E&S WORKSHEET # 11

Channel Design Data

PROJECT NAME: ATLANTIC SUNRISE PROPOSED NATURAL GAS PIPELINE

LOCATION: ELDRED TOWNSHIP, SCHUYLKILL COUNTY

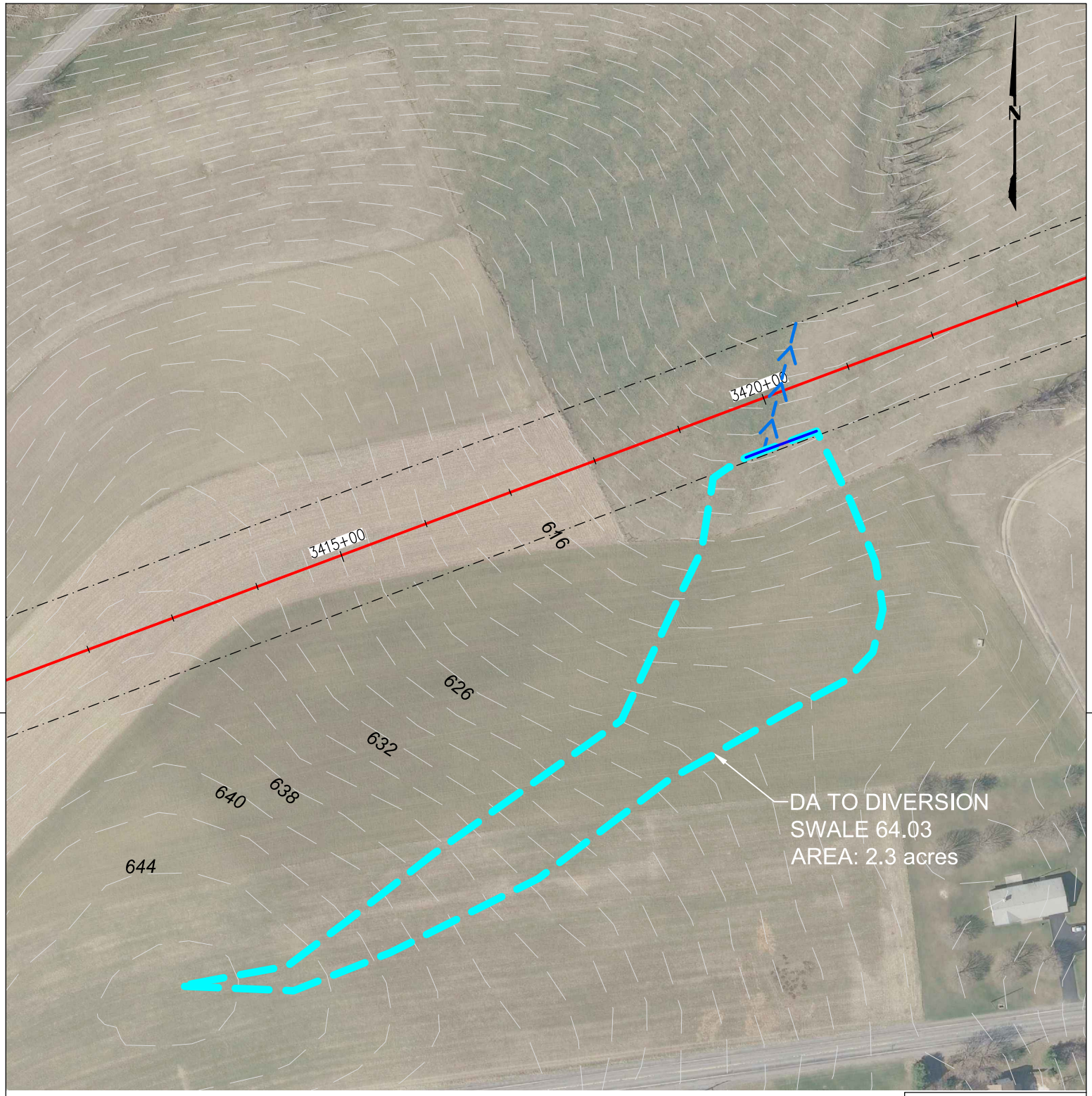
PREPARED BY: ESS DATE: 08/17/2016

CHECKED BY: AJB DATE: 04/10/2017

CHANNEL OR CHANNEL SECTION		SWALE 64.03 LINING	SWALE 64.03 GRASS			
TEMPORARY OR PERMANENT?	(T OR P)	T	T			
DESIGN STORM	(2, 5, OR 10 YR)	2	2			
ACRES	(AC)	2.3	2.3			
MULTIPLIER[1]	(1.6, 2.25, or 2.75)[1]	1.6	1.6			
Qr (REQUIRED CAPACITY)	(CFS)	3.68	3.68			
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.68	3.71			
PROTECTIVE LINING[2]		SC150	SC150/ GRASS			
n (MANNING'S COEFFICIENT)[2]		0.05	0.045			
Va (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A			
V (CALCULATED AT FLOW DEPTH d)	(FPS)	3.51	3.79			
τa (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00	2.00			
τd (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.78	1.68			
CHANNEL BOTTOM WIDTH	(FT)	2	2			
CHANNEL SIDE SLOPES	(H:V)	2	2			
D (TOTAL DEPTH)	(FT)	2.0	2.0			
CHANNEL TOP WIDTH @ D	(FT)	10	10			
d (CALCULATED FLOW DEPTH)	(FT)	0.38	0.36			
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.52	3.44			
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	5.26	5.56			
d50 STONE SIZE	(IN)	N/A	N/A			
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	1.05	0.98			
R (HYDRAULIC RADIUS)		0.28	0.27			
S (BED SLOPE)[3]	(FT/FT)	0.075	0.075			
Sc (CRITICAL SLOPE)	(FT/FT)	0.058	0.048			
.7Sc	(FT/FT)	0.041	0.033			
1.3Sc	(FT/FT)	0.076	0.062			
STABLE FLOW?	(Y/N)	N	Y			
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.10	0.1			
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.5			
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.5			
DESIGN METHOD FOR PROTECTIVE LINING [5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS	(S)	S	S			

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 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.

