HORIZONTAL DIRECTIONAL DRILL ANALYSIS
NORTH ZINNS MILL ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E38-194
PA-LE-0055.0000-RD-16
(SPLP HDD No. S3-0101-16)

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

The installation of the 20-inch diameter pipeline by HDD was initiated before the temporary injunction issued by the Pennsylvania Department of Environmental Protection (PADEP) Environmental Hearing Board on July 25, 2017. This first HDD had multiple inadvertent returns (IR), and therefore, the installation of the second pipeline (16-inch diameter) requires reanalysis. The IRs for the 20-inch pipeline were remediated and the HDD installation for the 20-inch diameter pipeline was completed.

The 16-inch pipeline HDD is referred to herein as HDD S3-0101-16.

PIPE INFORMATION

16-Inch: 0.438 wall thickness; X-70.

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

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 1,180 foot (ft)
- Entry/Exit angle: 12-14 degrees
- Maximum Depth of cover: 90 ft
- Depth under Snitz Creek: (eight) 8 ft
- Pipe design radius: 1,600 ft

ROOT CAUSE ANALYSIS FOR THE 20-INCH PIPELINE INSTALLATION INADVERDENT RETURNS

Prior to the onset of drilling, the North Zinns Mill Road/Snitz Creek 20-inch HDD, S3-0101-20, was field modified by HDD specialists to lengthen the extent of the HDD, increase the depth of cover under Waters of the Commonwealth, and sharpen the entry exit angles into bedrock. Despite these field changes to the drilling profile, IRs occurred during the pilot phase of the HDD. The occurrence of the IR events at the crossing of Snitz Creek during the installation of the 20-inch diameter pipeline resulted from a combination of preferential pathways in the unconsolidated and weathered overburden; the presence of interconnected horizontal and vertical fractures in limestone, dolomite, and shale bedrock; and the presence of potentially shallow groundwater. Multiple efforts to seal the fluid pathways were attempted during the drilling process, which resulted in some benefit, but did not fully resolve the IR issues during the pilot hole phase. The reaming phase was successful, which is likely due to the large volume of cuttings in combination with the drilling fluids sealing off the fluid movement pathways in the bedrock. This “packing off” of fluid movements in the bedrock during the reaming phases of an HDD has been documented as a common occurrence during HDDs on the Mariner Pipeline Project.

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GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

HDD S3-0101-16 is located within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. The Gettysburg-Newark Lowland Section consists of rolling lowlands, shallow valleys, and isolated hills. Bedrock in the area of HDD S3-0101-16 belongs to the Cambrian age Snitz Creek Formation part of the Conococheague Group. The Snitz Creek Formation consists of light-gray to dark-gray, very finely to finely crystalline dolomite. Much of the dolomite is argillaceous, silty, or sandy. Thickness is 300 to 400 ft.

Due to the karst geology present at this HDD location, geophysical testing was conducted and analyzed.

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater in the watershed occupied by the HDD S3-0101-16 originates as precipitation or snowmelt through the overburden soils. Shallow groundwater generally occurs under unconfined conditions within the upper portion of the bedrock. The groundwater table occurs within both the overburden soils and bedrock (at 5 to 85 ft bgs) proximate to the HDD path and contributes flow to local shallow groundwater discharge zones supporting Snitz Creek which crosses above the HDD profile. The uppermost groundwater table is presumed to occur within the uppermost bedrock or near the soil/bedrock interface under unconfined conditions.

Based upon Tetra Tech's geotechnical exploration activities completed in October and November of 2015, groundwater was not encountered in the three (3) shallow geotechnical soil borings (SB-01 through SB-03), located near the originally proposed eastern and western drill entry/exit points and near the middle of that drill profile between North Zinns Mill Road and North Cornwall Road

Subsequent geotechnical exploration activities were completed in November 2017 at three (3) geotechnical soil borings (B-1, B-2, and B-2A). Bore B-1, located 130 ft northeast of the western HDD entry encountered groundwater at 43 ft bgs and had a completion depth of 170 ft bgs. At Bore B-2, located 166 ft east of North Cornwall Road, groundwater was encountered at 2.9 ft bgs and completion depth was 105 ft bgs. A second bore named B-1, located east of Quinten Road and 950 ft west of the HDD exit point, encountered groundwater at 24 ft bgs and had a completion depth of 152 ft bgs. Bore B-2A, located east of Tice Road and 300 ft east of the eastern HDD exit point, encountered water at 27 ft bgs and the completion depth was 153 ft bgs.

Based on incomplete information in the PaGWIS database, it appears that the majority of the identified wells in vicinity to the S3-0101 HDD were completed as 6-inch-diameter open-rock wells at depths ranging from 120 to 466 feet bgs. Based solely on the PaGWIS database, the depth to bedrock ranges from 3 to 85 feet bgs, and well construction consists of 17 to 104 feet of steel casing with the open-rock portions of the wells extending from 17 feet to 466 feet bgs. Reported well yields range from 2 to 100 gpm. During development of nineteen of these wells, static water level measurements were recorded and water levels ranged from 5 to 85 feet bgs with an average of 38 feet bgs. Based on the information provided in the PaGWIS database, the majority of the wells identified above were completed in the Snitz Creek Formation.

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

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INADVERTENT RETURN (IR) DISCUSSION

After multiple IRs occurred during the installation of the 20-inch pipe, HDD specialists reviewed the original 16-inch HDD design summarized above; the "as built" 20-inch HDD profile; the IR reports; and the geophysics data. Based on that review, the HDD specialists predicted that the original design profile or a modified 16-inch HDD profile paralleling the installed 20-inch pipeline would produce an IR at or before 200 ft into the pilot profile where the drill crossed the first stream, and an IR to a Water of the Commonwealth would occur.

As presented in the Conclusion section below, the profile for the 16-inch pipeline has been redesigned so that it is extensively longer and much deeper, with the degree of entry and exit angles maximized as allowed by the stress radius of the pipeline.

ADJACENT FEATURES ANALYSIS

This HDD location is located 0.9 miles north of the Town of Quentin in Lebanon County, Pennsylvania, set within a rural residential area, and crosses under North Zinns Mill Road, North Cornwall Road, and Quentin Road. Water resources crossed by the HDD includes Snitz Creek (S-A17) and wetland W-A13. The pipeline route follows parallel to an existing SPLP pipeline easement that crosses under Snitz Creek.

Snitz Creek has a perennial flow regime and is not designated as high quality. Wetland W-A13 is classified as emergent. Although wetland W-A13 is not designated as an exceptional value wetland, it provides a buffer and is riparian to Snitz Creek. This HDD avoids surficial impacts to Snitz Creek, wetland W-A13, the floodway of Snitz Creek, a Federal Emergency Management Agency (FEMA) 100-year floodplain, and existing underground gas pipelines parallel to the easement and orientation of the HDD**.**

Based upon the data from the PaGWIS, review of aerial photography, and landowner communications issued in 2018, eleven (11) domestic (private) supply wells were identified within 450 ft of the proposed HDD. The PaGWIS reported well depths are 100 to 150 ft bgs, with a reported static water level of 30 ft bgs. No water supply well complaints were received during drilling of the 20-inch pipeline.

To identify water well locations relative to the revised (extended) 16-inch HDD profile, in January 2019 SPLP sent certified letters to all landowners of the additional 14 properties within 450 ft of the revised HDD alignment. Public Water Suppliers within 0.5 mile were also identified and notified of the project. Copies of these communications are provided in Attachment 2.

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

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of HDD S3-0101-16 includes an evaluation of open cut alternatives and a re-route analysis. As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the Project, SPLP considered several different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and

stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

Open-cut Analysis

Sunoco Pipeline, L.P. (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.

While an open cut installation of the pipeline is technically feasible, the logistics associated with this method would significantly increase the length of time the affected properties would be subject to construction disturbance and would directly affect adjacent residential home sites due to the workspace requirements to accommodate the open trench method while constructing between two existing in-service pipelines

There is one (1) minor stream crossing and one (1) emergent wetland within the HDD profile. This stream is not listed as high quality or exceptional value. Open cut impacts to this resources would be minimal, but would require modification of the state and federal permits. Moreover, any produced groundwater in the open excavations would be pumped to a discharge filtration structure. The current feasible filtration ability, however, does not exceed 50 microns. Therefore, cloudy water (from suspended fine clay and silt particles) would be discharged downstream regardless of all control methods employed for the entire duration of the use of open cut construction techniques.

A conventional auger bore is generally limited to 200 linear ft at a time, varying by the underlying substrate. Due to the spacing constraints at the HDD location and changes in elevation at the resources to be bored past, there are no subset locations within this length of area to feasibly employ this type of installation method.

Re-Route Analysis

The pipeline route as currently permitted follows an existing SPLP easement. This alignment bypasses or avoids directly impacting North Zinns Road, North Cornwall Road, Quentin Road, and stream S-A17.

The North Zinns Mill Road HDD is set within an area of residential development with adjacent agricultural lands. The underlying geology is the Snitz Creek Formation consisting of dolomite and limestone with interbedded sandstone. To the north and south, the geologic formations consist of the Millbach and Schaefferstown Formations, undivided, and the Buffalo Springs Formation, respectively. There is no reasonable alternative pipeline route in the vicinity that can avoid an underlying karst formation.

There are no existing utility corridors to the north or south that provide a practical alternative route. Any alternate route considered to the north or south would require the clearing of a new “greenfield” corridor through existing woodlands, potentially increase the number of stream crossings, and possibly encroach on additional private residences before it could rejoin the current route.

In summary, due to the setting surrounding the overall route of the Mariner II pipelines in this area, there is no alternative route that could avoid conflicts with existing development. 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 significant legal action to acquire a new easement.

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This re-route analysis conducted for the North Zinns Mill Road HDD confirms the conclusions reached in the previously submitted alternatives analysis.

HORIZONTAL DIRECTIONAL DRILL REDESIGN

Additional geologic investigations have been completed, and the "as built" record for the 20-inch pipeline has been utilized in the redesign of the planned 16-inch HDD. The redesign adjusts the HDD profile deeper to minimize the risk of drilling fluid loss, drilling difficulties, and IRs. A summary of the redesign factors is provided below. The original and redesigned 16-inch HDD plan and profile drawings are provided in Attachment 3.

Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 3,050 ft
- Entry/Exit angle: 8-16 degrees
- Maximum Depth of cover: 137 ft
- Depth below Snitz Creek: 115 ft
- Pipe design radius: 2,000 ft

As shown on Figure 2, the redesigned HDD profile for the 16-inch pipeline is 1,870 ft longer, with a maximum depth of cover increased by 37 ft from the permitted design. In addition, the entry/exit angles have been increased from 12-14 degrees to 16 degrees allowing for a sharper and quicker entry into and exit out of competent rock. The revised profile is 110 ft deeper below the crossing of Snitz Creek.

CONCLUSION

Based on the original and revised profiles for HDD S3-0101-16, the revised profile is longer and deeper into bedrock than the original profile. Therefore, the revised profile greatly reduces the risk of IRs. Procedures established and documented in SPLP's revised IR Assessment, Preparedness, Prevention, and Contingency (PPC) Plan (April 2018 plan) across all ME II spreads have proven to be very effective in eliminating IRs and minimizing the extent of IRs.

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

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

- SPLP will require and enforce the use of annular pressure monitoring during the drilling of the pilot holes, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus to manage development of pressures that can induce an IR;

- SPLP inspectors will ensure that an appropriate diameter pilot tool, relative to the diameter of the drilling pipe, is used to ensure adequate "annulus spacing" around the drilling pipe exits to allow good return flows during the pilot drilling;

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

- SPLP will require monitoring of the drilling fluid viscosity, such that fissures and fractures in the subsurface are sealed during the drilling process;

- Tool face pressure during pilot phase drilling will be used to identify specific locations, or zones, of geologic weakness within the annulus as potential locations for proactive treatment by grout injections to minimize the movement of drilling fluids outside of the borehole annulus, or stabilization of the annulus wall to minimize collapse of the surrounding geologic materials into the annulus;

- During all drilling phases, the use of Loss Control Materials (LCMs) can be implemented if indications of a potential IR are noted or an IR is observed; and

- If LCMs prove ineffective to mitigate loss of returns or IRs, then grouting of the pilot hole may be implemented. Generally, the use of LCMs are less effective below 70 ft of the ground surface. The AP below that depth can exceed the effective stabilization capability of LCMs. This HDD is below 70 ft of depth for the horizontal length of the profile. Accordingly, the corrective action needed to address the presence of fractures or unstable geology at greater depths below ground requires grouting of the HDD annulus. Two types of grouting will be utilized for corrective actions to seal fractures and stabilize zones of weak geology. These are: 1) grouting using “neat cement”; and 2) grouting using a sand/cement mix. Neat cement grout is a slurry of Portland cement and water. The sand/cement grout mix is a slurry of mostly sand with a small percentage of Portland cement and activators that after setup results in a material having the competency of a friable sandstone or mortar. Both grouting actions require tripping out the drilling tool, and then tripping in with an open-ended drill stem to apply or inject the grout mixes.

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FEASIBILITY DETERMINATION

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

2/4/2019

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

Date

Pertaining to the practice of geology

2/4/2019

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Date

Pertaining to the pipeline stress and HDD geometry

2/1/19

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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

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February 4, 2019

Mr. Matthew Gordon
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Re: Sunoco PA Pipeline Project Mariner East II, North Zinn's Mill Road HDD S3-0101, PA-LE-0055.0000-RD-16
Hydrogeological Re-Evaluation Report
West Cornwall Township
Lebanon County, Pennsylvania
Rettew Project No. 096302010

EXECUTIVE SUMMARY

1. During the completion of Horizontal Directional Drill (HDD) S3-0101 for installation of the 20-inch diameter pipeline, multiple inadvertent returns (IRs) were identified during the pilot phase commencing at approximately 125 feet (ft.) from the east entry point.

2. The North Zinn's Mill Road HDD bore path is underlain by sedimentary rocks of the Cambrian age Snitz Creek Formation (Csc) composed of crystalline dolomite with laminated limestone and shale interbeds.

3. Geologic mapping, published reports, and field observations indicate a moderate degree of bedrock fracturing in the Snitz Creek Formation characterized by a blocky, moderately to well-developed pattern of abundant open and steeply dipping joints. This structural fabric provides moderate to high bedrock permeability with the interface between the bedrock surface and overlying mantle typified by weathered bedrock pinnacles and the presence of solution cavities in some areas.

   Water-bearing zones generally occur in secondary openings along bedding planes, joints, faults, and fractures. Water-bearing zones in the Snitz Creek Formation are reported to be distributed within the first 25 to 200 feet of the subsurface, with the greatest density of water-bearing zones occurring within the upper 125 feet of the subsurface (half occur above 125 feet and 90% occur at depths of less than 186 feet). The overall density of water-bearing zones in the Snitz Creek Formation is 0.56 per 50 feet of well depth with the greatest density of water-bearing zones occurring within the upper 150 feet of the subsurface. As a result, the storage and transmission of groundwater in the Snitz Creek Formation is primarily dependent on the degree and extent of fracturing and joint development.

5. To date, HDD operations have been completed at the North Zinn's Mill Road site for the 20-inch pipeline. The 20-inch product pipe pull was completed on August 15, 2018.

6. Based on the hydro-structural characteristics of the underlying geology, field observations made during the installation of the 20-inch pipeline, and the proposed 16-inch HDD profile within shallow unconsolidated soil materials and shallow bedrock, the proposed 16-inch HDD is susceptible to the inadvertent return of drilling fluids during HDD operations. A redesigned 16-inch HDD profile (**Attachment 2, Figure 2**) and Best Management Practices (BMPs) during drilling operations will be used to reduce the risk of an IR. The 16-inch HDD

profile has been re-designed to allow for a deeper crossing beneath Snitz Creek. The inclination of the entry and exit angles has been increased as a means to install the 16-inch pipe through protective soils and bedrock in closer proximity to the entry and exit points than the original, shorter and shallower profile. From a geologic perspective, the longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling best management practices will be used to reduce the risk of an IR.

1.0 INTRODUCTION

The purpose of this report is to describe the hydrogeologic setting of the North Zinn's Mill Road (S3-0101) HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project Mariner East II (PPP-ME2) Project. The North Zinn's Mill Road HDD (the site) is located in West Cornwall Township, Lebanon County, Pennsylvania. The site is located approximately 3.4 miles south of Lebanon and approximately 4.25 miles north of the Pennsylvania Turnpike (I-76). The HDD was designed to be drilled under Snitz Creek, an existing sanitary sewer, North Cornwall Road, the existing 8-inch Mariner East I Sunoco pipeline (at Stations 6+65 and 12+83), and under North Zinn's Mill Road (refer to **Figure 1**). This hydrogeologic report is part of the response to the Corrected Stipulated Order dated August 10, 2017, related to the potential for the inadvertent return of drilling fluids during proposed drilling operations.

HDD S3-0101 is located within the Great Valley Section of the Ridge and Valley Physiographic Province (Pennsylvania Department of Conservation and Natural Resources [PA DCNR], 2000). The Geologic Formation which underlies the site is the Cambrian Age Snitz Creek Formation, which reportedly consists of oolitic dolomite and limestone with sandstone and shale interbeds. The dominant topography in areas underlain by the Snitz Creek Formation is typified by rolling valleys of low relief. Local relief is low to moderate and ranges in the vicinity of the site from approximately 495 feet above mean sea level (AMSL) to 560 feet AMSL (Google Earth, 2017). The site is drained by adjacent Snitz Creek which flows north and west, crossing the proposed east-west HDD path. Snitz Creek ultimately discharges to Quittapahilla Creek approximately 3.75 miles to the north. The area surrounding the HDD consists predominantly of wooded areas, farm fields, and suburban residential properties which surround the Fairview Golf Course.

The proposed redesigned 16-inch HDD entry point is at a surface elevation of 541 feet AMSL and forms a slightly concave HDD profile that slopes gently upward toward the west to an elevation of 555 feet AMSL at the HDD exit point. The proposed redesigned 16-inch HDD will cross under Snitz Creek at 115 feet bgs, the sanitary sewer at 125 feet bgs, North Cornwall Road at 129 feet bgs, the existing 8-inch Mariner East I pipeline (STA 7+67) at approximately 110 feet bgs, the existing 8-inch Mariner East I pipeline (STA 27+69) at 87 feet bgs, and North Zinn's Mill Road at 72 feet bgs. The proposed 16-inch HDD is approximately located between Stations 12287+50 and 12318+00 on the pipeline, for an overall horizontal length of 3,050 feet and a pipe length/bore path length of 3,083 feet. The existing 20-inch and proposed 16-inch S3-0101 HDD locations are shown on **Figure 1**.

2.0 GEOLOGY AND SOILS

Four available published and online references were reviewed to evaluate the geology and soils present in the vicinity of the proposed North Zinn's Mill Road HDD S3-0101. Detailed

descriptions of the soils and bedrock geology underlying the site are included in the following section.

HDD S3-0101 site is situated in the Great Valley Section of the Ridge and Valley Physiographic Province (PA DCNR, 2000). The geologic structure of the Ridge and Valley Physiographic Province is characterized by a series of alternating ridges formed on more resistant sandstones and quartzites and valleys underlain by more easily eroded shales and limestones. The dominant topographic form at the site is a very broad valley exhibiting low to moderate relief. The dominant geologic structure consists of severe folds, thrust sheets, nappes, overturned folds, and steep faults. The drainage pattern within this physiographic section is dendritic and typified by karst (i.e., subsurface drainage).

According to Google Earth (2017), the bedrock underlying the site consists of the Cambrian age Snitz Creek Formation. Geyer and Wilshusen (1982) describe this formation as a gray, medium- to coarsely crystalline oolitic dolomite with limestone, sandstone, and shale interbeds. The bedrock geology at the site is identified on **Figure 2**. This formation is well bedded and thick to massive. Fracturing consists of joints which have a blocky pattern. The joints are moderately well developed, moderately to highly abundant, are regularly spaced with a moderate distance between fractures, and are open and steeply dipping. The Snitz creek Formation is moderately resistant to weathering; slightly to moderately weathered to a shallow depth; irregularly shaped; and the interface between bedrock and mantle is characterized by pinnacles in most places. This carbonate (karst) formation has good subsurface drainage but little surface drainage. The porosity of the weathered portion of this formation is of moderate to high magnitude, resulting in moderate to high permeability. The ease of excavation (and drilling) is classified as generally easy (fast) in the limestone, but is somewhat more difficult (slowed) in the dolomite due to the presence of numerous sandstone interbeds.

According to the United States Department of Agriculture Soil Survey for Lebanon County, Pennsylvania, surficial materials located within approximately 450 feet of the proposed drill path consist primarily of silt loam (approximately 83 percent [%]) with minor amounts of silty clay loam (8%) and rock outcrops (9%). A site map showing the spatial distribution of the various soils and rock along with the soil profile descriptions is included as **Attachment 1**.

3.0 HYDROGEOLOGY

Bedrock geology ultimately influences the storage, transmission, and use of groundwater. Geologic factors such as rock type, intergranular porosity, rock strata inclination, faults, joints, bedding planes, and solution channels affect groundwater movement and availability. According to Royer (1983), the Snitz Creek Formation is one of the least reliable aquifers in the Lebanon Valley. Reported well yields range from 4 to 500 gallons per minute (gpm), and the median domestic yield is 6 gpm. The specific capacities of 13 domestic wells range from 0.1 to 120 gpm, and the median is 1.4 gpm.

Locally, shallow groundwater discharges to the gaining portions of nearby streams such as Snitz Creek, and deeper regional groundwater flow toward larger surface streams discharging toward points of regional groundwater discharge such as the Susquehanna River. Based on the geotechnical report and boring logs included as **Attachment 2**, groundwater was not encountered

in SB-01, SB-02 or SB-03, which were drilled to 18 feet bgs, 6 feet bgs, and 7 feet bgs, respectively. Based on results of geotechnical drilling completed during November 2018, groundwater was measured in Boring B-1 at a depth of 24 feet bgs on November 12, 2018 and in Boring B-2A at 27 feet bgs on November 19, 2018. No groundwater modeling was performed for the area surrounding HDD S3-0101.

Water-bearing zones generally occur in secondary openings along bedding planes, joints, faults, and fractures. According to Low, et. al. (2002), water-bearing zones in the Snitz Creek Formation are reported to be distributed within the first 25 to 200 feet of the subsurface, with the greatest density of water-bearing zones occurring within the upper 125 feet of the subsurface (half occur above 125 feet and 90% occur at depths of less than 186 feet). The overall density of water-bearing zones in the Snitz Creek Formation is 0.56 per 50 feet of well depth with the greatest density of water-bearing zones occurring within the upper 150 feet of the subsurface. As a result, the storage and transmission of groundwater in the Snitz Creek Formation is primarily dependent on the degree and extent of fracturing and joint development.

