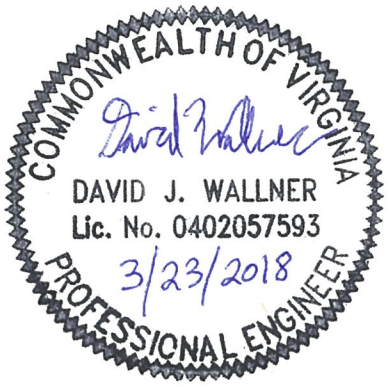
By virtue of this seal and signature, all supporting documents included in this package are accurate and support the design presented herein.



Water Bar 1 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 1 is 0.2 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 1 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 1 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 3 foot long end treatment will ensure sheet flow conditions leaving Water Bar 1. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 1.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.20	water bar drainage area, ac
	S =	0.435	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **3 ft**

Velocity Check ------> **0.88 fps**

Water Bar 2 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 2 is 0.13 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 2 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 2 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 2. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 2.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.13	water bar drainage area, ac
	S =	0.57	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **1.01 fps**

Water Bar 3 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 3 is 0.11 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 3 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 3 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 3. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 3.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.11	water bar drainage area, ac
	S =	0.588	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **1.03 fps**

Water Bar 4 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 4 is 0.58 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area.Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath for Water Bar 4 begins as sheet flow in a HSG B wooded area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.15.

The flowpath exiting the Water Bar 4 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration (T_c)

As shown, the time of concentration of Water Bar 4 is 16 minutes.

Equation	Reference
$T_{t(sheet)} = 0.225*L_{sheet}^{0.42}*s^{-0.19}*C^{-1.0}$	Seelye Method for calculating overland flow time (VDOT's preferred method, described in Appendix 6D-1 of the VDOT Drainage Manual)
$V_{unpaved} = 16.1345*s^{0.5}$	Equation for average velocity for "Unpaved" surface condition from TR-55, Appendix F
$V_{paved} = 20.3282*s^{0.5}$	Equation for average velocity for "Paved" surface condition from TR-55, Appendix F
$T_{t(shallow)} = L_{shallow}/(3600*V_{unpaved/paved}$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for shallow concentrated flow)
$r = a/p_w$	Definition of hydraulic radius (r), which is equal to the cross sectional flow area (a) divided by the wetted perimeter (p_w)
$V_{channel} = (1.49*r^{2/3}*s^{1/2})/n$	Equation 3-4 (Manning's Equation) from TR-55, Chapter 3
$T_{t(channel)} = L_{channel}/(3600*V_{channel})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for channel flow)
$T_c = T_{t(sheet)} + T_{t(shallow)} + T_{t(channel)}$	Equation 3-2 for time of concentration from TR-55, Chapter 3

Sheet Flow

ID	Description	[1]Rational Method Runoff Coefficient, C				[2]Flow Length, L_{sheet} (ft)	Land Slope, s (ft/ft)		Travel Time, $T_{t(sheet)}$ (hr)
AB	Sheet Flow	0.15				100.0	0.150		0.248

Shallow Concentrated Flow

ID	Description	Paved/Unpaved				[3]Flow Length, $L_{shallow}$ (ft)	[4]Watercourse Slope, s (ft/ft)	Average Velocity, $V_{unpaved/paved}$ (ft/s)	Travel Time, $T_{t(shallow)}$ (hr)
BC	Downslope	Unpaved				311.0	0.386	10.02	0.009
CD	Waterbar	Unpaved				60.0	0.050	3.61	0.005

Channel Flow

ID	Description	[5]Manning's n	[6]Cross Sectional Flow Area, a (sf)	[6]Wetted Perimeter, p_w (ft)	Hydraulic Radius, r (ft)	Flow Length, $L_{channel}$ (ft)	Channel Slope, s (ft/ft)	Average Velocity, $V_{channel}$ (ft/s)	Travel Time, $T_{t(channel)}$ (hr)

T_c (hr) =	0.261
T_c (min) =	16

[1] Selected appropriate Rational Method runoff coefficient (C) from Table 4-5b in the Virginia Stormwater Management Handbook

[2] Assume a maximum sheet flow length of 100-ft per PS&S

[3] Assume a maximum shallow concentrated flow length of 1,000-ft in Franklin County and Roanoke County per the PS&S

[4] For waterbars, assume a channel slope of 5% (i.e., the maximum slope per General Detail MVP-17) to be conservative

[5] Assume n=0.03 for all natural/man-made channels to be conservative

[6] Assume bank-full elevation per TR-55

IV. Summary

As shown, the water bar end treatment calculator indicates a 6 foot long end treatment will ensure sheet flow conditions leaving Water Bar 4. For ease of construction, a water bar end treatment length of 15 feet will be used for Water Bar 4.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	16	time of concentration to water bar, min
	A =	0.58	water bar drainage area, ac
	S =	0.2	weir discharge overland slope, ft/ft
Computed	i =	4.5	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **6 ft**

Velocity Check ------> **0.60 fps**

Water Bar 5 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 5 is 0.95 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area.Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath for Water Bar 5 begins as sheet flow in a HSG B wooded area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.15.

The flowpath exiting the Water Bar 5 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration (T_c)

As shown, the time of concentration of Water Bar 5 is 28 minutes.

Equation	Reference
$T_{t(sheet)} = 0.225*L_{sheet}^{0.42}*s^{-0.19}*C^{-1.0}$	Seelye Method for calculating overland flow time (VDOT's preferred method, described in Appendix 6D-1 of the VDOT Drainage Manual)
$V_{unpaved} = 16.1345*s^{0.5}$	Equation for average velocity for "Unpaved" surface condition from TR-55, Appendix F
$V_{paved} = 20.3282*s^{0.5}$	Equation for average velocity for "Paved" surface condition from TR-55, Appendix F
$T_{t(shallow)} = L_{shallow}/(3600*V_{unpaved/paved}$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for shallow concentrated flow)
$r = a/p_w$	Definition of hydraulic radius (r), which is equal to the cross sectional flow area (a) divided by the wetted perimeter (p_w)
$V_{channel} = (1.49*r^{2/3}*s^{1/2})/n$	Equation 3-4 (Manning's Equation) from TR-55, Chapter 3
$T_{t(channel)} = L_{channel}/(3600*V_{channel})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for channel flow)
$T_c = T_{t(sheet)} + T_{t(shallow)} + T_{t(channel)}$	Equation 3-2 for time of concentration from TR-55, Chapter 3

Sheet Flow

ID	Description	[1]Rational Method Runoff Coefficient, C				[2]Flow Length, L_{sheet} (ft)	Land Slope, s (ft/ft)		Travel Time, $T_{t(sheet)}$ (hr)
AB	Sheet Flow	0.15				100.0	0.120		0.259

Shallow Concentrated Flow

ID	Description	Paved/Unpaved				[3]Flow Length, $L_{shallow}$ (ft)	[4]Watercourse Slope, s (ft/ft)	Average Velocity, $V_{unpaved/paved}$ (ft/s)	Travel Time, $T_{t(shallow)}$ (hr)
BC	Downslope	Unpaved				305.0	0.413	0.41	0.205
CD	Waterbar	Unpaved				22.0	0.050	3.61	0.002

Channel Flow

ID	Description	[5]Manning's n	[6]Cross Sectional Flow Area, a (sf)	[6]Wetted Perimeter, p_w (ft)	Hydraulic Radius, r (ft)	Flow Length, $L_{channel}$ (ft)	Channel Slope, s (ft/ft)	Average Velocity, $V_{channel}$ (ft/s)	Travel Time, $T_{t(channel)}$ (hr)

T_c (hr) =	0.466
T_c (min) =	28

[1] Selected appropriate Rational Method runoff coefficient (C) from Table 4-5b in the Virginia Stormwater Management Handbook

[2] Assume a maximum sheet flow length of 100-ft per PS&S

[3] Assume a maximum shallow concentrated flow length of 1,000-ft in Franklin County and Roanoke County per the PS&S

[4] For waterbars, assume a channel slope of 5% (i.e., the maximum slope per General Detail MVP-17) to be conservative

[5] Assume n=0.03 for all natural/man-made channels to be conservative

[6] Assume bank-full elevation per TR-55

IV. Summary

As shown, the water bar end treatment calculator indicates a 8 foot long end treatment will ensure sheet flow conditions leaving Water Bar 5. For ease of construction, a water bar end treatment length of 15 feet will be used for Water Bar 5.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	28	time of concentration to water bar, min
	A =	0.95	water bar drainage area, ac
	S =	0.26	weir discharge overland slope, ft/ft
Computed	i =	3.4	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **8 ft**

Velocity Check ------> **0.68 fps**

Water Bar 6 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 6 is 0.61 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area.Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath for Water Bar 6 begins as sheet flow in a HSG D wooded area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.21.

The flowpath exiting the Water Bar 6 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration (T_c)

As shown, the time of concentration of Water Bar 6 is 9 minutes.

Equation	Reference
$T_{t(sheet)} = 0.225*L_{sheet}^{0.42}*s^{-0.19}*C^{-1.0}$	Seelye Method for calculating overland flow time (VDOT's preferred method, described in Appendix 6D-1 of the VDOT Drainage Manual)
$V_{unpaved} = 16.1345*s^{0.5}$	Equation for average velocity for "Unpaved" surface condition from TR-55, Appendix F
$V_{paved} = 20.3282*s^{0.5}$	Equation for average velocity for "Paved" surface condition from TR-55, Appendix F
$T_{t(shallow)} = L_{shallow}/(3600*V_{unpaved/paved}$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for shallow concentrated flow)
$r = a/p_w$	Definition of hydraulic radius (r), which is equal to the cross sectional flow area (a) divided by the wetted perimeter (p_w)
$V_{channel} = (1.49*r^{2/3}*s^{1/2})/n$	Equation 3-4 (Manning's Equation) from TR-55, Chapter 3
$T_{t(channel)} = L_{channel}/(3600*V_{channel})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for channel flow)
$T_c = T_{t(sheet)} + T_{t(shallow)} + T_{t(channel)}$	Equation 3-2 for time of concentration from TR-55, Chapter 3

Sheet Flow

ID	Description	[1]Rational Method Runoff Coefficient, C				[2]Flow Length, L_{sheet} (ft)	Land Slope, s (ft/ft)		Travel Time, $T_{t(sheet)}$ (hr)
AB	Sheet Flow	0.21				100.0	0.440		0.144

Shallow Concentrated Flow

ID	Description	Paved/Unpaved				[3]Flow Length, $L_{shallow}$ (ft)	[4]Watercourse Slope, s (ft/ft)	Average Velocity, $V_{unpaved/paved}$ (ft/s)	Travel Time, $T_{t(shallow)}$ (hr)
BC	Downslope	Unpaved				338.0	0.343	9.45	0.010
CD	Waterbar	Unpaved				8.0	0.050	3.61	0.001

Channel Flow

ID	Description	[5]Manning's n	[6]Cross Sectional Flow Area, a (sf)	[6]Wetted Perimeter, p_w (ft)	Hydraulic Radius, r (ft)	Flow Length, $L_{channel}$ (ft)	Channel Slope, s (ft/ft)	Average Velocity, $V_{channel}$ (ft/s)	Travel Time, $T_{t(channel)}$ (hr)

T_c (hr) =	0.155
T_c (min) =	9

[1] Selected appropriate Rational Method runoff coefficient (C) from Table 4-5b in the Virginia Stormwater Management Handbook

[2] Assume a maximum sheet flow length of 100-ft per PS&S

[3] Assume a maximum shallow concentrated flow length of 1,000-ft in Franklin County and Roanoke County per the PS&S

[4] For waterbars, assume a channel slope of 5% (i.e., the maximum slope per General Detail MVP-17) to be conservative

[5] Assume n=0.03 for all natural/man-made channels to be conservative

[6] Assume bank-full elevation per TR-55

IV. Summary

As shown, the water bar end treatment calculator indicates a 8 foot long end treatment will ensure sheet flow conditions leaving Water Bar 6. For ease of construction, a water bar end treatment length of 15 feet will be used for Water Bar 6.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	9	time of concentration to water bar, min
	A =	0.61	water bar drainage area, ac
	S =	0.220	weir discharge overland slope, ft/ft
Computed	i =	5.5	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **8 ft**

Velocity Check ------> **0.63 fps**

Water Bar 7 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 7 is 0.33 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 7 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 7 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 5 foot long end treatment will ensure sheet flow conditions leaving Water Bar 7. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 7.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.33	water bar drainage area, ac
	S =	0.274	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **5 ft**

Velocity Check ------> **0.70 fps**

Water Bar 8 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 8 is 0.16 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 8 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 8 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 3 foot long end treatment will ensure sheet flow conditions leaving Water Bar 8. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 8.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.16	water bar drainage area, ac
	S =	0.267	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **3 ft**

Velocity Check ------> **0.69 fps**

Water Bar 10 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 10 is 0.12 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 10 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 10 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 10. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 10.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.12	water bar drainage area, ac
	S =	0.392	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.84 fps**

Water Bar 11 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 11 is 0.08 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 11 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 11 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 11. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 11.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.08	water bar drainage area, ac
	S =	0.455	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.90 fps**

Water Bar 12 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 12 is 0.08 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 12 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 12 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 12. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 12.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.08	water bar drainage area, ac
	S =	0.513	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.96 fps**

