

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
CAMPBELL CREEK/GEORGE CREEK CROSSING
PADEP SECTION 105 PERMIT NO. E31-234
PA-HU-0110.0000-SR-16
(SPLP HDD# S2-0155-16)**

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This reevaluation of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline that traverses under George Creek, and wetland K-68 in Tell Township, Huntingdon County, has been completed 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) can commence. The installation of the 20-inch pipe is complete.

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: 850 foot (ft)
- Entry/Exit angle: 10 degrees
- Maximum Depth of cover: 38 ft
- Depth below wetland K-68: 3-15 ft
- Depth below George Creek: 38 ft
- Pipe design radius: 1,600 feet

ROOT CAUSE ANALYSIS FOR THE 20" PIPE INSTALLATION IR

A single IR of approximately 20 gallons in total volume occurred during the pilot hole phase for installation of the 20-inch pipeline. At the time of the IR, the drilling motor was 60 feet from the exit point and approximately 19 feet below ground surface (bgs). In the HDD industry this IR event is considered a "punch out" IR, which is not uncommon and are difficult to prevent.

The occurrence of the IR resulted from the shallow depth of cover on the HDD exit radius while exiting out of the bedrock.

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (PABTGS, 2001), the HDD location is in the Appalachian Mountain Section of the Ridge and Valley Physiographic Province of Pennsylvania, and is underlain by sedimentary rocks consisting of sandstone, siltstone, shale, conglomerate, limestone, and dolomite. The site geology for the redesigned 16-inch HDD profile is mapped from west to east as the Devonian age Onondaga Formation (Doo) and the Hamilton Group (Dh)(Berg and Dodge, 1981).

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Attachment 1 provides an extensive discussion on the geology and results of the geotechnical investigation performed at this location, which informs this analysis.

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater at the site occurs in a fractured, solution prone carbonate and clastic sedimentary bedrock aquifer system within the geology described above. Water-bearing zones generally occur in secondary openings developed along bedding planes, joints, faults and fractures. In the carbonate sequences, the water-bearing zones may form in solution-enhanced secondary openings. Most of the water-bearing zones penetrated by wells occur in individual fractures or groups of interconnected fractures that can be sufficiently enlarged by dissolution of the bedrock (Taylor et al., 1982).

Reported depths of 228 domestic and nondomestic wells in the Onondaga Formation ranged from 35 to 500 feet below ground surface (bgs). Well yields ranged from 0 to 1,400 gallons per minute (gpm). Water-bearing zones among 88 wells reviewed showed an even distribution to a depth of 300 feet.

The depths of 243 domestic and non-domestic water supply wells in the Hamilton Group range from 10 to 695 feet below ground surface (bgs), with yields ranging from 1 to 380 gpm. Water-bearing zones among 198 wells reviewed are most frequent from 50 to 350 feet bgs and are relatively common to a depth of 350 feet, with the deepest water-bearing zone being reported at 635 feet bgs (Taylor et al., 1982).

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

INADVERTENT RETURN (IR) DISCUSSION

HDD specialists and geologists employed by SPLP have investigated subsurface geologic conditions and studied the performance of the HDD during installation of the 20-inch pipeline. As stated above, the Campbell Creek/George Creek HDD experienced a "punch out" IR. This event has been taken into account in the revision of the drilling profile for the 16-inch pipeline. These revisions are presented and discussed below in the Redesign Horizontal Directional Drill section of this analysis.

ADJACENT FEATURES ANALYSIS

This HDD location is 2.6 miles north-northeast of the community of Richvale in Huntingdon County, Pennsylvania, and 0.1 miles east of Shade Valley Road. This HDD passes under two tributaries to George Creek, S-K91 & S-K-93, and wetland K-68. Unnamed tributaries S-K61 & S-K93 are classified as Cold Water Fisheries and are not classified as high quality. Wetland K-68 has emergent, scrub shrub and forested components and is not classified as exceptional value wetland.

SPLP identified all landowners with property located within 450 feet of the HDD alignment and provided these landowners with a notice via both certified and first-class mail that included an offer to sample the landowner's private water supply/well in accordance with the terms of the Order and the Water Supply Assessment, Preparedness, Prevention and Contingency Plan. The letter also requested that each landowner contact the Right-of-Way agent for the local area and provide SPLP with information regarding: (1) whether the landowner has a well; (2) where that well is located, and its depth and size if known; and (3) whether the landowner would like to have the well sampled. In accordance with paragraph 10 of the Order,

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copies of the certified mail receipts for the letters sent to landowners have been provided to Karyn Yordy, Executive Assistant, Office of Programs at the Department's Central Office.

As a result of this communication effort, no water wells were identified within the 450-foot radius of the alignment; however, four wells and one spring were identified between approximately 502 and 1,070 feet from the western entry/exit point of the HDD. No information pertaining to the well depth, depth to water or well yield was provided by the landowners.

To further avoid and mitigate any adverse effects from the HDD to private water wells, and in accordance with the requirements of the Stipulated Order, SPLP will transmit a copy of this HDD analysis to all landowners having a property line within 450 feet of any direction of this HDD location.

ALTERNATIVES ANALYSIS

As required by the Order, the reevaluation of HDD S2-0155-16 includes an analysis of open cut alternatives and potential re-routes. As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the Project, SPLP considered several different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

Open-cut Analysis

Conversion to an open cut trenched crossing method would result in direct but temporary impacts to tributaries to George Creek (streams S-K91, S-K93), wetland W-K68 (palustrine emergent wetland), wetland W-K68 (palustrine shrub/scrub wetland), and wetland W-K68 (palustrine forested wetland). SPLP specifications require a minimum of 48 inches of cover between the installed pipeline and the bottom of the watercourse. To meet this cover requirement, during trenched construction through this area, a workspace with a width up to 75 feet would be required to accommodate the pipelines and provide sufficient space for trench excavation, spoil storage, and sufficient separation between pipelines (for integrity management).

An open cut trenched crossing method replacing the HDD would result in impacts to wetland W-K68, including approximately 0.65 acre impact to emergent wetlands, 0.37 acre of impacts to shrub/scrub wetland, and 0.23 acre to forested wetland vegetative cover types. The HDD will largely avoid surface impacts to biological features and as currently proposed, results in no surface impacts to wetlands (impact avoidance) compared to the open cut alternative.

Open cut impacts to these resources would require modification of the state and federal permits. Moreover, any produced groundwater in the open excavations would be pumped to a discharge filtration structure. The current feasible filtration ability, however, does not exceed 50 microns. Therefore, cloudy water (from suspended fine clay and silt particles) would be discharged downstream regardless of all control methods employed for the entire duration of the use of open cut construction techniques.

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Conventional auger bores are technically limited to less than 200 linear feet varying by the underlying substrate. Due to the linear extent of the water and wetland resources, there are no subset locations within the length of the HDD to feasibly employ this type of construction method.

Re-Route Analysis

Due the general route of the Mariner II Project in this area of the state is from west to east, and general southwest to northeasterly direction of George Creek, no practicable re-route option lies to the north or south of the proposed route that would not ultimately transect this stream and similar wetland resources. The geology across the broader area, miles in extent, is similar; therefore, no reasonable re-route is available that would not alter the subsurface geologic conditions. The pipeline route as currently permitted follows an existing SPLP easement and bypasses or avoids directly impacting forested, shrub/scrub and emergent wetlands; forested lands, and George Creek.

Shifting the north would result in new "greenfield" corridor through existing woodlands George Creek and would still require a crossing of George Creek and adjacent resource. An existing utility corridor occurs 0.2 miles to the south; however, the shift south would require the clearing of a "greenfield" corridor to deviate from the SPLP easement, and then again to return to the SPLP easement. This variance would not avoid the need to cross the same road, streams, and adjacent resources of the currently permitted route, but would significantly increase impacts to forested lands in the easement transitions.

In summary, due to the location of Campbell Creek, George Creek, and woodlands and wetlands adjacent to them, there is no alternative route that could avoid conflicts with existing woodlands, streams, and wetland buffers.

This re-route analysis conducted for the Campbell Creek/George Creek HDD confirms the conclusions reached in the previously submitted alternatives analysis.

REDESIGNED HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,152 foot (ft)
- Entry/Exit angle: 16 degrees
- Maximum Depth of cover: 75 ft
- Depth below wetland K-68: 44-75 ft
- Depth below George Creek: 74 ft
- Pipe design radius: 1,800 feet

CONCLUSION

Based on a comparison of the original and revised profiles for HDD S2-0155-16, the revised profile will be increased by 302 feet and the depth of profile will be increased by 37 feet to be sure the pipe is installed in bedrock below the aquatic resources. The entry/exit angles were increased by 5 to 6 degrees allowing the drill to more quickly enter bedrock, therefore minimizing the amount of time the HDD is within the unconsolidated overburden. 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. Additionally SPLP has engaged and requires proactive responses to Losses of Circulation which precede the occurrence of IRs.

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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;
- 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 upon detection of a Loss of Circulation (LOC) or 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 Losses of Circulation 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 which is highly reactive to bentonite and induces solidification. 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

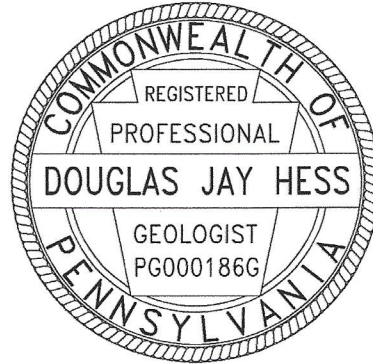

Larry J. Gremminger, CWB
Geotechnical Evaluation Leader
Mariner East 2 Pipeline Project

2-11-2019
Date

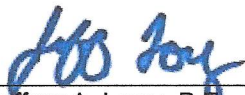
Pertaining to the practice of geology


Douglas J. Hess, P.G.
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Skelly and Loy, Inc.
Director of Groundwater
and Site Characterization
Geo-Environmental Services

2/11/19
Date



Pertaining to the pipeline stress and HDD geometry


Jeffrey A. Lowy, P.E.
License No. PE 082759
Rooney Engineering, Inc.
Civil Engineer

2/19/19
Date



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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

February 8, 2019

Mr. Matthew Gordon
Sunoco Pipeline, L.P.
535 Fritztown Road
Sinking Spring, PA 19608

Engineers

Environmental
Consultants

Surveyors

Landscape
Architects

Safety
Consultants

RE: Sunoco Pipeline, L.P. Pipeline Project - Mariner East II
George Creek HDD S2-0155, PA-HU-0110.0000-SR
Hydrogeologic Re-Evaluation Report for 16-Inch Pipeline
Tell Township, Huntingdon County, Pennsylvania
RETTEW Project No. 096302011

EXECUTIVE SUMMARY

1. This hydrogeologic re-evaluation was prepared as a result of inadvertent returns (IRs) that occurred at the George Creek (a.k.a Campbell Creek) horizontal directional drill (HDD) S2-0155 location as the 20-inch HDD was being completed.
2. The site is underlain by carbonate and sedimentary rocks of the Devonian age Onondaga Formation (Doo) and Hamilton Group (Dh).
3. Water-bearing zones in the underlying geology generally occur in secondary openings along bedding planes, joints, faults, fractures, and solution openings. The permeability of these features is enhanced by dissolution of the carbonate bedrock.
4. Water-bearing zones in the Onondaga Formation and Hamilton Group occur on average approximately 140 and 350 feet below ground surface (bgs), respectively. Water-bearing zones in the Hamilton Group occur most frequently from 50 to 350 feet bgs and are relatively common to a depth of 350 feet, while water-bearing zones in the Onondaga Formation are evenly distributed to a depth of approximately 300 feet.
5. The HDD profile for the proposed 16-inch drill has been redesigned to increase its depth beneath the identified streams and wetlands overlying the bore path.
6. Based on the hydro-structural characteristics of the underlying geology, information obtained from the installation of the 20-inch pipe, and occurrence of IRs during the installation of the 20-inch pipe, the George Creek HDD is susceptible to IRs of drilling fluids during HDD operations for the planned 16-inch drill. The redesigned 16-inch HDD profile and proactive HDD best management practices (BMPs) during drilling operations will be used to reduce the risk of an IR.

1.0 INTRODUCTION

The purpose of this report is to describe the geologic and hydrogeologic setting of the George Creek (a.k.a. Campbell Creek) S2-0155 horizontal directional drill (HDD) location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project - Mariner East II (PPP-ME2) Project. The George Creek HDD is located in Tell Township, Huntingdon County, Pennsylvania as shown on **Figure 1**. The HDD was designed to be drilled



under Wetlands K-68PEM, K-68PSS-1, and K-68PFO-1 and Streams S-K93 and S-K91. The redesigned 16-inch HDD profile will underlie these same features. This re-evaluation report is being prepared as a result of two inadvertent returns (IRs) that occurred during completion of the George Creek HDD.

The proposed 16-inch HDD profile was redesigned on January 25, 2019 to increase the overall length of the boring and increase the depth of the HDD bore beneath the resources described above. The inclination of the entry and exit angles has been increased in order to install the 16-inch pipe through protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original, shorter and shallower profiles. The redesigned 16-inch western HDD entry/exit point is at a surface elevation of approximately 736 feet above mean sea level (AMSL) and the redesigned eastern entry/exit is at a surface elevation of approximately 692 feet AMSL. The inclination of the western and eastern entry/exit angles has been increased to 16° and 15°, respectively, to install the boring through the soils and bedrock in closer proximity to the entry/exit points and to deepen the profile beneath the streams to approximately 75 feet (S-K93), 74 feet (S-K91), and 44-45 feet (W-K68, W-K68PSS-1, W-K68PFO-1). This increased depth will be approximately 25 feet deeper than the 20-inch pipeline. The existing 20-inch and proposed 16-inch S2-0155 HDD locations are shown on **Figure 1** and the redesigned 16-inch profile is included as **Attachment 1**.

2.0 GEOLOGY AND SOILS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (PABTGS, 2001), the site is in the Appalachian Mountain Section of the Ridge and Valley Physiographic Province of Pennsylvania, and is underlain by sedimentary rocks consisting of sandstone, siltstone, shale, conglomerate, limestone, and dolomite. Local topography is characterized by a northeast to southwest trending succession of long narrow ridges and broad to narrow valleys, with some karst terrain. Natural slopes are steep and geologic structures include open and closed plunging folds with narrow hinges and planar limbs, and a variety of faults. These rocks generally have good surface drainage (Sevon, 2000). Based on the United States Geologic Survey (USGS) 7.5-Minute Aughwick and Blairs Mills Topographic Quadrangle Maps shown on **Figure 1**, the site is situated at an approximate elevation range of 880 to 840 feet AMSL. Surface topography at the site slopes to the east along the HDD bore path towards George Creek. The major surface water feature is George Creek which flows to the northeast and then southeast before discharging into Tuscarora Creek which, in turn, ultimately discharges to the Juniata River.

The site geology for the redesigned 16-inch HDD profile is mapped west to east as the Devonian age Onondaga Formation (Doo) and the Hamilton Group (Dh) as shown on **Figure 2** (Berg and Dodge, 1981).