Well records from the PA DCNR Pennsylvania Groundwater Information System (PaGWIS) database were reviewed to identify domestic water supply wells located within a ½-mile radius of the proposed HDD right-of-way boundary (PaGWIS, 2019). The search identified 25 wells within the ½-mile radius of the HDD. These wells consist of 26 domestic water supply wells, one domestic recharge well and two closed-loop geothermal wells (total of 29 wells). A map showing the well locations relative to the proposed HDD location is included as **Figure 3**. Well construction details were not reported for all of the wells. Based on incomplete information in the PaGWIS database (**Figure 3**), it appears that the majority of the identified wells were completed as 6-inch-diameter open-rock wells at depths ranging from 120 to 466 feet bgs. Based solely on the PaGWIS database, the depth to bedrock ranges from 3 to 85 feet bgs, and well construction consists of 17 to 104 feet of steel casing with the open-rock portions of the wells extending from 17 feet to 466 feet bgs. Reported well yields range from 2 to 100 gpm. Nineteen static water level measurements were recorded and range from 5 to 85 feet bgs with an average of 38 feet bgs. Based on the information provided in the PaGWIS database, the majority of the wells identified above were completed in the Snitz Creek Formation.

Other Sunoco subcontractors have researched private water supplies with 450 feet of HDD S3-0101 in January 2019. Eleven water wells were identified within the 450-foot buffer of the alignment. No information pertaining to depth to bedrock, depth to water, or pump setting was reported. A map of these locations is included as **Attachment 3**.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces are natural linear features that are unaffected by local topographic relief and, as a result, are considered surface manifestations of concentrated high-angle bedrock fracturing. Fracture traces may be observed on aerial photographs as linear topography, straight stream segments, vegetation, or soil tonal alignments. The Web-based Pennsylvania Imagery Navigator, United States Geological Survey (USGS) 7.5-minute Topographic Quadrangle Map, and Google Earth Pro were used to access, download, and view aerial imagery of the HDD site. Fourteen series of historical aerial photographs were analyzed that included photography dated August 1937, October 1956, July 1970, April 1992, April 1999, April 2003, April 2004, April 2005, September

2005, October 2008, September 2010, September 2012, April 2013, and September 2015 (Pennsylvania Spatial Data Access [PASDA], 2019, and Google Earth Pro, 2019). No fracture traces were discernible in any of these aerial images proximate to the HDD. In addition, two geologic reports (Royer, 1983, and Geyer, et al., 1958) published by the Pennsylvania Geological Survey were reviewed to determine if any fracture traces were mapped in the vicinity of the HDD site. No fracture traces were shown on the geologic maps in either of these reports.

5.0 GEOTECHNICAL EVALUATION

The geotechnical evaluation of the HDD S3-0101, North Zinn's Mill Road site was completed in three phases. Three geotechnical borings (SB-01, SB-02, and SB-03) were completed in October and November, 2015 during the phase I preliminary investigation of HDD S3-0101 and prior to initiating HDD operations. Two additional borings (B-1 and B-2) were completed in October and November 2017 during the second phase geotechnical investigation. Two supplemental borings (B-1 and B-2A) were completed in November 2018 as part of the phase III geotechnical investigation and re-evaluation for the redesigned 16-inch HDD. The borings were completed to investigate soil and bedrock conditions using hollow-stem augers with split spoons for soil sampling and a core barrel/bit for rock coring. The boring logs and other supporting information are included as **Attachment 2.** The locations of soil borings SB-01, SB-02, and SB-03 completed during the phase I geotechnical investigation are included with the phase I geotechnical report included in **Attachment 2**. Boring logs and other supporting information generated during all three phases of the geotechnical evaluation are also included in **Attachment 2.**

During the preliminary phase I geotechnical investigation, two shallow borings (SB-01 and SB-03) were completed on October 7, 2015. SB-02 was completed on November 13, 2015. SB-01 was located approximately 95 feet southeast of the proposed 16-inch HDD exit point, and SB-02 was located along the drill path approximately 650 feet east of the proposed HDD exit point. SB-03 was located approximately 1,170 feet east of the proposed HDD exit point. Boring B-1 was located approximately 148 feet northeast of the proposed 16-inch HDD exit point. Boring B-2 was located approximately 1,332 feet northeast of the proposed 16-inch HDD exit point. During the completion of Boring B-2, a metallic object was encountered, and the boring terminated prior to reaching the scheduled completion depth. Offset Boring B-2A (2018) was located approximately 275 feet northeast of the proposed HDD entry point. The generalized subsurface profile observed in the borings is described as follows.

SB-01: The top 1.2 inches consisted of topsoil. The interval from approximately 0.1 to 7.5 feet consisted of yellow brown SILT, some fine SAND, and a trace of fine GRAVEL (USCS ML); and from 7.5 to 18.0 feet of light gray, fractured LIMESTONE. The total depth of the boring was 18.0 feet bgs. Groundwater was not encountered.

SB-02: Less than one inch consisted of topsoil. The interval from 0.1 to 4.0 feet consisted of brown, clayey SILT with a trace of fine to coarse SAND; and a trace of fine GRAVEL. The interval from 4.0 to 6.0 feet consisted of interlayered light gray LIMESTONE and fine to medium SAND and SILT. The total depth of the soil boring was 6.0 feet bgs where auger refusal was encountered on LIMESTONE. Groundwater was not encountered.

SB-03: The upper 3.0 inches consisted of topsoil. The overburden from 0.3 to 7.0 feet consisted of fine sandy SILT mixed with limestone GRAVEL (ML). Total depth of the boring was 7.0 feet where auger refusal was encountered on LIMESTONE. Groundwater was not encountered.

Boring B-1: The interval from ground surface to 5.0 ft. bgs., consists of medium stiff, brown CLAY with SAND (CL). From 5.0 feet to total depth of the boring at 170 feet bgs consists of slightly weathered to weathered, very broken to massive, interbedded, DOLOMITE, LIMESTONE, and SHALE. Rock Quality Designation (RQD) ranged from very poor (0%) to excellent (94%). Groundwater was measured at 43.0 feet bgs after the rock coring was completed.

Boring B-2: The interval from ground surface to 8.5 ft. bgs consists of SILT with trace amounts of SAND, GRAVEL, and woody materials (MH and ML). The interval from 8.5 feet to the total depth of the boring at 105 feet bgs consists of slightly weathered to weathered, broken to massive, interbedded DOLOMITE and LIMESTONE. RQD ranged from poor (31%), to excellent (100%). Groundwater was measured at 5.5 ft. bgs after the rock coring was completed.

Boring B-1: The interval from ground surface to 15 ft. bgs consists of poorly graded GRAVEL with SILT and SAND (GP-GM). Boring B-1 was completed to a total depth of 152 ft. bgs with top of bedrock encountered at approximately 15 ft. bgs. The bedrock consists of light gray to light gray-brown to blue-gray, slightly to highly weathered, interbedded LIMESTONE and DOLOMITE. The rock coring logs describe the bedrock as ranging from slightly to highly weathered and very broken to massive, with intervals of fracturing, calcite veins, and solutioning activity. RQD ranged from poor (48%), to excellent (100%). Groundwater was measured at 4 ft. bgs while drilling and 24.0 ft. bgs after rock coring was completed.

Boring B-2A: The interval from ground surface to 9 ft. bgs was hand-cleared and drilled without sampling. Boring B-2A was completed to a total depth of 153 ft. bgs with top of bedrock encountered at approximately 9.5 ft. bgs. The bedrock consists of light gray to blue gray and dark gray, slightly to highly weathered, interbedded LIMESTONE and DOLOMITE. The rock coring logs describe the bedrock as ranging from slightly to highly weathered and very broken to massive, with intervals of fracturing, calcite veins, and solutioning activity. RQD ranged from fair (50%), to excellent (100%). Groundwater was measured at 27.0 ft. bgs after rock coring was completed.

The boring logs indicate that the soil (weathered bedrock)/bedrock interface ranges from approximately 5 feet (B-1, 2017) to 15 feet (B-1 of the Phase III 2018 geotechnical investigation) bgs.

Please note that Skelly and Loy or RETTEW Associates, Inc. did not oversee or direct the geotechnical drilling programs associated with HDD S3-0101 including, but not limited to, the selection of boring locations, determination of location, determination of surface elevation, target depths, observations of rock cores during drilling operations, and preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other Sunoco Pipeline, L.P. contractors. Skelly and Loy and RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework of the analysis of the proposed 16-inch drill at HDD S3-0101 for this report.

6.0 FIELD OBSERVATIONS

On August 31, 2018, an Inadvertent Return (IR) occurred within Snitz Creek while drilling the pilot hole for the 20-inch HDD operations. The pilot bit was approximately 125 feet from entry when the IR occurred. Drilling fluid seeped into Snitz Creek and the driller ceased drilling operations immediately and constructed a coffer dam and silt fencing around the IR location and pumped the drilling fluid into a frac tank. Upon approval from the PA DEP to restart HDD operations, the original pilot hole was grouted on March 9, 2018. On March 14, 2018, Laney Drilling began to drill a nominal 10 5/8-inch diameter borehole for the second HDD pilot hole. On March 15, 2018, a second IR occurred in Snitz Creek when the pilot bit was located approximately 183 feet from the entry point and 43 feet below ground surface (bgs). Drilling fluid was determined to be entering Snitz Creek via three small seep areas at the base of the eastern bank of Snitz Creek, approximately 30 to 40 feet south of the center line of the drill path. Again, the driller immediately ceased drilling and began cleanup operations. On April 19, 2018, drilling operations for the second pilot hole resumed following restart approval from the PA DEP and application of loss control material (LCM) into the borehole. On April 20, 2018, drilling ceased due to an IR that entered the Snitz Creek containment. Following restart approval from PA DEP on May 26, 2018, Laney Drilling pumped a 1,750-gallon LCM "pill" into the borehole to seal leaks and drilling resumed. On June 1, 2018, drilling operations for the second pilot hole were shut down due to a 2-quart IR in Snitz Creek, at the location of the August 31, 2017 IR. Following restart approval from the PA DEP, on June 10, 2018, drilling operations shut down again, this time during reaming of the borehole for an IR volume of approximately 1-cup at a new location several feet upstream of the temporary stream crossing. On June 14, 2018, restart approval was granted by the PA DEP and the driller completed the pilot hole drilling on June 21, 2018. On June 28, 2018, Laney ceased 24-inch pull reaming due to an IR in Snitz Creek, at the location of the August 31, 2017 IR and the June 10 IR inside the approved containment area. On July 26, 2018, restart approval was granted by the PA DEP and on July 30, 2018, Laney resumed reaming. There were no further IRs and the 20-inch pipe pull was completed on August 15, 2018. The locations of the above-referenced IRs are identified on the redesigned HDD profile included in **Attachment 2**.

From a hydrogeologic perspective, the IR locations are hydraulically upgradient from the bore alignment, which is indicative of a complex karst fracture system. The only bedrock outcrops visible at the site are those in the stream bed, and visible bedding planes are subparallel to the bore alignment. The fact that there is an inflow of water at the site of the IRs both during drilling operations and during the time that drilling was suspended points to a natural fracture system that is carrying trace quantities of drilling fluid to surface along the edge of Snitz Creek. Moreover, the discharges are significantly different than those which occur in a true IR. The ratio of drilling fluid to water

appears to be quite small in the discharge areas. This is not an unusual condition in areas that have active hydrology.

7.0 GEOPHYSICAL SURVEY CONSIDERATIONS

RETTEW completed a multi-technique geophysical survey at the North Zinn's Mill HDD on December 27, 2018. The purpose of the survey was to provide supplemental information to the geotechnical drilling programs and to detect and delineate subsurface voids or low-density zones and provide a bedrock profile. These methods, and their general results are as follows:

- Microgravity delineated minor low-density zones in the survey area. These zones could represent relatively insignificant karst-related air-, water-, or mud-filled voids, or locally deeper rock/thicker soils.

- Seismic refraction and multichannel analysis of surface waves (MASW) results confirmed the presence of a semi-irregular bedrock surface and "epikarst" zone.

- Electrical resistivity imaging (ERI) identified a conductive surface layer overlying a discontinuous resistive layer, with the discontinuities possibly suggesting the presence of deep epikarst "cutters" or clay seams possibly associated with fracture zones.

Results from the geophysical techniques are consistent with each other, and with the geology as mapped by the PA Geological Survey; all suggesting that the local bedrock is mildly karstified, with a few potential anomalous zones of concern. The top-of-rock is expected to be slightly pinnacled (irregular) with interfingered competent rock and residual clay soil.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL

Groundwater occurring in the watershed occupied by the North Zinn's Mill Road HDD originates as precipitation or snowmelt. The precipitation infiltrates through the overburden soils. Shallow groundwater generally occurs under unconfined conditions within the upper portion of the bedrock. Based on site-specific geotechnical data (Section 5.0) and information obtained from the PaGWIS database (Section 3.0), the groundwater table occurs within both the overburden soils and bedrock (5 to 85 feet bgs) proximate to the HDD path and contributes flow to local shallow groundwater discharge zones supporting Snitz Creek which crosses above the HDD profile.

Logs of the seven geotechnical borings indicate that the soil thickness near the HDD ranges from approximately 5 to 15 feet and consists predominantly of silt with some sand, clay, and gravel. Recorded descriptions of the bedrock cores included weathered, very broken to massive interbedded dolomite, limestone and shale. Data tabulated for supply wells found in the PaGWIS database (**Figure 3**) within a /½-mile radius of the HDD trace recorded measured water levels in the bedrock aquifer ranging from 5 to 85 feet bgs. Although groundwater was not encountered in the three shallow geotechnical soil borings (SB-01 through SB-03), depth to water measurements of 43 and 5.5 feet bgs were obtained from phase two geotechnical core borings B-1 and B-2, respectively, and 24 and 27 feet bgs from phase three geotechnical core borings B-1 and B-2A, respectively.

This formation is primarily anisotropic, with the predominant flow direction parallel to bedrock strike. The transport of groundwater in the fractured bedrock is generally greatest within highly permeable fractures and solution channels, and the orientation of bedding planes and fractures primarily influence the direction of groundwater flow. Some site-specific evaluation of the bedrock has been completed in the area proximate to the geotechnical borings completed along this HDD profile and at bedrock outcrops identified along the stream bank proximate to the IR locations identified on the redesigned 16-inch HDD profile included with **Attachment 2**. No detailed characterization or groundwater flow modeling of the bedrock aquifer was performed as part of this hydrogeologic re-evaluation.

The groundwater flow direction in the overburden soils is presumed to mimic surface topography which slopes gently eastward toward Snitz Creek. Snitz Creek is sustained by local shallow groundwater flow discharges. The geotechnical reports and boring logs included as **Attachment 2** show that groundwater was not present in four of the five soil borings in the unconsolidated soils. The depth to water proximate to the HDD path based on a measured depth to water is as deep as 43 feet bgs. As previously referenced above, based on the PaGWIS database (Section 3.0), measured water levels in private supply wells located within ½-mile of the site range from 5 to 85 feet bgs. Based on this information, the uppermost groundwater table is presumed to occur within the uppermost bedrock or near the soil/bedrock interface under unconfined conditions.

9.0 CONCLUSIONS

Based on published geologic and hydrogeologic information, the S3-0101 North Zinn's Mill Road HDD location is underlain by carbonate sedimentary rocks (interbedded limestone, dolomite, sandstone, and trace shale) of the Snitz Creek Formation. Groundwater movement within these rocks is primarily through a network of interconnected secondary openings (e.g., fractures, joints, and faults) that were developed by external forces following deposition of the beds. Geotechnical rock core observations confirm that the local bedrock ranges from fractured and very broken to massive interbedded dolomite, limestone, and shale comprised of well-developed thick to massive steeply dipping joint and bedding planes. Importantly, solutioning of these structural features observed during the geotechnical investigations and 20-inch HDD operations are indicative of a complex karst fracture system. All of the private water supply wells identified in the vicinity of the HDD are constructed in bedrock, indicating that none of the domestic wells relies on the shallow unconsolidated overburden as a source of groundwater supply. The uppermost unconsolidated soils and weathered bedrock, and potentially the bedrock aquifer, provide sustainable groundwater discharge to Snitz Creek, nearby unnamed tributaries, and the Susquehanna River.

The proposed redesigned 16-inch HDD profile extends entirely within both the shallow unconsolidated regolith materials and weathered to unweathered bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and the known HDD profile through shallow soils and bedrock, the North Zinn's Mill Road HDD site is susceptible to the inadvertent return of drilling fluids during HDD operations. The redesigned 16-inch HDD profile has been lengthened so that the eastern entry point is approximately 1,520 feet east of the originally proposed entry point location to allow for deeper crossings beneath Snitz Creek (115 feet bgs vs. 51 feet bgs), existing 8-inch Mariner I East pipelines (110 feet bgs and 87 feet bgs vs. 58 feet bgs), sanitary sewer (125 feet bgs vs. 62 feet bgs), North Cornwall Road (129 feet bgs vs. 70 feet bgs),

and North Zinn's Mill Road (72 feet bgs vs. 40 feet bgs). Additionally, the redesigned 16-inch HDD profile is deeper than the as-built profile for the 20-inch HDD although the original proposed 16-inch HDD profile was shallower than the as-built profile for the 20-inch HDD. The inclination of the entry and exit angles for the 16-inch pipeline has been increased as a means to install the pipe through the overlying protective soils and bedrock in closer proximity to the entry and exit points than the original, shorter profile. From a geologic perspective, the laterally adjusted, longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling BMPs, will be used to reduce the risk of an IR. Drilling BMPs are described in the Horizontal Directional Drill Analysis of the overall re-evaluation package.

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11.0 CERTIFICATION

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

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

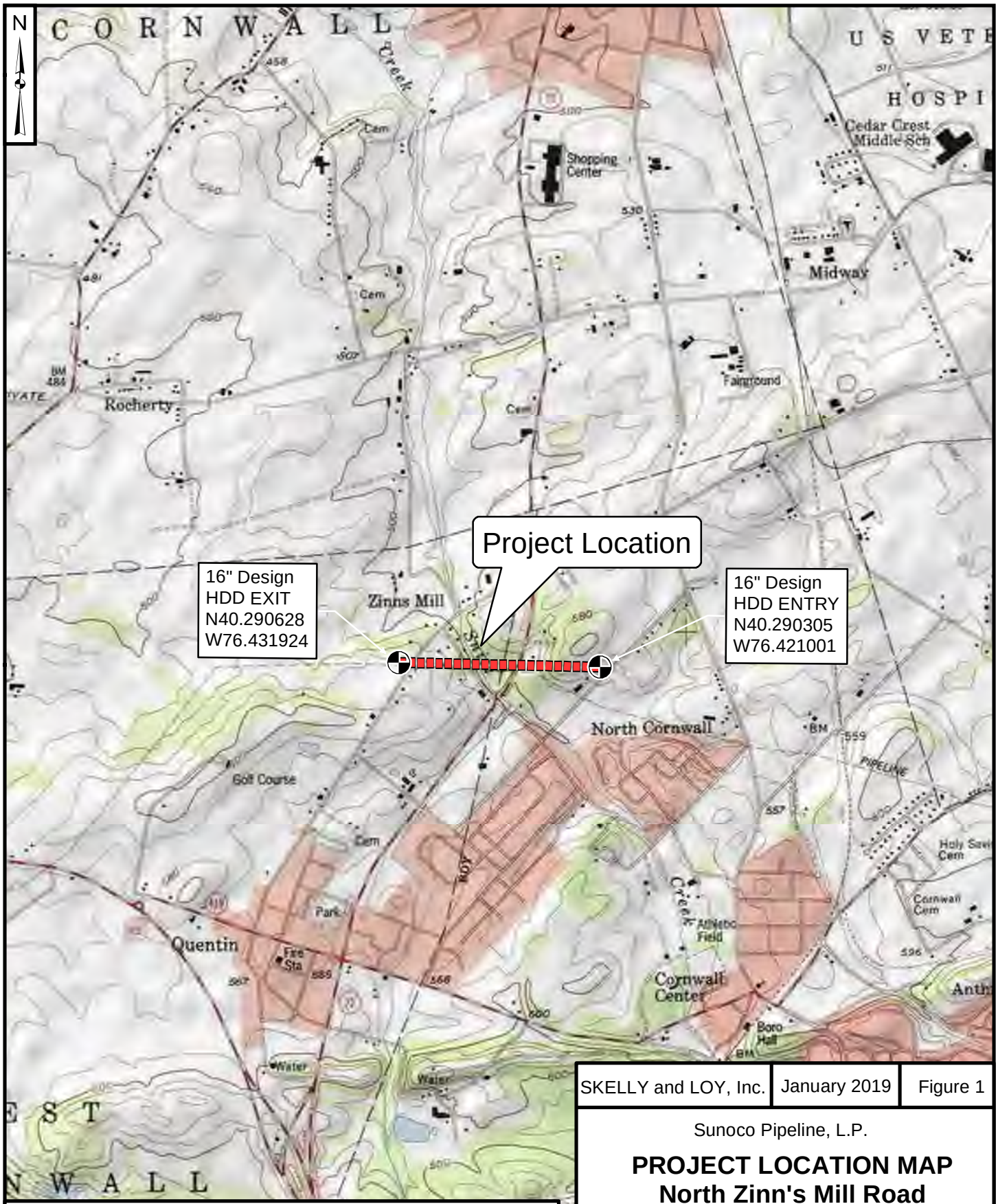
Douglas J. Hess, P.G.
License No. PG-000186-G

Sincerely yours,

SKELLY and LOY, Inc.

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

Enclosure
cc: R17-0296.HYD
File: HYDROGEOLOGIC_REPORT-North Zinn's Mill Road_DJH (2-4-19) - 16 FINAL.docx



SKELLY and LOY, Inc. | January 2019 | Figure 1

Sunoco Pipeline, L.P.

PROJECT LOCATION MAP
North Zinn's Mill Road

Cornwall Borough and North Cornwall and West Cornwall Townships
Lebanon County, Pennsylvania

Job No. R17-0296.004

Feet
0 500 1,000 2,000

Date Saved: 1/23/2019 2:32:06 PM

Document Path: Z:\R17-0296\2019\Zinns Mill\Location Map.mxd

Sources: Digital Bedrock Geology
"Geologic map of Pennsylvannia" (1980)

N

16" Design
HDD EXIT
N40.290628
W76.431924

16" Design
HDD ENTRY
N40.290305
W76.421001

Cms

Csc

Cbs

N Cornwall Rd

N Zinns Mill Rd

Zinns Mill

Snitz Creek

Quentin Rd

Sycamore Mill Cir

Patricia Dr

Tice Ln

72

Legend

- HDD Entry / Exit
- HDD Bore Path

GEOLOGY

- Csc — Snitz Creek Formation
- Cbs — Buffalo Springs Formation
- Cms — Millbach and Schaefferstown Formations, undivided

✳ Location Coordinates noted in PA DEP Emergency Response Incident Report

Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US

SKELLY and LOY, Inc.	January 2019	Figure 2

Sunoco Pipeline, L.P.

