HORIZONTAL DIRECTIONAL DRILL ANALYSIS
PHOENIXVILLE PIKE ROAD
PADEP SECTION 105 PERMIT NO.: E15-862
PA-CH-0290.0000-RD
(SPLP HDD No. S3-0421)

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This reevaluation of the horizontal directional drill (HDD) installation of a 20-inch diameter pipeline under Phoenixville Pike Road has been completed in accordance with Condition No. 3 of the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L (Order). Condition No. 3 stipulates for HDDs initiated after the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board (July 25, 2017), a reevaluation must be performed on HDDs for which an inadvertent return (IR) occurs during the installation of one pipe (20-inch or 16-inch diameter) where a second pipe will thereafter be installed in the same right-of-way (ROW).

The installation of the 16-inch diameter pipeline at HDD S3-0421 was initiated after the temporary injunction issued by the PADEP Environmental Hearing Board on July 25, 2017. The 16-inch pipeline HDD had two (2) inadvertent returns (IRs), and therefore, installation of the second pipeline (20-inch diameter) requires reevaluation. The IRs for the 16-inch pipeline were easily remediated, and the HDD was completed when the pipe was pulled on 8/24/19.

The 20-inch pipeline HDD is referred to herein as HDD S3-0421.

PIPE INFORMATION

20-Inch: 0.456 wall thickness; X-65

Pipe stress allowances are an integral part of the design calculations performed for each HDD. For steel pipe the “pipe stress allowance” is the amount of curvature that a piece or length of pipeline can bend without resulting in damages such as a “kink” or “crimp” in the wall of the pipe. The innate curvature ability of pipe is termed the “free stress radius”. The stress allowance of the pipe is determined by the ductility of the steel, wall thickness, and the diameter of the pipe. An HDD design is limited by the horizontal distance between the points of entry and exit and the free stress radius of the pipe.

Ductility of the steel used for pipelines is determined by the percentage of carbon within the steel. Generally, steel pipe is categorized as either “low carbon” having less than 0.3% carbon content within the steel, or “high carbon” having greater than 3% carbon within the steel. As the carbon content within the steel used to make the pipe increases, the flexibility (ductility) of the pipe is decreased. The X65 20-inch pipe utilized on the Mariner project is a low carbon (high ductility) steel pipe.

The design of an HDD profile accounts for the free stress radius of the pipeline segment to be pulled into the drilled entry, through the entry radius of curvature at maximum horizontal depth, out the exit radius leaving maximum depth, and out the drilled exit; therefore, each HDD has a minimum of four (4) points of pipeline curvature to assess for pipeline stress. Additionally, a horizontally drilled profile is not a “perfect” pathway, especially when drilled through rock formations. The pilot tool cutting into the rock face has a larger cutting face than the drill stem pushing the tool forward, which results in flexibility of the tooling within the pilot hole, and as a result the pilot tool will drift in orientation as proceeding forward because the cutting tool will proceed easier into softer material while cutting due to natural variances in hardness of the materials being cut, whether they are soils or rock. Steering of the pilot tool is used to correct drifting as it occurs. As a result of this natural drifting during completion of the pilot hole, the entire length of the drilled pilot hole is assessed for stress allowances at three (3) joint intervals before reaming of the annulus is permitted. If errors during pilot drilling or reaming occur and a mid-point is identified that would breach the pipe stress allowance, then the use of an over-reamed annulus is assessed for breach of the stress allowance. In cases where an over-reamed annulus will not correct the stress problem, the HDD has to be re-drilled.

Specifics for the original permitted 20-inch HDD plan and profile are discussed in the original permitted HDD design summary below. Specifics for the revised 20-Inch HDD plan and profile are discussed in the Redesigned Horizontal Directional Drill Design Summary at the end of this report.

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ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 20-INCH

- Horizontal length: 4,330 foot (ft)
- Entry/Exit angle: 12-13 degrees
- Maximum Depth of cover: 117 ft
- Depth below stream crossing: 44 ft
- Pipe design radius: 2,000 ft

The original profile design factors are below the pipeline stress allowances for all points of analysis.

INADVERTENT RETURN DISCUSSION

During the pilot drilling phase for the 16-inch pipeline, by May 24, 2019, the pilot drill achieved a distance of 4,066 of the planned 4,330 total horizontal distance when it experienced a loss of circulation (LOC) but no IR occurred. This placed the pilot tool face 63 percent along the ascent to exit on the profile at a depth of approximately 75 feet. In response to the LOC, on June 1, the driller began drilling an intercept bore from the northwest entry/exit towards the existing pilot bore. By June 5th, the intercept bore had been advanced a horizontal distance of 224 feet and was thought to have entered the opposing the pilot bore. As such, that same day, the southeast drilling unit completed tripping in tools and advanced the pilot bore another 61 feet northwest towards the northwest entry/exit to approximately Station 2+13 when an LOC occurred and on June 6th an upland IR occurred in three discharge locations totaling 75 gallons. Two of the locations were south of the alignment, due south of Stations 1+28 and 1+68, and the third was due north of the alignment at Station 1+01. According to the initial IR report, the IRs occurred as "the drilling contractor was advancing the tool and drill string back through the intersected pilot hole towards the northwest exit point to complete the pilot hole tool run". These IRs were easily managed and were immediately cleaned up. They occurred as the pilot tool was ascending to exit and overburden was thinning. At the locations of the IRs, overburden ranged from 27 to 44 feet thick and was likely comprised of relatively weak, highly weathered, schistose saprolite. At the end of the pilot drill phase for a relatively long HDD (4,338 feet horizontal distance, as drilled in this case) drilling fluid pressures tend to increase in order to maintain circulation back to the drilling rig and this pressure increase may have contributed to the IRs, as well. Containment was installed around the IRs and these IR locations continued to reactivate, from time to time, during the completion of the pilot and subsequent reams and swabs associated with HDD construction. The containments and vacuum trucks were used to manage the reactivations. The pilot drill phase for the 16-inch pipeline installation was completed on June 19, 2019. Reaming and swabbing occurred until August 19th and pulling of the 16-inch pipe was completed on August 24, 2019.

A second "punch out" IR totaling 25 gallons, occurred on August 19, 2019 within the HDD staging area. The drill was completing its final swab pass in preparation for pipe pull back. Drilling was immediately stopped upon discovery of the IR. All drilling fluid was contained within the limit of disturbance. Construction crew members used a vacuum truck to recover the drilling fluid and the driller extended the drill exit pit to encompass the punch out release location.

GEOLOGIC ANALYSIS

Most of the alignment for S3-0421 is located within the Glenarm Wissahickon Formation Greystone Schist. This formation is described as a dark grey to dark greenish-grey, fine-grained muscovite-chlorite schist, with feldspar porphyroclast, coarse-grained magnetite. The northwest end of the alignment from approximately Stations 6+00 to the northwest entry/exit on the proposed profile is located within the Peters

Creek Tectonite, identified by others as the Octoraro Formation. The tectonite is a very fine-grained silver, green or black phylite, comprised of muscovite and chlorite, and quartz veins are common.

Published geologic maps show a northeast trending regional structural fabric across Chester County. As a result of tectonic processes (extensive regional heating and compression with folding and localized fault zones), the metamorphic rocks of Chester County are fractured and jointed, with some regional faulting of demonstrable offset. The published geologic maps reviewed for this evaluation did not identify any mapped fault zones or other significant structural features crossing the HDD alignment. There is no known or mapped karst geology, or sinkholes in the area of this HDD.

Fracture trace analysis identified one of the fracture trace trending ENE and intersecting the HDD alignment one-third of the way from the northwest to southeast entry/exits at approximately Station 13+50 on the proposed profile. A second, NNE trending, fracture trace intersects the alignment through the western ramps of the Boot Road / Route 202 interchange at approximately Station 38+15 on the proposed profile. The fracture trace in the northwestern section of the profile was corroborated by a possible sag in the contact between rippable and marginally rippable bedrock identified by a seismic refraction geophysical survey.

AGS completed a multi-method geophysical survey at the S3-0421 HDD site, January 22 through March 15, 2019. The AGS geophysical profiles were run along East Boot Road and Ship Road. Traffic intersections and driveways could not be blocked for data acquisition; therefore, the seismic array was "leapfrogged" over those locations resulting in zones of lower data density. Also, due to the limits of geophysical survey methods, data could not be obtained to maximum profile depth. However, data were able to be interpreted to elevations reflective of the descent of the profile to maximum depth after entry and at depths associated with ascent of the profile prior to exit. As such, the geophysical data is very useful for assessing variations in bedrock conditions along those sections of the profile where the IRs occurred during installation of the 16-inch line and where IRs would most likely occur along the proposed 20-inch profile. The seismic refraction method yielded an interpretation that generally depicts the base of rippable bedrock (approximate base of saprolite) at a maximum of 45 ft bgs. Deeper zones of rippable bedrock are shown in two areas on the profiles in Attachment C of Attachment 1.

The MASW method yielded an interpretation that depicts near vertical low velocity zones (faults, fractures, or highly weathered zones) at Stations 4+75, 7+25 and 15+75 on the geophysical survey profiles. The depth to rippable bedrock surrounding these zones is generally shown as being deeper than 45 ft bgs. The low velocity zone at Station 15+75 correlates with deeper zone of rippable bedrock identified on the seismic refraction profile at Station 16+20. The contact between the Peters Creek tectonite and Wissahickon schist occurs between the low velocity zones at Stations 4+75 and 7+25 which may be indicative of faulting at the contact.

The IRs that occurred during drilling for installation of the 16-inch line, described in Section 3.0, were punch-out IRs that occurred between Stations 1+01 and 1+68 at the end the pilot hole, and do not appear to be related to any structural features identified by either the geophysical surveys or fracture trace analysis.

Attachment 1 provides a discussion on the geology and the results of geotechnical and geophysical investigations performed for HDD S3-0421.

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater in the schistose units of Chester County is stored and moves within unconsolidated saprolite and highly weathered and fractured bedrock materials, near the land surface, and within more competent fractured bedrock, at depth. Some saturated zones within the saprolite may be under perched conditions. Groundwater in this hydrogeologic setting moves through the weathered bedrock zone down into an

interconnected network of joints and fractures in more competent rock. In general, it is assumed that groundwater flow proximal to HDD S3-0421 moves along gradients established by a water table surface that is a subdued reflection of the local topography. The topography indicates most groundwater flow in the area of the HDD alignment is towards East Branch Chester Creek to the southwest. Some shallow groundwater flow near the southeast entry/exit may be east towards a headwater drainage of Ridley Creek.

Based on geotechnical boring logs and a PAGWIS data base search, local groundwater levels vary from 2.5 to 96 feet below ground surface with an average of 40 feet below ground surface. The shallow end of the range is likely representative of a perched water table. It is assumed that most of the HDD profile will be under saturated conditions. There will likely be a pressure head difference between the elevation of the local water table and both entry/exits, indicating potential for a groundwater discharge during construction of the HDD; however groundwater production from the annulus occurred on only one (1) day during the reaming phase for installation of the 16-inch pipeline.

Forty-three of the PAGWIS records for wells completed in the Wissachickon formation listed well yields. The maximum reported well yield was 180 gallons per minute (gpm), the minimum reported yield was 0.75 gpm and the average well yield was 22 gpm. The PAGWIS search produced one domestic well record with a yield value for wells completed in the Octoraro formation (or Peters Creek tectonite) of 15 gpm.

Attachment 1 provides a discussion on the hydrogeology at this location.

ADJACENT FEATURES ANALYSIS

This HDD is located in West Goshen and West Whiteland Townships in Chester County, Pennsylvania. The pipeline alignment parallels Ship Road, East Boot Rd, and crosses under Route 202 and is set within light commercial and urban residential developments for the majority of its length. The HDD crosses under a headwater of South Chester Creek (S-H30), and parallels an existing SPLP pipeline corridor.

SPLP identified one hundred seventy-six (176) landowners within 450 ft of the HDD alignment. SPLP sent each of these landowners a notice letter via both certified and first-class mail that included an offer to sample the landowner's private water source (well or spring) in accordance with the terms of the Order and the Water Supply Assessment, Preparedness, Prevention and Contingency Plan. The letter also requested that each landowner contact the Right-of-Way agent for the local area and provide SPLP with information regarding: (1) whether the landowner has a water source; (2) where that water source is located, and its depth and size if known; and (3) whether the landowner would like to have the water source 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 PADEP's Central Office.

As a result of this public outreach, SPLP identified and tested two (2) private water sources. The remaining landowners verified the use of public water supply or no water use on the parcel. The two private water sources are 462 ft. and 620 ft. away from the HDD profile. No water supply complaints were received during drilling for the 16-inch HDD, and none have been received since completion of the 16-inch pipeline installation.

In accordance with the requirements of the Stipulated Order, SPLP will transmit a copy of this HDD analysis to all landowners having a property line within 450 ft of any direction of this HDD location.

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ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of HDD S3-0421 includes an evaluation of construction alternatives and a re-route analysis. As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the Project, SPLP considered several different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the construction methods and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

Open-cut Analysis

The HDD alignment is within an existing SPLP utility easement and parallels existing SPLP pipelines but also public water and sewer utility lines while passing through and under multiple residential and commercial properties, and multiple buried utilities owned by other companies along Ship and East Boot Road. An open cut/conventional auger bore construction plan to replace the proposed HDD is feasible. It appears sufficient space is available on the north side of Ship and East Boot Road for the first 1,500 linear foot, then flipping to the south side for the remaining 1,800 ft, crossing under Route 220, and then returning to the north side of East Boot Road to return to the original endpoint. To implement an open cut/auger bore construction plan would require cooperation or condemnation of multiple private land owners to accept a revised permanent easement, or second permanent easement outside of the current easement where sufficient space would be available to install a new pipeline by conventional methods. The easement revision or addition is required to account for the final pipeline location and temporary workspace needed to implement the open cut/bore construction plan to avoid structures encroaching onto and into the existing SPLP easement. This plan would require construction to occur very close to existing pipelines and underground infrastructure.

SPLP specifications require a minimum of 48-inches of cover over the installed pipelines. The Pennsylvania Department of Transportation (PADOT) cover requirements under public roadways is 60-inches of cover. The HDD as planned avoids a conventional auger bore, or open cut of Route 202 and East Boot Rd. The HDD also avoids direct open cut impacts to stream S-H30.

Although technically feasible, open cut techniques were proposed during the original assessment and permitting of the Pennsylvania Pipeline Project, and rejected by the landowners. Accordingly, obtaining the necessary easement to employ open cut techniques at this stage will likely require adverse condemnation proceedings. Given that the two upland IRs experienced during drilling for installation of the 16-inch pipeline were readily contained and cleaned up and resulted in no harm to human health or the environment, SPLP's opinion is that an HDD crossing of this area remains the preferred methodology.

Use of Conventional Auger Bore

Planning for a conventional bore must account for the extent or width of the feature (road, stream, etc.) being bored under, as well as the length and width of the setup-entry pit for setting the boring equipment within while operating, and the receiving pit through which the product pipeline is pulled back through after the boring machinery exits.

Based on experience gained during construction of the Mariner II Pipeline project, conventional auger bores should be limited to approximately 200 linear ft at a time, or less, varying by the underlying substrate. Conventional auger bores for the 16-inch pipeline, attempted at longer distances, have at times had alignment drift and elevation deflections occur which have complicated installation.

A conventional auger bore could be used in combination with open cut construction, as discussed above, to install the 20-inch pipe as well as subset footages and road intersect/crossing within the length of the permitted HDD. Obtaining the necessary easements to employ a conventional auger bore at this stage, however, will likely require adverse condemnation proceedings. Given that the two upland IRs experienced during drilling for installation of the 16-inch pipeline were readily contained and cleaned up and resulted in no harm to human health or the environment, SPLP's opinion is that an HDD crossing of this area remains the preferred methodology.

FlexBor Analysis

SPLP contractors attempted three (3) FlexBors and partially completed two of these to replace HDDs on the Mariner Project. One FlexBor failed in the pilot phase and was replaced with a conventional bore under a highway and open cut construction. The two partially successful FlexBors completed the pilot phases, but both had difficulties completing the reaming phase. SPLP's analysis is that this technology is not perfected for larger diameter bore attempts.

Direct Pipe Bore Analysis

The direct pipe bore method is also known as "microtunneling". This method of pipeline installation is a remote-controlled, continuously supported pipe jacking method. During the direct pipe installation, operations are managed by an operator in an above-ground control room alongside of the installation pit. Rock and soil cutting and removal occurs by drilling fluid injection through the cutting tool during rotation at the face of the bore, and the cuttings are forced into inlet holes in the crushing cone at the tool face for circulation to a recycling plant through a closed system. The entire operating system for this method of pipeline installation, including the cutting tool drive hydraulics, fluid injection, fluid return, and operating controls are enclosed inside the outside diameter bore pipe (or casing pipe) being installed. At the launching point/entry pit, the bore pipe is attached to a "jacking block" that hammers the bore pipe while the tool is cutting through the substrate or geology. The cutting tool face is marginally larger in diameter than the pipe it is attached to. As a result, there is minimal annulus space, which minimizes the potential for drilling fluid returns or the production of groundwater returning back to the point of entry. Unlike an HDD, this technology has no steering capability. Changes in direction are made by adjusting the cutting angle of the tool face which results in a maximum of 4 degrees radius between the point of entry and exit.

SPLP's construction contractors have successfully completed one (1) Direct Pipe Bore approximately 925 ft on the Pennsylvania Pipeline Project (PPP) at the crossing of the Frankston Branch of the Juniata River in Blair County. This Direct Pipe Bore was setup within a relatively flat area immediately outside the river floodplain and bored under the floodplain, wetlands, and river, exiting at the toe of a mountain slope.

The Direct Pipe Bore method requires substantially more surface workspace than required for an HDD for the setup and operation of the entry pit due to the space requirements for the hydraulic jacking press and supporting equipment which approximates the equipment assembly for operating an HDD, plus layout room for the casing pipe string to be jacked into place.

The best application of this technique would be at the crossing of Route 220, however the alternate route as discussed above is on the south side of East Boot Road within private property, not along SPLP's current easement. Although feasible, implementation of one or more Direct Pipe bores in combination with open cut installation segments would require additional easements for the workspace for setup of the equipment

and re-alignment of the pipeline installation as discussed above. Obtaining the necessary easements to employ a direct pipe bore at this stage, however, will likely require adverse condemnation proceedings. Given that the two upland IRs experienced during drilling for installation of the 16-inch pipeline were readily contained and cleaned up and resulted in no harm to human health or the environment, SPLP's opinion is that an HDD crossing of this area remains the preferred methodology.

Re-Route Analysis

The general route of the Mariner II project in this area of Pennsylvania is from northwest to the southeast. The pipeline route as currently permitted follows an existing SPLP easement through light commercial and urban residential development and bypasses or directly avoids impacting multiple commercial and residential properties, underground utilities, and multiple roadways.

The nearest existing alternative corridor occurs 1.0 miles northeast of the current alignment and contains three utility lines. Accessing this alternative corridor would require creation of a additional utility easement to deviate away from the current route prior to the setting of the S3-0421 HDD (1.25 miles northwest), approximately at the intersect of Highway 30/Exton Bypass, then route 1.4 miles northeast; then follow the alternative corridor for 1.8 miles to Greenhill Road; then create a new utility corridor along the south side of Greenhill Road for 1.6 miles to access the SPLP valve station location. Due to the settings surrounding the overall route of the Mariner II pipelines in this area, there is no alternative route that could avoid conflicts with existing commercial and/or residential properties. Since SPLP possesses no prior rights for multiple utility lines in any nearby existing corridor, nor any new corridor that could be developed, SPLP anticipates adverse condemnation proceedings to acquire a new easement as described. Given that the two upland IRs experienced during drilling for installation of the 16-inch pipeline were readily contained and cleaned up and resulted in no harm to human health or the environment, SPLP's opinion is that the current route is preferred.

HORIZONTAL DIRECTIONAL DRILL REDESIGN

SPLP has considered all geologic data and the events during installation of the 16-inch pipeline and has redesigned the 20-inch HDD profile. A summary of the redesign factors is provided below. The original and redesigned HDD plan and profile for the 20-inch pipeline are provided in Attachment 2.

Revised Horizontal Directional Drill Design Summary: 20-inch

- Horizontal length: 4,391 feet (ft)
- Entry/Exit angles: 13 - 16 degrees
- Maximum depth of cover: 210 ft
- Depth below stream crossing: 140 ft
- Pipe design radius: 2,400 ft

The redesigned HDD profile has been lowered 98 ft below the design depth originally permitting; increases the angle of entry into the northwest radius, and lowers the profile depth well below the installed 16-inch pipeline to reduce the potential for IRs as occurred during installation of the 20-inch pipeline. The remaining design factors are below the pipeline stress allowances for all points of analysis.

CONCLUSION

Based on the original and revised profile for the 20-inch HDD, the revised HDD profile increases the depth in bedrock for a majority of the HDD profile; therefore, adjustments to the plan of construction for the 20-inch pipeline represent a reduced risk of IRs that would impact uplands and the one water resource (SH-

30, a headward section of South Chester Creek) over the profile. No water supply impacts occurred during installation of the 16-inch pipe and only two private water sources have been identified in the area of HDD S3-0421, one 462 ft. and one 620 ft. away from the HDD alignment. As such, the risk of a water supply impact is very small. Upland and punch out IRs are common on entry and exit of HDD drilling tools. Two of these types of IRs were easily managed, without impacts, during construction of the 16-inch line. Although IRs originating from deeper locations along the profile did not occur during construction of the 16-inch line, measures will be taken to minimize that type of IR potential. In particular, upon the start of this HDD, SPLP will employ the following HDD best management practices:

- SPLP will provide the drilling crew and company inspectors the location(s) data on potential zones of higher risk for fluid loss and IRs, including the area related to previous IRs, and potential zones of fracture concentration identified by geophysical surveys and fracture trace analysis, so that monitoring can be enhanced when drilling through these locations;

- The S3-0421 20-inch HDD will be drilled as an intercept drill, so as to minimize drilling fluid pressures within the entry and exit radius of the profile to reduce IR potential;

- SPLP will mandate annular pressure monitoring during the drilling of the pilot hole, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus, managing development 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 require monitoring of the drilling fluid viscosity, such that fractures in the subsurface are sealed during the drilling process;

- During the reaming phase, the driller can implement both push and pull reaming to minimize IR potential at this HDD;

- SPLP will implement short-tripping of the reaming tools as indicated by monitoring of return flows, to ensure an open annulus is maintained to manage the potential inducement of IRs;

- During all drilling phases, the use of Loss Control Materials (LCMs) will be implemented upon detection of a LOC or indications of a potential IR are noted or an IR is observed. The use of LCMs, however, is less effective 70 ft-bgs. Accordingly, the preferred corrective action needed to address the presence of fractures or LOC at greater depths below ground will require grouting of the HDD annulus. Two types of grouting may be utilized for corrective actions to seal fractures. These are: 1) grouting using “neat cement”; and 2) grouting using a sand/cement mix. Neat cement grout is a slurry of Portland cement and water which is highly reactive to bentonite and induces solidification. The sand/cement grout mix is a slurry of mostly sand with a small percentage of Portland cement and activators that result in a material having the competency of a friable sandstone or mortar, after setup. Both grouting actions require tripping out the drilling tool, and then tripping in with an open-ended drill stem to apply or inject the grout mixes. Either of these grouting actions may be implemented upon the first detection of an LOC with the selection of the treatment based upon the circumstances of the LOC, being small or large in magnitude. The monitoring PGs and Drilling Specialists will assess the LOCs and make a determination as to which LOCS will require remediation and the method employed.

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FEASIBILITY DETERMINATION

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

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

12-16-2019
Date:

Larry J. Gremminger, CWB
Vice President – Environmental
Geotechnical Evaluation Leader
Mariner East 2 Pipeline Project

Pertaining to the practice of geology

12/16/19
Date:

Richard T. Wardrop, P.G.
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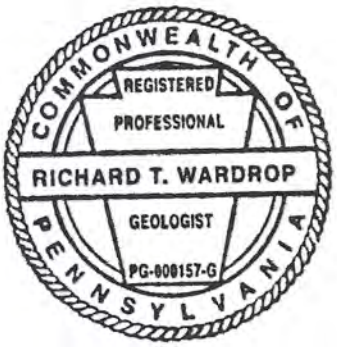
Lead Hydrogeologist



Pertaining to the pipeline stress and HDD geometry

12/16/19
Date:

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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

HDD HYDROGEOLOGIC REEVALUATION REPORT

Mariner East II
Spread 6
HDD S3-0421
Phoenixville Pike Road
West Goshen and West Whiteland Townships, Chester County, Pennsylvania

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

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December 2019

HDD HYDROGEOLOGIC REEVALUTION REPORT

Mariner East II
Spread 6
HDD S3-0421
Phoenixville Pike Road
West Goshen and West Whiteland Townships
Chester County, Pennsylvania

December 2019

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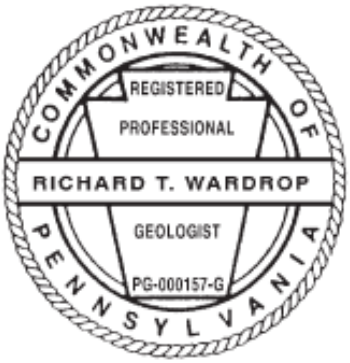
FIGURES

ATTACHMENTS

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



12/16/2019

Richard T. Wardrop, P. G. — Date
License No. PG000157G

1.0 INTRODUCTION

Sunoco Pipeline, L.P., (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare horizontal directional drill (HDD) Hydrogeologic Reevaluation Reports (HRRs) for certain HDDs associated with the Mariner East II pipeline project. This HRR has been prepared for HDD S3-0421 (the 20-inch HDD for this location), in accordance with Condition No. 3 of the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L. Condition No. 3 stipulates, for HDDs initiated after the temporary injunction issued by the Pennsylvania Department of Environmental Protection (DEP) Environmental Hearing Board on July 25, 2017, a reanalysis must be performed on HDDs for which an inadvertent return (IR) occurs during the installation of one pipeline (20-inch or 16-inch diameter) where a second pipeline will thereafter be installed in the same right-of-way (ROW). Installation of the 16-inch pipeline at HDD-S3-0421 was completed on 8/24/2019. On 6/6/19, during the drilling of the pilot hole, for the 16-inch line, an IR with three upland points of discharge occurred outside of the Limit of Disturbance (LOD), triggering a reevaluation for installation of the 20-inch pipe. The discussion presented in this report is based on a permitted plan and profile (P&P) developed by Tetra Tech/Rooney (Tetra Tech) for the 20-inch line, revised 09/30/2016, as compared to a proposed P&P revised 12/11/2019 (see **Attachment A**).

Figure 1 shows the location of the alignment for HDD S3-0421, with topographic information for the surrounding area. The 20-inch HDD will run in the same right-of-way (ROW) as the 16-inch pipeline. The HDD alignment spans mostly land in residential use. Starting at the northwest entry/exit the alignment runs southeast, subparallel to Ship Road and turns eastward to become coincident with East Boot Road. Moving further to the southeast the alignment is tracking parallel to East Boot Road as it passes beneath the Boot Road / State Route 202 interchange, exiting at the HDD's southeast entry/exit, east of the interchange. Other than a residential community, the alignment passes an area of light commercial land use north of the alignment between Stations 10+50 and 15+50, and SPLP's Boot Road Pump Station due north of the alignment between Stations 31+00 and 34+50 (proposed profile) .

This HRR is based on geotechnical boring reports; geologists and construction field observations during drilling for the installation of the 16-inch pipe; geophysical surveys, and the interpretation of published information. Tetra Tech advanced a series of five geotechnical borings between June and December 2015 to facilitate HDD design. These were supplemented by three additional geotechnical borings advanced by Intertek/PSI between October and December 2017. Note that GES did not oversee or direct either of the geotechnical boring programs, including selection of the number and location of borings, the determination of surface elevations and target depths, observations of rock cores during drilling operations and the preparation of boring logs. In addition, Advance Geological Services (AGS) was subcontracted by GES to perform a geophysical survey scope of work that was developed by ETP. This work was performed January through March 2019. GES relied on these reports and incorporated the information presented therein into the general geologic and hydrogeologic framework for this HRR.

