HORIZONTAL DIRECTIONAL DRILL ANALYSIS
GOMBACH ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PADEP SECTION 102 PERMIT NO.: PA-WM1-0111.0000-RD
(SPLP HDD# S1B-0260)

GOMBACH ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PADEP SECTION 102 PERMIT NO.: PA-WM1-0111.0000-RD
(SPLP HDD# S1B-0260)

This reanalysis of a horizontal directional drill (HDD) installation of a 20-inch diameter pipeline crossing under Bushy Run Creek, Stream S202, and Gombach Road (west to east), in Penn 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 2 on the list of HDDs included on Exhibit 2. This HDD was not initiated before the issuance of the Order.

The original permitted HDD profile was evaluated for potential Inadvertent Return (IR) occurrences during drilling activities and determined to have an elevated risk. Based upon additional geologic investigations and the characteristics of the subsurface geology the proposed HDD is being abandoned, and being replaced with a conventional construction plan consisting of 783 foot (ft) of open trench pipeline lay, and one FlexBor approximately 600 ft in length. The abandonment of this HDD is to avoid the potential for IRs of drilling fluids to the land surface or Waters of the Commonwealth during pipeline installation.

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: 980 foot (ft)
- Entry/Exit angle: 9 - 14 degrees
- Maximum Depth of cover: 29 ft
- Depth of cover under streams: 20 – 21 ft
- Pipe design radius: 1,800 ft

A copy of the original HDD plan and profile is included as Figure 1 in Attachment 3.

GEOLOGIC ANALYSIS

Bedrock in the area of HDD S1B-0260 is the Monongahela Group. The Monongahela Group contains cyclic sequences of sedimentary limestone, shale, sandstone and coal. Limestone is the primary rock type. The overburden can range for six to nine feet thick and is primarily composed of fine to medium sand silt and clay from weathered limestone, sandstone and shale. The base of the Monongahela Group is bounded by the Pittsburgh Coal which is found approximately 137 to 188 feet below the entry/exit points. The Redbank Coal is a minor coal found in the area, 70 to 100 feet above the Pittsburgh Coal.

Based on published geologic data, the limestones within the Monongahela Group do not support development of karst features; therefore, the use of geophysics assessments was not conducted.

Coal Mining

The Pittsburgh Coal is known to have been extensively deep mined in the area below the area of this HDD. Detailed abandoned mine maps of the area were assembled by TetraTech and show the base of the Pittsburgh Coal running from approximately 864 ft above mean sea level (amsl) at the north end of the drill and 881 ft amsl at the south end of the drill. The lowest elevation of the HDD on the profile occurs at Station 3+60 at approximately 975 ft amsl. . The roof of deep mining at this position is estimated to be at elevation 876 ft amsl; therefore approximately 99 feet of rock exists between the mine roof and the bottom of the HDD profile. The mines underlying the HDD profile were retreat mined, and closure of mine operations was prior to 1936. The estimated mine void height is 8.5 ft.

These detailed maps were also used to determine the absence or presence of ventilation shafts, access slopes and other access points relative to the HDD alignment and profile. No such features were identified in near vicinity to the HDD. A ventilation shaft and access slope were identified approximately 500 feet west of the profiles.

DEP's eMapPA web site (http://www.depgis.state.pa.us/emappa/) was used to search for any mine subsidence complaints adjacent to the HDD location. This search revealed a single home owner complaint located approximately 0.5 miles southwest of the southern entry/exit point. A field visit to this home was performed by the DEP Cambria Office which revealed some hairline cracks in the house foundation; however, a determination was made by DEP to exclude the possibility of mine subsidence.

Mine Pools

Regional mine pool maps for abandoned Pittsburgh coal mines in southwestern Pennsylvania were published by the National Mine Reclamation Center at West Virginia University. The area of HDD S1B-0260 appears on the Irwin, PA, Quadrangle and overlies the eastern edge of a flooded mine region referred to as Lyons Run. No monitoring points, shafts, or sealed shafts are shown on the map. Mine discharge points are shown approximately nine miles southwest of HDD in the area of North Irwin and Shawtown, PA, and approximately four miles northeast in the area of Export, PA on the Slicksville Quadrangle.

If a HDD encounters a mine pool there is a potential to create a new mine pool discharge at one of the entry/exit points. As described above, the WPA map of the Claridge Mine show the lowest elevation of the proposed HDD S1B-0260 at approximately 99 feet above the roof of the mine. The entry/exit point elevations are approximately 102 feet (south) and approximately 34 feet (north) above the lowest elevation of the HDD; therefore, there was no risk of creating a new mine pool discharge from the HDD intersecting the mine pool. The lowest elevation of the profile in the revised construction plan of open trench pipeline lay and FlexBor is the same as for the HDD, and therefore, the FlexBor alternative also has no potential for creating a new mine pool discharge.

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

Subsidence Potential

Tetra Tech mine engineers reviewed the mine maps and the location and elevation of the planned HDD. The HDD is underlain by two coal mines that were operated by different owners. Maps for both mines were reviewed. The WPA (Works Progress Administration) prepared generalized maps of abandoned mines during the 1930's by reviewing maps available to them at that time. Their map for this area was also reviewed. The information regarding mining practices utilized and timing of mining could not be determined from the available maps. The maps appear to show the initial mining of the Penn Manor mine prior to 1918, and some secondary mining later.

The estimated maximum subsidence that the pipeline may experience in the future is the difference between the subsidence estimated using the original strength (900 psi) of coal and the subsidence estimated using degraded strength (600 psi) of coal. This differential subsidence is shown on Figure 5 in the subsidence report provided in Attachment 2. There are two primary areas of potential future subsidence. One area is centered at HDD Station 2+47 and occurs within a retreat mined area that was not completely caved based on our interpretation of the 3D seismic data. The increased subsidence at this location was estimated to be about 0.38 foot (4.6 inches). The second area of increased subsidence occurs just beyond where the HDD exits to the surface on the south end. This area is again located in a retreat mined area that was interpreted as not being completely caved. The additional subsidence at this area is estimated to be about 0.68 foot (8.2 inches).

Since this HDD is now abandoned and replaced with an open cut/FlexBor construction plan, which will place the new pipeline at depths shallower than an HDD, there is no risk of subsidence effects related to the replacement construction plan. The findings by the pipeline engineers is included within the report provided in Attachment 2.

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

There is very little primary porosity associated with the sedimentary rocks of western Pennsylvania for the storage and movement of groundwater. The primary occurrence of groundwater in the Monongahela Group is associated with the interconnected network of secondary porosity features characteristic of the bedrock. These include bedrock joints and fractures, faults, and bedding plane partings.

The Pennsylvania Groundwater Information System (PaGWIS) reported 17 residential wells within a 0.5 mile radius of the HDD. Eleven wells are completed to depths between 110 and 305 feet. Six wells have no reported depths. Depth to bedrock in the reported wells ranges between 1 and 21 feet. Published median well yields in this area have been measured at approximately 15 to 100 gallons per minute (estimated) in the Monongahela Group. Well yields in the residential wells identified using PaGWIS near the bore path range from 0.5 to 12 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 hydrogeology and results of the geotechnical investigation performed at this location.

INADVERTENT RETURNS DISCUSSION

An HDD has not been initiated at this location.

All of the IRs to date in Spreads 1 and 2 for the Mariner II pipeline have occurred while drilling through cyclic sequences of sandstone, shale, limestone, clays seams and coal present within western Pennsylvania bedrock formations, including the Allegheny Group, Casselman Formation, Glenshaw Formation, Monongahela Group, and Waynesburg Formation. In general, the IRs have been related to shallow overburden (especially under water bodies), large elevation changes between entries and entry/exits, coarse grained unconsolidated materials near the surface (such as alluvium and mine spoil), and the interconnectivity of open bedrock structural features that is difficult to predict.

As stated in the introduction, the proposed HDD is being abandoned and replaced with a conventional construction open cut/FlexBor construction plan. The intended pilot process in advance of the FlexBor reaming is an “air hammer”, therefore no pressurized drilling fluids will be used during the pilot phase. The FlexBor reaming process does not used pressurized bentonite based drilling fluids, but rather high volume air flows with minimal water injection, with the cuttings returning to the entry through an enclosed casing. As a result, the new construction plan substantially reduces the risk for an IR.

GOMBACH ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PADEP SECTION 102 PERMIT NO.: PA-WM1-0111.0000-RD
(SPLP HDD# S1B-0260)

ADJACENT FEATURES ANALYSIS

The HDD location is 1.0 miles northeast of the city of Harrison City in Westmoreland County set within a mixture of residential home sites, light industrial developments, deciduous woodlands and agricultural field. The general route of the Mariner II pipeline in this area is from south to north.

The crossing of streams S201 and S202 is located immediately north of Watt Road, approximately 250 feet north of the intersection with Gongaware Road and wetland W59 is located immediately east, approximately 45 feet from the pipeline alignment.

Individual home sites occur in the immediate vicinity of the HDD location along both sides of Main Street, Watt Road, Gongaware Road, and Gombach Road with the nearest home site located 96 ft east of the alignment.

During the original project planning by SPLP a survey of land owners within 150 feet of the ROW was performed. All land owners were contacted with an offer for SPLP to test their wells, but no land owners requested that their wells be tested.

SPLP has more recently identified all landowners with property located within 450 ft of the HDD alignment. There are twenty-seven (27) 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 Yordy, Executive Assistant, Office of Programs at the Department's Central Office.

SPLP has confirmed that all properties within 450 ft of the HDD profile have public water supply.

ALTERNATIVES ANALYSIS

As required by the Order, the reanalysis of S1B-0260 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.

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

Based on the results of this reevaluation, the proposed open cut/FlexBor alternative is the preferred method of installation to cross Watt Road, Flour Bag Fort Land, Gombach Road, and Gongaware Road and minimize impacts to private residences and athletic fields. Additionally, the FlexBor minimizes impact to streams S201 and S202, which are Chapter 93 designated Trout Stocked Fisheries.

GOMBACH ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PADEP SECTION 102 PERMIT NO.: PA-WM1-0111.0000-RD
(SPLP HDD# S1B-0260)

Open-cut Analysis

Conversion to an all open cut construction plan would result in direct but temporary impacts to PADEP designated trout stocked fisheries. 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 S201 and S202, an open cut workspace with a width of 75 feet would be required to accommodate pipeline and provide sufficient space for trench excavation, and spoil storage. The assessed area of impact by this open cut plan would directly affect 0.042 acres of stream bed and 0.355 acres of floodway. S201 (Bushy Creek) is a 16 foot-wide perennial stream. To make this conventional crossing would require the damming the stream using a 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 FlexBor below these resources.

In addition, open cutting this area would result in temporary impacts to 4 roads, a portion of an athletic field, a residential properties. The relatively short FlexBor avoids surface impacts to several infrastructure and biological features.

Re-Route Analysis

There are no existing utility corridors in any direction for several miles that would provide an established alternate corridor for consideration.

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 open cut/FlexBor construction plan is co-located within the existing SPLP 12” pipeline ROW and rerouting would cause new greenfield impacts. In addition, given the size, length, and general perpendicular direction of stream S201 (Bushy Creek), no practicable re-route option lies to the east or west of the proposed route that would not ultimately cross Bushy Creek.

CONCLUSION

As stated in the introduction, SPLP is abandoning the proposed HDD and is submitting to the Pennsylvania Department of Environmental Protection a Chapter 102 and Chapter 105 permit modification package for review and approval. The permit modification package proposes a change in crossing methodology from the original or a revised HDD design to a combination of open cut and FlexBor to complete pipeline installation across the area encompassed by the original design of HDD No. S1B-0260. Figure 2 and 3 in Attachment 3 presents the replacement open cut/FlexBor design replacing the original permitted HDD.

GOMBACH ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PADEP SECTION 102 PERMIT NO.: PA-WM1-0111.0000-RD
(SPLP HDD# S1B-0260)

ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

HDD HYDROGEOLOGIC REEVALUATION REPORT

Mariner East II
Spread 1
HDD S1B-0260
Gombach Road
Penn Township, Westmoreland County, Pennsylvania

Prepared for:

Sunoco Pipeline, L.P.

Prepared by:

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

May 2018

1866716_1.docx

HDD HYDROGEOLOGIC REEVALUTION REPORT

Mariner East II
Spread 1
HDD S1B-0260
Gombach Road
Penn Township, Westmoreland County, Pennsylvania

May 2018

Prepared for:

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

Prepared by:

Michael D. Antonetti, P.G.
Sr. Project Manager

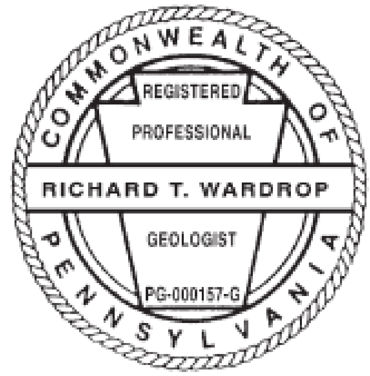
Reviewed by:

Richard T. Wardrop, P. G.
Principle Hydrogeologist

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

1866716_1.docx

By affixing my seal to this document, I am certifying that the geologic 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.



March 21, 2018

Richard T. Wardrop, P. G. Date

Lic. No. PG000157G

TABLE OF CONTENTS

FIGURES

ATTACHMENTS

1.0 INTRODUCTION

Sunoco Pipeline, L.P., (SPLP) retained Groundwater & Environmental Services, Inc. (GES) to prepare Hydrogeologic Reevaluation Reports (HRRs) for horizontal directional drills (HDDs) listed on Exhibit 2 of Stipulated Order EHB Docket No. 2017-009-L signed August 10, 2017. This report discusses the hydrogeologic reevaluation for PA-WM1-0111, HDD S1B-0260, the 20-inch HDD installation for this location. The planned alignment for HDD S1B-0260 is in Penn Township, Westmoreland County, PA., and runs north to south, crossing both Gombach and Watt Roads and two streams, including Bushy Run Creek (S201) and an unnamed tributary (S202). A map depicting the location of the HDD is presented as **Figure 1**. The discussion presented in this report is based on an alignment and profile developed by Tetra Tech/Rooney, revised on September 30, 2016 (original boring) and a FlexBor alternative which includes a section of open-trench pipe installation (see **Attachment A**). The FlexBor alternative was examined to greatly reduce risk of loss of circulation (LOC) and/or inadvertent returns (IRs) by eliminating use of drilling fluids under pressure. This alternative includes approximately 612 feet of FlexBor installation and approximately 771 feet of open trench installation. The intended pilot process in advance of the FlexBor reaming is an "air hammer", therefore no pressurized drilling fluids would be used during the pilot phase. The Flexbor reaming process does not use pressurized bentonite based drilling fluids, but rather high volume air flows with a minimal amount of water injection and the cuttings return to the entry through an enclosed casing. As a result, the new construction plan substantially reduces the risk for an IR.

This report presents the following information:

- Geologic and hydrogeologic characteristics in the area of HDD S1B-0260;
- Summaries of studies performed pertinent to reevaluation, including fracture trace analysis and geotechnical borings;
- A site conceptual model; and
- Reevaluation recommendations.

The contents of this report were developed from interpretation of published information, field observations, and related field studies. Site geotechnical boring programs were conducted by Tetra Tech in June 2013, and more recently by Terracon Consultants, Inc. (Terracon) in September 2017, in support of the HDD S1B-0260 reevaluation. Please note that GES did not oversee or direct either geotechnical drilling program, including, but not limited to, the selection of number and location of borings, determination of surface elevations, target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and any core photographs that resulted from these programs were generated by the two SPLP contractors. GES relied on these reports and incorporated their data into the general geologic and hydrogeologic framework for this hydrogeologic reevaluation report.

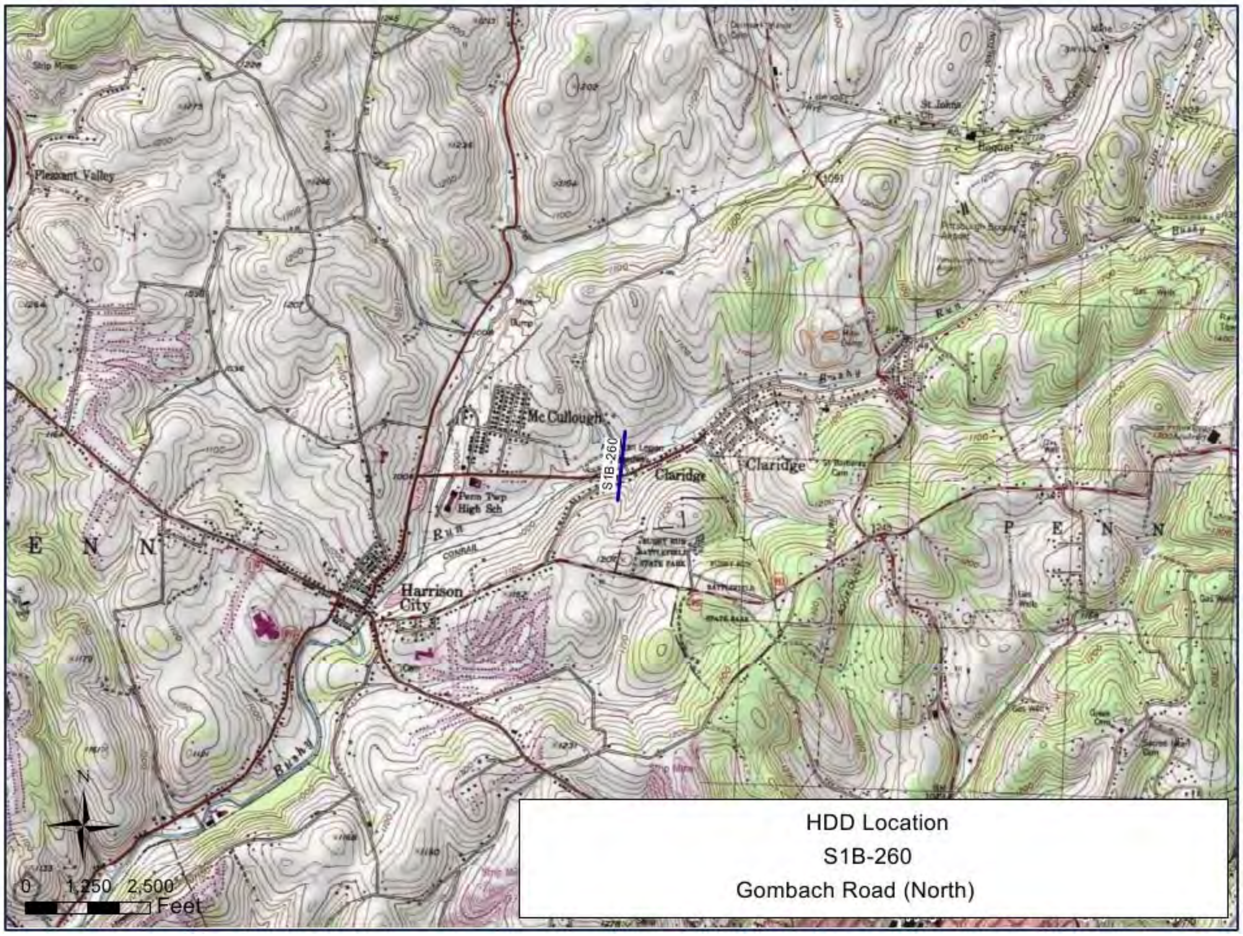


Figure 1. Site Location Map (modified from USGS Irwin 7.5 minute Topo Quad. Map, rev. 1980)

2.0 HDD GEOLOGY / HYDROGEOLOGY

2.1 Physiography

HDD S1B-0260 is located within the Allegheny Mountain Section of the Appalachian Plateaus Province, which is characterized by wide ridges separated by broad valleys.

2.1.1 Topography

The topography in the area of HDD S1B-0260 is relatively flat along the northern entry/exit point, dipping down slightly progressing westward over the flood plains of S202 and Bushy Run Creek (S201), then increases in elevation at the southern entry/exit point. The HDD overall length is 980 feet. The elevation at the lower northern entry/exit point is 1,009 feet above mean sea level (ft amsl) and the elevation of the southern entry/exit point is approximately 1,077 ft amsl. The FlexBor's south exit within the bore pit is placed further north, 52 feet south of Gongaware Road at an elevation of 1,015 ft amsl and the north exit within the bore pit it is further south, approximately 40 feet north of Gombach Road at an elevation of approximately 988 ft amsl. The area surrounding the HDD is comprised of rural properties with housing along nearby sections of roadway. The site location is depicted on **Figure 1**.

2.1.2 Hydrology

The nearest surface water bodies to the HDD location are two streams (S201 [Bushy Run Creek] and S202). The original HDD plan had the drill enter 337 feet north of Bushy Run Creek and cross 20 feet below it. The FlexBor passes 19 feet below Bushy Run Creek. Stream S202 merges with Bushy Run Creek along the Right-of-Way (ROW) and Bushy Run Creek flows southwest, merges with Brush Creek and ultimately discharges to the Youghiogheny River.

2.2 Geology

Bedrock in the area of HDD S1B-0260 is of the Monongahela Group. The Monongahela Group contains cyclic sequences of sedimentary limestone, shale, sandstone and coal. Limestone is the primary rock type. The overburden can range for six to nine feet thick and is primarily composed of fine to medium sand, silt and clay from weathered limestone, sandstone and shale. **Figure 2** is a map depiction site bedrock geology.

2.2.1 Soils

Representative soil descriptions across the profile are seen in the geotechnical boring logs for boring HDD-16 (June 2013) and borings B1-7E and B1-7W (September 2017). The soils are comprised of "lean" clays with varying amounts of silt, sand, and rock fragments. The USDA NRCS Web Soil Survey for Westmoreland County (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx) lists the primary soils across the area of interest as the Clarksburg silt loams, Thorndale silt loam and the Dormont-Culleoka complex, all derived from weathered limestone, sandstone and shale; and the Linside silt loam derived from fine-silty alluvium. Bedrock was encountered at approximately 14.4 feet in the geotechnical boring HDD-16 and between 10 and 20 ft bgs in B1-7E and B1-7W, drilled for this reevaluation. The bores for the HDD and FlexBor will through approximately 450 feet of the area mapped as Linside silt loam across the flood plain of Bushy Run Creek. The bores passing beneath the flood plain of Bushy Run Creek (S201) may encounter more sandy alluvial material at depths greater than 20 feet bgs.

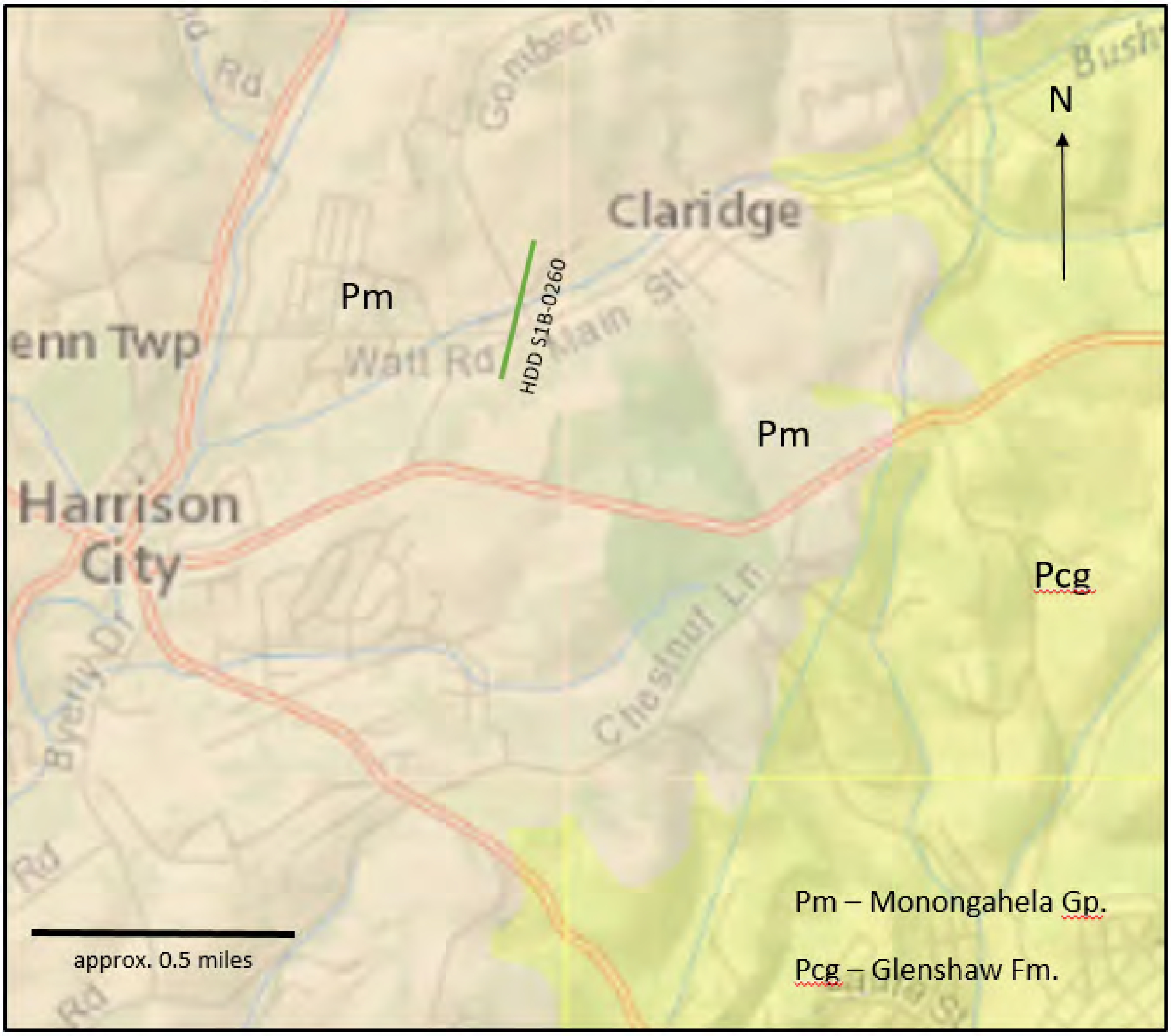


Figure 2. Site Geology (modified from PADCNR Map Viewer, http://www.gis.dcnr.state.pa.us/maps/index.html)

2.2.2 Bedrock Lithology

The HDD profile is within the mapped area of the Monongahela Group consisting of cyclic sequences of limestone, shale, calcareous shale, sandstone and coal. The base of the Monongahela Group is bounded by the Pittsburgh Coal which is found approximately 127 feet below the land surface at the position of the lowest part of the HDD and FlexBor profiles. The Redstone Coal can occur 70 to 100 feet above the Pittsburgh Coal in the area which would put it 27 to 57 feet below the same position (Skema 1988). The Monongahela Group is listed between 270 and 300 feet thick (Geyer and Wilshusen 1982).

2.2.3 Structure

Figure 3 shows the HDD S1B-0260 alignment on a Pittsburgh Coal structure contour map, positioned on the eastern limb of the Port Royal (Irwin) syncline and the western limb of the Grapeville anticline (Skema, 1988). As shown, bedrock is dipping gently to the northwest.

Nickelsen and Hough (1967) conducted regional mapping of joints in shale, coal and sandstone in the Appalachian Plateau. In the vicinity of HDD S1B-0260, two systematic joint sets were mapped with approximate trends of NW and WNW. Less frequent non-systematic joints were mapped approximately orthogonal to the systematic joints.

Figure 3. Structure Contour Map (modified from Skema, 1988)

2.2.4 Fracture Trace Analysis

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. Several orientations are present in the set of fracture traces. One fracture trace is oriented ENE and crosses the northern end of both the HDD and FlexBor alignments.

Figure 4. Fracture Trace Map

2.2.5 Karst

Based on published geologic data, no karst features are anticipated within the area of construction.

2.2.6 Mining

The Pittsburgh Coal is known to have been extensively deep mined in the area. Skema (1988) shows the base of the Pittsburgh coal in the area of HDD S1B-0260 at an elevation between 860 and 880 ft amsl; however, question mark symbols label the contouring due north of the HDD indicating uncertainty in the interpretation. Detailed abandoned mine maps of the area were obtained from the PA Department of Environmental Protection (DEP) California District Office. A 1-inch =200 ft scale map of the Claridge Mine in the Pittsburgh Coal shows the base of the Pittsburgh Coal running from approximately 637 ft amsl to 648 ft amsl below the HDD profile. Further research performed by Tetra Tech, Inc., using a map generated during the Works Progress Administration (WPA) concluded that the base of the Pittsburgh Coal in the Claridge Mine runs 235 feet higher, similar to that shown by Skema (1988) from approximately 864 to 881 ft amsl beneath the HDD S1B-0260 profils and that the elevations plotted on the Detailed Mine Map were relative elevations based on an arbitrary datum. The lowest elevation of the HDD on the permitted profile occurs at Station3+60, at an elevation of 975 ft amsl. The roof of deep mining at his position is estimated to be at elevation 876 ft amsl, allowing for 99 feet of rock between the mine roof and installed pipe.

The WPA Map and Detailed Maps (see Attachment C) were used to determine the absence or presence of ventilation shafts, access slopes and other access points relative to the HDD alignment and profile. No such features were identified in close proximity to HDD S1B-0260. A shaft and slope were identified approximately 500 feet west of the alignment.