Water Bar 13 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 13 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 13 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 13 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 13. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 13.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.488	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.93 fps**

Water Bar 14 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 14 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 14 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 14 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 14. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 14.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.513	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.96 fps**

Water Bar 15 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 15 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 15 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 15 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 15. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 15.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.520	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.96 fps**

Water Bar 16 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 16 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 16 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 16 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 16. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 16.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.520	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.96 fps**

Water Bar 17 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 17 is 0.04 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 17 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 17 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 0 foot long end treatment will ensure sheet flow conditions leaving Water Bar 17. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 17.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.04	water bar drainage area, ac
	S =	0.427	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **0 ft**

Velocity Check ------> **0.87 fps**

Water Bar 18 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 18 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 18 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 18 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 18. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 18.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.532	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.98 fps**

Water Bar 19 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 19 is 0.09 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 19 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 19 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 19. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 19.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.09	water bar drainage area, ac
	S =	0.692	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **1.11 fps**

Water Bar 20 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 20 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 20 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 20 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 20. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 20.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.778	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **1.18 fps**

Water Bar 21 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 21 is 0.1 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 21 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 21 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 21. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 21.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.10	water bar drainage area, ac
	S =	0.766	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **1.17 fps**

Water Bar 23 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 23 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 23 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 23 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 23. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 23.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.826	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **1.22 fps**

Water Bar 24 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 24 is 0.13 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 24 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 24 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 24. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 24.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.13	water bar drainage area, ac
	S =	0.733	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **1.14 fps**

Water Bar 25 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 25 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 25 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 25 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 25. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 25.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.855	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **1.24 fps**

Water Bar 29 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29 is 0.19 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 3 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.19	water bar drainage area, ac
	S =	0.444	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **3 ft**

Velocity Check ------> **0.89 fps**

Water Bar 29.1 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.1 is 0.04 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.1 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.1 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.1. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.1.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.04	water bar drainage area, ac
	S =	0.488	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.93 fps**

Water Bar 29.2 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.2 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.2 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.2 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.2. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.2.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.469	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.92 fps**

Water Bar 29.3 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.3 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.3 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.3 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.3. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.3.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.442	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.89 fps**

Water Bar 29.4 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.4 is 0.11 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.4 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.4 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.4. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.4.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.11	water bar drainage area, ac
	S =	0.421	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.87 fps**

Water Bar 29.5 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.5 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.5 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.5 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.5. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.5.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.429	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.88 fps**

Water Bar 29.6 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.6 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.6 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.6 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.6. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.6.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.374	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.82 fps**

Water Bar 29.7 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.7 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.7 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.7 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.7. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.7.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.334	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.77 fps**

Water Bar 29.8 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.8 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.8 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.8 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.8. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.8.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.375	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.82 fps**

Water Bar 29.9 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.9 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.9 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.9 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.9. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.9.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.361	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.80 fps**

Water Bar 29.10 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 29.10 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 29.10 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 29.10 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 29.10. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 29.10.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.324	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.76 fps**

Water Bar 30 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 30 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 30 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 30 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 30. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 30.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.303	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.74 fps**

Water Bar 31 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 31 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 31 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 31 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 31. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 31.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.296	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.73 fps**

Water Bar 31.1 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 31.1 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 31.1 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 31.1 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 31.1. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 31.1.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.363	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.81 fps**

Water Bar 31.2 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 31.2 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 31.2 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 31.2 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 31.2. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 31.2.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.317	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.75 fps**

Water Bar 31.3 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 31.3 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 31.3 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 31.3 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 31.3. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 31.3.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.324	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.76 fps**

Water Bar 32 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 32 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 32 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 32 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 32. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 32.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.347	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.79 fps**

Water Bar 33 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 33 is 0.09 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 33 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 33 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 33. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 33.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.09	water bar drainage area, ac
	S =	0.202	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.60 fps**

Water Bar 34 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 34 is 0.04 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 34 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 34 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 34. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 34.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.04	water bar drainage area, ac
	S =	0.374	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.82 fps**

Water Bar 35 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 35 is 0.11 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 35 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 35 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 35. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 35.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.11	water bar drainage area, ac
	S =	0.402	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.85 fps**

Water Bar 36 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 36 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 36 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 36 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 36. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 36.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.324	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.76 fps**

Water Bar 37 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 37 is 0.15 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 37 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 37 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 37. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 37.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.15	water bar drainage area, ac
	S =	0.197	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.59 fps**

Water Bar 38 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 38 is 0.09 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

Composite Curve Number (CN) Calculator				
LAND USE	**HSG**	**CN**	**AREA (%)**	**AreaWeighted CN**
Impervious	D	98	22%	22
Meadow	D	78	0%	0
Wooded	D	77	78%	60
			100%	82

II. Runoff Coefficient

The drainage area for Water Bar 38 includes impervious cover, which has a runoff coefficient (C) of 0.90 per Table 4-5a. Therefore, a composite C of 0.36 was calculated as shown below to more accurately represent the runoff condition within the drainage area.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

Composite Runoff Coefficient (C) Calculator					
LAND USE	**HSG**	**C**	**Area %**	**Area Weighted C**	
Impervious	D	0.9	22%	0.20	
Meadow	D	0.25	0%	0.00	
Wooded	D	0.21	78%	0.16	
			100%	0.36	<--- Composite C

III. Time of Concentration (T_c)

A minimum time of concentration of 5 minutes was assumed for Water Bar 38 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 38. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 38.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.09	water bar drainage area, ac
	S =	0.181	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.36	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.57 fps**

Water Bar 39 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 39 is 0.12 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

Composite Curve Number (CN) Calculator				
LAND USE	**HSG**	**CN**	**AREA (%)**	**AreaWeighted CN**
Impervious	D	98	22%	22
Meadow	D	78	0%	0
Wooded	D	77	78%	60
			100%	82

II. Runoff Coefficient

The drainage area for Water Bar 39 includes impervious cover, which has a runoff coefficient (C) of 0.90 per Table 4-5a. Therefore, a composite C of 0.36 was calculated as shown below to more accurately represent the runoff condition within the drainage area.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

Composite Runoff Coefficient (C) Calculator					
LAND USE	**HSG**	**C**	**Area %**	**Area Weighted C**	
Impervious	D	0.9	22%	0.20	
Meadow	D	0.25	0%	0.00	
Wooded	D	0.21	78%	0.16	
			100%	0.36	<--- Composite C

III. Time of Concentration (T_c)

A minimum time of concentration of 5 minutes was assumed for Water Bar 39 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 3 foot long end treatment will ensure sheet flow conditions leaving Water Bar 39. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 39.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.12	water bar drainage area, ac
	S =	0.141	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.36	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **3 ft**

Velocity Check ------> **0.50 fps**

Water Bar 40 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 40 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

Composite Curve Number (CN) Calculator				
LAND USE	**HSG**	**CN**	**AREA (%)**	**AreaWeighted CN**
Impervious	D	98	20%	20
Meadow	D	78	0%	0
Wooded	D	77	80%	62
			100%	81

II. Runoff Coefficient

The drainage area for Water Bar 40 includes impervious cover, which has a runoff coefficient (C) of 0.90 per Table 4-5a. Therefore, a composite C of 0.35 was calculated as shown below to more accurately represent the runoff condition within the drainage area.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

Composite Runoff Coefficient (C) Calculator					
LAND USE	**HSG**	**C**	**Area %**	**Area Weighted C**	
Impervious	D	0.9	20%	0.18	
Meadow	D	0.25	0%	0.00	
Wooded	D	0.21	80%	0.17	
			100%	0.35	<--- Composite C

III. Time of Concentration (T_c)

A minimum time of concentration of 5 minutes was assumed for Water Bar 40 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 40. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 40.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.141	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.35	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.70 fps**

Water Bar 41 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 41 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 41 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 41 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 41. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 41.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.268	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.69 fps**

Water Bar 42 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 42 is 0.25 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

Composite Curve Number (CN) Calculator				
LAND USE	**HSG**	**CN**	**AREA (%)**	**AreaWeighted CN**
Impervious	D	98	43%	42
Meadow	D	78	0%	0
Wooded	D	77	57%	44
			100%	86

II. Runoff Coefficient

The drainage area for Water Bar 42 includes impervious cover, which has a runoff coefficient (C) of 0.90 per Table 4-5a. Therefore, a composite C of 0.51 was calculated as shown below to more accurately represent the runoff condition within the drainage area.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

Composite Runoff Coefficient (C) Calculator					
LAND USE	**HSG**	**C**	**Area %**	**Area Weighted C**	
Impervious	D	0.9	43%	0.39	
Meadow	D	0.25	0%	0.00	
Wooded	D	0.21	57%	0.12	
			100%	0.51	**<--- Composite C**

III. Time of Concentration (T_c)

A minimum time of concentration of 5 minutes was assumed for Water Bar 42 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 8 foot long end treatment will ensure sheet flow conditions leaving Water Bar 42. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 42.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.25	water bar drainage area, ac
	S =	0.125	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.51	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **8 ft**

Velocity Check ------> **0.47 fps**

Water Bar 43 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 43 is 0.1 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 43 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 43 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 43. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 43.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.10	water bar drainage area, ac
	S =	0.200	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.60 fps**

Water Bar 44 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 44 is 0.11 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 44 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 44 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 44. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 44.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.11	water bar drainage area, ac
	S =	0.182	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.57 fps**

Water Bar 45 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 45 is 0.11 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 45 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 45 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 45. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 45.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.11	water bar drainage area, ac
	S =	0.200	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.60 fps**

Water Bar 46 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 46 is 0.25 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 46 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 46 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 4 foot long end treatment will ensure sheet flow conditions leaving Water Bar 46. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 46.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.25	water bar drainage area, ac
	S =	0.218	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **4 ft**

Velocity Check ------> **0.62 fps**

Water Bar 47 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 47 is 0.08 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 47 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 47 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 47. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 47.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.08	water bar drainage area, ac
	S =	0.189	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.58 fps**

Water Bar 48 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 48 is 0.09 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 48 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 48 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 48. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 48.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.09	water bar drainage area, ac
	S =	0.222	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.63 fps**

Water Bar 49 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 49 is 0.12 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 49 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 49 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 49. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 49.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.12	water bar drainage area, ac
	S =	0.452	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.90 fps**

Water Bar 50 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 50 is 0.09 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 50 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 50 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 50. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 50.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.09	water bar drainage area, ac
	S =	0.468	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.91 fps**

Water Bar 51 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.526	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.97 fps**

Water Bar 51.1 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.1 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.1 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.1 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.1. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.1.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.450	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.90 fps**

Water Bar 51.2 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.2 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.2 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.2 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.2. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.2.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.413	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.86 fps**

Water Bar 51.3 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.3 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.3 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.3 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.3. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.3.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.466	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.91 fps**

Water Bar 51.4 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.4 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.4 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.4 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.4. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.4.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.528	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.97 fps**

Water Bar 51.5 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.5 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.5 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.5 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.5. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.5.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.627	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **1.06 fps**

Water Bar 51.6 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.6 is 0.06 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.6 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.6 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.6. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.6.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.06	water bar drainage area, ac
	S =	0.496	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.94 fps**

Water Bar 51.7 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.7 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.7 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.7 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.7. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.7.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.503	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.95 fps**

Water Bar 51.8 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.8 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.8 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.8 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.8. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.8.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.455	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.90 fps**

Water Bar 51.9 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.9 is 0.04 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.9 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.9 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.9. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.9.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.04	water bar drainage area, ac
	S =	0.363	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.81 fps**

Water Bar 51.10 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.10 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.10 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.10 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.10. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.10.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.348	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.79 fps**

Water Bar 51.11 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 51.11 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 51.11 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 51.11 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 51.11. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 51.11.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.244	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.66 fps**

Water Bar 52 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 52 is 0.13 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 52 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 52 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 52. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 52.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.13	water bar drainage area, ac
	S =	0.198	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.60 fps**

Water Bar 53 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 53 is 0.05 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 53 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 53 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 53. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 53.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.05	water bar drainage area, ac
	S =	0.150	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.52 fps**

Water Bar 54 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 54 is 0.07 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 54 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 54 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 54. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 54.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.07	water bar drainage area, ac
	S =	0.191	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.58 fps**

Water Bar 55

I. Summary

As shown, the composite CN does not exceed 71. Therefore, a site specific analysis is not required and the end treatment length for Water Bar 55 can be sized using the standard sizing table per the MVP 17.3 Water Bar End Treatment Detail. The drainage area to Water Bar 55 is 0.29 acres, so a water bar end treatment length of 10 feet will be used for Water Bar 55.

Composite Curve Number (CN) Calculator				
LAND USE	HSG	CN	AREA (%)	Area Weighted CN
Impervious	C	98	3%	3
Meadow	C	71	25%	18
Wooded	C	70	72%	50
			100%	71

Water Bar 56 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 56 is 0.19 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 56 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 56 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 4 foot long end treatment will ensure sheet flow conditions leaving Water Bar 56. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 56.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.29	water bar drainage area, ac
	S =	0.138	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **4 ft**

Velocity Check ------> **0.50 fps**

Water Bar 57 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 57 is 0.91 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area.Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath for Water Bar 57 begins as sheet flow in a HSG B meadow area with slopes between 2-6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.14.

