rosgen (1994) and Schumm et al. (1984); instead best professional judgment determines if the gully has stabilized or will continue to incise and or widen (Figure 87). This lack of standardization may lead to costly decisions, such as the unnecessary implementation of an RSC or rip-rap. This study aims to address lack of a CEM for gullies downslope of pipe outlets by developing a protocol based on the work of Schumm et al. (1984) and the assessment data collected for Objective One.

Figure 2. Examples of gullies downslope of pipe outlets

Methods

The ratio between the measured cross-sectional area, maximum depth, and width at the top of bank and the respective bankfull characteristic were calculated for both North Carolina Mountain and Piedmont physiographic regions using regional curves developed by Harman et al. (1999) and Harman et al. (2014) (Equation 3 through Equation 8). Slope influences channel stability (Bledsoe, 2002), and these impacts were accounted for by identifying the ratios of the channel bed slope between cross-sections at the time of the assessment and the average slope of land along the flow path *prior* to pipe installation. Hereinafter "intermediate" will refer to the channel bed slope between assessed cross-sections (Figure 88). Due to vegetation conflicts and time constraints, the channels were not surveyed using a total station. The channel bed slope was estimated using the most recent and publicly available digital elevation model (DEM) data and the channel GIS shapefile (NC DPS, 2016). The average slope of the land prior to pipe installation was estimated by adding the median of the bank heights recorded for the BEHI assessment to the estimated channel bed elevation at the first and last measured cross-sections.

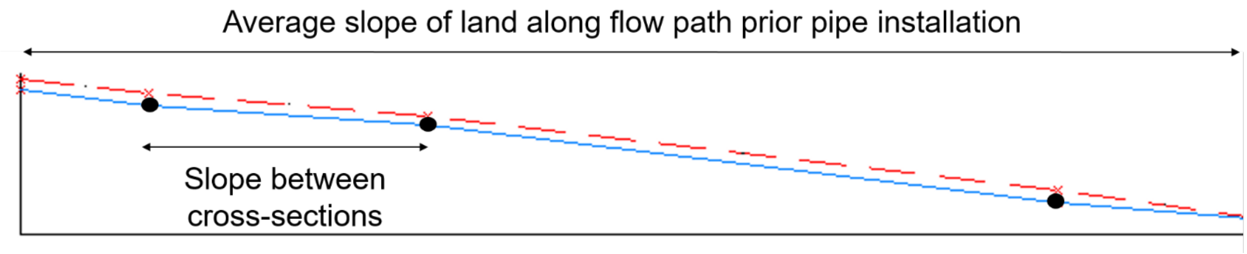


Figure 3. Average slope of land along flow path prior to pipe installation (dashed line) and channel bed slope (solid line) between cross-sections (black circles) for channel downslope pipe outlet

The stages for the proposed CEM were identified using BEHI scores and the ratio between the intermediate slope (S_{INT}) and average slope of the land (S_{LAND}) (Figure 89). A BEHI score of 30 was chosen as a threshold to ensure each stage of degradation was represented by the assessed cross-sections. The proposed stages include:

1. Stage I: no channelization ($S_{INT}/S_{LAND} = 0$ and BEHI = 0);
2. Stage II: incision ($S_{INT}/S_{LAND} > 1$ and BEHI ≤ 30);
3. Stage III: incision and widening ($S_{INT}/S_{LAND} > 1$ and BEHI > 30);
4. Stage IV: widening ($S_{INT}/S_{LAND} \leq 1$ and BEHI > 30);
5. Stage V: quasi-equilibrium ($S_{INT}/S_{LAND} \leq 1$ and BEHI ≤ 30).

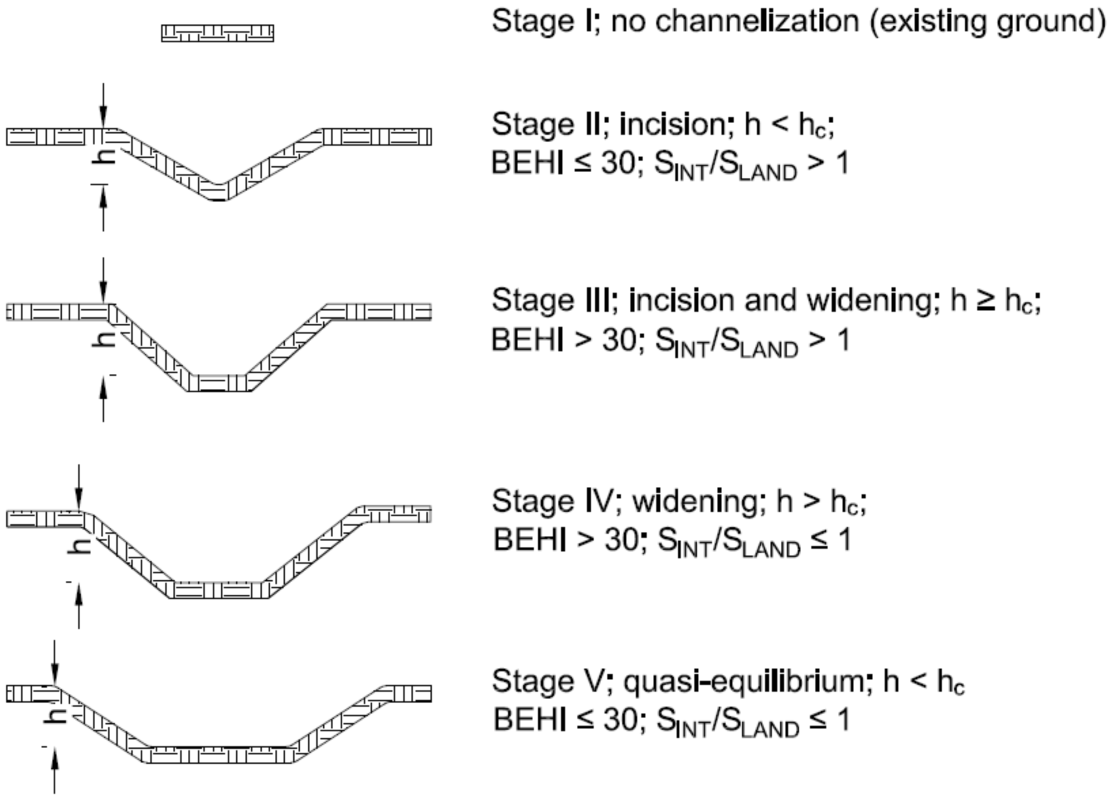


Figure 4. Proposed channel evolution model for channels downslope of pipe outlets; h, h_c, BEHI, and S_{INT}/S_{LAND} refers to bank height, critical bank height, Bank Erosion Hazard Index, and ratio of the intermediate slope to the average slope of land, respectively

The protocol for identifying the stage of degradation for gullies was developed using a decision tree and predictors described in Table 9 and Table 11. Decision trees have optimized the siting and design of green stormwater infrastructure and stream restoration projects (Bledsoe et al., 2017; Dagenais et al., 2017; Schultze et al., 2019). This analysis works well for decision making because it accounts for correlation among predictors, identifies patterns within datasets, and is easy to interpret (Kotsiantis, 2013; Myles et al., 2004). However, decision trees may over-fit training data and cause high variance and low predictive accuracy (Hastie et al., 2009). The decision tree was built using RStudio™ (RStudio Team, 2021) and data from 109 cross-sections. Appendix E includes a summary of the data describing each cross-section, and Table 121 provides the predictor variables and response (stage of degradation) used in the analyses. Objectives Three and Four include a more in-depth discussion regarding decision trees.

Table 1. Summary of predictor variables and responses for proposed channel evolution model

Site	**PT**[a]	**Q_u**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**ST**
DE162	995	2	0.06	3.5	2	0	0	22	0	100	0	0	77	2	3	0	6	3	7	3	3	ii
MP024	2086	1	0.10	3.5	37	35	4	211	28	72	0	0	58	3	5	0	4	6	66	7	5	iv
MP078	1031	1	0.08	2	0	0	0	1073	0	0	100	0	90	2	2	0	28	1	2	2	2	iii
MP120	2124	1	0.10	4	21	21	0	229	0	69	31	0	80	4	6	0	0	33	84	4	4	i
MP138	2069	3	0.10	1.5	12	8	3	329	0	36	64	0	76	3	4	0	28	11	33	5	5	iv
MP142	2121	3	0.06	2	0	0	0	185	0	100	0	0	55	1	1	0	6	0	1	3	2	iv
MP143	2126	1	0.10	3	101	97	6	8	14	78	4	3	73	5	6	0	3	80	258	6	6	i
MP152/ OUT2104/ OUT2106	2105	2	0.06	3	6	2	1	1118	0	10	64	27	81	2	3	0	17	3	7	5	5	iv
MP152/ OUT2104/ OUT2106	2108	1	0.06	3	6	2	1	1118	0	10	64	27	81	2	3	283	12	3	7	5	5	iii
MP152/ OUT2104/ OUT2106	2110	1	0.08	3	6	2	1	1118	0	10	64	27	81	2	3	542	4	3	7	5	5	v
MP152/ OUT2104/ OUT2106	2111	2	0.10	3	6	2	1	1118	0	10	64	27	81	2	3	573	5	3	7	5	5	iii
MP219	482	1	0.06	3	35	30	1	678	0	41	0	59	69	3	5	0	16	25	91	6	6	v
MP225	1044	3	0.10	3.5	11	0	1	1844	0	99	0	1	57	2	3	0	27	1	14	13	8	iii
MP225	1045	2	0.10	3.5	11	0	1	1844	0	99	0	1	57	2	3	342	21	1	14	13	8	iii
MP225	1046	1	0.10	3.5	11	0	1	1844	0	99	0	1	57	2	3	543	18	1	14	13	8	ii
MP225	1047	1	0.10	3.5	11	0	1	1844	0	99	0	1	57	2	3	839	12	1	14	13	8	iv
MP225	1048	2	0.10	3.5	11	0	1	1844	0	99	0	1	57	2	3	1453	3	1	14	13	8	v
MP227	502	1	0.04	2	1	0	0	1154	0	100	0	0	55	1	2	0	36	0	1	4	2	ii
MP227	2043	2	0.10	2	1	0	0	1154	0	100	0	0	55	1	2	1016	2	0	1	4	2	iv
MP227	2045	4	0.06	2	1	0	0	1154	0	100	0	0	55	1	2	347	21	0	1	4	2	iii
MP228	628	2	0.06	2	0	0	0	2261	0	100	0	0	55	0	1	0	9	0	0	3	2	iv
MP229	506	1	0.06	2.5	0	0	0	2446	0	0	0	100	77	1	1	0	7	1	1	2	2	iv
MP257	2059	1	0.10	1.5	16	16	1	1070	55	45	0	0	43	0	1	0	28	0	2	3	11	ii
Site	**PT**[a]	**Q_u**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**ST**

