

**HDD PA-CH-0111.0000 (W-C43)**

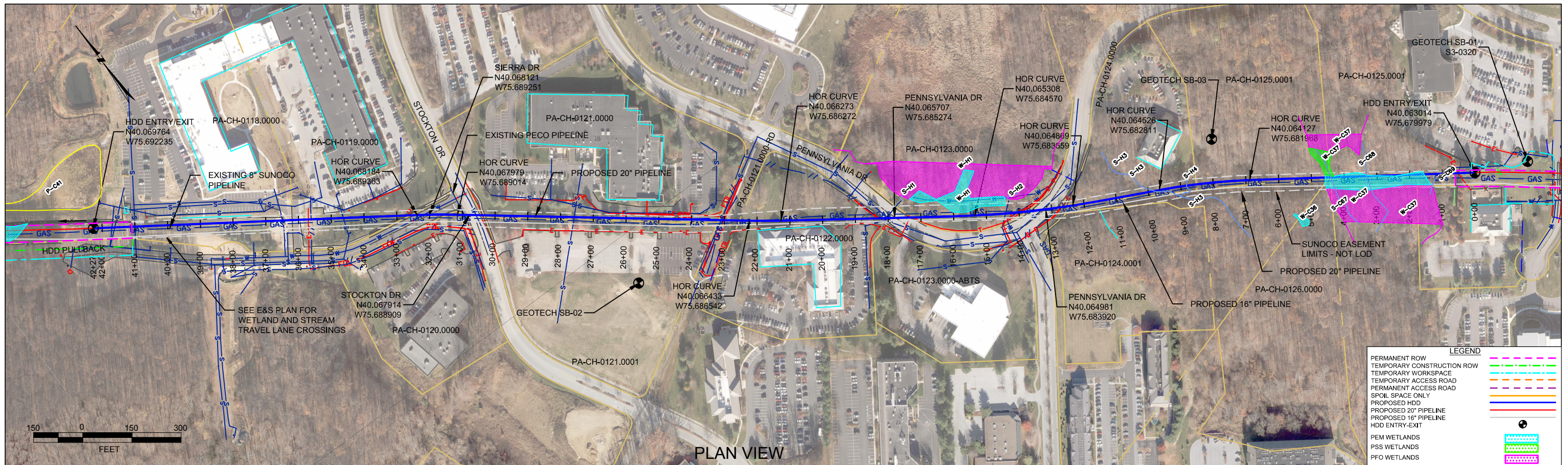
After consideration of the all data points, including the sensitivity of the area and geotechnical results, the preliminary design of this drill has been found to be adequate for safe installation and operation (see Attachment A for the drill design and the geotechnical investigation report).

The drill would enter/exit 1,000 feet from the edge of the western most boundary of wetland W-C43PEM/PFO and would enter/exit 110 feet from the eastern most edge of wetland W-C43PEM/PFO. The drill would pass 80 feet under the western most boundary of wetland W- C43PEM/PFO and 10 feet under the eastern most boundary of W-C43PEM/PFO. 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 a silty sand or clay at either ends of the wetland and a graphitic felsic gneiss beneath the central portion of the wetland. Given the design, the threat of inadvertent return has been reduced to the maximum extent practicable. Implementing this design, along with adherence to the *Pennsylvania Pipeline Project Inadvertent Return Contingency Plan – with Special Bog Turtle Procedures* will ensure the bog turtle is not impacted as result of this HDD.

