HORIZONTAL DIRECTIONAL DRILL ANALYSIS
GLEN RIDDLE ROAD and SOUTHEASTERN PENNSYLVANIA RR CROSSING
PADEP SECTION 105 PERMIT NO.: E23-524
PA-DE-0100.0000-RR
(SPLP HDD# S3-0620)

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This reevaluation of the horizontal directional drill (HDD) installation of the 20-inch and 16-inch diameter pipelines that traverses Glen Riddle Road (Rd) and Southeastern Pennsylvania Railroad (RR) in Upper Chichester Township, Delaware County, Pennsylvania is in accordance with the Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L for HDDs listed on Exhibit 3 of the Stipulated Order.

During drilling to install the permitted 16-inch pipeline, multiple inadvertent returns (IRs) occurred which resulted in drilling fluids entering Waters of the Commonwealth. In addition, groundwater was encountered at the southeastern end of the HDD, near Stream S-I2, resulting in produced water control issues and worker safety concerns. Ultimately the first HDD attempt was abandoned and the entire bore hole was filled with grout.

SPLP completed additional geotechnical investigations of the drilling area to assess if the HDD could be redesigned to pass through better bedrock conditions; however the new data revealed continuing inconsistencies in rock quality at depths through and below the HDD design limitations. Therefore, SPLP has elected to abandon any future HDD attempts to install the pipelines through this area and has developed an alternate installation method that minimizes impacts to Waters of the Commonwealth using a combination of open trench construction method in uplands and through aquatic resources, direct pipe bores, and a conventional auger bore underneath Glenn Riddle Road.

The 20-inch and 16-inch HDDs are collectively referred to herein as HDD S3-0620.

PIPE INFORMATION

20-Inch: 0.456 wall thickness; X-65

16-Inch: 0.438 wall thickness; X-70

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 20-INCH

- Horizontal length: 3,338 feet (ft)
- Entry/Exit angle: 10-16 degrees
- Maximum depth of cover: 215 ft
- Pipe design radius: 2,000 ft

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 3,416 feet (ft)
- Entry/Exit angle: 10-16 degrees
- Maximum depth of cover: 230 ft
- Pipe design radius: 1,600 ft

Pipe stress allowances are an integral part of the design calculations performed for each HDD. The implemented HDD design maximized the entry angle at the northwest end of the HDD at 16 degrees which was the allowable “break over” radius for connecting the drill pipe segment to the open trench lay pipe during tie-in. The bottom radius at 2000 ft of curvature left only a marginal buffer to the pipe pull through stress, which allowed for some variation in the actually drilled hole, before damage to the pipe could occur in pullback. Additional depth of the horizontal run could have been designed into the profile; however as

noted in the summary above, additional geotech data showed that even a 50 + ft of additional depth would not have placed the profile into competent bedrock. The exit radius at 12 degrees was set to account for pullback of the HDD pipe segment into this hole. Immediately south of the south HDD entry/exit point, the topography rises steeply, and this exit radius allowed for a safe pullback of the HDD pipe string, even though cranes would have been necessary to hold and cradle the pipe segment coming down the hillside during pullback. A higher entry/exit angle high radius would have resulted in safety concerns during pipe pullback due to the height above ground the pipe would have had to be lifted to during pullback.

HDD technology will not be used to complete the pipeline installations in this section of the project.

INADVERTENT RETURN DISCUSSION

During the pilot hole drilling phase of S3-0620, there were several IRs in which drilling fluids entered Waters of the Commonwealth, including three unnamed tributaries to Chester Creek (Streams S-I1, S-I2, and S-I3) and a wetland (WL-I1). These IRs were contained and cleaned up using sand bag containments, flumes and pump arounds. Once the pilot bore was completed, the south HDD entry/exit point, and some IR locations developed into locations of produced water to be contained and controlled.

The hydrogeologic factors that contributed to the IRs was the deeply weathered and fractured metamorphic bedrock of the Ultramafic Rock and Wilmington Complex rock and the elevation difference along the profile between the upland area northwest of Glen Riddle Road and lowlands associated with flood plain of stream S-I2 and Chester Creek. The pilot boring from the lowlands under the upland area to the northwest, provided a preferential pathway for groundwater to flow, under a pressure head originating within the upland, and created the groundwater discharges.

Figures 1 and 2 in Attachment 2 provide a plan and cross section view of the HDD bore hole and locations of the IRs. Additional written description of the IR events during the drilling of HDD-620 is provided in Section 3.0 of the Hydrogeologic Analysis Report provided in Attachment 1.

GEOLOGIC ANALYSIS

The northwestern 2,600 ft of the HDD S3-0620 alignment is underlain by undifferentiated Ultramafic Rocks, including serpentinite, chlorite schist, anthophyllite-chlorite schist, and talc-tremolite schist (Bosbyshell, 2017; Blackmer, 2005). The southeast quarter of the proposed path is comprised of the Confluence Gneiss of the Wilmington Complex, which is an amphibolite-facies gneiss including hornblende plagioclase granofels, interlayered mafic, felsic, and intermediate orthogneiss, and amphibolite (Bosbyshell, 2001). Other nearby formations include the Wissahickon Schist to the east, the Lima Granite to the north, and the Baltimore Gneiss to the northwest (Blackmer, 2005).

Following the HDD alignment, the boundary between the Ultramafic Rocks and the Wilmington Complex is encountered approximately 2,600 feet southeast of the northwest entry/exit point. This lithologic contact corresponds with the location of IRs and persistent groundwater discharge that occurred during drilling activities for the 16-inch pipe.

The revised construction plans are for 1,648 ft of open trench construction, two direct bores, and a conventional auger bore. These boring methods are cased and enclosed, and the direct bores have a closed fluid control system. All of these bores will pass through overburden or highly weathered and weak bedrock with low RQD values. The geology at this location presents no risks to the construction methods planned in replacement of the HDD.

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

HYDROGEOLOGIC ANALYSIS, GROUND WATER, AND WELL PRODUCTION ZONES

In Southeastern Pennsylvania, groundwater generally flows downward from recharge zones in the uplands, laterally through primary pore structures, fractures and bedding planes, and then flows upward to discharge into creeks and wetlands. At HDD S3-0620 groundwater is expected to flow naturally from the northwest uplands to the southeast, discharging to wetland W-I1, Chester Creek and stream S-I2.

Groundwater storage and flow at HDD S3-0620-20 occurs in relatively competent bedrock in fractures, faults, and lithologic contacts where differential weathering has occurred. Groundwater is expected to flow preferentially through the larger fractures, faults, and shear zones. In this setting, groundwater can also occur perched in the saprolitic zone. Here groundwater occupies primary pore space within coarse-grained material and in residual fractures remnant within weathered bedrock. (Low et al., 2002).

A review of the PaGWIS database identified forty-three (43) residential wells within one mile of HDD S3-0620. The reported median depth to water was 39 feet, ranging from 7 to 190 feet. It can be assumed that the HDD profile transects water producing zones in bedrock that are the source of water to these wells.

The revised construction plans are for 1,648 ft of open trench construction, two direct bores, and a conventional auger bore. These boring methods are cased and enclosed, and the direct bores have a closed fluid control system. All of these bores will pass through overburden, or highly weathered and weak bedrock with low RQD values. The geology at this location presents no risks to the construction methods planned in replacement of the HDDs.

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

ADJACENT FEATURES ANALYSIS

The crossing of Glen Riddle Rd and Southeastern Pennsylvania RR is in Upper Chichester Township, Delaware County, approximately 9.5 miles (mi) southeast of the community of West Chester, and approximately 14.7 mi southwest of Philadelphia, Pennsylvania.

The pipeline route follows an existing SPLP utility easement with three existing pipelines and runs parallel to (in a southeasterly direction), and on the northeast side, of South Pennell Rd to approximately 705 feet southeast of the southern extent of the Turnbridge Apartments parking lot.

Aquatic resources along the route include three unnamed tributaries to Chester Creek (Streams S-I1, S-I2, and S-I3) and a wetland (WL-I1). Chester Creek occurs to the southwest and the route passes parallel to the creek channel at the southeast end.

SPLP's public outreach results verified the presence of two (2) water wells within 450 ft of the proposed HDD. A water well map is provided as Figure 4 in the Hydrogeologic Reevaluation Report provided in Attachment 1. No water supply impact complaints were received during drilling of the HDD-620 16-inch borehole.

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ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of HDD S3-0620 includes an evaluation of construction alternatives and a re-route analysis. As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the project, SPLP considered a number of different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures.

Re-Route Analysis

SPLP evaluated other routes around the area but reasonable alternatives are not existent due to the density of roads and developments surrounding the existing route. Residential and commercial development dominates the landscape for miles to the east and west of the existing SPLP easement with no other identifiable existing utility easements that could be considered as alternatives. In addition, a route to the west or east would likely impact more forested areas, possibly wetlands, and require a “greenfield”, or new, right-of-way through these areas resulting in more permanent impacts when compared to following an existing easement, and affecting previously unencumbered properties.

Open-cut Analysis

In this area of the Mariner II Pipeline project, this use of an HDD construction method was selected to be employed in many instances due to the amount of residential and commercial development adjacent to and encroaching upon the existing SPLP easement, since the HDD method generally avoids direct disturbance of lands between the points of entry and exit. However, as previously discussed, SPLP performed additional geologic investigations and has determined from this data that a revised HDD design will not be able to avoid the subsurface geologic conditions that resulted in abandonment of the first HDD attempt.

SPLP evaluated the select use of open cut construction of the existing permitted right-of-way and determined this would have the least impact, and most effective means, for installing the pipelines and restoring the previous IR areas where adequate space exists to employ conventional construction methods.

Use of Conventional Auger Bore

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

Based on the track record of installations during construction of this pipeline project, conventional auger bores should be limited to approximately 200 linear feet or less, varying by the underlying substrate at a proposed bore location. Conventional auger bores for the 20-inch pipeline, attempted at longer distances, have at times had alignment drift and elevation deflections which have complicated installation. Drift and deflection are safety concerns when boring adjacent to in-service pipelines and other utilities, and there are three existing in service pipelines within the existing SPLP easement. Adequate spacing between the existing pipelines exists to allow for a conventional auger bore of the pipelines at the crossing of Glenn Riddle Road.

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Use of Direct Pipe Bore

The direct pipe bore method is also known as "microtunneling". This method of pipeline installation is a remote-controlled, continuously supported pipe jacking method. During the direct pipe installation, operations are managed by an operator in an above-ground control room alongside of the installation pit. Rock and soil cutting and removal occurs by drilling fluid injection through the cutting tool during rotation at the face of the bore, and the cuttings are forced into inlet holes in the crushing cone at the tool face for circulation to a recycling plant through a closed system. The entire operating system for this method of pipeline installation, including the cutting tool drive hydraulics, fluid injection, fluid return, and operating controls are enclosed inside the 50-inch outside diameter bore pipe being installed. At the launching point/entry pit, the bore pipe is attached to a "jacking block" that hammers the bore pipe while the tool is cutting through the substrate or geology. The cutting tool face is marginally larger in diameter than the pipe it is attached to. As a result, there is minimal annulus space, which minimizes the potential for drilling fluid returns or the production of groundwater returning back to the point of entry. Once the bore pipe (48-inch inside diameter and 50-inch outside diameter) is installed, the 16-inch and 20-inch product pipelines will be bundled together using spider gaskets and spacers for separation, and to prevent cathodic protection short circuits, and then both pipes will be pulled through the bore pipe simultaneously.

SPLP evaluated the use of direct pipe bore to pass by congested areas and difficult crossing features within the alignment of HDD S3-0620. The construction specialists who operate this boring equipment identified two segment of this alignment to employ the direct pipe bore method of construction. These include a section of the alignment where residences are too close to the existing easement to provide workspace for open trench construction, second area with residences in near proximity, and the crossing of a railroad.

CONCLUSION

As stated previously, SPLP properly abandoned the originally permitted S3-0620 HDD and proposes to replace it with conventional open trench construction for 1,648 ft of the route; a 98 ft conventional auger bore under Glen Riddle Road; a 995 ft direct bore past residences and under the Southeast Pennsylvania Transportation Authority's (SEPTA) Railroad; and a 819 ft direct bore past residences and under Riddlewood Drive.

The revised construction plan will involve the open cut of Wetland WL-I1, an Exceptional Value (EV) wetland, to install both pipes and an open cut to install the 20-inch pipe across Stream S-I2. An open trench installation method across these resources will result in temporary, short-term, impacts to streams and wetlands, but will eliminate the risk of uncontrolled discharges associated with IRs and facilitate restoration of resources impacted by previous IRs in the area. Stream S-I2 will be crossed via an open trench method for the 20-inch pipeline with the appropriate dam and pump bypass installed to convey stream flow across the workspace and outlet downstream within the permitted limit-of-disturbance (LOD), such that work will be conducted in a dry stream channel. After the stream bypass is in place, the trench will be excavated and the pipe will be installed. Wetland WL-I1 will be crossed via the open trench method for both the 20 and 16-inch pipelines. Excavation for both the stream and wetland crossings will be conducted in accordance with all the Projects' permit conditions and requirements. In order to efficiently complete all construction activities and minimize resource impacts for the 20-inch pipe, SPLP is proposing a 50-foot-wide LOD across the perennial stream. In addition, to install both pipes at the same time and minimize the duration of construction through Wetland WL-I1, while maintaining safety standards for working over "hot lines", SPLP is requesting an approximate 110-foot wide LOD through the PEM portion of WL-I1. As such, there will be no impact to the PFO portion of this EV wetland.

Attachment 2 contains the HDD plan and profile with the IR location data, and the plan and profile views of the conventional auger bore and two direct bores discussed above.

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To address the additional impacts associated with these proposed changes in construction methods, a Chapter 102 & Chapter 105 permit modification package has been submitted to PADEP for review.

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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 alternative construction plans presented within this re-revaluation report will minimize the risk of IRs and impacts to public and private water supplies during the construction phases for this segment of the Mariner II Pipeline Project.

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

5/17/2019

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

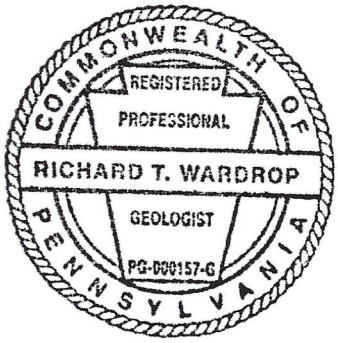
Date

Pertaining to the practice of geology

5/17/19

Richard T. Wardrop, P.G.
License No. PG-000157-G
Groundwater & Environmental Services, Inc.
Lead Hydrogeologist

Date



Pertaining to the pipeline stress and geometry

5/17/19

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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

HDD HYDROGEOLOGIC REEVALUATION REPORT

Mariner East II
Spread 6
HDD S3-0620
Glen Riddle Road, Southeastern Pennsylvania RR
Upper Chichester Township, Delaware County, Pennsylvania

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

Groundwater & Environmental Services, Inc.
440 Creamery Way, Suite 500
Exton, Pennsylvania 19341

May 2019

HDD HYDROGEOLOGIC REEVALUTION REPORT

Mariner East II
Spread 6
S3-0620
Glen Riddle Road, Southeastern Pennsylvania RR
Upper Chichester Township, Delaware County, Pennsylvania

May 2019

Prepared for:

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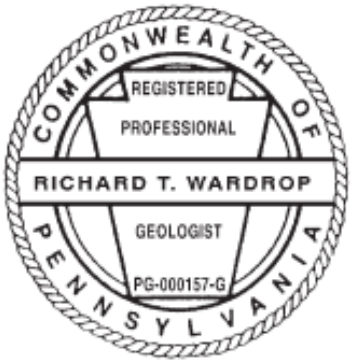
By affixing my seal to this document, I am certifying that the geologic and hydrogeologic information is true and correct. I further certify I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information.



May 17, 2019

Richard T. Wardrop, P. G.
Lic. No. PG000157G

Date

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Attachment B. Geotechnical Boring Reports and Logs
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1.0 INTRODUCTION

Sunoco Pipeline, L.P., (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare a horizontal directional drill (HDD) Hydrogeologic Reevaluation Reports (HRRs) for the Mariner East II pipeline project. This HRR is for the 20-inch pipe installation at Glenn Riddle Road, Southeastern Pennsylvania RR, PA-DE-0100.0000-RR (HDD S3-0620) in Upper Chichester Township, Delaware County, Pennsylvania. The alignment for HDD S3-0620 runs northwest to southeast, crossing the SEPTA Railroad, Glen Riddle Rd, intermittent wetlands (W-I1) and Tributary 541 of Chester Creek (S-I2). A map depicting the location of the HDD alignment is presented as **Figure 1**. An HRR is required for this HDD in accordance with Exhibit 3 of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017 (Stipulated Order) requiring that an HRR be completed approved for installation of a second pipe when an Inadvertent Return (IR) occurs during construction activities associated with installation of the first pipe. At S3-0620, IRs occurred during construction activity for the 16-inch pipe (which was not completed), and installation of both the 16 and 20-inch pipelines is pending. SPLP is submitting a major Chapter 105 permit modification package to construct both pipes at this location, which includes converting the original HDDs for each pipe into a combination of open trench, two direct pipe borings and one conventional auger boring. Because the proposed modification incorporates trenchless construction methods (direct bores and a conventional auger bore), an HRR is required to analyze the proposed design change for installation of the pipelines.

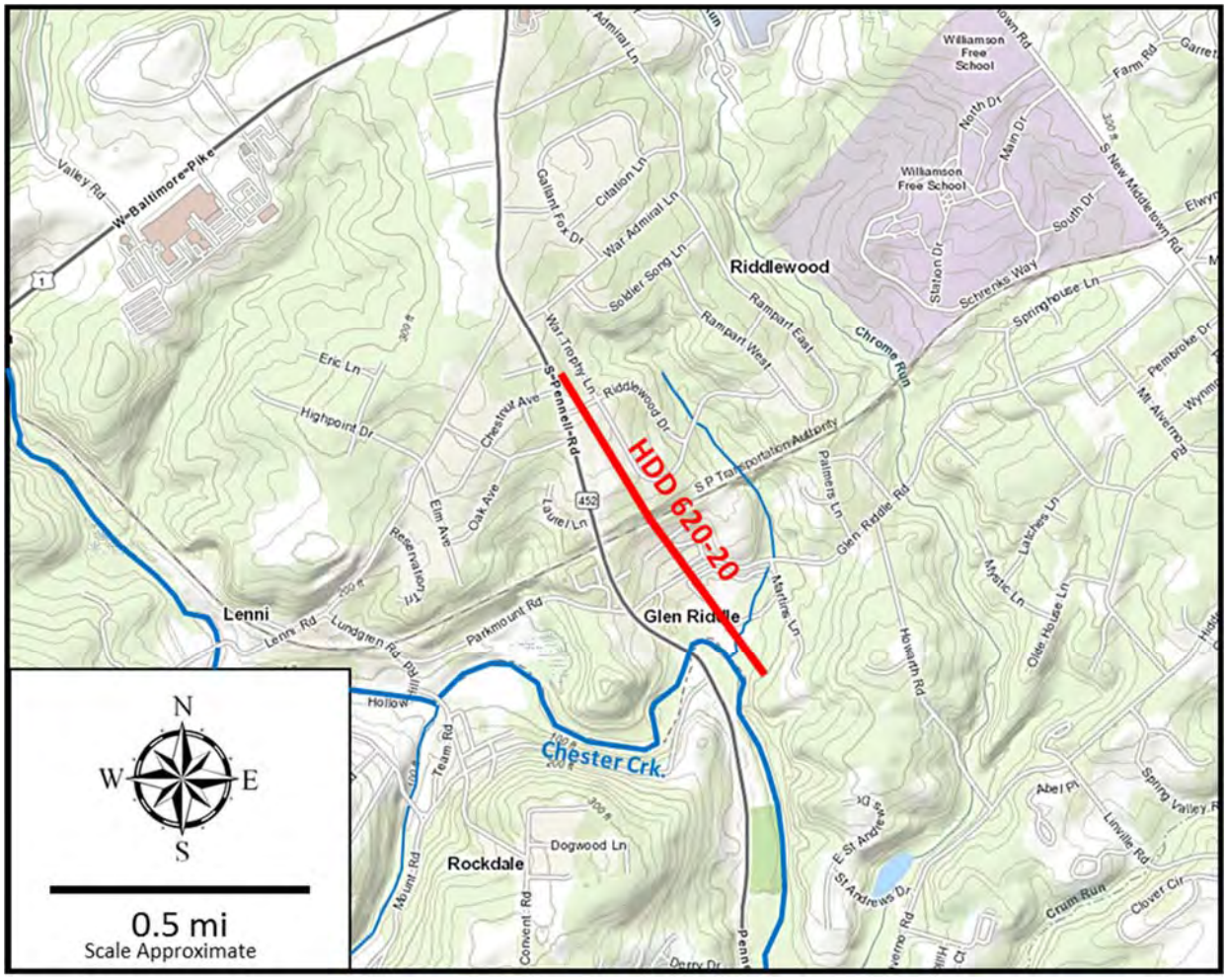

Figure 1. Site Location Map (modified PASDA, 2017).

The direct pipe construction method uses a hydraulically jacked tunneling drill head to advance and steer excavation of the pipeline borehole along the design profile. A 48-inch diameter steel casing, slightly smaller than the cutter, is advanced directly behind the drill head such that the bore is simultaneously and continuously cased during completion. A relatively small volume of drilling fluid (compared to HDD drilling) is conveyed to the drill head where it lubricates the cutter and entrains cuttings. The drilling fluid, laden with cuttings, is conveyed back to entry along lines that lay within the steel casing providing for total control of the drilling fluid pathway. As such, direct bore pipe installations eliminate the risk of IRs through total control of the drilling fluid pathway.

The conventional auger bore drilling method is used for shorter straight profiles as the drill head is not steered. Entry and receiving pits are required at either end of the bores to provide space for the bore equipment. Similar to the direct bore method, a 48-inch steel casing, slightly smaller than the drill head, is advanced directly behind the drill head such that the bore is simultaneously and continuously cased as the boring advances. Water, as opposed to drilling fluid, is used to lubricate the drill head and cuttings are conveyed back to entry inside the casing via the mechanical action of turning auger blades. Thus, there is no IR risk because no drilling fluids are not used.

This HRR provides a comparison of the permitted HDD S3-620 (plan and profile revised 5/10/16) to the proposed permit modification plans SPLP is proposing to install a 48-inch casings at the two direct pipe borings and one conventional auger boring to accommodate installation of both the 16-inch pipe and 20-inch pipe within these conduits simultaneously.

The objective of this report is to evaluate the hydrogeologic conditions relative to the proposed construction alternative to 1) eliminate, reduce, or control the release or inadvertent returns (IRs) of HDD drilling fluids and 2) minimize/eliminate impact to water supplies at the location during and after trenchless construction options. The report references information from construction activities intended to install HDD S3-0620-16. Drilling of the HDD S3-0620-16 pilot boring commenced June 10, 2017 and construction activity was permanently suspended in October 2018 during swabbing of the HDD annulus.

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of HDD S3-0620;
- Summaries of studies performed pertinent to reevaluation, including fracture trace analysis, geotechnical borings, and geophysical surveys;
- An updated site conceptual model; and
- A reevaluation summary with conclusions.

The contents of this report were developed from the review of published information, field observations acquired from the initial attempt of the 16-inch installation and related field studies. Site geotechnical boring programs were conducted by Tetra Tech in September 2015, by Terracon Consultants, Inc. (Terracon) in 2017 for the original design, and by Allied Well Drilling in support of the HDD S3-620 re-design. Note that GES did not oversee or direct the Tetra Tech's or Terracon's geotechnical drilling program, including, but not limited to, the selection of number and location of borings, determination of surface elevations, target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and any core photographs that resulted from these programs were generated by the two SPLP contractors. GES relied on these reports and incorporated their data into the general geologic and hydrogeologic framework for this HRR. GES did participate in the Allied Well Drilling geotechnical borings in terms of selection of locations and, observing and logging each bore.

As described in the Stipulated Order (pages 3 and 4), the HRRs will provide information to eliminate, reduce, or control the release or inadvertent return (IR) of HDD drilling fluids to the surface of the ground

or impact to water supplies at the location during HDD operations. The HRRs are not intended to evaluate potential adverse effects of nearby man-made structures from HDD operations.

2.0 HDD GEOLOGY / HYDROGEOLOGY

2.1 Physiography

HDD S3-0620-20 is located within the Piedmont Uplands Section of the Piedmont Physiographic Province in Southeast Pennsylvania. The Piedmont Uplands Section is characterized by broad, rounded to flat-topped hills and shallow valleys with low to moderate topographic relief. The geology of this region is generally comprised of meta-igneous and metasedimentary rocks of Proterozoic to Early- to Mid-Paleozoic age that have been severely folded and fractured (PaGEODE, 2019).

2.1.1 Topography

The alignment of the original permitted drill profile for HDD S3-0620 trends NW to SE with a horizontal distance of approximately 3,338 feet (see **Attachment A**). The topography slopes SE from the northwest entry/exit in an upland at an elevation of 277 feet above mean sea level (ft amsl) to the southeast entry/exit, due north of a tributary to Chester Creek at an elevation of 69 ft amsl. A relatively steep section of slope occurs between Stations 12+00 and 21+00.

2.1.2 Hydrology

HDD S3-0620 is located within the Chester Creek drainage basin. Chester Creek is used for a public water supply and is an important regional trout stream. The HDD S3-0620 right-of-way (ROW) crosses a tributary (stream S-I2) which discharges to Chester Creek 170 ft to the south. The drill path ROW crosses PEM wetland W-I1 between Stations 28+00 and 30+00 (permitted profile).

2.2 Geology

2.2.1 Soils

Unconsolidated materials along the drill path in the area of HDD S3-0620 were characterized by four geotechnical borings installed by Tetra Tech (SB-01, SB-02, SB-03, and SB-04), two borings installed by Terracon (B6-24W and B6-24E), four borings installed by Allied Well Drilling (3+60, 18+50, 24+00, and 26+75), and U.S. Department of Agriculture NRCS Web Soil Survey for Delaware County (USDA NRCS, 2017).

Soil depth ranged from 12.3 ft to 75 ft below ground surface (bgs) as defined in the geotechnical borings and reflect the deep weathering of bedrock that occurs in the regional setting. The geotechnical boring logs describe the soils as lean clay, poorly graded sand, and silty sand following the USCS classification system. Soil taxonomy includes the Neshaminy Series (Fine-loamy, mixed, superactive, mesic Ultic Hapludalfs) derived from ultramafic bedrock in the upland area, the Glenelg and Manor Series (Fine-loamy, mixed, semiactive, mesic Typic Hapludults) in the amphibolite facies gneiss on the slopes approaching Chester Creek, and the Wehadkee Series (Fine-loamy, mixed, active, nonacid, thermic Fluvaquentic Endoaquepts) derived from alluvium in the Chester Creek flood plain (USDA NRCS, 2017).

2.2.2 Bedrock Lithology

The northwestern 2,600 ft of the HDD S3-0620 alignment is underlain by undifferentiated Ultramafic Rocks, including serpentinite, chlorite schist, anthophyllite-chlorite schist, and talc-tremolite schist (Bosbyshell, 2017; Blackmer, 2005). The southeast quarter of the proposed path is comprised of the Confluence Gneiss of the Wilmington Complex, which is an amphibolite-facies gneiss including hornblende plagioclase granofels, interlayered mafic, felsic, and intermediate orthogneiss, and amphibolite (Bosbyshell, 2001). **Figure 2** is a map depicting site bedrock geology local to HDD S3-0620. Other nearby
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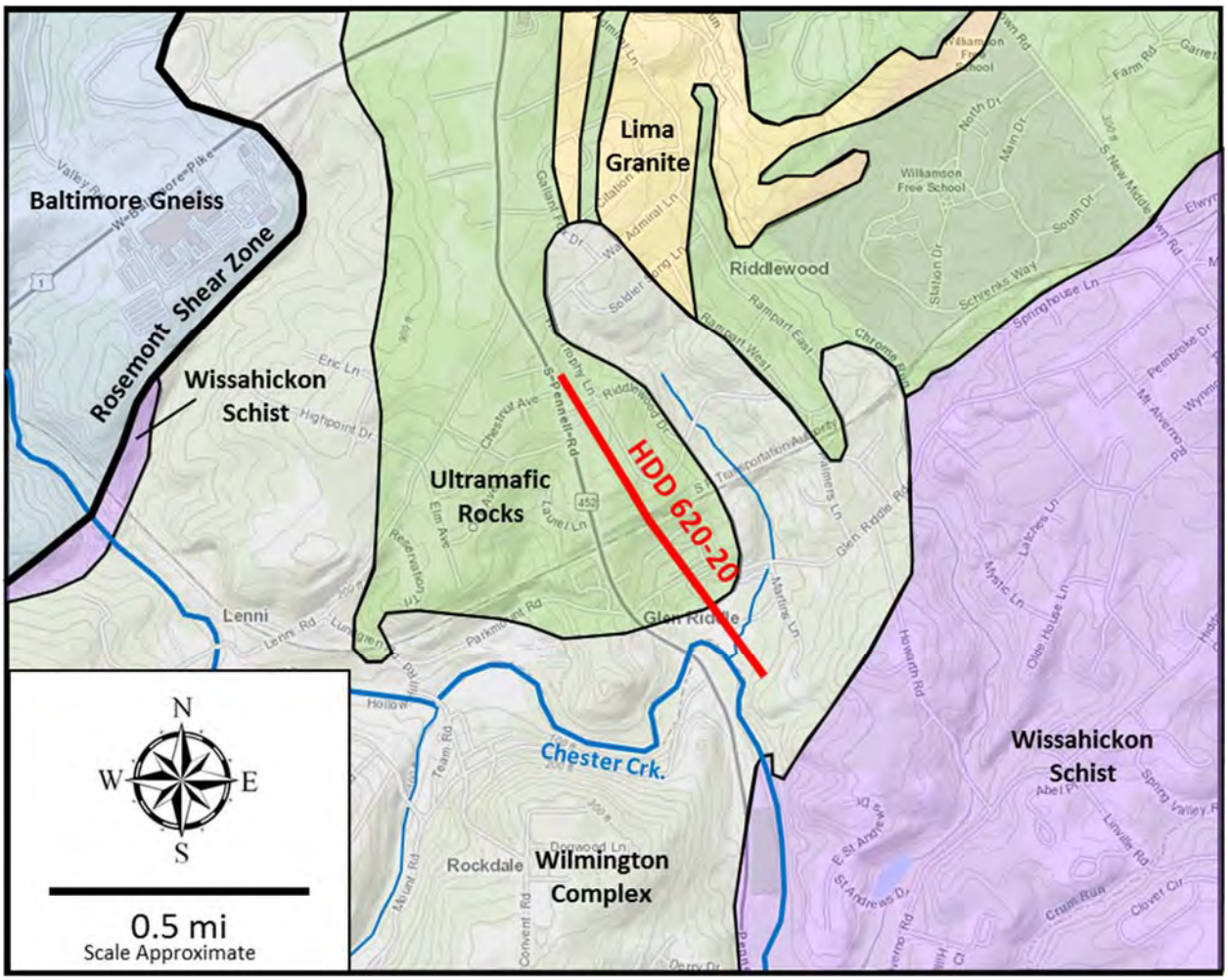

Figure 2. Geologic map (modified from Blackmer, 2005).

formations include the Wissahickon Schist to the east, the Lima Granite to the north, and the Baltimore Gneiss to the northwest (Blackmer, 2005).

The boundary between the Ultramafic Rocks and the Wilmington Complex is encountered approximately 2,600 feet southeast of the northwest entry/exit point. This lithologic contact corresponds with the location of IRs and persistent groundwater discharge that occurred during advancement of the pilot bore for the 16-inch pipe.

2.2.3 Structure

The rocks at the HDD S3-0620 site experienced multiple episodes of metamorphism. They are strongly foliated, folded, fractured, and sheared. The Novotni Brothers Quarry, located 700 ft southwest of the southeast entry/exit point, reveals a synform and four shear zones that strike northeast, likely intercepting the HDD S3-0620 alignment near the S-I2 tributary crossing (Kellog et al., 2001). These shear zones may be related to the Rosemont Shear Zone, which displays northeast/southwest dextral slip. These intensely sheared features promote enhanced bedrock weathering at depth and represent zones for preferential fluid migration.

2.2.4 Fracture Trace Analysis

Fracture trace analysis of high altitude aerial photography was performed for the area of interest to identify potential zones of bedrock weakness along the drill path (see **Figure 3**). Fracture traces (one mile in length or less) and lineaments (greater than one mile in length) are the surficial expression on natural landscapes of vertical zones of bedrock fracture concentration. Fracture trace analysis is partly subjective; therefore, every mapped fracture trace does not necessarily represent a zone of bedrock fracture concentration.

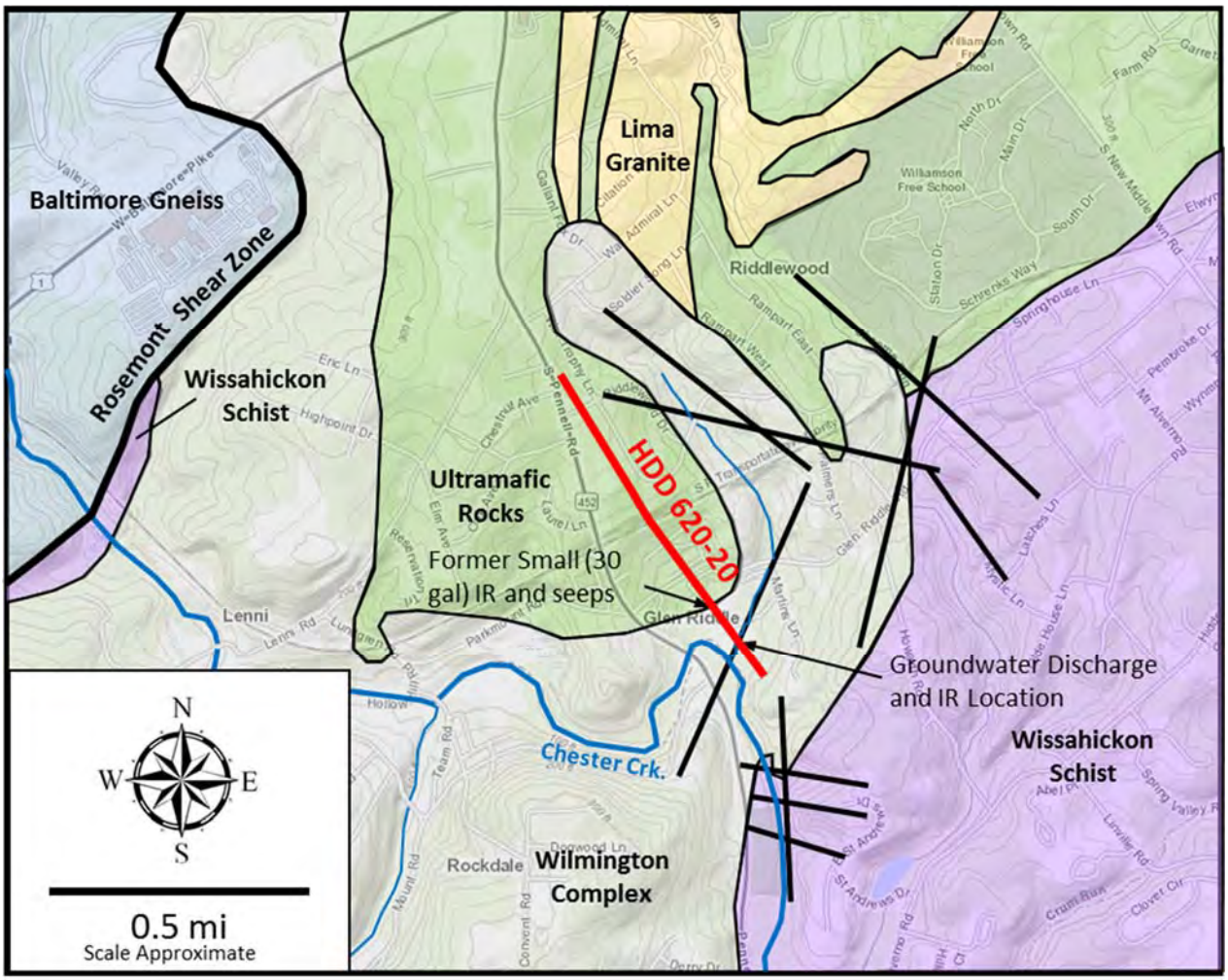

Figure 3. Fracture Trace Map

Aerial photographic images used to perform the fracture trace analysis were obtained through the Pennsylvania Imagery Navigator (PASDA, 2017). Stereo pair images at the 1:20,000-scale collected during flights contracted by the USDA between 1937 and 1942 were viewed with a Topcon MS-3 Stereoscope. The observed traces were transferred onto the geologic map for further evaluation (see **Figure 3**).