MP257	2061	2	0.10	1.5	16	16	1	1070	55	45	0	0	43	0	1	109	24	0	2	3	11	iv
MP257	2062	2	0.10	1.5	16	16	1	1070	55	45	0	0	43	0	1	346	20	0	2	3	11	iii
MP292	2083	2	0.10	4	45	42	6	283	1	99	0	0	61	2	5	0	40	2	44	11	5	i
MP311	999	1	0.06	2	0	0	0	214	0	100	0	0	58	1	2	686	4	0	1	2	2	v
MP311	1000	1	0.06	2	0	0	0	214	0	100	0	0	58	1	2	902	2	0	1	2	2	ii
MP318	2084	1	0.10	1.5	4	4	0	953	0	100	0	0	56	2	3	0	25	1	10	4	3	v
MP319	2082	1	0.06	1.5	112	106	5	294	18	82	0	0	53	2	4	0	9	1	82	31	7	iv
MP356	2046	0	0.06	2	7	5	4	461	0	30	0	70	93	4	4	0	18	14	27	5	5	iii
MP359	1006	1	0.06	2	7	7	4	246	0	0	0	100	92	4	5	0	4	22	42	3	4	iv
MP360	1008	1	0.06	2	2	2	1	387	0	0	0	100	89	3	4	0	6	7	14	3	3	iv
MP361	1003	0	0.06	2	1	1	0	199	0	0	0	100	90	2	3	0	11	4	7	2	3	iv
MP415	1018	0	0.03	2.5	1	1	0	1532	0	90	0	10	60	1	2	0	57	0	2	2	2	iii
MP415/ MP416	1019	1	0.06	2	5	4	0	1735	0	99	0	1	59	2	3	182	55	1	8	4	3	ii
MP415/ MP416	1020	1	0.06	2	5	4	0	1735	0	99	0	1	59	2	3	168	52	1	8	4	3	iii
MP415/ MP416	1021	1	0.06	2	5	4	0	1735	0	99	0	1	59	2	3	502	45	1	8	4	3	ii
MP415/ MP416	1022	1	0.06	2	5	4	0	1735	0	99	0	1	59	2	3	1044	33	1	8	4	3	ii
MP415/ MP416	1023	1	0.06	2	5	4	0	1735	0	99	0	1	59	2	3	1568	21	1	8	4	3	iv
MP415/ MP416	1024	1	0.06	2	5	4	0	1735	0	99	0	1	59	2	3	2168	11	1	8	4	3	iv
MP415/ MP416	1026	1	0.06	2	5	4	0	1735	0	99	0	1	59	2	3	1331	26	1	8	4	3	iv
MP416	1017	1	0.03	2	4	3	0	1772	0	100	0	0	59	2	3	0	63	1	8	4	3	iii
MP425	1033	1	0.08	2.5	11	9	1	2180	0	12	0	88	81	3	3	0	31	19	47	4	4	iii
MP425/ MP426	1034	1	0.10	2.5	28	26	1	2368	0	5	7	89	83	3	3	352	18	16	39	7	8	v
MP425/ MP426	1035	1	0.10	2.5	28	26	1	2368	0	5	7	89	83	3	3	441	16	16	39	7	8	iv
MP425/ MP426	1036	1	0.08	2.5	28	26	1	2368	0	5	7	89	83	3	3	676	12	16	39	7	8	iv
MP425/ MP426	1037	2	0.08	2.5	28	26	1	2368	0	5	7	89	83	3	3	790	11	16	39	7	8	iv
Site	**PT**[a]	**Q_u**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**ST**
MP425/ MP426	1039	2	0.06	2.5	28	26	1	2368	0	5	7	89	83	3	3	971	6	16	39	7	8	iii

MP426	1041	2	0.06	2.5	18	17	0	2481	0	0	11	89	84	2	3	0	32	15	34	9	10	iii
MP426	1042	1	0.06	2.5	18	17	0	2481	0	0	11	89	84	2	3	269	21	15	34	9	10	iii
MP427	185	1	0.06	2.5	0	0	0	3251	0	0	0	100	86	2	2	0	25	1	3	2	2	i
MP433	1010	1	0.10	3	15	15	0	4544	0	100	0	0	61	3	4	0	56	5	34	4	4	ii
MP433	1011	1	0.10	3	15	15	0	4544	0	100	0	0	61	3	4	241	35	5	34	4	4	iii
MP433	1012	1	0.06	3	15	15	0	4544	0	100	0	0	61	3	4	298	31	5	34	4	4	iv
MP433	1013	1	0.08	3	15	15	0	4544	0	100	0	0	61	3	4	556	24	5	34	4	4	iv
MP433	1014	1	0.08	3	15	15	0	4544	0	100	0	0	61	3	4	775	18	5	34	4	4	iv
MP433	1015	1	0.08	3	15	15	0	4544	0	100	0	0	61	3	4	1186	1	5	34	4	4	iv
MP458	989	2	0.10	3.5	8	6	1	1090	61	39	0	0	46	1	2	0	14	0	4	13	5	iv
MP458	990	1	0.10	3.5	8	6	1	1090	61	39	0	0	46	1	2	150	12	0	4	13	5	ii
MP458	991	1	0.06	3.5	8	6	1	1090	61	39	0	0	46	1	2	297	6	0	4	13	5	iii
MP459	2065	1	0.10	3.5	17	15	4	289	71	30	0	0	53	1	4	0	15	0	17	26	7	iv
MP459	2067	NA	0.08	3.5	17	15	4	289	71	30	0	0	53	1	4	114	14	0	17	26	7	ii
MP465	2096	NA	0.03	1.5	3	2	0	388	0	100	0	0	73	3	3	0	20	4	12	3	3	v
MP467	1054	2	0.08	3	1	0	0	317	0	0	100	0	82	2	2	0	16	2	4	2	2	iii
MP467	1057	1	0.06	3	1	0	0	317	0	0	100	0	82	2	2	206	10	2	4	2	2	iii
MP469	1062	1	0.06	2.5	3	0	1	1269	0	0	0	100	89	3	4	273	23	9	19	3	4	iii
MP469/ W18	1063	1	0.06	2.5	12	0	1	1426	0	0	0	100	87	3	3	595	7	17	37	4	4	iv
MP472	2093	1	0.10	1.25	37	33	15	165	0	39	48	14	85	4	4	0	2	74	172	5	5	i
MP495	984	1	0.06	2	2	0	1	3316	0	0	0	100	90	2	2	0	1	6	12	3	3	v
MP507	997	1	0.04	1.5	0	0	0	661	0	0	0	100	77	1	2	0	27	1	1	2	2	v
MP508	962	1	0.06	2.5	2	1	0	1162	0	0	1	99	85	3	3	0	30	5	12	3	4	ii
MP508	963	2	0.06	2.5	2	1	0	1162	0	0	1	99	85	3	3	136	27	5	12	3	4	ii
MP508	964	1	0.06	2.5	2	1	0	1162	0	0	1	99	85	3	3	316	25	5	12	3	4	ii
MP508	965	1	0.06	2.5	2	1	0	1162	0	0	1	99	85	3	3	1048	15	5	12	3	4	iii
Site	**PT**[a]	**Q_u**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**ST**
MP508	966	2	0.08	2.5	2	1	0	1162	0	0	1	99	85	3	3	1244	13	5	12	3	4	ii
MP508	967	1	0.08	2.5	2	1	0	1162	0	0	1	99	85	3	3	1497	9	5	12	3	4	iv

MP508	968	1	0.10	2.5	3	2	0	979	0	0	1	99	83	2	3	1362	5	4	10	3	3	iii
MP508	972	1	0.06	3	4	2	0	811	0	0	1	99	81	2	3	745	0	4	9	3	3	iv
MP508A	970	0	0.04	1.25	0	0	0	66	0	0	0	100	77	1	1	0	0	0	1	2	2	v
MP508C	974	0	0.04	1	0	0	0	393	0	0	0	100	77	1	2	0	19	0	1	2	2	v
MP508D	976	0	0.05	1.5	1	1	0	433	0	0	0	100	77	2	3	0	19	2	4	2	2	ii
MP511	973	0	0.04	3	1	1	0	163	0	0	0	100	77	2	2	0	2	1	4	2	3	iii
MP511	969	1	0.08	3	1	1	0	163	0	0	0	100	77	2	2	150	1	1	4	2	3	iv
MP525	2088	1	0.10	4	38	38	1	104	0	46	51	3	71	4	6	0	4	38	129	4	5	iii
MP558	2080	1	0.06	1	1	0	1	440	0	31	0	69	92	3	3	0	0	4	9	3	3	i
MP559	2079	1	0.10	1	2	0	0	704	0	28	0	72	82	2	2	0	26	1	2	11	12	v
MP573	2074	2	0.08	3.5	31	30	1	1824	0	26	66	8	67	3	4	0	21	16	67	5	5	iv
MP578	2076	1	0.10	2.5	12	10	6	58	6	50	0	44	87	4	6	0	0	33	72	4	4	v
MP591	2071	2	0.10	4	1	1	0	3605	0	0	8	92	82	2	2	0	6	2	6	3	3	v
MP591	2072	2	0.10	4	1	1	0	3605	0	0	8	92	82	2	2	347	3	2	6	3	3	v
MP615	993	1	0.06	2.5	11	9	1	122	54	46	0	0	48	1	3	0	13	0	7	21	5	iv
MP785	2102	NA	0.10	2	8	8	2	73	0	100	0	0	67	NA	NA	0	2	14	45	3	3	i
MP814	982	1	0.06	4	29	25	15	311	0	0	0	100	90	4	4	0	11	63	128	5	6	iv
MP840	609	1	0.06	2.5	5	4	2	2001	1	66	0	34	76	3	4	0	28	7	20	3	3	iv
MP840	979	2	0.06	2.5	5	4	2	2001	1	66	0	34	76	3	4	319	22	7	20	3	3	iii
MP840	980	1	0.06	2.5	5	4	2	2001	1	66	0	34	76	3	4	471	12	7	20	3	3	iv
OUT2111	474	1	0.06	2	0	0	0	458	0	57	0	43	70	1	2	0	18	1	2	2	2	iv
POW162	996	2	0.06	2	0	0	0	868	0	100	0	0	74	1	2	0	20	0	1	2	2	ii
POW162	998	NA	0.06	2	0	0	0	868	0	100	0	0	74	1	2	599	6	0	1	2	2	ii
W10	959	1	0.06	2	1	0	1	2965	0	0	100	0	89	2	3	0	74	3	5	3	3	iii
W10	1027	2	0.06	2	1	0	1	2965	0	0	100	0	89	2	3	788	43	3	5	3	3	iv
Site	**PT**[a]	**Q_u**[b]	**MN**[c]	**PD**[d]	**WA**[e]	**OA**[f]	**IA**[g]	**R**[h]	**A**[i]	**B**[j]	**C**[k]	**D**[l]	**CN**[m]	**V_1**[n]	**V_{10}**[o]	**DI**[p]	**DE**[q]	**Q_{p1}**[r]	**Q_{p10}**[s]	**D_1**[t]	**D_{10}**[u]	**ST**
W10	1028	1	0.06	2	1	0	1	2965	0	0	100	0	89	2	3	1236	34	3	5	3	3	iv
W10	1029	1	0.06	2	1	0	1	2965	0	0	100	0	89	2	3	1951	15	3	5	3	3	iv
W11	957	1	0.04	2	5	5	0	3045	0	0	74	26	80	3	4	0	5	9	23	3	3	v
W13	1004	1	0.06	1.5	8	8	5	242	0	0	0	100	92	2	3	0	8	25	48	4	4	iii

W13	1005	1	0.06	1.5	8	8	5	242	0	0	0	100	92	2	3	51	0	25	48	4	4	iv
W18	1059	3	0.06	1	9	0	1	1483	0	0	0	100	86	3	3	0	34	19	44	4	4	iv
W19C	1065	2	0.06	3	3	0	2	945	0	0	0	100	94	3	3	708	4	8	14	4	5	iv

Note ST refers to stage of channel degradation; [a] Point number, [b] Median approximate unconfined compressive strength of channel banks (lb/ft^3), [c] Median Manning's roughness coefficient of channel banks ($s/ft^{1/3}$), [d] Pipe diameter (ft), [e] Pipe outlet watershed area (ac) [f] Pipe outlet offsite area within watershed (ac), [g] Pipe outlet impervious area within watershed (ac), [h] Radial distance of pipe outlet to stream (ft), [I] Downslope hydrologic soil group (HSG) A soils (%), [j] Downslope HSG B soils (%), [k] Downslope HSG C soils (%), [l] Downslope HSG D soils (%), [m] Composite curve number (CN) for pipe outlet watershed, [n] Maximum velocity for 1-yr, 24-hr storm event: Permissible velocity, [o] Maximum velocity for 10-yr, 24-hr storm event: Permissible velocity, [p] Distance from pipe outlet to cross-section (ft), [q] Estimated elevation difference between cross-section and outfall (ft), [r] Peak discharge for 1-yr, 24-hr storm event for pipe outlet watershed (ft^3/s), [s] Peak discharge for 10-yr, 24-hr storm event for pipe outlet watershed (ft^3/s), [t] Duration of 1-yr, 24-hr storm event for pipe outlet watershed (hr), [u] Duration of 10-yr, 24-hr storm event for pipe outlet watershed (hr)

Results and discussion

The distribution of degradation among the 109 cross-sections was slightly skewed towards Stages III and IV (Table 122). This unbalanced dataset has caused the decision tree to be biased towards these stages (Figure 90). However, these stages represent the gully conditions that would most benefit from retrofits so this bias should not result in unnecessary implementations of RSCs or other retrofits (e.g., rip-rap). The root node error and accuracy for the decision tree were 61 and 39%, respectively. These metrics indicate poor model performance and more data is needed to train the decision tree to correctly predict the true stage of degradation.

