HORIZONTAL DIRECTIONAL DRILL ANALYSIS
HORSE VALLEY ROAD CROSSING
PADEP SECTION 105 PERMIT NO. E50-258
PA-PE-0002.0000-RD & PA-PE-0002.0000-RD-16
(SPLP HDD No. S2-0157)

HORSE VALLEY ROAD CROSSING
PADEP SECTION 105 PERMIT NO. E50-258
PA-PE-0002.0000-RD & PA-PE-0002.0000-RD-16
(SPLP HDD No. S2-0157)

This reanalysis for the horizontal directional drill (HDD) of the Sunoco Pipeline, LP (SPLP) 16-inch and 20-inch diameter pipeline crossing of stream L7, Wetlands L1 and L2, and Horse Valley Road in Toboyne Township, Perry County, is in accordance with Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L for HDDs listed on Exhibit 2 of the Stipulated Order. This HDD is number 12 on the list of HDDs included on Exhibit 2. This HDD was not initiated before the issuance of the Order.

PIPE INFORMATION

20-Inch: 0.456 wall thickness; X-65
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: 20-INCH

- Horizontal length: 1,557 foot (ft)
- Entry/Exit angle: 8-16 degrees
- Maximum Depth of cover: 50 ft
- Depth under Horse Valley Road: 14 ft
- Depth under stream: 23 ft
- Depth under wetlands: 10-50 ft
- Pipe design radius: 2,000 ft

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,597 ft
- Entry/Exit angle: 8-16 degrees
- Maximum Depth of cover: 52 ft
- Depth under Horse Valley Road: 17 ft
- Depth under stream: 24 ft
- Depth under wetlands: 10-50
- Pipe design radius: 1,600 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

The geology at this HDD location is mapped as the Martinsburg Formation of Ordovician age. The Martinsburg Formation consists of a buff-weathered, dark gray shale with thin interbeds of siltstone, metabentonite, and fine-grained sandstone. A brown-weathered, medium-grained sandstone with interbeds of shale and siltstone is found in the middle of the formation. The basal part of the formation is generally described as a limy shale and silty limestone but no evidence of this was observed near the Horse Valley HDD. This formation is described as well bedded with thick to massive bedding in the sandstone, and thin to fissile bedding in the limestone and shale. Bedrock fracturing occurs as irregularly spaced, open and nearly vertical joints. Cleavage is dominant and highly developed in the formation. The cleavage and joints provide a secondary porosity of low magnitude and low permeability. The Martinsburg is moderately weathered to a moderate depth, resulting in small to large platy fragments. The overlying mantle is thin. From an engineering standpoint, excavation of this formation is moderately easy in the shale and difficult in the sandstone. Foundation stability is good, provided the excavation is completed to sound material.

Drilling rates are described as fast. Cut slope stability is fair in the shale and good in the sandstone (Geyer and Wilshusen, 1982). Based on published mapping, Horse Valley lies within an anticline with the more resistant sandstones forming the ridges and less resistant shale forming the valley floor (Royer, 1984).

Based on published geologic data, no karst features are anticipated within the subsurface profile for this HDD; therefore, the use of geophysics assessments was not considered for this HDD.

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

The hydrogeologic setting of the Horse Valley Road HDD location is dominated by groundwater flow through secondary openings along geologic features including bedding planes, joints and fractures. This is supported by the observation of weathering, fractures, and joints in the geotechnical cores and identified outcrop. In addition, field measurements of local geologic structure support the published information and referenced vertical and near vertical joint sets. Joint openings are generally restricted to the first 100 to 200 feet below weathered bedrock and largely disappear at depths greater than 300 to 400 feet due to compression from the overlying material.

The yield of wells drilled in the shale is typically adequate for domestic supplies ranging from 1 to 15 gallons per minute (gpm) (Lohman, 1938). In these rock types of Perry County, water-bearing zones generally occur in the secondary openings along bedding planes, joints, faults and fractures (Lohman, 1938). At this location, the HDD is relatively perpendicular to the axial plane of the anticline with strata dipping away from the axial plane (likely northwest and southeast). Accordingly, local groundwater flow within Horse Valley is anticipated to migrate downdip within the bedrock along bedding and fracture planes from areas of higher elevation to lower elevations along the valley floor.

Limited well data is available relative to the Martinsburg Formation. The Reedsville Formation is considered to be a stratigraphic equivalent to the Martinsburg Formation. However, no data on the Reedsville Formation is available in Perry County (Royer, 1984). Accordingly, the following data is from the Reedsville Formation in Juniata County. The depths of 38 reported wells range from 31 to 435 feet below the ground surface (bgs) and yields ranging from 1 to 50 gallons per minute (gpm). The median depths for both domestic and nondomestic wells is 130 feet bgs. Median well yields are reported as 12 gpm for domestic wells and 20 gpm for non-domestic wells. Based on limited data, water-bearing zones are most abundant within 50 feet bgs to 150 feet bgs. Few water-bearing zones were reported below 200 feet bgs. The deepest water-bearing zone was reported at 350 feet bgs (Taylor, 1982). Groundwater was encountered in geotechnical borings at the Horse Valley HDD at depth ranging from 8.0 feet to 20 feet bgs. The production zone for waters wells in a bedrock formation is from the well bottom to highest point of water inflow from the water bearing seams, joints, and fractures in the rock formation.

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

INADVERTENT RETURN (IR) DISCUSSION

An HDD has not been initiated at this location.

No IRs were reported along the alignment of the HDD S2-0157 on the list of IRs for Mariner East I as documented in the IR Preparedness, Prevention and Contingency (PPC) Plan for Perry County.

Sunoco Pipeline, L.P. (SPLP) HDD consultants reviewed the HDD design and geotechnical data for this area and determined that the risk of IRs to the waters and wetlands overlying the HDD could be reduced by increasing the depth of the HDD. The results of the new geotechnical core borings at the entry and exit points show the revised HDD profile will encounter and transition through shale for the entire profile. Overall rock quality parameters improve as depth below ground increases. The west core data show mudstone at top of bedrock with a recovery value of 50, and RQD value of 22, improving as depth increases with recovery values consistently at 100 and RQD values ranging from 28-90. At maximum profile depth the recovery value is 100 and RQD value is 65. This is indicative of moderate to good overall rock integrity and strength at profile depth. The east core data, which should be representative of the majority of the HDD profile under natural resources shows the top of bedrock as shale with a recovery value of 100 and RQD value of 90. Proceeding to profile depth the HDD will enter and progress through shale with recovery values consistently at 100, and RQD values ranging from 90 to 100. At maximum profile depth the recovery value is 100 and RQD value is 100, indicative of good overall rock integrity and excellent strength at profile depth. As such, the revised profiles present a reduced risk of creating an IR.

ADJACENT FEATURES ANALYSIS

The crossing of Horse Valley Road is located in rural Perry County, approximately 2.2 miles east-northeast of the community of Waterloo, PA. This HDD location is within unmanaged deciduous woodlands, wetlands, and an agricultural field. The HDD would cross under two (2) exceptional value (EV) wetlands (L1 & L2) and one (1) stream (L7). Wetlands L1 and L2 are designated “EV” due to wild trout watershed contribution. Stream L7 is a designated high quality-cold water fishery (HQ-C). A 0.35 acre impoundment occurs approximately 40 ft north of the HDD location and a 0.43 acre impoundment occurs approximately 110 feet south of the HDD location.

SPLP has identified all landowners with property located within 450 ft of the HDD alignment. There are four (4) individual landowners with properties located within 450 ft of the HDD alignment. SPLP sent each of these landowners a notice letter via both certified and first class mail on October 30, 2017, 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, 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.

SPLP’s outreach has confirmed that no private water wells occur within 450 ft of the HDD profile.

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of S2-0157 includes an evaluation of open cut alternatives and a re-route analysis. 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 a number of 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

Sunoco Pipeline, L.P. (SPLP) specifications require a minimum of 48-inches of cover over the installed pipelines. To meet these cover requirements, during construction through the stream and wetlands would require a minimum authorized open cut work space 75 ft in width to accommodate the 16 and 20-inch pipelines, allowing for each pipeline to be installed with sufficient separation for integrity management. The assessed area of impact by this open cut plan would directly affect approximately 0.02 acres of state water bottoms, 1.26 acres of emergent wetland, 0.49 acres of shrub-scrub wetland, and 0.42 acres of forested wetland.

Due to the existing saturated ground conditions, a significant volume of produced groundwater will fill all the excavations during the open cut process. These water volumes can be pumped to a discharge filtration structure; however, the current feasible filtration ability does not exceed 50 microns, therefore, cloudy water (from suspended fine clay and silt particles) would be discharged to the watershed regardless of all control methods employed for the entire duration of this crossing until completion.

The crossing distance of the emergent and forested wetlands, a distance of approximately 1,250 ft, is beyond the technical limits of a conventional auger bore.

Re-Route Analysis

The pipeline route as currently permitted follows parallel to one (1) existing Sunoco pipeline. In accordance with state and federal guidance, SPLP has routed the Project to be co-located with existing pipeline and other utility corridors to avoid new “greenfield” routing alignments, to the maximum extent practicable. This avoids and minimizes new and permanent impacts on previously undisturbed land, land use encumbrance, and site-specific and cumulative impacts on land, environmental, and community resources.

There are no existing utility corridors to the north that would provide a practical alternative route. Any alternate route considered north of the existing utility corridor would require the clearing of a new “greenfield” corridor which would significantly increase impacts to natural resources in comparison to the exiting route and HDD location.

An existing cleared utility corridor lies approximately 725 feet to the south of the SPLP easement and general parallels the SPLP easement at a near equivalent offset parallel for miles to the east and west of the HDD location. Utilizing this corridor would move the project away from the existing Sunoco pipeline while transecting the same resources. Immediate to Horse Valley Road, this easement bisects two (2) residential locations and is in near proximity to two others; therefore in comparison to the proposed HDD location, this alternate route is not preferred.

RECONSIDERATION OF THE HORIZONTAL DIRECTIONAL DRILL

As stated above, SPLP HDD consultants reviewed the HDD designs and geotechnical data for this location. Based upon this review, it was determined that the risk of IRs to waters of the Commonwealth overlying the HDD could be reduced by increasing the depth of the original permitted HDD profile. Additional geologic investigations have been completed and utilized in the redesign of the planned HDD.

HORSE VALLEY ROAD CROSSING
PADEP SECTION 105 PERMIT NO. E50-258
PA-PE-0002.0000-RD & PA-PE-0002.0000-RD-16
(SPLP HDD No. S2-0157)

The redesign adjusts the HDD profile deeper to place the HDD pathway through bedrock having better structural integrity than a shallower profile and increases the overall length of the HDD due to pipe design requirements. A summary of the redesign factors is provided below.

Revised Horizontal Directional Drill Design Summary: 20-inch

- Horizontal length: 2,170 foot (ft)
- Entry/Exit angle: 12-18 degrees
- Maximum Depth of cover: 110 ft
- Depth under Horse Valley Road: 76 ft
- Depth under stream: 84 ft
- Depth under wetlands: 60-80 ft
- Pipe design radius: 2,400 ft

Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 2,125 foot (ft)
- Entry/Exit angle: 12-18 degrees
- Maximum Depth of cover: 100 ft
- Depth under Horse Valley Road: 70 ft
- Depth under stream: 76 ft
- Depth under wetlands: 60-70 ft
- Pipe design radius: 2,000 ft

As shown on Figure 2, the redesigned HDD profile for the 20-inch pipeline is 613 ft longer, with a depth of cover below the streams and wetlands increased by 30-59 ft from the permitted design. In addition, the entry/exit angles have been increased allowing for a sharper and quicker descent into more competent rock. As shown on Figure 4 the redesigned HDD profile for the 16-inch pipeline is 528 ft longer, with a depth of cover below the streams and wetlands increased by 20-53 ft and designed for a sharp and quick entry and exit from the horizontal depth.

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

- SPLP will require and enforce the use of annular pressure 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 the reaming phase, the use of Loss Control Materials (LCMs) can be implemented if indications of a potential IR are noted or an IR is observed; and

- If LCMs prove ineffective to mitigate loss of returns or IRs, then grouting of the pilot hole may be implemented.

CONCLUSION

It is SPLP's intent to modify the original profile design and to pursue a deeper and longer HDD profile. Figure 1 and 3 in Attachment 2 presents the original HDD plan and profiles. Figure 2 and 4 in Attachment 2 present the revised HDD plan and profiles.

HORSE VALLEY ROAD CROSSING
PADEP SECTION 105 PERMIT NO. E50-258
PA-PE-0002.0000-RD & PA-PE-0002.0000-RD-16
(SPLP HDD No. S2-0157)

ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

RETTEW

We answer to you.

3020 Columbia Avenue, Lancaster, PA 17603 ● Phone: (800) 738-8395
E-mail: rettew@rettew.com ● Website: rettew.com

Engineers
Environmental Consultants
Surveyors
Landscape Architects
Safety Consultants

November 30, 2017

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

RE: Sunoco Pipeline, L.P. Pipeline Project - Mariner East II
Horse Valley Road Horizontal Directional Drill Location (S2-0157)
Hydrogeological Re-evaluation Report
Toboyne Township, Perry County, Pennsylvania
RETTEW Project No. 096302011

EXECUTIVE SUMMARY

1. The Corrected Stipulated Order dated August 9, 2017 requires a re-evaluation of the Horse Valley Road Horizontal Directional Drill (HDD) location, including a geologic report.
2. The Horse Valley Road HDD is underlain by clastic sedimentary rocks of the Martinsburg Formation (Om) of Ordovician age.
3. Geologic mapping, published reports, and field mapping indicate steeply dipping beds with jointing and fracturing.
4. Water-bearing zones generally occur in secondary openings along bedding planes, joints, and fractures. Water-bearing zones in the Reedsville Formation, a stratigraphic equivalent in neighboring Juniata County, are frequent within 50 to 150 feet of the ground surface.
5. To date, no HDD operations have started for the proposed 16-inch or 20-inch pipelines.
6. Based on the hydro-structural characteristics of the underlying geology, and proposed HDD profile, the Horse Valley Road HDD is susceptible to the inadvertent return (IR) of drilling fluids during HDD operations for the planned 16-inch and 20-inch drills. The redesigned HDD profile and HDD best management practices 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 Horse Valley Road (S2-0157) HDD location (the site) on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project - Mariner East II (PPP-ME2) Project. The Horse Valley Road HDD is located in Toboyne Township, Perry County, Pennsylvania (refer to **Figure 1**). The HDD was designed to be drilled under Horse Valley Road, a small stream (S-Q69) and a wetland complex. This re-evaluation report is part of the response to the Corrected Stipulated Order dated August 9, 2017.

The proposed HDD profile was lengthened and deepened on November 27, 2017 to provide additional protective cover beneath the stream and wetland complex. The HDD entry on the western side of the profile is at an elevation of approximately 1,175 feet above mean sea level (AMSL) for the proposed 16-inch drill and 1,178 feet AMSL for the proposed 20-inch drill. The exit on the eastern side of the profile is at an elevation of approximately of 1,093 feet AMSL for the proposed 16-inch drill and 1,094 feet AMSL for the proposed 20-inch drill. The HDD is located approximately between Stations 8614+00 and 8635+00 along the pipeline. The inclination of the entry and exit angles has been increased to install the pipe through protective soils, residual soils, and bedrock, and in closer proximity to the entry and exit points than the original, shallower profile. Due to the approximate 82-foot (16-inch) and 84-foot (20-inch) elevation difference between the HDD entry (west) and HDD exit (east), the potential for produced groundwater exists. However, the difference in elevation is not extreme, and water produced during the pilot and reaming phases will be recycled. This water reuse will allow for the continual HDD process to reduce the amount of water required at the HDD rig, while simultaneously allowing the drilling fluid viscosity to be adjusted to account for free water that ensures that the returns are maintained as a flowable slurry. Copies of the revised HDD profiles are included in **Attachment 1.**

2.0 GEOLOGY AND SOILS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (BTGS, 2001 and Sevon, 2000), the site is in the Appalachian Mountain Section of the Ridge and Valley Physiographic Province of Pennsylvania, which is regionally underlain by sedimentary rocks consisting of sandstone, siltstone, shale, conglomerate, limestone, and dolomite. Local topography is characterized by long narrow ridges and broad to narrow valleys. (Royer, 1984 and Sevon, 2000).

