HORIZONTAL DIRECTIONAL DRILL ANALYSIS
GRADYVILLE ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E23-524
PA-DE-0032.0000-RD and PA-DE-0032.0000-RD-16
(SPLP HDD No. S3-0580 and HDD S3-0580-16)

GRADYVILLE ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E23-524
PA-DE-0032.0000-RD and PA-DE-0032.0000-RD-16
(SPLP HDD No. S3-0580 and HDD S3-0580-16)

This reanalysis of the horizontal directional drill (HDD) installation of a 16-inch and 20-inch diameter pipeline paralleling Valley Road between Gradyville Road and Sycamore Mills 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 20 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: 3,214 feet (ft)
- Entry/Exit angle: 10 degrees
- Maximum Depth of cover: 102 ft
- Pipe design radius: 2,400 ft

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 3,146 ft
- Entry/Exit angle: 10-12 degrees
- Maximum Depth of cover: 121 ft
- Pipe design radius: 1,800 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

HDD S3-0580 and HDD S3-0580-16, hereinafter collectively referred to as HDD S3-0580, are located within the Piedmont Uplands Section of the Piedmont Physiographic Province in southeastern Pennsylvania. The Piedmont Uplands Section is characterized by broad, rounded to flat-topped hills and shallow valleys with low to moderate topographic relief. The geologic structure of this section is severely folded and faulted. Bedrock in the area is comprised of crystalline, Precambrian to Early Paleozoic-aged weathered Baltimore Gneiss having quartzofeldspathic granulite facies and undifferentiated amphibolite facies to the south, and the “Sycamore Mills Formation” (a migmatitic gneiss) to the southeast. Regional fabric (relict bedding and structure) strikes northeast/southwest.

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.

GRADYVILLE ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E23-524
PA-DE-0032.0000-RD and PA-DE-0032.0000-RD-16
(SPLP HDD No. S3-0580 and HDD S3-0580-16)

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

The Baltimore gneiss unit mapped beneath the HDD S3-0580 location is generally characterized as a unit of relatively poor groundwater production. Groundwater flow occurs through fractures, faults, and lithologic contacts in the metamorphic rocks and through pores and residual fractures in weathered rock and soils. Fracture flow is likely to result in large seasonal fluctuations in water table (between 5 and 15 feet).

Based upon the well information reported to the Pennsylvania Groundwater Information System (PAGWIS), the well depths in this formation vary from 5 to 61 ft below ground surface (bgs), which is consistent with the median well yield of 12 gallons per minute (gpm) reported for wells completed in gneiss throughout southeast Pennsylvania (Low et al., 2002). Median well depth of residential wells is reported by PAGWIS as a depth of 150 ft bgs. Soil borings conducted for this Project HDD reported depth to groundwater between 8 and 26 feet bgs. No municipal water supply wells or municipal surface intakes are indicated on the PAGWIS database within 1,000 ft of HDD S3-0580.

The production zone for water wells in this bedrock formation is from the well bottom to highest point of water inflow from the water bearing seams, joints, and fractures in the rock formation. Water wells in bedrock can only pump water from inside the surface casing and open rock interval within the bore annulus, and water volume from the top water elevation down to the pump intake.

The HDD profiles subject to this Reevaluation will physically pass through the potential "recharge zones" of water wells in vicinity to the HDD. As stated above, as referenced from the Hydrogeologic Report in Attachment 1, *"Groundwater flow occurs through fractures, faults, and lithologic contacts in the metamorphic rocks and through pores and residual fractures in weathered rock and soils".* To explain further, this means that available groundwater is stored within, and moves through, fissures and bedding plane partings in the bedrock. A water well in a bedrock formation is a simple vertical hole in the bedrock that intercepts water bearing fissures and bedding plane partings and provides an open vertical annulus for the water within the bedrock to flow into and fill (recharge) with a volume of water rising towards the land's surface until equilibrium with the piezometric surface in bedrock formation is achieved.

Any technically defensible analysis of the movement of groundwater in this unique geology is dependent upon information on the orientation of the fissures and bedding plane partings; their width; do they dip or incline, and to what extent hydrostatic forces or the effects of gravity influence the movement of water in these bedrock features. This information, however, cannot be determined for a given well location in this geology even with extensive geologic coring and water investigation because the bedrock characteristics for these features and behavior can vary significantly in each core. Furthermore, the private water supply yields are governed by well construction and resulting well efficiency and its relation to the available water bearing fissures and bedding plane parting horizons they intercept and does not reflect a homogenous consistency as seen in layered unconsolidated aquifers.

In addition, the effect of the HDD on a given water supply well will depend upon the level of use and resultant groundwater draw at a specific time. According to water use data published by Pennsylvania State University (https://extension.psu.edu/water-system-planning-estimating-water-needs), in general, a household will use 50 to 100 gallons per person per day (200 to 400 gallons per day for a family of four). For a drilled well, the borehole provides a significant amount of water storage. A typical 6-inch-diameter well will store about 1.5 gallons of water for every foot of standing water in the borehole and a 10-inch well stores about 4 gallons of water per foot. Therefore, a 6-inch-diameter well with about 100 feet of standing water in the borehole would contain about 150 gallons of stored water.

Use of this water and the resulting draw upon adjacent groundwater within the fractured bedrock is cyclic throughout the day, with the greatest demand occurring during morning and evening hours and on weekend days and holidays when residents are generally home.

In sum, the variability of the well yield and production can and often varies greatly over relatively short distances and time periods in these complex rock formations. The well production can be influenced by seasonal variability in precipitation, well construction, well consumption rates, recharge rates, infiltration rates, radius of influence (ROI) of other well systems, multiple production zones, and known and unknown geologic structural features (i.e., fissures, bedding planes and rock type). For these reasons discussed above, and consistent with the permit and incorporated plans, as amended, Sunoco Pipeline, L.P. (SPLP) will offer baseline, active drilling, and post drilling monitoring of all wells in the 450 feet buffer zone. This data will be used to evaluate the water chemistry and other physical characteristics of the water quality at the specific well location before, during and after construction, and if an impact occurs, the permit requires replacement of the water supply to the satisfaction of the well owner.

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

INADVERTENT RETURN (IR) DISCUSSION

HDD specialists for SPLP reviewed the original HDD designs summarized above, and determined that that the design profiles for the 16 and 20-inch HDDs have no apparent significant faults given the setting and nature of the geologic strata. However, features of concern from this HDD review include the complex structural geology with a high degree of fracturing and proximity to residential wells. To address these features, minor adjustments in the profile design have been proposed.

Minor fluid losses and IRs have occurred at some nearby HDDs in the same geology. Experience has demonstrated that these issues often occur at lithologic boundaries, at entry/exit points, and at fracture crossings identified by fracture trace analysis. Although the geology at HDD S3-0580 is similar, the increased fracture density as evidenced in the geotechnical data core obtained for this location indicates an increased risk for fluid losses and IRs as compared to nearby HDDs.

Two recent geotechnical cores at each end of the HDD reveal that the designed horizontal profile is set within competent bedrock. At the west core location recovery values range from 86-100 and rock quality designation (RQD) values range from 28 at the bedrock surface to 96 during profile penetration. At profile depth, the recovery value is 100 and RQD value is 63. At the southeast entry point, during profile penetration, the recover values range from 86-100 and RQD values range from 16-73. At profile depth, the recovery value is 100 and RQD value is 73.

These values 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 55 ft of elevation difference between the maximum ground elevation in the middle of this HDD and the HDD entry (east) side, the potential for producing groundwater during the HDD exists once the pilot hole has progressed approximately 400 ft into the profile and through its' completion. This difference in elevation is not extreme; however, progressing through a fracture zone could elevate the volume of produced water. Generally, 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 at the HDD

entry, and then hauled away for treatment and disposal. Prior to the start of the pilot hole drilling, 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. In accordance with the HDD Inadvertent Return Assessment, Preparedness and Contingency Plan (IR Plan), SPLP will immediately report any surfacing of groundwater to the Pennsylvania Department of Environmental Protection (PADEP). SPLP will promptly thereafter notify the landowners with private water supplies located within 450 feet of the alignment, described in more detail in the Adjacent Features Analysis below, that a surfacing of groundwater occurred and that their water supply may be impacted.

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

This HDD location is approximately 3 miles southwest of the city of Edgemont in Delaware County, Pennsylvania. The pipeline alignments follow parallel to Valley Road and cross under Gradyville Road and Yarnall Lane, and will parallel other utility lines along the roadway, including existing SPLP pipelines.

This HDD location is set within suburban residential developments for the majority of its length as it proceeds parallel to Valley Road. The HDD does not cross under any aquatic resources.

Pre-Construction, SPLP identified and attempted to contact all landowners with a parcel of land within 150 feet of the HDD alignments. Thirteen (13) water wells were identified and tested as a result of that outreach. Of these, 5 of these wells were within 450 feet of the HDD profile.

SPLP subsequently identified forty-three (43) 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, which 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 its depth and size if known; and (3) whether the landowner would like to have the well sampled. In accordance with paragraph 10 of the Order, copies of the certified mail receipts for the letters sent to landowners have been provided to Karyn Yordy, Executive Assistant, Office of Programs at the Department's Central Office.

SPLP's public outreach results to date have identified the presence of 37 water wells, of which 26 are within 450 ft of the proposed HDD. Three tracts are connected to public water supplies. A water supply illustration is included in Section 2.3 of the Hydrogeologic Report in Attachment 1.

To further avoid and mitigate any adverse effects from the HDD to private water wells, and in accordance with the requirements of the Stipulated Order, SPLP will transmit a copy of this HDD analysis to all landowners having a property line within 450 ft of any direction of this HDD location. In addition, in accordance with the IR Plan and Operations Plan, SPLP has offered all landowners with a private water supply source located within 450 feet from the HDD alignment an alternative temporary water supply (e.g., water buffalo with potable water adequate for purposed served) that will be installed and maintained, at SPLP's expense, for the entire period of the HDD construction activities. Furthermore, 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.

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of HDD S3-0580 includes an evaluation of open cut alternatives and a re-route analysis. As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the Project, SPLP considered several different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

Open-cut Analysis

SPLP specifications require a minimum of 48 inches of cover over the installed pipelines. The Pennsylvania Department of Transportation (PADOT) cover requirements under public roadways is 60 inches of cover.

While an open cut installation of the pipeline is possible, the logistics associated with this method would significantly increase the length of time the affected properties would be subject to construction disturbance. To minimize impact to the public users of the primary and intersecting roadways, open cut construction would require obtaining a permit from PADOT to undertake night-time construction with a lane closure while “stove piping” the new pipeline installations. Under this construction scenario the pipeline construction proceeds in 80-170 ft segments; a trench is cut, pipe segments held in place and welded to the preceding segment end; the weld is inspected and approved and coated and then backfilled to within 20-30 ft of the segment end. Only 1 to 2 segments of pipe could be completed per night due to the time requirements to complete each welding and coating procedure to specification. Steel plates are laid over the backfilled segments and minimally permitted open end before the stop of construction to allow for daytime roadway use. This sequence of construction events is repeated until the entire lay segment is completed. Additionally, the pipeline parallels an existing overhead utility line in the full alignment of the HDD in this location. Open trenching would require an offset from the road and that corridor, creating new edge and clearing trees along the alignment.

There are no aquatic resource crossings within or above the HDD profiles. Any produced groundwater in the open excavations would be pumped to a discharge filtration structure. The currently feasible filtration ability does not exceed 50 microns, so with an open cut crossing alternative, it is possible that cloudy water (from suspended fine clay and silt particles) would be discharged in uplands with the use of open cut construction techniques.

Alternatively, conventional auger bore is technically limited to less than 300 linear ft of relatively flat land surface at a single attempt. Due to the curvature requirements to follow the exiting utility easement and

the inability to steer an auger bore into curves, this construction methodology cannot be employed as an alternate method at this this location.

Re-Route Analysis

The pipeline route as currently permitted follows an existing SPLP easement under and along the public right-of-way of Valley Road through suburban areas northwest of the City of Lima. The existing SPLP pipeline were installed by conventional construction methods before general development of the area. This alignment avoids directly impacting Valley Road (except for a small portion of workspace) for the vast majority of its length; Gradyville Road; and two (2) intersecting roads. Nineteen (19) intersecting private driveways are also avoided by this HDD.

The general route of the Mariner II project in this area of the state is from northwest to the southeast.

Residential and commercial developments line both sides of the road along the entire length of this HDD and the vicinity, and there are no reasonably available alternative routes for this pipeline segment that parallel existing corridors to avoid this crossing location. Any reasonable alternative route that does not follow existing corridors would require creation of a new right-of-way through existing residential yards, and would potentially require impacts on new aquatic resources, residences, and forest areas. Many houses and developments would be involved/impacted under an alternative route in this area.

In summary, due to the urban setting surrounding the overall route of the Mariner II pipelines in this area, there is no reasonable alternative route that would better avoid conflicts with existing development than the proposed route.

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

RECONSIDERATION OF THE HORIZONTAL DIRECTIONAL DRILL

HDD specialists and geologists employed by SPLP have investigated the HDD design and subsurface geologic conditions for HDD S3-0580, and made minor adjustments to the profile design, which included a minor extension in length of the 20-inch as detailed in the introduction section above. Upon the start of these HDDs, SPLP will employ the following HDD best management practices:

- SPLP will mandate annular pressure monitoring during the drilling of the pilot hole, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus, managing development pressures that can induce an IR;

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

- A produced water management system will be implemented before drilling begins to handle water in excess of that required for the HDD. If excessive water is generated during the HDD, all wells within a 450-ft radius of the HDD would be monitored periodically to evaluate changes in the water table;

- Soil cuttings will be carefully monitored for presence of volatile organics. If olfactory evidence, elevated photoionization detector (PID) readings, or a sheen suggests significant petroleum concentrations, drilling would be suspended until samples can be analyzed. Cuttings would be screened before disposal, as required by law;

- SPLP will mandate short-tripping of the reaming tools to ensure an open annulus is maintained to manage the potential inducement of IRs;

- 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;

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

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

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

CONCLUSION

Other than the implementation of the above described drilling practices and procedures, no significant changes to the HDD plans for the pipelines at this location are recommended or planned.

