

HDD PA-DE-0104.0008-WX (S-H37, S-H39, S-H40, and S-H41)

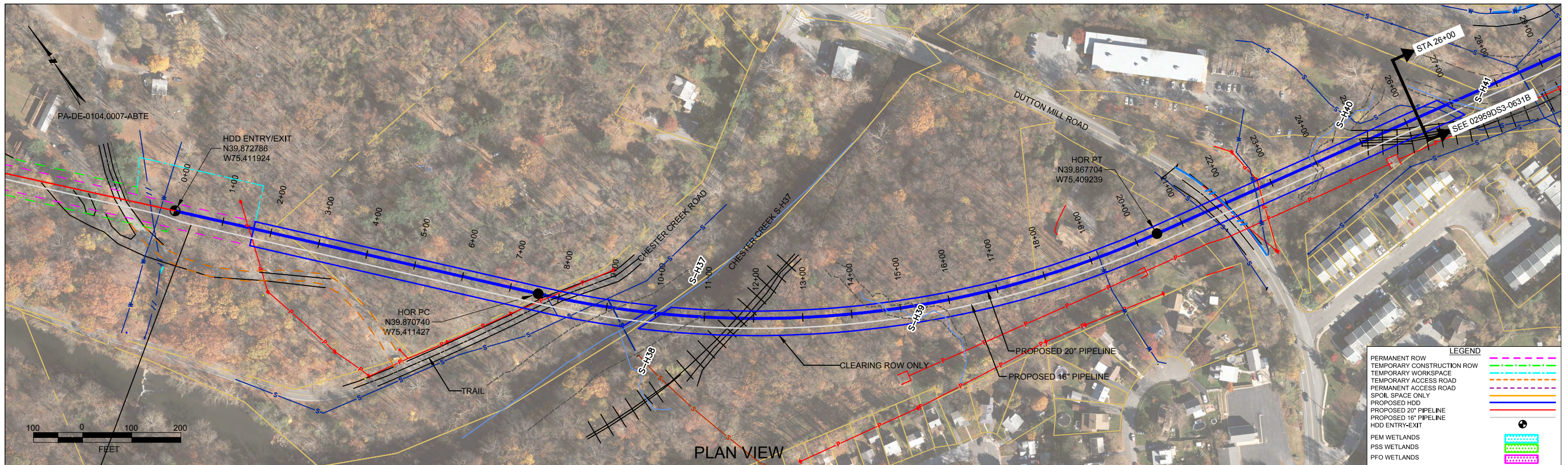
Given the design, the threat of inadvertent return has been reduced to the maximum extent practicable and in this case that threat is considered to be low. Implementing this design, along with adherence to the Pennsylvania Pipeline Project Inadvertent Return Contingency Plan will ensure inadvertent impacts,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

The drill will enter/exit 991 feet northwest of stream H37. The drill will pass 50 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 and schist.

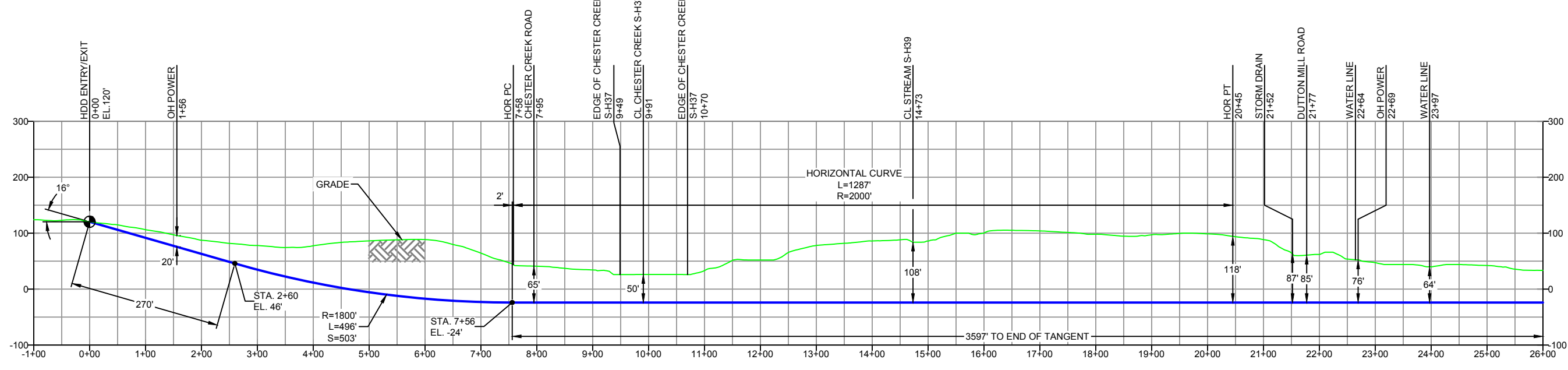
The drill will enter/exit 1473 feet northwest of stream H39. The drill will pass 108 feet under this stream. Using the results of the geotechnical investigation, as well as several other data points, the entry/exit, angles, and depths have been configured to pass through the best substrates while maintaining pipe integrity (e.g., no large bends). The majority of the substrate that will be passed through is estimated to be silty sand, schist and gneiss.