As described in the Stipulated Order (pages 3 and 4), the HRRs will provide information to eliminate, reduce, or control the release or IR of HDD drilling fluids to the surface of the ground or impact to water supplies at the specified location(s) during HDD operations. The HRRs are not intended to evaluate potential adverse effects on nearby man-made structures from HDD activities

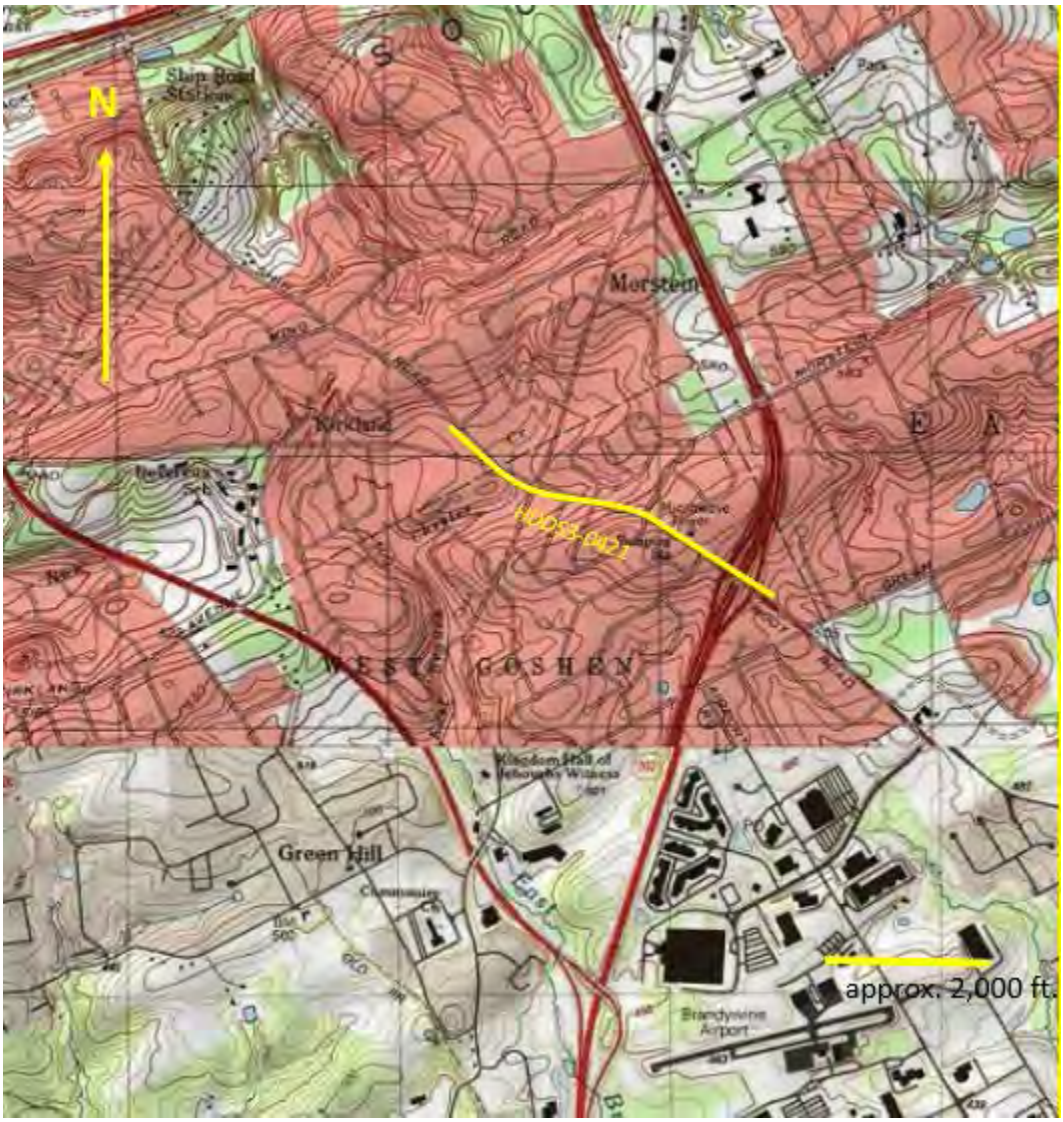


Figure 1. Site Location Map (modified from PA GEODE)

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of at HDD S3-0421;
- Summaries of studies performed pertinent to reevaluation, including fracture trace analysis, geotechnical borings; and a geophysical survey;
- A site conceptual model; and
- A reevaluation summary with conclusions and recommendations.

2.0 HDD GEOLOGY / HYDROGEOLOGY

2.1 Physiography

HDD S3-0421 is located in southeastern Pennsylvania within the Piedmont Physiographic Province, Piedmont Upland Section. Broad, rounded to flat-topped hills and shallow valleys, with low to moderate topographic relief, characterize the Piedmont Uplands Section. The geology of this region is generally comprised of meta-igneous and metasedimentary rocks (gneiss and schist) of Proterozoic to Early- to Mid-Paleozoic age that have been severely folded and fractured. The area along the HDD alignment is comprised of mostly residential properties with limited light commercial use and the Sunoco Boot Road NGL pumping station due north of the southeast section of the alignment.

2.1.1 Topography

Figure 1 shows the area around HDD S3-0421 in an upland with a high point at approximately one third of the way along the alignment, moving southeast to northwest. The proposed P&P provided in **Attachment A** shows the northwest entry/exit point to be at elevation 524 feet above mean sea level (ft-amsl) and the southeast entry/exit point at elevation 521 ft-amsl. The aforementioned high point in the southeast section of the alignment has an elevation of approximately 575 ft-amsl and the low point along the alignment is at approximately 505 ft-amsl where the alignment crosses stream S-H30.

2.1.2 Hydrology

Most of the HDD S3-0421 alignment lies within the headwater drainage of East Branch Chester Creek. The alignment crosses a head ward section of East Branch Chester Creek (S-H30) at approximately Station 9+48 (proposed profile). There are no other water resource crossings shown in **Attachment A**. A small section of the alignment, located east of Route 202 is located in a headwater drainage of Ridley Creek, and two ponds feeding this stream are located over 2,500 feet east of the exit/entry.

2.2 Geology

2.2.1 Surface Soils

Surface soils along the HDD alignment were researched on the United States Department of Agriculture Natural Resources Conservation Service - Web Soil Survey web site (USDA NRCS). Most of the alignment plots within Urban land-Udorthents (UugB) on eight percent slopes, described as occurring on hills within urban settings with 80 percent pavement, buildings and other artificial cover, and 15 percent of the soil derived from schist and gneiss. Typical profiles are comprised of loam and silty-clay loam to 40 inches over bedrock, and the material is described as well-drained with water tables at about 60 inches (5.0 feet) below surface. Soils in the area of the Route 202 / Boot Road interchange are mapped as Glenelg silt loams on slopes from 3 to 15 percent. The Glenelg soils are weathered from mica schist and range from loams to clay loams that grade to channery fine sandy loam, at approximately 54 inches depth. The loams are considered well-drained and water tables typically occur at greater than 80 inches (6.7 feet).

Soils along HDD S3-0471 were characterized by eight geotechnical borings, five drilled by Tetra Tech and three drilled by Intertek/PSI (see locations in **Attachment A**). In general, the unconsolidated materials logged in the geotechnical borings is comprised of saprolite (sand, silt and gravel size material weathered from schist bedrock). The soil transitions to highly weathered bedrock with depth. The depth of highly weathered bedrock is variable between boring locations and can be as high as 118.5 feet as recorded for boring B1-421 located proximal to the northwest entry/exit.

2.2.2 Bedrock Lithology

As shown on **Figure 2**, most of the alignment for S3-0421 is located within the Glenarm Wissahickon Formation Greystone Schist as mapped by Bosbyshell (2006). This formation is described as a dark grey to dark greenish-grey, fine-grained muscovite-chlorite schist, with feldspar porphyroclasts, coarse-grained magnetite. Discontinuous quartz veins and pods are common throughout the unit. The northwest end of the alignment from approximately Stations 6+00 to the northwest entry/exit on the proposed profile is located within the Peters Creek Tectonite (Bosbyshell 2006), identified by others as the Octoraro Formation (see contact on proposed profile, **Attachment A**). The tectonite is a very fine-grained silver, green or black phylite, comprised of muscovite and chlorite, and quartz veins are common. Due to fine laminae this rock tends to break in very thin sheets.

2.2.3 Structure

Geologic maps prepared by Berg et. al (1980) and Bosbyshell (2006), show a northeast trending regional structural fabric across Chester County. As a result of tectonic processes (extensive regional heating and compression with folding and localized fault zones), the metamorphic rocks of Chester County are fractured and jointed, with some regional faulting of demonstrable offset. The published geologic maps reviewed for this evaluation did not identify any mapped fault zones or other significant structural features crossing the HDD alignment. Bosbyshell (2006) shows the northeast trending Cream Valley Fault approximately 0.7 miles southeast of the HDD S3-0421 southeast entry/exit and shows local schistocity dipping 61 to 89 degrees southeast.

2.2.4 Fracture Trace Analysis

Fracture traces are the linear expression on the land surface of vertical to near vertical planar zones of fracture concentration that can be mapped using aerial imagery. These zones of fracture concentration can be preferred pathways for fluid migration. Fracture trace analysis is partly subjective; therefore, every mapped fracture trace does not necessarily represent a zone of bedrock fracture concentration. The baseline photography used for the fracture trace analysis for HDD S3-0421 consisted of historic photographic stereo pairs from the US Department of Agriculture (USDA) and US Geological Survey (USGS), available through the Pennsylvania Imagery Navigator web site. The fracture trace analysis was based on a composite of interpretations for multiple 1937-1942 USDA (1-20,000) aerial photograph stereo pairs viewed with a Topcon MS-3 Stereo Scope and the traces observed were transferred to a single photo for further evaluation.

Figure 3 presents a fracture trace map prepared from the air photo analysis. The analysis identified several fracture traces in the area of the HDD. One of the fracture traces trends ENE and intersects the HDD alignment one-third of the way from the northwest to southeast entry/exits at approximately Station 13+50 on the proposed profile. A second, NNE trending, fracture trace intersects the alignment through the western ramps of the Boot Road / Route 202 interchange at approximately Station 38+15 on the proposed profile. The fracture trace in the northwestern section of the profile was corroborated by a possible sag in the contact between rippable and marginally rippable bedrock identified by a seismic refraction geophysical survey performed by AGS (see Section 2.4**)**. The fracture trace through the western ramps of the Boot Road / Route 202 interchange passes through a zone of limited geophysical survey data density due to road intersections and limited access for the AGS geophysical surveys, such that the geophysical data could not be interpreted.

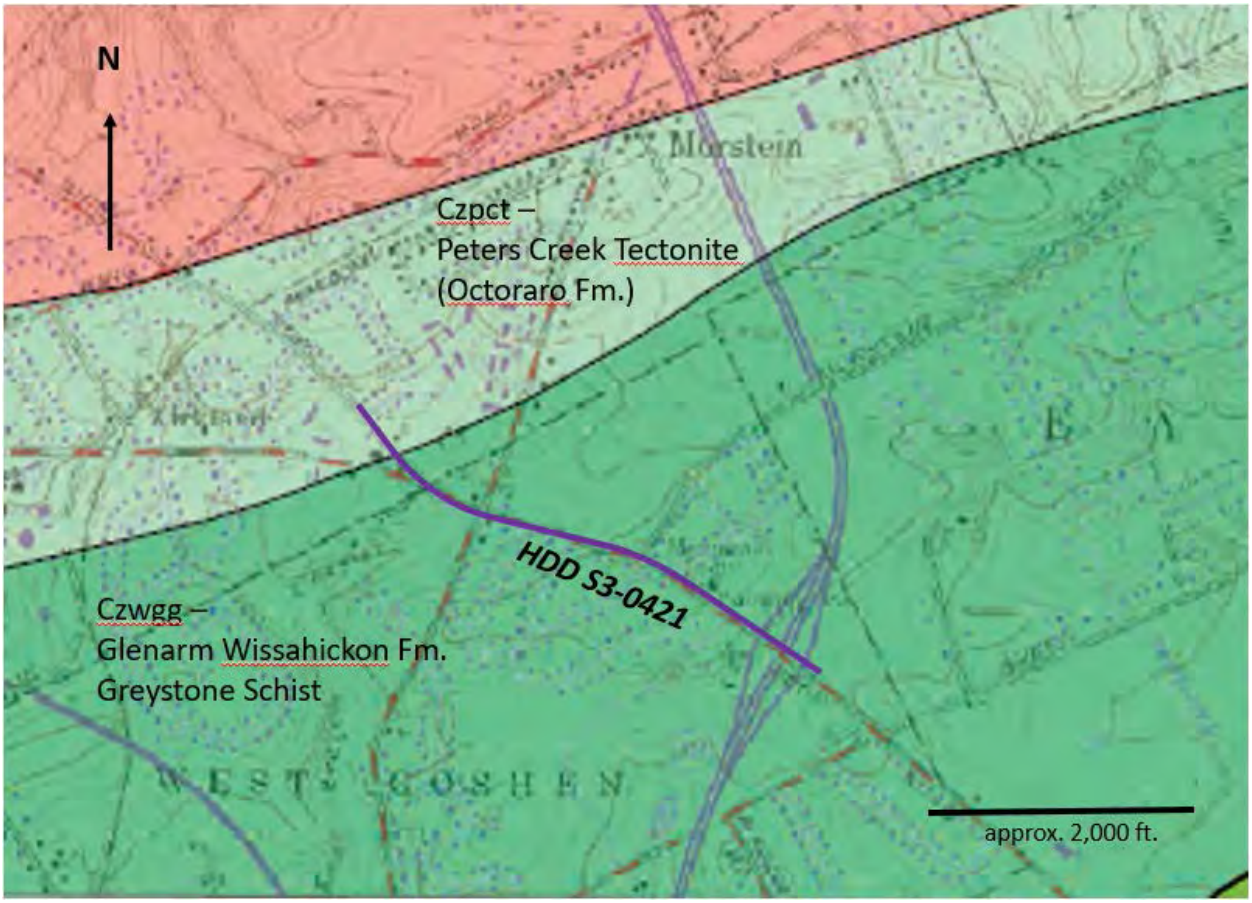


Figure 2. Local Bedrock Geology (mod. from Bosbyshell, 2006)

2.2.5 Karst

There are no known or mapped sinkholes or other karst features in the area of HDD S3-0421, which is consistent with the published mapped bedrock in the area under the alignment.

2.2.6 Mining

Based on a review of the PADEP eMapPA web site and historic references no active or historic subsurface or surface mining operations were identified at or near the HDD S3-0421 alignment.

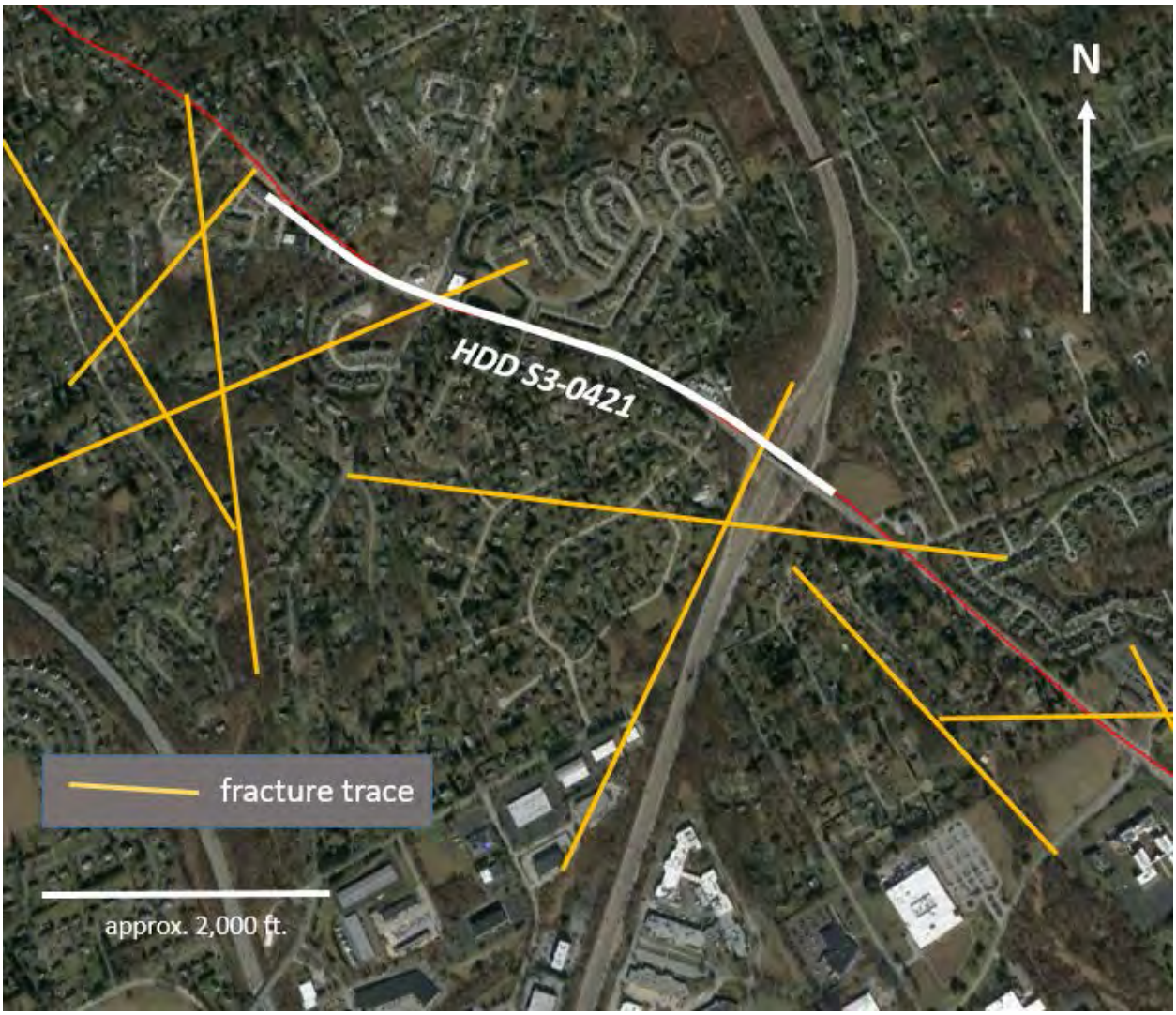


Figure 3. Fracture Trace Map

2.2.7 Rock Engineering Properties

Geyer and Wilshusen (1982) report the following with respect to the engineering properties of Wissahickon Schist Formation. At the time of publication, it is assumed the authors referred to the present day Peters Creek tectonite or Octoraro formation as the Wissahickon albite-chlorite schist and the Glenarm Wissahickon formation – greystone schist as the olioclase-mica schist of the Wissahickon formation. Their descriptions are generalized to include all forms of Wissahickon schist.

- Bedding: Fissile to thin; steeply dipping in most places.
- Fracturing: Cleavage has a platy pattern; well developed; highly abundant; displays an even regularity; very closely spaced; open and steeply dipping. Joints are for the most part irregular, poorly formed, widely spaced, steeply dipping, and open.
- Weathering: Moderately resistant; often highly weathered to a moderate depth, resulting in uneven, hackly, small-sized, plate-like rubble at the base of exposures; overlying mantle is thin.
- Ease of excavation: Moderately easy; difficult in unweathered rock; moderate drilling rates.

2.2.8 Results of Geotechnical Borings

The locations of the geotechnical borings advanced for characterization of HDD S3-0421 are shown on the P&Ps in **Attachment A** and boring logs are provided in **Attachment B**.

Original Geotechnical Borings (Tetra Tech)

Tetra Tech completed five geotechnical borings in the HDD-0421 area between June and December 2015. These borings were labeled and located proximal to the proposed profile alignment (**Attachment A**), as follows:

- SB01-S3-0421 Station 8+35
- SB02- S3-0421 Station 19+70
- SB03- S3-0421 Station 31+40
- SB04- S3-0421 Station 42+45 (northnorthwest of southeast entry/exit
- SB05-S3-0410 Station -2+40 (northwest of the northwest entry/exit)

Each boring encountered relatively weak unconsolidated material derived from decomposed schistose and phylittic bedrock. This material consists of vari-colored silt, sand and gravel with mica flakes and quartz pieces. Based on the log for SB-01 these materials can occur to greater than 65 feet below ground surface (ft bgs) at the HDD site. United Soil Classicfication System (USCS) designations included SM (sandy silt) and ML (silt). Four of the five borings were advanced to auger refusal. Bedrock was cored at SB02-S3-0421 from 14 to 22 ft bgs. Core recoveries were very good (96 to 100 percent) and the Rock Quality Designations (RQDs) were very poor to poor (as defined by ASTM STP 984, 1988) at 24.5 and 42 percent. This rock was described as intensely to moderately fractured, partially decomposed, variegated gray schist. Water levels measured at the five TetraTech borings were highly variable, ranging from 8 to 55 ft bgs, and two boring, SB02 and SB04 were noted as being dry with total depths of 22 and 30 feet, respectively. Petroleum odors were noted in soil samples taken from SB03 (68.0 to 68.4 ft bgs) and SB05 (13.0 to 24.4 ft bgs); however, on-site HDD inspectors were alerted to this information and but did not detect any petroleum affected cuttings during pilot hole drilling or reaming for HDD S3-0421-16.

PSI/Intertek Geotechnical Borings

PSI/Intertek drilled three borings between October and December 2017, one (B1-421) approximately 55 feet north of the northwest entry/exit on the proposed S3-0421 profile (see **Attachment A** for locations), one (B2) approximately 100 feet north of Station 36+05, and a third (B2A) approximate 24 feet northwest of B2 (advanced because B2 was terminated when tooling ceased within the bore hole). The variations in core recovery and RQD, with depth, are shown on **Figure 4**.

Boring B1-421 was advanced to a total depth of 150 feet. Rock coring began at 69.5 ft bgs at the depth of roller bit refusal. Highly weathered schist with very poor recovery and RQD was logged to a depth of 118.5 feet, after which recovery and RQD gradually improved. In the interval from 118.5 ft bgs to 143.5 the schist was described as weathered to slightly weathered, core recovery ranged from 63 to 92 percent and RQD was very poor to fair (28 to 63 percent). Vertical fractures were noted in the interval from 128.5 to 133.5 feet. At depth of 143 feet to the final depth of 150 feet, the schistose rock became more competent with recovery at 100 percent and RQD being good to excellent (ranging from 78 to 94 percent). The deepest, horizontal section of the proposed profile is at a depth of approximately 158 ft bgs relative to boring B1-421. There was a partial loss of water return from approximately 136 ft bgs to the final depth of 150 feet. The water level in the boring was measured at 12.3 ft bgs one day after final depth was achieved.

B1-421

Depth (feet)	Apprx. Elev. Elevation (ft amsl)	REC (perc)	RQD (perc)
69.5	458.5		
75	453	0	0
80	448	0	0
85	443	1	0
90	438	0	0
95	433	33	8
100	428	29	20
105	423	0	0
110	418	0	0
115	413	0	0
120	408	0	0
125	403	70	28
130	398	92	63
135	393	63	21
140	388	100	94
145	383	100	78
150	378	100	88

Water Level 12.3 ft.

B-2

Depth (feet)	Apprx. Elev. Elevation (ft amsl)	REC (perc)	RQD (perc)
39	533		
45	527	100	67
50	522	100	58
55	517	100	82
60	512	100	58
65	507	100	70
70	502	100	67
75	497	94	83
80	492	100	68
85	487	100	43
90	482	100	88
95	477	100	84
100	472	100	77
105	467	100	90
110	462	47	0
115	457	87	70
120	452	100	78
124	448	0	0

No water level recorded

B-2A

Depth (feet)	Apprx. Elev. Elevation (ft amsl)	REC (perc)	RQD (perc)
31	543		
35	539	100	67
40	534	100	50
45	529	100	52
50	524	100	43
55	519	100	53
60	514	100	75
65	509	100	78
70	504	100	87
75	499	100	81
80	494	100	100
85	489	100	97
90	484	100	100
95	479	100	87
100	474	100	98
105	469	100	98
110	464	100	98
115	459	100	92
120	454	100	100
125	449	100	100
130	444	100	98
135	439	100	100
140	434	100	93
145	429	100	73
150	424	100	98
155	419	100	92
160	414	100	100
165	409	100	100
170	404	100	93
175	399	100	93
180	394	100	98
185	389	100	99
190	384	100	80
195	379	100	88
200	374	100	86
205	369	100	100
210	364	100	84
215	359	100	98
220	354	100	98
225	349	100	100
230	344	100	100
235	339	100	90
240	334	100	100
245	329	100	54

Water Level 27 ft.

RQD Classifications

V. Poor	0	25
Poor	25	50
Fair	50	75
Good	75	90
Excellent	90	100

Figure 4. Recovery and RQD with Depth for Borings B1-421, B2, and B2A

Boring B2 was advanced to a total depth of 124 feet. Rock coring began at 39 ft bgs at the depth of split-spoon sampler refusal. Relatively competent schistose bedrock (described as weathered to highly weathered) was observed from 39 to 90 ft bgs with all but one recovery value at 100 percent and all but one RQD value ranging from fair to good (58 to 90 percent). Less weathered mica schist (described as slightly weathered to weathered) was observed from 90 ft bgs to total depth at 124 ft bgs. The recoveries in this section ranged from 87 to 100 percent, except for two values of 47 percent and 0 percent (at the bottom of the boring where the tooling ceased). The RQDs were similar, ranging from fair to good (70 to 90 percent), except for two values at 0 percent. Occasional quartzite seams were observed throughout the core. No water levels were recorded for this boring and B2 was terminated at 124 ft bgs due to tooling ceasing in the borehole. The deepest, horizontal section of the proposed profile is lower in elevation than the bottom of B2.

Boring B2A was offset and advanced approximately 24 feet northwest of B2. B2A was advanced with augers to refusal at 31 ft bgs where coring was initiated. All recovery values from 31 ft bgs to final depth at 245 ft bgs were 100 percent. RQD was poor to fair (ranging from 43 to 67 percent) from 31 to 55 ft bgs; but became more competent with RQDs mostly good to excellent (75 to 100 percent) from 55 ft bgs to final depth (245 ft bgs), except for two values at 73 and 54 percent. Occasional quartzite seams were observed throughout the core. The planned, deepest, horizontal section of the proposed profile is at approximately 187 ft bgs, relative to boring B2A, well within the zone of competent bedrock. The water level in the boring was measured at approximately 27 ft bgs upon completion of drilling activities.

2.3 Hydrogeology

2.3.1 Occurrence of Groundwater

Groundwater in the schistose units of Chester County is stored and moves within unconsolidated saprolite and highly weathered and fractured bedrock materials, near the land surface, and within more competent fractured bedrock, at depth. Some saturated zones within the saprolite may be under perched conditions.

Groundwater in this hydrogeologic setting moves through the weathered bedrock zone down into an interconnected network of joints and fractures in more competent rock. Fracture traces can represent potential near-vertical planar zones of fracture concentration and preferred pathways for fluid movement.

In general, it is assumed that groundwater flow proximal to HDD S3-0421 moves along gradients established by a water table surface that is a subdued reflection of the local topography. The alignment of HDD S3-0421 lies on the drainage divide between the Chester Creek watershed and the Ridley Creek watershed in an upland area. The topography indicates most groundwater flow in the area of the HDD alignment is towards East Branch Chester Creek to the southwest. Some shallow groundwater flow near the southeast entry/exit may be east towards a headwater drainage of Ridley Creek.

2.3.2 Groundwater Levels and HDD entry/exit elevations

Groundwater levels were variable among the geotechnical borings advanced in the area of HDD S3-0421. Three of the five shallow borings advanced by Tetra Tech encountered water at depths ranging from 2.5 to 68 ft bgs and two were dry. The shallow measurement may be more representative of a perched water table than the true water table for the area. Interek/PSI boring B1-421 was drilled to a depth of 150 feet and a water level of 12.3 ft bgs, or approximately at elevation 515 ft amsl, was recorded the day after drilling completion. Boring B2A was drilled to a depth of 245 feet and a water level of 27 ft bgs or approximate elevation 547 ft amsl was recorded upon completion of drilling.

A PAGWIS search of wells was completed for domestic wells in the Octoraro and Wissahickon formations within approximately one mile of the proposed alignment. The search produced 52 records containing

static water levels. The maximum depth to water was 96 feet, the minimum depth to water was 20 feet and the average was 40 feet.

Assuming groundwater will be encountered at approximately 27 ft bgs, most of the profile will be within saturated conditions. The elevation of the northwest entry/exit on the proposed profile is 523 ft amsl and southeast entry/exit is at 521 ft amsl. Taking into account all of the above referenced sources of local groundwater levels, there is likely a pressure head difference between the elevation of the local water table and both entry/exits, indicating the potential for groundwater discharge during construction of the HDD. Consistent with this indication, a temporary (approximately one day duration) ground water discharge, of between 30 and 50 gpm, occurred during the 26-inch ream for the 16-inch pipe at S3-0421.

2.3.3 Well Yields

Forty-three of the PAGWIS records for wells completed in the Wissachickon formation listed well yields. The maximum reported well yield was 180 gallons per minute (gpm), the minimum reported yield was 0.75 gpm and the average well yield was 22 gpm.

The PAGWIS search produced one domestic well record with a yield value for wells completed in the Octoraro (or Peters Creek tectonite). The reported yield was 15 gpm.

2.3.4 Water Supply Well Survey

SPLP performed a preconstruction survey of landowners with the entirety or part of their parcels falling within 450-feet of the HDD S3-0421 alignments. The HDD alignment with the 450-foot zone is presented on **Figure 5**. Two private water source wells were identified and sampled by GES, on behalf of SPLP, with homeowner consent. Neither land owner was able to report the depth of their well; however, considering the average depth of wells listed in the above mentioned PAGWIS search and typical well casing lengths, the elevations of the open rock, productive, zones for local wells likely correlates to the elevation of sections of the 20-inch proposed profile. Neither well owner issued a complaint during construction of the 16-inch line.

2.4 Summary of Geophysical Studies

AGS completed a multi-method geophysical survey at the S3-0421 HDD site, January 22 through March 15, 2019. The stated purpose of the survey was to identify bedrock fractures, faults, or zones of bedrock weakness that could lead to IRs or LOCs during drilling operations. The survey results, including seismic refraction and multi-spectral analysis of surface waves (MASW) profiles, plotted onto HDD profiles are included in **Attachment C**.

The AGS geophysical profiles were run along East Boot Road and Ship Road. Traffic intersections and driveways could not be blocked for data acquisition; therefore, the seismic array was “leapfrogged” over those locations resulting in zones of lower data density. Also, due to the limits of geophysical survey methods, data could not be obtained to maximum profile depth. The lowest HDD pipe profile elevations are 400 ft-amsl for the 16-inch as built pipe and 370 ft-amsl for the proposed 20-inch pipe. As shown in **Attachment C** the MASW data were interpreted to a bottom elevation of 390 to 400 ft-amsl and the seismic refraction data were interpreted to a bottom elevation that varied from 450 to 500 ft-amsl. However, data were able to be interprested to elevations reflective of the descent of the profile to maximum depth after entry and at depths associated with ascent of the profile prior to exit. As such, the geophysical data is very useful for assessing variations in bedrock conditions along those sections of the profile where the IR occurred during installation of the 16-inch line and where IRs would most likely occur along the proposed 20-inch profile.