DEP's eMapPA web site (http://www.depgis.state.pa.us/emappa/) was used to search for any mine subsidence complaints proximal to the HDD S1B-0260 alignment. The search revealed a single home owner complaint for a house located approximately 0.5 miles southwest of the southern entry/exit. GES contacted the DEP's Cambria District Office to obtain more details regarding the complaint. Compliant ID: 189967, was recorded on 5/23/2000 and resolved on 5/24/2000. A field visit to 168 Nancy Drive was performed by the District Office which revealed some hairline cracks in the house foundation; however, a determination was made by PADEP that excluded the possibility of mine subsidence as the cause for the cracks.

Regional mine pool maps for abandoned Pittsburgh Coal seam mines in southwestern Pennsylvania were published by the National Mine Reclamation Center at West Virginia University (Ziemkiewicz, et. al., 2004). The area of HDD S1B-0260 appears on the map for the Irwin, PA, Quadrangle and overlies the eastern edge of a flooded mine region referred to as Lyons Run. No monitoring points, shafts, or sealed shafts are shown on the map, as are shown on the maps of other quadrangles. Mine discharge points are shown approximately nine miles southwest of HDD S1B-0260 in the area of North Irwin and Shawtown, PA, and approximately four miles northeast HDD S1B-0260 in the area of Export, PA (on the map for the Slicksville Quadrangle).

If a HDD encounters a mine pool there is a potential to create a new mine pool discharge at one of the entry/exit points. As described above, the WPA map of the Claridge Mine show the lowest elevation of HDD S1B-0260 at approximately 99 feet above the roof of the mine. The entry/exit point elevations are approximately 102 feet (south) and approximately 34 feet (north) above the lowest elevation of the HDD profile; therefore, there was no risk of creating a new mine pool discharge from the HDD intersecting the mine pool. The lowest elevation of the profile in the revised construction plan of open trench pipeline lay and Flexbor is the same as for the HDD, and therefore, the FlexBor alternative also has no potential for creating a new mine pool discharge.

2.2.7 Rock Engineering Properties

The Monongahela Group rock properties are as follows (Geyer and Wilshusen 1982):

- Well developed, thin beds in sandstone and siltstone; thicker beds in limestone; shale is fissile and very thick; claystone has very poor bedding.
- 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.
- Drilling rates are moderate to fast.

2.2.8 Results of Geotechnical Borings

Original Geotechnical Boring

Geotechnical boring HDD-16 was drilled by Tetra Tech in 2013 approximately 58 feet north of the proposed bore path, due south of Bushy Run Creek. The boring was drilled to a depth of 14.9 feet before encountering weathered bedrock. The overburden contained sandy, gravelly clays in the upper five feet grading to a silty loam at depth.

Terracon Geotechnical Borings

Two geotechnical borings were advanced by Terracon in September 2017. Boring B1-7E is located near the northern, lower elevation entry/exit point (approx.1,020 ft amsl) while B-7W is found near the southern entry/exit point at the higher elevation (approx. 1,059 ft amsl). Soil was encountered for the first 10.5 feet in B-7E and consisted of sandy lean and sandy fat clay. At a depth of 10.5 feet, the soil entered highly weathered shale, with occasional clay seams, grading to split-spoon refusal at 14.3 feet. Boring B1-7W encountered lean clay to a depth of 20 feet where moderately weathered limestone was encountered. Groundwater was not encountered in the soil horizon of either boring.

<u>B1-7E</u>

Highly weathered bedrock was encountered in boring B1-7E at 14.3 feet bgs and coring began at 18.5 feet bgs (approx. elevation 1,001.5 ft amsl). The bedrock consisted primarily of moderately to highly weathered interbedded shale, siltstone, claystone, and sandstone to 77 feet bgs (approx. 943 ft amsl). A washed out coal seam was observed between 35.4 to 36.5 ft bgs with no reported loss of drilling fluids (water) in that interval. The remainder of the bore to 146 ft bgs was comprised predominantly of sandstone. Approximately 4.5 feet of coal was cored from 117 ft to 121.5 ft bgs (approx. 903 to 898.5 ft amsl). This puts the seam approximately 28.5 feet above the estimated position of the the Claridge Mine, discussed in **Section 2.2.6** of this report and below the estimated position of the Redstone Coal in the area. A large percentage of the cored interval from 132 to total depth at 146 ft bgs (approx. 874 to 888 ft amsl) was described as "washed out". This zone is slightly higher than the estimated position of the Claridge Mine void (approximately 858 to 866 ft amsl) at the location of boring B1-7E.

The driller at B1-7E communicated to GES' Professional Geologists (PGs) that fluids were lost at 58.2 feet bgs and did not return over the entire run to 62.5 feet bgs. The fluid loss was attributed to a 25 to 30 degree fracture noted in the core that exhibited iron staining on the fracture face.

Core recovery values were high for most of the core (ranging from 83 to 100%) except from 82 to 92 ft bgs where values dipped below 80% and at the bottom of the boring from 132 to 146 ft bgs (approximately 888 to 874 ft amsl) where recoveries ranged as low as 17%. As described above, this zone is slightly higher than the estimated position of the Claridge Mine void at the location of boring B1-7E. Overall rock quality designation (RQD) values were poor ranging from 0 to 93%, but with an average value of 41%. One zone of higher RQD values was noted from 97 to 117 ft bgs (approx. elevation 903 to 913 ft amsl) in sandstone where values ranged from 75 to 93%. Examination of the core photographs in Terracon's report indicates that reported RQD values may be lower than the actual values because much of the breakage is horizontal along bedding.

B1-7W

Weathered bedrock was encountered in boring B1-7W at 20.0 ft bgs (approx. 1,039 ft amsl) and includes limestone, claystone, and siltstone to 97.5 feet bgs (approx. 961.5 ft amsl). A predominantly sandstone interval occurred from 97.5 ft bgs to the bottom of the boring at 177.5 ft bgs. A 1.6-foot coal seam followed by mudstones was described on the log, interbedded with the sandstone from 150.9 to 152.5 ft bgs (approx. elevation 906.5 to 908.1 ft amsl). This coal is below the estimated position of the Redstone Coal in the area. Broken bedrock zones were seen in the photographs of the cores from 95 to 116.5 ft bgs and from 156 to 164 ft bgs and the Terracon log describes intermittent highly fractured zones from at depth of 106 ft bgs to total depth at 177.5 ft bgs (approx. elevation 953 to 881.5 ft amsl). The estimated Claridge Mine roof elevation is approximately 889 ft amsl at the location of B1-7W; however, the log and core do not indicate the boring passed through the mine.

Core recovery values were generally good after the initial zone of variable recoveries in the first cores to a depth of 42.5 ft bgs. After that, recoveries ranged from 83 to 100% except for the run from 92.5 to 97.5 ft bgs, which had a recovery of 72%. Reported RQD values were generally low ranging from 0 to 96%, but averaging 54%. The RQDs did show an increasing trend with depth and the values from 57.5 to bottom of hole at 177.5 ft bgs ranged from 30 to 96%. Similar to B1-7E, a zone of elevated RQDs is noted within the sandstones from 117.5 to 142.5 ft bgs (approx. elevations 916.5 to 941.5 ft amsl). Examination of the core photographs in Terracon's report indicates that reported RQD values may be lower than the actual values because much of the breakage is horizontal along bedding.

2.3 Hydrogeology

2.3.1 Occurrence of Groundwater

There is very little primary porosity associated with the sedimentary rocks of western Pennsylvania for the storage and movement of groundwater. The primary occurrence of groundwater in the Monongahela Group is associated with the interconnected network of secondary porosity features characteristic of the bedrock. These include bedrock joints and fractures, faults, and bedding plane partings.

The Pennsylvania Groundwater Information System (PaGWIS) reported 17 residential wells within a half-mile radius of the HDD. Eleven wells are completed to depths between 110 and 305 feet. Six wells have no reported depths. Depth to bedrock in the reported wells ranges between 1 and 21 feet.

2.3.2 Ground Elevation Between HDD Entry/exit/Exits

For the original HDD profile the southern entry/exit point is at 1,077 ft amsl and the northern point is lower at 1,009 ft amsl, for an elevation difference of 68 feet. Moving south down the slope from the northern entry/exit point, the surface elevation drops gently across Gombach Road and flattens approaching stream S202 and Bushy Run at Station 3+37 at an elevation of approximately 996 ft amsl. The land surface gradually rises from Bushy Run across several small road cuts and hillside terraces to the southern entry/exit at Station 9+80. The elevation difference from entry to exit on the FlexBor is approximately 27 feet from bore pit entry to bore pit exit with the low side to the north.

2.3.3 Water Levels

Published soil data indicate the regional depth to water in the overburden soils is 16 to 24 inches. Depth to water in the bedrock aquifer was measured during the advance of the new geotechnical borings. A water level of 39.7 feet bgs (approx. 980 ft amsl) was noted in the geotechnical boring B1-7E (north) and at 46 feet bgs (approx. 1013 ft amsl) in boring B1-7W (south). As shown on the profiles in Attachment A, Bushy

Run Creek is at an elevation of approximately 995 ft amsl and groundwater levels are expected to approach this horizon moving towards the stream from either direction.

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. Well yields in the residential wells identified using PAGWIS near the bore path range from 0.5 to 12 gallons per minute.

2.3.5 Water Supply Wells within 450 feet of Alignment

SPLP performed a survey of landowners within 450 feet of the ROW. To date, no landowners have responded to certified mail containing offers to have their wells tested. In addition, SPLP has confirmed that all properties within 450 feet of the HDD profile are on a public water supply.

2.4 Summary of Geophysical Studies

A 3-D seismic survey was performed to assess potential impacts from subsidence of the Pittsburgh Coal mine. The results of that survey are discussed in the Horizontal Directional Drill Analysis.

3.0 OBSERVATIONS TO DATE

3.1 On This HDD Alignment

3.1.1 ME I
No IRs were reported for the Gombach HDD S1B-0260 site during the ME I pipeline installation.

3.1.2 ME II
No drilling activities have been initiated at HDD S1B-0260 as part of the ME II pipeline installation.

3.2 On Other HDD Alignments in Similar Hydrogeologic Settings

3.2.1 ME I
The closest borings to HDD S1B-0260 is HDD S1B-0250, Norfolk Southern Railroad. The geologic and hydrogeologic setting is considered similar to HDD S1B-0260. It is reported that during the installation of the 12-inch ME I pipeline, as many as four incidences occurred where mud exited on the surface. This was attributed to a boring profile that was too close to the surface.

3.2.2 ME II

All of the IRs to date in Spreads 1 and 2 for the ME II pipeline have occurred while drilling through cyclic sequences of sandstone, shale, limestone, clays seams and coal present within western Pennsylvania bedrock formations, including the Allegheny Group, Casselman Formation, Glenshaw Formation, Monongahela Group, and Waynesburg Formation. Entries and exits pass through alluvium, colluvium and soils developed on top of weathered bedrock, and in the case of HDD S1B-0270, mine spoil. In general, the IRs have been related to shallow overburden (especially under water bodies), large elevation changes between entries and entry/exits, coarse grained unconsolidated materials near the surface (such as alluvium and mine spoil), and the interconnectivity of open bedrock structural features that is difficult to predict.

4.0 SUMMARY AND CONCLUSIONS OF HDD HYDROGEOLOGIC EVALUATION

4.1 HDD Site Conceptual Model

If the local water table is equivalent to the level of Bushy Run Creek then it is estimated that approximately 60 percent of the original HDD profile, and 85 percent of the FlexBor will be through saturated materials. Hydraulically, the HDD profiles represent minimal risk of excessive groundwater production because the profile is relatively symmetrical with entry exits both above the local water table high. The entry elevation in the bore pit for the FlexBor on the north end is approximately 988 ft amsl and the elevations of streams S201 (Bushy Run Creek) and S202 are approximately 995 and 1,000 ft amsl, respectively. As such, some groundwater production may occur at the entrance in the north bore pit of the FlexBor.

Geotechnical boring information and the local geomorphology suggest the FlexBor may start in weathered bedrock on the north end with an increasing chance of being advanced through unconsolidated materials moving south. Based on stream evolution over time, sandy alluvium may surround and underlie Bushy Run Creek, which would be more conductive with a higher capacity to transmit fluids. For example, material above the FlexBor could be entirely unconsolidated alluvium under Bushy Run Creek where the distance from pipe to surface is 19 feet.

Overall, bedrock RQD values for the two new geotechnical borings were logged as being highly variable, ranging from 0 to 96 %, but with average values of 41 and 54 %. A 20 to 25-foot thick zone of sandstone demonstrating higher RQDs, ranging from 80 to 100%, can be correlated between the two borings. Based on the two borings, the top of this zone occurs approximately between elevations 941.5 ft amsl in the south and 933 ft amsl in the north. At this position, the high RQD zone is below the HDD profile, by approximately 33 to 42 feet at the low point in the profile.

Subsidence of rock overlying deep coal mines can cause subvertical fracture zones overlain by dilated zones (zones of bedding plane partings) that become interconnected and develop preferred pathways of fluid flow (Kendorski, 1993). Such an interconnected pathway may have contributed to the water loss experienced during the advance of geotechnical boring B1-7E between 58.2 and 62.5 feet bgs. The roof of the Claridge Mine is estimated to be approximately 73 feet below this zone. The variability of RQD values may be related to potential subsidence of bedrock into the deep coal mine and a zone of fracture concentration as indicated by the fracture trace passing through the north end of the drill. Additional information concerning evaluation of the potential effects of deep mining on HDD installation is provided in the Horizontal Directional Drill Analysis.

If an HDD encounters a mine pool there is a potential to create a new mine pool discharge at one of the entry/exit points. However, the lowest elevation of the permitted HDD profile was at approximately 99 feet above the roof of the mine. The elevation of the low point of the FlexBor alternative is the same as for the HDD and therefore also does not indicate a risk for creating a new mine pool discharge.

SPLP performed a survey of landowner's wells within 450 feet of the ROW. To date, no landowners have responded to certified mail containing offers to have their wells tested and SPLP has confirmed that all landowners within 450 feet of the HDD alignment are on a public water supply.

4.2 Recommendations

In terms of reducing the risk of loss of circulation (LOC) and of IRs, the FlexBor alternative is favorable over the original HDD because drilling fluids under pressure are not used to advance the bore. Under this alternative, the approximate 612 foot pilot for the FlexBor will be advanced with an air hammer from north of Gombach Road, under steams S202 and S201 (Bushy Run Creek), Watt Road and Gongaware Road. The intended pilot process in advance of the FlexBor reaming is an “air hammer”; therefore, no pressurized drilling fluids will be used during the pilot phase. The FlexBor reaming process uses high volume air flows with a minimal amount of water to remove excavated material, as opposed to bentonite based drilling fluid as is done for HDD installations. For both the FlexBor pilot and reaming a casing follows the drill bit, within which cuttings are transported back to the bore pit; therefore, there is no potential to clog the annulus and there is no associated risk of a drilling fluid LOC or IR. An additional 783 feet of open trench installation is associated with the FlexBor alternative which also does not have any associated risk for LOCs and IRs. Under site conditions the FlexBor may temporarily produce groundwater at the north bore pit and the driller should plan on using the standard construction best management practices to manage groundwater production if it occurs.

Based on information provided by, and the expertise of, the HDD team, as well as our experience with the relevant hydrogeology and geology, GES believes that the implementation of the FlexBor alternative will minimize the risk of IRs and LOCs and minimize the likelihood of harm to the environment. Furthermore, based on such information, expertise and experience, GES believes that the FlexBor alternative is a practicable measure to prevent impacts to any private water supplies. In the unlikely event of an impact to a private water supply, SPLP will implement the procedures of the IR PPC Plan.

5.0 REFERENCES

Geyer, A. R. and J. P. Wilshusen, (rev. 1982) *Engineering Characteristics of the Rocks of Pennsylvania.* PaDER, ORM, Pa Geol. Surv., 4th ser., EGR-1.

Kendorski, F. (1993), *Effect of High-Extraction Coal Mining on Surface and Ground Waters,* 12th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1993, pp. 412-425.

Nickelsen, R. P. and Hough, V. D. (1967) *Jointing in the Appalachian Plateau of Pennsylvania*, GSA Bull. v. 78, p. 609-630.

PA DCNR (Department of Conservation and Natural Resources) Map Viewer (http://www.gis.dcnr.state.pa.us/maps/index.html).

DEP (Pennsylvania Department of Environmental Protection) eMapPA web site (http://www.depgis.state.pa.us/emappa/)

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

Skema, V. W., (1988), *Coal Resources of Westmoreland County, Pennsylvania – Part 1, Coal Crop Lines, Mined Out Areas, and Structure Contours*. Pa. Geol. Surv., 4th. Ser., MRR-94.

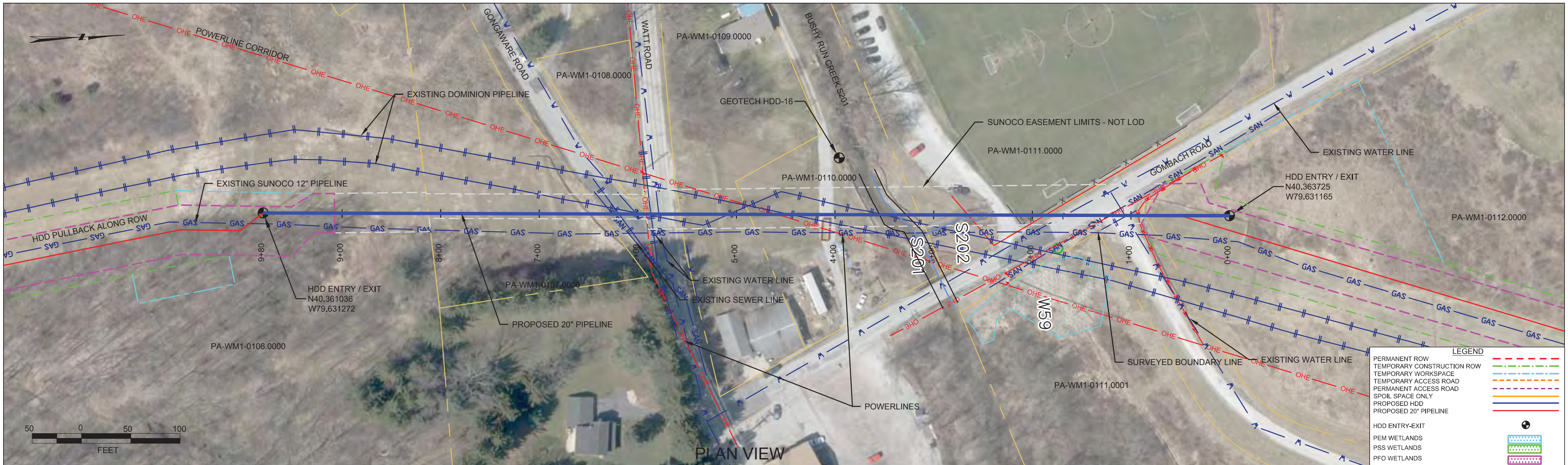
USDA NRCS WSS, United States Department of Agriculture, Natural Resources Conservation Service – Web Soil Survey for Westmoreland County, (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx).

USGS (United States Geological Survey), Irwin, Pennsylvania, 1:24,000 topographic quadrangle map, rev. 1982.

Ziemkiewicz, P., et. al., (2004) Final Technical Report - EPA Region III Mine Pool Project (WV173 Phase IV), National Mine Land Reclamation Center, West Virginia Water Res. Inst.. Coop. Ag. No. DE-AM26-99FT40463.

Attachment A

HDD and FlexBor Plan and Profiles



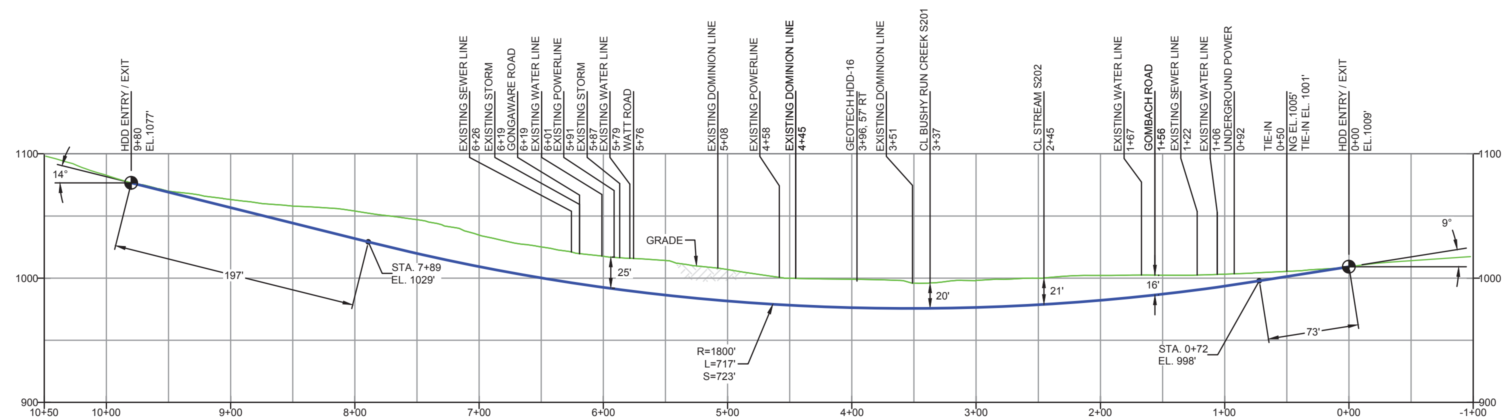
WESTMORELAND COUNTY, PENNSYLVANIA - PENN TOWNSHIP
S1B-0260

PROFILE VIEW

GEOTECH HDD-16

- -NG EL. 998'
- -CL/SC/GC (0.0' - 7.0')
- -SM (7.0' - 14.4')
- -SILT STONE (14.4' - 14.9')
- -COMPLETION DEPTH EL. 983'

NOTE: REFER TO TEST BORING LOG HDD-16 FOR COMPLETE SOIL MATERIAL DESCRIPTION



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):980'
   HDD PIPE LENGTH (S=):993'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-1.51	TO	ES-1.51	EROSION & SEDIMENT PLAN
SHEET 38	TO	SHEET 39	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/17/16	RMB	05/17/16	AAW	05/17/16
EP		JTW	03/15/16	RMB	03/15/16	AAW	03/15/16

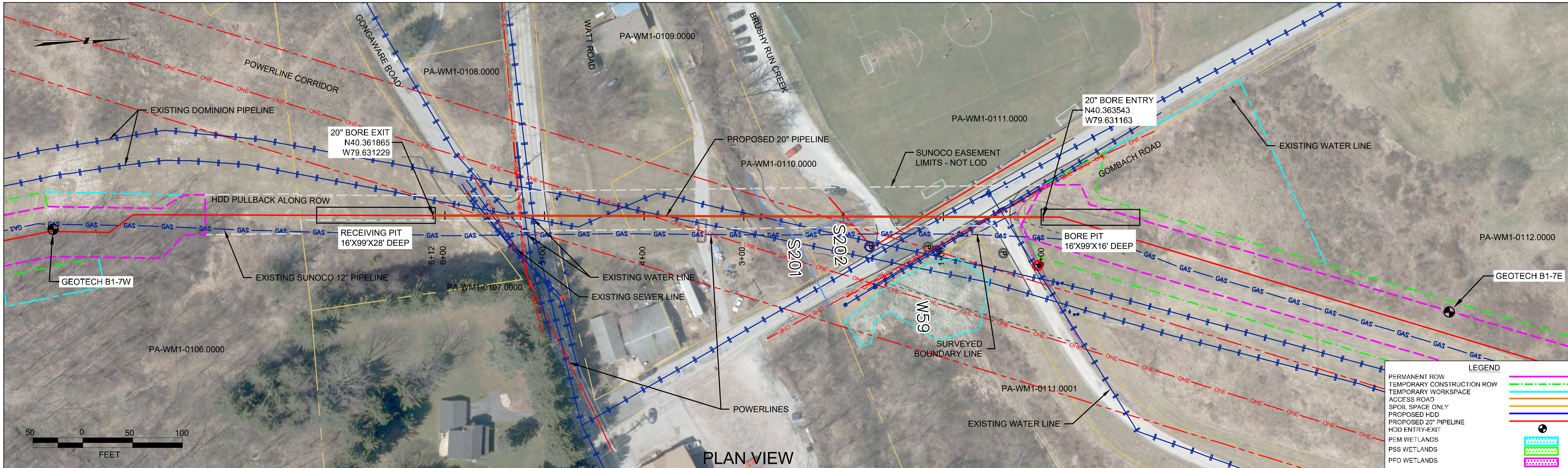
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY (303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
GOMBACH ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100' DWG. NO: PA-WM1-0111.0000-RD



WESTMORELAND COUNTY, PENNSYLVANIA - PENN TOWNSHIP

PROFILE VIEW

GEOTECH B1-7E

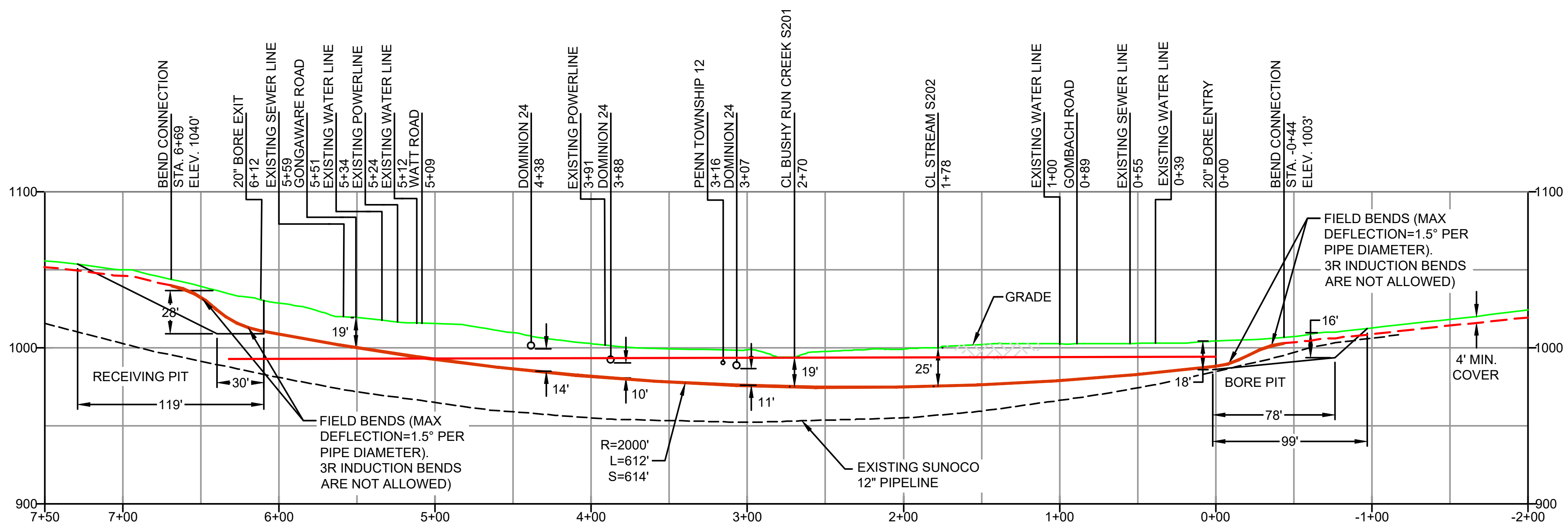
- NG EL. 1046'
- SANDY LEAN CLAY CL (0.0' - 2.0')
- SANDY FAT CLAY CH (2.0' - 5.0')
- SANDY LEAN CLAY CL (5.0' - 10.5')
- GROUNDWATER (39.7')
- SHALE CLAYSTONE/SANDSTONE (10.5' - 146.0')
- BORING TERMINATED EL. 900'

NOTE: REFER TO TEST BORING LOG B1-7E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-7W

- NG EL. 1094'
- LEAN CLAY CL (0.0' - 20.0')
- GROUNDWATER (46.0')
- LIMESTONE/ CLAYSTONE/SANDSTONE (20.0' - 177.5')
- BORING TERMINATED EL. 916.5'

NOTE: REFER TO TEST BORING LOG B1-7W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):612'
   HDD PIPE LENGTH (S=):614'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: FLEX BORE.
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-1.51	TO	ES-1.51	EROSION & SEDIMENT PLAN
SHEET 38	TO	SHEET 39	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
A	ISSUED FOR REVIEW	MRS	05/01/18	RMB	05/01/18	AAW	05/01/18

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

FLEX BORE
GOMBACH ROAD
PENNSYLVANIA PIPELINE PROJECT

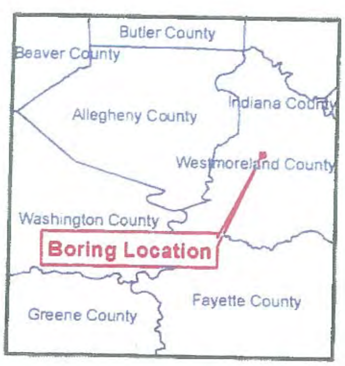
SCALE: 1"=100'

DWG. NUMBER: PA-WM1-0111.0000-RD

Attachment B

Geotechnical Boring Logs

Source: Topo data from USGS DLG; Roads from DelDOT



N
W E
S

Figure

Boring Location HDD-16
Sunoco Mariner East Project
Westmoreland County, PA

0 250 500 1,000 Feet

1 inch = 500 feet

Tetra Tech, Inc.
Phone: (302) 738-7551
Toll Free: (800) 462-0910
www.tetratech.com

S:\03-Projects\Intercompany\TT - Rooney (RE)\GIS\Boring Map HDD-16.mxd

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

TEST BORING LOG

Project Name: SUNOCO MARINER EAST	Project No.: 103IP2762
Project Location: WESTMORELAND COUNTY, PA	Page 1 of 1
Test Boring No.: HDD-16	Dates(s) Drilled: 06/13/13
Inspector: E. WATT	Drilling Contractor: CONNELLY
Drilling Method: SPT - ASTM D1586	Driller: T. REDMAN
Surface Elevation (ft):	Groundwater Depth (ft): Not Encountered
Total Depth (ft): 14.9	

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *			N
1	3.5	5.0	0.0		10	CL/ SC/ GC	WET BROWN SILTY CLAY AND CLAYEY SAND WITH SOME	1	1	1	2
				7.0			FINE TO COARSE GRAVEL. SOFT. POTENTIAL FILL.				
2	8.5	10.0	7.0		13	SM	LIGHT BROWN FINE TO MEDIUM SAND WITH A LITTLE F-C	5	7	10	17
							GRAVEL AND SOME SILT.				
3	13.5	14.9			13		LIGHT BROWN FINE TO MEDIUM SAND WITH A LITTLE F-C	3	10	50/5"	>50
				14.4			GRAVEL AND SOME SILT.				
			14.4	14.9			LIGHT GRAY TO BROWN FRACTURED AND GRAVELLY SILTSTONE				
							AUGER REFUSAL AT 14.9'.				
							BORING LOCATION SURROUNDED BY STANDING WATER				
							FROM PREVIOUS NIGHT'S RAIN EVENT.				

