

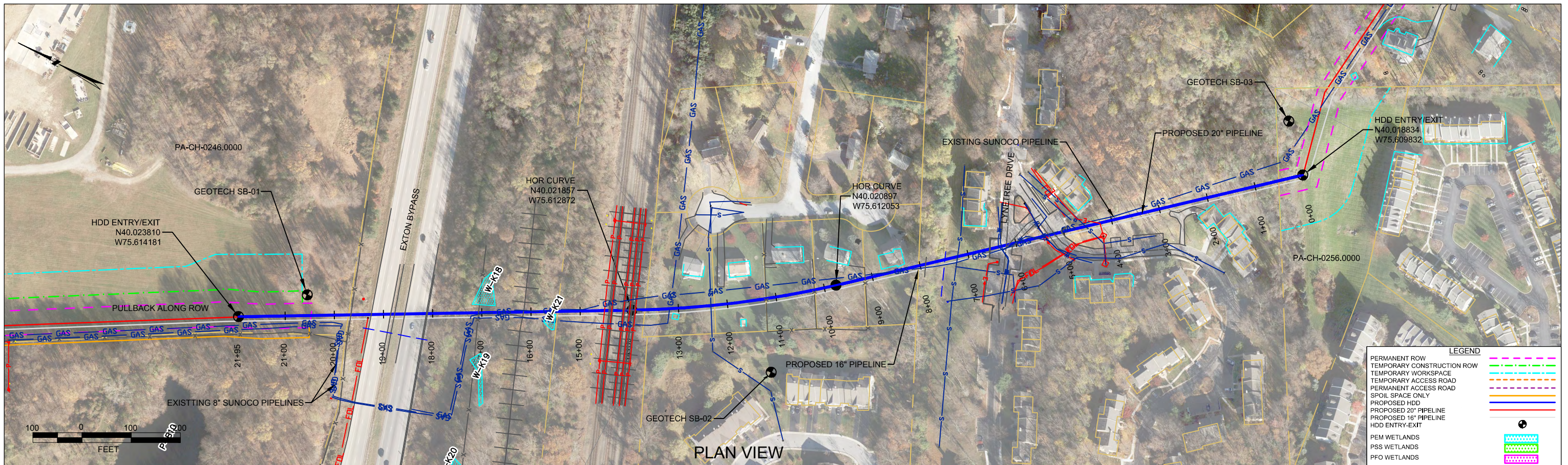
HDD PA-CH-0256.0000-RR (W-K18, W-K21, and AMTRAK railway)

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 low. 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 does not pass under wetland K18 but passes near the western most boundary. The drill will enter/exit 495 feet northwest of this area. The drill will pass 70 feet under this area. Using the results of the geotechnical investigation, as well as several other data points, the entry/exit, angles, and depths have been configured to pass through the best substrates while maintaining pipe integrity (e.g., no large bends). The majority of the substrate that will be passed through is estimated to be silty sand.