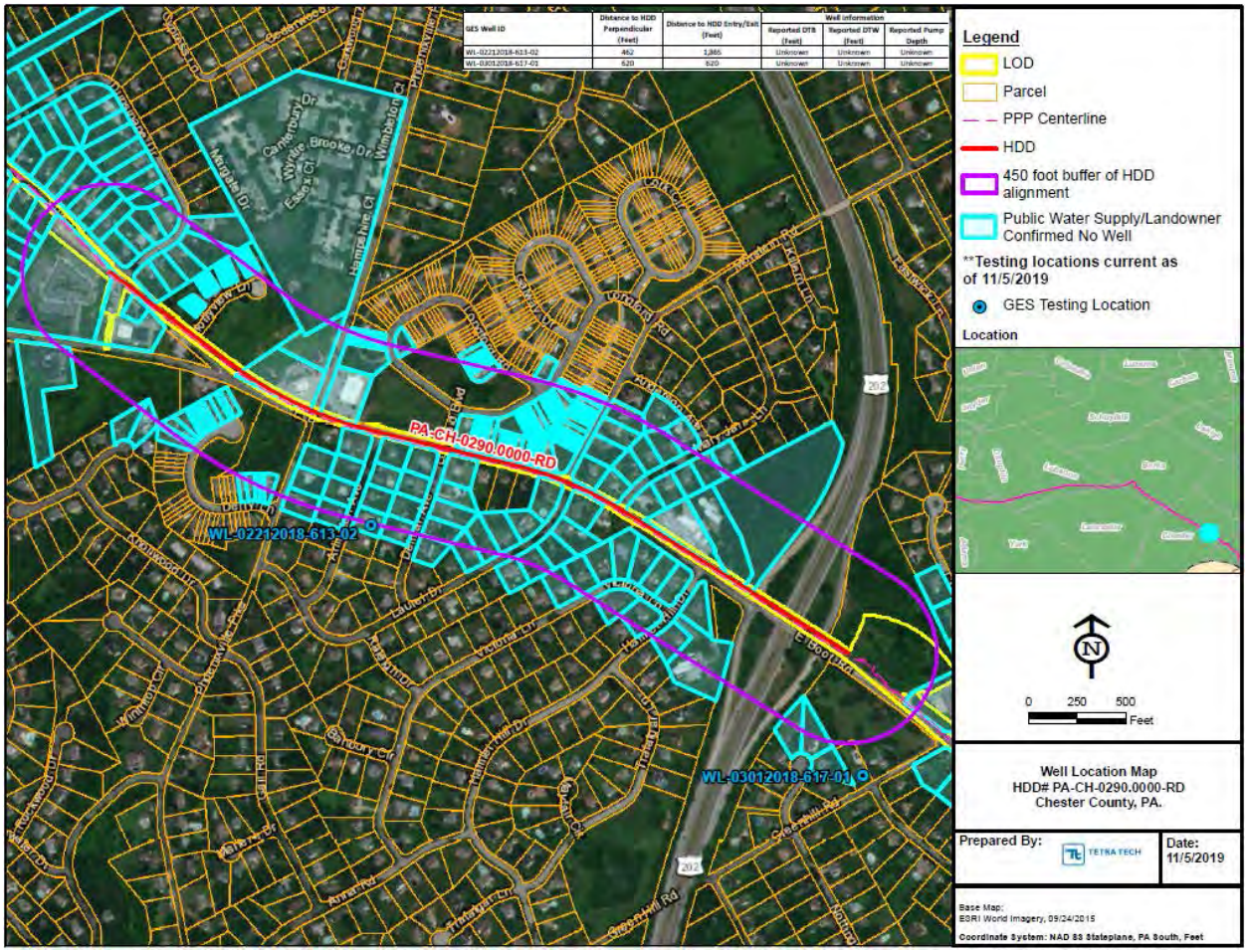


Figure 5. Well Search Map - Properties within 450 feet of HDD Alignment

The seismic refraction method yielded an interpretation that generally depicts the base of rippable bedrock (approximate base of saprolite) at a maximum of 45 ft bgs. Deeper zones of rippable bedrock are shown in the areas of Station 13+00 and 16+20 on the profiles in **Attachment C**. Although the Station 13+00 area is within a zone of low data density, one of the fracture traces described in Section 2.2.4 crosses the alignment there. Other zones of low velocity anomalies occur centered on Stations 3+25 and 35+30. Also of note is the abrupt change in the base of rippable bedrock at the contact between the Peters Creek tectonite and Wissahickon schist.

The MASW method yielded an interpretation that depicts near vertical low velocity zones (faults, fractures, or highly weathered zones) at Stations 4+75, 7+25 and 15+75 on the profiles in **Attachment C**. The depth to rippable bedrock surrounding these zones is generally shown as being much deeper than 45 ft bgs. The low velocity zone at Station 15+75 correlates with deeper zone of rippable bedrock identified on the seismic refraction profile at Station 16+20. The contact between the Peters Creek tectonite and Wissahickon schist occurs between the low velocity zones at Stations 4+75 and 7+25 which may be indicative of faulting at the contact.

The IRs that occurred during drilling for installation of the 16-inch line, described in Section 3.0, were punch-out IRs that occurred between Stations 1+01 and 1+68 at the end the pilot hole, and do not appear to be related to any structural features identified by either the geophysical surveys or fracture trace analysis.

3.0 HDD OBSERVATIONS TO DATE

3.1 On This HDD Alignment

Drilling commenced for installation of the 20-inch line at S3-0421 on 7/15/2017. By 7/20/17, the pilot hole had been advanced 783 of the planned 4,330 total planned horizontal distance from the northwest entry/exit towards the southeast entry/exit, without any IRs. At that time, construction activity at S3-0421 was suspended and was not reinitiated until 4/3/2019. In the interim, SPLP elected to install the 16-inch line first. Upon reinitiation, the pilot hole for the 16-inch line was advanced from the southeast entry/exit to the northwest entry/exit. By 5/24/19, the pilot reached a distance of 4,066 of the planned 4,340 total horizontal distance and experienced a loss of circulation (LOC) but no IR occurred. This placed the cutting face 63 percent along the ascent to exit on the profile at a depth of approximately 75 feet.

In response to the LOC, on 6/1/19 the driller began drilling an intercept pilot bore from the northwest entry/exit towards the pilot hole drilled from the southeast. By 6/5/19, the intercept bore had been advanced a horizontal distance of 224 feet and was thought to have intercepted. As such, that same day, the drilling unit at the southeast completed tripping in tools and advance of the pilot hole resumed. On 6/6/19, after the pilot hole was advanced 61 feet to approximately Station 2+13, an LOC and an IR (with three upland discharges totaling 75 gallons) occurred. Two of the discharges were south of the alignment, due south of Stations 1+60 and 2+00, and the third discharge was due north of the alignment at Station 1+33 on the proposed profile. According to the initial IR report, the IR occurred as "the drilling contractor was drilling through the intersected pilot hole". These discharges were easily managed and were immediately cleaned up. They occurred as the pilot hole was ascending to exit and overburden was thinning. At the locations of the IR, overburden ranged from 27 to 44 feet thick (see proposed profile, **Attachment A**) and was likely comprised of relatively weak, highly weathered, schistose saprolite. At the end of the pilot hole for a relatively long HDD (4,371 feet horizontal distance in this case) drilling fluid pressures tend to increase in order to maintain circulation back to the drilling rig and this pressure increase may have contributed to the IR, as well. Containment was installed around these locations which continued to reactivate, from time to time, during the completion of the pilot and subsequent reams and swabs associated with HDD construction. The containments and vacuum trucks were used to manage the reactivations. The pilot hole was completed on 6/19/19. Reaming and swabbing occurred until 8/19/19 and pulling of the 16-inch pipe was completed on 8/24/19.

SPLP reported a second punch-out IR of 25 gallons that occurred on 8/19/19 within the HDD staging area. The drill was completing its final swab pass in preparation for pipe pull back. Drilling was immediately stopped upon discovery of the IR. All drilling fluid was contained within the limit of disturbance. Construction crew members used a vacuum truck to recover the drilling fluid and the driller extended the drill exit pit to encompass the punch out release location.

The upland IRs that occurred during construction of 16-inch line at HDD S3-0421 appear unrelated to any geologic discontinuities identified through fracture trace analysis or geophysical surveys, but are related to the thinning of overburden and, potentially increase in annular drilling fluid pressure, at the end of the pilot profile. The overburden bedrock is this section of the pilot hole was highly weathered and fractured and had a thickness of 0 to 44 feet.

The potential for a groundwater discharge is discussed in Section 2.3.2. On 7/20/19, during a 26-inch ream pass, the driller reported groundwater discharge of 30 to 50 gpm occurred in the returns to the mud pit at the southeast entry/exit. At the time of the discharge, the reamer was traveling from southeast to northwest and the cutting face was at approximately Station 22+40 (on proposed profile). This was a temporary discharge that was not observed after 7/20/19.

3.2 On Other HDD Alignments in Similar Hydrogeologic Settings

IRs have occurred during the drilling of other ME II HDDs in the metamorphic rocks of Chester and Delaware County. These IRs have typically occurred where bedrock is weathered and densely fractured (sometimes indicated by a fracture trace or fracture trace intersection) or where the profile approaches an entry/exit point, closer to the surface, where unconsolidated overburden material thins and there is less overburden strength to contain drilling fluid pressures. Drilling fluid pressure tend to increase at the end of relatively long HDDs in order to maintain circulation back to the drill rig. In some cases, overburden thickness is reduced where the deepest part of the profile passes under a stream occupying a section of the alignment with the lowest surface elevation along the profile.

4.0 SUMMARY AND RECOMMENDATIONS

4.1 HDD Site Conceptual Model

HDD S3-0421 is located along a developed stretch of East Boot Road and Ship Road in West Goshen and West Whiteland Townships, Chester County, PA. The HDD alignment traverses relatively flat, upland ground, with a high spot at approximately Station 31+50 on the proposed profile (see **Attachment A**). This drill lies between the East Branch Chester Creek to the west and south and Ridley Creek to the east and is mostly within the Chester Creek watershed. The only water resource crossed by the alignment is stream S-H30 (a headwater section of East Branch Chester Creek) at Station 9+70 on the proposed profile.

The drill path is mostly within the schistose bedrock of the Glenarm Wissahickon formation Greystone Schist with the northwest end extending into the Peters Creek Tectonite. In general, the alignment transects bedrock with a thick covering of highly weathered and fractured bedrock (saprolite) over more competent bedrock. Examination of geotechnical boring data and results of a geophysical study indicate the thickness of the zone of weaker material averages 45 feet but can be over 100 feet thick. A MASW geophysical survey mapped the presence of three near-vertical zones of low velocity, indicating possible fracturing or faulting. Projecting these features to the elevation of the proposed profile indicates these features cross the profile at approximately Stations 5+40, 7+20 and 16+40. Fracture trace analysis identified two potential zones of fracture concentration crossing the proposed alignment, one at approximately Station 13+50 and the other at approximately Station 38+15. Neither fracture trace, however, correlates with a potential zone of fracturing or faulting identified by the geophysical survey. The fracture trace at Station 13+50 does correlate with a possible sag in the contact between rippable and marginally rippable bedrock identified by the seismic refraction geophysical survey.

The current permitted P&P for the 20-inch line shows a profile that ranges from 0 to approximately 107 ft-bgs. The deepest, horizontal section of the permitted P&P is at an elevation of approximately 468 ft amsl. In contrast, by steepening the entrance/exit angle at the northwest entry/exit and increasing the profile radius, the proposed profile achieves a lower elevation of 370 ft amsl along the horizontal section, 98 feet deeper than the permitted profile and 30 feet deeper than the as-built profile for the 16-inch line. The only IRs that occurred during installation of the 16-inch pipe occurred as upland IRs at the end of the pilot hole, on the ascent of the profile to exit, where saprolitic overburden materials were thinning, and when annular drilling fluid pressures may have been increasing to maintain circulation. On 6/6/19, SPLP reported an IR with three discharges totaling 75 gallons that occurred within 170 feet (horizontal distance) from exit at the northwest entry/exit where the overburden was 44 feet thick or less. This IR was not associated with the geologic discontinuities indicated by the geophysical survey or fracture trace analysis. For each of the three discharge locations, all drilling fluid was contained and managed using vacuum trucks. These discharge locations reactivated from time to time during the completion of construction but were easily managed. SPLP reported a second, punch-out, IR of 25 gallons within the HDD staging area during completion of the final swab pass before the 16-inch pipe was pulled. The mud pit was extended to manage this IR. Similar occurrences of highly manageable upland IRs should be anticipated during construction of the 20-inch line.

Based on various sources of local water level data in relation to the proposed profile, most of the profile will be within saturated conditions. The elevation of the northwest entry/exit on the proposed profile is 524 ft amsl and southeast entry/exit is at 521 ft amsl. A representative water level elevation of approximately 527 feet amsl was recorded at geotechnical boring B2A located on an upland along the profile. As such, there is likely a pressure head difference between the elevation of the local water table and both entry/exits, indicating a potential for groundwater discharge during construction of the HDD. Consistent with this indication, a temporary (approximately one day) ground water discharge, between 30 and 50 gpm, occurred during the 26-inch ream for the 16-inch pipe at S3-0421.

Two private water supply wells were identified on land parcels that intersect a 450-feet survey limit drawn around the S3-0421 alignment. One of these wells is located approximately 460 feet from the alignment and the other is located approximately 620 feet from the alignment. Both have been sampled per existing HDD program protocols. Well depths and casing lengths were not available from the well owners; however, considering typical casing lengths, the elevations of the open rock groundwater production zones for these wells are likely to occur at the elevation of certain sections of the HDD proposed profile. That said, neither well owner issued a complaint during construction of the 16-inch line.

4.2 Conclusions and Recommendations

The synthesis of regional and local geologic data together with past performance during drilling for the 16-inch pipeline indicate that the risk of IRs remains, especially on the end of the pilot profile during ascent to exit. For the 16-inch line, this occurred at the northwest exit; however, a similar response would be expected at the southeast end if the pilot for the 20-inch line were drilled northwest to southeast. As such, drilling operations should account for conditions identified in this HRR to minimize the risk of IRs.

Managing drilling fluid circulation at slightly lower annular pressures and slightly higher viscosities may help to preclude LOCs and IRs. Another approach is to manage the installation using an intercept drill with the intercept completed in the horizontal run of the alignment. This would reduce increasing annular pressure with distance as the pilot approaches exit.

Two private water wells have been identified at 460 and 620 feet from the alignment of the 20-inch line. These wells will continue to be included in SPLP's groundwater monitoring program and the landowners will be afforded a post-construction sampling event after installation of the 20-inch line.

Based on information provided by, and the expertise of, the HDD team, as well as our experience with the relevant hydrogeology and geology, GES believes that implementation of the planned profile for the 20-inch line at S3-0421 and best management practices inherent to the ME II construction project, including station specific references to areas of concern identified in this HRR, will minimize the risk of IRs and minimize the likelihood of an impact to the environment. Furthermore, based on such information, expertise and experience, GES believes that implementation of the proposed 20-inch P&P for S3-0421 profile represents a very small risk of any impact to an active private water supply based on distance to identified private water sources.

REFERENCES

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Bosbyshell, H., 2006, Bedrock Geologic Map of the Chester Valley and Piedmont Portion of the Germantown, Malvern, Norristown, and Valley Forge Quadrangles, Chester, Delaware, Montgomery, and Philadelphia Counties, Pennsylvania, OFR OFBM-06-4.0, Pa. Geol. Surv., 4th Ser.

Geyer, Alan R. and J. Peter Wilshusen (1982*). Engineering Characteristics of the Rocks of Pennsylvania*. Department of Environmental Resources, Office of Resources Management, Bureau of Topographic and Geologic Survey. Harrisburg, PA, Environmental Geology Report 1, 1982.

Websites

PaGEODE, Pennsylvania Department of Conservation and Natural Resources. http://www.gis.dcnr.state.pa.us/geology/

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

Pennsylvania Groundwater Information System (PAGWIS), http://www.docs.dcnr.pa.gov/topogeo/groundwater/pagwis/records/index.htm

Pennsylvania Imagery Navigator, http://maps.psiee.psu.edu/ImageryNavigator

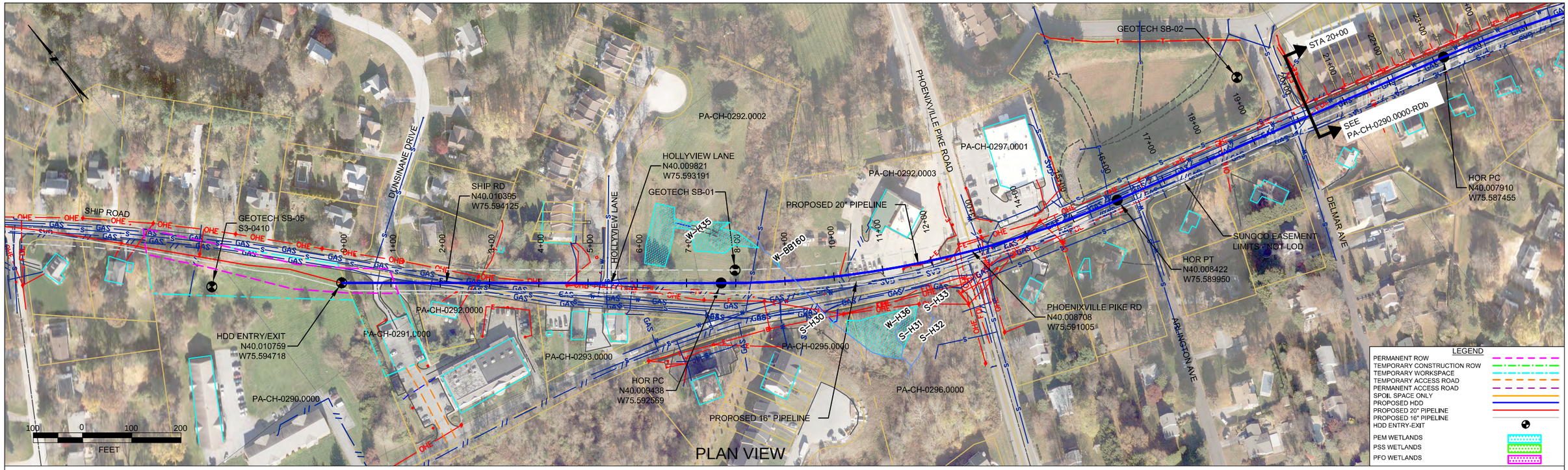
United States Department of Agriculture - Natural Resources Conservation Service (USDA NRCS) Web Soil Survey, https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Attachment A

Plans and Profiles

Permitted Plan and Profile, rev. 9/30/16

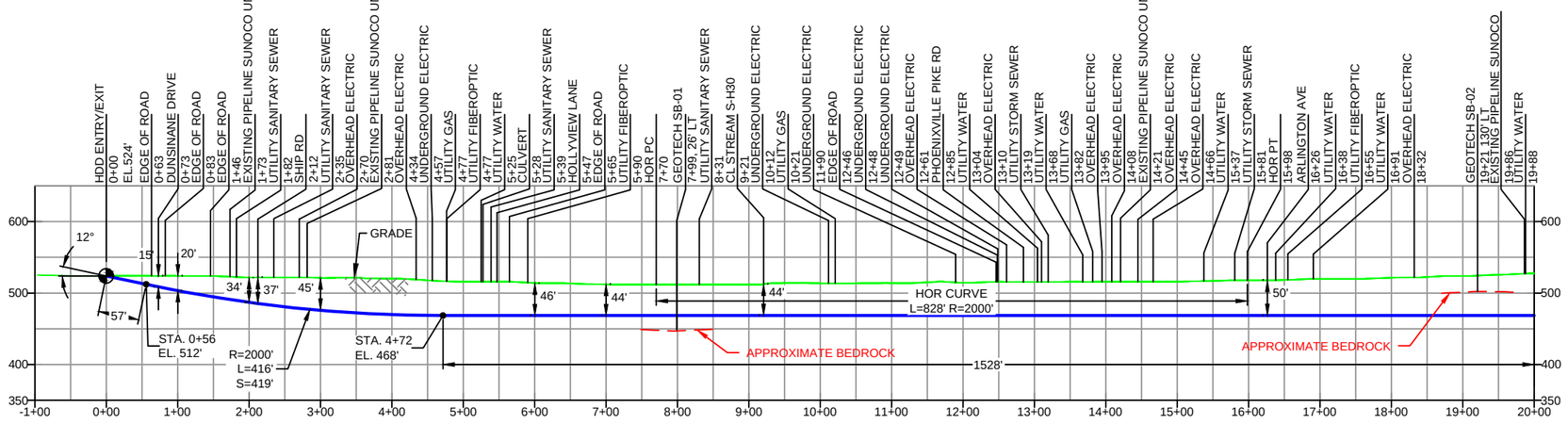
Proposed Plan and Profile, rev. 12/11/19 showing geology,
as-built 16-inch profile, and IRs



PLAN VIEW

PROFILE VIEW

WEST WHITELAND COUNTY, PENNSYLVANIA - CHESTER TOWNSHIP
WEST GOSHEN COUNTY, PENNSYLVANIA - CHESTER
S3-0421A



GEOTECH SB-01

-NG EL. 512'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 11.0')
-GROUNDWATER (23.0')
-SM (11.5' - 63.5')
-FRACTURED SCHIST (63.5' - 65.0')
-COMPLETION DEPTH EL. 447'

GEOTECH SB-02

-NG EL. 522'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.5')
-MICA SCHIST (8.5' - 14.0')
-WEATHERED SCHIST (14.0' - 22.0')
-COMPLETION DEPTH EL. 500'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-05

-NG EL. 530'
-TOPSOIL (0' - 0.5')
-GROUNDWATER (8.0')
-SM (0.5' - 23.5')
-WEATHERED SCHIST (23.5' - 24.4')
-COMPLETION DEPTH EL. 505'

NOTE: REFER TO TEST BORING LOG S3-0410 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

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2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4350'
   HDD PIPE LENGTH (S=):4357'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-6.54	TO	ES-6.56	EROSION & SEDIMENT PLAN
SHEET 36	TO	SHEET 38	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	JVA	03/26/15	RMB	03/26/15	AAW	03/26/15

Sunoco Logistics Partners L.P.

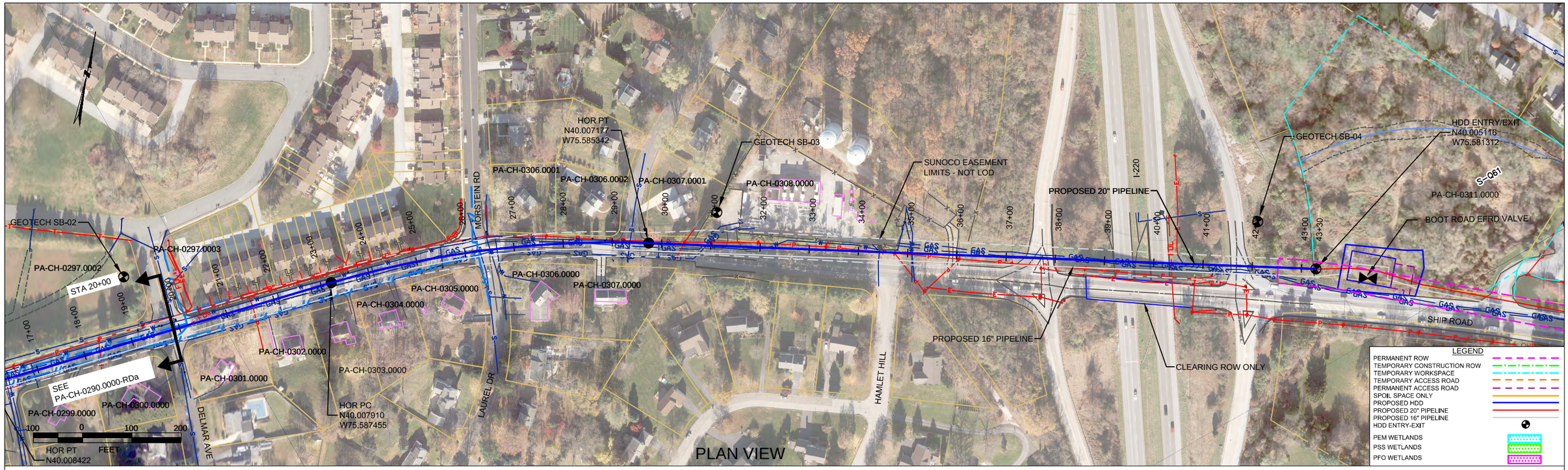
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

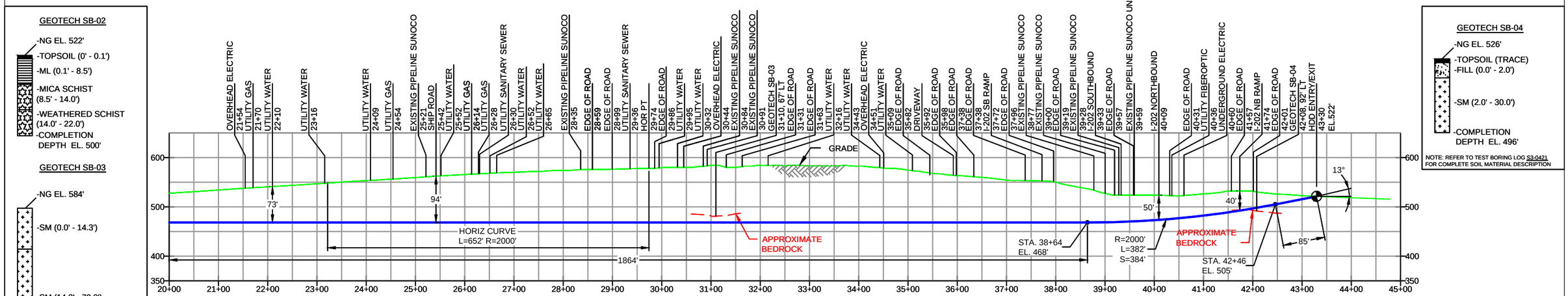
DWG. NO: PA-CH-0290.0000-RDa



PLAN VIEW

PROFILE VIEW

WEST WHITELAND COUNTY, PENNSYLVANIA - CHESTER TOWNSHIP
WEST GOSHEN COUNTY, PENNSYLVANIA - CHESTER
S3-0421B



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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4350'
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   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
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NOTES

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REF. DRAWING

ES-6.54	TO	ES-6.56	EROSION & SEDIMENT PLAN
SHEET 36	TO	SHEET 38	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
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EP		MRS	11/13/15	RMB	11/13/15	AAW	11/13/15
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	JVA	03/26/15	RMB	03/26/15	AAW	03/26/15

Sunoco Logistics Partners L.P.

