SUNOCO PIPELINE
An ENERGY TRANSFER Company

535 Fritztown Road
Sinking Spring, PA 19608

May 22, 2019

Via Electronic Mail
Mr. Scott R. Williamson
Program Manager, Waterways & Wetlands Program
Pennsylvania Department of Environmental Protection
Southcentral Regional Office
909 Elmerton Avenue
Harrisburg, PA 17110-8200

Re: DEP HDD Re-Evaluation Report – Request for Additional Information
Old U.S. 220 16" Horizontal Directional Drill (S2-0109-16)
Permit No. E07-459
Blair Township, Blair County

Dear Mr. Williamson:

In compliance with the Corrected Stipulated Order dated August 10, 2017 a Re-Evaluation Report for the above-referenced horizontal directional drill (HDD) was submitted to the Pennsylvania Department of Environmental Protection (Department) on February 12, 2019. In a letter dated March 28, 2019, the Department requested further information, please accept this letter as a response. Your requests are bolded below followed by Sunoco Pipeline, LP (SPLP) responses.

1. **As required by Paragraph 4. and 5. of the Environmental Hearing Board's August 10, 2017 Corrected Stipulated Order, SPLP failed to fully utilize information gathered during the HDD of the 20-inch bore as part of the HDD Re-evaluation for the 16-inch pipeline. Please gather geologic and drilling information collected by various site personnel during the 20-inch bore which can be used to synthesize a comprehensive analysis of how all data was used to design the proposed 16-inch bore path. The HDD re-evaluation report should discuss how the operational or geologic cause of each inadvertent return, the magnitude of the inadvertent returns) and associated loss of circulation, the best management practice used to contain and minimize the inadvertent return, and the drilling procedure or technique used to progress the boring were considered in the proposed 16-inch redesign.**

   Additionally, the report does not explain how the redesign will greatly reduce the risk of IR's or impacts to water supplies within 450 feet, especially since it appears the 16-inch HDD redesign was done in Jan 2018 and the Geologic Report wasn't completed until Feb 2019.

   This information described above should be used to describe why the chosen bore path for the 16-inch pipeline was determined and how such information has been used to minimize the potential for IR's to occur and as part of the discussion of construction alternatives, including why HDD activity is still the preferred and chosen methodology for pipeline construction at this location.

SPLP utilized all information obtained from the drilling of the 20-inch HDD in our internal assessment and evaluation of the 16-inch HDD profile as revised. The inadvertent return (IR) information presented graphically on Figure 1 in Attachment 2 presents the plan and cross section views of the IR events occurring during the of the 20-inch HDD. This figure presents the reality of events occurring during this HDD in relation to the depth of profile and allowed for correlation to geologist monitoring data during active drilling.

As identified in the Root Cause Analysis section of the Re-Evaluation Report, the three IRs resulted from the shallow depth of the 20-inch profile at the IR locations in combination with the HDD annulus becoming clogged by cuttings. Analyzed against the 2017 geotechnical investigation data, all three IRs occurred either in unconsolidated soils or highly weathered siltstone. These materials have low integrity and lack the strength to prevent the migration of drilling fluids, but are strong enough to require a mud motor/rock tool to cut the material which requires the circulation of drilling fluid.

The IR events and magnitude include an IR of 100 gallons on June 28, 2017, 300 gallons on July 1, 2017, and 30 gallons on August 31, 2017. Considering that the minimum flow rate to rotate a 400 class rig mud motor during pilot drilling is 350 gallons per minute, and minimum flow during reaming is 450 gallons per minute, these IR events were quickly identified and responded to.

The profile was redesigned to reduce the potential of IRs during the 16-inch HDD. The entry and exit angles of the 16-inch HDD profile have been increased to allow the drilling tools to advance through the unconsolidated soils and weathered bedrock into competent bedrock quicker and closer to the entry and exit points. The profile was adjusted such that in the event a “punch in/out” IR occurs, it is more likely occur in an upland area and within the limits of disturbance where it can be controlled quickly and contained by LOD perimeter controls. Secondly, the profile maximum depth has been increased by 32 ft to 111 ft below ground surface (bgs). This places more of the profile through bedrock with higher rock quality designation (RQD) values as identified in the 2017 geotechnical investigation. These design changes along with best management drilling practices will be used to reduce the risk of IRs from occurring during the completion of the 16-inch HDD.

Specifics relative to the redesigned 16-inch HDD profile include; (1) a 20-degree angle to the normal ground surface is set at the entry, which exceeds normal parameters and requires digging of a ramped surface for setting the drilling rig on, but this accelerates the entry into competent rock. Adversely, this also requires using custom-fabricated bends for connecting the drill pipeline segment to the standard open cut pipe; (2) the HDD exit point is chasing a rapidly increasing slope as proceeding west, which complicates the exit design. Paralleling a rising slope results in a linear extension of the profile in close proximity to the land surface which elevates the risk of an IR. Therefore, an additional buffer to the adjacent wetlands was added by relocating the exit further west, as limited by the increasing slope to minimize IR risk. The end result of the entry and exit points results in the required design of the profile tangents and horizontal design. There is only 115 ft of horizontal run, which is very limited in extent to make corrections in the profile when coming out of the entry 2,400 ft radius, to hit the 2,000 ft exiting radius.

As mentioned in the Alternative Analysis of the Re-Evaluation Report, the HDD methodology was confirmed to be the preferred installation method because ultimately it will cause the least amount of direct impact to the environment and natural resources. Changing the installation technique to open cut would result in a direct impact to the stream, floodway and the exceptional value wetland that would need to be crossed. Open cut installation would result in 0.03 acres of state water bottom, 0.3 acres of floodway, and 0.94 acres of exception value wetlands being directly impacted. Further, any dewatering required to maintain the open cut trench would result in the potential discharge of cloudy water downstream regardless of the utilization of filtrations bags and structures.

Re-routing the pipeline is not a viable option since no matter which route is considered, streams and wetlands would still be crossed, there would be additional direct impacts to additional wetlands (W-BB47 and W-L60) and streams (S-L82 and S-L81), and a new greenfield would need to be created.

The only other possible construction methods not discussed in the Re-Evaluation Report include FlexBor, and Direct Pipe Bore.

SPLP contractors attempted three (3) FlexBors and partially completed two of these to replace HDDs on the Mariner Project. One FlexBor failed in the pilot phase and was replaced with a conventional auger bore under a highway and open cut construction. The two partially successful FlexBors completed the pilot phases, but both had difficulties completing the reaming phase. SPLP's analysis is that this technology is not perfected for larger diameter bore attempts. Therefore, SPLP did not include this method in alternatives analysis section of the Re-Evaluation Report.

The Direct Pipe Bore method is also known as "microtunneling". This method of pipeline installation is a remote-controlled, continuously supported pipe jacking method. During the direct pipe installation, operations are managed by an operator in an above-ground control room alongside of the installation pit. Rock and soil cutting and removal occurs by drilling fluid injection through the cutting tool during rotation at the face of the bore, and the cuttings are forced into inlet holes in the crushing cone at the tool face for circulation to a recycling plant through a closed system. The entire operating system for this method of pipeline installation, including the cutting tool drive hydraulics, fluid injection, fluid return, and operating controls are enclosed inside the outside diameter bore pipe (or casing pipe) being installed. At the launching point/entry pit, the bore pipe is attached to a "jacking block" that hammers the bore pipe while the tool is cutting through the substrate or geology. The cutting tool face is marginally larger in diameter than the pipe it is attached to. As a result, there is minimal annulus space, which minimizes the potential for drilling fluid returns or the production of groundwater returning back to the point of entry.

SPLP's construction contractors have successfully completed one (1) Direct Pipe Bore approximately 925 ft in extent on the Mariner Pipeline project. The Old U.S. 220 HDD length is 1,965 ft, which exceeds the limits of Direct Pipe bore technology. Subsets of the profile length were studied and plans developed for two (2) Direct Pipe Bores in combination with the use of conventional auger bore and open cut construction to replace the HDD. After layout of the workspace for the Direct Pipe Bore entry, exits, and means of access to these locations, the impacts to streams, wetlands, and clearing of forested lands

exceeded the impacts of a straight conventional open cut construction plan; therefore, these plans were abandoned.

Based on the analysis of all alternatives, the HDD method remains the preferred option for this location.

2. Relating to the Analysis of geologic strength at profile depth:

a. There is no analysis in the re-evaluation report specifically tying the revised drill path to any specific zones noted on the core boring logs, or why the revised 16-inch path was chosen. Please provide a discussion addressing the use of this data in designing the bore path.

SPLP reviewed the daily drilling reports, previously completed geotechnical investigations, and HDD Inspection Daily Reports for each event that resulted in an IR. The results of the geotechnical investigation were used in determining the root cause(s) of the three IRs reported during the completion of the 20-inch HDD. Further, the depth of the pilot tool/reamer was compared to the geotechnical investigation to determine if the pilot bit was advancing through unconsolidated material or highly weathered and fractured bedrock. This information was then utilized to redesign the 16-inch profile resulting in an increase in the entry and exit angles and the overall depth of the profile. These modifications were made to minimize the distance the profile would be completed in unconsolidated material or highly weathered or fractured bedrock. Once in bedrock, the profile was designed to be advanced through good quality bedrock (i.e., RQD values greater than 50).

b. Provide an explanation and discussion of why no new core borings were performed in the area of the first IR, especially in consideration that only one of the previous core borings was performed in proximity to the depth of the proposed 16-inch bore path.

Based on the results of the root cause analysis and the very shallow nature of the 20-inch HDD bore path, it was determined that because competent zones were identified within the geotechnical boring completed in 2017, information from additional geotechnical investigations (i.e., additional borings) would be unlikely to provide any supplemental information that could be utilized to further reduce the potential for IRs during the completion of the proposed 16-inch HDD.

3. Relating to the consideration of Overburden Strength Analysis: The geologic report provides a description of soils underlying the site but does not include any analysis or discussion of the overburden strength. Please provide additional information/discussion to address the consideration of overburden strength analysis, especially in the area where the first IR occurred, as per the requirements of paragraph 4 ii of the EHB corrected and stipulated order.

The results of the standard penetration tests, which are the most frequently used subsurface drilling test, provide quantitative, as opposed to qualitative, information on the density of the overburden material.

The additional testing, which includes water content, grain-size, and Atterberg Limits, further provide quantitative information on the overburden. The Order is not clear when defining overburden strength, which is not a common geotechnical engineering term. Each of the drilling and laboratory tests are typically used to determine the stress-strain relationship of soils, and in turn shear strength; however, the Order did not request a calculation of the shear strength over various overburden layers.

From a qualitative perspective, results of the 2014 and 2017 geotechnical investigation identified the overburden as being very loose to very dense material typified by a very soft to hard consistency. The material identified in the split-spoon samples ranged from silty clays to fine- to medium-grained sand and clay. The silt and clay content showed a generally decreasing trend with depth as the sampler approached the soil/bedrock interface. These results suggest that there is a higher potential for an IR to occur while the profile is approaching the soil/bedrock interface. This was the rationale used for increasing the entry and exit angles to allow the boring to be advanced more quickly through the unconsolidated zone before encountering competent bedrock.

4. **Relating to the Open Cut Alternatives discussion: The open-cut and conventional bore analysis refers to the preferred use of "Direct Pipe" at this location. While other parts of this discussion refer to HDD. It is unclear whether SPLP is proposing to use a HDD or a "Direct Pipe" (aka: micro-tunneling) on all or part of the Old US 220 Highway Crossing. SPLP should clarify the pipeline installation methodology proposed this section and any other applicable sections of the report.**

As stated above, SPLP did analyze the potential use of a Direct Pipe bore, and the impacts from access and workspace exceeded the impacts associated with an open cut construction plan and were subsequently abandoned. Based on the analysis of all alternatives, the HDD method remains the preferred option for this location.

5. **Relating to the Re-route analysis/evaluation included: SPLP's Re-route analysis mentions a high-voltage electrical tower right-of-way exists parallel to the proposed 16-inch HDD to the south. SPLP does not discuss in any detail whether they explored using this "right-of-way". Please provide analysis and discussion of using this "right-of-way" and why it was eliminated as an option.**

Re-routing the pipeline to cross this area while adjacent to the existing electrical utility “right of way” was considered but ultimately rejected by SPLP because it would result in the same landowners and Waters of the Commonwealth being crossed. SPLP could not encroach within the utility cleared and maintained corridor.

6. Relating to the overall Geologic and Hydrogeologic Report:

a. The Geologic Report section 2.0 Geology and soils does not appear to be correct for the Old US 220 Highway Crossing site and may be referencing/referring to another HDD site.

The report has been revised and is included as an attachment.

b. The Geologic Report 4.0 Fracture Trace Analysis mentions eight fracture traces were identified and are shown on Figure 2 and 3 or the report. Figures 2 and 3 of the report only show one inferred fracture trace.

The report has been revised and is included as an attachment.

7. Relating to the Analysis of Well Production Zones and use of information obtained during construction of the 20-inch pipeline; The re-evaluation report fails to include evaluation of the information and any data collected for the five private water supplies within 450 feet of the HDD. It is also unclear about whether any of the five water supplies are the same as any of the three water supplies within 0.5 miles that were identified from the PaGWIS database.

Any private or public water supply data obtained within 450 feet or otherwise obtained in the vicinity of the 20-inch or proposed 16-inch HDD should be used and discussed as part of this HDD re-evaluation. This data should include but not be limited to any applicable water supply sampling data and any water supply complaints that SPLP may have obtained and received for water supplies within 450 of the HDD or within the general vicinity during construction of the 20-inch pipeline. The results of the SPLP's water supply sampling program, investigation, disposition of the complaint, and any correlation or non-correlation to SPLP's construction activities should be evaluated and discussed in the HDD re-evaluation report and used to demonstrate that the proposed 16-inch HDD activity will minimize the potential for IR's and impacts to water supplies. Please revise the re-evaluation report to include this information.

In accordance with the Order, SPLP conducted a survey in an effort to locate any water supply wells within 450 feet of the Old U.S. 220 HDD profile. A total of five water wells (none of which were identified within the 0.5-mile radius search of the Pennsylvania Groundwater Information System) were identified and are represented on Attachment 3 of the Hydrogeologic Re-Evaluation Report. Four water quality samples were collected from one of the identified locations (WL-11012016-499-01) during various stages of completion of the 20-inch HDD. None of the parameters typically identified in samples impacted by drilling fluids (i.e., turbidity, total suspended solids, iron and manganese) were identified at concentrations that would indicate impacts associated with the migration of drilling fluids into the water supply. A second location (WL05162017-475-01) was only sampled prior to the initiation of construction activities because the water supply well ran dry while it was being purged during HDD operations and no other attempts were made to sample this location. The remaining locations

(WL-09072017-614-02, WL-09272017-614-01 and WL-09272017-614-02) were sampled once, either during or shortly following completion of the 20-inch HDD. None of the parameters typically identified in samples impacted by drilling fluids (i.e., turbidity, total suspended solids, iron and manganese) were identified in these samples at concentrations exceeding the Department's established primary and secondary drinking water standards (MCLs/SMCLs). As a result of these findings, no impacts to groundwater quality were identified that can be attributed to installation of the Old U.S. 220 20-inch HDD. Summary tables containing the analytical results from the various water quality sampling events are attached.