Notes/Comments:

Pocket Pentrometer Testing

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

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

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 – Gombach Road
Commonwealth of Pennsylvania
Drawing # PA-WM1-0111.0000-RD
PO #20170811-1
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 Gombach Road (Drawing # PA-WM1-0111.0000-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 B1-7W and B1-7E, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test borings, B1-7W and B1-7E were drilled between September 5 and 14, 2017 to depths of 177.5 and 146.0 feet, respectively as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of interlayered sedimentary rock comprised of limestone, claystone, siltstone, sandstone, and shale. 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 from 60 feet at B1-7W was not tested due to fissile conditions. Unconfined compressive strength test results are shown on the attached reports.

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

Sincerely,
Terracon Consultants, Inc.

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

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

Attch:

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

TEST BORING LOCATION PLAN

N

APPROXIMATE BORING LOCATION

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

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

Terracon
Consulting Engineers & Scientists

201 Hammer Mill Road Rocky Hill, Ct 06067
PH. (860) 721-1900 FAX. (860) 721-1939

TEST BORING LOCATION PLAN

Gombach Road HDD Cores B1-7W and B1-7E
PA-WM1-0111.0000-RD
Westmoreland County, Pennsylvania

Exhibit
A-2

EXPLORATION RESULTS

BORING LOG NO. B1-7W Gombach Rd (south) West

PROJECT: Mariner East Pipeline Borings

SITE: Spread 1

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

LOCATION PA-WM1-0111.0000-RD
20170811-1
Latitude: 40.360817° Longitude: -79.631217°

Approximate Surface Elev: 1059 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	LEAN CLAY (CL), with claystone, trace organic matter, trace rock fragments, brown, very stiff									
			5		X	14	7-9-7 N=16			2.0
10.0	Layered black claystone, trace organic matter, trace rock fragments	1049+/-	10		X	18	7-10-7 N=17			-
	LEAN CLAY (CL), with rock fragments and claystone, brown, very stiff									
			15		X	10	10-15-7 N=22			+4.0
20.0	4-inch layer of poorly graded sand with silt at 18.5 feet	1039+/-	20		X	10	24-50/2"			+4.0
22.5	Run 1, Hard, moderately weathered, brownish gray LIMESTONE, thinly bedded, close joint, slightly open, with a 1-inch lean clay seam at 22 feet	1036.5+/-			Core	29		40	5 3.5 1.5	
27.5	Run 2, Medium to soft, highly weathered, light brown CLAYSTONE, with clay seams, very thinly bedded, close joint, open	1031.5+/-	25		Core	30		7	2 3.5 1.75 1 1.75	
	Run 3 From 27.5 to 28 feet: highly weathered CLAYSTONE From 28 to 28.4 and 30 to 31.5 feet: Hard, moderately weathered, gray (with red traces) LIMESTONE, thinly bedded, close joint, slightly open		30		Core	52			2.5 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

Notes:

WATER LEVEL OBSERVATIONS

▽ *46' on 9/7/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-05-2017	Boring Completed: 09-08-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B1-7W Gombach Rd (south) West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD 20170811-1
Latitude: 40.360817° Longitude: -79.631217°

Approximate Surface Elev: 1059 (Ft.) +/-

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	32.5	From 28.4 to 30.5 feet: LEAN CLAY, brown; from 31.2 to 31.5 feet: vertical joint; from 31.5 to 32.5 feet: LEAN CLAY Run 3 *(continued)*	1026.5+/-				52		23	5.5 2.5 2	
	37.5	Run 4, From 33 to 33.7 feet and last 4-inches: LIMESTONE, rest of run: hard LEAN CLAY	1021.5+/-	35			43		22	2.75 2.75 3 2 3.25	
	42.5	Run 5, Most of run was washed away: SILTSTONE with severely weathered CLAYSTONE with clay layers	1016.5+/-	40			28		0	4 2.5 7.25 8.5 6	
	47.5	Run 6, Moderately hard to hard, highly weathered, bluish gray with yellowish seams SILTSTONE, thinly bedded, close joints, open From 43.5 to 44.3 feet: highly fractured zone	1011.5+/-	45	▽		60		20	5.25 4.25 2 3.25 2	
	52.5	Run 7, Similar to 48.4 feet, highly weathered and fractured From 48.4 to 52.5 feet: Hard, slightly weathered, bluish gray (with yellow seams) SANDSTONE, thinly bedded, close joints, slightly open At 51.4, 51.6, 51.8, low angle joint	1006.5+/-	50			55		8	5 3.25 1 1.25 1	
	57.5	Run 8, Hard, slightly weathered, gray SANDSTONE, thinly bedded, close joints, slightly open	1001.5+/-	55			60		65	2.75 2 2.75 2 1.75	
				60			58			3.75 1.5	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ *46' on 9/7/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-05-2017	Boring Completed: 09-08-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B1-7W Gombach Rd (south) West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD
20170811-1
Latitude: 40.360817° Longitude: -79.631217°

Approximate Surface Elev: 1059 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 9, Similar to 60 feet From 60 to 62.5 feet: 62.5 Hard, slightly weathered, dark gray SILTSTONE, thinly bedded, close joints, slightly open *(continued)*	996.5+/-				58		62	3.25 2 2.5	
	Run 10, Similar to 65 feet From 65 to 66.2 feet: Highly weathered, black carbonated SHALE From 66.2 to 67.5 feet: Highly weathered, gray CLAYSTONE 67.5	991.5+/-	65			51		32	3.75 2.75 3 3 4.5	
	Run 11, Hard, slightly weathered, dark gray (with white seams) SANDSTONE, thinly bedded, close joints, slightly open At 71.7 and 72.2 feet: angled, stained joint 72.5	986.5+/-	70			60		55	3.25 2.5 1.5 2 4	
	Run 12, Similar From 73.8 to 74.2 feet: carbonated black SHALE layer 77.5	981.5+/-	75			60		80	3.75 3 2 1.75 1.5	
	Run 13, Similar From 77.8 to 78 feet: high angle joint Form 79.3 to 79.6 feet: vertical joint 82.5	976.5+/-	80			58		68	3 2.75 2.25 3.5 2	
	Run 14, Similar From 85.7 to 86 feet: high angled joint 87.5	971.5+/-	85			60		53	3 1.5 1 2.5 2.5	
			90			58			6.5 5	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

46' on 9/7/17

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-05-2017	Boring Completed: 09-08-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B1-7W Gombach Rd (south) West

PROJECT: Mariner East Pipeline Borings

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

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD
20170811-1
Latitude: 40.360817° Longitude: -79.631217°

Approximate Surface Elev: 1059 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
92.5	Run 15, SImilar to 89 feet From 89 to 89.3 feet: SILTSTONE, highly fractured From 89.3 to 91.2 feet SILTSTONE, dark gray From 91.2 to 92.5 feet: Hard, moderately weathered, black SHALE, thinly bedded, close joints, slightly to moderately open *(continued)*	966.5+/-				58		30	6.25 3 4.25	
97.5	Run 16, Similar to 93.8 feet, black weathered SHALE From 93.8 to 97.5 feet: Hard, weathered, gray LIMESTONE, thinly bedded, close joints, slightly open	961.5+/-	95			43		47	11 5.5 3 1 1.5	
102.5	Run 17, Hard, slightly to moderately weathered, gray limy SANDSTONE, thinly bedded, close to moderately close, slightly to moderately open	956.5+/-	100			60		80	4.5 8 7.25 2 1.75	
107.5	Run 18, Similar From 102.8 to 103.6 feet: angled stained joint and weathered zone At 105.2 feet: seam of clay From 105.9 to 106.2 feet: angled joint From 106.2 to 107.5 feet: highly fractured and weathered zone	951.5+/-	105			54		45	4.5 2.25 2.5 3.75 7.75	
112.5	Run 19, Similar At 108.2, 108.4, 110, 110.3 and 111.4 feet: stained angled fractures From 111.5 to 112 feet: highly fractured zone	946.5+/-	110			60		48	7.25 6.5 2.75 1.75 2.5	
117.5	Run 20, Similar From 112.5 to 113.6 feet: highly weathered, fractured zone with gray clay seams At 115.5 feet: low angled joint	941.5+/-	115			57		70	7.5 2.5 2 1.25 1.25	
	Run 21, Hard, slightly weathered, gray, fine-grained SANDSTONE, thinly bedded, close joint, slightly open At 117.8 feet: angle joint		120			60			3 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

▽ *46' on 9/7/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-05-2017	Boring Completed: 09-08-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B1-7W Gombach Rd (south) West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD 20170811-1
Latitude: 40.360817° Longitude: -79.631217°

Approximate Surface Elev: 1059 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
122.5	Run 21, Hard, slightly weathered, gray, fine-grained SANDSTONE, thinly bedded, close joint, slightly open At 117.8 feet: angle joint *(continued)*	936.5+/-				60		90	2 2.25 1.75	
127.5	Run 22, Similar, close to moderately close joints	931.5+/-	125			60		96	3.25 1.25 1 1.75 1.25	
132.5	Run 23, Similar, close to moderately close joints At 128 and 128.2 feet: high angle stained joint	926.5+/-	130			60		96	3 1.75 1.5 1.25 1	
137.5	Run 24, Similar, close joints At 133.3 feet: low angle joint	921.5+/-	135			58		86	1.75 1.75 1.5 1 1	
142.5	Run 25, Similar, with limy components, joints slightly to moderately open At 138.1, 138.3 and 138.5 feet: low angled joints	916.5+/-	140			60		80	1.75 1.5 1.25 1.25	
147.5	Run 26, Similar From 145 to 145.5 feet: highly fractured zone, close joints At 145.5, 145.8 and 146.25 feet: low angled joints From 146.9 to 147.2, vertical fracture	911.5+/-	145			59		68	1.75 1.5 1.5 .5 .75	
			150			51			1.25 1.5	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ *46' on 9/7/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-05-2017	Boring Completed: 09-08-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B1-7W Gombach Rd (south) West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD
20170811-1
Latitude: 40.360817° Longitude: -79.631217°

Approximate Surface Elev: 1059 (Ft.) +/-

GRAPHIC LOG	DEPTH / Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
	Run 27, Similar to 150.9 feet From 150.9 to 152,5 feet: COAL with pyrite 152.5 At 148.5, 150.5 feet: angle joint From 150.5 to 151,1 feet: highly fractured zone *(continued)*	906.5+/-				51		47	2 5 7	
	Run 28, Hard, severely weathered, dark gray SILTSTONE, very thinly bedded, joints close to moderately close, slightly open to open From 153 to 153.4 feet: vertical fracture At 154 feet: stained, high angle joint From 154 to 154.6 feet: highly weathered, fractured zone 157.5	901.5+/-	155			60		71	8.25 3.75 3.75 2.25 2.25	
	Run 29, Hard to soft, highly weathered, light gray, limy SILTSTONE, very thinly bedded, close joint, open From 158.9 to 159.2 feet and 159.5 to 160 feet: gray fat CLAY From 160.2 to 161 feet: highly weathered and fractured zone At 161, 161.8, 162.2 and 162.3 feet: angled joints 162.5	896.5+/-	160			60		38	4.25 5.5 3.25 4 2.75	
	Run 30, Hard to medium, highly weathered, dark gray SILTSTONE, very thinly bedded, close joints, moderately open to open From 162.5 to 163.7 feet: highly weathered fractured zone 167.5	891.5+/-	165			50		42	9.25 5 2.5 5.25 3.75	
	Run 31, Hard, moderately to slightly weathered, dark gray SANDSTONE, thin bedding, joints close to moderately close, slightly to moderately open From 167.9 to 168.1 feet: highly fractured zone 172.5	886.5+/-	170			58		85	5.25 1.75 1.75 1.75 2.25	
	Run 32, Similar From 172.5 to 173.4 feet: highly weathered, fractured zone, black. 177.5	881.5+/-	175			58		60	8.5 4.5 3.25 2.25 2	
	Boring Terminated at 177.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

46' on 9/7/17

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-05-2017	Boring Completed: 09-08-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-1

BORING LOG NO. B1-7E Gombach Rd (north) East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD 20170811-1
Latitude: 40.364654° Longitude: -79.63078°

Approximate Surface Elev: 1020 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
2.0	**SANDY LEAN CLAY (CL)**, trace gravel and organic matter, brown, stiff	1018+/-								
5.0	**SANDY FAT CLAY (CH)**, trace gravel, brown, stiff	1015+/-	5		X	14	9-6-4 N=10			
10.5	**SANDY LEAN CLAY (CL)**, with rock fragments, gray-brown, stiff	1009.5+/-	10		X	15	5-5-6 N=11			
18.5	Highly weathered SHALE, occasional clay seams, brown Highly weathered SHALE, gray Advance to 18.5 feet, begin rock core	1001.5+/-	15		X	10	8-15-50//2"			
22.0	Run 1, Soft to medium hard, moderately to highly weathered, dark gray CLAYSTONE, very thinly bedded, joints low angle to horizontal, very close to close, tight to open, smooth, discolored to decomposed At 20.3 feet: Moderately hard, slightly to moderately weathered, gray SANDSTONE, very thinly bedded, joints low angle to horizontal, very close, smooth, tight to open, discolored	998+/-	20		Core	42		25	1 2 1.5 1.5	
27.0	Run 2, Similar (SANDSTONE)	993+/-	25		Core	60		23	2.5 1 2 1.5 1.5	
	Run 3, Medium to moderately hard, slightly to moderately weathered, gray to dark gray SHALE, with interbedded siltstone, thinly bedded, joints horizontal to low angle, very close to close, slightly open to open, smooth, discolored		30		Core	57		17	2.5 4 4	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ *39.7' on 9/13/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-11-2017	Boring Completed: 09-14-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-2

BORING LOG NO. B1-7E Gombach Rd (north) East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD
20170811-1
Latitude: 40.364654° Longitude: -79.63078°

Approximate Surface Elev: 1020 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
32.0		988+/-				57			3 4	
37.0	Run 4, Similar Coal layer from 35.4 to 36.5 feet, (washed out)	983+/-	35			51		20	4 3.5 4.5 3 4.5	
42.0	Run 5, Hard, slightly weathered, gray to dark gray SILTSTONE, thinly bedded, joints close, slightly to moderately open From 37 to 37.5 feet: highly fractured zone At 38.3 feet: 1-inch seam of gray clay	978+/-	40	▽		59		25	5 3.5 3 2.5 2.5	
47.0	Run 6, Similar From 43.5 to 44.4 feet: SANDSTONE, light gray From 44.4 to 46.4 feet: SILTSTONE, dark gray From 46.4 to 47 feet: Severely weathered, black SHALE, thinly bedded, joints close, slightly open to open	973+/-	45			57		24	3.5 2 3.75 4.5 3.75	
52.0	Run 7, From 47 to 48 feet: SHALE, with interbedded sandstone From 48 to 52 feet: Hard, slightly weathered, dark to light gray SANDSTONE, with interbedded shale, thinly bedded, joints close, slightly open	968+/-	50			59		56	2 2 1.5 1.5 2.5	
57.0	Run 8, Hard, slightly to moderately weathered, dark gray SILTSTONE, thinly bedded, joint close, slightly to moderately open At 56.5, 56.7, 56.8 feet: gray clay seams (<1-inch)	963+/-	55			60		45	4.25 3.25 1.75 2.75 3.5	
			60			60		37	4.25 2 2	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ *39.7' on 9/13/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-11-2017	Boring Completed: 09-14-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-2

BORING LOG NO. B1-7E Gombach Rd (north) East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD 20170811-1

Latitude: 40.364654° Longitude: -79.63078°

Approximate Surface Elev: 1020 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
62.0	Run 9, Similar From 57.9 to 58.3 and 60.83 to 61 feet: vertical joints At 57.1 feet: low angle fracture At 61.5 feet: high angle fracture From 61 to 62 feet: severely to moderately weathered *(continued)*	958+/-				60			2.75 3.25	
67.0	Run 10, Similar From 65.6 to 66.7 feet: possible washed out At 62.2 feet: low angle fracture From 64 to 64.7 feet: grayish clay seams	953+/-	65			50		0	5 6 5.25 2.5 11.5	
72.0	Run 11, Hard, moderately to severely weathered, dark and light gray, limy SILTSTONE, thinly bedded, joints close, slightly open to open From70.8 to 71.2 feet: vertical joint From 70.8 to 72 feet: highly weathered and fractured zone From 69 to 69.2 feet: vertical joint	948+/-	70			57		54	3 3.25 1.5 3 5.25	
77.0	Run 12, Similar From 72 to72.2 feet: highly fractured zone From 72.6 to 72.7 feet: clay seam From 74.4 to 75.3 feet: high angle joint From 75.6 to 76.4 feet: low angle stained joint From 72.8 to 75.6 feet: limy SANDSTONE	943+/-	75			56		39	8 3.5 3.25 4 3.5	
82.0	Run 13, Hard to moderately hard, moderately to severely weathered, dark gray, limy SANDSTONE, interbedded with limy siltstone, very thinly bedded, joints close, moderately open to open, At 77.6, 77.8, 81 and 81.2 feet: low angle joint At 78.5, 79.8 feet: high angle joint	938+/-	80			58		36	10.5 4.25 6.5 2.25 2.25	
87.0	Run 14, Hard to medium, severely to moderately weathered, light gray, limy SANDSTONE, very thinly bedded, joints close to very close, moderately open to open	933+/-	85			41		29	6 6 8.75 5.25 6.75	
	Run 15, Hard to medium, severely weathered, dark gray, SANDSTONE, thinly bedded, joints close, open From 89.5 to 89.9 feet: vertical joint From 89.9 to 92 feet: highly fractured zone		90			47		23	4 4.25 2.75	

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

Notes:

WATER LEVEL OBSERVATIONS

39.7' on 9/13/17

201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-11-2017	Boring Completed: 09-14-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-2

BORING LOG NO. B1-7E Gombach Rd (north) East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD
20170811-1
Latitude: 40.364654° Longitude: -79.63078°

Approximate Surface Elev: 1020 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
92.0	928+/-					47			5 6	
97.0	923+/-	Run 16, Moderately hard to hard, slightly weathered, dark gray, fine-grained SANDSTONE, thinly bedded, joints close, moderately open to open	95			60		83	3 1.5 2 4 2	
102.0	918+/-	Run 17, Hard, slightly weathered, dark gray with light gray seams, fine-grained SANDSTONE, thinly bedded, joints close to moderately close, moderately open to open	100			62		93	4.75 1.5 1.5 1.75 2	
107.0	913+/-	Run 18, Similar From 105.2 to 105.3 feet: interbedded limestone	105			59		84	1.75 1.25 1.25 1.5 2	
112.0	908+/-	Run 19, Similar At 117.8 feet: close joints, moderately wide	110			60		93	2 1.5 1.25 1.25 2.25	
117.0	903+/-	Run 20, Similar From 116.7 to 117 feet: carbonated SHALE, vertical joints, open	115			58		75	2 1.5 1.5 1.75 1	
		Run 21, Black COAL, highly fractured, with pyritic seams From 121.5 to 122 feet: Gray SILTSTONE, vertical joints	120			60		13	2 2.5 3	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

39.7' on 9/13/17

201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-11-2017	Boring Completed: 09-14-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-2

BORING LOG NO. B1-7E Gombach Rd (north) East

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated Magnolia, TX 77354

SITE: Spread 1

LOCATION PA-WM1-0111.0000-RD 20170811-1

Latitude: 40.364654° Longitude: -79.63078°

Approximate Surface Elev: 1020 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
122.0		898+/-				60			3 3.5	
127.0	Run 22, Hard, slightly to moderately weathered, light and dark gray, fine-grained, limy SANDSTONE, thinly bedded, primary joint set, low angle, close, slightly to moderately open, secondary joint set, high angle, close, moderately open to open From 126.2 to 127 feet: highly weathered with vertical joints	893+/-	125			60		81	6.5 3.5 5 1.5 2.25	
132.0	Run 23, Hard to medium, moderately to severely weathered, light and dark gray, fine-grained, limy SANDSTONE, thinly to very thinly bedded, primary joint set, high angle, close to very close, open to moderately wide, secondary joint set, low angle, close, slightly open to open At 128.5, 129.6 to 129.9, 130.6 feet: high angle joints At 131 to 132 feet: highly fractured zone	888+/-	130			58		45	3.5 3.75 3.75 3 3.5	
137.0	Run 24, Entire run washed away from 132 to 136.5 feet, formation similar to previous run.	883+/-	135			10		5	18 6.75 6.5 5.5 8.75	
142.0	Run 25, 28-inches of run was washed, possible the interval of 137.7 feet to 140 feet, formation similar to previous run From 137 to 137.3 feet: vertical joint	878+/-	140			32		22	6.5 2.25 3.5 4 4.5	
146.0	Run 26, Similar, severely weathered	874+/-	145			34		29	5.5 4 3 4.75	

Boring Terminated at 146 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

39.7' on 9/13/17

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-11-2017	Boring Completed: 09-14-2017
Drill Rig: Diedrich D-50	Driller: Terra Testing, Inc.
Project No.: J217P078	Exhibit: A-2

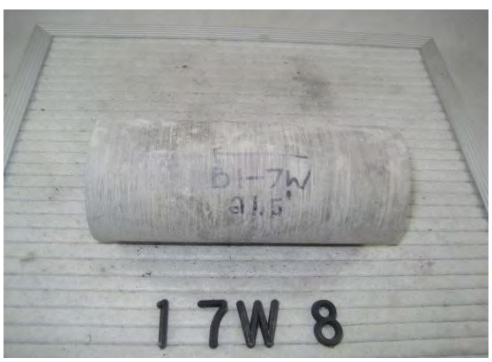
ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B1-7W	Lithology :	Limestone
Sample No.:	1	Moisture Content :	As received
Sample Depth:	21.5 feet	Lab Temperature :	70° F
Sampling Date:	9/5/17	Loading Rate:	55 psi/s
		Time to Failure:	16 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	52,840 lb
Length:	4.54 in	Compressive Strength:	17,161 psi
L/D:	2.29	Compressive Strength:	118.32 Mpa
End Area:	3.08 in^2	Unit Weight	162 pcf

Photographs mislabeled as 1-7W-8

Before the Test



After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (south)
Spread : Spread 1

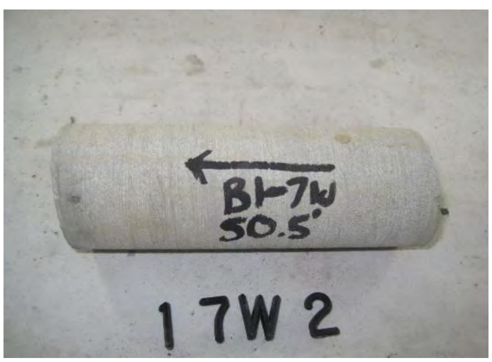
Project:	Mariner East Pipeline	Terracon	Performed by:	H. Whitford
Project No	J217P078		Test Date:	10/13/2017
Location:	Spread 1	77 Sundial Ave., Suite 401 W	Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	Manchester, New Hampshire	Review Date :	10/13/2017

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

Boring No.:	B1-7W	Lithology :	Sandstone
Sample No.:	2	Moisture Content :	As received
Sample Depth:	50.5 feet	Lab Temperature :	70° F
Sampling Date:	9/5/17	Loading Rate:	55 psi/s
		Time to Failure:	15 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	49,480 lb
Length:	4.34 in	Compressive Strength:	16,233 psi
L/D:	2.20	Compressive Strength:	111.92 Mpa
End Area:	3.05 in^2	Unit Weight	160 pcf

Before the Test



After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (south)
Spread : Spread 1

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

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.:	B1-7W	Lithology :	Sandstone
Sample No.:	3	Moisture Content :	As received
Sample Depth:	79 feet	Lab Temperature :	70° F
Sampling Date:	9/5/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	21,220 lb
Length:	4.27 in	Compressive Strength:	6,962 psi
L/D:	2.17	Compressive Strength:	48.00 Mpa
End Area:	3.05 in^2	Unit Weight	166 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (south)
Spread : Spread 1

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

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

Boring No.:	B1-7W	Lithology :	Sandstone
Sample No.:	4	Moisture Content :	As received
Sample Depth:	101 feet	Lab Temperature :	70° F
Sampling Date:	9/5/17	Loading Rate:	55 psi/s
		Time to Failure:	6 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	19,690 lb
Length:	4.10 in	Compressive Strength:	6,460 psi
L/D:	2.08	Compressive Strength:	44.54 Mpa
End Area:	3.05 in^2	Unit Weight	164 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (south)
Spread : Spread 1

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

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.:	B1-7W
Sample No.:	5
Sample Depth:	117 feet
Sampling Date:	9/5/17

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

Diameter:	1.97	in
Length:	4.38	in
L/D:	2.22	
End Area:	3.05	in^2

Maximum Axial Load at Failure:	22,930	lb
Compressive Strength:	7,523	psi
Compressive Strength:	51.87	Mpa
Unit Weight	171	pcf

Before the Test

After the Test

Drawing # :	PA-WM1-0111.0000-RD
PO # :	20170811-1
Crossing :	Gombach Rd (south)
Spread :	Spread 1

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

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

Boring No.:	B1-7W	Lithology :	Sandstone
Sample No.:	6	Moisture Content :	As received
Sample Depth:	127 feet	Lab Temperature :	70° F
Sampling Date:	9/5/17	Loading Rate:	55 psi/s
		Time to Failure:	5 min

Diameter:	1.97 in	Maximum Axial Load at Failure:	16,580 lb
Length:	3.17 in	Compressive Strength:	5,440 psi
L/D:	1.61	Compressive Strength:	37.50 Mpa
End Area:	3.05 in^2	Unit Weight	170 pcf

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

Before the Test

After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (south)
Spread : Spread 1

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

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

Boring No.:	B1-7W	Lithology :	Sandstone
Sample No.:	7	Moisture Content :	As received
Sample Depth:	136.5 feet	Lab Temperature :	70° F
Sampling Date:	9/5/17	Loading Rate:	55 psi/s
		Time to Failure:	10 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	31,800 lb
Length:	4.72 in	Compressive Strength:	10,328 psi
L/D:	2.38	Compressive Strength:	71.21 Mpa
End Area:	3.08 in^2	Unit Weight	169 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (south)
Spread : Spread 1

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

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

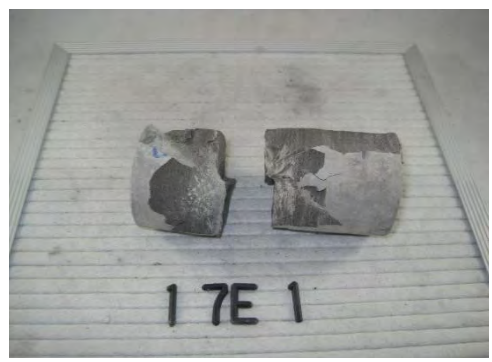
Boring No.:	B1-7E	Lithology :	Shale
Sample No.:	1	Moisture Content :	As received
Sample Depth:	29.5 feet	Lab Temperature :	70° F
Sampling Date:	9/11/17	Loading Rate:	55 psi/s
		Time to Failure:	8 min

Diameter:	1.93 in	Maximum Axial Load at Failure:	25,690 lb
Length:	3.55 in	Compressive Strength:	8,781 psi
L/D:	1.84	Compressive Strength:	60.54 Mpa
End Area:	2.93 in^2	Unit Weight	171 pcf

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

Before the Test

After the Test



Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (north)
Spread : Spread 1

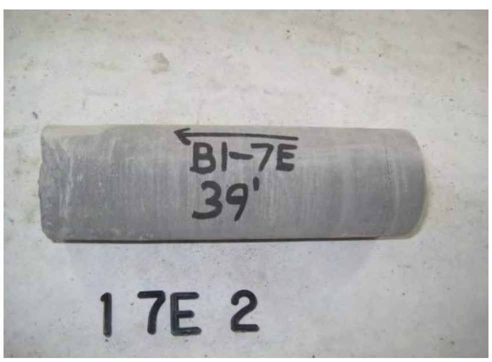
Project:	Mariner East Pipeline	Terracon 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	H. Whitford
Project No	J217P078		Test Date:	10/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/13/2017

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

Boring No.:	B1-7E	Lithology :	Siltstone
Sample No.:	2	Moisture Content :	As received
Sample Depth:	39 feet	Lab Temperature :	70° F
Sampling Date:	9/11/17	Loading Rate:	55 psi/s
		Time to Failure:	8 min

Diameter:	1.96 in	Maximum Axial Load at Failure:	25,580 lb
Length:	4.45 in	Compressive Strength:	8,478 psi
L/D:	2.27	Compressive Strength:	58.45 Mpa
End Area:	3.02 in^2	Unit Weight	165 pcf

Before the Test



After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (north)
Spread : Spread 1

Project:	Mariner East Pipeline	Terracon 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	H. Whitford
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

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

Boring No.: B1-7E
Sample No.: 3
Sample Depth: 48.5 feet
Sampling Date: 9/11/17

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

Diameter: 1.97 in
Length: 4.44 in
L/D: 2.25
End Area: 3.05 in^2

Maximum Axial Load at Failure: 34,470 lb
Compressive Strength: 11,309 psi
Compressive Strength: 77.97 Mpa
Unit Weight 163 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (north)
Spread : Spread 1

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

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

Boring No.:	B1-7E	Lithology :	Siltstone
Sample No.:	4	Moisture Content :	As received
Sample Depth:	59 feet	Lab Temperature :	70° F
Sampling Date:	9/11/17	Loading Rate:	55 psi/s
		Time to Failure:	9 min

Diameter:	1.96 in	Maximum Axial Load at Failure:	29,250 lb
Length:	4.52 in	Compressive Strength:	9,694 psi
L/D:	2.31	Compressive Strength:	66.84 Mpa
End Area:	3.02 in^2	Unit Weight	165 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (north)
Spread : Spread 1

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

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.

