HORIZONTAL DIRECTIONAL DRILL ANALYSIS
SUSQUEHANNA RIVER CROSSING
PADEP SECTION 105 PERMIT NOS.: E67-920 and E22-619
PA-YO-0063.0000-RR-16
(SPLP HDD No. S2-0280)

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This reevaluation of the horizontal directional drill (HDD) installation of a 16-inch diameter pipeline that traverses under the Susquehanna River has been completed in accordance with Stipulated Order issued under Environmental Hearing Board Docket No. 2017-009-L (Order). During drilling of the first HDD and installation of the 20-inch diameter pipeline, an inadvertent return (IR) was identified during the pilot phase intersect from the East HDD unit; therefore, the second HDD requires reevaluation in accordance with the Order. The first HDD and 20-inch pipeline installation was initiated before the issuance of the Order.

PIPE INFORMATION

16-Inch: 0.438 wall thickness; X-70

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

ORIGINAL HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 6,706 feet (ft.)
- Entry/Exit angle: 9 degrees
- Maximum Depth of cover: 79 ft.
- Pipe design radius: 1,600 ft.

ROOT CAUSE ANALYSIS FOR THE 20" PIPE INSTALLATION IR

Based upon an analysis by the project geologists and drilling specialists, the occurrence of the two IR events during the installation of the 20" pipe on the Susquehanna River is likely to have been caused by the movement of drilling fluids through fractures and contact/bedding planes in the overlying geologic formation where a Diabase dike had intruded into the Gettysburg Formation, and retention capabilities within the geology were exceeded by the annular bore pressure. As stated in the Hydrogeologic Report (Attachment 1) a Loss of Circulation (LOC) was detected during drilling of the pilot phase in proximity to the IR locations, and the LOC event has been concluded to be the key indicator of the resulting IRs.

GEOLOGIC AND HYDROGEOLOGIC ANALYSIS

HDD S2-0280 is located within the Great Valley Section, also known as the Cumberland Valley Section of the Ridge and Valley Physiographic Province (Pennsylvania Department of Conservation and Natural Resources [PA DCNR], 2000). The dominant topography in areas underlain by the Gettysburg Formation is typified by undulating hills of low relief, to small hills and ridges that are higher than the surrounding countryside. In areas underlain by Diabase, the topography is composed of undulating hills of medium relief with moderately steep and stable natural slopes. Where the Diabase was formed as dikes, the topography is expressed as narrow ridges, whereas areas of larger intrusions or flows form hills of moderate relief. Local relief is low to moderate and ranges from approximately 200 feet above mean sea level (AMSL) to 500 feet AMSL (Google Earth Pro, 2017).

The site is drained by two shallow, unnamed tributary streams and the Susquehanna River, which flows from northwest to southeast across the east-west HDD profile. The unnamed tributaries flow to the north and northeast across the western quarter of the HDD trace before discharging to the Susquehanna River.

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The proposed HDD bore path passes beneath the Susquehanna River, and drilling operations will proceed from both the east and west, performing an "intersect" drill. Accordingly, the entry and exit points are situated on both the eastern and western shores of the river. The area surrounding the eastern shore HDD consists predominantly of an open industrialized floodplain bound to the east by nearby residential properties. The area surrounding the western shore HDD consists of a rural area composed primarily of heavily forested terrain interspersed with suburban residential properties and some open agricultural land.

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

HYDROGEOLOGY, GROUND WATER, AND WELL PRODUCTION ZONES

Bedrock geology ultimately influences the storage, transmission, and use of groundwater. Geologic factors such as rock type, intergranular porosity, rock strata inclination, faults, joints, bedding planes, and solution channels affect groundwater movement and availability. In general, groundwater generally occurs under unconfined conditions within the upper portion of the bedrock and under confined or semi-confined conditions in the deeper portions of the bedrock.

The groundwater flow system in clastic, sedimentary rock typified by the Gettysburg Formation was conceptualized as a series of sedimentary beds with relatively high transmissivity separated by beds exhibiting lower transmissivities. This sequence of beds exhibits different hydraulic properties that collectively act as a series of alternating aquifers, and confining or semi-confining units, forming a leaky multi-aquifer system (LMAS). Groundwater flow paths within the clastic rocks have both local and regional components. Locally, shallow groundwater discharges to the gaining portions of nearby streams, and deeper regional groundwater flow is toward points of regional groundwater discharge such as the Susquehanna River. Groundwater divides may be different for each portion of the groundwater flow system and therefore may not coincide with surface water divides.

The Gettysburg Formation is the uppermost rock unit near HDD S2-0280 beneath much of the river bed, and extending to the eastern shore. On the western shore, and extending approximately 800 feet into the river bed, the site is mapped as being underlain by Diabase. Based upon Tetra Tech's geotechnical exploration activities completed between November 5 and 16, 2014, groundwater was encountered in Boring SB-01 on the York County side overlying the Diabase at a depth of 13 feet below ground surface (bgs), and auger refusal was encountered at 21.5 feet. At Boring SB-03, on the eastern (Dauphin County) shore overlying the Gettysburg Formation, groundwater was not encountered. Nine feet of bedrock was cored at SB-03, and the total depth of the boring was 53 feet bgs. A more recent geotechnical report of exploration activities performed from September 26 through October 5, 2017 was prepared by Intertek Professional Service Industries Inc. According to this report, Boring B-1 (located on the western [York County] shore) encountered groundwater at 15 feet bgs, Diabase bedrock at 30.5 feet, and the bedrock was cored from 30.5 feet to 365 feet bgs. At Boring B-2, groundwater was encountered at 9.2 feet bgs, red/brown sandstone was encountered at 30.5 feet, and interbedded red/brown sandstone and limestone fanglomerate were cored from 30.5 to 160 feet bgs.

Attachment 1 provides an extensive discussion on the hydrogeology which informs this analysis.

INADVERTENT RETURN (IR) DISCUSSION

HDD specialists and geologists employed by SPLP have investigated the HDD design and subsurface geologic conditions. Based on the hydro-structural characteristics of the underlying geology, and the proposed HDD profiles entry/exits within shallow unconsolidated soil materials and presence of Diabase contact faces to interbedded sandstone and limestone, the proposed Susquehanna River 16-inch HDD is

susceptible to IRs of drilling fluids during future HDD operations. A re-designed 16-inch HDD profile, and implementation of drilling Best Management Practices (BMPs) during drilling operations, will be used to reduce the risk of IRs. The 16-inch HDD profile has been re-designed to allow for a deeper crossing beneath the Susquehanna River. The inclination of the entry and exit angles has been increased in order to install the 16-inch pipe through protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original, shorter and shallower profile. From a geologic perspective, the longer and deeper profile, in conjunction with the drilling best management practices, will be used to reduce the risk of an IR.

ADJACENT FEATURES ANALYSIS

This HDD location is 7.1 miles southeast of the City of Harrisburg in Dauphin and York Counties, Pennsylvania. The pipeline alignment crosses under the Susquehanna River from approximately 0.5 mile east of the intersection of Interstate Highway 76 and the River to a location 0.1 mile southwest of Aviation Way.

This HDD location is set under the Susquehanna River (stream S-A22) for the majority of its length, and also traverses beneath forested land at its western entry/exit point and commercial land at its eastern exit/entry point. The HDD also crosses under stream S-H56, wetland BB1, and wetland A-18 which are not designated under Chapter 93 as high quality or exceptional value resources. This HDD traverses beneath two cultural resources sites, avoiding impacts to both. A third cultural resources site is located at the west end/western entry point for the re-designed HDD, but the proposed workspace (which was previously approved for a trenched crossing within the right-of-way and has an approved and actively implemented site avoidance plan) has not changed and does not threaten the site.

SPLP has identified all landowners with property located within 450 ft. of the HDD alignment. There are 23 individual landowners with properties located within 450 ft. of the HDD alignment. SPLP sent each of these landowners a notice letter via both certified and first-class mail on December 1, 2017, that included an offer to sample the landowner's private water supply/well in accordance with the terms of the Order and the Water Supply Assessment, Preparedness, Prevention and Contingency Plan. The letter also requested that each landowner contact the Right-of-Way agent for the local area and provide SPLP with information regarding: (1) whether the landowner has a well; (2) where that well is located, and its depth and size if known; and (3) whether the landowner would like to have the well sampled. In accordance with paragraph 10 of the Order, copies of the certified mail receipts for the letters sent to landowners have been provided to Karyn Yordy, Executive Assistant, Office of Programs at the Department's Central Office.

To date, SPLP has received 20 responses from individual landowners, the remaining 3 parcels were confirmed to be vacant land. Of the 20 that responded, two (2) have confirmed the use of a private water well, and the remaining landowners responded verifying the use of public water supply and/or the SUEZ water company confirmed the parcels are connected to public water. Both private water wells have been located and tested. Neither of these well locations is within 450 ft of the HDD profile.

SPLP agents performed testing and monitoring of the adjacent water wells during the completion of the 20-inch HDD. No affects from the HDD have been documented during monitoring and no complaints were received from the well owner.

To further avoid and mitigate any adverse effects from the HDD to private water wells, and in accordance with the requirements of the Stipulated Order, SPLP will transmit a copy of this HDD analysis to all landowners having a property line within 450 ft. of any direction of this HDD location.

The confirmed well locations are depicted on the well location map provided within the Hydrogeologic Report provided in Attachment 1.

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ALTERNATIVES ANALYSIS

As required by the Order, the reevaluation of HDD S2-0280 includes an analysis of open cut alternatives and potential re-routes. As part of the PADEP Chapter 105 permit process for the Mariner II East Project, SPLP developed and submitted for review a project-wide Alternatives Analysis. During the development and siting of the Project, SPLP considered several different routings, locations, and designs to determine whether there was a practicable alternative to the proposed impact. SPLP performed this determination through a sequential review of routes and design techniques, which concluded with an alternative that has the least environmental impacts, taking into consideration cost, existing technology, and logistics. The baseline route provided for the pipeline construction was to cross every wetland and stream on the project by open cut construction procedures. The Alternatives Analysis submitted to PADEP conceptually analyzed the potential feasibility of any alternative to baseline route trenched resource crossings (e.g., reroute, conventional bore, HDD). The decision-making processes for selection of the HDD instead of an open cut crossing methodology is discussed thoroughly in the submitted alternatives analysis and was an important part of the overall PADEP approval of HDD plans as currently permitted. As described below, the open cut and re-route analyses have confirmed the conclusions reached in the previously submitted Alternatives Analysis.

Open-cut Analysis

Conversion to an open cut trenched crossing method would result in direct but temporary impacts to the Susquehanna River (stream S-A22), stream S-H56 (PADEP-designated warmwater fishery), wetland BB1 (palustrine emergent wetland), wetland A18 (palustrine forested wetland), and two cultural resources sites that would be avoided with an HDD crossing method. SPLP specifications require a minimum of 48 inches of cover between the installed pipeline and the bottom of the watercourse. To meet this cover requirement, during trenched construction through this area, a workspace with a width up to 75 feet would be required to accommodate the pipelines and provide sufficient space for trench excavation, spoil storage, and sufficient separation between pipelines (for integrity management). The assessed area of impact by this open cut plan would directly affect approximately 6.8 acres of river/stream bed and 8.07 acres of impact to the floodway of the river and stream, compared to no river/stream bed impacts and only 1.06 acres of floodway impact for the currently proposed HDD. Both the Susquehanna River (stream S-A22) and stream S-H56 have perennial flow regimes. The crossing of the Susquehanna River is extensive in width (3,908 ft) and has extensive fluctuations in water flows and water elevations. Due to this width and changes in the water regime, the practical means to cross the river is by open water trench excavation, pipe lay, and backfilling. To minimize the duration of the crossing and equipment operations within the river, a dual line core holes would be drilled on 8-ft intervals over the line of the pipeline trench, explosive charges would be set at 10-12 ft of rock depth, and the trench line would be established by detonation to shatter the bedrock, followed by mechanical excavation and sidecasting of the excavated materials. The pipeline would be placed by a push-float method, and then sunk into the excavated trench, followed by backfilling using side sweeping of the excavated materials back into the open trench to cover the pipeline. This method would result in significant but temporary effects to water quality. Conventional crossings of the two smaller streams would require using upstream and downstream sandbag diversion dams or coffer dams, pumping stream flow around the trench/workspace, pumping out (from the in-stream workspace or excavated areas) any produced groundwater discharge or seepage around/under the dams (through water filter bags), for the duration of the crossing event. SPLP's preferred method is to drill below these resources to avoid and minimize impacts to water and wetland resources, cultural resources and other features (e.g., railroads) present.

In addition, converting to an open cut trenched crossing method through this area would result in impacts to wetland BB1 and wetland A18, including approximately 0.042 acre and 0.13 acre of impacts to PEM and PFO wetland vegetative cover types, respectively. The HDD will largely avoid surface impacts to biological features and as currently proposed, results in no surface impacts to wetlands (impact avoidance) compared to the open cut alternative.

Open cut impacts to these resources would require modification of the state and federal permits. Moreover, any produced groundwater in the open excavations would be pumped to a discharge filtration structure. The current feasible filtration ability, however, does not exceed 50 microns. Therefore, cloudy water (from suspended fine clay and silt particles) would be discharged downstream regardless of all control methods employed for the entire duration of the use of open cut construction techniques.

Finally, conventional auger bore is technically limited to less than 200 linear ft. at a time varying by the underlying substrate. Due to the spacing constraints at the location of this HDD, there are no subset locations within this length of area to feasibly employ this type of installation method.

Re-Route Analysis

The pipeline route as currently permitted follows an existing SPLP easement and then deviates to the north for this HDD to avoid impacts to forested wetlands which provide a buffer, along with other forested lands, along the western shoreline of the Susquehanna River. This alignment bypasses or avoids directly impacting forested wetlands, forested land, two cultural resources sites, and the Harrisburg International Airport situated on the eastern shoreline of the Susquehanna River.

The general route of the Mariner II Project in this area of the state is from west to east.

As noted previously, this HDD was shifted to the north to avoid forested wetlands. If the pipeline route was shifted further to the north, it would cross existing subsurface utility lines situated between the proposed route and Interstate Highway 76. Additionally, the shift further to the north would result in new “greenfield” corridor through existing woodlands along the northern shoreline of the Susquehanna River. This more northern alignment would locate the pipeline on the east side of the Susquehanna River in a commercial area high density residential area prior to it adjoining with an existing utility corridor. An existing pipeline corridor is located approximately 0.3 mile south of this HDD. Use of this corridor as an alternative route to the replace the HDD proposed for this crossing would require additional impacts to woodlands and necessitate traversing under the Harrisburg International Airport to adjoin with the utility corridor on the east side of the Susquehanna River.

In summary, due to the woodlands along the western and eastern shoreline of the Susquehanna River and the urban setting and location of the Harrisburg International Airport along the west shoreline of the Susquehanna River, there is no alternative route that could avoid conflicts with existing development and existing woodland buffers to Susquehanna River.

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

REDESIGNED HORIZONTAL DIRECTIONAL DRILL DESIGN SUMMARY: 16-INCH

- Horizontal length: 7,380 ft.
- Entry/Exit angle: 13-15 degrees
- Maximum Depth of cover: 245 ft.
- Depth below Susquehanna River: 113-131 ft.
- Pipe design radius: 2,000 ft.

The 16-inch HDD profile has been re-designed to allow for a deeper crossing beneath the Susquehanna River than was completed for the 20-inch pipeline installation. The inclination of the entry and exit angles has been increased in order to install the 16-inch pipe through protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original, shorter and shallower profile. From a geologic

perspective, the longer and deeper profile, in conjunction with the proposed engineering controls and/or drilling best management practices, will be used to reduce the risk of an IR.

This HDD is planned as an "intercept drill". An intercept drill utilizes a drilling rig on each end of the HDD, drilling the pilot hole towards an "intercept point" in the horizontal run of the planned profile. Once the two pilot holes meet up and are joined together, then one drilling rig chases the other rig's drilling stem string out to maintain drilling stem within the pilot hole for the entire length of the profile. Reaming of the profile is typically completed by one drilling rig alone, typically pulling the reaming tool through the profile, or may be done by two rigs operating on each end, called a pull/push reaming process.

Upon the start of this HDD, SPLP will employ the following HDD best management practices:

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

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

- SPLP's drilling contractor will utilize the drilling and monitoring log data for the 20-inch HDD as guidance on approaching the potential zone where drilling fluids were lost, Station 44+10 (first IR) and Station 44+50 (second IR) during the 20-inch HDD, such that corrective action by injection of Loss Control Materials (LCMs), or grouting can be implemented if the APM or return of drilling fluids indicate a loss in the same general area of the profile, or elsewhere;

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

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

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

- During all drilling phases, the use of LCMs can be implemented if indications of a potential IR are noted or an IR is observed, and

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

CONCLUSION

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

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FEASIBILITY DETERMINATION

Based on the information reviewed by the HDD Re-evaluation Team, consisting of the Geotechnical Evaluation Leader, Professional Geologists, Professional Engineers, and HDD Specialists, it is the HDD Re-evaluation Team's professional opinion that the proposed HDD design and implementation of the management measures contained within this re-revaluation report will minimize the risk of IRs and impacts to public and private water supplies during the construction phases of the HDD.

