

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS  
PINEY CREEK CROSSING  
PADEP SECTION 105 PERMIT NO.: E07-459  
PA-BL-0126.0000-RD AND PA-BL-0126.0000-RD-16  
(SPLP HDD No. S2-0142)**

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This reanalysis of the horizontal directional drill (HDD) installation of a 20-inch and 16-inch diameter pipeline crossing under Stream S-M3, Wetland M26, Lower Piney Creek Road, Stream S-M30 (Piney Creek), and High Street (State Road 866), 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 9 on the list of HDDs included on Exhibit 2. Activities at this HDD were initiated and suspended in June of 2017, before the issuance of the Order on August 9, 2017.

**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: 1,529 feet (ft)
- Entry/Exit angle: 16 degrees
- Maximum Depth of cover: 70 ft
- Depth under UNT to Piney Creek (Stream S-M33): 37 ft
- Depth under Piney Creek (Stream S-M30): 35 ft
- Depth under adjacent wetlands (Wetland M26): 35 ft
- Pipe design radius: 1,556 ft

**ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH**

- Horizontal length: 1,575 ft
- Entry/Exit angle: 16 degrees
- Maximum Depth of cover: 75 ft
- Depth under UNT to Piney Creek (Stream S-M33): 41 ft
- Depth under Piney Creek (Stream S-M30): 35 ft
- Depth under adjacent wetlands (Wetland M26): 35 ft
- Pipe design radius: 1,600 ft

**GEOLOGIC AND HYDROGEOLOGIC ANALYSIS**

The western portion of HDD S2-0142 is underlain by carbonate and clastic sedimentary rocks of the undivided Coburn through Loysburg Formations (Ocl) in the western portion of this HDD. The formations include the Coburn, Salona, Nealmont, Benner, Snyder, Hatter, and Loysburg. Geologic mapping, published reports, and field observations indicate the presence of jointed and fractured bedrock with low to high angle joints. The properties of the Coburn through Loysburg Formations in the HDD location are generally consistent and are characterized as follows:

- Well bedded, thick and fissile to flaggy;
- Joints are moderately to highly abundant, moderately well developed with blocky and platy patterns, regular, moderately spaced, and steeply dipping to vertical;

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- Most joints are open; however, some are filled with calcite. Well-bedded sandstone, thick bedded to massive; shale is thin; claystone bedding is very poor; limestone varies from nodular to well-bedded;
- The overlying mantle is moderately thick and the bedrock-mantle is usually pinnacled;
- Excavation is difficult and the pinnacles present a special problem. Drilling rates are moderate in the Coburn, Solana, Benner, Hatter, and Lysburg formations. Drilling rates are fast in the Nealmont and Snyder formations;
- Slope stability is good in the limestone and fair to poor in the shaly limestone; however, slope stability is fair where bedding is steeply inclined toward cut slopes;
- Sinkholes are common in the carbonate units of the Coburn Formation.

The eastern portion of HDD S2-0142 is underlain by Bellefonte and Axemann Formations (Oba). The Geologic mapping, published reports, and field observations indicate the presence of jointed and fractured bedrock with low to high angle joints. The Bellefonte and Axemann Formations are generally consistent and are characterized as follows:

- Well bedded and thick to medium (Bellefonte) and thick to thin (Axemann);
- Joints occur as steep to gently dipping joint sets that are moderately abundant, moderately to well developed, and moderately spaced. Most joints are open; however, some are filled with calcite;
- These rocks are moderately resistant to weathering and slightly weathered to a shallow depth. Weathering results in the formation of blocky fragments;
- The overlying mantle displays a variable thickness and bedrock pinnacles are characteristic features of this formation;
- Excavation is difficult and the bedrock pinnacles present a special problem. Drilling rates in this formation are slow;
- Slope stability is generally good, but intersecting joint and bedding planes can be problematic in deep cuts; and

Two geotechnical drilling investigations were conducted at this HDD. The initial investigation was performed in September and January of 2015 during the preliminary investigation of HDD S2-0142, and prior to initiating HDD operations. A second phase of geotechnical drilling was performed in August of 2017.

Karst geology is present at this HDD location, and a geophysical survey was performed. As is discussed in the Hydrogeology Report in Attachment 1, the results of this assessment indicated a high degree of fracturing in the near subsurface geology from immediately west of Piney Creek to within 200 of the west end of the HDD. As is presented in the Reconsideration of the Horizontal Directional Drill section below. The use of HDD best management practices such as annular pressure monitoring, the use of Loss Control Materials, and potentially grouting, will be implemented to maintain returns in both the pilot and reaming phases of the HDD as measure to reduce the risk of inadvertent returns (IRs) to the land surface or waters of the Commonwealth.

Attachment 1 provides an extensive discussion and results on two geotechnical drilling investigations as well as the general geology in the vicinity of this HDD.

## **HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES**

Groundwater at the site occurs in a fractured carbonate and clastic sedimentary bedrock aquifer system within the geology described above. Water-bearing zones generally occur in secondary openings developed along bedding planes, joints, faults and fractures. These features provide ready

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pathways for transporting water in the dolomite and limestone through the enhancement of the primary and secondary openings by solution activity.

A review of published data on water wells provided information on the hydrogeology underlying HDD S2-0142. The depths of 27 domestic wells in the Coburn Formation range from 28 to 400 ft below ground surface (bgs). The median well depth is 200 ft bgs, with five wells less than 100 ft deep and four wells greater than 300 ft deep. The depths of 36 reported domestic and non-domestic wells in the Bellefonte and Axemann Formations range from 42 to 500 ft bgs, with the median well depth of 156 bgs for domestic wells. Well yields ranged from 1 to 30 gallons per minute. The production zone for water wells in this geology is from the well bottom to highest point of water inflow from the water bearing seams, joints, and fractures in the rock formation.

The Pennsylvania Groundwater Information System (PaGWIS) reports three wells recorded within 0.5 mile of HDD S2-0142. All three wells are domestic wells with unknown water levels.

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

#### **INADVERTENT RETURNS DISCUSSION**

An HDD was initiated at this location and an IR occurred during drilling operations in June of 2017. An initial loss of fluid circulation was observed along the HDD trajectory at 82 ft from entry while drilling through limestone and shale. Drilling fluids were subsequently observed discharging into Stream S-M33 (UNT to Piney Creek). Drilling operations were shut down while containment and remedial measures were implemented. The investigation of this IR event identified the shallow depth of the original design profile for this HDD as the root cause; subsequently, this HDD was stopped for reevaluation.

The results of the new geotechnical core borings at the entry and exit points show the revised HDD profile will encounter and transition through mudstone and dolomite in the east portion and shale in the west portion. Overall rock quality parameters improve as depth below ground increases. The west core data show shale at top of bedrock with a recovery value of 50, and RQD value of 87, improving as depth increases with recovery values consistently at 100 and RQD values ranging from 77-90. At maximum profile depth, the recovery value is 100 and RQD value is 98. This is indicative of moderate to good overall rock integrity and strength at profile depth. The east core data shows the top of bedrock as shale with a recovery value of 100 and RQD value of 85. Proceeding to profile depth the HDD will enter and progress through mudstone with recovery values consistently at 100, and RQD values ranging from 78 to 100.

At maximum depth of the revised profile, the geotechnical data is indicative of good overall rock quality, which assists in suppression of IRs.

#### **ADJACENT FEATURES ANALYSIS**

This HDD location is approximately 3.7 miles southwest of Williamsburg, Pennsylvania. Land uses in the vicinity include managed or unmanaged forests, oil and gas (existing aboveground mainline valve), rural residential, and agriculture. The HDD would cross under two streams and one palustrine emergent (PEM) wetland. The crossings of streams S-M30 and S-M33 are located approximately 135 feet east and 270 feet west, respectively, of Lower Piney Creek Road. The crossing of Wetland M26, a PEM wetland, is located 135 feet east of Lower Piney Creek Road.

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Stream S-M30 (Piney Creek) and Stream S-M33 have perennial flow regimes and are considered high quality cold water fisheries (HQ-CWF) under Chapter 93 designations and, as classified by Pennsylvania Fish and Boat Commission (PAFBC), are tributary to a Class A stream, one of the Commonwealth's most high-quality trout waters. Wetland M26 is composed of PEM vegetative cover and designated as an exceptional value (EV) wetland under Pennsylvania Department of Environmental Protection (PADEP) Chapter 105.17, due to its proximity to a naturally reproducing trout stream. This HDD avoids direct surface impacts to these high quality streams and exceptional value wetlands.

Pre-construction, SPLP identified and attempted to contact all landowners with a parcel of land within 150 feet of the HDD alignments. Two (2) water wells were identified and tested as a result of that outreach.

SPLP has identified all landowners with property located within 450 feet of the HDD alignment. There are 9 (nine) individual landowners located within 450 feet 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 (ROW) 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.

To date, four (4) landowners responded verifying the presence of private wells, all of which are within 450 ft of the HDD profile.

Based upon the understanding of the groundwater levels and movement through the overburden and subsurface bedrock fractures and fissures as described in the hydrogeology report, SPLP believes that HDD activities could affect individual well use during active drilling for wells located within 150 linear ft, on either side of the profile, and wells out to 175 ft on either side of the profile set along potential identified fracture zones where water flow in the geology is less restrained. Use of the wells within this area draws upon the ground water reserves through underground porosity, fissures, and fractures. The HDD is an active "pressure event" in the aquifer that pushes upon the static ground water and at minimum could agitate settled sediments within the water bearing zones, or could result in transport of diluted drilling fluids towards the withdrawn zone for individual wells. As a result, active well use during HDD activities potentially could result in the uptake of turbid water. While this does not present a health hazard, it can be unsightly to users and could affect taste.

SPLP will engage in a final outreach to encourage landowners to make advance arrangements for the supply of alternative water sources as necessary during the HDDs. Agents for SPLP will initiate direct contact by phone or in person, and SPLP will prepare a second communication specifically directed to all landowners with known wells, or unidentified water supplies within 175 ft of the HDD profiles. The letter will communicate our analysis regarding their water supply. It will clearly state the preference to establishing communications in advance of the work; permission to perform monitoring during the HDDs, and landowners preference to installing alternative water in advance of the HDDs.

During the active HDD process, any landowner contacting SPLP with concerns about their water supply will be responded to. If an impact from the HDD is verified, then SPLP will encourage the affected landowner to allow the installation of alternative water supply.

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## **ALTERNATIVES ANALYSIS**

As required by the Order, the reanalysis of S2-0142 includes an evaluation of open cut alternatives and a re-route analysis. As part of the PADEP Chapter 105 permit process for the Pennsylvania Pipeline 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 analyzed the potential feasibility of any alternative to the baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

### **Open-cut Analysis**

Conversion to an open cut trenched crossing method would result in direct but temporary impacts to: Streams S-M30 and S-M33, PADEP-designated HQ-CWFs and PAFBC-designated tributary to a Class A stream, one of the Commonwealth's most high-quality trout waters; and Wetland M26, a PEM wetland that is a PADEP-designated EV wetland, due to its proximity to a naturally reproducing trout stream.

SPLP specifications require a minimum of 48 inches of cover between the installed pipeline and the bottom of the watercourse. To meet this cover requirement, during trenched construction through the two streams (Streams S-M30 and S-M33), a workspace with a width up to 75 feet would be required to accommodate the pipelines and provide sufficient space for trench excavation, spoil storage, and sufficient separation between pipelines (including the existing 8-inch Sunoco pipeline and two proposed lines) for integrity management. The assessed area of impact by this open cut plan would directly affect approximately 0.8 acre of stream bed. Conventional crossings of these streams would require using upstream and downstream sandbag diversion dams or coffer dams, pumping stream flow around the trench/workspace, pumping out (from the in-stream workspace or excavated areas) any produced groundwater discharge or seepage around/under the dams (through water filter bags), for the duration of the crossing event. Although the temporary impacts would be controlled and managed using these appropriate best management practices, SPLP's preferred method is to drill below these resources.

Converting to an open cut trenched crossing method through this area would also result in 0.01 acre of temporary impacts to Wetland M26, a PEM wetland, designated as an exceptional value wetland under PADEP Chapter 105.17 due to its proximity to a naturally reproducing trout stream. The HDD will largely avoid surface impacts to biological features. In addition, as currently proposed, impacts from the HDD travel lane use results in 0.001 acre of temporary impacts to Wetland M26, 147 square feet (sq. ft.) of temporary impacts to Stream S-M30, and 30 sq. ft. of temporary impacts to Stream S-M33 of, resulting in a minimization of impacts to water resources. By contrast, the travel lane use associated with the open cut alternative results in 0.09 acre of temporary impacts to these water resources.

A conventional auger bore cannot replace this HDD due the length limitations of this technology and changes in elevation across its length. When considering the use of conventional auger bore to

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replace portions of this HDD, all the surface features listed above and Piney Creek Road have various elevational settings relative to the surrounding topography and adjacent features to be considered. A review of the HDD profile cross section illustrates that in each instance on all these, large areas of the adjacent slopes would have to be excavated to get down to the depth required to secondarily excavate a trench for the entry, receiving, and pipe segment pull back phase. At the crossing of stream S-M33 and adjacent wetlands, the presence of Lower Piney Creek Road to the east negates the ability to setup either the bore entry or pipeline pull back pits. Lower Piney Creek Road could be bored from the west side, but the east side proximity of Piney Creek prohibits either entry or pull back setup. Piney Creek itself is set too far below the adjacent slopes to cross by conventional auger bore.

### **Re-Route Analysis**

In accordance with state and federal guidance, SPLP has co-located the Project route within the existing SPLP pipeline or 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, new land use encumbrance, and site-specific and cumulative impacts on land, environmental, and community resources.

Because streams S-M30 and S-M33 extend north and south of this HDD and Wetland M26 extends further to the south of this HDD, no practicable re-route option lies to the north or south of the proposed route that would not ultimately cross streams or wetlands. Furthermore, if shifted to the north, the angle necessary to create a more northerly HDD would potentially place the pipelines parallel to or along the stream bed of Stream S-M34. As noted in the project permit application, reroutes to the north/south were not considered feasible as they would result in the clearing of additional forested lands (and potentially other wetlands) as well as previously undisturbed habitat, and potentially increased public health and safety/hazards risks to nearby residences in the area.

Lastly, the current route utilizes existing easements that were acquired for pipelines before the time development surrounding the existing pipeline commenced. Accordingly, development surrounding the existing easement took place with the knowledge of existing pipelines and a permanent encumbrance on the land. By contrast, using a "greenfield" corridor outside of the existing developments in any direction away from the existing easement would require additional landowners to accept the establishment of a new encumbrance for pipeline use that did not exist at the time of acquisition.

### **RECONSIDERATION OF THE HORIZONTAL DIRECTIONAL DRILL**

Additional geologic investigations have been completed and utilized in the redesign of the planned HDDs. These redesigns adjust 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: 1,766 foot (ft)
- Entry/Exit angle: 16-17 degrees
- Maximum Depth of cover: 88 ft
- Depth under UNT to Piney Creek (Stream S-M33): 67 ft
- Depth under Piney Creek (Stream S-M30): 60 ft
- Depth under adjacent wetlands (Wetland M26): 61 ft
- Pipe design radius: 2,200 ft

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**Revised Horizontal Directional Drill Design Summary: 16-inch**

- Horizontal length: 1,674 foot (ft)
- Entry/Exit angle: 16-18 degrees
- Maximum Depth of cover: 86 ft
- Depth under UNT to Piney Creek (Stream S-M33): 60 ft
- Depth under Piney Creek (Stream S-M30): 56 ft
- Depth under adjacent wetlands (Wetland M26): 54 ft
- Pipe design radius: 2,100 ft

As shown on Figure 2, the redesigned HDD profile for the 20-inch pipeline is 237 ft longer, with a depth of cover below the streams and wetlands increased by 25-30 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 99 ft longer, with a depth of cover below the streams and wetlands increased by 19-21 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. The risk of IRs increases on entry and exit of the drilling tool and other measures are required to minimize IR potential. In particular, upon the start of these HDDs, Sunoco will employ the following HDD best management practices:

- SPLP will notify the drilling contractor of the high degree of fracturing in the karst geology west of Piney Creek, and provide them with the materials for reference against the profile such that the driller will know to pay close attention while the tools are progressing through this portion of the profile;
- SPLP will mandate rotational drilling of the pilot hole until competent bedrock is reached, such that the initial drilling at entry is performed at fluid pressures less than those required to operate the mud motor drive;
- 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

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- 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.

**ATTACHMENT 1**

**GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT**

December 21, 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  
Lower Piney Creek Horizontal Directional Drill Location (S2-0142)  
Hydrogeological Re-evaluation Report  
Woodbury Township, Blair County, Pennsylvania  
RETTEW Project No. 096302011

## EXECUTIVE SUMMARY

1. The Corrected Stipulated Order dated August 10, 2017 requires a re-evaluation of Lower Piney Creek Horizontal Directional Drill (HDD) Location S2-0142, including a geologic report.
2. The Lower Piney Creek HDD is underlain by carbonate and clastic sedimentary rocks of the undivided Coburn through Loysburg Formations (Ocl) and the undivided Bellefonte and Axemann Formations (Oba).
3. Geologic mapping, published reports, and field observations indicate the presence of jointed and fractured bedrock with low to high angle joints.
4. Water-bearing zones generally occur in secondary openings along bedding planes, joints, faults and fractures. Median well depth in the undivided Coburn through Loysburg Formations is 200 feet below the ground surface (bgs) and 156 feet bgs in the undivided Bellefonte and Axemann Formations.
5. The proposed HDD profile has been lengthened and deepened to provide additional cover beneath the streams that underlie the HDD profile.
6. Based on the hydro-structural characteristics of the underlying geology, and proposed HDD profile, the Lower Piney Creek 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 Lower Piney Creek (S2-0142) HDD location (the site) on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project-Mariner II East (PPP-ME2) Project. The Lower Piney Creek HDD is located in Woodbury Township, Blair County, Pennsylvania (refer to **Figure 1**). The HDD was designed to be drilled under a small unnamed tributary stream (S-M33) and associated wetland, Lower Piney Creek Road, Piney Creek, and High Street (SR 866). This re-evaluation report is part of the response to the Corrected Stipulated Order dated August 10, 2017 related to the inadvertent return of drilling fluids that occurred during HDD operations performed at the site on June 26, 2017.

The proposed HDD profile was lengthened and deepened on September 22, 2017 to provide additional protective cover beneath the stream and wetland crossings. The HDD entry on the eastern side of the

profile is at an elevation of approximately 1,115 feet above mean sea level (AMSL) for the proposed 16-inch drill, and 1,113 feet AMSL for the proposed 20-inch drill. The HDD exit on the western side of the profile is at an elevation of approximately of 1,123 feet AMSL for the proposed 16-inch drill and 1,150 feet AMSL for the proposed 20-inch drill. The inclination of the entry and exit angles has been increased to install the pipe through these protective soils, residual soils, and bedrock; and in closer proximity to the entry and exit points than the original, shorter and shallower profile. The proposed 20-inch and 16-inch HDDs are located between Stations 6730+00 and 6749+00 on the overall pipeline alignment. The proposed S2-0142 HDD locations are shown on **Figure 1**. Based on the annular pressure and formation pressure capacity curves provided by Directional Project Support (DPS) as part of the overall re-evaluation submittal, the weakest points in the profile are the HDD entry, exit and the stream crossings. At the S-M33 crossing, the HDD profile is approximately 60 feet below the stream for the proposed 16-inch drill and 97 feet below the stream for the proposed 20-inch drill. At the Piney Creek crossing, the HDD profile is approximately 56 feet below the stream for the proposed 16-inch drill and 88 feet below the stream for the proposed 20-inch drill. 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, underlain by sedimentary rocks consisting of sandstone, siltstone, shale, conglomerate, limestone, and dolomite. Local topography is characterized by long narrow ridges, broad to narrow rolling valleys of low relief, and natural slopes that are gentle and stable with some karst terrane (Sevon, 2000). The Lower Piney Creek HDD is located on the west limb of an anticline that has a strike trending northeast-southwest and dipping to the northwest.

According to the United States Department of Agriculture (USDA) Soil Surveys of Blair County, Pennsylvania, soils in the vicinity of the Piney Creek HDD consist of 12 separate soil units. A USDA map that depicts the area surrounding the HDD, along with soil profile descriptions, is included as **Attachment 2**.

The geology underlying the western portion of the Lower Piney Creek HDD is mapped as the undivided Coburn through Loysburg Formations (Ocl) of Ordovician age as shown on **Figure 2**. These formations include the Coburn, Salona, Nealmont, Benner, Snyder, Hatter and Loysburg. The Coburn Formation is described as a medium-gray to very dark gray, fossiliferous and shaly limestone. Bedding is described as well bedded and thick, and fissile to flaggy. Joints are moderately to highly abundant, moderately well developed with blocky and platy patterns, regular, moderately spaced, and steeply dipping to vertical. Most joints are open; however, some are filled with calcite. These rocks are moderately resistant to weathering and slightly weathered to a shallow depth. The shaly limestone is moderately weathered to a deeper depth. Weathering in the limestone results in medium-sized blocks. The shaly limestone weathers to small, pencil-like, flat fragments. The overlying mantle is moderately thick and the bedrock-mantle is usually pinnacled. From an engineering standpoint, excavation is difficult and the pinnacles present a special problem. Drilling rates are moderate in the shaly limestone of the Coburn Formation. Slope stability is good in the limestone and fair to poor in the shaly limestone; however, slope stability is fair where bedding is steeply inclined toward cut slopes. While foundation stability is fair, excavations should be completed to sound material and evaluated for areas of collapse. Subsurface drainage is good and surface drainage is poor. Sinkholes are common in the carbonate units of the Coburn Formation.

Secondary porosity of moderate to high magnitude is provided by joints and solution features resulting in high permeability (Geyer and Wilshusen, 1982).

The Salona Formation is described as a dark gray to black, laminated, medium to coarse-grained, fossiliferous limestone with chert nodules. Bedding is described as well bedded and mostly fissile to flaggy with a few thick beds. Joints are moderately well developed with primary blocky patterns and secondary platy patterns, fairly regular, moderately well developed, moderately to highly abundant, and with moderate space between fractures. Most fractures are open but some are filled with calcite. Fractures are reported to be steeply dipping to vertical. These rocks are moderately resistant to weathering and slightly weathered to a shallow depth; shaly limestone beds weather moderately to a deeper depth. Limestone units weather to medium blocks and shaly limestone weathers to small, flat, pencil-like fragments. The overlying mantle is thick and characterized by bedrock pinnacles. From an engineering standpoint, excavation is difficult and the pinnacles present a special problem. Drilling rates are moderate. Slope stability is good in the limestone; however, the shaly limestone is susceptible to moisture and provides only fair, short-term stability. Foundation stability is good when excavations are completed to sound material, but should be thoroughly investigated for solution activity. Subsurface drainage is good and surface drainage is poor. Sinkholes are common in the Salona Formation. Secondary porosity is moderate to high due to joints and solution activity. Permeability is low to moderate (Geyer and Wilshusen, 1982).

The Nealmont Formation is described as a medium gray, coarsely crystalline, fossiliferous limestone at the top of the formation and a thin bedded, finely crystalline, shaly limestone at the base. The Nealmont Formation is typically well bedded and fissile to flaggy, with rare thickly bedded strata. Joints primarily exhibit blocky patterns with a few displaying platy patterns. Joints are moderately well developed, moderately to highly abundant, fairly regular and show a moderate distance between joints. Most fractures are open but some are filled with calcite. Joints are typically steeply dipping to vertical. The Nealmont Formation is moderately resistant to weathering and slightly weathered to a shallow depth. Weathering results in medium-sized blocks. The overlying mantle is moderately thick and usually characterized by sinkhole development and bedrock pinnacles. From an engineering standpoint, excavation is difficult and bedrock pinnacles present a special problem often requiring additional excavation to sound material. Drilling rates are fast. Slope stability is good, however steeply dipping beds inclined toward the cut face only provide fair stability. Foundation stability is good and should be excavated to sound material thoroughly investigated for solution activity. Subsurface drainage is good and surface drainage is poor. Secondary porosity is moderate to high due to jointing and bedrock solution activity. Permeability is moderate (Geyer and Wilshusen, 1982).

The upper portion of the Benner Formation is described as a light to dark gray, very finely crystalline limestone that includes a high-calcium limestone known as the Valentine Member and an argillaceous (shaly) limestone with metabentonite beds known as the Valley View Member. The Benner Formation is well bedded and fissile to flaggy with some locally thick beds. Joints are typically steeply dipping, moderately well developed, moderately to highly abundant, fairly regularly distributed with a moderate distance between joints. Most joints have a blocky pattern, but some are platy. Most fractures are open but some are filled with calcite. The Benner Formation is moderately resistant to weathering and is only slightly weathered to shallow depths, resulting in medium sized joint blocks. The shaly limestone is moderately weathered to a deeper depth and weathers to form small, pencil-like fragments. The mantle is moderately thick and characterized by sinkhole development and bedrock pinnacles. From an

engineering standpoint, excavation is difficult and the bedrock pinnacles present a special problem often requiring additional excavation to sound material. Drilling rates are moderate. Slope stability is good; however, steeply dipping beds inclined toward the cut face provide only fair stability. Foundation stability is good and should be excavated to sound material with thorough investigation for solution activity. Subsurface drainage is good and surface drainage is poor. Secondary porosity is moderate to high due to the presence of joints and bedrock solution activity. Permeability is low (Geyer and Wilshusen, 1982).

The Snyder Formation is described as a medium to medium dark gray, coarsely crystalline limestone containing limestone conglomerate beds. There are numerous impure bands of medium medium-dark gray limestone with mud cracks and ripple marks, laminated, finely crystalline dolomitic limestone, light gray, very finely crystalline limestone, and medium dark gray, fine-grained oolitic and mud pellet limestone. The Snyder Formation is well bedded and platy to thick. Joints are moderately well developed and abundant, regularly spaced, and show a moderate distance between joints. Joints generally display a blocky pattern although a few show a platy pattern. Most joints are steeply dipping and open, but some are filled with calcite. The Snyder is moderately resistant to weathering and slightly weathered to a shallow depth. From an engineering standpoint, excavation is difficult and bedrock pinnacles present a special problem often requiring additional excavation to sound material. Drilling rates are fast. Slope stability is good, however steeply dipping beds inclined toward the cut face only provide fair stability. Foundation stability is good and should be investigated for sinkhole development and bedrock solution activity. Subsurface drainage is good and surface drainage is poor. Sinkholes are common in the Snyder Formation. Secondary porosity is moderate to high due to the presence of joints and bedrock solution activity. Permeability is low to moderate (Geyer and Wilshusen, 1982).

The Hatter Formation is described as a medium gray, silty and shaly limestone that is laminated and dolomitic. The Hatter Formation is typically well bedded, fissile to flaggy, though thick bedded in some locations. Joints are typically steeply dipping to vertical, moderately well developed, moderately to highly abundant, and fairly regularly spaced with a moderate distance between joints. Most fractures are open but some are filled with calcite. The Hatter Formation is moderately resistant to weathering and slightly weathered to a shallow depth resulting in medium-sized blocks. The shaly limestone is moderately weathered to a deeper depth. The mantle is moderately thick and characterized by bedrock pinnacles. From an engineering standpoint, excavation is difficult and bedrock pinnacles present a special problem often requiring additional excavation to sound material. Drilling rates are moderate. Slope stability is generally good, but only fair in the shaly limestone. However, steeply dipping beds inclined toward the cut face provide fair stability. Foundation stability is generally good, but due to the common occurrence of sinkholes in the Hatter Formation, foundations should be excavated to sound material and thoroughly investigated for bedrock solution activity. Subsurface drainage is good and surface drainage is poor. Secondary porosity is moderate to high due to bedrock jointing and solution activity. Permeability is moderate to high (Geyer and Wilshusen, 1982).