The Onondaga Formation (Doo) consists primarily of interbedded dark gray limestone, shaly limestone and calcareous and noncalcareous shale. The formation contains two members, the upper Selinsgrove Limestone (dark gray argillaceous, fossiliferous limestone) and the lower calcareous Needmore Shale. Bedding features in the Onondaga Formation are described as well bedded, with individual strata varying from flaggy to thick in nature. Joints have a blocky to seamy pattern, are fairly well developed, moderately abundant, moderately to closely spaced and open and vertical. The joint, bedding and fracture-plane openings provide a secondary porosity of moderate magnitude and low permeability. These rocks are moderately weathered to a deep depth with deeper weathering occurring in the shales. Weathering results in small- to medium-sized blocks and elongated fragments at the base of the formation. The overlying mantle is thin and surface drainage is good. From an engineering standpoint, excavation of this formation is difficult with fast drilling rates. Slope stability is classified as good in the limestone member

but only fair in the shale member. Foundation stability is good, provided the excavation is to sound material and solution cavities are investigated and mitigated (Geyer and Wilshusen, 1982).

The Hamilton Group (Dh) includes the Mahantango Formation (Dmh) and the Marcellus Formation (Dmr). The Mahantango Formation consists of gray, brown and olive interbedded shales, siltstones, and very fine-grained sandstones or claystones containing marine fossils. Oolitic hematite occurs near the top of the Mahantango Formation, while the middle section contains medium to coarse grained sandstone and thin conglomerate layers occur. The Marcellus Formation consists of very dark to black, fissile, homogeneous carbonaceous shales. The group is well bedded with the shale units having thin to flaggy beds and the sandstone units having thin, flaggy to medium beds. Joints are well developed, closely spaced, mostly open, and steeply dipping. The joints produce smooth, even faced, sharp edged rectangular blocks in the sandstone units. Joint and bedding plane openings provide a secondary porosity of low to moderate magnitude. The Hamilton Group is poorly to moderately resistant to weathering, with the shale units being less resistant to weathering. The overlying mantle is thin and surface drainage is considered good. Slope stability is good in the sandstone units but only fair in the shale. Excavation is classified as moderately easy to difficult and drilling rates are typically fast to moderate. Foundation stability is good when material is excavated to sound bedrock (Geyer and Wilshusen, 1982).

According to the United States Department of Agriculture (USDA) Soil Surveys of Huntingdon County, Pennsylvania, soils in the vicinity of the George Creek HDD consist of eight separate soil units. A USDA map that depicts the mapped area, along with the soil profile descriptions, is included as **Attachment 2**.

3.0 HYDROGEOLOGY

Groundwater at the site occurs in a fractured, solution prone carbonate and clastic sedimentary bedrock aquifer system within the geology described above. Water-bearing zones generally occur in secondary openings developed along bedding planes, joints, faults and fractures. In the carbonate sequences, the water-bearing zones may form in solution-enhanced secondary openings. Most of the water-bearing zones penetrated by wells occur in individual fractures or groups of interconnected fractures that can be sufficiently enlarged by dissolution of the bedrock (Taylor et al., 1982).

A summary of the review of published data on water wells completed in the Onondaga Formation and the Hamilton Group is provided below.

Reported depths of 228 domestic and non-domestic wells in the Onondaga Formation range from 35 to 500 feet bgs. The median well depth for 144 domestic and 24 non-domestic wells was 141 and 215 feet, respectively. Well yields ranged from 0 to 1,400 gallons per minute (gpm) with a median well yield of 10 gpm for domestic wells and 66 gpm for non-domestic wells. Water-bearing zones among 88 wells inventoried showed an even distribution to a depth of 300 feet. Approximately 25% of the wells drilled deeper than 300 feet penetrated water-bearing zones, with the deepest water-bearing zone being reported at 460 feet bgs (Taylor et al., 1982).

The depths of 243 domestic and non-domestic water supply wells in the Hamilton Group range from 10 to 695 feet bgs, with yields ranging from 1 to 380 gpm. The median well depth for domestic wells is 173 feet bgs and 300 feet bgs for non-domestic wells. The median well yield for domestic wells is 12 gpm and 38 gpm for non-domestic wells. Water-bearing zones among 198 wells inventoried are most frequent

from 50 to 350 feet bgs and are relatively common to a depth of 350 feet, with the deepest water-bearing zone being reported at 635 feet bgs (Taylor et al., 1982).

A water well records search of the Pennsylvania Groundwater Information System (PaGWIS, January 18, 2019) was completed with a search radius of 0.5-miles. No water well records were identified within the 0.5-mile search radius.

Other Sunoco subcontractors have researched private water supplies within 450 feet of the George Creek HDD in January 2019. No additional water wells were identified within the 450-foot radius of the alignment; however, four wells and one spring were identified between approximately 502 and 1,070 feet from the western entry/exit point of the HDD as shown on **Attachment 3**. No information pertaining to well depth, depth to water or well yield was reported.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces are natural linear features that are unaffected by local topographic relief and, as a result, are considered surface manifestations of concentrated high-angle bedrock fracturing. Fracture traces may be observed on aerial photographs as linear topography, straight stream segments, vegetation or soil tonal alignments. These linear features may be the surficial representation of deeper fractures, joints, faults or bedding planes within the subsurface which can transmit groundwater through the fractured bedrock aquifer at the site. Fracture traces underlying, or in close proximity to, the George Creek HDD were evaluated using historical aerial photographs from the years 1993 through 2016 (Google Earth, 2017), the Blairs Mills 7.5 Minute Quadrangle Geologic Maps (Berg and Dodge, 1981) and United States Geological Survey (USGS) Aughwick and Blairs Mills, PA 7.5 Minute Quadrangle Topographic Maps. The photographs, publications and maps were reviewed to approximate locations of natural linear fracture trace features or lineaments expressed on the ground surface.

Figures 2 and 3 show the results of the fracture trace analysis overlain on the geologic map of the site and an aerial base map. Thirteen fracture traces were identified within close proximity of the George Creek HDD that are likely related to the primary geologic structure of the area. Due to the nature of the ridges and folded geology near the site, the most prominent fracture traces trend approximately northeast-southwest (NE-SW). Perpendicular fracture traces were identified as approximately northwest-southeast (NW-SE) trending fracture lineaments which are presumed to be stress-related joint sets. None of the identified fracture traces cross the proposed 16-inch HDD bore path. General surface drainage patterns near the site are characterized by linear stream reaches trending NE-SW or NW-SE that reflect the local geologic structure.

5.0 GEOTECHNICAL EVALUATION

Two phases of geotechnical drilling investigation were performed at the site; the initial investigation was performed in October 2014 during the preliminary investigations of George Creek HDD and prior to initiating the 20-inch HDD operations. A second phase of geotechnical drilling was performed in September of 2017. The 2014 test borings were advanced by hollow-stem auger drilling methods to an approximate maximum depth of 30 feet bgs or until auger refusal. NQ-sized wireline rock coring methods were utilized in any borings continued past auger refusal. The 2014 borings are designated as SB-01, SB-02, and SB-03. The second phase (2017) of test drilling was completed using a combination of hollow-stem auger drilling and NQ-sized wireline rock coring methods. The boring completed in 2017 was

designated as B-01. Soil, residual soil and weathered bedrock collected during both investigations were sampled using split-spoon samplers. Geotechnical boring logs for both investigations are included in **Attachment 1**.

Borings SB-01 and SB-02 were located approximately 200 feet to the west and approximately 225 feet southeast of the western entry/exit of HDD S2-0155, respectively. Boring SB-03 was located approximately 350 feet east of the eastern entry/exit of HDD S2-0155. Boring B-01 was located approximately 170 feet south of the western entry/exit of HDD S2-0155. The locations of these borings are identified on **Figures 2 and 3**.

The generalized subsurface profile at the site, as observed in the borings, is described as follows:

- Soil and residual soil depths vary from boring to boring; 29.9 feet at SB-01, 15 feet at SB-02, 10.6 feet at SB-03, and 10.7 feet at B-01. The residual soils are described as follows:
 - **Boring S2-0155 SB-01:** Topsoil, silty/clayey fine to medium SAND (SC), silty CLAY (CL), with trace to some fine sand and trace gravel, weathered to partially weathered SHALE. The boring was completed to 29.9 feet bgs. Groundwater was not encountered in this boring.
 - **Boring S2-0155 SB-02:** Topsoil, decomposed bedrock consisting of fine SAND (SC) and silty clay, trace fine gravel, weathered fissile SHALE. Auger refusal occurred at 14.4 feet bgs. Groundwater was encountered at 11 feet bgs.
 - **Boring S2-0155 SB-03:** Topsoil, decomposed bedrock consisting of fine SAND (SC) with some silt and a little to some shale gravel, partially weathered SHALE. Auger refusal occurred at 10 feet bgs. Groundwater was encountered at 4 feet bgs.
 - **Boring B-01:** Medium dense, moist SANDSTONE fragments (GW-GM) with silt, dense, moist silty SAND (SM) with sandstone fragments, very dense, moist SANDSTONE (GP-GM) with sand and silt. Auger refusal occurred at 10.7 feet bgs and groundwater was encountered at 3.8 feet bgs.

- From the initiation of coring operations to the total depth of the NQ cores, weathered bedrock and bedrock were encountered and are described as follows:
 - **Boring SB-01:** Rock coring was not completed at this location.
 - **Boring SB-02:** SB-02 was completed to a total depth of 25 feet bgs. A highly fractured dark gray SHALE with trace calcite deposits was encountered from 15 to 25 feet bgs. Rock recoveries were between 52% and 67% and rock quality designations (RQD) were very poor (0%).
 - **Boring SB-03:** Rock coring was not completed at this location.
 - **Boring B-01:** B-01 was completed to a total depth of 130 feet bgs. From 10.7 to 27 feet bgs dark gray, very fine to fine grained, very thin to medium bedded, weathered to slightly weathered, soft to medium hard calcareous SANDSTONE with calcite veins and shale interbeds was observed. The sandstone was vertically bedded, fractured and broken from 12 to 14 feet bgs, was vertically fractured and bedded between 17 and 22 feet bgs and had nearly vertical fractures between 22 and 27 feet bgs. Rock recoveries ranged from 64 to 96%, and RQDs were very poor (0% to 18%). From 27 to 58 feet bgs dark gray, very fine grained, very thin- to thick-bedded, slightly weathered, medium to moderately hard SHALE interbedded with calcareous sandstone was observed. The SHALE was very broken between

27 and 29 feet bgs, with interbedded siltstone from 28 to 29 feet bgs, and was broken from 44.9 to 46 feet bgs. Vertical bedding was observed between 32 and 47 feet bgs, while fractures were present between 32 and 37 feet bgs. Rock recoveries ranged from 84 to 100%, and RQDs ranged from very poor (8%) to good (82%). The lowest RQD values were observed in the interval containing the section of very broken shale between 27 and 29 feet bgs. From 58 to 124 feet bgs dark gray very fine- to fine-grained, thin- to medium-bedded, slightly weathered, medium hard to very hard calcareous SANDSTONE with calcite veins and interbedded shale was observed. Vertical bedding and fractures were observed between 57 and 62 feet bgs and nearly vertical beds were encountered between 72 and 77 feet bgs. Calcite crystals were present between 62.9 to 63.2 feet bgs, while calcite crystals were observed in fractures at 76.4 to 76.6 and 94 to 95.5 feet bgs. Broken zones were encountered between 65 to 65.8 and 87.5 to 87 feet bgs. Rock recoveries ranged from 92 to 100%, and RQDs ranged from very poor (20%) to excellent (94%). The lowest RQD value was observed in the interval containing the section of vertical bedding and fractures (57 to 62 feet bgs). From 124 to 130 feet bgs dark gray, very fine-grained, very thin- to medium-bedded, slightly weathered, medium hard SHALE with hard calcite veining and interbedded sandstone was observed. Rock recoveries for this interval were 100% and RQDs ranged from fair to good (66% to 83%). Groundwater was observed at 4.5 feet bgs at the completion of coring operations.

Unconfined compressive strength testing was performed on core samples, and the results are summarized in the table below.

Boring	Sample Depth (feet bgs)	Compressive Strength (tons per square foot)
B-01	39	86.69
B-01	47	102.28
B-01	56.3	74.64
B-01	77	313.93
B-01	87.8	276.14
B-01	97.3	383.32
B-01	107	237.40
B-01	117.8	500.54
B-01	127.5	214.11

Please note Skelly and Loy or RETTEW did not oversee or direct the geotechnical drilling program associated with the HDD S2-0155 including, but not limited to, the selection of boring locations and target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other SPLP contractors. Skelly and Loy and RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework included in this report.

6.0 GEOPHYSICAL SURVEY CONSIDERATIONS

No karst geology was observed during the field reconnaissance, mapped as being present at this HDD location, no carbonate bedrock was observed in the geotechnical borings, and no evidence of subsidence was observed during the completion of the 20-inch HDD. Based on the lack of karst geologic features, and lack of thick carbonate sequences at the depths anticipated for the proposed 16-inch HDD, the use of geophysical surveys during re-evaluation was considered but was ultimately not implemented at the George Creek HDD location. Therefore, the results of geophysical surveys would be unlikely to enhance the evaluation or provide additional information that would reduce the risk of an IR.

7.0 FIELD OBSERVATIONS

RETTEW staff were on-site during HDD activities for the 20-inch pipe, which began on October 31, 2017. On November 8, 2017, as the pilot hole was being completed an IR occurred at an approximate trajectory length of 60 feet from the eastern entry/exit point and 19.2 feet bgs. The occurrence of IRs in the vicinity of an HDD entry or exit point is not uncommon. Approximately 20 gallons of drilling fluid was released to the ground surface. Some of the fluid released flowed into wetland K68 PEM. This IR was classified as a “punch out” IR and following the containment and cleanup of the released drilling fluids, drilling resumed, with the pilot hole completed on November 8, 2017. The 20-inch ream pass was started on November 9, 2017 and completed on November 25th, 2017. Similar to the completion of the pilot hole, there was a “punch out” IR as the 20-inch ream pass was being completed with the reamer located approximately 20 feet from the exit point. No drilling fluids or cuttings left the limits of disturbance or impacted any Waters of the Commonwealth. The 30-inch ream pass began on November 29, 2017 and was completed on December 6, 2017. The 20-inch product pipe was successfully pulled through on December 8, 2017. The 16-inch pilot boring was started on December 12, 2017 and had reached a trajectory length of 658.9 feet when drilling was stopped for the holiday break and never resumed as a result of the January 3, 2018 project-wide shut down ordered by the Pennsylvania Department of Environmental Protection.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL AND CONCLUSION

Based on published geologic and hydrogeologic information, geotechnical investigation results, and field observations during completion of the 20-inch HDD and pipe installation, the George Creek HDD location is underlain by carbonate and clastic sedimentary rocks of the Onondaga Formation and Hamilton Group. The hydrogeologic setting is dominated by groundwater flow that occurs in secondary openings formed along geologic features that include bedding planes, joints, and fractures. These secondary openings may be enlarged or enhanced to some degree by dissolution of any carbonate rocks.

The originally designed 16-inch HDD profile was relatively shallow at the eastern and western entry/exit points compared to the land surface, wetlands (K-68PEM, K-68PSS-1, and K-68PFO-1), and surface streambeds (S-K93 and S-K 91) and passed through both soil overburden and fractured bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and geologic information obtained and utilized during installation of the 20-inch HDD, HDD S2-0155 is susceptible to the IR of drilling fluids during HDD operations. As a result, the proposed 16-inch HDD profile was redesigned to a depth greater than the as-built 20-inch HDD bore path to allow for a deeper crossing beneath the identified streams and wetlands. The revised profile is approximately 75 feet (S-K93) and 74 feet (S-K91) below the streams and 44-45 feet below the wetlands (K-68PEM, K-68PSS-1, and K-68PFO-1) (this will be approximately 25 feet deeper than the 20-inch pipeline). The inclination of the entry and exit angles has been increased to allow the pipe to be installed through protective soils, residual soils, and bedrock, and in closer proximity to the entry and exit points than the original, shorter and

shallower profile. From a geologic perspective, the longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling BMPs, will be used to reduce the risk of an IR and/or a loss of drilling fluid. Drilling BMPs are described in the Horizontal Directional Drill Analysis component of the overall re-evaluation package.