According to the United States Department of Agriculture (USDA) Soil Surveys of Perry County, Pennsylvania, soils within the vicinity of the drill path for HDD S2-0157 consist of 11 distinct soil units. A USDA map that depicts the mapped area, along with the soil profile descriptions, is included as **Attachment 2**.

The site geology is mapped as the Martinsburg Formation (Om) of Ordovician age. The Martinsburg Formation consists of a buff-weathered, dark gray shale with thin interbeds of siltstone, metabentonite, and fine-grained sandstone. A brown-weathered, medium-grained sandstone with interbeds of shale and siltstone is found in the middle of the formation. The basal part of the formation is generally described as a limy shale and silty limestone but no evidence of this was observed near the Horse Valley HDD. This formation is described as well bedded with thick to massive bedding in the sandstone, and thin to fissile bedding in the limestone and shale. Bedrock fracturing occurs as irregularly spaced, open and nearly vertical joints. Cleavage is dominant and highly developed in the formation. The cleavage and joints provide a secondary porosity of low magnitude and low permeability. The Martinsburg is moderately weathered to a moderate depth, resulting in small to large platy fragments. The overlying mantle is thin. From an engineering standpoint, excavation of this formation is moderately easy in the shale and difficult in the sandstone. Foundation stability is good, provided the excavation is completed to sound material. Drilling rates are described as fast. Cut slope stability is fair in the shale and good in the sandstone (Geyer and Wilshusen, 1982). Based on published mapping, Horse Valley lies within an anticline with the more resistant sandstones forming the ridges and less resistant shale forming the valley floor (Royer, 1984).

3.0 HYDROGEOLOGY

Groundwater at the site occurs in a fractured sedimentary bedrock aquifer system within the geology described in Section 2.0. Secondary porosity related to the joints, fractures and bedding planes is the primary path for ground water flow. Joint openings are generally restricted to the first 100 to 200 feet below weathered bedrock and largely disappear at depths greater than 300 to 400 feet due to compression from the overlying material. The yield of wells drilled in the shale is typically adequate for domestic supplies ranging from 1 to 15 gallons per minute (gpm) (Lohman, 1938). In these rock types of Perry County, water-bearing zones generally occur in the secondary openings along bedding planes, joints, faults and fractures (Lohman, 1938). At this location, the HDD is relatively perpendicular to the axial plane of the anticline with strata dipping away from the axial plane (likely northwest and southeast). Accordingly, local groundwater flow within Horse Valley is anticipated to migrate downdip within the bedrock along bedding and fracture planes from areas of higher elevation to lower elevations along the valley floor.

Limited well data is available relative to the Martinsburg Formation. The Reedsville Formation is considered to be a stratigraphic equivalent to the Martinsburg Formation. However, no data on the Reedsville Formation is available in Perry County (Royer, 1984). As a result, data from the Reedsville Formation in Juniata County is summarized as follows. The depths of 38 reported wells range from 31 to 435 feet below the ground surface (bgs) and yields ranging from 1 to 50 gpm. The median depths for both domestic and nondomestic wells is 130 feet bgs. Median well yields are reported as 12 gpm for domestic wells and 20 gpm for non-domestic wells. Based on limited data, water-bearing zones are most abundant within 50 feet bgs to 150 feet bgs. Few water-bearing zones were reported below 200 feet bgs. The deepest water-bearing zone was reported at 350 feet bgs (Taylor, 1982). Groundwater was encountered in geotechnical borings at the Horse Valley HDD at depth ranging from 8.0 feet to 20 feet bgs as discussed in Section 5.0

Well records reviewed within a 0.5-mile radius of the HDD location were obtained from the Pennsylvania Groundwater Information System (PaGWIS). A single well record was available and is summarized below. The well location is shown on **Figures 2** and **3.**

Well No.	Well Use	Casing Depth (feet)	Total Depth (feet)	Water Level (feet)	Yield (gpm)
505314	DOMESTIC	59	175	150	30

As a condition of the corrected stipulated order, other Sunoco subcontractors have researched private water supplies located within 450 feet of the Horse Valley HDD. No private were identified within 450 feet of the Horse Valley HHD, however one well was identified approximately 539 feet southwest of the HDD entry and is included in **Attachment 3.** Well construction details were not available.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces underlying, or in close proximity to, the site were evaluated using historical aerial photographs from the years 1995 through 2015 (Google Earth, 2017) and the Blairs Mills, Pennsylvania Geologic Quadrangle Maps from Atlas 61 (Berg and Dodge, 1981 and Royer, 1984). The photographs,

publications and maps were reviewed to approximate the locations of natural linear fracture trace features or lineaments expressed on the ground surface. The linear features may be the surficial representation of deeper high angle fractures, joints, faults or bedding planes within the subsurface which can transmit groundwater through the fractured bedrock aquifer at the site.

Figures 2 and **3** show the results of the fracture trace analysis overlain on the geologic map of the site and an aerial basemap. Eight fracture traces were identified within close proximity to the Horse Valley Road HDD that are likely related to the primary geologic structure. Four of the fracture traces trend approximately northeast-southwest (NE-SW), parallel to geologic strike. Four perpendicular fracture traces trend northwest-southeast (NW-SE) and may represent joint sets. Due to the nature of the ridges and folded geology near the site, the bedding-parallel fracture traces trend approximately NE-SW. Bedding-perpendicular fracture traces were identified in the approximately NW-SE fracture lineaments which are presumed to be stress-related joint sets. General surface drainage patterns near the site are characterized by linear stream reaches trending NE-SW or NW-SE that reflect the general geologic structure.

5.0 GEOTECHNICAL EVALUATION

Two geotechnical drilling investigations were performed at the site; the first was performed in October 2014 and the second in August 2017. The 2014 test borings were advanced by hollow-stem augers and NQ-sized wireline rock coring techniques. These borings are designated as SB-01 and SB-02. The 2017 test borings were advanced using the mud rotary method and are designated B3-5E and B3-5W. Soil, residual soil and weathered bedrock were sampled using split-spoon samplers. Geotechnical boring logs are included in **Attachment 1**.

Boring SB-01 was located approximately 125 feet southeast of the HDD entry on the west side of the profile. Boring SB-02 was located approximately 850 feet east-southeast of the HDD entry and near the midpoint of the profile. Boring B3-5W was located near the HDD entry and B3-5E was located near the HDD exit. The locations of the borings are depicted on **Figure 2** and **Figure 3.**

In general, the subsurface profile at the site, as observed in the borings, is described as follows:

- Soil and residual soil depths vary from boring to boring; 18.5 feet at SB-01, 15 feet at SB-02, 29.0 feet at B3-5W, and 13.0 feet in B3-5E. The residual soils are described as follows:
    - **Boring SB-01**: LEAN CLAY (CL) with silty clay, little fine sand and a trace to little fine shale gravel from the ground surface to 13.5 feet bgs. CLAYEY SAND (SC) with some silty clay, and some fine to coarse gravel comprised of shale from 13.5 feet bgs to 18.5 feet bgs. Auger refusal was encountered at 20.0 feet bgs. Groundwater was observed at 17.5 feet bgs.
    - **Boring SB-02**: Silty SAND (SM) and Clayey SAND (SC) with little to some unweathered shale to 15.9 feet. Auger refusal was encountered at 15.0 feet bgs. Groundwater was observed at 8.0 feet bgs.
    - **Boring B3-5E**: Lean CLAY (CL) composed of weathered shale. Groundwater was encountered at 20.0 feet bgs.
    - **Boring B3-5W:** Lean CLAY (CL). Groundwater was encountered in rock strata in this boring.

- At depths of auger or split-spoon refusal, and to the total depth of the NQ cores, weathered bedrock and bedrock were encountered and are described as follows:
    - **Boring B3-5E:** B3-2E was completed to a total depth of 85.0 feet bgs. From 15.0 feet to 85.0 feet bgs, fresh to moderately weathered SHALE was observed. The SHALE is described as thinly bedded with moderately dipping to vertical joints. The joints are very close to close, smooth to rough, open to tight with some iron staining and some are infilled with calcite. Rock quality designations (RQDs) in the shale were very poor to excellent (0% to 100%) and generally increase with depth. Recoveries were good to excellent (54 inches to 60 inches) and consistent throughout the coring runs. Groundwater was encountered at 20 feet bgs and a loss of circulation was noted at 46 feet bgs.
    - **Boring B3-5W:** B3-2W was completed to a depth of 135 feet bgs. From 29 feet to 45 feet bgs, severely weathered and fractured SHALE was encountered. From 45 feet to 115 feet bgs, slightly to severely weathered SHALE was observed. In this interval, joints are described as horizontal to vertical with close to moderately close spacing with some calcite infilling. From 115 feet to 135 feet bgs, fresh to slightly weathered SHALE with high angle to vertical bedding. Joints are described as low angle to vertical and close to moderately spaced with some calcite infilling. RQDs were very poor to excellent (0% to 90%). The highest RQDs were observed from 110 feet to 120 feet bgs. Recoveries were fair to excellent (32 inches to 60 inches) and generally increase with depth. Full recoveries (60 inches) were obtained from 85 feet to 135 feet bgs. Groundwater was not observed in this boring.

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

Boring	Sample Depth (feet bgs)	Compressive Strength (psi)
B3-5W	75	14,990
B3-5W	91	2,436
B3-5W	95	1,247
B3-5W	115	7,454
B3-5W	134	1,504
B3-5E	34	9,496
B3-5E	54	3,337
B3-5E	74	6,939
B3-5E	84	7,054

Please note that RETTEW did not oversee or direct the geotechnical drilling program associated with the Horse Valley Road HDD, including but not limited to, the selection of boring locations, determination of location, determination of surface elevation, 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 Sunoco Pipeline, L.P. contractors. RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework of the analysis of the Horse Valley Road HDD in this report.

6.0 FIELD OBSERVATIONS

A field investigation was performed by a RETTEW geologist on October 14, 2017 to identify rock outcrops for fracture fabric analysis, possible ground-truthing of fracture traces identified during the desktop evaluation, and to identify potential sensitive receptors to IRs. A small outcrop was identified near the HDD entry as shown on **Figures 2** and **3**. The outcrop consists of gray shale with evidence of extensive weathering (oxidation) along the bedding planes. The strike of bedding at this outcrop is 51° with a dip angle of 35°SE. The average strike of the primary joint set is 154° with a dip angle of 79°SW. The strike and dip of bedding is consistent with published geologic data, mapping, and fracture traces identified in Section 4.0. The near vertical joints are consistent with the published geologic and geotechnical core data presented in Section 5. No additional sensitive receptors to IRs beyond the previously mapped streams and wetlands were identified during the site reconnaissance.

7.0 CONCEPTUAL HYDROGEOLOGIC MODEL AND CONCLUSION

Based on published geologic and hydrogeologic information, and the evaluation of geotechnical borings from the site, the Horse Valley Road HDD location is underlain by clastic sedimentary rocks of the Martinsburg Formation. The hydrogeologic setting is dominated by groundwater flow through secondary openings along geologic features including bedding planes, joints and fractures. This is supported by the observation of weathering, fractures, and joints in the geotechnical cores and identified outcrop. In addition, field measurements of local geologic structure support the published information and referenced vertical and near vertical joint sets. Well records indicate that water-bearing zones in the analogous Reedsville Formation are common from depths of 50 feet to 250 feet bgs.

The originally proposed 16-inch and 20-inch HDD profiles were relatively shallow at the entry and exit points, and passed through both the unconsolidated overburden and fractured bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and the proposed HDD profiles, the Horse Valley Road HDD site is susceptible to the inadvertent return of drilling fluids during HDD operations. As a result, the HDD profile has been redesigned to allow for deeper crossings beneath the wetland complex and stream. The inclination of the entry and exit angles has been increased to allow the pipe to be installed through the protective soils, residual soils, and bedrock 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 best management practices, will be used to reduce the risk of an IR.

8.0 REFERENCES

Berg, T. M., and Dodge, C. M., compilers and eds., 1981, Atlas of preliminary geologic quadrangle maps of Pennsylvania: Pennsylvania Geological Survey, 4th ser., Map 61, 636 p.

Geyer, A. R., and P. J. Wilshusen, 1982, Engineering Characteristics of the Rocks of Pennsylvania, Pennsylvania Topographic and Geologic Survey, Environmental Geology Report 1, Second Edition, 300 pages.

Google Earth Pro, 2017, Version 7.1.8.3036, November 27, 2017.

Lohman, S.W., 1938, Ground Water in South-Central Pennsylvania, Commonwealth of Pennsylvania, Topographic and Geologic Survey, Bulletin W 5, 315 pages.

Pennsylvania Bureau of Topographic and Geologic Survey, Department of Conservation and Natural Resources, 2001, Bedrock Geology of PA, Edition: 1.0, Digital Map. Retrieved from internet September 18, 2017; HTTP://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspxDL Data: Page oexp.zip [HTTP://www.dcnr.state.pa.us/topogeo/map1/bedmap.aspx].

Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Groundwater Information System (PaGWIS) database, website address: http://www.dcnr.pa.gov/Conservation/Water/Groundwater/PAGroundwaterInformationSystem/Pages/default.aspx, accessed November 28, 2017.

Royer, D.W., 1984, Summary of Groundwater Resources of Perry County, Pennsylvania, Pennsylvania Geologic Survey, 4th Series, Water Resource Report 54, 70 pages.

Sevon, D., 2000, Map 13, Physiographic Provinces of Pennsylvania, Pennsylvania Bureau of Topographic and Geologic Survey, Harrisburg, Pennsylvania.

Taylor, L. E., 1982, Groundwater Resources of the Juniata River Basin, Pennsylvania, Pennsylvania Geologic Survey, 4th Series, Water Resource Report 54, 144 pages.

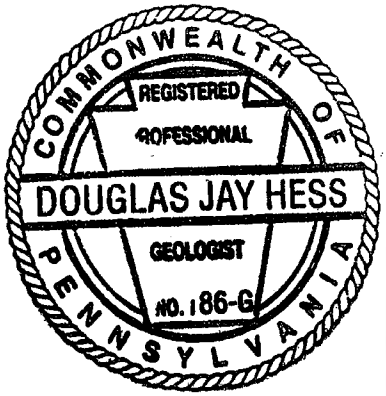
United States Department of Agriculture, 2017, Natural Resources Conservation Service, Published Soil Surveys for Pennsylvania, Blair County, Pennsylvania: website address: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx, accessed November 28, 2017.

9.0 CERTIFICATION

The studies and evaluations presented in this report (other than Section 5) were completed under the direction of a licensed professional geologist (P.G.), and are covered under the P.G. seals that follow.