One fracture trace intercepts HDD S3-0620 alignment near the southeast end of the HDD at the S-I2 tributary crossing. This fracture trace corresponds with the shear zones in the Novotni Quarry, and IR location, and an induced groundwater discharge point in the S-I2 tributary.

2.2.5 Karst

Based on published geologic data, no karst features are anticipated within the region of HDD S3-0620 as limestone and marble units are absent from the mapped formations.

2.2.6 Mining

Although Delaware County has an active aggregate and building stone quarry industry, a review of the PADEP eMapPA database revealed no mines or quarries within 1 mile of the HDD S3-0620 ROW (PADEP, 2017). The only quarry identified during field observations was the Novotni Brothers aggregate quarry 700 feet southwest of the drill path.

2.2.7 Rock Engineering Properties

Rock unconfined compressive strength was determined by Terracon for core samples collected from borings B6-24W and B6-24E (see **Attachment B**). Twelve measurements from the ultramafic rocks in boring B6-24W were reported, with a mean compressive strength of 11,135 psi (ranging from 3,090 psi to 31, 075 psi). Mean unconfined compressive strength of gneiss sampled in B6-24E was 17,433 psi (range 10,400 psi to 27,479 psi for the four samples). These values are similar to the compressive strength reported in the literature of 8,381 psi for schist and 25,230 psi for gneiss (Johnson and Degraff, 1988). Note, however, that numerous weathered, fractured, and sheared zones were encountered in these borings and the compressive strength may be significantly lower than that reported for solid core samples selected for strength testing.

2.2.8 Results of Geotechnical Borings

Tetra Tech Borings

Tetra Tech advanced four geotechnical borings (SB-01, SB-02, SB-03, and SB-04) to support the original HDD profile design from September 2016 to January 2016. The locations for these borings are shown on the permitted plan and profile in **Attachment A** and the logs are provided in **Attachment B**. The reported depths to bedrock were >30, 75 31, and 12.3 feet for SB-01 through SB-04, respectively. Groundwater was encountered at depths of 38.0 feet for SB-02, 28.0 feet for SB-03, and 4.0 feet for SB-04. Soils included silty sand, clayey sand, lean clay, and low plasticity silt. Rock core collected in SB-03 reported mafic gneiss with a compressive strength of 8,325 psi.

Terracon Borings

Two geotechnical borings were drilled by Terracon in September 2017 with the objective of collecting rock core from the maximum planned depth of the HDD. B6-24W was located near the northwest entry/exit point and was drilled to a total depth of 300.5 feet. B6-24E was located within the ROW near the southeast entry/exit point and drilled to a depth of 102 feet (see **Attachment A** for locations). Unconsolidated material derived from weathered bedrock were encountered in B6-24W to a depth of 32 feet and in B6-24E to a depth of 25 feet. Some of these materials were saprolitic showing banding from weathered gneiss. In general, these materials were coarse grained in texture showing little fine grain material and low cohesion. Rock coring started below the unconsolidated material. Groundwater was not encountered in B6-24W but was measured at a level of 35 feet below ground surface (ft bgs) in B6-24E after the total depth had been achieved.

Based on core sample descriptions, recovery and Rock Quality Determinations (RQDs) the log for B6-24W reflects relatively weak, fractured, highly weathered gneiss and schist to a depth of 82 feet. Poor recovery and RQD in heavily weathered bedrock persisted to approximately 82 ft bgs. Heavily weathered bedrock zones were noted from 137 to 182 ft bgs and over the five-foot interval from 217 to 222 ft bgs. Recovery was generally good between 82 and 227 ft bgs, but was poor in a zone from 227 to 242 ft bgs. After 242 ft bgs recovery was excellent (consistently 100%). RQD was highly variable from 82 to 142 ft bgs ranging from 16 to 98 percent. Lower values were logged in the zone from 142 to 242 ft bgs. From 242 to total depth at 300.5 ft bgs, RQDs were variable but higher ranging from 43 to 100 percent.

At B6-24E, rock descriptions indicated heavily weathered bedrock from 25 to 57 ft bgs. Poor recovery and RQD generally correlated with the heavily weathered bedrock zone. After 57 ft bgs bedrock was less weathered to the total depth (102 ft bgs), except for heavily weathered rock described for the five-foot run from 67 to 72 ft bgs. After 57 ft bgs recovery and RQD were good and became excellent after 72 ft bgs to total depth.

Allied Well Drilling Borings
In October 2018, PSI/Intertek contracted Allied Well Drilling to advance four geotechnical borings along the HDD S3-0620 alignment. Drilling activities were observed by GES and who prepared the boring logs presented in **Attachment B**. The boring locations were named based upon alignment stationing at locations 3+60, 18+50, 24+00, and 26+75. This placed all four borings in northwest portion of the HDD within the mapped Ultramafic Rocks. The total boring depths ranged from 60 (Sta. 18+50) to 360 (Sta. 3+60) ft bgs. For these borings, the highly weathered bedrock/saprolitic zone ranged from 30 to 49.3 ft bgs.

For the rock cores, after the first couple of core runs, most sections of core in all four borings showed good to excellent recovery ranging from 70 to 100 percent. Boring 3+60, 24+00 and 26+75 had two zones showing 10 to 25 feet of lower core recoveries ranging from 40 to 70 percent. The bottom ten feet of coring at 3+60 (350 to 360 ft bgs) showed zero percent recovery.

RQDs in all four borings were highly variable. RQD in rock cores from boring 3+60 was generally very poor to poor (0 to 50 percent) from the start of coring at 49.3 to 160 ft bgs. From 160 to 345 ft bgs RQDs were generally good to excellent (75 to 100 percent). Zones of weaker rock were interbedded from 170 to 175 ft bgs, 260 to 275 ft bgs, and 290 to 300 ft bgs; and very poor RQD was logged for the last 15 feet of boring 3+60.

The RQD for cores obtained from boring 18+50 were all poor to fair (25 to 75 percent), except for the five-foot run from 70 to 75 ft. bgs, which showed good RQD (88 percent).

The RQD in boring 24+00 was highly variable to a depth of 169 feet, ranging from very poor to fair (0 to 75 percent) with a large portion of very poor zones. From 169 to 194 ft bgs the RQD was good to excellent. The last five-foot core run from 194 to 198 ft bgs showed fair RQD at 62 percent.

The RQD in boring 26+75 was mostly very poor (0 to 25 percent) with a few five-foot intervals of poor RQD rock (25 to 50 percent). Only one five-foot interval of good RQD was logged from 121 to 126 ft bgs.

2.3 Hydrogeology

In the humid climate of Southeastern Pennsylvania, groundwater generally flows downward from recharge zones in the uplands, laterally through primary pore structures, fractures and bedding planes, and then flows upward to discharge into creeks and wetlands. At HDD S3-0620 groundwater is expected to flow naturally from the northwest uplands to the southeast, discharging to wetland W-I1, Chester Creek and stream S-I2.

2.3.1 Occurrence of Groundwater

Groundwater storage and flow at HDD S3-0620-20 occurs in relatively competent bedrock in fractures, faults, and lithologic contacts where differential weathering has occurred. Groundwater is expected to flow preferentially through the larger fractures, faults, and shear zones. In this setting, groundwater can also occur perched in the saprolitic zone. Here groundwater occupies primary pore space within coarse-grained material and in residual fractures remnant within weathered bedrock. (Low et al., 2002).

2.3.2 Water Level

Wet soils was encountered in borings SB-01 (23 ft bgs), SB-02 (38 ft bgs), SB-03 (28 ft bgs), and SB-04 (4 ft bgs). Water levels were measured inside the augers at SB-02 (38 ft bgs) and SB-4 (4 ft bgs).

The log from Terracon boring B6-24W, located near the northwestern entry/exit on the permitted profile, indicates groundwater was not encountered and the log from boring B6-24E, located near the southeastern entry/exit on the permitted profile, indicates groundwater level of 35 ft bgs after the boring was completed. B6-24E was drilled proximal to SB-04 that had a reported water level of 4 ft bgs. It may be that the shallow water level at SB-04 represents localized shallow perched water and the deeper water level in B6-24E is more representative of the regional water table.

A review of the PaGWIS database (PA DCNR, 2017) identified eight (8) residential wells within one mile of HDD S3-0620. The median depth to water was 39 feet, ranging from 15 to 51 feet.

2.3.3 Ground Elevation Between HDD Entry/Exits

The permitted HDD profile drops 208 feet from the northwestern entry/exit (elevation 277 ft amsl) to the southeastern entry/exit (elevation 69 ft amsl). The lowest topographic point along the alignment is stream S-I2 at an elevation of approximately 65 ft. amsl, located 102 feet northwest of the southeast entry/exit. Assuming a water table mound in the upland along the northwest section of the profile and groundwater discharge area near stream S-I2 and Chester Creek, this profile represents a high probability of creating a groundwater discharge at the southeast entry/exit upon completion of the pilot bore for the HDD.

Alternatively, the proposed major modification consists of two direct bores, one conventional auger bore and open trench sections. The profiles and locations for the direct bores and conventional auger bore are provided in **Attachment A**. The direct bore furthest to the northwest is in the upland area, is relatively horizontal, has a horizontal length of 819 feet and the maximum depth to the boring will be approximately 18 feet. At this shallow depth, in this setting and with this geometry there is minimal risk of a groundwater discharge created by the boring.

Moving southeast the next direct bore underlies the transition from the upland area (elevation 254 ft amsl) to a lower surface elevation area approaching the flood plain of Chester Creek (elevation 106 ft amsl). The deepest part of the profile is approximately 62 ft bgs. Given this geometry, there is a potential to create a groundwater discharge at the southeast end of the bore. However, because the direct pipe method pulls a large diameter pipe string as the cutting head advances and the annulus between this pipe and borehole is small, there is less probability of a groundwater discharge, than with conventional HDD drilling where a large annulus is created between the borehole and drill string.

The third boring, a conventional auger bore, is furthest southwest along the alignment, crosses under Glenn Riddle Road, and has a horizontal distance of 93 feet. The bore will be set to a depth of 14 feet on the northwest side of the road and to a depth of 11 feet on the southeast side of the road. Shallow (perched) groundwater may be encountered at this location given the water level measured in SB-04; however, the drill will be approximately horizontal and there is very little risk of creating a groundwater discharge.

2.3.4 Local Water Supply Wells

Median yield reported for eight nearby (within one mile) residential wells in the PaGWIS database (PA DCNR, 2017) was 10.2 gpm, ranging from 2 to 50 gpm. This is consistent with the median well yield of 12 gpm reported in the literature for wells completed in gneiss throughout Southeast Pennsylvania (Low et al., 2002).

2.3.5 Water Supply Wells within 450 of ROW

During the planning for advancement of the HDD 620 drills, a survey of landowner parcels within 450 feet of the HDD alignment was performed. Four landowners with private water supplies on parcels that

intersected the 450-foot boundary responded positively to SPLP's offer to have their wells tested (**Figure 4**). Only two of the wells, WL-09202017-608-01 and WL-01262017-551-03 actually fall within the 450-foot boundary. Well WL-09202017-608-01 is located relatively far from the HDD alignment (3392 feet) and WL-01262017-551-03 is located relatively close to the alignment (approximately 66 feet south of the southeast entry/exit). Well depth information was not provided by either well owner however it can be assumed that the HDD profile transects water producing zone in bedrock that are the source of water to these well. None of the well owners accepted an offer by SPLP to provide temporary water during construction associated with the 16-inch pipe and no water supply impact complaints were registered during that time.

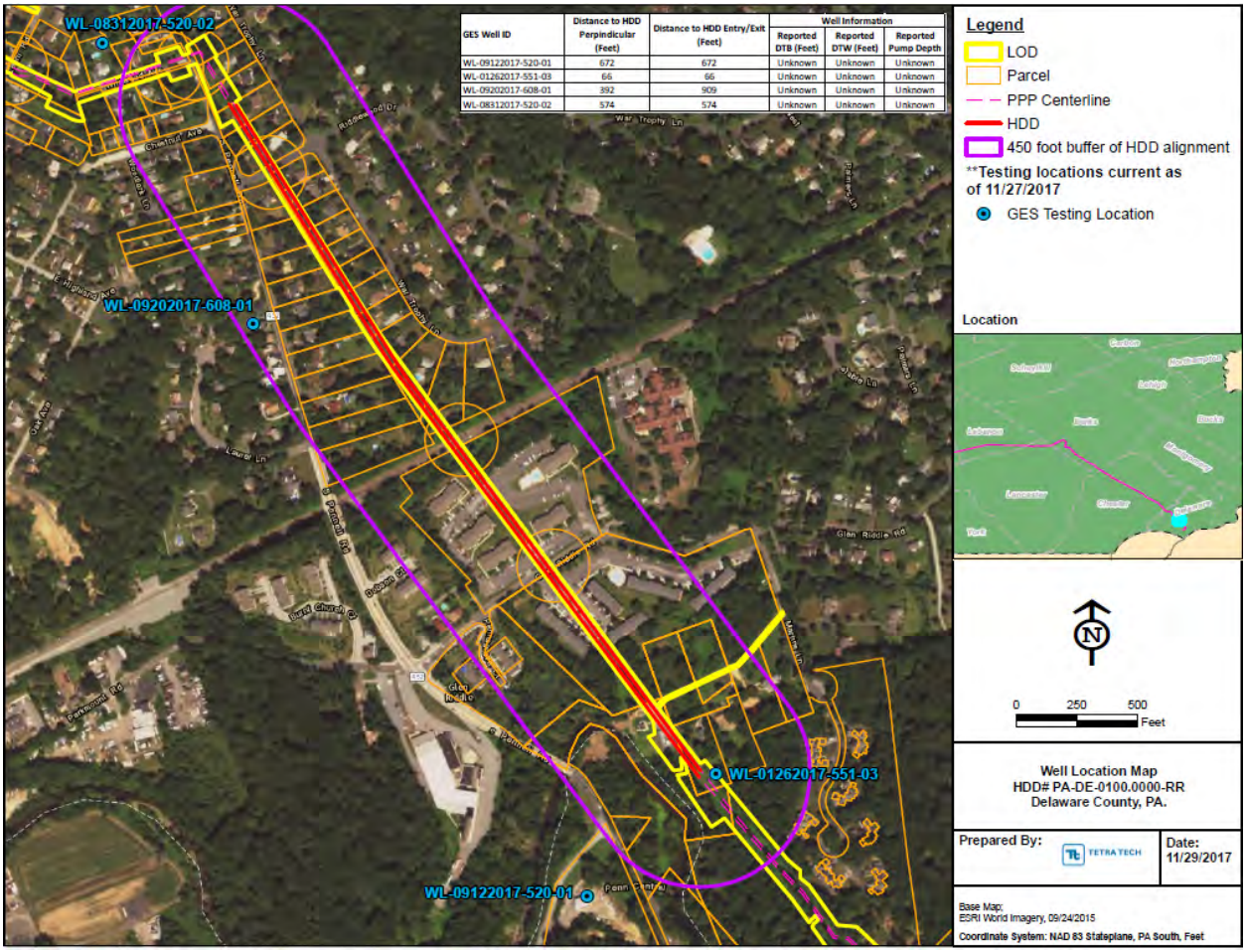

Figure 4. 450-ft Water Supply Survey Map

Aqua America operates a municipal surface water intake on Chester Creek 170 ft southwest of the ROW, 216 ft upstream from where tributary S-I4 discharges to Chester Creek.

2.4 Summary of Geophysical Studies

Geophysical studies were performed for S3-0620 by Quantum Geophysics in three separate survey events. The first event was conducted in June 2018 and used MASW (multi-channel analysis of surface waves), microgravity, and 3D electrical resistivity imaging (ERI) geophysical methods. The second event was conducted in September 2018 and used microgravity survey and a ground penetrating radar (GPR) methods. The third event was conducted between September and November 2018 and used MASW and 3D-ERI geophysical methods. Referencing stationing on the permitted plan and profile, the first geophysical survey

event covered the alignment ROW from approximately Station 25+00 to 29+00, the second event covered the alignment ROW from approximately Station 22+80 to 29+50, and the third event covered the alignment ROW from approximately Station 23+20 to 29+70 (see **Attachment A**). The reports for the three geophysical survey events are provided in **Attachment C**.

The basic findings of the three reports combined are that the depth of highly weathered bedrock is approximately 50 to 67 feet over the Ultramafic Rock (located in the northwest portion of the profile) and 18 to 38 feet deep over the Wilmington Complex rocks (located in the southeastern portion of the profile). The studies identified four low gravity anomalies potentially representing voids, fractures, or localized depressions in the top of competent bedrock. These anomalies were best observed in the merged Residual Gravity Contour Map, a section of which is shown in **Figure 5** along with the locations of IRs. The low gravity anomaly #1 (farthest northwest) measures approximately 30' x 30', is located at the entrance to the parking lot from Glen Riddle Road, is not associated with an IR, and was not corroborated by data from the other geophysical methods. Low gravity anomaly #2 is located in the parking lot and the grassy median between two apartment buildings. It is the largest of the four anomalies, extends from approximately station 24+50 to station 28+00, and is associated with two IR areas located between the apartment buildings, approximately between station 26+70 and station 27+50. Around station 26+00, residual gravity progressively decreased towards the western apartment building. GES advanced two shallow geotechnical boreholes (620-#20 and 620-#44 on **Figure 5**) to determine whether the low residual gravity measurements near the building were caused by voids. Though no voids were reported, the low number of blow counts (1 to 2 per 6 inches) need to advance the split-spoon sampler were very close to what is typically observed when driving a sampler through soils in a collapsed void. No drilling fluid was observed in the soil samples.

Low gravity anomaly #3 is located in the wetlands along the eastern side of the ROW. It is centered at about station 29+00, and is associated with two IRs. The IRs straddle a linear expression of the anomaly (at about station 28+85) which is suggestive of a fracture zone. Low gravity anomaly #4 is located at approximately station 30+10 and is also linear in shape potentially reflecting a fracture zone.

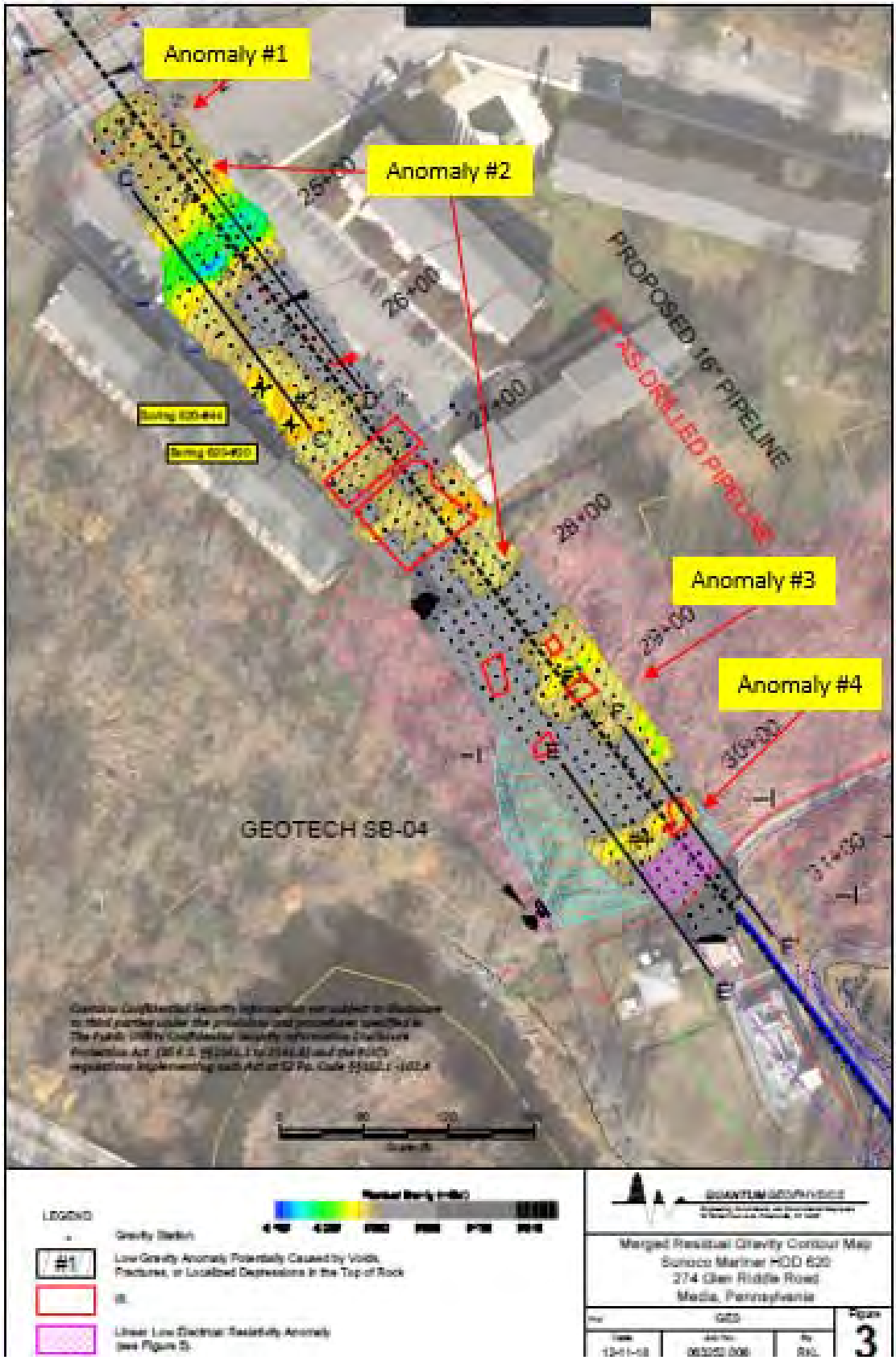

Figure 5. Geophysical Survey Map (Quantum Geophysics, December 2018)

3.0 OBSERVATIONS TO DATE

3.1 During Construction for 16-inch line

Hydrogeologic conditions associated with HDD S2-0620 were problematic during attempts to prepare the bore to install the 16-inch pipe. HDD activities at this location spanned from June 2017 to October 2018. During that time the 16-inch pipe bore was fully drilled and partially swabbed (horizontal distance of approximately 34+47 feet) but the 16-inch pipe was never pulled. Most drilling advanced from the southeast entry/exit to the northwest entry/exit. At one point, 12-inch casing was installed 296 feet northwest from the southeast entry/exit in an attempt to mitigate IRs and groundwater flow to the surface. At another time, an attempt was made to intercept the pilot boring by drilling an intercept bore southwest from the northwest entry/exit, but was unsuccessful. Eventually SPLP decided to abandon the original 16-inch HDD and install a short HDD for a 16-inch pipe connecting the valve station due west of Station 31+50 to the original southeast entry/exit point. This allowed start of service for one of the two planned ME II pipelines in Spread 6, using a section of an existing 12-inch pipeline that connects to the valve station. Completion of the ME II 16-inch line and 24-inch line in Spread 6 will be facilitated by the installation of both lines across the former S3-0620 alignment using the proposed combination of trenching, two direct bores and one conventional auger bore.

Several upland and water resource IRs, groundwater discharges, and two land subsidence features occurred during attempts to construct the 16-inch pipe at HDD-S3-0620. All of these issues occurred southwest of Glen Riddle Road within the Tunbridge Apartment Building complex and along a vegetated slope between the apartment complex and stream S-I2 to the southeast. The hydrogeologic factors that contributed to these issues are the deeply weathered and fractured metamorphic bedrock of the Ultramafic Rock and Wilmington Complex rock and the elevation difference along the profile between the upland area northwest of Glen Riddle Road and lowlands associated with flood plain of stream S-I2 and Chester Creek. Based on geotechnical borings and geophysical studies the depth of unconsolidated saprolitic materials across the alignment can be as much as 75 feet and very poor RQD bedrock can persist to greater depths. The overburden along the permitted profile for the 20-inch line, which was being used for 16-inch line construction, ranged from 0 to 60 feet southeast of Glen Riddle Road (see **Attachment A**). Drilling the pilot boring from the lowlands under the upland area to the northwest, provided a preferential pathway for groundwater to flow, under a pressure head originating within the upland, and created the groundwater discharges. Additional related factors appear to be the contact between the Ultramafic Rock and Wilmington Complex Rocks that occurs near Station 27+00, where IRs and a groundwater discharge occurred; and a northeast trending fracture trace plus geophysical anomalies indicating bedrock fracture zones that were preferred pathways for drilling fluid and groundwater movement. Groundwater yield and unconsolidated weathered bedrock material hampered attempts to keep the reamed borehole open. After multiple swab passes the removal of overburden materials contributed to the creation of two subsidence features. Grouting events have been completed to remediate the two subsidence features and to abandon the HDD borehole drilled for the 16-inch pipe.

The direct pipe and conventional auger boring technologies eliminate the risk of IRs in that direct pipe installations features total control of the drilling fluid pathway and conventional auger bore drilling does not utilize drilling fluids. In addition, simultaneous and continuous installation of the 48-inch casing and conveyance of drilling fluids and cuttings inside the casing, eliminates the need to swab the borehole, eliminating excess removal of unconsolidated material, preventing the development voids and associated ground subsidence features.

3.2 On Other HDDs in Similar Hydrogeologic Settings

IRs have occurred during the drilling of other ME II HDDs in the metamorphic rocks of Chester and Delaware County. These IRs have typically occurred where bedrock is densely fractured (sometimes

indicated by a fracture trace or fracture trace intersection) or where the profile approaches an entry/exit point, closer to the surface, where unconsolidated overburden material thins and there is less overburden strength to contain drilling fluid pressures. In some cases, overburden thickness is reduced where the deepest part of the profile passes under a stream occupying a section of the alignment with the lowest surface elevation along the profile.

4.0 SUMMARY AND CONCLUSIONS

4.1 HDD Site Conceptual Model

The geologic formations within the hydrogeologic setting associated with the alignment for the original permitted S3-0620 20-inch pipe includes the Ultramafic Rocks to the northwest and Wilmington Complex Rocks to the southeast. The change in surface elevation along the profile between the upland area northwest of Glen Riddle Road and lowlands associated with flood plain of stream S-I2 and Chester Creek occurs at the contact between the two formations (approximately Station 27+00 on the permitted profile, see **Figure 2** and **Attachment A**). Geotechnical borings and geophysical surveys show the thickness of highly weathered bedrock over both formations can be as large as 75 feet and very poor RQD rock can persist much deeper.

IR events, during attempts to install the 16-inch pipe, happened because the highly weathered bedrock overburden located at the areas of the occurrences was 0 to 60 feet thick and the material strength was insufficient to contain drilling fluid pressures. Groundwater discharges occurred because HDD drilling contributed a preferential pathway for groundwater flow from higher pressure head, in the uplands to the northwest, to lower head in the lowlands to the southeast. It appears as though the contact between the Ultramafic Rocks and Wilmington Complex and other fracture zones were factors contributing to the location of some of the IRs and groundwater discharge points.

Four subsurface void zones were identified along the HDD alignment during drilling activities for the 16-inch line. These were created by the removal of unconsolidated, highly weathered, bedrock materials by multiple swabs in an attempt to keep the bore open to pull the pipe. Two surface subsidence features were identified, as well. Eventually SPLP suspended any efforts to complete construction of the 16-inch line and the voids and the abandoned 16-inch pipe bore were sealed with grout.

SPLP is proposing a combination of alternative construction methods to install both the 16-inch and 20-inch NGL pipelines along the alignment of HDD S3-0620 intended to eliminate IRs, void development, surface subsidence and groundwater discharge that occurred during HDD construction activities. The alternative methods include one direct pipe drill from Station 2+45 to 10+65, a second direct pipe drill from Station 10+65 to 20+60, and a conventional auger bore under Glenn Riddle Road from Station 22+65 to 23+66 (using permitted HDD profile stationing, see **Attachment A**). All of the remaining portions of the permitted HDD alignment would be completed using conventional trenching construction. This includes the crossing of wetland W-1 and stream S-12.

The direct pipe construction method uses a tunneling drill head to advance and steer excavation of the pipeline borehole along the design profile. A large steel casing, slightly smaller than the cutter, is advanced directly behind the drill head such that the bore is continuously and simultaneously cased during completion. Electrical power and drilling fluid discharge and suction lines lay within the steel casing providing for total control of the drilling fluid pathway. The volume of drilling fluid required is much less than that required for standard HDD drilling and the annulus between the borehole wall and casing is less than 2 inches. As such, this method eliminates the risk of IRs. In addition, simultaneous and continuous installation of the 48-inch casing and conveyance of drilling fluids and cuttings inside the casing, eliminates the need to swab the borehole, eliminating excess removal of unconsolidated material, preventing the development voids and associated ground subsidence features. For the direct pipe installations, SPLP will install a 48-inch casing. Once the direct pipe casing is in place, the 16- and 20-inch NGL pipes will be installed inside the casing. Spacers will used to prevent the two pipes from contacting each other or contacting the external casing during installation.

The proposed direct bore furthest to the northwest is entirely in the upland, has a horizontal distance of 819 feet, has a relatively flat profile radius of 4,200 feet and a maximum depth of approximately 20 ft bgs. This drill has no IR risk and there is a very small risk for ground subsidence or a groundwater discharge.

The second proposed direct bore has a horizontal distance of 995 feet and travels under the slope on the surface connecting the upland area to the lowland area. The northwest entry/exit is at an elevation of 254 ft amsl and the southwest entry exit is at 106 ft amsl. The profile radius is 2,700 feet and the maximum thickness of overburden is approximately 62 feet. This direct bore also has no IR risk and very small subsidence risk. Given the geometry and depth of the profile, there is a small risk for a groundwater discharge. The small diameter of the annulus between the borehole and casing reduces that risk; however, the contractor should plan to manage a groundwater discharge, if it occurs.

The conventional auger bore drilling method is used for shorter straight profiles as the drill head is not steered. Entry and receiving pits are required at either end of the drill to provide space for the drilling equipment and tooling, and too facilitate the pipe pull. These pits are excavated to depths required to accommodate the entry and exit elevations for the bore. As with the direct pipe method, a steel casing is continuously and simultaneously installed behind the cutter to hold the bore open and has a diameter that is only slightly smaller than the bore hole diameter. Auger flights behind the cutter remove cuttings through the casing to the entry point as the cutter turns. No drilling fluids are used as the cutter is lubricated and cooled using water. As such, this method also eliminates the risk of IRs. In addition, as with the direct pipe method, simultaneous and continuous installation of the 48-inch casing and conveyance of cuttings inside the casing, eliminates the need to swab the borehole, eliminating excess removal of unconsolidated material, preventing the development voids and associated ground subsidence features. SPLPs proposed alternative is to install a 48-inch casing by conventional auger bore method, which will be large enough to accommodate both the 16-inch and 20-inch ME II pipelines. Once the casing is installed, the 16- and 20-inch NGL pipes will be installed inside the casing. Spacers will used to prevent the two pipes from contacting each other or contacting the external casing during installation.

The conventional auger bore is located in the lowland and crosses under Glen Riddle Road. It has a horizontal distance of 98 feet and is a straight drill with a slight dip to the southeast. Bore pits will be constructed on either side of Glenn Riddle Road. The bore pit northwest of the road will be excavated to a maximum depth of 14 feet and the bore pit southeast of Glen Riddle Road will be excavated to a depth of 11 feet. This bore has no risk of an IR or groundwater discharge and, very small subsidence risk. Given the topographic position for the drill, shallow groundwater may be encountered in the boring pits.

As proposed, installation of the remainder of the 16-inch and 20-inch lines along the originally permitted S3-00620 alignment will be accomplished by standard trench construction to a depth of approximately four feet. Portions of the trenching will cross wetland W-1 and stream S-12. Contractors will install these crossing in accordance with the methods outlined in the major modification of the Chapter 105 permit for this crossing under review by the Pennsylvania Department of Environmental Protection (Department).

4.2 Conclusions and Recommendations

Hydrogeologic conditions encountered during attempts to install the 16-inch pipe at HDD S3-0620 presented difficulties leading to IRs, groundwater discharges and land subsidence. SPLP is proposing to greatly reduce the risk of these events during construction of both the 16-inch line and the 20-inch line along the original permitted alignment using a combination of pipe installation methodologies; including, direct pipe, conventional auger bore, and standard trench installations to simultaneously install both pipes. Taking this approach IR risk is eliminated and subsidence risk is very small. Given the geometry and depth of the profile for the second direct bore there is a risk for a groundwater discharge due to the elevation

change along the profile. In addition, groundwater seepage may be encountered in the boring pits excavated for the conventional auger bore under Glen Riddle Road.

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PaGEODE, Pennsylvania Department of Conservation and Natural Resources. http://www.gis.dcnr.state.pa.us/geology/. Accessed 2019.

PASDA, Pennsylvania Spatial Data Access , http://www.pasda.psu.edu/.

