STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: I80-115 C-1 Site
LOCATION: Tunkhannock Township
PREPARED BY: SRH **DATE:** 11/17/2022
CHECKED BY: **REV. DATE**

CHANNEL OR CHANNEL SECTION		**Swale 1**	**Swale 1**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)		0
ACRES	(AC)	9.63	9.63
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	26.50	26.50
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	26.50	26.50
PROTECTIVE LINING[2]		**Grass**	**NAG C125**
n (MANNING'S COEFFICIENT)[2]		0.040	0.031
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	5.28	6.39
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	4.00	2.30
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	2.49	2.22
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	3.00	3.00
D (TOTAL DEPTH)	(FT)	1.50	1.50
CHANNEL TOP WIDTH @ D	(FT)	11.00	11.00
d (CALCULATED FLOW DEPTH)	(FT)	1.00	0.89
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	8.00	7.34
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	2.00	2.25
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	4.99	4.15
R (HYDRAULIC RADIUS)		0.60	0.54
S (BED SLOPE)[3]	(FT/FT)	0.0400	0.0400
Sc (CRITICAL SLOPE)	(FT/FT)	0.0287	0.0180
$0.7S_c$	(FT/FT)	0.0201	0.0126
$1.3S_c$	(FT/FT)	0.0373	0.0234
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.3960	0.4265
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

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CHANNEL OR CHANNEL SECTION		**Swale 2**	**Swale 2**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)		0
ACRES	(AC)	3.03	3.03
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	8.33	8.33
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	8.33	8.33
PROTECTIVE LINING[2]		**Grass**	**NAG S75**
n (MANNING'S COEFFICIENT)[2]		0.050	0.031
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	3.31	4.73
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	4.00	1.60
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	1.60	0.37
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	3.00	3.00
D (TOTAL DEPTH)	(FT)	1.14	1.14
CHANNEL TOP WIDTH @ D	(FT)	8.84	8.84
d (CALCULATED FLOW DEPTH)	(FT)	0.64	0.50
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.84	5.00
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	3.13	4.00
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	2.52	1.76
R (HYDRAULIC RADIUS)		0.42	0.34
S (BED SLOPE)[3]	(FT/FT)	0.0400	0.0400
Sc (CRITICAL SLOPE)	(FT/FT)	0.0499	0.0207
$0.7S_c$	(FT/FT)	0.0349	0.0145
$1.3S_c$	(FT/FT)	0.0649	0.0270
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.1589	0.1774
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

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CHANNEL OR CHANNEL SECTION		**Swale 3**	**Swale 3**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)		0
ACRES	(AC)	14.56	14.56
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	40.44	40.44
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	40.44	40.44
PROTECTIVE LINING[2]		**Grass**	**NAG C125**
n (MANNING'S COEFFICIENT)[2]		0.040	0.040
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	5.49	5.49
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	4.00	2.30
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	2.26	2.26
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	3.00	3.00
D (TOTAL DEPTH)	(FT)	1.60	1.60
CHANNEL TOP WIDTH @ D	(FT)	11.60	11.60
d (CALCULATED FLOW DEPTH)	(FT)	1.10	1.10
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	8.60	8.60
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	1.82	1.82
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	8.03	8.03
R (HYDRAULIC RADIUS)		0.73	0.73
S (BED SLOPE)[3]	(FT/FT)	0.0330	0.0330
Sc (CRITICAL SLOPE)	(FT/FT)	0.0331	0.0331
$0.7S_c$	(FT/FT)	0.0232	0.0232
$1.3S_c$	(FT/FT)	0.0430	0.0430
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.4529	0.4529
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

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CHANNEL OR CHANNEL SECTION		**Swale 3 lower**	**Swale 3 lower**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)		0
ACRES	(AC)	14.56	14.56
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	40.44	40.44
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	40.44	40.44
PROTECTIVE LINING[2]		**NAG 350**	**NAG 350/grass**
n (MANNING'S COEFFICIENT)[2]		0.033	0.028
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	8.11	8.11
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	12.00	3.20
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	3.44	3.18
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	3.00	3.00
D (TOTAL DEPTH)	(FT)	1.34	1.34
CHANNEL TOP WIDTH @ D	(FT)	10.04	10.04
d (CALCULATED FLOW DEPTH)	(FT)	0.84	0.77
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.04	6.62
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	2.38	2.60
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	5.44	4.88
R (HYDRAULIC RADIUS)		0.59	0.55
S (BED SLOPE)[3]	(FT/FT)	0.0660	0.0660
Sc (CRITICAL SLOPE)	(FT/FT)	0.0248	0.0187
$0.7S_c$	(FT/FT)	0.0173	0.0131
$1.3S_c$	(FT/FT)	0.0322	0.0243
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.5109	0.4684
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