The flowpath exiting the Water Bar 57 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration (T_c)

As shown, the time of concentration of Water Bar 57 is 24 minutes.

Equation	Reference
$T_{t(sheet)} = 0.225*L_{sheet}^{0.42}*s^{-0.19}*C^{-1.0}$	Seelye Method for calculating overland flow time (VDOT's preferred method, described in Appendix 6D-1 of the VDOT Drainage Manual)
$V_{unpaved} = 16.1345*s^{0.5}$	Equation for average velocity for "Unpaved" surface condition from TR-55, Appendix F
$V_{paved} = 20.3282*s^{0.5}$	Equation for average velocity for "Paved" surface condition from TR-55, Appendix F
$T_{t(shallow)} = L_{shallow}/(3600*V_{unpaved/paved}$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for shallow concentrated flow)
$r = a/p_w$	Definition of hydraulic radius (r), which is equal to the cross sectional flow area (a) divided by the wetted perimeter (p_w)
$V_{channel} = (1.49*r^{2/3}*s^{1/2})/n$	Equation 3-4 (Manning's Equation) from TR-55, Chapter 3
$T_{t(channel)} = L_{channel}/(3600*V_{channel})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for channel flow)
$T_c = T_{t(sheet)} + T_{t(shallow)} + T_{t(channel)}$	Equation 3-2 for time of concentration from TR-55, Chapter 3

Sheet Flow

ID	Description	[1]Rational Method Runoff Coefficient, C				[2]Flow Length, L_{sheet} (ft)	Land Slope, s (ft/ft)		Travel Time, $T_{t(sheet)}$ (hr)
AB	Sheet Flow	0.14				100.0	0.030		0.361

Shallow Concentrated Flow

ID	Description	Paved/Unpaved				[3]Flow Length, $L_{shallow}$ (ft)	[4]Watercourse Slope, s (ft/ft)	Average Velocity, $V_{unpaved/paved}$ (ft/s)	Travel Time, $T_{t(shallow)}$ (hr)
BC	Downslope	Unpaved				551.3	0.114	5.45	0.028
CD	Waterbar	Unpaved				52.3	0.050	3.61	0.004

Channel Flow

ID	Description	[5]Manning's n	[6]Cross Sectional Flow Area, a (sf)	[6]Wetted Perimeter, p_w (ft)	Hydraulic Radius, r (ft)	Flow Length, $L_{channel}$ (ft)	Channel Slope, s (ft/ft)	Average Velocity, $V_{channel}$ (ft/s)	Travel Time, $T_{t(channel)}$ (hr)

T_c (hr) =	0.393
T_c (min) =	24

[1] Selected appropriate Rational Method runoff coefficient (C) from Table 4-5b in the Virginia Stormwater Management Handbook

[2] Assume a maximum sheet flow length of 100-ft per PS&S

[3] Assume a maximum shallow concentrated flow length of 1,000-ft in Franklin County and Roanoke County per the PS&S

[4] For waterbars, assume a channel slope of 5% (i.e., the maximum slope per General Detail MVP-17) to be conservative

[5] Assume n=0.03 for all natural/man-made channels to be conservative

[6] Assume bank-full elevation per TR-55

IV. Summary

As shown, the water bar end treatment calculator indicates a 8 foot long end treatment will ensure sheet flow conditions leaving Water Bar 57. For ease of construction, a water bar end treatment length of 15 feet will be used for Water Bar 57.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	24	time of concentration to water bar, min
	A =	0.91	water bar drainage area, ac
	S =	0.093	weir discharge overland slope, ft/ft
Computed	i =	3.7	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **8 ft**

Velocity Check ------> **0.41 fps**

Water Bar 58 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 58 is 0.2 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 58 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 58 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 3 foot long end treatment will ensure sheet flow conditions leaving Water Bar 58. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 58.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.20	water bar drainage area, ac
	S =	0.048	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **3 ft**

Velocity Check ------> **0.29 fps**

Water Bar 59 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 59 is 0.08 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 59 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 59 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 59. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 59.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.08	water bar drainage area, ac
	S =	0.016	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.17 fps**

Water Bar 60 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 60 is 0.08 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 60 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 60 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 1 foot long end treatment will ensure sheet flow conditions leaving Water Bar 60. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 60.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.08	water bar drainage area, ac
	S =	0.286	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **1 ft**

Velocity Check ------> **0.72 fps**

Water Bar 61 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 61 is 0.18 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 61 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 61 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 3 foot long end treatment will ensure sheet flow conditions leaving Water Bar 61. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 61.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.18	water bar drainage area, ac
	S =	0.098	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **3 ft**

Velocity Check ------> **0.42 fps**

Water Bar 62 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 62 is 0.37 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 62 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 62 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 6 foot long end treatment will ensure sheet flow conditions leaving Water Bar 62. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 62.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.37	water bar drainage area, ac
	S =	0.060	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **6 ft**

Velocity Check ------> **0.33 fps**

Water Bar 63 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 63 is 0.48 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 63 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 63 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 7 foot long end treatment will ensure sheet flow conditions leaving Water Bar 63. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 63.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.48	water bar drainage area, ac
	S =	0.340	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **7 ft**

Velocity Check ------> **0.78 fps**

Water Bar 64 Site Specific Analysis

I. Drainage Area

As shown, the drainage area to Water Bar 64 is 2.21 Acres. This is greater than the 1.5 acre-maximum in the MVP 17.3 Water Bar End Treatment Detail and, therefore, requires a site-specific analysis to determine the water bar end treatment length.

II. Runoff Coefficient

The flowpath for Water Bar 64 begins as sheet flow in a HSG A meadow area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.1.

The flowpath exiting the Water Bar 64 end treatment will be along HSG A meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.1.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration (T_c)

As shown, the time of concentration of Water Bar 64 is 22 minutes.

Equation	Reference
$T_{t(sheet)} = 0.225*L_{sheet}^{0.42}*s^{-0.19}*C^{-1.0}$	Seelye Method for calculating overland flow time (VDOT's preferred method, described in Appendix 6D-1 of the VDOT Drainage Manual)
$V_{unpaved} = 16.1345*s^{0.5}$	Equation for average velocity for "Unpaved" surface condition from TR-55, Appendix F
$V_{paved} = 20.3282*s^{0.5}$	Equation for average velocity for "Paved" surface condition from TR-55, Appendix F
$T_{t(shallow)} = L_{shallow}/(3600*V_{unpaved/paved}$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for shallow concentrated flow)
$r = a/p_w$	Definition of hydraulic radius (r), which is equal to the cross sectional flow area (a) divided by the wetted perimeter (p_w)
$V_{channel} = (1.49*r^{2/3}*s^{1/2})/n$	Equation 3-4 (Manning's Equation) from TR-55, Chapter 3
$T_{t(channel)} = L_{channel}/(3600*V_{channel})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for channel flow)
$T_c = T_{t(sheet)} + T_{t(shallow)} + T_{t(channel)}$	Equation 3-2 for time of concentration from TR-55, Chapter 3

Sheet Flow

ID	Description	[1]Rational Method Runoff Coefficient, C				[2]Flow Length, L_{sheet} (ft)	Land Slope, s (ft/ft)		Travel Time, $T_{t(sheet)}$ (hr)
AB	Sheet Flow	0.10				100.0	0.230		0.343

Shallow Concentrated Flow

ID	Description	Paved/Unpaved				[3]Flow Length, $L_{shallow}$ (ft)	[4]Watercourse Slope, s (ft/ft)	Average Velocity, $V_{unpaved/paved}$ (ft/s)	Travel Time, $T_{t(shallow)}$ (hr)
BC	Downslope	Unpaved				992.4	0.352	9.57	0.029
CD	Waterbar	Unpaved				16.9	0.050	3.61	0.001

Channel Flow

ID	Description	[5]Manning's n	[6]Cross Sectional Flow Area, a (sf)	[6]Wetted Perimeter, p_w (ft)	Hydraulic Radius, r (ft)	Flow Length, $L_{channel}$ (ft)	Channel Slope, s (ft/ft)	Average Velocity, $V_{channel}$ (ft/s)	Travel Time, $T_{t(channel)}$ (hr)

T_c (hr) =	0.373
T_c (min) =	22

[1] Selected appropriate Rational Method runoff coefficient (C) from Table 4-5b in the Virginia Stormwater Management Handbook

[2] Assume a maximum sheet flow length of 100-ft per PS&S

[3] Assume a maximum shallow concentrated flow length of 1,000-ft in Franklin County and Roanoke County per the PS&S

[4] For waterbars, assume a channel slope of 5% (i.e., the maximum slope per General Detail MVP-17) to be conservative

[5] Assume n=0.03 for all natural/man-made channels to be conservative

[6] Assume bank-full elevation per TR-55

IV. Summary

As shown, the water bar end treatment calculator indicates a 8 foot long end treatment will ensure sheet flow conditions leaving Water Bar 64. For ease of construction, a water bar end treatment length of 20 feet will be used for Water Bar 64.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	22	time of concentration to water bar, min
	A =	2.21	water bar drainage area, ac
	S =	0.261	weir discharge overland slope, ft/ft
Computed	i =	3.8	computed from IDF, in/hr
Enter Flow Parameters	C =	0.10	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **8 ft**

Velocity Check ------> **0.68 fps**

Water Bar 65 Site Specific Analysis

I. Drainage Area

As shown, the drainage area to Water Bar 65 is 2.19 Acres. This is greater than the 1.5 acre-maximum in the MVP 17.3 Water Bar End Treatment Detail and, therefore, requires a site-specific analysis to determine the water bar end treatment length.

II. Runoff Coefficient

The flowpath for Water Bar 65 begins as sheet flow in a HSG B meadow area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.19.

The flowpath exiting the Water Bar 65 end treatment will be along HSG B meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.19.

TABLE 4-5B
Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)
Rural Land Use
STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration (T_c)

As shown, the time of concentration of Water Bar 65 is 15 minutes.

Equation	Reference
$T_{t(sheet)} = 0.225*L_{sheet}^{0.42}*s^{-0.19}*C^{-1.0}$	Seelye Method for calculating overland flow time (VDOT's preferred method, described in Appendix 6D-1 of the VDOT Drainage Manual)
$V_{unpaved} = 16.1345*s^{0.5}$	Equation for average velocity for "Unpaved" surface condition from TR-55, Appendix F
$V_{paved} = 20.3282*s^{0.5}$	Equation for average velocity for "Paved" surface condition from TR-55, Appendix F
$T_{t(shallow)} = L_{shallow}/(3600*V_{unpaved/paved})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for shallow concentrated flow)
$r = a/p_w$	Definition of hydraulic radius (r), which is equal to the cross sectional flow area (a) divided by the wetted perimeter (p_w)
$V_{channel} = (1.49*r^{2/3}*s^{1/2})/n$	Equation 3-4 (Manning's Equation) from TR-55, Chapter 3
$T_{t(channel)} = L_{channel}/(3600*V_{channel})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for channel flow)
$T_c = T_{t(sheet)} + T_{t(shallow)} + T_{t(channel)}$	Equation 3-2 for time of concentration from TR-55, Chapter 3

Sheet Flow

ID	Description	[1]Rational Method Runoff Coefficient, C	[2]Flow Length, L_{sheet} (ft)	Land Slope, s (ft/ft)	Travel Time, $T_{t(sheet)}$ (hr)
AB	Sheet Flow	0.19	100.0	0.110	0.208

Shallow Concentrated Flow

ID	Description	Paved/Unpaved	[3]Flow Length, $L_{shallow}$ (ft)	[4]Watercourse Slope, s (ft/ft)	Average Velocity, $V_{unpaved/paved}$ (ft/s)	Travel Time, $T_{t(shallow)}$ (hr)
BC	Downslope	Unpaved	579.0	0.055	3.78	0.043
CD	Waterbar	Unpaved	46.0	0.050	3.61	0.004

Channel Flow

ID	Description	[5]Manning's n	[6]Cross Sectional Flow Area, a (sf)	[6]Wetted Perimeter, p_w (ft)	Hydraulic Radius, r (ft)	Flow Length, $L_{channel}$ (ft)	Channel Slope, s (ft/ft)	Average Velocity, $V_{channel}$ (ft/s)	Travel Time, $T_{t(channel)}$ (hr)
								T_c (hr) =	0.254
								T_c (min) =	15

[1] Selected appropriate Rational Method runoff coefficient (C) from Table 4-5b in the Virginia Stormwater Management Handbook

[2] Assume a maximum sheet flow length of 100-ft per PS&S

[3] Assume a maximum shallow concentrated flow length of 1,000-ft in Franklin County and Roanoke County per the PS&S

[4] For waterbars, assume a channel slope of 5% (i.e., the maximum slope per General Detail MVP-17) to be conservative

[5] Assume n=0.03 for all natural/man-made channels to be conservative

[6] Assume bank-full elevation per TR-55

IV. Summary

As shown, the water bar end treatment calculator indicates a 18 foot long end treatment will ensure sheet flow conditions leaving Water Bar 65. For ease of construction, a water bar end treatment length of 20 feet will be used for Water Bar 65.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	15	time of concentration to water bar, min
	A =	2.19	water bar drainage area, ac
	S =	0.165	weir discharge overland slope, ft/ft
Computed	i =	4.5	computed from IDF, in/hr
Enter Flow Parameters	C =	0.19	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **18 ft**

Velocity Check ------> **0.54 fps**

Water Bar 66 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 66 is 0.11 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

Composite Curve Number (CN) Calculator				
LAND USE	**HSG**	**CN**	**AREA (%)**	**AreaWeighted CN**
Impervious	D	98	8%	8
Meadow	D	78	50%	39
Wooded	D	77	42%	32
			100%	79

II. Runoff Coefficient

The drainage area for Water Bar 66 includes impervious cover, which has a runoff coefficient (C) of 0.90 per Table 4-5a. Therefore, a composite C of 0.29 was calculated as shown below to more accurately represent the runoff condition within the drainage area.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

Composite Runoff Coefficient (C) Calculator					
LAND USE	**HSG**	**C**	**Area %**	**Area Weighted C**	
Impervious	D	0.9	8%	0.07	
Meadow	D	0.25	50%	0.13	
Wooded	D	0.21	42%	0.09	
			100%	0.29	**<--- Composite C**

III. Time of Concentration (T_c)

A minimum time of concentration of 5 minutes was assumed for Water Bar 66 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 66. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 66.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.11	water bar drainage area, ac
	S =	0.099	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.29	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.42 fps**

Water Bar 67 Site Specific Analysis

I. Drainage Area

The drainage area to Water Bar 67 is 0.1 acres, and has a curve number (CN) greater than 71 based on the soil and land uses present within the drainage area. Therefore, this drainage area requires a site-specific analysis to determine the water bar end treatment length per the MVP 17.3 Water Bar End Treatment Detail.

