

**HORIZONTAL DIRECTIONAL DRILL ANALYSIS
HILDENBRAND ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PA-WM1-0023.0000-RD
(SPLP HDD# S1B-0190)**

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This reanalysis of the horizontal directional drill (HDD) installation of a 20-inch diameter pipeline crossing under streams S225 and S172 and Hildenbrand Road (west to east), in Sewickley Township, Westmoreland County, is in accordance with Stipulated Order (Order) issued under Environmental Hearing Board Docket No. 2017-009-L for HDDs listed on Exhibit 2 of the Order. This HDD is number 3 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

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: 1,078 foot (ft)
- Entry/Exit angle: 12-13 degrees
- Maximum Depth of cover: 50 ft
- Depth of cover under streams: 30-34 ft
- Pipe design radius: 1,400 ft

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

Bedrock in the area of HDD S1B-0190 is the cyclic sequences of the Waynesburg Formation and Monongahela Group. The western entry/exit point is located in a narrow wedge of the Monongahela Group. It contains cyclic sequences of sedimentary limestone, shale, sandstone, and coal. The base is bounded by the bottom of the Pittsburgh coal. The eastern entry/exit point is located in an area underlain by the Waynesburg Formation. Similar sedimentary sequences exist with the addition of calcareous shale with siderite nodules and medium to light gray sandstone in the upper member of Waynesburg. The upper member thickness ranges from 5 to 50 ft and the Little Washington coal marks its base. The middle member is predominantly medium gray shale, sandstone, and light gray siltstone, and ranges in thickness from 50 to 110 ft. Its base is the Waynesburg A coal.

A review of published mining and geological data indicate that the Pittsburgh coal has been deep mined beneath HDD S1B-0190 and the base of the Pittsburgh coal, at an approximate elevation of 600 ft amsl, is 350 feet below grade at this location (Skema, 1988). The lowest elevations in the profiles for the original boring and the revised boring are 942 and 920.66 ft amsl, respectively, therefore it is estimated that the revised boring will be a minimum of 321 ft above the base of the Pittsburgh seam.

Karst geology is not present at this HDD location; therefore the use of geophysics assessments was not conducted.

Attachment 1 provides an extensive discussion on the geology, hydrogeology, and results of the geotechnical investigation performed at this location, which informs the following analysis.

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Groundwater is stored and moves within the network of fractured Waynesburg Formation and Monongahela Group bedrock. In the vicinity of this HDD, regional systematic joints are oriented northwest and west-

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northwest. These may represent preferred pathways for groundwater flow. These fractures can act as conduits for groundwater movement and/or represent areas of weakness in the rock.

Groundwater was reported at elevations ranging from approximately of 971 to 991 ft above mean sea level (amsl) at boring B1-6W, representing the western portion of the revised boring. Groundwater was reported at an elevation of approximately of 987 to 990 ft amsl at boring B1-6E, representing the eastern portion of the revised boring. Based on these approximations, the water table is 25 ft or more below the boring entry/exit points; therefore, the boring will be under the water table for large percentage of the drill. Based on the path and elevation of the boring, and estimated water level elevations, the risk of excessive groundwater discharge and table lowering is small for this drill.

The Pennsylvania Groundwater Information System (PaGWIS) reported two residential wells in the area. One 170-foot deep well is listed as being just south of Apple Mill Road and east of the intersection of Hildenbrand Road. The second well, completed at a depth of 200 feet, is listed as being located west of the Hildenbrand Road and Apple Mill Road intersection; approximately 75 to 100 feet south of the current plan profile liner station marker 5+00 for the revised boring

The PaGWIS listing for the 200-ft deep potable well closest to the HDD (PA Well ID 647547) reported casing from ground surface to a depth of 20 ft, with a water bearing zone between 48 and 71 ft below grade and a yield of 2 gallons per minute. The production zone for waters wells is from the well bottom to highest point of water inflow from the water bearing seams, joints, and fractures in the rock formation.

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

INADVERTENT RETURNS DISCUSSION

An HDD has not been initiated at this location.

Sunoco Pipeline, L.P. (SPLP) HDD consultants reviewed the HDD design and geotechnical data for this area and determined that the risk of IRs to the waters overlying the HDD could be reduced by increasing the depth of the HDD profile. The redesign of the horizontal run of the HDD is now a minimum of 57 ft below Stream S225 and 61 ft below Stream S172.

In general, the IRs during construction of the Mariner II pipeline have been related to shallow overburden (especially under water bodies), large elevation changes between entries and exits, coarse grained unconsolidated materials near the surface (such as alluvium and mine spoil), deep coal mines, and the interconnectivity of open bedrock structural features that is difficult to predict. This HDD is not associated with these conditions, except for the potential for unidentified open bedrock structural features.

The results of the core borings at the entry and exit points show the HDD will encounter variable bedrock strength conditions as depth to profile increases. During the transition to maximum depth the recovery values vary from 53 to 60 and RQD values varies from 16 to 76. At maximum depth of profile, which is also the depth of profile under Hildenbrand Road and streams the rock layer has an recovery value of 60 and RQD value of 91. This is indicative of moderate to good overall rock quality which assists in suppression of IRs.

ADJACENT FEATURES ANALYSIS

This HDD location is approximately 1.5 miles southeast of Lowber, Pennsylvania, and is set within agricultural lands with a low density of private residences scattered across the general area or adjacent to the public roads.

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During the original project planning by SPLP a survey of land owners within 150 feet of the ROW was performed and two land owners responded positively to an offer to have their wells tested. As stated previously there are two private water wells proximal to the drill documented in the PaGWIS system. Well #647547 is in very close proximity to the western entry/exit point (~50 feet) for the revised drill but is up gradient of the HDD profile. The next nearest residence is 276 ft northwest and up gradient of the middle of the HDD profile.

SPLP has identified all landowners with property located within 450 ft of the HDD alignment. There are eight (8) individual landowners with properties located within 450 ft of the HDD alignment. SPLP sent each of these landowners a notice letter via both certified and first class mail on October 31, 2017, that included an offer to sample the landowner's private water supply/well in accordance with the terms of the Order and the Water Supply Assessment, Preparedness, Prevention and Contingency Plan. The letter also requested that each landowner contact the Right-of-Way agent for the local area and provide SPLP with information regarding: (1) whether the landowner has a well; (2) where that well is located, and 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 Yorby, Executive Assistant, Office of Programs at the Department's Central Office.

To date, only one landowner has responded; which is the nearest well location to the HDD profile. The information on this well has been acquired and the well has been tested.

Based on the response to the mailings and direct contact, the landowners with private water wells determined to be at risk during the HDD will be offered alternative water supplies until the HDD is complete; including the responding landowner discussed above.

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of S1B-0190 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 a number of different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

As described below, several alternatives to the previously permitted HDD were evaluated.

The proposed HDD alternative is the primary plan of installation to cross Hildenbrand Road, and minimize impact to Pennsylvania Fish and Boat Commission (PAFBC) designated Approved Trout Water tributaries.

Open-cut Analysis

Conversion to open cut would result in direct but temporary impacts to PAFBC designated Approved Trout Waters. SPLP specifications require a minimum of 48-inches of cover over the installed pipeline beneath the bottom of the watercourse. To meet this cover requirement, during construction through stream S172, an open cut workspace with a width of 75 feet would be required to accommodate pipeline and provide sufficient space

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for trench excavation, spoil storage, and allowing the pipeline to be installed with sufficient separation from the existing 12" pipeline for integrity management. In addition, a nearby tributary to S172 would also likely need to be impacted under an open-cut alternative. The assessed area of impact by this open cut plan would directly affect 0.40 acres of state water bottom and 0.606 acres of floodway. Use of conventional methods to complete this crossing would require the damming the stream using an upstream and downstream geotube, while simultaneously pumping around all stream flows, and pumping out of all produced groundwater discharge from the excavated shallow soil horizons and water seepage below the geotube dams installed in the channel for the entire duration of the open cut crossing event. Although the temporary impacts would be controlled and managed using these appropriate mitigation measures, the preferred method is to drill below these resources.

Additional impacts at this site resulting from an open cut crossing would include difficulty for landowners to access their driveways from the public road during the Hildenbrand Road crossing.

Re-Route Analysis

In accordance with state and federal guidance, SPLP has routed the Project to be co-located with existing pipeline and other utility corridors to avoid new "greenfield" routing alignments, to the maximum extent practicable. This avoids and minimizes new and permanent impacts on previously undisturbed land, land use encumbrance, and site-specific and cumulative impacts on land, environmental, and community resources. The Hildenbrand Crossing HDD is co-located within a common corridor containing three existing pipeline, including an existing SPLP 12" pipeline ROW. Rerouting would cause new greenfield impacts. In addition, given the size, length, and general direction of streams S225 and S172, no practicable re-route option lies to the east or west of the proposed route that would not ultimately cross these streams.

RECONSIDERATION OF THE HORIZONTAL DIRECTIONAL DRILL

SPLP HDD consultants reviewed the HDD designs and geotechnical data for this area. Based upon this review, it was determined that the risk of IRs to waters overlying the HDD could be reduced by increasing the depth of the original permitted HDD profile. Additional geologic investigations have been completed and utilized in the redesign of the planned HDD. The redesign adjusts the HDD profile deeper to place the HDD pathway through bedrock having better structural integrity than a shallower profile and increase the overall length of the HDD due to pipe design requirements. A summary of the redesign factors is provided below.

Revised Horizontal Directional Drill Design Summary: 20-inch

- Horizontal length: 1,651 foot (ft)
- Entry/Exit angle: 11-12 degrees
- Maximum Depth of cover: 68 ft
- Depth of cover under streams: 57-61 ft
- Pipe design radius: 2,000 ft

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

- SPLP will require and enforce the use of annular pressure monitoring during the drilling of the pilot holes, which assists in immediate identification of pressure changes indicative of loss of return flows or over pressurization of the annulus to manage development of pressures that can induce an IR;
- SPLP inspectors will ensure that an appropriate diameter pilot tool, relative to the diameter of the drilling pipe, is used to ensure adequate "annulus spacing" around the drilling pipe exits to allow good return flows during the pilot drilling;

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- SPLP will implement short-tripping of the reaming tools as return flow monitoring indicates to ensure an open annulus is maintained to manage the potential inducement of IRs;
- SPLP will require monitoring of the drilling fluid viscosity, such that fissures and fractures in the subsurface are sealed during the drilling process;
- During the reaming phase, the use of Loss Control Materials can be implemented if indications of a potential IR are noted or an IR is observed;
- If LCMs prove ineffective to mitigate loss of returns or IRs, then grouting of the pilot hole may be implemented; and
- If necessary, the pilot hole and reaming phases at the point of entry for the HDD may utilize casing, hammered into the substrate down to structurally better rock, to prevent vertical or lateral movement of drilling fluids at shallow depths.

CONCLUSION

It is SPLP's intent to modify the original profile design and to pursue a deeper and longer HDD profile. Figure 1 in Attachment 2 presents the original HDD plan and profile. Figure 2 presents the revised HDD plan and profile.

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**ATTACHMENT 1
GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT**



HDD HYDROGEOLOGIC REEVALUATION REPORT

**Mariner East II
Spread 1
HDD S1B-0190
Hildenbrand Road
Sewickley Township, Westmoreland County, Pennsylvania**

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

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

November 2017



HDD HYDROGEOLOGIC REEVALUATION REPORT

**Mariner East II
Spread 1
HDD S1B-0190
Hildenbrand Road
Sewickley Township, Westmoreland County, Pennsylvania**

November 2017

Prepared for:

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

Prepared by:

A handwritten signature in black ink that reads 'John L. Vasalani'.

Jack L. Vasalani, P.G.
Principal Hydrogeologist

Reviewed by:

A handwritten signature in blue ink that reads 'Richard L. Wardrop'.

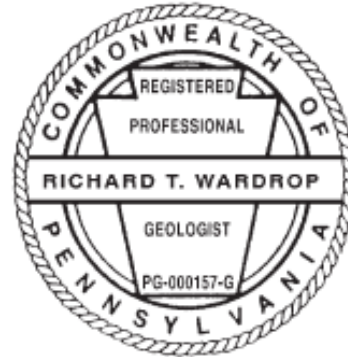
Richard Wardrop, P.G.
Lead Hydrogeologist

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



November 27, 2017



Richard T. Wardrop, P. G.

date

Lic. No. PG000157G

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ATTACHMENTS

- Attachment A. Original and Revised Plan and Profiles
- Attachment B. Geotechnical Boring Logs

1.0 INTRODUCTION

Sunoco Logistics/Energy Transfer Partners (SXL/ETP) retained Groundwater & Environmental Services, Inc. (GES) to prepare HDD Hydrogeological Reevaluation Reports (HRRs) for horizontal directional drills (HDDs) listed on Exhibit 2 of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017. This report discusses the HRR for HDD S1B-0190 the 20-inch line near Hildenbrand Road in Sewickley Township, Westmoreland County, PA. A map depicting the location of the HDD with topographic information on the surrounding area is presented as **Figure 1**.