8-16-2018
Date

Larry J. Gremminger, CWB
Geotechnical Evaluation Leader
Mariner East 2 Pipeline Project

Pertaining to the practice of geology as set forth in the attached Hydrogeologic Re-evaluation Report

8/16/18
Date

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

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
DOUGLAS JAY HESS
GEOLOGIST
PG000186G

Pertaining to Pipe Stress and HDD Geometry

8/16/18
Date

Jeffrey A. Lowy, P.E.
License No. PE082759
Rooney Engineering, Inc.
Civil Engineer

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JEFFREY A. LOWY
ENGINEER
PE082759
8/16/18

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ATTACHMENT 1

GEOLOGY AND HYDROGEOLOGICAL EVALUATION REPORT

449 Eisenhower Boulevard, Suite 300
Harrisburg, PA 17111-2302

E-mail: skellyloy@skellyloy.com
Internet: www.skellyloy.com

SKELLY AND LOY
ENGINEERING - ENVIRONMENTAL CONSULTANTS

Phone: 717-232-0593
800-892-6532

Fax: 717-232-1799

August 9, 2018

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

Re: Sunoco PA Pipeline Project Mariner East II, Susquehanna River Horizontal Directional Drill (HDD), Location (S2-0280)
Hydrogeological Re-Evaluation Report
Lower Swatara Township, Dauphin County, and Fairview Township, York County, Pennsylvania
Rettew Project No. 096302011

EXECUTIVE SUMMARY

1. During drilling of the first HDD S2-0280 and installation of the 20-inch-diameter pipeline, an inadvertent return (IR) was identified during the pilot phase intersect from the East HDD unit; therefore, the second HDD for installation of the 16-inch HDD S2-0280 requires re-evaluation in accordance with the Corrected Stipulated Order of August 10, 2017, including a hydrogeologic report.

2. The Susquehanna River HDD bore path is underlain by sedimentary rocks of the Triassic age Gettysburg Formation (Trg) and crystalline intrusive (igneous) rocks composed of Jurassic age Diabase (Jd).

3. Geologic mapping, published reports, and field observations indicate a moderate degree of bedrock fracturing in the Gettysburg Formation, characterized by a blocky, moderately to well-developed pattern of open joints with low angle northwest dipping beds. Geologic mapping, published reports, and field observations indicate that the younger diabase is characterized by moderately abundant, well-developed, and open joints exhibiting a blocky pattern that generally intruded along gently dipping bedding planes and fractures of older rock.

4. Water-bearing zones generally occur in secondary openings along bedding planes, joints, faults, and fractures. Water-bearing zones in the Gettysburg Formation are reported to be distributed within the first 5 to 900 feet of the subsurface, with the greatest density of water-bearing zones occurring within the upper 288 feet of the subsurface (half occur below 115 feet and 90% occur at depths of less than 288 feet). Water-bearing zones in the diabase generally occur in the upper, weathered portion of the bedrock; however, half of these occur within the uppermost 75 feet of the subsurface, with the greatest density of water-bearing zones occurring within the upper 350 feet of

the subsurface. As a result, the storage and transmission of groundwater in the diabase is primarily dependent on the degree and extent of fracturing and joint development.

5. To date, the 30-inch ream and 20-inch pipe pullback are complete. Two IRs were observed in the Susquehanna River during the completion of the 20-inch HDD at similar locations along the trajectory length approximately 410 feet east of the western shoreline and 130 feet south of the bore path. The initial IR occurred on July 19, 2017, and was estimated to consist of 495 gallons of drilling fluids. A second small volume IR occurred in the river on September 15, 2017, approximately 30 feet west of the initial IR location. No HDD operations have been started at the Susquehanna River site for the proposed 16-inch pipeline.

6. Based on the hydro-structural characteristics of the underlying geology and the proposed HDD profiles within shallow unconsolidated soil materials and generally shallow bedrock, the proposed Susquehanna River 16-inch HDD is susceptible to the inadvertent return of drilling fluids during future HDD operations. A redesigned 16-inch HDD profile and implementation of Best Management Practices (BMPs) during drilling operations will be used to reduce the risk of an IR. The proposed 16-inch HDD profile has been redesigned to allow for a deeper crossing beneath the Susquehanna River. The inclination of the entry and exit angles has been increased in order to install the 16-inch pipe through protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original shorter and shallower profile. 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.

1.0 INTRODUCTION

The purpose of this report is to describe the hydrogeologic setting of the Susquehanna River (S2-0280) HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project-Mariner East II (PPP-ME2) Project. The Susquehanna River HDD (the site) is located in Lower Swatara Township, Dauphin County, and Fairview Township, York County, Pennsylvania. The site is located approximately 7 miles southeast of Harrisburg and approximately 0.5 mile south of Highspire and the Pennsylvania Turnpike (I-76). The HDD was designed to be drilled under Marsh Run Road, the Susquehanna River, two small tributary streams discharging to the river, a wetland, a railway, and numerous buried and overhead utilities (refer to **Figure 1**). This hydrogeologic report is part of the response to the Corrected Stipulated Order dated August 10, 2017, related to the potential for the inadvertent return of drilling fluids during proposed drilling operations.

HDD S2-0280 is located within the Great Valley Section, also known as the Cumberland Valley Section of the Ridge and Valley Physiographic Province (Pennsylvania Department of Conservation and Natural Resources [PA DCNR], 2000). The dominant topography in areas underlain by the Gettysburg Formation is typified by undulating hills of low relief, to small hills and ridges that are higher than the surrounding countryside. In areas underlain by diabase, the

topography is comprised of undulating hills of medium relief with moderately steep and stable natural slopes. Where the diabase was formed as dikes, the topography is expressed as narrow ridges; whereas areas of larger intrusions or flows form hills of moderate relief. Local relief is low to moderate and ranges from approximately 200 feet above mean sea level (AMSL) to 500 feet AMSL (Google Earth Pro, 2017). The site is drained by two shallow unnamed tributary streams and the Susquehanna River which flows from northwest to southeast across and over the east-west HDD alignment. The unnamed tributaries flow to the north and northeast across the western quarter of the HDD alignment before discharging to the Susquehanna River. The proposed HDD bore profile passes beneath the Susquehanna River, and drilling operations will proceed from both the east and west. As a result, the entry and exit points are situated on both the eastern and western shores of the river. The area surrounding the eastern shore HDD consists predominantly of an open industrialized floodplain bound to the east by nearby residential properties. The area surrounding the western shore HDD consists of a rural area composed primarily of heavily forested terrain interspersed with suburban residential properties and some open agricultural land.

The redesigned 16-inch HDD entry/exit point on the eastern shore is at a surface elevation of 309 feet AMSL and forms a slightly concave HDD profile that slopes gently upward toward the west to an elevation of 493 feet AMSL at the HDD entry/exit point on the western shore. As stated above, the proposed 16-inch HDD will be completed by drilling toward the center of the HDD trace from entry points located on the east and west ends of the bore path. The proposed 16-inch HDD crosses under unnamed tributary stream S-H58 at depths ranging from 53 to 107 feet below ground surface (bgs), the Columbia Gas pipeline at 250 feet bgs, unnamed tributary stream S-H56 at 245 feet bgs, the west shore Norfolk-Southern railway at 165 feet bgs, the Susquehanna River at 131 to 135 feet bgs, Wetland W-BB1 at 130 to 135 feet bgs, the Buckeye pipeline at 25 to 135 feet bgs, Sunoco's Mariner East 1 pipeline at 90 feet bgs, and the east shore Norfolk-Southern railway at 55 to 70 feet bgs. The proposed 16-inch HDD is located between Pipeline Project Station Nos. 11156+00 and 11228+00, for an overall horizontal length of 7,380 feet. The proposed S2-0280 HDD location is shown on **Figure 1**.

2.0 GEOLOGY AND SOILS

Fourteen available published and online references were reviewed to evaluate the hydrogeology and soils present in the vicinity of the proposed Susquehanna River HDD (S2-0280). Detailed descriptions of the soils and bedrock geology underlying S2-0280 are included in the following section.

According to the United States Department of Agriculture Soil Survey of York and Dauphin Counties, Pennsylvania, soils within 450 feet of the drill path for HDD S2-0280 on the western, or York County, shore of the river consist of Neshaminy channery silt loam, 3 to 8% slopes (NaB); Watchung silt loam, 0 to 8% slopes, extremely boulder (WbB); Mount Lucas silt loam, 3 to 8% slopes (MdB); Neshaminy channery silt loam, 8 to 25% slopes (NdD); and Neshaminy channery silt loam, 25 to 45% slopes (NdE). On the eastern, or Dauphin County, shore, the soils are described as Urban land, alluvial materials (Ua); Urban land, limestone

materials (Ub); and Tioga fine sandy loam, high bottom (Tg). A site map showing the spatial distribution of the various soils, along with the soil profile descriptions, is included as **Attachment 1**.

The geologic structure of the Ridge and Valley Physiographic Province is characterized by a series of alternating ridges formed on more resistant sandstones and quartzites and valleys underlain by more easily eroded shales and limestones. Bedrock in the Ridge and Valley Province is severely folded with numerous anticlines and synclines, faults, and thrust faults. The site is underlain by an igneous intrusive feature known as the York Haven Pluton composed of Jurassic age diabase (Jd) that occurs on the western side of the Susquehanna River and extends to the east approximately 800 feet beneath the river. Adjacent to and paralleling the eastern edge of the diabase unit extending under the river is a section of metamorphosed or "baked sediments" that include the argillite described below. A majority of the river bed extending to the eastern shore is underlain by the Triassic age Gettysburg Formation. The bedrock geology mapped at the site is depicted on **Figure 2**.

The Jurassic age diabase is dark gray to black, dense, very fine-grained, and consists of 90 to 95% labradorite and augite. The diabase occurs primarily as intrusive dikes and sheets that are highly resistant to weathering. Weathering of this unit produces characteristic large rounded boulders and a thin soil mantle. Jointing in this unit is characterized as having a blocky pattern with individual joints being well-developed, moderately abundant, regularly spaced, open, and steeply dipping. Joint openings provide a very low secondary porosity with low permeability. The topography is characterized by undulating hills of medium relief with natural slopes that are moderately steep and stable. Where the diabase occurs as dikes, it typically forms narrow ridges, whereas the larger intrusions form hills of moderate relief. Excavation and/or drilling are slow due to the density and hardness of the rock.

According to Geyer and Wilshusen (1982), the Triassic age Gettysburg Formation is composed of reddish-brown shale and soft, red-brown, medium- to fine-grained sandstone with a minor amount of yellowish-brown shale and sandstone. It may be metamorphosed by the intrusive diabase to form baked sediments of dark purple to black argillite. The Gettysburg Formation is moderately to well-bedded with individual beds ranging from thin to flaggy (sandstone, siltstone, and shale) and thick to massive (conglomerate, limestone fanglomerate, and quartz fanglomerate) with moderately developed, moderately abundant, closely spaced, naturally occurring fractures known as joints. These joints are typically blocky, open, and steeply dipping. Primary porosity occurs in the weathered portion of the formation. The joint and bedding plane openings collectively provide a secondary porosity in unweathered rock. The topography is characterized by undulating valleys of low relief. Natural slopes are moderately steep and stable, and cut slope stability is rated fair to poor due to the tendency for rapid weathering when exposed to moisture. The overlying soil mantle is generally thin. The shales comprising the formation are also moderately weathered to a moderate depth, whereas areas underlain by sandstones and conglomerates exhibit much less weathering. The formation is moderately easy to excavate. The rock reportedly provides good foundation stability. Drilling rates are typically moderate to fast except in areas where rock is adjacent to diabase intrusions

because the "baked" rock is harder and the drilling rate is slower (Becher and Root, 1981; Geyer and Wilshusen, 1982; and, Low, et. al., 2002). **Figure 2** depicts an area of this baked rock along the western shore of the Susquehanna River.

3.0 HYDROGEOLOGY

Bedrock geology ultimately influences the storage, transmission, and use of groundwater. Geologic factors such as rock type, intergranular porosity, rock strata inclination, faults, joints, bedding planes, and solution channels affect groundwater movement and availability. According to Wood (1980) and Low (2002), groundwater within the clastic rocks of the Gettysburg Formation occurs under both unconfined (i.e., water table) and confined conditions. In general, groundwater generally occurs under unconfined conditions within the upper portion of the bedrock and under confined or semi-confined conditions in the deeper portions of the bedrock. The groundwater flow system in clastic, sedimentary rock typified by the Gettysburg Formation was conceptualized by Wood (1980) as a series of sedimentary beds with relatively high transmissivity separated by beds exhibiting lower transmissivities. This sequence of beds exhibits different hydraulic properties that collectively act as a series of alternating aquifers and confining or semi-confining units forming a leaky multi-aquifer system (LMAS). Groundwater flow paths within the clastic rocks have both local and regional components. Locally, shallow groundwater discharges to the gaining portions of nearby streams, and deeper regional groundwater flow is toward points of regional groundwater discharge such as the Susquehanna River. Groundwater divides may be different for each portion of the groundwater flow system and therefore may not coincide with surface water divides.

According to McGlade and Geyer (1976), the Gettysburg Formation is the uppermost rock unit in the vicinity of HDD S2-0280 beneath the majority of the river bed and extending to the eastern shore. On the western shore and extending approximately 800 feet into the river bed, the site is mapped as being underlain by diabase. Based on Tetra Tech's geotechnical exploration activities completed between November 5 and 16, 2014, groundwater was encountered in Boring SB-01 on the York County side overlying the diabase at a depth of 13 feet bgs, and auger refusal was encountered at 21.5 feet. At Boring SB-03 on the eastern (Dauphin County) shore overlying the Gettysburg Formation, groundwater was not encountered. Nine feet of bedrock were cored at SB-03, and the total depth of the boring was 53 feet bgs. A more recent geotechnical report of exploration activities performed from September 26 through October 5, 2017, was prepared by Intertek Professional Service Industries Inc. According to this report, Boring B-1 (located on the western [York County] shore) encountered groundwater at 15 feet bgs and diabase bedrock at 30.5 feet, and the bedrock was cored from 30.5 feet to 365 feet bgs. At Boring B-2, groundwater was encountered at 9.2 feet bgs, red/brown sandstone was encountered at 30.5 feet, and interbedded red/brown sandstone and limestone fanglomerate were cored from 30.5 to 160 feet bgs. The two referenced geotechnical reports are included as **Attachment 2**.

The direction of groundwater flow within the clastic rocks of the Gettysburg Formation in Dauphin and York Counties is largely controlled by the hydraulic gradient and spatial variability

of hydraulic conductivity. The groundwater flow system in the clastic rocks is highly anisotropic with the predominant flow direction parallel to bedrock strike. The potential for localized well interference related to groundwater pumping is generally greatest for wells aligned parallel to strike, rather than in wells drilled in the direction of bedding dip (i.e., perpendicular to strike). The presence of diabase often acts as a barrier to flow (Becher and Root, 1981; and Wood, 1980). No groundwater modeling was performed for the area surrounding HDD S2-0280.

According to Low, et. al. (2002), the depths of water-bearing zones in 322 wells completed in the Gettysburg Formation range from 5 to 900 feet bgs. Fifty percent (50%) of the 669 water-bearing zones reported were penetrated at a depth of less than 115 feet with 90% of the water-bearing zones occurring at a depth of less than 288 feet. The greatest density of water-bearing zones (0.65 per 50 feet of well depth) is from 51 to 100 feet bgs. The density of water-bearing zones encountered at depths greater than 401 feet are based on the presence of 4 or fewer water-bearing zones per 50-foot interval. The overall density of water-bearing zones in the Gettysburg Formation is 0.41 per 50-feet of well depth.

The dense, uniform, crystalline, non-granular matrix of the diabase is devoid of bedding planes or consistent foliation and therefore exhibits very low primary porosity and hydraulic conductivity. Abundant, joint openings within the diabase provide very low secondary porosity (low permeability). As a result, the storage and transmission of groundwater in the diabase are primarily dependent on the degree and extent of fracturing. Water levels in the diabase show a strong seasonal influence. A thin mantle of stiff clay that is relatively impervious to moisture generally overlies diabase bedrock. This results in poor drainage in low-lying areas underlain by diabase (Low, et. al, 2002). Water levels from 191 inventoried wells within this unit range from flowing at the land surface to 155 feet bgs with a median water level of 14 feet bgs. Springs are common in ravines, draws, and other depressions crossed by diabase dikes (Low, et. al, 2002).