To date, no water well complaints or allegations of groundwater quality impacts have been received relative to the construction of the Old U.S. 220 20-inch HDD. As a result, no groundwater investigations have been conducted. Based on the lack of any documented adverse impacts to groundwater quality and absence of any reported water well complaints, SPLP does not see the need to revise the report to reflect this finding.

8. Related to Pipe Stress Radius: Provide further explanation of how the following statement applies to this HDD re-evaluation: "Pipe stress allowances are an integral part of the design calculations performed for each HDD."

For steel pipe the "pipe stress allowance" is the amount of curvature that a piece or length of pipeline can bend without resulting in damages such as a "kink" or "crimp" in the wall of the pipe. The innate curvature ability of pipe is termed the "free stress radius". The stress allowance of the pipe is determined by the ductility of the steel, wall thickness, and the diameter of the pipe. An HDD design is limited by the horizontal distance between the points of entry and exit and the free stress radius of the pipe.

Ductility of the steel used for pipelines is determined by the percentage of carbon within the steel. Generally, steel pipe is categorized as either "low carbon" having less than 0.3% carbon content within the steel, or "high carbon" having greater than 3% carbon within the steel. As the carbon content within the steel used to make the pipe increases, the flexibility (ductility) of the pipe is decreased. The X70 16-inch pipe utilized on the Mariner project is a low carbon (high ductility) steel pipe.

The design of an HDD profile accounts for the free stress radius of the pipeline segment to be pulled into the drilled entry, through the entry radius of curvature at maximum horizontal depth, out the exit radius leaving maximum depth, and out the drilled exit; therefore, each HDD has a minimum of four (4) points of pipeline curvature to assess for pipeline stress. Additionally, a horizontally drilled profile is not a "perfect" pathway, especially when drilled through rock formations. The pilot tool cutting into the rock face has a larger cutting face than the drill stem pushing the tool forward, which results in flexibility of the tooling within the pilot hole, and as a result the pilot tool will drift in orientation as proceeding forward because the cutting tool will proceed easier into softer material while cutting due to natural variances in hardness of the materials being cut, whether they are soils or rock. Steering of the pilot tool is used to correct drifting as it occurs. As a result of this natural drifting during completion of the pilot hole, the entire length of the drilled pilot hole is assessed for stress allowances at three (3) joint intervals

before reaming of the annulus is permitted. If errors during pilot drilling or reaming occur and a mid-point is identified that would breach the pipe stress allowance, then the use of an over-reamed annulus is assessed for breach of the stress allowance. In cases where an over-reamed annulus will not correct the stress problem, the HDD has to be re-drilled.

All the information and stress assessment procedures discussed above are incorporated into the profile design and implemented in analysis of the drilling profile to ensure the integrity of the pipeline as installed. Specific items concerning the design of the revised profile for the 16-inch HDD were provided in the response to Item 1 above.

SPLP submits that we have been, and are, in complete compliance with the agreed terms and analysis requirements of the Order, as agreed to by the Department, and that no further analysis is required for the Department to consent to the start of this HDD. SPLP requests that the Department approve the Re-evaluation Report for Old U.S. 220 Highway Crossing HDD (S2-0109-16) as soon as possible.

Sincerely,

Larry J. Gremminger, CWB
Vice-President – Environmental, Health & Safety
Energy Transfer Partners
Mariner East 2 Pipeline Project

Pertaining to the practice of geology and information conveyed.

5/22/2019
Date

Douglas J. Hess, P.G.
License No. PG-000186-G
Skelly and Loy, Inc.
Director of Groundwater
and Site Characterization
Geo-Environmental Services

Attachments as stated.

RETTEW

We answer to you.

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Engineers
Environmental Consultants
Surveyors
Landscape Architects
Safety Consultants

February 8, 2019
Revised May 22, 2019

Mr. Matthew Gordon
Sunoco Pipeline, LP
535 Fritztown Road
Sinking Spring, PA 19608

RE: Sunoco Pipeline, LP Pipeline Project - Mariner East II
Palmer Lane (Old Route 220) HDD Location S2-0109
PA-BL-0001.0031-RD-16
Hydrogeological Re-Evaluation Report for 16-inch Pipeline
Blair Township, Blair County, Pennsylvania
RETTEW Project No. 096302011

EXECUTIVE SUMMARY

1. This hydrogeologic re-evaluation was prepared as a result of inadvertent returns (IRs) of drilling fluids that occurred at the Palmer Lane (AKA Old Route 220) horizontal directional drill (HDD) S2-0109 location as the 20-inch HDD was being completed.
2. The Palmer Lane HDD site is underlain by carbonate and sedimentary rocks of the Devonian age Hamilton Group (Dh) and Onondaga and Old Port Formations, undivided (Doo).
3. Water-bearing zones in the underlying geology generally occur in secondary openings along bedding planes, joints, faults, fractures, and solution openings. The permeability of these features can be enhanced by dissolution of the carbonate bedrock units.
4. Water-bearing zones generally occur in secondary openings along bedding planes, joints, faults, fractures, and solution openings. Water-bearing zones in the Hamilton Group occur most frequently within 350 feet of the ground surface, and within 300 feet of the ground surface in the Onondaga and Old Port Formations.
5. The HDD profile for the proposed 16-inch drill has been redesigned to increase its depth beneath the roads, utilities, stream and wetlands.
6. Based on the hydro-structural characteristics of the underlying geology, information obtained from installation of the 20-inch pipe, and the IR that occurred during the installation of the 20-inch pipe, the Palmer Lane HDD is susceptible to an IR of drilling fluids during HDD operations for the planned 16-inch drill. The redesigned 16-inch HDD profile and proactive HDD best management practices (BMPs) during drilling operations will be used to reduce the risk of an IR.

1.0 INTRODUCTION

The purpose of this report is to describe the geologic and hydrogeologic setting of the Palmer Lane (S2-0109) HDD location (the site) on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project - Mariner East II (PPP-ME2) Project. The Palmer Lane HDD is located in Blair Township, Blair County, Pennsylvania (refer to **Figure 1**). The HDD was designed to be drilled under Dry Run (S-M69) and two

Palustrine Forested (PFO) wetlands (Wetlands M79PFO and M49PFO). This re-evaluation report was prepared as a result of IRs of drilling fluids that occurred during installation of the 20-inch pipe.

The original 16-inch HDD profile was redesigned on January 8, 2018. The profile was lengthened to deepen the profile beneath the resources described above. The deeper profile increases the depth of the pipe to 107 feet below Dry Run and increases the depth of cover where two IRs occurred during installation of the 20-inch pipe. The redesigned western HDD entry/exit is at a surface elevation of approximately 1,095 feet above mean sea level (AMSL) and the redesigned eastern entry/exit is at an elevation of approximately 1,139 feet AMSL. The as-built 20-inch pipeline and proposed 16-inch HDD locations are shown on **Figure 1**, and the 20-inch as-built profile and redesigned 16-inch profile are included as **Attachment 1**.

2.0 GEOLOGY AND SOILS

Based upon publications by the Pennsylvania Bureau of Topographic and Geologic Survey (PABTGS, 2001), the site is in the Appalachian Mountain Section of the Ridge and Valley Physiographic Province of Pennsylvania, and is underlain by sedimentary rocks consisting of sandstone, siltstone, shale, conglomerate, limestone, and dolomite. Local topography is characterized by a northeast to southwest trending succession of long narrow ridges and broad to narrow valleys, with some karst terrain. Natural slopes are steep and geologic structures include both open and closed plunging folds with narrow hinges and planar limbs, and a variety of faults. These rocks generally have good surface drainage (Sevon, 2000). Based on the United States Geologic Survey (USGS) 7.5-Minute Frankstown Topographic Quadrangle Map shown on **Figure 1**, the site is situated at an approximate elevation range of 1140 to 1100 feet AMSL. Surface topography at the site generally slopes to the east and west along the proposed HDD bore path towards Dry Run. The major surface water feature is Dry Run which flows to the northeast before discharging into Beaverdam Branch Juniata River which, in turn, ultimately discharges to the Juniata River.

The site geology is mapped west to east as the Devonian age Hamilton Group and the Onondaga and Old Port Formations, undivided, as shown on **Figure 2** (Berg and Dodge, 1981). The Palmer Lane HDD is located on the west limb of an anticline that has a strike trending north-south and dipping to the west.

The Hamilton Group (Dh) includes the Mahantango Formation (Dmh) and the Marcellus Formation (Dmr). The Mahantango Formation consists of gray, brown and olive interbedded shales, siltstones, and very fine-grained sandstones and claystones containing marine fossils. Oolitic hematite occurs near the top of the Mahantango Formation, while the middle section contains medium to coarse grained sandstone and thin conglomerate layers. The Marcellus Formation consists of very dark to black, fissile, homogeneous carbonaceous shales. The group is well bedded with the shale units having thin to flaggy beds and the sandstone units having thin, flaggy to medium beds. Joints are well developed, closely spaced, mostly open, and steeply dipping. The joints produce smooth, even faced, sharp edged rectangular blocks in the sandstone units. Permeability is described as moderate with joint and bedding plane openings providing a secondary porosity of low to moderate magnitude. The Hamilton Group is poorly to moderately resistant to weathering, with the shale units being less resistant to weathering. The overlying mantle is thin. Slope stability is classified as good in the sandstone units but only fair in the shale. The ease of excavation is classified as moderately easy in the shale to difficult in the siltstone and sandstone. The drilling rates are reported to range from moderate to fast. Foundation stability is good when material is excavated to sound bedrock. Surface drainage is considered to be good. (Geyer and Wilshusen, 1982).

The undivided Onondaga and Old Port Formations (Doo) are described as interbedded dark-gray limestone, shaley limestone, and calcareous and noncalcareous shale (Onondaga); and an upper unit of calcareous quartz sandstone and a lower unit of chert, cherty limestone and calcareous shale (Old Port). Bedding features in these formations are described as well bedded and flaggy to thick in nature. Most joints are blocky to seamy; moderately abundant, open and vertical. Joints and bedding plane fractures are moderately to closely spaced and provide secondary porosity of moderate magnitude with low to moderate permeability. These rocks are moderately weathered with the deepest weathering occurring in the shales. Weathering results in small- to medium-sized blocks. The overlying mantle is thin and surface drainage is good. From an engineering standpoint, excavation (and drilling) is classified as difficult with slope stability being generally good in the limestone member and fair in the shale member. Foundation stability is good, provided the excavation is completed to sound material and identified solution cavities are investigated and mitigated (Geyer and Wilshusen, 1982).

According to the United States Department of Agriculture (USDA) Soil Surveys of Blair County, Pennsylvania, soils within approximately 450 feet of the proposed 16-inch drill path for the Palmer Lane HDD consist of six separate soil units. A USDA soils map that depicts the mapped area, along with the soil profile descriptions, is included as **Attachment 2**.

3.0 HYDROGEOLOGY

Groundwater at the site occurs in a fractured carbonate and sedimentary bedrock aquifer system within the geologic units described in Section 2.0. In these rock types of Blair County, water-bearing zones generally occur in the secondary openings along bedding planes, joints, faults and fractures. Most of the water-bearing zones penetrated by wells occur in individual fractures or groups of interconnected fractures that may be sufficiently enlarged by dissolution of the bedrock to provide pathways for the transport of water (Taylor, 1982). In central Pennsylvania, many of the water-bearing rocks, such as sandstone, alternate with less permeable rocks such as shale. In areas with tilted rock strata or on the flanks of anticlines, such as the Palmer Lane HDD, water flows downdip in the permeable formations (Lohman, 1938). At the S2-0109 location, the proposed HDD exit point is at a higher elevation and position on the limb of the anticline in contrast to the proposed HDD entry point which is at the base of the limb. Based on these geologic structural features, it is assumed that primary groundwater flow is downdip and to the west.

A summary of the review of published information on water wells completed in the Hamilton Group and Onondaga and Old Port Formations is provided below.

The depths of 243 domestic and non-domestic water supply wells completed in the Hamilton Group range from 10 to 695 feet below ground surface (bgs), with yields ranging from 1 to 380 gallons per minute (gpm). The median well depth for domestic wells is 173 feet bgs and 300 feet bgs for non-domestic wells. The median well yield for domestic wells is 12 gpm and 38 gpm for non-domestic wells. Water-bearing zones among 198 wells reviewed are most frequent from 50 to 350 feet bgs and are relatively common to a depth of 350 feet, with the deepest water-bearing zone being reported at 635 feet bgs (Taylor et al., 1982).

Reported depths of 228 domestic and non-domestic wells in the Onondaga Formation ranged from 35 to 500 feet bgs. The median well depth for 144 domestic and 24 non-domestic wells was 141 and 215 feet, respectively. Well yields ranged from 0 to 1,400 gallons gpm with median well yields of 10 gpm for domestic wells and 66 gpm for non-domestic wells. Water-bearing zones among 88 wells inventoried

showed an even distribution to a depth of 300 feet. Approximately 25% of the wells drilled deeper than 300 feet penetrated water-bearing zones, with the deepest water-bearing zone being reported at 460 feet bgs (Taylor et al., 1982).

Well records reviewed within a 0.5-mile radius of the Palmer Lane HDD location were obtained from the Pennsylvania Groundwater Information System (PaGWIS, January 14, 2019). A total of three well records were available and are summarized below. The well locations are shown on **Figures 2 and 3.**

Well No.	Well Use	Casing Depth (feet)	Total Depth (feet)	Water Level (feet)	Yield (gpm)
58581	Domestic	25	45	20	5
58522	Domestic	27	102	13	5
58513	Unknown	40	130	50	10

As a condition of the corrected Stipulated Order, other Sunoco subcontractors researched private water supplies with 450 feet of the Palmer Lane HDD in January 2019. Five water supply wells were identified within the 450-foot buffer of the HDD alignment. Two reported well depths ranged between 150 and 200 feet bgs. Information regarding depth to water was available for only one of the five wells, with a reported depth to water ranging between 40 and 50 feet bgs. The depth to the pump was reported as 75 feet bgs in one of the wells. A map of these locations is included as **Attachment 3.**

4.0 FRACTURE TRACE ANALYSIS

Fracture traces are natural linear features that are unaffected by local topographic relief and, as a result, are considered surface manifestations of concentrated high-angle bedrock fracturing. Fracture traces may be observed on aerial photographs as linear topography, straight stream segments, vegetation or soil tonal alignments. The linear features may be the surficial representation of deeper fractures, joints, faults or bedding planes within the subsurface which can transmit groundwater through the fractured bedrock aquifer underlying the Palmer Lane HDD. Fracture traces underlying, or in close proximity to, the site were evaluated using historical aerial photographs from the years 1984 through 2016 (Google Earth, 2018), the Frankstown Quadrangle Geologic Map (Berg and Dodge, 1981), Plate 1 (Taylor, 1982) and the Hollidaysburg, PA USGS 7.5 Minute Quadrangle Topographic Map. These photographs, publications and maps were reviewed to approximate the locations of natural linear fracture trace features or lineaments expressed on the ground surface.

Figures 2 and **3** show the results of the fracture trace analysis overlain on the geologic map of the site and an aerial base map. One fracture trace was identified within close proximity to the Palmer Lane HDD that is likely related to the primary geologic structure. The fracture trace trends approximately northeast-southwest (NE-SW), parallel to geologic strike.