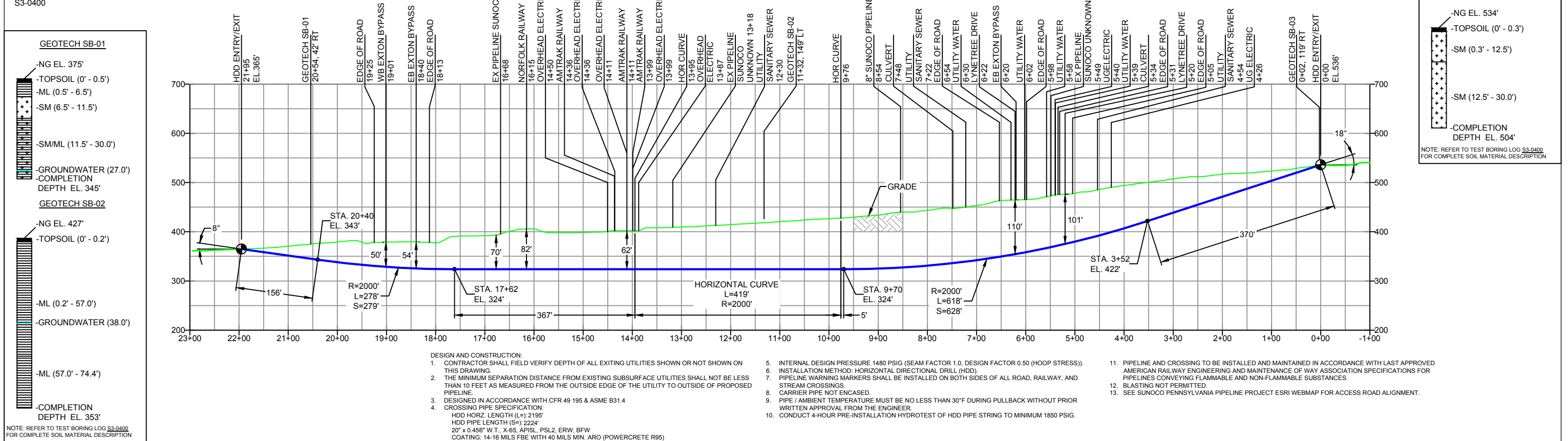
The drill does not pass under wetland K21 but passes near the eastern most boundary. The drill will enter/exit 635 feet northwest of this area. The drill will pass 75 feet under this area. Using the results of the geotechnical investigation, as well as several other data points, the entry/exit, angles, and depths have been configured to pass through the best substrates while maintaining pipe integrity (e.g., no large bends). The majority of the substrate that will be passed through is estimated to be silty sand.

The drill will enter/exit 784 feet northwest of the AMTRAK railway crossing. The drill will pass 62 feet under this stream. Using the results of the geotechnical investigation, as well as several other data points, the entry/exit, angles, and depths have been configured to pass through the best substrates while maintaining pipe integrity (e.g., no large bends). The majority of the substrate that will be passed through is estimated to be silty sand.



CHESTER COUNTY PENNSYLVANIA, WEST WHITELAND TOWNSHIP
S3-0400

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): 2195'
HDD PIPE LENGTH (S): 2224'
20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
- INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
- 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.
- PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
- BLASTING NOT PERMITTED.
- SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTE: REFER TO TEST BORING LOG S3-0400 FOR COMPLETE SOIL MATERIAL DESCRIPTION

- 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		REVISIONS	
ES-6.49	TO	ES-6.50	EROSION & SEDIMENT PLAN
SHEET 33	TO	SHEET 34	AERIAL SITE PLAN
		EP1	REVISED PER PADEP COMMENTS
		EP	
		0	ISSUED FOR CONSTRUCTION
DWG NO	DWG NO	DESCRIPTION	NO.

