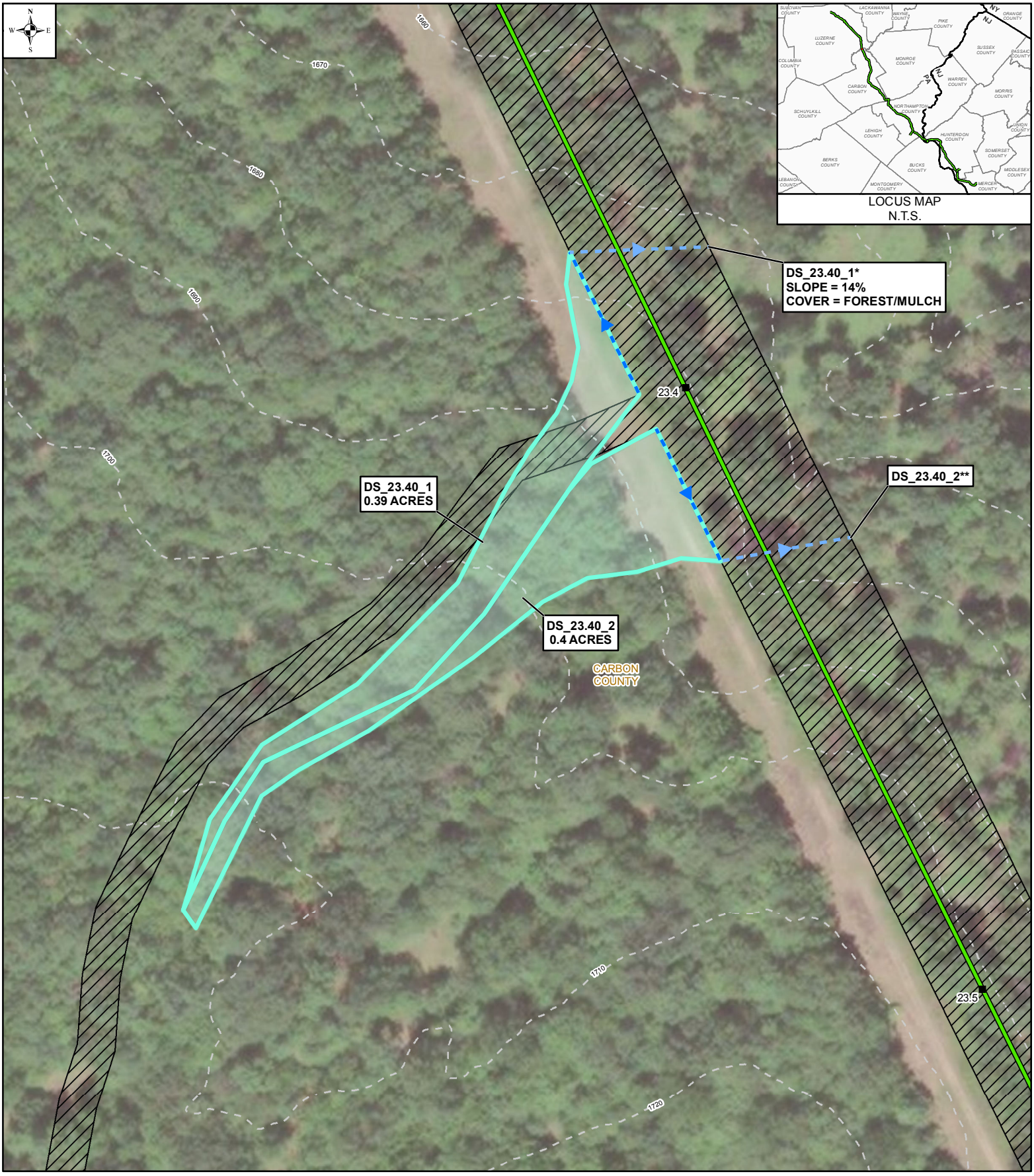
Appendix 2B
Carbon County



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_23.40

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 28 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_23.40_1
0.39 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 23.40_1	100	0.4	0.030	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 23.40_1	431	FOREST	0.053	0.58	12.40
	103	PAVEMENT	0.116	6.92	0.25

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
23.17

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 23.40_1	1	FOREST	0.20	0.31	0.06	0.30
	2	INDUSTRIAL	0.69	0.08	0.06	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	23.17	2.64	3.20	3.68	2.64	3.20	3.68

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.30	3.20	0.39	0.31	0.38	0.43

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_23.40_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.39		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.38		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	8.12		
PROTECTIVE LINING[2,6]		P300		
n (MANNING'S COEFFICIENT)[2]		0.034		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.68		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.50		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	13.89 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	13.89		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.74		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.08		
S_C (CRITICAL SLOPE)	(FT/FT)	0.029		
$.7S_c$	(FT/FT)	0.021		
$1.3S_c$	(FT/FT)	0.038		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

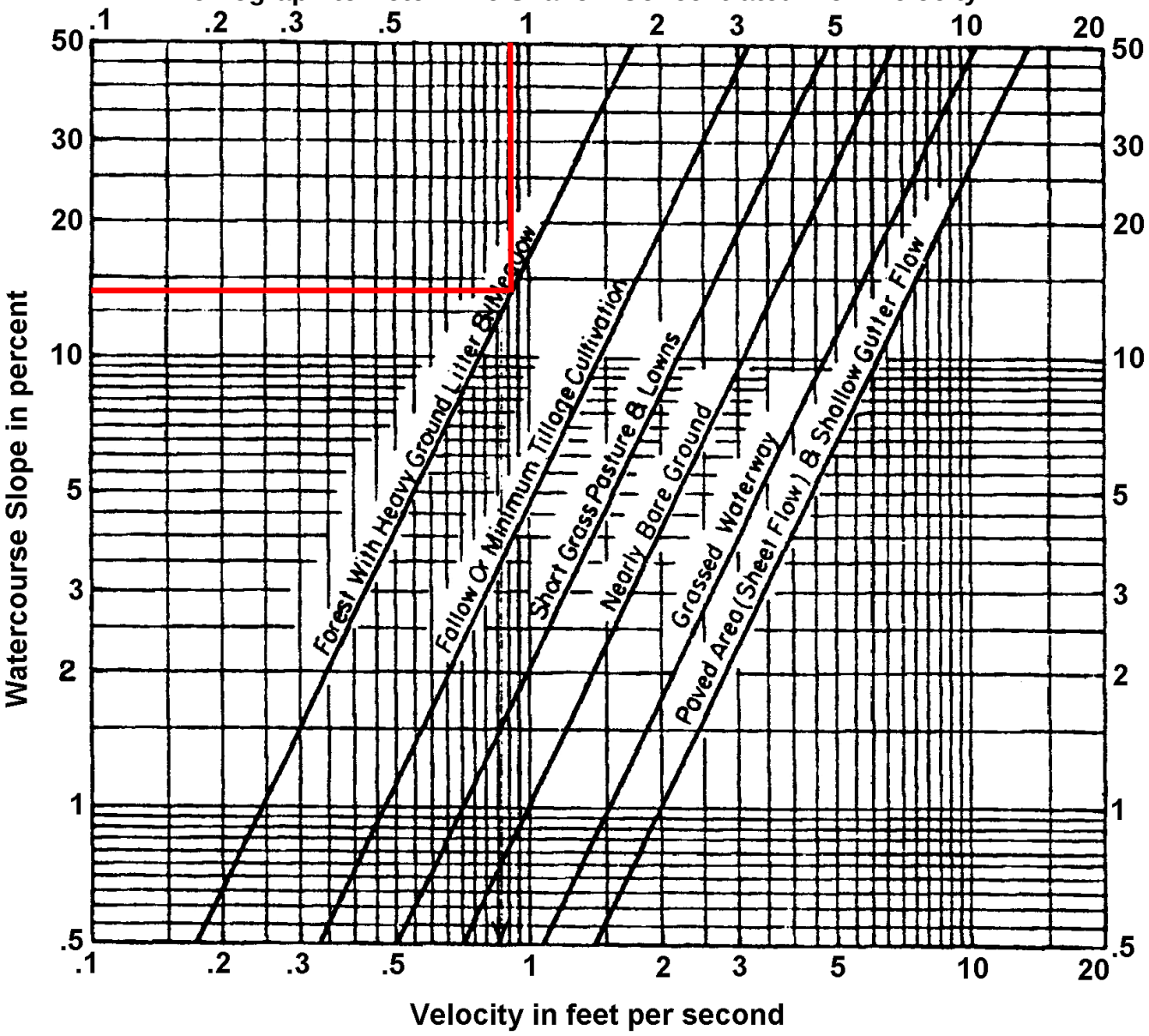
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_23.40_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_23.40_2
0.4 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 23.40_2	100	0.4	0.029	10.61

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 23.40_2	392	FOREST	0.046	0.54	12.11
	58	PAVEMENT	0.103	6.52	0.15

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
22.86

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 23.40_2	1	FOREST	0.20	0.30	0.06	0.24
	2	INDUSTRIAL	0.69	0.02	0.01	
	3	OPEN SPACE	0.28	0.08	0.02	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	22.86	2.66	3.22	3.71	2.66	3.22	3.71

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.24	3.22	0.40	0.26	0.31	0.36

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

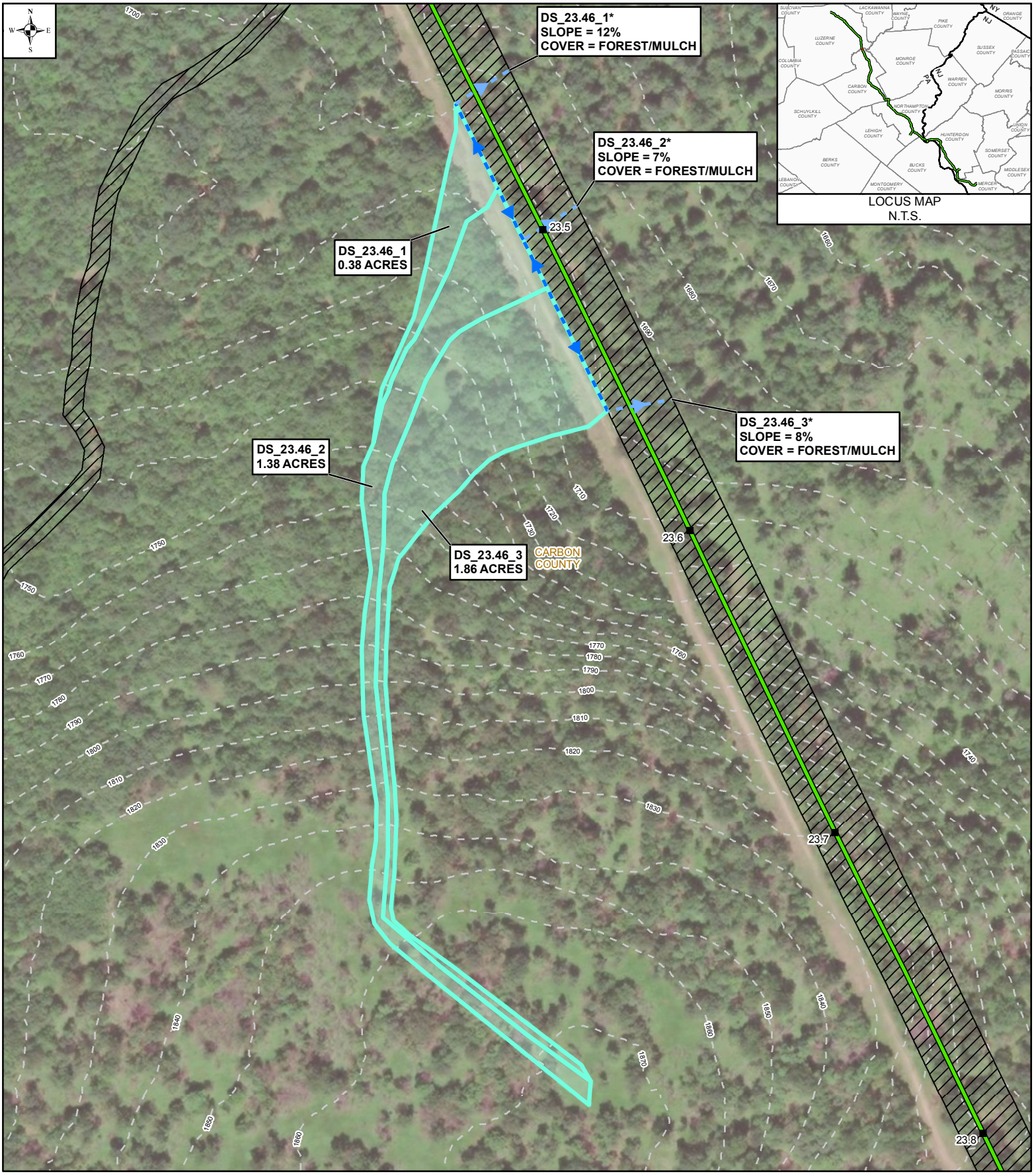
LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_23.40_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.4		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.31		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.92		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.61		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	9.52 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	9.52		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.76		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.19		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.026		
S_C (CRITICAL SLOPE)	(FT/FT)	0.080		
$.7S_c$	(FT/FT)	0.056		
$1.3S_c$	(FT/FT)	0.105		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_23.46

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	APPROVED BY: MJD 10/2019	SCALE: 1 INCH = 200 FEET
CHECKED BY:JMB 10/2019	REV. DATE: 10/2019	REV.: 1

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 29 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_23.46_1
0.38 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 23.46_1	100	0.4	0.095	8.04

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 23.46_1	367	FOREST	0.087	0.74	8.24
	87	PAVEMENT	0.092	6.17	0.24

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
16.52

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 23.46_1	1	FOREST	0.20	0.28	0.06	0.25
	2	INDUSTRIAL	0.69	0.03	0.02	
	3	OPEN SPACE	0.28	0.07	0.02	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	16.52	3.16	3.80	4.30	3.16	3.80	4.30

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.25	3.80	0.38	0.30	0.37	0.41

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_23.46_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.38		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.37		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	6.42		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.41		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.68		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	21.28 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	21.28		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	10.64		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.66		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.054		
S_C (CRITICAL SLOPE)	(FT/FT)	0.074		
$.7S_c$	(FT/FT)	0.052		
$1.3S_c$	(FT/FT)	0.097		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

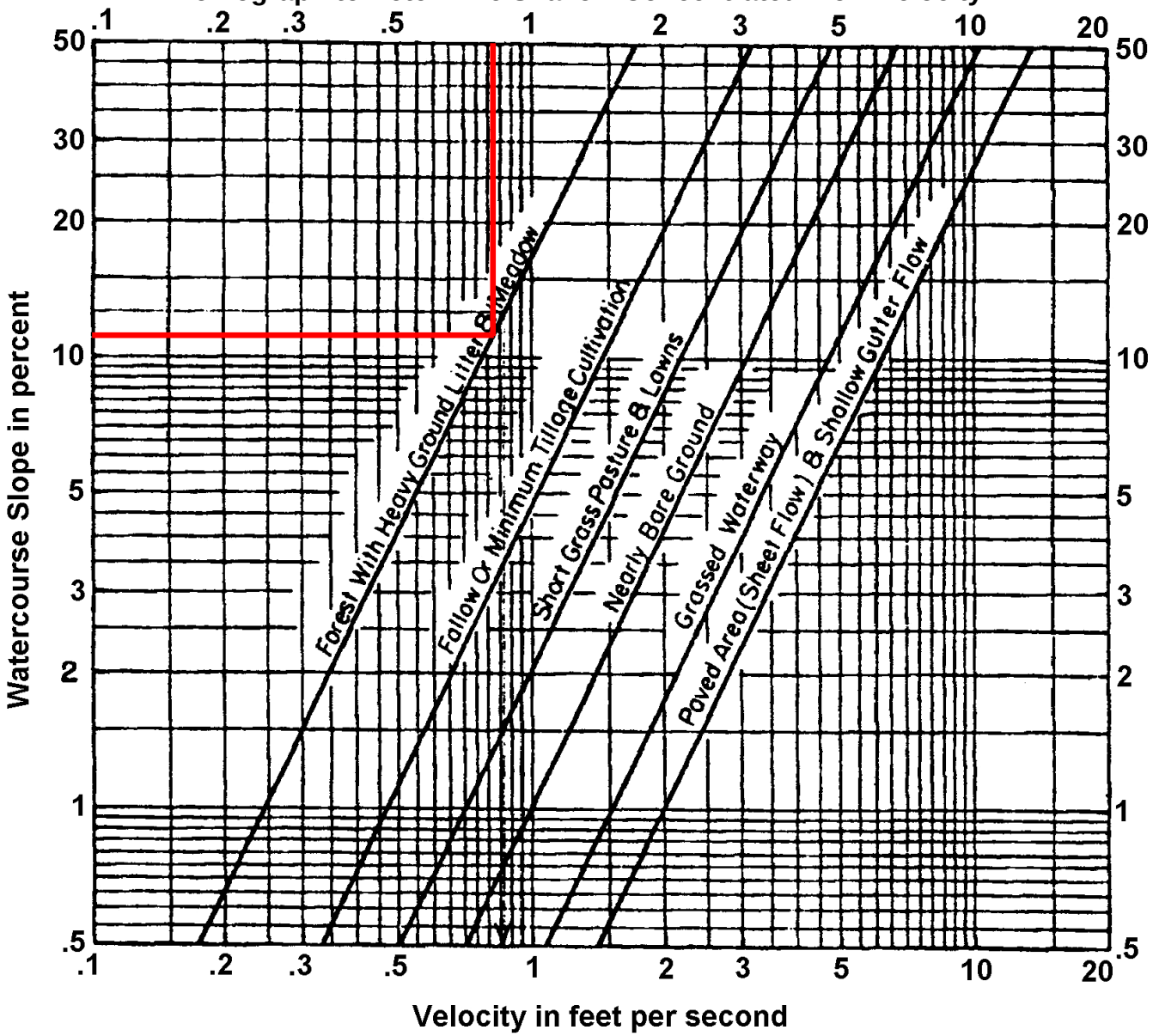
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_23.46_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 12%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_23.46_2
1.38 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 23.46_2	100	0.4	0.030	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 23.46_2	1497	FOREST	0.105	0.82	30.60
	66	PAVEMENT	0.092	6.17	0.18

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
41.31

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 23.46_2	1	FOREST	0.20	1.22	0.24	0.22
	2	INDUSTRIAL	0.69	0.03	0.02	
	3	OPEN SPACE	0.28	0.13	0.04	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	41.31	1.82	2.24	2.64	1.82	2.24	2.64

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.22	2.24	1.38	0.55	0.67	0.80

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_23.46_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.38		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.67		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.76		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.74		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.37		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.13 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.13		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.07		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.02		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.012		
S_C (CRITICAL SLOPE)	(FT/FT)	0.174		
$.7S_c$	(FT/FT)	0.122		
$1.3S_c$	(FT/FT)	0.226		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

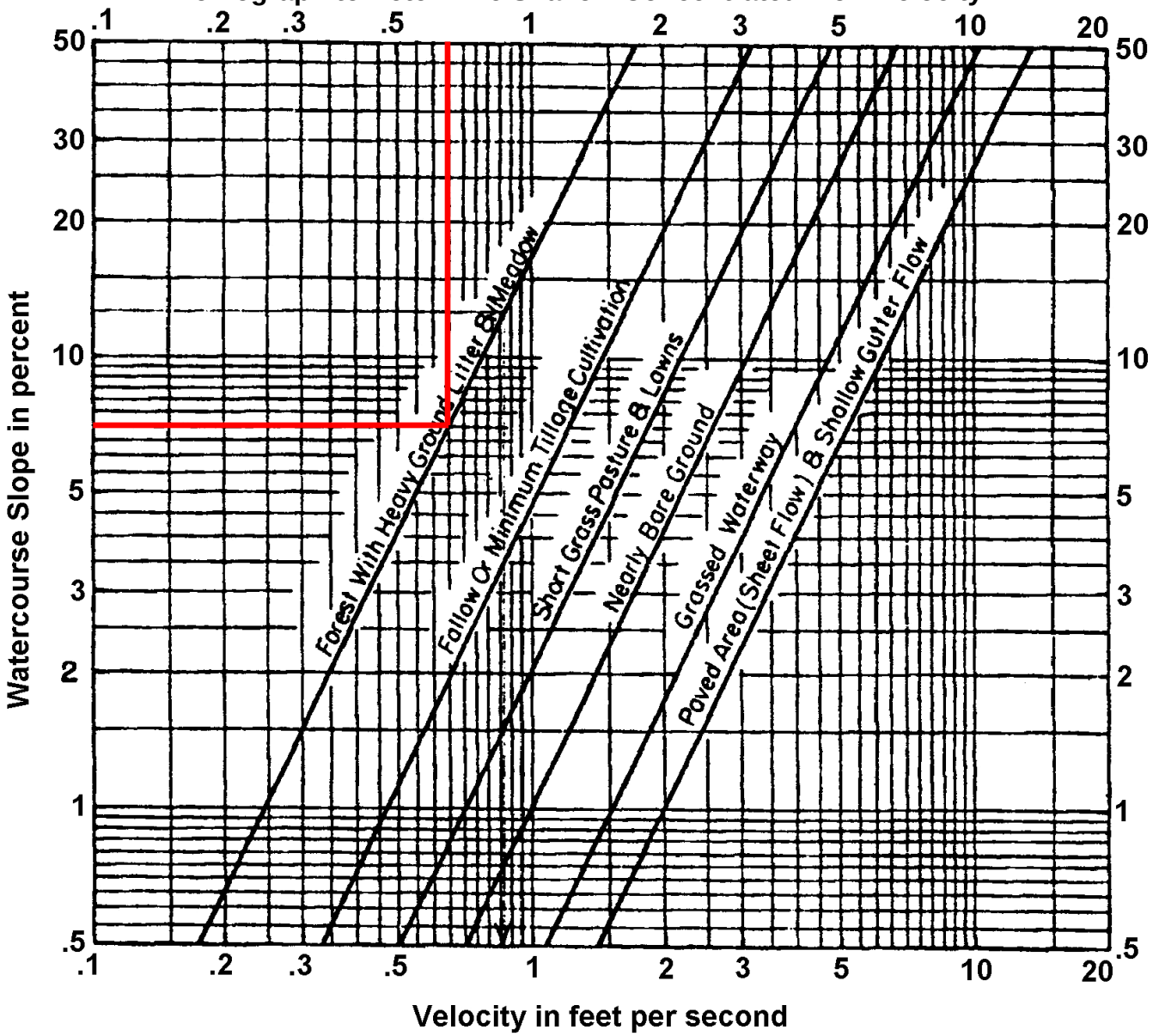
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_23.46_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_23.46_3
1.86 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 23.46_3	100	0.4	0.016	12.19

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 23.46_3	1377	FOREST	0.114	0.85	27.02
	48	PAVEMENT	0.104	6.56	0.12

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
39.33

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 23.46_3	1	FOREST	0.20	1.66	0.33	0.22
	2	INDUSTRIAL	0.69	0.04	0.03	
	3	OPEN SPACE	0.28	0.16	0.04	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	39.33	1.88	2.31	2.73	1.88	2.31	2.73

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.22	2.31	1.86	0.76	0.94	1.10

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_23.46_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.86		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.94		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.36		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.73		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.00		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.29 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.29		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.14		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.79		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.032		
S_C (CRITICAL SLOPE)	(FT/FT)	0.086		
$.7S_c$	(FT/FT)	0.060		
$1.3S_c$	(FT/FT)	0.112		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

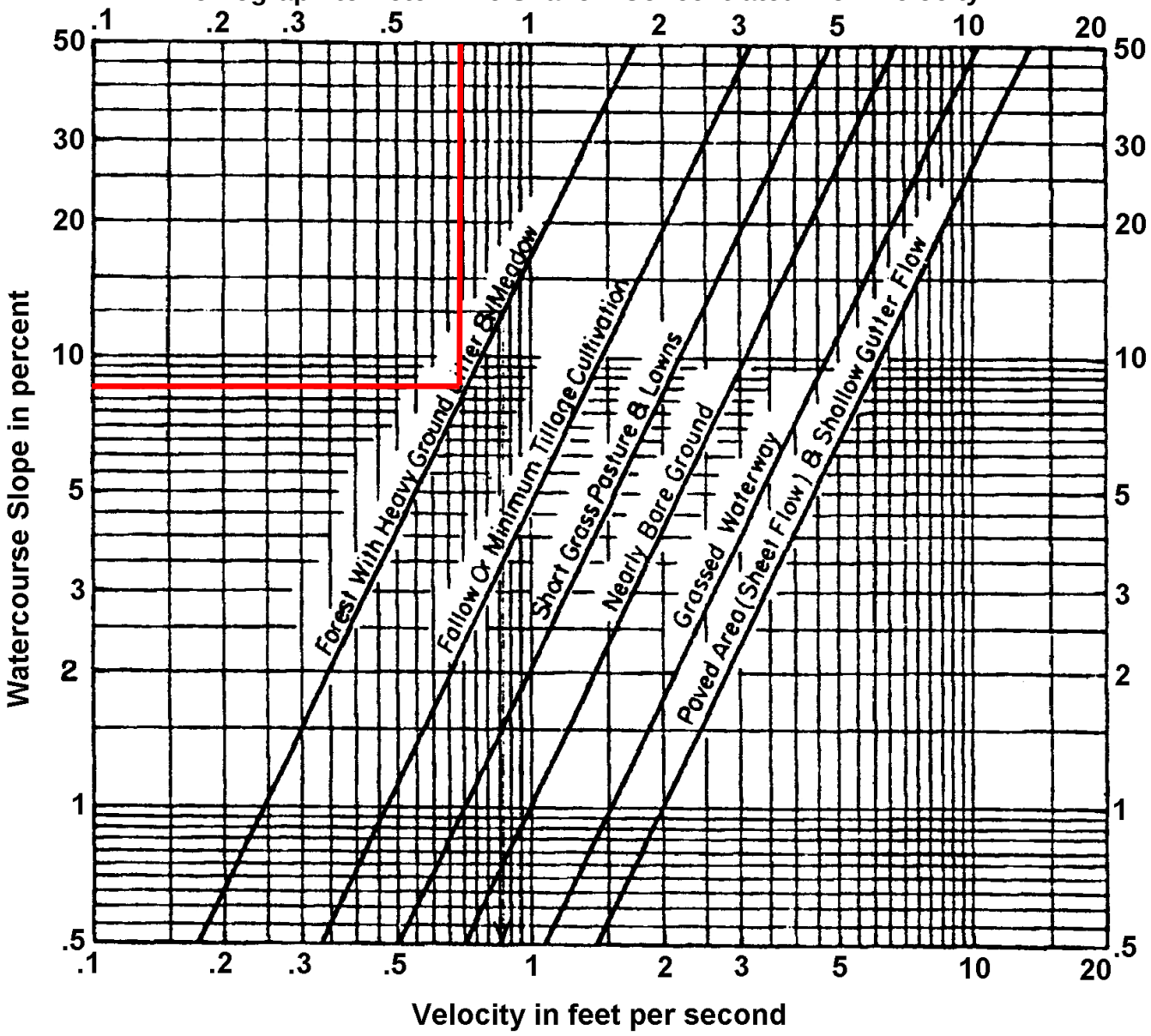
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_23.46_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

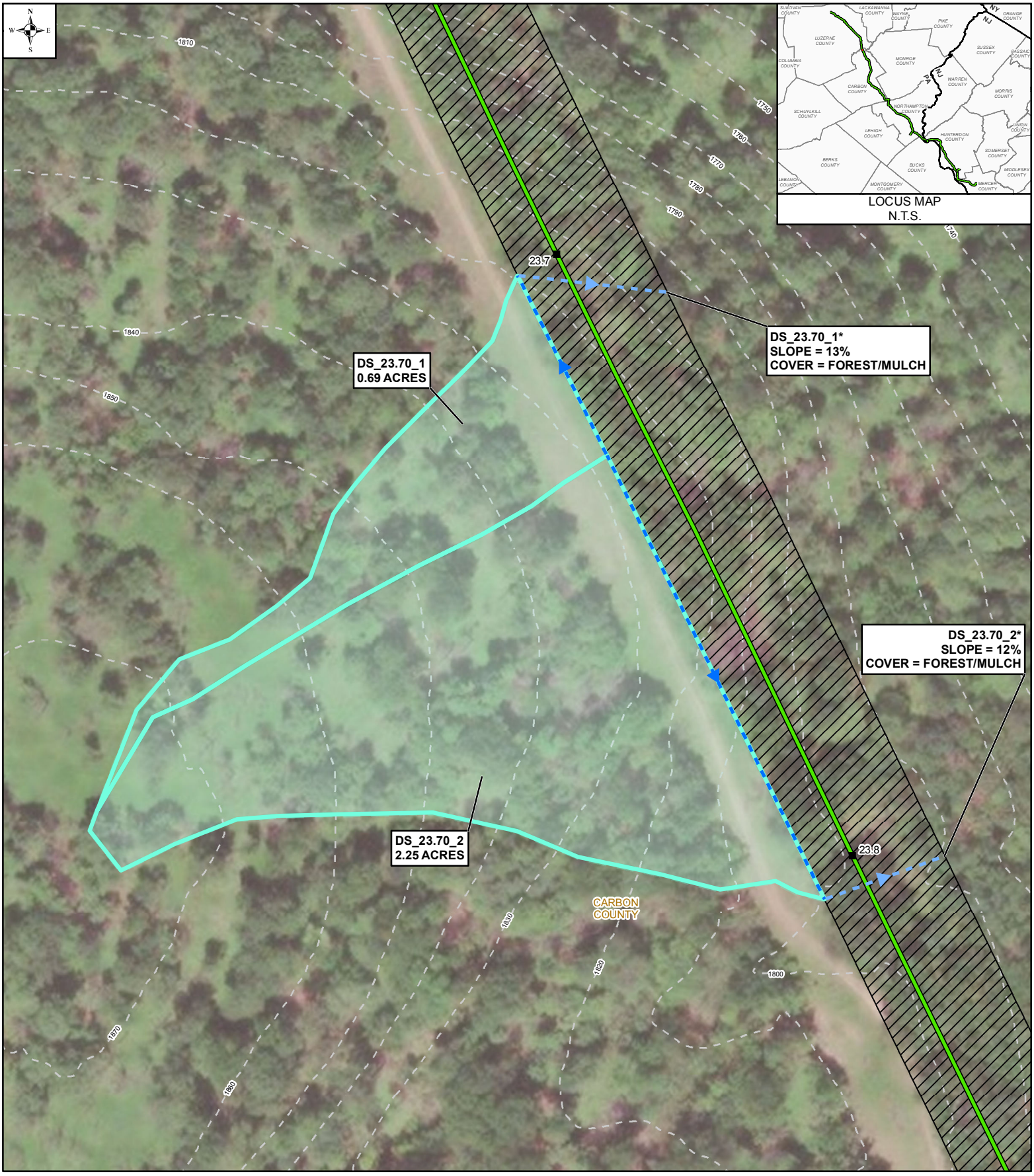


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 8%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_23.70

CARBON COUNTY, PENNSYLVANIA

0 50 100 FEET

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

PennEast PIPELINE

DWG NO: PAGE 30 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_23.70_1
0.69 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 23.70_1	100	0.4	0.026	10.88

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 23.70_1	399	FOREST	0.108	0.83	8.04
	55	AVEMEN	0.104	6.56	0.14

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
19.06

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 23.70_1	1	FOREST	0.20	0.56	0.11	0.23
	2	INDUSTRIAL	0.69	0.03	0.02	
	3	OPEN SPACE	0.28	0.10	0.03	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	19.06	2.94	3.55	4.04	2.94	3.55	4.04

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.23	3.55	0.69	0.47	0.57	0.65

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_23.70_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.69		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.57		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.42		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.24		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.59		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.62 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.62		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.31		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.08		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.051		
S_C (CRITICAL SLOPE)	(FT/FT)	0.082		
$.7S_c$	(FT/FT)	0.057		
$1.3S_c$	(FT/FT)	0.106		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

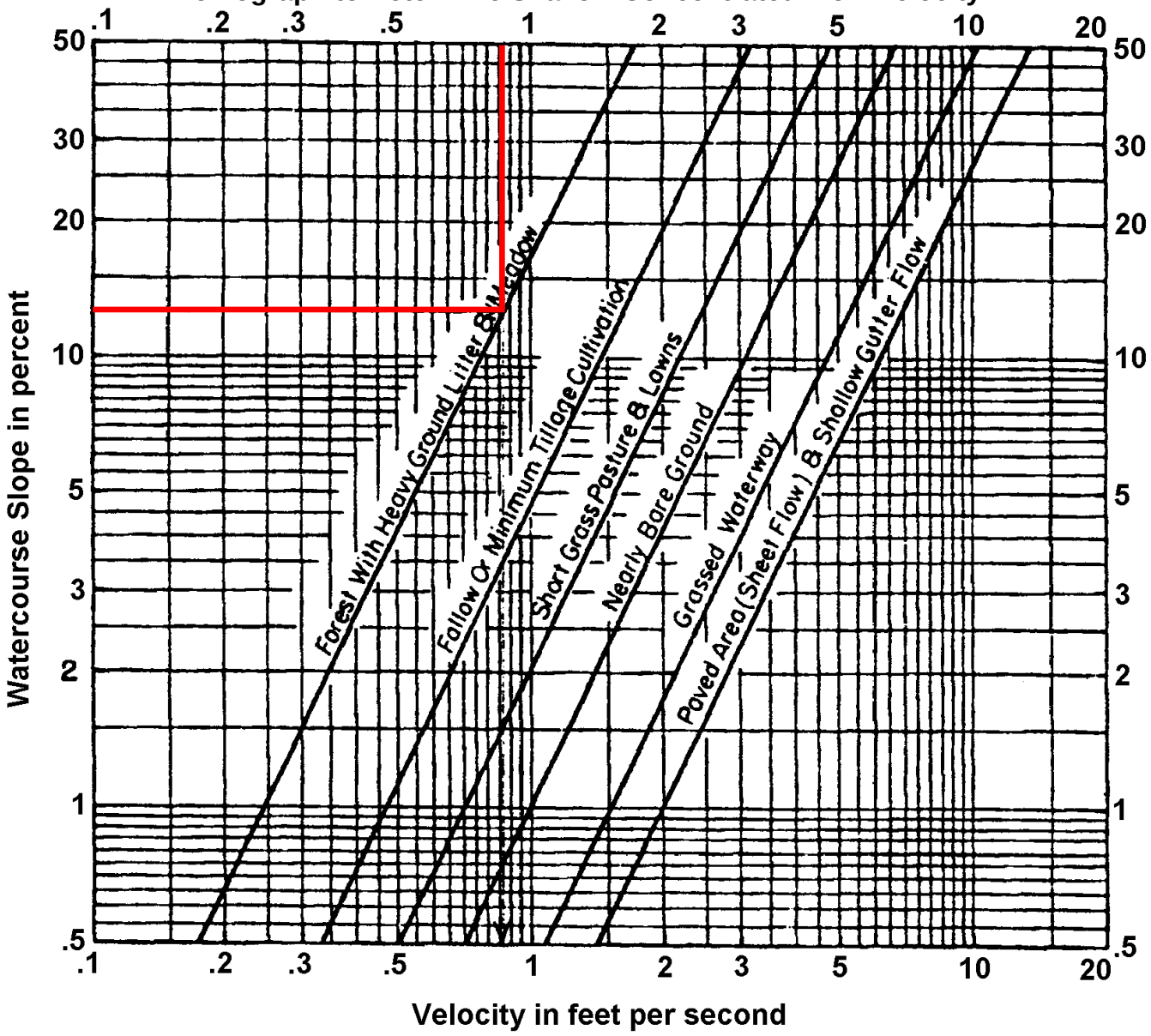
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_23.70_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_23.70_2
2.25 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 23.70_2	100	0.4	0.040	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 23.70_2	408	FOREST	0.147	0.96	7.05
	67	PAVEMENT	0.149	7.85	0.14

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
17.03

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 23.70_2	1	FOREST	0.20	1.87	0.37	0.23
	2	INDUSTRIAL	0.69	0.07	0.05	
	3	OPEN SPACE	0.28	0.31	0.09	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	17.03	3.11	3.75	4.25	3.11	3.75	4.25

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.23	3.75	2.25	1.59	1.91	2.16

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_23.70_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.25		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.9		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.63		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	6.53		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.9 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.90		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.45		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.86		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.072		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

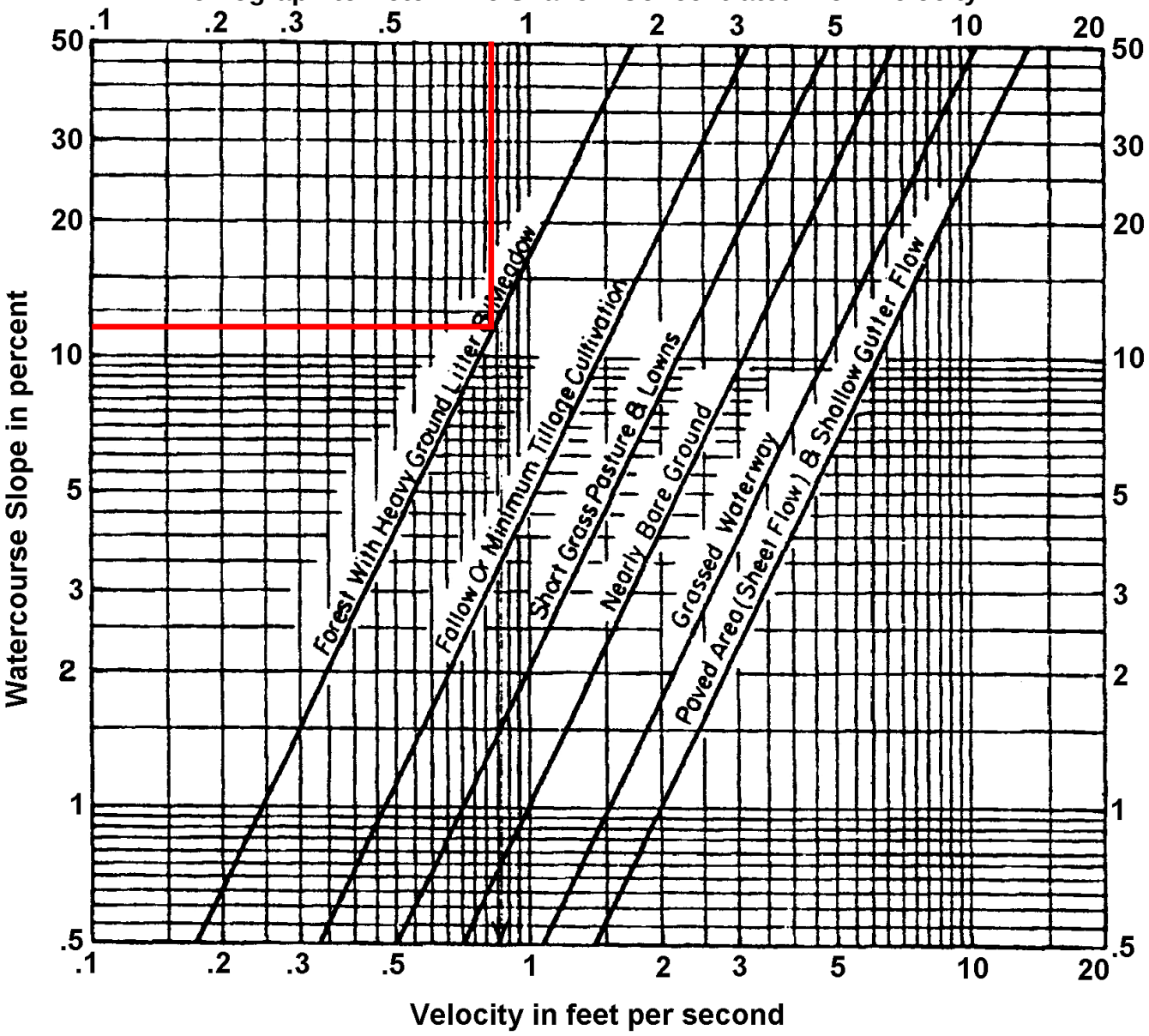
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_23.70_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

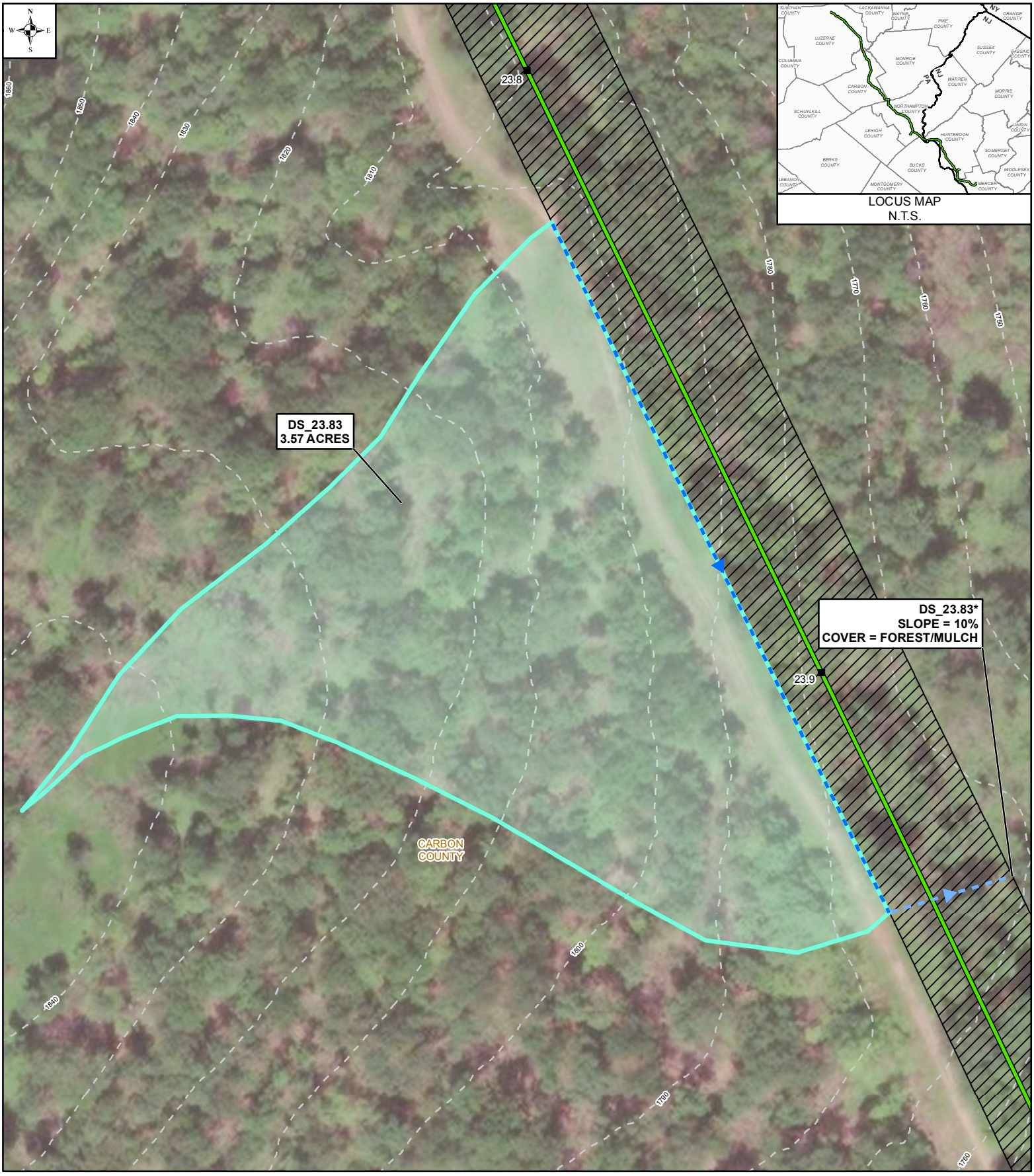


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 12%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_23.83

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 31 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 23.38	100	0.4	0.036	10.08

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 23.38	617	FOREST	0.100	0.80	12.92
	41	PAVEMENT	0.049	4.50	0.15

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
23.16

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 23.38	1	FOREST	0.20	3.04	0.61	0.23
	2	INDUSTRIAL	0.69	0.12	0.08	
	3	OPEN SPACE	0.28	0.41	0.11	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	23.16	2.64	3.20	3.68	2.64	3.20	3.68

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.23	3.20	3.57	2.13	2.58	2.97

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_23.83		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.57		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.58		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.52		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.03		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.28		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.77 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.77		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.39		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.10		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.041		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

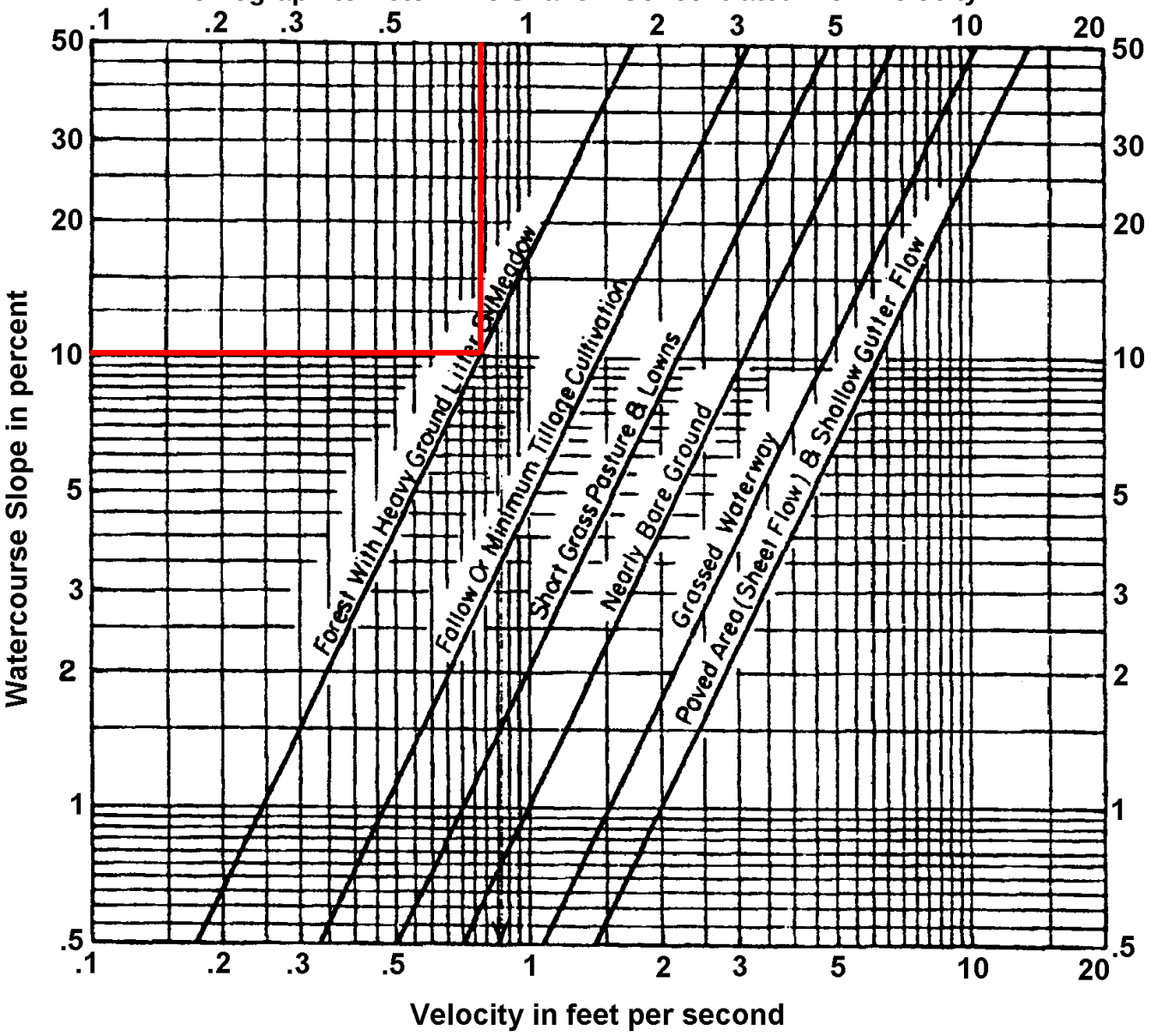
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_23.83

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

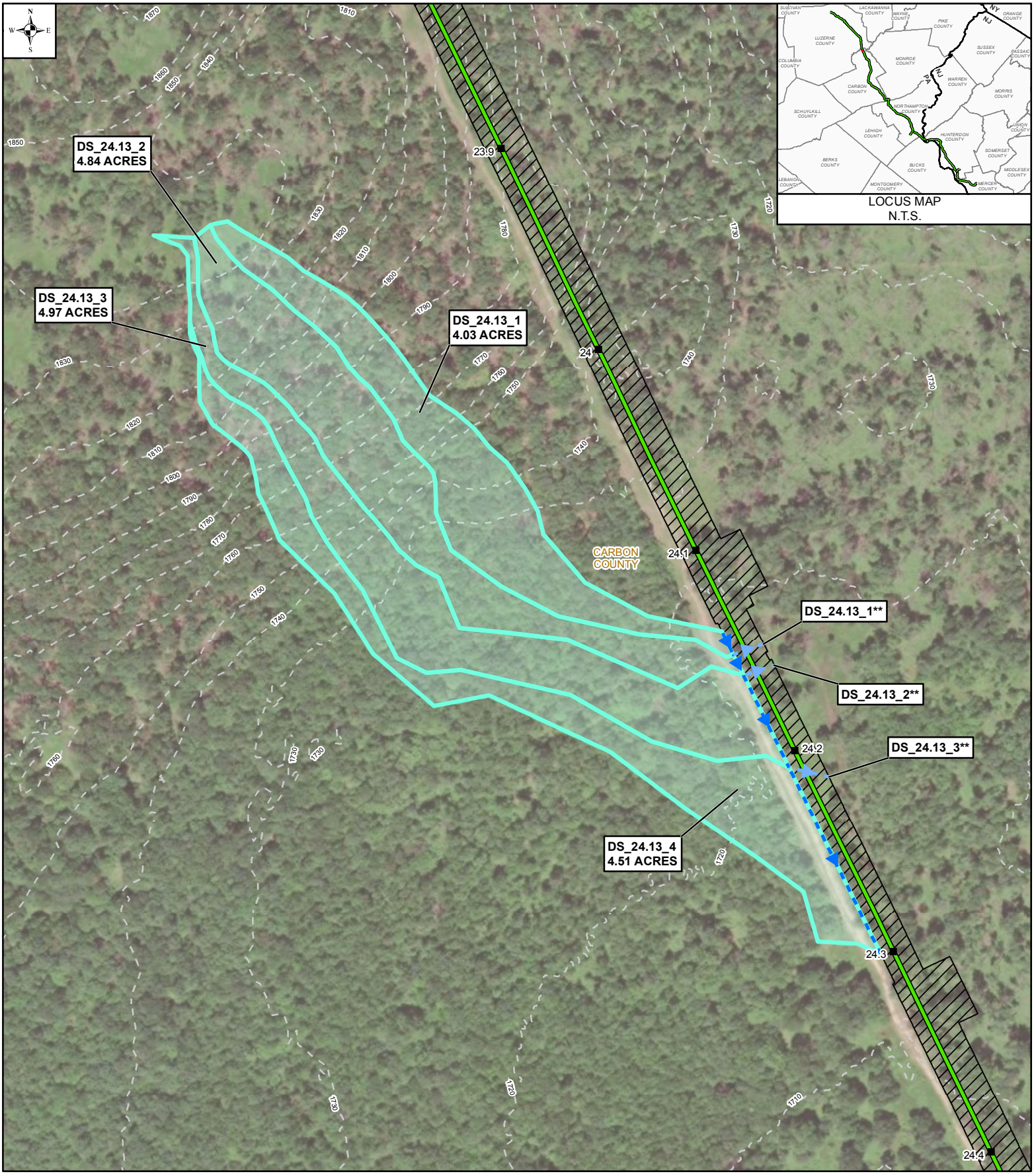


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 10%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_24.13

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 300 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 150 300 FEET

PennEast PIPELINE

DWG NO: PAGE 32 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_24.13_1
4.03. ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 24.13_1	100	0.4	0.072	8.58

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 24.13_1	1517	FOREST	0.081	0.72	35.31
	100	PAVEMENT	0.020	2.87	0.58

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
44.47

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 24.13_1	1	FOREST	0.20	3.97	0.79	0.20
	2	INDUSTRIAL	0.69	0.02	0.01	
	3	OPEN SPACE	0.28	0.04	0.01	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	44.47	1.72	2.13	2.52	1.72	2.13	2.52

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.13	4.03	1.41	1.74	2.06

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_24.13_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.03		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.74		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	13.64		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.09		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	100 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	100.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	50.00		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	12.50		
R (HYDRAULIC RADIUS)		0.25		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.115		
$.7S_c$	(FT/FT)	0.080		
$1.3S_c$	(FT/FT)	0.149		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_24.13_2
4.84 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 24.13_2	100	0.4	0.061	8.92

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 24.13_2	1692	FOREST	0.072	0.68	41.77
	90	PAVEMENT	0.011	2.13	0.70

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
51.39

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 24.13_2	1	FOREST	0.20	4.77	0.95	0.20
	2	INDUSTRIAL	0.69	0.02	0.01	
	3	OPEN SPACE	0.28	0.05	0.01	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	51.39	1.55	1.92	2.29	1.55	1.92	2.29

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.92	4.84	1.52	1.88	2.24

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_24.13_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.84		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.88		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	12.28		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.98		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	100 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	100.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	50.00		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	12.50		
R (HYDRAULIC RADIUS)		0.25		
S (BED SLOPE)[3, 7]	(FT/FT)	0.018		
S_C (CRITICAL SLOPE)	(FT/FT)	0.150		
$.7S_c$	(FT/FT)	0.105		
$1.3S_c$	(FT/FT)	0.195		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_24.13_3
4.97 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 24.13_3	100	0.4	0.041	9.78

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 24.13_3	2005	FOREST	0.062	0.63	53.34
	86	PAVEMENT	0.047	4.41	0.33

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
63.45

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 24.13_3	1	FOREST	0.20	4.75	0.95	0.21
	2	INDUSTRIAL	0.69	0.08	0.06	
	3	OPEN SPACE	0.21	0.14	0.03	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	63.45	1.32	1.64	1.97	1.32	1.64	1.97

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.21	1.64	4.97	1.36	1.69	2.03

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_24.13_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.97		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.69		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.87		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.51		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.16		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	29.41 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	29.41		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	14.71		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	3.68		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.005		
S_C (CRITICAL SLOPE)	(FT/FT)	0.155		
$.7S_c$	(FT/FT)	0.108		
$1.3S_c$	(FT/FT)	0.201		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_24.13_4
4.51 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 24.13_4	100	0.4	0.067	8.72

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 24.13_4	2405	FOREST	0.046	0.54	74.28
	87	PAVEMENT	0.046	4.36	0.33

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
83.34

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 24.13_4	1	FOREST	0.20	3.79	0.76	0.22
	2	INDUSTRIAL	0.69	0.20	0.14	
	3	OPEN SPACE	0.21	0.52	0.11	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	83.34	1.06	1.32	1.60	1.06	1.32	1.60

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.22	1.32	4.51	1.06	1.33	1.61

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

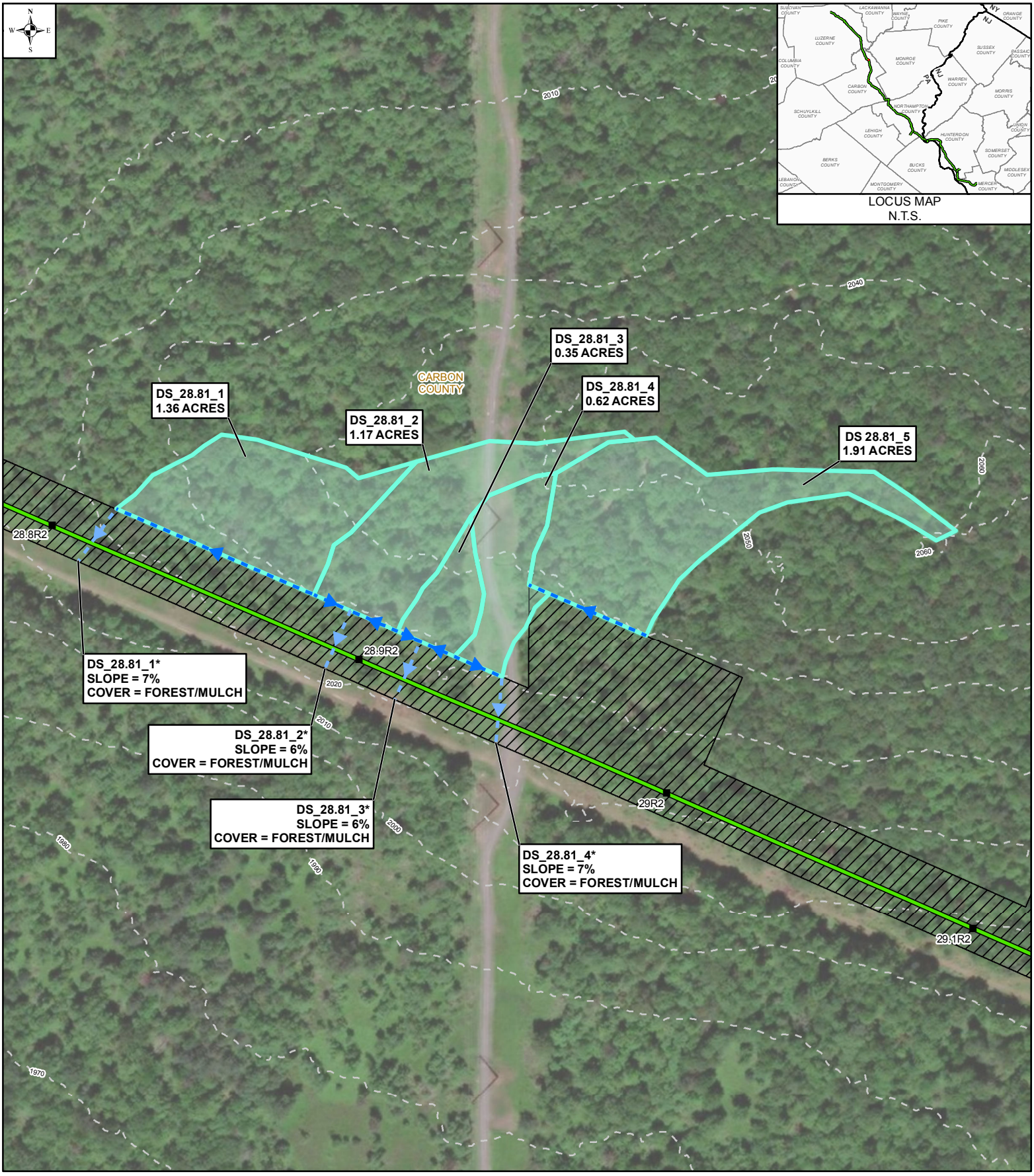
LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_24.13_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.51		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.33		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	6.24		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.80		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.37		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	62.5 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	62.50		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	31.25		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	7.81		
R (HYDRAULIC RADIUS)		0.25		
S (BED SLOPE)[3, 7]	(FT/FT)	0.012		
S_C (CRITICAL SLOPE)	(FT/FT)	0.151		
$.7S_c$	(FT/FT)	0.106		
$1.3S_c$	(FT/FT)	0.196		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_28.81

CARBON COUNTY, PENNSYLVANIA

0 100 200 FEET

PennEast PIPELINE

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 200 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

DWG NO: PAGE 33 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_28.81_1
1.36 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 28.81_1	100	0.4	0.011	13.30

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 28.81_1	428	FOREST	0.043	0.52	13.67

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
26.98

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 28.81_1	1	FOREST	0.16	1.36	0.22	0.16

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	26.98	2.41	2.94	3.40	2.41	2.94	3.40

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.16	2.94	1.36	0.52	0.64	0.74

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_28.81_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.36		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.64		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.96		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.08		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.09 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.09		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.55		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.89		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.137		
$.7S_c$	(FT/FT)	0.096		
$1.3S_c$	(FT/FT)	0.178		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

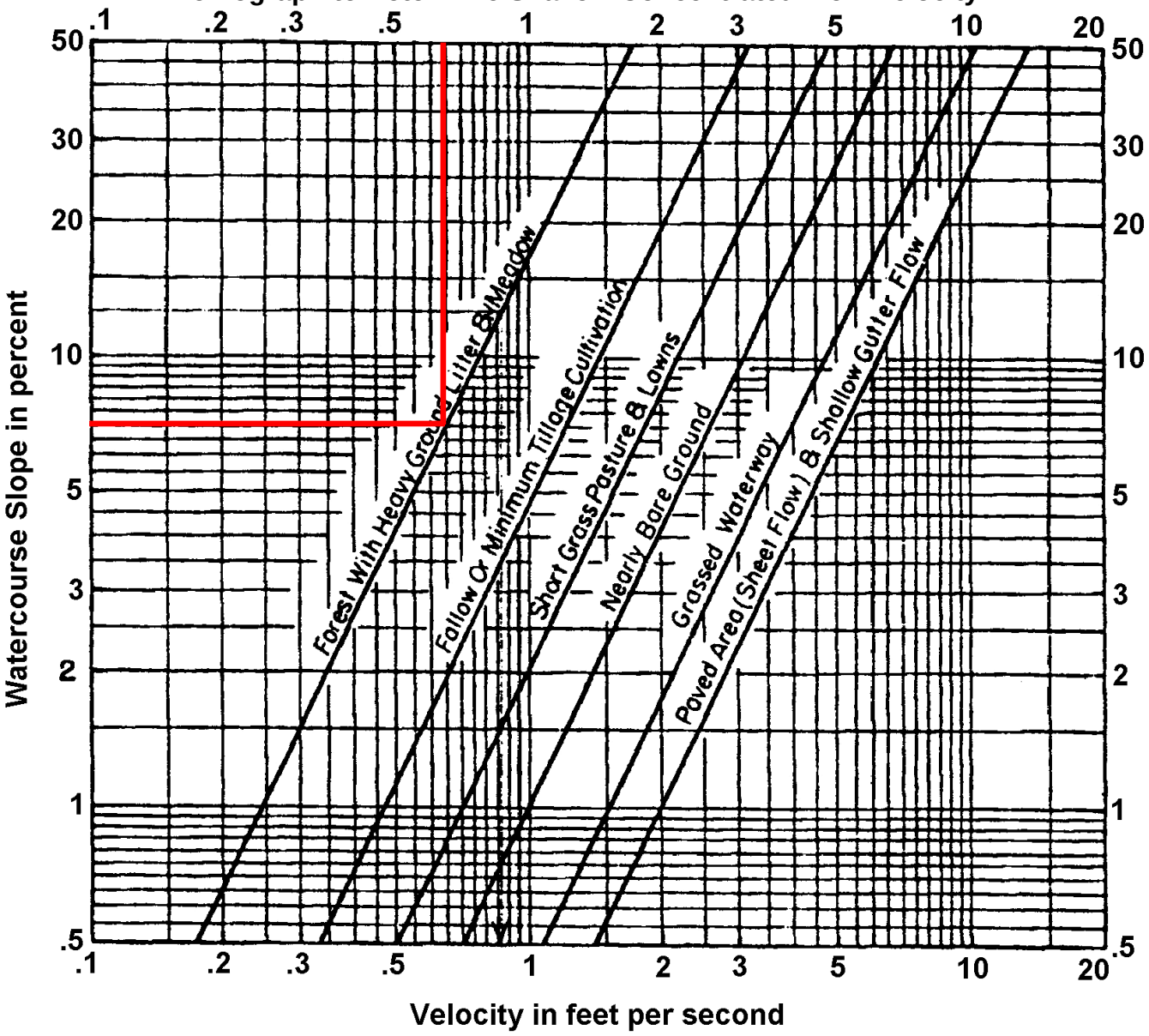
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_23.81_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_28.81_2
1.17 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 28.81_2	100	0.4	0.034	10.22

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 28.81_2	79	FOREST	0.038	0.49	2.68
	20	PAVEMENT	0.025	3.21	0.10
	425	FOREST	0.035	0.47	15.05

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
28.06

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 28.81_2	1	FOREST	0.16	1.02	0.16	0.18
	2	OPEN SPACE	0.21	0.12	0.03	
	3	INDUSTRIAL	0.69	0.03	0.02	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	28.06	2.35	2.87	3.33	2.35	2.87	3.33

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.18	2.87	1.17	0.49	0.60	0.70

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_28.81_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.17		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.6		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.26		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.11		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	9.09 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	9.09		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.55		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.14		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.131		
$.7S_c$	(FT/FT)	0.092		
$1.3S_c$	(FT/FT)	0.170		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

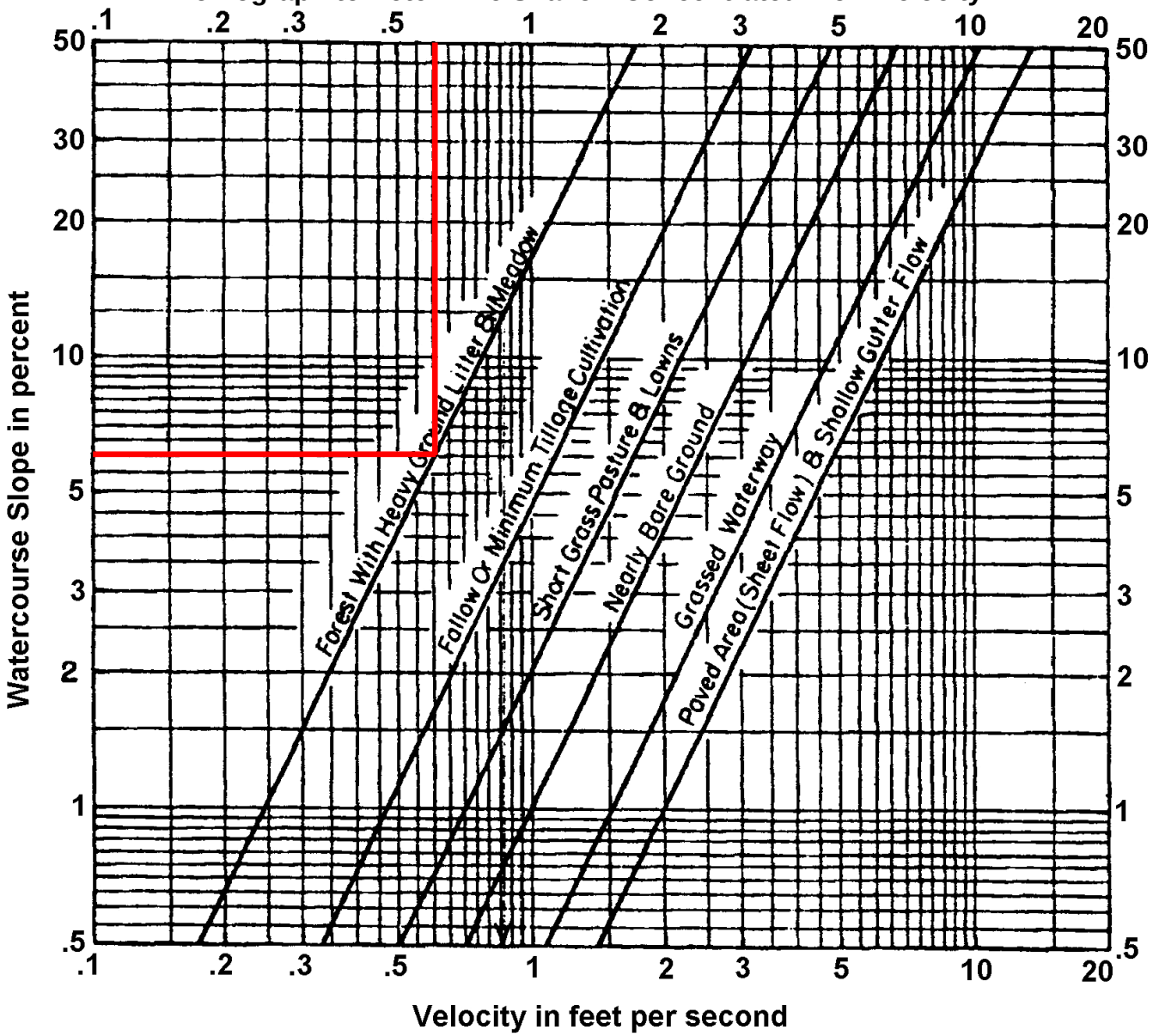
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_28.81_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 6%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.6 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_28.81_3
0.35 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 28.81_3	100	0.4	0.040	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 28.81_3	137	FOREST	0.058	0.61	3.77

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
13.61

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 28.81_3	1	FOREST	0.16	0.35	0.06	0.16

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	13.61	3.46	4.14	4.64	3.46	4.14	4.64

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.16	4.14	0.35	0.19	0.23	0.26

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_28.81_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.35		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.23		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.31		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.85		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.06		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	10 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	10.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.00		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.25		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.034		
S_C (CRITICAL SLOPE)	(FT/FT)	0.080		
$.7S_c$	(FT/FT)	0.056		
$1.3S_c$	(FT/FT)	0.104		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

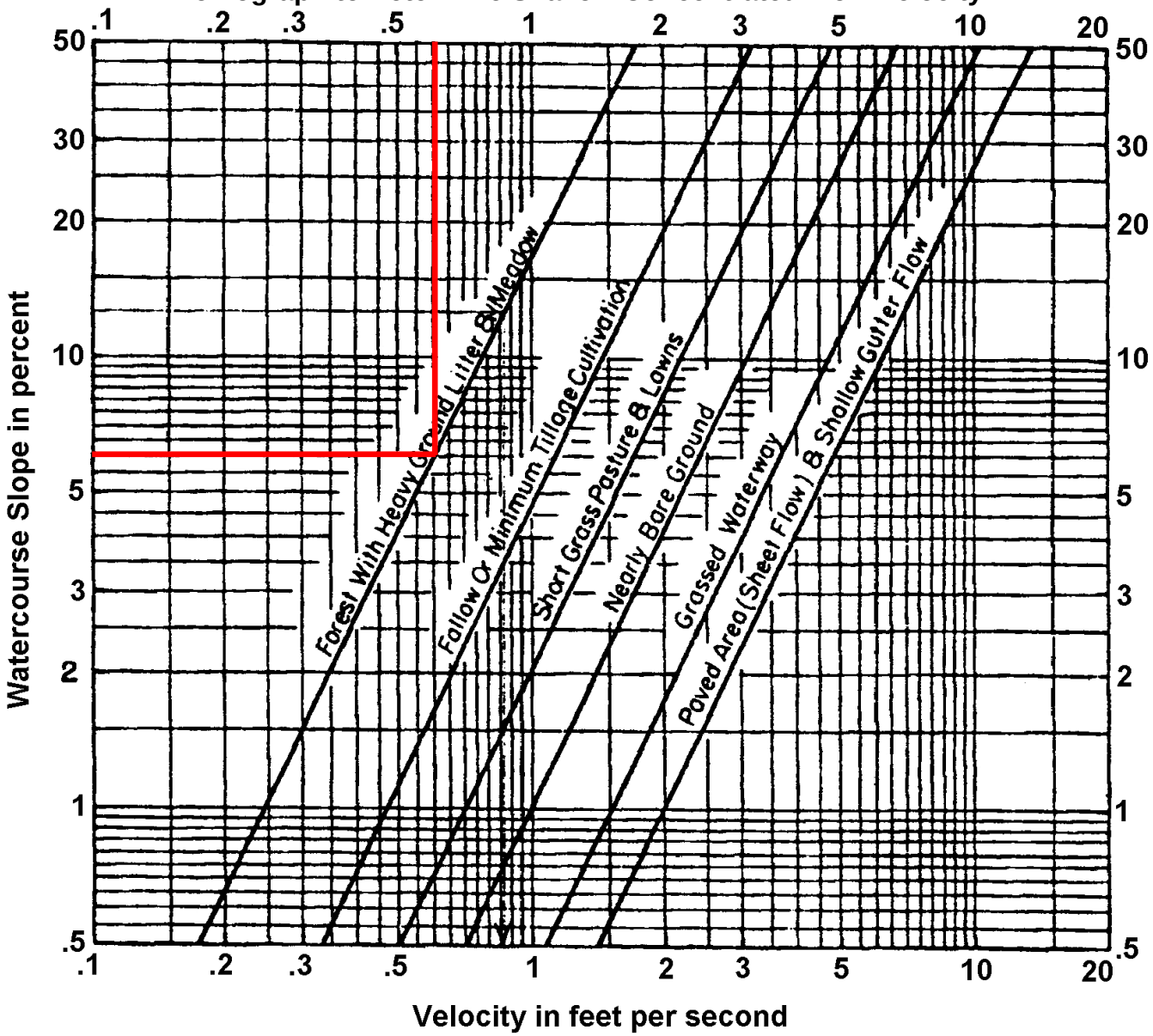
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_28.81_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 6%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.6 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_28.81_4
0.62 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 28.81_4	60	0.4	0.050	7.36

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 28.81_4	48	SHORT GRASS	0.063	1.75	0.46
	25	PAVEMENT	0.040	4.07	0.10
	260	SHORT GRASS	0.046	0.54	8.03

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
15.95

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 28.81_4	1	FOREST	0.16	0.21	0.03	0.26
	2	INDUSTRIAL	0.69	0.08	0.06	
	3	OPEN SPACE	0.21	0.33	0.07	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	15.95	3.22	3.86	4.36	3.22	3.86	4.36

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.26	3.86	0.62	0.51	0.61	0.69

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_28.81_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.62		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.26		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.80		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.78		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.37		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	18.52 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	18.52		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	9.26		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.31		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.012		
S_C (CRITICAL SLOPE)	(FT/FT)	0.159		
$.7S_c$	(FT/FT)	0.111		
$1.3S_c$	(FT/FT)	0.207		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

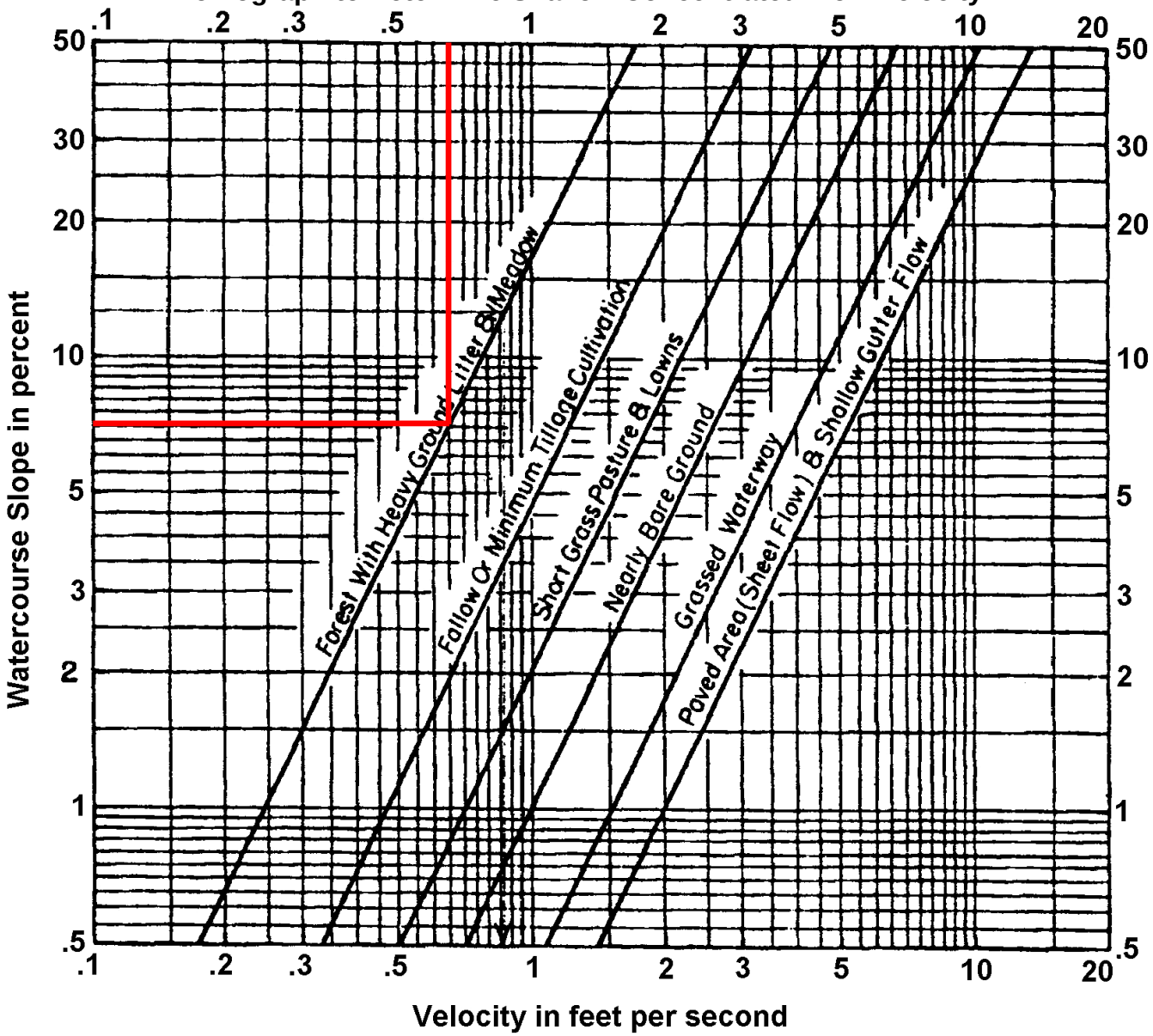
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_28.81_4 & DS_28.81_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_28.81_5
1.91 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 28.81_5	100	0.4	0.032	10.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 28.81_5	775	FOREST	0.023	0.38	33.85

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
44.22

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 28.81_5	1	FOREST	0.16	1.91	0.31	0.16

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	44.22	1.73	2.14	2.53	1.73	2.14	2.53

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.16	2.14	1.91	0.53	0.65	0.77

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_28.81_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.91		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.65		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.31		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.50		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.16		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	20.83 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	20.83		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	10.42		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.60		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.005		
S_C (CRITICAL SLOPE)	(FT/FT)	0.158		
$.7S_c$	(FT/FT)	0.110		
$1.3S_c$	(FT/FT)	0.205		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

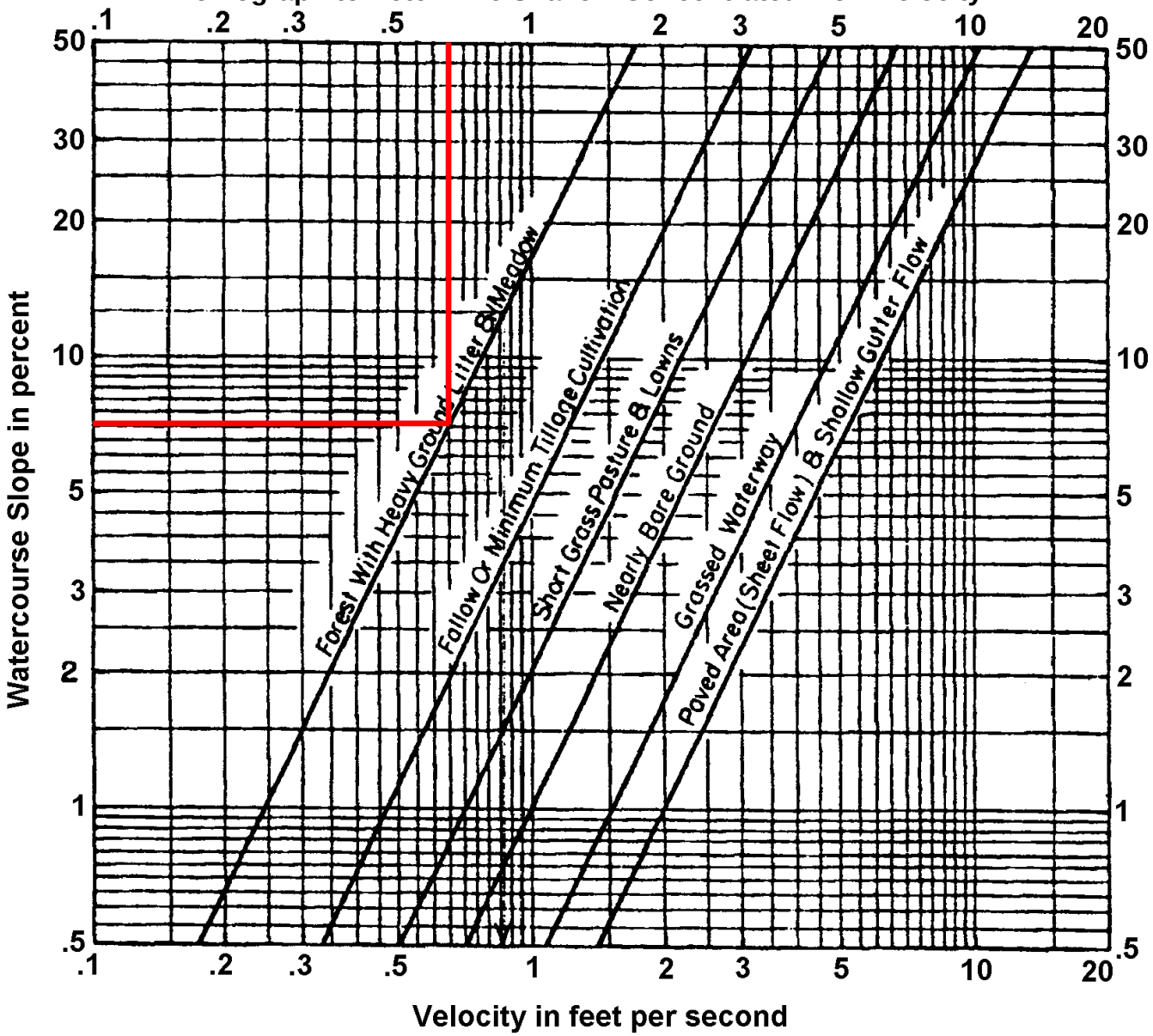
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_28.81_4 & DS_28.81_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

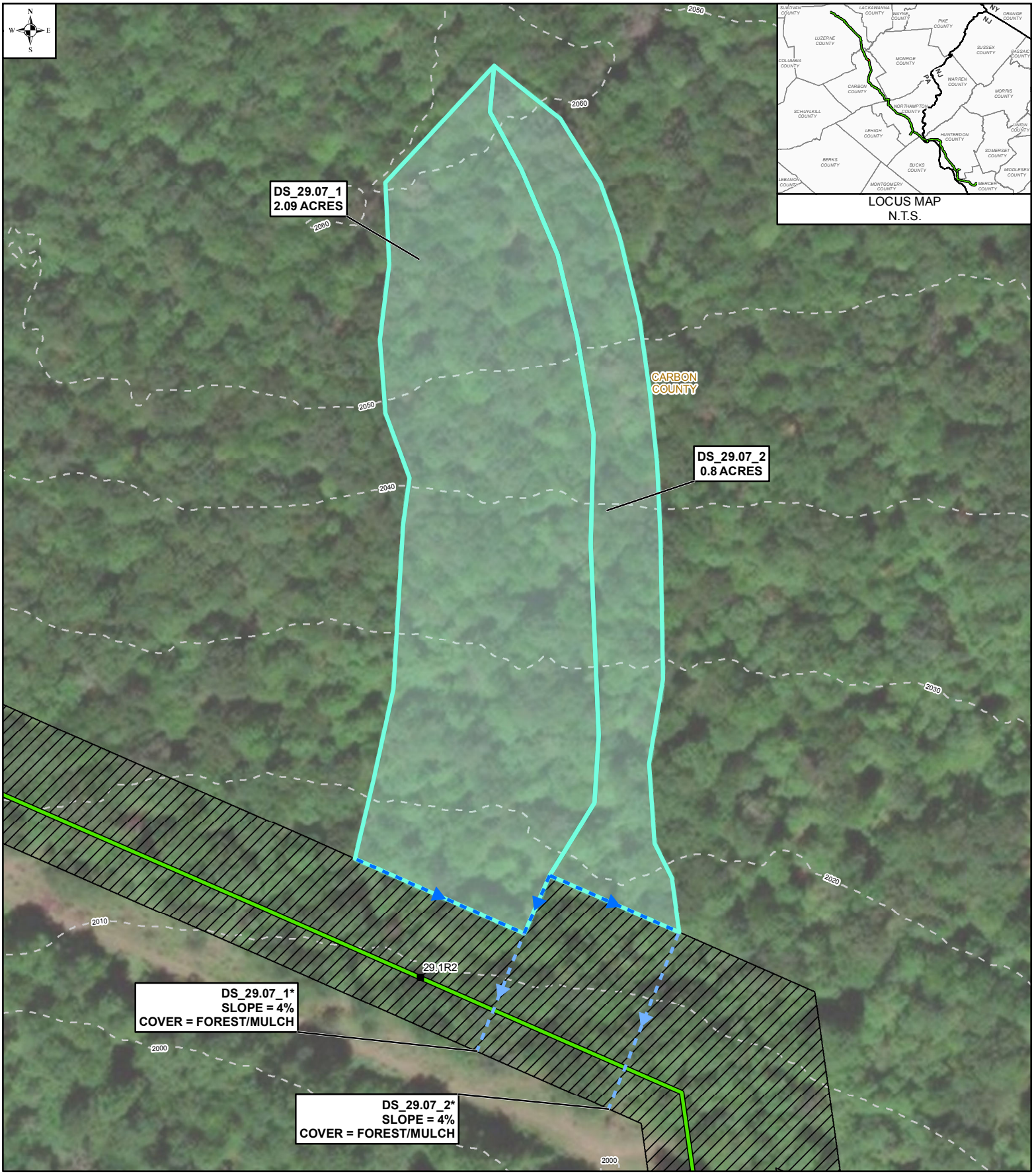


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_29.07

CARBON COUNTY, PENNSYLVANIA

0 50 100 FEET

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

PennEast PIPELINE

DWG NO: PAGE 34 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_29.07_1
2.09 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 29.07_1	100	0.4	0.045	9.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 29.07_1	614	FOREST	0.071	0.67	15.26

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
24.84

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 29.07_1	1	FOREST	0.20	2.09	0.42	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	24.84	2.53	3.08	3.55	2.53	3.08	3.55

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.08	2.09	1.06	1.29	1.49

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_29.07_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.09		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.29		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.31		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.85		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.22		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.35 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	12.35		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.17		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.54		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.007		
S_C (CRITICAL SLOPE)	(FT/FT)	0.078		
$.7S_c$	(FT/FT)	0.055		
$1.3S_c$	(FT/FT)	0.101		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

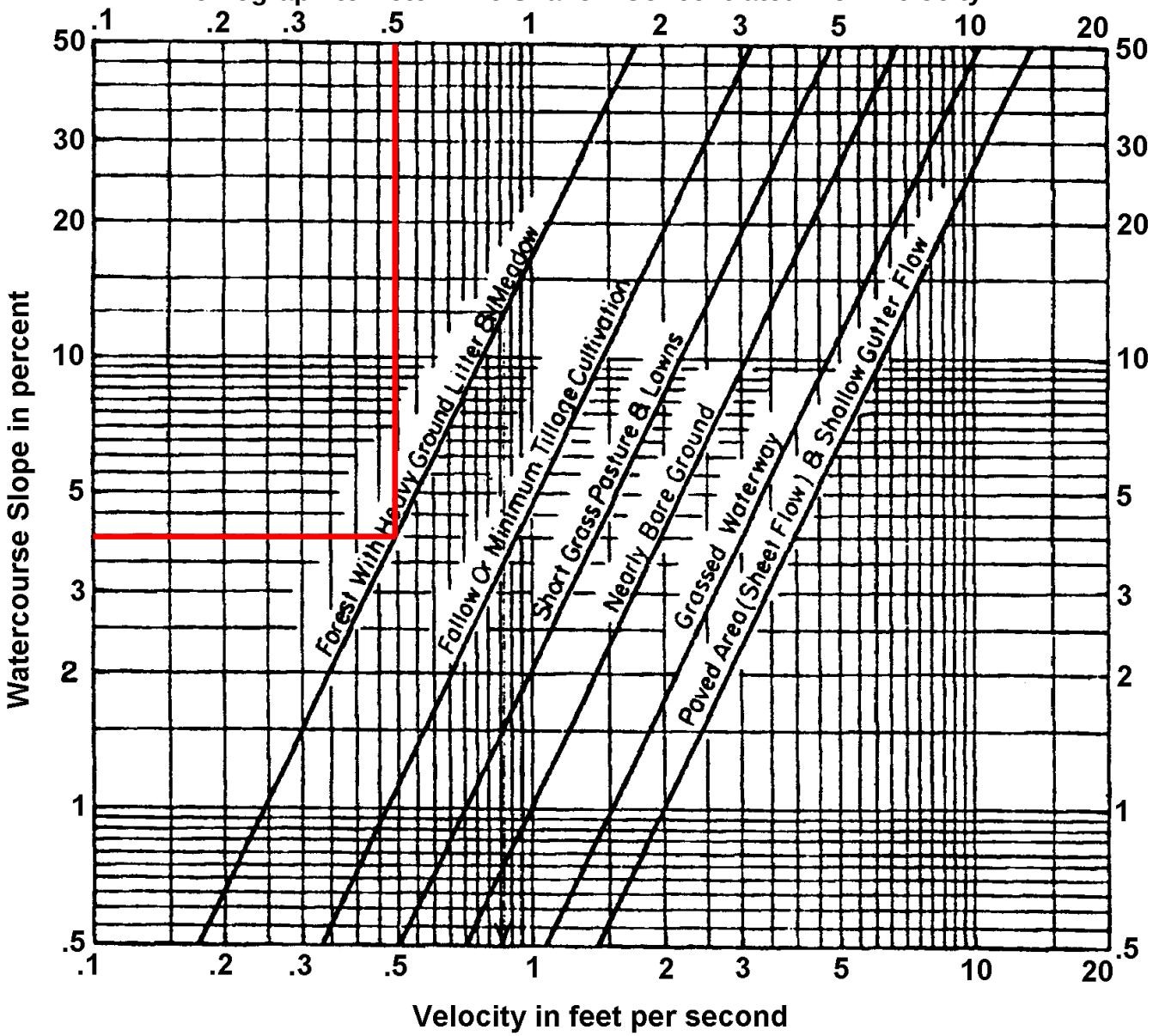
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_29.07_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 4%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.5 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.5 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_29.07_2
0.8 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 29.07_2	100	0.4	0.043	9.67

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 29.07_2	627	FOREST	0.070	0.67	15.70

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
25.37

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 29.07_2	1	FOREST	0.20	0.80	0.16	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	25.37	2.50	3.04	3.51	2.50	3.04	3.51

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.04	0.80	0.40	0.49	0.56

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_29.07_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.8		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.49		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.97		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.93		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.12		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.35 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	12.35		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.17		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.54		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.036		
S_C (CRITICAL SLOPE)	(FT/FT)	0.078		
$.7S_c$	(FT/FT)	0.055		
$1.3S_c$	(FT/FT)	0.101		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

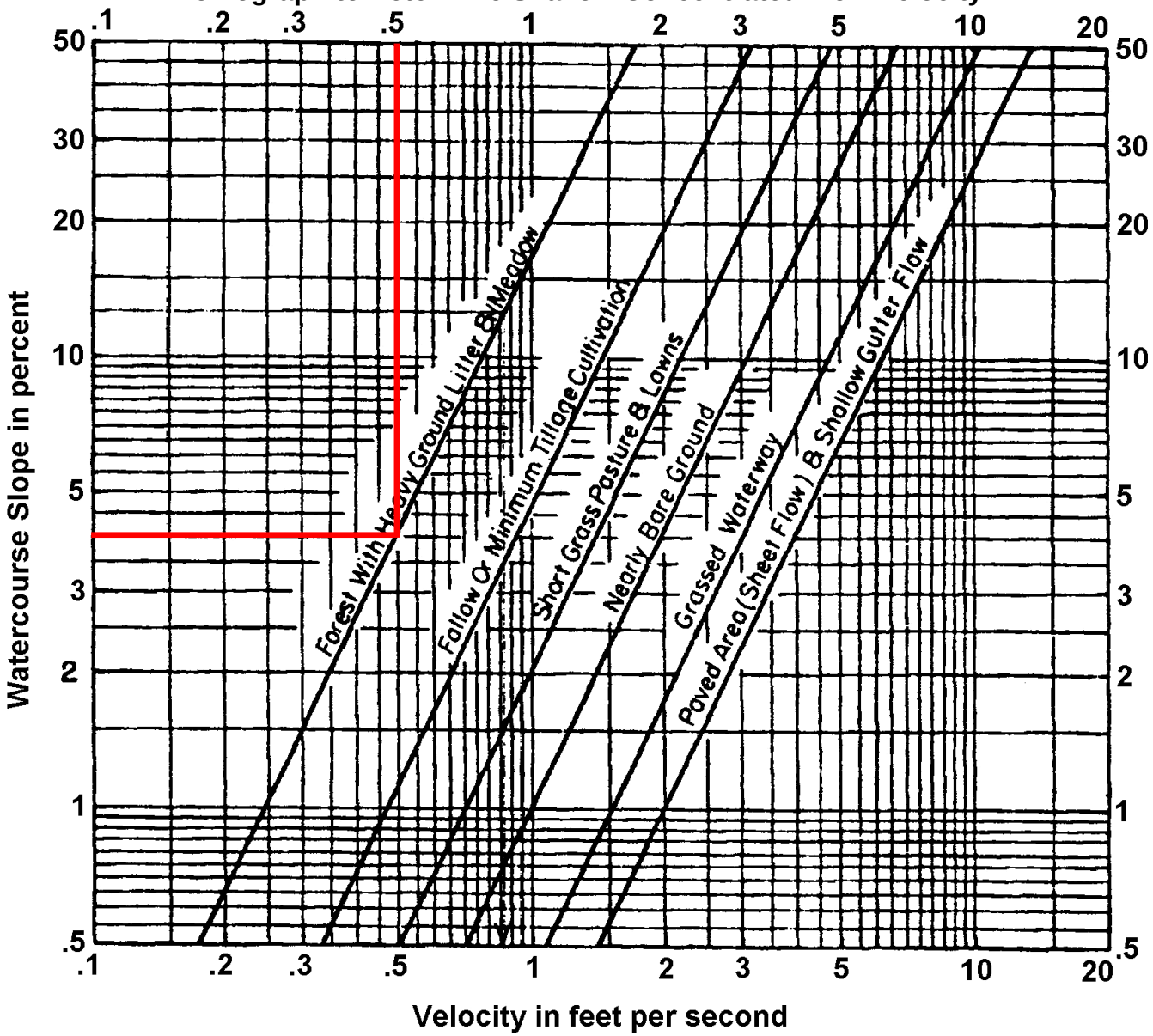
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_29.07_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

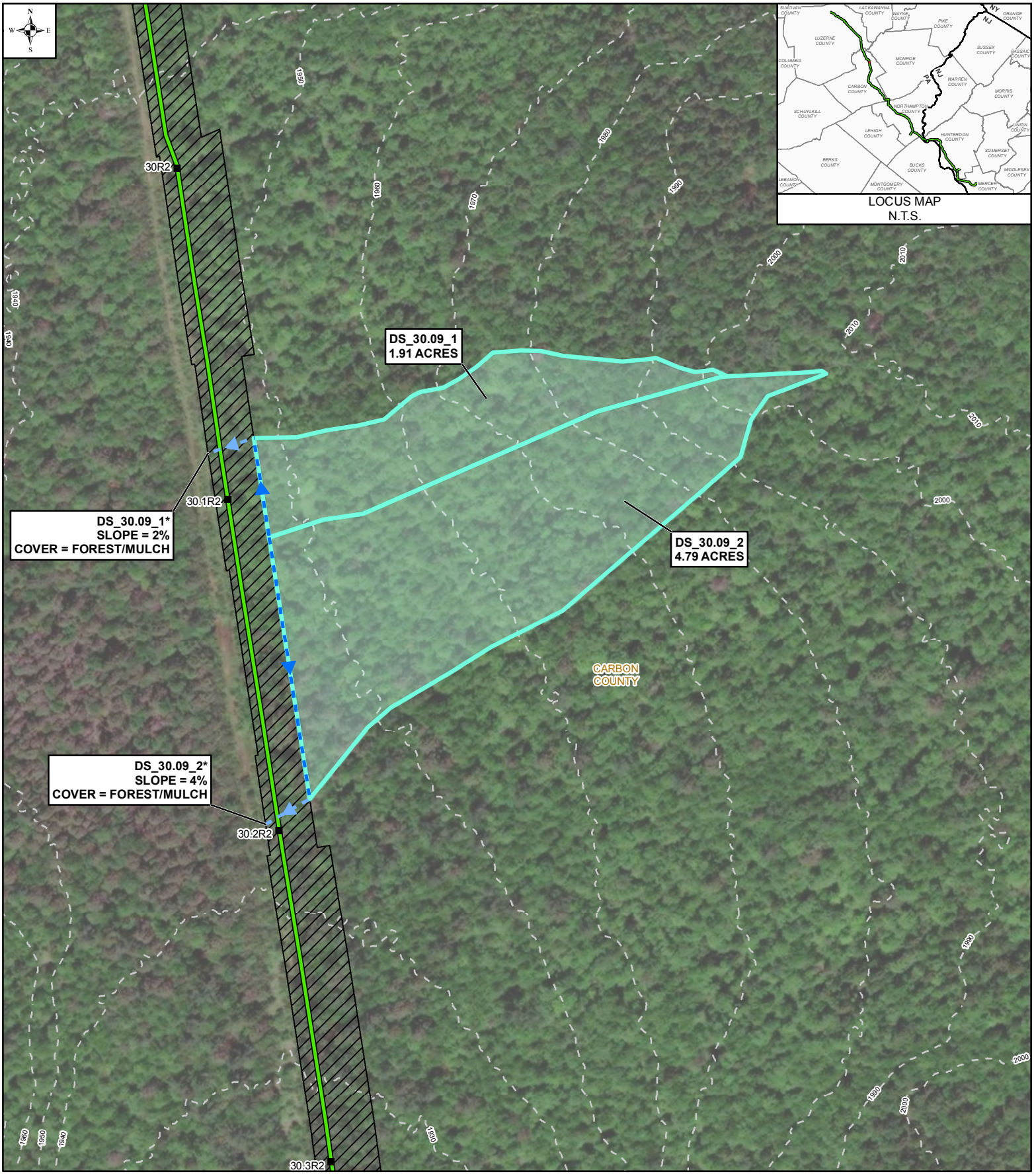


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 4%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.5 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.5 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_30.09

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 200 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 35 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_30.09_1
1.91 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 30.09_1	100	0.4	0.081	8.34

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 30.09_1	691	FOREST	0.066	0.65	17.82

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
26.16

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 30.09_1	1	FOREST	0.20	1.91	0.38	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	26.16	2.46	2.99	3.46	2.46	2.99	3.46

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.99	1.91	0.94	1.14	1.32

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_30.09_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.91		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.14		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.58		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.55		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.19		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	22.73 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	22.73		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	11.36		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.84		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.006		
S_C (CRITICAL SLOPE)	(FT/FT)	0.157		
$.7S_c$	(FT/FT)	0.110		
$1.3S_c$	(FT/FT)	0.204		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

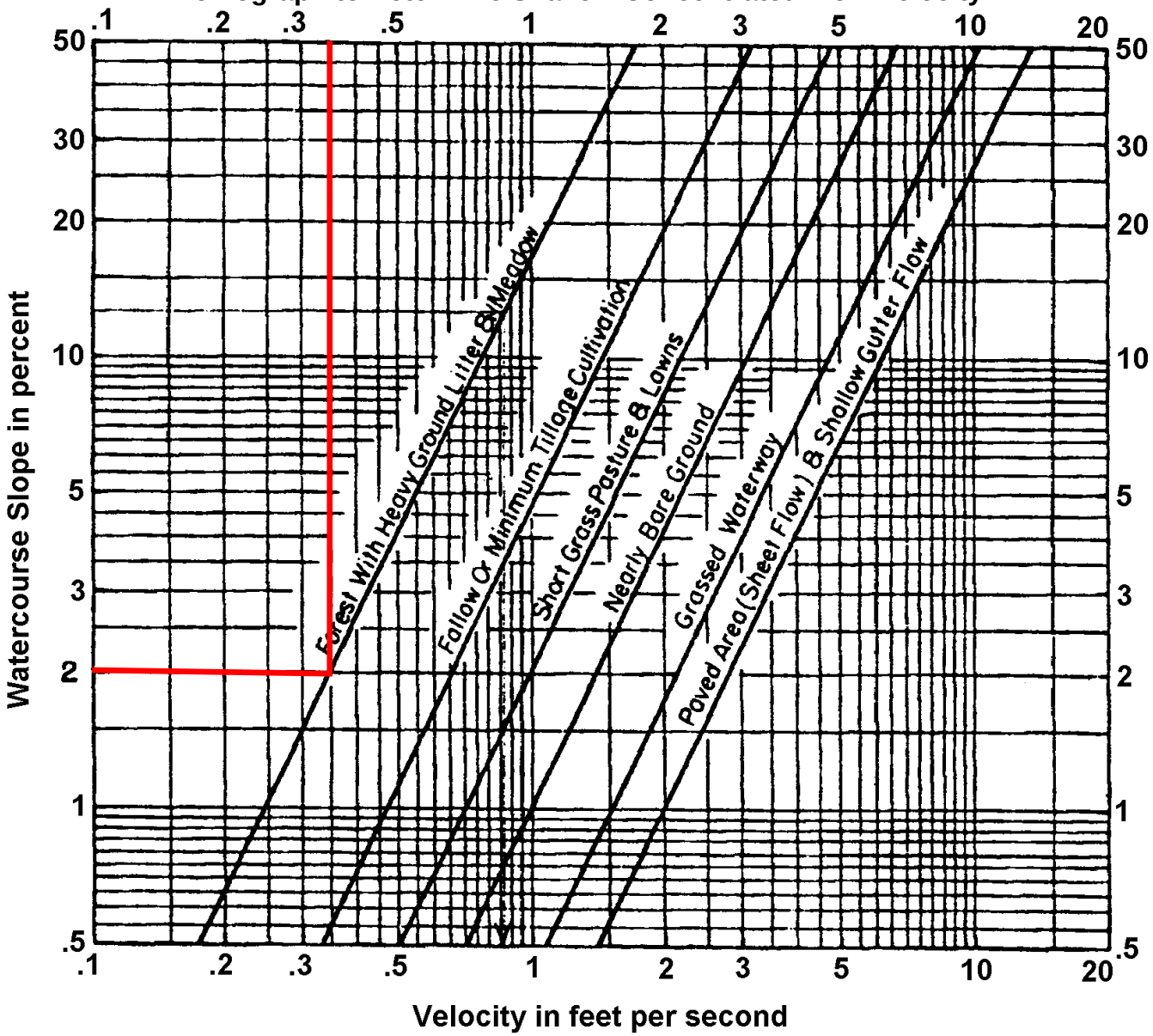
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_30.09_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 2%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.35 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.35 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_30.09_2
4.79 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 30.09_2	100	0.4	0.061	8.92

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 30.09_2	980	FOREST	0.060	0.62	26.50

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
35.42

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 30.09_2	1	FOREST	0.20	4.79	0.96	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	35.42	2.02	2.48	2.91	2.02	2.48	2.91

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.48	4.79	1.94	2.38	2.79

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_30.09_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.79		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.38		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.67		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.79		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.37		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	37.04 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	37.04		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	18.52		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	4.63		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.012		
S_C (CRITICAL SLOPE)	(FT/FT)	0.153		
$.7S_c$	(FT/FT)	0.107		
$1.3S_c$	(FT/FT)	0.199		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

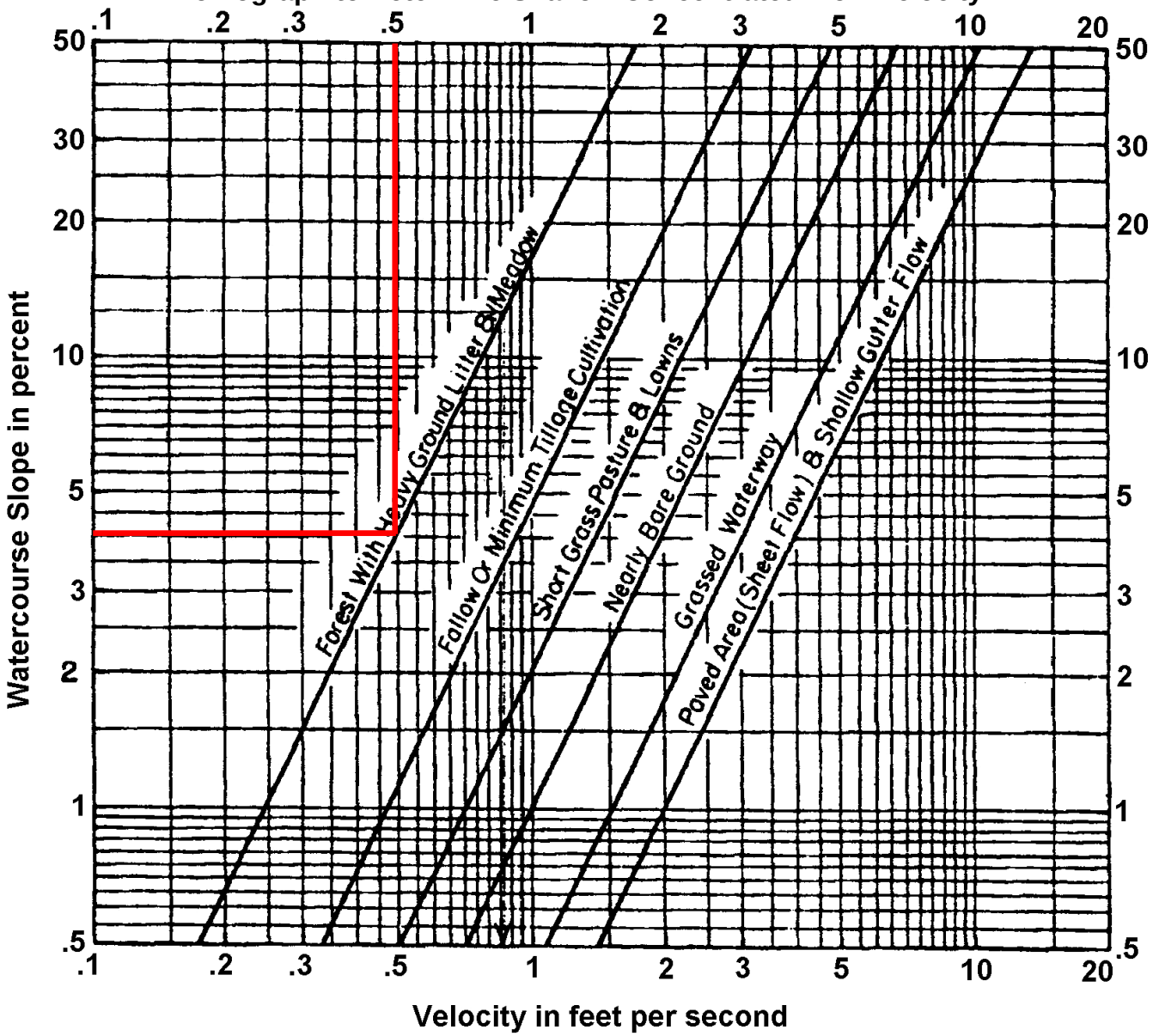
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_30.09_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