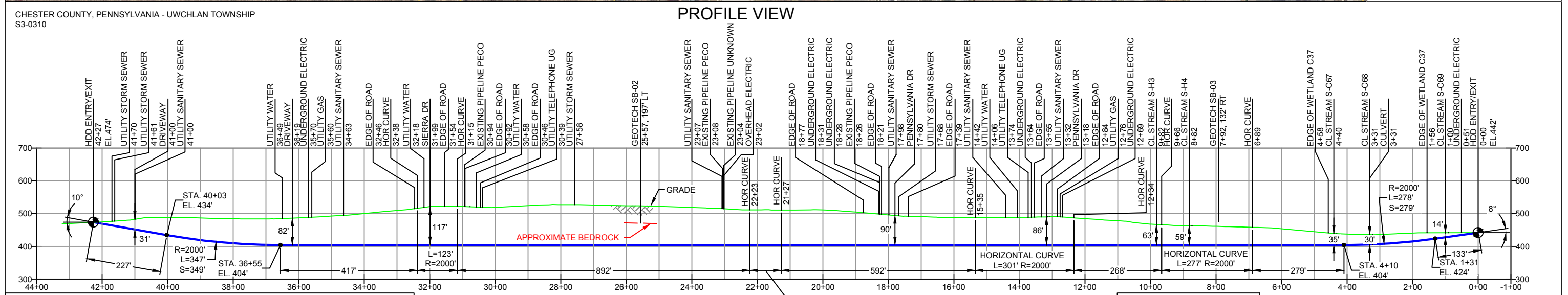
**HDD PA-CH-0124.0000 (W-C37)**

After consideration of the all data points, including the sensitivity of the area and geotechnical results, the preliminary design of this drill has been found to be adequate for safe installation and operation (see Attachment A for the drill design and the geotechnical investigation report).

The Drill is offset to the south of Wetland H1PEM/PFO. The drill would enter/exit 2,500 feet from the edge of the western most boundary of the wetland H1PEM/PFO and would enter/exit 200 feet from the eastern most edge of wetland C37PEM/PFO. The drill would pass 11 feet to the south of Wetland H1PEM/PFO and at a depth of 86 feet at its closest point and 20 feet under the eastern most boundary of Wetland C37PEM/PFO. 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 a silty sand at either ends of the wetland and gneiss bedrock beneath the central portion of the wetland. Given the design, the threat of inadvertent return has been reduced to the maximum extent practicable. Implementing this design, along with adherence to the *Pennsylvania Pipeline Project Inadvertent Return Contingency Plan – with Special Bog Turtle Procedures* will ensure the bog turtle is not impacted as result of this HDD.



PLAN VIEW



PROFILE VIEW

CHESTER COUNTY, PENNSYLVANIA - UWCHLAN TOWNSHIP  
S3-0310

GEOTECH SB-01	GEOTECH SB-02	GEOTECH SB-03
-NG EL. 495'	-NG EL. 516'	-NG EL. 475'
-TOPSOIL (0' - 0.1')	-TOPSOIL (0' - 0.3')	-TOPSOIL (0' - 0.3')
-GROUNDWATER (30.5')	-GROUNDWATER (38.0')	-GROUNDWATER (25.0')
-SM (0.1' - 73.8')	-SM (6.5' - 45.0')	-SM (9.0' - 53.0')
-COMPLETION DEPTH EL. 421'	-FRACTURED GNEISS (45.0' - 51.5')	-WEATHERED GNEISS (53.0' - 61.3')
	-COMPLETION DEPTH EL. 471'	-COMPLETION DEPTH EL. 389'

- 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)=4227'  
HDD PIPE LENGTH (S)=4232'  
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.

NOTE: REFER TO TEST BORING LOG S3-0320 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTE: REFER TO TEST BORING LOG S3-0310 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-6.32	TO ES-6.35	EROSION & SEDIMENT PLAN	
SHEET 19	TO SHEET 20	AERIAL SITE PLAN	
		EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
		EP1	REVISED PER PADEP COMMENTS
		EP	
		0	ISSUED FOR CONSTRUCTION
DWG NO	DWG NO	DESCRIPTION	DESCRIPTION