The drill will enter/exit 2397 feet northwest of stream H40. The drill will pass 64 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 clay, silty sand and gneiss.

The drill crosses stream H41 in two places. The drill will enter/exit 2696 feet northwest of stream H41 at the first crossing. The drill will enter/exit 3106 feet northwest of stream H41 at the second crossing. The other entry/exit point is 2044 feet southeast of this second crossing. The drill will pass 48 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 clay, silty sand and gneiss.



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): 5150'
 HDD PIPE LENGTH (S): 5180'
 20" x 0.456" W.T., X-65, API5L, 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-6.28	TO ES-6.29	NO.	DESCRIPTION
SHEET 17	TO SHEET 19	EP1	EROSION & SEDIMENT PLAN
		EP	REVISED PER PADEP COMMENTS
		C	ISSUED FOR BID
		B	ISSUED FOR BID
		A	ISSUED FOR REVIEW
DWG NO	DWG NO	NO.	DESCRIPTION

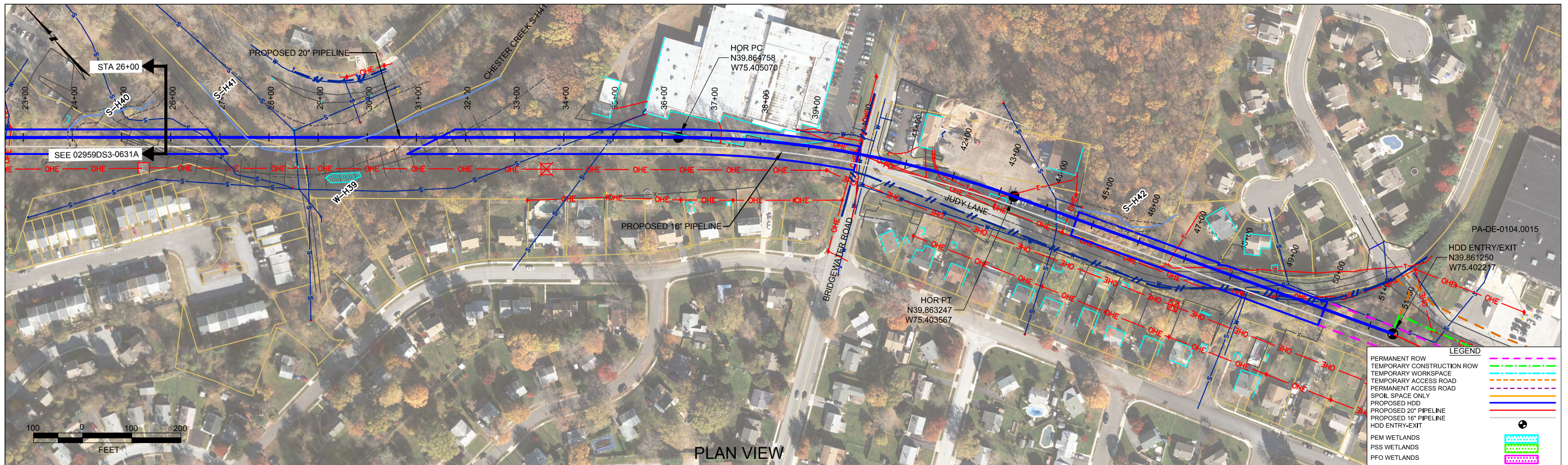
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
CHESTER CREEK
PENNSYLVANIA PIPELINE PROJECT