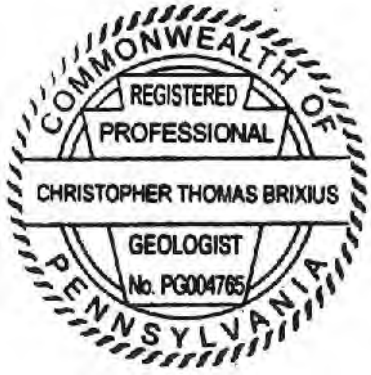
By affixing my seal to this document, I am certifying that, to my knowledge and belief, the information herein is true and correct. I further certify, that I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information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

Douglas J. Hess, PG
License No. PG000186G



Ethan E. Prout, PG
License No. PG003884

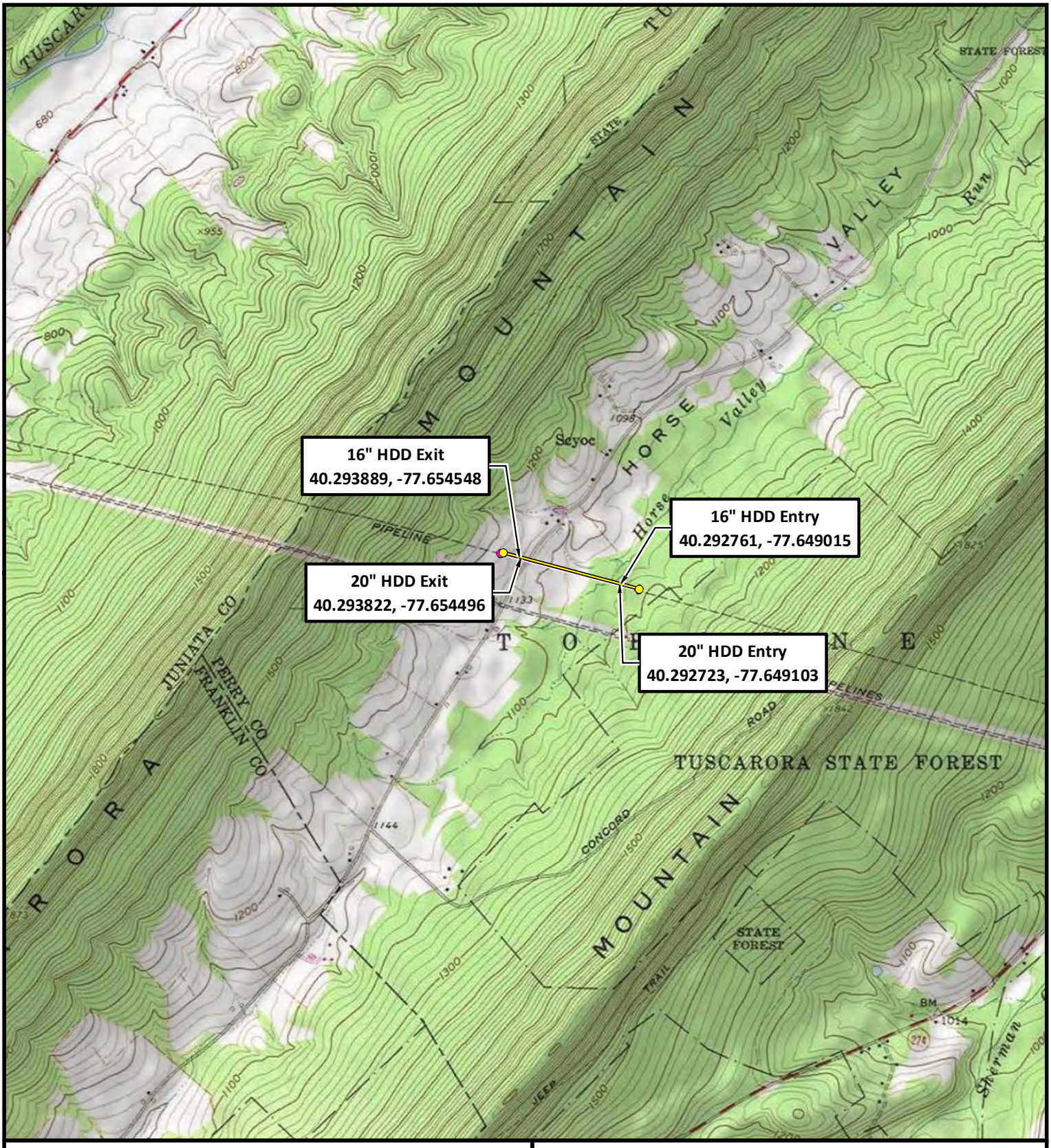
Christopher T. Brixius, PG
License No. PG004765



Z:\Shared\Projects\09630\096302011\GS\Hydrogeology Review\Horse Valley Road\Horse Valley Final.DOCX

RETTEW

FIGURES



16" HDD Entry/Exit

20" HDD Entry/Exit

16" HDD Profile

20" HDD Profile

Blairs Mills, PA USGS 7.5' Topographic Quadrangle 11/29/2017

Sunoco Pipeline, L.P.

Horse Valley Road HDD Location

Figure 1 - Topographic Basemap

Toboyne Township, Perry County, PA

Project No. 096302011

N W E S

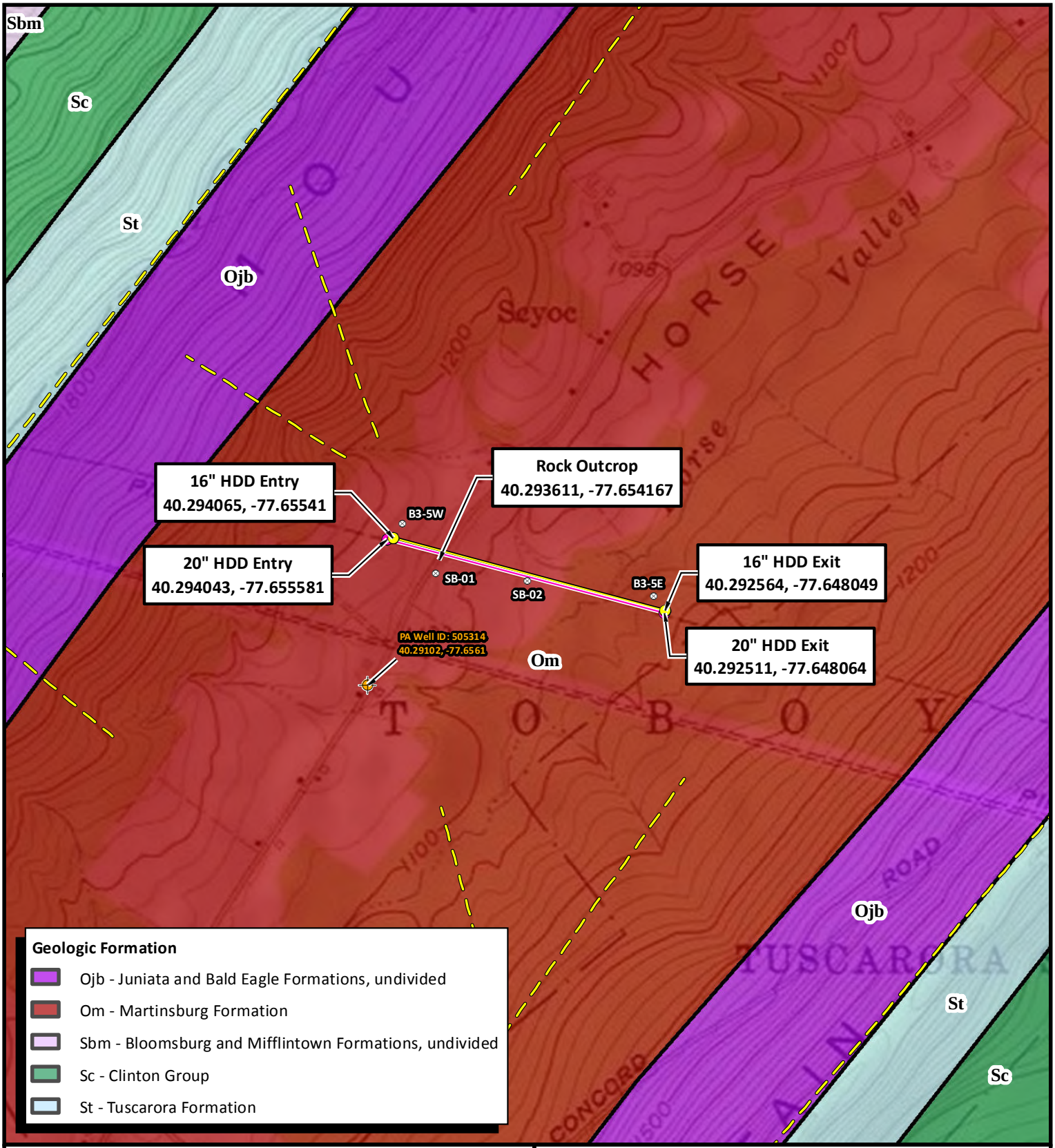
0 2,000 Feet

1 inch = 2,000 feet

Sunoco Logistics Partners L.P.

RETTEW

N:\Shared\Projects\09630\096302011\GIS\MapDocs\Horse Valley Road\096302011_HorseValleyRd_Fig1_TopoBasemap_8x11.mxd



Sunoco Pipeline, L.P.

Horse Valley Road HDD Location

Figure 2 - Geologic Map

Toboyne Township, Perry County, PA

Project No. 096302011

N W E S

0 1,000 Feet

1 inch = 1,000 feet

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

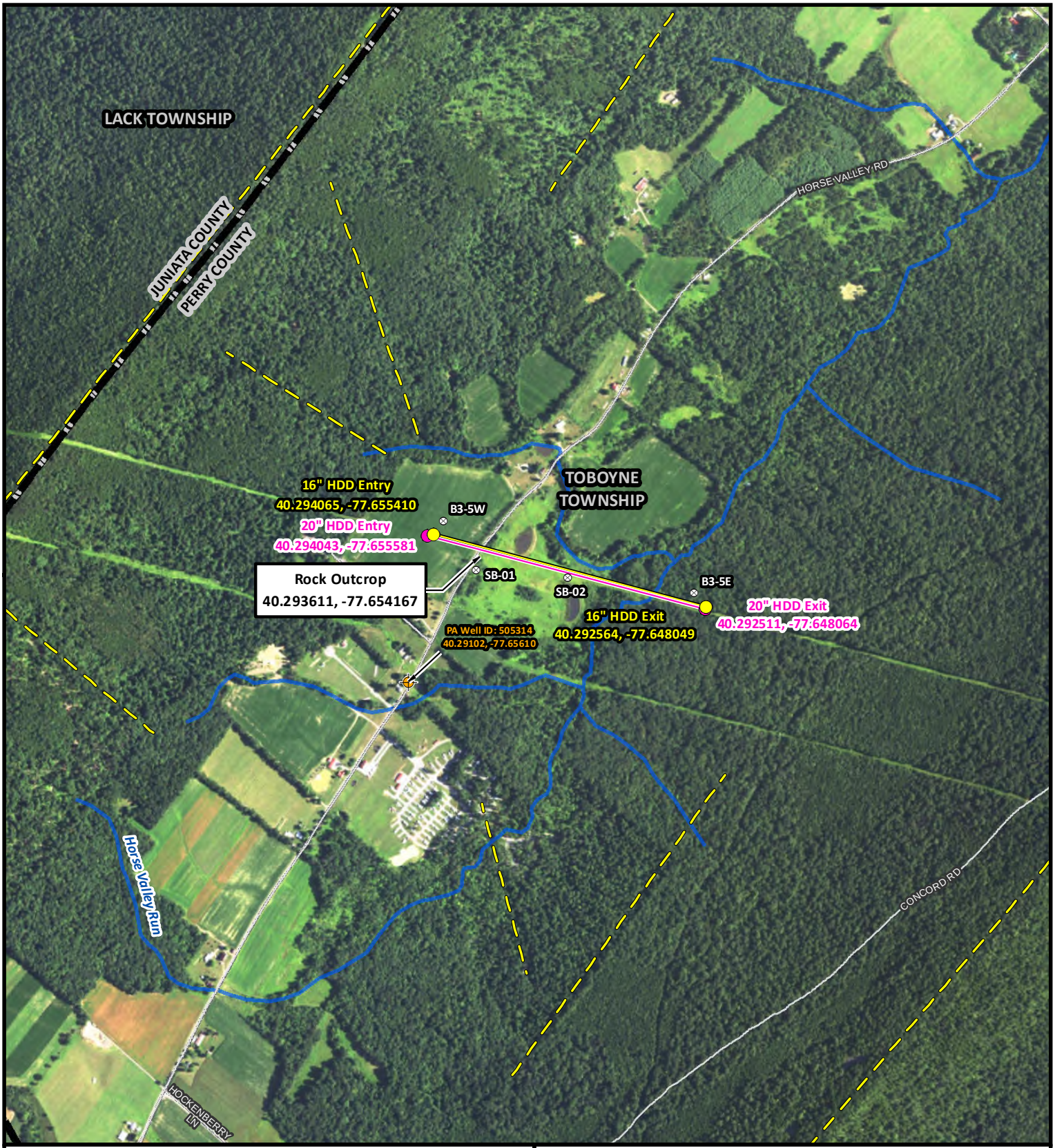
Sunoco Logistics Partners L.P.

RETTEW

Blairs Mills, PA USGS 7.5' Topographic Quadrangle

11/29/2017

N:\Shared\Projects\09630\096302011\GIS\MapDocs\Horse Valley Road\096302011_HorseValleyRd_Fig2_GeologicMap_8x11.mxd



Residential Well
Soil Boring
16" HDD Entry/Exit
20" HDD Entry/Exit
16" HDD Profile
20" HDD Profile
Inferred Fracture Trace
NHD Stream
Road
County Boundary

11/29/2017

Sunoco Pipeline, L.P.

Horse Valley Road HDD Location

Figure 3 - Aerial Basemap

Toboyne Township, Perry County, PA

Project No. 096302011

N W E S

0 1,000 Feet

1 inch = 1,000 feet

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

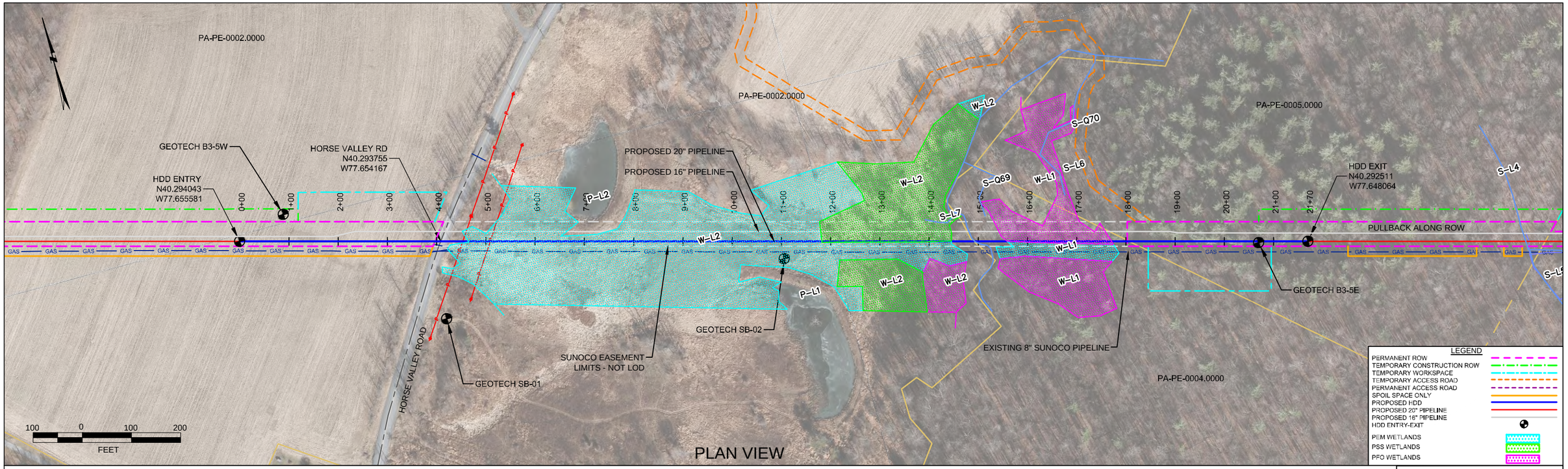
Sunoco Logistics Partners L.P.

