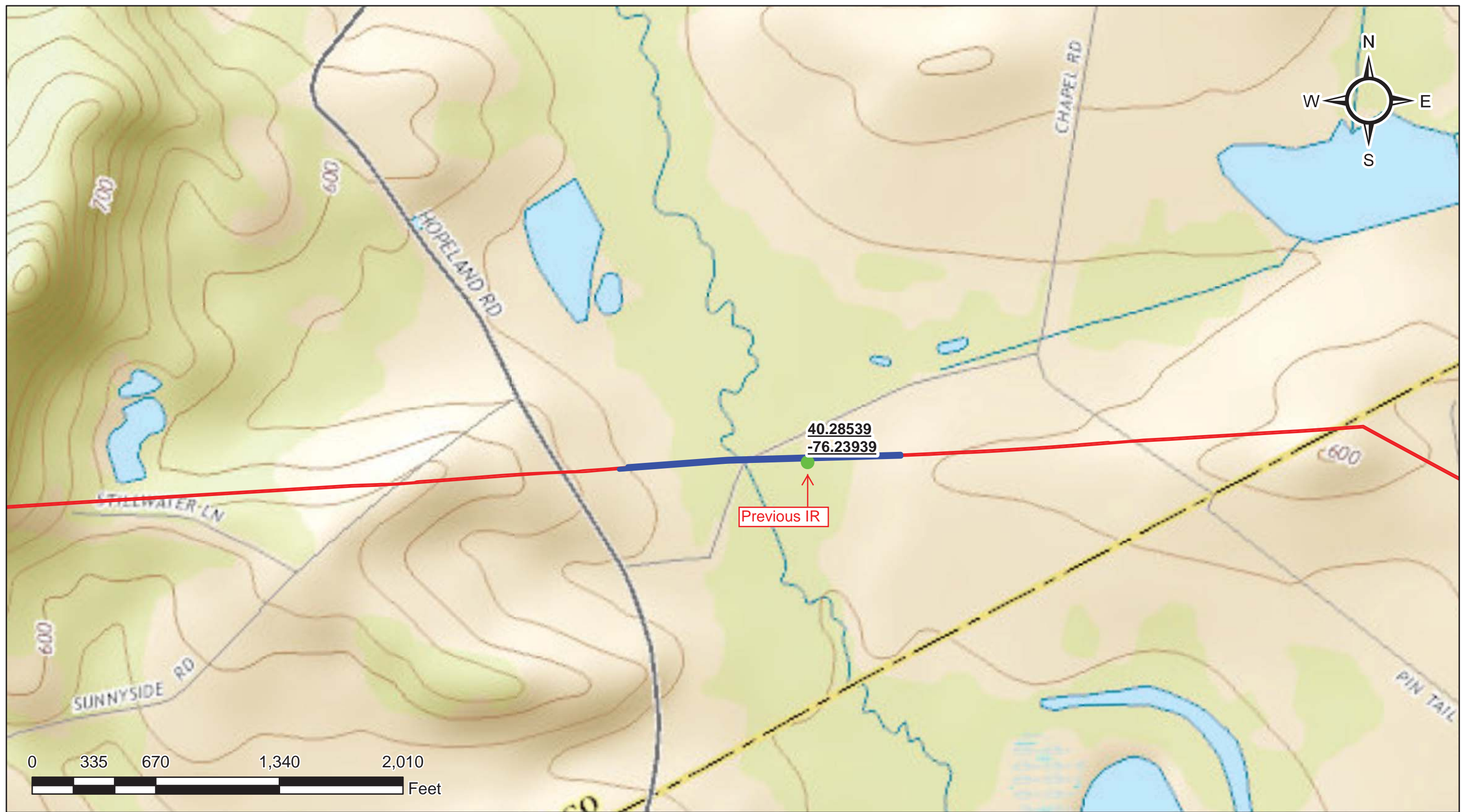


HDD PA-LE-0117.0000-WX (PEM-H14, PEM-H13, S-C86)

Given the design, the threat of inadvertent return has been reduced to the maximum extent practicable and in this case that threat is considered to be medium. Implementing this design, along with adherence to the Pennsylvania Pipeline Project Inadvertent Return Contingency Plan will ensure inadvertent impacts, if they were to occur, are also minimized to the maximum extent.

The drill will enter/exit 230 feet from the western edge of Grassy Wetland H14 (PEM-H14) and enter/exit 870 feet from the eastern edge. The horizontal directional drill will enter/exit 750 feet from the western edge of Grassy Wetland H13 (PEM-H13) and enter/exit 130 feet from the eastern edge. The drill also enters/exits 720 feet from the western edge of Middle Creek (S-C86) and enters/exits 810 feet from the creek's eastern edge. The drill will pass between 30 and 70 feet below PEM-H14 and PEM-H13, and it will cross 70 feet below Middle Creek. The geotechnical results, as well as other data points, were used to determine the entry/exit angles, and depths to pass through the best substrates while maintaining the pipe integrity (e.g., no large bends). According to the geotechnical report the primary substrates being drilled through are fine sands with silt.