According to Low, et. al. (2002), the depths of water-bearing zones from 145 wells completed in the diabase range from 4 to 583 feet bgs. Fifty percent (50%) of the 249 water-bearing zones reported were penetrated at a depth of less than 75 feet with 90% of the water-bearing zones occurring at a depth of less than 226 feet. The greatest density of water-bearing zones (0.57 per 50 feet of well depth) is from 301 to 350 feet bgs. The density of water-bearing zones encountered at depths greater than 301 feet are based on the presence of 4 or fewer water-bearing zones per 50-foot interval. The overall density of water-bearing zones in the diabase is 0.41 per 50-feet of well depth.

Well records obtained from the PA DCNR Pennsylvania Groundwater Information System (PaGWIS) database were reviewed to identify domestic water supply wells located within a 0.5-mile radius of the proposed HDD right-of-way boundary (PaGWIS, 2017). The search identified 9 wells within a 0.5-mile radius of the HDD. These wells consist of two private supply wells, two groundwater withdrawal industrial supply wells, one industrial supply well listed as unused, one supply well listed as unused/destroyed, and three abandoned groundwater monitoring wells. A map showing the well locations relative to the proposed HDD

location is included as **Figure 3**. Please note that, based on field reconnaissance, several other dwellings were observed on Marsh Run Road that are likely supplied by individual wells. Well construction details were not reported for all of the wells listed in the database. Based on incomplete information in the PaGWIS database (**Figure 3**), it appears that the two domestic wells were completed as 6-inch-diameter open-rock wells, one at 200 feet bgs (ID #156643), and one at 300 feet bgs (ID #425209). The three abandoned monitoring wells are listed as being 22 feet deep and were most likely constructed as 2-inch or 4-inch PVC wells corresponding to the location of a Turkey Hill convenience store located at the intersection of State Route (S.R.) 0230 and White House Lane. Well ID #17839 and #17840 are both listed as industrial supply wells owned by Pennsy Supply. Well #17839 was constructed as a 10-inch-diameter open-rock well completed to a depth of 700 feet bgs, and Well #17840 was constructed as an 8-inch-diameter well completed to a depth of 500 feet bgs. Well #17586 is listed as a 200-foot-deep, 8-inch-diameter well. Well #17574 is listed as a 6-inch-diameter well completed to 225 feet bgs and owned by the Harrisburg International Airport. Based solely on the PaGWIS database, only Well ID #156643 and #425209 listed the depth to bedrock as 3 to 21 feet bgs, respectively, with well construction consisting of 21 feet and 40 feet of steel casing, respectively, and the open-rock portions of the wells extending from 31 feet to 202 feet bgs, respectively. Reported well yields range from 30 to 450 gallons per minute (gpm). Five static water level measurements were recorded from the above-referenced wells with the depth to water ranging from 20 to 60 feet bgs. Based on the geologic mapping available for the area, it appears that the two wells identified on the west shore were completed in the diabase, and the seven wells identified on the eastern shore were completed in the Gettysburg Formation.

Results of a field reconnaissance completed for SPLP by Groundwater and Environmental Services (GES) verified two additional supply wells situated within the 0.5-mile radius of the HDD alignment. The GES identification numbers assigned to these wells are WL-02162018-630-01 and WL-12142017-617-01 as depicted on **Figure 3**. Based on these mapped locations, the wells are situated between 484 and 1,693 feet perpendicular to the HDD bore path and approximately 852 and 1,693 feet from the HDD entry/exit location on the western shore of the river. Although no groundwater yield, depth to water, or well construction details are available for these wells, both are mapped as being completed in diabase.

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. Fracture traces underlying, or in close proximity to, the site were evaluated using historical aerial photography. The Web-based Pennsylvania Imagery Navigator, United States Geological Survey (USGS) 7.5-minute Topographic Quadrangle Map, and Google Earth Pro were used to access, download, and view aerial imagery of the HDD site. Eight series of historical aerial photographs were evaluated that included photography dated September 1937, October 2001, March 2002, November 2004, July 2008, July 2010, June 2013, and May 2015 (Pennsylvania Spatial Data Access [PASDA], 2017,

and Google Earth Pro, 2017). Since the site area is generally undeveloped, the more recent, leaf off, higher-resolution photographs from 2004 and 2008 were the most useful for fracture trace evaluation.

Three fracture traces were identified proximate to the HDD bore path in the area south and southeast of the portion of the proposed HDD profile located on the western shore of the Susquehanna River. The approximate locations of these fracture traces, copied from Plate 1, Part 2, in Wood (1980) and McGlade and Geyer (1976), are depicted on the Geology Map included as **Figure 2**. Two of these mapped fracture traces are roughly parallel and trend northeast-southwest at a low angle approximately 1,600 feet (0.3 mile) and 4,400 feet (0.8 mile) east of the proposed HDD exit point (western end of HDD). A third fracture trace is mapped as trending northwest-southeast in the area immediately south of the HDD bore path. While this fracture trace is not mapped as intersecting the HDD bore path, it nearly crosses the bore path at a location approximately 940 feet from the western HDD entry/exit point. The identified fracture traces are related to the primary geologic structure in the vicinity of the HDD site. These fracture traces are presented on both the Geology Map (**Figure 2**) and the Groundwater Well Location Map (**Figure 3**). The local surface drainage patterns near the HDD site are generally characterized by the linear stream reaches of Marsh Run, the Susquehanna River, and two unnamed tributary streams that generally trend northwest-southeast and southwest-northeast, which appear to reflect the local geologic structure.

5.0 GEOTECHNICAL EVALUATION

Two phases of geotechnical investigation were performed at the Susquehanna River HDD S2-0280 drill site; one was performed in 2014 and the other in 2017. Two geotechnical borings were completed in November 2014 during the preliminary investigation of HDD S2-0280 and prior to initiating HDD operations. Two additional borings (B-1 and B-2) were completed from September to October 2017. The four borings are located in the vicinity of the HDD limit of disturbance (LOD) as shown on the site plan and profile included with **Attachment 2**. The boring logs and other supporting information (location mapping, rock core photographs, rock core descriptions, and geotechnical laboratory results) are included as **Attachment 2**. The borings were completed to investigate soil, residual soil, and bedrock conditions using hollow-stem augers with split spoons for soil sampling and a core barrel/bit for rock coring.

SB-01 was completed on November 5, 2014, and SB-03 was completed on November 5 and 6, 2014. A planned third boring (SB-02) was canceled. SB-01 was located on the western shore of the Susquehanna River within the diabase unit. SB-03 was located near the drill entry/ exit site on the eastern shore in the Gettysburg Formation. Boring B-1 (completed in 2017 during the second phase of geotechnical investigation) was located approximately 100 feet northwest of the proposed HDD entry/exit point on the western shore. Boring B-2 (also completed in 2017) was located approximately 130 feet northwest of the HDD entry/exit point on the eastern shore. The generalized subsurface profile observed in the borings is described below.

- **SB-01:** The top 24 inches consisted of topsoil which was characterized as silt with a little fine sand. The interval from approximately 9 to 20 feet bgs consisted of sands, silts, and gravel. The auger encountered bedrock at 20 feet bgs. The total depth of the boring was 21.5 feet bgs. Groundwater was encountered at a depth of 13 feet bgs.

- **SB-03:** No topsoil was observed. The interval from 3.0 to 14.7 feet was characterized as historic fill consisting of silt, sand, gravel, and coal fines. The interval from 14.7 feet to 37.0 feet consisted of silty clays, sands, and gravel. Weathered sandstone and siltstone were found from 37 to 43.2 feet. The bedrock was cored from 44.0 to 53.0 feet. The bedrock cores consisted of fractured maroon and reddish-brown sandstone and conglomerate. The total depth of the boring was 53.0 feet bgs. Groundwater was not encountered.

- **B-1:** The upper 11.7 feet consisted of silts and sands. The interval from 11.7 to 30.5 feet was described as completely decomposed diabase. The bedrock was cored from 30.5 to 365 feet. The interval from 30.5 to 37 feet was described as highly weathered, very broken, and fractured diabase. The interval from 37 to 365 feet was described as slightly weathered to fresh, hard to very hard, broken to slightly broken diabase. From 30.5 to 67 feet, the Rock Quality Designation (RQD) ranged from very poor to good (0 to 80%). Below 67 feet, the RQD was generally good to excellent (75 to 100%), with seven of the five-foot core runs being designated fair (RQD = 52 to 70%) and the last core run from 360 to 365 feet bgs designated as poor (RQD = 47%). The total depth of the boring was 365 feet bgs. Groundwater was encountered at 15 feet bgs.

- **B-2:** No topsoil was observed. The interval from 0 to 8.5 feet was characterized as fill which consisted of silt, sand, gravel, and coal fines. The interval from 8.5 to 30.5 feet bgs was characterized as alluvium consisting of silt and sandy silty clay and gravel; also, the field logger noted a highly weathered diesel odor in both the 15- to 17-foot bgs interval and the 26- to 27-foot bgs interval. The bedrock was cored from 30.5 to 160 feet. The interval from 30.5 to 160 feet was reddish-brown, fine-grained, thinly bedded sandstone, interbedded with limestone fanglomerate. The majority of the bedrock was described as slightly to moderately weathered with some intervals noted to be highly or completely weathered. The RQD ranged from very poor to excellent. The total depth of the boring was 160 feet bgs. Groundwater was encountered at 9.2 feet bgs.

Please note that Skelly and Loy/RETTEW did not oversee or direct the geotechnical drilling programs associated with the S2-0280 HDD including but not limited to the selection of

boring locations, determination of locations, determination of surface elevation, target depths, observations of rock cores during drilling operations, and 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. Skelly and Loy/RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework of the analysis of proposed S2-0280 Susquehanna River HDD for this report.

6.0 FIELD OBSERVATIONS

Based on a site reconnaissance performed by Skelly and Loy geologists on November 28, 2017, there are extensive bedrock exposures in the vicinity of the HDD entry/exit point located on the west shore of the Susquehanna River. These bedrock exposures occur in cut slopes along Marsh Run Road and on top of the diabase ridge and consist predominantly of medium to dark gray and reddish-brown crystalline rock characteristic of the diabase unit. No structural geologic measurements could be obtained due to the metamorphosed crystalline nature of the massive diabase outcrops. Exposures of the Gettysburg Formation were also observed but were inaccessible due to their locations on private property. General, published structural geologic measurements of the Gettysburg Formation indicate that the bedrock strike is generally to the north-northeast (between 20° and 70°) with bedding dip ranging from 27° to 80° northwest. The field observations are consistent with the mapped geologic measurements of the Gettysburg Formation approximately 0.5 mile southwest, south, and southeast of the HDD trace described in McGlade and Geyer (1976) and Wood (1980).

According to available geologic mapping, the western third of the proposed HDD bore path is underlain by bedrock mapped as diabase; this mapping is consistent with Skelly and Loy's field observations. In addition, a baked zone of the Gettysburg Formation extends from the edge of the diabase/Gettysburg contact approximately 800 feet toward the east shore of the Susquehanna River (see **Figure 2**). The rocks comprising the baked zone have been metamorphosed by the intrusive diabase to form very hard dark purple to black argillite. Published geologic mapping also shows that the eastern two-thirds of the HDD bore path are underlain by the Gettysburg Formation; however, the presence of the Susquehanna River and considerable thickness of Quaternary Alluvium on the east shore floodplain of the river precluded confirmation of this bedrock geology proximate to the eastern shore HDD entry/exit point. In addition to the unnamed tributaries and private water supplies, additional potential environmental receptors of concern were identified within the defined 0.5-mile HDD buffer area. These potential receptors consist of several dwellings, livestock barns, and associated residential properties situated within 1,000 feet of the west shore HDD entry/exit point. As referenced in Section 3.0, well construction details for receptors proximate to the site were not reported for all of the wells listed in the PaGWIS database. The database reported that 5 of the 9 wells located within 1,000 feet of the west shore HDD entry/exit point are unused: 3 are abandoned and sealed with another unused. The drilled depths of the 5 existing groundwater supply wells range from 200 to 700 feet bgs with reported static water level depths between 20 and 60 feet bgs. According to the PaGWIS database, two of the five existing wells are used as domestic supplies and three are utilized as industrial groundwater supply sources. Although

small portions of the open-rock intervals of these supply wells are exposed to the same bedrock aquifer penetrated by the HDD drilling operations, these supply wells obtain the majority of their groundwater from deeper portions of the aquifer situated well below the existing 20-inch HDD alignment and proposed 16-inch HDD bore profile.

During advancement of the 20-inch pilot hole on August 17, 2017, and following an IR noted on July 19, 2017, an initial loss of a small volume of drilling fluids (estimated to be 495 gallons) was observed in the Susquehanna River at a location along the trajectory length approximately 410 feet east of the western shoreline and 130 feet south of the bore path. The fluid from this IR was observed to be discharging from a discrete point in the river bed. At the time of the IR, the bit was 4,385 feet from the east shore entry point and 2,935 feet from the west shore exit point and at a depth estimated to be approximately 113 feet bgs while drilling through baked shales, siltstones, and sandstones of the Gettysburg Formation. This IR event may be due to encountering an area of increased bedrock fracturing or density of the baked shales, siltstones, and sandstones in the area immediately east of the diabase intrusion known as the York Haven Pluton. Drilling operations were shut down while containment measures were implemented in an elliptical area measuring approximately 35 feet by 20 feet. Upon resuming drilling operations, reactivation of this IR was observed on August 24, 2017; however, the IR ceased following the temporary shutdown of drilling operations in compliance with an order issued by the Pennsylvania Department of Environmental Protection's (PA DEP) Environmental Hearing Board (EHB). After this temporary work stoppage and before HDD drilling operations could be resumed in September, the loss of drilling fluid viscosity (integrity) within the completed portion of the HDD borehole resulted in a breakdown of the drilling fluid sealing the borehole wall and an overall loss of open annular space within the borehole.

Upon restarting and advancing the 20-inch pilot hole following the temporary shutdown, a second IR occurred approximately 30 feet west of the first IR location. The second IR occurred on September 15, 2017, approximately one month after the second IR at the initial IR location (August 24, 2017). The fluid from this second IR was observed to be discharging from nearly the same discharge point in the river bed as the initial IR. The second IR location was approximately 380 feet east of the western shoreline and 130 feet south of the bore path. At the time of the second IR, the bit was approximately 4,415 feet from the east shore entry point and 2,965 feet from the west shore exit point at a depth estimated to be 113 feet bgs. Drilling operations were again shut down while containment and mitigation measures were implemented. The locations of the initial and second IRs are shown on **Figures 1** through **3**).

7.0 GEOPHYSICAL SURVEY CONSIDERATIONS

Although some thin-bedded limestone fanglomerate units occur within a 0.5-mile radius of the HDD, no karst geology was observed during the field reconnaissance or is mapped as being present at this HDD location. The Corrected Stipulated Order states that the use of geophysical surveys should be considered in karst areas; however, based on the lack of karst geologic features and extensively fractured bedrock, the use of geophysical surveys during re-evaluation was considered but ultimately not implemented at the Susquehanna River HDD

location. The decision was also made because the results of geophysical surveys would not likely provide additional information that would reduce the risk of an IR. In addition, results of geophysical surveys in karst, with the resolution necessary to image features that could affect the HDD, are typically limited to the upper 20 to 50 feet of the ground surface. Based on our experience working in karst geology, the lack of mapped karst geology along the HDD bore path, and lack of continuous thick-bedded limestone units, the diabase and Gettysburg Formations are not deemed susceptible to the solution activity present in other more thickly bedded carbonate geologic formations in Pennsylvania. In our professional opinion, geophysical surveys would not provide relevant information on the formational thickness of interbedded sandstone, shale, diabase, and thin beds of limestone fanglomerate at depths greater than 50 feet bgs along the HDD profile. Based on the preceding discussion and given the fact that the HDD profile is more than 100 feet below the river bottom, geophysical survey data would not enhance the evaluation of the profile or effectively reduce the risk of an IR.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL

Groundwater occurring in the watershed occupied by the Susquehanna River HDD originates as precipitation or snowmelt. The precipitation infiltrates through the overburden soils. As previously described, shallow groundwater generally occurs under unconfined conditions within the upper portion of the bedrock LMAS. Based on site-specific geotechnical data (Section 5.0) and information obtained from the PaGWIS database (Section 3.0), the groundwater table occurs within the upper portion of the bedrock (20 to 60 feet bgs) proximate to the HDD path and contributes flow to local, shallow groundwater discharge zones supporting the unnamed tributaries and Susquehanna River which cross above the HDD profile. Available site-specific data suggest that the groundwater table proximate to the HDD path is relatively shallow and may exist in some areas of the unconsolidated overburden soils proximate to the soil/bedrock interface. The shallow water table contributes flow to these local shallow groundwater discharge zones sustaining several unnamed tributaries that flow above (across) the proposed HDD profile before discharging to the Susquehanna River. The thickness of the regolith and saturated regolith varies according to the underlying geohydrologic unit and topographic setting (Low, et. al, 2002).