GEOLOGY MAP
NORTH ZINN'S MILL ROAD

Cornwall Borough and North Cornwall and West Cornwall Townships
Lebanon County, Pennsylvania

Job No: R17-0296.004

Feet
0 75 150 300

Legend

- HDD Bore Path
- 1/2 Mile Radius of Proposed HDD
- Parcel Boundries
- PAGWIS Wells with ID's

Coordinate System: NAD 1983 StatePlane Pennsylvania South FIPS 3702 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS © 2019 HERE

SKELLY and LOY, Inc.	January 2019	Figure 3

Sunoco Pipeline, L.P.

WELL LOCATION MAP
NORTH ZINN'S MILL ROAD

Cornwall Borough and North Cornwall and West Cornwall Townships
Lebanon County, Pennsylvania

Job No: R17-0296.004

Feet: 0 175 350 700

Document Path: Z:\R17-0296\2019\Zinns Mill\Well Location Map Zinns Mill.

ATTACHMENT 1

United States Department of Agriculture

Natural Resources Conservation Service

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

Custom Soil Resource Report for Lebanon County, Pennsylvania

N. ZINNS MILL RD. 16" HDD

January 17, 2019

Contents

Soil Map

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

Custom Soil Resource Report
Soil Map

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Lebanon County, Pennsylvania
Survey Area Data: Version 14, Sep 19, 2018

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

Date(s) aerial images were photographed: Mar 26, 2011—Jul 2, 2011

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CkA	Clarksburg silt loam, 0 to 3 percent slopes	10.4	9.6%
CkB	Clarksburg silt loam, 3 to 8 percent slopes	2.1	2.0%
DfA	Duffield silt loam, 0 to 3 percent slopes	4.2	3.8%
DfB	Duffield silt loam, 3 to 8 percent slopes	31.6	29.1%
DfC	Duffield silt loam, 8 to 15 percent slopes	14.7	13.6%
HaB	Hagerstown silt loam, 3 to 8 percent slopes	4.8	4.4%
HbC	Hagerstown silty clay loam, 8 to 15 percent slopes	4.5	4.2%
HeB	Hagerstown-Rock outcrop complex, 3 to 8 percent slopes	2.1	1.9%
HeC	Hagerstown-Rock outcrop complex, 8 to 25 percent slopes	21.8	20.1%
Me	Melvin variant silt loam	9.8	9.0%
No	Nolin variant silt loam	2.5	2.3%
Totals for Area of Interest		**108.5**	**100.0%**

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called

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

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

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

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

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

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

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

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

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can

be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

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

Lebanon County, Pennsylvania

CkA—Clarksburg silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: l57r
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 48 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Clarksburg and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Clarksburg

Setting

Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Parent material: Residuum weathered from limestone

Typical profile

Ap - 0 to 8 inches: silt loam
Bt - 8 to 27 inches: silt loam
Btx - 27 to 51 inches: silt loam
C - 51 to 84 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 20 to 36 inches to fragipan; 60 to 99 inches to
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

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

Minor Components

Thorndale

Percent of map unit: 5 percent
Landform: Depressions

Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

CkB—Clarksburg silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l57s
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 48 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Clarksburg

Setting

Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Parent material: Residuum weathered from limestone

Typical profile

Ap - 0 to 8 inches: silt loam
Bt - 8 to 27 inches: silt loam
Btx - 27 to 51 inches: silt loam
C - 51 to 84 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 36 inches to fragipan; 60 to 99 inches to
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Thorndale
Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

DfA—Duffield silt loam, 0 to 3 percent slopes

Map Unit Setting
National map unit symbol: l57w
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition
Duffield and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Duffield

Setting
Landform: Hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from limestone and siltstone

Typical profile
Ap - 0 to 10 inches: silt loam
Bt - 10 to 53 inches: silty clay loam
C - 53 to 72 inches: silt loam

Properties and qualities
Slope: 0 to 3 percent
Depth to restrictive feature: 48 to 120 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Ryder

Percent of map unit: 3 percent
Landform: Hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Clarksburg

Percent of map unit: 3 percent
Landform: Valley flats
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Thorndale

Percent of map unit: 2 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

Penlaw

Percent of map unit: 2 percent
Landform: Swales
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

DfB—Duffield silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l57x
Elevation: 200 to 1,500 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Duffield

Setting

Landform: Hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from limestone and siltstone

Typical profile

Ap - 0 to 10 inches: silt loam
Bt - 10 to 53 inches: silty clay loam
C - 53 to 72 inches: silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 48 to 120 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups

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

Minor Components

Clarksburg

Percent of map unit: 5 percent
Landform: Valley flats
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Ryder

Percent of map unit: 3 percent
Landform: Hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Thorndale

Percent of map unit: 2 percent
Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

DfC—Duffield silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: l57y
Elevation: 300 to 1,000 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Duffield and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Duffield

Setting

Landform: Hills
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Fine-loamy residuum weathered from limestone and shale

Typical profile
H1 - 0 to 10 inches: silt loam
H2 - 10 to 42 inches: channery silty clay loam
H3 - 42 to 78 inches: channery silt loam

Properties and qualities
Slope: 8 to 15 percent
Depth to restrictive feature: 48 to 111 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

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

HaB—Hagerstown silt loam, 3 to 8 percent slopes

Map Unit Setting
National map unit symbol: 2rc98
Elevation: 600 to 1,750 feet
Mean annual precipitation: 37 to 45 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 155 to 190 days
Farmland classification: All areas are prime farmland

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

Description of Hagerstown

Setting
Landform: Hills
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope, base slope, interfluve
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Clayey residuum weathered from limestone

Typical profile
Ap - 0 to 10 inches: silt loam

Bt1 - 10 to 21 inches: silty clay loam
Bt2 - 21 to 56 inches: silty clay
C - 56 to 73 inches: silty clay loam
R - 73 to 83 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 43 to 98 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.7 inches)

Interpretive groups

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

Minor Components

Opequon

Percent of map unit: 5 percent
Landform: Ridges
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Carbo

Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Summit, backslope, shoulder
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Funkstown

Percent of map unit: 3 percent
Landform: Valley floors
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave, linear
Hydric soil rating: No

Timberville

Percent of map unit: 2 percent
Landform: Hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Head slope, base slope

Down-slope shape: Concave, linear
Across-slope shape: Convex, concave, linear
Hydric soil rating: No

HbC—Hagerstown silty clay loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tb0g
Elevation: 600 to 1,750 feet
Mean annual precipitation: 37 to 45 inches
Mean annual air temperature: 46 to 54 degrees F
Frost-free period: 155 to 181 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Hagerstown

Setting

Landform: Hills
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Clayey residuum weathered from limestone

Typical profile

Ap - 0 to 8 inches: silty clay loam
Bt1 - 8 to 19 inches: silty clay loam
Bt2 - 19 to 31 inches: silty clay
C - 31 to 59 inches: silty clay
R - 59 to 69 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 40 to 79 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Other vegetative classification: Moist Loams (ML2)
Hydric soil rating: No

Minor Components

Carbo

Percent of map unit: 10 percent
Landform: Hills
Landform position (two-dimensional): Summit, backslope, shoulder
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Opequon

Percent of map unit: 10 percent
Landform: Hills
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Nose slope, side slope, crest
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

HeB—Hagerstown-Rock outcrop complex, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l586
Elevation: 300 to 1,500 feet
Mean annual precipitation: 30 to 50 inches
Mean annual air temperature: 44 to 57 degrees F
Frost-free period: 130 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Hagerstown and similar soils: 65 percent
Rock outcrop: 20 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hagerstown

Setting

Landform: Ridges, valley floors
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex

Across-slope shape: Linear, convex
Parent material: Residuum weathered from limestone

Typical profile
H1 - 0 to 8 inches: silt loam
H2 - 8 to 60 inches: silty clay

Properties and qualities
Slope: 3 to 8 percent
Depth to restrictive feature: 40 to 70 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.4 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: B
Hydric soil rating: No

Description of Rock Outcrop

Setting
Landform: Valley sides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Bedrock exposures

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydric soil rating: No

Minor Components

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

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

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

HeC—Hagerstown-Rock outcrop complex, 8 to 25 percent slopes

Map Unit Setting

National map unit symbol: l587
Elevation: 400 to 3,000 feet
Mean annual precipitation: 30 to 46 inches
Mean annual air temperature: 44 to 57 degrees F
Frost-free period: 130 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Hagerstown

Setting

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

Typical profile

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

Properties and qualities

Slope: 8 to 25 percent
Depth to restrictive feature: 40 to 84 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.6 inches)

Interpretive groups

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

Description of Rock Outcrop

Setting

Landform: Valley sides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Bedrock exposures

Properties and qualities

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

Minor Components

Opequon

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

Me—Melvin variant silt loam

Map Unit Setting

National map unit symbol: l58q
Elevation: 300 to 1,500 feet
Mean annual precipitation: 30 to 55 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 133 to 205 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Melvin, Coarse Variant

Setting

Landform: Flood plains
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Alluvium

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 25 inches: silt loam
H3 - 25 to 60 inches: gravelly loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: 48 to 99 inches to lithic bedrock

Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Very high (about 12.2 inches)

Interpretive groups

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

Minor Components

Lindside

Percent of map unit: 7 percent
Hydric soil rating: No

Holly

Percent of map unit: 3 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

No—Nolin variant silt loam

Map Unit Setting

National map unit symbol: l590
Elevation: 300 to 1,500 feet
Mean annual precipitation: 30 to 50 inches
Mean annual air temperature: 41 to 62 degrees F
Frost-free period: 130 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Nolin

Setting

Landform: Valleys
Landform position (three-dimensional): Talf
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: Alluvium derived from sedimentary rock over residuum weathered from limestone and shale

Typical profile

H1 - 0 to 15 inches: silt loam
H2 - 15 to 50 inches: silt loam
H3 - 50 to 60 inches: gravelly silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 60 to 99 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: Very high (about 12.2 inches)

Interpretive groups

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

Minor Components

Hagerstown

Percent of map unit: 8 percent
Hydric soil rating: No

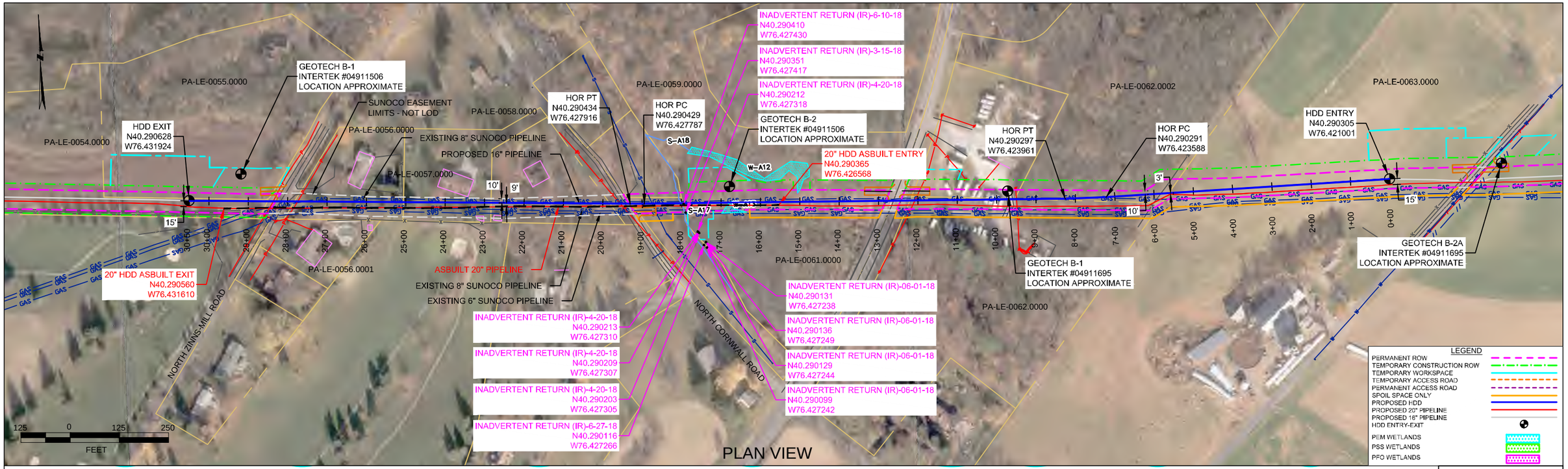
Clarksburg

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

Melvin

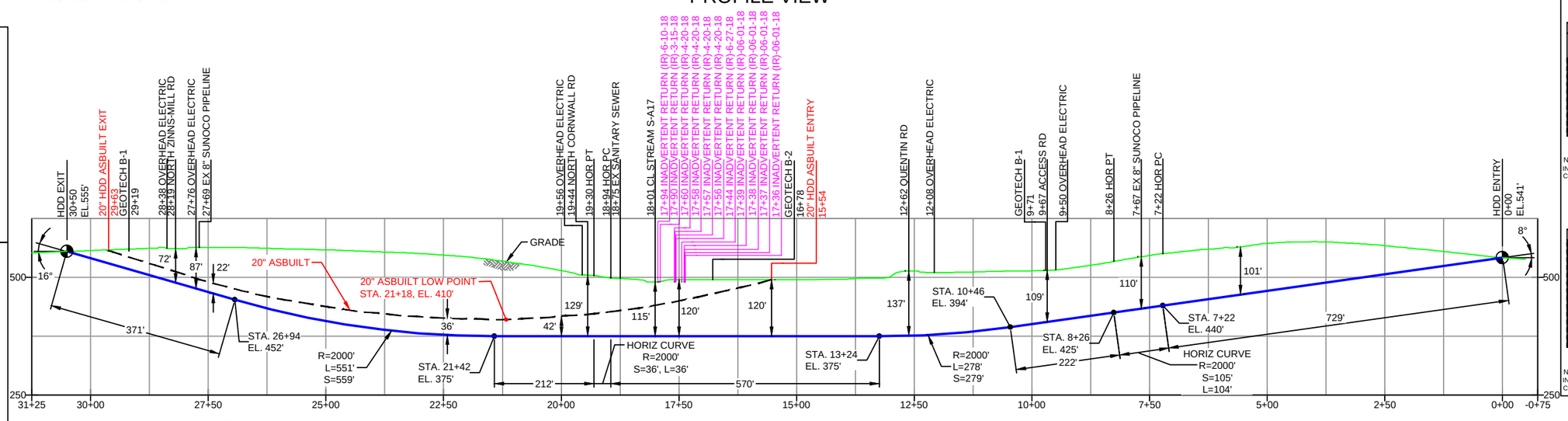
Percent of map unit: 2 percent
Landform: Flood plains
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: Yes

ATTACHMENT 2



PLAN VIEW

PROFILE VIEW



GEOTECH B-1
NG EL. 556'
-RESIDIUUM-CLAY CL (0.0' - 5.0')
-GROUNDWATER (43.0')
-DOLOMITE/LIMESTONE /SHALE (5.0' - 170.0')
-BORING TERMINATED EL.386'
NOTE: REFER TO TEST BORING LOG B-1 INTERTEK PROJECT #04911506 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2
NG EL. 495'
-FILL ML (0.0' - 3.5')
-GROUNDWATER (2.9')
-FILL MH (3.5' - 8.5')
-DOLOMITE/LIMESTONE (8.5' - 105.0')
-BORING TERMINATED EL.390'
NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PROJECT #04911506 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-1
NG EL. 515'
-NO SAMPLING (0.0' - 5.0')
-FILL GP-GM (5.0' - 15.0')
-GROUNDWATER (24.0')
-LIMESTONE/DOLOMITE (15.0' - 152.0')
-BORING TERMINATED EL.363'
NOTE: REFER TO TEST BORING LOG B-1 INTERTEK PROJECT #04911695 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2A
NG EL. 543'
-NO SAMPLING (0.0' - 9.5')
-GROUNDWATER (27.0')
-LIMESTONE/DOLOMITE (9.5' - 153.0')
-BORING TERMINATED EL.390'
NOTE: REFER TO TEST BORING LOG B-1 INTERTEK PROJECT #04911695 FOR COMPLETE SOIL MATERIAL DESCRIPTION

LEBANON COUNTY, PENNSYLVANIA - WEST CORNWALL TOWNSHIP
S3-0101-16

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=): 3050'
   HDD PIPE LENGTH (S=): 3083'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
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 2625 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

ES-5.32	TO	ES-5.32	EROSION & SEDIMENT PLAN	
SHEET 18	TO	SHEET 18	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP6	REDESIGNED PER CLIENT REQUEST AND ADDED GEOTECH INFORMATION	MRS	12/07/18	RMB	12/07/18	AMC	12/07/18
EP5	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	04/10/18	RMB	04/10/18	CAG	04/10/18
EP4	REVISED DEPTH UNDER STREAM S-A17	MRS	12/20/17	RMB	12/20/17	AMC	12/20/17
EP3	LENGTHENED DRILL AND LOWERED UNDER STREAM S-A17	MRS	12/07/17	RMB	12/07/17	AMC	12/07/17
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	JTW	05/18/16	RMB	05/18/16	AAW	05/18/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
N ZINNS MILL ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'

DWG. NO: PA-LE-0055.0000-RD-16

LEGEND:

◎ Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0101
LEBANON COUNTY, WEST CORNWALL TOWNSHIP, PA
SUNOCO PENNSYLVANIA PIPELINE PROJECT

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	N. ZINNS MILL ROAD, LEBANON, PA		Page 1 of 1
HDD No.:	S3-0101	Dates(s) Drilled: 10-07-15	Inspector: J. COSTELLO
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: E. ODGEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 18.0
Boring Location Coordinates:		40°17'25.92"N	76°25'53.56"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 (<1"")					
1	3.0	5.0	0.1		6	ML	YELLOWISH BROWN SILT, SOME FINE SAND, TRACE FINE	1	2	1	2	**3**
				8.0			GRAVEL. (USCS: ML)					
2	7.5	8.0	8.0	8.1			PARTIALLY WEATHERED GRAY LIMESTONE	5	50/1"			**>50**
							AUGER REFUSAL. PERFORMED 3 OFF-SETS TO ATTEMPT TO GO					
							DEEPER, ALL OFF-SETS RESULTED IN AUGER REFUSAL AT 7.5'.					
							ROCK CORING					
RUN 1	8.0	13.0	8.0		60	ROCK	LIGHT GRAY FRACTURED LIMESTONE.	TCR: 100%, SCR: 97%, RQD: 66%				
RUN 2	13.0	18.0		18.0	60		LIGHT GRAY FRACTURED LIMESTONE.	TCR: 100%, SCR: 88, RQD: 68%				
							CAVED AND DRY AT 8'.					
							CORE TESTING RESULTS (DEPTH 14-14.5'):					
							COMPRESSIVE STRENGTH: 2,960 PSI					
							UNIT WEIGHT: 174.6 PCF					

Notes/Comments:
Pocket Pentrometer Testing

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

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

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	44 N. CORNWALL ROAD, LEBANON, PA		Page 1 of 1
HDD No.:	S3-0101	Dates(s) Drilled: 11-13-15	Inspector: J. COSTELLO
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: E. ODGEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 6.0
Boring Location Coordinates:		40°17'25.79"N	76°25'46.42"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 (<1"")					
1	3.0	5.0	0.1	4.0	21	CL	BROWN CLAYEY SILT, TRACE F-C SAND, TRACE FINE GRAVEL.	2	12	31	50	**43**
			4.0				INTERLAYERED LIGHT GRAY PARIALY WEATHERED LIMESTONE AND					
				6.0			FINE TO MEDIUM SAND AND SILT.					
							AUGER REFUSAL AT 6'. OFF-SET BORING AND CONTINUOUSLY					
							AUGERED TO REFUSAL AT 6'.					

Notes/Comments:
Pocket Pentrometer Testing

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

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

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	N. CORNWALL RD, LEBANON, PA		Page 1 of 1
HDD No.:	S3-0101	Dates(s) Drilled: 10-07-15	Inspector: J. COSTELLO
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: E. ODGEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 7.0
Boring Location Coordinates:		40°17'25.73"N	76°25'39.40"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		6	ML	BROWN FINE SANDY SILT, INTERMIXED WITH LIMESTONE GRAVEL	2	5	11	7	**16**
				7.0			AND COBBLES. (USCS: ML).					
							AUGER REFUSAL AT 7'. OFF-SET BORING TWICE WITH SHALLOWER					
							AUGER REFUSAL.					
							AREA HAS LIMESTONE OUTCROPS, AND NEARBY CREEK BOTTOM					
							IS ROCKY.					

Notes/Comments:
Pocket Pentrometer Testing

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.

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0101

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S3-0101	SB-01	1	8	13	100	97	66	8	18	Slight	Limestone	Massive	Light gray	Fractures ranging from 2° to 62°, Avg. 21°
		2	13	18	100	88	68							

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0101

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.) From	Depth of Sample (ft.) To	Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318) Liquid Limit, %	Atterburg Limits (ASTM D4318) Plastic Limit, %	Atterburg Limits (ASTM D4318) Plasticity Index, %	USCS Classif. (ASTM D2487)
S3-0101	SB-01	1	3.0	5.0	21.0	79.9	38	27	11	ML
	SB-02	1	3.0	5.0	5.5	24.1	-	-	-	-
	SB-03	1	3.0	5.0	12.5	63.1	35	25	10	ML

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-01	2	14-14.5	2,960	174.6

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0101

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S3-101	N. Zinns Mill Road	SB-01	**Snitz Creek Formation** - Thick-bedded, medium- to coarsely crystalline dolomite, in part oolitic, containing laminated limestone and sandstone interbeds	Gently rolling to level terrain	Snitz Creek	crystalline dolomite containing laminated limestone and sandstone interbeds	350		
		SB-02							
		SB-03							

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

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

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

Relative Proportions

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

Particle Size Identification

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

COHESIVE SOILS

(Silt, Clay & Combinations)

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

Plasticity

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

ROCK

(Rock Cores)

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

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

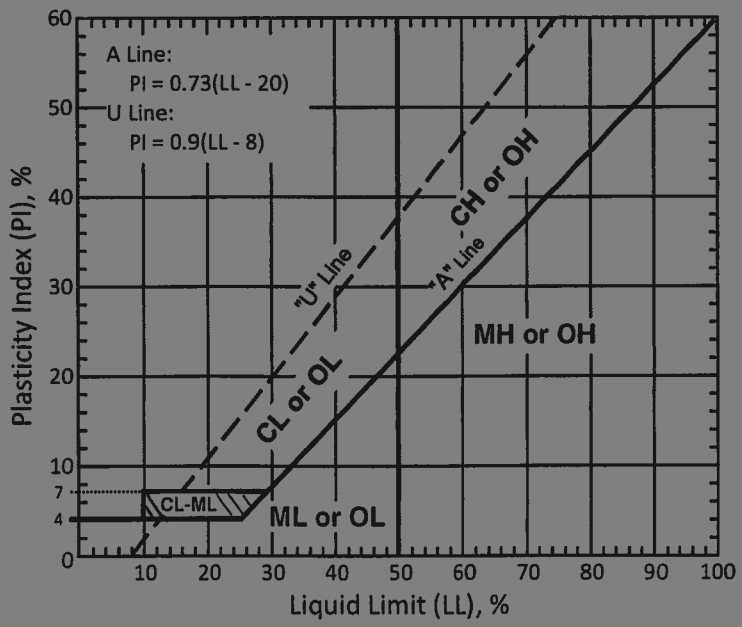
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

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

Major Divisions		Group Symbols	Typical Descriptions
Fine–grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)	ML	norganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays , sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays (Liquid limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silts
	Highly organic soils	Pt	Peat and other highly organic soils

For soils plotting nearly on A line use dual symbols i.e ., I_p = 29.5, w_L=60 gives CH-MH. When w_L is near 50 use CL-CH or ML-MH. Take near as ± 2 percent.