J1_D7012c_01-15-16,Rev.0

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

Boring No.:	B1-7E	Lithology :	Siltstone
Sample No.:	5	Moisture Content :	As received
Sample Depth:	68.5 feet	Lab Temperature :	70° F
Sampling Date:	9/11/17	Loading Rate:	55 psi/s
		Time to Failure:	9 min

Diameter:	1.98 in	Maximum Axial Load at Failure:	31,330 lb
Length:	4.51 in	Compressive Strength:	10,175 psi
L/D:	2.28	Compressive Strength:	70.15 Mpa
End Area:	3.08 in^2	Unit Weight	169 pcf

Before the Test

After the Test

Drawing # : PA-WM1-0111.0000-RD
PO # : 20170811-1
Crossing : Gombach Rd (north)
Spread : Spread 1

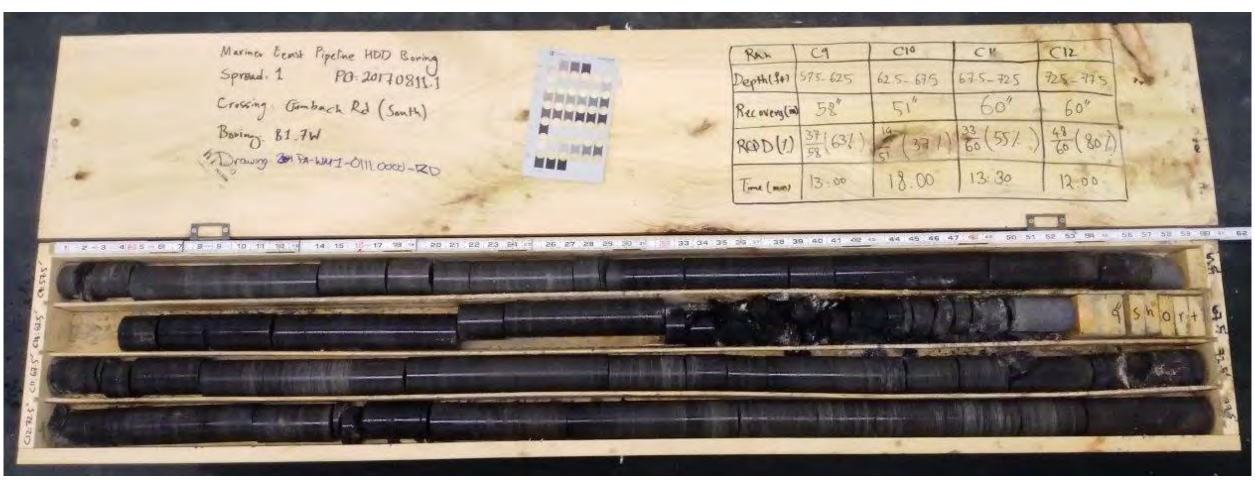
Project:	Mariner East Pipeline	Terracon 77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Performed by:	H. Whitford
Project No	J217P078		Test Date:	10/13/2017
Location:	Spread 1		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.		Review Date :	10/13/2017

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.

Terracon

Photograph 1: B1-7W, Samples C-1 to C-4 (20 to 37.5 feet)

Photograph 2: B1-7W, Samples C-5 to C-8 (37.5 to 57.5 feet)



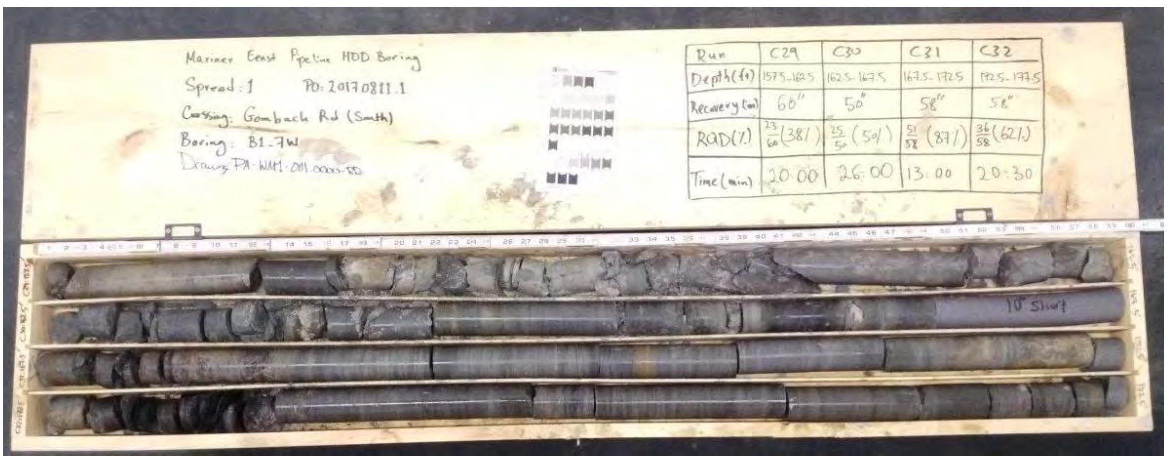
Photograph 3: B1-7W, Samples C-9 to C-12 (57.5 to 77.5 feet)

Photograph 4: B1-7W, Samples C-13 to C-16 (77.5 to 97.5 feet)

Photograph 5: B1-7W, Samples C-17 to C-20 (97.5 to 117.5 feet)

Photograph 6: B1-7W, Samples C-21 to C-24 (117.5 to 137.5 feet)

Photograph 7: B1-7W, Samples C-25 to C-28 (137.5 to 157.5 feet)



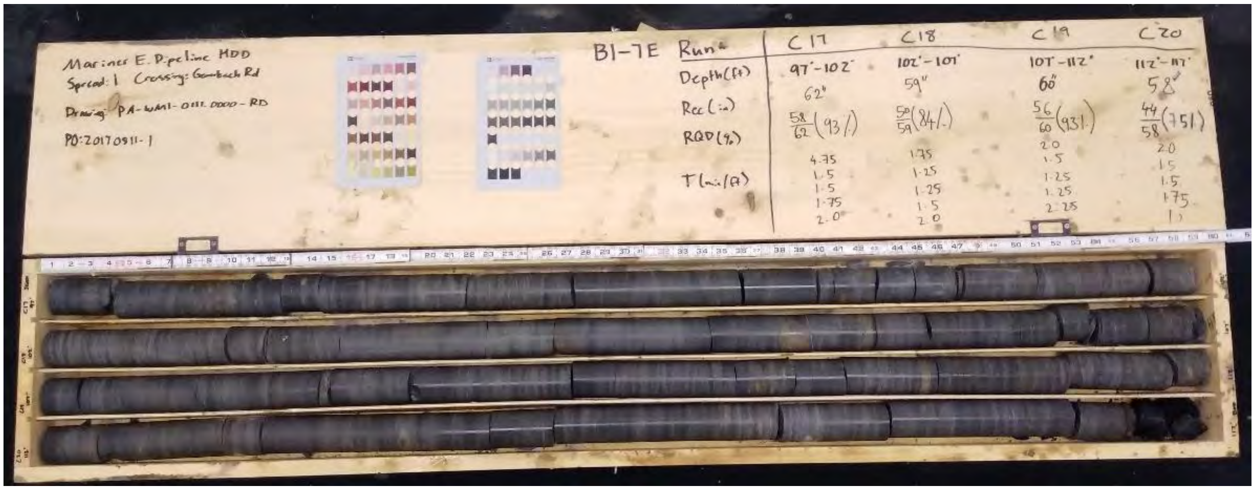
Photograph 8: B1-7W, Samples C-29 to C-32 (157.5 to 177.5 feet)

Photograph 1: B1-7E, Samples C-1 to C-4 (18.5 to 37 feet)

Photograph 2: B1-7E, Sample C-5 to C-8 (37 to 57 feet)

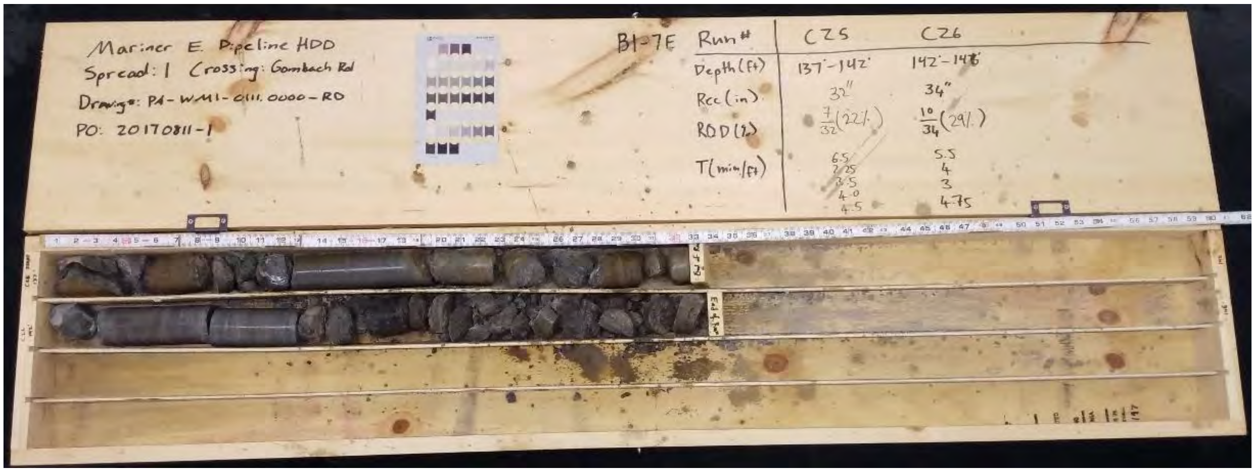
Photograph 3: B1-7E, Sample C-9 to C-12 (57 to 77 feet)

Photograph 4: B1-7E, Sample C-13 to C-16 (77 to 97 feet)



Photograph 5: B1-7E, Samples C-17 to C-20 (97 to 117 feet)

Photograph 6: B1-7E, Samples C-21 to C-24 (177 to 137 feet)



Photograph 7: B1-7E, Samples C-25 to C-26 (137 to 147 feet)

SUPPORTING INFORMATION

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

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

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

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

[F] If soil contains 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.

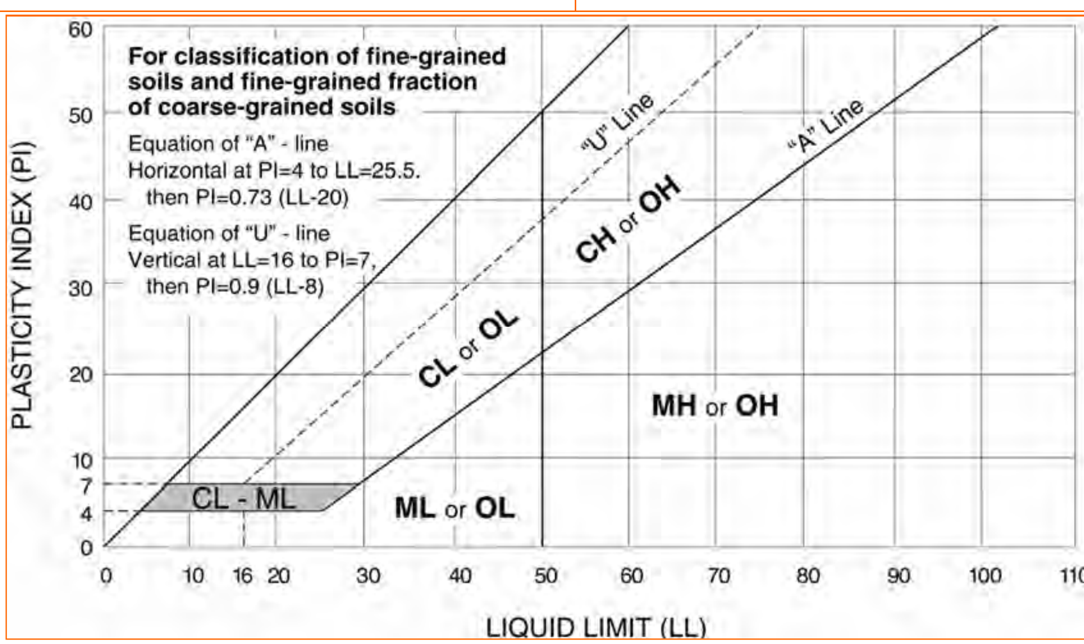
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[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]

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

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

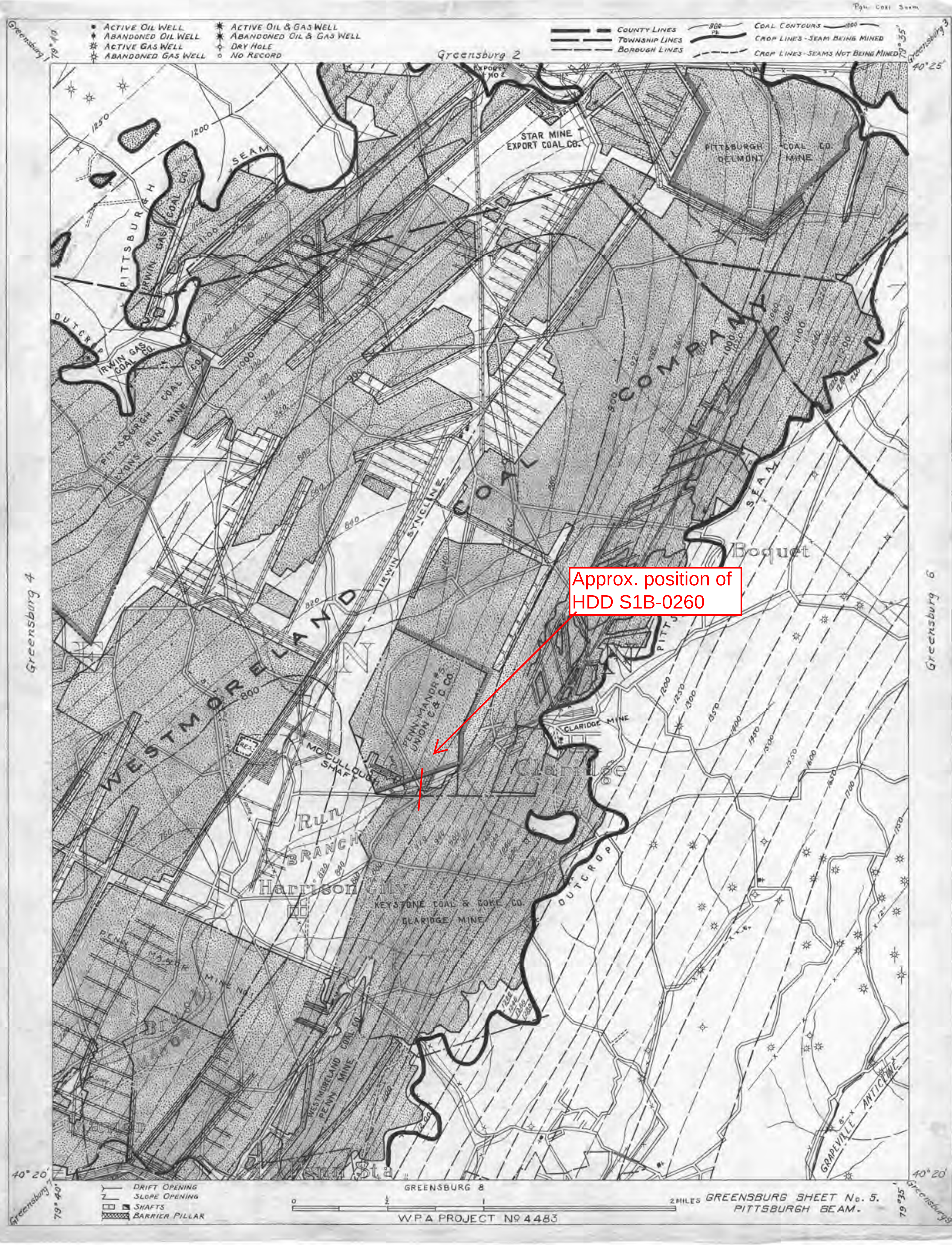
Joint Openness Descriptors

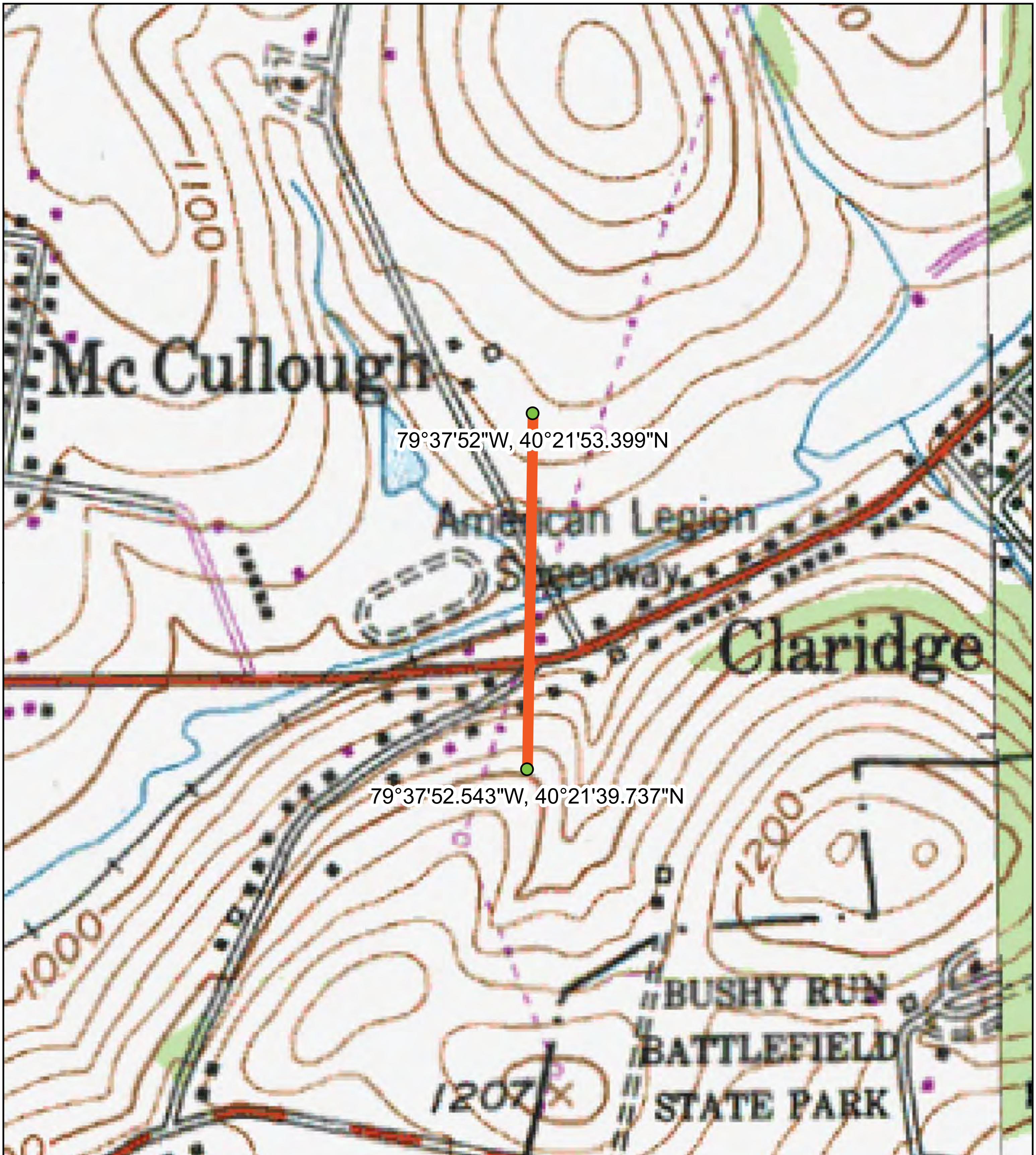
Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

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

Attachment C

WPA Mine Map
and
PADEP Detailed Mine Report


Approx. position of
HDD S1B-0260
Active Oil Well
Abandoned Oil Well
Active Gas Well
Abandoned Gas Well
Active Oil & Gas Well
Abandoned Oil & Gas Well
Dry Hole
No Record
County Lines
Township Lines
Borough Lines
Coal Contours
Crop Lines - Seam Being Mined
Crop Lines - Seams Not Being Mined
Greensburg 1
Greensburg 2
Greensburg 3
Greensburg 4
Greensburg 6
Greensburg 7
Greensburg 8
Greensburg 9
79° 40'
79° 35'
40° 25'
40° 20'
Star Mine
Export Coal Co.
Pittsburgh Coal Co.
Delmont Mine
Pittsburgh & Irwin Gas Coal Co.
Irwin Gas Coal Co.
Pittsburgh Coal Co.
Lyons Run Mine
Westmoreland Coal Company
Irwin Syncline
Penn Manor #5
Union C & C Co.
McCullough Shaft
Claridge Mine
Claridge
Boquet
Run
Branch
Harrison City
Keystone Coal & Coke Co.
Claridge Mine
Penn Manor Mine No.
Westmoreland Coal Co.
Penn Mine
Outcrop
Seam
Grapeville Anticline
Drift Opening
Slope Opening
Shafts
Barrier Pillar
0
½
1
2 Miles
Greensburg Sheet No. 5.
Pittsburgh Seam.
W.P.A. Project No 4483



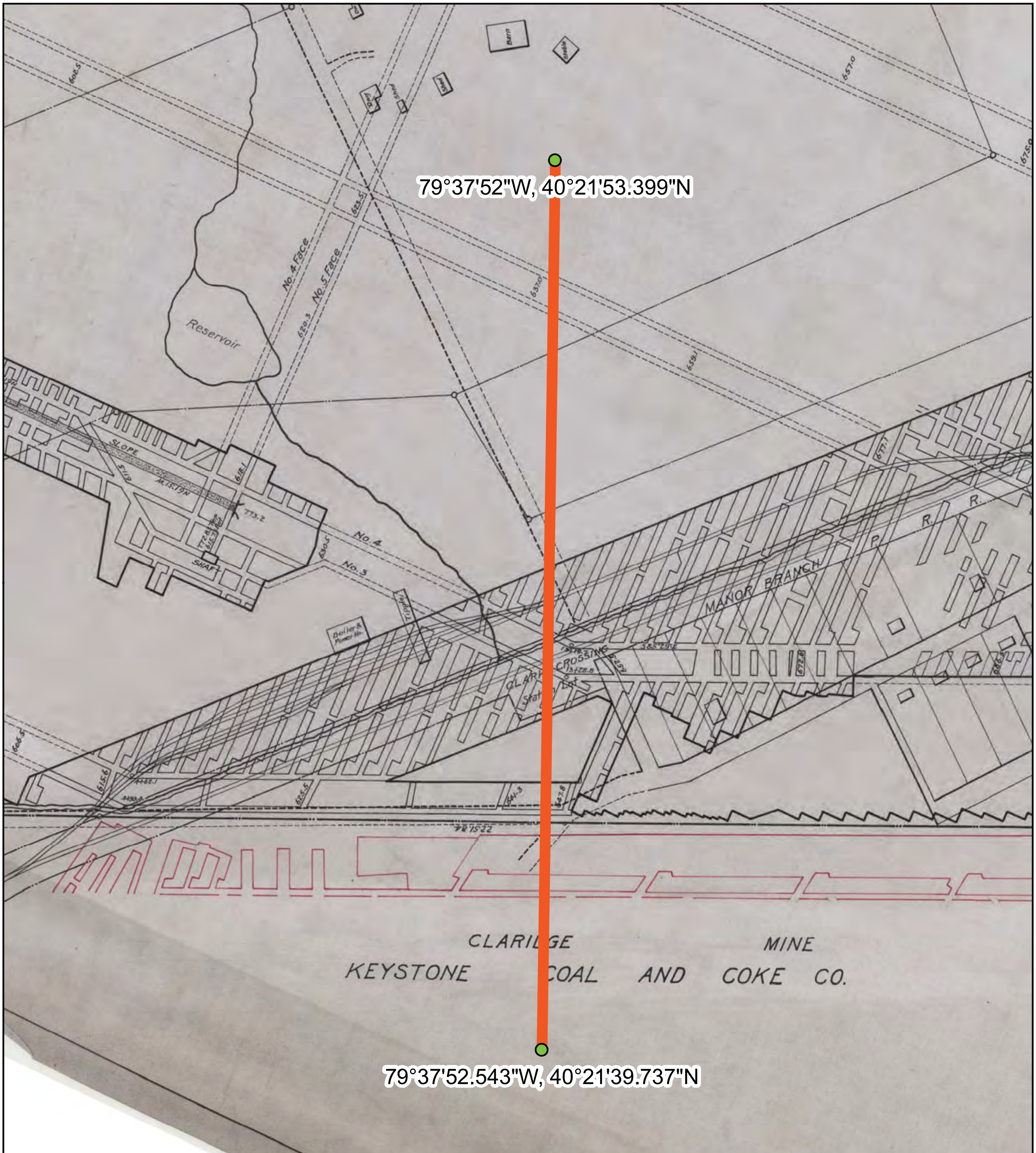
pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

This map was prepared using information considered to be the best historic data available. The Department cannot verify the accuracy or completeness of this information or alignment of images.

Scale: 1 inch = 500 feet

USGS Topographic Map

USGS 7.5' Irwin, PA Quadrangle



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

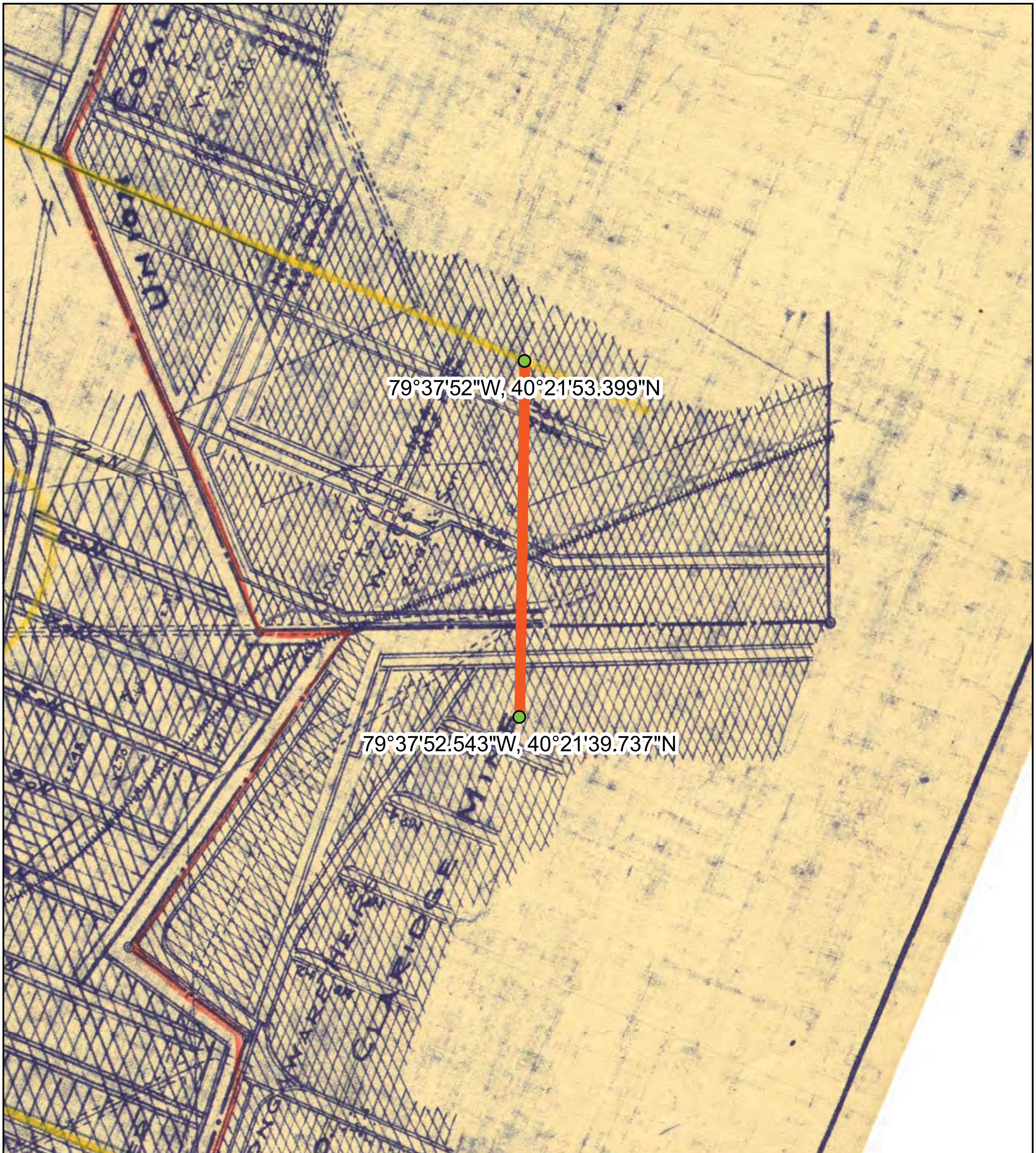
This map was prepared using information considered to be the best historic data available. The Department cannot verify the accuracy or completeness of this information or alignment of images.