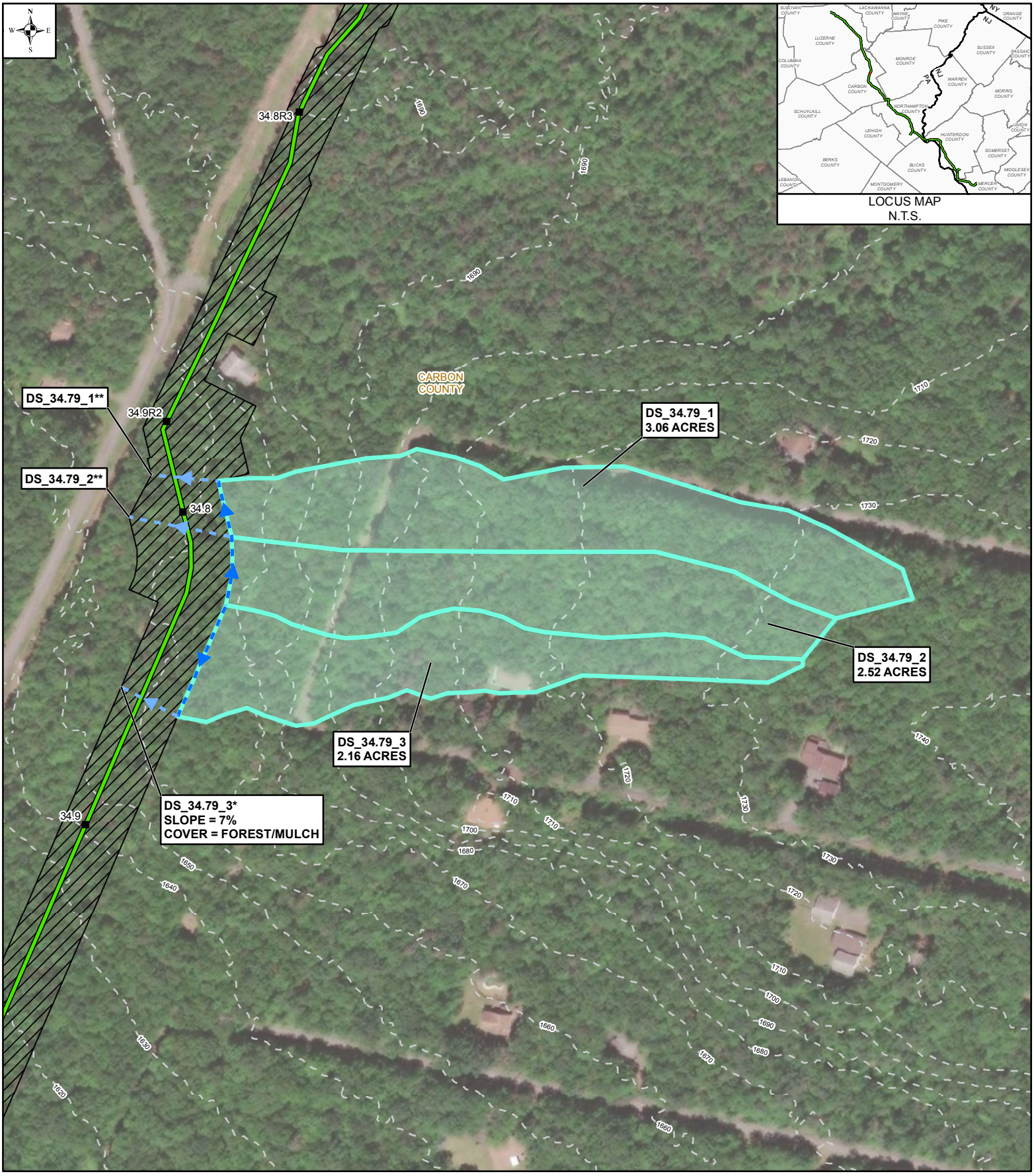


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 4%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.5 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.5 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_34.79

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 200 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 36 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_34.79_1
3.06 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 34.79_1	100	0.4	0.030	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 34.79_1	152	FOREST	0.026	0.41	6.24
	362	PAVEMENT	0.025	3.21	1.88
	563	FOREST	0.103	0.81	11.62

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
30.27

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 34.79_1	1	FOREST	0.20	2.95	0.59	0.22
	2	INDUSTRIAL	0.69	0.11	0.08	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	30.27	2.24	2.74	3.19	2.24	2.74	3.19

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.22	2.74	3.06	1.49	1.82	2.13

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_34.79_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.06		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.83		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.05		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.12		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.37		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	11.49 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	11.49		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.75		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.44		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.044		
S_C (CRITICAL SLOPE)	(FT/FT)	0.079		
$.7S_c$	(FT/FT)	0.055		
$1.3S_c$	(FT/FT)	0.102		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_34.79_2
2.52 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 34.79_2	100	0.4	0.025	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 34.79_2	649	FOREST	0.052	0.57	18.85
	28	PAVEMENT	0.107	6.65	0.07
	195	FOREST	0.138	0.93	3.48

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
33.38

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 34.79_2	1	FOREST	0.20	2.48	0.50	0.21
	2	INDUSTRIAL	0.69	0.04	0.03	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	33.38	2.10	2.58	3.02	2.10	2.58	3.02

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.21	2.58	2.52	1.10	1.35	1.58

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_34.79_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.52		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.35		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.22		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.92		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.15		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	9.26 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	9.26		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.63		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.16		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.037		
S_C (CRITICAL SLOPE)	(FT/FT)	0.081		
$.7S_c$	(FT/FT)	0.057		
$1.3S_c$	(FT/FT)	0.105		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_34.79_3
2.16 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 34.79_3	100	0.4	0.025	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 34.79_3	322	FOREST	0.034	0.46	11.57
	90	PAVEMENT	0.067	5.26	0.29
	508	FOREST	0.098	0.79	10.75

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
33.58

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 34.79_3	1	FOREST	0.20	2.06	0.41	0.22
	2	INDUSTRIAL	0.69	0.10	0.07	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	33.58	2.10	2.57	3.00	2.10	2.57	3.00

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.22	2.57	2.16	1.01	1.23	1.45

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_34.79_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.16		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.24		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.78		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.65		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	13.51 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	13.51		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.76		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.69		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.026		
S_C (CRITICAL SLOPE)	(FT/FT)	0.077		
$.7S_c$	(FT/FT)	0.054		
$1.3S_c$	(FT/FT)	0.100		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

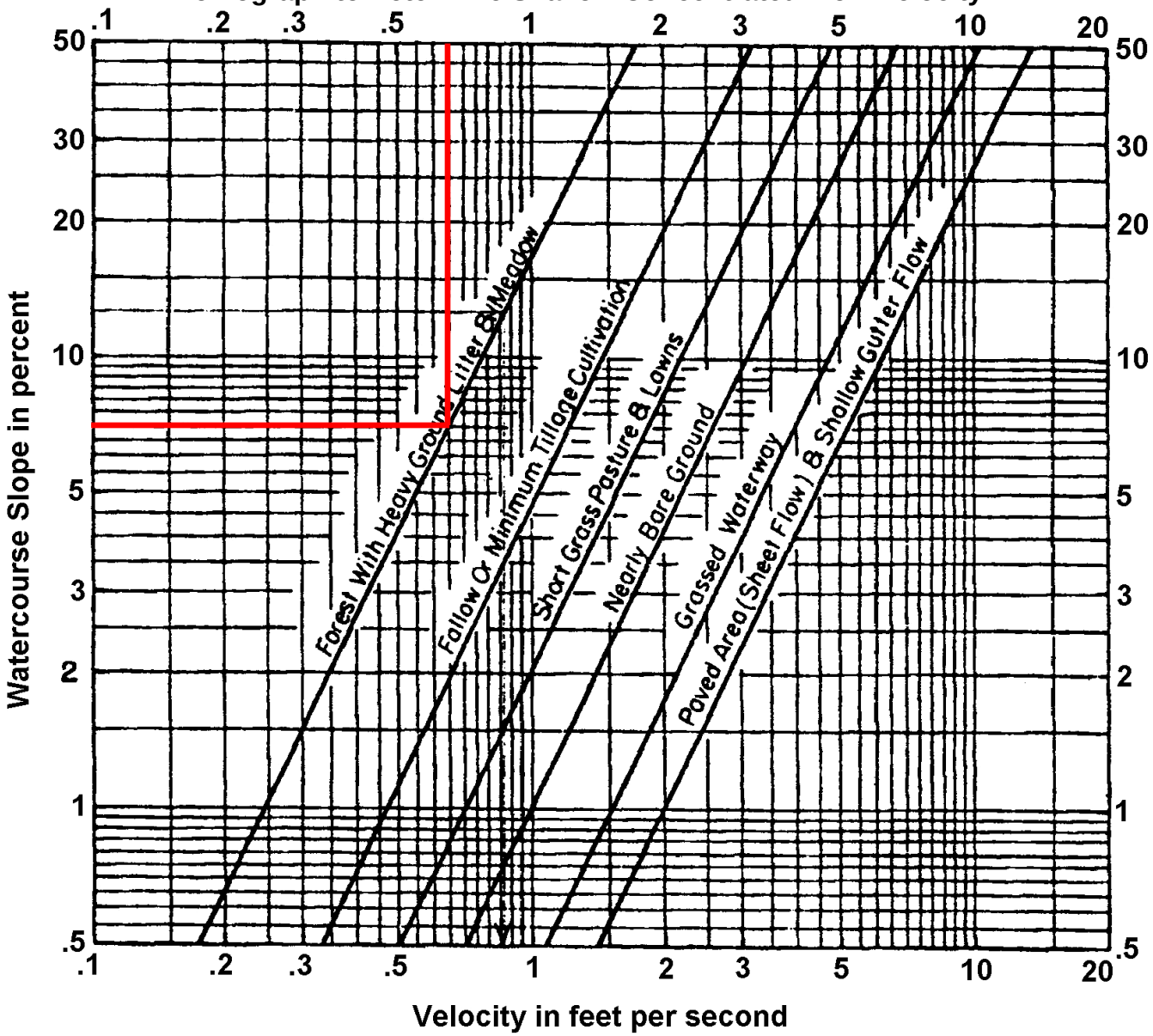
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_34.79_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

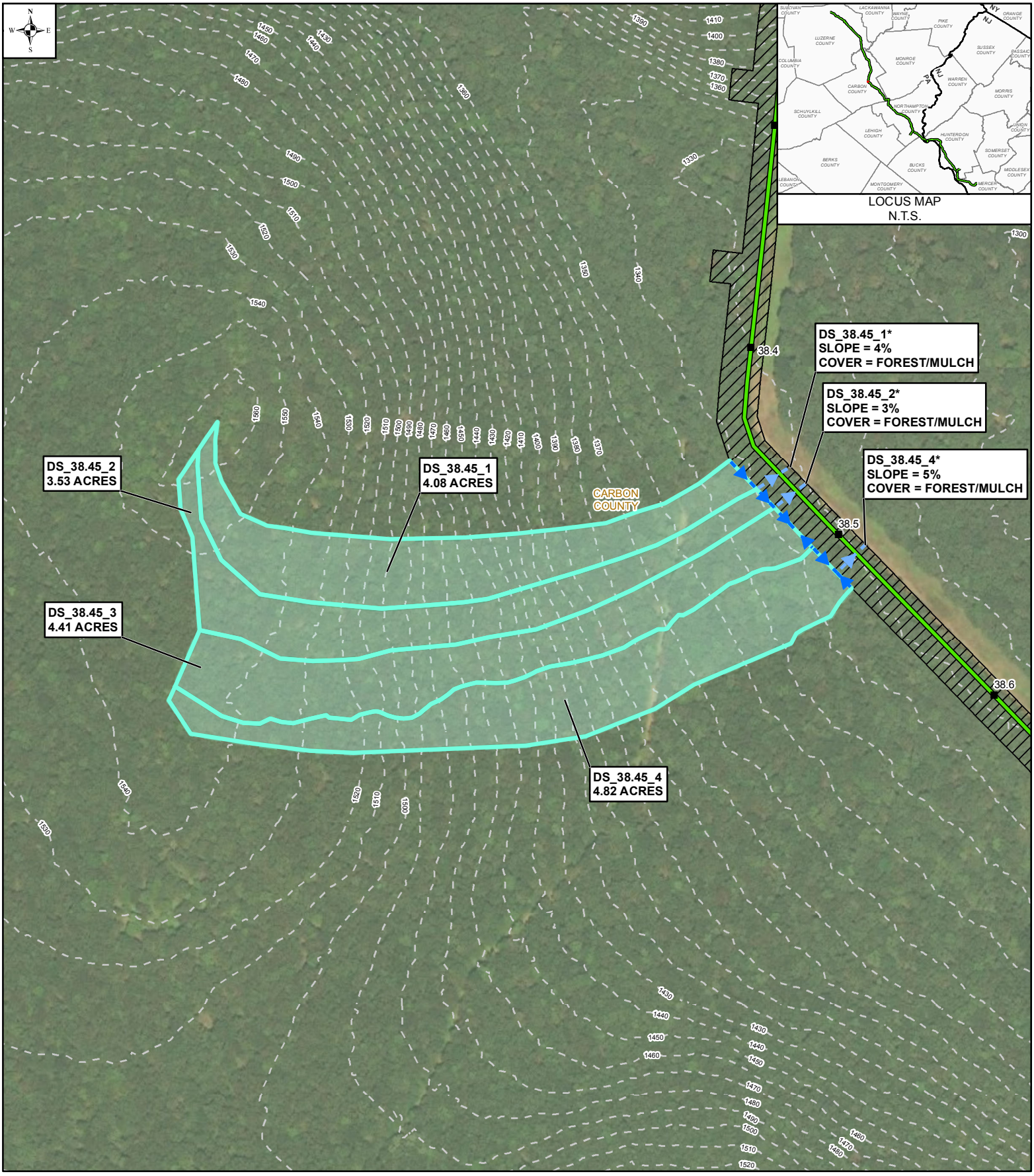


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_38.45

CARBON COUNTY, PENNSYLVANIA

0 150 300 FEET

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 300 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

PennEast PIPELINE

DWG NO: PAGE 37 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.45_1
4.08 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.45_1	100	0.4	0.051	9.30

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.45_1	1578	FOREST	0.139	0.94	28.04
	27	SHORT GRASS	0.067	1.80	0.25

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
37.58

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.45_1	1	FOREST	0.20	4.06	0.81	0.20
	2	INDUSTRIAL	0.69	0.02	0.01	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	37.58	1.94	2.39	2.81	1.94	2.39	2.81

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.39	4.08	1.60	1.97	2.32

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.45_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.08		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.97		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.08		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.47		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.66		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	11.36 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	11.36		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.68		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.42		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.021		
S_C (CRITICAL SLOPE)	(FT/FT)	0.079		
$.7S_c$	(FT/FT)	0.055		
$1.3S_c$	(FT/FT)	0.102		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

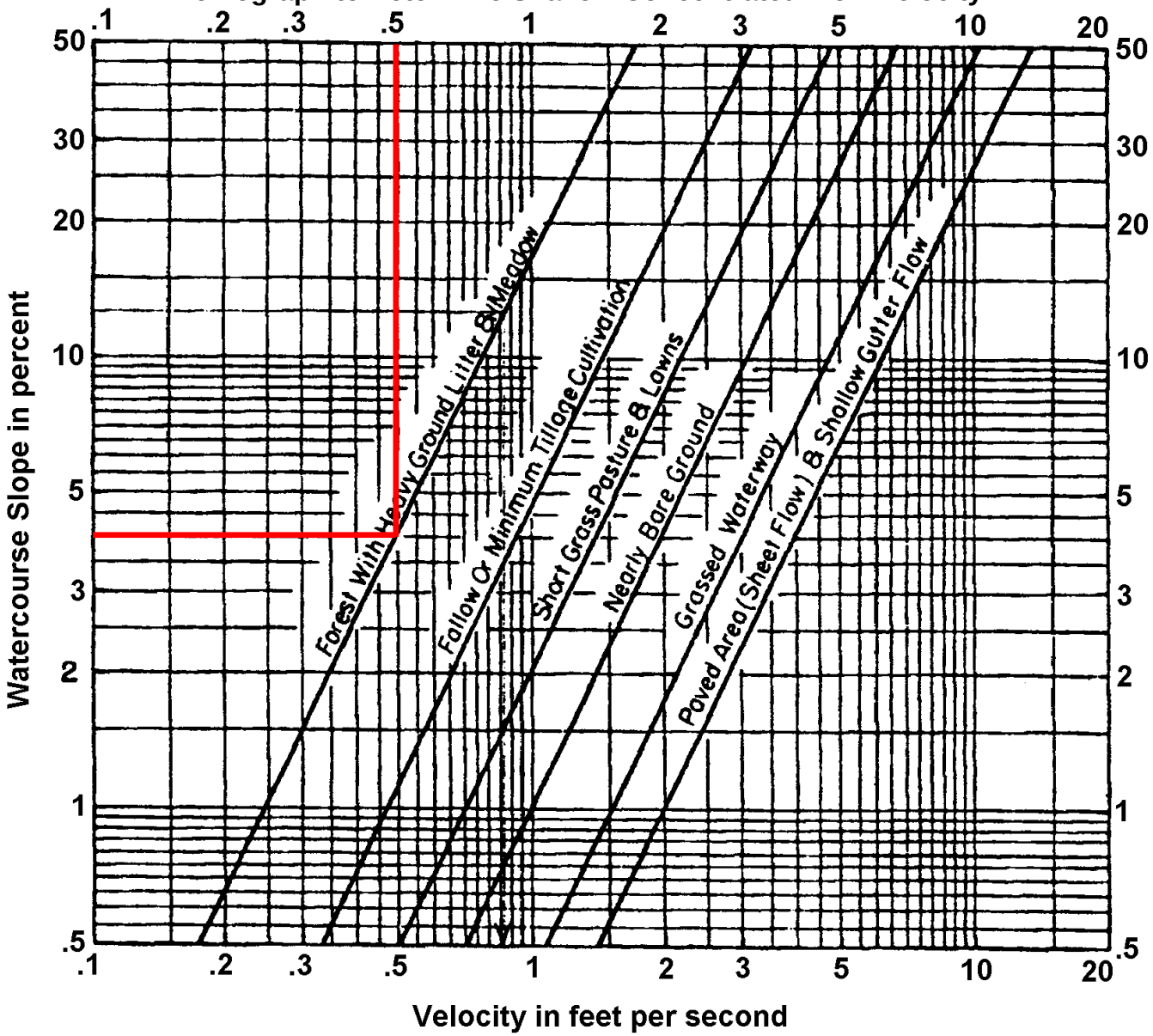
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.45_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 4%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.5 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.5 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.45_2
3.53 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.45_2	100	0.4	0.050	9.34

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.45_2	1777	FOREST	0.118	0.86	34.27
	19	SHORT GRASS	0.105	2.26	0.14

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
43.75

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.45_2	1	FOREST	0.20	3.52	0.70	0.20
	2	INDUSTRIAL	0.69	0.01	0.01	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	43.75	1.74	2.15	2.55	1.74	2.15	2.55

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.15	3.53	1.24	1.53	1.81

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.45_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.53		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.53		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.79		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.31		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	10.87 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	10.87		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.43		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.36		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.079		
$.7S_c$	(FT/FT)	0.055		
$1.3S_c$	(FT/FT)	0.103		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

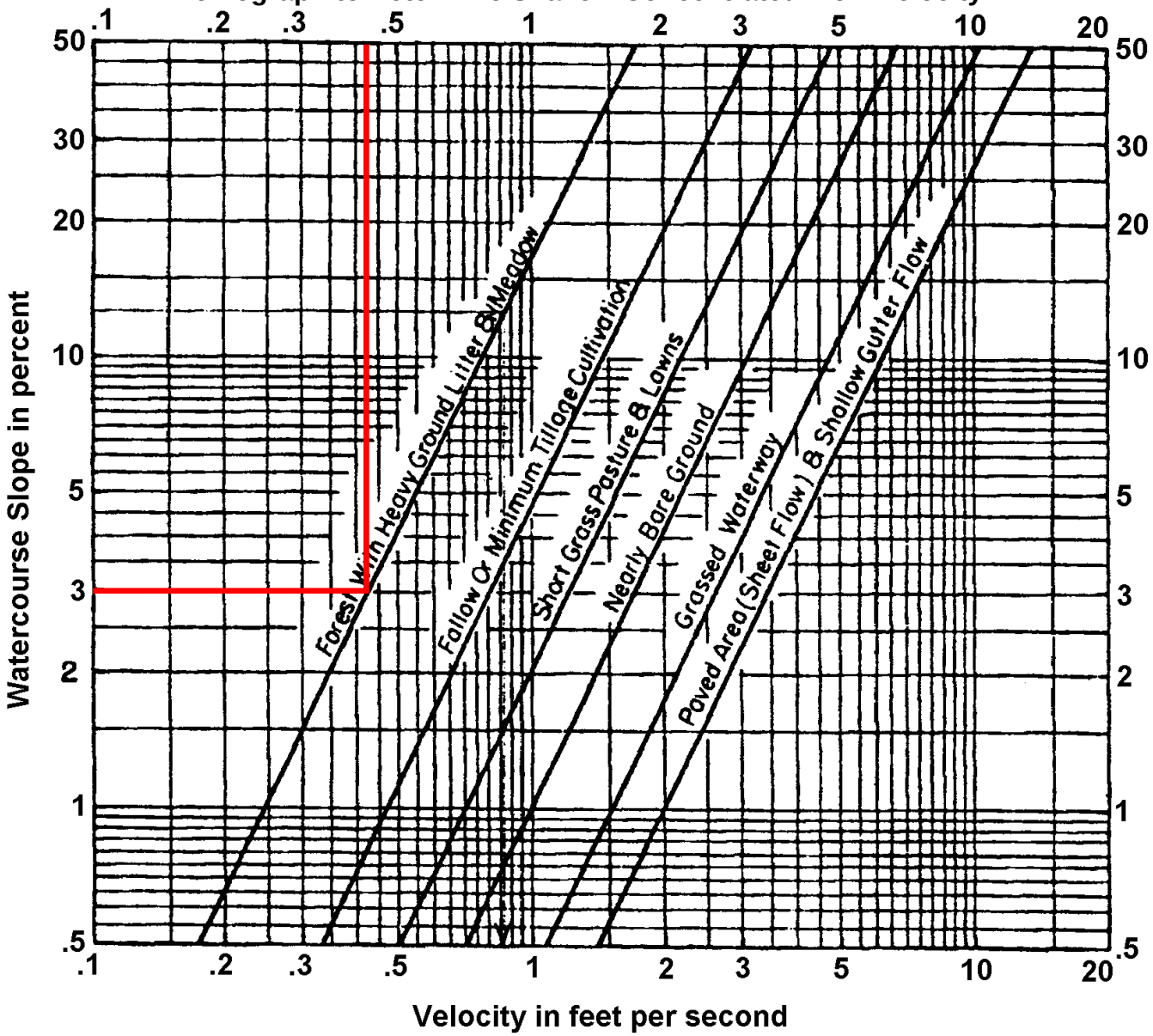
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.45_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 3%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.45 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.45 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.45_3
4.41 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.45_3	100	0.4	0.030	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.45_3	1554	FOREST	0.132	0.91	28.33

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
38.86

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.45_3	1	FOREST	0.20	4.41	0.88	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	38.86	1.90	2.33	2.75	1.90	2.33	2.75

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.33	4.41	1.67	2.06	2.42

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.45_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.41		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	9.92		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	18.70		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.044		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.18		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	11.76 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	17.65		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	11.76		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	5.88		
R (HYDRAULIC RADIUS)		0.46		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.040		
$.7S_c$	(FT/FT)	0.028		
$1.3S_c$	(FT/FT)	0.052		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.45_4
4.82 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.45_4	100	0.4	0.020	11.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.45_4	1667	FOREST	0.124	0.89	31.36

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
42.93

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.45_4	1	FOREST	0.20	4.82	0.96	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	42.93	1.77	2.18	2.58	1.77	2.18	2.58

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.18	4.82	1.71	2.10	2.49

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.45_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.82		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.1		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.48		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.23		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.50		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.5 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	12.50		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.25		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.56		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.048		
S_C (CRITICAL SLOPE)	(FT/FT)	0.078		
$.7S_c$	(FT/FT)	0.054		
$1.3S_c$	(FT/FT)	0.101		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

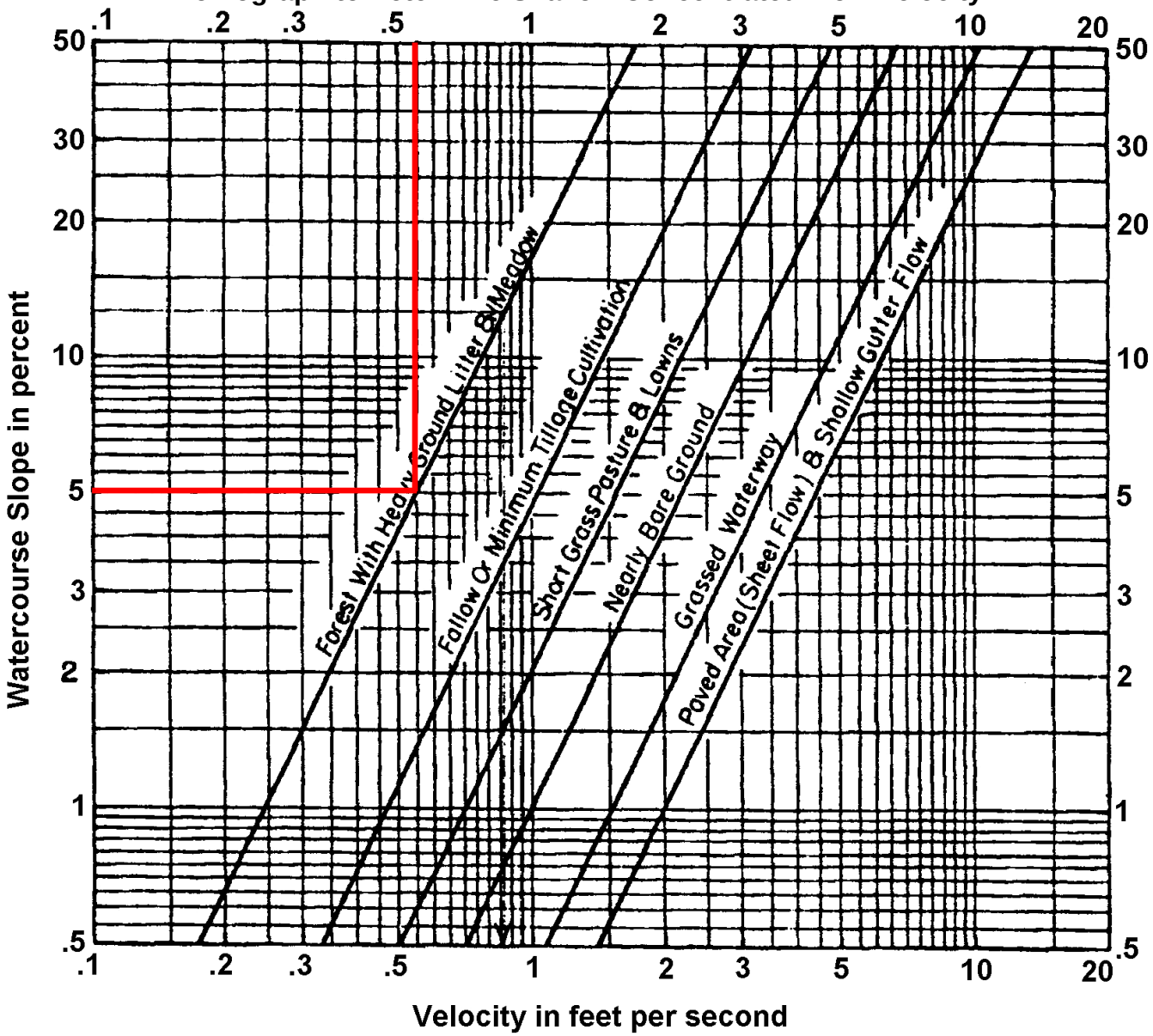
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.45_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

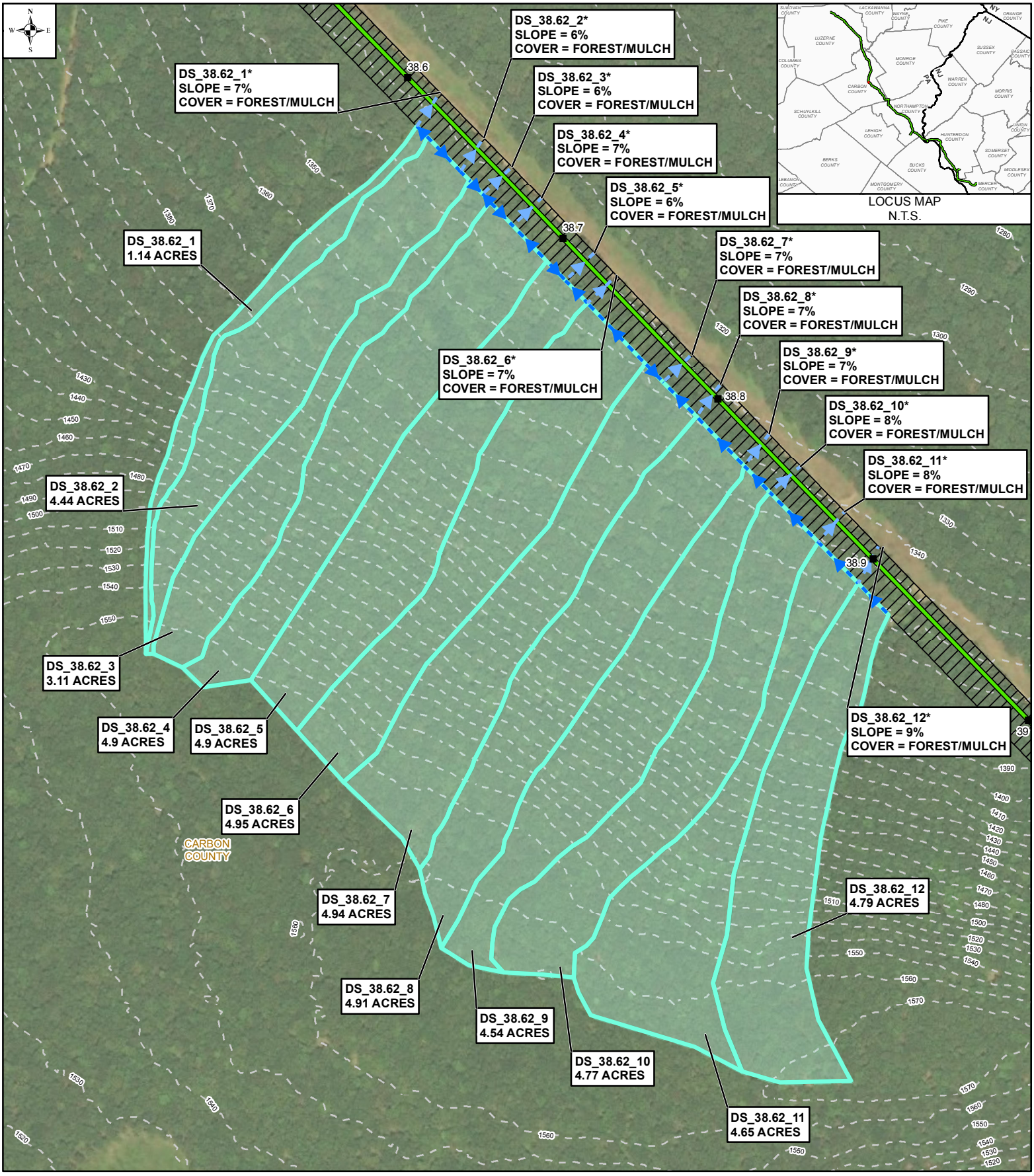


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 5%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.6 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_38.62

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 300 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 150 300 FEET

PennEast PIPELINE

DWG NO: PAGE 38 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_1
1.14 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_1	100	0.4	0.070	8.63

$$T_{c(sheet\ flow)} = \left[\frac{2(L)(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_1	1373	FOREST	0.157	1.00	22.95

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
31.59

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_1	1	FOREST	0.20	1.14	0.23	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	31.59	2.18	2.67	3.11	2.18	2.67	3.11

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.67	1.14	0.50	0.61	0.71

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.14		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.61		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.40		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.68		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	13.16 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	13.16		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.58		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.64		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.057		
S_C (CRITICAL SLOPE)	(FT/FT)	0.064		
$.7S_c$	(FT/FT)	0.045		
$1.3S_c$	(FT/FT)	0.083		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

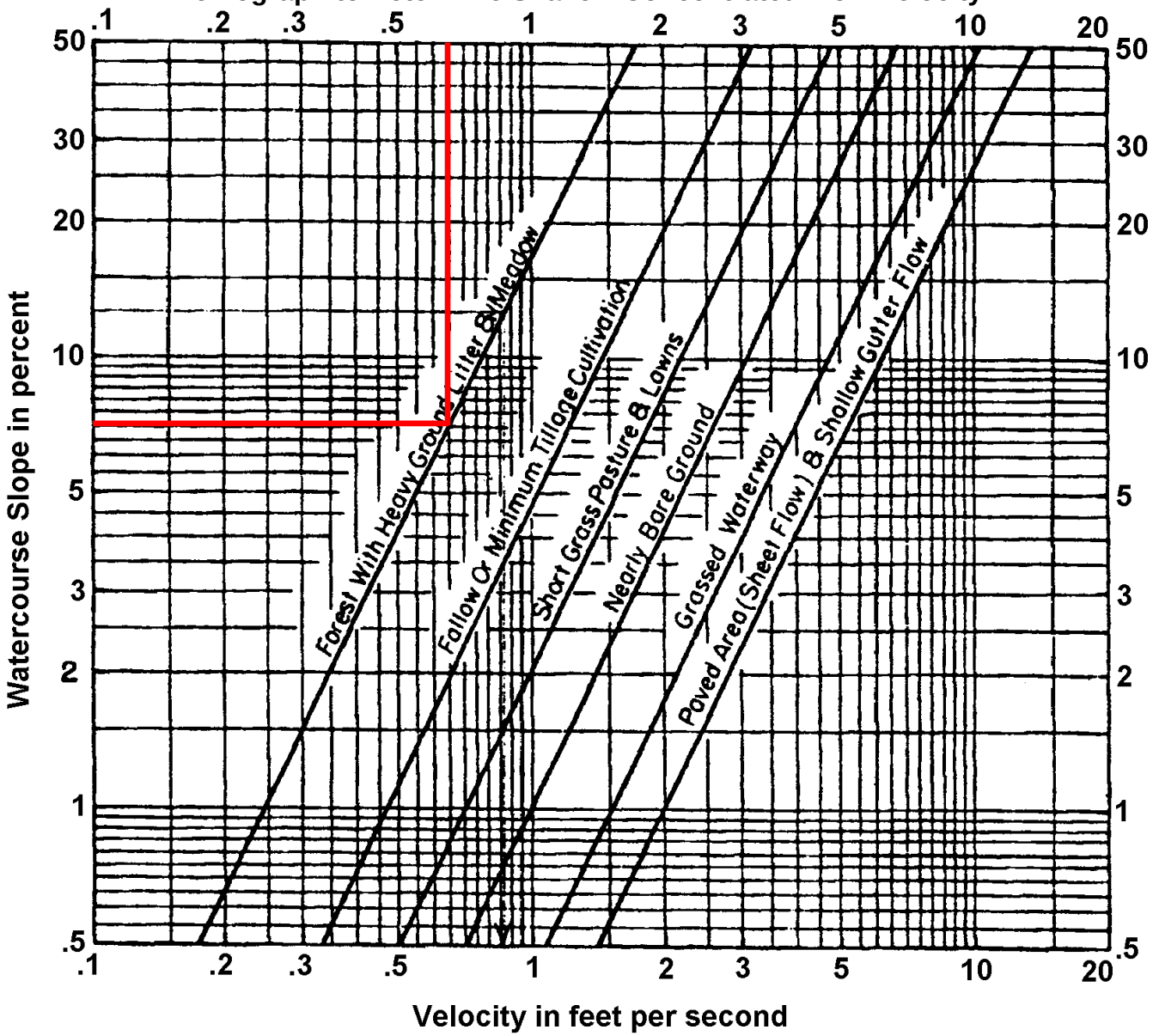
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_2
4.44 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_2	100	0.4	0.070	8.63

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_2	1380	FOREST	0.155	0.99	23.22

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
31.85

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_2	1	FOREST	0.20	4.44	0.89	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	31.85	2.17	2.65	3.10	2.17	2.65	3.10

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.65	4.44	1.93	2.36	2.75

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.44		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.36		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.54		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.43		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.28		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	14.93 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	14.93		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.46		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.87		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.009		
S_C (CRITICAL SLOPE)	(FT/FT)	0.012		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.016		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

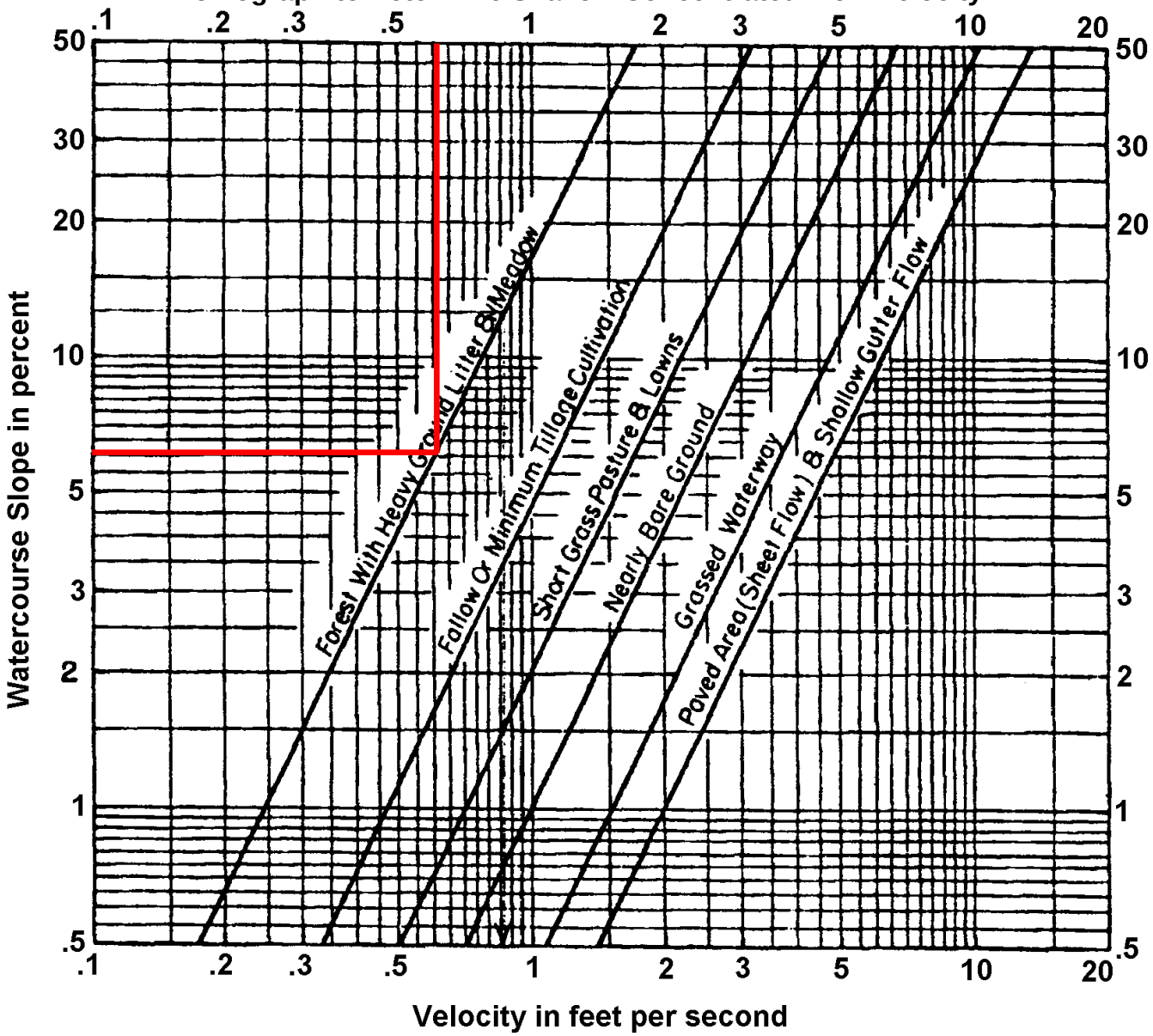
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 6%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.6 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_3
3.11 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_3	100	0.4	0.070	8.63

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_3	1380	FOREST	0.168	1.03	22.30

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
30.94

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_3	1	FOREST	0.20	3.11	0.62	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	30.94	2.21	2.70	3.15	2.21	2.70	3.15

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.70	3.11	1.38	1.68	1.96

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.11		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.68		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.20		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.19		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.69		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	14.71 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	14.71		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.35		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.84		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.022		
S_C (CRITICAL SLOPE)	(FT/FT)	0.124		
$.7S_c$	(FT/FT)	0.087		
$1.3S_c$	(FT/FT)	0.161		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

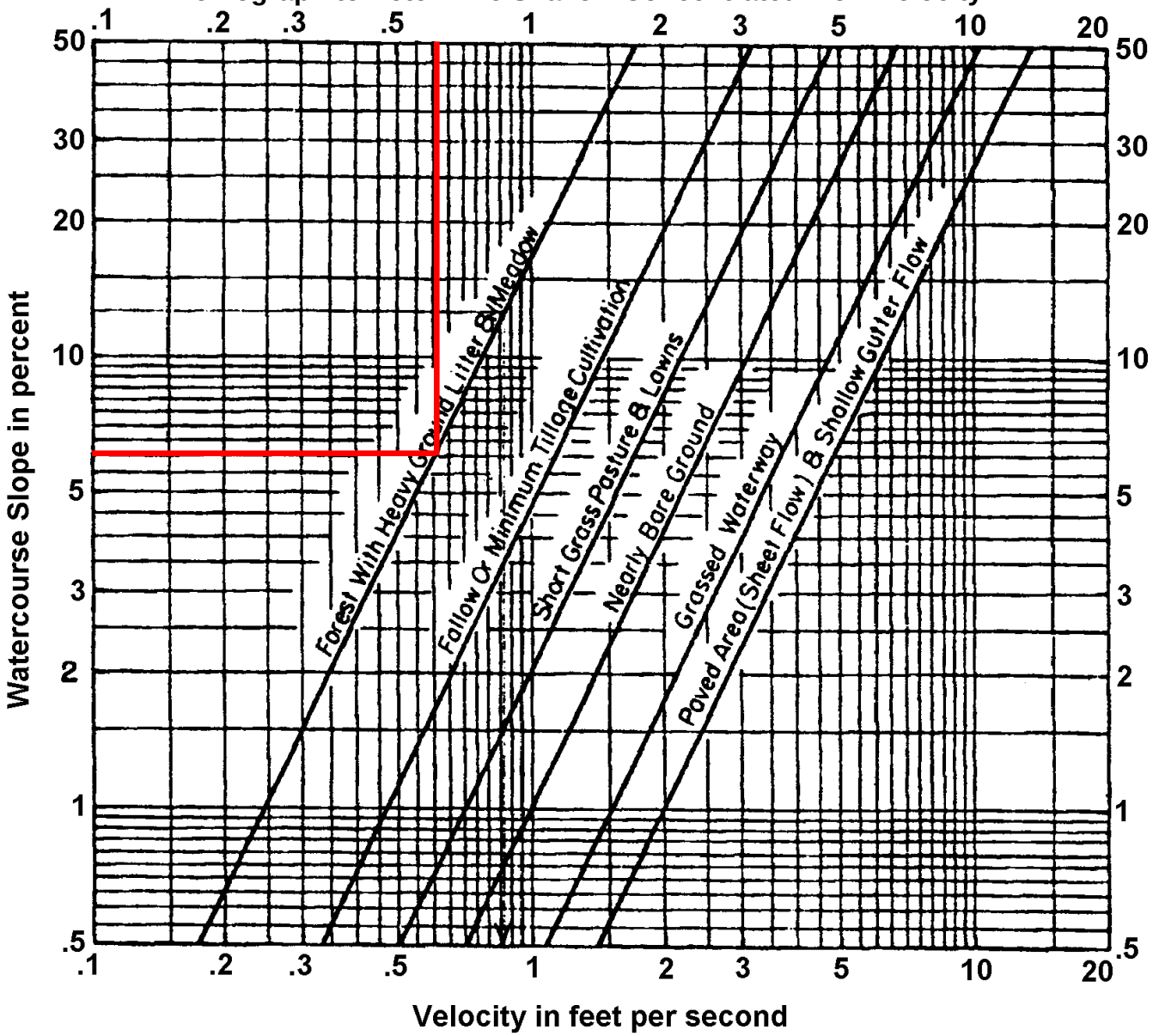
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 6%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.6 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_4
4.9 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_4	100	0.4	0.060	8.95

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_4	1352	FOREST	0.158	1.00	22.53

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
31.48

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_4	1	FOREST	0.20	4.90	0.98	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	31.48	2.19	2.67	3.12	2.19	2.67	3.12

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.67	4.90	2.14	2.62	3.06

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.9		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.62		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.35		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.69		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.84		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	15.87 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	15.87		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.98		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.027		
S_C (CRITICAL SLOPE)	(FT/FT)	0.076		
$.7S_c$	(FT/FT)	0.053		
$1.3S_c$	(FT/FT)	0.099		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

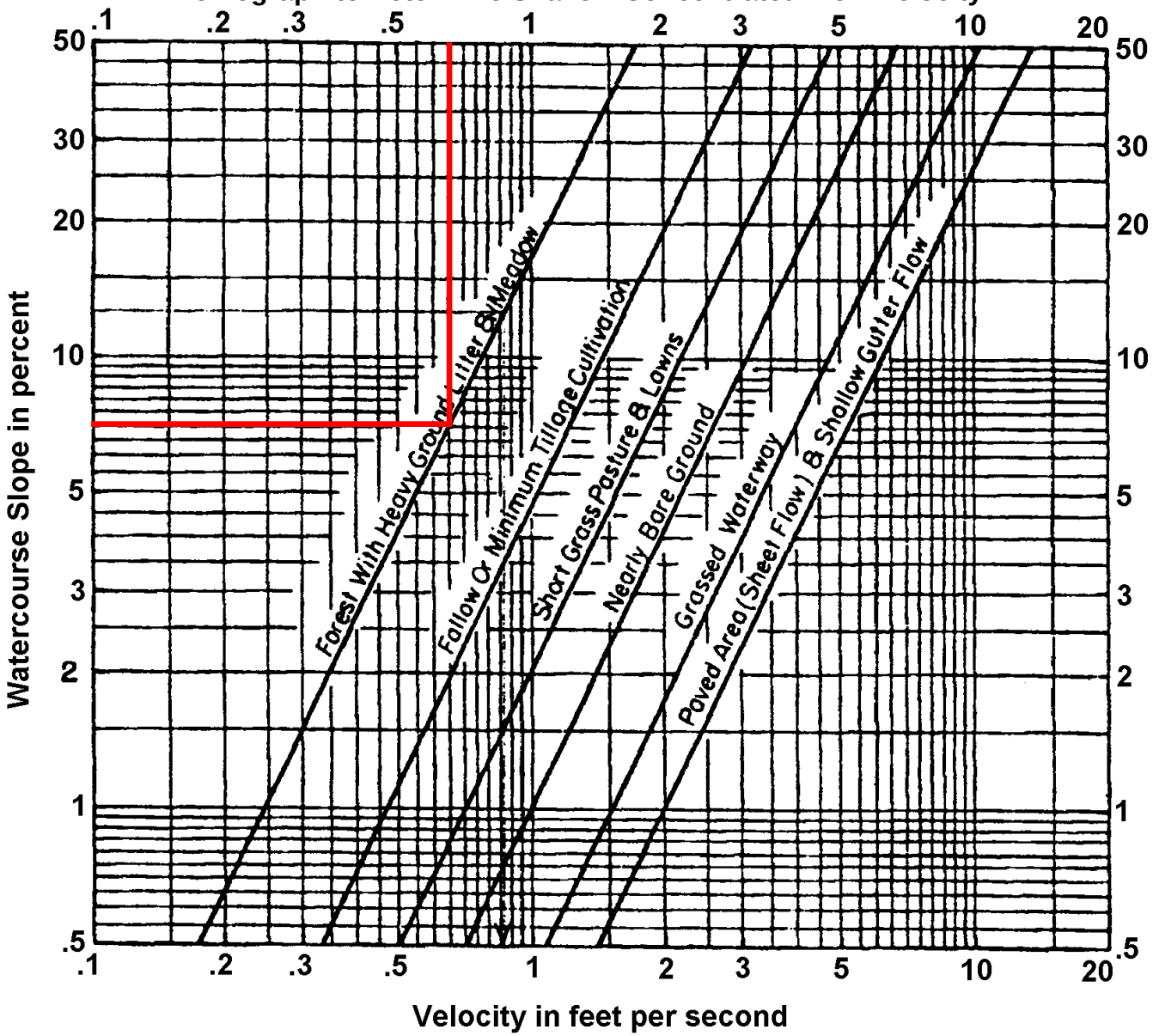
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_5
4.9 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_5	100	0.4	0.090	8.14

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_5	1243	FOREST	0.169	1.03	20.03

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
28.17

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_5	1	FOREST	0.20	4.90	0.98	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	28.17	2.35	2.86	3.32	2.35	2.86	3.32

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.86	4.90	2.30	2.80	3.26

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.9		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.81		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.32		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.13		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.84		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	10.31 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	10.31		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.15		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.29		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.027		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

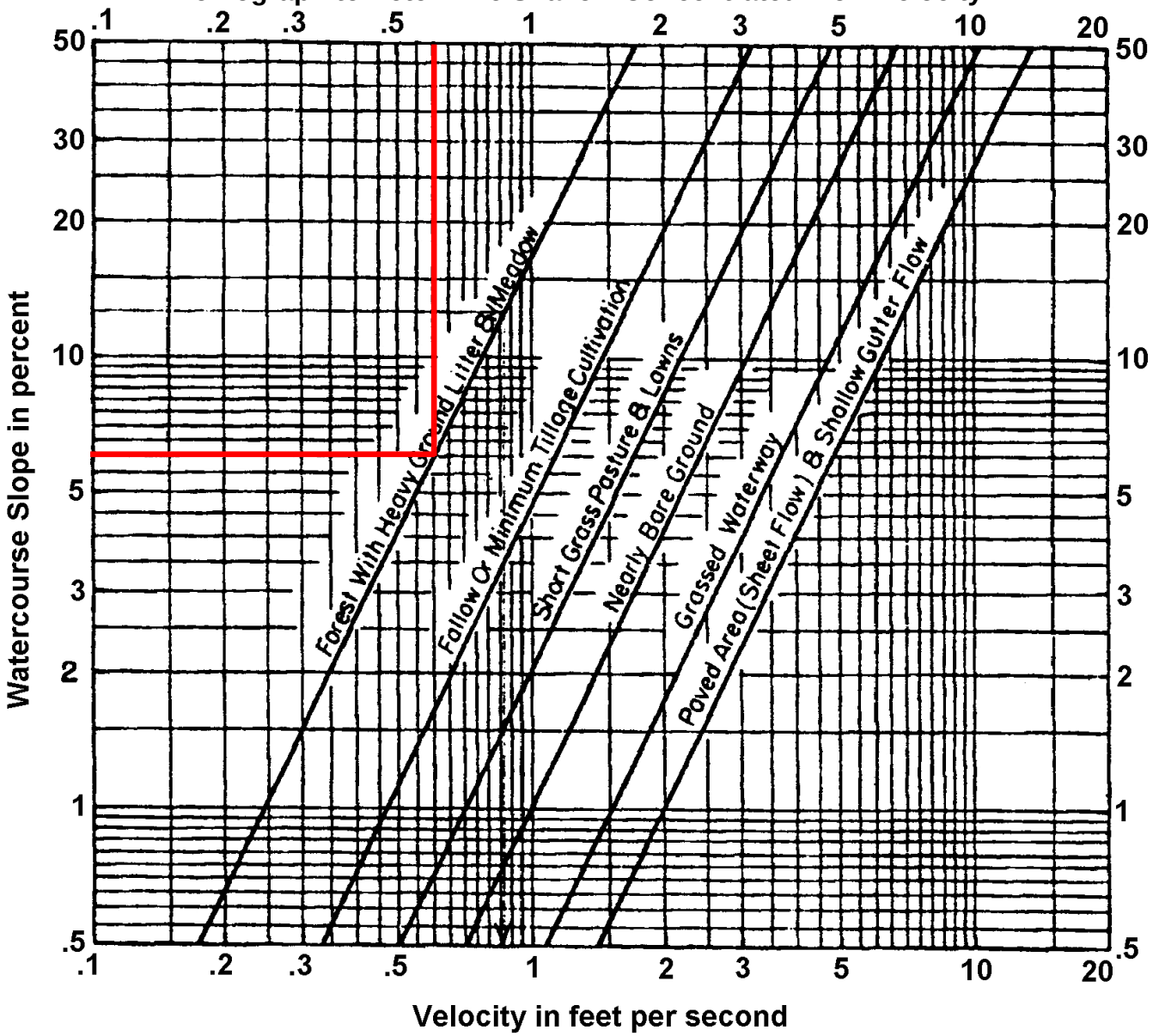
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 6%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.6 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.6 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_6
4.95 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_6	100	0.4	0.090	8.14

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_6	1243	FOREST	0.169	1.03	20.03

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
28.17

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_6	1	FOREST	0.20	4.95	0.99	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	28.17	2.35	2.86	3.32	2.35	2.86	3.32

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.86	4.95	2.32	2.83	3.29

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.95		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.83		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.68		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.30		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	11.36 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	11.36		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.68		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.42		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.016		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

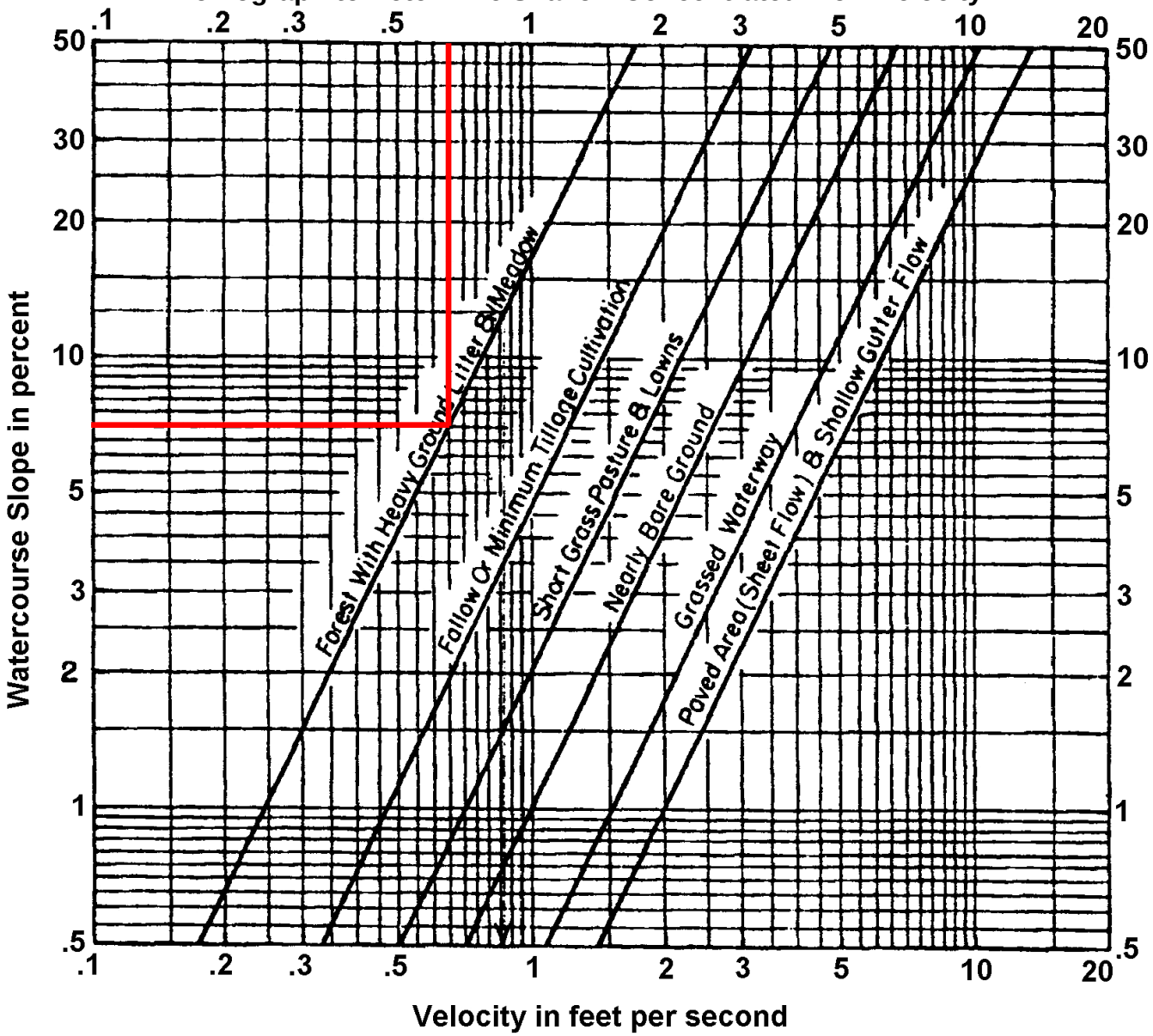
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_7
4.94 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_7	100	0.4	0.050	9.34

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_7	1167	FOREST	0.186	1.09	17.92

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
27.26

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_7	1	FOREST	0.20	4.94	0.99	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	27.26	2.39	2.92	3.38	2.39	2.92	3.38

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.92	4.94	2.37	2.88	3.34

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.94		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.88		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.25		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.53		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.03		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	9.26 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	9.26		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.63		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.16		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.033		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

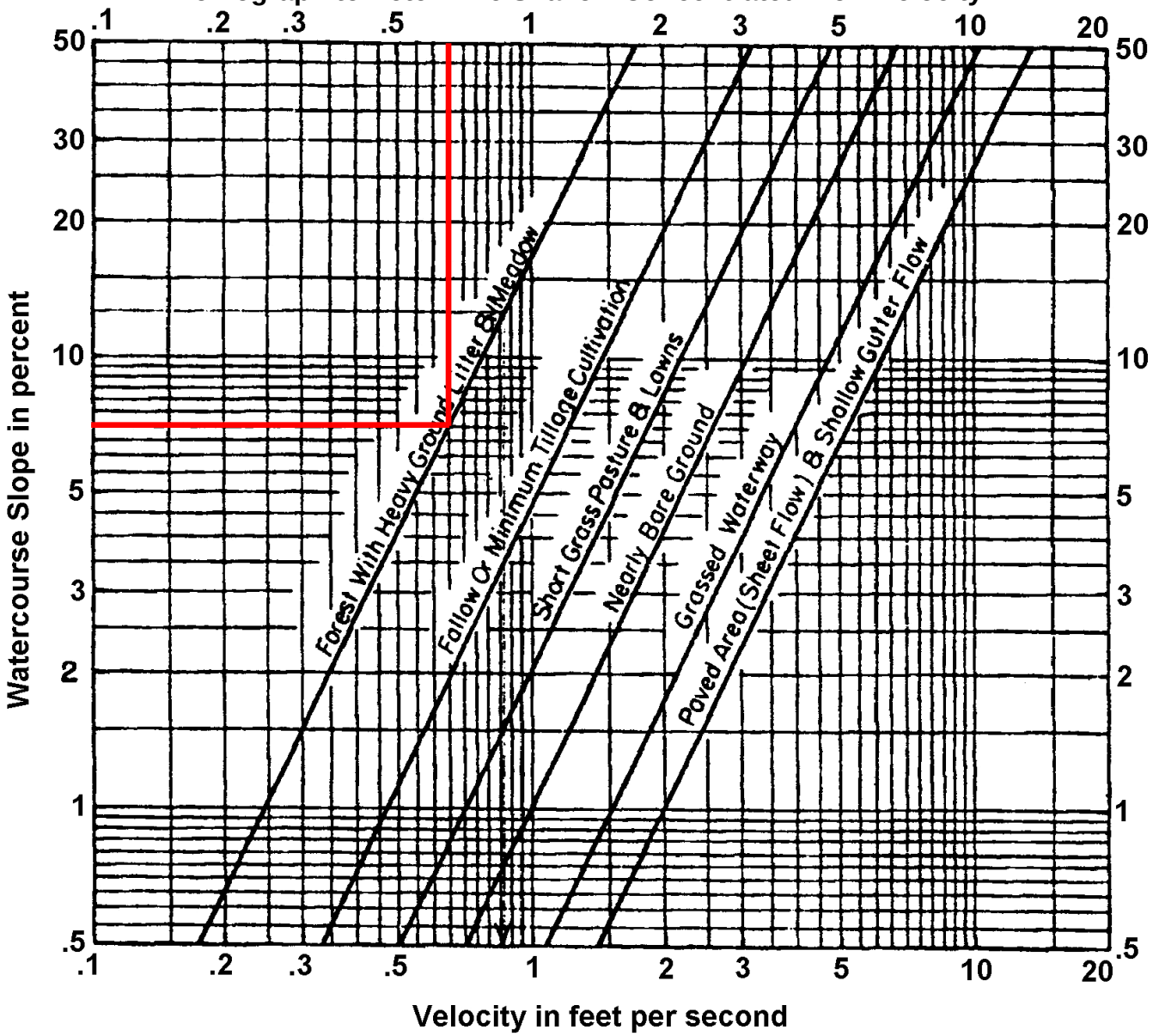
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_8
4.91 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_8	100	0.4	0.030	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_8	1265	FOREST	0.172	1.04	20.21

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
30.73

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_8	1	FOREST	0.20	4.91	0.98	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	30.73	2.22	2.71	3.16	2.22	2.71	3.16

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.71	4.91	2.18	2.67	3.11

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.91		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.67		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.43		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.32		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.26 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.26		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.03		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.018		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

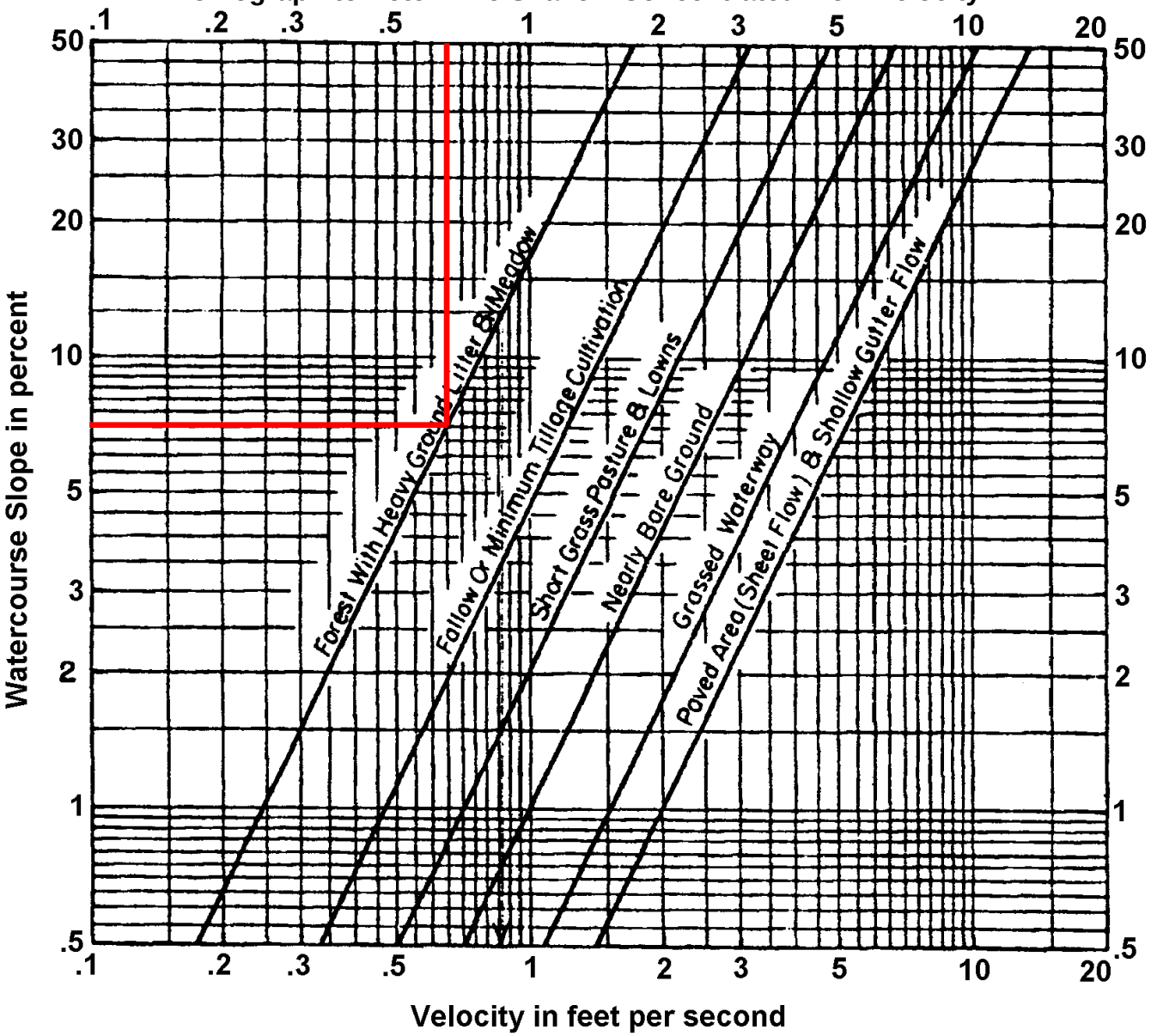
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_9
4.54 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_9	100	0.4	0.050	9.34

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_9	1270	FOREST	0.172	1.04	20.29

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
29.62

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_9	1	FOREST	0.20	4.54	0.91	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	29.62	2.27	2.78	3.23	2.27	2.78	3.23

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.78	4.54	2.06	2.52	2.93

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_9		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.54		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.52		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.82		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.87		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.06		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.05 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	12.05		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.02		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.51		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.034		
S_C (CRITICAL SLOPE)	(FT/FT)	0.078		
$.7S_c$	(FT/FT)	0.055		
$1.3S_c$	(FT/FT)	0.102		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

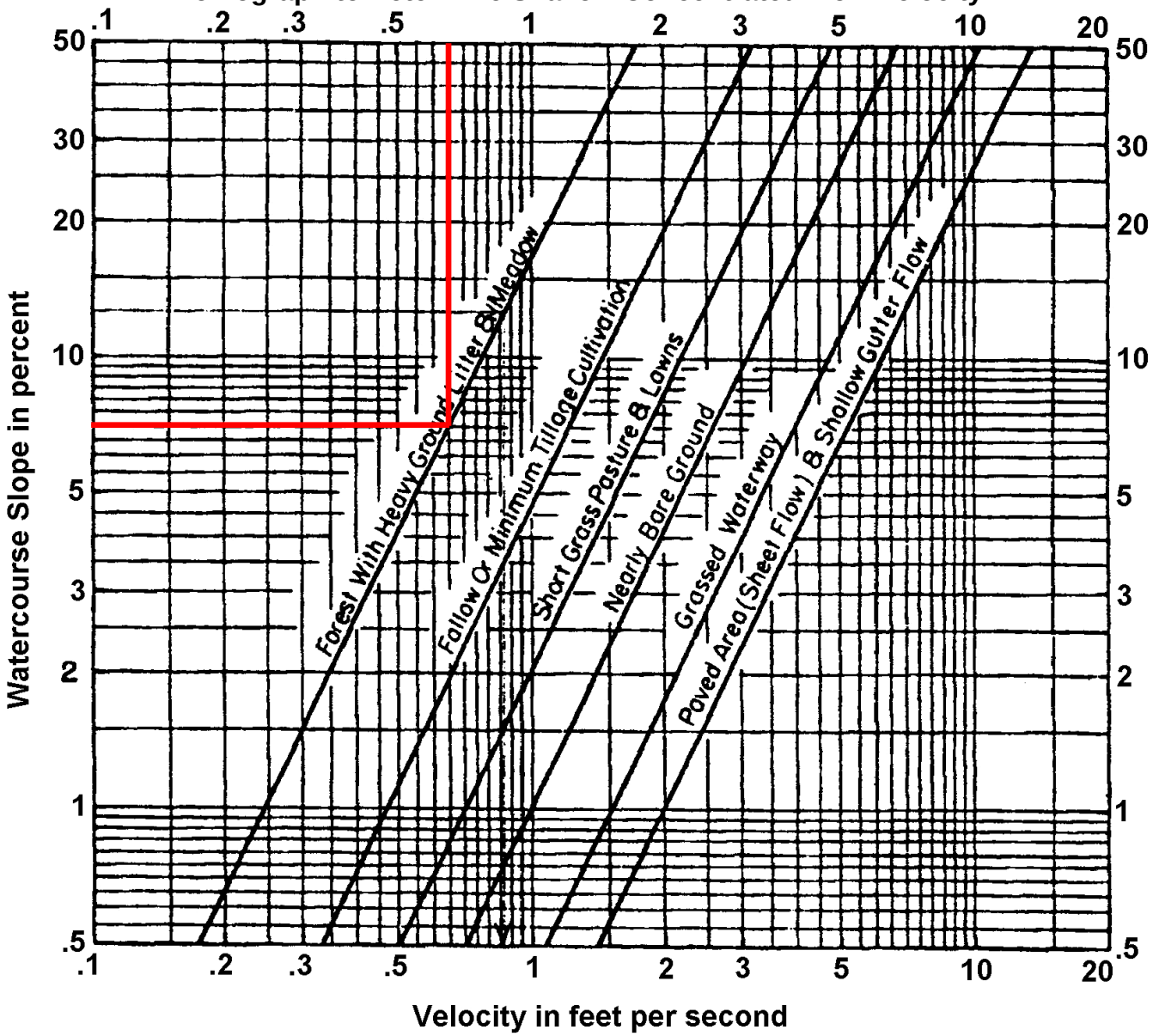
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_9

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_10
4.77 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_10	100	0.4	0.050	9.34

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_10	1270	FOREST	0.172	1.04	20.29

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
29.62

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_10	1	FOREST	0.20	4.77	0.95	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	29.62	2.27	2.78	3.23	2.27	2.78	3.23

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.78	4.77	2.17	2.65	3.08

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_10		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.77		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.65		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.87		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.13		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.15		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	10.75 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	10.75		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.34		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.037		
S_C (CRITICAL SLOPE)	(FT/FT)	0.065		
$.7S_c$	(FT/FT)	0.046		
$1.3S_c$	(FT/FT)	0.085		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

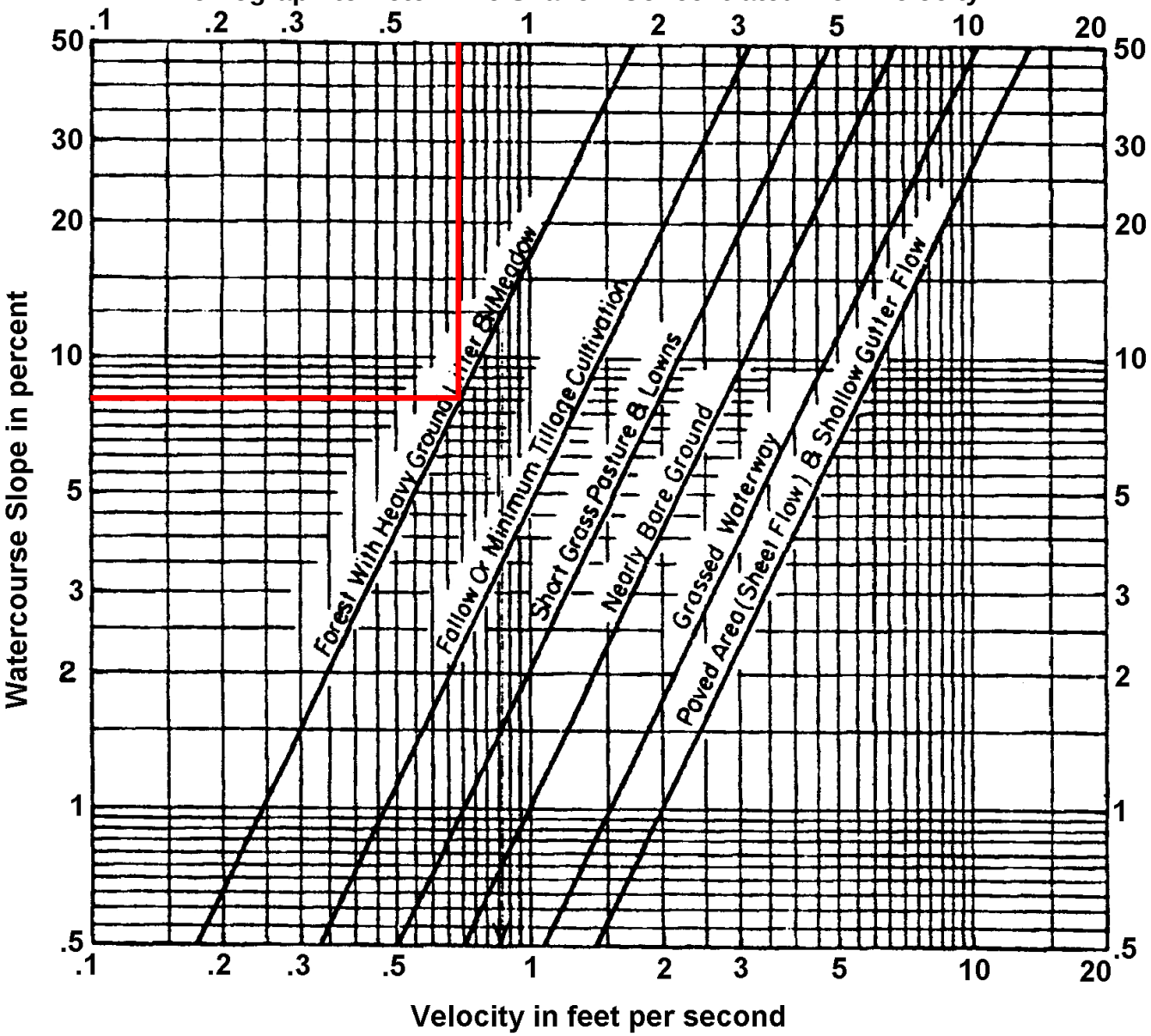
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_10

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 8%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_11
4.65 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_11	100	0.4	0.041	9.78

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_11	1270	FOREST	0.180	1.07	19.83

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
29.61

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_11	1	FOREST	0.20	4.65	0.93	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	29.61	2.27	2.78	3.23	2.27	2.78	3.23

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.78	4.65	2.11	2.58	3.00

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_11		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.65		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.58		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.69		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.30		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.37		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	9.35 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	9.35		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.67		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.17		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.044		
S_C (CRITICAL SLOPE)	(FT/FT)	0.067		
$.7S_c$	(FT/FT)	0.047		
$1.3S_c$	(FT/FT)	0.087		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

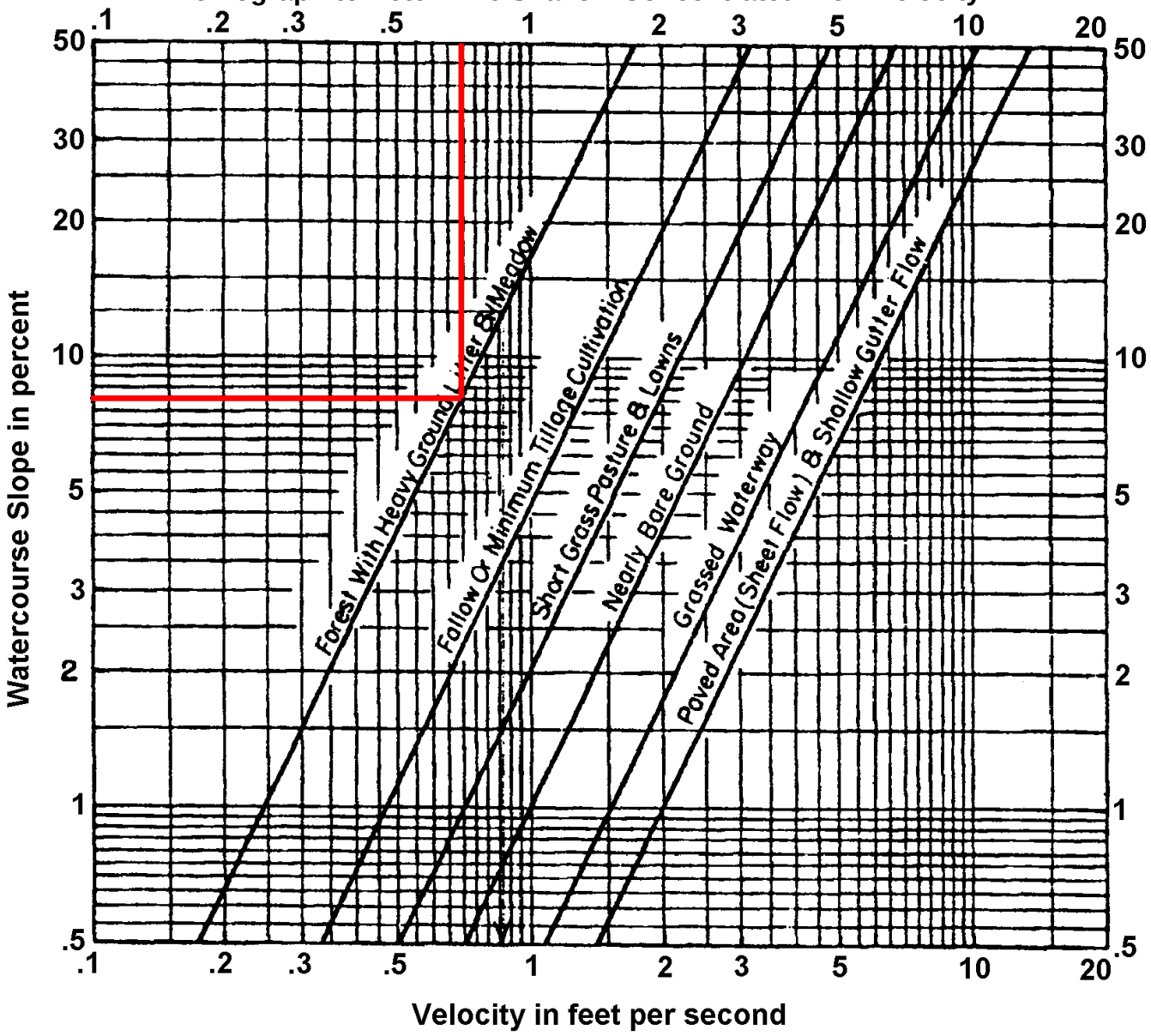
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_11

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 8%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_38.62_12
4.79 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 38.62_12	100	0.4	0.040	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 38.62_12	1136	FOREST	0.181	1.07	17.69

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
27.53

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 38.62_12	1	FOREST	0.20	4.79	0.96	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	27.53	2.38	2.90	3.36	2.38	2.90	3.36

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.90	4.79	2.28	2.78	3.22

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_38.62_12		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.79		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.78		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	6.03		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.50		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.77 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.77		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.39		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.10		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.049		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

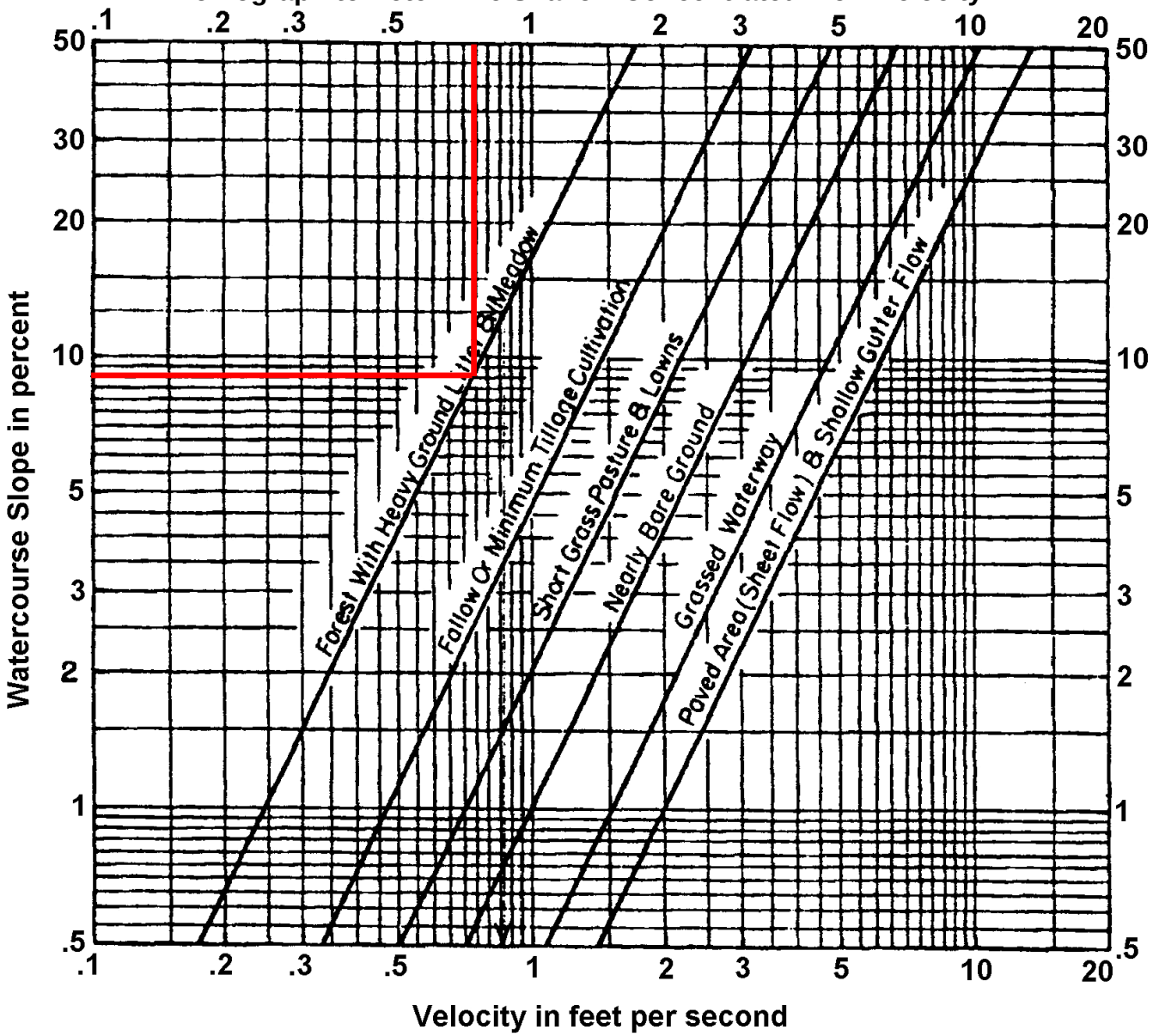
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_38.62_12

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

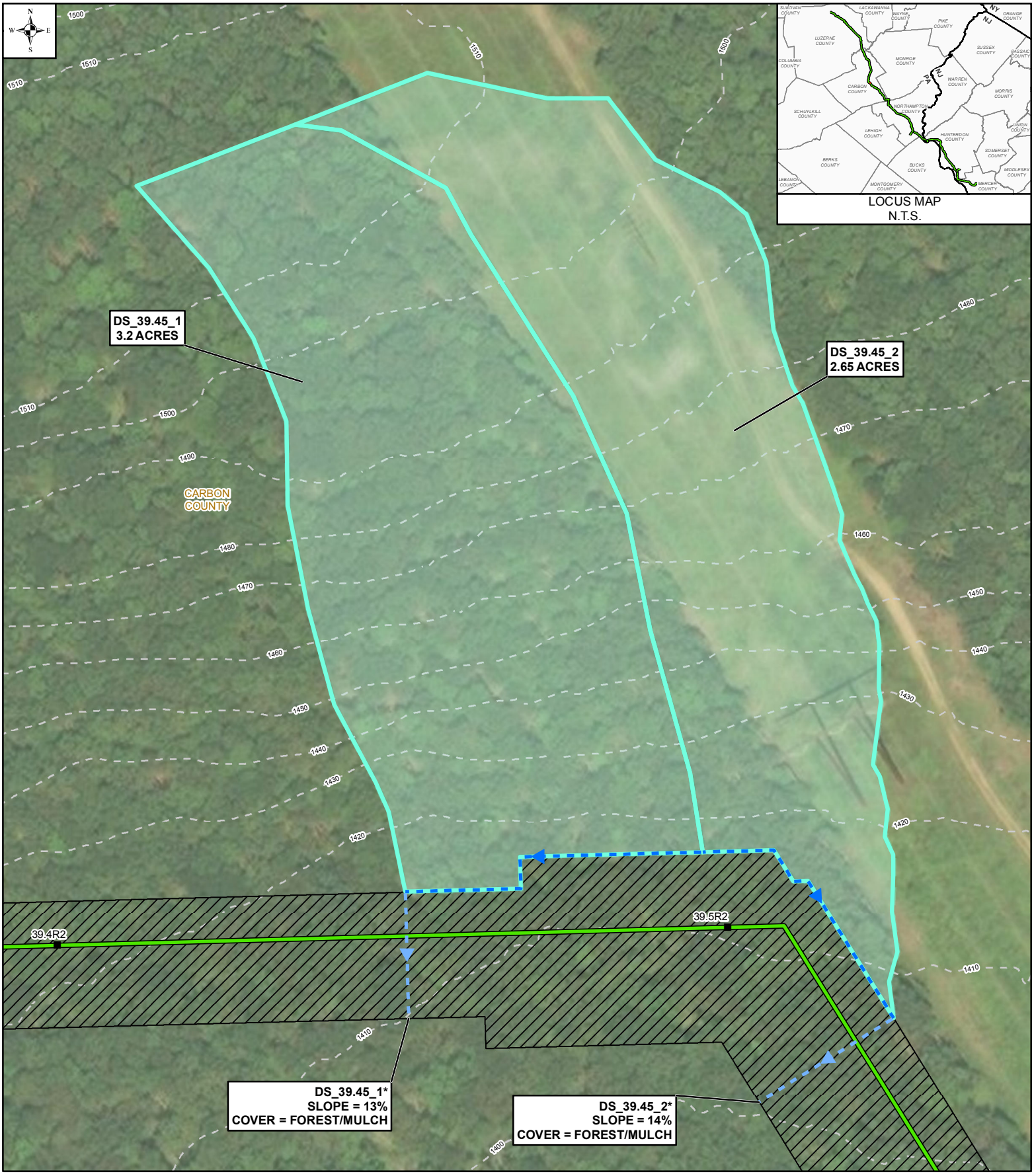


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 9%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_39.45

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 39 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_39.45_1
3.2 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 39.45_1	100	0.4	0.030	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 39.45_1	732	FOREST	0.133	0.92	13.30

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
23.82

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 39.45_1	1	FOREST	0.20	3.20	0.64	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	23.82	2.60	3.15	3.63	2.60	3.15	3.63

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.15	3.20	1.66	2.02	2.32

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_39.45_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.2		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.02		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.21		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.62		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.69		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.09 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.09		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.55		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.89		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.022		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

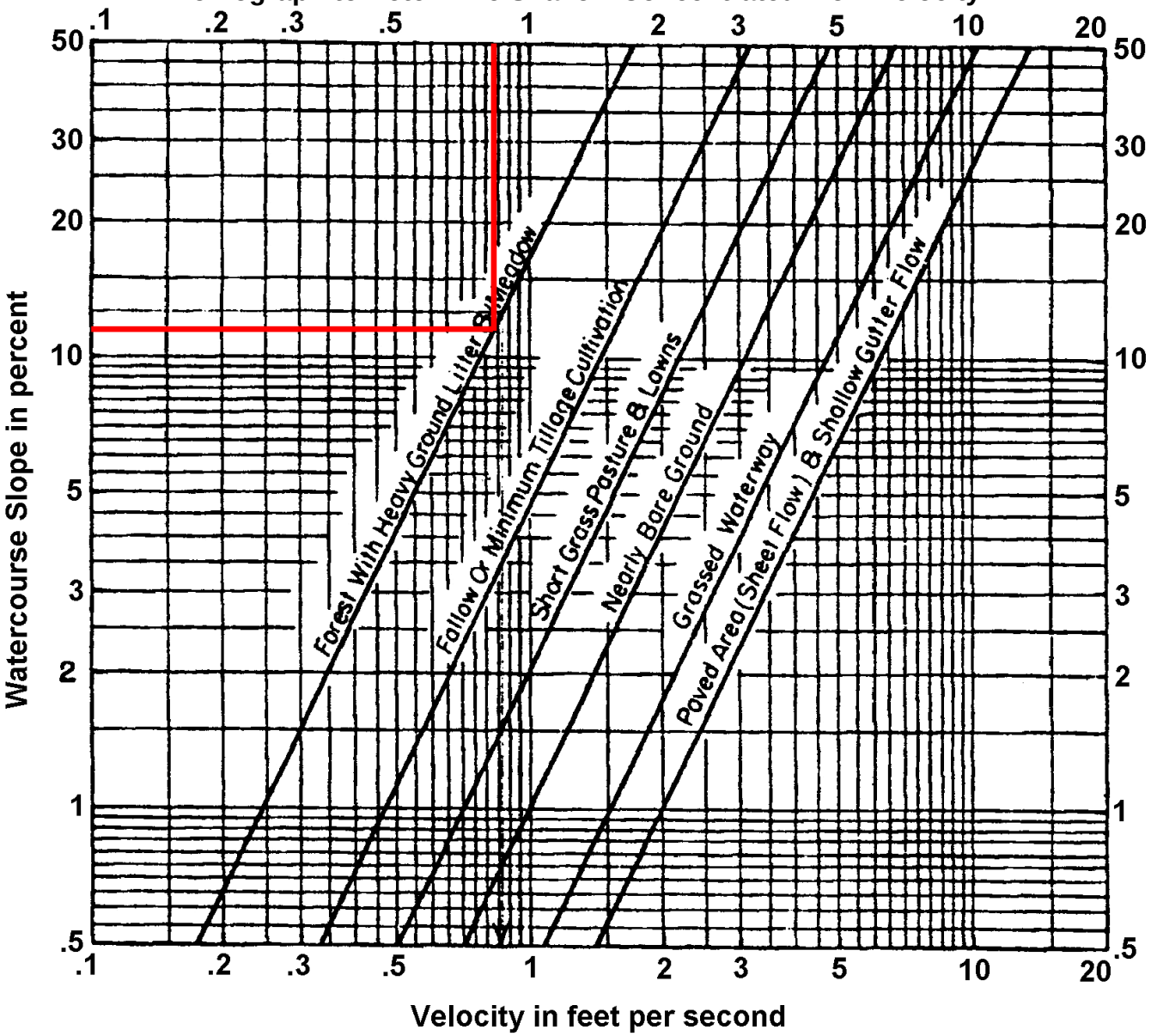
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_39.45_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_39.45_2
2.65 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 39.45_2	64	0.4	0.020	9.39

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 39.45_2	253	SHORT GRASS	0.047	1.51	2.79
	179	FOREST	0.089	0.75	3.97
	477	SHORT GRASS	0.155	2.74	2.90
	87	FOREST	0.070	0.67	2.18

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
21.24

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 39.45_2	1	FOREST	0.20	0.50	0.10	0.28
	2	OPEN SPACE	0.28	2.06	0.58	
	3	INDUSTRIAL	0.69	0.09	0.06	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	21.24	2.77	3.35	3.84	2.77	3.35	3.84

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.28	3.35	2.65	2.05	2.48	2.84

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		**DS_39.45_2a**	DS_39.45_2b	
TEMPORARY OR PERMANENT?	(T OR P)	**T**	T	
DESIGN STORM	(2, 5, OR 10 YR)	**5**	5	
ACRES	(AC)	**2.65**	2.65	
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	**N/A**	N/A	
Q_r (REQUIRED CAPACITY)	(CFS)	**2.48**	2.48	
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	**2.93**	4.66	
PROTECTIVE LINING[2,6]		**C125**	S150	
n (MANNING'S COEFFICIENT)[2]		**0.022**	0.055	
V_a (ALLOWABLE VELOCITY)	(FPS)	**N/A**	N/A	
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	**3.28**	2.39	
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	**2.25**	1.75	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	**0.56**	1.68	
CHANNEL BOTTOM WIDTH	(FT)	**0**	0	
CHANNEL SIDE SLOPES	(H:V)	**7.14 / 0**	15.63 / 0	
D (TOTAL DEPTH)	(FT)	**1.00**	1.00	
CHANNEL TOP WIDTH @ D	(FT)	**7.14**	15.63	
d (CALCULATED FLOW DEPTH)	(FT)	**0.50**	0.50	
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	**3.57**	7.81	
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	**0**	0	
d_{50} STONE SIZE	(IN)	**N/A**	N/A	
A (CROSS-SECTIONAL AREA)	(SQ. FT)	**0.89**	1.95	
R (HYDRAULIC RADIUS)		**0.22**	0.23	
S (BED SLOPE)[3]	(FT/FT)	**0.018**	0.054	
S_C (CRITICAL SLOPE)	(FT/FT)	**0.013**	0.076	
$.7S_c$	(FT/FT)	**0.009**	0.053	
$1.3S_c$	(FT/FT)	**0.018**	0.099	
STABLE FLOW?	(Y/N)	**Y**	N	
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	**N/A**	0.50	
FREEBOARD BASED ON STABLE FLOW	(FT)	**0.50**	N/A	
MINIMUM REQUIRED FREEBOARD[4]	(FT)	**0.50**	0.50	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		**S**	S	

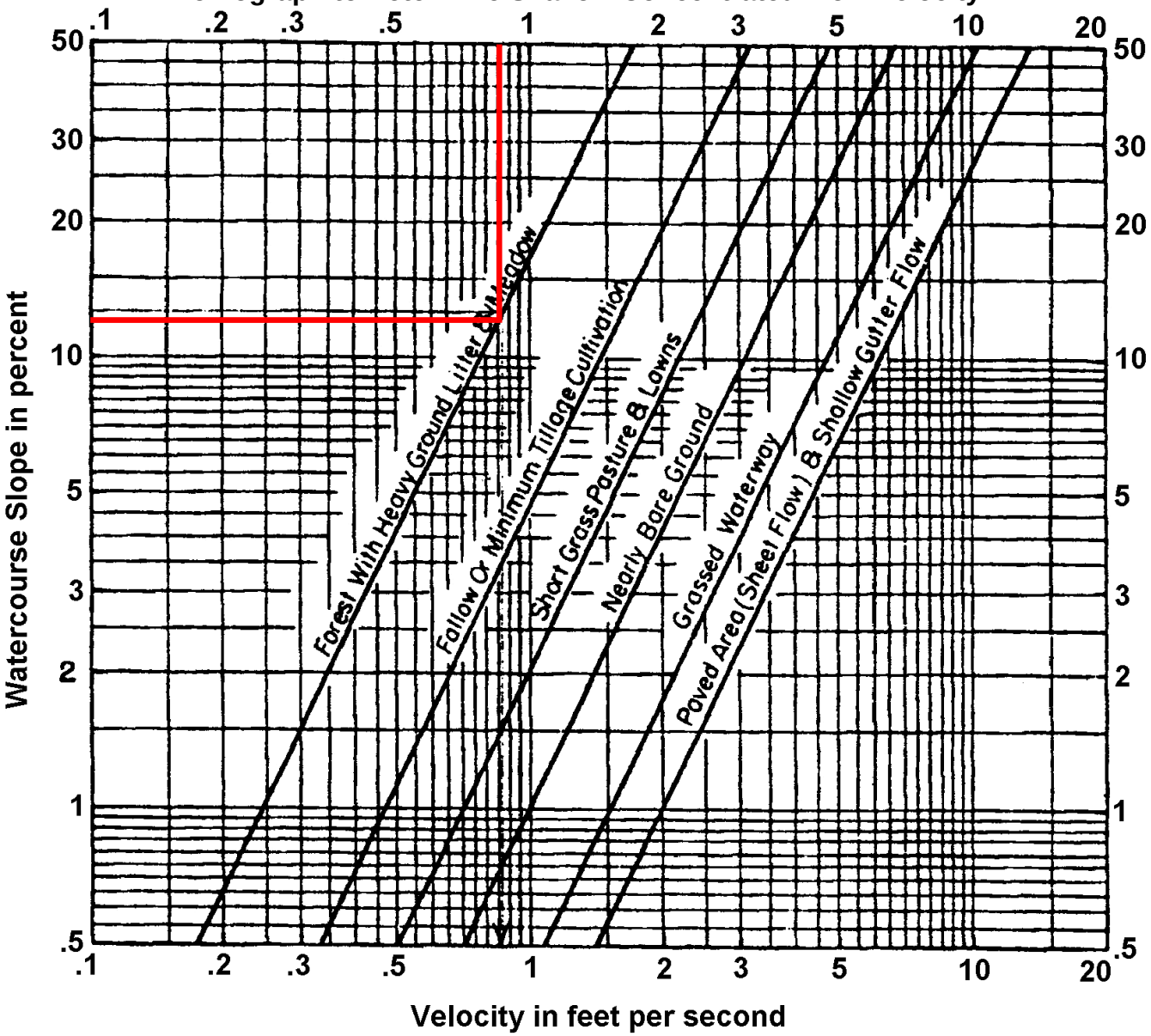
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design methods is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.

