

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
BULRUSH CROSSING
PADEP SECTION 105 PERMIT NO.: E11-352
PA-CA-0091.0016-RD-16
(SPLP HDD# S2-0100-16)**

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This reevaluation of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline that traverses exceptional value wetlands and a waterbody in Cresson Township, Cambria County, Pennsylvania is in accordance with Condition No. 3 of the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L. Condition No. 3 stipulates, for HDDs initiated after the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board on July 25, 2017, a reanalysis must be performed on HDDs for which an inadvertent return (IR) occurs during the installation of one pipe (20-inch or 16-inch diameter) where a second pipe will thereafter be installed in the same right-of-way (ROW).

The 20-inch HDD was initiated after July 25, 2017 and an IR occurred during its installation, thereby necessitating a reanalysis before the installation of the second pipe (16-inch) could commence. There was one additional IR during the installation of the 20 inch pipe. The installation of the 20-inch pipe is complete.

The 16-inch pipe HDD is referred to herein as HDD S2-0100.

PIPE INFORMATION

16-Inch: 0.438 wall thickness; X-70

Pipe stress allowances are an integral part of the design calculations performed for each HDD.

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,684 feet (ft)
- Entry/Exit angle: 8 degrees
- Maximum depth of cover: 45 ft
- Maximum depth of cover under wetland M59: 40 ft
- Maximum depth of cover under wetland L62: 25 ft
- Pipe design radius: 1,600 ft

ROOT CAUSE ANALYSIS FOR THE 20-INCH PIPE INSTALLATION IR

The occurrence of the IR events during the installation of the 20-inch pipe under wetland M59 is likely to have resulted from the shallow depth of overburden over the profile on the western end of the HDD as the pilot hole drilling motor was rising to the western exit point. Bedrock fractures may have contributed to IRs as fracture traces have been mapped crossing the northwestern part of the profile.

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

HDD S2-0100-16 is located within the Allegheny Front Section of the Appalachian Plateaus Province, which is characterized by rounded to linear hills cut by narrow valleys that rise in a stepwise manner, northwest and north to the Plateaus escarpment. Most of the bedrock underlying the area of HDD S2-0100-16 belongs to the Pennsylvanian age Pottsville Formation. The Pottsville Formation consists mainly of medium-grained to conglomeratic sandstone beds (ranging in thickness from about 10 to 70 feet), with minor amounts of siltstone, claystone, shale, thin discontinuous coals, and two marine limestones. Mining of coal in the Pottsville is limited. The formation contains resistant sandstone rock units that tend to

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underlie local ridges. The northwestern end of the revised alignment lies within the Allegheny Formation that is above the Pottsville Formation in stratigraphic sequence. The Allegheny Formation is composed primarily of cyclic sequences of clay shale, claystone, siltstone, sandstone, limestone, and coal. The sandstones are fine to medium grained, sometimes conglomeratic, lenticular fluvial channel deposits that average 10 to 30 feet in thickness. Northwest of the alignment, the formation contains economically significant coal beds (the Upper and Lower Freeport coals, the Upper, Middle, and Lower Kittanning coals, the Clarion coal, and the Brookville coal).

Karst geology is not present at this HDD location; therefore, the use of geophysics assessments was considered but not conducted because the results from these types of assessments would provide no data to assist in the redesign of this HDD.

Attachment 1 provides an extensive discussion on the geology, and results of geotechnical investigations performed at this location.

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater in the Pottsville and Allegheny Formations is stored and moves through an interconnected network of joints, fractures, and bedding plane openings. Water tables in the area of the HDD can be high therefore there is likely some groundwater storage and movement within the soils and weathered bedrock near the surface. Construction activities for the 20-inch line were suspended after completion of the pilot boring in October 2017. When preparations were being made to resume drilling in the spring of 2018, the groundwater discharge was discovered from the northwestern exit point. This discharge was created by the same pressure head difference that creates the local wetlands. Water table highs in the uplands to northwest, east, and south create an upward head on the water table in the local lowland across which the HDD S2-0100 drills area located. Local groundwater discharges and surface water runoff support the wetlands and form the headwater tributary that flows to the Lilly Reservoirs to the southwest. Near vertical zones of fracture concentration manifested as fracture traces mapped along the northwest end of the revised HDD S2-0100-16 profile could provide preferred pathways for upward groundwater flow in this setting.

Published data for the Pottsville Group indicate well yields of approximately 15 gpm. Allegheny Group well yields range from 0 to 180 gpm with a median of 12 gpm. There are no records of wells within one mile of HDD S2-0100-16 according in the Pennsylvania Groundwater Information System (PaGWIS). Groundwater was encountered in the two Tetra Tech soil geotechnical borings, SB-02 and SB-03, at 5 and 6 ft bgs, respectively. The drilling fluid level at the completion of two deeper bedrock Intertek PSI borings was at the surface for B-01 and 16 ft bgs for B-02.

SPLP performed a survey of land owners within 450 feet of the ROW for the revised profile and no land owners responded positively to an offer to have their wells tested. The PaGWIS database reports no water supply wells within 450 feet of the ROW.

Attachment 1 provides an extensive discussion on the hydrogeology and results of the geotechnical investigation performed at this location.

INADVERTENT RETURN (IR) DISCUSSION

During the 20-inch pilot hole phase, IRs appeared at two locations south of the alignment as the drilling motor was rising towards the exit at the northwest end of the profile. The locations of the IRs are indicated on Figures 1 and 2 in Attachment 2.

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A detailed discussion of these IRs is provided in the Hydrogeologic Report provided in Attachment 1.

ADJACENT FEATURES ANALYSIS

HDD S2-0100-16 is located approximately 1.2 mi southeast of the intersection of Eger Road and Zoskey Road, in Washington Township, Cambria County, approximately 3.5 miles (mi) southeast of the community of Cresson, and 9.5 mi west of Hollidaysburg, Pennsylvania. This HDD crosses two exceptional value wetlands (M59 and L62) and one exceptional value waterbody (S-M81).

S-M81 is designated as a coldwater fishery under Pennsylvania Code Chapter 93, as a stream that is tributary to a stream with naturally-reproducing trout populations. Wetlands L62 and M59 are designated as exceptional value wetlands due to the presence of the federally-endangered northeastern bulrush (*Scirpus ancistrochaetus*), and for being within the floodplain of a stream tributary to a wild trout fishery. Wetland L62 has multiple components, with vegetation classes of emergent and forested. Wetland M59 is an emergent, scrub-shrub, and forested wetland. This HDD avoids surficial impacts to stream S-M81, wetlands L62 and M59, and surficial impacts to the floodway of stream S-M81, forested and scrub-shrub wetlands, forested woodlands, threatened and endangered species habitat (i.e., bulrush and bat swarming block), and state game lands.

SPLP's public outreach results indicated there are zero (0) water wells within 450 ft of the proposed HDD. There are zero (0) public water supplies within a one-half (0.5) mile radius.

ALTERNATIVES ANALYSIS

This HDD, is part of a larger reroute alternative referred to as the Cresson-Altoona Southern Bypass and is discussed in Section 3.3 of the Project Alternatives Analysis. The Cresson-Altoona Southern Bypass avoids the heavily developed City of Altoona, the National Register of Historic Places (NRHP)-listed Allegheny Portage Railroad National Historic Site, and the National Historic Landmark (NHL) District - Allegheny Portage Railroad of the Penn Canal (Key 123985). This major re-route alternative is co-located with existing utility corridors for the majority of its length. Following selection of this major re-route, SPLP implemented the Management of Change (MOC) process which resulted in the adoption of several minor route variations, including HDD S2-0100, to avoid and minimize impacts to environmental resources.

During the PADEP Chapter 105 permit process, SPLP created and submitted for review a project-wide alternatives analysis. The baseline route provided for the pipeline construction to cross every wetland and stream on the project by open trench construction procedures. The alternatives analysis submitted to PADEP conceptually analyzed the feasibility of any alternative to trenched resource crossings (e.g., reroute, bore, HDD). The decision-making processes for determining the proposed crossing route and method are discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. Where HDDs received PADEP Chapter 105 and 102 authorizations, they have already been evaluated to be the most practicable alternative that avoids and minimizes impacts to the waters of the Commonwealth and the environment in general.

This HDD avoids surface impacts that if an open cut method was utilized would directly affect: 21 square feet of state water bottoms; 0.86 acre of floodway; 1.47 acres of exceptional value wetlands, including 0.75 acre of forested wetland conversion; 2.66 acres of forested woodlands; and 0.80 acre of state game lands.

A conventional auger bore is a practical means of pipeline installation that can avoid the occurrence of IRs. However, conventional auger bore installation is constrained by topography, substrate type and

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variability, shallow groundwater, and is restricted to lengths that are ideally less than 200 ft. To avoid the surface impacts to aquatic resources as described above, the horizontal length of two of the forested wetland crossings are greater than 300 feet, which is beyond the technically practicable limits of an auger bore to complete regardless of substrate conditions.

A direct pipe installation is also a practical means of pipeline installation that can avoid the occurrence of IRs. However, a direct pipe installation bore installation is limited to 750 ft in extent, and this is well under the total length of regulated and protected resources at this HDD location.

HORIZONTAL DIRECTIONAL DRILL REDESIGN

Additional geologic investigation has been completed, and the “as built” record for the 20-inch pipeline has been utilized in the redesign of the planned 16-inch HDD. The redesign adjusts the HDD profile deeper to minimize the risk of drilling fluid loss, drilling difficulties, and IRs. A summary of the redesign factors is provided below. The original and redesigned 16-inch HDD plan and profile drawings are provided in Attachment 2.

Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 1,900 ft
- Entry/Exit angle: 14 - 16
- Maximum Depth of cover: 107 ft
- Depth of cover under wetland M59: 63 - 107 ft
- Maximum depth of cover under wetland L62: 47 - 60 ft
- Pipe design radius: 1,800 – 2,000 ft

CONCLUSION

Based on the original and revised profiles for HDD S2-0100-16, the revised profile is lengthened by 216 ft, the depth of profile increased by 62 ft, and the entry/exit angles were increased by 6 to 8 degrees allowing the drill to quickly enter into and exit out of bedrock and minimize parts of the profile at the exit and entrance where overburden is thin. The revised HDD profile greatly reduces the risk of creating IRs.

Procedures established and documented in SPLP’s revised IR Assessment, Preparedness, Prevention, and Contingency (PPC) Plan (April 2018 plan) across all ME II spreads have proven to be very effective in eliminating IRs and minimizing the extent of IRs. For this HDD, measures may be required to control groundwater produced by drilling activities in the northwest part of the drill.

The redesign of the HDD will not prevent all IRs. IR’s are common on entry and exit of the drilling tool and other measures are required to minimize IR potential. In particular, upon the start of this HDD, SPLP will employ the following HDD best management practices:

- SPLP will provide the drilling crew and company inspectors the location(s) data on potential zones of higher risk for fluid loss and IRs, including the area related to previous IRs, and potential zones of fracture concentration identified by the fracture trace analysis, so that monitoring can be enhanced when drilling through these locations.
- SPLP will require and enforce the use of annular pressure (AP) monitoring during the drilling of the pilot holes, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus to manage development of pressures that can induce an IR;

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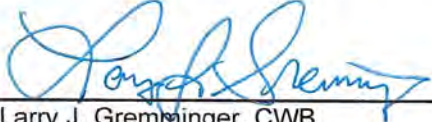
- SPLP inspectors will ensure that an appropriate diameter pilot tool, relative to the diameter of the drilling pipe, is used to ensure adequate “annulus spacing” around the drilling pipe exits to allow good return flows during the pilot drilling;
- SPLP will implement short-tripping of the reaming tools as return flow monitoring indicates to ensure an open annulus is maintained to manage the potential inducement of IRs;
- SPLP will require monitoring of the drilling fluid viscosity, such that fissures and fractures in the subsurface are sealed during the drilling process;
- During all drilling phases, the use of Loss Control Materials (LCMs) will be implemented if indications of a potential IR are noted or an IR is observed. The use of LCMs, however, is less effective below 70 ft of the ground surface. The AP below that depth can exceed the effective stabilization capability of LCMs. Accordingly, the preferred corrective action needed to address the presence of fractures or unstable geology at greater depths below ground will require grouting of the HDD annulus. Two types of grouting will be utilized for corrective actions to seal fractures and stabilize zones of weak geology. These are: 1) grouting using “neat cement”; and 2) grouting using a sand/cement mix. Neat cement grout is a slurry of Portland cement and water. The sand/cement grout mix is a slurry of mostly sand with a small percentage of Portland cement and activators that after setup results in a material having the competency of a friable sandstone or mortar. Both grouting actions require tripping out the drilling tool, and then tripping in with an open-ended drill stem to apply or inject the grout mixes.

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FEASIBILITY DETERMINATION


Based on the information reviewed by the Geotechnical Evaluation Leader, Professional Geologists, Professional Engineers, and HDD specialists, the HDD Reevaluation Team's opinion is that the proposed HDD design and implementation of the management measures contained within this re-evaluation report will minimize the risk of IRs and impacts to public and private water supplies during the construction phases of the HDD.