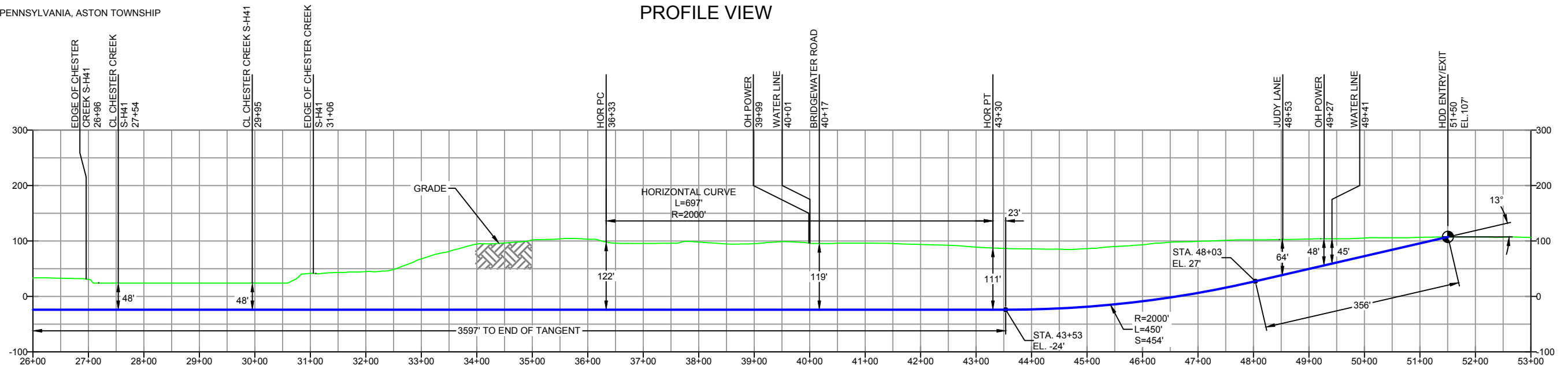
SCALE: 1"=200' DWG. NO: PA-DE-0104.0008-WXa



PLAN VIEW

DELAWARE COUNTY, - PENNSYLVANIA, ASTON TOWNSHIP
S3-0631B

PROFILE VIEW



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- 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.
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REF. DRAWING

DWG NO	DWG NO	DESCRIPTION	NO.	DESCRIPTION
ES-6.26	TO ES-6.29	EROSION & SEDIMENT PLAN		
SHEET 17	TO SHEET 19	AERIAL SITE PLAN	EP1	REVISED PER PADEP COMMENTS
			EP	
			C	ISSUED FOR BID
			B	ISSUED FOR BID
			A	ISSUED FOR REVIEW

REVISIONS

BY	DATE	CHK	DATE	APP	DATE
MRS	05/26/16	RMB	05/26/16	AAW	05/26/16
MRS	03/23/16	RMB	03/23/16	AAW	03/23/16
DLM	08/21/15	RMB	08/21/15	AAW	08/21/15
DLM	07/31/15	RMJB	07/31/15	AAW	07/31/15
JAM	03/24/15	RMB	03/24/15	AAW	03/24/15

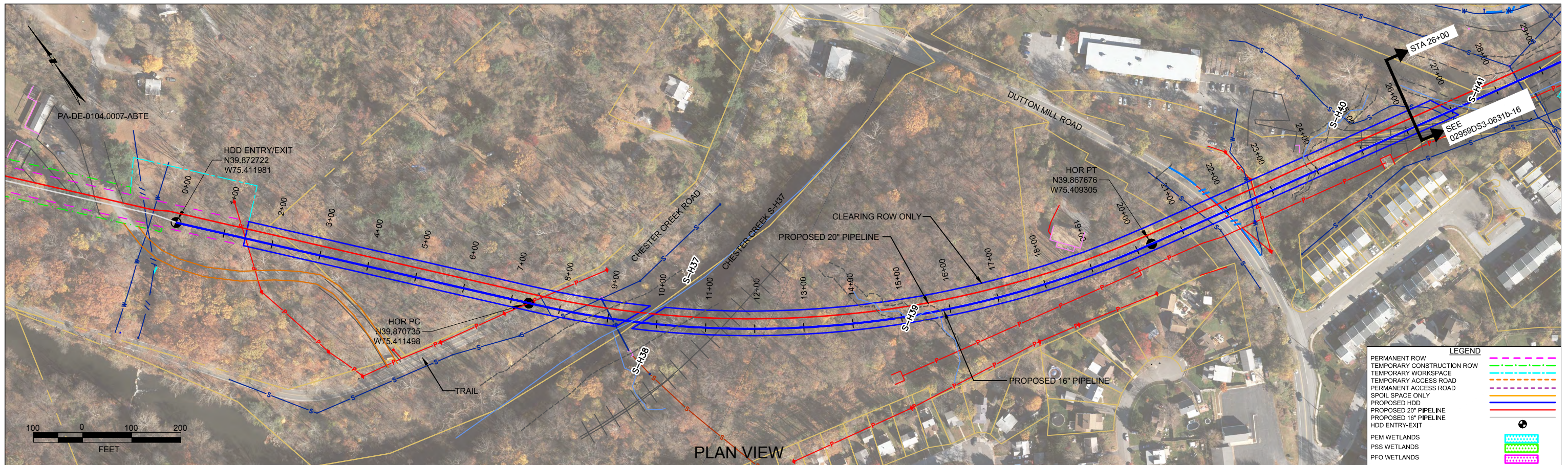


SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
CHESTER CREEK
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