CLEAN WATER DIVERSION ID:
DS_39.45_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

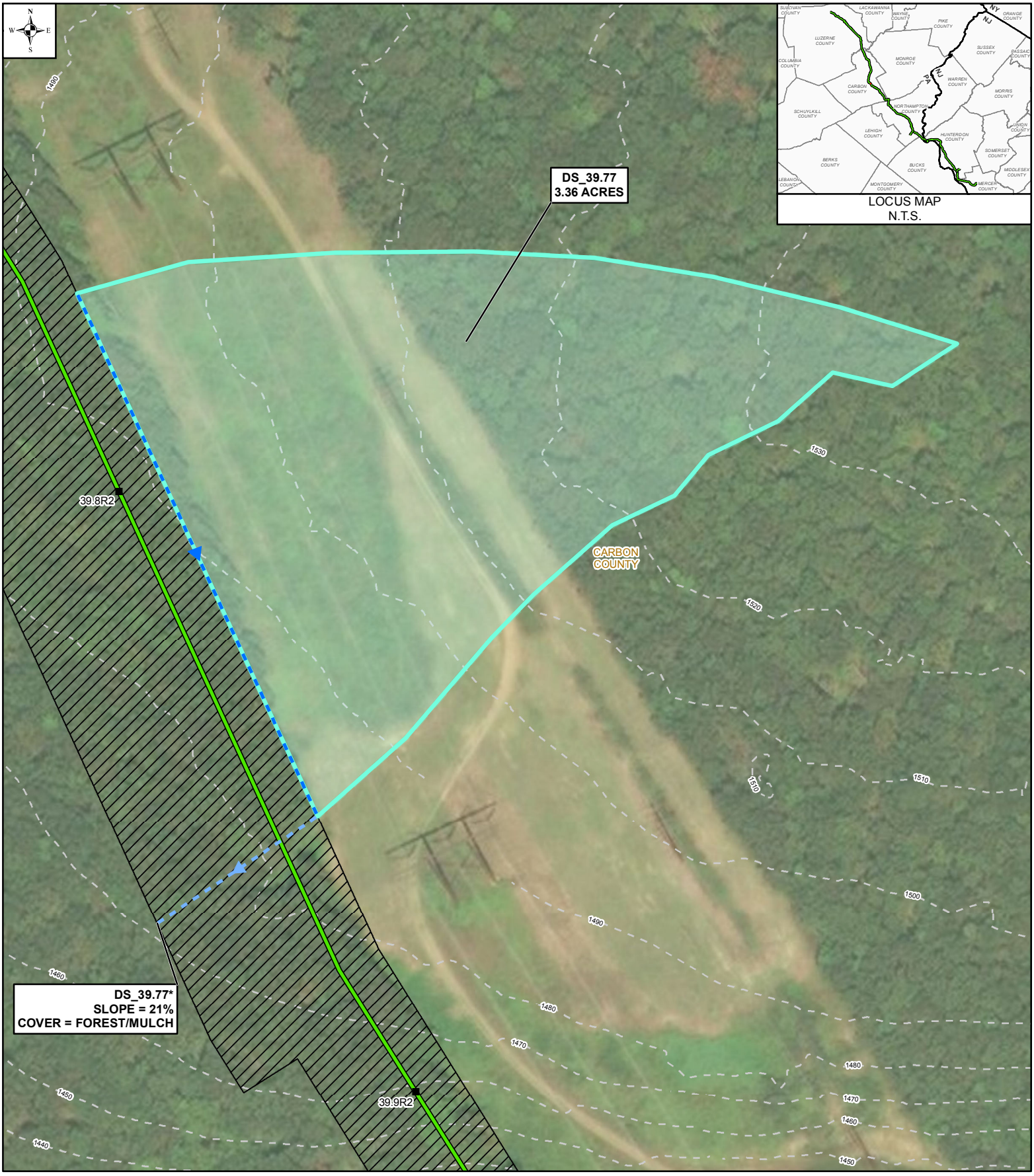


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_39.77

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 100 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 40 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 39.77	100	0.4	0.025	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 39.77	370	FOREST	0.065	0.64	9.61
	235	ORT GRA	0.068	1.82	2.16

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
22.75

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 39.77	1	FOREST	0.20	1.23	0.25	0.26
	2	OPEN SPACE	0.28	2.06	0.58	
	3	INDUSTRIAL	0.69	0.07	0.05	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	22.75	2.67	3.23	3.72	2.67	3.23	3.72

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.26	3.23	3.36	2.32	2.82	3.24

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_39.77		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.36		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.82		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.41		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.71		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.69		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	9.52 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	9.52		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.76		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.19		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.022		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

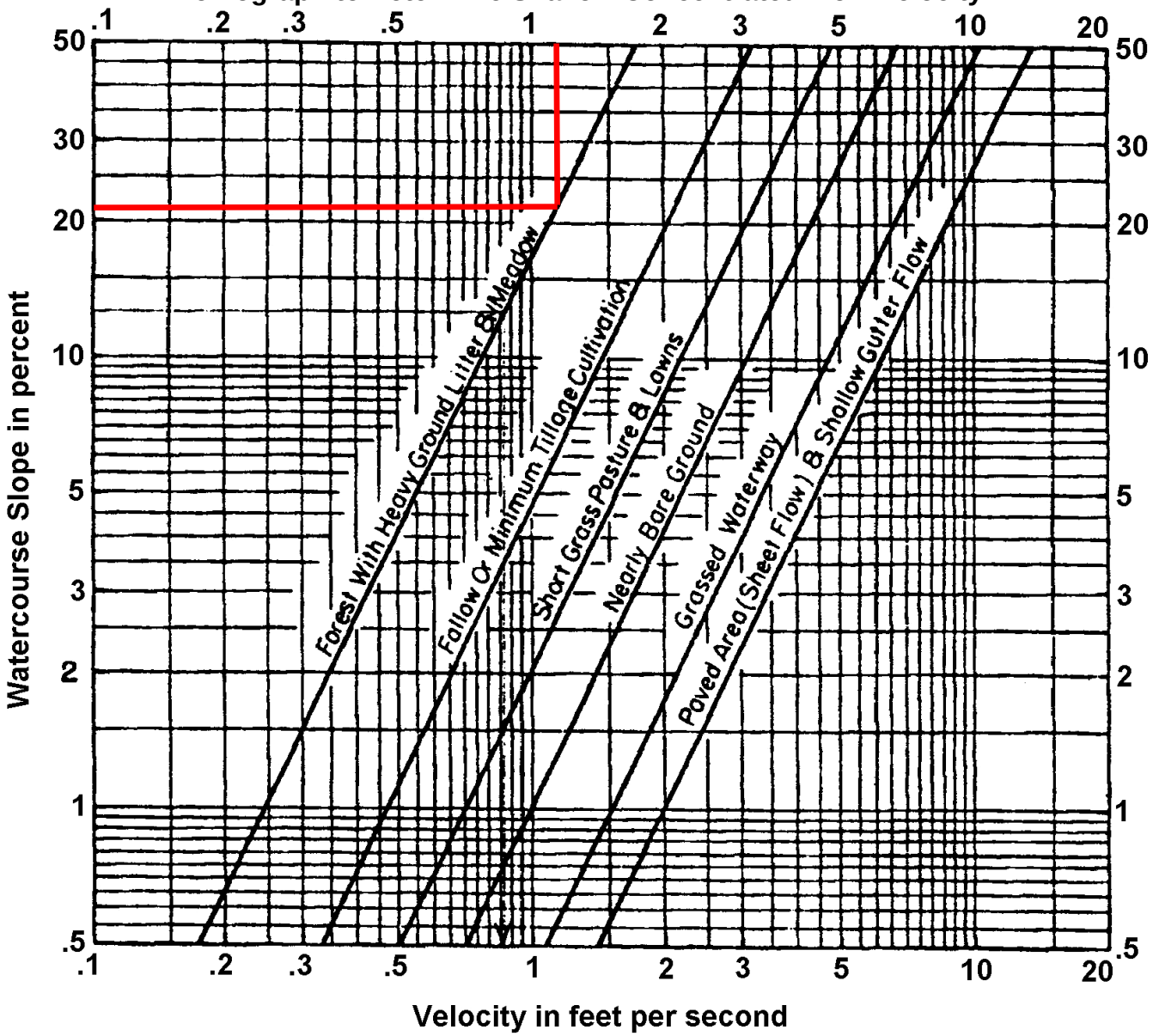
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_39.77

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

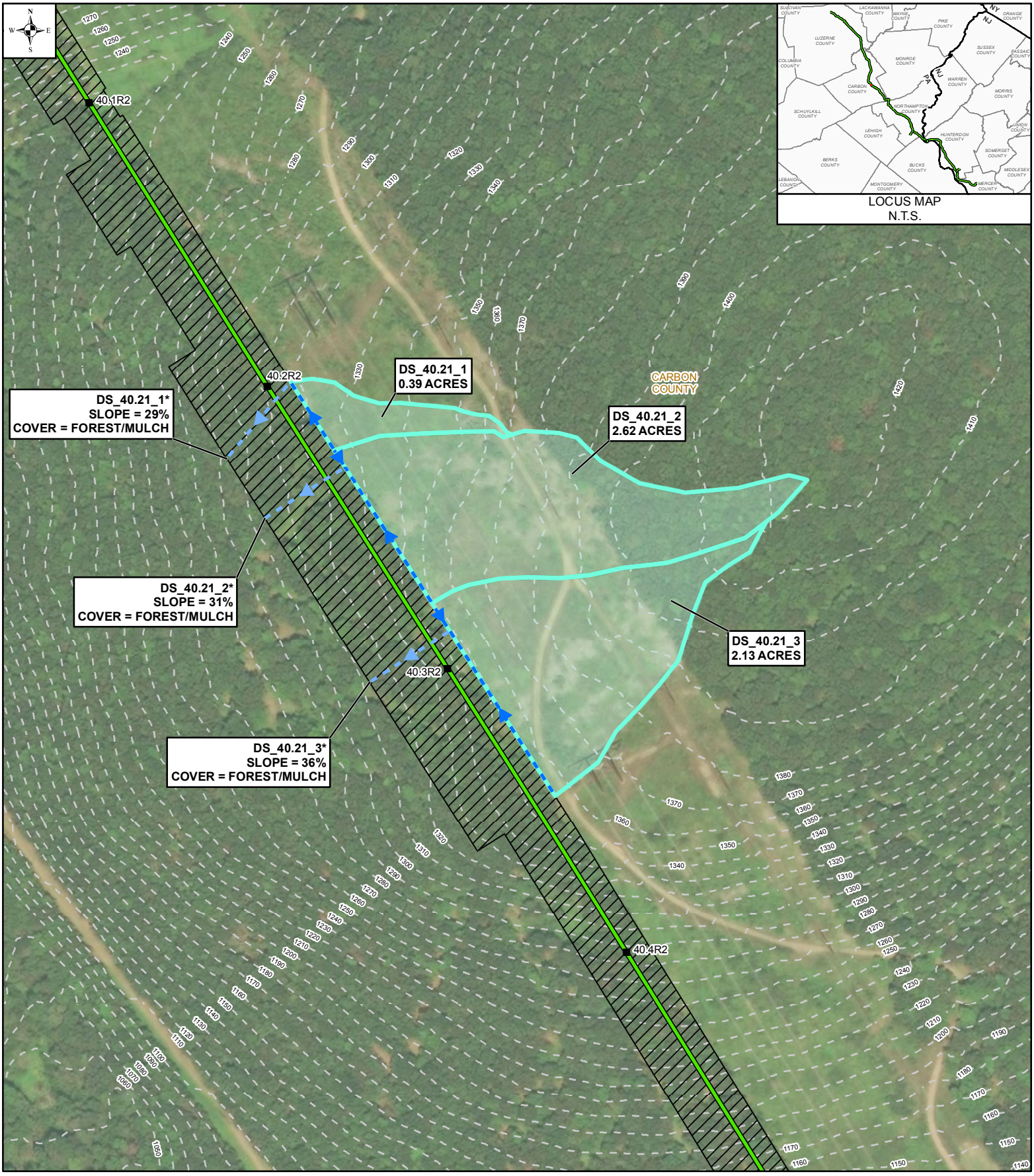


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 21%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_40.21

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 200 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 41 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_40.21_1
0.385 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 40.21_1	100	0.4	0.200	6.76

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 40.21_1	272	SHORT GRASS	0.118	2.39	1.90

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
8.65

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 40.21_1	1	OPEN SPACE	0.28	0.38	0.11	0.29
	2	INDUSTRIAL	0.69	0.01	0.00	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	8.65	4.13	4.88	5.37	4.13	4.88	5.37

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.29	4.88	0.39	0.45	0.54	0.59

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_40.21_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.385		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.543		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.82		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	6.47		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.18		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.19 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.19		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.60		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.90		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.07		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

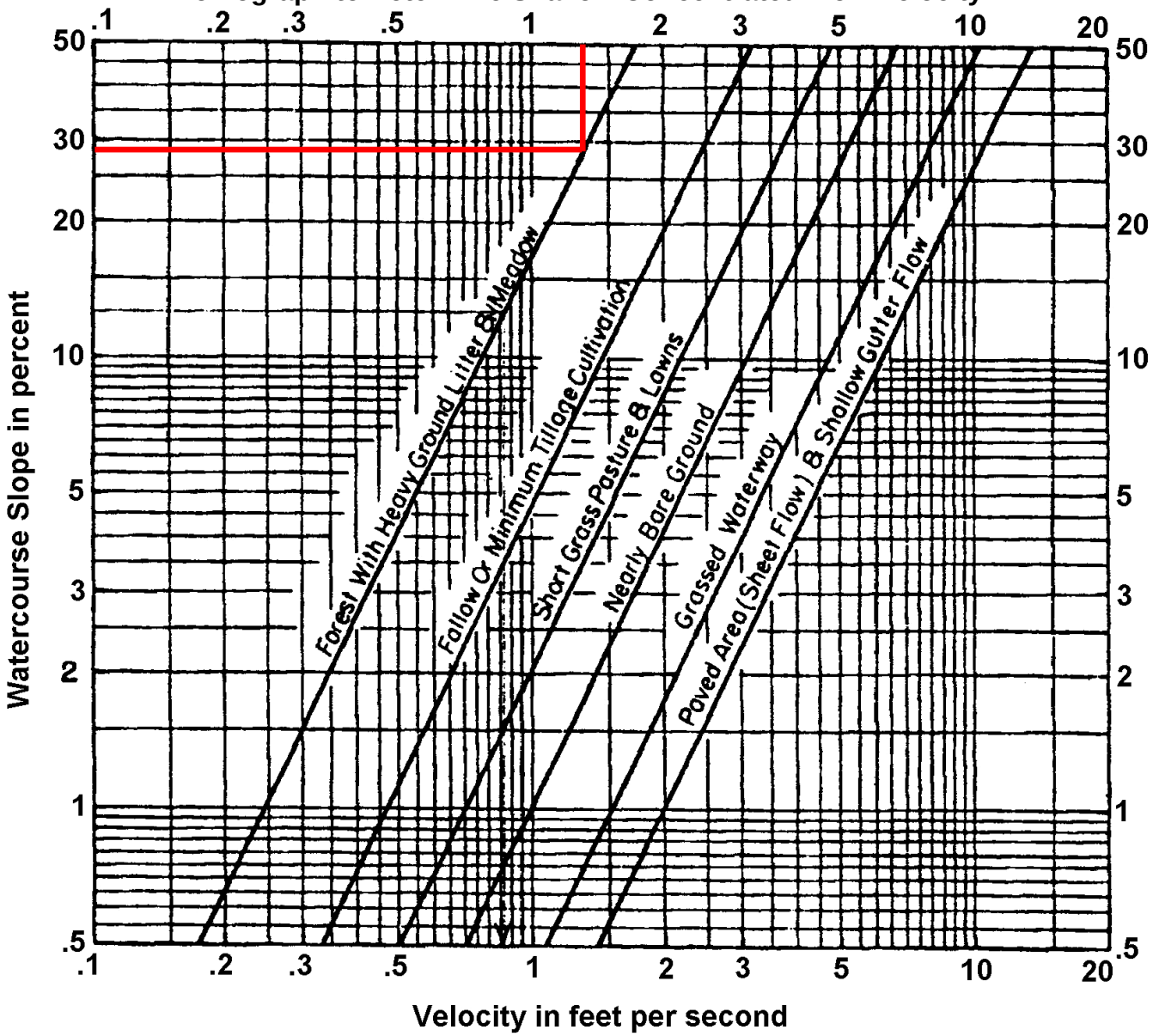
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_40.21_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 29%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.3 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.3 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_40.21_2
2.62 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 40.21_2	100	0.4	0.070	8.63

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 40.21_2	349	FOREST	0.112	0.84	6.91
	334	SHORT GRASS	0.156	2.75	2.02

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
17.57

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 40.21_2	1	OPEN SPACE	0.28	1.75	0.49	0.26
	2	INDUSTRIAL	0.69	0.06	0.04	
	3	FOREST	0.20	0.81	0.16	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	17.57	3.07	3.69	4.19	3.07	3.69	4.19

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.26	3.69	2.62	2.13	2.56	2.91

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_40.21_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.62		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.56		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.95		
PROTECTIVE LINING[2,6]		P300		
n (MANNING'S COEFFICIENT)[2]		0.034		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.48		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.68		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.26 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.26		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.63		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.66		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.086		
S_C (CRITICAL SLOPE)	(FT/FT)	0.034		
$.7S_c$	(FT/FT)	0.024		
$1.3S_c$	(FT/FT)	0.045		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

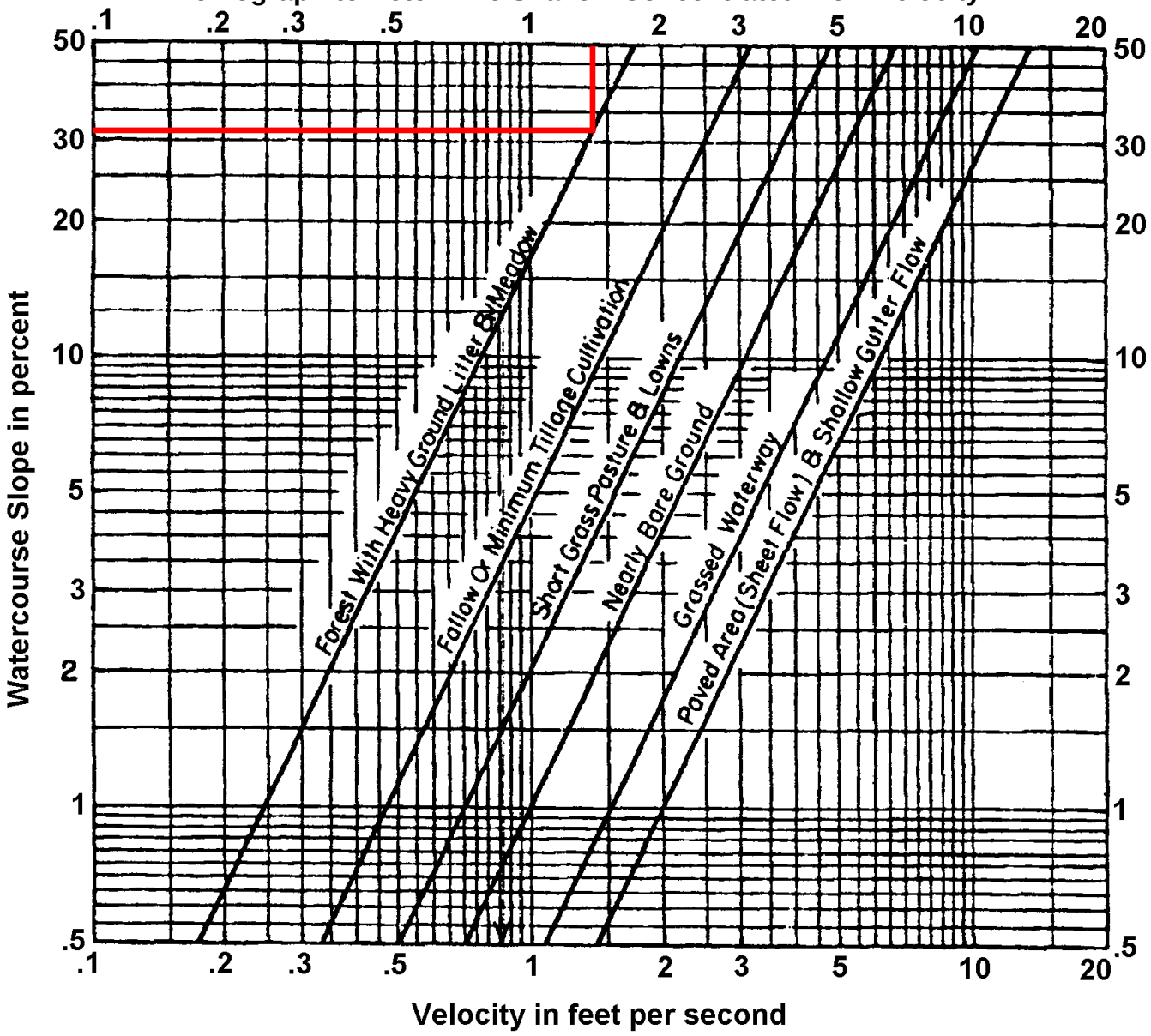
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_40.21_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 31%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.4 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.4 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_40.21_3
2.13 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 40.21_3	100	0.4	0.100	7.94

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 40.21_3	141	FOREST	0.112	0.84	2.79
	319	SHORT GRASS	0.116	2.37	2.24

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
12.98

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 40.21_3	1	OPEN SPACE	0.28	1.72	0.48	0.30
	2	INDUSTRIAL	0.69	0.14	0.10	
	3	FOREST	0.20	0.27	0.05	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	12.98	3.54	4.22	4.73	3.54	4.22	4.73

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.30	4.22	2.13	2.24	2.67	2.99

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_40.21_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.13		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.67		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.76		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.039		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.51		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.00		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.28 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	4.92		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.28		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.64		
R (HYDRAULIC RADIUS)		0.37		
S (BED SLOPE)[3, 7]	(FT/FT)	0.032		
S_C (CRITICAL SLOPE)	(FT/FT)	0.042		
$.7S_c$	(FT/FT)	0.029		
$1.3S_c$	(FT/FT)	0.054		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

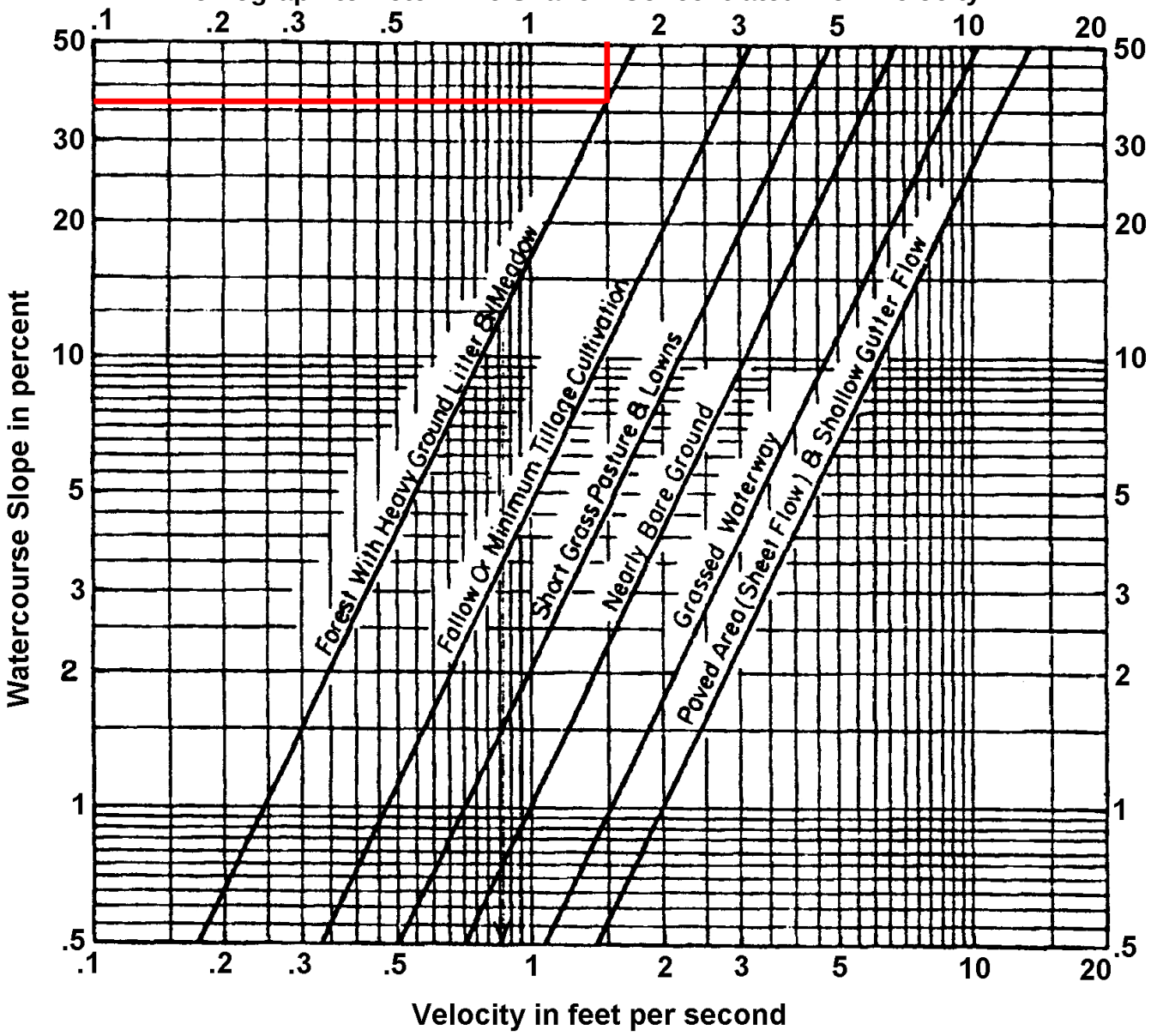
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_40.21_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

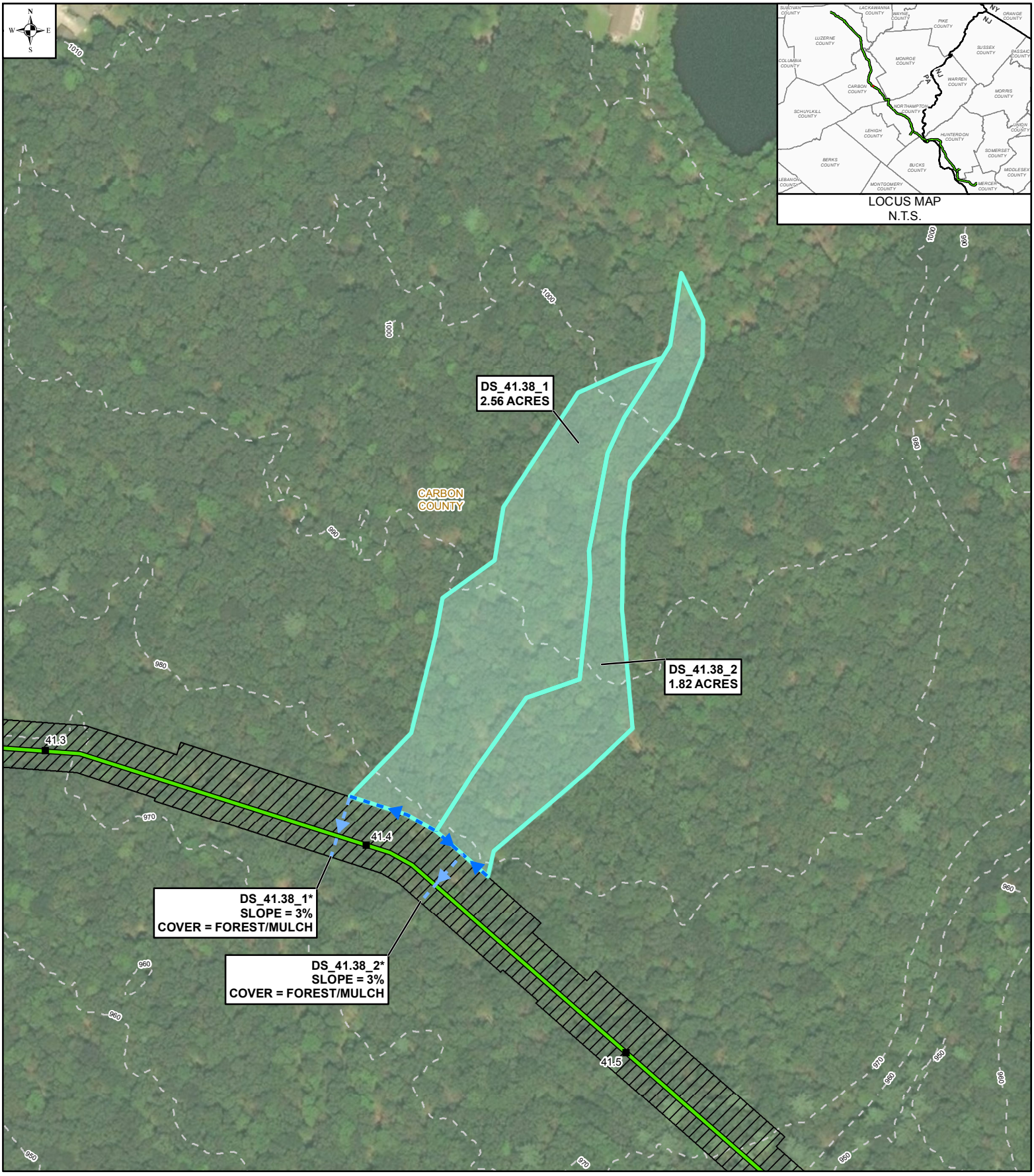


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 36%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.5 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.5 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_41.38

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 200 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 42 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_41.38_1
2.56 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 41.38_1	100	0.4	0.027	10.79

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 41.38_1	803	FOREST	0.030	0.44	30.71

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
41.50

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 41.38_1	1	FOREST	0.16	2.65	0.42	0.16

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	41.50	1.81	2.23	2.64	1.81	2.23	2.64

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.16	2.23	2.65	0.77	0.95	1.12

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_41.38_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.56		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.95		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.29		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.16		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	22.73 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	22.73		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	11.36		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.84		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.120		
$.7S_c$	(FT/FT)	0.084		
$1.3S_c$	(FT/FT)	0.156		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

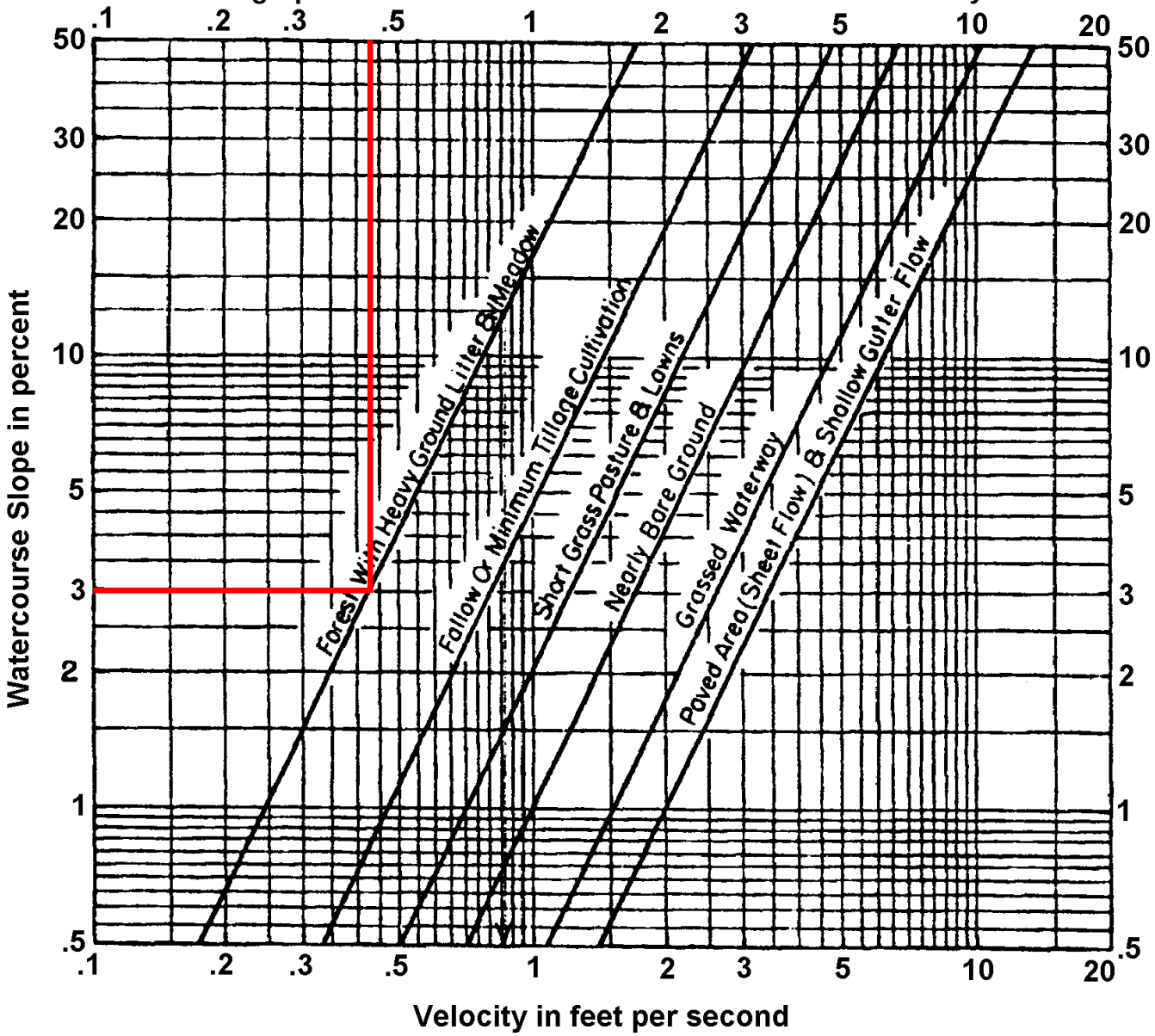
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_41.38_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 3%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.4 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.4 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_41.38_2
1.82 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 41.38_2	100	0.4	0.033	10.29

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 41.38_2	992	FOREST	0.025	0.40	41.56

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
51.85

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 41.38_2	1	FOREST	0.16	1.82	0.29	0.16

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	51.85	1.54	1.91	2.27	1.54	1.91	2.27

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.16	1.91	1.82	0.45	0.55	0.66

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_41.38_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.82		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.56		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.68		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.10		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.59		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.2 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	12.20		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.10		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.52		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.019		
S_C (CRITICAL SLOPE)	(FT/FT)	0.126		
$.7S_c$	(FT/FT)	0.088		
$1.3S_c$	(FT/FT)	0.164		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

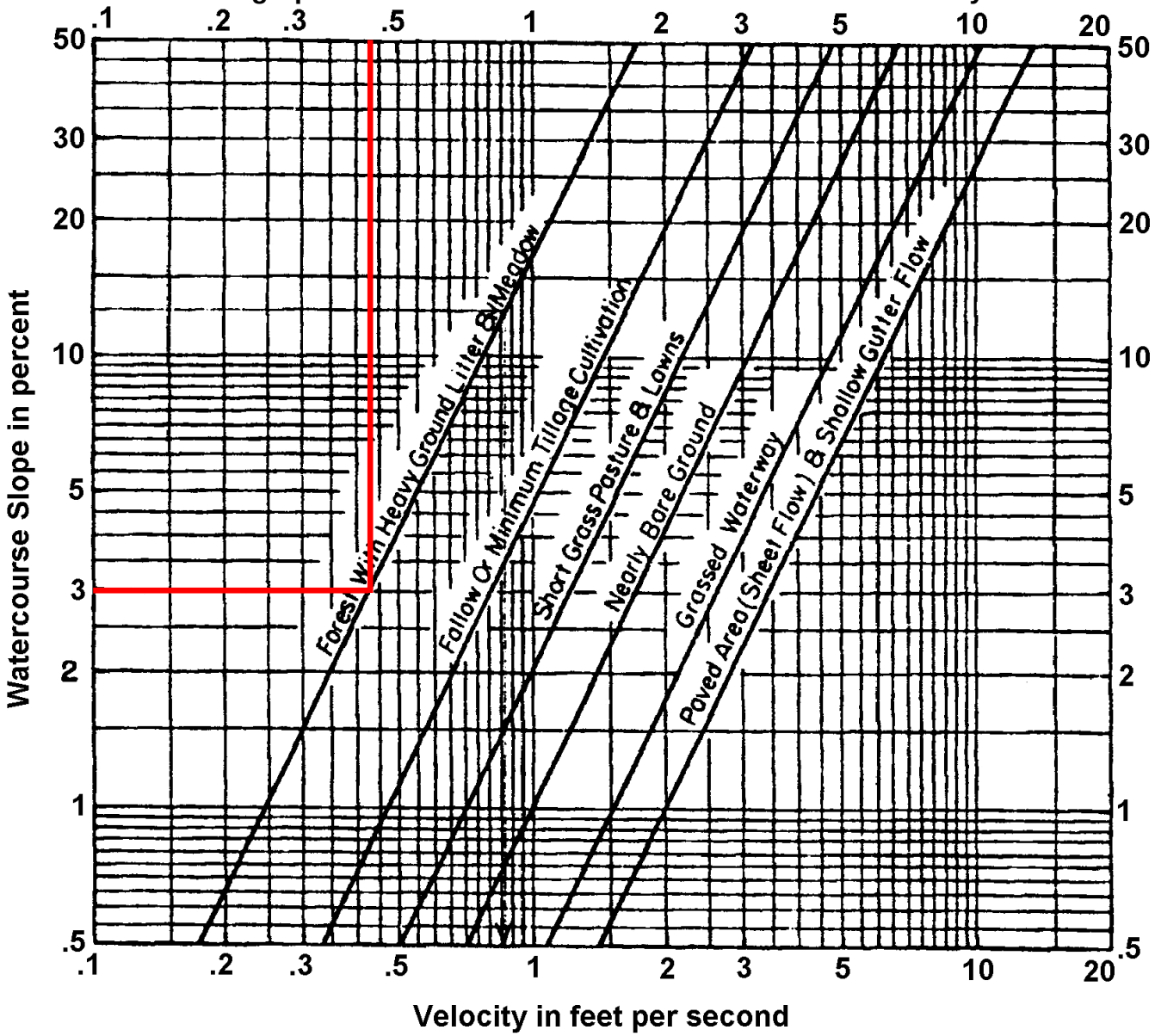
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_41.38_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

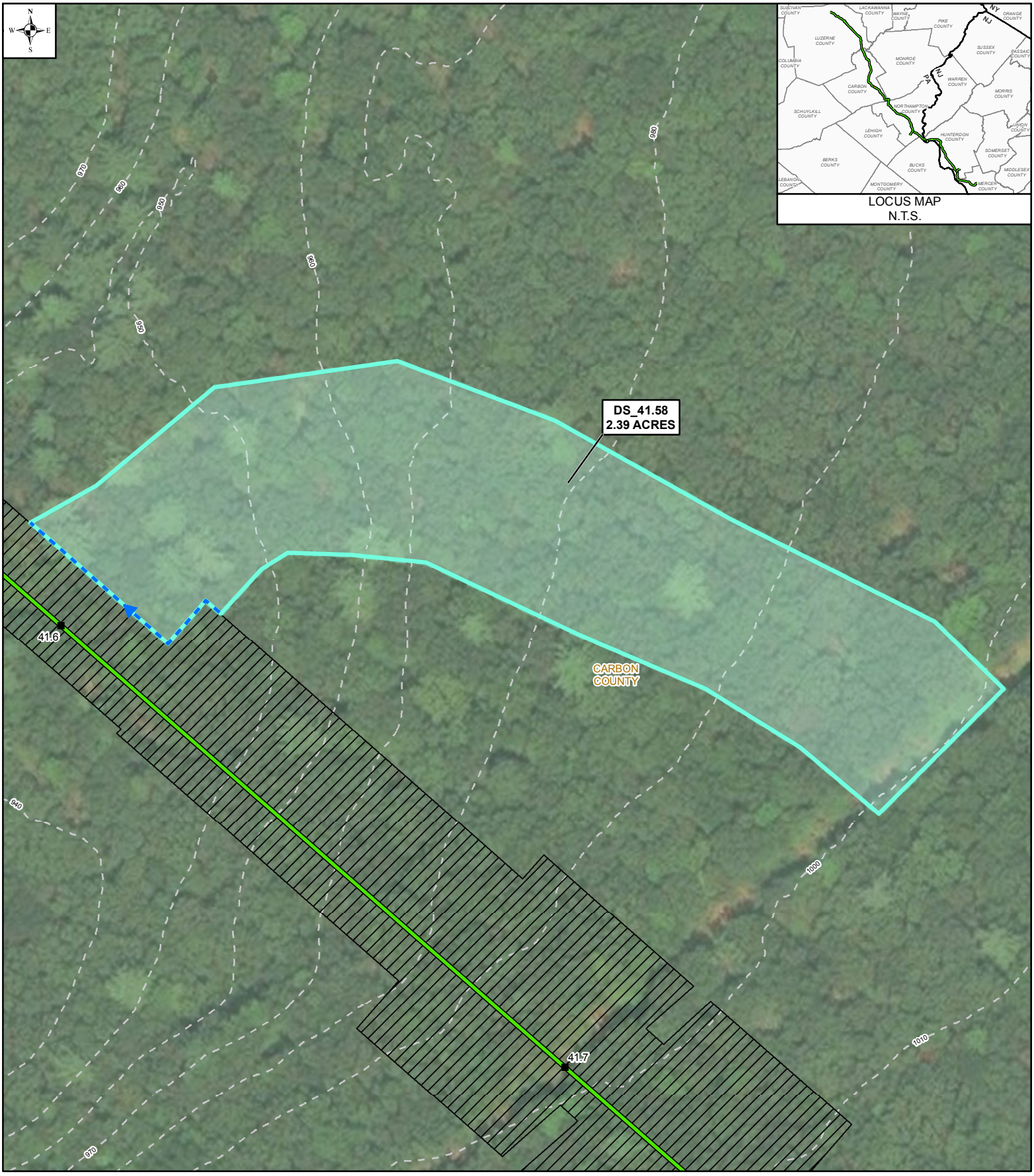


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 3%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.4 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.4 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LOCUS MAP
N.T.S.

LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_41.58

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 100 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 43 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 41.58	100	0.4	0.056	9.10

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 41.58	773	FOREST	0.067	0.65	19.78

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
28.88

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 41.58	1	FOREST	0.20	2.39	0.48	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	28.88	2.31	2.82	3.28	2.31	2.82	3.28

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.82	2.39	1.10	1.35	1.57

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

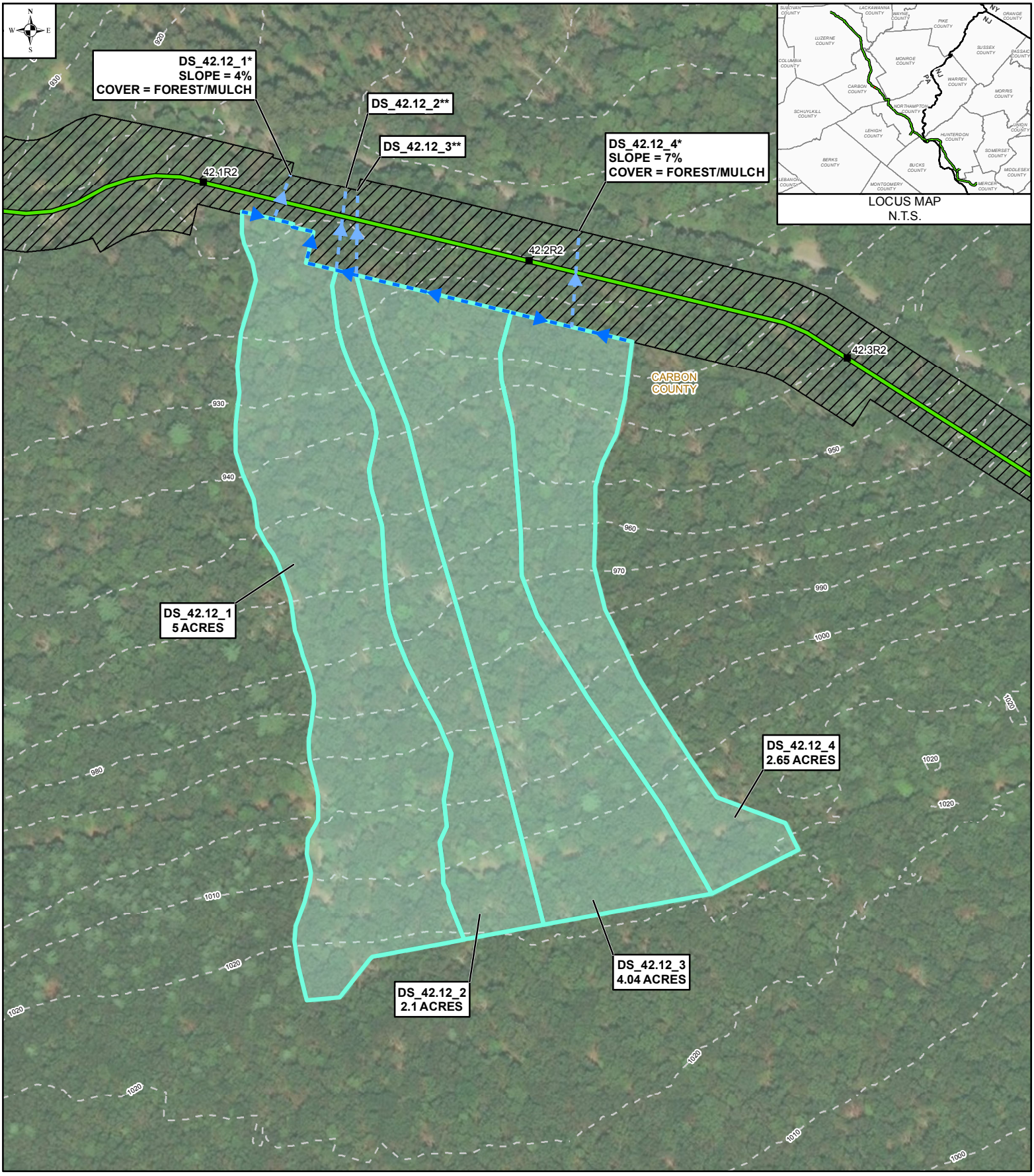
LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_41.58		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.39		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.35		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.82		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.72		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	31.25 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	31.25		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	15.63		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	3.91		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.154		
$.7S_c$	(FT/FT)	0.108		
$1.3S_c$	(FT/FT)	0.201		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_42.12

CARBON COUNTY, PENNSYLVANIA

0 100 200 FEET

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 200 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

PennEast PIPELINE

DWG NO: PAGE 44 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_42.12_1
5 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 42.12_1	100	0.4	0.060	8.95

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 42.12_1	1186	FOREST	0.094	0.77	25.62

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c* (minutes)
34.58

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 42.12_1	1	FOREST	0.20	5.00	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	34.58	2.06	2.52	2.95	2.06	2.52	2.95

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.52	5.00	2.06	2.52	2.95

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_42.12_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.00		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.52		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	9.46		
PROTECTIVE LINING[2,6]		P300		
n (MANNING'S COEFFICIENT)[2]		0.034		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.85		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.65		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	15.63 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	15.63		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.81		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.95		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.085		
S_C (CRITICAL SLOPE)	(FT/FT)	0.029		
$.7S_c$	(FT/FT)	0.020		
$1.3S_c$	(FT/FT)	0.038		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

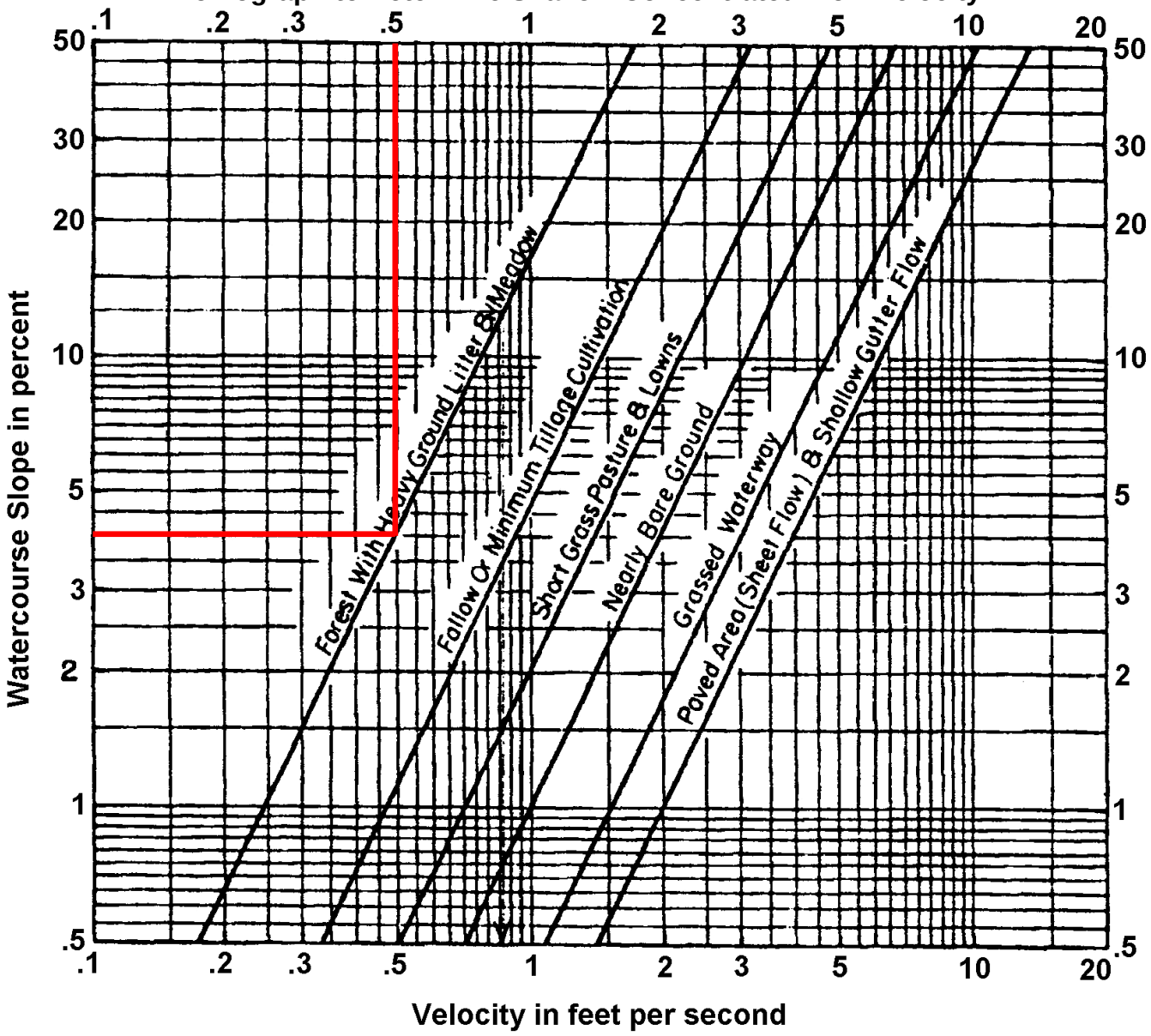
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_41.12_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 4%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.5 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.5 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_42.12_2
2.1 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 42.12_2	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 42.12_2	1004	FOREST	0.098	0.79	21.25

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c* (minutes)
32.23

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 42.12_2	1	FOREST	0.20	2.10	0.42	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	32.23	2.15	2.64	3.08	2.15	2.64	3.08

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.64	2.10	0.90	1.11	1.29

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_42.12_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.1		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.11		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.12		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.78		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.90		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	14.71 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	14.71		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.35		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.84		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.061		
S_C (CRITICAL SLOPE)	(FT/FT)	0.063		
$.7S_c$	(FT/FT)	0.044		
$1.3S_c$	(FT/FT)	0.082		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_42.12_3
4.04 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 42.12_3	100	0.4	0.060	8.95

$$T_{c(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)\sqrt{\quad}^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 42.12_3	966	FOREST	0.102	0.80	20.04

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c* (minutes)
28.99

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 42.12_3	1	FOREST	0.20	3.90	0.78	0.22
	2	INDUSTRIAL	0.69	0.14	0.10	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	28.99	2.31	2.81	3.27	2.31	2.81	3.27

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.22	2.81	4.04	2.02	2.47	2.87

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		**DS_42.12_3a**	DS_42.12_3b	
TEMPORARY OR PERMANENT?	(T OR P)	**T**	T	
DESIGN STORM	(2, 5, OR 10 YR)	**5**	5	
ACRES	(AC)	**4.04**	4.04	
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	**N/A**	N/A	
Q_r (REQUIRED CAPACITY)	(CFS)	**2.47**	2.47	
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	**4.78**	2.82	
PROTECTIVE LINING[2,6]		**C125**	C125	
n (MANNING'S COEFFICIENT)[2]		**0.022**	0.022	
V_a (ALLOWABLE VELOCITY)	(FPS)	**N/A**	N/A	
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	**5.35**	2.71	
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	**2.25**	2.25	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	**1.50**	0.37	
CHANNEL BOTTOM WIDTH	(FT)	**0**	0	
CHANNEL SIDE SLOPES	(H:V)	**7.14 / 0**	8.33 / 0	
D (TOTAL DEPTH)	(FT)	**1.00**	1.00	
CHANNEL TOP WIDTH @ D	(FT)	**7.14**	8.33	
d (CALCULATED FLOW DEPTH)	(FT)	**0.50**	0.50	
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	**3.57**	4.17	
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	**0**	0	
d_{50} STONE SIZE	(IN)	**N/A**	N/A	
A (CROSS-SECTIONAL AREA)	(SQ. FT)	**0.89**	1.04	
R (HYDRAULIC RADIUS)		**0.22**	0.22	
S (BED SLOPE)[3]	(FT/FT)	**0.048**	0.012	
S_C (CRITICAL SLOPE)	(FT/FT)	**0.013**	0.013	
$.7S_c$	(FT/FT)	**0.009**	0.009	
$1.3S_c$	(FT/FT)	**0.018**	0.017	
STABLE FLOW?	(Y/N)	**Y**	N	
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	**N/A**	0.50	
FREEBOARD BASED ON STABLE FLOW	(FT)	**0.50**	N/A	
MINIMUM REQUIRED FREEBOARD[4]	(FT)	**0.50**	0.50	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		**S**	S	

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design methods is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_42.12_4
2.65 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 42.12_4	100	0.4	0.040	9.84

$$T_{c(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 42.12_4	905	FOREST	0.101	0.80	18.86

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c* (minutes)
28.70

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 42.12_4	1	FOREST	0.20	2.54	0.51	0.22
	2	OPEN SPACE	0.69	0.11	0.08	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	28.70	2.32	2.83	3.29	2.32	2.83	3.29

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.22	2.83	2.65	1.35	1.65	1.92

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_42.12_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.65		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.65		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.03		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.43		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	11.36 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	11.36		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.68		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.42		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.079		
$.7S_c$	(FT/FT)	0.055		
$1.3S_c$	(FT/FT)	0.102		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

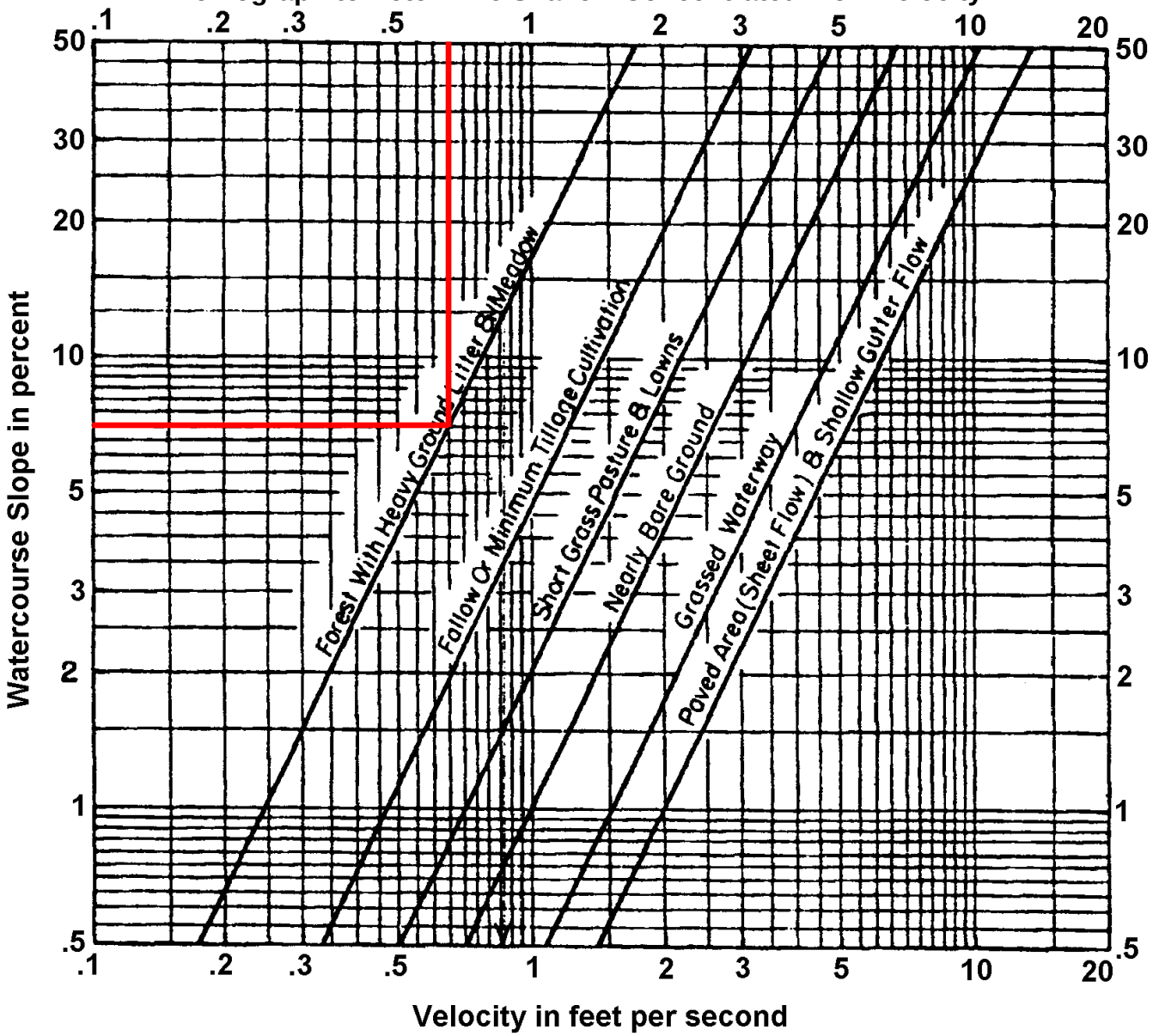
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_42.12_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

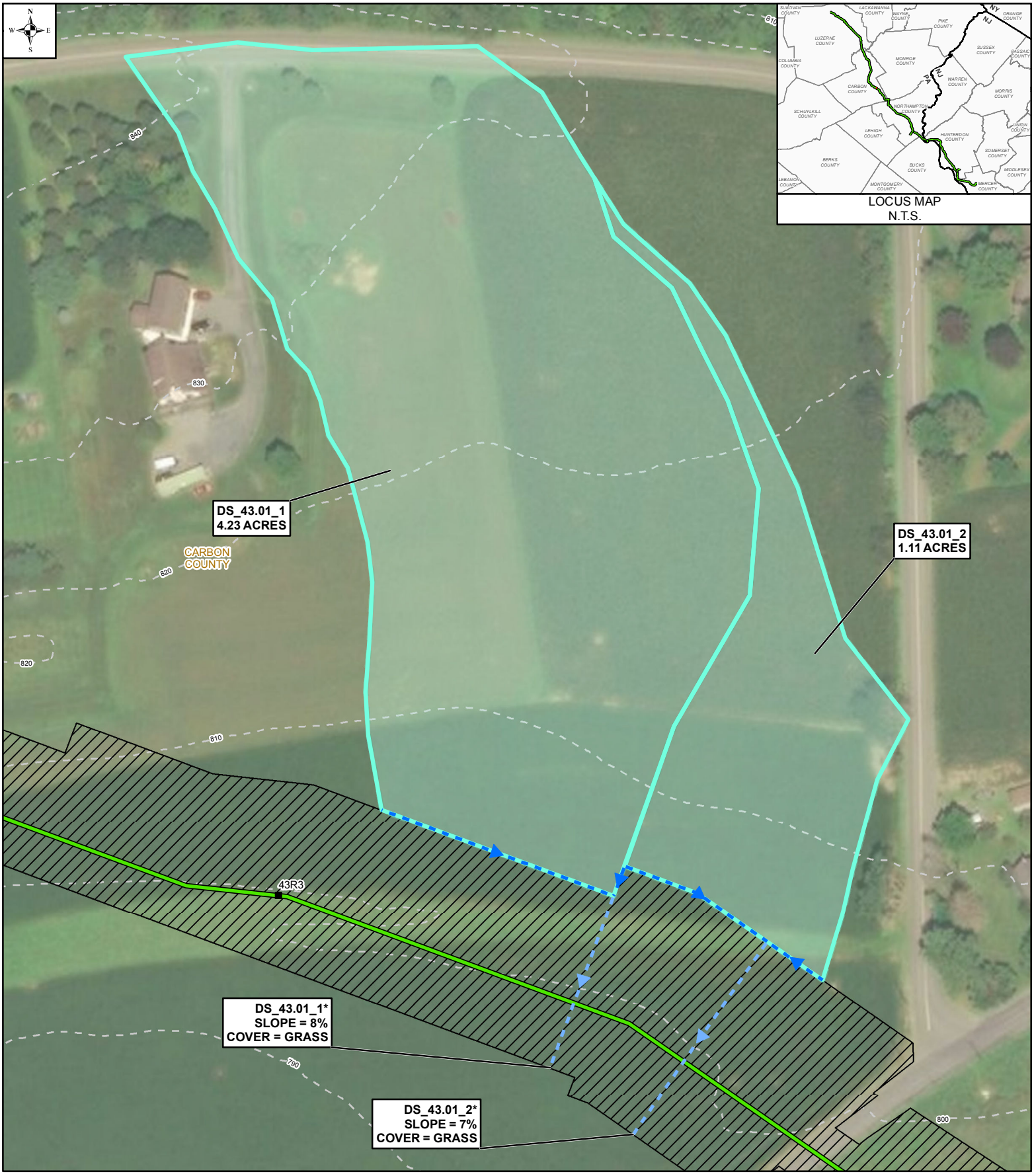


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.7 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.7 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_43.01

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 45 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_43.01_1
4.23 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 43.01_1	100	0.4	0.030	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 43.01_1	669	SHORT GRASS	0.040	1.39	8.01

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
18.53

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 43.01_1	1	PASTURE	0.40	1.61	0.64	0.30
	2	OPEN SPACE	0.21	2.49	0.52	
	3	INDUSTRIAL	0.69	0.13	0.09	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	18.53	2.98	3.60	4.09	2.98	3.60	4.09

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.30	3.60	4.23	3.75	4.52	5.14

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_43.01_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.23		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	4.52		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	7.23		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.60		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	22.22 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	22.22		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	11.11		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.78		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.012		
$.7S_c$	(FT/FT)	0.008		
$1.3S_c$	(FT/FT)	0.015		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

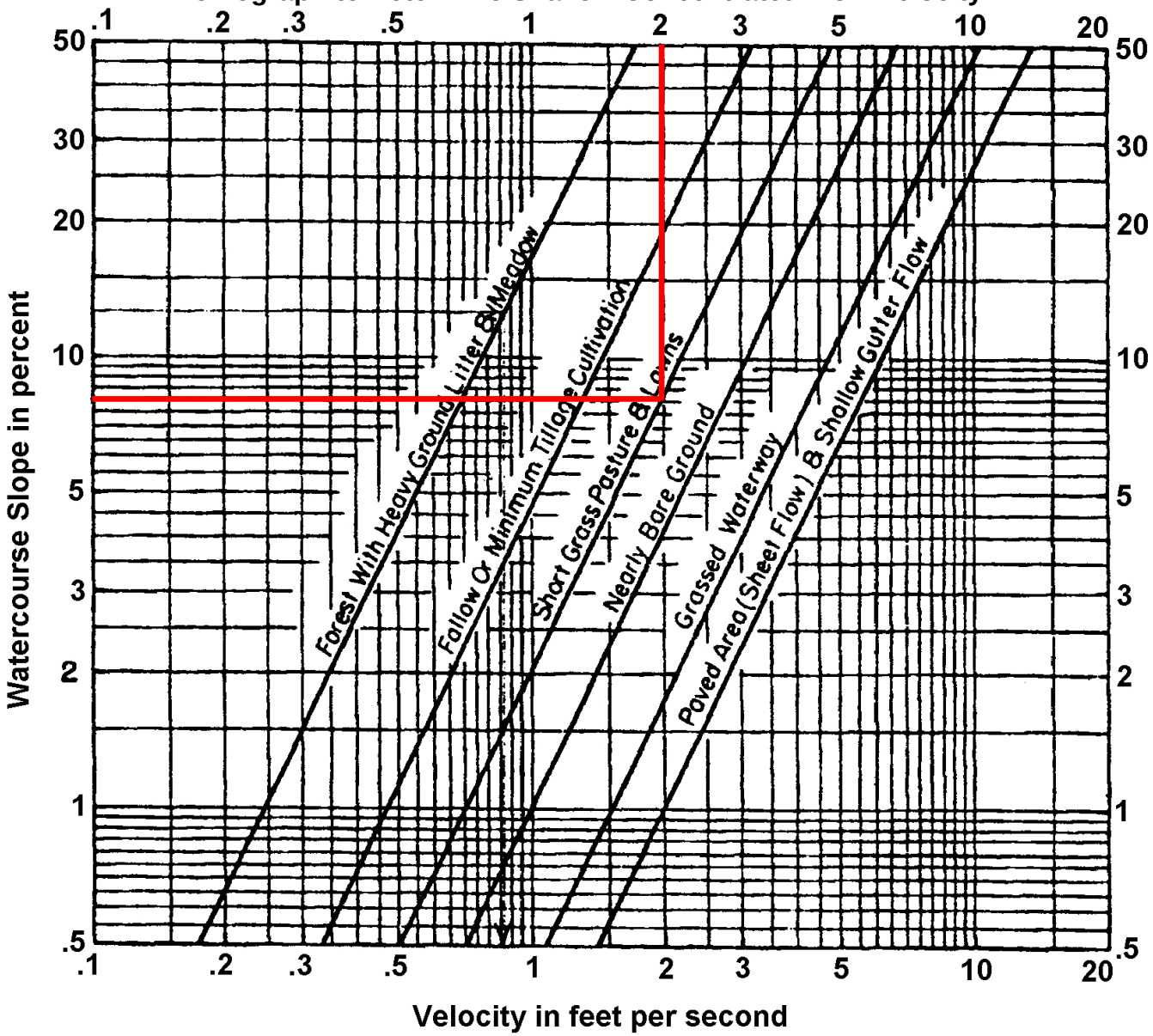
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_43.01_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 8%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

2.0 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_43.01_2
1.12 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 43.01_2	100	0.4	0.030	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 43.01_2	618	SHORT GRASS	0.035	1.30	7.91

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
18.43

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 43.01_2	1	PASTURE	0.40	0.48	0.19	0.29
	2	OPEN SPACE	0.21	0.64	0.13	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	18.43	2.99	3.61	4.10	2.99	3.61	4.10

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.29	3.61	1.12	0.98	1.18	1.34

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_43.01_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.12		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.18		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.62		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.97		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.15		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	14.71 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	14.71		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	7.35		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.84		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.037		
S_C (CRITICAL SLOPE)	(FT/FT)	0.077		
$.7S_c$	(FT/FT)	0.054		
$1.3S_c$	(FT/FT)	0.100		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

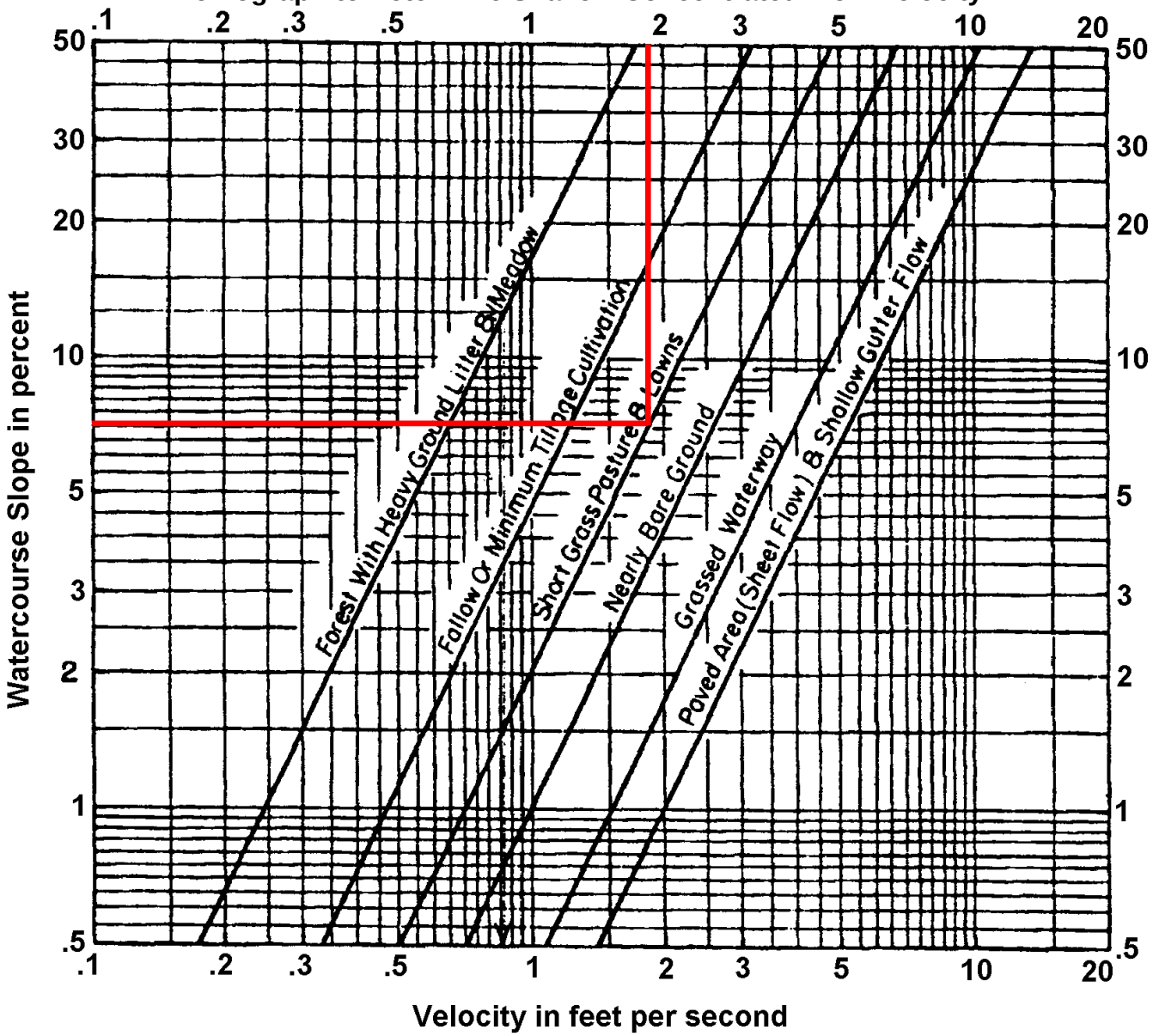
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_43.01_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

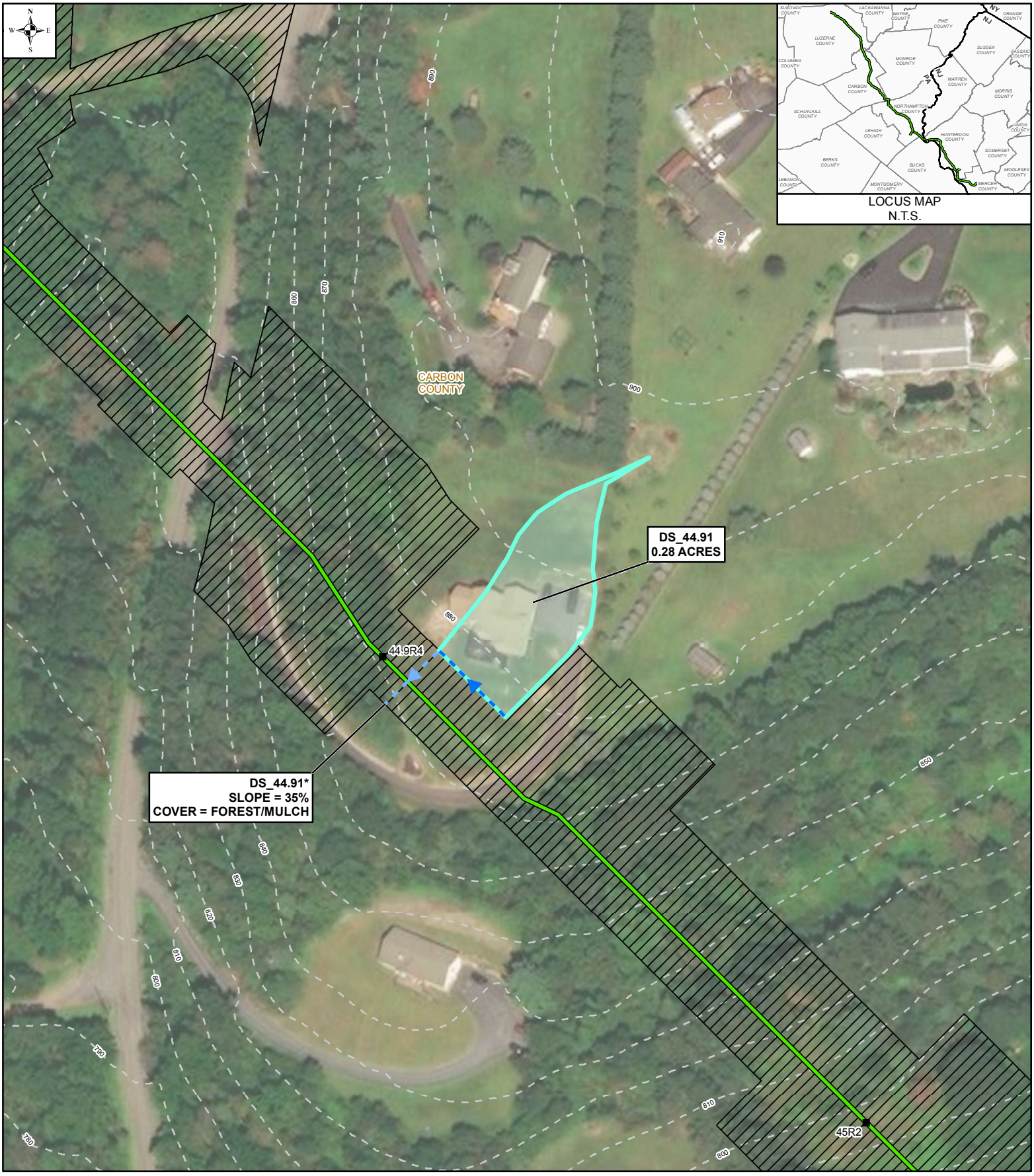


TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

1.9 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_44.91

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 46 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 44.91	100	0.4	0.070	8.63

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 44.91	30	SHORT GRASS	0.100	2.20	0.23
	54	PAVEMENT	0.074	5.53	0.16
	68	SHORT GRASS	0.118	2.39	0.47

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
9.50

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 44.91	1	INDUSTRIAL	0.69	0.09	0.06	0.36
	2	OPEN SPACE	0.21	0.19	0.04	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	9.50	4.00	4.74	5.23	4.00	4.74	5.23

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.36	4.74	0.28	0.41	0.48	0.53

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_44.91		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.28		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.85		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.08		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.78		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.41		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.77 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.77		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.39		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.10		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.013		
S_C (CRITICAL SLOPE)	(FT/FT)	0.172		
$.7S_c$	(FT/FT)	0.121		
$1.3S_c$	(FT/FT)	0.224		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

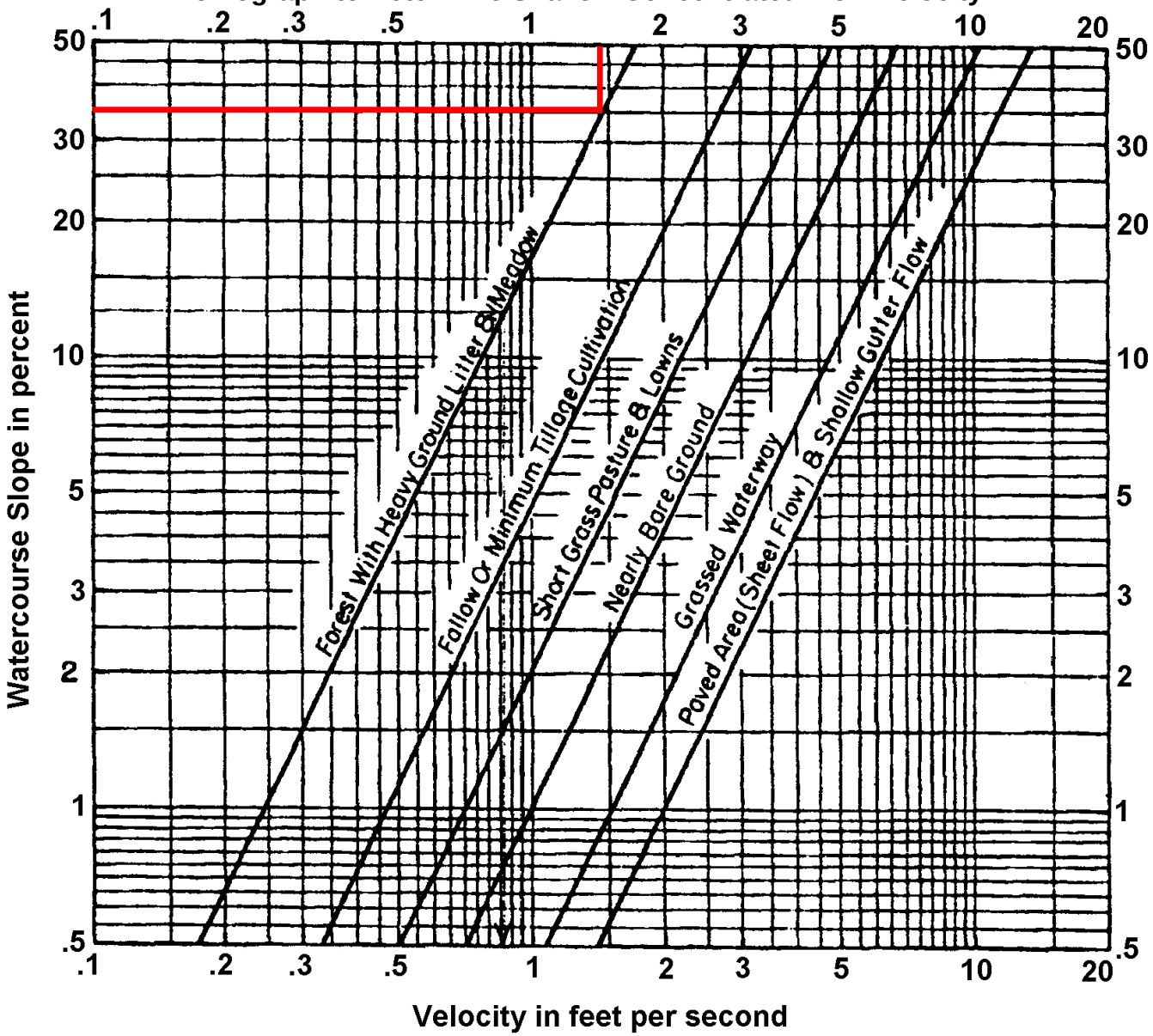
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_44.91

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

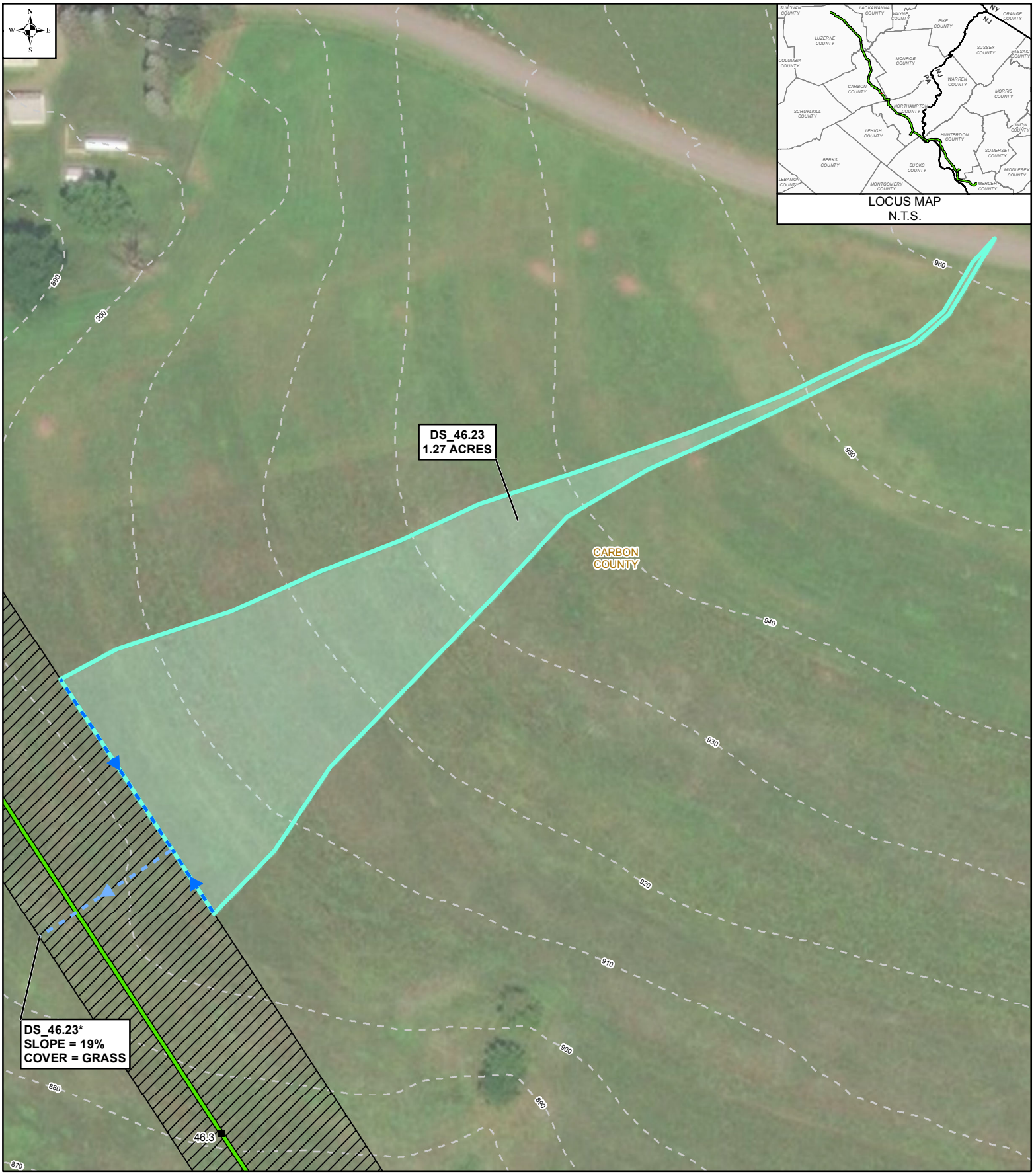


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 35%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.4 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.4 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_46.23

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 47 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 46.23	100	0.4	0.079	8.39

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 46.23	726	SHORT GRASS	0.072	1.87	6.48

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
14.87

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 46.23	1	PASTURE	0.50	1.27	0.64	0.50

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	14.87	3.33	3.99	4.49	3.33	3.99	4.49

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.50	3.99	1.27	2.11	2.53	2.85

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_46.23		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.27		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.53		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.32		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.28		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	10.53 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	10.53		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.26		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.32		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

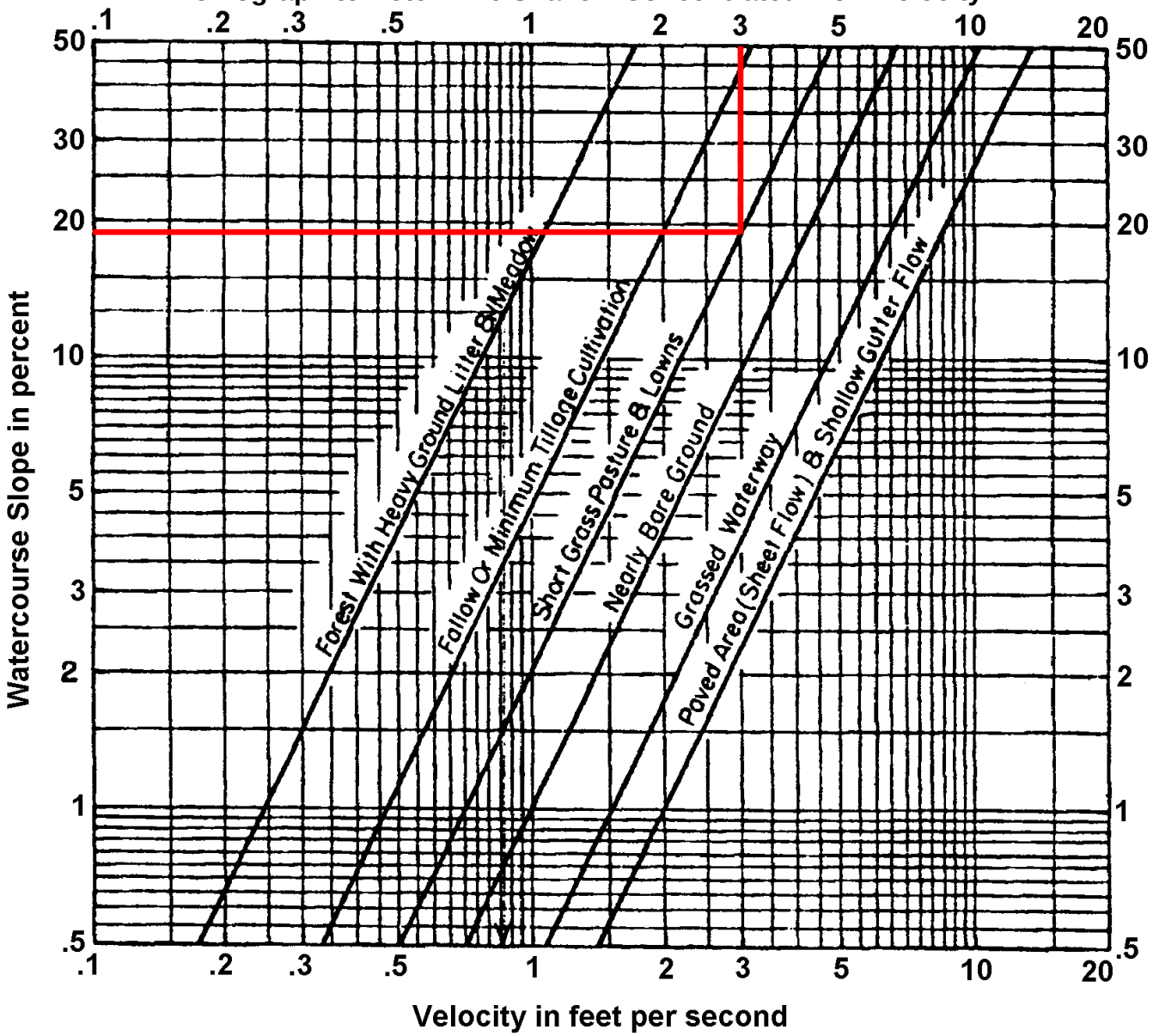
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_46.23

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

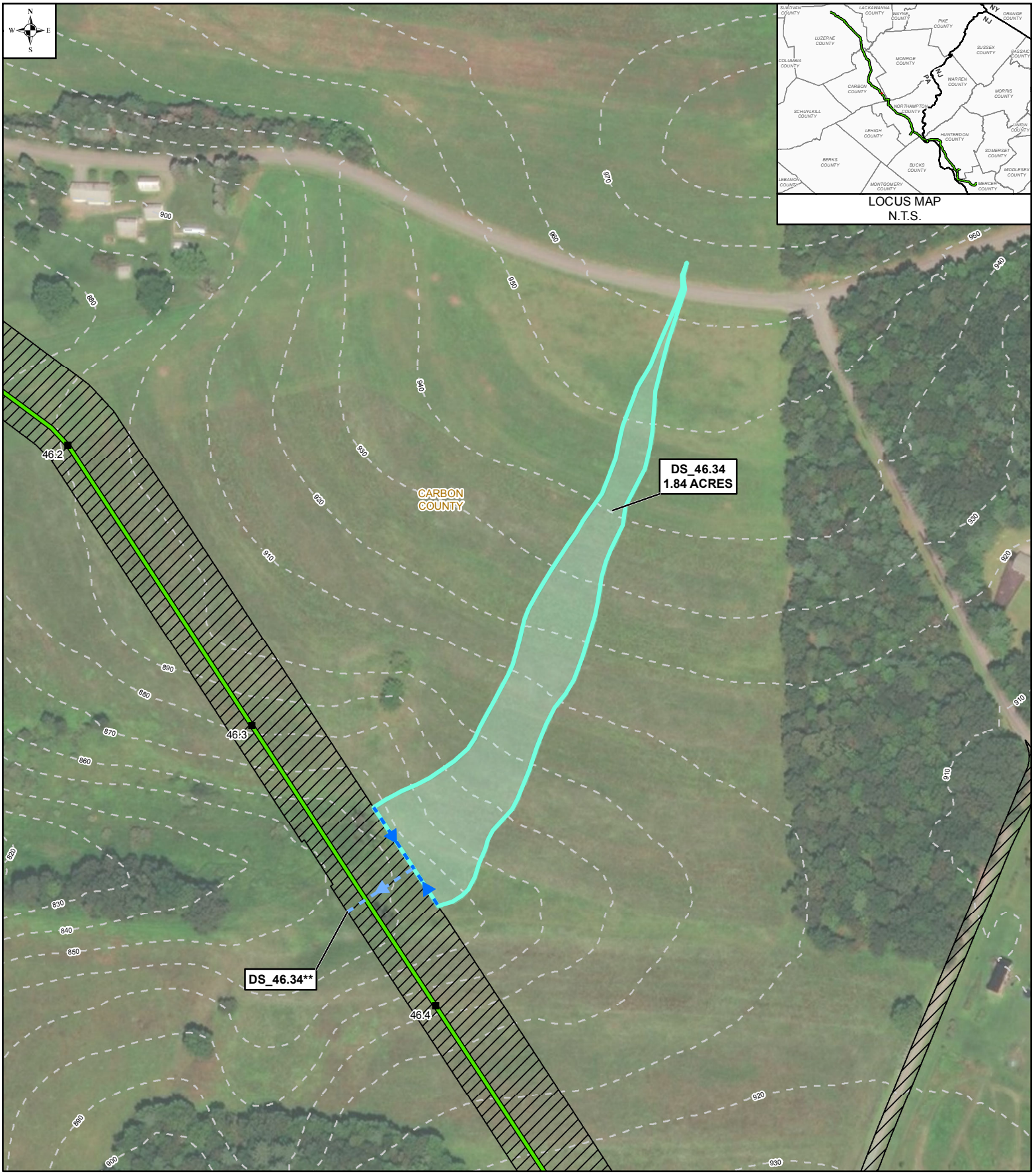


TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 19%

SHALLOW CONCENTRATED FLOW VELOCITY = 3.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

3.0 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_46.34

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 200 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 100 200 FEET

PennEast PIPELINE

DWG NO: PAGE 48 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 46.34	100	0.4	0.080	8.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 46.34	1015	SHORT GRASS	0.093	2.12	7.97

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
16.34

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 46.34	1	PASTURE	0.50	1.68	0.84	0.48
	2	OPEN SPACE	0.28	0.16	0.04	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	16.34	3.18	3.82	4.32	3.18	3.82	4.32

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.48	3.82	1.84	2.81	3.38	3.82

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

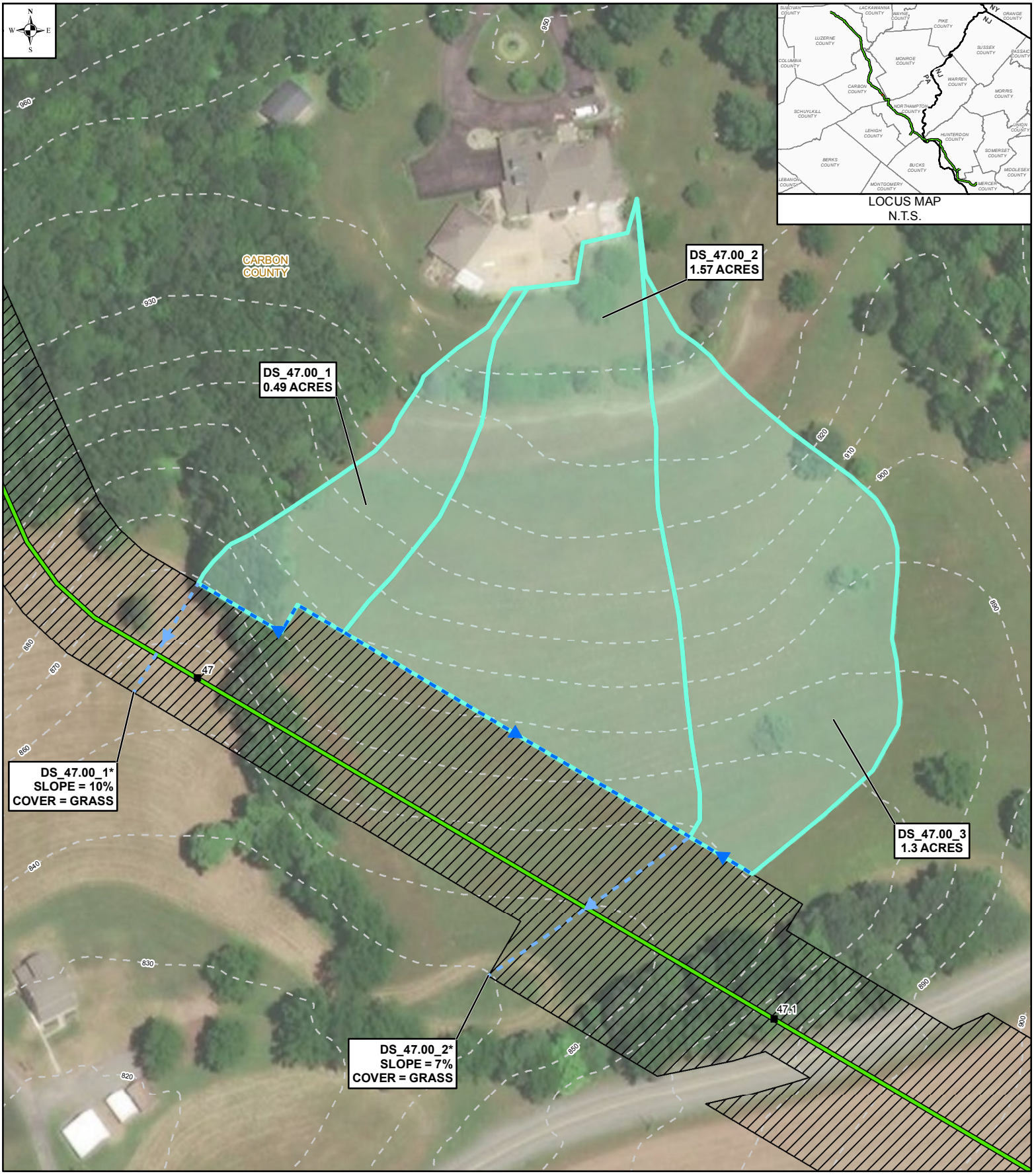
LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_46.34		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.84		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	3.38		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.89		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.044		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.79		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.51 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	5.26		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.51		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.75		
R (HYDRAULIC RADIUS)		0.38		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.052		
$.7S_c$	(FT/FT)	0.036		
$1.3S_c$	(FT/FT)	0.067		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_47.00

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 49 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_47.00_1
0.49 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 47.00_1	100	0.4	0.060	8.95

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 47.00_1	139	SHORT GRASS	0.223	3.29	0.70
	119	FOREST	0.320	1.42	1.39

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
11.05

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 47.00_1	1	FOREST	0.20	0.11	0.02	0.26
	2	OPEN SPACE	0.28	0.38	0.11	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	11.05	3.78	4.49	4.99	3.78	4.49	4.99

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.26	4.49	0.49	0.49	0.58	0.64

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_47.00_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.49		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.58		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.41		
PROTECTIVE LINING[2,6]		P550		
n (MANNING'S COEFFICIENT)[2]		0.041		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.38		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	4.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	3.90		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.41 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.41		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.20		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.55		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.125		
S_C (CRITICAL SLOPE)	(FT/FT)	0.052		
$.7S_c$	(FT/FT)	0.037		
$1.3S_c$	(FT/FT)	0.068		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

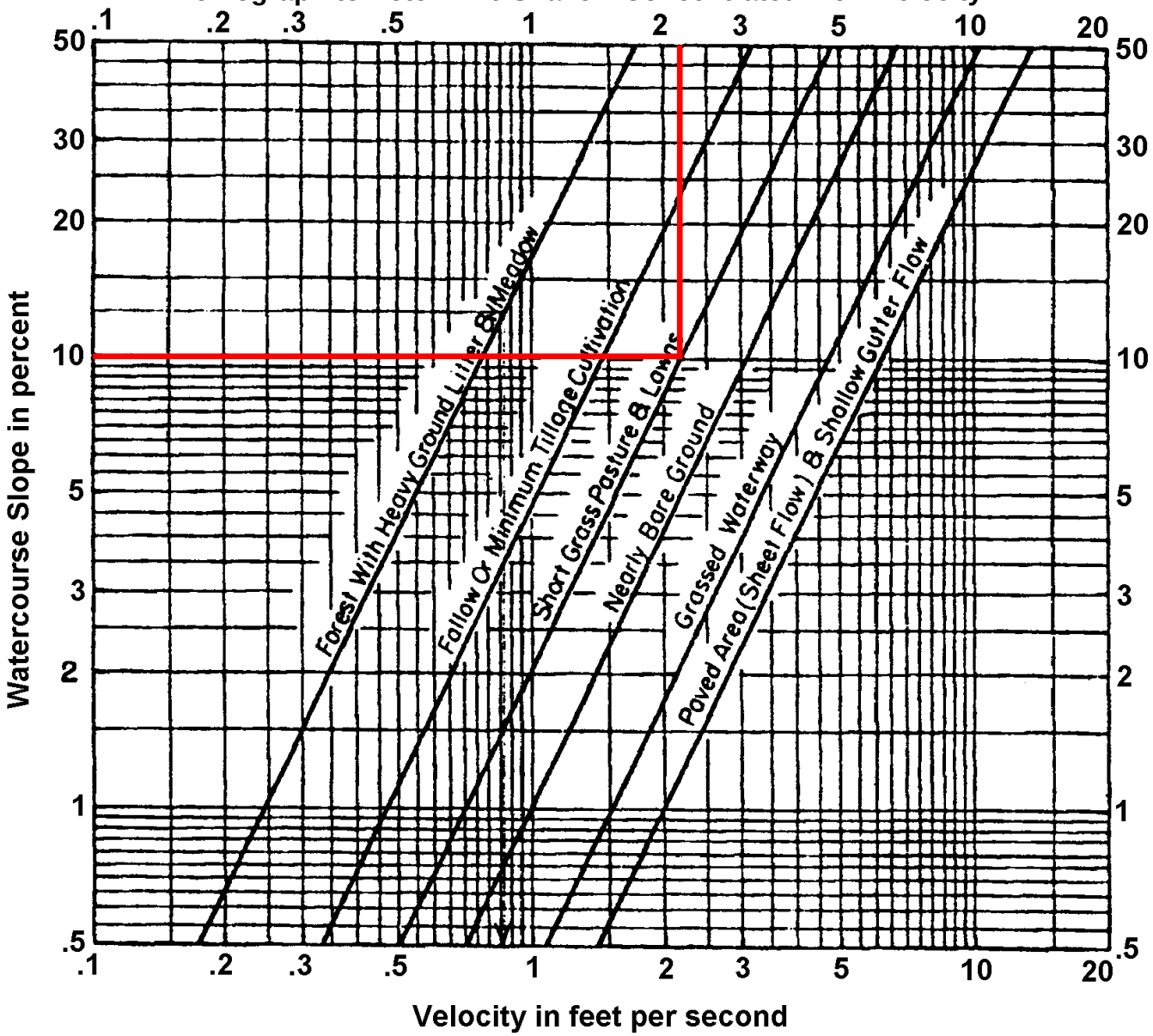
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_47.00_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 10%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.2 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

2.2 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_47.00_2
1.58 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 47.00_2	100	0.4	0.010	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 47.00_2	408	SHORT GRASS	0.208	3.18	2.14

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
15.75

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 47.00_2	1	FOREST	0.20	0.07	0.01	0.28
	2	OPEN SPACE	0.28	1.51	0.42	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	15.75	3.24	3.89	4.39	3.24	3.89	4.39

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.28	3.89	1.58	1.41	1.70	1.92

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_47.00_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.58		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.7		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.21		
PROTECTIVE LINING[2,6]		P300		
n (MANNING'S COEFFICIENT)[2]		0.034		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.41		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.00		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.50		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.09		
S_C (CRITICAL SLOPE)	(FT/FT)	0.037		
$.7S_c$	(FT/FT)	0.026		
$1.3S_c$	(FT/FT)	0.048		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

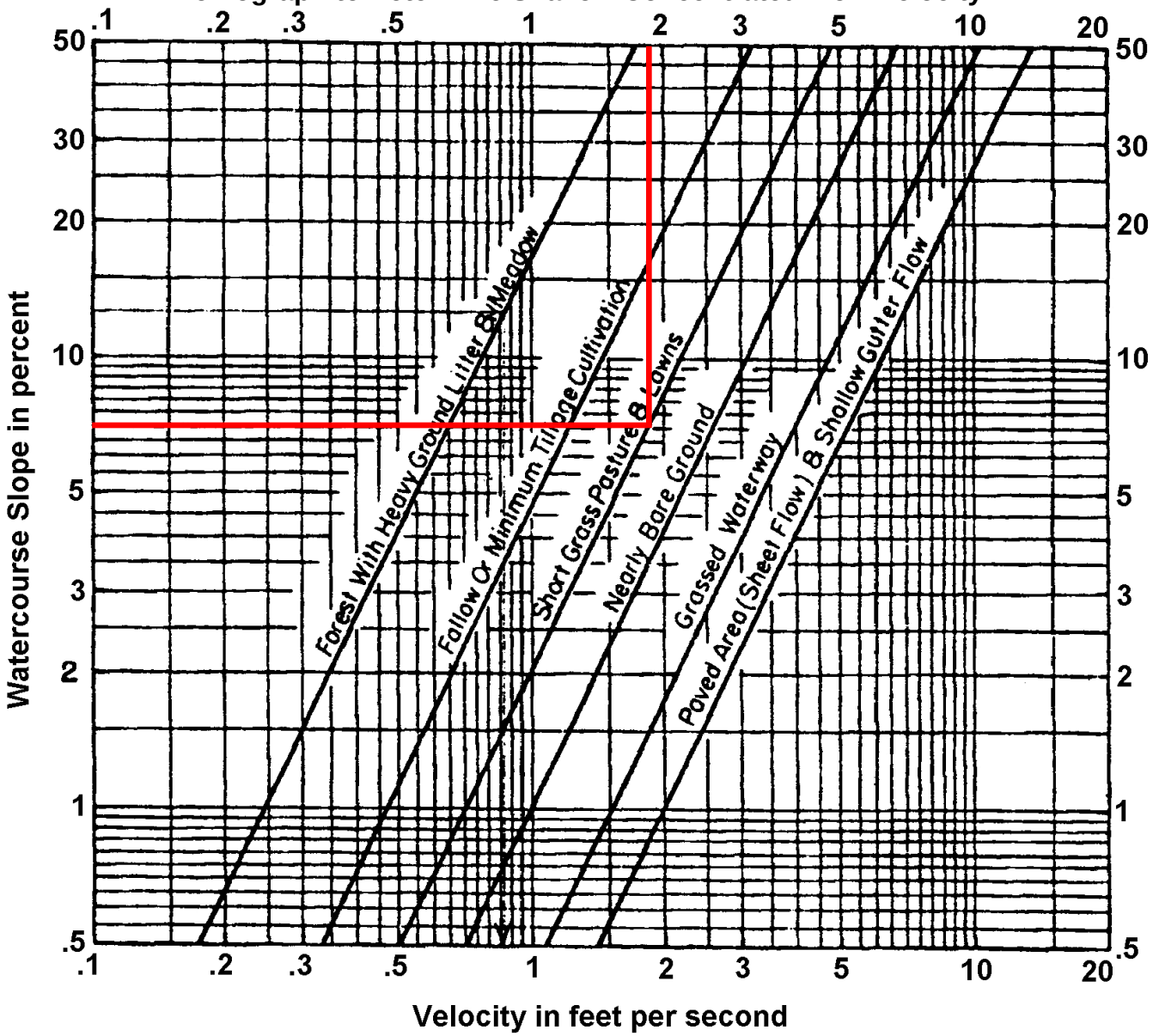
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_47.00_2 & DS_47.00_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

1.9 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_47.00_3
1.3 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 47.00_3	100	0.4	0.010	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 47.00_3	565	SHORT GRASS	0.149	2.69	3.50

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
17.11

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 47.00_3	1	FOREST	0.20	0.02	0.00	0.28
	2	OPEN SPACE	0.28	1.28	0.36	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	17.11	3.11	3.74	4.24	3.11	3.74	4.24

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.28	3.74	1.30	1.13	1.35	1.54

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_47.00_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.3		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.36		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.09		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.91		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.09		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	12.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	12.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.49		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.62		
R (HYDRAULIC RADIUS)		0.23		
S (BED SLOPE)[3, 7]	(FT/FT)	0.035		
S_C (CRITICAL SLOPE)	(FT/FT)	0.077		
$.7S_c$	(FT/FT)	0.054		
$1.3S_c$	(FT/FT)	0.101		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

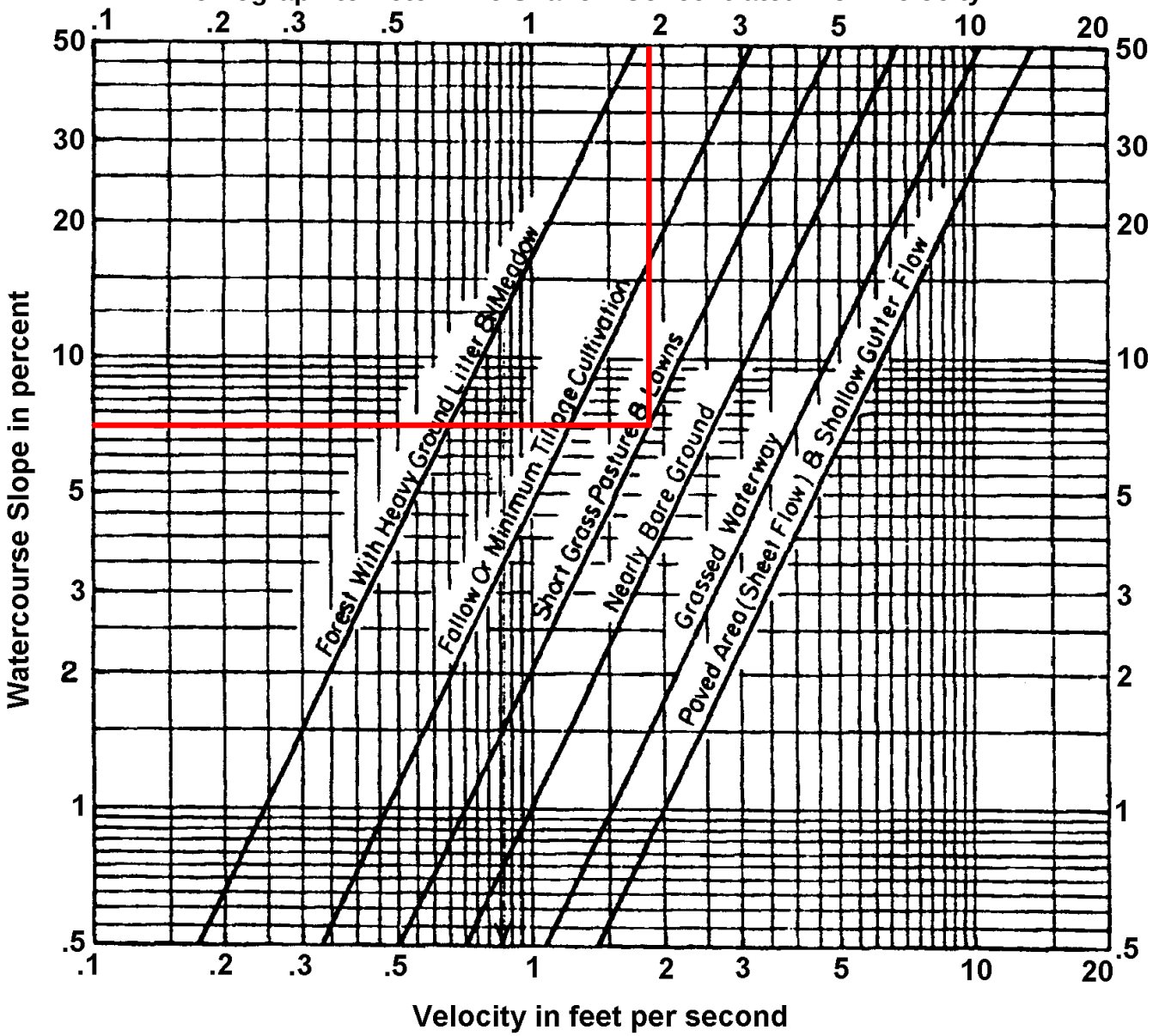
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_47.00_2 & DS_47.00_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

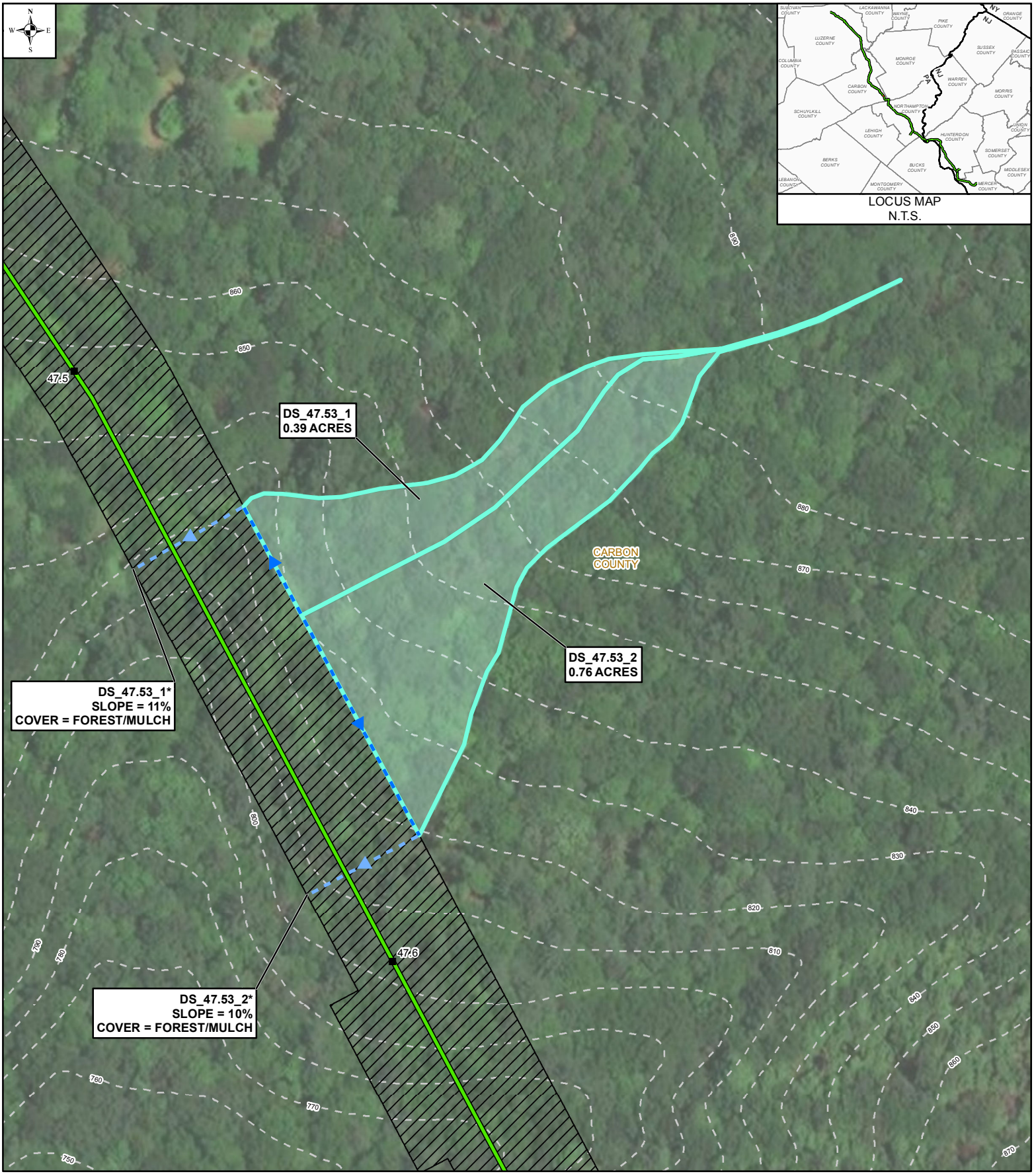


TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 7%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

1.9 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_47.53

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 100 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 50 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_47.53_1
0.39 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 47.53_1	100	0.8	0.069	11.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 47.53_1	317	FOREST	0.177	1.06	4.99

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
16.97

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 47.53_1	1	FOREST	0.20	0.39	0.08	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	16.97	3.12	3.75	4.25	3.12	3.75	4.25

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.12	0.39	0.24	0.29	0.33

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_47.53_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.39		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.24		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.08		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	6.11		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.03 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.03		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.02		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.50		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.072		
S_C (CRITICAL SLOPE)	(FT/FT)	0.016		
$.7S_c$	(FT/FT)	0.011		
$1.3S_c$	(FT/FT)	0.020		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

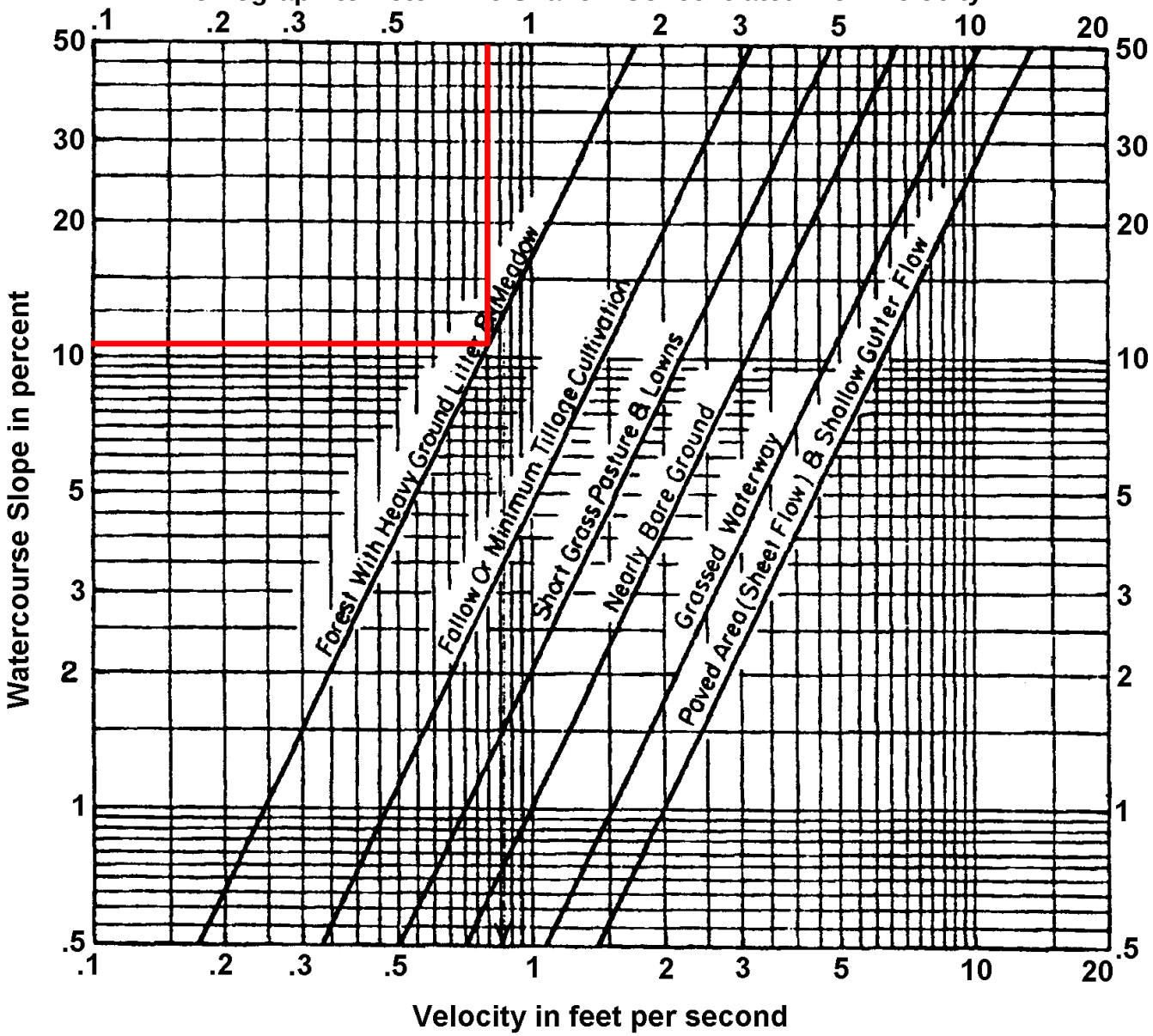
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_47.53_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 11%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_47.53_2
0.76 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 47.53_2	100	0.8	0.060	12.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 47.53_2	615	FOREST	0.117	0.86	11.91

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
24.28

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 47.53_2	1	FOREST	0.20	0.76	0.15	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	24.28	2.57	3.12	3.60	2.57	3.12	3.60

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.57	0.76	0.39	0.47	0.55

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_47.53_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	2		
ACRES	(AC)	0.76		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.39		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.05		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.14		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.75		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.92 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	3.92		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.96		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.49		
R (HYDRAULIC RADIUS)		0.19		
S (BED SLOPE)[3, 7]	(FT/FT)	0.056		
S_C (CRITICAL SLOPE)	(FT/FT)	0.098		
$.7S_c$	(FT/FT)	0.069		
$1.3S_c$	(FT/FT)	0.127		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

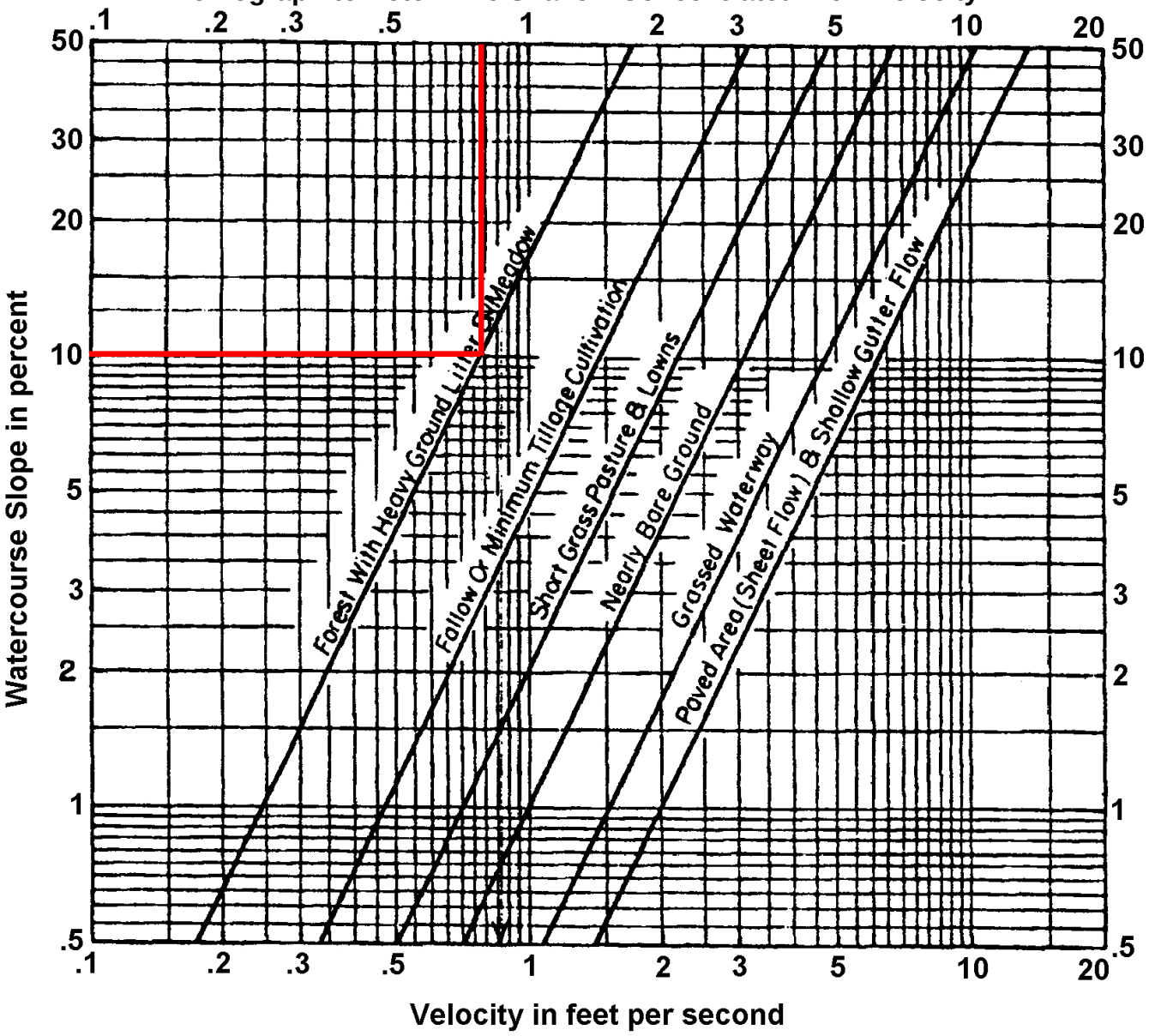
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_47.53_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

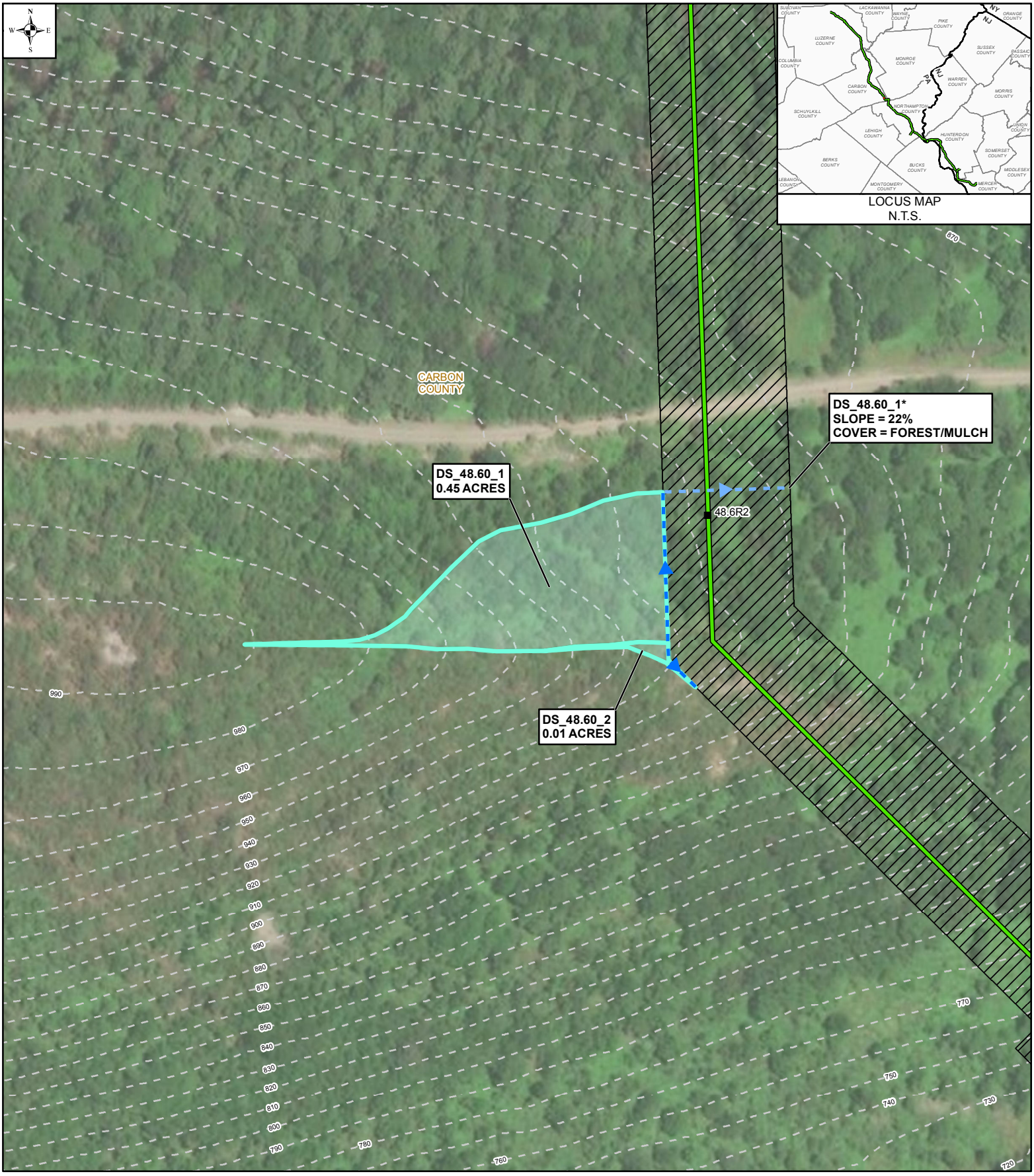


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 10%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_48.60

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 100 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 51 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_48.60_1
0.45 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 48.60_1	100	0.4	0.110	7.77

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 48.60_1	266	FOREST	0.210	1.15	3.85

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
11.61

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 48.60_1	1	FOREST	0.20	0.45	0.09	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	11.61	3.70	4.41	4.91	3.70	4.41	4.91

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	4.41	0.45	0.33	0.40	0.44

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION[7]		DS_48.60_1a	**DS_48.60_1b**	
TEMPORARY OR PERMANENT?	(T OR P)	T	**T**	
DESIGN STORM	(2, 5, OR 10 YR)	5	**5**	
ACRES	(AC)	0.45	**0.45**	
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A	**N/A**	
Q_r (REQUIRED CAPACITY)	(CFS)	0.4	**0.4**	
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.53	**2.26**	
PROTECTIVE LINING[2,6]		EXISTING GRASS	**P300**	
n (MANNING'S COEFFICIENT)[2]		0.08	**0.034**	
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	**N/A**	
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	0.72	**4.34**	
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00	**3.00**	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.37	**2.68**	
CHANNEL BOTTOM WIDTH	(FT)	0	**0**	
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0	**4.17 / 0**	
D (TOTAL DEPTH)	(FT)	1.00	**1.00**	
CHANNEL TOP WIDTH @ D	(FT)	5.88	**4.17**	
d (CALCULATED FLOW DEPTH)	(FT)	0.50	**0.50**	
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94	**2.08**	
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0	**0**	
d_{50} STONE SIZE	(IN)	N/A	**N/A**	
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74	**0.52**	
R (HYDRAULIC RADIUS)		0.21	**0.20**	
S (BED SLOPE)[3]	(FT/FT)	0.012	**0.086**	
S_C (CRITICAL SLOPE)	(FT/FT)	0.185	**0.037**	
$.7S_c$	(FT/FT)	0.130	**0.026**	
$1.3S_c$	(FT/FT)	0.241	**0.048**	
STABLE FLOW?	(Y/N)	Y	**Y**	
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	**N/A**	
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	**0.50**	
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	**0.50**	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	**S**	

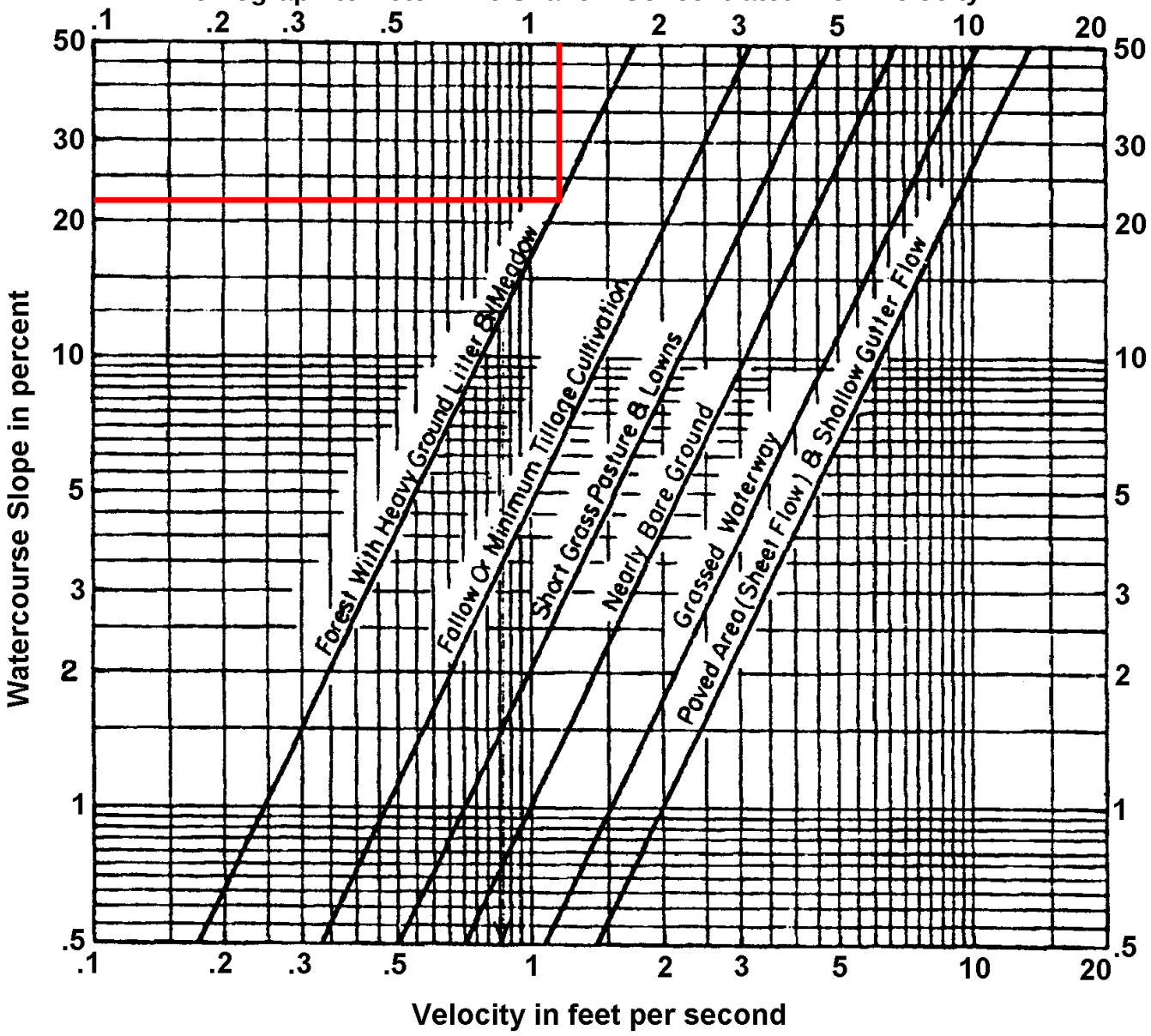
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design methods is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. For this temporary channel, the percent slope changes along the diversion sock, therefore it was designed in two segments. The calculations above demonstrate that the shear stress and capacity were checked for both scenarios and the more conservative lining and diversion sock diameter were selected and implemented into the design. The table above shows both scenarios, and the column in bold is the more conservative design used to satisfy both scenarios.