Logs of the three geotechnical borings drilled from November 2014 through October 2017 indicated that the soil thickness near HDD S2-0280 ranges from approximately 12 to 37 feet and consists of various soils ranging from alluvium composed of silt, sandy silty clay, and gravel; silts and sands; silty clays, sands, and gravel; weathered sandstone and siltstone; to historic fill consisting of silt, sand, gravel, and coal fines. Recorded descriptions of the bedrock cores included sandstone, conglomerate, limestone fanglomerate, and diabase. Data tabulated for supply wells found in the PaGWIS database (**Figure 3**) within a 0.5-mile radius of the HDD trace recorded measured water levels in the bedrock aquifer ranging from 20 to 60 feet bgs. Although groundwater was not encountered in the single shallow geotechnical soil boring (SB-03) completed in the soil regolith, depth to water measurements ranging from 9 to 15 feet bgs were obtained from geotechnical soil boring SB-01 and geotechnical core borings (B-1 and B-2) completed within the bedrock to total depths of 365 feet bgs and 160 feet bgs, respectively.

The Gettysburg Formation is highly anisotropic, with the predominant groundwater flow direction parallel to bedrock strike. Groundwater flow in the fractured bedrock is generally greatest within highly permeable fractures, and the orientation of bedding planes and fractures primarily influence the direction of groundwater flow. Some site-specific evaluation of the bedrock has been completed in the area proximate to the geotechnical core borings completed along this HDD profile; however, no detailed characterization or groundwater flow modeling of the bedrock aquifer was performed as part of this hydrogeologic re-evaluation.

The groundwater flow direction in the overburden soils is presumed to mimic surface topography which rapidly slopes to the east on the west shore of the Susquehanna River and very gently slopes to the west on the east shore of the river. The unnamed tributaries, nearby Marsh Run, and Susquehanna River are sustained by local shallow groundwater flow discharges. The unnamed tributaries flow to the north and east, beginning near the western entry/exit point of the HDD, and eventually discharge to the Susquehanna River. The geotechnical report and boring logs included as **Attachment 2** show that groundwater was present in the unconsolidated soils and the depth to water can be quite shallow proximate to the HDD path based on a measured depth to water of 9 feet bgs (Boring B-2). As stated above, measured water levels in private supply wells located within 0.5 mile of the site range from 20 to 60 feet bgs. Based on this information, the uppermost groundwater table is presumed to occur within the uppermost soils under unconfined conditions.

9.0 CONCLUSIONS

Based on published geologic and hydrogeologic information, the S2-0280 Susquehanna River HDD location is underlain by clastic sedimentary rocks (conglomerate, sandstone, siltstone, and limestone fanglomerate) of the Gettysburg Formation and dense, very fine to coarsely crystalline intrusive diabase. Groundwater movement within these rocks is primarily through a network of interconnected secondary openings (e.g., fractures, joints, and faults) that were developed by external forces following deposition of the beds and intrusion of the diabase. Geotechnical rock core observations confirm that the local bedrock ranges from fractured and broken to massive sandstone, conglomerate, siltstone, limestone fanglomerate, and diabase comprised of well-developed thin to massive moderately steeply dipping joint and bedding planes (no bedding planes in the diabase). All of the private water supply wells identified in the vicinity of the HDD are constructed in bedrock, indicating that none of the domestic wells relies on the shallow unconsolidated overburden as a source of groundwater supply. The uppermost unconsolidated soils and weathered bedrock, and potentially the bedrock aquifer, provide sustainable groundwater discharge to the unnamed tributaries, wetlands, and Susquehanna River.

The proposed 16-inch HDD profile extends entirely within both the shallow unconsolidated regolith materials and weathered to unweathered bedrock. Based on the hydro-structural characteristics of the underlying geology described in this report and the known HDD profile through shallow soils and bedrock, the Susquehanna River HDD site is susceptible to the

inadvertent return of drilling fluids during HDD operations. The redesigned HDD 16-inch profile has been lengthened to allow for a deeper crossing beneath the unnamed tributary streams, wetlands, existing pipelines, Susquehanna River, railways, and utilities. The inclination of the entry and exit angles for the 16-inch pipeline has been increased as a means to install the pipe through the overlying protective soils, residual soils, and bedrock in closer proximity to the entry and exit points than the original, shorter profile. 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 future IRs.

10.0 RECOMMENDATION

The IRs that occurred during the 20-inch pilot hole drilling occurred when the drilling tools were at approximately Stations 44+10 (first IR) and 44+50 (second IR) on the HDD profile and have been correlated to a documented loss of containment (LOC). It is our professional opinion that a similar LOC event is possible during the proposed 16-inch pilot hole drilling. If this LOC event is repeated, the drilling contractor should be prepared to implement a grout seal of the loss point feature using either a cement slurry or high density bentonite plug in accordance with the Inadvertent Return Assessment, Preparedness, Prevention and Contingency Plan, revised April 2018 (IR APPC Plan), as a means to reduce the risk of additional discharges and adequately protect public health and safety and the environment.

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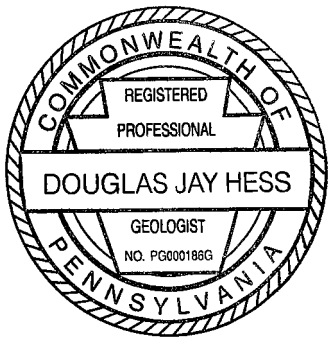
12.0 CERTIFICATION

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

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



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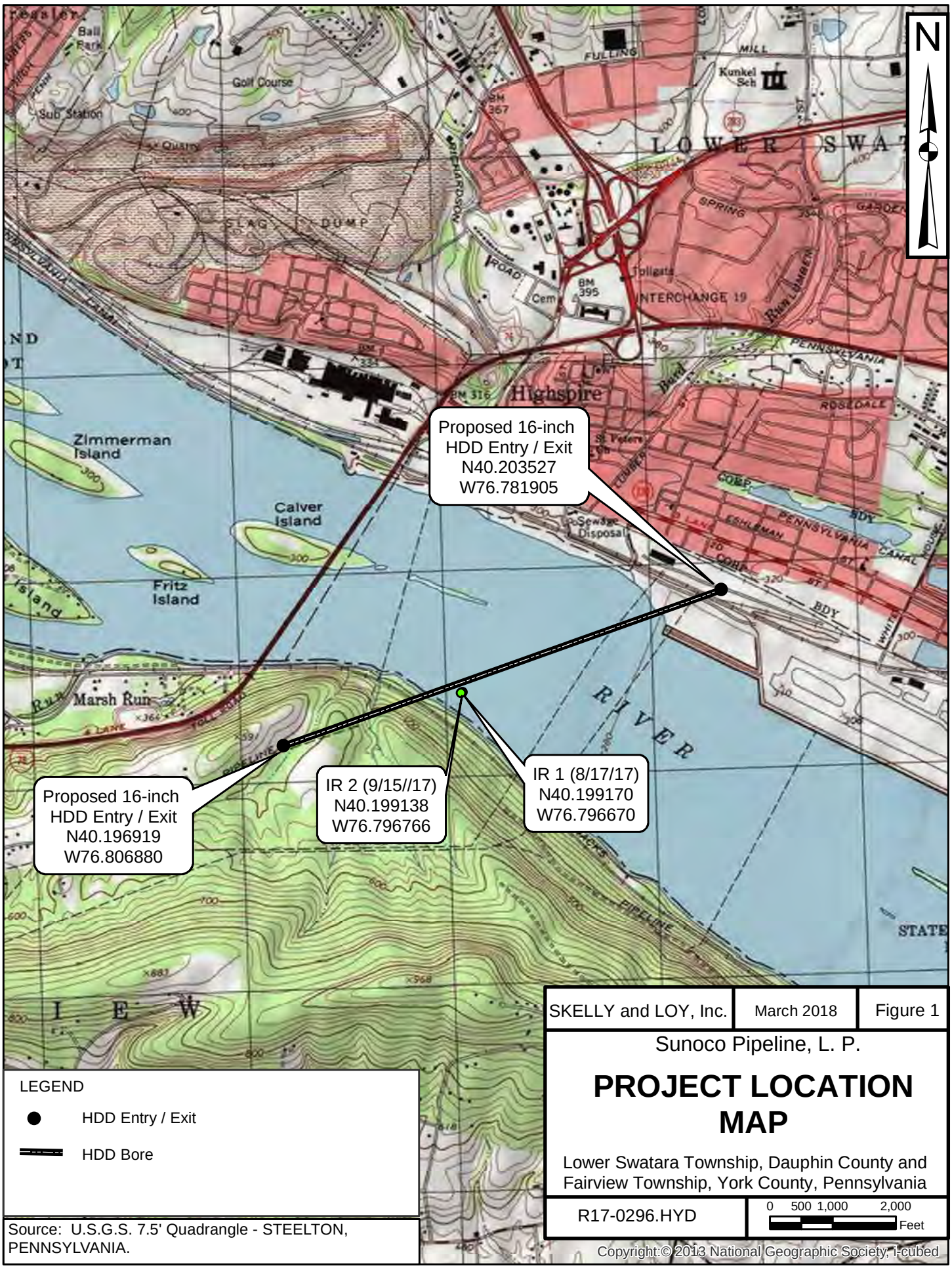
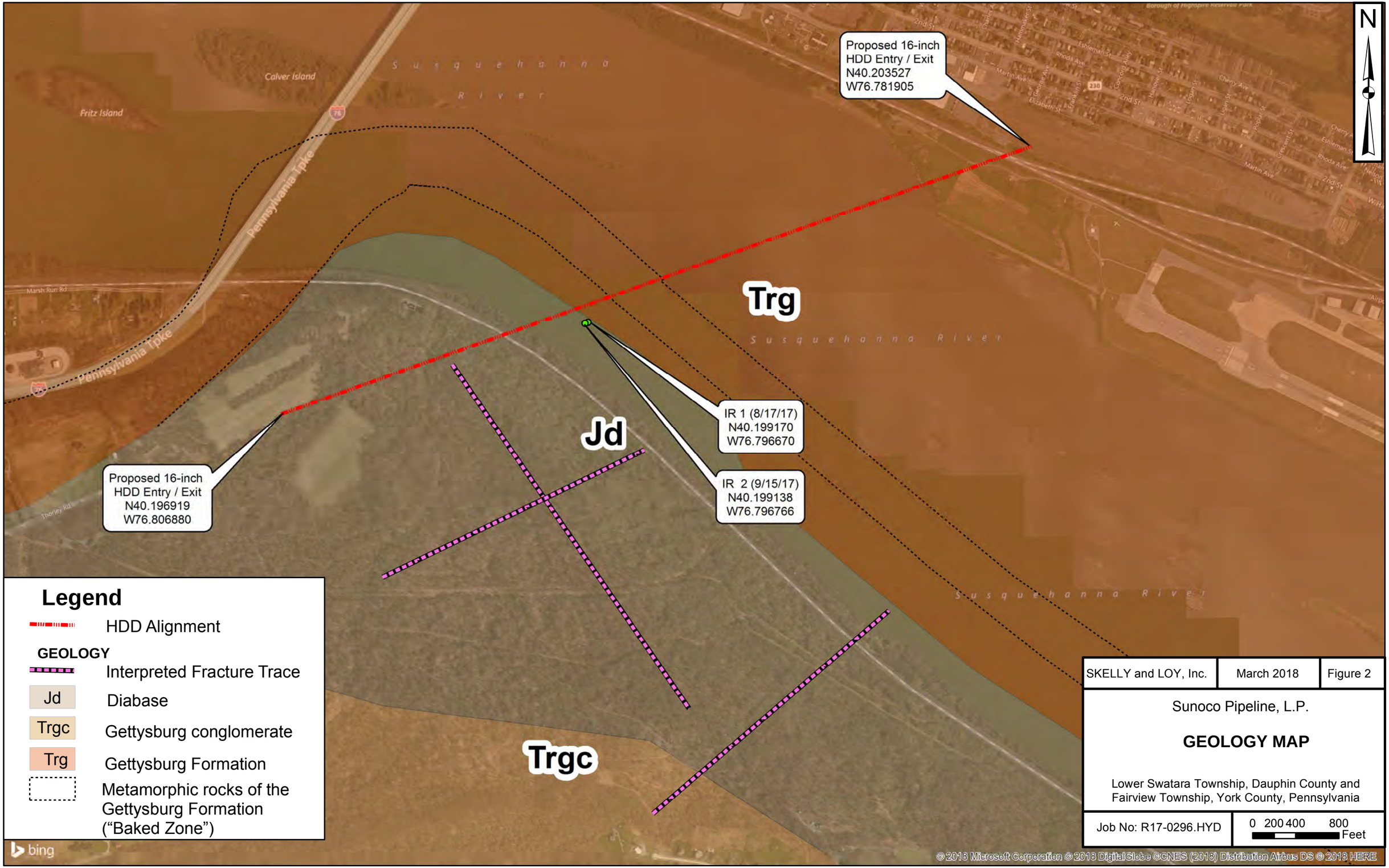
Sincerely yours,

SKELLY and LOY, Inc.

Douglas J. Hess, P.G.
Director of Groundwater
and Site Characterization
Geo-Environmental Services

Enclosure
cc: R17-0296.HYD
File: HYDROGEOLOGIC_REPORT-Susquehanna River 08-09-2018.docx


N
Proposed 16-inch
HDD Entry / Exit
N40.203527
W76.781905
IR 1 (8/17/17)
N40.199170
W76.796670
IR 2 (9/15//17)
N40.199138
W76.796766
Proposed 16-inch
HDD Entry / Exit
N40.196919
W76.806880
Zimmerman Island
Calver Island
Fritz Island
Highspire
Marsh Run
RIVER
LOWER SWA
INTERCHANGE 19
PENNSYLVANIA CANAL
PIPELINE
LEGEND
HDD Entry / Exit
HDD Bore
Source: U.S.G.S. 7.5' Quadrangle - STEELTON, PENNSYLVANIA.
SKELLY and LOY, Inc.
March 2018
Figure 1
Sunoco Pipeline, L. P.
PROJECT LOCATION MAP
Lower Swatara Township, Dauphin County and Fairview Township, York County, Pennsylvania
R17-0296.HYD
0 500 1,000 2,000
Feet
Copyright:© 2013 National Geographic Society, i-cubed



SKELLY and LOY, Inc.	March 2018	Figure 2

Sunoco Pipeline, L.P.

GEOLOGY MAP

Lower Swatara Township, Dauphin County and
Fairview Township, York County, Pennsylvania

Job No: R17-0296.HYD	0 200 400 800 Feet

N

Proposed 16-inch
HDD Entry / Exit
N40.196919
W76.806880

Proposed 16-inch
HDD Entry / Exit
N40.203527
W76.781905

17586
40.20611N
-76.78639W

636499
40.20278N
-76.77725W

637132
40.20278N
-76.77725W

17840
40.20056N
-76.77444W

17839
40.20056N
-76.77444W

636500
40.20278N
-76.77725W

17574
40.19944
-76.77722

WL - 02182018 - 630 - 01
40.199406
-76.802728

425209
40.2N
-76.81333W

WL - 12142017 - 617 - 01
40.195262
-76.812153

156643
40.19639N
-76.80111W

IR 1 (8/17/17)
N40.199170
W76.796670

IR 2 (9/15/17)
N40.199138
W76.796766

Zimmerman Island
Hoak Island
Fritz Island
Calver Island
Susquehanna River
Pennsylvania Turnpike
Marsh Run Rd
Memorial Park
Borough of Highspire Reservoir Park

Legend

- Interpreted Fracture Trace
- Proposed HDD
- 0.5 Mile Radius of Proposed HDD
- Field Verified Well Locations
- PAGWIS Well ID
- Parcel Boundary

SKELLY and LOY, Inc.	July 2018	Figure 3

Sunoco Pipeline, L.P.