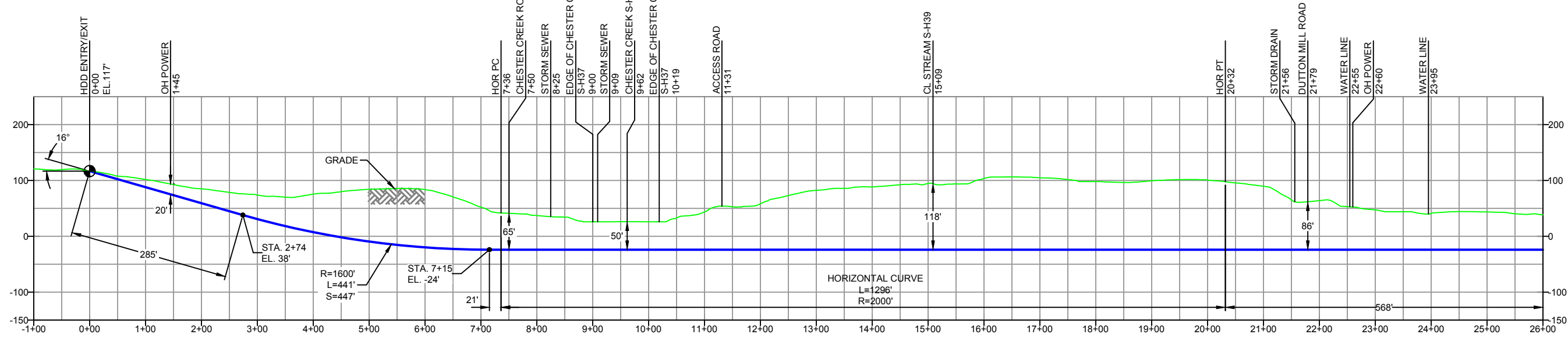
DWG. NO: PA-DE-0104.0008-WXB



PLAN VIEW

DELAWARE COUNTY, PENNSYLVANIA - ASTON TOWNSHIP
S3-0631A-16

PROFILE VIEW



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 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ. LENGTH (L): 5160'
HDD PIPE LENGTH (S): 5188'
16" x 0.438" W.T., X-70, API5L, 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).
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 - 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.

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REF. DRAWING

ES-6.28	TO	ES-6.29	EROSION & SEDIMENT PLAN
SHEET 17	TO	SHEET 19	AERIAL SITE PLAN

REVISIONS

EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/23/16	RMB	03/23/16	AAW	03/23/16
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

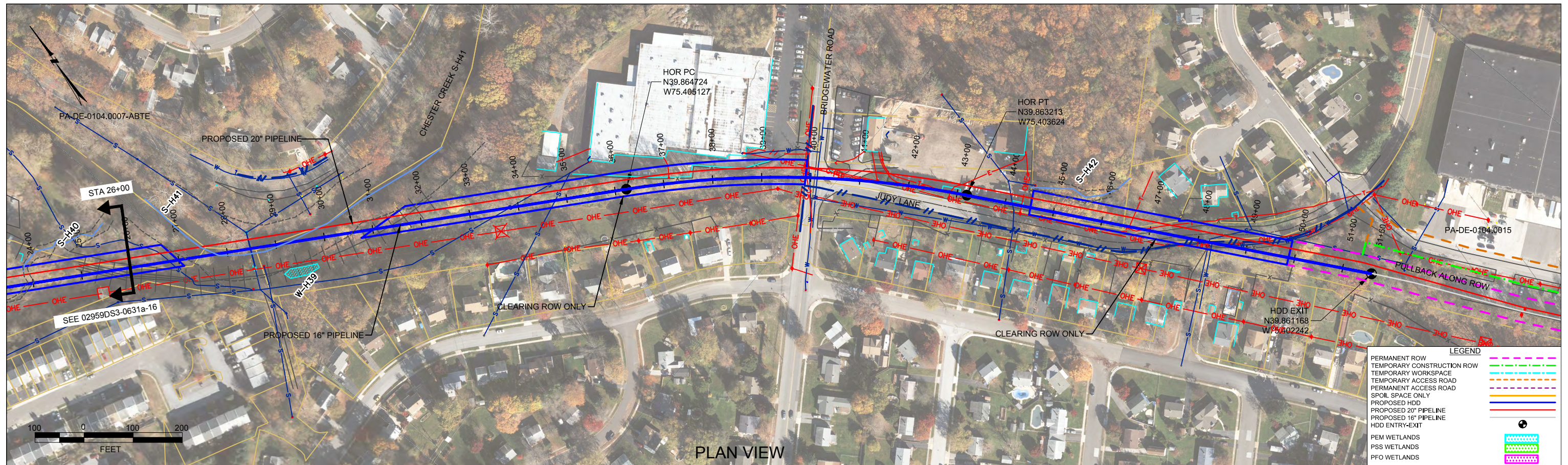
Sunoco Logistics Partners L.P.