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SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

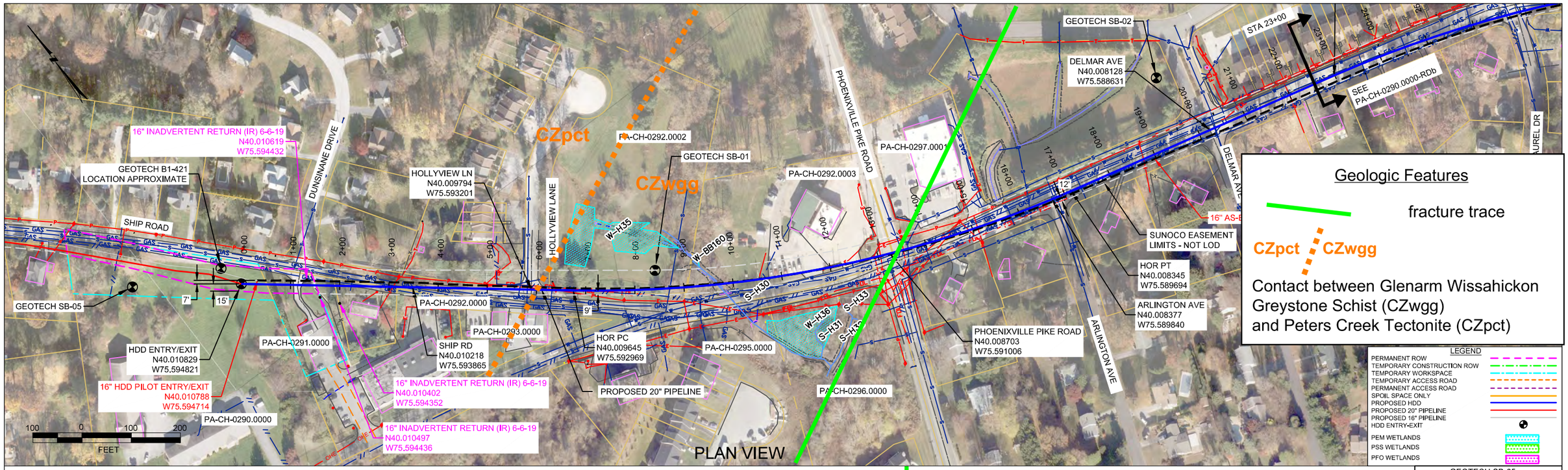
SCALE: 1"=200'

DWG. NO: PA-CH-0290.0000-RDb

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421

PLAN VIEW

PROFILE VIEW



Geologic Features

fracture trace

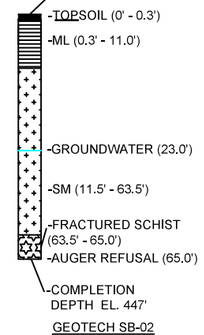
CZpct CZwgg

Contact between Glenarm Wissahickon Greystone Schist (CZwgg) and Peters Creek Tectonite (CZpct)

LEGEND

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

GEOTECH SB-01



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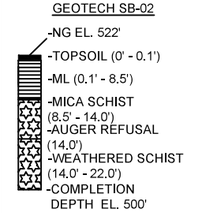
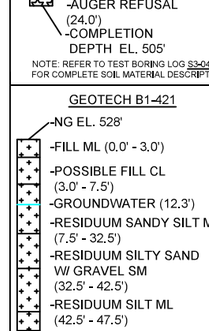


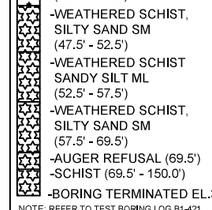
NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-05



NOTE: REFER TO TEST BORING LOG S3-0410 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-421



NOTE: REFER TO TEST BORING LOG B1-421 INTERTEK PSI PROJECT #04911508 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4391'
   HDD PIPE LENGTH (S=):4423'
   20" x 0.456" W.T., X-65, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

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

REF. DRAWING

ES-6,54	TO	ES-6,56	EROSION & SEDIMENT PLAN
SHEET 36	TO	SHEET 38	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED 16" AS-BUILT, IR INFORMATION AND INCREASED DEPTH OF 20" DESIGN PER CLIENT REQUEST	MRS	12/11/19	RMB	12/11/19	AMC	12/11/19
EP4	ADDED ADDITIONAL GEOTECH INFORMATION	MRS	02/08/19	RMB	02/08/19	AMC	02/08/19
EP3	LOWERED DRILL BOTTOM ELEVATION TO 400' AND SWITCHED CENTERLINE PER CLIENT REQUEST	MRS	03/15/18	RMB	03/15/18	AMC	03/15/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16

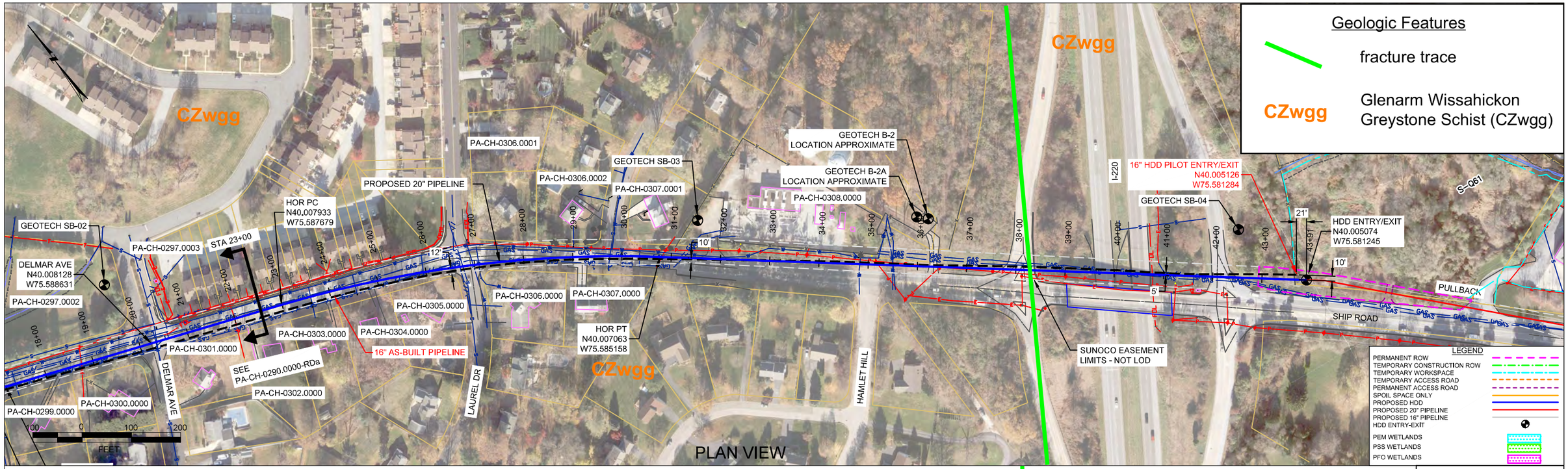
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

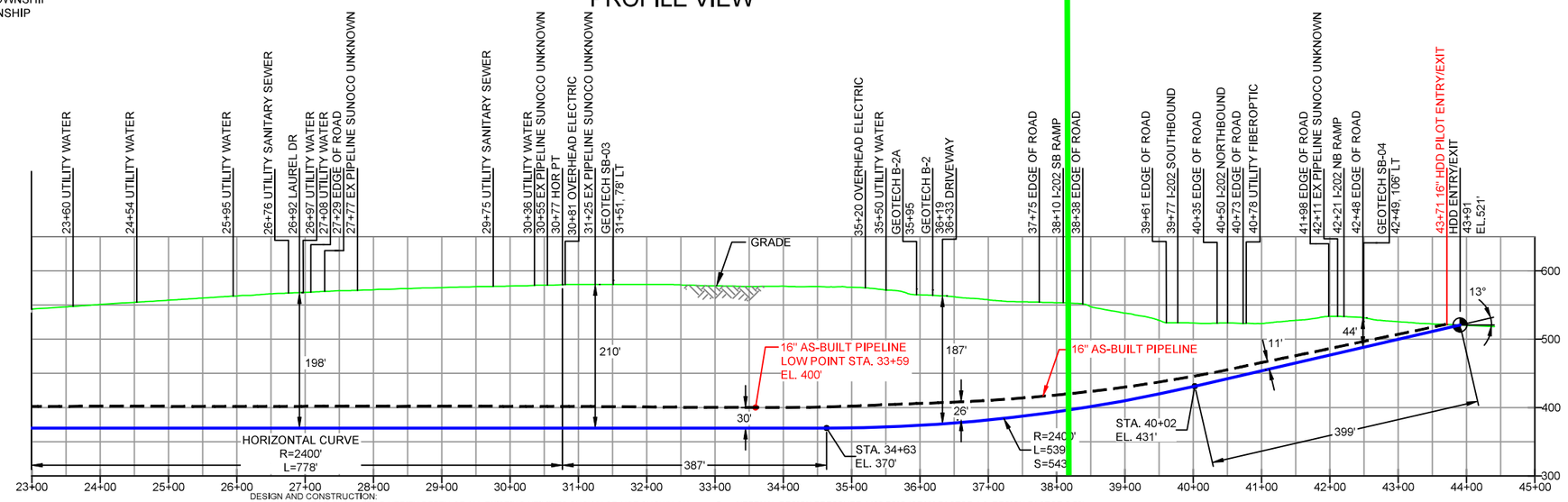
HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' | DWG. NO: PA-CH-0290.0000-RDa



CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421

PROFILE VIEW



GEOTECH SB-02
-NG EL. 522'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.5')
-MICA SCHIST (8.5' - 14.0')
-AUGER REFUSAL (14.0')
-WEATHERED SCHIST (14.0' - 22.0')
-COMPLETION DEPTH EL. 500'

GEOTECH SB-03
-NG EL. 584'
-SM (0.0' - 14.3')
-SM (14.3' - 70.0')
-GROUNDWATER (68.0')
-DRILLING TERMINATED EL. 514'

GEOTECH SB-04
-NG EL. 526'
-TOPSOIL (TRACE)
-FILL (0.0' - 2.0')
-SM (2.0' - 30.0')
-COMPLETION DEPTH EL. 496'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2
-NG EL. 572'
-TOPSOIL (0' - 0.42')
-FILL, SANDY SILT ML (0.42' - 2.0')
-RESIDUUM SILTY SAND W/ GRAVEL SM (2.0' - 8.0')
-WEATHERED SCHIST, SILTY SAND SM (8.0' - 32.5')
-SCHIST (32.5' - 124.0')
-BORING TERMINATED EL.448'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PSI PROJECT #04911526 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2A
-NG EL. 574'
-AUGERED WITHOUT SAMPLING (0.0' - 31.0')
-GROUNDWATER (27.0')
-SCHIST (32.5' - 245.0')
-BORING TERMINATED EL.329'

NOTE: REFER TO TEST BORING LOG B-2A INTERTEK PSI PROJECT #04911526 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 4391'
   HDD PIPE LENGTH (S=): 4423'
   20" x 0.456" W.T., X-65, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

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

REF. DRAWING

ES-6.54	TO	ES-6.56	EROSION & SEDIMENT PLAN	
SHEET 36	TO	SHEET 38	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED 16" AS-BUILT, IR INFORMATION AND INCREASED DEPTH OF 20" DESIGN PER CLIENT REQUEST	MRS	12/11/19	RMB	12/11/19	AMC	12/11/19
EP4	ADDED ADDITIONAL GEOTECH INFORMATION	MRS	02/08/19	RMB	02/08/19	AMC	02/08/19
EP3	LOWERED DRILL BOTTOM ELEVATION TO 400' AND SWITCHED CENTERLINE PER CLIENT REQUEST	MRS	03/15/18	RMB	03/15/18	AMC	03/15/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	11/13/15	RMB	11/13/15	AAW	11/13/15

Sunoco Logistics Partners L.P.

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SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

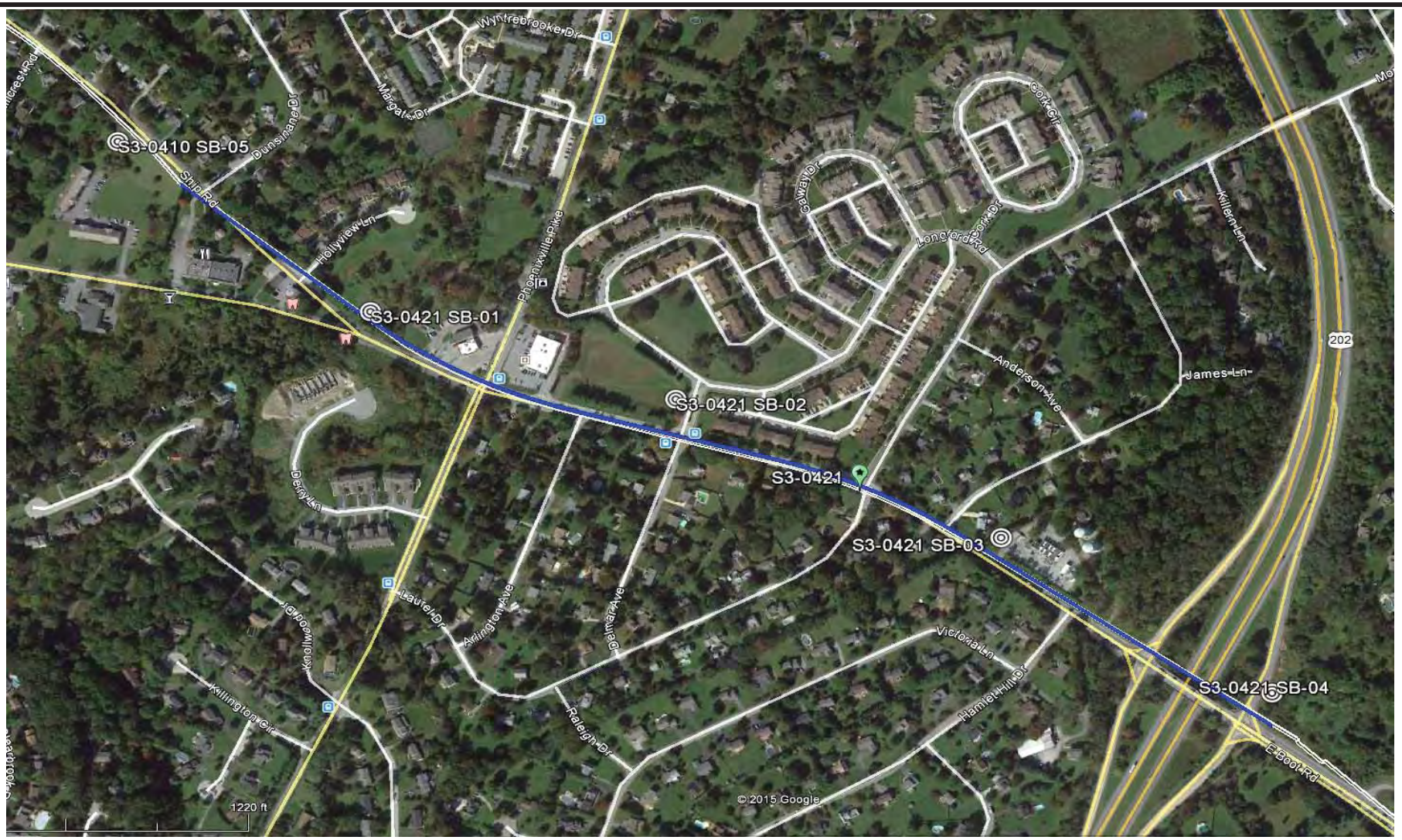
DWG. NO: PA-CH-0290.0000-RDb

Attachment B

Geotechnical Boring Logs

Tetra Tech - 2015

PSI/Intertek - 2017



LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0421
CHESTER COUNTY, W. WHITELAND/GOSHEN TWP, 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:	NORTHWYN CT APTS, 803 BOOT ROAD, WEST CHESTER, PA		Page 1 of 1
HDD No.:	S3-0410	Dates(s) Drilled: 08-04-15	Inspector: J. COSTELLO
Boring No.:	SB-05	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 8.0	Total Depth (ft): 24.4
Boring Location Coordinates:		40° 0' 40.30" N	75° 35' 43.63" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.5			TOPSOIL (6")					
1	3.0	5.0	0.5		16		DR, VARIEGATED BROWN FINE TO MEDIUM SAND (WITH LAYERS OF	1	4	4	4	**8**
							MICA SCHIST), SOME SILT.					
2	8.0	10.0			15		DR, VARIEGATED BROWN AND REDDISH BROWN FINE TO MEDIUM	1	4	5	7	**9**
						SM	SAND, SOME SILT, MICACEOUS.					
3	13.0	15.0			12		DR, GRAY AND REDDISH BROWN FINE TO MEDIUM SAND (WITH LAYERS	1	5	10	21	**15**
							OF MICA SCHIST), SOME SILT.					
4	18.0	20.0			14		HIGHLY WEATHERED GRAY SCHIST.	7	5	21	27	**26**
				23.5								
5	23.0	24.4	23.5		14		DARK GRAY HIGHLY WEATHERED TO PARTIALLY WEATHERED	7	32	50/5"		**>50**
				24.4			SCHIST.					
							AGUER REFUSAL AT 24'.					
							WET ON SPOON AT 8'.					
							WATER LEVEL THROUGH AUGERS AT 8.					
							CAVED AT 21.5', WATER LEVE ON CAVE AT 2.5'.					
							PETROLEUM ODORS APPARENT WITHIN SAMPLES 3 TO 5,					
							AND DURING AUGURING.					

Notes/Comments:
Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

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

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

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	HOLLYVIEW LAND, WEST CHESTER, PA		Page 1 of 1
HDD No.:	S3-0421	Dates(s) Drilled: 12-16-15	Inspector: J. COSTELLO
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: E. ODGEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): SEE BELOW	Total Depth (ft): 65.0
Boring Location Coordinates:		40° 0'34.01"N	75°35'32.69"W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.3			TOPSOIL (3")					
1	3.0	5.0	0.3		21	ML	DR, MOTTLED BROWN AND GRAY SILT AND FINE SAND,	1	5	6	7	**11**
							MICACEOUS.					
2	8.0	10.0			17		DR, MOTTLED REDDISH BROWN AND GRAY SILT AND FINE SAND,	1	2	4	4	**6**
				11.5			MICACEOUS (USCS: ML).					
3	13.0	15.0	11.5		24	SM	DR SHIST, VARIEGATED BROWN AND GRAY FINE SAND WITH SOME	1	1	4	7	**5**
							SILT, MICACEOUS.					
4	18.0	20.0			24		SAME	1	3	6	8	**9**
5	23.0	25.0			24		DR SCHIST, VARIEGATED BROWN AND GRAY MICACEOUS FINE SAND	1	8	15	21	**23**
							AND SILT, TRACE FINE UNWEATHERED ROCK FRAGS.					
6	28.0	30.0			24		SAME	2	9	22	24	**31**
7	33.0	35.0			10		SAME	1	3	8	10	**11**
8	38.0	40.0			16		SAME	1	13	22	39	**35**
9	43.0	45.0			20		DR SCHIST, VARIEGATED BROWN AND GRAY MICACEOUS FINE SAND	1	3	12	22	**15**
							AND SILT, TRACE BLACK NODULES, TRACE FINE ROCK FRAGS.					
10	48.0	49.9			14		SAME	3	8	27	50/5"	**35**
11	53.0	55.0			12		DR, VARIEGATED WHITE, RED, BROWN FINE SAND AND SILT.	1	5	10	18	**15**
							(USCS: SM) (WEATHERED SCHIST)					
12	58.0	60.0			11		DR, VARIEGATED GRAY AND WHITE FINE SAND, SOME SILT, TRACE	1	5	6	28	**11**
				63.5			FINE UNWEATHERED ROCK FRAGS., MICACEOUS.					
13	63.0	64.4	63.5	65.0	10		PARTIALLY WEATHERED GNEISS OR SCHIST.	5	50	50/5"		**>50**
							AUGER REFUSAL AT 65'.					
							WATER LEVEL THROUGH AUGERS AT 23' (MAY BE PERCHED).					
							CAVED AND WET AT 55'.					

Notes/Comments:

Pocket Pentrometer Testing
S1: 2.5 TSF
S2: 1.5 TSF

DR: DECOMPOSED ROCK

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

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

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	INTERSECTION OF BOOT ROAD AND LONGFORD BLVD, WEST CHESTER, PA		Page 1 of 1
HDD No.:	S3-0421	Dates(s) Drilled: 08-30-15	Inspector: J.COSTELLO
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: E.ODEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 22.0
Boring Location Coordinates:		40° 0' 30.750" N	75° 35' 19.318" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.1			TOPSOIL (2")					
1	3.0	5.0	0.1		19	ML	DARK BROWN SILT AND FINE SAND, POTENTIALLY ORGANIC, TRACE	4	3	4	4	**7**
				8.5			F-C GRAVEL (APPARENT FILL MATERIAL).					
2	8.0	8.8			6		WEATHERED TO PARTIALLY WEATHERED MICA SCHIST.	13	50/3"			**>50**
							AUGER REFUSAL AT 12.5', OFF-SET BORING 10' NORTH AND					
							CONTINUOUSLY AURGERED TO 13'.					
3	13.0	13.9			5		WEATHERED TO PARTIALLY WEATHERED MICA SCHIST.	41	50/5"			**>50**
							AUGER REFUSAL AT 14'.					
							ROCK CORING					
RUN 1	14.0	16.0	14.0		23	FRACTURED SCHIST	VARIEGATED GRAY SCHIST WITH MICA, PARTIALLY DECOMPOSED,	TCR: 96%, SCR: 33%, RQD: 24.5%				
							INTENSELY FRACTURED.					
RUN 2	16.0	22.0		22.0	72		MODERATELY FRACTURED VARIEGATED GRAY SCHIST, MICA.	TCR: 100%, SCR: 46%, RQD: 42%				
							DRY AND CAVED AT 13'.					
							CORE TESTING RESULTS (RUN 2, DEPTH 20-21.5'):					
							COMPRESSIVE STRENGTH: 4,040 PSI					
							UNIT WEIGHT: 154.2 PCF					

Notes/Comments:
Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

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

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

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	SUNOCO BOOT ROAD PUMP STATION, WEST CHESTER, PA		Page 1 of 1
HDD No.:	S3-0421	Dates(s) Drilled: 06-28-15	Inspector: E. WATT
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 68.0	Total Depth (ft): 70.0
Boring Location Coordinates:		40° 0' 25.653" N	75° 35' 5.227" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.0			TOPSOIL (NONE, GRAVEL SURFACE)					
1	3.0	5.0	0.0		18		BROWN AND ORAGNE BROWN MICACEOUS FINE SAND, SOME SILT,	1	2	3	4	**5**
						SM	TRACE UNWEATHERED FINE GRAVEL.					
2	8.0	10.0			14		DR SCHIST, VARIEGATED BROWN, ORANGE BROWN, LIGHT GRAY	5	6	5	5	**11**
				14.3			FINE TO MEDIUM SAND, SOME SILT, TRACE FINE SCHIST GRAVEL.					
3	13.0	15.0	14.3		24		DR SCHIST, VARIEGATED WHITE AND ORANGE BROWN FINE TO	6	23	32	35	**86**
							MEDIUM SAND, SOME SILT, TRACE FINE SCHIST GRAVEL.					
4	18.0	18.5			6		DR SCHIST, BROWN FINE TO MEDIUM SAND, SOME SILT, WITH A	50/6"				**>50**
							LITTLE FINE TO COARSE SCHIST GRAVEL.					
5	23.0	23.5			6		DR SCHIST, BROWN FINE TO MEDIUM SAND, TRACE SILT, WITH A	50/6"				**>50**
							LITTLE TO SOME F-C SCHIST GRAVEL.					
6	28.0	28.5			6		DR SCHIST, VARIEGATED SHADES OF BROWN FINE TO MEDIUM SAND,	50/6"				**>50**
							LITTLE SILT, WTH A LITTLE F-C SCHIST GRAVEL.					
7	33.0	33.4			5		SAME	50/5"				**>50**
8	38.0	38.4			5		SAME	50/5"				**>50**
						SM						
9	43.0	43.5			5		DR SCHIST, VARIEGATED SHADES OF BROWN FINE TO MEDIUM SAND,	50/6"				**>50**
							SOME SILT, WTH A LITTLE F-C SCHIST GRAVEL.					
10	48.0	48.5			5		DR SCHIST, VARIEGATED SHADES OF BROWN FINE TO MEDIUM SAND,	50/6"				**>50**
							LITTLE SILT, WTH A LITTLE F-C SCHIST GRAVEL.					
11	53.0	53.3			4		SAME	50/4"				**>50**
12	58.0	58.3			3		SAME	50/3"				**>50**
13	63.0	63.3			3		DR SCHIST, GRAY TO DARK GRAY FINE TO MEDIUM SAND, LITTLE	50/3"				**>50**
							SILT, WITH A LITTLE F-C SCHIST GRAVEL.					
14	68.0	68.4		70.0	5		SAME, STARTED TO GET WET, STRONG PERTROLEUM ODOR.	50/5"				**>50**
							DISCONTIUED DRILLING AT 70'; DID NOT WANT TO					
							BRING UP PETROLEUM ODOR CUTTINGS TO SURFACE DUE TO					
							NEARBY RESIDENTS.					

Notes/Comments:
Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

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

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

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	N202 ON-RAMP FROM BOOT ROAD, WEST CHESTER, PA		Page 1 of 1
HDD No.:	S3-0421	Dates(s) Drilled: 06-18-15	Inspector: J.COSTELLO
Boring No.:	SB-04	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 30.0
Boring Location Coordinates:		40° 0' 19.841" N	75° 34' 53.309" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.0			TOPSOIL (TRACE")					
			0.0	2.0		FILL	FILL MATERIALS - SILT AND FINE SAND, CRUSHED GRAVEL.					
1	3.0	5.0	0.0		14		DR SCHIST, VARIEGATED REDDISH BROWN, BROWN, GRAY FINE TO	1	4	5	6	**9**
							MEDIUM SAND, SOME SILT, TRACE UNWEATHERED GRAVEL.					
2	8.0	10.0			18		DR SCHIST, VARIEGATED LIGHT GRAY TO TAN, FINE TO MEDIUM	4	9	12	19	**21**
							SAND WITH ALITTLE SILT, TRACE UNWEATHERED FINE GRAVEL.					
3	13.0	14.5			18		DR SCHIST, LIGHT GRAY TO TAN, FINE TO MEDIUM SAND WITH SOME	9	36	50/6"		**86**
							SILT, TRACE UNWEATHERED FINE GRAVEL.					
4	18.0	18.9			10	SM	DR SCHIST, LIGHT GRAY TO TAN, FINE TO MEDIUM SAND WITH SOME	7	50/5"			**>50**
							SILT, TRACE UNWEATHERED F-C GRAVEL.					
5	23.0	24.0			10		DR SCHIST, VARIEGATED OLIVE, GRAY, BROWN FINE TO MEDIUM	4	50/6"			**>50**
							SAND, SOME SILT, WITH LAYERING OF UNWEATHERED SCHIST.					
6	28.0	29.3			14		DR SCHIST, VARIEGATED OLIVE, GRAY, BROWN FINE TO MEDIUM	4	42	50/3"		**>50**
				30.0			SAND, SOME SILT, WITH LAYERING OF UNWEATHERED SCHIST.					
							AUGERED TO 30'.					
							CAVED AND DRY AT 29'.					

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.

BORING B1-421

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	11/1/17	**DRILLER:** M. Shepard	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME-85 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.998-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

Water
- 10/31/2017 @ 1:28 p.m. 23.8 feet
- 11/2/2017 @ 9:57 a.m. 12.3 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ Moisture × PL ◪ LL ✚ (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	0			S-1	15	**FILL**-Gray-brown, Gravelly SILT with Sand, moist	ML	WH-3-8-8 N=11	14		
	5			S-2	19	**Possible FILL**-Brown, Sandy Lean CLAY, trace Gravel, moist	CL	2-4-4-4 N=8	19		LL = 33 PL = 23
	10			S-3	19	**RESIDUUM**-Soft, Light red-yellow-brown, Sandy SILT, micaceous, moist	ML	3-2-2-3 N=4	33		Non-Plastic Fines=65.4%
	15			S-4	20	**RESIDUUM**-Medium Stiff to Stiff, Yellow-brown to light brown to gray-brown, Sandy SILT, trace Gravel, micaceous, moist		2-3-5-4 N=8	31		
	20			S-5	17		ML	2-2-3-4 N=5	30		Fines=60.1%
	25			S-6	21			3-4-5-5 N=9	32		
	30										

Continued Next Page

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Total Quality. Assured.

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911508
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike (PPP6)
Chester Co., PA
PA-CH-0311.0000-RDa-16/PO#20171027

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

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	11/1/17	**DRILLER:** M. Shepard	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME-85 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.998-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

BORING B1-421

Water
- 10/31/2017 @ 1:28 p.m. 23.8 feet
- 11/2/2017 @ 9:57 a.m. 12.3 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / STRENGTH, tsf	Additional Remarks
	30			S-7	24	**RESIDUUM**-Medium Stiff to Stiff, Yellow-brown to light brown to gray-brown, Sandy SILT, trace Gravel, micaceous, moist	ML	2-4-4-5 N=8	23		Non-Plastic Fines=61.3%
	35			S-8	24	**RESIDUUM**-Medium Dense, Light brown to light gray-brown, Silty SAND with Gravel, micaceous, moist	SM	4-6-8-10 N=14	26		
	40			S-9	15			3-8-11-12 N=19	20		Fines=37.6%
	45			S-10	11	**RESIDUUM**-Very Stiff, Light brown, SILT with Sand, trace Gravel, micaceous, moist *Wet spoon	ML	7-10-14-16 N=24	25		Non-Plastic Fines=72.6%
	50			S-11	17	**Highly Weathered Mica SCHIST Sampled As:**-Very Dense, Light brown, Silty SAND, trace Gravel, moist *Wet spoon	SM	22-45-50/5"	15	>>	
	55			S-12	11	**Highly Weathered Mica SCHIST Sampled As:**-Very Stiff, Light brown, Sandy SILT, trace Gravel, moist *Wet spoon	ML	13-13-14-20 N=27	22		Fines=63.9%
	60						SM			>>	

Continued Next Page

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PROJECT NO.: 04911508
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike (PPP6)
Chester Co., PA
PA-CH-0311.0000-RDa-16/PO#20171027

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

BORING B1-421

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	11/1/17	**DRILLER:** M. Shepard	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME-85 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.998-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

Water
- 10/31/2017 @ 1:28 p.m. 23.8 feet
- 11/2/2017 @ 9:57 a.m. 12.3 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / STRENGTH, tsf	Additional Remarks
	60			S-13	12	**Highly Weathered Mica SCHIST Sampled As:**-Dense to Very Dense, Light brown to gray-brown, Silty SAND, trace Garvel, micaceous, moist *Wet spoons		12-23-30-46 N=53	17		
	65			S-14	17		SM	17-20-25-26 N=45	14		Fines=34.5%
				S-15	2	Rollerbit refusal @ 69.5 feet		50/2"	12		
	70			R-1	0	**Highly Weathered Mica SCHIST**-No recovery from rock coring operations.		RQD=0 Rec=0%			1 min. 1 min. 1 min. 2 min. 1 min.
	75			R-2	0			RQD=0 Rec=0%			1 min. 1 min. 1 min. 1 min. 1 min.
	80			R-3	1	Recovery from core run R-3 consisted of two gravel-sized fragments of mica schist.		RQD=0 Rec=1%			1 min. 1 min. 2 min. 3 min. 2 min.
	85			R-4	0			RQD=0 Rec=0%			1 min. 2 min. 2 min. 3 min. 2 min.
	90					*Continued Next Page*					

STANDARD PENETRATION TEST DATA: N in blows/ft ◎; Moisture ×; PL ◪; LL ✚; 0 25 50
STRENGTH, tsf: ▲ Qu ✳ Qp; 0 2.0 4.0

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PROJECT NO.: 04911508
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike (PPP6)
Chester Co., PA
PA-CH-0311.0000-RDa-16/PO#20171027

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

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	11/1/17	**DRILLER:** M. Shepard	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME-85 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.998-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

BORING B1-421

Water
10/31/2017 @ 1:28 p.m. 23.8 feet
11/2/2017 @ 9:57 a.m. 12.3 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	90			R-5	20	**Mica SCHIST**-Yellow-gray-brown to dark gray-brown, Weathered to Highly Weathered, very broken to massive, moderately hard to hard		RQD=8 Rec=33%			5 min. 5 min. 4 min. 8 min. 6 min.
	95			R-6	18			RQD=20 Rec=29%			7 min. 4 min. 2 min. 4 min. 1 min.
	100			R-7	0	**Highly Weathered Mica SCHIST**-No recovery from rock coring operations.		RQD=0 Rec=0%			1 min. 1 min. 3 min. 4 min. 2 min.
	105			R-8	0			RQD=0 Rec=0%			2 min. 1 min. 3 min. 5 min. 2 min.
	110			R-9	0			RQD=0 Rec=0%			1 min. 2 min. 2 min. 2 min. 1 min.
	115			R-10	0			RQD=0 Rec=0%			1 min. 3 min. 2 min. 2 min. 2 min.
	120					*Continued Next Page*					

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PROJECT NO.: 04911508
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike (PPP6)
Chester Co., PA
PA-CH-0311.0000-RDa-16/PO#20171027

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

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	11/1/17	**DRILLER:** M. Shepard	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME-85 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.998-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

BORING B1-421

Water
10/31/2017 @ 1:28 p.m. 23.8 feet
11/2/2017 @ 9:57 a.m. 12.3 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	120			R-11	42	**Mica SCHIST**-Green-gray to dark gray-brown, Weathered to Slightly Weathered, very broken to massive, moderately hard		RQD=28 Rec=70%			2 min. 4 min. 7 min. 11 min. >> Q_u = 121.5 tsf 5 min.
	125			R-12	55			RQD=63 Rec=92%			4 min. 5 min. >> Q_u = 128.5 tsf 5 min. 7 min. 7 min.
	130			R-13	38	Some vertical fractures from 128.5 to 133.5 feet.		RQD=21 Rec=63%			5 min. 2 min. 2 min. 6 min. >> Q_u = 86.8 tsf 9 min.
	135			R-14	60	Increased RPMs of core barrel. Partial loss of water return from ~136 feet to test boring termination.		RQD=94 Rec=100%			2 min. 3 min. 3 min. 4 min. 4 min.
	140			R-15	60			RQD=78 Rec=100%			4 min. 4 min. >> Q_u = 98.9 tsf 5 min.
	145			R-16	60	**Mica SCHIST**-Gray, Slightly Weathered, slightly broken to massive, moderately hard to hard		RQD=88 Rec=100%			5 min. 6 min. >> Q_u = 480.8 tsf 5 min. 5 min. 5 min.
	150			R-17	18			RQD=81			>> Q_u = 390.5 tsf 3 min.