WELL LOCATION MAP

Lower Swatara Township, Dauphin County and
Fairview Township, York County, Pennsylvania

Job No: R17-0296.HYD

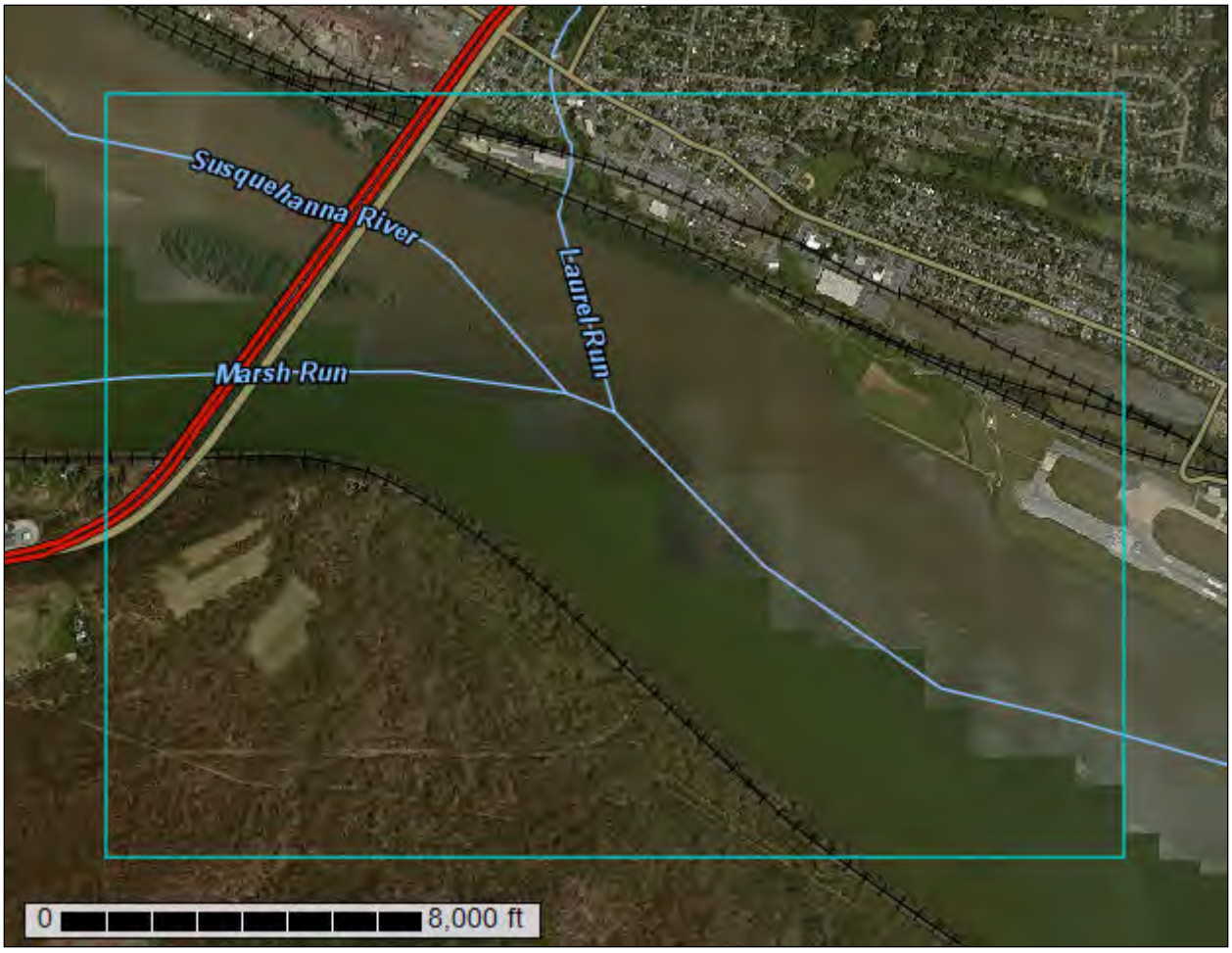
0 250 500 1,000 Feet

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 Dauphin County, Pennsylvania, and York County, Pennsylvania



November 28, 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.

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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 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 scales ranging from 1:15,800 to 1:24,000.

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: Dauphin County, Pennsylvania
Survey Area Data: Version 13, Nov 27, 2017

Soil Survey Area: York County, Pennsylvania
Survey Area Data: Version 11, Oct 4, 2017

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Mar 29, 2011—Aug 15, 2013

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND

MAP INFORMATION

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
At	Atkins silt loam	17.7	1.0%
CnB2	Chavies fine sandy loam, 3 to 8 percent slopes, moderately eroded	10.4	0.6%
CnC2	Chavies fine sandy loam, 8 to 15 percent slopes, moderately eroded	7.6	0.4%
DvB2	Duncannon very fine sandy loam, 3 to 8 percent slopes, moderately eroded	2.1	0.1%
LeB2	Lawrenceville very fine sandy loam, 2 to 8 percent slopes, moderately eroded	19.9	1.1%
LrC2	Lewisberry gravelly sandy loam, 8 to 15 percent slopes, moderately eroded	11.4	0.6%
Rv	Riverwash	0.4	0.0%
Ta	Tioga fine sandy loam	18.3	1.0%
Tg	Tioga fine sandy loam, high bottom	123.7	7.0%
Ua	Urban land, alluvial materials	198.8	11.2%
Ub	Urban land, limestone materials	24.3	1.4%
W	Water	847.9	48.0%
Subtotals for Soil Survey Area		**1,282.6**	**72.5%**
Totals for Area of Interest		**1,768.0**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BgB	Birdsboro silt loam, 3 to 8 percent slopes	3.0	0.2%
BsD	Brecknock channery silt loam, 8 to 25 percent slopes, very stony	1.8	0.1%
BsF	Brecknock channery silt loam, 25 to 60 percent slopes, very stony	62.7	3.5%
LgD	Legore channery silt loam, 15 to 25 percent slopes	18.9	1.1%
MdB	Mount Lucas silt loam, 3 to 8 percent slopes	3.8	0.2%
MeB	Mount Lucas silt loam, 0 to 8 percent slopes, very bouldery	24.7	1.4%
NaB	Neshaminy channery silt loam, 3 to 8 percent slopes	15.9	0.9%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
NaC	Neshaminy channery silt loam, 8 to 15 percent slopes	3.0	0.2%
NdD	Neshaminy channery silt loam, 8 to 25 percent slopes, extremely bouldery	206.6	11.7%
NdE	Neshaminy channery silt loam, 25 to 45 percent slopes, extremely bouldery	134.3	7.6%
WbB	Watchung silt loam, 0 to 8 percent slopes, extremely bouldery	10.8	0.6%
Subtotals for Soil Survey Area		**485.4**	**27.5%**
Totals for Area of Interest		**1,768.0**	**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.

Dauphin County, Pennsylvania

At—Atkins silt loam

Map Unit Setting

National map unit symbol: l4mr
Elevation: 200 to 3,000 feet
Mean annual precipitation: 32 to 55 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Atkins and similar soils: 85 percent
Minor components: 14 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Atkins

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: Acid alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 10 inches: silt loam
H2 - 10 to 30 inches: silt loam
H3 - 30 to 60 inches: gravelly silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 60 to 99 inches to lithic bedrock
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.06 to 2.00 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Minor Components

Barbour

Percent of map unit: 6 percent
Hydric soil rating: No

Philo

Percent of map unit: 6 percent
Hydric soil rating: No

Saprists

Percent of map unit: 2 percent
Landform: Depressions
Hydric soil rating: Yes

CnB2—Chavies fine sandy loam, 3 to 8 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: l4nm
Elevation: 300 to 1,000 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 45 to 59 degrees F
Frost-free period: 120 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Chavies

Setting

Landform: Terraces
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sandstone and siltstone

Typical profile

H1 - 0 to 9 inches: fine sandy loam
H2 - 9 to 30 inches: fine sandy loam
H3 - 30 to 66 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Available water storage in profile: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Tioga, high bottom

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

Captina

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

CnC2—Chavies fine sandy loam, 8 to 15 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: l4nn
Elevation: 300 to 1,300 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 45 to 59 degrees F
Frost-free period: 120 to 190 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Chavies

Setting

Landform: Terraces
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sandstone and siltstone

Typical profile

H1 - 0 to 9 inches: fine sandy loam
H2 - 9 to 30 inches: fine sandy loam
H3 - 30 to 66 inches: gravelly fine sandy loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches

Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.6 inches)

Interpretive groups

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

Minor Components

Captina

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

Bedington

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

DvB2—Duncannon very fine sandy loam, 3 to 8 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: l4nz
Mean annual precipitation: 35 to 48 inches
Mean annual air temperature: 50 to 61 degrees F
Frost-free period: 150 to 180 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Duncannon

Setting

Landform: Terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Riser
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Coarse-silty loess over residuum weathered from sedimentary rock

Typical profile

H1 - 0 to 16 inches: very fine sandy loam
H2 - 16 to 58 inches: silt loam
H3 - 58 to 99 inches: channery silt loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 9.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

LeB2—Lawrenceville very fine sandy loam, 2 to 8 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: l4pd
Elevation: 300 to 850 feet
Mean annual precipitation: 40 to 52 inches
Mean annual air temperature: 50 to 57 degrees F
Frost-free period: 140 to 205 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Lawrenceville

Setting

Landform: Upland slopes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Silty eolian deposits

Typical profile

H1 - 0 to 8 inches: very fine sandy loam

H2 - 8 to 25 inches: silt loam
H3 - 25 to 44 inches: silt loam
H4 - 44 to 74 inches: channery silt loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: 24 to 38 inches to fragipan; 72 to 96 inches to paralithic bedrock
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 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 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Tioga, high bottom

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

Duncannon

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

LrC2—Lewisberry gravelly sandy loam, 8 to 15 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: l4ph
Elevation: 300 to 1,500 feet
Mean annual precipitation: 38 to 48 inches
Mean annual air temperature: 48 to 57 degrees F
Frost-free period: 165 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

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

Description of Lewisberry

Setting

Landform: Ridges
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Residuum weathered from conglomerate and/or residuum weathered from sandstone

Typical profile

H1 - 0 to 12 inches: gravelly sandy loam
H2 - 12 to 46 inches: gravelly sandy loam
H3 - 46 to 62 inches: extremely gravelly sandy loam
H4 - 62 to 72 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 48 to 84 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.3 inches)

Interpretive groups

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

Minor Components

Steinsburg

Percent of map unit: 5 percent
Landform: Hillsides
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Penn

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Arendtsvillle

Percent of map unit: 5 percent

Hydric soil rating: No

Rv—Riverwash

Map Unit Setting

National map unit symbol: l4q0
Elevation: 500 to 2,250 feet
Mean annual precipitation: 32 to 47 inches
Mean annual air temperature: 37 to 55 degrees F
Frost-free period: 101 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Potomac

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Recent sandy and gravelly alluvium derived from sedimentary rock

Typical profile

A - 0 to 4 inches: gravelly sandy loam
C - 4 to 65 inches: extremely gravelly sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 61 to 120 inches to lithic bedrock
Natural drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Frequent
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): 5s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

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

Basher
Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Barbour
Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Ta—Tioga fine sandy loam

Map Unit Setting
National map unit symbol: l4q2
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: 130 to 205 days
Farmland classification: All areas are prime farmland

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

Description of Tioga

Setting
Landform: Flood plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Acid alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 9 inches: fine sandy loam
H2 - 9 to 60 inches: fine sandy loam
H3 - 60 to 69 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: 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: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: Very high (about 12.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Philo

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

Lindside

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

Tioga, high bottom

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

Tg—Tioga fine sandy loam, high bottom

Map Unit Setting

National map unit symbol: l4q3
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: 130 to 205 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Tioga

Setting

Landform: Flood plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Acid alluvium derived from sedimentary rock

Typical profile

H1 - 0 to 9 inches: fine sandy loam
H2 - 9 to 60 inches: fine sandy loam
H3 - 60 to 69 inches: gravelly fine sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: 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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very high (about 12.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Lindside

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

Tioga, flooded

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

Philo

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

Ua—Urban land, alluvial materials

Map Unit Setting

National map unit symbol: l4q4

Elevation: 300 to 850 feet
Mean annual precipitation: 36 to 52 inches
Mean annual air temperature: 44 to 57 degrees F
Frost-free period: 130 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition
Urban land: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Pavement, buildings and other artifically covered areas

Minor Components

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

Ub—Urban land, limestone materials

Map Unit Setting
National map unit symbol: l4q5
Elevation: 460 to 1,500 feet
Mean annual precipitation: 30 to 46 inches
Mean annual air temperature: 44 to 57 degrees F
Frost-free period: 130 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition
Urban land: 90 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Pavement, buildings and other artifically covered areas

Minor Components

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

W—Water

Map Unit Setting

National map unit symbol: svq1
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 120 to 214 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Water

Setting

Parent material: Rivers streams ponds

Properties and qualities

Runoff class: Negligible
Frequency of ponding: Frequent

York County, Pennsylvania

BgB—Birdsboro silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l6v1
Elevation: 200 to 1,200 feet
Mean annual precipitation: 38 to 50 inches
Mean annual air temperature: 46 to 59 degrees F
Frost-free period: 140 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Birdsboro and similar soils: 92 percent
Minor components: 8 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Birdsboro

Setting

Landform: Alluvial fans, terraces
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Tread
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Old reddish alluvium derived from sedimentary rock

Typical profile

Ap - 0 to 9 inches: silt loam
Bt - 9 to 49 inches: silt loam
C - 49 to 73 inches: very gravelly sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 72 to 99 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 (0.60 to 2.00 in/hr)
Depth to water table: About 24 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Penn

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Summit, shoulder, backslope

Landform position (three-dimensional): Interfluve, side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Lamington

Percent of map unit: 3 percent
Landform: Depressions, terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: Yes

BsD—Brecknock channery silt loam, 8 to 25 percent slopes, very stony

Map Unit Setting

National map unit symbol: l6v7
Elevation: 250 to 1,000 feet
Mean annual precipitation: 40 to 48 inches
Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 165 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Brecknock

Setting

Landform: Ridges, hills
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Red metamorphosed residuum weathered from sandstone and shale and/or residuum weathered from porcellanite

Typical profile

H1 - 0 to 7 inches: channery silt loam
H2 - 7 to 30 inches: channery silt loam
H3 - 30 to 42 inches: very channery silt loam
H4 - 42 to 52 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 40 to 60 inches to lithic bedrock
Natural drainage class: Well drained

Runoff class: High
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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.4 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

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

BsF—Brecknock channery silt loam, 25 to 60 percent slopes, very stony

Map Unit Setting
National map unit symbol: l6v8
Elevation: 250 to 1,000 feet
Mean annual precipitation: 40 to 48 inches
Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 165 to 200 days
Farmland classification: Not prime farmland

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

Description of Brecknock

Setting
Landform: Ridges, hills
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Red metamorphosed residuum weathered from sandstone and shale and/or residuum weathered from porcellanite

Typical profile
H1 - 0 to 7 inches: channery silt loam
H2 - 7 to 30 inches: channery silt loam
H3 - 30 to 42 inches: very channery silt loam
H4 - 42 to 52 inches: bedrock

Properties and qualities

Slope: 25 to 35 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 40 to 60 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: High
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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.4 inches)

Interpretive groups

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

Minor Components

Stony areas

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

LgD—Legore channery silt loam, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: l6xd
Elevation: 80 to 2,000 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 150 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Legore and similar soils: 90 percent
Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Legore

Setting

Landform: Hillsides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from anorthosite and/or residuum weathered from diabase

Typical profile

H1 - 0 to 10 inches: channery silt loam
H2 - 10 to 30 inches: silty clay loam
H3 - 30 to 60 inches: sandy loam

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Channery areas

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

Rock outcrop

Percent of map unit: 1 percent
Hydric soil rating: No

MdB—Mount Lucas silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l6y0
Elevation: 300 to 2,000 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 130 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Mount lucas and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mount Lucas

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Parent material: Residuum weathered from diabase

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 37 inches: channery clay loam
H3 - 37 to 60 inches: gravelly loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 48 to 99 inches to lithic bedrock
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 0.60 in/hr)
Depth to water table: About 6 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Neshaminy

Percent of map unit: 7 percent
Landform: Hillslopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Interfluve, side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Watchung

Percent of map unit: 3 percent
Landform: Depressions
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

MeB—Mount Lucas silt loam, 0 to 8 percent slopes, very bouldery

Map Unit Setting

National map unit symbol: l6y1
Elevation: 300 to 2,000 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 130 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Mount lucas and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mount Lucas

Setting

Landform: Hillslopes
Landform position (two-dimensional): Footslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Parent material: Residuum weathered from diabase

Typical profile

H1 - 0 to 9 inches: channery silt loam
H2 - 9 to 38 inches: channery clay loam
H3 - 38 to 60 inches: gravelly loam

Properties and qualities

Slope: 3 to 8 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 48 to 99 inches to lithic bedrock
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 0.60 in/hr)
Depth to water table: About 6 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Neshaminy

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Interfluve, side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Watchung

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

NaB—Neshaminy channery silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l6yb
Elevation: 80 to 2,000 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 130 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Neshaminy, channery silt loam, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Neshaminy, Channery Silt Loam

Setting

Landform: Hillsides
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from diabase

Typical profile

H1 - 0 to 8 inches: channery silt loam
H2 - 8 to 15 inches: gravelly silty clay loam
H3 - 15 to 70 inches: channery clay loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well 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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Watchung, silt loam

Percent of map unit: 4 percent
Landform: Depressions
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