5.0 GEOTECHNICAL EVALUATION

Two geotechnical drilling evaluations were performed at the site; one in September of 2015 and one in September of 2017. The 2015 evaluation consisted of three test borings, which were advanced by hollow-stem auger methods and split-spoon samplers to sample the soil, residual soil and weathered bedrock. An NQ-sized wireline rock coring technique was used to collect a core from one of the 2015 sampling locations. The more recent 2017 test boring was advanced using mud-rotary and NQ-sized wireline rock coring methods. Soil, residual soil and weathered bedrock were sampled using split-spoon samplers. The boring completed in 2017 is designated as B3-6W. Geotechnical boring logs from both investigation phases are included in **Attachment 4**.

Borings SB-01 and B3-6W were located near the western end of the Palmer Lane HDD boring profile. Boring SB-02 was located near the center of the profile. Boring SB-03 was located near the eastern end of the HDD profile. The locations of these borings are depicted on **Figures 2** and **3.**

In general, the subsurface profile at the site, as observed in the borings, is described as follows:

- Soil and residual soil depths vary from boring to boring; 30 feet at SB-01, 22 feet at SB-02, 18.5 feet at SB-03, and 51 feet at B3-6W. The residual soils are described as follows:
    - **Boring SB-01**: decomposed bedrock consisting of fine to medium SAND and CLAY (SC) with some silty clay, silty CLAY (CL) and variegated silty CLAY (CL) and fine SAND (SC) with partially weathered shale. Groundwater was observed at 15 feet bgs through the augers and the boring was terminated at 30 feet bgs.
    - **Boring SB-02**: silty CLAY (CL) and fine to medium sand with trace sandstone gravel. Groundwater was observed at 7.5 feet bgs through the augers. Auger refusal occurred at 22 feet bgs and the boring was terminated at 32 feet bgs.
    - **Boring SB-03:** decomposed bedrock consisting of SILT (ML) and fine sand with lens of sandstone gravel and partially weathered shale. Groundwater was not encountered in this boring location. The boring was terminated at 30 feet bgs.
    - **Boring B3-6W:** lean CLAY with sand (CL) and fat CLAY (CH) (possibly highly weathered shale), highly weathered SILTSTONE with interbedded sandstone, highly weathered SANDSTONE with clay and highly weathered SHALE with trace clay. Groundwater was observed at 20.0 feet bgs during the drilling process.
- At depths of auger or split-spoon refusal and to the total depth of the NQ cores, weathered bedrock and bedrock were encountered and described as follows:
    - **Boring SB-02:** SB-02 was cored from 22 to a total depth of 32 feet bgs. Dark gray intensely to moderately fractured calcareous shale was encountered. Rock recovery ranged from 73% to 100% in the core runs. Rock quality designations (RQDs) ranged from very poor to fair (0% to 63%), and the RQD value generally increased with depth.
    - **Boring B3-6W:** B3-6W was completed to a total depth of 171 feet. From 51 feet to 81 feet moderately hard to hard, moderately to slightly weathered SHALE with occasional calcite veins was encountered. The primary joint sets were low angle to moderately dipping, very closely to closely spaced and tight to moderately open. From 81 to 86 feet moderately hard to hard slightly to highly weathered SHALE was observed. Because of the severity of fracturing, it was not possible to fully identify details pertaining to the joints present in this interval. From 86 to 131 feet moderately hard to hard, fresh to slightly weathered SHALE was observed. The primary joint sets were low angle to moderate dipping, very closely to closely

spaced and slightly to moderately open. A highly weathered zone was observed between 123.3 to 124.1 feet with a less fractured interval observed between 126 and 131 feet. From 131 to 86 feet moderately hard to hard, fresh to slightly weathered SHALE with occasional calcite veins was encountered. The primary joint set were low angle to moderate dipping, very closely to closely spaced and slightly open to open. RQDs in the SHALE ranged from very poor to excellent (16% to 100%). The lowest RQD was encountered in the severely fractured zone observed between 81 and 86 feet. The highest RQDs were encountered between 141 and 146 feet and 151 and 156 feet.

Unconfined compressive strength testing was performed on core samples collected from borings SB-02 and B3-6W and the results are summarized in the table below.

Boring	Sample Depth (feet bgs)	Compressive Strength (pounds per square inch)
SB-02	29-29.5	3,040
SB-02	30-30.5	3,430
B3-6W	90	4,126
B3-6W	108	3,583

Please note that RETTEW Associates, Inc. or Skelly and Loy, Inc. did not oversee or direct the geotechnical drilling program associated with the Palmer Lane HDD including, but not limited to, the selection of boring locations and target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other Sunoco Pipeline, L.P. contractors. RETTEW and Skelly and Loy relied on these reports and incorporated the data into the general geologic and hydrogeologic framework included in this report.

6.0 FIELD OBSERVATIONS

RETTEW geologists were onsite during 20-inch pipeline HDD drilling activities. The 20-inch pipeline boring was started on June 22, 2017 and the pilot hole was completed on July 1, 2017. Two IR events occurred during the pilot hole drilling with the first occurring on June 28, 2017 with approximately 100 gallons of drilling fluids being released. Drilling activities were suspended to address the June 28, 2017 IR and resumed on June 30, 2017. The second IR occurred on July 1, 2017 when approximately 300 gallons of drilling fluids were released as the pilot hole was being completed. Both IRs were contained and remediated and on July 6, 2017, the 30-inch ream pass was started and continued until July 25, 2017 when all PPP-ME2 Project HDD activities were suspended by order of the Pennsylvania Department of Environmental Protection (PA DEP). Following PA DEP's restart approval, the 30-inch ream pass was resumed on August 28, 2017 and completed on August 30, 2017. As the 30-inch ream pass was being completed, an IR was observed near the limit of disturbance (LOD) with approximately 30 gallons of drilling fluids having flowed outside of the LOD and into the wetlands. Consequently, HDD activities were suspended until restart approval was granted by the PA DEP. HDD activities resumed on September 25, 2017, with the completion of the swab pass. On September 26, 2017, the 20-inch product pipe was pulled through to complete HDD activities at the Palmer Lane HDD site.

A field investigation was performed by a RETTEW geologist on November 2, 2017 to identify rock outcrops for fracture fabric analysis, and to identify potential sensitive receptors to IRs. An outcrop was identified approximately 2.3 miles west of the 20-inch HDD entry point along geologic strike as shown on **Figure 2**. The outcrop consisted of thinly bedded soft shale interbeds of the Hamilton Group. The strike of bedding at this outcrop is 353° with a dip of 40° west-northwest (WNW). The field data is consistent with published geologic data, mapping, and fracture traces referenced in Section 4.0. No additional sensitive receptors to IRs beyond the previously mapped streams and wetlands were identified during the site reconnaissance.

7.0 GEOPHYSICAL SURVEY CONSIDERATIONS

No karst geology was observed during the field reconnaissance and none is mapped as being present at this HDD location. In addition, no carbonate bedrock was observed in the geotechnical borings, and no evidence of subsidence was observed during completion of the 20-inch HDD boring. Based on the lack of karst geologic features, and the lack of thick carbonate sequences at the depths anticipated for the proposed 16-inch HDD, the use of geophysical surveys during re-evaluation was considered but was ultimately not implemented at the Palmer Lane HDD location because the results of geophysical surveys would not likely provide additional information that would reduce the risk of an IR.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL AND CONCLUSION

Based on published geologic and hydrogeologic information, and the evaluation of geotechnical borings from the site, the Palmer Lane HDD location is underlain by sedimentary rocks of the Hamilton Group and the Onondaga and Old Port Formations. The hydrogeologic setting is dominated by groundwater flow through secondary openings along geologic features including bedding planes, joints, faults, and fractures. These secondary openings may be enlarged or enhanced by dissolution of the constituent carbonate rocks. Observed weathering, fractures, and joints in the geotechnical cores may be indicative of the high yields reported from some domestic and non-domestic wells completed in the Onondaga Formation. In addition, field measurements of local geologic structure support the published information regarding the presence of vertical and near vertical joint sets. Well records indicate that water-bearing zones in water wells close to the site are common to depths of 350 feet bgs in the Hamilton Group and to depths of 300 feet bgs in the Onondaga and Old Port Formations.

The originally designed 16-inch HDD profile was relatively shallow at the entry and exit points and passed through both unconsolidated overburden and fractured bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and geologic information obtained and utilized during installation of the 20-inch pipe, the Palmer Lane site is susceptible to the inadvertent return of drilling fluids during HDD operations. As a result, the proposed 16-inch HDD profile has been redesigned to allow for deeper crossings beneath Dry Run (S-M69) and Wetlands M79PFO and M49PFO. The deeper profile increases the depth of the proposed 16-inch pipe to 107 feet below Dry Run and increases the depth of protective cover where two previous IRs occurred during installation of the 20-inch pipe. From a geologic perspective, the longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling BMPs, will be used to reduce the risk of an IR and/or a loss of drilling fluids. Drilling BMPs are described in the Horizontal Directional Drill Analysis component of the overall re-evaluation package.

9.0 REFERENCES

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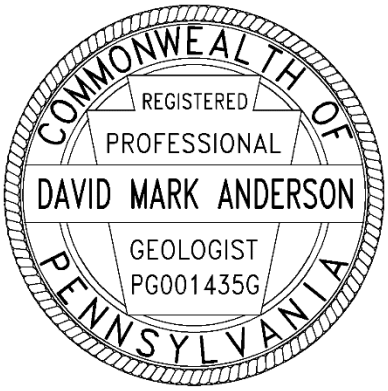
10.0 CERTIFICATION

The studies and evaluations presented in this report (other than Section 5.0) were completed under the direction of a licensed professional geologist (PG) and are covered under the PG seals that follow.

By affixing my seal to this document, I am certifying that, to my knowledge and belief, the information herein is true and correct. I further certify, that 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 herein.

Douglas J. Hess, PG
License No. PG000186G

David M. Anderson, PG
License No. PG001435G

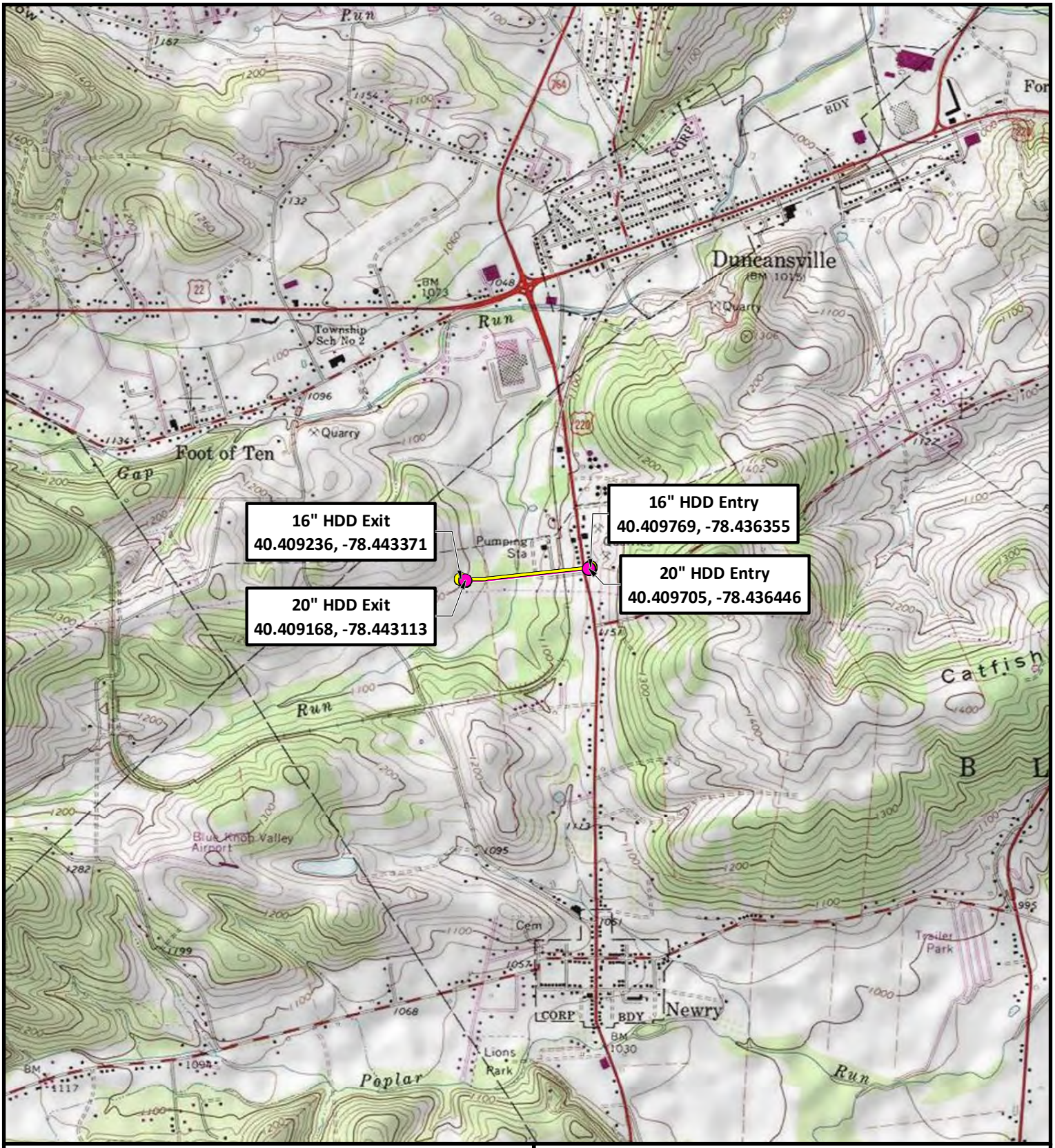


Enclosures

Z:\Shared\Projects\09630\096302011\GS\Hydrogeology Review\Old Route 220\DEP Response\Palmer Lane (Old Route 220) S2-0109 Hydro Report 2-8-19_rev. 5-22-19.docx

RETTEW

FIGURES



16" HDD Entry/Exit

20" HDD Entry/Exit

16" HDD Profile

20" HDD Profile

Frankstown, PA USGS 7.5' Topographic Quadrangle

2/6/2019

Sunoco Pipeline, L.P.

Old Route 220 HDD Location

Figure 1 - Topographic Basemap

Blair Township, Blair County, PA

Project No. 096302011

N W E S

0 1,000 2,000 Feet

1 inch = 2,000 feet

Sunoco Logistics Partners L.P.