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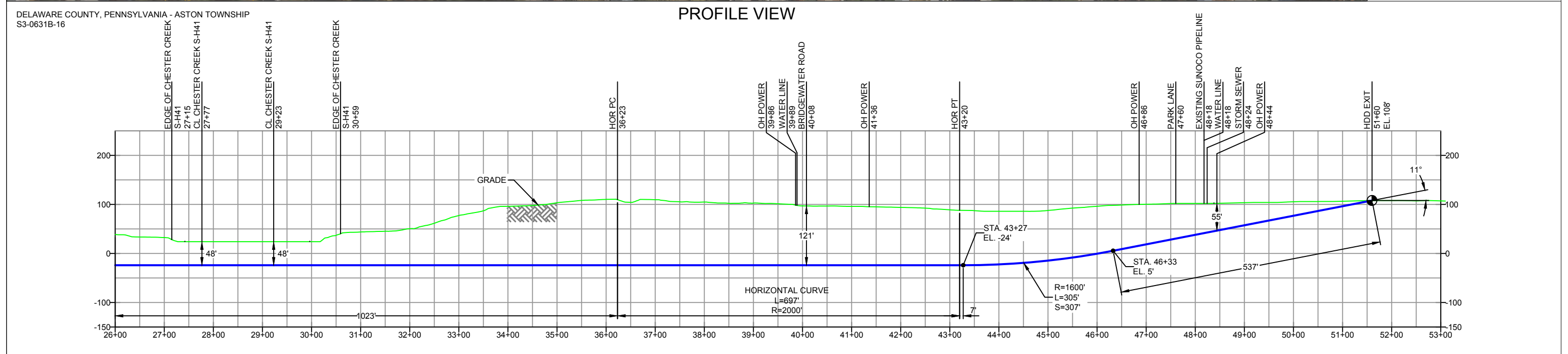
SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
CHESTER CREEK
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO: PA-DE-0104.0008-WXa-16



PLAN VIEW



PROFILE VIEW

DELAWARE COUNTY, PENNSYLVANIA - ASTON TOWNSHIP
S3-0631B-16

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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	
ES-6.28	TO ES-6.29 EROSION & SEDIMENT PLAN
SHEET 17	TO SHEET 19 AERIAL SITE PLAN