9.0 REFERENCES

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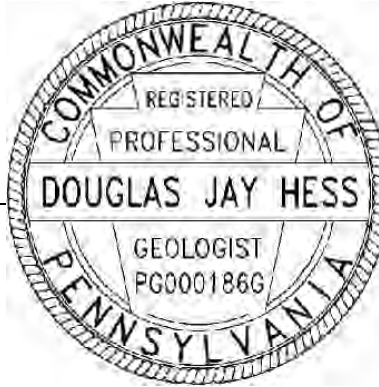
10.0 CERTIFICATION

The studies and evaluations presented in this report (other than Section 5.0) were completed under the direction of a licensed professional geologist (PG) and are covered under the PG seals that follow.

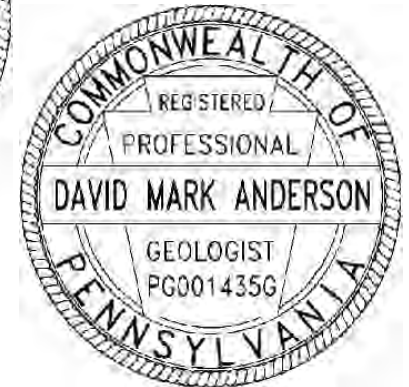
By affixing my seal to this document, I am certifying that, to my knowledge and belief, the information herein is true and correct. I further certify, that I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information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



Douglas J. Hess, PG
License No. PG000186G



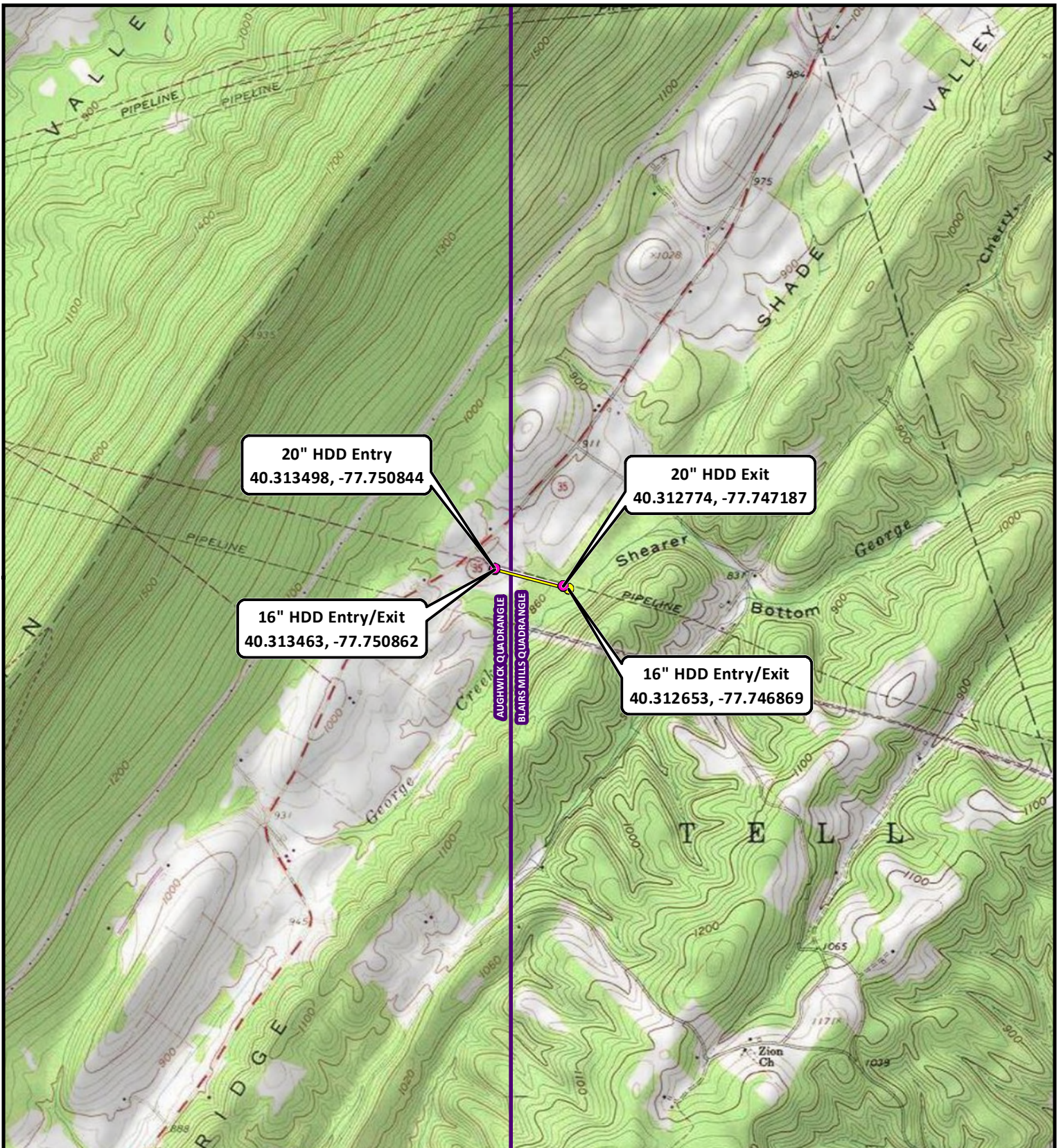
David M. Anderson, PG
License No. PG001435G



Enclosures

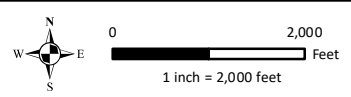
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FINAL.docx

FIGURES

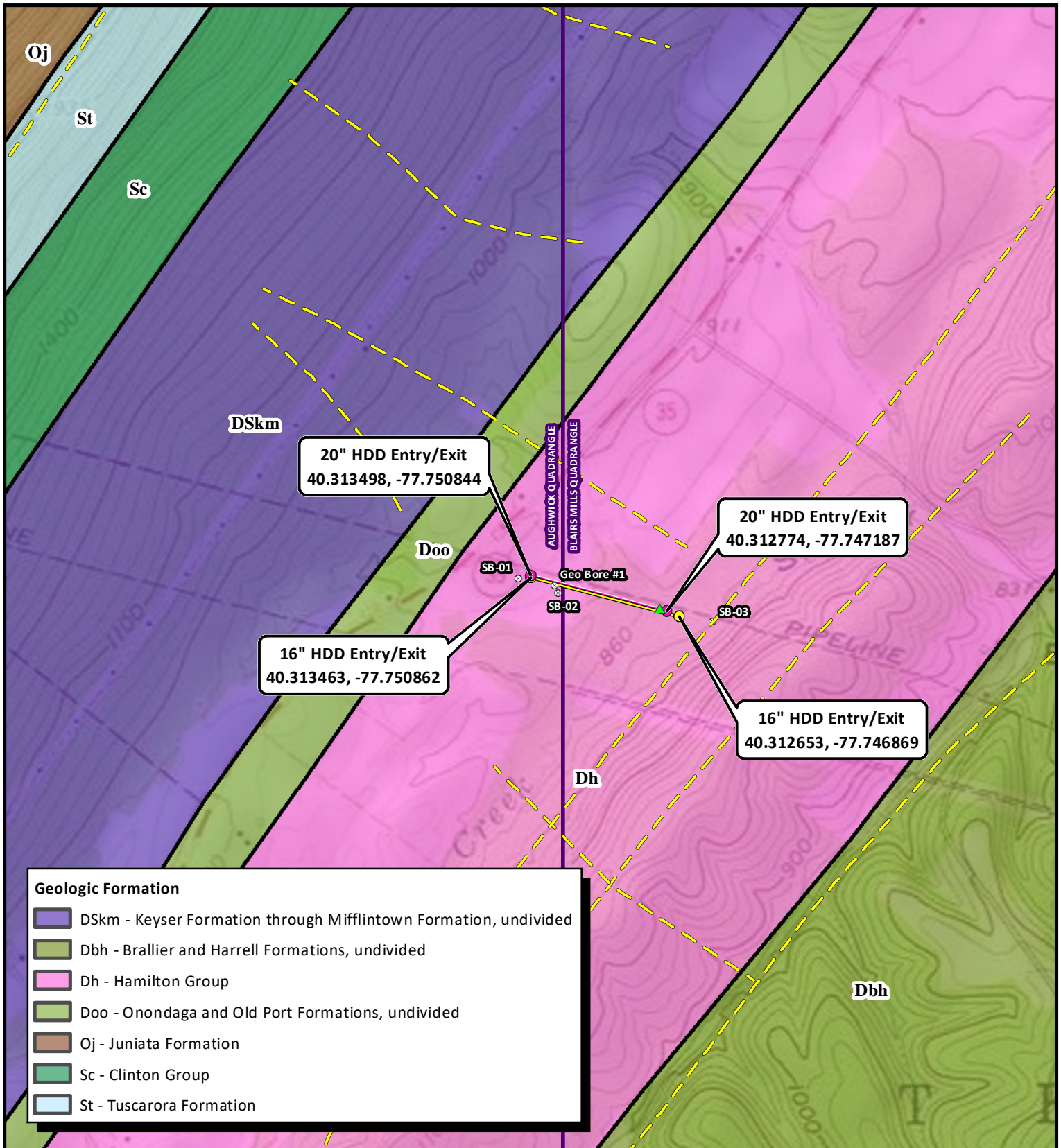


- 16" HDD Entry/Exit
- 20" HDD Entry/Exit
- 16" HDD Profile
- 20" HDD Profile

Sunoco Pipeline, L.P.
George Creek HDD Location
Figure 1 - Topographic Basemap
 Tell Township, Huntingdon County, PA
 Project No. 096302011



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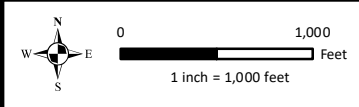


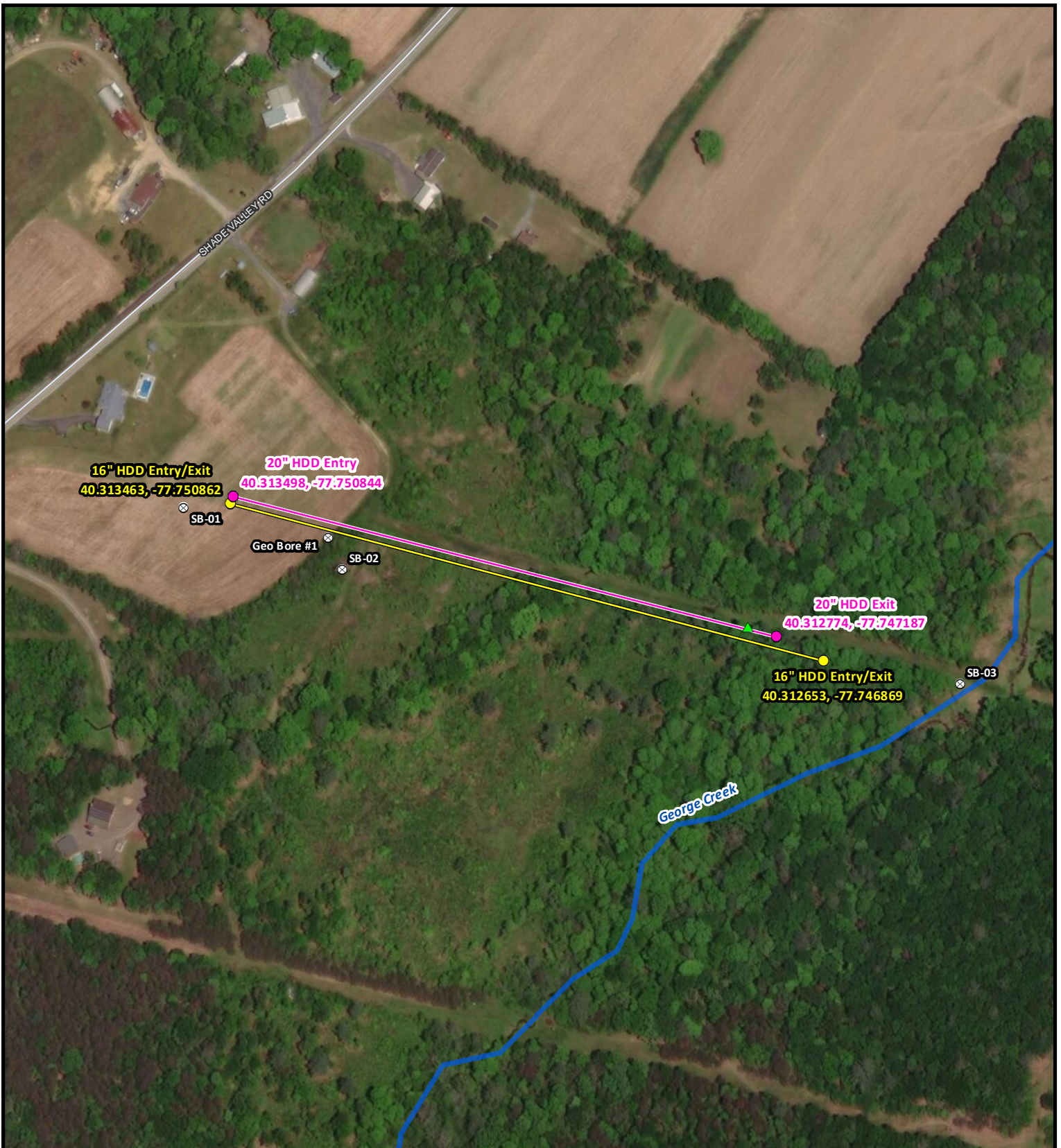
Geologic Formation









	DSkm - Keyser Formation through Mifflintown Formation, undivided
	Dbh - Brallier and Harrell Formations, undivided
	Dh - Hamilton Group
	Doo - Onondaga and Old Port Formations, undivided
	Oj - Juniata Formation
	Sc - Clinton Group
	St - Tuscarora Formation

	Inadvertent Return		16" HDD Profile
	Soil Boring		20" HDD Profile
	16" HDD Entry/Exit;		Inferred Fracture Trace
	20" HDD Entry/Exit		

Sunoco Pipeline, L.P.
George Creek HDD Location
Figure 2 - Geologic Map
 Tell Township, Huntingdon County, PA
 Project No. 096302011

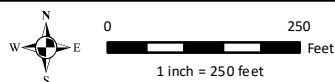




- | | | | |
|---|--------------------|---|-----------------|
|  | Inadvertent Return |  | 16" HDD Profile |
|  | Boring Location |  | 20" HDD Profile |
|  | 20" HDD Entry/Exit |  | NHD Stream |
|  | 16" HDD Entry/Exit |  | Road |