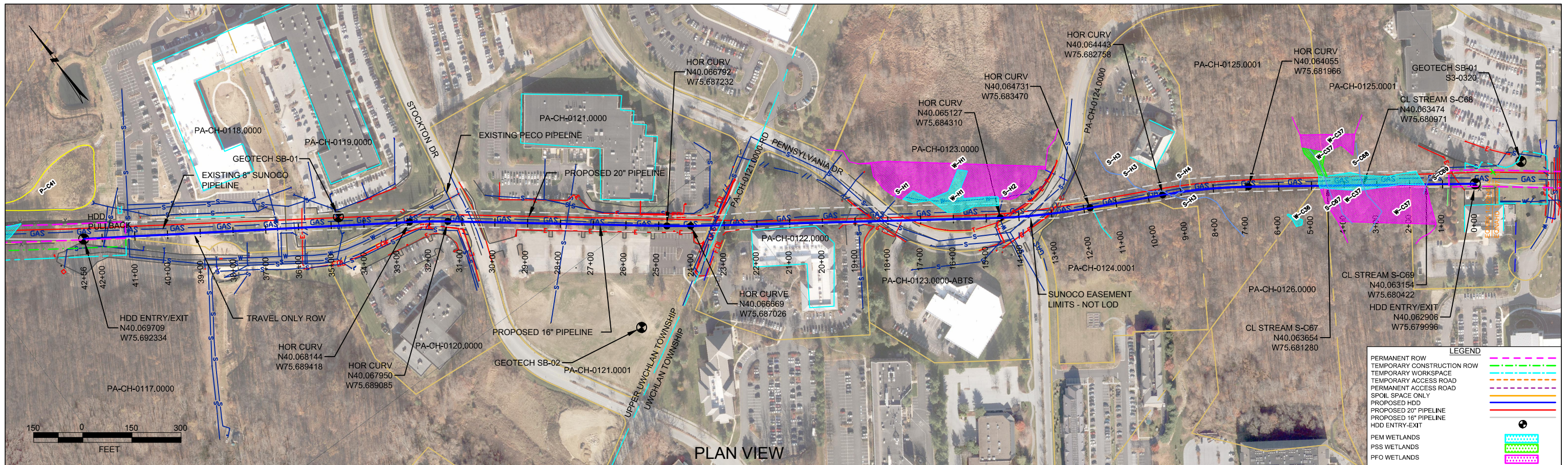
**Sunoco Logistics Partners L.P.**

**TETRA TECH ROONEY**  
(303) 792-5911

**SUNOCO PIPELINE, L.P.**

20-INCH HORIZONTAL DIRECTIONAL DRILL  
PENNSYLVANIA DRIVE  
PENNSYLVANIA PIPELINE PROJECT

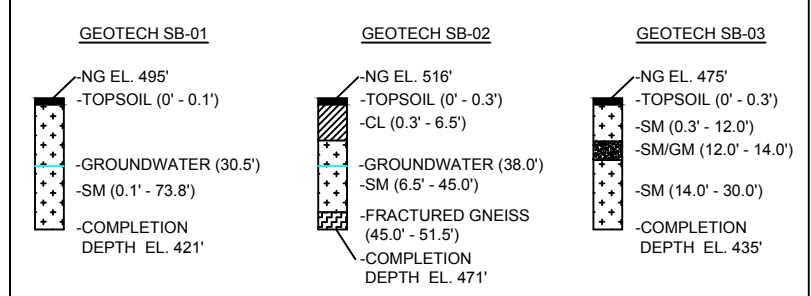
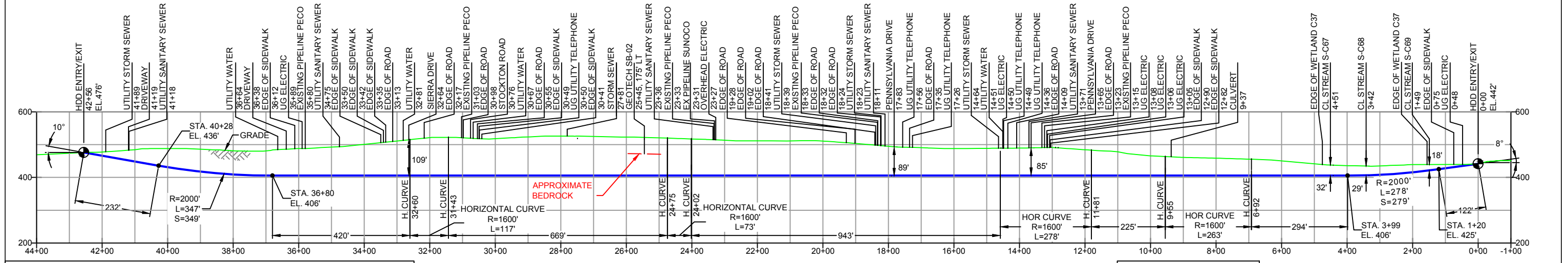
SCALE: 1"=300' DWG. NO. PA-CH-0124.0000-RD