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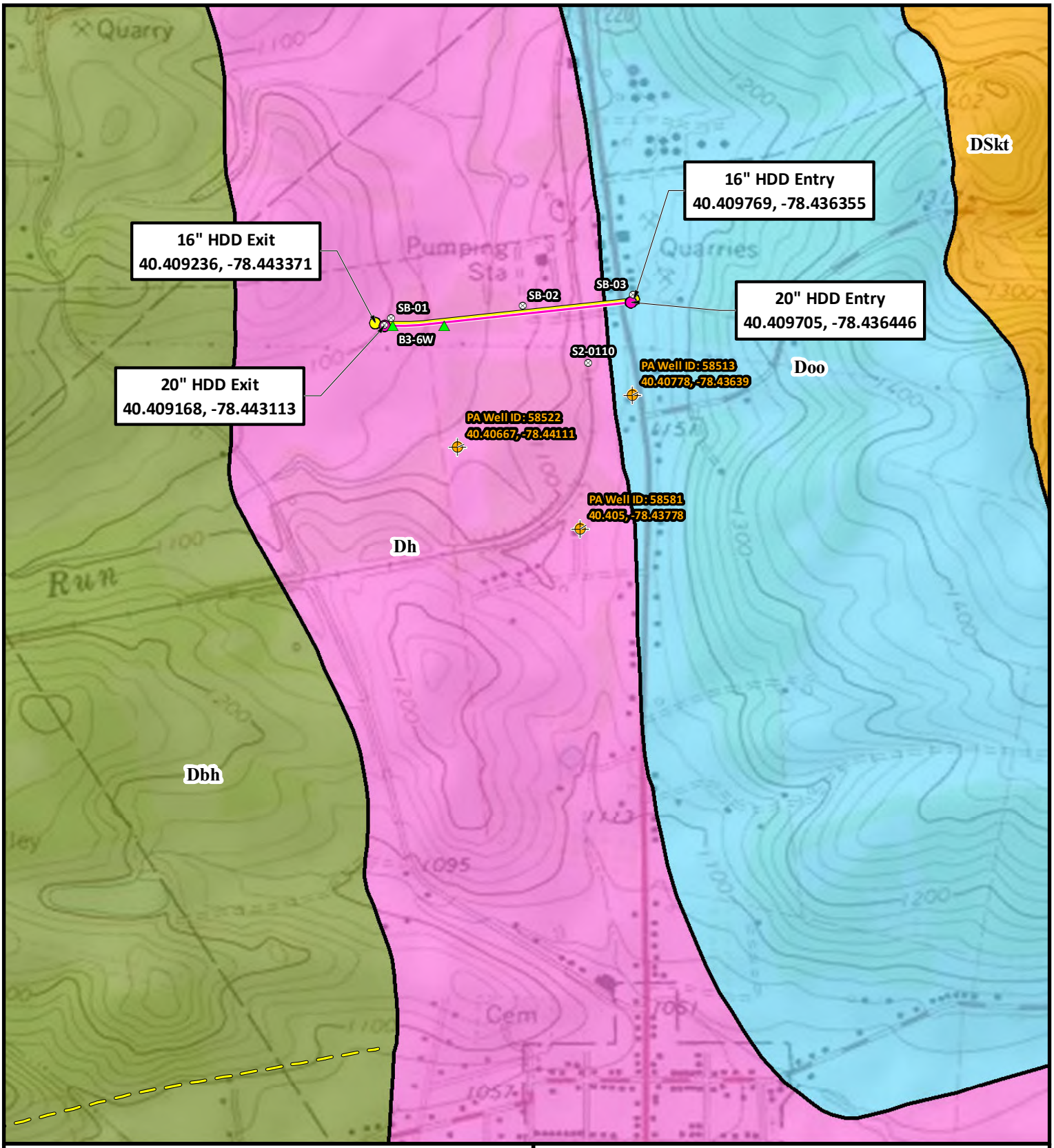

Inadvertent Return
Residential Well
Soil Boring
16" HDD Entry/Exit
20" HDD Entry/Exit
16" HDD Profile
20" HDD Profile
Inferred Fracture Trace

Geologic Formation

DSkt - Keyser and Tonoloway Formations, undivided
Dbh - Brallier and Harrell Formations, undivided
Dh - Hamilton Group
Doo - Onondaga and Old Port Formations, undivided

Hollidaysburg, PA USGS 7.5' Topographic Quadrangle

2/8/2019

Sunoco Pipeline, L.P.

Old Route 220 HDD Location

Figure 2 - Geologic Map

Blair Township, Blair County, PA
Project No. 096302011

N
W E
S

0 1,000 Feet

1 inch = 1,000 feet

Sunoco Logistics Partners L.P.

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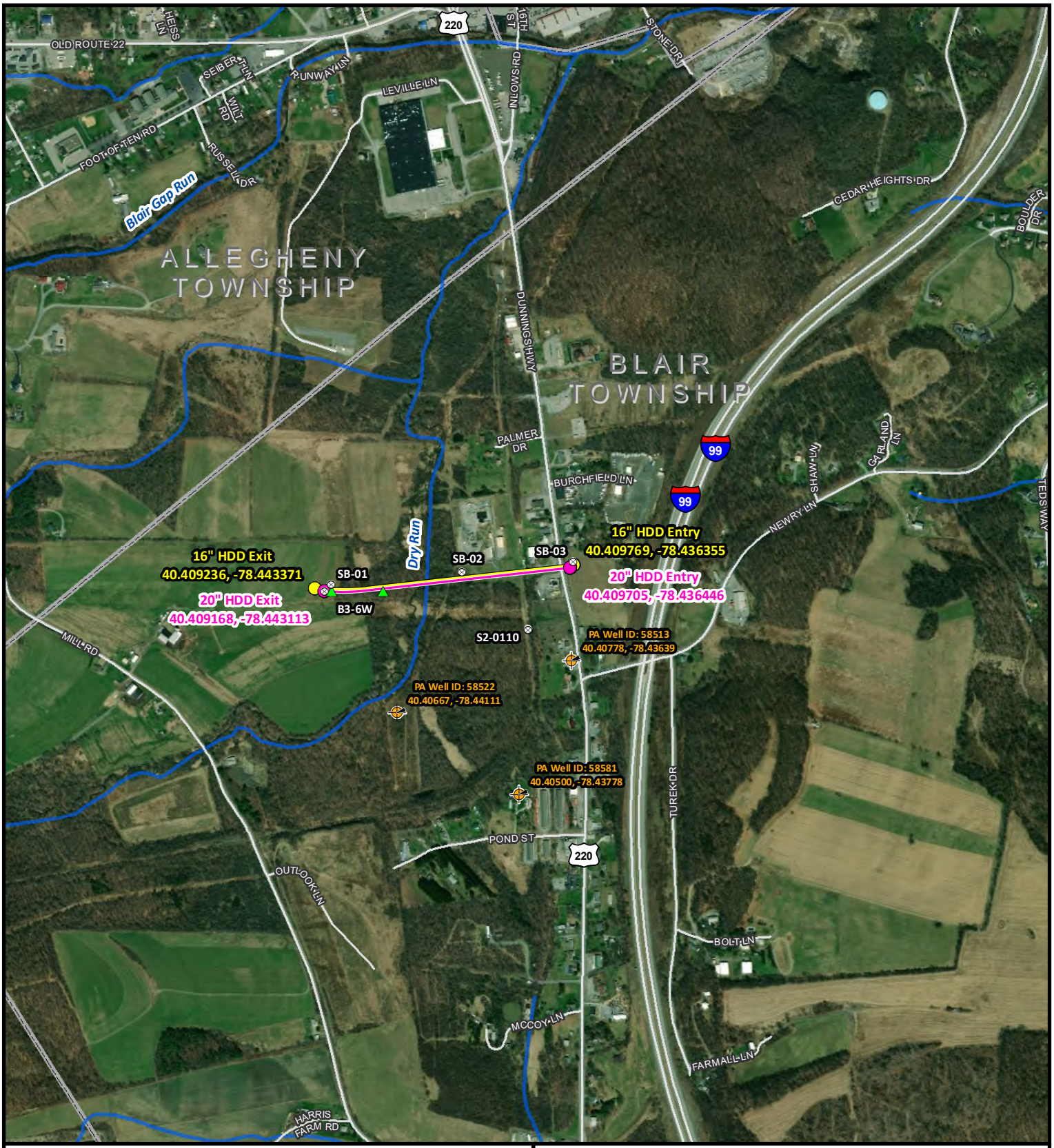

Inadvertent Return

Residential Well

Soil Boring

16" HDD Entry/Exit

20" HDD Entry/Exit

16" HDD Profile

20" HDD Profile

NHD Stream

Road

Municipal Boundary

Sunoco Pipeline, L.P.

Old Route 220 HDD Location

Figure 3 - Aerial Basemap

Blair Township, Blair County, PA

Project No. 096302011

N

W E

S

0 1,000 Feet

1 inch = 1,000 feet

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Sunoco Logistics Partners L.P.

2/8/2019

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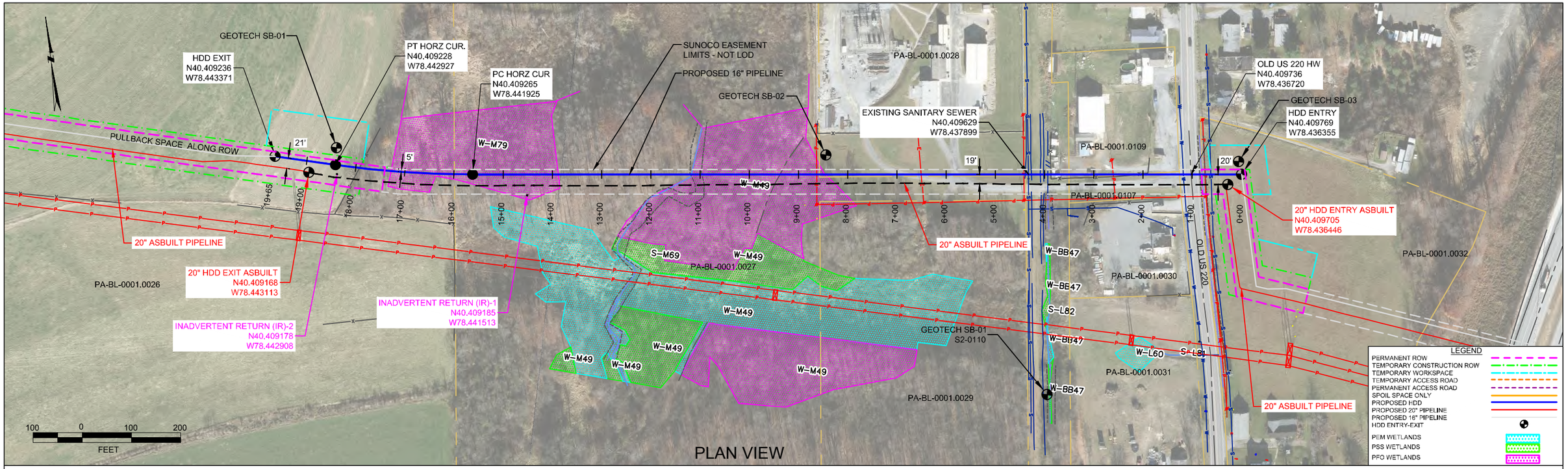
RETTEW

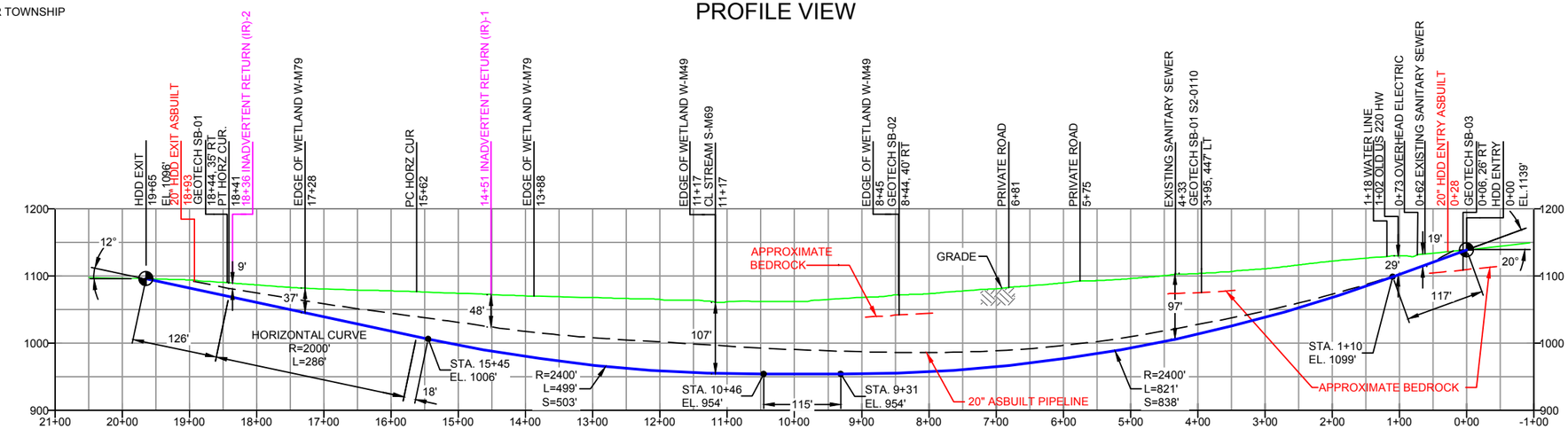
ATTACHMENT 1
HDD PROFILE AND GEOTECHNICAL BORING LOGS



PLAN VIEW

PROFILE VIEW

BLAIR COUNTY PENNSYLVANIA, BLAIR TOWNSHIP
S2-0109-16



GEOTECH SB-01
-NG EL. 1092'
-TOPSOIL (0' - 0.6')
-SC (0.6' - 11.5')
-GROUNDWATER (15.0')
-CL (11.5' - 21.5')
-CL/SC (21.5' - 30.0')
-COMPLETION DEPTH EL. 1062'

GEOTECH SB-02
-NG EL. 1072'
-TOPSOIL (0' - 0.1')
-GROUNDWATER (7.5')
-CL (0.1' - 18.0')
-FRACTURED SHALE (18.0' - 32.0')
-COMPLETION DEPTH EL. 1040'

GEOTECH SB-03
-NG EL. 1139'
-TOPSOIL (0' - 0.6')
-ML (0.6' - 18.5)
-WEATHERED SHALE (18.5' - 30.0')
-COMPLETION DEPTH EL. 1109'

NOTE: REFER TO TEST BORING LOG S2-0109 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH SB-01
-NG EL. 1110'
-TOPSOIL (0' - 0.2')
-FILL (0.2' - 3.0')
-SC (3.0' - 10.0')
-ML/CL (10.0' - 13.8')
-GROUNDWATER (16.5')
-WEATHERED SHALE (13.8' - 30.0')
-COMPLETION DEPTH EL. 1080'

NOTE: REFER TO TEST BORING LOG S2-0110 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=):1965'
   HDD PIPE LENGTH (S=): 2003'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 2100 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 2625 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

ES-3.21	TO	ES-3.22	EROSION & SEDIMENT PLAN	
SHEET 13	TO	SHEET 14	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	DESIGN CHANGE PER DPS	MRS	01/08/18	RMB	01/08/18	CAG	01/08/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	DLM	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/18/16	RMB	05/18/16	AAW	05/18/16
EP		MRS	11/13/15	RMB	11/13/15	AAW	11/13/15
B	ADDED GEOTECH INFO	MRS	10/05/15	RMB	10/05/15	AAW	10/05/15
A	ISSUED FOR BID	MRS	08/31/15	RMB	08/31/15	AAW	08/31/15