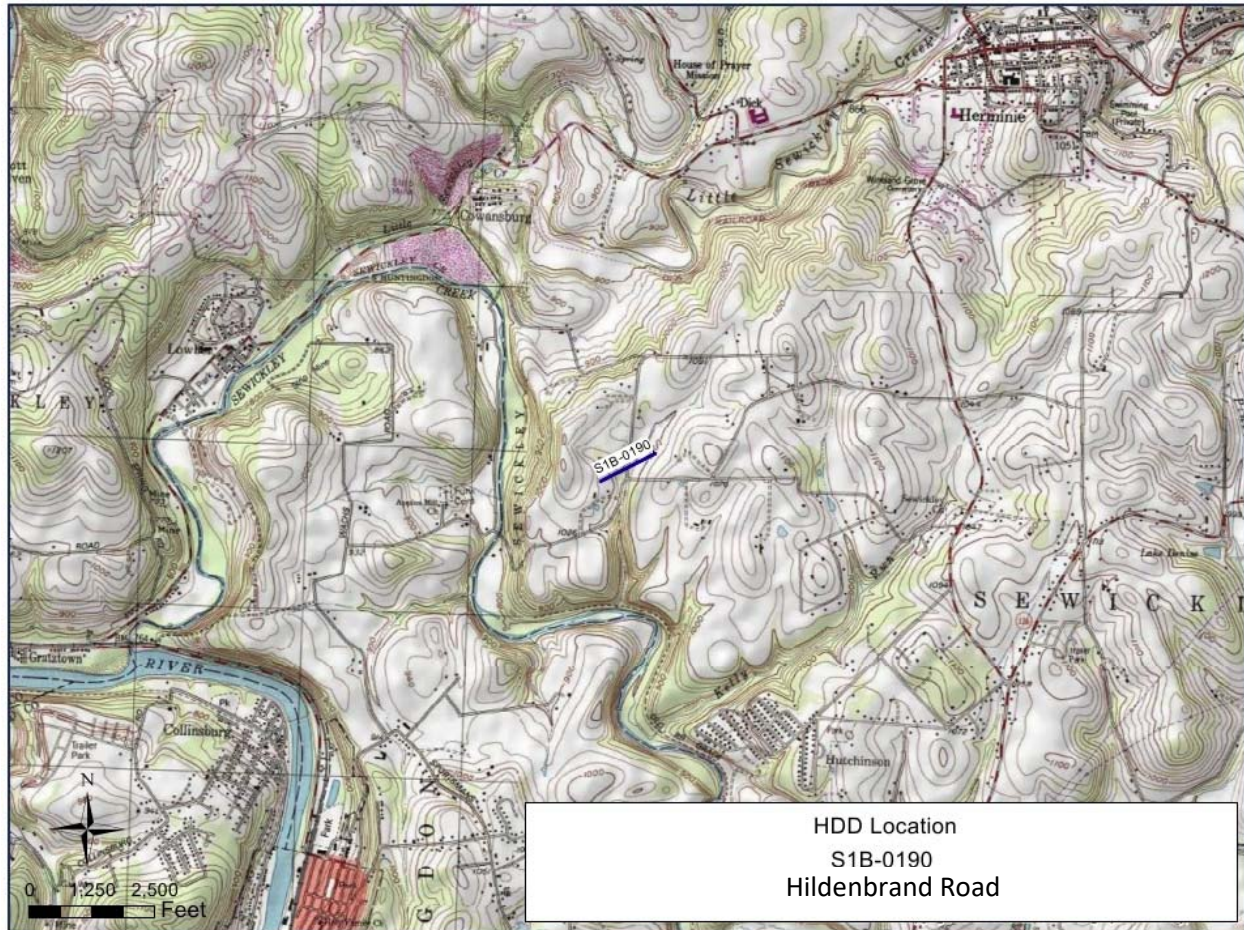


Figure 1. Site Location Map (modified from USGS Smithton 1:24,000 Topo. Quad., rev. 1970)

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of the HDD;
- Summaries of studies performed pertinent to reevaluation, including recent geotechnical borings fracture trace analysis 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 Terracon Consultants, Inc. (Terracon), in August and September 2017 in support of the HDD S1B-0120 reevaluation. Please note that GES did not oversee or direct the geotechnical drilling



program, including, but not limited to, the selection of number and location of borings, determination of surface elevations, target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and any core photographs that resulted from these programs were generated by an SPLP contractor. GES relied on these reports and incorporated their data into the general geologic and hydrogeologic framework for this hydrogeologic reevaluation report.

2.0 HDD GEOLOGY / HYDROGEOLOGY

The discussion presented in this report is based on an alignment and profile developed by Tetra Tech/Rooney, revised on 09/30/2016 (original boring). GES has also been provided a proposed alternative profile for HDD S1B-0190, revised 11/14/17 (revised boring) (see **Attachment A**). The revised boring profile was developed to increase the depth of the borehole by extending the east and west entry/exit points and making the profile deeper. The purpose is to minimize the risk of inadvertent returns by installing the pipes deeper into competent bedrock. For the purpose of this assessment, GES utilized both HDD designs to evaluate the hydrogeologic conditions at HDD S1B-0190.

2.1 Physiography

2.1.1 Topography

The topography in the area of HDD S1B-0190 is relatively flat along the eastern entry point, dipping down slightly as it progresses westward with a continued slightly increasing elevation at the western entry point. The ground surface profile is slightly concave near the western center and then transitions to gently sloping upward to the west. The revised boring is located between Stations 1692+02 and 1709+73 on the pipeline, for an overall length of 1,651 feet (N40.238972 / W79.745517 to N40.240999 / W79.740298). The western entry/exit point for the original boring and the revised boring are at approximate elevations 1,019 and 1042 feet above mean sea level (ft amsl), respectively. The eastern entry/exit point for the original boring and the revised boring are at elevations 1,008 and 1,015 ft amsl, respectively. The area surrounding the HDD is comprised of rural properties. The site location is depicted on **Figure 1**.

2.1.2 Hydrology

The nearest surface water body to the HDD location is a small stream (S172) which crosses the alignment due west of Hildenbrand Road. Another tributary, S225 flows into S172 due north of the alignment. S172 flows south approximately one mile where it enters Sewickley Creek. From the western entry/exit point of the revised plan profile the drill will pass under S172 at approximately 845 feet east along the alignment and will cross approximately 57 feet below it, 27 feet below the originally proposed crossing depth.

2.2 Geology

2.2.1 Soils

Soils across the profile are generally comprised of silt loam, grading to silty clay loam with depth. They are identified by USDA NRCS WSS (<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>), west to east across the HDD S1B-0190 profile as Guernsey silt loam (3 to 8 % slope), Dormont silt loam (8 to 15 % slope), Clarksburg silt loam (3 to 8 % slope), and Guernsey silt loam (8 to 15 % slope). According to NRCS information, the eastern and western entry/exit points are likely to encounter bedrock at an approximate depth of 5 to 6 ft bgs. The depth to bedrock thickness across the central area of the profile is deeper and unspecified NRCS. Depth to the water table in these soils ranges from 16 to 44 inches bgs.

2.2.2 Bedrock Lithology

Bedrock in the area of HDD S1B-0190 is the cyclic sequences of the Waynesburg Formation and Monongahela Group. The western entry/exit point is location in a narrow wedge of the Monongahela Group. It contains cyclic sequences of sedimentary limestone, shale, sandstone, and coal. The base is bounded by the bottom of the Pittsburgh coal. The eastern entry/exit point is located in an area underlain by the Waynesburg Formation. Similar sedimentary sequences exist with the addition of calcareous shale with siderite nodules and medium to light gray sandstone in the upper member of Waynesburg. The upper member thickness ranges from 5 to 50 feet and the Little Washington coal marks its base. The middle member is predominantly medium gray shale, sandstone, and light gray siltstone, and ranges in thickness from 50 to 110 feet. Its base is the Waynesburg A coal. **Figure 2** depicts the formation contacts as depicted

on the *Greater Pittsburgh Region Geologic Map* (Wagner, et. al, 1975) between the Waynesburg Formation and Monongahela Group.

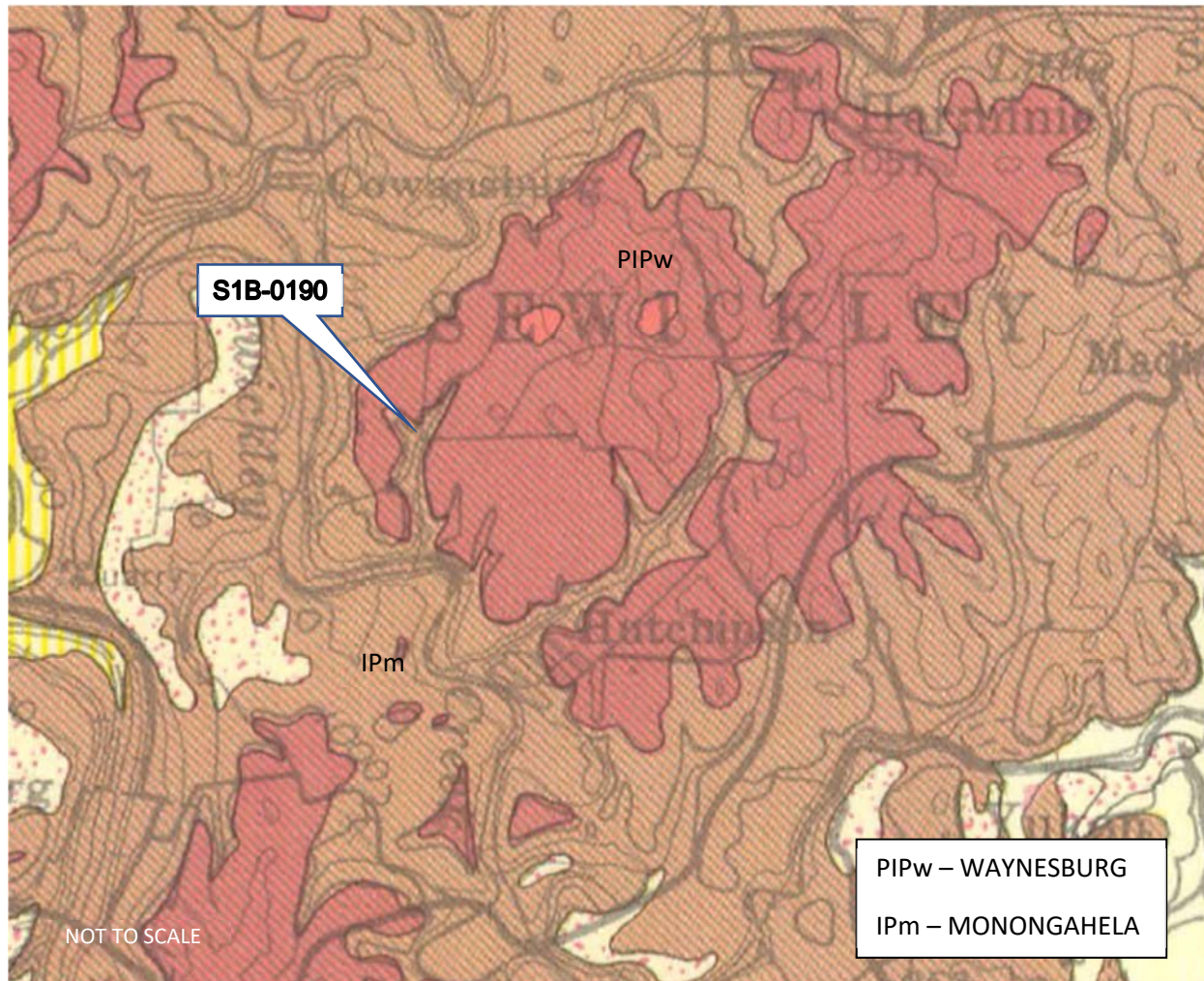


Figure 2. Bedrock Geology Map (modified from Wagner, et. al, 1975)

2.2.3 Structure

Skema (1988) provides structure contour maps for persistent coal beds in Westmoreland County. Using this resource and structure contours mapped for the Pittsburgh coal, HDD S1B-0190 is located due west of the axis of the Port Royal (Irwin) Syncline (see **Figure 3**). At this location, the coal beds have a slight dip to the east.