The Loysburg Formation is comprised of the Clover Member and the Milroy Member. The Clover Member is described as a light to medium gray, shaly limestone. The Milroy Member is described as an alternating medium-gray, limestone, dolomitic limestone, and dolomite. The Loysburg Formation is well bedded and thick. Joints are moderately well developed, moderately to highly abundant, fairly regularly spaced, and display a moderate distance between joints. Joints show a blocky pattern and platy patterns locally. Most joints are steeply dipping to vertical and open, but some are filled with calcite. The Loysburg Formation is moderately resistant to weathering and slightly weathered to a shallow depth resulting in medium-sized

blocks. The mantle is moderately thick and characterized by bedrock pinnacles. From an engineering standpoint, excavation is difficult and bedrock pinnacles present a special problem often requiring additional excavation to sound material. Drilling rates are moderate. Slope stability is generally good; however, steeply dipping beds inclined toward the cut face provide only fair stability. Foundation stability is good, but due to the common occurrence of sinkholes in the Loysburg Formation, the bedrock should be investigated for solution activity. Subsurface drainage is good and surface drainage is poor. Secondary porosity is moderate to high due to joints and bedrock solution activity. Permeability is moderate (Geyer and Wilshusen, 1982).

The geology underlying the eastern portion of the Lower Piney Creek HDD is mapped as the undivided Bellefonte and Axemann Formations (Oba) of Ordovician age as shown on **Figure 2**. The Bellefonte Formation consists primarily of light to medium gray, very fine-grained dolomite although minor sandstone, chert, and medium crystalline dolomite are also present. Bedding is described as well bedded and thick to medium. Joints occur as steep to gently dipping joint sets that are moderately abundant, moderately to well developed with blocky patterns, regular, and moderately spaced. Most joints are open, however some are filled with calcite. These rocks are moderately resistant to weathering and slightly weathered to a shallow depth. Weathering results in the formation of blocky fragments. The overlying mantle displays a variable thickness and bedrock pinnacles are characteristic features of this formation. From an engineering standpoint, excavation is difficult and the bedrock pinnacles present a special problem often requiring additional excavation to sound material. Drilling rates in this formation are slow. Slope stability is generally good, but intersecting joint and bedding planes can be problematic in deep cuts. Foundation stability is good and should be evaluated for areas of collapse. Subsurface drainage is good and surface drainage is minor. Secondary porosity of low to moderate magnitude is provided by joints and bedrock solution features. Permeability is low (Geyer and Wilshusen, 1982).

The Axemann Formation consists of light gray, fossiliferous and coarsely crystalline limestone, interbedded with fine-grained dolomitic limestone, and some oolitic and conglomeratic limestone. Flint and chert concretions are found throughout the formation. This unit is described as well bedded, with individual beds ranging from thick to thin. Joints are steeply dipping, moderately abundant, well developed, regularly spaced with a blocky pattern, and with a moderate distance between joints. Most joints are open, however some are filled with calcite. These rocks are moderately resistant to weathering and only slightly weathered to a shallow depth. Weathering results in small to large blocky fragments. The thickness of the overlying mantle is variable due to the presence of bedrock pinnacles. From an engineering standpoint, excavation is difficult and the bedrock pinnacles present a special problem often requiring additional excavation to sound material. Drilling rates in this formation are moderate. Slope stability is good, however steeply dipping beds toward the cut slope may require moderate to gentle slope gradients. Secondary porosity of moderate to high magnitude is provided by joints and bedrock solution features. Permeability is moderate (Geyer and Wilshusen, 1982).

### **3.0 HYDROGEOLOGY**

Groundwater at the site occurs in a fractured carbonate and clastic sedimentary bedrock aquifer system within the geology described in Section 2.0. In these rock types of Blair County, water-bearing zones generally occur in secondary openings developed along bedding planes, joints, faults and fractures. Most of the water-bearing zones penetrated by wells occur in individual fractures or groups of interconnected fractures that can be sufficiently enlarged by dissolution of the bedrock. These features provide ready

pathways for transporting water in the dolomite and limestone through the enhancement of the primary and secondary openings by solution activity (Taylor, 1982).

A review of published data on water wells provided information on the hydrogeology underlying the site. The depths of 27 domestic wells in the Coburn Formation range from 28 to 400 feet bgs. Well yields ranged from 1 to 25 gallons per minute (gpm) in 25 wells, and the median well yield is 6 gpm. The median well depth is 200 feet bgs, with five wells less than 100 feet deep and four greater than 300 feet deep (Taylor, 1982).

The depths of 36 reported domestic and non-domestic wells in the Bellefonte and Axemann Formations range from 42 to 500 feet bgs, with yields ranging from 1 to 250 gpm. The median well depth for domestic wells is 156 feet bgs. Median well yields are 10 gpm for domestic wells and 30 gpm for non-domestic wells. Ten of the reported domestic wells meet domestic yield requirements at depths of less than 100 feet bgs. Eight domestic wells had to be drilled to depths greater than 300 feet to meet desired yields (Taylor, 1982).

Well records reviewed within a 0.5-mile radius of the HDD location were obtained from the Pennsylvania Groundwater Information System (PaGWIS, October 11, 2017). A total of three well records were available and are summarized below. The well locations are shown on **Figures 2 and 3**.

Well No.	Well Use	Casing Depth	Total Depth	Water Level	Yield
60027	Domestic	31 feet	185 feet	Unknown	Unknown
59929	Domestic	80 feet	105 feet	Unknown	Unknown
3672	Domestic	Unknown	1,010 feet	Unknown	Unknown

As a condition of the corrected Stipulated Order, other Sunoco subcontractors have researched private water supplies with 450 feet of the Lower Piney Creek HDD in November of 2017. One additional spring and three wells were identified within the 450-foot buffer of the alignment. The well depths range from 149 feet bgs to 250 bgs. Information regarding depth to water is limited to one well with a reported depth to water of 70 feet bgs. A map of these locations is included as **Attachment 3**.

#### 4.0 FRACTURE TRACE ANALYSIS

Fracture traces underlying, or in close proximity to, the Lower Piney Creek HDD were evaluated using historical aerial photographs from the years 1994 through 2015 (Google Earth, 2017), the Frankstown 7.5 Minute Quadrangle Geologic Map (Berg and Dodge, 1981) and United States Geological Survey (USGS) 7.5 Minute Quadrangle Topographic Map. 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 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. A total of seven fracture traces were identified within approximately one mile of the

site that are likely related to the primary geologic structure of the area discussed above. Due to the nature of the ridges and folded geology near the site, several of the bedding-parallel fracture traces trend approximately Northeast-Southwest (NE-SW). Bedding-perpendicular fracture traces were identified in the approximately West-East (W-E) fracture lineaments which are presumed to be stress-related joint sets. General surface drainage patterns near the site are characterized by linear stream reaches in NE-SW or W-E trends that reflects the local geologic structure. Lower Piney Creek flows generally SW-NE where it discharges to the Juniata River, which forms a structurally controlled regional groundwater discharge boundary in Blair and Mifflin Counties.

## 5.0 GEOTECHNICAL EVALUATION

Two geotechnical drilling investigations were performed at the site; the initial investigation was performed in September and January of 2015 during the preliminary investigation of HDD S2-0142, and prior to initiating HDD operations. A second phase of geotechnical drilling was performed in August of 2017. The 2015 test borings were advanced by hollow-stem augers and NQ-sized wireline rock coring techniques. These borings are designated as SB-01, SB-02, and SB-03. The more recent 2017 test borings were advanced using mud-rotary and NQ-sized wireline rock coring methods. Soil, residual soil and weathered bedrock were sampled using split-spoon samplers. These borings are designated as B3-1W and B3-1E. Geotechnical boring logs are included in **Attachment 1**.

Boring SB-01 was located approximately 400 feet southeast of the HDD exit. SB-02 was located approximately 250 feet north of the profile on the west side of Lower Piney Creek Road. SB-03 was located approximately 50 feet north of the HDD entry. Boring B3-1W was located approximately 360 feet southeast of the HDD exit, and Boring B3-1E was located approximately 80 north of the HDD entry. The locations of these borings are depicted on **Figures 2 and 3**.

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

- Soil and residual soil depths vary from 9 to 11 feet bgs. The residual soils are described as follows:
  - **Boring SB-01:** SILT (ML) with some fine sand and fine to coarse SAND and GRAVEL (SM/GM) with little silt. The boring was terminated at auger refusal (10 feet bgs). Two additional attempts were made and refusal was encountered at 8 feet and 8.5 feet bgs, respectively. Groundwater was not encountered.
  - **Boring SB-02:** CLAY and SILT (CL/ML), trace fine sand, trace gravel (limestone). Auger refusal was encountered at 9 feet bgs. Groundwater was not encountered.
  - **Boring SB-03:** Fine SAND (SM) with some silt, little fine gravel. CLAY and SILT (CL/ML), fine to coarse SAND and GRAVEL (SM/GM) with some silt. Auger refusal was encountered at 11 feet bgs. A second attempt was made to auger deeper, but refusal was encountered at 11.8 feet bgs. Groundwater was not encountered.
  - **Boring B3-1W:** Lean CLAY (CL) with trace sand. Refusal was encountered at 10 feet bgs. Groundwater was not encountered.
  - **Boring B3-1E:** Lean CLAY (CL) with gravel. Cobbles and weathered bedrock were encountered at 4.5 feet bgs. A roller bit was used to drill to 15 feet bgs and casing was installed to 13.5 feet bgs to facilitate coring. Groundwater was not encountered.
- 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 SB-01:** Rock coring was not completed at this location.
- **Boring SB-02:** SB-02 was completed to a total depth of 17 feet bgs. A gray moderately to highly fractured limestone with calcite deposits was encountered from 9 to 17 feet bgs. Fracture plane dips ranged from 15° to 45°. Rock recoveries were good (92% to 94%) and rock quality designations (RQD) were poor (17% to 54%).
- **Boring SB-03:** Rock coring was not completed at this location.
- **Boring B3-1W:** B3-1W was completed to a total depth of 195 feet bgs. From 10 to 195 feet bgs, a dark gray SHALE and calcareous SHALE were observed. The shale was fine grained, moderately hard to hard, and fresh to moderately weathered. Joints range from low to high angle and are closely spaced. Some joints are filled with coal, and calcareous veins were observed at 56, 71 to 73, 80, 151, 152.5, and 167.5 feet bgs. At 80 feet bgs, pyrite was observed in the veins. Quartz veins were observed from 108 to 110 feet bgs. At 135 feet bgs, a 2-inch thick seam of soft, dark, oily clay was observed with highly weathered shale present at 138 feet bgs. Rock recoveries were very poor to excellent (23% to 100%) and generally excellent below a depth of 35 feet bgs. RQDs were very poor to excellent (0% to 100%). The weakest recoveries and RQDs were reported at the transition from soil/residuum/weathered mantle and the bedrock interface. Poor RQDs were reported from 30.5 to 35 feet bgs (33%) and from 50 to 55 feet bgs (42%). From 55 feet bgs to the completion depth of 195 feet bgs, RQDs were fair to excellent (67% to 100%). Groundwater was encountered at 14.5, 24.5, and 27.5 feet bgs during, and up to 14 hours after, drilling operations.
- **Boring B3-1E:** B3-1E was completed to a total depth of 190 feet bgs. A light gray argillaceous SHALE was observed from 15 to 35 feet bgs. The shale is described as moderately hard, slightly weathered and thinly bedded. Joints are moderately dipping and closely spaced. Some clay joint filling was also observed. In the shale, recoveries were excellent (95% to 100%) and RQDs were good to excellent (80% to 91%). A very light gray argillaceous MUDSTONE was observed from 35 to 105 feet bgs. The mudstone is described as medium to hard and slightly to moderately weathered. Moderate to high angle closely-spaced joints were identified. Some joints were filled with clay. Some quartz and calcite veins were observed. A void was encountered from 98 to 100 feet bgs. In the mudstone, recoveries were good to excellent (75% to 100%) and RQDs were poor to excellent (28% to 100%). From 105 to 180 feet bgs, a very light gray to medium gray argillaceous DOLOMITE was encountered. The dolomite is described as hard and fresh to slightly weathered. Within the dolomite unit, joints are low angle to vertical and closely spaced. Recoveries were excellent (92% to 100%) and RQDs were poor to excellent (25% to 100%). From 180 to 190 feet bgs, a medium dark gray argillaceous, calcareous LIMESTONE was encountered. The limestone is described as hard and fresh, with low angle closely spaced joints. In the limestone, recoveries were good to excellent (80% to 100%) and RQDs were fair to excellent (68% to 90%). Groundwater was observed at 64.5, 89.0, and 105.5 feet bgs during, and up to 14 hours after, drilling operations.

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

Boring	Sample Depth (feet bgs)	Compressive Strength (psi)
SB-02	14	16,180
B3-1W	29	19,450
B3-1W	51	15,770
B3-1W	72	23,601
B3-1W	92	21,473
B3-1W	112	20,110
B3-1W	132	7,937
B3-1W	137	1,916
B3-1W	147	25,319
B3-1W	157	25,573
B3-1E	35	12,575
B3-1E	54	6,542
B3-1E	75	6,771
B3-1E	95	19,679
B3-1E	115	948
B3-1E	132	2,490
B3-1E	147	25,589
B3-1E	152	>29,829

It should be noted that RETTEW did not oversee or direct the geotechnical drilling program associated with the Lower Piney Creek 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 Lower Piney Creek HDD in this report.

## 6.0 FIELD OBSERVATIONS

RETTEW staff were on-site on June 26, 2017 when an IR occurred during HDD drilling operations. At 12:10 PM, an initial loss of fluid circulation was observed along the HDD trajectory at a distance of 82 feet while drilling through limestone and shale. Drilling fluids were subsequently observed discharging into stream S-M33 at 2:25 P.M. Based on site observations S-M33 is a disappearing, or sinking, limestone stream located northwest of the associated wetland shown on the HDD profile (**Attachment 2**). This surface stream feature may drain to subsurface solution features underlying the HDD profile. Drilling operations were shut down while containment and remedial measures were implemented.

A field investigation was performed by RETTEW staff on October 20, 2017, to identify rock outcrops for fracture fabric analysis, evaluation and ground-truthing of fracture traces identified during the desktop exercise, and to identify potential sensitive receptors to IRs. Readily accessible bedrock outcrops were limited in the immediate vicinity of the HDD. Strike and dip structural geologic measurements were collected from a small exposure of limestone bedrock identified on **Figures 2 and 3**. The average strike of bedding measured at this outcrop was 39° with an average dip of 36° NW. The average strike of the joints identified at this outcrop was 280° with an average dip of 20° SW. These field data are consistent with the published geologic data, mapping, and fracture traces identified in Section 4.0.

Based on the initial IR event and above site reconnaissance, no additional sensitive receptors beyond the previously mapped surface stream S-M33, associated wetland, and Piney Creek were identified.

## **7.0 GEOPHYSICAL SURVEY**

A non-evasive geophysical survey was performed at the Lower Piney Creek HDD from December 6th through December 8<sup>th</sup>, 2017. The purpose of the geophysical survey was to determine the depth to bedrock, overburden thickness, and identify areas of solid and fractured rock. Seismic refraction and electrical resistivity methods were used in the survey. The multichannel analysis of surface waves (MASW) method was proposed, but not performed, due to shallow bedrock limitations. The geophysical survey report is provided as **Attachment 4**; a summary is provided below.

Results of the seismic refraction survey indicated stratigraphy of unconsolidated material and bedrock. Depth to bedrock was estimated at 20 feet bgs along to the pipeline alignment, in addition to the occurrence of karst pinnacling in the carbonate rock. Several low-velocity zones were identified in underlying bedrock that may be indicative of weathered or fractured zones. Along the pipeline profile, these zones were identified at stations 6729+00, 6731+00, 6732+50, 6734+00, and 6737+00. Seismic data returns across Piney Creek had signal interference. As a result, the data across Piney Creek are not included on the seismic profiles.

Results of the electrical resistivity survey indicated similar stratigraphy of unconsolidated material overlying bedrock. Overburden thickness was estimated at 10 to 30 feet bgs, with shallower depths more correlative to the overburden thickness observed in geotechnical borings drilled at this location and described in Section 5.0. The layer of low-resistivity zones over high-resistivity zones generally correlate to overburden overlying more competent bedrock. Low-resistivity zones observed at deeper depths within bedrock may represent weathered or fractured bedrock. Along the pipeline profile, these zones were identified at stations 6729+00, 6730+25, 6731+50, 6732+00, 6732+75, 6733+25, 6734+00, 6735+00, 6736+00, 6736+50, 6738+00, and 6739+00.

## **8.0 CONCEPTUAL HYDROGEOLOGIC MODEL AND CONCLUSION**

Based on published geologic and hydrogeologic information, and the evaluation of geotechnical borings from the site, the Lower Piney Creek HDD location is underlain by carbonate and clastic sedimentary rocks of the Coburn through Loysburg Formations (undivided), and Axemann and Bellefonte Formations (undivided). The hydrogeologic setting is dominated by groundwater flow that occurs in secondary openings formed along geologic features that include bedding planes, joints, faults, and fractures. The secondary openings may be enlarged or enhanced to some degree by dissolution of the underlying carbonate rocks. Field measurements, geotechnical rock core observations, and shallow geophysical

survey results confirmed that local bedrock is moderately to highly fractured with low to high angle joints. The proposed HDD profile is relatively shallow compared to the land surface and surface streambeds (S-M33 and Piney Creek), and passes through both the soil overburden and the fractured bedrock. Based on the hydro-structural characteristics of the underlying geology, the revised profile through shallow soils and bedrock, and the previous IR that occurred during HDD operations, the Lower Piney Creek HDD is susceptible to the inadvertent return of drilling fluids during HDD operations. As a result, the HDD profile was re-designed to allow for deeper crossings beneath the streams. The inclination of the entry and exit angles has been increased as a means to install the pipe through these protective soils, residual soils, and bedrock, and in closer proximity to the entry and exit points than the original, shorter and shallower profile. From a geologic perspective, the longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling best management practices, will be used to reduce the risk of an IR. The locations of fracture zones identified during the geophysical survey will be monitored during HDD operations.

## 9.0 REFERENCES

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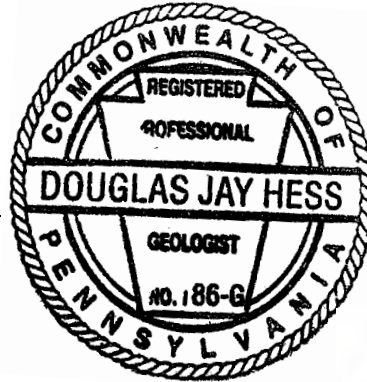
United States Department of Agriculture, 2017, Natural Resources Conservation Service, Published Soil Surveys for Pennsylvania, Blair County, Pennsylvania: website address: <https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>, accessed October 10, 2017.

### 10.0 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

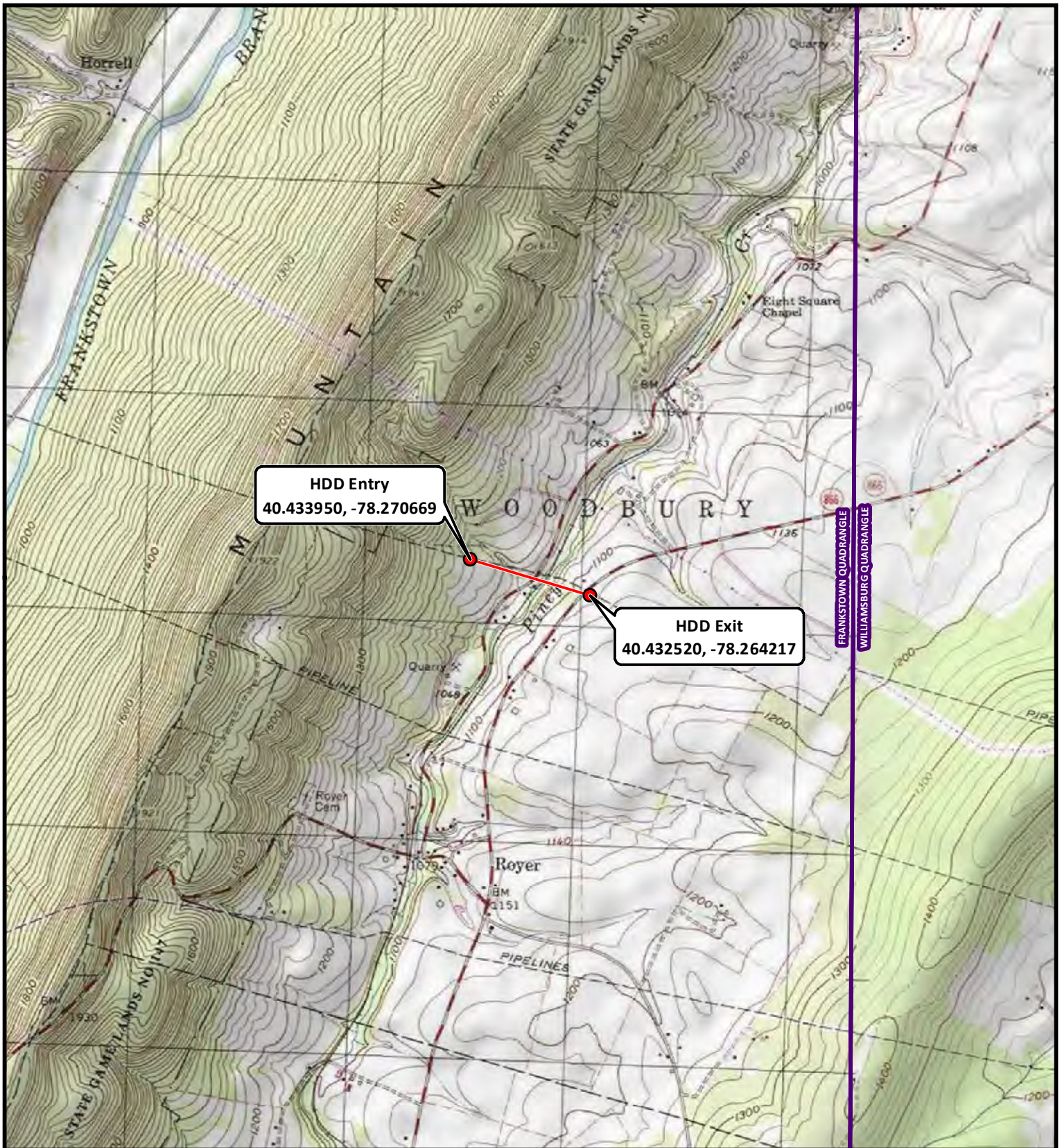


Christopher T. Brixius, PG  
License No. PG004765



**REVIEW**

**FIGURES**



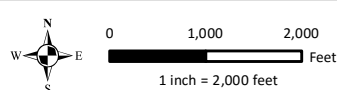
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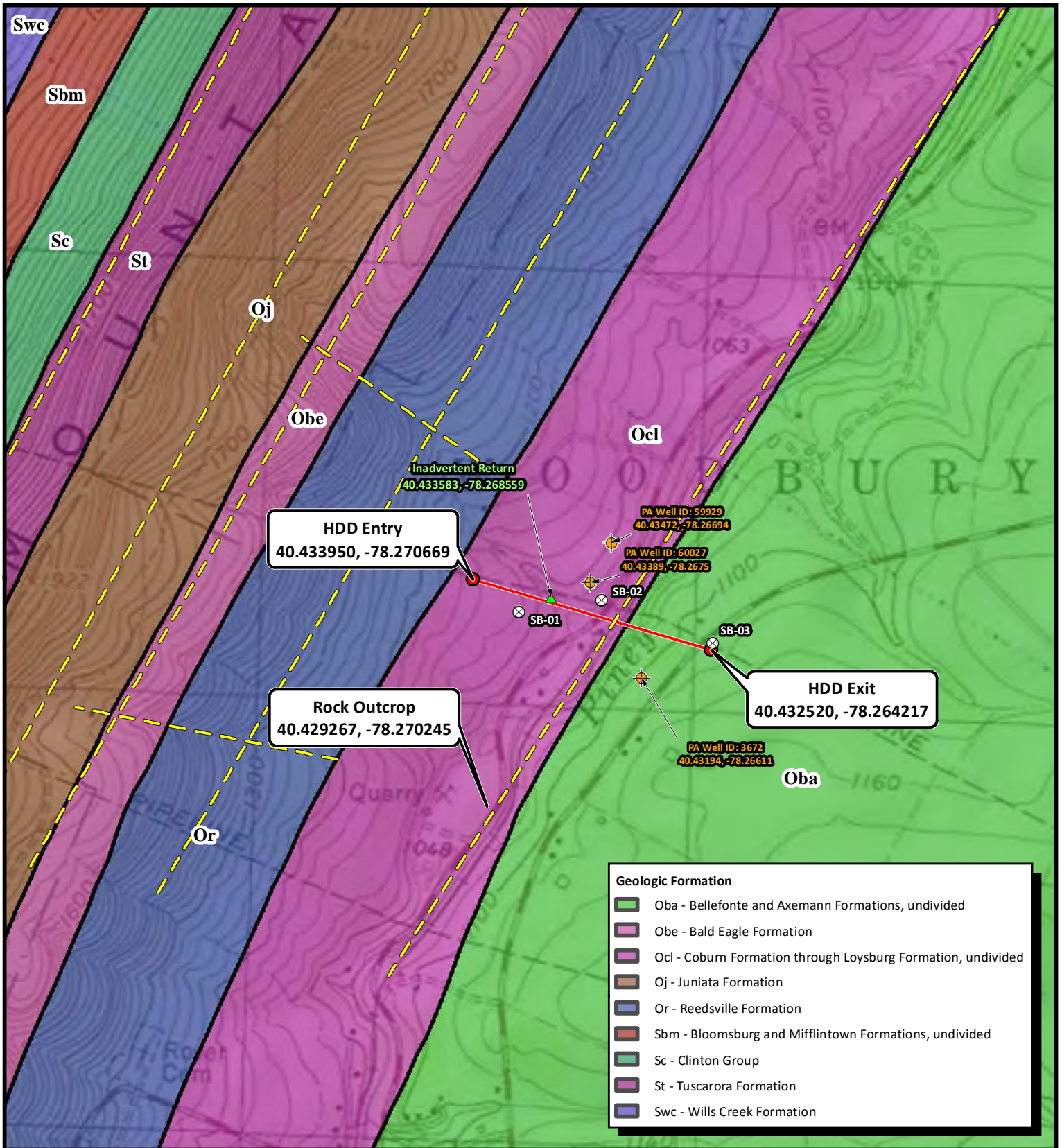
**HDD Exit**  
40.432520, -78.264217