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PROJECT NAME: I80-115 C-1 Site
LOCATION: Tunkhannock Township
PREPARED BY: SRH **DATE:** 11/17/2022
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flow includes 2 culverts from the west pipe capacity

CHANNEL OR CHANNEL SECTION		**Swale 4 upper**	**Swale 4 upper**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)		0
ACRES	(AC)	8.60	8.60
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	24.90	24.90
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	24.90	24.90
PROTECTIVE LINING[2]		**Grass**	**NAG C125BN**
n (MANNING'S COEFFICIENT)[2]		0.040	0.026
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	5.57	7.76
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	4.00	2.80
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	2.79	2.24
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	3.00	3.00
D (TOTAL DEPTH)	(FT)	1.43	1.43
CHANNEL TOP WIDTH @ D	(FT)	10.58	10.58
d (CALCULATED FLOW DEPTH)	(FT)	0.93	0.75
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.58	6.50
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	2.15	2.67
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	4.47	3.21
R (HYDRAULIC RADIUS)		0.57	0.47
S (BED SLOPE)[3]	(FT/FT)	0.0500	0.0500
Sc (CRITICAL SLOPE)	(FT/FT)	0.0291	0.0133
$0.7S_c$	(FT/FT)	0.0203	0.0093
$1.3S_c$	(FT/FT)	0.0378	0.0173
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.3885	0.4365
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

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flow includes 2 culverts from the west pipe capacity

CHANNEL OR CHANNEL SECTION		**Swale 4 berm**	**Swale 4 berm**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)		0
ACRES	(AC)	8.60	8.60
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	24.90	24.90
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	24.90	24.90
PROTECTIVE LINING[2]		**Grass**	**NAG C125BN**
n (MANNING'S COEFFICIENT)[2]		0.040	0.040
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	4.18	4.18
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	4.00	2.80
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	2.24	2.26
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	11.50	11.50
D (TOTAL DEPTH)	(FT)	1.22	1.22
CHANNEL TOP WIDTH @ D	(FT)	30.06	30.06
d (CALCULATED FLOW DEPTH)	(FT)	0.72	0.72
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	18.56	18.56
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	2.78	2.78
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	5.95	5.92
R (HYDRAULIC RADIUS)		0.36	0.36
S (BED SLOPE)[3]	(FT/FT)	0.0500	0.0500
Sc (CRITICAL SLOPE)	(FT/FT)	0.0292	0.0290
$0.7S_c$	(FT/FT)	0.0204	0.0203
$1.3S_c$	(FT/FT)	0.0379	0.0377
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.2257	0.2257
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

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flow includes 2 culverts from the west pipe capacity

CHANNEL OR CHANNEL SECTION		**Swale 4 lower**	**Swale 4 lower**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)		0
ACRES	(AC)	8.60	8.60
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	40.44	40.44
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	40.44	40.44
PROTECTIVE LINING[2]		**Grass**	**NAG C125BN**
n (MANNING'S COEFFICIENT)[2]		0.040	0.025
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	6.03	8.5
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	4.00	2.80
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	2.79	2.55
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	3.00	3.00
D (TOTAL DEPTH)	(FT)	1.76	1.76
CHANNEL TOP WIDTH @ D	(FT)	12.56	12.56
d (CALCULATED FLOW DEPTH)	(FT)	1.26	1.02
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	9.56	8.12
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	1.59	1.96
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	7.29	5.12
R (HYDRAULIC RADIUS)		0.73	0.61
S (BED SLOPE)[3]	(FT/FT)	0.0400	0.0400
Sc (CRITICAL SLOPE)	(FT/FT)	0.0270	0.0111
$0.7S_c$	(FT/FT)	0.0189	0.0078
$1.3S_c$	(FT/FT)	0.0351	0.0144
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.5698	0.6503
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

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CHANNEL OR CHANNEL SECTION		**Swale 5**	**Swale 5**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)		0
ACRES	(AC)	12.45	12.45
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	34.20	34.20
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	34.20	34.20
PROTECTIVE LINING[2]		**Grass**	**NAG S75**
n (MANNING'S COEFFICIENT)[2]		0.040	0.033
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	3.37	3.91
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	4.00	1.60
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	0.96	0.88
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	3.00	3.00
D (TOTAL DEPTH)	(FT)	2.03	2.03
CHANNEL TOP WIDTH @ D	(FT)	14.18	14.18
d (CALCULATED FLOW DEPTH)	(FT)	1.53	1.41
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	11.18	10.46
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	1.31	1.42
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	10.13	8.79
R (HYDRAULIC RADIUS)		0.87	0.80
S (BED SLOPE)[3]	(FT/FT)	0.0100	0.0100
Sc (CRITICAL SLOPE)	(FT/FT)	0.0254	0.0179
$0.7S_c$	(FT/FT)	0.0178	0.0126
$1.3S_c$	(FT/FT)	0.0330	0.0233
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.3867	0.4135
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: I80-115 C-1 Site
LOCATION: Tunkhannock Township
PREPARED BY: SRH **DATE:** 11/17/2022
CHECKED BY: **REV. DATE**