Pertaining to Horizontal Directional Drilling Practices and Procedures; Conventional Construction; Alternatives; and Environmental Effects

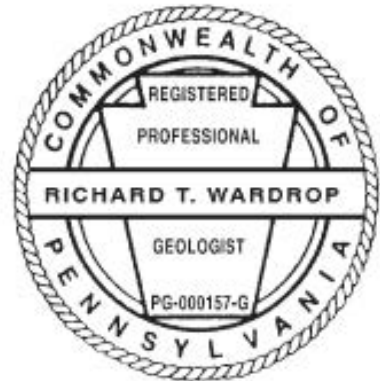

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Geotechnical Evaluation Leader
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2/2/2019
Date

Pertaining to the practice of geology


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Date



Pertaining to the pipeline stress and HDD geometry


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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT



HDD HYDROGEOLOGIC REEVALUATION REPORT

**Mariner East II
Spread 2
HDD S2-0100-16
Wetland (Bulrush)
Juniata & Washington Township, Cambria County, Pennsylvania**

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

**Groundwater & Environmental Services, Inc.
440 Creamery Way, Suite 500
Exton, Pennsylvania 19341**

February 2019



HDD HYDROGEOLOGIC REEVALUATION REPORT

**Mariner East II
Spread 2
HDD S2-0100-16
Wetland (Bulrush)
Juniata & Washington Township, Cambria County, Pennsylvania**

February 2019

Prepared for:

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Reviewed by:

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Principal Geologist

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By affixing my seal to this document, I am certifying that the geologic and hydrogeologic information is true and correct. I further certify I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information.



February 1, 2019



Richard T. Wardrop, P. G.

date

Lic. No. PG000157G

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ATTACHMENTS

- Attachment A. Original and Revised Plan and Profile
- Attachment B. Geotechnical Reports

1.0 INTRODUCTION

Sunoco Pipeline, L.P., (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare HDD Hydrogeologic Reevaluation Reports (HRRs) for horizontal directional drills (HDDs) listed on Exhibit 2 of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017. This report discusses the hydrogeologic reevaluation for HDD S2-0100-16 (the 16-inch HDD for this location). The planned alignment for HDD S2-0100-16 is in Wetland (Bulrush), Juniata & Washington Township, Cambria County, approximately 1.34 miles northeast of the intersection of Mountain Road and Sand Springs Road and within State Games Lands 198. The discussion presented in this report is based on an alignment and profile for HDD S2-0100-16 developed by Tetra Tech/Rooney, revised on October 7, 2016 (permitted profile), and a revised profile developed by Tetra Tech Rooney dated January 16, 2019. (see Attachment A). The revised boring profile was developed to increase the depth of the borehole by extending the northwest entry/exit points and making the profile longer. The purpose is to minimize the risk of inadvertent returns (IRs) by installing the pipes deeper into competent bedrock.

A map depicting the location of the HDD with topographic information for the surrounding area is presented as Figure 1.

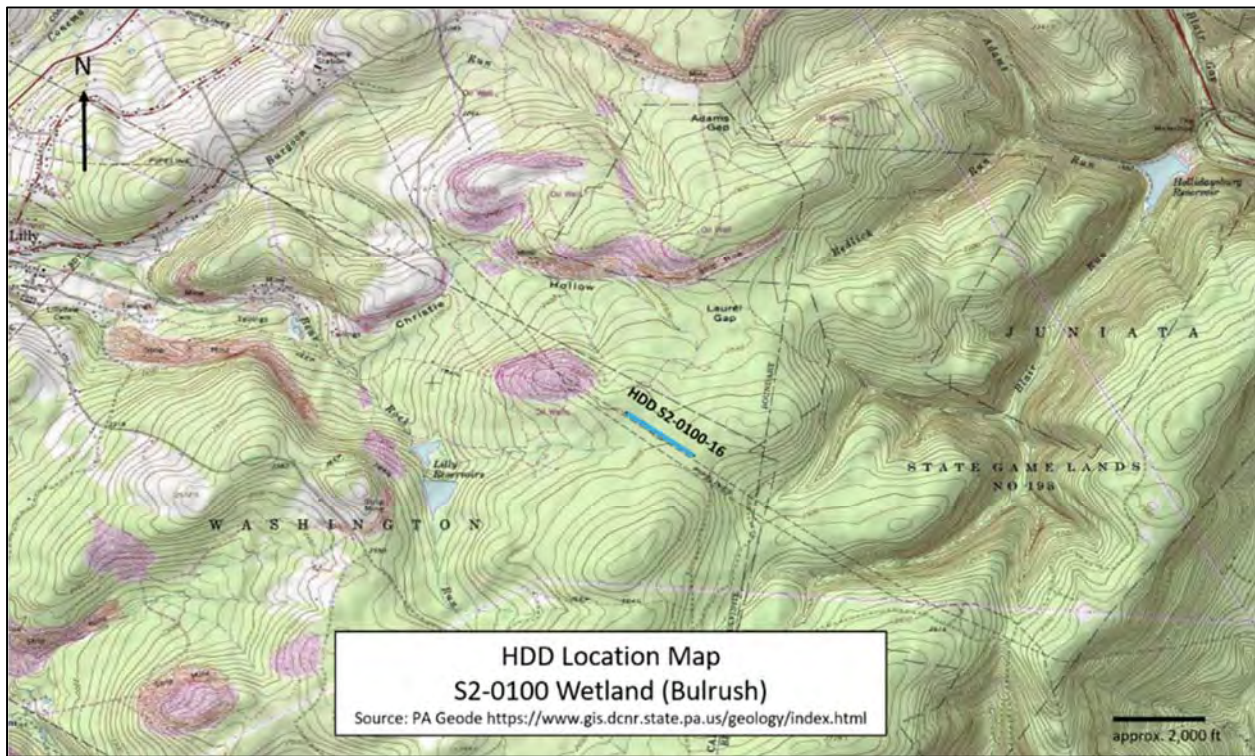


Figure 1. Site Location Map (modified from PA GEODE)

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of HDD S2-0100-16;
- Summaries of studies performed pertinent to reevaluation, including fracture trace analysis and geotechnical borings;
- A site conceptual model; and
- A reevaluation summary with conclusions.



The contents of this report were developed from interpretation of published information, field observations, and related field studies. Site geotechnical boring programs were conducted by Tetra Tech in March 2017 and by Intertek PSI in December 2018 and January 2019 (see Attachment B). Please note that GES did not oversee or direct geotechnical drilling program, including, but not limited to, the selection of number and location of borings, determination of surface elevations, target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical report, boring logs, and any core photographs that resulted from these programs were generated by the SPLP contractors. GES relied on these reports and incorporated the data into the general geologic and hydrogeologic framework for this hydrogeologic reevaluation report.

2.0 HDD GEOLOGY / HYDROGEOLOGY

2.1 Physiography

HDD S2-0100-16 is located within the Allegheny Front Section of the Appalachian Plateaus Province, which is characterized by rounded to linear hills cut by narrow valleys that rise in a stepwise manner, northwest and north to the Plateaus escarpment. The area surrounding the HDD is comprised of undeveloped forested land, with the exception of several wind turbine sites, approximately one mile north and south of the HDD S2-0100-16 alignment.

2.1.1 Topography

The elevation along HDD S2-0100-16 decreases along a gentle slope downward from southeast to northwest. The designed profile for the original 16-inch line is approximately 1,684 feet long, horizontally. The surface elevation at the northwestern entry/exit is 2,593 ft amsl and at the southeastern entry/exit location is 2,614 ft amsl. The revised profile relocates the northwestern entry/exit approximately 216 feet to the northwest. This extends the overall horizontal distance for the 16-inch HDD to 1,900 feet and raises the northwestern entry/exit point six feet to elevation 2,599 ft amsl.

2.1.2 Hydrology

The nearest surface water body to the HDD location are the three wetland complexes (W-M59, W-L62, W-and L67) underlain by HDD S2-0100-16. These wetlands feed an unnamed perennial tributary that flows southwest to the nearest surface water body, the Lilly Reservoirs along Bear Rock Run, located approximately 0.8 miles to the southwest of HDD S2-0100-16. No streams are identified crossing the HDD S2-0100-16 profile.

2.2 Geology

2.2.1 Soils

Based on information obtained from the National Resource Conservation Service Web Soil Survey database (USDA NRCS Web Soil Survey for Cambria County), soils along HDD S2-0100-16 are generally comprised of very stoney, sand, silt, and clay loams. These soils are poorly to well-drained and the local water table is typical 0 to 18 inches from surface. The Letonia very stoney loamy sand on 3 to 8 percent slope (LtB) occupies approximately 25 percent of the southeastern portion of the HDD profile for which the water table is reported to be greater than 80 inches from surface. The top of bedrock as reported for these soils is from 4.7 to 7.5 feet below ground surface (ft bgs).

2.2.2 Bedrock Lithology

PAGEODE shows the bedrock underlying the revised alignment as the Allegheny and Pottsville Formations. Other, mostly older references refer to these units as Groups. Most of the bedrock underlying the area of HDD S2-0100-16 belongs to the Pennsylvanian age Pottsville Formation. The Pottsville Formation consists mainly of medium-grained to conglomeratic sandstone beds (ranging in thickness from about 10 to 70 feet), with minor amounts of siltstone, claystone, shale, thin discontinuous coals, and two marine limestones. Mining of coal in the Pottsville is limited. The formation contains resistant sandstone rock units that tend to underlie local ridges. Total thickness of the Pottsville Formation ranges from about 20 to 275 feet (Greenberger and others, 2001; McElroy, 2001). Figure 2 is a map depicting site bedrock geology for the area surrounding HDD S2-0100-16 (McElroy, 1998).

The northwestern end of the revised alignment lies within the Allegheny Formation that is above the Pottsville Formation in stratigraphic sequence. The Allegheny Formation is composed primarily of cyclic sequences of clay shale, claystone, siltstone, sandstone, limestone, and coal. Northwest of the alignment, the formation contains economically significant coal beds (the Upper and Lower Freeport coals, the

Upper, Middle, and Lower Kittanning coals, the Clarion coal, and the Brookville coal). The sandstones are fine to medium grained, sometimes conglomeratic, lenticular fluvial channel deposits that average 10 to 30 feet in thickness. The Allegheny Formation ranges from about 280 to 320 feet in thickness (McElroy, 2001).

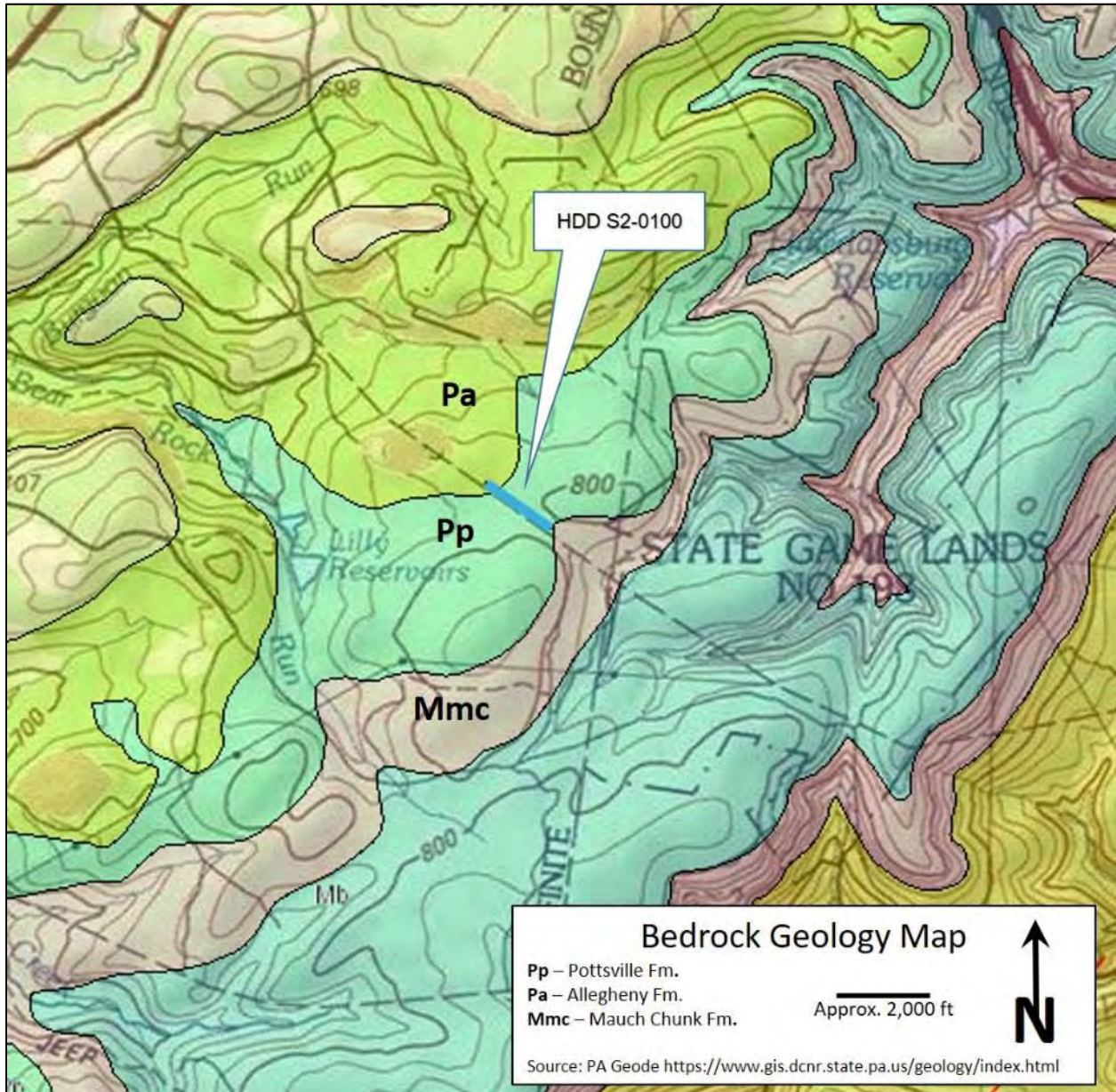


Figure 2. Bedrock Geology (modified from McElroy, 1998)

2.2.3 Structure

Glover (1990) provides structure contour maps for persistent coal beds in Cambria County. Using this resource and structure contours mapped for the Lower Kittanning coal, HDD S2-0100-16 is located topographically below the Lower Kittanning coal. The Lower Kittanning coal will not intersect the HDD S2-0100-16 profile. Only the Brookville coal is mapped in the northwestern part of the revised HDD S2-0100-16 profile. Figure 3 shows the HDD S2-0100-16 location on the structure contour map. The HDD

is located approximately 6.3 miles southeast of the axis of the Wilmore Syncline and approximately 3.2 miles northwest of the axis of the Pavia Anticline and bedding dips gently to the northwest.

