HORIZONTAL DIRECTIONAL DRILL ANALYSIS
VALLEY ROAD CROSSING
PADEP SECTION 105 PERMIT NO. E23-524
PA-DE-0046.0000-RD and PA-DE-0046.0000-RD-16
(SPLP HDD No. S3-0591)

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PADEP SECTION 105 PERMIT NO.E23-524
PA-DE-0046.0000-RD and PA-DE-0046.0000-RD-16
(SPLP HDD No. S3-0591)

This reanalysis of the horizontal directional drill (HDD) installation of a 16-inch and 20-inch diameter pipeline crossings of streams S-C42, S-C41, S-C40, S-C39; wetlands C21, C19, C18; Valley Road and Darlington Road in Delaware County, has been completed in accordance with Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L for HDDs listed on Exhibit 2 of the Stipulated Order. This HDD is number 21 on the list of HDDs included on Exhibit 2. This HDD was not initiated before the issuance of the Order.

PIPE INFORMATION

20-Inch: 0.456 wall thickness; X-65

16-Inch: 0.438 wall thickness; X-70

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

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 20-INCH

- Horizontal length: 4,226 feet (ft)
- Entry/Exit angle: 10 degrees
- Maximum Depth of cover: 108 ft
- Depth under roads: 45-81 ft
- Depth under streams: 31-82 ft
- Depth under wetlands: 60-76 ft
- Pipe design radius: 2,000 ft

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 4,223 (ft)
- Entry/Exit angle: 10 degrees
- Maximum Depth of cover: 128 ft
- Depth under roads: 53-91 ft
- Depth under streams: 35-90 ft
- Depth under wetlands: 51-60 ft
- Pipe design radius: 1,600 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

The bedrock geology at HDD S3-0591 consists of the Baltimore Gneiss subgroup of undifferentiated amphibolite facies gneiss (Blackmer, 2005). This is a heterogeneous felsic, intermediate to mafic amphibolite felsic gneiss. Swirling migmatite leucosomes (light colored swirls) with biotite rich restite layers are common (Blackmer, 2005). Secondary lithology is a mafic gneiss comprised of hornblende-plagioclase-amphibole and garnets. This HDD alignment rests on the southern flank Avondale Anticline. The regional structural fabric of bedrock is aligned northeast.

Karst geology is not present at this HDD location; therefore, the use of geophysics assessments was not conducted because the results from these types of assessments would provide no data to assist in the redesign of these HDDs.

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater in the Piedmont Physiographic Province of Delaware County in the area of the HDD occurs within the secondary porosity provided by fractures in the bedrock and, to a lesser degree, within primary porosity created by weathering of the bedrock to soil. Perched water table conditions can be found associated with the weathered bedrock/competent bedrock contact. The water table gradients are subdued reflections of the topography, thus groundwater is moving from the local uplands to nearby valleys, where it discharges to local streams. Deep inter-basin groundwater flow is probably negligible (Balmer and Davis, 1996) in the region of the HDD. Depth to groundwater along this alignment is consistent within the region with depths ranging from 5 to 45 ft below ground surface (bgs). The geotechnical borings associated with this HDD have initial water level readings consistent within this range.

A Pennsylvania Groundwater Information System (PaGWIS) search for well records within 0.5 miles of the HDD resulted in 39 listings. Based on these listings and water level data on the geotechnical boring logs, the depth to groundwater in the area of the HDD ranges between the 15 to 77 ft bgs. The average water level for the area is approximately 35 ft bgs.

The PaGWIS search provided well yield records ranging between 1.5 to 100 gallons per minute (gpm) with an average of 24 gpm in the area of HDD. The production zone for waters wells in this formation is from the well bottom to highest point of water inflow from the water bearing overburden above competent bedrock, and seams, joints, and fractures in the upper bedrock of the formation.

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

INADVERTENT RETURNS DISCUSSION

The existing SPLP 8-inch and 12-inch pipelines in this area of the county were installed by open trench construction, and therefore have no IR history.

To date for the ME II project, four HDDs in similar metamorphic bedrock environments in Delaware County have experienced IR events. At these locations, drilling fluids under pressure migrated into open fractures at profile depth within bedrock and traveled to the surface.

HDD specialists for Sunoco Pipeline, L.P. (SPLP) reviewed the original HDD designs summarized above, and determined that that the design profiles for the 16 and 20-inch HDDs could be improved to lower the risk of IRs to the land surface or waters of the Commonwealth. As presented and discussed in the conclusions section below, the profiles for both the 16 and 20-inch pipelines have been redesigned deeper, incorporating the increased entry and exit angles allowed by the stress radius of the pipelines, which sharpens the pilot hole entry radius run down to horizontal depth and exit radius return to the land surface.

Two recent geotechnical cores at each end of the HDD were utilized in the profile redesign. At the west core location bedrock starts at 65 ft bgs. Initial bedrock values are poor, the recovery value is 36 and rock quality designation (RQD) is 42. This quickly transitions and at 85 ft bgs the recovery value is 100 and RQD value is 81. Proceeding to profile depth of -192 ft bgs on this core, recovery values are consistently at 100, and RQD values range from 91-100. At the southeast entry point, bedrock commences at 33 ft bgs.

Initial bedrock values are poor but immediately transition to a recovery value of 97 and RQD value of 71. Proceeding down to profile depth recovery values are consistent at 100 and RQD values range from 94-95. These values at profile depth are indicative of good to very good rock quality, which assists in the prevention of IRs.

POTENTIAL FOR AND MANAGEMENT OF PRODUCED GROUNDWATER

Due to the approximate 102 ft of elevation difference between the HDD entry (east) side, and HDD exit (west) side, the potential for producing groundwater during the HDD exists once the pilot hole has progressed approximately 1,900 ft into the profile and is at or approaching Station 25+00 on the HDD profile. This is approximately 2,500 ft before completion of the pilot hole. This difference in elevation is not extreme, and the produced water during the pilot and reaming phases will be utilized in the continuing HDD process and decrease the amount of water imported at the HDD rig, while simultaneously the drilling fluid viscosity is adjusted to account for produced water to ensure the returns are maintained as a flowable slurry.

Excess produced groundwater, or groundwater produced during non-drilling periods with either be captured, filtered, and discharged to the land surface at the edge of the temporary workspace, or if the means of filtration is insufficient to prevent the discharge of turbid water to a water of the Commonwealth, then the produced waters will be pumped to storage tanks staged at the temporary workspace adjacent to Valley Road, and then hauled away for treatment and disposal. Prior to reaching this extent of progress on the pilot hole , the contractor will have pre-prepared filtration structures and filtration bags in place to capture, filter, and discharge produced water. Portable storage tanks will be immediately available if the filtration system fails to clean the produced water sufficiently for discharge.

If groundwater discharges through the annulus of the HDD persists after the pipeline is pulled into place, then SPLP will grout the annulus surrounding the pipeline with bentonite plugs using tremie pipes pushed into the profile a minimum of 15 ft into the annulus, with the high viscosity grout then pumped into place until it's pressurized back to the annulus opening.

ADJACENT FEATURES ANALYSIS

HDD No. S3-0591 is located approximately 1-mile west of Lima, in Middletown Township, Delaware County, Pennsylvania. The current land use surround the HDD location is small to large tract residential sites set within deciduous woods. The pipeline route follows parallel to two (2) existing SPLP pipelines in a common easement. The HDD profiles cross under West Forge Road, New Darlington Road, Hermitage Lane, Darlington Road, and Valley Road; three streams and three wetlands.

Since the original date of installation of the existing SPLP pipelines, adjacent urban residential developments and related infrastructure have continued to increase in proximity and density. Currently, private residences, driveways, various utilities (e.g. overhead and underground electric lines, underground water lines, sewage lines, and a gas lines) are immediately adjacent to and abutting the existing permanent utility easement, and parallel to and crossing perpendicular to the easement. The presence of these structures necessitated the HDD construction method to avoid affects to residential yards, pubic infrastructure and utilities that could result from conventional open cut pipeline construction.

In accordance with the terms of the Order, SPLP has identified all landowners with property located within 450 ft of the HDD alignment. There are eighty-three (83) individual landowners with properties located within 450 ft of the HDD alignment. SPLP sent each of these landowners a notice letter via both certified and first class mail on October 31, 2017, that included an offer to sample the landowner's private water supply/well in accordance with the terms of the Order and the Water Supply Assessment, Preparedness, Prevention and Contingency Plan. The letter also requested that each landowner contact the Right-of-

Way agent for the local area and provide SPLP with information regarding: (1) whether the landowner has a well; (2) where that well is located, and it's depth and size if known; and (3) whether the landowner would like to have the well sampled. In accordance with paragraph 10 of the Order, copies of the certified mail receipts for the letters sent to landowners have been provided to Karyn Yordy, Executive Assistant, Office of Programs at the Department's Central Office.

SPLP's public outreach results to date have identified the presence of 28 water wells within 450 ft of the proposed HDD. These occur at distances from the profile of 25 ft out to 450 ft and farther. Well depths vary from 25 ft to 700 ft. Thirty-six properties are served by public water supply. SPLP assumes that additional landowner water supply information will continue to be acquired prior to the initiation of these HDDs. Attachment 2 presents a graphic view of the currently identified well locations in relation to the HDD profiles.

Based upon the understanding of the groundwater levels and movement through the overburden and subsurface bedrock fractures and fissures as described in the hydrogeology report, SPLP believes that HDD activities could affect individual well use during active drilling for wells located within 150 linear ft. General household daily water use is typically 500 to 1,000 gallons per day varying by number of occupants, with use peaking during morning and evening hours and on weekends. As a result, groundwater withdrawal of these wells should be gradual and cyclic, not abrupt, and not propagate in the extent and magnitude in as would be the case for a public water well. Additionally, each well should recharge from several directions in the surrounding formation, not just from one bearing or direction, which decreases the direct draw of water from around the HDD profile. The yield and quality of these wells is governed by their depth, construction and location within to the geologic structural horizon (porosity, fissures, and fractures) from where they draw groundwater. The HDD is an active "pressure event" in the aquifer that pushes upon the static ground water and could potentially agitate settled sediments within the water bearing zones, or could result in transport of diluted drilling fluids towards the withdrawn zone for individual wells. As a result, active well use during HDD activities potentially over the duration of the HDD construction could result in the uptake of turbid water. While this does not present a health hazard, it can be an aesthetic issue for users and could affect taste.

SPLP will engage in a second and final effort to encourage landowners to make advance arrangements for the supply of alternative water sources as necessary during the HDDs. Agents for SPLP will initiate direct contact by phone or in person, and SPLP will prepare a second communication specifically directed to all landowners with known wells, or unidentified water supplies within 450 ft of the HDD profiles. The letter will communicate our analysis regarding their water supply. It will clearly state the preference to establishing communications in advance of the work; permission to perform monitoring during the HDDs, and landowners' preference to installing alternative water in advance of the HDDs.

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

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

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of S3-0591 included an evaluation of open cut alternatives and a re-route analysis. As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the Project, SPLP considered a number of different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this

determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

Open-cut Analysis

If open trench construction methods were used for this area crossed by the proposed HDDs, a 75-foot wide construction corridor would be required. The impacts to streams S-C39, S-C40, and S-C42 would increase to 39 square feet (sq ft), 279 sq ft, and 613 sq ft, respectively. In comparison, an HDD crossing would have no impact to the bed or banks of these three streams. The total floodway impacts from open trench construction in this corridor would total 0.586 acres, approximately 0.565 acres more than the currently permitted HDD crossing method. Changing to an open trench crossing of this area would also impact wetlands C18, C19, C21, and C24. Total impacts to these wetlands would be 0.023 acres, 0.106 acres, 0.051 acres, and 0.002 acres, respectively, with approximately 0.025 acres of permanent conversion of forested vegetation to lower successional vegetation in the palustrine forested (PFO) wetland C21.

Considering the number and location of adjacent features and utilities, an excavation of sufficient size to accommodate an open trench method could result in disturbances to residences and damages and disruption of service on existing utility lines; therefore the open cut alternative is not preferred.

The length of this segment (4,100 feet) would exceed the technical limits / capability to use a conventional auger bore or other bore variations. The restricted surface area in combination with the alterations in easement direction impeded the use of shorter bore lengths.

Re-Route Analysis

As discussed in the Alternatives Analysis, in accordance with state and federal guidance, SPLP has routed this crossing to be co-located with existing pipeline and other utility corridors to avoid new “greenfield” routing alignments, to the maximum extent practicable. This avoids and minimizes new and permanent impacts on previously undisturbed land, land use encumbrance, and site-specific and cumulative impacts on land, environmental, and community resources.

The general orientation of the existing SPLP easement, and planned route of pipeline installation is from the northwest to the southeast. No practicable re-route option lies to the north or south of the proposed route that would not transect the same infrastructure and urban developments transected by the proposed route.

There are no existing corridors to the north-northeast of the existing SPLP easement that could provide an opportunity for co-locating the new pipelines. Residential developments continue to the north-northeast for 1.7 miles before undeveloped lands exist that could be utilized for routing without being impeded by existing developments. To relocate the intended route of installation would require re-routing of the project for miles of its length, which is well beyond the scope of alternatives of this HDD reanalysis as set by the Order. Undertaking an extensive reroute of this nature just transfers the encumbrance of a

utility easement from a pre-existing location, where the presence of pipeline utilities was and is well known to past and current landowners to a new set of previously unencumbered lands and landowners.

Approximately 1-mile southeast of this HDD location, a railroad right-of-way provides an existing established corridor that could be considered; however, this right-of-way never intersects the existing SPLP easement. Therefore, consideration of the use of this right-of-way must consider the direct effects to the adjacent urban development to offset the pipeline route for many miles and then at some point return to the existing route of the SLPL easement. Considering the location and density of adjacent developments this right-of-way does not constitute a suitable alternate route, and would only transfer the encumbrance of a utility easement from a pre-existing location, where the presence of pipeline utilities was and is well known to past and current landowners to a new set of previously unencumbered lands and landowners

RECONSIDERATION OF THE HORIZONTAL DIRECTIONAL DRILL

Additional geologic investigations have been completed and utilized in the redesign of the planned HDD. The redesign adjusts the angles of entry and exit to accelerate the penetration of competent bedrock and sets the HDD profile deeper to place the HDD horizontal run through bedrock having better structural integrity than a shallower profile. A summary of the redesign factors is provided below.

Original Horizontal Directional Drill Design Summary: 20-inch

- Horizontal length: 4,266 feet (ft)
- Entry/Exit angle: 14-15 degrees
- Maximum Depth of cover: 188 ft
- Depth under roads: 75-126 ft
- Depth under streams: 71-129 ft
- Depth under wetlands: 100-110 ft
- Pipe design radius: 2,400 ft

Revised Horizontal Directional Drill Design Summary: 16-inch

- Horizontal length: 4,232 feet (ft)
- Entry/Exit angle: 14-15 degrees
- Maximum Depth of cover: 188 ft
- Depth under roads: 68-148 ft
- Depth under streams: 91-146 ft
- Depth under wetlands: 90-110 ft
- Pipe design radius: 2,000 ft

Upon the start of these HDDs, Sunoco will employ the following HDD best management practices as follows:

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

- SPLP will require and enforce the use of annular pressure monitoring during the drilling of the pilot holes, which assists in immediate identification of pressure changes indicative of loss of

return flows or over pressurization of the annulus to manage development of pressures that can induce an IR;

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

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

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

- Based upon the behavior of the soil overburden and near subsurface geology during the entry and exit of the pilot phase, casing of the pilot hole can be implemented to control IR where the profile depth is shallow and oversight of the pilot indicates a long term risk of IR that should be controlled;

- During the reaming phase, the use of Loss Control Materials can be implemented if indications of a potential IR are noted or an IR is observed;

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

- SPLP will prepare and stage the materials required to manage groundwater flow back to the southeastern entry/exit point to control potential groundwater discharge during HDD installations.

CONCLUSION

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

VALLEY ROAD CROSSING
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PA-DE-0046.0000-RD and PA-DE-0046.0000-RD-16
(SPLP HDD No. S3-0591)

ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

HDD HYDROGEOLOGICAL REEVALUATION REPORT

Mariner East II
Spread 6
HDD S3-0591
Valley Road
Middletown Township, Delaware County, Pennsylvania

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

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

January 2018

HDD HYDROGEOLOGIC REEVALUATION REPORT

Mariner East II
Spread 6
HDD S3-0591
Valley Road
Middletown Township, Delaware County, Pennsylvania

January 2018

Prepared for:

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Prepared By:

Gary M.B. Kribbs, P.G.
Project Hydrogeologist

Reviewed By:

David J. Demko, P.G.
VP, Principal Hydrogeologist

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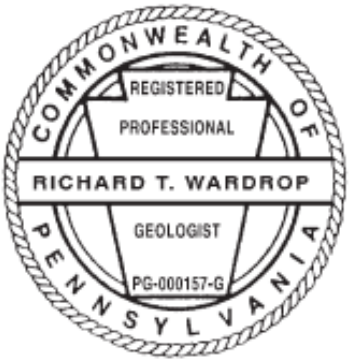
By affixing my seal to this document, I am certifying that the information is true and correct. I further certify I am licensed to practice in the Commonwealth of Pennsylvania and that it is within my professional expertise to verify the correctness of the information.