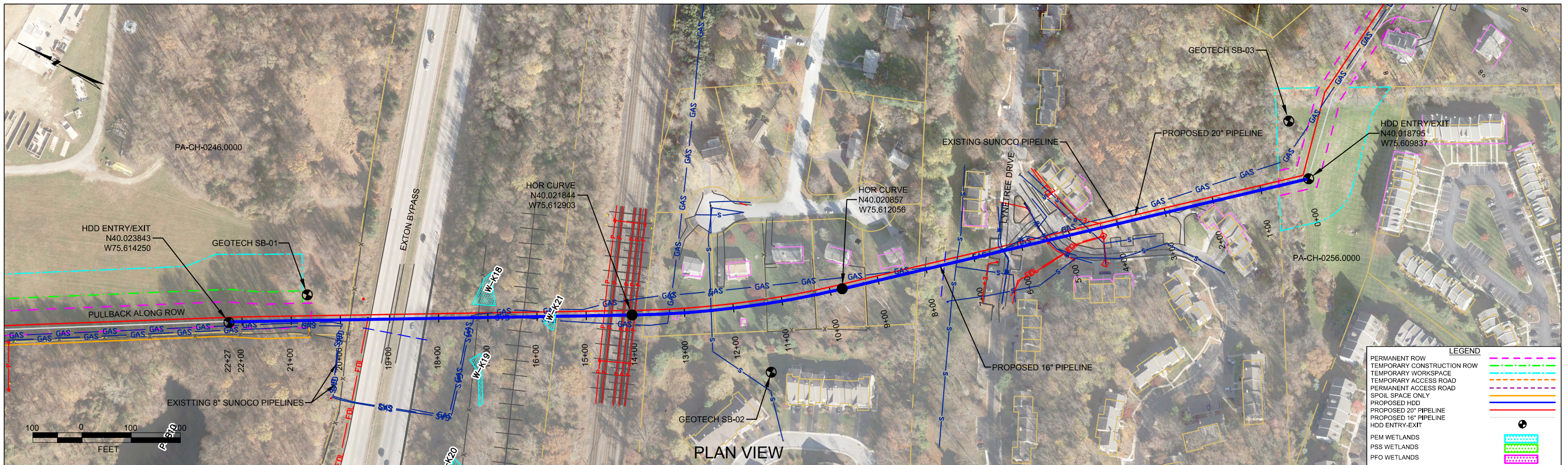
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

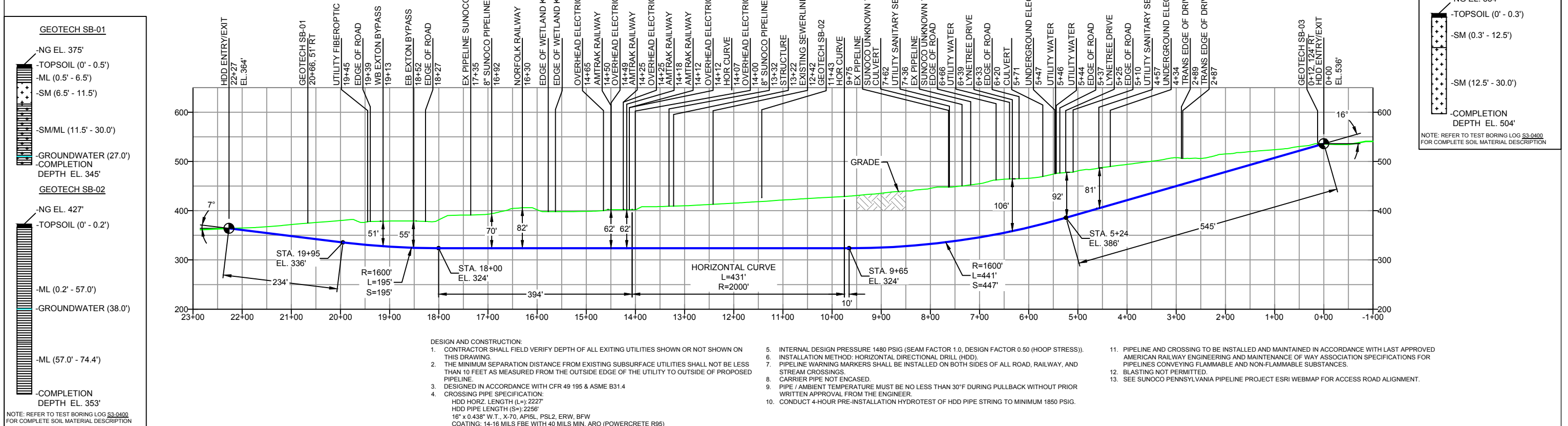
20-INCH HORIZONTAL DIRECTIONAL DRILL
EXTON BYPASS
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'
DWG. NO: PA-CH-0256.0000-RR



CHESTER COUNTY PENNSYLVANIA, WEST WHITELAND TOWNSHIP
S3-0400-16

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): 2227'
HDD PIPE LENGTH (S): 2256'
16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
 - 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.
 - PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
 - BLASTING NOT PERMITTED
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