Lehigh, channery

Percent of map unit: 4 percent
Landform: Hillsides
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Brecknock

Percent of map unit: 4 percent
Landform: Ridges, hills
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Legore

Percent of map unit: 4 percent
Landform: Hillsides
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Mount lucas, silt loam

Percent of map unit: 4 percent
Landform: Hillsides, hillslopes
Landform position (two-dimensional): Summit, footslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear, concave
Across-slope shape: Convex, concave, linear
Hydric soil rating: No

NaC—Neshaminy channery silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: l6yc
Elevation: 80 to 2,000 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 130 to 220 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Neshaminy, channery silt loam, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Neshaminy, Channery Silt Loam

Setting

Landform: Hillsides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from diabase

Typical profile

H1 - 0 to 8 inches: channery silt loam
H2 - 8 to 15 inches: gravelly silty clay loam
H3 - 15 to 70 inches: channery clay loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well 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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

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

Minor Components

Mount lucas, silt loam

Percent of map unit: 5 percent
Landform: Hillsides, hillslopes
Landform position (two-dimensional): Summit, footslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear, concave
Across-slope shape: Convex, concave, linear
Hydric soil rating: No

Legore

Percent of map unit: 5 percent
Landform: Hillsides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Lehigh, channery

Percent of map unit: 5 percent
Landform: Hillsides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Brecknock

Percent of map unit: 5 percent
Landform: Ridges, hills
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

NdD—Neshaminy channery silt loam, 8 to 25 percent slopes, extremely bouldery

Map Unit Setting

National map unit symbol: l6yf
Elevation: 80 to 2,000 feet

Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 130 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Neshaminy, extremely bouldery, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Neshaminy, Extremely Bouldery

Setting

Landform: Hillsides
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from diabase

Typical profile

H1 - 0 to 8 inches: channery silt loam
H2 - 8 to 15 inches: gravelly silty clay loam
H3 - 15 to 70 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: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

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

Minor Components

Mount lucas, very bouldery

Percent of map unit: 5 percent
Landform: Hillsides, hillslopes
Landform position (two-dimensional): Summit, footslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear, concave
Across-slope shape: Convex, concave, linear
Hydric soil rating: No

Legore

Percent of map unit: 5 percent

Landform: Hillsides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Lehigh, channery

Percent of map unit: 5 percent
Landform: Hillsides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Brecknock

Percent of map unit: 5 percent
Landform: Ridges, hills
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

NdE—Neshaminy channery silt loam, 25 to 45 percent slopes, extremely bouldery

Map Unit Setting

National map unit symbol: l6yg
Elevation: 80 to 2,000 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 130 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Neshaminy, extremely bouldery, and similar soils: 75 percent
Minor components: 24 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Neshaminy, Extremely Bouldery

Setting

Landform: Hillsides
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from diabase

Typical profile

H1 - 0 to 8 inches: channery silt loam
H2 - 8 to 15 inches: gravelly silty clay loam
H3 - 15 to 70 inches: channery clay loam

Properties and qualities

Slope: 25 to 45 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

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

Minor Components

Legore

Percent of map unit: 9 percent
Landform: Hillsides
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Brecknock

Percent of map unit: 7 percent
Landform: Ridges, hills
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Side slope, interfluve
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Mount lucas, very bouldery

Percent of map unit: 5 percent
Landform: Hillsides, hillslopes
Landform position (two-dimensional): Summit, footslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear, concave
Across-slope shape: Convex, concave, linear
Hydric soil rating: No

Lehigh, channery

Percent of map unit: 3 percent
Landform: Hillsides
Landform position (two-dimensional): Shoulder, backslope

Landform position (three-dimensional): Side slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

WbB—Watchung silt loam, 0 to 8 percent slopes, extremely bouldery

Map Unit Setting

National map unit symbol: l6zy
Elevation: 80 to 2,000 feet
Mean annual precipitation: 34 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 120 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Watchung, extremely bouldery, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Watchung, Extremely Bouldery

Setting

Landform: Depressions
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Residuum weathered from diabase

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 18 inches: clay
H3 - 18 to 25 inches: clay
H4 - 25 to 30 inches: clay
H5 - 30 to 40 inches: clay
H6 - 40 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: 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 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 10.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C/D
Hydric soil rating: Yes

Minor Components

Mount lucas, very bouldery

Percent of map unit: 5 percent
Landform: Hillsides, hillslopes
Landform position (two-dimensional): Summit, footslope, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear, concave
Across-slope shape: Convex, concave, linear
Hydric soil rating: No

Neshaminy, extremely bouldery

Percent of map unit: 4 percent
Landform: Hillsides
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Legore

Percent of map unit: 3 percent
Landform: Hillsides
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Croton

Percent of map unit: 3 percent
Landform: Depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

Lehigh, channery

Percent of map unit: 3 percent
Landform: Hillsides
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Dunning

Percent of map unit: 2 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope

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

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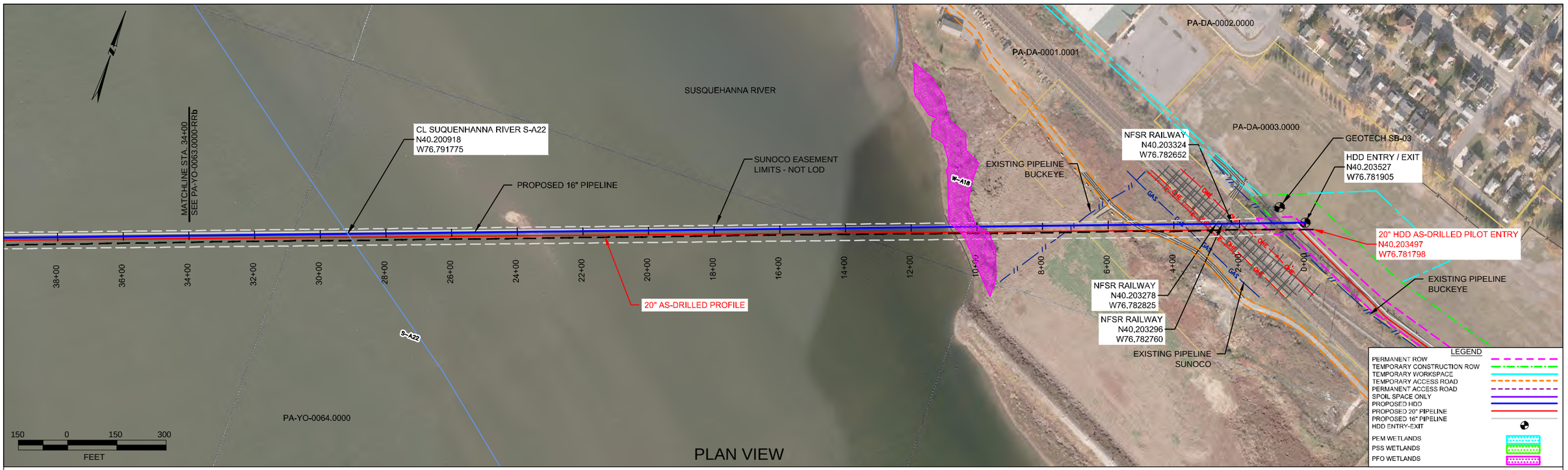
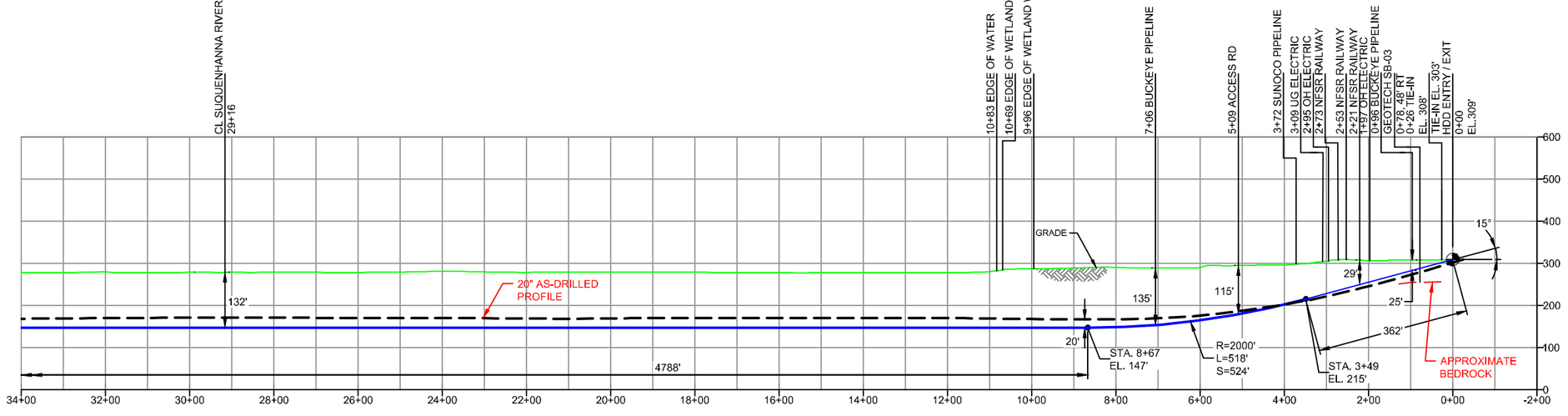


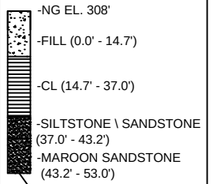
PLAN VIEW

PROFILE VIEW



YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP
DAUPHIN COUNTY, PENNSYLVANIA - LOWER SWATARA TOWNSHIP
S2-0280-16

GEOTECH SB-03



NOTE: REFER TO TEST BORING LOG S2-0280 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=):7380'
   HDD PIPE LENGTH (S=):7436'
   16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.
13. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
14. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
15. 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-4.20	TO	ES-4.04	EROSION & SEDIMENT PLAN	
SHEET 13	TO	SHEET 2	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP4	RELOCATED DRILL ENTRY/EXIT - DESIGN CHANGE PER CLIENT REQUEST	MRS	02/19/18	RMB	02/19/18	AMC	02/19/18
EP3	REVISED PER PADEP COMMENTS RECEIVED 01-30-17	DLM	02/01/17	RMB	02/01/17	CAG	02/01/17
3	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT	MRS	01/06/17	RMB	01/06/17	AAW	01/06/17
2	REVISED PER ENGINEERING COMMENTS	MRS	08/31/16	RMB	08/31/16	AAW	08/31/16
1	REVISED PER COMMENTS FROM REI REVIEW	MRS	02/19/16	RMB	02/19/16	AAW	02/19/16
0	ISSUED FOR CONSTRUCTION	MRS	01/19/16	RMB	01/19/16	AAW	01/19/16

Sunoco Logistics Partners L.P.

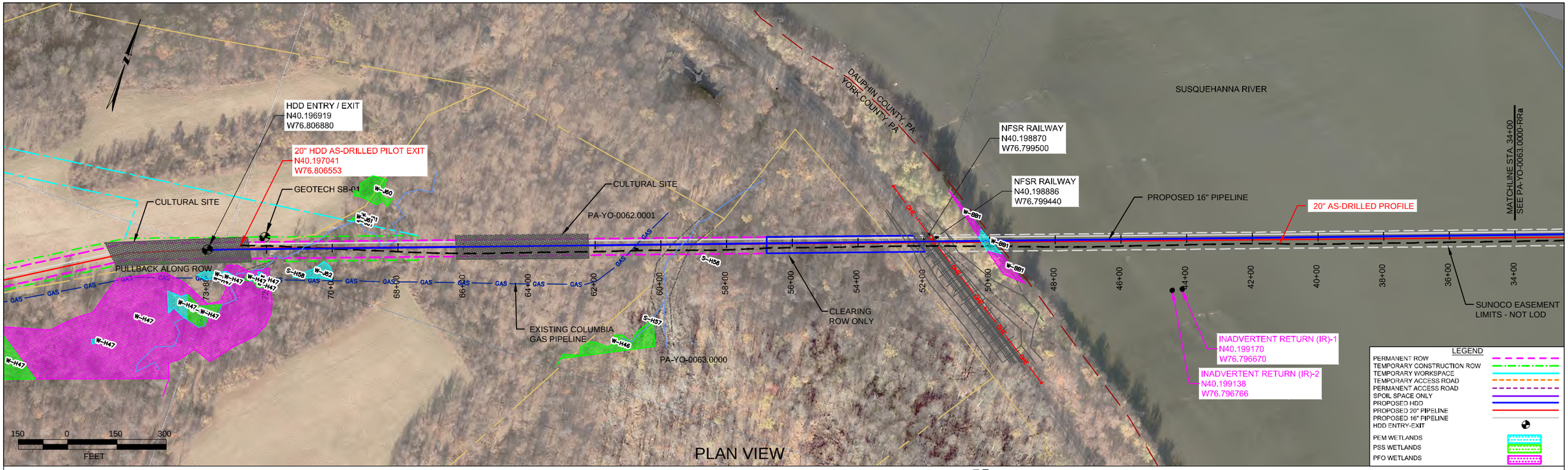
TETRA TECH ROONEY
(303) 792–5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
SUSQUEHANNA RIVER
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'

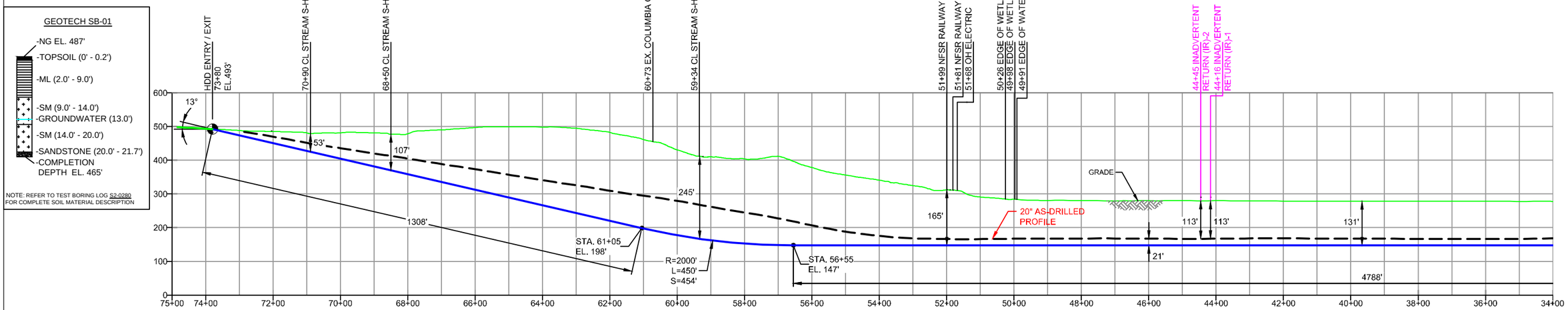
DWG. NO: PA-YO-0063.0000-RRa-16



PLAN VIEW

PROFILE VIEW

YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP
DAUPHIN COUNTY, PENNSYLVANIA - LOWER SWATARA TOWNSHIP
S2-0280-16



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=):7380'
   HDD PIPE LENGTH (S=):7436'
   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 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.
13. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
14. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
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NOTES

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4. CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL UTILITIES. CONTACT ONE CALL AT 811 PRIOR TO DIGGING.
5. SUNOCO EMERGENCY HOTLINE NUMBER IS #1-800-786-7440.

REF. DRAWING

ES-4.20	TO	ES-4.04	EROSION & SEDIMENT PLAN	EP4	RELOCATED DRILL ENTRY/EXIT - DESIGN CHANGE PER CLIENT REQUEST	MRS	02/19/18	RMB	02/19/18	AMC	02/19/18
SHEET 13	TO	SHEET 2	AERIAL SITE PLAN	EP3	REVISED PER PADEP COMMMENTS RECEIVED 01-30-17	DLM	02/01/17	RMB	02/01/17	CAG	02/01/17
				3	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT	MRS	01/06/17	RMB	01/06/17	AAW	01/06/17
				2	REVISED PER ENGINEERING COMMENTS	MRS	08/31/16	RMB	08/31/16	AAW	08/31/16
				1	REVISED PER COMMENTS FROM REI REVIEW	MRS	02/19/16	RMB	02/19/16	AAW	02/19/16
				0	ISSUED FOR CONSTRUCTION	MRS	01/19/16	RMB	01/19/16	AAW	01/19/16
DWG NO		DWG NO	DESCRIPTION	NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE

Sunoco Logistics Partners L.P.

