RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage:Outfall JNC11b - John's Creek Watershed		
Amount of fall per riffle:	0.30	(feet)
Length of individual riffle:	15	(feet)
Design Flows		
Q1	12.2	(cfs)
Q2	29	(cfs)
Q10	182.8	(cfs)
Q100	595.3	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	130	(feet)
Trial Riffle Depth:	1.5	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.020	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

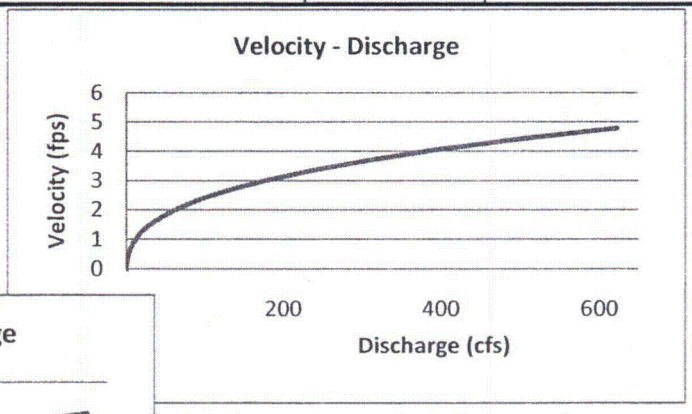
Calculate Q100:

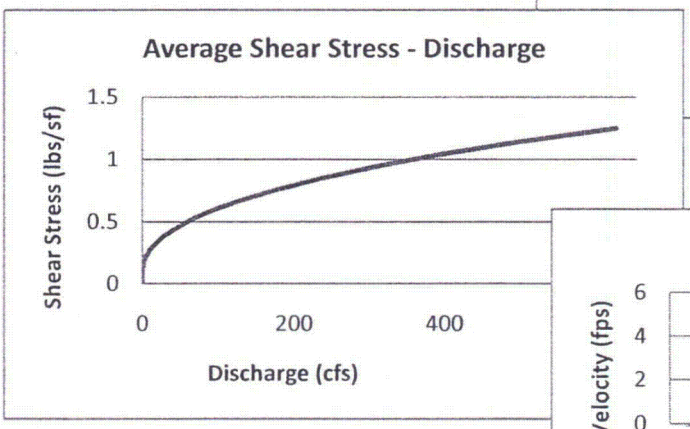
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

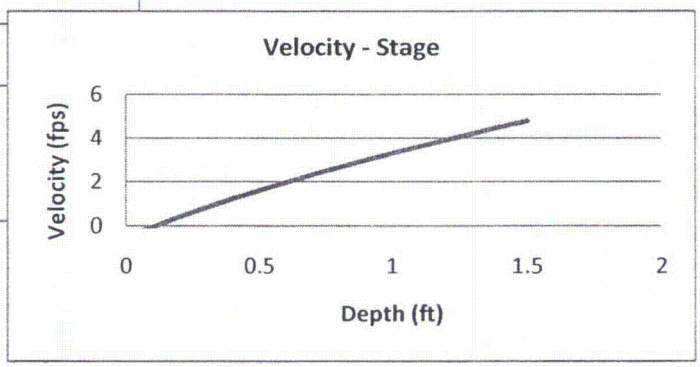
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	86.7	
	Manning's n at Q100	0.044	
	Cross-Sectional Area - A	130.0	(sf)
	Hydraulic Radius - Rh	1.0	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	622.2	(cfs)
	Average Velocity for Q100	4.8	(fps)
	Average Velocity for Q10	3.0	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.2	
turbulent	Reynold Number	442568	
	Calculated Average Shear Stress $\tau = \gamma RhS$	1.2	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	3.1	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
Checked By: GAT Date: 3/11

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

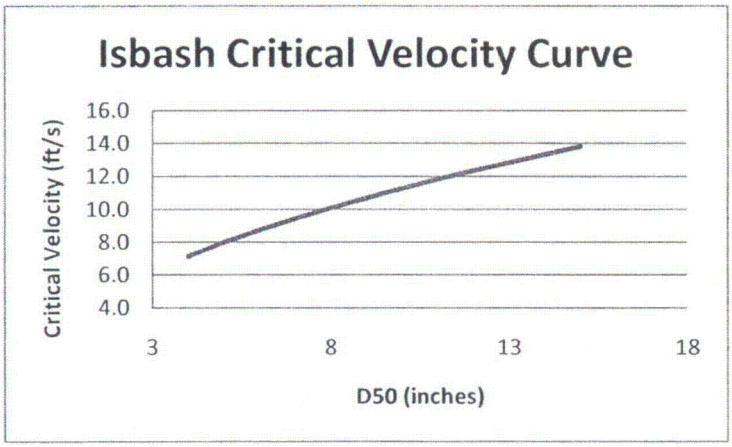
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	4.79	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	1.2	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.02	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	179	(mm)
	D	7	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

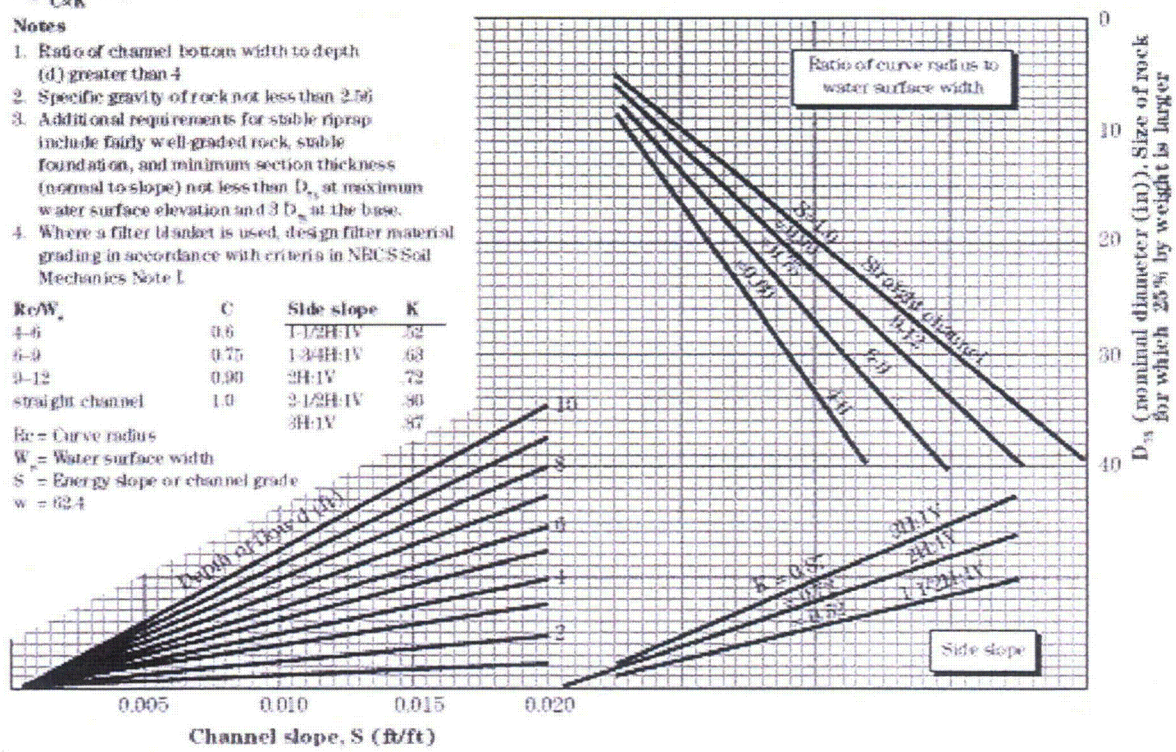
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{50} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NRCS Soil Mechanics Note 1.

R_c/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

R_c = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
γ_w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.31	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage:Outfall B2 - John's Creek Watershed		
Amount of fall per riffle:	1.00	(feet)
Length of individual riffle:	28	(feet)
Design Flows		
Q1	3.9	(cfs)
Q2	4.4	(cfs)
Q10	29	(cfs)
Q100	265.9	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	63	(feet)
Trial Riffle Depth:	1.25	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.036	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

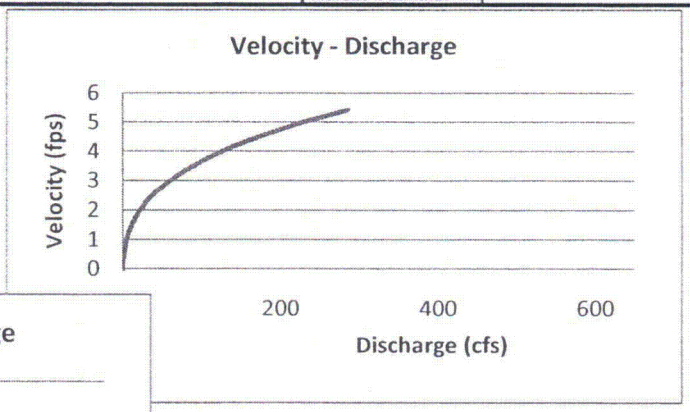
Calculate Q100:

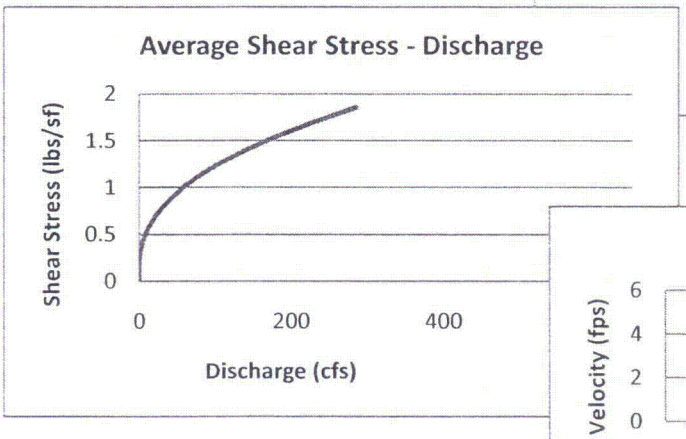
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

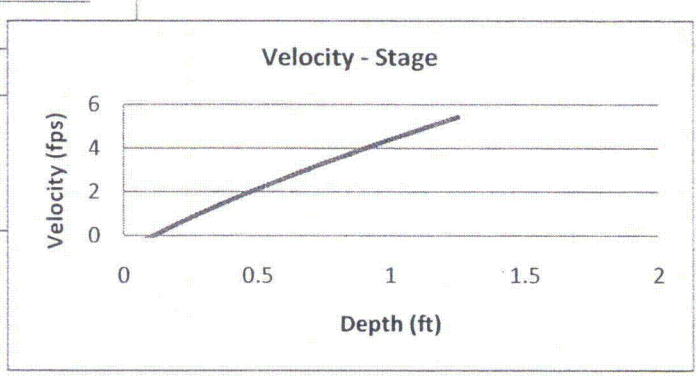
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	50.4	
	Manning's n at Q100	0.046	
	Cross-Sectional Area - A	52.5	(sf)
	Hydraulic Radius - Rh	0.8	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	284.8	(cfs)
	Average Velocity for Q100	5.4	(fps)
	Average Velocity for Q10	1.9	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.3	
turbulent	Reynold Number	417757	
	Calculated Average Shear Stress $\tau = \gamma RhS$	1.9	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	4.6	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
Checked By: GAT Date: 3/11

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

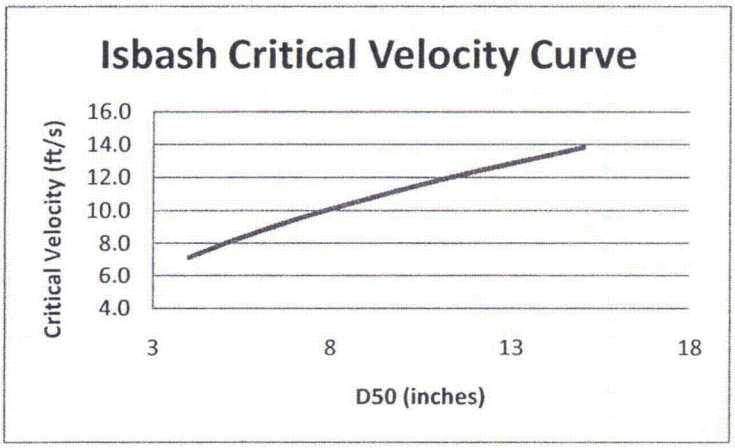
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	5.42	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	1.9	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.02	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	239	(mm)
	D	9	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

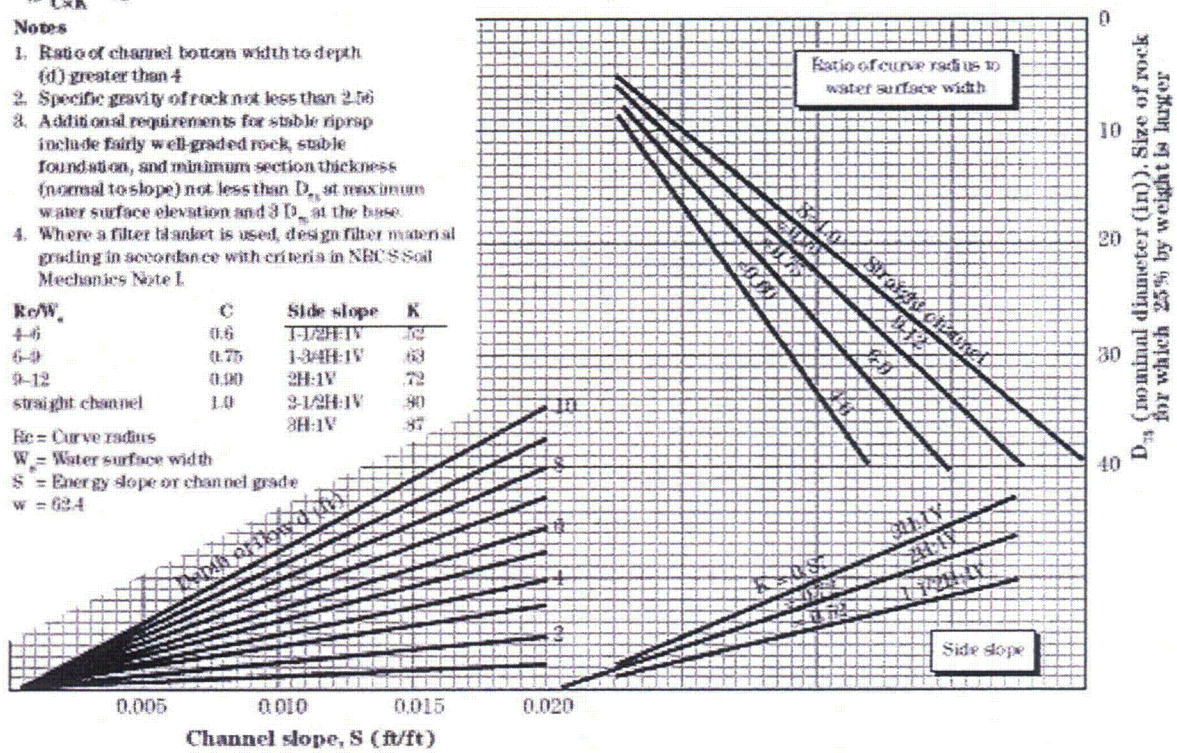
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NRCS Soil Mechanics Note I.

Rc/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

Rc = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.46	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage:Outfall B2 - John's Creek Watershed		
Amount of fall per riffle:	1.50	(feet)
Length of individual riffle:	30	(feet)
Design Flows		
Q1	3.9	(cfs)
Q2	4.4	(cfs)
Q10	29	(cfs)
Q100	265.9	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	63	(feet)
Trial Riffle Depth:	1.15	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.050	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

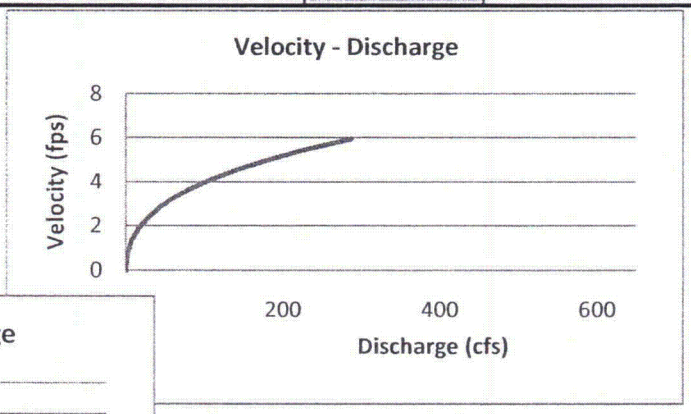
Calculate Q100:

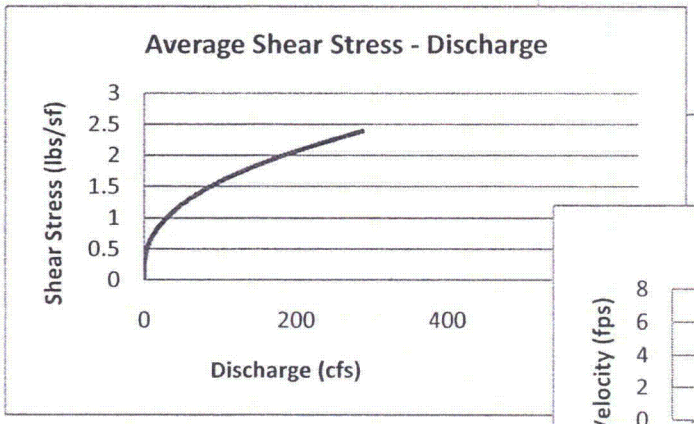
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

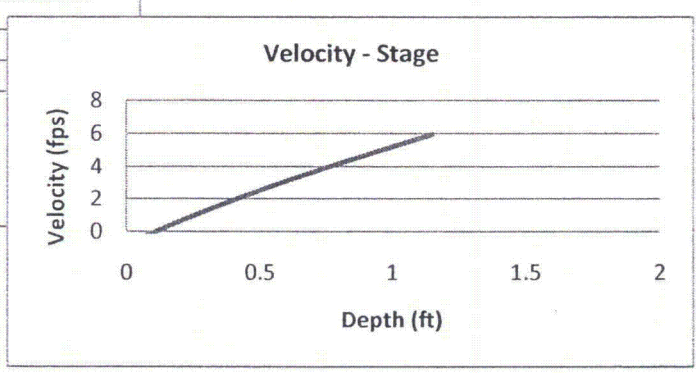
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	54.8	
	Manning's n at Q100	0.047	
	Cross-Sectional Area - A	48.3	(sf)
	Hydraulic Radius - Rh	0.8	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	287.1	(cfs)
	Average Velocity for Q100	5.9	(fps)
	Average Velocity for Q10	2.0	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.3	
turbulent	Reynold Number	421198	
	Calculated Average Shear Stress $\tau = \gamma RhS$	2.4	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	6.0	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
Checked By: GAT Date: 3/11

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

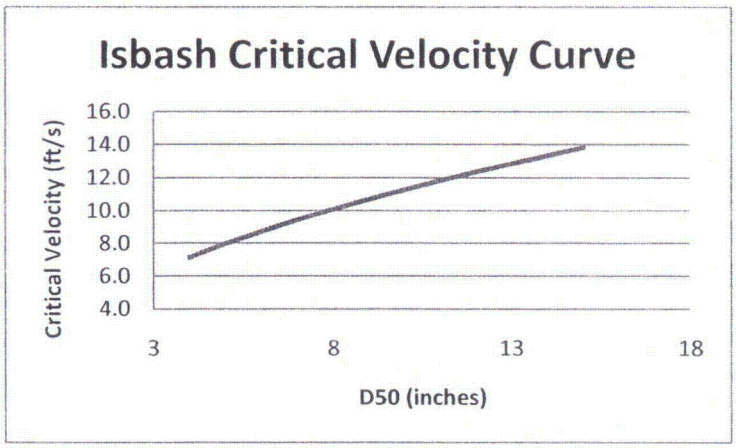
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	5.94	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	2.4	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.03	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	289	(mm)
	D	11	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