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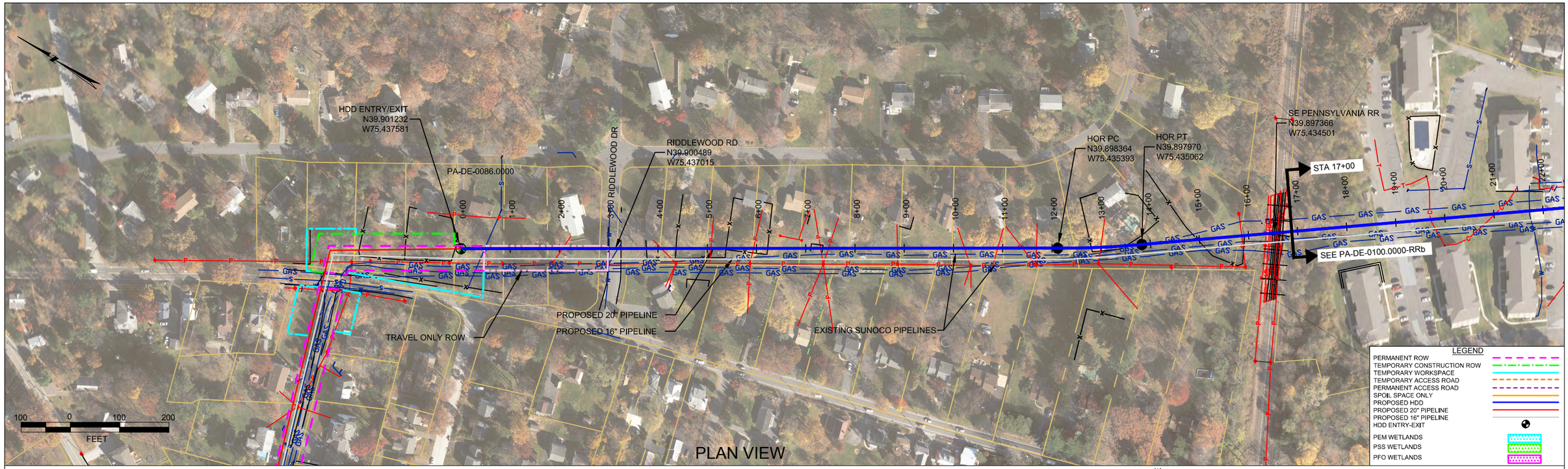
Attachment A

Plan and Profiles

Permitted HDD S3-0620 Plan and Profile (rev. 5/10/16)

Permitted HDD S3-0620 Plan and Profile Showing Proposed Bores

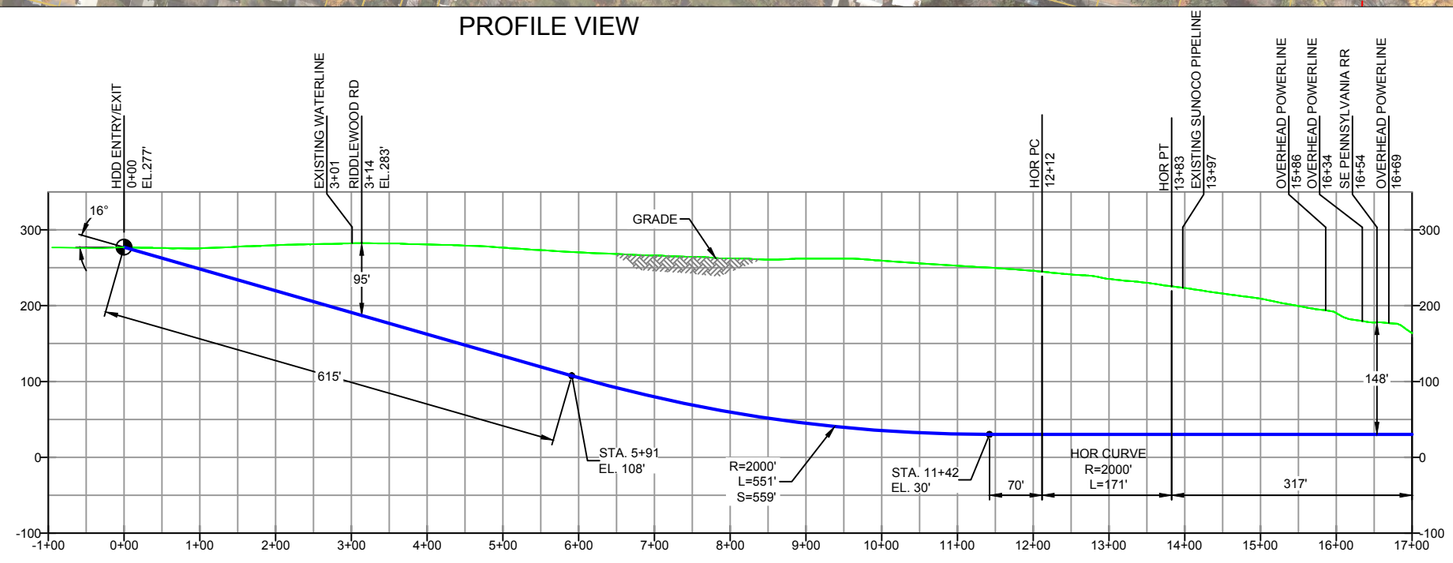
Direct Bores and Auger Bore Plan and Profiles



PLAN VIEW

DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP
S3-0620

PROFILE VIEW



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=): 3338'
   HDD PIPE LENGTH (S=): 3373'
   20" x 0.456" W.T., X-65, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 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.
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12. BLASTING NOT PERMITTED.
13. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-6.18	TO	ES-6.20	EROSION & SEDIMENT PLAN
SHEET 12	TO	SHEET 13	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP1	REVISED PER PADEP COMMENTS	MRS	05/10/16	RMB	05/10/16	AAW	05/10/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ISSUED FOR BID / DESIGN CHANGE	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	JAM	03/27/15	RMB	03/27/15	AAW	03/27/15

Sunoco Logistics Partners L.P.

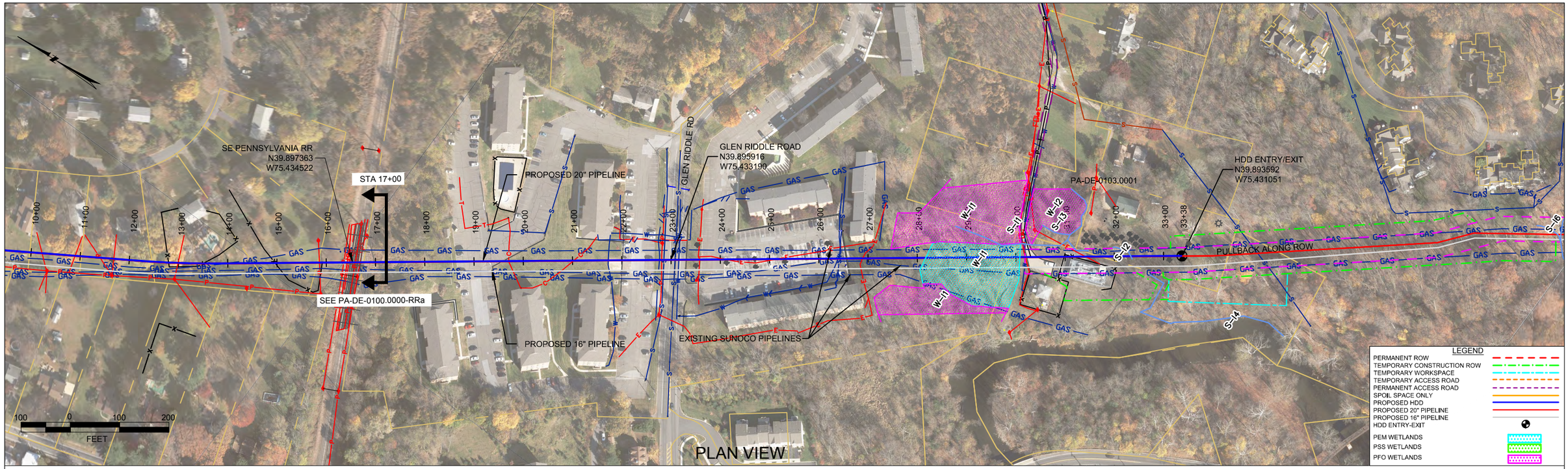
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
GLEN RIDDLE RD, SOUTHEASTERN PENNSYLVANIA RR
PENNSYLVANIA PIPELINE PROJECT

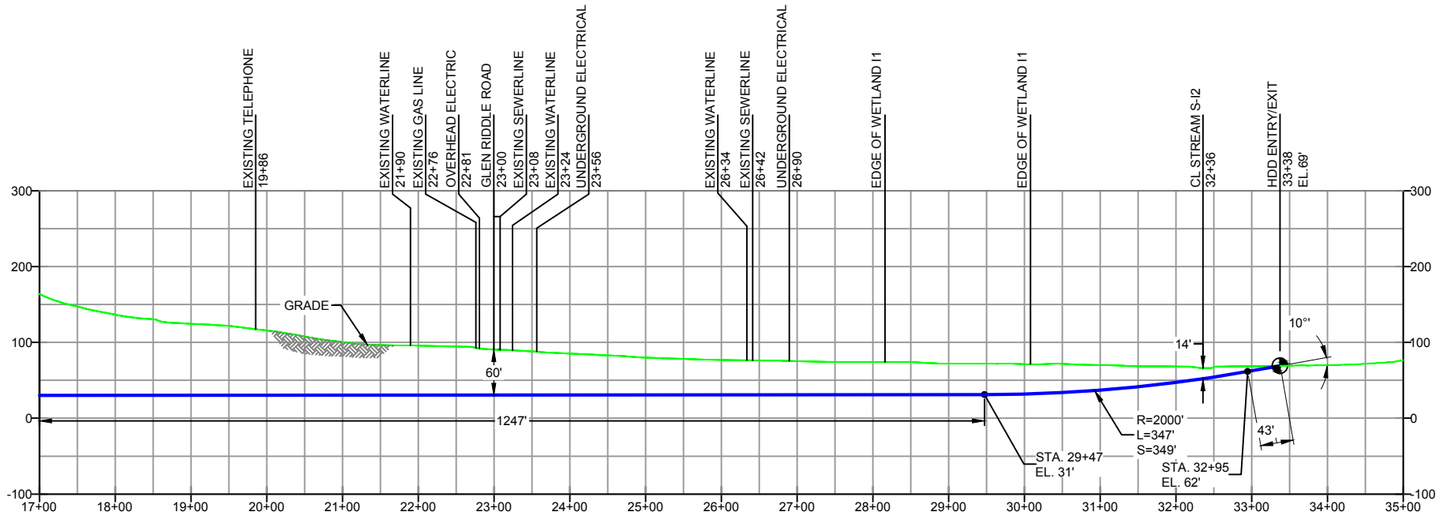
SCALE: 1"=200'

DWG. NO: PA-DE-0100.0000-RRa



PLAN VIEW

PROFILE VIEW



DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP
S3-0620

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   HDD PIPE LENGTH (S=):3373'
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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

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REF. DRAWING

ES-6.18	TO	ES-6.20	EROSION & SEDIMENT PLAN	
SHEET 12	TO	SHEET 13	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	NO.

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
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EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
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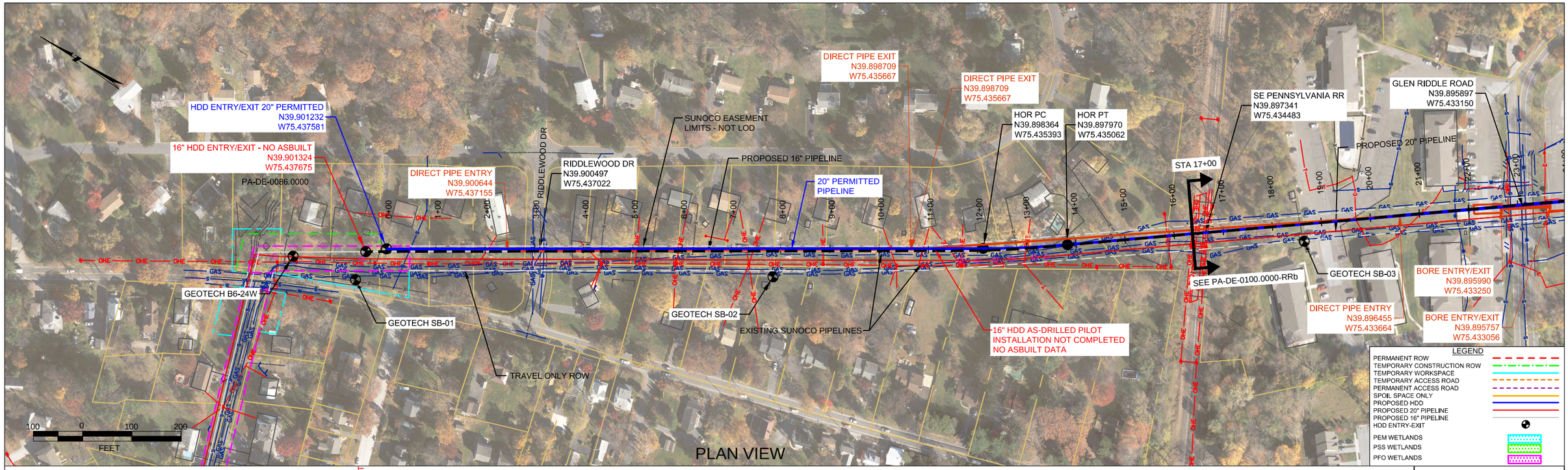
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

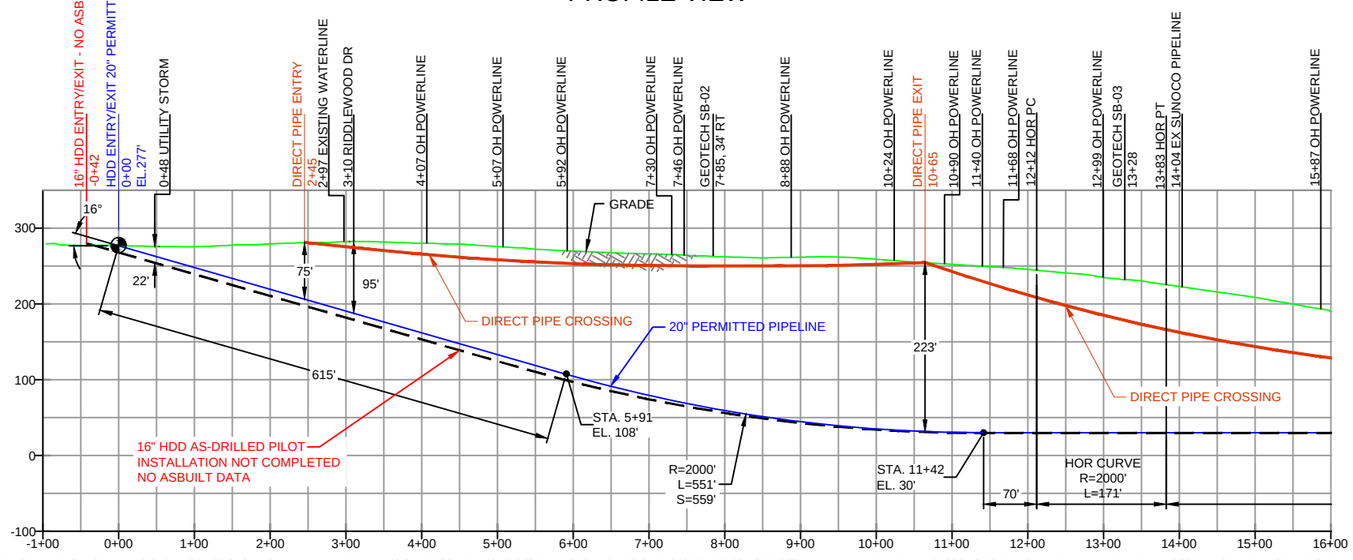
20-INCH HORIZONTAL DIRECTIONAL DRILL
GLEN RIDDLE RD, SOUTHEASTERN PENNSYLVANIA RR
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' | DWG. NO: PA-DE-0100.0000-RRb



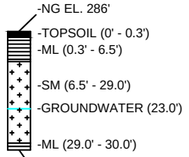
PLAN VIEW

PROFILE VIEW

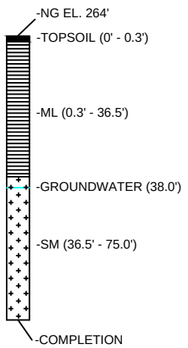


DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP
S3-0620

GEOTECH SB-01



GEOTECH SB-02



NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

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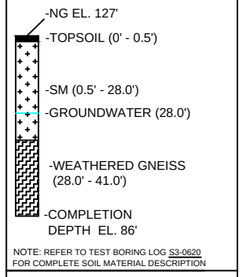
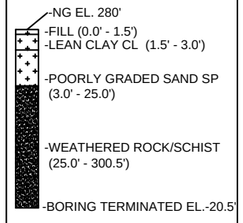
12. BLASTING NOT PERMITTED.

GEOTECH SB-03



NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-24W



NOTE: REFER TO TEST BORING LOG B6-24W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

FOR REEVALUATION USE ONLY

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
A	ISSUED FOR REVIEW	MRS	04/22/19	RMB	04/22/19	AMC	04/22/19

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GLEN RIDDLE RD, SOUTHEASTERN PENNSYLVANIA RR
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200'

DWG. NO: PA-DE-0100.0000-RRa

DIRECT PIPE EXIT
N39.898709
W75.435667

DIRECT PIPE EXIT
N39.898709
W75.435667

HOR PC
N39.898364
W75.435393

HOR PT
N39.897970
W75.435062

STA 17+00

SE PENNSYLVANIA RR
N39.897341
W75.434483

20" PERMITTED PIPELINE

PROPOSED 20" PIPELINE

GLEN RIDDLE ROAD
N39.895897
W75.433150

GLEN RIDDLE RD

16" INADVERTENT RETURN (IR)-1
N39.895367
W75.432675

16" HDD AS-DRILLED PILOT
INSTALLATION NOT COMPLETED
NO ASBUILT DATA

16" INADVERTENT RETURN (IR)-2
N39.893830
W75.431250

16" HDD ENTRY/EXIT - NO ASBUILT
N39.893354
W75.430797

PA-DE-0103.0001

PULLBACK ALONG ROW

SEE PA-DE-0100.0000-RR□

GEOTECH SB-03

BORE ENTRY/EXIT
N39.895990
W75.433250

DIRECT PIPE ENTRY
N39.896455
W75.433664

BORE ENTRY/EXIT
N39.895757
W75.433056

SUNOCO EASEMENT
LIMITS - NOT LOD

EXISTING SUNOCO PIPELINES

GEOTECH SB-04

PROPOSED 16" PIPELINE

16" INADVERTENT RETURN (IR)-3
N39.893700
W75.431215

16" INADVERTENT RETURN (IR)-4
N39.893600
W75.431262

HDD ENTRY/EXIT 20" PERMITTED
N39.893593
W75.431032

GEOTECH B6-24E

100 0 100 200
FEET

PLAN VIEW

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

DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP
S3-0620

PROFILE VIEW

16+36 OH POWERLINE
16+64 SE PENNSYLVANIA RR
16+69 OH POWERLINE
19+56 DRIVEWAY
19+71 UTILITY TV UG
DIRECT PIPE ENTRY 20+60
21+03 UTILITY TV UG
21+73 EXISTING WATERLINE
BORE ENTRY/EXIT 22+65
22+81 EXISTING GAS LINE
22+81 OH POWERLINE
23+07 EXISTING SEWERLINE
23+09 GLEN RIDDLE ROAD
23+16 EXISTING WATERLINE
23+58 UG ELECTRICAL
BORE ENTRY/EXIT 23+66
16" INADVERTENT RETURN (IR)-1 25+44
26+39 EXISTING WATERLINE
26+41 EXISTING SEWERLINE
26+90 UG ELECTRICAL
GEOTECH SB-04 29+68, 95' RT
30+19 EXISTING WATERLINE
30+19 UTILITY FIBEROPTICS
16" INADVERTENT RETURN (IR)-2 32+32
16" INADVERTENT RETURN (IR)-3 32+76
16" INADVERTENT RETURN (IR)-4 32+98
HDD ENTRY/EXIT 20" PERMITTED 33+38 EL. 69'
16" HDD ENTRY/EXIT - NO ASBUILT 34+47

GRADE
147'
20" PERMITTED PIPELINE
76'
52'
60'
48'
48'
43'
23'
26'
20'
43'
10"'
DIRECT PIPE CROSSING
CASED BORE CROSSING
STA. 29+47
EL. 31'
R=2000'
L=347'
S=349'
STA. 32+95
EL. 62'
16" HDD AS-DRILLED PILOT
INSTALLATION NOT COMPLETED
NO ASBUILT DATA
1565'

16+00 17+00 18+00 19+00 20+00 21+00 22+00 23+00 24+00 25+00 26+00 27+00 28+00 29+00 30+00 31+00 32+00 33+00 34+00 35+00
300 200 100 0 -100

GEOTECH SB-03
- NG EL. 127'
- TOPSOIL (0' - 0.5')
- SM (0.5' - 28.0')
- GROUNDWATER (28.0')
- WEATHERED GNEISS (28.0' - 41.0')
- COMPLETION DEPTH EL. 86'

GEOTECH SB-04
- NG EL. 72'
- TOPSOIL (0' - 0.1')
- SC (0.1' - 4.0')
- GROUNDWATER (4.0')
- CL (4.0' - 6.5')
- SM (6.5' - 12.0')
- WEATHERED GNEISS (12.0' - 12.3')
- COMPLETION DEPTH EL. 60'

NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-24E
- NG EL. 72'
- TOPSOIL (0.0' - 0.3')
- SILTY SAND SM (0.3' - 9.0')
- SEVERELY WEATHERED ROCK (9.0' - 25.0')
- SAMPLER REFUSAL (20.2')
- GROUNDWATER (35.0')
- MAFIC GNEISS (25.0' - 102')
- BORING TERMINATED EL.-30.0'

NOTE: REFER TO TEST BORING LOG B6-24E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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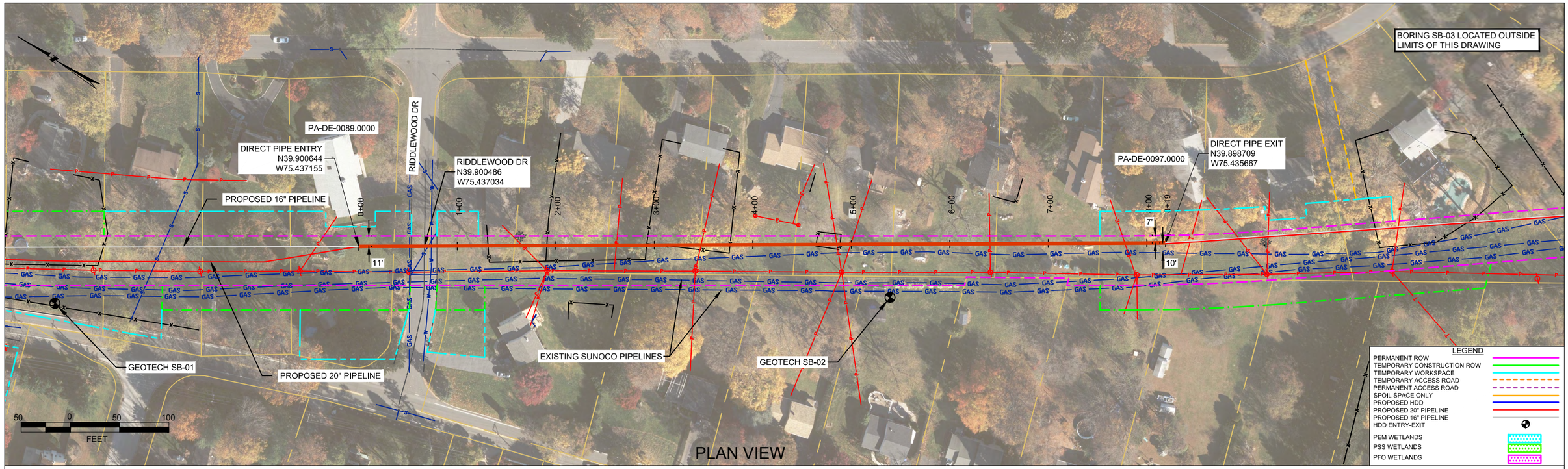
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' | DWG. NO: PA-DE-0100.0000-RR□



PLAN VIEW

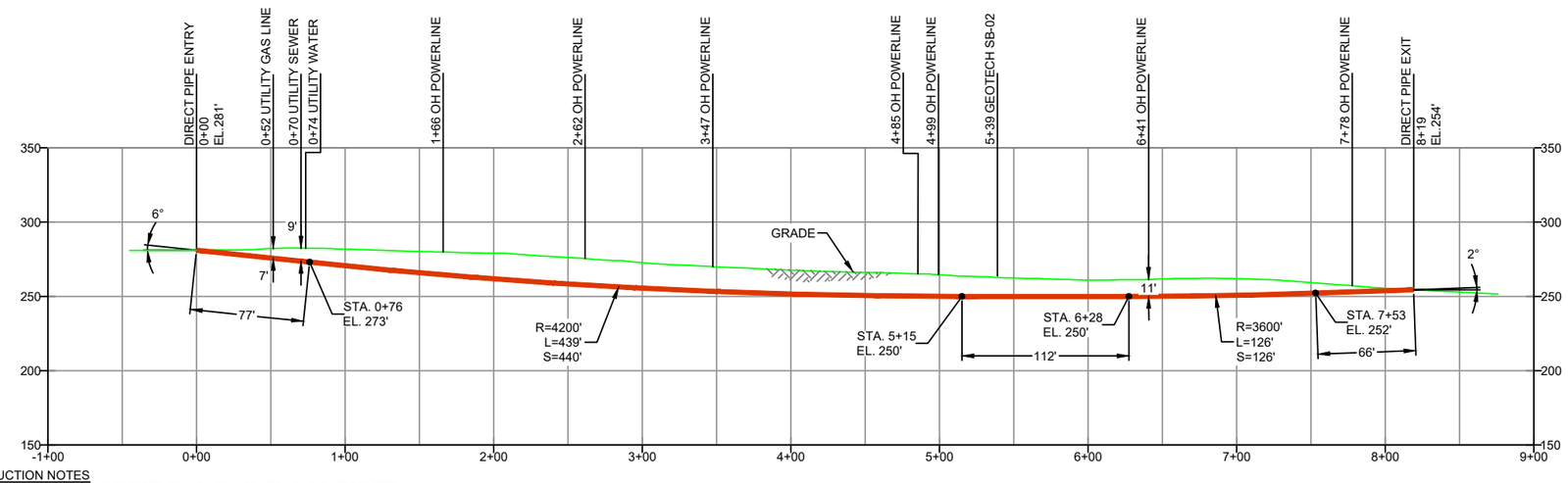
DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP

PROFILE VIEW

GEOTECH SB-01
-NG EL. 286'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 6.5')
-SM (6.5' - 29.0')
-GROUNDWATER (23.0')
-ML (29.0' - 30.0')
-COMPLETION DEPTH EL. 256'

GEOTECH SB-02
-NG EL. 264'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 36.5')
-GROUNDWATER (38.0')
-SM (36.5' - 75.0')
-COMPLETION DEPTH EL. 189'

NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION



GEOTECH SB-03
-NG EL. 127'
-TOPSOIL (0' - 0.5')
-SM (0.5' - 31.0')
-GROUNDWATER (28.0')
-WEATHERED GNEISS (28.0' - 41.0')
-COMPLETION DEPTH EL. 86'

NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

CONSTRUCTION NOTES

1. 20" AND 16" PIPE WILL BE BUNDLED TOGETHER AND INSTALLED INTO A SINGLE WELDED STEEL CASING (42" OD, 1.00" WT, X-70) USING DIRECT PIPE METHOD.
2. 20" WELDED STEEL PIPE: 20" OD x 0.456" WT, X-65, API-5L, PSL2, ERW, BFW, DRL
3. 16" WELDED STEEL PIPE: 16" OD x 0.438" WT, X-70, API-5L, PSL2, ERW, BFW, DRL
   HORIZONTAL PIPE LENGTH (L) = 819'
   PIPE LENGTH (S) = 821'
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
4. 20" DESIGN PRESSURE: 1480 PSIG
   CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF PIPE STRING TO MINIMUM 1850 PSIG.
5. 16" DESIGN PRESSURE: 2100 PSIG
   CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF PIPE STRING TO MINIMUM 2625 PSIG.
6. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
7. THE COATING ON THE CARRIER PIPE SHALL BE INSPECTED IMMEDIATELY PRIOR TO ITS INSTALLATION AND ALL DAMAGED COATING SHALL BE REPAIRED IN ACCORDANCE WITH SUNOCO'S PIPELINE COATING SPECIFICATIONS.
8. INSTALL CATHODIC PROTECTION TEST LEADS AS SPECIFIED ON THE ALIGNMENT SHEETS OR SUNOCO CORROSION TECHNICIAN.
9. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
10. WELDED JOINTS INSIDE R.O.W. SHALL BE 100% X-RAYED.
11. CONTRACTOR WILL MAINTAIN A MINIMUM 4' OF COVER TO THE TOP OF PIPE USING FIELD BENDS.
12. CONTRACTOR WILL MAINTAIN A MINIMUM 24" OF COVER FROM ALL EXISTING UTILITIES.
13. CONTRACTOR WILL MAINTAIN A MINIMUM 5' OF COVER FROM BOTTOM OF STREAMS.
14. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
15. IN ADDITION TO THE SITE-SPECIFIC INFORMATION PROVIDED IN THIS DRAWING, GENERAL REQUIREMENTS INCLUDED IN ALIGNMENT SHEETS, PERMITS AND APPROVAL FROM FEDERAL, STATE AND LOCAL AGENCIES ALSO APPLY.
16. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
17. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-6.18	TO	ES-6.20	EROSION & SEDIMENT PLAN
SHEET 12	TO	SHEET 13	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
0	ISSUED FOR CONSTRUCTION	MRS	03/08/19	RMB	03/08/19	AMC	03/08/19

Sunoco Logistics Partners L.P.

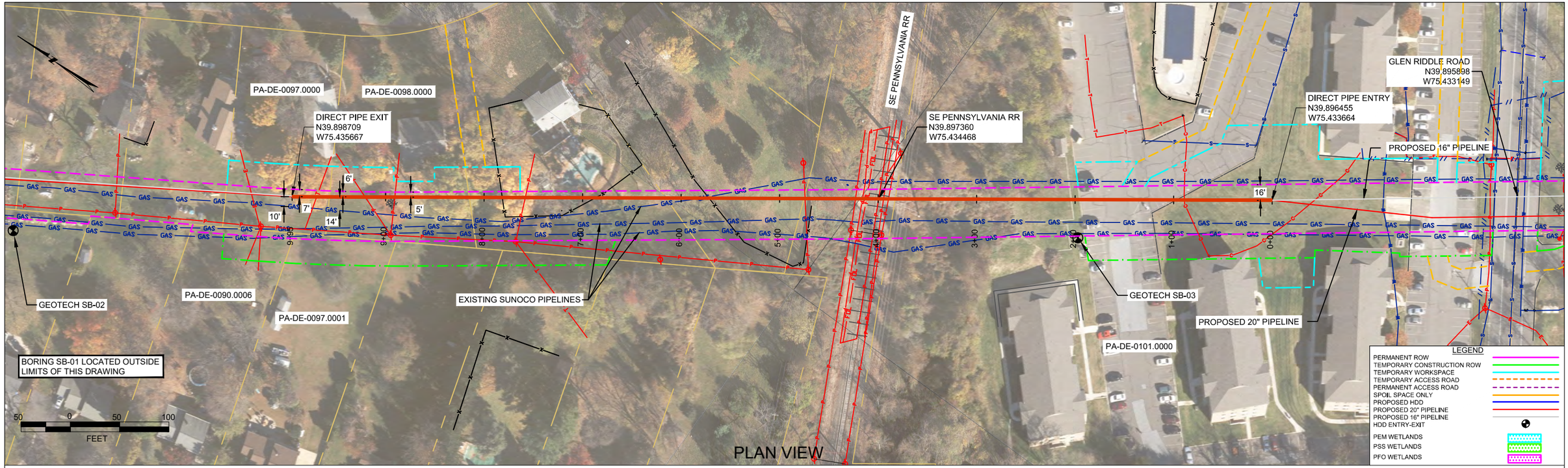
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

DIRECT PIPE
RIDDLEWOOD DR
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100'

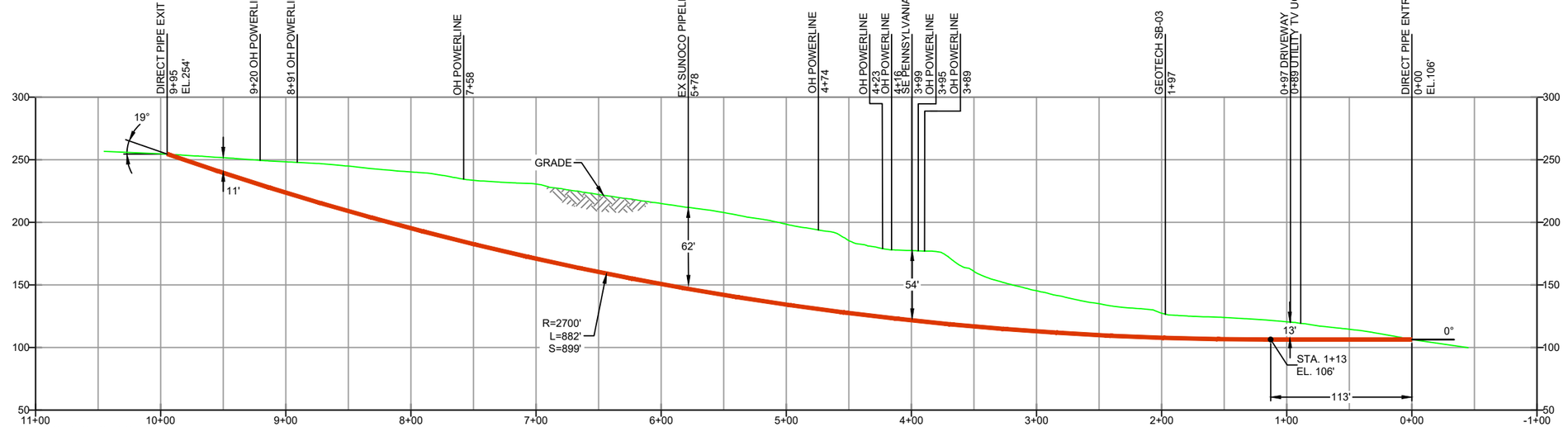
DWG. NO: PA-DE-0089.0000-RD



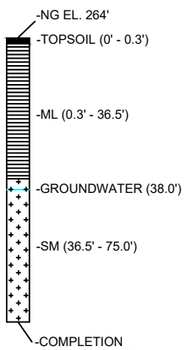
PLAN VIEW

DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP

PROFILE VIEW



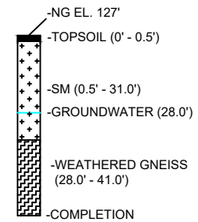
GEOTECH SB-01



GEOTECH SB-02

NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-03



NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

CONSTRUCTION NOTES

1. 20" AND 16" PIPE WILL BE BUNDLED TOGETHER AND INSTALLED INTO A SINGLE WELDED STEEL CASING (48" OD. 0.750" WT, X-52) USING DIRECT PIPE METHOD.
2. 20" WELDED STEEL PIPE: 20" OD x 0.456" WT, X-65, API-5L, PSL2, ERW, BFW, DRL
3. 16" WELDED STEEL PIPE: 16" OD x 0.438" WT, X-70, API-5L, PSL2, ERW, BFW, DRL
   HORIZONTAL PIPE LENGTH (L) = 995'
   PIPE LENGTH (S) = 1012'
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
4. 20" DESIGN PRESSURE: 1480 PSIG
   CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF PIPE STRING TO MINIMUM 1850 PSIG.
5. 16" DESIGN PRESSURE: 2100 PSIG
   CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF PIPE STRING TO MINIMUM 2625 PSIG.
6. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
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8. INSTALL CATHODIC PROTECTION TEST LEADS AS SPECIFIED ON THE ALIGNMENT SHEETS OR SUNOCO CORROSION TECHNICIAN.
9. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
10. WELDED JOINTS INSIDE R.O.W. SHALL BE 100% X-RAYED.
11. CONTRACTOR WILL MAINTAIN A MINIMUM 4' OF COVER TO THE TOP OF PIPE USING FIELD BENDS.
12. CONTRACTOR WILL MAINTAIN A MINIMUM 24" OF COVER FROM ALL EXISTING UTILITIES.
13. CONTRACTOR WILL MAINTAIN A MINIMUM 5' OF COVER FROM BOTTOM OF STREAMS.
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16. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
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NOTES

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

REF. DRAWING

ES-6.18	TO	ES-6.20	EROSION & SEDIMENT PLAN
SHEET 12	TO	SHEET 13	AERIAL SITE PLAN

DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
0	ISSUED FOR CONSTRUCTION	MRS	03/08/19	RMB	03/08/19	AMC	03/08/19

Sunoco Logistics Partners L.P.