Discontinuities in the form of joints, fractures, faults and bedding plane partings are imprinted in the broadly folded bedrock in the region. These features can act as conduits for groundwater movement and/or represent areas of weakness in the rock. Fold axes can be areas of increased density of fracturing (McElroy, 1998). Nickelsen and Hough (1967) conducted regional mapping of joints in shale, coal, and

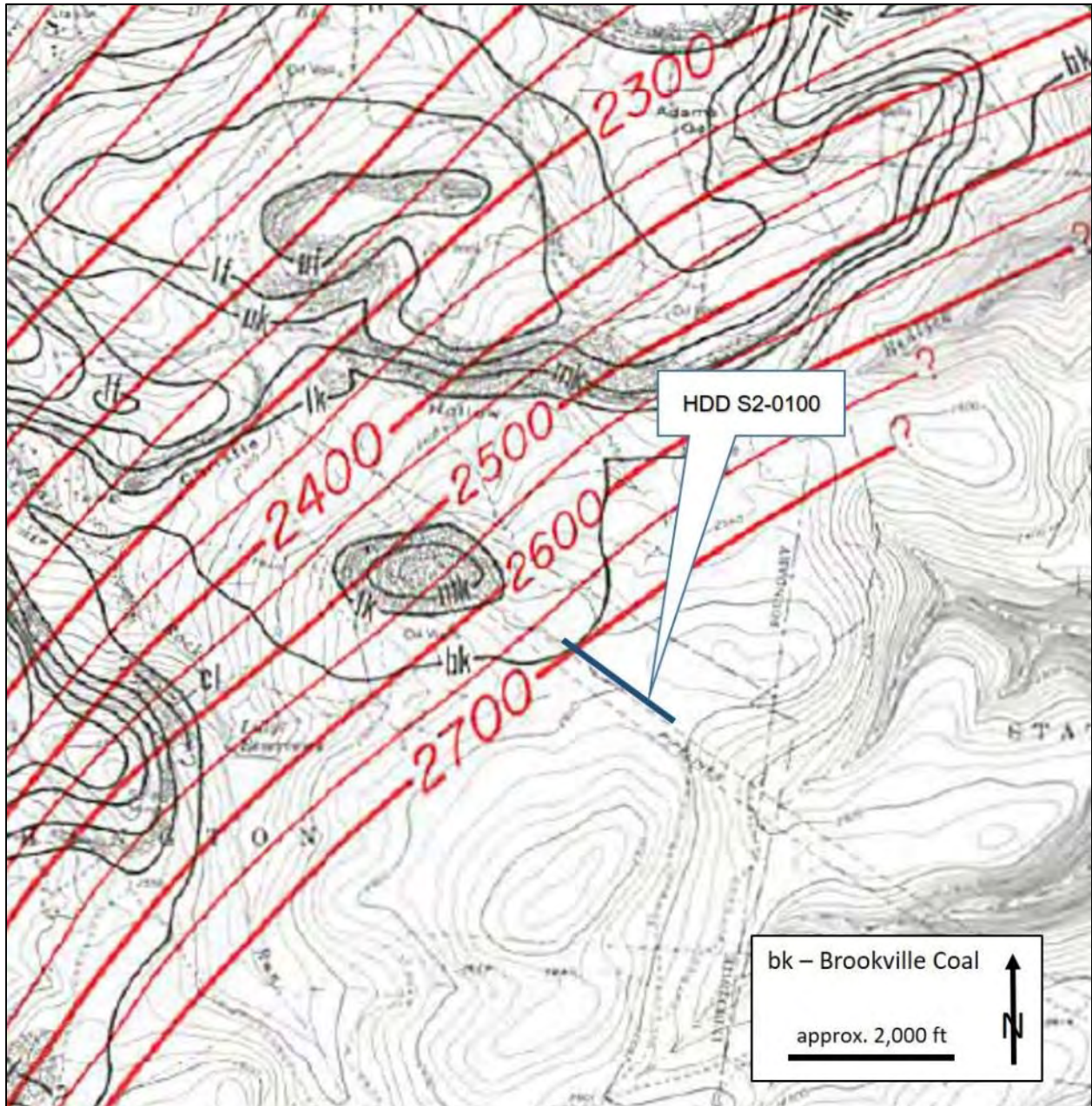


Figure 3. Structure Contour Map of the Lower Kittanning Coal (modified from Glover, 1990)

sandstone in the Appalachian Plateau. In the vicinity of HDD S2-0100-16, two systematic joint sets were mapped with approximate trends of WNW to NW. Less frequent non-systematic joints were mapped approximately orthogonal to the systematic joints.

2.2.4 Fracture Trace Analysis

Fracture trace analysis using high altitude aerial photography was performed for the area of interest to identify potential zones of bedrock weakness along drill paths. Fracture traces (one mile in length or less) and lineaments (greater than one mile in length) are the surficial expression on natural landscapes of vertical zones of bedrock fracture concentration. Fracture trace analysis is partly subjective; therefore, every mapped fracture trace does not necessarily represent a zone of bedrock fracture concentration.

Figure 4 shows a fracture trace map prepared for this reevaluation. This mapping was performed using aerial stereographic pairs flown in the summer of 1939. As such, much of the land surface appears

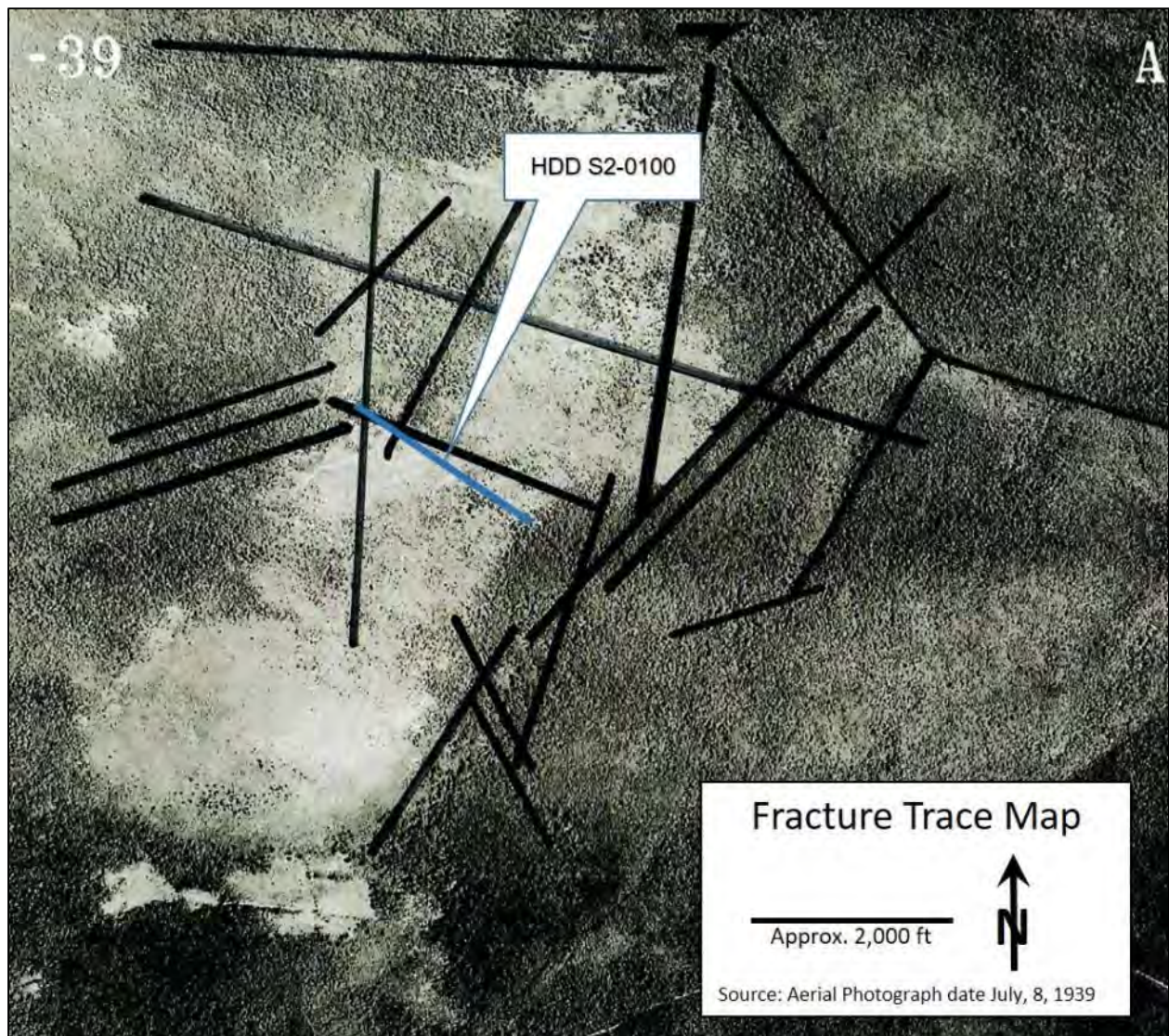


Figure 4. Fracture Trace Map

undeveloped and fracture traces are more easily seen. Multiple traces in the area of interest are seen oriented WNW, NNE, NE and ENE accounting for one of the major systematic joint sets of Nickelsen and Hough (1967) and two of the orthogonal non-systematic sets.

The proposed path of the revised boring is shown in blue on Figure 4 and transects three of the mapped fracture traces. The three traces intersect HDD S2-0100-16 at two locations proximal to the northwestern end of the drill path.

2.2.5 Karst

Based on published geologic data, no karst features are anticipated within the LOD of HDD S2-0100-16. The potential of karst conditions is not anticipated because minor limestone units within the Pottsville and Allegheny formations are not prone to the development of karst features.

2.2.6 Mining

Research of available public resources indicates deep mining has not occurred under the HDD alignment. A search using the Pennsylvania Mine Map Atlas web site shows the HDD is on land for which the mineral rights are owned by the Cambria Iron Company but deep mining has not occurred. This is consistent with the geologic mapping that shows economically viable coals are northwest of the HDD and do not underlie the planned drill. Figure 5 shows the HDD alignment superimposed onto an image of the Cambria Iron Company map acquired from the Pennsylvania Mine Map Atlas web site.