flow equals the principle spillway capacity of sediment basin 5A

CHANNEL OR CHANNEL SECTION		**Swale A**	**Swale A**
TEMPORARY OR PERMANENT?	(T OR P)	P	P
DESIGN STORM	(2, 5, OR 10 YR.)	10	10
ACRES	(AC)	44.40	na
MULTIPLIER	(1.6, 2.25, OR 2.75)[1]	2.75	2.75
Q_r (REQUIRED CAPACITY)	(CFS)	34.20	34.20
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	34.20	34.20
PROTECTIVE LINING[2]		**Grass**	**NAG S75**
n (MANNING'S COEFFICIENT)[2]		0.040	0.034
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A
V (CALCULATED AT FLOW DEPTH d)	(FPS)	3.01	3.42
τ_a (MAXIMUM ALLOWABLE SHEAR STRESS)	(LB/FT2)	4.00	1.60
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT2)	0.78	0.72
CHANNEL BOTTOM WIDTH	(FT)	2.00	2.00
CHANNEL SIDE SLOPES	(H:V)	3.00	3.00
D (TOTAL DEPTH)	(FT)	1.75	1.75
CHANNEL TOP WIDTH @ D	(FT)	12.50	12.50
d (CALCULATED FLOW DEPTH)	(FT)	1.25	1.16
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	9.50	8.96
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	1.60	1.72
d_{50} STONE SIZE	(IN)	N/A	N/A
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	7.23	6.35
R (HYDRAULIC RADIUS)		0.73	0.68
S (BED SLOPE)[3]	(FT/FT)	0.0100	0.0100
Sc (CRITICAL SLOPE)	(FT/FT)	0.0270	0.0199
$0.7S_c$	(FT/FT)	0.0189	0.0140
$1.3S_c$	(FT/FT)	0.0351	0.0259
STABLE FLOW?	(Y/N)	Y	Y
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A
FREEBOARD BASED ON STABLE FLOW	(FT)	0.2822	0.2975
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 1/4 Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.

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CHANNEL ANALYSIS

> > > Swale 1-grass

Name	Swale 1-grass
Discharge	26.5
Channel Slope	0.04
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Good 65-79%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	26.5 cfs	5.28 ft/s	1 ft	0.04	4 lbs/ft2	2.49 lbs/ft2	1.61	STABLE	--
Underlying Substrate	Straight	26.5 cfs	5.28 ft/s	1 ft	0.04	1.75 lbs/ft2	1.5 lbs/ft2	1.17	STABLE	--

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ANALYSIS COMPUTATIONS

> > > > View Computation

Inputs	
Channel Discharge (Q):	26.5 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.04 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Good 65-79%
Soil Type:	Silt Loam (SM)
Channel Lining Options	

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
n = 1.486 / Q * A * R(2/3)$S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

Unreinforced Vegetation

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
Unreinforced Vegetation	0.04	1 ft	4.99 ft2	8.31 ft	0.6 ft	5.28 ft/s	1.2	2.49 lbs/ft2	1.61 (SFL)
Underlying Substrate	0.04	1 ft	4.99 ft2	8.31 ft	0.6 ft	5.28 ft/s	1.2	1.5 lbs/ft2	1.17 (SFL)

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CHANNEL ANALYSIS

> > > Swale 1-matting

Name	Swale 1-matting
Discharge	26.5
Channel Slope	0.04
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

C125

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
C125 Unvegetated	Straight	26.5 cfs	6.39 ft/s	0.89 ft	0.031	2.3 lbs/ft2	2.22 lbs/ft2	1.04	STABLE	D
Underlying Substrate	Straight	26.5 cfs	6.39 ft/s	0.89 ft	0.031	1.68 lbs/ft2	1.36 lbs/ft2	1.24	STABLE	D

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ANALYSIS COMPUTATIONS

> > > > View Computation

Inputs	
Channel Discharge (Q):	26.5 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.04 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	None
Vegetation Density:	None
Soil Type:	Silt Loam (SM)
Channel Lining Options	
C125 Protection Type	Temporary