II. Runoff Coefficient

The flowpath exiting the Water Bar 67 end treatment will be along HSG D meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.25.

TABLE 4-5B

Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)

Rural Land Use

STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration

A minimum time of concentration of 5 minutes was assumed for Water Bar 67 because the drainage area is less than or equal to 0.5 acres.

IV. Summary

As shown, the water bar end treatment calculator indicates a 2 foot long end treatment will ensure sheet flow conditions leaving Water Bar 67. For ease of construction, a water bar end treatment length of 10 feet will be used for Water Bar 67.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	5	time of concentration to water bar, min
	A =	0.10	water bar drainage area, ac
	S =	0.043	weir discharge overland slope, ft/ft
Computed	i =	6.6	computed from IDF, in/hr
Enter Flow Parameters	C =	0.25	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **2 ft**

Velocity Check ------> **0.28 fps**

Water Bar 70 Site Specific Analysis

I. Drainage Area

As shown, the drainage area to Water Bar 70 is 1.88 Acres. This is greater than the 1.5 acre-maximum in the MVP 17.3 Water Bar End Treatment Detail and, therefore, requires a site-specific analysis to determine the water bar end treatment length.

II. Runoff Coefficient

The flowpath for Water Bar 70 begins as sheet flow in a HSG B meadow area with slopes greater than 6%. Therefore, the runoff coefficient used in the sheet flow time of concentration calculation will be 0.19.

The flowpath exiting the Water Bar 70 end treatment will be along HSG B meadow with slopes greater than 6%. Therefore, the runoff coefficient used in the end treatment calculation will be 0.19.

TABLE 4-5B
Rational Equation Coefficients for SCS Hydrologic Soil Groups (A, B, C, D)
Rural Land Use
STORM FREQUENCIES OF LESS THAN 25 YEARS

Land Use	Treatment / Practice	Hydrologic Condition	HYDROLOGIC SOIL GROUP/SLOPE											
			A			B			C			D		
			0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Pasture or Range		Good	0.07	0.09	0.10	0.18	0.20	0.22	0.27	0.29	0.31	0.32	0.34	0.35
	Contoured	Good	0.03	0.04	0.06	0.11	0.12	0.14	0.24	0.26	0.28	0.31	0.33	0.34
Meadow			0.06	0.08	0.10	0.10	0.14	0.19	0.12	0.17	0.22	0.15	0.20	0.25
Wooded		Good	0.05	0.07	0.08	0.08	0.11	0.15	0.10	0.13	0.17	0.12	0.15	0.21

Source: Maryland State Highway Administration

III. Time of Concentration (T_c)

As shown, the time of concentration of Water Bar 70 is 15 minutes.

Equation	Reference
$T_{t(sheet)} = 0.225*L_{sheet}^{0.42}*s^{-0.19}*C^{-1.0}$	Seelye Method for calculating overland flow time (VDOT's preferred method, described in Appendix 6D-1 of the VDOT Drainage Manual)
$V_{unpaved} = 16.1345*s^{0.5}$	Equation for average velocity for "Unpaved" surface condition from TR-55, Appendix F
$V_{paved} = 20.3282*s^{0.5}$	Equation for average velocity for "Paved" surface condition from TR-55, Appendix F
$T_{t(shallow)} = L_{shallow}/(3600*V_{unpaved/paved})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for shallow concentrated flow)
$r = a/p_w$	Definition of hydraulic radius (r), which is equal to the cross sectional flow area (a) divided by the wetted perimeter (p_w)
$V_{channel} = (1.49*r^{2/3}*s^{1/2})/n$	Equation 3-4 (Manning's Equation) from TR-55, Chapter 3
$T_{t(channel)} = L_{channel}/(3600*V_{channel})$	Equation 3-1 for travel time from TR-55, Chapter 3 (equation as noted defines variables used when estimating travel time specifically for channel flow)
$T_c = T_{t(sheet)} + T_{t(shallow)} + T_{t(channel)}$	Equation 3-2 for time of concentration from TR-55, Chapter 3

Sheet Flow

ID	Description	[1]Rational Method Runoff Coefficient, C				[2]Flow Length, L_{sheet} (ft)	Land Slope, s (ft/ft)		Travel Time, $T_{t(sheet)}$ (hr)
AB	Sheet Flow	0.19				100.0	0.060		0.233

Shallow Concentrated Flow

ID	Description	Paved/Unpaved				[3]Flow Length, $L_{shallow}$ (ft)	[4]Watercourse Slope, s (ft/ft)	Average Velocity, $V_{unpaved/paved}$ (ft/s)	Travel Time, $T_{t(shallow)}$ (hr)
BC	Downslope	Unpaved				404.4	0.166	6.57	0.017
CD	Waterbar	Unpaved				52.5	0.050	3.61	0.004

Channel Flow

ID	Description	[5]Manning's n	[6]Cross Sectional Flow Area, a (sf)	[6]Wetted Perimeter, p_w (ft)	Hydraulic Radius, r (ft)	Flow Length, $L_{channel}$ (ft)	Channel Slope, s (ft/ft)	Average Velocity, $V_{channel}$ (ft/s)	Travel Time, $T_{t(channel)}$ (hr)
								T_c (hr) =	0.254
								T_c (min) =	15

[1] Selected appropriate Rational Method runoff coefficient (C) from Table 4-5b in the Virginia Stormwater Management Handbook

[2] Assume a maximum sheet flow length of 100-ft per PS&S

[3] Assume a maximum shallow concentrated flow length of 1,000-ft in Franklin County and Roanoke County per the PS&S

[4] For waterbars, assume a channel slope of 5% (i.e., the maximum slope per General Detail MVP-17) to be conservative

[5] Assume n=0.03 for all natural/man-made channels to be conservative

[6] Assume bank-full elevation per TR-55

IV. Summary

As shown, the water bar end treatment calculator indicates a 15 foot long end treatment will ensure sheet flow conditions leaving Water Bar 70. For ease of construction, a water bar end treatment length of 20 feet will be used for Water Bar 70.

End Treatment Length Calculator

Enter Site Specific Data	Tc =	15	time of concentration to water bar, min
	A =	1.88	water bar drainage area, ac
	S =	0.443	weir discharge overland slope, ft/ft
Computed	i =	4.5	computed from IDF, in/hr
Enter Flow Parameters	C =	0.19	calculated composite runoff coefficient
	Cw =	3.33	weir coefficient (rectangular)
	n =	0.24	sheetflow, dense grasses
	H =	0.1	sheetflow depth over weir, ft

Computed Weir Length ------> **15 ft**

Velocity Check ------> **0.89 fps**

i. New Impervious Cover: Access Roads

New impervious cover in Spread 10 includes three (3) access roads (MVP-MLV-AR-28 through -30). Increased volumes of stormwater runoff resulting from access roads will be controlled utilizing the methodology established in *MVP-33.1 through MVP-33.3 Gap Graded Gravel Detail for Mainline Valve Pads and Permanent Access Roads*.

Each access road consists of a geogrid, underlain by a 2-inch layer of clean-washed choker stone, geotextile fabric, an open-graded subbase reservoir, and compacted earthen baffles to detain water within the access road. The access road surface will consist of two gravel tracks, with a center aisle top-dressed with soil and seeded with a meadow seed mix per *MVP-ES11.2 Upland Meadow Seed Mix and Application Rates* or *MVP-ES11.3 Upland Steep Slope Seed Mix and Application Rates*.

Pre- and post-construction runoff volumes for the 10-year 24-hour storm were calculated using the Montgomery and Franklin County design storm values of 5.00 and 5.70 inches, respectively, per *PSS&S Section 4.2.2 Design Storms*. Runoff volumes were calculated for both the drainage area to each gap graded gravel access road and for the access road footprint alone. Results are shown below.

10-YEAR STORM DATA FULL RUN-ON DRAINAGE AREA					
SITE	TIME OF CONCENTRATION (PRE / POST) [HR]	CURVE NUMBER (PRE / POST)	DRAINAGE AREA [FT^2]	Q_{10} PEAK FLOW (PRE / POST) [CFS]	Q_{10} VOLUME (PRE / POST) [FT^3]
MLV-AR-28	0.16 / 0.16	71 / 71	456,413	30.45 / 30.39	80,296 / 80,297
MLV-AR-29	0.12 / 0.12	55 / 66	582	0.02 / 0.03	63 / 72
MLV-AR-30	0.13 / 0.13	82 / 82	43,339	5.31 / 5.31	13,387 / 13,387

10-YEAR STORM DATA ACCESS ROAD FOOTPRINT					
SITE	TIME OF CONCENTRATION (PRE / POST) [HR]	CURVE NUMBER (PRE / POST)	DRAINAGE AREA [FT^2]	Q_{10} PEAK FLOW (PRE / POST) [CFS]	Q_{10} VOLUME (PRE / POST) [FT^3]
MLV-AR-28	0.10 / 0.10	75 / 83	23,522	2.01 / 2.59	4,794 / 6,214
MLV-AR-29	0.10 / 0.10	55 / 78	305	0.01 / 0.03	34 / 62
MLV-AR-30	0.10 / 0.10	58 / 78	871	0.07 / 0.16	174 / 385

Increases in run-off volumes for both the drainage area and access road only are further summarized below.

		Peak Flow (cfs)	Hydrograph Volume (ac-ft)	Hydrograph Volume (ft^3)	Required Treatment Volume (ft^3)
MLV-AR-28 FULL DA	Pre	30.45	1.84334	80296	1
	Post	30.39	1.84337	80297	
MLV-AR-28 AR ONLY	Pre	2.01	0.11006	4794	1420
	Post	2.59	0.14265	6214	

MLV-AR-29 FULL DA	Pre	0.02	0.00145	63	9
	Post	0.03	0.00165	72	
MLV-AR-29 AR ONLY	Pre	0.01	0.00078	34	28
	Post	0.03	0.00142	62	

MLV-AR-30 FULL DA	Pre	5.31	0.30732	13387	0
	Post	5.31	0.30732	13387	
MLV-AR-30 AR ONLY	Pre	0.04	0.00262	114	126
	Post	0.1	0.00551	240	

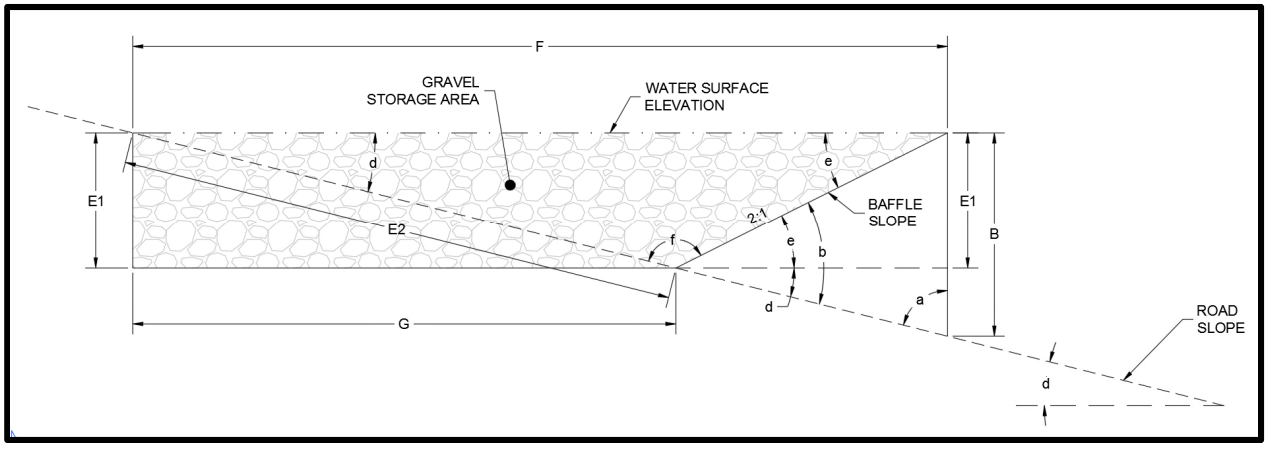
The runoff volume increase when considering only the access road is greater than the resulting runoff volume increase when considering the full drainage area. As a result, the reservoir within the access road is conservatively sized to accommodate the required volume computed using the road footprint only. Any increase in runoff volume from pre- to post-construction condition must be stored within the gap graded gravel to meet flood protection requirements per 9VAC25-870-66.C.2.