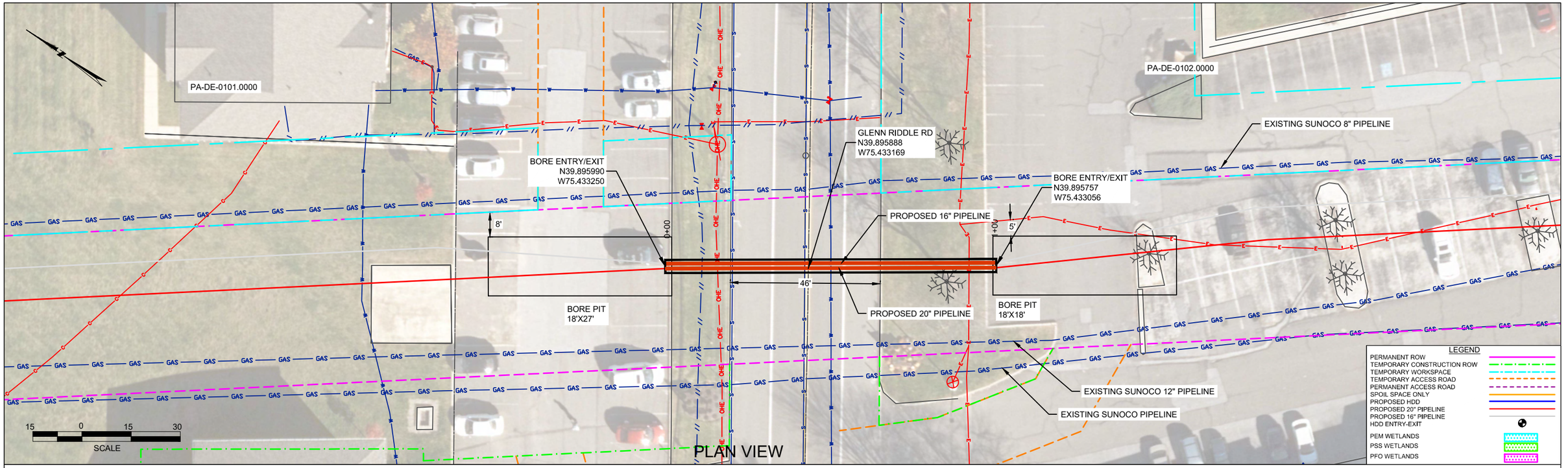
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

DIRECT PIPE
SEPTA RAILROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100'

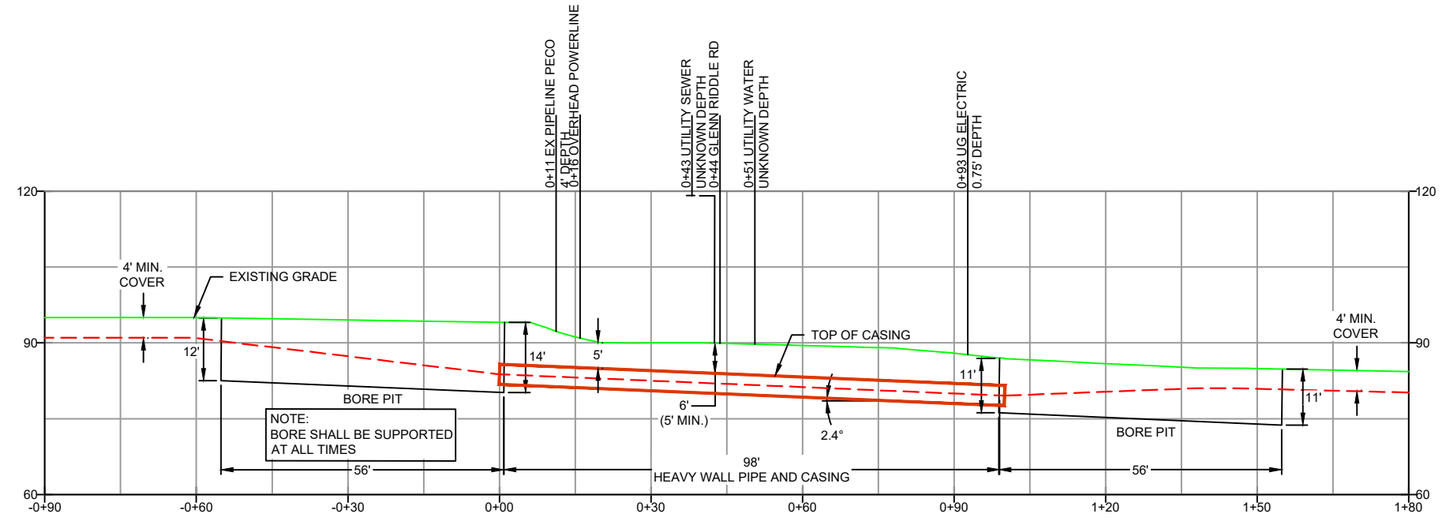
DWG. NO: PA-DE-0100.0000-RR



PLAN VIEW

DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP

PROFILE VIEW



CONSTRUCTION NOTES

1. 20" AND 16" PIPE WILL BE BUNDLED TOGETHER AND INSTALLED INTO 48" x 0.750" W.T. x X-52 CASING USING AUGER BORE METHOD.
2. HORIZONTAL PIPE LENGTH (L) = 98'
   PIPE LENGTH (S) = 98'
3. 20" WELDED STEEL PIPE: 20" OD x 0.456" WT, X-65, API-5L, PSL2, ERW, BFW, DRL COATING 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
4. 16" WELDED STEEL PIPE: 16" OD x 0.438" WT, X-70, API-5L, PSL2, ERW, BFW, DRL COATING 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
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6. 16" DESIGN PRESSURE: 2100 PSIG
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5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-6.18	TO	ES-6.18	EROSION & SEDIMENT PLAN
SHEET 12	TO	SHEET 12	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
0	ISSUED FOR CONSTRUCTION	LKR	02/11/19	RMB	02/11/19	AMC	02/11/19

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

AUGER BORE (CASED)
GLENN RIDDLE DRIVE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=30'

DWG. NO.: PA-DE-0101.0000-RD

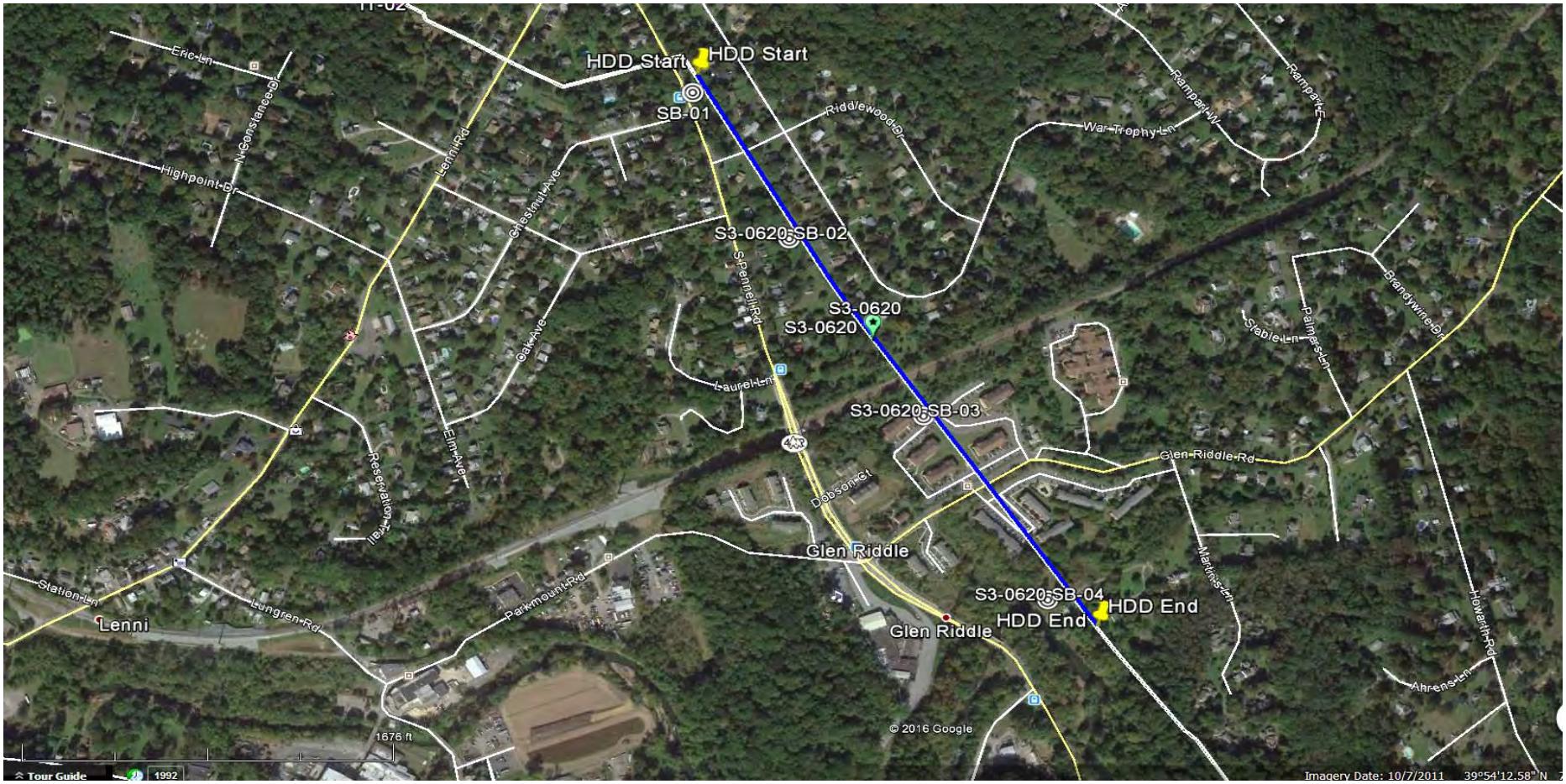
Attachment B

Geotechnical Boring Reports and Logs

Tetra-Tech 2015

Terracon 2017

Allied Well Drilling 2018



LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0620
DELAWARE COUNTY, MIDDLETOWN 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:	RIDDLEWOOD DRIVE, MEDIA, PA DE-0086		Page 1 of 1
HDD No.:	S3-0620	Dates(s) Drilled: 09-09-15	Inspector: J. COSTELLO
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: E. ODGEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): SEE BELOW	Total Depth (ft): 30.0
Boring Location Coordinates:		39° 54' 4.657" N	75° 26' 16.398" 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 (4")					
1	3.0	5.0	0.3		3	ML	REDDISH BROWN SILT AND FINE SAND, TRACE FINE GRAVEL, TRACE	2	3	4	4	**7**
				6.5			MICA. (USCS: ML).					
2	8.0	10.0	6.5		20		DR WEATHERED TO A VARIEGATED REDDISH BROWN FINE	2	3	4	6	**7**
							SAND AND SILT, TRACE MICA.					
3	13.0	15.0			24		DR WEATHERED TO A REDDISH BROWN FINE SAND AND SILT,	3	4	7	8	**11**
						SM	TRACE UNWEATHERED FINE GRAVEL, TRACE MICA.					
4	18.0	20.0			24		DR WEATHERED TO A REDDISH BROWN FINE SAND AND SILT,	2	4	4	5	**8**
							TRACE UNWEATHERED FINE GRAVEL. (USCS: SM), TRACE MICA.					
5	23.0	25.0			24		DR WEATHERED TO A REDDISH BROWN FINE SAND WITH SOME	1	5	10	13	**15**
				29.0			SILT, TRACE MICA, AND UNWEATHERED FINE GRAVEL.					
6	28.0	30.0	29.0		24	ML	DR WEATHERED TO A VARIEGATED YELLOW BROWN AND	2	5	7	10	**12**
				30.0			BROWN SILT AND FINE SAND.					
							WET ON SPOON AT 23'.					
							WATER LEVEL NOT ENCOUNTERED THROUGH AUGERS					
							CAVED AND DRY AT 27'.					

Notes/Comments:

Pocket Pentrometer Testing
S2: 2.75 TSF
S6: 2.5 TSF

DR: DECOMPOSED ROCK

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

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

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:	RIDDLEWOOD DRIVE, MEDIA, PA DE-0090.0004		Page 1 of 1
HDD No.:	S3-0620	Dates(s) Drilled: 09-09/10-15	Inspector: J. COSTELLO
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: E. ODGEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 38.0	Total Depth (ft): 75.0
Boring Location Coordinates:		39° 53' 57.462" N	75° 26' 10.827" 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		4		REDDISH BROWN SILT AND FINE SAND, TRACE MICACEOUS.	6	4	10	8	**14**
2	8.0	10.0			24		DR WEATHERED TO A LAYERED REDDISH BROWN AND LIGHT	3	9	10	11	**19**
							GRAY SILT AND FINE SAND, TRACE FINE GRAVEL.					
3	13.0	15.0			24		SAME.	5	11	15	18	**26**
4	18.0	20.0			24		DR, WEATHERED TO A LAYERED YELLOW BROWN AND BROWN SILT	3	9	11	15	**20**
						ML	WITH SOME FINE SAND, TRACE FINE GRAVEL.					
5	23.0	25.0			24		DR, WEATHERED TO A VARIEGTED GRAY, YELLOW, WHITE SILT AND	2	5	11	14	**16**
							FINE SAND, TRACE FINE GRAVEL. (USCS: ML)					
6	28.0	30.0			24		SAME	4	11	18	23	**29**
7	33.0	35.0			24		SAME (USCS: ML).	4	9	15	16	**24**
				36.5								
8	38.0	40.0	36.5		12		DR, WEATHERED TO A LAYERED GRAY AND REDDISH BROWN, FINE	2	5	14	15	**19**
							TO MEDIUM SAND WITH SOME SILT.					
9	43.0	44.9			19		SAME	4	15	40	50/5"	**55**
10	48.0	50.0			23		SAME.	4	6	12	46	**18**
11	53.0	55.0			24		SAME.	3	7	16	18	**23**
						SM						
12	58.0	60.0			15		DR, WEATHERED TO A LAYERED GRAY AND REDDISH BROWN, FINE	2	5	12	20	**17**
							TO MEDIUM SAND AND SILT.					
13	63.0	65.0			20		SAME.	2	9	15	50	**24**
14	68.0	69.0			12		DR, WEATHERED TO A VARIEGATED REDDISH BROWN AND GRAY	6	50/6"			**>50**
							WITH BLACK SPECS, M-C SAND, SOME SILT, A LITTLE F-GRAVEL.					
15	73.0	74.3		75.0	9		SAME.	2	21	50/3"		**>50**

Notes/Comments:

Pocket Pentrometer Testing
S4; 3.5 TSF

DR: DECOMPOSED ROCK
AUGERED TO 75'.
WET ON SPOON AT 38'.
WATER LEVEL THROUGH AUGERS AT 38'.
CAVED AT 37', MOIST.

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:	GLENN RIDDLE APTS., MEDIA, PA		Page 1 of 1
HDD No.:	S3-0620	Dates(s) Drilled: 11-17-15	Inspector: J. COSTELLO
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: E. ODGEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 28.0	Total Depth (ft): 36.0
Boring Location Coordinates:		39° 53' 48.63" N	75° 26' 3.03" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.5			TOPSOIL (6")					
1	3.0	5.0	0.5		12		DR, DARK BROWN MICACEOUS FINE TO MEDIUM SAND, SOME SILT,	4	7	12	12	**19**
							TRACE FINE GRAVEL.					
2	8.0	10.0			19		DR, VARIEGATED BROWN, TAN, WHITE FINE TO MEDIUM SAND, SOME	4	7	10	12	**17**
							SILT, TRAVE FINE GRAVEL.					
3	13.0	15.0			24	SM	SAME.	2	8	12	31	**20**
4	18.0	20.0			24		SAME.	2	12	31	50	**43**
5	23.0	25.0			24		SAME.	2	10	11	27	**21**
				28.5								
6	28.0	30.0	28.0	31.0	8		DR, HIGHLY WEATHERED TO PARTIALLY WEATHERED MAFIC GNEISS.	6	50/5"			**>50**
							AUGER REFUSAL AT 31'.					
							ROCK CORING					
RUN 1	31.0	36.0	31.0		40	WEATH. TO PARTIALLY WEATH. GNEISS	WHITE AND GRAY MAFIC GNEISS, HIGHLY WEATHERED AND	TCR: 67%, SCR: 7%, RQD: 0%				
				36.0			FRACTURED.					
RUN 2	36.0	41.0	36.0		43		WHITE AND GRAY MAFIC GNEISS, WEATHERED TO PARTIALLY	TCR: 72%, SCR: 22%, RQD: 13%				
				41.0			WEATHERED, SINGLE 8" INTACT SECTION AT 38.8'.					
							CORE TESTING RESULTS (DEPTH 39-39.5 '):					
							COMPRESSIVE STRENGTH: 8,325 PSI					
							UNIT WEIGHT: 163.4 PCF					
							WET ON SPOON AT 28'.					
							CAVED AT 30'.					

Notes/Comments:
Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

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

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

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	GLENN RIDDLE APTS., MEDIA, PA		Page 1 of 1
HDD No.:	S3-0620	Dates(s) Drilled: 01-05-16	Inspector: E. WATT
Boring No.:	SB-04	Drilling Method: SPT - ASTM D1586	Driller: E. ODGEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 4.0	Total Depth (ft): 12.3
Boring Location Coordinates:		39°53'39.27"N	75°25'55.63"W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.1			TOPSOIL (<1")					
1	3.0	5.0	0.1	4.0	11	SC	BROWN TO DARK BROWN MICACEOUS FINE SAND, SOME SILTY CLAY.	1	3	4	6	**7**
			4.0			CL	MOTTLED (BROWN AND GRAY) MICACEOUS SILTY CLAY WITH A					
				6.5			LITTLE FINE SAND. (USCS: CL).					
2	8.0	10.0	6.5		15	SM	DR, BROWN MICACEOUS FINE TO COARSE SAND, TRACE FINE TO	2	7	17	20	**24**
				12.0			COARSE GRAVEL, A LITTLE SILT.					
3	12.0	12.3	12.0	12.3	<1		PARTIALLY WEATHERED MAFIC GNEISS.	50/3"				**0**
							AUGER REFUSAL AT 12'.					
							AUGER STARTED GRINDING AT 7'.					
							CAVED AT 8'. WATER LEVEL ON CAVE AT 4'.					
							OFF-SET BORING 10' NW AND AUGERED TO REFUSAL AT 11'.					
							MOVED BORING WEST TO AVOID VERIZON AND SUNOCO LINES.					
							PHRAGMITE, STANDING SURFACE WATER, AND SMALL STREAM					
							IN AREA OF PROPOSED BORING.					
							ENCOUNTERED GROUNDWATER COULD BE A RESULT OF					
							PERCHED WATER CONDITIONS (CLAY AT 4').					

Notes/Comments:

Pocket Pentrometer Testing
S1: 2.75 TSF

DR: DECOMPOSED ROCK

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

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

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0620

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					
S3-0620	SB-03	1	31	36	67	7	0	31	36	Heavily	Mafic Gneiss	Massive	Gray/white	Rubble, increasingly weathered with depth
		2	36	41	72	22	13	36	41	Heavily	Mafic Gneiss	Massive	Gray/white	Mostly rubble, single unweathered section

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0620

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)
S3-0620	SB-01	2	8.0	10.0	31.8	62.2	39	27	12	ML
		3	13.0	15.0	25.6	40.9				
		4	18.0	20.0	33.6	47.4	35	26	9	SM
		5	23.0	25.0	21.6	30.9	-	-	-	-
		6	28.0	30.0	17.4	53.1	-	-	-	-
	SB-02	2	8.0	10.0	30.5	60.8	-	-	-	-
		4	18.0	20.0	34.3	75.6	-	-	-	-
		5	23.0	25.0	22.6	69.2	38	26	12	ML
		7	33.0	35.0	22.4	61.6	37	26	11	ML
		10	48.0	50.0	22.0	35.2	-	-	-	-
		12	58.0	60.0	21.5	41.1	-	-	-	-
		15	73.0	74.3	15.1	23.9	-	-	-	-
	SB-03	2	8.0	10.0	13.6	30.7	-	-	-	-
		3	13.0	15.0	13.0	23.2	NV	NP	NP	SM
		4	18.0	20.0	10.7	31.9	-	-	-	-
		5	23.0	25.0	9.9	22.4	-	-	-	-
		6	28.0	30.0	11.5	35.6	NV	NP	NP	SM
	SB-04	1	3.0	5.0	22.0	81.9	41	23	18	CL
		2	8.0	10.0	7.2	15.3	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-03	2	39.0 - 39.5	8,325	163.4

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0620

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
S3-0620		SB-01	Ultramafic rocks - Includes serpentine, steatite, and other products of alteration of peridotites and pyroxenites.	Generally level	Ultramafic rocks (Probably lower Paleozoic)	Serpentinite; Secondary - pyroxenite; Other - peridotite	No information found during literature review	Ranges from 15 to 70 ft bgs, Avg. 35 ft bgs (.5 mile radius)	All part of Glenarm Supergroup a name given to provincial series of pre-Cambrian metamorphosed sedimentary rocks present in northern VA, MD, southeastern PA, western NJ, and possibly southeastern NY. Rocks from this assemblage consists of a thick sequence of metasedimentary rock and include the following formations; Setters metaquartzite, Cockeysville marble, Wissahickon Schist (along with subset of the Octoraro schist), Peters Creek metaquartzite and meta siltstones and the Peach Bottom Clate (Geology of Pennsylvania SP-1, 1999). Drilling in these formations generally difficult to very difficult except where fractures and weathered exposed zones present.
		SB-02		Generally level, slightly sloping to the east					
		SB-03		Generally level, slightly sloping to the southeast					
		SB-04	Mafic gneiss - Dark, medium grained; includes rocks of probable sedimentary origin; may be equivalent to pCAmgh in places.	Generally level	Mafic gneiss (Probably lower Paleozoic)	Mafic gneiss; Secondary - paragneiss			

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.

October 17, 2017

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

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

Re: Geotechnical Site Characterization
Mariner East 2 Pipeline Project
Spread 6 – Glen Riddle Road_SE_PA_RR
Commonwealth of Pennsylvania
Drawing # PA-DE-0100.0000-RRa and PA-DE-0100.0000-RRb
PO # 20170908-4
Terracon Project No. J217P078

Dear Mr. Sessions:

This letter provides a summary of the bedrock characterization for the Mariner East 2 Pipeline Project crossing to be located at Glen Riddle Road_SE_PA_RR (Drawing # PA-DE-0100.0000-RRa and PA-DE-0100.0000-RRb) in the Commonwealth of Pennsylvania. Our services were performed in general accordance with our proposal number PJ2175108 dated July 28, 2017. Our scope of services included advancing two borings, designated as B6-24W and B6-24E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B6-24W and B6-24E were drilled between September 25 and September 30, 2017 to depths of 300.5 and 102.0 feet, respectively as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of metamorphic rock comprised of schist at B6-24W and gneiss at B6-24E. Final test boring logs documenting overburden soil and bedrock conditions as well as photographs of the rock core samples are attached.

Rock compressive strength testing was performed on samples from approximately 20-foot intervals within the bedrock strata at each boring location. As an exception to the planned 20-foot intervals, rock samples from B6-24W near 32, 52, 70, and 190 feet and from B6-24E near 45 feet were not tested due to highly fractured or weathered conditions. Unconfined compressive strength test results are shown on the attached reports.

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

Sincerely,
Terracon Consultants, Inc.

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

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

Attch:

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

TEST BORING LOCATION PLAN

N

APPROXIMATE BORING LOCATION

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

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

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

TEST BORING LOCATION PLAN

Glenn Riddle Road HDD Core B6-24W and B6-24E
PA-DE-0100.0000-RRa
Delaware County, Pennsylvania

Exhibit

A-2

EXPLORATION RESULTS

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°
Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)
0							
FILL -							
1.5	278.5+/-						
LEAN CLAY (CL), with silt, roots, trace sand, light brown, medium stiff				10	3-3-5 N=8		
3.0	277+/-						
POORLY GRADED SAND (SP), trace silt and gravel, light brown, medium dense to dense, (completely weathered rock)		5		15	4-5-5 N=10		
		10		15	4-7-9 N=16		
		15		16	6-8-13 N=21		
		20		16	13-19-25 N=44		
25.0	255+/-	25		16	16-22-46 N=68		
Very severely weathered rock, red, brown, green, and gray, very dense							
Competent rock at 30 feet, start coring at 32 feet		30					
32.0	248+/-						
Run 1, Soft, very severely weathered, brown and orange, medium-grained, highly weathered rock, could not measure joints due to weathering		35		41		35	1 1 2

Penetrometer Test (tsf)

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017 | Boring Completed: 09-29-2017

Drill Rig: Mobile B-57 | Driller: Terracon/S. Bray

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°
Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
37.0	243+/-			41		2 2
		Run 2, Very soft, very severely weathered rock, brown, orange, green, and gray	40	22.5	0	1 1 2 2 2
42.0	238+/-					
		Run 3, Similar	45	19.5	0	1 1 1 1 2
47.0	233+/-					
		Run 4, Similar	50	14	0	1 1 2 2 1
52.0	228+/-					
		Run 5, Similar	55	15.5	0	1 1 1 1 1
57.0	223+/-					
		Run 6, Similar	60	25	0	1 1 2 1 1
62.0	218+/-					
		Run 7, Soft, very severely weathered, brown and gray, medium-grained, SCHIST, primary joint set, low angle, close spacing, rough, decomposed, open	65	55	66	1 1 2 2 1
67.0	213+/-					
		Run 8, Very soft, very severely weathered rock, brown to gray	70	36	0	1 1 1

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017 | Boring Completed: 09-29-2017

Drill Rig: Mobile B-57 | Driller: Terracon/S. Bray

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°
Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
72.0	208+/-	Run 8, Very soft, very severely weathered rock, brown to gray *(continued)*		36		2 3
77.0	203+/-	Run 9, Very soft, very severely weathered rock, brown, green, gray, and red	75	14	7	1 1 1 1 2
82.0	198+/-	Run 10, Moderately hard, severely weathered, brown, green, and gray, medium-grained, SCHIST, primary joint set, low angle, very close spacing, rough, decomposed, open, vugs throughout	80	34.5	38	1 2 1 2 2
87.0	193+/-	Run 11, Hard, moderately weathered, brown, green, and gray, medium-grained, SCHIST, primary joint set, moderately dipping, close spacing, rough, discolored, open	85	60	98	2 2 2 3 4
92.0	188+/-	Run 12, Similar, decomposed joints	90	58.5	83	2 2 2 3 3
97.0	183+/-	Run 13, Very soft, very severely weathered rock, brown, green, gray, and red	95	38.5	19	1 1 2 2 3
102.0	178+/-	Run 14, Soft, very severely to severely weathered, brown, gray, red, green, and yellow, medium-grained, SCHIST, highly fractured throughout, could not measure joints	100	60	18	2 2 3 4 4
		Run 15, Moderately hard, severely weathered, brown, gray, red, green, and yellow, medium-grained, SCHIST, primary joint set, high angle, very close spacing, rough, decomposed to discolored, open	105	60	32	2 3 3

Penetrometer Test (tsf)

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017 | Boring Completed: 09-29-2017

Drill Rig: Mobile B-57 | Driller: Terracon/S. Bray

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°
Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
107.0	173+/-				60			3 3	
Run 16, Similar, vertical joints, very close spacing, rough, discolored, open		110							
112.0	168+/-				60		43	2 2 3 2 3	
Run 17, Moderately hard, slightly weathered, brown, gray, green, and orange, medium-grained, SCHIST, primary joint set, moderately dipping, close spacing, rough, discolored, open; secondary joint set, low angle, close spacing, rough, discolored, open		115							
117.0	163+/-				60		83	2 2 2 3 3	
Run 18, Soft, severely weathered, dark brown, gray, and orange, medium-grained, SCHIST, highly fractured throughout run, could not determine joints		120							
122.0	158+/-				37		18	2 3 3 3 3	
Run 19, Moderately hard, moderately weathered, brown, gray, red, green, and yellow, medium-grained, SCHIST, primary joint set, high angle, very close spacing, rough, decomposed to discolored, open		125							
127.0	153+/-				60		16	2 2 3 3 3	
Run 20, Similar		130							
132.0	148+/-				45.5		34	2 2 2 2 3	
Run 21, Hard, slightly weathered, brown, gray, and green, medium-grained, SCHIST, primary joint set, moderately dipping, close spacing, rough, discolored, open; secondary joint set, high angle, moderately close spacing, rough, discolored, open		135							
137.0	143+/-				60		77	2 2 2 3 3	
Run 22, Moderately hard, moderately weathered, brown, gray, red, and green, medium-grained, SCHIST, primary joint set, high angle, close spacing, rough, decomposed, open		140			56.5		68	2 2 2	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017 | Boring Completed: 09-29-2017

Drill Rig: Mobile B-57 | Driller: Terracon/S. Bray

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°
Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
142.0	138+/-					56.5			2 3	
		Run 23, Very soft, very severely weathered, green, and brown, medium-grained, MICA SCHIST, highly fractured throughout, could not measure joints	145			38		0	2 2 1 1 1	
147.0	133+/-									
		Run 24, Similar, completely weathered from 148 to 152 feet	150			46		12	2 2 2 2 2	
152.0	128+/-									
		Run 25, Very soft to soft, very severely weathered with completely weathered zones, brown and green, SCHIST, highly fractured throughout, could not measure joints	155			60		0	1 2 2 1 1	
157.0	123+/-									
		Run 26, Very soft to moderately hard, moderately to very severely weathered, green and brown, medium-grained, MICA SCHIST, primary joint set, moderately dipping, very close spacing, rough, decomposed, open	160			60		38	2 2 2 2 3	
162.0	118+/-									
		Run 27, Soft to moderately hard, moderately weathered, brown and green, medium-grained, SCHIST, primary joint set, moderately dipping, close spacing, rough, decomposed, open; secondary joint set, high angle, very close spacing, rough, decomposed, open, severely weathered zones throughout	165			60		47	1 1 1 2 3	
167.0	113+/-									
		Run 28, Soft, severely weathered rock, friable, highly fractured throughout, could not measure joints	170			60		0	1 1 1 1 1	
172.0	108+/-									
			175			52.5		50	1 1 2	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017 | Boring Completed: 09-29-2017

Drill Rig: Mobile B-57 | Driller: Terracon/S. Bray

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°
Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
177.0	103+/-	Run 29, Hard, moderately weathered, brown and gray, medium-grained, SCHIST, primary joint set, moderately dipping, close spacing, rough, discolored, open, highly weathered zones throughout				52.5			2 2	
		Dark brown at 173 feet *(continued)*								
182.0	98+/-	Run 30, Moderately hard, moderately to severely weathered, brown, orange, green, and gray, medium-grained, SCHIST, primary joint set, high angle, very close spacing, rough, decomposed, open; secondary joint set, vertical, very close spacing, rough, decomposed, open	180			50		7	2 2 3 2 2	
187.0	93+/-	Run 31, Hard, moderately weathered, gray, brown, orange, and green, medium-grained, SCHIST, primary joint set, high angle, very close spacing, rough, decomposed, open; secondary joint set, high angle, very close, rough, decomposed, open, highly fractured and severely weathered zones throughout	185			60		18	2 2 2 2 3	
192.0	88+/-	Run 32, Moderately hard, severely weathered, gray, green, brown, and orange, medium-grained, SCHIST, highly fractured throughout, could not measure joints	190			31.5		0	2 2 2 2 2	
197.0	83+/-	Run 33, Moderately hard, moderately weathered, gray, green, brown, red, and orange, medium-grained, SCHIST, primary joint set, high angle, very close spacing, rough, decomposed, open; highly fractured throughout, healing/secondary mineralization	195			60		0	2 2 3 2 3	
202.0	78+/-	Run 34, Similar, secondary vertical fractures	200			60		18	2 2 2 2 2	
207.0	73+/-	Run 35, Hard, moderately weathered, gray, brown, and orange, medium-grained, SCHIST, primary joint set, moderately dipping, close spacing, rough, discolored, open; secondary joint set, high angle, decomposed, open, vugs throughout, weathered zone at 204 feet	205			57		71	2 2 1 2 2	
		Run 36, Moderately hard, moderately weathered, gray, green, and black, medium-grained, SCHIST, primary joint set, high angle, very close spacing, rough, decomposed, open; secondary joint set, vertical, very close, rough, decomposed, open	210			49.5		27	2 2 1	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017 | Boring Completed: 09-29-2017

Drill Rig: Mobile B-57 | Driller: Terracon/S. Bray

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°

Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
212.0		68+/-				49.5			2 2	
217.0	Run 37, Hard, slightly weathered, brown, gray, and green, medium-grained, SCHIST, primary joint set, high angle, very close spacing, rough, decomposed, open, highly fractured throughout	63+/-	215			60		25	2 2 2 3 2	
222.0	Run 38, Very soft to soft, very severely to severely weathered, brown, gray, and green, medium-grained, SCHIST, primary joint set, moderately dipping, very close spacing, rough, decomposed, open, completely weathered from 217 to 218 feet, severely weathered from 218 to 220 feet	58+/-	220			45		25	1 1 2 2 3	
227.0	Run 39, Moderately hard, moderately weathered, dark gray, and green, medium-grained, SCHIST, primary joint set, high angle, close spacing, rough, decomposed, open; secondary mineralization/healing on joint surfaces Severe weathering from 222 to 223 feet	53+/-	225			53		40	1 2 2 3 3	
232.0	Run 40, Similar to 228.7 feet Slight recovery from 228.7 to 232 feet, sandy material encountered (Fault zone from 228.7 to 242 feet)	48+/-	230			14.5		14	1 1 1 2 2	
237.0	Run 41, Slight recovery from 232 to 236.5 feet, sandy material encountered From 236.5 to 237.8 feet, Hard, gravel size rock, gray, brown and orange	43+/-	235			5.5		0	1 1 1 1 2	
242.0	Run 42, Similar to 237.8 feet Slight recovery from 237.8 to 242 feet, sandy material encountered	38+/-	240			9		0	1 1 1 1 1	
	Run 43, Hard, slightly weathered, dark gray, and red, medium-grained, SCHIST, primary joint set, moderately dipping, close spacing, rough, discolored, open; secondary joint set, high angle, very close spacing, rough, disintegrated, open		245			60		44	2 2 2	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS
Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017	Boring Completed: 09-29-2017
Drill Rig: Mobile B-57	Driller: Terracon/S. Bray
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°
Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Run / Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
247.0	33+/-					60			2 3	
		Run 44, Similar	250			60		62	1 2 2 3 3	
252.0	28+/-									
		Run 45, Similar	255			60		59	2 2 2 3 2	
257.0	23+/-									
		Run 46, Very hard, slightly weathered, dark gray, blue, and purple, medium-grained, mica, hornblende, SCHIST, primary joint set, high angle, close spacing, rough, discolored and disintegrated, open	260			60		66	2 2 2 2 2	
262.0	18+/-									
		Run 47, Very hard, fresh, dark gray, and blue, medium-grained, mica, quartz, hornblende, plagioclase, SCHIST, primary joint set, moderately dipping, close spacing, rough, discolored, open Quartz vein at 265 feet, 2-inches thick	265			60		89	2 2 3 2 2	
267.0	13+/-									
		Run 48, Hard, slightly weathered, dark gray, white, and blue, medium-grained, mica, quartz, hornblende, SCHIST, primary joint set, moderately dipping, close spacing, rough, disintegrated, open	270			60		43	2 3 2 2 2	
272.0	8+/-									
		Run 49, Hard, slightly weathered, dark gray and black, medium-grained, mica, quartz, hornblende, SCHIST, primary joint set, moderately dipping, close spacing, rough, disintegrated, open Vertical fracture at 275 feet	275			60		75	2 2 2 2 2	
277.0	3+/-									
		Run 50, Very hard, fresh, dark gray, black, and blue, medium-grained, mica, quartz, hornblende, SCHIST, primary joint set, moderately dipping, moderately close to close spacing, rough, fresh, tight	280			60		100	2 2 2	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017 | Boring Completed: 09-29-2017

Drill Rig: Mobile B-57 | Driller: Terracon/S. Bray

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B6-24W Glen Riddle Road_SE_PA_RR West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRa
20170908-4
Latitude: 39.90166° Longitude: -75.43797°
Approximate Surface Elev: 280 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
282.0	-2+/-	60		2 2
Run 51, Similar, high angle joint at 284 feet, rough, discolored, open		60	84	2 2 1 1 2
287.0	-7+/-			
Run 52, Similar, moderately close spacing		60	100	1 2 2 1 1
292.0	-12+/-			
Run 53, Similar, no joints measured, wide spacing		60	100	1 1 2 1 2
297.0	-17+/-			
Run 54, Very hard, fresh, dark gray and blue, medium-grained, mica, quartz, hornblende, SCHIST, primary joint set, high angle, wide spacing, rough, fresh, open		42	88	1 1 2
300.5	-20.5+/-			
Boring Terminated at 300.5 Feet				

DEPTH (Ft.): 285, 290, 295, 300

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

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-26-2017 | Boring Completed: 09-29-2017

Drill Rig: Mobile B-57 | Driller: Terracon/S. Bray

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B6-24E Glen Riddle Road_SE_PA_RR East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRb
20170908-4
Latitude: 39.893354° Longitude: -75.430797°
Approximate Surface Elev: 72 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0.3	71.5+/-	Topsoil
		SILTY SAND (SM), light brown, very loose to loose
9.0	63+/-	Very severely weathered rock, gray and brown, visible banding, medium dense
		Sampler refusal at 20.2 feet
		Roller bit to 25 feet, begin rock core at 25 feet
25.0	47+/-	Run 1, Moderately hard, slightly weathered, bluish-gray, fine-grained, MAFIC GNEISS, foliation, primary joint set, moderately dipping, close spacing
27.0	45+/-	Completely weathered rock from 26 to 27 feet

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
		16	5-4-3 N=7			
5		16	2-2-1 N=3			
10		18	3-5-5 N=10			
15		15	2-3-8 N=11			
20		2	100/3"			
25		12		42	1.25 0.75 0.25	
30		25		15	1.5 1.5 1.5	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

35' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-29-2017 | Boring Completed: 09-30-2017

Drill Rig: CME-850 | Driller: Terracon/Peter M.