RETTEW

N:\Shared\Projects\09630\096302011\GIS\MapDocs\Horse Valley Road\096302011_HorseValleyRd_Fig3_AerialBasemap_8x11.mxd

RETTEW

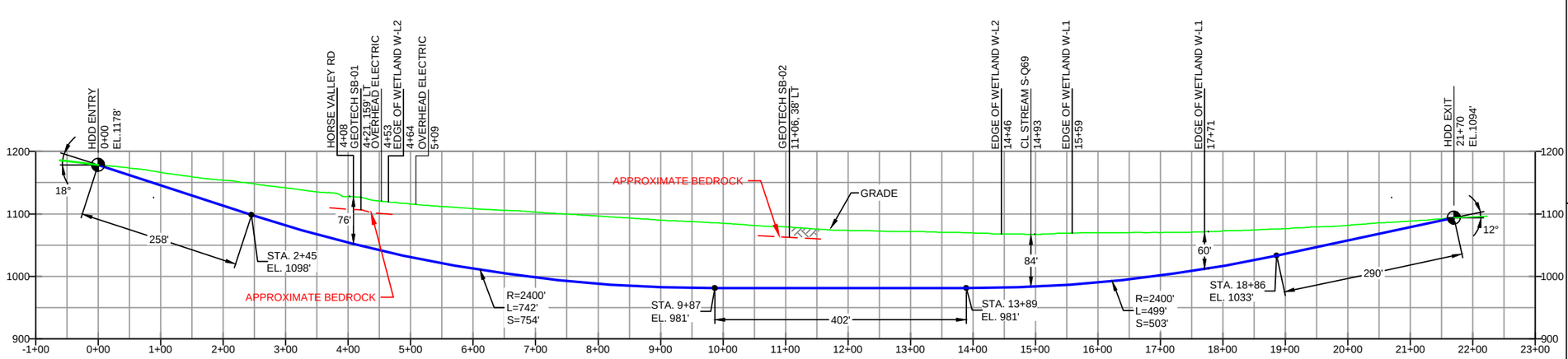
ATTACHMENT 1
GEOTECHNICAL BORING LOGS



PLAN VIEW

PERRY COUNTY PENNSYLVANIA, TOBOYNE TOWNSHIP
S2-0157

PROFILE VIEW



GEOTECH SB-01

-NG EL. 1126'
-TOPSOIL (0' - 0.1')
-CL (0.1' - 13.5')
-SC (13.5' - 18.5')
-GROUNDWATER (17.5')
-SHALE (18.5' - 20.3')
-COMPLETION DEPTH EL. 1106'

GEOTECH SB-02

-NG EL. 1079'
-TOPSOIL (0' - 0.2')
-SM (0.2' - 3.5')
-GROUNDWATER (8.0')
-SC (3.5' - 15.0')
-SHALE (15.0' - 15.9')
-COMPLETION DEPTH EL. 1063'

NOTE: REFER TO TEST BORING LOG S2-0157 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B3-5W

-NG EL. 1140'
-LEAN CLAY W/ GRAVEL CL (0.0' - 29.0')
-WEATHERED ROCK/SHALE (29.0' - 135.0')
-BORING TERMINATED EL. 1005'

NOTE: REFER TO TEST BORING LOG B3-5W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B3-5E

-NG EL. 1175'
-LEAN CLAY CL (0.0' - 13.0')
-GROUNDWATER (20.0')
-WEATHERED ROCK/SHALE (13.0' - 85.0')
-BORING TERMINATED EL. 1090'

NOTE: REFER TO TEST BORING LOG B3-5E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 2170'
   HDD PIPE LENGTH (S=): 2207'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-3.03	TO	ES-3.03	EROSION & SEDIMENT PLAN
SHEET 2	TO	SHEET 2	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	MOVED DRILL ENTRY/EXIT LOCATION - DESIGN PER MICHELS	MRS	11/27/17	RMB	11/27/17	CAG	11/27/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
C	ADDED GEOTECH INFO	MRS	09/14/15	RMB	09/14/15	AAW	09/14/15
B	ISSUED FOR BID	MRS	07/31/15	RMB	07/31/15	AAW	07/31/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HORSE VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NUMBER: PA-PE-0002.0000-RD

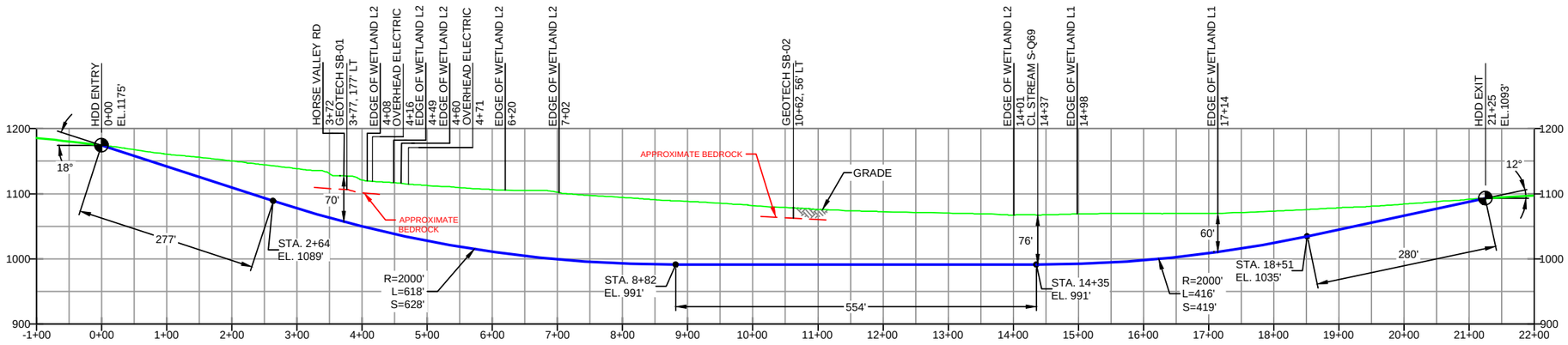
PERRY COUNTY PENNSYLVANIA, TOBOYNE TOWNSHIP
S2-0157-16

PA-PE-0002.0000
PA-PE-0005.0000
PA-PE-0004.0000
GEOTECH B3-5W
HDD ENTRY
N40.294065
W77.655410
HDD EXIT
N40.292564
W77.648049
PROPOSED 16" PIPELINE
PULLBACK ALONG ROW
GEOTECH SB-01
GEOTECH SB-02
GEOTECH B3-5E
SUNOCO EASEMENT
LIMITS - NOT LOD
EXISTING 8" SUNOCO PIPELINE
PROPOSED 20" PIPELINE
HORSE VALLEY ROAD
P-L1
P-L2
W-L1
W-L2
S-L1
S-L2
S-L3
S-L4
S-L5
S-L6
S-L7
S-069
S-070
100 0 100 200
FEET

LEGEND
PERMANENT ROW
TEMPORARY CONSTRUCTION ROW
TEMPORARY WORKSPACE
TEMPORARY ACCESS ROAD
PERMANENT ACCESS ROAD
SPOIL SPACE ONLY
PROPOSED HDD
PROPOSED 20" PIPELINE
PROPOSED 16" PIPELINE
HDD ENTRY-EXIT
PEM WETLANDS
PSS WETLANDS
PFO WETLANDS

PLAN VIEW

PROFILE VIEW



GEOTECH SB-01
-NG EL. 1126'
-TOPSOIL (0' - 0.1')
-CL (0.1' - 13.5')
-SC (13.5' - 18.5')
-GROUNDWATER (17.5')
-SHALE (18.5' - 20.3')
-COMPLETION DEPTH EL. 1106'

GEOTECH SB-02
-NG EL. 1079'
-TOPSOIL (0' - 0.2')
-SM (0.2' - 3.5')
-GROUNDWATER (8.0')
-SC (3.5' - 15.0')
-SHALE (15.0' - 15.9')
-COMPLETION DEPTH EL. 1063'

NOTE: REFER TO TEST BORING LOG S2-0157 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B3-5W
-NG EL. 1140'
-LEAN CLAY W/ GRAVEL CL (0.0' - 29.0')
-WEATHERED ROCK/SHALE (29.0' - 135.0')
-BORING TERMINATED EL. 1005'

NOTE: REFER TO TEST BORING LOG B3-5W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B3-5E
-NG EL. 1175'
-LEAN CLAY CL (0.0' - 13.0')
-GROUNDWATER (20.0')
-WEATHERED ROCK/SHALE (13.0' - 85.0')
-BORING TERMINATED EL. 1090'

NOTE: REFER TO TEST BORING LOG B3-5E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 2125'
   HDD PIPE LENGTH (S=): 2158'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

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

REF. DRAWING

ES-3.03	TO	ES-3.03	EROSION & SEDIMENT PLAN	
SHEET 2	TO	SHEET 2	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	MOVED DRILL ENTRY/EXIT LOCATION - DESIGN PER MICHELS	MRS	11/27/17	RMB	11/27/17	CAG	11/27/17
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	JTW	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
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

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HORSE VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NO: PA-PE-0002.0000-RD-16

LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S2-0157
PERRY COUNTY, TOBOYNE 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:	HORSE VALLEY ROAD, NEW GERMANTOWN, PA		Page 1 of 1
HDD No.:	S2-0157	Dates(s) Drilled: 10-14-14	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 17.5	Total Depth (ft): 20.3

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.1			TOPSOIL (<1").					
1	3.0	5.0	0.1		16	CL	MOTTLED (LIGHT GRAY, ORANGE BROWN, YELLOW BROWN, LIGHT	1	7	12	13	**19**
							BROWN) SANDY CLAY. (USCS: CL)					
2	8.0	9.1			18		VARI-COLORED SILTY CLAY WITH A LITTLE FINE SAND, AND A TRACE	6	18	22	30	**40**
				13.5			TO A LITTLE FINE SHALE GRAVEL.					
3	13.0	13.9	13.5		9	SC	DARK GRAY FINE SAND WITH SOME SILTY CLAY AND SOME	2	50/3"			**>50**
							UNWEATHERED SHALE FINE TO COARSE GRAVEL.					
4	18.0	18.9					DARK GRAY FINE SAND AND SILTY CLAY WITH A LITTLE	1	50/5"			**>50**
				18.5			UNWEATHERED SHALE FINE TO COARSE GRAVEL.					
5	20.0	20.3	18.5	20.3			GRAY TO DARK GRAY PARTIALLY WEATHERED SHALE.	50/3"				**>50**
							AUGER REFUSAL AT 20'.					
							WET ON SPOON AT 17.5'					
							WATER LEVEL THROUGH AUGERS AT 18.5'					
							CAVED AT 20'.					
							WATER LEVEL ON CAVE AT 18'.					

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:	HORSE VALLEY ROAD, NEW GERMANTOWN, PA		Page 1 of 1
HDD No.:	S2-0157	Dates(s) Drilled: 10-15-14	Inspector: E. WATT
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 8.0	Total Depth (ft): 15.9

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.2			TOPSOIL (2").					
1	3.0	5.0	0.2	3.5	18	SM	MOTTLED BROWN AND ORANGE BROWN SILTY FINE SAND.	2	17	24	27	**41**
			3.5	8.5			LIGHT GRAY TO BROWN FINE SAND AND SILTY CLAY.					
2	8.0	8.9	8.5		9		DR WEATHERED TO A FINE SAND WITH SOME SILTY CLAY AND	7	50/5"			**>50**
						SC	A LITTLE UNWEATHERED FINE SHALE GRAVEL.					
3	13.0	13.8			10		DARK GRAY FINE TO COARSE SAND WITH ALITTLE SILTY CLAY,	3	50/4"			**>50**
				15.0			AND SOME FINE TO COARASE UNWEATHERED SHALE GRAVEL.					
4	15.0	15.9	15.0	15.9	7		PARTIALLY WEATHERED DARK GRAY SHALE.	2	50/5"			**>50**
							AUGER REFUSAL AT 15'. SUBSEQUENTLY OFF-SET BORING					
							AND CONTINUOSLY AUGERED TO REFUSAL AT 15.9'.					
							CAVED AT 15'. WATER LEVEL IN OPEN BOREHOLE AT 8'.					

Notes/Comments:

Pocket Pentrometer Testing
S1: 4 TSF

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 S2-0157

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.) From	Depth of Sample (ft.) To	Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318) Liquid Limit, %	Atterburg Limits (ASTM D4318) Plastic Limit, %	Atterburg Limits (ASTM D4318) Plasticity Index, %	USCS Classif. (ASTM D2487)
S2-0157	SB-01	1	3.0	5.0	16.6	58.7	31	21	10	CL
		2	8.0	9.1	15.1	83.0	-	-	-	-
		3	13.0	13.9	11.2	30.0	-	-	-	-
		4	18.0	18.9	19.3	47.8	-	-	-	-
		5	21.0	21.3	8.3	16.3	-	-	-	-
	SB-02	1	3.0	5.0	14.1	40.7	-	-	-	-
		2	8.0	8.9	17.3	30.3	-	-	-	-
		3	13.0	13.8	14.6	13.5	-	-	-	-
		4	15.0	15.9	10.1	19.5	-	-	-	-

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0157

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
S2-0157	Shearer	SB-01 SB-02	**Martinsburg Fm** - buff-weathering, dark-gray to purple shale and slate with thin interbeds of siltstone, metabentonite, and fine-grained sandstone.	Rolling hills (ridge & valley)	Martinsburg Fm	Shale and slate with interbedded siltstone		20-59	

Note : Source of well log data - http://www.dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm. All other sources as referenced in comments section.

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

Density	***N (blows)****
Very Loose	5 or less
Loose	6 to 10
Medium Dense	11 to 30
Dense	31to 50
Very Dense	51 or more

Relative Proportions

Description Term	*Percent*
Trace	1 - 10
Little	11 - 20
Some	21 - 35
And	36 - 50

Particle Size Identification

Boulders	8 in. diameter or more	
Cobbles	3 to 8 in. diameter	
Gravel	Coarse (C)	3 in. to ¾ in. sieve
	Fine (F)	¾ in. to No. 4 sieve
Sand	Coarse (C)	No. 4 to No. 10 sieve (4.75mm-2.00mm)
	Medium (M)	No. 10 to No. 40 sieve (2.00mm – 0.425mm)
	Fine (F)	No. 40 to No. 200 sieve (0.425 – 0.074mm)
Silt/Clay	Less Than a No. 200 sieve (<0.074mm)	

COHESIVE SOILS

(Silt, Clay & Combinations)

Consistency	***N (blows)****
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

Degree of Plasticity	*Plasticity Index*
None to Slight	0 - 4
Slight	5 - 7
Medium	8- 22
High to Very High	> 22

ROCK

(Rock Cores)

Rock Quality Designation (RQD), %	***Rock Quality Description***
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).

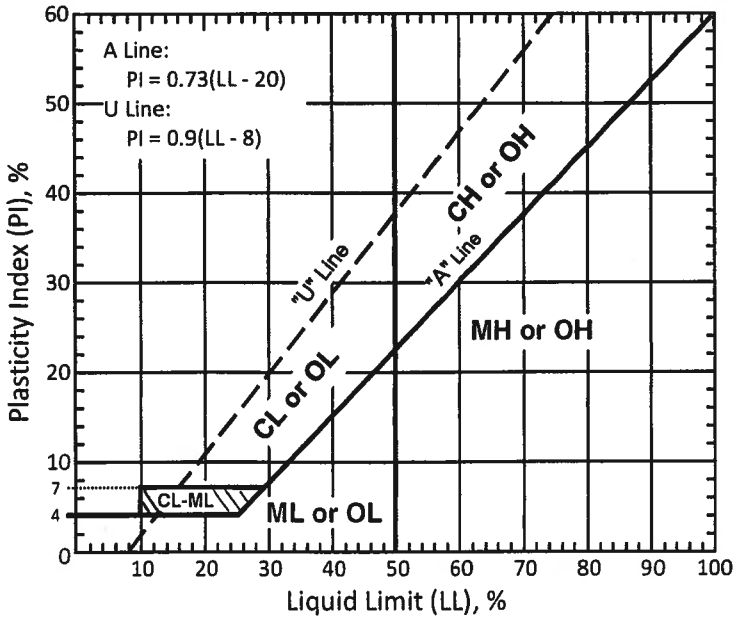
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

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	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine Percentage of sand and gravel from grain size curve. Depending on Percentage of fines (fraction smaller than No. 200 sieve), coarse-grained soils are classified as follows: Less than 5 percent GW, GP, SW, SP; More than 12 percent GM, GC, SM, SC; 5 to 12 percent Borderline cases requiring dual symbols[1]	$C_u=\frac{D_{60}}{D_{10}}$ greater than 4: $C_c=\frac{(D_{30})2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting C_u or C_c requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above A line with I_p greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 Sieve)	Clean sands (Little or no fines)	SW	Well graded sands, gravely sands, little or no fines		$C_u=\frac{D_{60}}{D_{10}}$ greater than 6: $C_c=\frac{(D_{30})2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting C_u or C_c requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits Plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above A line with I_p greater than 7	

Major Divisions		Group Symbols	Typical Descriptions
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	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 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

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.