As there were no major alterations of these HDD designs, the final designs for these HDD's are attached as Figures 1 and 2 Attachment 2.

GRADYVILLE ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E23-524
PA-DE-0032.0000-RD and PA-DE-0032.0000-RD-16
(SPLP HDD No. S3-0580 and HDD S3-0580-16)

ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

HDD HYDROGEOLOGIC REEVALUATION REPORT

Mariner East II
Spread 6
HDD S3-0580
Gradyville Road
Edgemont Township, Delaware County, Pennsylvania

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

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

February 2018

HDD HYDROGEOLOGIC REEVALUTION REPORT

Mariner East II
Spread 6
HDD S3-0580
Gradyville Road
Edgemont Township, Delaware County, Pennsylvania

February 2018

Prepared for:

Sunoco Pipeline, L.P.
535 Fritztown Road
Sinking Spring, Pennsylvania 19608

Prepared by:

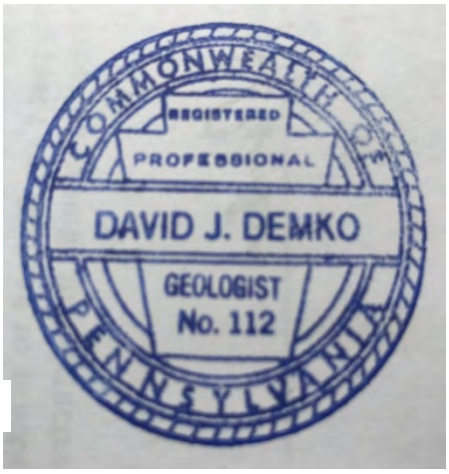
Martin F. Helmke, P.G.
Senior Hydrogeologist

Reviewed by:

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

Groundwater & Environmental Services, Inc.
440 Creamery Way, Suite 500
Exton, Pennsylvania 19341
(610) 458-1077

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.



February 22, 2018

David J. Demko, P. G. Date

License. No. PG000112G

TABLE OF CONTENTS

FIGURES

ATTACHMENTS

1.0 INTRODUCTION

Sunoco Pipeline, L.P. (SPLP), retained Groundwater & Environmental Services, Inc. (GES) to prepare a horizontal directional drill (HDD) Hydrogeologic Reevaluation Report (HRRs) for HDDs listed on Exhibit 2 of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017. This HRR has been prepared for both the 20-inch and 16-inch pipe associated with the Mariner East II pipeline project at Gradyville Road, PA-DE-0032.0000-RD (HDD S3-580 and HDD S3-580-16), hereinafter collectively referred to as HDD S3-0580. HDD S3-0580 runs parallel to Valley Road from Gradyville Road to Sycamore Mills Road in Edgemont Township, Delaware County, PA. A map depicting the location of the HDD with topographic information on the surrounding area is presented as **Figure 1**.

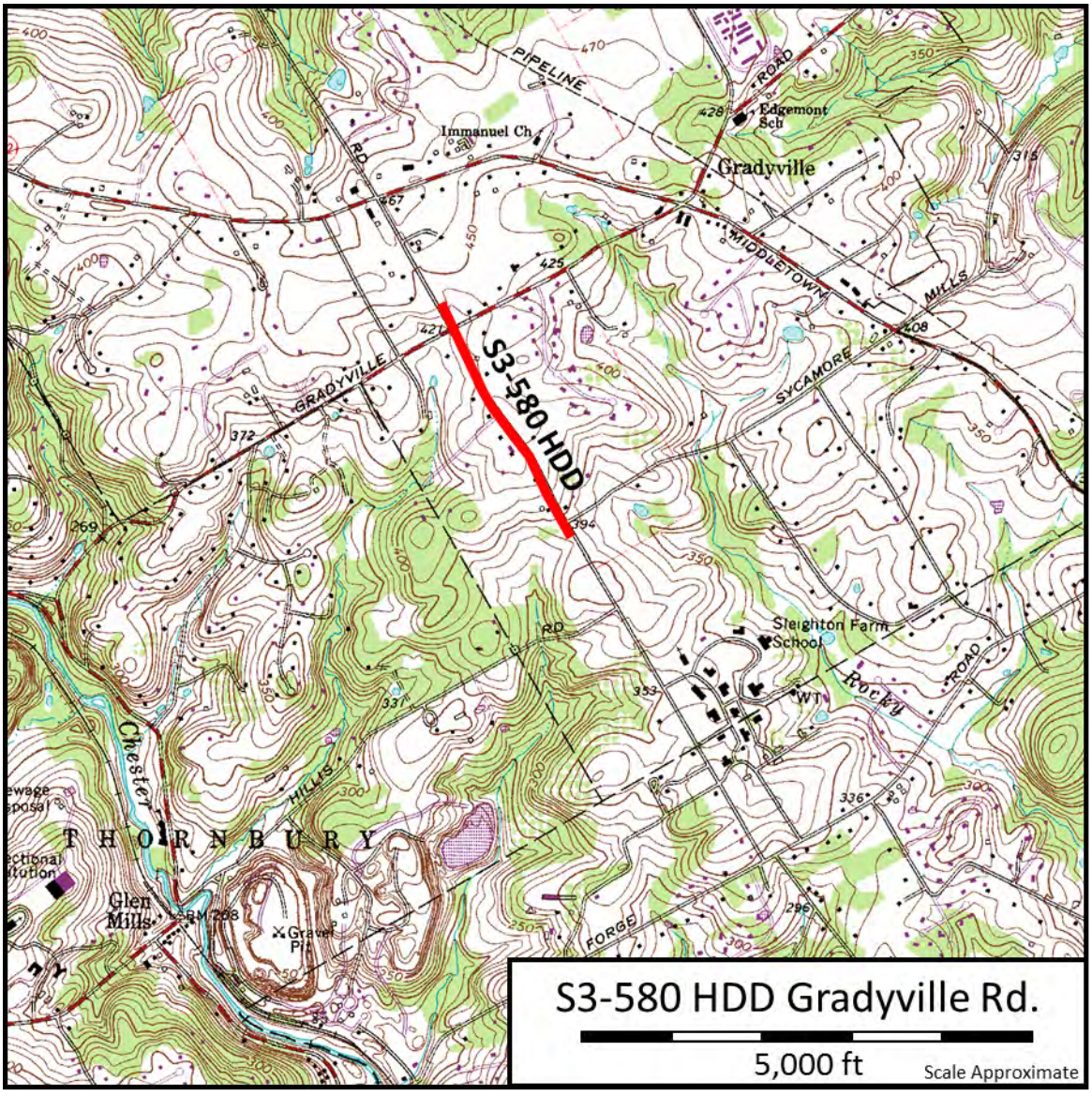


Figure 1. Site Location Map (modified from ESRI community topographic map, 2017; USGS. 2010. Media Quadrangle, Pennsylvania [topographic map]. 1:24,000, 7.5-Minute Series. Washington, D.C. 1 p.)

As described in the Stipulated Order (pages 3 and 4), this HRR 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.
This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of HDD S3-0580;
- Summaries of studies performed pertinent to reevaluation, including fracture trace analysis and geotechnical borings;
- A site conceptual model; and
- A reevaluation summary with conclusions.

The contents of this report were developed from interpretation of published information, field observations, and related field studies. 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 and September 2017 in support of the HDD S3-0580 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 soil, rock cores and water levels during drilling operations; or preparation of boring logs. The geotechnical reports, boring logs, and any core photographs that resulted from these programs were generated by the two SPLP contractors. GES relied on these reports and incorporated their data into the general geologic and hydrogeologic framework for this HRR.

2.0 HDD GEOLOGY / HYDROGEOLOGY

The discussion presented in this report is based on the alignment plan and profile developed by Tetra Tech/Rooney for both the 20-inch and 16-inch pipe installations, revised November 17, 2017 (**Attachment A**).

2.1 Physiography

HDD S3-0580 is located within the Piedmont Uplands Section of the Piedmont Physiographic Province in Southeast Pennsylvania. The Piedmont Uplands Section is characterized by broad, rounded to flat-topped hills and shallow valleys with low to moderate topographic relief. The geology of this region is generally comprised of meta-igneous and metasedimentary rocks of Proterozoic to Early- to Mid-Paleozoic age that have been severely folded and fractured.

2.1.1 Topography

The topography in the area of HDD S3-0580 has moderate relief, with a ground surface elevation at the northwestern entry/exit point of 432 feet above mean sea level (ft. amsl) and the entry/exit point 3,214 feet to the southeast at an elevation of 390 ft. amsl (**Figure 1**). The plan and profile reports the northwest and southeast ends to be located between coordinates N39.94019 / W75.47958 and N39.93258 / W75.47385, respectively. The HDD profile shows topography increasing from both ends to a maximum elevation of approximately 445 ft. amsl. The HDD is located in the uplands, 1 mile east of Chester Creek, which has an elevation of approximately 210 feet. The difference in elevation between the northern and southern ends is 40 feet less to the south.

The original plan and profiles, dated May 10, 2016, were modified in the November 27, 2017 revisions (**Appendix A**) by 1) moving the northwest entry/exit points of the 20" HDD profile 68 feet northwest and deepening the overall profile to where approximately 1,025 feet of the 20-inch drill now lies at depths 95 feet or greater below ground surface (bgs). The 16-inch profile runs 20 feet deeper than the 20-inch profile with the horizontal drill lengths are now at 3,214 feet for the 20-inch line and 3,145 feet for the 16-inch line, mostly because the northwestern entry/exit for the 20-inch line is located further to the northwest.

2.1.2 Hydrology

The nearest surface water body to the HDD is a small tributary to Chester Creek, 500 feet west of the site. Chester Creek is located 1 mile west of the HDD. A pond is located 3,400 feet southwest of HDD S3-0580 near the Glen Mills Quarry.

2.2 Geology

2.2.1 Soils

Unlithified materials along the drill path in the area of HDD S3-0580 were characterized by the four geotechnical borings installed by Tetra Tech (SB-01, SB-02, SB-03, and SB-04; **Attachment B**), the two more recent deep borings logged by Terracon (B6-3W and B6-3E; **Attachment B**), and the USDA NRCS Web Soil Survey for Chester and Delaware Counties (USDA NRCS, 2017).

Soil depth ranged from 8 feet to 55 feet below ground surface (ft. bgs) as defined in the geotechnical borings. The geotechnical boring logs describe the soils as sand, silty sand, silty clay, poorly graded sand, poorly graded gravel with sand, and poorly-graded sand with silt and gravel following the USCS classification system. Soil taxonomy includes the Glennville Series (Fine-loamy, mixed, active, mesic Aquic Fragiudults) and Glenelg Series (Fine-loamy, mixed, semi-active, mesic Typic Hapludults [USDA NRCS, 2017]).

The borings describe variegated and micaceous soil with weathered rock, indicating the presence of saprolite. Saprolite inherits properties of the bedrock, including fractures that may act as preferential flow paths for drilling fluids.

2.2.2 Bedrock Lithology

Bedrock in the area of HDD S3-0580 is comprised of crystalline, Precambrian- to Early Paleozoic-aged weathered Baltimore Gneiss (Blackmer, 2005). This unit is further subdivided into the quartzofeldspathic granulite facies to the north, undifferentiated amphibolite facies to the south, and the "Sycamore Mills Formation" (a migmatitic gneiss) to the southeast. As shown in **Figure 2**, the HDD S3-0580 bore passes through Baltimore Gneiss amphibolite and granulite facies (modified from Blackmer, 2005).

Regional fabric (relict bedding and structure) strikes northeast/southwest. Four geotechnical borings evenly spaced along the alignment were advanced to depths between 13.8 and 30 feet. The borings recorded "very intensely fractured," weathered gneiss, suggesting saprolite to a depth of at least 30 feet.

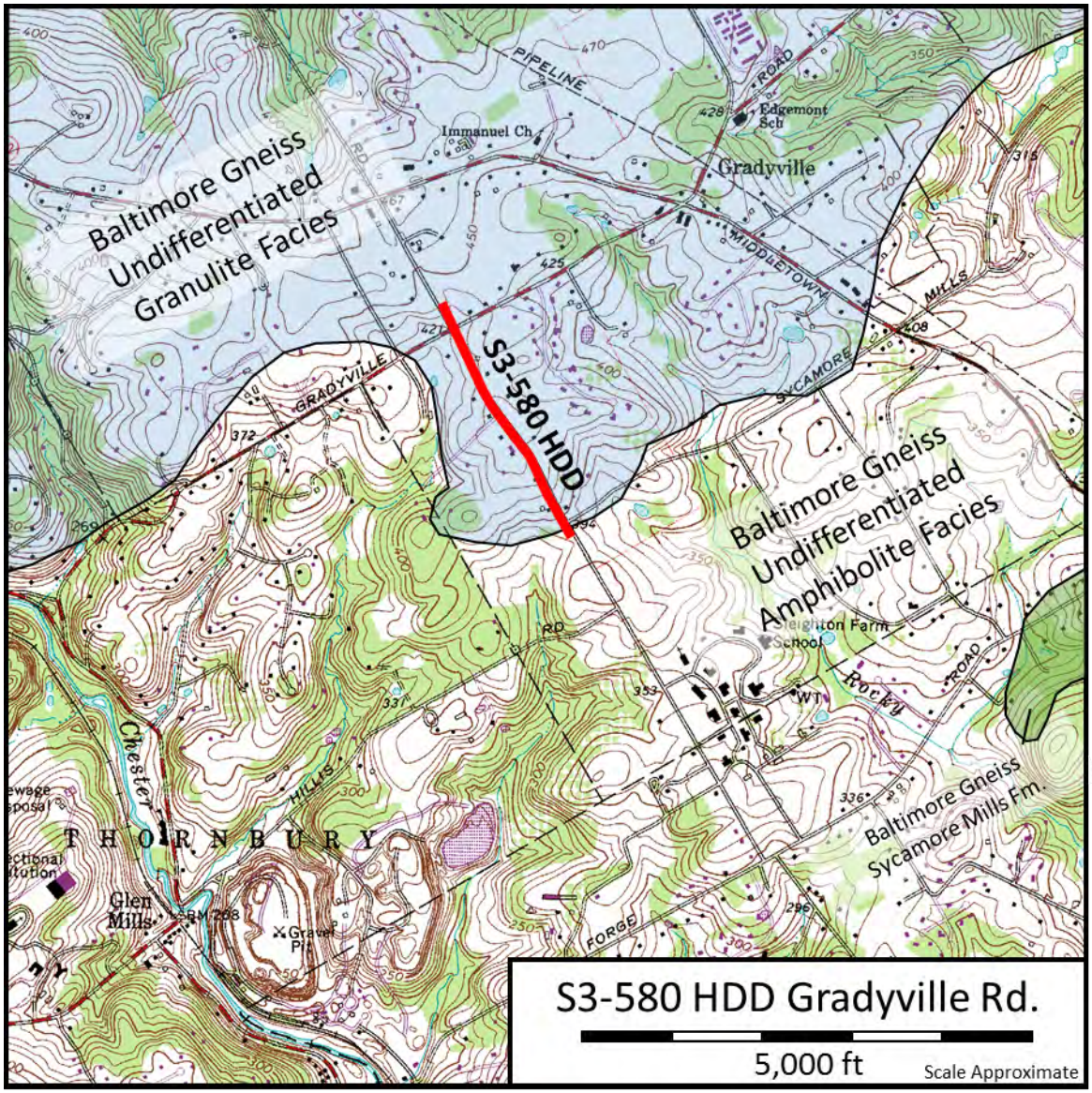


Figure 2. Site Geology (modified from Blackmer, 2005; USGS 2010. Media Quadrangle, Pennsylvania [topographic map]. 1:24,000, 7.5-Minute Series. Washington, D.C. 1 p.)