Continued Next Page

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PROJECT NO.: 04911508
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike (PPP6)
Chester Co., PA
PA-CH-0311.0000-RDa-16/PO#20171027

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

BORING B1-421

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	11/1/17	**DRILLER:** M. Shepard **LOGGED BY:** F. Hoffman	
COMPLETION DEPTH	150.0 ft	**DRILL RIG:**	CME-85 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.998-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

Water
- 10/31/2017 @ 1:28 p.m. 23.8 feet
- 11/2/2017 @ 9:57 a.m. 12.3 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
						Test boring terminated @ 150 feet		Rec=100%			3 min.

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Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911508
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike (PPP6)
Chester Co., PA
PA-CH-0311.0000-RDa-16/PO#20171027

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

04911508
HDD Boring
Phoenixville Pike (PPPL)
10/31 – 11/1/17
B-1 (69.5-138.3')
Box 1 of

Run #	Depths	Length	Rec	RQD
1	69.5-73.5	4.0'	0"	0"
2	73.5-78.5'	5.0'	0"	0"
3	78.5-83.5'	5.0'	0.5"	0"
4	83.5-88.5'	5.0'	0"	0"
5	88.5-93.5	5.0'	20"	4.5"
6	93.5-98.5'	5.0'	17.5"	12"
7	98.5-103.5'	5.0'	0"	0"
8	103.5-108.5'	5.0'	0"	0"
9	108.5-113.5'	5.0'	0"	0"

Run #	Depths	Length	Rec	RQD
10	113.5-118.5'	5.0'	0"	0"
11	118.5-123.5'	5.0'	42"	17"
12	123.5-128.5'	5.0'	55"	37.5"
13	128.5-133.5'	5.0'	37.5"	12.5"
14	133.5-138.5'	5.0'	60"	56.5"

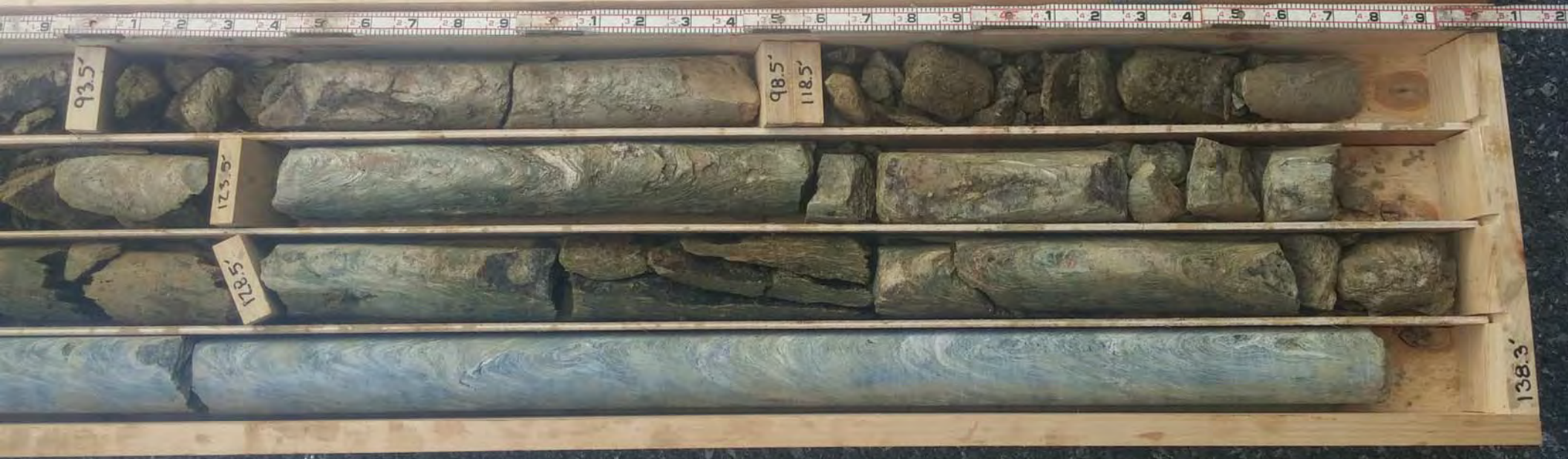
93.5'
98.5'
118.5'


04911508
HDD Boring
Pleasantville Pipe (PPPL)
10/31 - 11/1/17
B-1 (69.5 - 138.3')
Box 1 of
Run # | Depths | Length | Rec | RQD
1 | 69.5-73.5' | 4.0' | 0" | 0"
2 | 73.5-78.5' | 5.0' | 0" | 0"
3 | 78.5-83.5' | 5.0' | 0.5" | 0"
4 | 83.5-88.5' | 5.0' | 0" | 0"
5 | 88.5-93.5' | 5.0' | 20" | 4.5"
6 | 93.5-98.5' | 5.0' | 17.5" | 12"
7 | 98.5-103.5' | 5.0' | 0" | 0"
8 | 103.5-108.5' | 5.0' | 0" | 0"
9 | 108.5-113.5' | 5.0' | 0" | 0"
10 | 113.5-118.5' | 5.0' | 0" | 0"
11 | 118.5-123.5' | 5.0' | 42" | 17"
12 | 123.5-128.5' | 5.0' | 55" | 37.5"
13 | 128.5-133.5' | 5.0' | 37.5" | 12.5"
14 | 133.5-138.5' | 5.0' | 60" | 58.5"
69.5'
83.5'
88.5'
93.5'
98.5'
118.5'
123.5'
128.5'
133.5'
138.3'


0441308
HDD Boring
Phoenixville Pike (PPPL)
10/31 – 11/1/17
B-1 (69.5 – 138.3')
Box 1 of
2 | 73.5-78.5' | 5.0' | 0" | 0
3 | 78.5-83.5' | 5.0' | 0.5" | 0"
4 | 83.5-88.5' | 5.0' | 0" | 0"
5 | 88.5-93.5' | 5.0' | 20" | 4.5"
6 | 93.5-98.5' | 5.0' | 17.5" | 12"
7 | 98.5-103.5' | 5.0' | 0" | 0"
8 | 103.5-108.5' | 5.0' | 0" | 0"
9 | 108.5-113.5' | 5.0' | 0" | 0"
12 | 123.5-128.5'
13 | 128.5-133.5
14 | 133.5-138
69.5'
78.5'
83.5'
88.5'
93.5'
123.5'
128.5'
133.5'

Run #	Depths	Length	Rec	RQD
1	69.5-73.5	4.0'	0"	0"
2	73.5-78.5'	5.0'	0"	0"
3	78.5-83.5'	5.0'	0.5"	0"
4	83.5-88.5	5.0'	0"	0"
5	88.5-93.5	5.0'	20"	4.5"
6	93.5-98.5'	5.0'	17.5"	12"
7	98.5-103.5'	5.0'	0"	0"
8	103.5-108.5'	5.0'	0"	0"
9	108.5-113.5'	5.0'	0"	0"

Run #	Depths	Length	Rec	RQD
10	113.5-118.5'	5.0'	0"	0"
11	118.5-123.5'	5.0'	42"	17"
12	123.5-128.5'	5.0'	55"	37.5"
13	128.5-133.5'	5.0'	37.5"	12.5"
14	133.5-138.5'	5.0'	~~60"~~	~~56.5"~~



04911508
HDD Boring
Phoenixville Pike (PPP6)
11/1/17
B1-421 (138.3-150')
Box 2 of 2

Run #	Depths	Length	Rec.	RQD
15	138.5-143.5'	5.0'	60"	47"
16	143.5-148.5'	5.0'	60"	53"
17	148.5-150'	1.5'	18"	14.5"

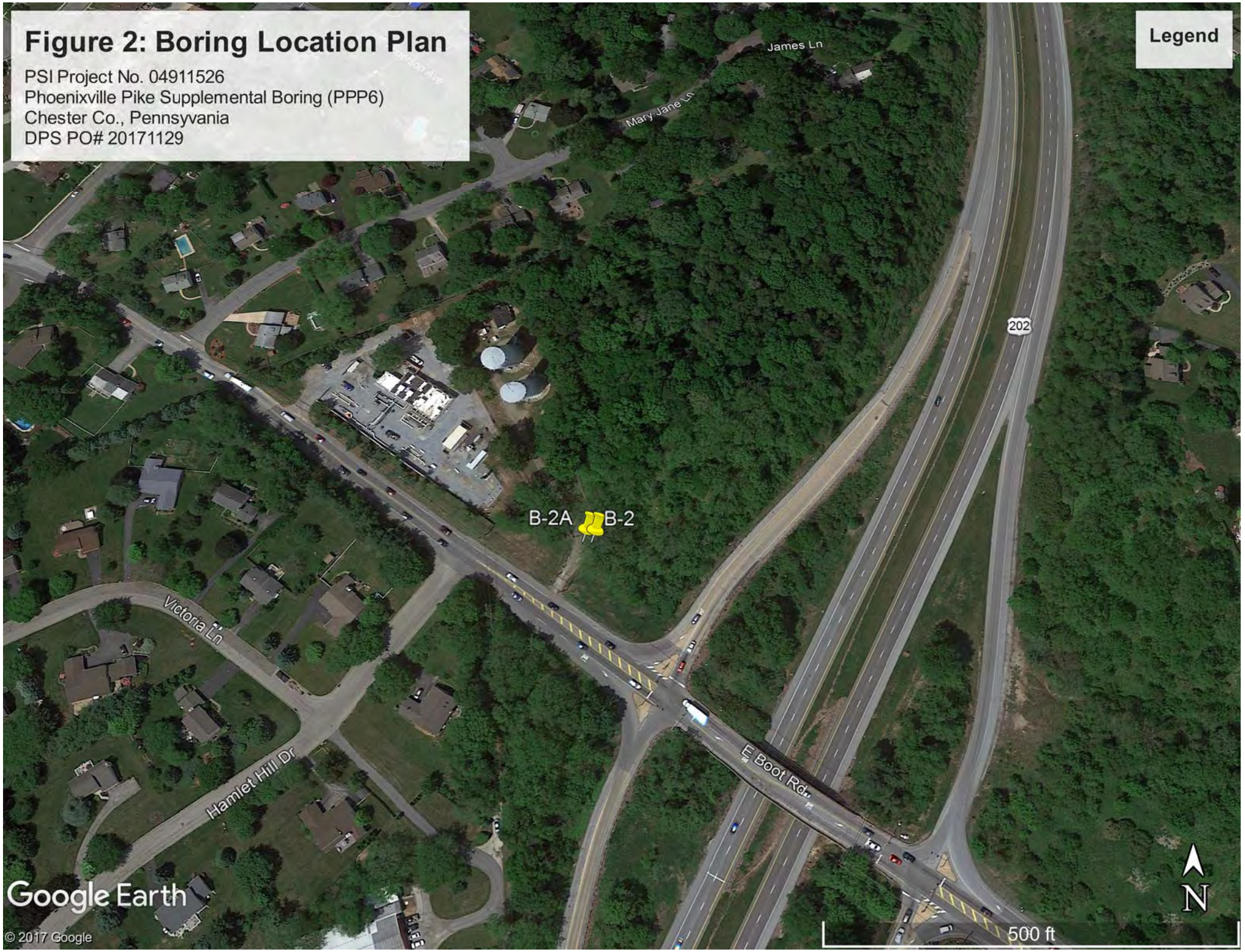

D4911508
HDD Boring
Phoenixville, PA to (PPW)
11/1/17
B1-921 (138.3-150')
Box 2 of 2
Run # | Depth | Length | Rec | RQD
15 | 138.5-143.5' | 5.0' | 60" | 47"
16 | 143.5-148.5' | 5.0' | 60" | 53"
17 | 148.5-150' | 1.5' | 18" | 14.5"
138.5'
143.5'
148.5'
150' EOB


148.5'
138.5'
138.5'
150'
EOB
143.5'

143.5'

Figure 2: Boring Location Plan

PSI Project No. 04911526
Phoenixville Pike Supplemental Boring (PPP6)
Chester Co., Pennsyvania
DPS PO# 20171129



BORING B-2

DATE STARTED:	12/1/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	12/5/17	**DRILLER:** J. Blemings	**LOGGED BY:** H. Patel
COMPLETION DEPTH	124.0 ft	**DRILL RIG:**	CME55 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water ▽ Pre-Core Not Enc.

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	0			S-1	10	5" topsoil/leafy matter **Probable FILL**-Brown, Sandy SILT, trace Gravel, moist	ML	3-3-3-4 N=6	11		
				S-2	18	**RESIDUUM**-Medium Dense, Red-brown to red-yellow-brown to light brown, Silty SAND with Gravel, moist		3-6-5-8 N=11	14		Non-Plastic Fines=37.1%
	5			S-3	24		SM	4-6-7-6 N=13	13		
				S-4	17			4-5-6-12 N=11	14		Fines=20.5%
				S-5	17	**Highly Weathered SCHIST Sampled As:**-Very Dense, Yellow-gray-brown to light green-gray, Silty SAND with Gravel, moist		36-35-50/5"	9	>>	
	10			S-6	18			16-28-31-26 N=59	8	>>	Fines=12.3%
	15			S-7	16			17-33-50/4"	14 10	>>	Fines=24.5%
	20			S-8	1		SM	50/1"	1	>>	
	25			S-9	1			50/1"	2	>>	
	30			S-10	1			50/1"	1	>>	

Continued Next Page

intertek psi
Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

DATE STARTED:	12/1/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	12/5/17	**DRILLER:** J. Blemings	**LOGGED BY:** H. Patel
COMPLETION DEPTH	124.0 ft	**DRILL RIG:**	CME55 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-2

Water ▽ Pre-Core Not Enc.

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	30					**Highly Weathered SCHIST Sampled As:**-Very Dense, Yellow-gray-brown to light green-gray, Silty SAND with Gravel, moist	SM				
						Highly Weathered SCHIST-No split-spoon recovery within this stratum.					
				S-11	0			50/0"		>>◎	
	35										
				S-12	0			50/0"		>>◎	
										>>	Q_u = 198.1 tsf 175.2 pcf
	40					**SCHIST**-Light gray-brown to dark gray, Slightly Weathered, very broken to massive, hard to very hard, occasional quartite seams No water return while drilling from 39 to 42 feet. Weathered layer from 40.8 to 42.2 feet.					4 min.
				R-1	60			RQD=67 Rec=100%			2 min.
										>>	Q_u = 185.4 tsf 177.7 pcf
						Weathered/Highly Weathered layer from 44 to 46.2 feet.					4 min.
	45										3 min.
				R-2	60			RQD=58 Rec=100%			3 min.
											4 min.
						Weathered layer @ 48.3 feet (~ 14-1/2 inches thick)					4 min.
											3 min.
	50										3 min.
				R-3	60			RQD=82 Rec=100%			3 min.
											4 min.
						Weathered layer @ 53.2 feet (~ 18-3/4 inches thick)					4 min.
											3 min.
	55									>>	Q_u = 193.7 tsf 165.2 pcf
				R-4	60			RQD=58 Rec=100%			3 min.
											3 min.
						Weathered/broken layer @ 58 feet (~ 4-1/2 inches thick) Weathered/broken layer @ 59 feet (~ 7-3/4					3 min.
	60					*Continued Next Page*					3 min.

Professional Service Industries, Inc.
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PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

DATE STARTED:	12/1/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	12/5/17	**DRILLER:** J. Blemings	**LOGGED BY:** H. Patel
COMPLETION DEPTH	124.0 ft	**DRILL RIG:**	CME55 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-2

Water Pre-Core Not Enc.

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ Moisture × PL ◪ LL ✚ (0 25 50) STRENGTH, tsf Qu ▲ Qp ✳ (0 2.0 4.0)	Additional Remarks
	60					inches thick)					3 min.
				R-5	60	**SCHIST**-Light gray-brown to dark gray, Slightly Weathered, very broken to massive, hard to very hard, occasional quartite seams		RQD=70 Rec=100%			3 min. 4 min. 6 min. 5 min.
	65									>> Q_u = 165.6 tsf 177.9 pcf	3 min.
				R-6	60			RQD=67 Rec=100%			4 min. 3 min. 5 min. 3 min.
						Weathered/Highly Weathered layer from 68.1 to 69 feet.					
	70										3 min. 4 min.
				R-7	57			RQD=83 Rec=94%			4 min.
										>> Q_u = 203.1 tsf 169.3 pcf	3 min.
						Weathered/Highly Weathered layer from 74 to 74.5 feet.					5 min.
	75										4 min.
				R-8	60			RQD=68 Rec=100%			3 min. 3 min. 5 min.
						Weathered/Highly Weathered layer @ 79 feet (~ 17-1/4 inches thick)					4 min.
	80										3 min.
				R-9	60			RQD=43 Rec=100%		>> Q_u = 105.9 tsf 172.7 pcf	3 min.
						Weathered layer @ 82.4 feet (~ 4-1/4 inches thick)					3 min. 3 min.
						Weathered/broken layer @ 84.6 feet (~ 4-1/2 inches thick)					
	85										4 min.
				R-10	60			RQD=88 Rec=100%			4 min. 4 min. 4 min.
	90					*Continued Next Page*					

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
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Telephone: (717) 230-8622

PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

DATE STARTED:	12/1/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	12/5/17	**DRILLER:** J. Blemings	**LOGGED BY:** H. Patel
COMPLETION DEPTH	124.0 ft	**DRILL RIG:**	CME55 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-2

Water Pre-Core Not Enc.

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	90			R-11	60	**SCHIST**-Light gray-brown to dark gray, Slightly Weathered, very broken to massive, hard to very hard, occasional quartite seams		RQD=84 Rec=100%		>> Q_u = 211.3 tsf 175.1 pcf	4 min. 3 min. 5 min. 5 min. 6 min.
	95			R-12	60			RQD=77 Rec=100%			4 min. 8 min. 8 min. 8 min. 5 min.
	100			R-13	60			RQD=90 Rec=100%		>> Q_u = 397.9 tsf 170.6 pcf	3 min. 3 min. 3 min. 3 min. 4 min.
	105			R-14	28	Limited recovery from core run R-14 which varied from Slightly Weathered to Weathered with brokeness ranging from very broken to slightly broken.		RQD=0 Rec=47%		>> Q_u = 351.1 tsf 167.4 pcf	4 min. 4 min. 4 min. 4 min. 2 min. 4 min.
	110			R-15	52			RQD=70 Rec=87%			3 min. 3 min. 4 min. 3 min.
	115			R-16	60			RQD=78 Rec=100%		>> Q_u = 276.8 tsf 170.7 pcf	2 min. 2 min. 3 min. 3 min. 2 min.
	120					Limited recovery from core run R-17 which					

Continued Next Page

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LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

BORING B-2

DATE STARTED:	12/1/17	**DRILL COMPANY:**	Uni-Tech Drilling
DATE COMPLETED:	12/5/17	**DRILLER:** J. Blemings	**LOGGED BY:** H. Patel
COMPLETION DEPTH	124.0 ft	**DRILL RIG:**	CME55 Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water: Pre-Core — Not Enc.

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 — 25 — 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 — 2.0 — 4.0)	Additional Remarks
	120					varied from Slightly Weathered to Weathered with brokeness ranging from broken to massive. **SCHIST**-Light gray-brown to dark gray, Slightly Weathered, very broken to massive, hard to very hard, occasional quartite seams					2 min. >> ▲ 408.3 tsf 170.2 pcf 2 min. 3 min. 2 min.
						Test boring terminated @ 124 feet due to tooling getting stuck in borehole. Tooling abandoned in ground and borehole grouted.					

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PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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PSI# 0491 1526
DPS# 20171129
HDD Boring (B-2)
Pheasantville Pike Rd - Supp
Depth 39 oft -
Box 1 of
Spread 6
12/01/17
Run | Depth | Rec (in) | RQD(in)
1 | 39.0-44.0 | 60" | 40"
2 | 44.0-49.0 | 60" | 34.5"
3 | 49.0-54.0 | 60" | 49.0"
4 | 54.0-59.0 | 60" | 35.0"
39.0
44.0
49.0
54.0
59.0
0491 1526
20171129
(B-2)


PSI # 20491.152C
DPS # 20171129
HDD Boring (B-2)
Pharmaceutical Rd - Supp
12/01/17
Depth 58.0ft - 74.5ft
Box 2of
Spread 6
Run | Depth (Ft) | Rec(in) | RQD(
5 | 59.0-64.0 | 60" | 42"
6 | 64.0-69.0 | 60" | 40"
7 | 69.0-74.0 | 56.5" | 50"
58.0
59.0
64.0
69.0
74.0


PSI # 0491 152C
DPS # 20171129
HDD Boring (B-2)
Pheasantville Pike Rd - Supp
12/04/17
Depth: 74.5ft - 93.0ft
Box: 3of
Spread 6
Depth(m) Rec(%) RQD(%)
8 74.0-79.0 60" 41"
9 79.0-84.0 60" 26"
10 84.0-89.0 60" 53"
11 89.0-94.0 60" 50.5"
74.5
79.0
84.0
89.0
93.0
PSI# 0491 152C
DPS # 20171129
HDD Boring (B-2)
12/04/17


PSI # 0
DPS # 201
HDD Boring
Phoenixville
12/04/17
Depth: 93.0ft - 114.0ft
Box 4 of
Spread 6
Run | Depth (ft) | Rec (in) | RQD (in)
12 | 94.0-99.0 | 60" | 46"
13 | 99.0-104.0 | 60" | 54"
14 | 104.0-109.0 | 28" | 0"
15 | 109.0-114.0 | 52" | 42"
93.0
94.0
99.0
104.0
109.0
114.0


PSI # 0491 1526
DPS # 20171129
HDD Boring (B-2)
12/04/17
Phoenixville Pike Rd. Supp
Depth
Bor. Sol
Spread 6
Run | Depth (ft) | Rec (in) | RQD (in)
16 | 1140-1190 | 60" | 47"
17 | 1190-1240
114.0
119.0
119.0

BORING B-2A

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger **LOGGED BY:**	H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core	Not Enc.
Upon Completion	27 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	0					Augured without sampling to 31 feet.					
	5										
	10										
	15										
	20										
	25					▼					
	30					*Continued Next Page*					

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Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
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Telephone: (717) 230-8622

PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

BORING B-2A

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger	**LOGGED BY:** H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water
- Pre-Core: Not Enc.
- Upon Completion: 27 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	30					Augured without sampling to 31 feet.					
				R-1	24	**SCHIST**-Light gray to green-gray-brown, Weathered to Slightly Weathered, very broken to massive, hard		RQD=67 Rec=100%			>> ▲ Q_u = 124.4 tsf 173.0 pcf
	35			R-2	60			RQD=50 Rec=100%			2 min. 1 min. 1 min. 1 min. 1 min.
											>> ▲ Q_u = 78.3 tsf 172.5 pcf
	40			R-3	60			RQD=52 Rec=100%			1 min. 2 min. 1 min. 1 min. 2 min.
	45			R-4	60	**SCHIST**-Light gray to dark green-gray, Slightly Weathered, very broken to massive, hard to very hard Weathered layer @ 46.4 feet (~ 7 inches thick)		RQD=43 Rec=100%			1 min. 1 min. 1 min. 1 min.
											>> ▲ Q_u = 206.9 tsf 169.8 pcf
	50			R-5	60	Weathered/Highly Weathered layer @ 52.1 feet (~ 5-3/4 inches thick) Weathered layer @ 54.1 feet (~ 7-1/2 inches thick)		RQD=53 Rec=100%			2 min. 2 min. 1 min. 2 min. 1 min. 1 min.
	55			R-6	60			RQD=75 Rec=100%			1 min. 2 min.
											>> ▲ Q_u = 214.0 tsf 176.2 pcf
	60					*Continued Next Page*					2 min. 2 min.