(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.

October 7, 2017

Directional Project Support, Inc.
33311 Lois Lane, Suite A
Magnolia, TX 77354

Attn: Mr. Robert Sessions
P: (318) 542 6657
E: fielduspl@Hotmail.com

Re: Geotechnical Site Characterization
Mariner East 2 Pipeline Project
Spread 3 – Horse Valley Road
Commonwealth of Pennsylvania
Drawing #PA-PE-0002.0000-RD
PO #20170811-3
Terracon Project No. J217P078

Dear Mr. Sessions:

This letter provides a summary of the bedrock characterization for the Mariner East 2 Pipeline Project crossing to be located at Horse Valley Road (Drawing #PA-PE-0002.0000-RD) in the Commonwealth of Pennsylvania. Our services were performed in general accordance with our proposal number PJ2175108 dated July 28, 2017. Our scope of services included advancing two borings, designated as B3-5W and B3-5E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B3-5W and B3-5E were drilled between August 22 and 26, 2017 to depths of 135 and 85 feet, respectively as shown on the attached **Test Boring Location Plan**. Test boring B3-5W was terminated before the target depth of 146 feet due to a malfunctioning core barrel retriever. Bedrock typically consisted of shale. Final test boring logs documenting overburden soil and bedrock conditions as well as photographs of the rock core samples are attached.

Rock compressive strength testing was performed on samples from approximately 20-foot intervals within the bedrock strata at each boring location. As an exception to the planned 20-foot intervals, the rock sample from B3-5W at 52 feet was not tested because the specimen broke during test preparation. Unconfined compressive strength test results are shown on the attached reports.

When laboratory soil testing results are available, we will submit a complete data report for the subject crossing. In the meantime, if you have questions, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Marc A. Gullison, E.I.T.
Staff Geotechnical Engineer

Lawrence J. Dwyer, P.E. (CT 15120)
Principal

Attch:

TEST BORING LOCATION PLAN
EXPLORATION RESULTS (Boring Logs, Laboratory Data, Rock Core Photographs)
SUPPORTING INFORMATION (Unified Soil Classification System, Description of Rock Properties)

TEST BORING LOCATION PLAN

N

APPROXIMATE BORING LOCATION

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: JGS	Project No. J217P078
Drawn by: SBL	Scale: N.T.S.
Checked by: LJD	File Name: J217P078 BLP
Approved by: LJD	Date: September. 2017

Terracon
Consulting Engineers & Scientists
201 Hammer Mill Road Rocky Hill, Ct 06067
PH. (860) 721-1900 FAX. (860) 721-1939

TEST BORING LOCATION PLAN

Horse Valley Road HDD Cores B3-5W and B3-5E
PA-PE-0002.0000-RD
Perry County, Pennsylvania

Exhibit

A-2

EXPLORATION RESULTS

BORING LOG NO. B3-5W Horse Valley Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION

Latitude: 40.294125° Longitude: -77.655224°

Approximate Surface Elev: 1140 (Ft.) +/-

DEPTH ELEVATION (Ft.)

GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
LEAN CLAY WITH GRAVEL (CL), light gray and brown, very stiff, (Residual shale)								
			X	18	5-7-8 N=15			4.5+
	5							
			X	13	6-8-11 N=19			4.5+
	10							
13.0 1127+/-								
LEAN CLAY WITH GRAVEL (CL), gray and brown, hard, (Degraded bedrock)			X	18	29-30-34 N=64			4.5+
	15							
			X	11	28-50/6"			
	20							
			X	12	6-15-26 N=41			
	25							
29.0 1111+/-			X	16	14-41-50/4"			
Weathered rock, very dense	30							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850X Driller: Terracon/Dave B.

Project No.: J217P078

BORING LOG NO. B3-5W Horse Valley Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION

Latitude: 40.294125° Longitude: -77.655224°

Approximate Surface Elev: 1140 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
Weathered rock, very dense *(continued)*									
					4	50/4"			
35.0	1105+/-	35							
Run 1, Soft, severely weathered, gray to dark gray SHALE, highly fractured, with clay seams, trace oxidation					32		0	2.5 2.5 3 2 2.5	
40.0	1100+/-	40							
Run 2, Soft to hard, severely weathered, dark gray SHALE, highly fractured joints, trace oxidation					46.5		0	2.5 2 4.5 4.5 5	
45.0	1095+/-	45							
Run 3, Moderately hard to hard, moderately weathered, dark gray argillaceous SHALE, laminated bedding, highly fractured, very close to close, trace pyrite and sandstone lenses Trace fossil fragments from 49 - 51 feet					60		12	2.5 2.5 2 2.5 2	
50.0	1090+/-	50							
Run 4, Similar					52		22	2 2 2.5 2.5 4	
55.0	1085+/-	55							
Run 5, Similar, increasing silty and sandy lenses at 55 feet					60		8	1.5 2 2 2.5 5	
60.0	1080+/-	60							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850X Driller: Terracon/Dave B.

Project No.: J217P078

BORING LOG NO. B3-5W Horse Valley Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

GRAPHIC LOG	LOCATION Latitude: 40.294125° Longitude: -77.655224° Approximate Surface Elev: 1140 (Ft.) +/- DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 6, Similar 65.0 1075+/-	65			54		7	3 3.5 2.5 2.5 3	
	Run 7, Similar to 65.5 feet At 65.5 feet: Hard, moderately weathered, dark gray, argillaceous SHALE, no visible bedding, highly fractured, shearing along calcite filled fractures, very close to close, large fracture fill at 65.5 feet 70.0 1070+/-	70			57		19	2 2 2.5 2.5 7	
	Run 8, Similar 75.0 1065+/-	75			58		28	2 3 2.5 2.5 2.5	
	Run 9, Moderately hard to hard, slightly weathered, dark gray SHALE, low angle joints, occasional vertical fracture shearing along vertical laminations, close to moderately close, thin sand lenses, calcite fracture filling 80.0 1060+/-	80			60		80	2.5 2 1.5 1.5 1.5	
	Run 10, Similar, increased fractures at 80 feet, moderately dipping, highly weathered from 80.2 - 81 feet 85.0 1055+/-	85			56		53	1.5 1.5 2 2.5 2	
	Run 11, Similar 90.0 1050+/-	90			60		75	1.5 1.5 1 1.5 1.5	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850X Driller: Terracon/Dave B.

Project No.: J217P078

BORING LOG NO. B3-5W Horse Valley Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION

Latitude: 40.294125° Longitude: -77.655224°

Approximate Surface Elev: 1140 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 12, Similar to 92 feet				
		92 feet: Hard, moderately weathered, dark gray, SHALE, shearing along vertical lamination, highly fractured (vertical and horizontal), close spacing				
95.0	1045+/-		95	60	37	1.5 2 2 2 3
		Run 13, Similar, slightly to moderately weathered, low angle to moderately dipping, close to moderately close, calcite fracture filling				
100.0	1040+/-		100	60	58	2 2 1.5 2 1.5
		Run 14, Similar				
105.0	1035+/-		105	59	83	1.5 1 1.5 2 1.5
		Run 15, Similar, vertical fracture 107 to 108.5 feet				
110.0	1030+/-		110	60	57	2 2 2 2 2
		Run 16, Similar				
115.0	1025+/-		115	60	90	2 2.5 2 2 2
		Run 17, Moderately hard, slight to fresh, dark gray SHALE, bedding high angle to vertical, no bedding joints encountered during this run; low angle joints moderate to wide spacing, partially filled with calcite-healed fractures throughout				
120.0	1020+/-		120	60	90	2 2.5 2 2 2.5

Penetrometer Test (tsf)

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850X Driller: Terracon/Dave B.

Project No.: J217P078

BORING LOG NO. B3-5W Horse Valley Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION

Latitude: 40.294125° Longitude: -77.655224°

Approximate Surface Elev: 1140 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
Run 18, Similar, high angle to vertical fractures, very close spacing, undulating to planar					
125.0	1015+/-	125	60	27	2.5 2.5 2 3 3
Run 19, Similar					
130.0	1010+/-	130	60	62	2.5 2 2 2 2
Run 20, Similar, occasional moderately spaced vertical fractures					
135.0 Core barrel retriever malfunction at 135 feet, terminate boring before target depth of 146 feet	1005+/-	135	60	65	2 2 2.5 2.5 2

Boring Terminated at 135 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850X Driller: Terracon/Dave B.

Project No.: J217P078

BORING LOG NO. B3-5E Horse Valley Road East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION

Latitude: 40.292575° Longitude: -77.648414°

Approximate Surface Elev: 1075 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
		LEAN CLAY (CL), trace organic matter, rock fragments, light brown to gray, stiff to hard							
			5		16	4-7-9 N=16			4+
					18	8-21-31 N=52			4+
			10						
13.0	1062+/-								
		Weathered rock, very dense			11	50/6"			
15.0	1060+/-		15						
		Run 1, Medium to moderately hard, fresh to moderately weathered, black, SHALE, very thin bedding, moderately dipping to vertical joints, very close to close, smooth to rough, open to tight, carbonaceous, iron staining in joints, occasional calcite in-filled joints			54		0	2 2.5 2 1.5 2.5	
20.0	1055+/-		20						
		Run 2, Similar			60		30	2.5 2 2.5 2.5 2.5	
25.0	1050+/-		25						
		Run 3, Similar			60		38	2 2 2.5 3 4	
30.0	1045+/-		30						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ 20' 8/26/17

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/25/2017 Boring Completed: 8/26/2017

Drill Rig: CME-850X Driller: Terracon/Dave B.

Project No.: J217P078

BORING LOG NO. B3-5E Horse Valley Road East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION

Latitude: 40.292575° Longitude: -77.648414°

Approximate Surface Elev: 1075 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 4, Similar									
	35.0	1040+/-	35			60		90	1.5 1.5 1.5 3.5 3	
	Run 5, Similar									
	40.0	1035+/-	40			60		67	2 2 1.5 3 2	
	Run 6, Similar									
	45.0	1030+/-	45			60		90	1.5 2 2 1.5 1.5	
	Run 7, Similar, with pyrite seams from 45 to 85 feet Loss of water circulation at 46 feet									
	50.0	1025+/-	50			60		67	2 2 2 2 2.5	
	Run 8, Similar									
	55.0	1020+/-	55			60		100	2 1.5 2 2 2	
	Run 9, Similar									
	60.0	1015+/-	60			58		93	2 2 2 1.5 2	

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *20' 8/26/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/25/2017 Boring Completed: 8/26/2017

Drill Rig: CME-850X Driller: Terracon/Dave B.

Project No.: J217P078

BORING LOG NO. B3-5E Horse Valley Road East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION

Latitude: 40.292575° Longitude: -77.648414°

Approximate Surface Elev: 1075 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
Run 10, Similar					
65.0	1010+/-	65	60	95	2 2 1.5 2.5 2
Run 11, Similar					
70.0	1005+/-	70	60	96	2 2 2 2 2
Run 12, Similar					
75.0	1000+/-	75	60	100	2.5 1.5 2 2 2
Run 13, Similar					
80.0	995+/-	80	60	95	2 1.5 2 1.5 2
Run 14, Similar					
85.0	990+/-	85	60	100	2 1.5 1.5 2 2
Boring Terminated at 85 Feet					

GRAPHIC LOG | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | Penetrometer Test (tsf)

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *20' 8/26/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/25/2017 | Boring Completed: 8/26/2017

Drill Rig: CME-850X | Driller: Terracon/Dave B.

Project No.: J217P078

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5W	Lithology :	Shale
Sample No.:	1	Moisture Content :	As received
Sample Depth:	52 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	0 min

Diameter:	N/A in	Maximum Axial Load at Failure:	N/A lb
Length:	N/A in	Compressive Strength:	N/A psi
L/D:	N/A	Compressive Strength:	N/A Mpa
End Area:	N/A in^2	Unit Weight	N/A pcf

Specimen broke during preparation

Before the Test

After the Test

Drawing # :	PA-PE-0002.0000-RD
PO # :	20170811-3
Crossing :	Horse Valley Road
Spread :	Spread 3

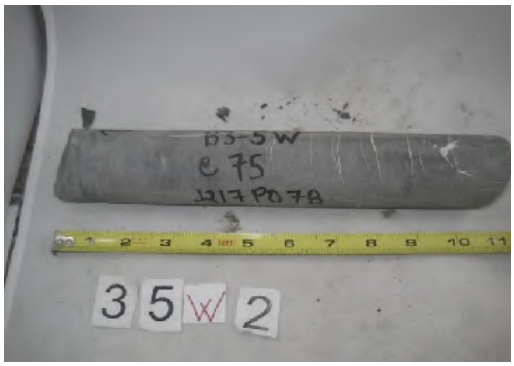
Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	10/3/2017
Location:	Spread 3			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/7/2017

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5W	Lithology :	Shale
Sample No.:	2	Moisture Content :	As received
Sample Depth:	75 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	14 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	45,690 lb
Length:	4.52 in	Compressive Strength:	14,990 psi
L/D:	2.29	Compressive Strength:	103.35 Mpa
End Area:	3.05 in^2	Unit Weight	169 pcf

Before the Test



After the Test

Drawing # :	PA-PE-0002.0000-RD
PO # :	20170811-3
Crossing :	Horse Valley Road
Spread :	Spread 3

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 3		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/7/2017

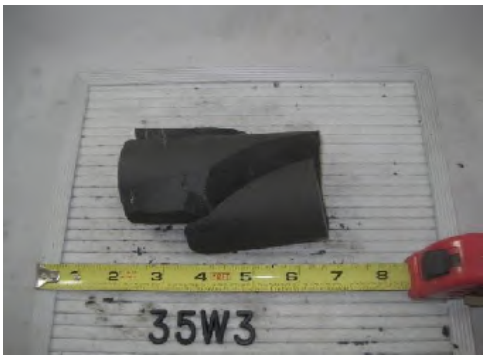
ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5W	Lithology :	Shale
Sample No.:	3	Moisture Content :	As received
Sample Depth:	95 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	1 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	3,840 lb
Length:	4.26 in	Compressive Strength:	1,247 psi
L/D:	2.15	Compressive Strength:	8.60 Mpa
End Area:	3.08 in^2	Unit Weight	170 pcf

Before the Test

After the Test



Drawing # :	PA-PE-0002.0000-RD
PO # :	20170811-3
Crossing :	Horse Valley Road
Spread :	Spread 3

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 3		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/7/2017

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5W	Lithology :	Shale
Sample No.:	3b	Moisture Content :	As received
Sample Depth:	91 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	2 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	7,500 lb
Length:	4.06 in	Compressive Strength:	2,436 psi
L/D:	2.05	Compressive Strength:	16.79 Mpa
End Area:	3.08 in^2	Unit Weight	170 pcf

Before the Test

After the Test

Drawing # : PA-PE-0002.0000-RD
PO # : 20170811-3
Crossing : Horse Valley Road
Spread : Spread 3

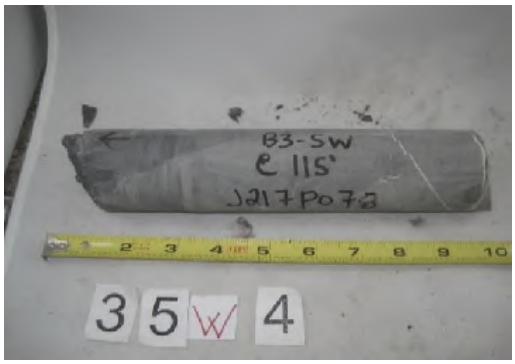
Project:	Mariner East Pipeline	Terracon	Performed by:	W. Shedd
Project No.	J217P078		Test Date:	10/6/2017
Location:	Spread 3		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/7/2017