Sunoco Pipeline, L.P.
George Creek HDD Location
Figure 3 - Aerial Basemap

Tell Township, Huntingdon County, PA
 Project No. 096302011

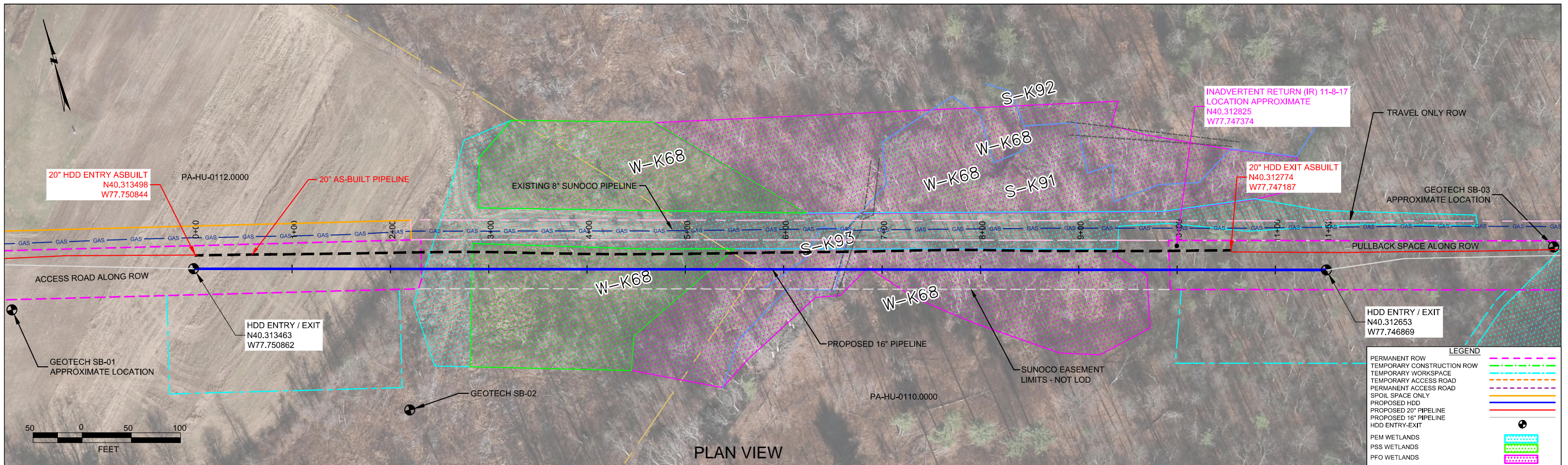


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



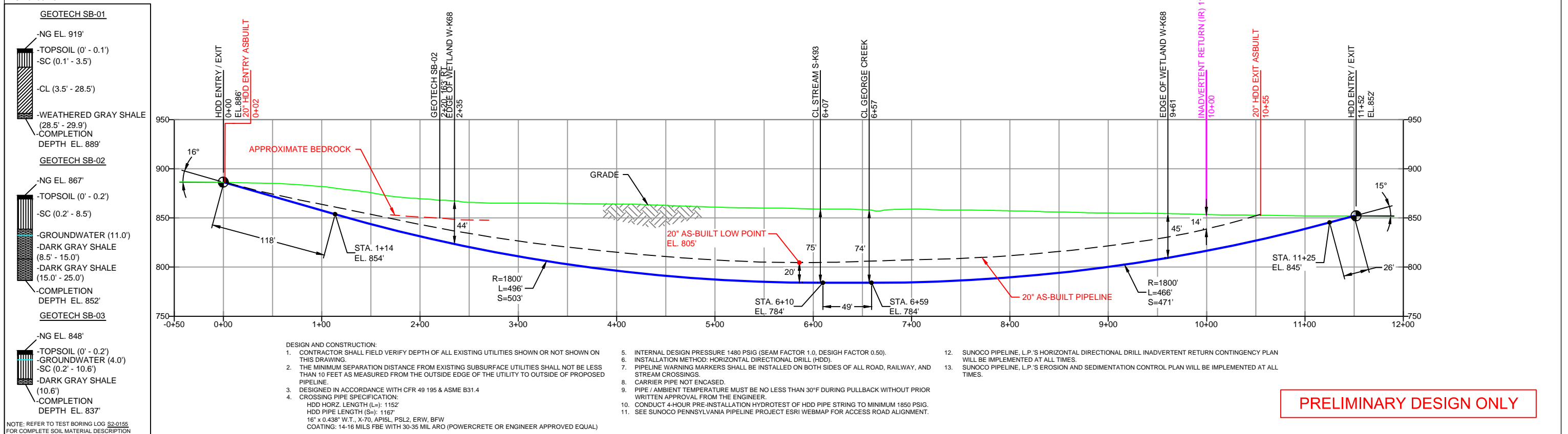


ATTACHMENT 1
HDD PROFILES AND GEOTECHNICAL BORING LOGS



PLAN VIEW
PROFILE VIEW

HUNTINGDON COUNTY PENNSYLVANIA, TELL TOWNSHIP
S2-0155-16



PRELIMINARY DESIGN ONLY

- 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-3.80	TO	ES-3.80	EROSION & SEDIMENT PLAN	EP3	DESIGN CHANGE - EXTENDED DRILL ENTRY/EXIT AND DEPTH	MRS	01/25/19	RMB	01/25/19	CAG	01/25/19
SHEET 48	TO	SHEET 49	AERIAL SITE PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
				EP1	REVISED PER PADEP COMMENTS	DLM	05/20/16	RMB	05/20/16	AAW	05/20/16
				EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
				B	ADDED GEOTECH INFO	MRS	09/14/15	RMB	09/14/15	AAW	09/14/15
				A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15
DWG NO	DWG NO	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE	

**Sunoco Logistics
Partners L.P.**

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GEORGE CREEK
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100' DWG. NO. PA-HU-0110.0000-SR-16



LEGEND:

⊙ Geotechnical Soil Boring (SB) Locations



GEOTECHNICAL BORING LOCATIONS
 HDD S2-0155
 HUNTINGDON COUNTY, TELL 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: 16410 SHADE VALLEY ROAD, BLAIRS MILLS, PA			Page 1 of 1		
HDD No.: S2-0155		Dates(s) Drilled: 10-13-14		Inspector: E. WATT	
Boring No.: SB-02		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 11.0		Total Depth (ft): 25.0	

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.2			TOPSOIL (2").						
1	3.0	5.0	0.2		12	SC	DR WEATHERED TO A VARIAGATED BROWN, GRAY, OR.BROWN FINE SAND AND SILTY CLAY, TRACE FINE GRAVEL.	3	10	11	10	21	
2	8.0	10.0	8.5		17		DARK GRAY WEATHERED FISSILE SHALE.	4	12	20	38	32	
3	13.0	13.9			10	ROCK	DARK GRAY WEATHERED FISSILE SHALE.	2	50/5"			>50	
4	14.4	15.0		15.0	4		DARK GRAY FISSILE SHALE.	12	50/1"			>50	
							AUGER REFUSAL AT 14.4'.						
							<u>ROCK CORING</u>						
RUN 1	15.0	20.0	15.0		31	ROCK	HIGHLY FRACTURED DARK GRAY SHALE, TRACE CALCITE DEPOSITS>	TCR: 52%, SCR: 0%, RQD: 0%					
RUN 2	20.0	25.0		25.0	40		HIGHLY FRACTURED DARK GRAY SHALE, TRACE CALCITE DEPOSITS>	TCR: 67%, SCR: 0%, RQD: 0%					
							WET TON SPOON AT 11'						
							WATER LEVELS THROUGH AUGERS AT 12.5'						
							CAVED AT 14'.						

Notes/Comments: Pocket Pentrometer Testing DR: DECOMPOSED ROCK

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.

N: Number of blows to drive spoon from 6" to 18" interval.



TETRA TECH

240 Continental Drive, Suite 200
 Newark, Delaware 19713
 302.738.7551
 fax: 302.454.5988

TEST BORING LOG

Project Name: SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406		
Project Location: 16410 SHADE VALLEY ROAD, BLAIRS MILLS, PA			Page 1 of 1		
HDD No.: S2-0155		Dates(s) Drilled: 10-13-14		Inspector: E. WATT	
Boring No.: SB-03		Drilling Method: SPT - ASTM D1586		Driller: S. HOFFER	
Drilling Contractor: HAD DRILLING		Groundwater Depth (ft): 4.0		Total Depth (ft): 10.6	

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N	
	From	To	From	To									
			0.0	0.2			TOPSOIL (2").						
1	3.0	5.0	0.2		13	SC	DR WEATHERED TO A GRAY TO GRAYISH BROWN FINE SAND WITH SOME SILT AND A LITTLE SHALE GRAVEL (FISSILE).	1	8	17	20	25	
2	8.0	8.9			7		DR WEATHERED TO A GRAY TO GRAYISH BROWN FINE SAND WITH WITH SOME SILT AND SOME SHALE GRAVEL (FISSILE).	2	50/5"			>50	
3	10.0	10.6		10.6	4		PARTIALLY WEATHERED DARK GRAY SHALE.	2	50/1"			>50	
							AUGER REFUSAL AT 10'. SUBSEQUENTLY OFF-SET BORING 15' WEST AND CONTINUOUSLY AUGERED TO AUGER REFUSAL AT 6'.						
							WET ON SPOON AT 4'.						
							WATER LEVEL THRU AUGERS AT 5.5'						
							CAVED 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 S2-0155**

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, %	
S2-0155	SB-01	1	3.0	5.0	14.4	92.7	-	-	-	-
		2	8.0	10.0	14.7	90.5	38	21	17	CL
		4	18.0	20.0	14.5	69.2	-	-	-	-
		5	23.0	25.0	12.2	63.4	33	20	13	CL
		6	28.0	29.9	13.6	83.7	-	-	-	-
	SB-02	1	3.0	5.0	19.3	43.9	-	-	-	-
		2	8.0	10.0	7.2	14.4	-	-	-	-
		4	14.4	15.0	8.9	29.3	-	-	-	-
	SB-03	1	3.0	5.0	8.1	36.0	-	-	-	-
		2	8.0	8.9	11.1	23.2	-	-	-	-
		3	10.0	10.6	5.5	16.1	-	-	-	-

Notes:

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

**REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0155**

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
S2-0155	Campbell	SB-01	Onondaga Formation - Medium-gray calcareous shale; marine fossils; medium-gray argillaceous limestone of Selinsgrove Member at top	Rolling hills (ridge & valley)	Onondaga Formation	Shale-limestone		35-70	The Onondaga Formation consists of two members - the upper Selinsgrove Limestone and the lower calcareous Needmore Shale.
		SB-02	Mahantango Fm - gray, dark gray, brown, and olive laminated shale; siltstone; and very fine-grained sandstone or claystone containing marine fossils		Mahatango (aka Hamilton Group)	Shale-siltstone, laminated, fossiliferous			
		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.

**ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0155**

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					
S2-0155	SB-2	1	15	20	52	0	0	15	20	Moderate	Dolostone	Massive	Gray	Heavily fractured, steeply dipping bedding, approximately 45°
S2-0155	SB-2	2	20	25	67	0	0	20	25	Moderate	Dolostone	Massive	Gray to dark gray	Same as above, some slight calcite filling of fractures

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 No. 10 to No. 40 sieve (M) (2.00mm – 0.425mm)
	Fine (F) No. 40 to No. 200 sieve (0.425 – 0.074mm)
Silt/Clay	Less Than a No. 200 sieve (<0.074mm)

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</u> <u>Quality Designation</u> <u>(RQD), %</u>	<u>Rock</u> <u>Quality Descripti</u> <u>on</u>
0-25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

***N - Standard Penetration Resistance.** Driving a 2.0" O.D., 1-3/8" I.D. sampler a distance of 18 inches into undisturbed soil with a 140 pound hammer free falling a distance of 30.0 inches. The number of hammer blows to drive the sampler through each 6 inch interval is recorded; the number of blows required to drive the sampler through the final 12 inch interval is termed the Standard Penetration Resistance (SPR) N-value. For example, blow counts of 6/8/9 (through three 6-inch intervals) results in an SPR N-value of 17 (8+9).

Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

Major Divisions		Group Symbols	Typical Descriptions	Laboratory Classifications			
Coarse Grained Soils (More than half of material is larger than No. 200 sieve)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3 Not meeting C_u or C_c requirements for GW		
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines			
		Gravel with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below A Line or I_p less than 4	Limits plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols	
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above A line with I_p greater than 7		
	Sands (More than half of coarse fraction is smaller than No. 4 Sieve)	Clean sands (Little or no fines)	SW	Well graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6: $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3 Not meeting C_u or C_c requirements for SW		
			SP	Poorly graded sands, gravelly sands, little or no fines			
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures	Atterberg limits below A Line or I_p less than 4	Limits Plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols	
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above A line with I_p greater than 7		
		Determine Percentage of sand and gravel from grain size curve. Depending on Percentage of fines (fraction smaller than No. 200 sieve), coarse-grained soils are classified as follows: Less than 5 percent GW, GP, SW, SP More than 12 percent GM, GC, SM, SC 5 to 12 percent Borderline cases requiring dual symbols ⁽¹⁾					
		Major Divisions		Group Symbols	Typical Descriptions	For soils plotting nearly on A line use dual symbols i.e., $I_p = 29.5$, $w_L = 60$ gives CH-MH. When w_L is near 50 use CL-CH or ML-MH. Take near as ± 2 percent.	
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silt and clays (Liquid limit less than 50)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity				
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays				
		OL	Organic silts and organic silty clays of low plasticity				
	Silt and Clays (Liquid limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts				
		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.