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PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

BORING B-2A

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger	**LOGGED BY:** H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core	Not Enc.
Upon Completion	27 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 / 25 / 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 / 2.0 / 4.0)	Additional Remarks
	60			R-7	60	**SCHIST**-Light gray to dark green-gray, Slightly Weathered, very broken to massive, hard to very hard		RQD=78 Rec=100%			2 min. 3 min. 2 min. 2 min. 2 min.
	65			R-8	60			RQD=87 Rec=100%			1 min. 2 min. 2 min. 2 min. 3 min.
	70			R-9	60			RQD=81 Rec=100%			>> Qu = 267.2 tsf 174.1 pcf 3 min. 2 min. 2 min. 3 min. 3 min.
	75			R-10	60	Quartzite layer from 77 to 78.5 feet.		RQD=100 Rec=100%			3 min. 4 min. 2 min. >> Qu = 219.4 tsf 168.8 pcf 4 min.
	80			R-11	60			RQD=97 Rec=100%			3 min. 3 min. 3 min. 3 min. 3 min.
	85			R-12	60			RQD=100 Rec=100%			3 min. 4 min. >> Qu = 316.1 tsf 175.6 pcf 2 min. 3 min.
	90					*Continued Next Page*					

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PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger	**LOGGED BY:** H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

BORING B-2A

Water

Pre-Core	Not Enc.
Upon Completion	27 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 / 25 / 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 / 2.0 / 4.0)	Additional Remarks
	90			R-13	60	**SCHIST**-Light gray to dark green-gray, Slightly Weathered, very broken to massive, hard to very hard Weathered fracture @ 91.7 feet		RQD=87 Rec=100%			3 min. 3 min. 2 min. >> Q_u = 264.4 tsf 174.8 pcf 2 min. 3 min.
	95			R-14	60			RQD=98 Rec=100%			2 min. 3 min. 2 min. 3 min. 2 min.
	100			R-15	60			RQD=98 Rec=100%			2 min. 3 min. >> Q_u = 239.5 tsf 173.7 pcf 2 min. 2 min.
	105			R-16	60			RQD=98 Rec=100%			2 min. 3 min. 3 min. 2 min. 3 min.
	110			R-17	60			RQD=92 Rec=100%			2 min. 2 min. >> Q_u = 268.3 tsf 177.7 pcf 3 min. 3 min.
	115			R-18	60			RQD=100 Rec=100%			3 min. 3 min. 2 min. 2 min. 2 min.
	120					*Continued Next Page*					

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BORING B-2A

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger	**LOGGED BY:** H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water
- Pre-Core: Not Enc.
- Upon Completion: 27 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	120			R-19	60	**SCHIST**-Light gray to dark green-gray, Slightly Weathered, very broken to massive, hard to very hard		RQD=100 Rec=100%			2 min. 3 min. >> Qu = 340.8 tsf 177.6 pcf 2 min. 2 min.
	125			R-20	60			RQD=98 Rec=100%			2 min. 2 min. 2 min. 3 min. 3 min.
	130			R-21	60			RQD=100 Rec=100%			2 min. 2 min. >> Qu = 364.1 tsf 173.5 pcf 2 min. 2 min.
	135			R-22	60			RQD=93 Rec=100%			2 min. 2 min. 2 min. 3 min. 2 min.
	140			R-23	60			RQD=73 Rec=100%			2 min. >> Qu = 432.1 tsf 172.1 pcf 3 min. 2 min. 2 min.
	145			R-24	60			RQD=98 Rec=100%			2 min. 2 min. 1 min. 3 min. 2 min.
	150					*Continued Next Page*					

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

BORING B-2A

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger	**LOGGED BY:** H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water
- Pre-Core — Not Enc.
- Upon Completion — 27 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 / 25 / 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 / 2.0 / 4.0)	Additional Remarks
	150			R-25	60	**SCHIST**-Light gray to dark green-gray, Slightly Weathered, very broken to massive, hard to very hard		RQD=92 Rec=100%			2 min. 2 min. 2 min. >> Q_u = 300.2 tsf 177.5 pcf 2 min. 2 min.
	155			R-26	60			RQD=100 Rec=100%			3 min. 3 min. 2 min. 2 min. 2 min. 2 min.
	160			R-27	60			RQD=100 Rec=100%			2 min. 3 min. >> Q_u = 230.0 tsf 174.6 pcf 2 min. 3 min.
	165			R-28	60	Weathered fracture @ 164.7 feet		RQD=93 Rec=100%			2 min. 3 min. 2 min. 2 min. 2 min. 3 min.
	170			R-29	60	Quartzite layer from 171.4 to 173 feet.		RQD=93 Rec=100%			7 min. >> Q_u = 796.2 tsf 163.8 pcf 3 min. 3 min. 3 min.
	175			R-30	60			RQD=98 Rec=100%			3 min. 3 min. 3 min. 3 min. 3 min.
	180					*Continued Next Page*					

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Professional Service Industries, Inc.
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Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

BORING B-2A

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger	**LOGGED BY:** H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core	Not Enc.	
Upon Completion	27 feet	

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ / Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	180			R-31	60	**SCHIST**-Light gray to dark green-gray, Slightly Weathered, very broken to massive, hard to very hard		RQD=99 Rec=100%			3 min. 3 min. 3 min. >> Qu = 443.0 tsf 166.4 pcf 3 min.
	185			R-32	60	Weathered layer @ 186.2 feet (~ 3-1/4 inches thick)		RQD=80 Rec=100%			3 min. 4 min. 3 min. 4 min. 3 min.
	190			R-33	60			RQD=88 Rec=100%			4 min. 5 min. 4 min. >> Qu = 582.2 tsf 170.7 pcf 3 min.
	195			R-34	60	Quartzite layer from 196.9 to 197.3 feet.		RQD=86 Rec=100%			3 min. 4 min. 3 min. 3 min. 3 min.
	200			R-35	60			RQD=100 Rec=100%			3 min. 3 min. >> Qu = 369.7 tsf 170.3 pcf 3 min.
	205			R-36	60			RQD=84 Rec=100%			3 min. 3 min. 3 min. 2 min. 2 min.
	210					*Continued Next Page*					

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PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

BORING B-2A

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger	**LOGGED BY:** H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core	Not Enc.
Upon Completion	27 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	210			R-37	60	**SCHIST**-Light gray to dark green-gray, Slightly Weathered, very broken to massive, hard to very hard		RQD=98 Rec=100%			2 min. 3 min. >> Q_u = 505.0 tsf 177.5 pcf 2 min. 3 min.
	215			R-38	60			RQD=98 Rec=100%			2 min. 3 min. 2 min. 2 min. 3 min.
	220			R-39	60			RQD=100 Rec=100%			2 min. 3 min. 2 min. >> Q_u = 290.8 tsf 176.6 pcf 3 min.
	225			R-40	60	Schist contains varying amounts of quartz/quartzite from 226 to 245 feet.		RQD=100 Rec=100%			3 min. 3 min. 3 min. 4 min. 5 min.
	230			R-41	60			RQD=90 Rec=100%			5 min. 4 min. >> Q_u = 381.7 tsf 175.0 pcf 4 min.
	235			R-42	60			RQD=100 Rec=100%			4 min. 3 min. 3 min. 3 min. >> Q_u = 335.1 tsf 171.5 pcf 4 min.
	240					*Continued Next Page*					

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PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

BORING B-2A

DATE STARTED:	12/14/17	**DRILL COMPANY:**	Allied Well Drilling
DATE COMPLETED:	12/19/17	**DRILLER:** B. Denniger **LOGGED BY:**	H. Patel
COMPLETION DEPTH	245.0 ft	**DRILL RIG:**	Versa Drill GT8 Track Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS2.000-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	F. Hoffman

REMARKS:

Water

Pre-Core	Not Enc.
Upon Completion	27 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ / Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	240			R-43	60	**SCHIST**-Light gray to dark green-gray, Slightly Weathered, very broken to massive, hard to very hard		RQD=100 Rec=100%			4 min. 4 min. 4 min. 4 min.
						Quartzite layer from 243 to 243.6 feet.					
				R-44	24			RQD=54 Rec=100%		>> Q_u = 232.9 tsf 479.2 pcf	5 min. 5 min.
	245					Test boring terminated @ 245 feet					

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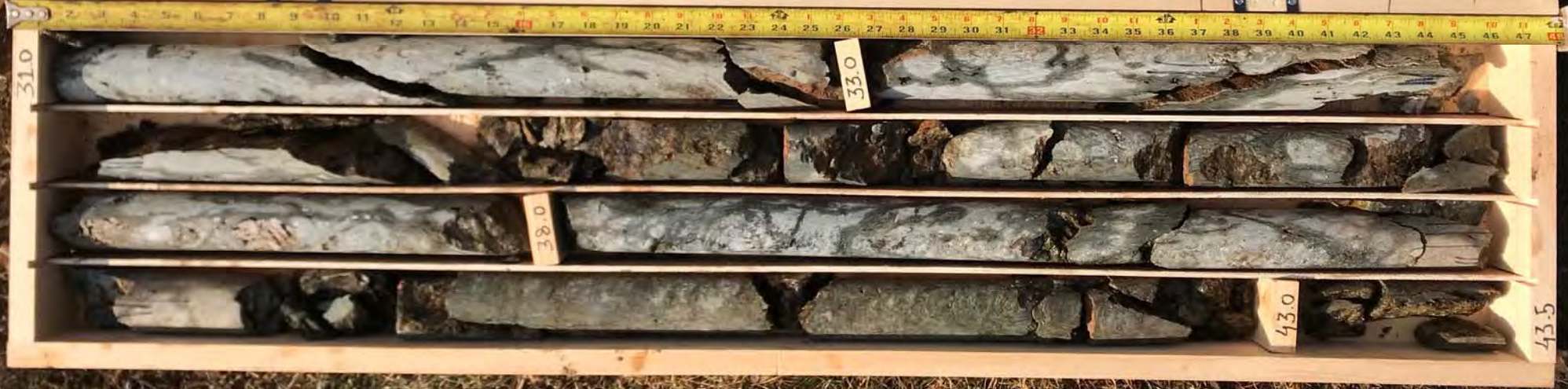
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911526
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Phoenixville Pike Supp. Boring (PPP6)
Chester Co., PA
DPS PO#20171129

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

PSI # 04911526
DPS # 20171129
HDD Boring (B-2A)-Offset
12/14/17
Depth: 31.0 - 43.5 Ft
Box: 1 of
Phoenixville Pike Rd - Rupp
Spread 6

Run	Depth (ft)	Rec (in)	RQD (in)
1	31.0-33.0	24.0	16.0
2	33.0-38.0	60.0	30.0
3	38.0-43.0	60.0	31.0



PSI #0491 1526
DPS #20171129
HDD Boring (B-2A)
12/14/17
Depth: 435A - 565ft
Box 2of
Phoenixville Pike ~~Rd~~ Supp
Spread 06

Run	Depth (ft)	Rec(in)	RQD(in)
4	43.0-48.0	60.0	26.0
5	48.0-53.0	60.0	32.0
6	53.0-58.0	60.0	45.0


PSI # 04911526
DPS # 20171129
HDD Boring (B-2A (offset))
12/14/17
Depth 56.5-71.0 ft
Box: 3of
Phoenixville Pike Rd-Supp
Spread 6
Run | Depth (ft) | Rec (in) | RQD (in)
7 | 58-63.0 | 60 | 47
8 | 630-68.0 | 60" | 52"
9 | 68.0-730 | 60" | 48.5
56.5
58.0
63.0
68.0
71.0

PSI # 0491152C
DPS # 20171129
HDD Boring (B-2A (offset))
12/14/17
Depth: 71.0 - 85.0 ft
Box: 4 of
Phoenixville Pike Rd - Supp
Spread 6

Run	Depth (ft)	Rec (in)	RQD (in)
10	73.0 - 78.0	60	60
11	78.0 - 83.0	60	58
12	83.0 - 88.0	60	60

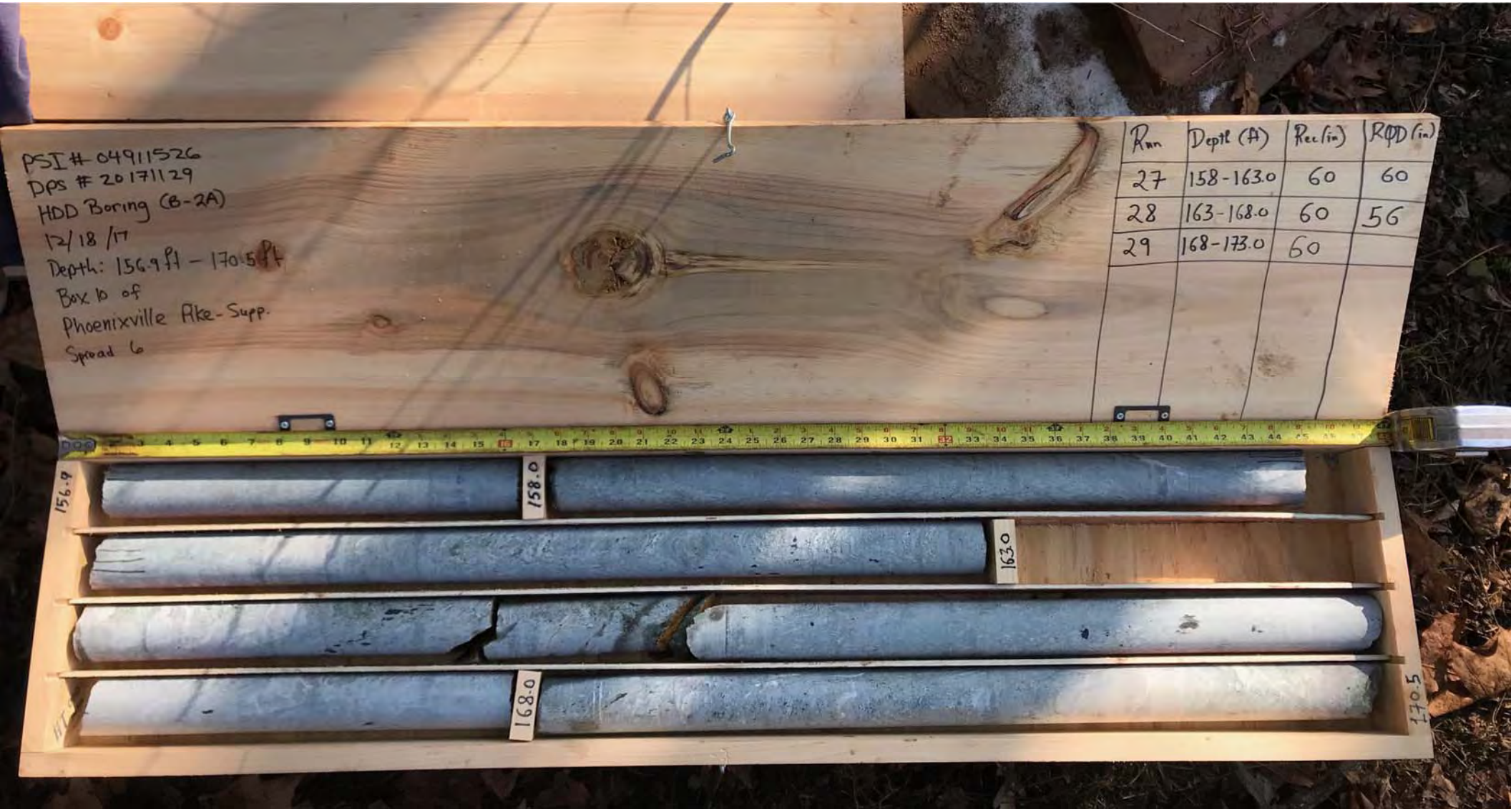

PSI # 0491 152C
DPS # 20171129
HDD Boring (B-2A)
12/14/17
Depth: 85.0 ft-
Box: 5of
Phoenixville Pike Rd Supp
Spread 06
Run | Depth (ft) | Rec (in) | RQD (in)
13 | 88.0-93.0 | 60" | 52"
14 | 93.0-98.0 | 60" | 59"
85.0
88.0
88.0
93.0
98.0


PSI # 0491-1526
DPS # 20171129
HDD Boring (B-2A)
12/14/17
Depth: 98.0 - 113.0ft
Box: 6 of
Phoenixville Pike Rd. Supp
Spread 6
Run | Depth (ft) | Rec (in) | RQD (in)
15 | 98.0 - 103.0 | 60" | 58.5"
16 | 103.0 - 108.0 | 60" | 59.0"
17 | 108.0 - 113.0 | 60" | 55.0"
98.0
103.0
108.0
113.0


PSI # 0491 152C
DPS # 20171129
HDD Boring (B-2A)
12/14/17
Depth: 113.0 - 128.0 ft
Box: 7 of
Pharmaville Pike Rd - Supp
Spread C
Run | Depth (ft) | Rec (in) | RQD (in
18 | 113.0-118.0 | 60" | 60"
19 | 118.0-123.0 | 60" | 60"
20 | 123.0-128.0 | 60 | 58.5
113.0
118.0
123.0
128.0


PSI # 04911526
DPS # 20171129
12/14/17
HDD Boring (B-2A)
Depth: 128.5 - 142.5 ft.
Box: 8 of
Phoenixville Pike Rd - Supp
Spread 6
Run | Depth(ft) | Rec(in) | RQD(in)
21 | 128 - 133 | 60" | 60"
22 | 133 - 138 | 60 | 56"
23 | 138 - 143 | 60 | 44"
128.5
133.0
138.0
142.5

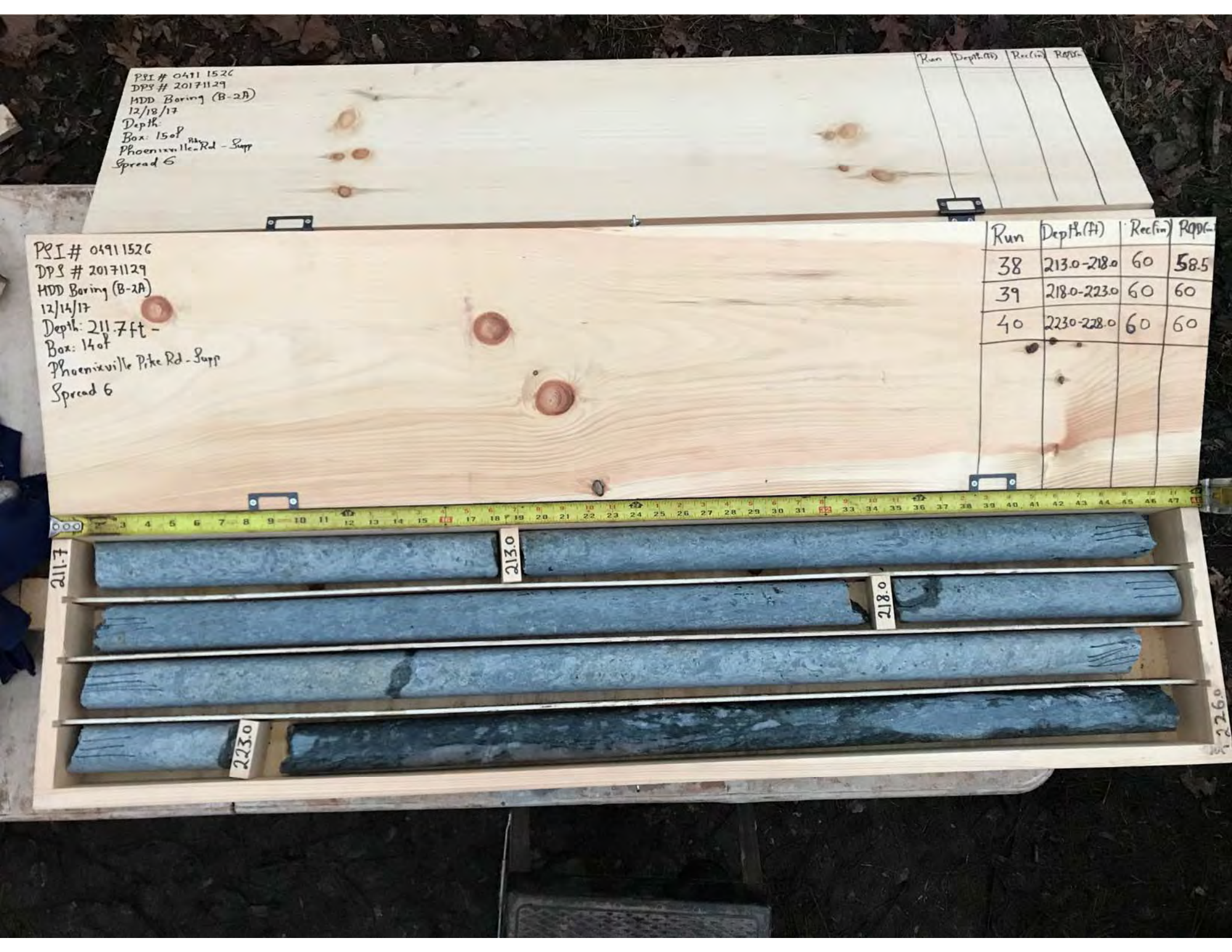

PSI # 0491526
DPS # 20171129
HDD Boring (B-2A)
Depth: 142.5ft -
Box 9 of
Phoenixville Pike Rd. Supp
Spread 6C
12/15/17
HT 080
Run | Depth (ft) | Rec (in) | RQD (in)
24 | 143.0 - 148.0 | 60 | 58.5
25 | 148.0 - 153.0 | 60 | 55.0
26 | 153.0 - 158.0 | 60 | 60.0
142.5
143.0
148
153.0
153.0
156.9


PSI # 04911526
DPS # 20171129
HDD Boring (B-2A)
12/18/17
Depth: 156.9ft – 170.5ft
Box 6 of
Phoenixville Ake-Supp.
Spread 6
Run | Depth (ft) | Rec (in) | RQD (in)
27 | 158-163.0 | 60 | 60
28 | 163-168.0 | 60 | 56
29 | 168-173.0 | 60 |
156.9
158.0
163.0
168.0
170.5


PSI # 0491 1529
DPS # 20171129
HDD Boring (B-2A)
Depth: 170.5ft - 183.7ft
Box: 11 of
Phoenixville Pike Rd - Supp
Spread 06
12/18/17
Run | Depth (ft) | Rec(in) | RQD(-
30 | 173.0 - 178.0 | 60 | 59
31 | 178.0 - 183.0 | 60 | 59.5
32 | 183.0 - 188.0 | 60 | 48
170.5
173.0
178.0
183.0
183.7


PSI # 0491 152G
DPS # 20171129
HDD Boring (B-2A)
12/18/17
Depth: 197.4ft -
Box: 13 of
Phoenixville Pike Rd - Supp
Spread 6
Run | Depth (ft) | Rec (in) | RQD (in)
1974
PSI # 0491 152G
DPS # 20171129
HDD Boring (B-2A (Upreamb))
12/18/17
Depth: 183.7ft - 197.7ft
Box: 12 of
Phoenixville Pike Rd - Supp
Spread 06
Run | Depth (ft) | Rec (in) | RQD (in)
33 | 188.0-193.0 | 60 | 53
34 | 193.0-198.0 | 60 | 51.5
1837
1880
1930
1974


PSI# 0491 1526
PSI # 0491 1526
DPS # 20171129
HDD Boring (B-2A)
12/18/17
Depth: 197.4ft - 211.7ft
Box: 13 of
Pharmaville Pike Rd - Supp
Spread 6
Run | Depth (ft) | Rec (in) | RQD (in)
35 | 198.0-203.0 | 60 | 60
36 | 203.0-208.0 | 60 | 50.5
37 | 208.0-213.0 | 60 | 59.0
197.4
198.0
203.0
208.0
208.0
211.7


PSI # 0491 1526
DPS # 20171129
HDD Boring (B-2A)
12/18/17
Depth:
Box: 15 of
Phoenixville Pike Rd - Supp
Spread 6
Run
Depth (ft)
Rec (in)
RQD (in)
PSI # 0491 1526
DPS # 20171129
HDD Boring (B-2A)
12/14/17
Depth: 211.7ft -
Box: 14 of
Phoenixville Pike Rd - Supp
Spread 6
Run
Depth (ft)
Rec (in)
RQD (in)
38
213.0-218.0
60
58.5
39
218.0-223.0
60
60
40
223.0-228.0
60
60
211.7
213.0
218.0
223.0
226.0


PSI # 0411 1526
DPS # 20171129
HDD Boring (B-2A)
12/18/17
Depth: 226.0ft - 240.0ft
Box: 15of 16
Phoenixville Pike Rd - Supp
Spread 6
Run | Depth (ft) | Rec (in) | RQD%
1 | 228.0 - 233.0 | 60 | 54
2 | 233.0 - 238.0 | 60 | 60
3 | 238.0 - 243.0 | 60 | 60
226.0
228.0
233.0
238.0
240.0


PSI# 0491 1526
DPS# 20171129
HDD Boring (B-28)
12/19/17
Depth: 240.0ft – 245.0ft
Box: 16 of 16
Phoenixville Pike Rd. Supp
Spread 6
Run
Depth (ft)
Rec(in)
RQD(in)
44
2430-2450
24
13
240.0
243.0
243.0
245.0
E.O.B

Attachment C

Geophysical Survey Report

Advanced Geological Services – May 2019

ADVANCED GEOLOGICAL SERVICES
3 Mystic Lane
Malvern, PA 19355
(610) 722-5500 (ph.)
(610) 722-0250 (fax)

May 28, 2019
Reference: 18-335-1

Ms. Lieschen Fish, P.G.
Groundwater & Environmental Services, Inc.
440 Creamery Way, Suite 500
Exton, PA 19341

Subject: MASW and Seismic Refraction Results
Horizontal Directional Drill Alignments:
S3-0421, S3-0460, S3-0580 and S3-0591
Chester and Delaware Counties, Pennsylvania

Dear Ms. Fish:

Advanced Geological Services (AGS) presents this letter report to Groundwater & Environmental Services, Inc. (GES) summarizing the geophysical investigation completed along Horizontal Directional Drill (HDD) alignments S3-0421, S3-0460, S3-0580, and S3-0591. Multichannel analysis of surface waves (MASW) and seismic refraction methods were used along the alignments to identify bedrock fractures, faults. or zones of bedrock weakness that could lead to inadvertent returns (IR) or loss of drilling fluids during drilling operations. Seismic data acquisition was completed between January 22 and March 15, 2019.

The length of the HDD alignments are shown below.

HDD Alignment	Length (ft)
S3-0421	4,400
S3-0460	3,600
S3-0580	3,150
S3-0591	4,250

Methods

Site Conditions

MASW and seismic refraction data were collected along the accessible roadsways along or adjacent to the HDD alignments. By running the geophysical lines along the roadways it was possible to use a land streamer and truck-mounted accelerated weight drop seismic source, both of which increased production rates over conventional spiked geophones and a sledge hammer source. Because data were collected along active roads, lane closures required traffic control personnel and signage throughout the survey. Intersecting crossroads and driveways

could not be blocked to allow data collection. Therefore, the seismic array was "leapfrogged" over those locations resulting in lower data density near the intersections and driveways.

Multichannel Analysis of Surface Waves (MASW) Overview

Briefly, a surface-wave survey entails measuring the velocity of surface waves using an array of motion detectors (geophones) placed on the ground surface. Because surface-wave velocity closely follows shear-wave velocity (90 to 95% of Vs), surface-wave velocity data can be used to estimate shear wave velocity (Vs).

Surface-Waves are seismic waves that travel along or near the surface of the earth; they are generated by both natural (e.g., wind, ocean waves) and man-made (e.g., hammer blow, traffic noise, factory vibration) sources. Surface-Waves travel in assemblages of frequencies, with each frequency having a corresponding wavelength. Because surface-waves are influenced by subsurface material to a depth approximately equal to the surface-wave's wavelength, a velocity vs. depth profile can be generated by measuring the velocity of surface-waves of varying wavelengths. Surface waves with shorter wavelengths (higher frequencies) respond to the material properties (e.g., stiffness) of shallower materials while waves with longer wavelengths (lower frequency) respond to deeper materials.

Specialized computer software is used to identify surface-waves in the recorded data and prepare a 'velocity spectrum' image, which the geophysical analyst interprets to produce a 'dispersion curve' to depict how velocity varies with frequency (hence, depth). The analyst then inputs the dispersion curve into a software inversion program, which generates a model that depicts subsurface velocity layering with depth.

Seismic Refraction Overview

The seismic refraction method uses the propagation of compression waves (P-waves) to map subsurface features. An energy source, such as a sledge hammer and strike plate is used to generate an elastic wave at several locations (shotpoints) along each survey line. The energy propagates downward from its initiation point at the ground surface. As the P-wave propagates through the ground it is refracted along boundaries between geologic layers with different seismic velocities. The velocity at which the seismic wave travels is a function of the density and elastic properties of the material.

Part of the refracted P-wave energy returns to the ground surface where it is detected by vibration-sensitive devices called geophones, which are placed in a co-linear array along the seismic survey line. The geophone data are fed to a seismograph, where they are recorded, and then to a computer, where they are analyzed to determine the depth and velocities of subsurface seismic layers. Key data for refraction analysis are the positions of the geophones and shotpoints along a seismic line, and the amount of time it takes for the refracted wave to travel from the shotpoint to each geophone location. Because the P-wave velocity (Vp) is the

fastest traveling of all types of seismic waves, it can be readily identified as the first deflection ("first break") on a seismic trace. Seismic array geometry and first break information is used as input data for refraction interpretation modeling software.

Field Procedures

A Geode 24-channel engineering seismograph manufactured by Geometrics, Inc. and a land streamer with 24 4.5-Hz geophones were used to conduct the seismic survey. The geophone spacing on the land streamer was set at 10 feet for a total spread length of 230 feet. The land streamer was towed behind a pick-up truck that had an accelerated weight drop seismic source mounted to the hitch receiver. The offset distance between the seismic source and the first geophone on the land streamer was set to 30 feet.

MASW records were recorded every 10 feet along the length of each HDD profile alignment using an offset of 30 feet for the accelerated weight drop source. Ten shots were stacked using the accelerated weight drop at each MASW record location to enhance the coherent signals and decrease random noise. Each MASW record provides one processed 1-D profile of Vs versus depth that is located in the center of the seismic spread. As the seismic spread is 230 feet long, each interpreted MASW record is located at 115 feet from the end of that geophone spread.

Refraction data were collected along each alignment using a series of overlapping spreads. Each 24-geophone land streamer spread is 230 feet long, and refraction data were collected every 200 feet, providing a 3 geophone (30 feet) overlap of each refraction spread. Seven shot locations placed along each refraction spread. The shot locations relative to geophone 1 (0 feet) were at -30, -5, 55, 115, 175, 235, and 260 feet. The accelerated weight drop source was used for the offset shot located at -30 feet, and a 12-lb sledge hammer and hard-rubber strike plate were used at all remaining shot locations. A minimum of 10 shots (strikes) were stacked at each shot location while monitoring data quality.

Because it was not possible to block active road intersections or driveways, the land streamer was leapfrogged over those areas. As a result, data density was lower in those portions of the profiles. MASW records could only get within 115 feet (the spread center point) of each leapfrogged road intersection of driveway, while refraction data could be collected right to the edge of each obstacle by placing geophone 1 or 24 at the edge of the obstacle and locating the far offset shots on the opposite side of the obstacle.

Elevation data of profiles were provided by GES personnel using a survey quality GPS instrument.

MASW Data Processing

MASW data quality ranged from fair to excellent. The data quality was lower in areas with very high noise levels or poor geophone to ground coupling caused by poor road surface conditions.

Seismic data were transferred from the seismograph to a desktop computer where they were processed using the *SeisImager/SW* software package by Geometrics, Inc. In general, surface wave data processing entails first producing a velocity spectrum image, which shows the phase velocity for the various frequencies of surface waves detected. This image is used as the basis for interpreting ("picking") a dispersion curve, which is a graph that depicts how surface-wave velocity varies with frequency (hence, with depth). The dispersion curve is then used to prepare an initial 1-D model of surface-wave velocity versus depth using a one-third wavelength approximation (i.e., a given phase velocity is assigned to a depth that is one-third of the wavelength of the corresponding surface-wave). The initial velocity layer model is then adjusted using an inversion process until the corresponding synthetic dispersion curve achieves a "best-fit" match to the original dispersion curve (the one that was interpreted from the observed data-i.e., the velocity spectrum image). The degree or closeness of the fit between the interpreted and synthetic curves (expressed as a RMS percentage error) provides an indication of how well the model represents actual subsurface conditions.

Separate, independent processing was performed for each MASW location (i.e. every 10 feet) along the length of each profile. The processing output for each data-set was a 1-dimensional (1-D) velocity layer model depicting S-wave velocity variations with depth at a single point (which is situated at the center of the geophone array). The velocity models were output as a tabulated ASCII text (.txt) files containing depth and velocity information.

The individual 1-D model results were then compiled using a spreadsheet to produce an xyz data file to be used in a contouring/mapping program. Processing within the spreadsheet consisted of converting model depths to elevations, and correcting profile distances in areas where the seismic profile deviated from the centerline of the HDD alignments. The resulting xyz data file was gridded and contoured using the Golden Surfer program to produce the final profile.

Refraction Tomography Data Processing

Seismic refraction data were processed using Geometrics SeisImager software package. Initially, first P-wave arrivals (first breaks) were identified for each shot location. The resulting time-distance curve for each spread was reviewed for consistency and quality of first break picks for all shots within each spread. Time-distance information were then used as input into refraction tomography model in the software package.

The SeisImager refraction tomography routine uses seismic first arrival times and survey geometry to derive subsurface information by using a non-linear optimization technique called generalized simulated annealing. The technique basically generates a velocity model of the subsurface, calculates travel time curves through forward modeling, then compares the calculated travel times to the observed travel times. The velocity model is then systematically modified to decrease the statistical error to a predetermined level. Of course the resulting

velocity model is reviewed by AGS geophysicists to verify that the model is realistically compatible with known existing geologic conditions of the site.