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5W	Lithology :	Shale
Sample No.:	4	Moisture Content :	As received
Sample Depth:	115 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	7 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	22,950 lb
Length:	4.50 in	Compressive Strength:	7,454 psi
L/D:	2.27	Compressive Strength:	51.39 Mpa
End Area:	3.08 in^2	Unit Weight	168 pcf

Before the Test



After the Test

Drawing # :	PA-PE-0002.0000-RD
PO # :	20170811-3
Crossing :	Horse Valley Road
Spread :	Spread 3

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 3		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/7/2017

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5W	Lithology :	Shale
Sample No.:	5	Moisture Content :	As received
Sample Depth:	134 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	1 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	4,630 lb
Length:	4.61 in	Compressive Strength:	1,504 psi
L/D:	2.33	Compressive Strength:	10.37 Mpa
End Area:	3.08 in^2	Unit Weight	169 pcf

Before the Test

After the Test

Drawing # :	PA-PE-0002.0000-RD
PO # :	20170811-3
Crossing :	Horse Valley Road
Spread :	Spread 3

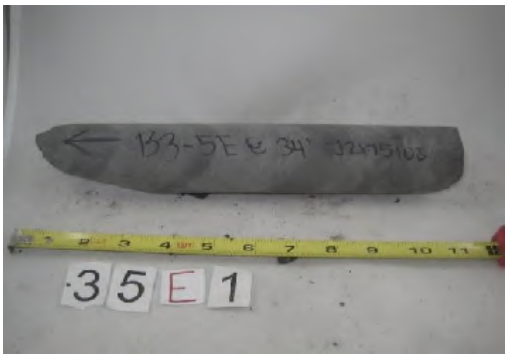
Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 3		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/7/2017

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5E	Lithology :	Shale
Sample No.:	1	Moisture Content :	As received
Sample Depth:	34 feet	Lab Temperature :	70° F
Sampling Date:	8/25/17	Loading Rate:	55 psi/s
		Time to Failure:	9 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	29,240 lb
Length:	4.44 in	Compressive Strength:	9,496 psi
L/D:	2.24	Compressive Strength:	65.47 Mpa
End Area:	3.08 in^2	Unit Weight	168 pcf

Before the Test



After the Test

Drawing # : PA-PE-0002.0000-RD
PO # : 20170811-3
Crossing : Horse Valley Road
Spread : Spread 3

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	10/3/2017
Location:	Spread 3			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/7/2017

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5E	Lithology :	Shale
Sample No.:	2	Moisture Content :	As received
Sample Depth:	54 feet	Lab Temperature :	70° F
Sampling Date:	8/25/17	Loading Rate:	55 psi/s
		Time to Failure:	3 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	10,170 lb
Length:	4.20 in	Compressive Strength:	3,337 psi
L/D:	2.13	Compressive Strength:	23.00 Mpa
End Area:	3.05 in^2	Unit Weight	169 pcf

Before the Test

After the Test

Drawing # : PA-PE-0002.0000-RD
PO # : 20170811-3
Crossing : Horse Valley Road
Spread : Spread 3

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	10/3/2017
Location:	Spread 3			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/7/2017

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5E	Lithology :	Shale
Sample No.:	3	Moisture Content :	As received
Sample Depth:	74 feet	Lab Temperature :	70° F
Sampling Date:	8/25/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	21,150 lb
Length:	3.65 in	Compressive Strength:	6,939 psi
L/D:	1.85	Compressive Strength:	47.84 Mpa
End Area:	3.05 in^2	Unit Weight	169 pcf

Comments : Due to lack of available specimens, the length to diameter ratio of the tested specimen is not conformant with ASTM D7012. The results obtained during testing may differ from those obtained from the test specimens that meet the requirements.

Before the Test

After the Test

Drawing # :	PA-PE-0002.0000-RD
PO # :	20170811-3
Crossing :	Horse Valley Road
Spread :	Spread 3

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	10/3/2017
Location:	Spread 3		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/7/2017

ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-5E	Lithology :	Shale
Sample No.:	4	Moisture Content :	As received
Sample Depth:	84 feet	Lab Temperature :	70° F
Sampling Date:	8/25/17	Loading Rate:	55 psi/s
		Time to Failure:	7 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	21,720 lb
Length:	4.52 in	Compressive Strength:	7,054 psi
L/D:	2.28	Compressive Strength:	48.64 Mpa
End Area:	3.08 in^2	Unit Weight	168 pcf

Before the Test

After the Test

Drawing # : PA-PE-0002.0000-RD
PO # : 20170811-3
Crossing : Horse Valley Road
Spread : Spread 3

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	10/3/2017
Location:	Spread 3			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/7/2017

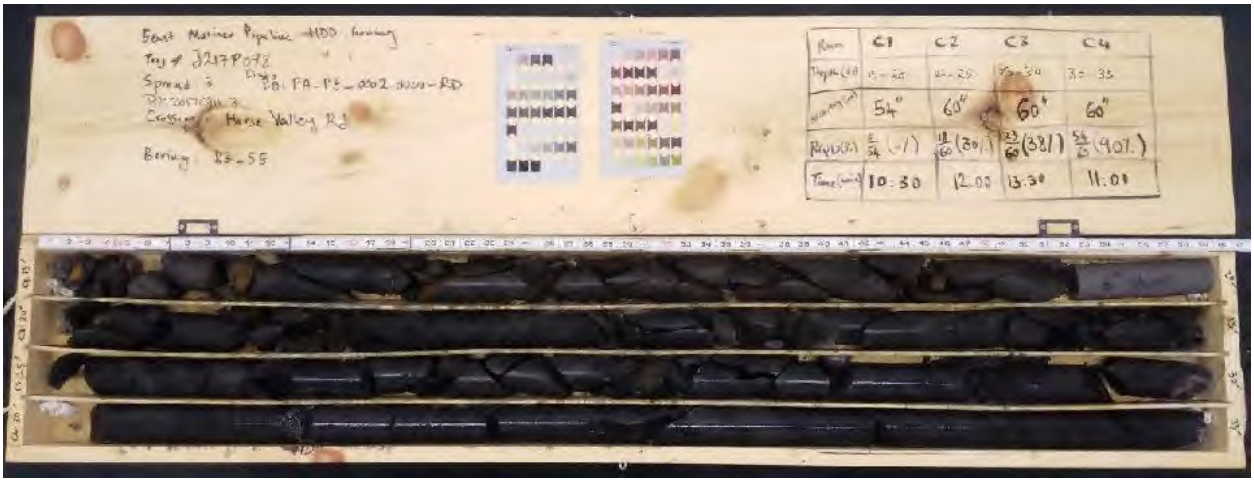
Photograph 1: B3-5W, Samples C-1 to C-4 (35 to 55 feet)

Photograph 2: B3-5W, Samples C-5 to C-8 (55 to 75 feet)

Photograph 3: B3-5W, Samples C-9 to C-12 (75 to 95 feet)

Photograph 4: B3-5W, Samples C-13 to C-16 (95 to 115 feet)

Photograph 5: B3-5W, Samples C-17 to C-20 (115 to 135 feet)



Photograph 1: B3-5E, Samples C-1 to C-4 (15 to 35 feet)

Photograph 2: B3-5E, Samples C-5 to C-8 (35 to 55 feet)

Photograph 3: B3-5E, Samples C-9 to C-12 (55 to 75 feet)

Photograph 4: B3-5E, Samples C-13 to C-14 (75 to 85 feet)

SUPPORTING INFORMATION

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 4 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ³ 4 and 1 £ Cc £ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A”		CL	Lean clay [K,L,M]
			PI < 4 or plots below “A” line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OL	Organic clay [K,L,M,N] / Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K,L,M]
			PI plots below “A” line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OH	Organic clay [K,L,M,P] / Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ³ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ³ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ³ 30% plus No. 200 predominantly sand, add “sandy” to group name.

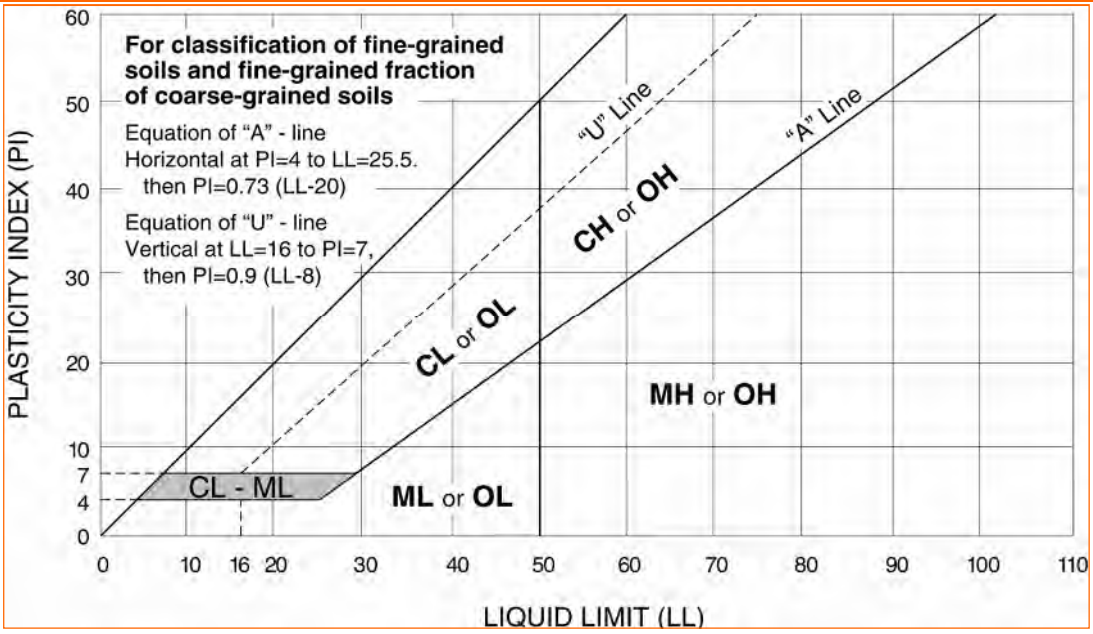
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ³ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very Slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately Severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very Severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.
HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)	
Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately Hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very Soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

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 Perry County, Pennsylvania

Horse Valley Road

November 28, 2017

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.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

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

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

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: 1:6,080 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 50 100 200 300

Feet
0 250 500 1000 1500

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 1:15,800.

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: Perry County, Pennsylvania
Survey Area Data: Version 12, Nov 27, 2017

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

Date(s) aerial images were photographed: Jun 18, 2010—Sep 25, 2010

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
AbB	Albrights silt loam, 3 to 8 percent slopes	14.3	7.9%
AoB	Andover very stony loam, 0 to 8 percent slopes	8.6	4.7%
Aw	Atkins silt loam	16.0	8.8%
BeC	Berks shaly silt loam, 8 to 15 percent slopes	14.0	7.7%
BhB	Berks stony silt loam, 3 to 8 percent slopes	46.9	25.8%
BhD	Berks stony silt loam, 8 to 25 percent slopes	23.1	12.7%
BrA	Brinkerton silt loam, 0 to 3 percent slopes	38.3	21.0%
BrB	Brinkerton silt loam, 3 to 8 percent slopes	17.3	9.5%
HfF	Hazleton channery sandy loam, 25 to 60 percent slopes, rubbly	0.0	0.0%
MdD	Meckesville very stony silt loam, 8 to 25 percent slopes	3.2	1.8%
SrD	Sideling gravelly loam, 8 to 25 percent slopes, extremely stony	0.1	0.1%
Totals for Area of Interest		**181.8**	**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 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.

Perry County, Pennsylvania

AbB—Albrights silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: r91p
Elevation: 500 to 2,800 feet
Mean annual precipitation: 34 to 48 inches
Mean annual air temperature: 40 to 60 degrees F
Frost-free period: 130 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Albrights and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Albrights

Setting

Landform: Ridges
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Head slope
Down-slope shape: Convex
Across-slope shape: Concave
Parent material: Fine-loamy colluvium derived from sedimentary rock

Typical profile

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

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 18 to 32 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 12 to 28 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Shelmadine

Percent of map unit: 5 percent
Landform: Drainageways
Landform position (two-dimensional): Toeslope

Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Alvira

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Leck kill

Percent of map unit: 5 percent
Hydric soil rating: No

Meckesville

Percent of map unit: 5 percent
Landform: Mountain valleys
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Lower third of mountainflank
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

AoB—Andover very stony loam, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: r91v
Elevation: 600 to 2,400 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition

Andover, very stony, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Andover, Very Stony

Setting

Landform: Mountain slopes
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Head slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Fine-loamy colluvium derived from sedimentary rock

Typical profile

H1 - 0 to 9 inches: gravelly loam
H2 - 9 to 18 inches: gravelly loam
H3 - 18 to 42 inches: gravelly loam
H4 - 42 to 60 inches: gravelly sandy clay loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 18 to 25 inches to fragipan; 72 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 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
Available water storage in profile: Very low (about 2.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Hydric soil rating: Yes

Minor Components

Buchanan

Percent of map unit: 10 percent
Hydric soil rating: No

Aw—Atkins silt loam

Map Unit Setting

National map unit symbol: r91z
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

Barbour

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

Philo

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

Saprists

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

BeC—Berks shaly silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: r926
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 214 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Berks

Setting

Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Acid silty residuum weathered from shale and siltstone

Typical profile

H1 - 0 to 7 inches: channery silt loam
H2 - 7 to 29 inches: very channery silt loam
H3 - 29 to 34 inches: extremely channery silt loam
H4 - 34 to 38 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Bedington
Percent of map unit: 5 percent
Hydric soil rating: No

Weikert
Percent of map unit: 4 percent
Hydric soil rating: No

Blairton
Percent of map unit: 3 percent
Hydric soil rating: No

Ernest
Percent of map unit: 3 percent
Hydric soil rating: No

BhB—Berks stony silt loam, 3 to 8 percent slopes

Map Unit Setting
National map unit symbol: r928
Elevation: 300 to 1,500 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 52 to 55 degrees F
Frost-free period: 170 to 214 days
Farmland classification: Not prime farmland

Map Unit Composition
Berks and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Berks

Setting
Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Acid silty residuum weathered from shale and siltstone

Typical profile
H1 - 0 to 7 inches: channery silt loam
H2 - 7 to 29 inches: very channery silt loam
H3 - 29 to 34 inches: extremely channery silt loam
H4 - 34 to 38 inches: bedrock

Properties and qualities
Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 2.6 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

BhD—Berks stony silt loam, 8 to 25 percent slopes

Map Unit Setting
National map unit symbol: r929
Elevation: 300 to 1,500 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 52 to 55 degrees F
Frost-free period: 170 to 214 days
Farmland classification: Not prime farmland

Map Unit Composition
Berks and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Berks

Setting
Landform: Hillslopes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Acid silty residuum weathered from shale and siltstone

Typical profile
H1 - 0 to 7 inches: channery silt loam
H2 - 7 to 29 inches: very channery silt loam
H3 - 29 to 34 inches: extremely channery silt loam
H4 - 34 to 38 inches: bedrock

Properties and qualities
Slope: 8 to 25 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Hydric soil rating: No

BrA—Brinkerton silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: r92d
Elevation: 300 to 3,000 feet
Mean annual precipitation: 35 to 55 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: 80 percent
Minor components: 20 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: 0 to 3 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

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

Atkins

Percent of map unit: 6 percent
Landform: Flood plains
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Philo

Percent of map unit: 5 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: 4 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

BrB—Brinkerton silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: r92f
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
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

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

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

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

HfF—Hazleton channery sandy loam, 25 to 60 percent slopes, rubbly

Map Unit Setting

National map unit symbol: 2wkd3
Elevation: 330 to 2,230 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 50 to 56 degrees F
Frost-free period: 155 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Hazleton