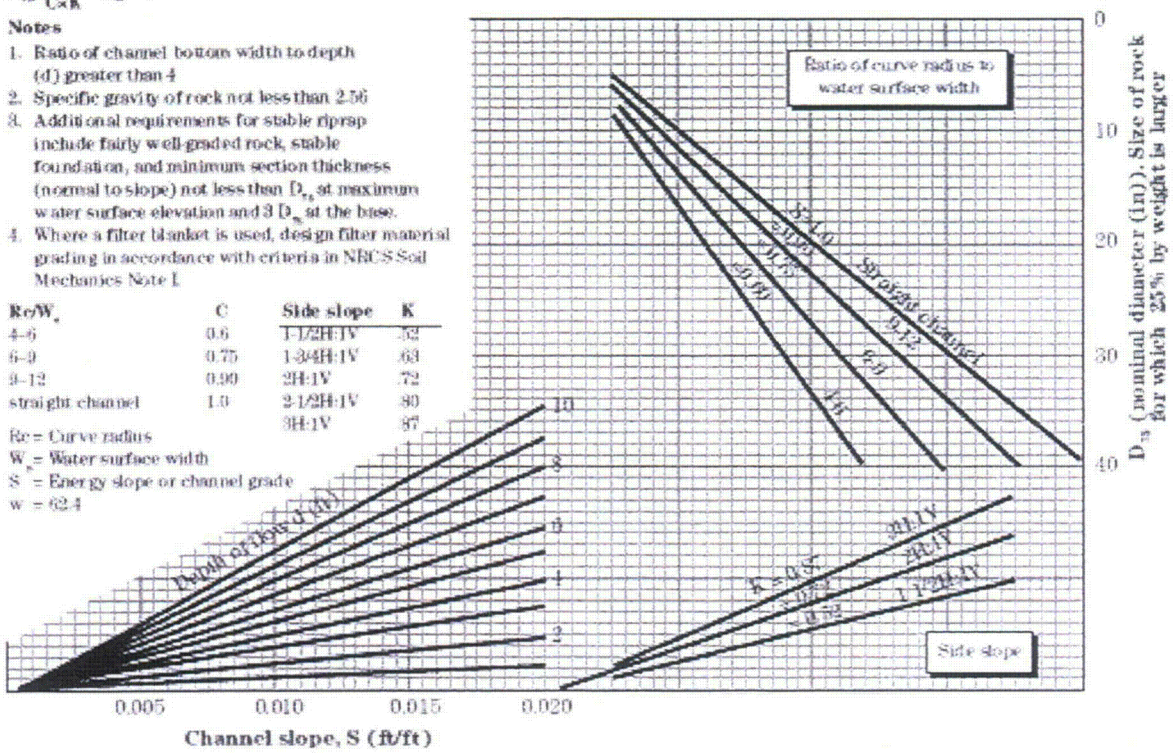
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{50} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NRCS Soil Mechanics Note I.

R_c/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

R_c = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.60	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage: DA10 John's Creek Watershed		
Amount of fall per riffle:	0.50	(feet)
Length of individual riffle:	30	(feet)
Design Flows		
Q1	5.3	(cfs)
Q2		(cfs)
Q10	126.1	(cfs)
Q100	324.2	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	62	(feet)
Trial Riffle Depth:	1.7	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.017	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

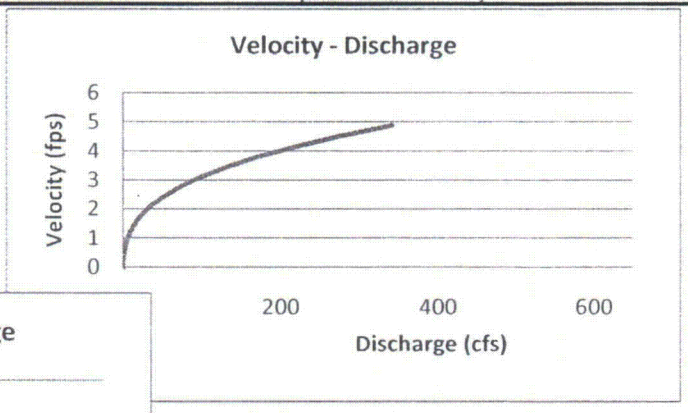
Calculate Q100:

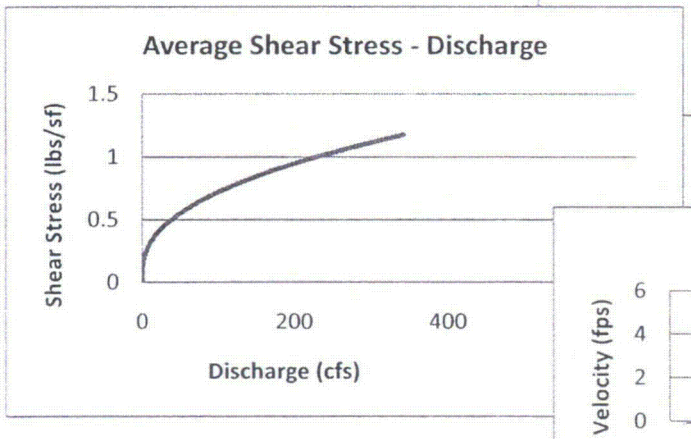
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

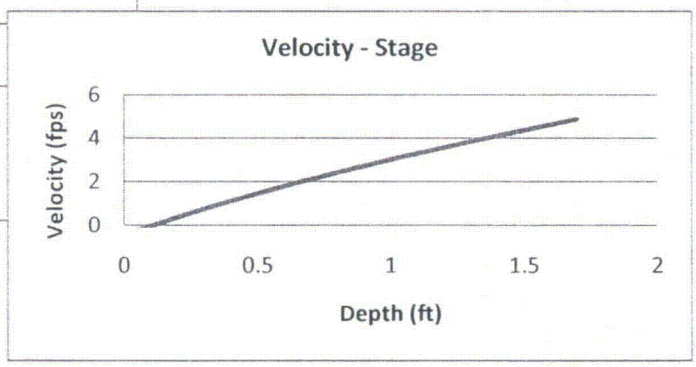
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	36.5	
	Manning's n at Q100	0.043	
	Cross-Sectional Area - A	70.3	(sf)
	Hydraulic Radius - Rh	1.1	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	342.2	(cfs)
	Average Velocity for Q100	4.9	(fps)
	Average Velocity for Q10	3.1	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.2	
turbulent	Reynold Number	509591	
	Calculated Average Shear Stress $\tau = \gamma RhS$	1.2	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	2.9	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
Checked By: GAT Date: 3/11

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

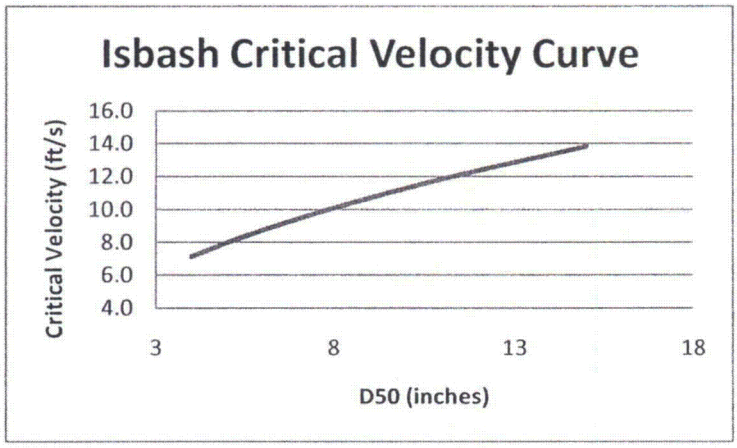
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where: C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	4.87	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	1.2	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	171	(mm)
	D	7	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

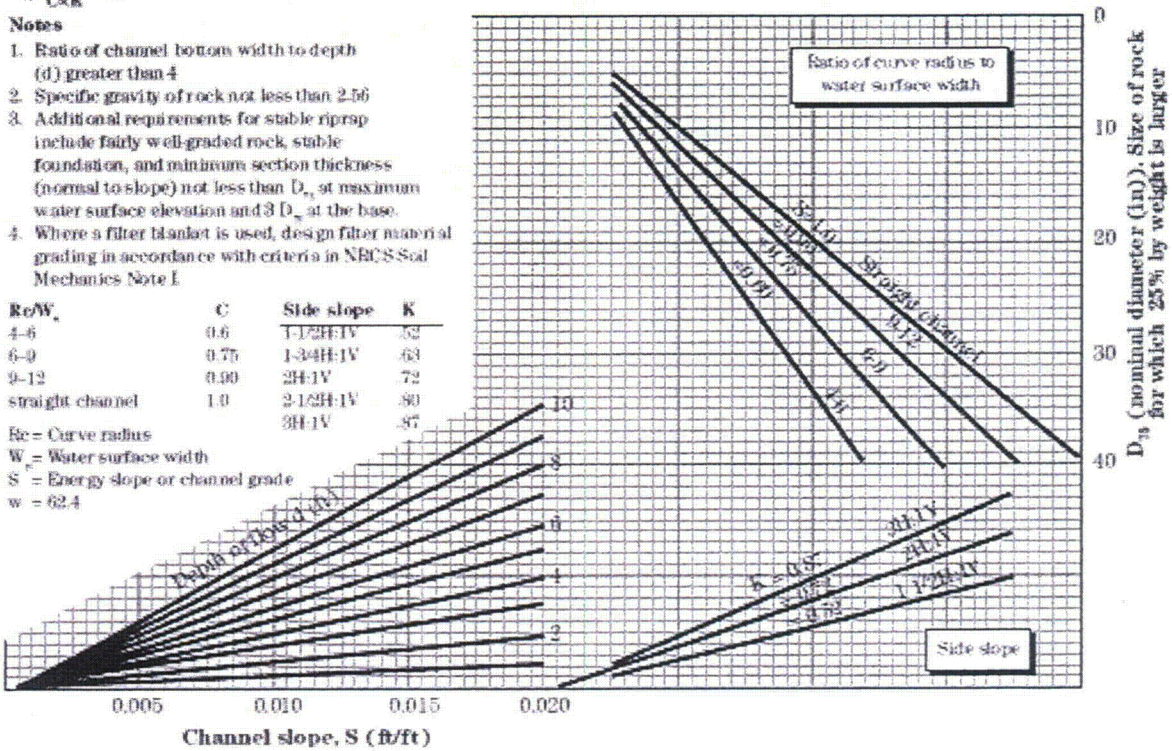
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NRCS Soil Mechanics Note I.

Rc/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

Rc = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.29	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage: DA10 John's Creek Watershed		
Amount of fall per riffle:	1.00	(feet)
Length of individual riffle:	30	(feet)
Design Flows		
Q1	5.3	(cfs)
Q2	20.46	(cfs)
Q10	126.1	(cfs)
Q100	324.2	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	62	(feet)
Trial Riffle Depth:	1.4	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.033	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

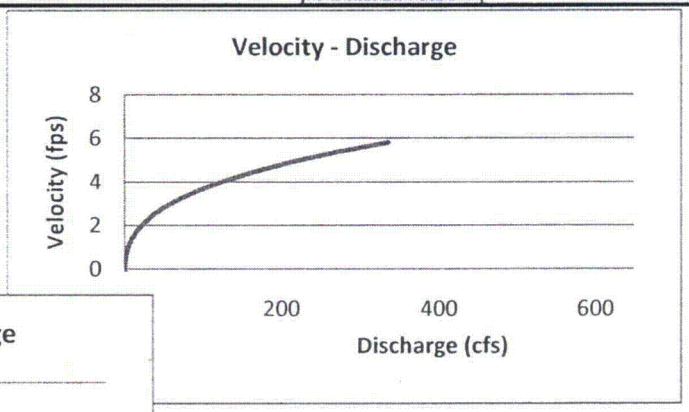
Calculate Q100:

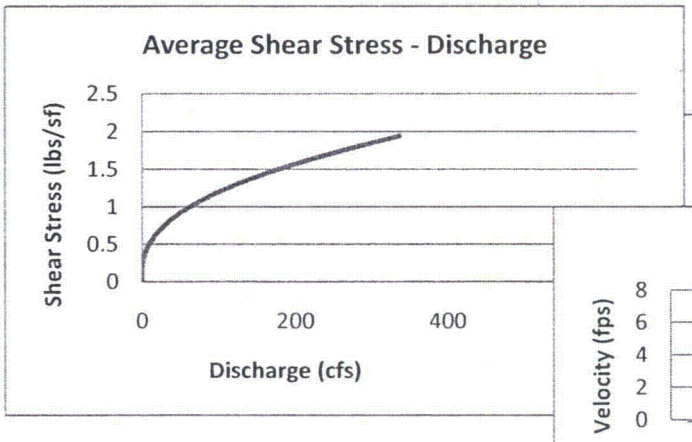
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

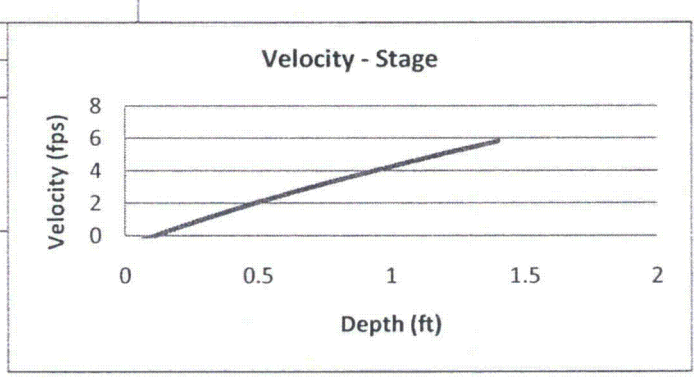
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	44.3	
	Manning's n at Q100	0.045	
	Cross-Sectional Area - A	57.9	(sf)
	Hydraulic Radius - Rh	0.9	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	336.0	(cfs)
	Average Velocity for Q100	5.8	(fps)
	Average Velocity for Q10	3.6	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.3	
turbulent	Reynold Number	500625	
	Calculated Average Shear Stress $\tau = \gamma RhS$	1.9	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	4.8	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
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RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

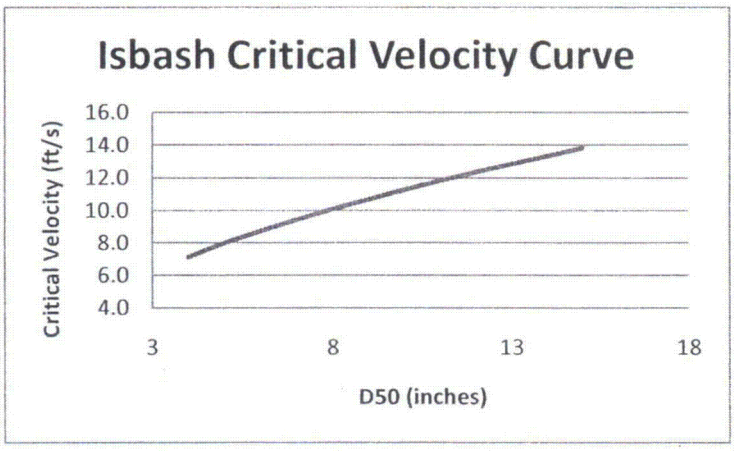
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	5.81	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	1.9	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.02	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	247	(mm)
	D	10	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

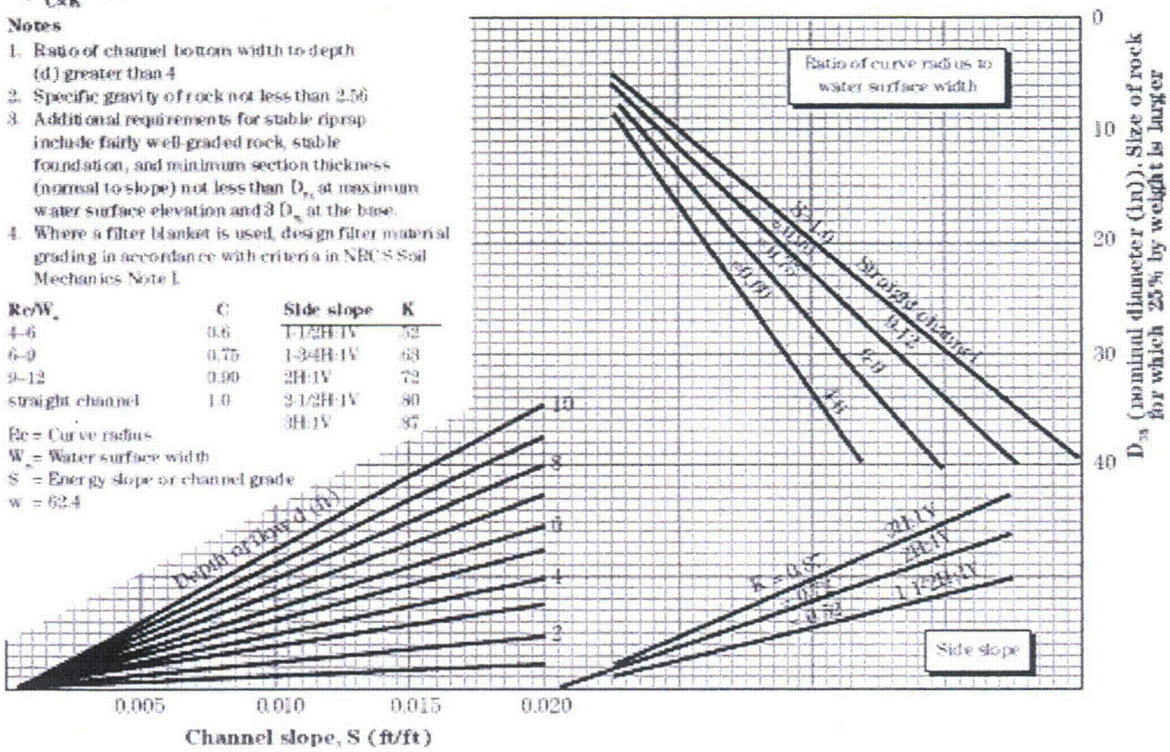
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NRCS Soil Mechanics Note 1.