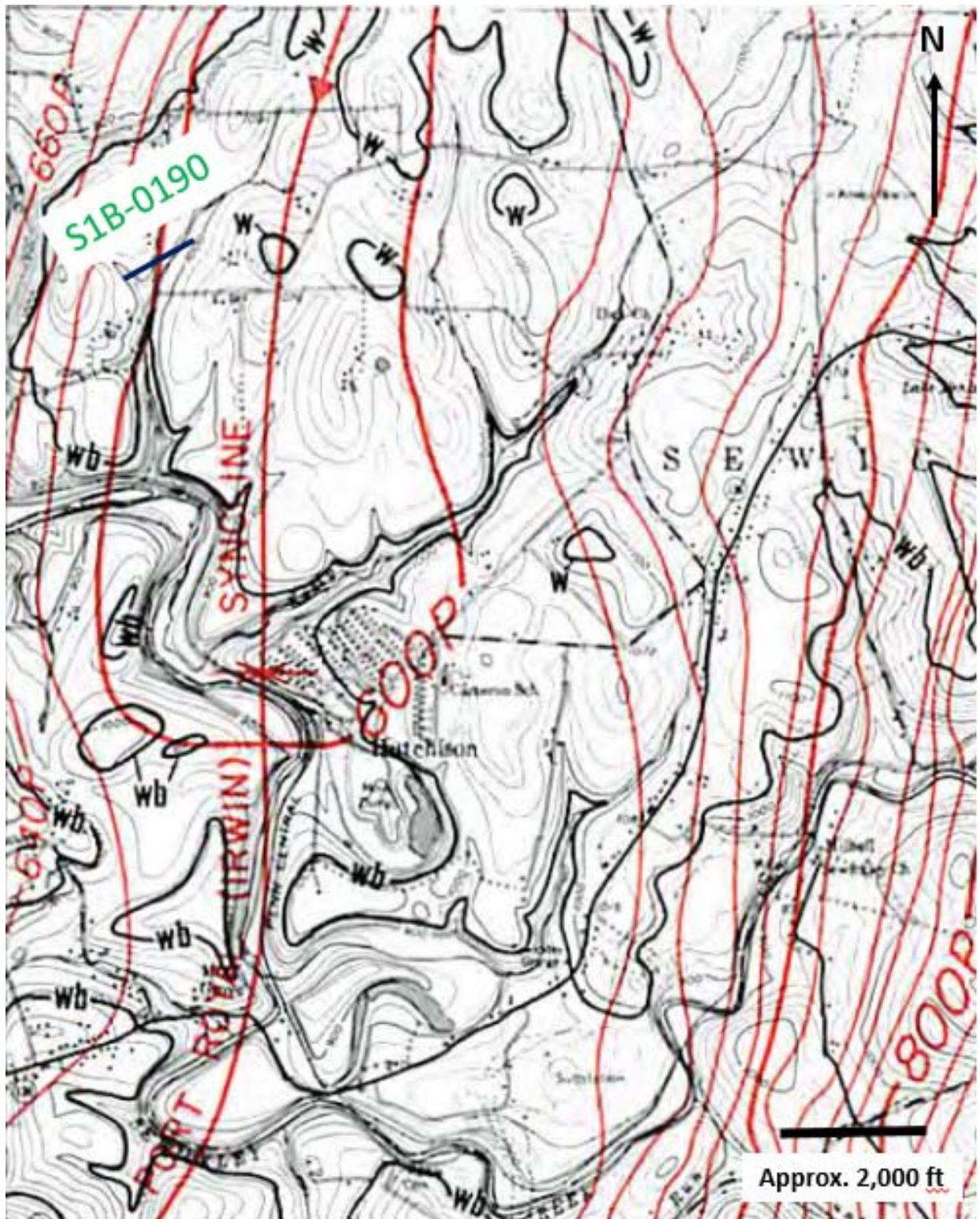


Figure 3. Structure Contours and Coal Crop Lines (modified from Skema, 1988)

Discontinuities in the form of joints and faults are imprinted in the broadly folded bedrock in the region. These fractures can act as conduits for groundwater movement and/or represent areas of weakness in the rock. Nickelsen and Hough (1967) conducted regional mapping of joints in shale, coal and sandstone in

the Appalachian Plateau. In the vicinity of HDD S1B-0190, two systematic joint sets were mapped with approximate trends of northwest and west-northwest. Less frequent non-systematic joints were mapped approximately orthogonal to the systematic joints.

2.2.4 Fracture Trace Analysis

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

Figure 4 shows a fracture trace map prepared for this reevaluation. This mapping was performed using aerial stereographic pairs flown in the spring of 1939. As such, much of the land surface appears undeveloped; therefore, fracture traces are more easily seen. Four general orientations are present in the set of fracture traces. Three of the orientations generally match the joint alignments mapped by Nickelsen and Hough (1967): a northwestern trending set and a west-northwestern trending set (systematic joint sets), and a set orthogonal to the northwest trending set (non-systematic joint set). The fourth pattern is generally oriented north to south.

The proposed path of the revised boring is shown in red on **Figure 4** and transects three of the mapped fracture traces.



Figure 4. Fracture Traces

2.2.5 Mining

Deep mining has occurred in proximity to the S1B-0190 boring profile. A review of published mining and geological data indicate that the Pittsburgh coal has been deep mined beneath HDD S1B-0190. Ziemkiewicz, et. al., (2004) show the area is underlain by the Hutchinson mine that was partially flooded or completely flooded by 2004. The base of the Pittsburgh coal is at an approximate elevation of 630 ft amsl here and the coal bed is estimated to be 6 to 8 feet thick (Tewalt, et. al., 1997). The revised profile shows the lowest surface elevation along the alignment at stream S172 at 978 ft amsl. This results in an estimate of minimal overburden thickness from the roof of the mine to land surface of 340 feet and an estimate of minimal thickness of bedrock from the roof of the mine to the pipeline profile of 283 feet. Examination of mine maps available through the Pennsylvania Mine Atlas (<http://www.minemaps.psu.edu/>) indicates an unmined portion of the seam may have been left under the southwest end of the profile.

The Waynesburg coal is known to outcrop at lower topographic elevation areas south of the S1B-0190 location but published documents do not show any strip or deep mining that correlates with the Waynesburg coal.

2.2.6 Rock Engineering Properties

Rock properties for the Monongahela Group, published in Geyer and Wilshusen (1982), are listed as follow:

- Well developed, thin beds in sandstone and siltstone; thicker beds in limestone; shale is fissile or very thick; claystone is very poorly bedded.
- Fracture joints are poorly to moderately well developed in sandstone and siltstone; poorly developed in claystone and shale; moderately to well developed in limestone; widely spaced in irregular intervals; blocky or platy pattern; spacing is closer in finer grained rocks; open and vertical.
- The limestones and sandstones are moderately resistant to weathering with no reference to development of karst terrain.
- Well-developed open joint systems in the sandstones and limestones provide fair secondary porosity for movement and storage of groundwater.
- Drilling rate is moderate to fast.

The Waynesburg Formation rock properties published in Geyer and Wilshusen (1982) are, as follow:

- Well-bedded; massive to flaggy to thin-bedded.
- Fracture Joints of a platy pattern; some have blocky pattern; moderately fractured; moderate distance between fractures; steeply dipping and open.
- Fast drilling rate.

2.2.7 Results of Geotechnical Borings

Two recent geotechnical borings were advanced to support the revised design of HDD S1B-0190 (B1-6W and B1-6E). There were no geotechnical boring presented in the risk assessment for this drill in the original ME II IR PPC Plan for Westmoreland County. The drill site inspector logs for each geotechnical boring are provided in **Attachment B**.

B1-6W

Geotechnical boring B1-6W was installed in the vicinity of HDD S1B-0190 station 3+34 for the revised boring. The overburden is described as a “fat clay (CH), with silt and with rock fragments” and relatively high Standard Penetration Test (STP) blow counts (31 to >50). Rock coring was initiated at a depth of 12 ft bgs and advanced to a final depth of 127 ft bgs. Rock Quality Determinations (RQDs) generally improved with depth at this boring ranging from 41 to 81% starting after 37 ft bgs. The rock type was mostly sandstone

from 12 to 73 ft bgs and shale, mudstone and limestone from 73 to 127 ft bgs, with one sandstone bed between mudstone between approximately 87 and 94 ft bgs.

Groundwater was reported at a depth of 48 ft bgs on 8/30/17. An additional measurement then reported groundwater at a depth of 28 ft bgs on 9/1/17. The initial depth to water of 48 ft bgs recorded on 8/30/17 closely corresponds to the depth to water reported on a driller's log for a local residential well (see **Section 2.3.1**); noting that the well driller log was recorded just south of and in very close proximity to boring B1-6W.

B1-6E

Geotechnical boring B1-6E was installed approximately 80 feet northwest of the eastern entry/exit for the revised boring. STP blow ranged from 9 to 14 before refusal at 14.0 ft bgs. Rock coring was initiated at a depth of 14 ft bgs and advanced to a final depth of 117 ft bgs. RQDs across all intervals of this boring varied over a range from 20 to 96 % with no apparent trend with depth and 50% having values of less than 60%. The rock types in this boring were mostly sandstones with a thickness of shale from approximately 23 to 39 ft bgs and, shale and mudstone from approximately 73 to 88 ft bgs.

Groundwater was reported at a depth of 17.7 ft bgs on 8/28/17. Another measurement reported groundwater at a depth of 20.8 ft bgs on 8/29/17. Base on one of the water level measurements from B1-6W and the two measurements from B1-6E the water table elevation in the area on the uplands away from the streams at HDD S1B-0190 ranges from 987 to 991 ft bgs.

2.3 Hydrogeology

2.3.1 Occurrence of Groundwater

Groundwater is stored and moves within the network of fractured Waynesburg Formation and Monongahela Group bedrock. Regional systematic joints are oriented northwest and west-northwest. These may represent preferred pathways for groundwater flow. The nature of bedrock discontinuities are described in the boring logs presented in Section 2.2.6. Local topography indicates that groundwater likely flows east and west towards the topographic low represented by the headwater tributaries of Sewickley Creek, then south towards Sewickley Creek.

Published soil data indicate the regional depth to water in the overburden soils is 16 to 24 inches. Regional depth to bedrock aquifer is estimated to be between 17 and 48 ft bgs based on the geotechnical borings and PaGWIS information.

The Pennsylvania Groundwater Information System (PaGWIS) reported two residential wells in the area. One 170-foot deep well is listed as being just south of Apple Mill Road and east of the intersection of Hildenbrand Road. The second well, completed at a depth of 200 feet, is listed as being located west of the Hildenbrand Road and Apple Mill Road intersection; approximately 75 to 100 feet south of the current plan profile liner station marker 5+00 for the revised boring. .

The PaGWIS listing for the 200-foot potable well closest to the bore (PA Well ID 647547) reported casing from surface to a depth of 20 feet. The data also reported a water bearing zone between 48 and 71 feet below grade with a yield of 2 gallons per minute.

2.3.2 Ground Elevation between HDD entry/exits

The surface elevation of west entry/exit for the revised boring is approximately 1,042 ft amsl and the surface elevation of the east entry/exit for the revised boring is approximately 1015 ft amsl. Compared to the original boring plan the west entry/exit point for the revised boring is approximately 16 feet higher as the

location was moved west onto higher ground. Similarly, the elevation of the east exit/entry is approximately 7 feet higher from the original to revised boring plan.

2.3.3 Water Level

Groundwater was reported at elevations ranging from approximately of 971 to 991 ft amsl at boring B1-6W, representing the western portion of the revised boring and groundwater was reported at elevation of approximately of 987 to 990 ft amsl at boring B1-6E, representing the eastern portion of the revised boring. Based on these approximations the water table is 25 feet or more below the revised boring entry/exit points thus the boring will be under the water table for large percentage of the drill. Based on the path and elevation of the revised boring, and estimated water level elevations, the risk of excessive groundwater discharge and table lowering is small for this drill.

2.3.4 Well Yields

Published median well yields in this area have been measured at approximately 15 to 100 gallons per minute (estimated) in the Monongahela Group. The Monongahela Group has very little primary porosity; porosity of sandstone is generally fair; secondary porosity from well-developed joint systems; low porosity and permeability (Geyer and Wilshusen, 1982).

Published data for the Waynesburg formation notes that domestic wells should not need to exceed a drilled depth of 200 feet for maximum yield. Joints provide a secondary porosity of low magnitude. (Geyer and Wilshusen, 1982).

2.3.5 Water Supply Wells within 150 and 450 feet of ROW

During the original planning by SPLP for advance of the HDD S1B-0190 drills, a survey of land owners within 150 feet of the ROW was performed and two land owners responded positively to an offer to have their wells tested. In terms of the current well survey program, no data regarding wells within the extended 450 feet of ROW are available at this time; pending responses from property owners.

As noted above in **Section 2.3.1**, there are two wells proximal to the drill documented in the PaGWIS system... Well #647547 is in very close proximity to the western entry/exit point (~50 feet) for the revised drill. Due to the uncertainty as to the completeness of the PaGWIS databases and the rural nature of this boring location there is the potential for additional wells to be present, but not accounted for in the PaGWIS system.

The two documented potable wells are as follows:

- PA Well ID #647547 at -79.74387 / 40.23915 and approximately 50 feet from ROW
- PA Well ID #151388 at -79.74111 / 40.23889 and approximately 550 feet from ROW
-

2.3.6 Potential Impact of Mining on Groundwater

Mine subsidence in this region potentially causes differing degrees of fracturing within the overburden due to different zones of compressive and tensile stresses. Compressive stresses cause the strata that is generally horizontally bedded to either shift laterally along the bedding planes or rupture, which increases the lateral movement of groundwater along horizontal bedding plane partings. Additional vertical and high angle fracture planes are created by the tensile stresses. The increased secondary porosity creates additional pathways for the vertical movement of groundwater and groundwater storage (Iannacchione, et. al., 2008). **Figure 5** depicts of the hydrologic responses that occur in five zones of deformation above areas of coal extraction and mine subsidence. These zones include (from mine to surface) the caved zone, fractured

zone, dilated zone, constrained strata zone, and surface fracture zone (Kendorski, 1993). The variable RQDs throughout boring B1-6E may be indicative of increased fracturing and bedding plane parting in a dilated zone above the mine, although the bottom of the boring is estimated to be approximately 283 feet above the roof of the mine.