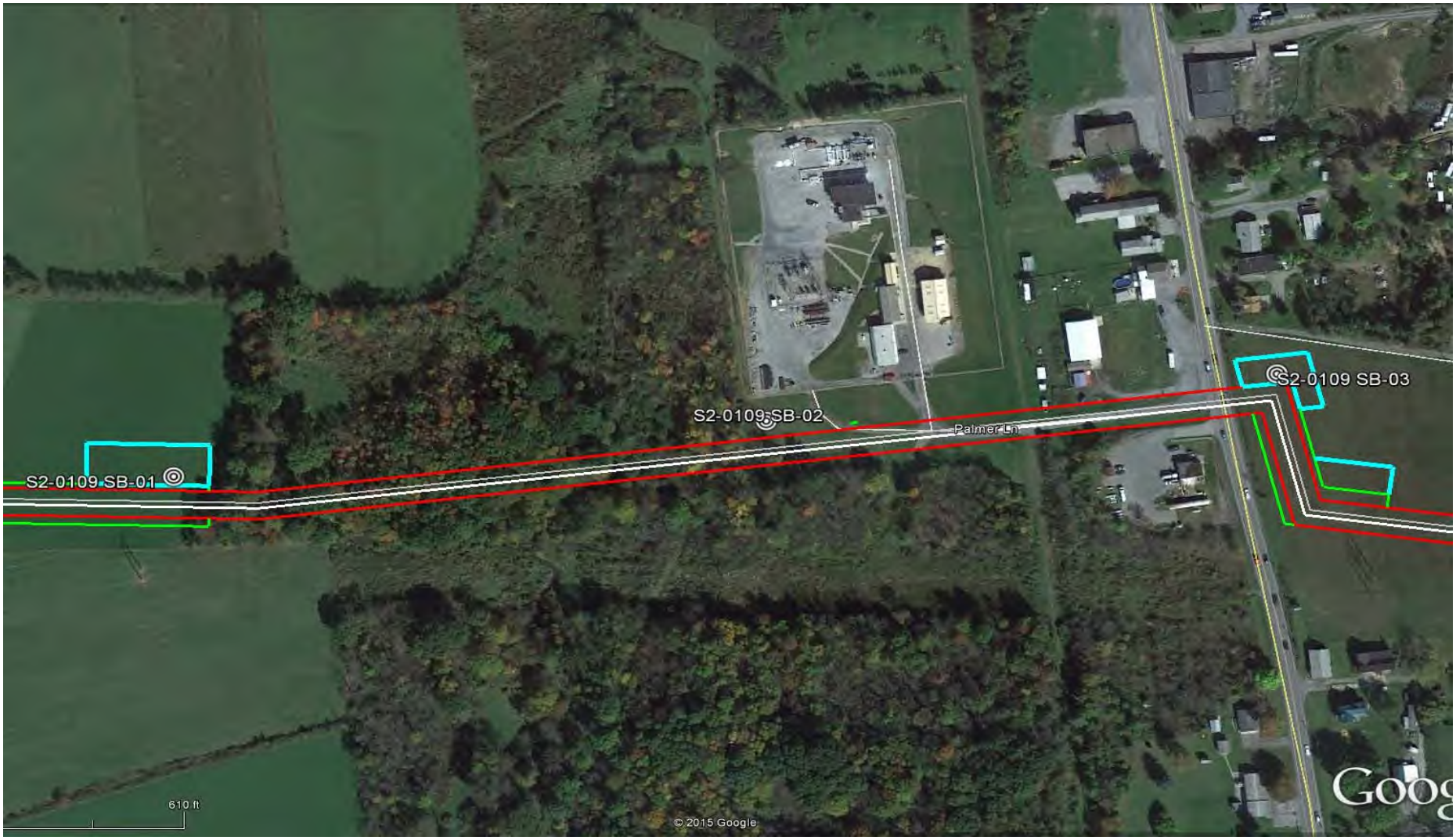
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
OLD US 220 HWY
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=200' | DWG. NO: PA-BL-0001.0031-RD-16



LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S2-0109
BLAIR COUNTY, BLAIR TOWNSHIP, PA
SUNOCO PENNSYLVANIA PIPELINE PROJECT

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	MILL ROAD, DUNCANSVILLE, PA		Page 1 of 1
HDD No.:	S2-0109	Dates(s) Drilled: 09-10-15	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: M. HYNES
Drilling Contractor:	HYNES	Groundwater Depth (ft): 15.0	Total Depth (ft): 30.0
Boring Location Coordinates:		40° 24' 33.565" N	78° 26' 34.559" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.6			TOPSOIL (7")					
1	3.0	5.0	0.6		14	SC	DR WEATHERED TO A BROWN AND GRAY FINE TO MEDIUM SAND AND	5	5	7	7	**12**
							CLAY, TRACE UNWEATHERED SHALE FRAGS.					
2	8.0	10.0			24		DR WEATHERED TO A BROWN AND GRAY FINE TO MEDIUM SAND,	4	7	7	8	**14**
				11.5			WITH SOME SILTY CLAY, TRACE UNWEATHERED SHALE FRAGS.					
3	13.0	15.0	11.5		20	CL	DR, MOTTLED GRAY, BROWN, ORANGE BRWN. SILTY CLAY, SOFT	4	5	6	6	**11**
							AT 15'. (USCS: CL)					
4	18.0	20.0			15		GRAY CLAY.	4	5	5	6	**10**
				21.5								
5	23.0	25.0	21.5		14	CL/ SC	DR, VARIEGATED (REDDISH BRWN, YELLOWISH BRWN, GRAY) SILTY	9	22	36	50	**58**
							CLAY & F-SAND, WITH UNWEATHERED SHALE FRAGS. (USCS: CL/SC)					
6	28.0	29.3		30.0	14		DR, VARIEGATED (REDDISH BROWN, YELLOWISH BROWN, GRAY)	25	15	50/3"		**>50**
							AUGER STARTED GRINDING AT 25'.					
							WET ON SPOON AT 15'.					
							WATER LEVEL THROUGH AUGERS AT 15'					
							CAVED AT 14', WATER LEVEL ON CAVE AT 14'.					

Notes/Comments:

Pocket Pentrometer Testing
S2: > 4 TSF
S3: 1.75 TSF
S4: 1.5 TSF

DR: DECOMPOSED ROCK

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

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

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	PALMER LAND, DUNCANSVILLE, PA		Page 1 of 1
HDD No.:	S2-0109	Dates(s) Drilled: 09-10/11-15	Inspector: E. WATT
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586	Driller: M. HYNES
Drilling Contractor:	HYNES	Groundwater Depth (ft): 7.5	Total Depth (ft): 32.0
Boring Location Coordinates:		40° 24' 34.575" N	78° 26' 21.778" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.1			TOPSOIL (2")					
1	3.0	5.0	0.1		20		MOTTLED (GRAY AND BROWN) SILTY CLAY AND FINE TO MEDIUM	3	3	4	6	**7**
							SAND, TRACR F-ROCK FRAGS.					
2	8.0	10.0			12	CL	MOTTLED (BROWN AND ORANGE BROWN) SILTY CLAY AND FINE TO	6	10	8	8	**18**
							MEDIUM SAND, TRACT FINE SANDSTONE GRAVEL. (USCS: CL)					
3	13.0	15.0			23		GRAY AND DARK GRAY SILTY CLAY AND FINE TO MEDIUM SAND,	1	1	1	1	**2**
				18.0			TRACE FINE SANDSTONE GRAVEL.					
4	18.0	20.0	18.0	22.0	5		DARK GRAY PARTIALLY WEATHERED SHALE.	50/5"				**>50**
							AUGER REFUSAL AT 22'.					
							ROCK CORING					
RUN 1	22.0	24.5	22.0		22		DARK GRAY INTENSELY FRACTURED DARK GRAY SHALE.	TCR: 73%, SCR: 28%, RQD: 0%				
RUN 2	24.5	29.5			44	SHALE	DARK GRAY INTENSELY FRACTURED CALCEROUS SHALE.	TCR: 73%, SCR: 38%, RQD: 18%				
RUN 3	29.5	32.0		32.0	30		DARK GRAY MODERATELY FRACTURED CALCEROUS SHALE.	TCR: 100%, SCR: 83%, RQD: 63%				
							WET ON SPOON AT 8'.					
							WATER LEVEL THROUGH AUGERS AT 7.5'.					
							CORE TESTING RESULTS (DEPTH 29-29.5'):					
							COMPRESSIVE STRENGTH: 3.040 PSI					
							UNIT WEIGHT: 166.6 PCF					
							CORE TESTING RESULTS (DEPTH 30-30.5'):					
							COMPRESSIVE STRENGTH: 3,430 PSI					
							UNIT WEIGHT: 179.4 PCF					

Notes/Comments:

Pocket Pentrometer Testing

4': 3.5 TSF

DR: DECOMPOSED ROCK

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

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

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	OLD US 220, DUNCANSVILLE, PA		Page 1 of 1
HDD No.:	S2-0109	Dates(s) Drilled: 09-11-15	Inspector: E. WATT
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: M. HYNES
Drilling Contractor:	HYNES	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 30.0
Boring Location Coordinates:		40° 24' 35.416" N	78° 26' 10.990" W

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
			0.0	0.6			TOPSOIL (7")					
1	3.0	5.0	0.6		14	ML	DR, MOTTLED GRAY AND BROWN SILT AND FINE SAND, LENSES	8	10	15	11	**25**
							OF SANDSTONE GRAVEL, AND M-C SAND.					
2	8.0	10.0			10		DR, MOTTLED GRAY AND BROWN SILT AND FINE SAND, TRACE	14	14	11	13	**25**
							UNWEATHERED SHALE FRAGS. (USCS: ML).					
3	13.0	15.0			10		DR, MOTTLED GRAY AND BROWN SILT WIITH SOME FINE TO MEDIUM	9	9	13	18	**22**
				18.5			SAND, TRACE FINE TO COARSE SHALE FRAGS. (USCS: ML).					
4	18.0	20.0	18.5		18	PARTIALLY WEATHERED SHALE	PARTIALLY WEATHERED BROWN AND LIGHT GRAY SHALE.	10	23	30	33	**53**
5	23.0	24.3			12		PARTIALLY WEATHERED GRAY SHALE.	13	35	50/3"		**>50**
6	28.0	29.1		30.0	11		PARTIALLY WEATHERED GRAY SHALE.	15	38	50/2"		**>50**
							AUGERED TO 30'.					
							CAVED AND DRY AT 15'.					

Notes/Comments:

Pocket Pentrometer Testing

S1, S2, S3: > 4 TSF

DR: DECOMPOSED ROCK

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

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

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0109 PALMER LANE

Location	Boring No.	Core Run	Core Depth (ft)		TCR (%)	SCR (%)	RQD (%)	Depth (ft)		Weathering	Classification	Bedding Thickness (ft)	Color	Discontinuity Data
			From	To				From	To					
S2-0109	SB-2	1	22	24.5	73	28	0	22	32	Moderate	Shale (Potential limestone)	Massive	Dark Gray	Fractures ranging from 0° to 20°, Avg. 12°
		2	24.5	29.5	73	38	17.5							
		3	29.5	32	100	83	63							

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0109 PALMER LAND

	Test				Water	Percent	Atterburg Limits (ASTM D4318)			USCS
HDD	Boring	Sample	Depth of Sample (ft.)		Content, %	Silts/Clays, %	Liquid	Plastic	Plasticity	Classif.
No.	No.	No.	From	To	(ASTM D2216)	(ASTM D1140)	Limit, %	Limit, %	Index, %	(ASTM D2487)
S2-0109	SB-01	1	3.0	5.0	10.2	41.5	-	-	-	-
		2	8.0	10.0	11.9	34.3	-	-	-	-
		3	13.0	15.0	24.9	98.7	36	23	13	CL
		5	23.0	25.0	16.0	51.2	33	21	12	CL/SC
		6	28.0	29.3	17.2	51.0	-	-	-	-
	SB-02	1	3.0	5.0	20.5	69.2	-	-	-	-
		2	8.0	10.0	26.5	75.2	43	25	18	CL
		3	13.0	15.0	29.4	57.5	-	-	-	-
		4	18.0	20.0	12.8	13.6	-	-	-	-
	SB-03	1	3.0	5.0	14.2	67.0	-	-	-	-
		2	8.0	10.0	14.8	63.3	33	25	18	ML
		3	13.0	15.0	13.6	79.6	35	26	9	ML
		4	18.0	20.0	13.2	60.0	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-02	2	29 - 29.5	3,040	166.6
SB-02	3	30 - 30.5	3,430	179.4

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0109 PALMER LANE

HDD No.	NAME	BORING NO.	REGIONAL GEOLOGY DESCRIPTION	GENERAL TOPOGRAPHIC SETTING	BEDROCK FORMATION	GENERAL ROCK TYPE	APPROX MAX FM THICKNESS (FT)	DEPTH TO ROCK (Ft bgs) based on nearby well drilling logs	NOTES / COMMENTS
S2-109	Palmer Lane	SB-01	**Hamilton Group**- The Mahantango Formation and the underlying Marcellus Formation make up the Hamilton Group.	Gentle slope upwards to the east, mix of farmland and woods	Mahatango (aka Hamilton Group)	Shale-siltstone, laminated, fossiliferous			
		SB-02							
		SB-03	**Onondaga and Old Port Formation** (undivided) consists of two members - the upper Selinsgrove Limestone and the lower calcerous Needmore Shale.		Onadaga-Old Port	Limestone and calcareous shale with occasional chert	100-200	4-32	

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

FIELD DESCRIPTION AND LOGGING SYSTEM FOR SOIL EXPLORATION

GRANULAR SOILS

(Sand, Gravel & Combinations)

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

Relative Proportions

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

Particle Size Identification

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

COHESIVE SOILS

(Silt, Clay & Combinations)

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

Plasticity

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

ROCK

(Rock Cores)

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

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

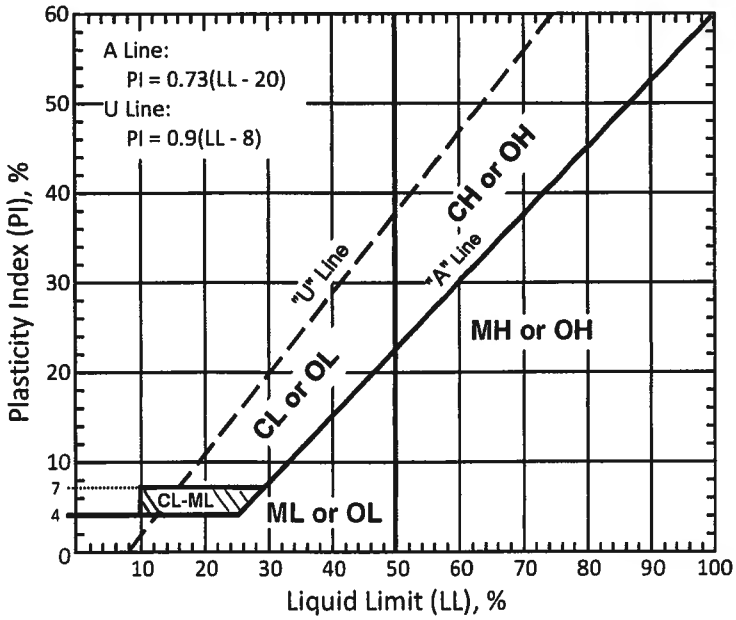
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

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

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

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



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

October 16, 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 3 – Old US 220 Hwy
Commonwealth of Pennsylvania
Drawing # PA-BL-0001.0031-RD
PO # 20170912-2
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 Old US 220 Hwy (Drawing # PA-BL-0001.0031-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 one boring, designated as B3-6W, visual classification and photography of the rock core samples, and laboratory testing of representative rock samples.