Project No.: J217P078 | Exhibit: A-2

BORING LOG NO. B6-24E Glen Riddle Road_SE_PA_RR East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRb
20170908-4
Latitude: 39.893354° Longitude: -75.430797°
Approximate Surface Elev: 72 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
		Run 2, Completely weathered rock to 28 feet	25		1.5 1.75
32.0	40+/-	At 28 feet: Medium hard, moderately to severely weathered, bluish-gray, fine-grained, MAFIC GNEISS, foliation, primary joint set, vertical, close spacing, some residual soil noted *(continued)*			
		Run 3, Similar	18	0	0.75 0.75 0.75 0.75 0.75
37.0	35+/-				
		Run 4, Completely weathered rock, brown	10	0	0.25 0.25 0.75 0.5 0.5
42.0	30+/-				
		Run 5, Similar	12	0	0.5 0.75 0.75 0.5 0.75
47.0	25+/-				
		Run 6, Similar to 48 feet At 48 feet: Medium hard, severely weathered, blue-gray, fine-grained, MAFIC GNEISS, foliation, highly fractured throughout, could not measure joints	40.5	10	0.5 1.75 1.5 1.5 2
52.0	20+/-				
		Run 7, Similar	42	34	2 2 2 2 2
57.0	15+/-				
		Run 8, Hard, moderately weathered, bluish-gray, fine-grained, MAFIC GNEISS, primary joint set, low angle to moderately dipping, close spacing, rough, discolored, open	32	53	2.5 2.5 2.5
60					

DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | Penetrometer Test (tsf)

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ *35' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-29-2017 | Boring Completed: 09-30-2017

Drill Rig: CME-850 | Driller: Terracon/Peter M.

Project No.: J217P078 | Exhibit: A-2

BORING LOG NO. B6-24E Glen Riddle Road_SE_PA_RR East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRb
20170908-4
Latitude: 39.893354° Longitude: -75.430797°
Approximate Surface Elev: 72 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
62.0	10+/-	Run 8, Hard, moderately weathered, bluish-gray, fine-grained, MAFIC GNEISS, primary joint set, low angle to moderately dipping, close spacing, rough, discolored, open *(continued)*				32			2.75 2	
67.0	5+/-	Run 9, Similar, very close to close spacing, highly fractured	65			50		37	4 4 3.5 3.5 3.5	
72.0	0+/-	Run 10, Similar, close spacing From 69 to 71 feet: Moderately to severely weathered with clay layer	70			42		50	2 3 3 2 2	
77.0	-5+/-	Run 11, Similar, close to moderately close spacing	75			58		85	2.5 2.5 2.5 2.75 3	
82.0	-10+/-	Run 12, Similar, quartz intrusions	80			58		93	3 3 2 3 4	
87.0	-15+/-	Run 13, Similar, secondary vertical fracture along interface with quartz intrusion from 86 to 87 feet	85			60		100	3.5 3.5 4 3.5 4.5	
		Run 14, Similar, wide spacing	90			60		100	4 4 3	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

35' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-29-2017 | Boring Completed: 09-30-2017

Drill Rig: CME-850 | Driller: Terracon/Peter M.

Project No.: J217P078 | Exhibit: A-2

BORING LOG NO. B6-24E Glen Riddle Road_SE_PA_RR East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0100.0000-RRb
20170908-4
Latitude: 39.893354° Longitude: -75.430797°

Approximate Surface Elev: 72 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
Run 14, Similar, wide spacing *(continued)*									
92.0	-20+/-				60			2 2	
Run 15, Similar		95							
97.0	-25+/-				60		100	2 3.75 4 4 4	
Run 16, Similar		100							
102.0	-30+/-				60		98	5 3 3.5 4 4	
Boring Terminated at 102 Feet									

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

35' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-29-2017 | Boring Completed: 09-30-2017

Drill Rig: CME-850 | Driller: Terracon/Peter M.

Project No.: J217P078 | Exhibit: A-2

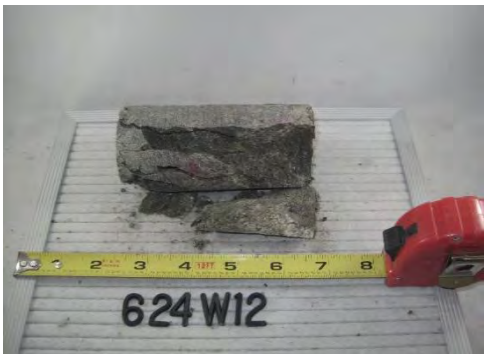
ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	12	Moisture Content :	As received
Sample Depth:	90 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	3 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	9,610 lb
Length:	4.42 in	Compressive Strength:	3,090 psi
L/D:	2.22	Compressive Strength:	21.30 Mpa
End Area:	3.11 in^2	Unit Weight	157 pcf

Before the Test

After the Test



Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

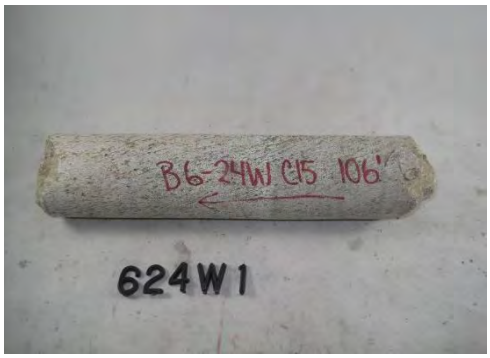
Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	1	Moisture Content :	As received
Sample Depth:	106 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	2.01 in	Maximum Axial Load at Failure:	20,450 lb
Length:	4.37 in	Compressive Strength:	6,445 psi
L/D:	2.17	Compressive Strength:	44.44 Mpa
End Area:	3.17 in^2	Unit Weight	162 pcf

Before the Test



After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

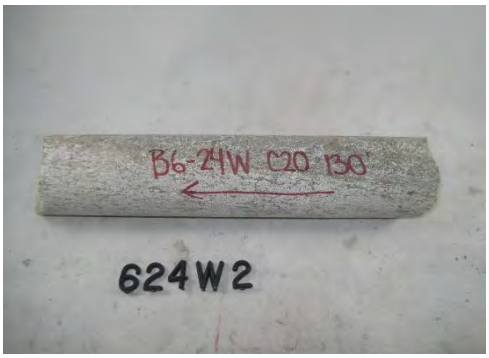
Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	2	Moisture Content :	As received
Sample Depth:	130 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	2.01 in	Maximum Axial Load at Failure:	20,940 lb
Length:	4.22 in	Compressive Strength:	6,599 psi
L/D:	2.10	Compressive Strength:	45.50 Mpa
End Area:	3.17 in^2	Unit Weight	165 pcf

Before the Test



After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	3	Moisture Content :	As received
Sample Depth:	138 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	8 min

Diameter:	2.00 in	Maximum Axial Load at Failure:	27,290 lb
Length:	4.59 in	Compressive Strength:	8,687 psi
L/D:	2.30	Compressive Strength:	59.89 Mpa
End Area:	3.14 in^2	Unit Weight	178 pcf

Before the Test

After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon	Performed by:	C. Santana
Project No.	J217P078	77 Sundial Ave., Suite 401 W	Test Date:	10/16/2017
Location:	Spread 6	Manchester, New Hampshire	Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	4	Moisture Content :	As received
Sample Depth:	159 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	16 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	51,990 lb
Length:	4.50 in	Compressive Strength:	16,716 psi
L/D:	2.26	Compressive Strength:	115.25 Mpa
End Area:	3.11 in^2	Unit Weight	166 pcf

Before the Test

After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

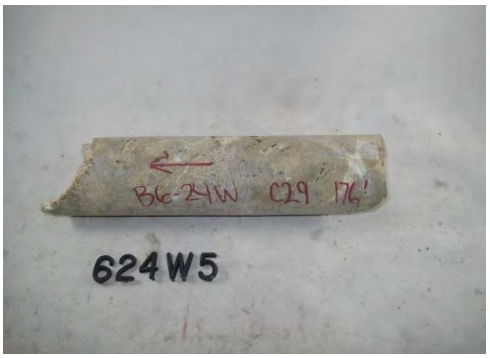
Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	5	Moisture Content :	As received
Sample Depth:	176 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	29 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	96,650 lb
Length:	4.92 in	Compressive Strength:	31,075 psi
L/D:	2.47	Compressive Strength:	214.25 Mpa
End Area:	3.11 in^2	Unit Weight	163 pcf

Before the Test



After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	6	Moisture Content :	As received
Sample Depth:	206 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	8 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	27,730 lb
Length:	4.38 in	Compressive Strength:	9,006 psi
L/D:	2.21	Compressive Strength:	62.09 Mpa
End Area:	3.08 in^2	Unit Weight	159 pcf

Before the Test

After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	7	Moisture Content :	As received
Sample Depth:	225 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	4 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	12,500 lb
Length:	4.06 in	Compressive Strength:	4,060 psi
L/D:	2.05	Compressive Strength:	27.99 Mpa
End Area:	3.08 in^2	Unit Weight	163 pcf

Before the Test

After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

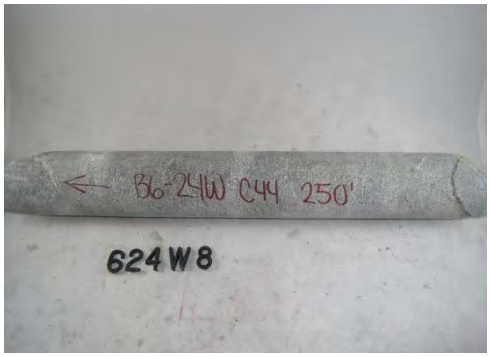
Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	8	Moisture Content :	As received
Sample Depth:	250 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	5 min

Diameter:	2.00 in	Maximum Axial Load at Failure:	15,130 lb
Length:	4.62 in	Compressive Strength:	4,816 psi
L/D:	2.31	Compressive Strength:	33.21 Mpa
End Area:	3.14 in^2	Unit Weight	167 pcf

Before the Test



After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

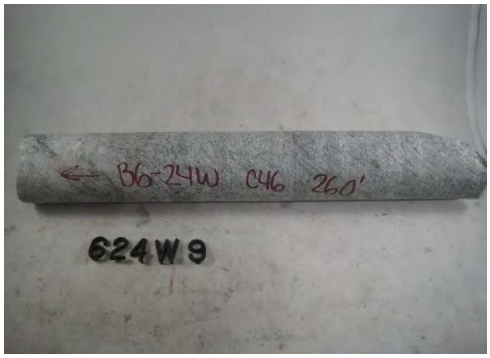
Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	9	Moisture Content :	As received
Sample Depth:	260 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	12 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	38,510 lb
Length:	4.52 in	Compressive Strength:	12,382 psi
L/D:	2.27	Compressive Strength:	85.37 Mpa
End Area:	3.11 in^2	Unit Weight	170 pcf

Before the Test



After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

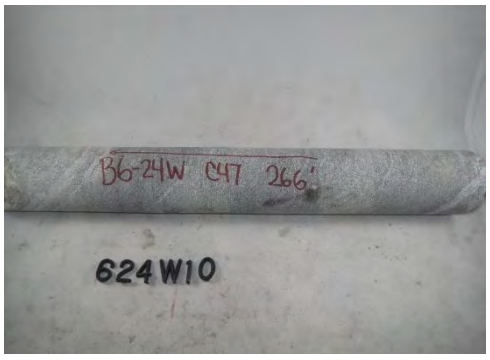
Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	10	Moisture Content :	As received
Sample Depth:	266 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	8 min

Diameter:	2.00 in	Maximum Axial Load at Failure:	25,340 lb
Length:	4.76 in	Compressive Strength:	8,066 psi
L/D:	2.38	Compressive Strength:	55.61 Mpa
End Area:	3.14 in^2	Unit Weight	167 pcf

Before the Test



After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

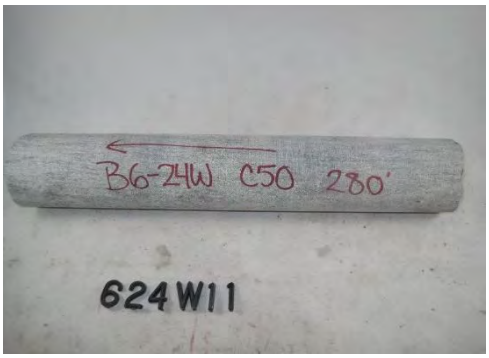
Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24W	Lithology :	Schist
Sample No.:	11	Moisture Content :	As received
Sample Depth:	280 feet	Lab Temperature :	70° F
Sampling Date:	9/26/17	Loading Rate:	55 psi/s
		Time to Failure:	22 min

Diameter:	2.00 in	Maximum Axial Load at Failure:	71,270 lb
Length:	4.81 in	Compressive Strength:	22,686 psi
L/D:	2.41	Compressive Strength:	156.41 Mpa
End Area:	3.14 in^2	Unit Weight	167 pcf

Before the Test



After the Test

Drawing # : PA-DE-0100.0000-RRa
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon		Performed by:	C. Santana
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24E	Lithology :	Gneiss
Sample No.:	1	Moisture Content :	As received
Sample Depth:	25 feet	Lab Temperature :	70° F
Sampling Date:	9/29/17	Loading Rate:	55 psi/s
		Time to Failure:	26 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	84,610 lb
Length:	4.40 in	Compressive Strength:	27,479 psi
L/D:	2.22	Compressive Strength:	189.46 Mpa
End Area:	3.08 in^2	Unit Weight	185 pcf

Before the Test

After the Test

Drawing # : PA-DE-0100.0000-RRb
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon	Performed by:	D. Savage
Project No.	J217P078		Test Date:	10/16/2017
Location:	Spread 6		Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/16/2017

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

Boring No.:	B6-24E	Lithology :	Gneiss
Sample No.:	2	Moisture Content :	As received
Sample Depth:	55 feet	Lab Temperature :	70° F
Sampling Date:	9/29/17	Loading Rate:	55 psi/s
		Time to Failure:	10 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	32,410 lb
Length:	4.54 in	Compressive Strength:	10,420 psi
L/D:	2.28	Compressive Strength:	71.85 Mpa
End Area:	3.11 in^2	Unit Weight	174 pcf

Before the Test

After the Test

Drawing # : PA-DE-0100.0000-RRb
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon		Performed by:	D. Savage
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24E	Lithology :	Gneiss
Sample No.:	3	Moisture Content :	As received
Sample Depth:	62.5 feet	Lab Temperature :	70° F
Sampling Date:	9/29/17	Loading Rate:	55 psi/s
		Time to Failure:	11 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	37,330 lb
Length:	3.79 in	Compressive Strength:	12,124 psi
L/D:	1.91	Compressive Strength:	83.59 Mpa
End Area:	3.08 in^2	Unit Weight	179 pcf

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

Before the Test

After the Test

Drawing # : PA-DE-0100.0000-RRb
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon		Performed by:	D. Savage
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

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

Boring No.:	B6-24E	Lithology :	Gneiss
Sample No.:	4	Moisture Content :	As received
Sample Depth:	76 feet	Lab Temperature :	70° F
Sampling Date:	9/29/17	Loading Rate:	55 psi/s
		Time to Failure:	19 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	61,300 lb
Length:	4.52 in	Compressive Strength:	19,709 psi
L/D:	2.27	Compressive Strength:	135.89 Mpa
End Area:	3.11 in^2	Unit Weight	175 pcf

Before the Test

After the Test

Drawing # : PA-DE-0100.0000-RRb
PO # : 20170908-4
Crossing : Glen Riddle Road_SE_PA_RR
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon		Performed by:	D. Savage
Project No.	J217P078			Test Date:	10/16/2017
Location:	Spread 6			Reviewed By :	L. Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/16/2017

Soil Boring Log

ID NO. **3+60**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**275 msl (est.)**	TOTAL DEPTH:	**360'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**3.8' bgs**		
JOB NO.	**204742**	BOREHOLE DIA.:	**6"**		
Logged By:	J. Valvik, P.G., A. Hirschfeld, P.G.	Drilling Method:	**Core Barrel**		
Dates Drilled:	**10/4/2018 to 10/12/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
0					(0'-5.5') Not Logged		
-2							
-4							
-6	SS-1	13	4,4, 5,8	19"	(5.5'-7.5') Light yellow and brown mottled saprolite, decomposed schist, flakey, stiff, clayey, trace coarse quartz	ML	
-8	SS-2	18	4,5, 8,10	20"	(7.5'-9.5') Same as above, very stiff		
-10					(9.5'-11') Not Logged		Borehole water at 3.8 feet bgs
-12					(11'-13') Attempted coring, no sample		
-14	SS-3	59	9,50/3	9"	(13'-15') Dark brown silty sand, weathered schist	SM	
-16	SS-4	36	8,10, 15,21	0"	(15'-17') Attempted coring, bit failure, no sample		
-18					(17'-20') Not Logged		
-20					(20'-21') Not Logged		
-22	SS-5	99	49, 50/3	1"	(21'-22') Brown saprolite, clayey, weathered schist, stiff	ML	
-24					(22'-24') Not Logged		
-26	SS-6	37	11,15, 18,19	19"	(24'-26') Tan-brown silt, stiff, trace fine-grained sand, trace rock fragments (pyritic/quartzic), schistose saprolite		
-28					(26'-29') Not Logged		
-30	SS-7	37	8,12, 15,22	20"	(29'-31') Buff-brown mottled saprolite, schistose, vey stiff, clayey		
-32					(31'-34') Not Logged		
-34	SS-8	17	6,11, 12,5	12"	(34'-36') Buff-brown mottled saprolite, schistose, vey stiff, clayey		
-36					(36'-38') Not Logged		
-38	SS-9	51	30,15, 17,34	13"	(38'-40') Brown-gray mottled saprolite, hard		
-40					(40'-44') Not Logged	WEATHERED GNEISS	Boring backfilled with grout, bentonite and topped with topsoil
-42							
-44	SS-10	71	24,24, 33,38	17"	(44'-46') Brown dark-gray saprolite, weathered gneiss/schist, very stiff, white, speckled-chalky		
-46					(46'-49') Not Logged		
-48	SS-11	50	50/4"	4"			49.3' Begin coring
-50					(49'-55') Gray -brown to dark-gray saprolite,		

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **3+60**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**275 msl (est.)**	TOTAL DEPTH:	**360'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**3.8' bgs**		
JOB NO.	**204742**	BOREHOLE DIA.:	**6"**		
Logged By:	J. Valvik, P.G., A. Hirschfeld, P.G.	Drilling Method:	**Core Barrel**		
Dates Drilled:	**10/4/2018 to 10/12/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-52	Core Run 1			42"	weathered gneiss/schist, hard but crumbly, with white mottling, speckled-chalky		49.3'-50'-RQD 0"/0% 50'-55'-RQD 0"/0%
-56	Core Run 3			60"	(55'-60') Dark gray and yellow to tan mottled gneiss, massive, coarse, crystalline in parts, high angle (70 degree) to low angle (30 degree) closed microfractures	**GNEISS**	55'-60'-RQD 58.5"/97.5%
-60	Core Run 4			55.5"	(60'-78.1') Gneiss, weathered black to dark brown and medium-brown (zone of rubble), zone at 66'-66.5' yellowish coarse crystalline quartz, tan mottled, weathered and decomposed		60'-65'-RQD 48"/80%
-66	Core Run 5			42"		**WEATHERED GNEISS**	65'-70'-RQD 6.5"/10.8%
-70	Core Run 6			60"			70'-75'-RQD 0"/0%
-76	Core Run 7			60"	(78.1'-80') Gneiss, solid with trace red garnet and ultramafic minerals	**WEATHERED GNEISS**	75'-80'-RQD 0"/0%
-80	Core Run 8			48.5"	(80'-82.7') Gneiss, saprolite, silty sand with little f-m, dark-brown to dark-gray clay and coarse gravel	**GNEISS**	80'-85'-RQD 4.5"/7.5%
-84					(82.7'-118') Alternating gneiss and weathered gneiss, solid to highly weathered, dark-brown to dark-gray slightly weathered garnet and ultramafic minerals, highly foliated, some fine to coarse-grained sand and silt, coarse white grains, some talc and decomposed quartzite, saprolite, biotite, talc,	**WEATHERED GNEISS**	Slightly weathered and fractured at 85'
-88	Core Run 9			29.5"			85'-90'-RQD 10.5"/17.5%
-92	Core Run 10			60"			90'-95'-RQD 18.5"/30.8%
-96	Core Run 11			54.5"			95'-100'-RQD 17.8"/29.2%
-100							

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Soil Boring Log

ID NO. **3+60**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**275 msl (est.)**	TOTAL DEPTH:	**360'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**3.8' bgs**		
JOB NO.	**204742**	BOREHOLE DIA.:	**6"**		
Logged By:	J. Valvik, P.G., A. Hirschfeld, P.G.	Drilling Method:	**Core Barrel**		
Dates Drilled:	**10/4/2018 to 10/12/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-102	Core Run 12			59.5"			Highly fractured (70 degree) 100'-105'-RQD 34"/57%
-104							
-106	Core Run 13			57.5"			105'-110'-RQD 4.5"/7.5%
-108							
-110	Core Run 14			46.5"			110'-115'-RQD 20.5"/34.7%
-112							
-114	Core Run 15			48"			silty sand and clay from 114.9' to 115' 115'-120'-RQD 13"/21.7%
-116					(118'-150') Sepentinite schist, solid, dark-brown to dark-gray and dark-green, slightly to moderately weathered, friable, micaceuos, red garnets, some sand and silt	**SERPENTINE**	
-118							
-120	Core Run 16			46"			120'-125'-RQD 14"/23.3%
-122							
-124	Core Run 17			24"			White talc zone from 125.3' to 125.5' 125'-130'-RQD 4"/6.67%
-126							
-128	Core Run 18			25.5"			130'-135'-RQD 0/0%
-130							
-132	Core Run 19			34"			135'-140'-RQD 8"/13.3% (124'-355') No recovery, weathered zone, sample washed out (124, 138', 142', 145', 149', and 355')
-134							
-136	Core Run 20			45"			140'-145'-RQD 19.5"/32.5%
-138							
-140	Core Run 21			27.5"			145'-150'-RQD 0/0%
-142							
-144							
-146							
-148							
-150							

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **3+60**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**275 msl (est.)**	TOTAL DEPTH:	**360'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**3.8' bgs**		
JOB NO.	**204742**	BOREHOLE DIA.:	**6"**		
Logged By:	J. Valvik, P.G., A. Hirschfeld, P.G.	Drilling Method:	**Core Barrel**		
Dates Drilled:	**10/4/2018 to 10/12/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-152	Core Run 22			60"	(150'-360') Gneiss, solid, hard, highly broken and fractured, blue to light-green, oxidized, quartzite, red and brown garnet, chlorite, muscovite, biotite, serpentenite, pyrite, white mottled	**GNEISS**	150'-155'-RQD 26.5"/44.2%
-154							
-156	Core Run 23						
-158				60"			155'-160'-RQD 36"/60.8%
-160							
-162	Core Run 24						
-164				60"			160'-165'-RQD 50.5"/84.2%
-166	Core Run 25						
-168				60"			165'-170'-RQD 56"/93.3%
-170							
-172	Core Run 26						
-174				44.5"			170'-175'-RQD 18.5"/30.8%
-176	Core Run 27			59"			
-178							175'-180'-RQD 56.5"/94.2%
-180							
-182	Core Run 28						
-184				60"			180'-185'-RQD 52"/86.7%
-186	Core Run 29						
-188				60"			185'-190'-RQD 60"/100%
-190							
-192	Core Run 30						
-194				60"			190'-195'-RQD 58.5"/97.5%
-196	Core Run 31						
-198				60"			195'-200'-RQD 57"/95%
-200							

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Soil Boring Log

ID NO. **3+60**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**275 msl (est.)**	TOTAL DEPTH:	**360'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**3.8' bgs**		
JOB NO.	**204742**	BOREHOLE DIA.:	**6"**		
Logged By:	J. Valvik, P.G., A. Hirschfeld, P.G.	Drilling Method:	**Core Barrel**		
Dates Drilled:	**10/4/2018 to 10/12/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-202	Core Run 32			60"			200'-205'-RQD 58"/96.7%
-204							
-206	Core Run 33						
-208				60"			205'-210'-RQD 54.5"/90.8%
-210	Core Run 34						
-212							
-214				60"			210'-215'-RQD 59"/98.3%
-216	Core Run 35						
-218				59.5"			215'-220'-RQD 57.5"/95.8%
-220	Core Run 36						220'-225'-RQD 58"/96.7%
-222				60"			
-224							
-226	Core Run 37						225'-230'-RQD 100"/100%
-228				60"			225'-230'-RQD 60"/100%
-230	Core Run 38						
-232				58"			230'-235'-RQD 52"/89%
-234							
-236	Core Run 39						
-238				60"			235'-240'-RQD 53"/88%
-240	Core Run 40						
-242				59"			240'-245'-RQD 53"/89%
-244							
-246	Core Run 41						
-248				60"			245'-250'-RQD 59.5/99%
-250							

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **3+60**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**275 msl (est.)**	TOTAL DEPTH:	**360'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**3.8' bgs**		
JOB NO.	**204742**	BOREHOLE DIA.:	**6"**		
Logged By:	J. Valvik, P.G., A. Hirschfeld, P.G.	Drilling Method:	**Core Barrel**		
Dates Drilled:	**10/4/2018 to 10/12/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-252	Core Run 42			60"			250'-255'-RQD 59.5"-99%
-254							
-256	Core Run 43						
-258				60"			255'-260'-RQD 53"/89%
-260							
-262	Core Run 44						
-264				60"			260"-265'-RQD 60"/0%
-266	Core Run 45						(260'-270') Not Logged
-268				60"			265'-270'-RQD 60"/0%
-270							
-272	Core Run 46						270'-275'-RQD 42"/70% Quartz and rubble zone at 273.5' to 274'
-274				60"			
-276	Core Run 47						
-278				60"			275'-280'-RQD 49"/82%
-280							
-282	Core Run 48						
-284				59"			280'-285'-RQD 59"/100%
-286	Core Run 49						
-288				60"			285'-290'-RQD 54.5"/91%
-290							
-292	Core Run 50						290'-295'-RQD 0"/0%
-294							Blue zones and red zones at 293'
-296	Core Run 51						
-298				60"			295'-300'-RQD 39"/65%
-300							

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Soil Boring Log

ID NO. **3+60**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**275 msl (est.)**	TOTAL DEPTH:	**360'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**3.8' bgs**		
JOB NO.	**204742**	BOREHOLE DIA.:	**6"**		
Logged By:	J. Valvik, P.G., A. Hirschfeld, P.G.	Drilling Method:	**Core Barrel**		
Dates Drilled:	**10/4/2018 to 10/12/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-302	Core Run 52			60"			Borehole terminated at 360 feet bgs
-304							300'-305'-RQD 60"/100%
-306	Core Run 53						
-308				59"			305'-310'-RQD 59"/100%
-310	Core Run 54						Weathered coarse crystalline garnet at 308' and 5" thick quartz vein at 315'
-312				60"			
-314							310'-315'-RQD 56"/93%
-316	Core Run 55						315'-320'-RQD 59"/98%
-318				60"			
-320	Core Run 56						
-322							
-324							320'-325'-RQD 46.5"/78%
-326	Core Run 57						
-328				60"			325'-330'-RQD 46.5"/78%
-330	Core Run 58						330'-335'-RQD 49.5"/83%
-332				55"			
-334							Vertical fractures (80 degree) to low angle (10 degree) fractures from 85'-330' filled with quartz, pyrite, garnet, mafic minerals, biotite
-336	Core Run 59						
-338				54"			
-340	Core Run 60						335'-340'-RQD 49.5"/92%
-342				39.5"			
-344							340'-345'-RQD 55"/92%
-346	Core Run 61						
-348				35"			345'-350'-RQD 0"/0%
-350							

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Soil Boring Log

ID NO. **3+60**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**275 msl (est.)**	TOTAL DEPTH:	**360'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**3.8' bgs**		
JOB NO.	**204742**	BOREHOLE DIA.:	**6"**		
Logged By:	J. Valvik, P.G., A. Hirschfeld, P.G.	Drilling Method:	**Core Barrel**		
Dates Drilled:	**10/4/2018 to 10/12/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-352	Core Run 62			0"			350'-355'-RQD 0"/0%
-354							
-356	Core Run 63			0"			355'-360'-RQD 0"/0%
-358							
-360							

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **18+50**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**NA**	TOTAL DEPTH:	**80'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**24'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**2 7/8"**		
Logged By:	Andy Westerbaan, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/15/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
0					(0'-6') Not Logged		Soft dig 0' to 6' bgs
-6	SS-1	49	8,17, 24,25	15"	(6'-8') Clay with fine sand, schist fragments, gray/brown, slightly moist, firm, weathered	CL	
-8					(8'-10') Same as above, schist with folliation, structure, weak, platy, light-gray, slightly moist		
-10	SS-2	46	19,20, 23,23	14"	(10'-15') Advanced casing		
-16	SS-3	29	14,13, 12,17	12"	(15'-17') Fine sand and silt matrix, weathered schist, elongated grains, some lamination, trace mica, brown, wet	ML	
-18					(17'-20') Advanced casing		
-22	SS-4	52	12,12, 21,31	14"	(20'-22') Fine sand and silty matrix, weathered schist, crude foliation, elongated grains, light brown to gray, wet	ML	
-24					(20'-22') Advanced casing		
-26	SS-5	64	14, 50/3	8"	(25'-30') Fine sand and silty matrix, weathered schist, crude foliation, elongated grains, light brown to gray, wet	ML	
-28				16"			Begin core sampling at 30' bgs
30							

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Soil Boring Log

ID NO. **18+50**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**NA**	TOTAL DEPTH:	**80'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**24'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**2 7/8"**		
Logged By:	Andy Westerbaan, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/15/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-32	SS-6	50	50/1"	NR	(30'-50') Schist, foliation present, elongated grains (gray to light-gray and light-brown), little mica flakes, moderate, weathered, slight iron staining, weak	**WEATHERED SCHIST**	Low angle fractures (20 degrees) 30'-35'
-34	CB-1			36"			30'-35' RQD - 25.5/42.5%
-36							Fractures (>45 degrees) from 38'-40'
-38	CB-2			60"			35'-40' RQD - 38.5"/64%
-40							Boring backfilled with grout, bentonite and topped with topsoil
-42	CB-3			60"			40'-45' RQD - 42.5"/71%
-44							
-46							45'-50' RQD - 37.5/63%
-48	CB-4			58"			Vertical fractures 47' 2"
-50							Highly weathered at 48'-50' bgs
-52	CB-5			60"	(50'-55') Schist, lamination throughout, moderate to highly fractured from 50'-53', some white low angle white stringers, gray to light gray, medium strength 53'-55' bgs	**SCHIST**	50'-55' RQD - 40.5/67.5%
-54							
-56					(55'-60') Schist, highly weathered from 56.5'-59' high angle fracture at 55.6', foliation and lamination less distinct, light gray, fine-grained matrix	**WEATHERED SCHIST**	
-58	CB-6			55"			55'-60' RQD - 35"/58%
-60							Vertical fractures at 63' and 64' 5"

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Soil Boring Log

ID NO. **18+50**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**NA**	TOTAL DEPTH:	**80'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**24'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**2 7/8"**		
Logged By:	Andy Westerbaan, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/15/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-62	CB-7			58"	(60'-65') Schist foliation less present, moderate strength, medium grains present	**SCHIST**	60'-65' RQD - 42.5"/71% Distinct white low angle stringers from 63' 6"-65'
-64							
-66					(65'-80') Schist, foliation and lamination less present (lacking), moderate strength, platy cleavage, weathered, light gray	**WEATHERED SCHIST**	Low angle white stringers at 65'-67'
-68	CB-8			60"			65'-70' RQD - 43,5"/73% Iron staining at 65' 6" and 68'-68.5'
-70							70'-75' RQD 53"/88%
-72	CB-9			60"			White low angle stringers at 74'-75' bgs
-74							75'-80' RQD - 44"/73%
-76							White low angle stringers at 75'-76.5' bgs
-78	CB-10			60"			Borehole terminated at 80 feet bgs
-80							

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **24+00**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**NA**	TOTAL DEPTH:	**198.6'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**2.50'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**2 7/8"**		
Logged By:	A. Westerbaan, P.G. & J. Valvik, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/3-4/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
0					(0'-6') Not Logged, soft dig		Boring backfilled with grout, bentonite and topped with topsoil
-6	SS-1	10	2,3, 5,5	14"	(6'-10') Clay and silt, mottled, iron staining, trace mica flakes, firm, brown	CL / ML	Soft dig 0' to 6' bgs
-10	SS-2	12	3,4, 6,6	24"			
-12					(10'-13') Not logged		Spun casing from 10'-13' bgs
-14	SS-3	5	WH,1, 2,3	24"	(13'-15') Clay with some silt, plastic, trace mica flakes, slightly firm, brown and gray	CL	
-16					(15'-18') Not logged		
-18					(18'-20') Sand medium to fine-grained with little silty clay and fine angular gravel, gray, loose, brown		Spun casing from 15'-18' bgs
-20	SS-4	0	WH	18"			
-22					(20'-23') Not logged		
-24	SS-5	23	9,17, 11,12	9"	(23'-25') Varigated gray-brown angular fine sub-angular gravel with fine to medium-grained sand, iron staining	SM	Spun casing from 20'-23' bgs
-26					(25'-28') Not logged, rotary washed		
-28					(28'-30') Gravel, subrounded and fine with medium-grained sand matrix, varicated color (gneiss), light-gray	GM	Begin core sampling at 30' bgs
-30	SS-6	21	22,22, 13,8	24"	(30'-33') Not logged, rotary washed	GNEISS	
-32		50/ 0"	50/0"		(33'-34') Gneiss, crudly foliated, strong, highly fractured, uneven grain structure, gray		Begin core run at 33' bgs
-34	CB-1			7"			33'-34' RQD - 0"/0%
-36	CB-2			31"	(34'-62.8') Gneiss, crudly foliated with subparrallel and unevenly distributed grains, low to medium fracture angles (30 to 45 degrees), strong, moderate weathering, highly fractured, iron staining, light-gray to gray	WEATHERED GNEISS	34'-36.8" RQD - 4.5"/14.5%
-38	CB-3			27.5"			36.8'-39' RQD - 17"/62%
-42	CB-4			59.5"			39'-44" RQD - 42"/70%
-48	CB-5			56"			44'-49' RQD - 9.5"/16%