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		EROSION & SEDIMENT PLAN	
ES-6.49	TO	ES-6.50	
SHEET 33	TO	SHEET 34	AERIAL SITE PLAN
		EP1	REVISED PER PADEP COMMENTS
		EP	
		0	ISSUED FOR CONSTRUCTION
DWG NO	TO	DWG NO	DESCRIPTION

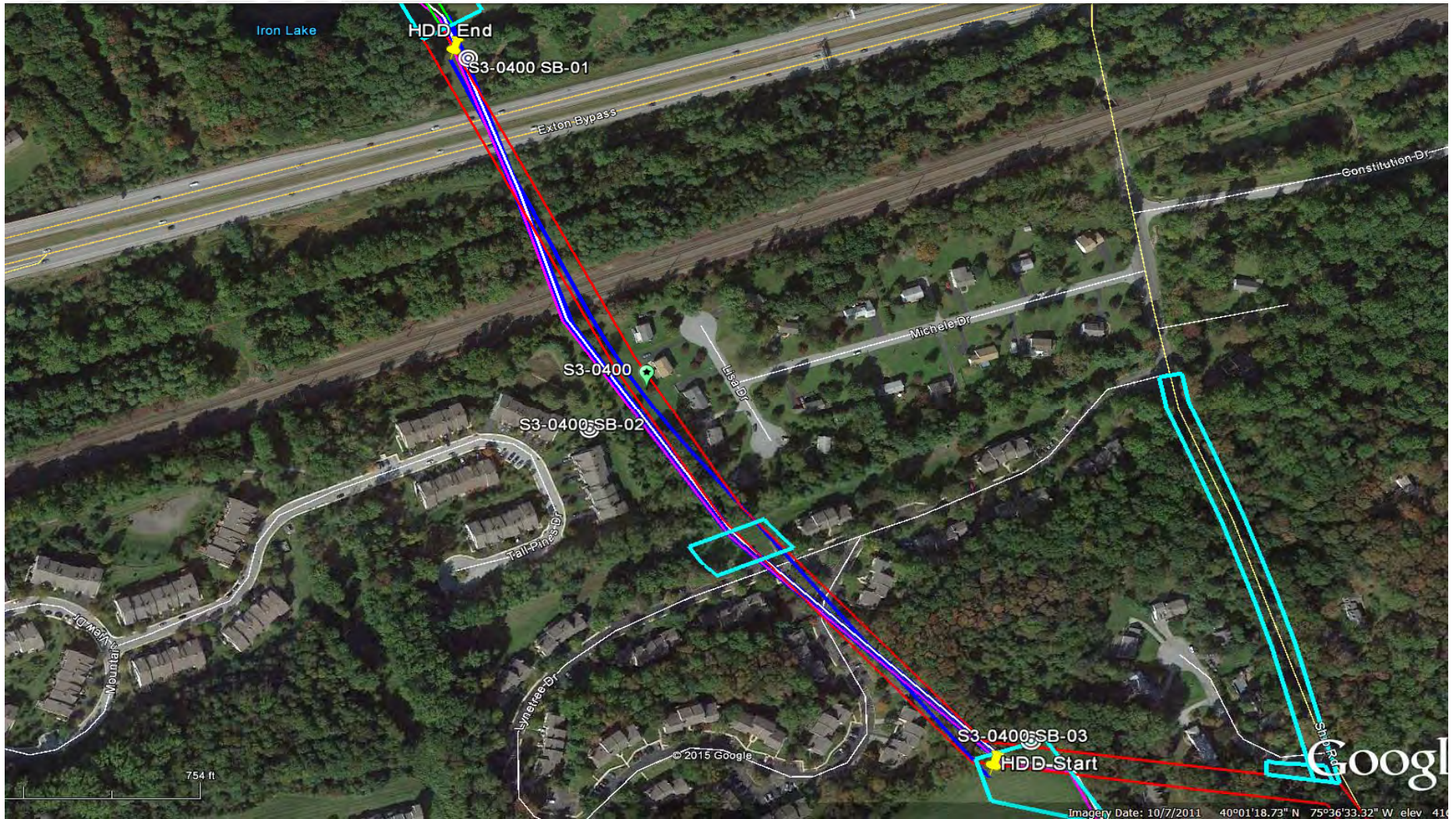
REVISIONS					
MRS	05/11/16	RMB	05/11/16	AAW	05/11/16
MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
MRS	02/19/16	RMB	02/19/16	AAW	02/19/16
BY	DATE	CHK	DATE	APP	DATE

(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
EXTON BYPASS
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO: PA-CH-0256.0000-RR-16



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S3-0400
 CHESTER COUNTY, WEST WHITELAND TOWNSHIP, PA
 SUNOCO PENNSYLVANIA PIPELINE PROJECT



TETRA TECH

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

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: TRAINING FACILITY, 500 LINCOLN HWY, EXTON, PA			Page 1 of 1		
HDD No.: S3-0400		Dates(s) Drilled: 06-12-15		Inspector: J. COSTELLO	
Boring No.: SB-01		Drilling Method: SPT - ASTM D1586		Driller: GREG	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 27.0		Total Depth (ft): 30.0	
Boring Location Coordinates:			40° 1' 24.672" N		75° 36' 49.675" 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	0.5			TOPSOIL (6")					
			0.5	3.0			DARK BROWN SILT WITH SOME FINE SAND,.					
1	3.0	5.0	3.0		20	ML	DR, VARIEGATED DARK BROWN, REDDISH BROWN, GRAY SILT WITH SOME FINE SAND, TRACE FINE ROCK FRAGMENTS.	1	2	3	8	5
				6.5								
2	8.0	10.0	6.5		15	SM	DR, REDDISH BROWN AND BROWN FINE TO MEDIUM SAND WITH SOME SILT, TRACE UNWEATHERED FINE ROCK FRAGMENTS.	5	5	7	10	12
				11.5								
3	13.0	15.0	11.5		18		DR, REDDISH BROWN AND BROWN FINE TO MEDIUM SAND AND SILT, TRACE FINE TO COARSE UNWEATHERED GRAVEL.	2	5	5	6	10
4	18.0	20.0			21		DR, VARIEGATED GRAY, REDDISH BROWN, YELLOWISH BROWN F-SAND AND SILT, TRACE FINE UNWEATHERED GRAV. (USCS: SM/ML)	1	2	4	4	6
5	23.0	25.0			20	SM/ML	DR, VARIEGATED GRAY, REDDISH BROWN, YELLOWISH BROWN F-SAND AND SILT, TRACE FINE UNWEATHERED GRAV. (USCS: SM/ML)	1	3	9	11	12
6	28.0	30.0			22		DR, STRATIFIED LAYERS OF GRAY, RED, BRWN, AND YELLOW BRWN FINE TO MEDIUM SAND AND SILT, WITH A LITTLE UNWEATHERED LIMESTONE GRAVEL.	4	22	22	28	44
				30.0								
							WATER LEVEL THROUGH AUGERS AT 27'.					
							CAVED AT 29'.					

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

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 Newark, Delaware 19713
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 fax: 302.454.5988