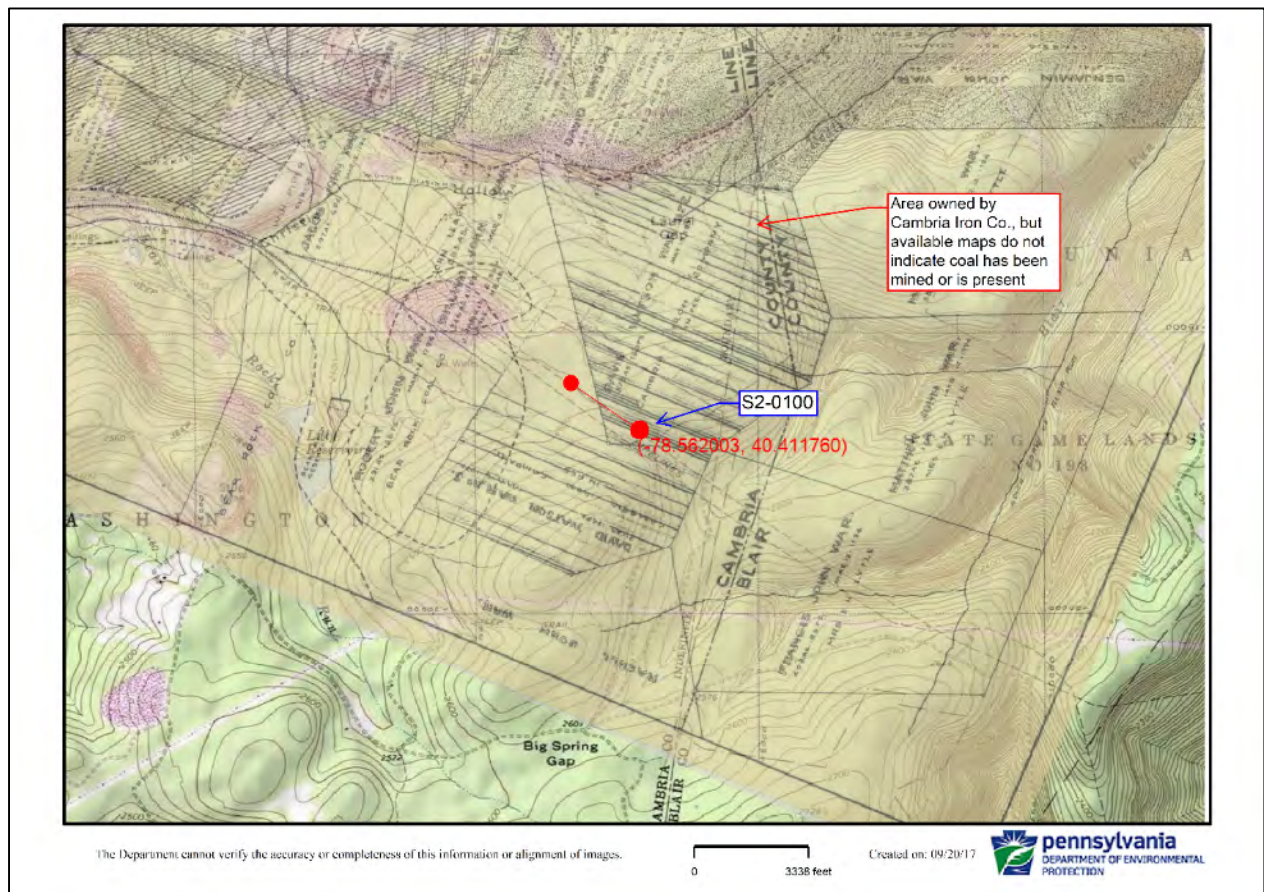


Figure 5. Cambria Iron Company Holdings (not to scale; modified from Pennsylvania Mine Map Atlas - BMSB_UMM_1000_0427-001)

The limits of Lower Kittanning deep coal mining are approximately 1.8 miles northwest and 0.9 mile north of the HDD S2-0100-16 alignment. No landowner complaints, including complaints associated with mine subsidence, were identified in the area of HDD S2-0100-16 using PADEP eMapPA web site.

2.2.7 Rock Engineering Properties

The Pottsville Formation rock properties are as follow (Geyer and Wilshusen, 1982):

- Light- to dark-gray, fine-grained to coarsely conglomeratic sandstone; subordinate amounts of gray shale, siltstone, limestone, coal, and underclay occur.
- Bedding is generally well developed with cross-bedding in sandstone and siltstone.
- Joints are moderately well formed; distribution is moderate to high; spacing is wide to moderate in sandstone, close in shale; patterns are mostly regular; open and vertical.
- Moderate drilling rates.

The Allegheny Formation Properties are as follow (Geyer and Wilshusen, 1982):

- Cyclic sequences of sandstone, shale, siltstone, claystone, limestone, coal, and underclay; major sandstone units are medium to coarse grained and sometimes conglomeratic.
- Bedding is fissile and thin bedded to massive and thick bedded depending on rock type; most major sandstone units are thick bedded; generally well developed; sandstone is frequently crossbedded.
- Joint formation, spacing, and density depend on rock type; more widely spaced in sandstone and closer spaced in finer grained rocks and coal; patterns are in many places regular but are locally very complex and irregular; most joints are open and subvertical.
- Moderate drilling rates.

2.2.8 Results of Geotechnical Borings

Tetra Tech Borings

Two geotechnical borings, SB-02 and SB-03, were installed to support the original boring profile design in January 2015 (see Attachment B). These borings were advanced to depths of 13.3 ft bgs and 11.1 ft bgs, respectively. On the revised profile boring SB-02 is located approximately 400 feet south of Station 7+87 with a surface elevation of approximately 2,605 ft amsl. Boring SB-03 is located approximately 175 feet north of Station 2+09 with a surface elevation of 2,614 ft amsl.

The soils logged in SB-02 were predominately clayey sand to auger refusal at a depth of 13.0 ft bgs. The soils logged in SB-03 were similar and auger refusal occurred at 11.0 ft bgs. Groundwater was encountered in SB-02 at approximately 5 ft bgs and in SB-03 at approximately 6 ft bgs.

Intertek PSI Borings

Two additional geotechnical borings, B-01 and B-02, were advanced in December 2018 and January 2019 in support of the redesigned plan and profile (see Attachment A). These borings were advanced to 150 and 141 ft bgs, respectively.

B-01 was located due north of the southeastern entry/exit location and was advanced to 150 ft bgs. The top 9.5 feet of the boring was described as silty sand and gravel residuum. Below that, highly weathered and fractured bedrock was described to 13 ft bgs before more competent Pottsville Formation bedrock was encountered. Rock cores below 13 ft bgs mostly consisted of siltstone with lesser amounts of sandstone and claystone. Vertical fractures were noted or observed in the core photographs at 69, 74, 99, 115 and 144 ft bgs. Recoveries were good after 27 ft bgs ranging from 83 to 100 percent with most over 90 percent. RQD values after 27 ft bgs were variable ranging from 42 to 96 percent, with most greater than 70 percent. RQDs of 96 percent were observed for two core runs from 37 to 42 ft bgs and from 127 to 137 ft. bgs. The water level in the boring at the end of the drill was at the surface.

B-02 was located due north of the northwestern entry/exit location on the original permitted profile, near Station 17+20 and was advanced to 141 ft bgs. The top 19.5 feet of the boring was described as silty clay, silty sand and silty gravel. Competent Pottsville or Allegheny Formation bedrock was encountered.

Below 19.5 ft bgs. Most of the rock cores were described as gray sandstone. Grey siltstone was present from 58 to 78 ft bgs, and grey siltstone transitioning to red and grey siltstone occurred from 118 to 141 ft bgs. A coal seam was present from 67 to 68 ft bgs. No vertical fractures were noted or observed on the Intertek PSI drill log or core photographs. Recoveries were good throughout the cores ranging from 83 to 100 percent with only one recovery below 93 percent. RQDs improved with depth, starting at 14 percent in the top core, ranging from 40 to 80 percent from 23 to 68 ft bgs, and being consistently greater than 80 percent from 68 to 138 ft bgs. The last core was 3 feet long with no RQD. The water level in the boring at the end of the drill was 16 ft bgs.

2.3 Hydrogeology

2.3.1 Occurrence of Groundwater

Groundwater in the Pottsville and Allegheny Formations is stored and moves through an interconnected network of joints, fractures, and bedding plane openings. Water tables in the area of the HDD can be high therefore there is likely some groundwater storage and movement within the soils and weathered bedrock near the surface.

2.3.2 Ground Elevation between HDD entry/exits

The surface elevation for the permitted profile at the southeastern entry/exit is approximately 2,614 feet above mean sea level (ft amsl) and is approximately 2,593 ft amsl at the northwestern entry/exit. The gradient on the ground surface over the profile is a continuous gentle slope from the southeastern entry/exit to the northwestern entry/exit. Since the water table is at or very close to ground surface there is a potential for a groundwater discharge at the northwestern entry/exit. The location and elevation for the southeastern entry/exit for the permitted and revised profiles for HDD S2 0100-16 are identical. The elevation of the northwestern/entry on the permitted profile is 20 feet lower. The northwestern entry/exit on the revised profile is 216 feet further northwest and is six feet higher than on the permitted profile, at approximately the same elevation as the northwestern entry/exit for the as-built 20-inch line profile. During construction of the 20-inch line a groundwater discharge occurred at the northwestern entry/exit after completion of the pilot boring. Construction activities for the 20-inch line were suspended after completion of the pilot boring in October 2017. When preparations were being made to resume drilling in the spring of 2018, the groundwater discharge was discovered from the northwestern exit point. This discharge was created by the same pressure head difference that creates the local wetlands. Water table highs in the uplands to northwest, east, and south create an upward head on the water table in the local lowland across which the HDD S2-0100 drills area located. Local groundwater discharges and surface water runoff support the wetlands and form the headwater tributary that flows to the Lilly Reservoirs to the southwest. Near vertical zones of fracture concentration manifested as fracture traces on the surface are mapped along the northwest end of the revised HDD S2-0100-16 profile could provide preferred pathways for upward groundwater flow in this setting.

To complete construction of the 20-inch line, a dual centrifuge system, 60 gallons per minute (gpm) each, was used to separate recovered solids and groundwater. Excess water (that which could not be used for mixing drilling fluid) was separated from solids (cuttings and drilling fluid additives) and the excess water was passed through a filter bag before discharging onto the ground under permit. A similar condition is likely to occur during drilling for the 16-inch line and similar measures will be required if a significant delay in completing the HDD occurs during active drilling.

2.3.3 Well Yields and Water Levels

Published data for the Pottsville Group (McElroy, 1998) indicate well yields of approximately 15 gpm but the sample size was small (n=3). Allegheny Group well yields ranged 0 to 180 gpm with a median of 12 gpm for a 45 well sample size. There are no records of wells within one mile of HDD S2-0100-16 according in the Pennsylvania Groundwater Information System (PaGWIS). Groundwater was

encountered in the two Tetra Tech geotechnical borings, SB-02 and SB-03, at 5 and 6 ft bgs, respectively. The drilling fluid level at the completion of the Intertek PSI borings was at the surface for B-01 and 16 ft bgs for B-02.

2.3.4 SPLP Water Supply Program

SPLP performed a survey of land owners within 450 feet of the ROW for the revised profile and no land owners responded positively to an offer to have their wells tested (see Figure 6). The PaGWIS database reports no water supply wells within 450 feet of the ROW.

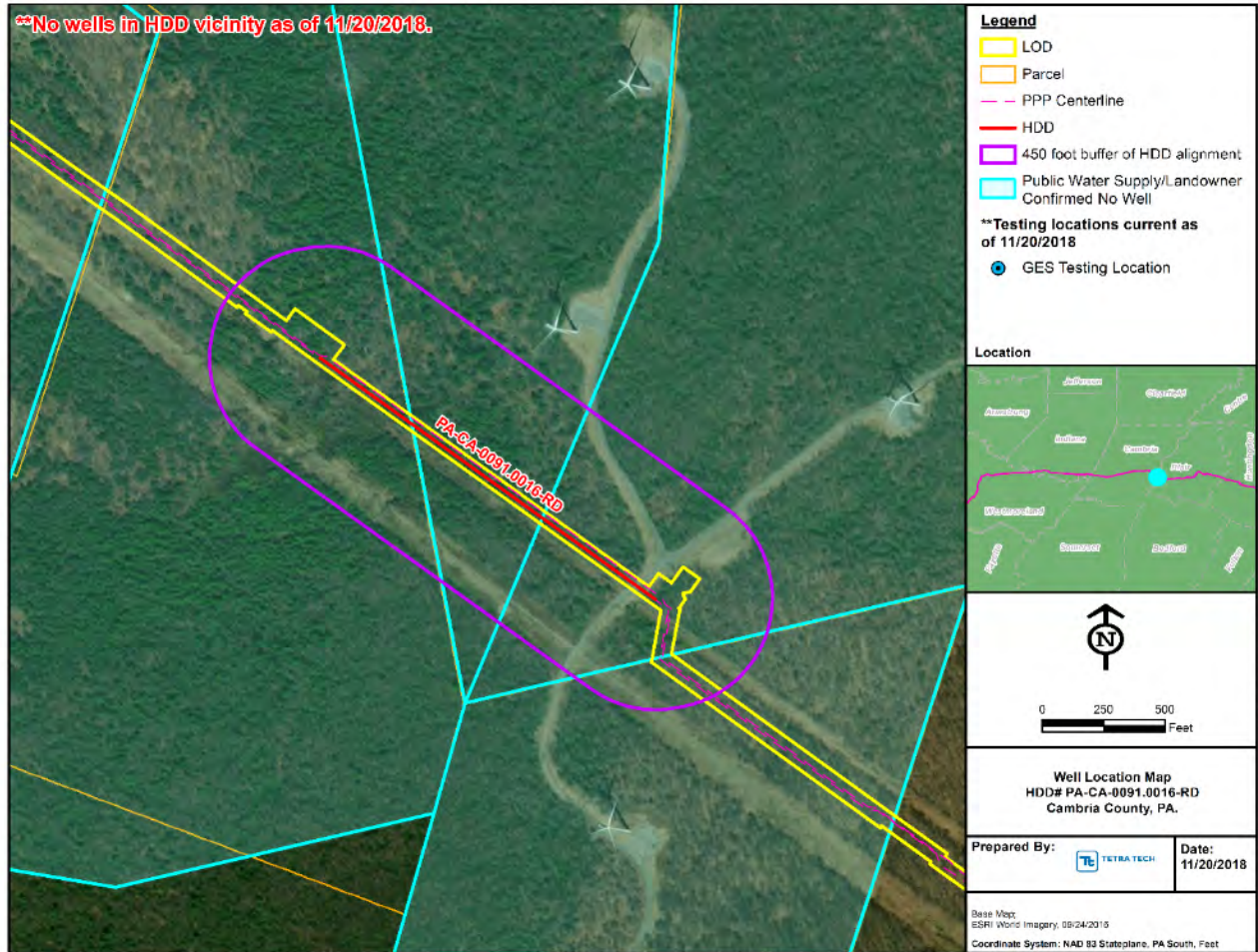


Figure 6. Water Supply Wells Sampled Within 450 Feet of ROW

2.4 Summary of Geophysical Studies

No geophysical studies were conducted for this reevaluation as there is no indication of karst development in the area and there is no evidence of deep mining below the alignment for HDD S2-0100-16.