2.2.3 Structure

The rocks at the HDD S3-0580 site experienced multiple episodes of metamorphism. They are strongly foliated, folded, fractured, and sheared. At least three sets of fracture patterns (striking N10°E, N60°E, and N20°W) are indicated by fracture trace analysis (see below). These appear to coincide with regional foliation and tectonic and neotectonic stress directions.

2.2.4 Fracture Trace Analysis

A fracture trace analysis was performed for the area of interest to identify potential zones of bedrock weakness along the drill path (**Figure 3**). The investigation yielded evidence of regional fracture traces trending approximately N10°E, N60°E, and N20°W. At least three linear features cross the drill path at 275 feet, 1,520 feet, and 2,740 feet from the northwest entry point, respectively.

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. Images were obtained through the Pennsylvania Imagery Navigator (PASDA, 2017). Stereo pair images at the 1:20,000-scale recorded by USDA between 1937 and 1942 were viewed, along with LiDAR images collected in 2008 (PASDA, 2017). The observed traces were transferred onto the geologic map for further evaluation. **Figure 3** shows fracture traces mapped (using stereo-paired aerial images from 1937 [blue lines] and using LiDAR imagery [orange lines]). Three of the LiDAR derived traces cross the HDD S3-0580 path.

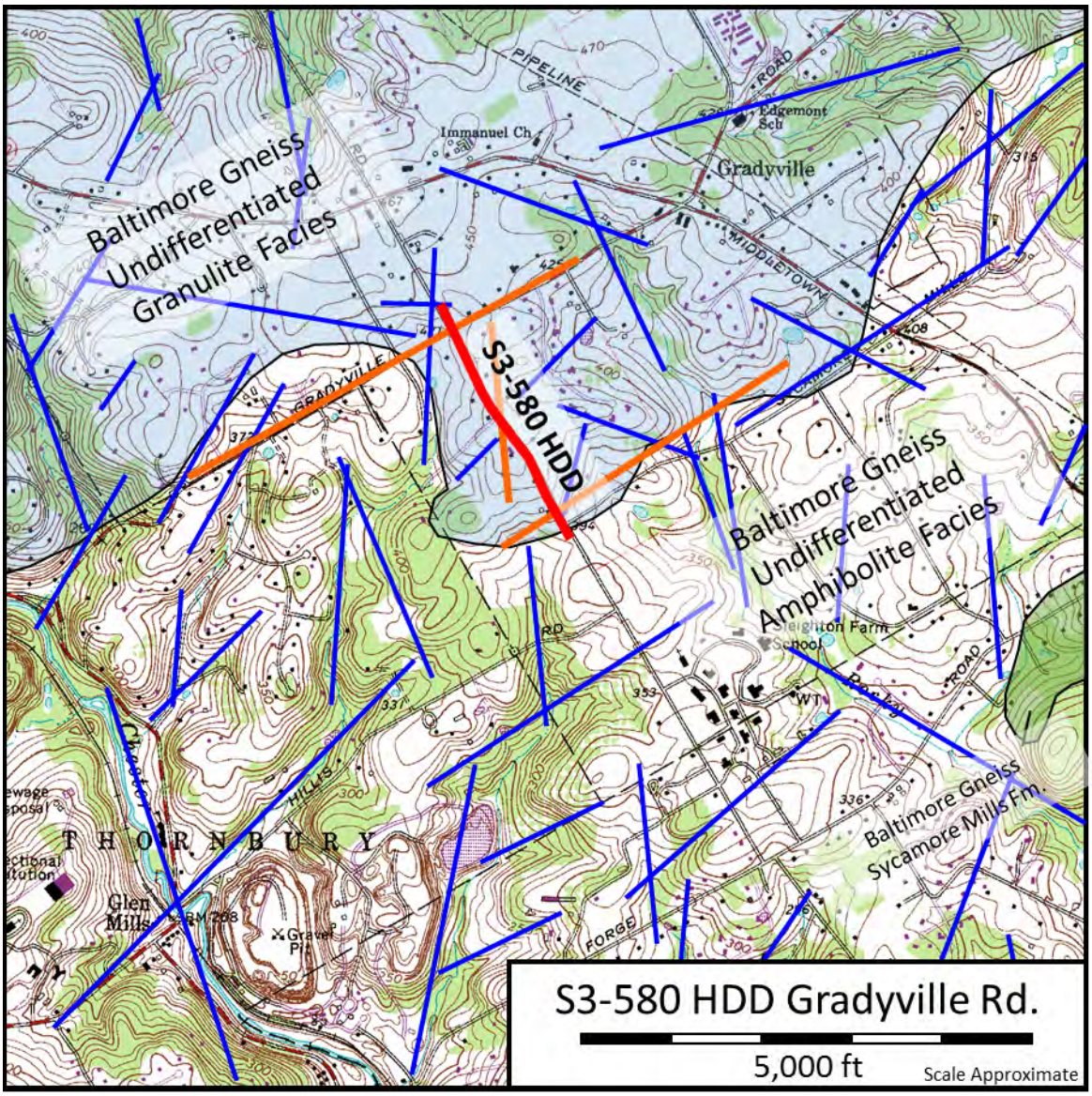


Figure 3. Fracture Trace Map

2.2.5 Karst

Based on published geologic data, no karst features are anticipated within the region of HDD S3-0580 as limestone and marble units are absent from the mapped formations.

2.2.6 Mining

A large (2,300-foot diameter by 400-foot deep) aggregate quarry is located one mile southwest of the S3-0580 HDD. No other quarries or mines were identified within 1,000 feet of the ROW by the eMapPA database (PADEP, 2017).

2.2.7 Rock Engineering Properties

Rock unconfined compressive strength was determined by Terracon for samples collected from boring B6-3W and Tetra Tech from borings SB-02 and SB-03 (**Attachment B**). Five measurements from the gneiss were reported, with a mean compressive strength of 11,708 psi (ranging from 6,707 psi to 16,190 psi). Mean unconfined compressive strength of amphibolite sampled in B6-3W was 10,840 psi (range 5,638 psi

to 19,425 psi for the three samples). These values are similar to the compressive strength reported in the literature of 8,381 psi for schist and 25,230 psi for gneiss (Johnson and Degraff, 1988). Note, however, that the numerous weathered, fractured, and sheared zones encountered by these boreholes indicate that in-situ the compressive strength may be significantly lower than reported by the laboratory.

2.2.8 Results of Geotechnical Borings

Original Geotechnical Borings
Four geotechnical borings (Tetra Tech borings SB-01, SB-02, SB-03, and SB-04) were installed to support the original boring profile design. The locations for these borings are shown on the plan and profiles in **Attachment A** and the logs are provided in **Attachment B**. The borings logs report depth to bedrock of 13 feet, 24 feet, 8 feet, and 30 feet for SB-01 through SB-04, respectively. Groundwater was encountered at depths of 8.0 feet for SB-01 and SB-02, >17.5 feet for SB-03, and 19 feet for SB-04. Soils included sand, gravel, silty sand, and clayey sand. Rock core collected in SB-02 and SB-03 reported gray gneiss that was decomposed and moderately to intensely fractured.

Recent Geotechnical Borings
Two geotechnical borings were drilled by Terracon in August and September 2017 with the objective of collecting rock core from the maximum planned depth of the HDD. B6-3W is located near the northwest entry point and B6-3E is located within the ROW near the southeast entry point. The locations for these borings are shown on the revised plan and profiles in **Attachment A** and the logs are provided in **Attachment B**. B6-3W reported weathered and fractured gneiss at 20 ft. bgs, followed by fractured amphibolite below 65 feet to the maximum cored depth of 130 feet. The coring rig lost mud returns below 75 feet in Boring B6-3W. Boring B6-24E encountered weathered schist and gneiss at 55 ft. bgs, followed by fractured schist and gneiss to the boring extent of 100 feet.

Rock Quality Designation (RQD) of core collected from boring B6-3W showed a general increase in RQD from 7.5% at 25 ft. bgs to 96% at 65 ft. bgs. However, it decreased below this interval, reaching minimum values of 13% and 20% at 95 and 115 ft. bgs, respectively. These values could indicate significant fracture zones at these depths. Boring B6-3E RQD improved to 75 ft. bgs, where the RQD ranged between 89% and 97% to the maximum boring depth of 100 ft. bgs.

2.3 Hydrogeology

The Baltimore Gneiss unit mapped beneath the HDD S3-0580 location is identified as a unit of relatively poor groundwater production. Nonetheless, quantities of water can flow through discrete fracture or shear zones and this unit serves as an important source of potable water for many households in the area. Soil borings reported depth to groundwater between 8 and 19 ft. bgs. Groundwater is expected to flow toward the southwest toward the tributary to Chester Creek, Chester Creek proper, and the large aggregate quarry (which has a depressed water table maintained at an elevation of 180 feet below mean sea level).

2.3.1 Occurrence of Groundwater

Groundwater flow at HDD S3-0580 occurs through fractures, faults, and lithologic contacts in the metamorphic rocks and through pores and residual fractures in weathered rock and soils (Low et al., 2002). Depth to groundwater ranges from 5 to 40 ft. bgs with reported well yields ranging from 3 to 30 gallons per minute (gpm) (Hall, 1934). Groundwater is expected to flow preferentially through fractures indicated by the fracture trace analysis. Fracture flow is likely to result in large seasonal fluctuations in water table (between 5 and 15 feet).

2.3.2 Ground Elevation Between HDD Entry/Exits

The boreholes drop 42 and 40 feet from the northwestern entry/exit to the southeastern entry/exit for the 20-inch and 16-inch lines, respectively. The highest topographic point along the alignment is 445 ft amsl, midway along the profile (**Attachment A**).

2.3.3 Water Level

Groundwater was encountered in borings SB-01 (8 ft. bgs), SB-02 (8 ft. bgs), SB-4 (19 ft. bgs), B6-3W (10 ft. bgs), and B6-3E (26 ft. bgs). Based on reported depth to water and topography from the plan and profile drawings, the water table appears to have a relatively low gradient, ranging in elevation between 360 and 420 ft. amsl along the bore path. A review of the Pennsylvania Groundwater Information System (PaGWIS) database (PA DCNR, 2017) identified 1,035 wells in similar rocks in Delaware County. Median depth to water was reported at 25.2 feet, with 5th and 95th percentiles of 5 and 61 feet, respectively. The elevation difference between the high end of the range of water level elevations underlying the highland central to the profiles (420 ft. amsl) and the southeastern entry/exits is approximately 30 to 32 feet for the 20-inch line and 16-inch line, respectively.

2.3.4 Well Yields

Median yield reported for 1,035 wells completed in Delaware County gneisses was 12 gallons per minute (gpm), which is 5th and 95th percentile values of 2 and 67 gpm, respectively. This is consistent with the median well yield of 12 gpm reported in the literature for wells completed in gneiss throughout Southeast Pennsylvania (Low et al., 2002).

2.3.5 Water Supply Wells within 150 and 450 feet of ROW

Ten (10) residential wells located within 150 feet of the ROW were sampled during the initial preconstruction assessment program. A total of twenty-six (26) properties with wells have been located within 450 feet of the ROW and all have been sampled prior to HDD start up **(see Figure 4)**. Notably, 50% of the wells sampled showed total coliform above 1 MPN/100ml and 95% of the wells showed turbidity > 1 NTU. Public water is connected to three (3) property parcels which lie within 450 ft. of the ROW. Published median well depth is 150 feet (PaGWIS, 2017). Residential wells in these rocks are generally constructed cased and un-grouted to bedrock then finished as an open-hole (i.e., no screen or casing) to the final well depth. These types of well constructions are susceptible to an increase in accumulation of natural sediments in the well bottoms over time, as well as, possible agitation of these sediments from drilling and the risk of migration of drilling fluids from the HDD to the wells.

There are no municipal water supply wells or municipal surface water intakes indicated on the PaGWIS database within 1,000 feet of HDD S3-0580; however, a tributary to Chester Creek is located 500 feet west of the LOD.