The advantage to using the refraction tomography method as opposed to other seismic refraction interpretation methods, such as layered inversion routines or the generalized reciprocal method (GRM), is that it can effectively image gradational seismic velocity variations laterally and vertically as are commonly observed in areas with a thick weathered bedrock surface, such as a saprolite. This can provide important information that can show weathered bedrock zones such as weathered fractures, or areas of high bedrock velocity that could indicate the presence of competent rock.

Modeled data from each spread were compiled using spreadsheet methods similar to those used for the MASW results to produce an xyz file for input into the Golden Surfer contouring and mapping program.

MASW and Seismic Refraction Results

Modeled MASW and seismic refraction results from data collected along HDD alignments S3-0421, S3-0460, S3-0580, and S3-0591 were plotted directly on the 11x17 Plan and Profile Plots provided, as requested by GES. Contoured Vs (MASW) and Vp (refraction tomography) values are shown on the attached Plot and Profile Plots.

Seismic refraction tomography results generally were able to estimate Vp to depths of up to 50 to 80 feet below grade depending upon location. Generally, the refraction results provide and estimate of the near surface conditions that can be expected to be encountered along each HDD alignment. According to the Catapillar D8R Ripper Performance chart shown on the Plan and Profiles Plots, a velocity of 6,000 fps corresponds to the rippable/marginally rippable interface of granite and 6,500 fps is the rippable/marginally rippable interface for schist. Based on that information, the top of the unweathered bedrock surface is estimated to be between 6,000 and 6,500 fps along the HDD alignments. Material with a Vp between 3,500 and 6,500 are considered rippable and are associated with saprolite or weathered rock. Also, comparison of Vp to available geotechnical boring information also indicated that the weathered bedrock surface corresponds to approximately 3,500 fps. Rippable material with a Vp of less than 3,500 fps are typical of highly weathered rock or overburden.

Locations where low Vp are deeply incised vertically into the refraction tomography profile may indicate the presence of enhanced bedrock weathering caused by a fault, bedrock fracture or in some instances, weathering along steeply dipping foliations.

MASW results were able to provide Vs information along the HDD alignments to depths of 150 feet or more along the HDD alignments. The bedrock surface in the profiles corresponds to a Vs of approximately 1,200 fps. Hard, unweathered rock is generally associated with Vs greater than approximately 2,500 fps. Similar to the refraction tomography profiles, vertical zones of

low Vs incised into the contoured profiles may indicate the presence of zones of bedrock weakness caused by faults, fractures or highly weathered, steeply dipping foliations. Low velocity zones that could indicate a fault or fracture are identified on the MASW contour profiles.

Summary and Closing

MASW and seismic refraction tomography methods were used to characterize subsurface conditions that will be encountered during completion of horizontal direction drilling along alignments S3-0421, S3-0460, S3-0580, and S3-0591. Contoured Vs and Vp results that were overlain on the Plot and Profile Plans of each alignment indicate the top of rock configuration as well as low velocity zones that could be caused by the presence of bedrock fractures, faults, or deeply weathered zone. Inadvertent returns or drilling fluid losses could be more likely to occur when drilling through low velocity zones.

All geophysical data and field notes collected as a part of this investigation will be archived at the AGS office. The data collection and interpretation methods used in this investigation are consistent with standard practices applied to similar geophysical investigations. The correlation of geophysical responses with probable subsurface features is based on the past results of similar surveys although it is possible that some variation could exist at this site. Intrusive field activities, such as soil borings and/or rock coring, would be needed to further investigate and confirm the presence or absence of identified and interpreted features. Due to the nature of geophysical data, no guarantees can be made or implied regarding the presence or absence of additional objects or targets beyond those identified.

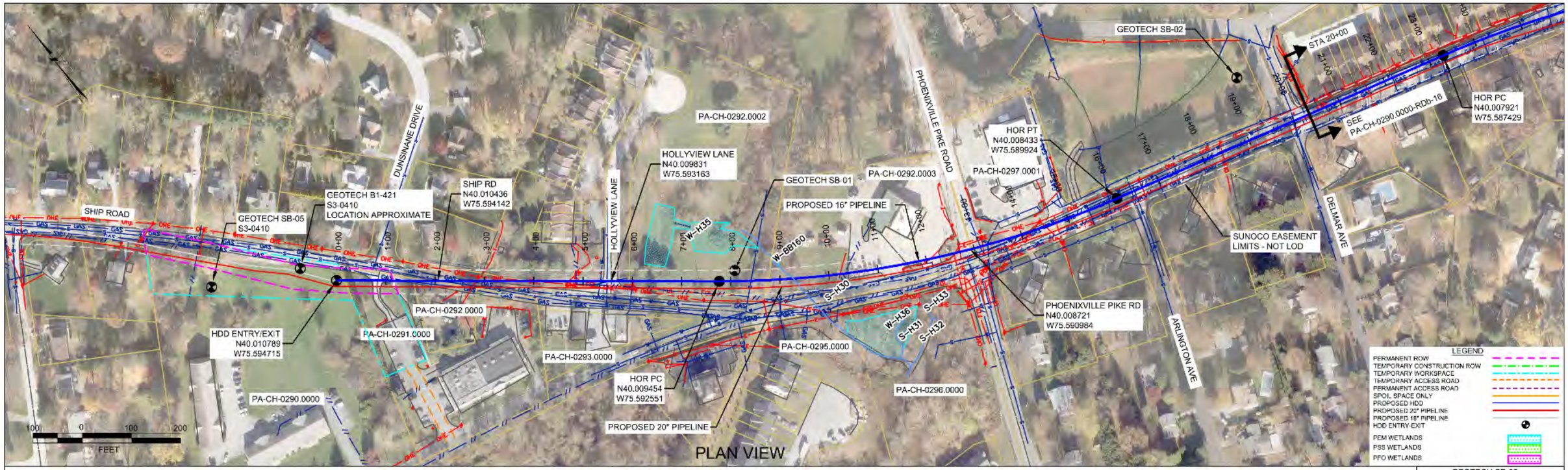
If you have any questions regarding the results of this field investigation, please contact me at 610-722-5500. It was a pleasure working with you on this project and we look forward to being able to provide you with sub-surface imaging services in the future.

Sincerely,

Donald Jagel

Donald Jagel, P.G.
Principal Geophysicist

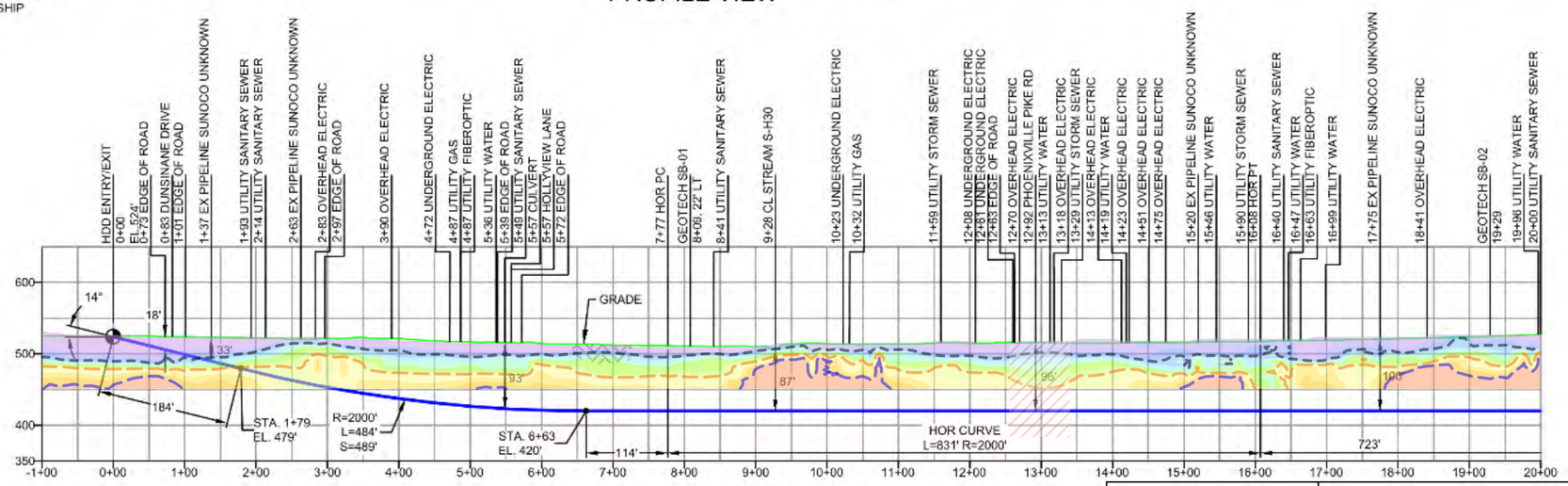
attachments: Contoured MASW Profiles: S3-0421-West, S3-0421-East, S3-0460, S3-0580, and S3-591
Contoured Seismic Refraction Tomography Profiles: S3-0421-West, S3-0421-East, S3-0460, S3-0580, and S3-591



PLAN VIEW

PROFILE VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421-16



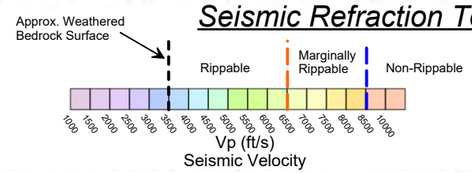
GEOTECH SB-01
-NG EL. 512'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 11.0')
-GROUNDWATER (23.0')
-SM (11.5' - 63.5')
-FRACTURED SCHIST (63.5' - 65.0')
-AUGER REFUSAL (65.0')
-COMPLETION DEPTH EL. 447'

GEOTECH SB-02
-NG EL. 522'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.5')
-MICA SCHIST (8.5' - 14.0')
-AUGER REFUSAL (14.0')
-WEATHERED SCHIST (14.0' - 22.0')
-COMPLETION DEPTH EL. 500'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

Seismic Refraction Tomography Results

Hatching identifies areas of low data density because of intersections and limited access. Contours in these areas should be relied on using discretion.



GEOTECH SB-05
-NG EL. 530'
-TOPSOIL (0' - 0.5')
-GROUNDWATER (8.0')
-SM (0.5' - 23.5')
-WEATHERED SCHIST (23.5' - 24.4')
-AUGER REFUSAL (24.0')
-COMPLETION DEPTH EL. 505'

NOTE: REFER TO TEST BORING LOG S3-0410 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-421
-NG EL. 528'
-FILL ML (0.0' - 3.0')
-POSSIBLE FILL CL (3.0' - 7.5')
-GROUNDWATER (12.3')
-RESIDUUM SANDY SILT ML (7.5' - 32.5')
-RESIDUUM SILTY SAND W/ GRAVEL SM (32.5' - 42.5')
-RESIDUUM SILT ML (42.5' - 47.5')
-WEATHERED SCHIST, SILTY SAND SM (47.5' - 52.5')
-WEATHERED SCHIST SANDY SILT ML (52.5' - 57.5')
-WEATHERED SCHIST, SILTY SAND SM (57.5' - 69.5')
-AUGER REFUSAL (69.5')
-SCHIST (69.5' - 150.0')
-BORING TERMINATED EL.378'

NOTE: REFER TO TEST BORING LOG B1-421 INTERTEK PSI PROJECT #G011508 FOR COMPLETE SOIL MATERIAL DESCRIPTION

ADVANCED GEOLOGICAL SERVICES

HDD421 West Plot and Profile Plan Showing Color Contoured Refraction Tomography Results

LOCATION: HDD421 West, Pennsylvania

CLIENT: Groundwater & Environmental Services, Inc.

PROJECT #: AGS18-335-1

ADVANCED GEOLOGICAL SERVICES, INC.

DATE: May 24, 2019

DRAWN BY: D. JAGEL

APPROVED BY: D. JAGEL

NOTES

1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
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REF. DRAWING

E8-6.54	TO	E8-6.56	EROSION & SEDIMENT PLAN
SHEET 36	TO	SHEET 36	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED ADDITIONAL GEOTECH	MRS	02/08/19	RMB	02/08/19	AMC	02/08/19
EP4	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	04/10/18	RMB	04/10/18	AMC	04/10/18
EP3	LOWERED DRILL BOTTOM ELEVATION TO 420' AND SWITCHED CENTERLINE PER CLIENT REQUEST	MRS	03/15/18	RMB	03/15/18	AMC	03/15/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	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

Sunoco Logistics Partners L.P.

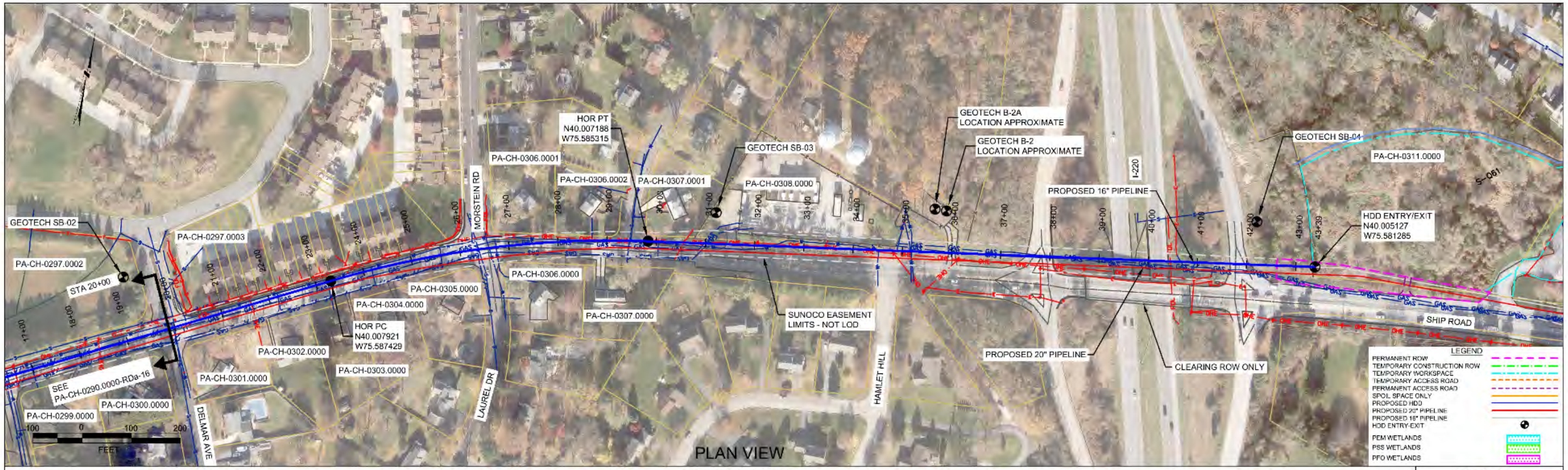
TETRA TECH ROONEY (303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

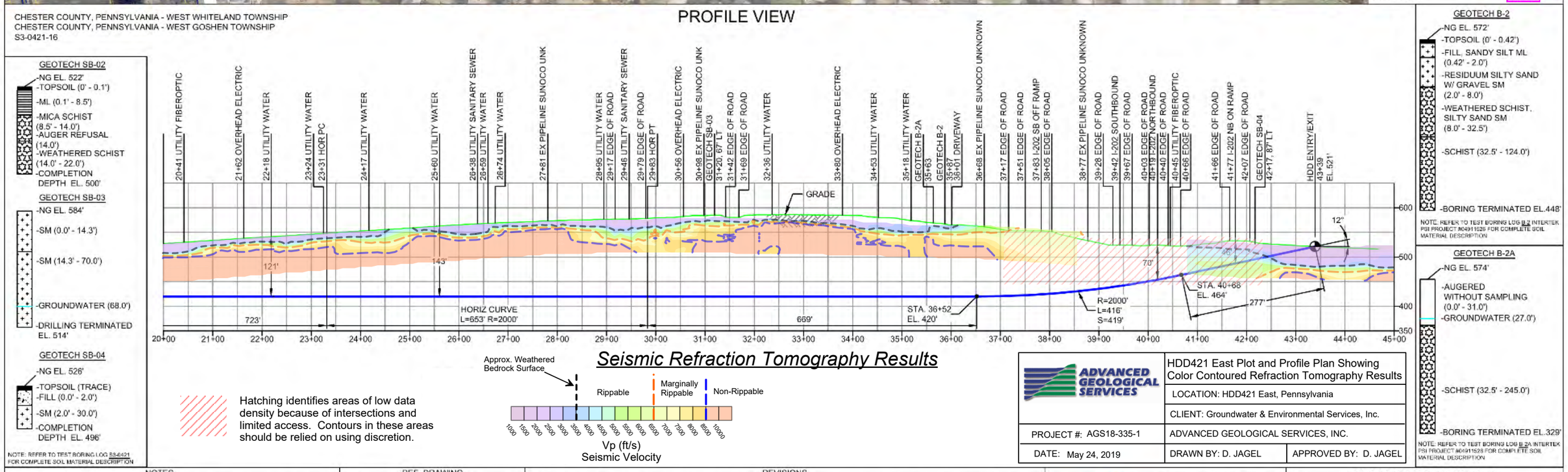
DWG. NUMBER: PA-CH-0290.0000-RDa-16



PLAN VIEW

PROFILE VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421-16



GEOTECH SB-02
-NG EL. 522'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.5')
-MICA SCHIST (8.5' - 14.0')
-AUGER REFUSAL (14.0')
-WEATHERED SCHIST (14.0' - 22.0')
-COMPLETION DEPTH EL. 500'

GEOTECH SB-03
-NG EL. 584'
-SM (0.0' - 14.3')
-SM (14.3' - 70.0')
-GROUNDWATER (68.0')
-DRILLING TERMINATED EL. 514'

GEOTECH SB-04
-NG EL. 526'
-TOPSOIL (TRACE)
-FILL (0.0' - 2.0')
-SM (2.0' - 30.0')
-COMPLETION DEPTH EL. 496'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2
-NG EL. 572'
-TOPSOIL (0' - 0.42')
-FILL, SANDY SILT ML (0.42' - 2.0')
-RESIDUUM SILTY SAND W/ GRAVEL SM (2.0' - 8.0')
-WEATHERED SCHIST, SILTY SAND SM (8.0' - 32.5')
-SCHIST (32.5' - 124.0')
-BORING TERMINATED EL.448'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PSI PROJECT #0491 1526 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2A
-NG EL. 574'
-AUGERED WITHOUT SAMPLING (0.0' - 31.0')
-GROUNDWATER (27.0')
-SCHIST (32.5' - 245.0')
-BORING TERMINATED EL.329'

NOTE: REFER TO TEST BORING LOG B-2A INTERTEK PSI PROJECT #0491 1528 FOR COMPLETE SOIL MATERIAL DESCRIPTION

Seismic Refraction Tomography Results

Hatching identifies areas of low data density because of intersections and limited access. Contours in these areas should be relied on using discretion.

ADVANCED GEOLOGICAL SERVICES	HDD421 East Plot and Profile Plan Showing Color Contoured Refraction Tomography Results
	LOCATION: HDD421 East, Pennsylvania
	CLIENT: Groundwater & Environmental Services, Inc.
PROJECT #: AGS18-335-1	ADVANCED GEOLOGICAL SERVICES, INC.
DATE: May 24, 2019	DRAWN BY: D. JAGEL / APPROVED BY: D. JAGEL

NOTES

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5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

ES-6.54	TO	ES-6.56	EROSION & SEDIMENT PLAN
SHEET 36	TO	SHEET 36	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED ADDITIONAL GEOTECH	MRS	02/08/19	RMB	02/08/19	AMC	02/08/19
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EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16

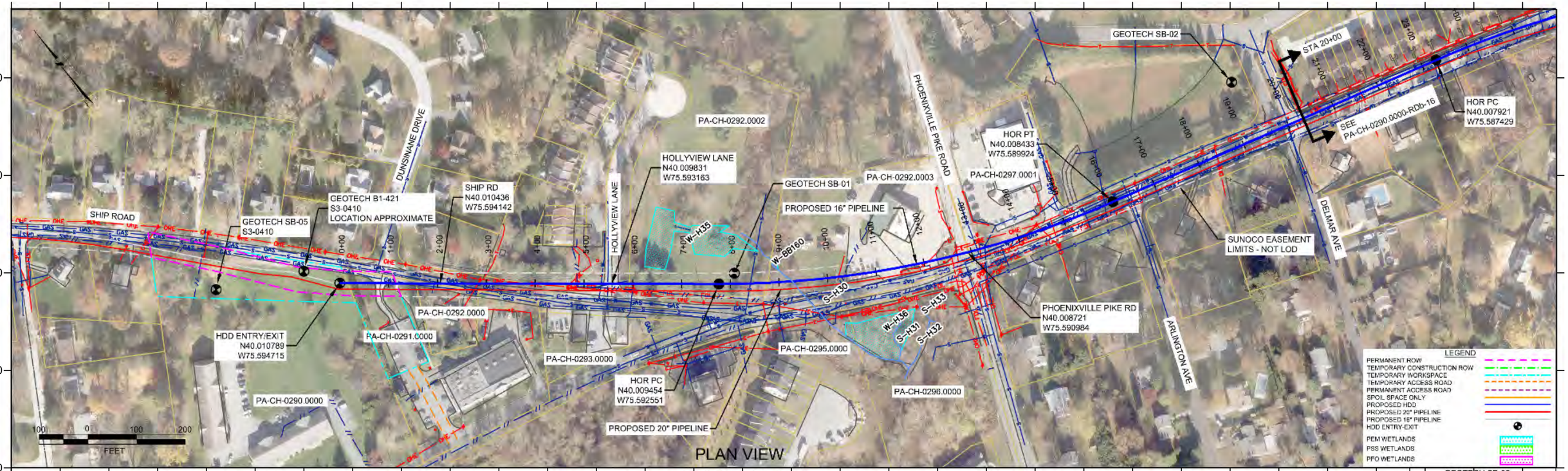
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

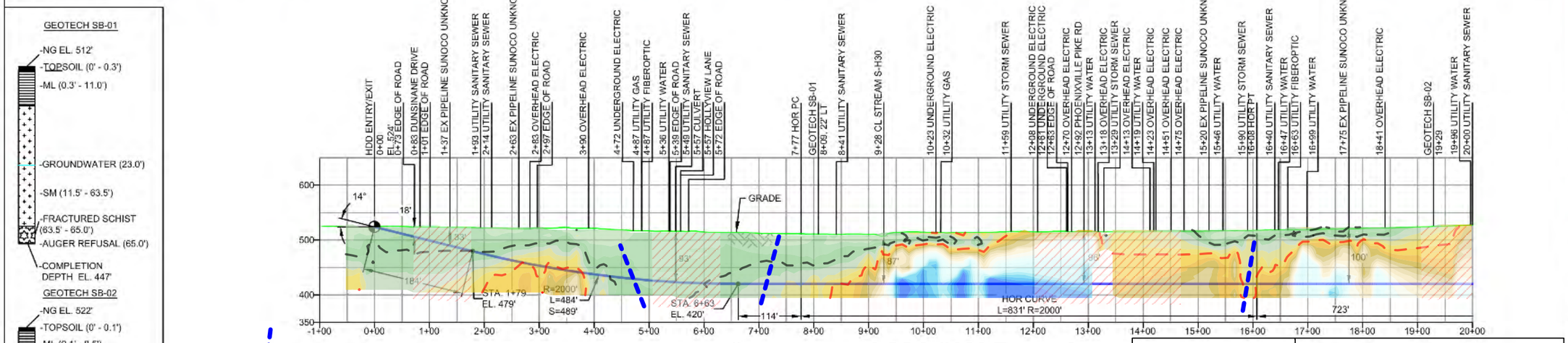
SCALE: 1"=200' | DWG. NUMBER: PA-CH-0290.0000-RDb-16



PLAN VIEW

PROFILE VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST NANTMEAL TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421-16



GEOTECH SB-01
- NG EL. 512'
- TOPSOIL (0' - 0.3')
- ML (0.3' - 11.0')
- GROUNDWATER (23.0')
- SM (11.5' - 63.5')
- FRACTURED SCHIST (63.5' - 65.0')
- AUGER REFUSAL (65.0')
- COMPLETION DEPTH EL. 447'

GEOTECH SB-02
- NG EL. 522'
- TOPSOIL (0' - 0.1')
- ML (0.1' - 8.5')
- MICA SCHIST (8.5' - 14.0')
- AUGER REFUSAL (14.0')
- WEATHERED SCHIST (14.0' - 22.0')
- COMPLETION DEPTH EL. 500'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

Low Velocity Zone (fault, fracture, or weathered zone)

Hatching identifies areas of low data density because of intersections and limited access. Contours in these areas should be relied on using discretion.

Contoured MASW Results

Vs (ft/s)
Shear Velocity

GEOTECH SB-05
- NG EL. 530'
- TOPSOIL (0' - 0.5')
- GROUNDWATER (8.0')
- SM (0.5' - 23.5')
- WEATHERED SCHIST (23.5' - 24.4')
- AUGER REFUSAL (24.0')
- COMPLETION DEPTH EL. 505'

NOTE: REFER TO TEST BORING LOG S3-0410 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-421
- NG EL. 528'
- FILL ML (0.0' - 3.0')
- POSSIBLE FILL CL (3.0' - 7.5')
- GROUNDWATER (12.3')
- RESIDUUM SANDY SILT ML (7.5' - 32.5')
- RESIDUUM SILTY SAND W/ GRAVEL SM (32.5' - 42.5')
- RESIDUUM SILT ML (42.5' - 47.5')
- WEATHERED SCHIST, SILTY SAND SM (47.5' - 52.5')
- WEATHERED SCHIST SANDY SILT ML (52.5' - 57.5')
- WEATHERED SCHIST, SILTY SAND SM (57.5' - 69.5')
- AUGER REFUSAL (69.5')
- SCHIST (69.5' - 150.0')
- BORING TERMINATED EL.378'

NOTE: REFER TO TEST BORING LOG B1-421 INTERTEK PSI PROJECT #G0115928 FOR COMPLETE SOIL MATERIAL DESCRIPTION

ADVANCED GEOLOGICAL SERVICES

HDD421 West Plot and Profile Plan Showing Color Contoured MASW Results

LOCATION: HDD421, Pennsylvania

CLIENT: Groundwater & Environmental Services, Inc.

PROJECT #: AGS18-335-1 | ADVANCED GEOLOGICAL SERVICES, INC.

DATE: May 24, 2019 | DRAWN BY: D. JAGEL | APPROVED BY: D. JAGEL

NOTES

1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
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5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

E8-6.54	TO	E8-6.56	EROSION & SEDIMENT PLAN	
SHEET 36	TO	SHEET 36	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED ADDITIONAL GEOTECH	MRS	02/08/19	RMB	02/08/19	AMC	02/08/19
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EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/27/16	AAW	10/07/16
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EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16

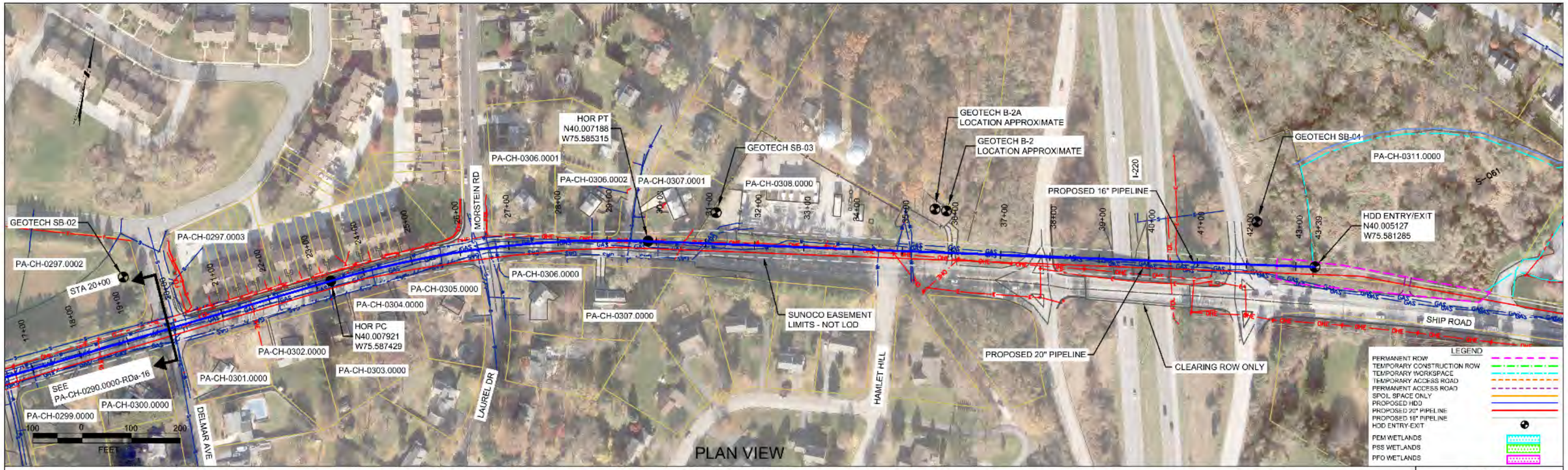
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY (303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

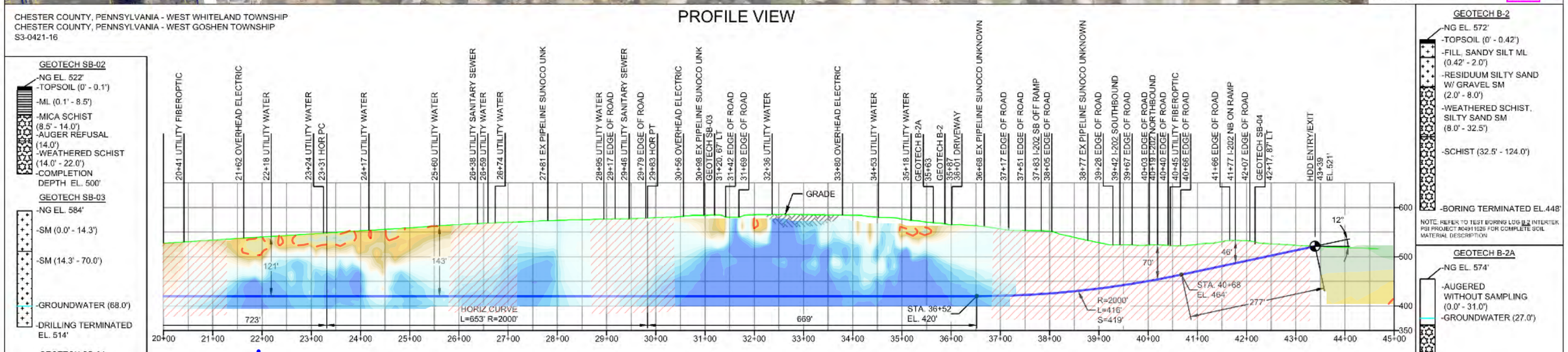
SCALE: 1"=200' | DWG. NUMBER: PA-CH-0290.0000-RDa-16



PLAN VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421-16

PROFILE VIEW



GEOTECH SB-02
-NG EL. 522'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.5')
-MICA SCHIST (8.5' - 14.0')
-AUGER REFUSAL (14.0')
-WEATHERED SCHIST (14.0' - 22.0')
-COMPLETION DEPTH EL. 500'

GEOTECH SB-03
-NG EL. 584'
-SM (0.0' - 14.3')
-SM (14.3' - 70.0')
-GROUNDWATER (68.0')
-DRILLING TERMINATED EL. 514'

GEOTECH SB-04
-NG EL. 526'
-TOPSOIL (TRACE)
-FILL (0.0' - 2.0')
-SM (2.0' - 30.0')
-COMPLETION DEPTH EL. 496'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2
-NG EL. 572'
-TOPSOIL (0' - 0.42')
-FILL, SANDY SILT ML (0.42' - 2.0')
-RESIDUUM SILTY SAND W/ GRAVEL SM (2.0' - 8.0')
-WEATHERED SCHIST, SILTY SAND SM (8.0' - 32.5')
-SCHIST (32.5' - 124.0')
-BORING TERMINATED EL.448'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PSI PROJECT #04911526 FOR COMPLETE SOIL MATERIAL DESCRIPTION

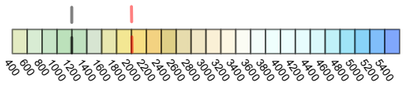
GEOTECH B-2A
-NG EL. 574'
-AUGERED WITHOUT SAMPLING (0.0' - 31.0')
-GROUNDWATER (27.0')
-SCHIST (32.5' - 245.0')
-BORING TERMINATED EL.329'

NOTE: REFER TO TEST BORING LOG B-2A INTERTEK PSI PROJECT #04911528 FOR COMPLETE SOIL MATERIAL DESCRIPTION

Low Velocity Zone (fault, fracture, or weathered zone)

Hatching identifies areas of low data density because of intersections and limited access. Contours in these areas should be relied on using discretion.