3.0 OBSERVATIONS TO DATE

3.1 On This HDD Alignment

3.1.1 ME I

No inadvertent returns (IRs) were reported along the alignment of the HDD S2-0100-16 on the list of IRs for ME I documented in the IR PPC Plan for Cambria County.

3.1.2 ME II

During the 20-inch pipeline pilot, IRs appeared at two locations south of the alignment as the drill path was rising to the surface at the exit (northwestern) side of the HDD. The locations of the IRs are indicated on revised plan and profile in Attachment A.

On October 3, 2017, an IR was discovered approximately 120 feet southwest of Station 16+35 along the as-built alignment for the 20-inch HDD. Approximately 50 gallons of drilling fluid was discovered in a wetland within an area of approximately 30 by 50 feet in dimensions. At the time of the IR, the driller was tripping out to add a sweeper sub to the drill stem; the borehole had been drilled to 1,753 feet, depth 22 ft bgs before tripping out had begun. Activities were stopped upon discovery and erosion control was installed around the IR area to control drilling fluid migration. A vacuum truck was brought to the site to recover drilling fluid. A botanist inspected the IR area and confirmed the IR was within a wetland, but no Bulrush plants were near the IR.

On October 10, 2017, the driller completed the trip out and began to trip back in. When the pilot bit reached Station 16+24, the IR that originated on 10/03/17 began seeping again. Approximately 300 gallons of drilling fluid seeped onto ground and the containment was expanded. The reactivated IR was contained and remediation was performed using vacuum truck.

On October 11, 2017, an IR occurred at a second location 25 feet southwest of Station 17+37 on the alignment when the pilot bit had been tripped in 1,700 feet. At this location the overburden was estimated to be 20 to 25 feet thick. Less than 50 gallons of drilling fluid was discovered on the surface within a wetland. Containment was installed and cleanup was performed assisted by a vacuum truck.

After the second IR the driller pulled up timber mats about 75 feet from northwestern entry/exit on center line and dug a pit approximately 6 by 6 by 6 feet deep with the intention of providing a path for pushing the tools out the remainder of the profile without the need to circulate drilling fluid. When the excavation was six feet deep, drilling fluid entered from the excavation floor. Next, the driller dug a trench, one bucket wide, from the dug pit northwest to the exit point. This allowed drilling fluid to travel back to the exit from the dug pit. The driller then pushed the pilot bit out the remainder of the profile to exit at approximately Station 18+70.

3.2 On Other HDD Alignments in Similar Hydrogeologic Settings

3.2.1 ME I

No IRs were reported on the list of IRs for ME I documented in the IR PPC Plan for site underlain by Pottsville Formation or Allegheny Formation bedrock.

3.2.2 ME II

All of the IRs to date in Spreads 1 and 2 for the ME II pipeline have occurred while drilling through the cyclic sequences of sandstone, shale, limestone, clays seams and coal present within northwestern Pennsylvania bedrock formations, including the Allegheny Formation, Casselman Formation,



Conemaugh Group, Glenshaw Formation, Monongahela Group, Pottsville Formation, and Waynesburg Formation. Entries and exits pass through alluvium, colluvium, and soils developed on top of weathered bedrock and/or mine spoils. In general, the IRs have been related to shallow overburden, coarse grained unconsolidated materials near the surface (such as alluvium and mine spoil), large elevation changes between entry/exits and the lowest elevation points along the profiles (sometimes creating soil plugs), elevated annular pressures and loss of fluids), and the interconnectivity of open bedrock structural features that is difficult to predict.

4.0 SUMMARY AND CONCLUSIONS OF HDD HYDROGEOLOGIC EVALUATION

4.1 HDD Site Conceptual Model

Based on the information provided in this reevaluation report, the revised drilling path for HDD S2-0100-16 should encounter competent Pottsville Formation and Allegheny Formation bedrock throughout most of the profile. The borehole crosses beneath two wetland complexes at a minimum depth of approximately 63 feet at the northwestern end of the alignment and a minimum depth of approximately 47 feet at the southeastern end of the alignment. Comparison of the permitted and revised profiles shows the HDD entrance and exit angles have been increased from 8 to 14 degrees at the northwest end and from 8 to 16 degrees on the southeast end. The middle of the revised profile is 65 feet deeper than the permit profile and 20 feet deep than the as-built profile for the 20-inch line. As seen in the information collected from two recent geotechnical borings (Intertek PSI B-01 and B-03, see Section 2.2.8), in general, the deeper profile will encounter bedrock with higher strength than that would have been encountered by the permitted profile. This increase in rock strength will reduce the risk of a loss of circulation or an IR. Some variability in RQD was observed with depth in B-01 and fracture trace analysis indicates HDD S2-0100-16 may pass through zones of increased bedrock fracturing within the northwestern part of the drill. Both of the IRs occurred that occurred during construction of the 20-inch line occurred in the northwestern part of the drill where the fracture traces are mapped.

The unconsolidated materials above bedrock described for the two Tetra-Tech borings and two Intertek PSI borings ranged from 9.5 and 19.5 feet thick, consisting of variable amounts of clay, silt, sand and gravel. All samples had some percentage of cohesive materials. These materials have less strength than the underlying competent bedrock emphasizing the benefit of increasing the entry and exit angles between the permitted and revised profile.

Water table elevations are anticipated to be at or near ground surface along the alignment of HDD S2-0100-16. There is risk of a groundwater discharge at the northwestern entry/exit for the revised profile as the position is similar to that of the northwestern entry/exit for the 20-inch line where a discharge occurred. Upward groundwater head pressures are likely present due to the surrounding uplands. Near vertical zones of fracture concentration, as indicated by fracture traces, may provide pathways for upward migration of groundwater. If an HDD boring encounters one of these zones it might cause the kind of groundwater discharge that developed during the 20-inch pilot bore.

The 450-foot water supply survey indicates no public or private water supplies will be at risk during the drilling of HDD S2-0100-16.

4.2 Conclusions and Recommendations

The revised profile for HDD S2-0100-16 the drill will be longer and reach deeper into more competent bedrock than the permitted profile, and as such reduces the risk of IRs. The entrance/exit angles have been steepened to reduce the horizontal distance where drilling will be passing through unconsolidated materials, which reduces the risk of punch in and punch out IRs. There are no private or public water supplies in the area, nor any abandoned or active deep coal mines.

Contractors should be prepared for losses of circulation while drilling through less competent bedrock as indicated by mapped fracture traces in the northwestern part of the revised profile and as indicated in the variable RQD in B-01. The drilling procedures should include the immediate suspension of drilling activity and assessment at the initial signs for fluid loss that was implemented by the ME II HDD program in the summer of 2018. Frequent suspension of drilling and grouting (or “squeeze grouting”) before resuming will most likely be required to inhibit IRs while drilling through any zones of lost



circulation, if encountered. Other standard ME II drilling practices to minimize IRs should be employed, as needed; including, but not limited to:

- Minimizing annular pressures to reduce the risk of IRs
- Reducing drilling fluid density, to maintain a clean borehole
- Controlling penetration rates to maintain a clean borehole.
- Re-establishing drilling fluid circulation slowly before advancing.

In addition, contractors should be prepared to manage the type of groundwater discharge that occurred at the northwestern entry/exit during the drilling of the 20-inch line for HDD S2-0100.

Based on information provided by, and the expertise of, the HDD team, as well as our experience with the relevant hydrogeology and geology, GES believes that the implementation of the revised profile for HDD S2-0100-16 will minimize the risk of IRs and LOCs and minimize the likelihood of harm to the environment. Furthermore, based on such information, expertise and experience, GES believes that implementation of the revised profile is a practicable measure, in conjunction with absence of known water private water supplies in the area, to prevent impacts to such water supplies. In the unlikely event of an impact to a private water supply, SPLP should implement procedures provided the April 2018 IR PPC Plan.

5.0 REFERENCES

Geyer, A. R. and J. P. Wilshusen, (rev. 1982) *Engineering Characteristics of the Rocks of Pennsylvania*. PaDER, ORM, Pa Geol. Surv., 4th ser., EGR-1.

Glover, A. D, (1990), *Coal Resources of Cambria and Blair Counties, Pennsylvania – Part I, Coal crop lines, mined out areas, and structure contours*, Pa. Geol. Surv., 4th. Ser., M-096.

McElroy, T. A. (1998), *Groundwater resources of Cambria County, Pennsylvania*, Pa. Geol. Surv., 4th. Ser., W67.

McElroy, T. A. (2001), *Groundwater Resources of Somerset County, Pennsylvania*. Pennsylvania Department of Environmental Resources, Office of Resource Management, Bureau of Topographic and Geologic Survey.

Nickelsen, R. P. and Hough, V. D. (1967) *Jointing in the Appalachian Plateau of Pennsylvania*, GSA Bull. v. 78, p. 609-630.

eMapPA, Pennsylvania Department of Environmental Protection
(<http://www.depgis.state.pa.us/emappa/>)

PAGEODE, Pennsylvania Department of Conservation and Natural Resources
(<https://www.gis.dcnr.state.pa.us/geology/index.html>).

PAGWIS, Pennsylvania Groundwater Information System
(<http://dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm>).

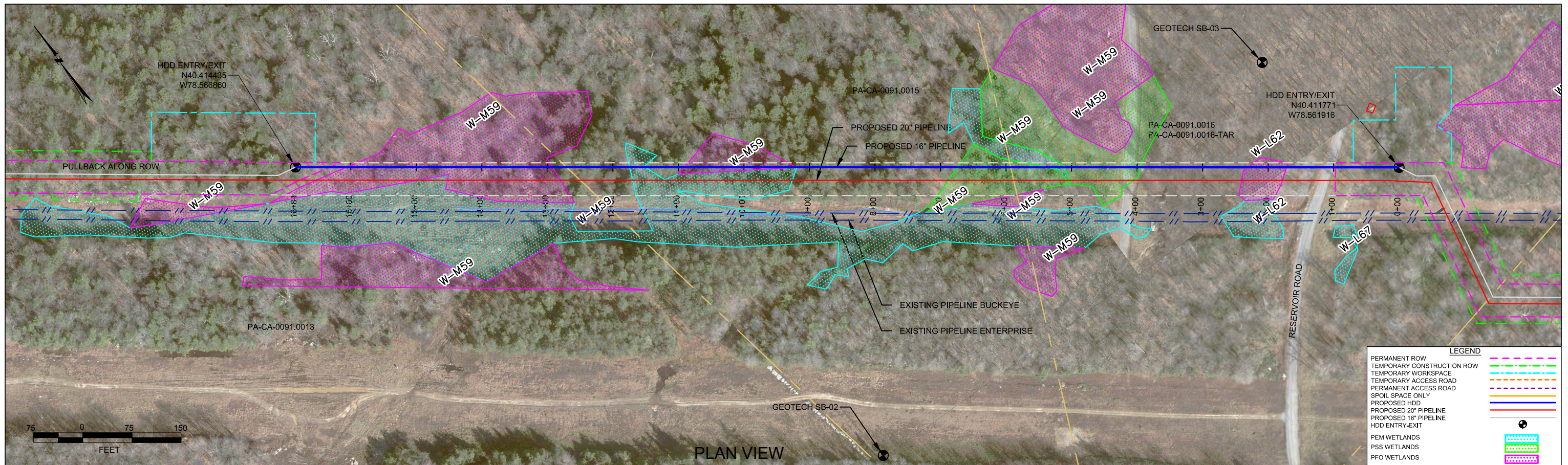
Penn State Mine Atlas (<http://www.minemaps.psu.edu>).