- HDD Entry/Exit
- HDD Profile

**Sunoco Pipeline, L.P.**  
**Lower Piney Creek HDD Location**

**Figure 1 - Topographic Basemap**  
Woodbury Township, Blair County, PA  
Project No. 096302011



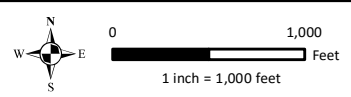


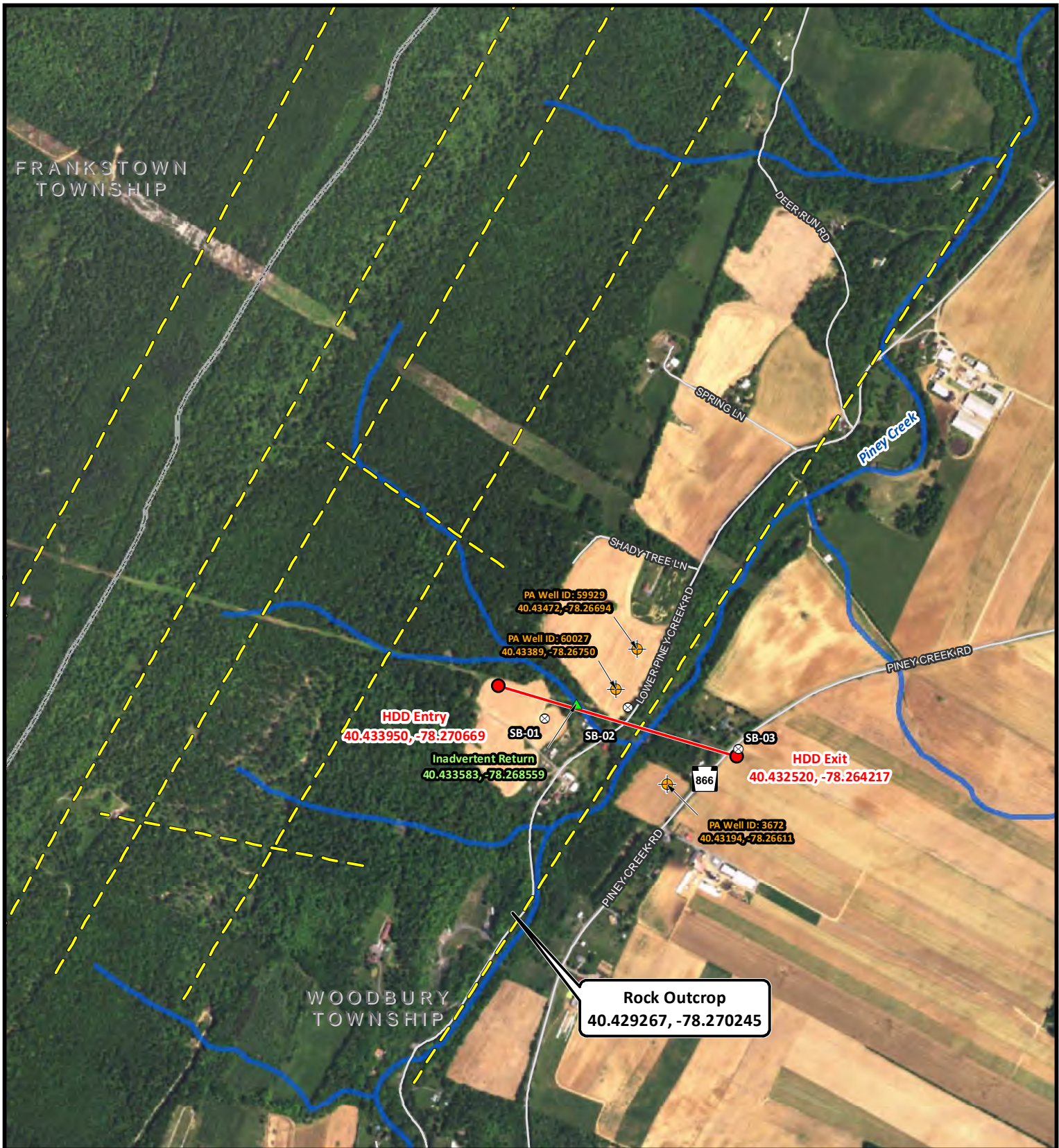
Geologic Formation	
	Oba - Bellefonte and Axemann Formations, undivided
	Obe - Bald Eagle Formation
	Ocl - Coburn Formation through Loysburg Formation, undivided
	Oj - Juniata Formation
	Or - Reedsville Formation
	Sbm - Bloomsburg and Mifflintown Formations, undivided
	Sc - Clinton Group
	St - Tuscarora Formation
	Swc - Wills Creek Formation










- Inadvertent Return
- Residential Well
- Boring Location
- HDD Entry/Exit
- HDD Profile
- Inferred Fracture Trace

**Sunoco Pipeline, L.P.**  
**Lower Piney Creek HDD Location**

**Figure 2 - Geologic Map**  
 Woodbury Township, Blair County, PA  
 Project No. 096302011







	Inadvertent Return		Inferred Fracture Trace
	Residential Well		NHD Stream
	Boring Location		Road
	HDD Entry/Exit		Municipal Boundary
	HDD Profile		

11/9/2017

**Sunoco Pipeline, L.P.**  
**Lower Piney Creek HDD Location**  
**Figure 3 - Aerial Basemap**  
 Woodbury Township, Blair County, PA  
 Project No. 096302011



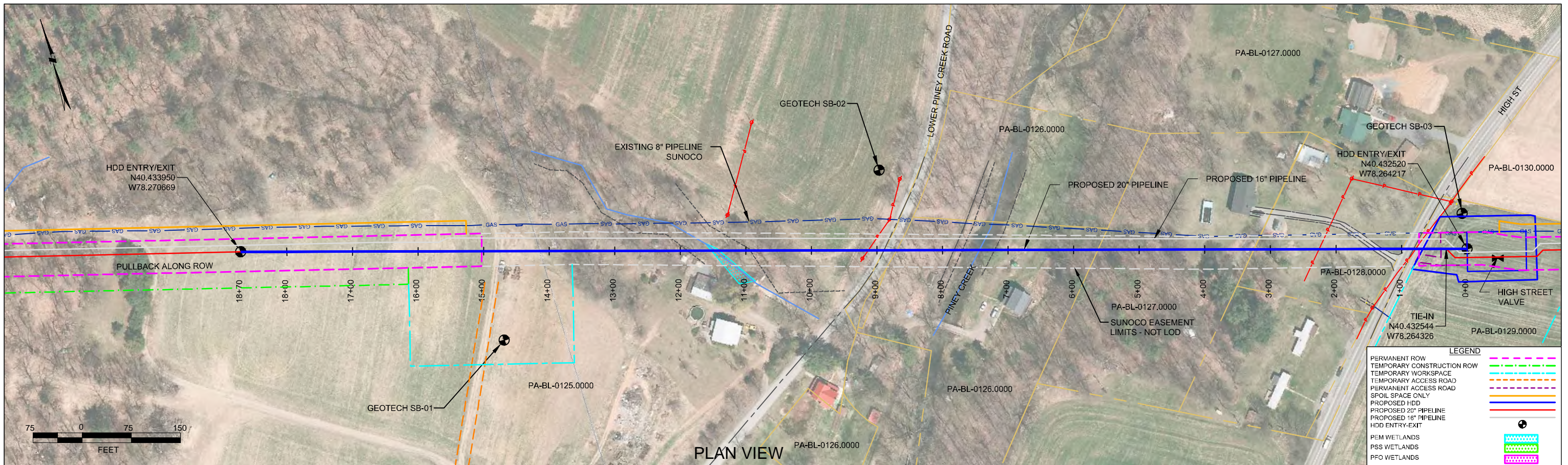
0 1,000  
Feet  
1 inch = 1,000 feet



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

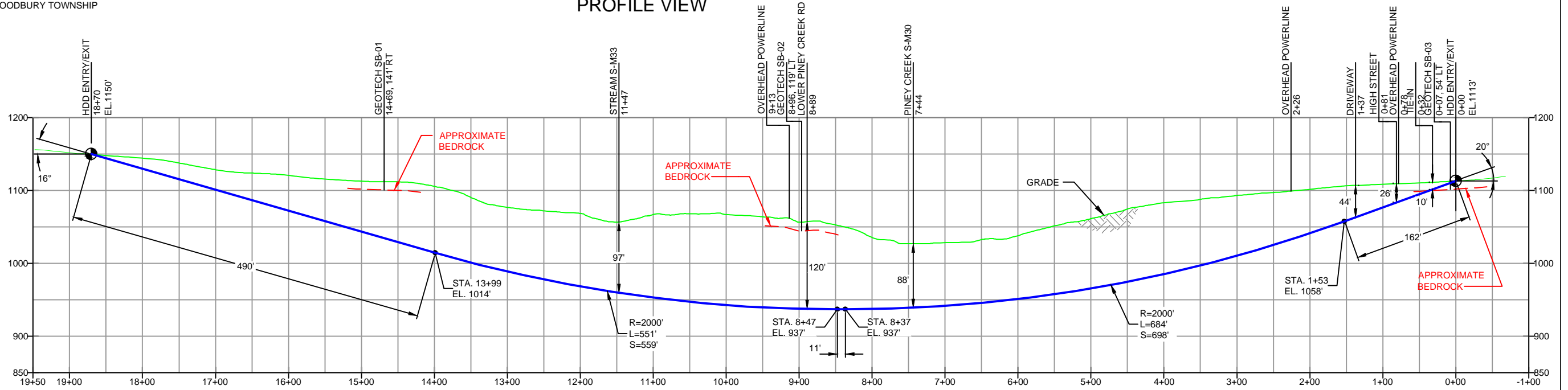
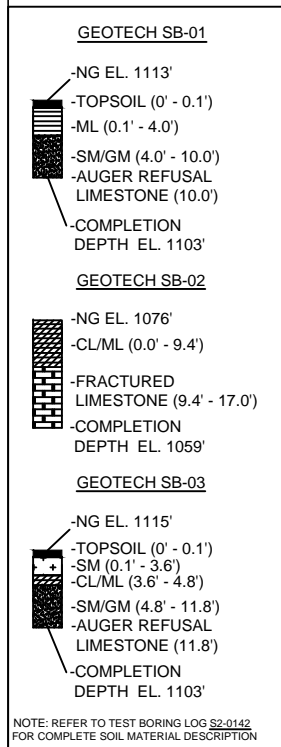
**REVIEW**

**ATTACHMENT 1  
GEOTECHNICAL BORING LOGS**



BLAIR COUNTY, PENNSYLVANIA - WOODBURY TOWNSHIP  
S2-0142

PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
  - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
  - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
  - CROSSING PIPE SPECIFICATION:  
HDD HORZ. LENGTH (L=): 1870'  
HDD PIPE LENGTH (S=): 1920'  
20" x 0.456" W.T., X-65, API5L PSL2, ERW, BFW  
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
  - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
  - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
  - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
  - CARRIER PIPE NOT ENCASED.
  - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
  - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
  - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
  - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
  - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REVISIONS

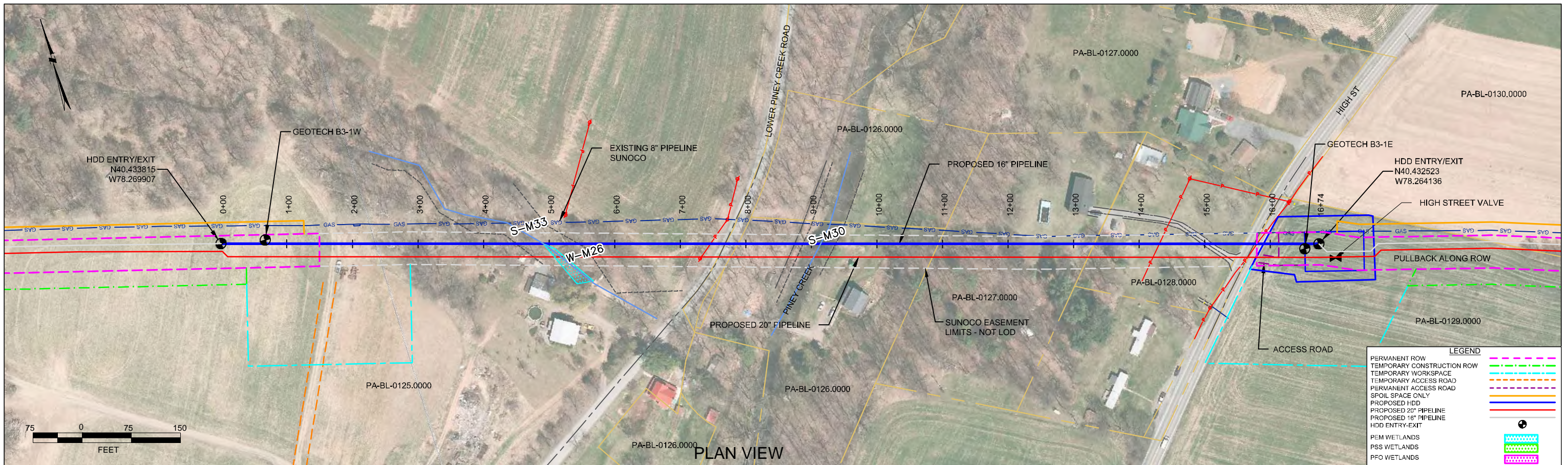
NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
4	DESIGN CHANGE - MOVED DRILL ENTRY/EXIT LOCATION	MRS	07/11/17	RMB	07/11/17	CAG	07/11/17
3	DESIGN CHANGE - MOVED DRILL ENTRY/EXIT LOCATION	MRS	06/19/17	RMB	06/19/17	CAG	06/19/17
2	REVISED PROFILE WITH 2017 LIDAR	MRS	03/21/17	RMB	03/21/17	CAG	03/21/17
1	REVISED PER ENGINEERING COMMENTS	MRS	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 PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL  
LOWER PINEY CREEK RD  
PENNSYLVANIA PIPELINE PROJECT

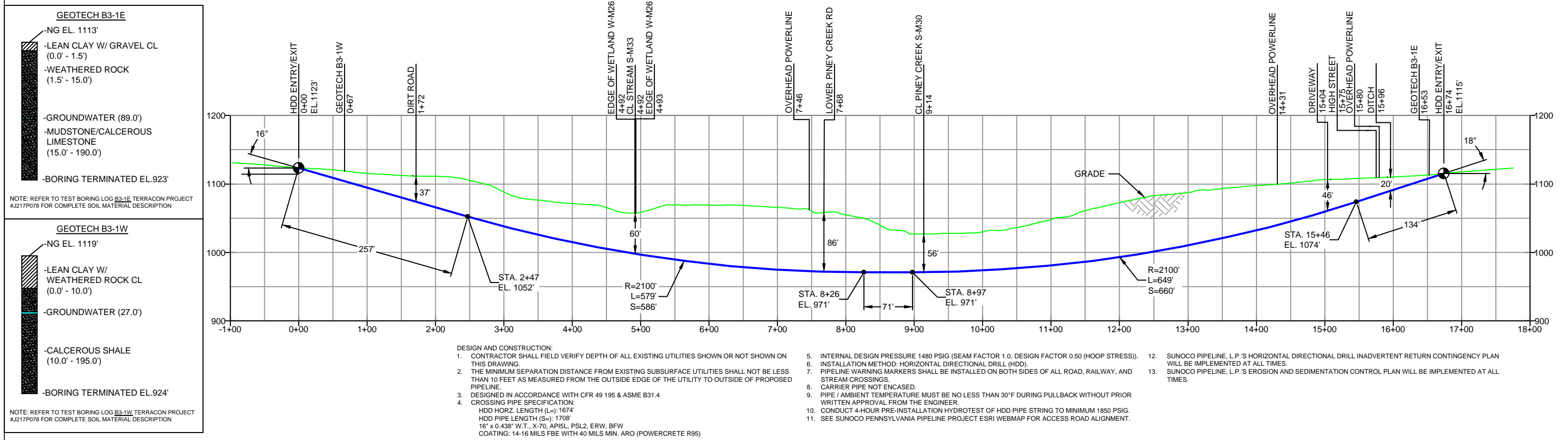
SCALE: 1"=150' DWG. NUMBER: PA-BL-0125.0000-RD



PLAN VIEW

BLAIR COUNTY, PENNSYLVANIA - WOODBURY TOWNSHIP  
S2-0142-16

PROFILE VIEW



NOTE: REFER TO TEST BORING LOG B3-1E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTE: REFER TO TEST BORING LOG B3-1W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
  - THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
  - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
  - CROSSING PIPE SPECIFICATION:  
HDD HORZ. LENGTH (L<sub>H</sub>): 1674'  
HDD PIPE LENGTH (S<sub>H</sub>): 1708'  
16" x 0.438" W.T., X-70, API5L PSL2, ERW, BFW  
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
  - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
  - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
  - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
  - CARRIER PIPE NOT ENCASED.
  - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
  - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
  - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
  - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
  - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

ES-3.57	TO	ES-3.58	EROSION & SEDIMENT PLAN	EP3	MOVED DRILL ENTRY/EXIT LOCATION - DESIGN PER MICHELS
SHEET 41	TO	SHEET 41	AERIAL SITE PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
				EP1	REVISED PER PADEP COMMENTS
				EP	
				B	ADDED GEOTECH INFO
				A	ISSUED FOR BID
DWG NO	DWG NO	DESCRIPTION	NO.	DESCRIPTION	

BY	DATE	CHK	DATE	APP	DATE
MRS	09/22/17	RMB	09/22/17	CAG	09/22/17
DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
MRS	09/04/15	RMB	09/04/15	AAW	09/04/15
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  
LOWER PINEY CREEK RD  
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'  
DWG. NO. PA-BL-0126.0000-RD-16



**LEGEND:**

☉ Geotechnical Soil Boring (SB) Locations



**TETRA TECH**

GEOTECHNICAL BORING LOCATIONS

HDD S2-0142

BLAIR COUNTY, WOODBURY 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:	LOWER PINEY CREEK ROAD, WILLIAMSBURG, PA	Page 1 of 1	
HDD No.:	S2-0142	Dates(s) Drilled:	01-11-15
Boring No.:	SB-01	Inspector:	E. WATT
Drilling Contractor:	HAD DRILLING	Drilling Method:	SPT - ASTM D1586
		Driller:	S. HOFFER
		Groundwater Depth (ft):	NOT ENCOUNTERED
		Total Depth (ft):	10.0

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (ft)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
	From	To	From	To								
			0.0	0.1			TOPSOIL (<1")					
1	3.0	5.0	0.1	4.0	11	ML	ORANGE BROWN SILT WITH SOME FINE SAND.	1	2	33	45	35
			4.0			SM/ GM	GRAY FINE TO COARSE SAND AND GRAVEL WITH A LITTLE SILT (WEATHERED LIMESTONE?)					
2	8.0	8.4			3		GRAY FINE TO COARSE SAND AND FINE GRAVEL (WEATHERED LIMESTONE?).	50/5"				
				10.0								
							AUGER REFUSAL AT 10'. OFF-SET BORING 21' SOUTH AND CONTINUOUSLY AUGERED TO REFUSAL AT 8'. OFF-SET AGAIN AND CONTINUOUSLY AUGERED TO REFUSAL AT 8.5 FEET. DRY AND CAVED AT 8'.					

Notes/Comments: Pocket Pentrometer Testing DR: DECOMPOSED ROCK

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

\* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.  
 N: Number of blows to drive spoon from 6" to 18" interval.





**GEOTECHNICAL LABORATORY TESTING SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S2-0142**

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S2-0142	SB-01	1	3.0	5.0	3.1	19.8	-	-	-	-
		2	8.0	8.4	6.2	30.5	-	-	-	-
	SB-02	1	3.0	5.0	25.4	95.5	-	-	-	-
		2	8.0	9.4	27.7	63.2	32	23	9	CL/ML
	SB-03	1	3.0	5.0	30.5	96.6	34	25	11	CL/ML
		2	8.0	8.4	3.2	29.6	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-02	2	14	16,180	174.5

**Notes:**

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

**REGIONAL GEOLOGY SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S2-0140**

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
S2-0142	Piney Creek Road	SB-01	Coburn Formation - consists of medium-gray to very dark gray, fossiliferous limestone and shaly limestone	Upland to mid-ridge	Coburn	Highly fossiliferous limestones and black shaly limestones to increasingly argillaceous		5-37	Karst conditions may be present, numerous depressions are mapped
		SB-02							Yields 6-25 gpm
		SB-03							The lower and middle portions of the Coburn Formation consist of interbedded crystalline, highly fossiliferous (conodonts) limestones and black shaly limestones, and the upper Coburn becomes increasingly argillaceous as it grades into the overlying Antes Shale.

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

**ROCK CORE DESCRIPTION SUMMARY  
SUNOCO PENNSYLVANIA PIPELINE PROJECT  
HDD S2-0142**

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S2-142	SB-2	1	9	12	94	22	17	9	12	Moderate	Limestone	Massive	Light Gray	Slightly fractured, Avg. Dip 37° (20° - 45°); Calcite infilling of small fractures
S2-142	SB-2	2	12	17	92	56	54	12	17	Moderate	Limestone	Massive	Light Gray	Slightly fractured, Avg. Dip 28° (15° - 60°); Calcite infilling of small fractures

# FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

## GRANULAR SOILS

(Sand, Gravel & Combinations)

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

### Particle Size Identification

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

### Relative Proportions

<u>Description Term</u>	<u>Percent</u>
Trace	1 - 10
Little	11 - 20
Some	21 - 35
And	36 - 50

## COHESIVE SOILS

(Silt, Clay & Combinations)

<u>Consistency</u>	<u>N (blows)*</u>
Very Soft	3 or less
Soft	4 to 5
Medium Stiff	6 to 10
Stiff	11 to 15
Very Stiff	16 to 30
Hard	31 or more

### Plasticity

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

## ROCK

(Rock Cores)

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

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

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

**UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]**

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

(1) Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC. well-graded gravel-sand mixture with clay binder.

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 – Lower Piney Creek Rd  
Commonwealth of Pennsylvania  
Drawing #PA-BL-0125.0000-RD  
PO #20170804-13  
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 Lower Piney Creek Rd (Drawing #PA-BL-0125.0000-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 B3-1W and B3-1E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B3-1W and B3-1E were drilled between August 8 and 14, 2017 to depths of 195 and 190 feet, respectively as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of shale at B3-1W and interlayered sedimentary rock comprised of shale, mudstone, dolomite, and limestone at B3-1E. 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. Unconfined compressive strength test results are shown on the attached reports.

**Geotechnical Site Characterization**

Mariner East 2 Pipeline – Spread 3 Lower Piney Creek Rd ■ Pennsylvania

Drawing #PA-BL-0125.0000-RD / PO #20170804-13

October 7, 2017 ■ Terracon Project No. J217P078



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

A handwritten signature in blue ink, appearing to read "Lawrence J. Dwyer".

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**



**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



201 Hammer Mill Road Rocky Hill, Ct 06067  
PH. (860) 721-1900 FAX. (860) 721-1939

**TEST BORING LOCATION PLAN**

Lower Piney Creek Road HDD Cores B3-1W and B3-1E  
PA-BL-0125.0000-RD  
Blair County, Pennsylvania

Exhibit

**A-2**

## **EXPLORATION RESULTS**

# BORING LOG NO. B3-1W Lower Piney Creek Rd. West

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.433778° Longitude: -78.26967°  Approximate Surface Elev: 1120 (Ft.) +/- ELEVATION (Ft.)								
LEAN CLAY (CL), trace sand, reddish orange, medium stiff		5		X	14	3-4-5 N=9			3.25
Similar, no sand, stiff, weathered rock at the tip of sampler		5		X	11	4-9-6 N=15 At 10-11.5' (2-50/3")			1.75
10.0 Offset borehole, augered to 8 feet, weathered rock at 5 feet, installed 4-inch casing to 10, began rock core at 10 feet Run 1, Moderately hard, slightly weathered, dark gray, fine grained SHALE, moderately dipping close joints, some infilling in weathered rock	1110+/-	10			14		0	2.75 3.0 1.75	0.75
15.0 Run 2, Similar, very slightly weathered	1105+/-	15	▽		29		80	2.75 2.75 2.5	
17.5 Run 3, Similar	1102.5+/-	17.5			30		87	1.25 2.75 2.75	
20.0 Run 4, Similar	1100+/-	20			60		91	3.0 2.25 2.25 4.0 3.0	
25.0 Run 5, Similar	1095+/-	25	▽		60		71	2.0 3.25 3.5 3.75 3.75	
		30	▽						

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 14.5' AB
- ▽ 24.5' after 20 hrs (08/09/17)
- ▽ 27.5' after 14 hrs (08/11/17)



Boring Started: 8/8/2017

Boring Completed: 8/10/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1W Lower Piney Creek Rd. West

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.433778° Longitude: -78.26967°  Approximate Surface Elev: 1120 (Ft.) +/-								
	ELEVATION (Ft.)								
30.5		1089.5+/-							
	Run 6, Similar				43		33	4.0 4.5 5.5 7.0 4.5	
35.0		1085+/-							
	Run 7, Hard, fresh, dark gray, fine-grained CALCAREOUS SHALE, high angle close joints				60		97	4.0 3.75 4.5 5.0 5.0	
40.0		1080+/-							
	Run 8, Similar				58		73	3.0 3.5 3.25 3.5 3.75	
45.0		1075+/-							
	Run 9, Similar				60		83	2.75 2.5 2.5 2.0 1.5	
50.0		1070+/-							
	Run 10, Hard, fresh, dark gray, fine-grained CALCAREOUS SHALE, moderately dipping close joints				60		42	4.0 4.0 5.25 4.75 5.25	
55.0		1065+/-							
	Run 11, Similar, 0.5" thick calcareous vein at 56'				60		77	2.5 2.25 2.0 2.75 2.25	
60.0		1060+/-							

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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:

Abandonment Method:  
Grouted to surface

**WATER LEVEL OBSERVATIONS**

- ▽ 14.5' AB
- ▽ 24.5' after 20 hrs (08/09/17)
- ▽ 27.5' after 14 hrs (08/11/17)



Boring Started: 8/8/2017

Boring Completed: 8/10/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1W Lower Piney Creek Rd. West

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.433778° Longitude: -78.26967°  Approximate Surface Elev: 1120 (Ft.) +/- ELEVATION (Ft.)								
	Run 12, Similar	65.0			60		84	2.5 2.25 2.5 2.0 2.0	
	Run 13, Similar	70.0			60		95	2.0 2.0 1.75 1.5 1.5	
	Run 14, Similar, 1/8" - 1" thick calcareous veins at 71'-73'	75.0			60		100	2.0 2.0 1.5 1.5 1.5	
	Run 15, Similar, some joints infilled with coal	80.0			60		100	3.5 2.0 2.25 2.5 2.5	
	Run 16, Similar, occasional calcareous veins with pyrite	85.0			60		90	2.5 2.5 2.5 3.0	
	Run 17, Similar	90.0			60		93	2.25 2.25 2.0 2.25 2.25	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 14.5' AB
- ▽ 24.5' after 20 hrs (08/09/17)
- ▽ 27.5' after 14 hrs (08/11/17)



Boring Started: 8/8/2017

Boring Completed: 8/10/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1W Lower Piney Creek Rd. West

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.433778° Longitude: -78.26967°  Approximate Surface Elev: 1120 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
95.0	Run 18, Similar, moderately dipping and high angle joints, occasional calcareous veins, thin layer of coal in joints  1025+/-	95			60		100	2.25 2.0 2.0 2.0 2.0	
100.0	Run 19, Similar, low angle and moderately dipping joints  1020+/-	100			60		67	2.25 3.25 2.5 2.25 2.0	
105.0	Run 20, Similar  1015+/-	105			60		88	2.0 2.0 1.75 2.0 1.75	
110.0	Run 21, Similar, 1/4" thick quartz veins at 108' - 110'  1010+/-	110			60		83	2.5 2.75 2.25 2.0 2.0	
115.0	Run 22, Similar  1005+/-	115			56		85	2.75 2.5 2.75 2.75 2.75	
120.0	Run 23, Similar  1000+/-	120			60		100	2.5 2.5 2.25 2.25 2.5	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 14.5' AB
- ▽ 24.5' after 20 hrs (08/09/17)
- ▽ 27.5' after 14 hrs (08/11/17)



Boring Started: 8/8/2017

Boring Completed: 8/10/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1W Lower Piney Creek Rd. West