REVISIONS	
EP1	REVISED PER PADEP COMMENTS
EP	
A	ISSUED FOR BID

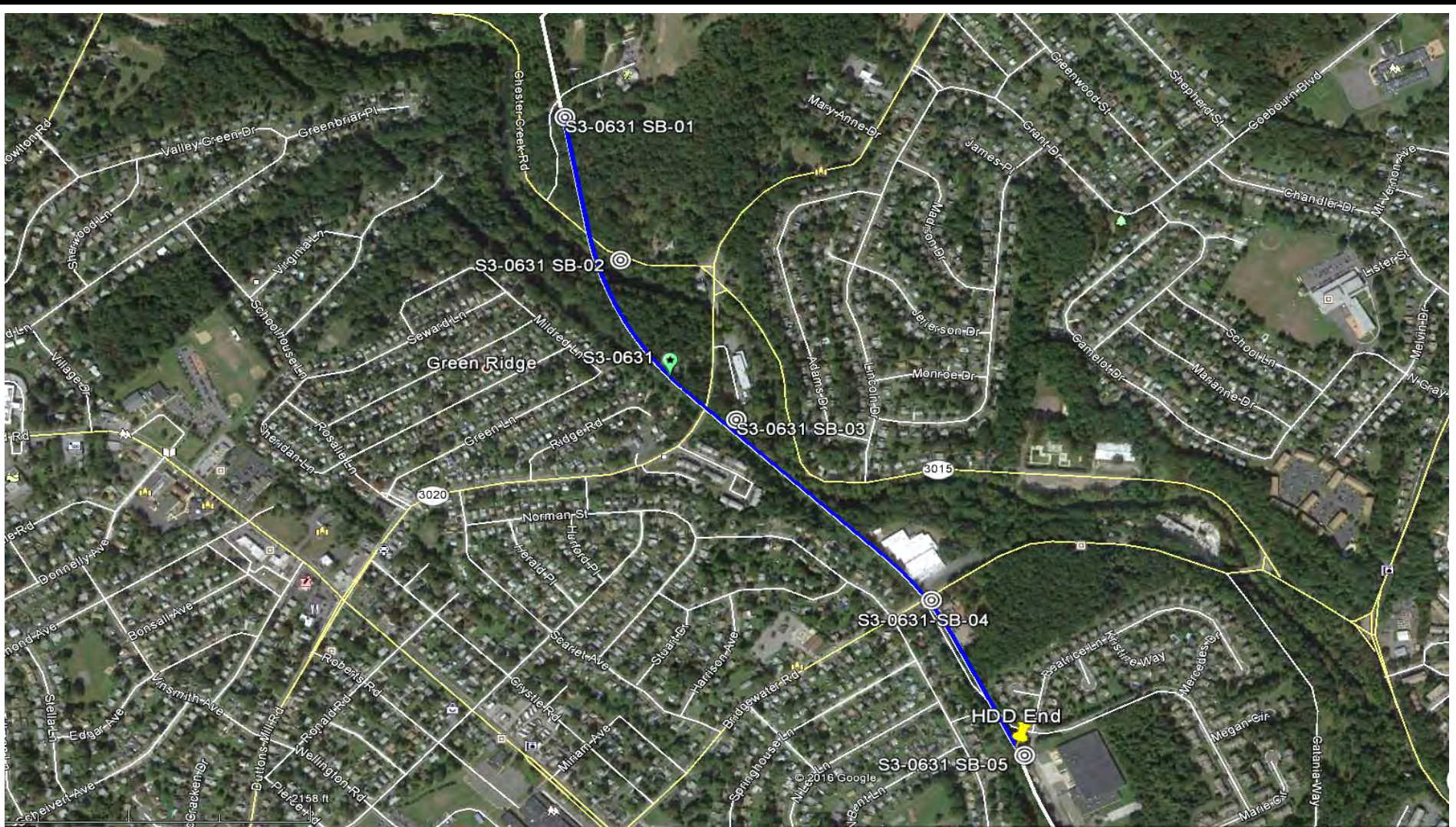
Sunoco Logistics Partners L.P.

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SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
CHESTER CREEK
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO: PA-DE-0104.0008-WXb-16



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S3-0631
 DELAWARE COUNTY, ASTON 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: DELAWARE COUNTY FIELD AND STREAM ASSOCIATION, ASTON, PA			Page 1 of 1		
HDD No.: S3-0631		Dates(s) Drilled: 05-24-16		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): 30.0	
Boring Location Coordinates:			39°52'21.89"N		75°24'42.73"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		24	SM	DR, BROWN MICACEOUS FINE TO MEDIUM SAND WITH SOME SILT.	3	4	4	5	8	
							(USCS: SM)						
2	8.0	10.0			24		DR, BROWN MICACEOUS FINE TO MEDIUM SAND WITH SOME SILT,	2	12	18	28	30	
							TRACE UNWEATEHRED GNEISS GRAVEL.						
3	13.0	14.2			12		SAME	12	50	50/2"		>50	
4	18.0	20.0			21	SAME (USCS: SM).	5	12	20	18	32		
				22.5									
5	23.0	23.3	22.5		4	PARTIALLY WEATHERED GNEISS	PARTIALLY WEATHERED GNEISS (WEATHERED TO FINE TO MEDIUM SAND AND F-C UNWEATHERED GRAVEL)	50/4"				>50	
							SAND AND F-C UNWEATHERED GRAVEL)						
6	28.0	28.2		30.0	3		SAME	50/3"				>50	
							AUGERED TO 30'.						
							BORING WAS MOVED 25' SOUTH TO AVOID UNDERGROUND UTILITIES.						
							AUGERS STARTED GRINDING AT 22.5'.						
							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.