CLEAN WATER DIVERSION ID:
DS_48.60_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 22%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.2 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.2 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_48.60_2
0.011 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 48.60_2	100	0.4	0.240	6.47

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 48.60_2	28	FOREST	0.360	1.51	0.31

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
6.78

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 48.60_2	1	FOREST	0.20	0.01	0.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	6.78	4.46	5.24	5.71	4.46	5.24	5.71

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	5.24	0.01	0.01	0.01	0.01

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

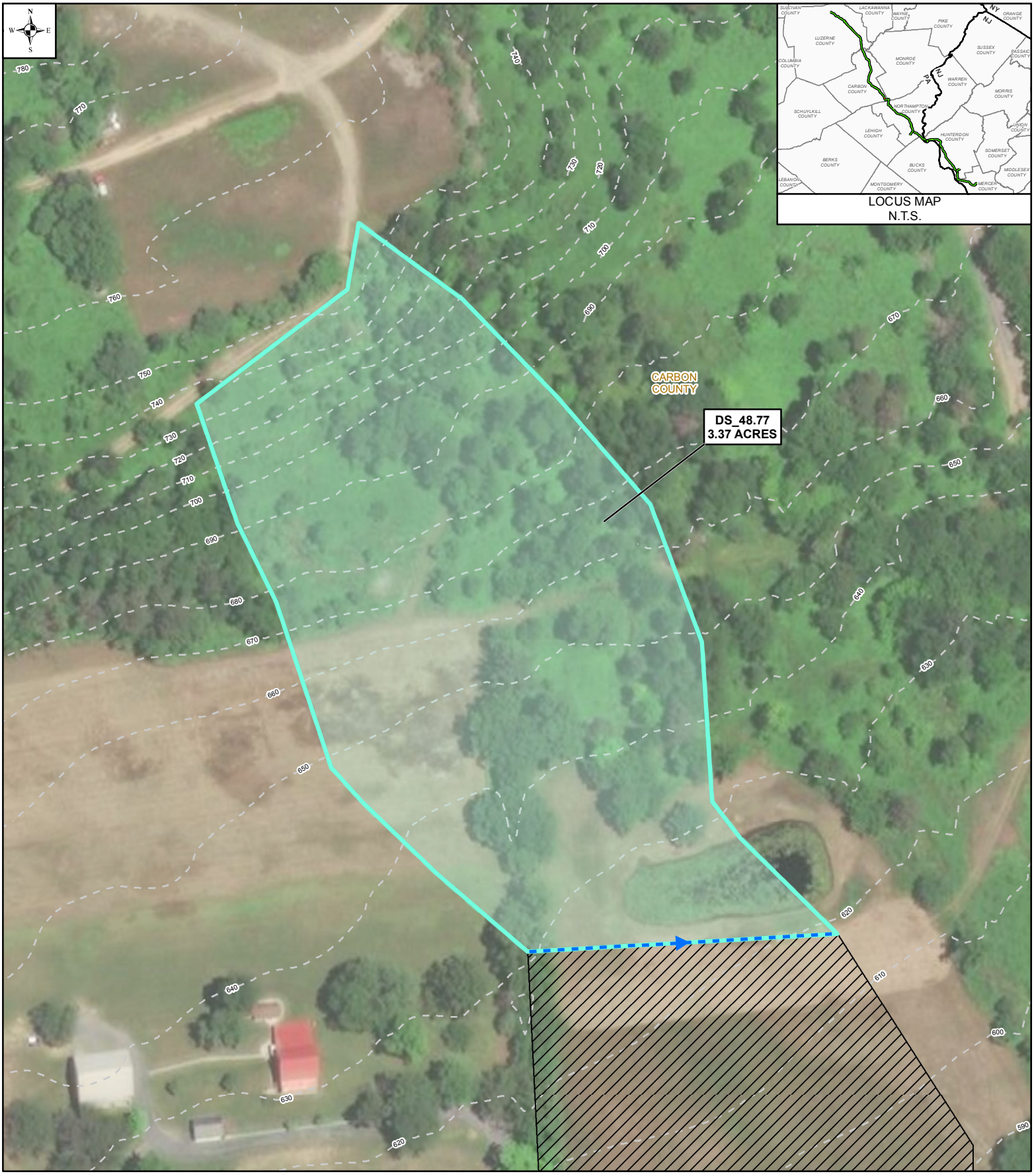
LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_48.60_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.011		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.012		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.09		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.54		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.44 / 0		
D (TOTAL DEPTH)	(FT)	0.67		
CHANNEL TOP WIDTH @ D	(FT)	2.96		
d (CALCULATED FLOW DEPTH)	(FT)	0.17		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	0.74		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.06		
R (HYDRAULIC RADIUS)		0.07		
S (BED SLOPE)[3, 7]	(FT/FT)	0.12		
S_C (CRITICAL SLOPE)	(FT/FT)	0.136		
$.7S_c$	(FT/FT)	0.095		
$1.3S_c$	(FT/FT)	0.177		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_48.77

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 100 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 50 100 FEET

PennEast PIPELINE

DWG NO: PAGE 52 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 48.77	100	0.8	0.330	8.31

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 48.77	461	FOREST	0.193	1.11	6.95
	145	SHORT GRASS	0.103	2.23	1.08

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
16.34

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 48.77	1	FOREST	0.20	2.17	0.43	0.23
	2	OPEN SPACE	0.28	1.20	0.34	

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	16.34	3.18	3.82	4.32	3.18	3.82	4.32

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.23	3.82	3.37	2.45	2.94	3.33

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

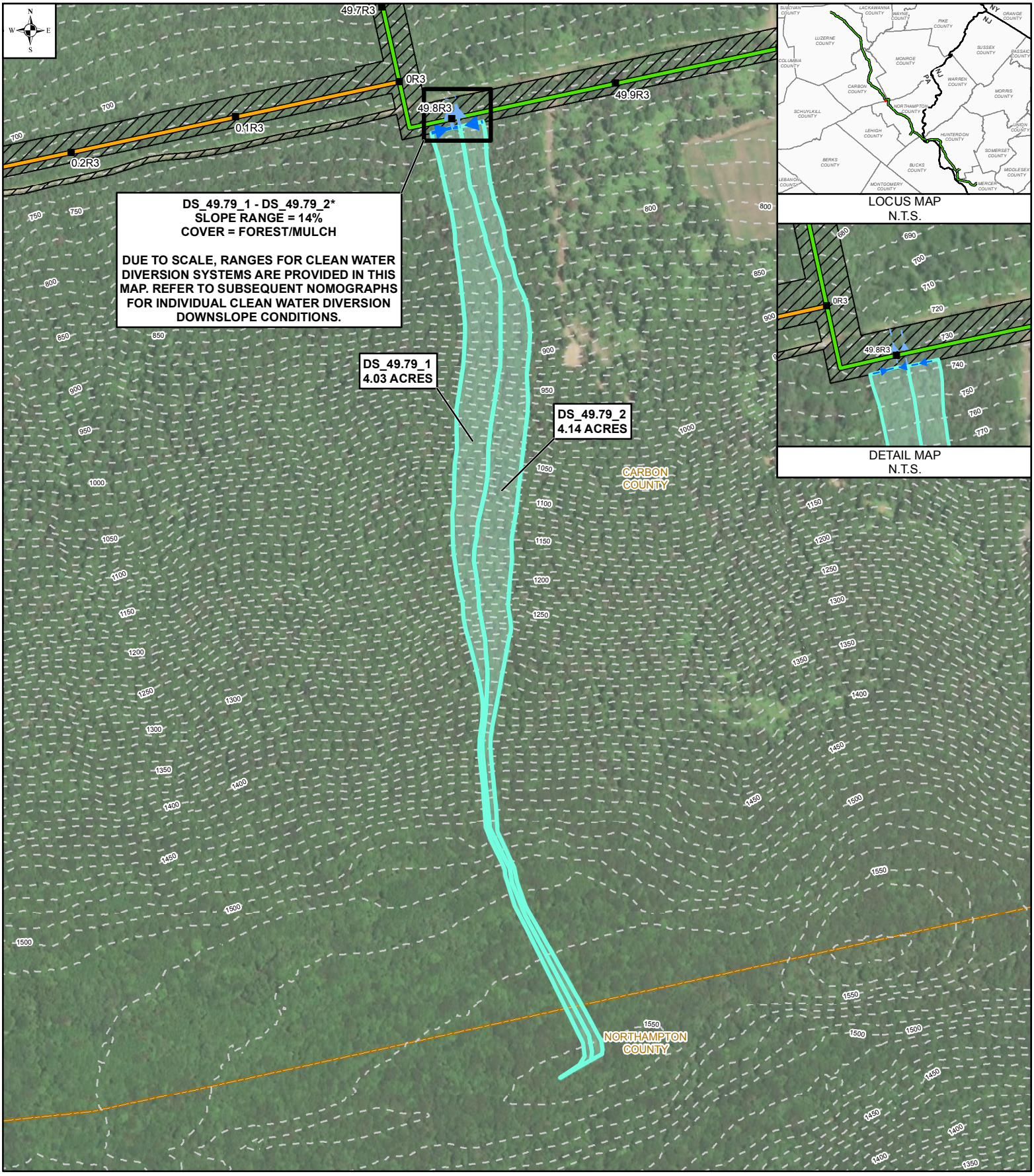
LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_48.77		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.37		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.94		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	8.15		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.74		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	23.81 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	23.81		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	11.90		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.98		
R (HYDRAULIC RADIUS)		0.24		
S (BED SLOPE)[3, 7]	(FT/FT)	0.057		
S_C (CRITICAL SLOPE)	(FT/FT)	0.061		
$.7S_c$	(FT/FT)	0.043		
$1.3S_c$	(FT/FT)	0.079		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_49.79

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 53 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.79_1
4.03 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.79_1	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.79_1	3008	FOREST	0.265	1.30	38.71

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c* (minutes)
53.26

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.79_1	1	FOREST	0.20	4.03	0.81	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.79_1	53.26	1.51	1.87	2.23	1.51	1.87	2.23

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.79_1	0.20	1.51	4.03	1.22	1.51	1.80

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.79_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.03		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.51		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.65		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.38		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.56 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.56		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.78		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.69		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

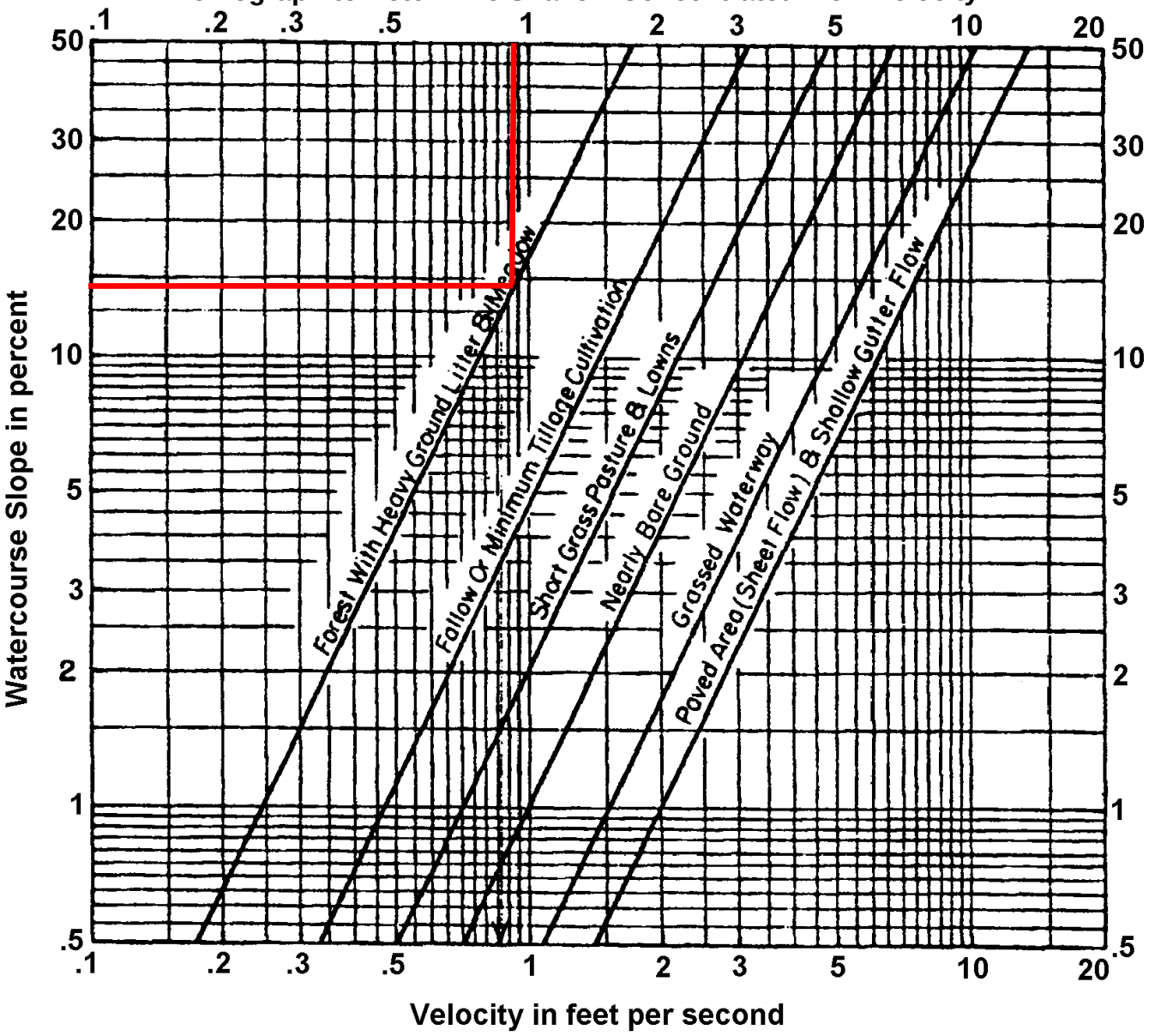
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.79_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.79_2
4.14 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.79_2	100	0.8	0.080	11.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.79_2	2945	FOREST	0.270	1.31	37.54

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
49.11

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.79_2	1	FOREST	0.20	4.14	0.83	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.79_2	49.11	1.60	1.98	2.36	1.60	1.98	2.36

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.79_2	0.20	1.60	4.14	1.33	1.64	1.95

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.79_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.14		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.64		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.95		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.88		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.1 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.10		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.05		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.76		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.026		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

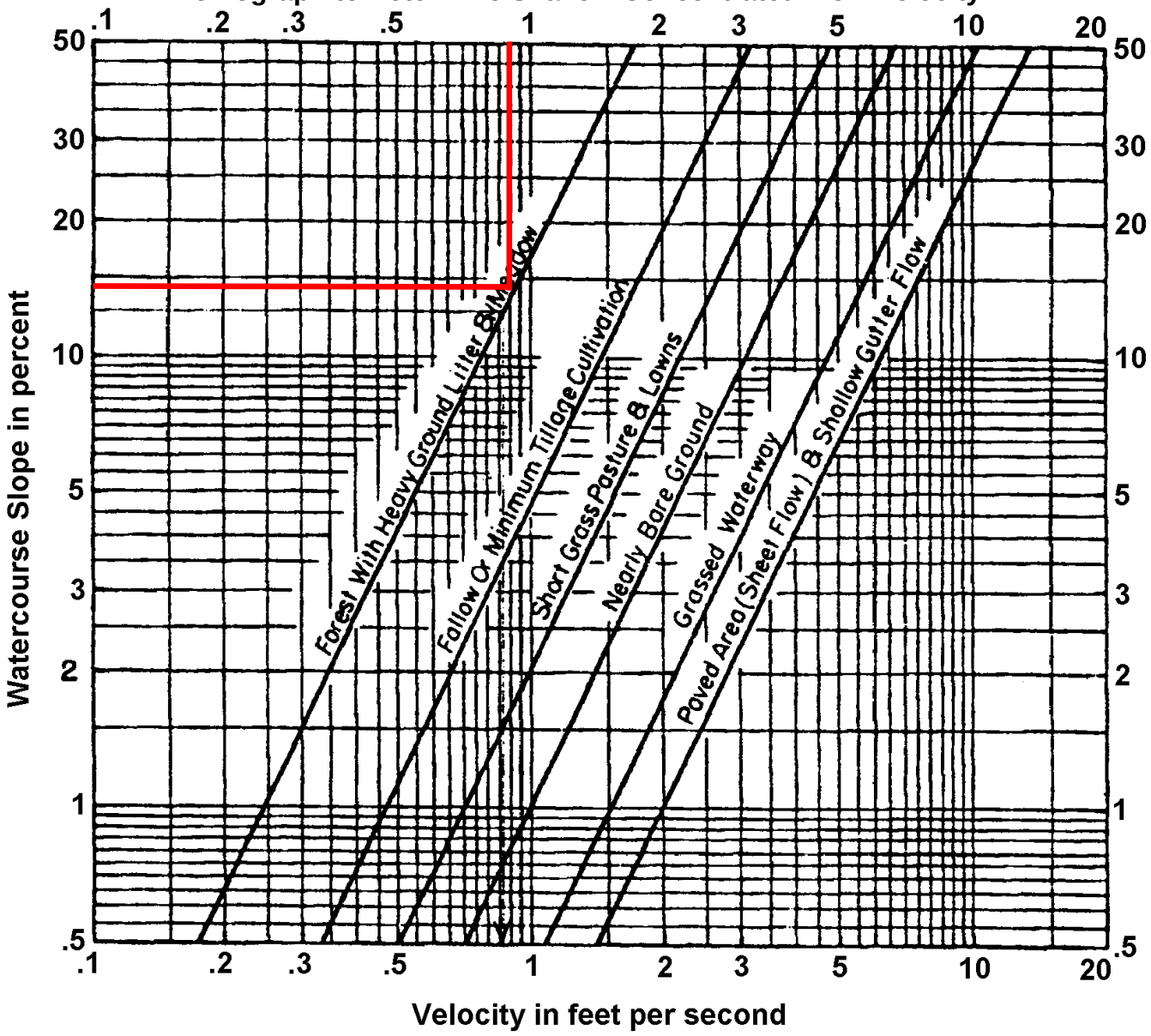
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.79_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

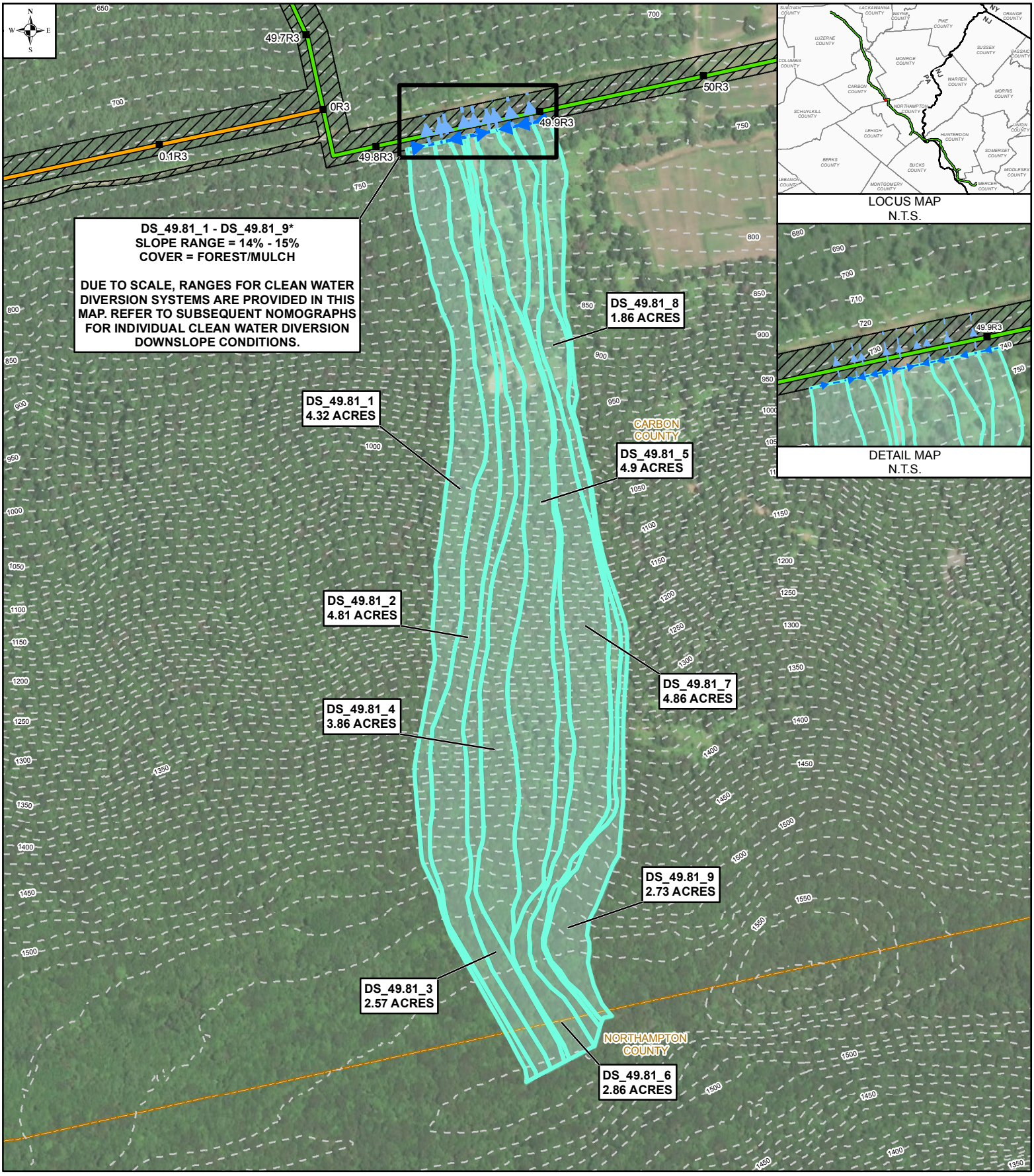


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_49.81

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 400 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 54 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_1
4.32 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_1	100	0.8	0.050	12.91

$$T_{c(sheet\ flow)} = \left[\frac{2(L)(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_1	2969	FOREST	0.270	1.31	37.85

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
50.76

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_1	1	FOREST	0.20	4.32	0.86	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_1	50.76	1.56	1.94	2.30	1.56	1.94	2.30

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_1	0.20	1.56	4.32	1.35	1.67	1.99

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.32		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.67		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.03		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.53		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.34		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.41 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.41		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.21		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.80		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.011		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

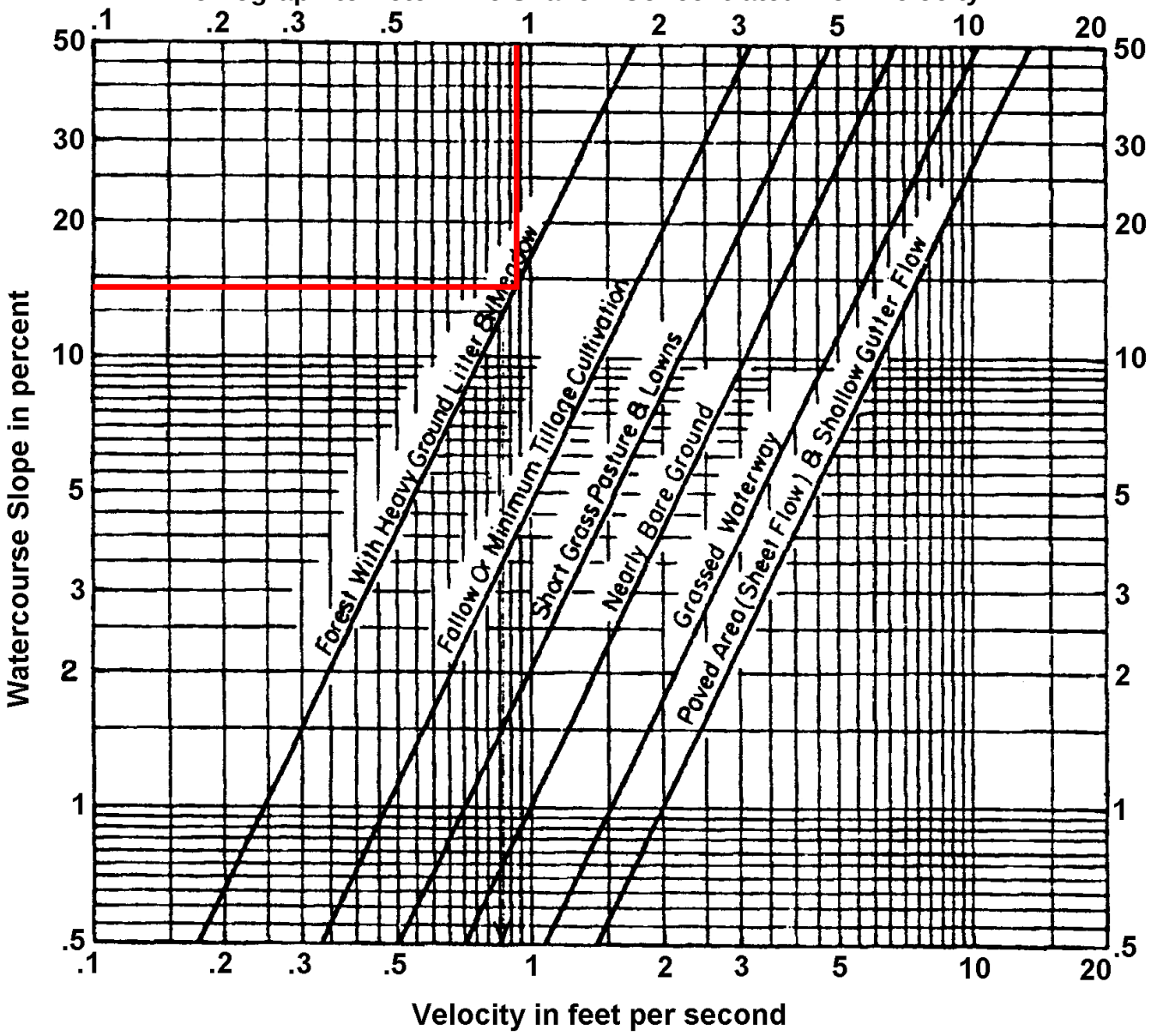
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_2
4.81 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_2	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_2	2969	FOREST	0.270	1.31	37.85

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c* (minutes)
50.76

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_2	1	FOREST	0.20	4.81	0.96	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_2	50.76	1.56	1.94	2.30	1.56	1.94	2.30

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_2	0.20	1.56	4.81	1.50	1.86	2.22

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.81		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.86		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.61		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.55		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.69		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.022		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

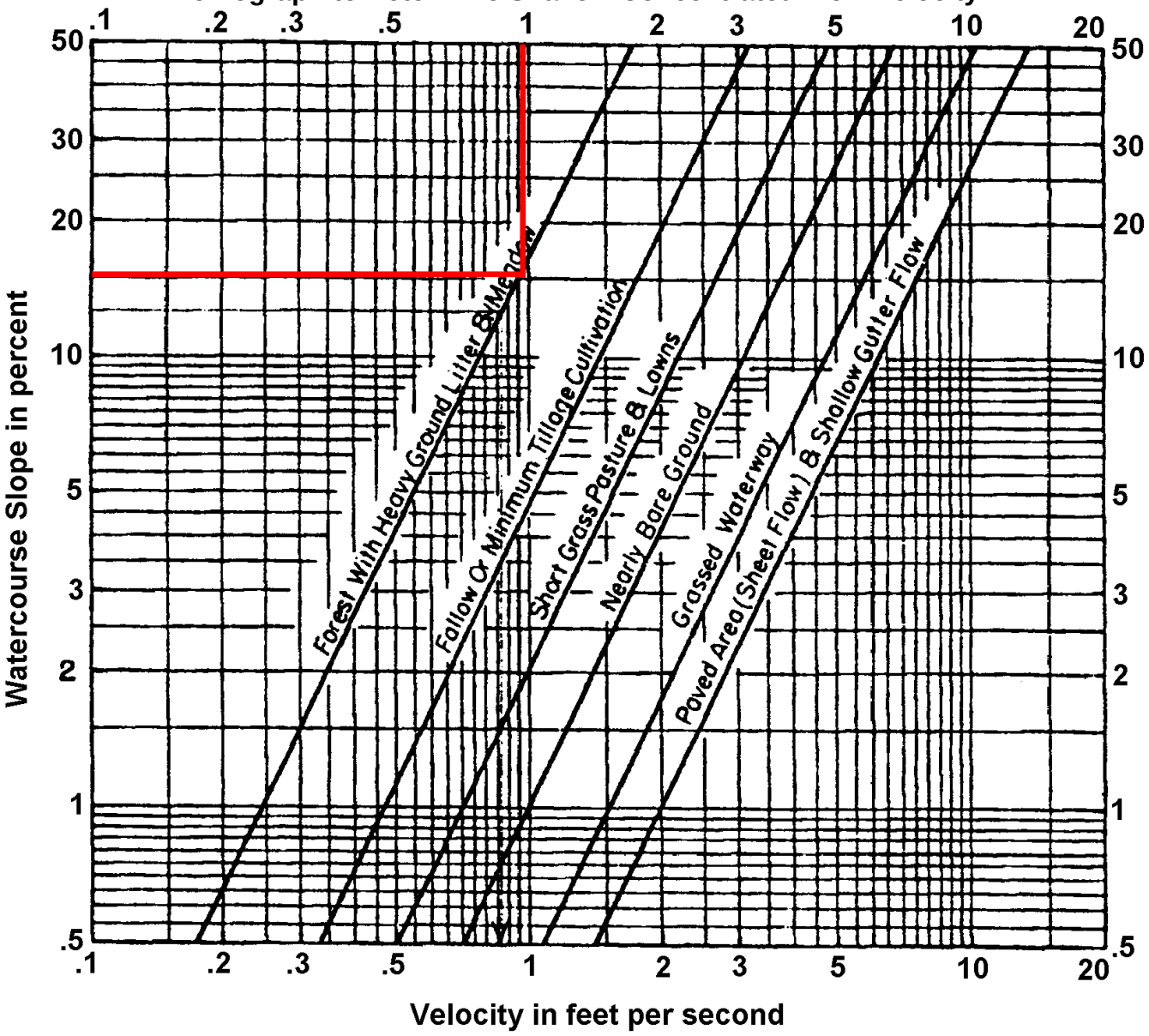
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_3
2.57 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_3	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_3	2925	FOREST	0.270	1.31	37.29

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
51.84

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_3	1	FOREST	0.20	2.57	0.51	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_3	51.84	1.54	1.91	2.27	1.54	1.91	2.27

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_3	0.20	1.54	2.57	0.79	0.98	1.17

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.57		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.98		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.43		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.83		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.12		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.25 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.25		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.78		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.036		
S_C (CRITICAL SLOPE)	(FT/FT)	0.086		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.112		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

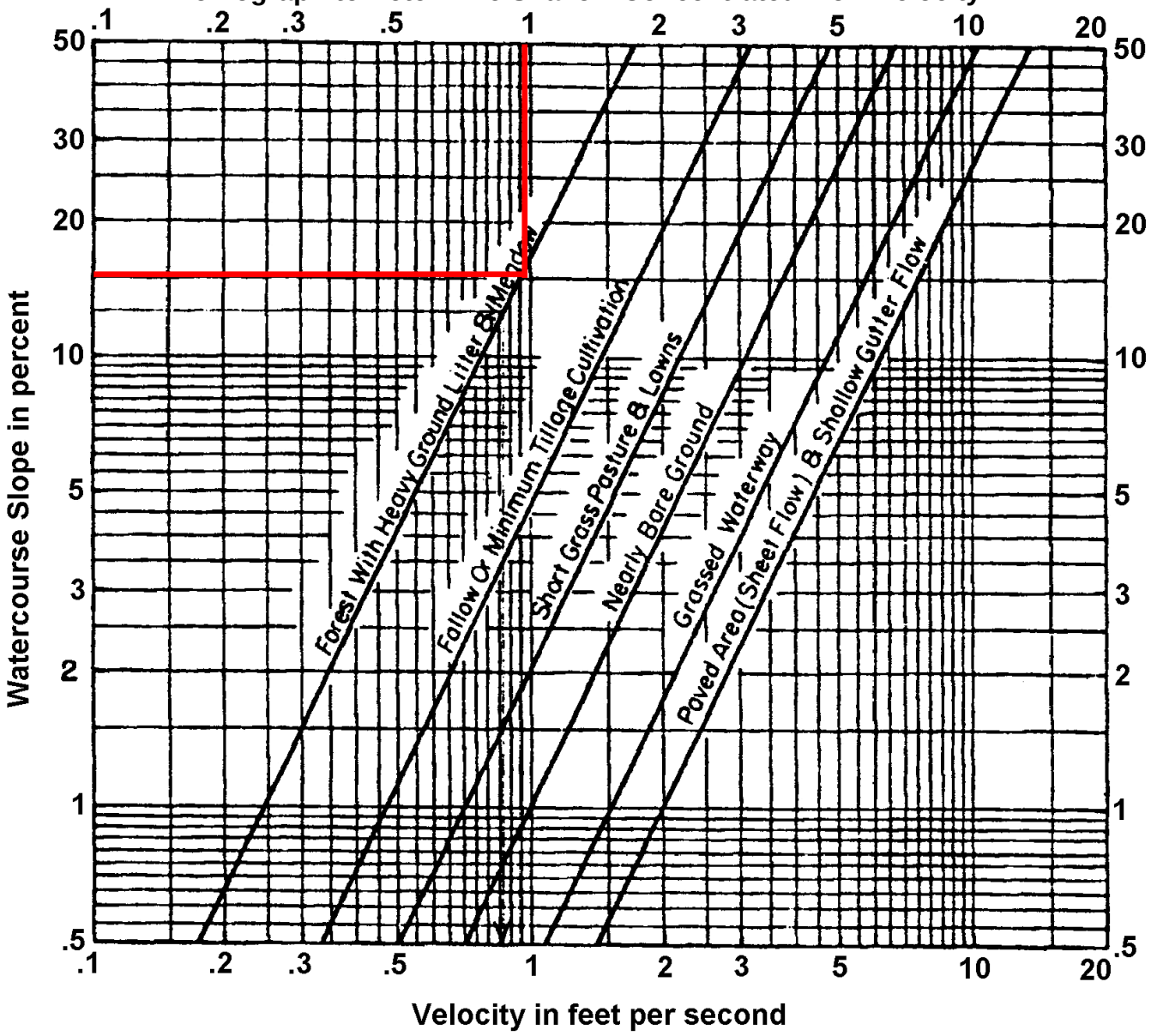
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_4
3.86 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_4	100	0.8	0.020	16.00

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_4	2916	FOREST	0.270	1.31	37.17

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.17

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_4		FOREST	0.20	3.86	0.77	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_4	53.17	1.51	1.87	2.23	1.51	1.87	2.23

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_4	0.20	1.51	3.86	1.17	1.44	1.72

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.86		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.44		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.17		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.16		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.94		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.1 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.10		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.05		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.76		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.03		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

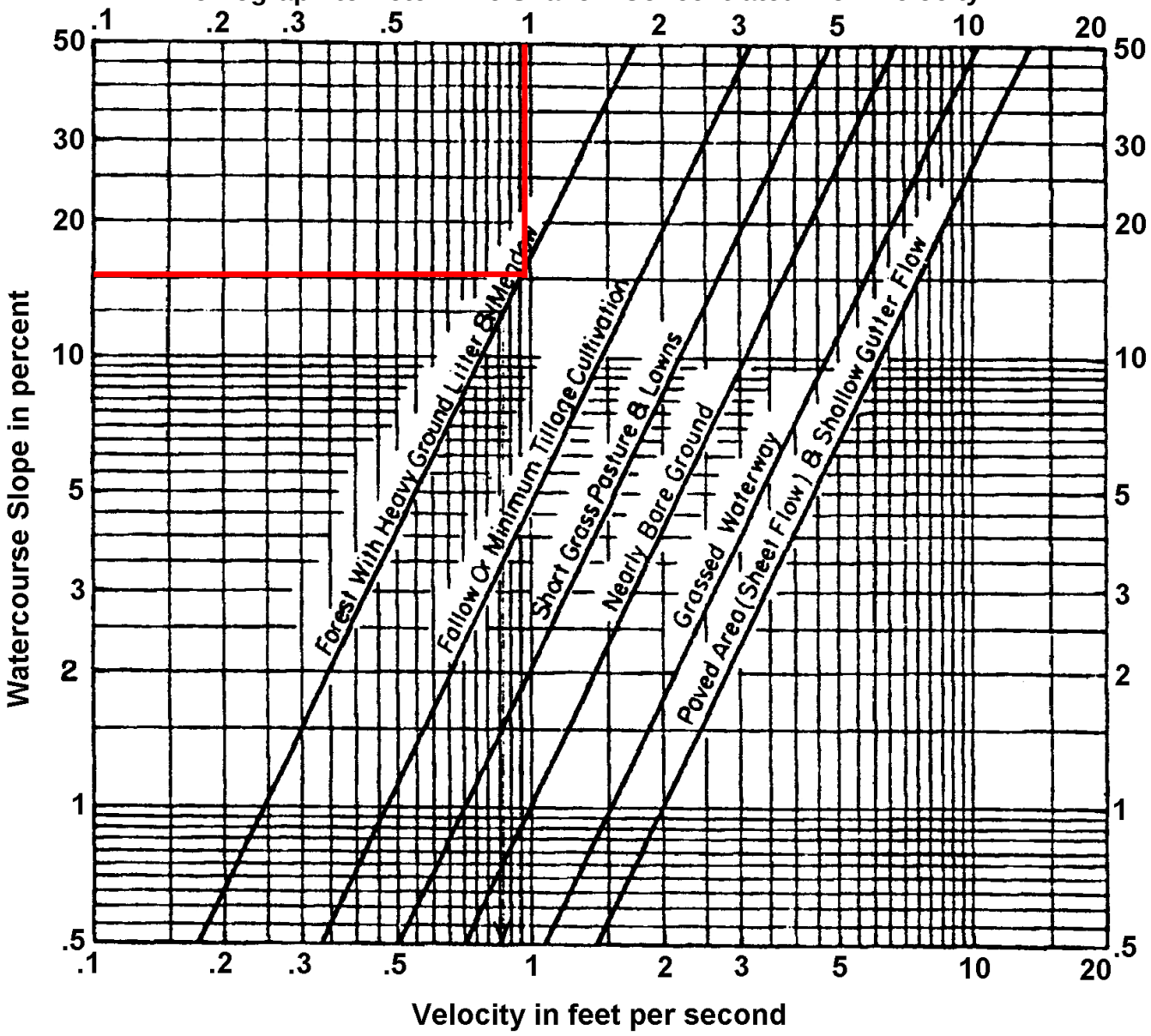
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_5
4.9 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_5	100	0.8	0.060	12.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_5	2916	FOREST	0.310	1.40	34.69

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
47.07

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_5		FOREST	0.20	4.90	0.98	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_5	47.07	1.65	2.04	2.43	1.65	2.04	2.43

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_5	0.20	1.65	4.90	1.62	2.00	2.38

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.9		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.54		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.39		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.99		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.75		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

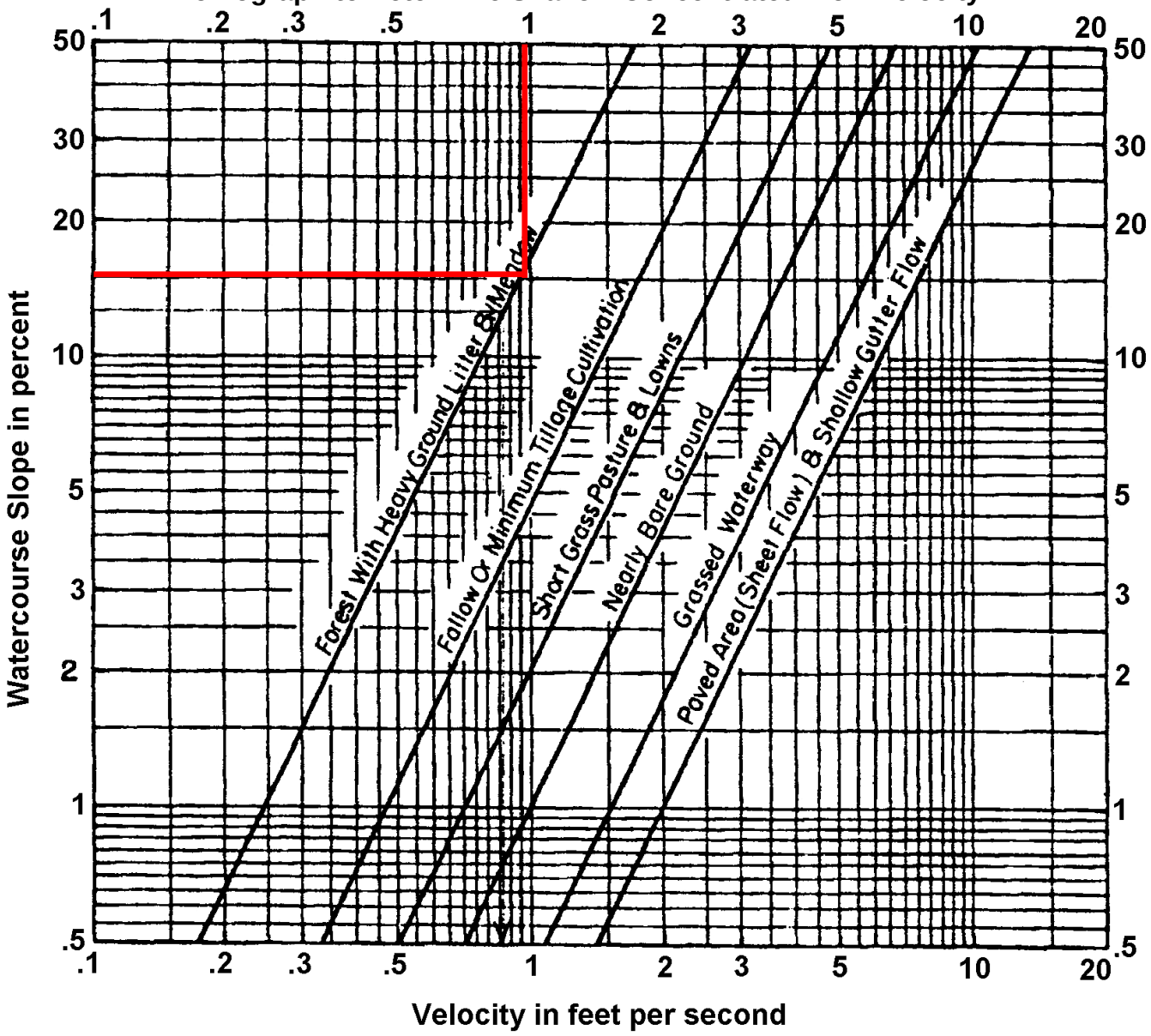
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_6
2.86 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_6	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_6	2977	FOREST	0.270	1.31	37.95

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
56.76

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_6	1	FOREST	0.20	4.86	0.97	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_6	56.76	1.44	1.78	2.13	1.44	1.78	2.13

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_6	0.20	1.44	4.86	1.40	1.73	2.07

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.86		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.73		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.29		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.95		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.47		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.21 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.21		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.11		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.78		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.015		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

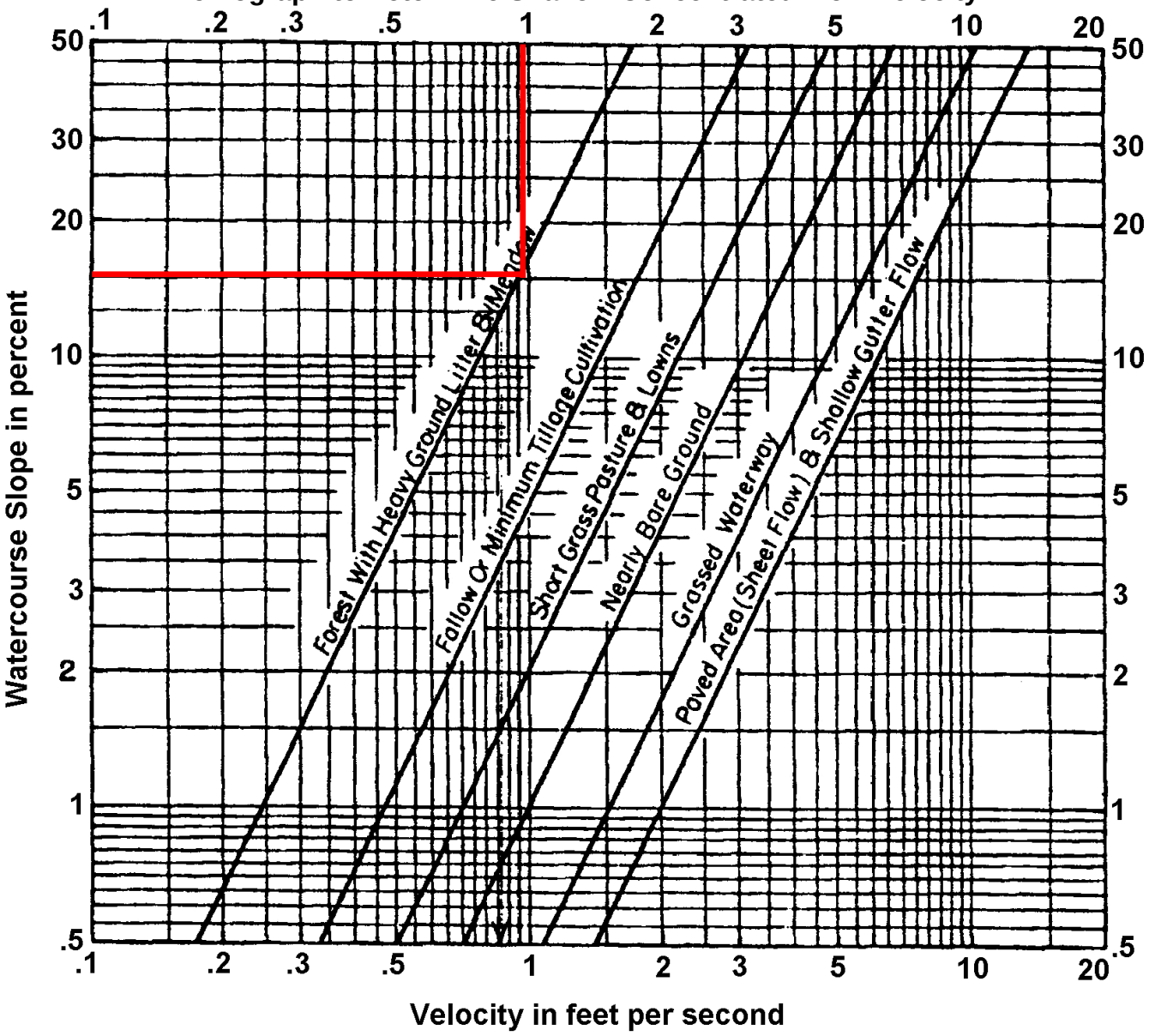
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_7
4.86 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_7	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_7	2915	FOREST	0.270	1.31	37.16

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
55.97

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_7	1	FOREST	0.20	4.86	0.97	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_7	55.97	1.45	1.80	2.15	1.45	1.80	2.15

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_7	0.20	1.45	4.86	1.41	1.75	2.09

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.86		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.75		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.92		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.15		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.14 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.14		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.57		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.89		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.070		
$.7S_c$	(FT/FT)	0.049		
$1.3S_c$	(FT/FT)	0.090		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

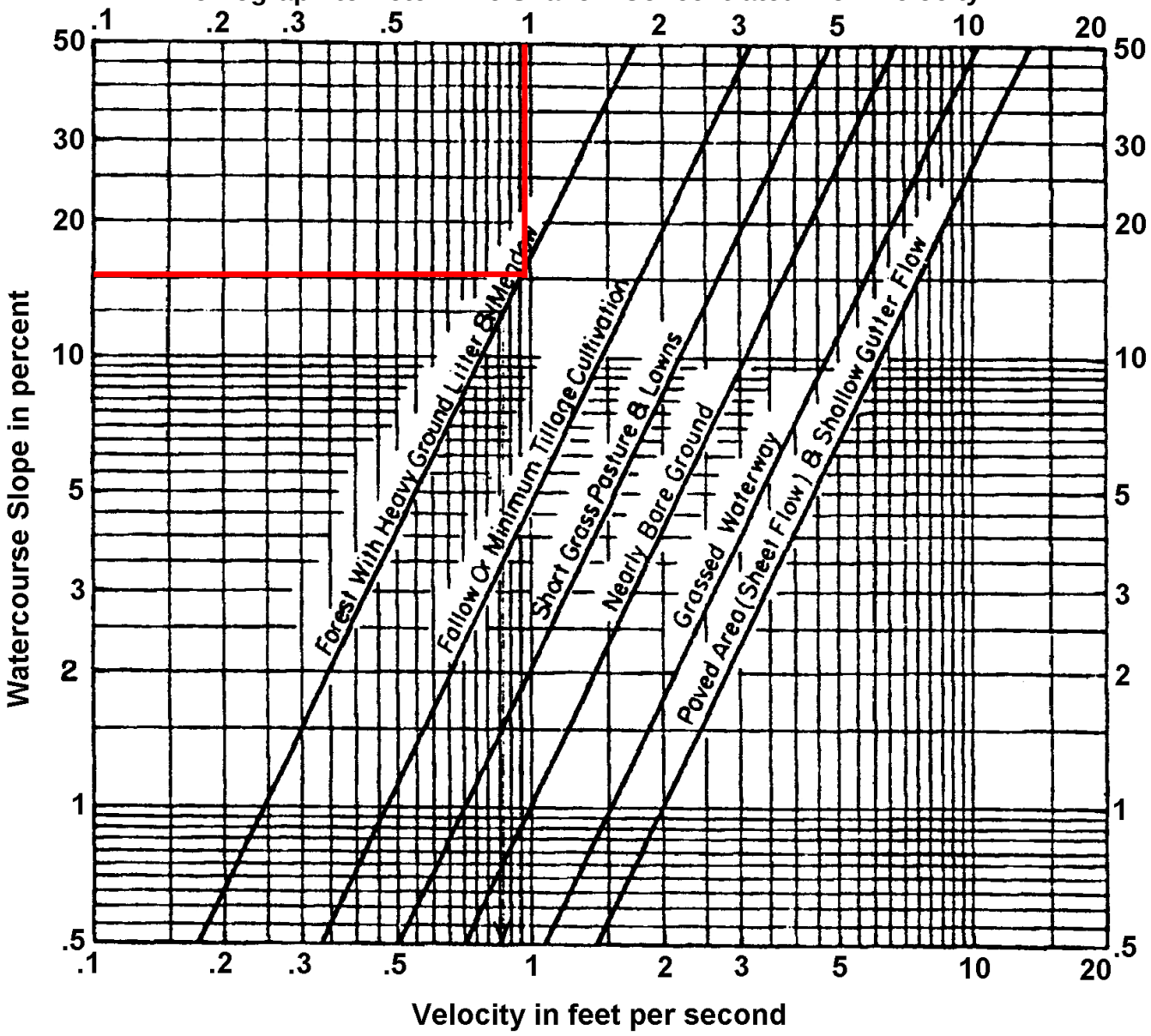
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_8
1.86 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_8	100	0.8	0.020	16.00

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_8	2902	FOREST	0.280	1.33	36.33

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
52.32

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_8	1	FOREST	0.20	1.86	0.37	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_8	52.32	1.53	1.89	2.26	1.53	1.89	2.26

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_8	0.20	1.53	1.86	0.57	0.70	0.84

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.86		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.704		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.89		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.21		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.50		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.016		
S_C (CRITICAL SLOPE)	(FT/FT)	0.088		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.114		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

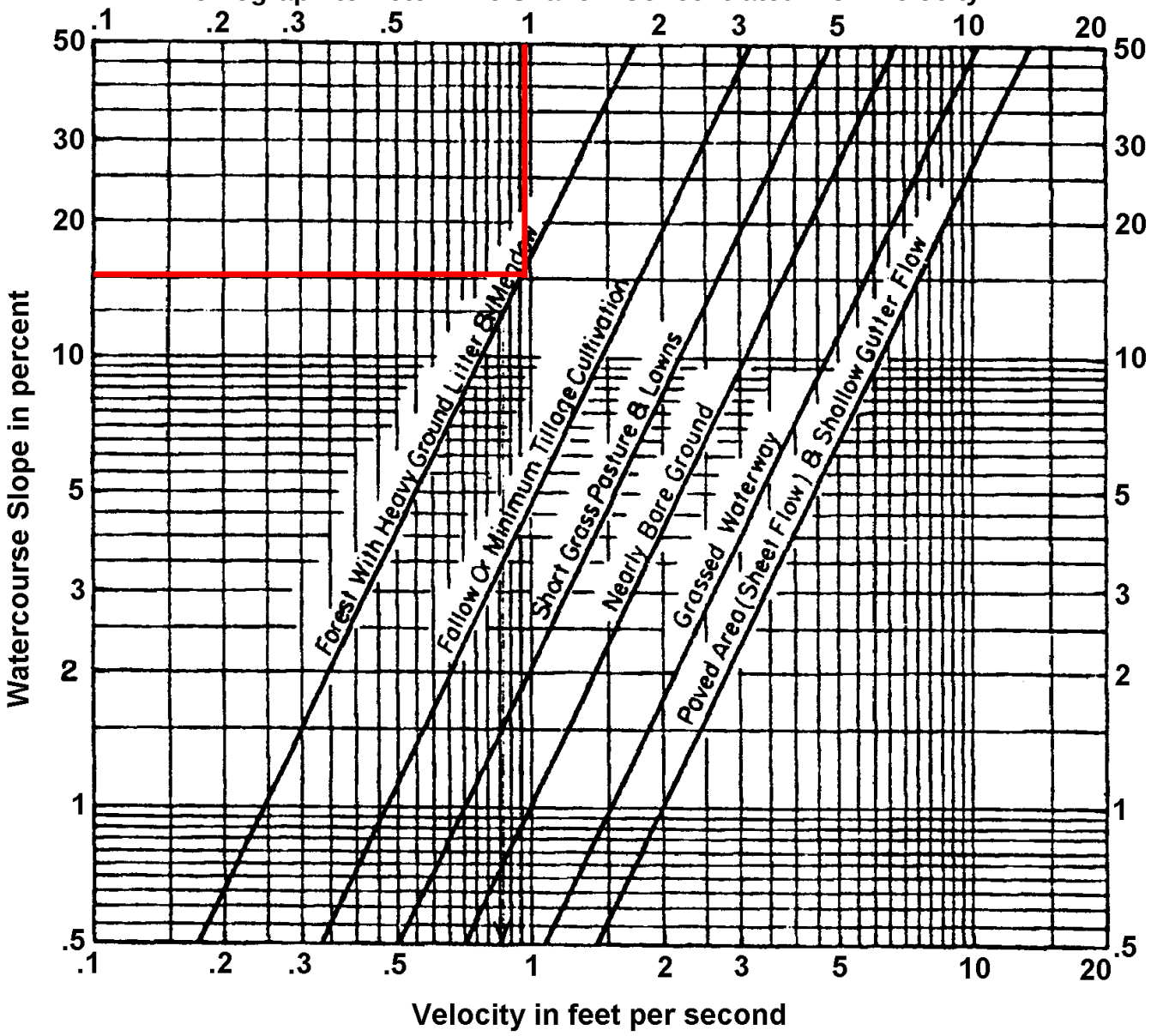
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.81_9
2.73 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.81_9	100	0.8	0.020	16.00

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.81_9	2902	FOREST	0.280	1.33	36.33

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
52.32

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.81_9	1	FOREST	0.20	2.73	0.55	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.81_9	52.32	1.53	1.89	2.26	1.53	1.89	2.26

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.81_9	0.20	1.53	2.73	0.83	1.03	1.23

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.81_9		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.73		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.03		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.60		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.92		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.22		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.67 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.67		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.33		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.83		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.039		
S_C (CRITICAL SLOPE)	(FT/FT)	0.085		
$.7S_c$	(FT/FT)	0.060		
$1.3S_c$	(FT/FT)	0.111		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

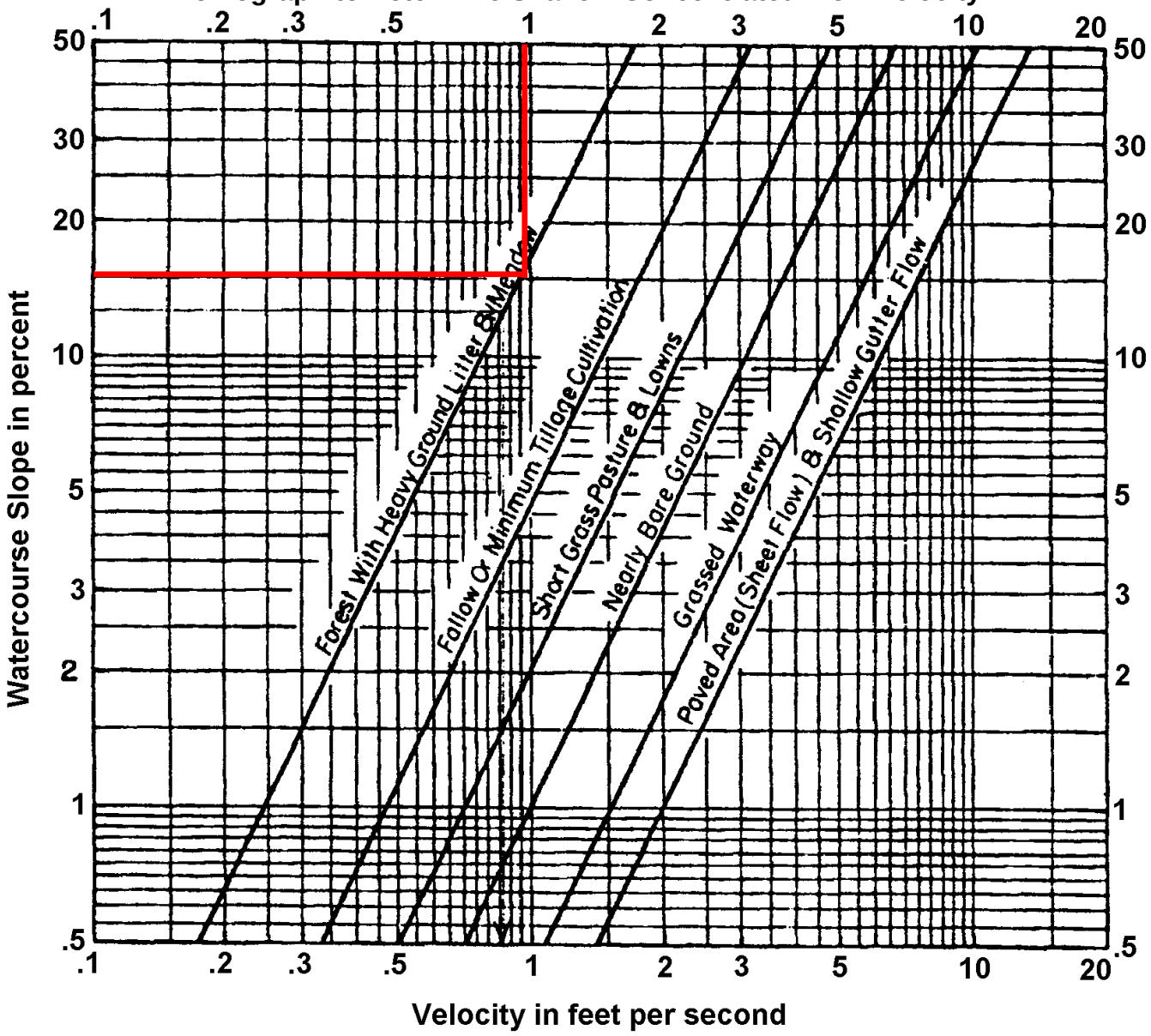
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.81_9

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

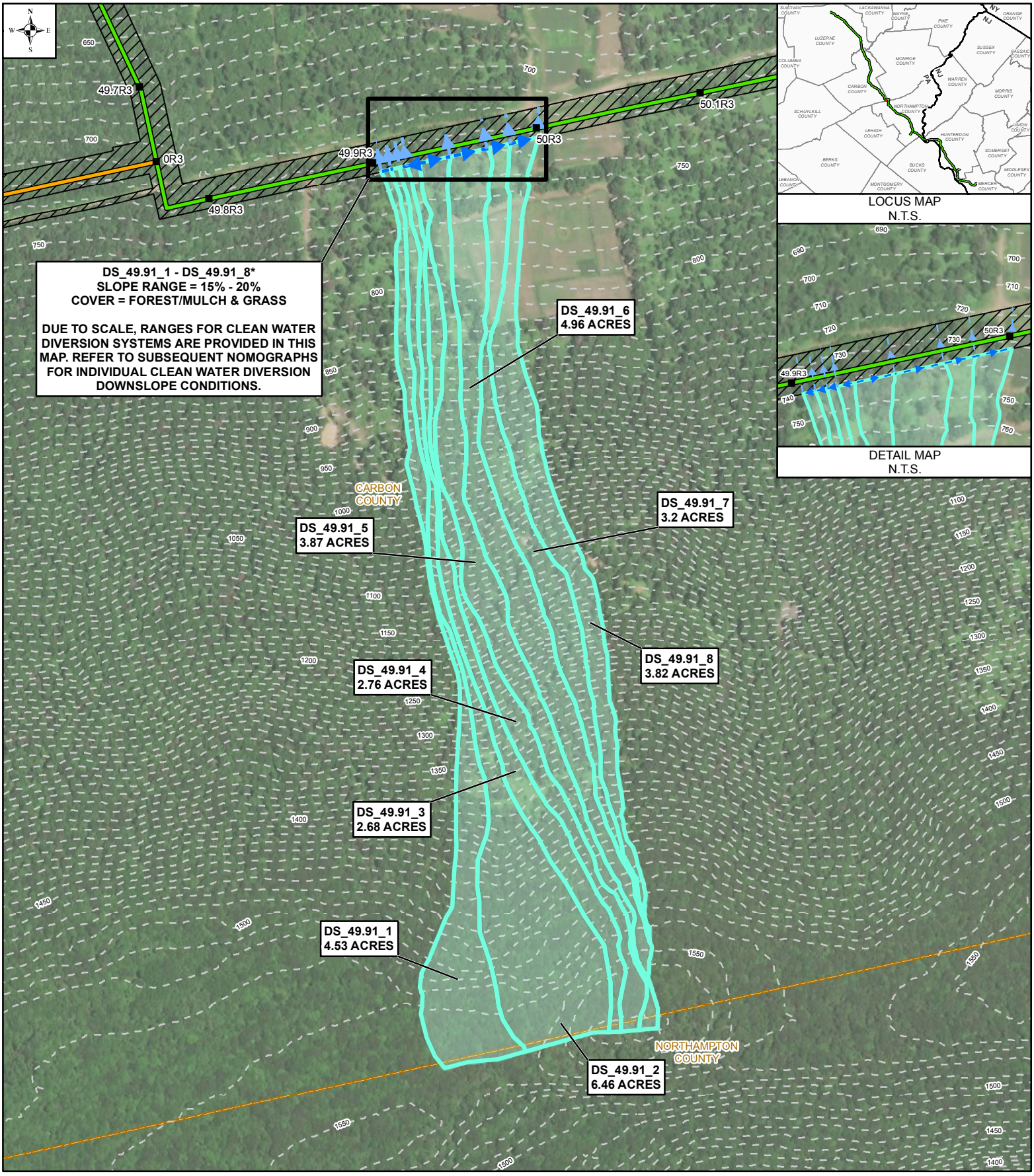


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_49.91

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 400 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 55 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.91_1
4.53 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.91_1	100	0.8	0.020	16.00

$$T_{c\,(sheet\ flow)} = \left[\frac{2(L)(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.91_1	2807	FOREST	0.270	1.31	35.78

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
51.78

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.91_1	1	FOREST	0.20	4.53	0.91	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.91_1	51.78	1.54	1.91	2.27	1.54	1.91	2.27

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.91_1	0.20	1.54	4.53	1.40	1.73	2.06

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.91_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.53		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.73		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.37		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.13		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.06 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.06		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.03		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.76		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

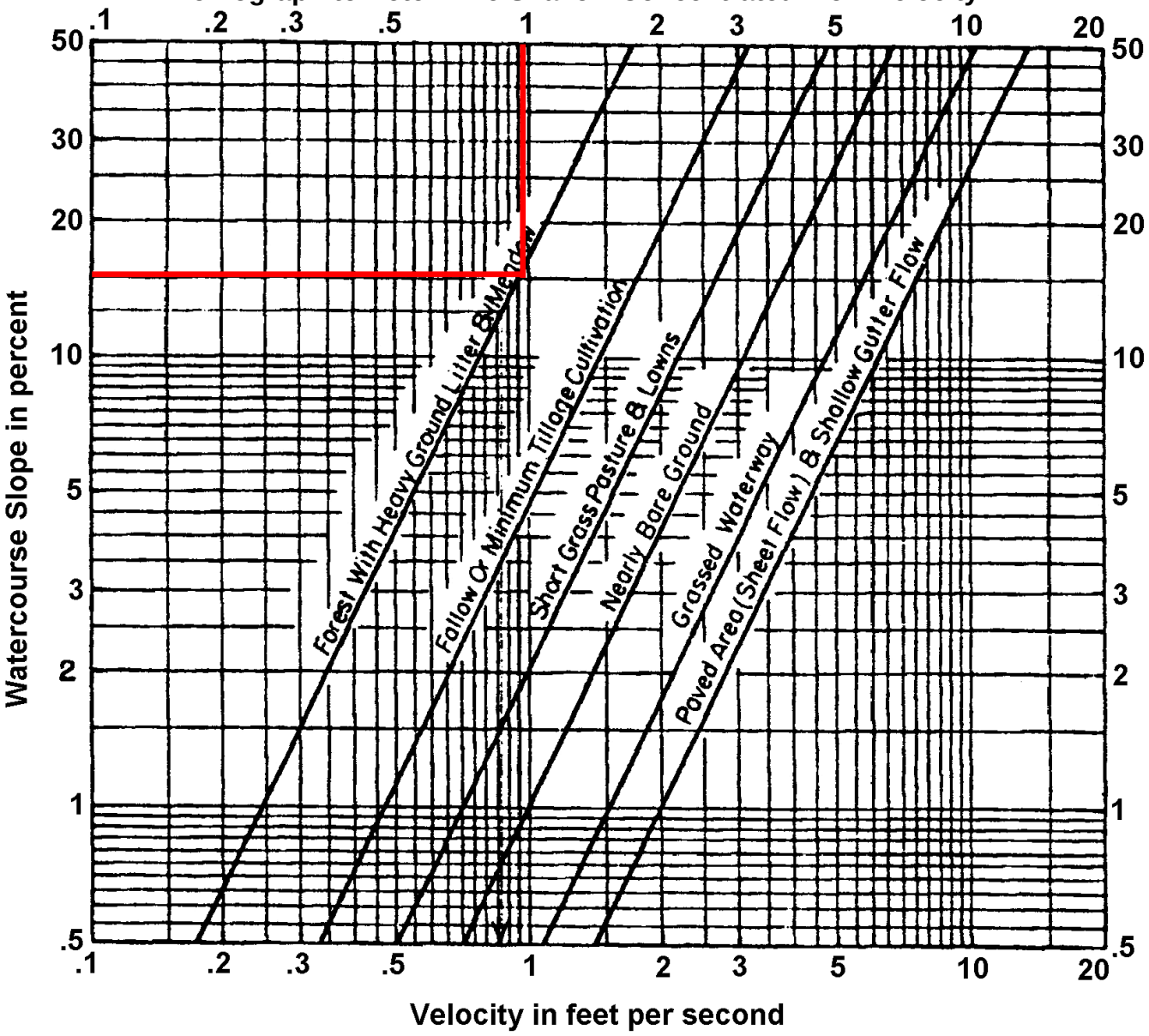
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2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.91_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.91_2
6.46 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.91_2	100	0.8	0.040	13.60

$$T_{c(sheet\ flow)} = \left[\frac{2(L)(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.91_2	2763	FOREST	0.280	1.33	34.59

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
48.19

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.91_2	1	FOREST	0.20	6.46	1.29	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.91_2	48.19	1.63	2.01	2.39	1.63	2.01	2.39

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.91_2	0.20	1.63	6.46	2.10	2.60	3.09

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.91_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	6.46		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.6		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.57		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.52		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.09		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.33 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.16		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.79		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.035		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

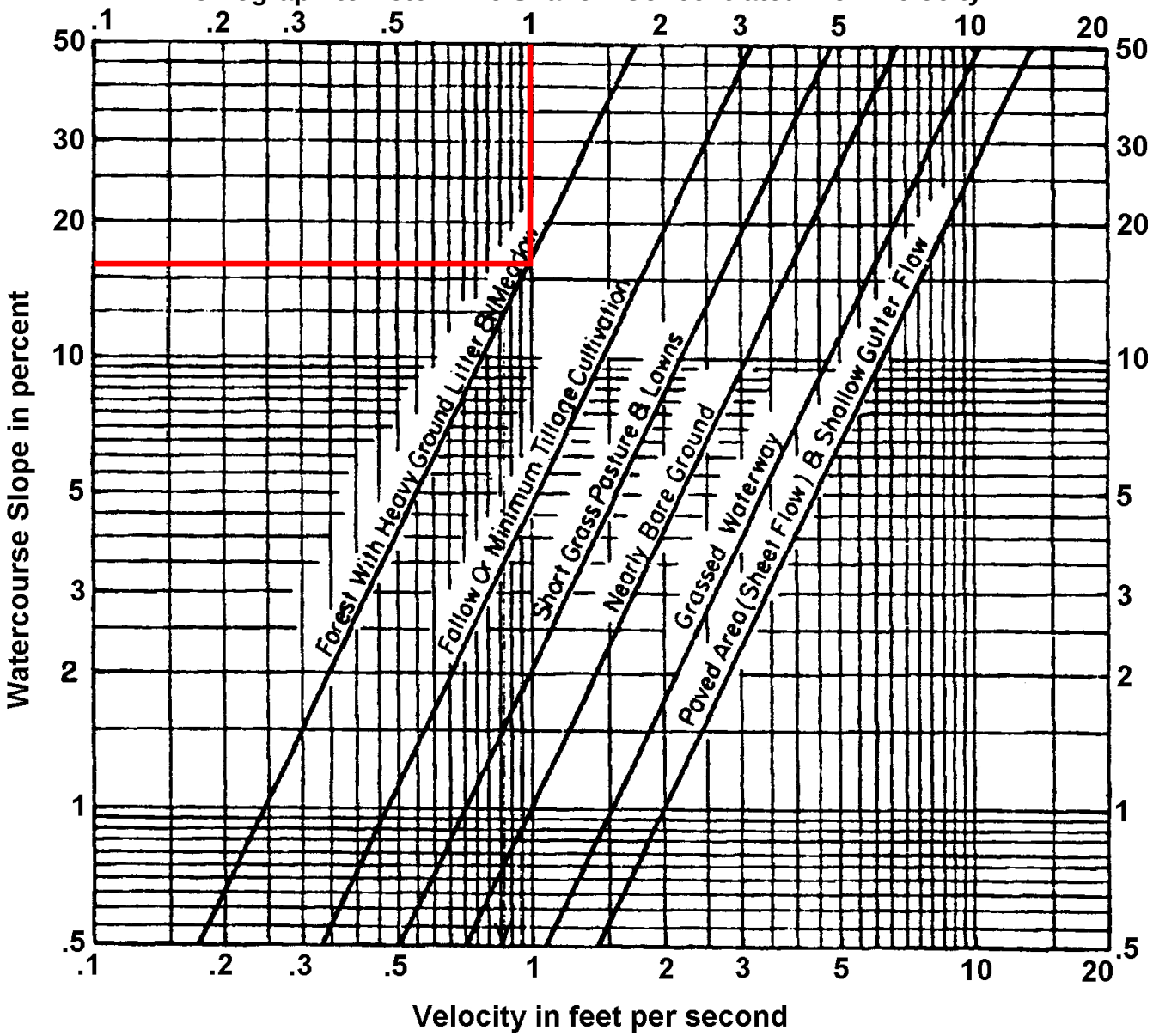
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.91_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.91_3
2.68 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.91_3	100	0.8	0.040	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.91_3	2782	FOREST	0.280	1.33	34.83

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
48.43

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.91_3	1	FOREST	0.20	2.68	0.54	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.91_3	48.43	1.62	2.00	2.38	1.62	2.00	2.38

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.91_3	0.20	1.62	2.68	0.87	1.07	1.28

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.91_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.68		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.07		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.51		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.93		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.25 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.25		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.78		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.086		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.112		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

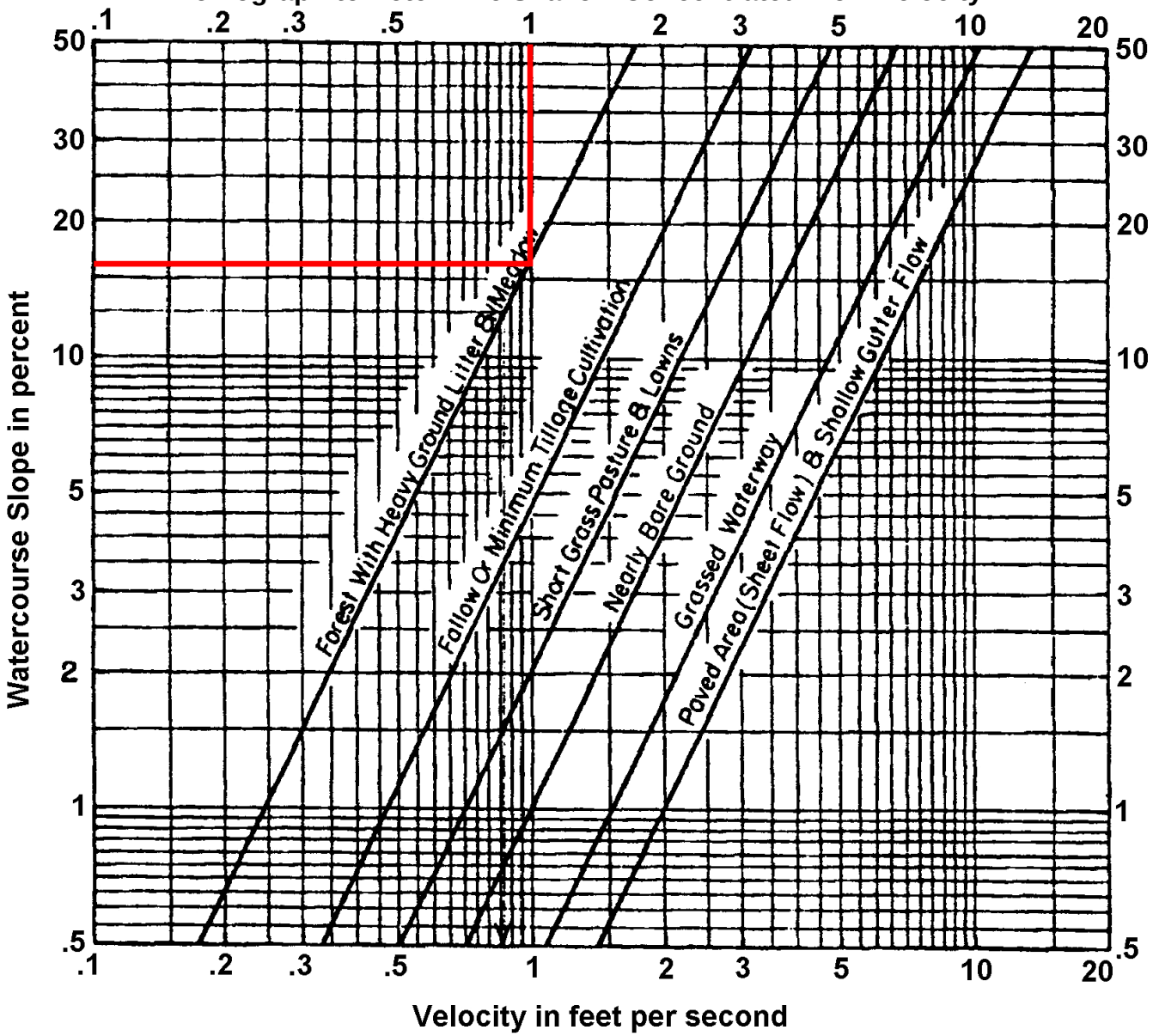
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.91_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.91_4
2.76 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.91_4	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.91_4	2817	FOREST	0.280	1.33	35.27

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
49.81

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.91_4	1	FOREST	0.20	2.76	0.55	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.91_4	49.81	1.59	1.96	2.33	1.59	1.96	2.33

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.91_4	0.20	1.59	2.76	0.88	1.08	1.29

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.91_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.76		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.08		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.14		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.46		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.25 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.25		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.78		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.023		
S_C (CRITICAL SLOPE)	(FT/FT)	0.086		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.112		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

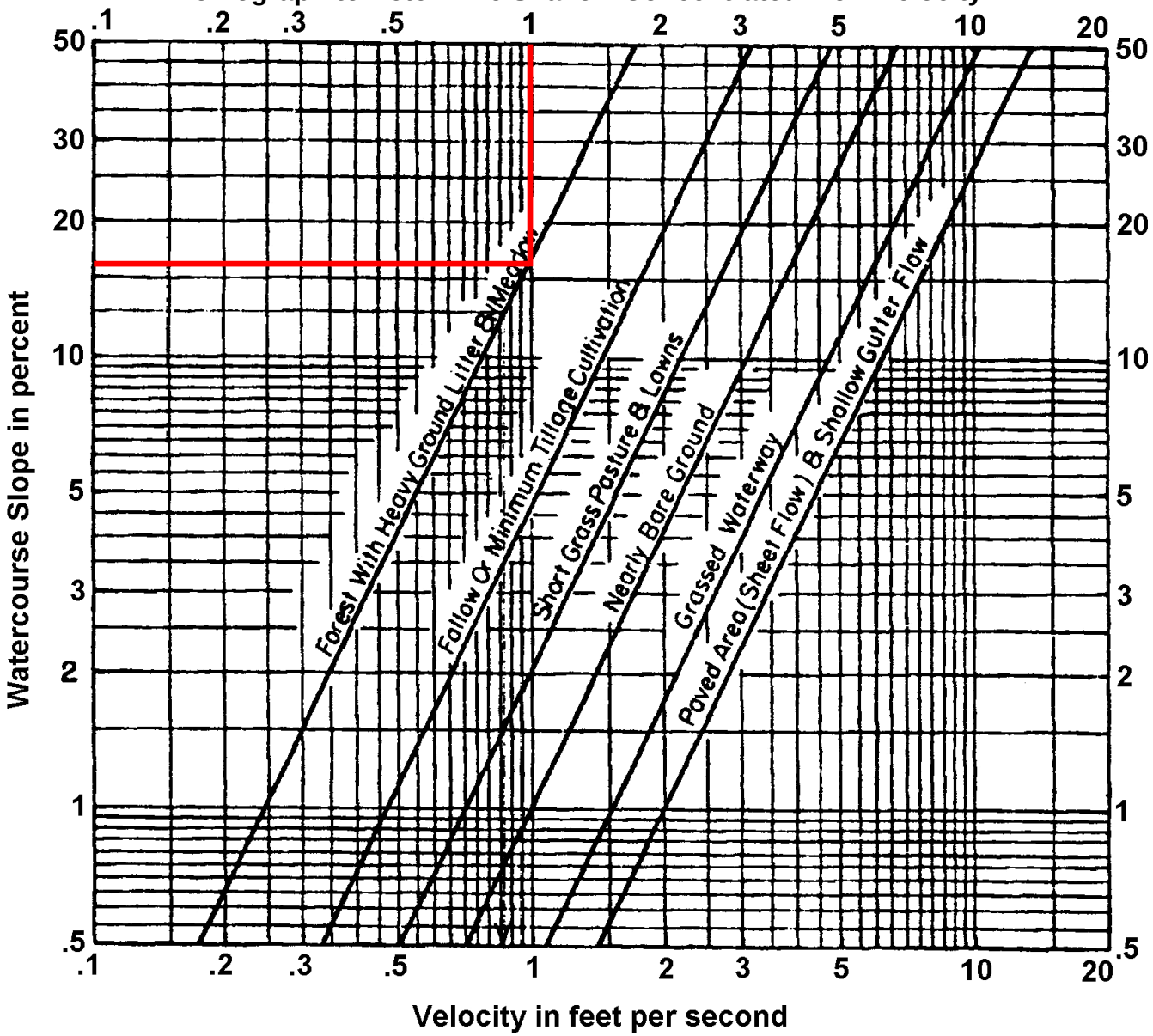
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.91_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.91_5
3.87 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.91_5	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.91_5	2817	FOREST	0.280	1.33	35.27

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
49.81

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.91_5	1	FOREST	0.20	3.87	0.77	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.91_5	49.81	1.59	1.96	2.33	1.59	1.96	2.33

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.91_5	0.20	1.59	3.87	1.23	1.52	1.81

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.91_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.87		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.52		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.92		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.44		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.8 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.80		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.40		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.85		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

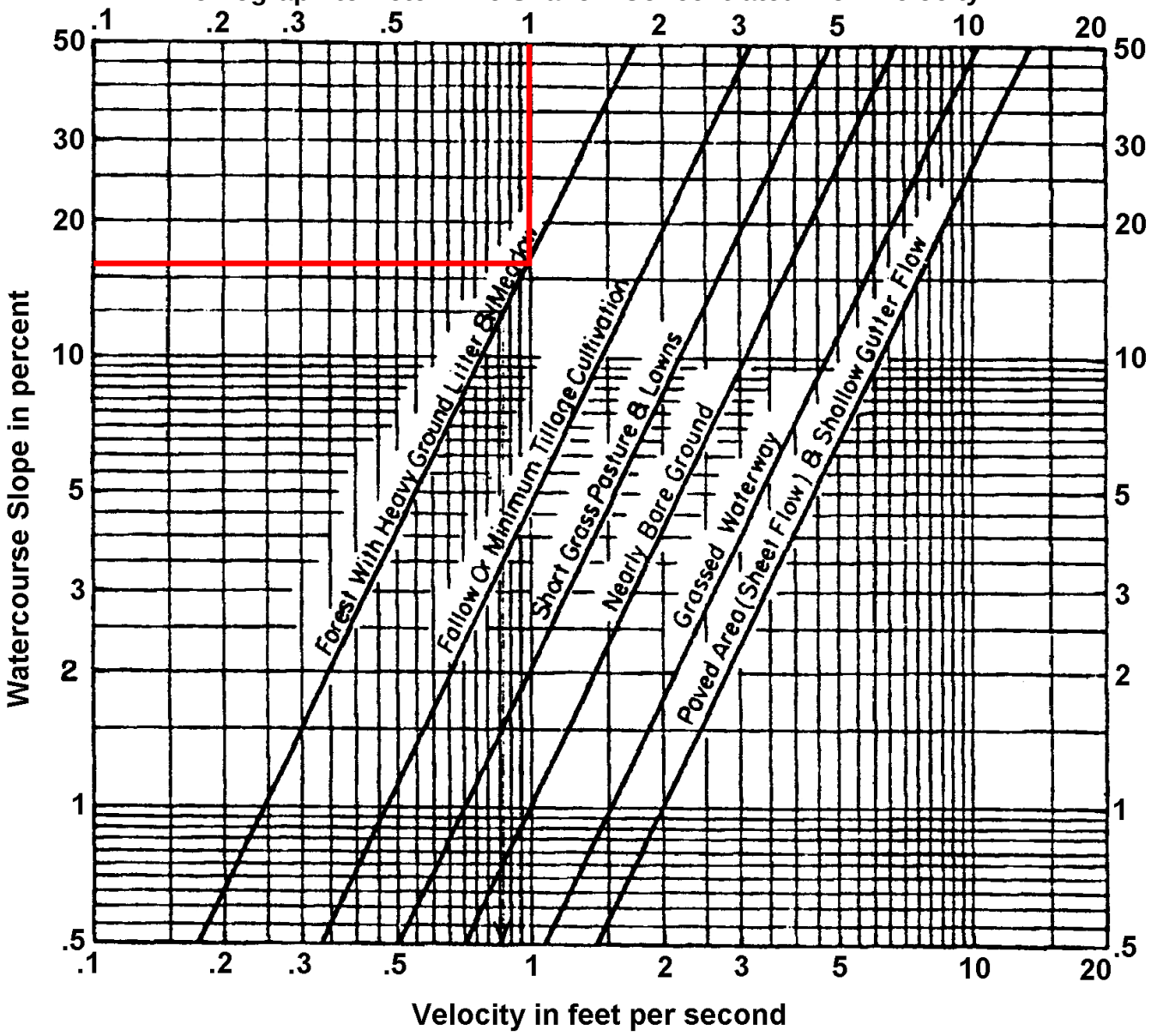
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.91_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.91_6
4.96 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS_49.91_6	100	0.8	0.170	9.70

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS_49.91_6	2631	FOREST	0.310	1.40	31.30

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
41.00

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS_49.91_6	1	FOREST	0.20	4.96	0.99	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
DS_49.91_6	41.00	1.83	2.25	2.66	1.83	2.25	2.66

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
DS_49.91_6	0.20	1.83	4.96	1.81	2.23	2.63

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.91_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.96		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.23		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.62		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.16		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.62 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.62		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.31		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.83		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.5		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

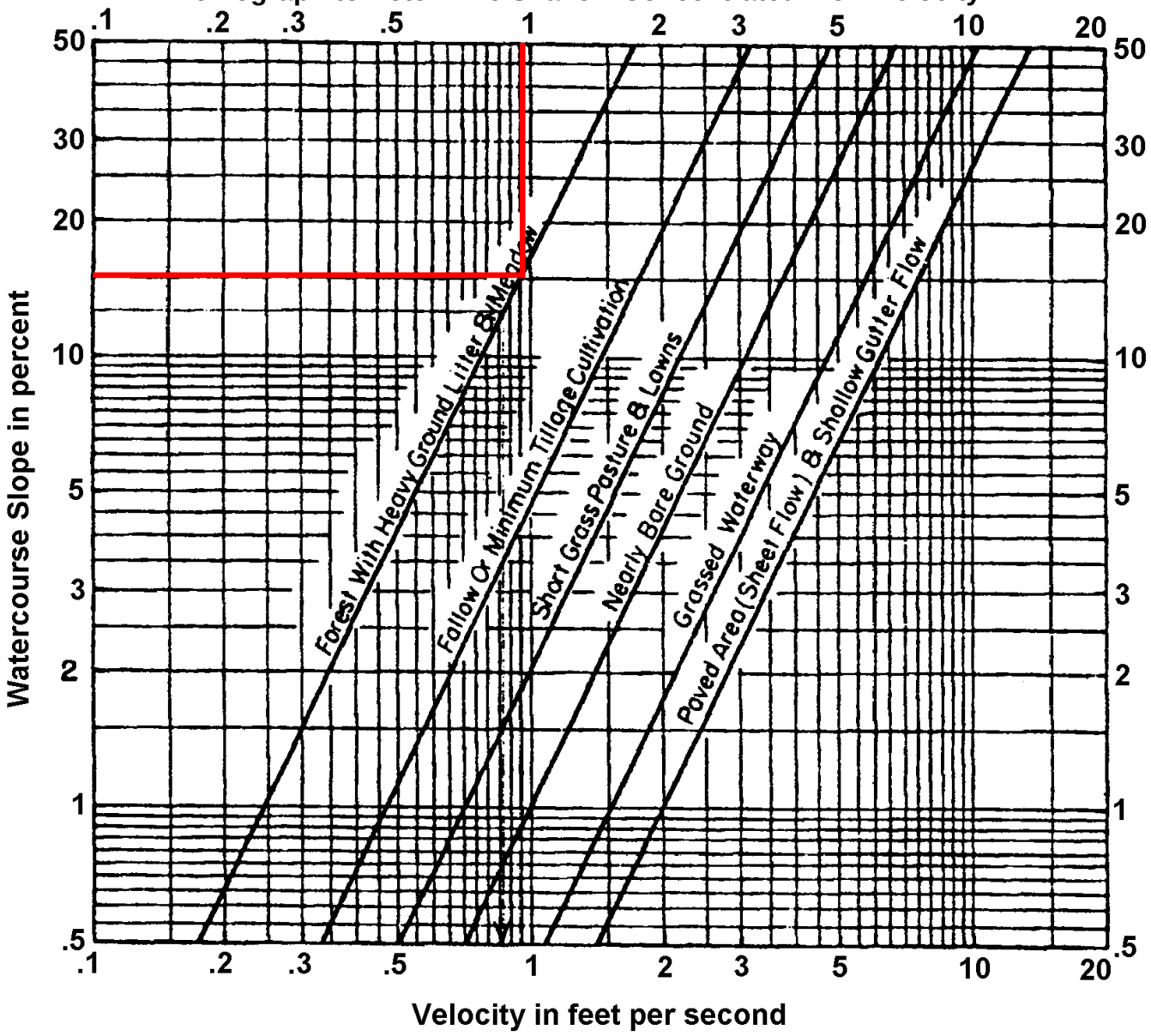
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.91_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.91_7
3.2 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 49.91_7	100	0.8	0.200	9.34

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 49.91_7	2537	FOREST	0.314	1.41	30.00

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
39.34

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 49.91_7	1	FOREST	0.20	3.20	0.64	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	39.34	1.88	2.31	2.73	1.88	2.31	2.73

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.31	3.20	1.20	1.48	1.74

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.91_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.2		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.60		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.59		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	8.06 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	8.06		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	4.03		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.01		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.026		
S_C (CRITICAL SLOPE)	(FT/FT)	0.082		
$.7S_c$	(FT/FT)	0.058		
$1.3S_c$	(FT/FT)	0.107		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

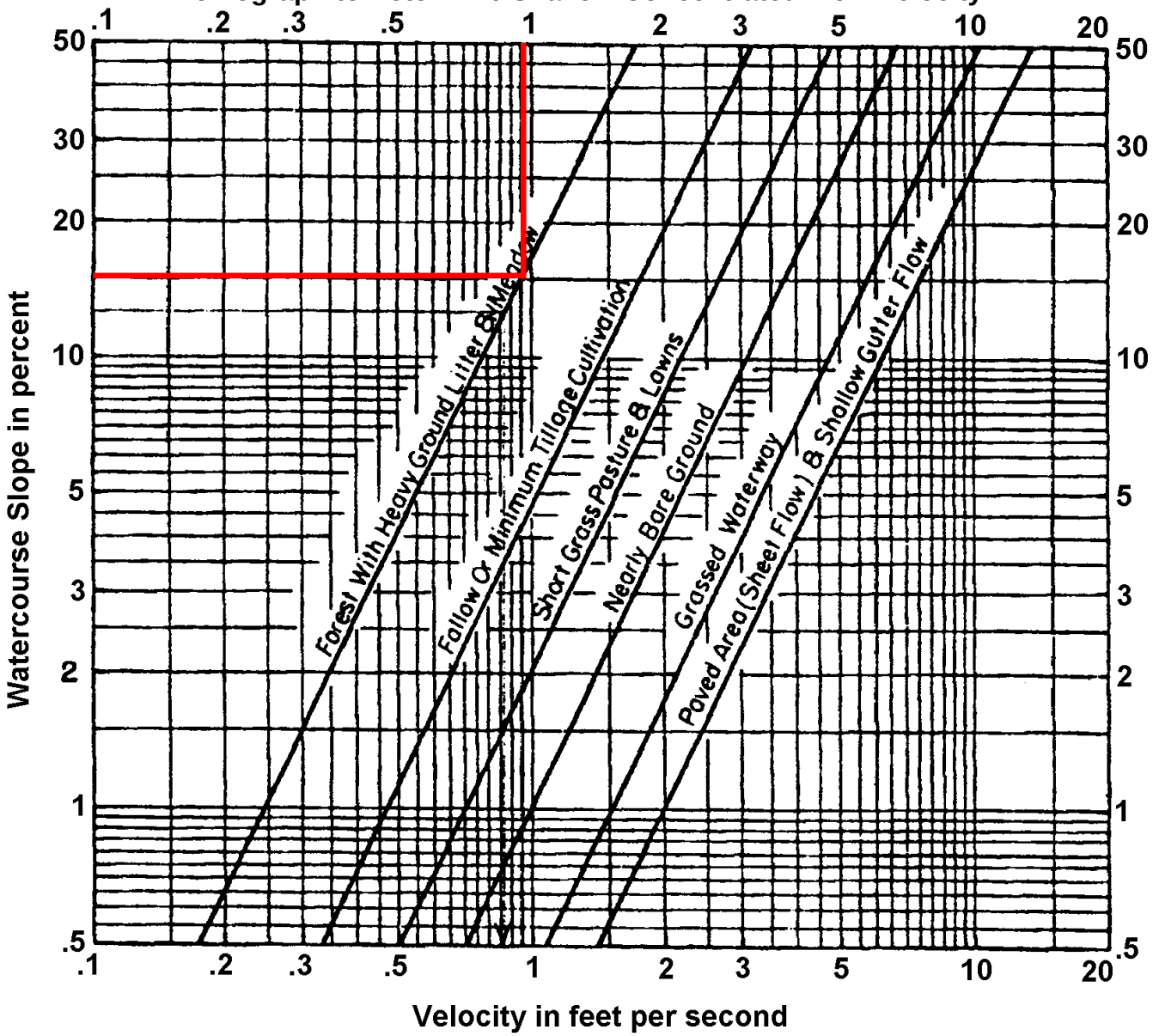
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.91_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_49.91_8
3.82 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 49.91_8	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 49.91_8	2628	FOREST	0.307	1.40	31.40

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
42.38

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 49.91_8	1	FOREST	0.20	3.82	0.76	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	42.38	1.79	2.20	2.60	1.79	2.20	2.60

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.20	3.82	1.36	1.68	1.99

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_49.91_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.82		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.68		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.20		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.56		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.9 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.90		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.45		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.86		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.057		
S_C (CRITICAL SLOPE)	(FT/FT)	0.070		
$.7S_c$	(FT/FT)	0.049		
$1.3S_c$	(FT/FT)	0.091		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

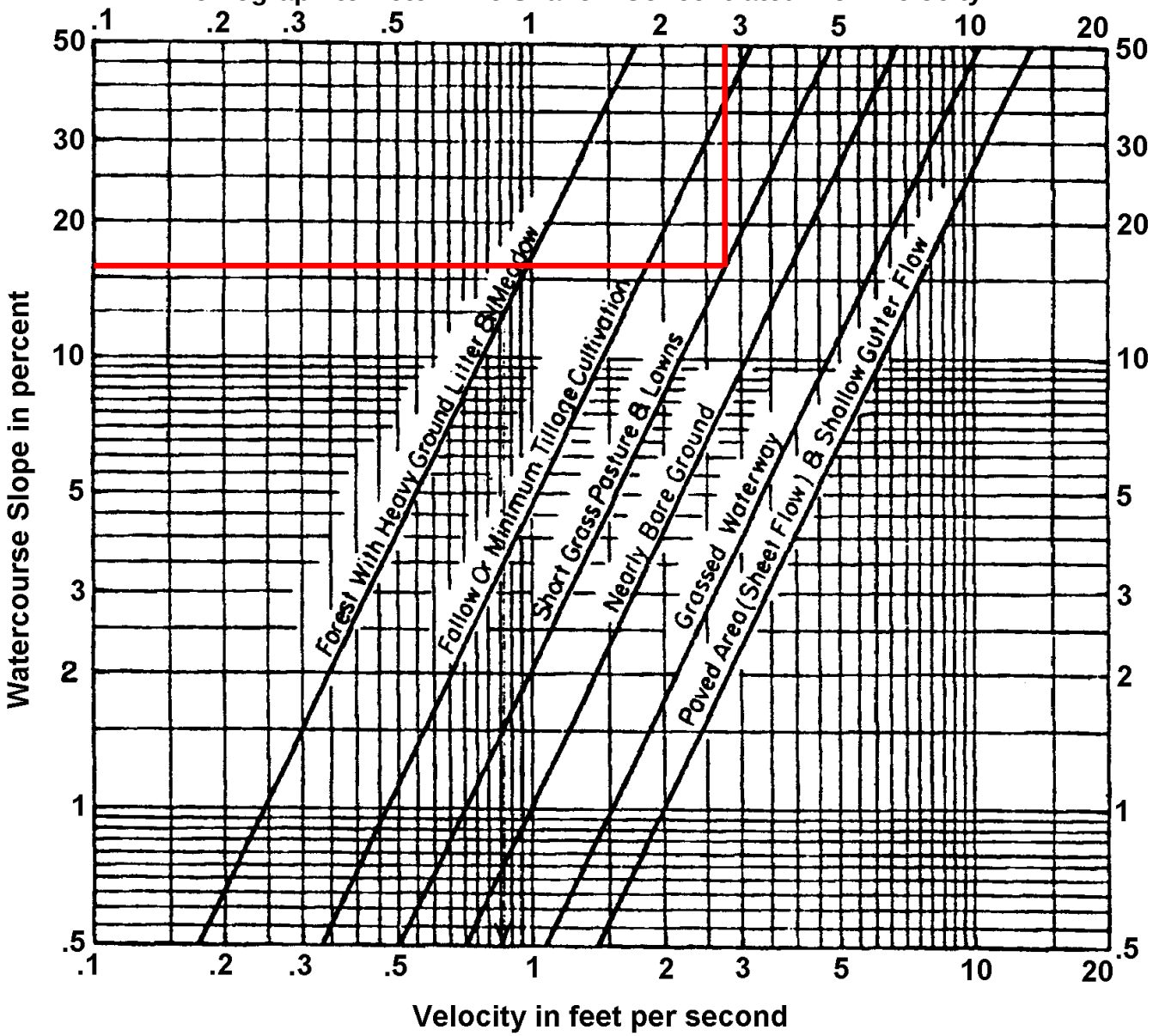
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_49.91_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