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **24+00**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**NA**	TOTAL DEPTH:	**198.6'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**2.50'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**2 7/8"**		
Logged By:	A. Westerbaan, P.G. & J. Valvik, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/3-4/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-52	CB-6			49.5"			49'-54' RQD - 26"/43%
-54							
-56							
-58	CB-7			55"			54'-59' RQD - 20.5"/34%
-60							
-62	CB-8			58"			59'-64' RQD - 11.5"/19%
-64					(62.8'-66.2') Gneiss, strong, competent, crude foliation, low to medium angle fractures (30 to 45 degrees)	**GNEISS**	
-66							
-68	CB-9			55.5"	(66.2'-69') Gneiss, highly weathered, weak to soft, gray-brown	**WEATHERED GNEISS**	64'-69' RQD - 33.5"/56%
-70					(69'-74') Gneiss, crude foliation, uneven distribution of grains, moderate weathering, medium fracture angle (45 degrees), moderate fractures, light-gray, strong, hard, competent		
-72	CB-10			60"			69'-74' RQD - 53.5"/89%
-74					(74'-79') Gneiss, highly weathered, weak to soft strength, gray-brown, highly fractured at 78.5'-79'		
-76							
-78	CB-11			54"			74'-79' RQD - 5.5"/9.1%
-80					(79'-89') Gneiss, strong, crude foliation with quartzite clasts, microfractures throughout, low to medium angle fractures (30 to 45 degrees) with stringers, slightly more defined foliation, tan to light gray, hard, strong	**GNEISS**	
-82	CB-12			60"			79'-84' RQD - 48"/80%
-84							
-86							
-88	CB-13			59.5"			84'-89' RQD - 46.5"/78%
-90					(89'-137') Schist, platy, weak, elongated parallel grains, high angle fractures (45 to 60 degrees) brown to dark-gray, moderate to highly fractured, moderate to highly weathered	**WEATHERED SCHIST**	
-92	CB-14			25.5"			89'-94' RQD - 9"/15%
-94							
-96							
-98	CB-15			50.5"			94'-99' RQD - 30"/50%
-100							

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **24+00**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**NA**	TOTAL DEPTH:	**198.6'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**2.50'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**2 7/8"**		
Logged By:	A. Westerbaan, P.G. & J. Valvik, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/3-4/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Recovery	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-102	CB-16			35"			99'-104' RQD - 0"/0%
-104							
-106							
-108	CB-17			60"			104'-109' RQD - 9"/15% Highly fractured from 110.6'-112.6' bgs
-110							
-112	CB-18			60"			109'-114' RQD - 25.5"/43%
-114							
-116							
-118	CB-19			51"			114'-119' RQD - 0"/0%
-120							
-122	CB-20			47.5"			119'-124' RQD - 10.5"/18%
-124							
-126							
-128	CB-21			49.5"			124'-129' RQD - 4.5"/7.5%
-130							
-132	CB-22			54"			129'-134' RQD - 8.5"/14%
-134							
-136					(137'-139') Gneiss, crude foliation, quartz clasts, hard, color varicated, spotty, tan quartzite with mineralized fractures throughout		
-138	CB-23			60"		**GNEISS**	134'-139' RQD - 28.5"/48%
-140					(139'-198.6') Gneiss, highly weathered and fractured, massive with bands of red quartz, microfractured throughout, gray to dark-gray and black, high angle fractures (45 to 60 degrees)	**WEATHERED GNEISS**	
-142	CB-24			52.5"			139'-144' RQD - 35"/58%
-144							
-146							
-148	CB-25			30"			144'-149' RQD - 30"/50%
-150							

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Soil Boring Log

ID NO. **24+00**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME-2 Delaware County**	SURFACE ELEV.:	**NA**	TOTAL DEPTH:	**198.6'**
ADDRESS:	**Glen Riddle Drive**	WATER DEPTH:	**2.50'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**2 7/8"**		
Logged By:	A. Westerbaan, P.G. & J. Valvik, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/3-4/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied Well Drilling**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-152	CB-26			39"			149'-154' RQD - 4"/7%
-154							
-156							
-158	CB-27			54"			154'-159' RQD - 11.5"/19%
-160							
-162	CB-28			27"			159'-164' RQD - 0"/0%
-164							
-166							
-168	CB-29			29.5"			164'-169' RQD - 15.5"/25%
-170							
-172	CB-30			59"			169'-174' RQD - 49"/82%
-174							
-176							
-178	CB-31			59"			174'-179' RQD - 49"/82%
-180							
-182	CB-32			60"			179'-184' RQD - 48.5"/81%
-184							
-186							
-188	CB-33			60"			184'-189' RQD - 54.5"/91%
-190							
-192	CB-34			60'			189'-194' RQD - 50"/83%
-194							Borehole terminated at 198.6' bgs
-196							
-198	CB-35			55"			194'-198.6' RQD - 34"/62%

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Soil Boring Log

ID NO. **26+75**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME2 - Delaware County**	SURFACE ELEV.:	**449.022**	TOTAL DEPTH:	**186'**
ADDRESS:	**Glen Riddle Drive, Glen Riddle PA**	WATER DEPTH:	**3.25'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**3"**		
Logged By:	S Tannen, P.G./B. Emilius, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/4-5/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
0					(0-6') Not Logged		
-6		8	2/3/4/4	24"	(6'-8') Dark gray micaceous silt, trace fine sand, moist	ML	Tremie grout to surface 15 bags of Type 1 and Type 2 portland cement.
-8					(8'-11') Not Logged		
-12		8	7/8/4/4	1"	(11'-13') Coarse quartz gravel, subrounded	GW	
-14					(13'-16') Not Logged		
-16					(16'-18') Multicolored coarse-to-fine gravel, coarse-to-fine sand, trace silt, rounded, surounded, subangular	GP	
-18		65	28/38/35/30	17"			Colluvium
-20					(18'-21') Not Logged		
-22		37	11/18/10/27	12"	(21'-23') Brown coarse-to-fine sand, fine gravel, trace silt, moist	SW	
-24					(23'-25') Not Logged		
-26		50	50/0		(26'-31') No Recovery	NO RECOVERY	
-32		61	11/50	5"	(31'-33') Dark gray weathered gneiss gravel and brown silt and sand	GM	
-34					(33'-36') Not Logged		
-38		50	50/0	14"	(36'-41') Dark gray gneiss	GNEISS	36'-38' - RQD 0"/0% 38'-41'-RQD 0"/0%
-40				4"			
-42					(41'-43') Brown micaceous silt with gravel	ML	41'-43'-RQD 0"/0%
-44				46"	(43'-101') Dark gray to dark gray gneiss with milky white quartz, fractured, mottled	GNEISS	
-46							43'-46' - RQD 0"/0%
-48				48"			46'-51'-RQD 9"/15%
-50							

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **26+75**

Groundwater & Environmental Services, Inc.

PROJECT:	**ME2 - Delaware County**	SURFACE ELEV.:	**449.022**	TOTAL DEPTH:	**186'**
ADDRESS:	**Glen Riddle Drive, Glen Riddle PA**	WATER DEPTH:	**3.25'**		
JOB NO.	**204742**	BOREHOLE DIA.:	**3"**		
Logged By:	S Tannen, P.G./B. Emilius, P.G.	Drilling Method:	**Split-spoon/Rock-coring**		
Dates Drilled:	**10/4-5/2018**	Sampling Method:	**Safety (140 lb hammer, 30" drop)**		
Drilling Company:	**Allied**	Soil Class. System:	**USCS**		
Drill Rig Type:	**D-50 Track-mounted**	Field Screening:	**NA**		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-52							
-54				60"			51'-56'-RQD 20"/33%
-56							
-58				60"			56'-61'-RQD 11"/18.3%
-60							
-62							
-64				60"			61'-66'-RQD 30"/50%
-66							
-68				42"			66'-71'-RQD 9"/15%
-70							
-72							
-74				49"			71'-76'-RQD 17"/28.3%
-76							
-78				60"			76'-81'-RQD 12"/20%
-80							
-82							81'-91' evidence of fractures with weathering due to water movment
-84				58"			81'-86'-RQD 4"/6.6%
-86							
-88							86'-91'-RQD 8"/13.3%
-90				58"			91'-96' evidence of fractures with weathering due to water movment
-92							
-94				31"			
-96							91'-96'-RQD 10"/16.6%
-98							
-100				27"			96'-101'-RQD 0"/0%

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **26+75**

Groundwater & Environmental Services, Inc.

PROJECT:	ME2 - Delaware County	SURFACE ELEV.:	449.022	TOTAL DEPTH:	186'
ADDRESS:	Glen Riddle Drive, Glen Riddle PA	WATER DEPTH:	3.25'		
JOB NO.	204742	BOREHOLE DIA.:	3"		
Logged By:	S Tannen, P.G./B. Emilius, P.G.	Drilling Method:	Split-spoon/Rock-coring		
Dates Drilled:	10/4-5/2018	Sampling Method:	Safety (140 lb hammer, 30" drop)		
Drilling Company:	Allied	Soil Class. System:	USCS		
Drill Rig Type:	D-50 Track-mounted	Field Screening:	NA		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-102					(101'-120.5') Greenish gray weathered gneiss/schist, saprolite	WEATHERED GNEISS	
-104				60"			101'-106'-RQD 0"/0%
-106							
-108				60"			106'-111'-RQD 0"/0%
-110							
-112				60"			111'-116'-RQD 0"/0%
-114							
-116				60"			116'-121'-RQD 0"/0%
-118							
-120					(120.5'-127') Greenish dark gray gneiss	GNEISS	
-122				60"			121'-126'-RQD 47"/78.3%
-124							
-126					(127'-131') Greenish gray clay with some gravel	CL	
-128				60"			126'-131'-RQD 0"/0%
-130					(131'-186') Greenish gray to dark-gray weathered gneiss with micaceous schist, saprolite, talc, calcite veins,	WEATHERED GNEISS	
-132							
-134				52"			131'-136'-RQD 0"/0%
-136							
-138				50"			136'-141'-RQD 0"/0%
-140							
-142				60"			141'-146'-RQD 0"/0%
-144							
-146				40"			146'-151'-RQD 0"/0%
-148							
-150							

Location:
Northing/Latitude:
Easting/Longitude:

General Comments:
bgs - below ground surface

Symbol Key:
Apparent Water Level

Soil Boring Log

ID NO. **26+75**

Groundwater & Environmental Services, Inc.

PROJECT:	ME2 - Delaware County	SURFACE ELEV.:	449.022	TOTAL DEPTH:	186'
ADDRESS:	Glen Riddle Drive, Glen Riddle PA	WATER DEPTH:	3.25'		
JOB NO.	204742	BOREHOLE DIA.:	3"		
Logged By:	S Tannen, P.G./B. Emilius, P.G.	Drilling Method:	Split-spoon/Rock-coring		
Dates Drilled:	10/4-5/2018	Sampling Method:	Safety (140 lb hammer, 30" drop)		
Drilling Company:	Allied	Soil Class. System:	USCS		
Drill Rig Type:	D-50 Track-mounted	Field Screening:	NA		

Depth (feet)	Sample Number	N-Value	Blow Counts	Rec-overy	SAMPLE LITHOLOGY (USCS)	Stratigraphy	Comments
-152							
-154				60"			151'-156'-RQD 0"/0%
-156							
-158							
-160				60"			156'-161'-RQD 7"/11.6%
-162							
-164				60"			161'-166'-RQD 13"/21.6%
-166							
-168							
-170				50"			166'-171'-RQD 0"/0%
-172							
-174				24"			171'-176'-RQD 0"/0%
-176							
-178							
-180				34"			176'-181'-RQD 12"/20%
-182							
-184				48"			181'-186'-RQD 23"/41.6%
-186							186'-Boring completed

Location:

Northing/Latitude:

Easting/Longitude:

General Comments:

bgs - below ground surface

Symbol Key:

Apparent Water Level

Groundwater & Environmental Services, Inc. Boring Log:

Sheet 1 of 1

Project: ETP/SXL Mariner 2 - Spread 6	Project Number: 204742	Client: ETP	Boring No. #20 (microG loc #30520)
Address, City, State: Tunbridge Apts, Glenn Riddle Rd Media, PA (S3-620)		Drilling Contractor: EarthCore	Drill Rig Type: Acker Soil Max - Truck Mounted
Logged By: Steven Tanen, PG	Date Started: 8/15/2018	Bit Type: Hollow Stem Auger	Diameter: 4 1/4-in ID / 7 1/4-in OD
Drill Crew: John Swope(driller),Bob Mannin	Date Completed: 8/15/2018	Hammer Type/Wt: 140#	CPT Pressure:
USA Ticket Number:	Date Backfilled: Tremmie grouted	Hammer Drop: 30-inches	
	Groundwater Depth: 0 hr 24 hr	Elevation:	Total Depth of Boring: 19.5 ft-bgs

Depth (feet)	Sample Type	Sample Interval (ft-bgs)	Blow Counts (blows/6-in)	Lithology **Soil Group Name:** modifier, color, moisture, density, grain size, other descriptors **Rock Description:** modifier, color, hardness, bedding and joint characteristics, solutions, void conditions.	Pocket Penetrometer Reading (PPR) **Comments:**
0		0 to 0.5		5-in asphalt (no gap)** w sandy c-f gravel subbase	Drilling started at 0.5 ft bgs
1	SS	0.5 to 2	2-3-3	soft, moist gray brown and orange mottled clayey SILT	Rec. = 1 of 1.5 ft
2					
3	SS	2 to 4	3-4-5-7	same, becoming very stiff. PPR = 2.25, with gray clayey	Rec. = 1.1 of 2 ft
4				streak.	
5	SS	4 to 6	3-5-7-9	PPR = 2.0	Rec. = 1.4 of 2 ft
6					
7	SS	6 to 8	3-4-4-5		Rec. = 1.4 of 2 ft
8				@6.85 ft becomes stiff, dark gray moist laminated	
9	SS	8 to 10	2-3-4-3	micaceous SILT, with wet sandy seams	Rec. = 1.6 ft of 2 ft
10					
11	SS	10 to 12	1-2-3-4	soft, dark grayr micaceous SILT, with wet fine sandy	Rec. = 1.4 of 2 ft
12				seams. PPR = 0.5	
13	SS	12 to 14	3-3-5-7	(spoon wet at 13.5 ft-bgs)	Rec. = 1.3 of 2 ft
14					
15	SS	14 to 16	2-3-4-21	same with wet sandy seams, water in spoon.	Rec. = 2 of 2 ft
16				@15.25 ft becomes very dense multi-colored layered	
17	SS	16 to 18	17-31-50/2	micaceous fine SAND, trace silt	Rec. = 0.8 of 1.1 ft
18					
19	SS	18 to 20	18-18-50/6	very dense yellow brown gravelly, silty coarse to fine SAND	Rec. = 0.8 of 1.5 ft
20				(angular to subrounded gravel/coarse sand).	
				End of boring 19.5 ft-bgs (spoon bouncing)	
				Tremie grouted bore to within 1-ft groundsurface. Packed	
				with bentonite chips (~6- to 8-in), with cold patch.	
				Cuttings taken from work area by OTIS	
				**double layer of ashphalt observed (no gap)	

Groundwater & Environmental Services, Inc.

Boring Log: Sheet 1 of 1

Project: ETP/SXL Mariner 2 - Spread 6	Project Number: 204742	Client: ETP	Boring No. #44 (offset ~6 ft W microG loc #30544)
Address, City, State: Tunbridge Apts, Glenn Riddle Rd Media, PA (S3-620)		Drilling Contractor: EarthCore	Drill Rig Type: Acker Soil Max - Truck Mounted
Logged By: Steven Tanen, PG	Date Started: 8/15/2018 1035	Bit Type: Hollow Stem Auger	Diameter: 4 1/4-in ID / 7 1/4-in OD
Drill Crew: John Swope(driller),Bob Manning	Completed: 8/15/2018	Hammer Type/Wt: 140#	CPT Pressure:
USA Ticket Number:	Backfilled: Tremmie grouted	Hammer Drop: 30-inches	
	Groundwater Depth: 0 hr 24 hr	Elevation:	Total Depth of Boring: 20 ft-bgs

Depth (feet)	Sample Type	Sample Interval (ft-bgs)	Blow Counts (blows/6-in)	Lithology **Soil Group Name:** modifier, color, moisture, density, grain size, other descriptors **Rock Description:** modifier, color, hardness, bedding and joint characteristics, solutions, void conditions.	Pocket Penetrometer Reading (PPR) **Comments:**
0		0 to 0.5		2 1/2- to 3-in asphalt (no gap)* w sandy c-f gravel subbase	Drilling started at 0.5 ft bgs
1	SS	0.5 to 2	2-2-2	soft, moist gray brown and orange mottled clayey SILT	Rec. = 0.8 of 1.5 ft
2					
3	SS	2 to 4	3-4-7-6	same. PPR = 1.25	Rec. = 1.5 of 2 ft
4					
5	SS	4 to 6	2-4-5-8	stiff becoming very stiff, layered moist gray and organge	Rec. = 1.8 of 2 ft
6				mottled clayey SILT and silty CLAY. PPR = 1.25	
7	SS	6 to 8	6-5-5-7	same, some mica observed. PPR = 3	Rec. = 1.9 of 2 ft
8					
9	SS	8 to 10	3-4-5-5	stiff, dark gray moist laminated micaceous SILT	Rec. = 1 ft of 2 ft
10					
11	SS	10 to 12	2-2-3-4	same, with wet fine sandy seams	Rec. = 1.4 of 2 ft
12				@ 12.4 ft wet sandy seams	
13	SS	12 to 14	1-2-3-4	PPR = 1.0	Rec. = 1.9 of 2 ft
14					
15	SS	14 to 16	2-2-3-8	same with wet sandy seams	Rec. = 1.9 of 2 ft
16					
17	SS	16 to 18	10-31-21-20	very dense, purple to yellow gravelly silty brown fine SAND	Rec. = 1.4 of 2 ft
18				to sub-rounded gravel) becoming red-brown to orange-brow	
19	SS	18 to 20	18-21-32-50/6	(angular to sub-rounded gravel frags and sand, qtz frags).	Rec. = 1.3 of 2 ft
20					
				End of boring 20 ft-bgs	
				Tremie grouted bore to within 1-ft groundsurface. Packed	
				with bentonite chips (~6- to 8-in), with cold patch.	
				Cuttings taken from work area by OTIS	
				*single layer of ashphalt observed	

Attachment C

Geophysical Survey Reports

Quantum Geophysics

December 2018

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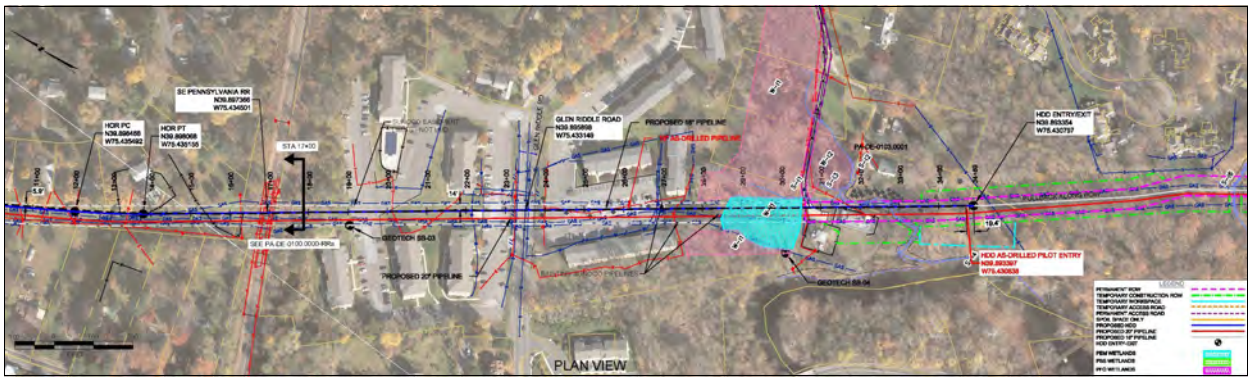
December 14, 2018

David Demko
GES
440 Creamery Way, Suite 500
Exton, Pennsylvania 19341

Re: Report
Geophysical Investigation
Sunoco Mariner Pipeline HDD620
Exton, PA

Dear Mr. Demko:

This report presents the findings of Quantum Geophysics' geophysical investigation carried-out in September and November of 2018 to obtain coverage in areas of HDD620 not previously investigated at the Tunbridge Apartments, 274 Glen Riddle Road, Media, PA. These specific areas included the northern portion of the Tunbridge Apartment parking lot (stations 24+00 to approximately 26+50), and the southern section of the HDD from the wetlands (approximately station 28+50) to just south of the access road (from Martins Lane) at approximately station 31+50. The investigation included the microgravity, multi-channel analysis of surface waves (MASW), and 3D electrical resistivity imaging (ERI) geophysical methods. With this investigation, there is now full coverage along HDD620 south of Glen Riddle Road with all three geophysical methods. Earlier investigations are described in reports dated June 14, 2018 and September 10, 2018.



HDD620 in plan view, from station 11+00 to station 34+89 (entry/exit). Glen Riddle Road crosses the HDD at approximately station 23+50.

This report is streamlined in order to focus on the findings of the geophysical investigation. Discussions of the various geophysical methods (e.g., how each method works, how data were collected, processed, and analyzed) have been placed in the following appendices: Appendix A (microgravity survey), Appendix B (MASW survey), and Appendix C (3D ERI survey).

FINDINGS

Figure 1 is a 3D ERI and MASW line location plan. The MASW lines are designated C-C', D-D', E-E', and F-F'. Lines A-A' and B-B' are in the report dated June 14, 2018. The 3D ERI electrode locations are represented by blue dots. Incidental releases (IRs), based on cadastral survey data and drone data provided by GES (see Appendix D), are indicated by red polygons in Figure 1.

The microgravity data from all investigations have been merged and are presented in Figure 2 as merged Bouguer Gravity Contour Map, and in Figure 3 as merged Residual Gravity Contour Map. IRs are also shown in Figures 2 and 3.

Figure 4 is the 3D ERI images for the northern portion of the HDD (stations 24+00 to approximately 26+50). The data is characterized by a "chevron-pattern" of very low electrical resistivity measurements. This pattern has no real geologic resemblance and is therefore most likely caused by interference from buried metal piping. Figure 5 is the 3D ERI images for the southern portion of the HDD from the wetlands to approximately station 28+50. There is a low electrical resistivity anomaly of approximately 10-50 ohm-meters (Ù-m) observed in the fully rendered and opaque images, as well as in the X, Y, and Z slices. The anomaly is widest at a depth of approximately 42 ft (max depth of exploration with 3D ERI), and tapers towards the surface. The anomaly is potentially caused by water or drilling mud. The anomaly is plotted in Figure 3. The anomaly is offset from the water line that extends out from the Aqua station.

V_s profiles for C-C' and D-D' are shown in Figure 6. V_s profiles for E-E' and F-F' are shown in Figure 7. The profiles are interpreted in terms of soil, decomposed rock, and competent rock, as reported in nearby borings by Tetra Tech (see Appendix E). While data quality was very good for lines C-C' and D-D', E-E' and F-F' are characterized by fair to poor data quality due potentially to encroaching upon the fenced-in Aqua station (pump and turbine noise), and poor ground coupling with rip rap along the southern portion of F-F'.

We make the following observations:

- There is a total of four (4) low gravity anomalies potentially caused by voids, fractures, or localized depressions in top of rock. They are best observed in the

merged Residual Gravity Contour Map (Figure 2), and are designated #1 through #4.

- Low gravity anomaly #1 measures approximately 30' x 30', is located at the entrance to the parking lot from Glen Riddle Road, and has a peak response of about -0.010 to -0.020 mGals. It is not associated with an IR, there is no corroborating MASW data because lines C-C' and D-D' start 10-20 ft south of the anomaly, and there is no corroborating ER anomaly. The MASW active receiver array extends to the edge of Glen Riddle Road but the result of the first shot record (SR) is plotted in the middle of the active receiver array which explains why the start of lines C-C' and D-D' are set-back from the road by ½ active receiver length.

- Low gravity anomaly #2 is located in the parking lot and the grassy median between the two apartment buildings. It is by far the most extensive in terms of spatial extent, extending from approximately station 24+50 to station 28+00. It has a peak response of -0.180 mGals. It is associated with the two IRs located between the apartment buildings. Between approximately station 24+50 and station 25+25, anomaly #2 is characteristically linear which suggests a potential fracture/fracture zone. However, there is no expression of a fracture/fracture zone in V_s profiles C-C' or D-D' or the 3D ERI data. Around station 26+00, residual gravity progressively decreases towards the western apartment building. GES advanced two boreholes (620-#20 and 620-#44) to determine whether the low residual gravity measurements near the building are caused by voids (see Figure 3 for location of 620-#20 and 620-#44). The borings report overburden soils characterized by relatively low blow counts, especially between 8 and 15 ft. The interval is described as soft, micaceous silt with wet fine sandy seams, with blow counts as low as 1 to 2 blows per 6 inches. Though no voids were reported, the reported blow counts are very close to what is typically observed drilling through voids - weight of hammer (or rod) to 1 to 2 blows per 6 inches. Copies of the boring logs are provided in Appendix F. The logs report no drilling mud.

- Low gravity anomaly #3 is located in the wetlands along the eastern side of the ROW. It is centered at about station 28+00, and is characterized by residual gravity measurements as low as -0.060 mGals. The anomaly is associated with two IRs. The IRs straddle a linear expression of the anomaly (at about station 28+85) which is suggestive of a fracture.

- Low gravity #4 is located at approximately station 30+10. It is a linear anomaly and therefore potentially caused by a fracture. It is associated with an IR and is within

several feet of the low electrical resistivity anomaly observed in the 3D ERI data.

Please call if you have any questions or if we can be of further assistance.

Sincerely,

Quantum Geophysics
A Division of Gannett Fleming, Inc.

Richard K. Lee

Richard K. Lee, P.G., R.GP.
President and Principal Geophysicist

RKL/jas

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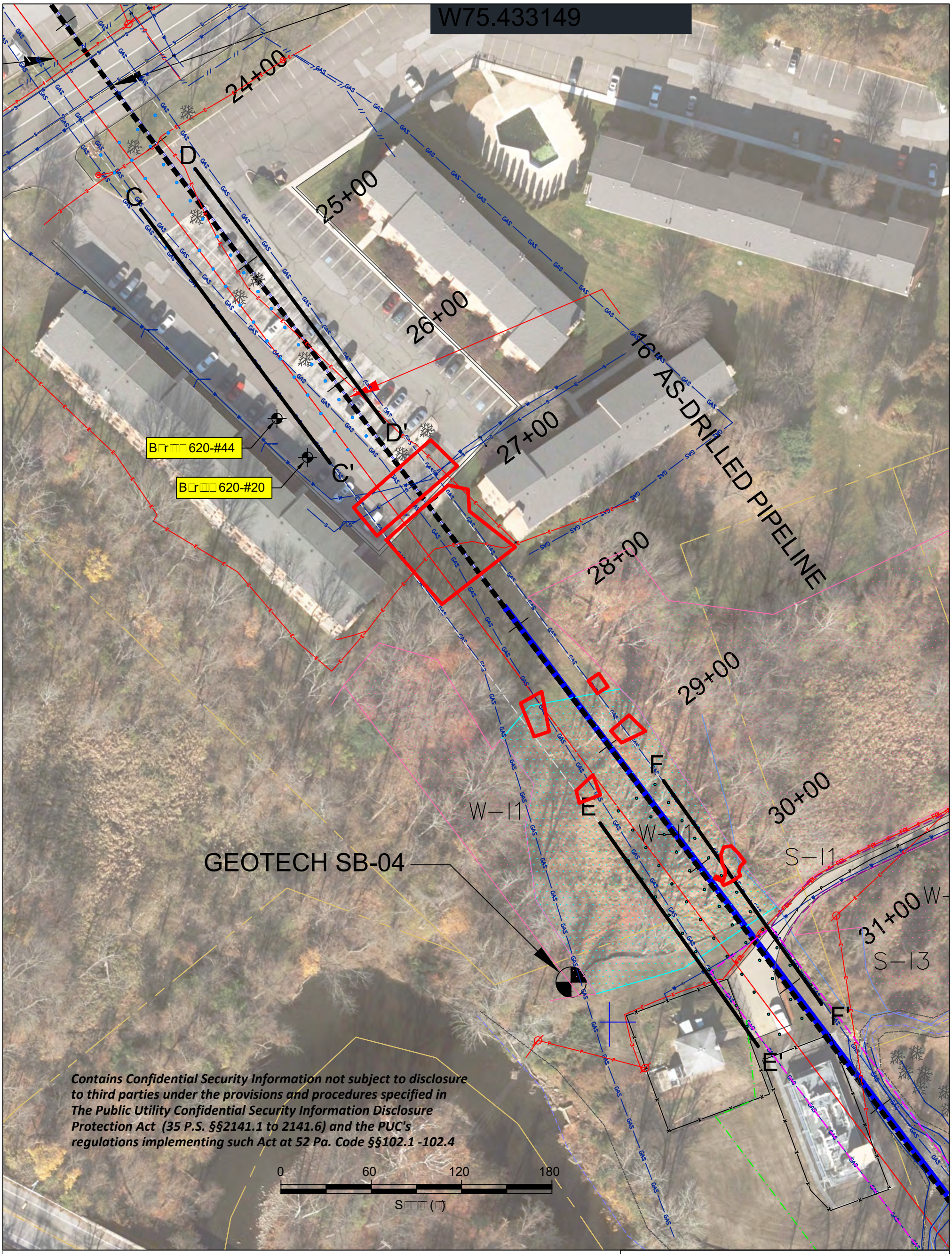

LEGEND

C — C' 3D ERI E□□□r□d□ L□□□□□□.

MASW L□□□.

B□r□□□ □□GES.

IR.

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3D ERI □□d MASW L□□□□□□□ P□□□
S□□□□□ M□r□□□r HDD 620
274 G□□□ R□dd□□ R□□d
M□d□□, P□□□□□□□□□□□

F□r:	GES	
D□□□: 12-11-18	J□□ N□.: 063252.008	B□: RKL

Figure **1**

W75.433149

24+00

25+00

26+00

27+00

28+00

29+00

30+00

31+00

16" AS-DRILLED PIPELINE

B□r□□ 620-#44

B□r□□ 620-#20

GEOTECH SB-04

W–I1

S–I1

W–I2

S–I3

C

C'

D

D'

E

E'

F

F'

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0 60 120 180

S□□□□ (□)

LEGEND

C — C' Gr□□□□ S□□□□□.

MASW L□□□.

B□r□□ □□ GES.

IR.

Bouguer Gravity (mGal)

3316.850 3316.980 3317.110 3317.240 3317.370 3317.500

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M□r□□d B□□□□□r Gr□□□□ C□□□□r M□□
S□□□□□ M□r□□r HDD 620
274 G□□□ R□dd□ R□□d
M□d□, P□□□□□□□□□□□

F□r:	GES	
D□□□: 12-5-18	J□□ N□: 063252.008	B□: RKL

Figure 2

W75.433149

24+00

25+00

26+00

27+00

28+00

29+00

30+00

31+00

PROPOSED 16" PIPELINE

16" AS-DRILLED PIPELINE

B□r□□ 620-#44

B□r□□ 620-#20

GEOTECH SB-04

W–I1

S–I1

S–I3

W–

#1

#2

#3

#4

A

A'

B

B'

C

C'

D

D'

E

E'

F

F'

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0 60 120 180

S□□□□ (□)

Residual Gravity (mGal)

-0.160 -0.080 0.000 0.080 0.160 0.240

LEGEND

. Gr□□□□□ S□□□□□□.

#1 L□□ Gr□□□□□ A□□□ □□□ P□□□□□□□□□□ C□□□□d □□ V□d□,
Fr□□□r□□, □r L□□□□□d D□□r□□□□□□ □□ □□□ T□□ □□R□□□

IR.

L□□□r L□□ E□□□r□□□□ R□□□□□□□□□ A□□□ □□□
(□□□ F□□r□ 5).