A site-specific analysis was performed for all access roads to determine the number of earthen baffles, earthen baffle spacing and subbase reservoir depth required to detain the increased volume from the 10-year storm, and allow the excess stormwater to infiltrate into the underlying soil. Details of the analysis are provided below.

Site	Road Length (ft)	Road Slope (ft/ft)	# of Baffles	Baffle Spacing (ft)	Baffle Height (ft)
MVP-MLV-AR-28	190	0.110	4	47	1
	170	0.142	2	85	1
	90	0.225	1	90	1
	92	0.087	2	46	1
	80	0.022	1	80	1
	106	0.082	4	26	1
	244	0.118	2	122	1
	141	0.050	2	70	1

	158	0.042	2	79	1
	100	0.115	4	25	1
	150	0.048	2	75	1
	293	0.291	4	73	1
	69	0.202	3	23	1
	28	0.067	1	28	1
MVP-MLV-AR-29	24	0.125	1	24	1.25
MVP-MLV-AR-30	70	0.001	1	70	.05

Because the slopes of the access roads vary significantly, storage calculations were performed for each, using the following methodology:



1. Determine the cross-section area (CSA) of storage behind each baffle, assuming a triangle based on bottom slope.

$$CSA = 0.5 \times A \times F \times \sin(e) + 0.5 \times E1 \times E2 \times \sin(a)$$

where CSA = Cross-sectional area; ft^2

$a = 90 - \tan^{-1}(\text{road slope})$

$b = \tan^{-1}(\text{road slope}) + \tan^{-1}(\text{baffle slope})$

$d = \tan^{-1}(\text{road slope})$

$e = \tan^{-1}(\text{baffle slope})$

$f = 180 - b$

$A = B \times (\sin(a)/\sin(b))$

B = baffle height

$E1 = A \times \sin(e)$

$E2 = A \times (\sin(e)/\sin(d))$

$F = A \times (\sin(f)/\sin(d))$

G = F - E1/baffle slope

2. Determine the storage volume available per earthen baffle.

$$Vavailable = CSA \times W \times n$$

where Vavailable = Storage volume per earthen baffle; ft^3

W = Stone width (12 ft)

n = Stone porosity (0.40)

3. Determine the number of baffle cells needed by dividing the storage volume per earthen baffle into the required treatment volume. Because it is necessary to round up to the next integer, the baffle design volume will always exceed the required treatment volume.

4. Determine the baffle cell spacing by dividing the number of baffles needed into the access road length.

To ensure the roads drain with the 72-hour maximum drawdown time, the design volumes were divided by the most conservative saturated hydraulic conductivity (Ksat) of the underlying soils. Each calculated drawdown time used the maximum depth of each triangular CSA and was multiplied by a Safety Factor of 2, resulting in the following drawdown times (all less than the 72-hour maximum). Note that several access roads span more than one different soil types with different Ksat rates.

MVP-MLV-AR-28		
MUSYM	3E	[-]
HSG	B	[-]
K_{SAT}	1.46	[IN/HR]
Max Depth	0.96	[FT]
Drawdown Time	16	[HR]
MUSYM	29	[-]
HSG	D	[-]
K_{SAT**}	0.26	[IN/HR]
Max Depth	0.92	[FT]
Drawdown Time*	43	[HR]
MUSYM	29	[-]
HSG	D	[-]
K_{SAT**}	0.26	[IN/HR]
Max Depth	0.92	[FT]
Drawdown Time	43	[HR]

MVP-MLV-AR-29		
MUSYM	7C	[-]
HSG	B	[-]
K_{SAT}	1.28	[IN/HR]
Max Depth	1.00	[FT]
Drawdown Time	19	[HR]

MVP-MLV-AR-30		
MUSYM	11A	[-]
HSG	B	[-]
K_{SAT}	1.3	[IN/HR]
Max Depth	0.50	[FT]
Drawdown Time	9	[HR]

*Note: 72-hour maximum drawdown time satisfied by reducing safety factor.
**Note: MUSYM 29 K_{SAT} assumed to equal MUSYM 25 K_{SAT}.

ii. New Impervious Cover: Main Line Valve Pads

New impervious cover in Spread 11 also includes five (5) main line valve sites (MVP-MLV-31 through -35). Increased volumes of stormwater runoff resulting from the main line valve pads will be controlled utilizing the methodology established in *MVP-33.1 through MVP-33.3 Gap Graded Gravel Detail for Mainline Valve Pads and Permanent Access Roads*. All pads will be located on relatively flat ground. The runoff volume increase when considering only the pad is greater than the resulting runoff volume increase when considering the full drainage area. As a result, the reservoir within the gap graded gravel pad is conservatively sized to accommodate the required volume computed using the pad footprint only.

Pre- and post-construction runoff volumes for the 10-year 24-hour storm were calculated using the Montgomery and Franklin County design storm values of 5.00 and 5.70 inches, respectively, per *PSS&S Section 4.2.2 Design Storms*.

10-YEAR STORM DATA					
SITE	TIME OF CONCENTRATION (PRE / POST) [HR]	CURVE NUMBER (PRE / POST)	DRAINAGE AREA [FT^2]	Q_{10} PEAK FLOW (PRE / POST) [CFS]	Q_{10} VOLUME (PRE / POST) [FT^3]
MLV-28	0.10 / 0.10	55 / 85	2,396	0.07 / 0.28	174 / 653
MLV-29	0.10 / 0.10	55 / 85	2,396	0.10 / 0.26	261 / 610
MLV-30	0.10 / 0.10	58 / 85	2,396	0.12 / 0.33	305 / 784

Any increase in runoff volume from pre- to post-construction condition must be stored within the gap graded gravel to meet flood protection requirements per 9VAC25-870-66.C.2. The calculated treatment volume required was then divided by the pad footprint and 40% void space to determine the depth of gravel required to store the 10-year 24-hour storm event. In this instance, calculated gravel depths for all pads were less than the 8-inch minimum required per *MVP-33.1 through MVP-33.3 Gap Graded Gravel Detail for Mainline Valve Pads and Permanent Access Roads*. Therefore, gravel

depths for all pads are 8 inches, providing storage beyond the 10-year 24-hour storm event.

MLV-28 Pad	Vreq	479	cf
	Area	2376	sf
	Dreq	0.50	ft
	Ddesign	8	in
	Vdesign	634	cf

MLV-29 Pad	Vreq	348	cf
	Area	2376	sf
	Dreq	0.37	ft
	Ddesign	8	in
	Vdesign	634	cf

MLV-30 Pad	Vreq	479	cf
	Area	2376	sf
	Dreq	0.50	ft
	Ddesign	8	in
	Vdesign	634	cf

To ensure the gravel pads drain with the 72-hour maximum drawdown time, the design volumes were divided by the most conservative saturated hydraulic conductivity (Ksat) of the underlying soils. Each calculated drawdown time was multiplied by a Safety Factor of 2, resulting in the following drawdown times, all less than the 72-hour maximum.

MVP-MLV-28		
MUSYM	3E	[-]
HSG	B	[-]
K_{SAT}	1.46	[IN/HR]
Depth	8	[IN]
Drawdown Time	11	[HR]

MVP-MLV-29		
MUSYM	7C / 7D	[-]

HSG	B	[-]
K_{SAT}	1.28	[IN/HR]
Depth	8	[IN]
Drawdown Time	13	[HR]

MVP-MLV-30		
MUSYM	11A	[-]
HSG	B	[-]
K_{SAT}	1.3	[IN/HR]
Depth	8	[IN]
Drawdown Time	12	[HR]

Results show the 10-year 24-hour storm event will be stored within the gravel layer with no overtopping, and with reasonable drawdown times before the next storm event.

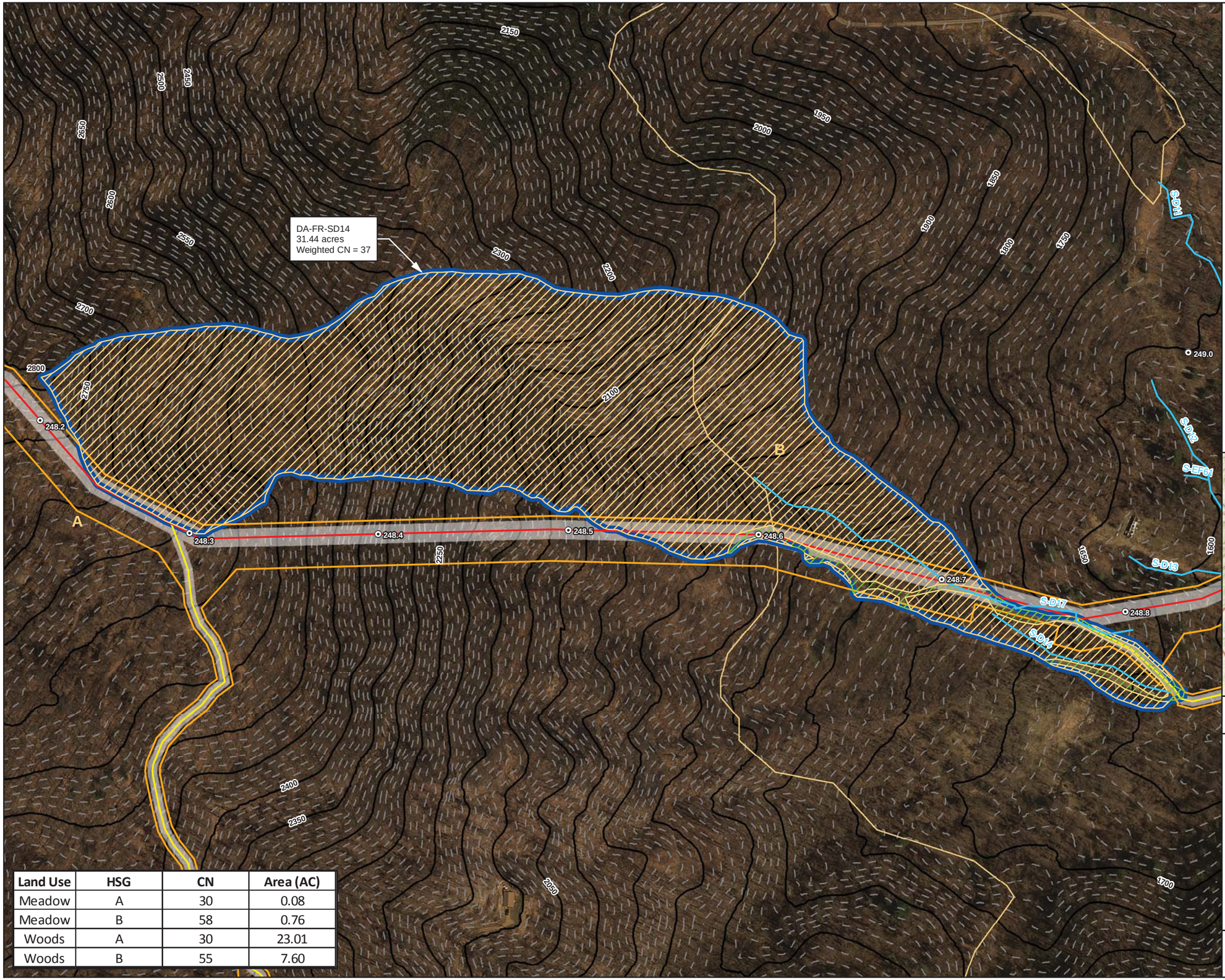
Construction Spread 10 - Approximate STA 10791+00 to Approximate STA 12371+10				
Drainage Area ID	**Existing Conditions Plan Sheet No.**	**Erosion and Sediment Control Plan Sheet No.**	**Post-Construction Stormwater Management Plan Sheet No.**	**Spread 10 - Culvert Design Calculations (pdf pages)**
Sta. 7+16.47 (S-D14) Culvert	14.70EX	14.70ES	14.70PC	pages 2-35

		Culvert Design					[1]Riprap Apron Outlet Protection Design						
Station	Corresponding Stream	[3]Culvert Diameter, d_o (in)	Culvert Material	[2]Pipe Slope (ft/ft)	Q (cfs)	Design Flow Frequency	d_{50} Riprap Size, d_{50} (in)	AASHTO Riprap Class	Placement Thickness per NSA Riprap Gradation, d (in)	Placement Thickness per AASHTO Riprap Gradation, d (in)	Apron Length, L_a (ft)	Apron Initial Width, W_i (ft)	Apron Terminal Width, W (ft)
7 + 16.47	S-D14	N/A (Box Culvert: Span=3.0-ft, Rise=3.0-ft)	Concrete	0.301	1.907	10-Yr	N/A - Scour protection needs to withstand tailwater velocity of 4.28 ft/s and shear stress of 1.20 psf. Suggest AASHTO Riprap Class A or equivalent. Note that scour protection should be placed within the channel from top-of-bank to top-of-bank, and extend from the culvert outlet to the limit of disturbance.						