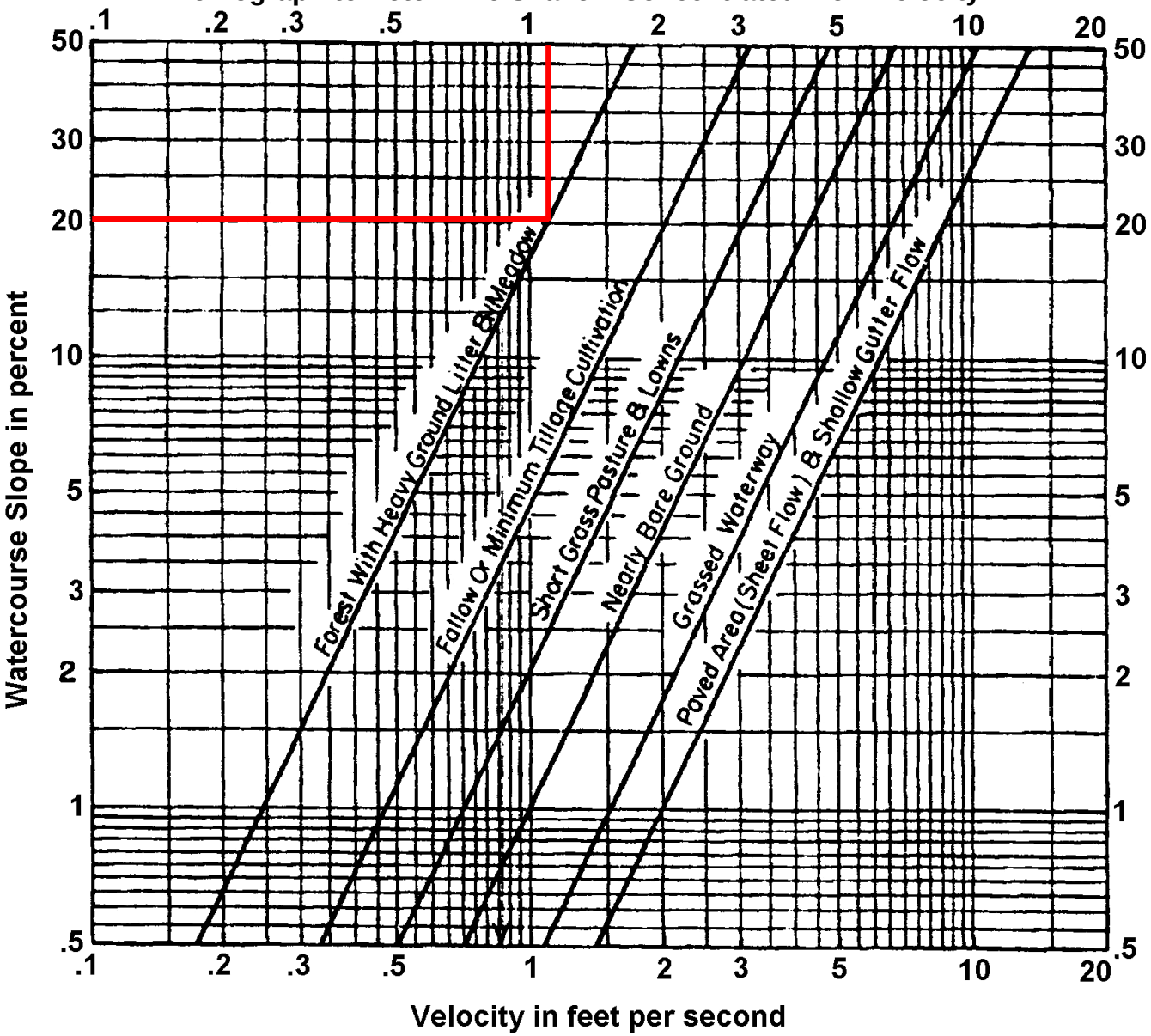
2.8 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION ID:
DS_49.91_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

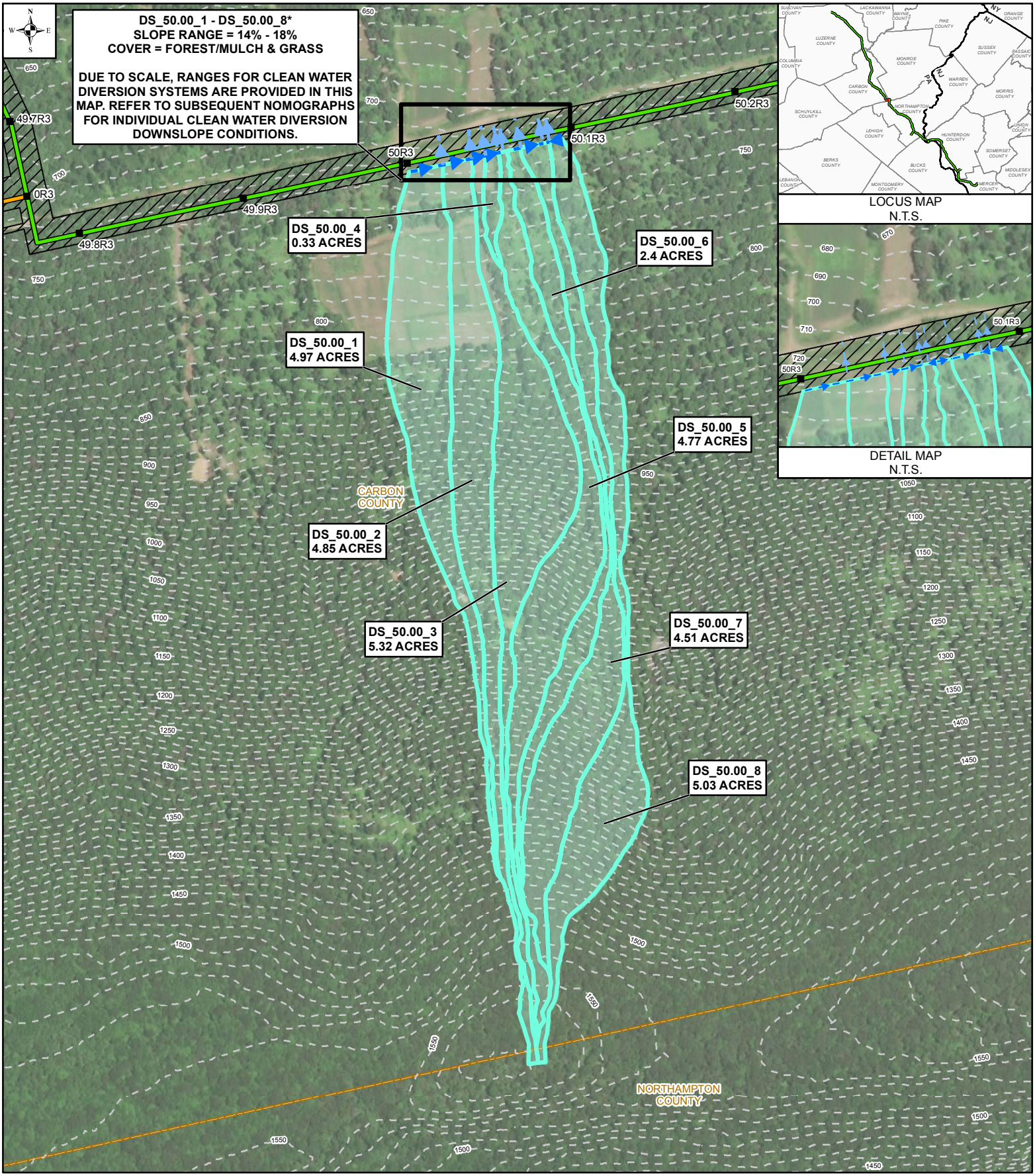


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 20%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.00

CARBON COUNTY, PENNSYLVANIA

0 200 400 FEET

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

PennEast PIPELINE

DWG NO: PAGE 56 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.00_1
4.97 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.00_1	100	0.8	0.320	8.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.00_1	2307	FOREST	0.326	1.44	26.77

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
35.14

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.00_1	1	FOREST	0.20	4.97	0.99	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	35.14	2.03	2.49	2.92	2.03	2.49	2.92

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.49	4.97	2.02	2.48	2.91

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.00_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.97		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.81		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.70		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.84		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.055		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

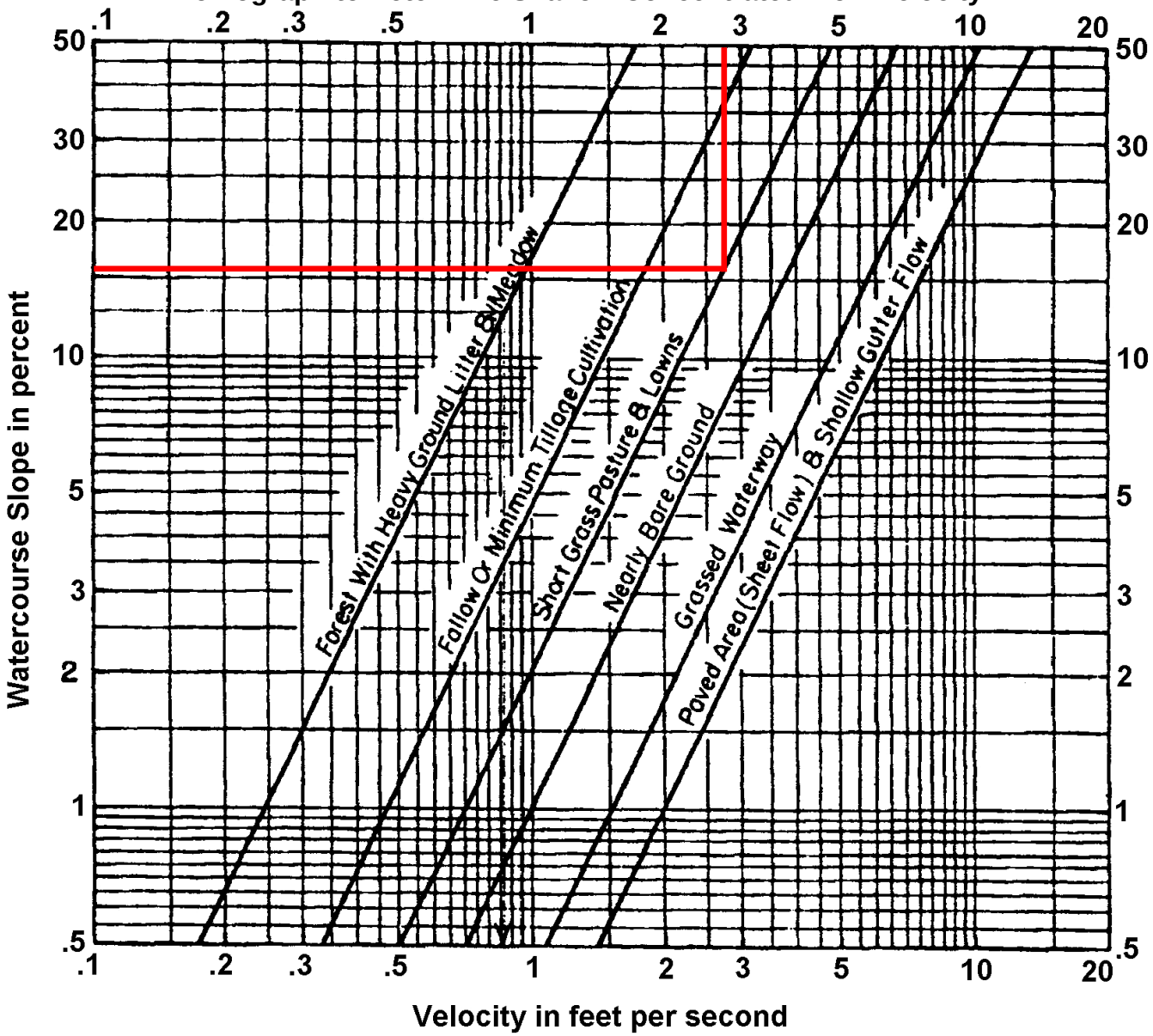
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.00_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

2.8 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.00_2
4.85 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.00_2	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.00_2	2878	FOREST	0.293	1.36	35.20

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
49.75

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.00_2	1	FOREST	0.20	4.85	0.97	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	49.75	1.59	1.96	2.34	1.59	1.96	2.34

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.96	4.85	1.54	1.91	2.27

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.00_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.85		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.91		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.18		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.62		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.69		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.04 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.04		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.52		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.88		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.022		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

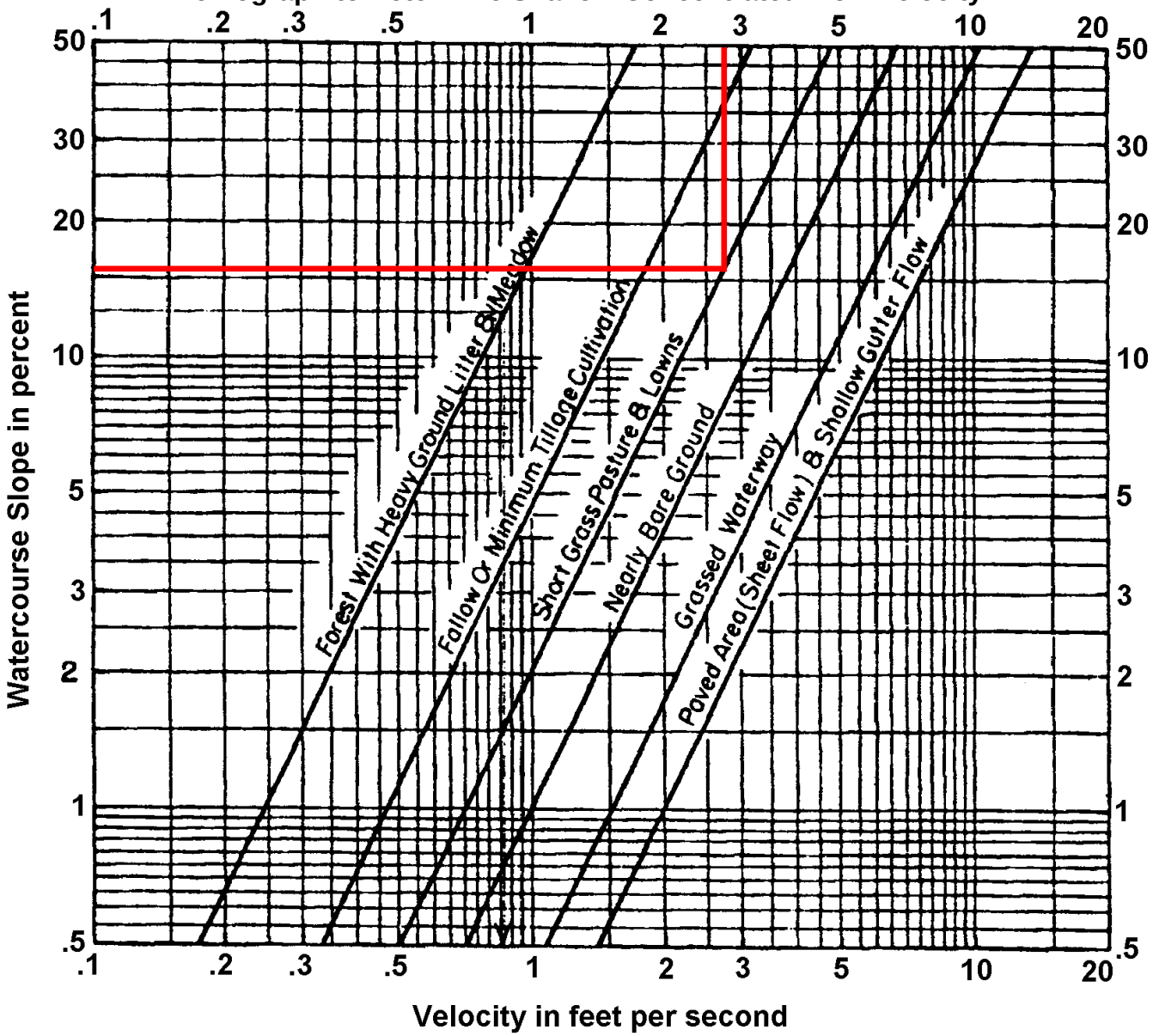
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.00_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

2.8 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.00_3
5.32 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.00_3	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.00_3	2810	FOREST	0.300	1.38	33.98

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.90

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.00_3	1	FOREST	0.20	5.32	1.06	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.90	1.66	2.05	2.43	1.66	2.05	2.43

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.05	5.32	1.76	2.18	2.59

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.00_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.32		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.18		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.89		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.21		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.40		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.52 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.52		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.76		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.94		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.045		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

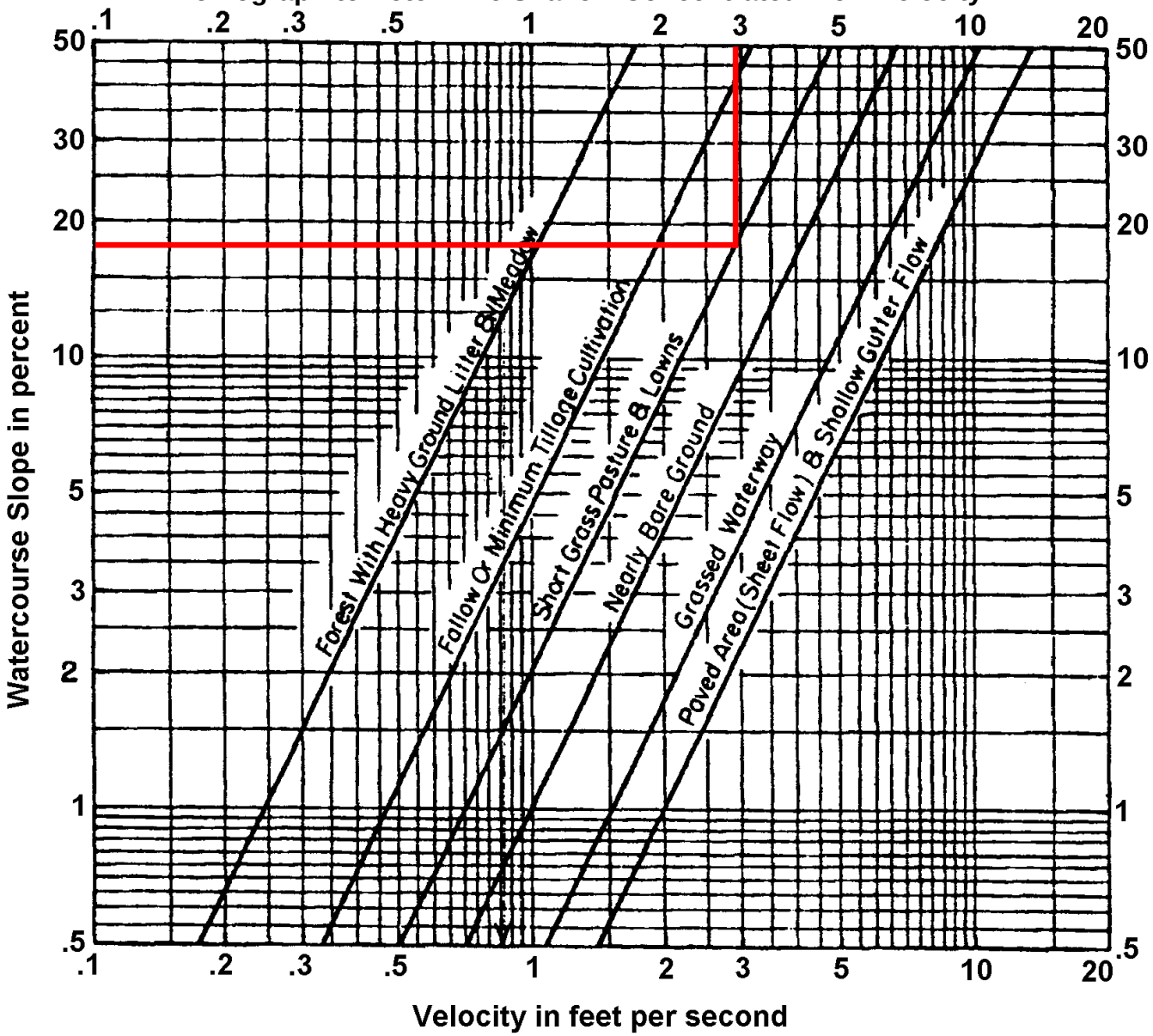
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.00_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = SHORT GRASS PASTURE & LAWNS
PERCENT SLOPE = 18%

SHALLOW CONCENTRATED FLOW VELOCITY = 2.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 4 FPS FOR GRASS COVER TYPES.

2.9 FPS < 4.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.00_4
0.33 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.00_4	100	0.8	0.160	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.00_4	369	FOREST	0.152	0.98	6.27

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
16.11

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.00_4	1	FOREST	0.20	0.33	0.07	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	16.11	3.20	3.84	4.35	3.20	3.84	4.35

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.84	0.33	0.21	0.26	0.29

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.00_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.33		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.26		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.11		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.22		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.3 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.30		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.65		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.91		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.136		
$.7S_c$	(FT/FT)	0.095		
$1.3S_c$	(FT/FT)	0.177		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

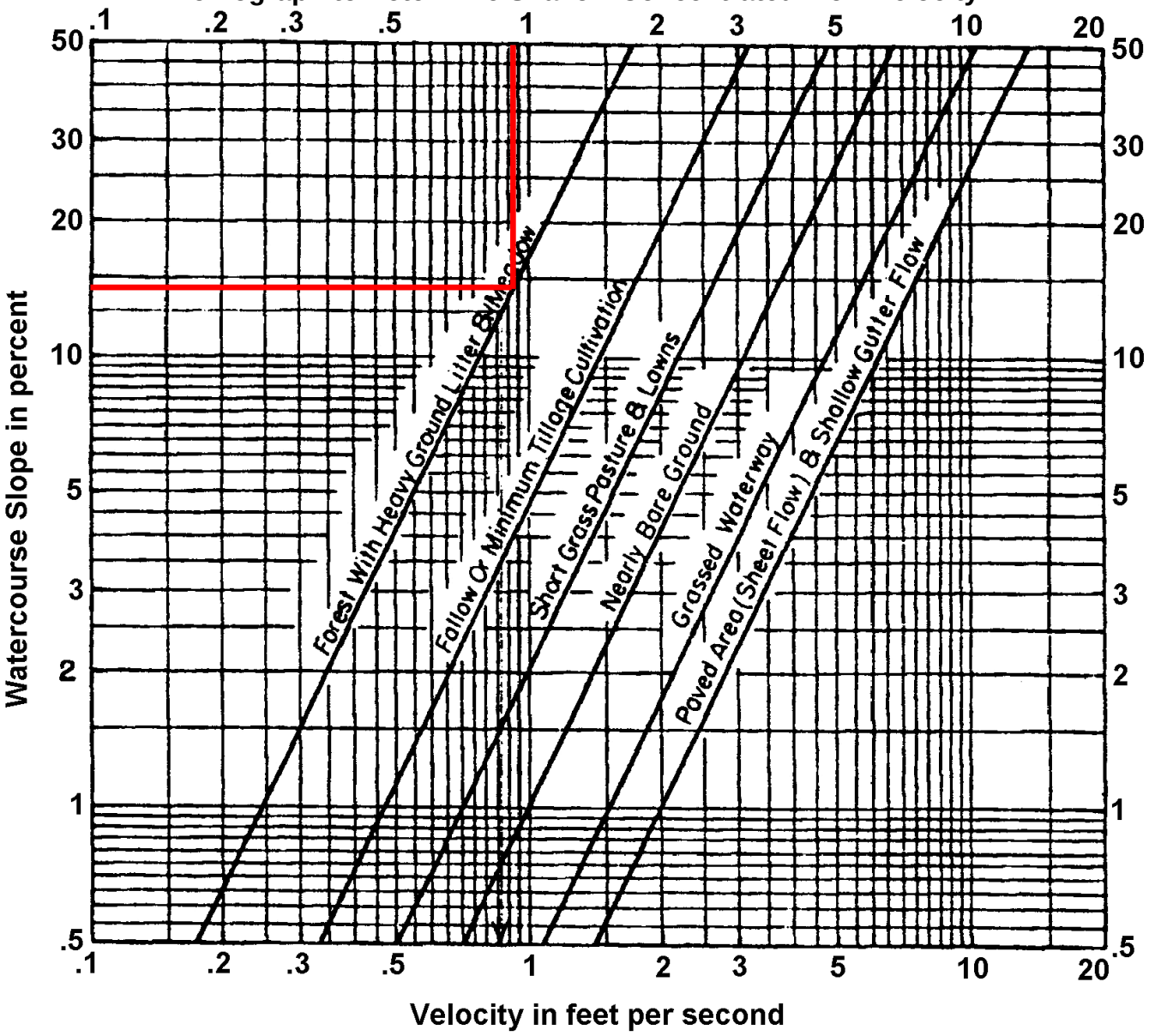
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.00_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.00_5
4.77 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.00_5	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.00_5	2961	FOREST	0.286	1.34	36.70

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
49.61

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.00_5	1	FOREST	0.20	4.77	0.95	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	49.61	1.59	1.97	2.34	1.59	1.97	2.34

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.97	4.77	1.52	1.88	2.24

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.00_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.77		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.88		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.13		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.26		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.94		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.75 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.75		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.88		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.97		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.03		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

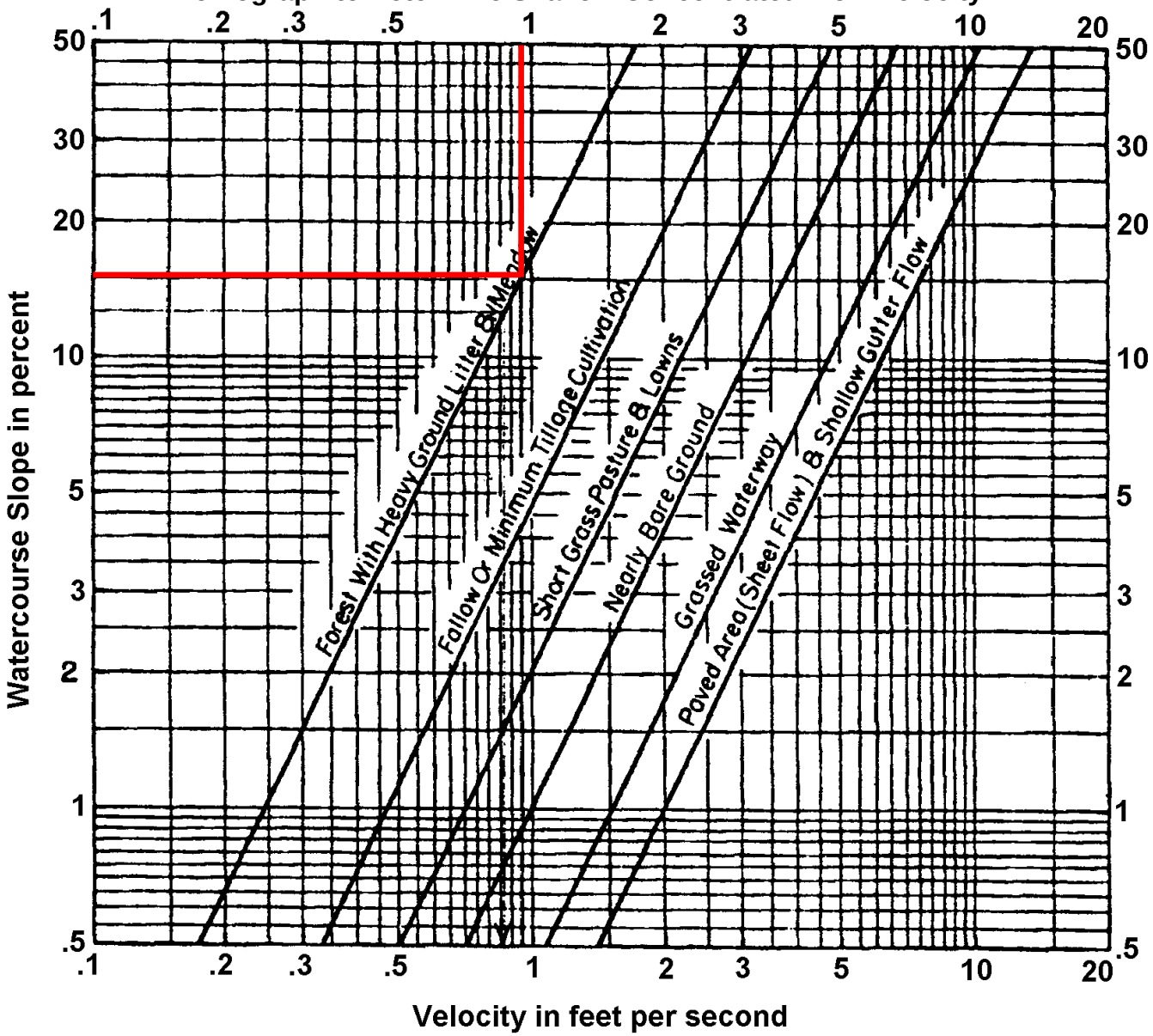
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.00_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.00_6
2.4 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.00_6	100	0.8	0.220	9.13

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.00_6	2452	FOREST	0.314	1.41	28.97

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
38.10

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.00_6	1	FOREST	0.20	2.40	0.48	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	38.10	1.92	2.36	2.78	1.92	2.36	2.78

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.36	2.40	0.92	1.13	1.34

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.00_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.4		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.14		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.10		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.22		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.59		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.58 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.58		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.79		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.95		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.051		
S_C (CRITICAL SLOPE)	(FT/FT)	0.083		
$.7S_c$	(FT/FT)	0.058		
$1.3S_c$	(FT/FT)	0.108		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

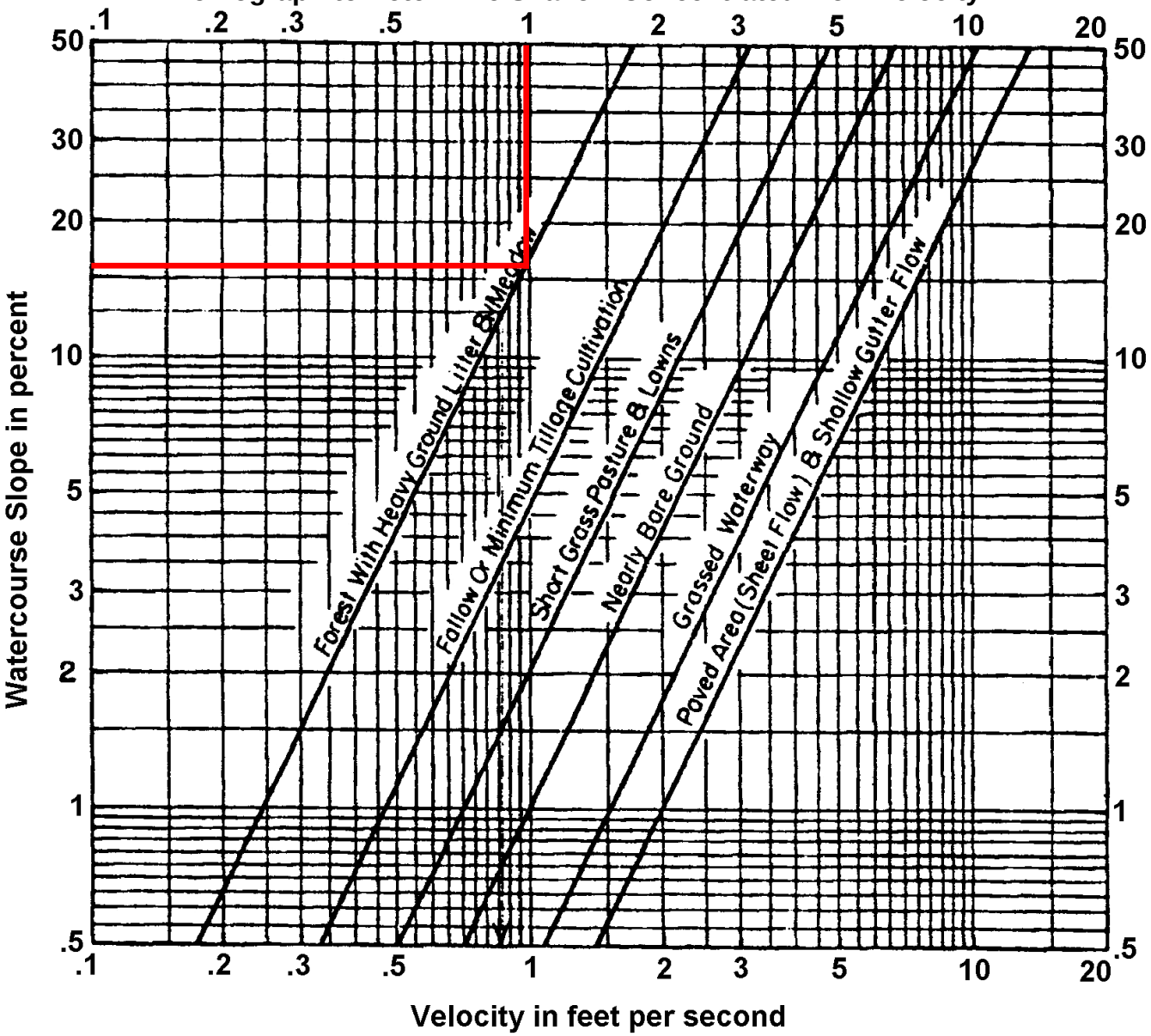
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.00_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.00_7
4.51 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.00_7	100	0.8	0.120	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.00_7	2742	FOREST	0.301	1.38	33.13

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
43.66

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.00_7	1	FOREST	0.20	4.51	0.90	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	43.66	1.75	2.15	2.55	1.75	2.15	2.55

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.15	4.51	1.58	1.95	2.30

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.00_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.51		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.95		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.99		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.53		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.34		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.29 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.29		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.14		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.79		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.011		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

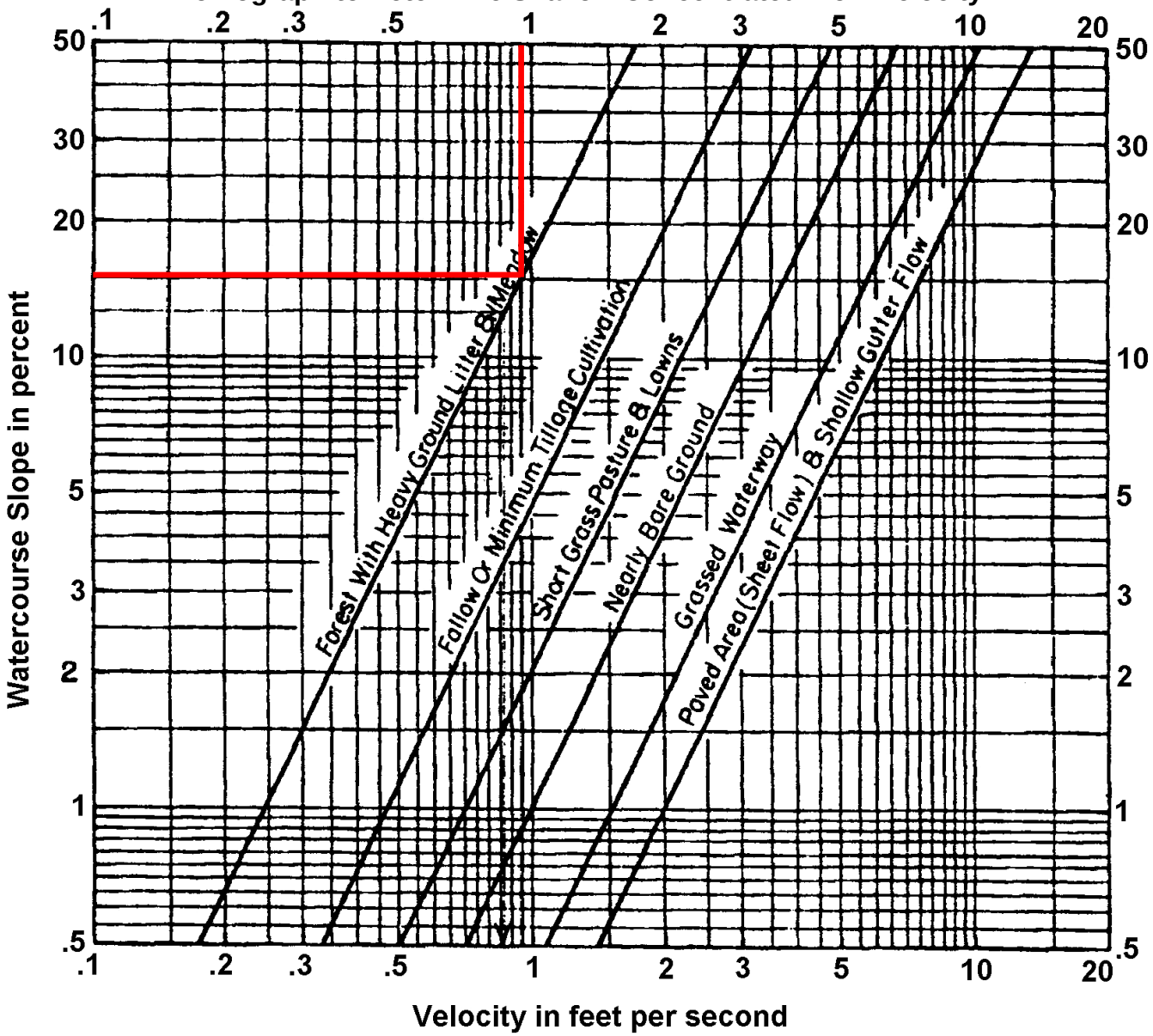
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.00_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.00_8
5.03 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.00_7	100	0.8	0.020	16.00

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.00_7	3003	FOREST	0.282	1.34	37.46

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.45

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.00_7	1	FOREST	0.20	5.03	1.01	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.45	1.50	1.86	2.22	1.50	1.86	2.22

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.86	5.03	1.51	1.87	2.24

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.00_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.03		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.88		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.29		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.85		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.85 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.85		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.42		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.86		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

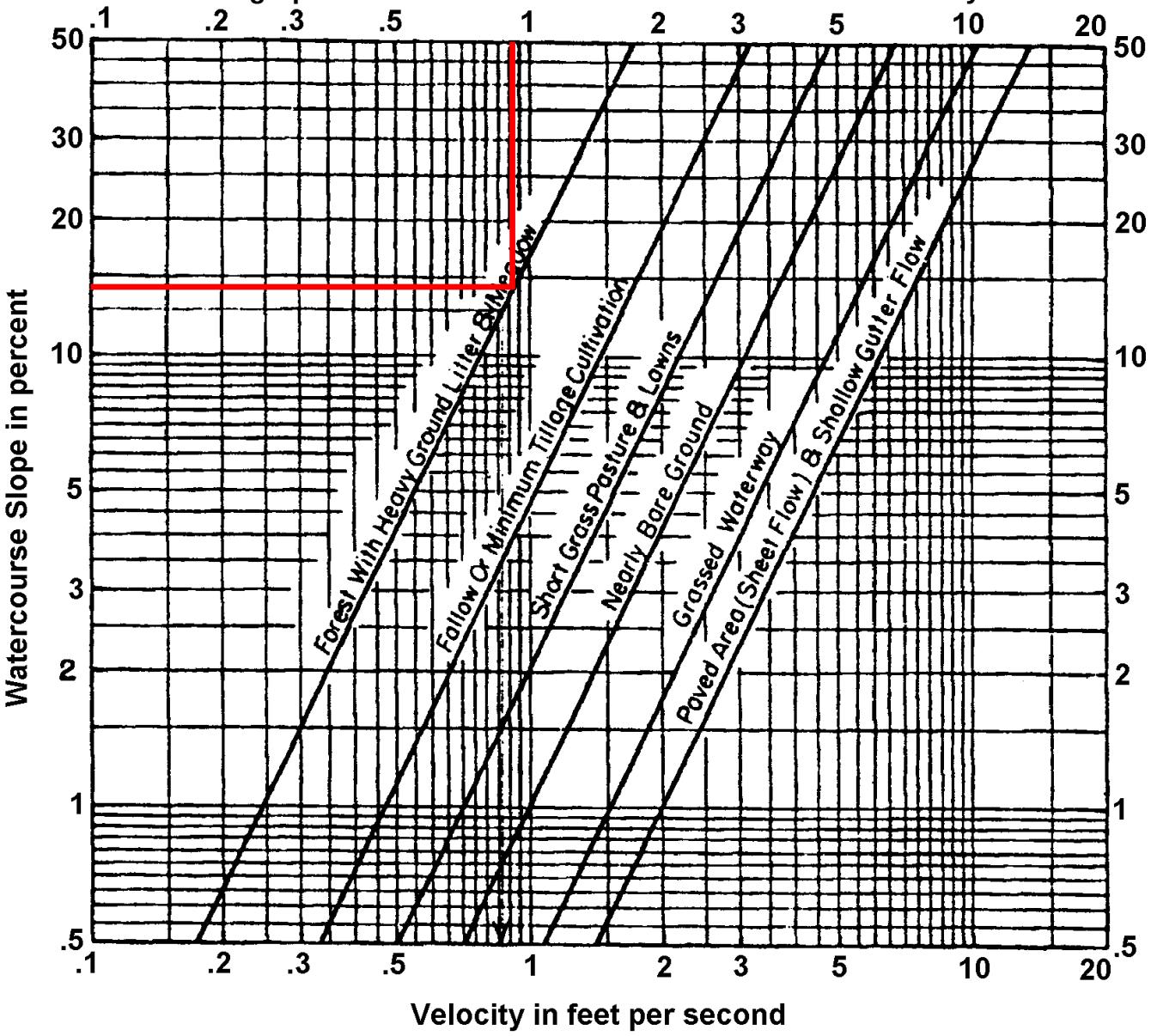
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.00_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

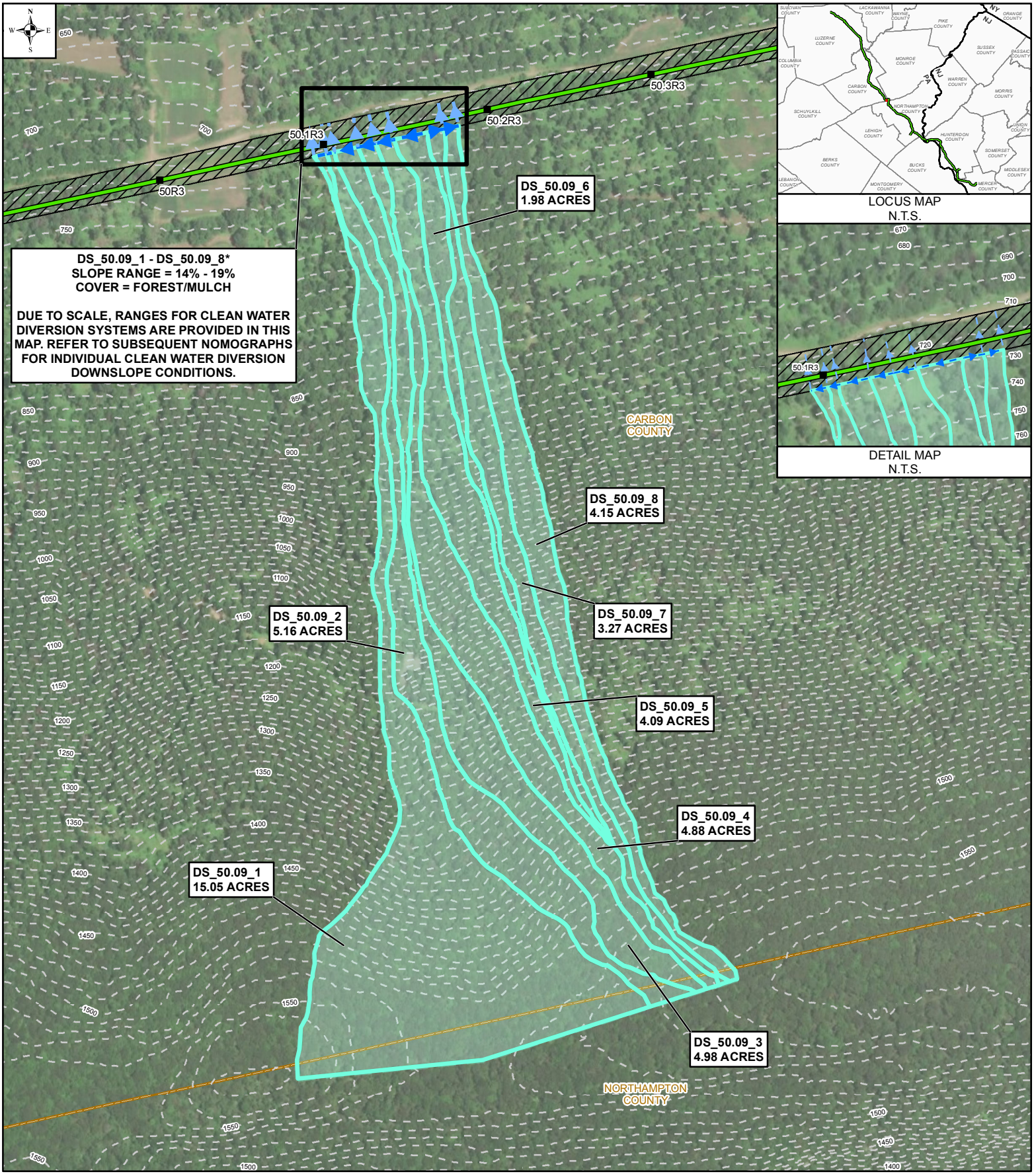


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.09

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 57 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.09_1
15.05 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.09_1	100	0.8	0.020	16.00

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.09_1	3068	FOREST	0.276	1.32	38.68

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
54.67

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.09_1	1	FOREST	0.20	15.05	3.01	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	54.67	1.48	1.83	2.19	1.48	1.83	2.19

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.83	15.05	4.45	5.52	6.59

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.09_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	15.05		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	5.52		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	10.53		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.044		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.06		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.9 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	10.34		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.90		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	3.45		
R (HYDRAULIC RADIUS)		0.43		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.043		
$.7S_c$	(FT/FT)	0.030		
$1.3S_c$	(FT/FT)	0.056		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

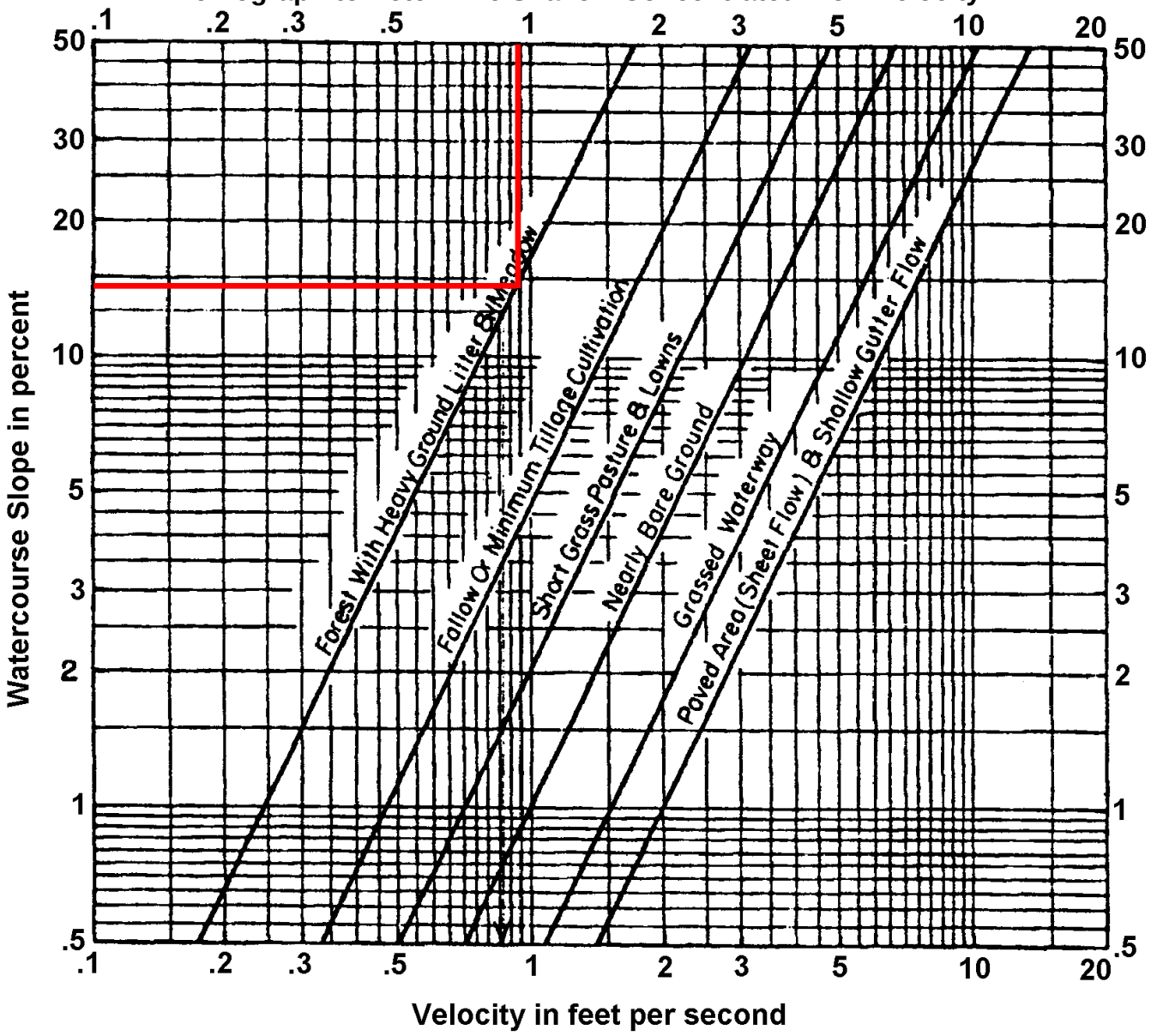
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.09_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.09_2
5.16 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.09_2	100	0.8	0.060	12.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.09_2	3086	FOREST	0.271	1.31	39.28

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
51.65

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.09_2	1	FOREST	0.20	5.16	1.03	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	51.65	1.54	1.91	2.28	1.54	1.91	2.28

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.91	5.16	1.59	1.97	2.35

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.09_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.16		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.97		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.00		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.74		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.19		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.84		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.038		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

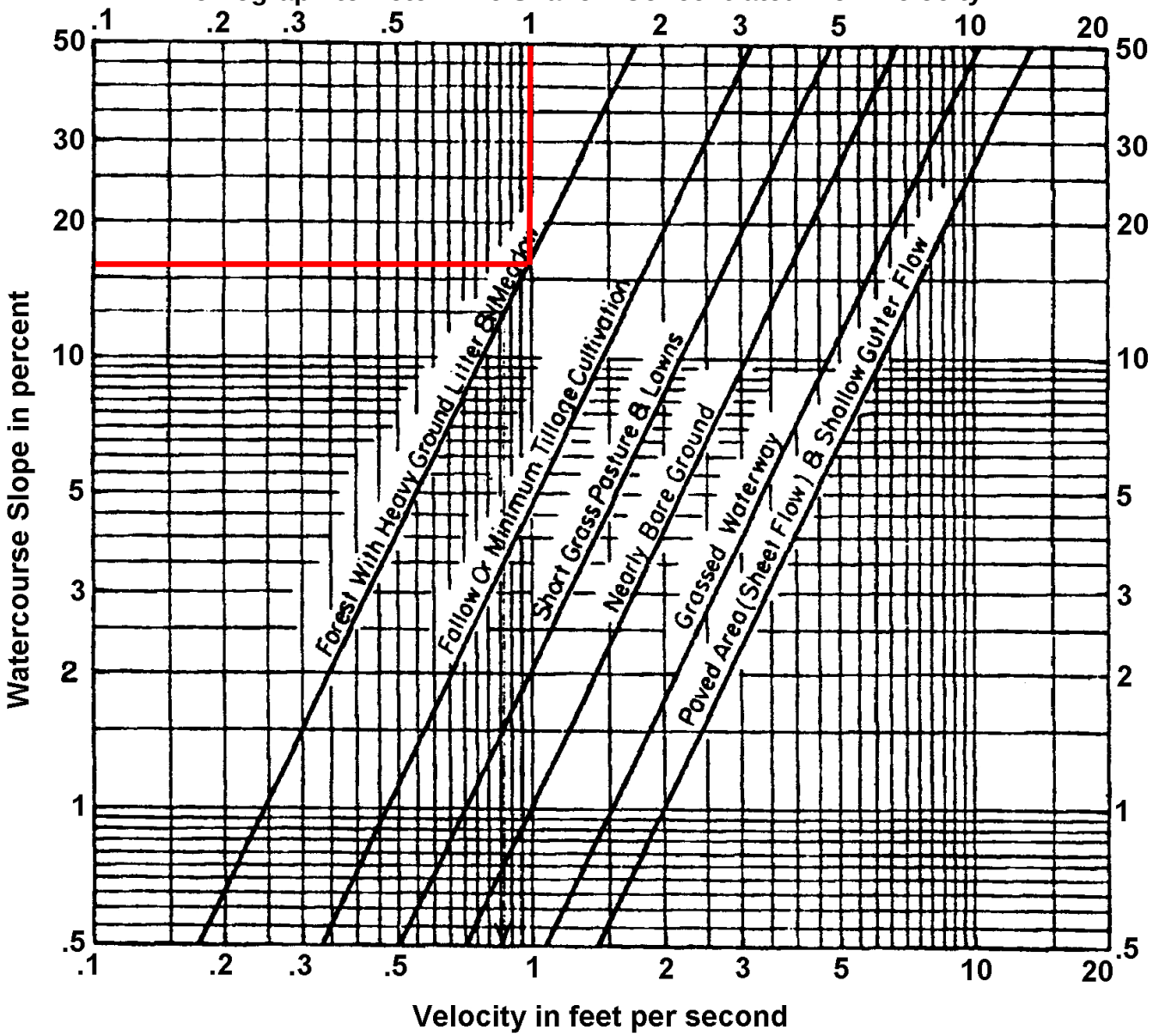
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.09_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.09_3
4.98 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.09_3	100	0.8	0.060	12.37

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.09_3	3098	FOREST	0.272	1.31	39.36

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
51.74

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.09_3	1	FOREST	0.20	4.98	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	51.74	1.54	1.91	2.27	1.54	1.91	2.27

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.91	4.98	1.54	1.90	2.26

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.09_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.98		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.9		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.53		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.01		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.84		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.04 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.04		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.52		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.88		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.027		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

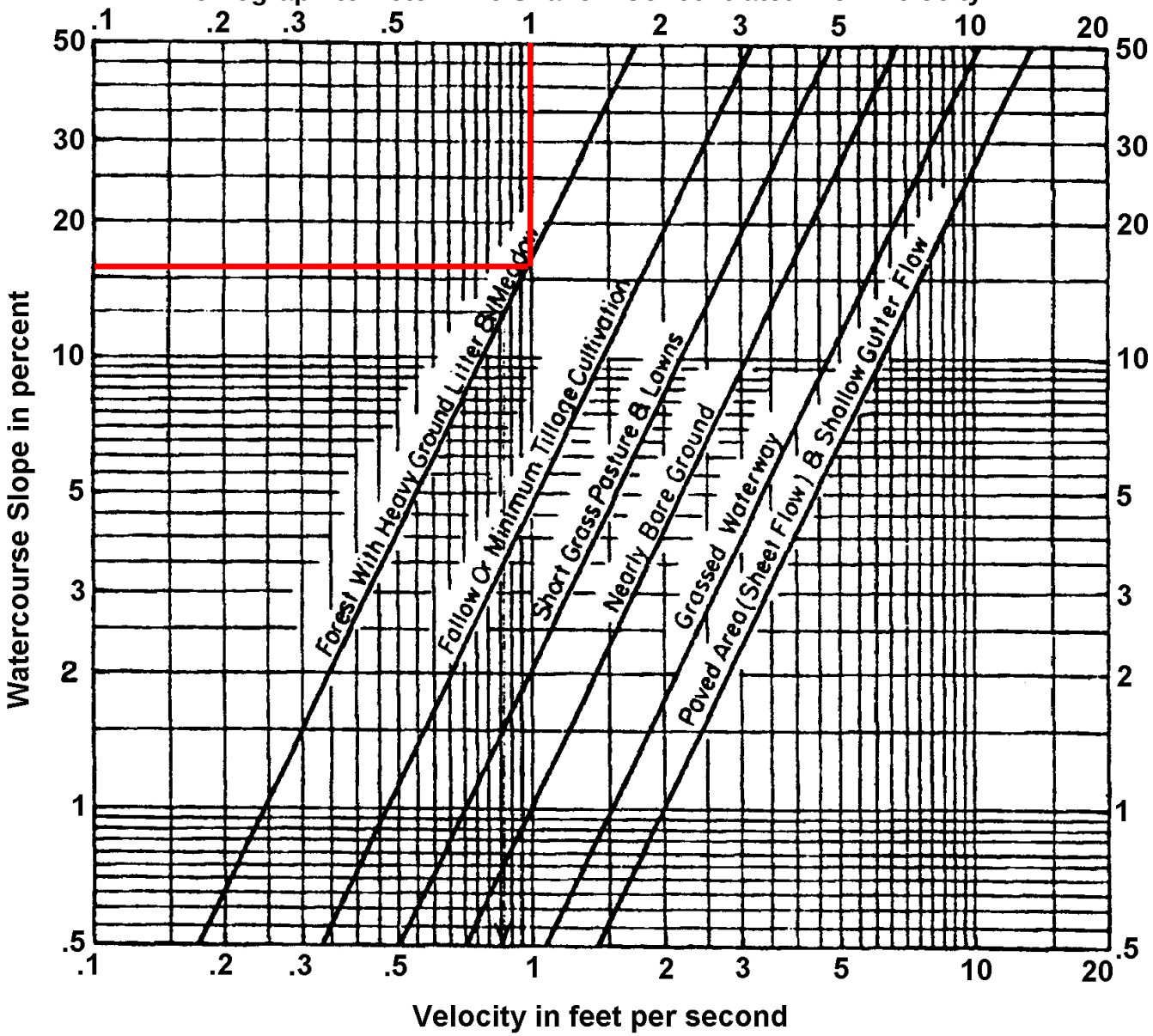
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.09_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.09_4
4.88 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.09_4	100	0.8	0.070	11.94

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.09_4	3011	FOREST	0.280	1.33	37.72

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
49.65

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.09_4	1	FOREST	0.20	4.88	0.98	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	49.65	1.59	1.97	2.34	1.59	1.97	2.34

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.97	4.88	1.55	1.92	2.28

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.09_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.88		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.92		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.56		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.16		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.49 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.49		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.25		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.81		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.5		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

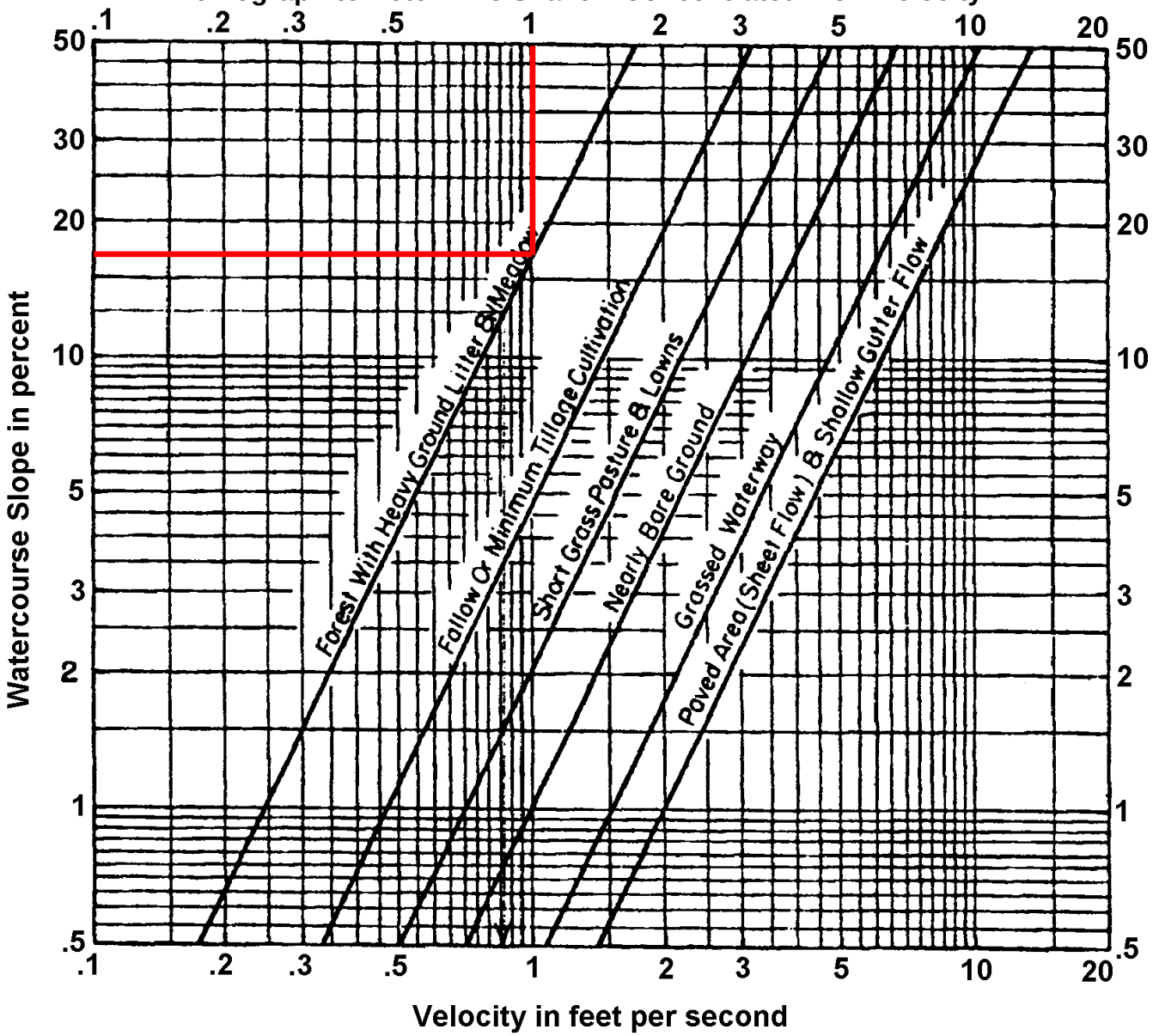
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.09_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 17%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.09_5
4.09 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.09_5	100	0.8	0.360	8.14

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.09_5	2396	FOREST	0.316	1.42	28.22

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
36.36

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.09_5	1	FOREST	0.20	4.09	0.82	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	36.36	1.99	2.44	2.86	1.99	2.44	2.86

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.44	4.09	1.62	1.99	2.34

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.09_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.09		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.99		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.86		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.27		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.50		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.87		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.018		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

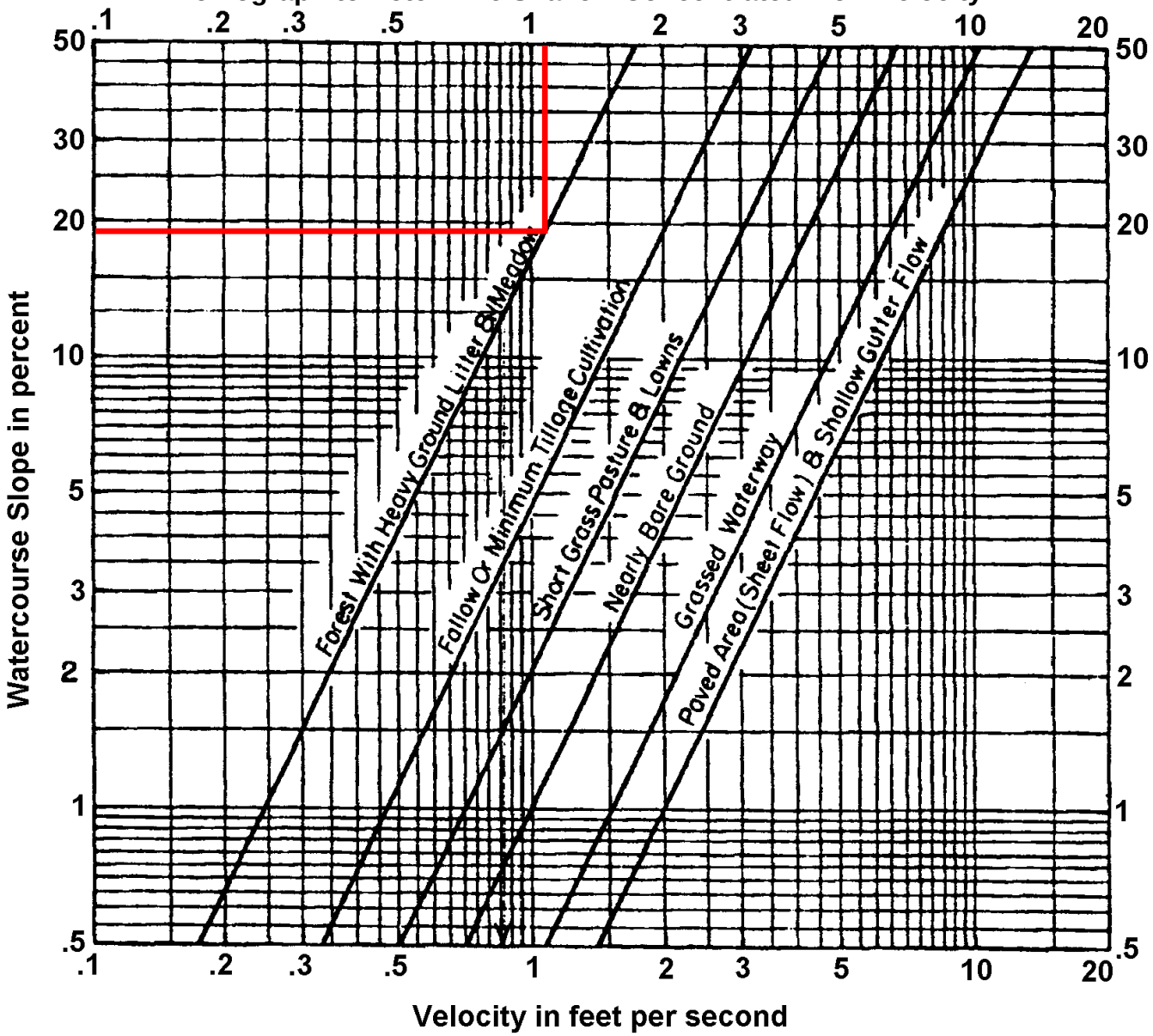
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.09_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 19%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.09_6
1.98 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.09_6	100	0.8	0.350	8.20

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.09_6	2373	FOREST	0.319	1.42	27.81

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
36.01

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.09_6	1	FOREST	0.20	1.98	0.40	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	36.01	2.00	2.45	2.88	2.00	2.45	2.88

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.45	1.98	0.79	0.97	1.14

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.09_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.98		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.97		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.05		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.27		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.53		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.67 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.67		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.33		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.83		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.017		
S_C (CRITICAL SLOPE)	(FT/FT)	0.085		
$.7S_c$	(FT/FT)	0.060		
$1.3S_c$	(FT/FT)	0.111		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

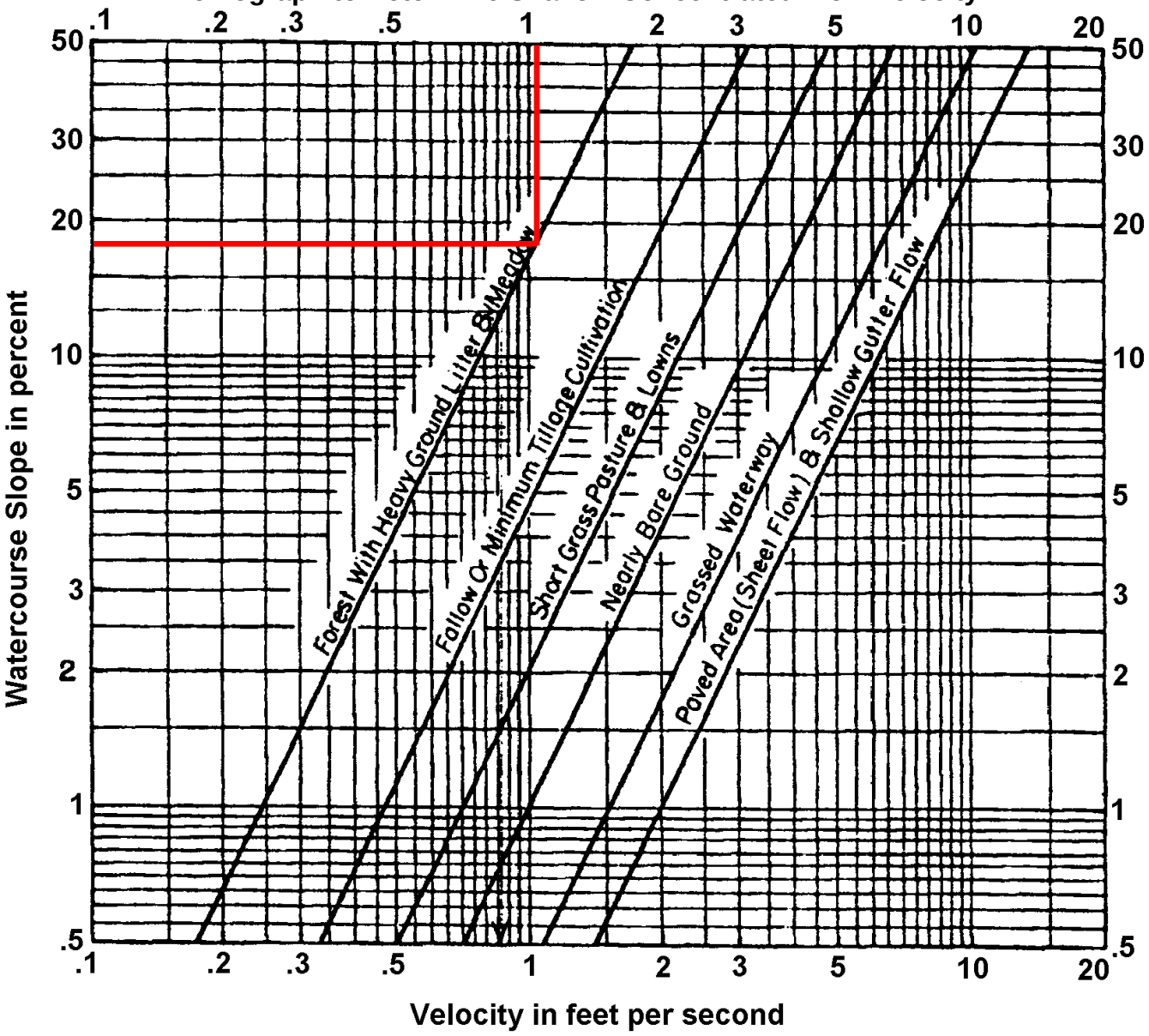
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.09_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 18%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.09_7
3.27 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.09_7	100	0.8	0.080	11.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.09_7	2945	FOREST	0.286	1.34	36.51

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
48.08

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.09_7	1	FOREST	0.20	3.27	0.65	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	48.08	1.63	2.01	2.39	1.63	2.01	2.39

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.01	3.27	1.07	1.32	1.57

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.09_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.27		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.32		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.93		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.52		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.66		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.67 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.67		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.33		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.83		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.021		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

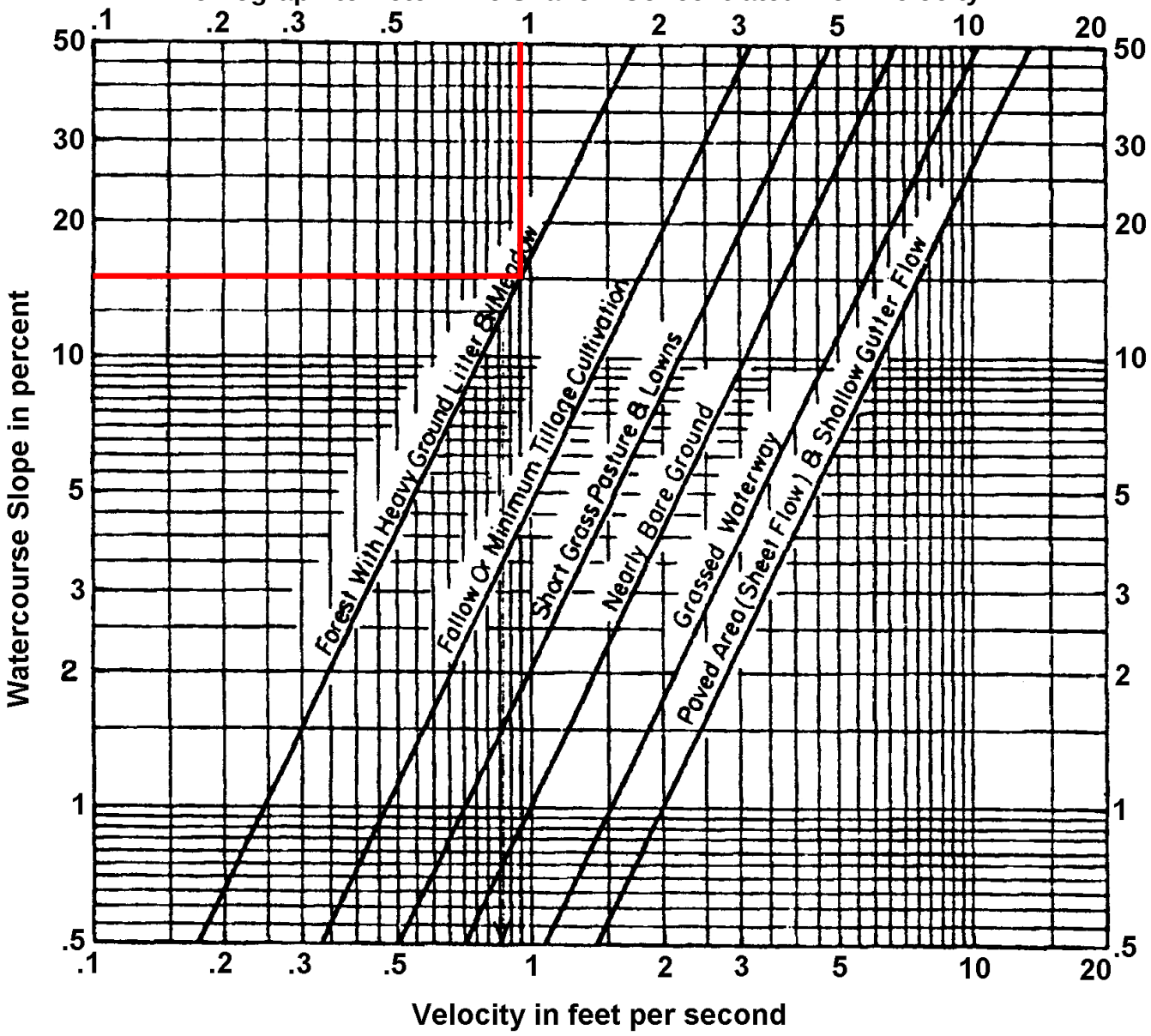
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.09_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.09_8
4.15 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.09_8	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.09_8	2905	FOREST	0.291	1.36	35.68

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.66

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.09_8	1	FOREST	0.20	4.15	0.83	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.66	1.67	2.06	2.44	1.67	2.06	2.44

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.06	4.15	1.38	1.70	2.02

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.09_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.15		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.71		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.92		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.44		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.8 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.80		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.40		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.85		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

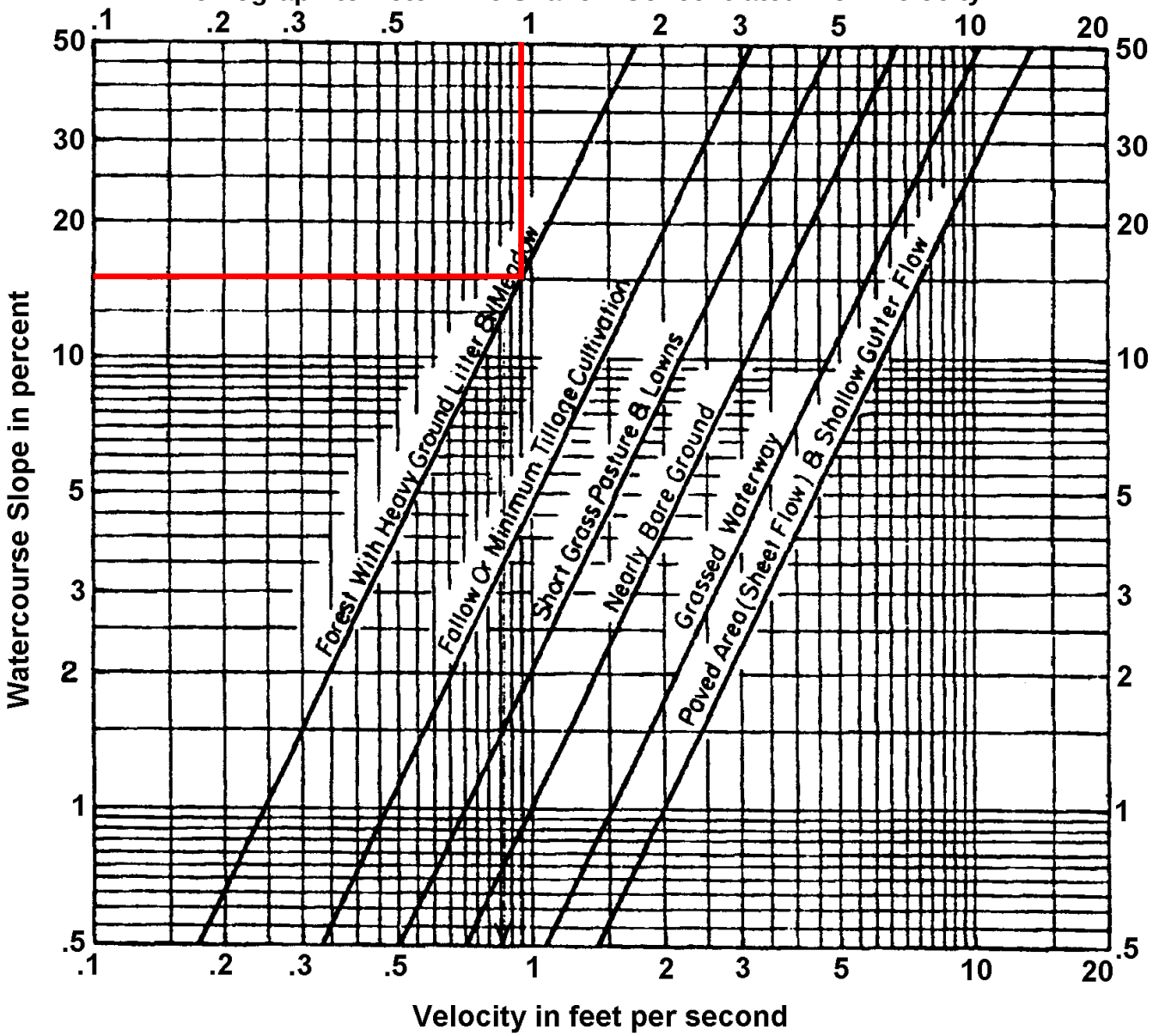
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.09_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

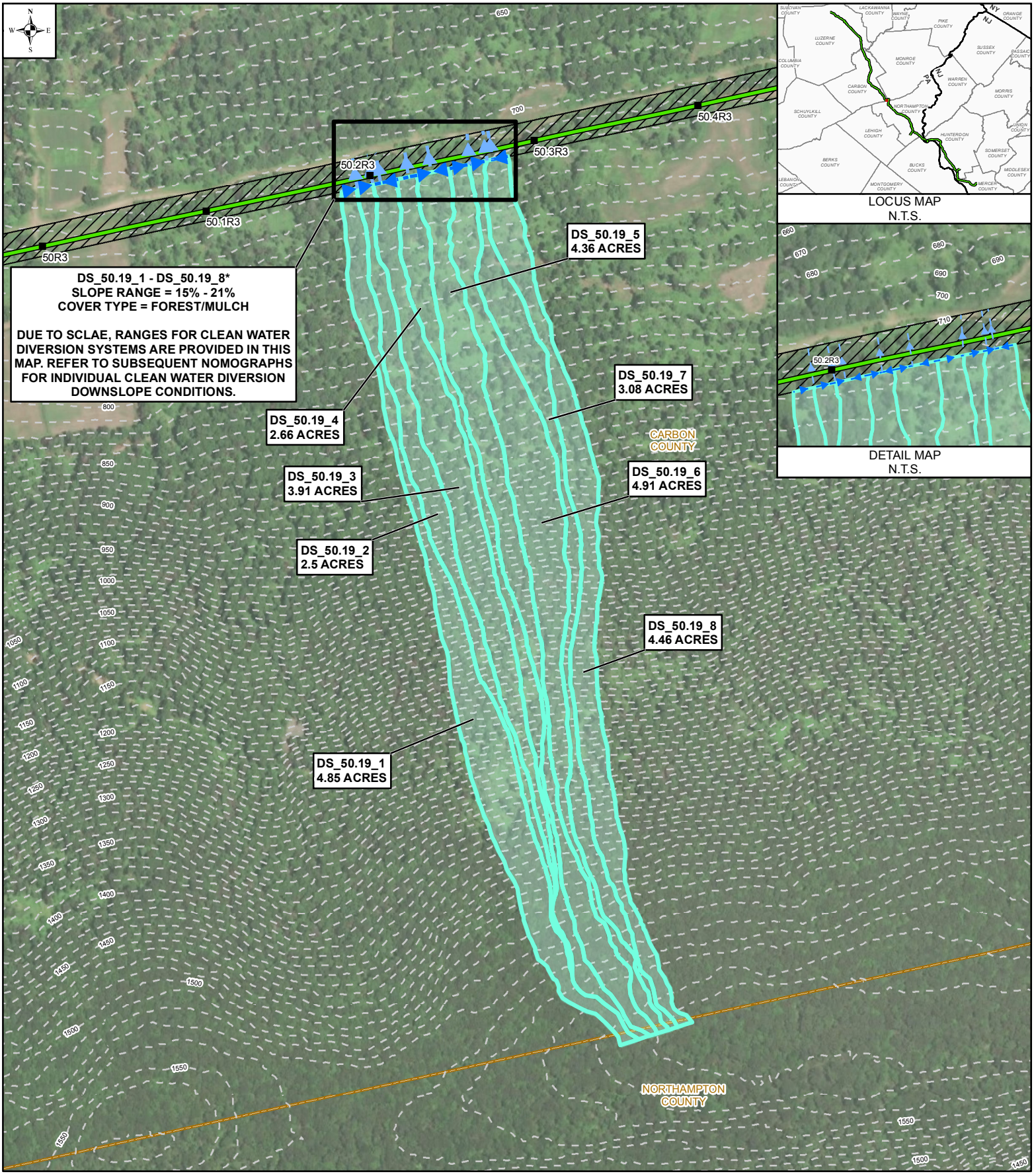


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.19

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 58 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.19_1
4.85 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.19_1	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.19_1	2917	FOREST	0.290	1.36	35.86

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.84

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.19_1	1	FOREST	0.20	4.85	0.97	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.84	1.66	2.05	2.43	1.66	2.05	2.43

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.05	4.85	1.61	1.99	2.36

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.19_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.85		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.99		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.82		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.43		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.58 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.58		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.29		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.82		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

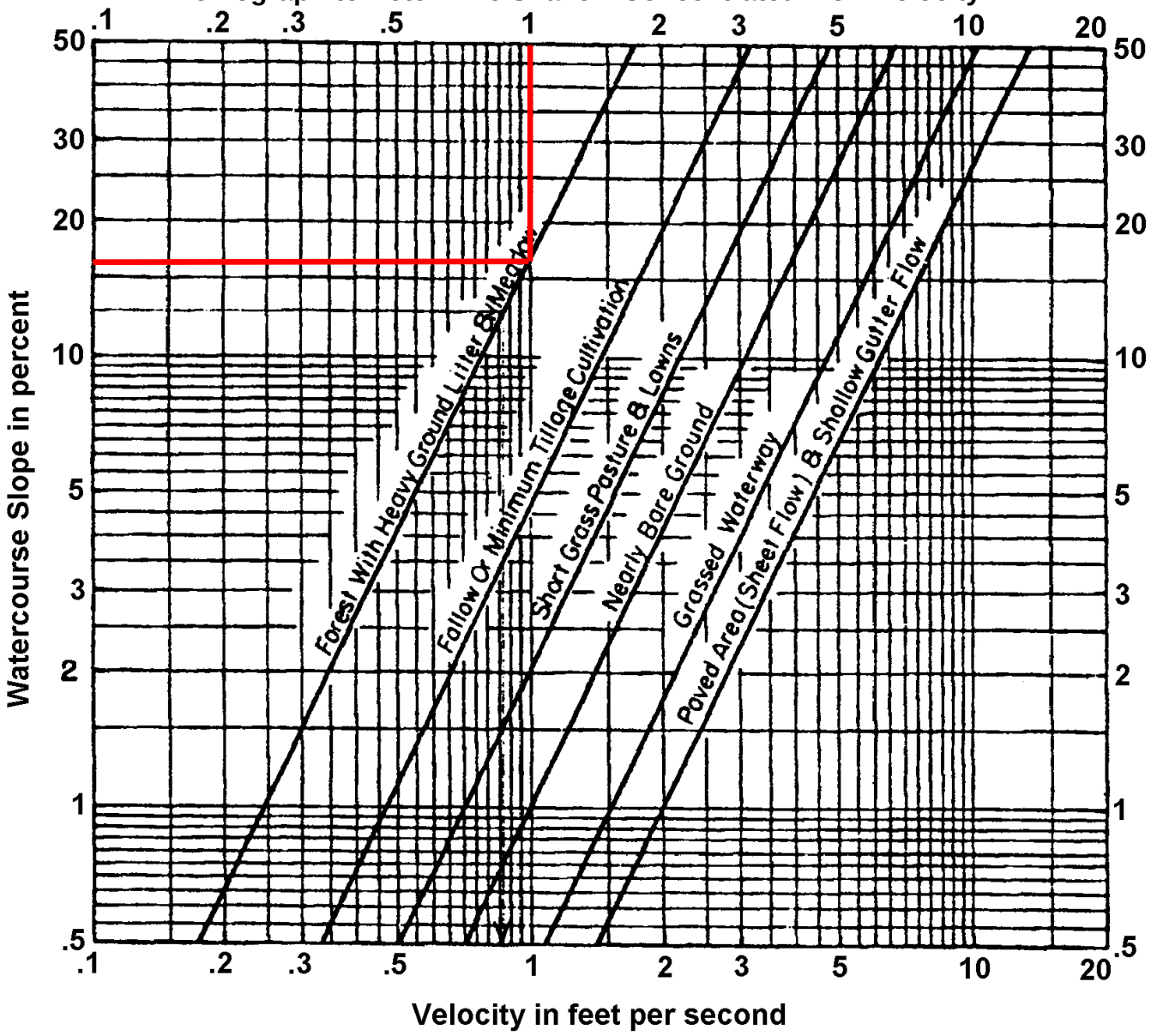
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.19_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.19_2
2.5 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.19_2	100	0.8	0.190	9.45

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.19_2	2605	FOREST	0.313	1.41	30.85

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
40.30

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.19_2	1	FOREST	0.20	2.50	0.50	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	40.30	1.85	2.28	2.69	1.85	2.28	2.69

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.28	2.50	0.92	1.14	1.34

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.19_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.5		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.14		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.50		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.91		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.22		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.29 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.29		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.14		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.79		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.039		
S_C (CRITICAL SLOPE)	(FT/FT)	0.086		
$.7S_c$	(FT/FT)	0.060		
$1.3S_c$	(FT/FT)	0.112		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

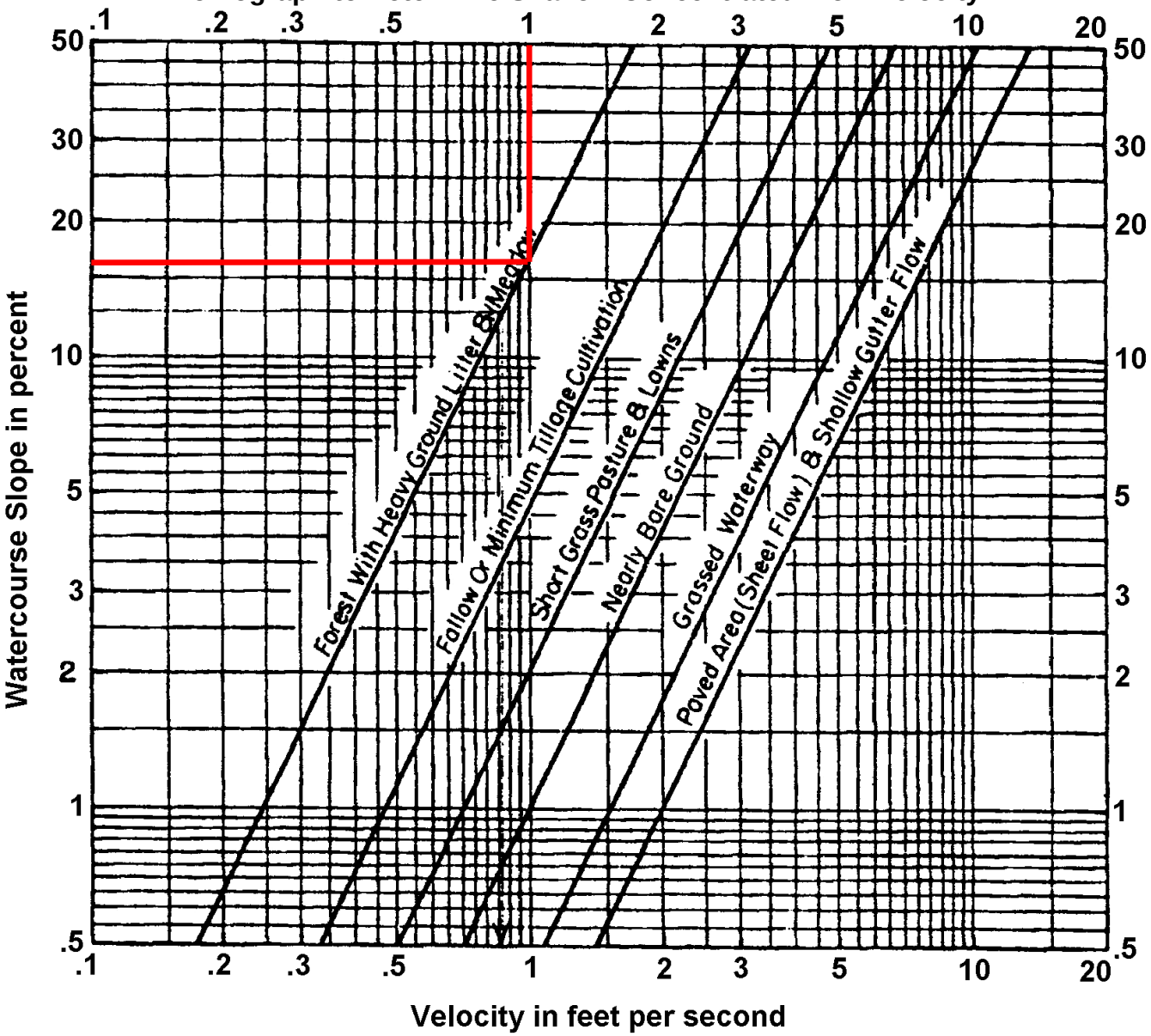
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.19_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.19_3
3.91 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.19_3	100	0.8	0.260	8.78

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.19_3	2343	FOREST	0.324	1.43	27.29

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
36.07

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.19_3	1	FOREST	0.20	3.91	0.78	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	36.07	2.00	2.45	2.88	2.00	2.45	2.88

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.45	3.91	1.56	1.92	2.25

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.19_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.91		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.92		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.84		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.79		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.99		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.75		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

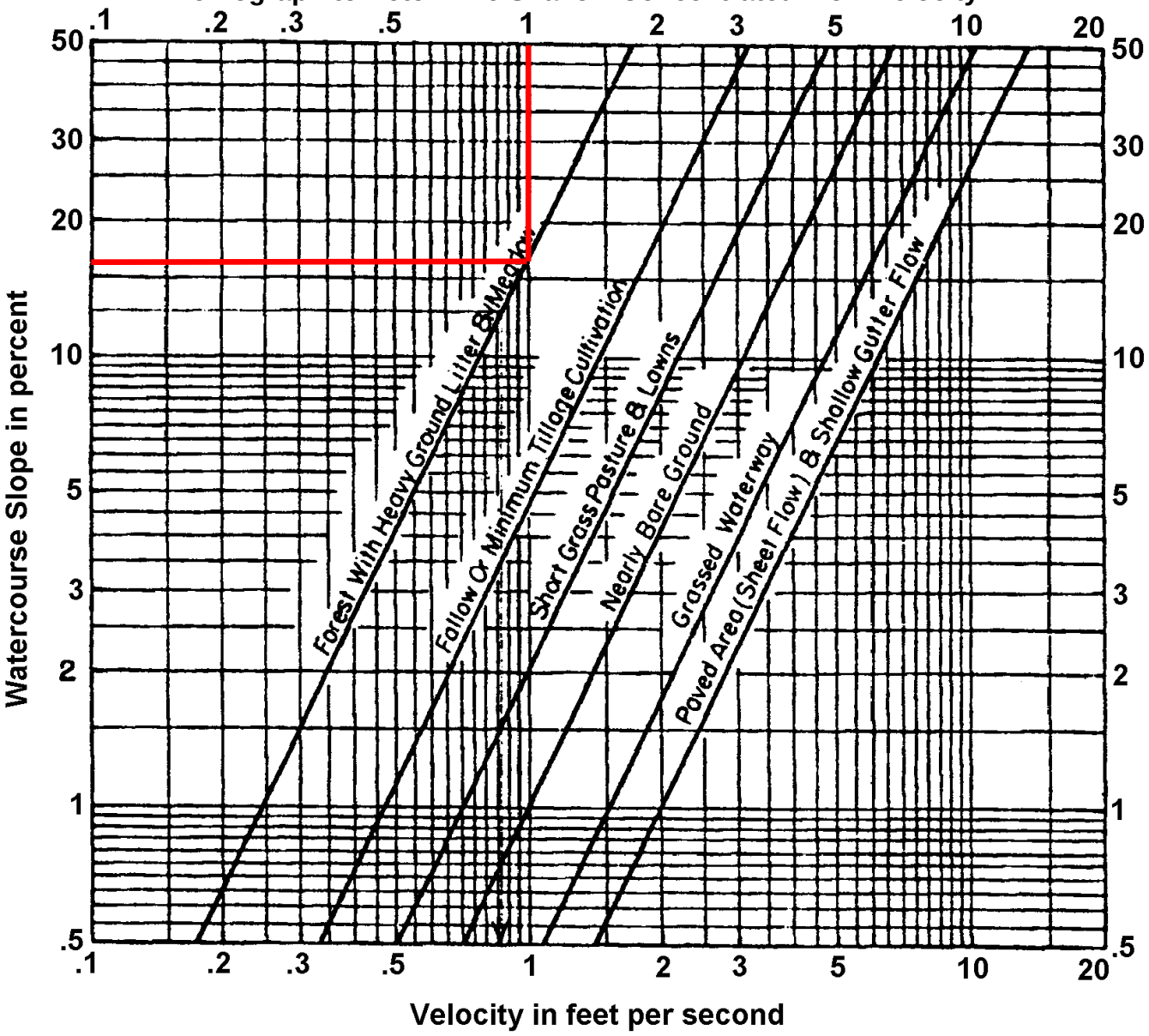
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.19_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.19_4
2.66 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.19_4	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.19_4	2922	FOREST	0.292	1.36	35.85

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.83

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.19_4	1	FOREST	0.20	2.66	0.53	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.83	1.66	2.05	2.43	1.66	2.05	2.43

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.05	2.66	0.89	1.09	1.30

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.19_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.66		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.09		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.42		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.05		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.50		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.33 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.16		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.79		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.016		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

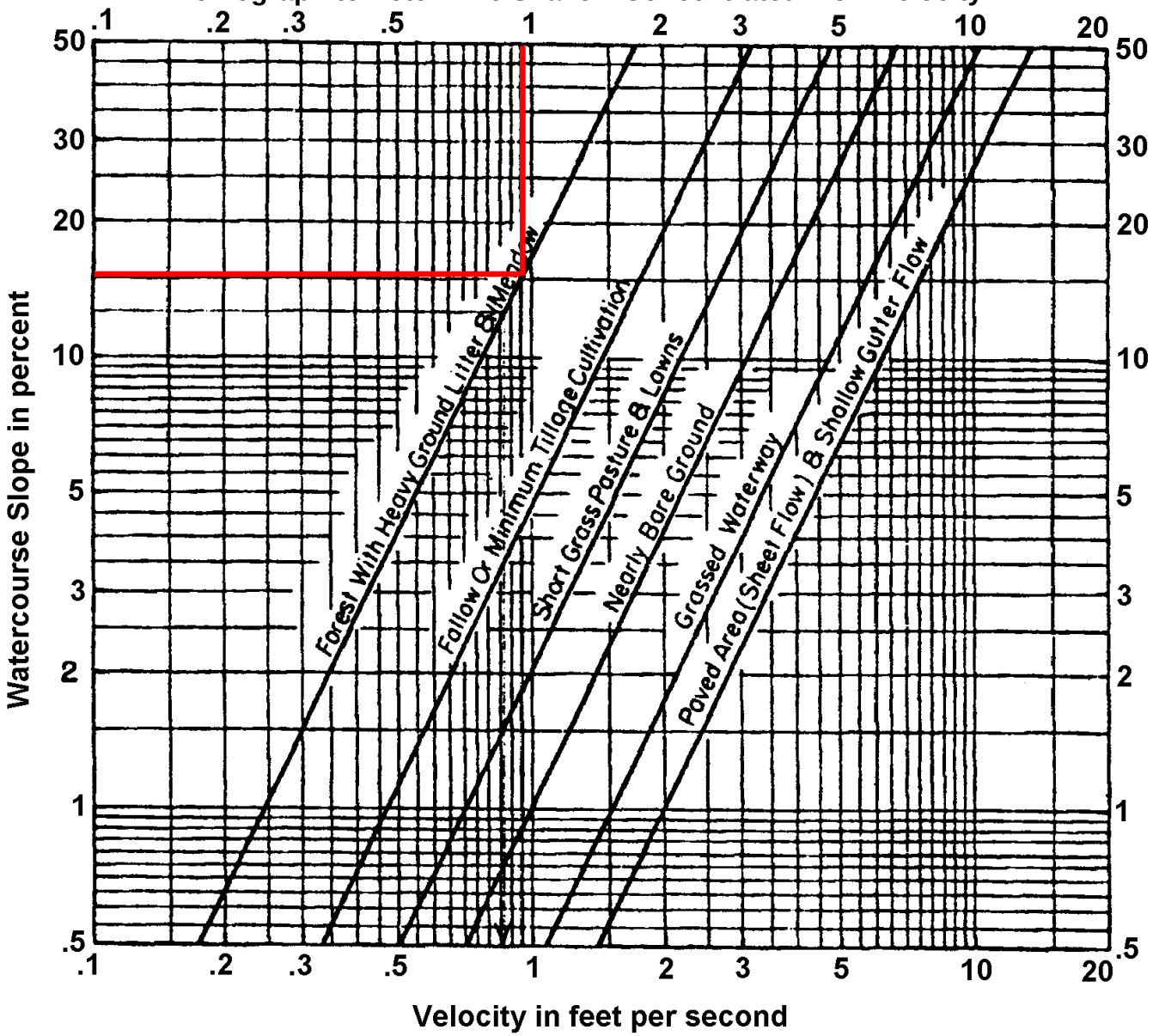
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.19_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.19_5
4.36 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.19_5	100	0.8	0.090	11.26

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.19_5	2896	FOREST	0.295	1.37	35.35

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.60

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.19_5	1	FOREST	0.20	4.36	0.87	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.60	1.67	2.06	2.44	1.67	2.06	2.44

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.06	4.36	1.45	1.80	2.13

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.19_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.36		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.8		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.59		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.40		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.1 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.10		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.05		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.76		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

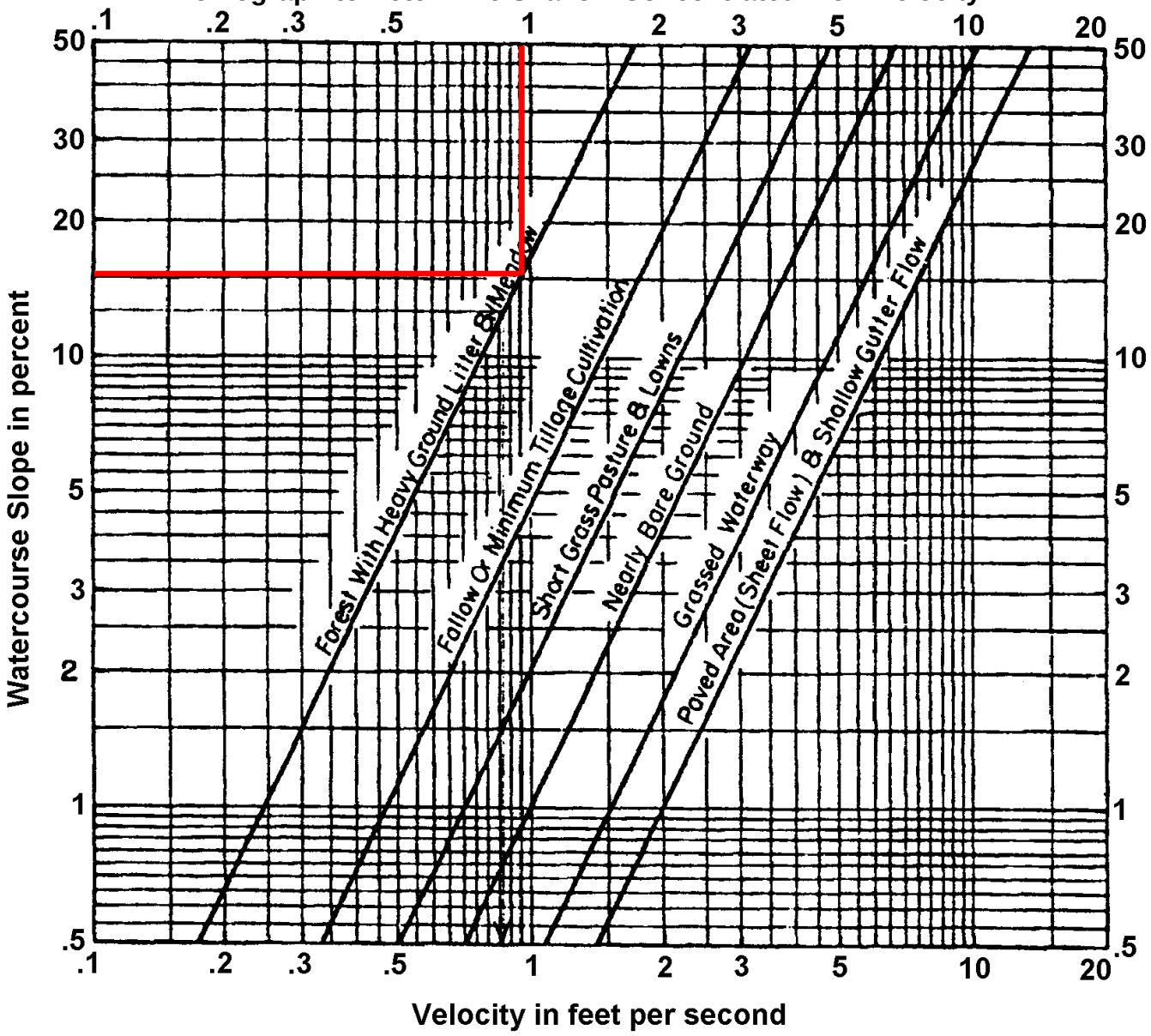
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.19_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.19_6
4.91 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.19_6	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.19_6	2888	FOREST	0.296	1.37	35.16

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.14

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.19_6	1	FOREST	0.20	4.91	0.98	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.14	1.68	2.07	2.46	1.68	2.07	2.46

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.07	4.91	1.65	2.04	2.42

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.19_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.91		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.04		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.61		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.28		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.97		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.84		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.031		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

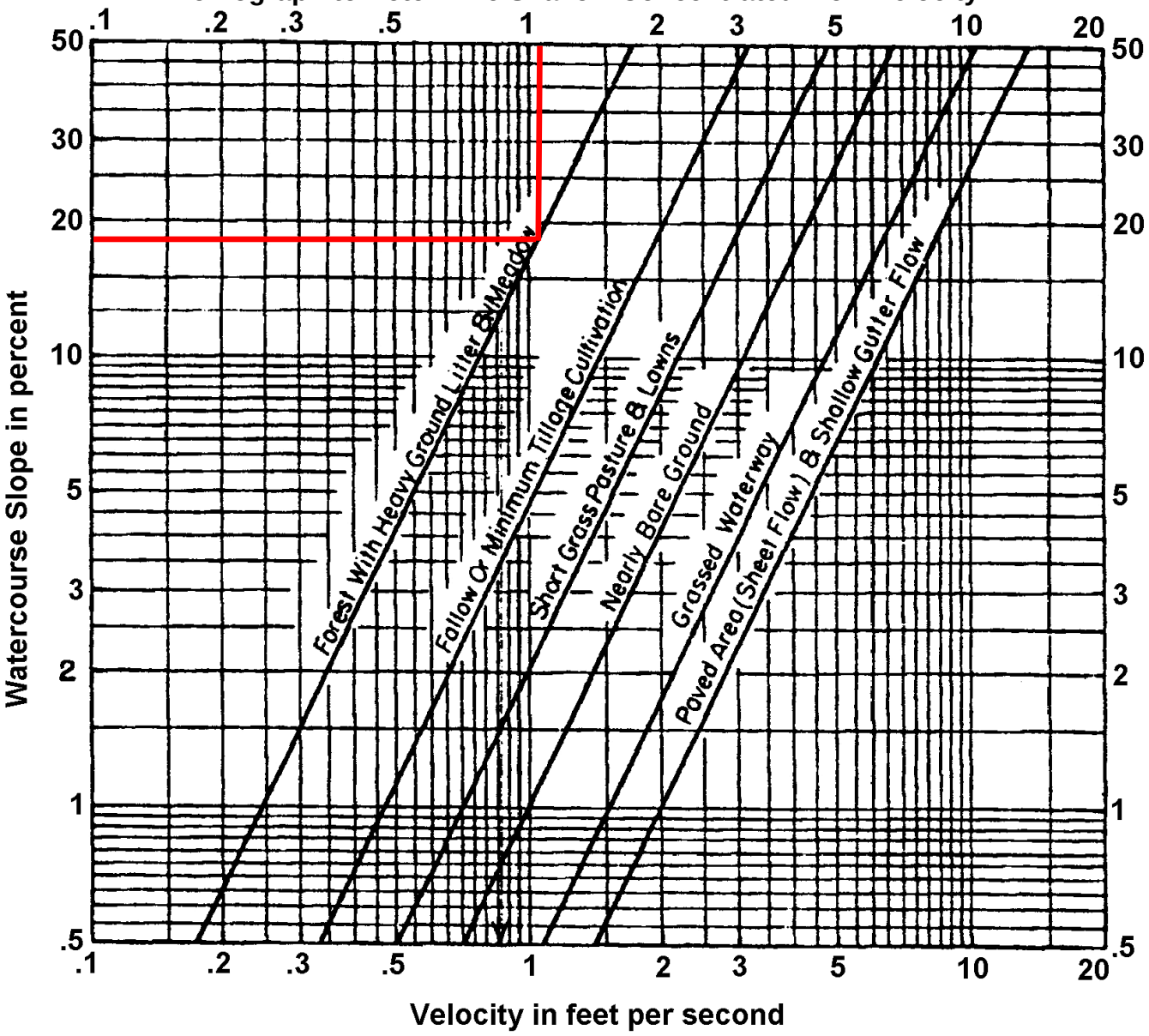
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.19_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 18%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.19_07
3.08 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.19_7	100	0.8	0.080	11.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.19_7	2903	FOREST	0.295	1.37	35.39