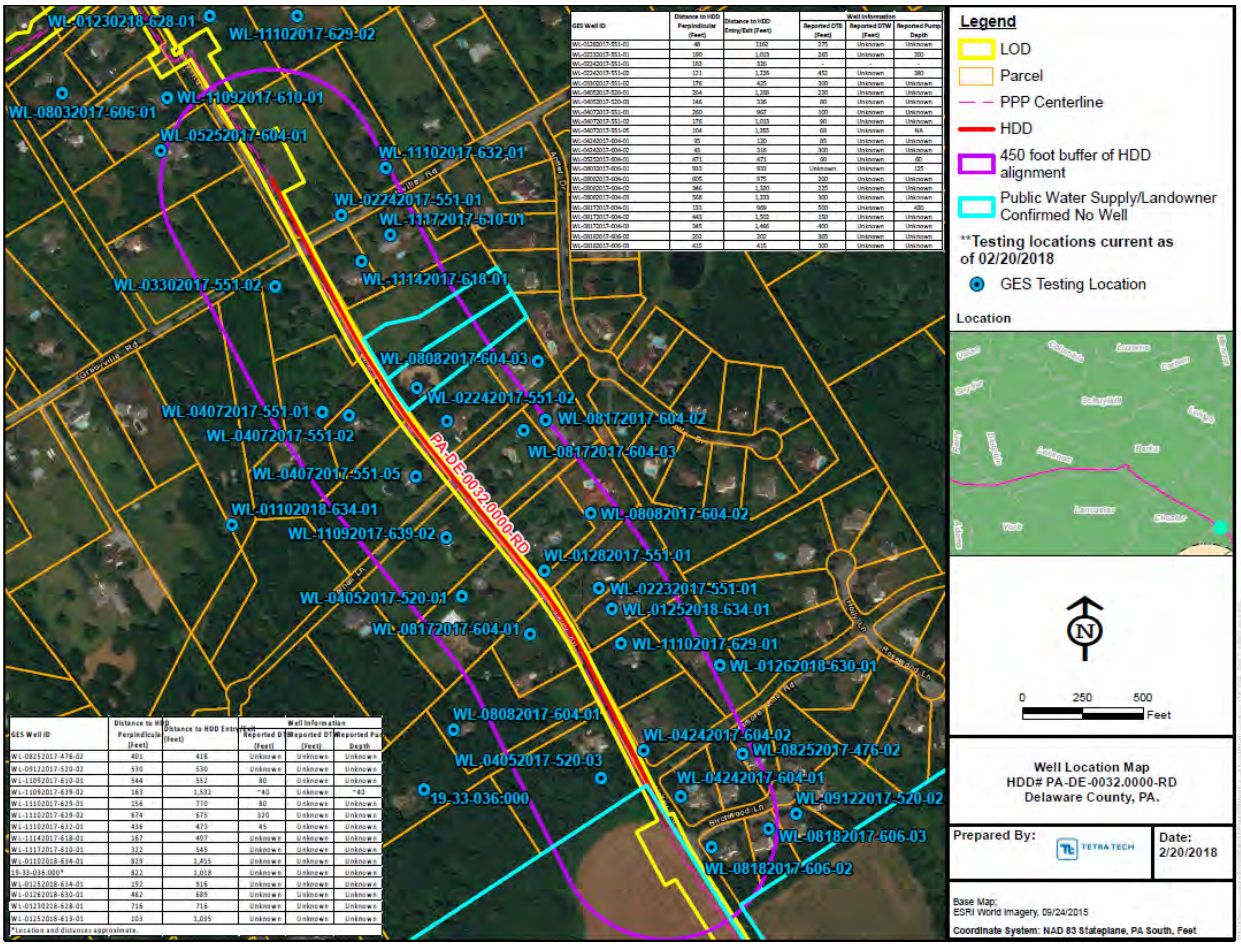


Figure 4. Sampled Residential Wells within 450 feet of HDD

2.4 Summary of Geophysical Studies

No geophysical studies were conducted for this reevaluation as there is no indication of karst development in the area and deep mining has not been identified beneath the HDD alignment.

3.0 OBSERVATIONS TO DATE

3.1 On This HDD Alignment

3.1.1 ME I

No IRs were reported along the alignment of the HDD S3-0580 drill on the list of IRs for ME I documented in the IR PPC Plan for Delaware County.

On April 10, 2015, a release of petroleum (diesel, kerosene, and gasoline) was reported west of Valley Road near the Valley Road/Gradyville Road intersection. A pinhole leak was identified in the Sunoco Pipeline Limited Partnership (SPLP) 12-inch-diameter Point Breeze to Montello Pipelines, which was temporarily repaired on April 11, 2015, then permanently repaired in July, 2017. Interim environmental response actions completed by SPLP included installation of soil borings, groundwater piezometers, and monitoring wells to delineate the magnitude and extent of impacted soil and groundwater associated with the release. The soil and groundwater data indicated a small area located next to the release point where free-product petroleum was reported in only one monitoring well location (MW-5). As part of the interim and ongoing site characterization work four (4) recovery wells were installed to remove the residual free product petroleum and to further characterize the nature and extent of the release. It is GES' understanding that this data has been incorporated as part of the HDD construction preparation and response planning activities.

3.1.2 ME II

No prior MEII HDDs have been completed along the HDD S3-0580 ROW.

3.2 On Other HDD Alignments in Similar Hydrogeologic Settings

3.2.1 ME I

No IRs were reported on the list of IRs for ME I documented in the IR PPC Plan for sites underlain by the Baltimore Gneiss.

3.2.2 ME II

Minor fluid losses and IR have occurred at nearby HDDs S3-0520 and S3-0560. Experience has demonstrated that these issues often occur at lithologic boundaries, at entry/exit points where overburden soils exhibit low cohesive properties, and at where fracture traces cross the alignments identified by fracture trace analysis. Although the geology at HDD S3-0560 is similar, a potential increase in bedrock fracture density at the HDD S3-0580 location and associated potential increase in risk for fluid losses and IRs is indicated by the fracture trace analysis.

4.0 SUMMARY AND CONCLUSIONS OF HDD HYDROGEOLOGIC EVALUATION

4.1 HDD Site Conceptual Model

HDD S3-0580 is located along an upland ridge that likely serves as a local groundwater recharge zone. The hydrogeologic conceptual model for HDD S3-0580 has groundwater flowing generally along topography away from the boring, mostly southwest towards Chester Creek and its tributaries. If significant volumes of drilling fluids were lost, they will tend to migrate along secondary paths of porosity toward groundwater discharge points or residential wells.

Groundwater flow is likely controlled by significant fracturing as indicated by the rock core RQDs and fracture trace analysis. Installing a horizontal boring within this flow system could lower the water table in the immediate vicinity of the borehole. There is a potential 30 to 32 foot elevation difference, between the water table from the central upland area of the drills, to the southeastern entry/exits. If the HDD contacts a significant fracture network, it could produce quantities of flow back groundwater greater than can be recycled and re-used in the drilling process. Subsequently, a groundwater flow back containment system should be deployed at the drill site to manage excess groundwater discharge to land surface.

The fracture trace analysis identified significant linear features crossing the drill path at (approximately) 275, 1,520, and 2,740 feet from the northwest entry/exit point. Risk of drilling fluid losses and IRs is increased at these locations. Risk of fluid losses and IRs is also increased near the entry/exit points as the bore passes through relatively non-cohesive soils and saprolite.

It has been verified that 26 properties are located within 450 feet of the HDD S3-0580 ROW with all but 3 properties served by residential wells. These wells are open cased at the same depth as the boring, which increases the risk of impact by drilling fluids. The nearest public water supply is located on North Middletown Road, approximately 1,500 feet north of the northwest HDD entry/exit. The exclusive historical use of residential wells in this neighborhood demonstrates network of geologic structures is sufficient to create enough secondary porosity for the aquifer to be productive for domestic water supplies.

The proposed HDD potentially may encounter the preexisting residual petroleum-contaminated soil and groundwater near the area of Valley Road and Gradyville Road at the northwestern entry/exit point of the HDD. HDD cuttings from this area will be field screened for petroleum residue. If detected, cuttings will be properly characterized onsite, segregated and managed separately for disposal. Similarly, petroleum affected groundwater if produced, will be screened for impact and an appropriate management program implemented prior to further advancement of the drill.

4.2 Recommendations

The synthesis of regional and local geologic land development data for the HDD S3-0580 site suggests a moderate- to high-risk of drilling mud loss, drilling difficulties related to bedrock type, the potential for inadvertent returns, and potential to encounter petroleum hydrocarbon residue already existing within the drill path. The location of the HDD along a groundwater recharge zone, a complex structural geology including a high degree of fracturing, 30 to 32 foot difference between the water table and southeast entry/exit point and close proximity of residential wells represent potential adverse risks for this HDD site. Recommendations to mitigate the risks include the following:

- The drill crew should be oriented, prior to initiation of drilling, to the locations of zones of higher risk for fluid loss and IRs, including fracture zones identified by the fracture trace analysis along the drill path at approximately 275 feet, 1,520 feet, and 2,740 feet from the northwest entry/exit

point. Other zones of elevated risk include the borehole entry/exit points where drilling fluids may migrate through shallow low cohesive soils and saprolite as the drill descends from the entry and shallows toward the drill exit.

- Given the risk for fluid losses and IRs, a fluid loss mitigation plan (i.e., grouting or sealing) should be developed and implemented during and after construction. The annulus between the installed pipe and borehole wall should be properly sealed upon completion to prevent possible long-term migration of groundwater through the borehole annulus.

- A flow back water management system is recommended before drilling to handle excess produced water. If significant flow back water is continuously generated, all wells within a 450 ft. radius of the alignment should be inspected periodically to evaluate changes to the water table level and well yields. A contingency plan to connect nearby residents to a supplemental water supply should be prepared in case it needs to be implemented. Identifying the closest public water service and its respective proximity to the HDD should also be completed.

- Drilling fluid returns, drill cuttings, and produced groundwater should be carefully monitored for presence of volatile organics during this project. If olfactory evidence, elevated photoionization detector (PID) readings, or a sheen suggest petroleum contamination drilling should be suspended until cuttings and water samples can be analyzed. Affected materials should be screened prior to disposal and a proper disposal plan prepared for such materials.

5.0 REFERENCES

Blackmer, G. C., 2005, Preliminary bedrock geologic map of a portion of the Wilmington 30- by 60-minute quadrangle, southeastern Pennsylvania: Pennsylvania Geological Survey, 4th ser., Open-File Report OFBM 05–01.0, 16 p.

Edgmont Township. 2015. Comprehensive Plan for the Township of Edgmont, http://edgmont.org, 129 p.

ESRI. 2017. Community Topographic Map, Pennsylvania Spatial Data Access.

Hall, G. M. 1934. Ground Water in Southeastern Pennsylvania, Geological Survey Water Resource Report 2, 255 p.

Johnson, R. B. and J. V. DeGraff. 1988. Principles of Engineering Geology, Wiley, 512 p.

Low, D. J., D. J. Hippe, and D. Yannacci. 2002. Geohydrology of Southeastern Pennsylvania. United States Geological Survey, Water-Resources Investigations Report 00-4166, 346 p.

Pennsylvania Geological Survey. Pennsylvania groundwater information system (PaGWIS). Pennsylvania Geological Survey, 4th series, SQL database, http://dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm.

PADEP. 2017. Pennsylvania Department of Environmental Protection eMapPA Database. http://www.depgis.state.pa.us/emappa/. Accessed 10/2017.

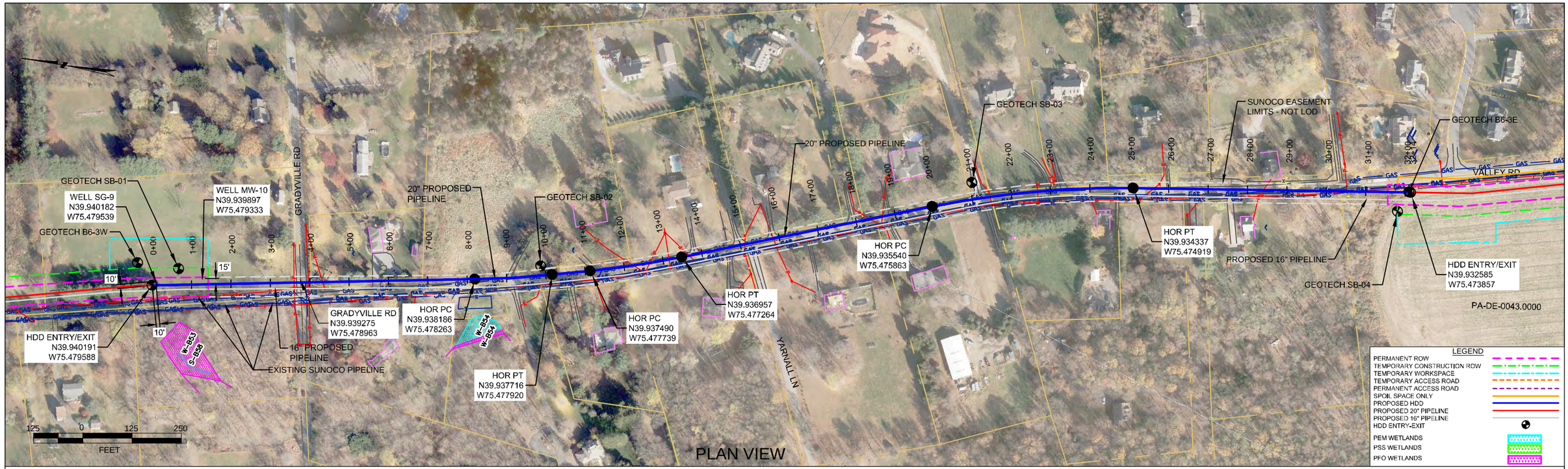
PASDA. 2017. Pennsylvania Spatial Data Access, http://www.pasda.psu.edu, 2008 LiDAR PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. Accessed October, 2017.

Tetra Tech, Inc., "HDD Inadvertent Return Assessment, Preparedness, Prevention and Contingency Plan, Pennsylvania Pipeline Project", submitted to PADEP as part of the Chapter 105 permit application, December, 2016 and amended, August 2017.

USDA NRCS. 2017. Web Soil Survey for Chester and Delaware Counties, Pennsylvania, https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx. Accessed 10/18/2017

USGS 2010. Media Quadrangle, Pennsylvania [topographic map]. 1:24,000, 7.5-Minute Series. Washington, D.C. 1 p.