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

C125

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
C125 Unvegetated	0.031	0.89 ft	4.15 ft2	7.62 ft	0.54 ft	6.39 ft/s	1.53	2.22 lbs/ft2	1.04 (SFP)
Underlying Substrate	0.031	0.89 ft	4.15 ft2	7.62 ft	0.54 ft	6.39 ft/s	1.53	1.36 lbs/ft2	1.24 (SFL)

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CHANNEL ANALYSIS

> > > Swale 2-Grass

Name	Swale 2-Grass
Discharge	8.33
Channel Slope	0.04
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Very Good 80-95%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	8.33 cfs	3.31 ft/s	0.64 ft	0.05	4 lbs/ft2	1.6 lbs/ft2	2.5	STABLE	--
Underlying Substrate	Straight	8.33 cfs	3.31 ft/s	0.64 ft	0.05	3.26 lbs/ft2	1.04 lbs/ft2	3.14	STABLE	--

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ANALYSIS COMPUTATIONS

> > > > View Computation

Inputs	
Channel Discharge (Q):	8.33 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.04 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Very Good 80-95%
Soil Type:	Silt Loam (SM)
Channel Lining Options	

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
n = 1.486 / Q * A * R(2/3)$S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

Unreinforced Vegetation

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
Unreinforced Vegetation	0.05	0.64 ft	2.51 ft2	6.05 ft	0.42 ft	3.31 ft/s	0.9	1.6 lbs/ft2	2.5 (SFL)
Underlying Substrate	0.05	0.64 ft	2.51 ft2	6.05 ft	0.42 ft	3.31 ft/s	0.9	1.04 lbs/ft2	3.14 (SFL)

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CHANNEL ANALYSIS

> > > Swale 2-matting

Name	Swale 2-matting
Discharge	8.33
Channel Slope	0.04
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	8.33 cfs	4.73 ft/s	0.5 ft	0.031	1.6 lbs/ft2	1.25 lbs/ft2	1.27	STABLE	D
Underlying Substrate	Straight	8.33 cfs	4.73 ft/s	0.5 ft	0.031	1.17 lbs/ft2	0.85 lbs/ft2	1.38	STABLE	D

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ANALYSIS COMPUTATIONS

> > > > View Computation

Inputs	
Channel Discharge (Q):	8.33 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.04 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	None
Vegetation Density:	None
Soil Type:	Silt Loam (SM)
Channel Lining Options	
S75 Protection Type	Temporary

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

S75

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
S75 Unvegetated	0.031	0.5 ft	1.76 ft2	5.18 ft	0.34 ft	4.73 ft/s	1.43	1.25 lbs/ft2	1.27 (SFP)
Underlying Substrate	0.031	0.5 ft	1.76 ft2	5.18 ft	0.34 ft	4.73 ft/s	1.43	0.85 lbs/ft2	1.38 (SFL)

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CHANNEL ANALYSIS

> > > swale 3-grass

Name	swale 3-grass
Discharge	44.04
Channel Slope	0.033
Channel Bottom Width	4
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Very Good 80-95%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	44.04 cfs	5.49 ft/s	1.1 ft	0.04	4 lbs/ft2	2.26 lbs/ft2	1.77	STABLE	--
Underlying Substrate	Straight	44.04 cfs	5.49 ft/s	1.1 ft	0.04	2.08 lbs/ft2	1.51 lbs/ft2	1.38	STABLE	--

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ANALYSIS COMPUTATIONS

> > > > View Computation

Inputs	
Channel Discharge (Q):	44.04 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.033 ft/ft
Bottom Width (B):	4 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Very Good 80-95%
Soil Type:	Silt Loam (SM)
Channel Lining Options	

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
n = 1.486 / Q * A * R(2/3)$S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

Unreinforced Vegetation

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
Unreinforced Vegetation	0.04	1.1 ft	8.03 ft2	10.96 ft	0.73 ft	5.49 ft/s	1.13	2.26 lbs/ft2	1.77 (SFL)
Underlying Substrate	0.04	1.1 ft	8.03 ft2	10.96 ft	0.73 ft	5.49 ft/s	1.13	1.51 lbs/ft2	1.38 (SFL)

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CHANNEL ANALYSIS

> > > swale 3-matting

Name	swale 3-matting
Discharge	44.04
Channel Slope	0.033
Channel Bottom Width	4
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

C125

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
C125 Unvegetated	Straight	44.04 cfs	5.49 ft/s	1.1 ft	0.04	2.3 lbs/ft2	2.26 lbs/ft2	1.02	STABLE	D
Underlying Substrate	Straight	44.04 cfs	5.49 ft/s	1.1 ft	0.04	1.68 lbs/ft2	1.51 lbs/ft2	1.12	STABLE	D

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	44.04 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.033 ft/ft
Bottom Width (B):	4 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	None
Vegetation Density:	None
Soil Type:	Silt Loam (SM)
Channel Lining Options	
C125 Protection Type	Temporary