PLAN VIEW

CHESTER COUNTY, PENNSYLVANIA - UWCHLAN & UPPER UWCHLAN TOWNSHIP  
S3-0310-16

PROFILE VIEW



DESIGN AND CONSTRUCTION:  
 1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.  
 2. 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.  
 3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4  
 4. CROSSING PIPE SPECIFICATION:  
 HDD HORIZ. LENGTH (L)=425'  
 HDD PIPE LENGTH (S)=426'  
 16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW  
 COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)

5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).  
 6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).  
 7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.  
 8. CARRIER PIPE NOT ENCASED.  
 9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.  
 10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.  
 11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBSITE FOR ACCESS ROAD ALIGNMENT.  
 12. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.  
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NOTES  
 1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83  
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 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-6.32	TO ES-6.35	EROSION & SEDIMENT PLAN	
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		EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
		EP1	REVISED PER PADEP COMMENTS
		EP	
		0	ISSUED FOR CONSTRUCTION
DWG NO	DWG NO	DESCRIPTION	DESCRIPTION

**Sunoco Logistics  
Partners L.P.**

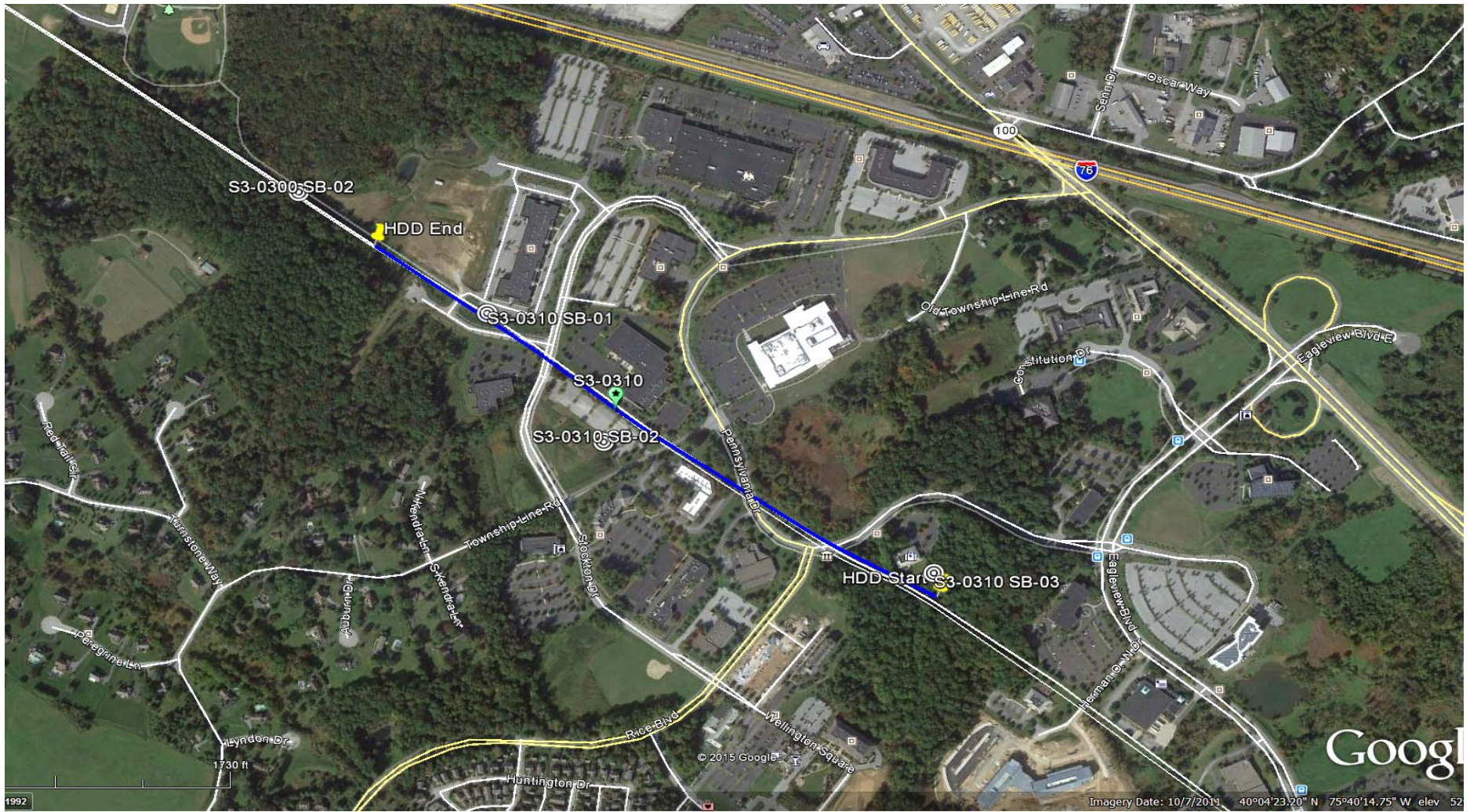
**SUNOCO PIPELINE, L.P.**

16-INCH HORIZONTAL DIRECTIONAL DRILL  
PENNSYLVANIA DRIVE  
PENNSYLVANIA PIPELINE PROJECT

**TETRA TECH ROONEY**  
(303) 792-5911

SCALE: 1"=300'