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

Figure 1: Site Vicinity Map

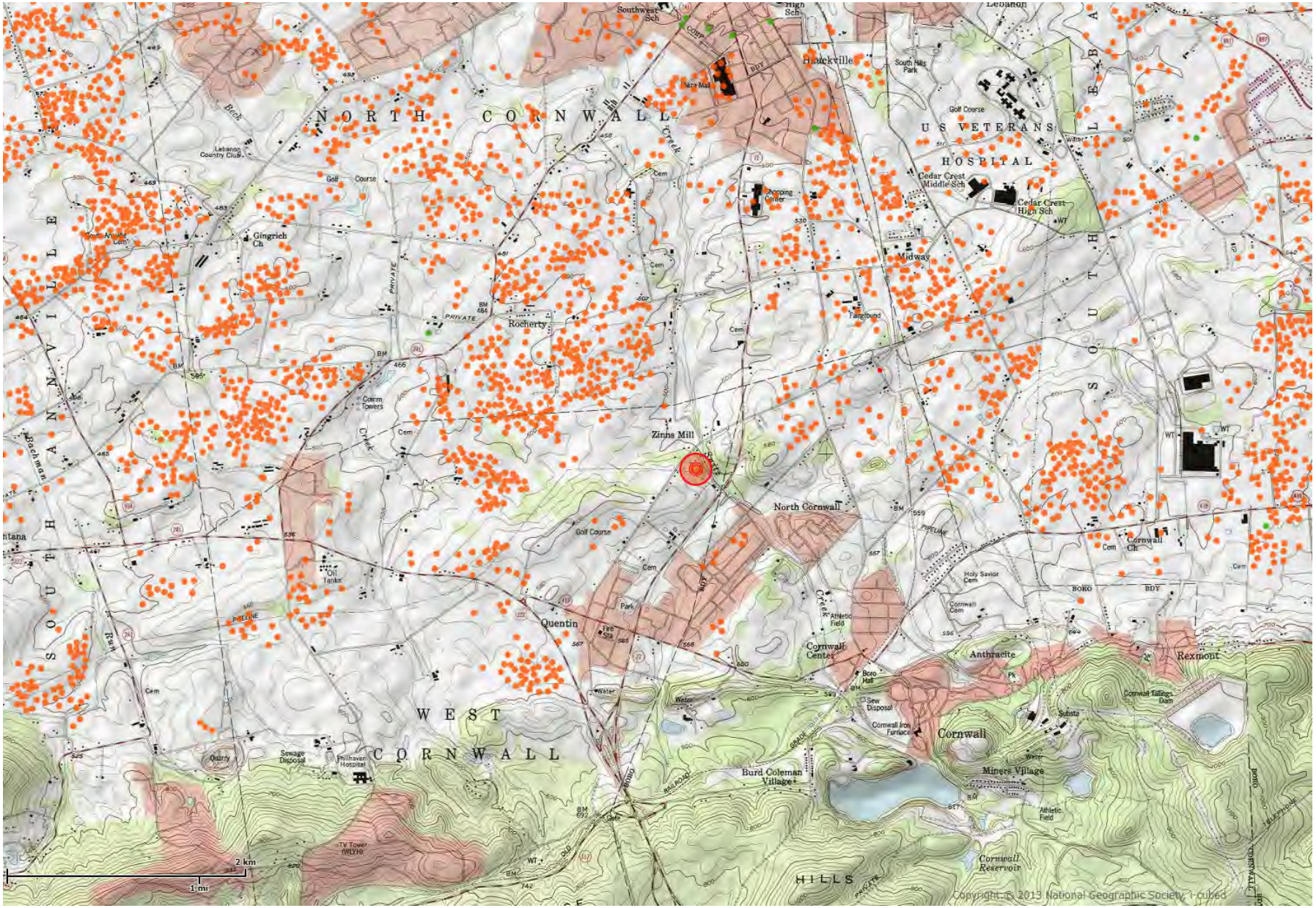


FIGURE 2: BORING LOCATION PLAN
"N. Zinn Mill RD" (PPP5) - Lebanon Co., PA
PSI Project No.: 04911506

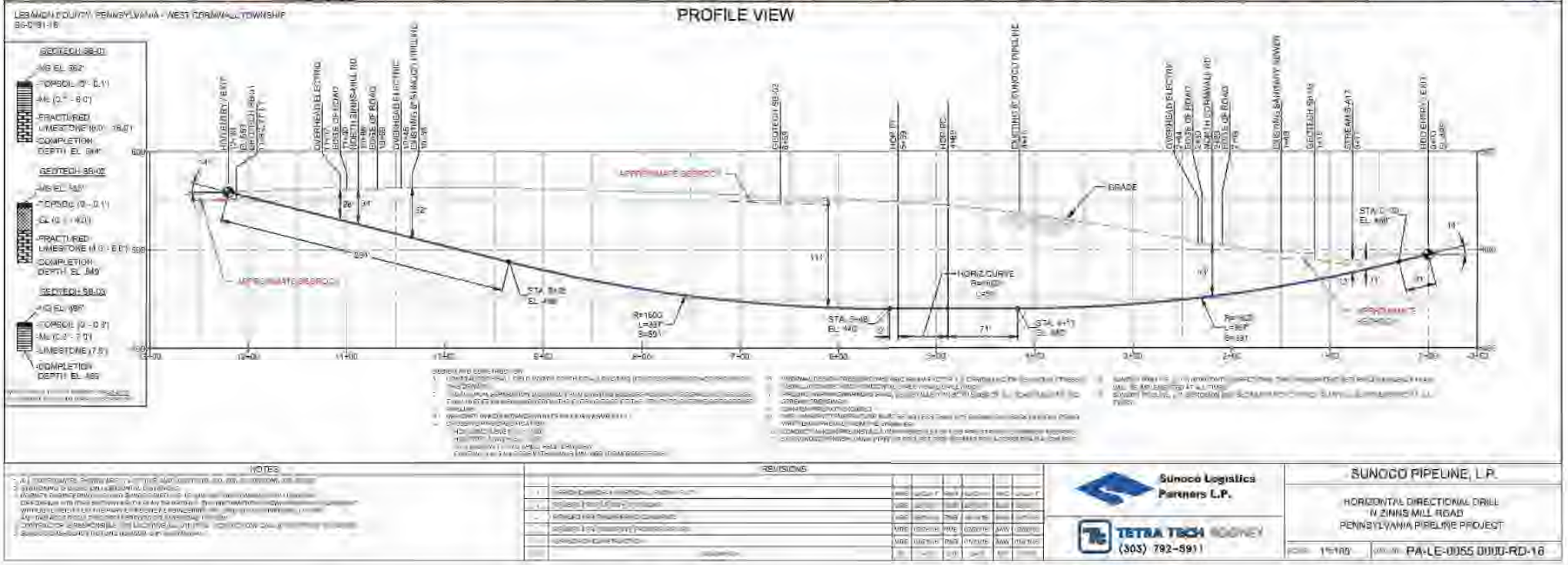
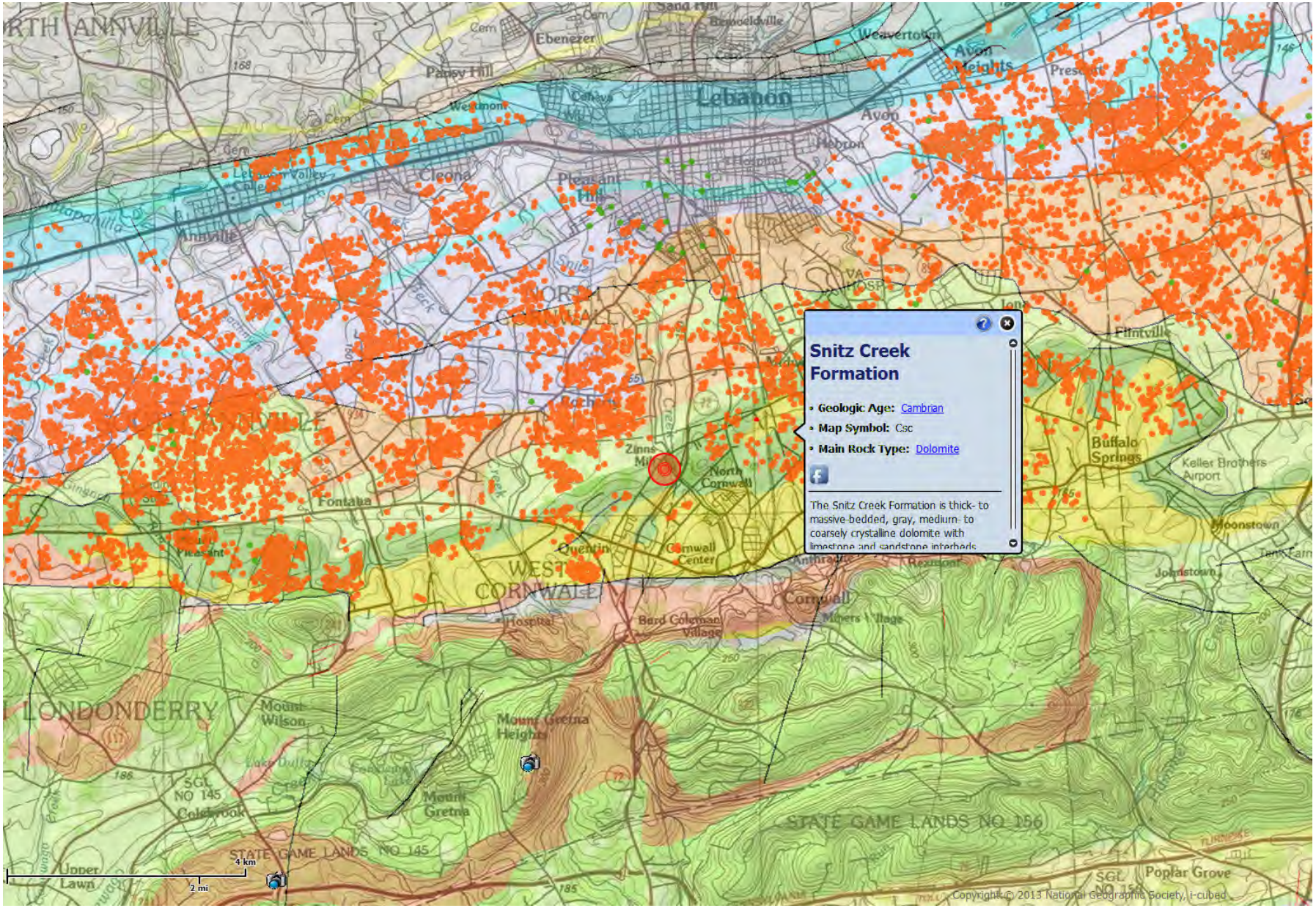


Figure 3: Site Geology Map



BORING B-1

DATE STARTED:	10/27/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/2/17	**DRILLER:** D. Novotny	**LOGGED BY:** Proczko/Lehman
COMPLETION DEPTH	170.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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	43.0 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	24	**RESIDUUM**-Medium Stiff, Brown, Lean CLAY with Sand, moist	CL	3-4-4-5 N=8	21		LL = 33 PL = 20 Fines=79.0%
	5			S-2	1	**Highly Weathered DOLOMITE**-Recovery consisted of several Domolite rock fragments with Silty Clay.		50/1"	19	>>	2 min.
				R-1	17	**DOLOMITE**-Light gray to gray, Weathered to Slightly Weathered, very broken to massive, moderately hard, quartz seams		RQD=63 Rec=74%			1 min. 1 min. 1 min.
	10			R-2	58			RQD=52 Rec=96%		>> Q_u = 401.4 tsf 172.9 pcf	1 min. 1 min. 1 min. 1 min. 1 min.
	15			R-3	60	**DOLOMITE Interbedded with Shale and Limestone**-Gray to dark gray, Slightly Weathered, very broken to massive, moderately hard, quartz seams		RQD=34 Rec=100%			1 min. 1 min. 1 min. 1 min. 1 min. 1 min. 1 min. 1 min.
	20			R-4	60	**LIMESTONE Interbedded with Dolomite**-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to hard, quartz seams Weathered layer from 19 to 19.5 feet. Shale interbeds of varying thickness between 17 and 22 feet.		RQD=66 Rec=100%		>> Q_u = 402.4 tsf 169.0 pcf	1 min. 2 min. 2 min. 2 min. 2 min. 2 min.
	25			R-5	60			RQD=66 Rec=100%			1 min. 1 min. 2 min.
	30			R-6	60	**DOLOMITE Interbedded with Limestone**-Light gray to dark gray, Slightly Weathered, broken to massive, hard, quartz seams		RQD=86		>> Q_u = 1031.1 tsf 169.3 pcf	2 min.

Continued Next Page

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

PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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

DATE STARTED:	10/27/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/2/17	**DRILLER:** D. Novotny	**LOGGED BY:** Proczko/Lehman
COMPLETION DEPTH	170.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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-1

Water

Pre-Core	Not Enc.
Upon Completion	43.0 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					**DOLOMITE Interbedded with Limestone**-Light gray to dark gray, Slightly Weathered, broken to massive, hard, quartz seams Weathered/very broken layer @ 31.9 feet (~ 3 inches thick) Weathered/very broken layer @ 32.8 feet (~ 6-3/4 inches thick)		Rec=100%			2 min. 2 min. 2 min. 3 min. 3 min.
	35			R-7	54			RQD=64 Rec=90%			3 min. 4 min. 4 min. 3 min. 3 min.
	40			R-8	54			RQD=64 Rec=90%			>> Q_u = 243.8 tsf 166.5 pcf 3 min. 3 min.
	45			R-9	60	**LIMESTONE Interbedded with Dolomite**-Light gray to dark gray, Slightly Weathered, broken to massive, hard, quartz seams		RQD=75 Rec=100%			3 min. 4 min. 4 min. 4 min. 8 min.
	50			R-10	60	**DOLOMITE Interbedded with Limestone**-Light gray to dark gray, Slightly Weathered, very broken to massive, hard, quartz seams		RQD=93 Rec=100%			>> Q_u = 470.1 tsf 166.9 pcf 18 min. 5 min. >> Q_u = 477.1 tsf 173.4 pcf 6 min. 6 min. 4 min. 5 min. 6 min.
	55			R-11	60			RQD=65 Rec=100%			6 min. 5 min. 6 min. 6 min. >> Q_u = 425.8 tsf 173.8 pcf
	60			R-12	60	**LIMESTONE Interbedded with Dolomite**-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to hard, quartz seams		RQD=90			6 min.

Continued Next Page

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

PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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

DATE STARTED:	10/27/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/2/17	**DRILLER:** D. Novotny	**LOGGED BY:** Proczko/Lehman
COMPLETION DEPTH	170.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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-1

Water

Pre-Core	Not Enc.
Upon Completion	43.0 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					**LIMESTONE Interbedded with Dolomite**-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to hard, quartz seams Shale interbeds of varying thickness between 62 and 72 feet.		Rec=100%			6 min. 6 min. 6 min. 4 min. 4 min.
				R-13	60			RQD=76			
	65					Broken/very broken layer @ 65.1 feet (~ 3-1/2 inches thick)		Rec=100%			4 min. 4 min. 3 min. 4 min.
											>> Q_u = 505.5 tsf 174.9 pcf
				R-14	60			RQD=80			4 min.
	70							Rec=100%			3 min. 4 min. 4 min. 4 min. 4 min.
				R-15	60			RQD=68			
	75							Rec=100%			4 min. 4 min. 2 min.
						Weathered layer @ 76.8 feet (~ 2 inches thick)					>> Q_u = 486.7 tsf 171.7 pcf
						Shale interbeds of varying thickness between 77 and 82 feet.					2 min.
				R-16	59			RQD=46			
	80							Rec=98%			2 min. 2 min. 2 min. 2 min. 2 min.
						DOLOMITE with Interbedded Limestone and Shale-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to very hard, quartz seams					
				R-17	60			RQD=24			
	85							Rec=100%			3 min. 2 min. 3 min. 3 min.
											3 min.
				R-18	48			RQD=34			>> Q_u = 496.2 tsf
	90					*Continued Next Page*					

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

PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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

BORING B-1

DATE STARTED:	10/27/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/2/17	**DRILLER:** D. Novotny	**LOGGED BY:** Proczko/Lehman
COMPLETION DEPTH	170.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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: 43.0 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							Rec=80%			167.9 pcf 4 min.
						LIMESTONE Interbedded with Dolomite and Shale-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to very hard, quartz seams					4 min. 3 min. 3 min. 3 min.
				R-19	55			RQD=72 Rec=92%			3 min.
	95										3 min. 3 min. 3 min. 3 min.
				R-20	60			RQD=56 Rec=100%			>> Q_u = 549.6 tsf 169.5 pcf 2 min.
	100					Weathered Shale layer from 100.2 to 101.1 feet. Shale interbeds of varying thickness between 102 and 112 feet.					3 min. 2 min. 2 min. 1 min.
				R-21	60			RQD=90 Rec=100%			1 min. 1 min. 2 min. 2 min.
	105										2 min.
				R-22	60			RQD=46 Rec=100%			>> Q_u = 1164.6 tsf 169.0 pcf 2 min. 2 min.
	110										8 min. 8 min. 8 min. 8 min.
				R-23	60	**DOLOMITE with Interbedded Shale**-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to very hard, quartz seams		RQD=94 Rec=100%			>> Q_u = 442.7 tsf 176.1 pcf >> Q_u = 580.5 tsf 173.5 pcf 6 min.
	115										5 min.
				R-24	60			RQD=34			
	120					*Continued Next Page*					

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

PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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

DATE STARTED:	10/27/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/2/17	**DRILLER:** D. Novotny	**LOGGED BY:** Proczko/Lehman
COMPLETION DEPTH	170.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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-1

Water

Pre-Core	Not Enc.
Upon Completion	43.0 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					**DOLOMITE with Interbedded Shale**-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to very hard, quartz seams Weathered Shale layer from 122.9 to 123.5 feet.		Rec=100%			6 min. 5 min. 5 min. 5 min.
				R-25	56			RQD=34 Rec=94%			>> Q_u = 551.2 tsf 171.1 pcf 5 min. 5 min. 5 min. 5 min. 5 min.
	125										
				R-26	59			RQD=68 Rec=98%			>> Q_u = 991.6 tsf 167.8 pcf 5 min. 5 min. 5 min. 5 min. 5 min. 5 min.
	130										
				R-27	49	**SHALE Interbedded with Dolomite**-Light gray to dark gray, Weathered to Slightly Weathered, very broken to massive, moderately hard to very hard, quartz seams Very broken layer @ 132.2 feet (~ 1 inch thick) Weathered/broken layer @ 133.1 feet (~ 1 inch thick) Weathered/very broken layer @ 135.6 feet (~ 2-1/2 inches thick)		RQD=20 Rec=82%			5 min. 5 min. 3 min.
	135										
				R-28	55	Very broken layer @ 139.2 feet (~ 4 inches thick) Broken layer @ 141.4 feet (~ 2 inches thick)		RQD=14 Rec=92%			2 min. 2 min. 2 min. 2 min. 2 min. 2 min.
	140										
				R-29	58	**SHALE Interbedded with Dolomite**-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to hard, quartz seams Weathered/broken layer @ 146.7 feet (~ 1-1/2 inches thick)		RQD=50 Rec=96%			>> Q_u = 403.7 tsf 479.7 pcf 2 min. 2 min. 2 min. 2 min. 2 min.
	145										
				R-30	47	**DOLOMITE with Interbedded Shale**-Light gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to very		RQD=26			
	150					*Continued Next Page*					

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

PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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

BORING B-1

DATE STARTED:	10/27/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/2/17	**DRILLER:** D. Novotny	**LOGGED BY:** Proczko/Lehman
COMPLETION DEPTH	170.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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	43.0 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					hard, quartz seams		Rec=78%			3 min. 3 min.
						SHALE Interbedded with Dolomite-Gray to dark gray, Slightly Weathered, broken to massive, modertately hard to very hard, quartz seams					2 min. >> Q_u = 588.5 tsf 174.4 pcf
				R-31	60			RQD=88 Rec=100%			2 min. 2 min. 2 min.
	155										2 min. 2 min. 2 min.
						DOLOMITE with Interbedded Shale-Gray to dark gray, Slightly Weathered, very broken to massive, moderately hard to very hard, quartz seams					2 min. 2 min. 2 min.
				R-32	60			RQD=50 Rec=100%			2 min. >> Q_u = 467.4 tsf 176.5 pcf
	160										2 min. 3 min. 3 min.
						DOLOMITE-Light gray to dark gray, Weathered to Slightly Weathered, very broken to massive, hard to very hard, quartz seams					3 min. 4 min. 4 min.
				R-33	40			RQD=10 Rec=66%			4 min. 4 min. 4 min.
	165										4 min. 4 min.
				R-34	25			RQD=0 Rec=70%			4 min. 4 min.
	170					Test boring terminated @ 170 feet					

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PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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


Run | Depth | Rec | RQD
R-1 | 5.1 - 7.0 | 1.4 | 1.2
R-2 | 7.0 - 12.0 | 4.8 | 2.6
R-3 | 12.0 - 17.0 | 5.0 | 1.7
17.0 - 22.0 | 5.0 | 3.3
Top
0 ft
20