Figure 1: Site Vicinity Plan

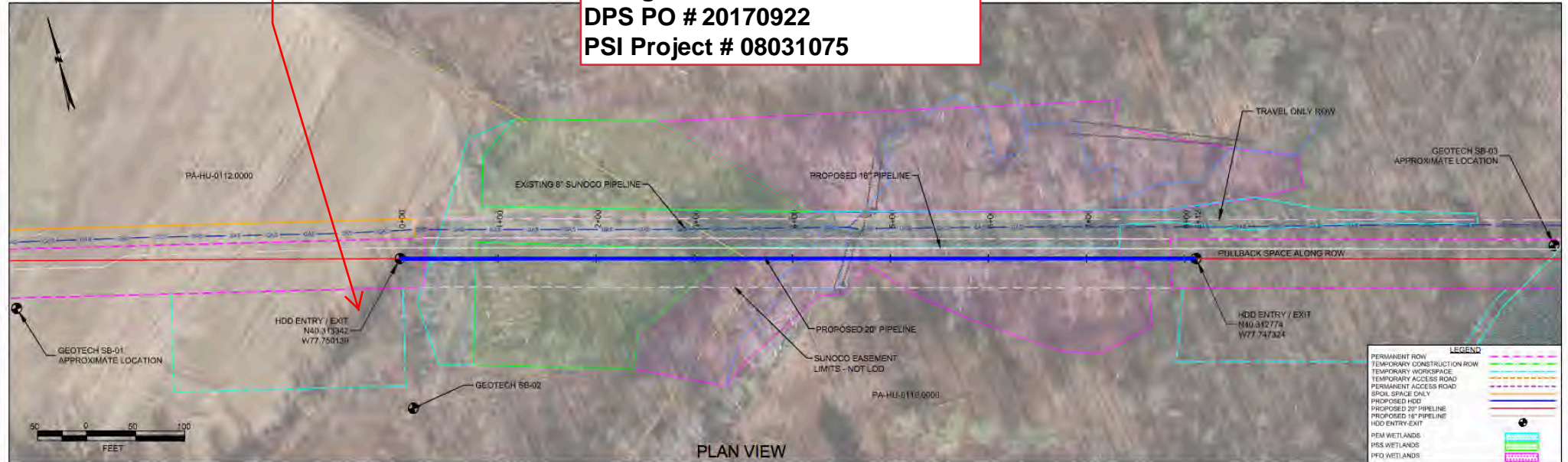
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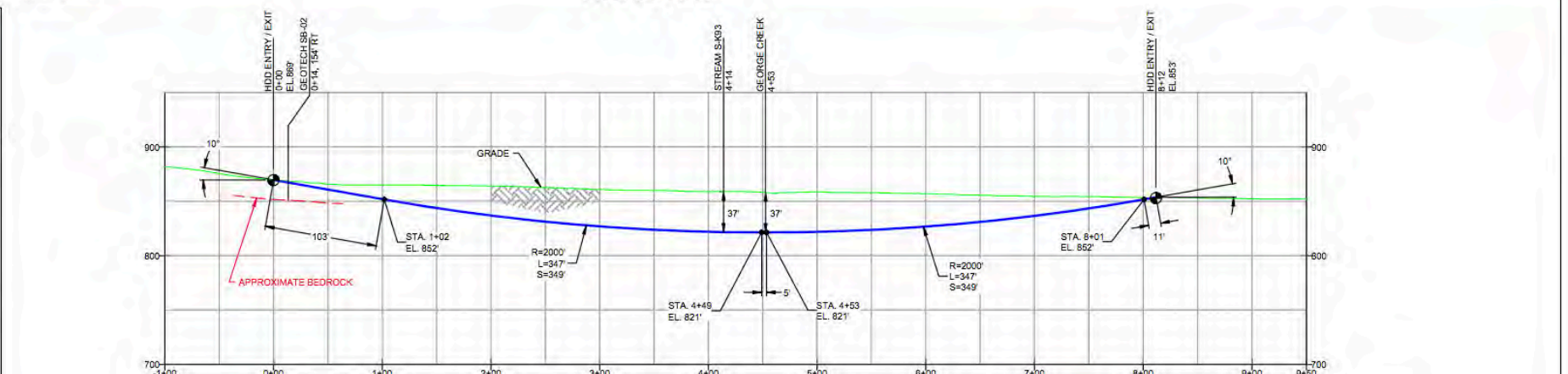
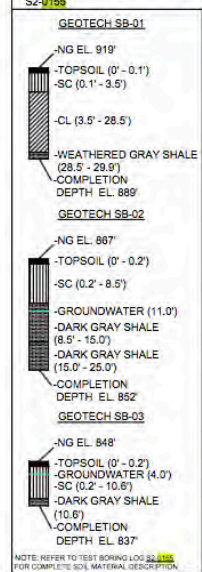


GEO BORE #1 (130 FT)

FIGURE 2: Boring Location Plan George Creek - PPP3 DPS PO # 20170922 PSI Project # 08031075



HUNTINGDON COUNTY PENNSYLVANIA, TELL TOWNSHIP S2-0155



NOTE: REFER TO TEST BORING LOG S2-0155 FOR COMPLETE SOIL MATERIAL DESCRIPTION

- NOTES**
- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
 - STATIONING IS BASED ON HORIZONTAL DISTANCES
 - ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, L.P. 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, L.P. 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 1-800-266-7440.

- 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) 812'
 HDD PIPE LENGTH (S) 817'
 20" x 0.456" W.T., 3.66 ANGLE, PS12, ERW, RWV COATING: 14-18 MILS FBE WITH 30 35 MIL AND (POWDERCOAT OR ENGINEER APPROVED EQUAL)
- INSTALLATION**
- 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 ESR: WSBMAP 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

REVISIONS		BY	DATE	CHK	DATE	APP	DATE
3	REVISED PROFILE WITH 2017 LIDAR	MRS	03/22/17	RMS	03/22/17	CAG	03/22/17
2	REVISED PER ENGINEERING COMMENTS	DLM	08/26/16	RMB	08/26/16	AAW	08/26/16
1	ADDED "TRAVEL ONLY ROW" ANNOTATION	MRS	02/18/16	RMB	02/18/16	AAW	02/18/16
6	ISSUED FOR CONSTRUCTION	MRS	12/22/15	RMB	12/22/15	AAW	12/22/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

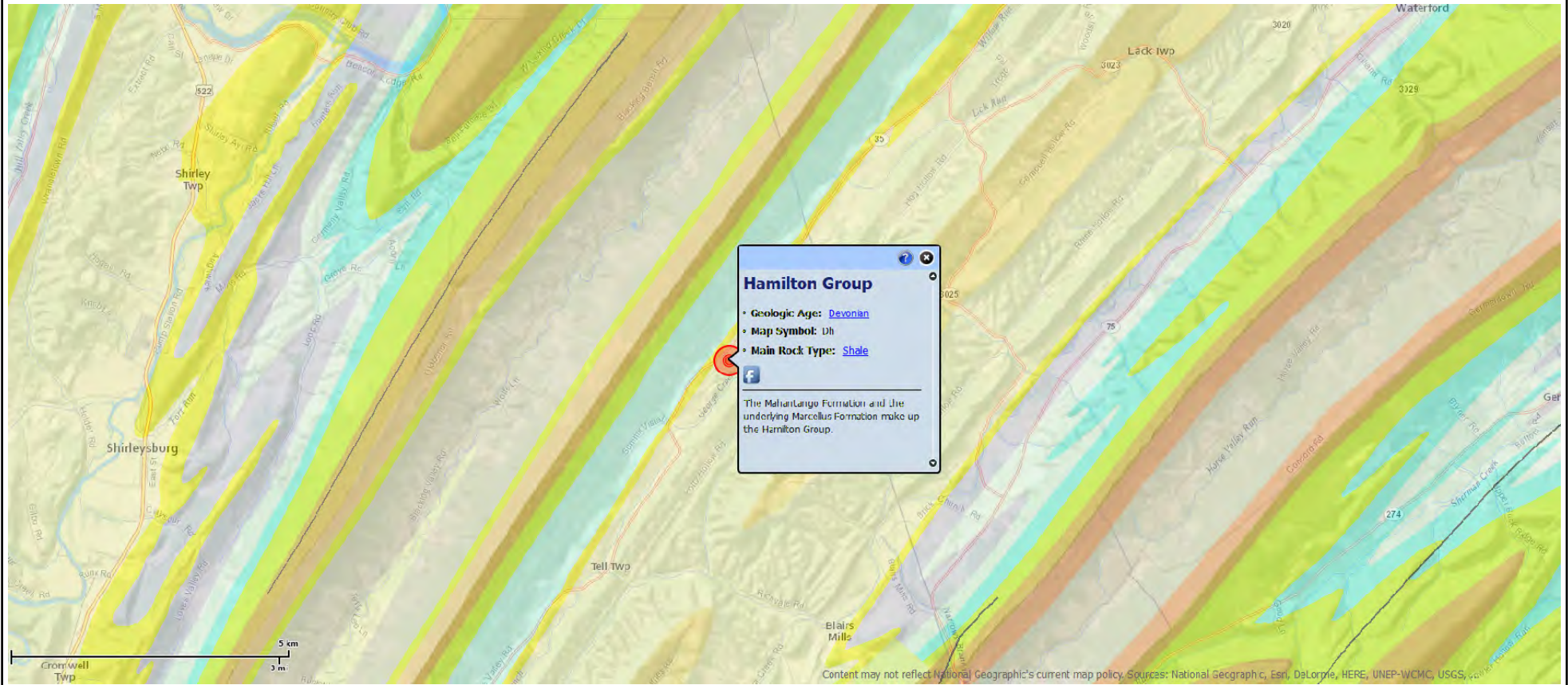
HORIZONTAL DIRECTIONAL DRILL
GEORGE CREEK
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100' DWG. NUMBER: PA-HU-0110.0000-SR

Figure 3: Site Geology Plan

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DATE STARTED: 9/26/17 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 9/28/17 **DRILLER:** D. Novotny **LOGGED BY:** K. Ebersole
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Diedrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 871 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: **HAMMER TYPE:** Automatic
LONGITUDE: **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette

BORING B-01

Water
 ▽ Pre-Core 3.8 feet
 ▽ Upon Completion 4.5 feet
BORING LOCATION:
 Refer to Boring Location Plan

REMARKS: Ground elevation estimated based on information contained on Google Earth

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 ⊙ × Moisture ⊠ PL ⊕ LL	STRENGTH, tsf ▲ Qu * Qp	Additional Remarks
870	0		S-1	17	17	RESIDUUM - Medium dense, moist, brown, SANDSTONE FRAGMENTS , with Silt	GW-GM	1-4-7-6 N=11	11	⊙		
865	5		S-2	24	24	RESIDUUM - Dense, moist, brown to gray, Silty SAND , with Sandstone Fragments S-2: Weathered layers	SM	8-18-27-43 N=45	18	×		Non-Plastic Fines=30.4%
860	10		S-3	6	6	WEATHERED ROCK - Very Dense, moist, dark gray, SANDSTONE , with Sand and Silt (Sampled as a Poorly Graded Gravel with Silt) Auger refusal encountered at approximately 10.7 feet	GP-GM	50/5"				>> ⊙ >> ⊙ 1 min.
855	15		R-1	14	14	BEDROCK - Dark gray, Calcareous SANDSTONE , very fine to fine grained, very thin to medium bedded, weathered to slightly weatherer, soft to medium hard (3-5), with calcite veins, shear dip, narrowly to moderately spaced discontinuity, interbedded with Shale R-1: Vertically fractured/broken Vertically bedded/fractured/broken from 12 to 14 feet		RQD=0 Rec=92%				>> ⊙ 2 min.
850	20		R-2	47	47			RQD=18 Rec=78%				>> ⊙ 3 min.
845	25		R-3	58	58	R-3: Vertically fractured/bedded		RQD=0 Rec=96%				>> ⊙ 2 min.
840	30		R-4	38	38	R-4: Near vertical fractures throughout		RQD=0 Rec=64%				>> ⊙ 2 min.
835	35		R-5	50	50	Very broken from 27 to 29 feet Siltstone interbedding from 28 to 29 feet		RQD=8				>> ⊙ 2 min. >> ⊙ 3 min. >> ⊙ 1 min. >> ⊙ 1 min.

Continued Next Page



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

PROJECT NO.: 08031075
PROJECT: George Creek PPP3 Pipeline Huntingdon Co.
LOCATION: Shade Valley Road
 Tell Township
 Huntingdon Co., PA

DATE STARTED: 9/26/17 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 9/28/17 **DRILLER:** D. Novotny **LOGGED BY:** K. Ebersole
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Diedrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 871 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: **HAMMER TYPE:** Automatic
LONGITUDE: **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette


BORING B-01

Water
 ▽ Pre-Core 3.8 feet
 ▼ Upon Completion 4.5 feet
BORING LOCATION:
 Refer to Boring Location Plan

REMARKS: Ground elevation estimated based on information contained on Google Earth

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				Additional Remarks
										N in blows/ft @				
840	30					BEDROCK - Dark gray, SHALE , very fine grained, very thin to thick bedded, slightly weathered, medium to moderately hard, with calcite veins, shear dip, narrowly to moderately spaced discontinuity, very steep to shear dip, bedding joint, interbedded with calcareous Sandstone		Rec=84%					1 min. 3 min.	
835	35		R-6	59		R-6: Vertically bedded/fractured		RQD=24 Rec=98%					>>⊙ 1 min. 3 min. 1 min.	
830	40		R-7	60		R-7: Vertical bedding		RQD=48 Rec=100%					>>⊙ 1 min. 2 min. 1 min. 2 min. 1 min.	
825	45		R-8	60		R-8: Vertical bedding Broken from 44.9 to 46 feet		RQD=74 Rec=100%					>>⊙ 1 min. 1 min. 1 min.	
820	50		R-9	59				RQD=46 Rec=98%					>>⊙ 1 min. 2 min. 1 min.	
815	55		R-10	60				RQD=82 Rec=100%					>>⊙ 1 min. 1 min.	
810	60		R-11	59		R-11: Vertical bedding/fractures		RQD=20					>>⊙ 1 min. 2 min. 1 min. 1 min.	

Continued Next Page

	Professional Service Industries, Inc.	PROJECT NO.: 08031075
	850 Poplar Street	PROJECT: George Creek PPP3 Pipeline Huntingdon Co.
	Pittsburgh, PA 15220	LOCATION: Shade Valley Road
	Telephone: (412) 922-4000	Tell Township
		Huntingdon Co., PA

DATE STARTED: 9/26/17 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 9/28/17 **DRILLER:** D. Novotny **LOGGED BY:** K. Ebersole
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Diedrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 871 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: **HAMMER TYPE:** Automatic
LONGITUDE: **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette

BORING B-01


Water
 ▽ Pre-Core 3.8 feet
 ▼ Upon Completion 4.5 feet
 ▽

BORING LOCATION:
 Refer to Boring Location Plan

REMARKS: Ground elevation estimated based on information contained on Google Earth

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				Additional Remarks		
										N in blows/ft ⊙						
										×	Moisture	■	PL			
												+	LL			
											STRENGTH, tsf					
											▲	Qu	*	Qp		
810	60					BEDROCK - Dark gray, Calcareous SANDSTONE , very fine to fine grained, very thin to medium bedded, slightly weathered, medium hard to very hard (4-9), with calcite veining, shear dip, closely to widely spaced discontinuity, moderate to shear dip bedding joint, interbedded with Shale Calcite crystals from 62.9 to 63.2 feet		Rec=98%							1 min.	
				R-12	60	Broken from 65 to 65.8 feet		RQD=42 Rec=100%							>> ⊙	1 min.
805	65														1 min.	
				R-13	60			RQD=94 Rec=100%							>> ⊙	1 min.
800	70														1 min.	
				R-14	60	R-14: Near vertical bedding		RQD=82 Rec=100%							>> ⊙	1 min.
795	75					Calcite crystals in fracture from 76.4 to 76.6 feet									1 min.	
				R-15	60			RQD=88 Rec=100%							>> ⊙	1 min.
790	80														1 min.	
				R-16	55			RQD=38 Rec=92%							>> ⊙	1 min.
785	85					Broken zone from 85.7 to 87 feet									2 min.	
				R-17	60			RQD=92							>> ⊙	1 min.
	90														1 min.	