Source: 363-2134-008 / March 31, 2012 / Page 382



0 75 150

SCALE IN FEET

ISSUED FOR PERMITTING

BL Companies
ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

LEGEND

DIVERSION SWALE

DIVERSION SWALE DRAINAGE AREA

CLEAN WATER CROSSING

TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC
ATLANTIC SUNRISE PROJECT
PROPOSED 42" CENTRAL PENN LINE SOUTH

Williams

DIVERSION DRAINAGE AREA MAP

PINE GROVE TOWNSHIP
SCHUYLKILL COUNTY, PENNSYLVANIA

NO.	DATE	BY	REVISION DESCRIPTION	W.O. NO.	CHK.	APP.
0	08/29/15	BL	ISSUED FOR PADEP SUBMITTAL	1161503	DAK	AJB
1	12/02/15	BL	ISSUED FOR PADEP RESUBMITTAL	1161503	DAK	AJB
2	Oct. 2016	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #1	1161503	DAK	AJB
3	April 2017	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #2	1161503	DAK	AJB

DRAWN BY: ESS	DATE: 01/15/15	ISSUED FOR BID:	SCALE: 1" = 150'
CHECKED BY: AJB	DATE: 01/15/15	ISSUED FOR CONSTRUCTION:	
APPROVED BY: AJB	DATE: 01/15/15	DRAWING NUMBER:	DIVERSION SWALE 64.03
WO: 1161503			

E&S WORKSHEET # 11

Channel Design Data

PROJECT NAME: ATLANTIC SUNRISE PROPOSED NATURAL GAS PIPELINE

LOCATION: PINE GROVE TOWNSHIP, SCHUYLKILL COUNTY

PREPARED BY: ESS DATE: 08/17/2016

CHECKED BY: AJB DATE: 04/10/2017

CHANNEL OR CHANNEL SECTION		SWALE 65.01 LINING	SWALE 65.01 GRASS			
TEMPORARY OR PERMANENT?	(T OR P)	T	T			
DESIGN STORM	(2, 5, OR 10 YR)	2	2			
ACRES	(AC)	0.5	0.5			
MULTIPLIER[1]	(1.6, 2.25, or 2.75)[1]	1.6	1.6			
Qr (REQUIRED CAPACITY)	(CFS)	0.80	0.80			
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	0.80	0.83			
PROTECTIVE LINING[2]		S75	GRASS			
n (MANNING'S COEFFICIENT)[2]		0.055	0.08			
Va (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A			
V (CALCULATED AT FLOW DEPTH d)	(FPS)	1.25	0.98			
τa (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55	1.00			
τd (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.29	0.36			
CHANNEL BOTTOM WIDTH	(FT)	2	2			
CHANNEL SIDE SLOPES	(H:V)	2	2			
D (TOTAL DEPTH)	(FT)	2.0	2.0			
CHANNEL TOP WIDTH @ D	(FT)	10	10			
d (CALCULATED FLOW DEPTH)	(FT)	0.25	0.32			
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.02	3.28			
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	7.87	6.25			
d50 STONE SIZE	(IN)	N/A	N/A			
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	0.64	0.84			
R (HYDRAULIC RADIUS)		0.20	0.25			
S (BED SLOPE)[3]	(FT/FT)	0.018	0.018			
Sc (CRITICAL SLOPE)	(FT/FT)	0.078	0.156			
.7Sc	(FT/FT)	0.055	0.109			
1.3Sc	(FT/FT)	0.101	0.202			
STABLE FLOW?	(Y/N)	Y	Y			
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.02	0.0			
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.5			
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.5			
DESIGN METHOD FOR PROTECTIVE LINING [5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS	(S)	S	S			

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 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.

Source: 363-2134-008 / March 31, 2012 / Page 382

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SCALE IN FEET

ISSUED FOR PERMITTING

ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

BL Companies

LEGEND

DIVERSION SWALE

DIVERSION SWALE DRAINAGE AREA

CLEAN WATER CROSSING

TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC
ATLANTIC SUNRISE PROJECT
PROPOSED 42" CENTRAL PENN LINE SOUTH

DIVERSION DRAINAGE AREA MAP

PINE GROVE TOWNSHIP
SCHUYLKILL COUNTY, PENNSYLVANIA

Williams

NO.	DATE	BY	REVISION DESCRIPTION	W.O. NO.	CHK.	APP.
0	08/29/15	BL	ISSUED FOR PADEP SUBMITTAL	1161503	DAK	AJB
1	12/02/15	BL	ISSUED FOR PADEP RESUBMITTAL	1161503	DAK	AJB
2	Oct. 2016	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #1	1161503	DAK	AJB
3	April 2017	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #2	1161503	DAK	AJB

DRAWN BY: ESS	DATE: 01/15/15	ISSUED FOR BID:	SCALE: 1" = 100'
CHECKED BY: AJB	DATE: 01/15/15	ISSUED FOR CONSTRUCTION:	
APPROVED BY: AJB	DATE: 01/15/15	DRAWING NUMBER:	DIVERSION SWALE 65.01
WO: 1161503			