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

C125

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
C125 Unvegetated	0.04	1.1 ft	8.03 ft2	10.96 ft	0.73 ft	5.49 ft/s	1.13	2.26 lbs/ft2	1.02 (SFP)
Underlying Substrate	0.04	1.1 ft	8.03 ft2	10.96 ft	0.73 ft	5.49 ft/s	1.13	1.51 lbs/ft2	1.12 (SFL)

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CHANNEL ANALYSIS

> > > Swale 3-lower

Name	Swale 3-lower
Discharge	44.04
Channel Slope	0.066
Channel Bottom Width	4
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Very Good 80-95%
Soil Type	Silt Loam (SM)

C350

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
C350 Unvegetated	Straight	44.04 cfs	9.02 ft/s	0.77 ft	0.028	3.2 lbs/ft2	3.18 lbs/ft2	1.01	STABLE	E
Underlying Substrate	Straight	44.04 cfs	9.02 ft/s	0.77 ft	0.028	2.34 lbs/ft2	2.26 lbs/ft2	1.04	STABLE	E
C350 Reinforced Vegetation	Straight	44.04 cfs	8.11 ft/s	0.84 ft	0.033	12 lbs/ft2	3.44 lbs/ft2	3.49	STABLE	E
Underlying Substrate	Straight	44.04 cfs	8.11 ft/s	0.84 ft	0.033	3.2 lbs/ft2	2.41 lbs/ft2	1.33	STABLE	E

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	44.04 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.066 ft/ft
Bottom Width (B):	4 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Very Good 80-95%
Soil Type:	Silt Loam (SM)
Channel Lining Options	
C350 Protection Type	Permanent

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

C350

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
C350 Unvegetated	0.028	0.77 ft	4.88 ft2	8.89 ft	0.55 ft	9.02 ft/s	2.14	3.18 lbs/ft2	1.01 (SFP)
Underlying Substrate	0.028	0.77 ft	4.88 ft2	8.89 ft	0.55 ft	9.02 ft/s	2.14	2.26 lbs/ft2	1.04 (SFL)
C350 Reinforced Vegetation	0.033	0.84 ft	5.44 ft2	9.28 ft	0.59 ft	8.11 ft/s	1.86	3.44 lbs/ft2	3.49 (SFP)
Underlying Substrate	0.033	0.84 ft	5.44 ft2	9.28 ft	0.59 ft	8.11 ft/s	1.86	2.41 lbs/ft2	1.33 (SFL)

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CHANNEL ANALYSIS

> > > Swale 4 upper grass

Name	Swale 4 upper grass
Discharge	24.9
Channel Slope	0.048
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Very Good 80-95%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	24.9 cfs	5.57 ft/s	0.93 ft	0.04	4 lbs/ft2	2.79 lbs/ft2	1.43	STABLE	--
Underlying Substrate	Straight	24.9 cfs	5.57 ft/s	0.93 ft	0.04	2.08 lbs/ft2	1.7 lbs/ft2	1.23	STABLE	--

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	24.9 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.048 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Very Good 80-95%
Soil Type:	Silt Loam (SM)
Channel Lining Options	

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
n = 1.486 / Q * A * R(2/3)$S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

Unreinforced Vegetation

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
Unreinforced Vegetation	0.04	0.93 ft	4.47 ft2	7.89 ft	0.57 ft	5.57 ft/s	1.3	2.79 lbs/ft2	1.43 (SFL)
Underlying Substrate	0.04	0.93 ft	4.47 ft2	7.89 ft	0.57 ft	5.57 ft/s	1.3	1.7 lbs/ft2	1.23 (SFL)

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CHANNEL ANALYSIS

> > > Swale 4-grass-section-upper

Name	Swale 4-grass-section-upper
Discharge	24.9
Channel Slope	0.048
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

C125BN

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
C125BN Unvegetated	Straight	24.9 cfs	7.76 ft/s	0.75 ft	0.026	2.8 lbs/ft2	2.26 lbs/ft2	1.24	STABLE	D
Underlying Substrate	Straight	24.9 cfs	7.76 ft/s	0.75 ft	0.026	2.05 lbs/ft2	1.42 lbs/ft2	1.44	STABLE	D

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	24.9 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.048 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	None
Vegetation Density:	None
Soil Type:	Silt Loam (SM)
Channel Lining Options	
C125BN Protection Type	Temporary

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

C125BN

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
C125BN Unvegetated	0.026	0.75 ft	3.21 ft2	6.76 ft	0.47 ft	7.76 ft/s	2	2.26 lbs/ft2	1.24 (SFP)
Underlying Substrate	0.026	0.75 ft	3.21 ft2	6.76 ft	0.47 ft	7.76 ft/s	2	1.42 lbs/ft2	1.44 (SFL)