USDA NRCS WSS, United States Department of Agriculture, Natural Resources Conservation Service – Web Soil Survey for Cambria County.
(<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>).



Attachment A

Original and Revised Plans and Profiles



PROFILE VIEW

CAMBRIA COUNTY, PENNSYLVANIA - JUANITA/WASHINGTON TOWNSHIP
S2-0100-16

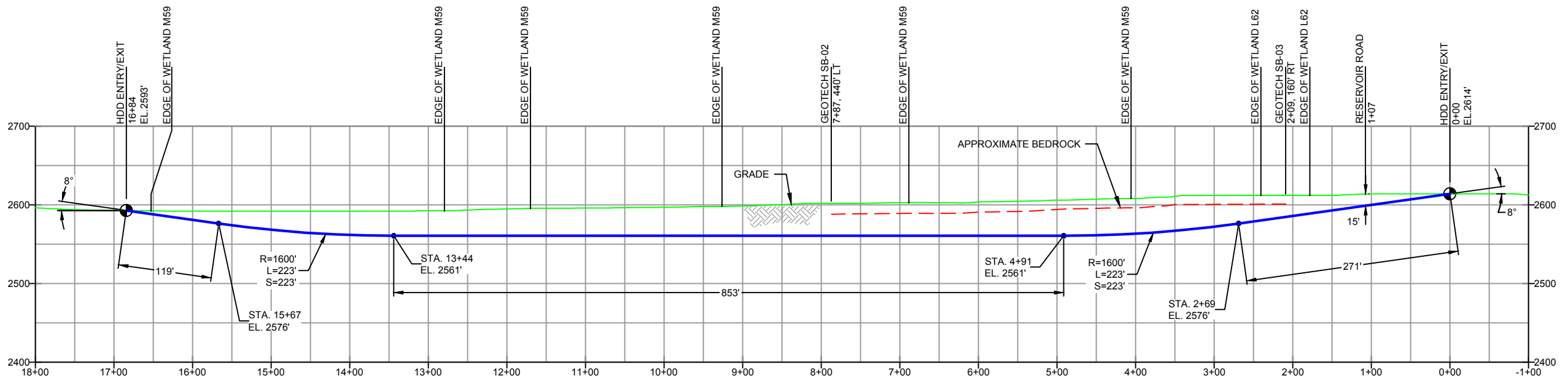
GEOTECH SB-02

- NG EL. 2605'
- GROUNDWATER (6.0')
- SC (0.0' - 13.3')
- COMPLETION DEPTH EL. 2591.5'

GEOTECH SB-03

- NG EL. 2614'
- GROUNDWATER (5.0')
- SC (0.0' - 11.1')
- COMPLETION DEPTH EL. 2603'

NOTE: REFER TO TEST BORING LOG S2-0100 FOR COMPLETE SOIL MATERIAL DESCRIPTION



- 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-): 1684'
HDD PIPE LENGTH (S-): 1688'
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).
 - 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-2.73	TO ES-2.74	NO.	DESCRIPTION
SHEET 47	SHEET 47	EP2	REVISED PAR PADEP COMMENTS RECEIVED 09-06-16
		EP1	REVISED PER PADEP COMMENTS
		EP	
		B	ADDED GEOTECH INFO
		A	ISSUED FOR BID
DWG NO	DWG NO	NO.	DESCRIPTION

Sunoco Logistics Partners L.P.

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
BULRUSH
PENNSYLVANIA PIPELINE PROJECT

TETRA TECH ROONEY
(303) 792-5911

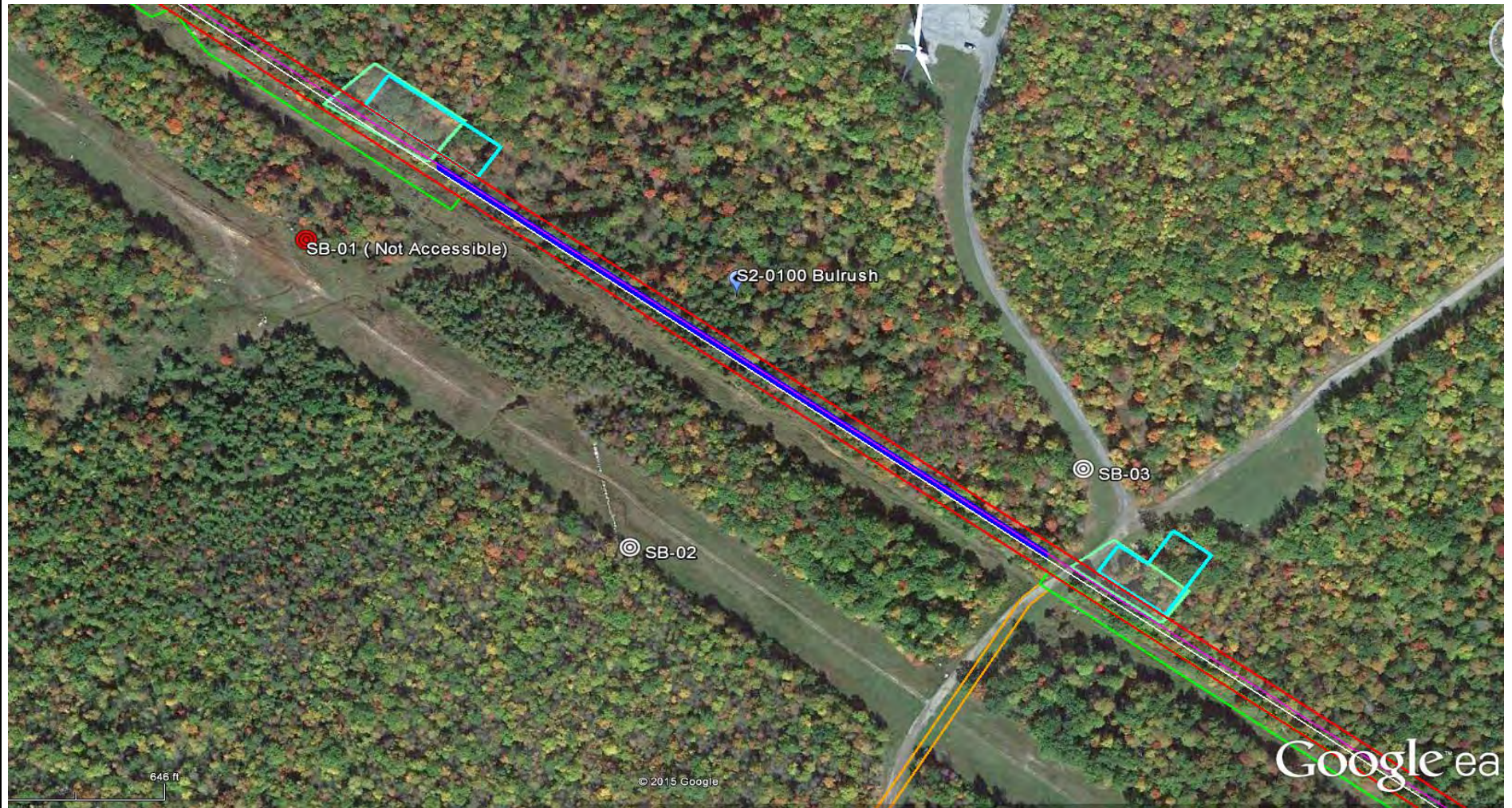
SCALE: 1"=150'

DWG. NO: PA-CA-0091.0016-RD-16



Attachment B

Geotechnical Reports



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S2-0100
 CAMBRIA COUNTY, WASHINGTON 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:	MOUNTAIN ROAD, LILLY, PA	Page 1 of 1	
HDD No.:	S2-0100	Dates(s) Drilled:	01-12-15
Boring No.:	SB-03	Inspector:	E. WATT
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	S. HOFFER
		Groundwater Depth (ft):	5.0
		Total Depth (ft):	11.1

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	0.0			NO DISCERNABLE TOPSOIL					
1	3.0	5.0	0.0		7		ORANGE BROWN FINE CLAYEY SAND WITH A TRACE OF FINE SANDSTONE GRAVEL.	1	2	9	10	11
2	8.0	9.7			12	SC	BROWN FINE TO MEDIUM SAND WITH SOME SILTY CLAY, WITH A LITTLE FINE TO COARSE SANDSTONE GRAVEL. USCS: SC).	3	21	28	50/2"	49
3	11.0	11.1		11.1	0		NO RETURN.	50/1"				
							AUGER REFUSAL AT 11'. OFF-SET BORING 15' NW AND CONTINUOUSLY AUGERED TO REFUSAL AT 11.					
							WET ON SPOON AT 6'.					
							WATER LEVEL THROUGH AUGERS AT 5'.					
							CAVED AT 11' (BOTH BORINGS)					
							WATER LEVEL ON CAVE AT 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.

**GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0100**

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, %	
S2-0100	SB-02	1	3.0	5.0	13.0	47.9	-	-	-	-
		2	8.0	10.0	11.2	40.3	36	23	13	SC
		3	13.0	13.3	16.6	33.7	-	-	-	-
	SB-03	1	3.0	5.0	13.1	40.3	-	-	-	-
		2	8.0	9.7	14.0	33.9	35	22	13	SC

Notes:

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

**REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0100**

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
S2-0100	Bulrush	SB-01	Pottsville Formation - consists mainly of well- to very well cemented, medium-grained to conglomeratic sandstone beds (ranging in thickness from about 10 to 70 feet), with minor amounts of siltstone, claystone, shale, and thin coals.	Upland Plateau	Pottsville	Sandstone with minor amounts of siltstone, claystone, shale, and thin coal	1,600	15-20	Limited boring data available, nearest boring log for location ~1.75-mile from drill location
		SB-02							
		SB-03							

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.

DATE STARTED: 12/28/18 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 1/3/19 **DRILLER:** T. Caton **LOGGED BY:** Q. Enberg
COMPLETION DEPTH: 150.0 ft **DRILL RIG:** Diedrich D-50
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 2611.508 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: 40.4118893° **HAMMER TYPE:** Automatic
LONGITUDE: -78.5618525° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette
REMARKS: Northing 393943.156, Easting 1742433.743 (Provided to PSI by DPS)

BORING B-01

Water During Drilling None Enc.
 Pre-Core Dry

BORING LOCATION:
 Refer to Figure 2: Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
										X Moisture <input checked="" type="checkbox"/> PL <input checked="" type="checkbox"/> LL STRENGTH, tsf ▲ Qu * Qp	
2535	75					BEDROCK - SILTSTONE , gray to mottled red, indistinct to thinly bedded, broken to massive, medium hard to hard, moderately weathered to fresh, interbedded with Fine Grained Sandstone, random fractures				>>▲ Qu = 208.9 tsf 30 min. pcf 5 min. 5 min. 5 min.	
2530	80			R-9	120	BEDROCK - SANDSTONE , gray, very thinly to thinly bedded, broken to massive, hard to very hard, moderately weathered to fresh, random fractures (MOH = 3)	RQD=75 Rec=100%			>>▲ Qu = 266.7 tsf 168.6 pcf 5 min. 5 min. 5 min.	
2525	85					BEDROCK - SILTSTONE , gray to mottled red, very thinly to thickly bedded, medium hard to hard, highly weathered to fresh, interbedded with Fine Grained Sandstone, random fracture				>>▲ Qu = 321.3 tsf 168.0 pcf 5 min. 7 min. 7 min.	
2520	90			R-10	100	(MOH = 3-4)	RQD=42 Rec=83%			>>▲ Qu = 395.0 tsf 165.4 pcf 7 min. 7 min. 7 min.	
2515	95									>>▲ Qu = 387.0 tsf 167.8 pcf 4 min. 4 min.	
2510	100										

Continued Next Page



Professional Service Industries, Inc.
 850 Poplar Street
 Pittsburgh, PA 15220
 Telephone: (412) 922-4000

PROJECT NO.: 08031201
PROJECT: Bulrush Pipeline HDD
LOCATION: Cresson & Washington Twps.
 Cambria Co., PA
 HDD Plan No. : PA-CA-0091.0016-RD

DATE STARTED: 12/28/18 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 1/3/19 **DRILLER:** T. Caton **LOGGED BY:** Q. Enberg
COMPLETION DEPTH: 150.0 ft **DRILL RIG:** Diedrich D-50
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 2611.508 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: 40.4118893° **HAMMER TYPE:** Automatic
LONGITUDE: -78.5618525° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette
REMARKS: Northing 393943.156, Easting 1742433.743 (Provided to PSI by DPS)

BORING B-01

Water	▽	During Drilling	None Enc.
	▽	Pre-Core	Dry
	▽		

BORING LOCATION:
Refer to Figure 2: Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
										X Moisture □ PL + LL 0 25 50	
										STRENGTH, tsf ▲ Qu * Qp 0 2.0 4.0	
2510	100			R-11	108	BEDROCK - SILTSTONE , gray to mottled red, very thinly to thickly bedded, medium hard to hard, highly weathered to fresh, interbedded with Fine Grained Sandstone, random fracture		RQD=87 Rec=90%			4 min. 4 min. 4 min. >> ▲ Qu = 263.4 tsf 168.5 pcf 4 min.
2505	105										4 min. 4 min. 4 min. >> ▲ Qu = 334.8 tsf 167.8 pcf 4 min.
2500	110					Vertical fractures from appx. 109.7 to 110.2 feet		RQD=73 Rec=87%			4 min. 4 min. >> ▲ Qu = 529.4 tsf 167.0 pcf 4 min.
2495	115			R-12	104						4 min. 4 min. >> ▲ Qu = 429.7 tsf 167.8 pcf 4 min.
2490	120										4 min. 4 min. >> ▲ Qu = 55.8 tsf 167.8 pcf 4 min.
2490	120			R-13	120			RQD=77 Rec=100%			4 min. 4 min. 4 min.