E&S WORKSHEET # 11

Channel Design Data

PROJECT NAME: ATLANTIC SUNRISE PROPOSED NATURAL GAS PIPELINE

LOCATION: PINE GROVE TOWNSHIP, SCHUYLKILL COUNTY

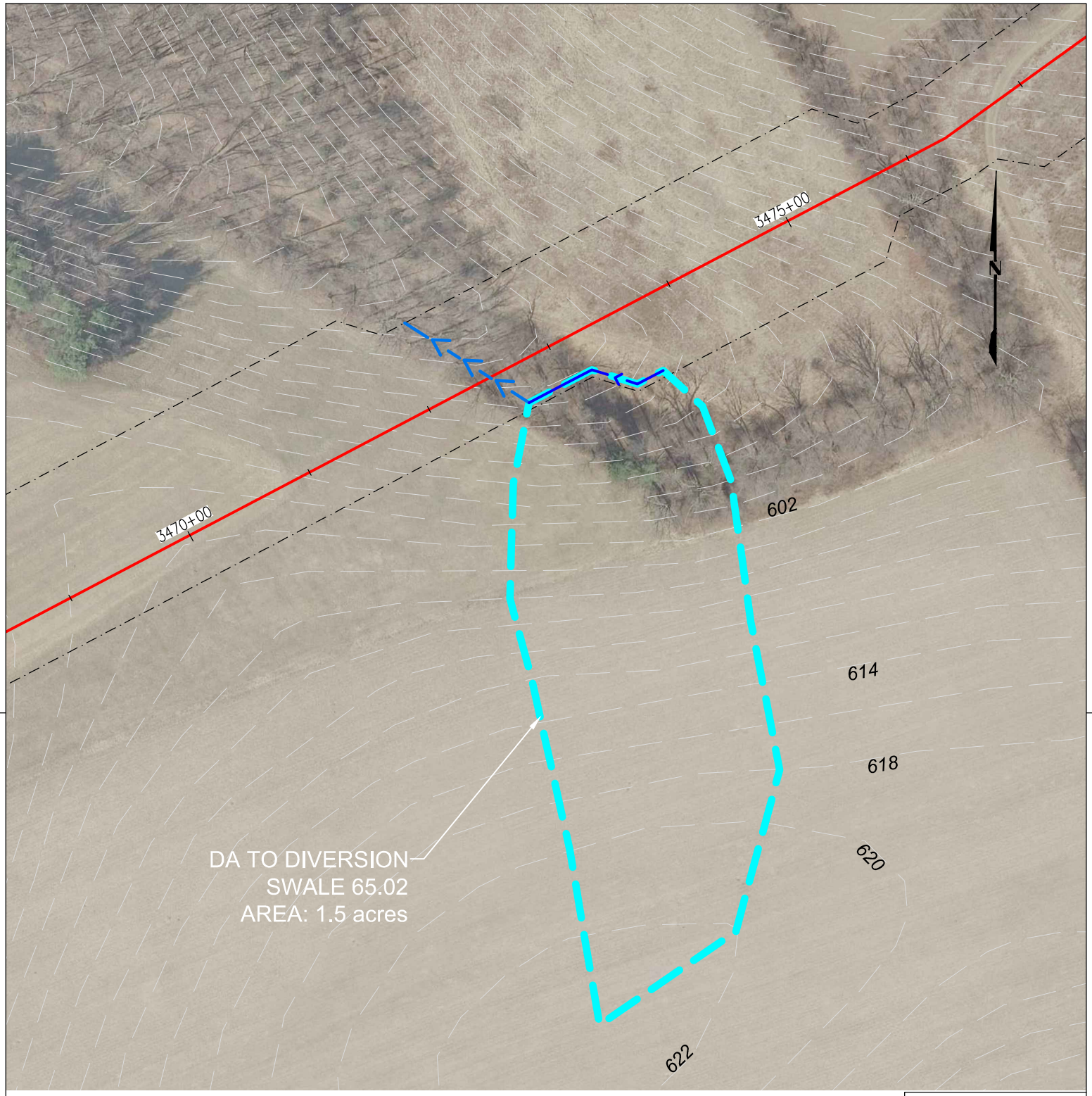
PREPARED BY: ESS DATE: 08/17/2016

CHECKED BY: AJB DATE: 04/10/2017

CHANNEL OR CHANNEL SECTION		SWALE 65.02 LINING	SWALE 65.02 GRASS			
TEMPORARY OR PERMANENT?	(T OR P)	T	T			
DESIGN STORM	(2, 5, OR 10 YR)	2	2			
ACRES	(AC)	1.5	1.5			
MULTIPLIER[1]	(1.6, 2.25, or 2.75)[1]	1.6	1.6			
Qr (REQUIRED CAPACITY)	(CFS)	2.40	2.40			
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.41	2.44			
PROTECTIVE LINING[2]		S75	GRASS			
n (MANNING'S COEFFICIENT)[2]		0.055	0.05			
Va (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A			
V (CALCULATED AT FLOW DEPTH d)	(FPS)	2.59	2.78			
τa (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.50	1.00			
τd (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.18	1.13			
CHANNEL BOTTOM WIDTH	(FT)	2	2			
CHANNEL SIDE SLOPES	(H:V)	2	2			
D (TOTAL DEPTH)	(FT)	2.0	2.0			
CHANNEL TOP WIDTH @ D	(FT)	10	10			
d (CALCULATED FLOW DEPTH)	(FT)	0.35	0.33			
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.38	3.32			
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	5.80	6.06			
d50 STONE SIZE	(IN)	N/A	N/A			
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	0.93	0.88			
R (HYDRAULIC RADIUS)		0.26	0.25			
S (BED SLOPE)[3]	(FT/FT)	0.055	0.055			
Sc (CRITICAL SLOPE)	(FT/FT)	0.072	0.060			
.7Sc	(FT/FT)	0.051	0.042			
1.3Sc	(FT/FT)	0.094	0.078			
STABLE FLOW?	(Y/N)	N	N			
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.07	0.1			
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.5			
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.5			
DESIGN METHOD FOR PROTECTIVE LINING [5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS	(S)	S	S			

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 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.

Source: 363-2134-008 / March 31, 2012 / Page 382



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SCALE IN FEET

ISSUED FOR PERMITTING

BL Companies
ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

LEGEND

DIVERSION SWALE

DIVERSION SWALE DRAINAGE AREA

CLEAN WATER CROSSING

TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC
ATLANTIC SUNRISE PROJECT
PROPOSED 42" CENTRAL PENN LINE SOUTH

DIVERSION DRAINAGE AREA MAP

PINE GROVE TOWNSHIP
SCHUYLKILL COUNTY, PENNSYLVANIA

Williams

NO.	DATE	BY	REVISION DESCRIPTION	W.O. NO.	CHK.	APP.
0	08/29/15	BL	ISSUED FOR PADEP SUBMITTAL	1161503	DAK	AJB
1	12/02/15	BL	ISSUED FOR PADEP RESUBMITTAL	1161503	DAK	AJB
2	Oct. 2016	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #1	1161503	DAK	AJB
3	April 2017	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #2	1161503	DAK	AJB

DRAWN BY: ESS	DATE: 01/15/15	ISSUED FOR BID:	SCALE: 1" = 100'
CHECKED BY: AJB	DATE: 01/15/15	ISSUED FOR CONSTRUCTION:	
APPROVED BY: AJB	DATE: 01/15/15	DRAWING NUMBER:	DIVERSION SWALE 65.02
WO: 1161503			