Scale: 1 inch = 200 feet

N

Detailed Mine Map

Claridge Mine
Keystone Coal and Coke Co.
BMSB_UMM_100_2096-001
Pittsburgh Coal Seam



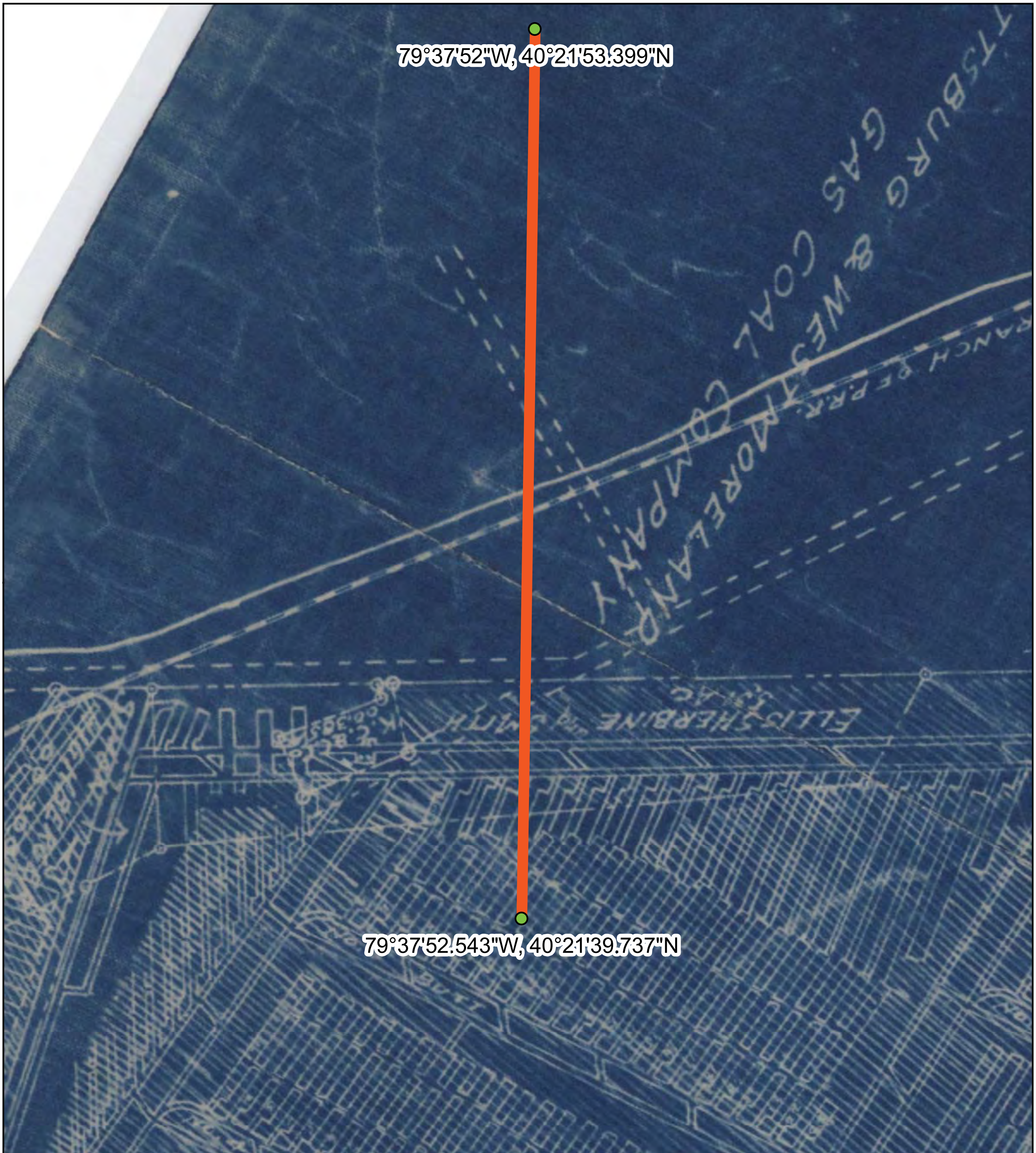
pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Scale: 1 inch = 500 feet

N

Detailed Mine Map

Claridge Mine
Keystone Coal and Coke Co.
PASC_R154-2587-1
Pittsburgh Coal Seam



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

This map was prepared using information considered to be the best historic data available. The Department cannot verify the accuracy or completeness of this information or alignment of images.

Scale: 1 inch = 200 feet

N

Detailed Mine Map

Claridge Mine
Keystone Coal and Coke Co.
0139_UMM_400_001
Pittsburgh Coal Seam

GOMBACH ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PADEP SECTION 102 PERMIT NO.: PA-WM1-0111.0000-RD
(SPLP HDD# S1B-0260)

ATTACHMENT 2

MINE SUBSIDENCE REPORT AND PIPELINE RISK ANALYSIS

SUBSIDENCE POTENTIAL REVIEW
GOMBACH ROAD
HORIZONTAL DIRECTIONAL DRILLED PIPELINE PROJECT
PENN TOWNSHIP, WESTMORELAND COUNTY, PA

May 2018

PRESENTED FOR

Sunoco Logistics, L.P.
525 Fritztown Road
Sinking Spring, PA

PRESENTED BY

Tetra Tech
661 Anderson Drive
Foster Plaza 7
Pittsburgh, PA 15220

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) was retained by Sunoco Logistics L.P. (Sunoco) to review the mining activity and subsidence potential of the abandoned coal mines below the planned Gombach Road horizontal directional drilled pipeline located in Penn Township, Westmoreland County, Pennsylvania. Our report follows.

BACKGROUND

Mine subsidence is defined by Pennsylvania Department of Environmental Protection (PA DEP) as "movement of the ground surface as a result of readjustments of the overburden due to collapse or failure of underground mine workings." Overburden is the soil and rock lying between the coal and the surface. When subsidence occurs at or near the location of an overlying structure, damage to the structure may occur. The potential impacts to surface structures are "generally classified as cosmetic, functional, or structural. Cosmetic damage refers to slight problems where only the physical appearance of the structure is affected, such as cracking in plaster or drywall. Functional damage refers to situations where the structure's use has been impacted, such as jammed doors or windows. A more significant impact on structural integrity is classified as structural damage. This includes situations where entire foundations require replacement due to severe cracking of supporting walls and footings." (PADEP, 2017). When a new structure is designed over areas where potential mine subsidence could result in structural damage, structural engineers can mitigate the damage concerns by improving the structural integrity of the structure or by isolating the structure from the subsidence. When structural improvement or isolation is not possible or is cost prohibitive, the hazards posed by mine subsidence can be mitigated by grouting the remnant mined entries (filling voids with concrete like material to prevent settling) to reduce the potential for subsidence.

The most effective mitigation method is to relocate the structure over areas where the coal has not been mined; however, in Pennsylvania mining regions, this is not always a possibility. When a structure is located over abandoned mine workings, predicting the probability and timing of future subsidence is not a clearly defined science. The probability of future subsidence depends on the remaining stability of the mine pillars, the columns of coal left in place to support the overlying overburden. The timing of any future failure of the pillars would depend on knowing the exact failure strength, the geometry of the mine pillars and the reduction in the strength of the mine pillars over time. There is, however, no way to know when pillar failure will occur. Mining maps are prepared by active mining companies when the mine was operating to indicate where mining occurred and the type of mining conducted. Maps of abandoned mines are used by mining engineers to verify the mine layout and to estimate the size of remaining voids and pillars. These maps often lack complete details of the mining and are sometimes inaccurate. Incomplete or inaccurate knowledge of mine configuration can introduce additional errors into any future subsidence prediction.

Most abandoned mine subsidence impacts to small buildings (such as houses or offices) that result in structural damage have occurred in areas of limited overburden, such as where the mine depth is less than 100 feet. Although the subsidence damage classifications above refer to surface impacts, similar classifications might be applicable for impacts to underground pipelines located below the ground surface. As an example, areas of minor ground movement after a pipeline has been installed within a horizontal drilled borehole may cause movement of the pipeline (similar to cosmetic or functional damage to a surface structure) but may not cause structural damage such as a break in the pipeline resulting in a loss of fluids or gas. Areas of potential structural damage should be avoided or mitigated.

The Keystone Coal and Coke's Claridge Mine and Union Coal and Coke's Penn Manor #5 Mine operated in Penn Township, Westmoreland County in the early 1900's. Their primary mining method was room and pillar mining. Mining was completed under the planned HDDP prior to 1918. These mines extracted the Pittsburgh coal at a mining height of approximately seven feet. Using the mine maps, obtained from the Pennsylvania Mine Atlas, the main entries appear to be ten feet wide and production room entries were about twenty-four feet wide. Based on the EPA Region III Mine Pool Project (Natural Mine Land Reclamation Center, 2004) these mines appear to be flooded under the pipeline location.

The mining method employed at the Claridge and Penn Manor #5 Mines was room and pillar mining utilizing hand loading (the coal was broken loose using explosives and loaded into carts manually). Main entries were primarily used for developing areas for the rooms. The rooms were more productive (higher tons per manhour) and recovered a higher percentage of the in place coal. The main entries were also used for men and material movement within the mines, for coal haulage, for air courses for mine ventilation and were configured to be stable for an extended period of time. The rooms were areas utilized exclusively for coal recovery, and were only configured for short term stability. They were designed to protect the miners while they were working there, but not for long term stability. At that time, mines did not use any mechanical roof support as used in today's mines. The main entries were supported primarily by the large adjacent coal pillars that would remain after mine closure. Rooms were advanced to the right or left of the main entries. After each room had advanced to its planned length, which was typically approximately one-half of the way between main entries, the small support pillar between rooms was systematically removed (mined) as the miners retreated, allowing the roof to collapse behind them. When this happened, surface subsidence would occur. Most subsidence would occur almost immediately, and all ground movements would be completed within a few weeks. The main entries needed to remain open for the duration of mining activities and thus relatively large pillars were left between these entries as support. The surface above those pillars should remain stable from subsidence for the long term. Areas between the caved production rooms and the large main entry support pillars or areas where the rooms were not retreated for whatever reason (poor mining condition, mine closures, etc.) have the highest risk of future subsidence because the pillars in these areas were not designed to provide long-term support. These medium-sized pillars are the primary areas of concern regarding potential for future subsidence. Based on the mine map, there may also be a few areas where mining did not occur and solid coal remains. Assuming that the mine map is accurate, those areas should be safe from future subsidence. As previously discussed, due to potential inaccuracies in the mine map, this cannot be guaranteed.

TYPES OF MINE SUBSIDENCE

Mine subsidence occurs in one of two physical forms, a trough or a sinkhole. A trough is a shallow, often broad, dish-shaped depression that develops when the overburden sags downward into a mine opening in response to roof collapse, the crushing of mine pillars, or the punching (pushing) of pillars into the mine floor. There can also be areas of surface heave around the edges of the subsidence troughs. Trough subsidence typically occurs in areas of deeper overburden, typically in areas of more than 100 feet of overburden. The depth and extent of the trough are closely related to the dimensions and thickness of the extracted coal.

A sinkhole is a depression in the ground surface that occurs due to localized collapse of the overburden directly into a mine opening (a room or entry). This is often called "chimney" type subsidence. Boundaries between the ground surface and the vertical walls of the sinkhole are often abrupt, and because sinkhole diameter generally increases with depth, the sinkhole in profile may initially resemble an open bottle with the top at the ground surface. Erosion of soil at the sinkhole's periphery may increase the diameter near the ground surface to create an hourglass profile. Sinkhole subsidence typically occurs in areas of shallow overburden, primarily 100 feet or less. Sinkhole-prone areas are the primary locations where subsidence causes severe structural damage to buildings on the surface. Sinkhole subsidence in an area of single-seam mining is usually limited to areas where the total thickness of the rock layers above the coal is no more than 6 to 10 times the thickness of the coal mined in the area. The soil thickness overlying the rock is not included in this estimate. (Kendorski, 2006).

CATEGORIES OF MINE SUBSIDENCE POTENTIAL

Mining-induced subsidence is caused when a seam of coal is extracted and overlying rock layers cave into the voids left by mining such that there is movement on the ground surface. The probability of subsidence is greater in areas where a high percentage of coal is removed. In an analysis of underground mines, subsidence potential can be classified into the following three general categories:

Category 1 – Subsidence probably occurred during or soon after mining.

Category 2 – Support area where subsidence is unlikely.

Category 3 – Area where subsidence may occur in the future if it has not already occurred.

Room and pillar mining, the method of mining commonly used in the project area, is a method of mining where mine entries were excavated through the coal seam. The unmined coal or coal pillars remained in place to support the roof. As the mine workings reach the extent of the mine boundaries, some areas are "retreat mined." In areas where retreat mining is employed, coal pillars are extracted for nearly full recovery (generally 80 to 90 percent recovery) of the coal seam. To accomplish full recovery in a safe manner, the roof of the mine is allowed to cave in a predictable controlled manner following coal extraction. This controlled caving process systematically relieves built-up stresses caused by the cantilever action of the mine roof thereby reducing the risk of catastrophic strata failure where men are working. The limits and extents of the subsidence are relatively predictable where retreat mining is employed because subsidence normally occurs soon after mining.

Category 1 refers to areas where nearly full extraction of the coal occurred as a result of retreat mining and there is very low probability of extensive future subsidence, although subsidence can occur at the edges of these areas due to failure of adjacent supporting pillars.

Category 2 refers to areas where the mine configuration and pillars are adequately designed to provide permanent support to the ground surface. The amount of coal removed in these areas is generally low to moderate. These areas, although mined, generally remain stable over the long term and typically include main entries and haulage routes as well as low-extraction-ratio room and pillar areas of the mines where retreat mining did not occur. Areas of mines delineated as Category 2 would have a relatively low probability of future subsidence.

Category 3 refers to areas underlain by room and pillar mines with a high percentage of coal removed and where retreat mining was not performed. In Category 3 areas, it is uncertain whether subsidence occurred and whether there remains a likelihood of subsidence in the future. In these areas, entries were driven through the coal, and the pillar sizes were smaller than what would generally be required to provide permanent support. In other words, the pillars were designed with a low factor of safety (caused by the high extraction ratio), and there would be an elevated risk of pillar, roof, or floor failure. If subsidence already occurred, the possibility of future subsidence is very unlikely. However, if subsidence has not previously occurred, the possibility of future subsidence remains high. Of the three categories, Category 3 would have the highest probability for future subsidence.

In mining subsidence terms, the extent of the potential area impacted by subsidence can be defined using a specific angle from the coal seam to the ground surface that could be affected if roof failure occurred at the mine level. The potential subsidence affected area can be directly overhead but could also be offset a certain horizontal distance from the roof failure location. The angle, termed the “angle-of-draw,” can vary depending on the overburden rock type (Peng, 1978). PA DEP accepts 20 degrees as the angle-of-draw for the flat-lying coal seams in the bituminous coal region; however, up to 35-degree angle-of-draws have been found to occur, primarily in deeply dipping mining areas. Because mining in the Claridge and Penn Manor #5 mines were in a flat-lying coal seam, a 20-degree angle-of-draw would be expected. There have also been instances of higher angles in specific cases, but those cases are extremely rare. The angle-of-draw can also be projected downward from a surface structure to determine what area within a mine could, if pillar or roof failure occurred, cause surface subsidence.

Tetra Tech reviewed the mine maps and the location and elevation of the planned horizontal boring. The boring is underlain by two coal mines that were operated by different owners. Maps for both mines were reviewed. The WPA (Works Progress Administration) prepared generalized maps of abandoned mines during the 1930’s by reviewing maps available to them at that time. Their map for this area was also reviewed. The information regarding mining practices utilized and timing of mining could not be determined from the available maps. The maps appear to show the initial mining of the Penn Manor mine prior to 1918, and some secondary mining later. Figure 1 depicts the areas within the mine that are within the angle-of-draw depicted downward from the level of the HDDP. Both angle-of-draws (20° and 35°) were shown on Figure 1. The area shown was created by using an angle-of-draw from the pipeline’s bottom elevation for the top of the coal seam. The areas shown within the extent of the mine within the angle-of-draw that if failure occurred the potential to affect the pipeline exist. A 15-foot horizontal zone on each side of the pipe (30 feet total) was also included. A total of 4.3 acres lies within the 20° angle of draw influence area, while 8.1 acres lie within a 35° angle of draw influence area. The categories of mine subsidence potential areas are shown on Figure 2 and summarized on Table 1.

TABLE 1

Angle of Draw	Subsidence Potential	Area (Acres) 20°	Area (Acres) 35°
Subsidence Category 1	Subsidence probably occurred during or soon after mining	2.3	4.6
Subsidence Category 2	Support area where subsidence is unlikely	0.6	1.0
Subsidence Category 3	Area where subsidence may occur in the future if it has not already occurred	1.4	2.5
Total		**4.3**	**8.1**

Within the overburden the strata can behave differently when subsidence occurs and depend on the distance above the coal seam and the mining thickness. These different zones are classified based on past research. A caved zone occurs from the roof of the mined coal and typically extends upwards for a distance of 6 to 10 times the mining thickness (Kendorski, 2006). In the case of the Claridge and Penn Manor #5 mines where the mined thickness is seven feet, this zone would be from 42 to 70 feet above the top of coal. Rock in this zone would have extensive fracturing and sizable voids. Above the cave zone and extending for 24 to 30 times the mining thickness a fractured zone would occur. In this zone, a lot of fractures would be present but the rock strata would remain as a single unit without extensive dislocated rock or voids present. At the Claridge and Penn Manor #5 mines, this zone would extend from 42 to 70 feet to 168 to 210 feet above the top of mining. The next zone would extend from the top of the fractured zone to about 60 times the mining thickness. This zone is termed the dilated zone. This zone would have small temporary fractures that would heal over time. The rock again would remain as a single unit. At the Claridge and Penn Manor #5 mines, this dilation zone would extend from 168 to 240 feet to 420 feet above the top of the coal. The zone above the dilated zone is termed the constrained or bending zone where no fracturing would occur. The zones are shown on Table 2.

Table 2: Zones of Strata Fracturing During Subsidence

Zone	Extent Above Coal Seam (ft.) (x mining height)	Impact to Strata	Voids Created
Constrained	Not Applicable	No Fractures	None
Dilation	Up to 60	Small Fractures	Micro
Fracture	Up to 30	Fractured	Minimal
Caved	Up to 10	Fractured	Sizable
Mined Coal Seam			

Determining induced strains from subsidence during active mining has become relatively accurate, especially for longwall mines. Numerous computer models have been developed by mining agencies and universities that use variations in the rock type within the overlying strata, mining thickness, and mine geometry at coal seam level to predict ground movements at the surface. These models not only predict the extent and amount of subsidence but can predict tilts and strains occurring at ground level. They can also be used to predict maximum strains if subsidence would occur, although their application for abandoned mines is less predictable as to the extent of subsidence. Mine subsidence from an abandoned mine is less uniform and predictable than subsidence during active mining. However, the use of models for actual mining should provide relatively similar results when predicting the potential strains from future subsidence of abandoned mines.

FINDINGS

The mine maps were reviewed by experienced mining engineers. Although the mining shown on the maps covering the area under the HDDP occurred about 100 years ago, the maps were found to be very detailed regarding the mining type and location of mining. The maps were georeferenced by PA DEP. In our opinion, the mine maps are generally a reliable indication of the extent of what was mined. There are a couple of potential areas of uncertainty – primarily at expected retreat mined areas where we are not certain if all of the coal was removed.

The horizontal directional boring starts on its southern most location at 190 feet above the mined coal. The descending boring will be approximately 80 feet above the mining when it levels about 550 feet horizontally from its start. The boring would then be fairly level for approximately 180 feet to a location where it will remain approximately 80 feet above the mine. From there the boring will ascend upward until it reaches the surface 1,383 feet from its start. At that this surface exit location the boring would be about 170 feet above the mine.

Figure 3 was prepared using the planned HDDP profile and adding the top of each fracture zone if subsidence would occur or has occurred. To be conservative, the top of each fracture zone was selected as the maximum value based on the Kendorski's research (Kendorski, 2006). The entire bore will be completed within the (fractured) zone. It is expected that the rock fracturing in this area may be severe due to the shallow depth of the coal and relatively thick coal extraction height. The presence of perched aquifers in the boring logs B1-7W and B1-7E may be an indication that at least some fractures have closed after mining was completed.

The PA DEP Bureau of Abandoned Mine Land Reclamation (BAMR) is responsible for maintaining an inventory of all abandoned mine related incidents in Pennsylvania. This includes mine subsidence incidents above abandoned mines such as the Claridge and Penn Manor mines. It is our understanding that their recording of these incidents began shortly after 1977. There have been no subsidence incidents reported and investigated in the area of the HDDP in the past 40 years.

When the earth subsides, the curvature of the strata can produce a horizontal strain within the strata. Some of this strain can be transferred to a rigid pipeline that is placed within the strata. Strain is defined as the amount of deformation in the direction of applied force divided by the initial length of the material. This results in a unitless number such as inches per inch. Strain can be induced by compression, tension or bending forces. Using historical subsidence data from primarily known conditions during longwall mining, models have been developed to predict strains at the ground surface caused by subsidence. These models, although not perfectly suited for use with abandoned mines, can be adapted to estimate strains within the strata at the elevations where the pipeline will be placed. Because the caved zone would be heavily fractured during subsidence, local strains within the caved zone cannot be accurately estimated. To estimate the strains that may be seen at the pipeline level in the zones above the caved zone, Tetra Tech engaged Dr. Keith Heasley, a mining engineer with experience using subsidence models to predict the possible strains. Dr. Heasley is a professor of mining engineering at West Virginia University. His full report can be found in Appendix A.

Modeling of the Claridge and Penn Manor #5 mines was conducted using a base coal strength of 900 pounds per square inch (psi) to simulate the strength of the coal at the time of mining. Subsequently, a coal strength of 600 psi was modeled to simulate the coal strength after the mine pillars degrade over time. The predicted subsidence with both coal strengths along the pipeline alignment is shown on Figure 4. The 900-psi coal subsidence plot indicates anticipated ground subsidence directly after mining. The 600-psi plot predicts the subsidence that may occur along the pipeline as the mine conditions degrade over time. It is unknown when or if the 600-psi conditions will ever occur. Mine subsidence at this site may have already occurred, may occur at some time in the future, or may never occur. Predicting the exact condition of the mine at this time, or at any precise time in the future, is not possible. Subsidence may also occur in different areas at different times so that the estimated subsidence in the model may not occur at the same time.

Tetra Tech employed 3D seismic technology to gain a better understanding of the strata fracturing and anomalies at mine level. The subsidence model was run to reflect this information.

LaModel was chosen as the mining-induced stress analysis program to estimate strain on the strata at the location of the pipeline within the strata. This program is primarily designed to calculate the seam stress and displacement within an underground mine. The software uses boundary elements for calculating the stresses and displacements in coal mines or other thin tabular seams or veins. During active mining, it can be used to optimize pillar sizes and mine layout by minimizing pillar stress. Multi-seam mining stress can also be reviewed. This program can also reasonably calculate surface subsidence. A medium distance of 150 feet above the Claridge and Penn Manor #5 mines was chosen for detailed analysis of mine subsidence. In the LaModel program, the overburden is modeled as a continuum. Therefore, the program shows the subsidence directly over the mined areas and within the angle of draw. The magnitude of subsidence decreases as the distance from the mine increases and the subsidence spreads. The program does not model any dilation of the overburden.

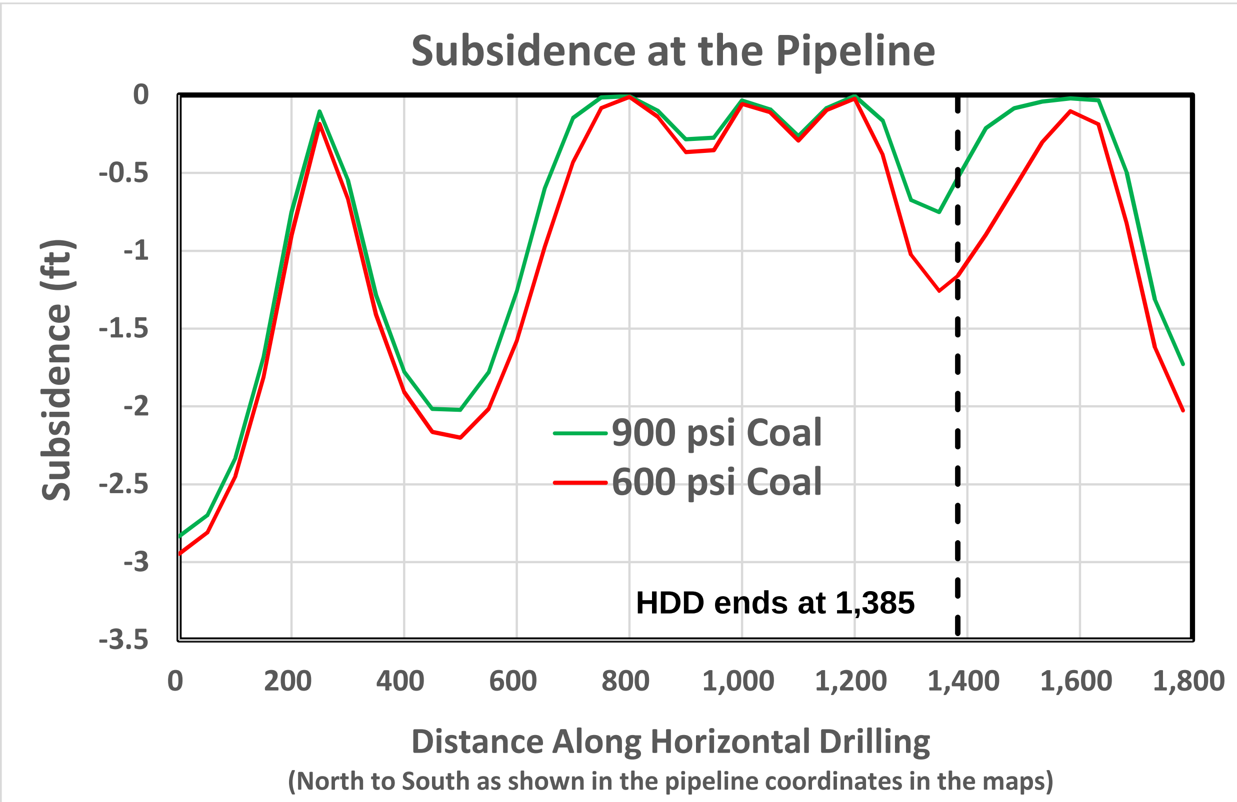


Figure 4. Estimated Subsidence

The estimated maximum subsidence that the pipeline may experience in the future is the difference between the subsidence estimated using the original strength (900 psi) of coal and the subsidence estimated using degraded strength (600 psi) of coal. This differential subsidence is shown on Figure 5. There are two primary areas of potential future subsidence. One area is centered at Station 6+50 and occurs within a retreat mined area that was not completely caved based on our interpretation of the 3D seismic data. The increased subsidence at this location was estimated to be about 0.38 foot (4.6 inches). The second area of increased subsidence occurs just beyond where the HDDP exits to the surface. This area is again located in a retreat mined area that was interpreted as not being completely caved. The additional subsidence at this area is estimated to be about 0.68 foot (8.2 inches).