[1]Designed in accordance with VESCH Std & Spec 3.18 assuming minimum tailwater condition ($T_w < 0.5d_o$).

[2]The slope was calculated from a combination of LIDAR and field notes taken for the stream channel characteristics.

[3]Requires roadway grading (fill of 1 foot) to install culvert with minimum recommended cover of 2 inches.



Land Use	HSG	CN	Area (AC)
Meadow	A	30	0.08
Meadow	B	58	0.76
Woods	A	30	23.01
Woods	B	55	7.60

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Permanent Access Road
- Limit of Disturbance
- Permanent Right-of-Way
- Meadow
- Woods
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

N
W E
S

1:3,120

260 130 0 260
Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area Map
DA-FR-SD14
Spread 10

Figure 1
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Agricultural Area from National Land Cover Database (NLCD) 2011, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016 and Radford University DEMs, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-SD17_Pre.mxd

DA-FR-SD14
31.44 acres
Weighted CN = 37

DA-FR-SD14 Permanent ROW
1.65 acres

Land Use	HSG	CN	Area (AC)
Meadow	A	30	0.69
Meadow	B	58	1.24
Gravel	B	85	0.10
Woods	A	30	21.96
Woods	B	55	6.24
Brush	A	30	0.44
Brush	B	48	0.78

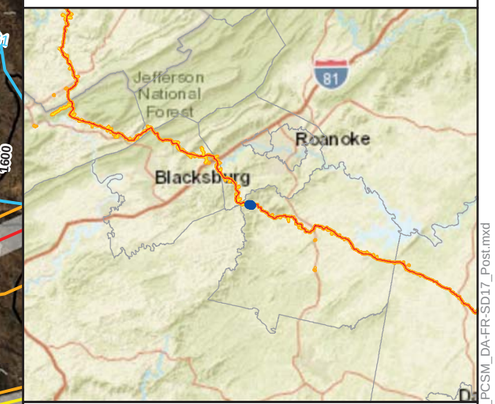
Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Permanent Access Road
- Limit of Disturbance
- Permanent Right-of-Way
- Brush
- Gravel
- Meadow
- Woods
- Drainage Area
- Hydrologic Soil Groups

NAD 1983 UTM 17N (feet)

1:3,120

260 130 0 260 Feet



Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area Map
DA-FR-SD14
Spread 10

Figure 2
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Agricultural Area from National Land Cover Database (NLCD) 2011, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016 and Radford University DEMs, Soils from NRCS Gridded Soil Survey Geographic (SSURGO) database 2014, Land Use digitized from ESRI World Imagery 2015.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\Franklin\MVP_PCSM_DA-FR-SD17_Post.mxd

DA-FR-SD14
31.44 acres
Weighted CN = 37

Pre-Construction Time of Concentration				
	Sheet	Shallow	Channel A	Calculated Time of Concentration (min)
S-D14	100.0 FT @ 36%	1487.10 FT @ 48.67%	1899.1 FT @ 22.22%	15.5

Legend

- Milepost
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Permanent Access Road
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:3,120

260 130 0 260 Feet

N W E S

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Pre-Construction Drainage Area and Time of Concentration DA-FR-SD14 Spread 10

Figure 3
Franklin County, Virginia

September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016 and Radford University DEMs.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\FranklinFigures 3-4\MVP_PCSM_DA-FR-SD17_3.mxd

DA-FR-SD14
31.44 acres
Weighted CN = 37

Post-Construction Time of Concentration				
	Sheet	Shallow	Channel A	Calculated Time of Concentration (min)
S-D14	100.0 FT @ 36%	1487.10 FT @ 48.67%	1899.1 FT @ 22.22%	15.5

Legend

- Milepost
- Permanent Waterbars
- Delineated Stream
- Existing 50' Contour
- Existing 10' Contour
- Alignment Centerline
- Permanent Access Road
- Limit of Disturbance
- Permanent Right-of-Way
- Time of Concentration
- Drainage Area

NAD 1983 UTM 17N (feet)

1:3,120

260 130 0 260 Feet

Mountain Valley Pipeline Project

Mountain Valley PIPELINE

Post-Construction Drainage Area and Time of Concentration DA-FR-SD14 Spread 10

Figure 4
Franklin County, Virginia
September, 2017

Data Sources: Imagery from ESRI Streaming Data 2014, Delineated streams surveyed by Tetra Tech Inc. 2014 to 2017, Transportation data from VITA map layer 2016, Elevation data derived from LiDAR provided by EQT 2016 and Radford University DEMs.

Document Path: PGH P:\GIS\EQT_MVP\Mapdocs\Drainage\MXD\FranklinFigures 3-4\MVP_PCSM_DA-FR-SD17_4.mxd

COMPOSITE CURVE NUMBER COMPUTATION SHEET

S-D14 Pre-Construction
See calculation in Hydraflow report

S-D17 Post-Construction				
LAND USE	**HSG**	**CN**	**AREA (AC)**	**Area Weighted CN**
Meadow	A	30	0.687	0.656
Meadow	B	58	1.241	2.289
Gravel	B	85	0.101	0.274
Woods	A	30	21.96	20.96
Woods	B	55	6.237	10.91
Brush	A	30	0.435	0.415
Brush	B	48	0.777	1.186
			31.44	37

= Composite CN

Table 1 – Manning's n Values for Sheet Flow

Land Surface Type	**Manning n**
Grass:	
Average Grass Cover	0.40
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Light Turf	0.20
Dense Turf	0.17 – 0.80
Dense Grass	0.17 – 0.30
Bermuda Grass	0.30 – 0.48
Dense Shrubbery and Forest Litter	0.40
Natural:	
Short Grass Prairie	0.10 – 0.20
Poor Grass Cover, Moderately Rough Surface	0.30 – 0.40
Sparse Vegetation	0.05 – 0.13
Oak Grasslands, Open Grasslands	0.60
Dense Cover of Trees and Bushes	0.80
Rangeland:	
Typical	0.13
No Debris Cover	0.09 – 0.34
20% Debris Cover	0.05 – 0.25
Woods:	
Light Underbrush	0.40
Dense Underbrush	0.80
Rural Residential (1 – 10 acre lots, Maintenance or grazing assumed)	0.40

Note:

Manning's n values for sheet flow that are used in Hydraflow Hydrographs are highlighted.

Sources:

-USACE, 1998, HEC-1 Flood Hydrograph Package User's Manual, Hydrologic Engineering Center, Davis, CA

-Soil Conservation Service, 1986, Urban Hydrology for Small Watersheds, Technical Release 55, U.S. Department of Agriculture, Washington, DC

Table 2 – Manning's n Values for Open Channel Flow

Channel Type	Manning n		
	Min.	Normal	Max.
1. Excavated or Dredged Channels[1]			
a. Earth, Straight, and Uniform:			
Clean, recently completed	0.016	0.018	0.020
Clean, after weathering	0.018	0.022	0.025
Gravel, uniform section, clean	0.022	0.025	0.030
With short grass, few weeds	0.022	0.027	0.033
b. Earth Winding and Sluggish:			
No vegetation	0.023	0.025	0.030
Grass, some weeds	0.025	0.030	0.033
Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
Earth bottom and rubble sides	0.028	0.030	0.035
Stony bottom and weedy banks	0.025	0.035	0.040
Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-Excavated or Dredged:			
No vegetation	0.025	0.028	0.033
Light brush on banks	0.035	0.050	0.060
d. Rock Cuts:			
Smooth and uniform	0.025	0.035	0.040
Jagged and irregular	0.035	0.040	0.050
e. Channels not Maintained, Weeds and Brush Uncut:			
Dense weeds, high as flow depth	0.050	0.080	0.120
Clean bottom, brush on sides	0.040	0.050	0.080
Same as above, highest stage of flow	0.045	0.070	0.110
Dense brush, high stage	0.080	0.100	0.140
2. Main Channels[2]			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective	0.040	0.048	0.055
f. Same as (d) with more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150

Notes:

[1]A Manning's n value of 0.040 was used in Hydraflow Hydrographs for roadside channels.

[2]A Manning's n value of 0.030 was used in Hydraflow Hydrographs for existing/natural channels.

Sources:

-ASCE, (1982), Gravity Sanitary Sewer Design and Construction, ASCE Manual of Practice No. 60, New York, NY

-Chow, V.T., (1959), Open Channel Hydraulics, McGraw-Hill, New York, NY

Watershed Model Schematic

Legend

Hyd.	Origin	Description
1	SCS Runoff	Culvt S-D14 Pre-
2	SCS Runoff	Culvt S-D14 Post-
3	SCS Runoff	Culvt S-D14 Preforested-

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow hyd(s)	Peak Outflow (cfs)							Hydrograph Description
			1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	SCS Runoff	------	0.000	-------	-------	-------	1.907	-------	-------	-------	Culvt S-D14 Pre-
2	SCS Runoff	------	0.000	-------	-------	-------	1.907	-------	-------	-------	Culvt S-D14 Post-
3	SCS Runoff	------	0.000	-------	-------	-------	1.907	-------	-------	-------	Culvt S-D14 Preforested-

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v11

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	0.000	1	n/a	0	------	------	------	Culvt S-D14 Pre-
2	SCS Runoff	0.000	1	n/a	0	------	------	------	Culvt S-D14 Post-
3	SCS Runoff	0.000	1	n/a	0	------	------	------	Culvt S-D14 Preforested-

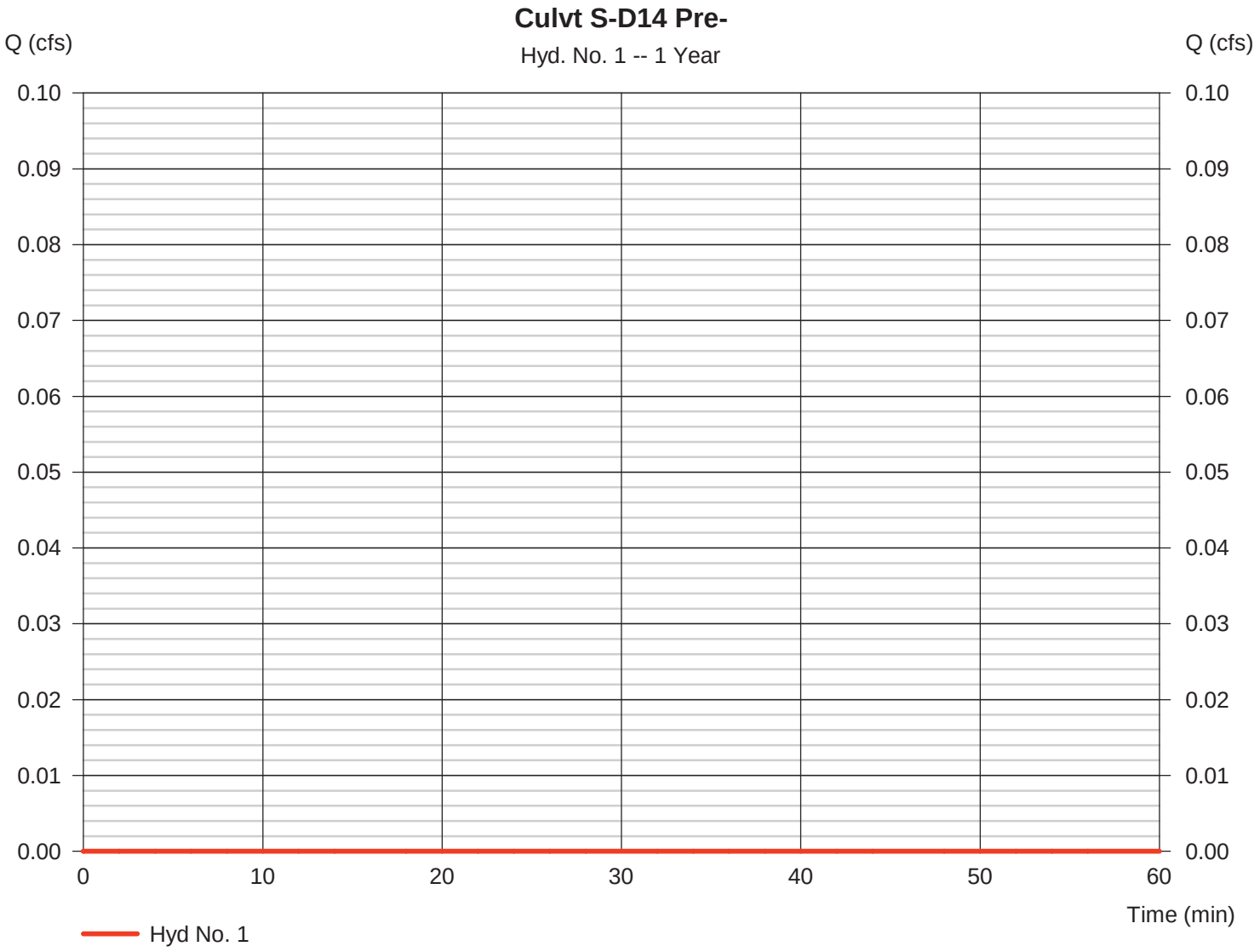
Hydrograph Report

Hyd. No. 1

Culvt S-D14 Pre-

Hydrograph type	= SCS Runoff	Peak discharge	= 0.000 cfs
Storm frequency	= 1 yrs	Time to peak	= n/a
Time interval	= 1 min	Hyd. volume	= 0 cuft
Drainage area	= 31.440 ac	Curve number	= 37*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0.075 x 30) + (0.758 x 58) + (23.011 x 30) + (7.597 x 55)] / 31.440