DWG. NO. PA-CH-0124.0000-RD-16



**LEGEND:**

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS  
 HDD S3-0310  
 CHESTER COUNTY, UPPER UWCHLAN/UWCHLAN TWP, 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: 730 STOCKTON, DOWNINGTOWN, PA			Page 1 of 1		
HDD No.: S3-0310		Dates(s) Drilled: 07-28/29-15		Inspector: E. WATT	
Boring No.: SB-01		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 30.5		Total Depth (ft): 73.8	
Boring Location Coordinates:			40° 4' 6.762" N		75° 41' 23.914" 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	0.1			TOPSOIL (1")						
1	3.0	5.0	0.1		12	SM	DARK BROWN FINE TO MEDIUM SAND WITH SOME SILT, TRACE FINE ROCK FRAGMENTS.	1	3	4	5	7	
2	8.0	10.0			16		DR, YELLOWISH BROWN FINE TO MEDIUM SAND WITH SOME SILT, TRACE FINE GNEISS FRAGMENTS.	1	5	12	15	17	
3	13.0	14.2			20		DR, YELLOWISH BROWN AND WHITE FINE TO MEDIUM SAND WITH SOME SILT, TRACE FINE GNEISS FRAGMENTS.	21	50	50/2"		>50	
4	18.0	19.9			19		DR, YELLOWISH BROWN AND WHITE FINE TO MEDIUM SAND WITH SOME SILT, TRACE FINE GNEISS FRAGMENTS.	5	21	41	50/5"	>50	
5	23.0	24.5			12		DR, YELLOWISH BROWN AND DARK BROWN FINE TO MEDIUM SAND WITH SOME SILT, WITH A LITTLE FINE GNEISS FRAGMENTS.	1	23	50/5"		>50	
6	28.0	29.4			16		DR, YELLOWISH BROWN AND DARK BROWN FINE TO MEDIUM SAND WITH A LITTLE SILT, WITH A LITTLE FINE GNEISS FRAGMENTS.	7	41	50/5"		>50	
7	33.0	33.8			9		DR, YELLOWISH BROWN AND DARK BROWN FINE TO MEDIUM SAND WITH SOME SILT, WITH A LITTLE FINE GNEISS FRAGMENTS.	8	50/4"			>50	
8	38.0	40.0			15		DR, VARIEGATED YELLOWISH BROWN TO BROWNISH YELLOW FINE SAND WITH SOME SILT. (WHITE AND BLACK LAYER)	13	15	30	29	45	
9	43.0	44.5			15		DR, VARIEGATED YELLOWISH BROWN TO BROWNISH YELLOW FINE SAND WITH SOME SILT.	3	13	50		63	
10	48.0	49.9			6		DR, VARIEGATED YELLOWISH BROWN TO BROWNISH YELLOW FINE SAND WITH SOME SILT.	2	15	23	50/5"	38	
11	53.0	54.4			8		DR, VARIEGATED (BROWN, BLACK, WHITE, YELLOW) CEMENTED FINE TO MEDIUM SAND, SOME SILT, TRACE F-C GNEISS FRAGMENTS.	25	18	50/5"		>50	
12	58.0	59.0			6		DR, VARIEGATED (BROWN, BLACK, WHITE, YELLOW) FINE TO MED. SAND, SOME SILT, A LITTLE F-C GNEISS FRAGMENTS. (USCS: SM).	15	50/6"			>50	
13	63.0	63.8			10		DR, VARIEGATED (BROWN, BLACK, WHITE, YELLOW) FINE TO MED. SAND, SOME SILT, A LITTLE F-C GNEISS FRAGMENTS.	15	50/4"			>50	
14	68.0	68.9			8		DR, REDDISH BROWN AND WHITE FINE TO MEDIUM SAND WITH SOME SILT, WITH A LITTLE F-C GNEISS FRAGMENTS.	15	50/5"			>50	
15	73.0	73.8			10		DR, REDDISH BROWN AND WHITE FINE TO MEDIUM SAND WITH SOME SAND, SOME SILT, A LITTLE F-C GNEISS FRAGMENTS. (USCS: SM).	25	50/4"			>50	
				73.8									

Notes/Comments:  
Pocket Pentrometer Testing  
 DR: DECOMPOSED ROCK  
 WET ON SPPON AT 30.5' CAVED AT 72'.  
 WATER LEVEL THROUGH AUGERS AT 30.5'.

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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 fax: 302.454.5988