The strains within the strata associated with the estimated future subsidence should the pillars fail are shown on Figure 5. The maximum strain values range from 0.25% to -0.25% and fluctuate continuously along the pipeline length. The level of strain that the pipeline may experience is a function of the ground movement and a function of how tightly the pipeline is coupled to the ground movement. If the pipeline can slide within the HDDP, then areas of tensile or compressive strain can be reasonably canceled by adjacent areas of the opposite strain.

The modeled strains are in the strata at the location of the pipeline alignment. The bored excavation for the HDDP will be larger than the pipe to be installed. As shown on Figure 6, the strain in the strata encompassing the hole, is not directly correlated to the strain imparted to the pipeline. The overbore (larger diameter of the hole compared to the pipe) leaves room for potential movement of the pipe within the strata. Transmission of the strain from the strata to the pipe associated with this project is being reviewed by pipeline engineers.

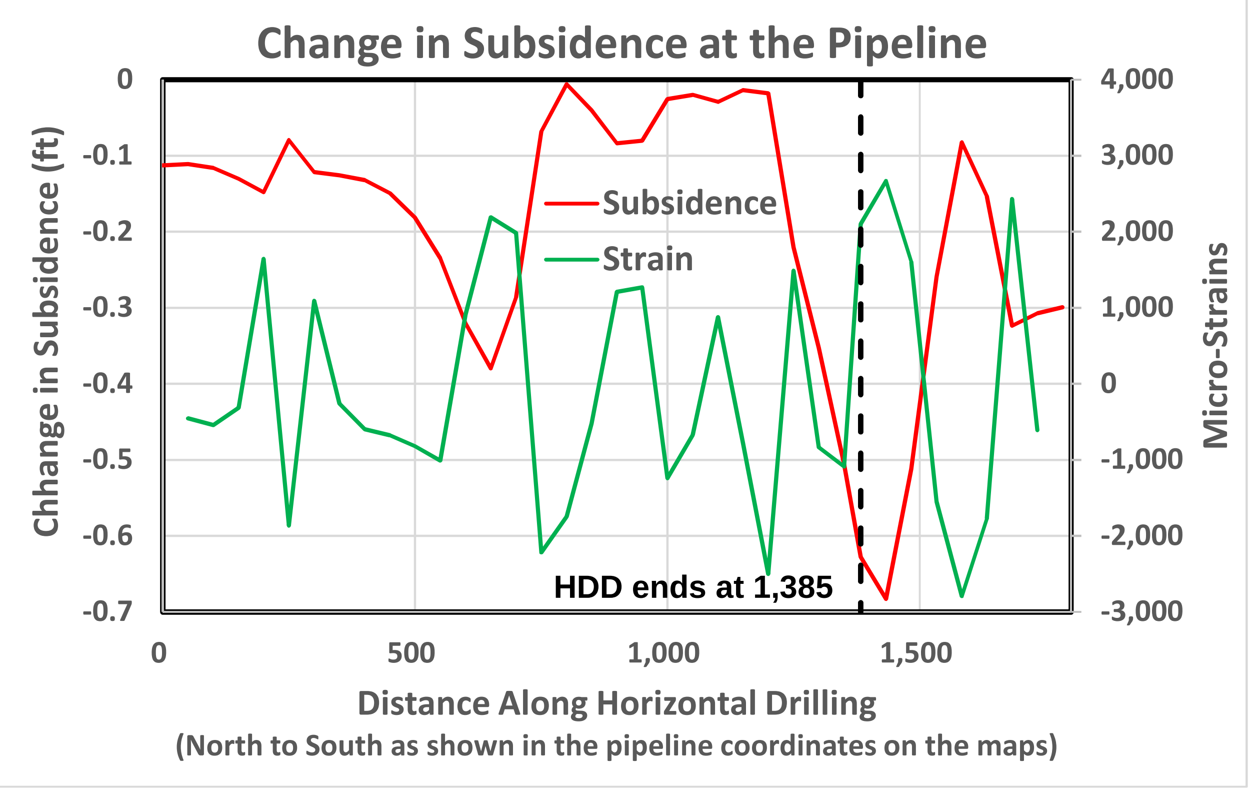
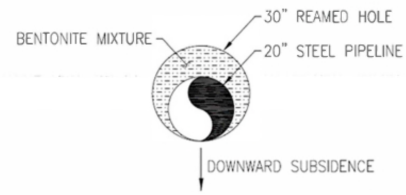


Figure 5. Change in Subsidence



HDDP 20”

Figure 6 – Borehole and Pipeline Cross Section

RECOMMENDATIONS

Based on the findings presented above Tetra Tech recommends the following actions:

- Provide the estimated maximum subsidence and strain within the strata to pipeline engineers for their use to assure that the pipeline stresses are within appropriate pipeline design standards, including an adequate factor of safety.
- Consider mitigating the subsidence strain by grouting the underlying abandoned coal mine if the pipeline stresses exceed appropriate pipeline design standards.

CLOSURE

The subsidence modeling calculates the stress and ground movement throughout the strata, from the coal seam to the surface. Numerical subsidence models have been calibrated both at the mine level (for optimizing pillar design) and at the surface (for subsidence prediction). Obviously, these are the locations where there is relatively simple access for performing the broad area measurements needed for the calibration of the model. Obtaining calibration measurements from within the solid rock mass between the mine and the surface is not very effective, since only limited locations can be practically measured versus wide area measurements in the mine or on the surface. In addition, underground subsidence has been observed in multi-seam mines and every indication is that the strain field is continuous throughout the overburden. Further, the numerical method used for simulating the rock strata is consistent with the physical laws of superposition and interpolation. Therefore, it is entirely reasonable and standard engineering practice to calculate/interpolate the subsidence at the location of the pipeline which is between the calibrated mine and surface locations. The model calculations are based on average subsidence parameters which may certainly have some variable for each individual site. Also, predicting subsidence from pillar failure and incomplete caving is different than the complete caving subsidence used to develop the subsidence parameters.

In areas where the pipeline is to be located greater than 50 feet below the ground surface, the drill will be over-bored to a diameter larger than the pipeline. This will decrease the frictional drag between the earth and the pipeline, and maintaining this low-friction environment over the life of the pipeline would help decouple the pipeline from any ground movements and subsidence-induced strains.

This report was prepared to assist Sunoco in the evaluation of the subject project. The scope of this report is limited to the specific project, location, and time described herein. The report presents Tetra Tech's understanding of site conditions as discernible from information provided by others and obtained by Tetra Tech. Maps in this report are included only to aid the reader and should not be considered surveys. If additional data concerning this site becomes available, Tetra Tech should be informed so that we may examine the information and, if necessary, modify this report accordingly.

Respectfully submitted,

Thomas A Gray

Thomas A. Gray, P.E.
Mining Engineer

Farley Wood, P.E.
Mining Engineer

Keith Heasley, PhD, P.E.
Mining Engineer

CERTIFICATION

SUBSIDENCE POTENTIAL REVIEW
GOMBACH ROAD
HORIZONTAL DIRECTIONAL DRILLED PIPELINE PROJECT

By affixing my seal to this document I am confirming that the project conditions were reviewed and that accepted engineering practices were used to arrive at the reported results. Subsidence engineering is not an exact science and professional judgement was used to assess the many variables that exist, and is subject to those limitations that may be included in the Subsidence Report and information provided by third parties.

Thomas A Gray — 5/15/18

Thomas Gray, P.E. — Date

License No. 26978-E

The term certify as used herein is defined as follows: An engineer's certification of condition is a declaration of professional judgement. It does not constitute a warranty or guarantee, either expressed or implied.

TETRA TECH ROONEY

Date: 5/15/2018

To: Mathew Gordon
Project Manager
Sunoco Logistics, L.P.
525 Fritztown Road
Sinking Spring, PA

Subject: **Subsidence Potential Review Gombach Road Horizontal Directional Drilled Pipeline Project – Penn Township, Westmoreland County, PA**
Mariner East II TTR Project: 204-3110 1.1 PPP1

Mr. Gordon,

Tetra Tech Rooney has reviewed the above referenced subsidence report in addition to a Finite Element Analysis (FEA) model and we have confirmed that if the predicted subsidence does in fact occur in the future, the resulting stresses within the pipeline will still be in compliance with ASME B31.4.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ALAN DEAN SHAUERS
ENGINEER
PE077947

Sincerely,

Dean Shauers, P.E.
Tetra Tech Rooney

Attachments:

Geotechnical Report: Subsidence Potential Review Gombach Road Horizontally Directional Drilled Pipeline – Penn Township, Washington County, PA

CC: Larry Gremminger, CWB, Environmental Project Consultant
Thomas A. Gray, P.E., Energy and Natural Resources Manager, Tetra Tech, Inc.

Tetra Tech Rooney
115 Inverness Drive East, Suite 300, Englewood, CO 80112
Tel 303.792.5911 Fax 303.792.0227 rooney-eng.com tetratech.com

REFERENCES

Kendorski, F. S. (2006) Effect of Full-Extraction Underground Mining on Ground and Surface Waters a 25-Year Retrospective, 25th International Conference on Ground Control Mining, Morgantown WV 2006

National Mine Land Reclamation Center (2004) EPA Region III Mine Pool Project, 2004

PADEP (2017) Technical Guide to Mine Subsidence, Pennsylvania Department of the Environment Website http://www.dep.state.pa.us/msi/technicalguidetoms.html

The Pennsylvania State University (2014) Pennsylvania Mine Map Atlas, http://www.minemaps.psu.edu/

Peng, Syd S. (1978) Coal Mine Ground Control, John Wiley and Sons, Inc. 1978

FIGURES

LEGEND

LIMIT OF POTENTIAL INFLUENCE AREA ON PIPELINE

REFERENCE: KEYSTONE COAL AND COKE'S CLARIDGE MINE AND UNION COAL AND COKE'S PENN MANOR #5 MINE MAPS – OBTAINED FROM PA DEP – DATED: JAN. 24TH, 1919 AND DEC. 13TH, 1960

0 100 200
SCALE IN FEET

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

REVISIONS

NO.	BY	DATE	REMARKS

SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA

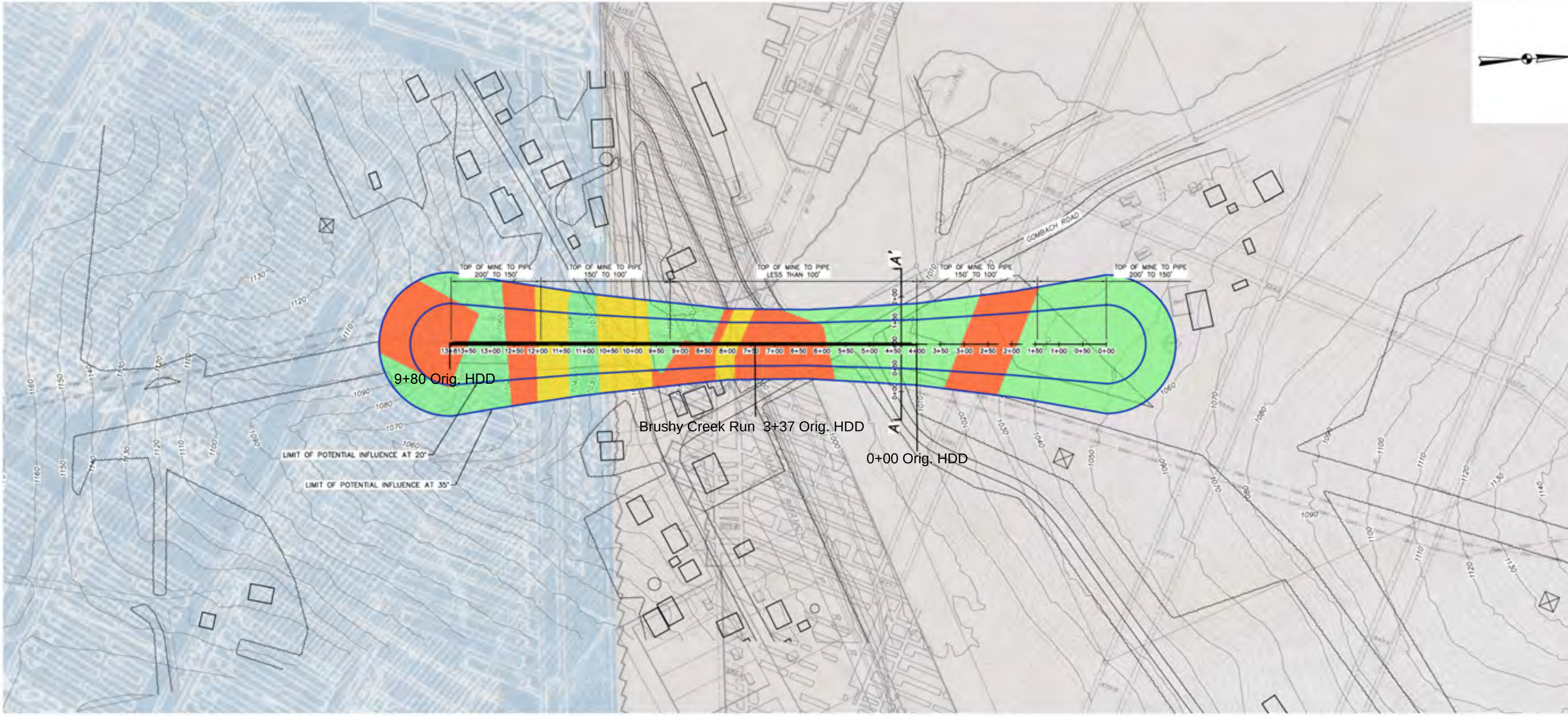
PENNSYLVANIA PIPELINE PROJECT

PROJECT LOCATION WITH ANGLE OF DRAW

WESTMORELAND COUNTY
GOMBACH ROAD
MINE AREA

DATE:	2/20/18
PROJECT NO.:	
DESIGNED BY:	TG
DRAWN BY:	JSM
CHECKED BY:	TG

FIGURE 1



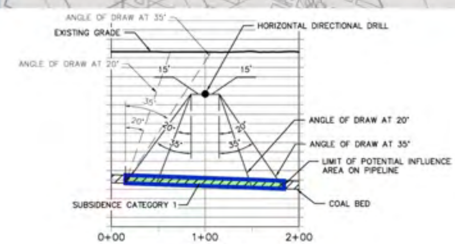
LEGEND

LIMIT OF POTENTIAL INFLUENCE AREA ON PIPELINE	(blue line)
SUBSIDENCE CATEGORY 1	(green)
SUBSIDENCE CATEGORY 2	(yellow)
SUBSIDENCE CATEGORY 3	(red)

CATEGORIES OF MINE SUBSIDENCE POTENTIAL

CATEGORY 1: SUBSIDENCE PROBABLY OCCURRED DURING OR SOON AFTER MINING.
CATEGORY 2: SUPPORT AREA WHERE SUBSIDENCE UNLIKELY.
CATEGORY 3: AREAS WHERE SUBSIDENCE MAY HAVE OCCURRED OR MAY OCCUR IN THE FUTURE.

REFERENCE: KEYSTONE COAL AND COKE'S CLARIDGE MINE AND UNION COAL AND COKE'S PENN MANOR #5 MINE MAPS – OBTAINED FROM PA DEP – DATED: JAN. 24TH, 1919 AND DEC. 13TH, 1960



A–A'
NOT TO SCALE

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

REVISIONS

NO.	BY	DATE	REMARKS

SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA

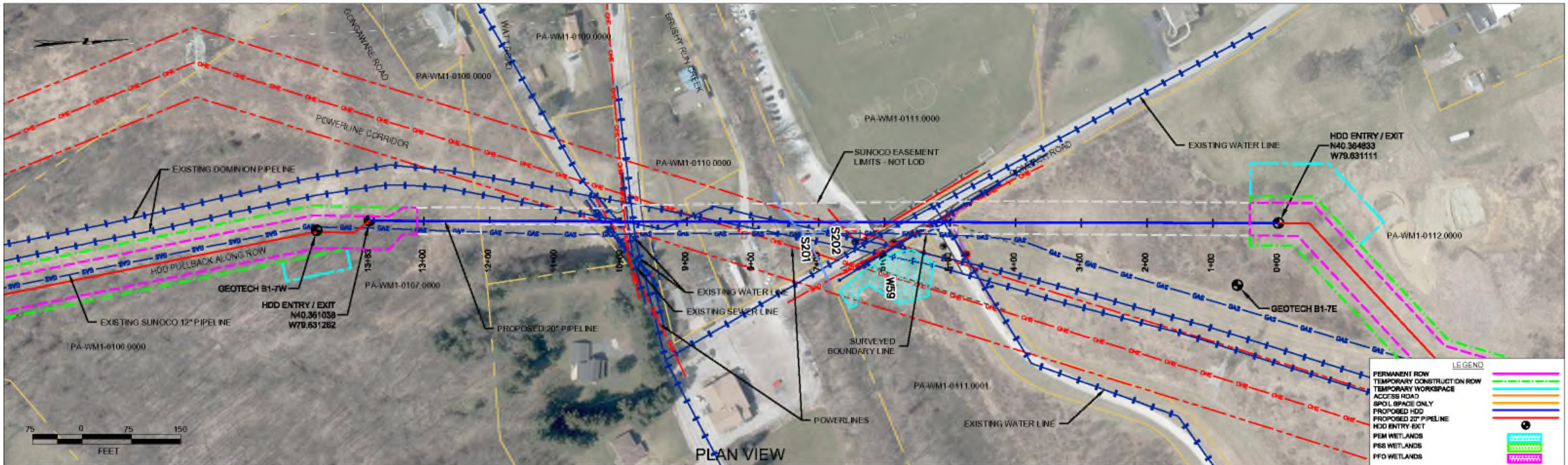
PENNSYLVANIA PIPELINE PROJECT

PROJECT LOCATION WITH SUBSIDENCE CATEGORIES

WESTMORELAND COUNTY
GOMBACH ROAD
MINE AREA

DATE:	2/20/18
PROJECT NO.:	
DESIGNED BY:	TG
DRAWN BY:	JSM
CHECKED BY:	TG

FIGURE 2



WESTMORELAND COUNTY, PENNSYLVANIA - PENN TOWNSHIP
S1B-0260

PROFILE VIEW

GEOTECH B1-7E

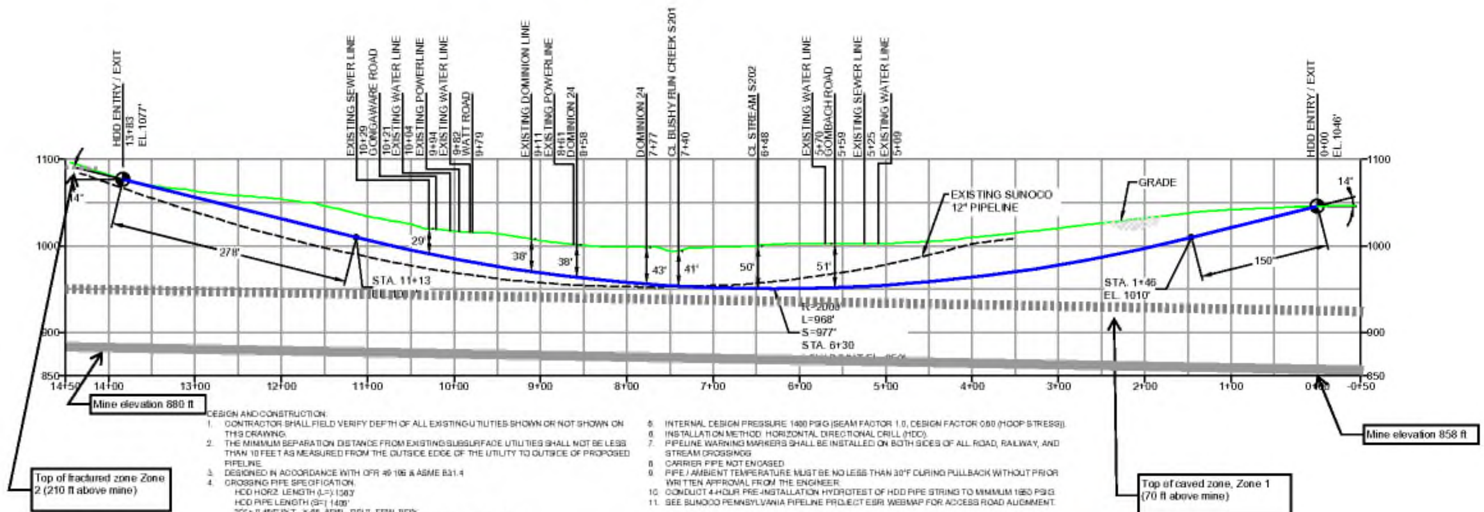
- NG EL. 1046'
- SANDY LEAN CLAY CL (0.0' - 2.0')
- SANDY FAT CLAY CH (2.0' - 5.0')
- SANDY LEAN CLAY CL (5.0' - 10.5')
- GROUNDWATER (39.7')
- SHALE CLAYSTONE/SANDSTONE (10.5' - 146.0')
- BORING TERMINATED EL. 900'

NOTE: REFER TO TEST BORING LOG B1-7E TERRACON PROJECT #J217P070 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-7W

- NG EL. 1094'
- LEAN CLAY CL (0.0' - 20.0')
- GROUNDWATER (46.0')
- LIMESTONE/ CLAYSTONE/SANDSTONE (20.0' - 177.5')
- BORING TERMINATED EL. 916.5'

NOTE: REFER TO TEST BORING LOG B1-7W TERRACON PROJECT #J217P070 FOR COMPLETE SOIL MATERIAL DESCRIPTION



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1383'
   HDD PIPE LENGTH (S=): 1406'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE: 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.80 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-1.81	TO	ES-1.81	EROSION & SEDIMENT PLAN
SHEET 38	TO	SHEET 39	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP7	UPDATED STREAM CROSSING LABEL	MRS	02/12/18	RMB	02/12/18	CAG	02/12/18
EP6	UPDATED GEOTECH INFO PROVIDED BY DPS	MRS	11/15/17	RMB	11/16/17	CAG	11/16/17
EP5	UPDATED GEOTECH INFO	MRS	10/30/17	RMB	10/30/17	CAG	10/30/17
EP4	DESIGN UPDATED PER EPS DESIGN REVIEW	MRS	10/27/17	RMB	10/27/17	CAG	10/27/17
EP3	DESIGN CHANGE PROVIDED BY DPS - RELOCATED DRILL ENTRY	MRS	09/20/17	RMB	07/20/17	CAG	09/20/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
GOMBACH ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' DWG NUMBER: PA-WM1-0111.0000-RD

Reference: Tetra Tech Rooney Drawing PA-WM1-0111.0000-RD - Dated 2/12/18

Figure 3 - HDD Plan and Profile

APPENDIX A

LAMODEL ANALYSIS OF SUBSIDENCE POTENTIAL
GOMBACH ROAD
HORIZONTAL DIRECTIONAL DRILLED PIPELINE PROJECT
PENN TOWNSHIP, WESTMORELAND COUNTY, PA

May 2018

PRESENTED FOR

Sunoco Logistics, L.P.
525 Fritztown Road
Sinking Spring, PA

PRESENTED BY

Tetra Tech
661 Anderson Drive
Foster Plaza 7
Pittsburgh, PA 15220

TETRA TECH

TABLE OF CONTENTS

FIGURES

INTRODUCTION

The Sunoco Logistic L.P. is planning to horizontally directional drill (HDD) a pipeline under Gombach Road in the strata over the abandoned Claridge and Penn Manor #5 Mines in Penn Township, Westmoreland County, PA. The HDD section under the Gombach Road will be about 1,383 ft long and 80 ft above the mine level. The objective of this investigation is to utilize the LaModel boundary-element program to analyze the future subsidence potential over the abandoned Mines, and in particular, to determine any potential subsidence and associated strains that may occur along the proposed pipeline alignment.

MINING BACKGROUND

The Keystone Coal and Coke's Claridge Mine and Union Coal and Coke's Penn Manor #5 Mine operated in Penn Township, Westmoreland County in the early 1900's. Their primary mining method was room and pillar mining. Mining was completed under the planned HDDP prior to 1918. These mines extracted the Pittsburgh coal seam at a mining height of approximately seven feet. Using the mine maps, obtained from the Pennsylvania Mine Atlas, the main entries appear to be ten feet wide and production room entries were about twenty-four feet wide. Based on the EPA Region III Mine Pool Project (Natural Mine Land Reclamation Center, 2004) these mines appear to be flooded under the pipeline location.

The mining method employed at the Claridge and Penn Manor #5 Mines was room and pillar mining utilizing hand loading (the coal was broken loose using explosives and loaded into carts manually). Main entries were primarily used for developing areas for the rooms. The rooms were more productive (higher tons per man-hour) and recovered a higher percentage of the in place coal. The main entries were also used for men and material movement within the mines, for coal haulage, for air courses for mine ventilation and were configured to be stable for an extended period of time. The rooms were areas utilized exclusively for coal recovery, and were only configured for short term stability. They were designed to protect the miners while they were working there, but not for long term stability. At that time, mines did not use any mechanical roof support as used in today's mines. The main entries were supported primarily by the large adjacent coal pillars that would remain after mine closure. Rooms were advanced to the right or left of the main entries. After each room had advanced to its planned length, which was typically one-half of the way between main entries, the small support pillar between rooms was systematically removed (mined) as the miners retreated, allowing the roof to collapse behind them. When this happened, surface subsidence would occur. Most subsidence would occur almost immediately, and all ground movements would be completed within a few weeks. The main entries needed to remain open for the duration of mining activities and thus relatively large pillars were left between these entries as support. The surface above those pillars should remain stable from subsidence for the long term. Areas between the caved production rooms and the large main entry support pillars or areas where the rooms were not retreated for whatever reason (poor mining condition, mine closures, etc.) have the highest risk of future subsidence because the pillars in these areas were not designed to provide long-term support. These medium-sized pillars are the primary areas of concern regarding potential for future subsidence. Based on the mine map, there may also be a few areas where mining did not occur and solid coal remains. Assuming that the mine map is accurate, those areas should be safe from future subsidence. As previously discussed, due to potential inaccuracies in the mine map, this cannot be guaranteed.

THE LAMODEL PROGRAM

The LaModel program is used to model the stresses and displacements on thin tabular deposits such as coal seams. It uses the displacement-discontinuity (DD) variation of the boundary-element method, and because of this formulation, it is able to analyze large areas of single or multiple-seam coal mines (Heasley, 1998). LaModel is unique among boundary element codes because the overburden material includes laminations which give the model a very realistic flexibility for stratified sedimentary geologies and multiple-seam mines. Using LaModel, the total vertical stresses and displacements in the coal seam are calculated, and optionally, the surface subsidence, or subsidence anywhere in the overburden, can be calculated. Amongst subsidence prediction programs, LaModel has the unique ability of be able to model the highly variable subsidence associated with time-dependent, pillar failure.

Since LaModel's original introduction in 1996, it has continually been upgraded and modernized as operating systems and programming languages have changed. The present program is written in Microsoft Visual C++ and runs in the windows operating system. It can be used to calculate convergence, vertical stress, overburden stress, element safety factors, pillar safety factors, intra-seam subsidence, etc. on single and multiple seams with complex geometries and variable topography. Presently, the program can analyze a 2000 x 2000 grid with 6 different material models and 52 different individual in-seam materials. It uses a forms-based system for inputting model parameters and a graphical interface for creating the mine grid. Also, it includes a utility referred to as a "Wizard" for automatically calculating coal pillars with a Mark-Bienawski pillar strength and another utility to assist with the development of "standard" gob properties. Recently, the LaModel program was interfaced with AutoCAD to allow mine plans and overburden contours to be automatically imported into the corresponding seam and overburden grids. Also, the output from LaModel can be downloaded into AutoCAD and overlain on the mine map for enhanced analysis and graphical display. Within the last couple of years, new algorithms have been added to the program to help optimize subsidence calculations (Yang, 2016).

LAMODEL MATERIAL PROPERTY INPUT

Mine Grid: The LaModel simulation of the Claridge and Penn Manor #5 Mines area encompassed a fairly large area of the abandoned mine (see the "Mine Grid" area in Figure 1) in order to keep any edge effects from the boundary conditions from affecting the area of interest around the pipeline alignment. This model area was 2,200 ft wide and 3,000 ft high. A relatively small element size of 2.5 ft was used to best model the given narrow entries and relatively narrow pillars. This smaller element size also facilitates using a thin lamination thickness for the overburden to optimize the subsidence angle-or-draw. With the 2.5 ft element width, the final grid size was 880 X 1200 elements. Based on the mine map, all boundaries of the model were simulated with symmetric boundary conditions. The actual mine grid was automatically generated from a digitized version of the Claridge and Penn Manor #5 Mines, and then adjusted for the seismic interpretation.

Overburden Grid: For inputting the overburden information in order to accurately simulate the overburden stress on the seam, an overburden grid was developed that was 500 ft wider than the mine grid on the north, south and west sides and 300 ft wider on the east side. The final overburden grid was 3000 ft wide by 4000 ft high and used 10 ft wide elements on a 300 X 400 element grid. The values for the overburden grid was then automatically generated from the AutoCAD topographic lines as shown in Figure 1. The result of the overburden grid generation process is the calculated overburden stress on the coal seam as plotted in Figure 2. In the plotted overburden stress, the lower stress areas under the stream valley running northeast to southwest in the center of the grid can be seen along with the higher stress areas under the ridges in the north and south. In particular, the variable stress under the pipeline can be seen as it: starts on a hill top in the north, travels across a broad, shallow valley and then moves toward a ridge top in the south.