Table 2. Summary of cross-sections used for channel degradation decision tree

Stage	Description	Quantity
I	No channelization; $S_{INT}/S_{LAND} = 0$ and BEHI = 0	7
II	Incision ($S_{INT}/S_{LAND} > 1$ and BEHI ≤ 30)	18
III	Incision and widening ($S_{INT}/S_{LAND} > 1$ and BEHI > 30)	27
IV	Widening ($S_{INT}/S_{LAND} \leq 1$ and BEHI > 30)	41
V	Quasi-equilibrium ($S_{INT}/S_{LAND} \leq 1$ and BEHI ≤ 30)	16

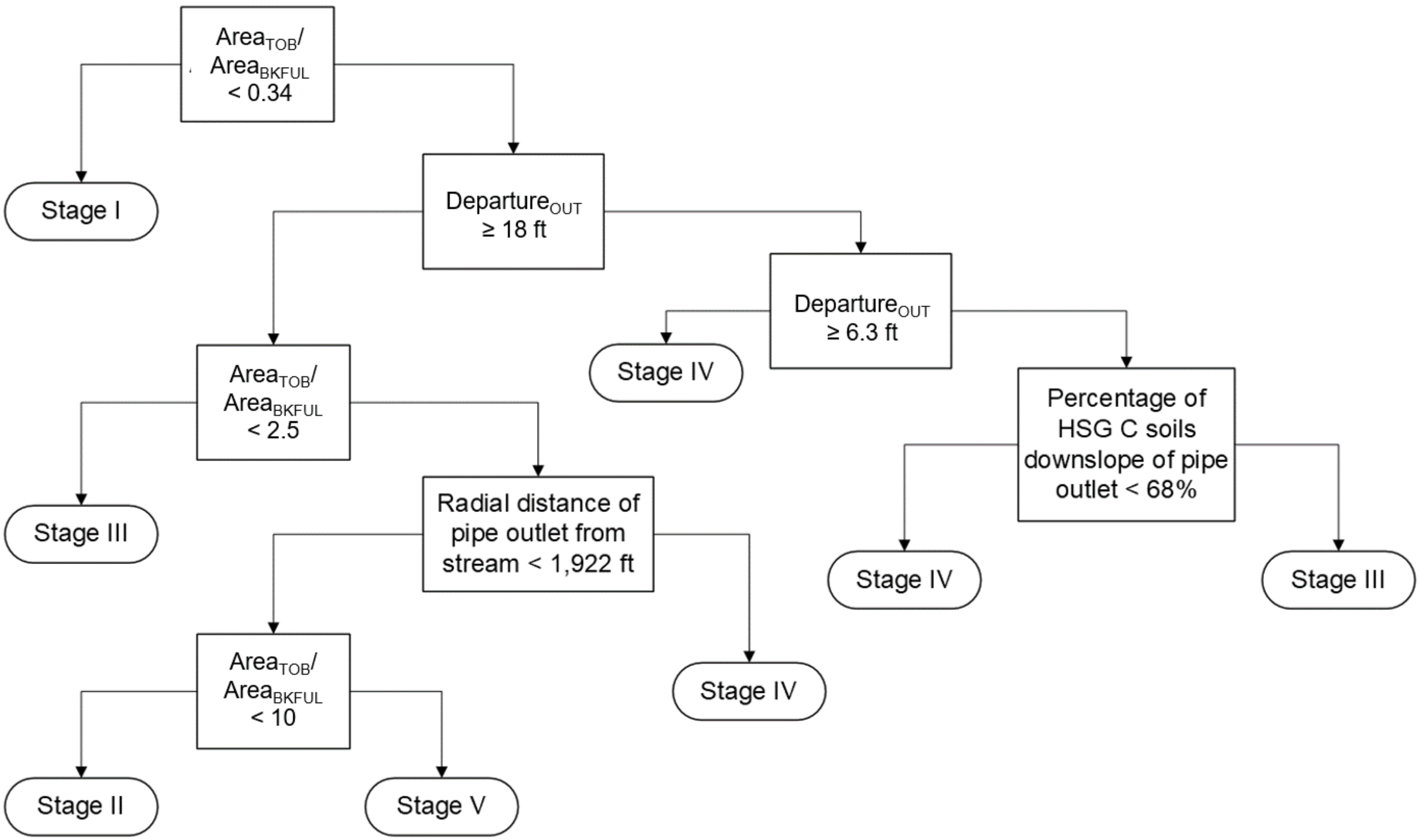


Figure 5. Decision tree for stages of degradation for gullies downslope of pipe outlets

The predictors included in the decision tree appear to be appropriate because they either affect the magnitude of erosion or describe channel stability. Bankfull discharge is the channel-forming flow that maintains stable channel dimensions and most effectively moves sediment loads over time (Doll et al., 2002; Leopold & Maddock, 1953; Metcalf et al., 2009; Sweet & Geratz, 2003; Wolman & Miller, 1960). Designers of stream restoration projects use bankfull dimensions to re-stabilize natural streams (Rosgen, 1994, 2011). The ratio between the measured and calculated bankfull area (Equation 2; Equation 5) included in the decision tree quantifies channel degradation; ratios greater than one indicate the channel is instable. $Departure_{OUT}$, or the estimated elevation difference between the cross-section and outfall, describes the potential depth of a headcut or incision that may occur. With regards to the radial distance to the stream, pipe outlets near a stream reduce the distance for a headcut to migrate upwards. This may lead to a gully forming quicker downslope of the pipe outlet. HSG C soils tend to be less permeable (NRCS, 2007), which reduces the potential for infiltration. Soils with higher infiltration rates tend to have a greater resistance to soil degradation (Hillel, 2003).

Future research is needed to validate the decision tree describing the stages of degradation for gullies located downslope of pipe outlets. This research should include cross-sectional surveys, bank pin erosion measurements, and BEHI assessments over several years to identify the channels' stage of degradation and evolution (Bledsoe et al., 2012; Hawley et al., 2012, 2020; Palmer et al., 2014; Rosgen, 2001). This research should also consider identifying and incorporating temporal predictors (e.g., pipe age) into the decision tree; previous studies have documented the extent of erosion varies with time and landscape and climatic changes (Shellberg et al., 2013; Sidorchuk, 1999; Vanmaercke et al., 2016).

Appendix K: Overview of HEC-RAS hydraulic, sediment transport, and BSTEM analyses

HEC-RAS models sediment transport using quasi-unsteady or unsteady flow hydraulics (Brunner, 2022). Quasi-unsteady flow simplifies hydrodynamics by representing a continuous hydrograph as a series of discrete steady flow profiles (Figure 91). 1D steady flow analyses calculate the water surface profiles by iteratively solving the energy equation (Equation 55). HEC-RAS uses the Manning's equation (Equation 56) to solve for discharge and velocity. 1D unsteady flow analyses iteratively solve the Saint-Venant equations for the conservation of mass (continuity) (Equation 57) and momentum (Equation 58) to calculate the water surface profiles. While unsteady flow analyses account for changes in flow over time, model stability is highly sensitive to channel geometry, roughness, and slope as well as the computational interval and modeled flow rates (Brunner, 2022).

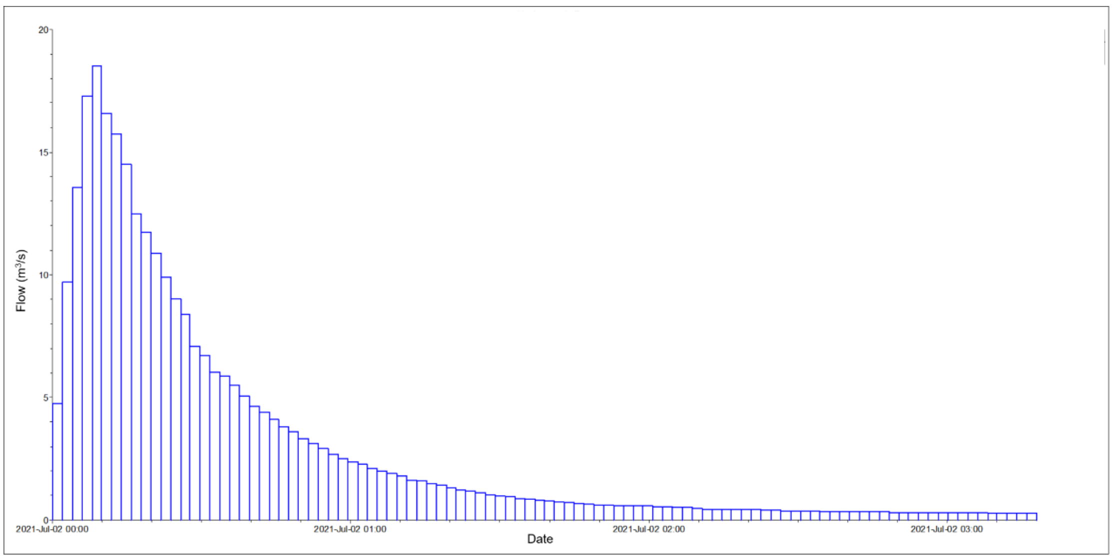


Figure 1. Continuous hydrograph modeled as discrete steady flow profiles

$$Z_2 + Y_2 + \frac{\alpha_2 * V_2^2}{2g} = Z_1 + Y_1 + \frac{\alpha_1 * V_1^2}{2g} + h_e$$ Equation 1

Where:
Z = elevation of main channel invert (ft)
Y = depth of water at cross-section (ft)
V = average velocity at cross-section (ft/s)
α = velocity weighing coefficient (1)
g = gravitational constant (32.2 ft/s^2)
h_e = energy head loss (ft)

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

Where:
Q = discharge (ft^3/s)
n = Manning's roughness coefficient ($s/ft^{1/3}$)
A = flow cross-sectional area (ft^2)
R_h = cross-sectional hydraulic radius (ft)
S_f = frictional slope (ft/ft)

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} - q = 0$$ Equation 3

Where:
Q = discharge (ft^3/s)
x = channel distance (ft)
A = flow cross-sectional area (ft^2)
t = time (s)
q = lateral inflow per unit length ($ft^3/s/ft$)

$$\frac{\partial Q}{\partial t} + \frac{\partial QV}{\partial x} + g * A * \left(\frac{\partial_z}{\partial_x} + S_f\right) = 0$$ Equation 4

Where:
Q = discharge (ft^3/s)
t = time (s)
V = average velocity at cross-section (ft/s)
x = channel distance (ft)
g = gravitational constant (32.2 ft/s^2)
A = flow cross-sectional area (ft^2)
z = water surface elevation (ft)
S_f = frictional slope (ft/ft)

2D HEC-RAS models require a computational mesh representing the entire channel geometry rather than cross-sectional geometry with known distances between cross-sections (Brunner, 2022). A Manning's roughness coefficient (n) is assigned to each cell, and the user must provide a 2D flow area polygon. Unlike 1D models that calculate a single water surface elevation (WSE) for a cross-section, 2D models compute a WSE for each cell using a Diffusion Wave form of the 2D continuity and momentum equations (Equation 59 through Equation 62). Average velocities (vertically and horizontally) are computed for each cell face. The average friction slope (S_f) is calculated for each cell face rather than multiplying S_f by the distance between cross-sections to quantify friction losses. Brunner (2022) recommends using 1D models if terrain data are only available for specific cross-sections and/or the streams are steep.