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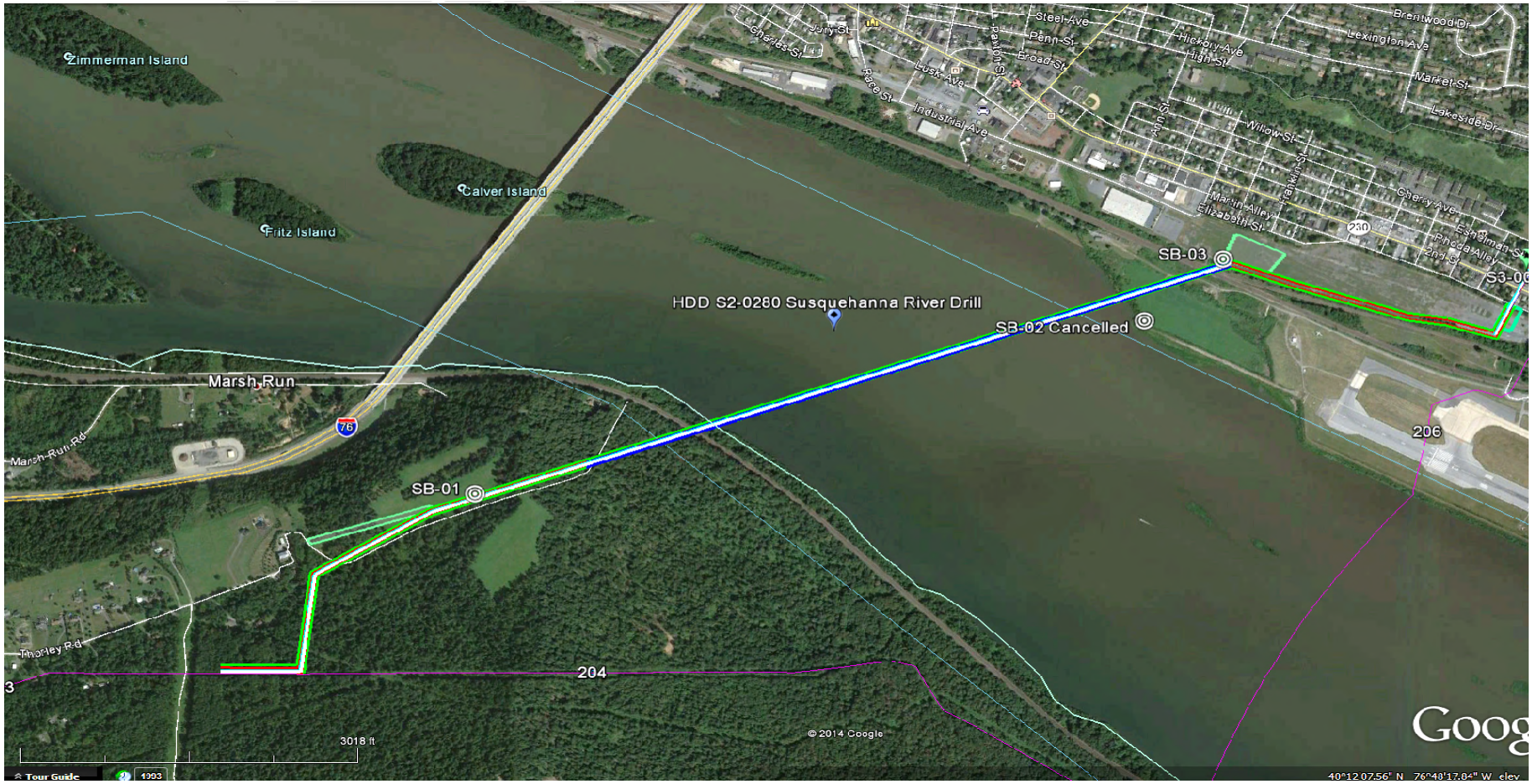
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
SUSQUEHANNA RIVER
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'

DWG. NO: PA-YO-0063.0000-RRb-16



LEGEND:

◎ Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S2-0280
YORK COUNTY, FAIRVIEW TOWNSHIP, AND
DAUPHIN COUNTY, LOWER SWATARA TOWHSHIP, 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:	WHITE HOUSE LAND, HIGHSPIRE, PA (HARRISBURG AIRPORT PROPERTY)		Page 1 of 1
HDD No.:	S2-0280	Dates(s) Drilled: 11-05-14	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 13.0	Total Depth (ft): 21.7

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	2.0			TOPSOIL (24")					
1	3.0	5.0	2.0		14	ML	MOTTLED ORANGE AND REDDISH BROWN SILT WITH A LITTLE	1	3	7	9	**10**
				9.0			FINE SAND.					
2	8.0	10.0	9.0	14.0	15	SM	DARK GRAY FINE TO MEDIUM SAND WITH SOME SILT.	2	2	12	17	**14**
3	13.0	15.0	14.0		19	SM	DR WEAHERED TO A GREENISH BROWN, GRAY, AND REDDISH BRWN	1	4	6	6	**10**
							FINE SAND AND SILT, TRACE FINE GRAVEL.					
4	18.0	19.0			12		DR WEATHERED TO A VARI-COLORED (GRAY, BROWN, WHITE) FINE	2	50/6"			**>50**
				20.0			TO MEDIUM SAND WITH SOME SILT.					
5	21.5	21.7	20.0		2		GRAY AND BROWN MEDIUM TO COARSE SAND AND FINE TO COARSE	50/2"				
				21.7			SANDSTONE GRAVEL (PARTIALLY WEATHERED SANDSTONE).					
							STARTED GRINDING AT 20'.					
							AUGER REFUSAL AT 21.5'.					
							WET ON SPOON AT 13'.					
							WATER LEVEL THROUGH AUGERS AT 14.5'.					
							CAVED AT 10', WATER LEVEL ON CAVE AT 4'.					

Notes/Comments:

Pocket Pentrometer Testing
S1: 2.5 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.

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	WHITE HOUSE LAND, HIGHSPIRE, PA (HARRISBURG AIRPORT PROPERTY)		Page 1 of 2
HDD No.:	S2-0280	Dates(s) Drilled: 11-05/06-14	Inspector: E. WATT
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 53.0

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
							NO DISCERNABLE TOPSOIL					
1	3.0	5.0	0.0		20	HISTORIC FILL (ML/SM)	DARK GRAY TO BLACK SILT AND FINE TO MEDIUM SAND WITH A LITTLE	6	8	5	6	**13**
							GRAVEL AND COAL (FILL)					
2	8.0	10.0			12		DARK GRAY TO BLACK SILT AND FINE TO MEDIUM SAND WITH A LITTLE	3	2	2	2	**4**
							GRAVEL AND COAL (FILL)					
3	13.0	15.0			17		DARK GRAY TO BLACK SILT AND FINE TO MEDIUM SAND WITH A LITTLE	WH	1	1	1	**2**
				14.7			GRAVEL AND COAL (FILL)					
4	18.0	20.0	14.7		24	CL	MOTTLED GRAY AND BROWN SILTY CLAY, TRACE FINE SAND, AND	1	4	6	10	**10**
							A TRACE FINE GRAVEL (USCS: CL)					
5	23.0	25.0			24		REDDISH BROWN TO MAROON SILTY CLAY WITH A LITTLE FINE SAND,	1	3	6	9	**9**
							AND A LITTLE FINE GRAVEL.					
6	28.0	29.5			18		DR WEATHERED TO A REDDISH BROWN MICACEOUS SILTY CLAY,	6	21	50		**>50**
							TRACE FINE SAND, AND TRACE UNWEATHERED GRAVEL.					
7	33.0	34.4			14		DR WEATHERED TO A REDDISH BROWN SILTY CLAY WITH A LITTLE TO	6	13	50/5"		
				37.0			SOME FINE SAND, TRACE UNWEATHERED FINE GRAVEL (USCS: CL).					
8	38.0	38.6	37.0		8		WEATHERED REDDISH BROWN SILTSTONE.	30	50/2"			
9	43.0	43.2		43.2	2		PARTIALLY WEATHERED MAROON SANDSTONE.	50/2"				
							SEE PAGE 2 FOR ROCK CORE DATA					

Notes/Comments:

Pocket Pentrometer Testing
S4: 3.5 TSF
S5: 2 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.

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TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	WHITE HOUSE LAND, HIGHSPIRE, PA (HARRISBURG AIRPORT PROPERTY)		Page 2 of 2
HDD No.:	S2-0280	Dates(s) Drilled: 11-05/06-14	Inspector: E. WATT
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): NOT ENCOUNTERED	Total Depth (ft): 53.0

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
							ROCK CORING		
RUN 1	44.0	48.0	44.0		46		MAROON SANDSTONE. ANGLED FRACTURE 44.65 TO 44.73, FRAC.	TCR: 96%, SCR: 83%, RQD: 72%	
				45.2			ZONE 45.08 TO 45.26.		
			45.2	45.4			CONGOMERATE LENSE.		
			45.4				REDDISH BROWN SANDSTONE, ANGLED FRACTURES 45.88-45.94,		
				47.0			FRACTURE ZONE 46.28-46.34. CALCITE VEIN 46.9.		
			47.0	47.2			CONGOMERATE LENSE.		
			47.2				REDDISH BROWN SANDSTONE. MECHANCICAL BREAK 47.63, FRAC.		
				48.0			ZONE 47.87 TO 48.0.		
RUN 2	48.0	53.0	48.0		54	ROCK	REDDISH BROWN SANDSTONE, FRAC. ZONE 48-48.5, ANGLED FRAC.	TCR: 90%, SCR: 57%, RQD: 48%	
				49.5			48.79-49.63.		
			49.5	49.7			CONGLOMERATE LENS, ANGLED FRAC. 49.55-49.63		
			49.7				RB SANDSTONE, FRAC. 50.2, ANGLED FRAC. 50.4-50.5, 50.57-50.66,		
				51.5			FRAC. 50.73.		
			51.5	51.9			MAROON SANDSTONE.		
			51.9	52.4			CONGLOMERATE LENS, FRAC. 52.0, ANGLED FRAC. 52.12-52.2.		
			52.4	52.5			MAROON SANDSTONE.		
			52.5	52.9			CONGLOMERATE LENS, ANGLED FRAC. 52.54-52.65.		
			52.9	53.0			MAROON SANDSTONE		
							CORE TESTING RESULTS (DEPTH 49'):		
							COMPRESSIVE STRENGTH: 13,090 PSI		
							UNIT WEIGHT: 146.8 PCF		
							CAVED AT 41', DRY.		

Notes/Comments:
Pocket Pentrometer Testing

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

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

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0280

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.) From	Depth of Sample (ft.) To	Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318) Liquid Limit, %	Atterburg Limits (ASTM D4318) Plastic Limit, %	Atterburg Limits (ASTM D4318) Plasticity Index, %	USCS Classif. (ASTM D2487)
S2-0280	SB-01	1	3.0	5.0	23.4	89.5	-	-	-	-
		2	8.0	10.0	16.3	24.9	-	-	-	-
		3	13.0	15.0	40.0	47.8	-	-	-	-
		4	18.0	19.0	29.8	28.8	-	-	-	-
	SB-03	2	8.0	10.0	31.2	57.9	-	-	-	-
		4	18.0	20.0	22.4	96.8	32	17	15	CL
		6	28.0	29.5	9.6	91.4	-	-	-	-
		7	33.0	34.4	11.6	80.2	30	20	10	CL
		8	38.0	38.6	7.0	55.7	-	-	-	-

Rock Core Testing Results				
Boring No.	Core Run	Approximate Depth (ft)	Compressive Strength (psi)	Unit Weight (pcf)
SB-03	2	49.0	13,090	146.8

Notes:

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0280

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
S2-0280	Susquehanna River	SB-01	Gettysburg Fm - reddish-brown to maroon silty mudstone and shale and soft, red-brown, medium- to fine-grained sandstone, with minor amounts of yellowish-brown shale and sandstone and thin beds of impure limestone.	Upland to river bank	Gettysburg Fm	Silty mudstone-shale-sandstone w/ some impure limestone	16,000	5-10	
		SB-02		Floodplain, Lowland, W. bank of river				20-30	
		SB-03		Lowland, W. of RR tracks					

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.

ROCK CORE DESCRIPTION SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0280

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					
S2-0280	SB-3	1	44	48	96	83	72	44	45	Slight	Silty Sandstone	Massive	Red	Single fracture, approximately 25°
								45	45.5	Moderate	Conglomerate	Laminar thin beds, well graded	Red	Near horizontal bedding
		2	48	53	90	57	48	45.5	52	Slight	Silty Sandstone	Massive	Red	Occasional conglomerate lens, fractures ranging from 0° to 45°, Avg. 21°
								52	53	Moderate	Conglomerate	Thin beds, less than 1"	Red to dark red	Bedding dip approximately 28°; few fractures along bedding surfaces

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).

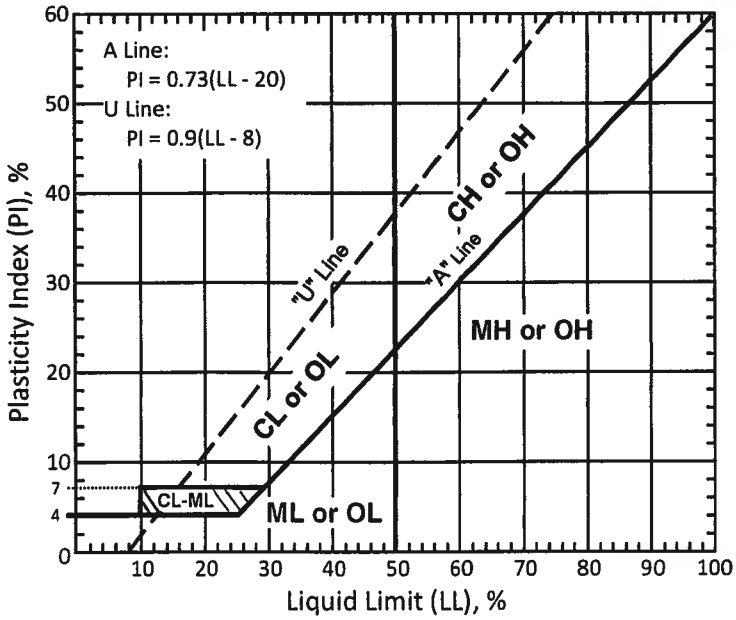
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

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.

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Figure 1: Site Vicinity Map

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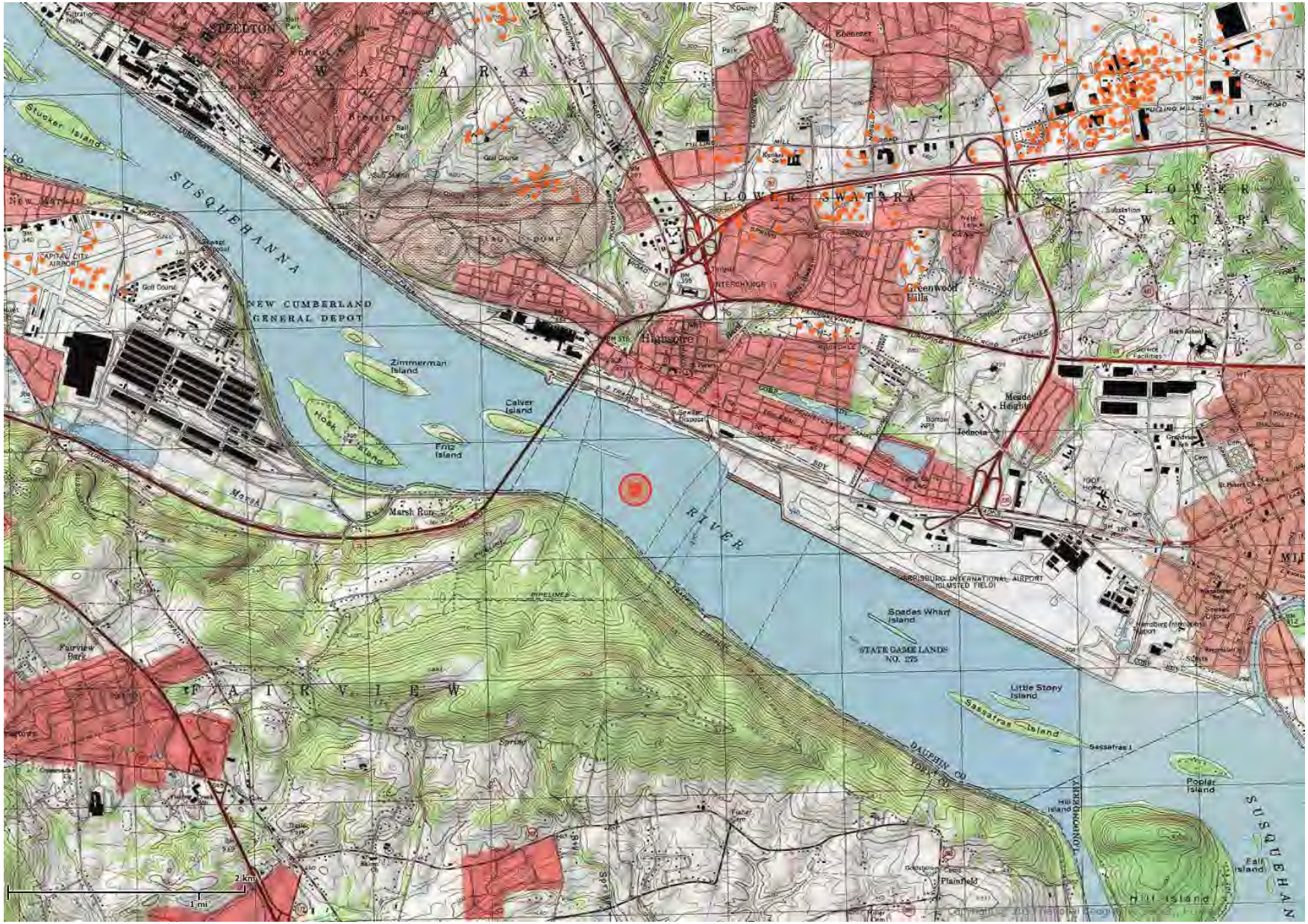