Overburden, Gob and Coal Properties: The material properties for the Claridge and Penn Manor #5 Mines model were generated using the LaModel subsidence optimization routines (Yang, 2016) to provide a subsidence factor (73%) and angle-of-draw consistent with the Pittsburgh Seam overburden and consistent with the 400 ft wide, 150 ft deep extraction panels that are adjacent to the pipeline alignment. This resulted in an average rock modulus of 3,000,000 psi and lamination thickness of 2.5 ft. for the overburden, and a final gob modulus of 8,300 psi for the strain-hardening gob model. For the initial model, intended to simulate the coal strength at the time of mining, a NIOSH recommended coal strength of 900 psi as implemented in the Mark-Bieniawski pillar strength formula by the LaModel coal wizard was used. To simulate the maximum potential subsidence that might occur over time after initial mining (assumedly due to coal, roof or floor degradation by oxidation, spalling, moisture, etc.), a 33% reduced coal strength (600 psi) was implemented into a separate “degraded mine” model.

POST-MINING MODEL RESULTS

Seam Convergence: Initially, the model with the 900 psi coal strength intended to simulate the mine conditions immediately after mining was run and analyzed in order to gain an understanding of the post-mining conditions. The first model output to be examined was the seam convergence as shown in Figure 3. In this output, the overburden convergence over the various size and shaped gobs is clearly visible. In particular, the panels adjacent to the pipeline show 2 to 3+ ft of convergence.

Pillar Safety Factors: Next, the safety factors of the remaining coal pillars were examined, as shown in Figure 4. (Note: the scale of this safety factor plot was set to give details on the pillars with safety factors less than 2.5). This figure shows that the “larger” pillars located in the main line entries are very stable. However, a number of the smaller pillars under the HDD area of 5+00 to 9+00 and 14+00 to 15+50 have marginal safety factors. These are the areas where the seismic analysis indicated openings in the retreated panels, which might otherwise have been assumed caved.

Subsidence: The next output from the post-mining model to be examined was the subsidence at the pipeline location (see Figure 5). This subsidence is directly correlated to the seam convergence shown in Figure 3. Similar to the convergence, the increase in surface subsidence due to wider and/or deeper panels is evident in Figure 5. Here the original predicted subsidence under the pipeline location can be seen. Generally, the HDD starts (0+00) in the center of a subsidence trough (to the north) then crosses through the center of another panel, which is partly supported by uncaved rib pillars (5+00 to 9+00). The HDD then crosses a couple of mainline pillars and the narrow end of a third extraction panel. As the HDD continues south, it is again crossing over the narrow end of a fourth extraction panel, which is partly supported by uncaved rib pillars (14+00 to 15+50). Finally, the HDD ends (13+85) in the center of a narrow fifth retreat panel.

The pipeline in the HDD sections ranges from 200 ft above the seam, at the entry and exit hillside locations, to 80 ft above the seam under the floor of the valley (which is only 100 ft above the seam). In LaModel, an average distance above the seam of 150 ft was used to calculate the subsidence values which are applied to the HDD pipeline. In the LaModel program, the overburden is modeled as a continuum. Therefore, the program does show the subsidence horizontally expand, within the angle-of-draw, and the magnitude decrease as the distance from the mine increases, but the program does not model any vertical dilation of the overburden, which minimizes the change in subsidence with depth.

To examine the details of the previous subsidence along the pipeline alignment, the subsidence above the seam has been interpolated from the output shown in Figure 6 directly to the pipeline coordinates, as shown in Figure 6 In this plot, the subsidence under the pipeline as it crosses over the various gob and mainline pillar areas is clearly visible.

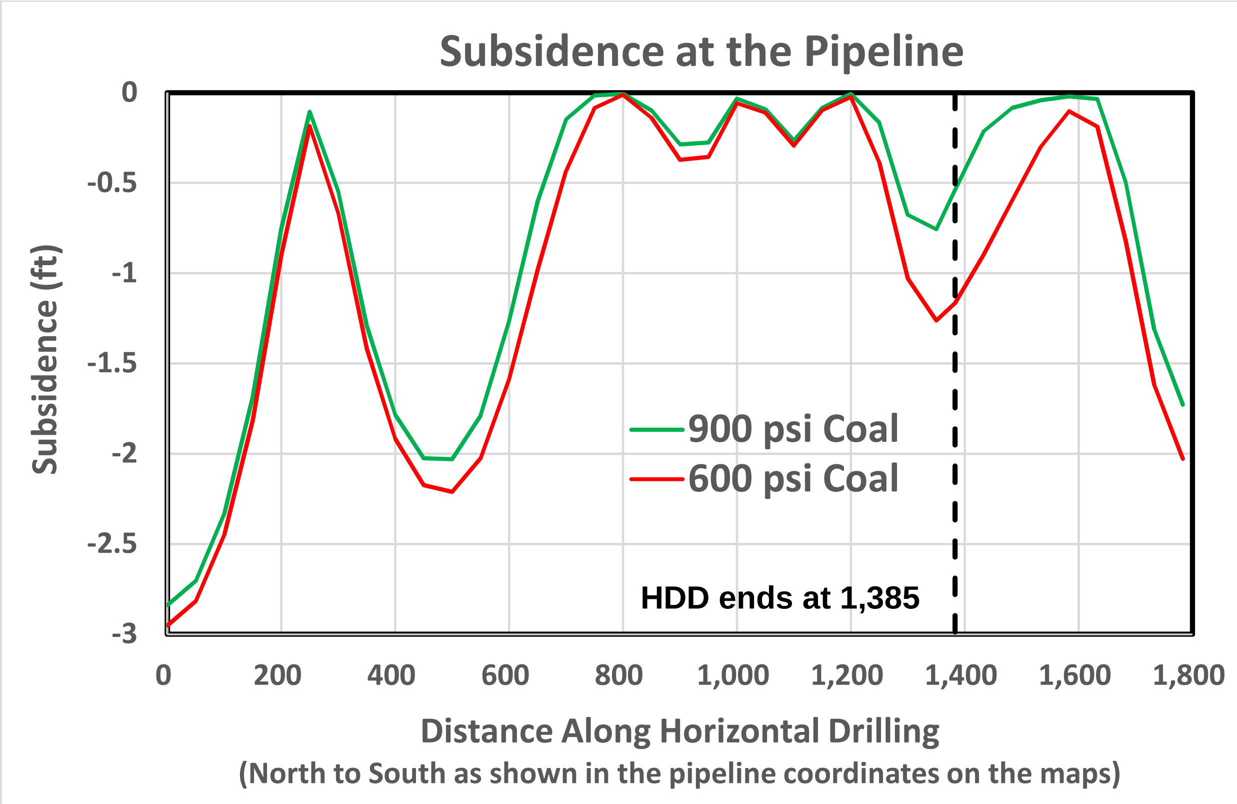


Figure 6. Subsidence prediction along the pipeline alignment at different coal strengths.

DEGRADED MINE MODEL RESULTS

As previously stated, the model with 900 psi coal strength (as shown in Figures 3, 4, and 5) was intended to simulate the mine conditions immediately after mining. The subsidence shown in Figure 5 and the 900 psi coal line in Figure 6 has assumedly already occurred immediately after mining. To simulate the maximum potential subsidence that might occur over time due to degradation of the coal, roof and/or floor by oxidation, spalling, moisture, etc., a model with a coal strength of 600 psi (a 33% strength reduction) was run, analyzed and compared with the post-mining 900 psi model.

Pillar Safety Factors: The first output to be closely examined from the degraded mine model was the change in pillar safety factors as shown in Figure 7. In this Figure, it is seen that the mainline pillars continue to show adequate safety factors. However, the pillar safety factors in the uncaved retreat areas (5+00 to 9+00 and 14+00 to 15+50) show significant reductions to below 1.0.

Additional Subsidence: When the thin rib pillars in the uncaved areas fail, they cause convergence directly over the pillar. Also, the pillar failure puts additional loading and associate convergence on the adjacent gob areas. The ground reaction to the pillar failures then results in additional overburden subsidence as shown in Figures 8 and 9. With a reduction in coal strength to 600 psi, the areas of greatest increased subsidence are the areas of the uncaved retreat pillars.

In the first area in the north between pipeline stations 5+00 to 8+00, the failure of the thin rib pillars results in an additional 0.4 ft (5 in) of subsidence. Similarly, between pipeline stations 12+00 and 16+00 the retreat pillar failure results in an additional 0.7 ft (8.5 in) of subsidence (see Figures 8 and 9).

Strains: The strains associated with the predicted post-mining subsidence are also shown in Figure 9. The maximum strain values at the HDD location range from 0.0020 to 0.0025, or 0.20% to 0.25%, and fluctuate continuously along the pipeline length. (note: the HDD only runs from 0+00 to 13+85 in Figure 9)

The level of strain that the pipeline may experience is both a function of the ground movement and also a function of how tightly the pipeline is coupled to the ground movement. If the pipe is tight within the horizontal borehole due to the drilling mud confining the pipe or collapse of the borehole, then it may be assumed that the pipe will experience the full ground strain as shown in Figure 9. If the pipeline is simply lying in the open horizontal borehole and can easily slide, then areas of tension or compression in the ground can be reasonably canceled by sliding of the pipe between adjacent areas of the opposite strain.

The degraded mine subsidence predicted in this model may have already occurred, may occur at some time in the future, or may never reach this level. Predicting the actual condition of the mine at this time, and at any given time in the future, is difficult.

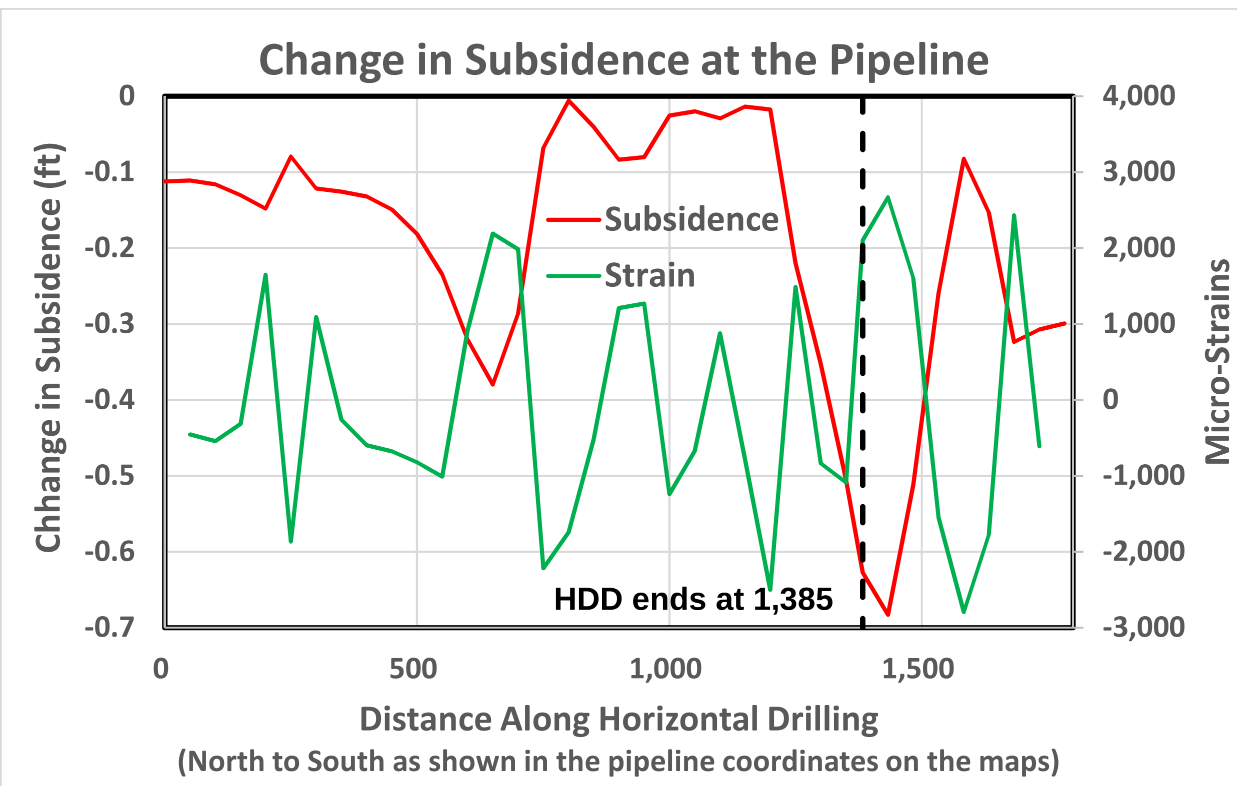


Figure 9. Predicted worst case subsidence and associated strains (tension is negative) .

REFERENCES

Heasley, K. A. (1998) Numerical Modeling of Coal Mines with a Laminated Displacement-Discontinuity Code, Ph.D. dissertation, Colorado School of Mines, 187 pp.

Kendorski, F. S. (2006) Effect of Full-Extraction Underground Mining on Ground and Surface Waters a 25-Year Retrospective, 25th International Conference on Ground Control Mining, Morgantown WV 2006

The Pennsylvania State University (2014) Pennsylvania Mine Map Atlas, http://www.minemaps.psu.edu/

Yang, J. (2016) Calibrating LaModel for Subsidence, M.S. thesis, West Virginia University, 93 pp.

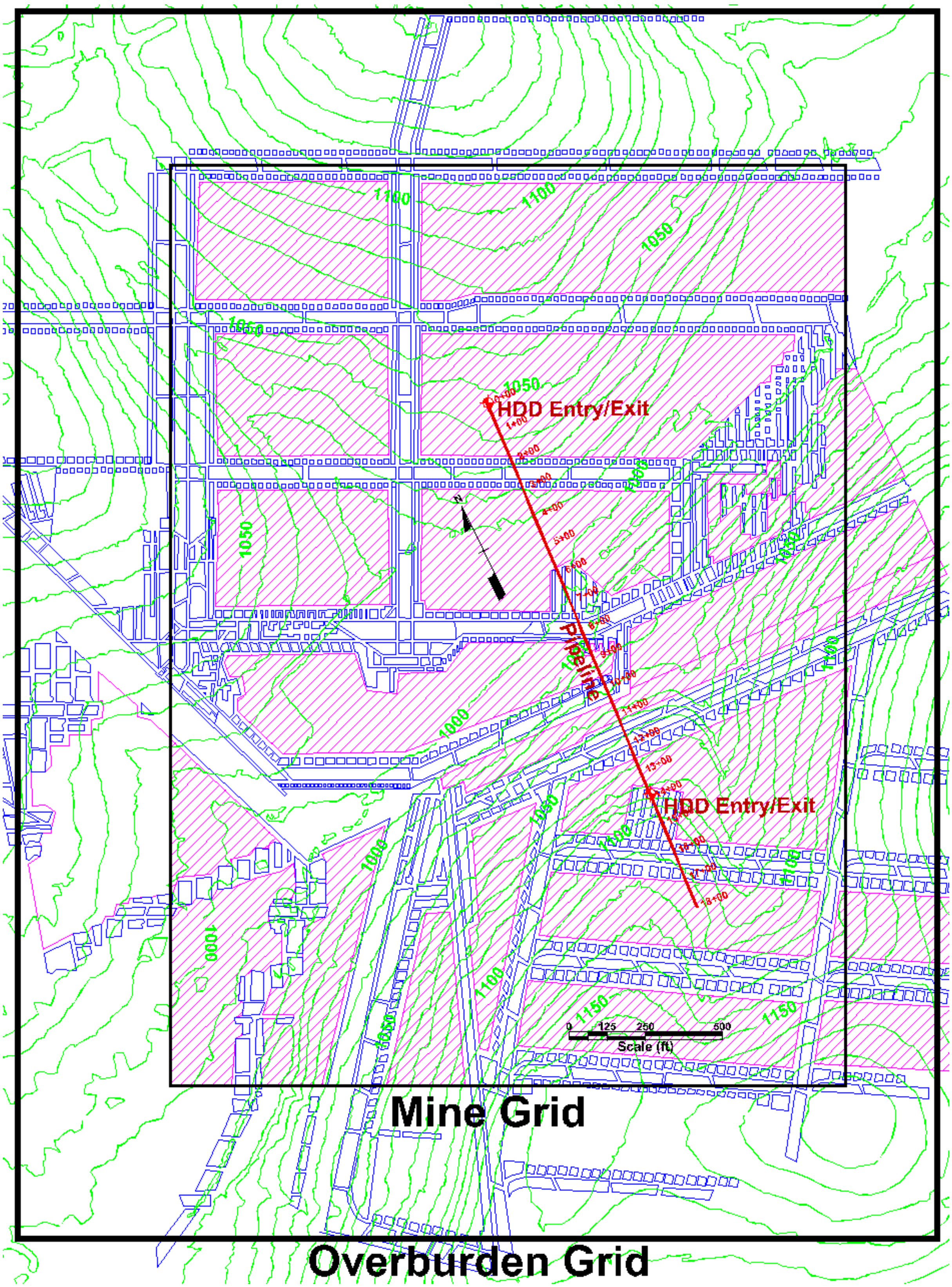


Figure 1. Map of mine and overlying pipeline.

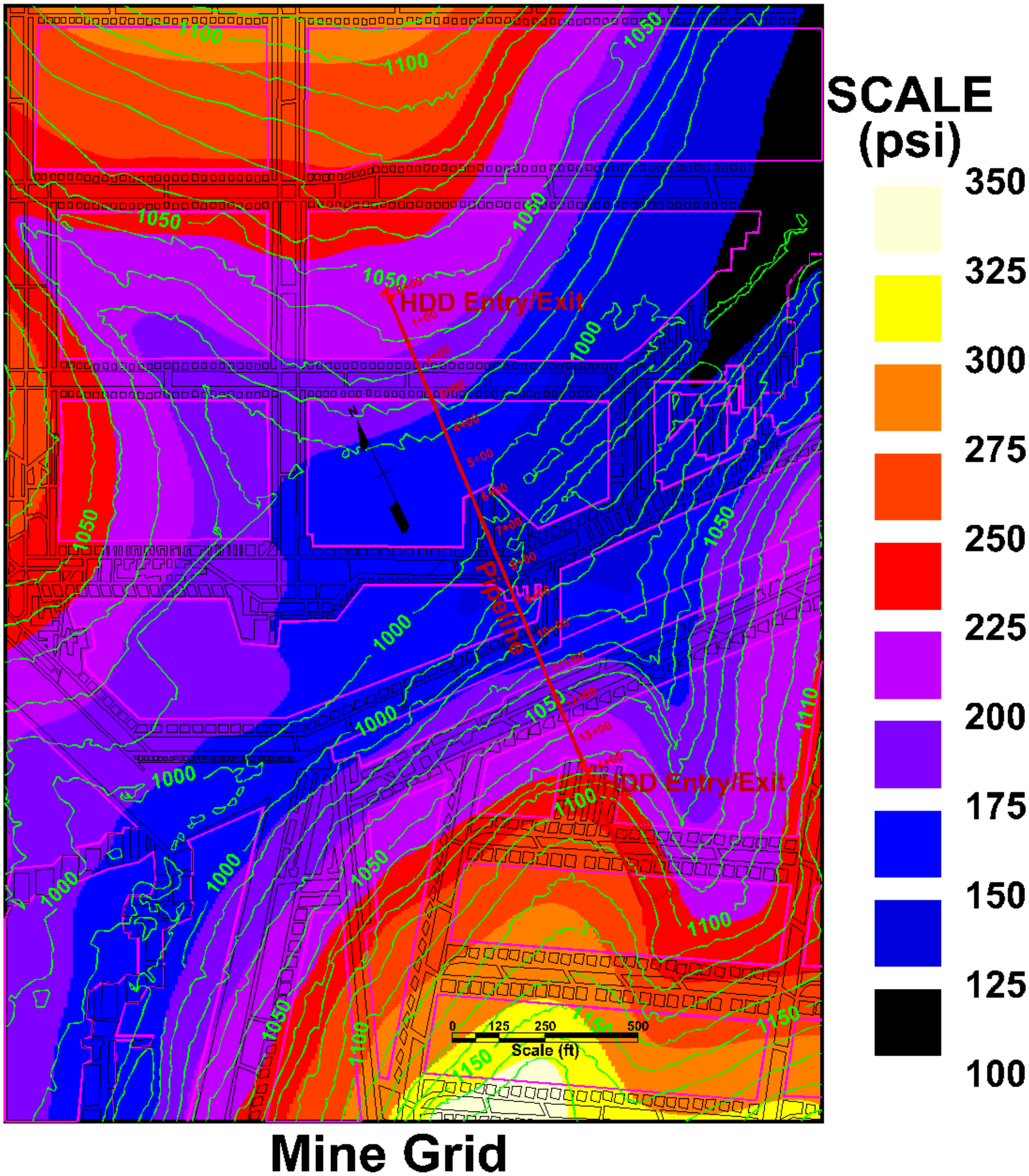


Figure 2. Overburden stress on the seam.

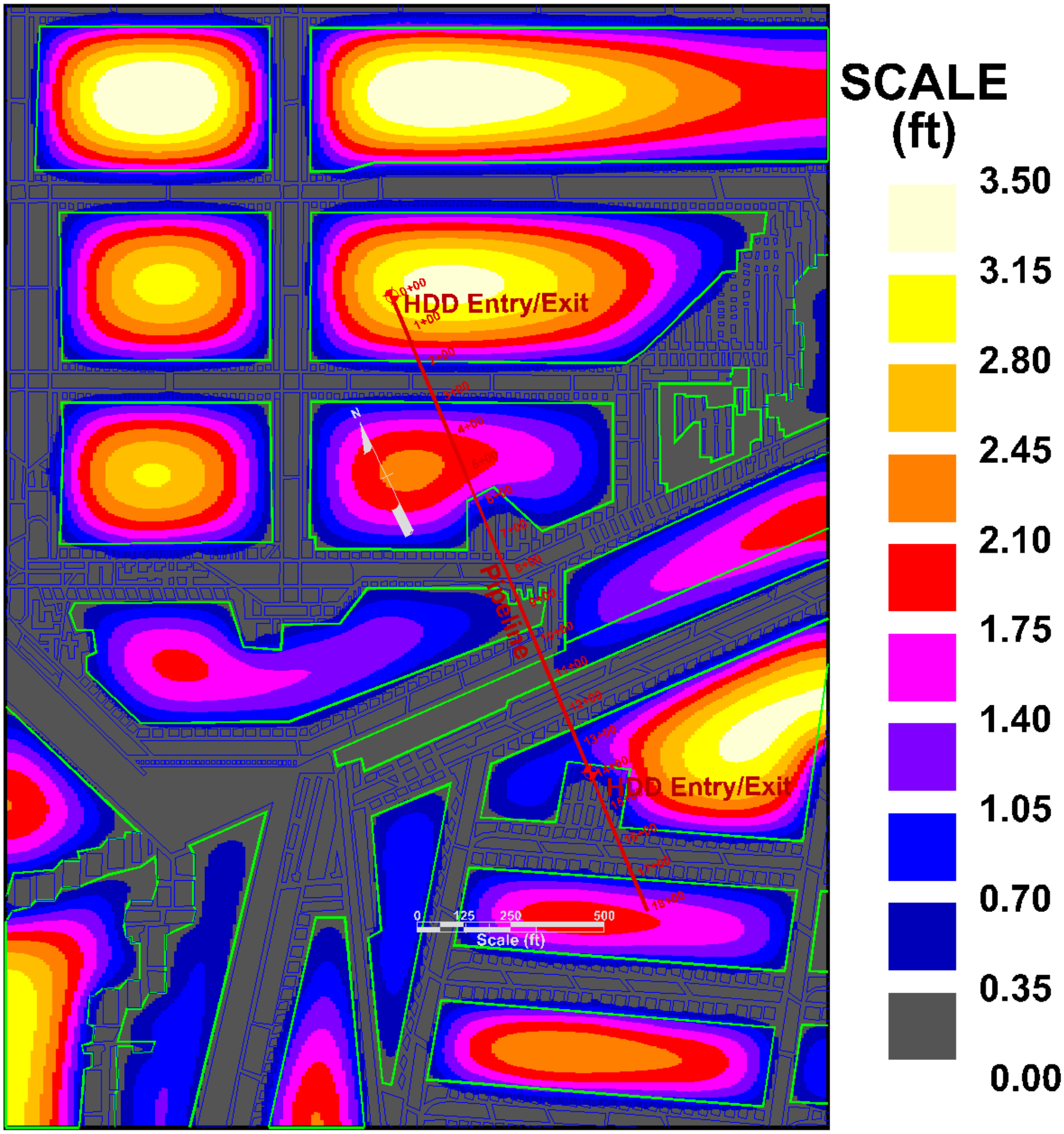


Figure 3. Seam convergence with 900 psi coal strength.

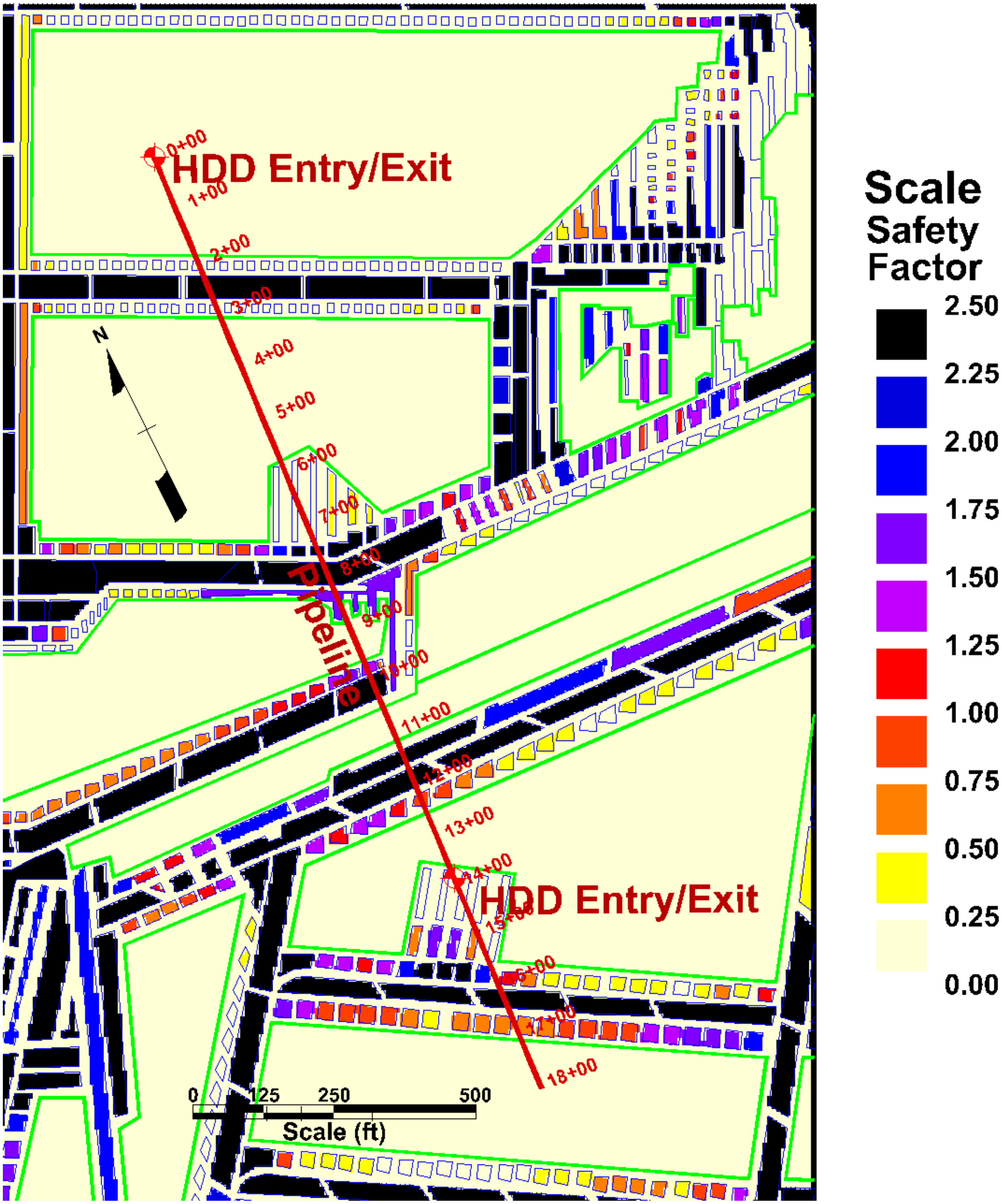


Figure 4. Pillar safety factors with 900 psi coal strength.