R_c/W_w	C	Side slope	K
4–6	0.6	1-1/2H:1V	52
6–9	0.75	1-3/4H:1V	63
9–12	0.90	2H:1V	72
straight channel	1.0	2-1/2H:1V	80
		3H:1V	87

R_c = Curve radius
W_w = Water surface width
S = Energy slope or channel grade
w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.48	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage: DA9 John's Creek Watershed		
Amount of fall per riffle:	0.50	(feet)
Length of individual riffle:	24	(feet)
Design Flows		
Q1	5.74	(cfs)
Q2		(cfs)
Q10	129.7	(cfs)
Q100	334.8	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	100	(feet)
Trial Riffle Depth:	1.25	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.021	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

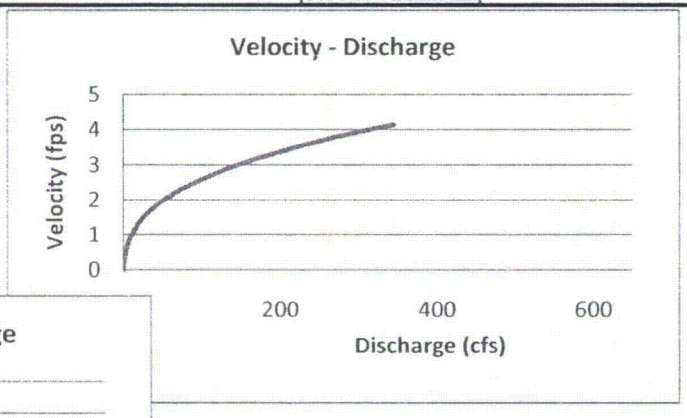
Calculate Q100:

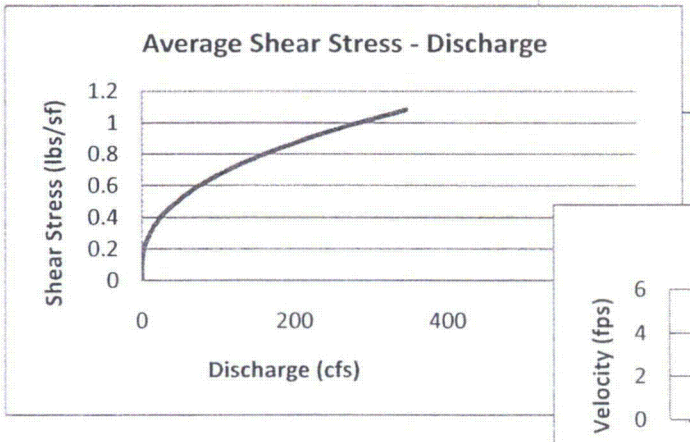
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

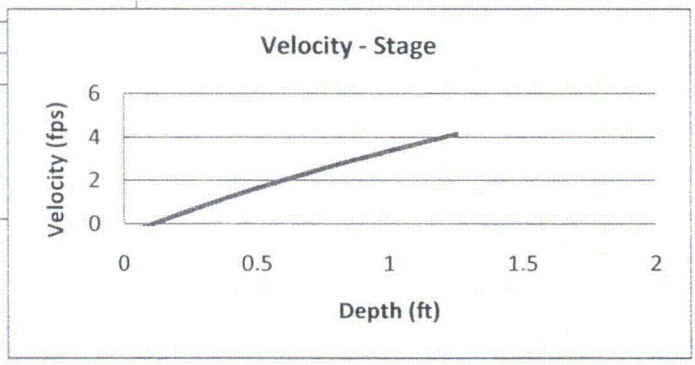
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	80.0	
	Manning's n at Q100	0.046	
	Cross-Sectional Area - A	83.3	(sf)
	Hydraulic Radius - Rh	0.8	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	345.4	(cfs)
	Average Velocity for Q100	4.1	(fps)
	Average Velocity for Q10	2.6	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.2	
turbulent	Reynold Number	319404	
	Calculated Average Shear Stress $\tau = \gamma RhS$	1.1	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	2.7	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
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RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

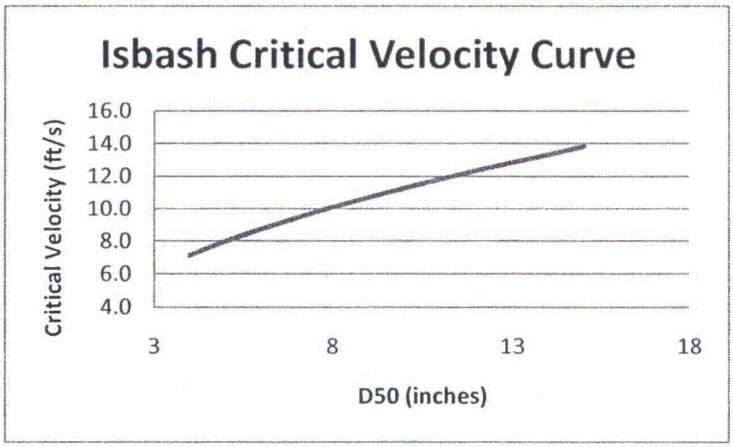
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	4.15	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress.

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	1.1	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	161	(mm)
	D	6	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

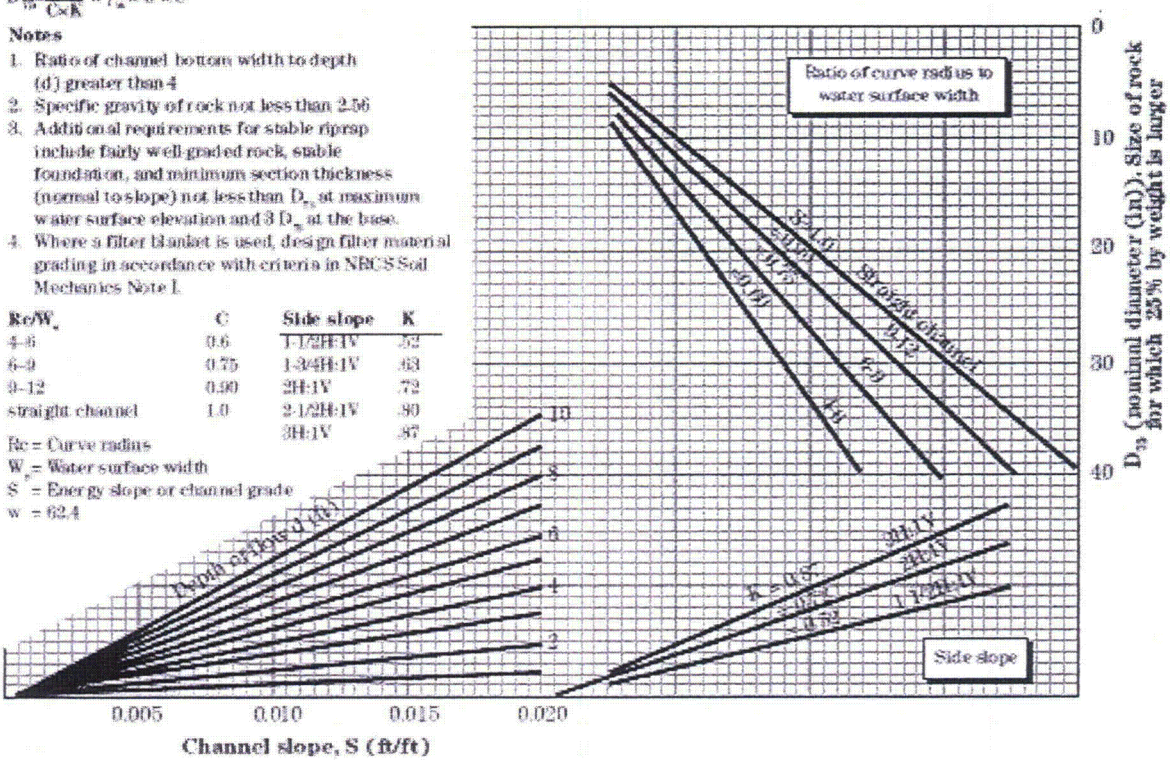
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NRCS Soil Mechanics Note I.

Rc/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

Rc = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.27	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage: DA9 John's Creek Watershed		
Amount of fall per riffle:	1.00	(feet)
Length of individual riffle:	24	(feet)
Design Flows		
Q1	5.74	(cfs)
Q2		(cfs)
Q10	129.7	(cfs)
Q100	334.8	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	100	(feet)
Trial Riffle Depth:	1.05	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.042	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

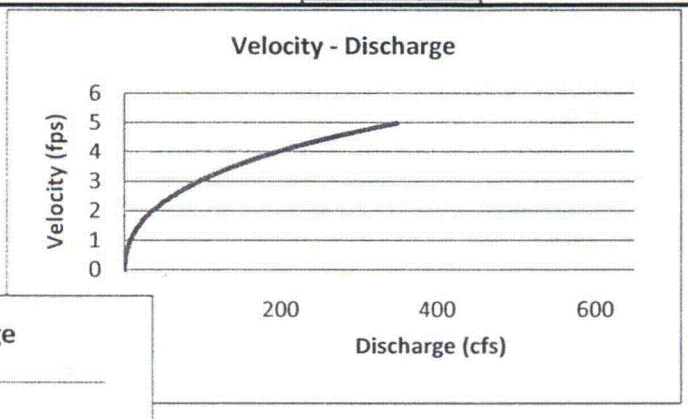
Calculate Q100:

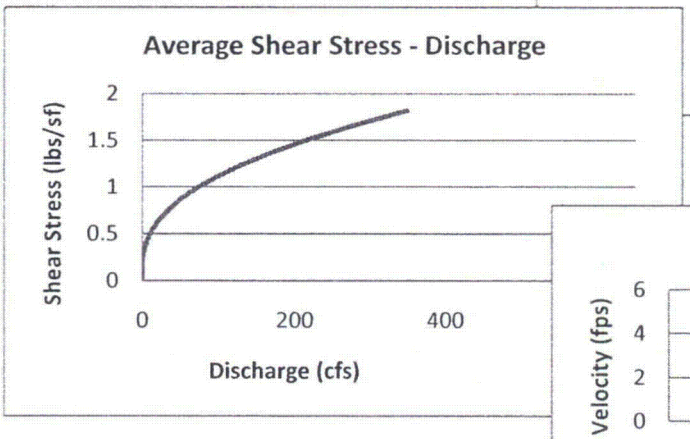
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

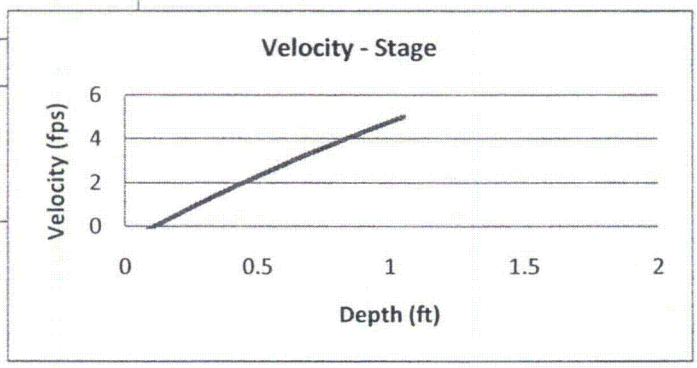
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	95.2	
	Manning's n at Q100	0.048	
	Cross-Sectional Area - A	70.0	(sf)
	Hydraulic Radius - Rh	0.7	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	348.9	(cfs)
	Average Velocity for Q100	5.0	(fps)
	Average Velocity for Q10	3.4	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.3	
turbulent	Reynold Number	322649	
	Calculated Average Shear Stress $\tau = \gamma RhS$	1.8	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	4.5	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
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RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

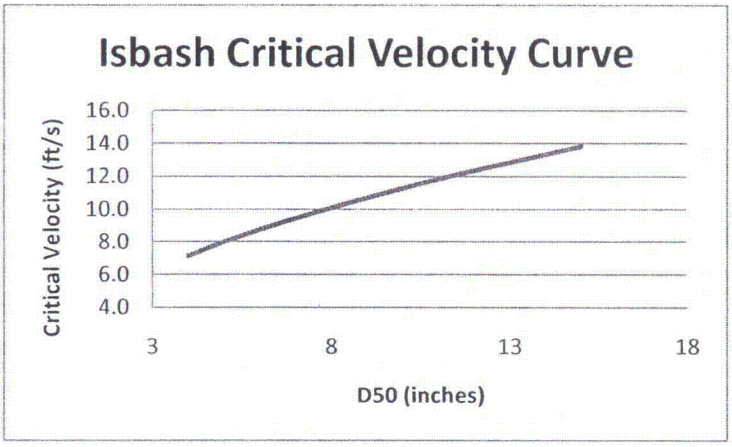
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	4.98	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	1.8	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.02	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	236	(mm)
	D	9	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

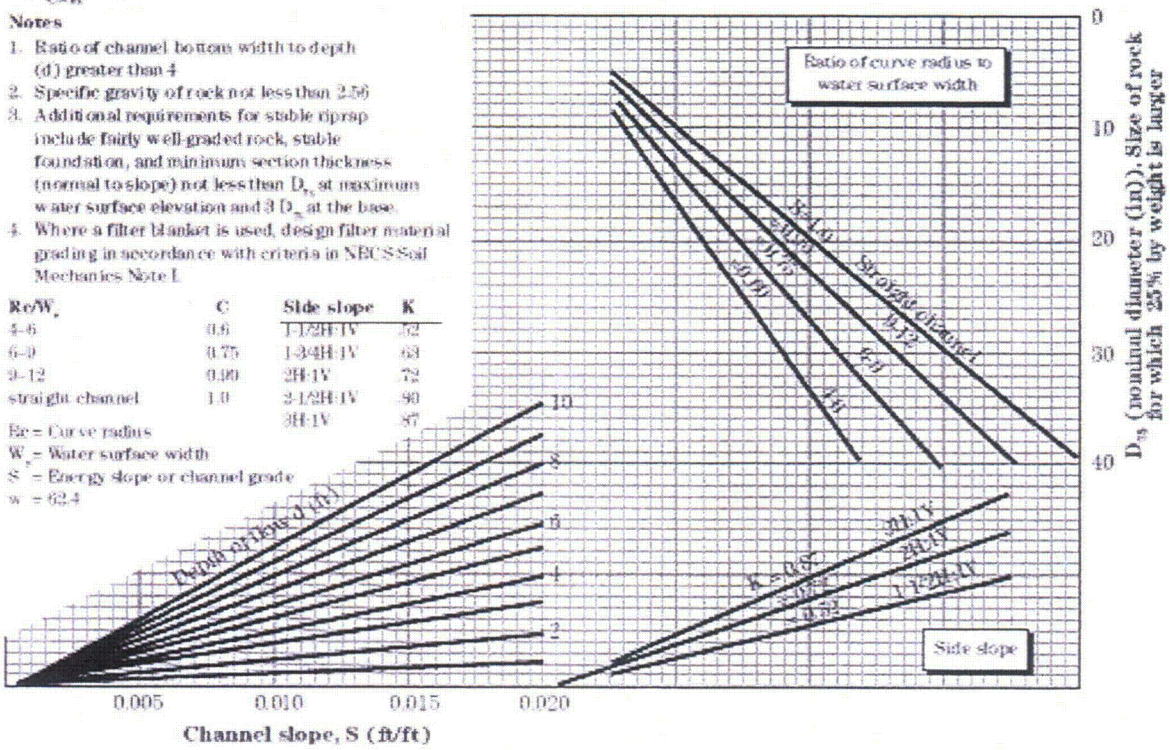
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NEC 5 Soil Mechanics Note L

R_c/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.90
		3H:1V	.87

R_c = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
γ_w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.45	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage: DA9 John's Creek Watershed		
Amount of fall per riffle:	1.00	(feet)
Length of individual riffle:	24	(feet)
Design Flows		
Q1	5.74	(cfs)
Q2		(cfs)
Q10	129.7	(cfs)
Q100	334.8	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	57	(feet)
Trial Riffle Depth:	1.4	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.042	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

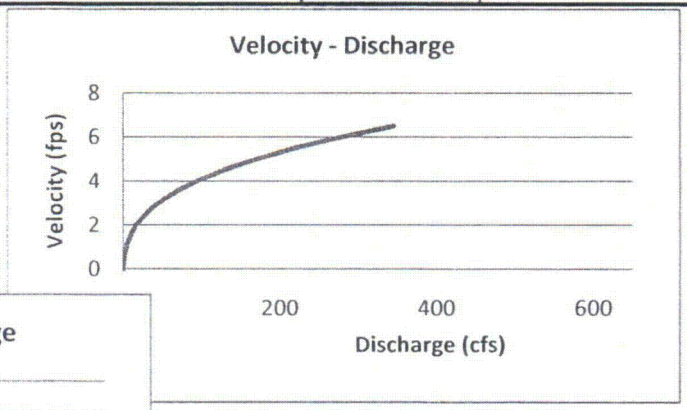
Calculate Q100:

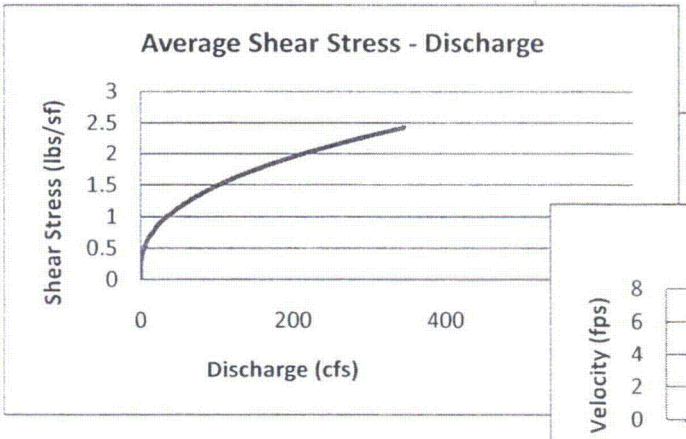
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

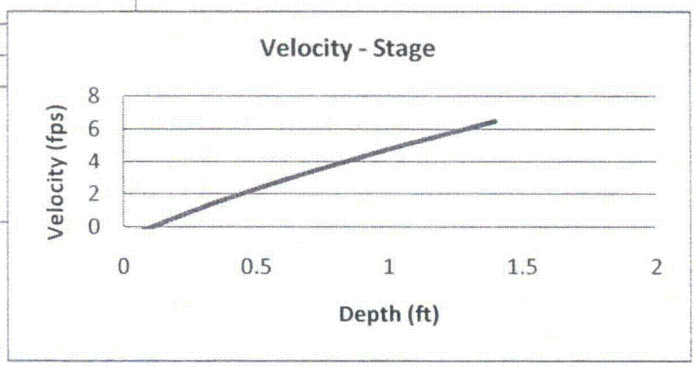
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	40.7	
	Manning's n at Q100	0.045	
	Cross-Sectional Area - A	53.2	(sf)
	Hydraulic Radius - Rh	0.9	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	345.3	(cfs)
	Average Velocity for Q100	6.5	(fps)
	Average Velocity for Q10	4.1	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.3	
turbulent	Reynold Number	559484	
	Calculated Average Shear Stress $\tau = \gamma RhS$	2.4	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	6.1	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
Checked By: GAT Date: 3/11

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

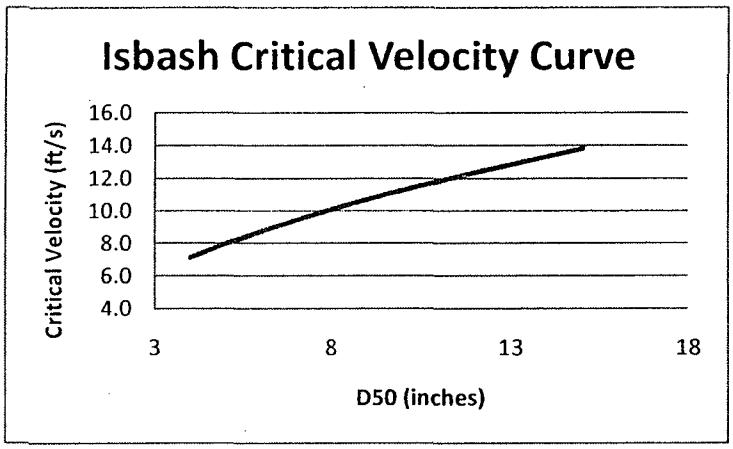
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	6.49	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	2.4	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.03	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	291	(mm)
	D	11	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

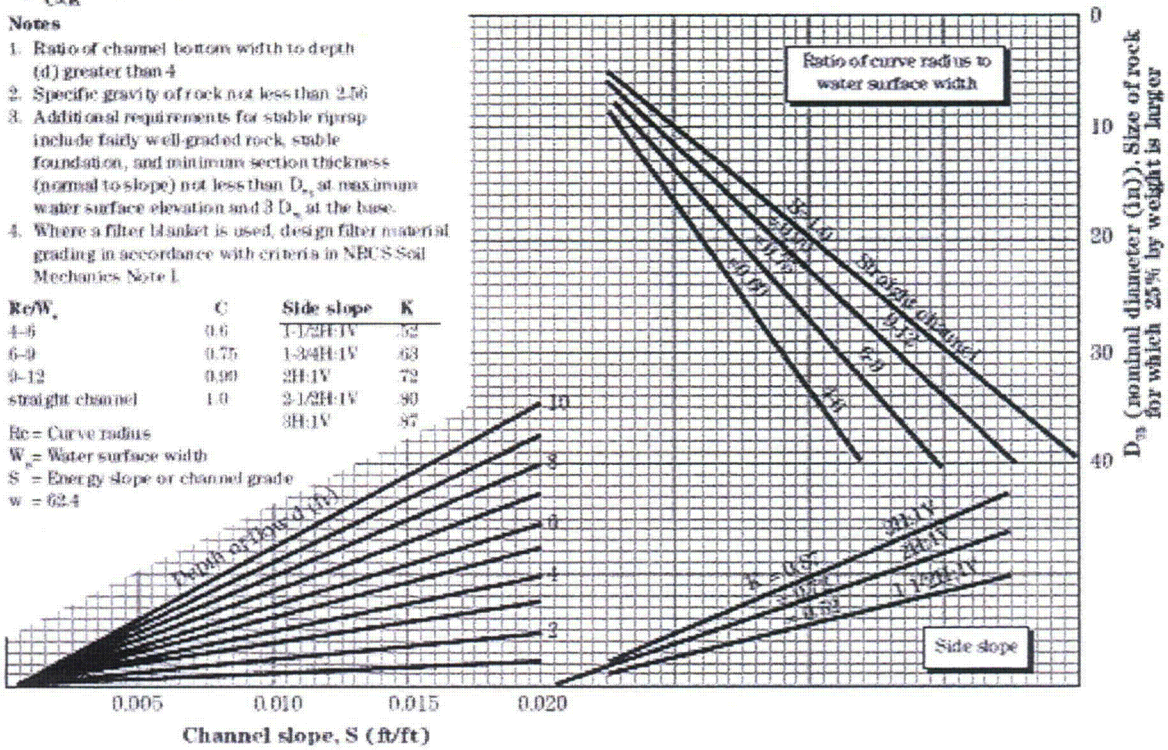
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NRCS Soil Mechanics Note 1.