Run
Depth
Rec.
RQD
TOP

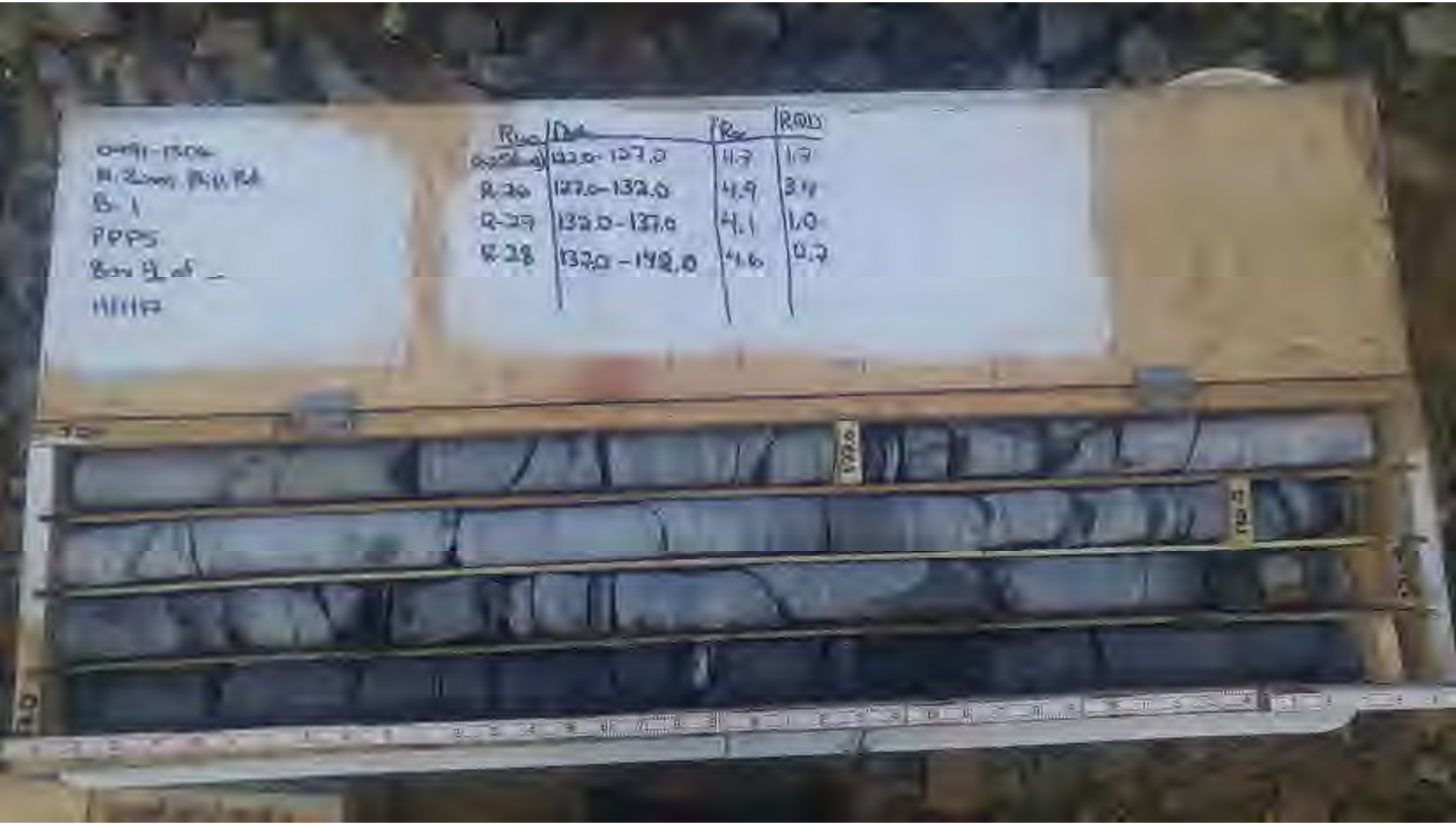

R-8
R-9
5.0
5.0
TOP

Run
Depth
Rec
RQD
R-11
R-12
R-13
TOP


Depth
Top


Run
Depth
TOP


Run | Depth | Rec | RQD
B-23 | 110.0-117.0 | 5.0 | 43
B-24 | 117.0-122.0 | 5.0 | 47
B-25 | 122.0-127.0 | 4.7 | 47
TOP
117.0
122.0
127.0


B-1
PPPS
R-26 127.0-132.0 4.9
132.0-137.0 4.1 1.0


R-33
R-34
5.0
3.3
0.5
0.0
EOB
1630

BORING B-2

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/1/17	**DRILLER:** B. Kirkpatrick	**LOGGED BY:** K. Ebersole
COMPLETION DEPTH	105.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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.
	11/1/2017 @ 7:40 a.m.	2.9 feet
	Post-Core	5.5 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**-Very Soft, Gray-brown, SILT, trace Sand, trace organics and woody matter, moist	ML	WH/18"-2 N=0	37		LL = 49 PL = 34 8.3% organics Fines=97.9%
	5			S-2	12	**FILL**-Dark brown, Elastic SILT, trace Sand and Gravel, trace woody matter, moist	MH	2-13-8-9 N=21	56		LL = 55 PL = 36 8.5% organics Fines=85.3%
	10			S-3	1	**Highly Weathered BEDROCK**- Limited sample recovery consisted of one large piece of gray-brown Sandstone gravel and three smaller pieces of gray to dark gray Dolomite Auger refusal @ 9.5 feet		50/1"		>>◎	1 min.
				R-1	29	**DOLOMITE**-Gray, Weathered to Slightly Weathered, very broken to slightly broken, very hard, calcite veins, laminated to narrow bedding, steep to very steep dip, closely to widely spaced discontinuity, flat to very steep dip, bedding joint		RQD=31 Rec=101%			1 min. 3 min. 1 min.
	15			R-2	60	**DOLOMITE**-Gray, Slightly Weathered, very broken to massive, very hard, calcite veins, laminated to narrow bedding, steep to very steep dip, closely to widely spaced discontinuity, flat to very steep dip, bedding joint Broken, rust staining in fractures from 18.3 to 18.5 feet.		RQD=68 Rec=100%		>>▲	1 min. Q_u = 475.6 tsf 173.8 pcf 2 min. 2 min. 3 min. 1 min. 2 min.
	20			R-3	60	Broken layer @ 21.7 feet (~3-1/2 inches thick)		RQD=77 Rec=100%			2 min. 2 min. 4 min. 2 min. 3 min.
	25			R-4	60			RQD=75 Rec=100%		>>▲	3 min. Q_u = 849.3 tsf 175.5 pcf 3 min. 2 min. 2 min.
	30			R-5	58			RQD=87			

Continued Next Page

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

PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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

BORING B-2

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/1/17	**DRILLER:** B. Kirkpatrick	**LOGGED BY:** K. Ebersole
COMPLETION DEPTH	105.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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.
	11/1/2017 @ 7:40 a.m.	2.9 feet
	Post-Core	5.5 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					**DOLOMITE**-Gray, Slightly Weathered, very broken to massive, very hard, calcite veins, laminated to narrow bedding, steep to very steep dip, closely to widely spaced discontinuity, flat to very steep dip, bedding joint		Rec=97%			3 min. 3 min. 4 min. 3 min. 3 min.
	35			R-6	60	Soil in fractures @ 36.3 feet Interbedded with Limestone from 37 to 42 feet; more Limestone than Dolomite.		RQD=80 Rec=100%		>> Q_u = 490.8 tsf 174.4 pcf	3 min. 3 min. 4 min. 2 min. 3 min.
	40			R-7	59	Rust staining in fractures from 41 to 41.2 feet.		RQD=68 Rec=98%			3 min. 3 min. 3 min. 3 min. 2 min.
	45			R-8	60			RQD=55 Rec=100%		>> Q_u = 949.1 tsf 176.0 pcf	3 min. 3 min. 3 min. 2 min. 2 min.
	50			R-9	58	**LIMESTONE**-Gray, Slightly Weathered, very broken to massive, hard, thinly bedded, moderate to very steep fractures, closely to widely spaced discontinuity, flat to steep dip, bedding joint		RQD=92 Rec=97%			3 min. 2 min. 3 min. 2 min. 3 min.
	55			R-10	60			RQD=75 Rec=100%		>> Q_u = 756.7 tsf 170.0 pcf	2 min. 3 min. 1 min. 2 min.
	60			R-11	60			RQD=95			

Continued Next Page

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

PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/1/17	**DRILLER:** B. Kirkpatrick	**LOGGED BY:** K. Ebersole
COMPLETION DEPTH	105.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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.
	11/1/2017 @ 7:40 a.m.	2.9 feet
	Post-Core	5.5 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					**LIMESTONE**-Gray, Slightly Weathered, very broken to massive, hard, thinly bedded, moderate to very steep fractures, closely to widely spaced discontinuity, flat to steep dip, bedding joint		Rec=100%			3 min. 3 min. 3 min. 2 min. 3 min.
	65			R-12	60			RQD=100 Rec=100%		>> Q_u = 731.9 tsf 171.1 pcf	3 min. 3 min. 4 min. 2 min. 2 min.
	70			R-13	60	Rust staining in fractures from 70.2 to 70.7 feet.		RQD=95 Rec=100%			2 min. 2 min. 3 min. 2 min. 2 min.
	75			R-14	60	**DOLOMITE**-Gray, Slightly Weathered, very broken to massive, laminated to thinly bedded, very steep to sheer dip, closely to widely spaced discontinuity, shallow to steep dip, bedding joint		RQD=75 Rec=100%		>> Q_u = 1741.4 tsf 172.4 pcf	2 min. 2 min. 3 min. 3 min. 3 min.
	80			R-15	60			RQD=100 Rec=100%			3 min. 3 min. 4 min. 2 min. 3 min.
	85			R-16	58	Weathered/broken with rust staining from 84 to 87 feet.		RQD=62 Rec=97%		>> Q_u = 1555.5 tsf 165.4 pcf	2 min. 2 min. 2 min. 3 min.
	90			R-17	54			RQD=35			

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Professional Service Industries, Inc.
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PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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

BORING B-2

DATE STARTED:	10/31/17	**DRILL COMPANY:**	Terra Testing, Inc.
DATE COMPLETED:	11/1/17	**DRILLER:**	B. Kirkpatrick **LOGGED BY:** K. Ebersole
COMPLETION DEPTH	105.0 ft	**DRILL RIG:**	Diedrich D-50 Track
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.
	11/1/2017 @ 7:40 a.m.	2.9 feet
	Post-Core	5.5 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					**DOLOMITE**-Gray, Slightly Weathered, very broken to massive, laminated to thinly bedded, very steep to sheer dip, closely to widely spaced discontinuity, shallow to steep dip, bedding joint		Rec=90%			4 min. 3 min. 6 min. 3 min. 3 min.
	95			R-18	60	Broken/very broken from 96 to 98 feet.		RQD=70 Rec=100%		>> Q_u = 428.9 tsf 172.1 pcf	3 min. 4 min. 3 min. 2 min.
	100			R-19	60	Limestone/calcite veins from 99.6 to 105 feet.		RQD=52 Rec=100%			3 min. 4 min. 7 min. 6 min.
				R-20	36			RQD=67 Rec=100%		>> Q_u = 615.5 tsf 174.5 pcf	4 min. 3 min. 3 min.
	105					Test boring terminated @ 105 feet					

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

PROJECT NO.: 04911506
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

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


DATE 10/31/17 BOX 1
22.0 FT SPREAD
PSI
DEPTH
R-1 9.6" - 12
R-2 12.0' - 17.0
R-3 17.0' - 22.0
5.0 3.4'
5.0' 3.8'
22.0


BORING B-2
BOX 2
DEPTH
FT. TO 35.4 FT.
SPREAD PPP # 5
PSI # 04911506
Tetra Tech Drawing PA-LE-0055.0000-RD-16
DEPTH
REC
R-4
22.0 - 27.0
5.0
R-5
4.8
R-6
27.0
32.0


RUN
DEPTH
REC
R-6
32.0 - 37.0'
5.0'
4.0
R-7
37.0' - 42.0'
4.9'
R-8
42.0' - 47.0'
5.0'
2.7'
R-9
4.9'
37.0'
47.0'


DEPTH
SPREAD # 5
R-9
5.0
R-10
5.0
R-11
R-12

DATE
BOX 5
DEPTH
FT. TO
FT. SPREAD
RUN
DEPTH
REC
RQD
R-12
62.0'-67.0'
5.0'
5.0'
R-13
67.0'-72.0'
5.0'
72.0
77.0


87.0'
92.0'


RUN
DEPTH
REC
%REC
R-18
92.0 97.0
5.0
5.5'
R-19
97.0' - 102.0'
5.0
2.6
R-20
102.0 - 105.0
3.0
2.0
97.0
102.0
105.0

GENERAL NOTES

SAMPLE IDENTIFICATION

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

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
RC: Rock Core
TC: Texas Cone
BS: Bulk Sample
PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

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

RELATIVE DENSITY OF COARSE-GRAINED SOILS

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

ANGULARITY OF COARSE-GRAINED PARTICLES

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

GRAIN-SIZE TERMINOLOGY

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

PARTICLE SHAPE

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

RELATIVE PROPORTIONS OF FINES

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

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

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

MOISTURE CONDITION DESCRIPTION

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

STRUCTURE DESCRIPTION

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

SCALE OF RELATIVE ROCK HARDNESS

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

ROCK BEDDING THICKNESSES

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

ROCK VOIDS

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

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

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

ROCK QUALITY DESCRIPTION

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

Degree of Brokeness

Characteristic	Description
Less than 1 inch	Very Broken
1 inch to 3 inches	Broken
3 inches to 6 inches	Slightly Broken
Greater than 6 inches	Massive

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

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

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

Method used to determine consistency or hardness (check one):
Field assessment: _____ Uniaxial lab test: _____ Other: _____ Rebound hammer (ASTM D5873): _____
* See NEH631.03 for consistency and density of soil materials. For very stiff soil, SPT N values = 15 to 30. For very soft rock or hard, soil-like material, SPT N values exceed 30 blows per foot.

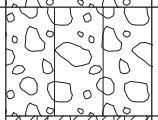
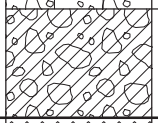
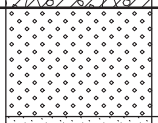
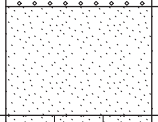
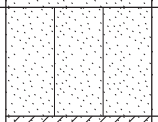
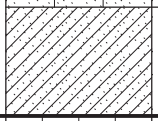
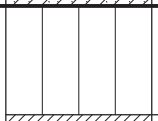
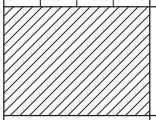
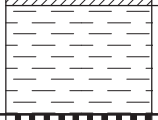
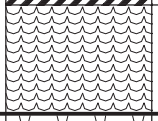
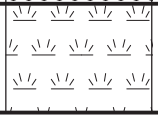
Bedding/ Discontinuity Dip (Abbrev.)	Description
Flat Dip (**Fld**)	Beds/Discontinuities dipping < 5 degrees
Shallow Dip (**Sld**)	Beds/Discontinuities dipping from 5 to 15 degrees
Moderate Dip (**Mdd**)	Beds/Discontinuities dipping from 15 to 30 degrees
Steep Dip (**Std**)	Beds/Discontinuities dipping from 30 to 45 degrees
Very Steep Dip (**Vsd**)	Beds/Discontinuities dipping from 45 to 60 degrees
Sheer Dip (**Srd**)	Beds/Discontinuities dipping > 60 degrees

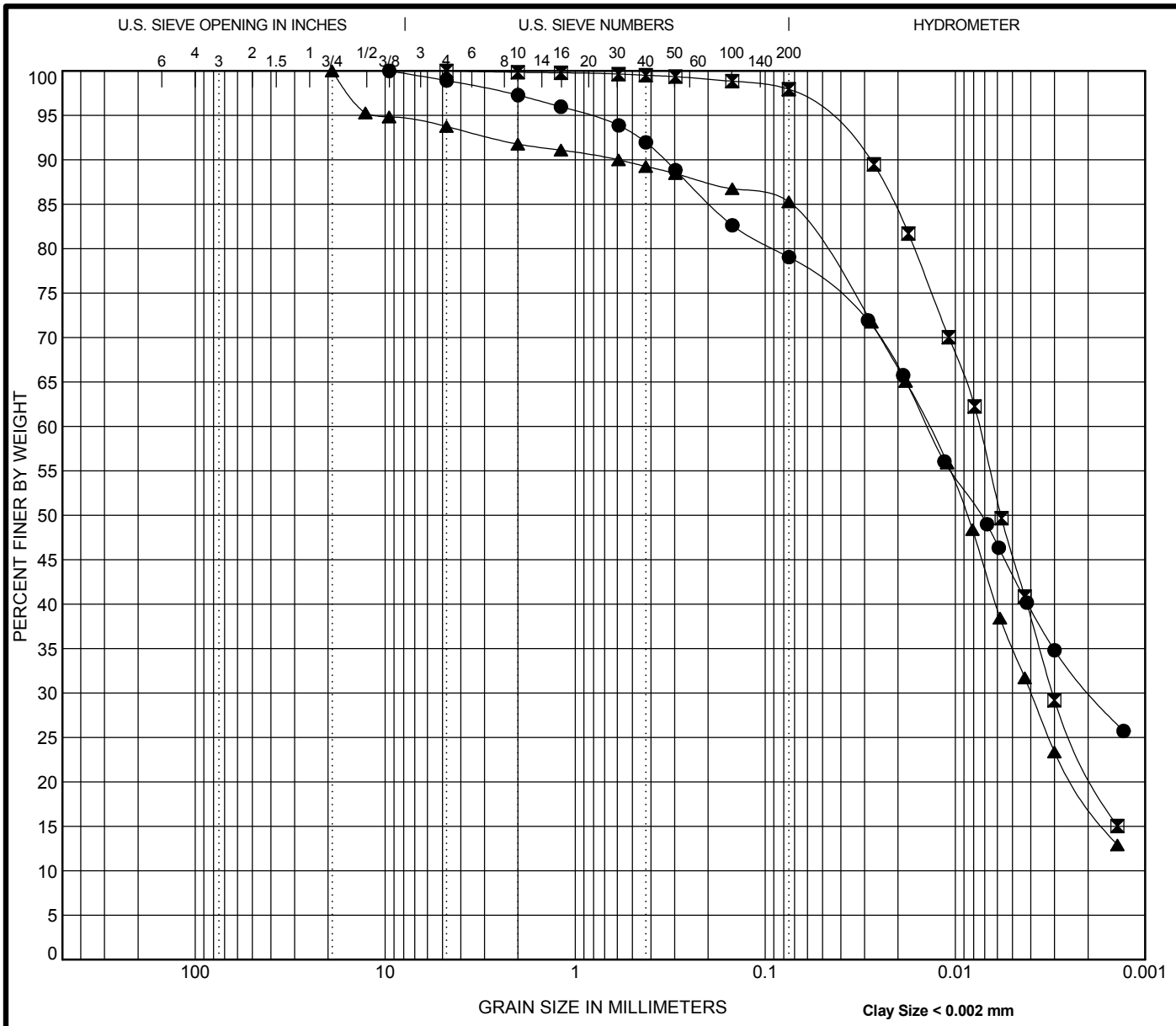
Table 29 - Bedding/Discontinuity Dip Descriptors

From PADOT Publication 222 “Geotechnical Investigations Manual”

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

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



Clay Size < 0.002 mm

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-1	1.0	Lean CLAY with Sand (CL)	33	20	13		
⊠	B-2	1.0	SILT (ML)	49	34	15		
▲	B-2	6.0	Elastic SILT (MH)	55	36	19		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	1.0	9.525	0.014	0.002		1.1	19.9	48.6	30.4
⊠	B-2	1.0	4.75	0.007	0.003		0.0	2.1	76.3	21.7
▲	B-2	6.0	19.05	0.014	0.004		6.3	8.5	67.5	17.8

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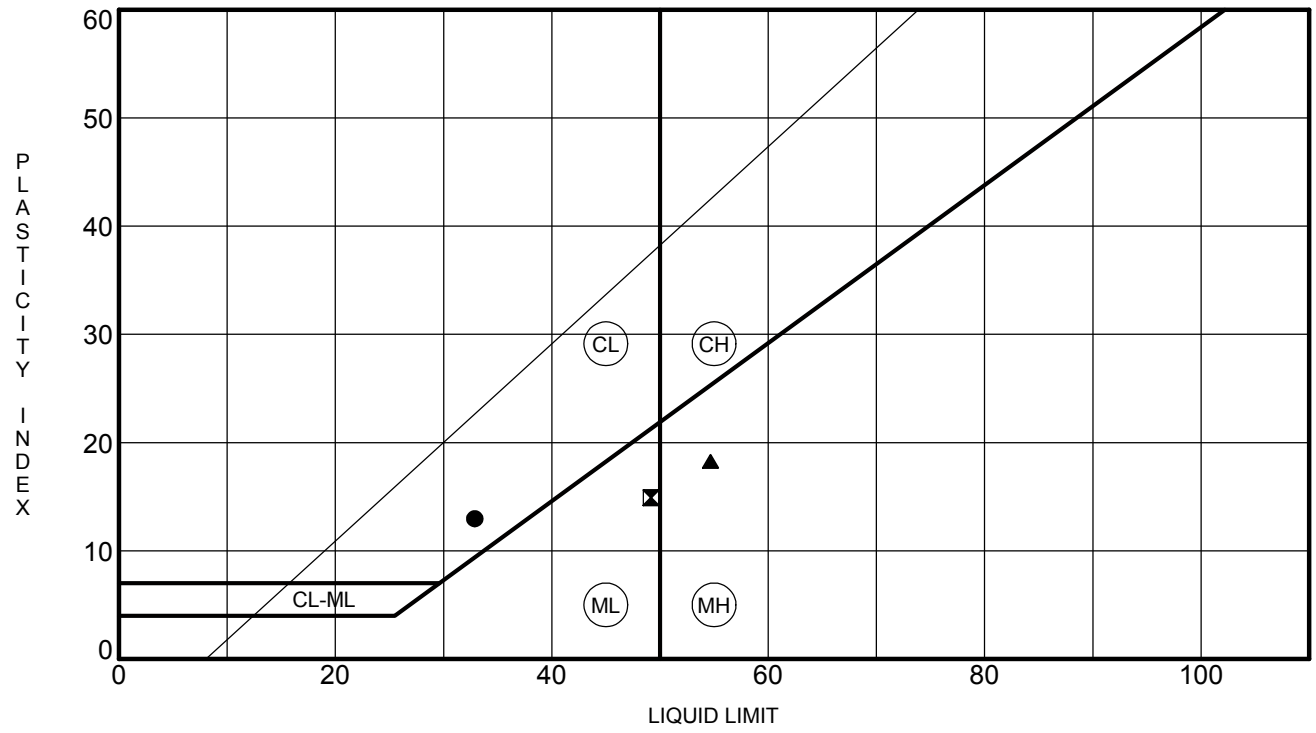
GRAIN SIZE DISTRIBUTION

Project: Energy Transfer HDD (DPS)
PSI Job No.: 04911506
Location: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA



	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**B-1**	**1.0**	**33**	**20**	**13**	**79.0**	**Lean CLAY with Sand (CL)**
⧓	**B-2**	**1.0**	**49**	**34**	**15**	**97.9**	**SILT (ML)**
▲	**B-2**	**6.0**	**55**	**36**	**19**	**85.3**	**Elastic SILT (MH)**

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ATTERBERG LIMIT RESULTS

PSI Job No.: 04911506
Project: Energy Transfer HDD (DPS)
Location: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA

Laboratory Summary Sheet

Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-1	1	33	20	13		79.0%		21			
B-1	5							19			
B-1	10.2				401.45						
B-1	19.8				402.37						
B-1	28.1				1031.15						
B-1	39.6				243.83						
B-1	47.1				1470.14						
B-1	49.2				477.08						
B-1	58.5				425.84						
B-1	68.4				505.54						
B-1	77.7				486.75						
B-1	89.4				496.25						
B-1	99				549.61						
B-1	109.2				1164.61						
B-1	116.4				442.73						
B-1	117.3				580.48						
B-1	123.9				551.23						
B-1	129.1				991.59						
B-1	144.7				403.75						
B-1	152.5				588.47						
B-1	160.8				467.35						
B-2	1	49	34	15		97.9%		37			
B-2	6	55	36	19		85.3%		56			
B-2	14				475.62						
B-2	25.6				849.29						
B-2	35.5				490.78						
B-2	45.1				949.08						
B-2	55				756.72						
B-2	65				731.91						
B-2	76				1741.37						
B-2	84.6				1555.46						
B-2	95.7				428.92						
B-2	102.8				615.54						

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Summary of Laboratory Results

PSI Job No.: 04911506
Project: Energy Transfer HDD (DPS)
Location: N. Zinns Mill Rd (PPP5)
Lebanon Co., PA
PA-LE-0055.0000-RD-16/PO#20171024

FIGURE 1: SITE VICINITY MAP

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www.visitPAparks.com
or call toll-free 888-PA-PARKS

Created using PA DCNR Map Viewer

Map created on Thu Nov 8 2018

Figure 2: Boring Location Plan

PPP5: N Zinns Mill Rd/Rte 72/Tice Ln
Lebanon Co, Pennsylvania
PSI Project No.: 04911696

FIGURE 3: SITE GEOLOGY MAP

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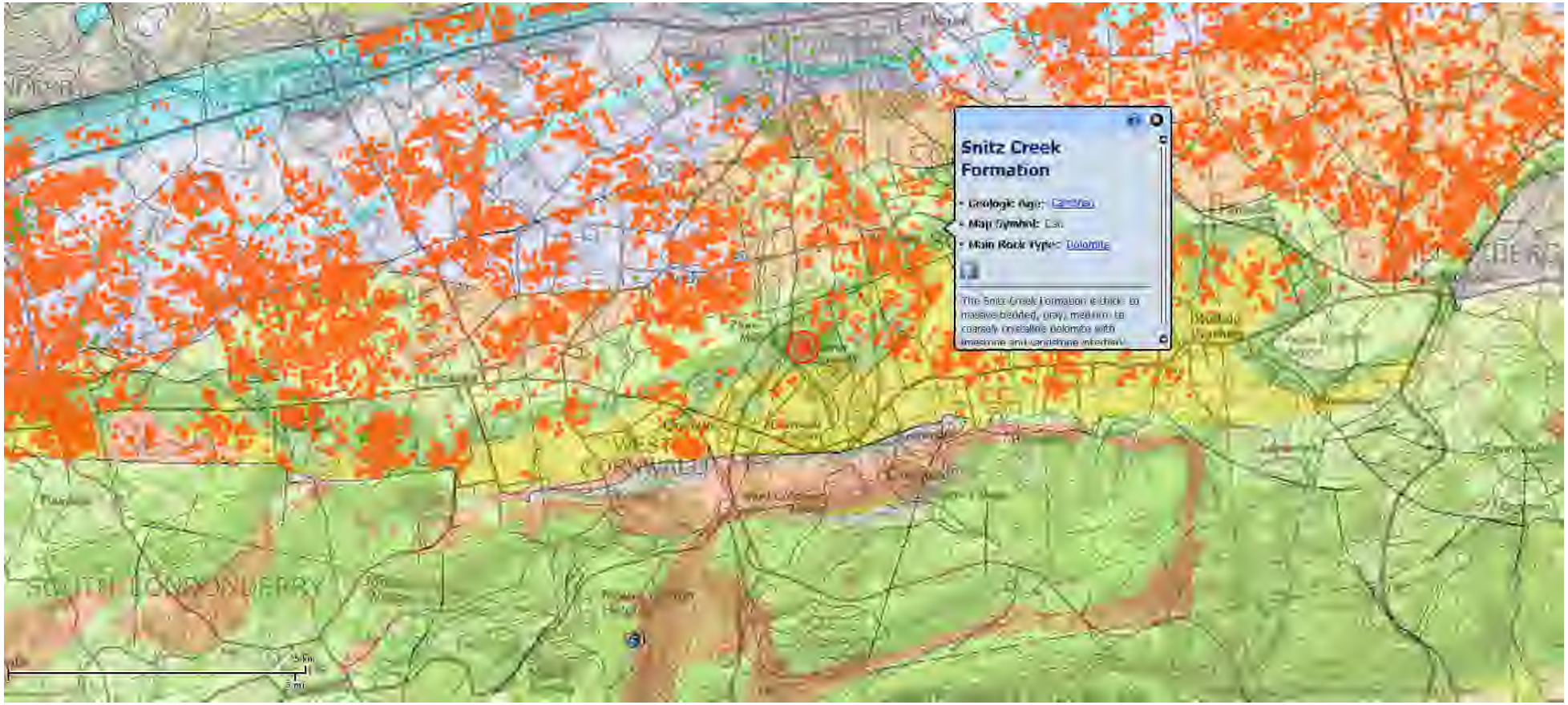

Created using PA DCNR Map Viewer

Map created on Thu Nov 8 2018

SINKHOLES AND KARST-RELATED FEATURES OF LEBANON COUNTY, PENNSYLVANIA

by W.E.Kochanov

1988

OPEN-FILE REPORT: 8802

0645

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC AND GEOLOGIC SURVEY

FIGURE 4: KARST MAP
PPP5: N.ZINNS MILL RD/RTE 72/TICE LN
LEBANON CO., PA
PSI PROJECT NO: 04911695

GeoBore B1

GeoBore B2/B2A

SYMBOLS

- individual sinkhole
- or sinkhole group
- closed depressions interpreted from aerial photographs
- surface mine, iron
- surface mine limestone/dolomite
- surface mine type unknown
- cave entrance
- bedding orientation strike and dip
- approximate strike and dip
- overturned, bed strike and dip
- joint orientation strike and dip
- joint orientation strike and 90° dip
- fault contact
- formation contact

0645

Compiled by W.E.Kochanov
1987 - 1/87

The work presented here has not been reviewed for formal publication.

Bureau of Topographic and Geologic Survey
P.O. Box 8453, Harrisburg, PA 17105-8453

BORING B-1

DATE STARTED:	11/8/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/12/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	152.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	514.997 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water: While Drilling 4 feet; Upon Completion 24 feet

BORING LOCATION: See Boring Location Plan

Boring east of Route 72 (RV Retail Sales)

REMARKS: Boring ground elevation provided by project surveyor.

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					Vacuum cleared to 4 feet bgs where a cobble-sized rock was encountered within the hole.					
						Drilled without sampling from 4 to 5 feet.					
510	5			S-1	12	**FILL**-Brown to light gray-brown, Poorly Graded GRAVEL with Silt and Sand, wet		23-21-20-30 N=41		◎	
505	10			S-2	15		GP-GM	43-20-9-9 N=29		◎	
500	15			S-3	0			50/0"			
				R-1	12	**Slightly Weathered to Completely Weathered LIMESTONE Interbedded with DOLOMITE**-Light gray, slightly broken to massive, horizontal fractures, with soil which washed out during rock coring operations		RQD=48 Rec=50%			1 min.
						Slightly Weathered LIMESTONE Interbedded with DOLOMITE-Gray to light gray-brown to blue-gray, very broken to massive, horizontal to vertical fractures					5 min.
											5 min.
										>> ▲ Q_u = 1055.6 tsf	169.0 pcf
											5 min.
				R-2	60			RQD=86 Rec=100%			
495	20					Quartz seam (~1 inch thick) at 20.4 feet.					4 min.
											3 min.
											4 min.
											4 min.
										>> ▲ Q_u = 970.6 tsf	170.0 pcf
											2 min.
				R-3	60			RQD=87			
490	25					*Continued Next Page*					

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

PROJECT NO.: 04911695
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

BORING B-1

DATE STARTED:	11/8/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/12/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	152.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	514.997 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water: While Drilling 4 feet; Upon Completion 24 feet

BORING LOCATION: See Boring Location Plan

Boring east of Route 72 (RV Retail Sales)

REMARKS: Boring ground elevation provided by project surveyor.

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	Additional Remarks
	25			**Slightly Weathered LIMESTONE Interbedded with DOLOMITE**-Gray to light gray-brown to blue-gray, very broken to massive, horizontal to vertical fractures Soft, brown, weathered zone at 25.6 feet. Soft, weathered zone with some solutioning activity from 26.7 to 27.3 feet.		Rec=100%		3 min. 1 min. >> Q_u = 288.1 tsf 167.7 pcf 3 min.
		R-4	59			RQD=80 Rec=98%		3 min. 2 min.
485	30			Soft, weathered zone at 30.7 feet. Vertical fracture from 32 to 33.5 feet.				>> Q_u = 653.7 tsf 2 min. 174.7 pcf 2 min. 3 min. 3 min. 3 min.
		R-5	60			RQD=66 Rec=100%		
480	35							2 min. 2 min. 2 min. >> Q_u = 611.3 tsf 169.5 pcf 3 min.
		R-6	60			RQD=87 Rec=100%		2 min.
475	40			**Slightly Weathered LIMESTONE**-Gray to light blue-gray, massive, horizontal to vertical farctures Vertical fracture from 42.6 to 43.7 feet.				2 min. 2 min. 3 min. 2 min.
		R-7	60			RQD=92 Rec=100%		>> Q_u = 1065.9 tsf 2 min. 167.9 pcf 2 min.
470	45			**Slightly Weathered DOLOMITE**-Gray to light gray, very broken to massive, horizontal to diagonal fractures Solutioning activity from 47.9 to 48.5 feet.				2 min. 2 min. 2 min.
		R-8	56	Weathered fracture at 49.3 feet.		RQD=78		>> Q_u = 1286.2 tsf
465	50			*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

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

PROJECT NO.: 04911695
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

DATE STARTED:	11/8/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/12/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	152.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	514.997 ft	**SAMPLING METHOD:**	2-in SS2.0-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 ground elevation provided by project surveyor.

BORING B-1

Water
While Drilling 4 feet
Upon Completion 24 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Route 72 (RV Retail Sales)

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Additional Remarks
	50			**Slightly Weathered DOLOMITE**-Gray to light gray, very broken to massive, horizontal to diagonal fractures Weathered layer (~ 1-1/4 inches thick) at 50.8 feet.	Rec=93%	173.2 pcf 3 min. 3 min. 3 min. >> Q_u = 774.6 tsf 173.0 pcf 2 min.
460	55	R-9	53	**Highly Weathered to Completely Weathered DOLOMITE**-Red-brown to gray, very broken to slightly broken, with soil which washed away during rock coring operations **NOTE: Water return was lost after this stratum was encountered and did not return for the remainder of the boring.**	RQD=60 Rec=88%	2 min. >> Q_u = 791.7 tsf 170.4 pcf 4 min.
455	60	R-10	60	**Slightly Weathered LIMESTONE**-Light gray, slightly broken to massive, horizontal to diagonal fractures **Slightly Weathered LIMESTONE Interbedded with DOLOMITE**-Light gray to dark gray, very broken to massive, horizontal to vertical farctures	RQD=100 Rec=100%	3 min. 3 min. 2 min. 3 min. >> Q_u = 878.2 tsf 169.7 pcf 4 min.
450	65	R-11	60		RQD=100 Rec=100%	2 min. 2 min. 2 min. 2 min. >> Q_u = 508.5 tsf 174.7 pcf 3 min.
445	70	R-12	60		RQD=100 Rec=100%	3 min. 3 min. 3 min. 3 min. >> Q_u = 1312.6 tsf 171.6 pcf
				Vertical fracture from 73.6 to 74.5 feet.		3 min.
440	75	R-13	60		RQD=100	

Continued Next Page

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PROJECT NO.: 04911695
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

BORING B-1

DATE STARTED:	11/8/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/12/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	152.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	514.997 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water — While Drilling 4 feet; Upon Completion 24 feet

BORING LOCATION: See Boring Location Plan

Boring east of Route 72 (RV Retail Sales)

REMARKS: Boring ground elevation provided by project surveyor.

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	Additional Remarks
	75			**Slightly Weathered LIMESTONE Interbedded with DOLOMITE**-Light gray to dark gray, very broken to massive, horizontal to vertical farctures		Rec=100%		2 min. 2 min. 2 min. >> Q_u = 1169.4 tsf 2 min. 169.4 pcf
		R-14	59			RQD=96		2 min.
435	80					Rec=98%		2 min. 2 min. 2 min.
				Slightly Weathered DOLOMITE-Light gray to dark gray, very broken to massive, horizontal fractures				>> Q_u = 1400.6 tsf 176.3 pcf 2 min.
		R-15	60			RQD=100		2 min.
430	85					Rec=100%		1 min. 2 min.
								>> Q_u = 867.5 tsf 175.3 pcf 2 min.
		R-16	60			RQD=92		2 min. 1 min.
425	90					Rec=100%		2 min. 1 min.
								2 min. >> Q_u = 2647.4 tsf 173.5 pcf 3 min.
		R-17	60			RQD=100		2 min.
420	95			**Slightly Weathered LIMESTONE**-Gray to light gray, massive		Rec=100%		1 min. 2 min. 2 min.
				Slightly Weathered LIMESTONE Interbedded with DOLOMITE-Gray to light gray, very broken to massive, horizontal to diagonal fractures				>> Q_u = 611.5 tsf 174.0 pcf 2 min.
		R-18	60			RQD=88		2 min.
415	100			*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

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

PROJECT NO.: 04911695
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

DATE STARTED:	11/8/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/12/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	152.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	514.997 ft	**SAMPLING METHOD:**	2-in SS2.0-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 ground elevation provided by project surveyor.

BORING B-1

Water
While Drilling 4 feet
Upon Completion 24 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Route 72 (RV Retail Sales)

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Additional Remarks
	100			**Slightly Weathered LIMESTONE Interbedded with DOLOMITE**-Gray to light gray, very broken to massive, horizontal to diagonal fractures		Rec=100%	1 min. 1 min.
				Slightly Weathered DOLOMITE-Gray to light gray-brown, broken to massive, horizontal to diagonal fractures, some solutioning activity			>> Q_u = 1364.3 tsf, 172.1 pcf 2 min. 1 min.
410	105	R-19	59			RQD=84 Rec=98%	1 min. 2 min. 2 min. >> Q_u = 920.4 tsf, 171.3 pcf 2 min.
405	110	R-20	60			RQD=70 Rec=100%	2 min. 2 min. 2 min. >> Q_u = 764.4 tsf, 176.6 pcf
				Slightly Weathered DOLOMITE-Gray to dark gray, massive, horizontal fractures, calcite seams and stringers			2 min.
400	115	R-21	60			RQD=92 Rec=100%	2 min. 2 min. 2 min. >> Q_u = 393.8 tsf, 176.7 pcf 3 min.
				Slightly Weathered LIMESTONE-Light gray to dark gray, very broken to massive, horizontal to diagonal fractures			2 min.
395	120	R-22	60			RQD=99 Rec=99%	2 min. 2 min. >> Q_u = 928.3 tsf, 173.6 pcf 2 min.
390	125	R-23	60			RQD=78	2 min. 2 min.

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LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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DATE STARTED:	11/8/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/12/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	152.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	514.997 ft	**SAMPLING METHOD:**	2-in SS2.0-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 ground elevation provided by project surveyor.

BORING B-1

Water
While Drilling 4 feet
Upon Completion 24 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Route 72 (RV Retail Sales)

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
	125					**Slightly Weathered LIMESTONE**-Light gray to dark gray, very broken to massive, horizontal to diagonal fractures		Rec=100%			2 min. 1 min. 2 min. >> Q_u = 491.1 tsf 173.9 pcf 1 min. 1 min.
385	130			R-24	59			RQD=78 Rec=98%			2 min. 2 min. 2 min. >> Q_u = 613.8 tsf 173.3 pcf
380	135			R-25	60	Vertical fracture at 137 feet.		RQD=100 Rec=100%			2 min. 1 min. 1 min. 1 min. >> Q_u = 953.0 tsf 170.9 pcf 1 min.
375	140			R-26	60			RQD=99 Rec=100%			1 min. 1 min. 1 min. >> Q_u = 746.8 tsf 173.5 pcf 1 min.
370	145			R-27	60			RQD=100 Rec=100%			1 min. 2 min. 2 min. 2 min. >> Q_u = 613.7 tsf 170.0 pcf
365	150			R-28	60			RQD=100			

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PROJECT NO.: 04911695
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

BORING B-1

DATE STARTED:	11/8/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/12/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	152.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	514.997 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
While Drilling 4 feet
Upon Completion 24 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Route 72 (RV Retail Sales)

REMARKS: Boring ground elevation provided by project surveyor.

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					**Slightly Weathered LIMESTONE**-Light gray to dark gray, very broken to massive, horizontal to diagonal fractures		Rec=100%			1 min. 1 min. 1 min.
						Test boring terminated @ 152 feet					

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PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

BORING B-2

DATE STARTED:	11/13/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/13/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	11.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	542.314 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water

BORING LOCATION:
See Boring Location Plan

Boring east of Tice Ln (agricultural field)

REMARKS: Boring ground elevation provided by project surveyor.

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					Hand- and air-cleared to 3 feet where a cobble- or boulder-sized rock was encountered.					
540						Drilled without sampling from 3 to 5 feet.					
	5			S-1	4	**Highly Weathered LIMESTONE Sampled As:**-Very Dense, Brown, Clayey GRAVEL with Sand, moist/wet	GC	9-50/4"		>>◎	
535						**Highly Weathered to Completely Weathered LIMESTONE**-Gray to light gray, very broken, with soil which washed away during rock coring activities		RQD=54 Rec=82%		>>◎ 1 min. >>◎ 4 min. >>◎ 3 min. >>◎ 3 min. >>◎ 3 min.	Q_u = 1133.8 tsf 170.5 pcf
	10			R-1	40	**Slightly Weathered LIMESTONE**-Light gray to dark gray, slightly broken to massive, horizontal fractures					
						Test boring terminated @ 11 feet Note: Driller terminated boring prior to scheduled depth due to suspected buried metallic object during coring. However, there was no evident damage of core bit as would be expected if bit encountered metal. Pipeline "survey" reconfirmed new lines were not present at this location. Nonetheless, the boring was offset to Boring 2A.					

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PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

BORING B-2A

DATE STARTED:	11/14/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/19/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	153.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	543.494 ft	**SAMPLING METHOD:**	2-in SS2.0-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 ground elevation provided by project surveyor.

Water Upon Completion 27 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Tice Ln (Ag. field)/appx 18' North of B2

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					Hand-cleared to 3 feet where a cobble-sized rock was encountered.					
540						Drilled without sampling to 9.5 feet where rollerbit refusal was encountered.					
	5					Casing refusal @ 7 feet					
535						Rollerbit refusal @ 9 feet					
	10			R-1	28	**Highly Weathered to Completely Weathered DOLOMITE**-No recovery within this stratum; the sample likely washed away during rock coring operations. **Water return was lost immediately upon the start of coring activities and did not return for the remainder of the boring.**		RQD=50 Rec=67%		>> Q_u = 402.0 tsf 174.6 pcf	5 min. 7 min.
530						**Slightly Weathered DOLOMITE**-Light gray to dark gray, very broken to massive, horizontal to diagonal fractures, trace calcite seams and stringers					5 min. 4 min.
	15			R-2	60	Weathered fracture at 13.3 feet. Two weathered fractures at 14.5 feet.		RQD=77 Rec=100%		>> Q_u = 648.5 tsf 174.3 pcf	3 min.
						Weathered fracture at 16.8 feet.					3 min. 4 min.
525						**Slightly Weathered LIMESTONE**-Light gray to blue-gray to dark gray, very broken to massive, horizontal fractures, trace calcite seams and stringers					3 min.
	20			R-3	60	Three weathered fractures at 18.8 feet. Weathered fracture at 20.4 feet.		RQD=83 Rec=100%		>> Q_u = 169.7 tsf 166.5 pcf	2 min. 2 min.
						Weathered fracture at 22.6 feet.					2 min. 3 min.
520											3 min.
	25					*Continued Next Page*					

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LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

DATE STARTED:	11/14/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/19/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	153.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	543.494 ft	**SAMPLING METHOD:**	2-in SS2.0-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 ground elevation provided by project surveyor.

BORING B-2A

Water Upon Completion 27 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Tice Ln (Ag. field)/appx 18' North of B2

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	Additional Remarks
	25	R-4	59	**Slightly Weathered LIMESTONE**-Light gray to blue-gray to dark gray, very broken to massive, horizontal fractures, trace calcite seams and stringers Weathered fracture at 25.6 feet. Weathered/broken/very broken layer from 27.1 to 28 feet.		RQD=64 Rec=98%		>> Q_u = 482.2 tsf 167.2 pcf 3 min.
515				**Highly Weathered to Completely Weathered LIMESTONE Interbedded with DOLOMITE**-Brown to gray, with soil which washed away during rock coring operations				2 min. 4 min. 2 min.
	30	R-5	11			RQD=15 Rec=18%		2 min. 1 min. 1 min.
510				**Highly Weathered to Completely Weathered DOLOMITE**-Gray to dark gray, very broken, with soil which washed away during rock coring operations				2 min.
	35	R-6	33	**Slightly Weathered LIMESTONE**-Blue-gray to very light gray, very broken to massive, horizontal to vertical fractures Weathered/highly weathered layer (~1-3/4 inches) at 36.5 feet.		RQD=42 Rec=55%		2 min. >> Q_u = 866.9 tsf 168.0 pcf 2 min. 4 min.
505				**Slightly Weathered to Weathered DOLOMITE**-Gray to light gray, very broken to massive, horizontal to vertical fractures, trace calcite stringers Soil layer (~3 inches) at 38 feet.				>> Q_u = 1165.2 tsf 175.8 pcf
	40	R-7	60	With quartz from 41.5 to 42.1 feet.		RQD=48 Rec=100%		2 min. 2 min. 2 min.
500				**Slightly Weathered DOLOMITE**-Gray to light gray, very broken to massive, horizontal to vertical fractures Trace calcite stringers from 43 to 48 feet.				3 min. 1 min. >> Q_u = 376.3 tsf 174.1 pcf
	45	R-8	60			RQD=57 Rec=100%		2 min. 2 min. 3 min.
495				Weathered fracture at 48.6 feet. With calcite seams and stringers from 49.2 to				3 min. >> Q_u = 393.4 tsf 175.0 pcf
	50			*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

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

PROJECT NO.: 04911695
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

BORING B-2A

DATE STARTED:	11/14/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/19/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	153.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	543.494 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water Upon Completion 27 feet

BORING LOCATION: See Boring Location Plan

Boring east of Tice Ln (Ag. field)/appx 18' North of B2

REMARKS: Boring ground elevation provided by project surveyor.