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.96

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.19_7	1	FOREST	0.20	3.08	0.62	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.96	1.66	2.05	2.43	1.66	2.05	2.43

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.05	3.08	1.02	1.26	1.50

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.19_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.08		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.26		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.44		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.81		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.09		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.37 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.37		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.18		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.80		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.035		
S_C (CRITICAL SLOPE)	(FT/FT)	0.086		
$.7S_c$	(FT/FT)	0.060		
$1.3S_c$	(FT/FT)	0.112		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

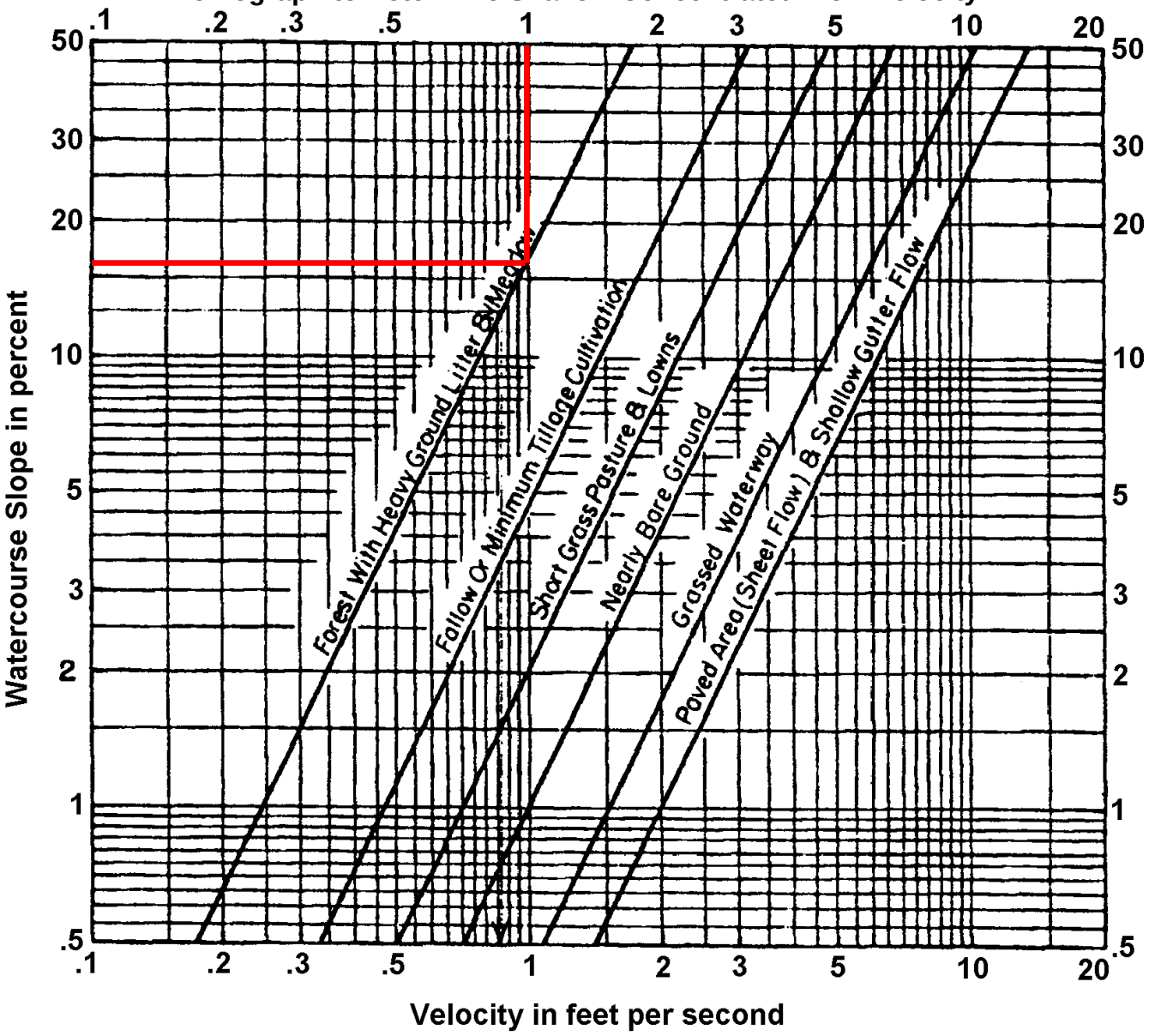
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.19_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.19_8
4.46 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.19_8	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.19_8	2884	FOREST	0.298	1.37	34.98

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
45.97

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.19_8	1	FOREST	0.20	4.46	0.89	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	45.97	1.68	2.08	2.46	1.68	2.08	2.46

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.08	4.46	1.50	1.85	2.20

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.19_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.46		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.85		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.59		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.06		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.40		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.68 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.68		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.84		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.71		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.045		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

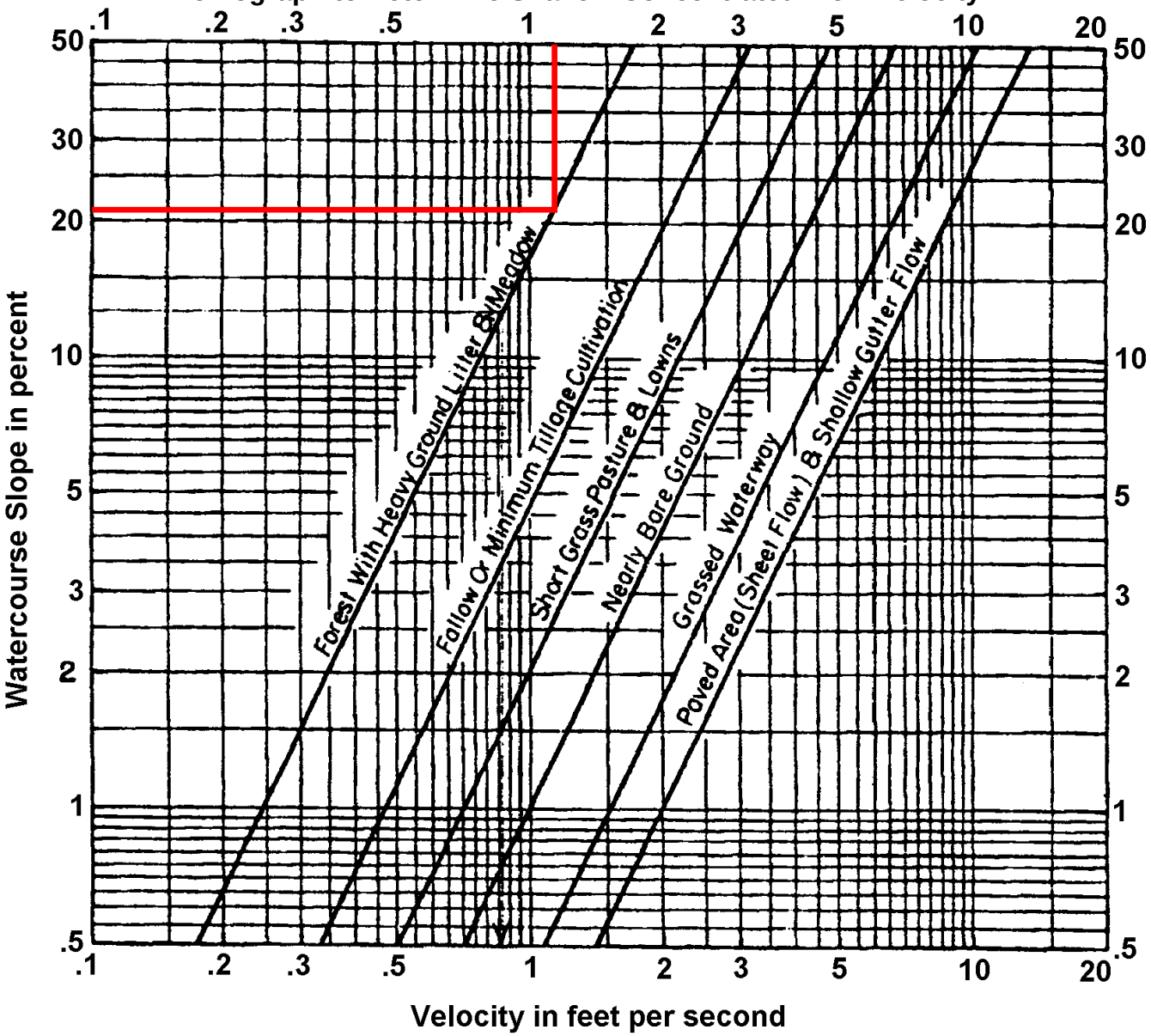
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.19_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

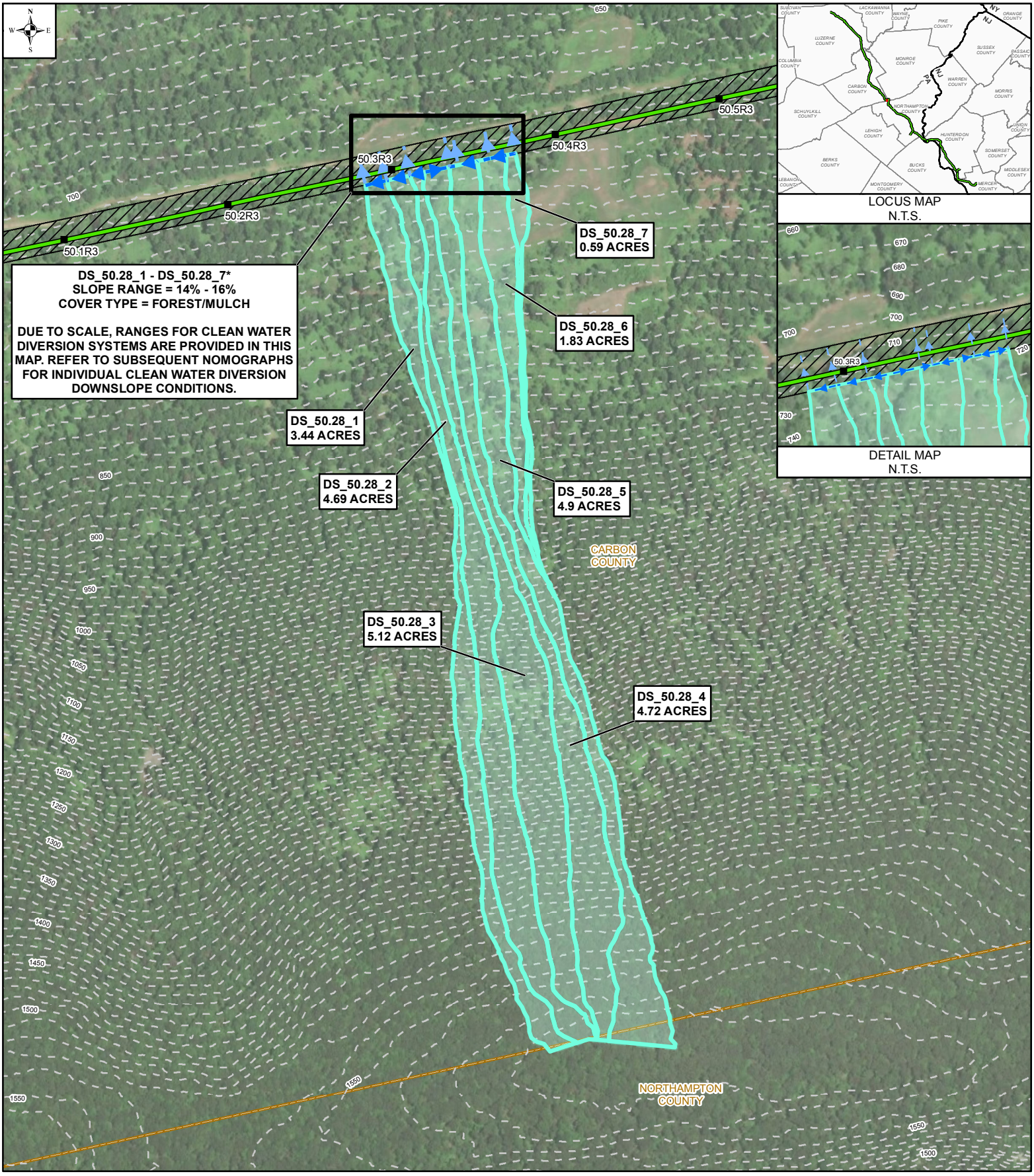


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 21%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.2 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.2 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.28

CARBON COUNTY, PENNSYLVANIA

0 200 400 FEET

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

PennEast PIPELINE

DWG NO: PAGE 59 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.28_1
3.44 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.28_1	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.28_1	2866	FOREST	0.300	1.38	34.66

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
45.64

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.28_1	1	FOREST	0.20	3.44	0.69	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	45.64	1.69	2.09	2.48	1.69	2.09	2.48

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.09	3.44	1.16	1.44	1.70

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.28_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.44		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.44		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.95		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.81		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.44		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.56 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.56		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.78		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.69		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.014		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

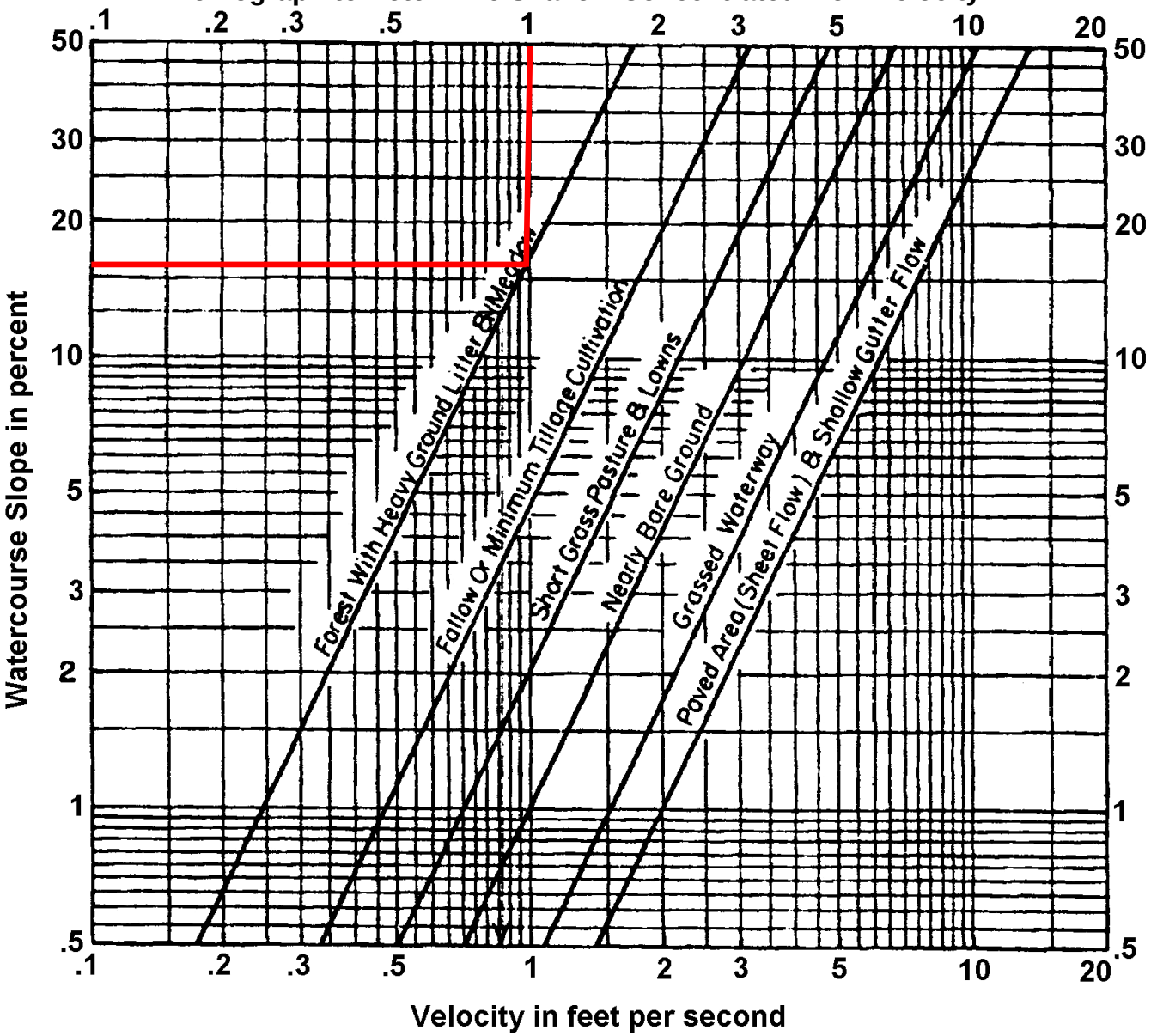
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2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.28_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.28_2
4.69 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.28_2	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.28_2	2866	FOREST	0.301	1.38	34.62

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
45.60

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.28_2	1	FOREST	0.20	4.69	0.94	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	45.60	1.69	2.09	2.48	1.69	2.09	2.48

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.09	4.69	1.59	1.96	2.32

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.28_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.69		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.96		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.78		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.40		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.87		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.41 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	8.11		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.41		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.70		
R (HYDRAULIC RADIUS)		0.42		
S (BED SLOPE)[3, 7]	(FT/FT)	0.014		
S_C (CRITICAL SLOPE)	(FT/FT)	0.115		
$.7S_c$	(FT/FT)	0.080		
$1.3S_c$	(FT/FT)	0.149		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

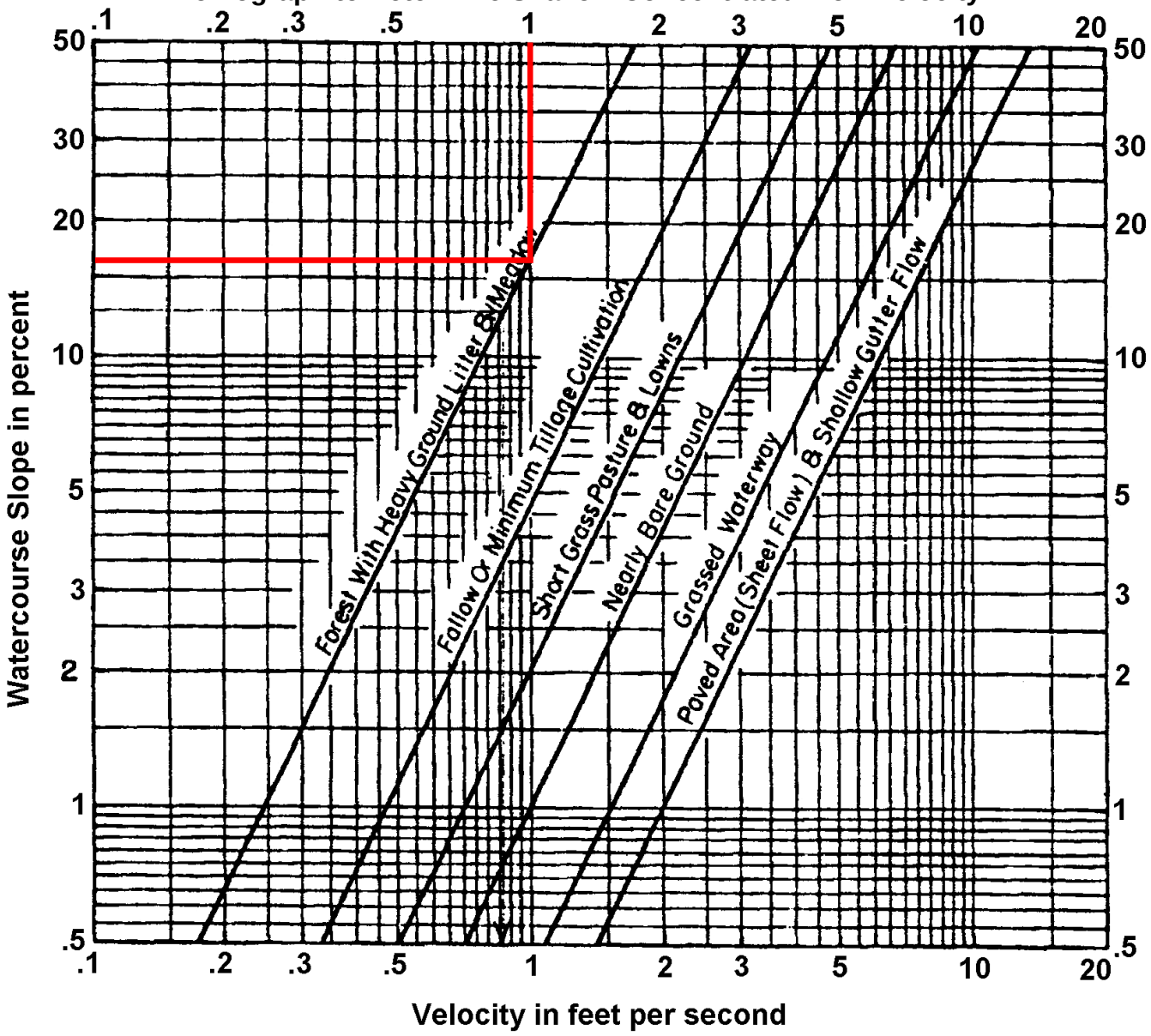
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.28_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.28_3
5.12 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.28_3	100	0.8	0.090	11.26

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.28_3	2862	FOREST	0.301	1.38	34.57

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
45.82

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.28_3	1	FOREST	0.20	5.12	1.02	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	45.82	1.69	2.08	2.47	1.69	2.08	2.47

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.08	5.12	1.73	2.13	2.53

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.28_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.12		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.13		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.28		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.36		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.03		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.02 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.02		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.01		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.75		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.033		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

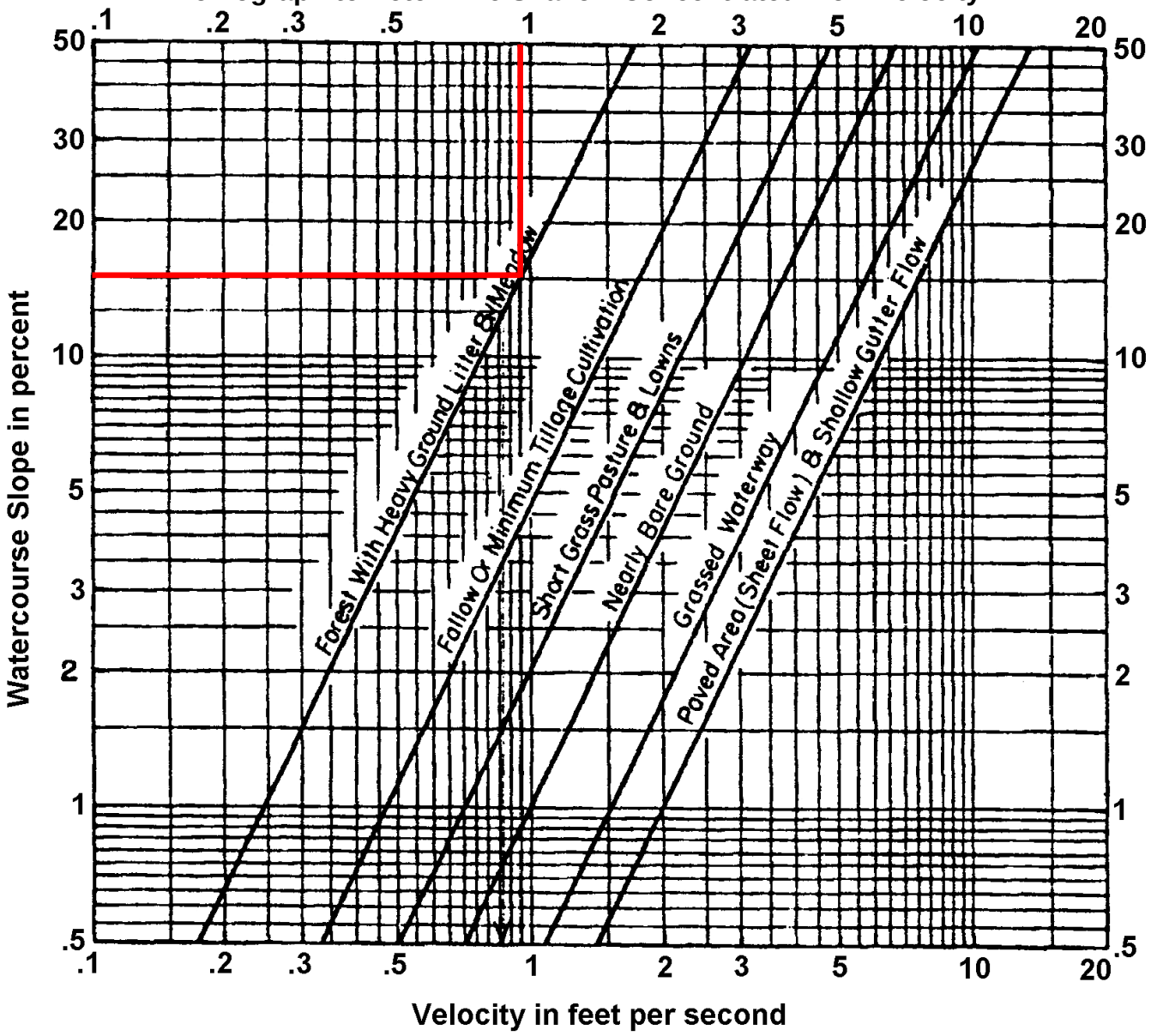
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.28_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.28_4
4.72 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.28_4	100	0.8	0.080	11.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.28_4	2828	FOREST	0.304	1.39	33.97

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
45.54

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.28_4	1	FOREST	0.20	4.72	0.94	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	45.54	1.69	2.09	2.48	1.69	2.09	2.48

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.09	4.72	1.60	1.97	2.34

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.28_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.72		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.97		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.26		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.53		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.12		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.75 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.75		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.87		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.72		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.036		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

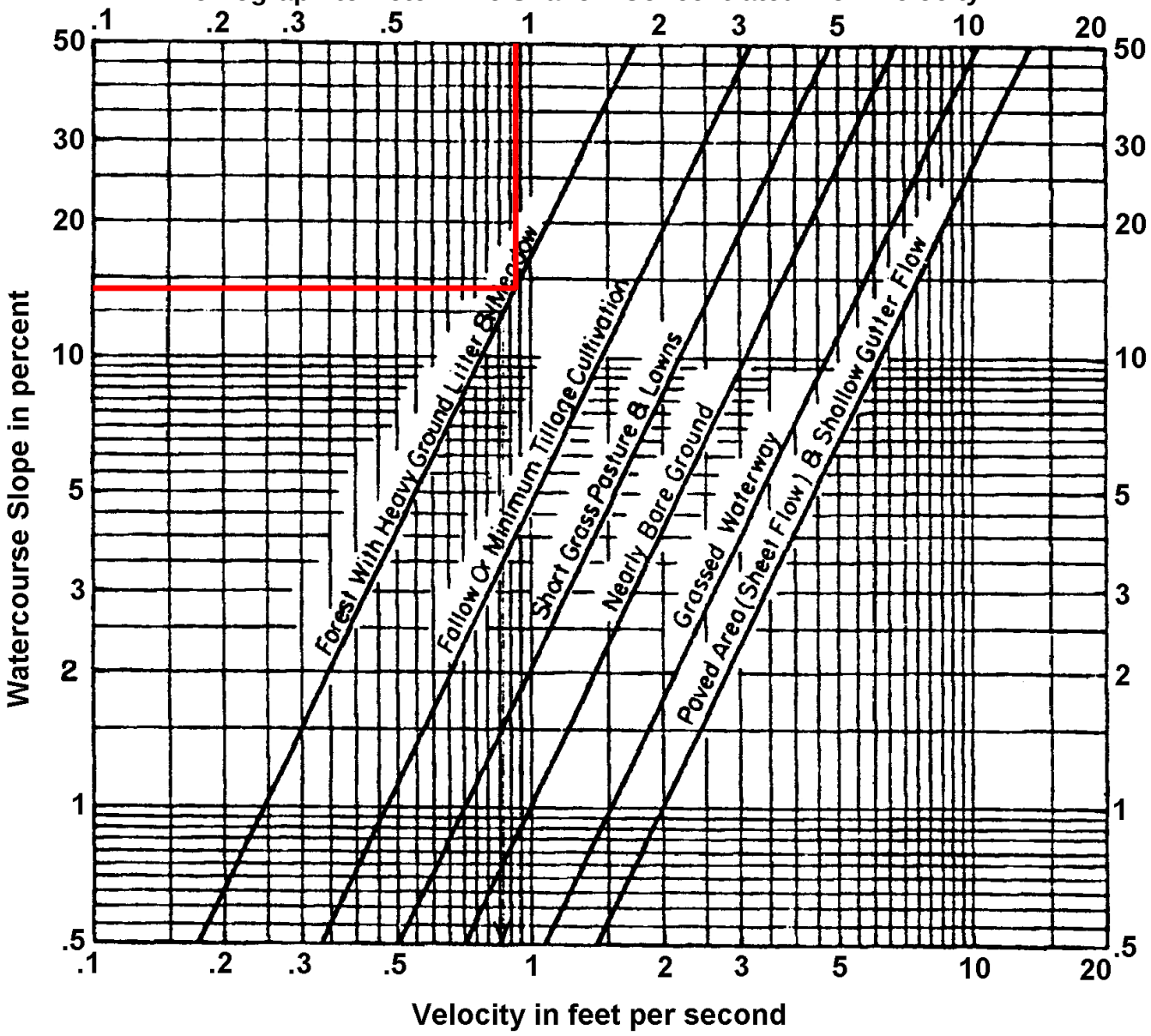
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.28_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.28_5
4.9 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.28_5	100	0.8	0.070	11.94

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.28_5	2876	FOREST	0.300	1.38	34.78

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.72

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.28_5	1	FOREST	0.20	4.90	0.98	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.72	1.66	2.05	2.44	1.66	2.05	2.44

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.05	4.90	1.63	2.01	2.39

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.28_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.9		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.01		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.61		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.25		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.69		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.78 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	8.67		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.78		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	2.89		
R (HYDRAULIC RADIUS)		0.42		
S (BED SLOPE)[3, 7]	(FT/FT)	0.011		
S_C (CRITICAL SLOPE)	(FT/FT)	0.113		
$.7S_c$	(FT/FT)	0.079		
$1.3S_c$	(FT/FT)	0.147		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

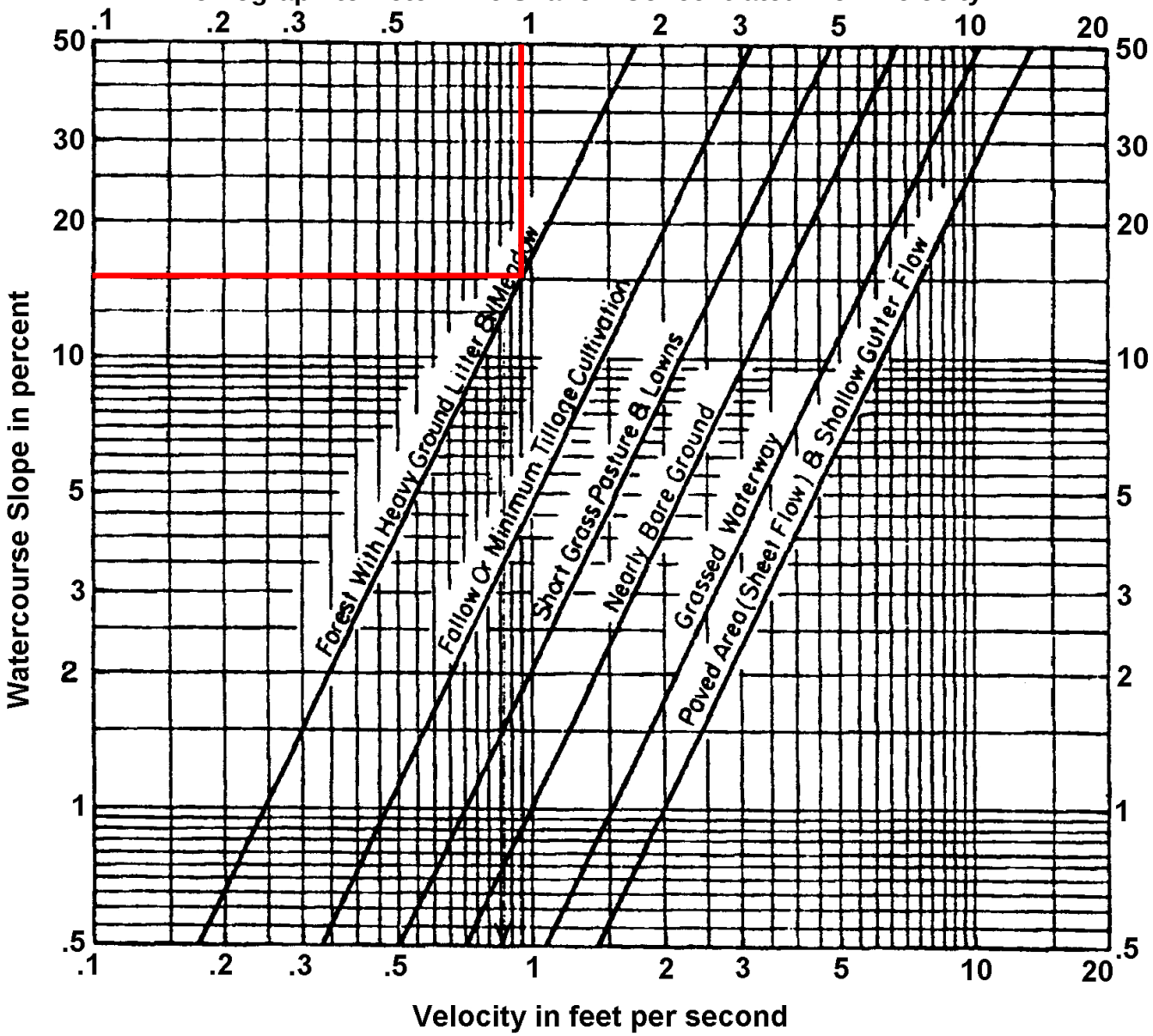
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.28_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.28_6
1.83 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.28_6	100	0.8	0.400	7.94

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.28_6	1421	FOREST	0.248	1.25	18.91

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
26.86

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.28_6	1	FOREST	0.20	1.83	0.37	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	26.86	2.42	2.94	3.41	2.42	2.94	3.41

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.94	1.83	0.88	1.08	1.25

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.28_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.83		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.08		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.16		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.72		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.03		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.41 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.41		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.70		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.68		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.033		
S_C (CRITICAL SLOPE)	(FT/FT)	0.089		
$.7S_c$	(FT/FT)	0.063		
$1.3S_c$	(FT/FT)	0.116		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

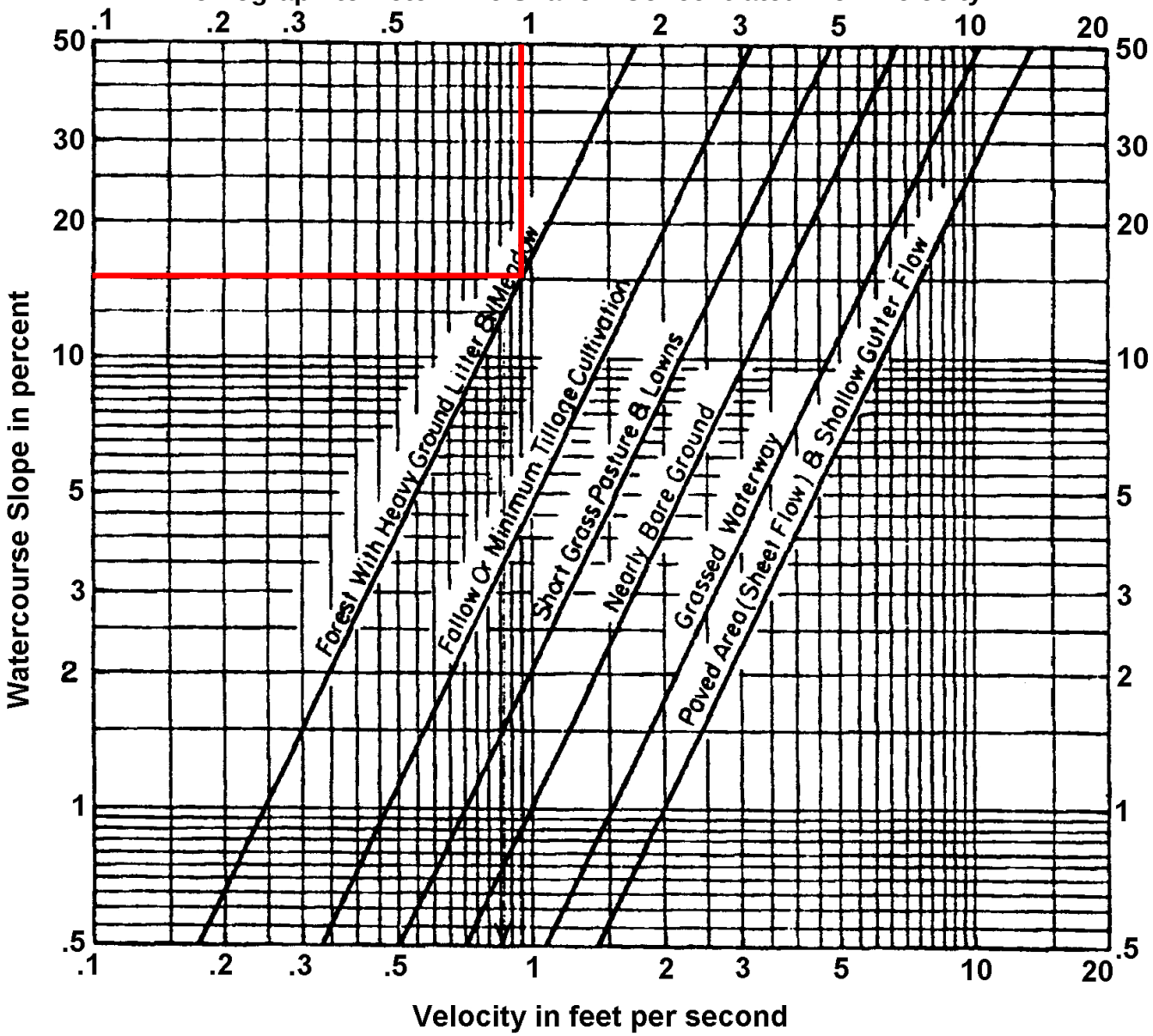
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.28_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.28_7
0.59 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.28_7	100	0.8	0.340	8.25

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.28_7	1275	FOREST	0.231	1.21	17.59

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
25.84

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.28_7	1	FOREST	0.20	0.59	0.12	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	25.84	2.47	3.01	3.48	2.47	3.01	3.48

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.01	0.59	0.29	0.36	0.41

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.28_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.59		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.36		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.21		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.73		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.03		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.59 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.59		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.79		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.70		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.033		
S_C (CRITICAL SLOPE)	(FT/FT)	0.089		
$.7S_c$	(FT/FT)	0.062		
$1.3S_c$	(FT/FT)	0.115		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

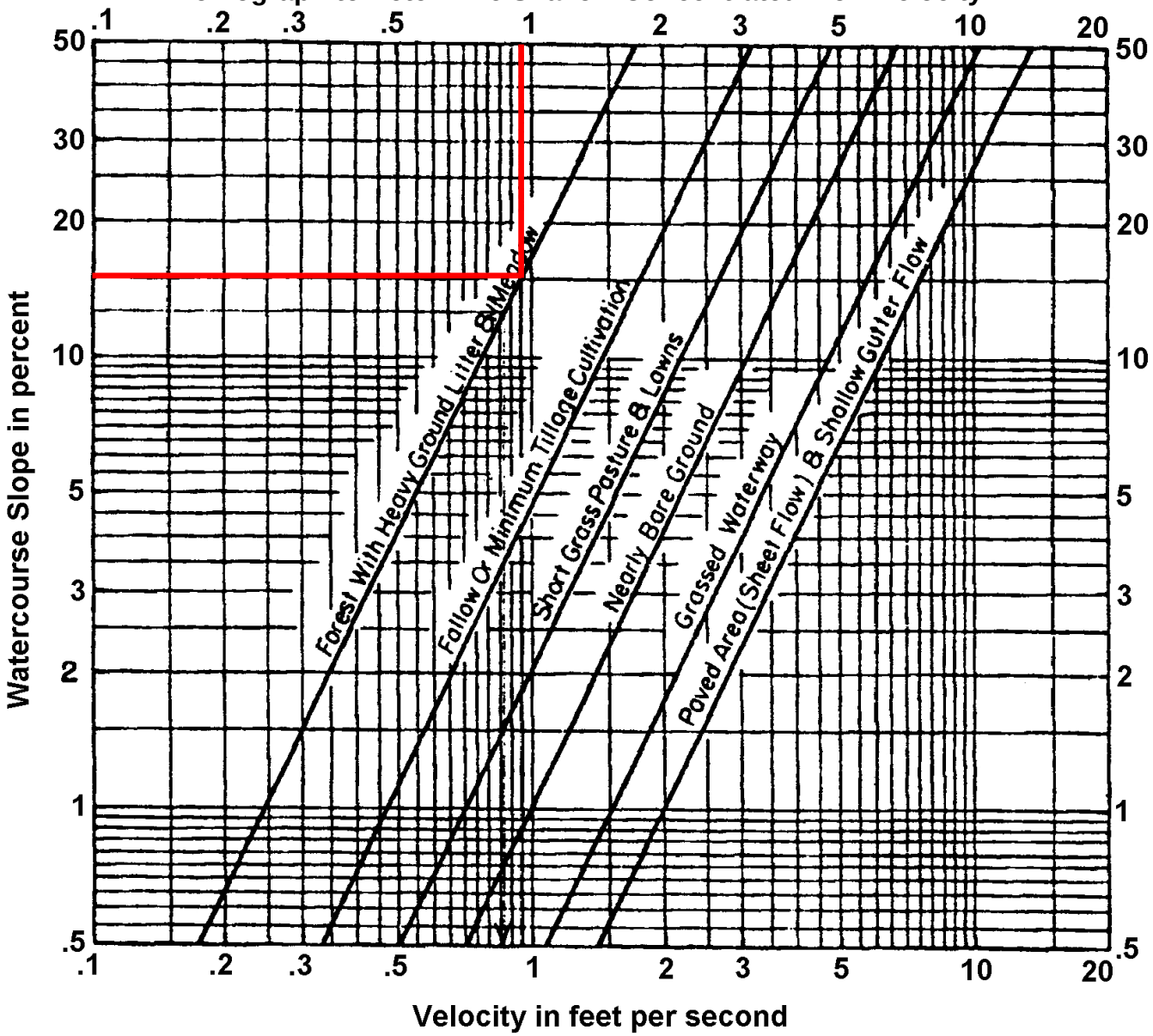
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.28_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

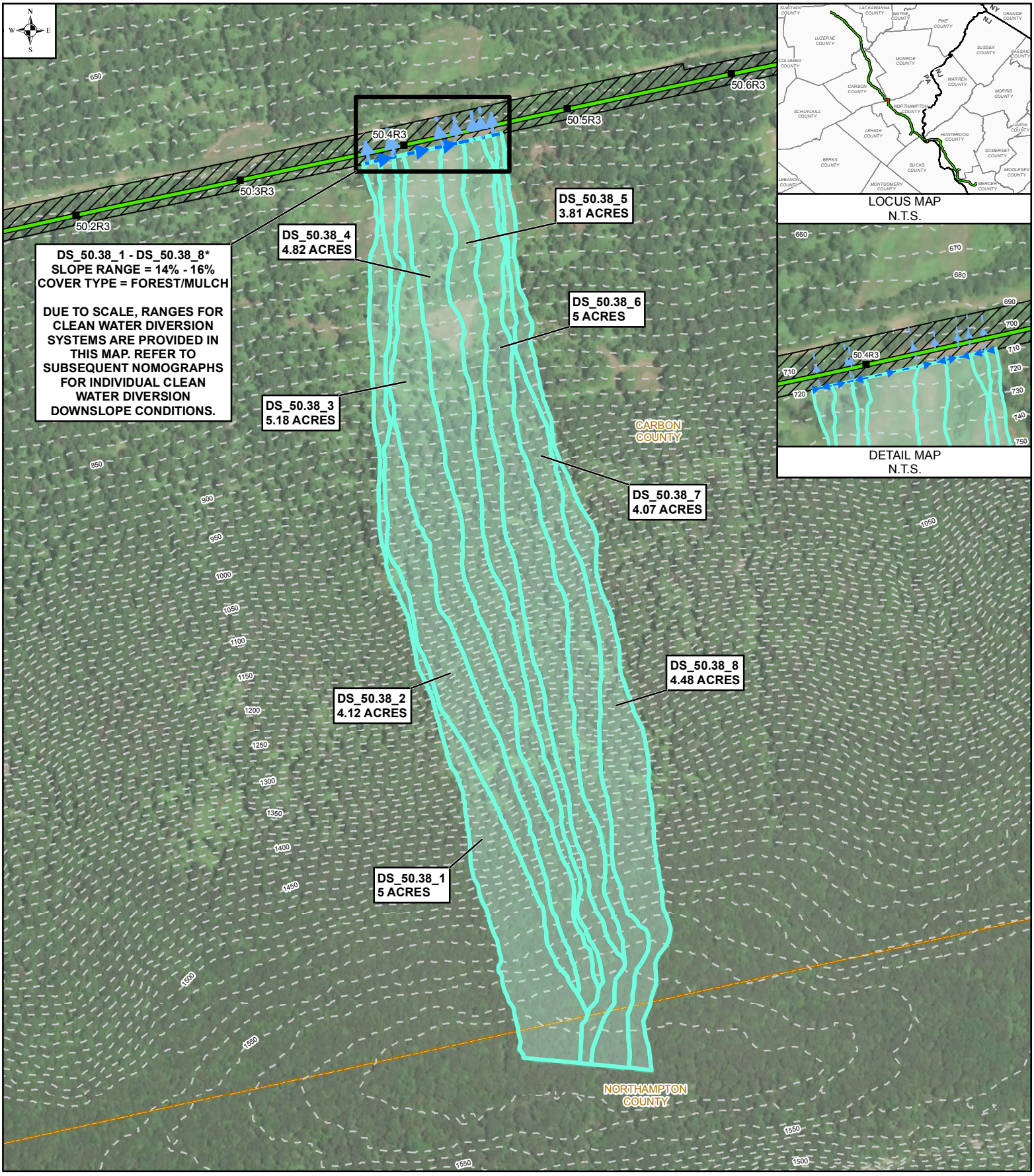


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.38

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 400 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 60 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.38_1
5 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.38_1	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.38_1	2929	FOREST	0.294	1.36	35.77

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
54.57

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.38_1	1	FOREST	0.20	5.00	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	54.57	1.48	1.83	2.19	1.48	1.83	2.19

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.83	5.00	1.48	1.83	2.19

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.38_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.84		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.19		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.94		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.37		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.15 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.15		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.58		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.64		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.044		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

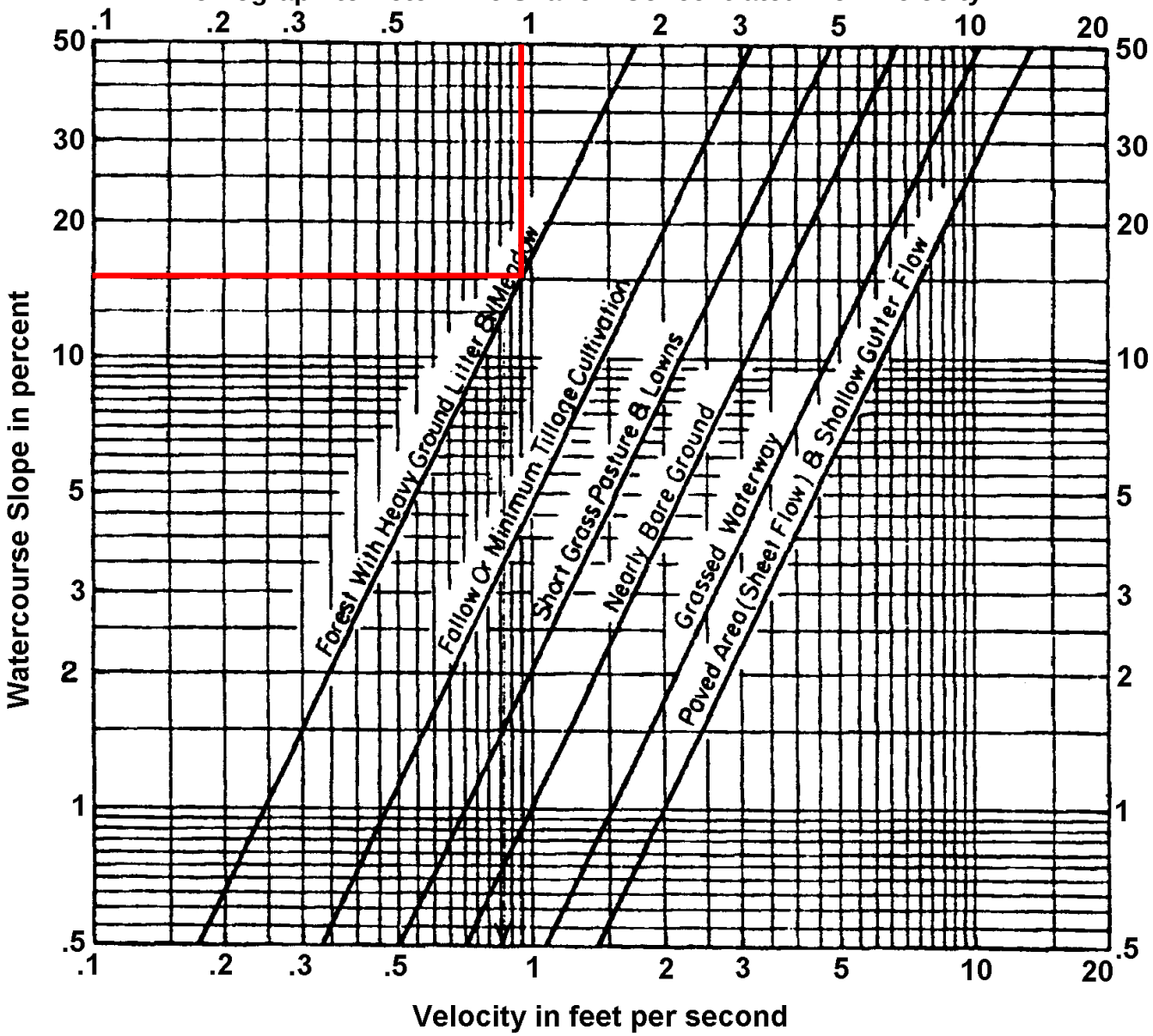
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.38_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.38_2
4.12 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.38_2	100	0.8	0.160	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.38_2	2791	FOREST	0.307	1.39	33.38

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
43.22

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.38_2	1	FOREST	0.20	4.12	0.82	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	43.22	1.76	2.17	2.57	1.76	2.17	2.57

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.17	4.12	1.45	1.79	2.12

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.38_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.12		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.79		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.59		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.80		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.99		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.75		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

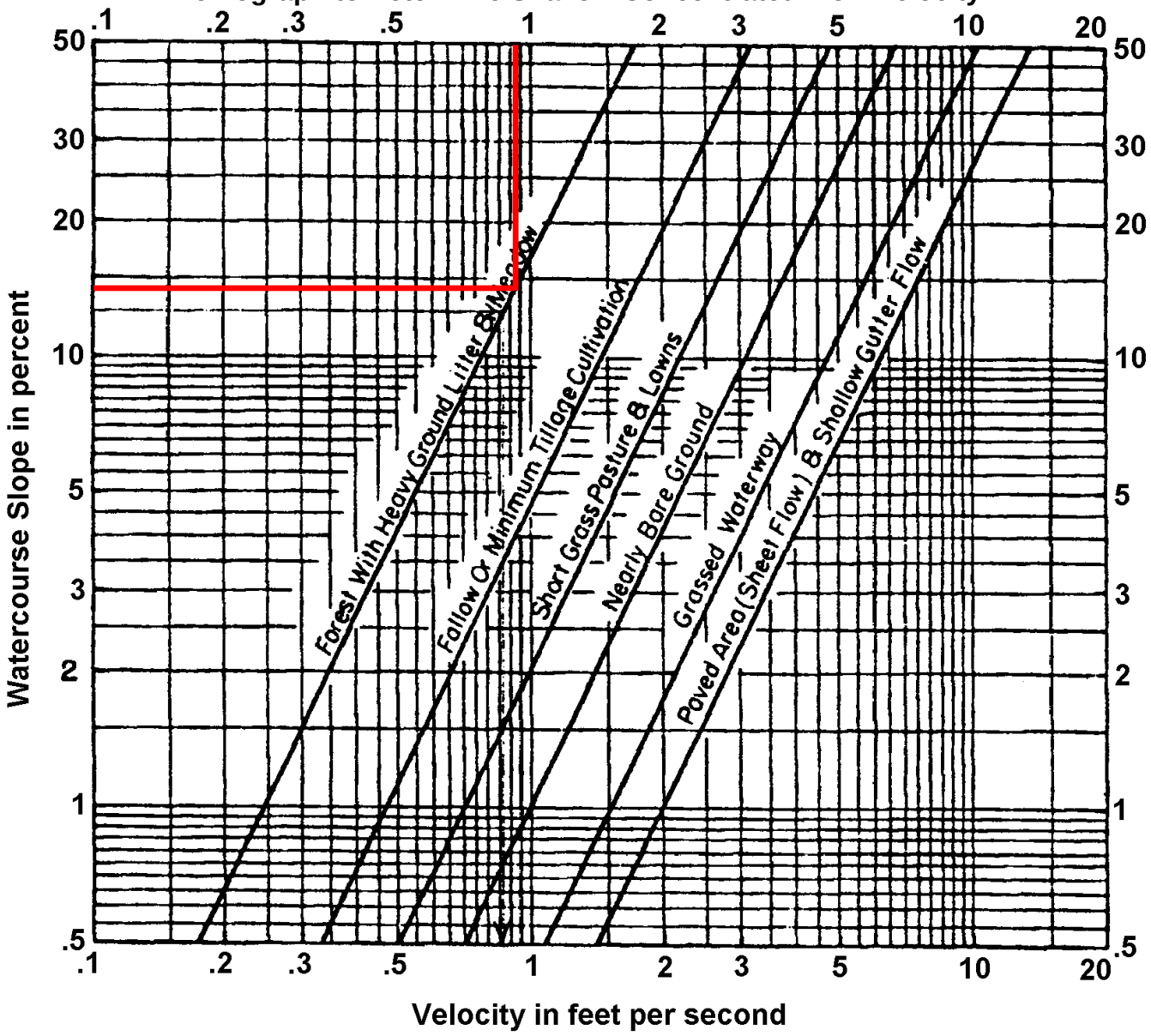
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.38_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.38_3
5.18 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.38_3	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.38_3	2851	FOREST	0.302	1.38	34.37

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
47.28

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.38_3	1	FOREST	0.20	5.18	1.04	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	47.28	1.65	2.04	2.42	1.65	2.04	2.42

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.04	5.18	1.71	2.11	2.51

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.38_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.18		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.11		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.93		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.49		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.06		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.50		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.87		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.034		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

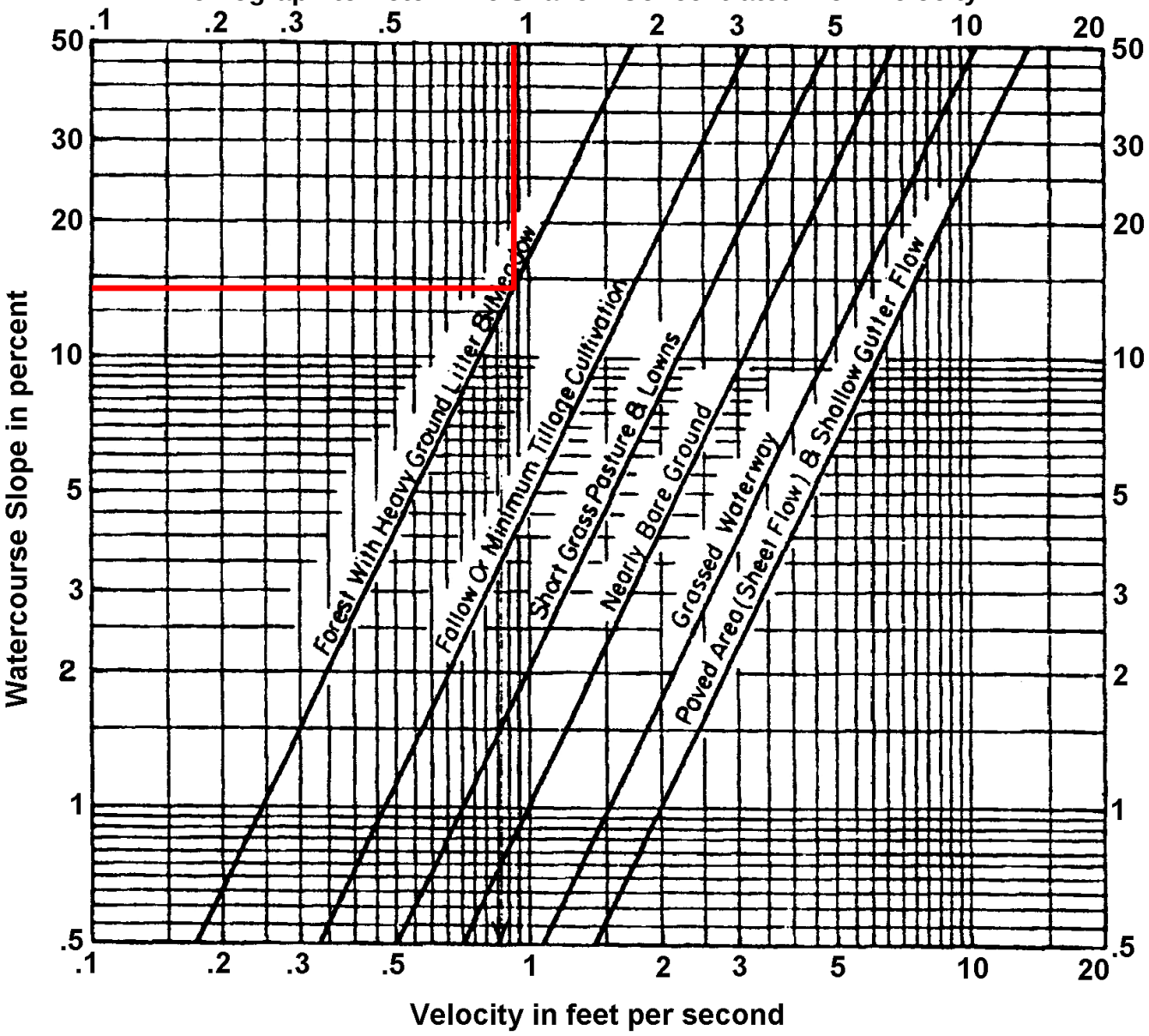
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.38_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.38_4
4.82 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.38_4	100	0.8	0.130	10.33

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.38_4	2749	FOREST	0.311	1.40	32.63

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
42.96

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.38_4	1	FOREST	0.20	4.82	0.96	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	42.96	1.77	2.18	2.58	1.77	2.18	2.58

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.18	4.82	1.70	2.10	2.48

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.38_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.82		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.1		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.52		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.68		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.19		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.02 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.02		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.01		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.75		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.038		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

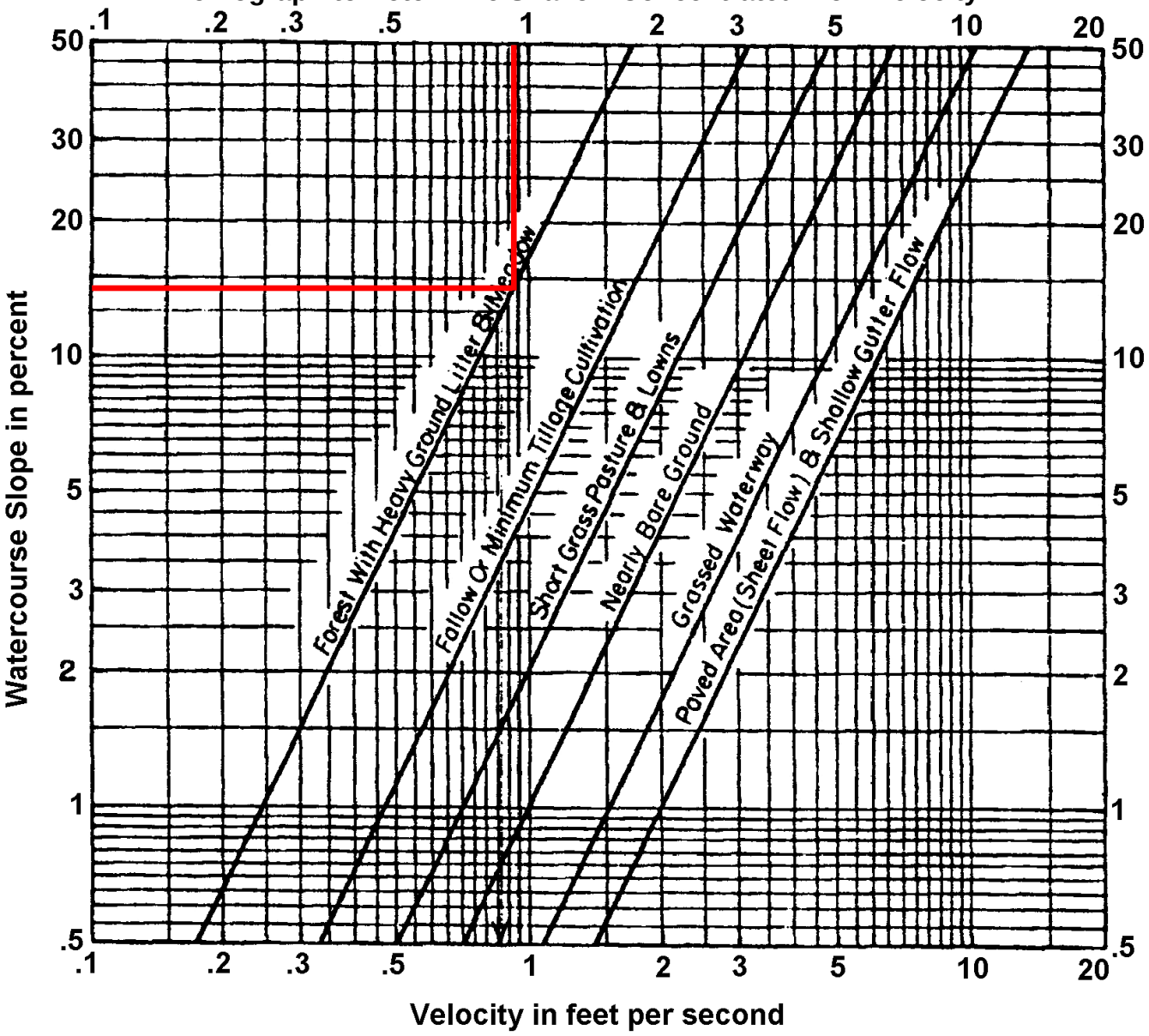
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.38_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.38_5
3.81 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.38_5	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.38_5	3023	FOREST	0.287	1.35	37.39

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
56.20

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.38_5	1	FOREST	0.20	3.81	0.76	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	56.20	1.45	1.80	2.15	1.45	1.80	2.15

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.80	3.81	1.10	1.37	1.64

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.38_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.81		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.37		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.87		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.06		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.90		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.65 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.65		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.82		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.71		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.029		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

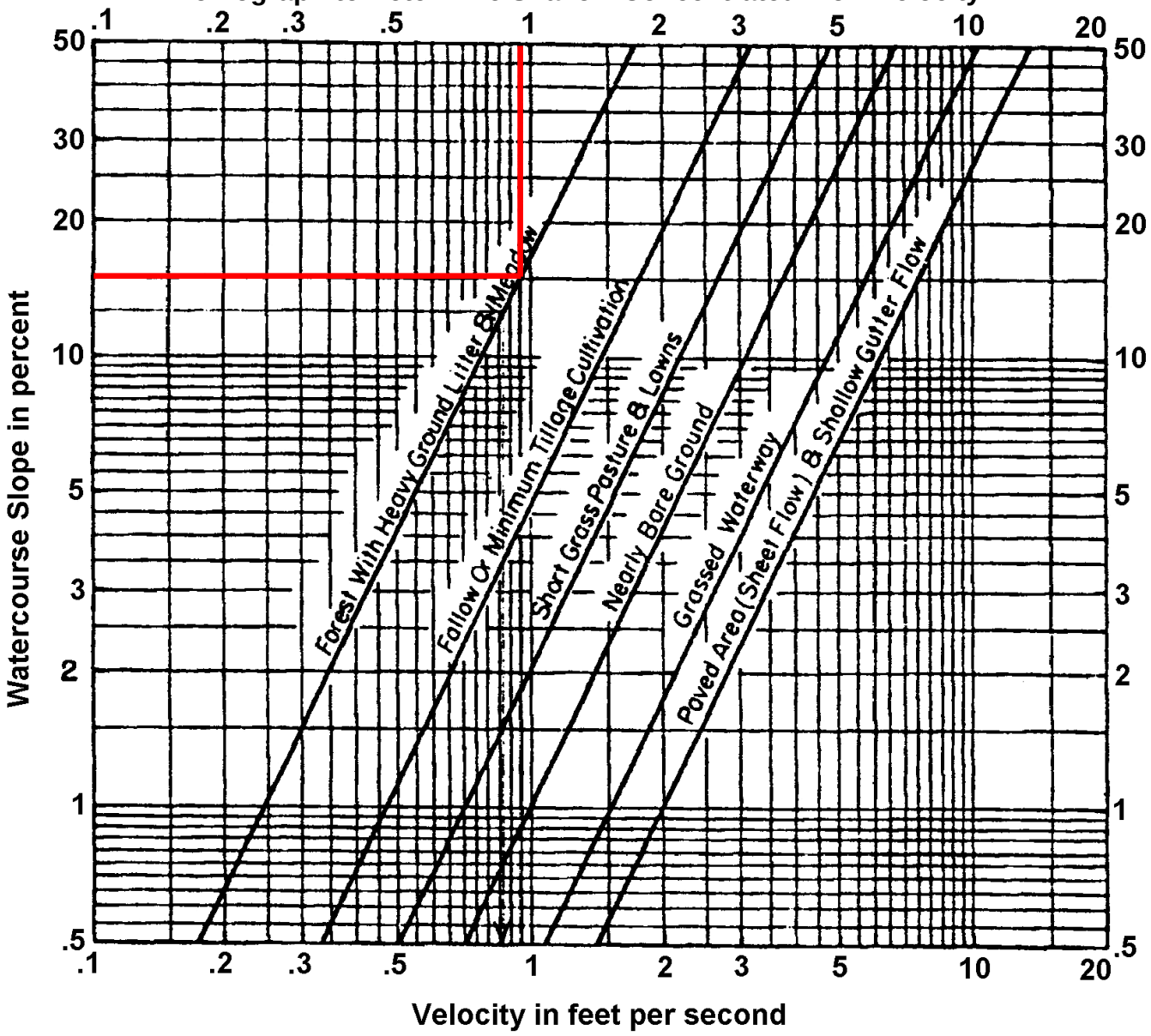
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.38_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.38_6
5 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.38_6	100	0.8	0.160	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.38_6	2689	FOREST	0.318	1.42	31.57

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
41.41

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.38_6	1	FOREST	0.20	5.00	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	41.41	1.81	2.23	2.64	1.81	2.23	2.64

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.23	5.00	1.81	2.23	2.64

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.38_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.24		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.56		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.30		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.06		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.60		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.034		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

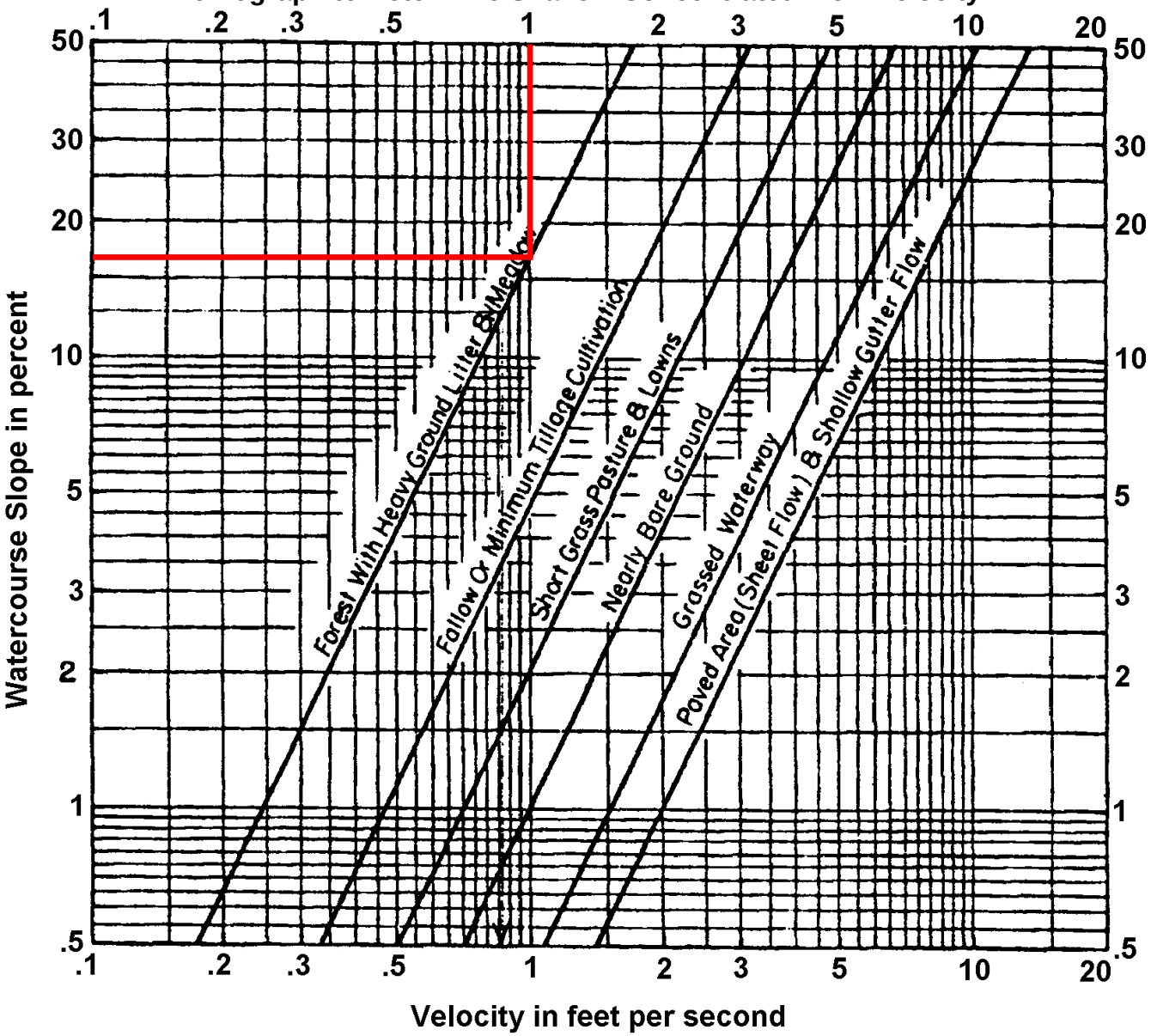
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.38_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.38_7
4.07 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.38_7	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.38_7	3039	FOREST	0.287	1.35	37.58

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
56.39

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.38_7	1	FOREST	0.20	4.07	0.81	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	56.39	1.44	1.79	2.14	1.44	1.79	2.14

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.79	4.07	1.18	1.46	1.74

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.38_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.07		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.46		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.64		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.76		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.44		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.60		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.014		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

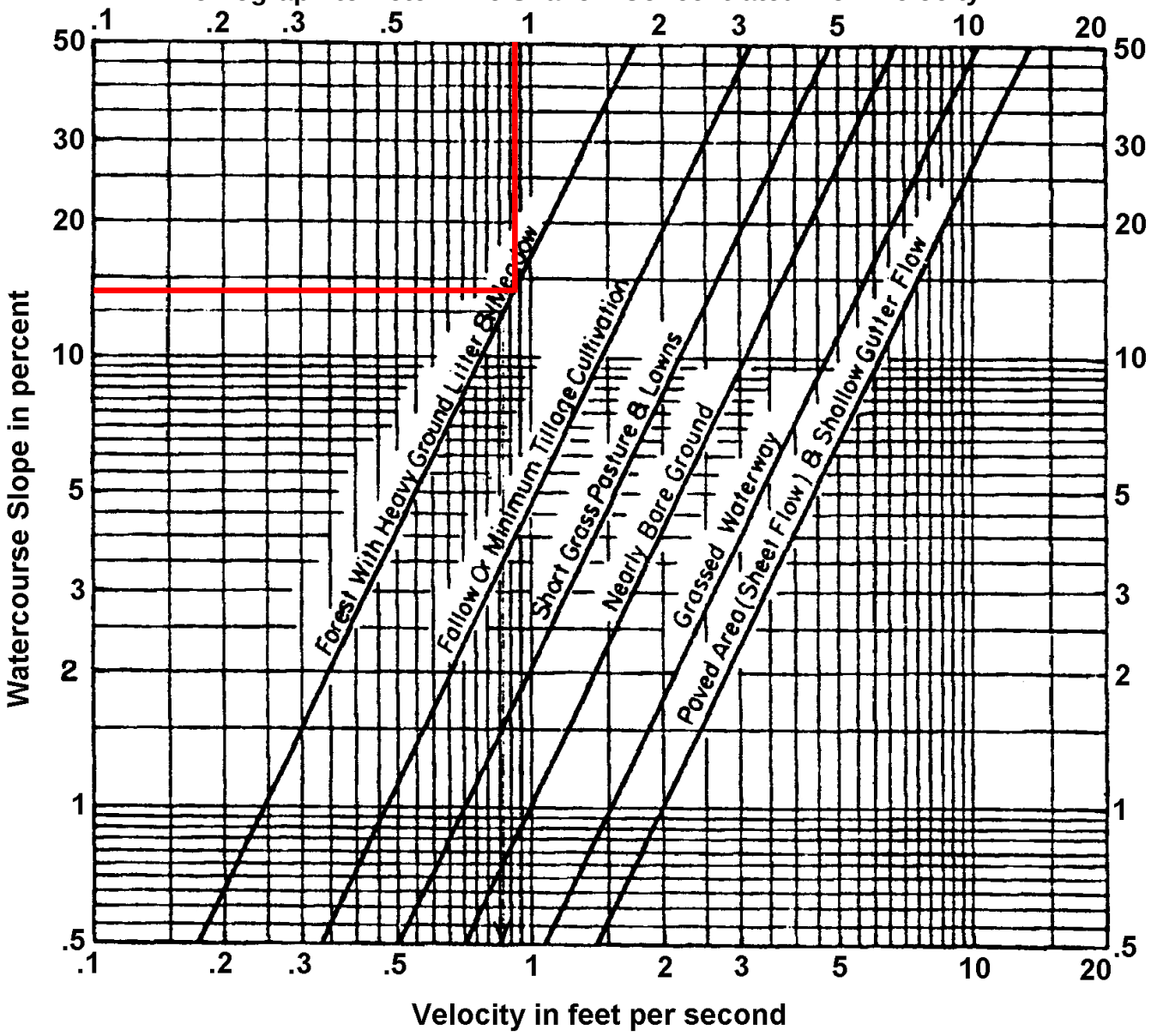
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.38_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.38_8
4.48 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.38_8	100	0.8	0.020	16.00

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.38_8	3058	FOREST	0.285	1.34	37.91

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.91

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.38_8	1	FOREST	0.20	4.48	0.90	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.91	1.49	1.85	2.21	1.49	1.85	2.21

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.85	4.48	1.34	1.66	1.98

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.38_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.48		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.66		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.05		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.24		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.59		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.05 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.05		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.53		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.63		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.019		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

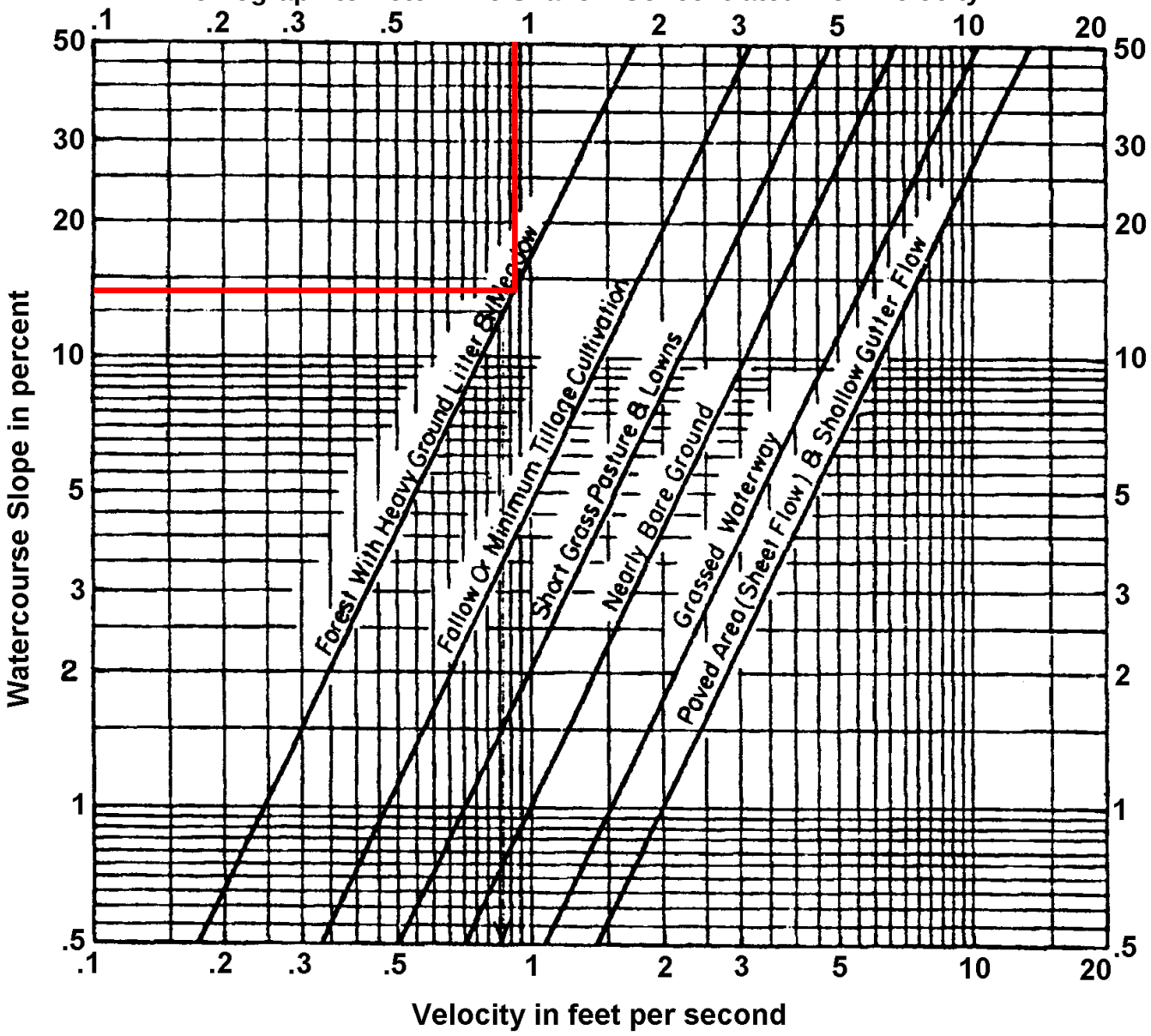
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.38_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

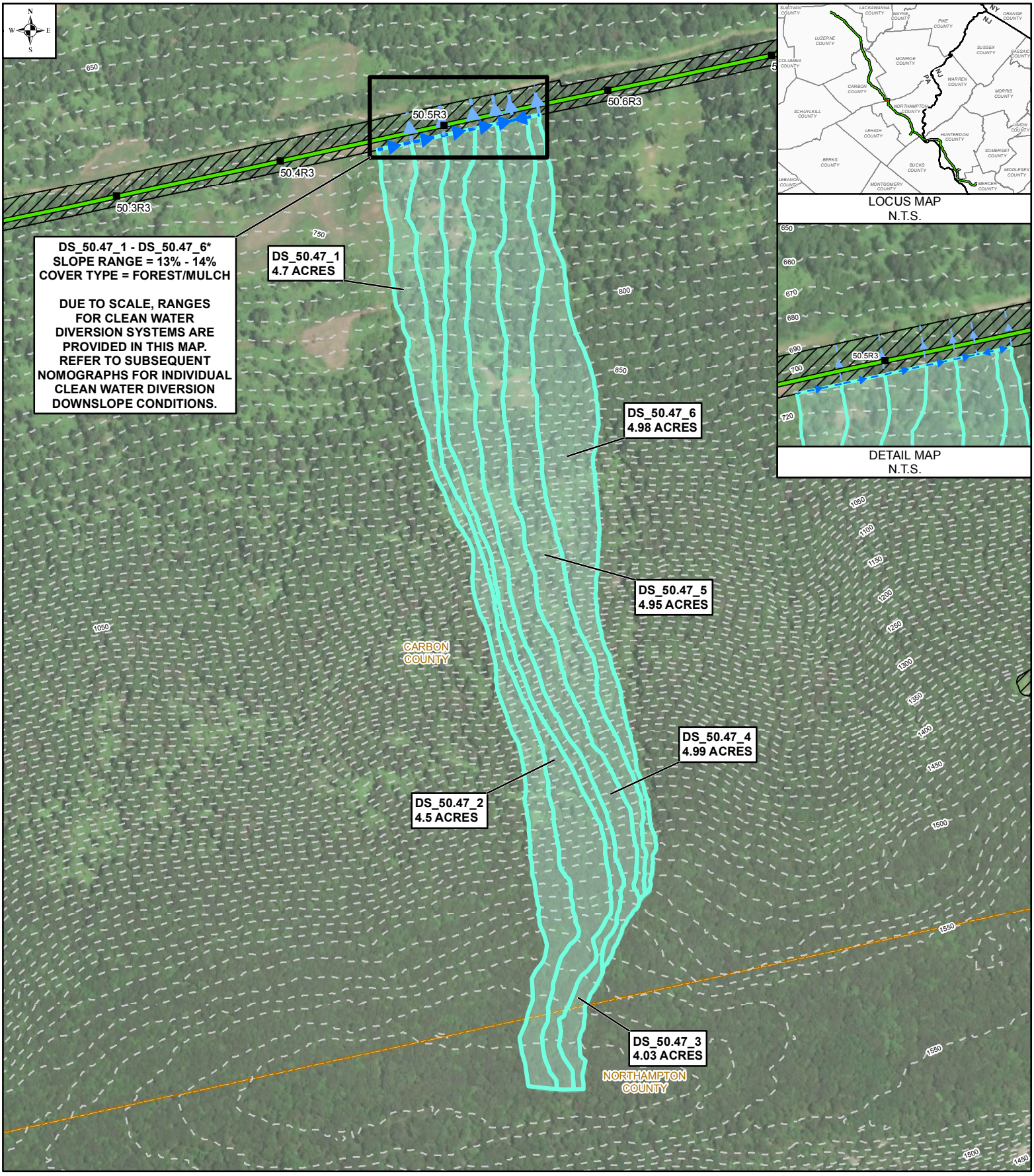


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.47

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 61 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.47_1
4.7 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.47_1	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.47_1	3077	FOREST	0.283	1.34	38.29

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
57.10

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.47_1	1	FOREST	0.20	4.70	0.94	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	57.10	1.43	1.77	2.12	1.43	1.77	2.12

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.77	4.70	1.34	1.67	2.00

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.47_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.7		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.67		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.63		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.96		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.87		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.32 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.32		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.66		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.66		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.028		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

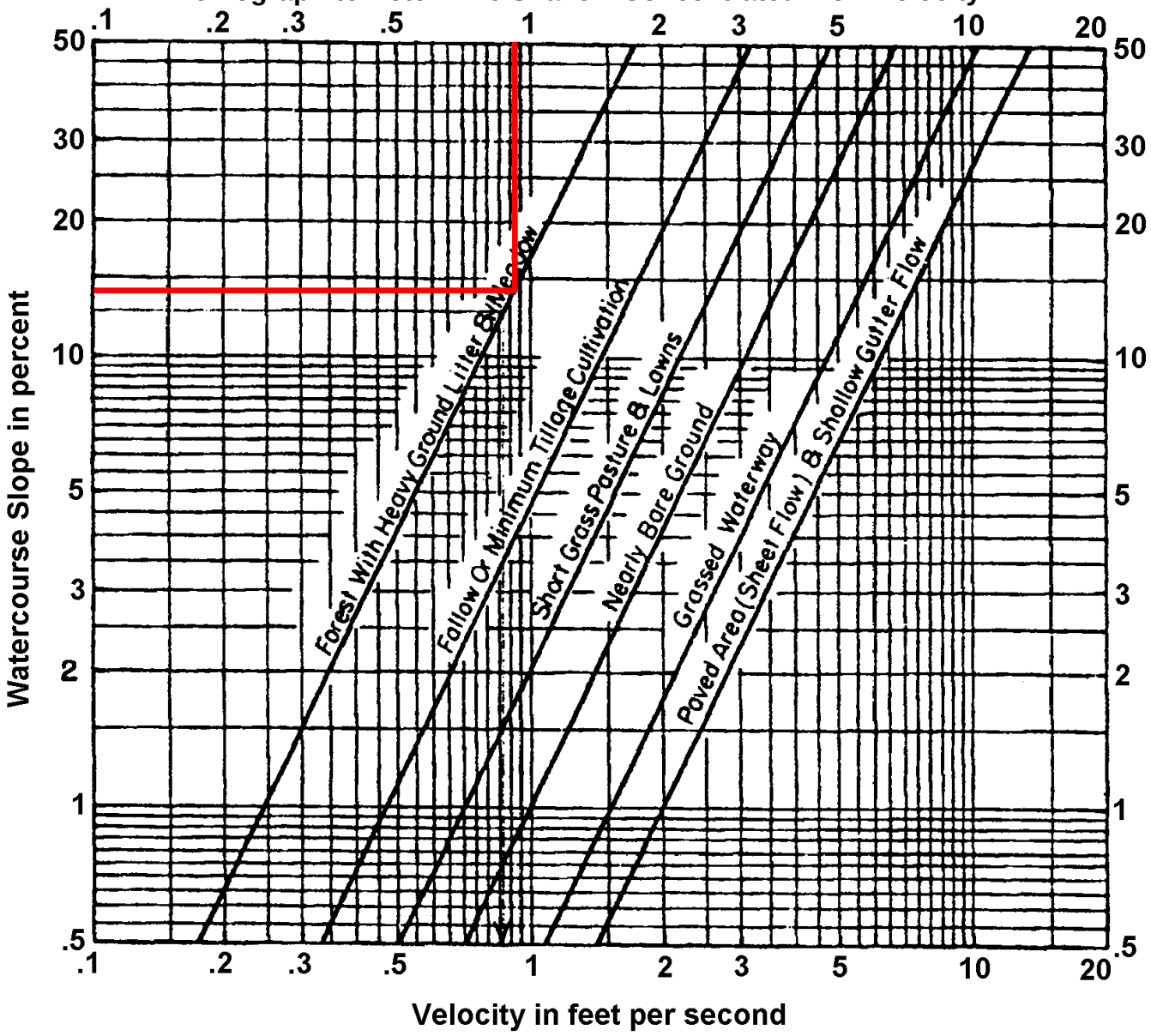
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.47_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.47_2
4.5 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.47_2	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.47_2	3132	FOREST	0.280	1.33	39.21

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
58.01

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.47_2	1	FOREST	0.20	4.50	0.90	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	58.01	1.41	1.75	2.10	1.41	1.75	2.10

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.75	4.50	1.27	1.58	1.89

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.47_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.5		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.58		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.30		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.65		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.19		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.68 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.68		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.84		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.71		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.038		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

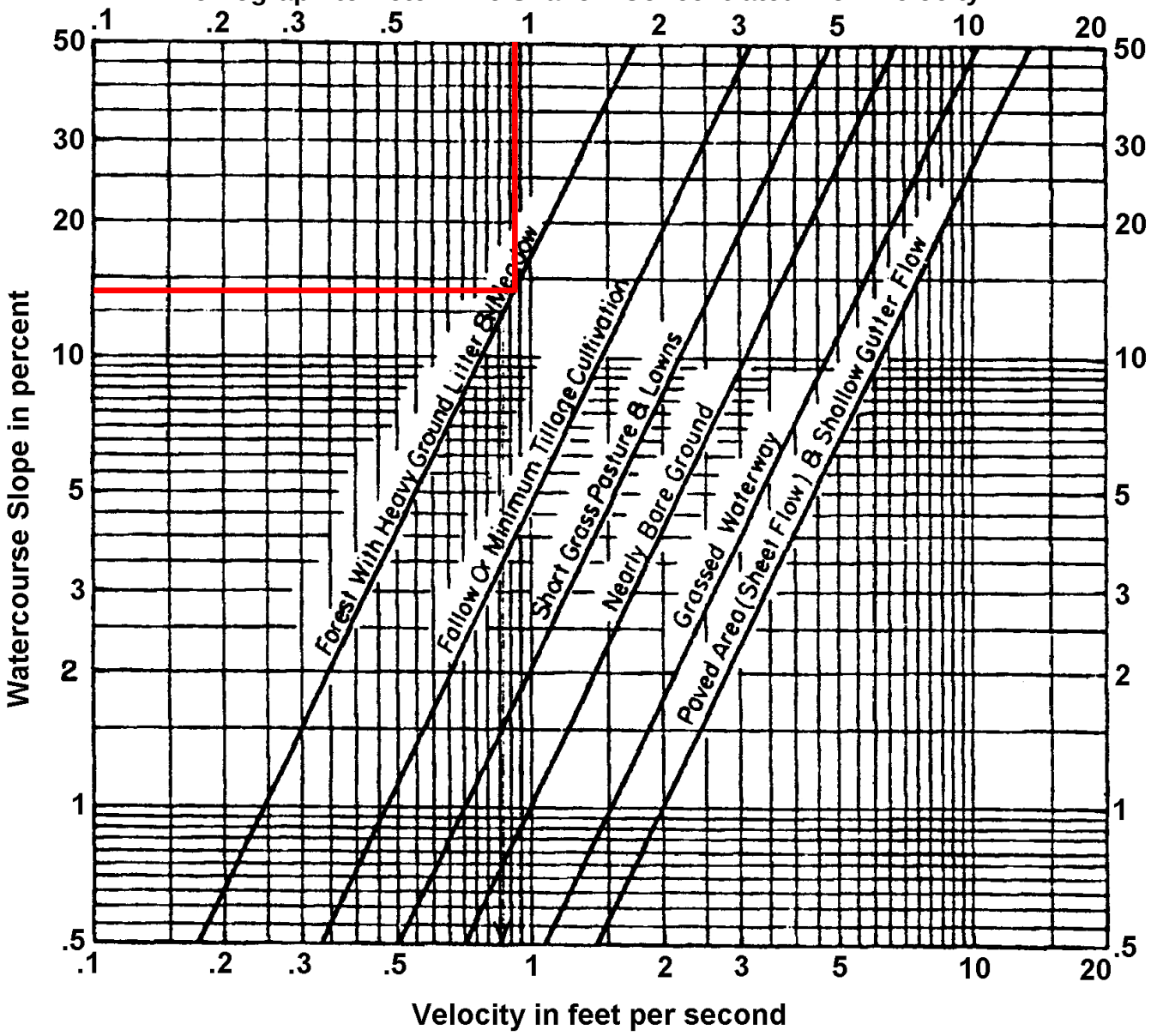
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.47_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.47_3
4.03 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.47_3	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.47_3	3199	FOREST	0.275	1.32	40.40

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
59.21

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.47_3	1	FOREST	0.20	4.03	0.81	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	59.21	1.39	1.73	2.07	1.39	1.73	2.07

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.73	4.03	1.12	1.39	1.67

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.47_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.03		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.39		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.40		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.91		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.85 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.85		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.92		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.73		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.088		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.114		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

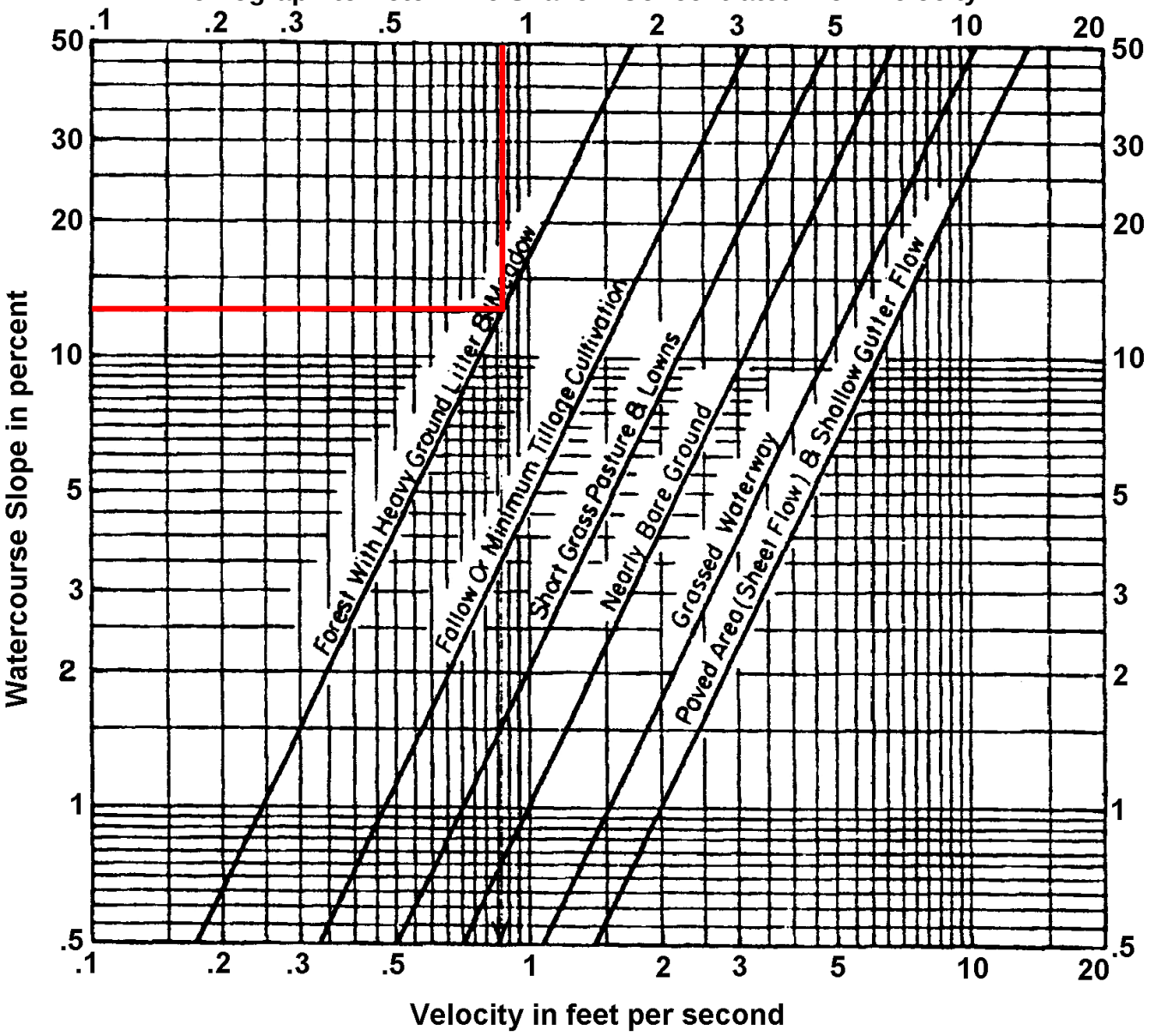
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.47_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.47_4
4.99 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.47_4	100	0.8	0.110	10.74

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.47_4	2793	FOREST	0.316	1.41	32.91

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
43.65

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.47_4	1	FOREST	0.20	4.99	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	43.65	1.75	2.15	2.55	1.75	2.15	2.55

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.15	4.99	1.74	2.15	2.55

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.47_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.99		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.15		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.27		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.63		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.06 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.06		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.03		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.76		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.055		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

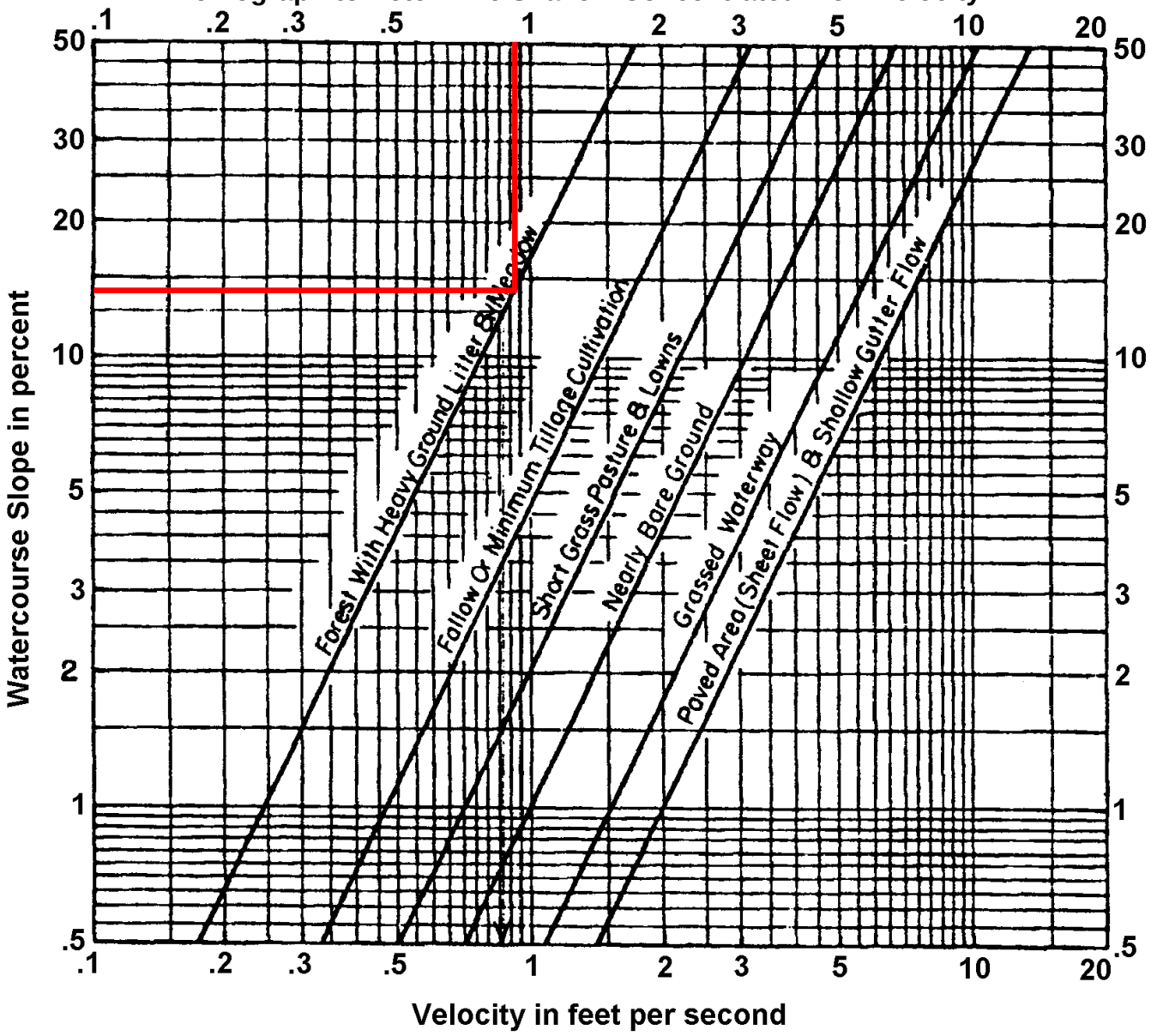
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.47_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.47_5
4.95 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.47_5	100	0.8	0.170	9.70

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.47_5	2564	FOREST	0.324	1.43	29.83

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
39.54

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.47_5	1	FOREST	0.20	4.95	0.99	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	39.54	1.87	2.31	2.72	1.87	2.31	2.72

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.31	4.95	1.86	2.28	2.69

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.47_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.95		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.28		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.98		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.20		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.97		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.68 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.68		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.84		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.71		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.031		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

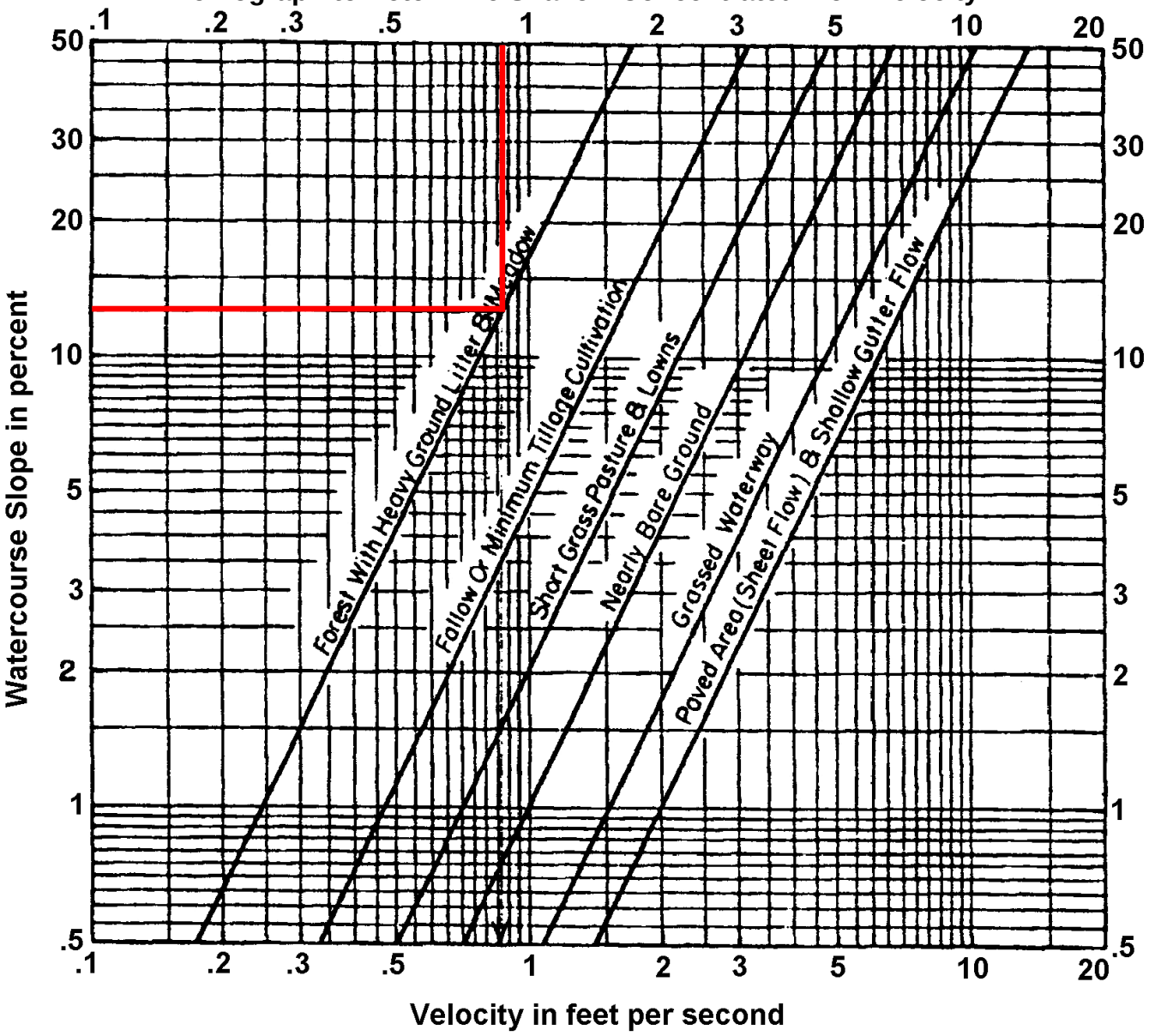
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.47_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.47_6
4.98 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.47_6	100	0.8	0.190	9.45

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.47_6	2536	FOREST	0.325	1.44	29.45

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
38.91

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.47_6	1	FOREST	0.20	4.98	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	38.91	1.90	2.33	2.75	1.90	2.33	2.75

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.33	4.98	1.89	2.32	2.74

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.47_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.98		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.32		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.19		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.44		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.59		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.17 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.17		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.09		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.77		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.051		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

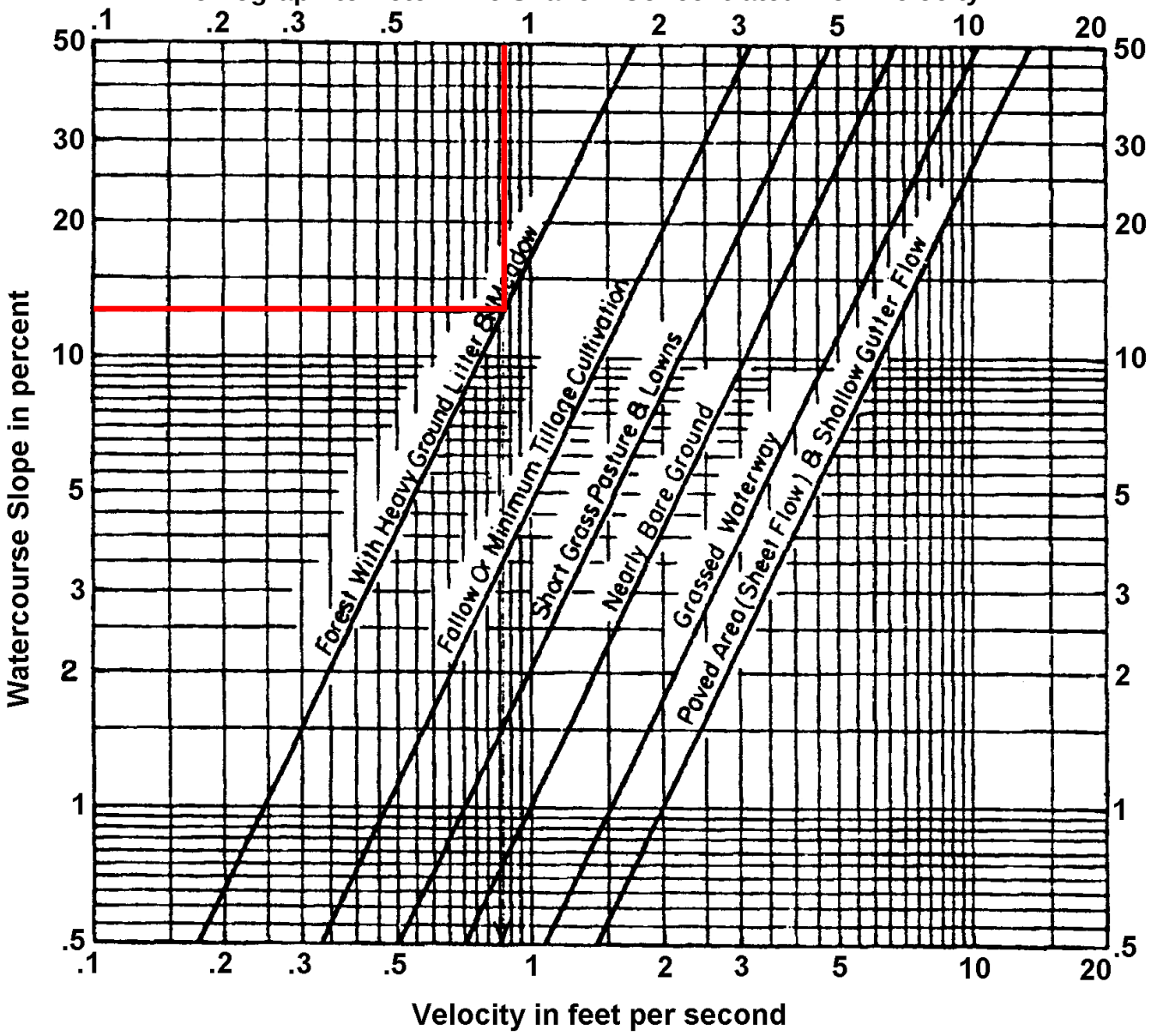
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.47_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