TR55 Tc Worksheet

Hyd. No. 1

Culvt S-D14 Pre-

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.800		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 36.00		0.00		0.00		
Travel Time (min)	**= 10.94**	**+**	**0.00**	**+**	**0.00**	**=**	**10.94**
Shallow Concentrated Flow							
Flow length (ft)	= 1487.10		0.00		0.00		
Watercourse slope (%)	= 48.67		0.00		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=11.26		0.00		0.00		
Travel Time (min)	**= 2.20**	**+**	**0.00**	**+**	**0.00**	**=**	**2.20**
Channel Flow							
X sectional flow area (sqft)	= 3.50		0.00		0.00		
Wetted perimeter (ft)	= 8.00		0.00		0.00		
Channel slope (%)	= 22.22		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=13.46						
			0.00				
					0.00		
Flow length (ft)	({0})1899.1		0.0		0.0		
Travel Time (min)	**= 2.35**	**+**	**0.00**	**+**	**0.00**	**=**	**2.35**

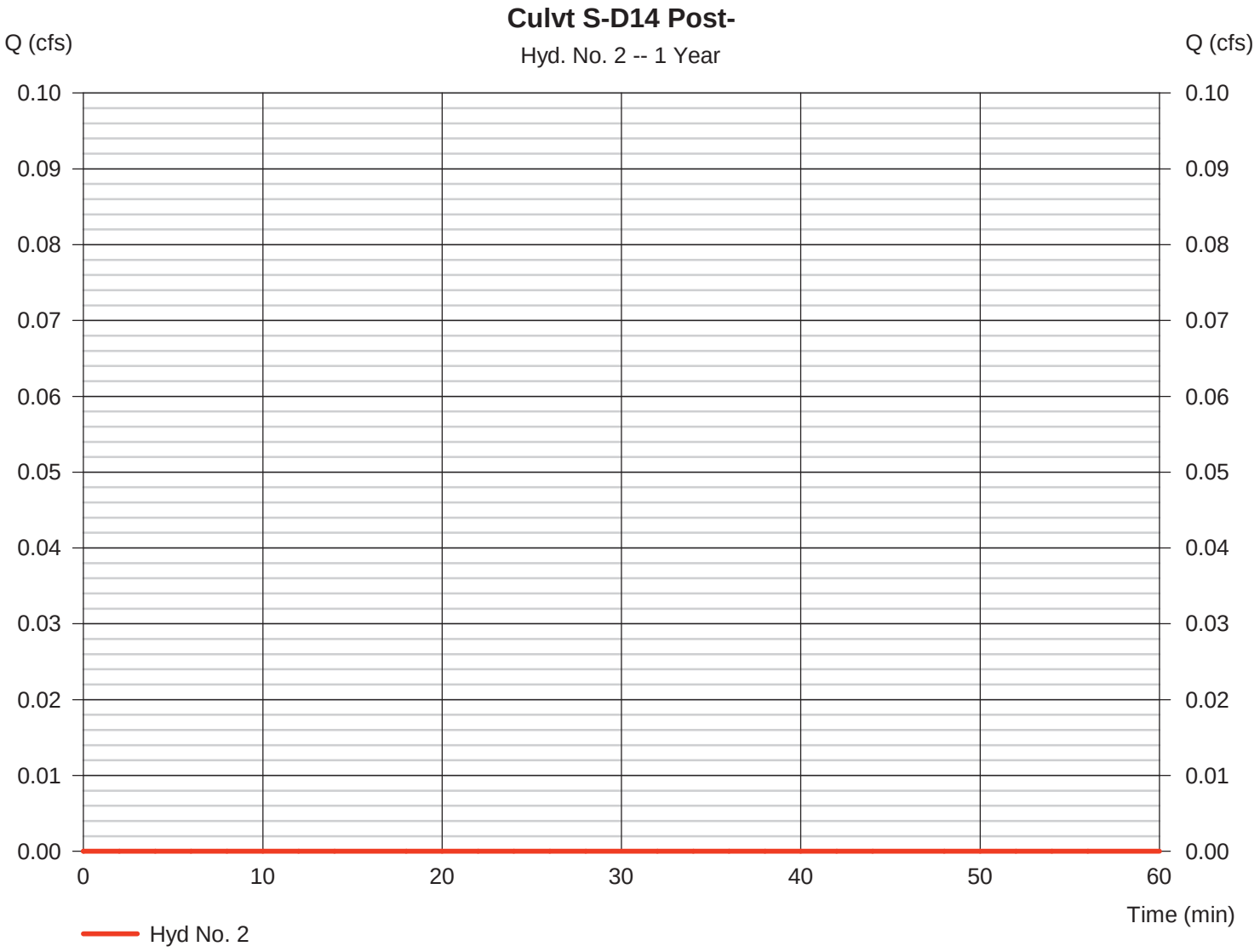
Total Travel Time, Tc ..... 15.50 min

Hydrograph Report

Hyd. No. 2

Culvt S-D14 Post-

Hydrograph type	= SCS Runoff	Peak discharge	= 0.000 cfs
Storm frequency	= 1 yrs	Time to peak	= n/a
Time interval	= 1 min	Hyd. volume	= 0 cuft
Drainage area	= 31.440 ac	Curve number	= 37
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484



TR55 Tc Worksheet

Hyd. No. 2

Culvt S-D14 Post-

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.800		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 36.00		0.00		0.00		
Travel Time (min)	**= 10.94**	**+**	**0.00**	**+**	**0.00**	**=**	**10.94**
Shallow Concentrated Flow							
Flow length (ft)	= 1487.10		0.00		0.00		
Watercourse slope (%)	= 48.67		0.00		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=11.26		0.00		0.00		
Travel Time (min)	**= 2.20**	**+**	**0.00**	**+**	**0.00**	**=**	**2.20**
Channel Flow							
X sectional flow area (sqft)	= 3.50		0.00		0.00		
Wetted perimeter (ft)	= 8.00		0.00		0.00		
Channel slope (%)	= 22.22		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=13.46						
			0.00				
					0.00		
Flow length (ft)	({0})1899.1		0.0		0.0		
Travel Time (min)	**= 2.35**	**+**	**0.00**	**+**	**0.00**	**=**	**2.35**

Total Travel Time, Tc ..... 15.50 min

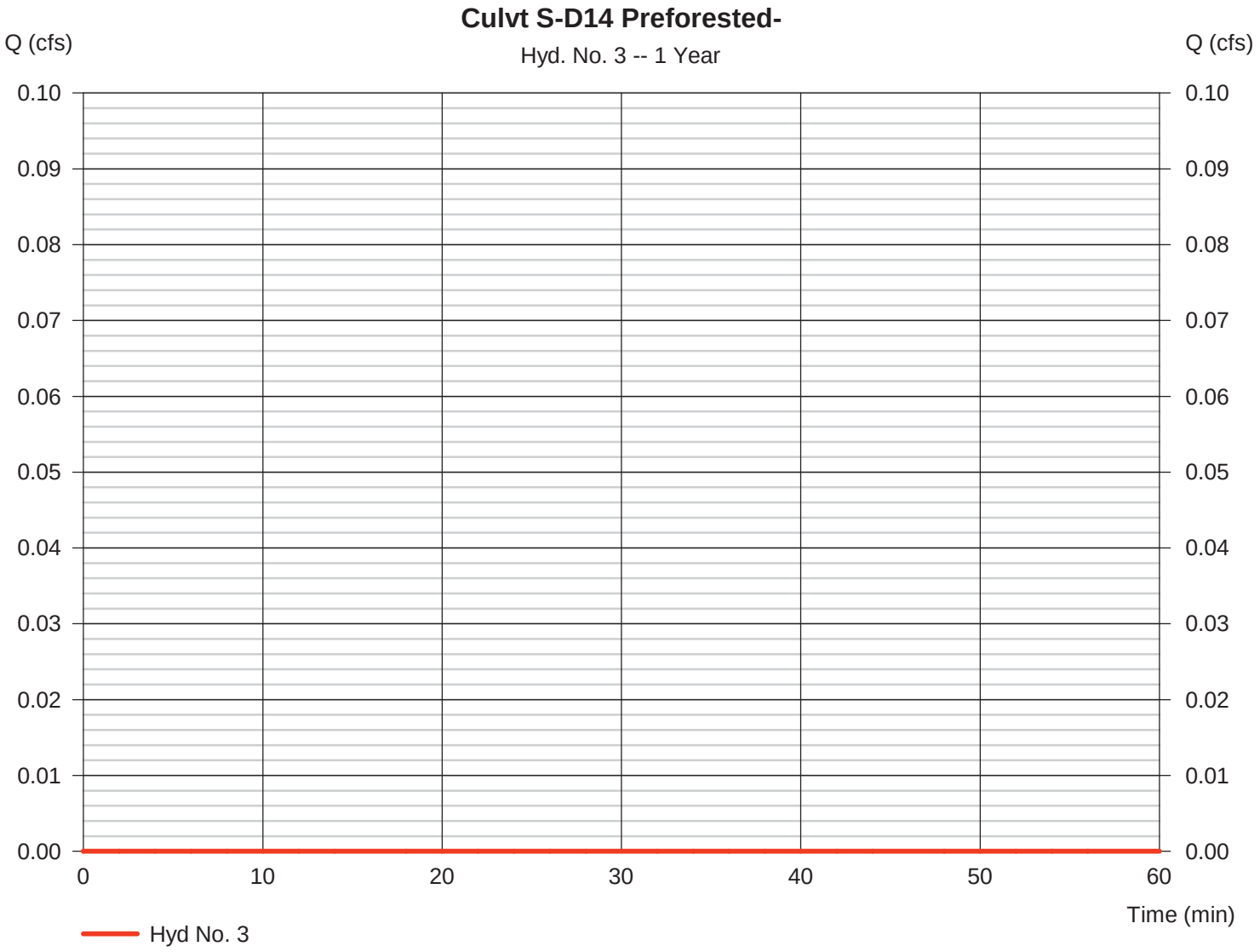
Hydrograph Report

Hyd. No. 3

Culvt S-D14 Preforested-

Hydrograph type	= SCS Runoff	Peak discharge	= 0.000 cfs
Storm frequency	= 1 yrs	Time to peak	= n/a
Time interval	= 1 min	Hyd. volume	= 0 cuft
Drainage area	= 31.440 ac	Curve number	= 37*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 15.50 min
Total precip.	= 3.30 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(23.087 x 30) + (8.356 x 55)] / 31.440



TR55 Tc Worksheet

Hyd. No. 3

Culvt S-D14 Preforested-

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.800		0.011		0.011		
Flow length (ft)	= 100.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.70		0.00		0.00		
Land slope (%)	= 36.00		0.00		0.00		
Travel Time (min)	**= 10.94**	**+**	**0.00**	**+**	**0.00**	**=**	**10.94**
Shallow Concentrated Flow							
Flow length (ft)	= 1487.10		0.00		0.00		
Watercourse slope (%)	= 48.67		0.00		0.00		
Surface description	= Unpaved		Unpaved		Paved		
Average velocity (ft/s)	=11.26		0.00		0.00		
Travel Time (min)	**= 2.20**	**+**	**0.00**	**+**	**0.00**	**=**	**2.20**
Channel Flow							
X sectional flow area (sqft)	= 3.50		0.00		0.00		
Wetted perimeter (ft)	= 8.00		0.00		0.00		
Channel slope (%)	= 22.22		0.00		0.00		
Manning's n-value	= 0.030		0.015		0.015		
Velocity (ft/s)	=13.46						
			0.00				
					0.00		
Flow length (ft)	({0})1899.1		0.0		0.0		
Travel Time (min)	**= 2.35**	**+**	**0.00**	**+**	**0.00**	**=**	**2.35**

Total Travel Time, Tc ..... 15.50 min

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2016 by Autodesk, Inc. v11

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to Peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph Description
1	SCS Runoff	1.907	1	738	31,488	------	------	------	Culvt S-D14 Pre-
2	SCS Runoff	1.907	1	738	31,488	------	------	------	Culvt S-D14 Post-
3	SCS Runoff	1.907	1	738	31,488	------	------	------	Culvt S-D14 Preforested-

Hydrograph Report

Hyd. No. 1

Culvt S-D14 Pre-

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.907 cfs
Storm frequency	=	10 yrs	Time to peak	=	738 min
Time interval	=	1 min	Hyd. volume	=	31,488 cuft
Drainage area	=	31.440 ac	Curve number	=	37*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.50 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(0.075 x 30) + (0.758 x 58) + (23.011 x 30) + (7.597 x 55)] / 31.440

Hydrograph Report

Hyd. No. 2

Culvt S-D14 Post-

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.907 cfs
Storm frequency	=	10 yrs	Time to peak	=	738 min
Time interval	=	1 min	Hyd. volume	=	31,488 cuft
Drainage area	=	31.440 ac	Curve number	=	37
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.50 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