TETRA TECH

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 Newark, Delaware 19713
 302.738.7551
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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT	Project No.:	103IP3406
Project Location:	1601 DUTTONS MILL ROAD, ASTON, PA	Page 1 of 1	
HDD No.:	S3-0631	Dates(s) Drilled:	01-25-16
Boring No.:	SB-03	Inspector:	J. COSTELLO
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	E. ODGEN
		Groundwater Depth (ft):	30.0
		Total Depth (ft):	41.5
Boring Location Coordinates:	39° 52' 2.05" N	75° 24' 29.61" 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	1.0			GRAVEL						
1	3.0	5.0	1.0		12	SM	DR, VARIEGATED BROWN MICACEOUS FINE TO MEDIUM SAND, SOME SILT.	1	3	4	6	7	
2	8.0	10.0			13		DR, BROWN AND GRAY MICACEOUS FINE SAND WITH A LITTLE SILT, GRAVELLY LENSE FROM 9 TO 9.5'.	1	3	12	13	15	
3	13.0	15.0			19		DR, BROWN MICACEOUS FINE TO COARSE SAND, A LITTLE SILT, WITH SOME FINE TO COARSE QUARTZ GRAVEL.	2	16	38	44	54	
4	18.0	20.0			16		DR, VARIEGATED BROWN MICACEOUS FINE TO MEDIUM SAND, SOME SILT, TRACE FINE GRAVEL.	1	3	6	5	9	
5	23.0	24.5			9		DR, VARIEGATED BROWN AND GRAY FINE TO MEDIUM SAND, SOME SILT, SOME UNWEATHERED F-C GNEISS GRAVEL (USCS: SM).	3	9	50		59	
				24.0									
6	28.0	28.3	24.0		2		PARTIALLY WEATHERED GNEISS	BROWN AND GRAY WEATHERED TO PARTIALLY WEATHERED GNEISS.	50/3"				>50
7	33.0	33.3		34.0	3		PARTIALLY WEATHERED GNEISS	SAME	50/3"				>50
							AUGER REFUSAL AT 34'.						
							<u>ROCK CORING</u>						
RUN 1	34.0	35.5	34.0		17	MAFIC GNEISS	WHITE AND GRAY INTENSELY FRACTURED MAFIC GNEISS	TCR: 94%, SCR: 55%, RQD: 22%					
RUN 2	35.5	40.5			60	MAFIC GNEISS	WHITE AND GRAY MODERATELY FRACTURED MAFIC GNEISS	TCR: 100%, SCR: 82%, RQD: 70%					
RUN 3	40.5	41.5		41.5	12	MAFIC GNEISS	WHITE AND GRAY INTENSELY FRACTURED MAFIC GNEISS	TCR: 100%, SCR: 62%, RQD: 37%					
							AUGER GRINDING STARTING AT 24'.						
							WET ON SPOON AT 30'.						
							WATER LEVEL THROUGH AUGERS AT 32'.						
							CAVED AT 32'.						
							<u>CORE TESTING RESULTS (DEPTH 37.5-38'):</u>						
							COMPRESSIVE STRENGTH: 3,375 PSI						
							UNIT WEIGHT: 168.5 PCF						
							<u>CORE TESTING RESULTS (DEPTH 38-38.5'):</u>						
							COMPRESSIVE STRENGTH: 11,268 PSI						
							UNIT WEIGHT: 168.0 PCF						

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.



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 Newark, Delaware 19713
 302.738.7551
 fax: 302.454.5988

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT	Project No.:	103IP3406
Project Location:	RICK'S TREE SERVICE, ASTON, PA	Page 1 of 1	
HDD No.:	S3-0631	Dates(s) Drilled:	10-10-15
Boring No.:	SB-04	Inspector:	J. COSTELLO
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	E. ODGEN
		Groundwater Depth (ft):	NOT ENCOUNTERED
		Total Depth (ft):	26.0
Boring Location Coordinates:	39°51'50.16"N	75°24'14.49"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		13	SM	DR, VARIEGATED GRAY, WHITE, BROWN, FINE TO MEDIUM SAND WITH A LITTLE SILT, TRACE F-C UNWEATHERED GRAVEL.	2	5	5	7	10	
2	8.0	10.0			24		SAME. MICACEOUS.	2	19	21	50	40	
3	13.0	14.4			15		DR, VARIEGATED GRAY, WHITE, BROWN, FINE TO MEDIUM SAND WITH A LITTLE SILT, TR. MICA, A LITTLE F-C UNWEATHERED GRAVEL.	2	25	50/5"		>50	
4	18.0	18.9			10		DR, VARIEGATED GRAY, WHITE, BROWN, FINE TO MEDIUM SAND WITH SOME SILT, TR. MICA, A LITTLE F-C UNWEATHERED GRAVEL. (SM).	5	50/5"			>50	
5	22.5	23.0	20.0	23.0	2		WEATHERED TO PARTIALLY WEATHERED GNEISS.	50/6"				>50	
							AUGER GRINDING AT 20'.						
							AUGER REFUSAL AT 22.5'.						
							<u>ROCK CORING</u>						
RUN 1	23.0	26.0	23.0		18		WHITE AND GRAY MAFIC GNEISS, WITH DECOMPOSED ZONES.	TCR: 50%, SCR: 50%, RQD: 23%					
							AT 26', MATERIAL TURNED TO DECOPOSED ROCK MATERIAL.						
							<u>CORE TESTING RESULTS (DEPTH 23.5-24')</u> :						
							COMPRESSIVE STRENGTH: 5,320 PSI						
							UNIT WEIGHT: 162.6 PCF						
							CAVED AND DRY AT 22.5'.						