R_c/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

R_c = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.61	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage: DA9 John's Creek Watershed		
Amount of fall per riffle:	0.50	(feet)
Length of individual riffle:	24	(feet)
Design Flows		
Q1	5.74	(cfs)
Q2		(cfs)
Q10	129.7	(cfs)
Q100	334.8	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	57	(feet)
Trial Riffle Depth:	1.7	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.021	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

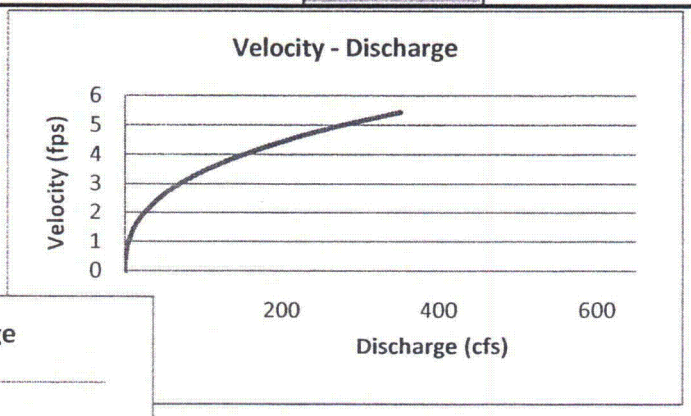
Calculate Q100:

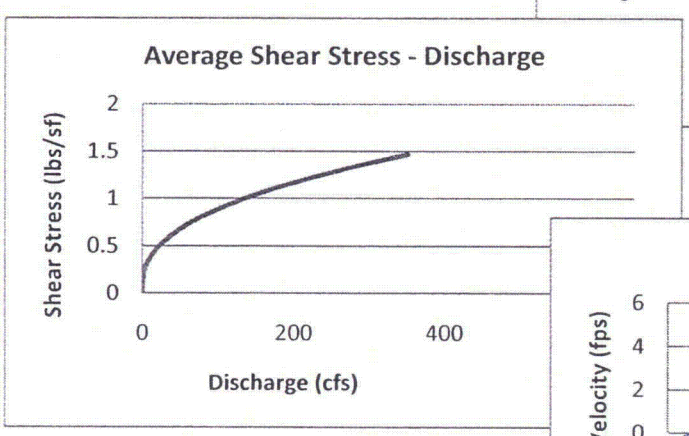
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

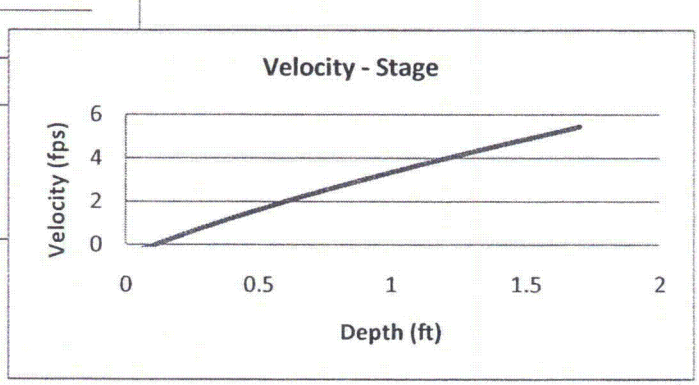
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	33.5	
	Manning's n at Q100	0.043	
	Cross-Sectional Area - A	64.6	(sf)
	Hydraulic Radius - Rh	1.1	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	351.7	(cfs)
	Average Velocity for Q100	5.4	(fps)
	Average Velocity for Q10	3.5	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.2	
turbulent	Reynold Number	569392	
	Calculated Average Shear Stress $\tau = \gamma RhS$	1.5	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	3.7	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
Checked By: GAT Date: 3/11

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

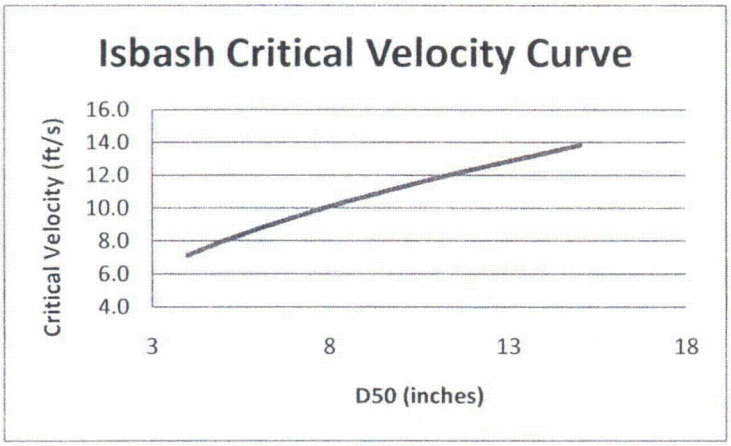
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	5.44	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	1.5	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.02	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	202	(mm)
	D	8	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

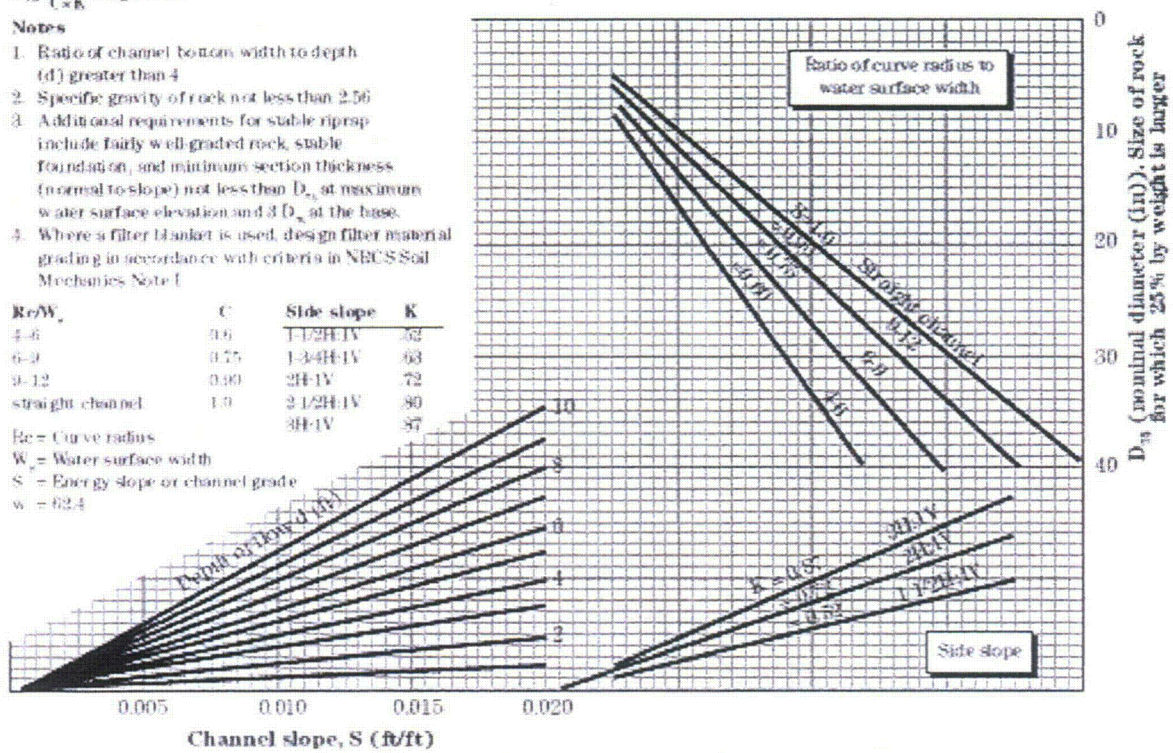
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NECS Soil Mechanics Note 1

R_c/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

R_c = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
γ_w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.37	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage:Outfall JNC11CD - Johns Creek Watershed		
Amount of fall per riffle:	0.30	(feet)
Length of individual riffle:	28	(feet)
Design Flows		
Q1	7.9	(cfs)
Q2	23.7	(cfs)
Q10	149.8	(cfs)
Q100	388.2	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	100	(feet)
Trial Riffle Depth:	1.6	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.011	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

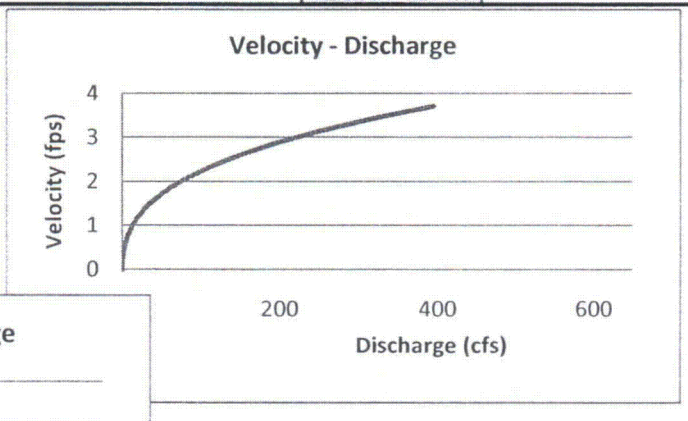
Calculate Q100:

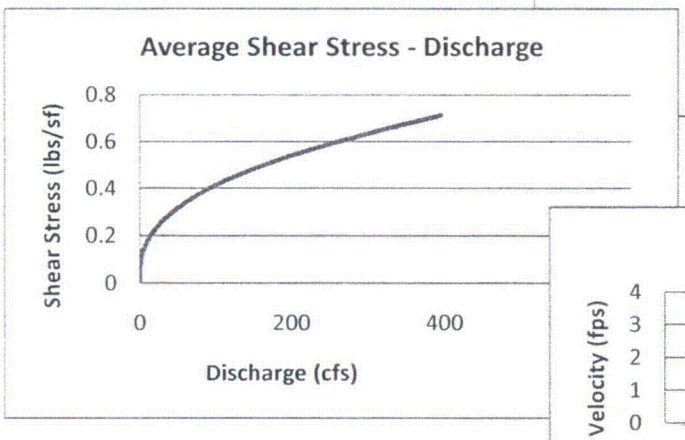
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

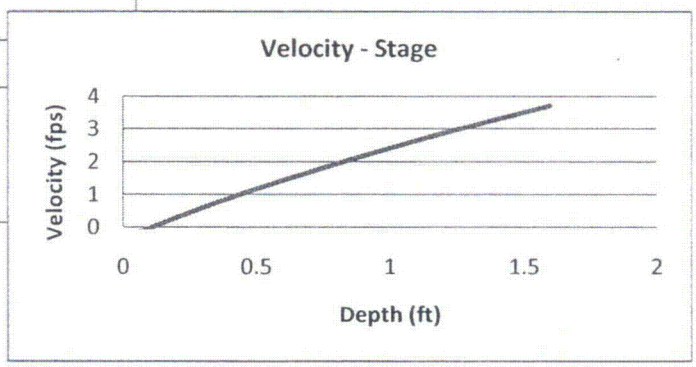
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	62.5	
	Manning's n at Q100	0.043	
	Cross-Sectional Area - A	106.7	(sf)
	Hydraulic Radius - Rh	1.1	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	395.4	(cfs)
	Average Velocity for Q100	3.7	(fps)
	Average Velocity for Q10	2.4	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.1	
turbulent	Reynold Number	365543	
	Calculated Average Shear Stress $\tau = \gamma RhS$	0.7	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	1.8	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
Checked By: GAT Date: 3/11

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

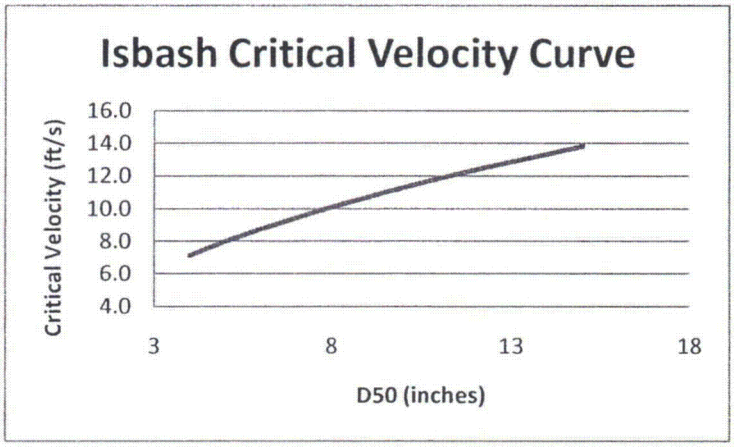
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where:
C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	3.71	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	0.7	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.00	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	118	(mm)
	D	5	(in)
	Is the movable particle less than proposed D50?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

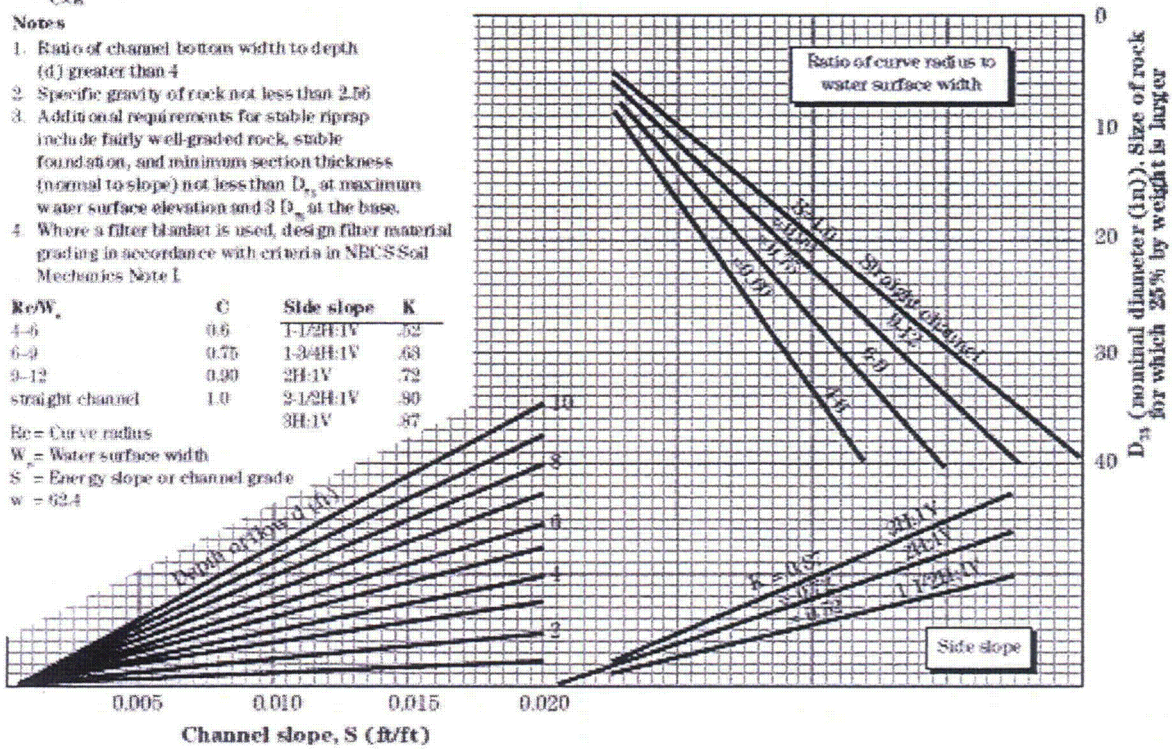
$$D_{75} = \frac{3.5}{C \times k} \times \gamma_s \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{50} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NEC S Soil Mechanics Note I.