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.433778° Longitude: -78.26967°  Approximate Surface Elev: 1120 (Ft.) +/- ELEVATION (Ft.)								
	Run 24, Hard, fresh, dark gray, fine-grained, CALCAREOUS SHALE, low angle joints, 3/4" thick calcareous vein at 123.5'	125			57		93	2.5 2.0 2.0 1.75 2.25	
	Run 25, Similar	130			60		100	2.25 2.25 2.0 2.0 2.0	
	Run 26, Similar	135			60		90	2.0 2.0 1.75 1.75 2.0	
	Run 27, Similar, 2" thick seam of soft dark gray oily clay at 135'. At 138' highly weathered SHALE with calcareous veins and 1/8" thick light gray clay layer.	140			60		68	2.5 2.5 2.5 2.5 2.5	
	Run 28, Similar	145			60		100	2.5 2.5 2.5 2.5 2.5	
	Run 29, Similar	150			60		98	2.0 1.75 1.75 2.5 2.5	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 14.5' AB
- ▽ 24.5' after 20 hrs (08/09/17)
- ▽ 27.5' after 14 hrs (08/11/17)



Boring Started: 8/8/2017

Boring Completed: 8/10/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1W Lower Piney Creek Rd. West

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.433778° Longitude: -78.26967°  Approximate Surface Elev: 1120 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
155.0	Run 30, Similar, 1/4" thick calcareous vein at 151' and 152.5'	155			60		93	2.5 2.5 2.0 1.75 1.75	
160.0	Run 31, Similar	160			60		93	2.0 1.75 1.75 1.75 1.75	
165.0	Run 32, Similar	165			60		95	2.25 2.0 2.25 2.5 2.5	
170.0	Run 33, Similar, 1/4" thick calcareous veins at 167.5'	170			60		95	2.75 2.25 2.0 2.0 2.0	
175.0	Run 34, Similar	175			60		100	2.75 2.75 2.5 2.5 2.0	
180.0	Run 35, Similar	180			57		90	3.0 2.75 3.0 3.0 2.25	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 14.5' AB
- ▽ 24.5' after 20 hrs (08/09/17)
- ▽ 27.5' after 14 hrs (08/11/17)



Boring Started: 8/8/2017

Boring Completed: 8/10/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1W Lower Piney Creek Rd. West

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.433778° Longitude: -78.26967°  Approximate Surface Elev: 1120 (Ft.) +/- ELEVATION (Ft.)								
	Run 36, Similar	185			60		98	2.25 1.75 1.75 1.75	
	Run 37, Similar	190			60		97	2.0 2.0 2.0 1.75	
	Run 38, Similar	195			60		67	2.0 2.0 2.0 2.0	
	<b>Boring Terminated at 195 Feet</b>	195							

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 14.5' AB
- ▽ 24.5' after 20 hrs (08/09/17)
- ▽ 27.5' after 14 hrs (08/11/17)



Boring Started: 8/8/2017

Boring Completed: 8/10/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1E Lower Piney Creek Rd. East

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.43252° Longitude: -78.264217°  Approximate Surface Elev: 1114 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
1.5	<b>LEAN CLAY WITH GRAVEL (CL)</b> , red, medium stiff Pieces of cobbles and weathered rock in top 4.5 feet	1112.5+/-		X	7	3-3-5 N=8			
4.5	Roller bit to 15 feet 4-inch casing installed to 13.5 feet Severely weathered rock	1109.5+/-							
15.0	Run 1, Moderately hard, slightly weathered, very light gray, argillaceous SHALE, moderately dipping close joints, highly weathered 1/4" thick layer at 19.5 feet, thinly bedded. Some joints infilled with clay	1099+/-			60		85	3.25 2.75 2.75 2.75 2.75	
20.0	Run 2, Similar	1094+/-			60		88	2.5 2.5 2.5 2.75 3.0	
25.0	Run 3, Medium hard, moderately weathered, very light gray, argillaceous, moderately dipping close joints	1089+/-			57		80	2.25 2.25 2.25 2.25 1.75	
30.0		1084+/-							

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

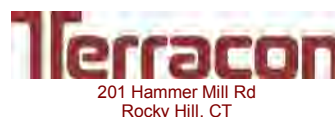
See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:  
Grouted to surface

**WATER LEVEL OBSERVATIONS**

- ▽ 64.5' AB (8/12/17)
- ▽ 105.5' after 14 hrs (08/13/17)
- ▽ 89.0' after 14 hrs (08/14/17)



Boring Started: 8/11/2017

Boring Completed: 8/14/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1E Lower Piney Creek Rd. East

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.43252° Longitude: -78.264217°  Approximate Surface Elev: 1114 (Ft.) +/- ELEVATION (Ft.)								
	Run 4, Similar	35.0			60		91	2.0 2.25 2.25 1.75 1.75	
	Run 5, Hard, slightly weathered, very light gray, argillaceous MUDSTONE, moderately dipping close joints, some joints infilled with clay vugs present	40.0			60		63	3.0 3.0 3.0 3.0	
	Run 6, Similar	45.0			60		78	3.25 3.25 3.25 3.25	
	Run 7, Similar	50.0			60		75	3.0 3.25 2.5 2.75 2.5	
	Run 8, Similar	55.0			60		83	3.0 3.0 2.75 2.75 3.0	
	Run 9, Slightly weathered, moderately dipping to high angle Joints, infilled with clay	60.0			60		100	3.25 3.25 3.5 2.5 2.75	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 64.5' AB (8/12/17)
- ▽ 105.5' after 14 hrs (08/13/17)
- ▽ 89.0' after 14 hrs (08/14/17)



Boring Started: 8/11/2017

Boring Completed: 8/14/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1E Lower Piney Creek Rd. East

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.43252° Longitude: -78.264217°  Approximate Surface Elev: 1114 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
65.0	Run 10, Medium hard, moderately weathered, very light gray to greenish gray, argillaceous MUDSTONE, moderately dipping close joints at 63'-64'	65	▽		60		90	3.0 3.0 2.25 2.25 2.25	
70.0	Run 11, Similar	70			60		90	2.5 3.0 3.5 3.25 3.25	
75.0	Run 12, Similar	75			60		100	3.5 3.75 3.75 3.0 2.5	
80.0	Run 13, Hard, slightly weathered, very light gray, argillaceous MUDSTONE, moderately dipping close joints, quarts intrusions 79.5' -80'	80			56		83	2.5 2.75 2.5 2.5 3.0	
85.0	Run 14, Similar, moderately weathered zone 84.0'-85.0', 1/4" thick calcareous vein at 83'	85			60		80	2.75 2.75 2.75 2.5	
90.0	Run 15, Similar	90	▽		60		87	3.0 3.0 2.75 3.0 2.5	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 64.5' AB (8/12/17)
- ▽ 105.5' after 14 hrs (08/13/17)
- ▽ 89.0' after 14 hrs (08/14/17)



Boring Started: 8/11/2017

Boring Completed: 8/14/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1E Lower Piney Creek Rd. East

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.43252° Longitude: -78.264217°  Approximate Surface Elev: 1114 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
95.0	Run 16, Similar, moderately weathered zone with quartz veins 93-94'	95			60		73	3.0 2.75 2.75 2.75	
100.0	Run 17, Similar, 5-inch layer of clay at 97', encountered void at 98-100'	100			45		28	3.0 3.0 2.75 0.25 0.25	
105.0	Run 18, Moderately hard, moderately weathered, moderately dipping to high angle joints, infilled with clay. 1" thick clay layer at 102'	105	▽		49		30	3.5 3.25 2.75 2.5 2.5	
110.0	Run 19, Hard, fresh, medium light gray argillaceous DOLOMITE, moderately dipping close joints	110			60		90	3.0 3.0 2.75 2.75 2.75	
115.0	Run 20, Similar, medium light gray to gray	115			60		100	2.75 2.25 2.25 2.25 2.25	
120.0	Run 21, Similar,	120			60		85	2.75 2.5 2.5 2.5 2.5	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 64.5' AB (8/12/17)
- ▽ 105.5' after 14 hrs (08/13/17)
- ▽ 89.0' after 14 hrs (08/14/17)



Boring Started: 8/11/2017

Boring Completed: 8/14/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1E Lower Piney Creek Rd. East

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.43252° Longitude: -78.264217°  Approximate Surface Elev: 1114 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
125.0	Run 22, Similar,  989+/-	125			60		80	2.5 2.5 2.25 2.25 2.25	
130.0	Run 23, Similar  984+/-	130			60		100	3.0 2.75 2.5 2.75 2.5	
135.0	Run 24, Similar, low to high angle joints, clay/silt layer 130' - 130.5'  979+/-	135			60		63	2.25 2.5 2.5 2.5 2.5	
140.0	Run 25, Hard, fresh, very light gray argillaceous DOLOMITE, moderately dipping close joints, 1" quartz vein at 148'  974+/-	140			60		90	2.5 2.5 2.75 2.75 2.5	
145.0	Run 26, Similar, very slightly weathered, joints with thin clay coating  969+/-	145			55		32	2.75 2.75 3.0 3.25 5.0	
150.0	Run 27, Hard, very slightly weathered, medium gray, argillaceous DOLOMITE, vertical close joints  964+/-	150			56		25	2.75 2.75 3.25 2.75 3.25	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

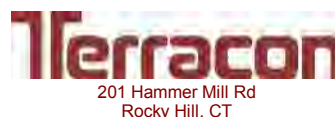
See Exhibit A-3 for description of field procedures.  
See Appendix B for description of laboratory procedures and additional data (if any).  
See Appendix C for explanation of symbols and abbreviations.

Notes:

Abandonment Method:  
Grouted to surface

**WATER LEVEL OBSERVATIONS**

- ▽ 64.5' AB (8/12/17)
- ▽ 105.5' after 14 hrs (08/13/17)
- ▽ 89.0' after 14 hrs (08/14/17)



Boring Started: 8/11/2017

Boring Completed: 8/14/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1E Lower Piney Creek Rd. East

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.43252° Longitude: -78.264217°  Approximate Surface Elev: 1114 (Ft.) +/- ELEVATION (Ft.)								
	Run 28, Hard, fresh, medium dark gray, argillaceous DOLOMITE, moderately dipping, moderately close joints with coal coating	155			57		95	3.5 2.75 3.0 3.0 3.0	
	Run 29, Similar, no joints present in this run, (solid core)	160			60		100	3.5 3.0 3.0 3.0 3.0	
	Run 30, Similar, grayish black 160'- 162', medium dark gray 162'-165', low angle joints	165			60		87	2.5 2.5 2.5 3.0 3.0	
	Run 31, Hard, fresh, medium dark gray, argillaceous DOLOMITE, low angle close joints	170			60		85	4.5 4.75 4.0 3.75 3.75	
	Run 32, Similar, moderately dipping to vertical joints	175			60		85	4.75 3.25 3.0 2.75 2.75	
	Run 33, Change at 178', medium dark gray, at 179' light gray, moderately dipping close joints	180			60		100	3.5 3.5 3.5 3.25 3.25	

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

- ▽ 64.5' AB (8/12/17)
- ▽ 105.5' after 14 hrs (08/13/17)
- ▽ 89.0' after 14 hrs (08/14/17)



Boring Started: 8/11/2017

Boring Completed: 8/14/2017

Drill Rig: CME-850

Driller: Terracon/Peter M.

Project No.: J217P078

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

# BORING LOG NO. B3-1E Lower Piney Creek Rd. East

**PROJECT:** Mariner East Pipeline Borings

**CLIENT:** Directional Project Support Incorporated  
Magnolia, TX 77354

**SITE:** Spread 3

GRAPHIC LOG	LOCATION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Latitude: 40.43252° Longitude: -78.264217°  Approximate Surface Elev: 1114 (Ft.) +/- ELEVATION (Ft.)								
DEPTH									
	Run 34, Similar, change at 180': Hard, fresh, medium dark gray, argillaceous CALCAREOUS LIMESTONE, low angle moderately close joints. Moderately weathered at 185'	185			60		90	3.5 3.75 2.75 2.75	
	Run 35, Similar, medium gray,	190			48		68	3.0 3.0 3.25 3.25	
	<b>Boring Terminated at 190 Feet</b>								

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

Hammer Type: Automatic

Advancement Method:  
Mud rotary with wireline

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

Notes:

Abandonment Method:  
Grouted to surface

See Appendix C for explanation of symbols and abbreviations.

WATER LEVEL OBSERVATIONS	
▽	64.5' AB (8/12/17)
▽	105.5' after 14 hrs (08/13/17)
▽	89.0' after 14 hrs (08/14/17)



Boring Started: 8/11/2017	Boring Completed: 8/14/2017
Drill Rig: CME-850	Driller: Terracon/Peter M.
Project No.: J217P078	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 3.GPJ

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

Boring No.: B3-1W  
 Sample No.: 1  
 Sample Depth: 29 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 16 min

Diameter: 1.87 in  
 Length: 4.41 in  
 L/D: 2.36  
 End Area: 2.75 in<sup>2</sup>

Maximum Axial Load at Failure: 53,420 lb  
 Compressive Strength: 19,450 psi  
 Compressive Strength: 134.11 Mpa  
 Unit Weight 167 pcf

Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 3
Client :	Directional Project Support Inc.

**Terracon**  
 77 Sundial Ave., Suite 401 W  
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	10/3/2017
Reviewed By :	L. Dwyer
Review Date :	10/7/2017

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

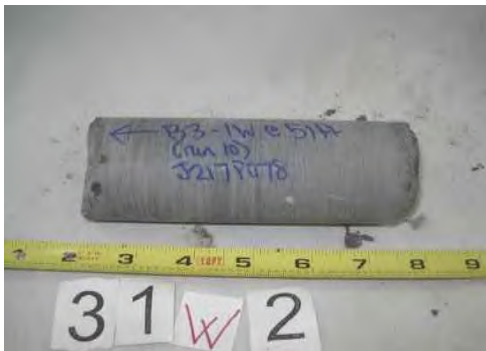
Boring No.: B3-1W  
 Sample No.: 2  
 Sample Depth: 51 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 14 min

Diameter: 1.92 in  
 Length: 4.05 in  
 L/D: 2.11  
 End Area: 2.90 in<sup>2</sup>

Maximum Axial Load at Failure: 45,660 lb  
 Compressive Strength: 15,770 psi  
 Compressive Strength: 108.73 Mpa  
 Unit Weight 167 pcf


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

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

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

Boring No.: B3-1W  
 Sample No.: 3  
 Sample Depth: 72 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 22 min

Diameter: 1.98 in  
 Length: 4.41 in  
 L/D: 2.23  
 End Area: 3.08 in<sup>2</sup>

Maximum Axial Load at Failure: 72,670 lb  
 Compressive Strength: 23,601 psi  
 Compressive Strength: 162.72 Mpa  
 Unit Weight 166 pcf

Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 3
Client :	Directional Project Support Inc.

**Terracon**  
 77 Sundial Ave., Suite 401 W  
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	10/3/2017
Reviewed By :	L. Dwyer
Review Date :	10/7/2017

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

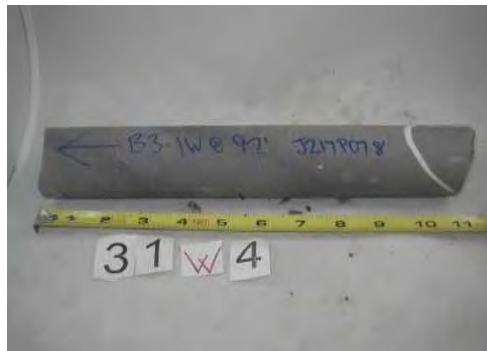
Boring No.: B3-1W  
 Sample No.: 4  
 Sample Depth: 92 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 20 min

Diameter: 1.97 in  
 Length: 4.42 in  
 L/D: 2.24  
 End Area: 3.05 in<sup>2</sup>

Maximum Axial Load at Failure: 65,450 lb  
 Compressive Strength: 21,473 psi  
 Compressive Strength: 148.05 Mpa  
 Unit Weight 167 pcf


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

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

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

Boring No.: B3-1W  
 Sample No.: 5  
 Sample Depth: 112 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 19 min

Diameter: 1.98 in  
 Length: 4.21 in  
 L/D: 2.13  
 End Area: 3.08 in<sup>2</sup>

Maximum Axial Load at Failure: 61,920 lb  
 Compressive Strength: 20,110 psi  
 Compressive Strength: 138.65 Mpa  
 Unit Weight 167 pcf


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

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

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

Boring No.: B3-1W  
 Sample No.: 6  
 Sample Depth: 132 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 7 min

Diameter: 1.98 in  
 Length: 4.32 in  
 L/D: 2.18  
 End Area: 3.08 in<sup>2</sup>

Maximum Axial Load at Failure: 24,440 lb  
 Compressive Strength: 7,937 psi  
 Compressive Strength: 54.73 Mpa  
 Unit Weight 167 pcf

Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 3
Client :	Directional Project Support Inc.

**Terracon**  
 77 Sundial Ave., Suite 401 W  
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	10/3/2017
Reviewed By :	L. Dwyer
Review Date :	10/7/2017

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

Boring No.: B3-1W  
 Sample No.: 7  
 Sample Depth: 137 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 2 min

Diameter: 1.97 in  
 Length: 2.68 in  
 L/D: 1.36  
 End Area: 3.05 in<sup>2</sup>

Maximum Axial Load at Failure: 5,840 lb  
 Compressive Strength: 1,916 psi  
 Compressive Strength: 13.21 Mpa  
 Unit Weight 159 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-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

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

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

Boring No.: B3-1W  
 Sample No.: 8  
 Sample Depth: 147 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 24 min

Diameter: 1.98 in  
 Length: 4.34 in  
 L/D: 2.19  
 End Area: 3.08 in<sup>2</sup>

Maximum Axial Load at Failure: 77,960 lb  
 Compressive Strength: 25,319 psi  
 Compressive Strength: 174.57 Mpa  
 Unit Weight 168 pcf


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

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

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

Boring No.: B3-1W  
 Sample No.: 9  
 Sample Depth: 157 feet  
 Sampling Date: 8/8/17

Lithology : Shale  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 24 min

Diameter: 1.98 in  
 Length: 4.43 in  
 L/D: 2.24  
 End Area: 3.08 in<sup>2</sup>

Maximum Axial Load at Failure: 78,740 lb  
 Compressive Strength: 25,573 psi  
 Compressive Strength: 176.32 Mpa  
 Unit Weight 169 pcf

Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 3
Client :	Directional Project Support Inc.

**Terracon**  
 77 Sundial Ave., Suite 401 W  
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	10/3/2017
Reviewed By :	L. Dwyer
Review Date :	10/7/2017

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

Boring No.: B3-1E  
 Sample No.: 1  
 Sample Depth: 35 feet  
 Sampling Date: 8/11/17

Lithology : Mudstone  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 12 min

Diameter: 1.98 in  
 Length: 4.51 in  
 L/D: 2.28  
 End Area: 3.08 in<sup>2</sup>

Maximum Axial Load at Failure: 38,720 lb  
 Compressive Strength: 12,575 psi  
 Compressive Strength: 86.70 Mpa  
 Unit Weight 174 pcf


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline	 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	A. Suprunenko
Project No.	J217P078		Test Date:	9/28/2017
Location:	Spread 3		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/7/2017

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

Boring No.: B3-1E  
 Sample No.: 2  
 Sample Depth: 54 feet  
 Sampling Date: 8/11/17

Lithology : Mudstone  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 6 min

Diameter: 1.97 in  
 Length: 3.82 in  
 L/D: 1.94  
 End Area: 3.05 in<sup>2</sup>

Maximum Axial Load at Failure: 19,940 lb  
 Compressive Strength: 6,542 psi  
 Compressive Strength: 45.10 Mpa  
 Unit Weight 174 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-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline	 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	A. Suprunenko
Project No:	J217P078		Test Date:	9/28/2017
Location:	Spread 3		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/7/2017

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

Boring No.: B3-1E  
 Sample No.: 3  
 Sample Depth: 75 feet  
 Sampling Date: 8/11/17

Lithology : Mudstone  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 6 min

Diameter: 1.95 in  
 Length: 4.09 in  
 L/D: 2.10  
 End Area: 2.99 in<sup>2</sup>

Maximum Axial Load at Failure: 20,220 lb  
 Compressive Strength: 6,771 psi  
 Compressive Strength: 46.68 Mpa  
 Unit Weight 71 pcf


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline	 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	A. Suprunenko
Project No.	J217P078		Test Date:	9/28/2017
Location:	Spread 3		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/7/2017

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

Boring No.: B3-1E  
 Sample No.: 4  
 Sample Depth: 95 feet  
 Sampling Date: 8/11/17

Lithology : Mudstone  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 18 min

Diameter: 1.95 in  
 Length: 3.77 in  
 L/D: 1.93  
 End Area: 2.99 in<sup>2</sup>

Maximum Axial Load at Failure: 58,770 lb  
 Compressive Strength: 19,679 psi  
 Compressive Strength: 135.68 Mpa  
 Unit Weight 175 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-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline	 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	A. Suprunenko
Project No:	J217P078		Test Date:	9/28/2017
Location:	Spread 3		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/7/2017

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

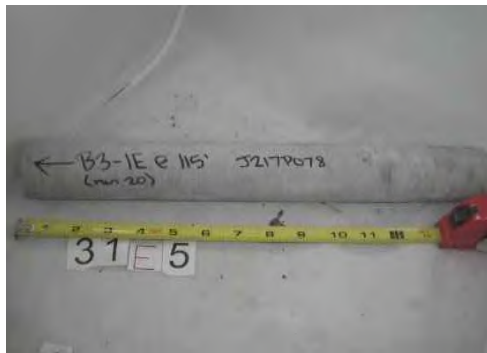
Boring No.: B3-1E  
 Sample No.: 5  
 Sample Depth: 115 feet  
 Sampling Date: 8/11/17

Lithology : Mudstone  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 1 min

Diameter: 1.97 in  
 Length: 4.13 in  
 L/D: 2.10  
 End Area: 3.05 in<sup>2</sup>

Maximum Axial Load at Failure: 2,890 lb  
 Compressive Strength: 948 psi  
 Compressive Strength: 6.54 Mpa  
 Unit Weight 160 pcf


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline	 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	A. Suprunenko
Project No:	J217P078		Test Date:	9/28/2017
Location:	Spread 3		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/7/2017

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

Boring No.: B3-1E  
 Sample No.: 6  
 Sample Depth: 132 feet  
 Sampling Date: 8/11/17

Lithology : Mudstone  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 1 min

Diameter: 1.97 in  
 Length: 4.48 in  
 L/D: 2.27  
 End Area: 3.05 in<sup>2</sup>

Maximum Axial Load at Failure: 2,490 lb  
 Compressive Strength: 817 psi  
 Compressive Strength: 5.63 Mpa  
 Unit Weight 176 pcf


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

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

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

Boring No.: B3-1E  
 Sample No.: 7  
 Sample Depth: 147 feet  
 Sampling Date: 8/11/17

Lithology : Dolomite  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 22 min

Diameter: 1.97 in  
 Length: 3.19 in  
 L/D: 1.62  
 End Area: 3.05 in<sup>2</sup>

Maximum Axial Load at Failure: 71,900 lb  
 Compressive Strength: 23,589 psi  
 Compressive Strength: 162.64 Mpa  
 Unit Weight 175 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-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

Project:	Mariner East Pipeline
Project No:	J217P078
Location:	Spread 3
Client :	Directional Project Support Inc.

**Terracon**  
 77 Sundial Ave., Suite 401 W  
 Manchester, New Hampshire

Performed by:	A. Suprunenko
Test Date:	10/6/2017
Reviewed By :	L. Dwyer
Review Date :	10/7/2017

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

Boring No.: B3-1E  
 Sample No.: 8  
 Sample Depth: 152 feet  
 Sampling Date: 8/11/17

Lithology : Dolomite  
 Moisture Content : As received  
 Lab Temperature : 70° F  
 Loading Rate: 55 psi/s  
 Time to Failure: 27 min

Diameter: 1.96 in  
 Length: 3.92 in  
 L/D: 2.00  
 End Area: 3.02 in<sup>2</sup>

Maximum Axial Load at Failure: >90,000 lb  
 Compressive Strength: >29,829 psi  
 Compressive Strength: >205.66 Mpa  
 Unit Weight 177 pcf

Machine reached loading capacity before specimen broke


Before the Test



After the Test



Drawing # : PA-BL-0125.0000-RD  
 PO # : 20170804-13  
 Crossing : Lower Piney Creek Rd  
 Spread : Spread 3

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

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## **SUPPORTING INFORMATION**

# UNIFIED SOIL CLASSIFICATION SYSTEM



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

<sup>A</sup> Based on the material passing the 3-inch (75-mm) sieve

<sup>B</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>C</sup> 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.

<sup>D</sup> 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

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

<sup>F</sup> If soil contains <sup>3</sup> 15% sand, add "with sand" to group name.

<sup>G</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup> If fines are organic, add "with organic fines" to group name.

<sup>I</sup> If soil contains <sup>3</sup> 15% gravel, add "with gravel" to group name.

<sup>J</sup> If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

<sup>K</sup> If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>L</sup> If soil contains <sup>3</sup> 30% plus No. 200 predominantly sand, add "sandy" to group name.

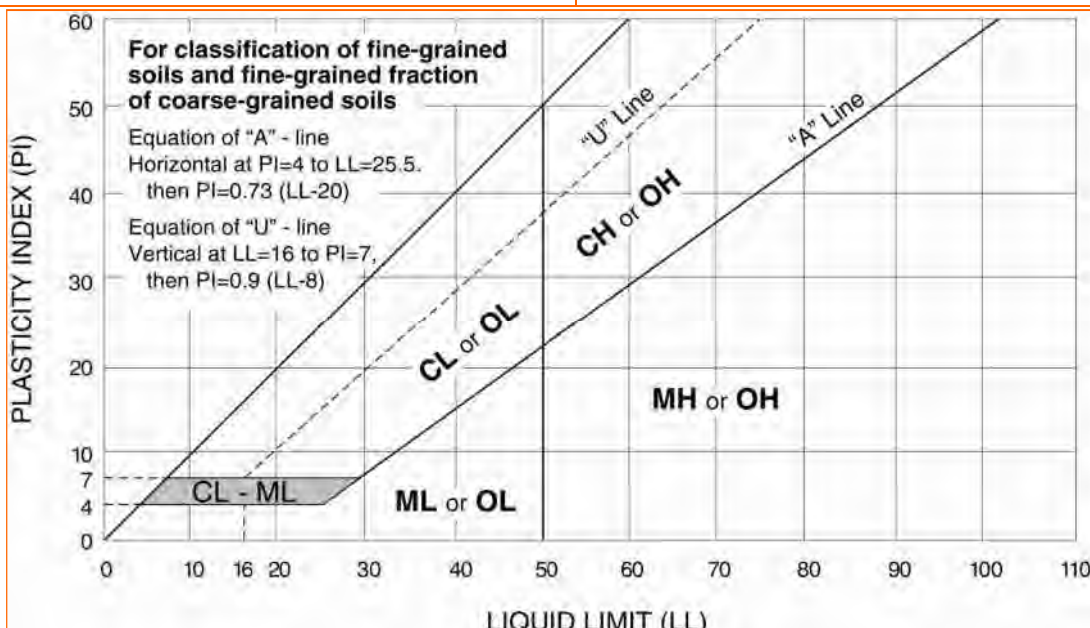
<sup>M</sup> If soil contains <sup>3</sup> 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

<sup>N</sup>  $PI \geq 4$  and plots on or above "A" line.

<sup>O</sup>  $PI < 4$  or plots below "A" line.

<sup>P</sup>  $PI$  plots on or above "A" line.

<sup>Q</sup>  $PI$  plots below "A" line.