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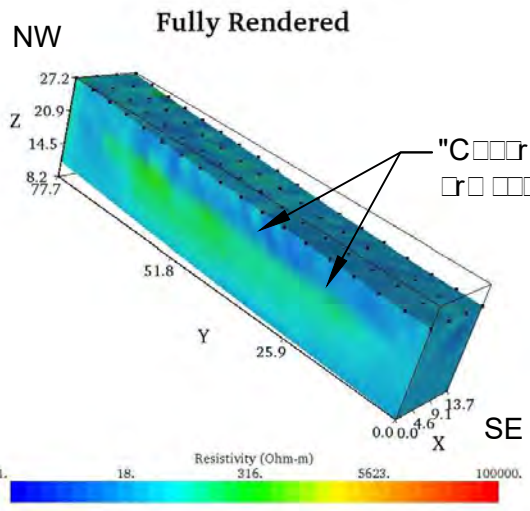
M□r□□d R□□d □□□Gr□□□□ C□□□□r M□□
S□□□□□ M□r□□r HDD 620
274 G□□□ R□dd□ R□□d
M□d□, P□□□□□□□□□□

F□r:	GES	
D□□: 12-11-18	J□□ N□: 063252.006	B□: RKL

Figure 3



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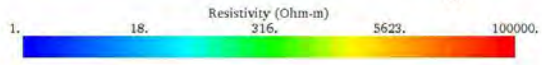

V□□□□□ □□□r 75 □□□-□ □□□□□ □□□□□ □□r□□d □□□□□□□

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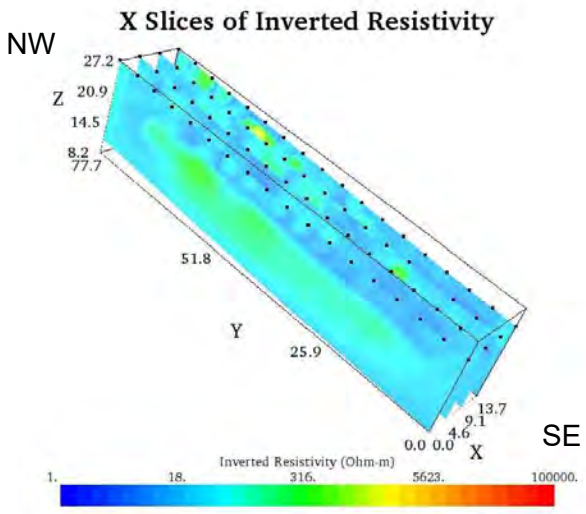

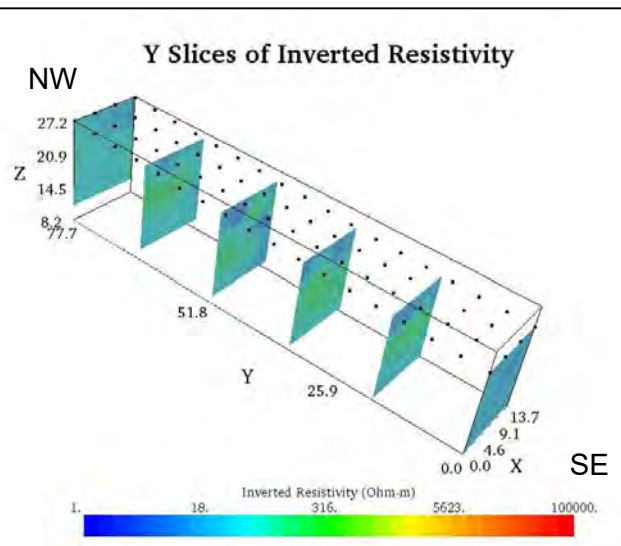

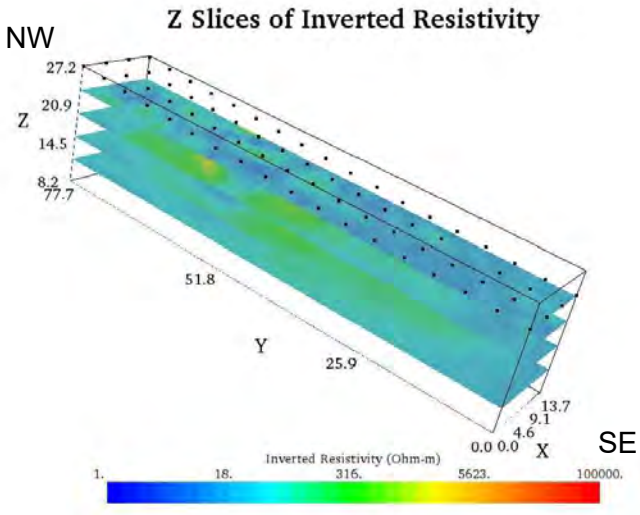

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N□□□□:

1. X, Y, □□d Z □x□□ □r□ □□ □ □□□r□. T□□ □□□□□ □r□ □r□□r□□ E□r□□l□ □□□□r3D □□ □□□□□d □□□□□ □□□□ □ □□r□□ □□□□□□□□.

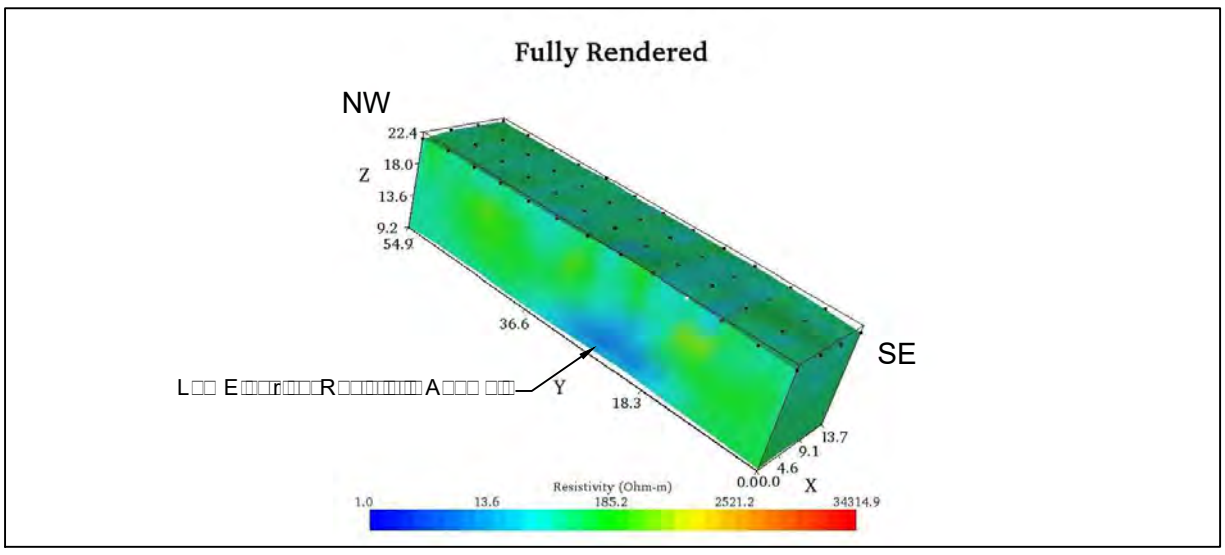
2. H□□□ □□□□□r□□□□r□□□□□□□□□□□ □ □□□□□r□□ □□□□□ □□ □□□□r□x□□ □□□□□□ 100 + □□□□ -□ □ □□□□□□□□□□□ □□d□□□□□□□ □□ □ □d□r□□□ □□ □□□□□□□□ □ □□□□□□□r□d r□□□□.

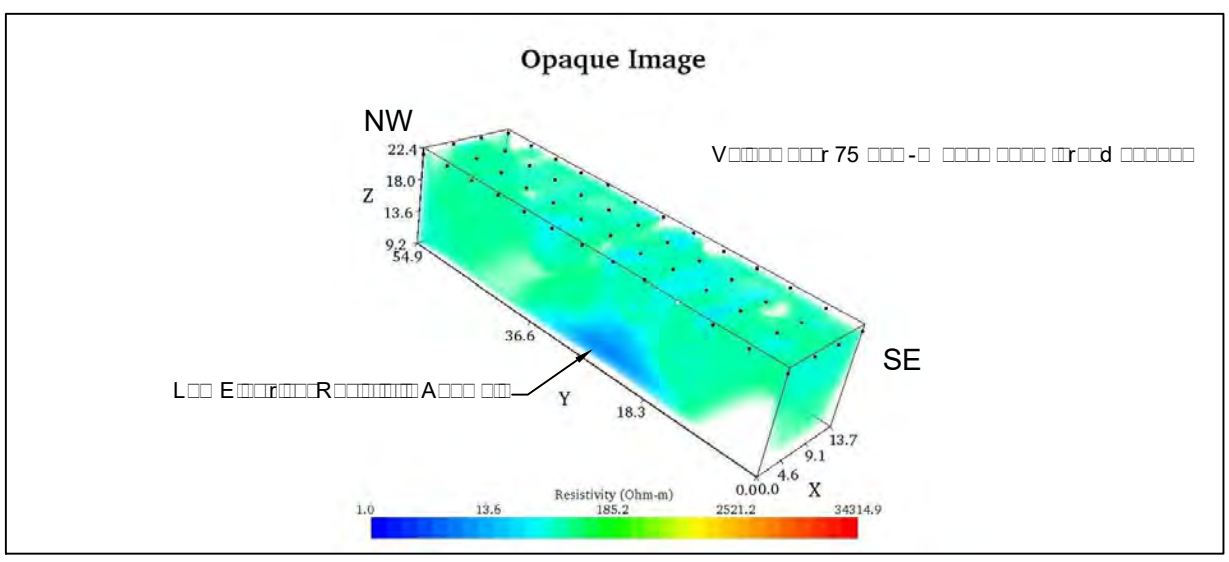
QUANTUMGEOPHYSICS
Engineering, Groundwater, and Environmental Geophysics
29 Richard Lee Lane, Phoenixville, PA 19460

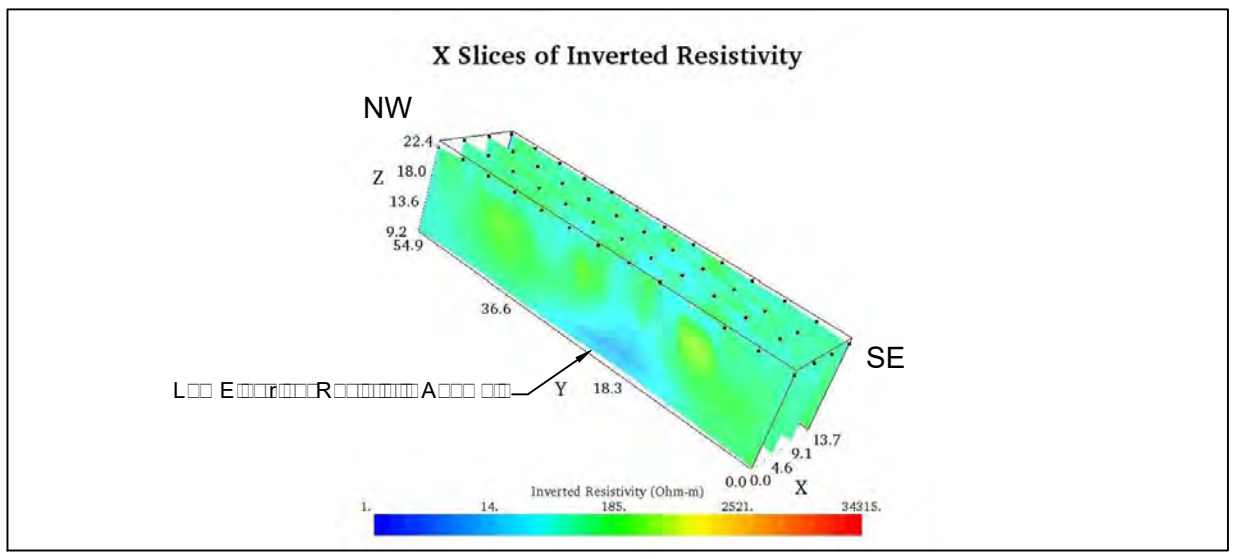
3D ERI R□d□□□-D□□□□□□ I□ □□□□□ - P□r□□□□ L□□
S□□□□□□ M□r□□□r HDD 620
274 G□□□ R□dd□□ R□□d
M□d□□, P□□□□□□□□□□□□

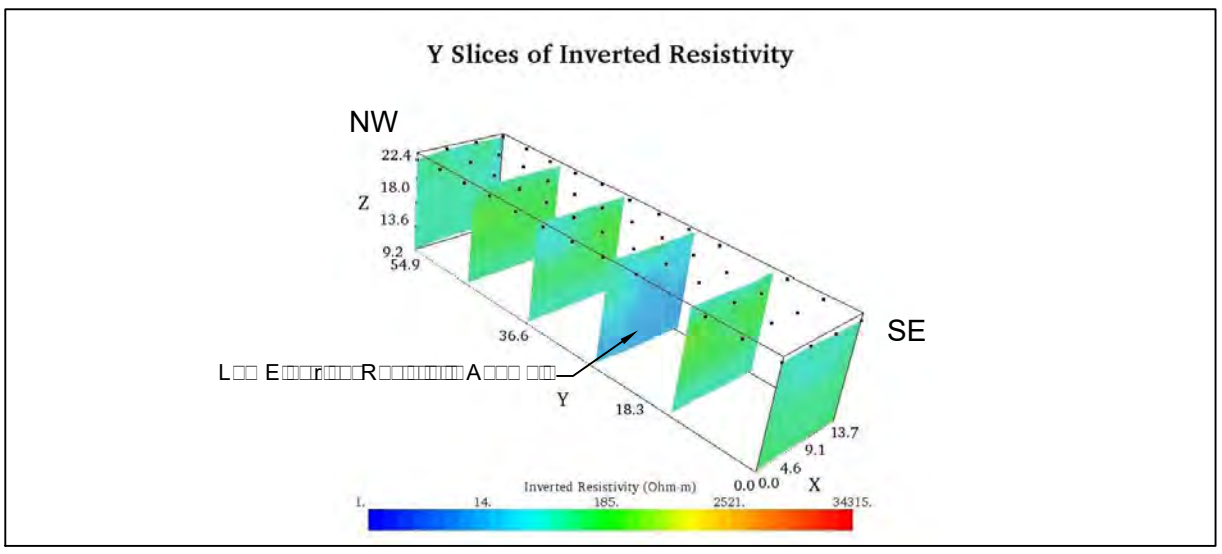
F□r:	GES	Figure
D□□□: 12-11-18	J□□ N□: 063252.008	B□: RKL

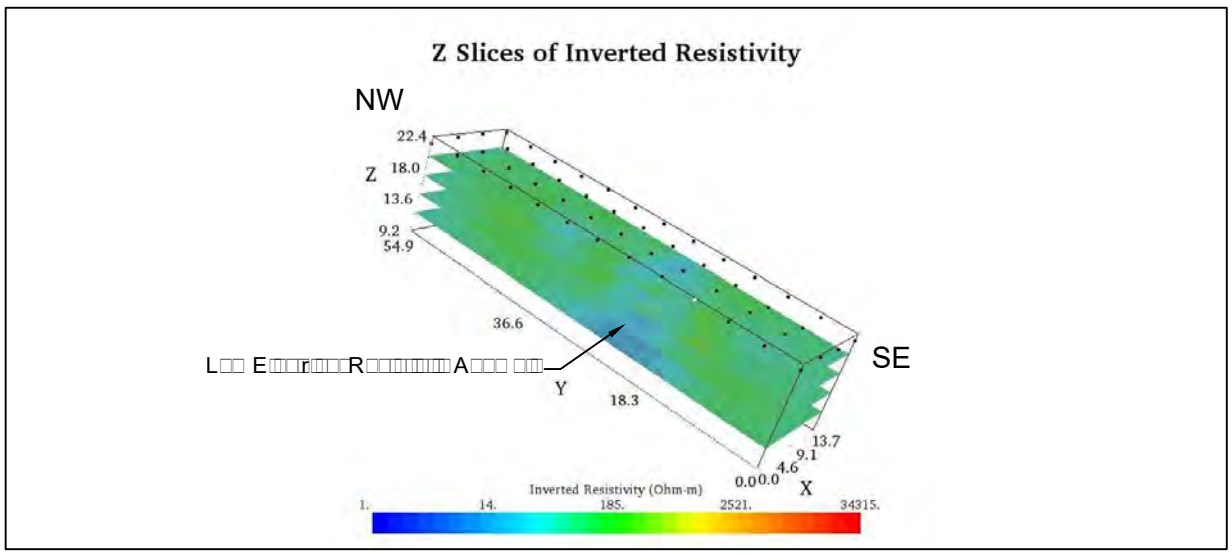
4











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N□□□□:

1. X, Y, □□d Z □x□□ □r□ □□ □ □□□r□. T□□ □□□□□r□ □r□□r□□ E□r□l□ □□□r3D □□ □□□□□d □□□□□ □□□□ □ □□r□□ □□□□□□□□.

2. H□□□ □□□□r□□□□r□□□□□□□□□□ □ □□□□□r□□ □□□□□ □□ □□□□r□x□□ □□□□□□ 100 + □□□□ -□ □ □□□□□□□□□□□ □□d□□□□□□□ □□ □ □d□r□□□ □□ □□□□□□□□ □ □□□□□□r□d r□□□□.

QUANTUMGEOPHYSICS
Engineering, Groundwater, and Environmental Geophysics
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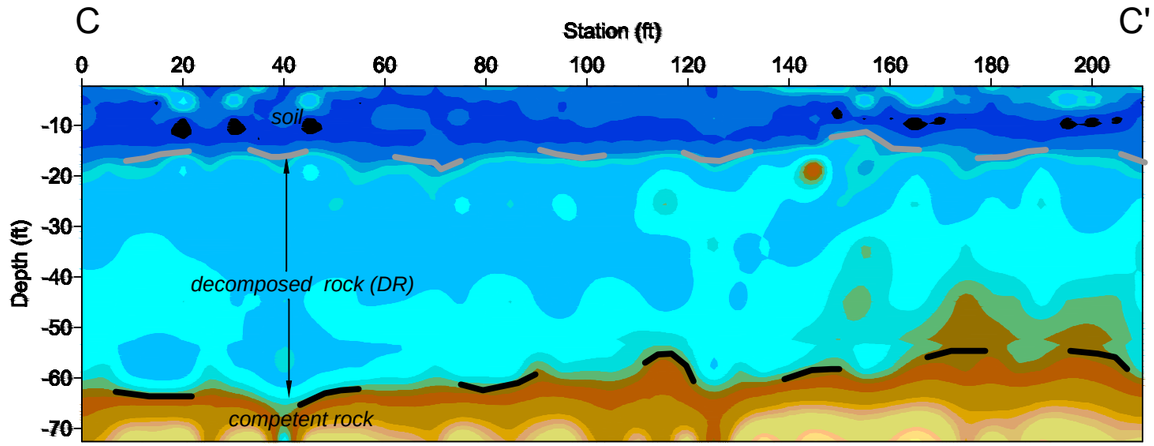
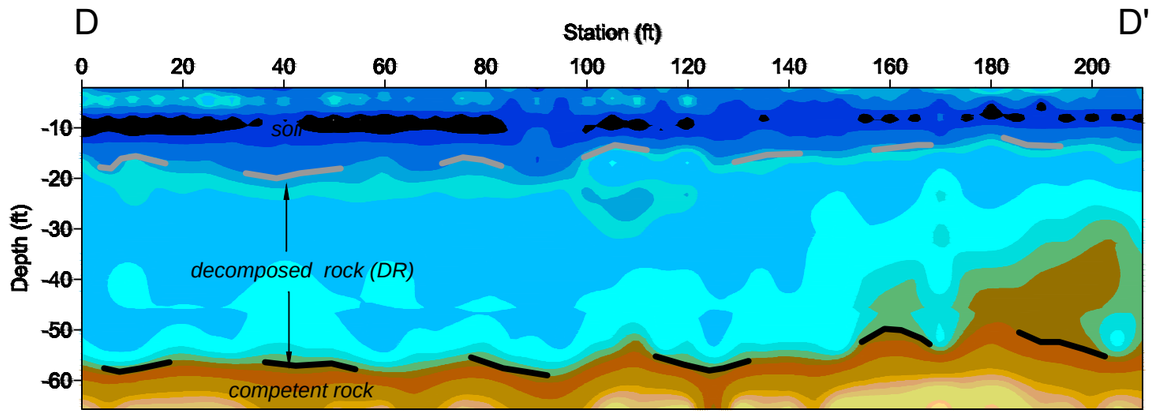
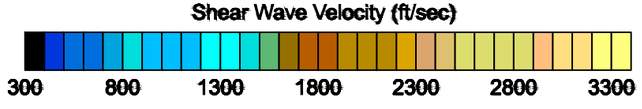
3D ERI R□d□□-D□□□□□ l□ □□□□- W□□□□□d□
S□□□□□□ M□r□□r HDD 620
274 G□□□ R□dd□□ R□□d
M□d□□, P□□□□□□□□□□□□

F□r:	GES	Figure
D□□□: 12-11-18	J□□ N□.: 063252.008	B□: RKL

5







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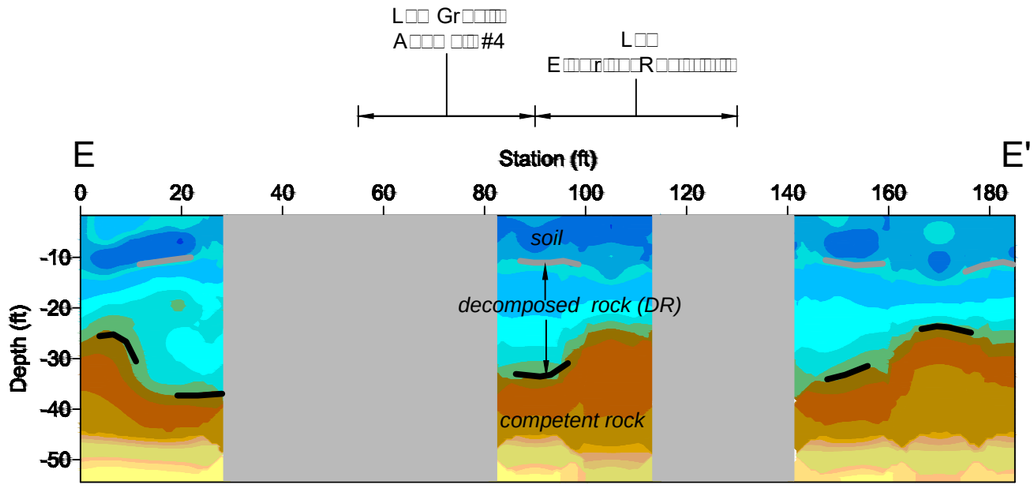
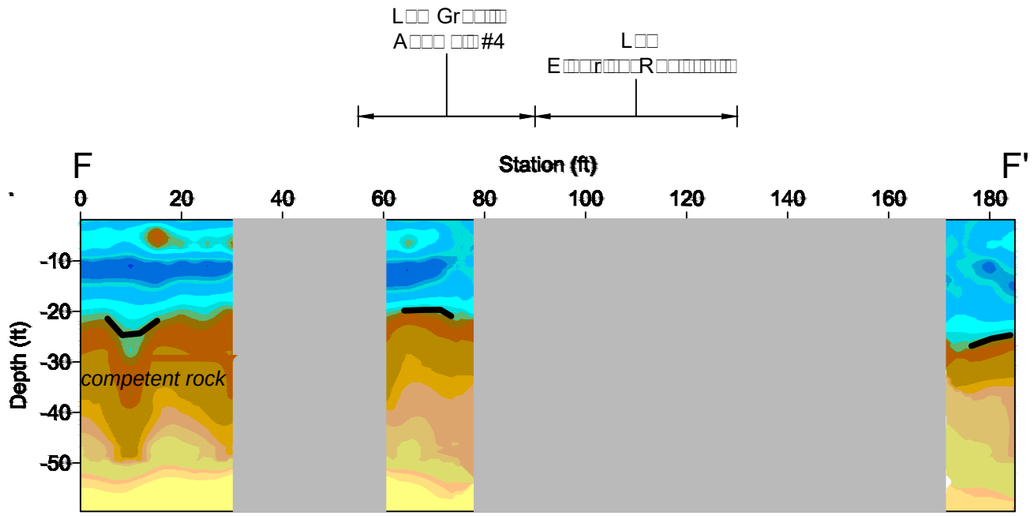
V□ Pr□□□□□ C-C' □□d D-D'
S□□□□□ M□r□□□r HDD 620
274 G□□□ R□dd□□ R□□d
M□d□□, P□□□□□□□□□□□

F□r:		Figure
D□□□: 12-11-18	J□□ N□: 063252.008	B□: RKL	**6**





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LEGEND

P□□r D□□□ Q□□□□□□

QUANTUMGEOPHYSICS
Engineering, Groundwater, and Environmental Geophysics
29 Richard Lee Lane, Phoenixville, PA 19460

V□ Pr□□□□□□ E-E □□d F-F"
S□□□□□ M□r□□□r HDD 620
274 G□□□ R□dd□□ R□□d
M□d□□, P□□□□□□□□□□

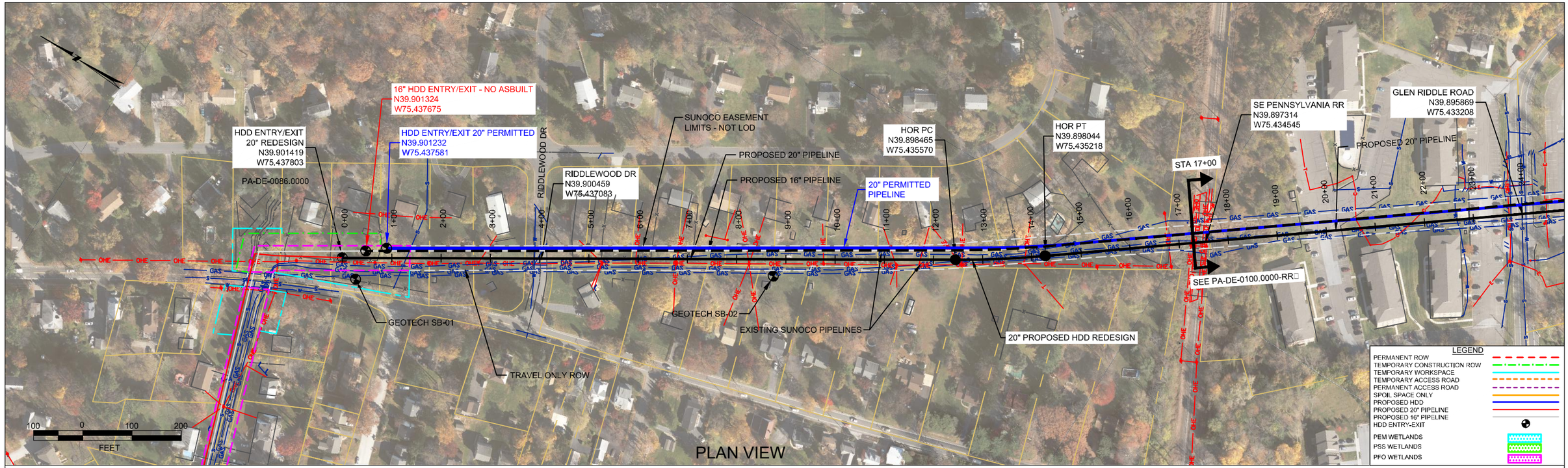
F□r:	GES	Figure 7
D□□□: 12-11-18	J□□ N□: 063252.008	B□: RKL

HORIZONTAL DIRECTIONAL DRILL ANALYSIS
GLEN RIDDLE ROAD and SOUTHEASTERN PENNSYLVANIA RR CROSSING
PADEP SECTION 105 PERMIT NO.: E23-524
PA-DE-0100.0000-RR
(SPLP HDD# S3-0620)

ATTACHMENT 2

HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILE WITH IR DATA

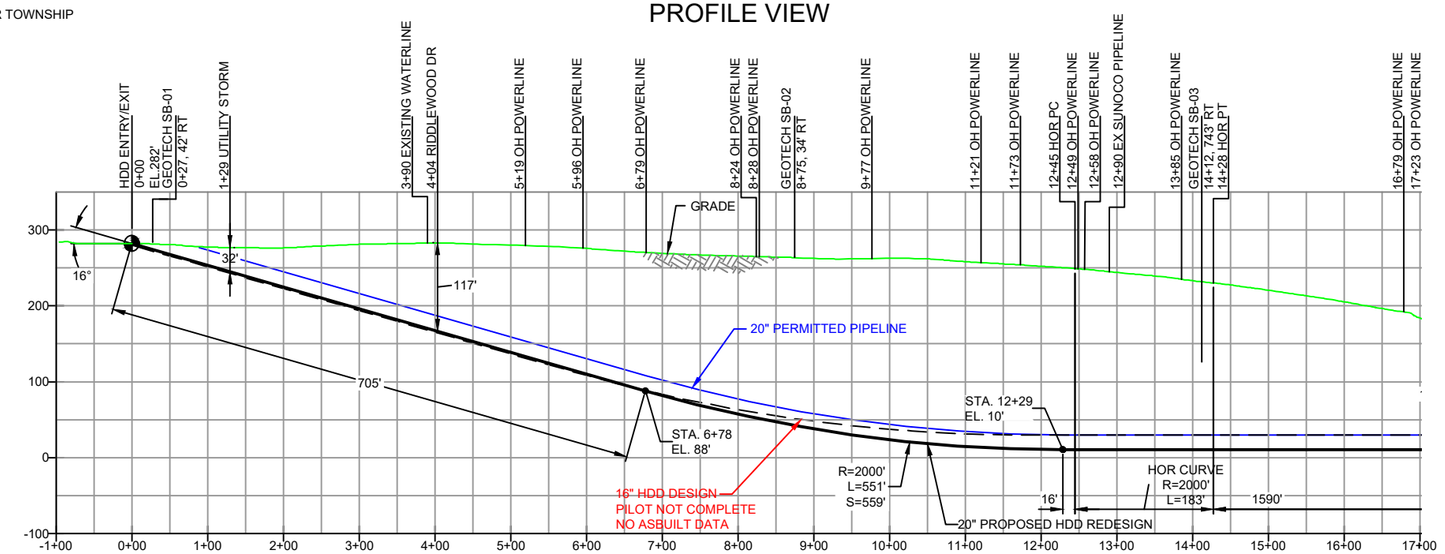
CONVENTIONAL AND DIRECT BORE PLAN AND PROFILES



PLAN VIEW

DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP
S3-0620

PROFILE VIEW



GEOTECH SB-01
-NG EL. 286'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 6.5')
-SM (6.5' - 29.0')
-GROUNDWATER (23.0')
-ML (29.0' - 30.0')
-COMPLETION DEPTH EL. 256'

GEOTECH SB-02
-NG EL. 264'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 36.5')
-GROUNDWATER (38.0')
-SM (36.5' - 75.0')
-COMPLETION DEPTH EL. 189'

NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-03
-NG EL. 127'
-TOPSOIL (0' - 0.5')
-SM (0.5' - 31.0')
-GROUNDWATER (28.0')
-WEATHERED GNEISS (28.0' - 41.0')
-COMPLETION DEPTH EL. 86'

NOTE: REFER TO TEST BORING LOG S3-0620 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=): 3560'
   HDD PIPE LENGTH (S=): 3600'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 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 1850 PSIG.
11. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.

Figure 1A: 16-Inch HDD Drilling Profile with IR Data

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
4	REVISED PROFILE WITH 2017 LIDAR	MRS	02/14/17	RMB	02/14/17	AAW	02/14/17
3	DESIGN CHANGE (OZ HDD DESIGN - RFI 0101)	DLM	12/16/16	RMB	12/16/16	AMC	12/16/16
2	REVISED PER ENGINEERING COMMENTS	MRS	08/12/16	RMB	08/12/16	AAW	08/12/16
1	REVISED PER COMMENTS FROM REI REVIEW	MRS	03/03/16	RMB	03/03/16	AAW	03/03/16
0	ISSUED FOR CONSTRUCTION	MRS	02/19/16	RMB	02/19/16	AAW	02/19/16

Sunoco Logistics Partners L.P.

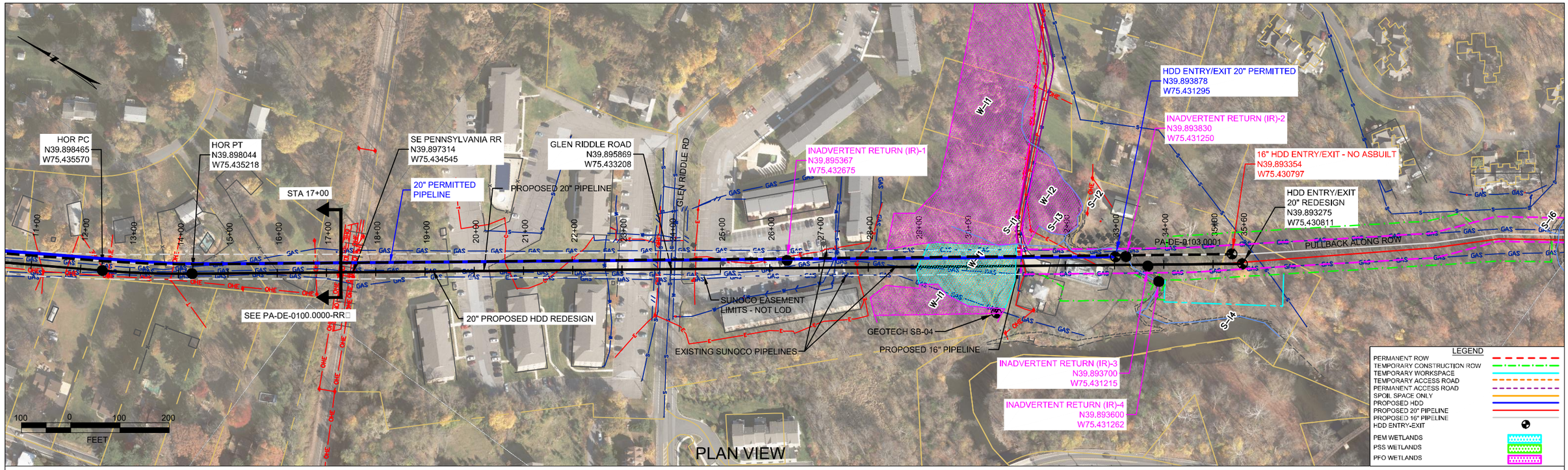
TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GLEN RIDDLE RD, SOUTHEASTERN PENNSYLVANIA RR
PENNSYLVANIA PIPELINE PROJECT

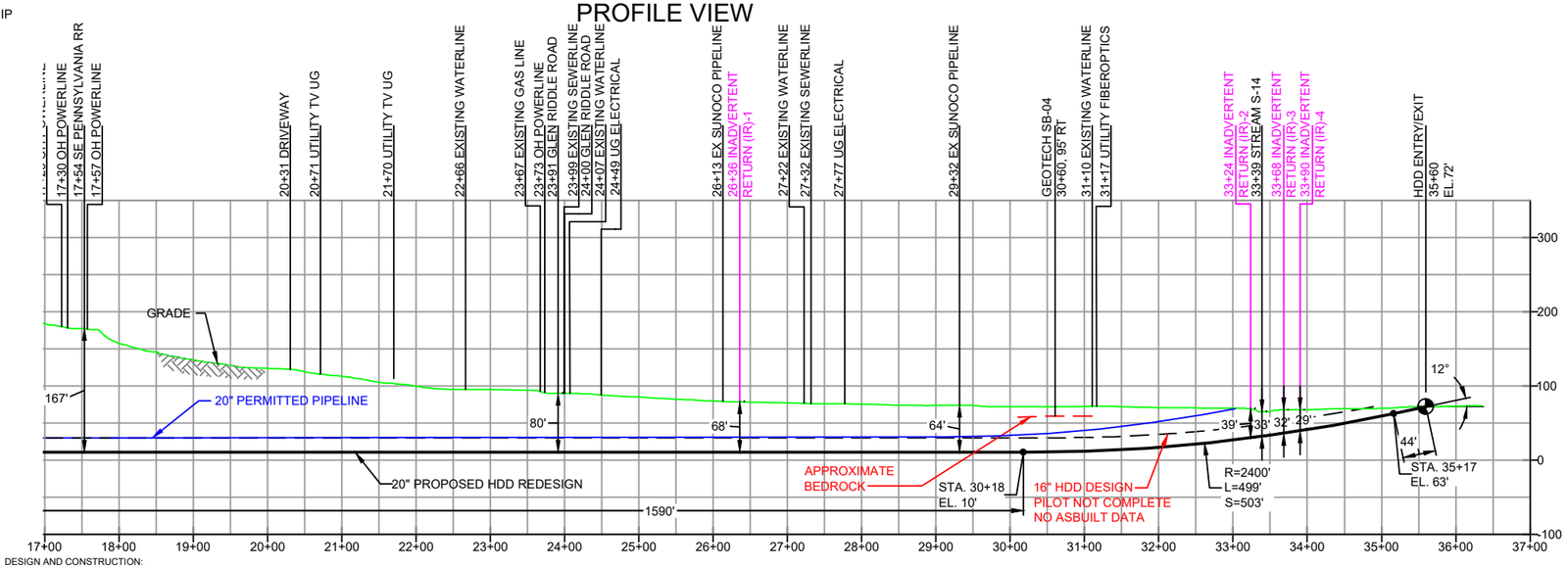
SCALE: 1"=200'

DWG. NO: PA-DE-0100.0000-RR



DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP
S3-0620

PROFILE VIEW



GEOTECH SB-03

-NG EL. 127'
-TOPSOIL (0' - 0.5')
-SM (0.5' - 31.0')
-GROUNDWATER (28.0')
-WEATHERED GNEISS (28.0' - 41.0')
-COMPLETION DEPTH EL. 86'

GEOTECH SB-04

-NG EL. 72'
-TOPSOIL (0' - 0.1')
-SC (0.1' - 4.0')
-GROUNDWATER (4.0')
-CL (4.0' - 6.5')
-SM (6.5' - 12.0')
-WEATHERED GNEISS (12.0' - 12.3')
-COMPLETION DEPTH EL. 60'

NOTE: REFER TO TEST BORING LOG S3-0620 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=): 3560'
   HDD PIPE LENGTH (S=): 3600'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 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 1850 PSIG.
11. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.