January 7, 2018

Richard T. Wardrop, P. G. date

Lic. No. PG000157G

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ATTACHMENTS

1.0 INTRODUCTION

Sunoco Pipeline, L.P., (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare HDD Hydrogeologic Reevaluation Reports (HRRs) for horizontal directional drills (HDDs) listed on Exhibit 2 of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017. This report discusses the hydrogeologic reevaluation for HDD S3-0591 and HDD S3-0591-16 (the 20-inch and 16-inch HDDs for this location, respectively), hereinafter collectively referred to as HDD S3-0591. The planned alignment for HDD S3-0591 is located east of Glen Mills, Pennsylvania, and north of the Franklin Mint in Middletown Township, Delaware County, Pennsylvania.

The discussion presented in this report is based on an alignment and profiles developed by Tetra Tech/Rooney, revised on September 30 (20-inch) and October 7 (16-inch), 2016 (the original profiles). GES has also been provided proposed alternative profiles for HDD S3-0591 revised November 15, 2017 (revised profiles) (see **Attachment A**). On the revised profiles, the northwestern and southeastern entry/points were only moved slightly; however, the depths of the profiles were increased 40 to 60 feet to reduce the risk of IRs by installing the pipes deeper into more competent bedrock.

A map depicting the location of the HDD with topographic information for the surrounding area is presented as **Figure 1**.

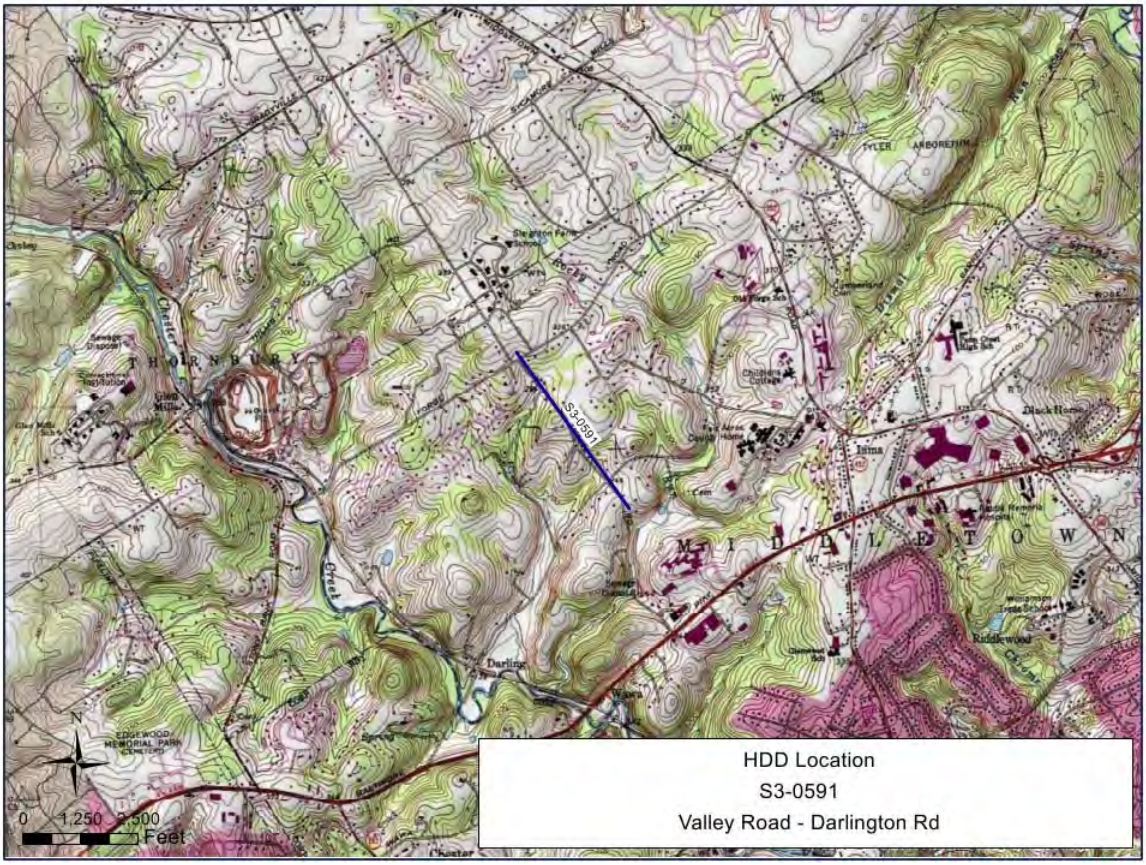


Figure 1. Site Location Map (modified from USGS Media 1:24,000 Topo. Quad., rev. 1994)

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of the HDD;
- Summaries of studies performed pertinent to reevaluation, including fracture trace analysis, geotechnical borings;
- A site conceptual model; and,
- Reevaluation recommendations.

The contents of this report were developed from interpretation of published information, field observations, and related field studies. No geophysical studies were performed due to lack of karstic terrain. Site geotechnical boring programs were conducted by Tetra Tech in October 2015 through February 2016 and more recently by Terracon Consultants, Inc. (Terracon) in August 2017, in support of the HDD S3-0591 reevaluation. Please note that GES did not oversee or direct either 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 hydrogeologic reevaluation report.

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.

2.0 HDD GEOLOGY/HYDROGEOLOGY

2.1 Physiography

2.1.1 Topography

The topography in the area of HDD S3-0591 is representative of the region for the Piedmont Physiographic Province of Pennsylvania with gently rolling hills. Total relief across the profile is approximately 120 feet. The difference in the updated revision is a minor lengthening by 40 feet southeast between entry /exit points for the 20-inch line and by 11 feet southeast for the 16-inch line; and an increase in depth of 40 for the 20-inch line and 60 feet for the 16-inch line.

2.1.2 Hydrology

The profiles cross two unnamed headwater ephemeral tributaries to Chester Creek flowing southwest to a point of convergence and the location of three ponds along Darlington Road. From the ponds a tributary continues to flow southwest to a point of convergence with the main stem of Chester Creek, approximately 0.9 miles southwest of the southeast entry/exit points. From this point of convergence Chester Creek flows approximately 7 miles southeast to Chester where it enters the Delaware River. Rocky Run drains in a sub parallel pattern to those unnamed tributaries down slope of the southeastern entry/exit point.

The two headwater ephemeral tributaries are labeled S-C42 and S-C40 on the profiles and occur at stations 9+10 and 30+94 on the revised 20-inch profile, respectively. On the original 20-inch profile the bore is shown as passing 89 feet below S-C42 which is increased to 129 feet on the revised profile. Similarly, that bore is shown passing 31 feet below S-C40 on the original profile and passing 71 feet below the stream on the revised profile.

2.2 Geology

2.2.1 Soils

Soils across the profile are classified as Glenelg channery loam with varying slopes from 0 to 15%. The soils are generally classified well-drained and parent material is a mica schist, or in this case, a felsic gneiss. The engineering classification is SM or silty sand. Depths vary from 18.5 feet to over 40 feet along the extent of the HDD (USDA NRCS, 2017). The logs for the more recent two geotechnical borings describe the overburden as sandy lean clay (CL). The mapping is generally consistent with geotechnical boring classifications, but the mapped surface soils are more silty and sandy on the steeper 8-15% slope and are more erodible.

The Glenelg series is widespread and has a shallow veneer of sandy lean clay, but most of this soil unit is comprised of partially weathered bedrock to a soil that is very sandy and permeable. Drilling within the overburden comprised of Glenelg series soils poses risk of an IR during entry and exit. A boulder of in-situ bedrock was logged for one of the original soil borings (SB-01).

2.2.2 Bedrock lithology

The profile alignments rest on the Proterozoic to early Paleozoic age Baltimore Gneiss subgroup of heterogeneous felsic gneiss. **Figure 2** shows the current published geology for the area (Blackmer, 2005).

The bedrock consists of the Baltimore Gneiss subgroup of undifferentiated amphibolite facies gneiss (Blackmer, 2005). This is a heterogeneous felsic, intermediate to mafic amphibolite felsic gneiss. Swirling migmatite leucosomes (light colored swirls) with biotite rich restite layers are common (Blackmer, 2005). Secondary lithology is a mafic gneiss comprised of hornblende-plagioclase-amphibole and garnets.

2.2.3 Structure

The HDD alignment rests on the southern flank Avondale Anticline (see **Figure 2**). The regional structural fabric of bedrock is aligned northeast. Precise strike and dip attitudes of foliation orientations at this HDD location are not known, but the recent geotechnical core borings reveal a foliation dip in the 23 to 30° range.

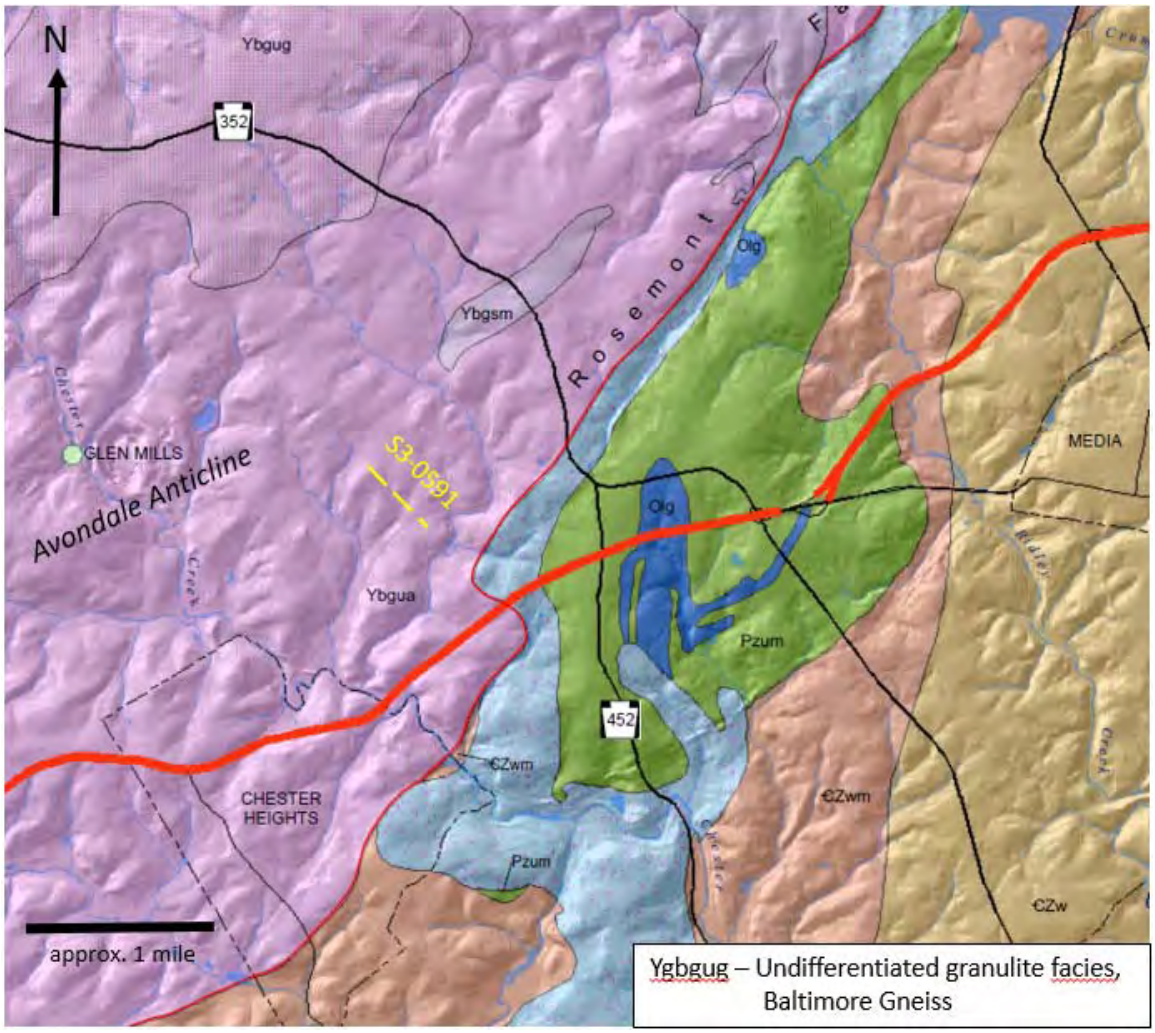


Figure 2. Site Geology (modified from Blackmer, 2005)

2.2.4 Fracture Trace Analysis

Fracture trace analysis using high altitude aerial photography was performed for the area of interest to identify potential zones of bedrock weakness along drill paths. 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.

A fracture trace analysis was conducted with a Topcon MS-3 stereo scope using 1937 USDA aerial photography stereo pairs obtained through Penn Pilot (see **Figure 3**). The data was then

superimposed onto one of the 1937 USDA aerial stereo pairs. As such, much of the land surface appears undeveloped providing an unobstructed view of fracture traces. HDD S3-0591 intersects five of the mapped fracture traces. All fracture traces within the image trend between NNE to WSW, generally parallel to the regional structural fabric. Two of the traces crossing the southeast portion of the alignment intersect approximately over the alignment. Fracture trace intersections can be areas of higher fracture density and secondary porosity.

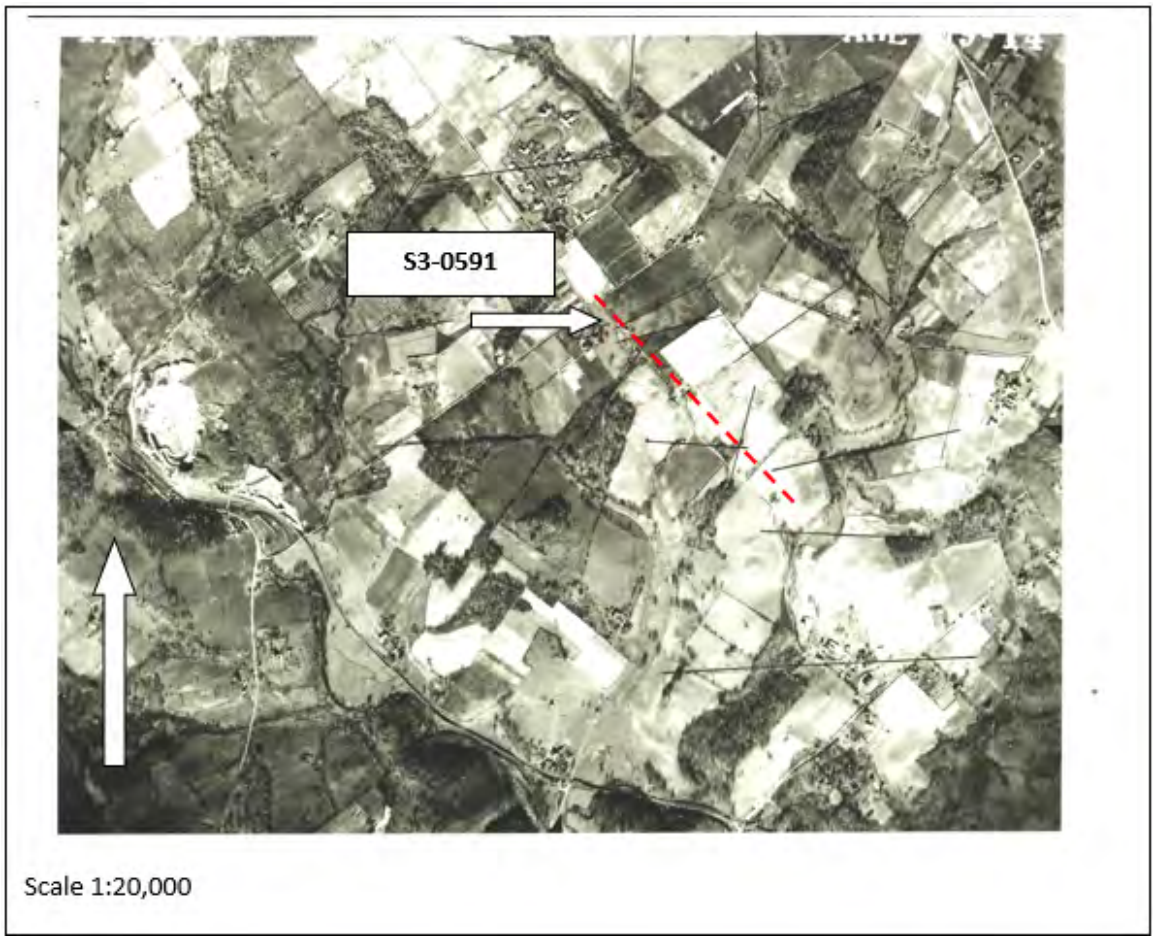


Figure 3. Fracture Trace Map

2.2.5 Karst

No karst terrain is present in the region of HDD S3-0591.

2.2.6 Mining

A large open pit mining or aggregate quarry is located approximately 1.3 miles west of the HDD S3-0591 location.

2.2.7 Rock engineering properties

Joints and other fractures in this area of the Baltimore Gneiss complex have an irregular pattern and are moderate in abundance, steeply dipping and open providing good surface drainage. Excavation is difficult and drilling rates are reportedly slow. Solid bedrock has unconfined compressive strength of 6,300 to 7,250 pounds per square inch (psi) (Geyer & Wilshusen, 1982).

The additional site specific geotechnical testing yielded substantially higher strengths in the boring B6-2W ranging between 7,000 to almost 13,000 psi values. Boring B6-2E yielded even higher values ranging from 8,600 to 20,000 psi unconfined strengths; projecting drilling rates to be slow.