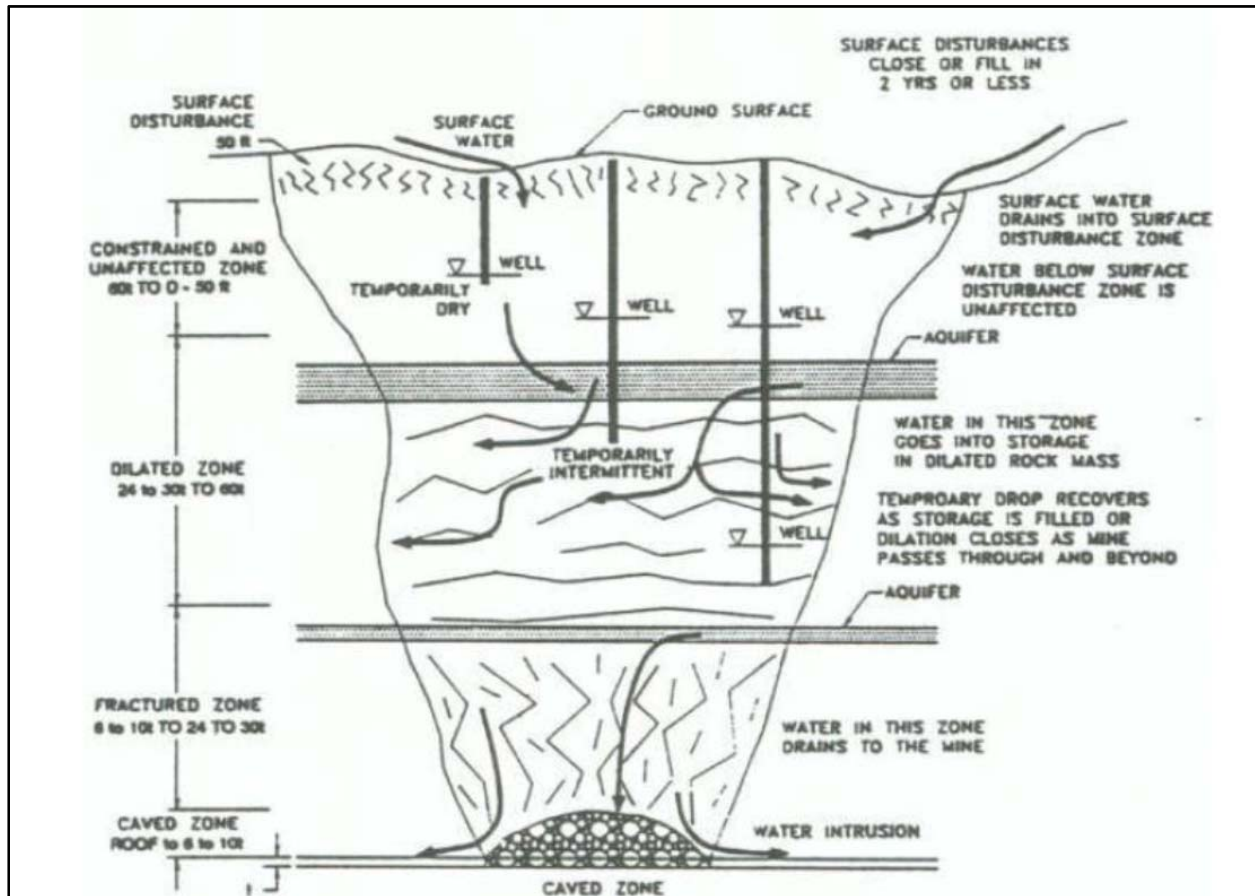


Figure 5: Hydrologic Response Zones (From Kendorski, 1993)

2.4 Summary of Geophysical Studies

No geophysical studies were performed for HDD S1B-0190. Thin limestone beds have been identified in the literature for the area and in the geotechnical boring logs; however, there is no indication of karst development in the area. Additionally, Pittsburgh coal deep mining is too deep in the area of the drill for geophysical surveys to accurately characterize the mine. The deepest part of the revised boring occurs at an elevation of approximately 921 ft amsl and the roof of the mine is estimated to be at approximately 638 ft amsl.



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 S1B 0190 drill on the list of IRs for ME I documented in the IR PPC Plan for Westmoreland County.

3.1.2 ME II

No drilling activities have been initiated yet at HDD S1B-0190 as part of the ME II pipeline installation.

3.2 On Other HDD Alignments in Similar Hydrogeologic Settings

3.2.1 ME I

Two IRs were reported on the list of IRs for ME I documented in the IR PPC Plans for western Pennsylvania counties in the same bedrock formations as SB1-0190. These were the IR at PA-WA-01.3.0000, Linden Creek Road, North Strabane Township, Washington County (40.2354, -80.1373) in the Waynesburg Formation and PA-AL-0033.00, Hayden Blvd., Elizabeth Township, Allegheny County (40.2210, -79.8480) in Monongahela Group bedrock.

3.2.2 ME II

All of the IRs in Spreads 1 and 2 for the ME II pipeline to date have occurred while drilling through the cyclic sequences of sandstone, shale, limestone, clays seams and coal present within western Pennsylvania bedrock formations, including the Allegheny Group, Casselman Formation, Glesnshaw Formation, Monongahela Group, and Waynesburg Formation. Entries and exits pass through alluvium, colluvium and soils developed on top weathered bedrock. In general, the IRs have been related to shallow overburden (especially under water bodies), large elevation changes between entries and exits, coarse grained unconsolidated materials near the surface (such as alluvium and mine spoil), deep coal mines, and the interconnectivity of open bedrock structural features that is difficult to predict. The revised boring for S1B-0190 is not associated with these conditions, except for the potential for unidentified open bedrock structural features.

4.0 SUMMARY AND CONCLUSIONS OF HDD HYDROGEOLOGIC EVALUATION

4.1 HDD Site Conceptual Model

The proposed revised boring is designed approximately 573 linear feet longer by extending the western entry/exit approximately 433 feet and the eastern entry exit approximately 140 feet. The western and eastern entry/exit elevations for the revised boring are higher than those of the original boring at approximately 1042 and 1015 ft amsl, respectively. The revised boring profile is deeper than the original, only running 30 feet below stream S172 in the original profile and running 57 feet below S127 on the revised profile. The deepest elevation of the revised boring is deeper than that of the original boring, as well, with the original boring at 942 ft amsl and the revised boring at 921 ft amsl (see **Attachment A**).

The NCS soil map predicts overburden soils will be between 6 and 9 ft bgs on top of bedrock and will generally consist of silt loams and to clayey silt loams. As described by TerraCon on the two recent geotechnical boring logs (B1-6E and B1-6W, see **Attachment B**) The overburden contains significant weathered bedrock and rock fragments thus HDD design and procedures targeted at reducing IR risk should account for these types of materials, upon entry and exit.

Based on published geologic and hydrogeologic information and the evaluation of the rock core descriptions on the TerraCon logs for B1-6E and B1-6W, HDD S1B-0190 HDD location is underlain by sequences of sedimentary rocks of the Waynesburg Formation and Monongahela Group. Carbonate rock beds, though present, are few and thin and the sequences are described as dominantly sandstone, mudstone and shale. The hydrogeologic setting is characterized by groundwater flow in secondary openings along geologic features including bedding planes, joints, and fractures. Rock coring at B1-6E (near the eastern entry/exit point) was initiated at a depth of 12 ft bgs) and advanced to a final depth of 127 ft bgs RQDs varied over a range from 20 to 96 % with no apparent trend with depth which may be indicative of some degree of mine subsidence along the east side of the profile. Rock coring at B1-6W (approximately 335 feet east of the western entry/exit point of the revised boring was initiated at a depth of 14 ft bgs and advanced to a final depth of 117 ft bgs. RQDs generally improved with depth ranging from 40 to 86% starting after 37 ft bgs. This is supported by the observation of the geotechnical cores. Three fracture traces intersect the alignment for the revised boring and may represent locations of increased fracturing and associated higher risk for fluid loss and IRs. No other major structural features are documented in close proximity of the bore path and there is a considerable thickness of bedrock (over 300 feet) between a local Pittsburgh coal deep mine and the revised boring.

The overburden over the former deep Pittsburgh coal mine is relatively large (estimated at 340 feet) as is the distance between the top of the mine and the lowest elevation of the HDD profile (283 feet) therefore the risk of IRs (at the surface) due to increased secondary porosity in the bedrock subsidence is relatively low.

Groundwater was reported at elevations ranging from approximately of 971 to 991 ft amsl at boring B1-6W, representative of the western portion of the revised boring and groundwater was reported at elevation of approximately of 987 to 990 ft amsl at boring B1-6E, representative of the eastern portion of the revised boring. Based on these approximations the water table is 25 feet or more below the revised boring entry/exit points and the boring will be under the water table for large percentage of the drill. Based on the path and elevation of the revised boring, and estimated water level elevations, the risk of excessive groundwater discharge and water table lowering is small for this HDD.

The PAGWIS database lists a potable well approximately 50 feet south of the alignment with water bearing zones between 48 and 71 feet bgs. At this location, the revised bore could intersect the reported water-bearing zones of the residential well increasing the chances of hydraulic communication with drilling fluids.

4.2 Conclusions and Recommendations

Based on the information provided in this reevaluation report, the planned drilling path for the revised boring for HDD S1B-0190 will encounter relatively competent Monongahela group and Waynesburg formation sedimentary bedrocks over most of the drill. Increasing the depth of the bore has reduced the risk of IRs. Variability in rock competency is to be expected based on the variability in the RQDs for geotechnical borings B1-6E and B1-6W, and possible presence of vertical zones of fracture concentration indicated by three fracture traces intersecting the alignment. Local groundwater levels in concert with the alignment should not create a condition in which the local water table will be adversely lowered. Given the increased depth of the bore there is an increased risk that drilling fluid could enter the water producing zone of a residential well proximal to the alignment and the drilling plan should recognize this potential.

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PaGWIS, Pennsylvania Groundwater Information System - (<http://dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm>).

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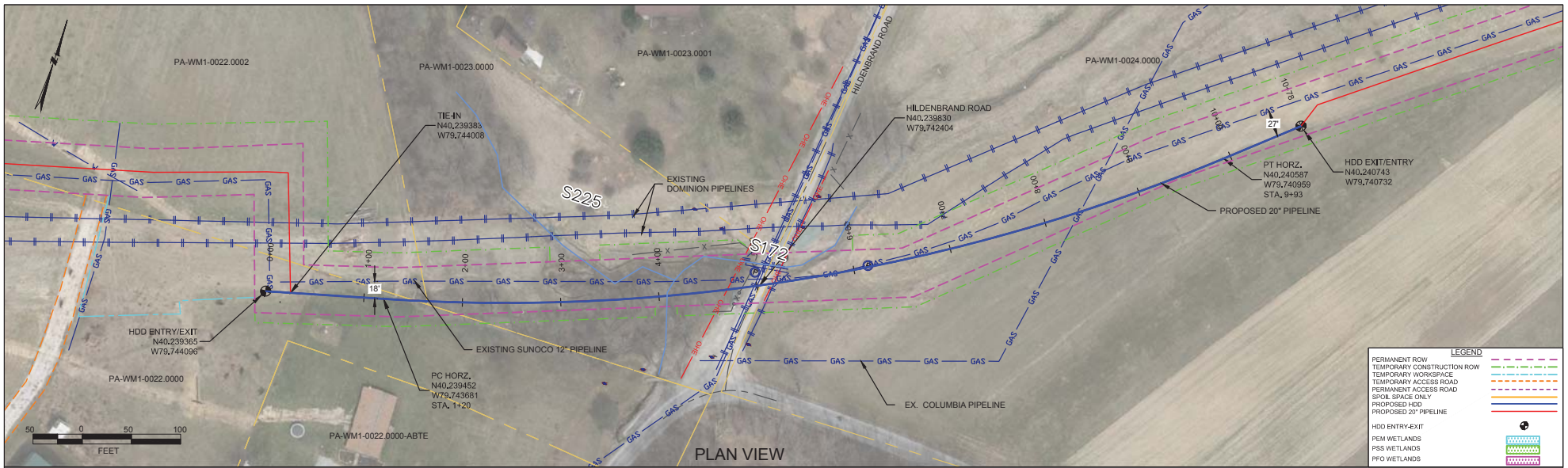
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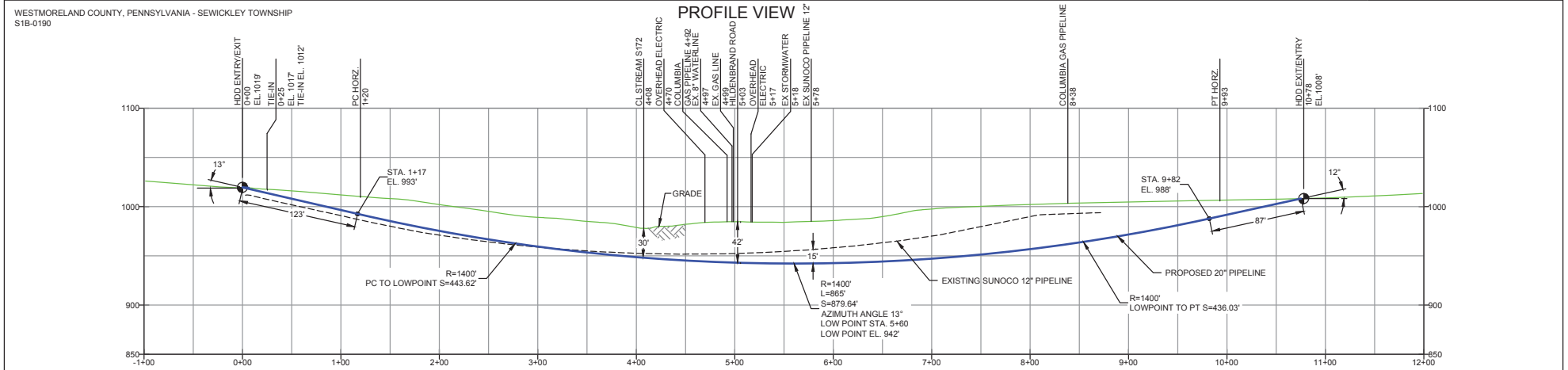