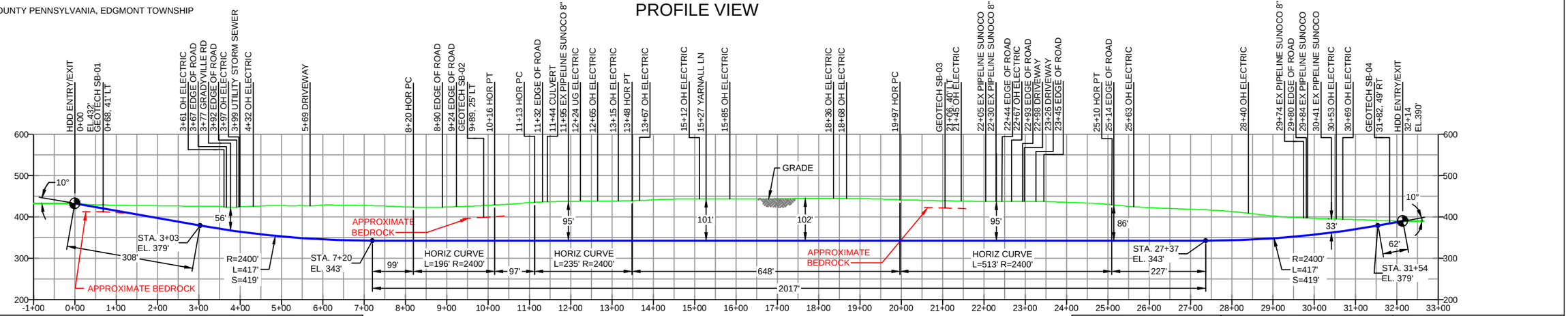
ATTACHMENT A



PLAN VIEW

PROFILE VIEW

DELAWARE COUNTY PENNSYLVANIA, EDGMONT TOWNSHIP
S3-0580



GEOTECH SB-01
- NG EL. 429'
- -TOPSOIL (0' - 0.7')
- -SC (0.7' - 6.5')
- -GROUNDWATER (8.0')
- -SM (6.5' - 13.5')
- -WEATHERED GNEISS (13.5' - 14.0')
- -COMPLETION DEPTH EL. 415'

GEOTECH SB-02
- NG EL. 430'
- -TOPSOIL (0' - 0.2')
- -GROUNDWATER (8.0')
- -SM (0.2' - 16.0')
- -WEATHERED GNEISS (16.0' - 24.0')
- -FRACTURED GNEISS (24.0' - 31.0')
- -COMPLETION DEPTH EL. 399'

GEOTECH SB-03
- NG EL. 439'
- -TOPSOIL (0' - 0.2')
- -SM (0.2' - 8.0')
- -FRACTURED GNEISS (8.0' - 17.5')
- -COMPLETION DEPTH EL. 421'

NOTE: REFER TO TEST BORING LOG S3-0580 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=):3214'
   HDD PIPE LENGTH (S=):3223'
   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 NO 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.

GEOTECH SB-04
- NG EL. 387'
- -TOPSOIL (0' - 0.2')
- -SM (0.7' - 30.0')
- -GROUNDWATER (19.0')
- -COMPLETION DEPTH EL. 357'

NOTE: REFER TO TEST BORING LOG S3-0580 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-3E
- NG EL. 390'
- -POORLY GRADED SAND W/ SILT AND GRAVEL SP-SM (0.0' - 55.0')
- -GROUNDWATER (26.0')
- -SCHIST/GNEISS (55.0' - 100.0')
- -BORING TERMINATED EL.290'

NOTE: REFER TO TEST BORING LOG B6-3E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-3W
- NG EL. 434'
- -TOPSOIL (0' - 1.0')
- -SILT WITH SAND ML (1.0' - 1.5')
- -POORLY GRADED SAND SP (1.5' - 13.0')
- -GROUNDWATER (10.0')
- -POORLY GRADED GRAVEL W/ SAND GP (13.0' - 18.0')
- -AMPHIBOLITE/GNEISS (18.0' - 130.0')
- -BORING TERMINATED EL. 304'

NOTE: REFER TO TEST BORING LOG B6-3W 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-6.07	TO	ES-6.09	EROSION & SEDIMENT PLAN	
SHEET 4	TO	SHEET 5	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	11/27/17	RMB	11/27/17	AMC	11/27/17
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	10/21/16	RBM	10/21/16	AAW	10/21/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/10/16	RMB	05/10/16	AAW	05/10/16
EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15

Sunoco Logistics Partners L.P.

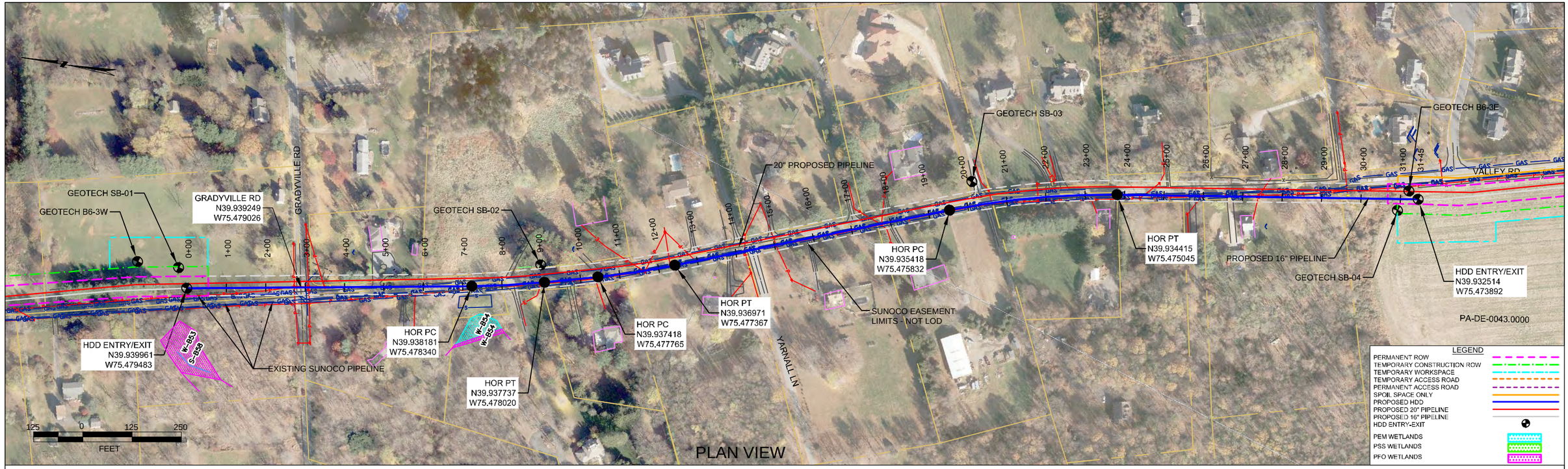
TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GRADYVILLE RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'

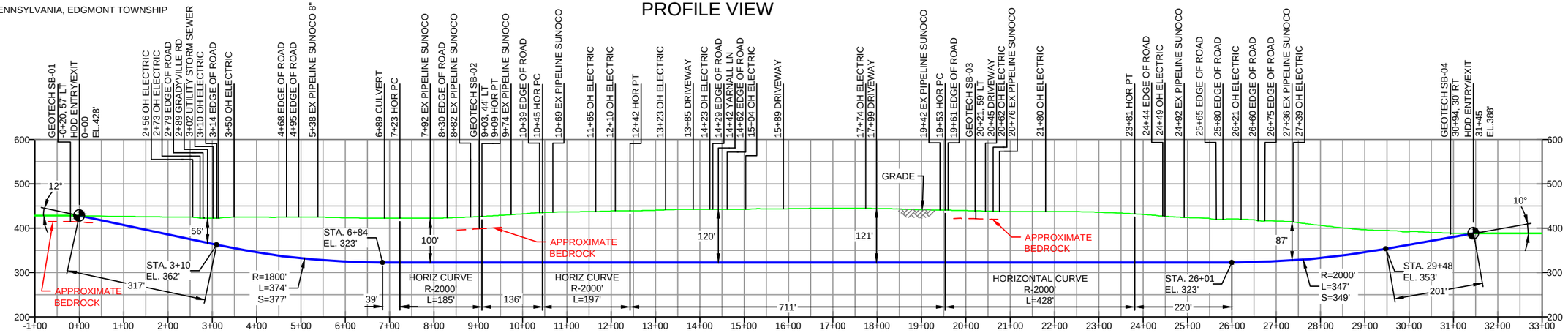
DWG. NUMBER: PA-DE-0032.0000-RD



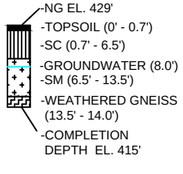
PLAN VIEW

PROFILE VIEW

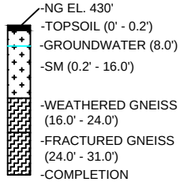
DELAWARE COUNTY PENNSYLVANIA, EDGMONT TOWNSHIP
S3-0580-16



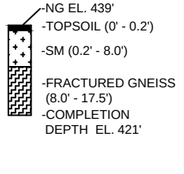
GEOTECH SB-01



GEOTECH SB-02



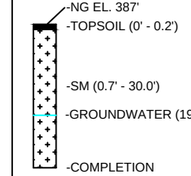
GEOTECH SB-03



NOTE: REFER TO TEST BORING LOG S3-0580 FOR COMPLETE SOIL MATERIAL DESCRIPTION

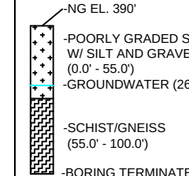
DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):3145'
   HDD PIPE LENGTH (S=):3160'
   16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, 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 NO 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.

GEOTECH SB-04



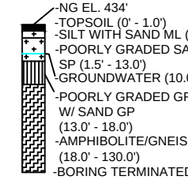
NOTE: REFER TO TEST BORING LOG S3-0580 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-3E



NOTE: REFER TO TEST BORING LOG B6-3E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-3W



NOTE: REFER TO TEST BORING LOG B6-3W 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-6.07	TO	ES-6.09	EROSION & SEDIMENT PLAN
SHEET 4	TO	SHEET 5	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP4	UPDATED GEOTECH INFO PROVIDED BY DPS	MRS	11/27/17	RMB	11/27/17	AMC	11/27/17
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	10/21/16	RMB	10/21/16	AAW	10/21/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/10/16	RMB	05/10/16	AAW	05/10/16
EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
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
GRADYVILLE RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'

DWG. NO: PA-DE-0032.0000-RD-16

ATTACHMENT B

October 11, 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 – Gradyville Road
Commonwealth of Pennsylvania
Drawing # PA-DE-0032.0001-RD
PO #20170804-18
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 Gradyville Road (Drawing # PA-DE-0032.0001-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 B6-3W and B6-3E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B6-3W and B6-3E were drilled between August 22 and September 7, 2017 to depths of 130.0 and 100.0 feet, respectively as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of metamorphic rock comprised of gneiss, amphibolite, and schist. 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 B6-3W. Rock compressive strength testing was not performed on samples from B6-3E, because we understand the pipe invert is above the bedrock surface. Unconfined compressive strength test results are shown on the attached reports.

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

Sincerely,
Terracon Consultants, Inc.

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

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

Attch:

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

TEST BORING LOCATION PLAN

N

APPROXIMATE BORING LOCATION

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

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

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

TEST BORING LOCATION PLAN

Gradyville Road HDD Cores B6-3W and B6-3E
PA-DE-0032.0001-RD
Delaware County, Pennsylvania

Exhibit

A-2

EXPLORATION RESULTS

BORING LOG NO. B6-3W Gradyville Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.94035° Longitude: -75.47946°

Approximate Surface Elev: 391 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
1.0	390+/-	Topsoil
1.5	389.5+/-	**SILT WITH SAND (ML)**, with roots, brown to yellow
		POORLY GRADED SAND (SP), trace silt, trace gravel, brown, medium dense
13.0	378+/-	
		POORLY GRADED GRAVEL WITH SAND (GP), trace silt, dark brown, dense
		Occasional cobbles from 15 to 18 feet
18.0	373+/-	
		Weathered rock
20.0	371+/-	
		Run 1, Hard, severely to moderately weathered, gray, coarse-grained GNEISS, primary joint set, high angle, very close spacing, wide
25.0	366+/-	
		Run 2, Hard, moderately to slightly weathered, gray to green, coarse-grained GNEISS, primary joint set, high angle dipping; secondary joint set, moderate dipping, close spacing, wide to open
30.0	361+/-	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
			11	2-3-3 N=6			
5			17	5-5-8 N=13			
10	▽		17	8-8-15 N=23			
15			10	16-24-20 N=44			
20			35.5		7.5	2 3 3 2 2	
25			52		28.0	2 3 3 4 4	
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:
Gneiss typically contained garnet, chlorite, plagioclase, quartz, and hornblende.

WATER LEVEL OBSERVATIONS

▽ 10' WD

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 Driller: Terracon/Clayton J.