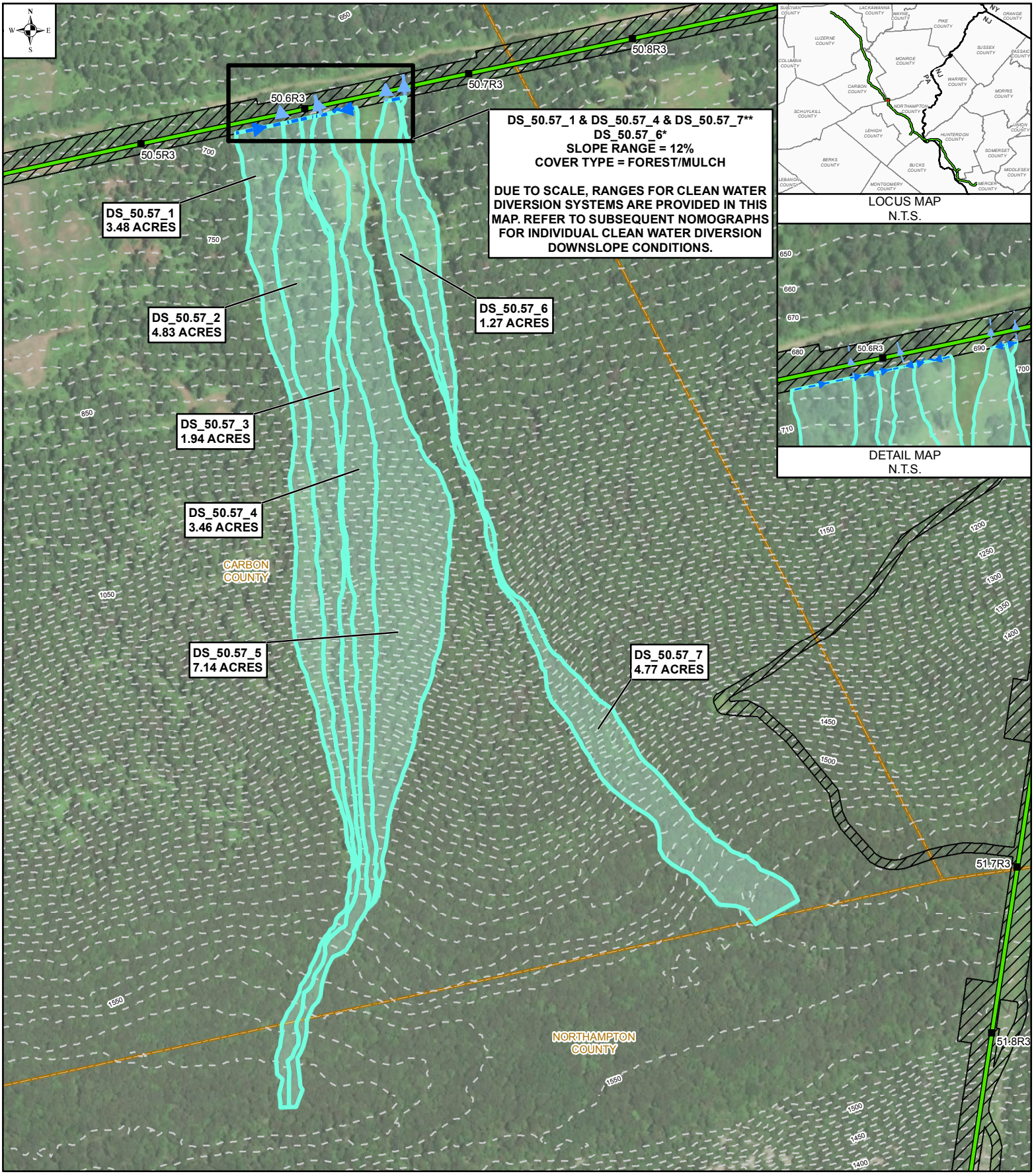


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.57

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 62 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.57_1
3.48 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.57_1	100	0.8	0.270	8.71

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.57_1	2384	FOREST	0.335	1.46	27.30

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
36.00

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.57_1	1	FOREST	0.20	3.48	0.70	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	36.00	2.00	2.45	2.88	2.00	2.45	2.88

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.45	3.48	1.39	1.71	2.01

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.57_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.48		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.71		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.37		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.48		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.75 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.75		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.88		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.97		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.57_2
4.83 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.57_2	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.57_2	3227	FOREST	0.276	1.32	40.68

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
59.49

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.57_2	1	FOREST	0.20	4.83	0.97	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	59.49	1.39	1.72	2.06	1.39	1.72	2.06

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.72	4.83	1.34	1.66	1.99

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.57_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.83		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.66		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.44		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.22		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.06 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.06		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.03		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.76		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.018		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.57_3
1.94 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.57_3	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.57_3	3232	FOREST	0.276	1.32	40.78

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
59.58

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.57_3	1	FOREST	0.20	1.94	0.39	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	59.58	1.38	1.72	2.06	1.38	1.72	2.06

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.72	1.94	0.54	0.67	0.80

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.57_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.94		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.67		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.79		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.96		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.3 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.30		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.65		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.91		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.084		
$.7S_c$	(FT/FT)	0.059		
$1.3S_c$	(FT/FT)	0.109		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.57_4
3.46 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.57_4	100	0.8	0.170	9.70

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.57_4	2549	FOREST	0.324	1.43	29.68

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
39.38

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.57_4	1	FOREST	0.20	3.46	0.69	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	39.38	1.88	2.31	2.73	1.88	2.31	2.73

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.31	3.46	1.30	1.60	1.89

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.57_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.46		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.6		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.17		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.90		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.49 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.49		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.25		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.81		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.026		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.57_5
7.14 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.57_5	100	0.8	0.160	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.57_5	3245	FOREST	0.254	1.27	42.66

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
52.50

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.57_5	1	FOREST	0.20	7.14	1.43	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	52.50	1.53	1.89	2.25	1.53	1.89	2.25

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.89	7.14	2.18	2.70	3.22

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.57_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	7.14		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.7		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	4.44		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.38		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.45 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	9.68		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.45		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	3.23		
R (HYDRAULIC RADIUS)		0.43		
S (BED SLOPE)[3, 7]	(FT/FT)	0.013		
S_C (CRITICAL SLOPE)	(FT/FT)	0.110		
$.7S_c$	(FT/FT)	0.077		
$1.3S_c$	(FT/FT)	0.144		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.57_6
1.25 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.57_6	100	0.8	0.240	8.95

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.57_6	933	FOREST	0.212	1.16	13.42

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
22.37

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.57_6	1	FOREST	0.20	1.27	0.25	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	22.37	2.69	3.26	3.75	2.69	3.26	3.75

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.26	1.27	0.68	0.83	0.95

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.57_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.25		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.78		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.74		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.95		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.14 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.14		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.57		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.89		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.084		
$.7S_c$	(FT/FT)	0.059		
$1.3S_c$	(FT/FT)	0.109		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

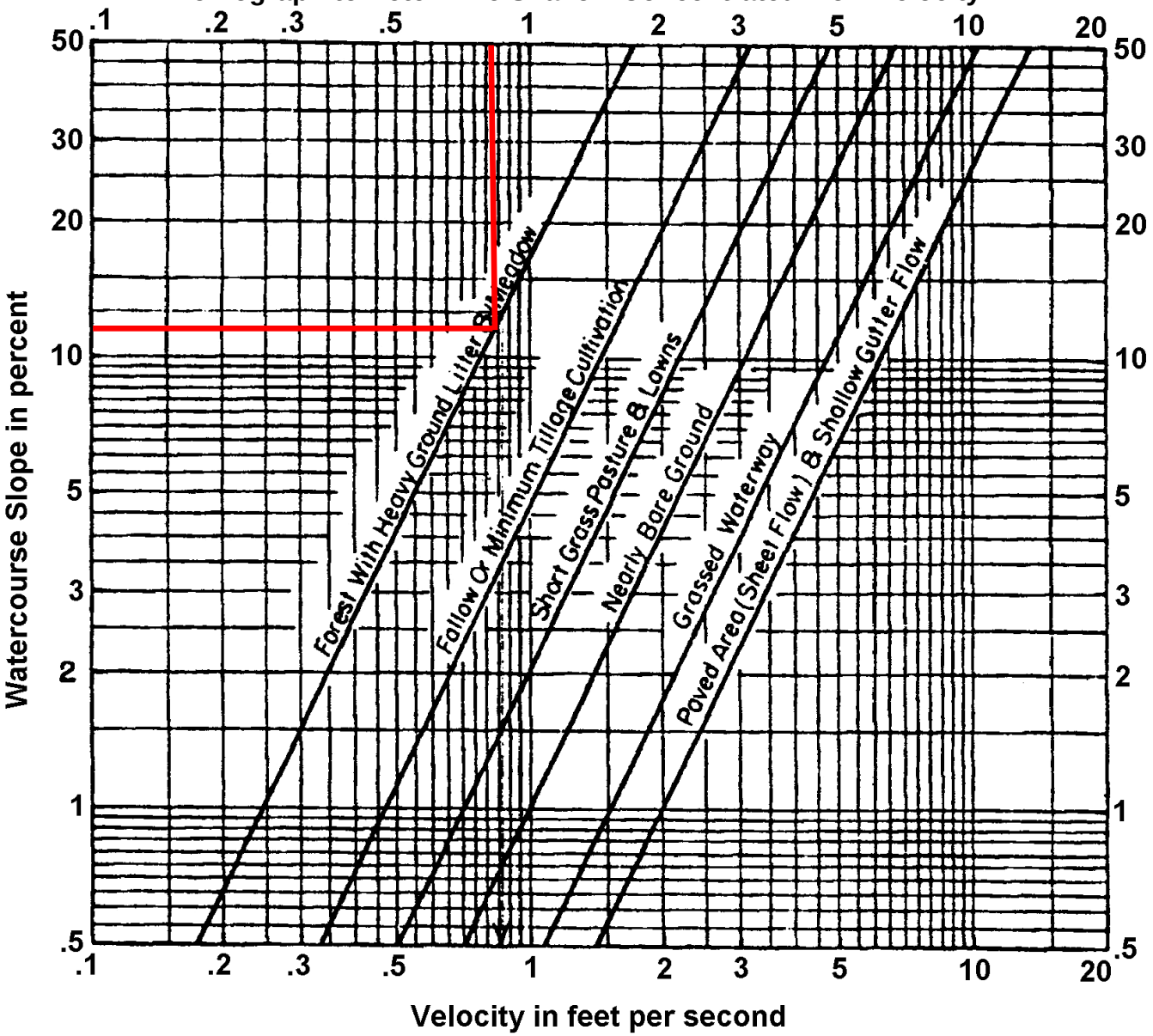
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.57_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 12%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.57_7
4.77 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.57_7	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.57_7	2910	FOREST	0.299	1.37	35.28

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
54.08

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.57_7	1	FOREST	0.20	4.77	0.95	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	54.08	1.49	1.85	2.21	1.49	1.85	2.21

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.85	4.77	1.42	1.76	2.10

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

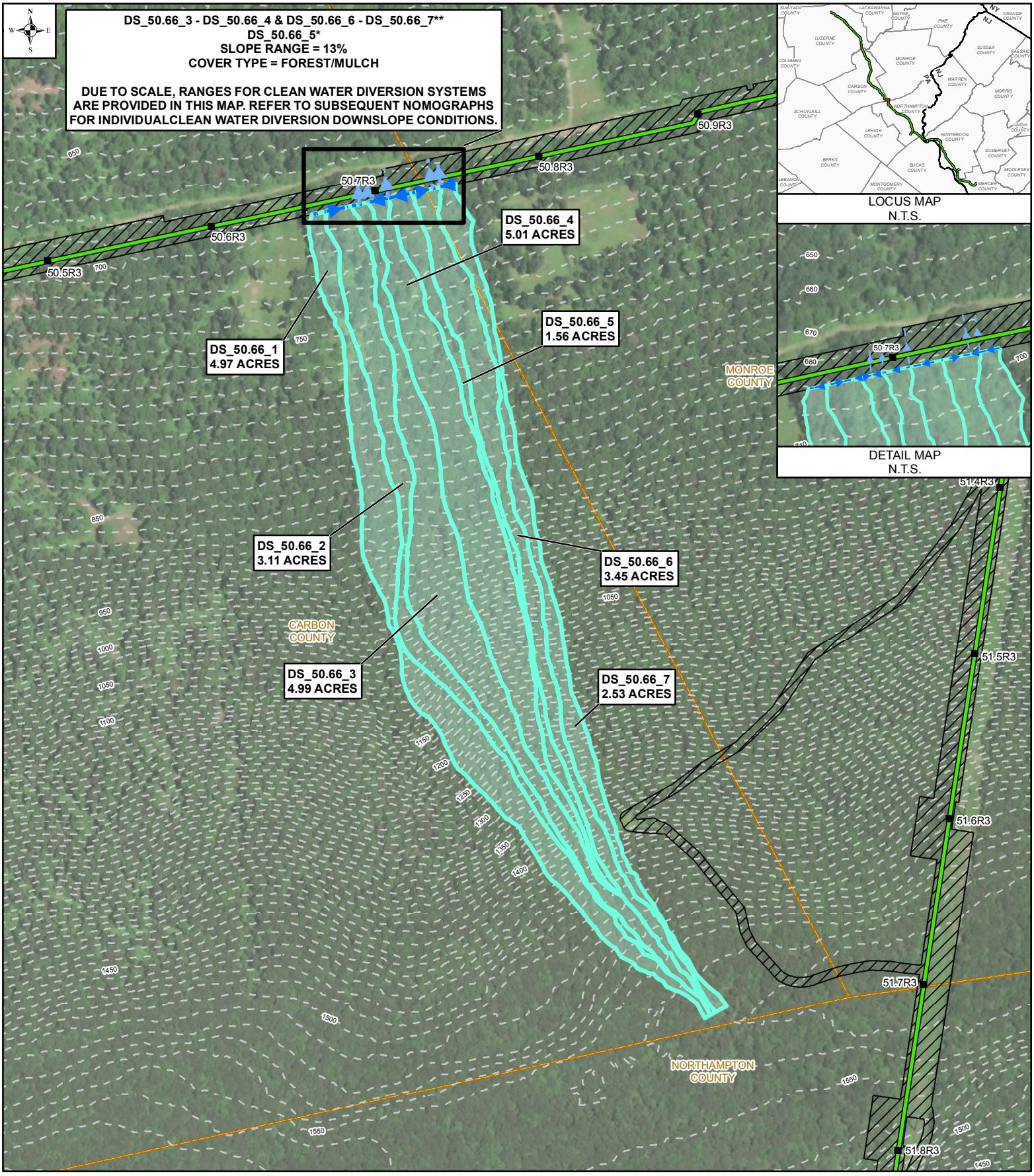
LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.57_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.77		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.76		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.61		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.08		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.50		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.8 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.80		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.40		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.85		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.016		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_50.66

CARBON & MONROE COUNTIES, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 63 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.66_1
4.97 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.66_1	100	0.8	0.040	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.66_1	3001	FOREST	0.292	1.36	36.82

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
50.42

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.66_1	1	FOREST	0.20	4.97	0.99	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	50.42	1.57	1.94	2.32	1.57	1.94	2.32

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.94	4.97	1.56	1.93	2.30

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.66_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.97		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.93		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.76		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.48		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.06		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.71 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.71		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.36		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.84		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.034		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.66_2
3.11 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.66_2	100	0.8	0.120	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.66_2	2778	FOREST	0.311	1.40	33.00

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
43.52

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.66_2	1	FOREST	0.20	3.11	0.62	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	43.52	1.75	2.16	2.56	1.75	2.16	2.56

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.16	3.11	1.09	1.34	1.59

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.66_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.11		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.34		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.42		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.63		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.50		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.87		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.023		
S_C (CRITICAL SLOPE)	(FT/FT)	0.070		
$.7S_c$	(FT/FT)	0.049		
$1.3S_c$	(FT/FT)	0.091		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.66_3
4.99 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.66_3	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.66_3	2880	FOREST	0.303	1.39	34.65

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
47.56

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.66_3	1	FOREST	0.20	4.99	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	47.56	1.64	2.03	2.41	1.64	2.03	2.41

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.03	4.99	1.64	2.02	2.40

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.66_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.99		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.02		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.06		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.45		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.09 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.09		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.55		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.89		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.66_4
5.01 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.66_4	100	0.8	0.300	8.50

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.66_4	2391	FOREST	0.338	1.46	27.26

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
35.76

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.66_4	1	FOREST	0.20	5.01	1.00	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	35.76	2.01	2.47	2.89	2.01	2.47	2.89

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.47	5.01	2.01	2.47	2.90

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.66_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.01		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.47		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.49		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.97		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.47		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.71 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.71		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.36		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.84		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.015		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.66_5
1.56 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.66_5	100	0.8	0.330	8.31

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.66_5	2366	FOREST	0.340	1.47	26.87

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
35.18

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.66_5	1	FOREST	0.20	1.56	0.31	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	35.18	2.03	2.49	2.92	2.03	2.49	2.92

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.49	1.56	0.63	0.78	0.91

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.66_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.56		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.78		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.30		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.56		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.67 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.67		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.33		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.83		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.026		
S_C (CRITICAL SLOPE)	(FT/FT)	0.085		
$.7S_c$	(FT/FT)	0.060		
$1.3S_c$	(FT/FT)	0.111		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

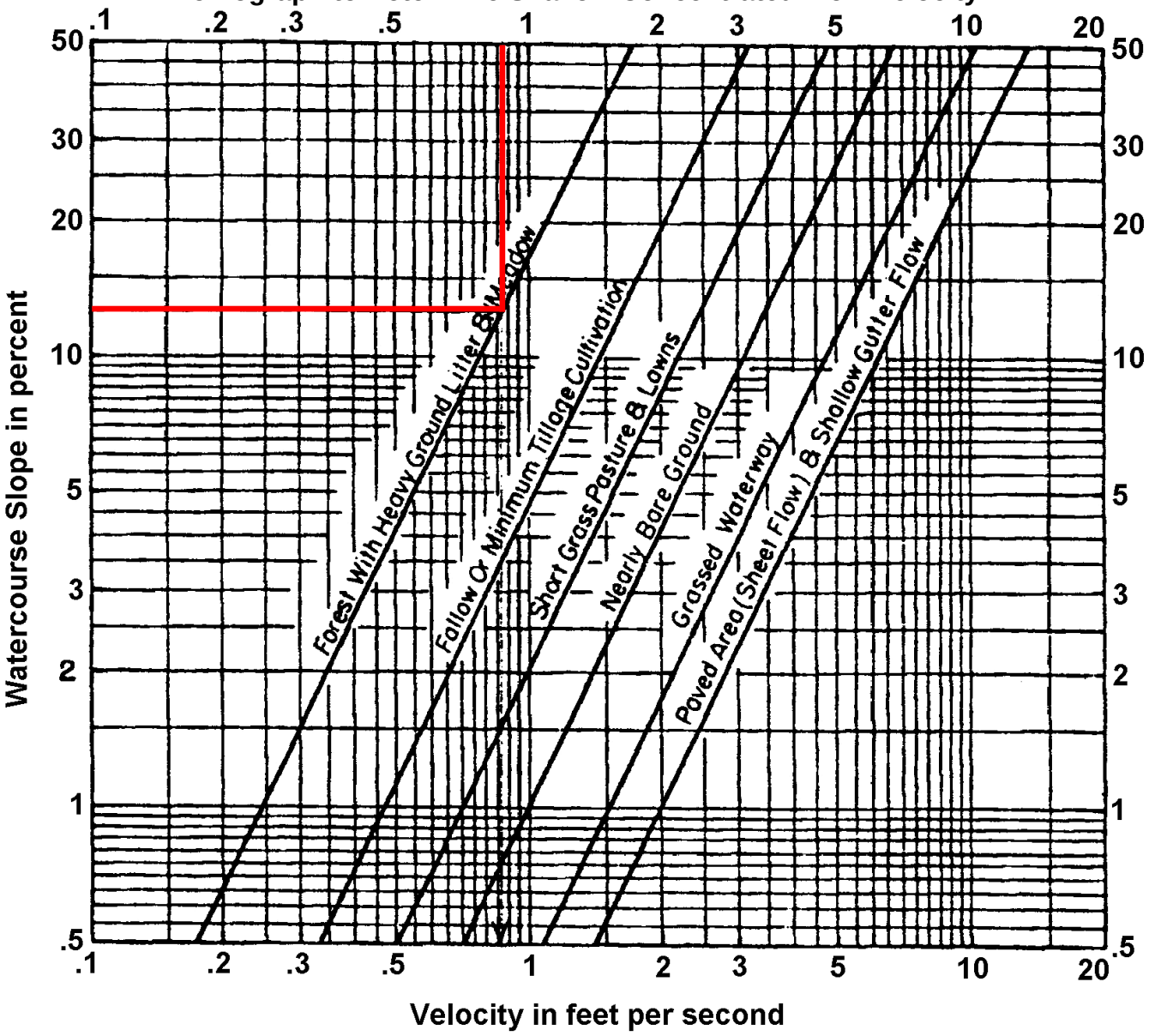
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_50.66_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_50.66_6
3.45 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON & MONROE COUNTIES
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 50.66_6	100	0.8	0.040	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 50.66_6	2824	FOREST	0.309	1.40	33.66

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
47.27

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON & MONROE COUNTIES
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 50.66_6	1	FOREST	0.20	3.45	0.69	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	47.27	1.65	2.04	2.42	1.65	2.04	2.42

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.04	3.45	1.14	1.41	1.67

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

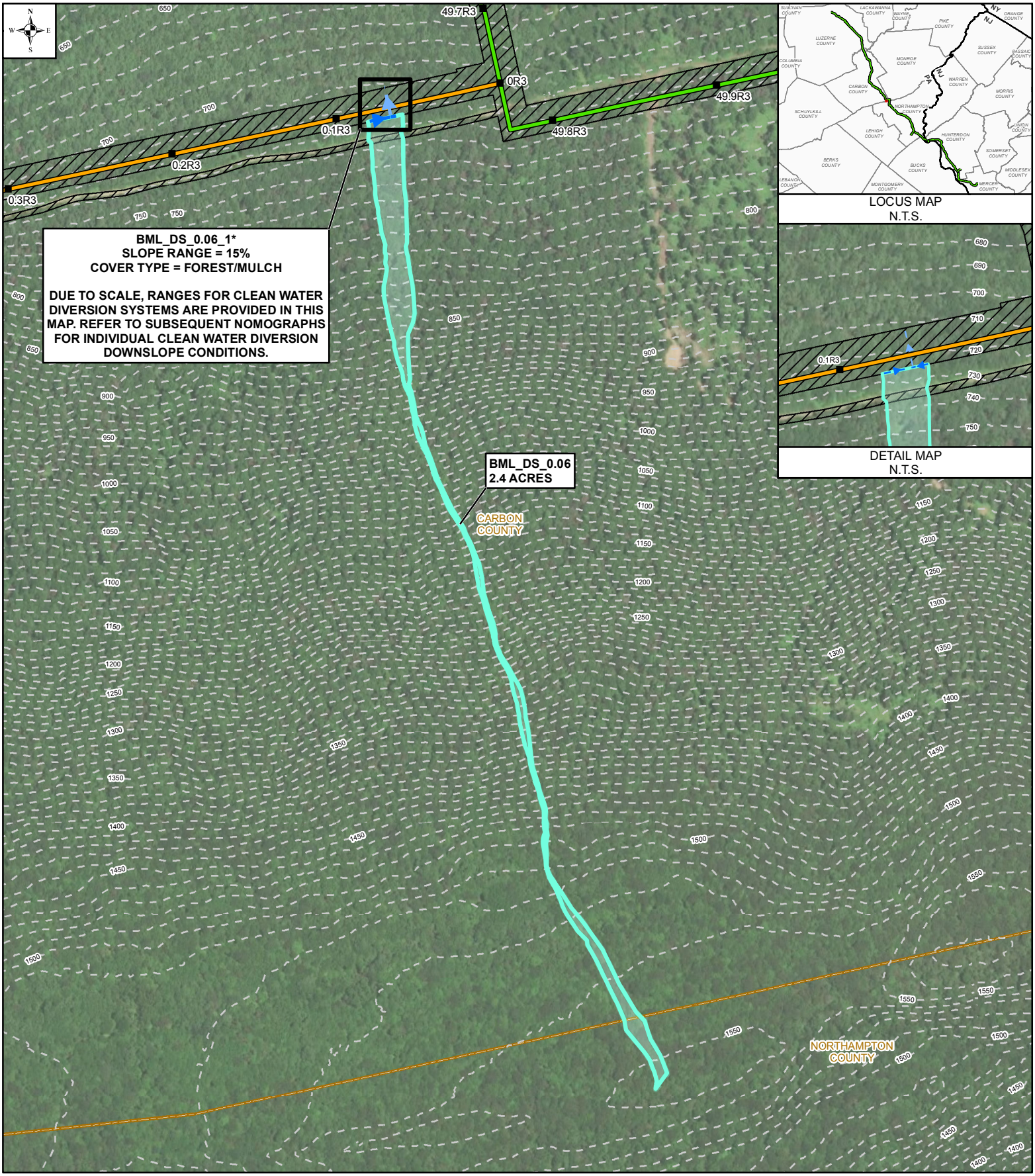
LOCATION: CARBON & MONROE COUNTIES

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_50.66_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.45		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.41		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.42		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.57		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.34		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.52 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.52		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.76		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.94		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.011		
S_C (CRITICAL SLOPE)	(FT/FT)	0.013		
$.7S_c$	(FT/FT)	0.009		
$1.3S_c$	(FT/FT)	0.017		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_BML_0.06

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 108 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.06	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.06	3140	FOREST	0.260	1.28	40.79

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
51.77

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.06	1	FOREST	0.20	2.40	0.48	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	51.77	1.54	1.91	2.27	1.54	1.91	2.27

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.91	2.40	0.74	0.92	1.09

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.06		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.4		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.916		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.57		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.14		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.088		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.114		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

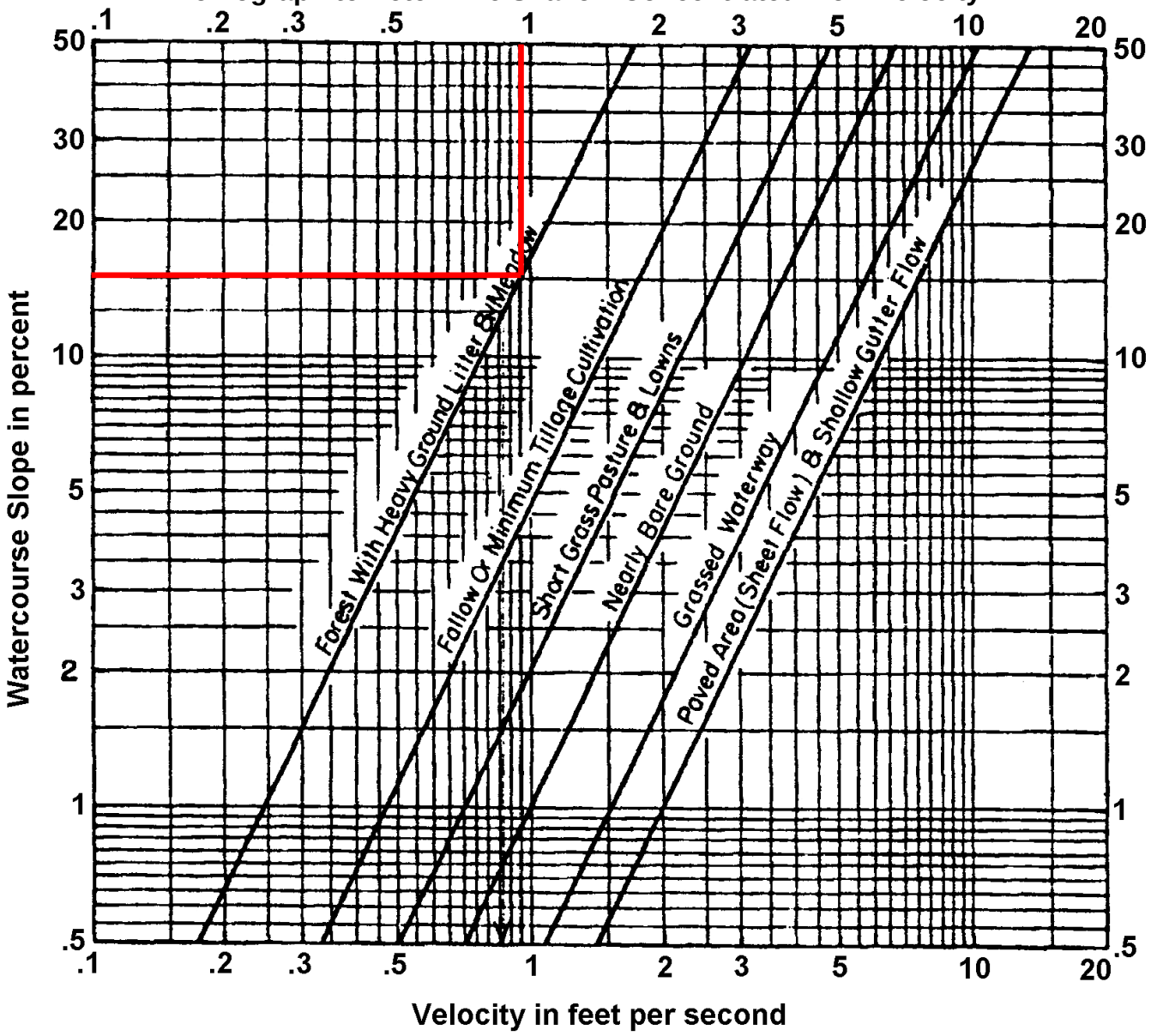
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.06

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

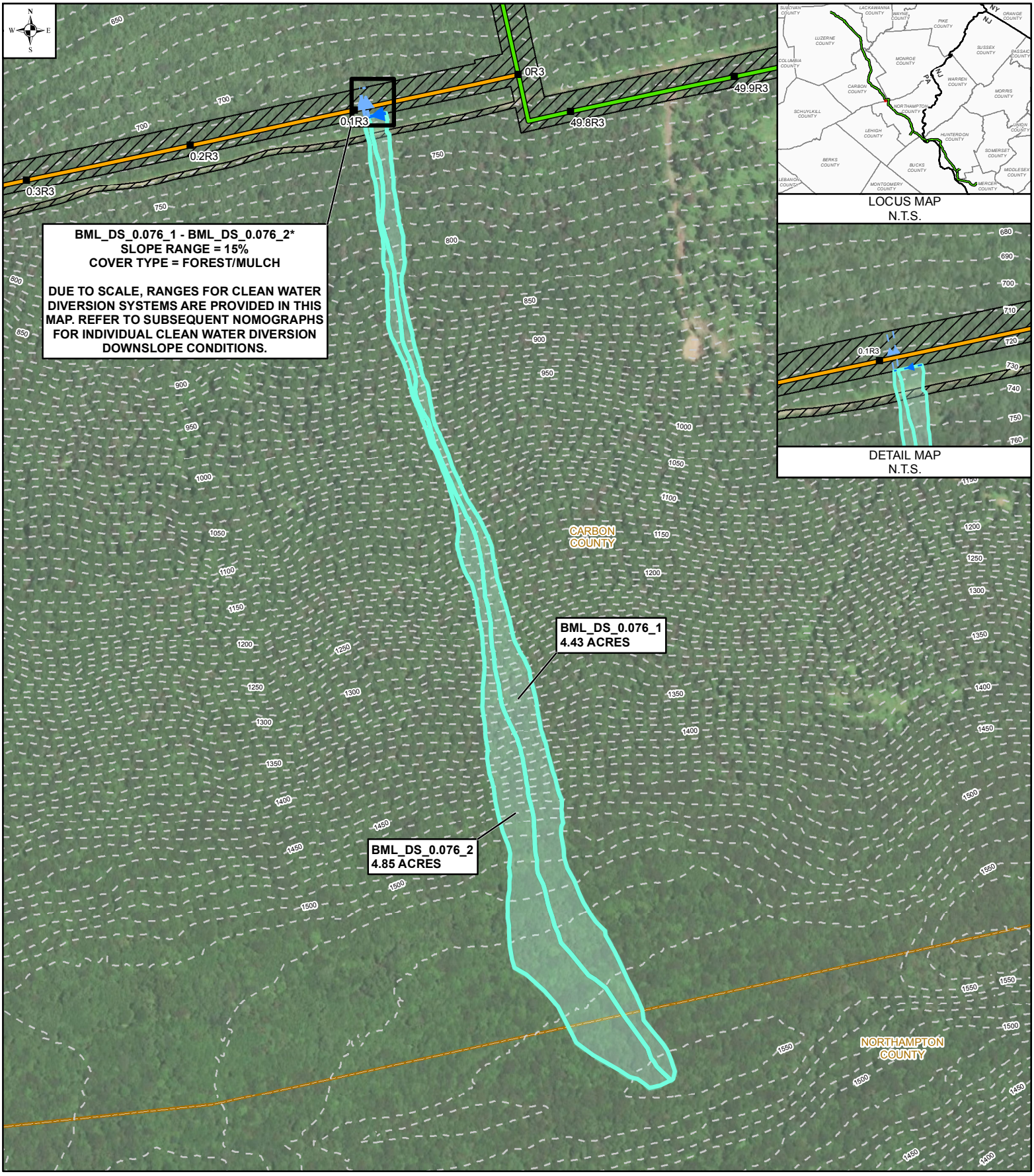


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_BML_0.076

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 400 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 109 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.076_1
4.43 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.076_1	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.076_1	3162	FOREST	0.260	1.28	41.08

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
52.06

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.076_1	1	FOREST	0.20	4.43	0.89	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	52.06	1.53	1.90	2.26	1.53	1.90	2.26

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.90	4.43	1.36	1.68	2.01

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.076_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.43		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.68		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.49		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.39		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

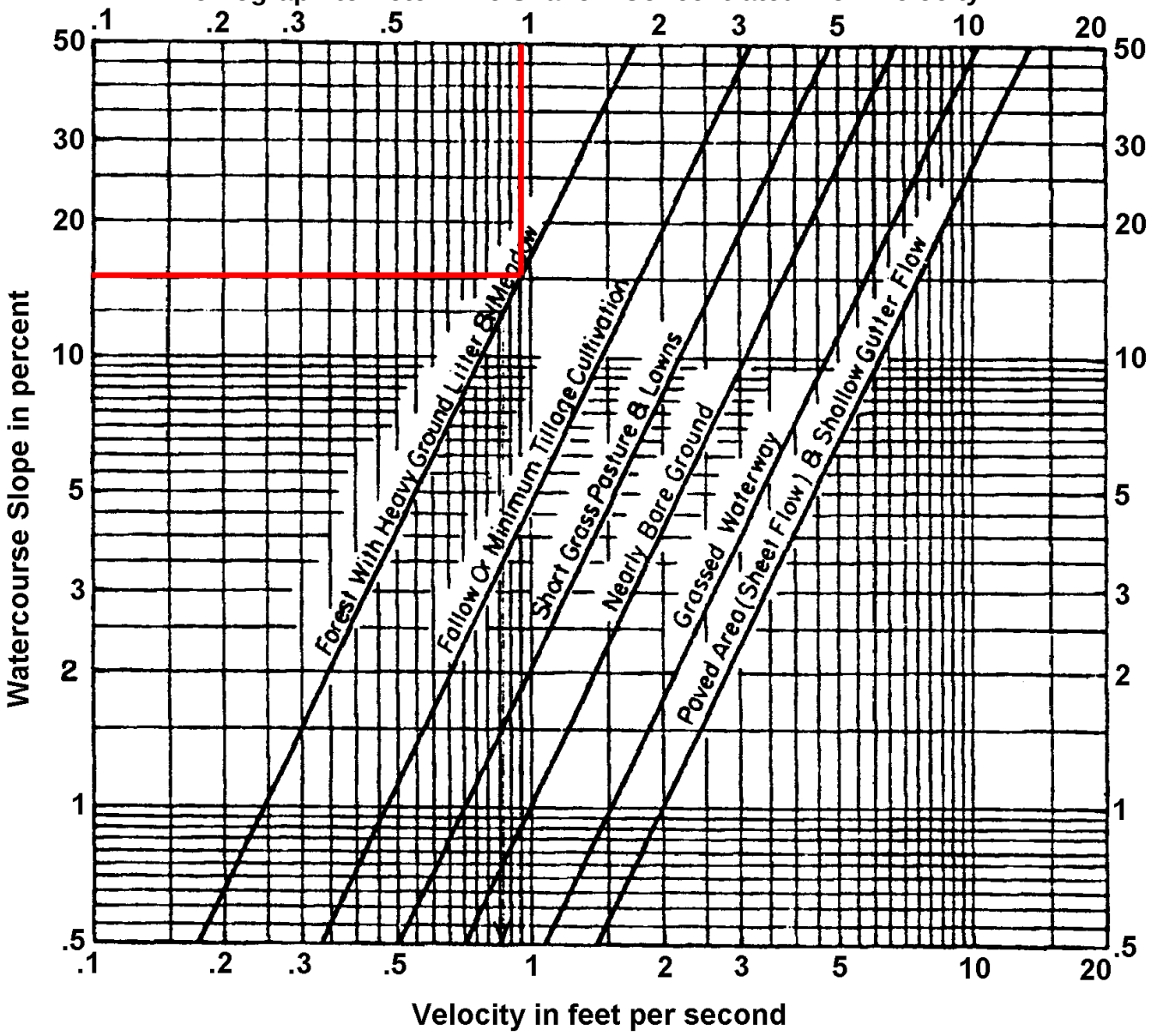
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.076_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.076_2
4.85 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.076_2	100	0.8	0.090	11.26

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.076_2	3242	FOREST	0.250	1.26	42.95

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
54.21

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.076_2	1	FOREST	0.20	4.85	0.97	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	54.21	1.49	1.84	2.20	1.49	1.84	2.20

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.84	4.85	1.44	1.79	2.14

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.076_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.85		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.79		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.76		
PROTECTIVE LINING[2,6]		EXISTING GRASS		
n (MANNING'S COEFFICIENT)[2]		0.07		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.20		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.25 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	9.38		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	6.25		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	3.13		
R (HYDRAULIC RADIUS)		0.43		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.111		
$.7S_c$	(FT/FT)	0.078		
$1.3S_c$	(FT/FT)	0.145		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

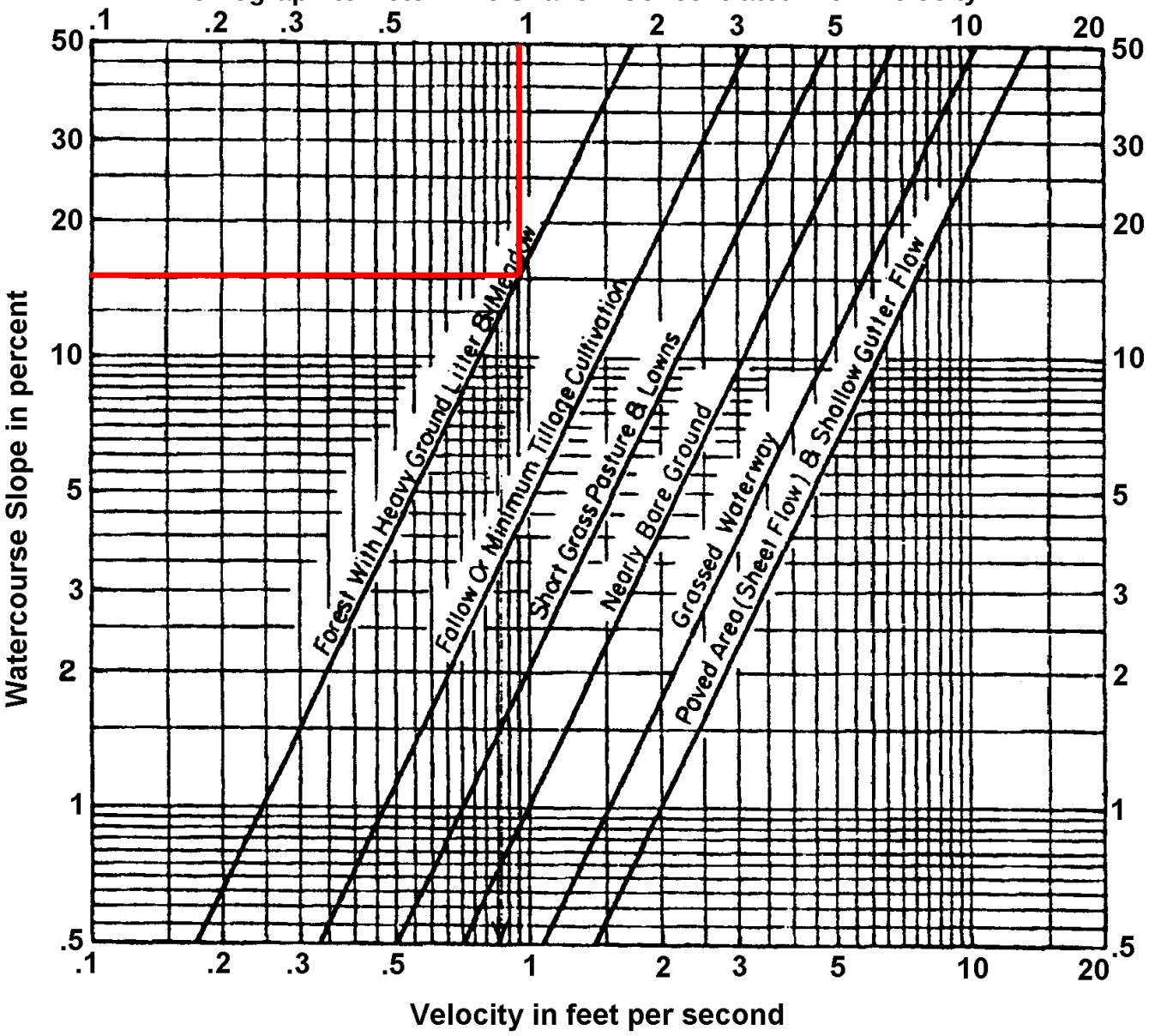
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.076_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

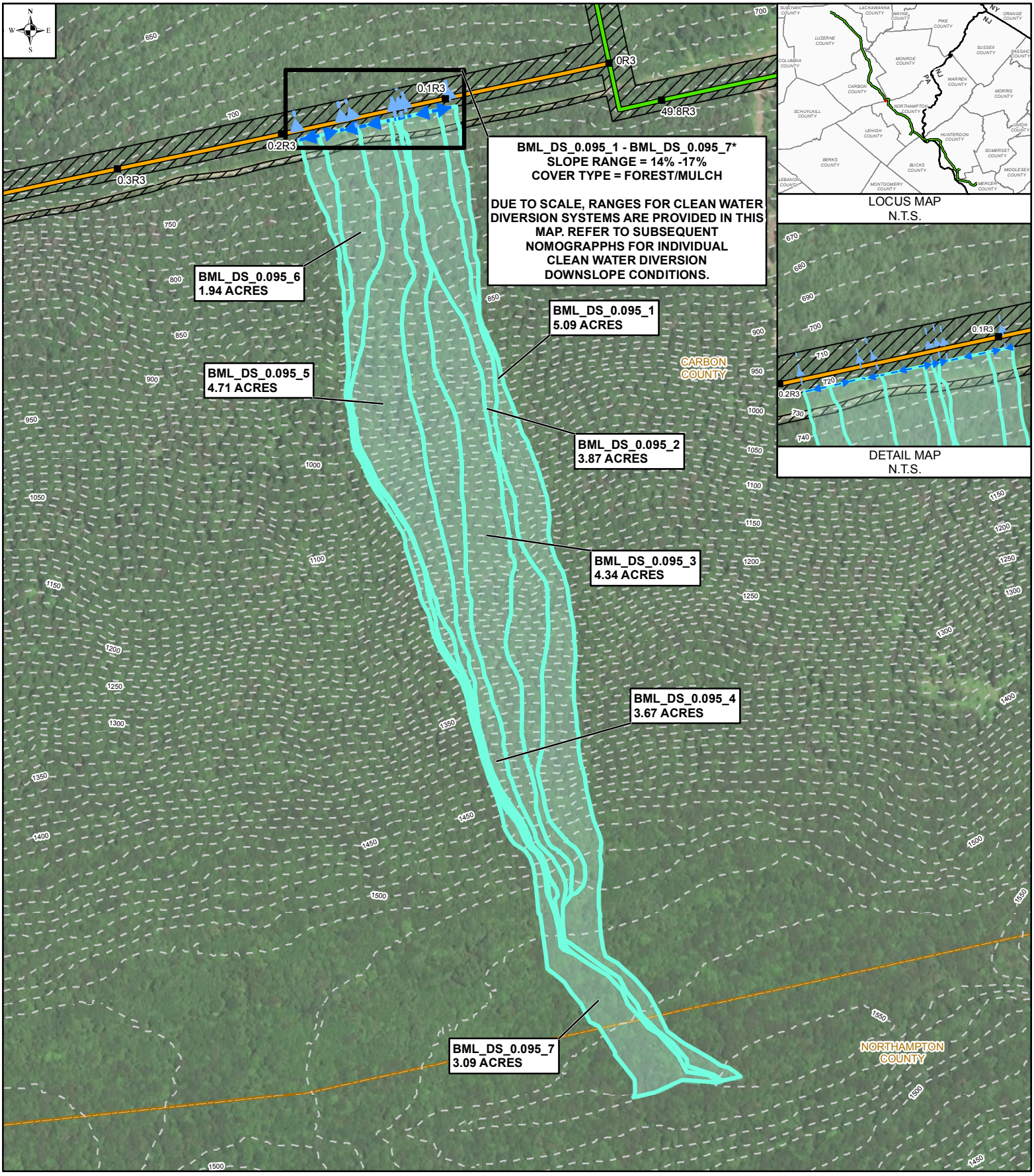


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_BML_0.095

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 400 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 110 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.095_1
5.09 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.095_1	100	0.8	0.080	11.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.095_1	3343	FOREST	0.250	1.26	44.29

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
55.86

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.095_1	1	FOREST	0.20	5.09	1.02	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	55.86	1.45	1.80	2.16	1.45	1.80	2.16

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.80	5.09	1.48	1.84	2.19

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.095_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.09		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.84		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.74		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.08		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.40		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.045		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

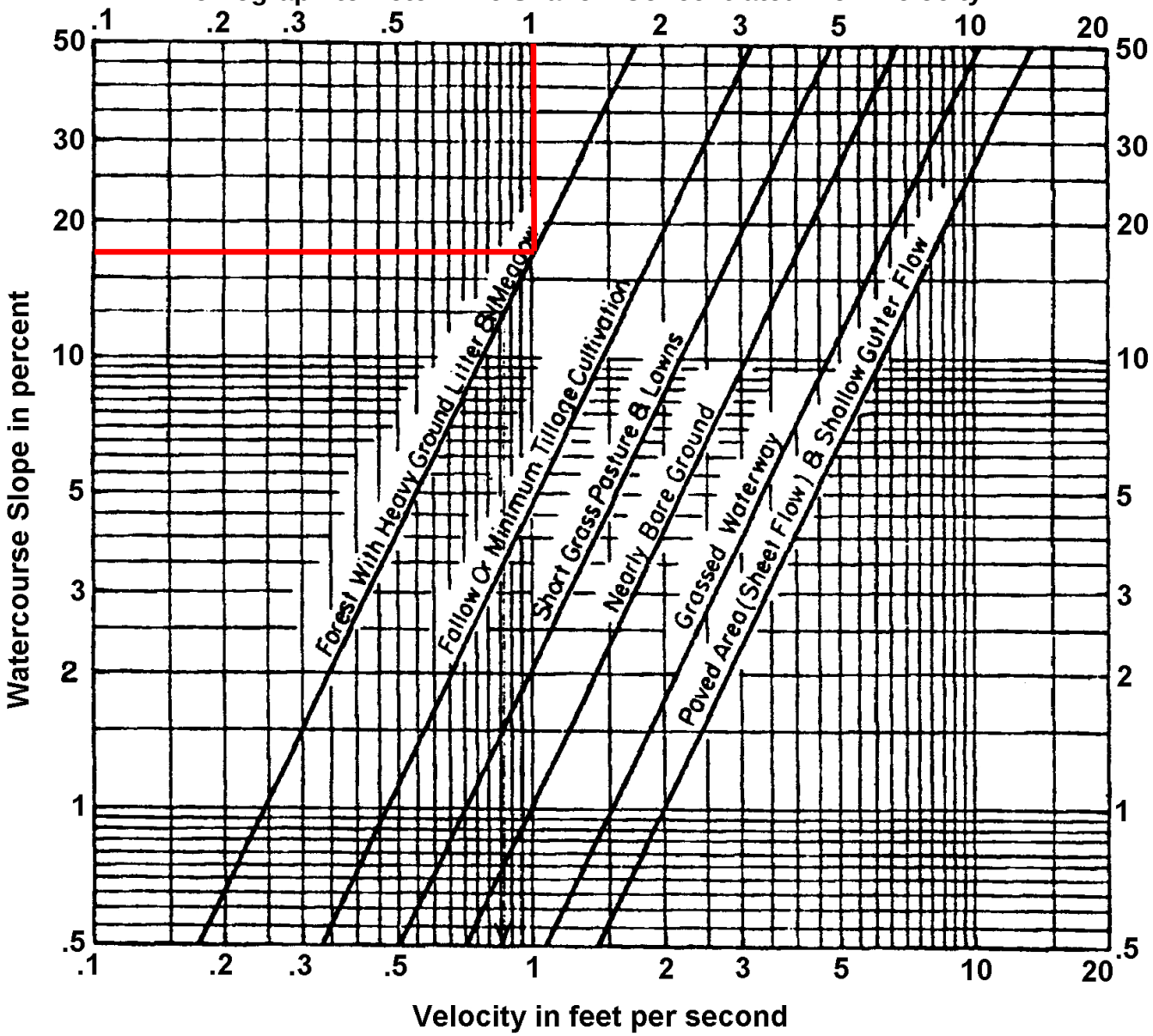
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.095_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 17%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.095_2
3.87 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.095_2	100	0.8	0.140	10.15

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.095_2	2477	FOREST	0.320	1.42	29.01

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
39.16

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.095_2	1	FOREST	0.20	3.87	0.77	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	39.16	1.89	2.32	2.73	1.89	2.32	2.73

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.32	3.87	1.46	1.80	2.12

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.095_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.87		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.8		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.49		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.39		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

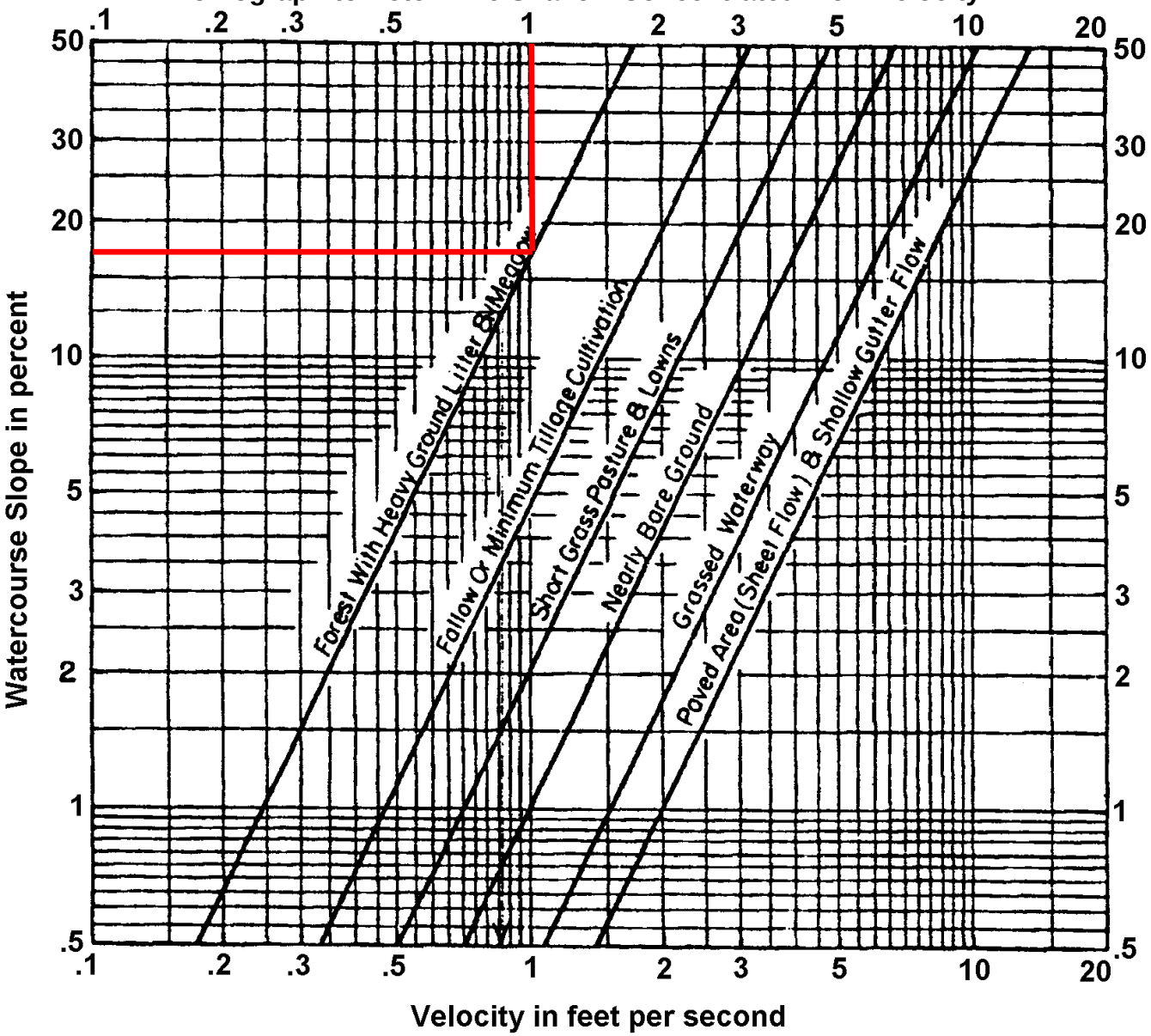
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.095_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 17%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.095_3
4.34 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.095_3	100	0.8	0.080	11.57

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.095_3	2487	FOREST	0.320	1.42	29.12

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
40.69

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.095_3	1	FOREST	0.20	4.34	0.87	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	40.69	1.84	2.26	2.67	1.84	2.26	2.67

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.26	4.34	1.59	1.96	2.32

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.095_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.34		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.96		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.11		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.20		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	7.69 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	7.69		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.85		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.96		
R (HYDRAULIC RADIUS)		0.22		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.083		
$.7S_c$	(FT/FT)	0.058		
$1.3S_c$	(FT/FT)	0.108		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

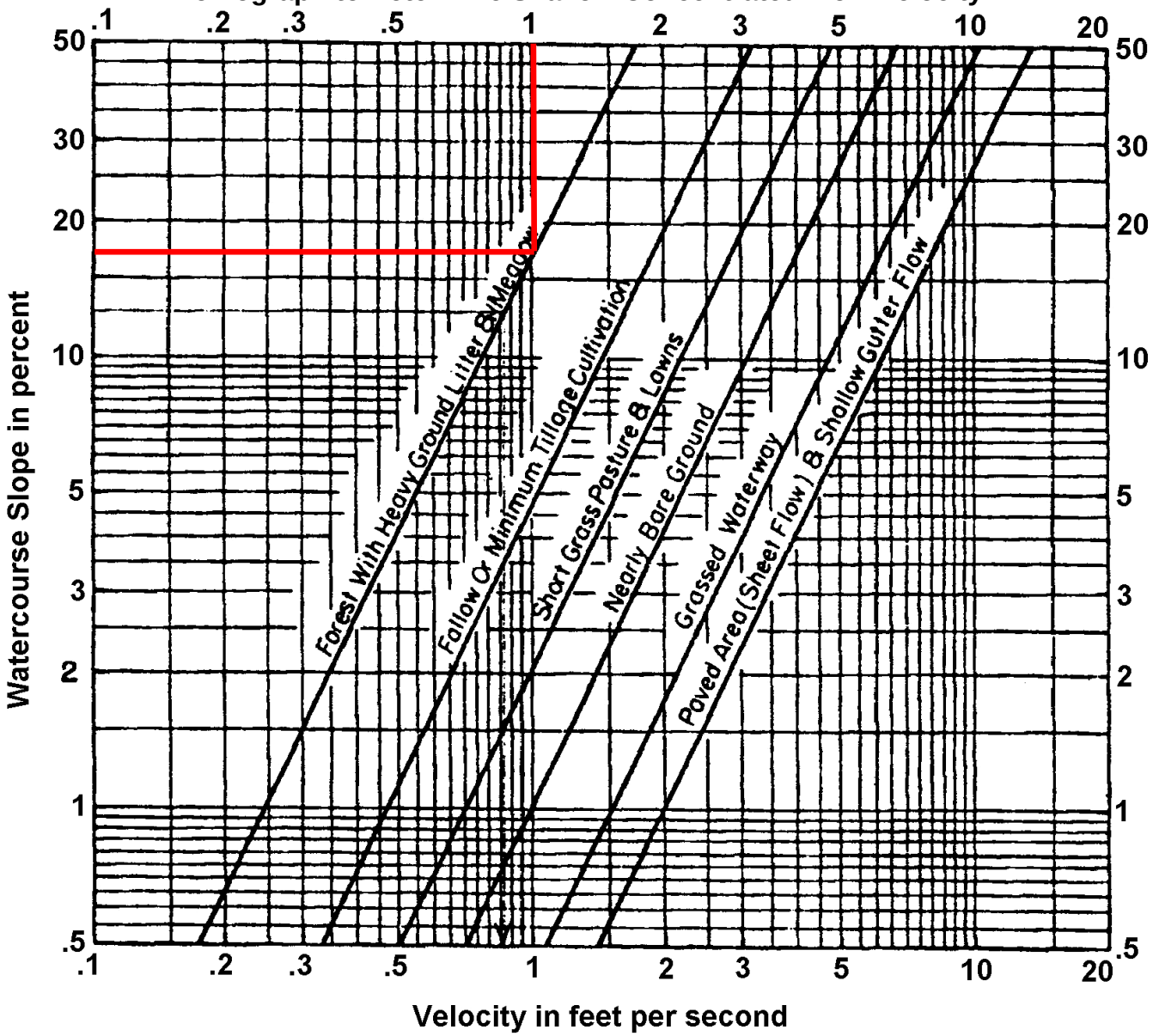
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.095_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 17%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.095_4
3.67 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.095_4	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.095_4	3296	FOREST	0.250	1.26	43.67

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
56.58

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.095_4	1	FOREST	0.20	3.67	0.73	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	56.58	1.44	1.79	2.14	1.44	1.79	2.14

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.79	3.67	1.06	1.31	1.57

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.095_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.67		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.31		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.88		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.41		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.25 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.25		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.78		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

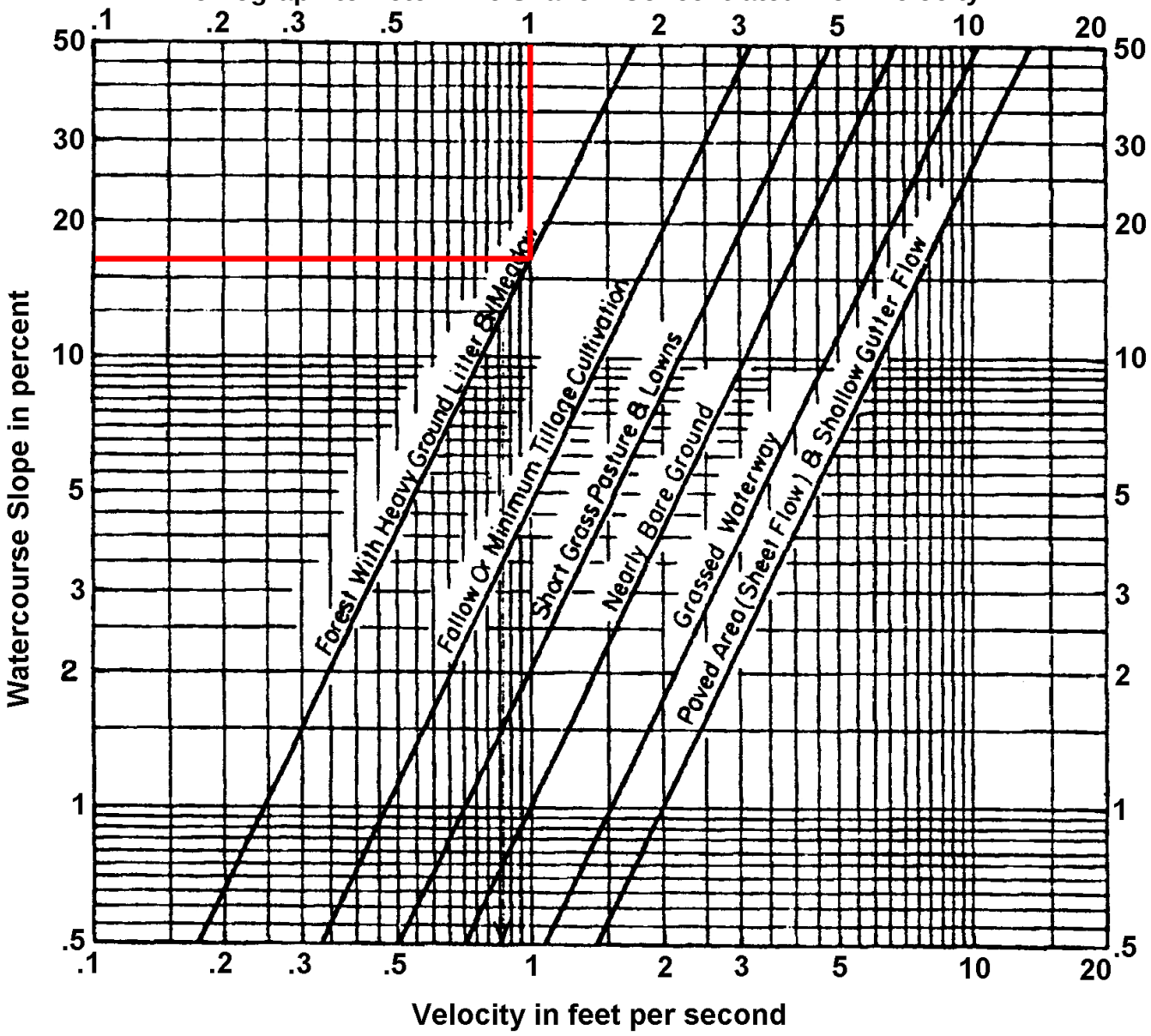
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.095_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.095_5
4.71 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.095_5	100	0.8	0.040	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.095_5	2708	FOREST	0.300	1.38	32.75

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
46.35

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.095_5	1	FOREST	0.20	4.71	0.94	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	46.35	1.67	2.07	2.45	1.67	2.07	2.45

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.07	4.71	1.58	1.95	2.31

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.095_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.71		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.95		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.05		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.15		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.94		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.03		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

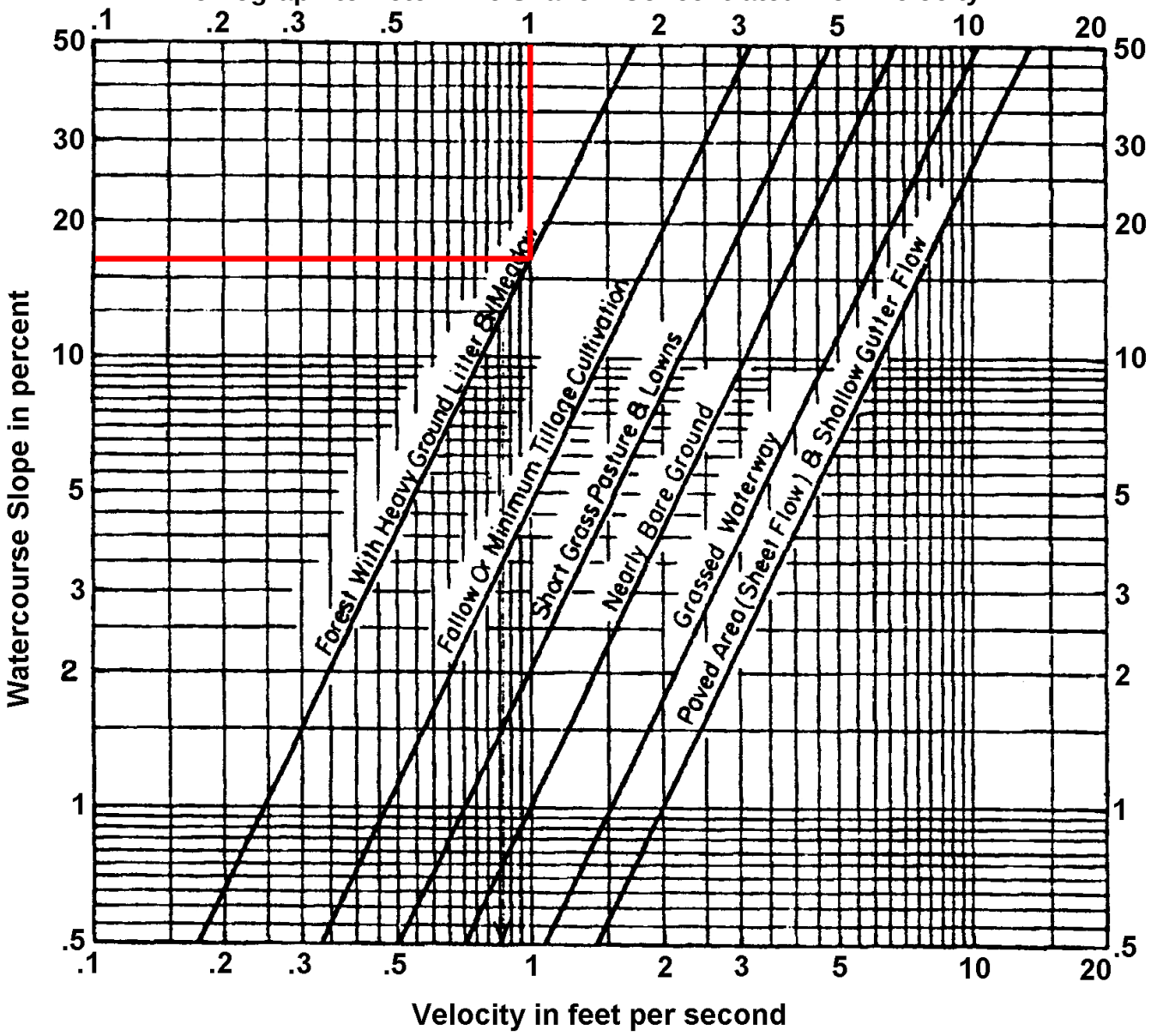
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.095_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.095_6
1.94 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.095_6	100	0.8	0.190	9.45

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.095_6	2487	FOREST	0.320	1.42	29.12

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
38.58

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.095_6	1	FOREST	0.20	1.94	0.39	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	38.58	1.91	2.34	2.76	1.91	2.34	2.76

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.34	1.94	0.74	0.91	1.07

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.095_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.94		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.91		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.02		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.47		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.75		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.56 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.56		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.78		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.69		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.024		
S_C (CRITICAL SLOPE)	(FT/FT)	0.089		
$.7S_c$	(FT/FT)	0.062		
$1.3S_c$	(FT/FT)	0.115		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

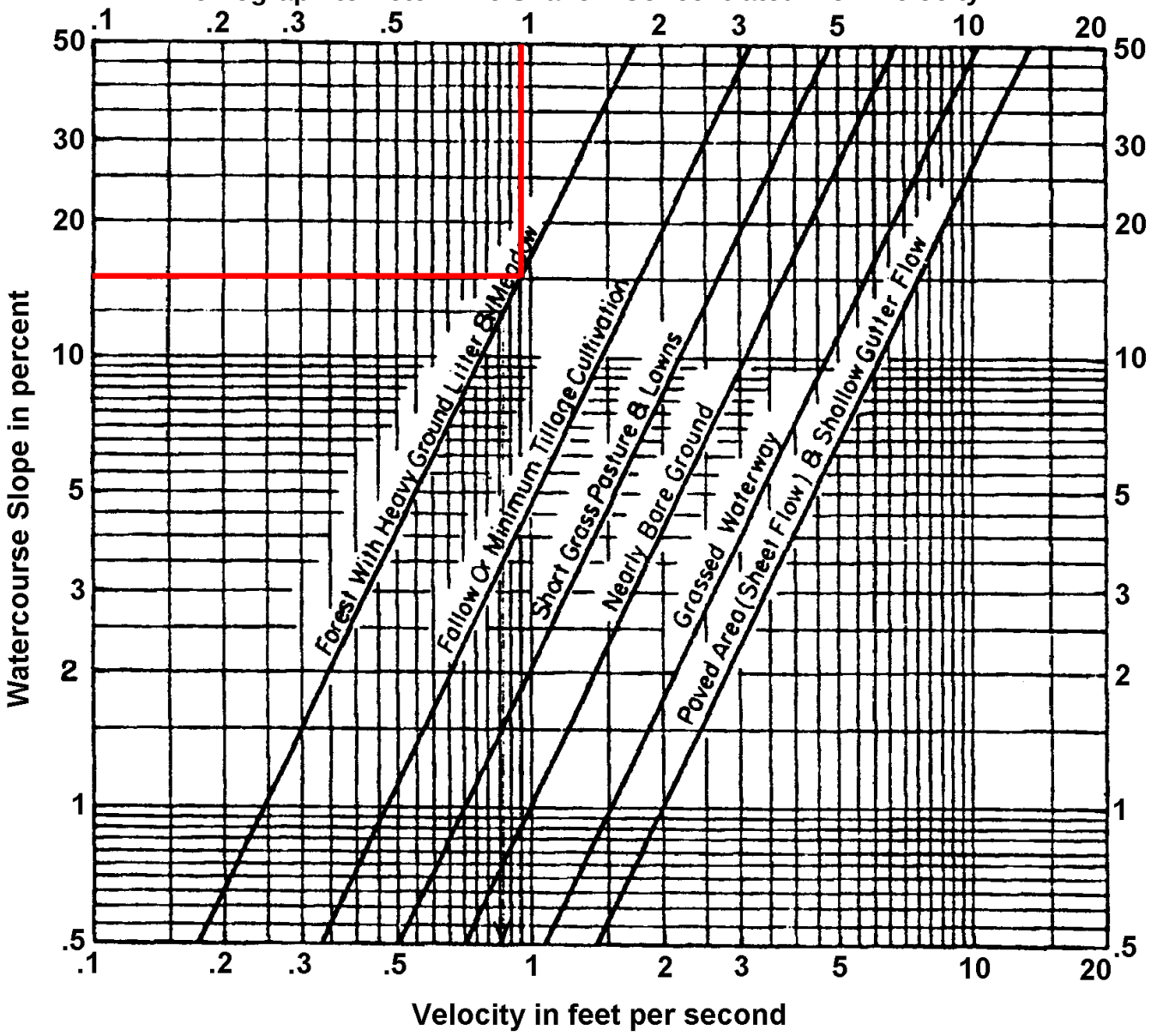
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.095_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.095_7
3.09 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.095_7	100	0.8	0.070	11.94

$$T_{c\,(sheet\ flow)} = \left[\frac{2(n)}{3(S)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.095_7	3193	FOREST	0.260	1.28	41.48

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c* (minutes)
53.42

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.095_7	1	FOREST	0.20	3.09	0.62	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.42	1.51	1.86	2.22	1.51	1.86	2.22

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.86	3.09	0.93	1.15	1.37

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.095_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.09		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.15		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.34		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.36		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.56 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.56		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.78		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.69		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

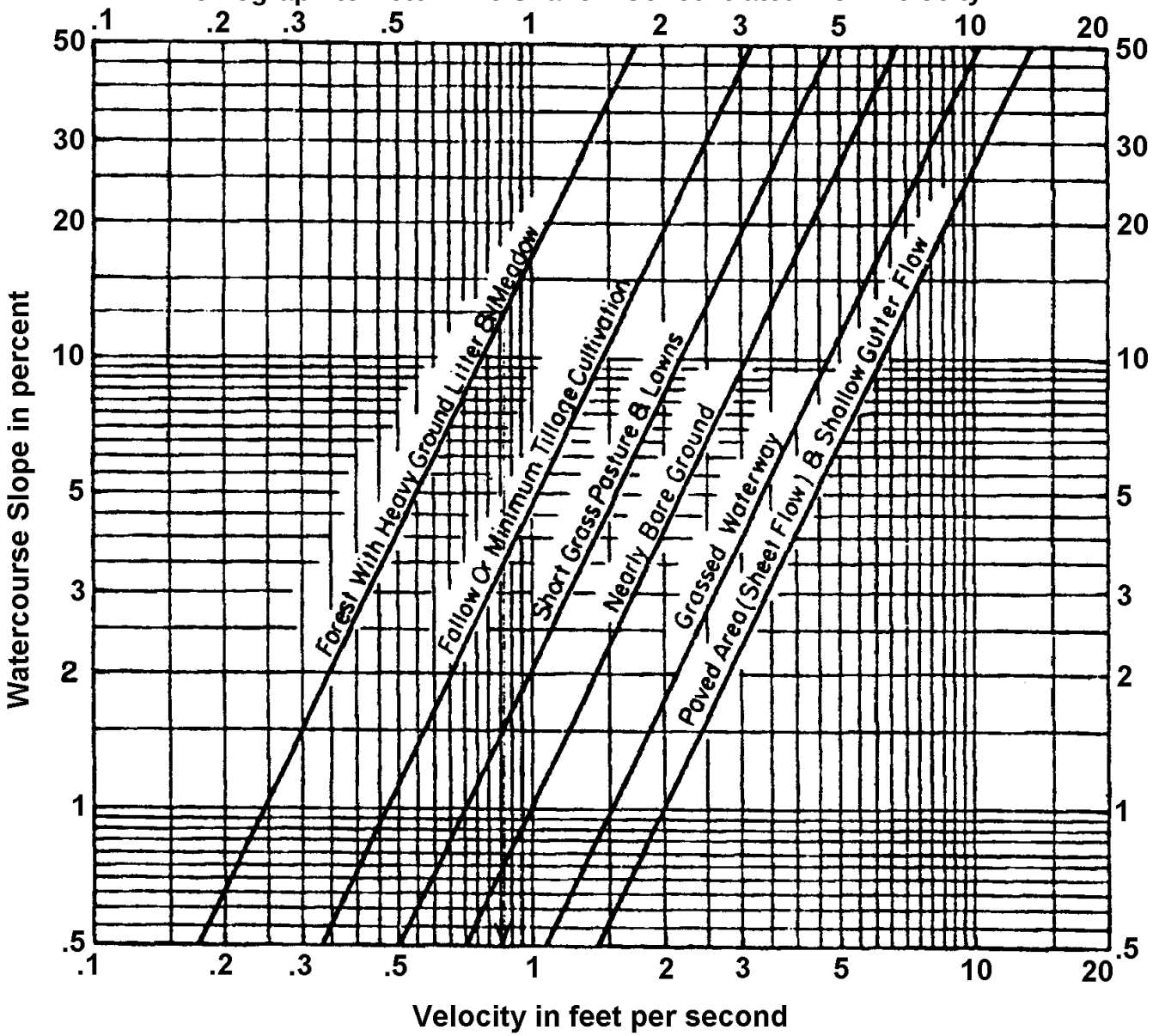
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.095_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

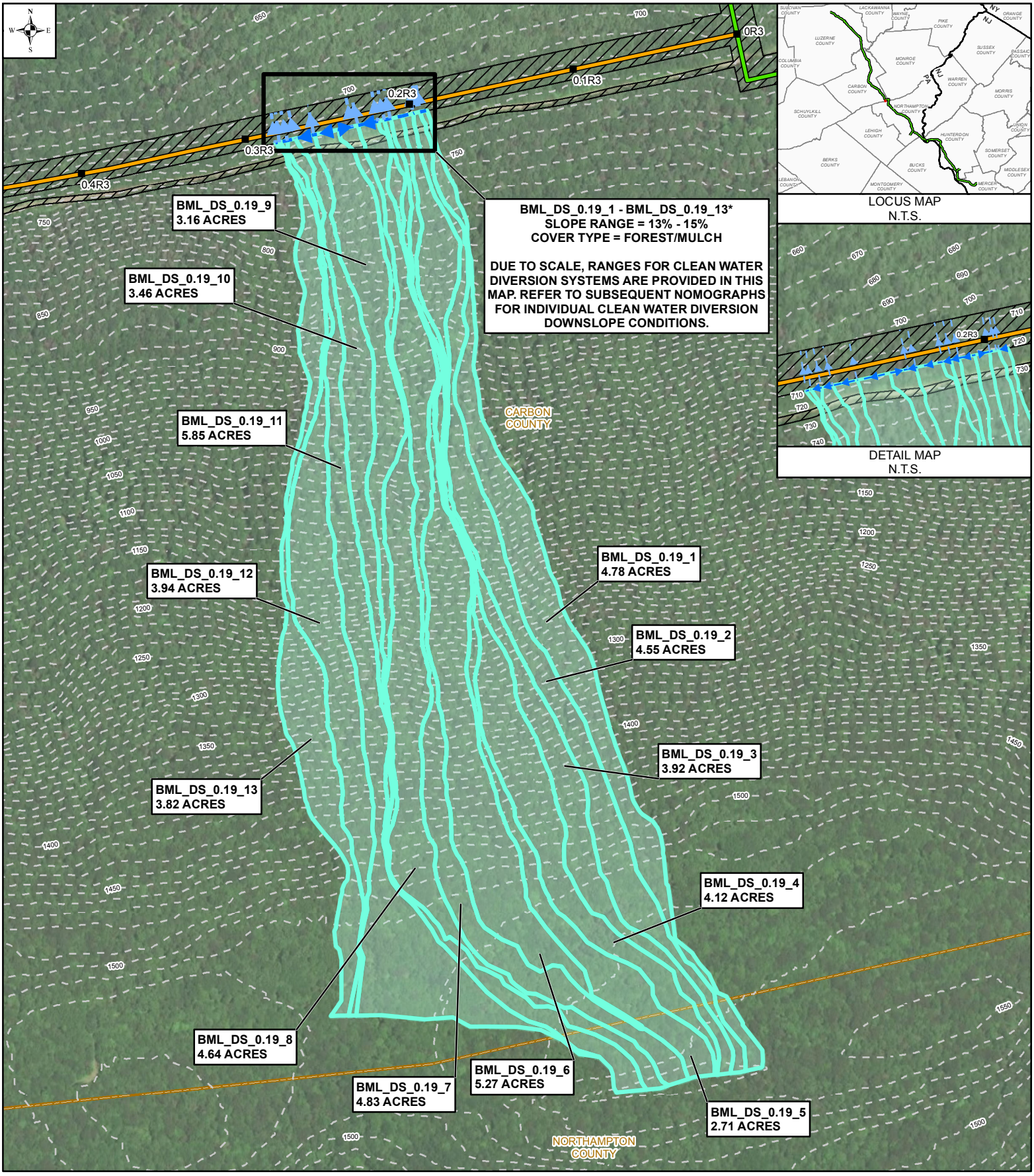


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_BML_0.19

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 111 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_1
4.78 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_1	100	0.8	0.100	10.98

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_1	3196	FOREST	0.260	1.28	41.52

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
52.50

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_1	1	FOREST	0.20	4.78	0.96	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	52.50	1.53	1.89	2.25	1.53	1.89	2.25

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.89	4.78	1.46	1.80	2.15

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.78		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.81		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.50		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.05		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.40		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.56 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.56		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.78		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.69		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.045		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

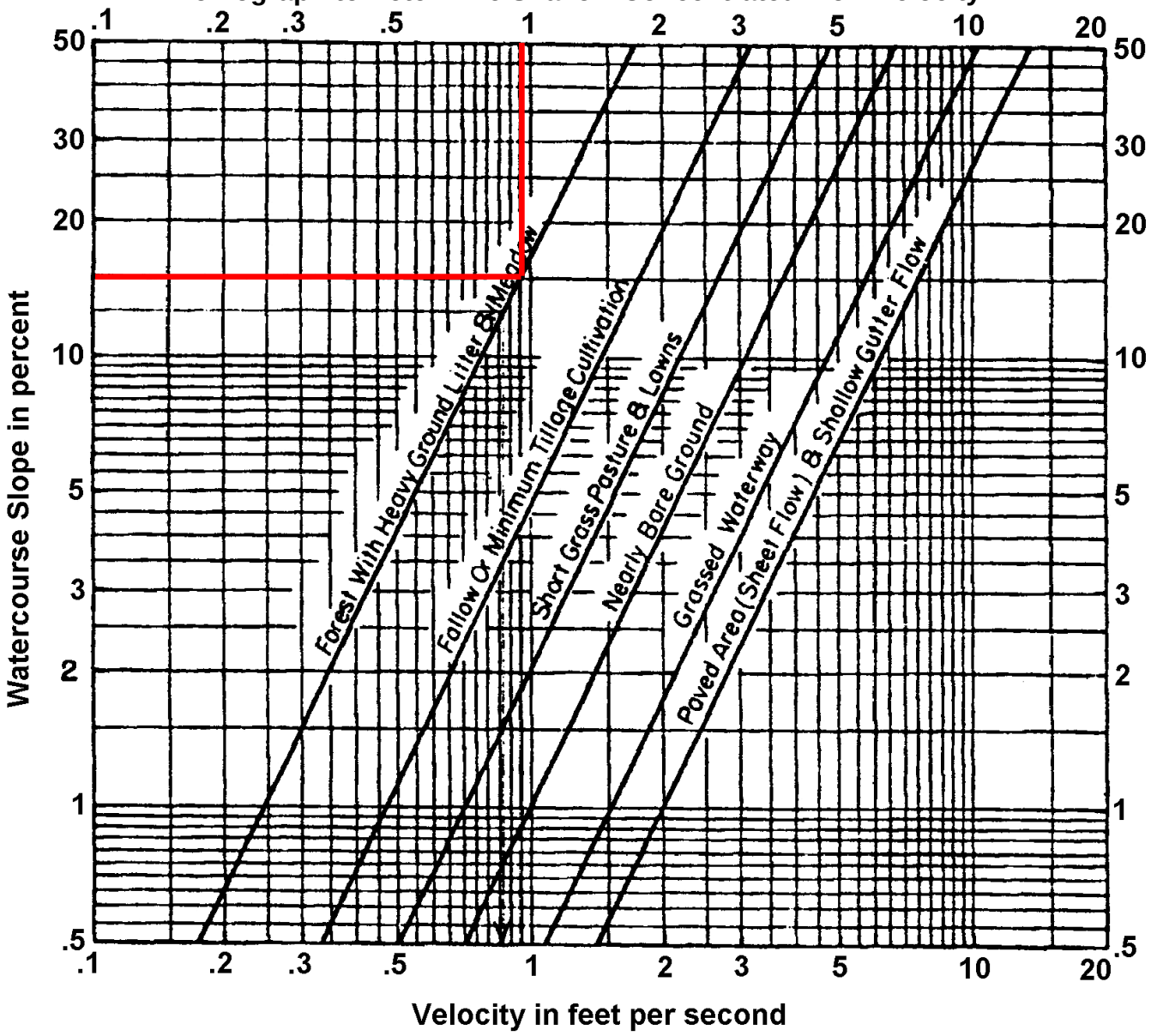
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_2
4.55 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_2	100	0.8	0.110	10.74

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_2	3230	FOREST	0.250	1.26	42.79

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.53

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_2	1	FOREST	0.20	4.55	0.91	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.53	1.50	1.86	2.22	1.50	1.86	2.22

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.86	4.55	1.37	1.69	2.02

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.55		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.69		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.76		
PROTECTIVE LINING[2,6]		SC150		
n (MANNING'S COEFFICIENT)[2]		0.05		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.25		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.40		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	6.25 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	6.25		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.78		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.045		
S_C (CRITICAL SLOPE)	(FT/FT)	0.071		
$.7S_c$	(FT/FT)	0.050		
$1.3S_c$	(FT/FT)	0.093		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

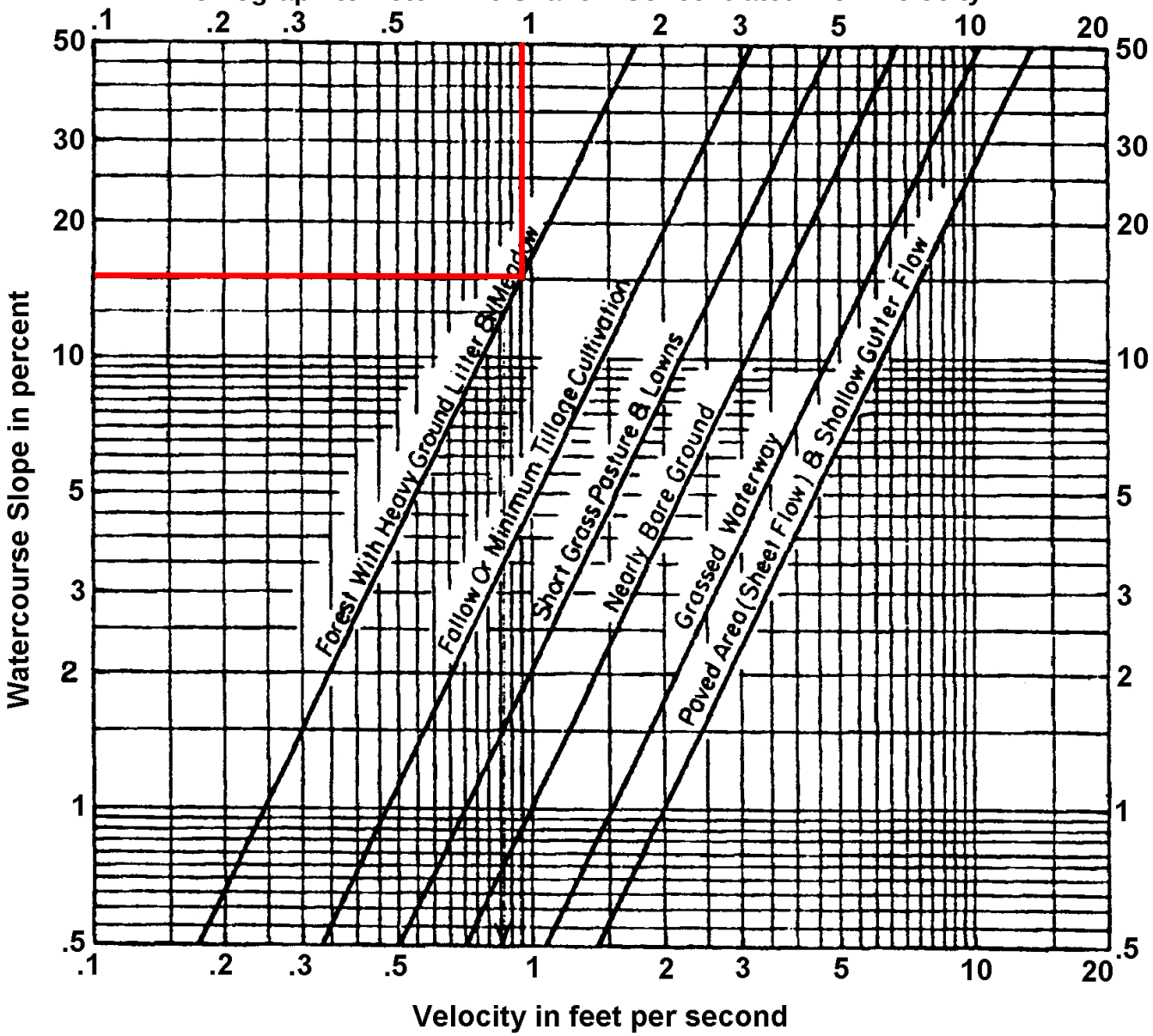
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_3
3.92 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_3	100	0.8	0.12	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_3	3240	FOREST	0.25	1.26	42.93

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.45

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_3	1	FOREST	0.20	3.92	0.78	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.45	1.50	1.86	2.22	1.50	1.86	2.22

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.86	3.92	1.18	1.46	1.74

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.92		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.46		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.57		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.23		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.62 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.62		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.81		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.70		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.055		
S_C (CRITICAL SLOPE)	(FT/FT)	0.089		
$.7S_c$	(FT/FT)	0.062		
$1.3S_c$	(FT/FT)	0.115		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

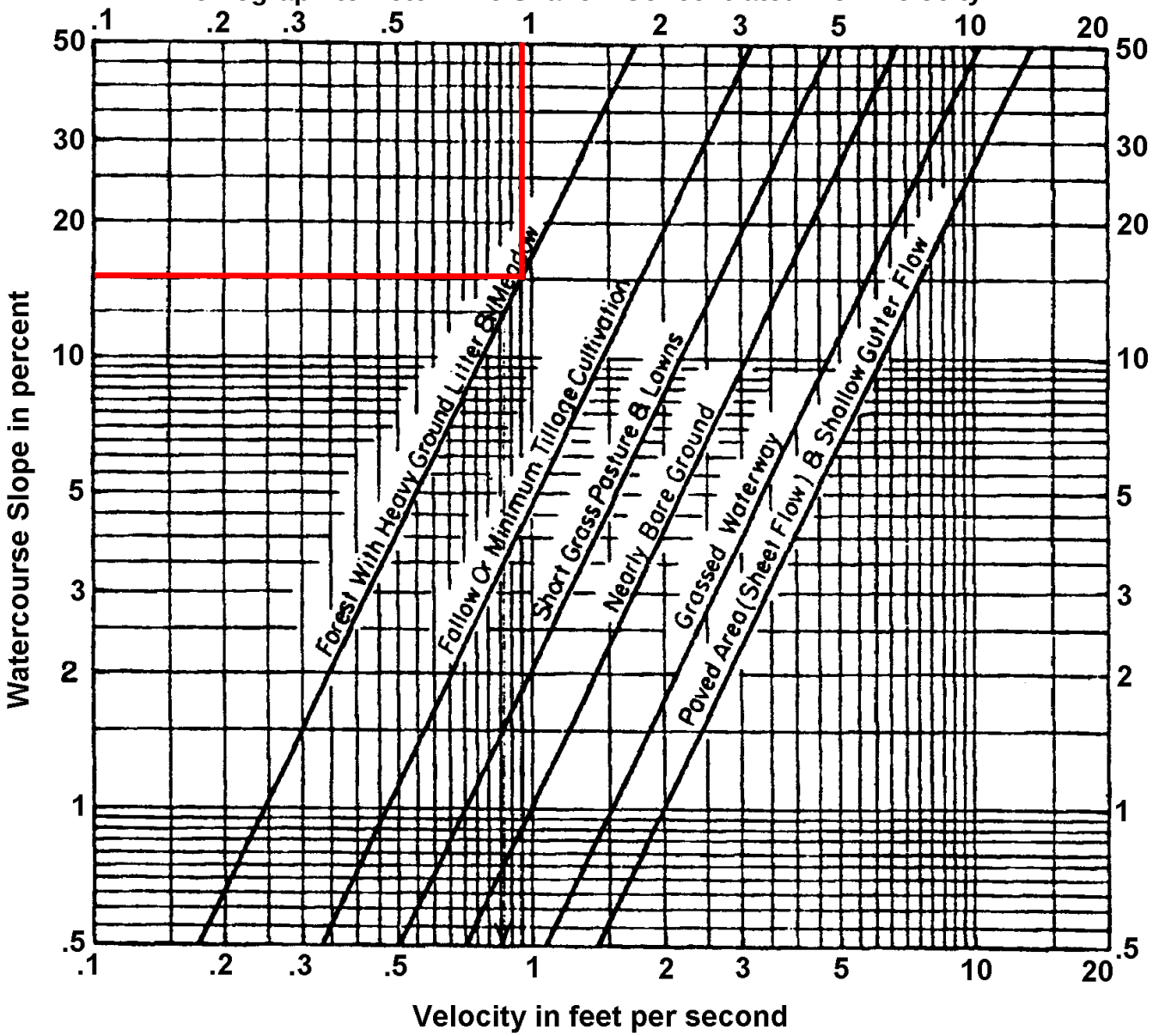
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_4
4.12 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_4	100	0.8	0.120	10.52

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_4	3281	FOREST	0.250	1.26	43.47

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.99

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_4	1	FOREST	0.20	4.12	0.82	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.99	1.49	1.85	2.21	1.49	1.85	2.21

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.85	4.12	1.23	1.52	1.82

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.12		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.52		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.88		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.12		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.94		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.59 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.59		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.79		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.70		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.03		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

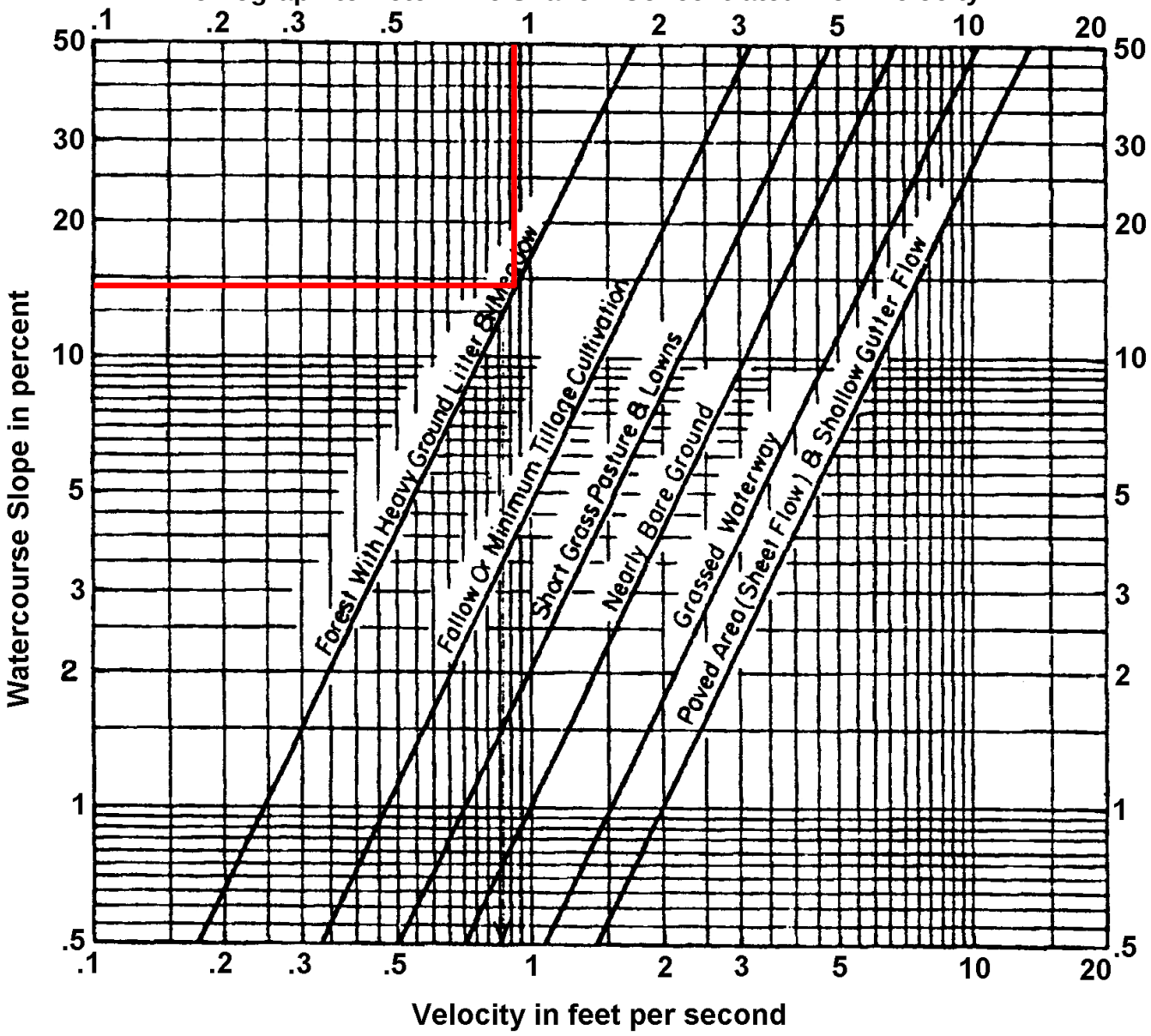
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_5
2.71 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_5	100	0.8	0.160	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_5	3252	FOREST	0.250	1.26	43.08

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
52.92

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_5	1	FOREST	0.20	2.71	0.54	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	52.92	1.52	1.88	2.24	1.52	1.88	2.24

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.88	2.71	0.82	1.02	1.21

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.71		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.02		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.61		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.15		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.99 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.99		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.99		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.75		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.087		
$.7S_c$	(FT/FT)	0.061		
$1.3S_c$	(FT/FT)	0.113		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

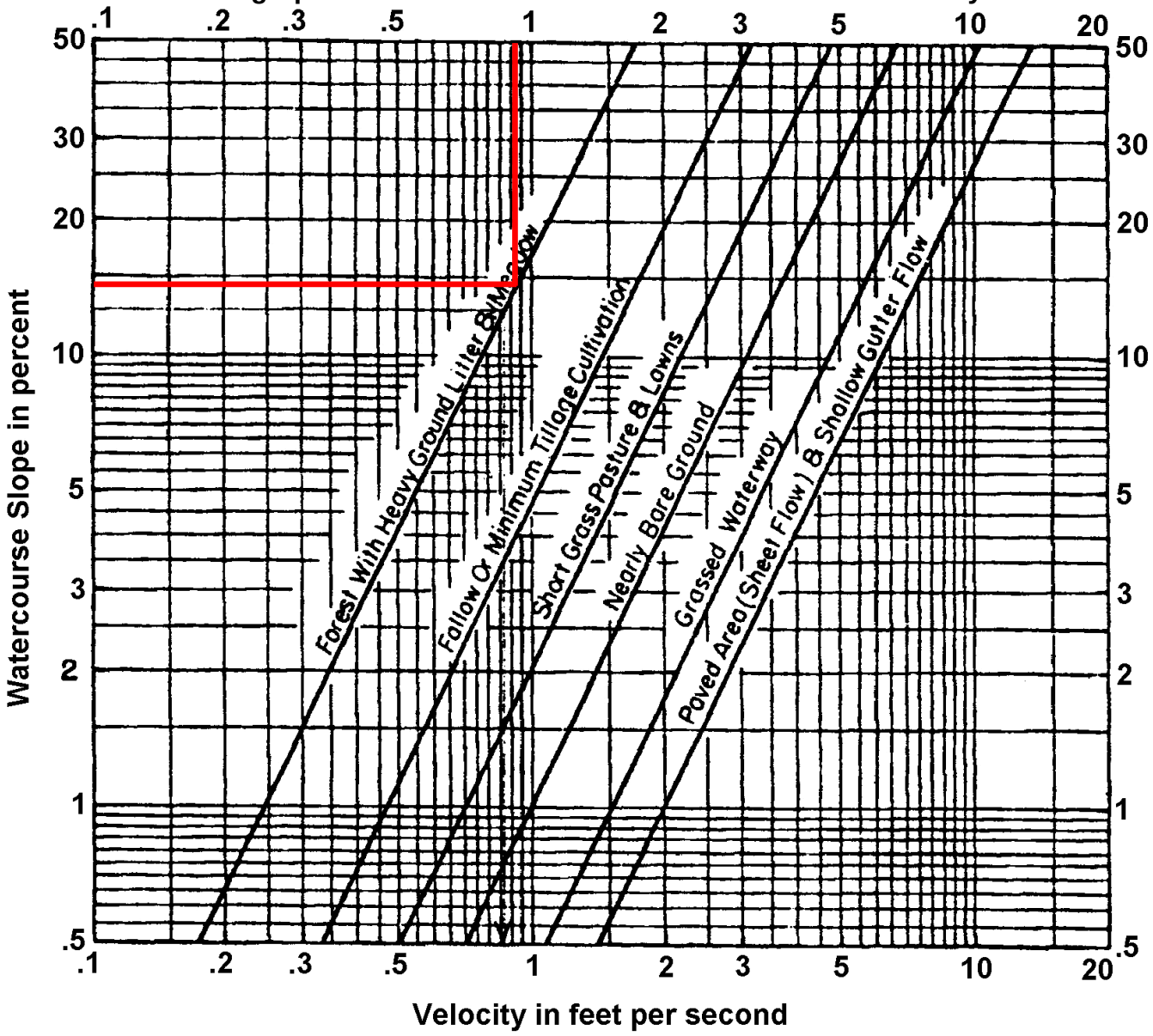
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_6
5.27 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_6	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_6	3173	FOREST	0.250	1.26	42.04

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
56.59

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_6	1	FOREST	0.20	5.27	1.05	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	56.59	1.44	1.79	2.14	1.44	1.79	2.14

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.79	5.27	1.52	1.88	2.25

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.27		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.88		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.28		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.25		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.50		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.63		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

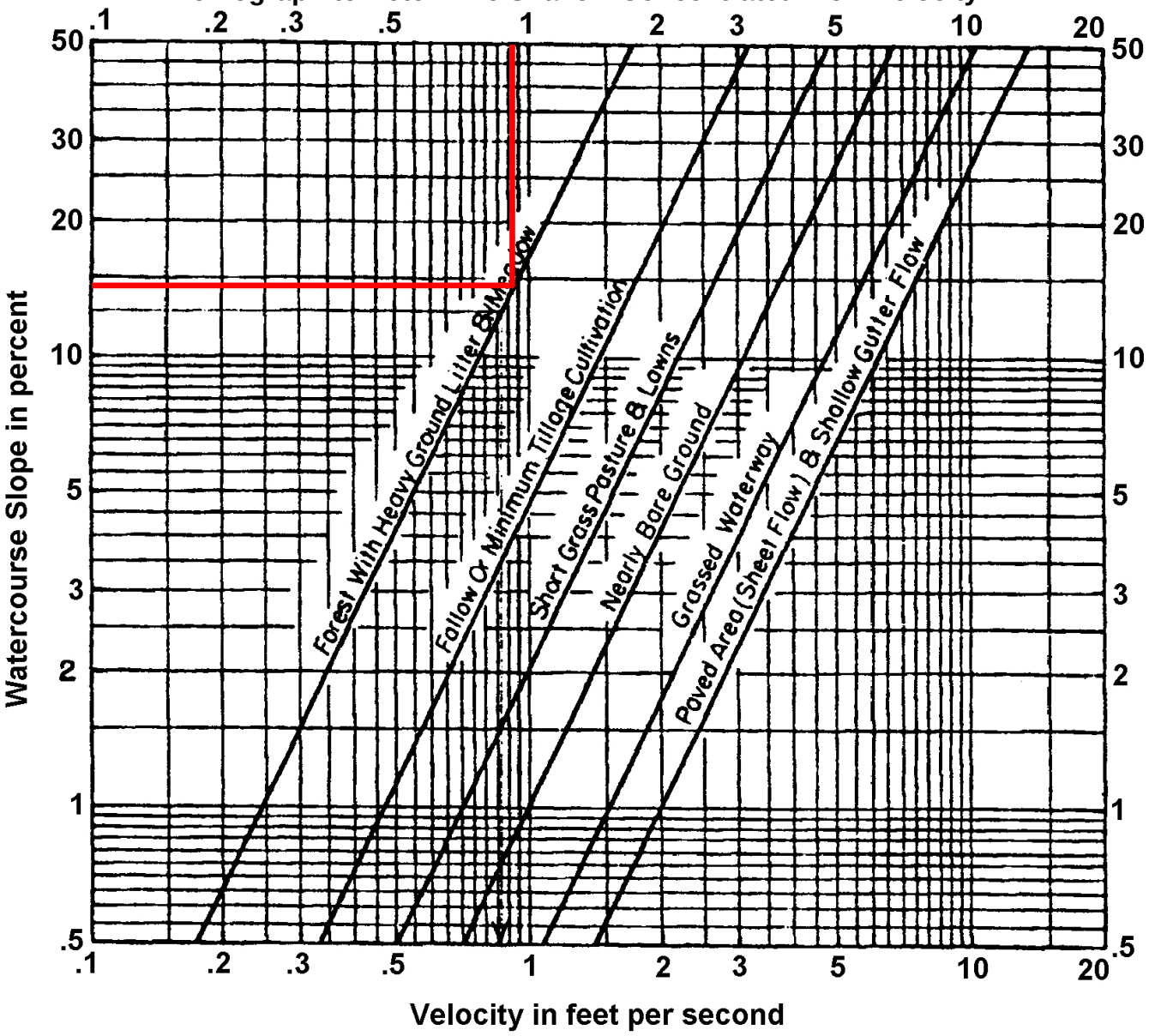
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_7
4.83 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_7	100	0.8	0.160	9.84

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_7	3376	FOREST	0.240	1.23	45.65

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
55.49

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_7	1	FOREST	0.20	4.83	0.97	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	55.49	1.46	1.81	2.17	1.46	1.81	2.17

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.81	4.83	1.41	1.75	2.09

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.83		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.75		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.67		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.63		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.72		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.88 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.88		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.94		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.74		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.023		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.018		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

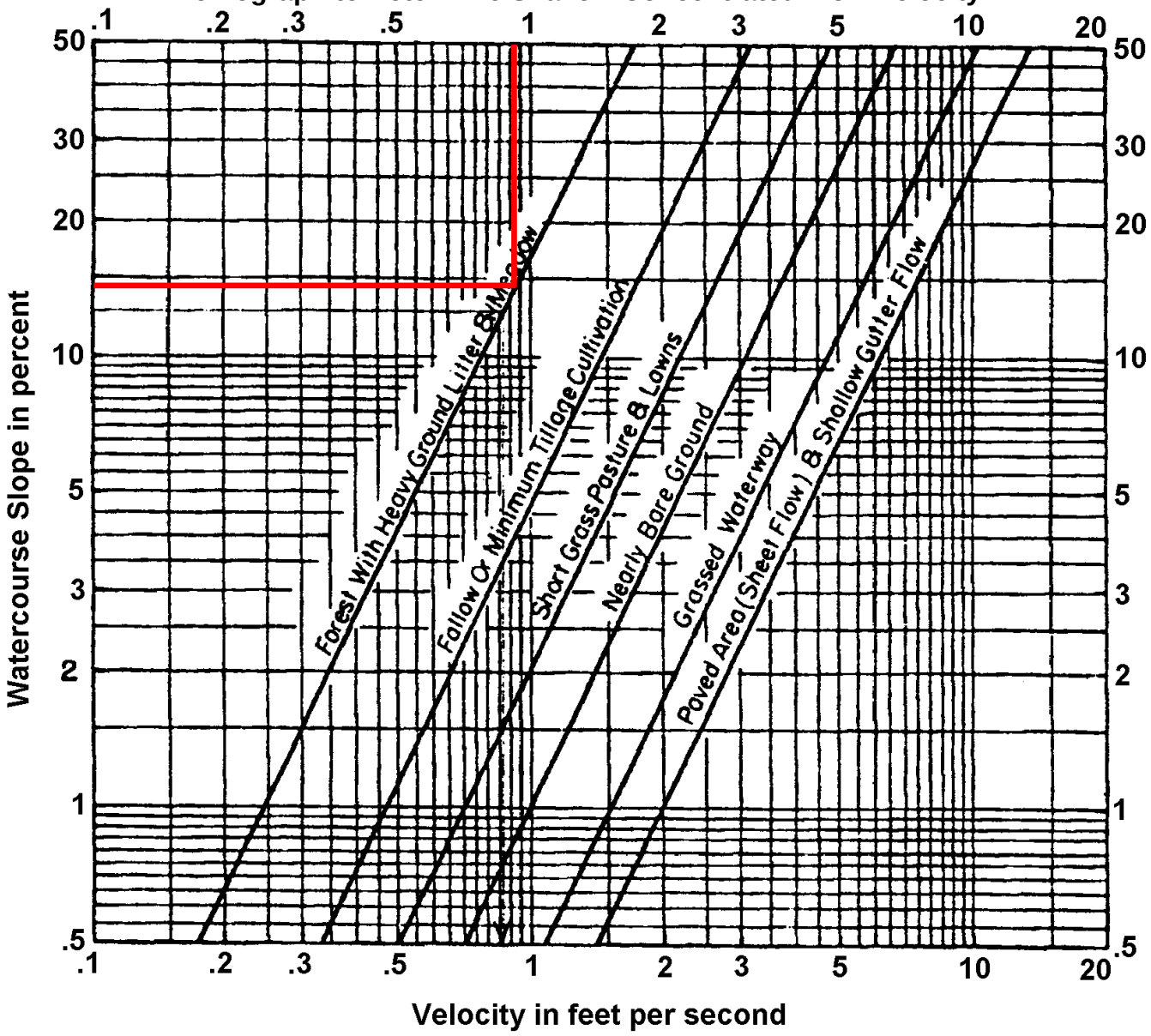
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_8
4.64 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_8	100	0.8	0.150	9.99