Attachment A

Original and Revised Plan and Profile



WESTMORELAND COUNTY, PENNSYLVANIA - SEWICKLEY TOWNSHIP
S1B-0190



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - 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.
 - DESIGNED IN ACCORDANCE WITH CFR 49.195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HDQZ LENGTH (L)=1079'
HDD PIPE LENGTH (SP)=1090'
20" x 0.456" W.T. X 65L APRIL PSL2 ERW 8FW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCONCRETE OR ENGINEER APPROVED EQUAL)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PIPE INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
- STATIONING IS BASED ON HORIZONTAL DISTANCES.
- 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.
- CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
- SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING				REVISIONS			
ES-1.14	TO	ES-1.14	EROSION & SEDIMENT PLAN				
SHEET 10	TO	SHEET 11	AERIAL SITE PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16
				EP1	REVISED PER PADEP COMMENTS	DLM	05/06/16
				EP		RMB	05/06/16
				1	REVISED PER COMMENTS FROM REI REVIEW 12-18-15	DLM	03/15/16
				0	ISSUED FOR CONSTRUCTION	RMB	03/15/16
DWG NO	DWG NO	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK
						DATE	APP
						DATE	DATE

**Sunoco Logistics
Partners L.P.**

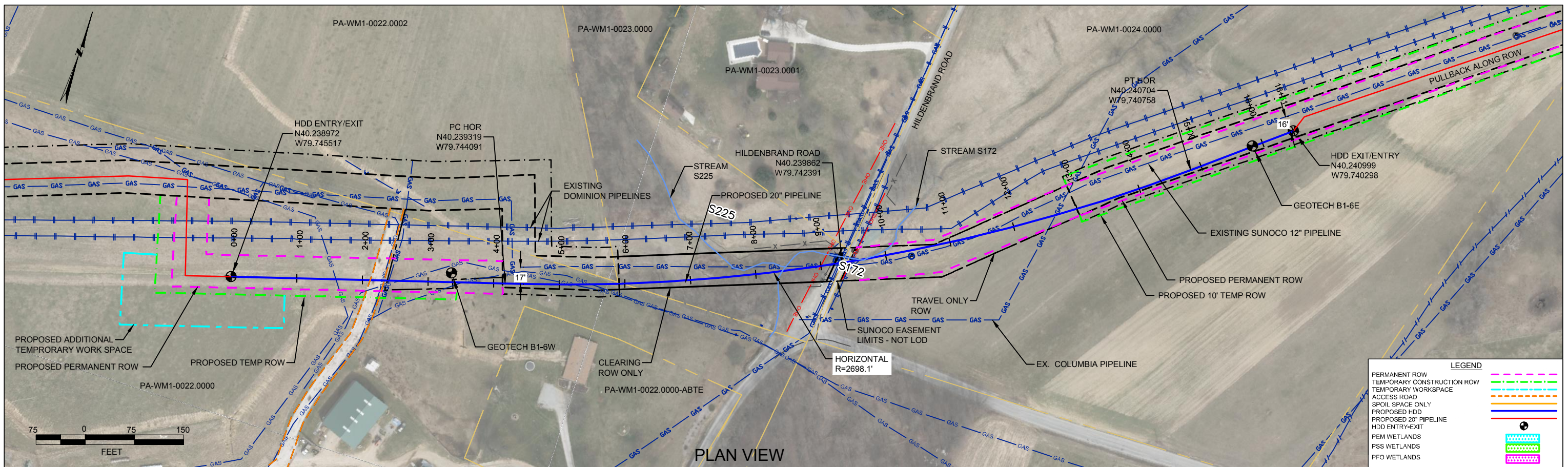
SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
HILDENBRAND ROAD
PENNSYLVANIA PIPELINE PROJECT

TETRA TECH ROONEY
(303) 792-5911

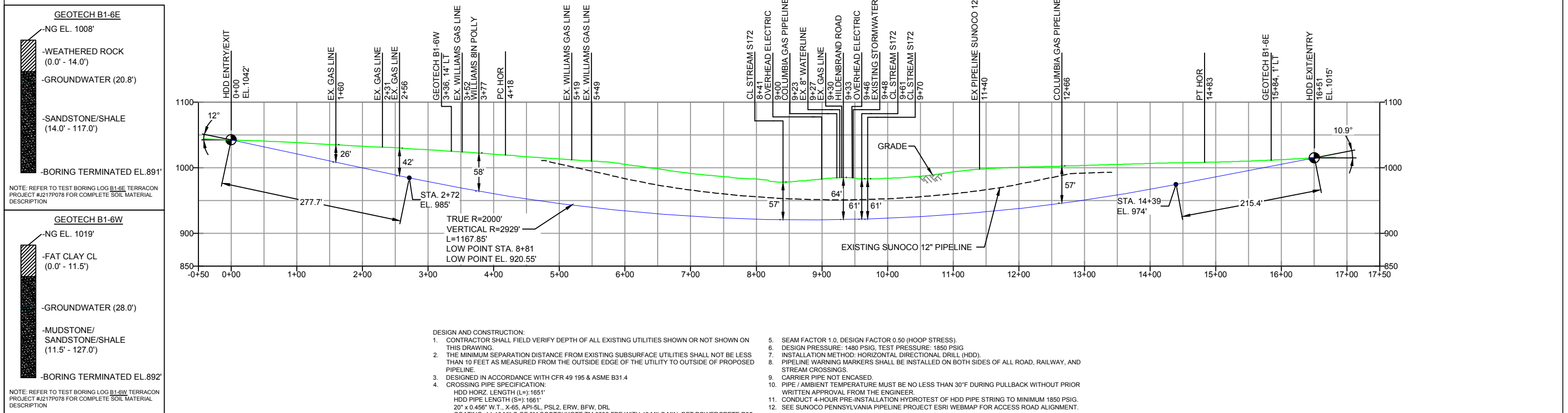
SCALE: 1"=100'

DWG. NO. PA-WM1-0023.0000-RD



WESTMORELAND COUNTY, PENNSYLVANIA - SEWICKLEY TOWNSHIP
S1B-0190

PROFILE VIEW



- DESIGN AND CONSTRUCTION:
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - 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.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HORZ LENGTH (L)=1651'
HDD PIPE LENGTH (S)=1661'
20" x 0.456" W.T., X-65, API-5L, PSL2, ERW, BFW, DRL
COATING: 14-16 MILS OF 3M SCOTCHKOTE TM 6233 FBE WITH 40 MILS MIN. DFT POWERCRETE R95
 - SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS).
 - DESIGN PRESSURE: 1480 PSIG, TEST PRESSURE: 1850 PSIG
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
- STATIONING IS BASED ON HORIZONTAL DISTANCES.
- 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.
- CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
- SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING		REVISIONS	
ES-1.14	TO	ES-1.14	DESCRIPTION
SHEET 10	TO	SHEET 11	AERIAL SITE PLAN
		EP5	UPDATED GEOTECH INFO PROVIDED BY DPS
		EP4	UPDATED GEOTECH INFO
		EP3	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT PER DPS DESIGN
		EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16
		EP1	REVISED PER PADEP COMMENTS
		EP	
DWG NO	DWG NO	NO.	DESCRIPTION

**Sunoco Logistics
Partners L.P.**

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HILDENBRAND ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' DWG. NUMBER: PA-WM1-0023.0000-RD



Attachment B

Geotechnical Boring Logs

October 13, 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 1 – Hildenbrand Road
Commonwealth of Pennsylvania
Drawing # PA-WM1-0023.0000-RD
PO #20170811
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 Hildenbrand Road (Drawing # PA-WM1-0023.0000-RD) in the Commonwealth of Pennsylvania. Our services were performed in general accordance with our proposal number PJ2175108 dated July 28, 2017. Our scope of services included advancing two borings, designated as B1-6W and B1-6E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B1-6W and B1-6E were drilled between August 25 and September 1, 2017 to depths of 127.0 and 117.0 feet, respectively as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of interlayered sedimentary rock comprised of sandstone, mudstone, shale, and limestone. Final test boring logs documenting overburden soil and bedrock conditions as well as photographs of the rock core samples are attached.

Rock compressive strength testing was performed on samples from approximately 20-foot intervals within the bedrock strata at each boring location. As an exception to the planned 20-foot intervals, a rock sample near 32 feet from B1-6W was not tested due to highly weathered conditions. Unconfined compressive strength test results are shown on the attached reports.

Geotechnical Site Characterization

Mariner East 2 Pipeline – Spread 1 Hildenbrand Road ■ Pennsylvania
Drawing #PA-WM1-0023.0000-RD / PO #20170811
October 13, 2017 ■ Terracon Project No. J217P078



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.

A handwritten signature in blue ink, appearing to read "Lawrence J. Dwyer", is positioned above the printed name and title.

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



**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

Hildenbrand Road HDD Cores B1-6W and B1-6E
PA-WM1-0023.0000-RD
Westmoreland County, Pennsylvania

Exhibit

A-2

EXPLORATION RESULTS

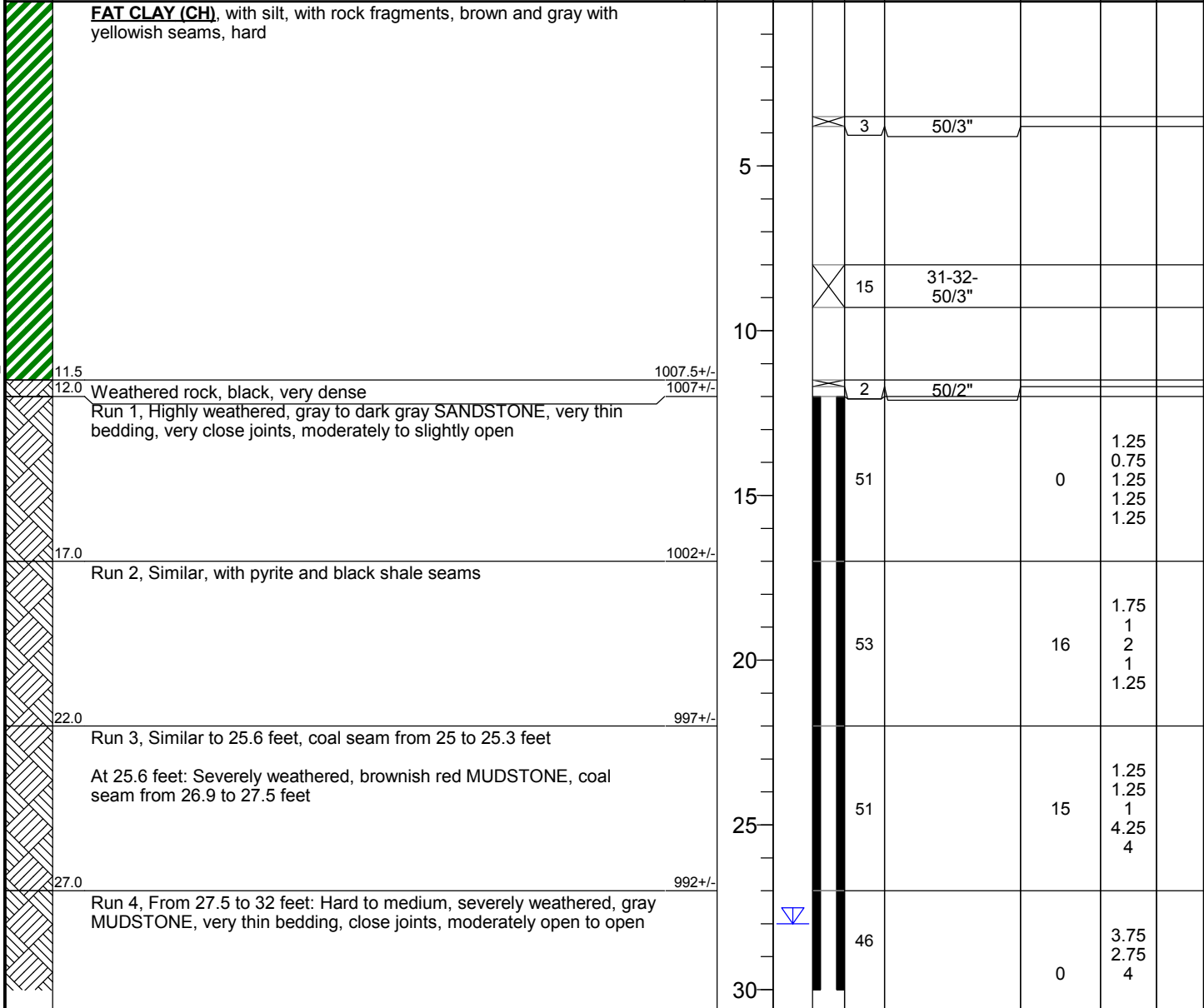
BORING LOG NO. B1-6W Hildenbrand Rd. West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.239288° Longitude: -79.744387° Approximate Surface Elev: 1019 (Ft.) +/- DEPTH _____ ELEVATION (Ft.) _____	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
--------------------	--	--------------------	---------------------------------	--------------------	-----------------------	---------------------------	----------------	---------------------------	--------------------------------