The ME1 drill through this wetland resulted in 60 gallons of inadvertent returns into the wetland which were manually cleaned up on site without the need for silt fence or other containment requirements. Based on the geotechnical report, the drill profile, and the small returns from the previous drill minimal inadvertent returns are expected. It is recommended that additional inspection be present during the drill to observe the wetland areas for potential inadvertent returns in the large wetland areas surrounding the drill.




Legend

- HDD Path
- Proposed Centerline

DRAWN	CHECKED	APPROVED	DATE	REV NO.	DESCRIPTION
AW	RB	RB	11/21/16	A	ISSUED FOR REVIEW

PREPARED BY:
TETRA TECH ROONEY
 (303) 792-5911

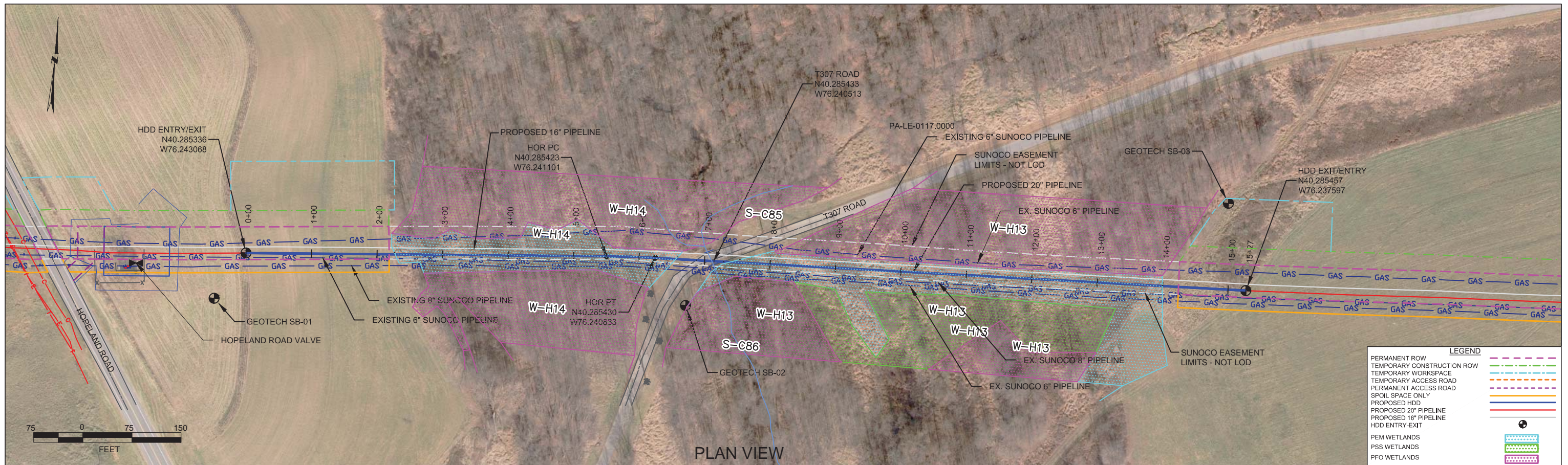

Sunoco Pipeline L.P.