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CHANNEL ANALYSIS

> > > Swale 4-berm-section-grass

Name	Swale 4-berm-section-grass
Discharge	24.9
Channel Slope	0.05
Channel Bottom Width	0
Left Side Slope	20
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Very Good 80-95%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	24.9 cfs	4.18 ft/s	0.72 ft	0.04	4 lbs/ft2	2.24 lbs/ft2	1.78	STABLE	--
Underlying Substrate	Straight	24.9 cfs	4.18 ft/s	0.72 ft	0.04	2.08 lbs/ft2	1.11 lbs/ft2	1.87	STABLE	--

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ANALYSIS COMPUTATIONS

> > > > View Computation

Inputs	
Channel Discharge (Q):	24.9 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.05 ft/ft
Bottom Width (B):	0 ft
Left Side Slope (ZL):	20 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Very Good 80-95%
Soil Type:	Silt Loam (SM)
Channel Lining Options	

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

Unreinforced Vegetation

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
Unreinforced Vegetation	0.04	0.72 ft	5.95 ft2	16.68 ft	0.36 ft	4.18 ft/s	1.23	2.24 lbs/ft2	1.78 (SFL)
Underlying Substrate	0.04	0.72 ft	5.95 ft2	16.68 ft	0.36 ft	4.18 ft/s	1.23	1.11 lbs/ft2	1.87 (SFL)

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CHANNEL ANALYSIS

> > > Swale 4-berm-section-grass

Name	Swale 4-berm-section-grass
Discharge	24.9
Channel Slope	0.05
Channel Bottom Width	0
Left Side Slope	20
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

C125BN

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
C125BN Unvegetated	Straight	24.9 cfs	4.18 ft/s	0.72 ft	0.04	2.8 lbs/ft2	2.24 lbs/ft2	1.25	STABLE	D
Underlying Substrate	Straight	24.9 cfs	4.18 ft/s	0.72 ft	0.04	2.05 lbs/ft2	1.11 lbs/ft2	1.84	STABLE	D

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	24.9 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.05 ft/ft
Bottom Width (B):	0 ft
Left Side Slope (ZL):	20 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	None
Vegetation Density:	None
Soil Type:	Silt Loam (SM)
Channel Lining Options	
C125BN Protection Type	Temporary

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

C125BN

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
C125BN Unvegetated	0.04	0.72 ft	5.95 ft2	16.68 ft	0.36 ft	4.18 ft/s	1.23	2.24 lbs/ft2	1.25 (SFP)
Underlying Substrate	0.04	0.72 ft	5.95 ft2	16.68 ft	0.36 ft	4.18 ft/s	1.23	1.11 lbs/ft2	1.84 (SFL)

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CHANNEL ANALYSIS

> > > Swale 4 lower grass

Name	Swale 4 lower grass
Discharge	44.04
Channel Slope	0.04
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Very Good 80-95%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	44.04 cfs	6.03 ft/s	1.26 ft	0.04	4 lbs/ft2	3.15 lbs/ft2	1.27	STABLE	--
Underlying Substrate	Straight	44.04 cfs	6.03 ft/s	1.26 ft	0.04	2.08 lbs/ft2	1.83 lbs/ft2	1.14	STABLE	--

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	44.04 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.04 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Very Good 80-95%
Soil Type:	Silt Loam (SM)
Channel Lining Options	

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
n = 1.486 / Q * A * R(2/3)$S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

Unreinforced Vegetation

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
Unreinforced Vegetation	0.04	1.26 ft	7.29 ft2	9.98 ft	0.73 ft	6.03 ft/s	1.24	3.15 lbs/ft2	1.27 (SFL)
Underlying Substrate	0.04	1.26 ft	7.29 ft2	9.98 ft	0.73 ft	6.03 ft/s	1.24	1.83 lbs/ft2	1.14 (SFL)

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CHANNEL ANALYSIS

> > > Swale 4 lower

Name	Swale 4 lower
Discharge	44.04
Channel Slope	0.04
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

C125BN

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
C125BN Unvegetated	Straight	44.04 cfs	8.5 ft/s	1.02 ft	0.025	2.8 lbs/ft2	2.55 lbs/ft2	1.1	STABLE	D
Underlying Substrate	Straight	44.04 cfs	8.5 ft/s	1.02 ft	0.025	2.05 lbs/ft2	1.53 lbs/ft2	1.34	STABLE	D

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	44.04 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.04 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	None
Vegetation Density:	None
Soil Type:	Silt Loam (SM)
Channel Lining Options	
C125BN Protection Type	Temporary