Advancement Method: Mud rotary with wireline		Notes:
Abandonment Method: Grouted to surface		
WATER LEVEL OBSERVATIONS		Boring Started: 08-30-2017 Drill Rig: Diedrich D-50 Project No.: J217P078
▽ 48' on 8/30/17 ▽ 28' on 9/1/17	201 Hammer Mill Rd Rocky Hill, CT	Boring Completed: 09-01-2017 Driller: Terra Testing, Inc. Exhibit: A-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 1.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B1-6W Hildenbrand Rd. West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 1.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.239288° Longitude: -79.744387° Approximate Surface Elev: 1019 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
DEPTH	ELEVATION (Ft.)								
32.0	Run 4, From 27.5 to 32 feet: Hard to medium, severely weathered, gray MUDSTONE, very thin bedding, close joints, moderately open to open (continued)	987+/-			46			4.5 6.25	
37.0	Run 5, Similar to 34.4 feet At 34.4 feet: Hard to moderately hard, severely to moderately weathered, gray to dark gray SANDSTONE, thin to very thin bedding, close joints, slightly open to open	982+/-			48		0	6.75 3 2 4.5 2.5	
42.0	Run 6, Hard, moderately weathered, dark gray SANDSTONE, very thin bedding, close joints, slightly open to moderately open	977+/-			56		41	6.25 3 3.25 1.5 2	
47.0	Run 7, Similar	972+/-			60		66	1.5 2 1.25 1.25 1.5	
52.0	Run 8, Similar, gray with black	967+/-	▽		60		61	1.5 1 1 1 0.75	
57.0	Run 9, Similar, coal seam from 53.5 to 54.4 feet	962+/-			54		41	1.25 2 1.5 1.75 1.25	
60	Run 10, Similar				59		53	1.5 1 1.25	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ 48' on 8/30/17
▽ 28' on 9/1/17



Boring Started: 08-30-2017

Boring Completed: 09-01-2017

Drill Rig: Diedrich D-50

Driller: Terra Testing, Inc.

Project No.: J217P078

Exhibit: A-1

BORING LOG NO. B1-6W Hildenbrand Rd. West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 1.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.239288° Longitude: -79.744387° Approximate Surface Elev: 1019 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
DEPTH									
62.0	Run 10, Similar (continued)	957+/-			59			1.25 2.75	
67.0	Run 11, Similar, dark gray	952+/-			60		81	3 2.5 2.75 2 3	
72.0	Run 12, Similar, dark gray	947+/-			60		45	2 2 2.25 2.25 5	
77.0	Run 13, Similar to 73.3 feet From 73.3 to 76.2 feet: weathered black SHALE At 76.2 feet: Hard, slightly to moderately weathered, light gray LIMESTONE, thin bedding, close joints, slightly open	942+/-			59		65	2.25 3 3 2.25 2.25	
82.0	Run 14, Hard, slightly weathered, light gray LIMESTONE, thick bedding, close to moderately close joints, slightly open to moderately open At 77.1 feet: 1-inch black carbonaceous shale Black carbonaceous beds between 81.2 and 81.8 feet	937+/-			60		78	4 1.25 1.75 1.25 3.75	
87.0	Run 15, Similar Black carbonaceous beds between 84.8 to 85 feet and 86.8 to 87 feet:	932+/-			60		71	3.25 1 2 1.25 2.25	
	Run 16, Similar, thin bedding, slightly open Coarse-grained SANDSTONE from 87.0 to 88.3 feet				59		78	3 3.25 2.5	
		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

WATER LEVEL OBSERVATIONS
▽ 48' on 8/30/17
▽ 28' on 9/1/17

Notes:



Boring Started: 08-30-2017	Boring Completed: 09-01-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B1-6W Hildenbrand Rd. West

PROJECT: Mariner East Pipeline Borings

**CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354**

SITE: Spread 1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 1.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.239288° Longitude: -79.744387° Approximate Surface Elev: 1019 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 16, Similar, thin bedding, slightly open				59			3 2.25	
92.0	Coarse-grained SANDSTONE from 87.0 to 88.3 feet (<i>continued</i>)	927+/-							
	Run 17, Similar to 93.5 feet								
	From 93.5 to 96.3 feet: Dark gray to black, SHALE with limestone beds						75	2.75 2.5 1.5 3.25 2.75	
97.0	At 96.3 feet: Hard, moderately to slightly weathered, bluish gray MUDSTONE, very thin bedding, close to moderately close joints, slightly to moderately open, with black carbonaceous layers	922+/-			60				
	Run 18, Hard, slightly to moderately weathered, dark gray MUDSTONE, thin bedding, close to moderately close joints, slightly open								
	Severely weathered from 97.7 to 98.0 feet				60		86	7.75 3.25 1.75 1.5 2	
102.0	Run 19, Similar to 103.9 feet	917+/-							
	From 103.9 to 105.7 feet: Black to dark gray SHALE, with limestone beds								
	At 105.7 feet: Hard, slightly to moderately weathered, black with dark gray SHALE, thin bedding, close to moderately close joints, slightly open to open, vertical joint from 104.8 to 105.3 feet				57		56	4.5 3.5 3.5 3.25 5	
107.0	Run 20, From 107 to 110 feet: MUDSTONE	912+/-							
	At 110 feet: Hard, moderately weathered, dark to light gray, SANDSTONE, thin to very thin bedding, close joints, slightly to moderately open, with black carbonaceous layers				57		56	10.25 2.5 2 0.75 1	
112.0	Run 21, Similar	907+/-							
					60		86	2 1.5 0.5 0.75 1.75	
117.0	Run 22, Similar to 120 feet	902+/-							
	From 120 to 122 feet: black SHALE				60		71	1.75 3 5.75	
		120							

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ 48' on 8/30/17
▽ 28' on 9/1/17



Boring Started: 08-30-2017

Boring Completed: 09-01-2017

Drill Rig: Diedrich D-50

Driller: Terra Testing, Inc.

Project No.: J217P078

Exhibit: A-1

BORING LOG NO. B1-6W Hildenbrand Rd. West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.239288° Longitude: -79.744387° Approximate Surface Elev: 1019 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 22, Similar to 120 feet							5.25	
	122.0 From 120 to 122 feet: black SHALE (<i>continued</i>) 897+/-				60			1.75	
	Run 23, Hard, slightly weathered, light gray, LIMESTONE, thin bedding, close to moderately close joints, slightly to moderately open						83	1.5	
	127.0 127.0 892+/-	125			60			1.25 1.25 1.25 3	
	Boring Terminated at 127 Feet								

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

- ▽ 48' on 8/30/17
- ▽ 28' on 9/1/17



Boring Started: 08-30-2017

Boring Completed: 09-01-2017

Drill Rig: Diedrich D-50

Driller: Terra Testing, Inc.

Project No.: J217P078

Exhibit: A-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 1.GPJ TERRACON_DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B1-6E Hildenbrand Rd. East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.240884° Longitude: -79.740482° Approximate Surface Elev: 1008 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
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DEPTH	Weathered rock, brown, medium dense 14.0 Similar, gray to dark gray, very dense Run 1, Soft to medium hard, slightly weathered, gray to dark gray SANDSTONE, medium bedding, low angle joints at close spacing, contains carbonaceous laminations 17.0 Run 2, Similar, high angle fractures at 18.1 to 18.3 feet and 20.0 to 20.5 feet 22.0 Run 3, Similar to 22.8 feet At 22.8 feet: Very soft to soft, slightly to moderately weathered, gray SHALE, laminated, low angle joints at close spacing Coal seams at 23.9 to 24.4 feet and 24.9 to 25.6 feet 27.0 Run 4, Similar, slightly to highly weathered, gray to black, close to very close joints	5							
	994+/-	10	X	17	12-12-12 N=24				
	991+/-	15	X	16	9-10-14 N=24				
	986+/-	20	▽	3	50/3"				
	981+/-	25	▽	32			63	2 1.5 1.5	
		30	▽	60			43	2 1 1 2 1	
		35	▽	38			20	2 5 6 3 7	
		40		53			50	4 3 4	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

Boring located in area of approximately 12 inches of cut, 6-inches of which is topsoil

WATER LEVEL OBSERVATIONS

▽ 17.7' on 8/28/17
▽ 20.8' on 8/29/17



Boring Started: 08-25-2017

Boring Completed: 08-29-2017

Drill Rig: Diedrich D-50

Driller: Terra Testing, Inc.

Project No.: J217P078

Exhibit: A-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 1.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

BORING LOG NO. B1-6E Hildenbrand Rd. East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - J217P078 - SPREAD 1.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.240884° Longitude: -79.740482° Approximate Surface Elev: 1008 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
32.0	Run 4, Similar, slightly to highly weathered, gray to black, close to very close joints (<i>continued</i>)	976+/-			53			3 3	
37.0	Run 5, Similar, soft, slightly weathered, gray, close	971+/-			60		80	4 5 6 4 6	
42.0	Run 6, Similar to 39.4 feet At 39.4 feet: Soft to moderately hard, slightly weathered, dark gray SANDSTONE, thick bedding, low angle joints at close to moderately close spacing	966+/-			47		50	8 5 7 6 7	
47.0	Run 7, Similar	961+/-			60		92	4 5 4 3 3	
52.0	Run 8, Hard, slightly weathered, dark gray SANDSTONE, thin bedding, moderately dipping joints at close spacing, slightly open to open	956+/-			58		36	2.75 1.5 2.25 2 1.25	
57.0	Run 9, Similar, coal seam from 53.8 to 54.6 feet	951+/-			56		53	1.5 2.75 4.5 1.75 1.5	
60	Run 10, Similar				42		38	1.25 1.5 2.5	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

WATER LEVEL OBSERVATIONS	
▽	17.7' on 8/28/17
▽	20.8' on 8/29/17

Notes:
Boring located in area of approximately 12 inches of cut, 6-inches of which is topsoil



Boring Started: 08-25-2017	Boring Completed: 08-29-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-2

BORING LOG NO. B1-6E Hildenbrand Rd. East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. J217P078 - SPREAD 1.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.240884° Longitude: -79.740482° Approximate Surface Elev: 1008 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
DEPTH									
Run 10, Similar (continued)		62.0			42			5 6	
Run 11, Similar		67.0			60		68	4.25 0.5 1.5 2 1.75	
Run 12, Similar, moderately to severely weathered, 2-inch clay seam at 70.8 feet		72.0			60		26	1.5 2 3.25 5.75 2.5	
Run 13, Similar to 72.5 feet From 72.5 to 73.6 feet: Moderately weathered, black SHALE At 73.6 feet: Hard, slightly weathered, gray, SANDSTONE with limestone beds, thin bedding, close joints, slightly open to open		77.0			58		58	5 4.75 2.25 2.75 6	
Run 14, Hard, slightly weathered, light gray, MUDSTONE with limestone beds, very thin bedding, close to moderately close joints, slightly open to open, with black shale seams from 79.2 to 79.8 feet		82.0			57		76	2.25 1.25 3.25 3.25 1.5	
Run 15, Similar		87.0			57		78	2.25 3 2.75 3.75 2	
Run 16, Similar to 88 feet At 88 feet: Hard, slightly weathered, bluish gray SANDSTONE, thin bedding, close joints, slightly open to open		90			57		91	2.5 4 1.75	

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

WATER LEVEL OBSERVATIONS

▽ 17.7' on 8/28/17
▽ 20.8' on 8/29/17

Notes:
Boring located in area of approximately 12 inches of cut, 6-inches of which is topsoil



Boring Started: 08-25-2017	Boring Completed: 08-29-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-2

BORING LOG NO. B1-6E Hildenbrand Rd. East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL_J217P078 - SPREAD 1.GPJ TERRACON DATATEMPLATE.GDT 10/13/17

GRAPHIC LOG	LOCATION PA-WM1-0023.0000-RD 20170811 Latitude: 40.240884° Longitude: -79.740482°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (in.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Approximate Surface Elev: 1008 (Ft.) +/-								
	DEPTH ELEVATION (Ft.)								
92.0	916+/-				57			1 1.25	
Run 17, Similar									
97.0	911+/-	95			58		50	1 1.75 4.5 2 4	
Run 18, Similar									
102.0	906+/-	100			60		73	2.5 2.5 2.75 3.25 3.25	
Run 19, Similar to 103 feet At 103 feet: Hard, slightly weathered, dark gray MUDSTONE, thin bedding, close joints, slightly open to open									
107.0	901+/-	105			54		56	2.75 9.25 8 3.25 3.5	
Run 20, Similar to 108.8 feet At 108.8 feet: Hard, slightly weathered, dark gray SANDSTONE, thin bedding, close to moderately close joints, slightly open									
112.0	896+/-	110			60		96	4 3 2 2 2.25	
Run 21, Similar, close joints									
117.0	891+/-	115			59		73	2 2.5 3.5 1 1.75	
Boring Terminated at 117 Feet									

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

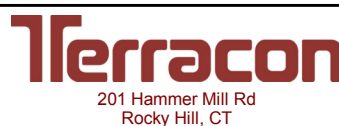
Abandonment Method:
Grouted to surface

Notes:

Boring located in area of approximately 12 inches of cut, 6-inches of which is topsoil

WATER LEVEL OBSERVATIONS

▽ 17.7' on 8/28/17
▽ 20.8' on 8/29/17



Boring Started: 08-25-2017

Boring Completed: 08-29-2017

Drill Rig: Diedrich D-50

Driller: Terra Testing, Inc.