PENNSYLVANIA PIPELINE PROJECT
INADVERTENT RETURN ASSESSMENTS

DRAWN: AW	CHECKED: RB
DATE: 11/21/16	SCALE: AS SHOWN

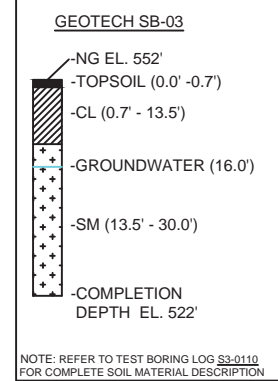
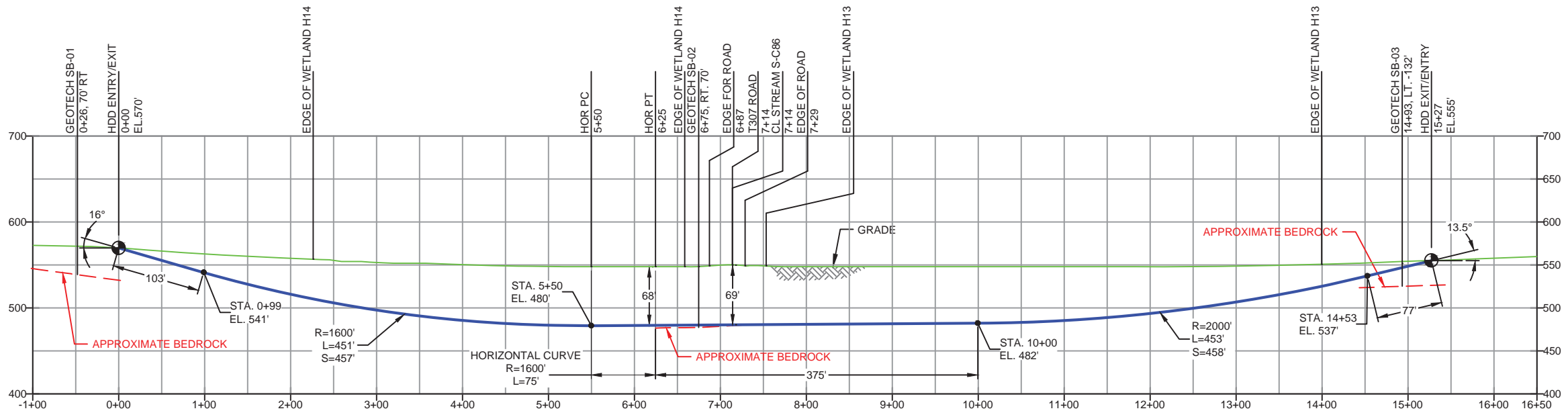
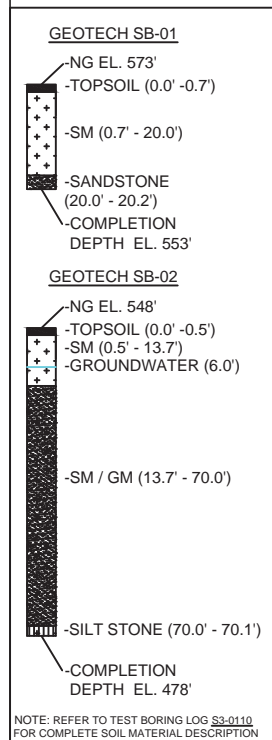
PA-LE-0117-WX-HDD

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PROFILE VIEW

LEBANON/LANCASTER COUNTY, PENNSYLVANIA - HEIDELBERG TOWNSHIP
S3-0110



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4 CROSSING PIPE SPECIFICATION.
 - HDD HORZ. LENGTH (L)=1527'
HDD PIPE LENGTH (S)=1545'
20" x 0.456" W.T., X-65, APISL, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
- STATIONING IS BASED ON HORIZONTAL DISTANCES.
- ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP, FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN.
- CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
- SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING	NO.	DESCRIPTION	NO.	DESCRIPTION
ES-5.66	TO	EROSION & SEDIMENT PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
SHEET 38	TO	AERIAL SITE PLAN	EP1	REVISED PER PADEP COMMENTS
			EP	
			C	ADDED GEOTECH INFO
			B	ISSUED FOR BID
			A	ISSUED FOR REVIEW

REVISIONS

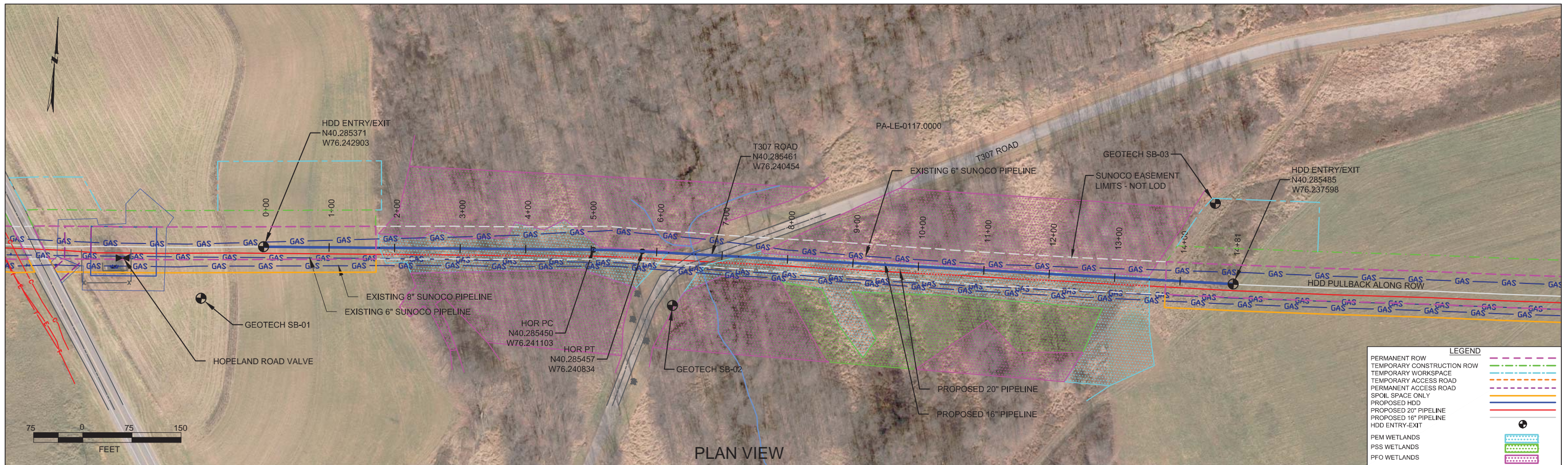
BY	DATE	CHK	DATE	APP	DATE
DLM	09/30/16	RMB	09/30/16	AAW	09/30/16
JTW	05/18/16	RMB	05/18/16	AAW	05/18/16
MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
MRS	09/22/15	RMB	09/22/15	AAW	09/22/15
DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
JVA	04/15/15	RMB	04/15/15	AAW	04/15/15



SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
CREEK & T307
PENNSYLVANIA PIPELINE PROJECT

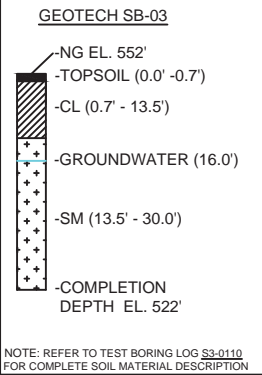
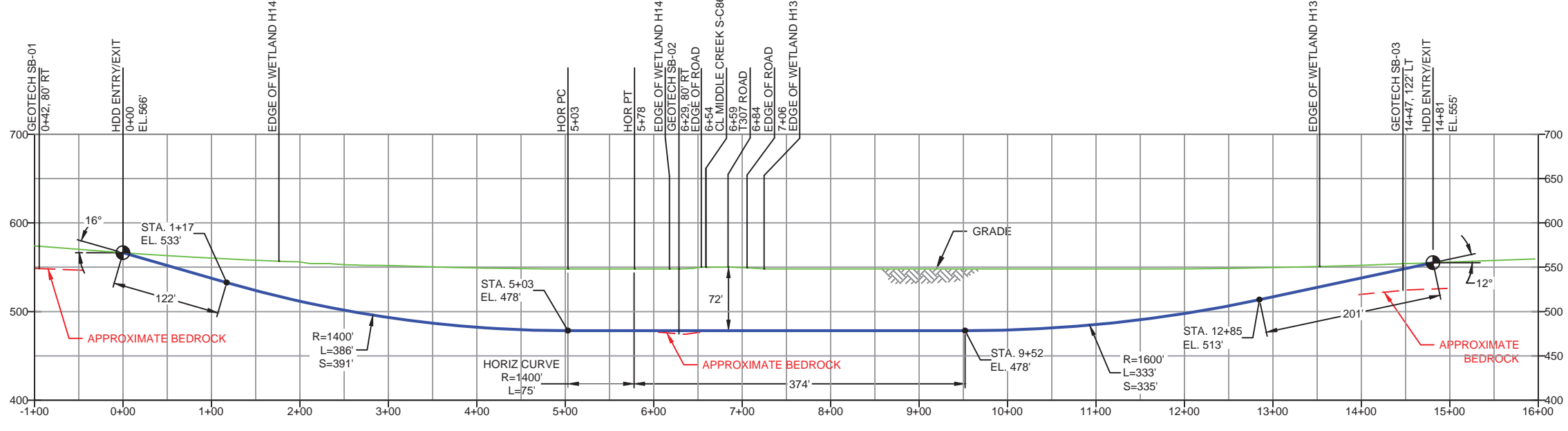
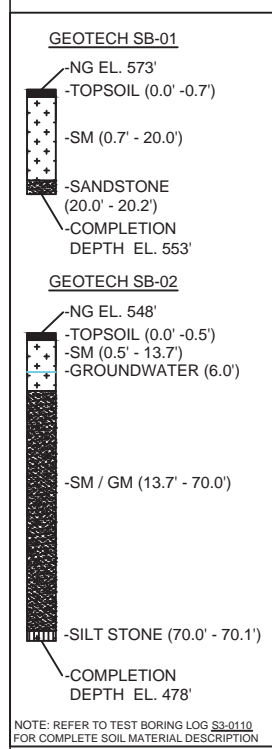
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PLAN VIEW