Rc/W_s	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.68
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

Rc = Curve radius
W_s = Water surface width
S = Energy slope or channel grade
w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.18	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

RIFFLE GRADE CONTROL DESIGN SHEET

WEIR CONSTRAINTS		
Project: UniStar - 1462103		
Riffle design for drainage:Outfall JNC11b - John's Creek Watershed		
Amount of fall per riffle:	0.30	(feet)
Length of individual riffle:	15	(feet)
Design Flows		
Q1	12.2	(cfs)
Q2	29	(cfs)
Q10	182.8	(cfs)
Q100	595.3	(cfs)
DESIGN INPUT		
Dimension		
Trial Riffle Width (greater than 14):	100	(feet)
Trial Riffle Depth:	1.75	(feet)
Trial Cobble Size:	6	(inches)
Trial Cobble Size:	0.5	(feet)
Trial Slope:	0.020	(decimal, ft/ft)

CALCULATIONS

Calculate Manning's n: (Eq 1.) (USDA, 2006)

n = manning's n
d = depth, ft.,
d50 = cobble size, ft

$$n = \frac{D^{1/6}}{21.6 * \log(D/d50) + 14}$$

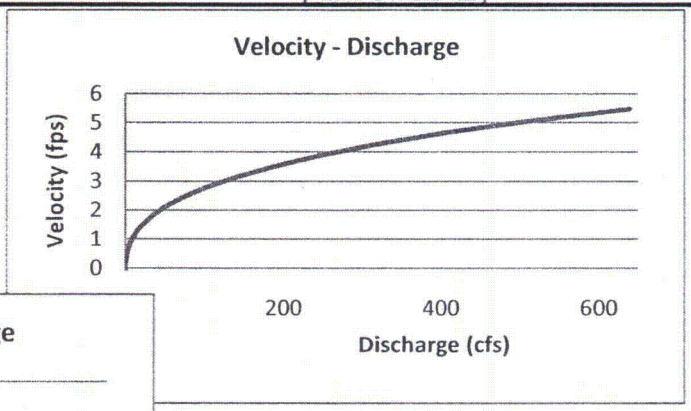
Calculate Q100:

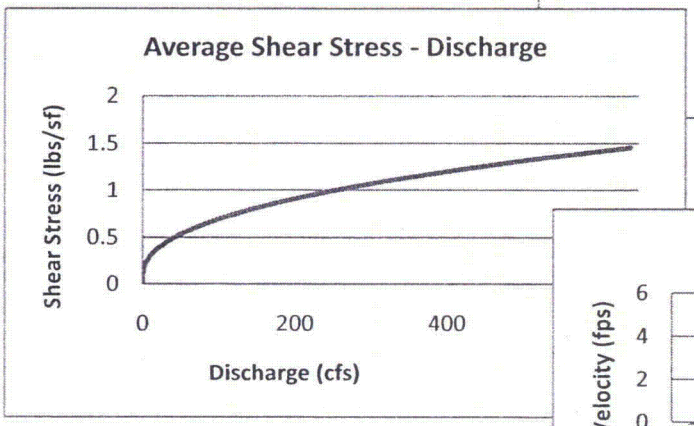
$$Q = 1.49/n * A * Rh^{2/3} * S^{1/2}$$

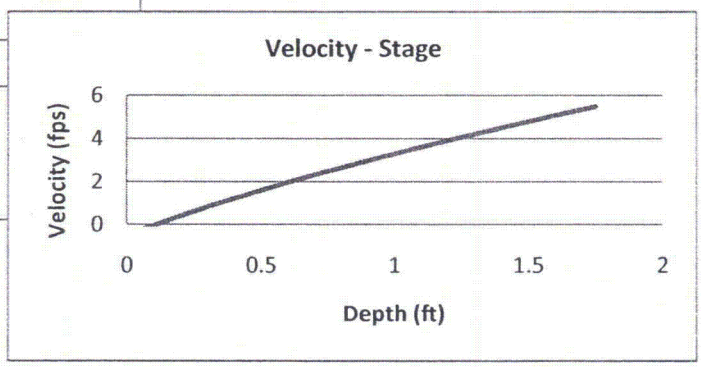
Where:
Q = flow (cfs)
1.49 = conversion factor
n = manning's n, determined by Eq 1
A = Area, which for a parabola = 2/3(T)(y), where T is top width (ft) and y is depth (ft)
Rh = hydraulic radius (ft), which for a parabola = $[2 (T)^2 (y)] / [3(T)^2 + 8 (y)^2]$ (Chow, 1959)

RIFFLE GRADE CONTROL DESIGN SHEET

Quick Check	OUTPUT		
OK	Width/Depth Ratio (Must be >10)	57.1	
	Manning's n at Q100	0.043	
	Cross-Sectional Area - A	116.7	(sf)
	Hydraulic Radius - Rh	1.2	(feet)
OK	Calculated Q100 (≥ and w/in 10% Actual Q100)	638.8	(cfs)
	Average Velocity for Q100	5.5	(fps)
	Average Velocity for Q10	3.1	(fps)
OK	Velocity Vegetation Stabilization Check	5.0	(fps)
subcritical	Froude Number	0.2	
turbulent	Reynold Number	590425	
	Calculated Average Shear Stress $\tau = \gamma RhS$	1.5	(lbs/sf)
	Max Shear Stress Multiplication Factor	2.5	
	Estimated Max Secondary Shear Stress	3.6	(lbs/sf)







Project: Calvert Cliffs Unit 3 Phase II Mitigation Plan
Subject: Riffle Grade Control Sizing Calculations
Computed By: CS Date: 2/11

Project No 1462103.
Sheet No. 2 of 5
Checked By: GAT Date: 3/11

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates

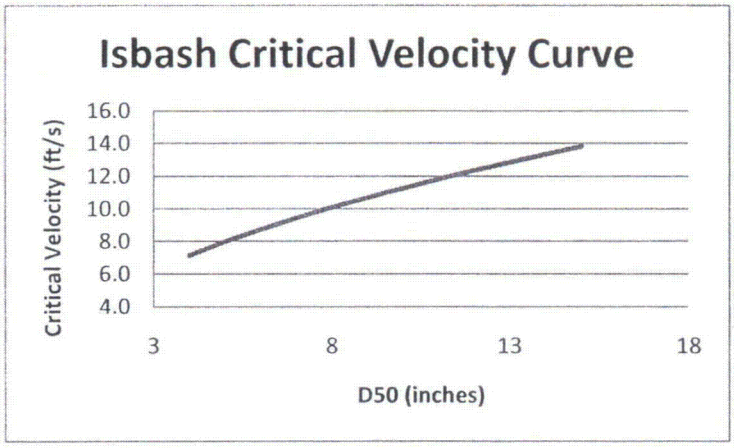
ISBASH (NRCS 2007)

Calculate critical velocity Vc for stone size

$$V_C = C\left(2g\frac{\gamma_s - \gamma_w}{\gamma_w}\right)^{1/2} D_{50}^{1/2}$$

Where: C=0.86 for high turbulence
C=1.20 for low turbulence
g-gravitational constant
γ = density, (s) stone, (w) water (lbs/cft)

Critical Velocity for D_{50}	8.74	(fps)
Calculated velocity for Q100	5.48	(fps)
Calculated velocity acceptable?	YES	



Cobble d50 size	AllowableVelocity for Q100
[inches]	[ft/sec]
4	7.1
5	8.0
6	8.7
7	9.4
8	10.1
9	10.7
10	11.3
11	11.8
12	12.4
15	13.8

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

Shield's (Sheilds, 1936; WARSSS, 2006)

Shield's Entrainment
Movable particle based on average stress,

$$D(in) = 77.966 * c^{1.042} * 0.03936996$$

$$D_{50} = \frac{\tau_c}{0.06(\rho_s - \rho)g}$$

Using average channel shear stress

Average Shear Stress	1.5	(lbs/sf)
Sediment Density	165	(lb/cf)
Shield's entrainment moveable particle	0.01	(ft)
Is the movable particle less than proposed D50?	YES	

Using secondary shear stress (Bathurst, Hey and Thorne, 1979)

Correction factor	2.5	
Shield's entrainment moveable particle	0.02	(ft)
Is the movable particle less than proposed D50?	YES	

ROSGEN COLORADO DATA (National Engineering Handbook, 2007)

Field data fit for Shield's relation

$D\ (mm) = 152.02\tau_c^{0.7355}$	D	200	(mm)
	D	8	(in)
	Is the movable particle less than proposed D50?	NO	

RIFFLE GRADE CONTROL DESIGN SHEET

Entrainment Estimates Continued

FAR WEST STATES (FWS) - LANES METHOD (National Engineering Handbook, 2007)

Figure TS14C–8 Lane's method

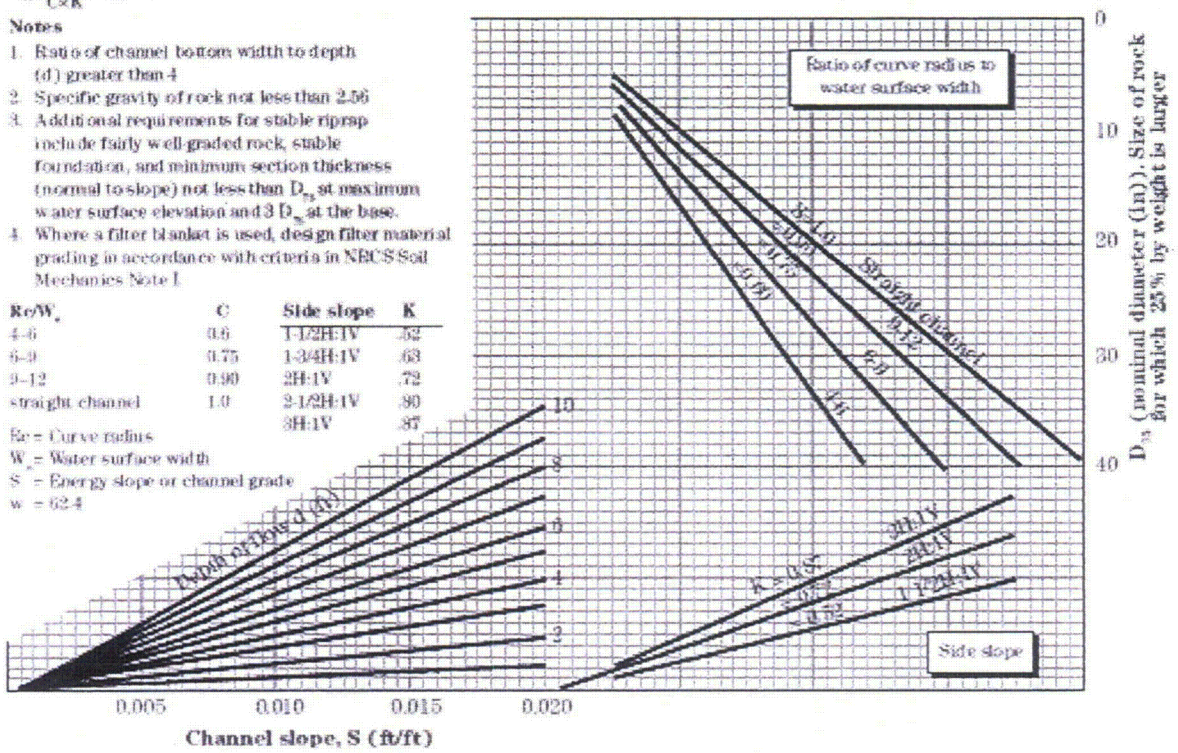
$$D_{75} = \frac{3.5}{C \times K} \times \gamma_w \times d \times S$$

Notes

1. Ratio of channel bottom width to depth (d) greater than 4
2. Specific gravity of rock not less than 2.56
3. Additional requirements for stable riprap include fairly well-graded rock, stable foundation, and minimum section thickness (normal to slope) not less than D_{75} at maximum water surface elevation and 3 D_{75} at the base.
4. Where a filter blanket is used, design filter material grading in accordance with criteria in NEC S Soil Mechanics Note I.

R_c/W_w	C	Side slope	K
4–6	0.6	1-1/2H:1V	.52
6–9	0.75	1-3/4H:1V	.63
9–12	0.90	2H:1V	.72
straight channel	1.0	2-1/2H:1V	.80
		3H:1V	.87

R_c = Curve radius
W_w = Water surface width
S = Energy slope or channel grade
w = 62.4



TS14C–10 (210–VI–NEH, August 2007)

C	0.6	
K	0.87	
D_{75}	0.36	(ft)
Is the calculated D_{75} less than the proposed D_{50}?	YES	

Project	Calvert Cliffs Unit 3 Phase II Mitigation Plan	Project No.	1462103
Subject	Riffle Grade Control Sizing Calculation - SE-4	Sheet No.	1 of 2
	Based on Anne Arundel County Specifications	Drawing No.	
Computed by	JJM Date 4/4/2011	Checked by	GAT Date 4/5/2011

OBJECTIVE:

Determine the dimensions and materials for the riffle grade control structures utilized for the SE-4 Reach (Unnamed Tributary to the Chesapeake Bay) regenerative stormwater conveyance practices.

ASSUMPTIONS:

The SE-4 reach is proposed to receive stormwater from the planned Unit 3 site development. Proposed condition design discharges for this reach were obtained from the Bechtel Corporation in October of 2009.

The design assumes that no additional stormwater will be routed through this reach and that the proposed conditions are a conservative estimate of the ultimate watershed condition.

PROCEDURE:

Flores, Hala, (2009). *Step Pool Storm Conveyance Design Calculator.* Anne Arundel County Department of Public Works, Annapolis, Maryland.

Flores, Markusic, McMonigle, and Underwood (2009). Step Pool Storm Conveyance. Anne Arundel County Department of Public Works, Annapolis, Maryland.

From TR-55, determine the pre- and post- development discharges for the 1, 10 and 100 year storm and associated time of concentration. For SE-4, Pre and Post development discharges are not equal since a large amount of stormwater from the site development is routed through the reach:

Drainage Area	Tc (hours)	100yr (CFS)	1yr (CFS)	10yr (CFS)
SE-4 Reach Pre-Development	0.321	169.0	10.0	101.1
SE-4 Reach Post-Development	0.321	395.2	23.0	236.7

As the valley width varies between the upper and lower portions of the site, two appropriate weir designs were utilized for the design.

Utilizing the site map, determine the length of conveyance areas and elevation drop through them. Calculate the desired number of weirs for the site based on the elevation drop through the weirs. **For SE-4, the reach is designed according to Anne Arundel County Specifications with 1' of drop per riffle and no slope on pools, with the reach having a regular riffle-pool distribution. Therefore all elevation change occurs within riffles.**

Two separate riffle widths were selected to meet site conditions, one each for the upper and lower portions of the reach.

The Step Pool Design Conveyance Calculator from Anne Arundel County Department of Public Works is utilized in this calculation. This calculator is modified to achieve the desired number elevation drop through the weirs coupled with the desired design discharges. Spreadsheets are attached to this calculation.

The water quality component was utilized for SE-4 designs. Water quality and quantity criteria are met in the storage in the sand filter and regenerative pools.

RESULTS:

Weir designs are summarized below:

Drainage Area	Cobble Size (Inches)	Width (Feet)	Depth (Feet)	Slope
SE-4 Upper	6	45	2.0	5.0%
SE-4 Lower	6	30	3.0	3.3%

Contact

2662 Riva Road
Annapolis, MD 21401
Phone 410 222 4091

Anne Arundel County Government
Department of Public Works
Bureau of Engineering
Watershed and Ecosystem Services and Restoration
Watershed Assessment and Planning

ANNE ARUNDEL COUNTY MARYLAND

Input values shaded in Grey "Required"
Calculated values are noted with dotted pattern
Check parameters in bold

Developed by: Hala Flores, P.E.
Date: 21-Dec-09

Checking the Channel Conveyance for the design flood				
Design Return Period (Yr)	T	100	1	10
Time of Concentration in minutes (Before Development)	t_c		10.30	
Pre development discharge (cfs)	Q_{pre}	169.0	10.0	101.0
Post development design discharge (cfs)	Q_{post}	395.2	23.0	236.7
Total available length (ft)	L	200	**Cascade Design (maximum 5 ft drop per segment)**	
Elevation drop over length (ft)	delta E	8.0	Design Width (ft)	
Total Cascade Length for Project (ft)	$L_{cascade}$	0.00	Design Depth (ft)	
Maximum Cascade Slope (ft/ft)	$Slope_{cascade}$	0.50	Roughness	0.05
Water Quality slope (ft/ft)	Slope	0.03	A	0.00
Average Length of Riffle Segments (ft), Minimum 10 ft	L_{riffle}	20	θ	#DIV/0!
Number of Riffle Segments for Project	N_{riffle}	5	P	#DIV/0!
Number of Cascade Segments for Project	$N_{cascade}$	0	R_h	#DIV/0!
Required Length of Pool Segments (ft)	L_{pool}	20	Design Velocity (ft/sec)	#DIV/0!
Cobble d50 size (ft) - choose - 6 inches	d50	**0.50**	Conveyed Q (cfs)	#DIV/0!
Top width of SPSC riffle channel (ft)	W	45.0	**No Cascade is Needed**	
Depth of SPSC riffle channel (ft)	D	2.0	Minimum Pool Depth "Use 3 pools" following each cascade segment (ft)	#DIV/0!
pools of the SPSC (ft)	h_p	**3.0**	**ok**	
Enter Desired Pool Depth (ft)	h_p	3.0	**subcritical/ok**	
Check Riffle Side Slope, Must be > 2H:1V		11.3		
Check the Froude Number to ensure Subcritical Flow Conditions		0.9		
Computed Roughness	n	0.04		
Riffle Cross Section Area (ft2), for parabola	A	60.00		
Theta - Intermediate step for solving	θ	0.18		
Riffle Hydraulic Perimeter (ft), for parabola	P	45.24		
Riffle Hydraulic Radius (ft), using Chow 1959	R_h	1.33		
Calculated Flow for design parameters (cfs)	Q	449.72		
Check Riffle Velocity (ft/sec)	V	7.50	**Required Number of Pools**	**5**
			Provided total pool depth (ft) =	15
			hydraulic power for return period 100 year storm is satisfied	

Isbash curve for Stone Density = 165 lb/ft3		
Cobble d50 size	Allowable Velocity (Supercritical)	Allowable Velocity (Subcritical)
[inches]	[ft/sec]	[ft/sec]
4	5.1	7.1
5	5.7	8.0
6	6.3	8.7
7	6.8	9.4
8	7.2	10.1
9	7.7	10.7
10	8.1	11.3
11	8.5	11.8
12	8.8	12.3
15	9.9	13.8
18	10.8	15.1

Adequate conveyance of design storm

Selected Cobble Size is Adequate for 100 year storm

Subcritical Flow is Predominant

Checking Quantity Management			
USDA 2006, n expressed in terms of d_{out} and d_{50} = 8 inches	n	0.04	Required Volume of Storage (Rational Hydrograph)
The width at the entrance riffle	W_{in}	45.00	
The velocity at the entrance riffle is calculated using Manning formula calculator and Q_{post} for the 1 year storm	V_{in}	7.57	Required Volume of Storage (ft3)
The depth at the entrance riffle is calculated using Manning formula calculator and Q_{post} for the 1 year storm	D_{in}	2.00	Volume provided in pools (ft3)
Enter Trial Value : The total pool depth needed to render the power equivalent to 100-year predevelopment/desired levels. This should be	D_{out}	6.57	Volume provided in voids (ft3)
This is the typical top width of the dead storage pool parabolic areas, 10:1 side slope	W_{out}	18	
The area is for a semi parabola	A_{out}	79	**Provided Volume of Storage (excludes infiltration) (ft3)**
protection volume	L_{add}	268	Infiltration Volume (ft3)
Theta - Intermediate step for solving	θ	0.97	
Hydraulic Perimeter (ft), for semi parabola	P_{out}	23	
Hydraulic Radius, using Chow 1959	R_h	3.41	
v_{out}, and d_{out}	f	0.22	
Solved using Solver equation: Bernoulli equation rewritten in terms of d_{out} as		0.00	

Required Volume of Storage (ft3)	100 Yr	1 Yr	10 Yr
	261925	15053	157132
Volume provided in pools (ft3)	2161		
Volume provided in voids (ft3)	5400		
Provided Volume of Storage (excludes infiltration) (ft3)	8561		
Infiltration Volume (ft3)	1000		
Peak Management of 100 year storm is not satisfied			
Peak Management of 1 year storm is not satisfied			
Peak Management of 10 year storm is not satisfied			

Checking Quality Management		
Site Drainage Area (Acres)	A	116
Contributory Impervious Area (Acres)	I	16.6
Volumetric Runoff Coefficient	Rv	0.18
Water Quality Volume, ft3	WQv	67758
Average Sand filter bed depth (ft) minimum 18 inches	d_f (Average of Pool and Riffles)	3.0
Width of sand filter (ft)	W_{sand}	30
Length of sand filter, where slope < = 5% (ft)	L_{sand}	200
Area of sand filter provided (ft2)	A_f Provided	**6000**
coefficient of permeability of filter media (ft/day)	k	3.50
height of water above filter bed- pool depth (ft)	h_f	3.00

Water quality requirement is satisfied in SPSC

design filter bed drain time (days), MDE recommended value	t_f	1.67
Required filter bed area (ft2)	$A_{f\ Required}$	2898

Contact

2662 Riva Road
Annapolis, MD 21401
Phone 410 222 8231

Anne Arundel County Government
Department of Public Works
Bureau of Engineering
Watershed and Ecosystem Services and Restoration
Watershed Assessment and Planning

ANNE ARUNDEL COUNTY
MARYLAND

Developed by: Hala Flores, P.E.
Date: 21-Dec-09

Input values shaded in Grey "Required"
Calculated values are noted with dotted pattern
Check parameters in bold