Rosgen (1994) classifies a stream steep if the channel bed slope is greater than 0.04 ft/ft; moderately steep streams have a bed slope between 0.02 and 0.04 ft/ft. Refer to Brunner et al. (2020) and Brunner (2022) for more details regarding the hydraulic computations for 1D and 2D HEC-RAS models.

Vertically averaged continuity equation

$$\frac{\partial H}{\partial t} + \frac{\partial (hu)}{\partial x} + \frac{\partial (hv)}{\partial y} - q = 0 \qquad \text{Equation 5}$$

Vertically averaged momentum equations

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial H}{\partial x} + v_t\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) - c_f u + fv$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} = -g\frac{\partial H}{\partial y} + v_t\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right) - c_f v + fu \qquad \text{Equation 6}$$

Where:
u = velocity in x direction (ft/s)
v = velocity in y direction (ft/s)
y = distance in lateral direction (t, y plane)
h = water depth (ft)
H = water surface elevation (ft)
v_t = horizontal eddy viscosity coefficient (lb/ft^2-s)
f = Coriolis parameter (rads/s)
c_f = nonlinear friction coefficient (dimensionless)

Laterally averaged continuity equation

$$\frac{\partial UB}{\partial x} + \frac{\partial WB}{\partial z} - qB = 0$$ Equation 7

Laterally averaged momentum equations

$$\frac{\partial UB}{\partial t} + U\frac{\partial UB}{\partial x} + W\frac{\partial UB}{\partial z} = -g\frac{\partial BH}{\partial x} + \frac{B}{p}\frac{\partial P}{\partial x} + \frac{1}{p}\frac{\partial B\tau_{xx}}{\partial x} + \frac{1}{p}\frac{\partial B\tau_{xz}}{\partial z}$$

$$\frac{1}{p}\frac{\partial v}{\partial y} = -g\frac{\partial H}{\partial z}$$ Equation 8

Where:
v = velocity in y direction (ft/s)
y = distance in lateral direction (t, y plane)
H = water surface elevation (ft)
v_t = horizontal eddy viscosity coefficient (lb/ft^2-s)
c_f = bottom friction coefficient (s/t$^{1/3}$)
f = Coriolis parameter (rads/s)
U = laterally averaged velocity in x direction (ft/s)
W = laterally averaged velocity in z direction (ft/s)
B = width (ft)
P = laterally averaged pressure (lb/ft^2)
τ_{xx} = turbulent stresses in xx direction (lb/ft^2)
τ_{xz} = turbulent stresses in xz direction (lb/ft^2)
q = lateral inflow per unit volume (ft^3/s/ft)

HEC-RAS solves for sediment routing using the Exner or sediment continuity equation (Brunner, 2022) (Equation 63). The Exner equation assumes the difference between sediment entering and leaving the channel is either stored or removed from storage. This difference in load is translated into changes to the channel bed through eroding or depositing sediment. If the channel's sediment transport capacity exceeds the sediment supply, HEC-RAS will erode the channel bed to satisfy the deficit. HEC-RAS divides the sediment load into grain classes and computes the sediment transport for each grain class to determine the total load eroded from or deposited onto the channel bed (Brunner, 2022). These computations occur for every specified increment, and the channel bed is updated multiple times per increment. HEC-RAS does not account for lateral channel movement because of the fixed channel boundaries within the reach.

$$(1-\lambda_p)*B\frac{\delta n}{\delta t} = -\frac{\delta Q_s}{\delta x}$$ Equation 9

Where:
λ_p = active layer porosity (unitless)
B = channel width (ft)
n = channel elevation (ft)
t = time (day)
Q_s = transported sediment load (ton/day)
x = distance (ft)

Sediment transport is highly sensitive to the sediment boundary condition, transport functions, sorting, and fall velocity methods (Brunner, 2022). HEC-RAS provides nine sediment transport functions developed from field and flume studies (Table 123). Apart from the Toffaleti functions, the transport functions are either a form of excess τ (Equation 64) or stream power (Equation 65; Equation 66). The Toffaleti functions follow the basic principles of the Einstein approach. Refer to Brunner (2022) for more details regarding each transport function.

Table 1. Summary of sediment transport functions in HEC-RAS (Brunner, 2022)

Sediment transport function	Mode of transport	Grain size range	Description
Ackers and White (Ackers and White, 1973)	Total load	Sand to fine gravel	Flume study; uses stream power function based on velocity and shear stress
Engelund-Hansen (Engelund-Hansen, 1967)	Total load	Sand	Flume study; uses stream power function based on velocity and shear stress
Laursen-Copeland (Laursen, 1958)	Total load	Coarse silt to gravel	Field and flume study; uses excess shear stress function
Meyer-Peter Müller (Meyer-Peter and Müller, 1948)	Bedload	Sand to gravel	Flume study; uses excess shear stress function
Toffaleti (Toffaleti, 1968)	Total load	Sand	Field study
Toffaleti-MPM (Williams and Julian, 1989)	Total load	Sand	Combination of Meyer-Peter Müller and Toffaleti
Toffaleti Limiter (Yaw et al., 2019)	Total load	Sand to gravel	Altered Toffaleti function to model gravel
Yang (Yang, 1973, 1984)	Total load	Sand to gravel	Flume and field study; uses stream power function based on velocity and slope
Wilcock and Crowe (Wilcock and Crowe, 2003)	Bedload	Sand to gravel	Flume and field study; uses excess shear stress function

$\varepsilon = 100 * k_d * (\tau_o - \tau_c)^a$ Equation 10

Where:
ε = erosion rate (in/s)
k_d = erodibility coefficient (in^3/lb*s)
τ_o = maximum shear stress (lb/in^2)
τ_c = critical shear stress (lb/in^2)
a = exponent typically assumed to be 1

$\omega = \tau * v$ Equation 11

Where:
ω = stream power (lb-ft/s)
τ = shear stress (lb/ft^2)
v = channel velocity (ft/s)

$$\omega = \rho * g * \frac{v}{W * d} * s$$ Equation 12

Where:
ω = stream power (lb-ft/s)
ρ = density of water (62.4 lb/ft^3)
g = gravitational constant (32.2 ft/s^2)
v = channel velocity (ft/s)
W = channel width (ft)
d = channel depth (ft)
s = channel bed slope (ft/ft)

To account for lateral retreat, HEC-RAS is often coupled with the Bank Stability and Toe Erosion (BSTEM) model developed by the United States Department of Agriculture- Agricultural Research Service (USDA-ARS) National Sedimentation Laboratory (Langendoen & Simon, 2008; Pollen-Bankhead & Simon, 2009; Simon et al., 2000, 2011; Simon & Collison, 2002). BSTEM uses flow parameters and bank geometry and geotechnical characteristics to model bank instability. Vegetative characteristics (e.g., root tensile strength, type) can also be simulated but these data are not required. The model provides default values based on soil type for unknown geotechnical characteristics (e.g., c'). BSTEM is comprised of two modules, bank stability and toe erosion, that account for each soil's layer driving (F_D) and resistive (F_R) (Figure 28). The modes of bank failure simulated in the model are horizontal layer (Equation 67), vertical slice (Equation 68), and cantilever shear failure (Equation 69) (Figure 92). A factor of safety (FoS) is calculated for each mode. A bank is stable if the FoS is greater than 1.3, conditionally stable if the FoS is between 1.0 and 1.3, and unstable if the FoS is less than 1.0. Toe erosion is calculated in BSTEM without a FoS using Equation 64 and Equation 70. The full derivation of the FoS calculations are included Langendoen & Simon (2008), Pollen-Bankhead & Simon (2009), Simon et al. (2000, 2011), and Simon & Collison (2002).

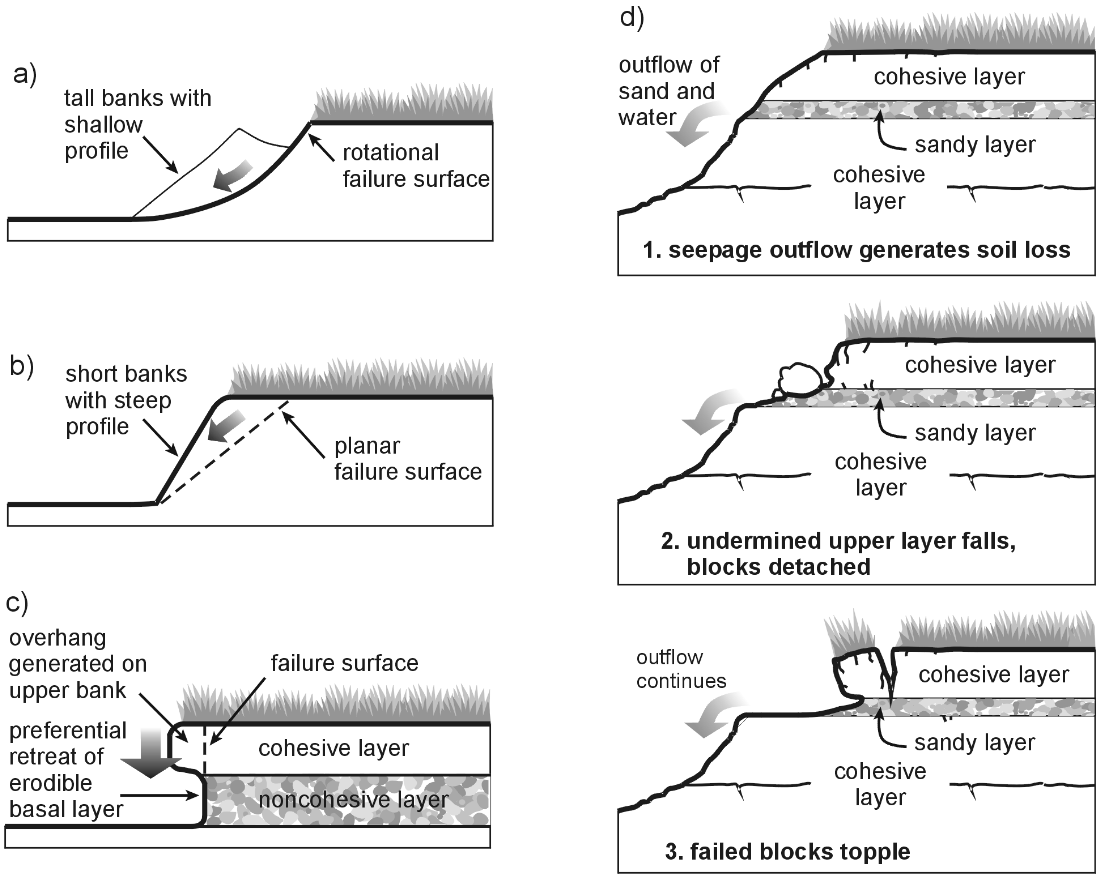


Figure 2. Examples of streambank failure (Langendoen & Ursic, 2016)

$$FoS_{HL} = \frac{\sum_{i=1}^{I} c_i^{'} L_i + \psi_i L_i \tan\phi_i^b + \left(W_i \cos\beta - U_i + P_i \cos(\alpha^{'} - \beta)\right) \tan\phi_i^{'}}{\sum_{i=1}^{I} W_i \sin\beta - P_i \sin(\alpha^{'} - \beta)} \quad \text{Equation 13}$$