## DESCRIPTION OF ROCK PROPERTIES



WEATHERING	
<b>Fresh</b>	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
<b>Very Slight</b>	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
<b>Slight</b>	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.
<b>Moderate</b>	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.
<b>Moderately Severe</b>	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.
<b>Severe</b>	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.
<b>Very Severe</b>	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
<b>Complete</b>	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)	
<b>Very Hard</b>	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
<b>Hard</b>	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
<b>Moderately Hard</b>	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.
<b>Medium</b>	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.
<b>Soft</b>	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.
<b>Very Soft</b>	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 <sup>1</sup>		
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) <sup>1</sup>		Joint Openness Descriptors	
RQD, as a percentage	Diagnostic description	Openness	Descriptor
Exceeding 90	Excellent	No Visible Separation	Tight
90 – 75	Good	Less than 1/32 in.	Slightly Open
75 – 50	Fair	1/32 to 1/8 in.	Moderately Open
50 – 25	Poor	1/8 to 3/8 in.	Open
Less than 25	Very poor	3/8 in. to 0.1 ft.	Moderately Wide
		Greater than 0.1 ft.	Wide

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

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.

**REVIEW**

**ATTACHMENT 2  
SOIL RESOURCES MAP AND PROFILE DESCRIPTIONS**



United States  
Department of  
Agriculture

**NRCS**

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 **Blair County, Pennsylvania**

## Lower Piney Creek Road



# Preface

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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](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951)).

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

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

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

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# How Soil Surveys Are Made

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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

## Custom Soil Resource Report

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

## Custom Soil Resource Report

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

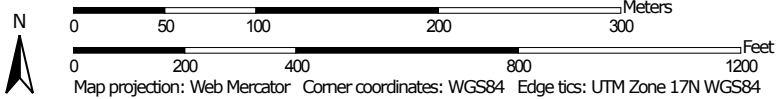
---

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: 1:4,150 if printed on A landscape (11" x 8.5") sheet.




### MAP LEGEND

**Area of Interest (AOI)**

 Area of Interest (AOI)




















**Soils**







 Soil Map Unit Polygons

 Soil Map Unit Lines


 Soil Map Unit Points

**Special Point Features**






-  Blowout
-  Borrow Pit
-  Clay Spot
-  Closed Depression
-  Gravel Pit
-  Gravelly Spot
-  Landfill
-  Lava Flow
-  Marsh or swamp
-  Mine or Quarry
-  Miscellaneous Water
-  Perennial Water
-  Rock Outcrop
-  Saline Spot
-  Sandy Spot
-  Severely Eroded Spot
-  Sinkhole
-  Slide or Slip
-  Sodic Spot

-  Spoil Area
-  Stony Spot
-  Very Stony Spot
-  Wet Spot
-  Other
-  Special Line Features


**Water Features**

 Streams and Canals

**Transportation**

-  Rails
-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads

**Background**

 Aerial Photography

### MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Blair County, Pennsylvania  
 Survey Area Data: Version 10, Sep 19, 2016

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

Date(s) aerial images were photographed: Mar 23, 2010—Feb 22, 2017

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

## Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BuB	Buchanan gravelly silt loam, 3 to 8 percent slopes	0.4	0.6%
HeD	Hagerstown-Rock outcrop complex, 8 to 25 percent slopes	4.4	6.3%
HuB	Hublersburg cherty silt loam, 3 to 8 percent slopes	2.8	4.1%
HuC	Hublersburg cherty silt loam, 8 to 15 percent slopes	13.9	20.2%
MuB	Murrill gravelly silt loam, 3 to 8 percent slopes	7.1	10.3%
MuC	Murrill gravelly silt loam, 8 to 15 percent slopes	16.0	23.2%
MuD	Murrill gravelly silt loam, 15 to 25 percent slopes	7.7	11.1%
MxD	Murrill extremely stony silt loam, 8 to 25 percent slopes	2.2	3.2%
OuD	Opequon silty clay loam, 15 to 25 percent slopes	5.0	7.3%
OxF	Opequon-Hagerstown-Rock outcrop complex, 25 to 50 percent slopes	1.9	2.7%
Qu	Quarries-Dumps complex	0.5	0.7%
UD	Udifulvents-Dystrochrepts complex	7.1	10.2%
<b>Totals for Area of Interest</b>		<b>69.0</b>	<b>100.0%</b>

## 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.

## Custom Soil Resource Report

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

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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.

## Blair County, Pennsylvania

### BuB—Buchanan gravelly silt loam, 3 to 8 percent slopes

#### Map Unit Setting

*National map unit symbol:* 16bk  
*Elevation:* 300 to 3,000 feet  
*Mean annual precipitation:* 35 to 55 inches  
*Mean annual air temperature:* 45 to 59 degrees F  
*Frost-free period:* 120 to 217 days  
*Farmland classification:* All areas are prime farmland

#### Map Unit Composition

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

#### Description of Buchanan

##### Setting

*Landform:* Mountain slopes, valley sides  
*Landform position (two-dimensional):* Footslope  
*Landform position (three-dimensional):* Lower third of mountainflank, base slope  
*Down-slope shape:* Concave, linear  
*Across-slope shape:* Linear, concave  
*Parent material:* Mountain slope colluvium derived from sedimentary rock

##### Typical profile

*H1 - 0 to 8 inches:* gravelly loam  
*H2 - 8 to 32 inches:* gravelly loam  
*H3 - 32 to 65 inches:* gravelly loam

##### Properties and qualities

*Slope:* 3 to 8 percent  
*Depth to restrictive feature:* 20 to 36 inches to fragipan  
*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 18 to 36 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Available water storage in profile:* Low (about 4.3 inches)

##### Interpretive groups

*Land capability classification (irrigated):* None specified  
*Land capability classification (nonirrigated):* 2w  
*Hydrologic Soil Group:* C  
*Hydric soil rating:* No

#### Minor Components

##### Andover

*Percent of map unit:* 6 percent  
*Landform:* Depressions  
*Landform position (three-dimensional):* Mountainbase

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*Down-slope shape:* Concave  
*Across-slope shape:* Concave  
*Hydric soil rating:* Yes

### **Berks**

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

### **Bedington**

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

### **Philo**

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

## **HeD—Hagerstown-Rock outcrop complex, 8 to 25 percent slopes**

### **Map Unit Setting**

*National map unit symbol:* 16c9  
*Elevation:* 400 to 3,000 feet  
*Mean annual precipitation:* 30 to 46 inches  
*Mean annual air temperature:* 44 to 57 degrees F  
*Frost-free period:* 130 to 200 days  
*Farmland classification:* Not prime farmland

### **Map Unit Composition**

*Hagerstown and similar soils:* 50 percent  
*Rock outcrop:* 30 percent  
*Minor components:* 5 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### **Description of Hagerstown**

#### **Setting**

*Landform:* Hills  
*Landform position (two-dimensional):* Backslope  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Residuum weathered from limestone

#### **Typical profile**

*H1 - 0 to 14 inches:* silty clay loam  
*H2 - 14 to 40 inches:* clay  
*H3 - 40 to 60 inches:* silty clay loam

#### **Properties and qualities**

*Slope:* 8 to 25 percent  
*Depth to restrictive feature:* 40 to 84 inches to lithic bedrock  
*Natural drainage class:* Well drained  
*Runoff class:* Medium

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*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)

*Depth to water table:* More than 80 inches

*Frequency of flooding:* None

*Frequency of ponding:* None

*Available water storage in profile:* High (about 10.6 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 6s

*Hydrologic Soil Group:* B

*Hydric soil rating:* No

### Description of Rock Outcrop

#### Setting

*Landform:* Valley sides

*Landform position (two-dimensional):* Shoulder, backslope

*Landform position (three-dimensional):* Mountainflank

*Down-slope shape:* Linear, convex

*Across-slope shape:* Linear, convex

*Parent material:* Bedrock exposures

#### Properties and qualities

*Depth to restrictive feature:* 0 to 4 inches to lithic bedrock

### Minor Components

#### Opequon

*Percent of map unit:* 5 percent

*Hydric soil rating:* No

## HuB—Hublersburg cherty silt loam, 3 to 8 percent slopes

### Map Unit Setting

*National map unit symbol:* 16cj

*Elevation:* 300 to 1,500 feet

*Mean annual precipitation:* 34 to 45 inches

*Mean annual air temperature:* 46 to 59 degrees F

*Frost-free period:* 139 to 199 days

*Farmland classification:* All areas are prime farmland

### Map Unit Composition

*Hublersburg and similar soils:* 90 percent

*Minor components:* 5 percent

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

## Description of Hublersburg

### Setting

*Landform:* Ridges on valleys  
*Landform position (two-dimensional):* Backslope  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Residuum weathered from cherty limestone

### Typical profile

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

### Properties and qualities

*Slope:* 3 to 8 percent  
*Depth to restrictive feature:* More than 80 inches  
*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 2.00 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Available water storage in profile:* Moderate (about 8.6 inches)

### Interpretive groups

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

## Minor Components

### Clarksburg

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

## HuC—Hublersburg cherty silt loam, 8 to 15 percent slopes

### Map Unit Setting

*National map unit symbol:* 16ck  
*Mean annual precipitation:* 36 to 46 inches  
*Mean annual air temperature:* 46 to 59 degrees F  
*Frost-free period:* 139 to 199 days  
*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Hublersburg and similar soils:* 90 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

## Description of Hublersburg

### Setting

*Landform:* Ridges on valleys  
*Landform position (two-dimensional):* Backslope  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Residuum weathered from cherty limestone

### Typical profile

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

### Properties and qualities

*Slope:* 8 to 15 percent  
*Depth to restrictive feature:* More than 80 inches  
*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 2.00 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Available water storage in profile:* Moderate (about 8.6 inches)

### Interpretive groups

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

## MuB—Murrill gravelly silt loam, 3 to 8 percent slopes

### Map Unit Setting

*National map unit symbol:* l6dm  
*Elevation:* 600 to 1,800 feet  
*Mean annual precipitation:* 35 to 46 inches  
*Mean annual air temperature:* 46 to 59 degrees F  
*Frost-free period:* 120 to 180 days  
*Farmland classification:* All areas are prime farmland

### Map Unit Composition

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

## Description of Murrill

### Setting

*Landform:* Valley sides  
*Landform position (two-dimensional):* Footslope

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*Landform position (three-dimensional):* Base slope

*Down-slope shape:* Concave

*Across-slope shape:* Concave

*Parent material:* Colluvium derived from sandstone over residuum weathered from limestone

### Typical profile

*H1 - 0 to 11 inches:* channery silt loam

*H2 - 11 to 60 inches:* channery silty clay loam

*H3 - 60 to 64 inches:* gravelly sandy clay loam

### Properties and qualities

*Slope:* 3 to 8 percent

*Depth to restrictive feature:* 72 to 99 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 (0.20 to 2.00 in/hr)

*Depth to water table:* More than 80 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):* 2e

*Hydrologic Soil Group:* B

*Hydric soil rating:* No

### Minor Components

#### Buchanan

*Percent of map unit:* 5 percent

*Hydric soil rating:* No

## MuC—Murrill gravelly silt loam, 8 to 15 percent slopes

### Map Unit Setting

*National map unit symbol:* 16dn

*Elevation:* 600 to 1,800 feet

*Mean annual precipitation:* 35 to 46 inches

*Mean annual air temperature:* 46 to 59 degrees F

*Frost-free period:* 120 to 180 days

*Farmland classification:* Farmland of statewide importance

### Map Unit Composition

*Murrill and similar soils:* 90 percent

*Minor components:* 5 percent

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

## Description of Murrill

### Setting

*Landform:* Valley sides

*Landform position (two-dimensional):* Footslope

*Landform position (three-dimensional):* Base slope

*Down-slope shape:* Concave

*Across-slope shape:* Concave

*Parent material:* Colluvium derived from sandstone over residuum weathered from limestone

### Typical profile

*H1 - 0 to 11 inches:* channery silt loam

*H2 - 11 to 60 inches:* channery silty clay loam

*H3 - 60 to 64 inches:* gravelly sandy clay loam

### Properties and qualities

*Slope:* 8 to 15 percent

*Depth to restrictive feature:* 72 to 99 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 (0.20 to 2.00 in/hr)

*Depth to water table:* More than 80 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):* 3e

*Hydrologic Soil Group:* B

*Hydric soil rating:* No

## Minor Components

### Buchanan

*Percent of map unit:* 5 percent

*Hydric soil rating:* No

## MuD—Murrill gravelly silt loam, 15 to 25 percent slopes

### Map Unit Setting

*National map unit symbol:* l6dp

*Elevation:* 400 to 3,800 feet

*Mean annual precipitation:* 34 to 60 inches

*Mean annual air temperature:* 48 to 57 degrees F

*Frost-free period:* 120 to 180 days

*Farmland classification:* Not prime farmland

**Map Unit Composition**

*Murrill and similar soils:* 90 percent

*Minor components:* 5 percent

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

**Description of Murrill**

**Setting**

*Landform:* Valley sides

*Landform position (two-dimensional):* Footslope

*Landform position (three-dimensional):* Base slope

*Down-slope shape:* Concave

*Across-slope shape:* Concave

*Parent material:* Colluvium derived from sandstone over residuum weathered from limestone

**Typical profile**

*H1 - 0 to 11 inches:* channery silt loam

*H2 - 11 to 60 inches:* channery silty clay loam

*H3 - 60 to 64 inches:* gravelly sandy clay loam

**Properties and qualities**

*Slope:* 15 to 25 percent

*Depth to restrictive feature:* 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 to high (0.20 to 2.00 in/hr)

*Depth to water table:* More than 80 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):* 4e

*Hydrologic Soil Group:* B

*Hydric soil rating:* No

**Minor Components**

**Laidig**

*Percent of map unit:* 5 percent

*Hydric soil rating:* No

**MxD—Murrill extremely stony silt loam, 8 to 25 percent slopes**

**Map Unit Setting**

*National map unit symbol:* 16dr

*Elevation:* 600 to 2,400 feet

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*Mean annual precipitation:* 35 to 46 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

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

### Description of Murrill

#### Setting

*Landform:* Valley sides  
*Landform position (two-dimensional):* Footslope  
*Landform position (three-dimensional):* Base slope  
*Down-slope shape:* Concave  
*Across-slope shape:* Concave  
*Parent material:* Colluvium derived from sandstone over residuum weathered from limestone

#### Typical profile

*H1 - 0 to 11 inches:* gravelly silt loam  
*H2 - 11 to 60 inches:* channery silty clay loam  
*H3 - 60 to 64 inches:* gravelly sandy clay loam

#### Properties and qualities

*Slope:* 15 to 25 percent  
*Percent of area covered with surface fragments:* 9.0 percent  
*Depth to restrictive feature:* 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 to high (0.20 to 2.00 in/hr)  
*Depth to water table:* More than 80 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:* B  
*Hydric soil rating:* No

### Minor Components

#### Buchanan

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

## **OuD—Opequon silty clay loam, 15 to 25 percent slopes**

### **Map Unit Setting**

*National map unit symbol:* 2sg9t  
*Elevation:* 300 to 3,000 feet  
*Mean annual precipitation:* 39 to 50 inches  
*Mean annual air temperature:* 47 to 56 degrees F  
*Frost-free period:* 155 to 192 days  
*Farmland classification:* Not prime farmland

### **Map Unit Composition**

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

### **Description of Opequon**

#### **Setting**

*Landform:* Hills  
*Landform position (two-dimensional):* Shoulder, summit, backslope  
*Landform position (three-dimensional):* Nose slope, side slope  
*Down-slope shape:* Convex  
*Across-slope shape:* Convex  
*Parent material:* Clayey residuum weathered from limestone and dolomite

#### **Typical profile**

*Ap - 0 to 5 inches:* silty clay loam  
*Bt1 - 5 to 13 inches:* silty clay  
*Bt2 - 13 to 16 inches:* silty clay  
*R - 16 to 26 inches:* bedrock

#### **Properties and qualities**

*Slope:* 15 to 25 percent  
*Depth to restrictive feature:* 12 to 20 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 (0.20 to 2.00 in/hr)  
*Depth to water table:* More than 80 inches  
*Frequency of flooding:* None  
*Frequency of ponding:* None  
*Salinity, maximum in profile:* Nonsaline (0.0 to 0.2 mmhos/cm)  
*Available water storage in profile:* Very low (about 1.3 inches)

#### **Interpretive groups**

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

## Minor Components

### Hagerstown

*Percent of map unit:* 5 percent

*Landform:* Ridges

*Landform position (two-dimensional):* Backslope, footslope

*Landform position (three-dimensional):* Side slope, base slope

*Down-slope shape:* Linear

*Across-slope shape:* Linear

*Hydric soil rating:* No

### Rock outcrop

*Percent of map unit:* 5 percent

*Landform:* Hills

*Landform position (two-dimensional):* Shoulder, summit, backslope

*Landform position (three-dimensional):* Nose slope, side slope, crest

*Down-slope shape:* Convex

*Across-slope shape:* Convex

*Hydric soil rating:* No

## OxF—Opequon-Hagerstown-Rock outcrop complex, 25 to 50 percent slopes

### Map Unit Setting

*National map unit symbol:* 16dv

*Elevation:* 300 to 3,000 feet

*Mean annual precipitation:* 30 to 46 inches

*Mean annual air temperature:* 44 to 59 degrees F

*Frost-free period:* 130 to 200 days

*Farmland classification:* Not prime farmland

### Map Unit Composition

*Opequon and similar soils:* 40 percent

*Hagerstown and similar soils:* 30 percent

*Rock outcrop:* 20 percent

*Minor components:* 8 percent

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

### Description of Opequon

#### Setting

*Landform:* Hills

*Landform position (two-dimensional):* Backslope, shoulder, summit

*Landform position (three-dimensional):* Side slope, crest

*Down-slope shape:* Convex

*Across-slope shape:* Convex

*Parent material:* Residuum weathered from limestone

#### Typical profile

*H1 - 0 to 8 inches:* silty clay loam

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*H2 - 8 to 16 inches: silty clay*  
*H3 - 16 to 20 inches: bedrock*

### Properties and qualities

*Slope: 35 to 50 percent*  
*Depth to restrictive feature: 12 to 20 inches to lithic bedrock*  
*Natural drainage class: Well drained*  
*Runoff class: High*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 2.00 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 2.7 inches)*

### Interpretive groups

*Land capability classification (irrigated): None specified*  
*Land capability classification (nonirrigated): 7e*  
*Hydrologic Soil Group: D*  
*Hydric soil rating: No*

## Description of Hagerstown

### Setting

*Landform: Valley floors, ridges*  
*Landform position (two-dimensional): Shoulder, backslope*  
*Landform position (three-dimensional): Side slope*  
*Down-slope shape: Linear, convex*  
*Across-slope shape: Linear, convex*  
*Parent material: Residuum weathered from limestone*

### Typical profile

*H1 - 0 to 8 inches: silty clay loam*  
*H2 - 8 to 41 inches: clay*  
*H3 - 41 to 60 inches: clay*

### Properties and qualities

*Slope: 35 to 45 percent*  
*Depth to restrictive feature: 40 to 84 inches to lithic bedrock*  
*Natural drainage class: Well drained*  
*Runoff class: High*  
*Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)*  
*Depth to water table: More than 80 inches*  
*Frequency of flooding: None*  
*Frequency of ponding: None*  
*Available water storage in profile: High (about 10.4 inches)*

### Interpretive groups

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

## Description of Rock Outcrop

### Setting

*Landform: Valley sides*

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*Landform position (two-dimensional):* Backslope, shoulder  
*Down-slope shape:* Convex, linear  
*Across-slope shape:* Convex, linear  
*Parent material:* Bedrock exposures

### Minor Components

#### Hublersburg

*Percent of map unit:* 5 percent  
*Landform:* Ridges on valleys  
*Landform position (two-dimensional):* Backslope  
*Landform position (three-dimensional):* Side slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Hydric soil rating:* No

#### Clarksburg

*Percent of map unit:* 2 percent  
*Hydric soil rating:* No

#### Holly

*Percent of map unit:* 1 percent  
*Landform:* Flood plains  
*Landform position (two-dimensional):* Toeslope  
*Landform position (three-dimensional):* Base slope  
*Down-slope shape:* Concave  
*Across-slope shape:* Concave  
*Hydric soil rating:* Yes

## Qu—Quarries-Dumps complex

### Map Unit Setting

*National map unit symbol:* l6dy  
*Elevation:* 300 to 1,300 feet  
*Mean annual precipitation:* 35 to 50 inches  
*Mean annual air temperature:* 44 to 57 degrees F  
*Frost-free period:* 120 to 214 days  
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Quarries:* 50 percent  
*Dumps:* 30 percent  
*Minor components:* 2 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### **Description of Quarries**

#### **Setting**

*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Variable

### **Description of Dumps**

#### **Setting**

*Down-slope shape:* Linear  
*Across-slope shape:* Linear  
*Parent material:* Mine spoil or earthy fill

### **Minor Components**

#### **Aquents**

*Percent of map unit:* 2 percent  
*Landform:* Hills  
*Landform position (two-dimensional):* Footslope  
*Landform position (three-dimensional):* Base slope  
*Down-slope shape:* Concave  
*Across-slope shape:* Concave  
*Hydric soil rating:* Yes

## **UD—Udifluents-Dystrochrepts complex**

### **Map Unit Setting**

*National map unit symbol:* 16f0  
*Elevation:* 200 to 1,300 feet  
*Mean annual precipitation:* 30 to 50 inches  
*Mean annual air temperature:* 45 to 55 degrees F  
*Frost-free period:* 120 to 214 days  
*Farmland classification:* Not prime farmland

### **Map Unit Composition**

*Udifluents and similar soils:* 50 percent  
*Dystrochrepts and similar soils:* 30 percent  
*Minor components:* 4 percent  
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### **Description of Udifluents**

#### **Setting**

*Landform:* Flood plains  
*Landform position (two-dimensional):* Toeslope  
*Landform position (three-dimensional):* Base slope  
*Down-slope shape:* Linear  
*Across-slope shape:* Linear

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*Parent material:* Alluvium

### Typical profile

*H1 - 0 to 6 inches:* channery silt loam

*H2 - 6 to 42 inches:* gravelly loam

*H3 - 42 to 60 inches:* silt loam

### Properties and qualities

*Slope:* 0 to 3 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Moderately well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)

*Depth to water table:* About 36 inches

*Frequency of flooding:* Frequent

*Frequency of ponding:* None

*Available water storage in profile:* Moderate (about 6.1 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 7s

*Hydrologic Soil Group:* C

*Hydric soil rating:* No

## Description of Dystrochrepts

### Setting

*Landform:* Mountain slopes

*Landform position (two-dimensional):* Backslope

*Landform position (three-dimensional):* Mountainflank

*Down-slope shape:* Linear, convex

*Across-slope shape:* Linear, convex

*Parent material:* Residuum weathered from sandstone and shale

### Typical profile

*H1 - 0 to 6 inches:* loam, flagstones

*H2 - 6 to 42 inches:* gravelly loam

*H3 - 42 to 60 inches:* silt loam

### Properties and qualities

*Slope:* 0 to 3 percent

*Depth to restrictive feature:* More than 80 inches

*Natural drainage class:* Moderately well drained

*Runoff class:* Low

*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.60 to 2.00 in/hr)

*Depth to water table:* About 36 inches

*Frequency of flooding:* Frequent

*Frequency of ponding:* None

*Available water storage in profile:* Low (about 6.0 inches)

### Interpretive groups

*Land capability classification (irrigated):* None specified

*Land capability classification (nonirrigated):* 7s

*Hydrologic Soil Group:* C

*Hydric soil rating:* No

## Custom Soil Resource Report

### Minor Components

#### Brinkerton

*Percent of map unit:* 2 percent

*Landform:* Hills

*Landform position (two-dimensional):* Foothlope

*Landform position (three-dimensional):* Base slope

*Down-slope shape:* Concave

*Across-slope shape:* Concave

*Hydric soil rating:* Yes

#### Holly

*Percent of map unit:* 2 percent

*Landform:* Backswamps, depressions on flood plains

*Landform position (two-dimensional):* Toeslope

*Landform position (three-dimensional):* Base slope

*Down-slope shape:* Concave

*Across-slope shape:* Linear

*Hydric soil rating:* Yes

# References

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- 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>

## Custom Soil Resource Report

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](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](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](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf)

**REVIEW**

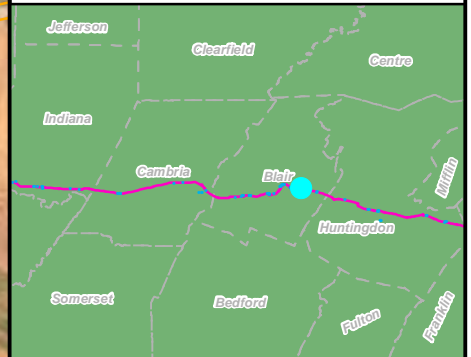
**ATTACHMENT 3  
SUPPLEMENTAL WATER SUPPLY INFORMATION**

GES Well ID	Distance to HDD Perpendicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
SP-04112017-520-05	53	715	NA	NA	NA
WL-04112017-520-04	77	328	250	70	240
WL-11082017-614-02	161	229	149	Unknown	Unknown
WL-11102017-631-01	248	544	180	Unknown	140

### Legend

-  LOD
  -  Parcel
  -  PPP Centerline
  -  HDD
  -  450 foot buffer of HDD alignment
- \*\*Testing locations current as of 11/27/2017**
-  GES Testing Location
  -  GES Spring Testing Location

### Location



0 250 500  
Feet

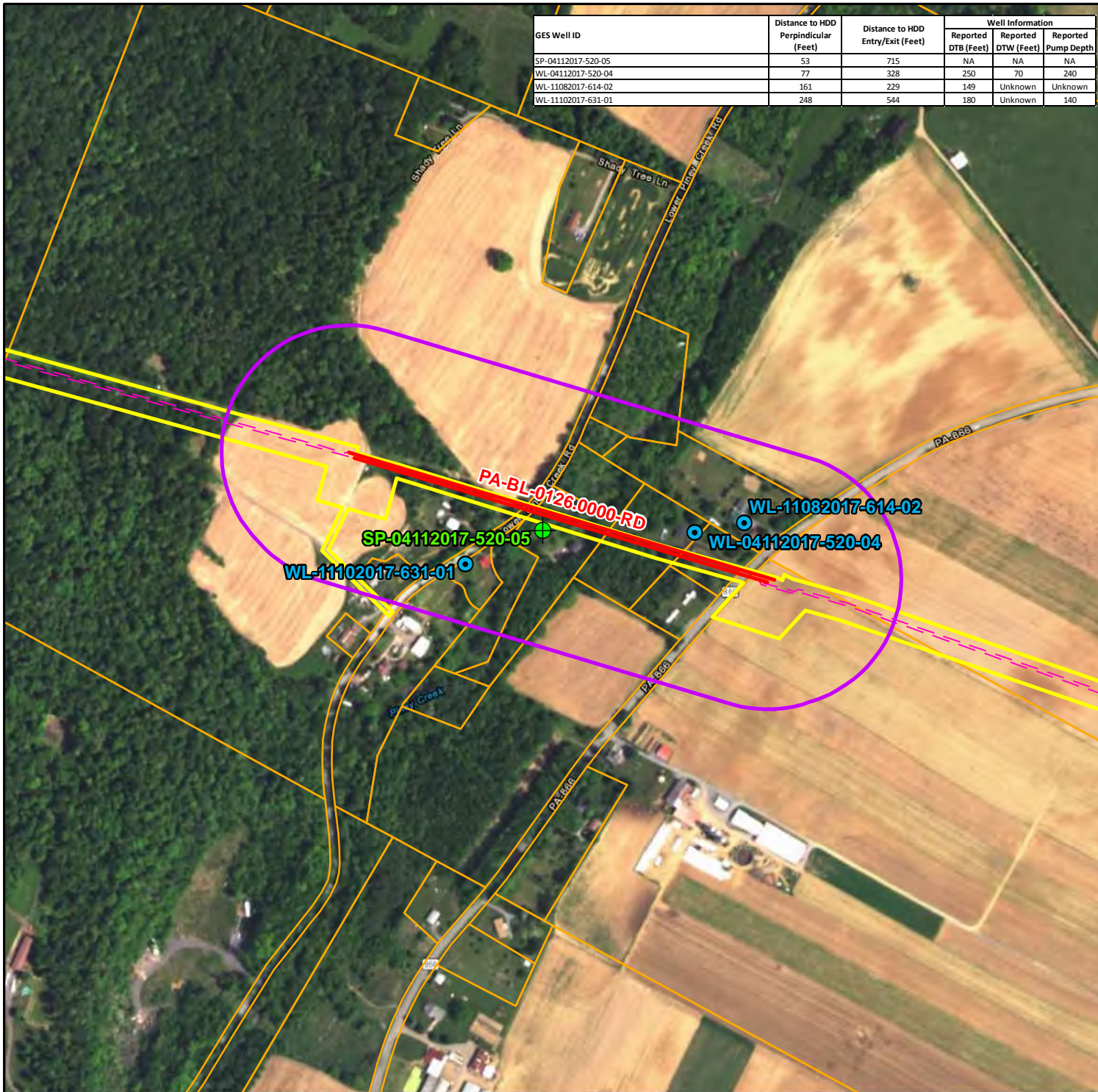
**Well Location Map**  
HDD# PA-BL-0126.0000-RD  
Blair County, PA.