2.2.8 Results of Geotechnical Borings

Site geotechnical boring programs were conducted by Tetra Tech in October 2015 through February 20016 and more recently by Terracon Consultants, Inc. (Terracon) in August 2017, in support of the HDD S3-0591 reevaluation (see **Attachment B**). The five (5) geotechnical borings advanced in 2015 were installed at both entry/exit points and at three locations along the drill path. Depths ranged from 18.5 to 39 feet in depth below ground surface (ft bgs). Boring S8-04 encountered bedrock at 31 ft bgs and cored into 7 feet of fractured gneiss. Borings S8-03 and S8-04 encountered ground water at depths of 35 feet and 28 feet, respectively,

Two (2) additional borings were conducted on the west and east entry/exit areas for the revised profiles as part of the recent geotechnical program yielding additional information. Soils were classified in a range from sandy lean clay to sandy silts as discussed in section 2.2.1. Boring B6-2W at the HDD northwestern entry/exit was drilled to a depth of 202.5 feet and encountered bedrock at 63.5 ft bgs. Rock cores for B6-2W were described as gneiss, with low to high angle fractures noted throughout the core. Core recoveries were high ranging from 92 to 100%. Rock Quality Indices (RQDs) steadily increased with depth to 80.5 ft bgs feet then remained high in the range from 81 to 100% for the remainder of the boring.

Boring B6-2E at the HDD southeastern entry/exit was drilled to a depth of 109 feet and bedrock was encountered at 33 ft bgs. Rock cores for B6-2E were described as gneiss and amphibolite, with low to high angle fractures noted throughout the core. Core recoveries were high after a depth of 49 feet ranging from 90 to 100%. RQDs were lower at the top of the core but increased with depth to within a range of 71 to 95%, with no trend, after 49 ft bgs.

2.3 Hydrogeology

2.3.1 Occurrence of Groundwater

Groundwater in the Piedmont Physiographic Province of Delaware County in the area of the HDD occurs within the secondary porosity provided by fractures in the bedrock and, to a lesser degree, within primary porosity created by weathering of the bedrock to soil. Perched water table conditions may be found associated with the weathered bedrock/competent bedrock contact. The water table gradients are subdued reflections of the topography thus groundwater is moving from the local uplands to nearby valleys, where it discharges to local streams. Deep interbasin groundwater flow is probably negligible (Balmer and Davis, 1996) in the region of the HDD. Depth to groundwater along this alignment is consistent within the region with depths ranging from 5 to 45 ft bgs. The geotechnical boring associated with HDD S3-0591 have initial water level readings consistent within this range.

2.3.2 Water Levels

A Pennsylvania Groundwater Information System (PaGWIS) search for well records within 0.5 miles of the HDD resulted in 39 listings. Based on these listings and water level data on the geotechnical boring logs, the depth to groundwater in the area of the HDD ranges between the 15 to 77 ft bgs in the area of HDD S3-0591. The average water level for the area is approximately 35 ft bgs.

2.3.3 Well Yields

The PaGWIS search provided well yield records ranging between 1.5 to 100 gallons per minute (gpm) with an average of 24 gpm in the area of HDD S3-0591.

2.3.4 Water Supply Wells near HDD

Domestic water supply wells located within the area of HDD S3-0591receive the majority of their supply from groundwater contained within the fractures and joints that provide secondary porosity in bedrock. The PaGWIS search listed 18 homes located along Valley Road near the HDD path. Only three (3) of these records provided information on well locations. The closest, is located 335 feet to the west of the alignment and is listed as 81 feet deep and has a reported yield of 50 gpm. Another is over 700 feet to the east of the alignment and the third is 450 feet SSW of the southeastern entry/exit point.

A current survey completed by ETP of water supplies within 450 feet of the alignment for HDD S3-0591 has resulted in identifying 28 properties and 20 domestic water supply wells within the 450-foot search area (see **Figure 4**).

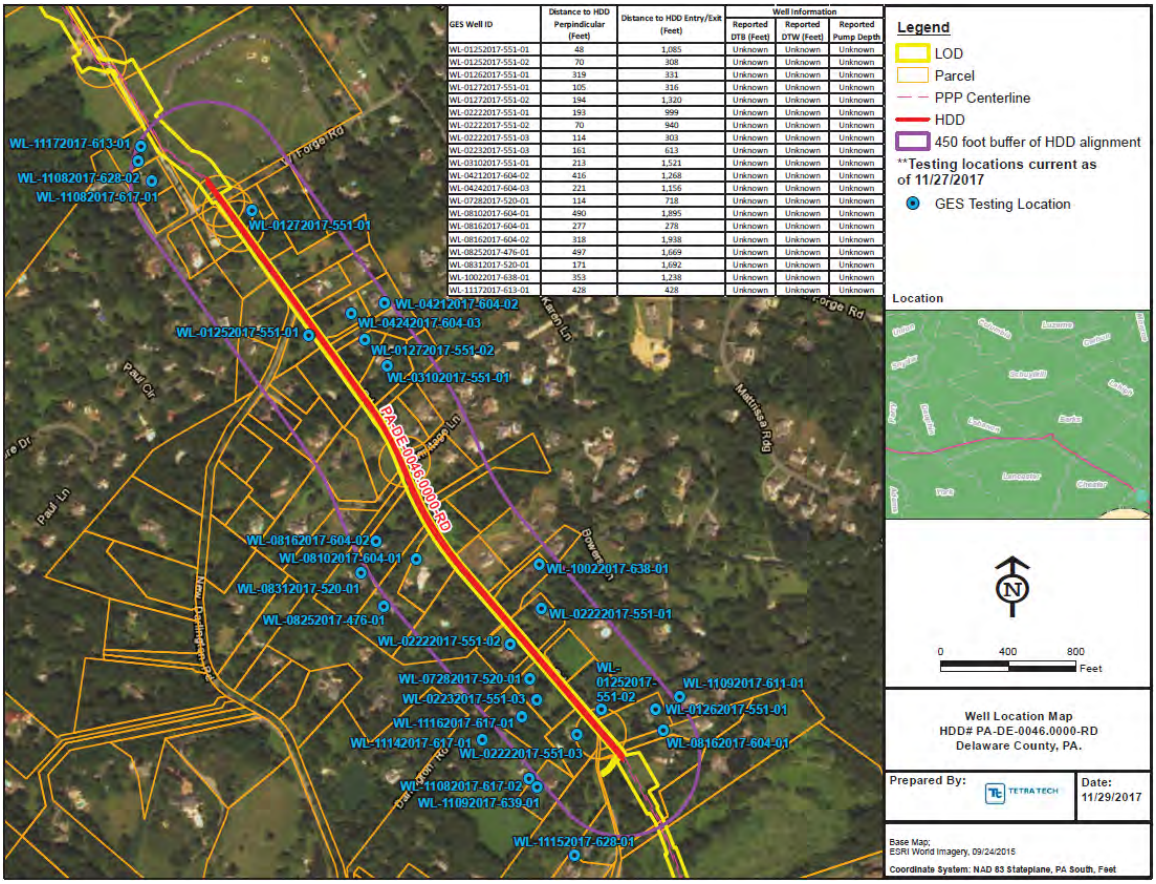


Figure 4. Current 450-Foot Domestic Well Survey Results

2.4 Geophysical Studies

No geophysical studies were performed at this location because no limestone nor karst terrain exists within the region of HDD S3-0591.

3.0 OBSERVATIONS TO DATE

3.1 On HDD S3-0591

3.1.1 ME I

No IRs occurred at this location during the installation of ME I.

3.1.2 ME II

Installation of the 16-inch and 20-inch pipes has not started at this location along ME II.

3.2 On other HDD Alignments

3.2.1 ME I

The only IR for ME I that occurred in Delaware County was at ME I HDD 24 near Edgemont PA, approximately two miles northwest of HDD S3-0591 in Baltimore Gneiss.

3.2.2 ME II

To date for the ME II project, a few HDD alignments in similar metamorphic bedrock environments have experienced IR events. In Delaware County, four HDDs locations have experienced IRs (HDD S3-0520, 0560, 0620 and 0631). At these locations, drilling fluids under pressure migrated into open fractures at depth within bedrock and traveled to the surface. Also groundwater discharges toward the point of entry have been present along three (3) other alignments in Spread 6, where there are large differences in hydraulic groundwater head and elevation between entry/exit points during drilling activity shutdown. These discharges, if large enough, can affect the local water table and possibly affect domestic water supply yields.

4.0 SUMMARY AND CONCLUSIONS

4.1 Site Conceptual Model

The revised boring profiles for HDD S3-0591 are deeper than the original profiles and, as such, represent a reduced risk of IRs by advancing the bores deeper into more competent bedrock. Important areas along the HDDs include parts of the drills that will pass under streams S-C42 and S-C40. The difference in boring depth between the original profile and the revised profile for the 20-inch boring is 40 feet (89 to 129 feet) for S-C42 and for S-C40 (31 to 71 feet). Similarly, the difference in boring depth between the original profile and the revised profile for the 16-inch boring is approximately 56 feet (90 to 146 feet) for S-C42 and for S-C40 (35 to 91 feet).

Like other ME II HDDs installed in the Baltimore Gneiss to date, installation of the two HDD S3-0591 pipes may be comparatively slow, with difficulties in maintaining a consistent angle of decent and horizontal elevation due to variations in bedrock composition and hardness. Although RQD values for the two most recent geotechnical borings for HDD S3-0591 are relatively high, variability in RQD values and five fracture trace intersections are indicative of weaker bedrock zones that may represent preferred pathways for drilling fluids, under pressure, to migrate. A fracture trace intersection was mapped on the southern part of the HDDs, which may represent a zone of less competent bedrock.

The overburden soils in the vicinity of HDD S3-0591 are comprised of highly weathered bedrock which has relatively low cohesive strength and can be up to 39 feet thick. As such, there is an increased risk of IRs in these horizons during entry and exit for these drills.

Based on groundwater level information obtained from geotech borings along the HDD path, a large percentage of each HDD will be below the local water table once it advances approximately 500-800 ft. to the northwest from the southeastern point of entry. The difference in elevation for both the 20-inch and 16-inch HDD is approximately 100 feet from a topographic high at the northwestern entry/exit to a lower elevation at the southeastern entry/exit. The profile of the water table and elevation differences between entry/exits from the northwest to the southeast may cause groundwater discharge or flow back along the bore during times of drilling shutdown toward the southeastern drill entry. Depending on the magnitude of the elevation difference between the water table under the elevated ground, mid-profile, and the southeast exit entry, this could create a depression in the local water table along the drill path that would most likely be temporary. This affect would occur during periods of non-drilling and before completion of the pipe installation, potentially affecting groundwater levels in local domestic supply wells. Approximately 20 domestic water wells are known to be present within 450-feet of the alignments.

4.2 Recommendations

Based on the discussion presented in **Section 4.1** and other information provided in this HRR the following are recommendations for the pending HDD S3-0591 installations:

1. Prepare a contingency plan for excess groundwater flow back for the southeastern HDD entry location which would include; 1) a groundwater containment, retention and re-infiltration system to manage potential excess groundwater discharge unable to be recirculated for drilling use, at the drill entry point during HDD shutdown periods; 2) a dedicated drainage way to the nearest surface water conveyance (Rocky Run) with appropriate erosion and sedimentation controls; and 3) a contingency plan to grout

pipe annulus and terminate any ongoing groundwater discharge, if that should persist, post installation.

2. Establish a communication and response plan to respond to complaints from well owners during HDD activities, confirm any impact from drilling operations and provide alternative water supplies where needed .
3. Identify domestic water supply wells within 150' of the HDD alignment and offer/provide a temporary water supply prior to HDD drilling. The offer would extend prior to and during any portion of the HDD installation and until completion of the pipe pullback work. Any well suspended from service during the HDD operation would be tested prior to its re-activation to document its water quality compared to pre-drilling conditions.
4. Evaluate the feasibility in implementing an early detection groundwater monitoring program using either appropriately located domestic wells (agreement with well owners required) or newly constructed monitoring wells (location logistics dependent) to detect drilling fluid migration toward domestic water supplies within areas of high well density.
5. Provide drilling operators, Environmental Inspectors (EIs) and field Professional Geologists (PGs) with mapping that locates areas where the HDD traverses or is in close proximity to fracture traces and bedrock faulting. These areas can be inspected with increased frequency and drilling operators can more closely monitor pressures when drilling through these horizons.
6. Address the potential for soil and bedrock weaknesses along each revised profile within the updated drilling plan for HDD S3-0591. Specifically identify unconsolidated horizons characterized with low cohesive overburden and the potential for IRs in proximity to HDD entries and exits. Review possible methods to improve mitigation of IRs in these horizons.

5.0 REFERENCES

Blackmer, G. C.; (2005); Preliminary Bedrock Geologic Map of a portion of the Wilmington 30-by 60-minute quadrangle, Southeastern PA.; Pennsylvania Geological Survey, 4th series. 16 pgs, 1 plate.

Balmer, W.T; Davis, D.K; (1996); Groundwater Resources of Delaware County Pennsylvania; USGS Water resources & Pennsylvania Geological Survey, 4th series. 67 pgs, 1 plate.

Geyer, A. R., Wilshusen, J. P. (1982); Engineering Characteristics of the Rocks of Pennsylvania, Harrisburg, PA. PA Geologic Survey Engineering Geology Report No. 1.

Penn Pilot data base http://www.pennpilot.psu.edu/: Pennsylvania Geologic & Topographic Library, United States Department of Agriculture, (1937); U.S.D.A. Aerial Photograph Data Base, Delaware County, 11-04-1937 ahl-59-14, ahl-59-13.

Pennsylvania Groundwater Information System (PaGWIS) http://dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm, Pennsylvania Topographic and Geological Survey, (2017); Pennsylvania Geological Survey, 4th series, SQL database.

United States Department of Agriculture Natural Resources Conservations Service (USDA NRCS), (2017) https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx; Custom Soil Resource Report for Delaware County, Pennsylvania HDD S3-0591, 103 pgs.

United States Geologic Survey (USGS); (Revised 1994) Media 7.5 Minute Series Topographic Quadrangle.

Attachment A

Original and Revised Plan and Profile

PA-DE-0046.0000

HDD ENTRY/EXIT
N39.922650
W75.465530

PULLBACK ALONG ROW

GEOTECH SB-01

W FORGE RD

GEOTECH SB-02

NEW DARLINGTON RD

HOR PC
N39.918996
W75.462278

PROPOSED 16" PIPELINE

GEOTECH SB-03

HOR PT
N39.917804
W75.461474

HERMITAGE LN

HOR PC
N39.917739
W75.461442

SUNOCO EASEMENT
LIMITS - NOT LOD

EXISTING SUNOCO PIPELINES

PROPOSED 20" PIPELINE

GEOTECH SB-04

HOR PT
N39.916170
W75.460270

EXISTING SUNOCO PIPELINES

DARLINGTON RD

SUNOCO EASEMENT
LIMITS - NOT LOD

GEOTECH SB-05

PA-DE-0069.0000

HDD ENTRY/EXIT
N39.913111
W75.457055

VALLEY RD

150 0 150 300
FEET

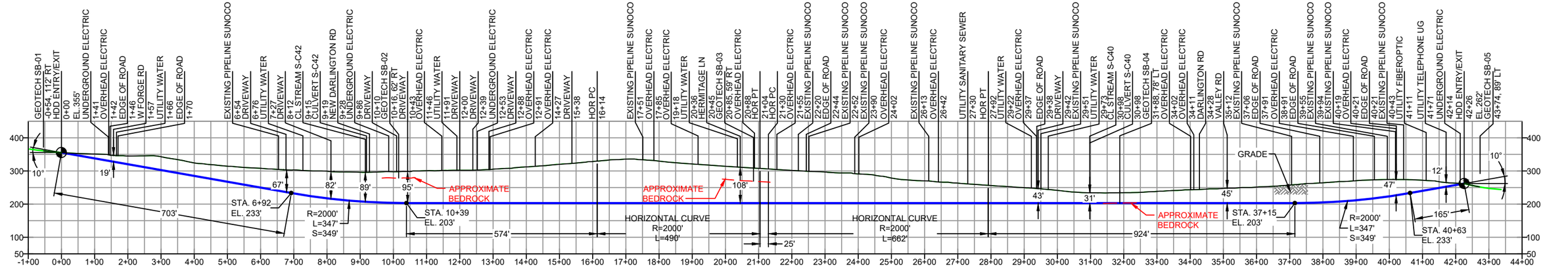
PLAN VIEW

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, MIDDLETOWN TOWNSHIP
S3-0591

PROFILE VIEW



GEOTECH SB-01
-NG EL. 358'
-FRACTURED GNEISS (0.0' - 4.0')
-TOPSOIL (4.0' - 5.5')
-SM (5.5' - 21.5')
-SM (21.5' - 29.9')
-COMPLETION DEPTH EL. 328'

GEOTECH SB-02
-NG EL. 295'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 11.5')
-GROUNDWATER (10.0')
-SM (11.5' - 18.5')
-BEDROCK (18.5') AUGER REFUSAL
-COMPLETION DEPTH EL. 276.5'

GEOTECH SB-03
-NG EL. 309'
-TOPSOIL (0' - 0.1')
-SM (0.1' - 40.0')
-GROUNDWATER (35.0')
-BEDROCK (40.0') AUGER REFUSAL
-COMPLETION DEPTH EL. 269'

NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4226'
   HDD PIPE LENGTH (S=):4242'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
5. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
6. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
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10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

GEOTECH SB-04
-NG EL. 238'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 6.0')
-SM (6.0' - 23.5')
-SM (23.5' - 31.0')
-GROUNDWATER (28.0')
-FRACTURED GNEISS (31.0' - 38.0')
-COMPLETION DEPTH EL. 200'

GEOTECH SB-05
-NG EL. 267'
-TOPSOIL (0' - 0.1')
-SM (0.1' - 30.0')
-COMPLETION DEPTH EL. 237'

NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTES

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REF. DRAWING

ES-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN	
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	JAM	03/18/15	RMB	03/27/15	AAW	03/27/15

Sunoco Logistics Partners L.P.