Project No.: J217P078

BORING LOG NO. B6-3W Gradyville Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION
Latitude: 39.94035° Longitude: -75.47946°
Approximate Surface Elev: 391 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
Run 3, Similar					5 4 4 4 3
35.0	356+/-	35	40	33.0	
Run 4, Hard, fresh, gray to green, coarse-grained GNEISS, primary joint set, high angle; secondary joint set, moderate dipping, close spacing, wide					4 4 4 4 4
40.0	351+/-	40	53.5	28.0	
Run 5, Hard, fresh, gray to green, coarse-grained GNEISS, primary joint set, moderately dipping; secondary joint set, vertical, close spacing, wide to open					4 5 5 6 3
45.0	346+/-	45	60	46.0	
Run 6, Very hard, fresh, gray to green, medium to coarse-grained GNEISS, primary joint set, moderately dipping; secondary joint set, high angle, close spacing, open					5 5 6 6 5
50.0	341+/-	50	57	78.0	
Run 7, Very hard, fresh, gray to green, medium to coarse-grained GNEISS, primary joint set, moderately dipping; secondary joint set, high angle, close to moderately close spacing, moderately open to open, vertical fracture from 50 to 50.9 feet Note: Changed core bit at 55 feet					7 8 8 10 12
55.0	336+/-	55	60	87.0	
Run 8, Similar					6 5 5 6 7
60.0	331+/-	60	60	78.0	

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

10' WD

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017
Drill Rig: Diedrich D-50 Driller: Terracon/Clayton J.
Project No.: J217P078

BORING LOG NO. B6-3W Gradyville Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.94035° Longitude: -75.47946°

Approximate Surface Elev: 391 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
Run 9, Similar, moderately close spacing					
65.0	326+/-	65	60	96.0	4 5 5 5 5
Run 10, Hard, fresh, black to green, fine-grained AMPHIBOLITE, primary joint set, moderately dipping; secondary joint set, high angle, close spacing, open to wide, vertical fracture at 69.5 feet			49.5	73.0	4 4 4 4 4
70.0	321+/-	70			
Run 11, Hard, fresh, black to green, fine-grained AMPHIBOLITE, primary joint set, moderately dipping; secondary joint set, low angle dipping, moderately close spacing, open			60	88.0	2 2 2 2 2
Note: Lost all water return at 75 feet					
75.0	316+/-	75			
Run 12, Hard to very hard, fresh, black to green, fine-grained AMPHIBOLITE, primary joint set, moderately dipping; secondary joint set, high angle dipping, close spacing, wide			60	62.0	2 2 2 2 2
80.0	311+/-	80			
Run 13, Very hard, fresh, black to green, fine-grained AMPHIBOLITE, primary joint set, moderately dipping; secondary joint set, high angle dipping, close spacing, open to wide			60	73.0	2 3 3 3 3
85.0	306+/-	85			
Run 14, Similar			60	63.0	2 2 3 2 3
90.0	301+/-	90			

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

10' WD

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 Driller: Terracon/Clayton J.

Project No.: J217P078

BORING LOG NO. B6-3W Gradyville Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION
Latitude: 39.94035° Longitude: -75.47946°
Approximate Surface Elev: 391 (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, Hard, fresh, black to green, fine-grained AMPHIBOLITE, primary joint set, high angle dipping; secondary joint set, vertical fractures, close spacing, wide Note: Pyrite noted on fracture faces from 90 to 100 feet	95.0 / 296+/-	95			60		13.0	2 3 3 2 3	
	Run 16, Hard to very hard, fresh, gray to green, medium-grained GNEISS, primary joint set, low angle; secondary joint set, high angle, close spacing, open to wide	100.0 / 291+/-	100			60		34.0	3 3 3 3 3	
	Run 17, Hard, fresh, gray to green, medium-grained GNEISS, primary joint set, moderately dipping, close spacing, wide	105.0 / 286+/-	105			60		26.0	2 3 3 3 3	
	Run 18, Hard, slight weathering on joints, gray to green, medium-grained GNEISS, primary joint set, moderately dipping, close spacing, wide Note: Schistose texture from 105 to 110 feet	110.0 / 281+/-	110			60		63.0	3 3 3 3 3	
	Run 19, Moderately hard, fresh, gray to green, fine-grained GNEISS, primary joint set, moderately dipping; secondary joint set, high angle, close spacing, wide	115.0 / 276+/-	115			60		20.0	2 2 6 3 2	
	Run 20, Similar	120.0 / 271+/-	120			60		32.0		

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

10' WD

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017
Drill Rig: Diedrich D-50 Driller: Terracon/Clayton J.
Project No.: J217P078

BORING LOG NO. B6-3W Gradyville Road West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.94035° Longitude: -75.47946°

Approximate Surface Elev: 391 (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 21, Similar									
					60		53.0	4 3 3 4 4	
125.0	266+/-	125							
Run 22, Similar									
					60		78.0	4 4 3 4 4	
130.0	261+/-	130							
Boring Terminated at 130 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:

WATER LEVEL OBSERVATIONS

▽ *10' WD*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 8/22/2017 Boring Completed: 8/24/2017

Drill Rig: Diedrich D-50 Driller: Terracon/Clayton J.

Project No.: J217P078

BORING LOG NO. B6-3E Gradyville Road East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.932597° Longitude: -75.473861°

Approximate Surface Elev: 348 (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)
POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM), with weathered rock, brown, medium dense to very dense								
	5			17	4-5-6 N=11			
	10			16	4-12-8 N=20			
	15			12	3-5-7 N=12			
	20			14	5-8-9 N=17			
	25	▽		12	6-6-8 N=14			
		▽						
	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

▽ *27' AB*
▽ *26' after 1.5 hrs*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 9/6/2017 Boring Completed: 9/7/2017
Drill Rig: Diedrich D-50 Driller: Terracon/Clayton J.
Project No.: J217P078

BORING LOG NO. B6-3E Gradyville Road East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.932597° Longitude: -75.473861°

Approximate Surface Elev: 348 (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)
		POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM), with weathered rock, brown, medium dense to very dense *(continued)*				9	44-50/3"			
			35			0	50/3"			
			40			18	14-27-50/4"			
			45			12	17-22-40 N=62			
			50			0	50/3"			
55.0	293+/-	Weathered rock, friable	55			4	50/5"			
60.0	288+/-		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

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

27' AB

26' after 1.5 hrs

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 9/6/2017 Boring Completed: 9/7/2017

Drill Rig: Diedrich D-50 Driller: Terracon/Clayton J.

Project No.: J217P078

BORING LOG NO. B6-3E Gradyville Road East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.932597° Longitude: -75.473861°

Approximate Surface Elev: 348 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Run	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
65.0	283+/-	Run 1, Moderately hard, severely weathered, orange-brown SCHIST/GNEISS, close joint spacing	48	16	2 10 2 2 2
70.0	278+/-	Run 2, Moderately hard, moderately weathered, gray SCHIST, close joint spacing At 67 feet : Moderately hard to hard, slightly weathered, gray, black, red GNEISS, very close to close joint spacing	59	73	2 2 3 2 3
75.0	273+/-	Run 3, Similar	59	90	4 4 11 3 3
80.0	268+/-	Run 4, Hard, slightly weathered, black/gray granitic GNEISS, close to moderately close joint spacing	58	NR	4 3 3 3 3
85.0	263+/-	Run 5, Hard, fresh, black/gray granitic GNEISS moderately close joint spacing	60	97	3 3 3 3 2
90.0	258+/-	Run 6, Similar, slightly weathered	60	93	3 3 4 3 5

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

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

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

27' AB
26' after 1.5 hrs

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 9/6/2017 | Boring Completed: 9/7/2017
Drill Rig: Diedrich D-50 | Driller: Terracon/Clayton J.
Project No.: J217P078

BORING LOG NO. B6-3E Gradyville Road East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 6

LOCATION

Latitude: 39.932597° Longitude: -75.473861°

Approximate Surface Elev: 348 (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 7, Similar									
					60		97	4 4 3 5 3	
95.0	253+/-	95							
Run 8, Similar									
					60		89	17 13 12 11 12	
100.0	248+/-	100							
Boring Terminated at 100 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:

WATER LEVEL OBSERVATIONS

27' AB
26' after 1.5 hrs

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 9/6/2017 Boring Completed: 9/7/2017

Drill Rig: Diedrich D-50 Driller: Terracon/Clayton J.

Project No.: J217P078

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

Boring No.:	B6-3W	Lithology :	Gneiss
Sample No.:	1	Moisture Content :	As received
Sample Depth:	20 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	11 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	36,560 lb
Length:	3.07 in	Compressive Strength:	11,995 psi
L/D:	1.56	Compressive Strength:	82.70 Mpa
End Area:	3.05 in^2	Unit Weight	166 pcf

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

Before the Test

After the Test

Drawing # :	PA-DE-0032.0001-RD
PO # :	20170804-18
Crossing :	Gradyville Road
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 :	10/11/2017

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

Boring No.:	B6-3W	Lithology :	Gneiss
Sample No.:	2	Moisture Content :	As received
Sample Depth:	41 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	15 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	49,850 lb
Length:	4.54 in	Compressive Strength:	16,190 psi
L/D:	2.29	Compressive Strength:	111.63 Mpa
End Area:	3.08 in^2	Unit Weight	174 pcf

Before the Test

After the Test

Drawing # :	PA-DE-0032.0001-RD
PO # :	20170804-18
Crossing :	Gradyville Road
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 :	10/11/2017

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

Boring No.:	B6-3W	Lithology :	Gneiss
Sample No.:	3	Moisture Content :	As received
Sample Depth:	58 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	20,860 lb
Length:	4.45 in	Compressive Strength:	6,707 psi
L/D:	2.24	Compressive Strength:	46.24 Mpa
End Area:	3.11 in^2	Unit Weight	173 pcf

Photographs are mislabeled as 6-3W-4

Before the Test

After the Test

Drawing # : PA-DE-0032.0001-RD
PO # : 20170804-18
Crossing : Gradyville Road
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 :	10/11/2017

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

Boring No.:	B6-3W	Lithology :	Amphibolite
Sample No.:	4	Moisture Content :	As received
Sample Depth:	77 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	18 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	59,810 lb
Length:	4.39 in	Compressive Strength:	19,425 psi
L/D:	2.22	Compressive Strength:	133.93 Mpa
End Area:	3.08 in^2	Unit Weight	193 pcf

Photographs are mislabeled as 6-3W-1

Before the Test

After the Test

Drawing # :	PA-DE-0032.0001-RD
PO # :	20170804-18
Crossing :	Gradyville Road
Spread :	Spread 6

Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No.	J217P078		Test Date:	10/11/2017
Location:	Spread 6		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/11/2017

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

Boring No.:	B6-3W	Lithology :	Amphibolite
Sample No.:	5	Moisture Content :	As received
Sample Depth:	84.5 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	7 min

Diameter:	1.99 in	Maximum Axial Load at Failure:	23,190 lb
Length:	4.92 in	Compressive Strength:	7,456 psi
L/D:	2.47	Compressive Strength:	51.41 Mpa
End Area:	3.11 in^2	Unit Weight	192 pcf

Photographs are mislabeled as 6-3W-3

Before the Test

After the Test

Drawing # :	PA-DE-0032.0001-RD
PO # :	20170804-18
Crossing :	Gradyville Road
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 :	10/11/2017

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

Boring No.:	B6-3W	Lithology :	Amphibolite
Sample No.:	6	Moisture Content :	As received
Sample Depth:	95 feet	Lab Temperature :	70° F
Sampling Date:	8/22/17	Loading Rate:	55 psi/s
		Time to Failure:	5 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	17,360 lb
Length:	3.61 in	Compressive Strength:	5,638 psi
L/D:	1.82	Compressive Strength:	38.87 Mpa
End Area:	3.08 in^2	Unit Weight	191 pcf

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

Before the Test

Photographs are mislabeled as 6-3W-5

After the Test

Drawing # : PA-DE-0032.0001-RD
PO # : 20170804-18
Crossing : Gradyville Road
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 :	10/11/2017

Photograph 1: B6-3W, Samples C-1 to C-4 (20 to 40 feet)

Photograph 2: B6-3W, Samples C-5 to C-8 (40 to 60 feet)

Photograph 3: B6-3W, Samples C-9 to C-12 (60 to 80 feet)

Photograph 4: B6-3W, Samples C-13 to C-16 (80 to 100 feet)

Photograph 5: B6-3W, Samples C-17 to C-20 (100 to 120 feet)

Photograph 6: B6-3W, Samples C-21 to C-22 (120 to 130 feet)

Photograph 1: B6-3E, Samples C-1 to C-4 (60 to 80 feet)

Photograph 2: B6-3E, Samples C-5 to C-8 (80 to 100 feet)

SUPPORTING INFORMATION

UNIFIED SOIL CLASSIFICATION SYSTEM

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

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

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

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

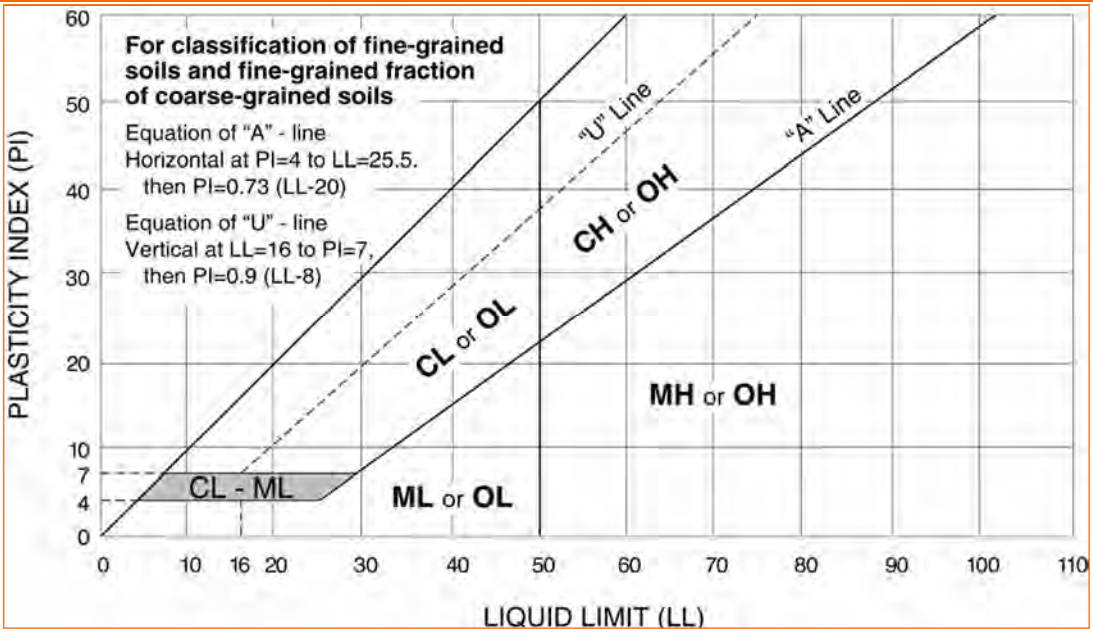
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very Slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately Severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very Severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.
HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)	
Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately Hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very Soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