Checking the Channel Conveyance for the design flood				
Design Return Period (Yr)	T	100	1	10
Time of Concentration in minutes (Before Development)	t_c		19.30	
Pre development discharge (cfs)	Q_{pre}	169.0	10.0	101.0
Post development design discharge (cfs)	Q_{post}	395.2	23.0	236.7
Total available length (ft)	L	300	Cascade Design (maximum 5 ft drop per segment)	
Elevation drop over length (ft)	delta E	5.0	Design Width (ft)	
Total Cascade Length for Project (ft)	$L_{cascade}$	0.00	Design Depth (ft)	
Maximum Cascade Slope (ft/ft)	$Slope_{cascade}$	0.50	Roughness	0.05
Water Quality slope (ft/ft)	Slope	0.02	A	0.00
Average Length of Riffle Segments (ft), Minimum 10 ft	L_{riffle}	30	θ	#DIV/0!
Number of Riffle Segments for Project	N_{riffle}	5	P	#DIV/0!
Number of Cascade Segments for Project	$N_{cascade}$	0	R_h	#DIV/0!
Required Length of Pool Segments (ft)	L_{pool}	30	Design Velocity (ft/sec)	#DIV/0!
Cobble d50 size (ft) - choose - 6 inches	**d50**	**0.50**	Conveyed Q (cfs)	#DIV/0!
Top width of SPSC riffle channel (ft)	W	30.0	No Cascade is Needed	
Depth of SPSC riffle channel (ft)	D	3.0	Minimum Pool Depth "Use 3 pools" following each cascade segment (ft)	#DIV/0!
pools of the SPSC (ft)	h_p	**4.0**	ok	
Enter Desired Pool Depth (ft)	h_p	4.0	subcritical/ok	
Check Riffle Side Slope, Must be > 2H:1V		5.0		
Check the Froude Number to ensure Subcritical Flow Conditions		0.8		
Computed Roughness	n	0.04		
Riffle Cross Section Area (ft2), for parabola	A	60.00		
Theta - Intermediate step for solving	θ	0.38		
Riffle Hydraulic Perimeter (ft), for parabola	P	30.78		
Riffle Hydraulic Radius (ft), using Chow 1959	R_h	1.95		
Calculated Flow for design parameters (cfs)	Q	462.00		
Check Riffle Velocity (ft/sec)	V	7.70		

Isbash curve for Stone Density = 165 lb/ft3		
Cobble d50 size	Allowable Velocity (Supercritical)	Allowable Velocity (Subcritical)
[inches]	[ft/sec]	[ft/sec]
4	5.1	7.1
5	5.7	8.0
6	6.3	8.7
7	6.8	9.4
8	7.2	10.1
9	7.7	10.7
10	8.1	11.3
11	8.5	11.8
12	8.8	12.3
15	9.9	13.8
18	10.8	15.1

Adequate conveyance of design storm

Selected Cobble Size is Adequate for 100 year storm

Subcritical Flow is Predominant

Required Number of Pools	5
Provided total pool depth (ft) =	20
hydraulic power for return period 100 year storm is satisfied	

Checking Quantity Management		
USDA 2006, n expressed in terms of d_{out} and d_{50} = 8 inches	n	0.04
The width at the entrance riffle	W_{in}	30.00
The velocity at the entrance riffle is calculated using Manning formula calculator and Q_{post} for the 1 year storm	V_{in}	7.57
The depth at the entrance riffle is calculated using Manning formula calculator and Q_{post} for the 1 year storm	D_{in}	3.00
Enter Trial Value : The total pool depth needed to render the power equivalent to 100-year predevelopment/desired levels. This should be	D_{out}	7.35
This is the typical top width of the dead storage pool parabolic areas, 10:1 side slope	W_{out}	24
The area is for a semi parabola	A_{out}	118
protection volume	L_{vol}	402
Theta - Intermediate step for solving	θ	0.89
Hydraulic Perimeter (ft), for semi parabola	P_{out}	29
Hydraulic Radius, using Chow 1959	R_h	4.04
V_{out}, and d_{out}	f	0.20
Solved using Solver equation: Bernoulli equation rewritten in terms of d_{out} as		0.00

Required Volume of Storage (Rational Hydrograph)

	100 Yr	1 Yr	10 Yr
Required Volume of Storage (ft3)	261925	15053	157132
Volume provided in pools (ft3)	5120		
Volume provided in voids (ft3)	8100		
Provided Volume of Storage (excludes infiltration) (ft3)	13220		
Infiltration Volume (ft3)			
Peak Management of 100 year storm is not satisfied			
Peak Management of 1 year storm is not satisfied			
Peak Management of 10 year storm is not satisfied			

Checking Quality Management		
Site Drainage Area (Acres)	A	118
Contributory Impervious Area (Acres)	I	16.6
Volumetric Runoff Coefficient	Rv	0.18
Water Quality Volume, ft3	WQv	67758
Average Sand filter bed depth (ft) minimum 18 inches	$d_{f(Average\ of\ Pool\ and\ Riffle)}$	3.0
Width of sand filter (ft)	W_{sand}	30
Length of sand filter, where slope < = 5% (ft)	L_{sand}	300
Area of sand filter provided (ft2)	$A_{s\ Provided}$	**9000**
coefficient of permeability of filter media (ft/day)	k	3.50
height of water above filter bed- pool depth (ft)	h_f	4.00

Water quality requirement is satisfied in SPSC

design filter bed drain time (days), MDE recommended value	t_f	1.67
Required filter bed area (ft2)	$A_{f\ Required}$	2484

Appendix F

List of Plan Details and Standard Specifications

PLAN DETAILS AND SPECIFICATION LIST
DRAFT FINAL PHASE II NONTIDAL WETLAND AND STREAM MITIGATION PLAN
CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT 3

GENERAL REQUIREMENTS
SUMMARY OF WORK
SUBMITTAL PROCEDURES
CONTRACTOR HEALTH AND SAFETY PLAN
ENVIRONMENTAL MANAGEMENT
TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS
EROSION AND SEDIMENT CONTROL
CLOSEOUT PROCEDURES

EARTHWORK
EARTHWORK AND DEWATERING
CLEARING AND GRUBBING

RESTORATION TECHNIQUE SPECIFICATIONS
REGENERATIVE STORMWATER CONVEYANCE (AA CO. SPEC)

TEMPORARY INSTREAM CONSTRUCTION MEASURES
MGWC 1.2: PUMP-AROUND PRACTICE

STREAM CROSSINGS
MGWC 4.1: FORD CROSSING

SLOPE PROTECTION AND STABILIZATION TECHNIQUES
MGWC 2.2: IMBRICATED RIPRAP
MGWC 2.4: LIVE STAKES
MGWC 2.5: LIVE FACINES
MGWC 2.7: BRUSH LAYERING
MGWC 2.10: ROOT WADS
MGWC 2.11: TOE PROTECTION

CHANNEL STABILIZATION AND REHABILITATION TECHNIQUES
MGWC 3.1: BOULDER PLACEMENT
MGWC 3.2: LOG VANES
MGWC 3.3: ROCK VANES
MGWC 3.4: J-HOOK VANES
MGWC 3.8: CROSS VANES
MGWC 3.9: STEP POOLS
LOG CHANNEL CUT-OFF STRUCTURES
ROOT WAD/LOG VANE STRUCTURES

SPECIAL EXCAVATION
WETLAND EXCAVATION
STREAM CHANNEL EXCAVATION AND FILL
TIDAL EXCAVATION

SPECIAL ENVIRONMENTAL CONTROLS
CONTRACTOR POLLUTION CONTROL PLAN

CONSERVATION PLANTING AND SEEDING
PLUG/CONTAINER PLANTING DETAIL
TREE PLANTING 1" CAL. TREE DETAIL
TREE/SHRUB PLANTING DETAIL
SOD MATS
CONSERVATION PLANTS AND SEEDING

WATER QUALITY MONITORING (DURING CONSTRUCTION)

Tree Protection
Calvert Cliffs Unit 3 Mitigation
Lusby, Maryland

The following presents the conditions and requirements for all tree protection associated with the Calvert Cliffs Unit 3 Mitigation.

PART 1 - GENERAL

1.1 Site Locations and Description

1.1.1 Woodland Branch

The site refers the Woodland Branch watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 1-9.

1.1.2 Johns Creek

The site refers the Johns Creek watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 10-24.

1.1.3 SE-4

The site refers the unnamed tributary draining to the bay called SE-4, as identified in Contract Drawings on plans 25 and 26.

1.2 SCOPE OF WORK

The primary objective of this effort is to protect planted trees listed on the planting plan included in the Contract Drawings throughout the site locations outlined above.

1.3 RELATED DOCUMENTS

A. Maryland State Highway Specification for High Visibility Planting, Section 710.

1.4 SUMMARY

A. This Section includes the following:

1. Installing Tree Protection.

1.5 SUBMITTALS

The following shall be submitted to the Engineer:

A. Source of supply for all materials shall be submitted to the Engineer two (2) weeks prior to planting.

B. Contractor shall submit a total accounting of tree protection installed in each individual planting area, including materials and dimensions.

PART 2 - EXECUTION

2.0 MATERIALS

Mesh. Mesh should consist of wire or plastic according to the following specifications and be at least 48" tall.

- 2-inch by 4-inch mesh at 12.5 gauge welded wire cage.
- 2-inch by 2-inch plastic mesh.

Stakes/Posts. Stakes or posts will be no shorter than 75 percent of the height of the mesh they are supporting after installation and consist of steel or wood of the following specifications.

- Minimum 2-inch diameter, powder coated steel fence post with riveted anchor spade.

- Minimum 2-inch by 2-inch square CCA treated wooden stake.

Tube and Post.

A. Tube shall be a minimum of 18 inches tall but can vary in diameter according to vegetation it is to contain. Tubes shall be Forestry Suppliers, Inc. Light Duty Tube tree Protector or equivalent as approved by the Engineer.

B. The stake is to match the height of the tube when fully installed and be of the same material detailed above in 2.2 Stakes/Posts but have a minimum dimension of 1 inch or 1 inch by 1 inch.

2.1 PREPARATION

A. Plant tree, plug, or container stock as required by the Tree Planting Specification in this package.

2.2 INSTALLATION

Installation of tree protection shall be according to the details found on the Contract Drawings.

A. Drive stakes or posts for both the mesh and tree tube into ground to a minimum depth of 1 foot such that the vegetation will be centered in both and the mesh and tube are secured to their respective posts.

   1. If fence post with anchor spade is used, install posts with the top of the anchor spade flush with the ground, still to a minimum depth of 1 foot.

B. Install tree tube flush with ground and secure to stake with zip ties or equivalent placed every no more than 12 inches apart with at least two securing the tube.

C. Install mesh around posts, flush with the ground. Secure the mesh to the stakes or posts with zip ties or equivalent placed every no more than 12 inches apart.

2.3 MAINTENANCE

A. The Contractor shall maintain and replace tree protection as needed for the period of 1 year in which the Contractor is maintaining the planted vegetation.

PART 3 - MEASUREMENT AND PAYMENT

This item is paid for on a per site, lump sum basis.

END OF SECTION

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Tree Planting
Calvert Cliffs Unit 3 Mitigation
Lusby, Maryland

The following presents the requirements for installation of imbricated planting associated with the UniStar Calvert Cliffs Unit 3 Mitigation Project.

PART 1 - GENERAL

1.1 Site Locations and Description

1.1.1 Woodland Branch

The site refers the Woodland Branch watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 1-9.

1.1.2 Johns Creek

The site refers the Johns Creek watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 10-24.

1.1.3 SE-4

The site refers the unnamed tributary draining to the bay called SE-4, as identified in Contract Drawings on plans 25 and 26.

1.2 SCOPE OF WORK

The primary objective of this effort is to plant the trees listed on the planting plan included in the Contract Drawings throughout the site locations outlined above.

1.3 RELATED DOCUMENTS

(none)

1.4 SUMMARY

A. This Section includes the following:

1. Tree Planting.

1.5 SUBMITTALS

A. Contractor shall submit a total count and of each species of tree planted in each individual planting area.

PART 2 - EXECUTION

2.0 MATERIALS

A. Trees and Shrubs. All plant materials shall be in accordance with the species, quantities, units, and sizes indicated on the Plant Schedules and in conformance with Maryland Standard Specification Section 710, "Tree, Shrub and Perennial Installation" unless superseded by this specification. All species planted shall be native varieties in Prince George's County, Maryland. All trees and shrubs will have at a minimum one branched growth at the time of planting. The plant species shown on the Plant Schedule may be unavailable from standard landscape nurseries. The Contractor shall make arrangements with competent wetland restoration and/or native plant supply sources to ensure a supply of the required materials. Source of supply for all plant materials shall be submitted to the Engineer two (2) weeks prior to planting.

2.1 PREPERATION

A. Lightly tamp soil and remove stones, rocks and other foreign material 2" or greater. If necessary, blend surface material with topsoil or subsoil.

2.2 PLANTING

A. Plant trees and shrubs according to details in Contract Drawings, between 8-9 feet off center from each other, in the tree planting season of October 15 to April 30.

B. Protect surrounding sod vegetation during planting, and restore disturbed areas in-kind.

2.3 MAINTENANCE

A. The contractor shall maintain and establish planted vegetation for the period of 1 year.

END OF SECTION

Thalweg Grading
Calvert Cliffs Unit 3 Mitigation
Lusby, Maryland

The following presents the requirements for installation of thalweg grading associated with the riffle grade control complex installation on the UniStar Calvert Cliffs Unit 3 Mitigation Project.

PART 1 - GENERAL

1.1 Site Locations and Description

1.1.1 Woodland Branch

The site refers the Woodland Branch watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 1-9.

1.1.2 Johns Creek

The site refers the Johns Creek watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 10-24.

1.2 SCOPE OF WORK

The primary objective of this specification is to describe the channel shaping which occurs between the riffle grade controls utilized in low-gradient portions of the mitigation plan. These thalwegs are used to convey the average daily flow of the stream (if present), providing benthic habitat and surface to groundwater connection of the stream. The variables used to base these grading parameters are based in scientific research on beaver-influenced channel morphology and stable reference reaches of stream on the project site.

1.3 Definitions

A. Sinuosity - the ratio of along-channel thalweg distance between riffle grade control structure centers to the straight line distance between the those two points.

B. Channel Depth - the distance between the adjacent floodplain elevation and the elevation of the center of the graded thalweg.

C. Channel Width - the distance between the left and right sides of the graded channel thalweg

D. Radius of Curvature - the radius of a meander bend in the channel thalweg, as measured to the center of the graded thalweg.

1.4 SUBMITTALS

A. Documentation of length and dimensions of the thalweg graded between each numbered riffle grade control.

B. Documentation of final volumes of excavation associated with thalweg grading

1.5 PROJECT CONDITIONS

A. The work is to be performed in stream and wetland areas simultaneously with the grading of the floodplain. Prior to any in-stream work the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings.

B. The project site is secure and the contractor will adhere to the security requirements of Units 1, 2, and Proposed Unit 3, as set forth by Constellation Energy Group, UniStar, and the Engineer.

C. It is the contractor's responsibility to ensure worker compliance with all Occupational Safety and Health Administration (OSHA) precautions while operations are in progress.

D. The contractor will utilize equipment as approved by the Engineer in the execution of thalweg grading. This includes any restrictions set for in defined in the specifications for Heavy Equipment Exclusion Areas, and other site disturbance minimization techniques set forth in the contract specifications.

PART 2 - EXECUTION

2.0 MATERIALS

Materials utilized for thalweg fill and grading shall conform with those set form in the Riffle Grade Control Specifications set for in the contract specifications.

2.1 CONSTRUCTION

The construction of thalweg grading includes components and installation methods that are intended to prevent documented failure mechanisms, including:

- Unanticipated channel thalweg migration out of acceptable limits.
- Down-cutting of the channel thalweg beyond acceptable limits.
- Excessive disturbance and soil compactions which would limit the success of installed plantings, which are critical to the long-term stability of the channel

Tolerances. Surface elevations and the intermediate slope channel thalweg shall conform to the elevations specified on the Contract Drawings or as directed by the Engineer. Tolerances of the finished thalweg are as follows:

Surface Elevation: ±0.1 ft

Placed material and excavation not conforming to the specified tolerance limits shall be removed and replaced as directed by the Engineer at no additional cost to the Owner.

Sequence of Construction. *Prior to any in-stream work, the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings or work during periods of no channel flow. The construction site is to be dewatered and the construction of the stabilization structure shall be scheduled to be completed during the fewest sequential number of workdays.*

Thalweg Grading. The installation of the channel thalweg shall be as follows:

- Install the upstream and downstream limits riffle grade controls.
- Utilizing a sinuosity of 1.2 (minimum) and 1.5 (maximum), and a minimum radius of curvature of five feet, lay out the path of the thalweg with the Engineer, avoiding trees, shrubs, and other valuable vegetation and the associated critical root zones as identified by the Engineer. The thalweg should begin in the center of a riffle grade control and end in the center of the downstream riffle grade control, focusing flows through the lowest elevation portion of the riffle grade control structure.
- Utilizing a small excavator, or the reach of a larger excavator where allowable with Heavy Equipment Exclusion Areas and other disturbance limiting controls, grade a channel thalweg no deeper than 0.6 feet and now wider than 2.5 feet according to the layout agreed to with the Engineer. Suggested

equipment includes "Dingo" style walk-behind excavators, hand work, and other methods as approved by the Engineer. Thalweg substrate shall be sands and silts as found on the site in existing reaches, or sand and woodchip fill as identified in the riffle grade control specifications for regenerative media.

- Thalweg shape may be approximately trapezoidal as excavated, however edges should be rounded by hand or other approved methods to approximate an approximate parabolic channel cross-sectional shape as shown in the Contract Drawings.
- Place log grade controls as described in the Contract Drawings and in the specifications. These structures shall be placed in thalweg locations as identified by the Engineer and oriented to specifications in-field. In certain locations, micro-pool topography may be required by the engineer in bends of the thalweg or below structures. The lowest portion of the log in the thalweg shall be at the inside of the meander bend. The depth of these features will be no greater than 1.5 feet in depth and length not to exceed 5 feet. As these structures are small, utilize hand work and approved equipment to limit disturbance.
- Seed, mulch, and stabilize the site according to the approved Erosion and Sediment Control plan and the planting described in the contract drawings and specifications.
- Thalweg excavation may be used as fill in oxbow wetlands if unsuitable as topsoil

Thalweg grading will be deemed installed correctly when the return of stream flow is accomplished without causing significant erosion under low-flow conditions, and when vegetation establishes to stabilize the banks. At the direction of the Engineer, the Contractor shall rework thalweg grading until the aforementioned condition is achieved.

END OF SECTION

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Temporary Construction Facilities and Controls
Calvert Cliffs Unit 3 Mitigation

Lusby, Maryland

The following presents the requirements related to the Contractor's responsibility to provide and maintain methods, equipment, and temporary construction, as necessary to provide controls over traffic and environmental conditions at the construction site and adjacent areas. Contractor shall remove evidence of temporary facilities as approved by the Contracting Officer at completion of work.

PART 1 - GENERAL

1.1 Site Locations and Description

The contractor shall utilize temporary construction facilities and controls as appropriate for all work areas.

1.2 Traffic Control

A. Conduct work so as to minimize obstruction of traffic, and maintain traffic on at least half of the roadway width at all times. Contractor shall coordinate with Engineer for any temporary roadway closure and MOT requirements.

B. At Contractor's expense construct access and haul roads necessary for proper prosecution of the work under this Contract. Construct with suitable grades and widths; sharp curves, blind corners, and dangerous cross traffic are to be avoided. Provide necessary lighting, signs, barricades, and distinctive markings for the safe movement of traffic. The method of dust control must be adequate to ensure safe operation at all times. Location, grade, width, and alignment of construction and hauling roads are subject to approval by the Contracting Officer. Lighting must be adequate to assure full and clear visibility for full width of haul road and work areas during any night work operations.