Prepared By: 

Date:  
12/4/2017

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

Coordinate System: NAD 83 Stateplane, PA South, Feet



C:\GIS\workspace\172\00126\PA-BL-0126\WellLocations\WellLocation\_PA\_BL\_0126\_0000.mxd

**REVIEW**

**ATTACHMENT 4  
GEOPHYSICAL SURVEY RESULTS**



**Final Report  
Geophysical Survey  
Bedrock Fracture Zone Detection  
~1800 Linear Feet of Proposed Pipeline – Piney Creek Site  
Hollidaysburg Environs, PA  
Enviroscan Project Number 121701**

**Prepared For: Gremminger & Associates, Inc.  
Prepared By: Enviroscan, Inc.  
December 11, 2017**





December 11, 2017

Mr. Larry Gremminger  
**Gremminger & Associates, Inc.**  
226 South Live Oak Street  
Belleville, TX 77418

**RE:** Geophysical Survey  
Bedrock Fracture Zone Detection  
~1800 Linear Feet of Proposed Pipeline – Piney Creek Site  
Hollidaysburg Environs, PA  
Enviroscan Project Number 121701

Dear Mr. Gremminger:

Pursuant to our proposal dated December 1, 2017, Enviroscan, Inc. (Enviroscan) has completed a combined seismic refraction and electrical resistivity survey at the above-referenced site. The purpose of the survey was to map the locations of potential bedrock fractures along client-designated sections of a proposed pipeline alignment totaling ~1800 lineal feet (separated into a ~1100-foot transect to the west of Piney Creek Road, and a ~630-foot transect to the east of Piney Creek Road). Fieldwork was conducted December 6 through 8, 2017 in the client-designated areas.

## Site Description

The geophysical survey area is the alignment of an approximate 1800-foot-long proposed pipeline route; however, due to access issues caused by roads, creeks, steep terrain, densely-wooded areas, and a stream, the alignment was discontinuous. Section 1 was located to the east of Piney Creek, while Section 2 was west of the creek (see Figure 1). The Geologic Map of Pennsylvania (Berg, T. M., Edmunds, W. E., Geyer, A. R., and others, 1980) indicates that these two areas are located within multiple formations, starting with the Reedsville Formation in the west, through the Coburn, Nealmont, Benner, and Loysburg Formations which are undivided, and end in the Bellefonte and Axemann Formations (also undivided). The divides are shown on Figure 1 (Ibid). All the formations are Ordovician in age and except for the Reedsville Formation (which is a sandstone/mudstone), are primarily carbonate rock types (limestone and dolomite).



Mr. Gremminger  
December 11, 2017  
Page 2

## Survey Methods

In order to provide the highest level of confidence and greatest cost-effectiveness, Enviroscan proposed a combined seismic refraction, MASW, and electrical resistivity survey. Seismic refraction can be used to determine the depth to bedrock and overburden thickness, as well as to show variations of the velocity of the bedrock. MASW data are used to provide information below the top of the rock, so that weathered fractures may be visible. Electrical resistivity imaging was used to map the electrical properties of the subsurface, revealing areas of fractured rock and solid bedrock. However, based on the shallow bedrock depths and rock type and conference with the client's on-site representative, MASW was not performed due to the limiting nature of the technique in such conditions.

### **Seismic Refraction Survey**

The principles of seismic refraction are described in the accompanying Introduction to Seismic Refraction (Appendix A), and generally involve measuring the travel times of shock waves traveling from a surficial source (shot point) to a linear array of ground motion sensors (geophones). The first arrival (P-wave) travel times can be inverted to provide a cross-sectional profile of the density stratification beneath the geophone array. While seismic P-wave velocity ( $V_p$ ) is – formally – inversely proportional to density, the strength of Earth materials increases with density such that in general the higher the density, the faster the P-wave velocity.

### ***Field Procedure***

To perform the seismic refraction field survey, Enviroscan completed the following specific tasks:

- Enviroscan recorded seismic records along three profiles (two west of the stream/road, and one east of the stream/road) oriented roughly west-east. The survey profiles are shown on the attached Figure 1.
- Recording employed a Geometrics Geode 24-channel digital signal stacking seismograph and successive linear arrays of 4.5 Hertz geophones with a constant 10-foot interval.
- Seismic travel times were recorded from shots at 40-foot intervals along the arrays, to ensure full data coverage and highly redundant, low-noise data. The seismic energy source was a seismic slide sledge hammer, in order to generate both an impulsive source for refraction waves.

Mr. Gremminger  
December 11, 2017  
Page 3

- Location control (with sub-meter accuracy) was maintained for each geophone and shot point using a Topcon Hyper-SR differential global positioning system (DGPS).
- The seismic wiggle trace data from each geophone, for each shot point, was recorded on the internal hard drive of the laptop controlling the seismograph, and was downloaded daily to USB drives for backup.

### ***Data Processing***

The data were subjected to refraction seismic processing.

- Refraction processing employed the SeisImager (by OYO Corporation) software suite. First arrival picking was done using the automatic function in Pickwin with minor manual adjustment. Traces without clear first arrivals were typically deleted, since the data collection was highly redundant, and the missing arrivals would be more than compensated by multiple arrivals sampling the same portion of the subsurface using other shot-receiver pairs.
- The arrival time data were subjected to tomographic inversion with no a-priori layer assignments to ensure objective results. Each inversion was run for a minimum of seven iterations, and continued until the root mean square (RMS) residual between the observed travel times and those predicted for the model ceased to decline between iterations. In all cases, the RMS was less than 4 milliseconds.
- Each model was also subjected to mild horizontal smoothing (Gaussian-weighted, 70-foot window) to eliminate potential artifacts due to over-fitting of the models.
- The final seismic refraction velocity ( $V_p$ ) model cross sections are shown on Figures 2A and 2B (bottom panel).

### **Electrical Imaging Survey**

Surface resistivity measurements involve driving an electrical current in the ground using two current electrodes at the ground surface. The apparent resistivity of the subsurface (essentially the mathematical inverse of terrain conductivity) is determined by measuring the potential difference, or voltage, between two potential electrodes with a known separation and position/orientation relative to the current electrodes. The depth and volume of the subsurface zone represented by the measured apparent resistivity is a function of the geometry of the current and potential electrodes located at the surface. The principles of electrical imaging are described in the accompanying Introduction to Electrical Imaging (Appendix B).

Mr. Gremminger  
December 11, 2017  
Page 4

Using an AGI Super Sting R8/IP resistivity meter, apparent resistivity readings were collected along two profiles, mimicking the seismic arrays (Figure 1). Along each profile, electrodes were spaced at the ground surface at 10-foot intervals. The locations of profile endpoints, as well other electrodes and topography changes, were surveyed using the Topcon Hyper-SR DGPS.

The measured apparent resistivities ( $\rho_a$ ) were plotted in the field as resistivity pseudosections depicting the apparent resistivity versus nominal survey depth for each profile, in order to confirm data quality. In post-field processing, the apparent resistivity pseudosections were mathematically inverted using EarthImager 2D Resistivity Software by Advanced Geosciences, Inc., to provide electrical images of true resistivity versus true depth along each profile. The 2D resistivity data are presented as a series of color contours of the true resistivity versus depth along each profile (Figures 2A and 2B, top panel).

## Results

The seismic refraction cross sections (Figures 2A and 2B, bottom panel) indicate a generalized two-layer stratigraphic model with a relatively slow transition from unconsolidated materials to competent rock based on the gradual change in velocity at the inferred rock boundary. The uppermost layer has a weighted averaged P-wave velocity (the **Pressure wave** created by the source hammer that travels through the soil and bedrock) of less than 1500 feet per second (fps), with a thickness of approximately 10 to 30 feet (shaded blue, with its lower extent bounded by a dashed black line). The deeper layer has a weighted averaged velocity of over 15000 fps (shaded orange to red), with its upper extent bounded by a solid black line. The uppermost layer velocities are consistent with unconsolidated soils, while the bottom layer velocities are consistent with bedrock (Carmichael, R. S., 1989). Please note that the seismic profiles represent an average velocity profile, with contours representing a smoothed and gradual interface between the unconsolidated soils and rock, with rock pinnacles and cutters typically extending both above and below the contour lines (depicted by the yellow-shaded “epikarst” zone, and bounded by the solid and dashed black lines). The seismic refraction data show a relatively consistent inferred bedrock surface with a depth of ~20 feet. Several areas along the seismic profiles show low-velocity zones that may be indicative of possible weathered or fractured zones.

Mr. Gremminger  
December 11, 2017  
Page 5

The electrical imaging data (Figures 2A and 2B, top panel) show a general depth-to-rock correlation with the seismic data at approximately 10 to 30 feet below grade. The resistivity profiles show a general low-resistivity zone at the surface over a relative high-resistivity zone along the profiles representing the suspected overburden and bedrock respectively. The high-resistivity zones likely represent competent bedrock, while the low-resistivity zones at the surface represent soils (more conductive). Deeper low-resistivity zones within the suspected bedrock most likely represent weathered or fractured zones – which may indicate potential migration pathways.

In conclusion, the electrical resistivity survey identified low-resistivity zones along the two profiles that may indicate the presence of fractures and migration pathways. These zones are shown highlighted with red dashed lines on Figures 2A and 2B. In general, the seismic profiles correlate well with low-velocity zones aligned in the same areas along the profiles. Please note that the geophysical survey alone cannot predict if a suspected fracture zone will or will not be a potential fluid pathway.

### **Limitations**

The geophysical survey described above was completed using standard and/or routinely accepted practices of the geophysical industry and equipment representing the best available technology. Enviroscan does not accept responsibility for survey limitations due to inherent technological limitations or unforeseen site-specific conditions. In particular, Enviroscan cannot make any warranties concerning the future occurrence or development of soil piping activity. However, we make every effort to identify and notify the client of such limitations or conditions.

Mr. Gremminger  
December 11, 2017  
Page 6

We have enjoyed and appreciated the opportunity to have worked with you. If you have any questions, please do not hesitate to contact me.

Sincerely,  
**Enviroscan, Inc.**



Charles H. Rhine, M.Sc., P.G.  
Senior Geophysics Project Manager

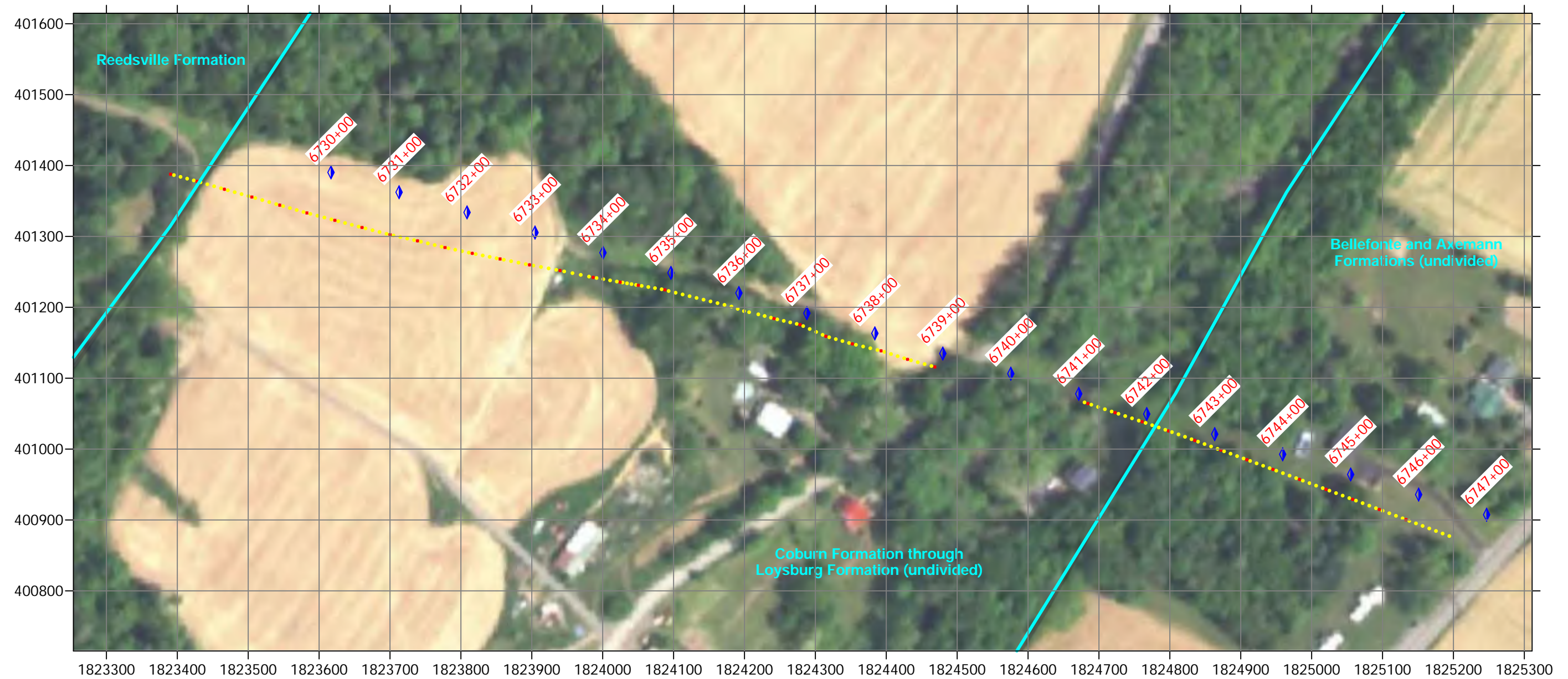
Technical Review By:  
**Enviroscan, Inc.**



Felicia K. Bechtel, M.Sc., P.G.  
President



- enc.: Figure 1: Geophysical Data Coverage and Geologic Map  
Figure 2A: Seismic & Electrical Resistivity West of Piney Creek  
Figure 2B: Seismic & Electrical Resistivity East of Piney Creek  
Appendix A: Introduction to Seismic Refraction  
Appendix B: Introduction to Electrical Imaging  
References



Notes:

Basemap image and geology from USGS WMS Servers (extracted Dec. 2017).

Coordinates in PA South State Plane, NAD38.

Seismic data from Geometrics 24-channel Geode System, 10-foot geophone spacing, 10-foot shot spacing.

Resistivity from AGI SuperSting resistivity meter, 56 electrodes, dipole-dipole array.

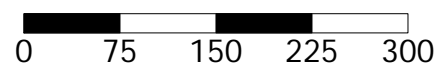
Geologic mapping information from Berg, et al., 1980.

**Geophysical Survey Legend**

- ..... Electrical Resistivity Electrodes
- \* Seismic Shot Locations
- Geologic Formational Contact
- ◆ Client-Provided Pipeline Stationing



Scale (ft)



Prepared by:



**Enviroscan, Inc.**

1051 Columbia Ave.  
Lancaster PA 17603  
717-396-8922  
www.enviroscan.com

Title:

**Geophysical Data Coverage & Geologic Map**

Project Location:

**Proposed Sunoco Pipeline Route  
Williamsburg, PA**

Figure

**1**

Project Number  
121701

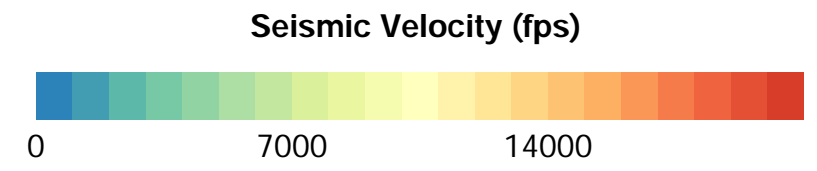
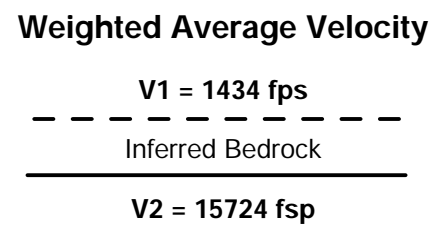
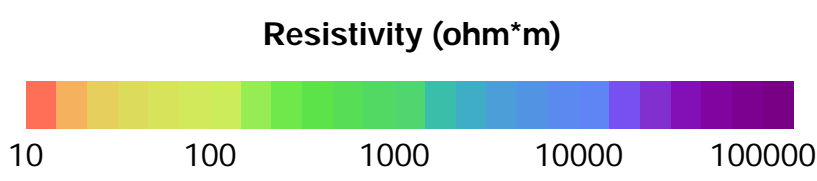
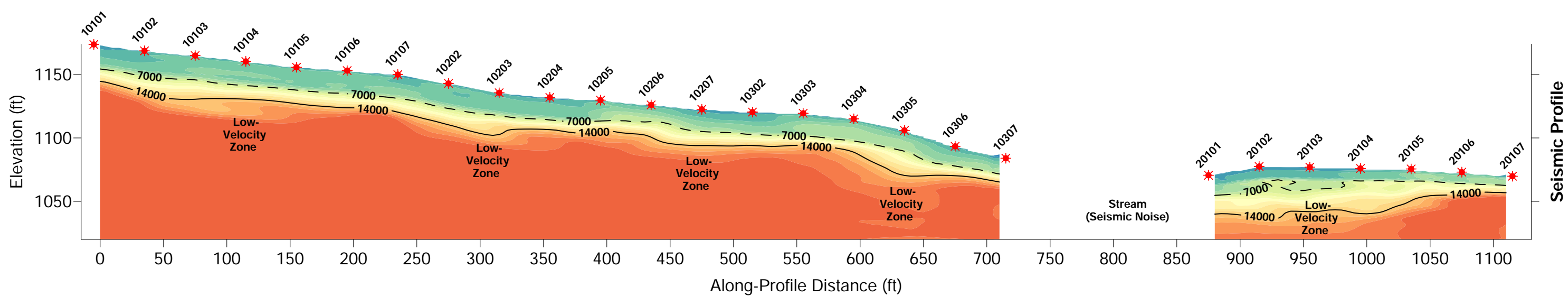
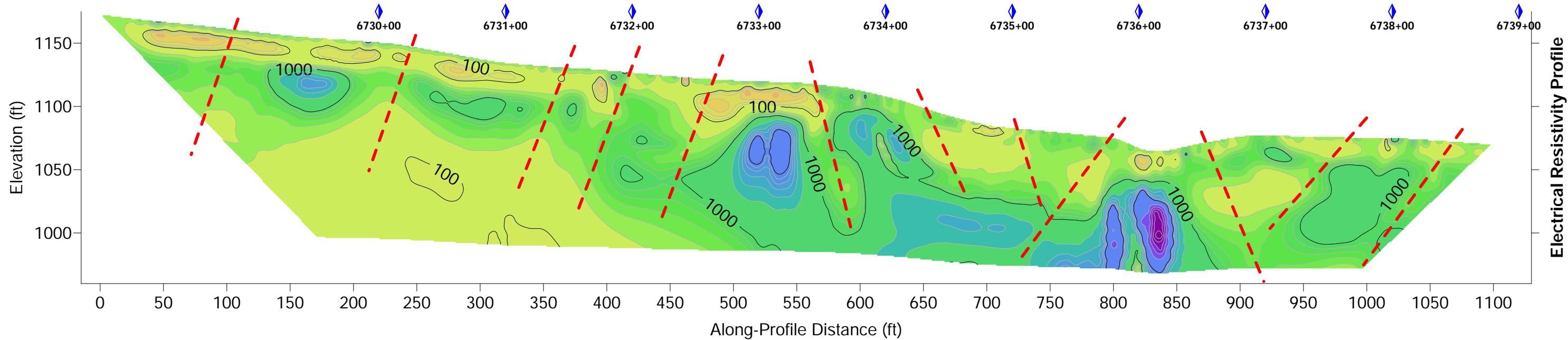
Revision/Issue  
12/15/2017

Original Scale  
1" = 150'

Survey Ending Date  
12/09/2017

Drawn by:  
CHR

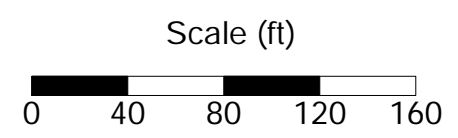
Approved by:  
FKB




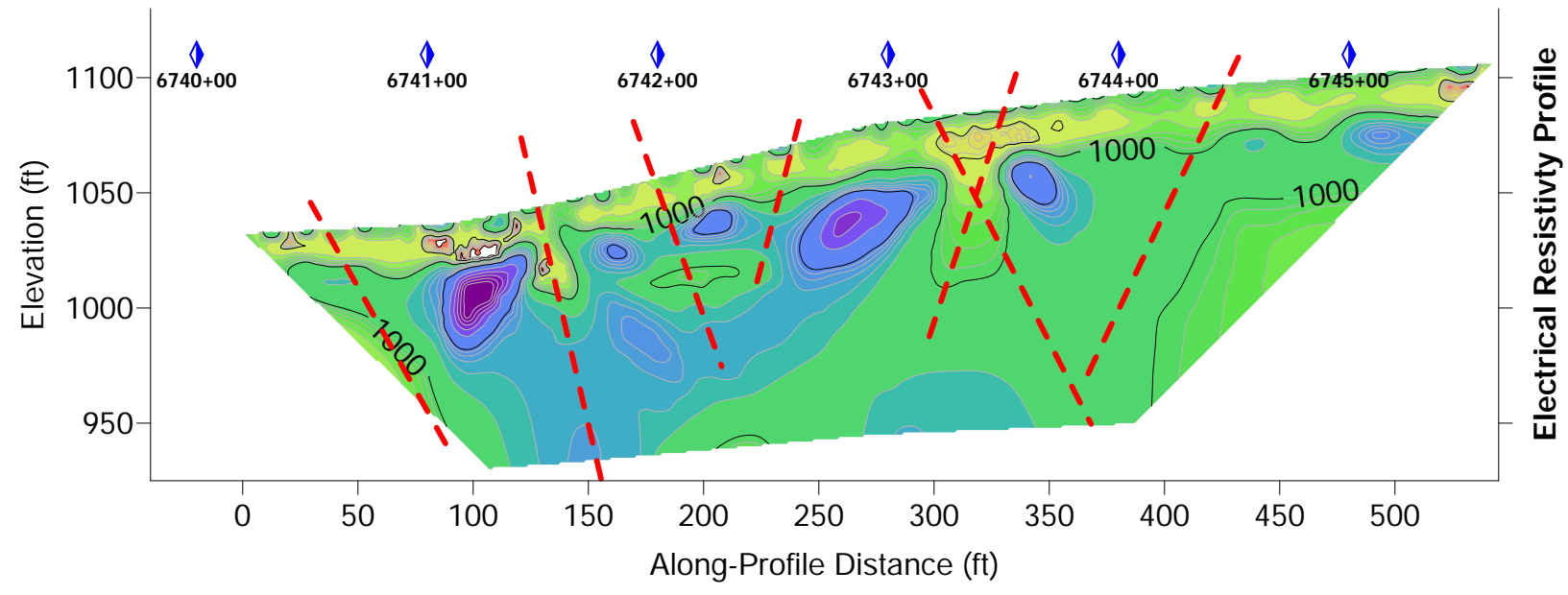
**Geophysical Survey Legend**

- - - Possible Fracture Zone
- \* Seismic Shot Location
- ♦ Survey Stakes (by others)

Notes:  
 Seismic data from Geometrics 24-channel Geode system, 10-foot geophone spacing, 10-foot shot spacing.  
 Resistivity from AGI SuperSting resistivity meter, 56 electrodes, dipole-dipole array.