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

C125BN

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
C125BN Unvegetated	0.025	1.02 ft	5.19 ft2	8.47 ft	0.61 ft	8.5 ft/s	1.92	2.55 lbs/ft2	1.1 (SFP)
Underlying Substrate	0.025	1.02 ft	5.19 ft2	8.47 ft	0.61 ft	8.5 ft/s	1.92	1.53 lbs/ft2	1.34 (SFL)

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CHANNEL ANALYSIS

> > > Swale 5

Name	Swale 5
Discharge	34.2
Channel Slope	0.01
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Very Good 80-95%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	34.2 cfs	3.37 ft/s	1.53 ft	0.04	4 lbs/ft2	0.96 lbs/ft2	4.18	STABLE	--
Underlying Substrate	Straight	34.2 cfs	3.37 ft/s	1.53 ft	0.04	2.08 lbs/ft2	0.54 lbs/ft2	3.86	STABLE	--

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	34.2 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.01 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Very Good 80-95%
Soil Type:	Silt Loam (SM)
Channel Lining Options	

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
n = 1.486 / Q * A * R(2/3)$S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

Unreinforced Vegetation

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
Unreinforced Vegetation	0.04	1.53 ft	10.13 ft2	11.71 ft	0.87 ft	3.37 ft/s	0.64	0.96 lbs/ft2	4.18 (SFL)
Underlying Substrate	0.04	1.53 ft	10.13 ft2	11.71 ft	0.87 ft	3.37 ft/s	0.64	0.54 lbs/ft2	3.86 (SFL)

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CHANNEL ANALYSIS

> > > Swale 5 matting

Name	Swale 5 matting
Discharge	34.2
Channel Slope	0.01
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	34.2 cfs	3.91 ft/s	1.41 ft	0.033	1.6 lbs/ft2	0.88 lbs/ft2	1.82	STABLE	D
Underlying Substrate	Straight	34.2 cfs	3.91 ft/s	1.41 ft	0.033	1.17 lbs/ft2	0.5 lbs/ft2	2.34	STABLE	D

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	34.2 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.01 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	None
Vegetation Density:	None
Soil Type:	Silt Loam (SM)
Channel Lining Options	
S75 Protection Type	Temporary

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

S75

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
S75 Unvegetated	0.033	1.41 ft	8.76 ft2	10.9 ft	0.8 ft	3.91 ft/s	0.77	0.88 lbs/ft2	1.82 (SFP)
Underlying Substrate	0.033	1.41 ft	8.76 ft2	10.9 ft	0.8 ft	3.91 ft/s	0.77	0.5 lbs/ft2	2.34 (SFL)

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CHANNEL ANALYSIS

> > > Swale A-grass

Name	Swale A-grass
Discharge	21.73
Channel Slope	0.01
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	Mix (Sod and Bunch)
Vegetation Density	Very Good 80-95%
Soil Type	Silt Loam (SM)

Unreinforced Vegetation

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
Unreinforced Vegetation	Straight	21.73 cfs	3.01 ft/s	1.25 ft	0.04	4 lbs/ft2	0.78 lbs/ft2	5.11	STABLE	--
Underlying Substrate	Straight	21.73 cfs	3.01 ft/s	1.25 ft	0.04	2.08 lbs/ft2	0.45 lbs/ft2	4.59	STABLE	--

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ANALYSIS COMPUTATIONS

> > > > View Computation

Inputs	
Channel Discharge (Q):	21.73 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.01 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	Mix (Sod and Bunch)
Vegetation Density:	Very Good 80-95%
Soil Type:	Silt Loam (SM)
Channel Lining Options	

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

Unreinforced Vegetation

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
Unreinforced Vegetation	0.04	1.25 ft	7.23 ft2	9.93 ft	0.73 ft	3.01 ft/s	0.62	0.78 lbs/ft2	5.11 (SFL)
Underlying Substrate	0.04	1.25 ft	7.23 ft2	9.93 ft	0.73 ft	3.01 ft/s	0.62	0.45 lbs/ft2	4.59 (SFL)

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CHANNEL ANALYSIS

> > > Swale A-matting

Name	Swale A-matting
Discharge	21.73
Channel Slope	0.01
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	21.73 cfs	3.42 ft/s	1.16 ft	0.034	1.6 lbs/ft2	0.72 lbs/ft2	2.21	STABLE	D
Underlying Substrate	Straight	21.73 cfs	3.42 ft/s	1.16 ft	0.034	1.17 lbs/ft2	0.42 lbs/ft2	2.76	STABLE	D