Where:
FoS_{HL} = factor of safety for horizontal layer failure
c_i' = effective cohesion of i^{th} vertical layer (lb/ft^2)
L_i = surface length along failure plane of i^{th} vertical layer (ft)
ψ_i = matric suction of i^{th} vertical layer (lb/ft^2)
ϕ_i^b = angle describing relationship between shear strength and ψ_i of i^{th} vertical layer (°)
W_i = weight of i^{th} vertical layer (lb)
β = failure-plane angle from horizontal (°)
U_i = hydrostatic-uplift force from positive pore-water pressure on saturated portion of failure place of i^{th} layer (lb/ft^2)
P_i = hydrostatic confining force from external water level acting on i^{th} vertical layer (lb/ft^2)
α' = local bank angle from horizontal (°)
$\phi_i^{'}$ = soil internal angle of friction of i^{th} layer from horizontal (°)
i = horizontal layer
I = total number of horizontal layers

$$FoS_{VS}=\frac{\cos\beta\sum_{j=1}^{J} c_j^{'}L_j + \psi_j \tan\phi_j^b + (N_j\text{-}U_j)\tan\phi_j^{'}}{\sin\beta\sum_{j=1}^{J}(N_j) - P_j} \qquad \text{Equation 14}$$

Where:
FoS_{VS} = factor of safety for vertical slices failure
β = failure-plane angle from horizontal (°)
c_j' = effective cohesion of j^{th} vertical slice (lb/ft^2)
L_j = surface length along failure plane of j^{th} vertical slice (ft)
ψ_j = matric suction of j^{th} vertical slice (lb/ft^2)
ϕ_j^b = angle describing relationship between shear strength and ψ_j of j^{th} vertical slice (°)
Nj = normal force acting on base of vertical slice (lb/ft^2)
U_j = hydrostatic-uplift force from positive pore-water pressures on sat. portion of failure place of i^{th} vertical slice (lb/ft^2)
$\phi_j^{'}$ = soil internal angle of friction of j^{th} slice from vertical (°)
P_j = hydrostatic confining force due to external water level acting on i^{th} vertical slice (lb/ft^2)
j = slice number
J = total number of vertical slices

$$FoS_{CF} = \frac{\sum_{i=1}^{I} c_i^{'} L_i + \psi_i L_i \tan\phi_i^b - U_i \tan\phi_i^{'}}{\sum_{i=1}^{I} W_i - P_i}$$ Equation 15

Where:
FoS_{CF} = factor of safety for cantilever shear failure
c_i' = effective cohesion of i^{th} vertical layer (lb/ft^2)
L_i = surface length along failure plane of i^{th} vertical layer (ft)
ψ_i = matric suction of i^{th} vertical layer (lb/ft^2)
ϕ_i^b = angle describing relationship between shear strength and ψ_i of i^{th} vertical layer (°)
U_i = hydrostatic-uplift force from positive pore-water pressures on sat. portion of failure place of i^{th} vertical layer (lb/ft^2)
$\phi_i^{'}$ = soil internal angle of friction of i^{th} layer from horizontal (°)
W_i = weight of i^{th} vertical layer (lb)
P_i = hydrostatic confining force due to external water level acting on i^{th} vertical layer (lb/ft^2)
i = horizontal layer
I = total number of horizontal layers

$$\tau_a = \gamma * R_h * S$$ Equation 16

Where:
τ_a = applied shear stress (lb/ft^2)
γ = unit weight of water (62.4 lb/ft^3)
R_h = cross-sectional hydraulic radius (ft)
S = channel slope (ft/ft)

The interaction between BSTEM and HEC-RAS is an iterative feedback process (CEIWR-HEC, 2015). The calculated WSEs from HEC-RAS allow BSTEM to determine the distribution of τ along the channel bank for each computational time step. The minimum and maximum angles (bounding failure planes) are found at 100 points or nodes spread out evenly between the user specified toe of slope and top of bank. The FoS representing type of failure is calculated at each node using the τ distribution; the FoS is compared to an initial guess representing the critical FoS (lowest FoS). If the calculated FoS is smaller than the initial guess, the calculated FoS becomes the new critical FoS and a more likely critical failure plane within the bounding failure planes is identified for each node. This process continues until the lowest possible FoS is achieved at each node. Once the final critical FoS has been identified for each node, BSTEM identifies the overall lowest failure plane along the channel bank. If the FoS for the lowest failure plane is less than 1.0, the sediment within the failure plane is added to the HEC-RAS sediment control volume in the channel and the geometry for the cross-section is updated.

Appendix L: Cost analyses for proposed designs

Table 1. Predicted costs for proposed rip-rap swales

Site	Mobilization ($)	Excavation ($)	Rip-rap ($)	Geotextile fabric ($)	Total ($)
MP458	18,573	64,688	625	2,740	86,626
MP459		36,269	350	1,536	56729
MP467		72,462	790	3,437	95,263
MP495		11,340	124	538	30,575
MP814		138,617	880	3,836	161,906
MP840		131,411	1,269	5,566	156,820

Table 2. Predicted costs for proposed maintained vegetated swales

Site	Mobilization[1] ($)	Excavation ($)	Sod ($)	Annual maintenance	Total ($)
MP458	18,573	64,688	31,100	15,348	129,710
MP459		36,269	17,437	8,605	80,886
MP467		72,462	48,773	24,070	163,879
MP495		11,340	7,633	3,767	41,314
MP814		138,617	31,100	15,348	203,639
MP840		131,411	63,179	31,179	244,343

[1] Costs associated with check dam installation and maintenance are not included

Table 3. Predicted costs for proposed un-maintained vegetated swales

Site	Mobilization[1] ($)	Excavation ($)	Plants ($)	Total ($)
MP458	18,573	64,688	3,231	86,492
MP459		36,269	1,812	56,654
MP467		72,462	5,067	96,103
MP495		11,340	793	30,707
MP814		138,617	3,231	160,421
MP840		131,411	6,564	156,549

[1] Costs associated with check dam installation and maintenance are not included