C. Erect and maintain temporary barricades to limit public access to hazardous areas. Whenever safe public access to paved areas such as roads, parking areas, recreational trails, or sidewalks is prevented by construction activities or is otherwise necessary, to ensure the safety of both pedestrian and vehicular traffic barricades will be required. Securely place barricades clearly visible with adequate illumination to provide sufficient visual warning of the hazard during both day and night.

D. Contractor vehicles and equipment shall be parked within erosion and sediment control devices in an area within the limits of construction, on staging areas designated for that purpose or in areas authorized by the Contracting Officer. The Contractor shall be responsible for maintaining security for Contractor-owned equipment/vehicles as well as for materials stored by the Contractor. The Contractor shall not be permitted to park or run vehicles on grass areas. Any damage done to vegetation shall be repaired or replaced by the Contractor at no cost.

1.3 Noise Control

Contractor's vehicles and equipment shall be such as to minimize noise to the greatest degree practicable. Noise levels shall conform to the latest OSHA standards and in no case will noise levels be permitted which interfere with the work of the Contracting Officer or others.

1.4 Dust Control

Contractor shall be responsible for controlling objectionable dust caused by his/her operation of vehicles and equipment, clearing and grubbing, or any other means used to complete the work. Contractor shall apply water or use other methods subject to the Contracting Officer's approval to limit dust in the air to a minimum.

1.5 Pest and Rodent Control

Contractor shall be responsible for providing rodent and pest control as necessary to prevent infestation of construction or storage areas. The use of pesticides and herbicides on-site must be approved in advance by the Contracting Officer. Contractor shall employ methods and use materials which will not adversely affect conditions at the site or on adjoining properties.

1.6 Water Control

A. Contractor shall provide methods to control surface water and water from excavations, trenching, and structures to prevent damage to the Work, the site, or adjoining properties.

1. Contractor shall control fill, grading and trenching operations to direct water away from excavations, pits, tunnels and other construction areas, and to direct drainage to proper runoff courses so as to prevent any erosion, damage, or nuisance.

2. It is solely the Contractor's responsibility to maintain the site in a dry and workable manner.

3. No standing water shall be allowed within the limits of work, except in finished wetland areas. The Contractor shall employ all means necessary to remove the water. If after receiving written notice from the Engineer to remove any standing water, the Contractor has not removed said water in 24 hours, the Contracting Officer has the option to employ any means necessary to remove the standing water. The cost of this effort will be deducted from any money owed to the Contractor.

B. Contractor shall provide, operate and maintain equipment and facilities of adequate size to control surface water.

C. Contractor shall dispose of drainage water in a manner to prevent flooding, erosion, or other damage to any portion of the site or any adjoining areas and in conformance with all environmental requirements.

1.7 Pollution Control

A. Contractor shall provide methods, means and facilities required to prevent contamination of soil, water or atmosphere by the discharge of noxious substances from construction operations.

B. Contractor shall provide equipment and personnel, perform emergency measures required to contain any spillages, and remove contaminated soils or liquids. Contractor shall excavate and properly dispose of any contaminated earth offsite, and replace with suitable compacted fill and topsoil subject to the Contracting Officer's approval. Any associated fines or corrective action required as a result of environmental impact resulting from the Contractor's activities is the sole responsibility of the Contractor.

C. Contractor shall take special measures to prevent harmful substances from entering public waters, and prevent disposal of wastes, effluents, chemicals, or other such substances adjacent to streams, or in sanitary or storm sewers. In the event of a spill, the Contractor shall immediately notify Contracting Officer of spill.

D. Contractor shall provide systems for control of atmospheric pollutants by preventing toxic concentrations of chemicals and harmful dispersal of pollutants into the atmosphere.

E. All Contractor's equipment used during construction shall conform to all current federal, state and local laws and regulations.

1.8 Temporary Signage

A. Immediately upon beginning work, provide a weatherproof glass-covered bulletin board not less than 36 by 48 inches in size for displaying the Equal Employment Opportunity poster, a copy of the wage decision contained in the Contract, Wage Rate Information poster and other information approved by the Contracting Officer. Locate the bulletin board at the project site in a conspicuous place easily accessible to all employees, as approved by the Contracting Officer

1.9 Fire Protection

A. Contractor shall provide temporary fire protection equipment for the protection of personnel and property during construction. Remove debris and flammable materials weekly to minimize potential hazards.

1.10 Identification of Employees

A. Contractor shall be responsible for furnishing to each employee, and for requiring each employee on the work to display, identification as approved and directed by the Contracting Officer. Prescribed identification shall immediately be delivered to the Contracting Officer for cancellation upon release of employees. When required, the Contractor shall obtain and provide fingerprints of persons employed on the Project. Contractor and subcontractor personnel shall wear identifying markings on hard hats clearly identifying the company for whom the employee works.

1.11 Contractor's Temporary Facilities

A. Provide and maintain administrative field office facilities within the construction area at the designated site.

B. Contractor shall construct a temporary 6-foot-high chain-link fence around trailers and materials. The fence shall include plastic strip inserts, colored brown, so that visibility through the fence is obstructed. Fence posts shall be driven, in lieu of concrete bases, where soil conditions permit. Trailers, materials, or equipment shall not be placed or stored outside the fenced area unless such trailers, materials, or equipment are assigned a separate

and distinct storage area by the Contracting Officer away from the vicinity of the construction site but within the military installation. Trailers, equipment, or materials shall not be open to public view with the exception of those items which are in support of ongoing work on any given day. Materials shall not be stockpiled outside the fence in preparation for the next day's work. Mobile equipment, such as tractors, wheeled lifting equipment, cranes, trucks, and other equipment, shall be parked within the fenced area at the end of each work day.

1.12 Submittals

A. Prior to the start of work, Contractor shall submit a site plan showing the locations and dimensions of temporary facilities (including layout details, equipment, and material storage area) (onsite and offsite), and access and haul routes, avenues of ingress/egress to the fenced area and details of the fence installation. Identify any areas which may have to be graveled to prevent the tracking of mud. Indicate if the use of a supplemental or other staging area is desired. Show locations of safety and construction fences, site trailers, construction entrances, trash dumpsters, temporary sanitary facilities, and working parking areas to be coordinated with and approved by the Contracting Officer.

B. Prior to testing, submit to the Contracting Officer current certification issued by Virginia Department of Health attesting that the backflow tester has successfully completed an approved certification course. Tester must not be affiliated with any company participating in any other phase of this Contract.

PART 2 - EXECUTION

2.0 MATERIALS

All materials used for traffic maintenance, whether temporary or permanent, shall be provided by the Contractor and approved by the Contracting Officer.

A. All work performed in providing facilities and services shall be done in a safe and workmanlike manner. Contractor shall not commence work earlier than 7 AM or later than 6 PM, Monday through Friday. No work shall be performed on weekends or holidays, or outside of the time of day restrictions unless approved by the Engineer.

B. Contractor shall provide all labor, materials, and equipment necessary to maintain vehicular and pedestrian

traffic throughout the project duration. Contractor shall be responsible for obtaining all permits, approvals, and pay any fees necessary from Federal, State, or local regulatory agencies required to access public roads with earth moving equipment. Signs, light, barricades, and manpower shall be provided wherever necessary to protect the traveling public from hazardous conditions in accordance with Federal, State, or local transportation and OSHA requirements.

C. Contractor shall maintain one lane of roadway open for thru traffic at all times on both John Kingman Road and Beulah Road when working in this area of the project site. Any work that will require complete road closure must be done after hours and coordinated with DPTMS.

D. Contractor's Temporary Facilities

1. The trailers or buildings shall be in good condition, free from visible damage, rust, and deterioration, and meet all applicable safety requirements. Trailers shall be roadworthy and comply with all appropriate state and local vehicle requirements. Failure to maintain storage trailers or buildings to these standards shall result in the removal of non-complying units at the Contractor's expense.

   Trailers which, in the opinion of the Contracting Officer, require exterior painting or maintenance will not be allowed on the installation property.

2. A sign not smaller than 24 inches by 24 inches shall be conspicuously placed on the trailer depicting the company name, business phone number(s), and emergency phone number. Trailers shall be anchored to resist high winds and must meet applicable state and local standards for anchoring mobile trailers.

3. Keep fencing in a state of good repair and proper alignment. Grassed or unpaved areas, which are not established roadways, will be covered with a layer of gravel as necessary to prevent rutting and the tracking of mud onto paved or established roadways, should the Contractor elect to traverse them with construction equipment or other vehicles; gravel gradation will be at the Contractor's discretion.

4. Adequate outside security lighting shall be provided at the Contractor's temporary facilities. Contractor shall be responsible for the security of its own equipment.

E. Mowing. Grass and weedy vegetation within areas utilized by the Contractor including work areas, administrative areas, and storage areas shall be kept mowed to control vegetative growth. Vegetation shall be mowed when it reaches a height of three (3) inches. Mowing shall be to a height of two (2) inches. Mowing shall be accomplished with a rotary mower that leaves clippings evenly distributed on the soil surface. Mowing shall be accomplished during periods in such manner that soil and grass will not be damaged. Towed or self- propelled riding mowers shall not be operated within three (3) feet of trees or shrubs. Areas adjacent to trees and shrubs shall be moved with hand-propelled mowers.

F. Erosion and Sediment Control. The contractor shall ensure that erosion and sediment control measures are installed according to the approved Erosion and Sediment Control Plan on the Contract Drawings, and specifications detailed therein. The Contractor is solely responsible for compliance with applicable erosion and sediment control laws, and shall be held liable for any violations incurred.

G. Heavy Equipment Exclusion Areas and Other Disturbance Limiting Activities

1. The Contractor, with the aid of the Engineer, shall indentify the Heavy Equipment Exclusion Areas as documented in the Contract Drawings. The Engineer may identify additional areas, trees, shrubs, and wetland areas for exclusion as part of this process. Exclusion areas shall be fenced with safety fence or otherwise delineated as approved by the Engineer.

2. The Contractor, through construction, shall make all efforts to avoid the usage of larger disturbance-causing equipment in these areas, and may only enter them with equipment which is designated as low ground pressure. Tracked equipment are to be rubber tracked or triple grouser shoed, with a manufacturer-rated ground pressure not to exceed 6.5 PSI.

3. The Contractor shall make all efforts to limit disturbance to existing vegetation, and only remove vegetation of 4" DBH with the approval of the Engineer. The Contractor shall limit damage to trees through contact, installing adequate tree protection where required by the Engineer.
4. Acceptable activities within exclusion areas include thalweg grading, creating micro-topography, planting, invasive species removal, debris and structure placement, and other activities as approved by the Engineer.

END OF SECTION

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Seeding
Calvert Cliffs Unit 3 Mitigation
Lusby, Maryland

The following presents the conditions and requirements for all seeding associated with the Calvert Cliffs Unit 3 Mitigation.

PART 1 - GENERAL

1.1 Site Locations and Description

1.1.1 Woodland Branch

The site refers the Woodland Branch watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 1-9.

1.1.2 Johns Creek

The site refers the Johns Creek watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 10-24.

1.1.3 SE-4

The site refers the unnamed tributary draining to the bay called SE-4, as identified in Contract Drawings on plans 25 and 26.

1.2 SCOPE OF WORK

Applying Seed Mix to riffle grade controls and step pool systems and to all other disturbed areas as shown on the construction drawings after completion of construction activities.

1.3 RELATED DOCUMENTS

A. Not applicable.

1.4 SUMMARY

A. This Section includes the following:

1. Material requirements.
2. Application.

1.5 SUBMITTALS

A. Documentation of type and amount of compost and seed mix will be submitted to the Engineer for review before seeding.

B. Documentation of final volumes of compost and seed shall be submitted upon the completion of the work.

1.6 MEETINGS

A. The Contractor shall attend project meetings including project initiation, weekly site status, and site close-out.

1.7 PROJECT CONDITIONS

A. The project site is surrounded by roads, walks, and occupied and/or operational facilities. Interference with adjoining roads, streets, walks, and other adjacent occupied or operational facilities during debris removal operations is to be minimized.

B. It is the contractor's responsibility to ensure worker compliance with all Occupational Safety and Health Administration (OSHA) precautions while operations are in progress.

PART 2 - EXECUTION

2.0 MATERIALS

Compost.

A. Compost shall have a pH between 5.0 and 7.0. It shall be stable and not reheat upon restacking. Compost shall have a moisture content between 30 and 55 percent, a particle size of .5" or less.

B. Compost shall be of the following type: Source-Separated Compost (Type B). Source-separated compost will be approved by the Maryland Department of the Agriculture (MDA). Compost shall be produced by an MDA certified compost operator. Compost shall have a soluble salt concentration not to exceed 5 ds (mmhos/cm).

C. Source-separated compost shall be one of the following types:

1. Tree leaf compost.

2. Non-tree leaf compost. When compost is from lawn clippings, it shall be tested for contaminant in conformance with COMAR 15.18.04.05.

Seed Mix.

A. The seed mix in each planting zone is to conform strictly to the seed mix specified in the Contract Drawings. The Contractor shall not apply or use any lime, fertilizer, or other amendments.

2.1 CONSTRUCTION

A. Any rocks or other debris larger than 2 inches shall be removed. For the cobble riffle sections, no rocks that are part of the grade control structure will be removed.

B. The Contractor shall install compost materials by mechanically blowing the compost into place at depths as specified on the construction drawings.

C. Seed shall be applied by broadcast spreader in two (2) passes in opposite directions in order to ensure uniform distribution. Equipment shall be calibrated to the satisfaction of the Engineer.

D. Seed mix will be applied over top of final grade without disturbing any structure components, grade or existing vegetation. Seed mix shall be applied to these areas at a rate of indicated on the Contract Drawings. Straw shall then be applied evenly by hand at a rate of three (3) bales per one thousand square feet, and shall be either tracked in or tacked using fiber mulch.

PART 3 - MEASUREMENT AND PAYMENT

Seeding will be measured and paid for at the Contract unit price per square yard. The payment will be in full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work.

END OF SECTION

Regenerative Stormwater Conveyance and Riffle Grade Control
Calvert Cliffs Unit 3 Mitigation

Lusby, Maryland

The following presents the requirements for installation of imbricated planting associated with the UniStar Calvert Cliffs Unit 3 Mitigation Project.

PART 1 - GENERAL

1.1 Site Locations and Description

1.1.1 Woodland Branch

The site refers the Woodland Branch watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 1-9.

1.1.2 Johns Creek

The site refers the Johns Creek watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 10-24.

1.1.3 SE-4

The site refers the unnamed tributary draining to the bay called SE-4, as identified in Contract Drawings on plans 25 and 26.

1.2 SCOPE OF WORK

The primary objective of this effort is to install the Riffle Grade Controls and Regenerative Stormwater Conveyance Systems as described in the Contract Drawings.

1.3 RELATED DOCUMENTS

A. Anne Arundel County Department of Public Works Standard Specifications for Step Pool Stormwater Conveyance Structures.

1.4 SUMMARY

A. This Section includes the following:

1. Material requirements.
2. Weir and pool construction.

1.5 MATERIALS OWNERSHIP

A. Except for materials indicated to be stockpiled or to remain onsite, cleared materials shall become Contractor's property and shall be removed from the site and properly disposed.

1.6 SUBMITTALS

A. Documentation of size and amount of all stone materials will be submitted to the engineer for review before material placement.

B. Documentation of final volumes of all materials used in this portion of the work shall be submitted upon the completion of the work. This includes: silica cobbles, boulders, compost, top soil, filter media, etc.

C. The contractor will submit as-built drawings that include accurate dimension, location, and relevant construction notes of each weir/pool complex. As-built drawings will be surveyed and certified by a surveyor registered in the State of Maryland.

1.7 MEETINGS

A. Attend project meetings including project initiation, weekly site status and site close-out.

1.8 PROJECT CONDITIONS

A. The work is to be performed in the stream channel. Prior to any in-stream work the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings.

B. The project site is surrounded by roads, walks and occupied and/or operation facilities. Interference with adjoining roads, streets, walks, and other adjacent occupied or operational facilities is to be minimized.

C. It is the contractor's responsibility to ensure worker compliance with all Occupational Safety and Health Administration (OSHA) precautions while operations are in progress.

PART 2 - EXECUTION

2.0 MATERIALS

The engineer will inspect all materials prior to and/or after installation to ensure compliance with the Contract Documents.

A. Bank Run Gravel and Sand. Sand shall meet the requirements of AASHTO specification. Bank-run gravel shall be BRG base in accordance with Anne Arundel Department of Publics Works Section 02621.02. Wood chips and mulch shall be in accordance with Anne Arundel Department of Publics Works Section 02860.02. These materials will be salvaged from within the project area where possible.

B. Cobble. Cobble shall be composed of a well-graded mixture of stone size so that 50% of the pieces, by weight, shall be larger than six (6) inches, the d_{50} size. A well graded mixture as used herein is defined as a mixture composed primarily of larger stone sizes but with a sufficient mixture of other sizes to fill the large voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size, nine (9) inches.

C. Sandstone Boulders. Sandstone boulders (aka, bog iron, ferracrete) is irregular and generally tabular in shape and neutral or acidic in pH. Sandstone boulders shall contain individual pieces between 2 and 6 feet in length (500 - 6,000lbs). The total weight of boulders shall contain not more than 10% of the pieces smaller than 15 inches in diameter.

D. Compost. Compost shall have a pH between 5.0 and 7.0. It shall be stable and not reheat upon restacking. Compost shall have a moisture content between 30 and 55 percent, a particle size of .5" or less.

   Compost shall be of the following type:
   Source-Separated Compost (Type B). Source-separated compost will be approved by the Maryland Department of the Agriculture (MDA). Compost shall be produced by an MDA certified compost operator. Compost shall have a soluble salt concentration not to exceed 5 ds (mmhos/cm).

   Source-separated compost shall be one of the following types:

- Tree leaf compost.

- Non-tree leaf compost. When compost is from lawn clippings, it shall be tested for contaminant in conformance with COMAR 15.18.04.05.

2.1 CONSTRUCTION

Tolerances. Surface elevations and the intermediate slope of the silica cobble, sandstone boulders and pool depths shall conform to the spot elevations specified on the Contract Drawings or as directed by the Engineer. Tolerances of the finished structure are as follows:

Surface Elevation: ±0.2 ft

Placed material not conforming to the specified tolerance limits shall be removed and replaced as directed by the Engineer at no additional cost to the Administration.

Sequence of Construction. Prior to any in-stream work, the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings. The working site is to be dewatered before constructing the weir/pool complex within the reach. The construction of individual reaches of regenerative stormwater conveyance shall be scheduled to be completed during the fewest sequential number of workdays.

Channel Formation and Filter Media. The installation of a regenerative stormwater conveyance system is to begin as follows:

- Excavate the channel or floodplain. Suitable materials for woody debris, bank run gravel, sand, woodchips, and mulch may be placed upstream for reuse within the reach.
- Unsuitable materials shall be removed from the channel and not reused in backfilling the regenerative stormwater conveyance. Unsuitable materials are trash, muck, clay, and silty soils.
- Bank run gravel and sand shall be placed by mechanical or other acceptable methods with a minimum of voids.
- The bank run gravel and sand shall be placed to form a neat and uniform surface area. No mortar is permitted
- A soil mix comprised of masonry or concrete sand, containing less than 10 percent silt and / or clay, mixed

and evenly blended with 20% wood chips or stump grindings, by volume will be prepared as needed for backfill.

- Soil mix will be placed in excavated channel in accordance with Contract Drawings and these Special Provisions to blend in with contiguous slopes, swales, or used to form pool bottom.
- The Engineer will approve the excavation as shown on the drawings or as directed by the Engineer before work continues.