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: TALL PINES DRIVE, WEST CHESTER, PA			Page 1 of 1		
HDD No.: S3-0400		Dates(s) Drilled: 06-16-15		Inspector: J. COSTELLO	
Boring No.: SB-02		Drilling Method: SPT - ASTM D1586		Driller: GREG	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 38.0		Total Depth (ft): 74.4	
Boring Location Coordinates:			40° 1' 15.624" N		75° 36' 46.117" 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	0.2			TOPSOIL (2")						
1	3.0	5.0	0.2		18	ML	DR, WEATHERED TO A VARIEGATED BROWN, GRAY, ORANGE BRWN SILT WITH SOME FINE MICACEOUS SAND, LITTLE F-GRAVEL.	4	6	4	8	10	
2	8.0	10.0			22		DR, VARIEGATED LAYERS OF BROWN, GRAY, OR.BRWN SILT WITH SOME FINE SAND, TRACE FINE GRAVEL.	1	3	4	7	7	
3	13.0	15.0			24		DR SHIIST, VARIEGATED GRAY AND BROWN MICACEOUS SILT WITH SOME FINE SAND, TRACE FINE UNWEATHERED GRAVEL.	1	3	6	8	9	
4	18.0	20.0			22		DR SHIST, LIGHT GRAY SILT WITH A LITTLE FINE SAND.	1	6	7	9	13	
5	23.0	25.0			22		DR SHIST, LIGHT GRAY SILT WITH A LITTLE FINE SAND.	1	3	6	12	9	
6	28.0	30.0			23		DR, VARIEGATED ORANGE AND YELLOW BROWN SILT WITH SOME FINE SAND (WEATHERED SCHIST). (USCS: ML).	1	2	8	17	10	
7	33.0	35.0			23		DR SCHIST, VARIEGATED ORANGE AND YELLOW BROWN SILT WITH SOME FINE SAND, TRACE UNWEATHERED FINE GRAVEL.	1	5	6	14	11	
8	38.0	40.0			24		DR SCHIST, VARIEGATED REDDISH BROWN AND GRAY SILT AND FINE SAND, TRACE UNWEATHERED FINE GRAVEL.	1	6	7	14	13	
9	43.0	45.0			13		DR SCHIST, VARIEGATED REDDISH BROWN AND GRAY SILT AND FINE SAND, TRACE UNWEATHERED FINE GRAVEL.	2	6	17	19	23	
10	48.0	50.0			16		DR SCHIST, VARIEGATED LIT GRAY TO OLIVE GRAY SILT WITH A LITTLE FINE SAND, MICACEOUS.	2	9	8	16	17	
11	53.0	55.0			12		DR SCHIST, VARIEGATED RED, YELLOW, GRAY, BRWN SILT WITH A LITTLE FINE SAND, MICACEOUS, TRACE F-GRAVEL (USCS: ML).	1	1	27	32	28	
12	58.0	59.3	57.0		18		ML	DR SCHIST, VARIEGATED GRAY, RED, YELLOW BRWN SILT WITH A LITTLE FINE SAND, MICACEOUS.	11	37	50/4"		>50
13	63.0	65.0			14	DR SCHIST, OLIVE GRAY MICACEOUS SILT WITH A LITTLE FINE SAND.		4	13	17	27	30	
14	68.0	70.0			18	DR SCHIST, OLIVE GRAY MICACEOUS SILT WITH A LITTLE FINE SAND.		8	19	25	45	44	
15	73.0	74.4			15	DR SCHIST, OLIVE GRAY MICACEOUS SILT AND FINE SAND, WITH A LITTLE UNWEATHERED FINE GRAVEL.		10	31	50/5"		>50	
			74.4										

Notes/Comments:
Pocket Pentrometer Testing
 DR: DECOMPOSED ROCK
 WET ON SPOON AT 38'.
 CAVED AT 66'.