Continued Next Page

	Professional Service Industries, Inc. 850 Poplar Street Pittsburgh, PA 15220 Telephone: (412) 922-4000	PROJECT NO.: 08031075 PROJECT: George Creek PPP3 Pipeline Huntingdon Co. LOCATION: Shade Valley Road Tell Township Huntingdon Co., PA
--	---	--

DATE STARTED: 9/26/17 **DRILL COMPANY:** Terra Testing, Inc.
DATE COMPLETED: 9/28/17 **DRILLER:** D. Novotny **LOGGED BY:** K. Ebersole
COMPLETION DEPTH: 130.0 ft **DRILL RIG:** Diedrich D-50 Track
BENCHMARK: N/A **DRILLING METHOD:** Hollow Stem Auger
ELEVATION: 871 ft **SAMPLING METHOD:** SS, 3' Centers
LATITUDE: **HAMMER TYPE:** Automatic
LONGITUDE: **EFFICIENCY:** N/A
STATION: N/A **OFFSET:** N/A **REVIEWED BY:** S. Simonette

BORING B-01

Water
 ▽ Pre-Core 3.8 feet
 ▼ Upon Completion 4.5 feet
 ▽
BORING LOCATION:
 Refer to Boring Location Plan

REMARKS: Ground elevation estimated based on information contained on Google Earth

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	
780						BEDROCK - Dark gray, Calcareous SANDSTONE , very fine to fine grained, very thin to medium bedded, slightly weathered, medium hard to very hard (4-9), with calcite veining, shear dip, closely to widely spaced discontinuity, moderate to shear dip bedding joint, interbedded with Shale Calcite veining/crystals in fractures from 94 to 95.5 feet	Rec=100%				1 min. 1 min. 1 min. 1 min. 1 min. 1 min. 1 min.
95			R-18	58	RQD=70 Rec=96%						>>⊕ 1 min.
775											3 min. >>▲ 1 min. 383.3 tsf 169.3 pcf 1 min.
100			R-19	60	RQD=74 Rec=100%						>>⊕ 1 min. 1 min.
770											2 min. 2 min. 1 min.
105			R-20	58	RQD=74 Rec=96%						>>⊕ 3 min. 2 min.
765											1 min. >>▲ 1 min. 237.4 tsf 166.4 pcf 1 min.
110			R-21	60	RQD=94 Rec=100%						>>⊕ 1 min. 2 min.
760											2 min. 3 min. 3 min.
115			R-22	56	RQD=80 Rec=94%						>>⊕ 1 min. 1 min.
755										2 min. >>▲ 1 min. 500.5 tsf 168.7 pcf 1 min.	
120			R-23	60	RQD=90					>>⊕	

Continued Next Page



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

PROJECT NO.: 08031075
PROJECT: George Creek PPP3 Pipeline Huntingdon Co.
LOCATION: Shade Valley Road
 Tell Township
 Huntingdon Co., PA

DATE STARTED: 9/26/17	DRILL COMPANY: Terra Testing, Inc.	BORING B-01
DATE COMPLETED: 9/28/17	DRILLER: D. Novotny LOGGED BY: K. Ebersole	
COMPLETION DEPTH: 130.0 ft	DRILL RIG: Diedrich D-50 Track	Water Pre-Core 3.8 feet
BENCHMARK: N/A	DRILLING METHOD: Hollow Stem Auger	Upon Completion 4.5 feet
ELEVATION: 871 ft	SAMPLING METHOD: SS, 3' Centers	BORING LOCATION: Refer to Boring Location Plan
LATITUDE:	HAMMER TYPE: Automatic	
LONGITUDE:	EFFICIENCY: N/A	
STATION: N/A OFFSET: N/A	REVIEWED BY: S. Simonette	
REMARKS: Ground elevation estimated based on information contained on Google Earth		

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
750	120					BEDROCK - Dark gray, Calcareous SANDSTONE , very fine to fine grained, very thin to medium bedded, slightly weathered, medium hard to very hard (4-9), with calcite veining, shear dip, closely to widely spaced discontinuity, moderate to shear dip bedding joint, interbedded with Shale		Rec=100%		X Moisture <input checked="" type="checkbox"/> PL <input checked="" type="checkbox"/> LL	1 min.
745	125		R-24	60	60	BEDROCK - Dark gray, SHALE , very fine grained, very thin to medium bedded, slightly weathered, medium hard (3-4), with hard calcite veining, shear dip, closely to widely spaced discontinuity, bedding joint, interbedded with Sandstone		RQD=66 Rec=100%		▲ Qu * Qp	1 min. 1 min. 1 min. 1 min. 1 min. 1 min.
			R-25	36	36			RQD=83 Rec=100%		>> @ >> @ >> @	2 min. 1 min. 1 min.
130						Boring terminated at approximately 130 feet					2 min.

	Professional Service Industries, Inc. 850 Poplar Street Pittsburgh, PA 15220 Telephone: (412) 922-4000	PROJECT NO.: 08031075
		PROJECT: George Creek PPP3 Pipeline Huntingdon Co.
		LOCATION: Shade Valley Road
		Tell Township Huntingdon Co., PA

PSI Project # 08031075 DATE 9/26/17

BORING B-1 Box 1 OF 9 DEPTH 0.0 FT TO 27.5 FT

SPREAD PPP # 3

HDD Common Name PA-HU-0110.0000 SR

RUN	DEPTH	REC	RQD
R-1	10.7 - 12.0	1.2'	0.0
R-2	12.0 - 17.0	3.9'	0.9
R-3	17.0 - 22.0	4.8'	0.0
R-4	22.0 - 27.0	3.2'	0.0
R-5	27.0 - 32.0	4.2'	0.4



PSI Project # 08031075 DATE 9/26/17
BORING B-1 BOX 2 OF 9 DEPTH 27.5 FT TO 42.8 FT
SPREAD PPP # 3
MDD Common Name PA-HU-0110,000 SR

RUN	DEPTH	REC	RQD
R-5	27.0' - 32.0'	4.2'	0.4'
R-6	32.0' - 37.0'	4.9'	1.2'
R-7	37.0' - 42.0'	5.0'	2.4'
R-8	42.0' - 47.0'	5.0'	3.7'



PSI Project # 08031075 DATE 9/27/11

BORING B-1 BOX 3 OF 9 DEPTH 42.8 FT. TO 55.4 FT.

SPREAD RPP # 13

HDD Common Name Pg-Hllr o11a 0000 SR

RUN	DEPTH	REC	RQD
R-8	42.0'-47.0'	5.0'	3.7'
R-9	47.0'-52.0'	4.9'	2.3'
R-10	52.0'-57.0'	5.0'	4.1'



PSI Project # 08031075 DATE 9/27/17

BORING B-1 Box 4 OF 9 DEPTH 55.4 FT TO 69.1 FT

SPRED PPP # 3

HDD Common Name PA-HU-0110.0000 SR

R/W	DEPTH	REC	RQD
R-10	52.0' - 57.0'	5.0'	4.1'
R-11	57.0' - 62.0'	4.9'	1.0'
R-12	62.0' - 67.0'	5.0'	2.1'
R-13	67.0' - 72.0'	5.0'	4.7'



PSI Project # 08031075 DATE 9/27/17
 Boring B-1 Box 5 OF 9 DEPTH 69.1 FT. TO 83.3 FT.
 SPREAD PPP # 3
 HDD Common Name PA-HU-0110.0000 SR

RUN	DEPTH	REC	RQD
R-13	67.0' - 72.0'	5.0'	4.7'
R-14	72.0' - 77.0'	5.0'	4.1'
R-15	77.0' - 82.0'	5.0'	4.4'
R-16	82.0' - 87.0'	4.6'	1.9'



PSI Project # 08031075 DATE 9/27/17
 Boring B-1 Box 6 of 9 DEPTH 83.3 FT. TO 98.6 FT.
 SPREAD PPP # 3
 HDD Common Name PA-HH-0110.0000 SR

RUN	DEPTH	REC	RQD
R-16	82.0' - 87.0'	4.6'	1.9'
R-17	87.0' - 92.0'	5.0'	4.6'
R-18	92.0' - 97.0'	4.8'	3.5'
R-19	97.0' - 102.0'	5.0'	3.7'



PSI Project # 08031075 DATE 9/28/17

BORING B-1 Box 7 of 9 DEPTH 98.6 FT. TO 113.2 FT

SPREAD PPP # 3

HDD Common Name PA-HU-0110.0000 SR

RUN	DEPTH	REC	RQD
R-19	97.0' - 102.0'	5.0'	3.7'
R-20	102.0' - 107.0'	4.8'	3.7'
R-21	107.0' - 112.0'	5.0'	4.7'
R-22	112.0' - 117.0'	4.7'	4.0'



RAFF
August 11/12/2008
1128
1128

Run Depth No. Feet

PSI Project # 08031075

DATE 9/28/07

BORING B-1 Box 8 OF 9

DEPTH 113.2 FT. TO 127.5 FT.

SPREAD PPP # 3

HDD Common Name PA-HU-0110.0000 SR

RUN	DEPTH	REC	ROD
R-22	112.0' - 117.0'	4.7	4.0'
R-23	117.0' - 122.0'	5.0'	4.5'
R-24	122.0' - 127.0'	5.0'	3.3'
R-25	127.0' - 130.0'	3.0'	2.5'



PSI Project # 08031075 DATE 9/28/17

BORING B-1 BOX 9 OF 9 DEPTH 127.5 FT. TO 130.0 FT.

SPREAD PPP # 3

HDD Common Name PA-HU-0110.0000 SR

RUN	DEPTH	REC	RQD
R-25	127.0-130.0	3.0	2.5

127.5

130.0



GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

- | | |
|---|---|
| SFA: Solid Flight Auger - typically 4" diameter flights, except where noted. | ☒ SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted. |
| HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted. | ■ ST: Shelby Tube - 3" O.D., except where noted. |
| M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry | ▮ RC: Rock Core |
| R.C.: Diamond Bit Core Sampler | ⬇ TC: Texas Cone |
| H.A.: Hand Auger | ☞ BS: Bulk Sample |
| P.A.: Power Auger - Handheld motorized auger | ☑ PM: Pressuremeter |
| | CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings |

SOIL PROPERTY SYMBOLS

- N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
- N₆₀: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
- Q_u: Unconfined compressive strength, TSF
- Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
- w%: Moisture/water content, %
- LL: Liquid Limit, %
- PL: Plastic Limit, %
- PI: Plasticity Index = (LL-PL),%
- DD: Dry unit weight, pcf
- ▼, ▼, ▼ Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS ANGULARITY OF COARSE-GRAINED PARTICLES

<u>Relative Density</u>	<u>N - Blows/foot</u>
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

<u>Description</u>	<u>Criteria</u>
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

<u>Component</u>	<u>Size Range</u>
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

<u>Description</u>	<u>Criteria</u>
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

<u>Descriptive Term</u>	<u>% Dry Weight</u>
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

<u>Q_u - TSF</u>	<u>N - Blows/foot</u>	<u>Consistency</u>
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

<u>Description</u>	<u>Criteria</u>
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

<u>Descriptive Term</u>	<u>% Dry Weight</u>
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

<u>Description</u>	<u>Criteria</u>	<u>Description</u>	<u>Criteria</u>
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick	Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick	Lensed:	Inclusion of small pockets of different soils
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing	Layer:	Inclusion greater than 3 inches thick (75 mm)
Slickensided:	Fracture planes appear polished or glossy, sometimes striated	Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
		Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

<u>Q_u - TSF</u>	<u>Consistency</u>
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

<u>Description</u>	<u>Criteria</u>
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

<u>Voids</u>	<u>Void Diameter</u>
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

<u>Component</u>	<u>Size Range</u>
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

<u>Rock Mass Description</u>	<u>RQD Value</u>
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.

Degree of Brokenness

<u>Characteristic</u>	<u>Description</u>
Less than 1 inch	Very Broken
1 inch to 3 inches	Broken
3 inches to 6 inches	Slightly Broken
Greater than 6 inches	Massive

Highly Weathered: Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS	
			GRAPH	LETTER		
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES	
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES	
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES	
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES	
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES	
	FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS 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	
SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50				MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS	
				CH	INORGANIC CLAYS OF HIGH PLASTICITY	
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS	

Table 4-3 Hardness and unconfined compressive strength of rock materials

Hardness category	Typical range in unconfined compressive strength (MPa)	Strength value selected (MPa)	Field test on sample	Field test on outcrop
Soil*	< 0.60		Use USCS classifications	
Very soft rock or hard, soil-like material	0.60–1.25		Scratched with fingernail. Slight indentation by light blow of point of geologic pick. Requires power tools for excavation. Peels with pocket knife.	
Soft rock	1.25–5.0		Permits denting by moderate pressure of the fingers. Handheld specimen crumbles under firm blows with point of geologic pick.	Easily deformable with finger pressure.
Moderately soft rock	5.0–12.5		Shallow indentations (1–3 mm) by firm blows with point of geologic pick. Peels with difficulty with pocket knife. Resists denting by the fingers, but can be abraded and pierced to a shallow depth by a pencil point. Crumbles by rubbing with fingers.	Crumbles by rubbing with fingers.
Moderately hard rock	12.5–50		Cannot be scraped or peeled with pocket knife. Intact handheld specimen breaks with single blow of geologic hammer. Can be distinctly scratched with 20d common steel nail. Resists a pencil point, but can be scratched and cut with a knife blade.	Unfractured outcrop crumbles under light hammer blows.
Hard rock	50–100		Handheld specimen requires more than one hammer blow to break it. Can be faintly scratched with 20d common steel nail. Resistant to abrasion or cutting by a knife blade, but can be easily dented or broken by light blows of a hammer.	Outcrop withstands a few firm blows before breaking.
Very hard rock	100–250		Specimen breaks only by repeated, heavy blows with geologic hammer. Cannot be scratched with 20d common steel nail.	Outcrop withstands a few heavy ringing hammer blows but will yield large fragments.
Extremely hard rock	> 250		Specimen can only be chipped, not broken by repeated, heavy blows of geologic hammer.	Outcrop resists heavy ringing hammer blows and yields, with difficulty, only dust and small fragments.

Method used to determine consistency or hardness (check one):



Field assessment: _____ Uniaxial lab test: _____ Other: _____ Rebound hammer (ASTM D5873): _____

* See NEH631.03 for consistency and density of soil materials. For very stiff soil, SPT N values = 15 to 30. For very soft rock or hard, soil-like material, SPT N values exceed 30 blows per foot.