Test boring, B3-6W was drilled between September 17 and 18, 2017 to a depth of 171.0 feet, as shown on the attached **Test Boring Location Plan**. Bedrock typically consisted of sedimentary rock comprised of shale. The final test boring log 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 the boring location. As an exception to the planned 20-foot intervals, rock samples from 53 feet to 83 feet were not tested due to highly fractured 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 Log, Laboratory Data, Rock Core Photographs)
SUPPORTING INFORMATION (Unified Soil Classification System, Description of Rock Properties)

TEST BORING LOCATION PLAN

APPROXIMATE BORING LOCATION

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

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

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

TEST BORING LOCATION PLAN

Old US 220 Highway HDD Cores B3-6W
PA-BL-0001.0031-RD
Blair County, Pennsylvania

Exhibit

A-2

EXPLORATION RESULTS

BORING LOG NO. B3-6W Old US 220 Hwy West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION PA-BL-0001.0031-RD
20170912-2
Latitude: 40.409177° Longitude: -78.443108°

Approximate Surface Elev: 1095 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
LEAN CLAY WITH SAND (CL), with mudstone and shale fragments, brown, stiff to very stiff					13	9-7-7 N=14			
		5			13	8-9-8 N=17			
		10			18	5-5-6 N=11			
		15			14	5-7-6 N=13			
18.0	1077+/-								
FAT CLAY (CH), (possible highly weathered shale), gray to dark brown, stiff		20	▽		15	1-3-7 N=10			
24.0	1071+/-								
Highly weathered, light gray SILTSTONE interbedded with sandstone, medium dense		25			13.5	3-4-10 N=14			
Highly weathered, gray-green to brown SANDSTONE with clay, dense		30							

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ *20' on 9/19/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-17-2017 | Boring Completed: 09-18-2017

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

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B3-6W Old US 220 Hwy West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION PA-BL-0001.0031-RD
20170912-2
Latitude: 40.409177° Longitude: -78.443108°
Approximate Surface Elev: 1095 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
				13	23-18-24 N=42			
Highly weathered, dark gray to black SHALE, trace clay		35		3	100/3"			
		40		6	55-25/0"			
		45		1	100/1"			
51.0	1044+/-	50						
Run 1, Moderately hard to hard, moderately to slightly weathered, dark gray to black SHALE with occasional calcite veins, primary joint set, low angle to moderately dipping, very close to close spacing, smooth, fresh to discolored, tight to moderately open				56		46	2.5 2 2.2 2.5 1.5	
56.0	1039+/-	55						
Run 2, Similar		60		60		28	3.5 2.5 4 2 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

▽ *20' on 9/19/17*

Terracon
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Rocky Hill, CT

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BORING LOG NO. B3-6W Old US 220 Hwy West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION PA-BL-0001.0031-RD
20170912-2
Latitude: 40.409177° Longitude: -78.443108°
Approximate Surface Elev: 1095 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)
61.0	1034+/-	Run 2, Similar *(continued)*		60		
		Run 3, Similar		57	55	2.5 2 1.5 2.5 2
66.0	1029+/-		65			
		Run 4, Similar		60	88	3 2 2.5 2.5 1.5
71.0	1024+/-		70			
		Run 5, Similar		60	62	2.5 2 2 3 3
76.0	1019+/-		75			
		Run 6, Similar		57	57	2 2.5 3 3 3
81.0	1014+/-		80			
		Run 7, Moderately hard to hard, slightly to highly weathered, dark gray to black SHALE, unable to properly identify joints due to severity of fractures		24	16	3 3 2.5 3 3
86.0	1009+/-		85			
		Run 8, Moderately hard to hard, fresh to slightly weathered, dark gray to black SHALE, primary joint set, low angle to moderately dipping, close spacing, smooth, fresh to discolored, slightly to moderately open		60	37	4 3 3 2.5 2
			90			

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ *20' on 9/19/17*

Terracon
201 Hammer Mill Rd
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BORING LOG NO. B3-6W Old US 220 Hwy West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION PA-BL-0001.0031-RD
20170912-2
Latitude: 40.409177° Longitude: -78.443108°
Approximate Surface Elev: 1095 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	RECOVERY (In.)	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
91.0	1004+/-	60			
Run 9, Similar		60	35	2.5 2.5 3.5 2.5 2	
96.0	999+/-				
Run 10, Similar		52	48	2 2.5 2 3 4	
101.0	994+/-				
Run 11, Similar		47	52	3 3.5 3.5 3 2.5	
106.0	989+/-				
Run 12, Similar		60	91	2 2 2.5 2 2	
111.0	984+/-				
Run 13, Similar		60	70	2 1.5 1.5 2 3	
116.0	979+/-				
Run 14, Similar		60	88	1.5 2 2 2 2.5	
120					

GRAPHIC LOG | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS

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

▽ *20' on 9/19/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-17-2017 | Boring Completed: 09-18-2017

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

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B3-6W Old US 220 Hwy West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION PA-BL-0001.0031-RD
20170912-2
Latitude: 40.409177° Longitude: -78.443108°
Approximate Surface Elev: 1095 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
121.0	974+/-	Run 14, Similar *(continued)*	60				
		Run 15, Similar, highly weathered from 123.3 to 124.1 feet	60		75	2.5 2.5 2 2.5 3	
126.0	969+/-						
		Run 16, Similar, less fractured	60		91	2.5 2 2 2 2	
131.0	964+/-						
		Run 17, Moderately hard to hard, fresh to slightly weathered, dark gray to black SHALE with occasional calcite veins, primary joint set, low angle to moderately dipping, close spacing, smooth, fresh to discolored, slightly open to open	60		86	2 2 2 2 2	
136.0	959+/-						
		Run 18, Similar	60		95	3 2 2 2 2	
141.0	954+/-						
		Run 19, Similar	60		100	2 2 2.5 2.5 2	
146.0	949+/-						
		Run 20, Similar	60		76	2.5 2.5 1.5 1.5 1.5	

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

Hammer Type: Automatic

Advancement Method:
Mud rotary with wireline

Abandonment Method:
Grouted to surface

Notes:

WATER LEVEL OBSERVATIONS

▽ *20' on 9/19/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-17-2017 | Boring Completed: 09-18-2017

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

Project No.: J217P078 | Exhibit: A-1

BORING LOG NO. B3-6W Old US 220 Hwy West

PROJECT: Mariner East Pipeline Borings

CLIENT: Directional Project Support Incorporated
Magnolia, TX 77354

SITE: Spread 3

LOCATION PA-BL-0001.0031-RD
20170912-2
Latitude: 40.409177° Longitude: -78.443108°
Approximate Surface Elev: 1095 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	Core rate (min/ft)	Penetrometer Test (tsf)
151.0	944+/-				60				
Run 20, Similar *(continued)*									
Run 21, Similar		155			60		100	2.5 2.5 2.5 3 2.5	
156.0	939+/-								
Run 22, Similar		160			60		96	2.5 2 2 2 2	
161.0	934+/-								
Run 23, Similar		165			60		91	2.5 2 2.5 2 2	
166.0	929+/-								
Run 24, Similar		170			58		58	3 2 2 2.5 2	
171.0	924+/-								
Boring Terminated at 171 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

▽ *20' on 9/19/17*

Terracon
201 Hammer Mill Rd
Rocky Hill, CT

Boring Started: 09-17-2017 | Boring Completed: 09-18-2017

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

Project No.: J217P078 | Exhibit: A-1

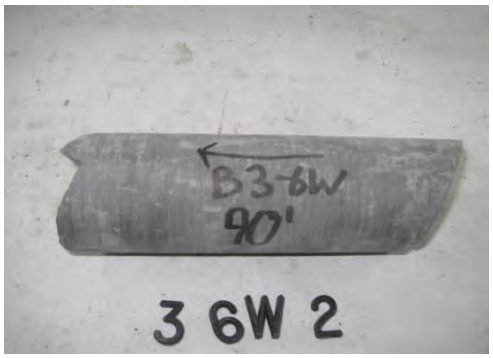
ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-6W	Lithology :	Shale
Sample No.:	2	Moisture Content :	As received
Sample Depth:	90 feet	Lab Temperature :	70° F
Sampling Date:	9/17/17	Loading Rate:	55 psi/s
		Time to Failure:	4 min

Diameter:	1.96 in	Maximum Axial Load at Failure:	12,450 lb
Length:	3.27 in	Compressive Strength:	4,126 psi
L/D:	1.67	Compressive Strength:	28.45 Mpa
End Area:	3.02 in^2	Unit Weight	168 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-BL-0001.0031-RD
PO # :	20170912-2
Crossing :	Old US 220 Hwy
Spread :	Spread 3

Project:	Mariner East Pipeline	Terracon	Performed by:	C. Santana
Project No.	J217P078		Test Date:	10/16/2017
Location:	Spread 3		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/16/2017

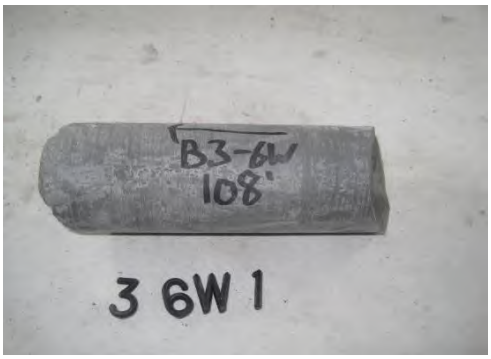
ASTM D7012 (Method C) Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Boring No.:	B3-6W	Lithology :	Shale
Sample No.:	1	Moisture Content :	As received
Sample Depth:	108 feet	Lab Temperature :	70° F
Sampling Date:	9/17/17	Loading Rate:	55 psi/s
		Time to Failure:	3 min

Diameter:	1.96 in	Maximum Axial Load at Failure:	10,810 lb
Length:	3.55 in	Compressive Strength:	3,583 psi
L/D:	1.81	Compressive Strength:	24.70 Mpa
End Area:	3.02 in^2	Unit Weight	167 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



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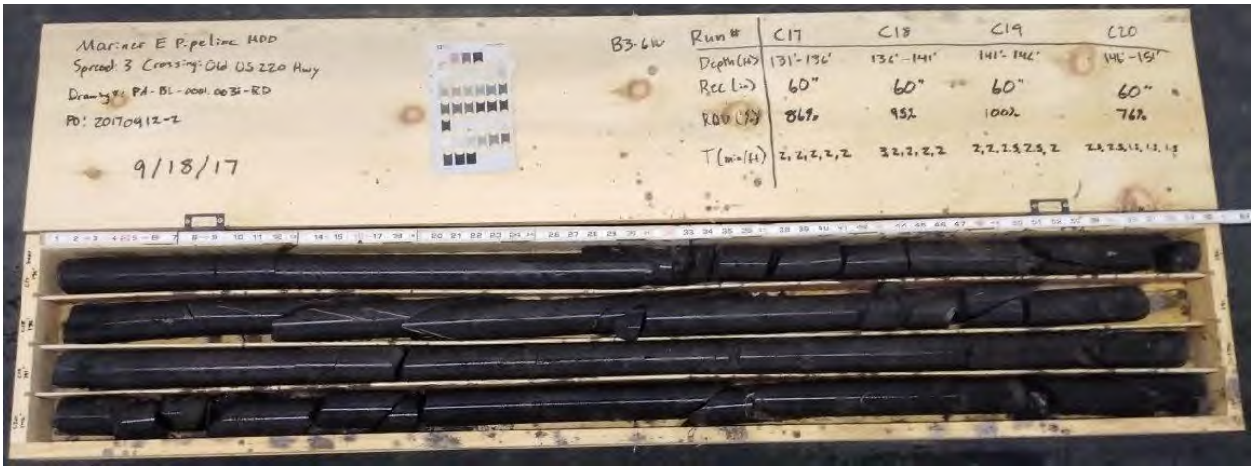
Location:	Spread 3		Reviewed By :	L.Dwyer
Client :	Directional Project Support Inc.	77 Sundial Ave., Suite 401 W Manchester, New Hampshire	Review Date :	10/16/2017

Photograph 1: B3-6W, Samples C-1 to C-4 (51 to 71 feet)

Photograph 2: B3-6W, Samples C-5 to C-8 (71 to 91 feet)

Photograph 3: B3-6W, Samples C-9 to C-12 (91 to 111 feet)

Photograph 4: B3-6W, Samples C-13 to C-16 (111 to 131 feet)



Photograph 5: B3-6W, C-17 to C-20 (131 to 151 feet)

Photograph 6: B3-6W, C-21 to C-24 (151 to 171 feet)

SUPPORTING INFORMATION

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu 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.

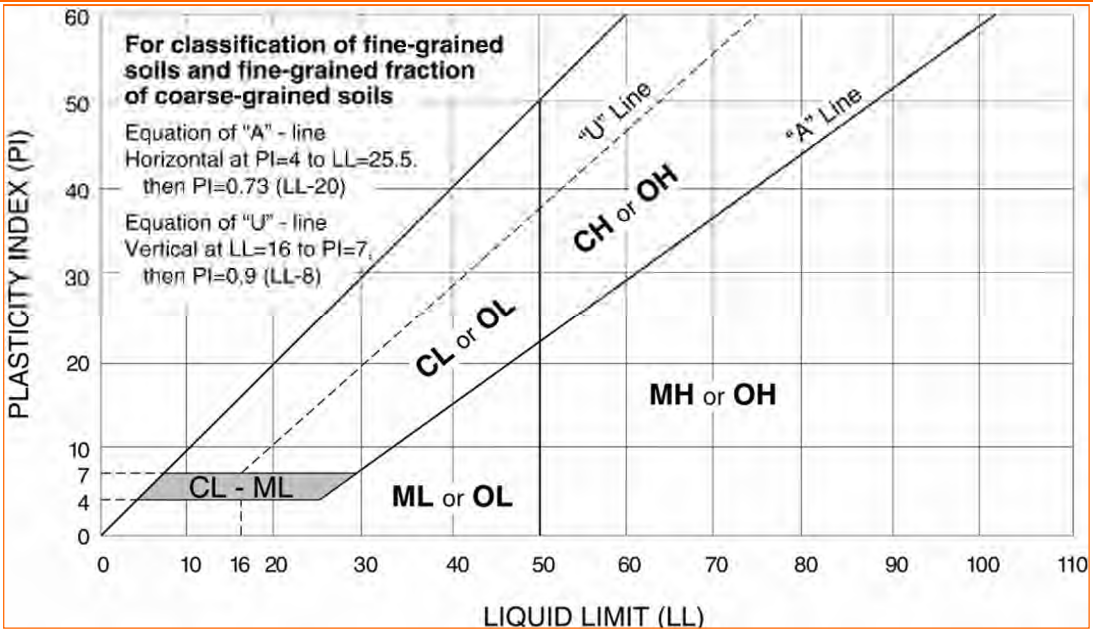
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[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.