LEBANON/LANCASTER COUNTY, PENNSYLVANIA - HEIDELBERG TOWNSHIP
S3-0110-16

PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L-): 1481'
HDD PIPE LENGTH (S-): 1498'
16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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- SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING	NO.	DESCRIPTION	NO.	DESCRIPTION
ES-5.66	TO	ES-5.67	EROSION & SEDIMENT PLAN	
SHEET 38	TO	SHEET 38	AERIAL SITE PLAN	EP2
				REVISD PER PADEP COMMENTS RECEIVED 09-06-16
				EP1
				REVISD PER PADEP COMMENTS
				EP
				B
				ADDED GEOTECH INFO
				A
				ISSUED FOR BID

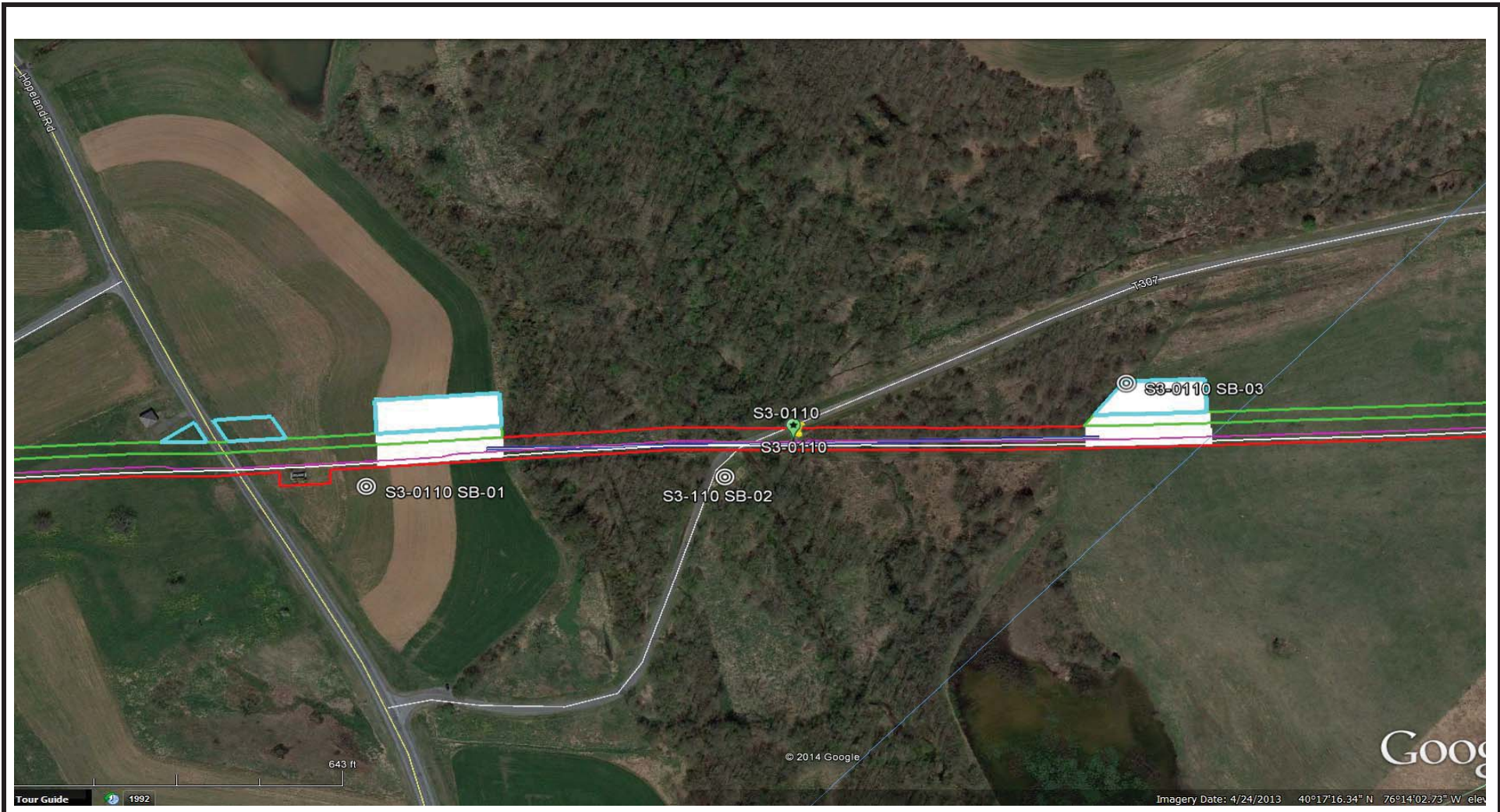
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
CREEK & T307
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' DWG. NO. PA-LE-0117.0000-WX-16



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S3-0110
 LEBANON COUNTY, SOUTH HEIDELBERG TOWNSHIP, PA
 SUNOCO PENNSYLVANIA PIPELINE PROJECT