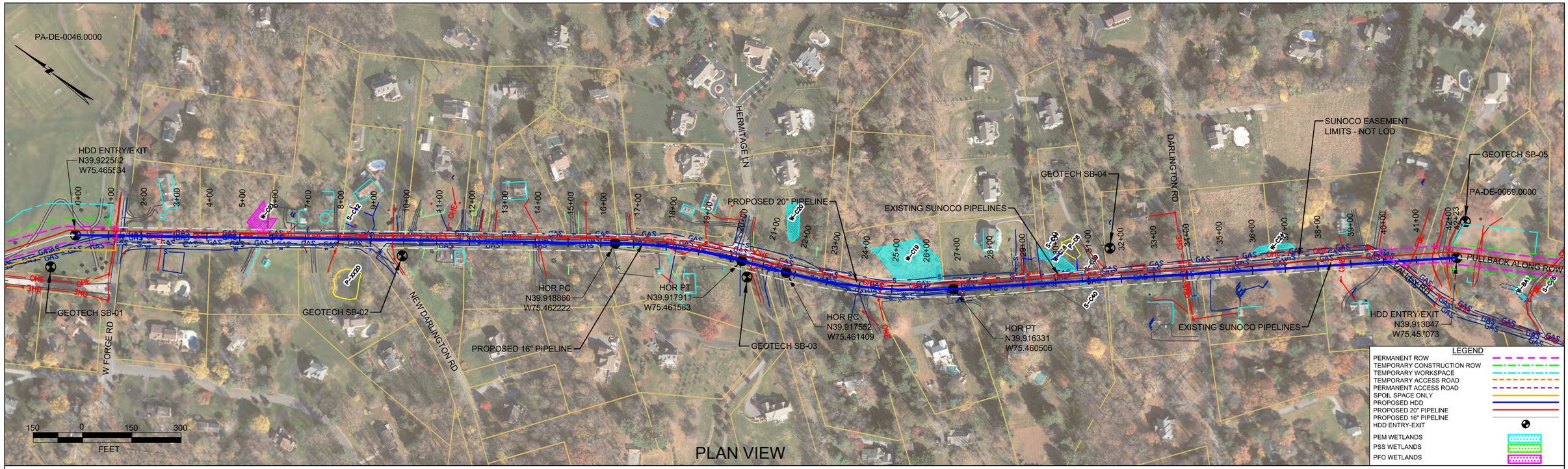
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'

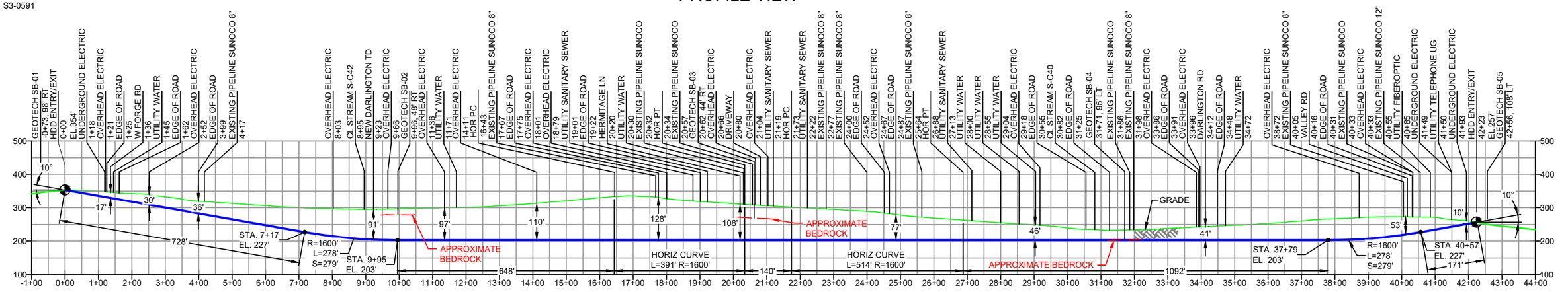
DWG. NO: PA-DE-0046.0000-RD



PLAN VIEW

DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591

PROFILE VIEW



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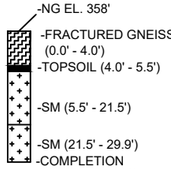

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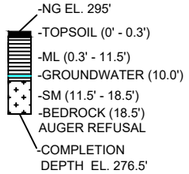

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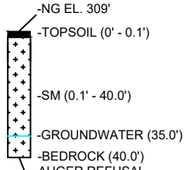

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5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
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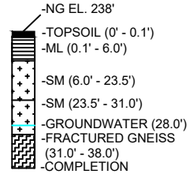
GEOTECH SB-04



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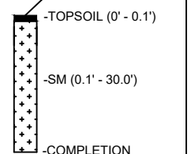

NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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REF. DRAWING

ES-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN	
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD / DARLINGTON RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'

DWG. NO: PA-DE-0046.0000-RD-16

PA-DE-0046.0000

HDD ENTRY/EXIT
N39.922651
W75.465512

GEOTECH B6-2W

PULLBACK ALONG ROW

W FORGE RD

GEOTECH SB-02

NEW DARLINGTON RD

HOR PC
N39.918992
W75.462255

HOR PT
N39.917805
W75.461455

HERMITAGE LN

GEOTECH SB-03

HOR PC
N39.917736
W75.461422

PROPOSED 16" PIPELINE

EXISTING SUNOCO PIPELINES

PROPOSED 20" PIPELINE

GEOTECH SB-04

HOR PT
N39.916198
W75.460282

DARLINGTON RD

SUNOCO EASEMENT
LIMITS - NOT LOD

EXISTING SUNOCO PIPELINES

VALLEY RD

PA-DE-0069.0000

GEOTECH B6-2E

HDD ENTRY/EXIT
N39.913026
W75.456947

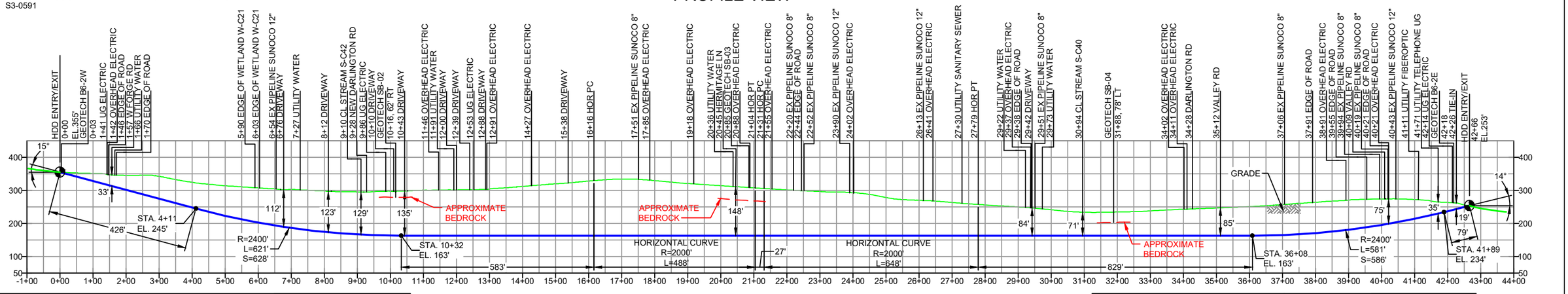
150 0 150 300
FEET

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

PLAN VIEW

DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591

PROFILE VIEW



GEOTECH SB-02
- NG EL. 295'
- TOPSOIL (0' - 0.3')
- ML (0.3' - 11.5')
- GROUNDWATER (10.0')
- SM (11.5' - 18.5')
- BEDROCK (18.5')
- AUGER REFUSAL
- COMPLETION DEPTH EL. 276.5'

GEOTECH SB-03
- NG EL. 309'
- TOPSOIL (0' - 0.1')
- SM (0.1' - 40.0')
- GROUNDWATER (35.0')
- BEDROCK (40.0')
- AUGER REFUSAL
- COMPLETION DEPTH EL. 269'

GEOTECH SB-04
- NG EL. 238'
- TOPSOIL (0' - 0.1')
- ML (0.1' - 6.0')
- SM (6.0' - 23.5')
- SM (23.5' - 31.0')
- GROUNDWATER (28.0')
- FRACTURED GNEISS (31.0' - 38.0')
- COMPLETION DEPTH EL. 200'

NOTE: REFER TO TEST BORING LOG S3-0591 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=): 4266'
   HDD PIPE LENGTH (S=): 4294'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. 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.
13. BLASTING NOT PERMITTED.

GEOTECH B6-2W
- NG EL. 355'
- SANDY LEAN CLAY CL (0.0' - 63.5')
- GROUNDWATER (29.0')
- GNEISS (63.5' - 202.5')
- BORING TERMINATED EL.152.5'

NOTE: REFER TO TEST BORING LOG B6-2W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-2E
- NG EL. 262'
- SANDY LEAN CLAY CL (0.0' - 33.0')
- GNEISS/AMPHIBOLITE (33.0' - 109.0')
- BORING TERMINATED EL.153'

NOTE: REFER TO TEST BORING LOG B6-2E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN

DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP4	UPDATED GEOTECH INFO PROVIDED BY DPS	MRS	11/15/17	RMB	11/15/17	AMC	11/15/17
EP3	INCREASED VERTICAL AND HORIZONTAL CURVE RADIUSES TO MATCH OZDD DESIGN	MRS	10/31/17	RMB	10/31/17	AMC	10/31/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15

Sunoco Logistics Partners L.P.

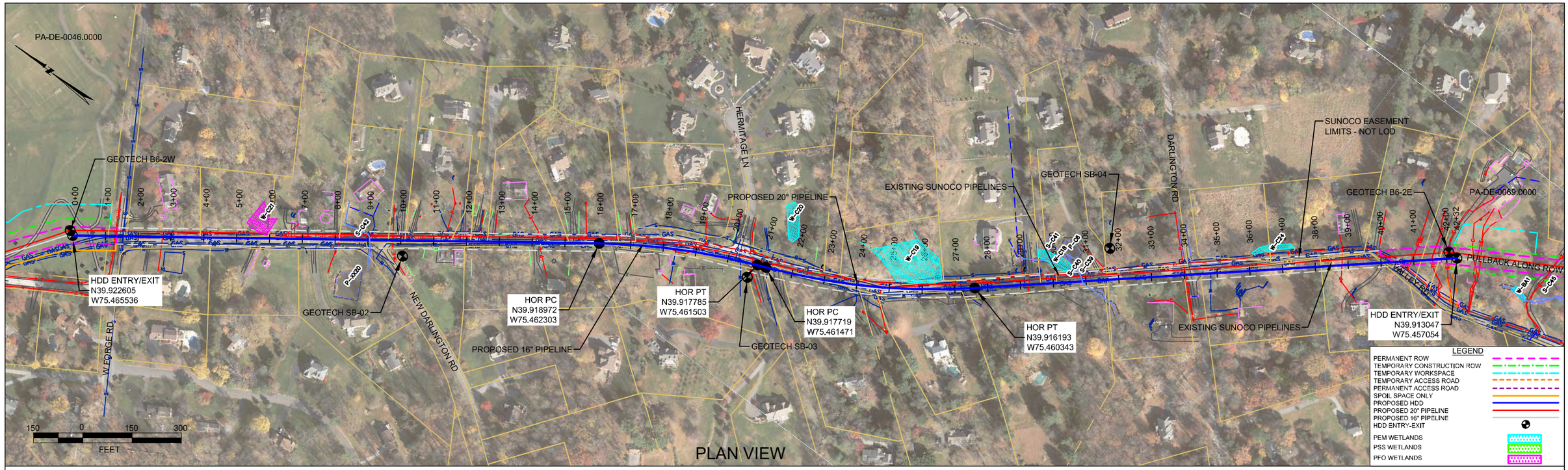
TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD / DARLINGTON RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'

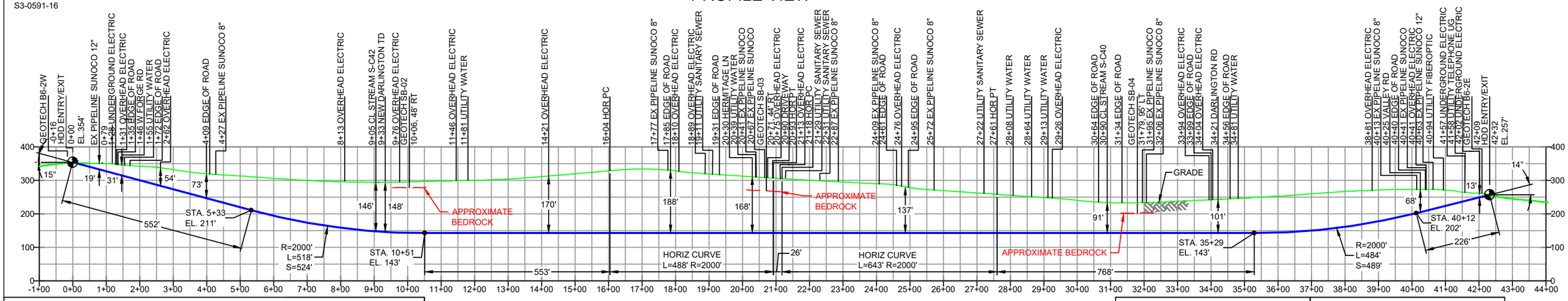
DWG. NUMBER: PA-DE-0046.0000-RD



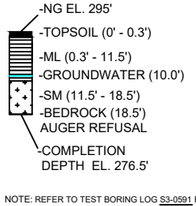
PLAN VIEW

DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591-16

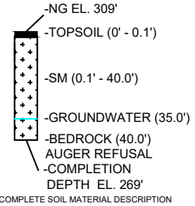
PROFILE VIEW



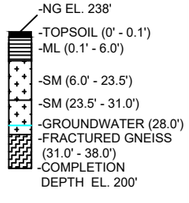
GEOTECH SB-02



GEOTECH SB-03



GEOTECH SB-04

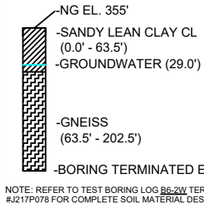


NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

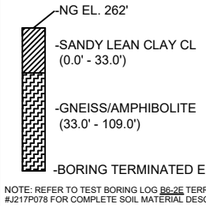
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 4232'
   HDD PIPE LENGTH (S=): 4269'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. 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.
13. BLASTING NOT PERMITTED.