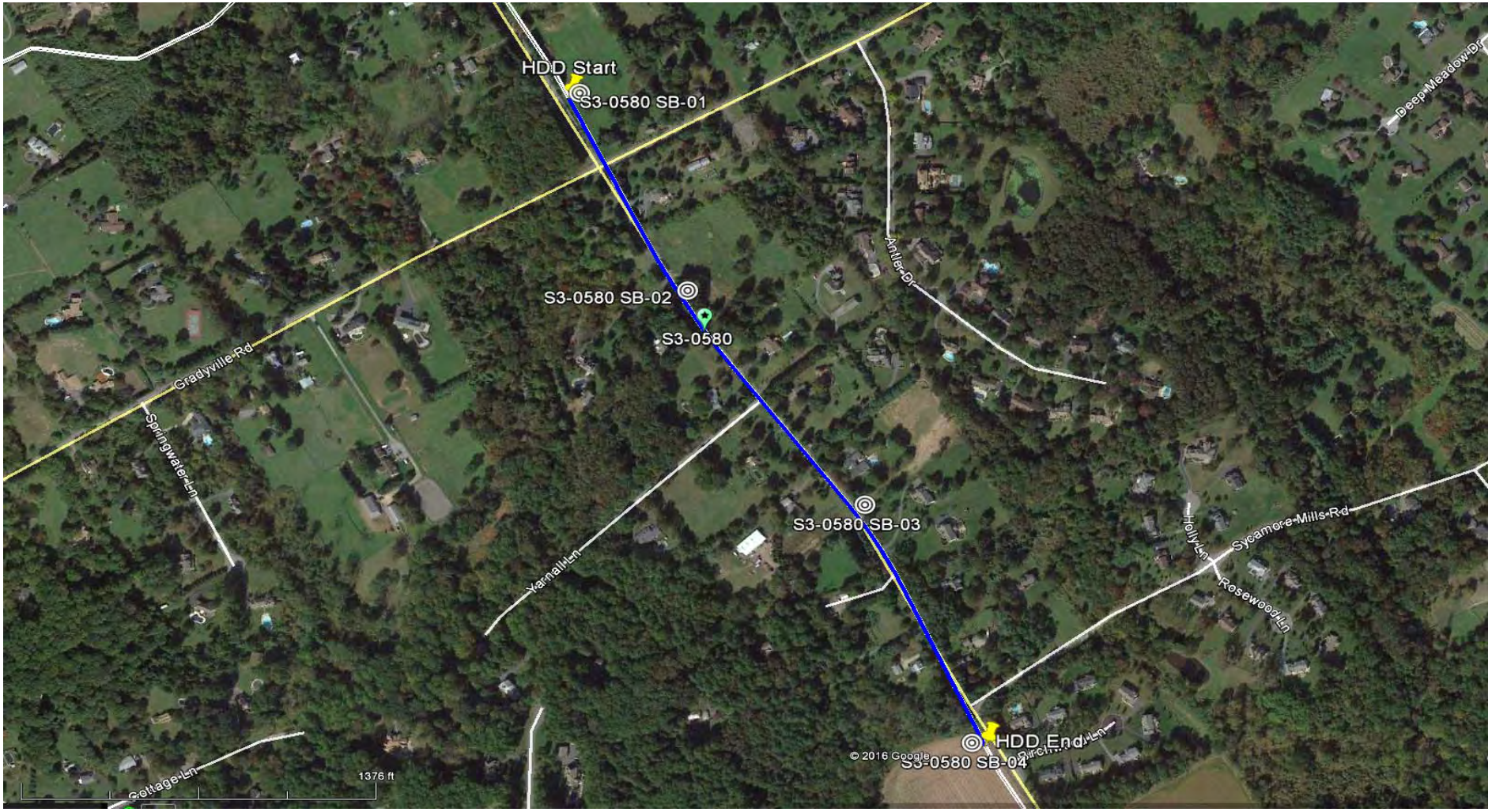
RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

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

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.



LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S3-0580
DELAWARE COUNTY, EDGMONT 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:	VALLEY ROAD, GLEN MILLS, PA		Page 1 of 1
HDD No.:	S3-0580	Dates(s) Drilled: 12-15-15	Inspector: J. COSTELLO
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 8.0	Total Depth (ft): 14.0
Boring Location Coordinates:		39°56'24.27"N	75°28'45.65"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	0.7			TOPSOIL (8")					
1	3.0	5.0	0.7		16	SC	DR, REDDISH BROWN WITH BLACK MOTTLES, FINE SAND AND SILTY	1	4	5	7	**9**
				6.5			CLAY, WITH A LITTLE FINE ROCK FRAGS. (USCS: SC)					
2	8.0	10.0	6.5		20	SM	DR, REDDISH BROWN TO ORANGE BROWN FINE SAND WITH SOME	4	5	3	3	**8**
				13.5			SILT, TRACE FINE ROCK FRAGMENTS.					
3	13.0	13.8	13.5	14.0	7		PARTIALLY WEATHERED SCHIST OR GNEISS.	8	50/4"			**>50**
							AUGER REFUSAL AT 14'. OFF-SET BORING AND CONTINUOUSLY					
							AUGERED TO REFUSAL AT 13.7'.					
							WATER LEVEL THROUGH AUGERS AT 8'.					
							CAVED AND WET AT 13'.					

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:	1320 VALLEY ROAD, GLEN MILLS, PA		Page 1 of 1
HDD No.:	S3-0580	Dates(s) Drilled: 11-01-15	Inspector: J. COSTELLO
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 8.0	Total Depth (ft): 31.0
Boring Location Coordinates:		39°56'16.13"N	75°28'40.42"W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.2			TOPSOIL (2")					
1	3.0	5.0	0.2		18		DARK REDDISH BROWN FINE TO MEDIUM SAND WITH SOME SILT,	2	2	4	6	**6**
							TRACE MICA.					
2	8.0	10.0			24	SM	DR, BROWN TO GRAY FINE TO MEDIUM SAND, SOME F-C UNWEATHERE	15	21	31	38	**52**
							GRAVEL, A LITTLE SILT.					
3	13.0	13.8			11		DR, BROWN TO GRAY FINE TO MEDIUM SAND, SOME F-C UNWEATHERE	22	50/4"			**>50**
				16.0			GRAVEL, A LITTLE SILT. (USCS: SM)					
4	18.0	19.4	16.0		12	GM/SM - PARTIALLY WEATHERED ROCK	INTERLAYERS OF GRAY F-M SAND AND PARTIALLY WEATHERED	23	38	50/5"		**>50**
							GNEISS.					
5	23.0	24.2			14		INTERLAYERS OF GRAY, WHITE, BRWON F-M SAND AND PARTIALLY	6	24	50/2"		**>50**
				24.0			WEATHERED GNEISS.					
							AUGER REFUSAL AT 24'.					
							ROCK CORING					
RUN 1	24.0	26.0	24.0		15	ROCK	INTENSELY FRACTURED GRAY GNEISS, WITH DECOMPOSED	TCR: 63%, SCR: 25%, RQD: 0%				
							ZONES.					
RUN 2	26.0	29.0			27		MODERATELY FRACTURED GRAY GNEISS	TCR: 75%, SCR: 44%, RQD: 42%				
RUN 2	29.0	31.0		31.0	20.5		GRAY GNEISS	TCR: 85%, SCR: 73%, RQD: 73%				
							CAVED AT 24'.					
							CORE TESTING RESULTS (DEPTH 29-29.5'):					
							COMPRESSIVE STRENGTH: 11,076 PSI					
							UNIT WEIGHT: 176.6 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:	1243 VALLEY ROAD, GLEN MILLS, PA		Page 1 of 1
HDD No.:	S3-0580	Dates(s) Drilled: 02-24-16	Inspector: E. WATT
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: D. BOLZE
Drilling Contractor:	CGC	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 17.5
Boring Location Coordinates:		39° 56' 7.31" N	75° 28' 31.84" 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	0.2			TOPSOIL (2")					
1	3.0	5.0	0.2			SM	ORANGE BROWN MICACEOUS FINE TO MEDIUM SAND WITH SOME	7	4	3	5	**7**
							SILT (USCS: SM).					
2	8.0	8.0		8.0			NO RECOVERY	50/0"				
							AUGER REFUSAL AT 8'.					
							ROCK CORING					
RUN 1	8.0	11.0	8.0	9.1	11		MODERATELY TO INTENSELY FRACTURED GNEISS.	TCR: 30%, SCR: 19%, RQD: 19%				
							OFFSET BORING BECAUSE AUGERS WERE MADE OUT OF PLUMB					
							DURING AUGER GRINDING TO 8'. AUGERED TO REFUSAL AT 5'.					
							ROCK CORING					
RUN 1	5.0	8.0	5.0		21	ROCK	VERY INTENSELY FRACTURED GNEISS (HIGHLY WEATHERED ROCK)	TCR: 58%, SCR: 0%, RQD: 0%				
RUN 2	8.0	12.0			24		VERY INTENSELY FRACTURED GNEISS (HIGHLY WEATHERED ROCK)	TCR: 50%, SCR: 8%, RQD: 0%				
RUN 3	12.0	17.5		17.5	38		VERY INTENSELY FRACTURED GNEISS (HIGHLY WEATHERED ROCK)	TCR: 57%, SCR: 26%, RQD: 7%				
							CORE TESTING RESULTS (DEPTH 12.5-13'):					
							COMPRESSIVE STRENGTH: 12,574 PSI					
							UNIT WEIGHT: 158.4 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:	VALLEY ROAD, GLEN MILLS, PA		Page 1 of 1
HDD No.:	S3-0580	Dates(s) Drilled: 10-13-15	Inspector: E. WATT
Boring No.:	SB-04	Drilling Method: SPT - ASTM D1586	Driller: E. OGDEN
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 19.0	Total Depth (ft): 30.0
Boring Location Coordinates:		39° 55' 57.39" N	75° 28' 26.63" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.7			TOPSOIL (8")					
1	3.0	5.0	0.7		16		DR, VARIEGATED LIGHT BROWN, BROWN, ORANGE BROWN FINE	2	4	6	7	**10**
							TO MEDIUM MICACEOUS SAND AND SILT.					
2	8.0	10.0			21		DR, VARIEGATED LIGHT BROWN, BROWN, ORANGE BROWN FINE	1	2	3	6	**5**
							MICACOUS SAND WITH SOME SILT.					
3	13.0	15.0			24		DR, VARIGATED TAN, DARK GRAY, BROWN, MICACEOUS FINE SAND,	1	2	3	4	**5**
						SM	SOME SILT.					
4	18.0	20.0			24		DR, VARIGATED TAN, DARK GRAY, BROWN, MICACEOUS FINE SAND	2	3	4	9	**7**
							AND SILT. (USCS: SM).					
5	23.0	25.0			24		DR, VARIEGATED BROWN, GRAY, WHITE, ORANGE BROWN FINE TO	2	7	12	18	**19**
							MEDIUM MICACEOUS SAND, SOME SILT.					
6	28.0	30.0		30.0	24		SAME.	3	12	1	41	**13**
							WET ON SPOON AT 16'					
							WATER LEVEL THROUGH AUGERS AT 19'					
							CAVED AT 26', WATER LEVEL ON CAVE AT 19'.					

Notes/Comments:
Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

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

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

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0580

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)
S3-0580	SB-01	1	3.0	5.0	32.7	39.4	37	23	14	SC
		2	8.0	10.0	59.2	29.1	-	-	-	-
		3	13.0	13.8	48.5	26.8	-	-	-	-
	SB-02	1	3.0	5.0	35.8	38.4	-	-	-	-
		2	8.0	10.0	5.2	11.5	-	-	-	-
		3	13.0	13.8	16.9	33.0	NV	NP	NP	SM
		4	18.0	19.4	7.3	25.7	-	-	-	-
		5	23.0	24.2	14.6	24.8	-	-	-	-
	SB-03	1	3.0	5.0	37.4	39.9	NV	NP	NP	SM
	SB-04	1	3.0	5.0	27.3	49.1	-	-	-	-
		2	8.0	10.0	23.3	30.7	-	-	-	-
		3	13.0	15.0	29.3	26.4	-	-	-	-
		4	18.0	20.0	32.8	42.0	42	30	12	SM
		5	23.0	25.0	21.9	27.7	-	-	-	-
		6	28.0	30.0	9.5	24.6	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-03	3	12.5-13.0	12,574	158.4
SB-02	2	29.0-29.5	11,076	176.6

Notes:

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

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0580

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					
S3-0580	SB-02	1	24	26	63	25	0	24	29	Moderate	Gneiss	Massive (thin mica foliations)	Gray	Fractures ranging from 18° to 22°, Avg. 21°; fractures parallel to foliation, no bedding visible
		2	26	29	75	44	42							
		3	29	31	85	73	73							
	SB-03	1	5	8	58	0	0	5	17.5	Heavily	Gneiss	Massive (thin mica foliations)	Gray	Rubble
		2	8	12	50	8	0							One large piece, the rest of the core was rubble
		3	12	17.5	57	26	7							Fractures ranging from 0° to 90°, Avg. 18° (based on larger, intact pieces)

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S3-0580

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
S3-0580	SB-01	Felsic gneiss - Light, medium grained; includes rocks of probable sedimentary origin.	Gently sloping to the south	Felsic gneiss (Precambrian age)	Felsic gneiss; Secondary - paragneiss	No information found during literature review	Ranges from 45 to 55 ft bgs, Avg. 46 ft bgs (.25 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 west					
	SB-03		Generally level					
	SB-04		Generally level					

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

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

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

Relative Proportions

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

Particle Size Identification

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

COHESIVE SOILS

(Silt, Clay & Combinations)

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

Plasticity

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

ROCK

(Rock Cores)

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

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

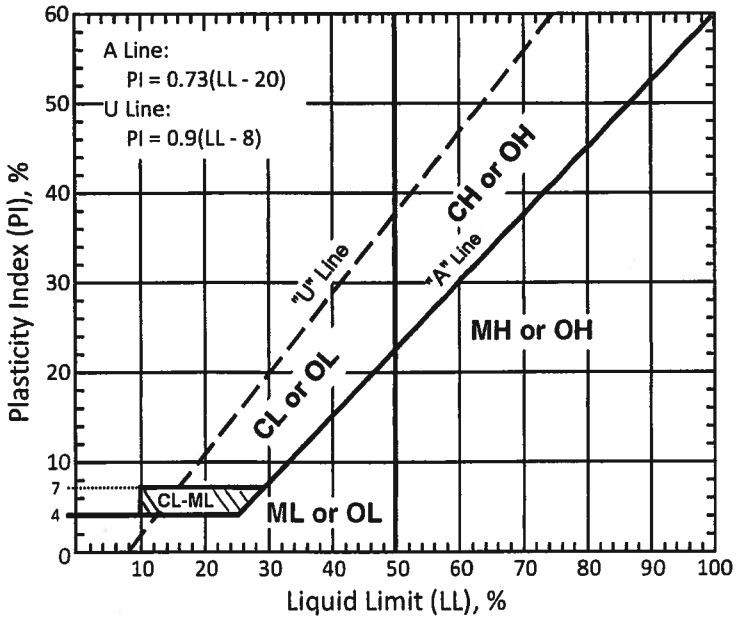
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