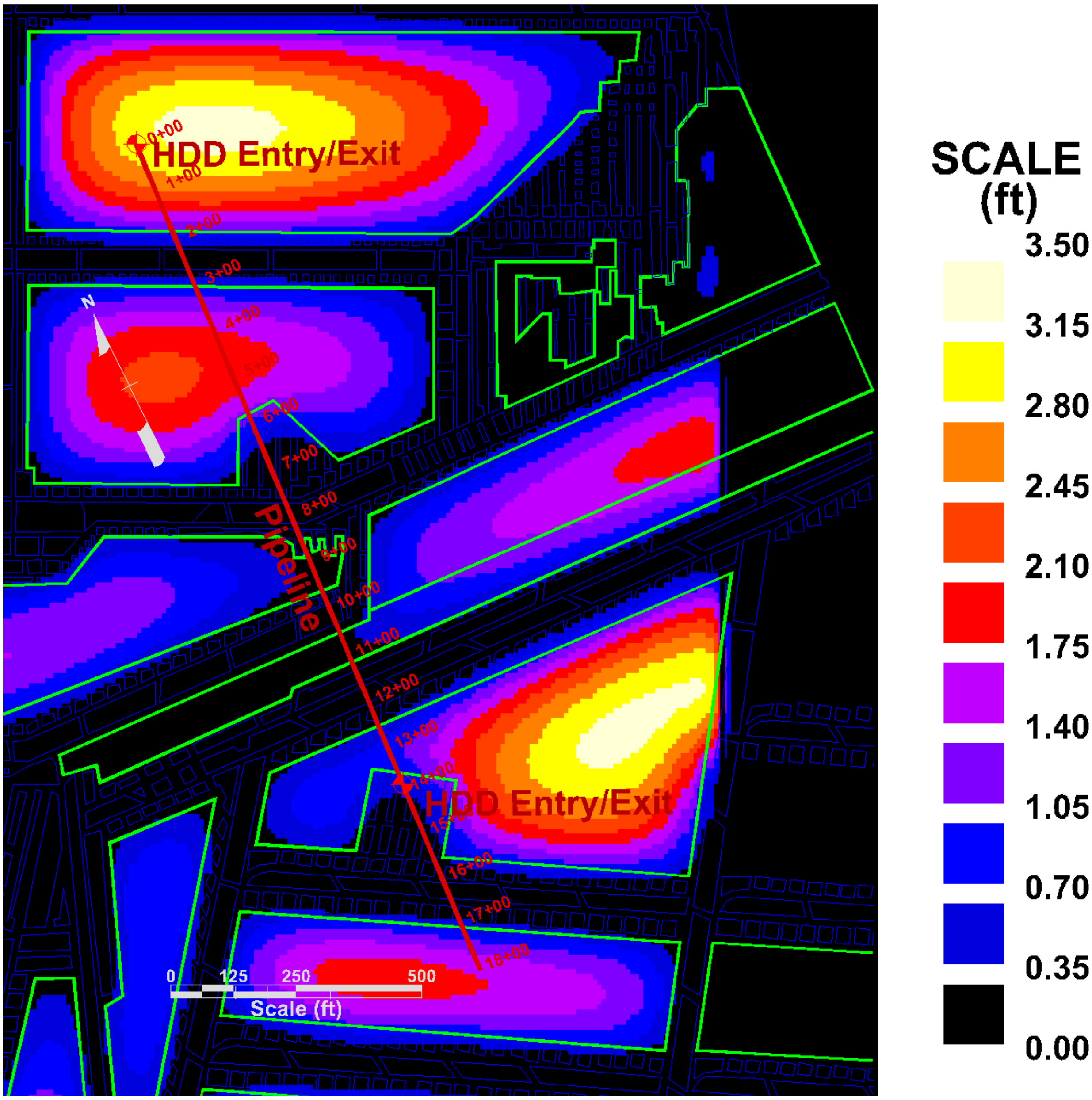


Figure 5. Subsidence at the pipeline for 900 psi coal strength.

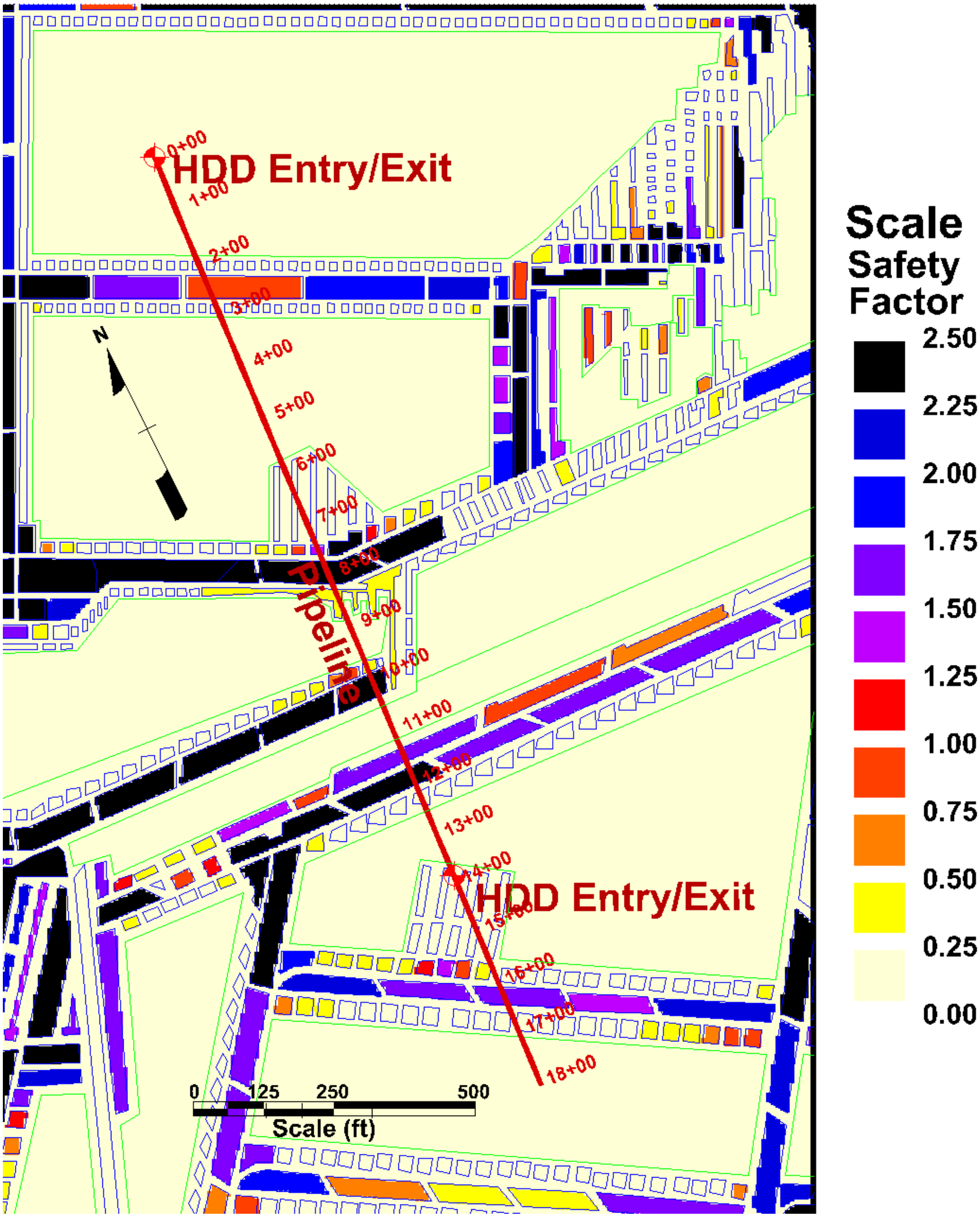


Figure 7. Pillar safety factor with 600 psi coal strength.

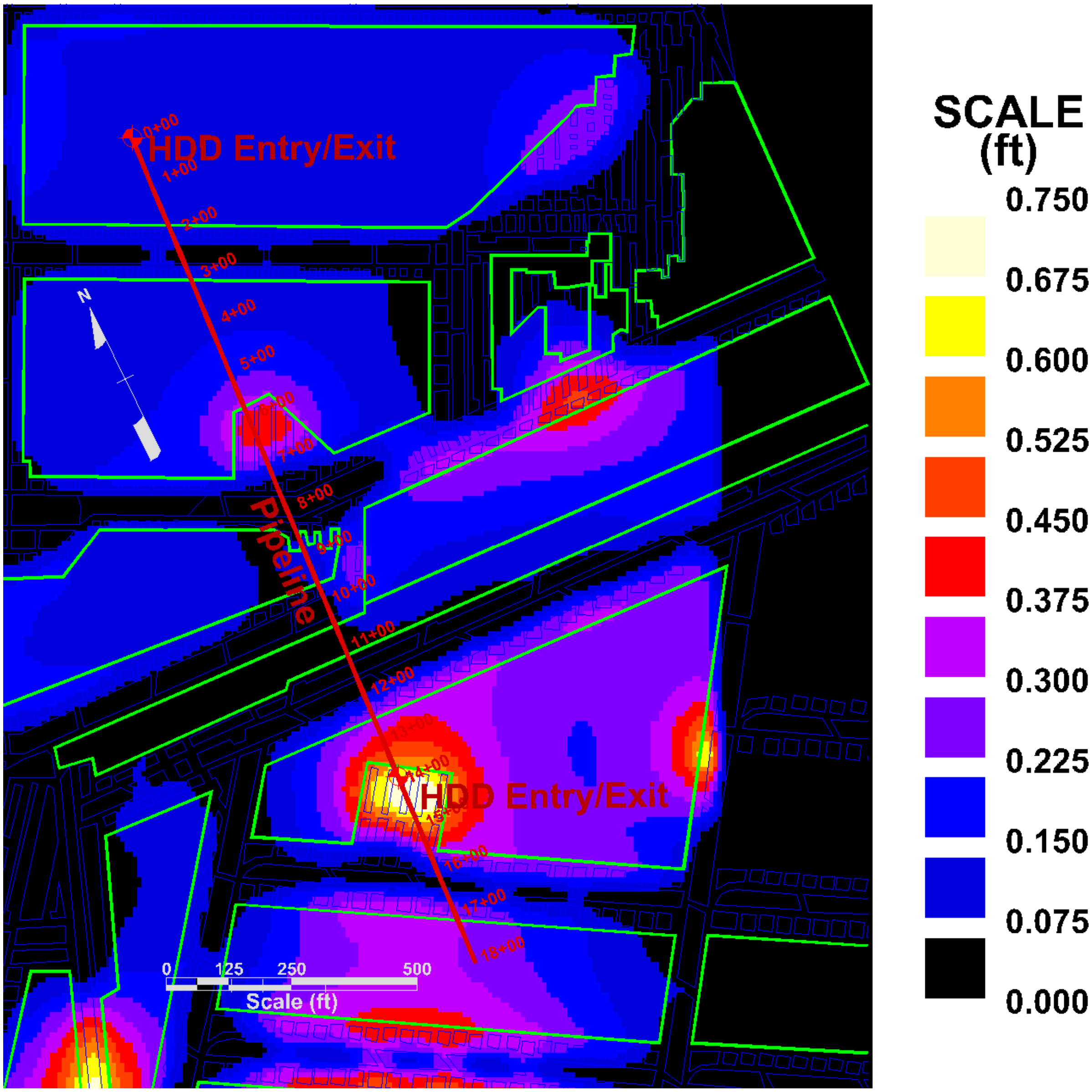


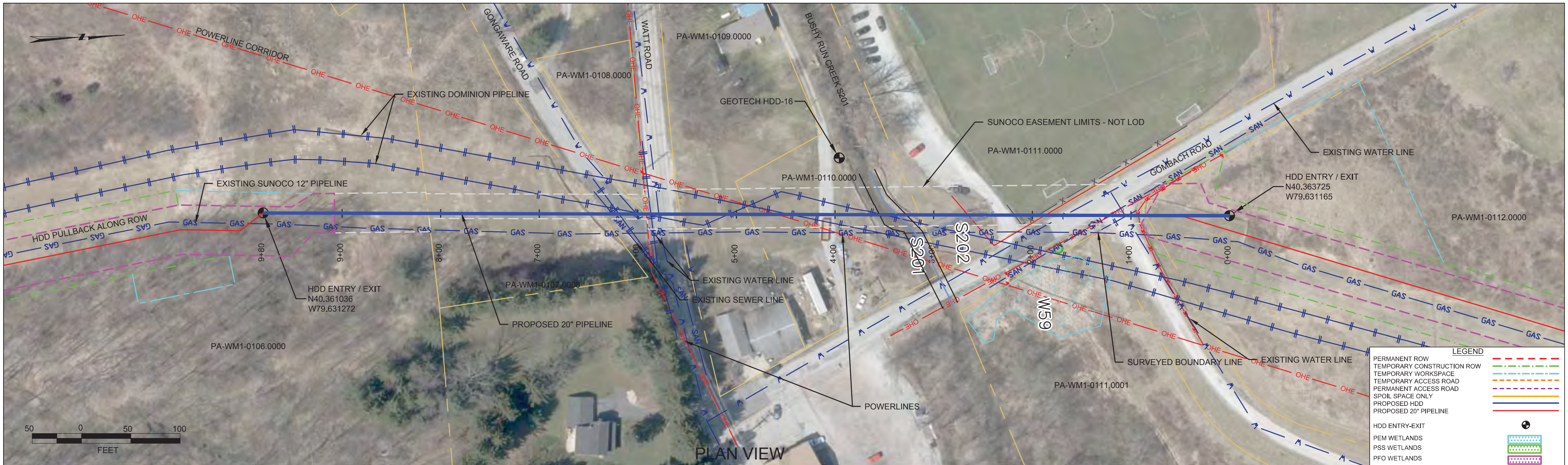
Figure 8. Increase in subsidence going from 900 psi coal to 600 psi coal.

GOMBACH ROAD CROSSING
PADEP SECTION 105 PERMIT NO.: E65-973
PADEP SECTION 102 PERMIT NO.: PA-WM1-0111.0000-RD
(SPLP HDD# S1B-0260)

ATTACHMENT 3

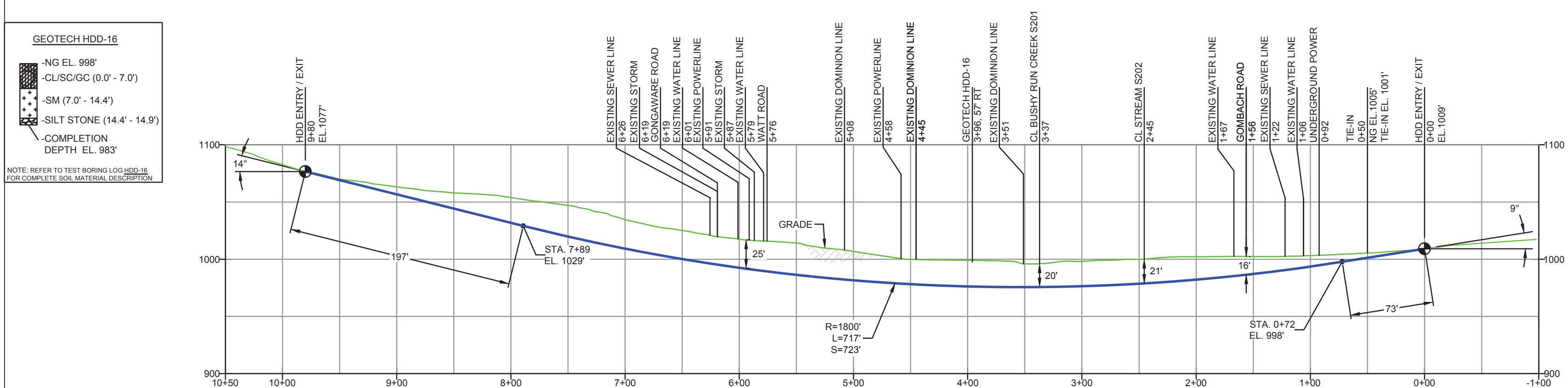
ORIGINAL HDD PROFILE, AND

ALTERNATIVE CONSTRUCTION PLAN OVERVIEW AND FLEXBOR PROFILE



WESTMORELAND COUNTY, PENNSYLVANIA - PENN TOWNSHIP
S1B-0260

PROFILE VIEW



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):980'
   HDD PIPE LENGTH (S=):993'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 1. Original HDD Plan and Profile

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-1.51	TO	ES-1.51	EROSION & SEDIMENT PLAN
SHEET 38	TO	SHEET 39	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/17/16	RMB	05/17/16	AAW	05/17/16
EP		JTW	03/15/16	RMB	03/15/16	AAW	03/15/16

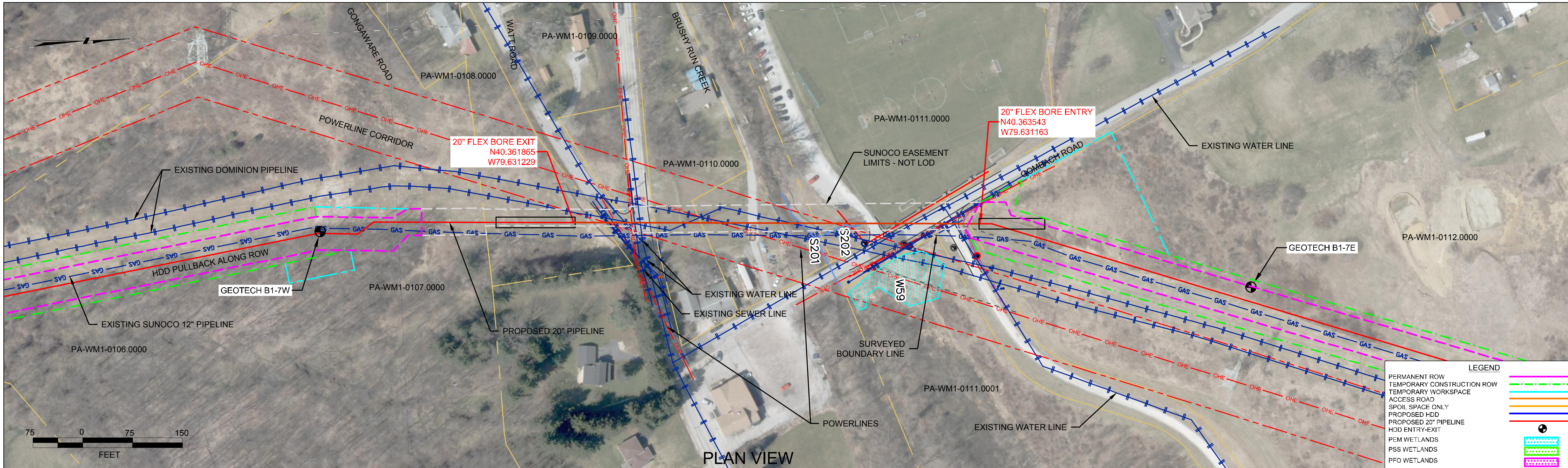
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

20-INCH HORIZONTAL DIRECTIONAL DRILL
GOMBACH ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100' | DWG. NO: PA-WM1-0111.0000-RD



WESTMORELAND COUNTY, PENNSYLVANIA - PENN TOWNSHIP
S1B-0260

PROFILE VIEW

GEOTECH B1-7E

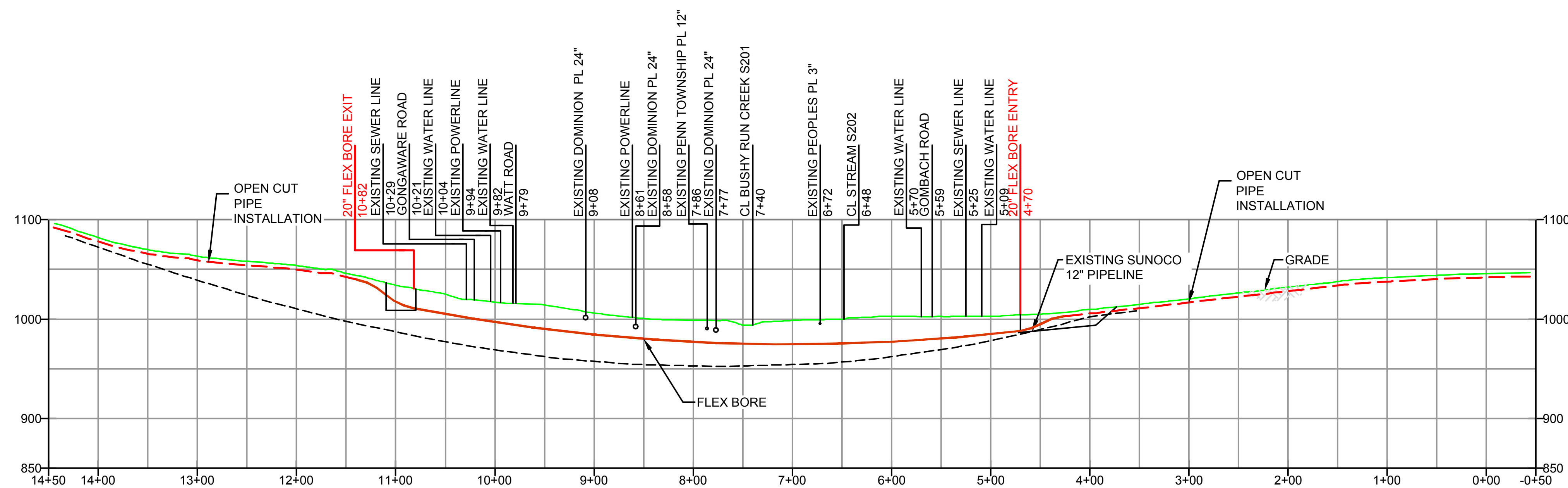
- NG EL. 1046'
- SANDY LEAN CLAY CL (0.0' - 2.0')
- SANDY FAT CLAY CH (2.0' - 5.0')
- SANDY LEAN CLAY CL (5.0' - 10.5')
- GROUNDWATER (39.7')
- SHALE CLAYSTONE/SANDSTONE (10.5' - 146.0')
- BORING TERMINATED EL. 900'

NOTE: REFER TO TEST BORING LOG B1-7E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-7W

- NG EL. 1094'
- LEAN CLAY CL (0.0' - 20.0')
- GROUNDWATER (46.0')
- LIMESTONE/ CLAYSTONE/SANDSTONE (20.0' - 177.5')
- BORING TERMINATED EL. 916.5'

NOTE: REFER TO TEST BORING LOG B1-7W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):1383'
   HDD PIPE LENGTH (S=):1405'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

Figure 2.

FOR PERMITTING PURPOSES ONLY

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-1.51	TO	ES-1.51	EROSION & SEDIMENT PLAN
SHEET 38	TO	SHEET 39	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP7	UPDATED STREAM CROSSING LABEL	MRS	02/12/18	RMB	02/12/18	CAG	02/12/18
EP6	UPDATED GEOTECH INFO PROVIDED BY DPS	MRS	11/15/17	RMB	11/15/17	CAG	11/15/17
EP5	UPDATED GEOTECH INFO	MRS	10/30/17	RMB	10/30/17	CAG	10/30/17
EP4	DESIGN UPDATED PER EPS DESIGN REVIEW	MRS	10/27/17	RMB	10/27/17	CAG	10/27/17
EP3	DESIGN CHANGE PROVIDED BY DPS - RELOCATED DRILL ENTRY	MRS	09/20/17	RMB	07/20/17	CAG	09/20/17
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	09/30/16	RMB	09/30/16	AAW	09/30/16

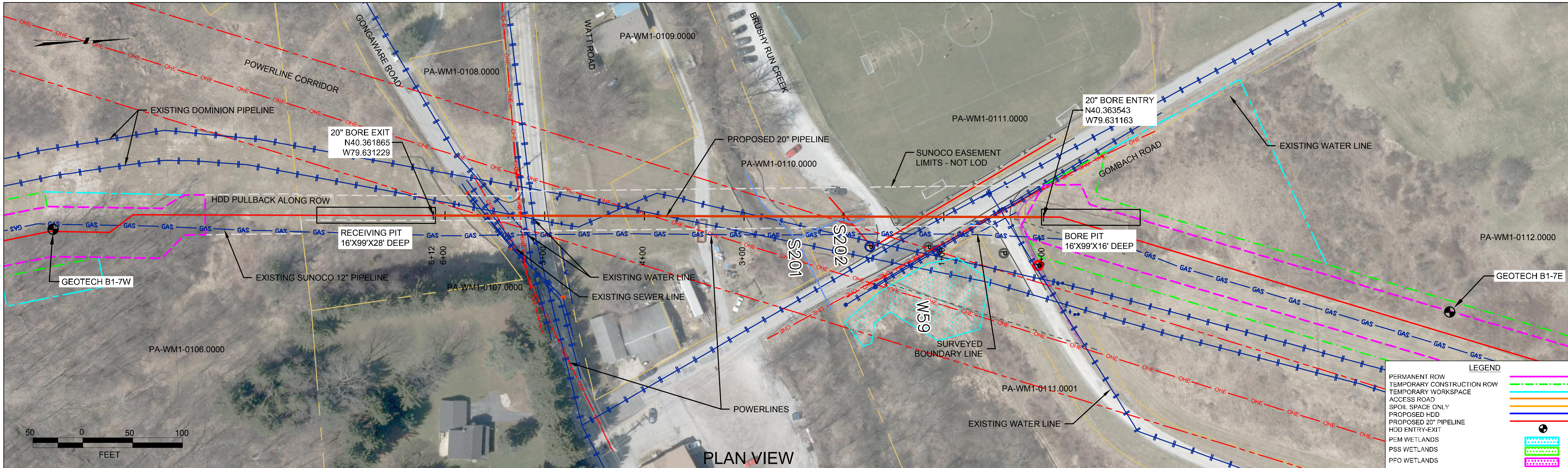
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

FLEX BORE AND HDD CROSSING OVERLAY
GOMBACH ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'
DWG. NUMBER: PA-WM1-0111.0000-RD



WESTMORELAND COUNTY, PENNSYLVANIA - PENN TOWNSHIP

PROFILE VIEW

GEOTECH B1-7E

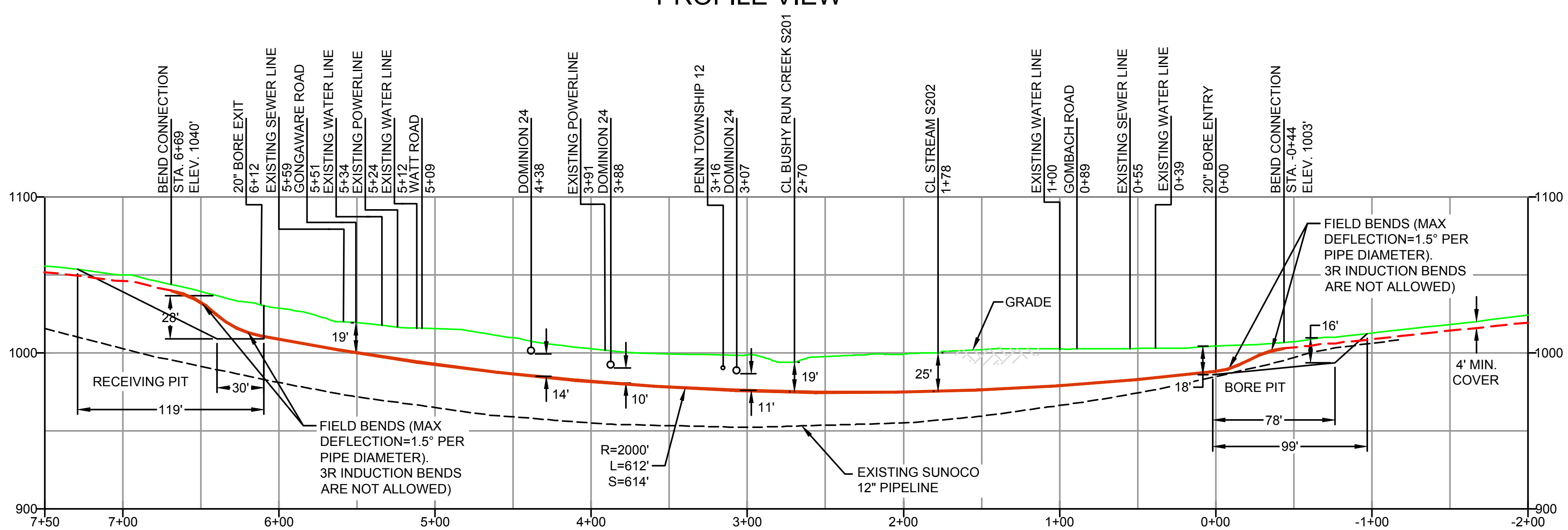
- NG EL. 1046'
- SANDY LEAN CLAY CL (0.0' - 2.0')
- SANDY FAT CLAY CH (2.0' - 5.0')
- SANDY LEAN CLAY CL (5.0' - 10.5')
- GROUNDWATER (39.7')
- SHALE CLAYSTONE/SANDSTONE (10.5' - 146.0')
- BORING TERMINATED EL. 900'

NOTE: REFER TO TEST BORING LOG B1-7E TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B1-7W

- NG EL. 1094'
- LEAN CLAY CL (0.0' - 20.0')
- GROUNDWATER (46.0')
- LIMESTONE/ CLAYSTONE/SANDSTONE (20.0' - 177.5')
- BORING TERMINATED EL. 916.5'

NOTE: REFER TO TEST BORING LOG B1-7W TERRACON PROJECT #J217P078 FOR COMPLETE SOIL MATERIAL DESCRIPTION



DESIGN AND CONSTRUCTION:

1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXISTING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):612'
   HDD PIPE LENGTH (S=):614'
   20" x 0.456" W.T., X-65, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: FLEX BORE.
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

Figure 3.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-1.51	TO	ES-1.51	EROSION & SEDIMENT PLAN
SHEET 38	TO	SHEET 39	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
A	ISSUED FOR REVIEW	MRS	05/01/18	RMB	05/01/18	AAW	05/01/18

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

FLEX BORE
GOMBACH ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=100'
DWG. NUMBER: PA-WM1-0111.0000-RD