**TEST BORING LOG**

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: 630 STOCKTON, DOWNINGTOWN, PA			Page 1 of 1		
HDD No.: S3-0310		Dates(s) Drilled: 07-30-15		Inspector: E. WATT	
Boring No.: SB-02		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 38.0		Total Depth (ft): 51.5	
Boring Location Coordinates:			40° 3' 59.736" N		75° 41' 16.420" 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		18	CL	BROWN WITH RED NODULES SILTY CLAY AND FINE SAND, TRACE	3	3	5	9	8	
				6.5			FINE GRAVEL. (USCS: CL).						
2	8.0	10.0	6.5		14	SM	DR, VARIEGATED (BROWN, RED, WHITE) FINE TO MEDIUM SAND WITH A	5	15	31		46	
							LITTLE SILT.						
3	13.0	13.8			13		DR, VARIEGATED (BROWN, RED, WHITE) FINE TO MEDIUM SAND WITH A	12	50/4"			>50	
							LITTLE SILT, TRACE F-C ROCK FRAGMENTS.						
4	18.0	20.0			18		DR, VARIEGATED (BROWN, RED, WHITE) FINE TO MEDIUM SAND WITH A	3	13	22	31	35	
							LITTLE SILT, TRACE F-C ROCK FRAGMENTS.						
5	23.0	25.0			21		DR, VARIEGATED (BROWN, RED, WHITE) FINE TO MEDIUM SAND WITH A	3	13	22	24	35	
							LITTLE SILT, TRACE F-C ROCK FRAGMENTS.						
6	28.0	30.0			24		DR, VARIEGATED (DARK BROWN, WHITE, REDDISH BROWN) FINE TO	2	10	12	21	22	
							MEDIUM SAND WITH A LITTLE SILT, TRACE MICA.						
7	33.0	34.5			13	DR, VARIEGATED (DARK BROWN, WHITE, REDDISH BROWN) FINE TO	1	15	50		65		
						MEDIUM SAND WITH A LITTLE SILT, TRACE MICA.							
8	38.0	38.6			4	DR, REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILT, TRACE	12	50/2"			>50		
						FINE GEISS ROCK FRAGS.							
9	43.0	43.5		45.0	0	NO RECOVERY (AUGER CUTTINGS - SIMILAR TO S8).	50/6"				>50		
						AUGER REFUSAL AT 45'.							
						<u>ROCK CORING</u>							
RUN 1	45.0	50.0	45.0		42	DECOMPOSED TO WEATH. ROCK	INTENSELY FRACTURED GRAY, WHITE AND RED GNEISS.	TCR: 70%, SCR: 32%, RQD: 13%					
RUN 2	50.0	51.0			12		INTENSELY FRACTURED DARK GRAY AND WHITE GNEISS (GRAVEL)	TCR: 100%, SCR: 25%, RQD: 0%					