Continued Next Page



Professional Service Industries, Inc.
 850 Poplar Street
 Pittsburgh, PA 15220
 Telephone: (412) 922-4000

PROJECT NO.: 08031201
PROJECT: Bulrush Pipeline HDD
LOCATION: Cresson & Washington Twps.
 Cambria Co., PA
 HDD Plan No. : PA-CA-0091.0016-RD


DATE STARTED: 12/28/18 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 1/3/19 **DRILLER:** T. Caton **LOGGED BY:** Q. Enberg
COMPLETION DEPTH: 150.0 ft **DRILL RIG:** Diedrich D-50
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 2611.508 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: 40.4118893° **HAMMER TYPE:** Automatic
LONGITUDE: -78.5618525° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette
REMARKS: Northing 393943.156, Easting 1742433.743 (Provided to PSI by DPS)

BORING B-01

Water	▽	During Drilling	None Enc.
	▼	Pre-Core	Dry
	▽		

BORING LOCATION:
Refer to Figure 2: Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
2485	125					BEDROCK - SILTSTONE , gray to mottled red, very thinly to thickly bedded, medium hard to hard, highly weathered to fresh, interbedded with Fine Grained Sandstone, random fracture				X Moisture □ PL + LL 0 25 50	>> Qu = 659.3 tsf 4 min. 167.8 pcf 6 min. 6 min. 6 min.
2480	130			R-14	120			RQD=96 Rec=100%		▲ Qu * Qp 0 2.0 4.0	>> Qu = 134.4 tsf 6 min. 163.5 pcf 6 min. 6 min. 6 min.
2475	135					BEDROCK - SANDSTONE , gray, very thinly bedded, blocky to massive, hard, fresh to slightly weathered, random fractures (MOH = 3-4)					>> Qu = 777.2 tsf 6 min. 168.4 pcf 4 min. 4 min. 4 min.
2470	140			R-15	119	BEDROCK - SILTSTONE , gray to mottled red, very thinly to thickly bedded, broken to massive, medium hard to hard, slightly weathered to fresh, interbedded with Sandstone, random fractures		RQD=61 Rec=99%			>> Qu = 395.9 tsf 4 min. 168.3 pcf 4 min. 4 min. 4 min.
2465	145					(MOH = 3-4)					4 min. 4 min. 4 min.
2460	150			R-16	36			RQD=77 Rec=100%			>> Qu = 281.1 tsf 5 min. 169.3 pcf 5 min.
<i>Continued Next Page</i>											

	Professional Service Industries, Inc. 850 Poplar Street Pittsburgh, PA 15220 Telephone: (412) 922-4000	PROJECT NO.: 08031201 PROJECT: Bulrush Pipeline HDD LOCATION: Cresson & Washington Twps. Cambria Co., PA HDD Plan No. : PA-CA-0091.0016-RD
---	---	---

DATE STARTED: 12/28/18	DRILL COMPANY: Terra Testing, Inc.	BORING B-01										
DATE COMPLETED: 1/3/19	DRILLER: T. Caton LOGGED BY: Q. Enberg											
COMPLETION DEPTH: 150.0 ft	DRILL RIG: Diedrich D-50	<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td rowspan="3" style="text-align: center; vertical-align: middle;">Water</td> <td style="text-align: center;">▽</td> <td>During Drilling</td> <td>None Enc.</td> </tr> <tr> <td style="text-align: center;">▼</td> <td>Pre-Core</td> <td>Dry</td> </tr> <tr> <td style="text-align: center;">▽</td> <td></td> <td></td> </tr> </table>	Water	▽	During Drilling	None Enc.	▼	Pre-Core	Dry	▽		
Water	▽			During Drilling	None Enc.							
	▼	Pre-Core		Dry								
	▽											
BENCHMARK: N/A	DRILLING METHOD: Hollow Stem Auger	BORING LOCATION: Refer to Figure 2: Boring Location Plan										
ELEVATION: 2611.508 ft	SAMPLING METHOD: SS, 3' Centers											
LATITUDE: 40.4118893°	HAMMER TYPE: Automatic											
LONGITUDE: -78.5618525°	EFFICIENCY: N/A											
STATION: N/A OFFSET: N/A	REVIEWED BY: S. Simonette											
REMARKS: Northing 393943.156, Easting 1742433.743 (Provided to PSI by DPS)												

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks												
										<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="text-align: center;">X</td> <td style="text-align: center;">Moisture</td> <td style="text-align: center;">▣</td> <td style="text-align: center;">PL</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">25</td> <td style="text-align: center;">+</td> <td style="text-align: center;">LL</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">25</td> <td style="text-align: center;">0</td> <td style="text-align: center;">50</td> </tr> </table>	X	Moisture	▣	PL	0	25	+	LL	0	25	0	50	
X	Moisture	▣	PL																				
0	25	+	LL																				
0	25	0	50																				
										<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="4" style="text-align: center;">STRENGTH, tsf</td> </tr> <tr> <td style="text-align: center;">▲</td> <td style="text-align: center;">Qu</td> <td style="text-align: center;">✱</td> <td style="text-align: center;">Qp</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">2.0</td> <td style="text-align: center;">0</td> <td style="text-align: center;">4.0</td> </tr> </table>	STRENGTH, tsf				▲	Qu	✱	Qp	0	2.0	0	4.0	
STRENGTH, tsf																							
▲	Qu	✱	Qp																				
0	2.0	0	4.0																				
						Boring terminated at approximately 150.0 feet Core Water at surface at completion of rock coring Borehole grouted on 1/4/19					5 min.												

	Professional Service Industries, Inc.	PROJECT NO.: 08031201
	850 Poplar Street	PROJECT: Bulrush Pipeline HDD
	Pittsburgh, PA 15220	LOCATION: Cresson & Washington Twps.
	Telephone: (412) 922-4000	Cambria Co., PA
		HDD Plan No. : PA-CA-0091.0016-RD

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 12/19/18 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 12/27/18 **DRILLER:** T. Caton **LOGGED BY:** Q. Enberg
COMPLETION DEPTH: 141.1 ft **DRILL RIG:** Diedrich D-50
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 2594.116 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: 40.4146157° **HAMMER TYPE:** Automatic
LONGITUDE: -78.5669493° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette
REMARKS: Northing 394950.218, Easting 1741027.232 (Provided to PSI by DPS)

BORING B-02

Water
 ∇ During Drilling None Enc.
 ▼ Pre-Core Dry
 ▼

BORING LOCATION:
 Refer to Figure 2: Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
0	0			S-1	18	Approximately 3 inches of TOPSOIL RESIDUUM - Very loose, damp, light brown, Silty SAND , little Gravel, trace Clay	SM	2-2-2 N=4		X Moisture □ PL + LL STRENGTH, tsf ▲ Qu * Qp	
2590	5			S-2	16	RESIDUUM - Very stiff, dry to damp, brown, Clayey SILT , little fine Sand, trace to little Gravel	ML	5-10-14 N=24			
2585	10			S-3	18	RESIDUUM - Very dense, dry, light brown to brown, Silty GRAVEL , little to some fine Sand, trace Clay	GM	21-43-41 N=84			>>⊙
2580	15			S-4	18	Decomposed Silty Shale at 14 feet RESIDUUM - Hard, damp to dry, light brown, Clayey SILT , little to some fine Sand, little Gravel	ML	14-16-28 N=44			⊙
2575	20			R-1	35	Auger refusal encountered at approximately 19.5 feet BEDROCK - SANDSTONE , gray, thickly laminated to thinly bedded, broken to massive, medium hard to very hard, moderately weathered to fresh, carbonaceous laminations (MOH = 2-3)		RQD=14 Rec=83%			>>⊙ = 500.9 tsf 162.1 pcf 2 min. 2 min. 3 min. 3 min.
2570	25					(MOH = 2-3)					

Continued Next Page



Professional Service Industries, Inc.
 850 Poplar Street
 Pittsburgh, PA 15220
 Telephone: (412) 922-4000

PROJECT NO.: 08031201
PROJECT: Bulrush Pipeline HDD
LOCATION: Cresson & Washington Twps.
 Cambria Co., PA
 HDD Plan No. : PA-CA-0091.0016-RD

DATE STARTED: 12/19/18 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 12/27/18 **DRILLER:** T. Caton **LOGGED BY:** Q. Enberg
COMPLETION DEPTH: 141.1 ft **DRILL RIG:** Diedrich D-50
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 2594.116 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: 40.4146157° **HAMMER TYPE:** Automatic
LONGITUDE: -78.5669493° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette
REMARKS: Northing 394950.218, Easting 1741027.232 (Provided to PSI by DPS)

BORING B-02

Water During Drilling None Enc.
 Pre-Core Dry

BORING LOCATION:
 Refer to Figure 2: Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
										X Moisture PL LL STRENGTH, tsf Qu Qp	
25				R-2	60	BEDROCK - SANDSTONE , gray, thickly laminated to thinly bedded, broken to massive, medium hard to very hard, moderately weathered to fresh, carbonaceous laminations		RQD=40 Rec=100%			>> Qu = 1607.2 tsf >> Qp = 172.6 pcf 3 min. 3 min. 2 min. 2 min. 2 min.
2565	30			R-3	60	(MOH = 2-3)		RQD=58 Rec=100%			>> Qu = 428.5 tsf >> Qp = 167.4 pcf 2 min. 1 min. 1 min.
2560	35			R-4	58	(MOH = 2-3)		RQD=52 Rec=96%			>> Qu = 1079.0 tsf >> Qp = 165.3 pcf 1 min. 2 min. 2 min. 2 min.
2555	40			R-5	116	(MOH = 3-4)		RQD=79 Rec=97%			>> Qu = 1008.6 tsf >> Qp = 157.7 pcf 2 min. >> Qu = 1139.3 tsf >> Qp = 158.9 pcf 2 min. 2 min. 2 min.
2550	45										>> Qu = 1139.3 tsf >> Qp = 158.9 pcf 2 min. 2 min.
2545	50										>> Qu = 1139.3 tsf >> Qp = 158.9 pcf 2 min. 2 min.

Continued Next Page



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 850 Poplar Street
 Pittsburgh, PA 15220
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PROJECT NO.: 08031201
PROJECT: Bulrush Pipeline HDD
LOCATION: Cresson & Washington Twps.
 Cambria Co., PA
 HDD Plan No. : PA-CA-0091.0016-RD

DATE STARTED: 12/19/18 **DRILL COMPANY:** Terra Testing, Inc.
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COMPLETION DEPTH: 141.1 ft **DRILL RIG:** Diedrich D-50
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 2594.116 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: 40.4146157° **HAMMER TYPE:** Automatic
LONGITUDE: -78.5669493° **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette
REMARKS: Northing 394950.218, Easting 1741027.232 (Provided to PSI by DPS)

BORING B-02

Water	▽	During Drilling	None Enc.
	▼	Pre-Core	Dry
	▽		

BORING LOCATION:
Refer to Figure 2: Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
										X Moisture □ PL + LL STRENGTH, tsf ▲ Qu * Qp	
75		[Graphic Log]				BEDROCK - SANDSTONE , gray, very thinly bedded to thickly bedded, broken to massive, hard to very hard, slightly weathered to fresh (MOH = 3-4)					2 min.
											2 min.
											2 min.
											>> Q _u = 705.1 tsf 160.8 pcf
2515	80			R-9	120			RQD=93 Rec=100%			3 min.
											3 min.
											3 min.
											>> Q _u = 576.6 tsf 161.6 pcf
											3 min.
2510	85										3 min.
										3 min.	
										3 min.	
										2 min.	
2505	90									>> Q _u = 862.6 tsf 157.0 pcf	
										2 min.	
										2 min.	
										2 min.	
2500	95			R-10	119	(MOH = 3-4)	RQD=99 Rec=99%			>> Q _u = 262.9 tsf 157.1 pcf	
										2 min.	
										2 min.	
										2 min.	
2495	100									>> Q _u = 889.6 tsf	

Continued Next Page



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REMARKS: Northing 394950.218, Easting 1741027.232 (Provided to PSI by DPS)