Project No.: J217P078

Exhibit: A-2

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

Boring No.: B1-6W
 Sample No.: 2
 Sample Depth: 52 feet
 Sampling Date: 8/30/17

Lithology : Sandstone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 4 min

Diameter: 1.95 in
 Length: 3.96 in
 L/D: 2.03
 End Area: 2.99 in²

Maximum Axial Load at Failure: 12,780 lb
 Compressive Strength: 4,279 psi
 Compressive Strength: 29.50 Mpa
 Unit Weight 144 pcf

Photograph after the test is mislabeled as 50ft

Before the Test



After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 1
Client :	Directional Project Support Inc.

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

Performed by:	H. Whitford
Test Date:	10/9/2017
Reviewed By :	L. Dwyer
Review Date :	10/12/2017

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

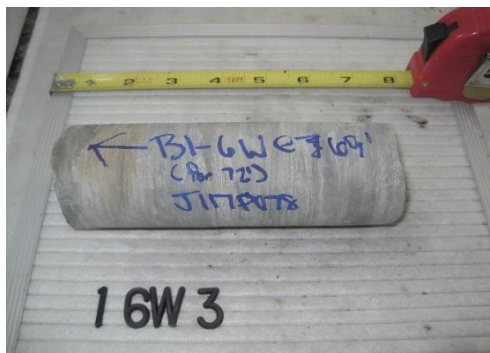
Boring No.: B1-6W
 Sample No.: 3
 Sample Depth: 69 feet
 Sampling Date: 8/30/17

Lithology : Sandstone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 6 min

Diameter: 1.95 in
 Length: 4.38 in
 L/D: 2.25
 End Area: 2.99 in²

Maximum Axial Load at Failure: 18,870 lb
 Compressive Strength: 6,318 psi
 Compressive Strength: 43.56 Mpa
 Unit Weight 169 pcf

Before the Test



After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 1
Client :	Directional Project Support Inc.

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

Performed by:	H. Whitford
Test Date:	10/9/2017
Reviewed By :	L.Dwyer
Review Date :	10/12/2017

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

Boring No.: B1-6W
 Sample No.: 4
 Sample Depth: 89 feet
 Sampling Date: 8/30/17

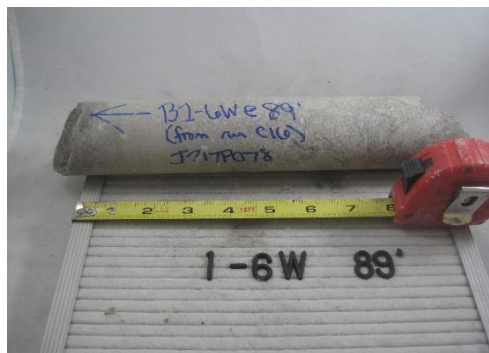
Lithology : Limestone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 7 min

Diameter: 1.98 in
 Length: 4.61 in
 L/D: 2.33
 End Area: 3.08 in²

Maximum Axial Load at Failure: 23,830 lb
 Compressive Strength: 7,739 psi
 Compressive Strength: 53.36 Mpa
 Unit Weight 157 pcf

Before the Test

After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 1
Client :	Directional Project Support Inc.

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

Performed by:	H. Whitford
Test Date:	10/9/2017
Reviewed By :	L. Dwyer
Review Date :	10/12/2017

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

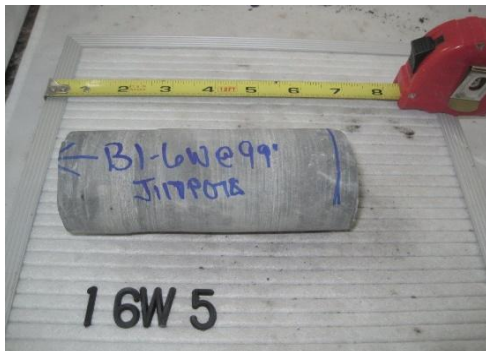
Boring No.: B1-6W
 Sample No.: 5
 Sample Depth: 99 feet
 Sampling Date: 8/30/17

Lithology : Mudstone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 7 min

Diameter: 1.95 in
 Length: 4.38 in
 L/D: 2.25
 End Area: 2.99 in²

Maximum Axial Load at Failure: 23,640 lb
 Compressive Strength: 7,916 psi
 Compressive Strength: 54.58 Mpa
 Unit Weight 167 pcf

Before the Test



After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline	<p style="margin: 0;">77 Sundial Ave., Suite 401 W Manchester, New Hampshire</p>	Performed by:	H. Whitford
Project No:	J217P078		Test Date:	10/9/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/12/2017

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

Boring No.: B1-6W
 Sample No.: 6
 Sample Depth: 109 feet
 Sampling Date: 8/30/17

Lithology : Mudstone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 6 min

Diameter: 1.98 in
 Length: 4.81 in
 L/D: 2.43
 End Area: 3.08 in²

Maximum Axial Load at Failure: 19,900 lb
 Compressive Strength: 6,463 psi
 Compressive Strength: 44.56 Mpa
 Unit Weight 164 pcf

Before the Test



After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 1
Client :	Directional Project Support Inc.

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

Performed by:	W. Shedd
Test Date:	10/7/2017
Reviewed By :	L. Dwyer
Review Date :	10/12/2017

The information contained in this report may not be reproduced except in its entirety without the express written consent of Terracon, Inc. Reports are relevant only to the items tested and may not be attributed to other work. Testing was performed in general accordance with the stated ASTM test method.

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

Boring No.: B1-6E
 Sample No.: 2
 Sample Depth: 52 feet
 Sampling Date: 8/25/17

Lithology : Sandstone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 10 min

Diameter: 1.98 in
 Length: 4.45 in
 L/D: 2.25
 End Area: 3.08 in²

Maximum Axial Load at Failure: 31,590 lb
 Compressive Strength: 10,260 psi
 Compressive Strength: 70.74 Mpa
 Unit Weight 142 pcf

Before the Test



After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 1
Client :	Directional Project Support Inc.

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

Performed by:	A. Suprunenko
Test Date:	10/3/2017
Reviewed By :	L.Dwyer
Review Date :	10/13/2017

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

Boring No.: B1-6E
 Sample No.: 3
 Sample Depth: 78 feet
 Sampling Date: 8/25/17

Lithology : Mudstone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 9 min

Diameter: 1.98 in
 Length: 4.46 in
 L/D: 2.25
 End Area: 3.08 in²

Maximum Axial Load at Failure: 31,200 lb
 Compressive Strength: 10,133 psi
 Compressive Strength: 69.86 Mpa
 Unit Weight 158 pcf


Before the Test



After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline	 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	C. Santana
Project No:	J217P078		Test Date:	10/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/13/2017

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

Boring No.: B1-6E
 Sample No.: 4
 Sample Depth: 87 feet
 Sampling Date: 8/25/17

Lithology : Mudstone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 8 min

Diameter: 1.97 in
 Length: 4.73 in
 L/D: 2.40
 End Area: 3.05 in²

Maximum Axial Load at Failure: 25,880 lb
 Compressive Strength: 8,491 psi
 Compressive Strength: 58.54 Mpa
 Unit Weight 151 pcf

Before the Test



After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline	<p style="margin: 0;">77 Sundial Ave., Suite 401 W Manchester, New Hampshire</p>	Performed by:	A. Suprunenko
Project No:	J217P078		Test Date:	10/3/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/13/2017

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

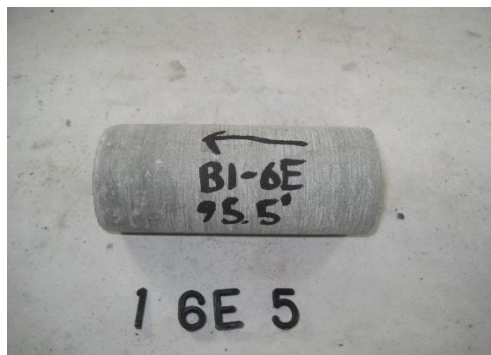
Boring No.: B1-6E
 Sample No.: 5
 Sample Depth: 95.5 feet
 Sampling Date: 8/25/17

Lithology : Sandstone
 Moisture Content : As received
 Lab Temperature : 70° F
 Loading Rate: 55 psi/s
 Time to Failure: 12 min

Diameter: 1.97 in
 Length: 4.20 in
 L/D: 2.13
 End Area: 3.05 in²

Maximum Axial Load at Failure: 39,980 lb
 Compressive Strength: 13,117 psi
 Compressive Strength: 90.44 Mpa
 Unit Weight 165 pcf

Before the Test



After the Test



Drawing # : PA-WM1-0023.0000-RD
 PO # : 20170811
 Crossing : Hildenbrand Rd.
 Spread : Spread 1

Project:	Mariner East Pipeline
Project No.	J217P078
Location:	Spread 1
Client :	Directional Project Support Inc.

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

Performed by:	C. Santana
Test Date:	10/13/2017
Reviewed By :	L.Dwyer
Review Date :	10/13/2017

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Photograph 1: B1-6W, Samples C-1 to C-4 (12 to 32 feet)



Photograph 2: B1-6W, Samples C-5 to C-8 (32 to 52 feet)



Photograph 3: B1-6W, Samples C-9 to C-12 (52 to 72 feet)



Photograph 4: B1-6W, Samples C-13 to C-16 (72 to 92 feet)



Photograph 5: B1-6W, Samples C-17 to C-20 (92 to 112 feet)



Photograph 6: B1-6W, Samples C-21 to C-23 (112 to 127 feet)



Photograph 1: B1-6E, Samples C-1 to C-4 (14 to 32 feet)



Photograph 2: B1-6E, Samples C-5 to C-7 (32 to 47 feet)



Photograph 3: B1-6E, Samples C-8 to C-11 (47 to 67 feet)



Photograph 4: B1-6E, Samples C-12 to C-15 (67 to 87 feet)



Photograph 5: B1-6E, Samples C-16 to C-19 (87 to 107 feet)



Photograph 6: B1-6E, Samples C-20 to C-21 (107 to 117 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
		Gravels with Fines: More than 12% fines ^C	$Cu < 4$ and/or $1 > Cc > 3$ ^E	GP	Poorly graded gravel ^F
	Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands: Less than 5% fines ^D	Fines classify as ML or MH	GM	Silty gravel ^{F,G,H}
		Sands with Fines: More than 12% fines ^D	Fines classify as CL or CH	GC	Clayey gravel ^{F,G,H}
	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}
			Inorganic: PI < 4 or plots below "A" line ^J	ML	Silt ^{K,L,M}
		Silts and Clays: Liquid limit 50 or more	Organic: Liquid limit - oven dried < 0.75	OL	Organic clay ^{K,L,M,N}
			Organic: Liquid limit - not dried < 0.75	OH	Organic silt ^{K,L,M,O}
		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}
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

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

^F If soil contains ³ 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 ³ 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 ³ 30% plus No. 200 predominantly sand, add "sandy" to group name.

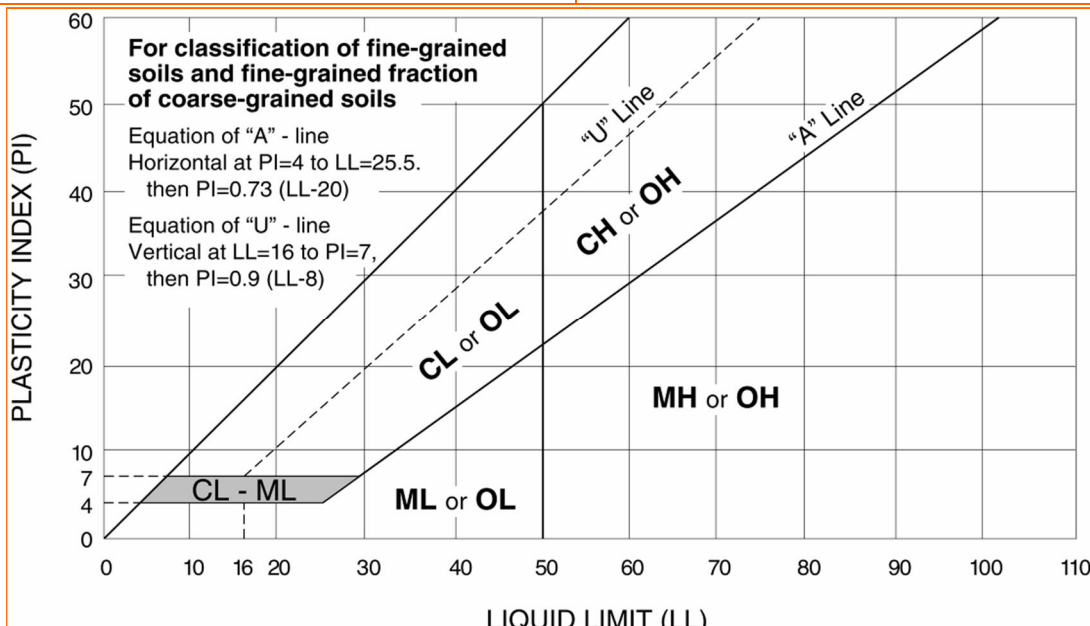
^M If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