RUN 3	51.0	51.5		51.5	5		INTENSELY FRACTURED DARK GRAY GNEISS (GRAVEL)	TCR: 83%, SCR: 67%, RQD: 0%					
							DIFFICULTY WITH CORE BARRELL JAMBING WITH ROCK GRAVEL.						
							OUT OF WATER AT 51.5', LARGE WATER LOSS.						
							<u>CORE TESTING RESULTS (RUN 1, DEPTH 47-47.5):</u>						
							COMPRESSIVE STRENGTH: 5,390 PSI						
							UNIT WEIGHT: 159.5 PCF						

Notes/Comments:

Pocket Pentrometer Testing  
 S1: 3.25 TSF

DR: DECOMPOSED ROCK

WET ON SPOON AT 38'.

WATER LEVEL THROUGH AUGERS AT 38'. CAVED AT 42'.

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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 fax: 302.454.5988

**TEST BORING LOG**

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406	
Project Location: WORLED TRAVEL, Inc., 620 PENNSYLVANIA DRIVE, EXTON, PA		Page 1 of 1	
HDD No.: S3-0310	Dates(s) Drilled: 06-14-15	Inspector: E. WATT	
Boring No.: SB-03	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° 3' 52.538" N 75° 40' 55.207" 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	4.0	0.3		10	SM	BROWN AND LIGHT BROWN FINE TO MEDIUM SAND AND SILT, WITH A LITTLE FINE GRAVEL.	11	50/6"				>50	
2	8.0	9.9			23		DR WEATHERED TO A BROWN, LIGHT BROWN, WHITE F-M SAND, SOME SILT, TRACE UNWEATHERED F-GRAVEL (GNEISS). (USCS: SM)	25	14	21	50/5"			35
3	13.0	13.4	12.0		5	SM/GM	DR WEATHERED TO A LIGHT BROWN F-M SAND WITH SOME SILT, AND FINE TO COARSE UNWEATHERED GNEISS GRAVEL.	50/5"						>50
4	18.0	18.5	14.0		5		DR WEATHERED TO A WHITE AND LIGHT BROWN FINE SAND, A LITTLE SILT, WITH A LITTLE FINE UNWEATHERED GNEISS GRAVEL.	50/5"						>50
5	23.0	23.2			2	SM	DR WEATHERED TO A WHITE AND LIGHT BROWN FINE SAND, SOME SILT, WITH A LITTLE FINE UNWEATHERED GNEISS GRAVEL.	50/2"						>50
6	28.0	28.0		30.0	0		NO RECOVERY.	50/0"						>50
							AUGERED TO 30'.							
							CAVED AND DRY AT 26'.							