Contoured MASW Results



Vs (ft/s)
Shear Velocity

ADVANCED GEOLOGICAL SERVICES

HDD421 East Plot and Profile Plan Showing Color Contoured MASW Results

LOCATION: HDD421, Pennsylvania

CLIENT: Groundwater & Environmental Services, Inc.

PROJECT #: AGS18-335-1 | ADVANCED GEOLOGICAL SERVICES, INC.

DATE: May 24, 2019 | DRAWN BY: D. JAGEL | APPROVED BY: D. JAGEL

NOTES

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

REF. DRAWING

E8-6.54	TO	E8-6.56	EROSION & SEDIMENT PLAN
SHEET 36	TO	SHEET 38	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED ADDITIONAL GEOTECH	MRS	02/08/19	RMB	02/08/19	AMC	02/08/19
EP4	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	04/10/18	RMB	04/10/18	AMC	04/10/18
EP3	LOWERED DRILL BOTTOM ELEVATION TO 420' AND SWITCHED CENTERLINE PER CLIENT REQUEST	MRS	03/15/18	RMB	03/15/18	AMC	03/15/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

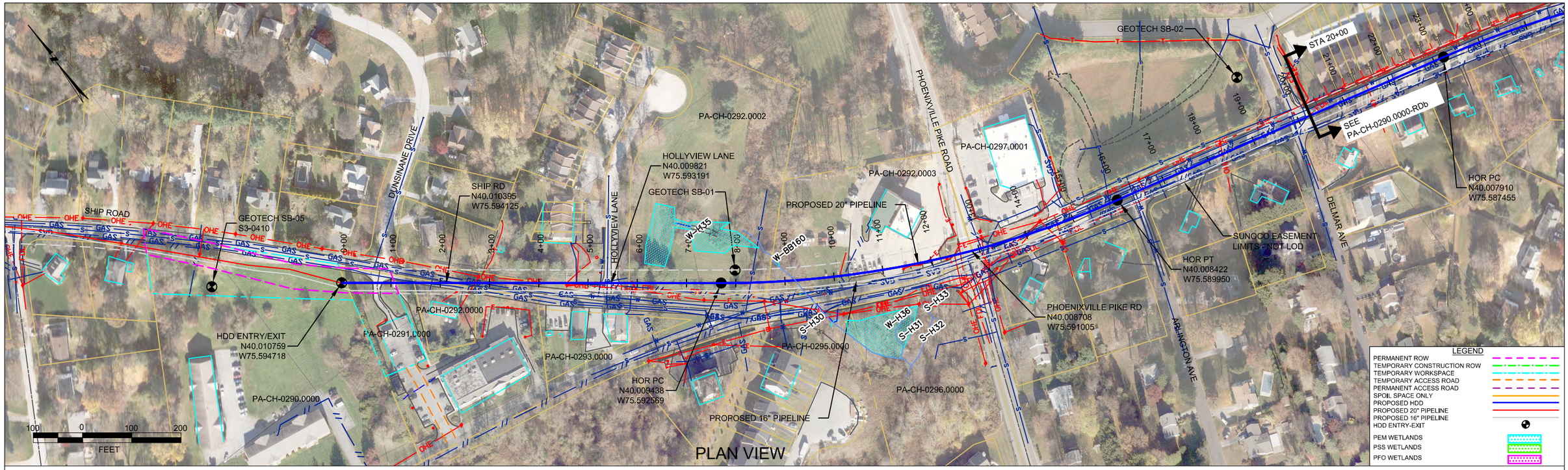
HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' | DWG. NUMBER: PA-CH-0290.0000-RDb-16

PHOENIXVILLE PIKE ROAD
PADEP SECTION 105 PERMIT NO.: E15-862
PA-CH-0290.0000-RD
(SPLP HDD No. S3-0421)

ATTACHMENT 2

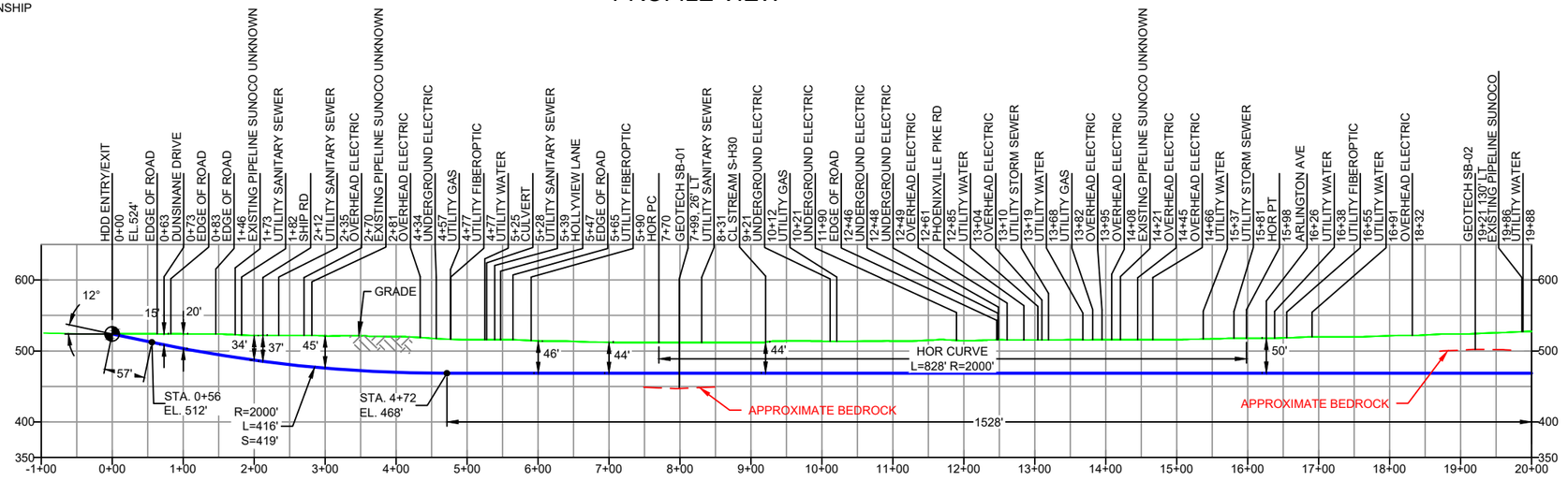
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



PLAN VIEW

PROFILE VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421A



GEOTECH SB-01

-NG EL. 512'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 11.0')
-GROUNDWATER (23.0')
-SM (11.5' - 63.5')
-FRACTURED SCHIST (63.5' - 65.0')
-COMPLETION DEPTH EL. 447'

GEOTECH SB-02

-NG EL. 522'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.5')
-MICA SCHIST (8.5' - 14.0')
-WEATHERED SCHIST (14.0' - 22.0')
-COMPLETION DEPTH EL. 500'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-05

-NG EL. 530'
-TOPSOIL (0' - 0.5')
-GROUNDWATER (8.0')
-SM (0.5' - 23.5')
-WEATHERED SCHIST (23.5' - 24.4')
-COMPLETION DEPTH EL. 505'

NOTE: REFER TO TEST BORING LOG S3-0410 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4350'
   HDD PIPE LENGTH (S=):4357'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 1A. Permitted 20-Inch HDD Plan and Profile``

NOTES

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

REF. DRAWING

ES-6.54	TO	ES-6.56	EROSION & SEDIMENT PLAN	
SHEET 36	TO	SHEET 38	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	JVA	03/26/15	RMB	03/26/15	AAW	03/26/15

Sunoco Logistics Partners L.P.

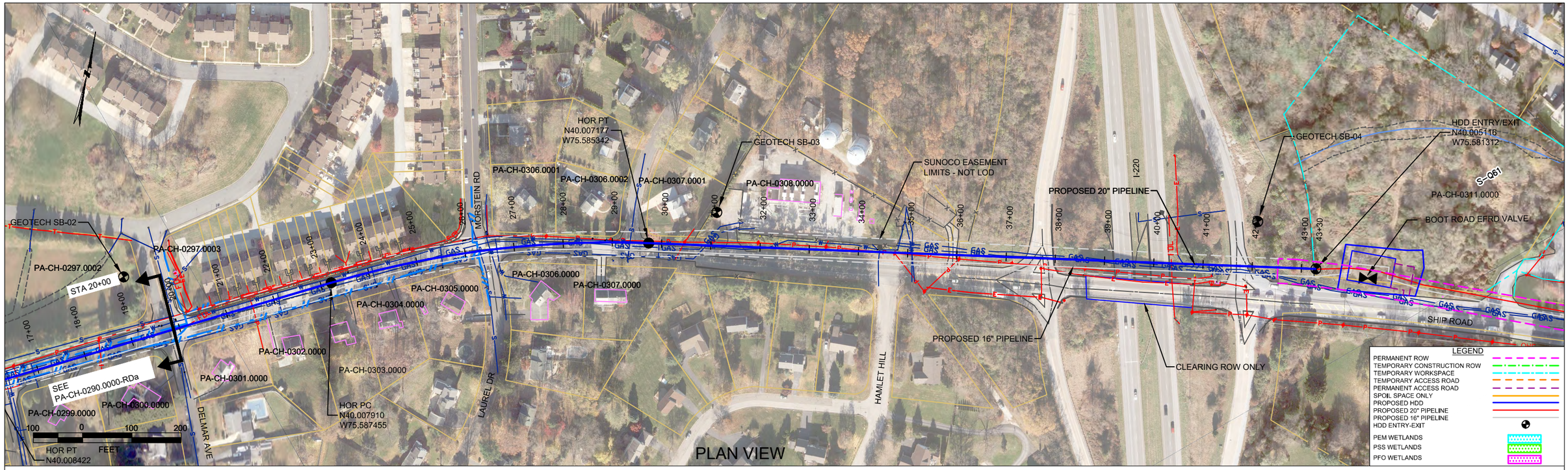
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

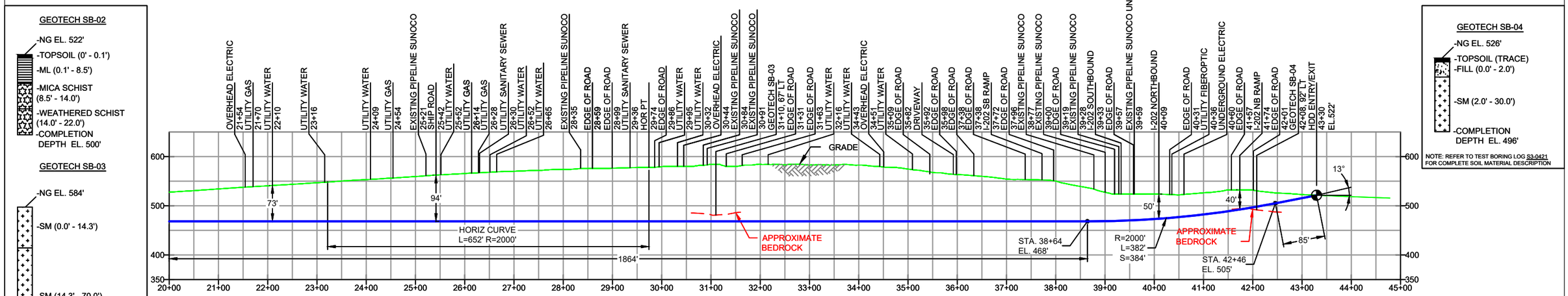
DWG. NO: PA-CH-0290.0000-RDa



PLAN VIEW

PROFILE VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421B



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4350'
   HDD PIPE LENGTH (S=):4357'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 1B. Permitted 20-Inch HDD Plan and Profile

NOTES

1. ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
2. STATIONING IS BASED ON HORIZONTAL DISTANCES.
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5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

ES-6.54	TO	ES-6.56	EROSION & SEDIMENT PLAN
SHEET 36	TO	SHEET 38	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	11/13/15	RMB	11/13/15	AAW	11/13/15
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	JVA	03/26/15	RMB	03/26/15	AAW	03/26/15

Sunoco Logistics Partners L.P.

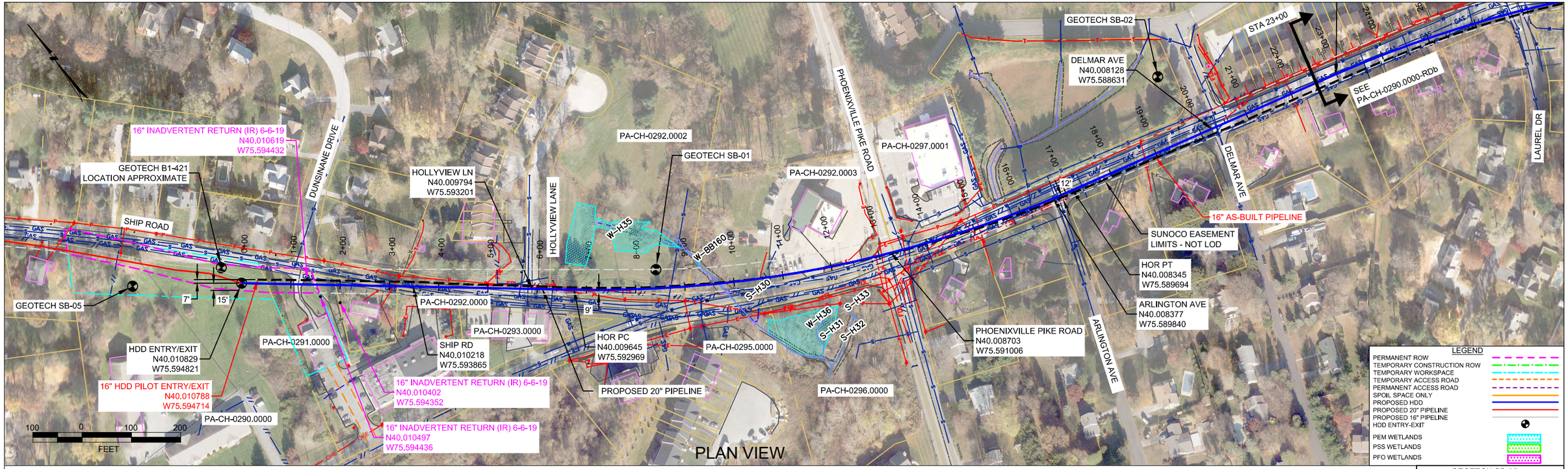
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

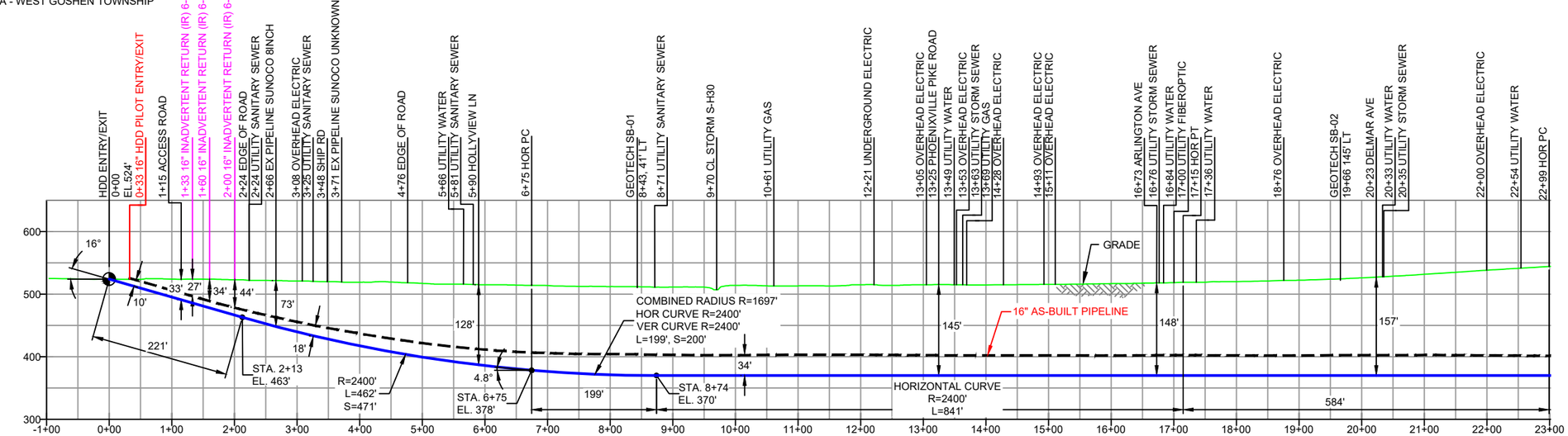
SCALE: 1"=200'

DWG. NO: PA-CH-0290.0000-RDb



CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421

PROFILE VIEW



DESIGN AND CONSTRUCTION:

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2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4391'
   HDD PIPE LENGTH (S=):4423'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

Figure 2A. Revised 20-Inch HDD Plan and Profile

GEOTECH SB-01
-NG EL. 512'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 11.0')
-GROUNDWATER (23.0')
-SM (11.5' - 63.5')
-FRACTURED SCHIST (63.5' - 65.0')
-AUGER REFUSAL (65.0')
-COMPLETION DEPTH EL. 447'

GEOTECH SB-02
-NG EL. 522'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.5')
-MICA SCHIST (8.5' - 14.0')
-AUGER REFUSAL (14.0')
-WEATHERED SCHIST (14.0' - 22.0')
-COMPLETION DEPTH EL. 500'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-05
-NG EL. 530'
-TOPSOIL (0' - 0.5')
-GROUNDWATER (8.0')
-SM (0.5' - 23.5')
-WEATHERED SCHIST (23.5' - 24.4')
-AUGER REFUSAL (24.0')
-COMPLETION DEPTH EL. 505'

NOTE: REFER TO TEST BORING LOG S3-0410 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-421
-NG EL. 528'
-FILL ML (0.0' - 3.0')
-POSSIBLE FILL CL (3.0' - 7.5')
-GROUNDWATER (12.3')
-RESIDUUM SANDY SILT ML (7.5' - 32.5')
-RESIDUUM SILTY SAND W/ GRAVEL SM (32.5' - 42.5')
-RESIDUUM SILT ML (42.5' - 47.5')
-WEATHERED SCHIST, SILTY SAND SM (47.5' - 52.5')
-WEATHERED SCHIST SANDY SILT ML (52.5' - 57.5')
-WEATHERED SCHIST, SILTY SAND SM (57.5' - 69.5')
-AUGER REFUSAL (69.5')
-SCHIST (69.5' - 150.0')
-BORING TERMINATED EL.378'

NOTE: REFER TO TEST BORING LOG B1-421 INTERTEK PSI PROJECT #0491508 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTES

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5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

ES-6.54	TO ES-6.56	EROSION & SEDIMENT PLAN	
SHEET 36	TO SHEET 38	AERIAL SITE PLAN	
DWG NO	DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED 16" AS-BUILT, IR INFORMATION AND INCREASED DEPTH OF 20" DESIGN PER CLIENT REQUEST	MRS	12/11/19	RMB	12/11/19	AMC	12/11/19
EP4	ADDED ADDITIONAL GEOTECH INFORMATION	MRS	02/08/19	RMB	02/08/19	AMC	02/08/19
EP3	LOWERED DRILL BOTTOM ELEVATION TO 400' AND SWITCHED CENTERLINE PER CLIENT REQUEST	MRS	03/15/18	RMB	03/15/18	AMC	03/15/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16

Sunoco Logistics Partners L.P.

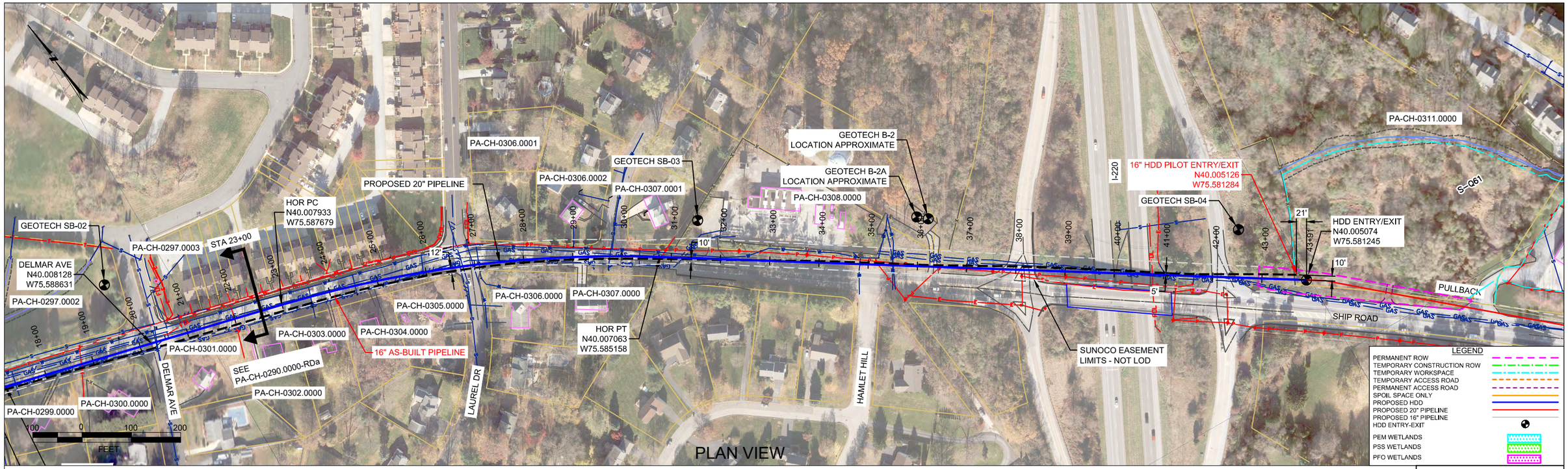
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

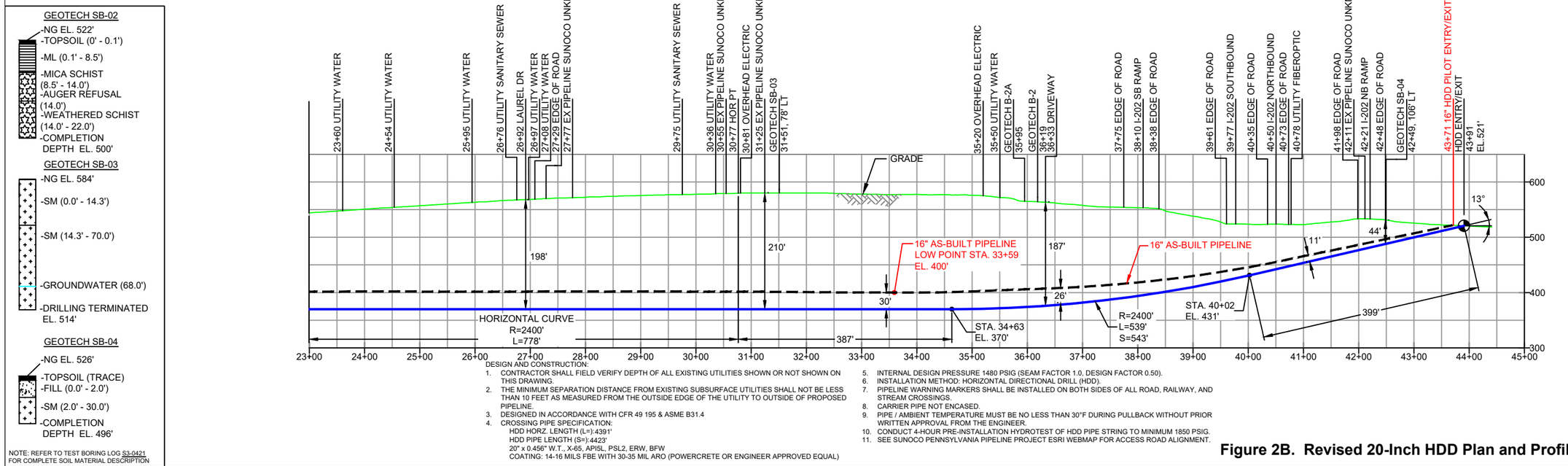
SCALE: 1"=200'

DWG. NO: PA-CH-0290.0000-RDa



PROFILE VIEW

CHESTER COUNTY, PENNSYLVANIA - WEST WHITELAND TOWNSHIP
CHESTER COUNTY, PENNSYLVANIA - WEST GOSHEN TOWNSHIP
S3-0421



GEOTECH SB-02
-NG EL. 522'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.5')
-MICA SCHIST (8.5' - 14.0')
-AUGER REFUSAL (14.0')
-WEATHERED SCHIST (14.0' - 22.0')
-COMPLETION DEPTH EL. 500'

GEOTECH SB-03
-NG EL. 584'
-SM (0.0' - 14.3')
-SM (14.3' - 70.0')
-GROUNDWATER (68.0')
-DRILLING TERMINATED EL. 514'

GEOTECH SB-04
-NG EL. 526'
-TOPSOIL (TRACE)
-FILL (0.0' - 2.0')
-SM (2.0' - 30.0')
-COMPLETION DEPTH EL. 496'

NOTE: REFER TO TEST BORING LOG S3-0421 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2
-NG EL. 572'
-TOPSOIL (0' - 0.42')
-FILL, SANDY SILT ML (0.42' - 2.0')
-RESIDUUM SILTY SAND W/ GRAVEL SM (2.0' - 8.0')
-WEATHERED SCHIST, SILTY SAND SM (8.0' - 32.5')
-SCHIST (32.5' - 124.0')
-BORING TERMINATED EL.448'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PSI PROJECT #04911526 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2A
-NG EL. 574'
-AUGERED WITHOUT SAMPLING (0.0' - 31.0')
-GROUNDWATER (27.0')
-SCHIST (32.5' - 245.0')
-BORING TERMINATED EL.329'

NOTE: REFER TO TEST BORING LOG B-2A INTERTEK PSI PROJECT #04911526 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4391'
   HDD PIPE LENGTH (S=):4423'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

Figure 2B. Revised 20-Inch HDD Plan and Profile

NOTES

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

REF. DRAWING

ES-6.54	TO	ES-6.56	EROSION & SEDIMENT PLAN	
SHEET 36	TO	SHEET 38	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP5	ADDED 16" AS-BUILT, IR INFORMATION AND INCREASED DEPTH OF 20" DESIGN PER CLIENT REQUEST	MRS	12/11/19	RMB	12/11/19	AMC	12/11/19
EP4	ADDED ADDITIONAL GEOTECH INFORMATION	MRS	02/08/19	RMB	02/08/19	AMC	02/08/19
EP3	LOWERED DRILL BOTTOM ELEVATION TO 400' AND SWITCHED CENTERLINE PER CLIENT REQUEST	MRS	03/15/18	RMB	03/15/18	AMC	03/15/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/11/16	RMB	05/11/16	AAW	05/11/16
EP		MRS	11/13/15	RMB	11/13/15	AAW	11/13/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
PHOENIXVILLE PIKE ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NO: PA-CH-0290.0000-RDb