RETTEW

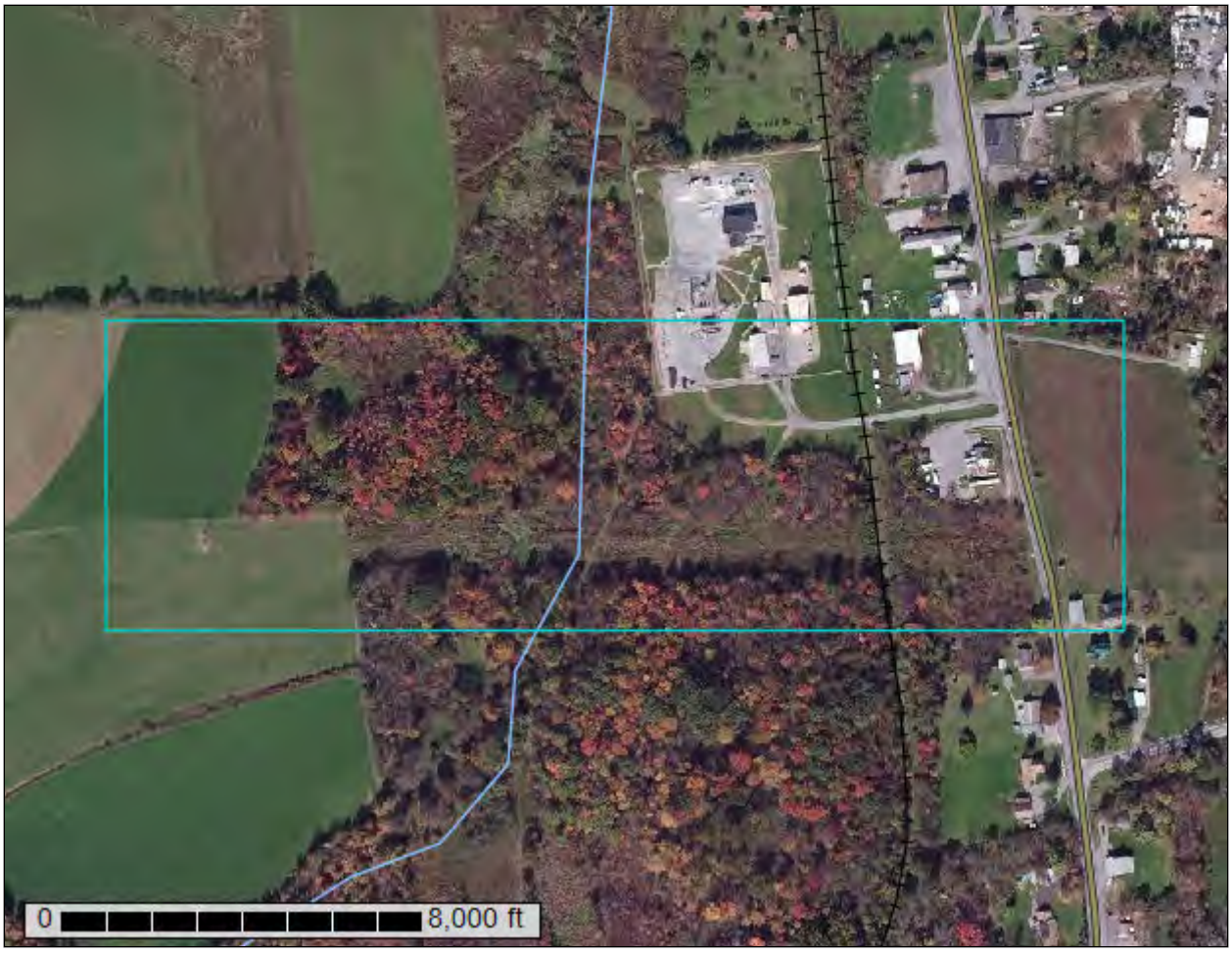
ATTACHMENT 2
SOIL RESOURCES MAP AND PROFILE DESCRIPTIONS

United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Blair County, Pennsylvania



November 10, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

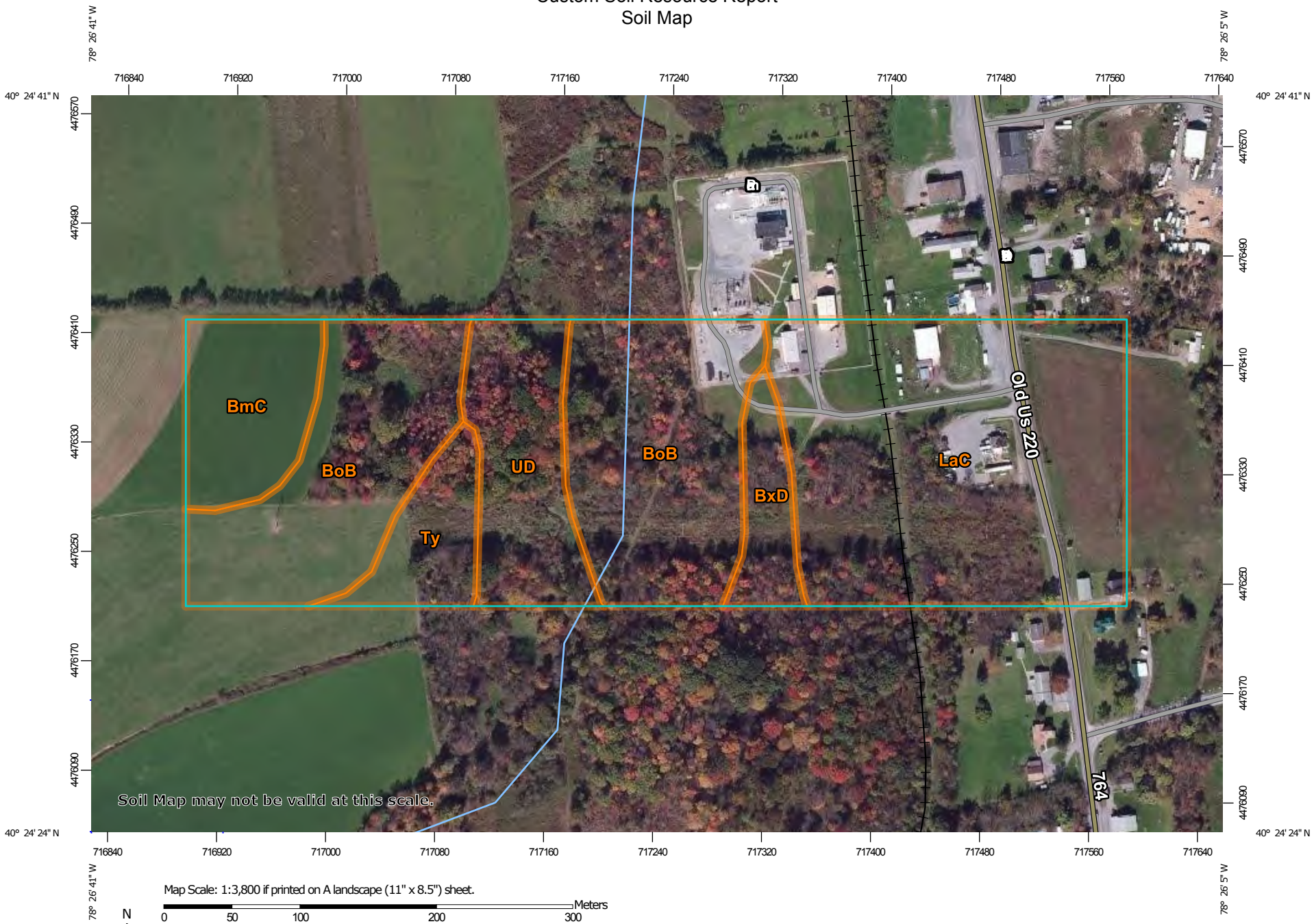
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:3,800 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 150 300 600 900

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Blair County, Pennsylvania
Survey Area Data: Version 12, Oct 27, 2017

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 23, 2010—Feb 22, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BmC	Berks-Weikert channery silt loams, 8 to 15 percent slopes	3.0	8.4%
BoB	Blairton silt loam, 3 to 8 percent slopes	12.7	35.2%
BxD	Buchanan extremely stony silt loam, 8 to 25 percent slopes	1.5	4.2%
LaC	Laidig channery loam, 8 to 15 percent slopes	13.0	36.2%
Ty	Tyler silt loam	1.9	5.4%
UD	Udifluvents-Dystrochrepts complex	3.8	10.6%
Totals for Area of Interest		**35.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it

was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Blair County, Pennsylvania

BmC—Berks-Weikert channery silt loams, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2sgbn
Elevation: 1,120 to 3,600 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 47 to 56 degrees F
Frost-free period: 148 to 192 days
Farmland classification: Not prime farmland

Map Unit Composition

Berks and similar soils: 55 percent
Weikert and similar soils: 35 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Berks

Setting

Landform: Mountain slopes, ridges
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Upper third of mountainflank, side slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Parent material: Residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

Ap - 0 to 8 inches: channery silt loam
Bw1 - 8 to 14 inches: very channery silt loam
Bw2 - 14 to 26 inches: very channery silt loam
C - 26 to 36 inches: extremely channery silt loam
R - 36 to 46 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 1 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: B
Other vegetative classification: Dry Uplands (DU2), Dry Uplands (DU3)
Hydric soil rating: No

Description of Weikert

Setting

Landform: Mountain slopes, ridges
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Upper third of mountainflank, side slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Parent material: Gray and brown acid residuum weathered from shale and siltstone and/or fine grained sandstone

Typical profile

Ap - 0 to 7 inches: channery silt loam
Bw - 7 to 10 inches: extremely channery silt loam
C - 10 to 15 inches: extremely channery silt loam
R - 15 to 25 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Somewhat excessively drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.0 mmhos/cm)
Available water storage in profile: Very low (about 1.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Other vegetative classification: Droughty Shales (SD2)
Hydric soil rating: No

Minor Components

Shelocta

Percent of map unit: 2 percent
Landform: Mountain slopes, ridges
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Lower third of mountainflank, side slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Rough

Percent of map unit: 2 percent
Landform: Mountain slopes, ridges
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Upper third of mountainflank, side slope

Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Gilpin

Percent of map unit: 2 percent
Landform: Mountain slopes, ridges
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Upper third of mountainflank, side slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Macove

Percent of map unit: 2 percent
Landform: Mountain slopes, ridges
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Lower third of mountainflank, side slope
Down-slope shape: Convex
Across-slope shape: Convex, linear
Other vegetative classification: Acid Loams (AL3)
Hydric soil rating: No

Blairton

Percent of map unit: 2 percent
Landform: Mountain slopes, ridges
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Upper third of mountainflank, head slope
Down-slope shape: Convex, concave
Across-slope shape: Convex, concave
Hydric soil rating: No

BoB—Blairton silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l6bf
Elevation: 300 to 1,300 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Blairton and similar soils: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Blairton

Setting

Landform: Depressions
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Head slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Local silty colluvium derived from shale and siltstone over acid silty residuum weathered from shale and siltstone

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 22 inches: channery silty clay loam
H3 - 22 to 26 inches: very channery loam
H4 - 26 to 30 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Natural drainage class: Somewhat poorly drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 6 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Brinkerton

Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

BxD—Buchanan extremely stony silt loam, 8 to 25 percent slopes

Map Unit Setting

National map unit symbol: l6bn

Elevation: 300 to 3,000 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 45 to 59 degrees F
Frost-free period: 110 to 217 days
Farmland classification: Not prime farmland

Map Unit Composition

Buchanan and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Buchanan

Setting

Landform: Mountain slopes, valley sides
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Lower third of mountainflank, base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Parent material: Mountain slope colluvium derived from sedimentary rock

Typical profile

H1 - 0 to 4 inches: cobbly loam
H2 - 4 to 30 inches: gravelly clay loam
H3 - 30 to 65 inches: channery clay loam

Properties and qualities

Slope: 8 to 25 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 20 to 36 inches to fragipan
Natural drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Hazleton

Percent of map unit: 5 percent
Hydric soil rating: No

Andover

Percent of map unit: 4 percent
Landform: Depressions
Landform position (three-dimensional): Mountainbase
Down-slope shape: Concave
Across-slope shape: Concave

Hydric soil rating: Yes

Berks

Percent of map unit: 2 percent
Hydric soil rating: No

Bedington

Percent of map unit: 2 percent
Hydric soil rating: No

Philo

Percent of map unit: 2 percent
Hydric soil rating: No

LaC—Laidig channery loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: l6cr
Elevation: 400 to 3,800 feet
Mean annual precipitation: 34 to 60 inches
Mean annual air temperature: 50 to 57 degrees F
Frost-free period: 120 to 175 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Laidig and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Laidig

Setting

Landform: Ridges
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Lower third of mountainflank
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Loamy colluvium derived from sandstone and siltstone

Typical profile

H1 - 0 to 8 inches: channery loam
H2 - 8 to 32 inches: very channery loam
H3 - 32 to 60 inches: very channery sandy clay loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 28 to 35 inches to fragipan
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.60 in/hr)
Depth to water table: About 30 to 48 inches
Frequency of flooding: None

Frequency of ponding: None
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Ty—Tyler silt loam

Map Unit Setting
National map unit symbol: l6dz
Elevation: 300 to 2,000 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 45 to 59 degrees F
Frost-free period: 120 to 180 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Tyler and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tyler

Setting
Landform: Terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Old alluvium derived from sedimentary rock

Typical profile
H1 - 0 to 9 inches: silt loam
H2 - 9 to 19 inches: silty clay loam
H3 - 19 to 50 inches: silty clay loam
H4 - 50 to 60 inches: stratified gravelly loam to silty clay loam

Properties and qualities
Slope: 0 to 3 percent
Depth to restrictive feature: 15 to 36 inches to fragipan
Natural drainage class: Somewhat poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Purdy

Percent of map unit: 5 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: Yes

Monongahela

Percent of map unit: 5 percent
Hydric soil rating: No

UD—Udifluvents-Dystrochrepts complex

Map Unit Setting

National map unit symbol: l6f0
Elevation: 200 to 1,300 feet
Mean annual precipitation: 30 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Not prime farmland

Map Unit Composition

Udifluvents and similar soils: 50 percent
Dystrochrepts and similar soils: 30 percent
Minor components: 4 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udifluvents

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 6 inches: channery silt loam
H2 - 6 to 42 inches: gravelly loam
H3 - 42 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 36 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Hydric soil rating: No

Description of Dystrochrepts

Setting

Landform: Mountain slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 6 inches: loam, flagstones
H2 - 6 to 42 inches: gravelly loam
H3 - 42 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 36 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Low (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Brinkerton

Percent of map unit: 2 percent
Landform: Hills
Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Holly

Percent of map unit: 2 percent
Landform: Backswamps, depressions on flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