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 S3-0310**

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water	Percent	Atterburg Limits (ASTM D4318)			USCS
			From	To	Content, % (ASTM D2216)	Silts/Clays, % (ASTM D1140)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Classif. (ASTM D2487)
S3-0300	SB-02	2	8.0	10.0	23.5	20.5	-	-	-	-
		3	13.0	15.0	31.7	22.6	-	-	-	-
		4	18.0	20.0	41.7	33.1	30	25	5	SM
		5	23.0	25.0	32.2	28.7	-	-	-	-
		6	28.0	30.0	23.4	24.2	-	-	-	-
S3-0310	SB-01	2	8.0	10.0	15.3	20.7	-	-	-	-
		4	18.0	19.9	10.2	24.7	-	-	-	-
		6	28.0	29.4	7.8	15.9	-	-	-	-
		9	43.0	44.5	14.8	25.1	-	-	-	-
		10	48.0	49.9	12.6	33.1	-	-	-	-
		12	58.0	59.0	8.5	36.6	31	25	6	SM
		14	68.0	68.9	13.1	32.3	-	-	-	-
	SB-02	1	3.0	5.0	20.5	67.1	39	22	17	CL
		2	8.0	10.0	8.7	17.3	-	-	-	-
		4	18.0	20.0	6.2	14.8	-	-	-	-
		7	33.0	34.5	13.7	11.9	-	-	-	-
		8	38.0	38.6	10.3	22.7	-	-	-	-
	SB-03	1	3.0	4.0	10.6	44.7	-	-	-	-
		2	8.0	9.9	10.8	28.3	NV	NP	NP	SM
4		18.0	18.5	4.9	20.1	-	-	-	-	
5		23.0	23.2	4.6	22.8	-	-	-	-	

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
S3-0310 SB-02	1	47.0-47.5	5,390	159.5

**Notes:**

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

**ROCK CORE DESCRIPTION SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S3-0310**

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					
S3-0310	SB-2	1	45	50	70	32	13	45	49	Moderate	Gneiss	4	White/Lt. gray	Fractures ranging from 2° to 42°, Avg. 27°
		2	50	51	100	25	0	49	51.5	Heavily	Gneiss	Massive	White/Lt. gray/black	Rubble, two pieces over 3"
		3	51	51.5	83	67	0							

**REGIONAL GEOLOGY SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S3-0310**

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
S3-0300	SB-02	Graphitic felsic gneiss - Includes Pickering Gneiss and small areas of marble; dominantly quartz and feldspar with varying amounts of graphite and various metamorphic minerals; medium grained, light to dark gray and greenish gray; sedimentary origin.	Generally level, slightly sloping to the west	Graphitic felsic gneiss (PreCambrian)	Graphitic gneiss	Unknown	See Notes.	Of the 23 well records within 0.5 miles of the site, only one had a recorded bedrock depth. Given the similar geology, bedrock depth is likely to be similar to other locations in this formation
S3-0310	SB-01		Gently sloping to the west					
	SB-02		Generally level					
	SB-03		Gently sloping to the South	Felsic and intermediate gneiss (PreCambrian)	Felsic gneiss		Ranges from 30 to 95 ft bgs, Avg. 52 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

### 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	$C_u = \frac{D_{60}}{D_{10}}$ 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  Atterberg limits above A line with $I_p$ greater than 7	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  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  Atterberg limits above A line with $I_p$ greater than 7	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			
		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 <sup>(1)</sup>					
		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 $\pm 2$ 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.