E&S WORKSHEET # 11

Channel Design Data

PROJECT NAME: ATLANTIC SUNRISE PROPOSED NATURAL GAS PIPELINE

LOCATION: PINE GROVE TOWNSHIP, SCHUYLKILL COUNTY

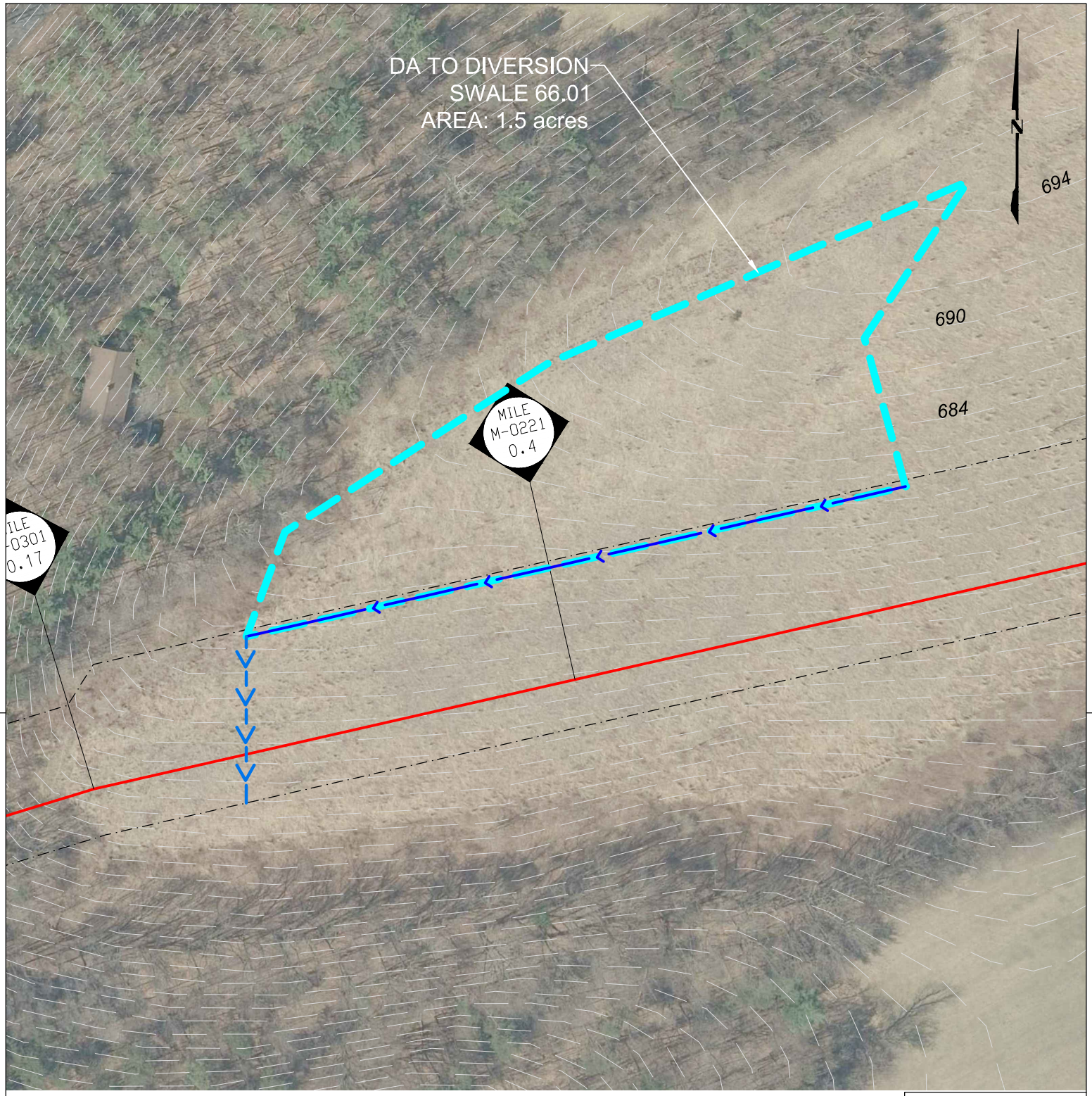
PREPARED BY: BWM DATE: 04/08/2017

CHECKED BY: AJB DATE: 04/10/2017

CHANNEL OR CHANNEL SECTION		SWALE 66.01 LINING	SWALE 66.01 GRASS			
TEMPORARY OR PERMANENT?	(T OR P)	T	T			
DESIGN STORM	(2, 5, OR 10 YR)	2	2			
ACRES	(AC)	1.5	1.5			
MULTIPLIER[1]	(1.6, 2.25, or 2.75)[1]	1.6	1.6			
Qr (REQUIRED CAPACITY)	(CFS)	2.40	2.40			
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.40	2.43			
PROTECTIVE LINING[2]		S75	GRASS			
n (MANNING'S COEFFICIENT)[2]		0.055	0.07			
Va (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A			
V (CALCULATED AT FLOW DEPTH d)	(FPS)	1.82	1.53			
τa (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55	1.00			
τd (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.57	0.65			
CHANNEL BOTTOM WIDTH	(FT)	2	2			
CHANNEL SIDE SLOPES	(H:V)	2	2			
D (TOTAL DEPTH)	(FT)	2.0	2.0			
CHANNEL TOP WIDTH @ D	(FT)	10	10			
d (CALCULATED FLOW DEPTH)	(FT)	0.45	0.52			
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.82	4.08			
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	4.41	3.85			
d50 STONE SIZE	(IN)	N/A	N/A			
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	1.32	1.58			
R (HYDRAULIC RADIUS)		0.33	0.37			
S (BED SLOPE)[3]	(FT/FT)	0.02	0.02			
Sc (CRITICAL SLOPE)	(FT/FT)	0.067	0.106			
.7Sc	(FT/FT)	0.047	0.074			
1.3Sc	(FT/FT)	0.088	0.138			
STABLE FLOW?	(Y/N)	Y	Y			
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.06	0.1			
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.5			
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.5			
DESIGN METHOD FOR PROTECTIVE LINING [5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS	(S)	S	S			

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 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.

Source: 363-2134-008 / March 31, 2012 / Page 382



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SCALE IN FEET

ISSUED FOR PERMITTING

BL Companies
ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

LEGEND

DIVERSION SWALE

DIVERSION SWALE DRAINAGE AREA

CLEAN WATER CROSSING

TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC
ATLANTIC SUNRISE PROJECT
PROPOSED 42" CENTRAL PENN LINE SOUTH

Williams

DIVERSION DRAINAGE AREA MAP

PINE GROVE TOWNSHIP
SCHUYLKILL COUNTY, PENNSYLVANIA

NO.	DATE	BY	REVISION DESCRIPTION	W.O. NO.	CHK.	APP.
0	08/29/15	BL	ISSUED FOR PADEP SUBMITTAL	1161503	DAK	AJB
1	12/02/15	BL	ISSUED FOR PADEP RESUBMITTAL	1161503	DAK	AJB
2	Oct. 2016	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #1	1161503	DAK	AJB
3	April 2017	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #2	1161503	DAK	AJB

DRAWN BY: ESS	DATE: 01/15/15	ISSUED FOR BID:	SCALE: 1" = 100'
CHECKED BY: AJB	DATE: 01/15/15	ISSUED FOR CONSTRUCTION:	
APPROVED BY: AJB	DATE: 01/15/15	DRAWING NUMBER:	DIVERSION SWALE 66.01
WO: 1161503			

E&S WORKSHEET # 11

Channel Design Data

PROJECT NAME: ATLANTIC SUNRISE PROPOSED NATURAL GAS PIPELINE

LOCATION: PINE GROVE TOWNSHIP, SCHUYLKILL COUNTY

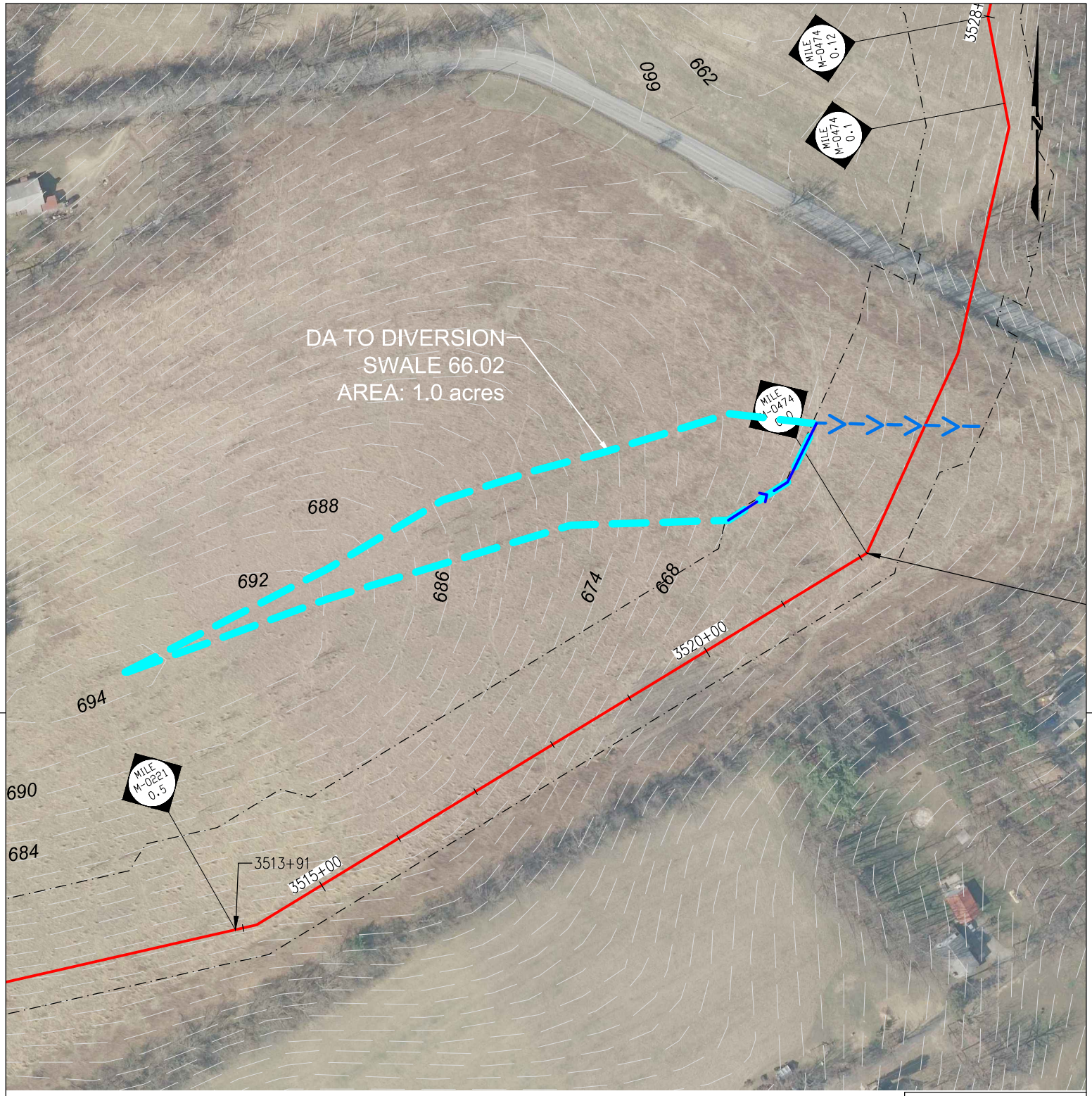
PREPARED BY: ESS DATE: 08/17/2016

CHECKED BY: AJB DATE: 04/10/2017

CHANNEL OR CHANNEL SECTION		SWALE 66.02 LINING	SWALE 66.02 GRASS			
TEMPORARY OR PERMANENT?	(T OR P)	T	T			
DESIGN STORM	(2, 5, OR 10 YR)	2	2			
ACRES	(AC)	1	1			
MULTIPLIER[1]	(1.6, 2.25, or 2.75)[1]	1.6	1.6			
Qr (REQUIRED CAPACITY)	(CFS)	1.60	1.60			
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	1.60	1.65			
PROTECTIVE LINING[2]		S75	GRASS			
n (MANNING'S COEFFICIENT)[2]		0.055	0.068			
Va (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A			
V (CALCULATED AT FLOW DEPTH d)	(FPS)	1.69	1.47			
τa (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55	1.00			
τd (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.50	0.57			
CHANNEL BOTTOM WIDTH	(FT)	2	2			
CHANNEL SIDE SLOPES	(H:V)	2	2			
D (TOTAL DEPTH)	(FT)	2.0	2.0			
CHANNEL TOP WIDTH @ D	(FT)	10	10			
d (CALCULATED FLOW DEPTH)	(FT)	0.35	0.40			
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.40	3.60			
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	5.71	5.00			
d50 STONE SIZE	(IN)	N/A	N/A			
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	0.95	1.12			
R (HYDRAULIC RADIUS)		0.27	0.30			
S (BED SLOPE)[3]	(FT/FT)	0.023	0.023			
Sc (CRITICAL SLOPE)	(FT/FT)	0.072	0.106			
.7Sc	(FT/FT)	0.050	0.074			
1.3Sc	(FT/FT)	0.093	0.138			
STABLE FLOW?	(Y/N)	Y	Y			
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.04	0.0			
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.5			
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.5			
DESIGN METHOD FOR PROTECTIVE LINING [5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS	(S)	S	S			

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 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.

Source: 363-2134-008 / March 31, 2012 / Page 382



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SCALE IN FEET

ISSUED FOR PERMITTING

BL Companies

ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

LEGEND

DIVERSION SWALE

DIVERSION SWALE DRAINAGE AREA

CLEAN WATER CROSSING

TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC
ATLANTIC SUNRISE PROJECT
PROPOSED 42" CENTRAL PENN LINE SOUTH

DIVERSION DRAINAGE AREA MAP

PINE GROVE TOWNSHIP
SCHUYLKILL COUNTY, PENNSYLVANIA

Williams

NO.	DATE	BY	REVISION DESCRIPTION	W.O. NO.	CHK.	APP.
0	08/29/15	BL	ISSUED FOR PADEP SUBMITTAL	1161503	DAK	AJB
1	12/02/15	BL	ISSUED FOR PADEP RESUBMITTAL	1161503	DAK	AJB
2	Oct. 2016	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #1	1161503	DAK	AJB
3	April 2017	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #2	1161503	DAK	AJB

DRAWN BY: ESS	DATE: 01/15/15	ISSUED FOR BID:	SCALE: 1" = 150'
CHECKED BY: AJB	DATE: 01/15/15	ISSUED FOR CONSTRUCTION:	
APPROVED BY: AJB	DATE: 01/15/15	DRAWING NUMBER:	DIVERSION SWALE 66.02
WO: 1161503			

E&S WORKSHEET # 11

Channel Design Data

PROJECT NAME: ATLANTIC SUNRISE PROPOSED NATURAL GAS PIPELINE

LOCATION: PINE GROVE TOWNSHIP, SCHUYLKILL COUNTY

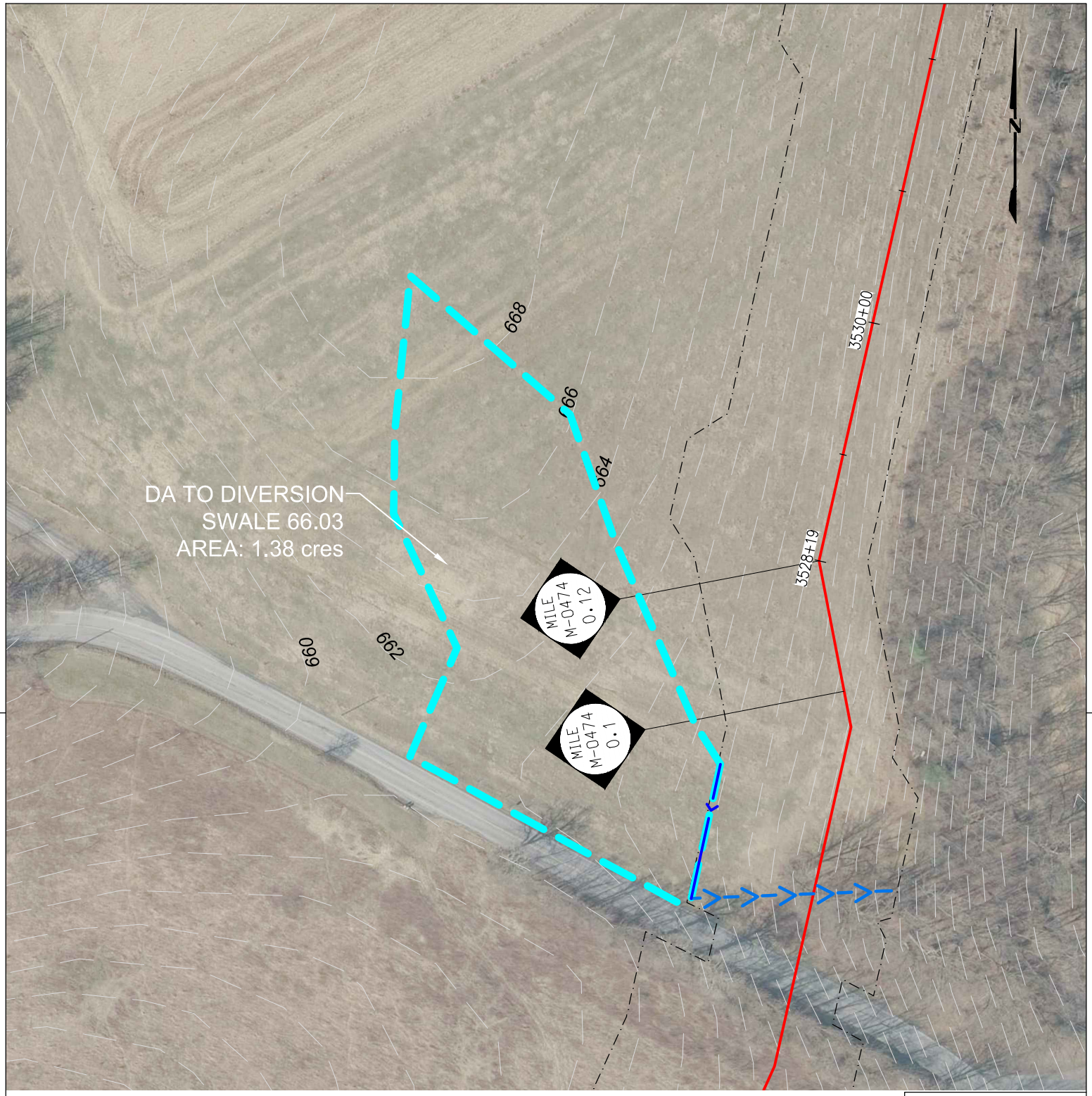
PREPARED BY: RMR DATE: 03/22/2017

CHECKED BY: AJB DATE: 04/10/2017

CHANNEL OR CHANNEL SECTION		SWALE 66.03 LINING	SWALE 66.03 GRASS			
TEMPORARY OR PERMANENT?	(T OR P)	T	T			
DESIGN STORM	(2, 5, OR 10 YR)	2	2			
ACRES	(AC)	1.38	1.38			
MULTIPLIER[1]	(1.6, 2.25, or 2.75)[1]	1.6	1.6			
Qr (REQUIRED CAPACITY)	(CFS)	2.21	2.21			
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	2.23	2.24			
PROTECTIVE LINING[2]		S75	GRASS			
n (MANNING'S COEFFICIENT)[2]		0.055	0.07			
Va (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A			
V (CALCULATED AT FLOW DEPTH d)	(FPS)	1.87	1.58			
τa (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55	1.00			
τd (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.60	0.93			
CHANNEL BOTTOM WIDTH	(FT)	2	2			
CHANNEL SIDE SLOPES	(H:V)	2	2			
D (TOTAL DEPTH)	(FT)	2.0	2.0			
CHANNEL TOP WIDTH @ D	(FT)	10	10			
d (CALCULATED FLOW DEPTH)	(FT)	0.42	0.48			
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	3.68	3.92			
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	4.76	4.17			
d50 STONE SIZE	(IN)	N/A	N/A			
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	1.19	1.42			
R (HYDRAULIC RADIUS)		0.31	0.34			
S (BED SLOPE)[3]	(FT/FT)	0.023	0.023			
Sc (CRITICAL SLOPE)	(FT/FT)	0.069	0.108			
.7Sc	(FT/FT)	0.048	0.075			
1.3Sc	(FT/FT)	0.089	0.140			
STABLE FLOW?	(Y/N)	Y	Y			
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.06	0.1			
FREEBOARD BASED ON STABLE FLOW	(FT)	0.50	0.5			
MINIMUM REQUIRED FREEBOARD[4]	(FT)	0.50	0.5			
DESIGN METHOD FOR PROTECTIVE LINING [5] PERMISSIBLE VELOCITY (V) OR SHEAR STRESS	(S)	S	S			

1. Use 1.6 for Temporary Channels; 2.25 for Temporary Channels in Special Protection (HQ or EV) Watersheds; 2.75 for Permanent Channels. For Rational Method, enter "N/A" and attach E&S Worksheets 9 and 10. For TR-55 enter "N/A" and attach appropriate Worksheets.
2. Adjust "n" value for changes in channel liner and flow depth. For vegetated channels, provide data for manufactured linings without vegetation and with vegetation in separate columns.
3. Slopes may not be averaged.
4. Minimum Freeboard is 0.5 ft. or 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.

Source: 363-2134-008 / March 31, 2012 / Page 382



0 50 100
SCALE IN FEET

ISSUED FOR PERMITTING

ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

LEGEND

DIVERSION SWALE

DIVERSION SWALE DRAINAGE AREA

CLEAN WATER CROSSING

TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC
ATLANTIC SUNRISE PROJECT
PROPOSED 42" CENTRAL PENN LINE SOUTH

DIVERSION DRAINAGE AREA MAP

PINE GROVE TOWNSHIP
SCHUYLKILL COUNTY, PENNSYLVANIA

NO.	DATE	BY	REVISION DESCRIPTION	W.O. NO.	CHK.	APP.
0	08/29/15	BL	ISSUED FOR PADEP SUBMITTAL	1161503	DAK	AJB
1	12/02/15	BL	ISSUED FOR PADEP RESUBMITTAL	1161503	DAK	AJB
2	Oct. 2016	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #1	1161503	DAK	AJB
3	April 2017	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #2	1161503	DAK	AJB

DRAWN BY: ESS	DATE: 01/15/15	ISSUED FOR BID:	SCALE: 1" = 100'
CHECKED BY: AJB	DATE: 01/15/15	ISSUED FOR CONSTRUCTION:	
APPROVED BY: AJB	DATE: 01/15/15	DRAWING NUMBER:	DIVERSION SWALE 66.03
WO: 1161503			

E&S WORKSHEET # 11

Channel Design Data

PROJECT NAME: ATLANTIC SUNRISE PROPOSED NATURAL GAS PIPELINE

LOCATION: PINE GROVE TOWNSHIP, SCHUYLKILL COUNTY

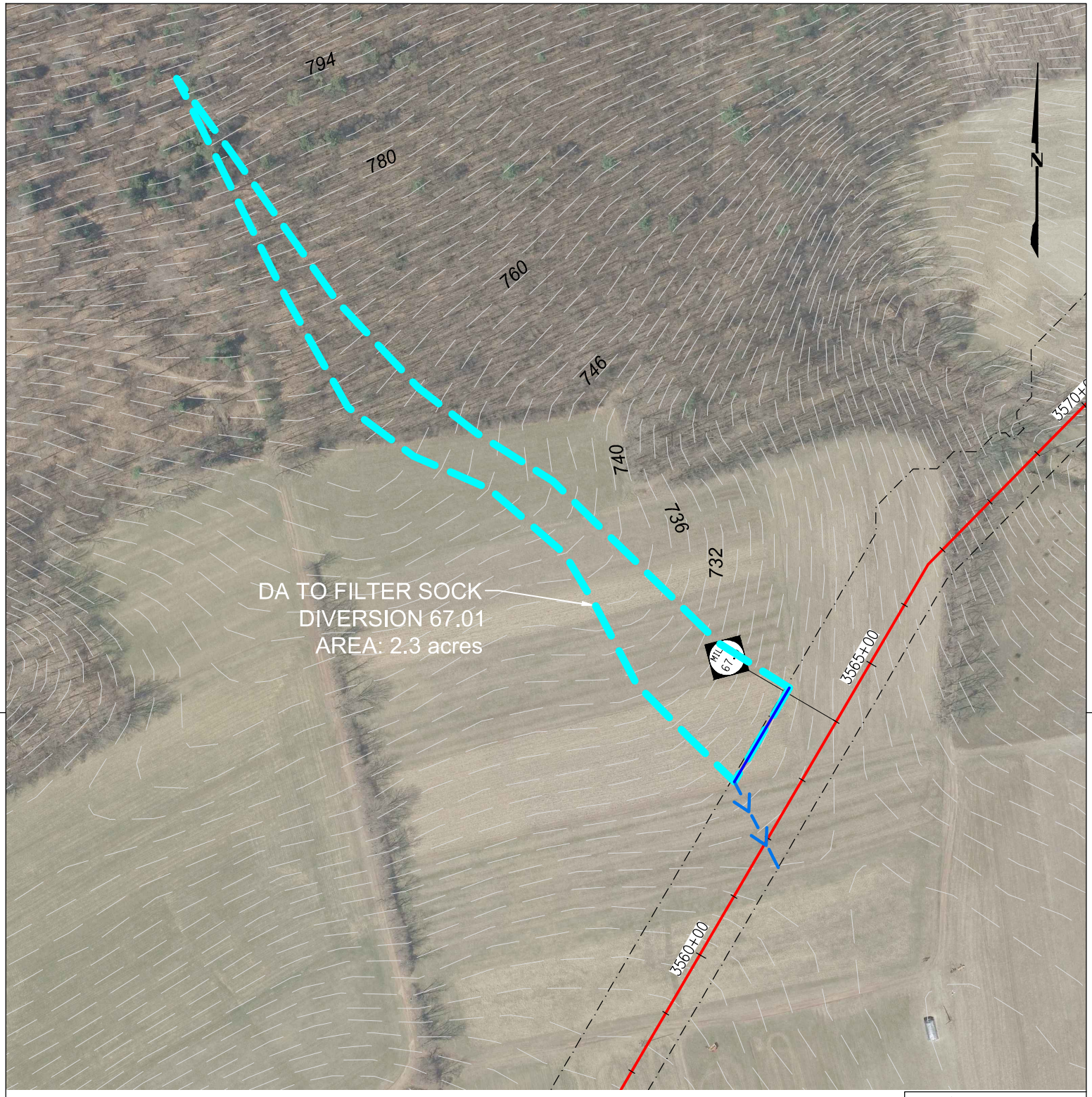
PREPARED BY: TLD DATE: 03/30/2017

CHECKED BY: AJB DATE: 04/10/2017

CHANNEL OR CHANNEL SECTION		FSD 67.01 LINING	FSD 67.01 GRASS			
TEMPORARY OR PERMANENT?	(T OR P)	T	T			
DESIGN STORM	(2, 5, OR 10 YR)	2	2			
ACRES	(AC)	2.3	2.3			
MULTIPLIER[1]	(1.6, 2.25, or 2.75)[1]	1.6	1.6			
Qr (REQUIRED CAPACITY)	(CFS)	3.68	3.68			
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	3.72	3.77			
PROTECTIVE LINING[2]		S75	GRASS			
n (MANNING'S COEFFICIENT)[2]		0.047	0.07			
Va (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A			
V (CALCULATED AT FLOW DEPTH d)	(FPS)	1.76	1.31			
τa (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	1.55	1.00			
τd (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	0.52	0.61			
CHANNEL BOTTOM WIDTH	(FT)	0	0			
CHANNEL SIDE SLOPES	(H:V)	6 : 0	6 : 0	:	:	:
D (TOTAL DEPTH)	(FT)	1.6	1.6			
CHANNEL TOP WIDTH @ D	(FT)	9.48	9.48			
d (CALCULATED FLOW DEPTH)	(FT)	0.84	0.98			
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.04	5.88			
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	0.00	0.00			
d50 STONE SIZE	(IN)	N/A	N/A			
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	2.12	2.88			
R (HYDRAULIC RADIUS)		0.41	0.48			
S (BED SLOPE)[3]	(FT/FT)	0.01	0.01			
Sc (CRITICAL SLOPE)	(FT/FT)	0.044	0.092			
.7Sc	(FT/FT)	0.031	0.065			
1.3Sc	(FT/FT)	0.057	0.120			
STABLE FLOW?	(Y/N)	Y	Y			
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.11	0.10			
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 separate 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.

Source: 363-2134-008 / March 31, 2012 / Page 382



0 100 200

SCALE IN FEET

ISSUED FOR PERMITTING

ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

BL Companies

LEGEND

DIVERSION SWALE

DIVERSION SWALE DRAINAGE AREA

CLEAN WATER CROSSING

TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC
ATLANTIC SUNRISE PROJECT
PROPOSED 42" CENTRAL PENN LINE SOUTH

DIVERSION DRAINAGE AREA MAP

PINE GROVE TOWNSHIP
SCHUYLKILL COUNTY, PENNSYLVANIA

Williams

NO.	DATE	BY	REVISION DESCRIPTION	W.O. NO.	CHK.	APP.
0	08/29/15	BL	ISSUED FOR PADEP SUBMITTAL	1161503	DAK	AJB
1	12/02/15	BL	ISSUED FOR PADEP RESUBMITTAL	1161503	DAK	AJB
2	Oct. 2016	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #1	1161503	DAK	AJB
3	April 2017	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #2	1161503	DAK	AJB

DRAWN BY: ESS	DATE: 01/15/15	ISSUED FOR BID:	SCALE: 1" = 200'
CHECKED BY: AJB	DATE: 01/15/15	ISSUED FOR CONSTRUCTION:	
APPROVED BY: AJB	DATE: 01/15/15	DRAWING NUMBER:	FILTER SOCK DIVERSION 67.01
WO: 1161503			