^N PI ³ 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		Joint Openness Descriptors	
RQD, as a percentage	Diagnostic description	Openness	Descriptor
Exceeding 90	Excellent	No Visible Separation	Tight
90 – 75	Good	Less than 1/32 in.	Slightly Open
75 – 50	Fair	1/32 to 1/8 in.	Moderately Open
50 – 25	Poor	1/8 to 3/8 in.	Open
Less than 25	Very poor	3/8 in. to 0.1 ft.	Moderately Wide
		Greater than 0.1 ft.	Wide

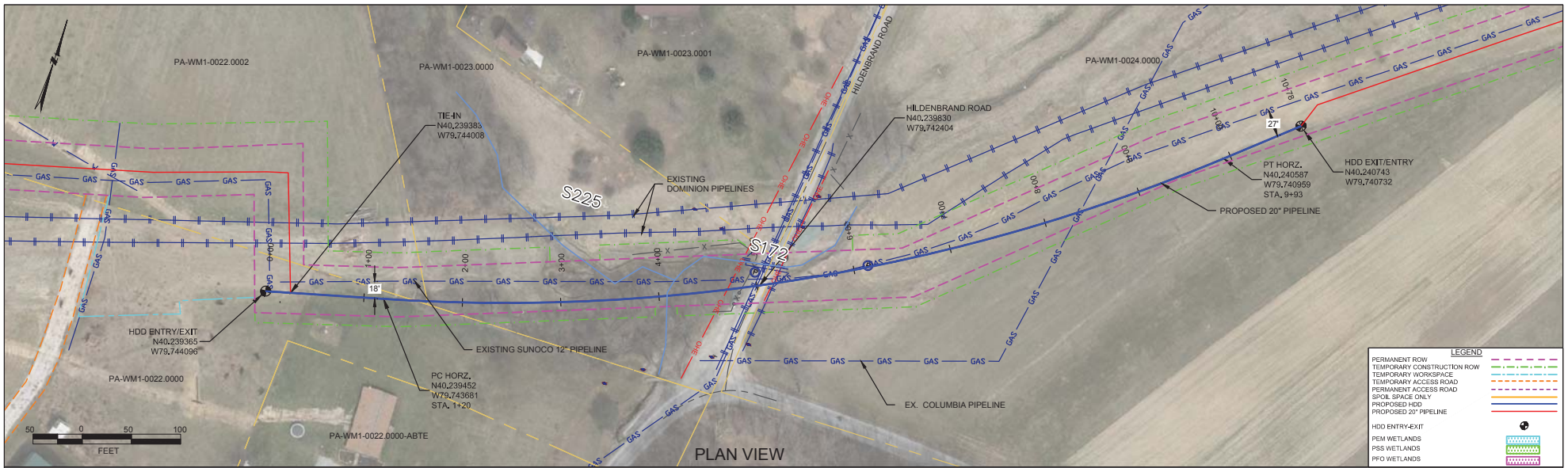
1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

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.

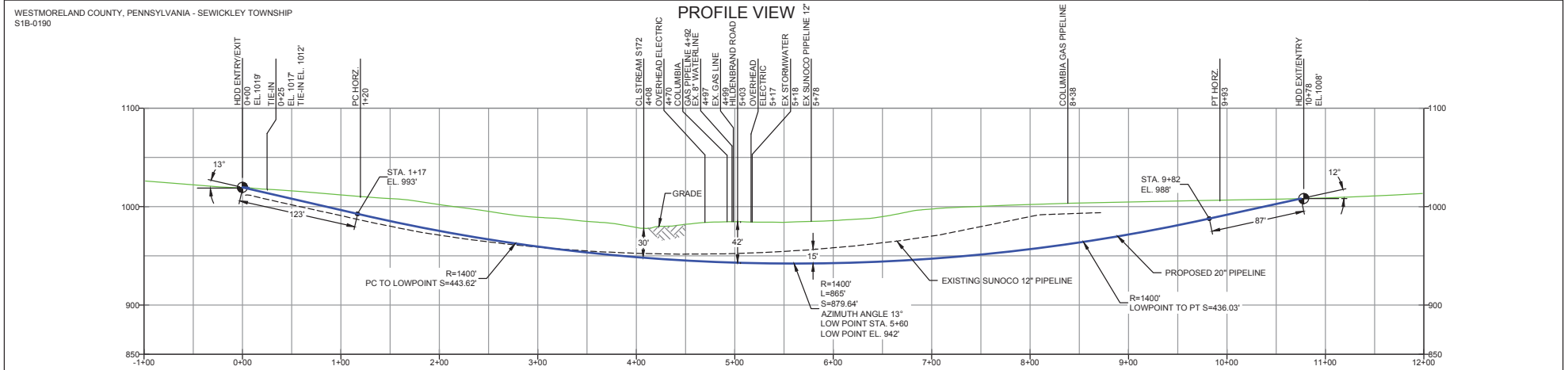
**HILDENBRAND ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PA-WM1-0023.0000-RD
(SPLP HDD# S1B-0190)**

ATTACHMENT 2

ORIGINAL AND REVISED HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



WESTMORELAND COUNTY, PENNSYLVANIA - SEWICKLEY TOWNSHIP
S1B-0190



- DESIGN AND CONSTRUCTION:**
- CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
 - 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.
 - DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
 - CROSSING PIPE SPECIFICATION:
HDD HDQZ LENGTH (L)=1079'
HDD PIPE LENGTH (SP)=1090'
20" x 0.456" W.T. X 65L APRIL PSL2 ERW 8FW
COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCONCRETE OR ENGINEER APPROVED EQUAL)
 - INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
 - INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 - PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 - CARRIER PIPE NOT ENCASED.
 - PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 - CONDUCT 4-HOUR PPE INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 - SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
 - SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
 - SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

- ALL COORDINATES SHOWN ARE IN LATITUDE AND LONGITUDE. ALL MSL ELEVATIONS ARE NAD83
- STATIONING IS BASED ON HORIZONTAL DISTANCES.
- 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.
- CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
- SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING				REVISIONS							
ES-1.14	TO	ES-1.14	EROSION & SEDIMENT PLAN	EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AJW	09/30/16
SHEET 10	TO	SHEET 11	AERIAL SITE PLAN	EP1	REVISED PER PADEP COMMENTS	DLM	05/06/16	RMB	05/06/16	AJW	05/06/16
				EP		DLM	03/15/16	RMB	03/15/16	AJW	03/15/16
				1	REVISED PER COMMENTS FROM REI REVIEW 12-18-15	MRS	12/18/15	RMB	12/18/15	AJW	12/18/15
				0	ISSUED FOR CONSTRUCTION	DLM	11/30/15	RMB	11/30/15	AJW	11/30/15
DWG NO		DWG NO	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE

**Sunoco Logistics
Partners L.P.**

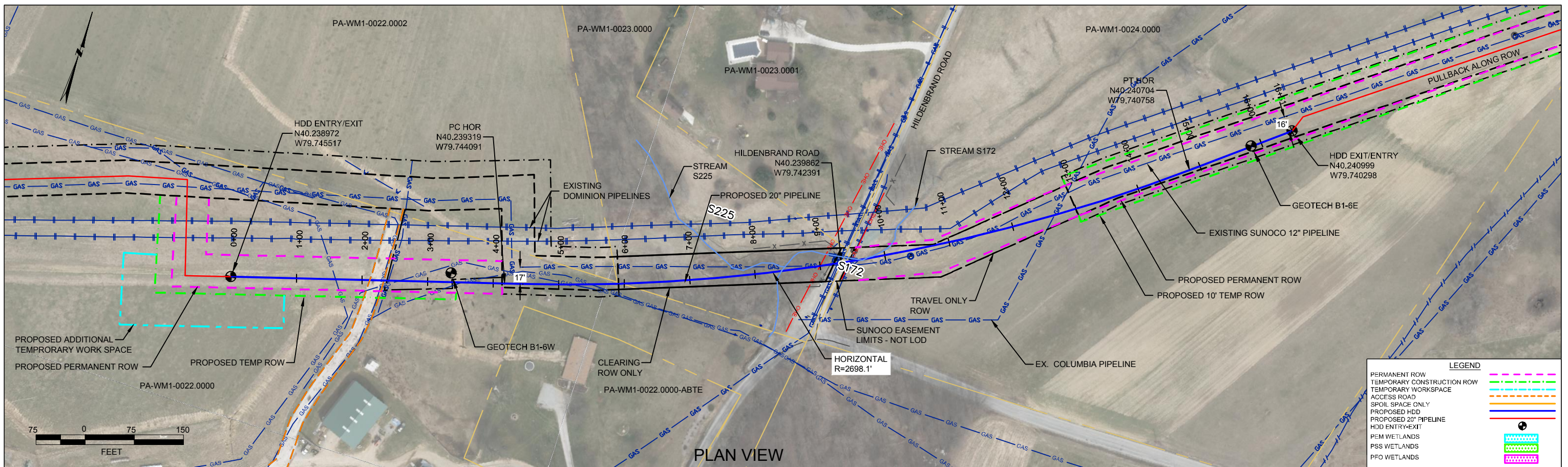
SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
HILDENBRAND ROAD
PENNSYLVANIA PIPELINE PROJECT

TETRA TECH ROONEY
(303) 792-5911

SCALE: 1"=100'

DWG. NO. PA-WM1-0023.0000-RD

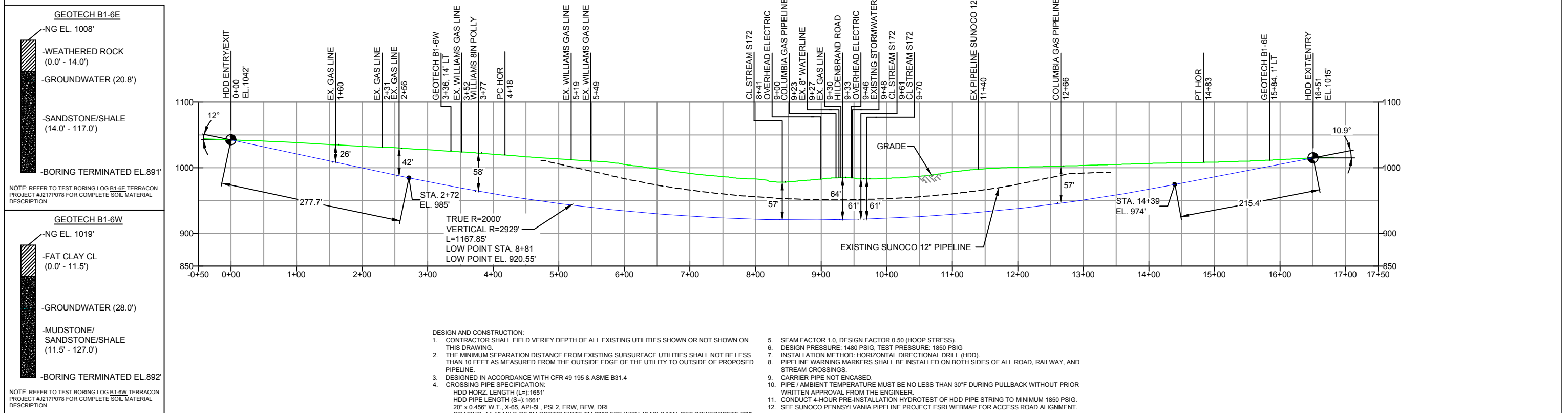


PLAN VIEW

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

WESTMORELAND COUNTY, PENNSYLVANIA - SEWICKLEY TOWNSHIP
S1B-0190

PROFILE VIEW



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 811-800-786-7440.

REF. DRAWING		REVISIONS	
ES-1.14	TO ES-1.14	EROSION & SEDIMENT PLAN	EP5 UPDATED GEOTECH INFO PROVIDED BY DPS
SHEET 10	TO SHEET 11	AERIAL SITE PLAN	EP4 UPDATED GEOTECH INFO
			EP3 DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT PER DPS DESIGN
			EP2 REVISED PER PADEP COMMENTS RECEIVED 09-06-16
			EP1 REVISED PER PADEP COMMENTS
			EP
DWG NO	DWG NO	DESCRIPTION	NO.

BY	DATE	CHK	DATE	APP	DATE
MRS	11/14/17	RMB	11/14/17	CAG	11/14/17
MRS	11/01/17	RMB	11/01/17	CAG	11/01/17
MRS	08/21/17	RMB	08/21/17	CAG	08/21/17
MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
DLM	05/06/16	RMB	05/06/16	AAW	05/06/16
DLM	03/15/16	RMB	03/15/16	AAW	03/15/16

**Sunoco Logistics
Partners L.P.**

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
HILDENBRAND ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' DWG. NUMBER: PA-WM1-0023.0000-RD

- 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)=1651'
HDD PIPE LENGTH (S)=1661'
20" x 0.456" W.T., X-65, API-5L, PSL2, ERW, BFW, DRL
COATING: 14-16 MILS OF 3M SCOTCHKOTE TM 6233 FBE WITH 40 MILS MIN. DFT POWERCRETE R95
 5. SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS).
 6. DESIGN PRESSURE: 1480 PSIG, TEST PRESSURE: 1850 PSIG
 7. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
 8. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
 9. CARRIER PIPE NOT ENCASED.
 10. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
 11. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
 12. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.