Laboratory Summary Sheet

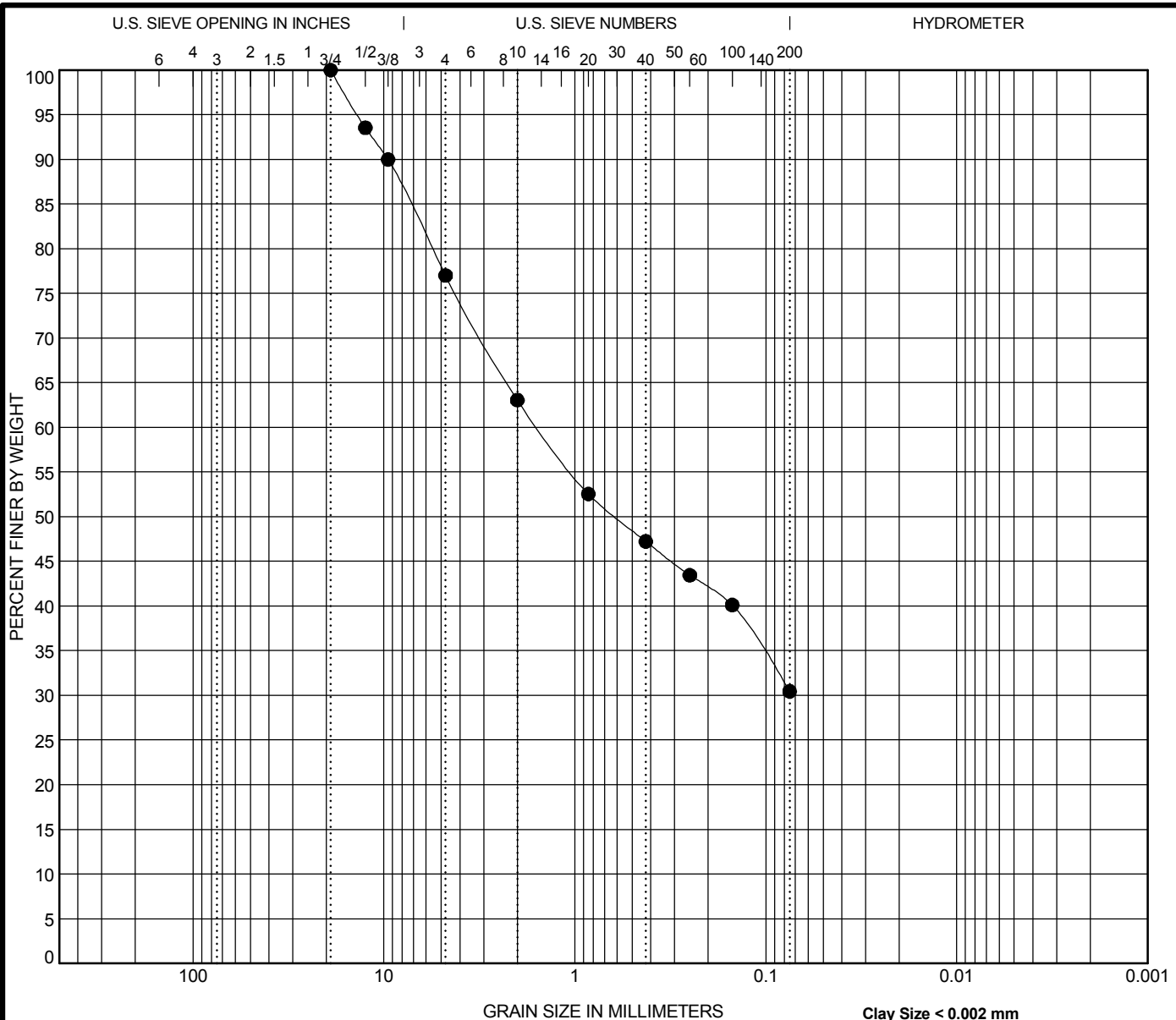
Sheet 1 of 1

Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Saturation (%)	Void Ratio
B-01	1							11			
B-01	6	0	0	0		30.4%		18			
B-01	39				86.69						
B-01	47				102.28						
B-01	56.3				74.64						
B-01	77				313.93						
B-01	87.8				276.14						
B-01	97.3				383.32						
B-01	107				237.40						
B-01	117.8				500.54						
B-01	127.5				214.11						



 Professional Service Industries
 850 Poplar Street
 Pittsburgh, PA 15220
 Telephone: (412) 922-4000
 Fax: (412) 922-4014

Summary of Laboratory Results


PSI Job No.: 08031075
 Project: George Creek PPP3 Pipeline Huntingdon Co.
 Location: Shade Valley Road
 Tell Township
 Huntingdon Co., PA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	LL	PL	PI	Cc	Cu
● B-01 6.0		NP	NP	NP		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-01 6.0	19	1.56			23.0	46.6	30.4	

 Professional Service Industries, Inc. 850 Poplar Street Pittsburgh, PA 15220 Telephone: (412) 922-4000 Fax: (412) 922-4014	GRAIN SIZE DISTRIBUTION	
	Project: George Creek PPP3 Pipeline Huntingdon Co. PSI Job No.: 08031075 Location: Shade Valley Road Tell Township	

Slake Test

08031075 B-1 R-3 18.0'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 7.68

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-5 27.6'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 5.55

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-7 37.0'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.14

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-9 46.7'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.45

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-11 57.8'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.15

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-13 67.5'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.45

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-14 76.6'



Start



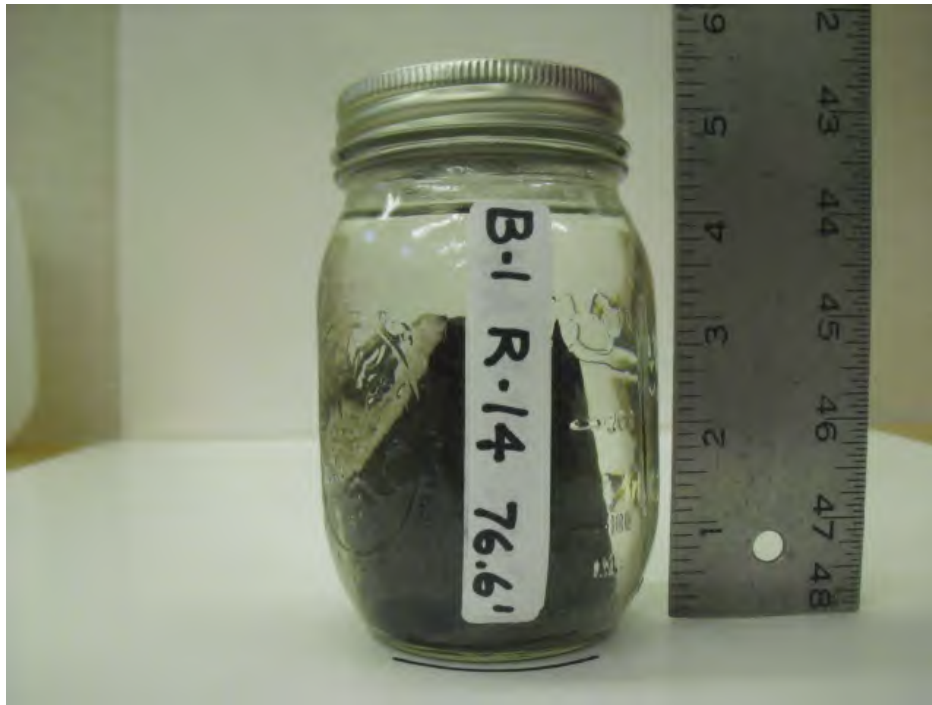
2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.57

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-15 77.6'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.52

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-17 87.5'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.59

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-19 97.0'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.43

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-21 107.5'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.65

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-23 117.2'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 4.96

Final Ph: 8.47

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions

Slake Test

08031075 B-1 R-25 127.2'



Start



2 Minute: Slake Index 6



4 Hour: Slake Index 6



8 Hour: Slake Index 6



24 Hour: Slake Index 6

Test date: October 5 & 6, 2017

Test Fluid: Distilled Water

Initial Ph: 5.01

Final Ph: 8.37

Slake Index Table

Jar Slake Index, Ij	General behavior during test
1	Degrades rapidly into a pile of flakes or mud
2	Breaks readily and/or forms many chips
3	Breaks slowly and/or forms few chips
4	Breaks rapidly and/or develops several fractures
5	Breaks slowly and/or develops few fractures
6	Very little or no change

Jar Slake Index Descriptions



ATTACHMENT 2
SOIL RESOURCES MAP AND PROFILE DESCRIPTIONS



United States
Department of
Agriculture



Natural
Resources
Conservation
Service

A product of the National
Cooperative Soil Survey,
a joint effort of the United
States Department of
Agriculture and other
Federal agencies, State
agencies including the
Agricultural Experiment
Stations, and local
participants

Custom Soil Resource Report for Huntingdon County, Pennsylvania

George Creek HDD — 16-inch Pipeline



Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

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scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

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identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

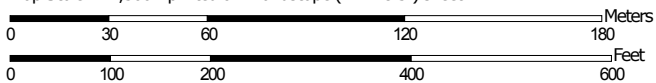
Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report Soil Map







































Map Scale: 1:2,300 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

- Area of Interest (AOI)**
-  Area of Interest (AOI)
- Soils**
-  Soil Map Unit Polygons
-  Soil Map Unit Lines
-  Soil Map Unit Points
- Special Point Features**
-  Blowout
-  Borrow Pit
-  Clay Spot
-  Closed Depression
-  Gravel Pit
-  Gravelly Spot
-  Landfill
-  Lava Flow
-  Marsh or swamp
-  Mine or Quarry
-  Miscellaneous Water
-  Perennial Water
-  Rock Outcrop
-  Saline Spot
-  Sandy Spot
-  Severely Eroded Spot
-  Sinkhole
-  Slide or Slip
-  Sodic Spot
-  Spoil Area
-  Stony Spot
-  Very Stony Spot
-  Wet Spot
-  Other
-  Special Line Features
- Water Features**
-  Streams and Canals
- Transportation**
-  Rails
-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads
- Background**
-  Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Huntingdon County, Pennsylvania
 Survey Area Data: Version 12, Sep 18, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 23, 2010—Mar 10, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
At	Atkins silt loam	6.3	68.3%
BrB	Brinkerton silt loam, 3 to 8 percent slopes	1.6	17.3%
WeB	Weikert channery silt loam, 3 to 8 percent slopes	1.3	13.9%
WeD	Weikert channery silt loam, 15 to 25 percent slopes	0.0	0.5%
Totals for Area of Interest		9.2	100.0%

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate

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pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Huntingdon County, Pennsylvania

At—Atkins silt loam

Map Unit Setting

National map unit symbol: 15yc
Elevation: 200 to 3,000 feet
Mean annual precipitation: 32 to 55 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Atkins and similar soils: 85 percent
Minor components: 14 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Atkins

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Acid alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 10 inches: silt loam
H2 - 10 to 30 inches: silt loam
H3 - 30 to 60 inches: gravelly silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 60 to 99 inches to lithic bedrock
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high
(0.06 to 2.00 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Minor Components

Philo

Percent of map unit: 6 percent
Hydric soil rating: No

Barbour

Percent of map unit: 6 percent
Hydric soil rating: No

Saprists

Percent of map unit: 2 percent
Landform: Depressions
Hydric soil rating: Yes

BrB—Brinkerton silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 15yv
Elevation: 300 to 3,000 feet
Mean annual precipitation: 30 to 65 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 217 days
Farmland classification: Not prime farmland

Map Unit Composition

Brinkerton and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brinkerton

Setting

Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Local fine-silty colluvium derived from sedimentary rock

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 18 inches: silty clay loam
H3 - 18 to 46 inches: silty clay loam
H4 - 46 to 65 inches: channery silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 15 to 34 inches to fragipan
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None

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Available water storage in profile: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4w

Hydrologic Soil Group: D

Hydric soil rating: Yes

Minor Components

Ernest

Percent of map unit: 10 percent

Hydric soil rating: No

Laidig

Percent of map unit: 5 percent

Landform: Mountains

Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Lower third of mountainflank

Down-slope shape: Concave

Across-slope shape: Concave

Hydric soil rating: No

Berks

Percent of map unit: 5 percent

Landform: Ridges, valleys

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Convex, linear

Across-slope shape: Convex, linear

Hydric soil rating: No

Atkins

Percent of map unit: 3 percent

Landform: Flood plains

Down-slope shape: Concave

Across-slope shape: Concave

Hydric soil rating: Yes

Philo

Percent of map unit: 2 percent

Hydric soil rating: No

WeB—Weikert channery silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v4vr

Elevation: 360 to 1,700 feet

Mean annual precipitation: 37 to 50 inches

Mean annual air temperature: 47 to 56 degrees F

Frost-free period: 148 to 192 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Weikert and similar soils: 85 percent

Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Weikert

Setting

Landform: Ridges

Landform position (two-dimensional): Backslope, shoulder

Landform position (three-dimensional): Nose slope

Down-slope shape: Convex

Across-slope shape: Convex

Parent material: Gray and brown acid residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

Ap - 0 to 7 inches: channery silt loam

Bw - 7 to 14 inches: very channery silt loam

C - 14 to 18 inches: extremely channery silt loam

R - 18 to 28 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Natural drainage class: Somewhat excessively drained

Runoff class: Low

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)

Available water storage in profile: Very low (about 1.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: D

Other vegetative classification: Droughty Shales (SD2)

Hydric soil rating: No

Minor Components

Berks

Percent of map unit: 9 percent

Landform: Ridges

Landform position (two-dimensional): Summit, shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Convex

Across-slope shape: Convex, linear

Hydric soil rating: No

Bedington

Percent of map unit: 5 percent

Landform: Hillslopes, hills

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Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Brinkerton

Percent of map unit: 1 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Concave
Hydric soil rating: Yes

WeD—Weikert channery silt loam, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: 2v4vs
Elevation: 340 to 4,040 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 47 to 56 degrees F
Frost-free period: 148 to 192 days
Farmland classification: Not prime farmland

Map Unit Composition

Weikert and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Weikert

Setting

Landform: Ridges
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Gray and brown acid residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

A - 0 to 6 inches: channery silt loam
Bw - 6 to 12 inches: very channery silt loam
C - 12 to 15 inches: extremely channery silt loam
R - 15 to 25 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Somewhat excessively drained

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Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high
(0.06 to 6.00 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)

Available water storage in profile: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6e

Hydrologic Soil Group: D

Other vegetative classification: Droughty Shales (SD3)

Hydric soil rating: No

Minor Components

Berks

Percent of map unit: 9 percent

Landform: Ridges

Landform position (two-dimensional): Summit, shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Convex

Across-slope shape: Convex, linear

Hydric soil rating: No

Ernest

Percent of map unit: 3 percent

Landform: Hillslopes

Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Side slope

Down-slope shape: Concave

Across-slope shape: Linear

Hydric soil rating: No

Wharton

Percent of map unit: 2 percent

Landform: Ridges

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Interfluvial, side slope, head slope

Down-slope shape: Concave

Across-slope shape: Concave

Hydric soil rating: No

Hartleton

Percent of map unit: 1 percent

Landform: Ridges

Landform position (two-dimensional): Shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear, concave

Across-slope shape: Linear, concave

Hydric soil rating: No

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**ATTACHMENT 3
450-FOOT WELL SURVEY**

GES Well ID	Distance to HDD Perpendicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-02132018-634-03	1,070	1,070	Unknown	Unknown	Unknown
WL-20102018-617-01	756	756	Unknown	Unknown	Unknown
WL-02132018-634-02	502	502	Unknown	Unknown	Unknown
WL-01262018-611-01	750	750	Unknown	Unknown	Unknown
SP-02132018-634-01	843	843	Unknown	Unknown	Unknown