E&S WORKSHEET # 11

Channel Design Data

PROJECT NAME: ATLANTIC SUNRISE PROPOSED NATURAL GAS PIPELINE

LOCATION: PINE GROVE TOWNSHIP, SCHUYLKILL COUNTY

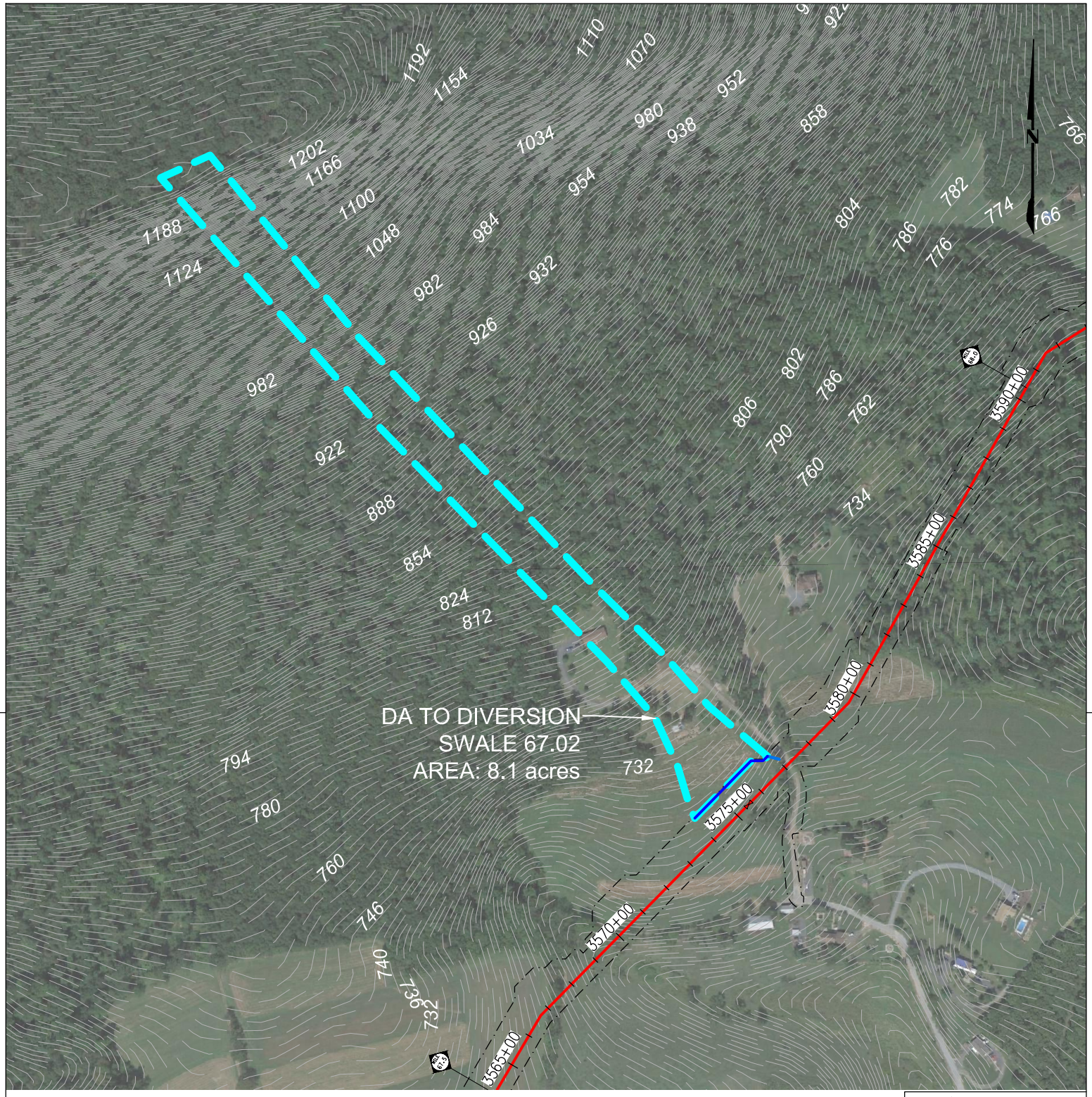
PREPARED BY: ESS DATE: 03/25/2015

CHECKED BY: AJB DATE: 04/10/2017

CHANNEL OR CHANNEL SECTION		SWALE 67.02 LINING	SWALE 67.02 GRASS			
TEMPORARY OR PERMANENT?	(T OR P)	T	T			
DESIGN STORM	(2, 5, OR 10 YR)	2	2			
ACRES	(AC)	8.1	8.1			
MULTIPLIER[1]	(1.6, 2.25, or 2.75)[1]	1.6	1.6			
Qr (REQUIRED CAPACITY)	(CFS)	12.96	12.96			
Q (CALCULATED AT FLOW DEPTH d)	(CFS)	12.97	12.97			
PROTECTIVE LINING[2]		SC150	SC150/ GRASS			
n (MANNING'S COEFFICIENT)[2]		0.043	0.05			
Va (ALLOWABLE VELOCITY)	(FPS)	N/A	N/A			
V (CALCULATED AT FLOW DEPTH d)	(FPS)	4.16	3.73			
τa (MAX ALLOWABLE SHEAR STRESS)	(LB/FT^2)	2.00	2.00			
τd (CALC'D SHEAR STRESS AT FLOW DEPTH d)	(LB/FT^2)	1.74	1.88			
CHANNEL BOTTOM WIDTH	(FT)	2	2			
CHANNEL SIDE SLOPES	(H:V)	2	2			
D (TOTAL DEPTH)	(FT)	2.0	2.0			
CHANNEL TOP WIDTH @ D	(FT)	10	10			
d (CALCULATED FLOW DEPTH)	(FT)	0.85	0.91			
CHANNEL TOP WIDTH @ FLOW DEPTH d	(FT)	5.38	5.64			
BOTTOM WIDTH: FLOW DEPTH RATIO	(12:1 MAX)	2.37	2.20			
d50 STONE SIZE	(IN)	N/A	N/A			
A (CROSS-SECTIONAL AREA)	(SQ. FT.)	3.12	3.48			
R (HYDRAULIC RADIUS)		0.54	0.57			
S (BED SLOPE)[3]	(FT/FT)	0.033	0.033			
Sc (CRITICAL SLOPE)	(FT/FT)	0.036	0.047			
.7Sc	(FT/FT)	0.025	0.033			
1.3Sc	(FT/FT)	0.046	0.061			
STABLE FLOW?	(Y/N)	N	Y			
FREEBOARD BASED ON UNSTABLE FLOW	(FT)	0.26	0.25			
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 separate 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.

Source: 363-2134-008 / March 31, 2012 / Page 382



0 200 400
SCALE IN FEET

ISSUED FOR PERMITTING

ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

LEGEND

DIVERSION SWALE

DIVERSION SWALE DRAINAGE AREA

CLEAN WATER CROSSING

TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC
ATLANTIC SUNRISE PROJECT
PROPOSED 42" CENTRAL PENN LINE SOUTH

DIVERSION DRAINAGE AREA MAP

PINE GROVE TOWNSHIP
SCHUYLKILL COUNTY, PENNSYLVANIA

NO.	DATE	BY	REVISION DESCRIPTION	W.O. NO.	CHK.	APP.
0	08/29/15	BL	ISSUED FOR PADEP SUBMITTAL	1161503	DAK	AJB
1	12/02/15	BL	ISSUED FOR PADEP RESUBMITTAL	1161503	DAK	AJB
2	Oct. 2016	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #1	1161503	DAK	AJB
3	April 2017	BL	PADEP TECHNICAL DEFICIENCY RESPONSE #2	1161503	DAK	AJB

DRAWN BY: ESS	DATE: 01/15/15	ISSUED FOR BID:	SCALE: 1" = 400'
CHECKED BY: AJB	DATE: 01/15/15	ISSUED FOR CONSTRUCTION:	
APPROVED BY: AJB	DATE: 01/15/15	DRAWING NUMBER:	DIVERSION SWALE 67.02
WO: 1161503			