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountaintop
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from acid sandstone

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 6 inches: channery sandy loam
E - 6 to 9 inches: channery sandy loam
Bs - 9 to 11 inches: channery sandy loam
Bw1 - 11 to 19 inches: channery sandy loam
Bw2 - 19 to 40 inches: very channery sandy loam
C - 40 to 60 inches: very flaggy sandy loam
R - 60 to 70 inches: bedrock

Properties and qualities

Slope: 25 to 60 percent
Percent of area covered with surface fragments: 18.0 percent
Depth to restrictive feature: 40 to 69 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Dekalb

Percent of map unit: 10 percent
Landform: Hillslopes, mountain slopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Upper third of mountainflank, mountaintop, side slope, interfluve, nose slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Other vegetative classification: Very Rocky, Acid Soils (RA3)
Hydric soil rating: No

Lehew

Percent of map unit: 5 percent
Landform: Hillslopes, mountain slopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Upper third of mountainflank, mountaintop, side slope, interfluve, nose slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

MdD—Meckesville very stony silt loam, 8 to 25 percent slopes

Map Unit Setting

National map unit symbol: r950
Elevation: 600 to 2,800 feet
Mean annual precipitation: 34 to 48 inches
Mean annual air temperature: 46 to 55 degrees F
Frost-free period: 130 to 210 days

Farmland classification: Not prime farmland

Map Unit Composition

Meckesville and similar soils: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Meckesville

Setting

Landform: Mountain slopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Lower third of mountainflank
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Sandstone, siltstone and shale colluvium derived from sedimentary rock

Typical profile

H1 - 0 to 7 inches: channery silt loam
H2 - 7 to 31 inches: gravelly silty clay loam
H3 - 31 to 60 inches: gravelly clay loam
H4 - 60 to 64 inches: gravelly clay loam

Properties and qualities

Slope: 15 to 25 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 25 to 48 inches to fragipan; 72 to 99 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 27 to 45 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Albrights

Percent of map unit: 5 percent
Hydric soil rating: No

SrD—Sideling gravelly loam, 8 to 25 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: rccg
Elevation: 500 to 2,400 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Sideling

Setting

Landform: Mountain slopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Fine-loamy colluvium derived from sedimentary rock

Typical profile

H1 - 0 to 4 inches: gravelly loam
H2 - 4 to 38 inches: gravelly clay loam
H3 - 38 to 74 inches: channery silty clay loam

Properties and qualities

Slope: 8 to 25 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 60 to 80 inches to lithic bedrock
Natural drainage class: Moderately well drained
Runoff class: 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 31 to 47 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Weikert

Percent of map unit: 5 percent
Hydric soil rating: No

Buchanan

Percent of map unit: 5 percent
Hydric soil rating: No

Fluvaquentic dystrudepts

Percent of map unit: 5 percent

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

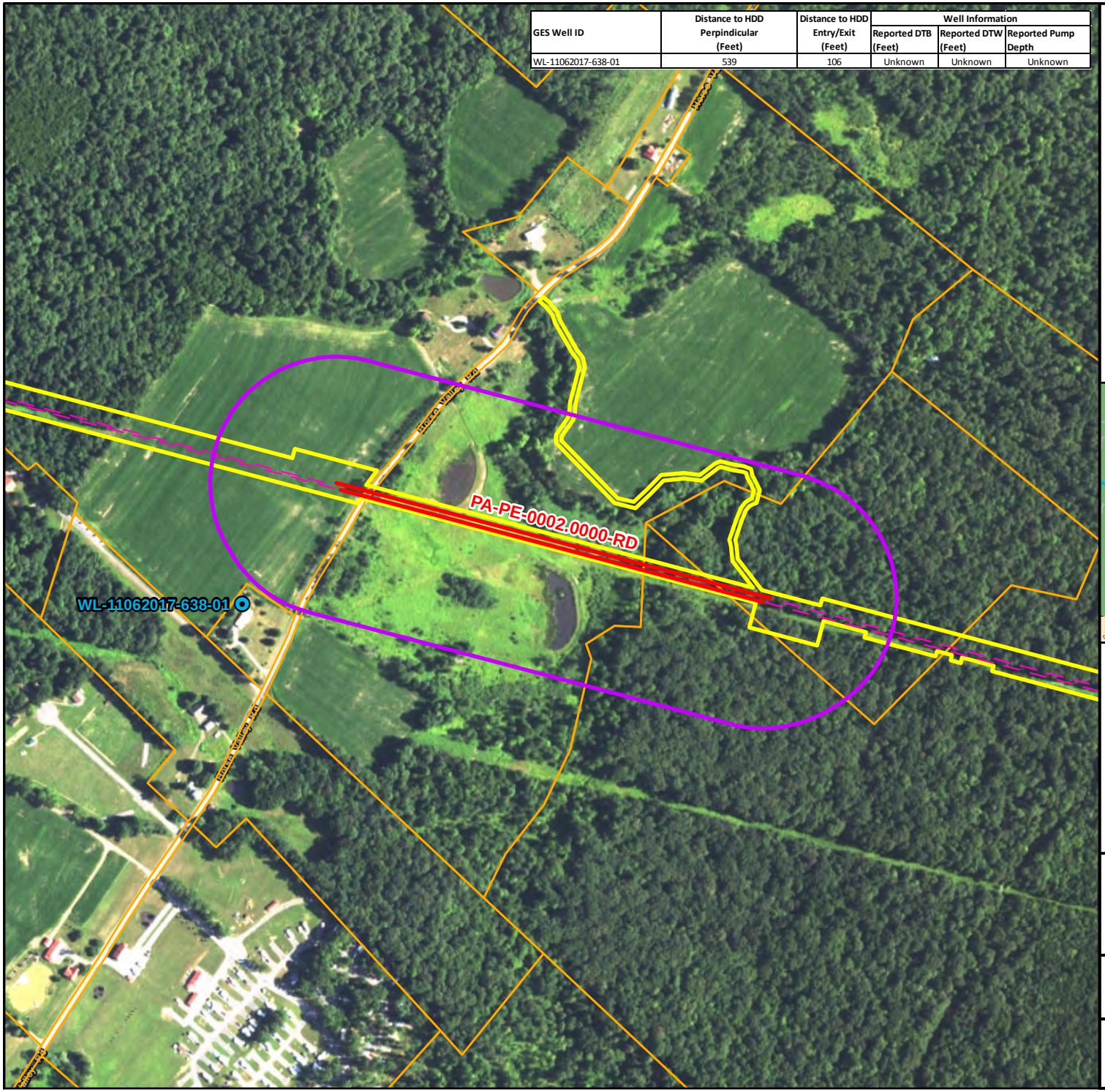
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

ATTACHMENT 3
450-FOOT WELL SURVEY

GES Well ID	Distance to HDD Perpindicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-11062017-638-01	539	106	Unknown	Unknown	Unknown



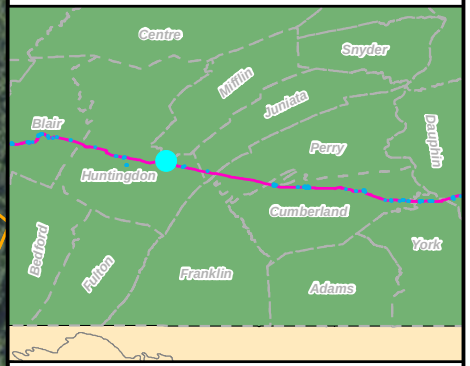
Legend

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

****Testing locations current as of 11/27/2017**

- GES Testing Location

Location



N

0 300 600

Feet

Well Location Map
HDD# PA-PE-0002.0000-RD
Perry County, PA.

Prepared By: [redacted]

Date: 11/27/2017

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

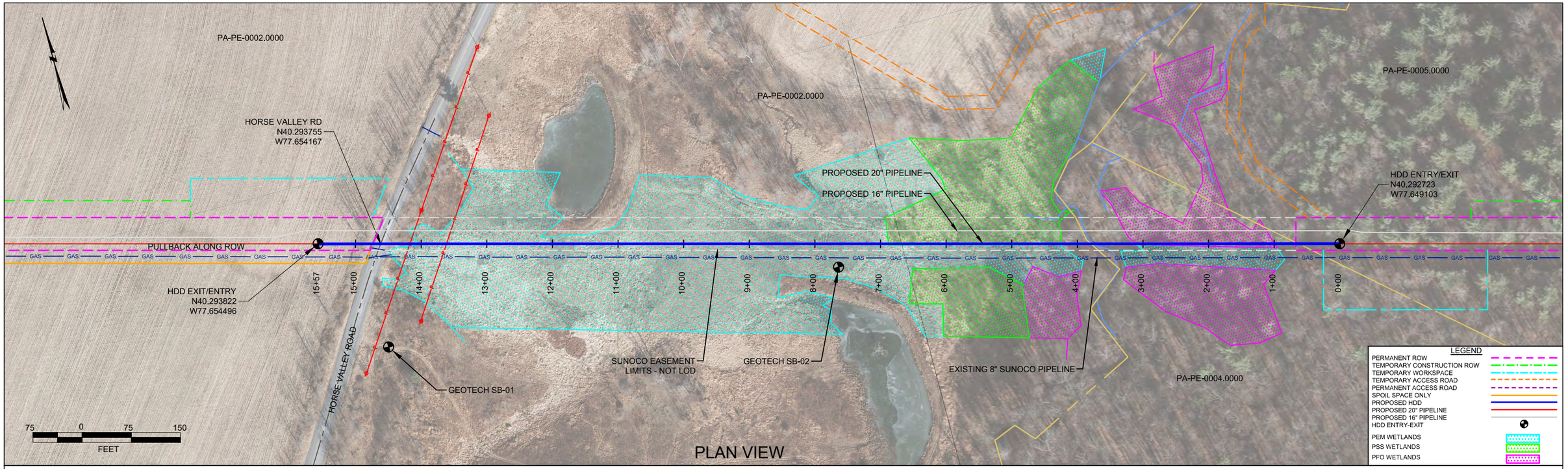
Coordinate System: NAD 83 Stateplane, PA South, Feet

P:\GIS\projects\112\c03938-PPL\MXD\WellLocations\WellLocation_PA_PE_0002_0000.mxd JL

HORSE VALLEY ROAD CROSSING
PADEP SECTION 105 PERMIT NO. E50-258
PA-PE-0002.0000-RD & PA-PE-0002.0000-RD-16
(SPLP HDD No. S2-0157)

ATTACHMENT 2

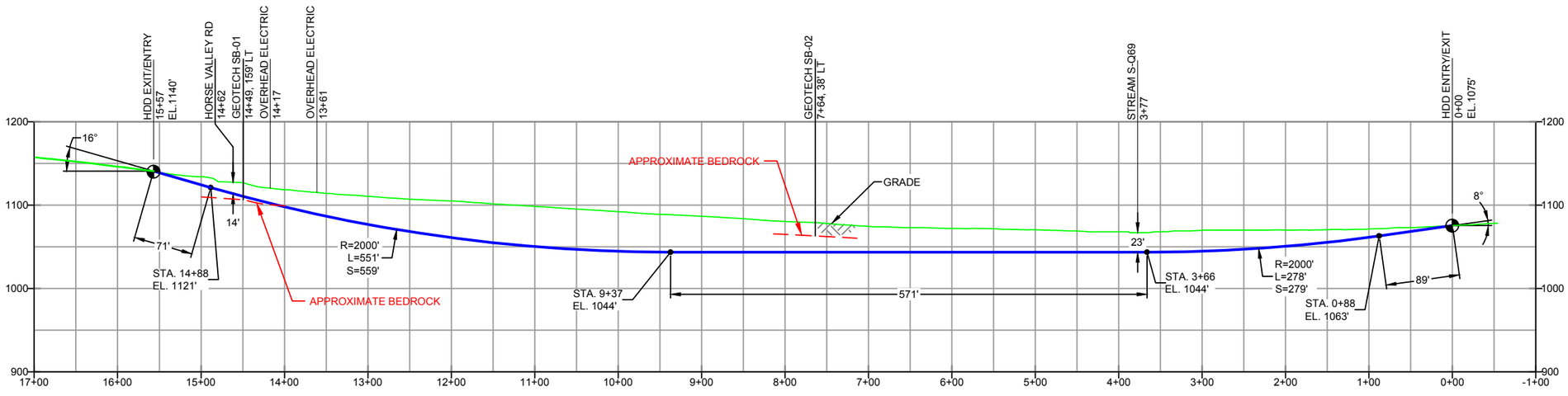
ORIGINAL AND REVISED HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



PLAN VIEW

PROFILE VIEW

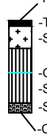
PERRY COUNTY PENNSYLVANIA, TOBOYNE TOWNSHIP
S2-0157



GEOTECH SB-01

-NG EL. 1126'
-TOPSOIL (0' - 0.1')
-CL (0.1' - 13.5')
-SC (13.5' - 18.5')
-GROUNDWATER (17.5')
-SHALE (18.5' - 20.3')
-COMPLETION DEPTH EL. 1106'

GEOTECH SB-02



-NG EL. 1079'
-TOPSOIL (0' - 0.2')
-SM (0.2' - 3.5')
-GROUNDWATER (8.0')
-SC (3.5' - 15.0')
-SHALE (15.0' - 15.9')
-COMPLETION DEPTH EL. 1063'

NOTE: REFER TO TEST BORING LOG S2-0157 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1557'
   HDD PIPE LENGTH (S=):1569'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
2	REVISED PROFILE WITH 2017 LIDAR	MRS	03/22/17	RMB	03/22/17	CAG	03/22/17
1	REVISED PER ENGINEERING COMMENTS	DLM	08/26/16	RMB	08/26/16	AAW	08/26/16
0	ISSUED FOR CONSTRUCTION	MRS	12/22/15	RMB	12/22/15	AAW	12/22/15

Sunoco Logistics Partners L.P.