GEOTECH B6-2W



NOTE: REFER TO TEST BORING LOG B6-2W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-2E



NOTE: REFER TO TEST BORING LOG B6-2E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP4	UPDATED GEOTECH INFO PROVIDED BY DPS	MRS	11/15/17	RMB	11/15/17	AMC	11/15/17
EP3	INCREASED VERTICAL AND HORIZONTAL CURVE RADIUSES TO MATCH OZDD DESIGN	MRS	10/31/17	RMB	10/31/17	AMC	10/31/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792–5911

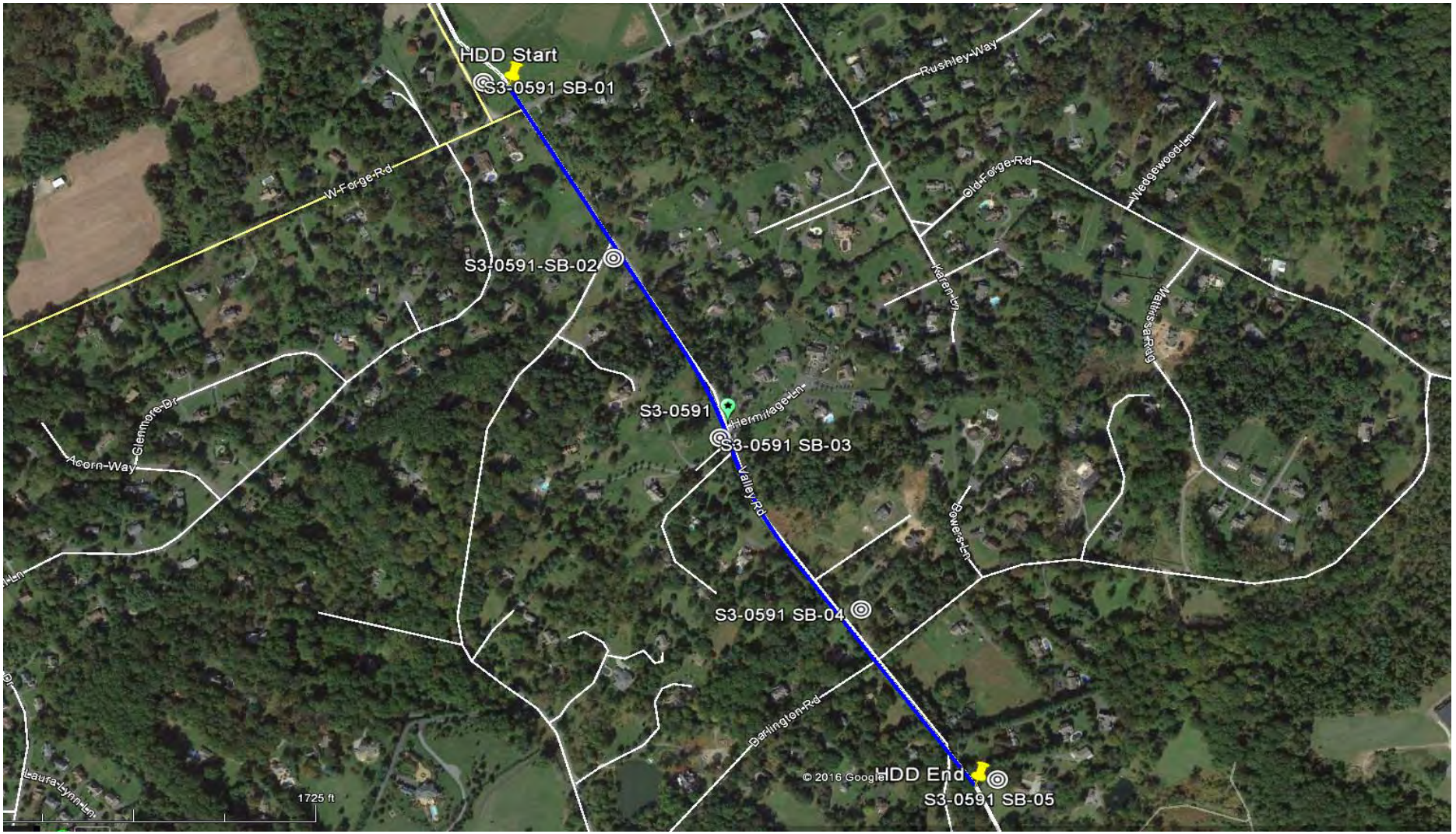
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD / DARLINGTON RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300' | DWG. NO: PA-DE-0046.0000-RD-16

Attachment B

Geotechnical Boring Logs



LEGEND:

◎ Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0591
DELAWARE COUNTY, MIDDLETOWN TWP, PA
SUNOCO PENNSYLVANIA PIPELINE PROJECT

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	438 VALLEY ROAD, MIDDLETOWN TWP. PARK, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 02-25-16	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: D. BOLZE
Drilling Contractor:	CSC	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 29.9
Boring Location Coordinates:		39° 55' 21.35" N	75° 27' 57.43" 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
							AUGERED TO REFUSAL AT 2'. COMMENCED ROCK CORE.					
RUN 1	2.0	5.5	2.0	3.6	23	BOULDER?	UNFRACTURED GNEISS	TCR: 55%, SCR: 50%, RQD: 44%				
			3.6	4.0			INTENSELY FRACTURED GNEISS					
			4.0	5.5			NO RECOVERY (SOIL)					
							SWITCHED TO ROLLERBIT AND DRIVE CASING					
1	8.0	10.0			<1		PIECES OF GNIESS GRAVEL	24	16	9	8	**25**
2	13.0	15.0			0	SM	NO RECOVERY	12	17	20	20	**37**
3	15.0	17.0			3		DR, GRAY MICACEOUS FINE TO MEDIUM SAND WITH SOME SILT.	15	13	10	8	**23**
4	18.0	20.0			12		DR, GRAY MICACEOUS FINE TO MEDIUM SAND WITH SOME SILT.	5	6	7	11	**13**
				21.5			(USCS: SM)					
5	23.0	24.8	21.5		21	SM	DR, BLACK AND DARK GRAY MICACEOUS FINE TO MEDIUM SAND	11	36	47	50/3"	**83**
							WITH SOME SILT, TRACE UNWEATHERED GNEISS GRAVEL.					
6	28.0	29.9			22		DR, VARIEGATED (GRAY, BROWN, TAN, WHITE) FINE TO MEDIUM	11	15	34	50/5"	**49**
				29.9			SAND, TRACE UNWEATHERED GNEISS GRAVEL.					
							CORE TESTING RESULTS (DEPTH 3-3.5'):					
							COMPRESSIVE STRENGTH: 12,232 PSI					
							UNIT WEIGHT: 185.1 PCF					

Notes/Comments:
Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

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

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

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:	328 VALLEY ROAD, MEDIA, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 12-15-15	Inspector: J. COSTELLO
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): SEE BELOW	Total Depth (ft): 18.5
Boring Location Coordinates:		39°55'12.91"N	75°27'49.14"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		11	ML	GRAY SILT, SOFT, ORGANIC ODOR.	1	1	1	2	**2**
							(USCS: ML).					
2	8.0	10.0			4		GRAY SILT.	3	4	3	5	**7**
				11.5								
3	13.0	14.2	11.5		24	SM	DR, GRAY TO DARK GRAY MICACEOUS FINE SAND WITH SOME	6	25	50/2"		**>50**
							SILT. (USCS: SM).					
4	18.0	18.4		18.5	3		SAME	50/5"				**>50**
							AUGER REFUSAL AT 18.5'.					
							WATER LEVEL THROUGH AUGERS AT 10'. COULD BE PERCHED					
							OVER ROCK.					
							CAVED AND WET AT 12'.					

Notes/Comments:

Pocket Pentrometer Testing
S1: 0.50 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:	250 VALLEY ROAD, MEDIA, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 10-31-15	Inspector: J. COSTELLO
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 35.0	Total Depth (ft): 40.0
Boring Location Coordinates:		39°55'4.07"N	75°27'42.03"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	0.1			TOPSOIL (1.5")					
1	3.0	5.0	0.1		8		BROWN FINE TO MEIDUM SAND AND SILT, WITH A LITTLE FINE TO	1	4	6	10	**10**
							COARSE GRAVEL.					
2	8.0	10.0			15		DR, YELLOWISH BROWN AND WHITE FINE SAND AND SILT, TRACE	1	4	6	11	**10**
							FINE ROCK FRAGS.					
3	13.0	15.0			22		DR, VARIEGATED BROWN, GRAY, WHITE FINE SAND AND SILT, TRACE	1	4	6	8	**10**
							FINE ROCK FRAGS.					
4	18.0	20.0			24		SAME	1	5	8	11	**13**
						SM						
5	23.0	25.0			21		SAME (USCS: SM)	3	8	11	13	**19**
6	28.0	30.0			24		SAME, INCREASED ROCK FRAGMENTS.	1	8	21	42	**29**
7	33.0	34.4			18		DR, VARIEGATED BROWN, GRAY, WHITE FINE SAND AND SILT, SOME	4	22	50/5"		**>50**
							FINE TO COARSE ROCK FRAGMENTS.					
8	38.0	38.8			6		SAME	22	50/4"			**>50**
				40.0								
							AUGER REFUSAL AT 40'.					
							WATER LEVEL THROUGH AUGERS AT 35'.					
							CAVED AT 35'.					

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
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fax: 302.454.5988

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	361 DARLINGTON ROAD, MEDIA, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 10-30/31-15	Inspector: J. COSTELLO
Boring No.:	SB-04	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 28.0	Total Depth (ft): 38.0
Boring Location Coordinates:		39° 54' 55.66" N	75° 27' 32.92" 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 (1.5")					
1	3.0	5.0	0.1		17	ML	DR, LAYERING OF BROWN AND GRAY SILT WITH SOME FINE SAND.	2	6	8	14	**14**
				6.0								
2	8.0	10.0	6.0		24	SM	DR, BROWN WITH BLACK NODULES FINE TO MEDIUM WITH SOME	4	13	14	18	**27**
							SILT.					
3	13.0	15.0			16		DR, VARIEGATED BROWN, WHITE, GRAY FINE TO MEDIUM SAND	2	15	16	21	**31**
							AND SILT, TRACE FINE GRAVEL. (USCS: SM)					
4	18.0	20.0			21		DR, BROWN AND DARK BROWN LAMINATED FINE TO MEDIUM SAND	2	6	12	22	**18**
				23.5			AND SILT.					
5	23.0	24.3	23.5		10	SM	DR, BROWN AND DARK BROWN LAMINATED FINE TO MEDIUM SAND	22	50	50/3"		**>50**
							WITH SOME SILT, TRACE F-C ROCK FRAGS.					
6	28.0	28.8			12		DR, BROWN AND DARK BROWN LAMINATED FINE TO MEDIUM SAND	6	50/3"			**>50**
				31.0			WITH SOME SILT, TRACE F-C ROCK FRAGS.					
							AUGER REFUAL AT 31'.					
							ROCK CORING					
RUN 1	31.0	36.0	31.0		46	ROCK	FRACTURED WHITE, PINK, GRAY GNIESS	TCR: 77%, SCR: 77%, RQD: 53%				
RUN 2	36.0	38.0		38.0	0		NO RECOVERY (DECOMPOSED GNEISS - SOIL)	TCR: 0%, SCR: 0%, RQD: 0%				
							RAN OUT OF WATER AT 38'. DISCONTINUED CORING.					
							CORE TESTING RESULTS (DEPTH 31.5-32'):					
							COMPRESSIVE STRENGTH: 6,170 PSI					
							UNIT WEIGHT: 160.7 PCF					

Notes/Comments:

Pocket Pentrometer Testing

S1: > 4 TSF

DR: DECOMPOSED ROCK

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

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

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:	143 VALLEY ROAD, MEDIA, PA		Page 1 of 1
HDD No.:	S3-0591	Dates(s) Drilled: 11-02-15	Inspector: J. COSTELLO
Boring No.:	SB-05	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 30.0
Boring Location Coordinates:		39° 54' 47.39" N	75° 27' 24.05" 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 (1.0")					
1	3.0	5.0	0.1		14		DR, BROWN AND WHITE FINE TO COARSE SAND , SOME SILT, WITH A	4	2	4	4	**6**
							LITTLE F-C GRAVEL.					
2	8.0	10.0			20		DR, VARIEGATED BROWN, RED, BLACK, WHITE FINE SAND AND SILT	1	2	3	5	**5**
							TRACE MIICA, TRACE FINE GRAVEL. (USCS: SM)					
3	13.0	15.0			24		SAME	1	2	4	6	**6**
						SM						
4	18.0	20.0			17		DR, VARIEGATED BROWN, GRAY, WHITE FINE TO MEDIUM SAND WITH	2	9	9	11	**18**
							SOME SILT, TRACE ROCK FRAGS, TRACE MICA					
5	23.0	25.0			21		DR, VARIEGATED BROWN, GRAY, WHITE FINE TO MEDIUM SAND WITH	1	4	5	7	**9**
							SOME SILT, TRACE ROCK FRAGS, TRACE MICA					
6	28.0	30.0			20		DR, VARIEGATED BROWN, GRAY, WHITE FINE TO MEDIUM SAND	2	5	7	11	**12**
				30.0			AND SILT, TRACE ROCK FRAGS, TRACE MICA (USCS: SM)					
							CAVED AND DRY AT 26'.					

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.

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0591

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					
S3-0591	SB-01	1	2	5.5	55	50	44	2	5.5	Slight	Gneiss	Massive	Light gray/ gray	One massive piece, foliation dipping approx. 24°
S3-0591	SB-04	1	31	36	77	77	53	31	36	Slight	Gneiss	Massive	White/pink/ dark gray	Fractures ranging from 8° to 30°, Avg. 21°

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0591

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)
S3-0591	SB-01	3	15.0	17.0	40.1	35.9	-	-	-	-
		4	18.0	20.0	27.9	35.0	36	27	9	SM
		5	23.0	24.8	10.5	24.1	-	-	-	-
		6	28.0	29.9	15.2	24.3	-	-	-	-
	SB-02	1	3.0	5.0	29.3	93.8	42	29	14	ML
		3	13.0	14.2	26.0	34.6	NV	NP	NP	SM
		4	18.0	18.4	16.3	31.4	-	-	-	-
	SB-03	2	8.0	10.0	18.3	47.0	-	-	-	-
		3	13.0	15.0	17.1	47.2	-	-	-	-
		5	23.0	25.0	13.4	35.5	28	23	5	SM
		6	28.0	30.0	16.5	39.9	-	-	-	-
		7	33.0	34.4	12.9	39.6	29	23	6	SM
		8	38.0	38.8	8.1	45.3	-	-	-	-
	SB-04	1	3.0	5.0	15.2	79.1	-	-	-	-
		2	8.0	10.0	11.1	32.1	-	-	-	-
		3	13.0	15.0	17.1	39.2	-	-	-	-
		4	18.0	20.0	18.2	42.1	NL	NP	NV	SM
		5	23.0	24.3	8.7	29.9	-	-	-	-
		6	28.0	28.8	9.5	25.9	-	-	-	-
	SB-05	1	3.0	5.0	7.1	24.8	-	-	-	-
		2	8.0	10.0	17.5	41.6	30	24	6	SM
		3	13.0	15.0	19.5	35.1	-	-	-	-
		4	18.0	20.0	10.1	23.8	-	-	-	-
		6	28.0	30.0	17.1	42.7	31	25	6	SM

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-01	1	3.0 - 3.5	12,232	185.1
SB-04	1	31.5 - 32.0	6,170	160.7

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0591

HDD No.	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
S3-0591	SB-01	Felsic gneiss - Light, medium grained; includes rocks of probable sedimentary origin.	Generally level, slightly sloping to the south	Felsic gneiss (Precambrian age)	Felsic gneiss; Secondary - paragneiss	No information found during literature review	Ranges from 14 to 75 ft bgs, Avg. 40 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 south					
	SB-03		Gently sloping to the southeast					
	SB-04		Gently sloping to the west					
	SB-05		Gently sloping to the south					

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 11, 2017 (Revised December 4, 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 – Valley Road/Darlington Road
Commonwealth of Pennsylvania
Drawing # PA-DE-0064.0000-RD
PO #20170804-17
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 Valley Road/Darlington Road (Drawing # PA-DE-0064.0000-RD) in the Commonwealth of Pennsylvania. Our services were performed in general accordance with our proposal number PJ2175108 dated July 28, 2017. Our scope of services included advancing two borings, designated as B6-2W and B6-2E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B6-2W and B6-2E were drilled between August 17 and 25, 2017 to depths of 202.5 and 109.0 feet, respectively as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of metamorphic rock comprised of gneiss and amphibolite. Final test boring logs documenting overburden soil and bedrock conditions as well as photographs of the rock core samples are attached.

Rock compressive strength testing was performed on samples from approximately 20-foot intervals within the bedrock strata at each boring location. Unconfined compressive strength test results are shown on the attached reports.

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
Drawn by:	SBL
Checked by:	LJD
Approved by:	LJD

Project No.	J217P078
Scale:	N.T.S.
File Name:	J217P078 BLP
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

Valley Road/Darlington Road HDD Cores B6-2W and B6-2E
PA-DE-0064.0000-RD
Delaware County, Pennsylvania

Exhibit
A-2

EXPLORATION RESULTS

BORING LOG NO. B6-2W Valley Rd/Darlington Rd West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.922642° Longitude: -75.465508°

Approximate Surface Elev: 355 (Ft.) +/-

DEPTH ELEVATION (Ft.)

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
				SANDY LEAN CLAY (CL), trace gravel, red brown, stiff to very stiff, (Degraded bedrock)			
5		X	13	7-12-10 N=22			2.25
10		X	18	3-4-5 N=9			1.75
15		X	17	2-3-7 N=10			1.0
		X	14	Change to dark gray at 18.5 feet 7-8-10 N=18			1.0
20		X	18	6-12-13 N=25			1.5
25	▽	X	15	7-8-9 N=17			1.0
30							

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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

Notes:

WATER LEVEL OBSERVATIONS

▽ *29' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/17/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850XR Driller: Terracon/Allen S.

Project No.: J217P078

BORING LOG NO. B6-2W Valley Rd/Darlington Rd West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.922642° Longitude: -75.465508°

Approximate Surface Elev: 355 (Ft.) +/-

DEPTH ELEVATION (Ft.)

GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
SANDY LEAN CLAY (CL), trace gravel, red brown, stiff to very stiff, (Degraded bedrock) *(continued)*								
	35		X	15	7-8-13 N=21			
Hard at 38.5 feet	40		X	15	21-18-16 N=34			1.25
	45		X	13	23-35-45 N=80			3.0
	50		X	12	27-50/6"			
	55		X	13	15-25-37 N=62			2.0
	60		X	9	40-50/4"			1.5

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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

Notes:

WATER LEVEL OBSERVATIONS

▽ 29' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/17/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850XR Driller: Terracon/Allen S.

Project No.: J217P078

BORING LOG NO. B6-2W Valley Rd/Darlington Rd West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.922642° Longitude: -75.465508°

Approximate Surface Elev: 355 (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)
		SANDY LEAN CLAY (CL), trace gravel, red brown, stiff to very stiff, (Degraded bedrock) *(continued)*								
63.5	291.5+/-					1	50/1"			
65.5	289.5+/-	Run 1, Hard, slightly weathered, dark gray to black with pink, fine to medium-grained GNEISS, low angle joints at close spacing, severely weathered from 65 to 68.5 feet	65			22		42	1.5 1.5	
70.5	284.5+/-	Run 2, Similar to 68.5 feet At 68.5 feet: Hard, slightly weathered, dark gray to black with white, fine to medium-grained GNEISS, low-angle joints at close to moderately close spacing	70			60		68	1.5 1.5 3.5 2.5 2.5	
75.5	279.5+/-	Run 3, Similar, pink from 72.6 to 73.9 feet, high angle fractures at 74.5 feet	75			58		73	2 2 2.5 2.5 3	
80.5	274.5+/-	Run 4, Similar, trace pink from 75.5 to 76.7 feet	80			60		90	3 2.5 3 3 3	
85.5	269.5+/-	Run 5, Similar, low angle to moderately dipping joints	85			60		81	4 3 3 3 3	
		Run 6, Similar	90			56		93	5 4 4 5.5 6.5	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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

Notes:

WATER LEVEL OBSERVATIONS

29' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/17/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850XR Driller: Terracon/Allen S.