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	Additional Remarks
	50	R-9	60	50.4 feet. **Slightly Weathered DOLOMITE**-Gray to light gray, very broken to massive, horizontal to vertical fractures Trace calcite stringers from 50.4 to 53 feet.		RQD=93 Rec=100%		2 min. 2 min. >> Q_u = 866.6 tsf 174.6 pcf 2 min.
490				Trace calcite seams and stringers from 53 to 58 feet,				2 min. 2 min.
	55	R-10	60			RQD=87 Rec=100%		2 min. 1 min. >> Q_u = 1029.6 tsf 175.7 pcf 2 min.
485				With calcite seams and stringers from 58 to 64.3 feet.				2 min. 1 min.
	60	R-11	58			RQD=63 Rec=97%		1 min. >> Q_u = 863.0 tsf 172.4 pcf 2 min.
480								1 min. 5 min.
	65	R-12	56	**Highly Weathered to Completely Weathered DOLOMITE**-Brown to gray-brown, very broken **Slightly Weathered DOLOMITE**-Black to light gray, very broken to massive, horizontal to vertical fractures With calcite seams and stringers from 65 to 73 feet.		RQD=85 Rec=93%		2 min. >> Q_u = 1655.6 tsf 174.9 pcf 2 min. 2 min. 3 min.
475								2 min. >> Q_u = 698.3 tsf 174.8 pcf
	70	R-13	60			RQD=98 Rec=100%		2 min. 2 min. 1 min. >> Q_u = 1330.4 tsf 176.0 pcf
470								3 min. 3 min.
	75			Vertical fracture from 74.6 to 74.9 feet.				

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.: 04911695
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

DATE STARTED:	11/14/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/19/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	153.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	543.494 ft	**SAMPLING METHOD:**	2-in SS2.0-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 ground elevation provided by project surveyor.

BORING B-2A

Water ▽ Upon Completion 27 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Tice Ln (Ag. field)/appx 18' North of B2

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
	75			R-14	60	**Slightly Weathered DOLOMITE**-Black to light gray, very broken to massive, horizontal to vertical fractures Weathered layer (~1 inch) at 75.9 feet.		RQD=96 Rec=100%			3 min. 3 min. >> Q_u = 717.5 tsf 174.9 pcf 2 min.
465						Trace calcite stringers from 78 to 83 feet.					2 min. 1 min.
	80			R-15	60			RQD=94 Rec=100%			2 min. 2 min. >> Q_u = 454.6 tsf 171.1 pcf
460						With calcite seams and stringers from 83 to 88 feet.					2 min. 2 min. 1 min.
	85			R-16	60			RQD=91 Rec=100%			>> Q_u = 274.4 tsf 2 min. 176.1 pcf 2 min.
455						Trace calcite stringers from 88 to 96.1 feet.					2 min. 2 min.
	90			R-17	60	Highly weathered/soil layer (3-1/4 inches) at 89 feet.		RQD=80 Rec=99%			>> Q_u = 258.9 tsf 2 min. 175.6 pcf 2 min. 3 min.
450											3 min. >> Q_u = 859.6 tsf 176.2 pcf 3 min.
	95			R-18	60			RQD=55 Rec=100%			3 min. 2 min.
						With calcite stringers from 96.1 to 97.5 feet. Vertical fractures from 96.4 to 97.8 feet.					2 min. 3 min.
445						Trace calcite stringers from 97.5 to 108 feet.					3 min. >> Q_u = 354.4 tsf 175.4 pcf
	100					*Continued Next Page*					

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Lebanon Co., PA

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

BORING B-2A

DATE STARTED:	11/14/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/19/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	153.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	543.494 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water Upon Completion 27 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Tice Ln (Ag. field)/appx 18' North of B2

REMARKS: Boring ground elevation provided by project surveyor.

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Additional Remarks
	100	R-19	60	**Slightly Weathered DOLOMITE**-Black to light gray, very broken to massive, horizontal to vertical fractures Mostly healed, highly fractures layer from 100 to 103 feet.	RQD=99 Rec=100%	2 min. 3 min. 2 min. 3 min.
440				Healed, highly fractured layer from 103.3 to 106.2 feet.		>> Q_u = 951.2 tsf 174.5 pcf
	105	R-20	59		RQD=98 Rec=98%	2 min. 2 min. 3 min.
435				Mostly healed, highly fractured layer from 108.9 to 111.9 feet.		>> Q_u = 889.4 tsf 173.5 pcf 3 min. 3 min.
	110	R-21	60		RQD=100 Rec=100%	2 min. 2 min.
430						>> Q_u = 955.6 tsf 174.3 pcf 3 min. 3 min.
	115	R-22	59	Weathered fracture at 115.5 feet.	RQD=88 Rec=98%	2 min. 2 min. 2 min.
425				Solutioning activity - highly weathered/soil seam (~2 inches) at 118.5 feet.		>> Q_u = 761.6 tsf 175.4 pcf 3 min. 2 min.
	120	R-23	60	Vertical quartz seam from 120.9 to 121.5 feet.	RQD=94 Rec=99%	2 min. 2 min.
420						>> Q_u = 435.2 tsf 175.0 pcf 2 min. 2 min.
	125			*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.: 04911695
PROJECT: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

BORING B-2A

DATE STARTED:	11/14/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/19/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	153.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	543.494 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water ▽ Upon Completion 27 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Tice Ln (Ag. field)/appx 18' North of B2

REMARKS: Boring ground elevation provided by project surveyor.

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	Additional Remarks
	125	R-24	60	With quartz and calcite seams and stringers from 124.9 to 127.6 feet. **Slightly Weathered DOLOMITE**-Black to light gray, very broken to massive, horizontal to vertical fractures		RQD=90 Rec=99%		2 min. 1 min. >> Q_u = 222.9 tsf 167.3 pcf 2 min.
415				**Slightly Weathered LIMESTONE**-Gray to light gray, broken to massive, horizontal to vertical fractures, trace calcite stringers Highly weathered/soil layer (~1-3/4 inches) at 128.3 feet. Vertical fracture from 128.8 to 129.7 feet.				2 min. 2 min.
	130	R-25	60	Vertical fracture from 130.3 to 130.7 feet.		RQD=93 Rec=100%		2 min. 2 min. 2 min. >> Q_u = 958.8 tsf 171.2 pcf 2 min.
410				Soil seam (~1-1/2 inches) at 133 feet.				2 min.
	135	R-26	59			RQD=95 Rec=98%		2 min. 2 min. 2 min. >> Q_u = 1279.5 tsf 175.7 pcf 2 min.
405				**Slightly Weathered LIMESTONE Interbedded with DOLOMITE**-Gray to light gray, broken to massive, horizontal to diagonal fractures, trace calcite stringers				2 min. 2 min.
	140	R-27	60			RQD=93 Rec=100%		2 min. 2 min. 1 min. >> Q_u = 1244.0 tsf 170.4 pcf 2 min.
400				**Slightly Weathered DOLOMITE Interbedded with LIMESTONE**-Gray to light gray, broken to massive, horizontal to vertical fractures, with quartz and calcite seams and stringers				2 min. 2 min.
	145	R-28	59			RQD=83 Rec=98%		2 min. 2 min. 2 min.
395				**Slightly Weathered LIMESTONE Interbedded with DOLOMITE**-Gray to light gray, very broken to massive, horizontal to diagonal fractures, trace calcite seams and stringers				2 min. >> Q_u = 861.6 tsf 172.2 pcf 2 min.
	150			*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: Energy Transfer HDD (DPS)
LOCATION: N. Zinns Mill Rd.-Rte. 72 (PPP5)
Lebanon Co., PA

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

BORING B-2A

DATE STARTED:	11/14/18	**DRILL COMPANY:**	Allied Well Drilling, Inc.
DATE COMPLETED:	11/19/18	**DRILLER:** G. Brugger	**LOGGED BY:** F. Hoffman
COMPLETION DEPTH	153.0 ft	**DRILL RIG:**	Diedrich D50
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/Rock Coring
ELEVATION:	543.494 ft	**SAMPLING METHOD:**	2-in SS2.0-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water Upon Completion 27 feet

BORING LOCATION:
See Boring Location Plan

Boring east of Tice Ln (Ag. field)/appx 18' North of B2

REMARKS: Boring ground elevation provided by project surveyor.

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-29	60	**Slightly Weathered LIMESTONE Interbedded with DOLOMITE**-Gray to light gray, very broken to massive, horizontal to diagonal fractures, trace calcite seams and stringers		RQD=86 Rec=100%			2 min. 2 min. 1 min. 2 min.
						Test boring terminated @ 153 feet					

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GENERAL NOTES

SAMPLE IDENTIFICATION

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

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
RC: Rock Core
TC: Texas Cone
BS: Bulk Sample
PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

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

RELATIVE DENSITY OF COARSE-GRAINED SOILS

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

ANGULARITY OF COARSE-GRAINED PARTICLES

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

GRAIN-SIZE TERMINOLOGY

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

PARTICLE SHAPE

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

RELATIVE PROPORTIONS OF FINES

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

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

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

MOISTURE CONDITION DESCRIPTION

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

STRUCTURE DESCRIPTION

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

SCALE OF RELATIVE ROCK HARDNESS

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

ROCK BEDDING THICKNESSES

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

ROCK VOIDS

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

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

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

ROCK QUALITY DESCRIPTION

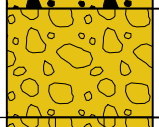
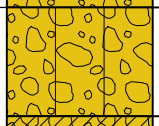
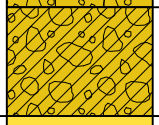
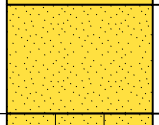
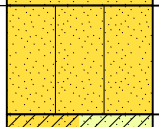
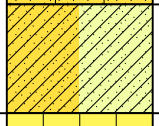
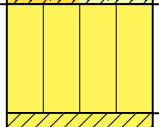
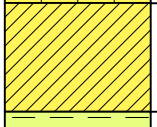
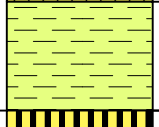
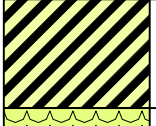
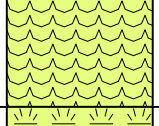
Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

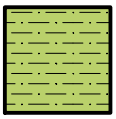
NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

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

Graphic Symbols for Materials and Rock Deposits

CONCRETE
Portland Cement Concrete

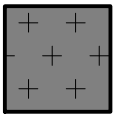
BITUMINOUS CONCRETE



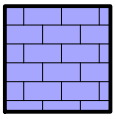
CLAYSTONE

COAL
Coal, Anthracite Coal

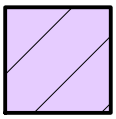
CONGLOMERATE/BRECCIA
Conglomerate, Breccia



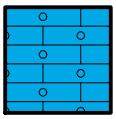
IGNEOUS ROCK
Anorthsite, Basalt, Metabasalt, Diabase (Gabbro), Gabbro, Granite/Granodionite, Homfels, Pegmatite, Rhyolite/Metarhyolite



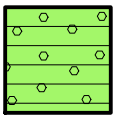
LIMESTONE
Limestone, Dolomite



METAMORPHIC ROCK
Amphibolite, Gneiss, Marble, Phyllite, Quartzite, Schist, Serpentinite, Slate

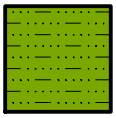


CHERT

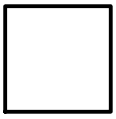


SANDSTONE
Sandstone, Orthoquarzite (Sandstone)

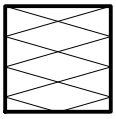
SHALE



SILTSTONE



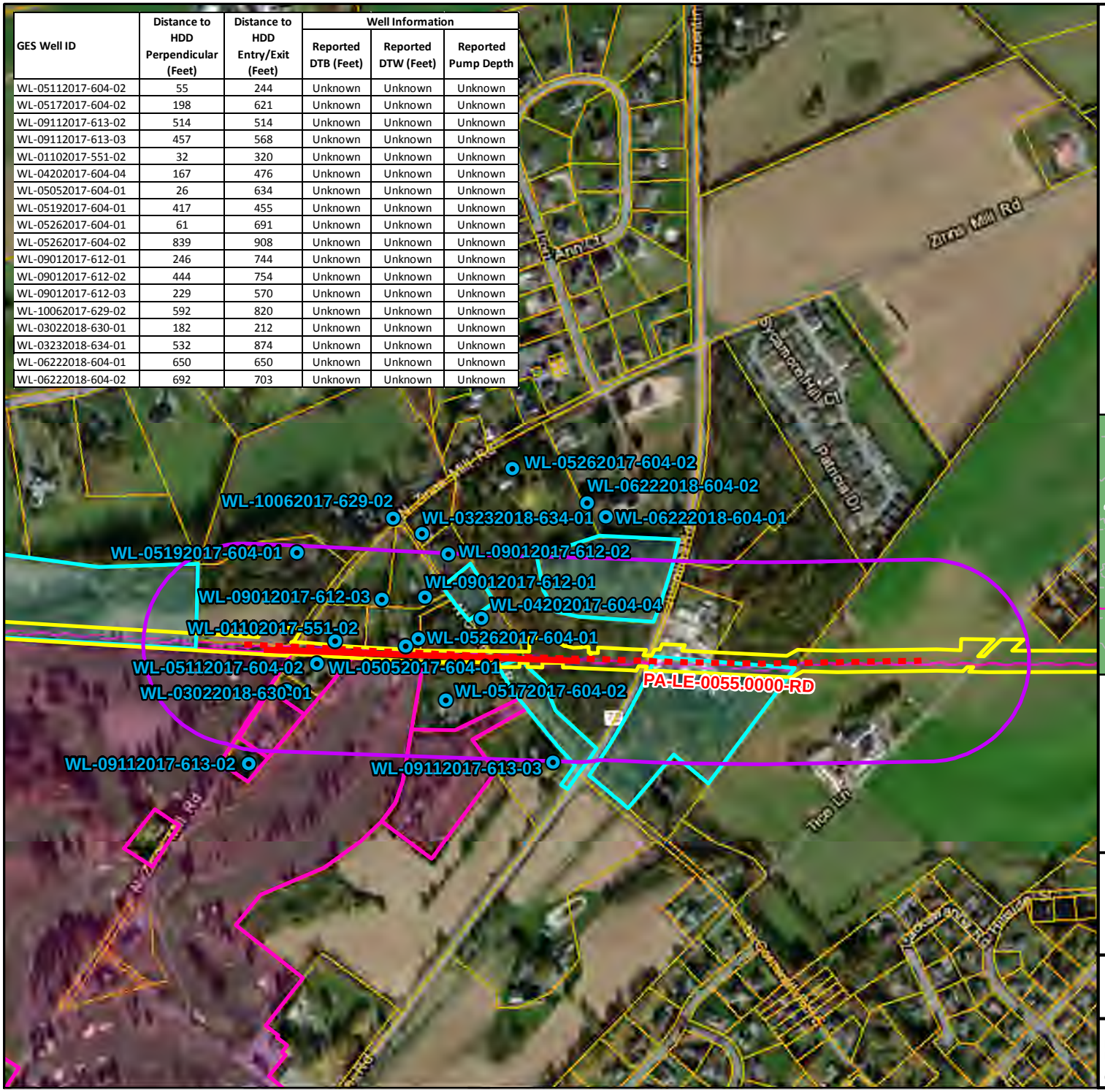
NO RECOVERY



VOID

ATTACHMENT 3

GES Well ID	Distance to HDD Perpendicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-05112017-604-02	55	244	Unknown	Unknown	Unknown
WL-05172017-604-02	198	621	Unknown	Unknown	Unknown
WL-09112017-613-02	514	514	Unknown	Unknown	Unknown
WL-09112017-613-03	457	568	Unknown	Unknown	Unknown
WL-01102017-551-02	32	320	Unknown	Unknown	Unknown
WL-04202017-604-04	167	476	Unknown	Unknown	Unknown
WL-05052017-604-01	26	634	Unknown	Unknown	Unknown
WL-05192017-604-01	417	455	Unknown	Unknown	Unknown
WL-05262017-604-01	61	691	Unknown	Unknown	Unknown
WL-05262017-604-02	839	908	Unknown	Unknown	Unknown
WL-09012017-612-01	246	744	Unknown	Unknown	Unknown
WL-09012017-612-02	444	754	Unknown	Unknown	Unknown
WL-09012017-612-03	229	570	Unknown	Unknown	Unknown
WL-10062017-629-02	592	820	Unknown	Unknown	Unknown
WL-03022018-630-01	182	212	Unknown	Unknown	Unknown
WL-03232018-634-01	532	874	Unknown	Unknown	Unknown
WL-06222018-604-01	650	650	Unknown	Unknown	Unknown
WL-06222018-604-02	692	703	Unknown	Unknown	Unknown



Legend

- LOD
- Parcel
- PPP Centerline
- PPP 1 HDD Alignment
- Proposed PPP 2 HDD Alignment
- Public Water Supply/Landowner Confirmed No Well
- Testing Refused

****Testing locations current as of 01/25/2019**

- GES Testing Location

Location

N

0 250 500

Feet

Well Location Map
HDD# PA-LE-0055.0000-RD
Lebanon County, PA.

Prepared By: TETRA TECH

Date: 1/25/2019

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

Coordinate System: NAD 83 Stateplane, PA South, Feet

P:\GIS\projects\112\0\0358-PPP\MXD\WellLocations\WellLocation_PA_LE_0055_0000.mxd LN

NORTH ZINNS MILL ROAD CROSSING
PADEP SECTION 105 PERMIT NO. E38-194
PA-LE-0055-0000-RD-16
(SPLP HDD No. S3-0101)

ATTACHMENT 2

LANDOWNER COMMUNICATIONS

SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

Re: Mariner East 2 – Pennsylvania Pipeline Project
Horizontal Directional Drilling Construction Notification
and Private Water Supply/Well Sampling Offer

Dear [redacted]

Sunoco Pipeline L.P. ("SPLP") is writing to inform you that a certain construction activity known as Horizontal Directional Drilling ("HDD") for Mariner East 2, also known as the Pennsylvania Pipeline Project, is located within 450 feet of your property boundary. This HDD will begin as soon as ten (10) days of the date of this letter.

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Thank you for your cooperation.

Mark McConnell
Land Project Manager
Representing Sunoco Pipeline L.P. | Office: (814) 204-0450

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Covered by and/or for use with U.S. Patents 6,244,763; 6,868,406; 7,216,110; 7,236,956; 7,236,970; 7,490,065; 7,567,940; 7,613,639; 7,743,043; 7,882,094; 8,027,926; 8,027,927; 8,027,935; 8,041,644; 8,046,823; 8,103,647; 8,195,579; 8,301,572; 8,392,391; 8,498,943 and 8,843,464.

SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

Re: Mariner East 2 – Pennsylvania Pipeline Project
Horizontal Directional Drilling Construction Notification
and Private Water Supply/Well Sampling Offer

Dear [redacted]

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Land Project Manager
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If YES, enter delivery address below: ☐No

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2. Article Number *(Transfer from service label)*

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SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

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- Attach this card to the back of the mailpiece, or on the front if space permits.

COMPLETE THIS SECTION ON DELIVERY

A. Signature: (☐ *Addressee* or ☐ *Agent*)

X

B. Received By: *(Printed Name)*

C. Date of Delivery

1. **Article Addressed to:**

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type

2. Article Number *(Transfer from service label)*

VOID

B Certified Mail
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SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

Re: Mariner East 2 – Pennsylvania Pipeline Project
Horizontal Directional Drilling Construction Notification
and Private Water Supply/Well Sampling Offer

Dear [redacted]

Sunoco Pipeline L.P. ("SPLP") is writing to inform you that a certain construction activity known as Horizontal Directional Drilling ("HDD") for Mariner East 2, also known as the Pennsylvania Pipeline Project, is located within 450 feet of your property boundary. This HDD will begin as soon as ten (10) days of the date of this letter.

As part of this construction activity, SPLP is offering private water supply/well testing at SPLP's expense if you have a private water supply/well located within 450 feet of the HDD alignment. SPLP will provide you copies of all test results from your private water supply/well. Please note that upon their request, we will provide the test results to the Pennsylvania Department of Environmental Protection as well.

To assist with this process, SPLP is requesting that you contact the Sunoco representative for your area by calling Amy Johnson at (717) 208-7735, to provide SPLP with the following information:

1. If you have a private water supply/well on your property;
2. The location of your private water supply/well on your property; and,
3. If you would like to have your private water supply/well tested.

If you would like to have your private water supply/well tested, you must contact the Sunoco Representative for your area within the next ten (10) days by calling Amy Johnson at (717) 208-7735. Your private water supply/well will be tested at a mutually-convenient time within ten (10) days of SPLP's receipt of your request for testing. If you do not contact the Sunoco representative, there will be no further contact from us regarding any private water supply/well testing.

If you have any questions or concerns, please do not hesitate to contact the Sunoco representative for your area by calling Amy Johnson at (717) 208-7735

Thank you for your cooperation.

Mark McConnell
Land Project Manager
Representing Sunoco Pipeline L.P. | Office: (814) 204-0450

Each sheet can be used for one Certified Mail piece, which can be sent without Physical Return Receipt Service (Option A) or with Physical Return Receipt Service (Option B).

CERTIFIED MAIL

PERCHERON FIELD SERVICES
REPRESENTING SUNOCO PIPELINE L.P.
P.O. BOX 10814
LANCASTER PA 17605

9407 1118 9956 0065 5158 53

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FROM 16652
01/25/2019
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PS Form 3800 6/02

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Instructions

1. Apply this label to the TOP EDGE of the mailpiece.
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U.S. Postal Service
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OUTBOUND TRACKING NUMBER
9407 1118 9956 0065 5158 53

FEES

Postage per piece	$0.470
Certified Fee	$3.450
Total Postage & Fees:	**$3.920**

ARTICLE ADDRESS TO:

[redacted]

Postmark Here

[redacted]

Delivery Address when used with A or Return Address when used with B

CERTIFIED MAIL

CERTIFIED MAIL

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- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

2. Article Number *(Transfer from service label)*

COMPLETE THIS SECTION ON DELIVERY

A. Signature: (☐ Addressee or ☐ Agent)

X

B. Received By: *(Printed Name)*

C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type

VOID

B Certified Mail
WITH Physical Return Receipt Service
(Uses Return Receipt Card)
Instructions

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SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

Re: Mariner East 2 – Pennsylvania Pipeline Project
Horizontal Directional Drilling Construction Notification
and Offer of Alternative Temporary Water Supply

Dear [redacted]

Previously, Sunoco Pipeline L.P. ("SPLP") wrote to inform you that certain construction activity known as Horizontal Directional Drilling ("HDD") for Mariner East 2, also known as the Pennsylvania Pipeline Project, is located within 450 feet of your property boundary. In that letter, SPLP offered private water supply/well testing at SPLP's expense if you have a private water supply/well located within 450 feet of the HDD alignments. If you have not yet requested testing of your qualifying private water supply/well, but now would like SPLP to have your private water supply/well tested, please contact the Sunoco representative for your area by calling Amy Johnson at (717) 208-7735.