TETRA TECH

240 Continental Drive, Suite 200
 Newark, Delaware 19713
 302.738.7551
 fax: 302.454.5988

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: HOPELAND ROAD, MIDDLECREEK WILDLIFE MANAGEMENT AREA, NEWMANSTOWN, PA					
HDD No.: S3-0110		Dates(s) Drilled: 12-14-14		Inspector: E. WATT	
Boring No.: SB-01		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): NOT ENCOUNTERED		Total Depth (ft): 20.2	
Boring Location Coordinates:		40° 17' 6.502" N		76° 14' 35.550" W	

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.7			TOPSOIL (8")						
1	3.0	5.0	0.7		24	SM	REDDISH BROWN FINE TO MEDIUM SAND, TRACE CONGLOMERATE, WITH A LITTLE SILT.	6	29	42	50	71	
2	8.0	9.4			14		REDDISH BROWN FINE TO MEDIUM SAND, TRACE CONGLOMERATE, WITH SOME SILT.	6	45	50/5"		>50	
3	13.0	13.7			8		REDDISH BROWN FINE TO MEDIUM SAND, TRACE CONGLOMERATE, WITH SOME SILT, TRACE UNWEATHERED GRAVEL.	8	50/2"			>50	
4	18.0	18.6			6		REDDISH BROWN FINE TO MEDIUM SAND, TRACE CONGLOMERATE, WITH SOME SILT, TRACE UNWEATHERED GRAVEL.	10	50/1"			>50	
5	20.0	20.2	20.0	20.2	2		PARTIALLY WEATHERED SANDSTONE GRAVEL.	50/2"					
							AUGER REFUSAL AT 20.0'. OFFSET BORING AND AUGURED TO REFUSAL AT 19.1'.						
							CAVED AND DRY AT 18'.						

Notes/Comments: Pocket Pentrometer Testing DR: DECOMPOSED ROCK

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.
 N: Number of blows to drive spoon from 6" to 18" interval.



TETRA TECH

240 Continental Drive, Suite 200
 Newark, Delaware 19713
 302.738.7551
 fax: 302.454.5988

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: MIDDLECREEK WILDLIFE MANAGEMENT AREA, NEWMANSTOWN, PA			Page 1 of 1		
HDD No.: S3-0110		Dates(s) Drilled: 11-21 & 12-15-14		Inspector: E. WATT	
Boring No.: SB-02		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 6.0		Total Depth (ft): 70.1	
Boring Location Coordinates:		40° 17' 6.866" N		76° 14' 26.278" W	

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.5			TOPSOIL (6")						
1	3.0	5.0	0.5		16	SM	MOTTLED (GRAY, GREENISH GRAY, LIGHT BROWN) FINE TO MEDIUM SAND WITH A LITTLE SILT, A LITTLE F-C GRAVEL.	2	7	11	11	18	
2	8.0	10.0		13.7	13		BROWN, YELLOW BROWN AND REDDISH BROWN MEDIUM TO COARSE SAND WITH A LITTLE SILT, LITTLE F-C GRAVEL.	1	6	14	22	20	
3	13.0	15.0	13.7		22	SM	MAROON FINE TO MEDIUM SAND WITH A LITTLE SILT, TRACE FINE QUARTZ GRAVEL.	6	17	25	28	42	
4	18.0	18.8			8		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A LITTLE CONGLOMERATE MATRIX.	24	50/4"			>50	
5	23.0	23.6			6		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A LITTLE CONGLOMERATE MATRIX.	20	50/1"			>50	
6	28.0	28.8			7		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A LITTLE CONGLOMERATE MATRIX.	34	50/4"			>50	
7	33.0	33.7			7		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A LITTLE CONGLOMERATE MATRIX.	27	50/2"			>50	
8	38.0	38.7			7		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A LITTLE CONGLOMERATE MATRIX.	7	50/2"			>50	
9	43.0	43.8			6		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A LITTLE CONGLOMERATE MATRIX.	20	50/3"			>50	
10	48.0	48.7			6		MAROON FINE TO MEDIUM SAND WITH SOME SILT WITH A LITTLE CONGLOMERATE MATRIX.	33	50/2"			>50	
11	53.0	53.4			5		MAROON FINE TO MEDIUM SAND WITH SOME SILT, WITH A LITTLE FINE TO COARSE SANDSTONE GRAVEL.	50/5"				>50	
12	58.0	58.3			3		SM/ GM	REDDISH BROWN MEDIUM TO COARSE SAND WITH SOME FINE TO COARSE GRAVEL, WITH A LITTLE SILT.	50/4"				
13	63.0	63.4			5			REDDISH BROWN MEDIUM TO COARSE SAND, SOME FINE TO COARSE GRAVEL, SOME SILT.	50/5"				
14	68.0	68.4			5	CONGLOMERATE GRAVEL.	LIGHT REDDISH BROWN FINE TO MEDIUM SAND, WITH A LITTLE CONGLOMERATE GRAVEL.	50/5"					
				70.0									
15	70.0	70.1	70.0			AUGUR REFUSAL AT 70'. WET ON SPOON AT 7'. WATER LEVEL THROUGH AUGERS AT 6'. CAVED AT 30'	PARTIALLY WEATHERED REDDISH BROWN CONGLOMERATE AND GRAY SILTSTONE.	50/1"					
				70.1									