Project No.: J217P078

BORING LOG NO. B6-2W Valley Rd/Darlington Rd West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.922642° Longitude: -75.465508°

Approximate Surface Elev: 355 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
90.5	264.5+/-	Run 7, Similar	60	96	5 5 5.5 5.5 6
95.5	259.5+/-	Run 8, Similar, quartz band from 99.6 to 100 feet	60	82	4.5 4.5 5.5 5.5 5.5
100.5	254.5+/-	Run 9, Very hard, fresh, dark gray to black, medium to coarse-grained GNEISS, primary joints low angle, close, rough, open	60	100	9.5 9 14.5 13 21
105.5	249.5+/-				
105.8	249+/-	Run 10, Changed drill bit to series 10	3	0	13.5/3"
		Run 11, Similar	117	100	3.5 3 3 4 4 4 4 4 3.5 4
115.5	239.5+/-	Run 12, Similar, moderately open	120		3.5 3.5 3 3.5

DEPTH (Ft.): 95, 100, 105, 110, 115, 120

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

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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

Notes:
Gneiss typically contained quartz, plagioclase, mica and hornblende

WATER LEVEL OBSERVATIONS

29' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/17/2017 | Boring Completed: 8/24/2017
Drill Rig: CME-850XR | Driller: Terracon/Allen S.
Project No.: J217P078

BORING LOG NO. B6-2W Valley Rd/Darlington Rd West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.922642° Longitude: -75.465508°

Approximate Surface Elev: 355 (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)
		Run 12, Similar, moderately open *(continued)*							3.5	
									3	
									3	
									3.5	
						120			3	
									3.5	
125.5	229.5+/-		125							
		Run 13, Very hard, fresh, dark gray to black, medium grained GNEISS, primary joint set low angle at close to moderately close spacing, rough, open; secondary joint set, moderately dipping, close, rough, open							3	
									3	
									3	
									3	
			130			116		92	3.5	
									3	
									3.5	
									3.5	
									3.5	
									4	
135.5	219.5+/-		135							
		Run 14, Similar							3.5	
									4	
									3.5	
									4	
									4.5	
			140			120		96	3	
									3.5	
									3.5	
									4	
									4.5	
145.5	209.5+/-		145							
		Run 15, Similar							5	
									4	
						120			4	
									4	
			150							

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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

Notes:
Gneiss typically contained quartz, plagioclase, mica and hornblende

WATER LEVEL OBSERVATIONS

▽ *29' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/17/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850XR Driller: Terracon/Allen S.

Project No.: J217P078

BORING LOG NO. B6-2W Valley Rd/Darlington Rd West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.922642° Longitude: -75.465508°

Approximate Surface Elev: 355 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 15, Similar *(continued)*					120		100	5.5 5 5 4.5 5 5.5	
	155.5	199.5+/-	155							
	Run 16, Similar, low angle to moderately dipping, increased quartz bands 160.5 to 165.5 feet		160			120		100	5 5 5 5 5.5 5 4.5 5 5 8	
	165.5	189.5+/-	165							
	Run 17, Similar, high angle fracture at 179 feet		170			119		100	6 5.5 5.5 6 5 3 3 3 3 3	
	175.5	179.5+/-	175							
	Run 18, Similar, close to wide spacing, weathered zone 183.5 to 184.1 feet					117			3 3.5 3.5 3.5	
			180							

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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

Notes:
Gneiss typically contained quartz, plagioclase, mica and hornblende

WATER LEVEL OBSERVATIONS

▽ 29' AB

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/17/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850XR Driller: Terracon/Allen S.

Project No.: J217P078

BORING LOG NO. B6-2W Valley Rd/Darlington Rd West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.922642° Longitude: -75.465508°

Approximate Surface Elev: 355 (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 18, Similar, close to wide spacing, weathered zone 183.5 to 184.1 feet *(continued)*									
185.5	169.5+/-	185			117		92	4.5 3 3.5 2.5 2 2.5	
Run 19, Similar, highly fractured 190.5 to 195.5 feet, increased quartz bands 190.5 to 195.5 feet		190			118		NR	2.5 2.5 3 3 3.5 3.5 3.5 3.5 3.5 3.5	
195.5	159.5+/-	195							
Run 20, Similar					84		100	3 3.5 4 3 3.5 2 5.5	
202.5	152.5+/-	200							
Boring Terminated at 202.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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

Notes:
Gneiss typically contained quartz, plagioclase, mica and hornblende
NR - Not recorded

WATER LEVEL OBSERVATIONS

▽ *29' AB*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/17/2017 Boring Completed: 8/24/2017

Drill Rig: CME-850XR Driller: Terracon/Allen S.

Project No.: J217P078

BORING LOG NO. B6-2E Valley Rd/Darlington Rd East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0064.0000-RD
20170804-17
Latitude: 39.91313° Longitude: -75.457051°

Approximate Surface Elev: 262 (Ft.) +/-

DEPTH ELEVATION (Ft.)

GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
SANDY LEAN CLAY (CL), trace gravel, brown, black and white								
	5		X	16	2-4-3 N=7			1.0
	10		X	16	10-11-12 N=23			
	15		X	15	7-7-8 N=15			
	20		X	12	11-12-13 N=25			
	25		X	11	17-24-32 N=56			
	30		X	14	32-42- 50/4"			

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

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-24-2017	Boring Completed: 08-25-2017
Drill Rig: CME-850XR	Driller: Terracon/Allen S.
Project No.: J217P078	Exhibit: A-2

BORING LOG NO. B6-2E Valley Rd/Darlington Rd East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0064.0000-RD
20170804-17
Latitude: 39.91313° Longitude: -75.457051°
Approximate Surface Elev: 262 (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)
		SANDY LEAN CLAY (CL), trace gravel, brown, black and white *(continued)*								
33.0	229+/-									
		Run 1, Medium hard, severely weathered, black/white/brown, micaceous GNEISS, high angle joints	35			27		6	1 1.5 2 1.5 1.5 1.5	
39.0	223+/-									
		Run 2, Similar	40			27		5	1 0.5 0.5 0.5 1.5 1.5 1 1 1 3.5	
49.0	213+/-		45							
		Run 3, Hard, slighly weathered, phaneritic, purple and black GNEISS, moderately dipping joints	50			55		71	2 3 4.5 6.5 9.5	
54.0	208+/-									
		Run 4, Similar to 54.5 feet, slightly weathered At 54.5 feet: Black and white AMPHIBOLITE, horizontal to high angle joints	55			117		71	4 3 3 2.5 2 2.5	
			60							

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-24-2017 | Boring Completed: 08-25-2017
Drill Rig: CME-850XR | Driller: Terracon/Allen S.
Project No.: J217P078 | Exhibit: A-2

BORING LOG NO. B6-2E Valley Rd/Darlington Rd East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0064.0000-RD
20170804-17
Latitude: 39.91313° Longitude: -75.457051°

Approximate Surface Elev: 262 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
Run 4, Similar to 54.5 feet, slightly weathered At 54.5 feet: Black and white AMPHIBOLITE, horizontal to high angle joints *(continued)*			117		2.5 2 2.5
64.0	198+/-				
Run 5, Similar		65 70	120	92	5 3.5 3.5 3.5 3.5 3.5 4 4.5 4.5 2.5
74.0	188+/-				
Run 6, Similar		75 80	120	94	5.5 4 3.5 4.5 4.5 2.5 3 4.5 3.5 3.5
84.0	178+/-				
Run 7, Similar		85 90	120	67	5 3.5 3.5 3.5 3.52.5 2.5

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

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-24-2017 | Boring Completed: 08-25-2017

Drill Rig: CME-850XR | Driller: Terracon/Allen S.

Project No.: J217P078 | Exhibit: A-2

BORING LOG NO. B6-2E Valley Rd/Darlington Rd East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION PA-DE-0064.0000-RD
20170804-17
Latitude: 39.91313° Longitude: -75.457051°
Approximate Surface Elev: 262 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 7, Similar *(continued)*								3 3.5 3.5	
	94.0	168+/-				120				
	Run 8, Similar to 98.5 feet At 98.5 feet: granitic GNEISS AT 102.7 feet: AMPHIBOLITE		95 100			120		95	3.5 3.5 4 4.5 4.5 12 5.5 4.5 4.5 4	
	104.0	158+/-								
	Run 9, Similar		105			54		72	4 4 9.5 3 1.5	
	109.0	153+/-								
	Boring Terminated at 109 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

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 08-24-2017 | Boring Completed: 08-25-2017

Drill Rig: CME-850XR | Driller: Terracon/Allen S.

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.:	B6-2W	Lithology :	Gneiss
Sample No.:	1	Moisture Content :	As received
Sample Depth:	83 feet	Lab Temperature :	70° F
Sampling Date:	8/23/17	Loading Rate:	55 psi/s
		Time to Failure:	8 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	27,840 lb
Length:	4.45 in	Compressive Strength:	8,951 psi
L/D:	2.24	Compressive Strength:	61.72 Mpa
End Area:	3.11 in^2	Unit Weight	186 pcf

Before the Test

After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

Project:	Mariner East Pipeline	Performed by:	A.Suprunenko
Project No.	J217P078	Test Date:	9/13/2017
Location:	Spread 6	Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	Review Date :	10/10/2017

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

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

Boring No.:	B6-2W	Lithology :	Gneiss
Sample No.:	2	Moisture Content :	As received
Sample Depth:	102 feet	Lab Temperature :	70° F
Sampling Date:	8/23/17	Loading Rate:	55 psi/s
		Time to Failure:	26 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	84,670 lb
Length:	4.48 in	Compressive Strength:	27,223 psi
L/D:	2.25	Compressive Strength:	187.69 Mpa
End Area:	3.11 in^2	Unit Weight	191 pcf

Before the Test

After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 6		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B6-2W	Lithology :	Gneiss
Sample No.:	3	Moisture Content :	As received
Sample Depth:	123 feet	Lab Temperature :	70° F
Sampling Date:	8/23/17	Loading Rate:	55 psi/s
		Time to Failure:	12 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	40,270 lb
Length:	4.42 in	Compressive Strength:	12,947 psi
L/D:	2.22	Compressive Strength:	89.27 Mpa
End Area:	3.11 in^2	Unit Weight	188 pcf

Before the Test

After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 6		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B6-2W	Lithology :	Gneiss
Sample No.:	4	Moisture Content :	As received
Sample Depth:	142 feet	Lab Temperature :	70° F
Sampling Date:	8/23/17	Loading Rate:	55 psi/s
		Time to Failure:	11 min

Diameter:	2.00 in	Maximum Axial Load at Failure:	36,840 lb
Length:	4.43 in	Compressive Strength:	11,727 psi
L/D:	2.22	Compressive Strength:	80.85 Mpa
End Area:	3.14 in^2	Unit Weight	188 pcf

Before the Test

After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon		Performed by:	A.Suprunenko
Project No.	J217P078			Test Date:	9/13/2017
Location:	Spread 6			Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire		Review Date :	10/10/2017

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

Boring No.:	B6-2W	Lithology :	Gneiss
Sample No.:	5	Moisture Content :	As received
Sample Depth:	152 feet	Lab Temperature :	70° F
Sampling Date:	8/23/17	Loading Rate:	55 psi/s
		Time to Failure:	10 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	34,350 lb
Length:	4.51 in	Compressive Strength:	11,044 psi
L/D:	2.27	Compressive Strength:	76.15 Mpa
End Area:	3.11 in^2	Unit Weight	187 pcf

Before the Test

After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 6		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B6-2W	Lithology :	Gneiss
Sample No.:	6	Moisture Content :	As received
Sample Depth:	162 feet	Lab Temperature :	70° F
Sampling Date:	8/23/17	Loading Rate:	55 psi/s
		Time to Failure:	7 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	21,650 lb
Length:	4.89 in	Compressive Strength:	6,961 psi
L/D:	2.46	Compressive Strength:	47.99 Mpa
End Area:	3.11 in^2	Unit Weight	164 pcf

Before the Test

After the Test

Drawing # :	PA-DE-0064.0000-RD
PO # :	20170804-17
Crossing :	Valley Rd/Darlington Rd
Spread :	Spread 6

Project:	Mariner East Pipeline	Terracon	Performed by:	A.Suprunenko
Project No.	J217P078		Test Date:	9/13/2017
Location:	Spread 6		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/10/2017

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

Boring No.:	B6-2E	Lithology :	Gneiss
Sample No.:	1	Moisture Content :	As received
Sample Depth:	49 feet	Lab Temperature :	70° F
Sampling Date:	8/24/17	Loading Rate:	55 psi/s
		Time to Failure:	8 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	26,230 lb
Length:	4.00 in	Compressive Strength:	8,605 psi
L/D:	2.03	Compressive Strength:	59.33 Mpa
End Area:	3.05 in^2	Unit Weight	160 pcf

Before the Test

After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

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

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

Boring No.:	B6-2E	Lithology :	Gneiss
Sample No.:	1c	Moisture Content :	As received
Sample Depth:	50 feet	Lab Temperature :	70° F
Sampling Date:	8/24/17	Loading Rate:	55 psi/s
		Time to Failure:	20 min

Diameter:	2.00 in	Maximum Axial Load at Failure:	64,570 lb
Length:	4.44 in	Compressive Strength:	20,553 psi
L/D:	2.22	Compressive Strength:	141.71 Mpa
End Area:	3.14 in^2	Unit Weight	163 pcf

Photographs are mislabeled as 6-2E-4

Before the Test

After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

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

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

Boring No.:	B6-2E	Lithology :	Amphibolite
Sample No.:	2	Moisture Content :	As received
Sample Depth:	59 feet	Lab Temperature :	70° F
Sampling Date:	8/24/17	Loading Rate:	55 psi/s
		Time to Failure:	10 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	33,450 lb
Length:	4.51 in	Compressive Strength:	10,755 psi
L/D:	2.27	Compressive Strength:	74.15 Mpa
End Area:	3.11 in^2	Unit Weight	175 pcf

Before the Test

After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

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

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

Boring No.:	B6-2E	Lithology :	Amphibolite
Sample No.:	3	Moisture Content :	As received
Sample Depth:	68 feet	Lab Temperature :	70° F
Sampling Date:	8/24/17	Loading Rate:	55 psi/s
		Time to Failure:	11 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	36,210 lb
Length:	4.41 in	Compressive Strength:	11,642 psi
L/D:	2.22	Compressive Strength:	80.27 Mpa
End Area:	3.11 in^2	Unit Weight	177 pcf

Before the Test

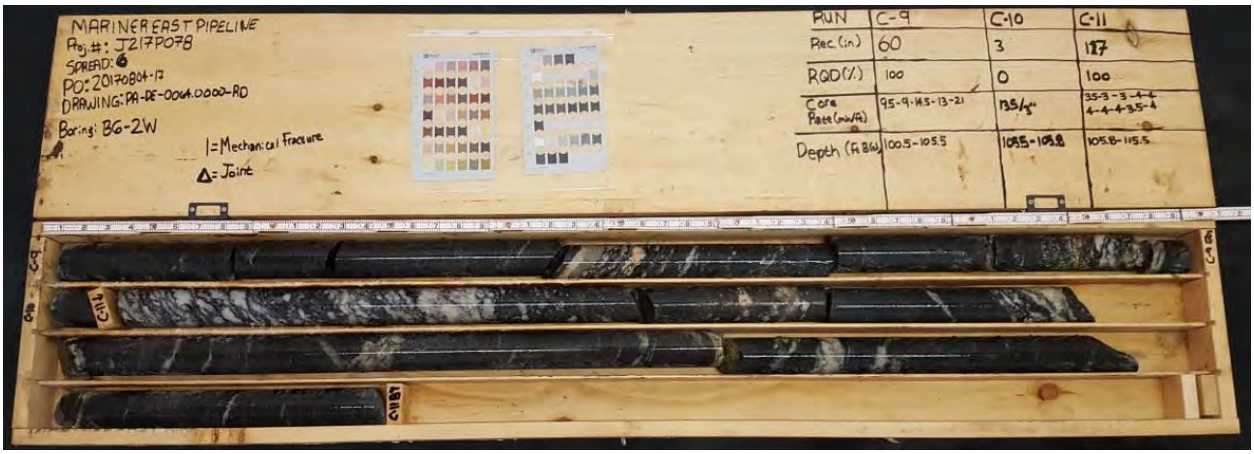
After the Test

Drawing # : PA-DE-0064.0000-RD
PO # : 20170804-17
Crossing : Valley Rd/Darlington Rd
Spread : Spread 6

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

Photograph 1: B6-2W, Samples C-1 to C-4 (63.5 to 80.5 feet)

Photograph 2: B6-2W, Samples C-5 to C-8 (80.5 to 100.5 feet)