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**

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT	Project No.:	103IP3406
Project Location:	BEHIND DURANT COURT, EXTON STATION COMMUNITY, PA	Page 1 of 1	
HDD No.:	S3-0400	Dates(s) Drilled:	06-16-15
Boring No.:	SB-03	Inspector:	E. WATT
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	S. HOFFER
		Groundwater Depth (ft):	NOT ENCOUNTERED
		Total Depth (ft):	30.0
Boring Location Coordinates:	40° 1' 8.538" N		75° 36' 34.227" 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	0.3			TOPSOIL (4")					
1	3.0	5.0			16	SM	DR SCHIST, VARIEGATED LIGHT GRAY, GRAY, AND BROWN FINE TO MEDIUM SAND WITH A LITTLE SILT.	3	5	12	12	17
2	8.0	10.0			18		DR SCHIST, VARIEGATED LIGHT GRAY, GRAY, AND BROWN FINE TO MEDIUM SAND WITH A LITTLE SILT, WITH A LITTLE F-C GRAVEL.	6	8	10	11	18
				12.5		SM	DR SCHIST, VARIEGATED LIGHT GRAY AND LIGHT BROWN FINE TO MEDIUM SAND WITH A LITTLE SILT.	7	50/3"			>50
3	13.0	13.8	12.5		10		DR SCHIST, VARIEGATED LIGHT GRAY AND LIGHT BROWN FINE TO MEDIUM SAND WITH A LITTLE SILT.	50/5"				>50
4	18.0	18.4			5		MEDIUM SAND WITH A LITTLE SILT.					
5	23.0	23.3			2		BROWN AND GRAY PARTIALLY WEATHERED SCHIST.	50/3"				>50
6	28.0	28.2		30.0	2		BROWN AND GRAY PARTIALLY WEATHERED SCHIST.	50/2"				>50
							AUGERED TO 30'.					
							AUGERS STARTED GRINDING AT 12.5'.					
							CAVED AND DRY AT 28'.					

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 S3-0400

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, %	
S3-0400	SB-01	1	3.0	5.0	22.0	69.7	-	-	-	-
		2	8.0	10.0	14.7	39.0	-	-	-	-
		3	13.0	15.0	19.1	46.8	-	-	-	-
		4	18.0	20.0	25.5	48.0	39	28	11	SM/ML
		6	28.0	30.0	14.5	47.8	-	-	-	-
	SB-02	2	8.0	10.0	20.4	68.6	-	-	-	-
		4	18.0	20.0	14.1	85.1	-	-	-	-
		6	28.0	30.0	16.4	75.0	28	23	5	ML
		8	38.0	40.0	16.5	63.0	-	-	-	-
		10	48.0	50.0	16.4	84.7	-	-	-	-
		11	53.0	55.0	19.7	80.5	32	25	7	ML
	SB-03	13	63.0	65.0	19.4	82.0	-	-	-	-
		1	1.0	3.0	5.0	16.9	-	-	-	-
		2	2.0	8.0	10.0	13.7	-	-	-	-
		3	3.0	13.0	13.8	18.3	-	-	-	-
4		4.0	18.0	18.4	16.6	-	-	-	-	
		6	6.0	28.0	28.2	18.7	-	-	-	-

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0400

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
S3-0400		SB-01	Conestoga Formation - Light-gray, thin-bedded, impure, contorted limestone having shale partings; conglomeratic at base; in Chester Valley, includes micaceous limestone in upper part, phyllite in middle, and alternating dolomite and limestone in lower part.	Gently sloping to the North	Conestoga Formation (Ordovician and Cambrian)	Limestone; secondary: phyllite; other types: conglomerate, dolostone, shale	At least 300	Ranges from 5 to 43 ft bgs, Avg. 23 ft bgs (.5 mile radius)	Few sinkholes mapped in this area, mostly depressions (potential soft soils)
		SB-02	Octoraro Formation - Includes albite-chlorite schist, phyllite, some hornblende gneiss, and granitized members.	Gently to moderately sloping to the North	Octoraro Formation (Probably Lower Paleozoic)	Schist; secondary: phyllite; other types: gneiss, gneiss, gneiss, gneiss	Unknown		
		SB-03	Octoraro Formation - Includes albite-chlorite schist, phyllite, some hornblende gneiss, and granitized members.	Gently to moderately sloping to the NW	Octoraro Formation (Probably Lower Paleozoic)	Schist; secondary: phyllite; other types: gneiss, gneiss, gneiss, gneiss	Unknown		

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					
	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.