Appendix M: R code for statistical analyses

```
# Packages####

source("https://www4.stat.ncsu.edu/~boos/courses/st505/functions.R.txt")
library(stats)
library(BSDA)
library(exactRankTests)
library(coin)
library(Rlab)
library(kSamples)
library(ggplot2)
library(dplyr)
library(caret)
library(tidyverse)
library(nortest)
library(nlme)
library(car)
#install.packages('gmodels')
library(gmodels)
#install.packages('ROCR')
library(ROCR)
#install.packages('imperials')
library(imperials)
#install.packages('hydroGOF')
library(hydroGOF)
library(tree)
library(lme4)
#install.packages('glmnet')
library(glmnet)
#install.packages('rpart')
library(rpart)
#install.packages('rpart.plot')
library(rpart.plot)
library(lmerTest)
#install.packages('pls')
library(pls)
#install.packages('leaps')
library(leaps)
library(caret)
#install.packages('MASS')
library(MASS)

# Occurrence Downslope Erosion ####

occ <- read.csv("C:/Users/sewaicko/Documents/Outlet Analysis Protocol
(NCDOT)/occurrence_imperial_new.csv", header=TRUE)

occ_tidy <- na.omit(occ)
```

```
occ_nzv <- nearZeroVar(occ_tidy,
                       saveMetrics = TRUE) # Checking for zero/near zero variance between predictor
variables

occ_nzv

occ_sub <- subset(occ_tidy, select = -c(site, resp_log, resp))

occ_resp <- occ_tidy[,c(22,23)]

occ_sc <- scale(occ_sub, center = TRUE, scale = TRUE)

occ_corr <- cor(occ_sc)

occ.cor <- findCorrelation(occ_corr,
                           cutoff = 0.80) # Checking for correlation between predictor variables

occ.cor

data.frame(colnames(occ_corr)) # Identifying columns with correlation > 0.80

occ_df <- data.frame(occ_sc, occ_resp)

set.seed(1) # Set seed to get same data partitions every time

occ_part <- createDataPartition(y = occ_df$resp_log,
                                p = 0.85,
                                list = FALSE)

occ_train <- occ_df[occ_part,]

occ_test <- occ_df[-occ_part,]

summary(occ_train)

summary(occ_test)

# Principal Components Regression

pca1 <- prcomp(occ_train[,c(-23, -24)])

summary(pca1)

pca1$rotation

write.csv(pca1$rotation, "C:/Users/sewaicko/Documents/Outlet Analysis Protocol
(NCDOT)/imperial pca.csv", row.names = TRUE)

pca_results <- abs(pca1$rotation)
```

```
write.csv(pca_results, "C:/Users/sewaicko/Documents/Outlet Analysis Protocol
(NCDOT)/imperial pca_absolute.csv", row.names = TRUE)

#str(pca1)

pca1_var <- pca1$sdev^2

pve <- pca1_var/sum(pca1_var)

plot(pve, xlab = "Principal Component",

    ylab = "Proportion of Variation Explained",

    ylim = c(0,1),

    type = 'b')

plot(cumsum(pve), xlab = "Prinicipal Component",

    ylab = "Accumulative Proportion of Variation Explained",

    ylim = c(0,1),

    type = 'b')

occ_comp <- data.frame(resp_log = occ_train[, "resp_log"], pca1$x[, 1:8])

log_occ_pca <- glm(resp_log ~.,

                data = occ_comp,

                family = binomial)

summary(log_occ_pca)

log_occ_test <- predict(pca1, newdata = occ_test[, 1:22])

log_pred <- predict(log_occ_pca, newdata = data.frame(log_occ_test[,1:8]), type = "response")

pred_log <- factor(ifelse(log_pred >= 0.5, "TRUE", "FALSE"))

table(occ_test$resp, pred_log)

confusionMatrix(pred_log, as.factor(occ_test$resp), positive = "TRUE")

# Occurrence of Downslope Erosion Training

occ1 <- glm(resp_log ~ pipe + offsite + watershed + impervious +
           radial + hsga + hsgb + hsgc + hsgd + cn + qp1 +
           qp10 + duration1 + duration10 + comp + mannings +
           bulk + sand + clay + departure + v1 + v10,
```

```
          family = binomial(link = "logit"),
          data = occ_train)

summary(occ1)

plot(predict(occ1), residuals(occ1), col = c("blue", "red"))

abline(h = 0, lty = 2, col = "grey")

predicted_occ1 <- predict(occ1, occ_train, type = "response")

# Decision Tree Occurrence of Downslope Erosion

#occ_tree <- subset(occ_tidy, select = -c(site, resp_log))

occ_tree <- subset(occ, select = -c(site, resp_log))

occ_tree$resp <- as.factor(occ_tree$resp)

set.seed(3) # Set seed to get same data partitions every time

occ_part <- createDataPartition(y = occ_tree$resp,
                                p = 0.85,
                                list = FALSE)

occ_train <- occ_tree[occ_part,]

occ_test <- occ_tree[-occ_part,]

tree_occ <- tree(resp ~., occ_train)

summary(tree_occ)

plot(tree_occ)

text(tree_occ, pretty = 0)

predict_occ_tree <- predict(tree_occ, occ_test, type = "class")

table_occ <- table(predict_occ_tree, occ_test$resp)

accuracy_test <- sum(diag(table_occ)) / sum(table_occ)

print(paste('occ test accuracy', accuracy_test))

precision_test <- 1/2 #True positive/Sum(true positive, false positive)

print(paste('occ test precision', precision_test))

# Magnitude of Erosion ####
```

```
# Bankfull Characteristics

# Generalized Linear Mixed Effects Models

mag_bkful <- read.csv("C:/Users/sewaicko/Documents/Outlet Analysis Protocol
(NCDOT)/bankfull_magnitude_imperial_new.csv",header=TRUE)

bkful_tidy <- na.omit(mag_bkful)

summary(bkful_tidy)

bkful_nzv <- nearZeroVar(bkful_tidy,
                    saveMetrics = TRUE)

bkful_nzv

bkful_sub <- subset(bkful_tidy, select = -c(name, site, point, width, area, slope, depth, casea,
caseb, v1, v10))

bkful_resp <- bkful_tidy[,c(2, 4, 5, 7)]

bkful_sc <- scale(bkful_sub, center = TRUE, scale = TRUE)

bkful_corr <- cor(bkful_sc)

bkful.cor <- findCorrelation(bkful_corr,
                       cutoff = 0.80)

bkful.cor

data.frame(colnames(bkful_corr))

bkful_df <- data.frame(bkful_sc, bkful_resp)

set.seed(4) # Set seed to get same data partitions every time

bkful_part <- createDataPartition(y = bkful_df$width,
                           p = 0.85,
                           list = FALSE)

bkful_train <- bkful_df[bkful_part,]

bkful_test <- bkful_df[-bkful_part,]

summary(bkful_train)

summary(bkful_test)

require(lmerTest)

area1 <- lmer(area ~ pipe + offsite + watershed + impervious +
```

```
            radial + hsga + hsgb + hsgc + hsgd + cn + qp1 +
            qp10 + duration1 + duration10 + comp +
            mannings + (1|site),
            data = bkful_train)

summary(area1)

#print(area1, correlation = TRUE)

area2 <- lmer(area ~ radial + hsgc + hsgd + cn + duration10 +
            (1|site),
            data = bkful_train)

summary(area2)

qqnorm(residuals(area2), main = "Area Residuals")

qqline(residuals(area2), col = "black", lwd = 1, lty = 2)

predict_area <- predict(area2, bkful_test, allow.new.levels = TRUE)

area_RMSE <- rmse(bkful_test$area, predict_area)

area_RMSE #11.37

area_NRMSE <- area_RMSE/(max(bkful_tidy$area) - min(bkful_tidy$area))

area_NRMSE #0.071

area_NSE <- NSE(predict_area, bkful_test$area)

area_NSE #

width1 <- lmer(width ~ pipe + offsite + watershed + impervious +
             radial + hsga + hsgb + hsgc + hsgd + cn + qp1 +
             qp10 + duration1 + duration10 + comp +
             mannings + distance + departure + (1|site),
             data = bkful_train)

summary(width1)

#print(width1, correlation = TRUE)

width2 <- lmer(width ~ radial + hsga + hsgb + hsgc + cn +
             duration10 + (1|site), data = bkful_train)

summary(width2)

qqnorm(residuals(width2), main = "Width Residuals")

qqline(residuals(width2), col = "black", lwd = 1, lty = 2)
```

```
predict_width <- predict(width2, bkful_test, allow.new.levels = TRUE)

width_RMSE <- rmse(bkful_test$width, predict_width)

width_RMSE #6.49

width_NRMSE <- width_RMSE/(max(bkful_tidy$width) - min(bkful_tidy$width))

width_NRMSE #0.094

width_NSE <- NSE(predict_width, bkful_test$width)

width_NSE #

depth1 <-lmer(depth ~ pipe + offsite + watershed + impervious +
        radial + hsga + hsgb + hsgc + hsgd + cn + qp1 +
        qp10 + duration1 + duration10 + comp +
        mannings + distance + departure + (1|site),
        data = bkful_train)

summary(depth1)

#print(depth1, correlation = TRUE)

depth2 <-lmer(depth ~ watershed + radial + hsgb + cn + duration10 +
        distance + (1|site), data = bkful_train)

summary(depth2)

qqnorm(residuals(depth2), main = "Depth Residuals")

qqline(residuals(depth2), col = "black", lwd = 1, lty = 2)

predict_depth <- predict(depth2, bkful_test, allow.new.levels = TRUE)

depth_RMSE <- rmse(bkful_test$depth, predict_depth)

depth_RMSE #7.69

depth_NRMSE <- depth_RMSE/(max(bkful_tidy$depth) - min(bkful_tidy$depth))

depth_NRMSE #0.21

depth_NSE <- NSE(predict_depth, bkful_test$depth)

depth_NSE #

# Decision Trees
```

```
#bkful_tree <- subset(bkful_tidy, select = -c(site, point, slope, casea, caseb, distance, departure,
v1, v10))

bkful_tree <- subset(mag_bkful, select = -c(site, point, slope, casea, caseb, distance, departure,
v1, v10))

set.seed(5) # Set seed to get same data partitions every time

bkful_tree_part <- createDataPartition(y = bkful_tree$width,
                              p = 0.85,
                              list = FALSE)

bkful_tree_train <- bkful_tree[bkful_tree_part,]

bkful_tree_test <- bkful_tree[-bkful_tree_part,]

tree_area <- tree(area ~. -width - depth, bkful_tree_train)

summary(tree_area)

plot(tree_area)

text(tree_area, pretty = 0)

predictions_area_tree <- tree_area %>% predict(bkful_tree_test)

area_tree_RMSE<- RMSE(predictions_area_tree, bkful_tree_test$area)

area_tree_RMSE #14.47

area_tree_NRMSE <- area_tree_RMSE/(max(bkful_tidy$area) - min(bkful_tidy$area))

area_tree_NRMSE #0.090

tree_width <- tree(width ~. -area - depth, bkful_tree_train)

summary(tree_width)

plot(tree_width)

text(tree_width, pretty = 0)

predictions_width_tree <- tree_width %>% predict(bkful_tree_test)

width_tree_RMSE<- RMSE(predictions_width_tree, bkful_tree_test$width)

width_tree_RMSE #11.65

width_tree_NRMSE <- width_tree_RMSE/(max(bkful_tidy$width) - min(bkful_tidy$width))

width_tree_NRMSE #0.17
```

```
tree_depth <- tree(depth ~. -area - width, bkful_tree_train)

summary(tree_depth)

plot(tree_depth)

text(tree_depth, pretty = 0)

predictions_depth_tree <- tree_depth %>% predict(bkful_tree_test)

depth_tree_RMSE<- RMSE(predictions_depth_tree, bkful_tree_test$depth)

depth_tree_RMSE #6.33

depth_tree_NRMSE <- depth_tree_RMSE/(max(bkful_tidy$depth) - min(bkful_tidy$depth))

depth_tree_NRMSE #0.17

# Volume of Eroded Soil

mag_vol <- read.csv("C:/Users/sewaicko/Documents/Outlet Analysis Protocol
(NCDOT)/volume_magnitude_imperial_new.csv",header=TRUE)

vol_tidy <- na.omit(mag_vol)

vol_nzv <- nearZeroVar(vol_tidy,
                       saveMetrics = TRUE)

vol_nzv

vol_sub <- subset(vol_tidy, select = -c(site, volume))

vol_resp <- vol_tidy[,c(22)]

vol_sc <- scale(vol_sub, center = TRUE, scale = TRUE)

vol_corr <- cor(vol_sc)

vol.cor <- findCorrelation(vol_corr,
                           cutoff = 0.80)

vol.cor

data.frame(colnames(vol_corr))

vol_df <- data.frame(vol_sc, vol_resp)

set.seed(10)

vol_data <- createDataPartition(y = vol_df$vol_resp,
```

```
                     p = 0.85,
                     list = FALSE)

vol_train <- vol_df[vol_data,]

vol_test <- vol_df[-vol_data,]

summary(vol_train)

summary(vol_test)

vol_train <- rbind(vol_train,vol_test[5,]) #Ensuring maximum response in training dataset

vol_test <- vol_test[-5,] #Removing maximum response from testing dataset

volume1 <- glm(vol_resp ~ pipe + offsite + watershed + impervious +
          radial + hsga + hsgb + hsgc + hsgd + cn + qp1 +
          qp10 + duration1 + duration10 + comp + mannings +
          bulk + sand + clay + departure + v1 + v10,
          data = vol_train)

summary(volume1)

#print(volume1, correlation = TRUE)

volume2 <- glm(vol_resp ~ qp1 + qp10 + v1 + v10,
          data = vol_train)

summary(volume2)

qqnorm(residuals(volume2), main = "Volume Residuals")

qqline(residuals(volume2), col = "black", lwd = 1, lty = 2)

predict_volume <- predict(volume2, vol_test, allow.new.levels = TRUE)

volume_RMSE <- rmse(vol_test$vol_resp, predict_volume)

volume_RMSE #0.44

volume_NRMSE <- volume_RMSE/(max(vol_tidy$volume) - min(vol_tidy$volume))

volume_NRMSE #0.17

volume_NSE <- NSE(predict_volume, vol_test$vol_resp)

volume_NSE #

# Combined Residual Plots

par(mfrow = c(2,2))
```

```
qqnorm(residuals(area2), main = "Area Residuals")

qqline(residuals(area2), col = "black", lwd = 1, lty = 2)

qqnorm(residuals(width2), main = "Width Residuals")

qqline(residuals(width2), col = "black", lwd = 1, lty = 2)

qqnorm(residuals(depth2), main = "Depth Residuals")

qqline(residuals(depth2), col = "black", lwd = 1, lty = 2)

qqnorm(residuals(volume2), main = "Volume Residuals")

qqline(residuals(volume2), col = "black", lwd = 1, lty = 2)

# Decision Tree

vol_tree <- subset(vol_tidy, select = -c(site))

vol_tree <- subset(mag_vol, select = -c(site))

set.seed(11) # Set seed to get same data partitions every time

vol_tree_part <- createDataPartition(y = vol_tree$volume,
                                     p = 0.85,
                                     list = FALSE)

vol_tree_train <- vol_tree[vol_tree_part,]

vol_tree_test <- vol_tree[-bkful_tree_part,]

tree_vol <- tree(volume ~., vol_tree_train)

summary(tree_vol)

plot(tree_vol)

text(tree_vol, pretty = 0)

predictions_vol_tree <- tree_vol %>% predict(vol_tree_test)

vol_tree_RMSE<- RMSE(predictions_vol_tree, vol_tree_test$volume)

vol_tree_RMSE #0.19

vol_tree_NRMSE <- vol_tree_RMSE/(max(vol_tidy$volume) - min(vol_tidy$volume))

vol_tree_NRMSE #0.072
```

```
# Propose Channel Evolution ####

cem_sub <- subset(bkful_sub <- subset(bkful_tidy, select = -c(name, site, point, slope, comp,
mannings)))

tree_cem1 <- rpart(caseb ~. -casea, data = cem_sub)

printcp(tree_cem1)

rpart.plot(tree_cem1)
```

Appendix N: UNCC final report

1.0 Introduction and Background

This research was conducted to understand the water quality, hydrology and site characteristics of flow from two outlet pipes along highway sites in Cabarrus County, North Carolina. For this work, several water quality parameters were examined, and the hydrologic response was determined along three points of the monitored outlets and their respective channels. Water samples were collected after every eligible storm event and sent for laboratory analysis. The hydrological analysis was conducted to understand the relation of rainfall to change in the water-level and channel discharge. This analysis, along with site analyses, can help to understand the selected channels' response to runoff conveyed from the outlet point. The results from the water quality and hydrological analysis can be used in future studies to mitigate pollutant loads and downstream erosion in receiving waters. The results can also contribute to planning stormwater control measures and tools that analyze outlets and their downstream flow.