In addition, as part of this construction activity, SPLP is offering landowners with a private water supply/well located within 450 feet of the HDD alignments to be connected to an alternative temporary water supply, such as a water buffalo, that will be installed and maintained at SPLP's expense for the entire period of HDD operations.

If you would like to be connected to an alternative temporary water supply, please contact the Sunoco representative for your area by calling Amy Johnson at (717) 208-7735.

Thank you for your cooperation.

Mark McConnell
Land Project Manager
Representing Sunoco Pipeline L.P.
Office: (814) 204-0450

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CERTIFIED MAIL

PERCHERON FIELD SERVICES
REPRESENTING SUNOCO PIPELINE L.P.
P.O. BOX 10814
LANCASTER PA 17605

9407 1118 9956 0065 5307 64

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PS Form 3800 6/02

A Certified Mail
WITHOUT Physical Return Receipt Service
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Instructions

1. Apply this label to the TOP EDGE of the mailpiece.
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U.S. Postal Service
Certified Mail Receipt

OUTBOUND TRACKING NUMBER
9407 1118 9956 0065 5307 64

FEES

Postage per piece	$0.470
Certified Fee	$3.450
Total Postage & Fees:	$3.920

ARTICLE ADDRESS TO:

[redacted]

Postmark Here

[redacted]

Delivery Address when used with A or Return Address when used with B

CERTIFIED MAIL

CERTIFIED MAIL

← Fold and Tear →

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3. Service Type

2. Article Number *(Transfer from service label)*

CERTIFIED MAIL

VOID

B Certified Mail
WITH Physical Return Receipt Service
(Uses Return Receipt Card)
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SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

Re: Mariner East 2 – Pennsylvania Pipeline Project
Horizontal Directional Drilling Construction Notification
and Offer of Alternative Temporary Water Supply

Dear [redacted]

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Office: (814) 204-0450

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CERTIFIED MAIL

PERCHERON FIELD SERVICES
REPRESENTING SUNOCO PIPELINE L.P.
P.O. BOX 10814
LANCASTER PA 17605

9407 1118 9956 0065 5350 80

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A Certified Mail

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U.S. Postal Service
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OUTBOUND TRACKING NUMBER
9407 1118 9956 0065 5350 80

FEES

Postage per piece	$0.470
Certified Fee	$3.450
Total Postage & Fees:	**$3.920**

ARTICLE ADDRESS TO:

[redacted]

Postmark Here

[redacted]

Delivery Address when used with A or Return Address when used with B

CERTIFIED MAIL

CERTIFIED MAIL

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B. Received By: *(Printed Name)*

C. Date of Delivery

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If YES, enter delivery address below: ☐ No

3. Service Type

2. Article Number *(Transfer from service label)*

VOID

B Certified Mail

WITH Physical Return Receipt Service

(Uses Return Receipt Card)

Instructions

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★ USA CMF - 134 04/17 ★

SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

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Horizontal Directional Drilling Construction Notification
and Offer of Alternative Temporary Water Supply

Dear [redacted]

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Office: (814) 204-0450

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P.O. BOX 10814
LANCASTER PA 17605

9407 1118 9956 0065 5381 11

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PS Form 3800 6/02

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3. Peel the Certified Mail label below and fold it over your envelope, just above the postage so that it covers the existing Certified Mail marking.

Delivery Address when used with A or Return Address when used with B

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U.S. Postal Service
Certified Mail Receipt

OUTBOUND TRACKING NUMBER
9407 1118 9956 0065 5381 11

FEES

Postage per piece	$0.470
Certified Fee	$3.450
Total Postage & Fees:	$3.920

ARTICLE ADDRESS TO:

[redacted]

Postmark Here

[redacted]

CERTIFIED MAIL

CERTIFIED MAIL

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A. Signature: (☐ *Addressee or* ☐ *Agent*)

X

B. Received By: *(Printed Name)*

C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type

VOID

B Certified Mail
WITH Physical Return Receipt Service
(Uses Return Receipt Card)
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★ USA CMF - 134 04/17 ★

SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

Re: Mariner East 2 – Pennsylvania Pipeline Project
Horizontal Directional Drilling Construction Notification
and Offer of Alternative Temporary Water Supply

Dear [redacted]

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Land Project Manager
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Office: (814) 204-0450

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CERTIFIED MAIL

PERCHERON FIELD SERVICES
REPRESENTING SUNOCO PIPELINE L.P.
P.O. BOX 10814
LANCASTER PA 17605

9407 1118 9956 0065 5340 14

PS Form 3800 6/02

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FROM 16652
01/25/2019
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WITHOUT Physical Return Receipt Service
(No Return Receipt Card)
Instructions

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U.S. Postal Service
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OUTBOUND TRACKING NUMBER
9407 1118 9956 0065 5340 14

FEES

Postage per piece	$0.470
Certified Fee	$3.450
Total Postage & Fees:	**$3.920**

ARTICLE ADDRESS TO:

[redacted]

Postmark Here

[redacted]

Delivery Address when used with A or Return Address when used with B

CERTIFIED MAIL

CERTIFIED MAIL

← Fold and Tear →

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X

B. Received By: *(Printed Name)*

C. Date of Delivery

1. Article Addressed to:

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type

2. Article Number *(Transfer from service label)*

CERTIFIED MAIL

VOID

B Certified Mail
WITH Physical Return Receipt Service
(Uses Return Receipt Card)
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★ USA CMF - 134.04/17 ★

SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

Re: Mariner East 2 – Pennsylvania Pipeline Project
Horizontal Directional Drilling Construction Notification
and Private Water Supply/Well Sampling Offer

Dear [redacted]

Sunoco Pipeline L.P. ("SPLP") is writing to inform you that a certain construction activity known as Horizontal Directional Drilling ("HDD") for Mariner East 2, also known as the Pennsylvania Pipeline Project, is located within 450 feet of your property boundary. This HDD will begin as soon as ten (10) days of the date of this letter.

As part of this construction activity, SPLP is offering private water supply/well testing at SPLP's expense if you have a private water supply/well located within 150 feet of the HDD alignment. SPLP will provide you copies of all test results from your private water supply/well. Please note that upon their request, we will provide the test results to the Pennsylvania Department of Environmental Protection as well.

To assist with this process, SPLP is requesting that you contact the Sunoco representative for your area by calling Amy Johnson at (717) 208-7735, to provide SPLP with the following information:

1. If you have a private water supply/well on your property;
2. The location of your private water supply/well on your property; and,
3. If you would like to have your private water supply/well tested.

If you would like to have your private water supply/well tested, you must contact the Sunoco Representative for your area within the next ten (10) days by calling Amy Johnson at (717) 208-7735. Your private water supply/well will be tested at a mutually-convenient time within ten (10) days of SPLP's receipt of your request for testing. If you do not contact the Sunoco representative, there will be no further contact from us regarding any private water supply/well testing.

If you have any questions or concerns, please do not hesitate to contact the Sunoco representative for your area by calling Amy Johnson at (717) 208-7735

Thank you for your cooperation.

Mark McConnell
Land Project Manager
Representing Sunoco Pipeline L.P. | Office: (814) 204-0450

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CERTIFIED MAIL

PERCHERON FIELD SERVICES
REPRESENTING SUNOCO PIPELINE L.P.
P.O. BOX 10814
LANCASTER PA 17605

9407 1118 9956 0065 5185 33

PS Form 3800 6/02

$3.920
US POSTAGE
FIRST-CLASS
FROM 16652
01/25/2019
stamps endicia

0625000876220

A Certified Mail
WITHOUT Physical Return Receipt Service
(No Return Receipt Card)
Instructions

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2. Apply address label below to the CENTER of the mailpiece.
3. Peel the Certified Mail label below and fold it over your envelope, just above the postage so that it covers the existing Certified Mail marking.

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U.S. Postal Service
Certified Mail Receipt

OUTBOUND TRACKING NUMBER
9407 1118 9956 0065 5185 33

FEES

Postage per piece	$0.470
Certified Fee	$3.450
Total Postage & Fees:	$3.920

ARTICLE ADDRESS TO:

[redacted]

Postmark Here

[redacted]

CERTIFIED MAIL

CERTIFIED MAIL

Delivery Address when used with A or Return Address when used with B

← Fold and Tear →

SENDER: COMPLETE THIS SECTION

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COMPLETE THIS SECTION ON DELIVERY

A. Signature: (☐ Addressee or ☐ Agent)

X

B. Received By: *(Printed Name)* | C. Date of Delivery

1. Article Addressed to:

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type

2. Article Number *(Transfer from service label)*

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(Uses Return Receipt Card)
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Certified Mail Labels (SDC-3930)

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SUNOCO PIPELINE
An ENERGY TRANSFER Partnership

January 25, 2019

BY CERTIFIED AND FIRST CLASS MAIL

[redacted]

Re: Mariner East 2 – Pennsylvania Pipeline Project
Horizontal Directional Drilling Construction Notification
and Offer of Alternative Temporary Water Supply

Dear [redacted]

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Thank you for your cooperation.

Mark McConnell
Land Project Manager
Representing Sunoco Pipeline L.P.
Office: (814) 204-0450

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PERCHERON FIELD SERVICES
REPRESENTING SUNOCO PIPELINE L.P.
P.O. BOX 10814
LANCASTER PA 17605

9407 1118 9956 0065 5317 30

PS Form 3800 6/02

$3.920
US POSTAGE
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FROM 16652
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Certified Fee	$3.450
Total Postage & Fees:	$3.920

ARTICLE ADDRESS TO:

[redacted]

Postmark Here

[redacted]

Delivery Address when used with A or Return Address when used with B

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B. Received By: *(Printed Name)*

C. Date of Delivery

1. Article Addressed to:

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

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Land Project Manager
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PERCHERON FIELD SERVICES
REPRESENTING SUNOCO PIPELINE L.P.
P.O. BOX 10814
LANCASTER PA 17605

9407 1118 9956 0065 5189 60

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PS Form 3800 6/02

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FEES

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Certified Fee	$3.450
Total Postage & Fees:	$3.920

ARTICLE ADDRESS TO:

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Delivery Address when used with A or Return Address when used with B

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A. Signature: (☐ Addressee or ☐ Agent)

X

B. Received By: *(Printed Name)*

C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type

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Certified Mail Labels (SDC-3930)

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PS Form 3800 6/02

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Total Postage & Fees:	$3.920

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[redacted]

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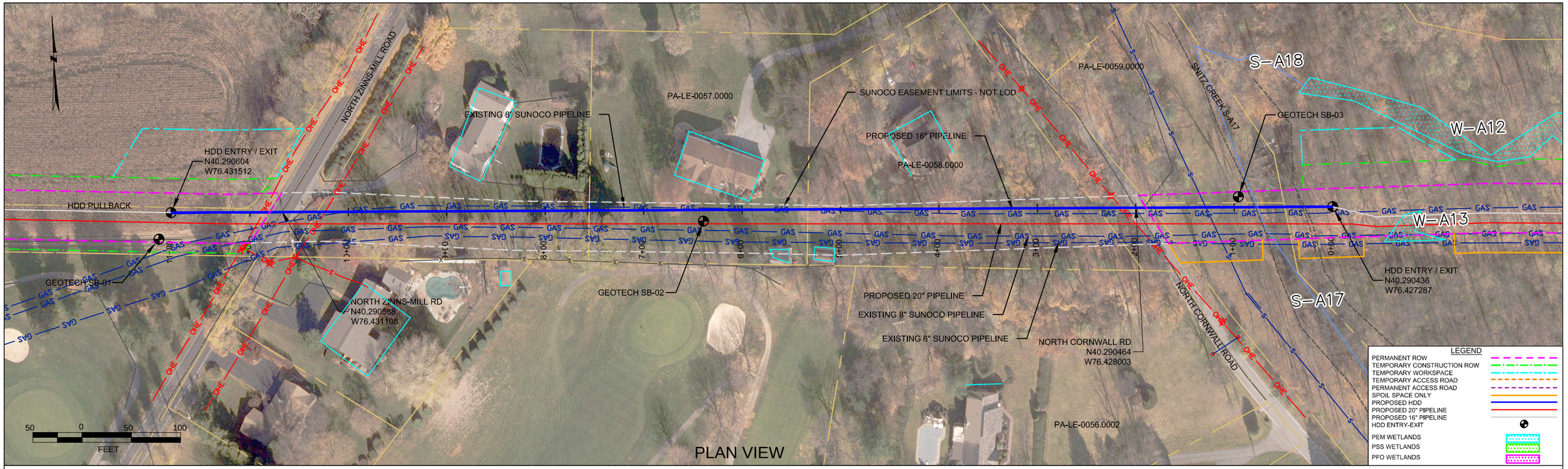
NORTH ZINNS MILL ROAD CROSSING
PADEP SECTION 105 PERMIT NO. E38-194
PA-LE-0055.0000-RD-16
(SPLP HDD No. S3-0101)

ATTACHMENT 3

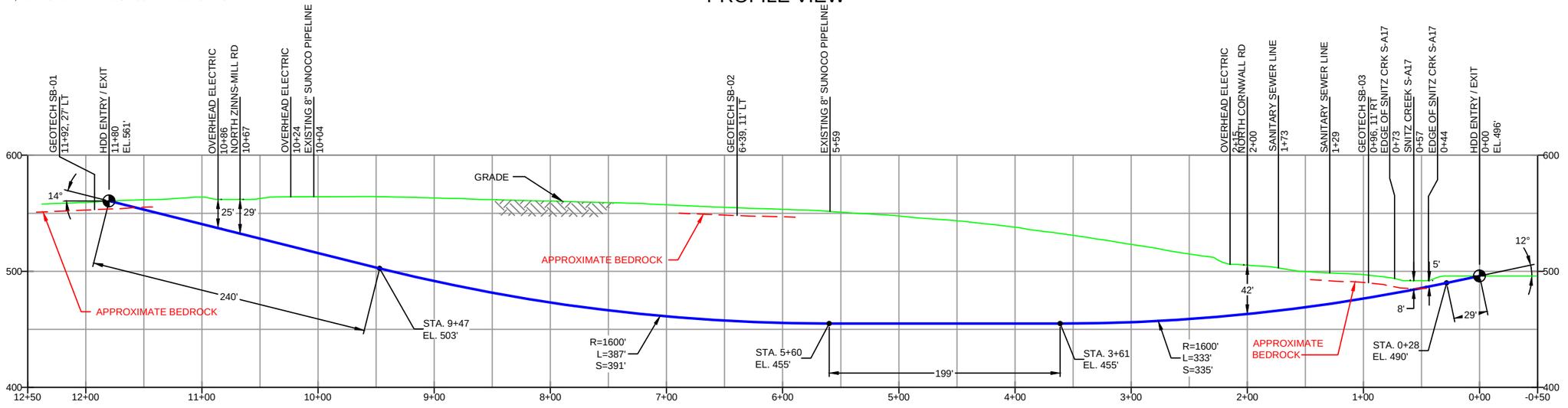
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES

LEBANON COUNTY, PENNSYLVANIA - WEST CORNWALL TOWNSHIP
S3-0101-16

PLAN VIEW



PROFILE VIEW



GEOTECH SB-01
-NG EL. 562'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 8.0')
-FRACTURED LIMESTONE (8.0' - 18.0')
-COMPLETION DEPTH EL. 544'

GEOTECH SB-02
-NG EL. 555'
-TOPSOIL (0' - 0.1')
-CL (0.1' - 4.0')
-FRACTURED LIMESTONE (4.0' - 6.0')
-COMPLETION DEPTH EL. 549'

GEOTECH SB-03
-NG EL. 496'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 7.0')
-LIMESTONE (7.0')
-COMPLETION DEPTH EL. 489'

NOTE: REFER TO TEST BORING LOG S3-0101 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=): 1180'
   HDD PIPE LENGTH (S=): 1196'
   16" x 0.438" W.T., X-70, 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 1. Permitted 16-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-5.32	TO	ES-5.32	EROSION & SEDIMENT PLAN	
SHEET 18	TO	SHEET 18	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	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	JTW	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
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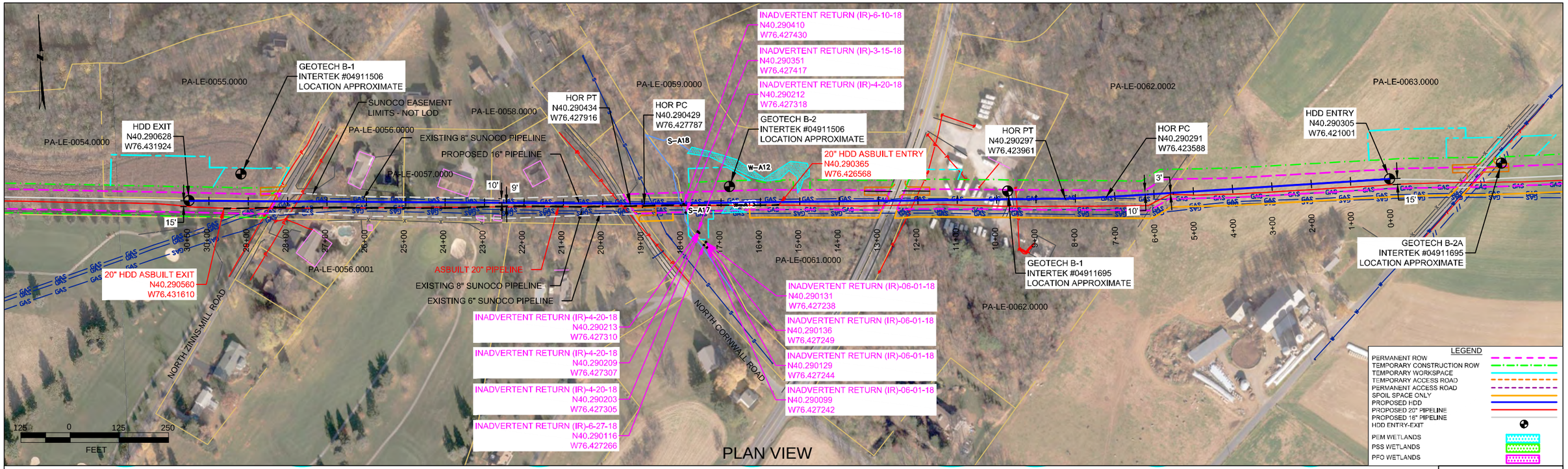
SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
N ZINNS MILL ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100'

DWG. NO: PA-LE-0055.0000-RD-16



PLAN VIEW

PROFILE VIEW

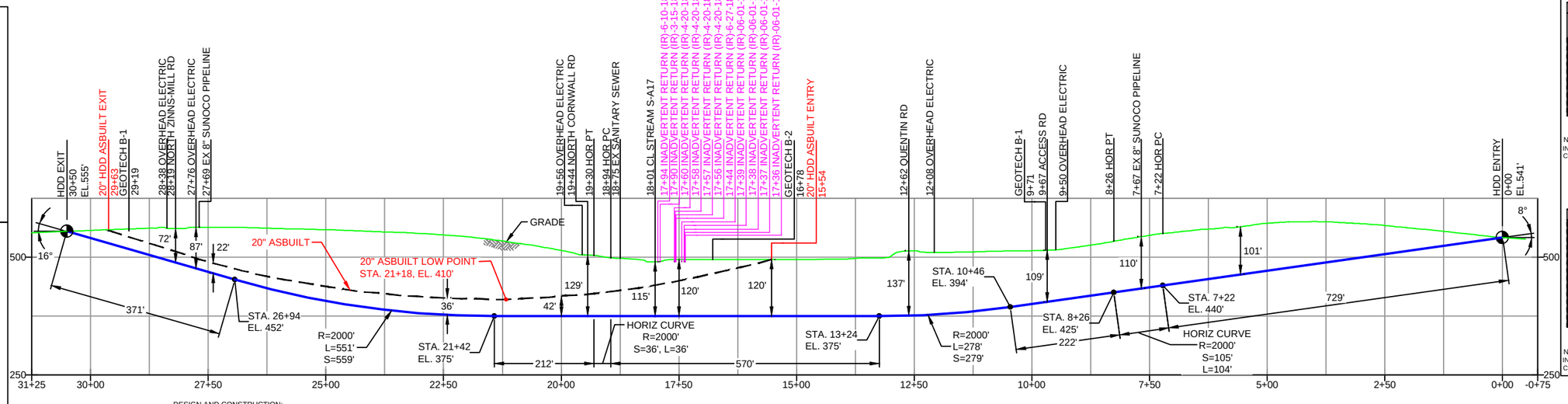
LEBANON COUNTY, PENNSYLVANIA - WEST CORNWALL TOWNSHIP
S3-0101-16

GEOTECH B-1
- NG EL. 556'
- -RESIDIUUM-CLAY CL (0.0' - 5.0')
- -GROUNDWATER (43.0')
- -DOLOMITE/LIMESTONE /SHALE (5.0' - 170.0')
- -BORING TERMINATED EL.386'

NOTE: REFER TO TEST BORING LOG B-1 INTERTEK PROJECT #04911506 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2
- NG EL. 495'
- -FILL ML (0.0' - 3.5')
- -GROUNDWATER (2.9')
- -FILL MH (3.5' - 8.5')
- -DOLOMITE/LIMESTONE (8.5' - 105.0')
- -BORING TERMINATED EL.390'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PROJECT #04911506 FOR COMPLETE SOIL MATERIAL DESCRIPTION



GEOTECH B-1
- NG EL. 515'
- -NO SAMPLING (0.0' - 5.0')
- -FILL GP-GM (5.0' - 15.0')
- -GROUNDWATER (24.0')
- -LIMESTONE/DOLOMITE (15.0' - 152.0')
- -BORING TERMINATED EL.363'

NOTE: REFER TO TEST BORING LOG B-1 INTERTEK PROJECT #04911695 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2A
- NG EL. 543'
- -NO SAMPLING (0.0' - 9.5')
- -GROUNDWATER (27.0')
- -LIMESTONE/DOLOMITE (9.5' - 153.0')
- -BORING TERMINATED EL.390'

NOTE: REFER TO TEST BORING LOG B-1 INTERTEK PROJECT #04911695 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=): 3050'
   HDD PIPE LENGTH (S=): 3083'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
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 2625 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 2. Revised 16-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-5.32	TO	ES-5.32	EROSION & SEDIMENT PLAN	
SHEET 18	TO	SHEET 18	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP6	REDESIGNED PER CLIENT REQUEST AND ADDED GEOTECH INFORMATION	MRS	12/07/18	RMB	12/07/18	AMC	12/07/18
EP5	UPDATED NOTE 5 AND 10 PER INCREASED 16" MOP	MRS	04/10/18	RMB	04/10/18	CAG	04/10/18
EP4	REVISED DEPTH UNDER STREAM S-A17	MRS	12/20/17	RMB	12/20/17	AMC	12/20/17
EP3	LENGTHENED DRILL AND LOWERED UNDER STREAM S-A17	MRS	12/07/17	RMB	12/07/17	AMC	12/07/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
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SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
N ZINNS MILL ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'

DWG. NO: PA-LE-0055.0000-RD-16