Figure 1B: 16-Inch Drilling Profile with IR Data

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
4	REVISED PROFILE WITH 2017 LIDAR	MRS	02/14/17	RMB	02/14/17	AAW	02/14/17
3	DESIGN CHANGE (OZ HDD DESIGN - RFI 0101)	DLM	12/16/16	RMB	12/16/16	AMC	12/16/16
2	REVISED PER ENGINEERING COMMENTS	MRS	08/12/16	RMB	08/12/16	AAW	08/12/16
1	REVISED PER COMMENTS FROM REI REVIEW	MRS	03/03/16	RMB	03/03/16	AAW	03/03/16
0	ISSUED FOR CONSTRUCTION	MRS	02/19/16	RMB	02/19/16	AAW	02/19/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
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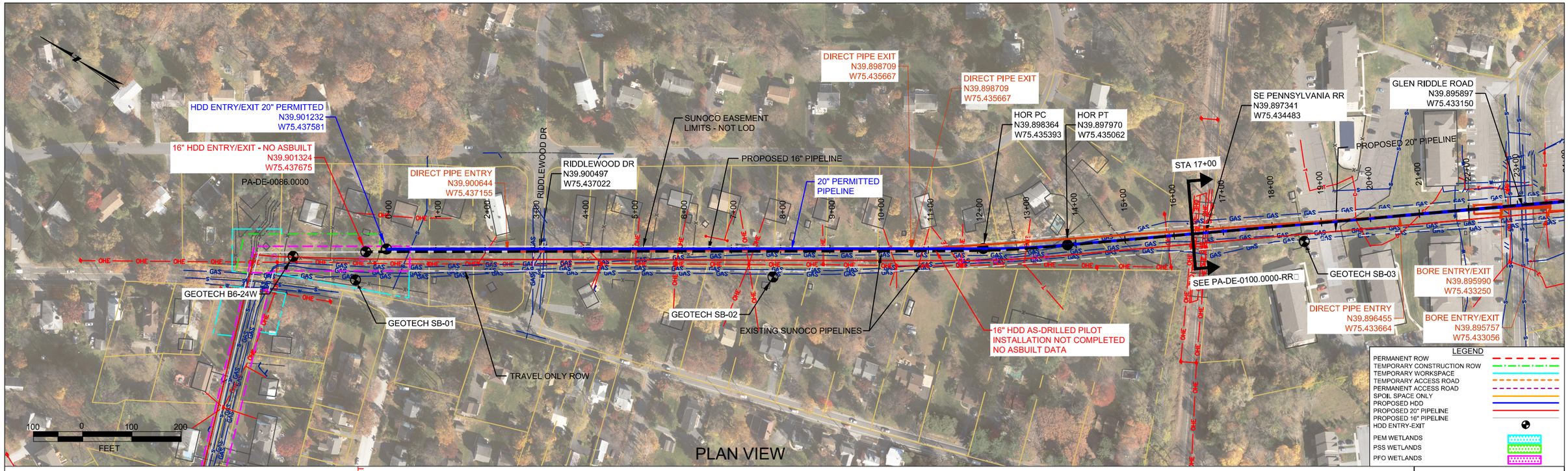
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GLEN RIDDLE RD, SOUTHEASTERN PENNSYLVANIA RR
PENNSYLVANIA PIPELINE PROJECT

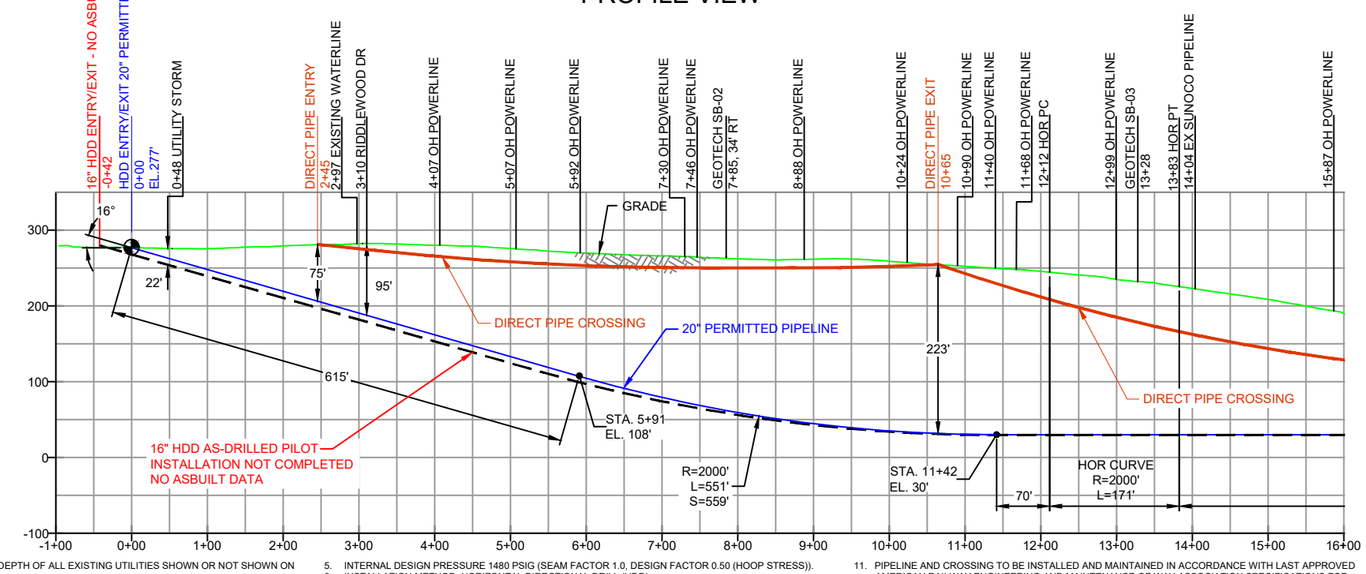
SCALE: 1"=200'

DWG. NO: PA-DE-0100.0000-RR□



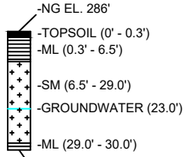
PLAN VIEW

PROFILE VIEW



DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP
S3-0620

GEOTECH SB-01



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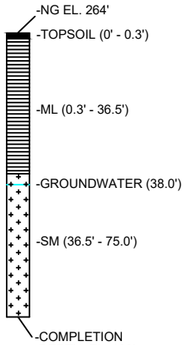
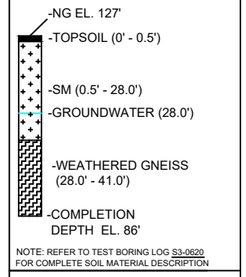


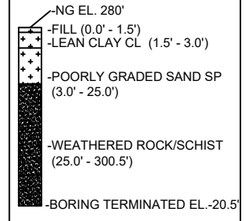
NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-03



NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-24W



NOTE: REFER TO TEST BORING LOG B6-24W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 3338'
   HDD PIPE LENGTH (S=): 3373'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 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 1850 PSIG.
11. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.

Figure 2A: HDD Plan and Profile with Replacement Bores

FOR REEVALUATION USE ONLY

NOTES

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
A	ISSUED FOR REVIEW	MRS	04/22/19	RMB	04/22/19	AMC	04/22/19

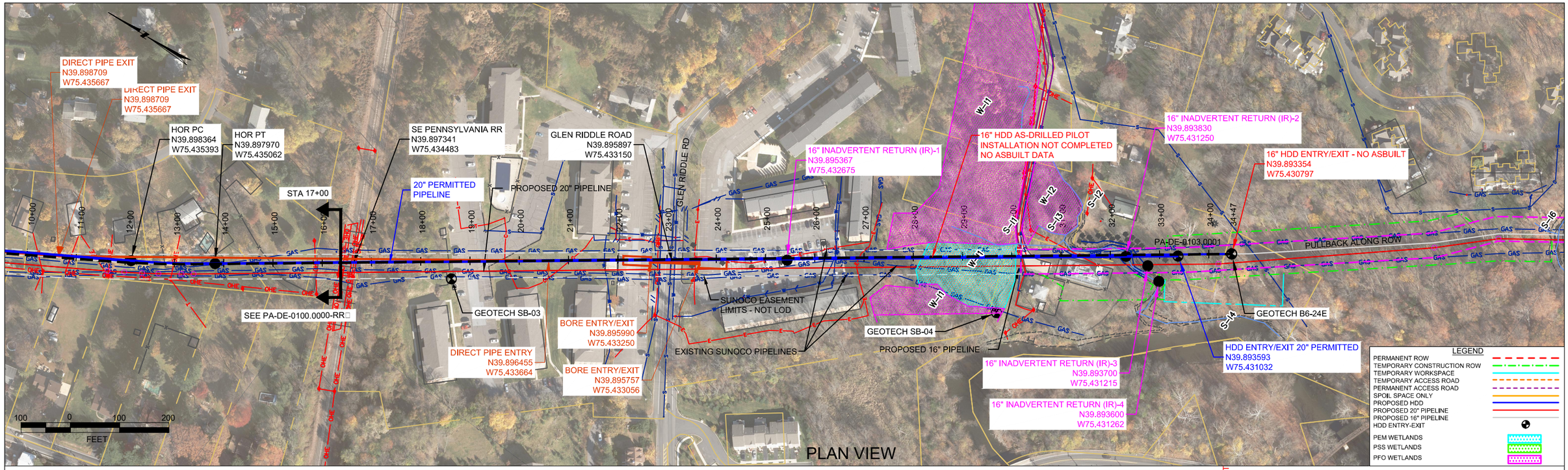
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

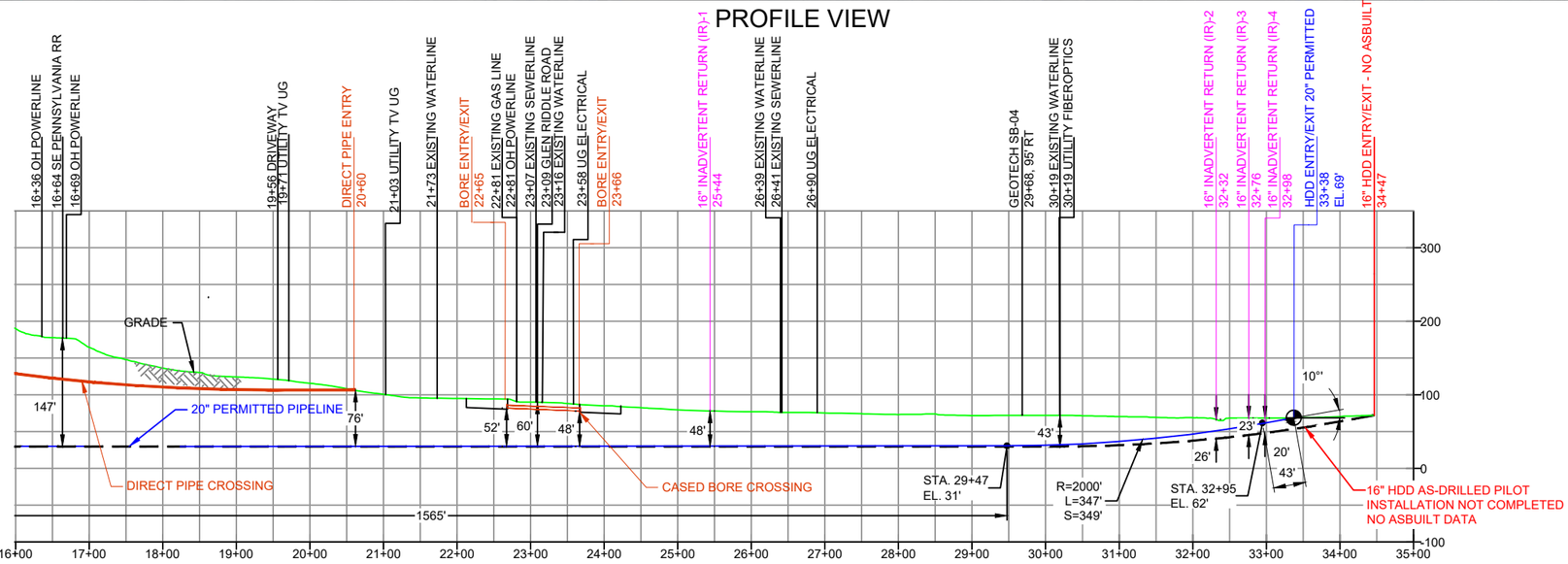
HORIZONTAL DIRECTIONAL DRILL
GLEN RIDDLE RD, SOUTHEASTERN PENNSYLVANIA RR
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' | DWG. NO: PA-DE-0100.0000-RR□



DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP
S3-0620

PROFILE VIEW



GEOTECH SB-03
-NG EL. 127'
-TOPSOIL (0' - 0.5')
-SM (0.5' - 28.0')
-GROUNDWATER (28.0')
-WEATHERED GNEISS (28.0' - 41.0')
-COMPLETION DEPTH EL. 86'

GEOTECH SB-04
-NG EL. 72'
-TOPSOIL (0' - 0.1')
-SC (0.1' - 4.0')
-GROUNDWATER (4.0')
-CL (4.0' - 6.5')
-SM (6.5' - 12.0')
-WEATHERED GNEISS (12.0' - 12.3')
-COMPLETION DEPTH EL. 60'

NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-24E
-NG EL. 72'
-TOPSOIL (0.0' - 0.3')
-SILTY SAND SM (0.3' - 9.0')
-SEVERELY WEATHERED ROCK (9.0' - 25.0')
-SAMPLER REFUSAL (20.2')
-GROUNDWATER (35.0')
-MAFIC GNEISS (25.0' - 102')
-BORING TERMINATED EL.-30.0'

NOTE: REFER TO TEST BORING LOG B6-24E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 3338'
   HDD PIPE LENGTH (S=): 3373'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 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 1850 PSIG.
11. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.

Figure 2B: HDD Plan and Profile with Replacement Bores

FOR REEVALUATION USE ONLY

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

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
A	ISSUED FOR REVIEW	MRS	04/22/19	RMB	04/22/19	AMC	04/22/19

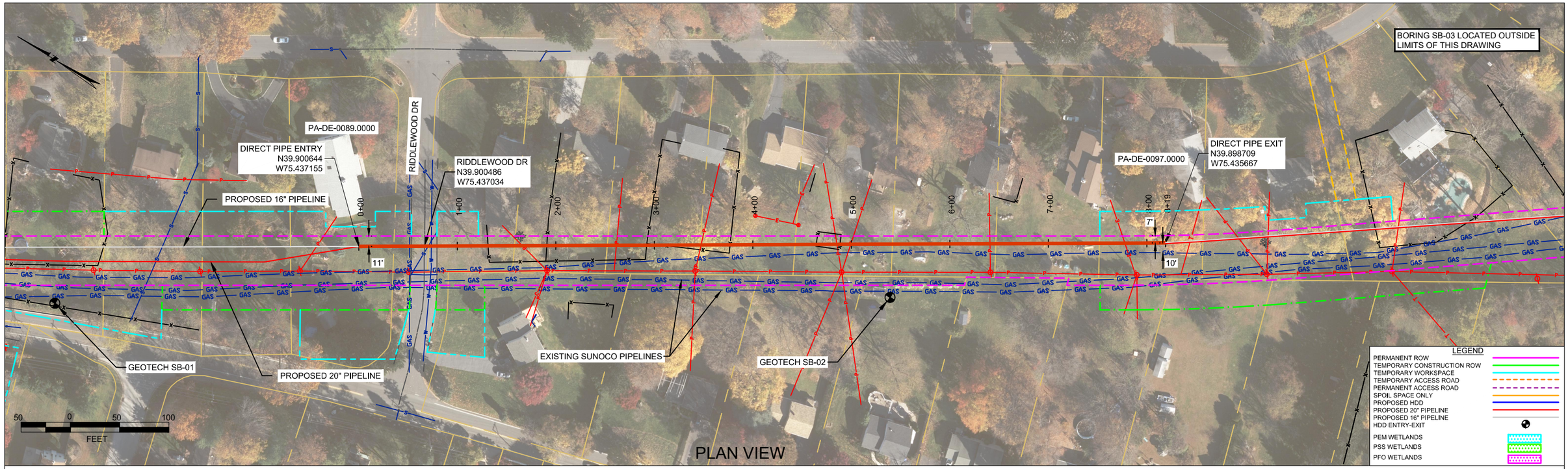
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GLEN RIDDLE RD, SOUTHEASTERN PENNSYLVANIA RR
PENNSYLVANIA PIPELINE PROJECT

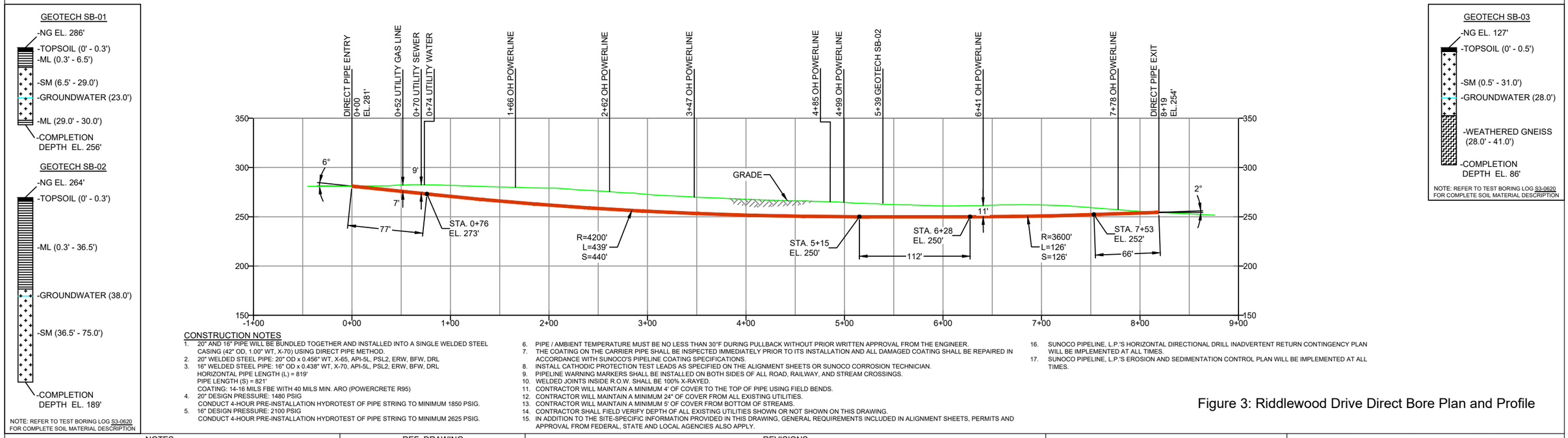
SCALE: 1"=200' | DWG. NO: PA-DE-0100.0000-RR□



PLAN VIEW

DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP

PROFILE VIEW



CONSTRUCTION NOTES

1. 20" AND 16" PIPE WILL BE BUNDLED TOGETHER AND INSTALLED INTO A SINGLE WELDED STEEL CASING (42" OD, 1.00" WT, X-70) USING DIRECT PIPE METHOD.
2. 20" WELDED STEEL PIPE: 20" OD x 0.456" WT, X-65, API-5L, PSL2, ERW, BFW, DRL
3. 16" WELDED STEEL PIPE: 16" OD x 0.438" WT, X-70, API-5L, PSL2, ERW, BFW, DRL
   HORIZONTAL PIPE LENGTH (L) = 819'
   PIPE LENGTH (S) = 821'
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
4. 20" DESIGN PRESSURE: 1480 PSIG
   CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF PIPE STRING TO MINIMUM 1850 PSIG.
5. 16" DESIGN PRESSURE: 2100 PSIG
   CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF PIPE STRING TO MINIMUM 2625 PSIG.
6. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
7. THE COATING ON THE CARRIER PIPE SHALL BE INSPECTED IMMEDIATELY PRIOR TO ITS INSTALLATION AND ALL DAMAGED COATING SHALL BE REPAIRED IN ACCORDANCE WITH SUNOCO'S PIPELINE COATING SPECIFICATIONS.
8. INSTALL CATHODIC PROTECTION TEST LEADS AS SPECIFIED ON THE ALIGNMENT SHEETS OR SUNOCO CORROSION TECHNICIAN.
9. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
10. WELDED JOINTS INSIDE R.O.W. SHALL BE 100% X-RAYED.
11. CONTRACTOR WILL MAINTAIN A MINIMUM 4' OF COVER TO THE TOP OF PIPE USING FIELD BENDS.
12. CONTRACTOR WILL MAINTAIN A MINIMUM 24" OF COVER FROM ALL EXISTING UTILITIES.
13. CONTRACTOR WILL MAINTAIN A MINIMUM 5' OF COVER FROM BOTTOM OF STREAMS.
14. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
15. IN ADDITION TO THE SITE-SPECIFIC INFORMATION PROVIDED IN THIS DRAWING, GENERAL REQUIREMENTS INCLUDED IN ALIGNMENT SHEETS, PERMITS AND APPROVAL FROM FEDERAL, STATE AND LOCAL AGENCIES ALSO APPLY.
16. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
17. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 3: Riddlewood Drive Direct Bore 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

DWG NO		DWG NO	DESCRIPTION
ES-6.18	TO	ES-6.20	EROSION & SEDIMENT PLAN
SHEET 12	TO	SHEET 13	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
0	ISSUED FOR CONSTRUCTION	MRS	03/08/19	RMB	03/08/19	AMC	03/08/19

Sunoco Logistics Partners L.P.

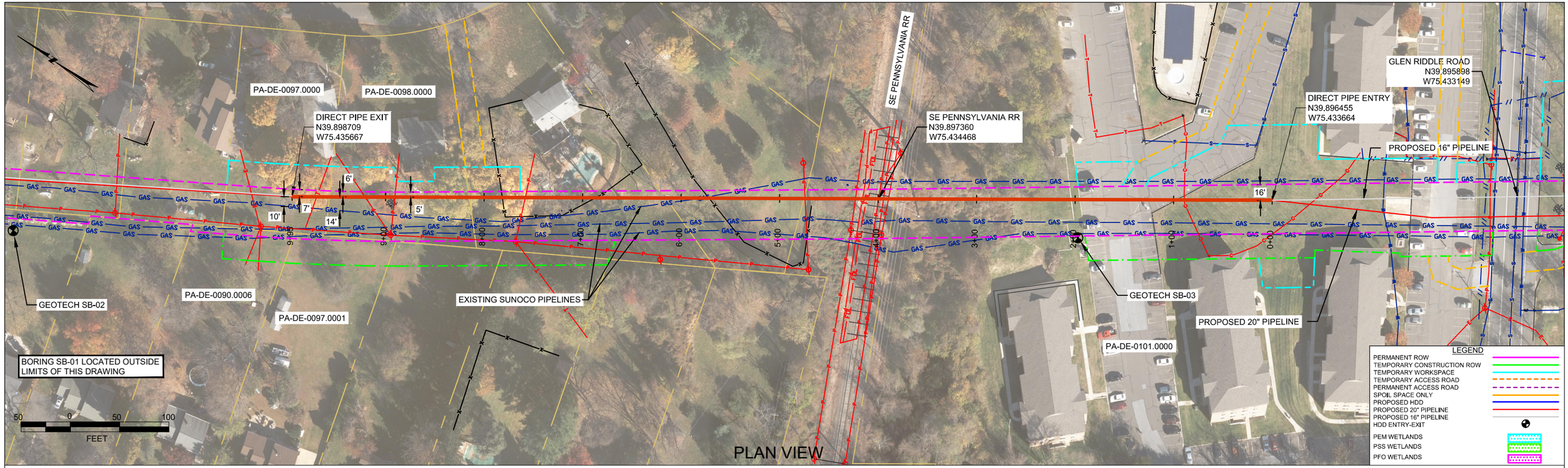
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

DIRECT PIPE
RIDDLEWOOD DR
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100'

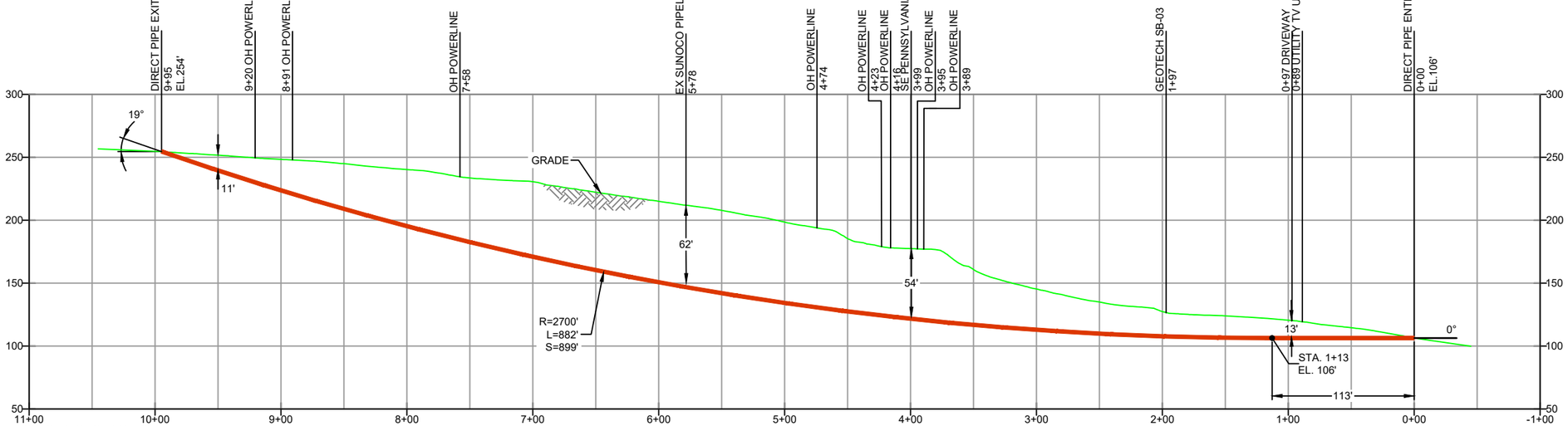
DWG. NO: PA-DE-0089.0000-RD



PLAN VIEW

PROFILE VIEW

DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP



GEOTECH SB-01
-NG EL. 286'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 6.5')
-SM (6.5' - 29.0')
-GROUNDWATER (23.0')
-ML (29.0' - 30.0')
-COMPLETION DEPTH EL. 256'

GEOTECH SB-02
-NG EL. 264'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 36.5')
-GROUNDWATER (38.0')
-SM (36.5' - 75.0')
-COMPLETION DEPTH EL. 189'

NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-03
-NG EL. 127'
-TOPSOIL (0' - 0.5')
-SM (0.5' - 31.0')
-GROUNDWATER (28.0')
-WEATHERED GNEISS (28.0' - 41.0')
-COMPLETION DEPTH EL. 86'

NOTE: REFER TO TEST BORING LOG S3-0620 FOR COMPLETE SOIL MATERIAL DESCRIPTION

CONSTRUCTION NOTES

1. 20" AND 16" PIPE WILL BE BUNDLED TOGETHER AND INSTALLED INTO A SINGLE WELDED STEEL CASING (48" OD. 0.750" WT, X-52) USING DIRECT PIPE METHOD.
2. 20" WELDED STEEL PIPE: 20" OD x 0.456" WT, X-65, API-5L, PSL2, ERW, BFW, DRL
3. 16" WELDED STEEL PIPE: 16" OD x 0.438" WT, X-70, API-5L, PSL2, ERW, BFW, DRL
   HORIZONTAL PIPE LENGTH (L) = 995'
   PIPE LENGTH (S) = 1012'
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
4. 20" DESIGN PRESSURE: 1480 PSIG
   CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF PIPE STRING TO MINIMUM 1850 PSIG.
5. 16" DESIGN PRESSURE: 2100 PSIG
   CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF PIPE STRING TO MINIMUM 2625 PSIG.
6. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
7. THE COATING ON THE CARRIER PIPE SHALL BE INSPECTED IMMEDIATELY PRIOR TO ITS INSTALLATION AND ALL DAMAGED COATING SHALL BE REPAIRED IN ACCORDANCE WITH SUNOCO'S PIPELINE COATING SPECIFICATIONS.
8. INSTALL CATHODIC PROTECTION TEST LEADS AS SPECIFIED ON THE ALIGNMENT SHEETS OR SUNOCO CORROSION TECHNICIAN.
9. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
10. WELDED JOINTS INSIDE R.O.W. SHALL BE 100% X-RAYED.
11. CONTRACTOR WILL MAINTAIN A MINIMUM 4' OF COVER TO THE TOP OF PIPE USING FIELD BENDS.
12. CONTRACTOR WILL MAINTAIN A MINIMUM 24" OF COVER FROM ALL EXISTING UTILITIES.
13. CONTRACTOR WILL MAINTAIN A MINIMUM 5' OF COVER FROM BOTTOM OF STREAMS.
14. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
15. IN ADDITION TO THE SITE-SPECIFIC INFORMATION PROVIDED IN THIS DRAWING, GENERAL REQUIREMENTS INCLUDED IN ALIGNMENT SHEETS, PERMITS AND APPROVAL FROM FEDERAL, STATE AND LOCAL AGENCIES ALSO APPLY.
16. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
17. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 4: Septa Railroad Direct Bore 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

DWG NO		DWG NO	DESCRIPTION
ES-6.18	TO	ES-6.20	EROSION & SEDIMENT PLAN
SHEET 12	TO	SHEET 13	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
0	ISSUED FOR CONSTRUCTION	MRS	03/08/19	RMB	03/08/19	AMC	03/08/19

Sunoco Logistics Partners L.P.

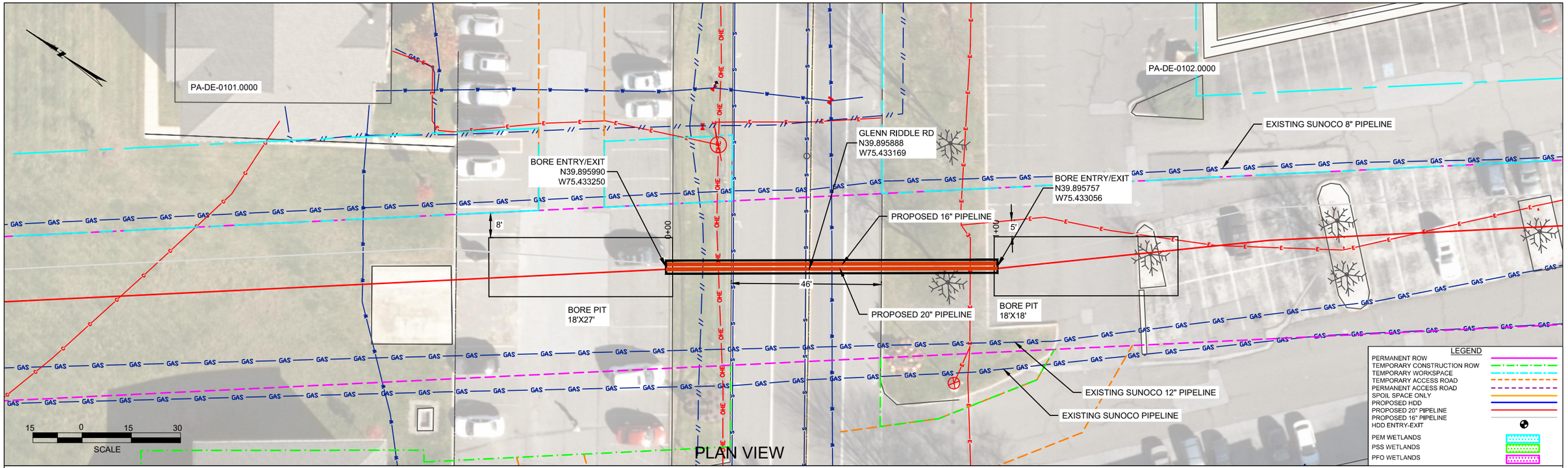
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

DIRECT PIPE
SEPTA RAILROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100'

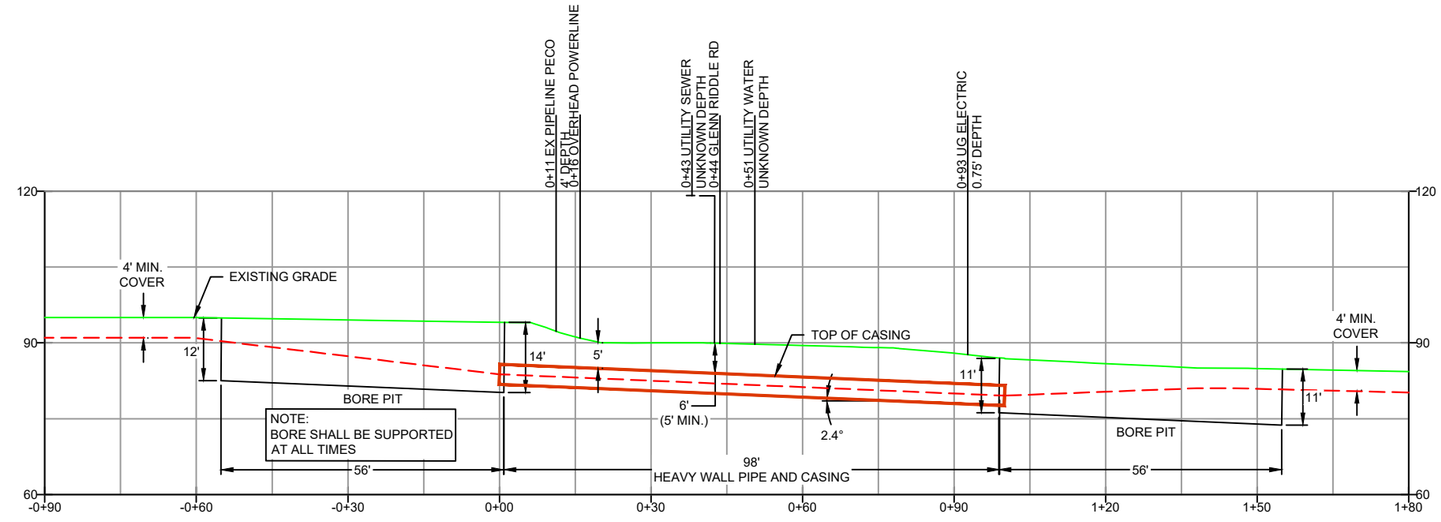
DWG. NO: PA-DE-0100.0000-RR



PLAN VIEW

DELAWARE COUNTY, PENNSYLVANIA - UPPER CHICHESTER TOWNSHIP

PROFILE VIEW



CONSTRUCTION NOTES

1. 20" AND 16" PIPE WILL BE BUNDLED TOGETHER AND INSTALLED INTO 48" x 0.750" W.T. x X-52 CASING USING AUGER BORE METHOD.
2. HORIZONTAL PIPE LENGTH (L) = 98'
   PIPE LENGTH (S) = 98'
3. 20" WELDED STEEL PIPE: 20" OD x 0.456" WT, X-65, API-5L, PSL2, ERW, BFW, DRL COATING 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
4. 16" WELDED STEEL PIPE: 16" OD x 0.438" WT, X-70, API-5L, PSL2, ERW, BFW, DRL COATING 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. 20" DESIGN PRESSURE: 1480 PSIG
6. 16" DESIGN PRESSURE: 2100 PSIG
7. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
8. THE COATING ON THE CARRIER PIPE SHALL BE INSPECTED IMMEDIATELY PRIOR TO ITS INSTALLATION AND ALL DAMAGED COATING SHALL BE REPAIRED IN ACCORDANCE WITH SUNOCO'S PIPELINE COATING SPECIFICATIONS.
9. INSTALL CATHODIC PROTECTION TEST LEADS AS SPECIFIED ON THE ALIGNMENT SHEETS OR SUNOCO CORROSION TECHNICIAN.
10. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
11. WELDED JOINTS INSIDE R.O.W. SHALL BE 100% X-RAYED.
12. CONTRACTOR WILL MAINTAIN A MINIMUM 4' OF COVER TO THE TOP OF PIPE USING FIELD BENDS.
13. CONTRACTOR WILL MAINTAIN A MINIMUM 24" OF COVER FROM ALL EXISTING UTILITIES.
14. CONTRACTOR WILL MAINTAIN A MINIMUM 5' OF COVER FROM BOTTOM OF STREAMS.
15. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
16. IN ADDITION TO THE SITE-SPECIFIC INFORMATION PROVIDED IN THIS DRAWING, GENERAL REQUIREMENTS INCLUDED IN ALIGNMENT SHEETS, PERMITS AND APPROVAL FROM FEDERAL, STATE AND LOCAL AGENCIES ALSO APPLY.
17. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
18. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 5: Glenn Riddle Drive Conventional Auger Bore

NOTES

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

REF. DRAWING			
ES-6.18	TO	ES-6.18	EROSION & SEDIMENT PLAN
SHEET 12	TO	SHEET 12	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS							
NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
0	ISSUED FOR CONSTRUCTION	LKR	02/11/19	RMB	02/11/19	AMC	02/11/19

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

AUGER BORE (CASED)
GLENN RIDDLE DRIVE
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=30'

DWG. NO.: PA-DE-0101.0000-RD