Prepared by:  <b>Enviroscan, Inc.</b> 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.enviroscan.com	Title:  <b>Seismic &amp; Electrical Resistivity Profiles West of Piney Creek</b>	Project Location: <b>Proposed Sunoco Pipeline Route Williamsburg, PA</b>		Figure  <b>2A</b>
		Project Number 121701	Revision/Issue 12/15/2017	
		Original Scale 1" = 80'	Survey Ending Date 12/09/2017	

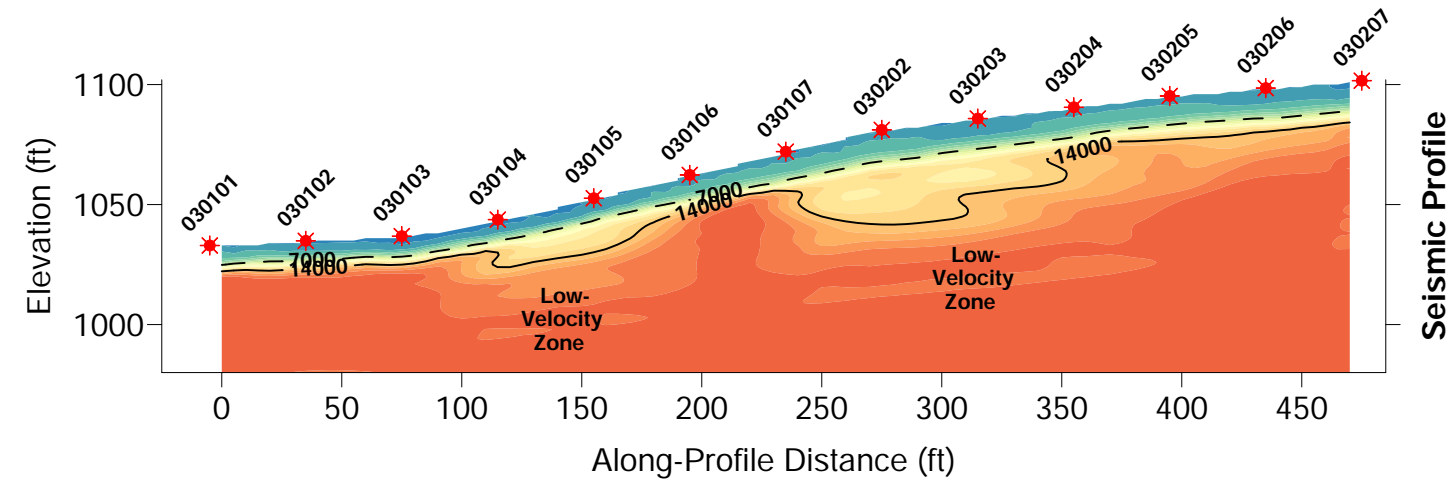


**Geophysical Survey Legend**

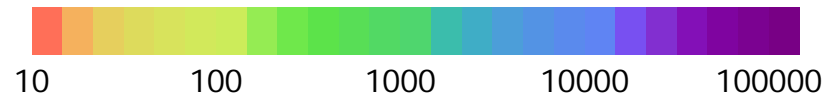
- Possible Fracture Zone
- Seismic Shot Location
- Survey Stakes (by others)

**Weighted Average Velocity**

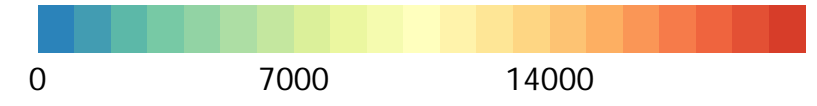
- - - - - **V1 = 1434 fps**  
 Inferred Bedrock  
 \_\_\_\_\_ **V2 = 15724 fsp**



**Resistivity (ohm\*m)**



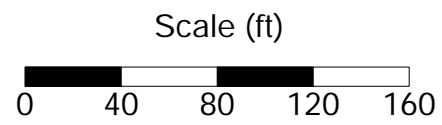
**Seismic Velocity (fps)**



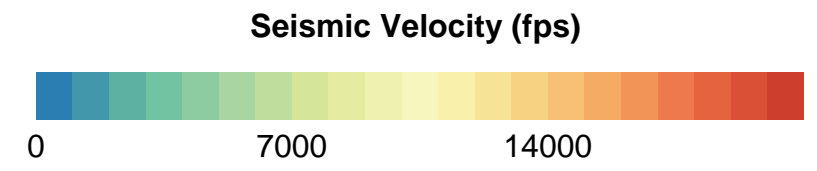
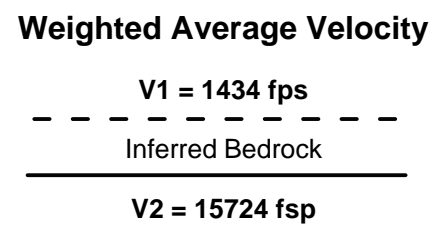
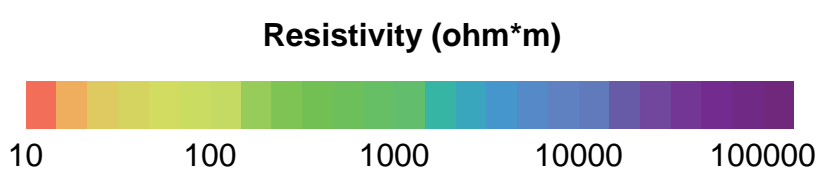
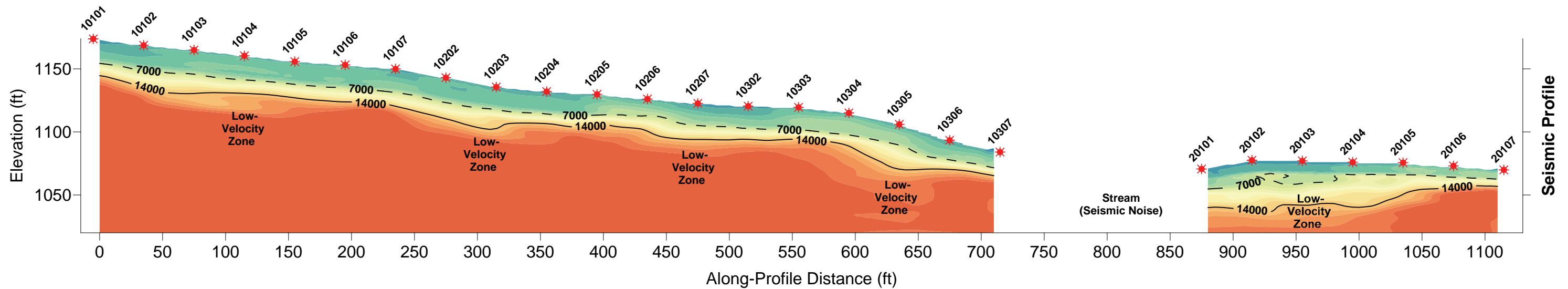
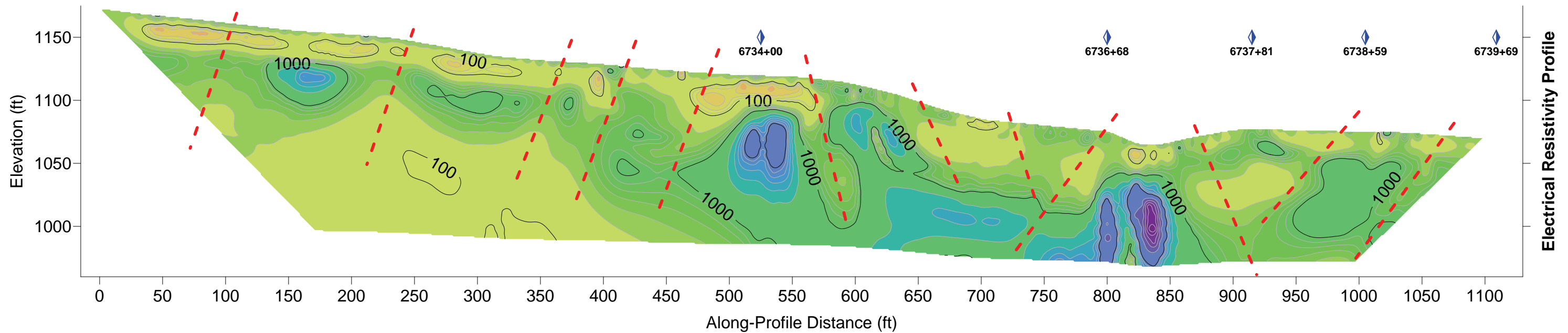
Notes:

Seismic data from Geometrics 24-channel Geode System, 10-foot geophone spacing, 10-foot shot spacing.

Resistivity from AGI SuperSting resistivity meter, 56 electrodes, dipole-dipole array.



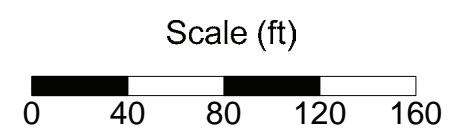
Prepared by:  <b>Enviroscan, Inc.</b> 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.enviroscan.com	Title:  <b>Seismic &amp; Electrical Resistivity Profiles East of Piney Creek</b>	Project Location: <b>Proposed Sunoco Pipeline Route Williamsburg, PA</b>		Figure  <b>2B</b>		
		Project Number 121701	Revision/Issue 12/15/2017		Drawn by: CHR	Approved by: FKB
		Original Scale 1" = 80'	Survey Ending Date 12/09/2017			



**Geophysical Survey Legend**

- - - Possible Fracture Zone
- \* Seismic Shot Location
- ◆ Survey Stakes (by others)

Notes:  
 Seismic data from Geometrics 24-channel Geode system, 10-foot geophone spacing, 10-foot shot spacing.  
 Resistivity from AGI SuperSting resistivity meter, 56 electrodes, dipole-dipole array.



Prepared by:  <b>Enviroscan, Inc.</b> 1051 Columbia Ave. Lancaster PA 17603 717-396-8922 www.enviroscan.com	Title: <b>Seismic &amp; Electrical Resistivity Profiles West of Piney Creek</b>	Project Location: <b>Proposed Sunoco Pipeline Route Williamsburg, PA</b>		Figure <h1 style="font-size: 2em;">2A</h1>
		Project Number 121701	Revision/Issue 12/11/2017	
		Original Scale 1" = 80'	Survey Ending Date 12/09/2017	
		Drawn by: CHR	Approved by: FKB	

**Appendix A**  
**Introduction to Seismic Refraction**





## Introduction to Seismic Refraction

By

Timothy D. Bechtel, Ph.D., P.G.

### Energy

Mechanical elastic (seismic) waves generated by a hammer blow, weight drop, or explosion.

### Sensitivity

Sensitive to elastic properties or moduli – generally strongly correlated with density.

### Basic Equipment

Recording Seismograph (generally 24 or more channels); Geophones (one for each channel); Geophone cable; Hammer or weight plus strike plate or explosives; Trigger switch.

### Common Applications

Determination of the depth and dip of soil horizons and bedrock surfaces. Recent processing advances allow some detection and delineation of discrete targets.

### Principles

In a uniform isotropic earth, the shock wave from a blow or explosion at the surface travels outward and downward in a hemispherical wave front like a three-dimensional ripple from a pebble in a still pond. At any point on the wave front, a straight line from the shock source to the wave front depicts the path of the seismic wave, and is called a ray path (see Figure SR-1). In reality, there are several independent shock waves; the fast-moving primary, compressional or P wave front; the slower moving secondary, shear or S wave (both of which form hemispherical wavefronts); and several disk-like wave fronts that travel only along the surface of the earth (called surface waves or ground roll). For the purposes of most seismic refraction surveys, only the fastest moving wave front — the P wave — is considered. S-wave refraction is used in selected circumstances where complete determination of elastic moduli is desired – particularly when it may be desirable to eliminate the effects of water saturation.



Introduction to Seismic Refraction

Page 2

In a layered earth, the hemispherical P shock wave defined by the radially distributed P ray paths are deflected according to the laws of optics (Snell's Law) at interfaces between materials with differing seismic velocities (i.e. densities or elastic properties). Figure SR-2 depicts the deflection of ray paths due to an increase in P velocity at a bedding plane. The type of deflection that a ray path will undergo is dependent upon the angle at which it strikes the interface, and falls into one of four categories:

- 1) Some direct rays (green in Figures SR-2 and SR-3) travel parallel to the ground surface at the seismic velocity of the upper layer, do not strike the underlying interface, and consequently are not deflected.
- 2) Reflected rays (purple in Figures SR-2 and SR-3) arise where direct rays strike the interface, and a portion of the energy is reflected symmetrically back towards the surface.
- 3) The portion of the energy of the incident direct wave that is not reflected upward is refracted, or bent as it crosses the interface – making refracted waves in the lower layer (red in Figures SR-2 and SR-3).
- 4) At a precise angle called the critical angle, the incident ray is refracted directly along the interface, and travels at the higher seismic velocity of the lower layer (see Critically Refracted Wave in Figure SR-3). As this critically refracted or head wave races along beneath the interface, it generates a secondary elastic disturbance that travels back to the surface along ray paths that define a wave front analogous to the bow wake of a ship. These returning rays again travel at the slower velocity of the upper layer.

To perform a refraction survey, a linear array of ground motion sensors or geophones is spaced out from the seismic source or shot point, forming a geophone spread. Each geophone is connected to a separate channel in a seismograph which records a wiggle trace representing the ground motion resulting from the passage of the various seismic rays.

As depicted in the time-distance (T-X) curve in Figure SR-4, the layered earth structure can be determined by analyzing the seismographic wiggle traces. At distances close to the seismic source, the first wiggle or ground motion (the first arrival after the shot) is due to passage of the direct wave travelling at the velocity of the upper layer. Reflected waves arrive later since they have by definition traveled a greater distance at the same velocity (additional later wiggles are caused by passage of the more slowly travelling S and surface waves). Beyond a distance dictated by the critical angle, the first arrival of seismic energy represents the head wave of the critically refracted ray. These refracted rays also by definition travel a greater distance than the direct wave. However, along part of their path, they have traveled at the higher velocity of the underlying more consolidated layer. At greater

distances from the shot point, where the path length in the higher velocity layer becomes significant, the head wave arrivals actually race past the direct wave and become the first arrival (see labeled crossover in Figure SR-4). By extension, it can be shown that if a third layer with even greater velocity lies at greater depth, the head wave from this layer will become the first arrival at a sufficient distance from the shot point.

In conventional seismic refraction, only the first P wave arrivals can be reliably selected on a wiggle trace record. The later reflected P wave arrivals are generally obscured by the slower-travelling S and surface waves, and the very slow air blast or sound wave from the shot. To interpret a seismic refraction record, the first arrival travel times are measured for each wiggle trace and plotted at the appropriate point on a time-distance (T-X) curve (see Figure SR-4). In a plane-layered earth, these first arrivals define a series of line segments, each representing a discrete layer. The seismic velocity of each layer is simply the reciprocal of the slope of the associated line segment. The thickness of each layer can be calculated from the distances where the line segments intersect. The mathematics for these calculations are easily derived, and can be found in any introductory geophysics text.

True geologic strata are rarely perfectly horizontal. The effect of a dipping interface on a travel time curve cannot be recognized using a single shot point. Calculations based on a T-X curve from a single shot point should always be considered as producing apparent depths to interfaces and apparent seismic velocities for all but the uppermost layer. To determine the true depths and dips of interfaces and the true seismic velocities, it is necessary to reverse the seismic line; that is, move the shot point to a location at or beyond the farthest geophone in the spread, and repeat the shot. The calculation of true depths, dips and velocities from reversed seismic lines is also readily performed.

### **Capabilities**

Conventional seismic refraction can yield accurate measurements of depths and attitudes of soil horizons, groundwater tables, and other relatively distinct and planar strata. Modern computer analysis of multi-fold seismic refraction data (i.e. with many and overlapping shot points) can provide delineation of undulating or even irregular (as opposed to simply planar) interfaces. The latest generation of computer processing techniques require very high-fold data, but in favorable conditions, are capable of resolving even discrete targets such as foundation elements, tunnels or cavities, and can resolve gradational boundaries as well as distinct interfaces. The seismic P-wave velocities of materials are generally an indication of relative density or compaction. S-wave refraction data (collected using specialized geophones, shock sources and field procedures) can provide S-

wave velocities that bear a well-constrained empirical relationship to standard penetration test (SPT) N values and therefore bearing capacity. For surveys where matching P- and S-wave velocities are determined, the dynamic elastic moduli of subsurface materials can be calculated (including Poisson's Ratio, Young's or Bulk Modulus, and Shear Modulus or Rigidity).

### **Limitations**

Seismic data is collected at spaced geophones, and therefore does not provide continuous profile data. If geophones are spaced too widely, thin layers can be missed entirely.

Conventional refraction interpretations are only accurate where the velocity of strata increase with depth. Velocity inversions not only alter the data, but are particularly insidious since the presence of a low velocity zone at depth is not apparent in first arrival data. The latest generation of computer processing techniques do allow detection and delineation of laterally restricted low velocity zones (e.g. tunnels, cavities, gravel lenses, etc.).

Sharp or dramatic interface relief such as limestone pinnacles cannot always be resolved even with very tight geophone spacing. Therefore, refraction profiles of expectedly irregular interfaces should be assumed to represent somewhat smoothed versions of actual relief (see e.g. Figure SR-5).

Seismic records can contain noise due to heavy machinery vibrations, vehicular traffic, and sometimes even wind or distant earthquakes. Care must be taken to identify potential sources of seismic noise prior to beginning a survey.

The effective survey depth is limited to approximately 1/5 of the greatest shotpoint to geophone distance. Therefore, very deep surveys may require impractically long lines (requiring consideration of other geophysical techniques such as seismic reflection).

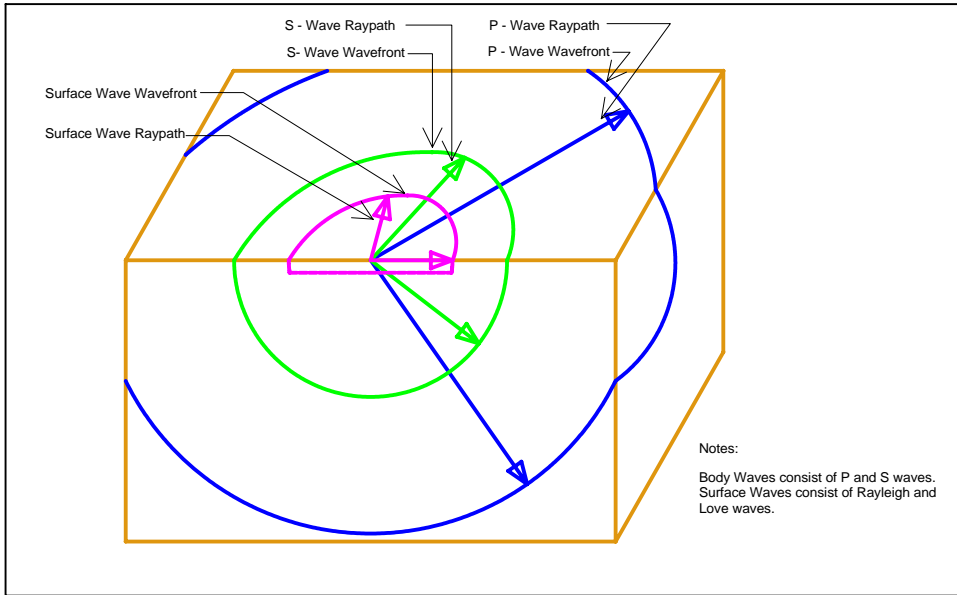


Figure SR-1

Seismic Wave Types

Rev. 01/2001

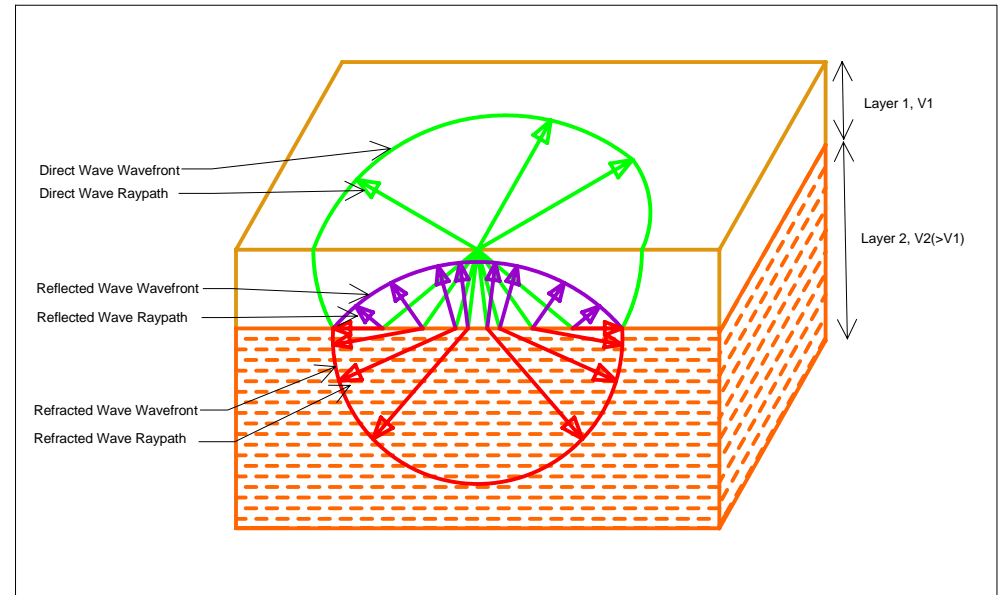


Figure SR-2

Effect of Layering on Body Wave Raypath

Rev. 01/2001

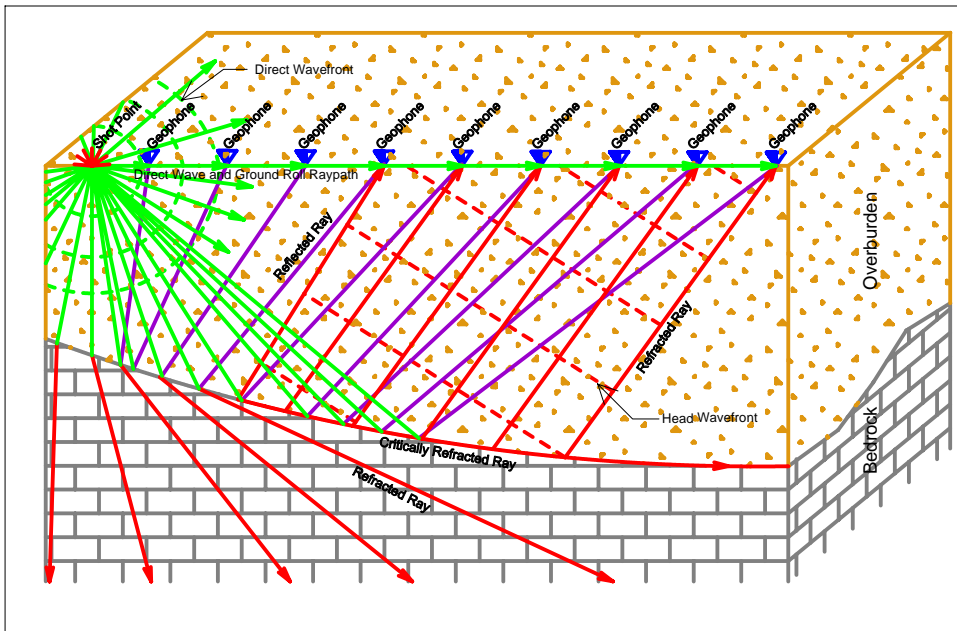


Figure SR-3

Seismic Ray Path Geometry

Rev. 01/2001

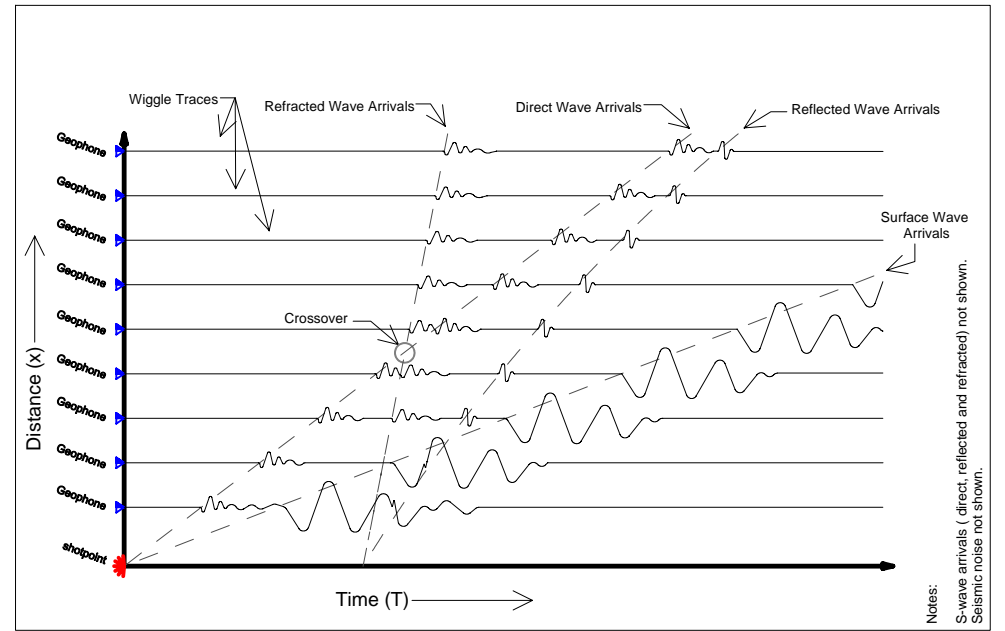
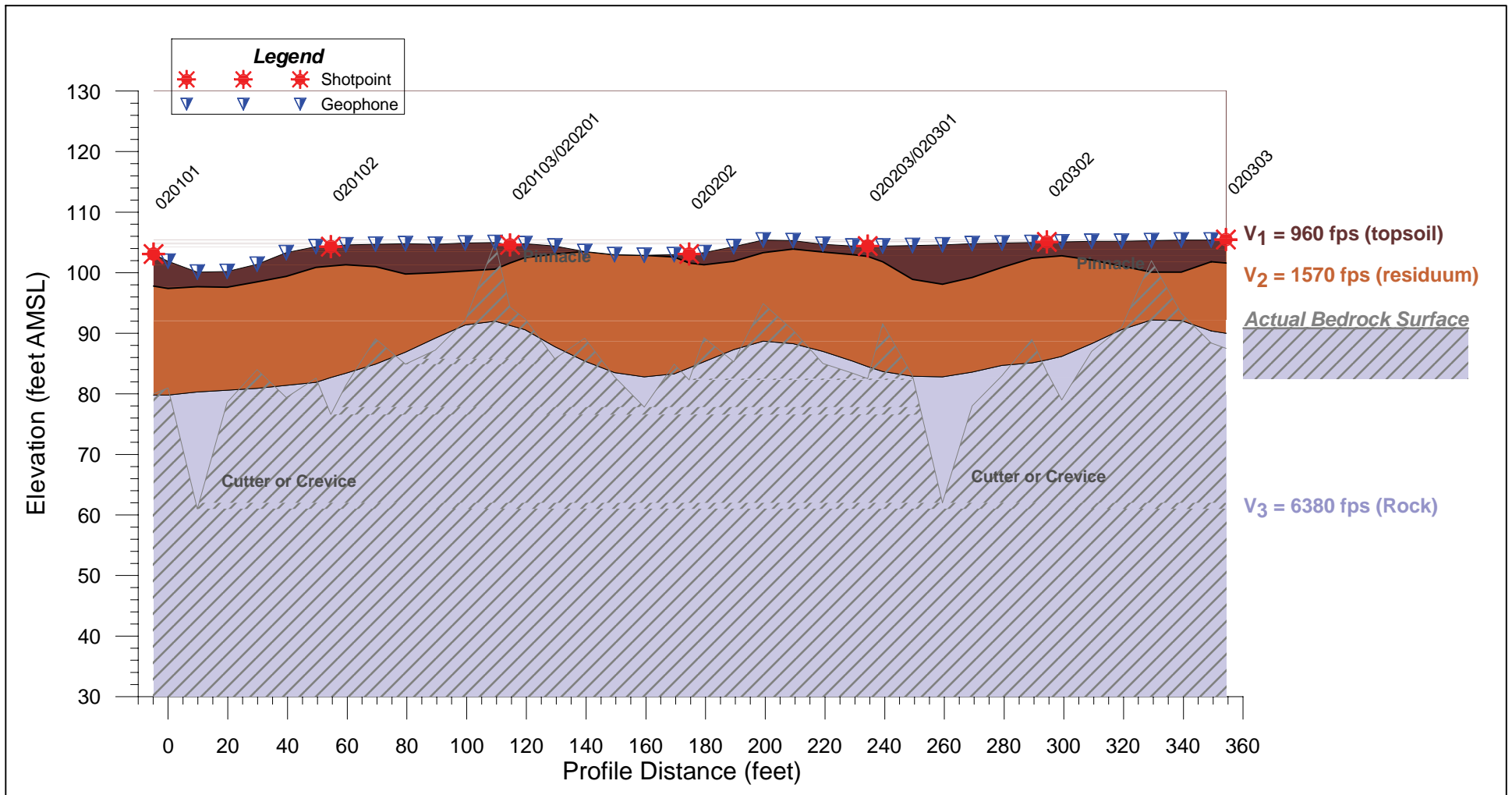


Figure SR-4

Idealized Seismic Record and T- X Graph

Rev. 01/2001





**Figure SR-5**

**Example Karst Terrane Seismic Profile**

Revised 01/2001



## **Appendix B**

### **Introduction to Electrical Imaging**





## Introduction to Electrical Imaging

by

**Timothy D. Bechtel, Ph.D., P.G.**

### **Energy**

Electrical currents injected into the subsurface between electrodes pushed into the ground surface or non-intrusive, protected capacitors.

### **Sensitivity**

Detects changes in electrical resistivity (the inverse of conductivity).

### **Basic Equipment**

*Either (traditional “steel spike electrode” method):*

Steel spike electrodes (called current electrodes) connected by wires to a current source (to inject current), and steel spike electrodes (called voltage electrodes) connected to a microvolt meter (to measure the surficial distribution of electrical potentials). Note that current and voltage electrodes differ only by that to which they are connected (i.e. current source or microvolt meter, respectively.) Modern systems use arrays of electrodes (connected to multi-channel cables and an automated electrode-switching/recording system) to take measurements from electrodes at different locations and spacings (which adjusts the survey depth and resolution). Electrodes are hand-pushed into the ground surface along desired survey profiles.