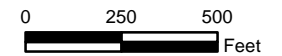
Legend

-  LOD
-  Parcel
-  PPP Centerline
-  HDD
-  450 foot buffer of HDD alignment

****Testing locations current as of 01/21/2019**

-  GES Testing Location
-  GES Spring Testing Location

Location



**Well Location Map
HDD# PA-HU-0110.0000-SR
Huntingdon County, PA.**

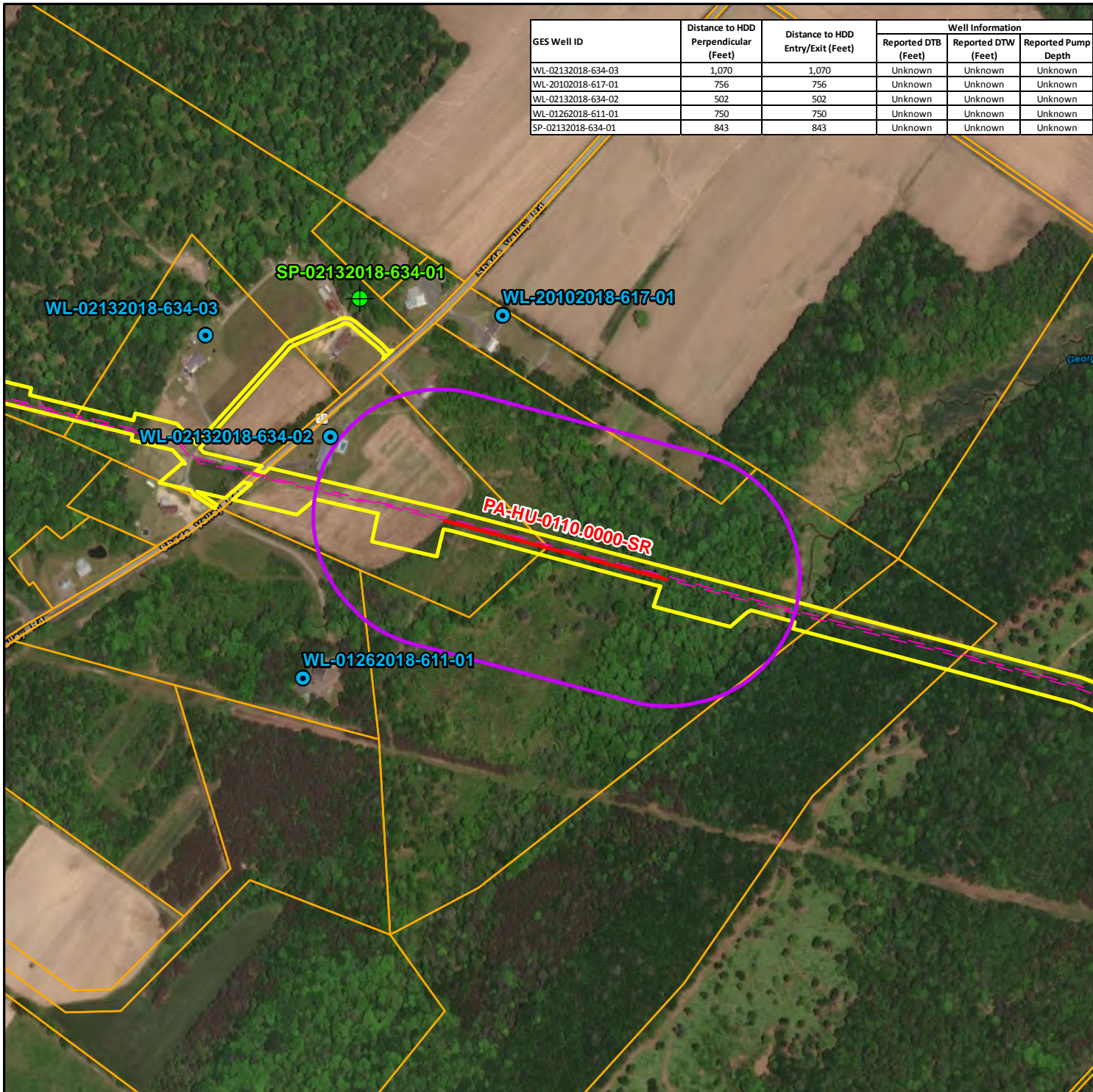
Prepared By:



Date:
1/21/2019

Base Map:
ESRI World Imagery, 09/24/2015

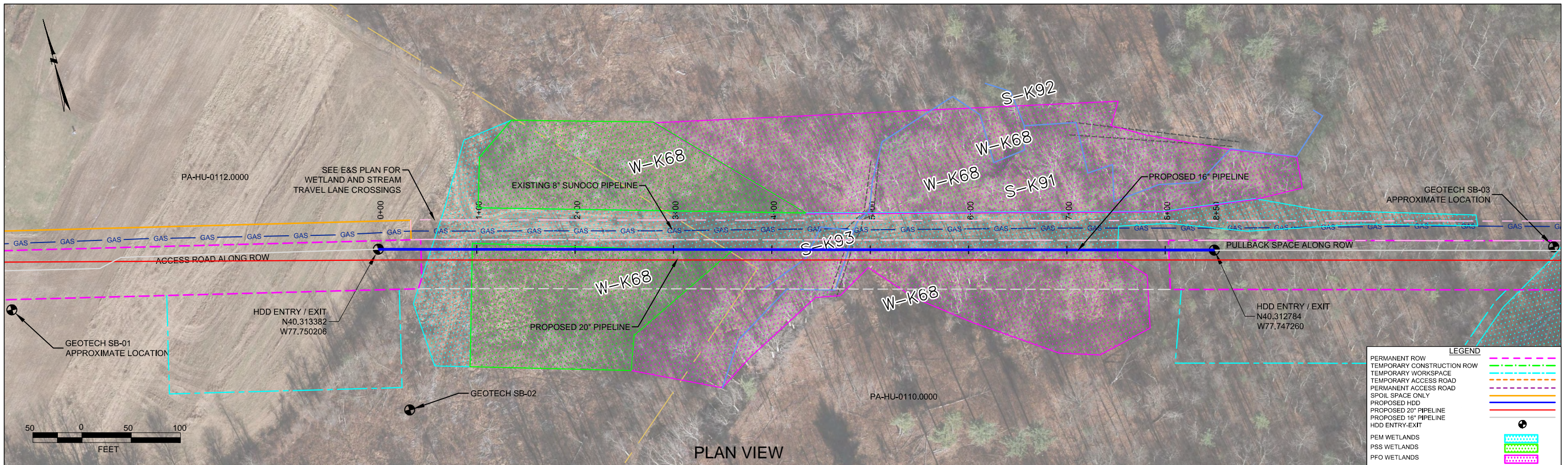
Coordinate System: NAD 83 Stateplane, PA South, Feet



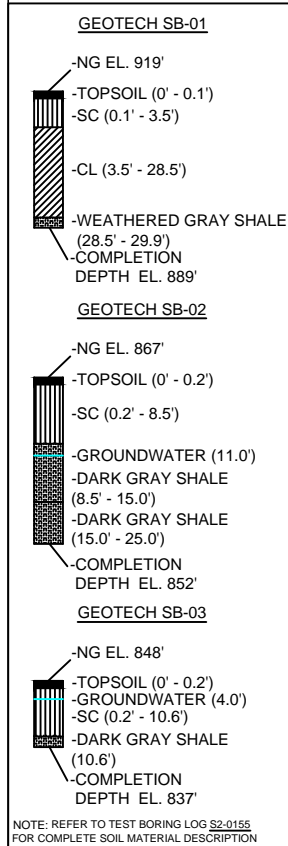
**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
CAMPBELL CREEK/GEORGE CREEK CROSSING
PADEP SECTION 105 PERMIT NO. E31-234
PA-HU-0110.0000-SR-16
(SPLP HDD# S2-0155-16)**

ATTACHMENT 2

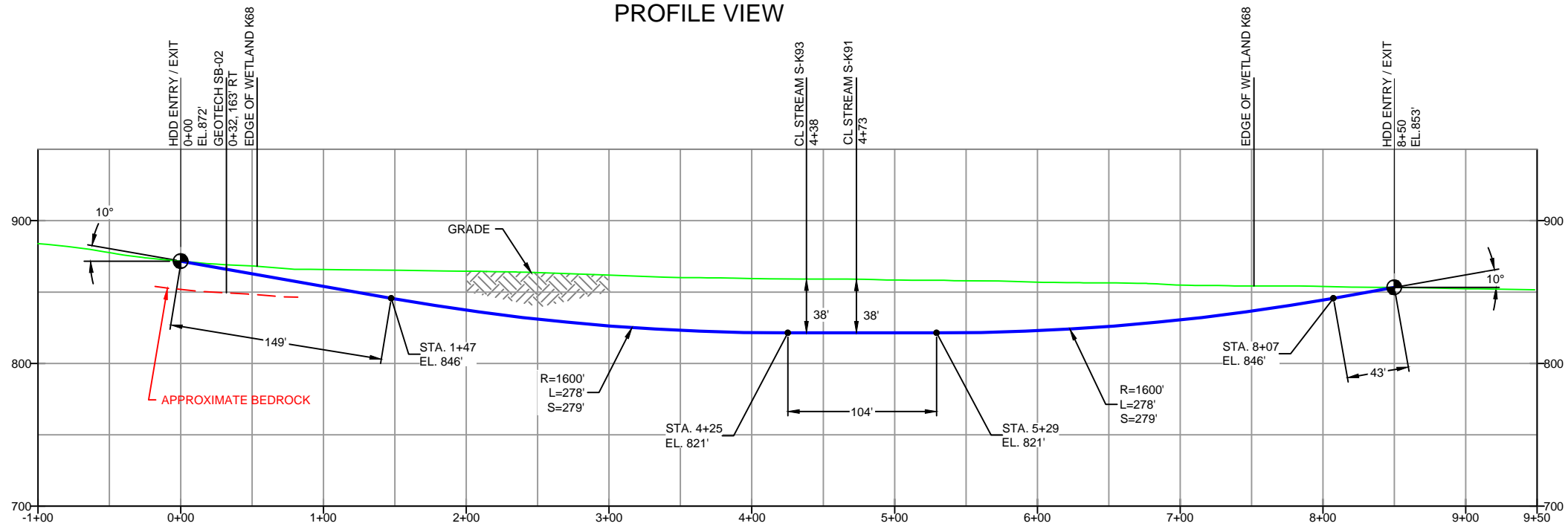
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



HUNTINGDON COUNTY PENNSYLVANIA, TELL TOWNSHIP
S2-0155-16



NOTE: REFER TO TEST BORING LOG S2-0155 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): 850'
HDD PIPE LENGTH (S): 854'
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.

Figure 1. Original Permitted 16-Inch HDD Plan and Profile

- 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-3.80	TO	ES-3.80	DESCRIPTION
SHEET 48	TO SHEET 49	EP2	REVISED PER 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.**

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
CAMPBELL CREEK
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100' DWG. NO: PA-HU-0110.0000-SR-16

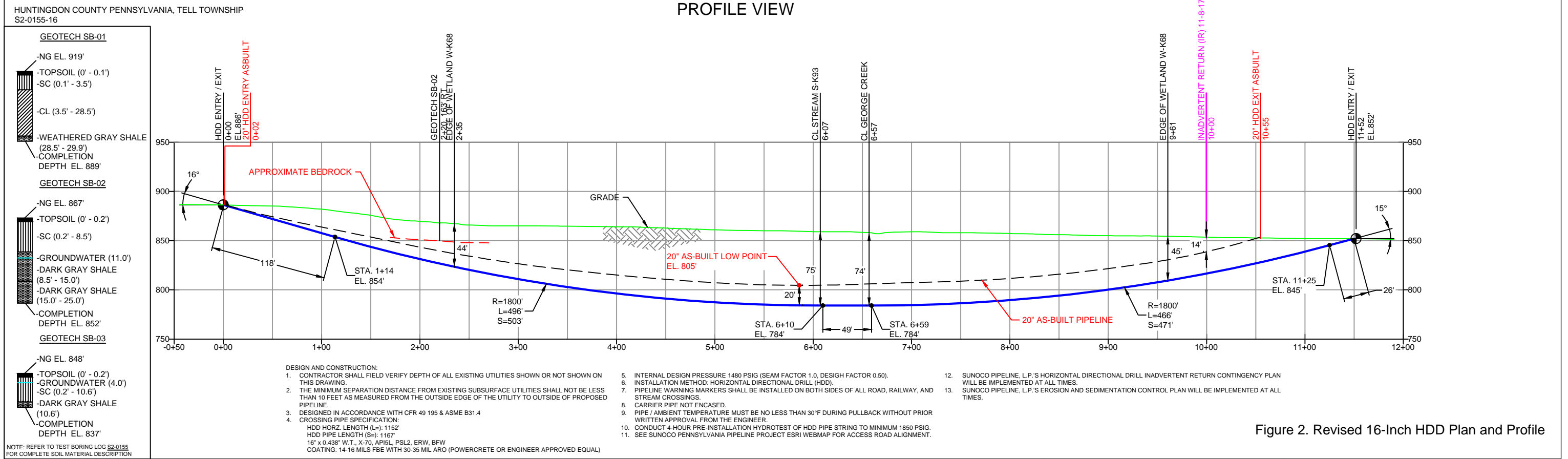
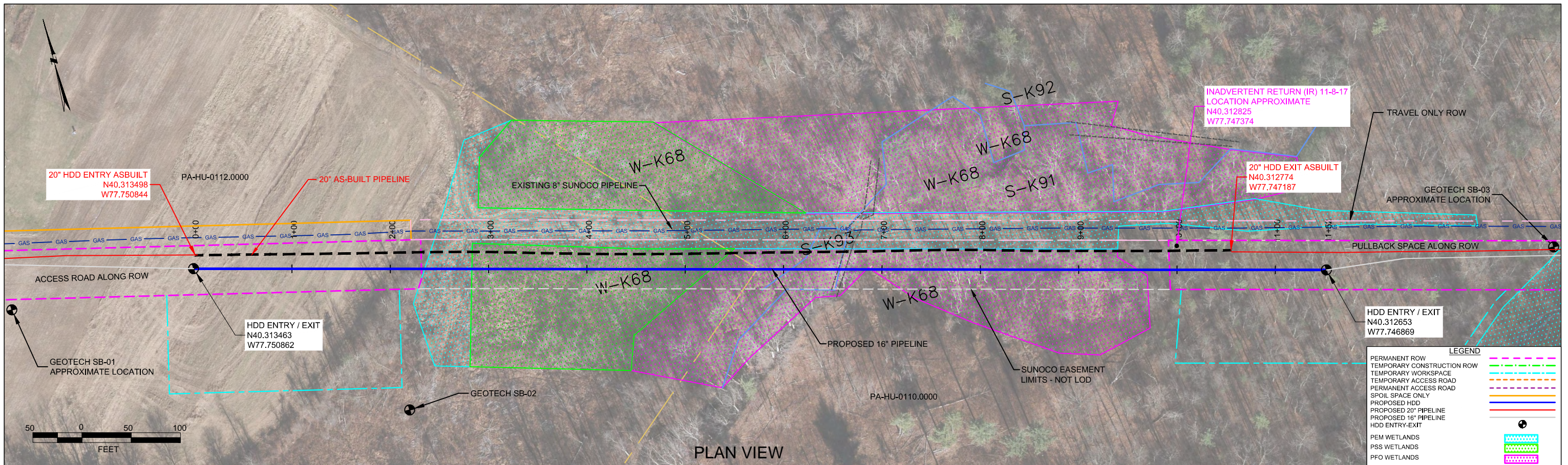


Figure 2. Revised 16-Inch HDD Plan and Profile

NOTES		REF. DRAWING		REVISIONS		SUNOCO PIPELINE, L.P.							
1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83 2. STATIONING IS BASED ON HORIZONTAL DISTANCES. 3. ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP ARE NOT RESPONSIBLE FOR LOCATION OF FOREIGN UTILITIES SHOWN IN PLOT PLAN OR PROFILE. THE INFORMATION SHOWN HEREON IS FURNISHED WITHOUT LIABILITY ON THE PART OF ROONEY ENGINEERING, INC. AND SUNOCO PIPELINE, LP. FOR ANY DAMAGES RESULTING FROM ERRORS OR OMISSIONS THEREIN. 4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING. 5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.		ES-3.80	TO ES-3.80	EROSION & SEDIMENT PLAN	EP3	DESIGN CHANGE - EXTENDED DRILL ENTRY/EXIT AND DEPTH	MRS	01/25/19	RMB	01/25/19	CAG	01/25/19	SUNOCO PIPELINE, L.P. HORIZONTAL DIRECTIONAL DRILL GEORGE CREEK PENNSYLVANIA PIPELINE PROJECT
		SHEET 48	TO SHEET 49	AERIAL SITE PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16	
					EP1	REVISED PER PADEP COMMENTS	DLM	05/20/16	RMB	05/20/16	AAW	05/20/16	DWG NO.
					EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16	DESCRIPTION
					B	ADDED GEOTECH INFO	MRS	09/14/15	RMB	09/14/15	AAW	09/14/15	NO.
					A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15	
		DWG NO.	DWG NO.	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE	

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY

 (303) 792-5911

SCALE: 1"=100' DWG. NO. PA-HU-0110.0000-SR-16