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CHANNEL ANALYSIS

> > > Swale A-matting

Name	Swale A-matting
Discharge	21.73
Channel Slope	0.01
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	21.73 cfs	3.42 ft/s	1.16 ft	0.034	1.6 lbs/ft2	0.72 lbs/ft2	2.21	STABLE	D
Underlying Substrate	Straight	21.73 cfs	3.42 ft/s	1.16 ft	0.034	1.17 lbs/ft2	0.42 lbs/ft2	2.76	STABLE	D

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ANALYSIS COMPUTATIONS

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Inputs	
Channel Discharge (Q):	21.73 cfs
Peak Flow Period (H):	hours
Channel Slope (S0):	0.01 ft/ft
Bottom Width (B):	2 ft
Left Side Slope (ZL):	3 (H : V)
Right Side Slope (ZR):	3 (H : V)
Existing Channel Bend:	No
Bend Coefficient (Kb):	1
Channel Bend Radius:	
Retardance Class of Vegetation:	C 6-12 in
Vegetation Type:	None
Vegetation Density:	None
Soil Type:	Silt Loam (SM)
Channel Lining Options	
S75 Protection Type	Temporary

Basic Relationships
A = Cross sectional area, ft2 (m2) = (B * D) + (Z_L / 2 * D2) + (Z_R / 2 * D2)
Where:
B = Base width of channel, ft (m)
D = Flow depth, ft (m)
Z_L = Left side bank slope (H : 1 V)
Z_R = Right side bank slope (H : 1 V)
P = Wetted perimeter, ft (m) = B + Z_L * D + Z_R * D
R = Hydraulic radius, ft (m) = A / P
V = Flow velocity, ft/s (m/s) = Q / A
Where:
Q = Channel discharge, cfs (cms)
Taua Average bed shear stress, psf (Pa) = 62.4 * R * S0
Where:
S0 = Gradient of channel, ft/ft (m/m)
Tau_0 = Maximum bed shear stress, psf (Pa) = 62.4 * D * S_0

Unvegetated Conditions Computations:
n = Manning's n = a * Tauab
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
n = Manning's n
a = Product specific coefficient from performance testing
b = Product specific coefficient from performance testing

SF_P = Product factor of safety = Tau_T / Tau_0
Where:
TauT = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_T / alpha * (Tau_S + alpha / 4.3)
Where:
alpha = unit conversion constant, 0.14 English, 6.5 Metric
Tau_S = Permissible shear stress of soil
SFL = Factor of safety of installed liner = Taup / Taua

Vegetated Computations:
n = Manning's n = alpha * Cn* Taua-0.4
and (iteratively solved)
$n = 1.486 / Q * A * R(2/3)S_0^{0.5}$
Where:
alpha = Unit conversion constant, 0.213 English, 1.0 Metric
Cn = Vegetation retardance coefficient
SF_P = Product factor of safety = Tau_{TV} / Tau_0
Where:
Tau_{TV} = Permissible shear stress from testing, psf (Pa)
Tau_p = In place permissible shear, psf (Pa) = Tau_S / (1 – C_{FTRM}) * (n / n_S)2
Where:
C_{FTRM} = Coefficient of TRM performance derived from testing Tau_S = Permissible shear stress of soil
n_S = Manning's of soil bed if left unprotected
SF_L = Factor of safety of installed liner = Tau_p / Tau_a

S75

Phase	Mannings N	Predicted flow depth (D)	Cross sectional area (A)	Wetted perimeter (P)	Hydraulic radius (R)	Flow velocity (V)	Froude number (FR)	Calculated Shear Stress	SFP/SFL
S75 Unvegetated	0.034	1.16 ft	6.35 ft2	9.33 ft	0.68 ft	3.42 ft/s	0.73	0.72 lbs/ft2	2.21 (SFP)
Underlying Substrate	0.034	1.16 ft	6.35 ft2	9.33 ft	0.68 ft	3.42 ft/s	0.73	0.42 lbs/ft2	2.76 (SFL)

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CHANNEL ANALYSIS

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Name	Swale A-matting
Discharge	21.73
Channel Slope	0.01
Channel Bottom Width	2
Left Side Slope	3
Right Side Slope	3
Low Flow Liner	
Retardence Class	C 6-12 in
Vegetation Type	None
Vegetation Density	None
Soil Type	Silt Loam (SM)

S75

Phase	Reach	Discharge	Velocity	Normal Depth	Mannings N	Permissible Shear Stress	Calculated Shear Stress	Safety Factor	Remarks	Staple Pattern
S75 Unvegetated	Straight	21.73 cfs	3.42 ft/s	1.16 ft	0.034	1.6 lbs/ft2	0.72 lbs/ft2	2.21	STABLE	D
Underlying Substrate	Straight	21.73 cfs	3.42 ft/s	1.16 ft	0.034	1.17 lbs/ft2	0.42 lbs/ft2	2.76	STABLE	D