This study quantified the water quality parameters and hydrological characteristics from six monitoring stations, situated along the existing channels for the two highway outlets. For the estimation of pollutant concentration, hydrological and water quality monitoring was used. After the sample collection and water quality analysis, the data analysis helped in understanding the trend of water quality parameters obtained. The following objectives for this work included the following:

1. Calculate pollutant concentrations in the channels streaming from outlets for the monitored storm events.
2. Determine the hydrology characteristics for both the channels on which monitoring is conducted.
3. Determine the changes in site conditions for the two monitored channels.

2.0 Methodology

The purpose of this project was to assess water quality and hydrology parameters of highway stormwater runoff from two selected outlet monitoring sites to establish their baseline characteristics. Runoff quality and quantity were monitored at two highway outlets and further downstream the outlet channels. Also, site conditions for the two monitoring locations were assessed. The monitoring data obtained was analyzed to determine the pollutant concentrations of total suspended solids (TSS), orthophosphate (PO_4), and nutrients (e.g., total Kjeldahl nitrogen (TKN), total nitrogen (TN), and total phosphate (TP)) in the water channel. Various criteria, including approachability, proximity, availability, and safety, discussed ahead, were used for finding ideal monitoring sites. The scope of this work includes two monitoring sites.

2.1 Selection of Monitoring Sites

Using historical data of highway outlets from NCDOT, 19 sites were visited and observed in Cabarrus County in August 2019. Most of these sites were located along or in proximity to the US 601 highway. An observational study was done to identify optimum sites for equipment installation and monitoring of storm runoff from outlets. After observing the sites, an analysis of each site was done based on the following parameters: (i) outlet channel definition; (ii) length and depth of the outlet channel; (iii) condition of runoff outlet, and nearby surrounding area as it could create hindrance during sample collection.

2.2 Site Description and Location

The two selected research sites for stormwater monitoring are located along the US 601 highway in Cabarrus County, North Carolina (NC). US 601 highway has an annual average daily traffic (AADT) of approximately 9,200 vehicles. The site names were designated as Site 591 and Site 573. Their locations are 35.25403, -80.50015 and 35.29624, -80.51313 respectively (Fig. 1). Both sites varied in terms of location, channel size, and outlet pipe size. Site 591 is in a much more open space and has land cover ranges from commercial areas to open developed lands, with the outlet monitoring station located with proximity to US 601. Unlike this, Site 573 is situated in a residential, wooded area with land cover including mixed forest, deciduous forest, and low development spaces.

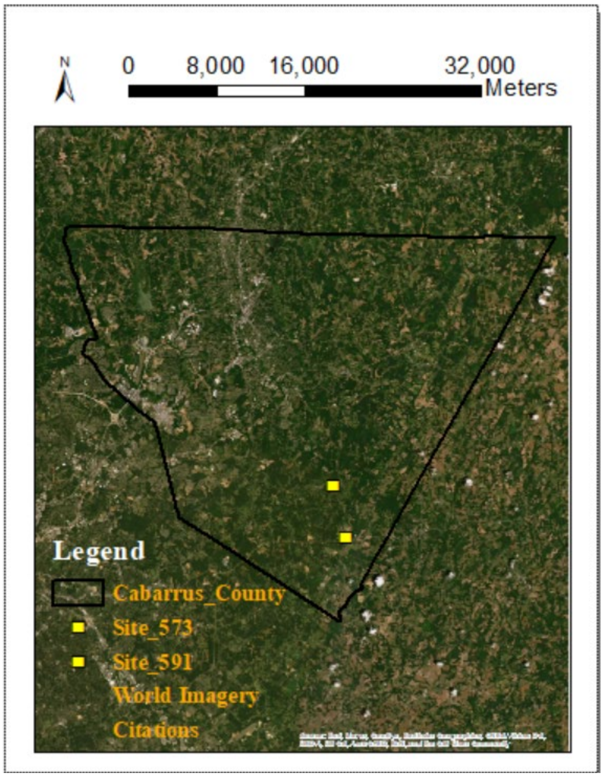


Figure. 1: Monitoring site locations

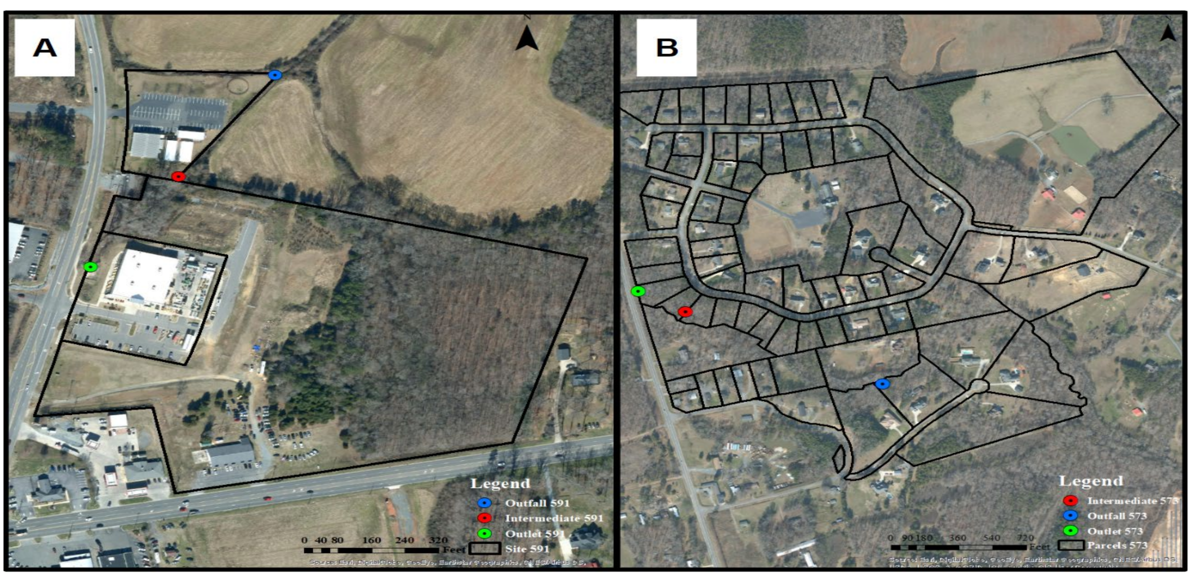


Figure 2: Monitoring locations for Sites 591 (A) & 573 (B)

Site 591

Site 591 is identified as Pipe ID MP-013-00591 (35.25403, -80.50015) and is located near a Tractor Supply store in Cabarrus County. The outlet channel is an open channel, stemming from a 48-inch diameter outlet pipe (Figure 3). For monitoring of runoff, three ISCO

6712 samplers were installed, with the first at the outlet (591-1), the second at an intermediate point (591-2) of the channel, and the third at the outfall (591-3)(See Figure 2 A). A 48-inch outlet pipe shown in Fig. 3 shows that highway runoff is carried through an unpaved channel section.

The shape of the channel is in the form of a trapezoidal channel section with some change in the channel's dimensions at the different monitoring stations. At Station 1, the approximate size of the channel is 3.5 feet deep, 4.5 feet base width, and 15 feet top width. The channel dimension at Station 2 is approximately 2.5 feet in depth with the base width being 5 feet, and 8 feet top width. Station 3 has a depth of 2.5 feet, the base width of 4 feet, and a top width of 6 feet.

Figure 3: The outlet at monitoring Site 591

Site 573

The second study site is identified from the Outlet Pipe ID MP-013-00573 (35.29624, -80.51313). For monitoring of runoff, three ISCO 6712 automated samplers were installed, at the beginning of the channel at the outlet (573-1), at an intermediate point (573-2), and near the outfall (573-3). The site had a 42-inch outlet pipe shown in Figure 4, which carried the runoff from the highway, through an eroded, unpaved channel section.

The shape of the channel is in the form of a trapezoidal channel section with a change in the channel's dimension at different monitoring stations. At Station 1, the approximate size of the channel is 3.5 feet deep, 5 feet base width, and 13 feet top width. The channel dimensions at Station 2 are approximately 4 feet in depth, 5 feet base width, and 10 feet top width. Station 3 has a depth of 3 feet, a base width of 7 feet, and a top width of 10 feet.

Figure 4: The outlet at monitoring Site 573

2.3 Data Collection

An automatic sampler ISCO Teledyne (6712 Full-Size Portable Sampler) was set up at each monitoring station, and it is used for collecting water samples and hydrology data from the outlet channel. During the sampling for the different parameters (TSS, PO_4, and nutrients), they were collected in different sampling bottles and were shipped to the laboratory for determining and analyzing the pollutant concentration for parameters. Characterization of these parameters helped in deducing the event mean concentrations (EMCs) in the channels streaming from outlets for the monitored storm events. This also determines the changes that may occur at outlet, intermediate, and outfalls in terms of water quality, and helps establish the relationships between monitored pollutants.

The equipment that is set up at the monitoring site for collecting the water samples from the channel includes ISCO 730 bubbler module, ISCO 6712 automated sampler, and a rain gauge. The rain gauges were connected to the sampler to measure the amount of precipitation from rainfall events, at both sites (Sites 591 and 573). Once the required precipitation level was achieved, the sampler was activated. Subsequent stations were fixed with level enablers for the collection of samples.

Table 1: Limit Standards for Parameters

Pollutant	Analytical Method	Reporting Limit (PQL)
Total Kjeldahl Nitrogen (TKN)	EPA Method 351.2	280 µg/L
Nitrate/Nitrite ($NO_{2\text{-}3}$-N)	Std. Method 4500 NO3 F EPA Method 353.2	11.2 µg/L
Total Nitrogen (TN)	-	17.5 µg/L
Orthophosphate (O-PO_4^{3-})	Std. Method 4500 PF EPA Method 365.1	12 µg/L
Total Phosphorus (TP)	Std. Method 4500 PF EPA Method 365.1	10 µg/L
Total Suspended Solids (TSS)	Std. Method 2540D	2.5 mg/L

Laboratory Analysis

After the collection of water samples from the monitoring stations, it was shipped to North Carolina State University (NCSU) Center for Applied Aquatic Ecology (CAAE) Laboratory for analysis of water quality characteristics.

Table 2: Sample Monitoring

Hydrology	• Data was collected using an ISCO 730 bubbler module. • Rainfall data was collected using a manual rain gauge and ISCO 674 tipping bucket rain gauge, which was installed at each outlet point with an area free of overhead obstructions. • All monitoring equipment recorded data on a two-minute interval. • The data was collected after each storm event (rainfall ≥ 0.10 in with minimum antecedent dry period (ADP) of 6 hours).