BORING B-02

Water	▽	During Drilling	None Enc.
	▼	Pre-Core	Dry
	▽		

BORING LOCATION:
Refer to Figure 2: Boring Location Plan

Elevation (feet)	Depth (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @	Additional Remarks
100						BEDROCK - SANDSTONE , gray, very thinly bedded to thickly bedded, broken to massive, hard to very hard, slightly weathered to fresh				X Moisture □ PL + LL STRENGTH, tsf ▲ Qu * Qp	
2490	105			R-11	120	(MOH = 3-4)		RQD=99 Rec=100%		164.9 pcf 2 min. 2 min. >> 2 min. >> Q _u = 384.6 tsf 163.8 pcf	
2485	110									1063.4 tsf 163.0 pcf	
2480	115			R-12	120	(MOH = 3-4)		RQD=92 Rec=100%		407.9 tsf 165.4 pcf	
2475	120									254.9 tsf 164.1 pcf	
2470	125			R-13	120	BEDROCK - SILTSTONE , gray to mottled red, thinly bedded to very thinly bedded, very broken to massive, very soft to medium hard, fresh to highly weathered (MOH = 2-3)		RQD=80 Rec=100%		239.5 tsf 168.1 pcf	

Continued Next Page



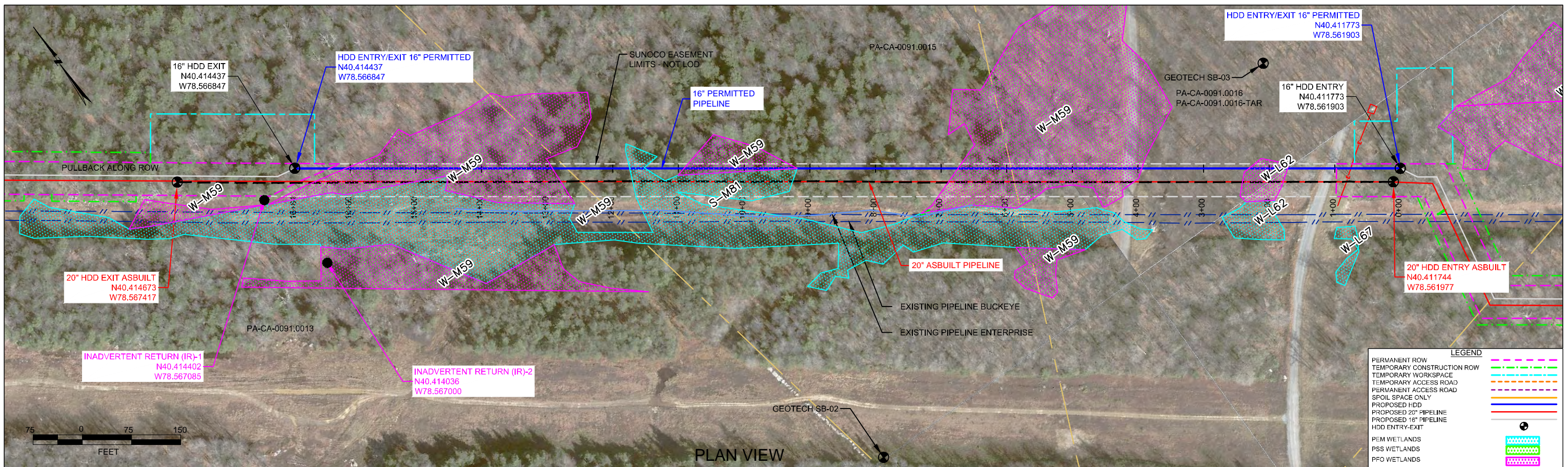
Professional Service Industries, Inc.
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PROJECT NO.: 08031201
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LOCATION: Cresson & Washington Twps.
 Cambria Co., PA
 HDD Plan No. : PA-CA-0091.0016-RD

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
BULRUSH CROSSING
PADEP SECTION 105 PERMIT NO.: E11-352
PA-CA-0091.0016-RD-16
(SPLP HDD# S2-0100)**

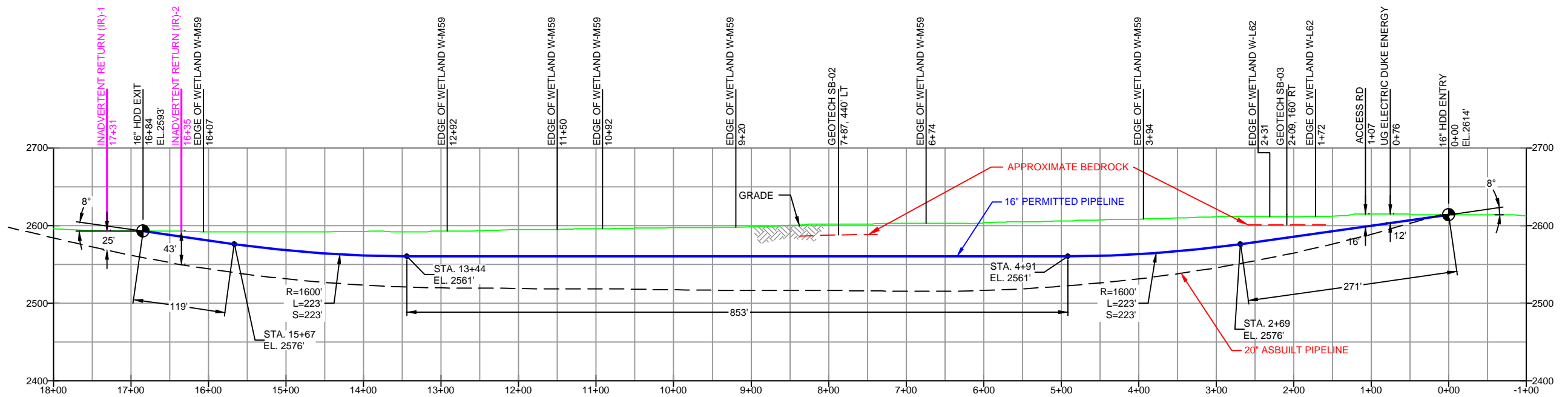
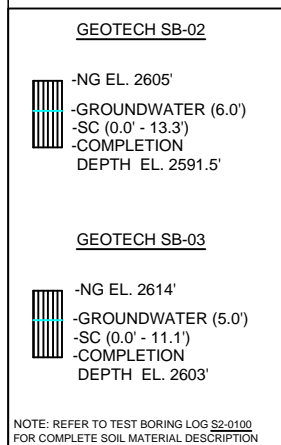
ATTACHMENT 2

HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



CAMBRIA COUNTY, PENNSYLVANIA - JUANITA/WASHINGTON TOWNSHIP
S2-0100-16

PLAN VIEW
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 HORIZ. LENGTH (L)=1684'
HDD PIPE LENGTH (S)=1688'
16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
 - 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.

PRELIMINARY EXHIBIT 3 IR HDD

Figure 1. Permitted 16-Inch HDD Plan and Profile with 20-Inch As Built and IRs

- 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 HEREIN 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.

REVISIONS		BY	DATE	CHK	DATE	APP	DATE
2	REVISED PROFILE WITH 2017 LIDAR	MRS	03/17/17	RMB	03/17/17	CAG	03/17/17
1	REVISED PER ENGINEERING COMMENTS	MRS	08/26/16	RMB	08/26/16	AAW	08/26/16
0	ISSUED FOR CONSTRUCTION	MRS	12/21/15	RMB	12/21/15	AAW	12/21/15

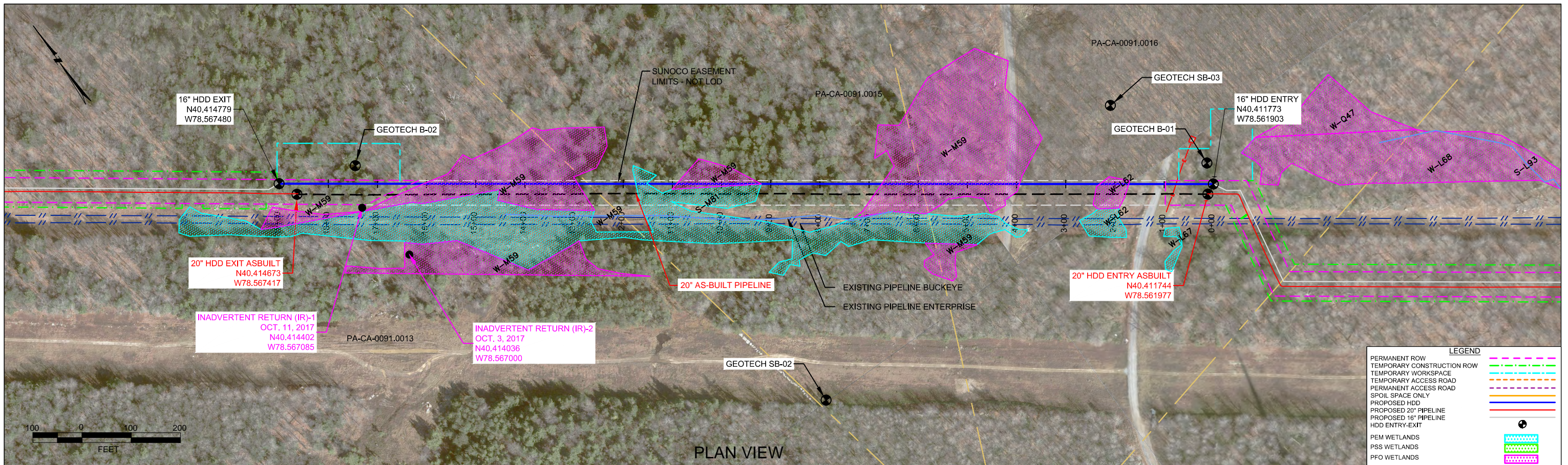
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

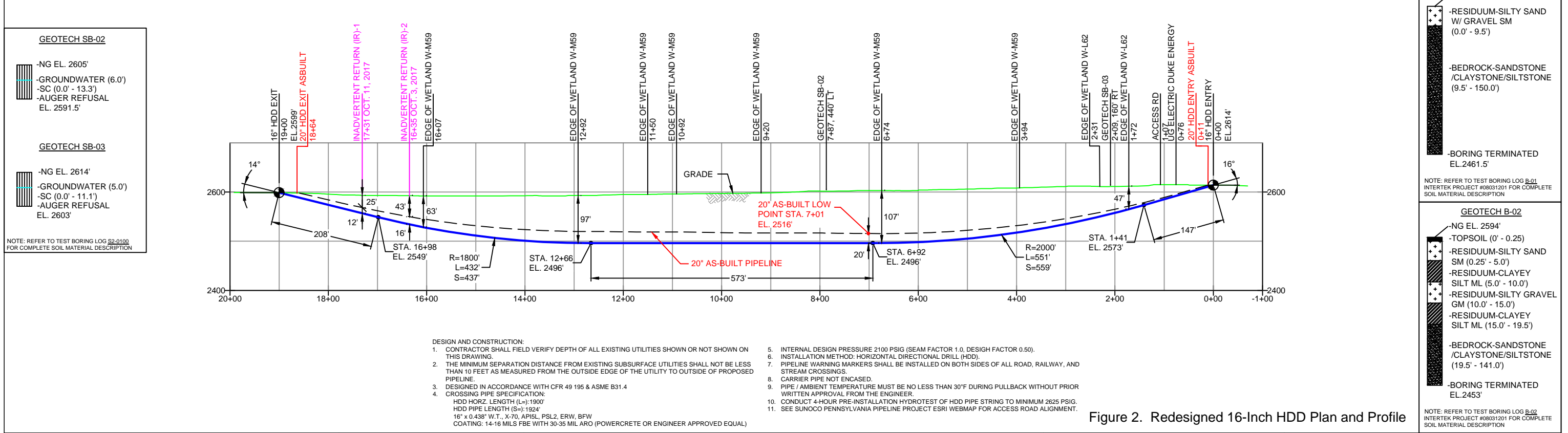
HORIZONTAL DIRECTIONAL DRILL
WETLAND
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' DWG. NO. PA-CA-0091.0016-SR-16 IR EXHIB



CAMBRIA COUNTY, PENNSYLVANIA - JUANITA/WASHINGTON TOWNSHIP S2-0100-16

PROFILE VIEW



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 811-900-786-7440.

REF. DRAWING		REVISIONS	
ES-2.73	TO ES-2.74	NO.	DESCRIPTION
SHEET 47	SHEET 47	EP3	DESIGN CHANGE PER CLIENT REQUEST
		EP2	REVISED PAR PADEP COMMENTS RECEIVED 09-06-16
		EP1	REVISED PER PADEP COMMENTS
		EP	
		B	ADDED GEOTECH INFO
		A	ISSUED FOR BID
DWG NO	DWG NO	NO.	DESCRIPTION

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)=1900'
HDD PIPE LENGTH (S)=1924'
16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
- INTERNAL DESIGN PRESSURE 2100 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 2625 PSIG.
- SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

Figure 2. Redesigned 16-Inch HDD Plan and Profile

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
WETLAND
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' DWG. NO. PA-CA-0091.0016-SR-16

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