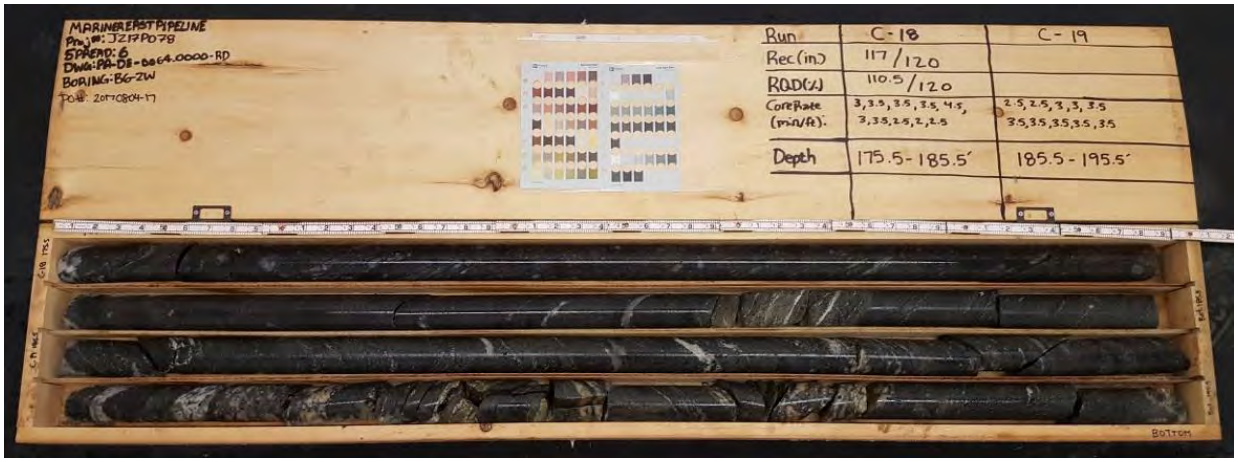


Photograph 3: B6-2W, Samples C-9 to C-11 (105.5 to 115.5 feet)

Photograph 4: B6-2W, Samples C-12 to C-13 (115.5 to 135.5 feet)

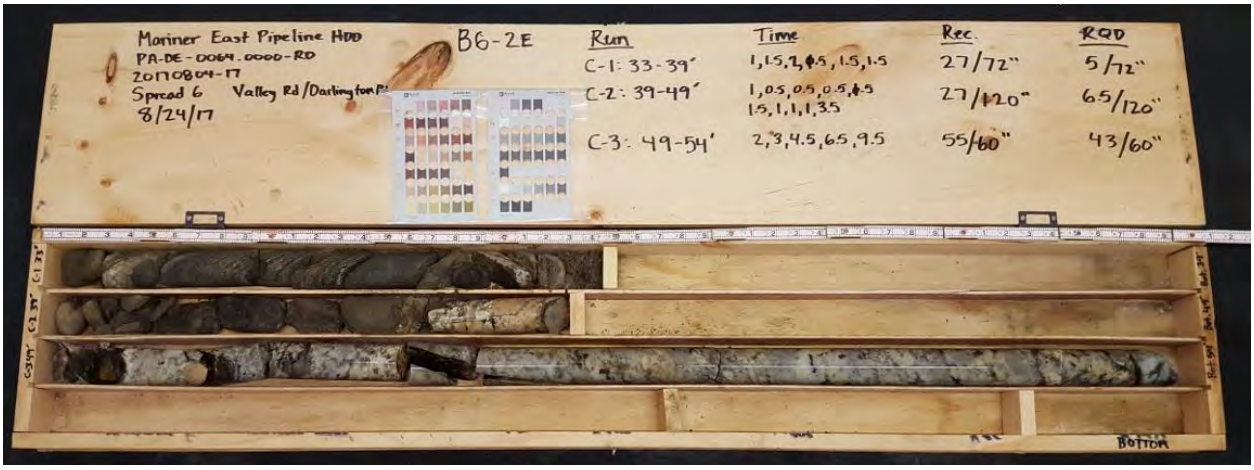
Photograph 5: B6-2W, Samples C-14 to C-15 (135.5 to 155.5 feet)

Photograph 6: B6-2W, Samples C-16 to C-17 (155.5 to 175.5 feet)



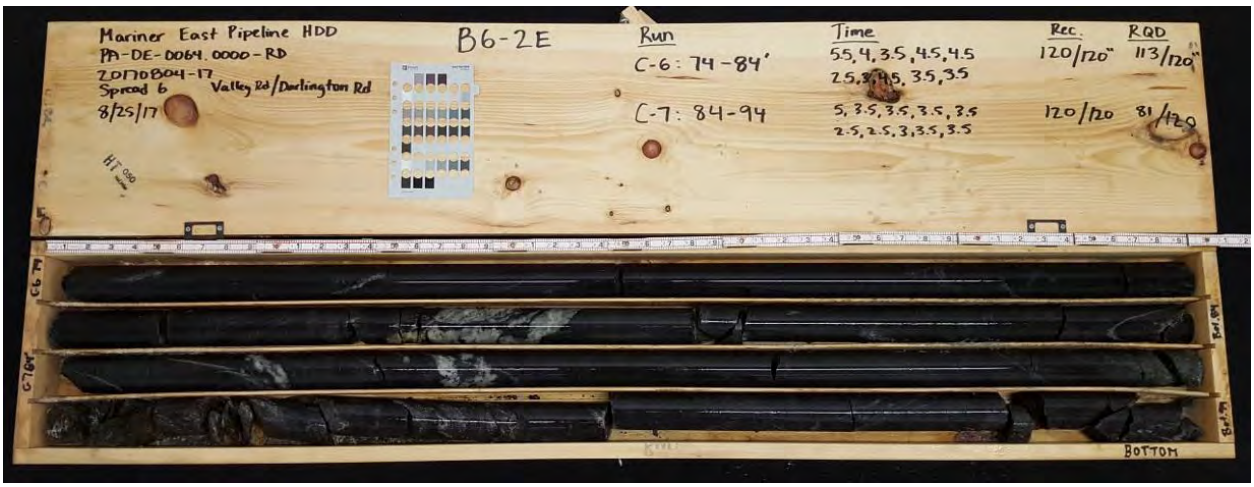
Photograph 7: B6-2W, Samples C-18 to C19 (175.5 to 195.5 feet)

Photograph 8: B6-2W, Sample C-20 (195.5 to 202.5 feet)



Photograph 1: B6-2E, Samples C-1 to C-3 (33 to 54 feet)

Photograph 2: B6-2E, Samples C-4 to C-5 (54 to 74 feet)



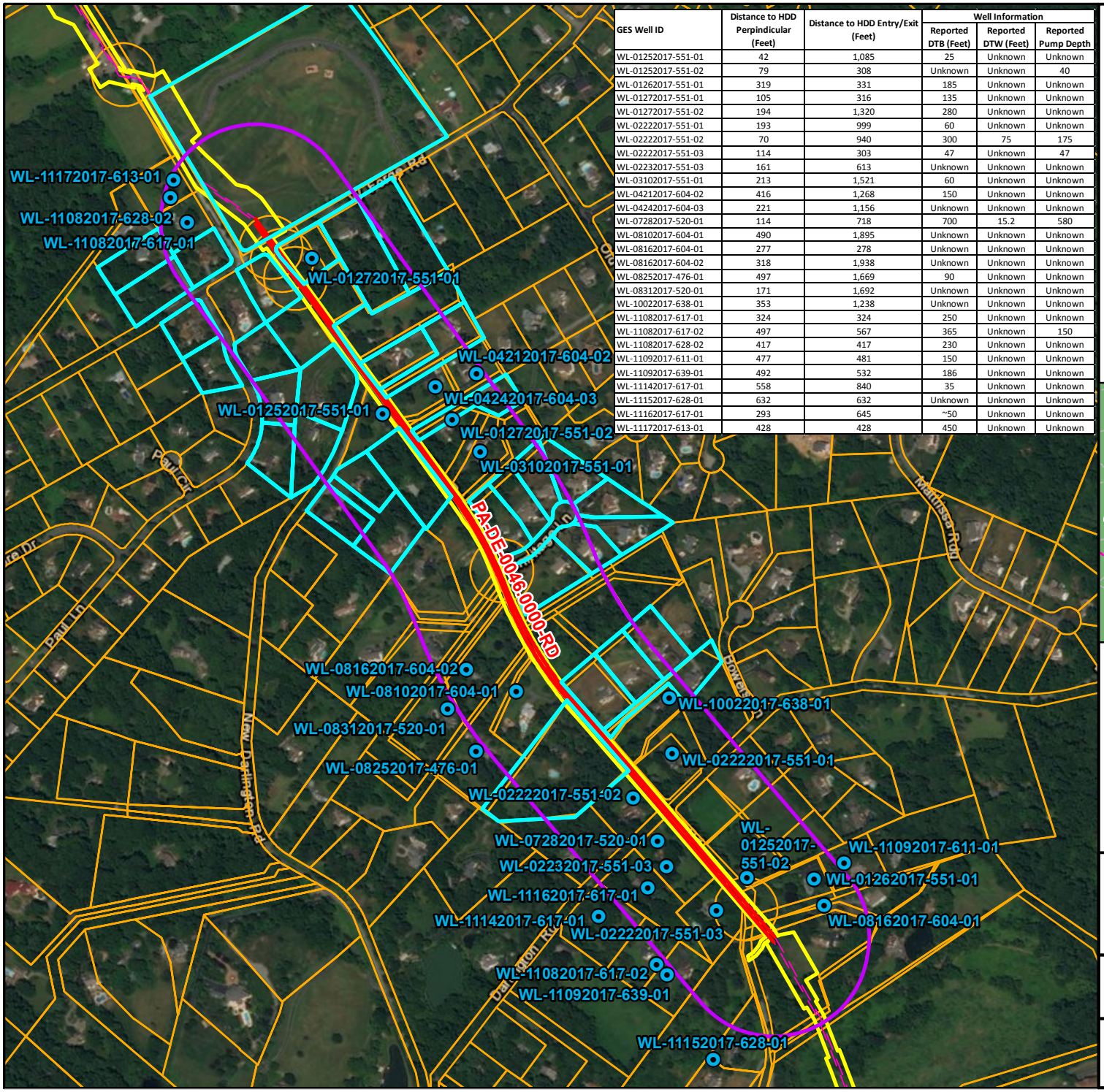
Photograph 3: B6-2E, Samples C-6 to C-7 (74 to 94 feet)

Photograph 4: B6-2E, Samples C-8 to C-9 (94 to 109 feet)

BOW TREE DRIVE / STRASBURG ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E15-862
PA-CH-0413.0000-RD & PA-CH-0413.0000-RD-16
(SPLP HDD# S3-0520)

ATTACHMENT 2

WATER SUPPLY ILLUSTRATION



GES Well ID	Distance to HDD Perpindicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-01252017-551-01	42	1,085	25	Unknown	Unknown
WL-01252017-551-02	79	308	Unknown	Unknown	40
WL-01262017-551-01	319	331	185	Unknown	Unknown
WL-01272017-551-01	105	316	135	Unknown	Unknown
WL-01272017-551-02	194	1,320	280	Unknown	Unknown
WL-02222017-551-01	193	999	60	Unknown	Unknown
WL-02222017-551-02	70	940	300	75	175
WL-02222017-551-03	114	303	47	Unknown	47
WL-02232017-551-03	161	613	Unknown	Unknown	Unknown
WL-03102017-551-01	213	1,521	60	Unknown	Unknown
WL-04212017-604-02	416	1,268	150	Unknown	Unknown
WL-04242017-604-03	221	1,156	Unknown	Unknown	Unknown
WL-07282017-520-01	114	718	700	15.2	580
WL-08102017-604-01	490	1,895	Unknown	Unknown	Unknown
WL-08162017-604-01	277	278	Unknown	Unknown	Unknown
WL-08162017-604-02	318	1,938	Unknown	Unknown	Unknown
WL-08252017-476-01	497	1,669	90	Unknown	Unknown
WL-08312017-520-01	171	1,692	Unknown	Unknown	Unknown
WL-10022017-638-01	353	1,238	Unknown	Unknown	Unknown
WL-11082017-617-01	324	324	250	Unknown	Unknown
WL-11082017-617-02	497	567	365	Unknown	150
WL-11082017-628-02	417	417	230	Unknown	Unknown
WL-11092017-611-01	477	481	150	Unknown	Unknown
WL-11092017-639-01	492	532	186	Unknown	Unknown
WL-11142017-617-01	558	840	35	Unknown	Unknown
WL-11152017-628-01	632	632	Unknown	Unknown	Unknown
WL-11162017-617-01	293	645	~50	Unknown	Unknown
WL-11172017-613-01	428	428	450	Unknown	Unknown

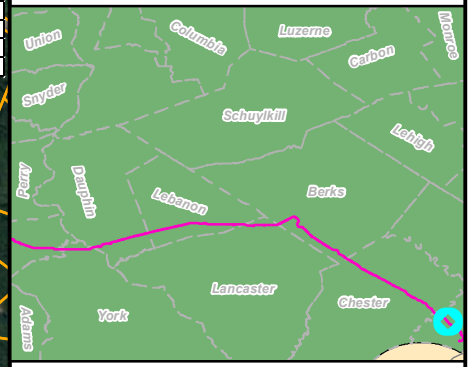
Legend

- LOD
- PPP Centerline
- Parcel
- HDD
- 450 foot buffer of HDD alignment
- Public Water Supply/Landowner Confirmed No Well

****Testing locations current as of 01/02/2018**

- GES Testing Location

Location



N

0 400 800

Feet

Well Location Map
HDD# PA-DE-0046.0000-RD
Delaware County, PA.

Prepared By: TETRA TECH

Date: 1/15/2018

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

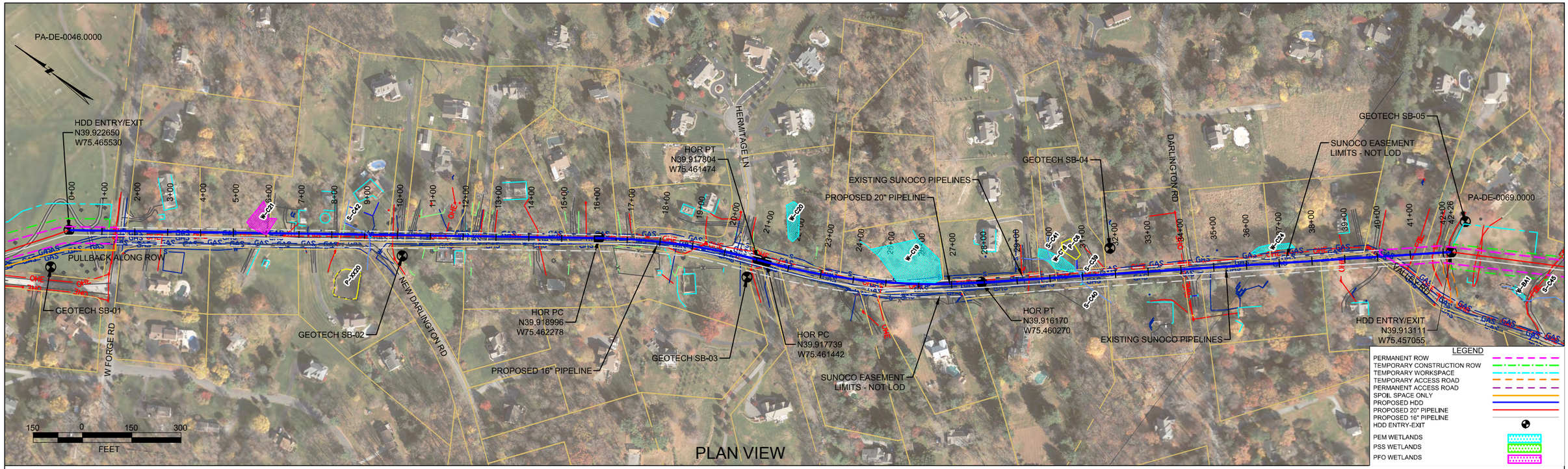
Coordinate System: NAD 83 Stateplane, PA South, Feet

P:\GIS\projects\112005938-PPP\MXD\WellLocations\WellLocation_PA_DE_0046_0000.mxd LN

VALLEY ROAD CROSSING
PADEP SECTION 105 PERMIT NO.E23-524
PA-DE-0046.0000-RD and PA-DE-0046.0000-RD-16
(SPLP HDD No. S3-0591)

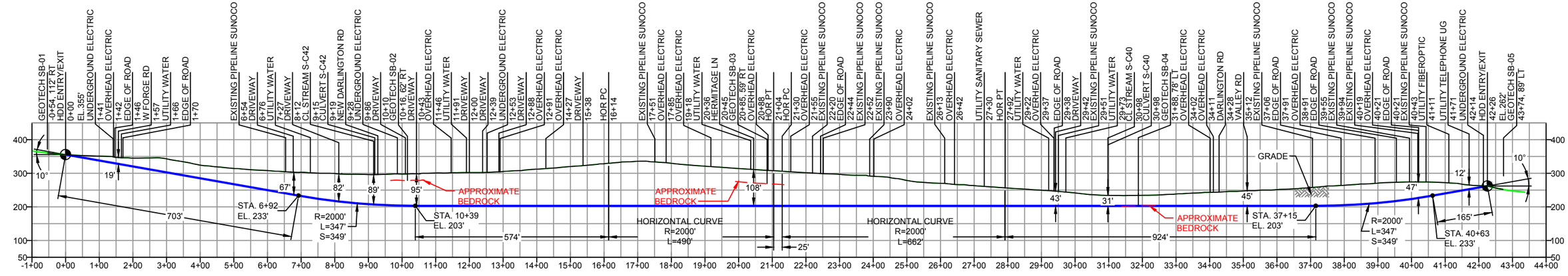
ATTACHMENT 3

ORIGINAL AND REVISED HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591

PROFILE VIEW



GEOTECH SB-01
-NG EL. 358'
-FRACTURED GNEISS (0.0' - 4.0')
-TOPSOIL (4.0' - 5.5')
-SM (5.5' - 21.5')
-SM (21.5' - 29.9')
-COMPLETION DEPTH EL. 328'