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.

**ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0631**

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					
S3-0631	SB-3	1	34	35.5	94	55	22	34	41.5	Slight	Mafic Gneiss	Massive	White/gray	Strongly foliated; fractures oriented along foliation, approx. 33°
		2	35.5	40.5	100	82	70							
		3	40.5	41.5	100	62	37							
	SB-4	1	23	26	50	50	23	23	26	Slight	Mafic Gneiss	Massive	White/gray	Nearly quartzite; Fractures ranging from 2° to 16°, Avg. 8°

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0631

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, %	
S3-0631	SB-01	1	3.0	5.0	11.4	25.2	NV	NP	NP	SM
		2	8.0	10.0	6.9	22.1	-	-	-	-
		3	13.0	14.2	5.7	23.5	-	-	-	-
		4	18.0	20.0	9.1	24.5	NV	NP	NP	SM
		5	23.0	23.3	5.4	11.5	-	-	-	-
		6	28.0	28.2	11.4	26.6	-	-	-	-
	SB-02	1	3.0	5.0	22.2	20.6	-	-	-	-
		2	8.0	10.0	14.0	19.9	-	-	-	-
		3	13.0	14.3	9.6	39.2	32	25	7	SM
	SB-03	1	3.0	5.0	8.6	24.3	-	-	-	-
		3	13.0	15.0	4.1	14.8	-	-	-	-
		4	18.0	20.0	19.0	25.0	NV	NP	NP	SM
		5	23.0	24.5	10.2	21.5	-	-	-	-
	SB-04	6	28.0	28.3	6.8	23.9	-	-	-	-
		1	3.0	5.0	16.0	17.3	-	-	-	-
		2	8.0	10.0	11.0	12.3	-	-	-	-
		3	13.0	14.4	7.5	11.9	-	-	-	-
		4	18.0	18.9	10.9	27.0	NV	NP	NP	SM
	5	22.5	23.0	7.7	20.9	-	-	-	-	
	SB-05	1	3.0	5.0	20.0	78.9	42	21	21	CL
		2	8.0	10.0	14.9	31.8	-	-	-	-
		3	13.0	15.0	19.3	26.2	-	-	-	-
		4	18.0	20.0	22.1	43.1	38	27	11	SM
		6	28.0	28.8	6.8	39.9	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-03	2	37.5 - 38.0	3,375	168.5
	2	38.0-38.5	11,268	168.0
SB-04	1	23.5 - 24.0	5,320	162.6

Notes:

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

**REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0631**

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
S3-0631	SB-01	Wissahickon Formation - Includes oligoclase-mica schist, some hornblende gneiss, some augen gneiss, and some quartz-rich and feldspar-rich members due to various degrees of granitization.	Gently sloping to the west	Wissahickon Formation	Mica schist; secondary: mafic gneiss; other types: augen gneiss, granitoid	No information found during literature review	Ranges from 20 to 38 ft bgs, Avg. 27 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 Slate (Geology of Pennsylvania SP-1, 1999). Drilling in these formations generally difficult to very difficult except where fractures and weathered exposed zones present.
	SB-02		Gently to moderately sloping to the south					
	SB-03		Generally level					
	SB-04	Mafic gneiss - Dark, medium grained; includes rocks of probable sedimentary origin; may be equivalent to pCAMgh in places.	Gently sloping to the south	Mafic gneiss (Probably lower Paleozoic)	Mafic gneiss; Secondary - paragneiss			
	SB-05	Pensauken and Bridgeton Formations , undifferentiated - Dark-reddish-brown, cross-stratified, feldspathic quartz sand and some thin beds of fine gravel and rare layers of clay or silt.	Gently sloping to the west	Pensauken and Bridgeton Formations, undifferentiated	Sand; Secondary gravel; Other - clay or mud, silt			

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

RQD: Rock Quality Designation

TCR: Total Core Recovery

SCR: Solid Core Recovery

***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.