*Or (innovative “capacitively-coupled electrode” method):*

Straight-wire capacitors which are capable of driving subsurface electrical currents and measuring surface potentials. The wire lengths and the distance between wires can be varied to adjust the survey depth and resolution. Capacitors are encased in torpedo-like protectors between the wire lengths, and the entire array (similar to a swimming rope with flotation buoys) is hand- or vehicle-towed along desired survey profiles.



## **Common Applications**

Electrical imaging produces color-contour cross sections (commonly called electrical images) of subsurface electrical resistivity variations. These images can depict a target that has a different electrical resistivity from its surroundings, such as: buried wastes (pits, trenches, etc.); conductive groundwater plumes; resistive hydrocarbon plumes; foundation elements; water-bearing or mineralized faults or fractures; clay seams in bedrock; soil moisture anomalies; soil voids; clay layers bounded by sand or sand lenses bounded by clay; the top of competent (non-water-bearing) rock.

## **Principles**

Electrical imaging can be performed by driving a harmless, very low amperage (e.g. 1 milliamp) DC electrical current in the ground between two steel spike electrodes. The depth to which the current flows is dictated by the separation of the two electrodes, and by the resistivity of subsurface materials. The flow of electrical current is mapped by measuring the electrical potential at various points of the ground surface using a very high impedance microvolt meter. Data suitable for determining a cross-sectional electrical image can be collected by taking many voltage readings with differing current electrode separations (i.e. different effective measurement depths) using different current electrode positions and voltage electrode positions (i.e. different locations along a profile). A two-dimensional image or cross-section is produced by employing electrodes in a linear array. Three-dimensional images (or color-contoured blocks of data) can be calculated using multiple linear arrays or grids of electrodes. The field-measured voltages, together with associated electrode positions, are mathematically inverted to provide the statistically best-fitting model of the subsurface resistivity distribution.

Electrical imaging can also be performed using straight-wire capacitors to drive currents and measure voltages. In this case, the length of the transmitter wire and the separation between the transmitter and receiver wires dictate the effective survey depth. Two- or three-dimensional data is collected by varying the lengths and separations of the transmitter and receiver capacitor wires for a given survey profile (i.e. the same profile is traversed several times using different wire lengths and separations).

## **Capabilities**

Electrical imaging can detect and delineate a target that has a different electrical resistivity from its surroundings. Particularly good targets for electrical imaging include: electrically conductive clay seams, and water-bearing or mineralized faults or fractures in resistive bedrock; electrically resistive hydrocarbon plumes in moist electrically conductive soils; highly conductive electrolytic groundwater plumes (e.g. leachate or saltwater intrusion); highly conductive or resistive wastes buried in “normal” soils; soil moisture anomalies (e.g. dam seepage or incipient sinkholes).

Where site conditions allow, capacitively-coupled electrode systems can collect greater quantities of data in a given time (or at a given cost) than the traditional steel spike systems. The capacitive systems can also be used on asphalt pavement (where steel spike systems would require drilling many electrode holes).

## **Limitations**

Electrical resistivities of differing materials have wide and overlapping ranges, making it impossible to positively identify a subsurface material based on its resistivity alone. For instance, profiling of the top-of-rock can be done by electrical imaging, but it is often difficult to specify exactly what resistivity contour corresponds with the top of rock (particularly where there is a weathering or saprolite zone). Since electrical resistivity (unlike seismic velocity) does not correlate with rippability or density, it is not typically the method of choice for rock profiling.

Based largely on a single well-publicized incident, electrical imaging has been promoted (by others) as a method for detecting bedrock cavities. However, since an air-filled cavity and competent rock are both electrical resistors, many cavities are not detectable using electrical methods (in this case, gravity would be the method of choice since air and competent rock have very different densities).

Electrical imaging data is susceptible to interference from underground utilities that capture and channel the subsurface current flow. This can be minimized in two-dimensional surveys by orienting the trace of an image perpendicular to any existing utilities.

Capacitively-coupled electrode systems suffer loss of signal penetration depth in highly conductive terranes. In addition, they are difficult to use in rugged or brushy terrain.

Survey depths using steel spike electrode systems can be limited by high contact resistances between the spikes and highly resistive surficial material.

## References

Berg, T. M., Edmunds, W. E., Geyer, A. R., and others, compilers, 1980, Geologic map of Pennsylvania: Pennsylvania Geological Survey, 4th ser., Map 1, 2nd ed., 3 sheets, scale 1:250,000.

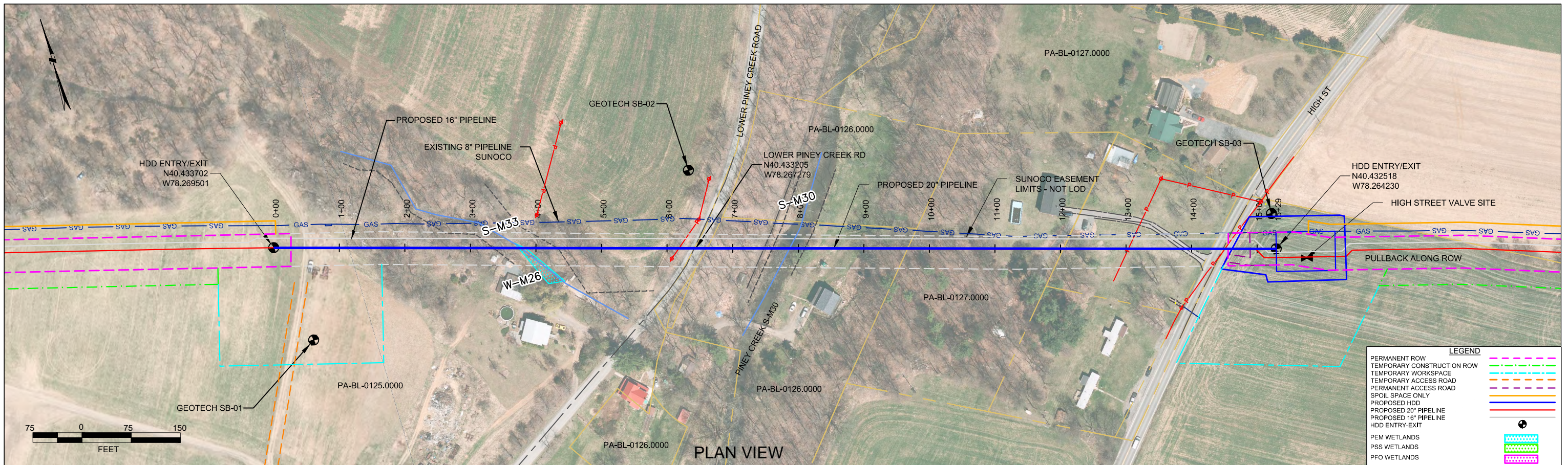
Carmichael, R. S. (1989), Physical Properties of Rocks and Minerals, CRC Press.



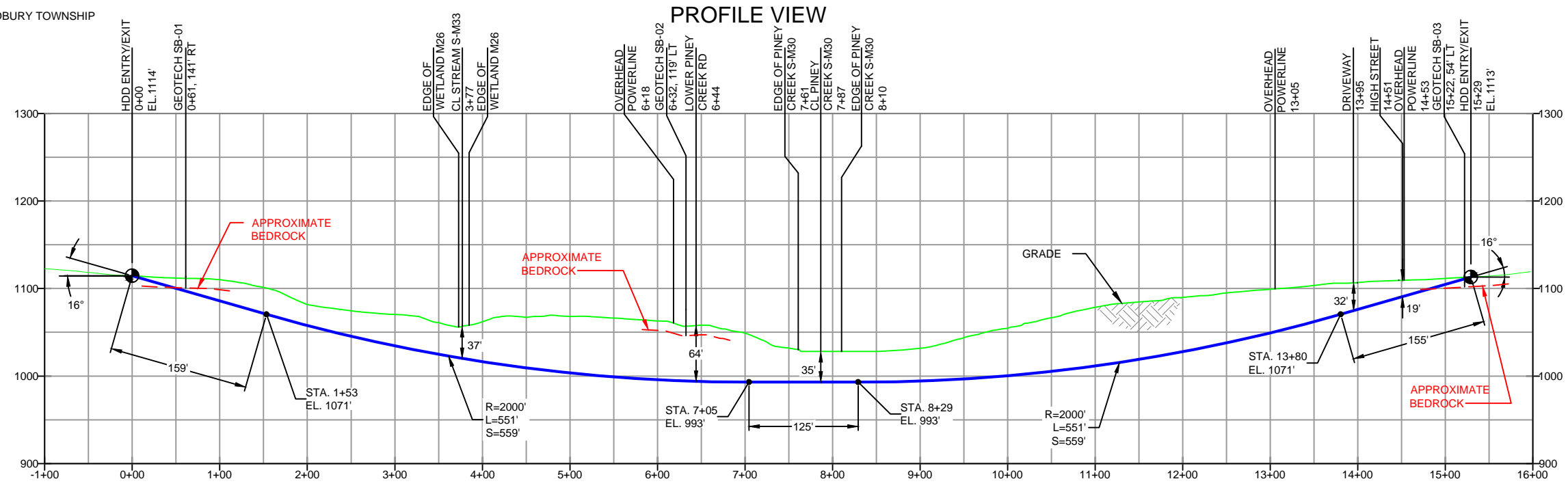
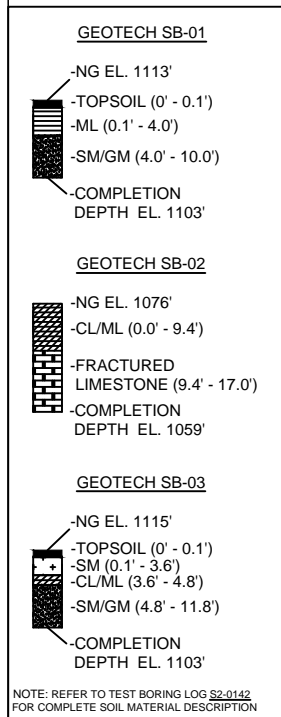
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PADEP SECTION 105 PERMIT NO.: E07-459  
PA-BL-0126.0000-RD AND PA-BL-0126.0000-RD-16  
(SPLP HDD No. S2-0142)**

**ATTACHMENT 2**

**ORIGINAL AND REVISED HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES**



BLAIR COUNTY, PENNSYLVANIA - WOODBURY TOWNSHIP  
S2-0142



DESIGN AND CONSTRUCTION:

- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
- THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
- DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
- CROSSING PIPE SPECIFICATION:  
HDD HORZ. LENGTH (L=): 1529'  
HDD PIPE LENGTH (S=): 1556'  
20" x 0.456" W.T., X-65, API5L, PSL2, ERW, 8FW  
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
- INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
- INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
- PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
- CARRIER PIPE NOT ENCASED.
- PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
- CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
- SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
- SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
- SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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REVISIONS

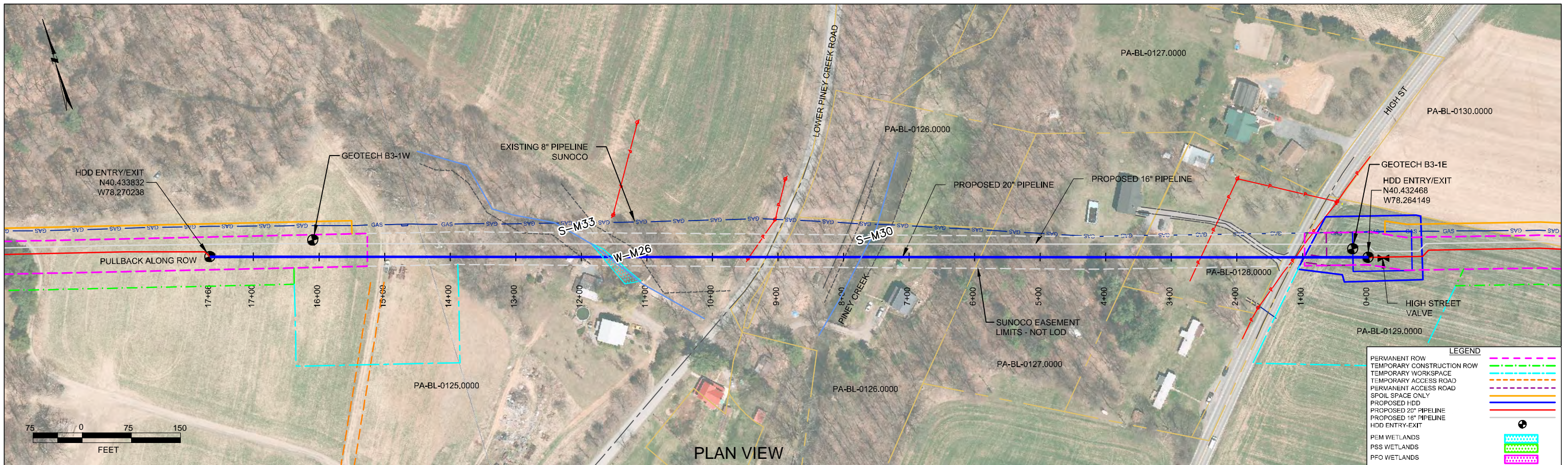
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SUNOCO PIPELINE, L.P.

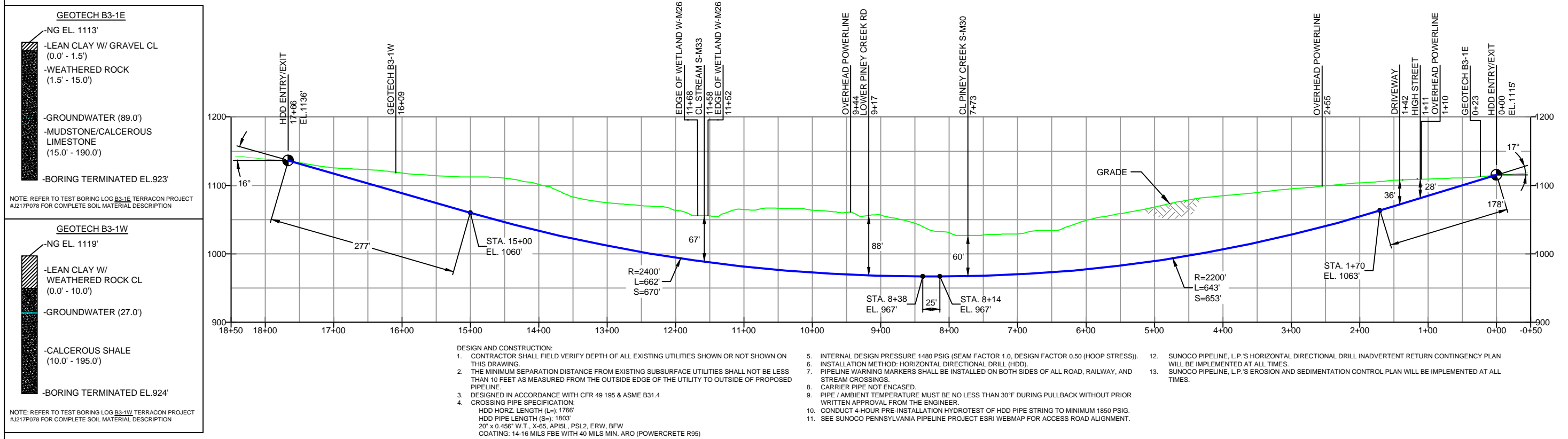
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PINEY CREEK  
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' DWG. NO: PA-BL-0126.000-RD



BLAIR COUNTY, PENNSYLVANIA - WOODBURY TOWNSHIP  
S2-0142

PROFILE VIEW



**GEOTECH B3-1E**  
 -NG EL. 1113'  
 -LEAN CLAY W/ GRAVEL CL (0.0' - 1.5')  
 -WEATHERED ROCK (1.5' - 15.0')  
 -GROUNDWATER (89.0')  
 -MUDSTONE/CALCEROUS LIMESTONE (15.0' - 190.0')  
 -BORING TERMINATED EL.923'

NOTE: REFER TO TEST BORING LOG B3-1E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

**GEOTECH B3-1W**  
 -NG EL. 1119'  
 -LEAN CLAY W/ WEATHERED ROCK CL (0.0' - 10.0')  
 -GROUNDWATER (27.0')  
 -CALCEROUS SHALE (10.0' - 195.0')  
 -BORING TERMINATED EL.924'

NOTE: REFER TO TEST BORING LOG B3-1W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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  - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
  - CROSSING PIPE SPECIFICATION:  
 HDD HORZ. LENGTH (L=): 1766'  
 HDD PIPE LENGTH (S=): 1803'  
 20" x 0.456" W.T., X-65, API5L PSL2, ERW, BFW  
 COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
  - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
  - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
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  - SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

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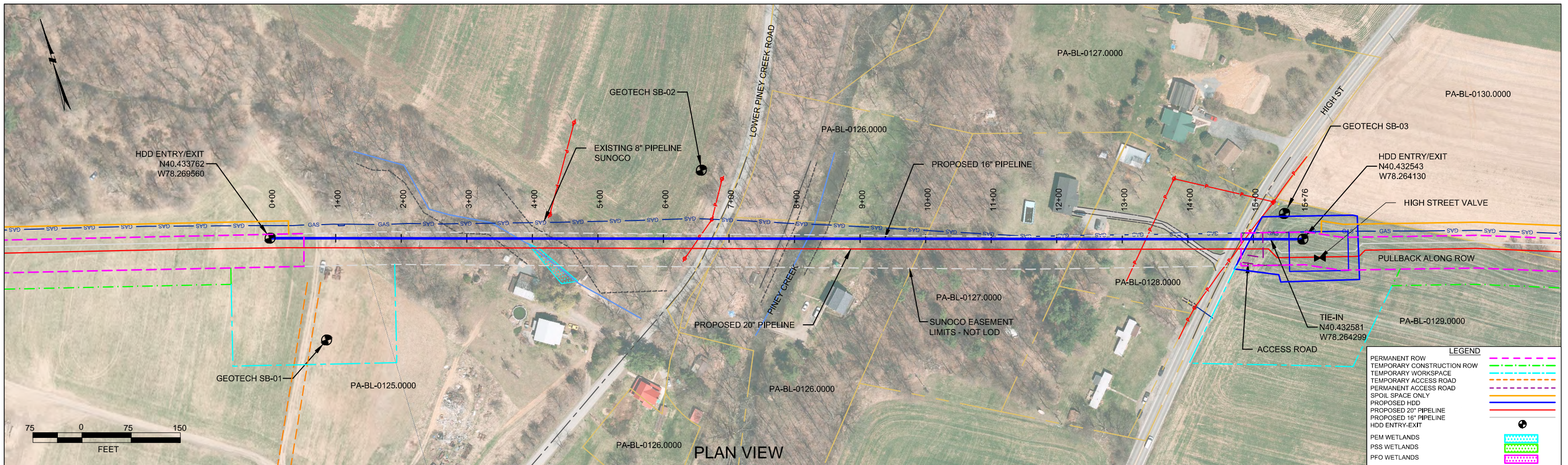
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Partners L.P.**

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

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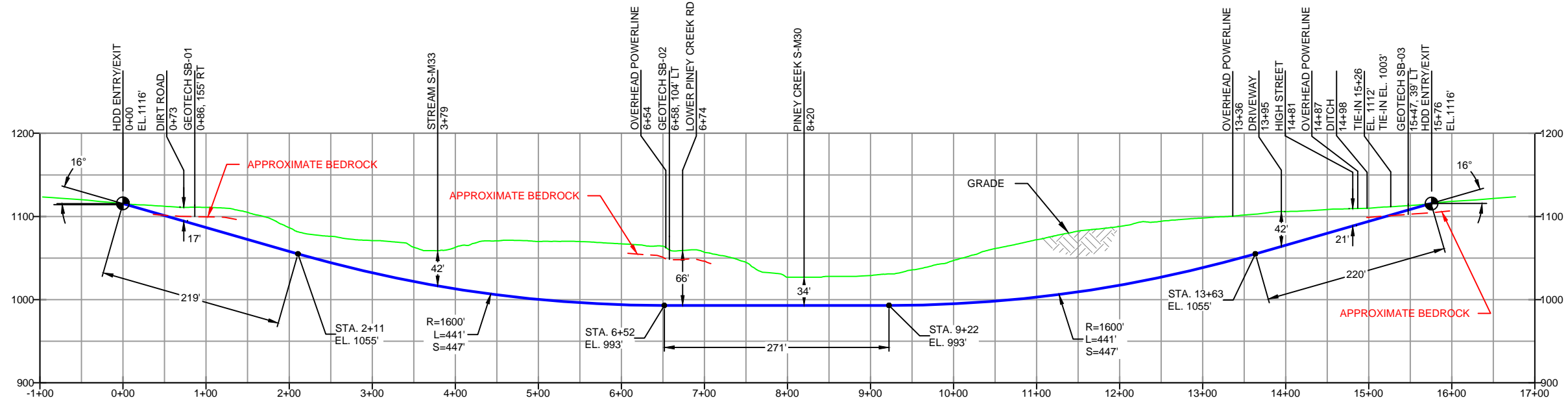
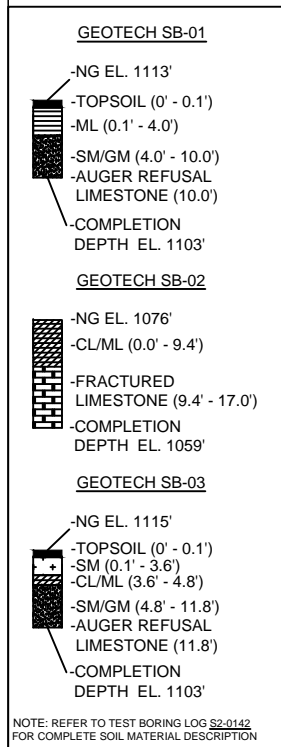
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PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'      DWG. NUMBER: PA-BL-0126.0000-RD



BLAIR COUNTY, PENNSYLVANIA - WOODBURY TOWNSHIP  
S2-0142-16

PROFILE VIEW



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  - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
  - CROSSING PIPE SPECIFICATION:  
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HDD PIPE LENGTH (S<sub>H</sub>): 1604'  
16" x 0.438" W.T., X-70, API5L PSL2, ERW, BFW  
COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
  - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
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REVISIONS

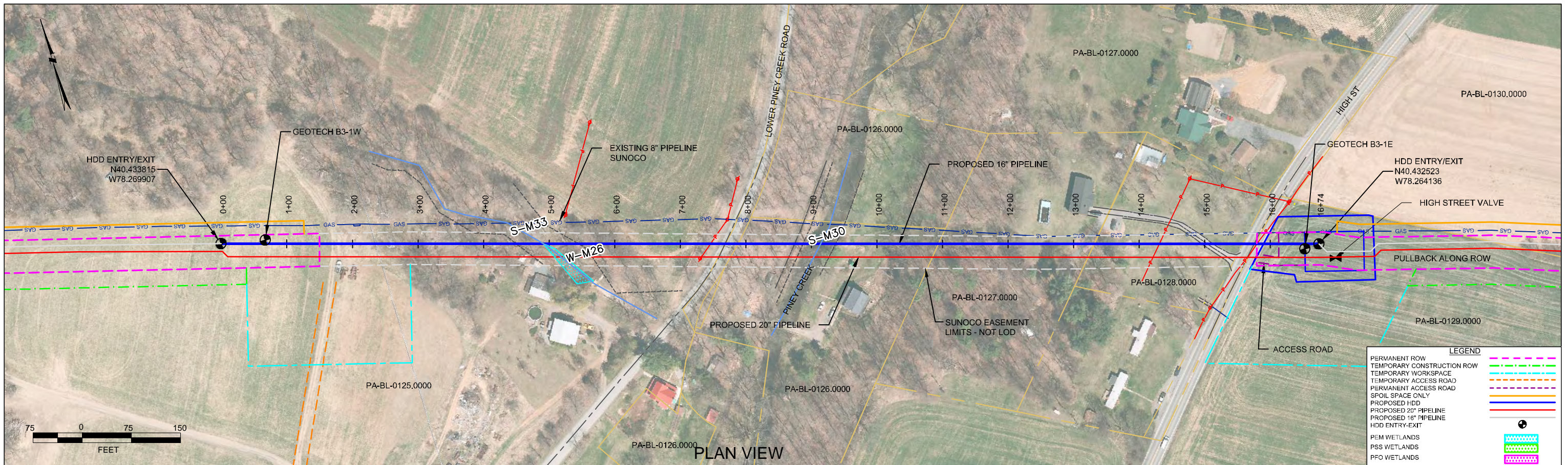
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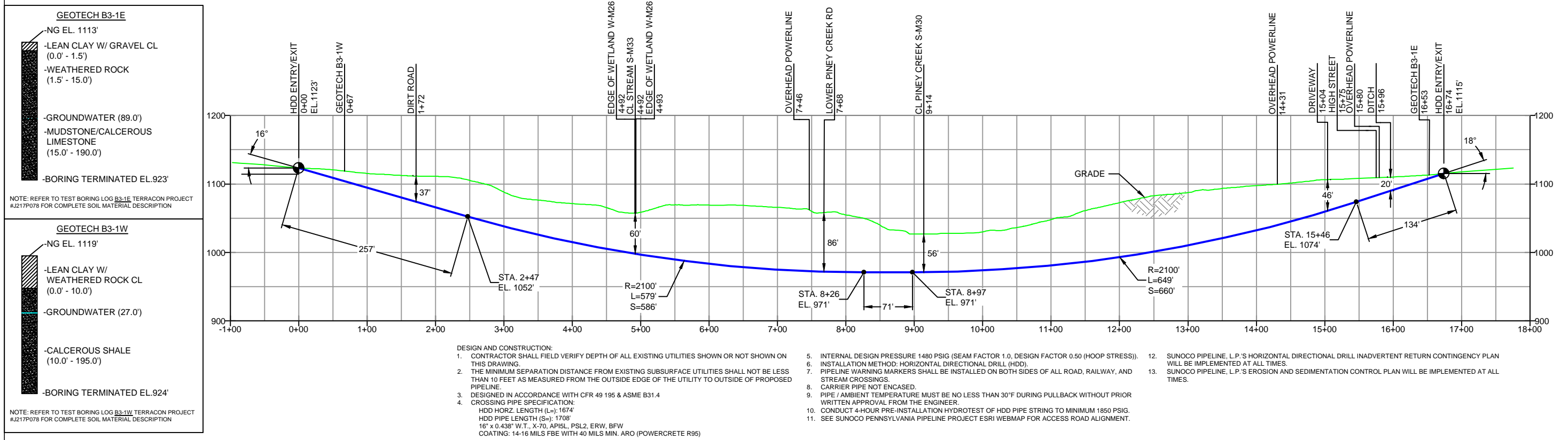
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LOWER PINEY CREEK RD  
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' DWG. NO. PA-BL-0125.0000-RD-16



BLAIR COUNTY, PENNSYLVANIA - WOODBURY TOWNSHIP  
S2-0142-16

PROFILE VIEW



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

REF. DRAWING		EROSION & SEDIMENT PLAN	
ES-3.57	TO	ES-3.58	EROSION & SEDIMENT PLAN
SHEET 41	TO	SHEET 41	AERIAL SITE PLAN
DWG NO	DWG NO	DESCRIPTION	NO.

REVISIONS		DATE	CHK	DATE	APP	DATE	
EP3	MOVED DRILL ENTRY/EXIT LOCATION - DESIGN PER MICHELS	MRS	09/22/17	RMB	09/22/17	CAG	09/22/17
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	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
B	ADDED GEOTECH INFO	MRS	09/04/15	RMB	09/04/15	AAW	09/04/15
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15
	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE

**Sunoco Logistics Partners L.P.**

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

**SUNOCO PIPELINE, L.P.**

HORIZONTAL DIRECTIONAL DRILL  
LOWER PINEY CREEK RD  
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'  
DWG. NO. PA-BL-0126.0000-RD-16