GEOTECH SB-02
-NG EL. 295'
-TOPSOIL (0' - 0.3')
-ML (0.3' - 11.5')
-GROUNDWATER (10.0')
-SM (11.5' - 18.5')
-BEDROCK (18.5') AUGER REFUSAL
-COMPLETION DEPTH EL. 276.5'

GEOTECH SB-03
-NG EL. 309'
-TOPSOIL (0' - 0.1')
-SM (0.1' - 40.0')
-GROUNDWATER (35.0')
-BEDROCK (40.0') AUGER REFUSAL
-COMPLETION DEPTH EL. 269'

NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4226'
   HDD PIPE LENGTH (S=):4242'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
5. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
6. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

GEOTECH SB-04
-NG EL. 238'
-TOPSOIL (0' - 0.1')
-ML (0.1' - 6.0')
-SM (6.0' - 23.5')
-SM (23.5' - 31.0')
-GROUNDWATER (28.0')
-FRACTURED GNEISS (31.0' - 38.0')
-COMPLETION DEPTH EL. 200'

GEOTECH SB-05
-NG EL. 267'
-TOPSOIL (0' - 0.1')
-SM (0.1' - 30.0')
-COMPLETION DEPTH EL. 237'

NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15
B	ISSUED FOR BID	DLM	07/31/15	RMB	07/31/15	AAW	07/31/15
A	ISSUED FOR REVIEW	JAM	03/18/15	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
VALLEY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'

DWG. NO: PA-DE-0046.0000-RD

PA-DE-0046.0000

HDD ENTRY/EXIT
N39.922651
W75.465512

GEOTECH B6-2W

PULLBACK ALONG ROW

W FORGE RD

NEW DARLINGTON RD

GEOTECH SB-02

HOR PC
N39.918992
W75.462255

HOR PT
N39.917805
W75.461455

HERMITAGE LN

GEOTECH SB-03

HOR PC
N39.917736
W75.461422

PROPOSED 16" PIPELINE

EXISTING SUNOCO PIPELINES

PROPOSED 20" PIPELINE

GEOTECH SB-04

HOR PT
N39.916198
W75.460282

DARLINGTON RD

SUNOCO EASEMENT
LIMITS - NOT LOD

EXISTING SUNOCO PIPELINES

VALLEY RD

PA-DE-0069.0000

GEOTECH B6-2E

HDD ENTRY/EXIT
N39.913026
W75.456947

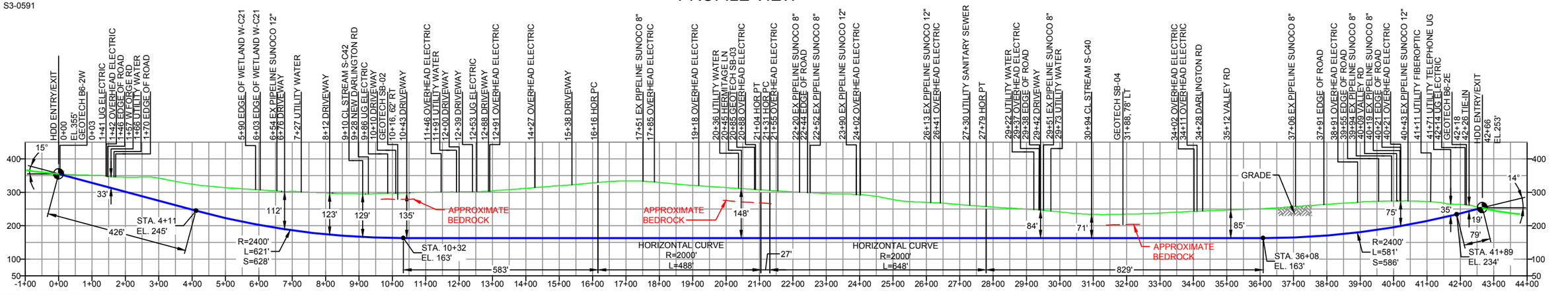
150 0 150 300
FEET

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

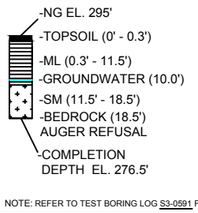
PLAN VIEW

DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591

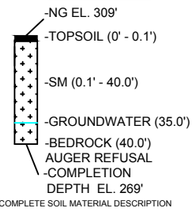
PROFILE VIEW



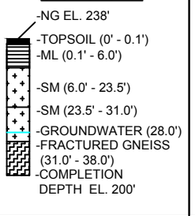
GEOTECH SB-02



GEOTECH SB-03



GEOTECH SB-04



NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
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2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 4266'
   HDD PIPE LENGTH (S=): 4294'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
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9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
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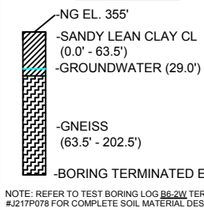
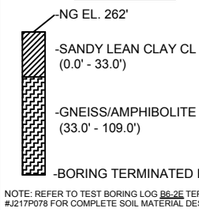
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
13. BLASTING NOT PERMITTED.

GEOTECH B6-2W



NOTE: REFER TO TEST BORING LOG B6-2W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-2E



NOTE: REFER TO TEST BORING LOG B6-2E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTES

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

REF. DRAWING

ES-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN
DWG NO		DWG NO	DESCRIPTION

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP4	UPDATED GEOTECH INFO PROVIDED BY DPS	MRS	11/15/17	RMB	11/15/17	AMC	11/15/17
EP3	INCREASED VERTICAL AND HORIZONTAL CURVE RADIUSES TO MATCH OZDD DESIGN	MRS	10/31/17	RMB	10/31/17	AMC	10/31/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15

Sunoco Logistics Partners L.P.

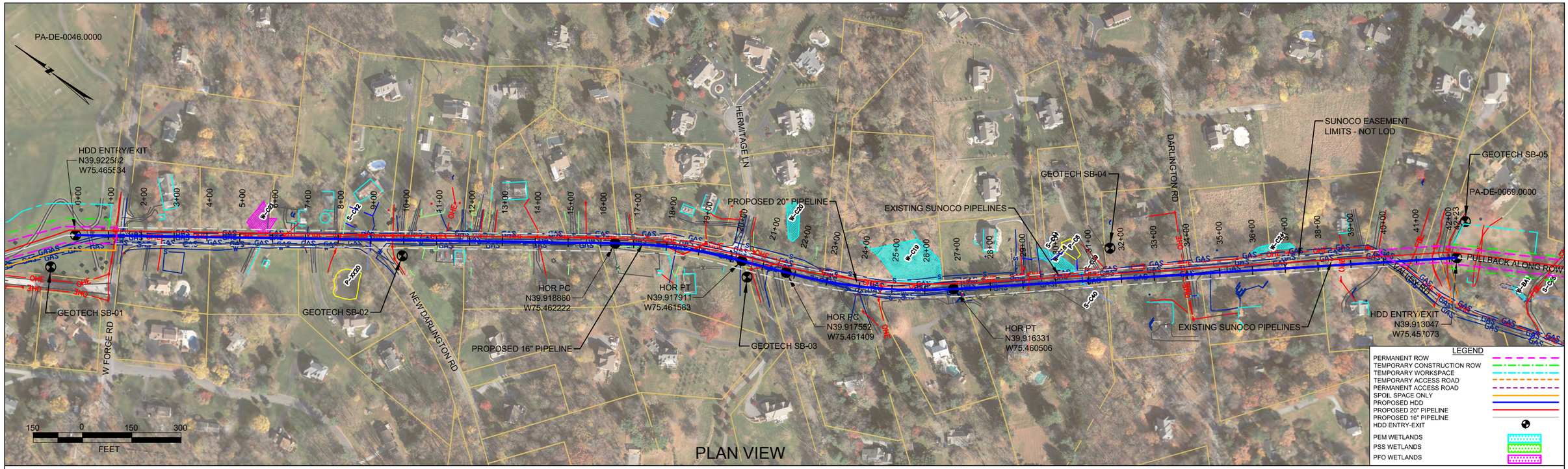
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD / DARLINGTON RD
PENNSYLVANIA PIPELINE PROJECT

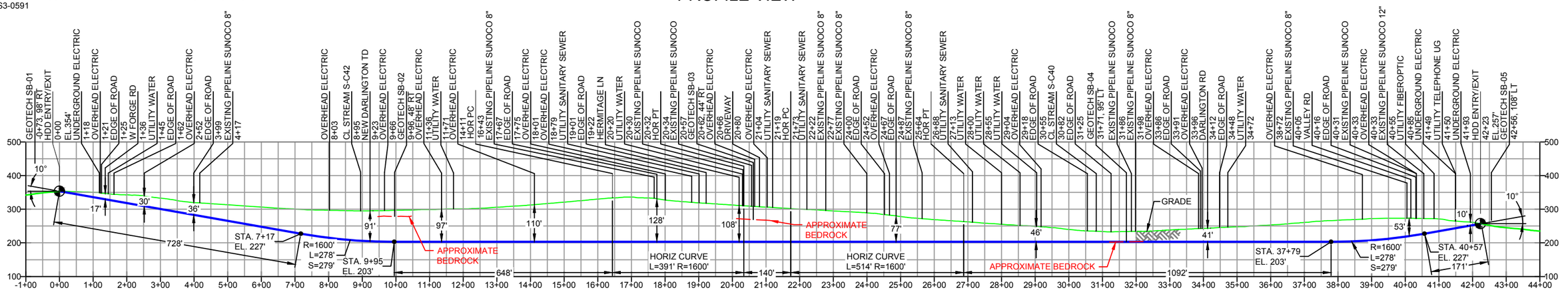
SCALE: 1"=300'

DWG. NUMBER: PA-DE-0046.0000-RD

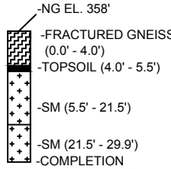


DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591

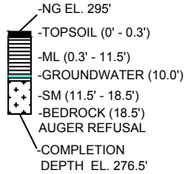
PROFILE VIEW



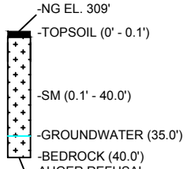
GEOTECH SB-01



GEOTECH SB-02



GEOTECH SB-03



NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):4226'
   HDD PIPE LENGTH (S=):4242'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
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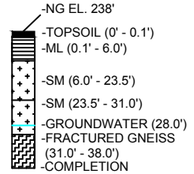
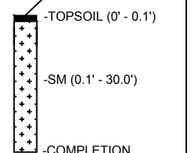
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES

GEOTECH SB-04



GEOTECH SB-05



NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

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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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-6.11	TO ES-6.14	EROSION & SEDIMENT PLAN	
SHEET 7	TO SHEET 9	AERIAL SITE PLAN	
DWG NO	DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

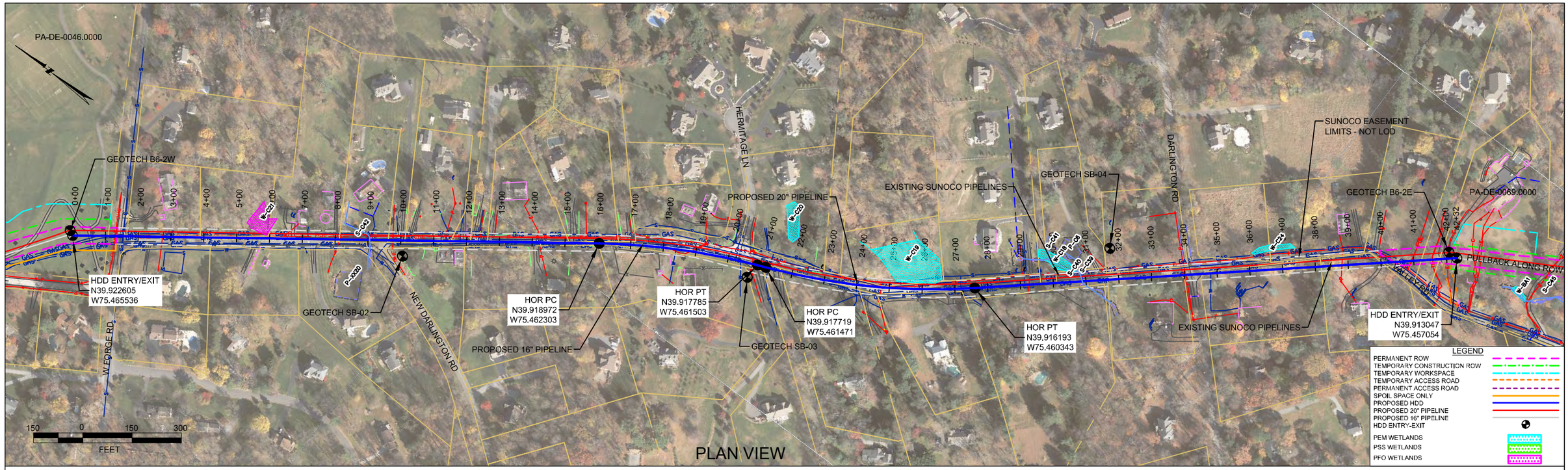
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD / DARLINGTON RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'

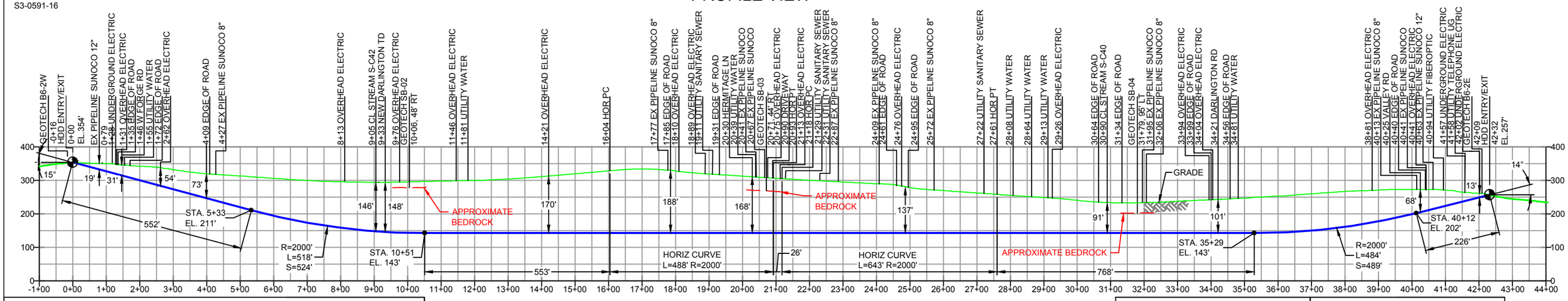
DWG. NO: PA-DE-0046.0000-RD-16



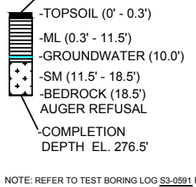
PLAN VIEW

DELAWARE COUNTY PENNSYLVANIA, MIDDLETOWN TOWNSHIP
S3-0591-16

PROFILE VIEW



GEOTECH SB-02



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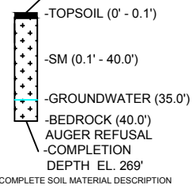
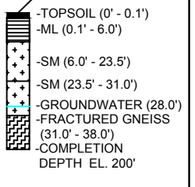


GEOTECH SB-04



NOTE: REFER TO TEST BORING LOG S3-0591 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=): 4232'
   HDD PIPE LENGTH (S=): 4269'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
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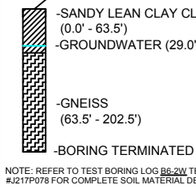
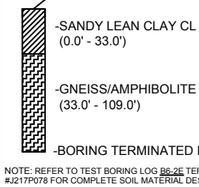
12. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
13. BLASTING NOT PERMITTED.

GEOTECH B6-2W



NOTE: REFER TO TEST BORING LOG B6-2W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-2E



NOTE: REFER TO TEST BORING LOG B6-2E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-6.11	TO	ES-6.14	EROSION & SEDIMENT PLAN
SHEET 7	TO	SHEET 9	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP4	UPDATED GEOTECH INFO PROVIDED BY DPS	MRS	11/15/17	RMB	11/15/17	AMC	11/15/17
EP3	INCREASED VERTICAL AND HORIZONTAL CURVE RADIUSES TO MATCH OZDD DESIGN	MRS	10/31/17	RMB	10/31/17	AMC	10/31/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/20/16	RMB	05/20/16	AAW	05/20/16
EP		MRS	03/15/16	RMB	03/15/16	AAW	03/15/16
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
VALLEY ROAD / DARLINGTON RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300' | DWG. NO: PA-DE-0046.0000-RD-16