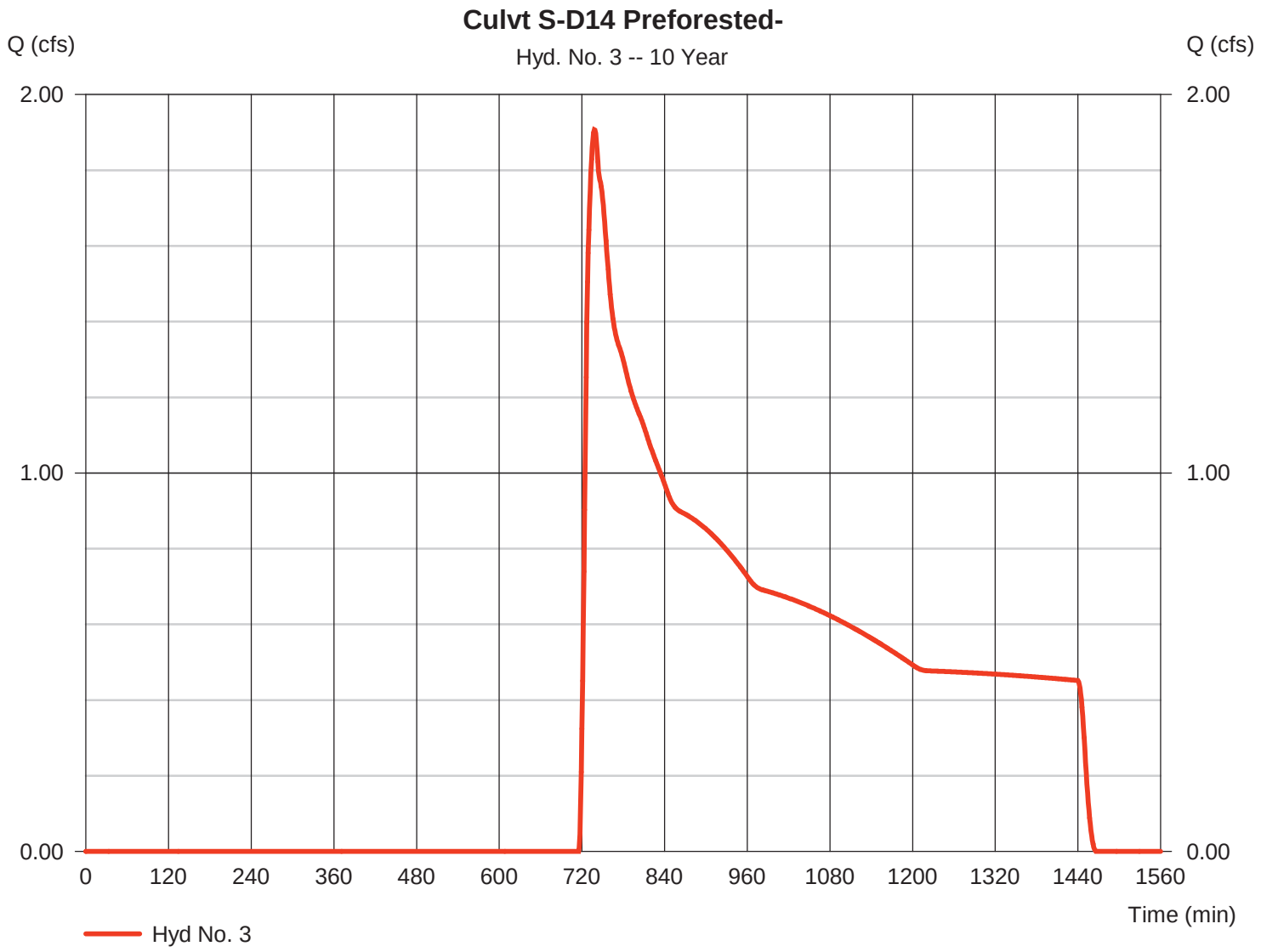
Hydrograph Report

Hyd. No. 3

Culvt S-D14 Preforested-

Hydrograph type	=	SCS Runoff	Peak discharge	=	1.907 cfs
Storm frequency	=	10 yrs	Time to peak	=	738 min
Time interval	=	1 min	Hyd. volume	=	31,488 cuft
Drainage area	=	31.440 ac	Curve number	=	37*
Basin Slope	=	0.0 %	Hydraulic length	=	0 ft
Tc method	=	TR55	Time of conc. (Tc)	=	15.50 min
Total precip.	=	5.70 in	Distribution	=	Type II
Storm duration	=	24 hrs	Shape factor	=	484

* Composite (Area/CN) = [(23.087 x 30) + (8.356 x 55)] / 31.440



Hydraflow Rainfall Report

Return Period (Yrs)	Intensity-Duration-Frequency Equation Coefficients (FHA)			
	B	D	E	(N/A)
1	0.0000	0.0000	0.0000	--------
2	69.8703	13.1000	0.8658	--------
3	0.0000	0.0000	0.0000	--------
5	79.2597	14.6000	0.8369	--------
10	88.2351	15.5000	0.8279	--------
25	102.6072	16.5000	0.8217	--------
50	114.8193	17.2000	0.8199	--------
100	127.1596	17.8000	0.8186	--------

File name: SampleFHA.idf

Intensity = B / (Tc + D)^E

Return Period (Yrs)	Intensity Values (in/hr)											
	5 min	10	15	20	25	30	35	40	45	50	55	60
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	5.69	4.61	3.89	3.38	2.99	2.69	2.44	2.24	2.07	1.93	1.81	1.70
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	6.57	5.43	4.65	4.08	3.65	3.30	3.02	2.79	2.59	2.42	2.27	2.15
10	7.24	6.04	5.21	4.59	4.12	3.74	3.43	3.17	2.95	2.77	2.60	2.46
25	8.25	6.95	6.03	5.34	4.80	4.38	4.02	3.73	3.48	3.26	3.07	2.91
50	9.04	7.65	6.66	5.92	5.34	4.87	4.49	4.16	3.88	3.65	3.44	3.25
100	9.83	8.36	7.30	6.50	5.87	5.36	4.94	4.59	4.29	4.03	3.80	3.60

Tc = time in minutes. Values may exceed 60.

-L - Mark Sladic\EQT\Project\112IC07157 MVP\Virginia Stormwater\Culvert Design - Other\Culvert S-D17\Franklin.pcp

Storm Distribution	Rainfall Precipitation Table (in)							
	1-yr	2-yr	3-yr	5-yr	10-yr	25-yr	50-yr	100-yr
SCS 24-hour	3.30	0.00	0.00	0.00	5.70	6.00	0.00	0.00
SCS 6-Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-1st	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-2nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-3rd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-4th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Huff-Indy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Hydraflow Table of Contents

ENERGY BALANCE METHOD

Inputs:

	1-Yr Event	
	Peak Flow, Q (cfs)	Runoff Volume, RV (cf)
Pre-Developed Condition	0.000	0
Developed Condition	0.000	0
Pre-Developed (Forest) Condition	0.000	0

*Peak Flow and Runoff Volume inputs taken from Hydraflow Hydrographs model

Calculations:

[1] ***Check #1:***	$Q_{developed} \leq IF \times [(Q_{pre\text{-}developed} \times RV_{pre\text{-}developed}) / RV_{developed}]$ ---------->	0.000	≤ OK	0.000
Check #2:	$Q_{developed} \leq Q_{pre\text{-}developed}$ ---------->	0.000	≤ OK	0.000
Check #3:	$Q_{developed}$ ***shall not*** be required to be ≤ $(Q_{forest} \times RV_{forest}) / RV_{developed}$ --->	0.000	***shall not*** be required to be ≤	0.000

STORMWATER QUANTITY REQUIREMENTS ARE SATISFIED

[1] Per VADEQ, the improvement factor can be waived if the road is being maintained within the current footprint.

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 1.907 cfs

Design Flow: 1.907 cfs

Maximum Flow: 1.907 cfs

Table 1 - Summary of Culvert Flows at Crossing: S-D14

Headwater Elevation (ft)	Total Discharge (cfs)	S-D14 Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1629.99	1.91	1.91	0.00	1
1631.21	9.27	9.27	0.00	Overtopping

Rating Curve Plot for Crossing: S-D14

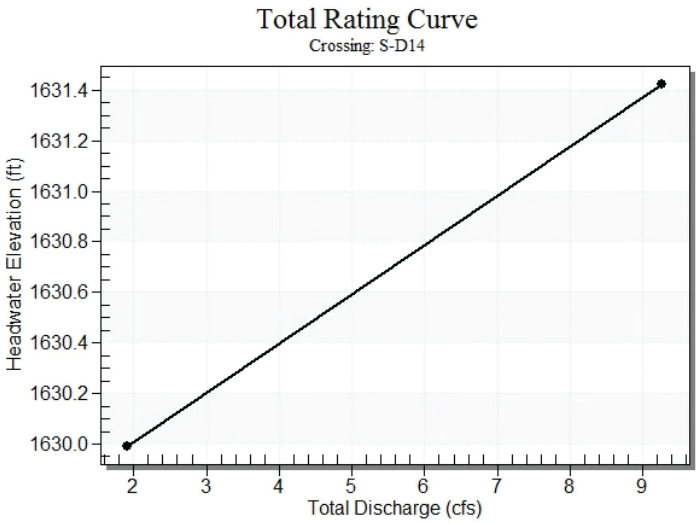


Table 2 - Culvert Summary Table: S-D14 Culvert

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277
1.91	1.91	1629.99	0.281	0.0*	1-S2n	0.112	0.238	0.112	0.064	5.523	4.277

* Full Flow Headwater elevation is below inlet invert.

****

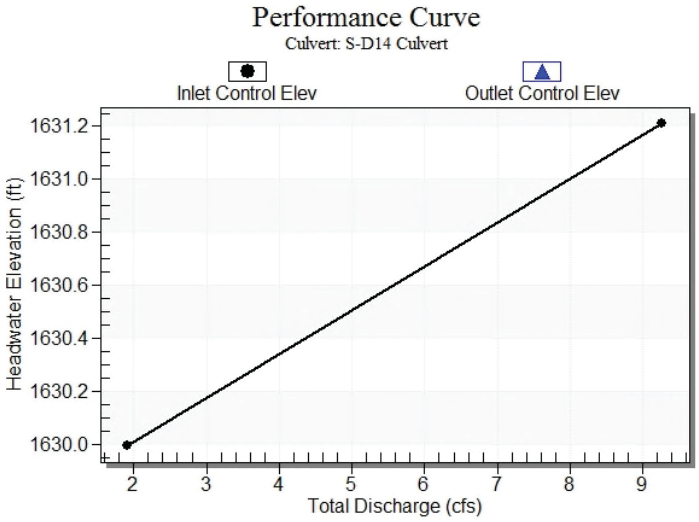
Straight Culvert

Inlet Elevation (invert): 1629.71 ft, Outlet Elevation (invert): 1627.30 ft

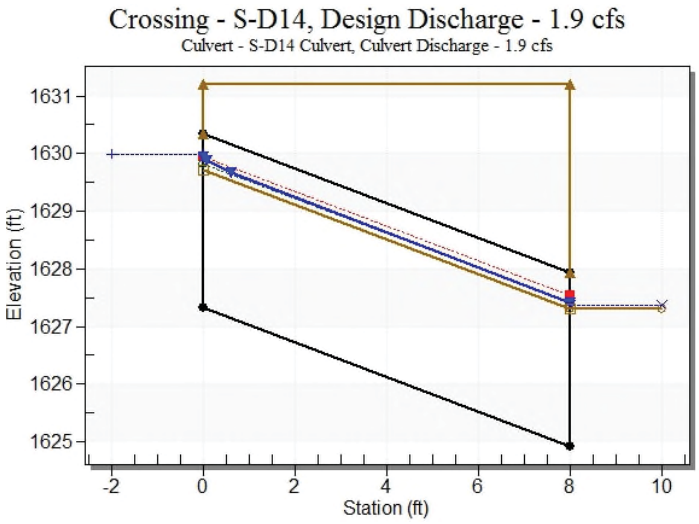
Culvert Length: 8.35 ft, Culvert Slope: 0.3010

****

Culvert Performance Curve Plot: S-D14 Culvert



Water Surface Profile Plot for Culvert: S-D14 Culvert



Site Data - S-D14 Culvert

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 1627.34 ft
Outlet Station: 8.00 ft
Outlet Elevation: 1624.93 ft
Number of Barrels: 1

Culvert Data Summary - S-D14 Culvert

Barrel Shape: Concrete Box
Barrel Span: 3.00 ft
Barrel Rise: 3.00 ft
Barrel Material: Concrete
Embedment: 28.50 in
Barrel Manning's n: 0.0120 (top and sides)
Manning's n: 0.0350 (bottom)
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: S-D14)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99
1.91	1627.37	0.06	4.28	1.20	2.99

Tailwater Channel Data - S-D14

Tailwater Channel Option: Rectangular Channel

Bottom Width: 7.00 ft

Channel Slope: 0.3010

Channel Manning's n: 0.0300

Channel Invert Elevation: 1627.30 ft

Roadway Data for Crossing: S-D14

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 8.00 ft

Crest Elevation: 1631.21 ft

Roadway Surface: Gravel

Roadway Top Width: 8.00 ft