Notes/Comments:
Pocket Pentrometer Testing DR: DECOMPOSED ROCK
 DRILL RIG BROKED DOWN AT 55'. REMOBILIZED TO CONTINUE DRILLING ON 12/15/14.

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.
 N: Number of blows to drive spoon from 6" to 18" interval.



TETRA TECH

240 Continental Drive, Suite 200
 Newark, Delaware 19713
 302.738.7551
 fax: 302.454.5988

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406	
Project Location: MIDDLECREEK WILDLIFE MANAGEMENT AREA, NEWMANSTOWN, PA		Page 1 of 1	
HDD No.: S3-0110	Dates(s) Drilled: 12-14-14	Inspector: E. WATT	
Boring No.: SB-03	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING	Groundwater Depth (ft): SEE BELOW	Total Depth (ft): 30.0	
Boring Location Coordinates: 40° 17' 8.951" N		76° 14' 15.746" W	

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.7			TOPSOIL (8")						
1	3.0	5.0	0.7		15	CL	REDDISH BROWN SILTY CLAY WITH SOME FINE SAND, TRACE FINE GRAVEL.	1	4	10	12	14	
2	8.0	10.0		13.5	14		REDDISH BROWN SILTY CLAY WITH A LITTLE FINE SAND, TRACE FINE GRAVEL (USCS: CL).	3	11	13	16	24	
3	13.0	13.9	13.5		9	SM	REDDISH BROWN MEDIUM TO COARSE SAND WITH A LITTLE SILT, WITH A LITTLE FINE TO COARSE GRAVEL.	8	50/5"			>50	
4	18.0	18.8			8		REDDISH BROWN MEDIUM TO COARSE SAND AND CLAYEY SILT, WITH A LITTLE FINE TO COARSE GRAVEL. (USCS: SM)	3	50/4"			>50	
5	23.0	24.4			16		REDDISH BROWN FINE TO COARSE SAND WITH A LITTLE SILT, TRACE FINE GRAVEL.	12	42	50/5"		>50	
6	28.0	28.8			7		REDDISH BROWN FINE TO MEDIUM SILTY SAND, TRACE FINE GRAVEL, (WEATHERED ROCK IN TIP).	7	50/3"			>50	
				30.0									
							AUGURED TO 30'.						
							MOIST RETURN AT 15' AND 18'.						
							WET ON SPOON AT 16".						
							WATER LEVEL THROUGH AUGERS AT 4'.						
							CAVED AT 26.5'. WATER LEVEL ON CAVE AT 4'.						

Notes/Comments: Pocket Pentrometer Testing DR: DECOMPOSED ROCK

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.
 N: Number of blows to drive spoon from 6" to 18" interval.

**GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0110**

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S3-0110	SB-01	1	3.0	5.0	6.9	16.4	-	-	-	-
		2	8.0	9.4	8.6	29.5	-	-	-	-
		3	13.0	13.7	7.9	28.3	-	-	-	-
		4	18.0	18.6	6.1	32.2	32	24	8	SM
		5	20.0	20.2	6.8	31.2	-	-	-	-
	SB-02	2	8.0	10.0	11.8	14.9	-	-	-	-
		4	18.0	18.8	12.4	21.0	-	-	-	-
		6	28.0	28.8	11.4	27.2	-	-	-	-
		8	38.0	38.7	12.8	20.7	-	-	-	-
		11	53.0	53.4	9.7	28.7	-	-	-	-
		13	63.0	63.4	14.4	29.2	-	-	-	-
		14	68.0	68.4	3.4	43.3	-	-	-	-
	SB-03	2	8.0	10.0	13.0	82.4	28	20	8	CL
		3	13.0	13.9	6.7	20.6	-	-	-	-
		4	18.0	18.8	11.0	47.5	33	25	8	SM
		5	23.0	24.4	17.2	12.1	-	-	-	-
		6	28.0	28.8	10.5	36.9	-	-	-	-

Notes:

- 1) Sample depths based on feet below grade at time of exploration.