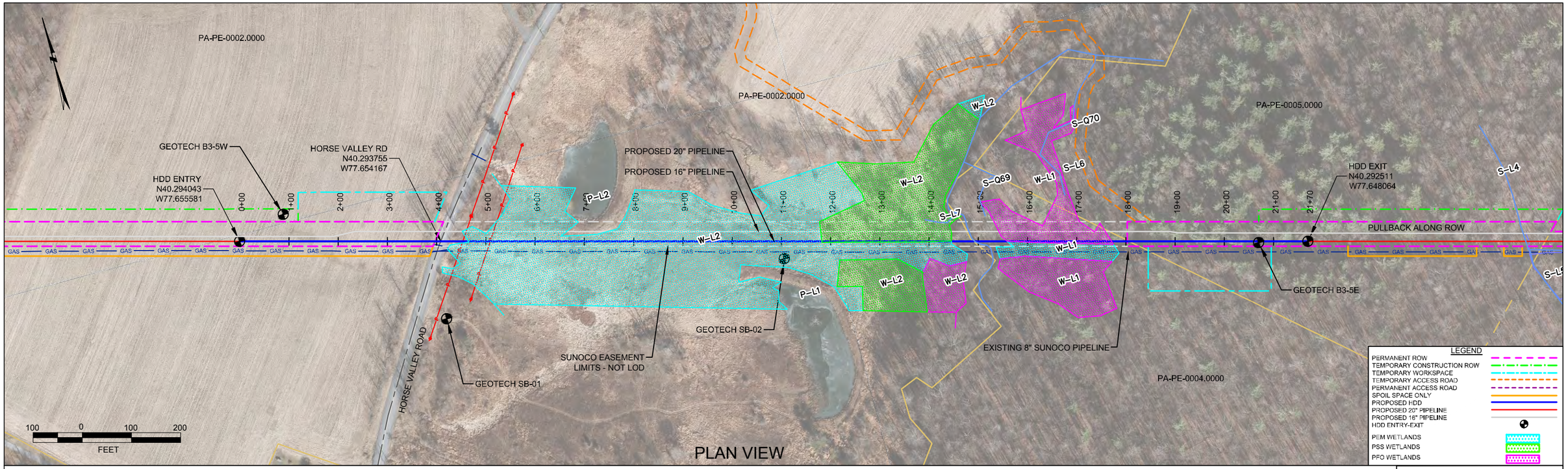
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HORSE VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

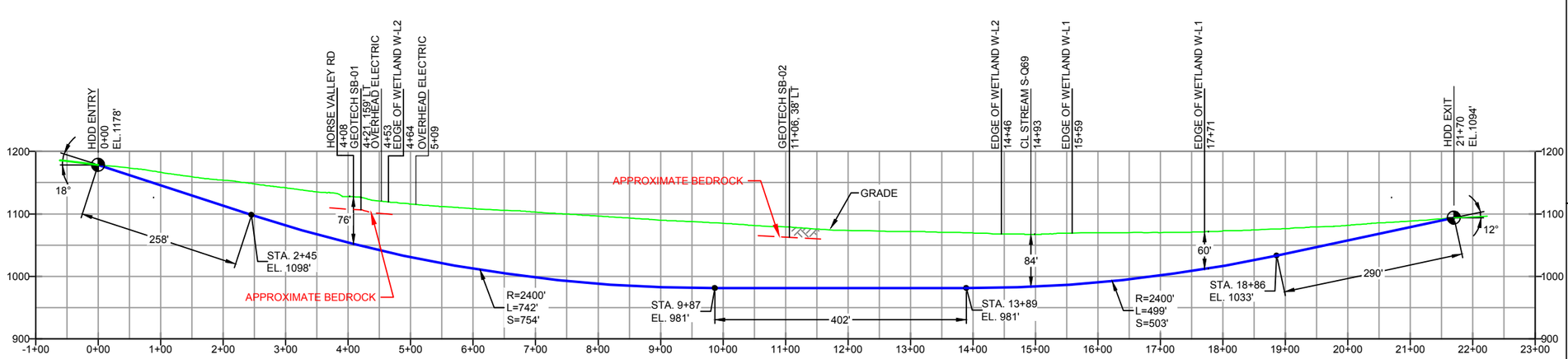
DWG. NUMBER: PA-PE-0002.0000-RD



PLAN VIEW

PROFILE VIEW

PERRY COUNTY PENNSYLVANIA, TOBOYNE TOWNSHIP
S2-0157



GEOTECH SB-01

-NG EL. 1126'
-TOPSOIL (0' - 0.1')
-CL (0.1' - 13.5')
-SC (13.5' - 18.5')
-GROUNDWATER (17.5')
-SHALE (18.5' - 20.3')
-COMPLETION DEPTH EL. 1106'

GEOTECH SB-02

-NG EL. 1079'
-TOPSOIL (0' - 0.2')
-SM (0.2' - 3.5')
-GROUNDWATER (8.0')
-SC (3.5' - 15.0')
-SHALE (15.0' - 15.9')
-COMPLETION DEPTH EL. 1063'

NOTE: REFER TO TEST BORING LOG S2-0157 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B3-5W

-NG EL. 1140'
-LEAN CLAY W/ GRAVEL CL (0.0' - 29.0')
-WEATHERED ROCK/SHALE (29.0' - 135.0')
-BORING TERMINATED EL. 1005'

NOTE: REFER TO TEST BORING LOG B3-5W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B3-5E

-NG EL. 1175'
-LEAN CLAY CL (0.0' - 13.0')
-GROUNDWATER (20.0')
-WEATHERED ROCK/SHALE (13.0' - 85.0')
-BORING TERMINATED EL. 1090'

NOTE: REFER TO TEST BORING LOG B3-5E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 2170'
   HDD PIPE LENGTH (S=): 2207'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

ES-3.03	TO	ES-3.03	EROSION & SEDIMENT PLAN	
SHEET 2	TO	SHEET 2	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	MOVED DRILL ENTRY/EXIT LOCATION - DESIGN PER MICHELS	MRS	11/27/17	RMB	11/27/17	CAG	11/27/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
C	ADDED GEOTECH INFO	MRS	09/14/15	RMB	09/14/15	AAW	09/14/15
B	ISSUED FOR BID	MRS	07/31/15	RMB	07/31/15	AAW	07/31/15

Sunoco Logistics Partners L.P.

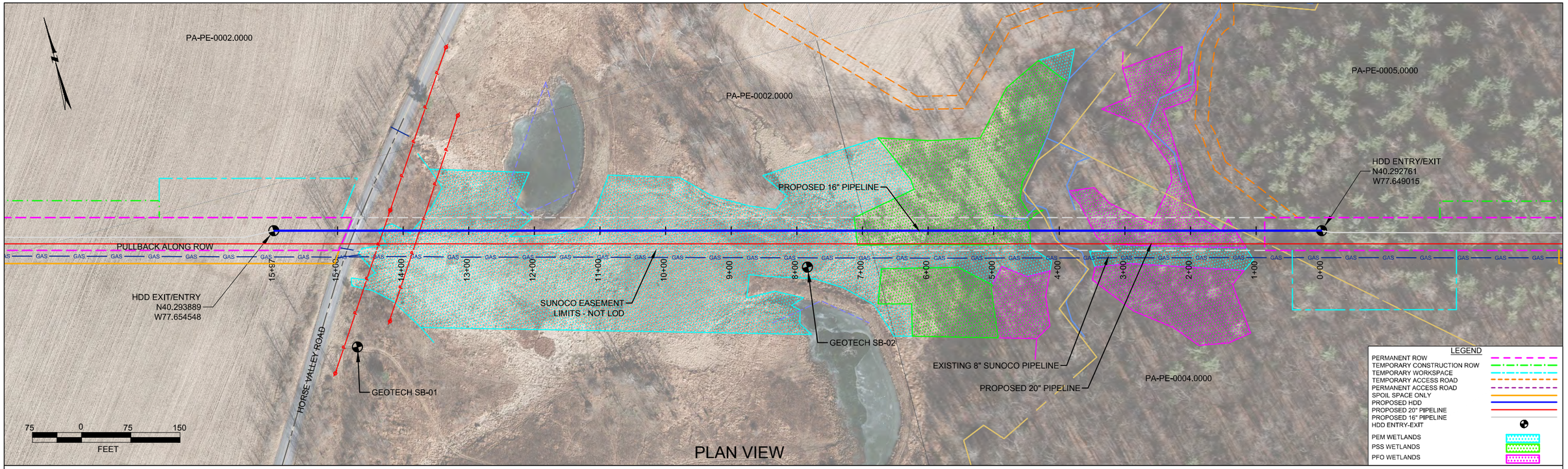
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HORSE VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NUMBER: PA-PE-0002.0000-RD



PLAN VIEW

PROFILE VIEW

PERRY COUNTY PENNSYLVANIA, TOBOYNE TOWNSHIP
S2-0157-16

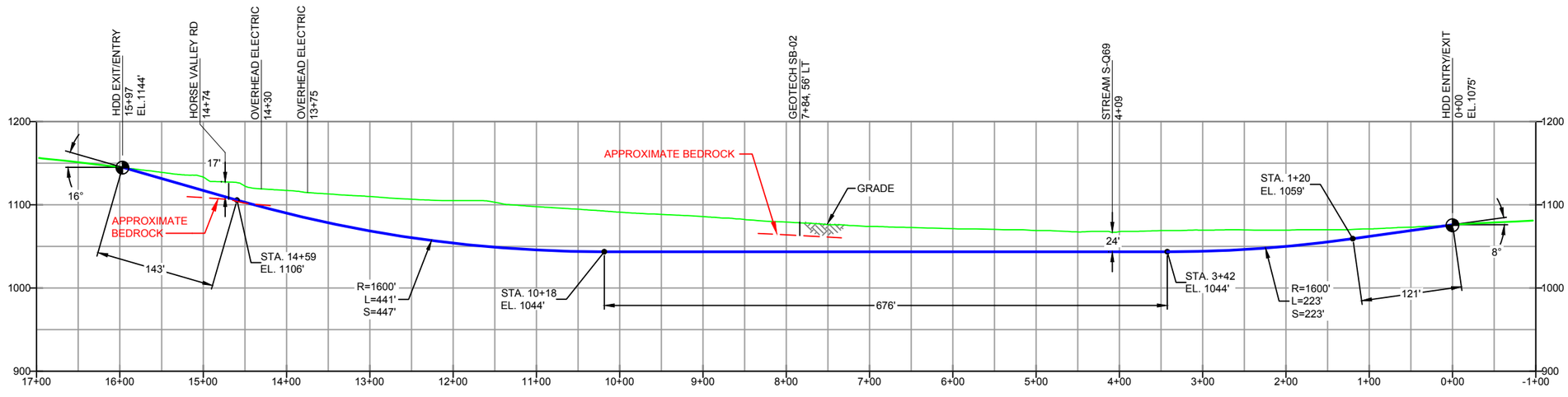
GEOTECH SB-01

-NG EL. 1126'
-TOPSOIL (0' - 0.1')
-CL (0.1' - 13.5')
-SC (13.5' - 18.5')
-GROUNDWATER (17.5')
-SHALE (18.5' - 20.3')
-COMPLETION DEPTH EL. 1106'

GEOTECH SB-02

-NG EL. 1079'
-TOPSOIL (0' - 0.2')
-SM (0.2' - 3.5')
-GROUNDWATER (8.0')
-SC (3.5' - 15.0')
-SHALE (15.0' - 15.9')
-COMPLETION DEPTH EL. 1063'

NOTE: REFER TO TEST BORING LOG S2-0157 FOR COMPLETE SOIL MATERIAL DESCRIPTION



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1597'
   HDD PIPE LENGTH (S=):1610'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
2	REVISED PROFILE WITH 2017 LIDAR	MRS	03/22/17	RMB	03/22/17	CAG	03/22/17
1	REVISED PER ENGINEERING COMMENTS	DLM	08/26/16	RMB	08/26/16	AAW	08/26/16
0	ISSUED FOR CONSTRUCTION	MRS	12/22/15	RMB	12/22/15	AAW	12/22/15

Sunoco Logistics Partners L.P.

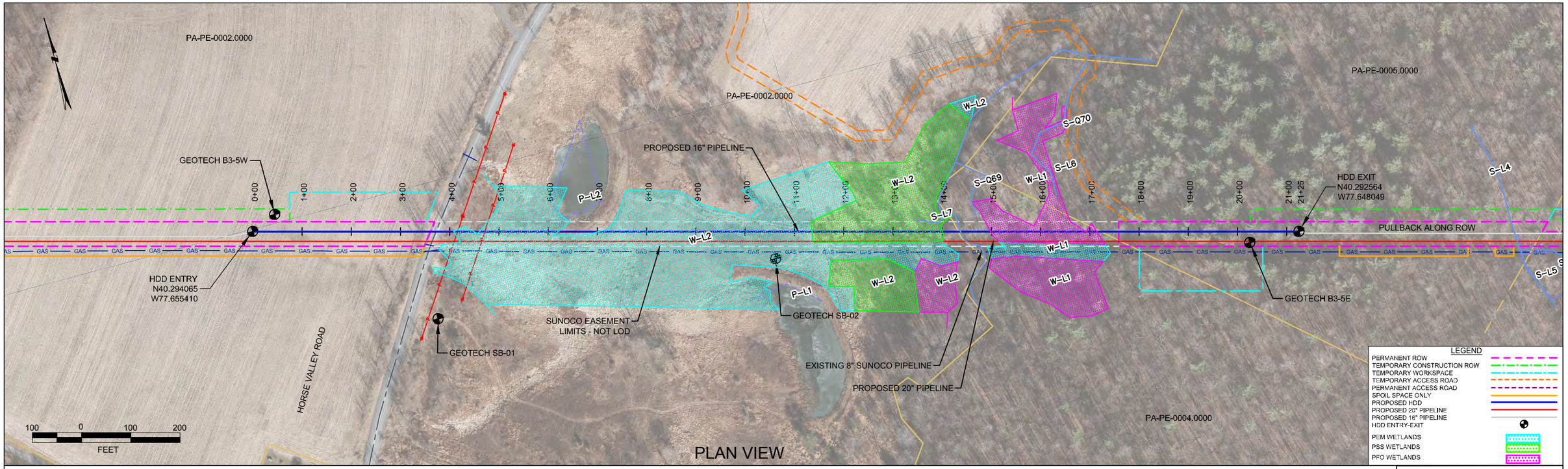
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HORSE VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'

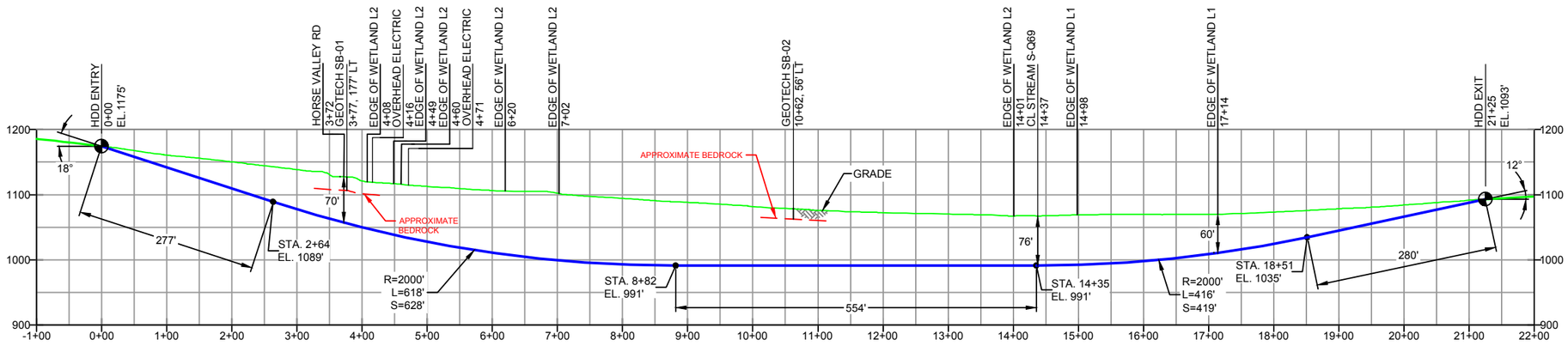
DWG. NO: PA-PE-0002.0000-RD-16



PLAN VIEW

PROFILE VIEW

PERRY COUNTY PENNSYLVANIA, TOBOYNE TOWNSHIP
S2-0157-16



GEOTECH SB-01

-NG EL. 1126'
-TOPSOIL (0' - 0.1')
-CL (0.1' - 13.5')
-SC (13.5' - 18.5')
-GROUNDWATER (17.5')
-SHALE (18.5' - 20.3')
-COMPLETION DEPTH EL. 1106'

GEOTECH SB-02

-NG EL. 1079'
-TOPSOIL (0' - 0.2')
-SM (0.2' - 3.5')
-GROUNDWATER (8.0')
-SC (3.5' - 15.0')
-SHALE (15.0' - 15.9')
-COMPLETION DEPTH EL. 1063'

NOTE: REFER TO TEST BORING LOG S2-0157 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B3-5W

-NG EL. 1140'
-LEAN CLAY W/ GRAVEL CL (0.0' - 29.0')
-WEATHERED ROCK/SHALE (29.0' - 135.0')
-BORING TERMINATED EL. 1005'

NOTE: REFER TO TEST BORING LOG B3-5W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B3-5E

-NG EL. 1175'
-LEAN CLAY CL (0.0' - 13.0')
-GROUNDWATER (20.0')
-WEATHERED ROCK/SHALE (13.0' - 85.0')
-BORING TERMINATED EL. 1090'

NOTE: REFER TO TEST BORING LOG B3-5E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 2125'
   HDD PIPE LENGTH (S=): 2158'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

ES-3.03	TO	ES-3.03	EROSION & SEDIMENT PLAN	
SHEET 2	TO	SHEET 2	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	MOVED DRILL ENTRY/EXIT LOCATION - DESIGN PER MICHELS	MRS	11/27/17	RMB	11/27/17	CAG	11/27/17
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	JTW	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
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

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HORSE VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NO: PA-PE-0002.0000-RD-16