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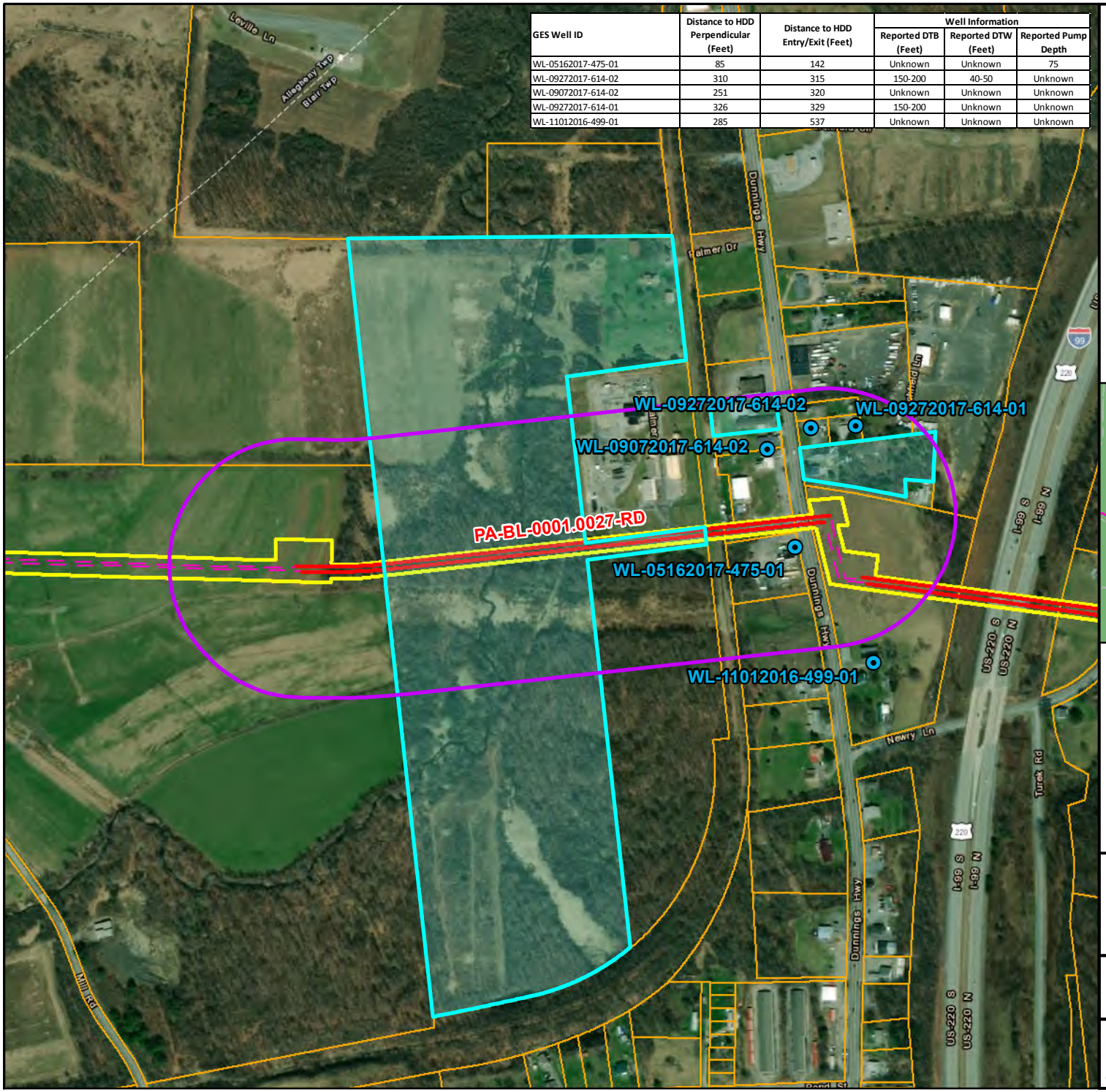
RETTEW

ATTACHMENT 3
450-FOOT WELL SURVEY



GES Well ID	Distance to HDD Perpendicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
WL-05162017-475-01	85	142	Unknown	Unknown	75
WL-09272017-614-02	310	315	150-200	40-50	Unknown
WL-09072017-614-02	251	320	Unknown	Unknown	Unknown
WL-09272017-614-01	326	329	150-200	Unknown	Unknown
WL-11012016-499-01	285	537	Unknown	Unknown	Unknown

Legend

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

****Testing locations current as of 07/30/2018**

- GES Testing Location

Location

N

0 250 500 Feet

Well Location Map
HDD# PA-BL-0001.0027-RD
Blair County, PA.

Prepared By: TETRA TECH

Date: 1/10/2019

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

Coordinate System: NAD 83 Stateplane, PA South, Feet

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Bugley Water Sample Analytical Results Summary

Parcel ID: 04.00-03..-011.00-000 (16821 Old Route 220 North)
Well Location Map ID: WL-09072017-614-02

Parameter	Units	Sample Date: 9/7/2017 Sample I.D.: 09072017-614-02	PA DEP Drinking Water MCL/SMCL
Coliform, fecal	col/100ml	< 1	-
E. Coli	MPN/100ml	< 1	-
Coliform, total	MPN/100ml	< 1	-
Dissolved Solids	mg/l	329	500
Suspended Solids	mg/l	49.2	-
Hardness (colorimetric) as CACO3	mg/l	98.2	-
Turbidity	NTU	1.88	-
Alkalinity	mg/l	ND	-
pH	SU	5.30	-
Specific Conductance	umhos/cm	541	-
Bromide	mg/l	ND	-
Chloride	mg/l	119	250
Sulfate	mg/l	16.0	250
Barium	mg/l	0.459	2
Calcium	mg/l	17.3	-
Iron	mg/l	**7.83**	0.3
Magnesium	mg/l	8.99	-
Manganese	mg/l	**0.150**	0.05
Potassium	mg/l	1.90	-
Sodium	mg/l	58.5	-
Methane	mg/l	0.03866	-
Ethane	mg/l	ND	-
Ethene	mg/l	ND	-
Propane	mg/l	ND	-
Benzene	mg/l	ND	0.005
Toluene	mg/l	ND	1
Ethylbenzene	mg/l	ND	0.7
Total Xylenes	mg/l	ND	10
Residual Bentonite	-	NA	-

20-inch HDD construction dates: June 22, 2017 through September 26, 2017
16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:
1. MCL - Maximum Primary Contaminant Level
2. SMCL - Maximum Secondary Contaminant Level
3. NA - Not Analyzed
4. ND - Not Detected
5. col/100ml - colonies per 100 milliliters
6. MPN/100ml - most probable number per 100 milliliters
7. mg/l - milligrams per liter
8. NTU - nephelometric turbidity units
9. SU - standard units
10. umhos/cm - micro ohms per centimeter

Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL

Lanzendorfer Well #1 Water Sample Analytical Results Summary

Parcel ID: 04.00-03..-028.00-000 (16824 Dunnings Highway)
Well Location Map ID: WL-09272017-614-02

Parameter	Units	Sample Date: 9/27/2017 Sample I.D.: 09272017-614-02	PA DEP Drinking Water MCL/SMCL
Coliform, fecal	col/100ml	14.0	-
E. Coli	MPN/100ml	10.9	-
Coliform, total	MPN/100ml	> 2419.6	-
Dissolved Solids	mg/l	31.0	500
Suspended Solids	mg/l	84.0	-
Hardness (colorimetric) as CACO3	mg/l	ND	-
Turbidity	NTU	195	-
Alkalinity	mg/l	22.5	-
pH	SU	7.94	-
Specific Conductance	umhos/cm	58.8	-
Bromide	mg/l	ND	-
Chloride	mg/l	5.90	250
Sulfate	mg/l	ND	250
Barium	mg/l	0.00621	2
Calcium	mg/l	3.89	-
Iron	mg/l	**47.5**	0.3
Magnesium	mg/l	ND	-
Manganese	mg/l	**0.0751**	0.05
Potassium	mg/l	ND	-
Sodium	mg/l	5.49	-
Methane	mg/l	0.0762	-
Ethane	mg/l	ND	-
Ethene	mg/l	ND	-
Propane	mg/l	ND	-
Benzene	mg/l	ND	0.005
Toluene	mg/l	ND	1
Ethylbenzene	mg/l	ND	0.7
Total Xylenes	mg/l	ND	10
Residual Bentonite	-	NA	-

20-inch HDD construction dates: June 22, 2017 through September 26, 2017
16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:
1. MCL - Maximum Primary Contaminant Level
2. SMCL - Maximum Secondary Contaminant Level
3. NA - Not Analyzed
4. ND - Not Detected
5. col/100ml - colonies per 100 milliliters
6. MPN/100ml - most probable number per 100 milliliters
7. mg/l - milligrams per liter
8. NTU - nephelometric turbidity units
9. SU - standard units
10. umhos/cm - micro ohms per centimeter

Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL

Lanzendorfer Well #2 Water Sample Analytical Results Summary

Parcel ID: 04.00-03..-028.01-001 (16828 Dunnings Highway)
Well Location Map ID: WL-09272017-614-01

Parameter	Units	Sample Date: 9/27/2017 Sample I.D.: 09272017-614-01	PA DEP Drinking Water MCL/SMCL
Coliform, fecal	col/100ml	< 1	-
E. Coli	MPN/100ml	< 1	-
Coliform, total	MPN/100ml	17.5	-
Dissolved Solids	mg/l	197	500
Suspended Solids	mg/l	ND	-
Hardness (colorimetric) as CACO3	mg/l	ND	-
Turbidity	NTU	0.637	-
Alkalinity	mg/l	110	-
pH	SU	7.05	-
Specific Conductance	umhos/cm	299	-
Bromide	mg/l	ND	-
Chloride	mg/l	1.80	250
Sulfate	mg/l	45.2	250
Barium	mg/l	ND	2
Calcium	mg/l	ND	-
Iron	mg/l	ND	0.3
Magnesium	mg/l	ND	-
Manganese	mg/l	ND	0.05
Potassium	mg/l	ND	-
Sodium	mg/l	68.9	-
Methane	mg/l	ND	-
Ethane	mg/l	ND	-
Ethene	mg/l	ND	-
Propane	mg/l	ND	-
Benzene	mg/l	ND	0.005
Toluene	mg/l	ND	1
Ethylbenzene	mg/l	ND	0.7
Total Xylenes	mg/l	ND	10
Residual Bentonite	-	NA	-

20-inch HDD construction dates: June 22, 2017 through September 26, 2017
16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:
1. MCL - Maximum Primary Contaminant Level
2. SMCL - Maximum Secondary Contaminant Level
3. NA - Not Analyzed
4. ND - Not Detected
5. col/100ml - colonies per 100 milliliters
6. MPN/100ml - most probable number per 100 milliliters
7. mg/l - milligrams per liter
8. NTU - nephelometric turbidity units
9. SU - standard units
10. umhos/cm - micro ohms per centimeter

Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL

Long Water Sample Analytical Results Summary

Parcel ID: 04.00-03..-031.00-000 (1800 Newry Lane)
Well Location Map ID: WL-11012016-499-01

Parameter	Units	Sample Date: 11/1/2016 Sample I.D.: 11012016-499-01	Sample Date: 6/6/2017 Sample I.D.: 06062017-604-01	Sample Date: 10/25/2017 Sample I.D.: 10252017-614-01	Sample Date: 6/12/2018 Sample I.D.: 06122018-611-02	PA DEP Drinking Water MCL/SMCL
Coliform, fecal	col/100ml	NA	NA	< 1	< 1	-
E. Coli	MPN/100ml	NA	NA	< 1	< 1	-
Coliform, total	MPN/100ml	NA	NA	< 1	< 1	-
Dissolved Solids	mg/l	163	184	158	264	500
Suspended Solids	mg/l	2.60	ND	2.87	6.30	-
Hardness (colorimetric) as CACO3	mg/l	138	145	135	176	-
Turbidity	NTU	10.7	7.49	10.6	19.8	-
Alkalinity	mg/l	120	118	118	118	-
pH	SU	7.67	7.33	7.78	7.29	-
Specific Conductance	umhos/cm	275	301	284	390	-
Bromide	mg/l	ND	ND	ND	ND	-
Chloride	mg/l	11.5	15.7	14.9	36.2	250
Sulfate	mg/l	8.73	8.83	7.89	10.2	250
Barium	mg/l	0.190	0.212	0.190	0.254	2
Calcium	mg/l	50.7	52.8	48.4	69.6	-
Iron	mg/l	**1.34**	**1.48**	**1.23**	**1.90**	0.3
Magnesium	mg/l	2.70	3.26	2.62	3.72	-
Manganese	mg/l	**0.198**	**0.199**	**0.180**	**0.237**	0.05
Potassium	mg/l	ND	ND	ND	2.27	-
Sodium	mg/l	4.09	4.36	3.95	7.32	-
Methane	mg/l	0.0135	ND	ND	0.0263	-
Ethane	mg/l	ND	ND	ND	ND	-
Ethene	mg/l	ND	ND	ND	ND	-
Propane	mg/l	ND	ND	ND	ND	-
Benzene	mg/l	ND	ND	ND	ND	0.005
Toluene	mg/l	ND	ND	ND	ND	1
Ethylbenzene	mg/l	ND	ND	ND	ND	0.7
Total Xylenes	mg/l	ND	ND	ND	ND	10
Residual Bentonite	-	NA	NA	NA	NA	-

20-inch HDD construction dates: June 22, 2017 through September 26, 2017
16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:
1. MCL - Maximum Primary Contaminant Level
2. SMCL - Maximum Secondary Contaminant Level
3. NA - Not Analyzed
4. ND - Not Detected
5. col/100ml - colonies per 100 milliliters
6. MPN/100ml - most probable number per 100 milliliters
7. mg/l - milligrams per liter
8. NTU - nephelometric turbidity units
9. SU - standard units
10. umhos/cm - micro ohms per centimeter

Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL

Amerigas Propane, LP Water Sample Analytical Results Summary

Parcel ID: 04.00.03..-013.02-000
Well Location Map ID: WL-05162017-475-01

Parameter	Units	5/16/2017 Pre-Construction	PA DEP Drinking Water MCL/SMCL
		Sample I.D.: 05162017-475-01	
Coliform, fecal	col/100ml	NA	-
E. Coli	MPN/100ml	NA	-
Coliform, total	MPN/100ml	NA	-
Dissolved Solids	mg/l	266	500
Suspended Solids	mg/l	13.0	-
Hardness (colorimetric) as CACO3	mg/l	127	-
Turbidity	NTU	35.0	-
Alkalinity	mg/l	103	-
pH	SU	6.93	-
Specific Conductance	umhos/cm	495	-
Bromide	mg/l	ND	-
Chloride	mg/l	72.1	250
Sulfate	mg/l	27.1	250
Barium	mg/l	0.0881	2
Calcium	mg/l	39.1	-
Iron	mg/l	**3.58**	0.3
Magnesium	mg/l	5.24	-
Manganese	mg/l	**0.126**	0.05
Potassium	mg/l	1.24	-
Sodium	mg/l	51.9	-
Methane	mg/l	ND	-
Ethane	mg/l	ND	-
Ethene	mg/l	ND	-
Propane	mg/l	ND	-
Benzene	mg/l	ND	0.005
Toluene	mg/l	ND	1
Ethylbenzene	mg/l	ND	0.7
Total Xylenes	mg/l	ND	10
Residual Bentonite	-	NA	-

20-inch HDD construction dates: June 22, 2017 through September 26, 2017
16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:
1. MCL - Maximum Primary Contaminant Level
2. SMCL - Maximum Secondary Contaminant Level
3. NA - Not Analyzed
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5. col/100ml - colonies per 100 milliliters
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9. SU - standard units
10. umhos/cm - micro ohms per centimeter

Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL