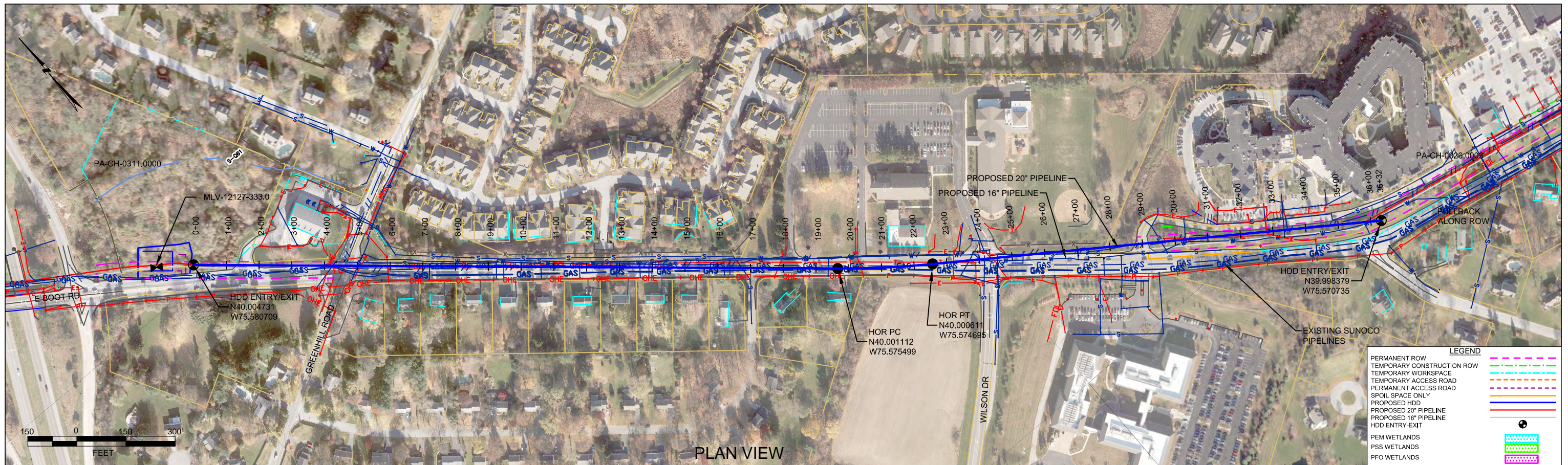


HDD PA-CH-0326.0000-RD (E Boot Road)

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.

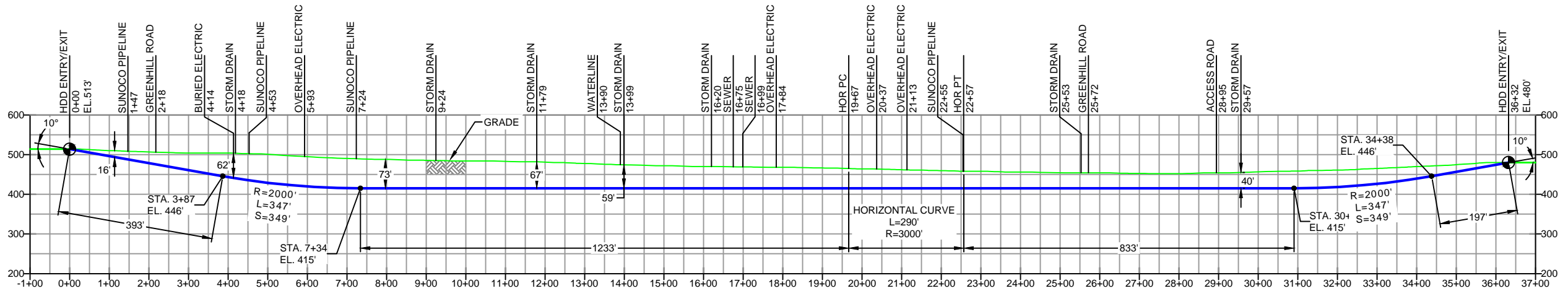
The drill will enter/exit 200 feet northwest of E Boot Road. The drill will continue under E Boot Road for approximately 2300 feet. This point is 1132 feet northwest of the southeast entry/exit point. The drill will pass between 40 and 73 feet under this road. Using the results of the geotechnical investigation, 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, and schist.



PLAN VIEW

CHESTER COUNTY PENNSYLVANIA, EAST & WEST GOSHEN TOWNSHIPS
S3-460

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-): 3632'
HDD PIPE LENGTH (S-): 3644'
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		REVISIONS		
ES-6.56	TO ES-6.59	EROSION & SEDIMENT PLAN	EP1 REVISED PER PADEP COMMENTS	
SHEET 38	TO SHEET 39	AERIAL SITE PLAN	EP	
			D DESIGN CHANGE	
			C ISSUED FOR BID	
			B ISSUED FOR BID	
			A ISSUED FOR REVIEW	
DWG NO	DWG NO	DESCRIPTION	NO.	DESCRIPTION

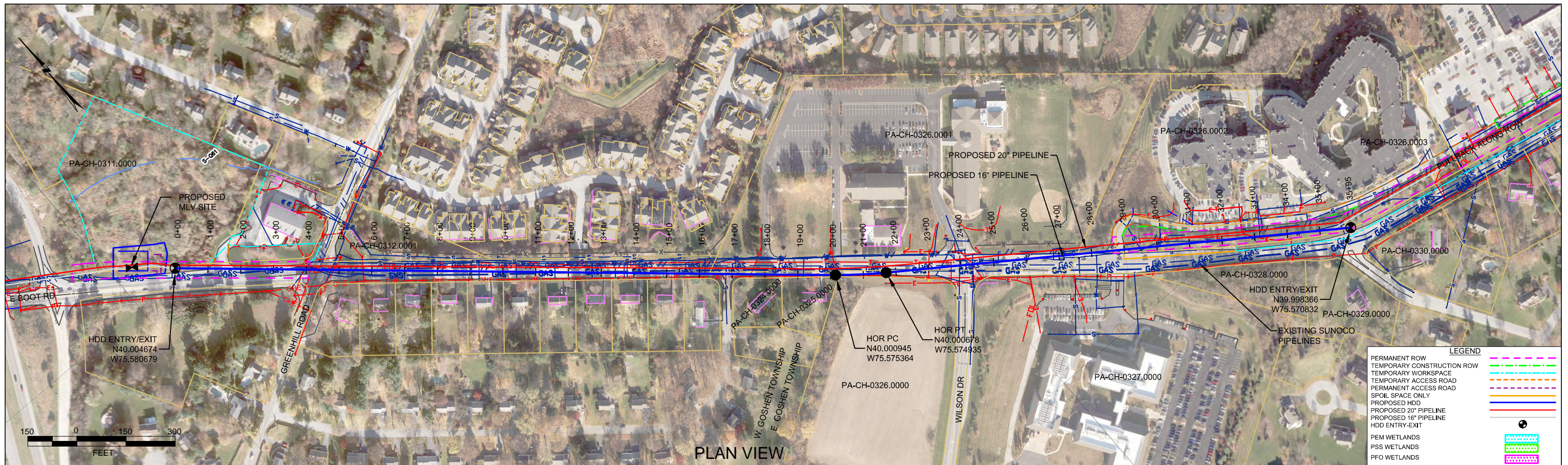
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
GREENHILL ROAD
PENNSYLVANIA PIPELINE PROJECT

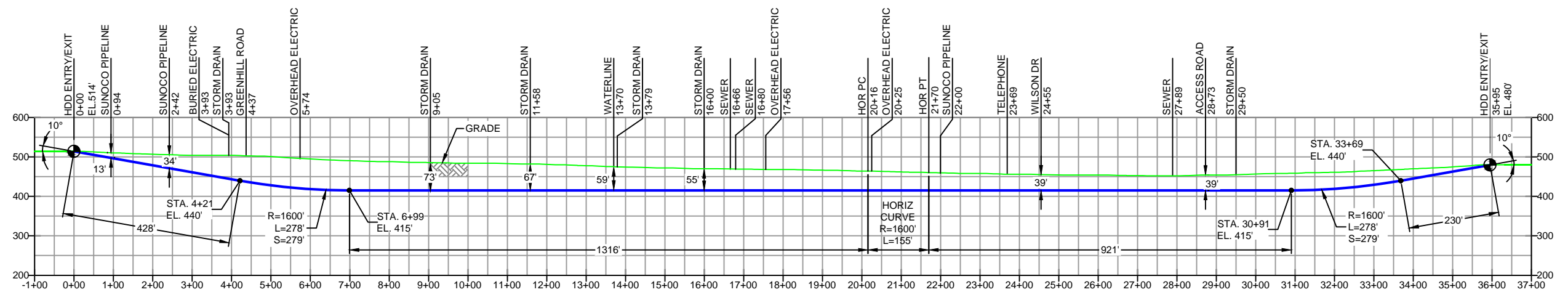
SCALE: 1"=300' DWG. NO. PA-CH-0326.0000-RD



PLAN VIEW

CHESTER COUNTY PENNSYLVANIA, EAST & WEST GOSHEN TOWNSHIPS
S3-0460-16

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-): 3595'
HDD PIPE LENGTH (S-): 3608'
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.

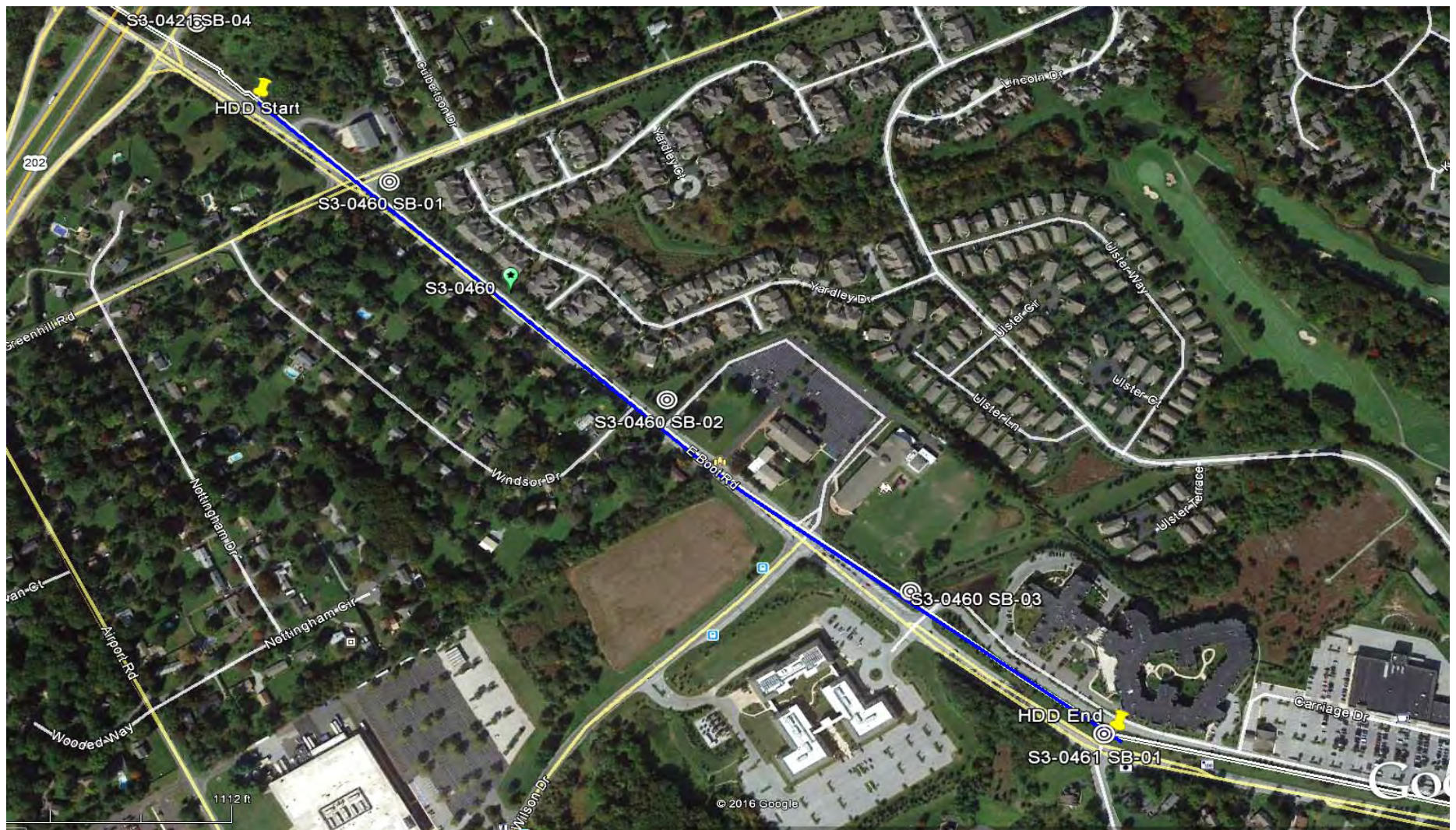
NOTES	
1.	ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2.	STATIONING IS BASED ON HORIZONTAL DISTANCES
3.	ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON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

REF. DRAWING		REVISIONS	
ES-6.58	TO ES-6.59	EROSION & SEDIMENT PLAN	
SHEET 38	TO SHEET 39	AERIAL SITE PLAN	
		EP1	REVISED PER PADEP COMMENTS
		EP	
		B	DESIGN CHANGE
		A	ISSUED FOR BID
DWG NO	DWG NO	DESCRIPTION	NO.

BY	DATE	CHK	DATE	APP	DATE
JTW	05/11/16	RMB	05/11/16	AAW	05/11/16
MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
MRS	10/27/15	RMB	10/27/15	AAW	10/27/15
MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

(303) 792-5911

SUNOCO PIPELINE, L.P.	
16-INCH HORIZONTAL DIRECTIONAL DRILL GREENHILL ROAD PENNSYLVANIA PIPELINE PROJECT	
SCALE: 1"=300'	DWG. NO. PA-CH-0326.0000-RD-16



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S3-0460
 CHESTER COUNTY, WEST/EAST GOSHEN 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: N202 ON-RAMP FROM BOOT ROAD, WEST CHESTER, PA			Page 1 of 1		
HDD No.: S3-0421		Dates(s) Drilled: 06-18-15		Inspector: J.COSTELLO	
Boring No.: SB-04		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): NOT ENCOUNTERED		Total Depth (ft): 30.0	
Boring Location Coordinates:			40° 0' 19.841" N		75° 34' 53.309" 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	0.0			TOPSOIL (TRACE")						
			0.0	2.0		FILL	FILL MATERIALS - SILT AND FINE SAND, CRUSHED GRAVEL.						
1	3.0	5.0	0.0		14	SM	DR SCHIST, VARIEGATED REDDISH BROWN, BROWN, GRAY FINE TO MEDIUM SAND, SOME SILT, TRACE UNWEATHERED GRAVEL.	1	4	5	6	9	
2	8.0	10.0			18		DR SCHIST, VARIEGATED LIGHT GRAY TO TAN, FINE TO MEDIUM SAND WITH A LITTLE SILT, TRACE UNWEATHERED FINE GRAVEL.	4	9	12	19	21	
3	13.0	14.5			18		DR SCHIST, LIGHT GRAY TO TAN, FINE TO MEDIUM SAND WITH SOME SILT, TRACE UNWEATHERED FINE GRAVEL.	9	36	50/6"		86	
4	18.0	18.9			10		DR SCHIST, LIGHT GRAY TO TAN, FINE TO MEDIUM SAND WITH SOME SILT, TRACE UNWEATHERED F-C GRAVEL.	7	50/5"			>50	
5	23.0	24.0			10		DR SCHIST, VARIEGATED OLIVE, GRAY, BROWN FINE TO MEDIUM SAND, SOME SILT, WITH LAYERING OF UNWEATHERED SCHIST.	4	50/6"			>50	
6	28.0	29.3			14		DR SCHIST, VARIEGATED OLIVE, GRAY, BROWN FINE TO MEDIUM SAND, SOME SILT, WITH LAYERING OF UNWEATHERED SCHIST.	4	42	50/3"		>50	
				30.0									
								AUGERED TO 30'.					
								CAVED AND DRY 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

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: BOOT ROAD AND GREENHILL RD, WEST CHESTER, PA			Page 1 of 1		
HDD No.: S3-0460		Dates(s) Drilled: 01-20-16		Inspector: E. WATT	
Boring No.: SB-01		Drilling Method: SPT - ASTM D1586		Driller: E. OGDEN	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): NOT ENCOUNTERED		Total Depth (ft): 41.0	
Boring Location Coordinates:			40° 0' 13.89" N		75° 34' 44.81" 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	0.3			TOPSOIL (3")						
1	3.0	5.0	0.3		SM	16	DR, BROWN TO ORANGE BROWN MICACEOUS FINE SAND AND SILT, TRACE FINE GRAVEL.	4	8	6	6	14	
2	8.0	10.0				19	DR, VARIEGATED BROWN AND GRAY MICACEOUS FINE SAND, SOME SILT, TR. F-QUARTZ GRAVEL, TRACE IRON STAINING. (USCS: SM)	1	4	19	22	23	
3	13.0	13.7				6	DR, VARIEGATED BROWN AND GRAY FINE TO MEDIUM SAND, SOME SILT, WITH A LITTLE F-C UNWEATHERED SCHIST GRAVEL.	21	50/2"			>50	
4	18.0	18.8				7	SAME	7	50/3"			>50	
5	23.0	24.5				14	SAME	2	13	50		63	
6	28.0	28.4				5	SAME (USCS: SM).	50/5"				>50	
				33.5									
7	33.0	33.7	33.5	34.0		4	GRAY WEATHERED TO PARTIALLY WEATHERED SCHIST.	6	50/2"			>50	
							AUGER REFUSAL AT 34'.						
							ROCK CORING						
RUN 1	34.0	36.0	34.0		20	WEATHERED TO PARTIALLY WEATHERED	GRAY INTENSELY FRACTURED SCHIST (MOSTLY RUBBLE), FOLIATED. (WEATHERED TO PARTIALLY WEATHERED SCHIST)	TCR: 83%, SCR: 8%, RQD: 0%					
RUN 2	37.0	41.0			41		SAME	TCR: 68%, SCR: 5%, RQD: 0%					
				41.0									
							AUGER STARTED GRINDING AT 32'.						
							CAVED AT 30'.						
							NOT ENOUGH INTACT CORE SAMPLE TO SELECT FOR COMPRESSIVE STRENGTH TESTING.						

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: ST. PETER AND PAUL CATHOLIC CHURCK, WEST CHESTER, PA			Page 1 of 1		
HDD No.: S3-0460		Dates(s) Drilled: 06-24-15		Inspector: E. WATT	
Boring No.: SB-02		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 28.0		Total Depth (ft): 75.0	
Boring Location Coordinates:			40° 0' 5.920" N		75° 34' 32.925" 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	0.1			TOPSOIL (1")						
1	3.0	5.0	0.1		7	SM	DR SCHIST, ORANGE BROWN MICACEOUS FINE TO MEDIUM SAND AND SILT.	1	3	3	2	6	
2	8.0	10.0			21		DR SCHIST, VARIEGATED LIGHT GRAY, WHITE, LIGHT BROWN FINE TO MEDIUM SAND AND SILT.	1	7	8	12	15	
3	13.0	15.0			24		DR SCHIST, VARIEGATED GRAY AND LIGHT BROWN FINE TO MEDIUM MICACEOUS SAND AND SILT.	1	4	7	9	11	
4	18.0	20.0			20		SAME	2	7	7	9	14	
5	23.0	25.0			24		SAME	1	5	6	11	11	
6	28.0	30.0			24		SAME	3	7	9	11	16	
7	33.0	35.0			15		SAME (USCS: SM)	6	9	19	24	28	
8	38.0	40.0			18		SAME	3	14	15	18	29	
9	43.0	45.0			14		DR SCHIST, VARIEGATED LIGHT GRAY, GRAY, AND BROWN MICACEOUS FINE TO MEDIUM SAND AND SILT.	5	20	25	40	45	
10	48.0	50.0			9		SAME	3	14	16	25	30	
11	53.0	55.0			14		SAME (USCS: SM)	8	17	26	35	43	
12	58.0	60.0			12		SAME	3	14	22	27	36	
13	63.0	64.3			13		SAME	8	40	50/4"		>50	
14	68.0	68.8			9		SAME	23	50/4"			>50	
15	73.0	73.8		75.0	8		SAME	20	50/4"			>50	
							AUGERED TO 75'.						

Notes/Comments: Pocket Pentrometer Testing DR: DECOMPOSED ROCK WET ON SPOON AT 32'. WATER LEVEL THROUGH AUGERS AT 28'. CAVED AT 45', WATER ON CAVE AT 26'.

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 S3-0460**

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, %	
S3-0421	SB-04	1	3.0	5.0	10.9	24.5	-	-	-	-
		2	8.0	10.0	4.8	12.5	-	-	-	-
		3	13.0	14.5	7.0	29.4	-	-	-	-
		5	23.0	24.0	7.8	28.5	-	-	-	-
		6	28.0	29.3	6.1	20.1	-	-	-	-
S3-0460	SB-01	1	3.0	5.0	14.1	47.0	-	-	-	-
		2	8.0	10.0	10.2	26.8	NV	NP	NP	SM
		3	13.0	13.7	5.5	20.8	-	-	-	-
		5	23.0	24.5	17.6	35.5	-	-	-	-
		6	28.0	28.4	9.2	39.1	NV	NP	NP	SM
		7	33.0	33.7	5.9	14.4	-	-	-	-
	SB-02	2	8.0	10.0	12.5	47.1	-	-	-	-
		4	18.0	20.0	15.5	47.7	-	-	-	-
		7	33.0	35.0	14.9	46.8	34	27	7	SM
		9	43.0	45.0	16.4	45.3	-	-	-	-
		11	53.0	55.0	14.4	47.2	31	24	7	SM
		13	63.0	64.3	15.4	48.0	-	-	-	-
	SB-03	15	73.0	73.8	14.2	43.5	-	-	-	-
		2	8.0	10.0	12.9	29.7	-	-	-	-
		3	13.0	15.0	13.2	28.6	-	-	-	-
4		18.0	20.0	10.7	20.5	-	-	-	-	
S3-0461	SB-01	5	23.0	25.0	12.0	23.1	-	-	-	-
		6	28.0	30.0	10.9	27.1	-	-	-	-
		2	8.0	10.0	15.8	34.9	-	-	-	-
		3	13.0	13.6	7.1	12.0	-	-	-	-
		4	18.0	18.9	7.1	11.7	-	-	-	-
		5	23.0	23.7	7.8	16.4	-	-	-	-
		6	28.0	28.6	5.3	15.4	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
(COULD NOT TEST, INSUFFICIENT CORE SEGMENT LENGTHS, RQD=0)				

Notes:

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

**ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0460**

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S3-0460	SB-1	1	34	36	83	8	0	34	37	Moderate	Schist	Massive	Light gray	Foliated, rubble; fractures ranging from 20° to 60°, avg. 47°
		2	36	41	68	5	0	37	41	Moderate	Schist	Massive	Gray to dark gray	Heavily foliated, rubble; fractures ranging from 28° to 80°, Avg. 58°

**REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0460**

HDD No.	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
S3-0421	SB-04	"Glenarm Wissahickon" formation - Lithologically similar to oligoclase-mica schist of the Wissahickon Formation (PZw), but also includes lenticular amphibolite bodies having ocean-floor basalt chemistry.	Generally level, slightly sloping to the East	"Glenarm Wissahickon" Formation (Proably Lower Paleozoic)	Mica schist; secondary: mafic gneiss; other types: amphibolite	Literature indicates uncertain but believed to be several miles thick	Ranges from 4 to 58 ft bgs, Avg. 20 ft bgs (.5 mile radius)	All part of Glenarm Supergroup a name given to provincial series of pre-Cambrian metamorphosed sedimentary rocks present in northern VA, MD, southeastern PA, western NJ, and possibly southeastern NY. Rocks from this assemblage consists of a thick sequence of metasedimentary rock and include the following formations; Setters metaquartzite, Cockeysville marble, Wissahickon Schist (along with subset of the Octoraro schist), Peters Creek metaquartzite and meta siltstones and the Peach Bottom Clate (Geology of Pennsylvania SP-1, 1999) . Drilling in these formations generally difficult to very difficult except where fractures and weathered exposed zones present.
S3-0460	SB-01	"Glenarm Wissahickon" formation - Lithologically similar to oligoclase-mica schist of the Wissahickon Formation (PZw), but also includes lenticular amphibolite bodies having ocean-floor basalt chemistry.	Generally Level	"Glenarm Wissahickon" Formation (Proably Lower Paleozoic)	Mica schist; secondary: mafic gneiss; other types: amphibolite	Literature indicates uncertain but believed to be several miles thick	Ranges from 1 to 72 ft bgs, Avg. 26 ft bgs (1 mile radius)	
	SB-02		Generally level, slightly sloping to the north					
SB-03	Generally level							
S3-0461	SB-01	Ultramafic rocks - Includes serpentine, steatite, and other products of alteration of peridotites and pyroxenites	Gently sloping to the southeast	Ultramafic rocks (probably lower Paleozoic age)	Serpentinite; Secondary - pyroxenite; Other - peridotite	No information found during literature review	Ranges from 7 to 21 ft bgs, Avg. 12 ft bgs (.5 mile radius)	

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

Relative Proportions

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

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 No. 10 to No. 40 sieve (M) (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)

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	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3 Not meeting C_u or C_c requirements for GW		
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines			
		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 Not meeting C_u or C_c requirements for SW		
			SP	Poorly graded sands, gravelly sands, little or no fines			
		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		
		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⁾					
		Major Divisions		Group Symbols	Typical Descriptions	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	MH or OH			
		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.