Water Quality	• Flow-proportional samples were collected using an ISCO 730 bubbler module, ISCO 6712 automated sampler, which were connected to a rain gauge or level-enabled sampler.
	• The water sample handling requirements and analysis laboratories:
	  ○ Nutrient Samples: total Kjeldahl nitrogen (TKN), nitrate + nitrite nitrogen ($NO_{2\text{-}3}$-N), total nitrogen (TN), orthophosphate (O-PO_4^{3-}), total phosphorus (TP), total suspended solids (TSS)
	    ○ NCSU Center for Applied Aquatic Ecology (CAAE) Laboratory
	    ○ Container- TSS: 1 L Nalgene bottle; Nutrients: 125 mL pre-acidified (H_2SO_4) plastic bottle; O-PO_4^{3-}: 60 mL glass bottle (20 mL removed from TSS bottle and passed through a 0.45 μm filter)
	    ○ Preservation- Put on ice and chilled to ≤ 4°C
	    ○ Maximum holding time- O-PO_4^{3-}holding time is 48 hour, holding time for TSS is seven days, and 28 days for all other parameters (TP, TKN, $NO_{2\text{-}3}$-N, TN)
	  ○ TN was calculated using the respective TKN and $NO_{2\text{-}3}$-N samples.
	• Nutrient samples were stored in the corresponding bottles following procedures as provided by NCSU CAAE.

Hydrology

The hydrology analysis was conducted to determine the water discharge, which drains in the channel during a storm event. To determine the discharge along the channel, changes in water level for each site were calculated using data from the ISCO 730 bubbler module. Along with this, laser level surveys were conducted to determine the cross-section of the channel. After finding the dimensions of the channels, the shape of the channels were determined. In this research, the shape of the channel was found to be generally trapezoidal. Taking the data from the laser-level survey and bubbler module, Manning's equation was used to calculate discharge from the water level.

Discharge (Q) = $\left(\frac{1}{n}\right) * A * R^{\frac{2}{3}} * \sqrt{S}$, where,

n = Manning's constant

A = Cross-sectional area of the channel, H * (T + B)/2

H = Height of water level

T = Upper Base of Channel

B = Lower Base of Channel

R = Hydraulic Radius (A/P)

P = Wetted Perimeter, $(B + 2) * \sqrt{H^2 + (\frac{T-B}{2})^2}$

S = Slope of Channel

3.0 Results and Discussion

Water Quality

Fourteen eligible storm events were sampled from December 2019 to March 2021 among the two sites. From the results, the mean, median, and standard deviation of the event mean concentrations (EMCs) for each site and each constituent were calculated. Table 3 summarizes the site-averaged event mean concentrations (EMCs) for each site and each constituent sampled, showing lower comparative values to other studies in the literature.

The direction of flow for each channel was from the outlet, to the intermediate point, then the outfall. However, the results do not show a consistent, observable pattern of either increase or decrease in EMCs of the constituents for either channel in the direction of flow. For Site 591, EMCs decreased from the outlet to the intermediate point, but increased from the intermediate point to the outfall. For Site 573, there was an increase following the direction of flow for TKN, NO_{2-3}-N, and NH_3-N. However, for TP, TSS and orthophosphate EMCs, a similar pattern to Site 591 was observed.

Table 3: Mean EMCs for per site (mg/L)

Site Name	TKN	NO_{2-3}-N	NH_3-N	TP	TSS	Ortho-P
Outlet (591-1)	0.77	0.27	0.11	0.17	57.76	0.03
Intermediate (591-2)	0.72	0.26	0.09	0.14	40.44	0.02
Outfall (591-3)	0.97	0.28	0.11	0.25	80.98	0.03
Outlet (573-1)	0.89	0.11	0.06	0.18	87.95	0.05
Intermediate (573-2)	0.93	0.13	0.07	0.17	74.25	0.03
Outfall (573-3)	1.81	0.35	0.08	0.50	281.65	0.07

Hydrology

The hydrology section consists of determining the relationship between discharge, calculated from the changes in the water level of the channel, and rainfall occurrence. The results from this hydrological analysis can contribute to decision making for control measures required to curtail the peak velocity of runoff which results in reducing downstream erosion.

The monitoring was rain-dependent, and the samples were collected only after a significant rainfall event (for this study, rainfall ≥ 0.10 inches with the minimum antecedent dry period of 48 hours). Table 4 indicates a subset of 12 storm events observed from December 2019 to February 2020. The recorded rainfall data were cross-verified from precipitation data of the closest United States Geological Survey (USGS) rain-gauge, situated at Rocky River Wastewater Treatment Plant, Concord, NC, with a proximity of 7 miles from the sites.

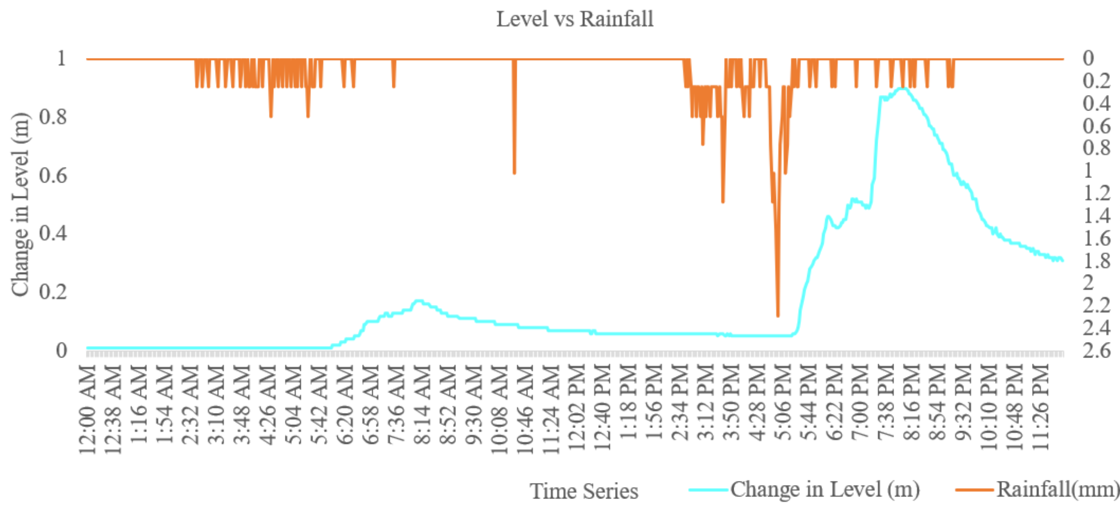
Discharge data, as shown in Table 4 was calculated for the outlet channels using water level data recorded by the ISCO 730 bubbler flow module. This data was used for determining the correlation between rainfall and discharge. The autosampler collected the data from the bubbler flow module to determine the changes in channel water levels for 2-minute increments, and the rain-gauge for finding the rainfall amount during the storm event. Table 4 consists of rainfall data, a change in water level, the dry period between two rainfall events, and water discharge during the rainfall event.

Table 4: Water level data for 12 storm events

Rainfall Date	Rainfall(mm)	Average level (mm)	Dry Period (Days)	Discharge (cm^3/s)
12-13-19	36.07	25.82	2	1.15
12-17-19	8.89	12.02	4	0.32
12-22-19	7.87	10.75	9	0.26
01-02-20	7.62	9.48	6	0.21
01-11-20	5.84	7.96	1	0.16
1-13-20	24.89	21.78	7	0.87
1-24-20	36.58	38.52	6	2.20
1-31-20	11.18	15.49	4	0.49
05-02-20	2.79	1.77	4	0.02
11-02-20	5.33	4.50	1	0.07
2-13-20	6.10	9.48	4	0.23
2-18-20	3.30	9.20	4	0.02
Mean	13.04	13.90	4.36	0.50
St. Deviation	12.29	10.26	2.5	0.64

Using the data from the storm event of January 24, 2020 as an example, a time series plot was graphed in Figure 5 to show an example of the change in water level in the outlet channel over the course of the rainfall event. The reason for choosing the rainfall event of January 24, 2020, was due to the higher rainfall intensity when compared to other rainfall events observed during the monitoring period, duration of the total rainfall event, and the antecedent dry period. From Figure 5, it can be easily observed that the water level in the channel increases with an increase in rainfall. From Manning's equation, it can be inferred that an increase in water level directly results in an increase of runoff discharge in the channel.

These increments in discharge cause an increase in peak velocity of runoff during the storm-event. This sudden increment in peak velocity in the channel disturbs the surface of channel and channel bank and can result in downstream erosion in the channel, damaging the shape and quality of water flowing through this channel. Along with that, the relation between the change in water-level and rainfall will additionally help in analyzing the channel's response to water runoff caused by rainfall. This type of analysis is useful in understanding the effect on channels caused by rainfall and determining the preventive/control action such as the implementation of stormwater control measures or along the water channel or at suitable points in the watershed for reducing downstream erosion and scouring in the channel.



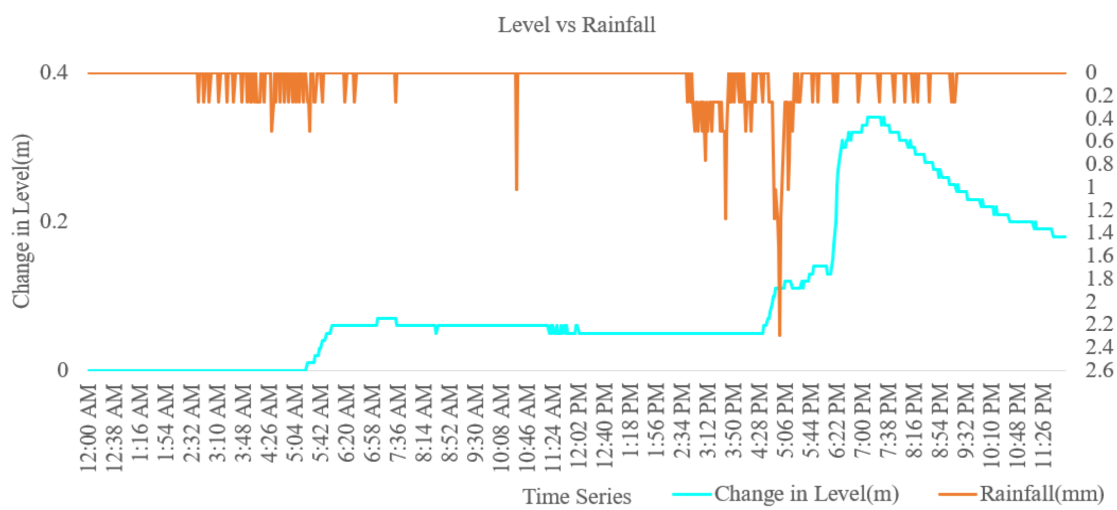


Figure 5 (A & B): Time series plot for storm-event for Site 591 (A) & 573 (B)

4.0 Conclusion

This monitoring study contributes to the understanding of baseline characteristics of water quality and hydrology of two outlet channels to inform planning and design for future mitigation strategies. During the monitoring, a related dataset of rainfall received, channel discharge, and pollutant concentration observed was created, which covered December 2019 to March 2021. The dataset created can contribute to NCDOT's database on the outlet's characteristics for water quality and hydrology.

The water quality results do not show a consistent, observable pattern of either increase or decrease in EMCs of the constituents for either channel in the direction of flow. The research shows that the channel is carrying lower pollutant concentrations than permissible limits for data collection and analysis covered in this research. The EMCs obtained for the pollutants were within the ranges of other similar research studies, however they were comparatively on the lower end of these ranges. This indicates that the channel can control the pollutant concentration and the values obtained are not concerning when compared with EMC's of similar type studies.