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

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

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

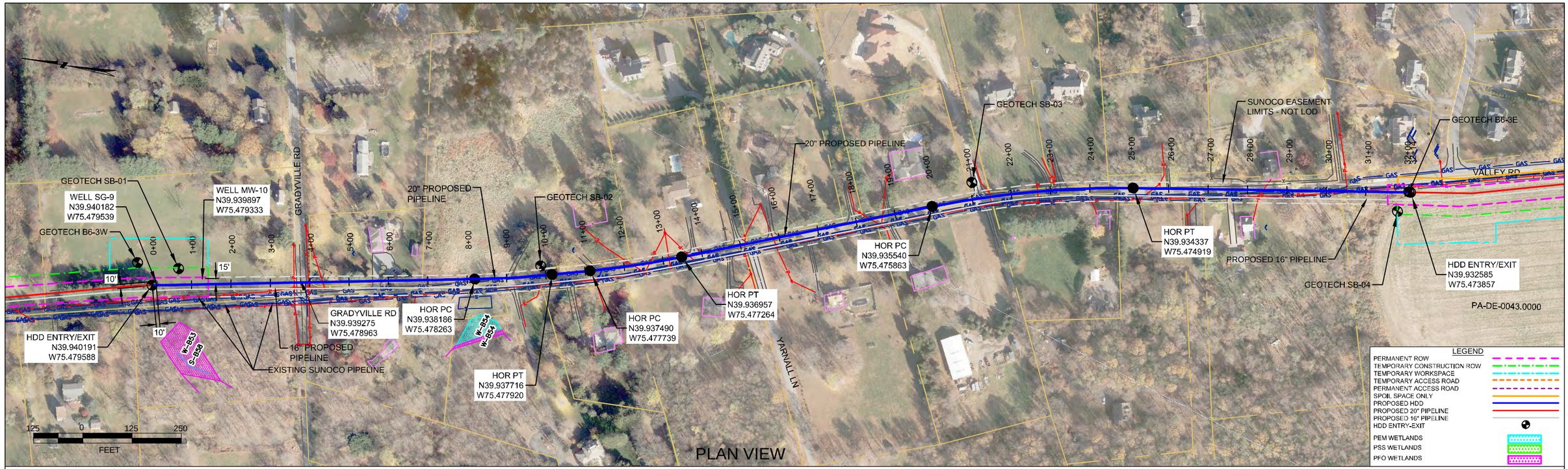


(1) Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC. well-graded gravel-sand mixture with clay binder.

GRADYVILLE ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E23-524
PA-DE-0032.0000-RD and PA-DE-0032.0000-RD-16
(SPLP HDD No. S3-0580 and HDD S3-0580-16)

ATTACHMENT 2

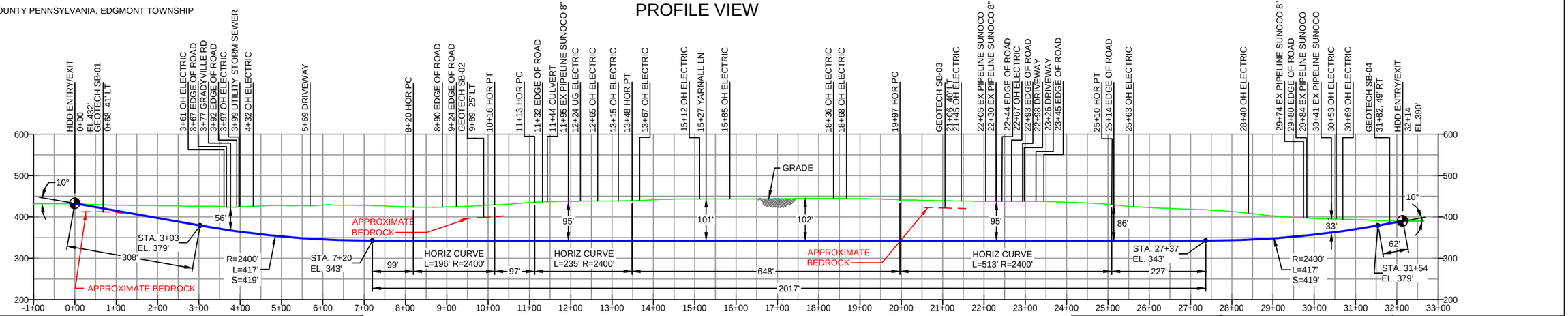
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



PLAN VIEW

PROFILE VIEW

DELAWARE COUNTY PENNSYLVANIA, EDGMONT TOWNSHIP
S3-0580



GEOTECH SB-01
- NG EL. 429'
- -TOPSOIL (0' - 0.7')
- -SC (0.7' - 6.5')
- -GROUNDWATER (8.0')
- -SM (6.5' - 13.5')
- -WEATHERED GNEISS (13.5' - 14.0')
- -COMPLETION DEPTH EL. 415'

GEOTECH SB-02
- NG EL. 430'
- -TOPSOIL (0' - 0.2')
- -GROUNDWATER (8.0')
- -SM (0.2' - 16.0')
- -WEATHERED GNEISS (16.0' - 24.0')
- -FRACTURED GNEISS (24.0' - 31.0')
- -COMPLETION DEPTH EL. 399'

GEOTECH SB-03
- NG EL. 439'
- -TOPSOIL (0' - 0.2')
- -SM (0.2' - 8.0')
- -FRACTURED GNEISS (8.0' - 17.5')
- -COMPLETION DEPTH EL. 421'

NOTE: REFER TO TEST BORING LOG S3-0580 FOR COMPLETE SOIL MATERIAL DESCRIPTION

Figure 1. 20-Inch HDD Plan and Profile

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=):3214'
   HDD PIPE LENGTH (S=):3223'
   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 NO 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.

GEOTECH SB-04
- NG EL. 387'
- -TOPSOIL (0' - 0.2')
- -SM (0.7' - 30.0')
- -GROUNDWATER (19.0')
- -COMPLETION DEPTH EL. 357'

NOTE: REFER TO TEST BORING LOG S3-0580 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-3E
- NG EL. 390'
- -POORLY GRADED SAND W/ SILT AND GRAVEL SP-SM (0.0' - 55.0')
- -GROUNDWATER (26.0')
- -SCHIST/GNEISS (55.0' - 100.0')
- -BORING TERMINATED EL.290'

NOTE: REFER TO TEST BORING LOG B6-3E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-3W
- NG EL. 434'
- -TOPSOIL (0' - 1.0')
- -SILT WITH SAND ML (1.0' - 1.5')
- -POORLY GRADED SAND SP (1.5' - 13.0')
- -GROUNDWATER (10.0')
- -POORLY GRADED GRAVEL W/ SAND GP (13.0' - 18.0')
- -AMPHIBOLITE/GNEISS (18.0' - 130.0')
- -BORING TERMINATED EL. 304'

NOTE: REFER TO TEST BORING LOG B6-3W 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-6.07	TO	ES-6.09	EROSION & SEDIMENT PLAN	
SHEET 4	TO	SHEET 5	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	11/27/17	RMB	11/27/17	AMC	11/27/17
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	10/21/16	RBM	10/21/16	AAW	10/21/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/10/16	RMB	05/10/16	AAW	05/10/16
EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
C	ISSUED FOR BID	DLM	08/21/15	RMB	08/21/15	AAW	08/21/15

Sunoco Logistics Partners L.P.

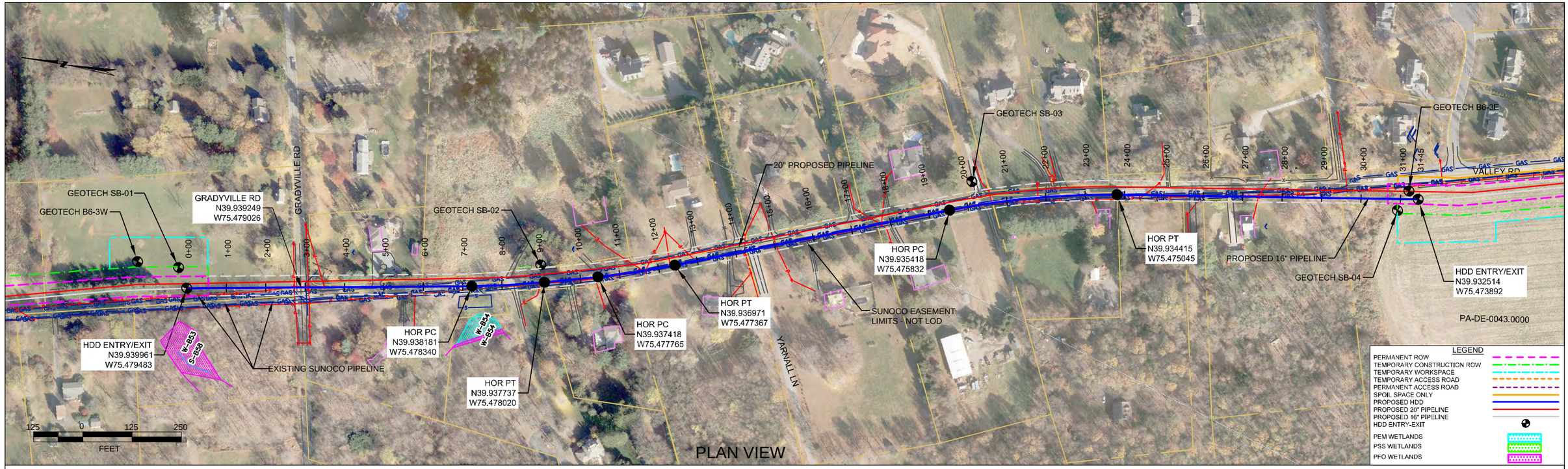
TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GRADYVILLE RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'

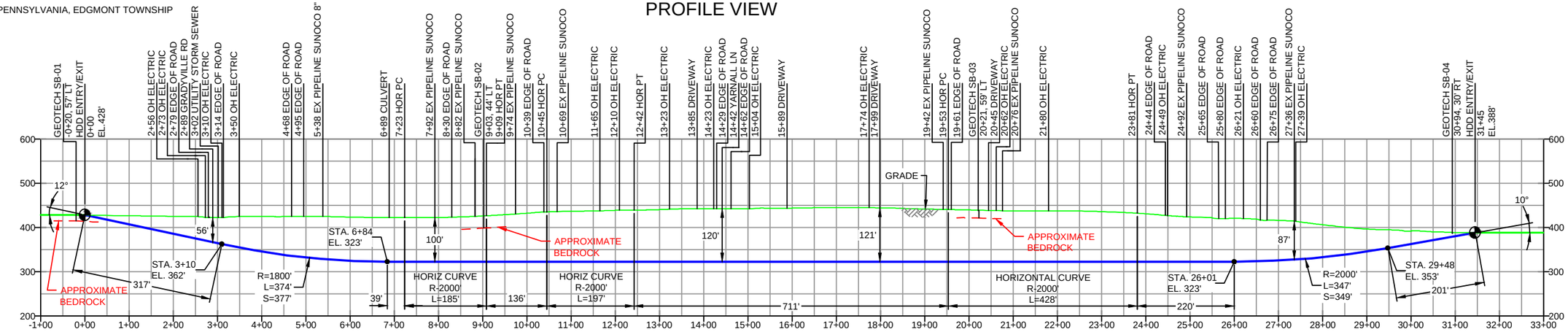
DWG. NUMBER: PA-DE-0032.0000-RD



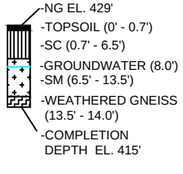
PLAN VIEW

PROFILE VIEW

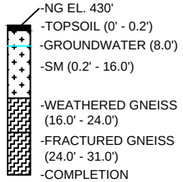
DELAWARE COUNTY PENNSYLVANIA, EDGMONT TOWNSHIP
S3-0580-16



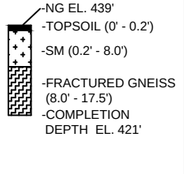
GEOTECH SB-01



GEOTECH SB-02



GEOTECH SB-03

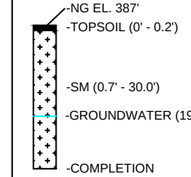


NOTE: REFER TO TEST BORING LOG S3-0580 FOR COMPLETE SOIL MATERIAL DESCRIPTION

Figure 2. 16-Inch HDD Plan and Profile

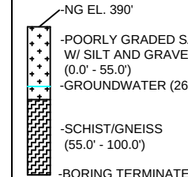
DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):3145'
   HDD PIPE LENGTH (S=):3160'
   16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, 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 NO 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.

GEOTECH SB-04



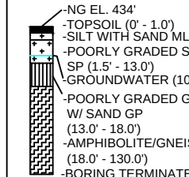
NOTE: REFER TO TEST BORING LOG S3-0580 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-3E



NOTE: REFER TO TEST BORING LOG B6-3E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B6-3W



NOTE: REFER TO TEST BORING LOG B6-3W 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-6.07	TO	ES-6.09	EROSION & SEDIMENT PLAN
SHEET 4	TO	SHEET 5	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	11/27/17	RMB	11/27/17	AMC	11/27/17
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	10/21/16	RMB	10/21/16	AAW	10/21/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/10/16	RMB	05/10/16	AAW	05/10/16
EP		MRS	02/26/16	RMB	02/26/16	AAW	02/26/16
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
GRADYVILLE RD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=250'

DWG. NO: PA-DE-0032.0000-RD-16