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0110

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S3-0110	Wetland H14 - T307	SB-01	Hammer Creek Formation - Gray and pale red, fine- to coarse-grained quartzose sandstone, siltstone, and mudstone	Lowland, wetlands area	Hammer Creek Fm	sandstone with quartz pebble conglomerate	9,360	32-71	
		SB-02	Hammer Creek Conglomerate - very coarse quartz conglomerate having abundant pebbles and cobbles of gray quartzite.		Hammer Creek Conglomerate	quartz conglomerate; reddish brown cross-bedded sandstone	2,580		
		SB-03	Hammer Creek Formation - Gray and pale red, fine- to coarse-grained quartzose sandstone, siltstone, and mudstone		Hammer Creek Fm	sandstone with quartz pebble conglomerate	9,360		

Note : Source of well log data - <http://www.dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm>. All other sources as referenced in comments section.

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

<u>Density</u>	<u>N (blows)*</u>
Very Loose	5 or less
Loose	6 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	51 or more

Particle Size Identification

Boulders	8 in. diameter or more
Cobbles	3 to 8 in. diameter
Gravel	Coarse (C) 3 in. to ¾ in. sieve
	Fine (F) ¾ in. to No. 4 sieve
Sand	Coarse (C) No. 4 to No. 10 sieve (4.75mm-2.00mm)
	Medium (M) No. 10 to No. 40 sieve (2.00mm – 0.425mm)
	Fine (F) No. 40 to No. 200 sieve (0.425 – 0.074mm)
Silt/Clay	Less Than a No. 200 sieve (<0.074mm)

Relative Proportions

<u>Description Term</u>	<u>Percent</u>
Trace	1 - 10
Little	11 - 20
Some	21 - 35
And	36 - 50

COHESIVE SOILS

(Silt, Clay & Combinations)

<u>Consistency</u>	<u>N (blows)*</u>
Very Soft	3 or less
Soft	4 to 5
Medium Stiff	6 to 10
Stiff	11 to 15
Very Stiff	16 to 30
Hard	31 or more

Plasticity

<u>Degree of Plasticity</u>	<u>Plasticity Index</u>
None to Slight	0 - 4
Slight	5 - 7
Medium	8- 22
High to Very High	> 22

ROCK

(Rock Cores)

<u>Rock Quality Designation (RQD), %</u>	<u>Rock Quality Description</u>
0-25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

***N - Standard Penetration Resistance.** Driving a 2.0" O.D., 1-3/8" I.D. sampler a distance of 18 inches into undisturbed soil with a 140 pound hammer free falling a distance of 30.0 inches. The number of hammer blows to drive the sampler through each 6 inch interval is recorded; the number of blows required to drive the sampler through the final 12 inch interval is termed the Standard Penetration Resistance (SPR) N-value. For example, blow counts of 6/8/9 (through three 6-inch intervals) results in an SPR N-value of 17 (8+9).

Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

Major Divisions		Group Symbols	Typical Descriptions	Laboratory Classifications				
Coarse Grained Soils (More than half of material is larger than No. 200 sieve)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW Well-graded gravels, gravel-sand mixtures, little or no fines	Determine Percentage of sand and gravel from grain size curve. Depending on Percentage of fines (fraction smaller than No. 200 sieve), coarse-grained soils are classified as follows: Less than 5 percent GW, GP, SW, SP More than 12 percent GM, GC, SM, SC 5 to 12 percent Borderline cases requiring dual symbols ⁽¹⁾	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3			
		GP Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting C_u or C_c requirements for GW					
		Gravel with fines (Appreciable amount of fines)	GM Silty gravels, gravel-sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols		
			GC Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above A line with I_p greater than 7			
	Sands (More than half of coarse fraction is smaller than No. 4 Sieve)	Clean sands (Little or no fines)	SW Well graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3			
			SP Poorly graded sands, gravelly sands, little or no fines		Not meeting C_u or C_c requirements for SW			
		Sands with fines (Appreciable amount of fines)	SM Silty sands, sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits Plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols		
			SC Clayey sands, sand-clay mixtures		Atterberg limits above A line with I_p greater than 7			
						For soils plotting nearly on A line use dual symbols i.e., $I_p = 29.5$, $w_L = 60$ gives CH-MH. When w_L is near 50 use CL-CH or ML-MH. Take near as ± 2 percent.		
		Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silt and clays (Liquid limit less than 50)		ML Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity			
CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays								
OL Organic silts and organic silty clays of low plasticity								
Silt and Clays (Liquid limit greater than 50)	MH Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts							
	CH Inorganic clays of high plasticity, fat clays							
	OH Organic clays of medium to high plasticity, organic silts							
Highly organic soils	Pt Peat and other highly organic soils							

(1) Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC. well-graded gravel-sand mixture with clay binder.