Surface Material Placement. The remainder of the regenerative stormwater conveyance system will be built beginning at upstream end of the channel. The following steps will be repeated for each riffle/weir within the reach:

- After the Engineer has approved the excavation as shown on the drawings or as directed by the Engineer, geotextile shall be placed over the prepared surface where sandstone boulders are to be placed.
- Sandstone boulders shall be placed by mechanical or other acceptable methods with a minimum of voids. The sandstone boulders shall be placed to form a neat and uniform surface area. No mortar is permitted.
- If necessary, sandstone can be chiseled or broken to achieve improved contact between stones.
- If geotextile is punctured during boulder placement, the boulders shall be fully removed for at least three feet outside the limits of the fabric puncture and a new geotextile patch with minimum overlap, shall be securely fastened over the puncture with securing pins.
- Cobble shall be placed by mechanical or other acceptable methods. The cobble shall be placed to form a neat and uniform surface area. No mortar is permitted.
- Cobble shall be graded from the smallest to the largest pieces as specified by the materials requirements and will be controlled by visual inspection.
- The thickness of the cobble layer shall be 1.5 x 1.5 times the d50 (9" in depth).

Finishing. The work on regenerative stormwater conveyance reaches will be completed as follows:

- All remaining bank run gravel and sand fill areas along the edges and at ends of the placed cobble shall be placed to blend in with contiguous slopes, swales, or existing ground.
- The Contractor shall install compost materials by mechanically blowing the compost into place at depths as specified on the construction drawings.

The finished regenerative stormwater conveyance system shall be backwashed as directed by the on-site Engineer with additional bank run gravel, sand, and cobble to seal the voids in the riffle and run sections of the system.

A regenerative stormwater conveyance system will be deemed installed correctly when the return of stream flow through the reach is accomplished without damaging piping flows in the riffle/pool complexes and no movement of the cobble or sandstone boulders. At the direction of the Engineer, the Contractor shall rework the reach until the aforementioned condition is achieved.

PART 3 - MEASUREMENT AND PAYMENT

Payment will be full compensation for all excavation, furnished stone, salvage, fill, disposal of excess material, and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

Bank Run Gravel and Sand. Measurement for bank run gravel and sand will be made of the volume measured in place, in cubic yards, and acceptably installed. Payment for bank run gravel and sand shall be paid on per cubic yard of sand and bank run gravel installed. Payment will be full compensation for all materials, excavation and installation of sand and bank run gravel and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans.

Cobble. Measurement for cobble will be made of the volume measured in place, in cubic yards, and acceptably installed. Payment for cobble shall be paid on per cubic yard of cobble installed. Payment will be full compensation for all materials, excavation and installation of cobble, and resetting of cobbles, and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans.

Sandstone Boulders. Measurement for sandstone boulders will be made of the volume measured in place and acceptably installed. Payment for sandstone boulders shall be paid on per cubic yard of sandstone boulder installed. Payment will be full compensation for all materials, excavation and installation of sandstone boulders, and resetting of sandstone boulders, and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans.

Compost. Measurement for compost will be made of the volume, in cubic yards, delivered to the site and acceptably installed. Payment for compost shall be paid on per cubic yard of compost installed. Payment will be full compensation for all materials, excavation and installation of compost and for all material, labor, equipment, tools, and incidentals necessary to complete the work as specified in these special provisions and on the plans

END OF SECTION

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Log and Woody Debris Placement
Calvert Cliffs Unit 3 Mitigation

Lusby, Maryland

The following presents the conditions and requirements for all placing logs and woody debris in banks associated with the Calvert Cliffs Unit 3 Mitigation.

PART 1 - GENERAL

1.1 Site Locations and Description

1.1.1 Woodland Branch

The site refers the Woodland Branch watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 1-9.

1.1.2 Johns Creek

The site refers the Johns Creek watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 10-24.

1.1.3 SE-4

The site refers the unnamed tributary draining to the bay called SE-4, as identified in Contract Drawings on plans 25 and 26.

1.2 SCOPE OF WORK

This work shall consist of the placement of logs within the stream at the locations described above to dissipate energy within the stream, provide habitat and flow diversity as specified on the Contract Documents or as directed by the Engineer.

1.3 RELATED DOCUMENTS

A. Not applicable.

1.4 SUMMARY

A. This Section includes the following:

1. Material requirements for logs used.

2. Installation of logs in bank.

1.5 SUBMITTALS

A. Documentation of dimension, type and placement of each log placed is to be submitted to the Engineer for approval before placement.

B. Documentation of final surveyed location and elevation of each log placed is to be submitted upon completion of the work.

1.6 MEETINGS

A. The Contractor shall attend project meetings including project initiation, weekly site status, and site close-out.

1.7 PROJECT CONDITIONS

A. The work is to be performed in the stream channel simultaneously with the grading of the channel. Prior to any in-stream work the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings.

B. The project site is surrounded by roads, walks, and occupied and/or operational facilities. Interference with adjoining roads, streets, walks, and other adjacent occupied or operational facilities during debris removal operations is to be minimized.

C. It is the Contractor's responsibility to ensure worker compliance with all Occupational Safety and Health Administration (OSHA) precautions while operations are in progress.

PART 2 - EXECUTION

2.0 MATERIALS

2.1.1 Logs

A. Logs are defined as tree trunks with a minimum diameter of 10 inches and minimum length of 8 feet. Logs may be salvaged from trees removed as part of the project construction. Logs may not be degraded, rotten and must be from trees harvested within the 12 months prior to

placement. Logs must consist of hardwood (oaks, maples, gums, locust, hickory, etc) and may not be utility poles or be chemically treated. Pine may not be used. This material shall be approved by the Engineer prior to placement.

B. Woody debris includes tree tops, limbs, and other lengths of natural woody materials smaller than those defined as logs. Materials obtained as firewood, short lengths, and chemically treated materials are not acceptable.

Tolerances. Surface elevations of log placements shall conform to the spot elevations specified on the Contract Drawings or as directed by the Engineer. Tolerances of the finished single log placements structure are as follows:

Surface Elevation: ±0.2 ft

Placed material not conforming to the specified tolerance limits shall be removed and replaced as directed by the Engineer at no additional cost to the Administration.

Sequence of Construction. Prior to any in-stream work, the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings. The construction site is to be dewatered before constructing the stone vane.

Log Placement. The placement of logs will be an element of the construction of rock vane and bank stabilization structures, as follows:

- Excavate the spot for the foundation stones. Suitable material for backfilling may be placed upstream of this excavation for immediate reuse.

- Place log within structures at the direction of the onsite engineer and the standard details. The placement of logs shall fit tightly against the finished rock structures. The placement of the log tightly against the stone structures prevents movement of the log and structure collapse.

- Position stones to complete the structure to within tolerances.

A log will be deemed installed correctly when the return of stream flow on the log is accomplished without log movement, which may cause damage to structures or the log to be carried

away with higher flows. At the direction of the Engineer, the Contractor shall rework the log until the aforementioned condition is achieved.

Woody Debris Placement. The woody debris is an enhancement practice for improving organic carbon content of soils, improving de-nitrification ability of soils, and enhancing habitat:

- The contractor shall install brush piles for habitat as directed by the Engineer.
- Place woody debris randomly throughout the floodplain corridor and as identified by the engineer for perching and habitat in wetlands and floodplain areas.

Woody debris is installed successfully upon meeting the distribution and density requirements of the Contract Drawings and the distribution as approved by the Engineer. At the direction of the Engineer, the Contractor shall rework the material until the aforementioned condition is achieved.

PART 3 - MEASUREMENT AND PAYMENT

Payment will be full compensation for all excavation, salvage, disposal of excess material, and for all materials, labor, equipment, tools, and incidentals necessary to complete the work.

END OF SECTION

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Imbricated Riprap
Calvert Cliffs Unit 3 Mitigation
Lusby, Maryland

The following presents the requirements for installation of imbricated riprap associated with the UniStar Calvert Cliffs Unit 3 Mitigation Project.

PART 1 - GENERAL

1.1 Site Locations and Description

1.1.1 Woodland Branch

The site refers the Woodland Branch watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 1-9.

1.1.2 Johns Creek

The site refers the Johns Creek watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 10-24.

1.1.3 SE-4

The site refers the unnamed tributary draining to the bay called SE-4, as identified in Contract Drawings on plans 25 and 26.

1.2 SCOPE OF WORK

The primary objective of this effort is to install imbricated riprap on the stream bank site locations described above during the grading of the stream channel and in the associated tree protection.

1.3 RELATED DOCUMENTS

A. Not applicable.

1.4 SUMMARY

A. This Section includes the following:

1. Material requirements.
2. Construction.

1.5 SUBMITTALS

A. Documentation of size and amount of foundation and riprap stones will be submitted to the engineer for review before stone placement.

B. Documentation of final volumes of stones, base material, backfill and topsoil shall be submitted upon the completion of the work.

1.6 MEETINGS

A. Attend project meetings including project initiation, weekly site status and site close-out.

1.7 PROJECT CONDITIONS

A. The work is to be performed in the stream channel simultaneously with the grading of the channel. Prior to any in-stream work the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings.

B. The project site is surrounded by roads, walks and occupied and/or operation facilities. Interference with adjoining roads, streets, walks, and other adjacent occupied or operational facilities during debris removal operations is to be minimized.

C. It is the contractor's responsibility to ensure worker compliance with all Occupational Safety and Health Administration (OSHA) precautions while operations are in progress.

PART 2 - EXECUTION

2.0 MATERIALS

A. Channel Sand and Gravel. Channel sand and gravel consist of salvaged excavation material to be taken from the channel bed within the project area. This material shall be free of roots and debris and be approved by the Engineer prior to placement.

B. Base Material. Furnished base material may be used as a substitute for channel sand and gravel. If suitable salvaged material is not available onsite for channel sand and gravel, with the written permission of the Engineer, the Contractor may furnish Base Material to the following gradations. This material shall be free of roots and debris and be approved by the Engineer prior to purchase.

% less than	U.S. Standard sieve size
100	3 in.
88-100	1.5 in.
69-100	0.75 in.
51-96	0.375 in.
32-77	No. 4
12-57	No. 8
0-38	No. 16
0-21	No. 30
0-3	No. 50
0	No. 100

C. Granular Filter. Granulated filter for imbricated riprap shall consist of stone or silica sand and gravel exhibiting the following gradations. The granular filter shall be free of large roots (1.5-inch diameter), rubbish, and other debris. A sample of the granular filter shall be submitted to the Engineer for approval prior to use.

% less than	U.S. Standard sieve size
100	3 in.
80-100	1.5 in.
60-100	0.75 in.
43-88	0.375 in.
23-68	No. 4
4-49	No. 8
0-29	No. 16
0-12	No. 30
0	No. 50

D. Riprap and Foundation Stone. Structural stone for the imbricated riprap bank shall consist of individually selected natural stone, sandstone, and appropriate native stone as approved by the Engineer. Foundation stone shall have a minimum diameter of 3 feet at the longest axis. Riprap stone shall have a minimum diameter of 2 feet measured at the longest axis, 1.5 feet in the intermediate axis and 1 foot in the shortest axis. Angular rocks shall be used to promote interlocking properties of the finished structure. A sample of the stone material shall be submitted to the Engineer at least 2 weeks prior to intended use. All stone shall be approved by the Engineer prior to placement.

2.1 CONSTRUCTION

The construction of the stone bank stabilization includes components and installation methods that are intended to prevent documented failure mechanisms, including:

- The installation of the channel sand and gravel below the foundation to prevent foundation erosion and stone collapse.
- The use of foundation stones to limit the movement of riprap stones when struck by ice or debris flows.
- The backfilling of each placed foundation or riprap stones to prevent voids and piping failures.
- The placement of stone at approved inclination to prevent structure collapse.

Tolerances. Surface elevations and the intermediate slope of the rock vanes shall conform to the spot elevations specified on the Contract Drawings or as directed by the Engineer. Tolerances of the finished structure are as follows:

Surface Elevation: ±0.2 ft

Placed material not conforming to the specified tolerance limits shall be removed and replaced as directed by the Engineer at no additional cost to the Administration.

Sequence of Construction. *Prior to any in-stream work, the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings. The construction site is to be dewatered and the construction of the stabilization structure shall be scheduled to be completed during the fewest sequential number of workdays.*

Foundation Stones. The installation of the stabilization structure will start by placing and backfilling the foundation stones, as follows:

- Excavate the area for the foundation stones. Suitable material for backfilling may be placed upstream of this excavation for immediate reuse.
- Unsuitable materials shall be removed from the excavation area and not reused in backfilling the stabilization structure. Unsuitable materials are trash, muck, and woody debris.
- If the excavation for the foundation encounters alluvial deposits of sand and gravel, the 6-inch foundation bed of channel sand and gravel need not be installed. If the excavation encounters bedrock, the Contractor shall work with the Engineer to adjust the stone sizes and placement to build on this bedrock.

- Place the layer of Channel Sand and Gravel on the foundation subgrade. Place the foundation stones and backfill around the stones with the upstream material. The foundation stones shall be placed so the long axis of the foundation stone is directed as shown on the Contract Drawings.

Riprap Stone. The remainder of the stabilization structure shall be built in rows with each row being tied into the bank at each end of the stabilization structure and backfilled to create a stable place to position the following row. The following steps shall be repeated until the entire stabilization structure is completed:

- Excavate channel banks for placement of riprap stones. Suitable material for blending riprap stones into existing banks may be placed upstream of this excavation for immediate reuse.
- The riprap stones shall be placed rigidly so the riprap stone rests upon both the stone below and stable in-situ soils. Backfill around riprap stone with the upstream material.
- Complete each row by placing riprap stones rigidly upon stones below. Riprap stones shall be placed as shown on the Contract Drawings.
- Place geotextile, on existing ground in the area to be backfilled behind the structure.
- Backfill around stones and in area between row of riprap stones and geotextile with granular filter to height 6 inches below top of riprap stones.

Topsoil. Upon completion of the stabilization structure topsoil will be placed over the area backfilled for future planting.

- Place a minimum of 6 inches of topsoil, over the area backfilled.

Imbricated Riprap will be deemed installed correctly when the return of stream flow is accomplished without causing erosion to the stream bank. At the direction of the Engineer, the Contractor shall rework the structure until the aforementioned condition is achieved.

END OF SECTION

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Glyphosate Application
Calvert Cliffs Unit 3 Mitigation
Lusby, Maryland

PART 1 - GENERAL

1.1 Description

This work shall consist of applying glyphosate to areas containing *Phragmites australis* and purple loosestrife in the wetland enhancement site and the swale that runs through the wetland creation site prior to grading and again after excavation to final grade. Glyphosate application shall occur in the fall.

After the controlled burn is completed glyphosate will be applied to the designated region again. Any additional applications (spring and/or fall) shall occur, if deemed necessary by the Engineer. Glyphosate applications shall occur in all areas where phragmites australis is observed. All herbicide applications shall be as specified in the Maryland Pesticide Applicators Law and in conformance with the manufacturer's recommendations. The Contractor shall provide a Certified Applicator of Pesticides (Category V for work in Aquatic Systems) to conduct the work. Daily herbicide application reports shall be provided to the Engineer.

PART 2 - EXECUTION

2.0 MATERIALS

Glyphosate. Glyphosate consists of aquatic glyphosate (N-(phosphonomethyl) glycine) and surfactant.

2.1 CONSTRUCTION

Evaluation. The limits of *Phragmites australis* and purple loosestrife control will be evaluated by the Administration prior to glyphosate application.

Application. The Contractor shall apply the initial round of glyphosate between August and September, after *Phragmites* has reached the tassel stage and purple loosestrife has reached peak bloom, as determined during the evaluation. The controlled burn will be started ----. The second application of glyphosate will be applied between August and September. An additional

application of glyphosate shall occur a minimum of 2 weeks prior to spring planting, if determined necessary by the Engineer.

Glyphosate shall be applied following the manufacturer's recommendations.

The Contractor shall be responsible for obtaining all necessary permits (i.e. Request for Permission to Use Herbicides for Aquatic Vegetation Management Purposes and ----) prior to initiating herbicide application.

PART 3 - MEASUREMENT AND PAYMENT

Glyphosate Application shall be measured and paid at the Contract unit price per square yard of application. The payment will be full compensation for all material, labor, equipment, tools, and incidentals necessary to complete the work. Repairs due to the Contractor's negligence as determined by the Engineer shall be done at no additional expense to the Administration.

END OF SECTION

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Excavation
Calvert Cliffs Unit 3 Mitigation
Lusby, Maryland

The following presents the requirements for excavation associated with the UniStar Calvert Cliffs Unit 3 Mitigation Project.

PART 1 - GENERAL

1.1 Site Locations and Description

1.1.1 Woodland Branch

The site refers the Woodland Branch watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 1-9.

1.1.2 Johns Creek

The site refers the Johns Creek watershed and all named and unnamed tributaries which flow to it within the site Property scope of work, as identified in Contract Drawings on plans 10-24.

1.1.3 SE-4

The site refers the unnamed tributary draining to the bay called SE-4, as identified in Contract Drawings on plans 25 and 26.

1.2 SCOPE OF WORK

The primary objective of this effort is to excavate the ground to elevations shown on the Construction Drawings at the site locations outlined above.

1.3 RELATED DOCUMENTS

None.

1.4 SUMMARY

A. This Section includes the following:

1. Excavation.

1.5 MATERIALS OWNERSHIP

A. Except for materials indicated to be stockpiled or to remain onsite, cleared materials shall become Contractor's property and shall be removed from the site and properly disposed.

1.6 SUBMITTALS

A. Documentation of weight and volume of excavated material removed from the site, including the weight of the disposal containers and/or the approximate filled volume.

B. Documentation of final disposal for all waste materials, including disposal documentation of special wastes such as tires, shall be submitted upon the completion of final disposal.

C. The contractor will submit as-built drawings that include accurate elevation of all work that is finished upon completion of excavation. As-built drawings will be surveyed and certified by a surveyor registered in the State of Maryland.

1.7 MEETINGS

A. Attend project meetings including project initiation, weekly site status and site close-out.

1.8 PROJECT CONDITIONS

A. The work is to be performed in the stream channel. Prior to any in-stream work the Contractor shall install stream flow diversion and dewatering facilities per the Contract Drawings.

B. The project site is surrounded by roads, walks and occupied and/or operation facilities. Interference with adjoining roads, streets, walks, and other adjacent occupied or operational facilities is to be minimized.

C. It is the contractor's responsibility to ensure worker compliance with all Occupational Safety and Health Administration (OSHA) precautions while operations are in progress.

PART 2 - EXECUTION

2.0 PREPARATION

A. Protect existing site improvements, such as intact fencing, fire hydrants and electrical poles to remain free from damage during construction.

1. If damaged, the contractor is responsible to restore damaged improvements to their original condition, as acceptable to Utility or Property Owner.

2.1 CONSTRUCTION

A. Tolerances. Surface elevations shall conform to 6" below the spot elevations specified on the Contract Drawings or as directed by the Engineer. Tolerances of the finished structure are as follows:

Surface Elevation: ±0.2 ft

Any unauthorized excavation, made below elevations or outside limits indicated on the Construction Drawings, the Contractor shall restore the excavation to proper elevations with approved fill materials placed and compacted as directed by the Engineer at no additional cost to the Administration.

B. Sequence of Construction. Prior to any work, the Contractor shall install stream flow diversion and/or dewatering facilities per the Contract Drawings. The working site is to be dewatered before excavation commences.

C. Grading.

1. Excavate the work area to 6" below final grade. Replace with finished topsoil. Chisel plow all disturbed areas to 6" depth prior to seeding and planting. Suitable materials for woody debris, bank run gravel, sand, woodchips, and mulch may be placed upstream for reuse within the reach.
2. Unsuitable materials shall be removed from the channel and not reused in backfilling the regenerative stormwater conveyance. Unsuitable materials are trash, muck, clay, and silty soils.
3. The contractor shall leave micro-topography in graded areas. The contractor shall not smooth all surfaces per conventional grading practices, but leave rough, uneven surfaces within the tolerances of excavation.

END OF SECTION

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