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_8	3455	FOREST	0.240	1.23	46.72

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
56.71

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_8	1	FOREST	0.20	4.64	0.93	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	56.71	1.44	1.78	2.13	1.44	1.78	2.13

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.78	4.64	1.33	1.65	1.98

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_8		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.64		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.66		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.86		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.97		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.50		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.00		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.50		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.63		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.016		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

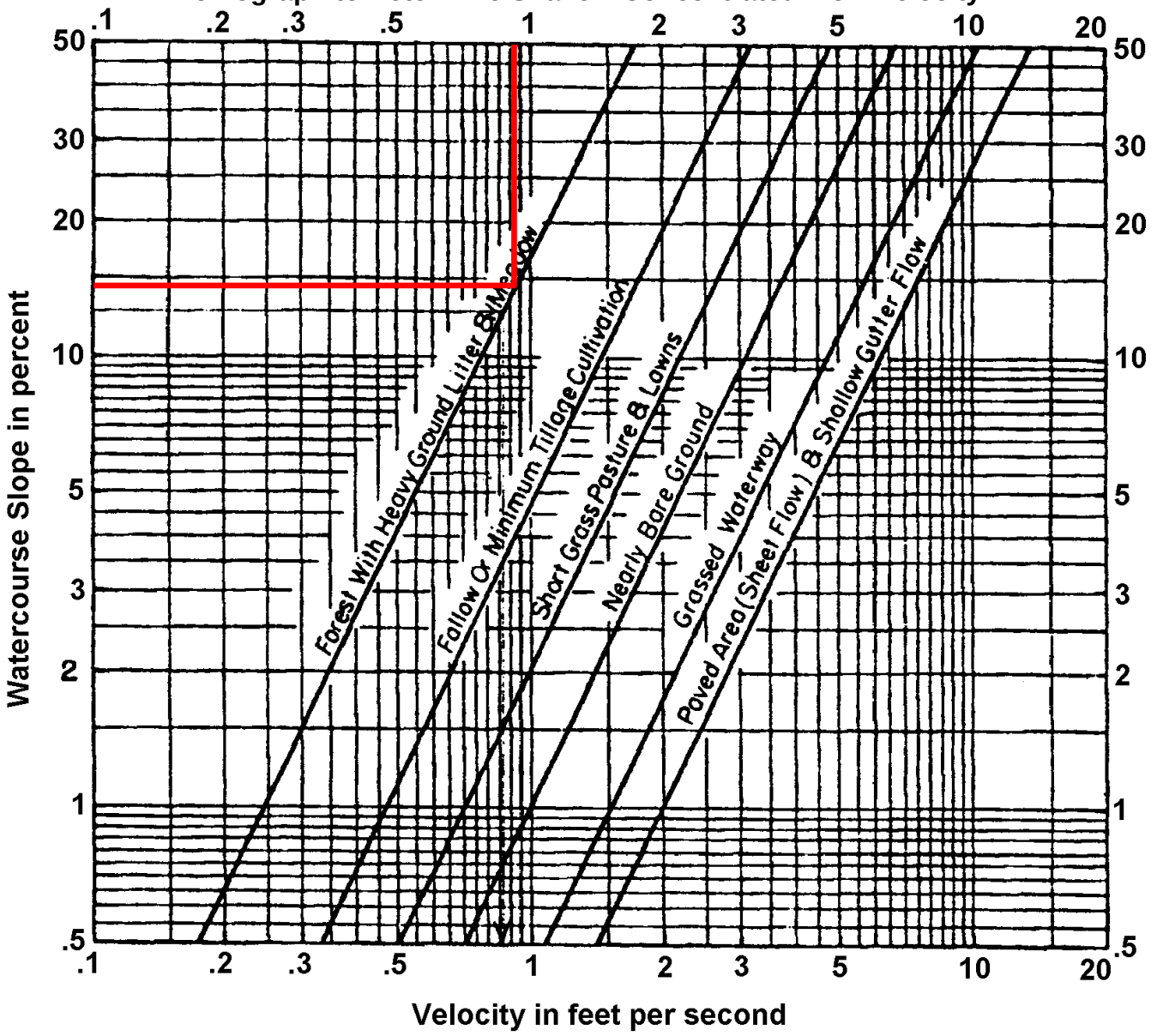
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_8

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_9
3.16 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_9	100	0.8	0.210	9.23

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_9	2255	FOREST	0.330	1.45	26.00

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
35.24

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_9	1	FOREST	0.20	3.16	0.63	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	35.24	2.03	2.49	2.92	2.03	2.49	2.92

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.49	3.16	1.28	1.57	1.84

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_9		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.16		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.57		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.55		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.75		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.43 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.43		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.72		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.68		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.014		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

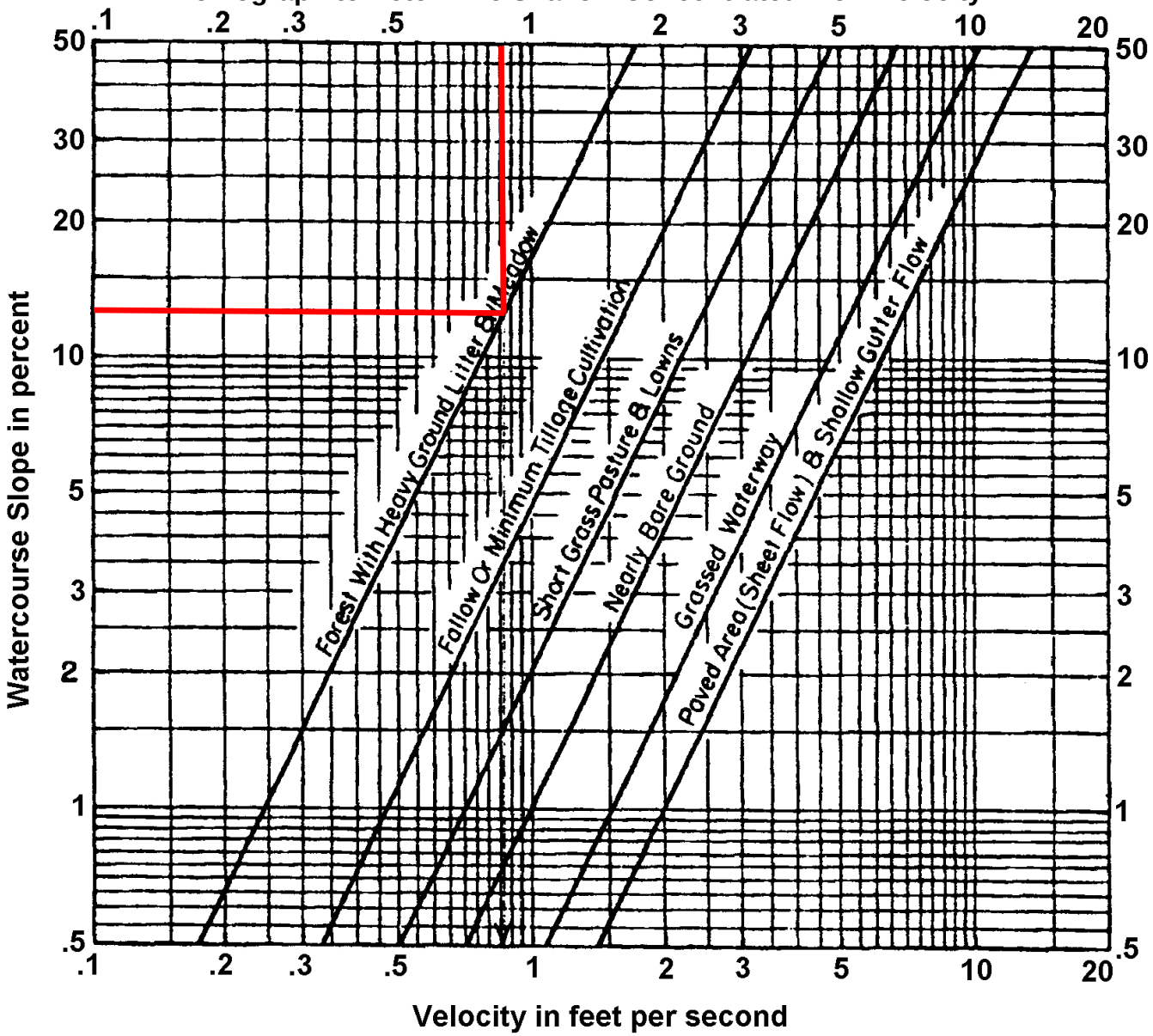
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_9

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_10
3.46 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_10	100	0.8	0.150	9.99

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_10	3315	FOREST	0.250	1.26	43.92

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.91

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_10	1	FOREST	0.20	3.46	0.69	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.91	1.49	1.85	2.21	1.49	1.85	2.21

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.85	3.46	1.03	1.28	1.53

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_10		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.46		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.28		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.39		
PROTECTIVE LINING[2,6]		S150		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.11		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.75		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	5.26 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	5.26		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.63		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.66		
R (HYDRAULIC RADIUS)		0.21		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.090		
$.7S_c$	(FT/FT)	0.063		
$1.3S_c$	(FT/FT)	0.117		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

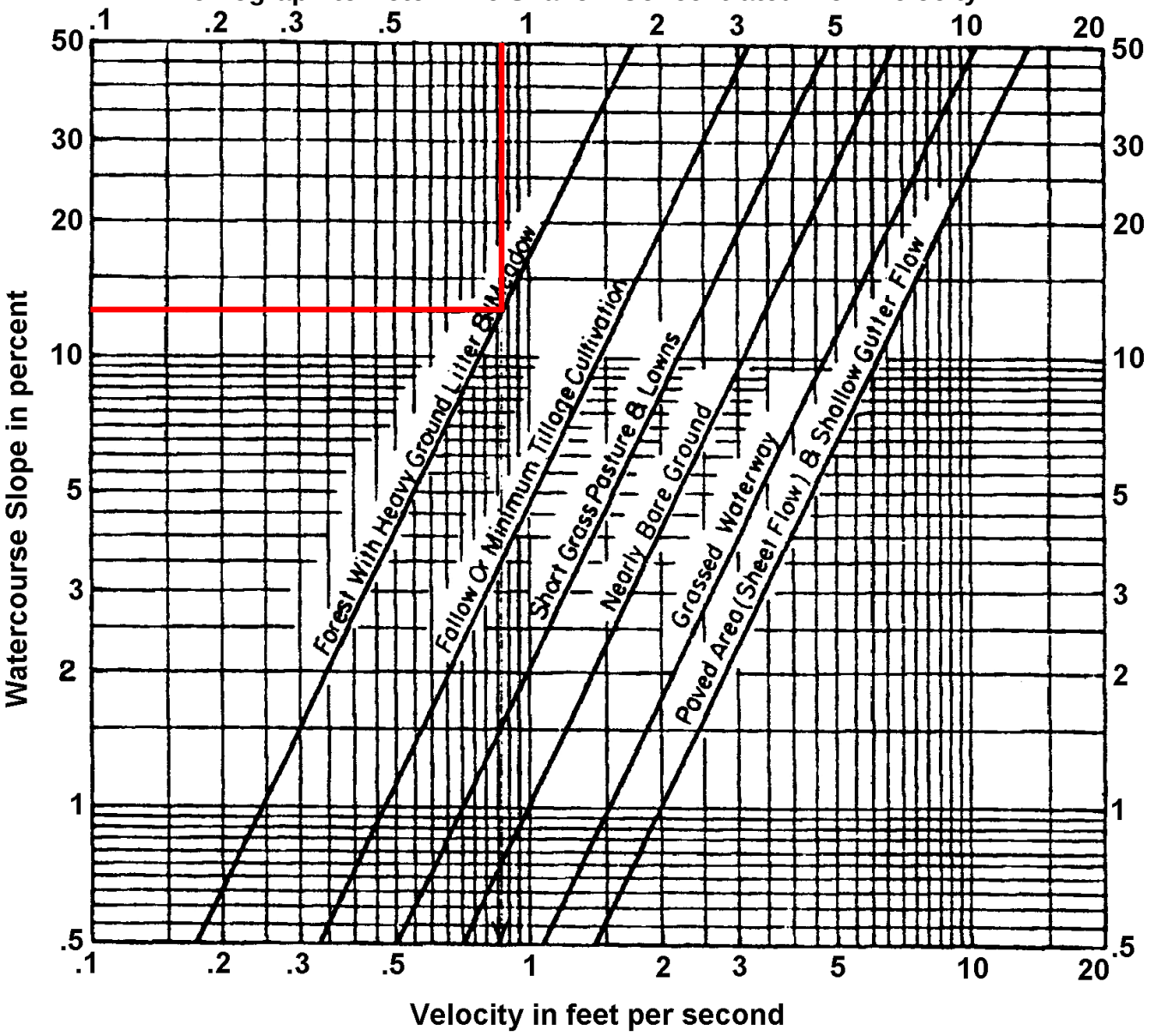
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_10

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_11
5.85 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_11	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_11	3185	FOREST	0.260	1.28	41.38

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
55.93

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_11	1	FOREST	0.20	5.85	1.17	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	55.93	1.45	1.80	2.15	1.45	1.80	2.15

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.80	5.85	1.70	2.11	2.52

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_11		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.85		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.11		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.40		
PROTECTIVE LINING[2,6]		C125BN		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	6.26		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.35		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.31		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.35 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.35		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.17		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.54		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.074		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.011		
$1.3S_c$	(FT/FT)	0.020		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

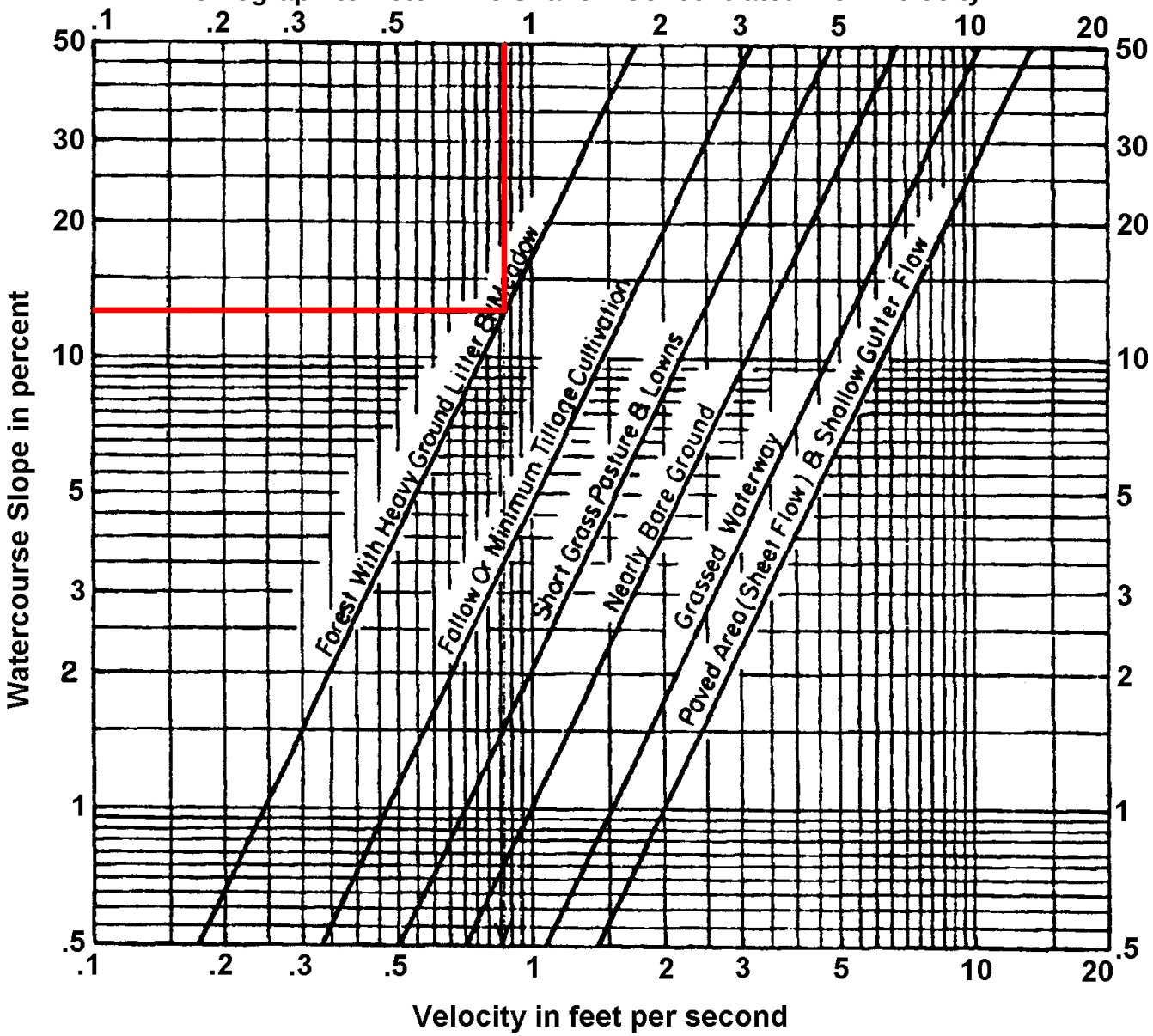
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_11

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_12
3.94 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.19_12	100	0.8	0.010	18.81

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.19_12	2768	FOREST	0.290	1.35	34.05

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
52.86

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.19_12	1	FOREST	0.20	3.94	0.79	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	52.86	1.52	1.88	2.24	1.52	1.88	2.24

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.88	3.94	1.20	1.48	1.77

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_12		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.94		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.48		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.78		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.67		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.25		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.76 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.76		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.38		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.60		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.04		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.010		
$1.3S_c$	(FT/FT)	0.019		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

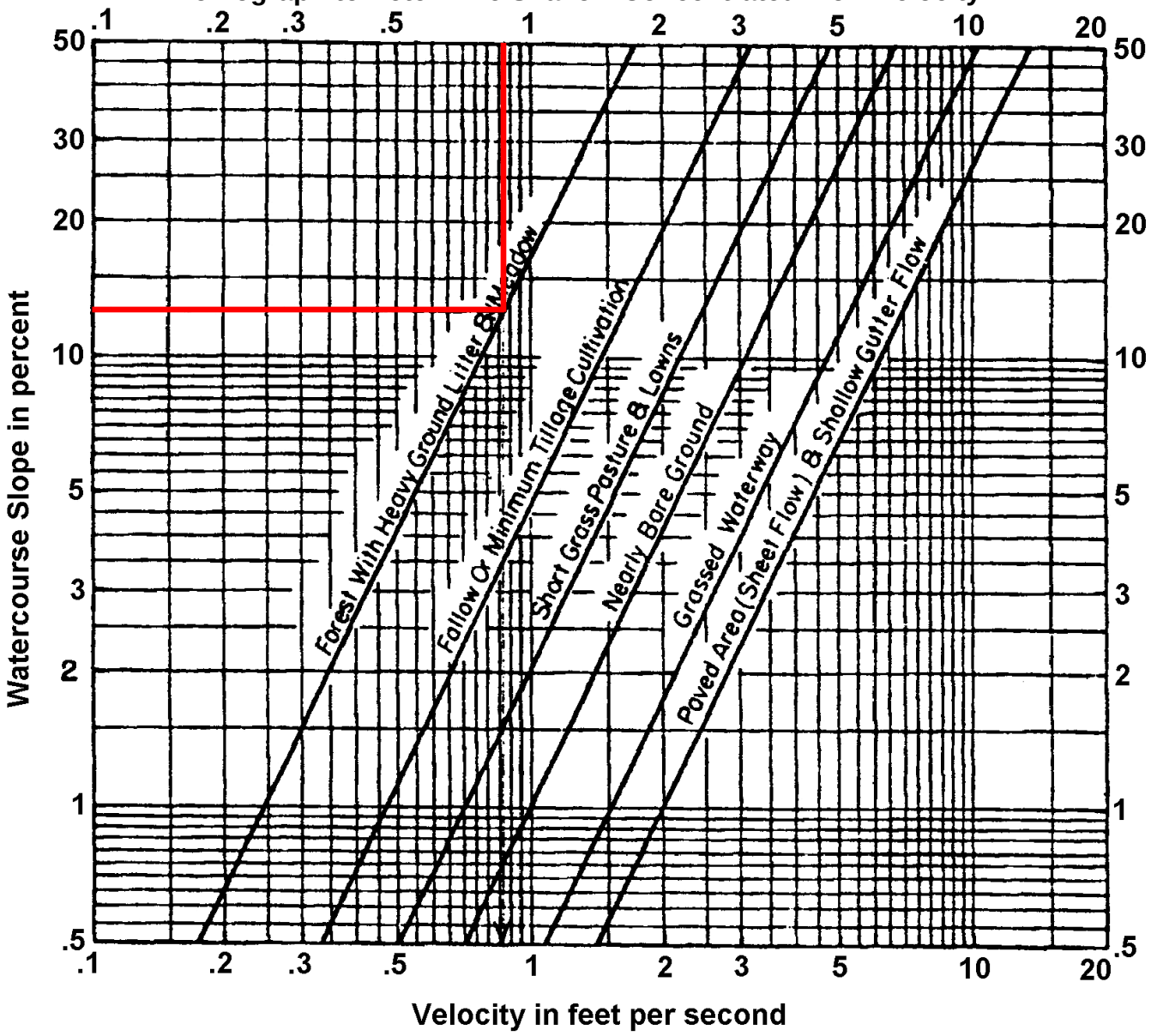
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_12

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.19_13
3.82 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 0.19_13	100	0.8	0.020	16.00

$$T_{c(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 0.19_13	2791	FOREST	0.290	1.35	34.33

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
50.33

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 0.19_13	1	FOREST	0.20	3.82	0.76	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	50.33	1.57	1.95	2.32	1.57	1.95	2.32

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.95	3.82	1.20	1.49	1.77

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.19_13	DS_BML_0.19_13	
TEMPORARY OR PERMANENT?	(T OR P)	T	T	
DESIGN STORM	(2, 5, OR 10 YR)	5	5	
ACRES	(AC)	3.82	3.82	
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A	N/A	
Q_r (REQUIRED CAPACITY)	(CFS)	1.49	1.49	
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.08	3.08	
PROTECTIVE LINING[2,6]		P300 (Unvegetated)	P300 (Vegetated)	
n (MANNING'S COEFFICIENT)[2]		0.034	0.034	
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A	
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.92	5.92	
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00	8.00	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	4.99	4.99	
CHANNEL BOTTOM WIDTH	(FT)	0	0	
CHANNEL SIDE SLOPES	(H:V)	4.17 / 0	4.17 / 0	
D (TOTAL DEPTH)	(FT)	1.00	1.00	
CHANNEL TOP WIDTH @ D	(FT)	4.17	4.17	
d (CALCULATED FLOW DEPTH)	(FT)	0.50	0.50	
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.08	2.08	
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0	0	
d_{50} STONE SIZE	(IN)	N/A	N/A	
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.52	0.52	
R (HYDRAULIC RADIUS)		0.20	0.20	
S (BED SLOPE)[3, 7]	(FT/FT)	0.16	0.16	
S_C (CRITICAL SLOPE)	(FT/FT)	0.037	0.037	
$.7S_c$	(FT/FT)	0.026	0.026	
$1.3S_c$	(FT/FT)	0.048	0.048	
STABLE FLOW?	(Y/N)	Y	Y	
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A	
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.50	
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S	

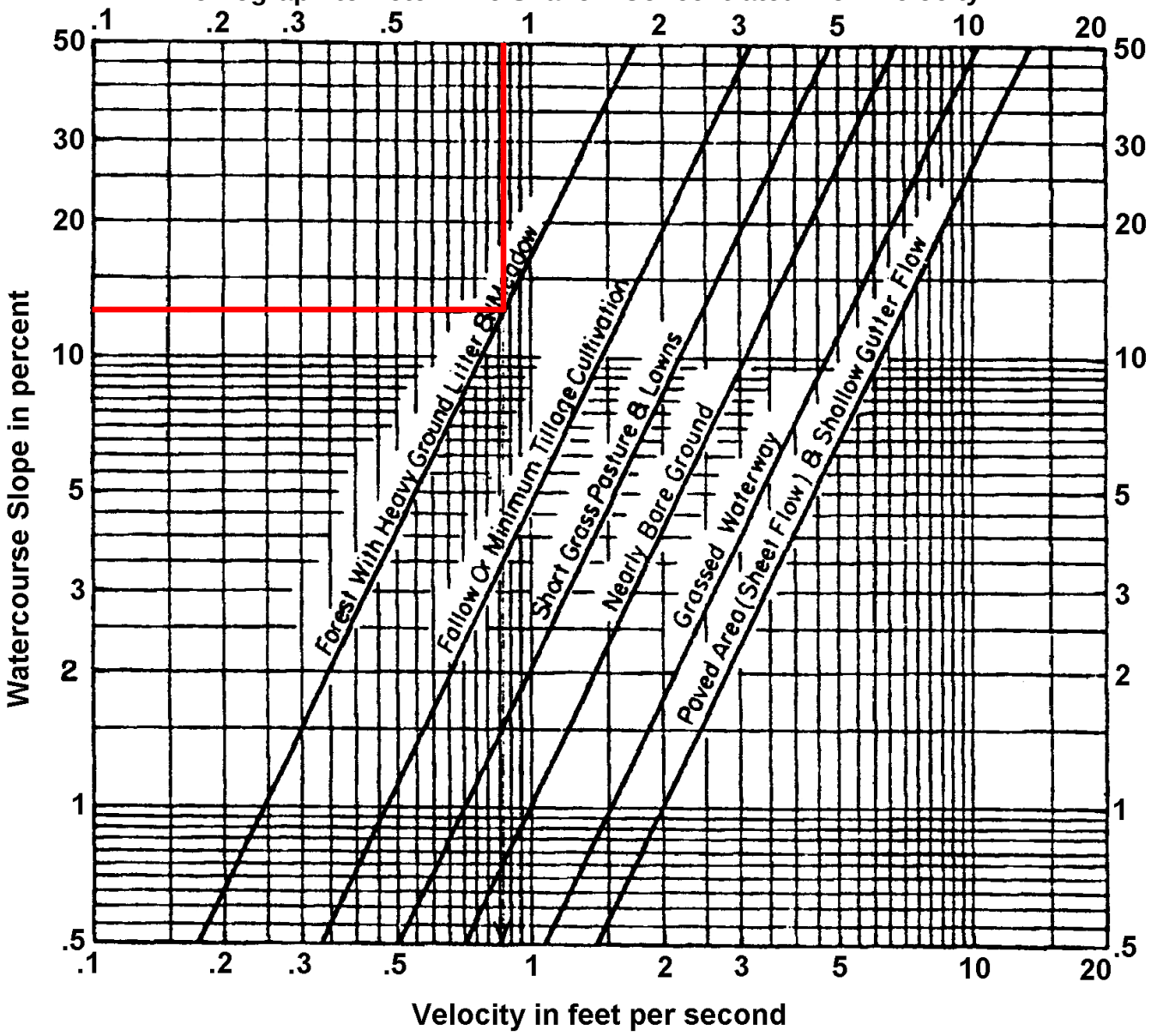
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.19_13

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

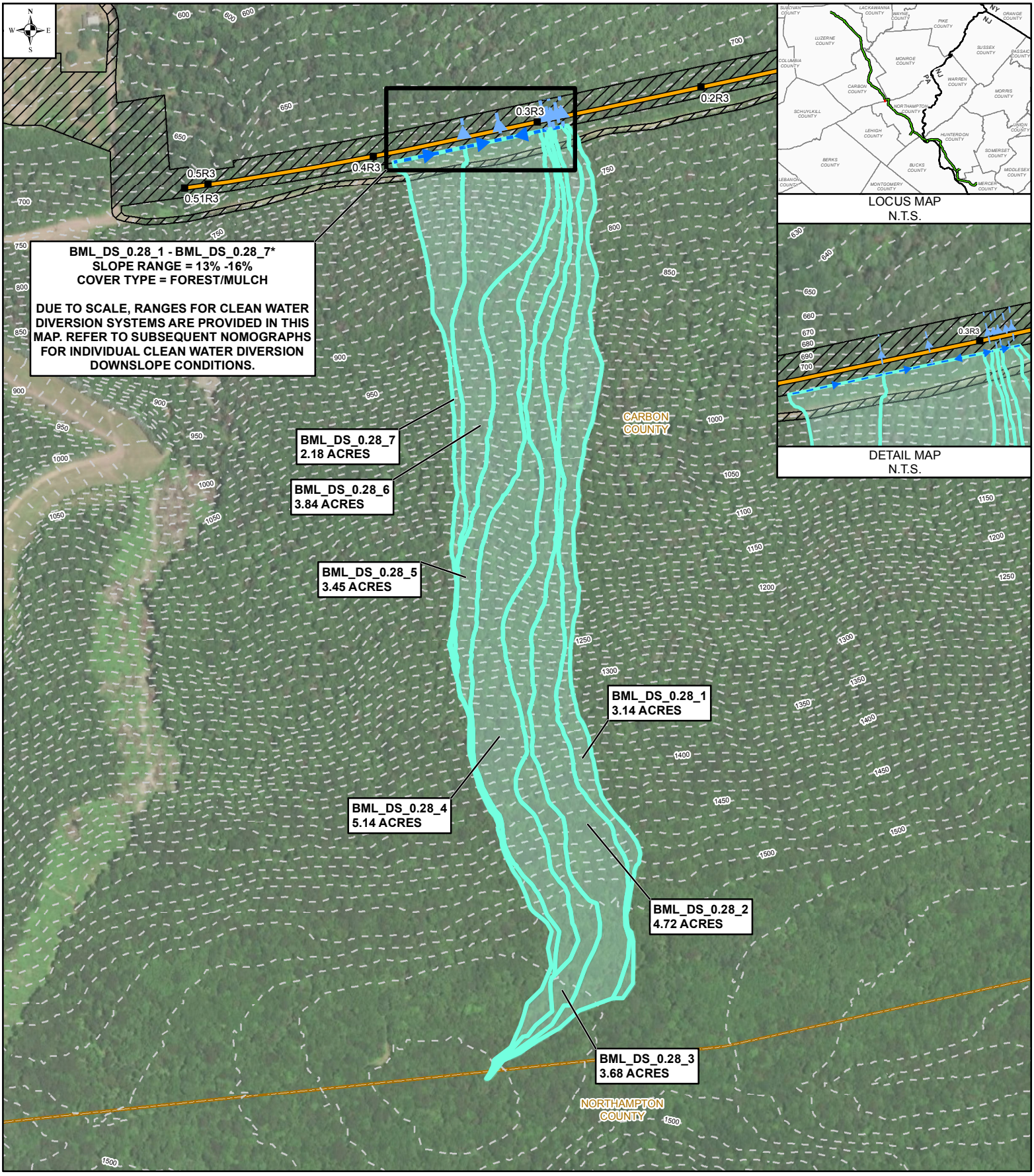


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_BML_0.28

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 112 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.28_1
3.14 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 0.28_1	100	0.8	0.020	16.00

$$T_{c(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 0.28_1	2768	FOREST	0.290	1.35	34.05

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
50.04

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 0.28_1	1	FOREST	0.20	3.14	0.63	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	50.04	1.58	1.96	2.33	1.58	1.96	2.33

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.96	3.14	0.99	1.23	1.46

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.28_1	DS_BML_0.28_1	
TEMPORARY OR PERMANENT?	(T OR P)	T	T	
DESIGN STORM	(2, 5, OR 10 YR)	5	5	
ACRES	(AC)	3.14	3.14	
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A	N/A	
Q_r (REQUIRED CAPACITY)	(CFS)	1.23	1.23	
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.94	2.94	
PROTECTIVE LINING[2,6]		P300 (Unvegetated)	P300 (Vegetated)	
n (MANNING'S COEFFICIENT)[2]		0.034	0.034	
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A	
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.88	5.88	
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00	8.00	
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	4.99	4.99	
CHANNEL BOTTOM WIDTH	(FT)	0	0	
CHANNEL SIDE SLOPES	(H:V)	4 / 0	4 / 0	
D (TOTAL DEPTH)	(FT)	1.00	1.00	
CHANNEL TOP WIDTH @ D	(FT)	4.00	4.00	
d (CALCULATED FLOW DEPTH)	(FT)	0.50	0.50	
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.00	2.00	
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0	0	
d_{50} STONE SIZE	(IN)	N/A	N/A	
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.50	0.50	
R (HYDRAULIC RADIUS)		0.20	0.20	
S (BED SLOPE)[3, 7]	(FT/FT)	0.16	0.16	
S_C (CRITICAL SLOPE)	(FT/FT)	0.037	0.037	
$.7S_c$	(FT/FT)	0.026	0.026	
$1.3S_c$	(FT/FT)	0.048	0.048	
STABLE FLOW?	(Y/N)	Y	Y	
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A	N/A	
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.50	
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.50	
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S	S	

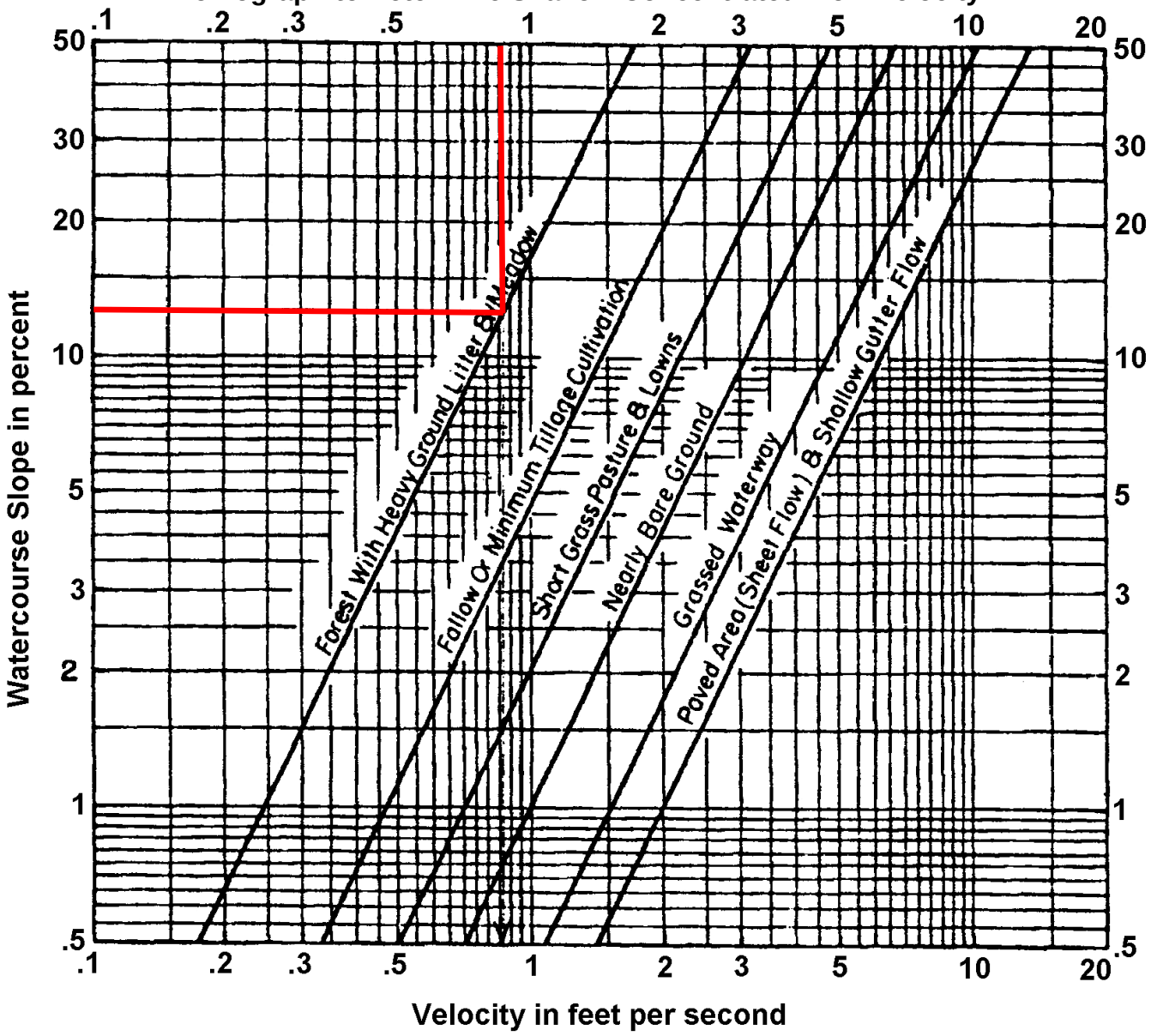
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.28_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.28_2
4.72 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.28_2	100	0.8	0.040	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.28_2	3082	FOREST	0.260	1.28	40.04

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.64

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.28_2	1	FOREST	0.20	4.72	0.94	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.64	1.50	1.86	2.22	1.50	1.86	2.22

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.86	4.72	1.42	1.75	2.09

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.28_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.72		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.75		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.75		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.94		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.18		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.7 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	3.70		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.85		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.46		
R (HYDRAULIC RADIUS)		0.19		
S (BED SLOPE)[3, 7]	(FT/FT)	0.07		
S_C (CRITICAL SLOPE)	(FT/FT)	0.016		
$.7S_c$	(FT/FT)	0.011		
$1.3S_c$	(FT/FT)	0.021		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

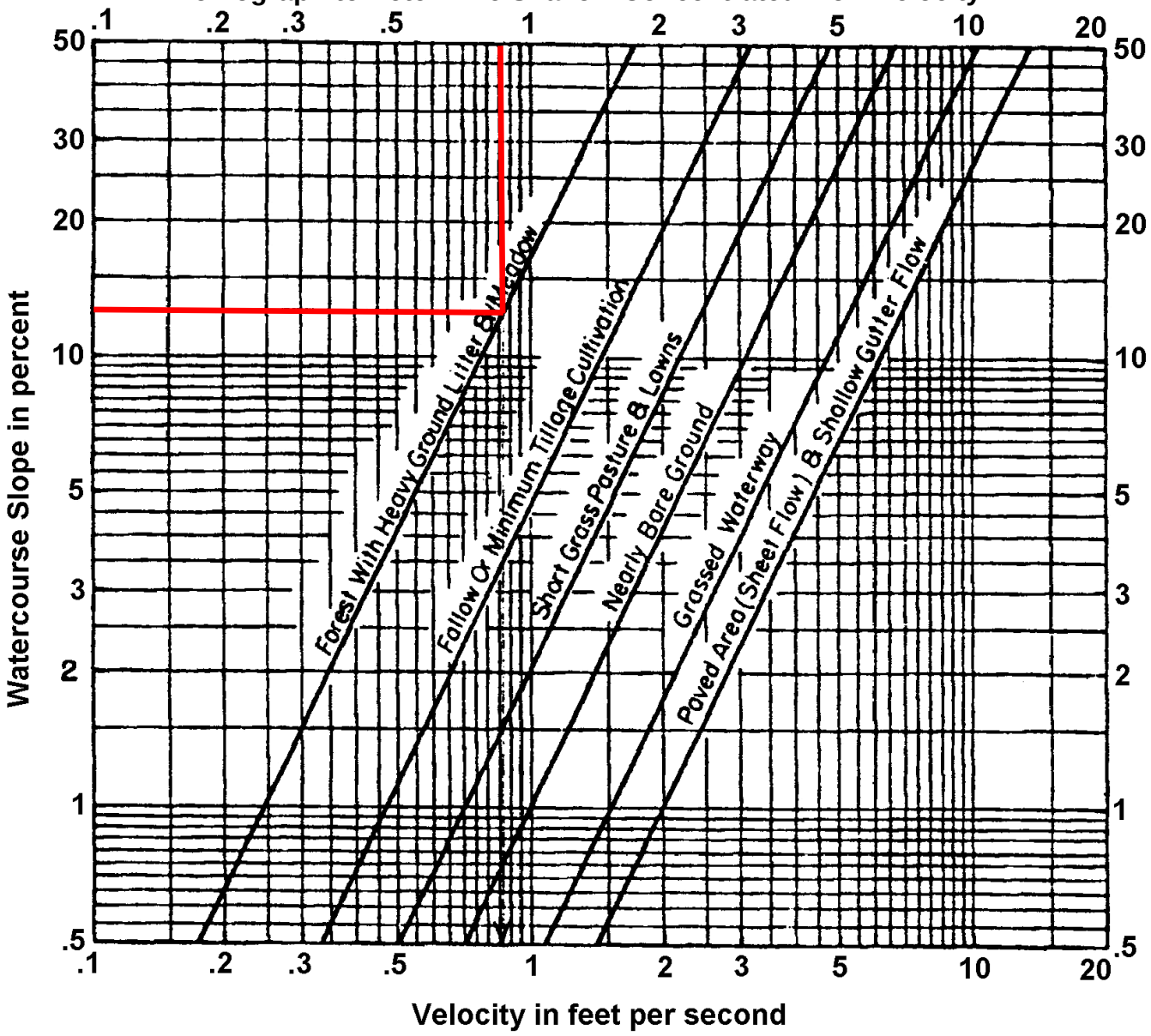
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.28_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.28_3
3.68 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.28_3	100	0.8	0.050	12.91

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.28_3	3149	FOREST	0.260	1.28	40.91

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
53.82

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.28_3	1	FOREST	0.20	3.68	0.74	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	53.82	1.50	1.85	2.21	1.50	1.85	2.21

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.85	3.68	1.10	1.36	1.63

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.28_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.68		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.36		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.76		
PROTECTIVE LINING[2,6]		P300		
n (MANNING'S COEFFICIENT)[2]		0.034		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.22		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.75		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.33 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	3.33		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.67		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.42		
R (HYDRAULIC RADIUS)		0.19		
S (BED SLOPE)[3, 7]	(FT/FT)	0.088		
S_C (CRITICAL SLOPE)	(FT/FT)	0.040		
$.7S_c$	(FT/FT)	0.028		
$1.3S_c$	(FT/FT)	0.052		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

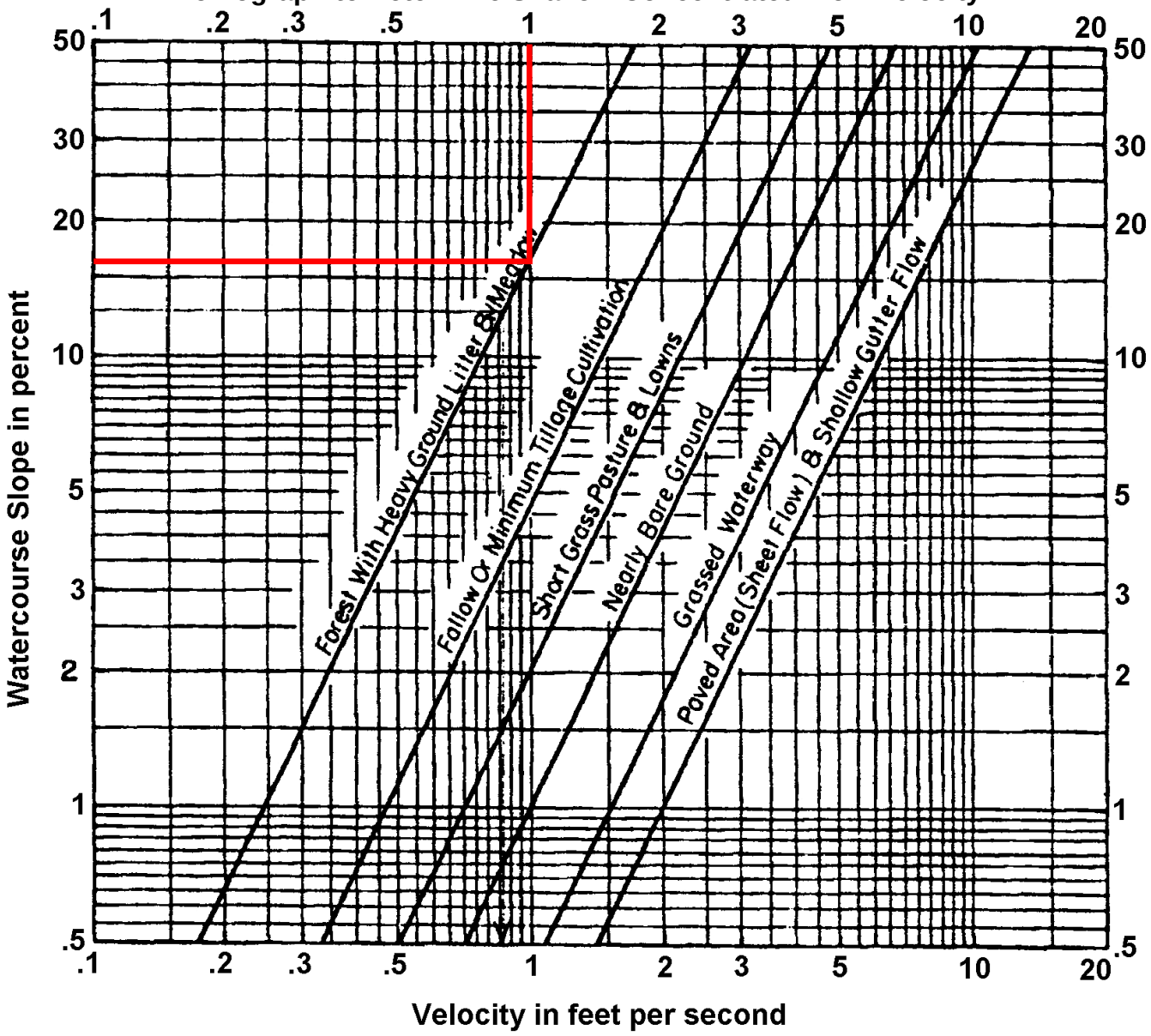
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.28_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.28_4
5.14 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.28_4	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.28_4	2727	FOREST	0.300	1.38	32.98

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
47.53

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.28_4	1	FOREST	0.20	5.14	1.03	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	47.53	1.64	2.03	2.41	1.64	2.03	2.41

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.03	5.14	1.69	2.09	2.48

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.28_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.14		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.09		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.26		
PROTECTIVE LINING[2,6]		C125BN		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	6.26		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.35		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.34		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.17 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.17		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.08		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.52		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.075		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.011		
$1.3S_c$	(FT/FT)	0.020		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

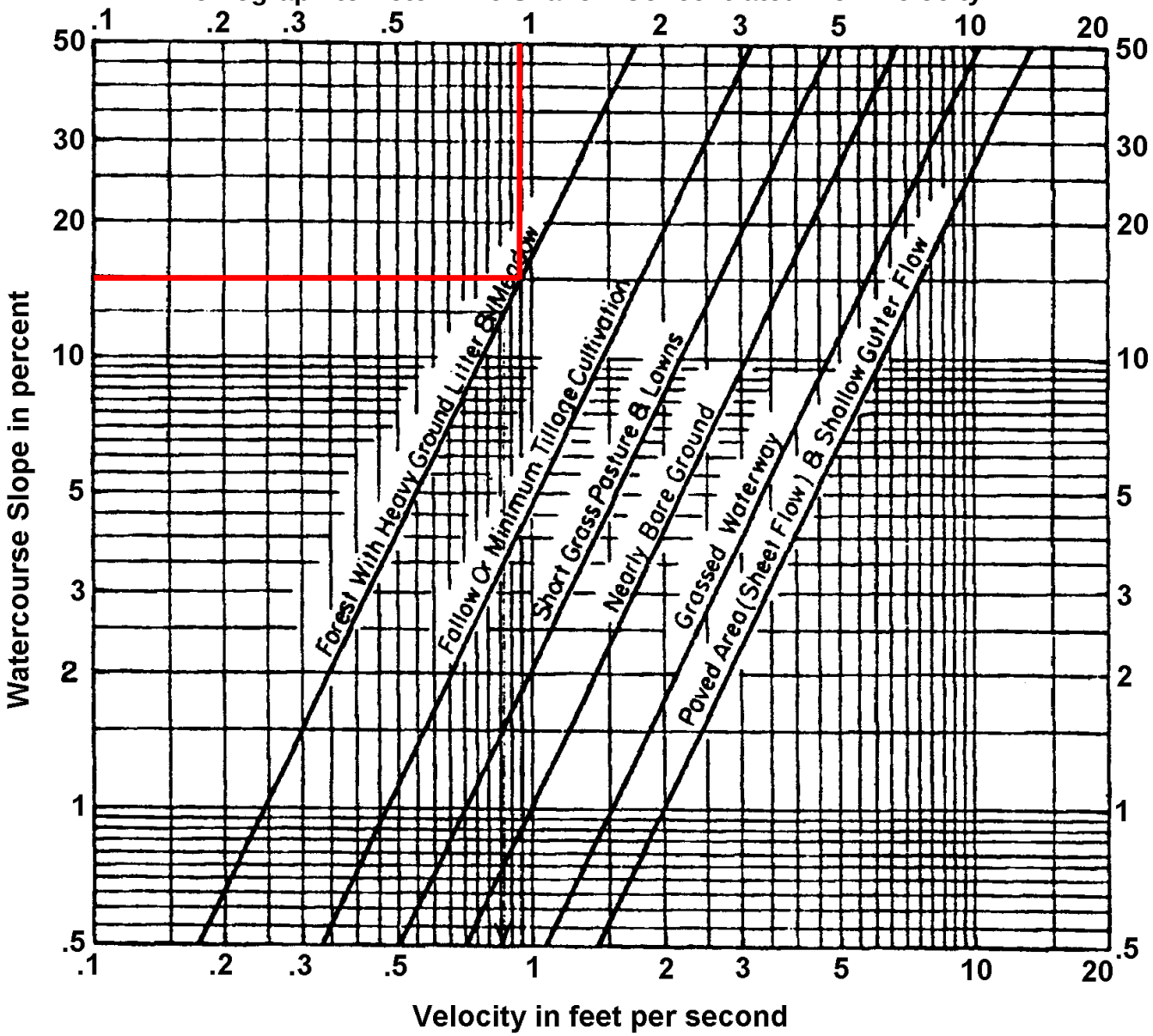
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.28_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 15%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.28_5
3.45 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.28_5	100	0.8	0.040	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.28_5	3142	FOREST	0.260	1.28	40.82

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
54.42

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.28_5	1	FOREST	0.20	3.45	0.69	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	54.42	1.48	1.84	2.20	1.48	1.84	2.20

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.84	3.45	1.02	1.27	1.52

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.28_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.45		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.27		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.73		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.13		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	4.26 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	4.26		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.13		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.53		
R (HYDRAULIC RADIUS)		0.20		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.015		
$.7S_c$	(FT/FT)	0.011		
$1.3S_c$	(FT/FT)	0.020		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

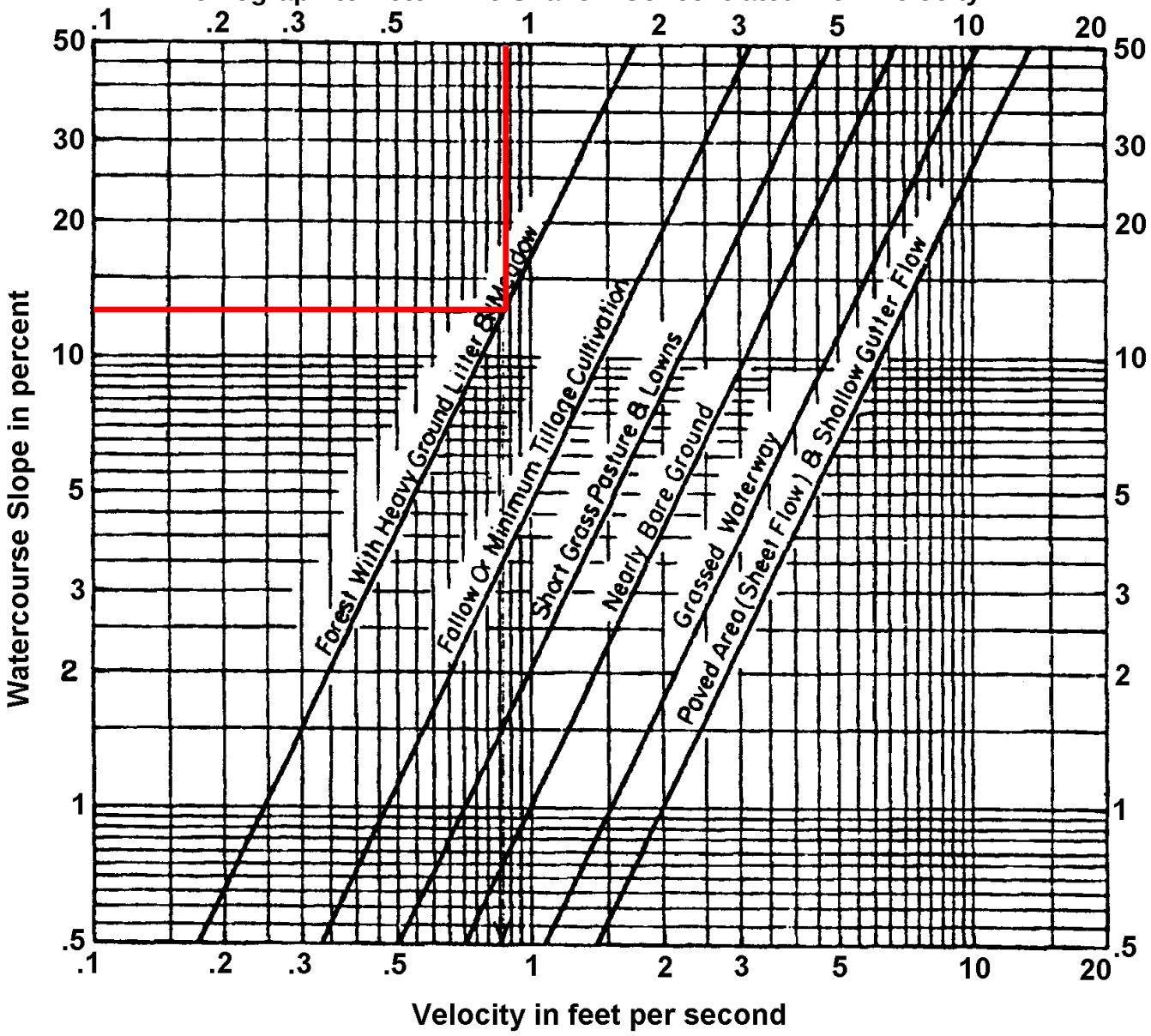
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.28_5

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.28_6
3.84 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.28_6	100	0.8	0.360	8.14

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.28_6	1722	FOREST	0.320	1.42	20.16

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
28.31

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.28_6	1	FOREST	0.20	3.84	0.77	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	28.31	2.34	2.85	3.31	2.34	2.85	3.31

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.85	3.84	1.80	2.19	2.54

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.28_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.84		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.19		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	5.60		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.019		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.92		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	2.86 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	4.29		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.86		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.43		
R (HYDRAULIC RADIUS)		0.35		
S (BED SLOPE)[3, 7]	(FT/FT)	0.01		
S_C (CRITICAL SLOPE)	(FT/FT)	0.010		
$.7S_c$	(FT/FT)	0.007		
$1.3S_c$	(FT/FT)	0.014		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

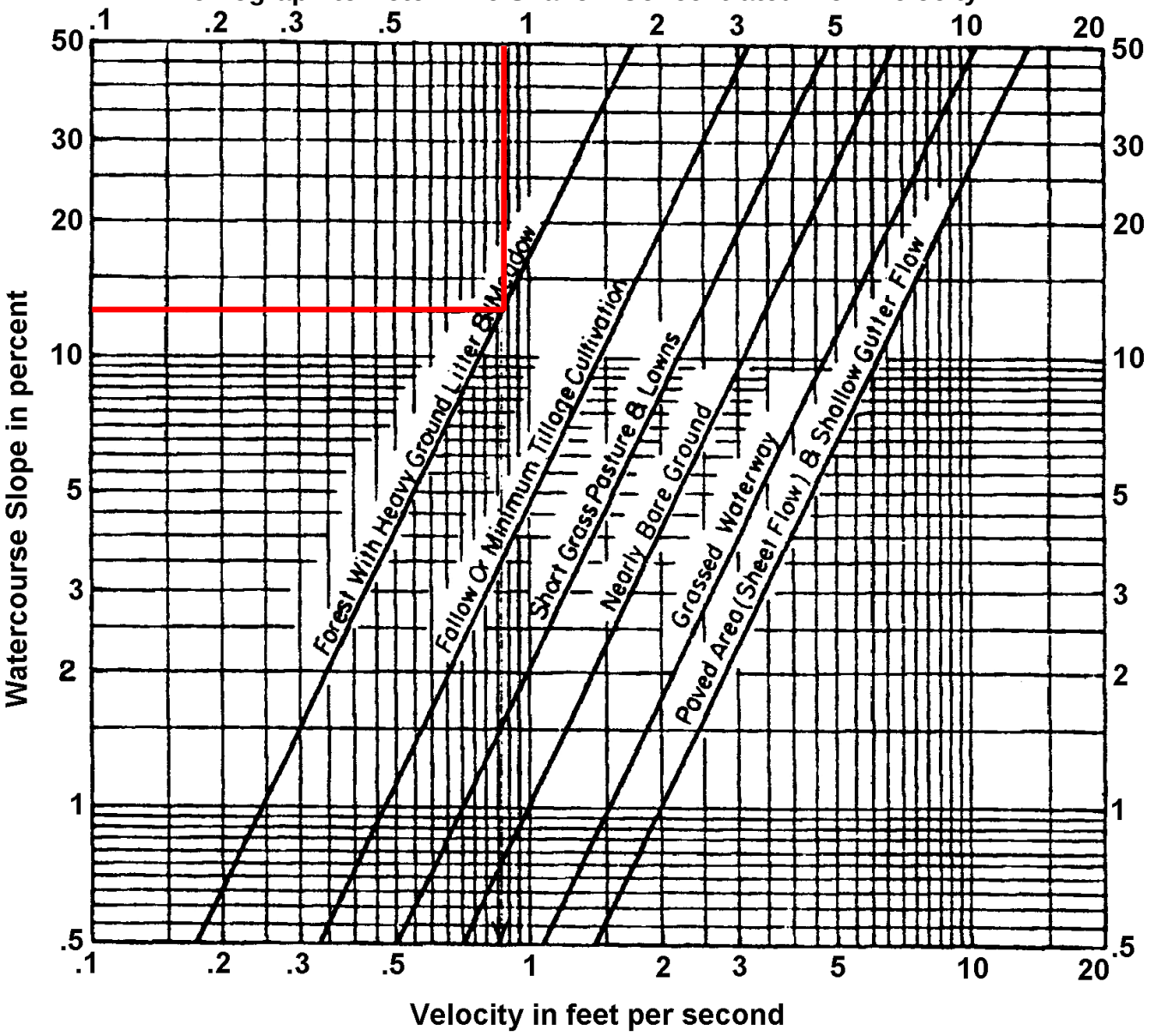
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.28_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.28_7
2.18 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.28_7	100	0.8	0.170	9.70

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.28_7	2099	FOREST	0.330	1.45	24.20

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
33.91

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.28_7	1	FOREST	0.20	2.18	0.44	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	33.91	2.08	2.55	2.99	2.08	2.55	2.99

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.55	2.18	0.91	1.11	1.30

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.28_7		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.18		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.11		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.49		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.65		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.56		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	2.56 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	2.56		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.28		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.32		
R (HYDRAULIC RADIUS)		0.17		
S (BED SLOPE)[3, 7]	(FT/FT)	0.05		
S_C (CRITICAL SLOPE)	(FT/FT)	0.019		
$.7S_c$	(FT/FT)	0.013		
$1.3S_c$	(FT/FT)	0.024		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

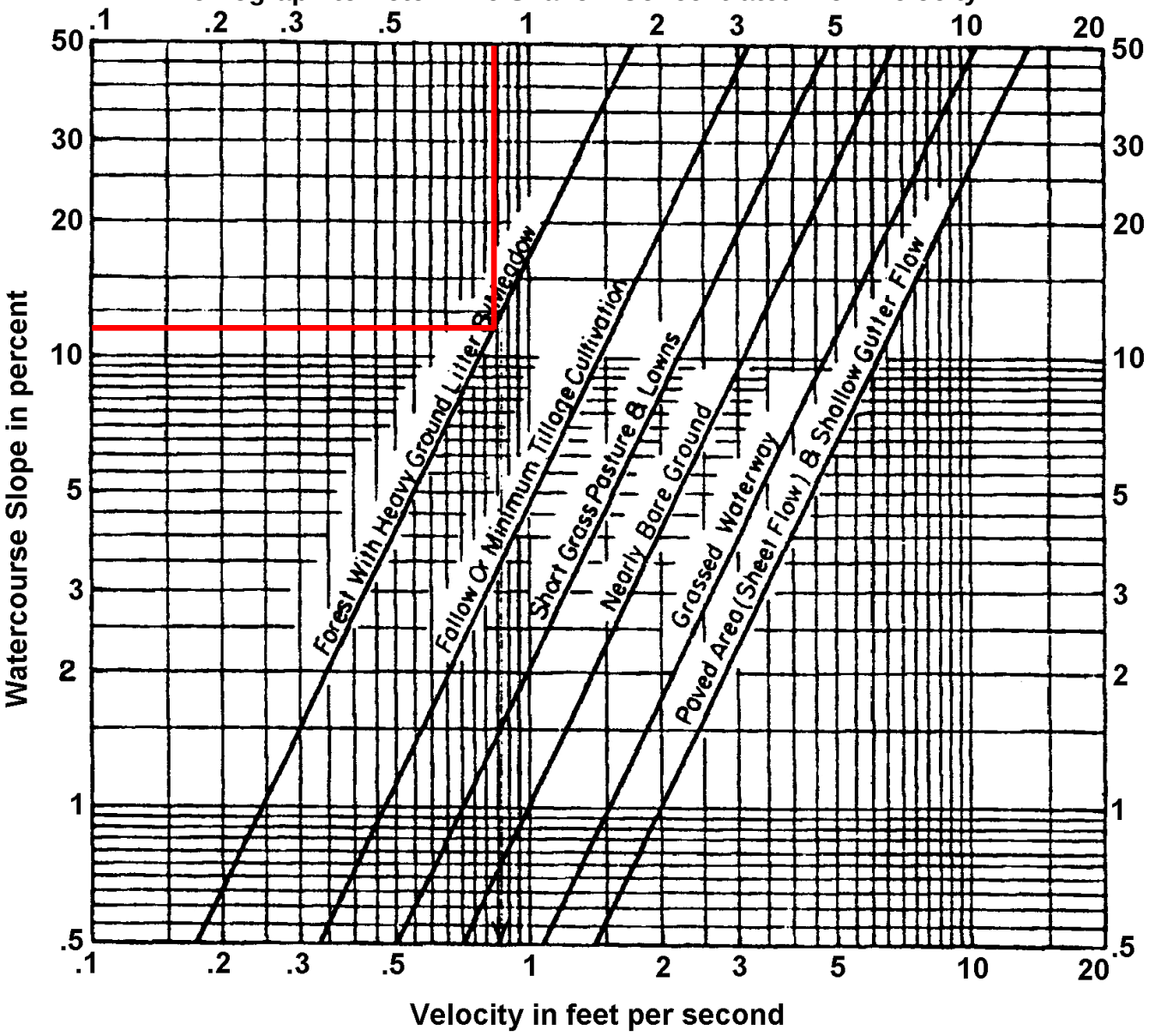
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.28_7

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

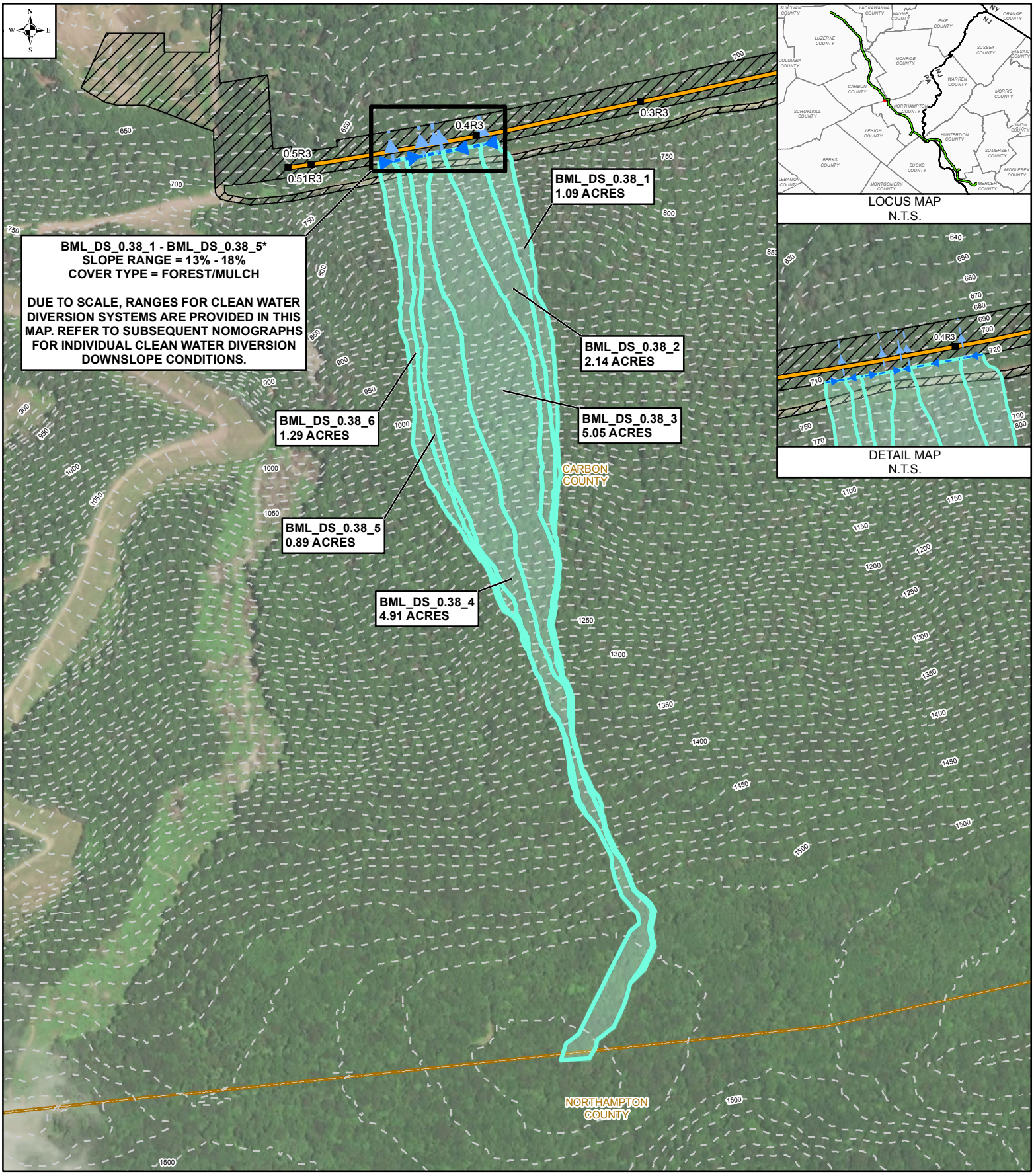


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 12%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.8 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.8 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- INDEX CONTOUR
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- DETAIL EXTENT
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_BML_0.38

CARBON COUNTY, PENNSYLVANIA

DRAWN BY:	SNP 10/2018	**APPROVED BY:**	MJD 10/2019	**SCALE:**	1 INCH = 400 FEET
CHECKED BY:	JMB 10/2019	**REV. DATE:**	10/2019	**REV.:**	1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 113 OF 114

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_1
1.09 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.38_1	100	0.8	0.260	8.78

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.38_1	1237	FOREST	0.350	1.49	13.85

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
22.64

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.38_1	1	FOREST	0.20	1.09	0.22	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	22.64	2.67	3.24	3.73	2.67	3.24	3.73

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.24	1.09	0.58	0.71	0.81

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.38_1		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.09		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.71		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.04		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.00		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	2.78 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	2.78		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.39		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.35		
R (HYDRAULIC RADIUS)		0.18		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.018		
$.7S_c$	(FT/FT)	0.013		
$1.3S_c$	(FT/FT)	0.023		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

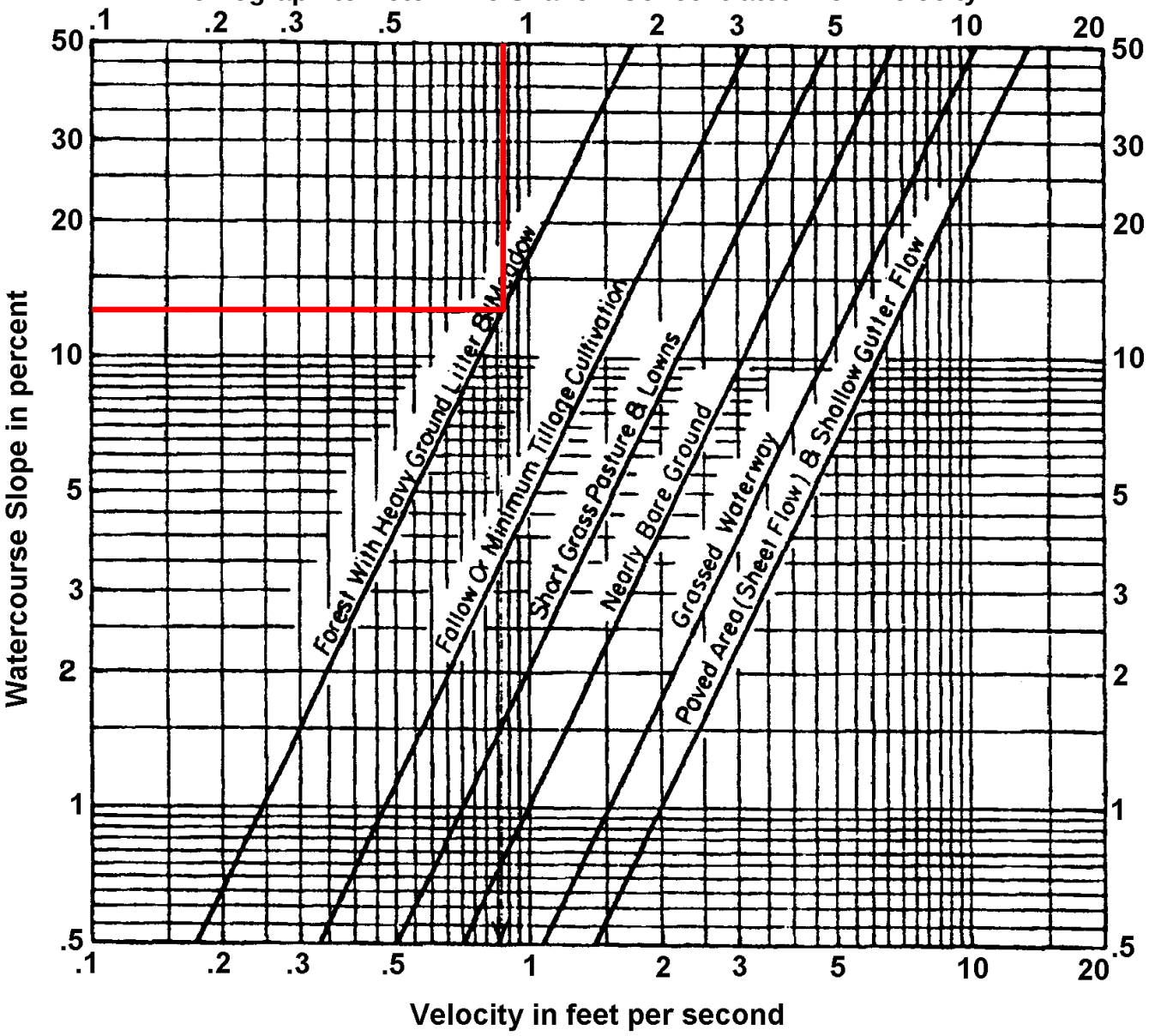
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.38_1

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 13%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_2
2.14 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.38_2	100	0.8	0.030	14.55

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.38_2	2695	FOREST	0.300	1.38	32.59

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
47.14

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.38_2	1	FOREST	0.20	2.14	0.43	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	47.14	1.65	2.04	2.42	1.65	2.04	2.42

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.04	2.14	0.71	0.87	1.04

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.38_2		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	2.14		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.87		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.68		
PROTECTIVE LINING[2,6]		P300		
n (MANNING'S COEFFICIENT)[2]		0.034		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	4.23		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.81		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.17 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	3.17		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.59		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.40		
R (HYDRAULIC RADIUS)		0.18		
S (BED SLOPE)[3, 7]	(FT/FT)	0.09		
S_C (CRITICAL SLOPE)	(FT/FT)	0.040		
$.7S_c$	(FT/FT)	0.028		
$1.3S_c$	(FT/FT)	0.053		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

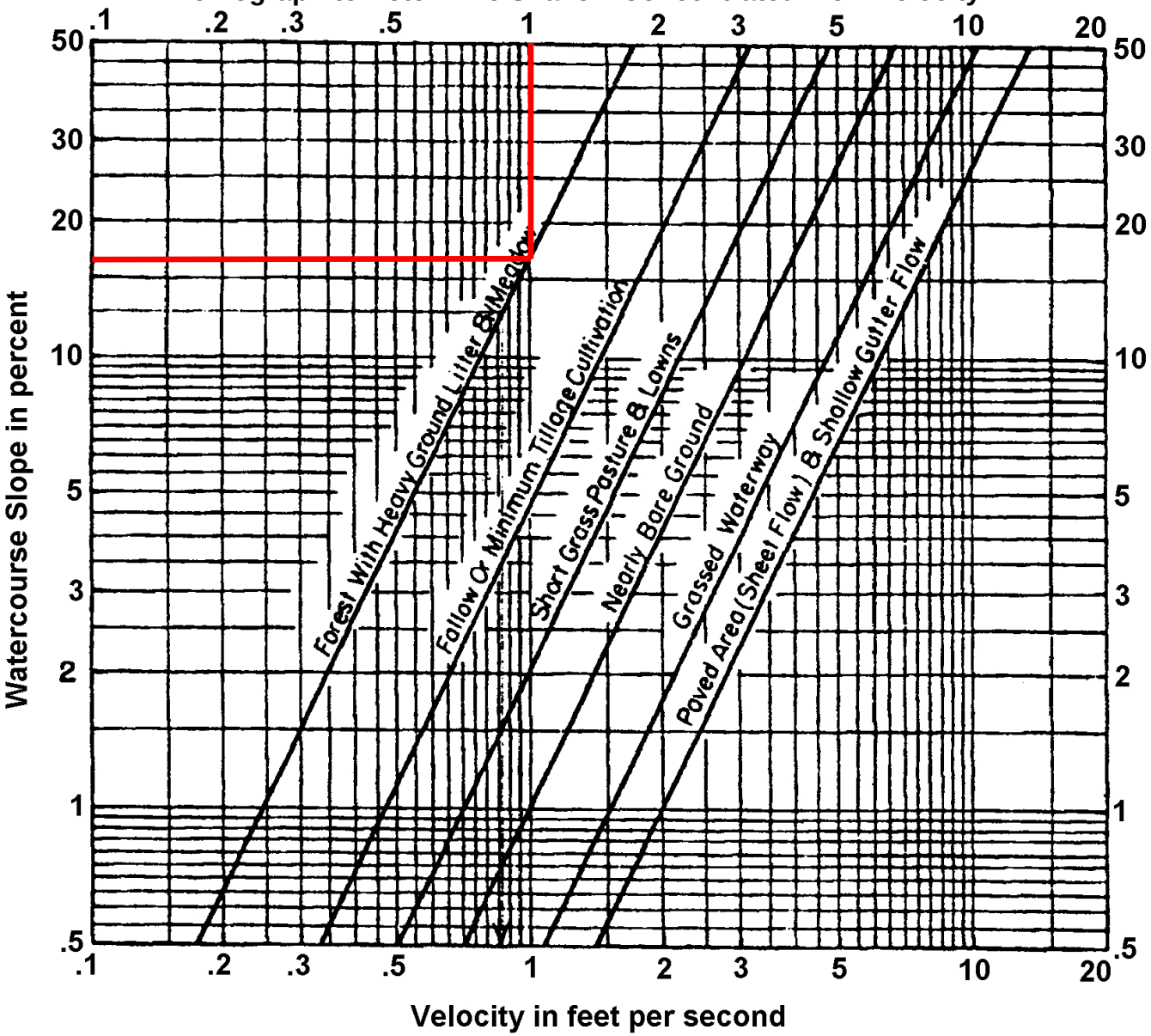
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.38_2

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 16%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.0 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.0 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_3
5.05 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.38_3	100	0.8	0.250	8.87

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.38_3	1807	FOREST	0.350	1.49	20.23

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
29.10

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.38_3	1	FOREST	0.20	5.05	1.01	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	29.10	2.30	2.81	3.26	2.30	2.81	3.26

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.81	5.05	2.32	2.83	3.30

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.38_3		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	5.05		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	2.84		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	7.19		
PROTECTIVE LINING[2,6]		P300		
n (MANNING'S COEFFICIENT)[2]		0.029		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	5.32		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	3.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	2.75		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	2.7 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	4.05		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.70		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.35		
R (HYDRAULIC RADIUS)		0.35		
S (BED SLOPE)[3, 7]	(FT/FT)	0.044		
S_C (CRITICAL SLOPE)	(FT/FT)	0.025		
$.7S_c$	(FT/FT)	0.018		
$1.3S_c$	(FT/FT)	0.033		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

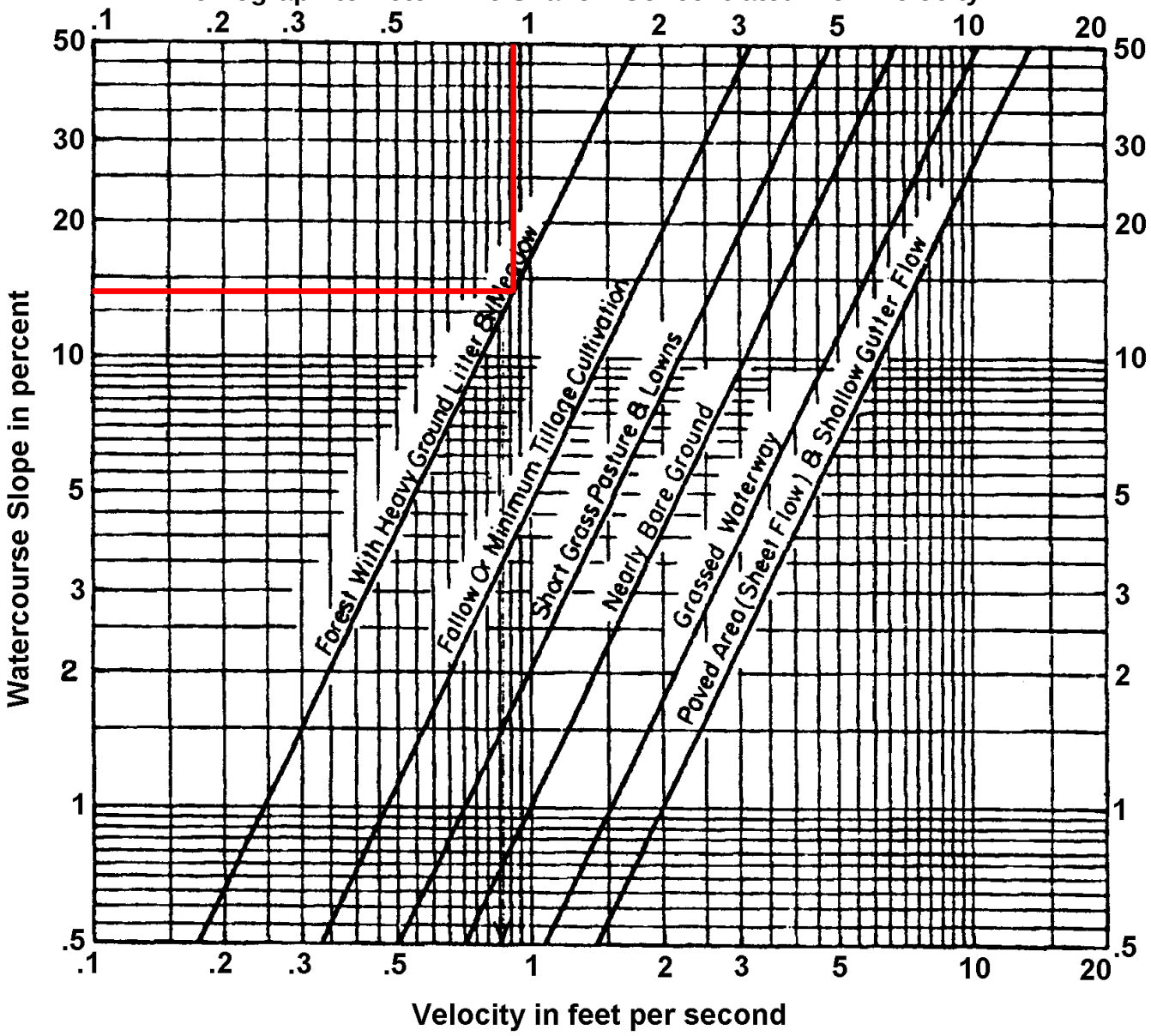
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.38_3

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_4
4.91 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.38_4	100	0.8	0.040	13.60

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.38_4	2966	FOREST	0.270	1.31	37.81

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
51.42

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.38_4	1	FOREST	0.20	4.91	0.98	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	51.42	1.55	1.92	2.28	1.55	1.92	2.28

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.92	4.91	1.52	1.88	2.24

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.38_4		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	4.91		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.88		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.86		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.044		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.00		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.87		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	2.86 / 0		
D (TOTAL DEPTH)	(FT)	1.50		
CHANNEL TOP WIDTH @ D	(FT)	4.29		
d (CALCULATED FLOW DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	2.86		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	1.43		
R (HYDRAULIC RADIUS)		0.35		
S (BED SLOPE)[3, 7]	(FT/FT)	0.014		
S_C (CRITICAL SLOPE)	(FT/FT)	0.056		
$.7S_c$	(FT/FT)	0.039		
$1.3S_c$	(FT/FT)	0.073		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

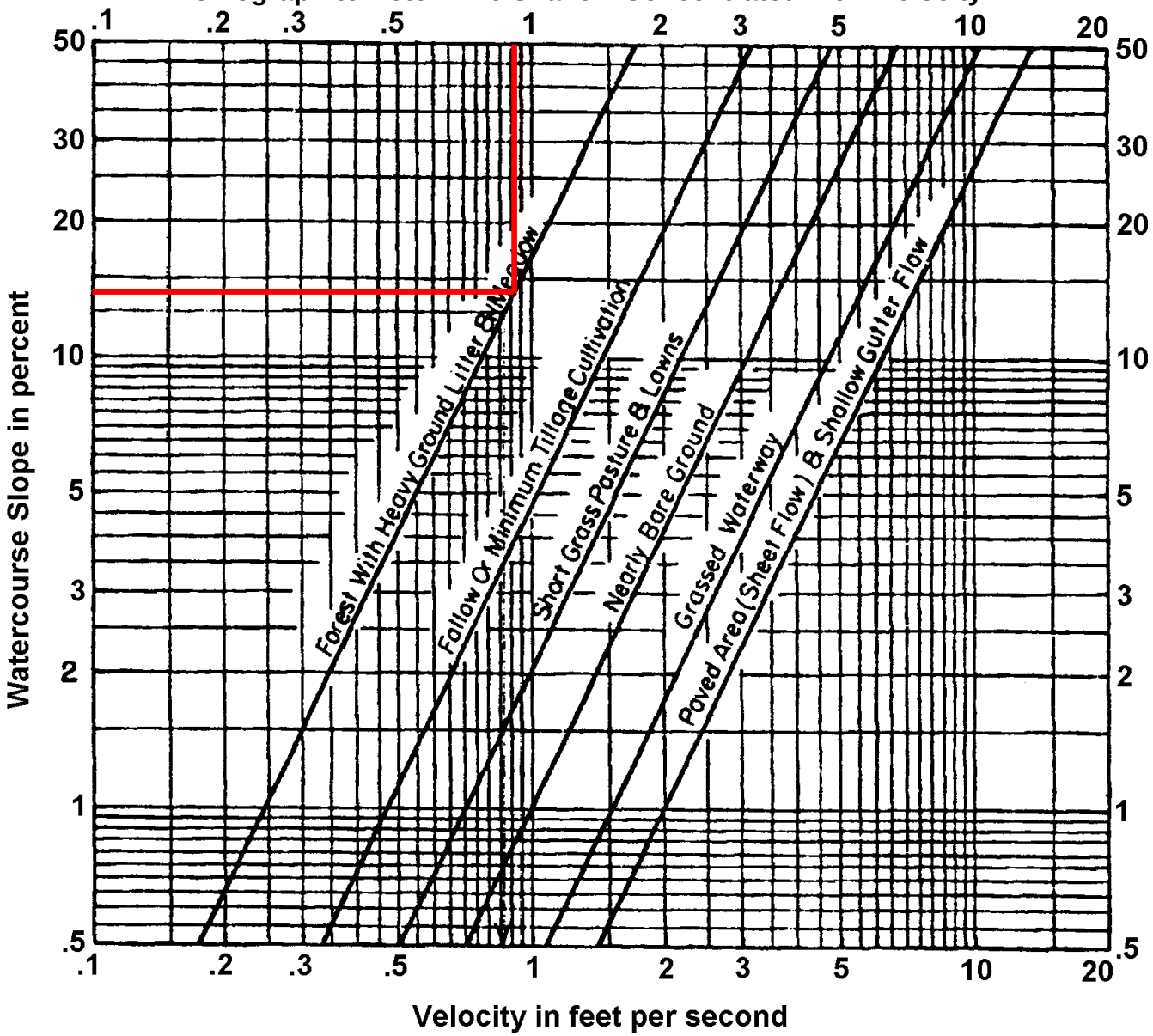
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.38_4

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 14%

SHALLOW CONCENTRATED FLOW VELOCITY = 0.9 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

0.9 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_5
0.89 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.38_5	100	0.8	0.270	8.71

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.38_5	1545	FOREST	0.350	1.49	17.30

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
26.01

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.38_5	1	FOREST	0.20	0.89	0.18	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	26.01	2.46	3.00	3.47	2.46	3.00	3.47

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	3.00	0.89	0.44	0.53	0.62

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.38_5		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	0.89		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.53		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.54		
PROTECTIVE LINING[2,6]		S75		
n (MANNING'S COEFFICIENT)[2]		0.055		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	1.37		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.78		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.13 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	3.13		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.56		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.39		
R (HYDRAULIC RADIUS)		0.18		
S (BED SLOPE)[3, 7]	(FT/FT)	0.025		
S_C (CRITICAL SLOPE)	(FT/FT)	0.106		
$.7S_c$	(FT/FT)	0.074		
$1.3S_c$	(FT/FT)	0.138		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

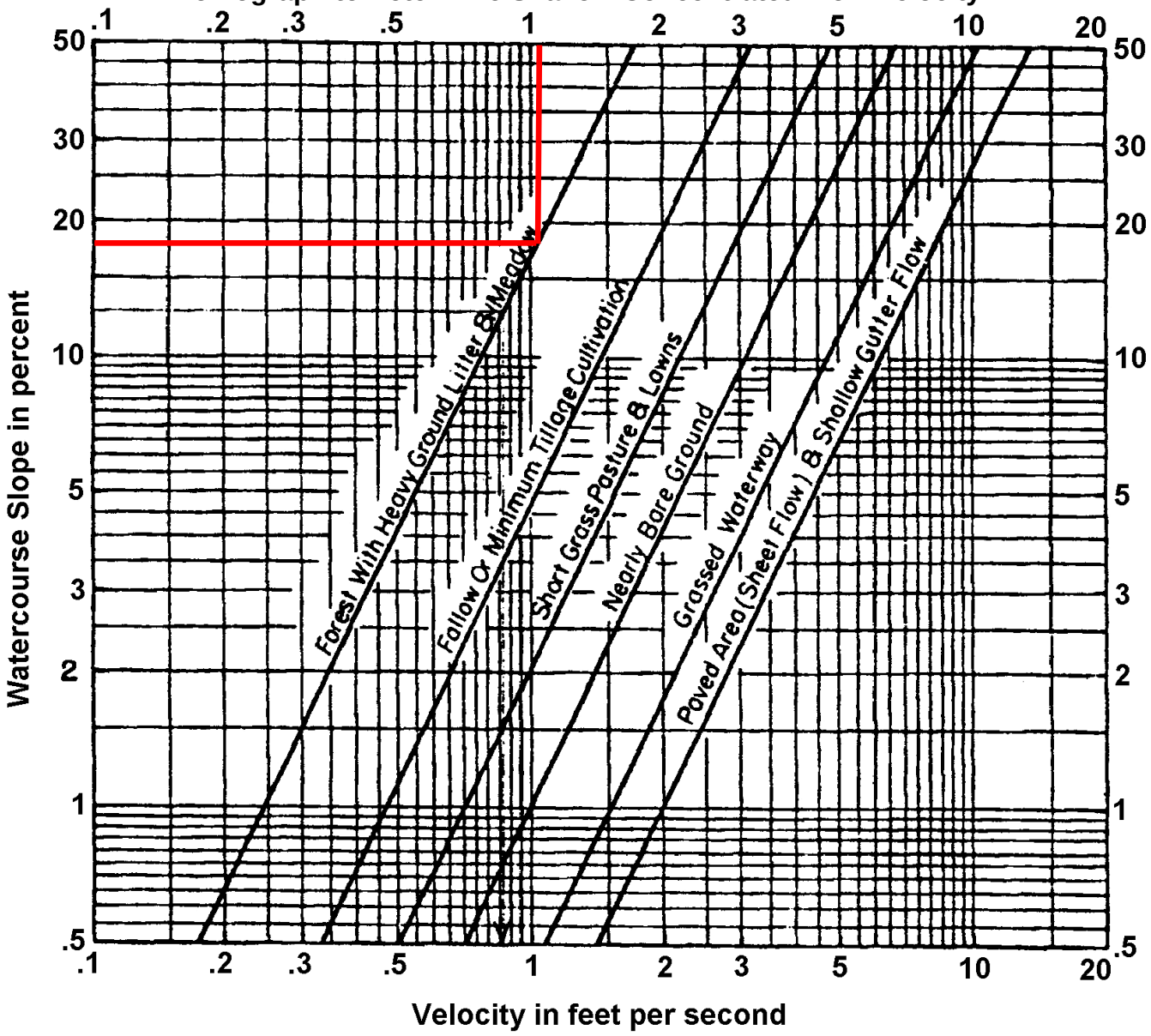
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.38_5 & DS_0.38_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity



TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 18%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.

CLEAN WATER DIVERSION

DRAINAGE AREA
DS_0.38_6
1.29 ACRES

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS BML_0.38_6	100	0.8	0.230	9.04

$$T_{c\,(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS BML_0.38_6	2168	FOREST	0.330	1.45	25.00

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
34.04

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/2018
CHECKED BY: KEK / JMB DATE: 10/15/2018

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS BML_0.38_6	1	FOREST	0.20	1.29	0.26	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	34.04	2.08	2.55	2.98	2.08	2.55	2.98

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	2.55	1.29	0.54	0.66	0.77

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.38_6		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	1.29		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	0.66		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.97		
PROTECTIVE LINING[2,6]		C125		
n (MANNING'S COEFFICIENT)[2]		0.022		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	2.96		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.25		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.62		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	2.63 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	2.63		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.32		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.33		
R (HYDRAULIC RADIUS)		0.17		
S (BED SLOPE)[3, 7]	(FT/FT)	0.02		
S_C (CRITICAL SLOPE)	(FT/FT)	0.018		
$.7S_c$	(FT/FT)	0.013		
$1.3S_c$	(FT/FT)	0.024		
STABLE FLOW?	(Y/N)	N		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.50		
FREEBOARD BASED ON STABLE FLOW	(FT)	N/A		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

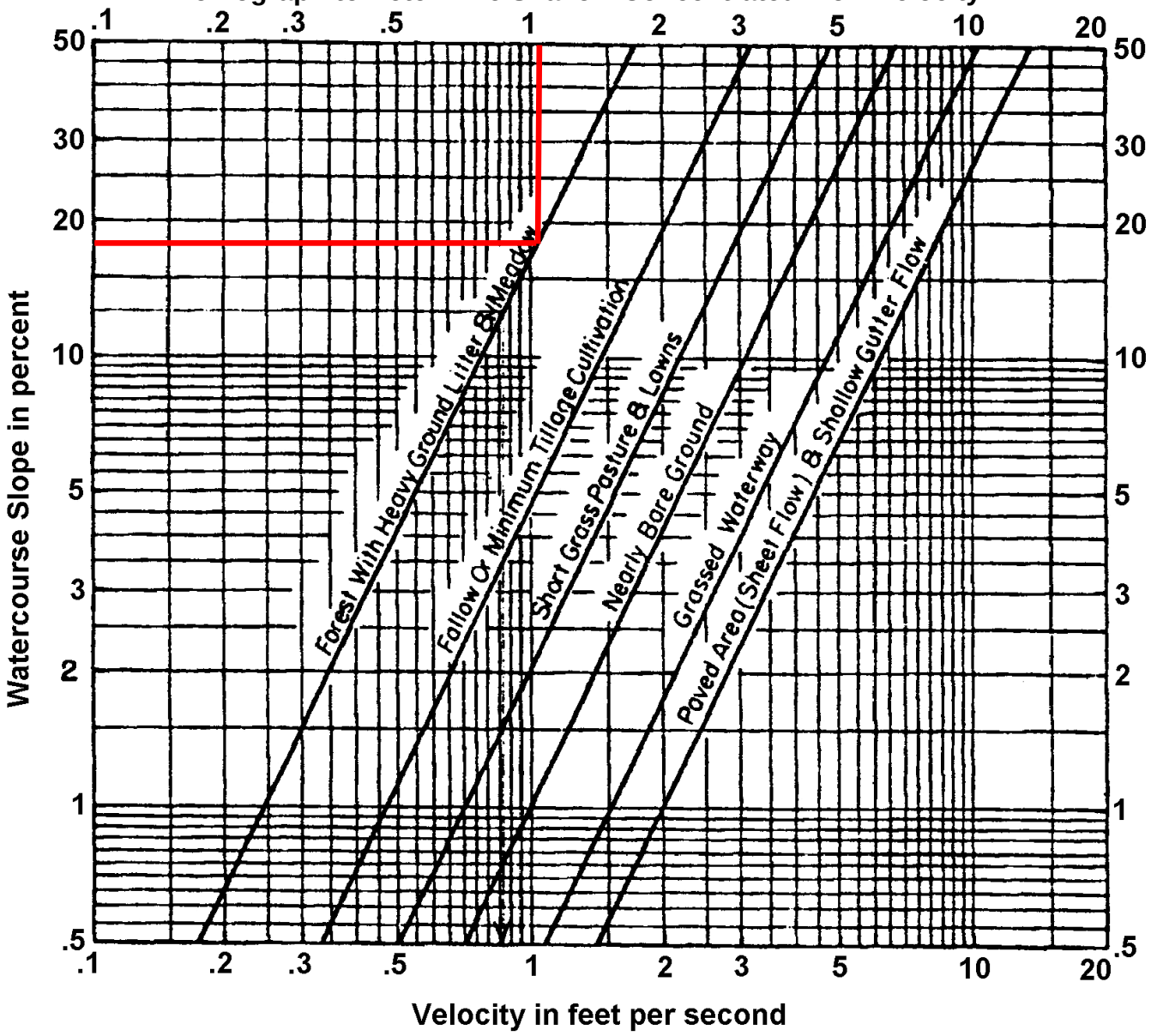
1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.

CLEAN WATER DIVERSION ID:
DS_0.38_5 & DS_0.38_6

Shallow Concentrated Flow

That portion of the flow path which is not channelized and cannot be considered sheet flow is considered shallow concentrated flow. The average velocity for shallow concentrated flow may be determined from Figure 5.1, in which average velocity is a function of slope and type of watercourse. **Note:** There is no maximum length for shallow concentrated flow in Pennsylvania.

FIGURE 5.1
Nomograph to Determine Shallow Concentrated Flow Velocity

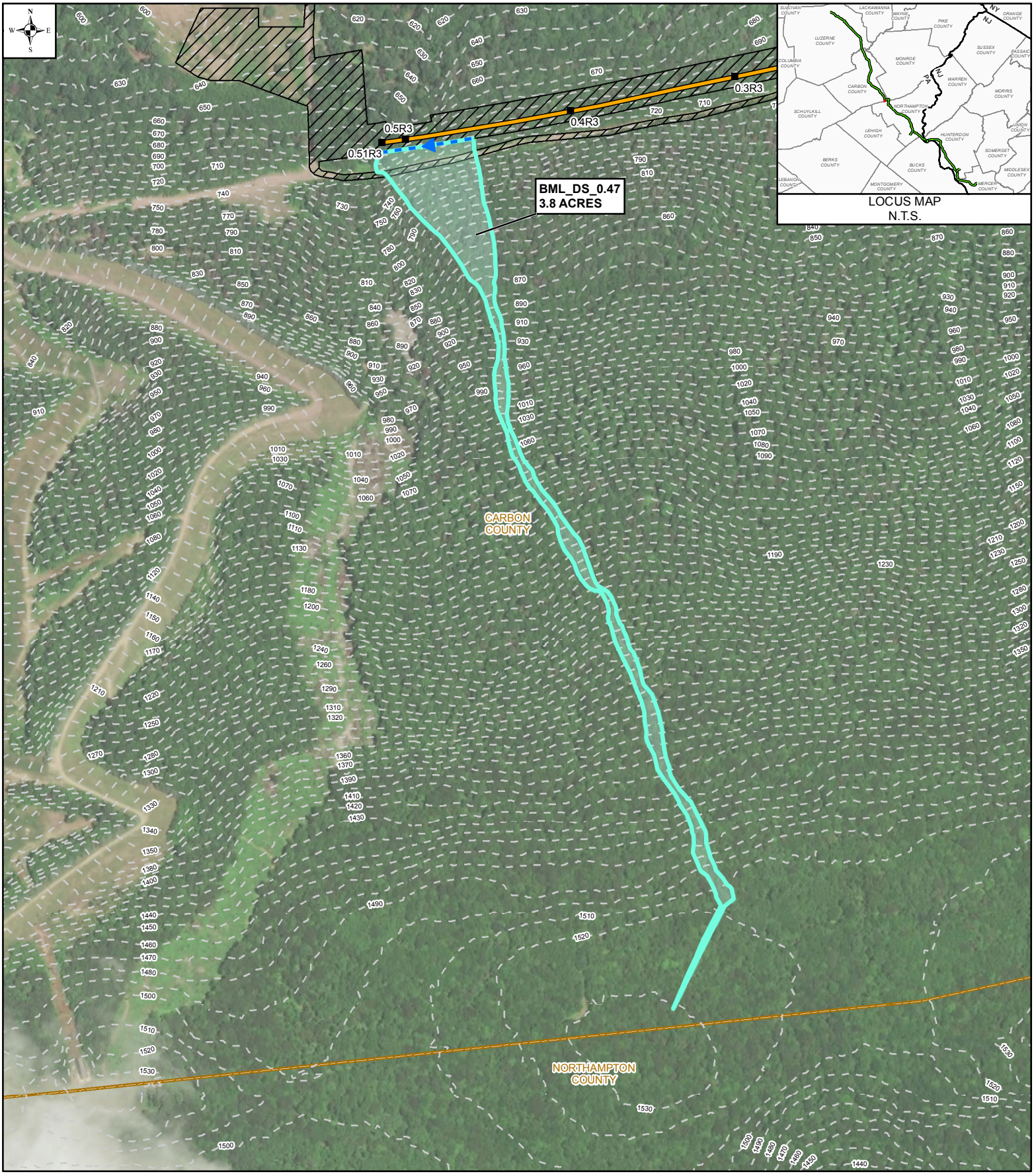


TR-55

DOWNSLOPE CONDITION
COVER TYPE = FOREST
PERCENT SLOPE = 18%

SHALLOW CONCENTRATED FLOW VELOCITY = 1.1 FPS (PER NOMOGRAPH)
PER TABLE G.1 OF THE E&S MANUAL, THE ALLOWABLE VELOCITY FOR DOWNSLOPE COVERS FOR CHANNELIZED FLOW IS 2 FPS FOR FORESTED/MULCH COVER TYPES.

1.1 FPS < 2.0 FPS THEREFORE THE ALLOWABLE VELOCITY IS NOT EXCEEDED.



LEGEND

- 1R — MILE POST (STATION EQUATON DUE TO RE-ROUTE)
- PROPOSED PENNEAST PIPELINE
- BLUE MOUNTAIN LATERAL
- HELLERTOWN LATERAL
- DIVERSION SOCK
- SLOPE PIPE
- DRAINAGE AREA
- PROPOSED CONSTRUCTION WORKSPACE
- INDEX CONTOUR
- COUNTY BOUNDARY

* CALLOUT INDICATES THE DOWNSLOPE CONDITIONS FROM THE LEVEL SPREADER AT THE POINT SHEET FLOW RETURNS TO CONCENTRATED FLOW.
** NO CONCENTRATED FLOW DOWNSLOPE OF LEVEL SPREADER. SHEET FLOW IS INTERCEPTED BY EXISTING DRAINAGE SYSTEM.
MAPS COMPILED UTILIZING ESRI BASEMAP AERIAL IMAGERY

PENNEAST PIPELINE PROJECT

CLEAN WATER DIVERSION MAPBOOK
DRAINAGE AREA DS_BML_0.47

CARBON COUNTY, PENNSYLVANIA

DRAWN BY: SNP 10/2018	**APPROVED BY:** MJD 10/2019	**SCALE:** 1 INCH = 400 FEET
CHECKED BY: JMB 10/2019	**REV. DATE:** 10/2019	**REV.:** 1

0 200 400 FEET

PennEast PIPELINE

DWG NO: PAGE 114 OF 114

STANDARD E&S WORKSHEET # 9
Time of Concentration

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/18
CHECKED BY: KEK / JMB DATE: 10/15/18

OVERLAND FLOW:

PATH NUMBER	LENGTH L (ft)	"n" VALUE	AVERAGE SLOPE S (ft/ft)	TIME T_{of} (minutes)
DS 0.47	100	0.8	0.040	13.60

$$T_{c(sheet\ flow)} = \left[\frac{2(\quad)(n)}{3(\quad)^{0.5}}\right]^{0.4673}$$

n	Type of Cover
0.02	smooth pavement
0.1	bare parched soil
0.3	poor grass cover
0.4	average grass cover
0.8	dense grass cover

(L = 150' maximum)

SHALLOW CONCENTRATED FLOW:

PATH NUMBER	LENGTH (ft)	TYPE OF COVER	AVERAGE SLOPE (ft/ft)	V (ft/sec)	TIME T_{sc} (minutes)
DS 0.47	2982	FOREST	0.280	1.33	37.33

CHANNEL FLOW:

PATH NUMBER	LENGTH (ft)	AREA (sq. ft.)	AVERAGE SLOPE (ft/ft)	WETTED PERIMETER (ft)	HYDRAULIC RADIUS (ft)	MANNING'S n	V (ft/sec)	CHANNEL TIME T_{ch} (minutes)

TIME OF CONCENTRATION:

T_c^* (minutes)
50.93

CHANNEL DIMENSIONS:

PATH NUMBER	BOTTOM WIDTH (ft)	LEFT SIDE SLOPE (H:V)	RIGHT SIDE SLOPE (H:V)	TOTAL DEPTH (ft)	TOP WIDTH (ft)

*Tc = Overland Flow Time + Shallow Concentrated Flow Time + Channel Flow Time

STANDARD E&S WORKSHEET # 10
Rational Equation

PROJECT NAME: PENNEAST PIPELINE PROJECT
LOCATION: CARBON COUNTY
PREPARED BY: MDN DATE: 10/15/18
CHECKED BY: KEK / JMB DATE: 10/15/18

DETERMINE WATERSHED "C" VALUES

CHANNEL NUMBER	DRAINAGE AREA NUMBER	TYPE OF COVER	C VALUE	AREA (acres)	(C X A)	C_w
DS 0.47	1	FOREST	0.20	3.80	0.76	0.20

DETERMINE RAINFALL INTENSITY:

CHANNEL NUMBER	T_c	Rainfall Depth R_2	R_5	R_{10}	Rainfall Intensity I_2	Rainfall Intensity I_5	Rainfall Intensity I_{10}
	50.93	1.56	1.93	2.30	1.56	1.93	2.30

DETERMINE PEAK RUNOFF RATES (Q = C x I x A)

CHANNEL NUMBER	C_w	I (inches/hr)	A (acres)	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)
	0.20	1.93	3.80	1.19	1.47	1.75

STANDARD E&S WORKSHEET #11
Channel Design Data

PROJECT NAME: PENNEAST PIPELINE PROJECT

LOCATION: CARBON COUNTY

PREPARED BY: MDN DATE: 10/2019

CHECKED BY: KEK / JMB DATE: 10/2019

CHANNEL OR CHANNEL SECTION		DS_BML_0.47		
TEMPORARY OR PERMANENT?	(T OR P)	T		
DESIGN STORM	(2, 5, OR 10 YR)	5		
ACRES	(AC)	3.8		
MULTIPLIER[1]	(1.6, 2.25, OR 2.75)[1]	N/A		
Q_r (REQUIRED CAPACITY)	(CFS)	1.47		
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.68		
PROTECTIVE LINING[2,6]		P550		
n (MANNING'S COEFFICIENT)[2]		0.041		
V_a (ALLOWABLE VELOCITY)	(FPS)	N/A		
V (CALCUALTED AT FLOW DEPTH d)	(FPS)	3.89		
τ_a (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	4.00		
τ_d (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	3.34		
CHANNEL BOTTOM WIDTH	(FT)	0		
CHANNEL SIDE SLOPES	(H:V)	3.45 / 0		
D (TOTAL DEPTH)	(FT)	1.00		
CHANNEL TOP WIDTH @ D	(FT)	3.45		
d (CALCULATED FLOW DEPTH)	(FT)	0.50		
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	1.72		
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0		
d_{50} STONE SIZE	(IN)	N/A		
A (CROSS-SECTIONAL AREA)	(SQ. FT)	0.43		
R (HYDRAULIC RADIUS)		0.19		
S (BED SLOPE)[3, 7]	(FT/FT)	0.107		
S_C (CRITICAL SLOPE)	(FT/FT)	0.057		
$.7S_c$	(FT/FT)	0.040		
$1.3S_c$	(FT/FT)	0.074		
STABLE FLOW?	(Y/N)	Y		
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	N/A		
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50		
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50		
DESIGN METHOD FOR PROTECTIVE LINING[5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS (S)		S		

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in seperate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or ¼ Total Channel Depth, whichever is greater.
5. Permissible velocity lining design method is not acceptable for channels with a bed slope of 10% or greater. Shear stress lining design method is required for channels with a bed slope of 10% or greater. Shear stress lining design method may be used for any channel bed slope.
6. In cases where existing grass is sufficient for the channel lining, S75 RollMax lining or product equivalent can be used in its place.
7. There is no significant percent slope change along the entire temporary channel, therefore the channel capacity and shear stress have been calculated based on the single bed slope value shown above.