Created using PA DCNR Map Viewer

Map created on Mon Sep 25 2017

FIGURE 2A: BORING LOCATION PLAN
Susquehanna River-PPP4
PSI Project No.: 04911488

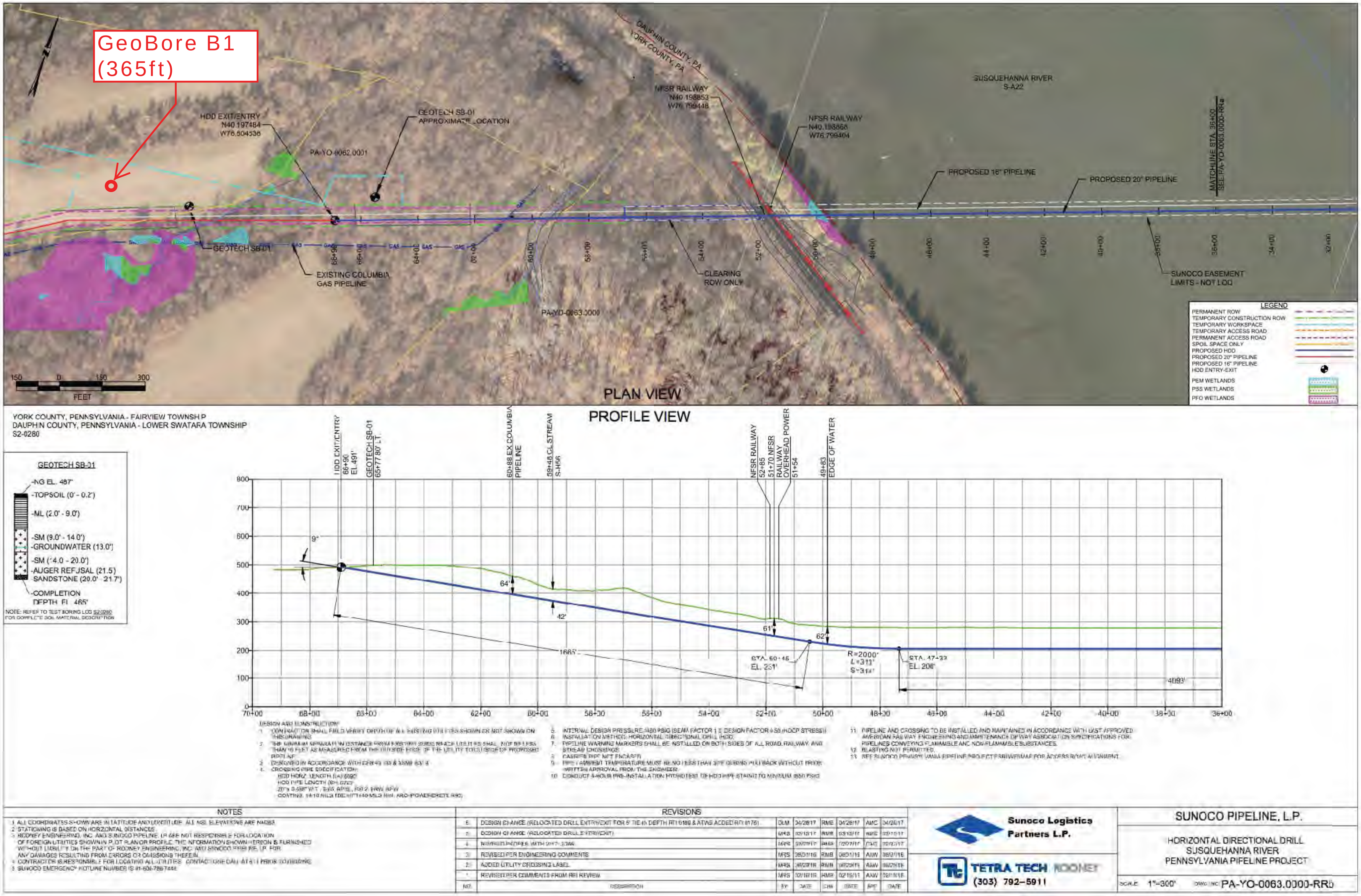

FIGURE 2B: BORING LOCATION PLAN
Susquehanna River-PPP4
PSI Project No.: 04911488

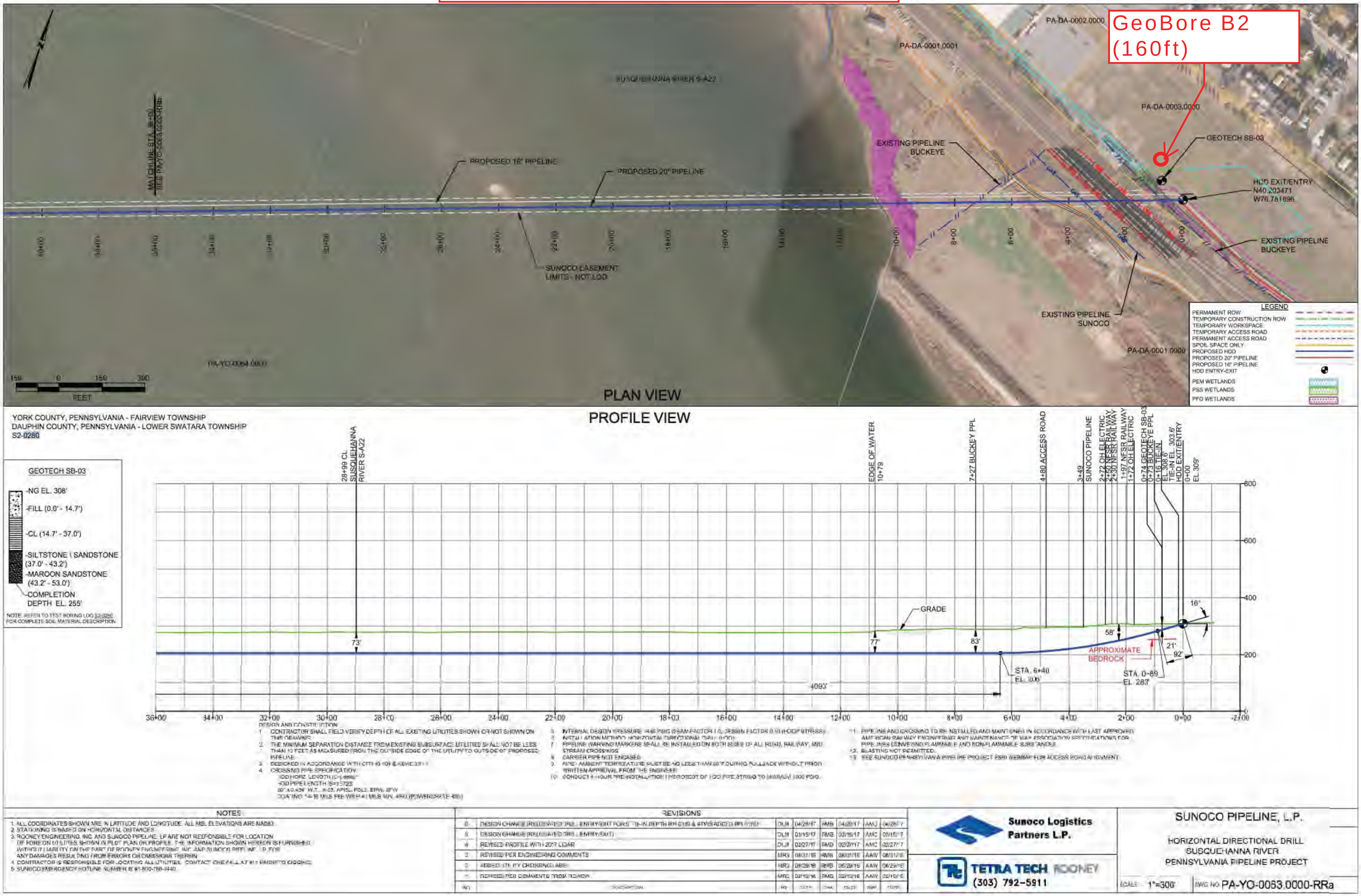

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Figure 3: Site Geology Map

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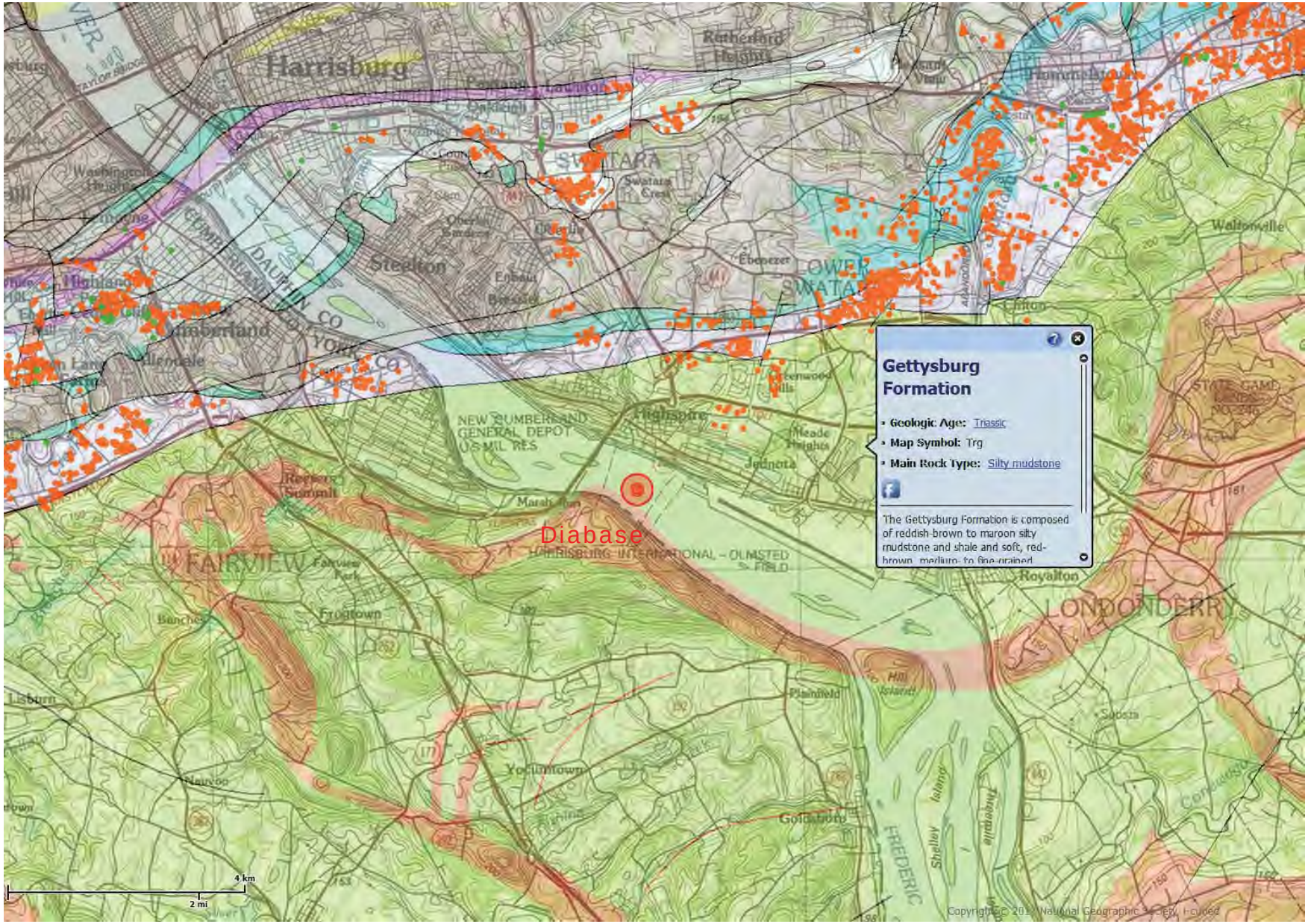

Created using PA DCNR Map Viewer

Map created on Mon Sep 25 2017

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water

While Drilling	15 feet	
Pre-Core (9-28-17)	Not Enc.	

BORING LOCATION:
See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	0			S-1	24	**RESIDUUM**- Stiff, Brown, SILT with Sand, moist	ML	9-7-7-9 N=14	18		
	5			S-2	24			4-4-5-8 N=9	21		LL = 27 PL = 22
	10			S-3	24	**RESIDUUM**- Loose, Green Brown, Silty SAND, moist	SM	WH-2-4-5 N=6	29		Fines=33.6%
	15			S-4	24	**RESIDUUM**- Very Loose, Variegated Colors (Brown/Yellow/Gray/White), Silty Clayey SAND, wet ~11.7 to 30 ft: Completely decomposed rock/diabase.	SC-SM	WH/18"-5	40		
	20			S-5	24			1-1-2-7 N=3	35		Fines=23.8%
	25			S-6	24	**RESIDUUM**- Dense to Very Dense, Variegated Colors (Brown/Yellow/Gray/White), Silty SAND, moist Refusal @ 30.5 ft	SM	18-17-23-30 N=40	12		Fines=24.5%
	30										

Continued Next Page

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

Water: While Drilling 15 feet; Pre-Core (9-28-17) Not Enc.

BORING LOCATION: See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	30			S-7	6	**BEDROCK** - Gray Brown, **DIABASE**, Highly Weathered, hard to very hard, very broken to broken Some highly weathered fracture zones from 32 to 37 feet		50-50/0"	11	>>◎	2 min.
				R-1	18			RQD=0 Rec=100%		>>◎	1 min. 1 min. 1 min.
	35			R-2	32			RQD=22 Rec=54%			1 min. 1 min. 1 min. 1 min. 1 min. 1 min.
	40			R-3	60	**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		RQD=80 Rec=100%		>>▲	1 min. Q_u = 950.5 tsf 186.9 pcf 2 min. 2 min.
	45			R-4	60	Field Logger Notes: "Magnet is attracted slightly to rock throughout stratum" "20-30 degree fracture zones appear randomly+rarely throughout stratum"		RQD=56 Rec=100%			2 min. 1 min. 2 min. 1 min.
	50			R-5	60			RQD=62 Rec=100%			2 min. 2 min. 2 min. 2 min.
	55			R-6	60			RQD=56 Rec=100%		>>▲	2 min. Q_u = 591.7 tsf 184.7 pcf 2 min. 2 min. 2 min. 2 min.
	60			R-7	60			RQD=46			2 min.

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Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION:
See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture ✕ / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	60					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			2 min.
						61 to 62 ft: 75 degree, 25 degree fractures					2 min.
											2 min.
											2 min.
											2 min.
	65			R-8	60	62 to 67 ft: Long vertical fracture throughout R-8		RQD=66 Rec=100%			2 min.
											2 min.
											2 min.
										>> Q_u = 1369.7 tsf	2 min.
										186.2 pcf	2 min.
						Below 67 feet, the Rock Mass Quality was Good to Excellent (RQD btwn 75 to 100%) unless otherwise noted below.					2 min.
	70			R-9	60			RQD=100 Rec=100%			2 min.
											2 min.
						Box 4 from 72 to 87 feet (end of 9-28-17)					2 min.
											2 min.
											2 min.
	75			R-10	60			RQD=100 Rec=100%			2 min.
											2 min.
										>> Q_u = 1064.4 tsf	2 min.
										186.3 pcf	2 min.
											2 min.
	80			R-11	60			RQD=100 Rec=100%			2 min.
											2 min.
											2 min.
											2 min.
											2 min.
	85			R-12	60	R-12: Fair Rock Mass Quality		RQD=60 Rec=100%			2 min.
											2 min.
											2 min.
											2 min.
											2 min.
	90			R-13	60			RQD=86			2 min.

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Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION:
See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture ✕ / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	90					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			1 min. 1 min. >> ▲ Q_u = 1051.4 tsf 185.2 pcf 2 min. 2 min.
	95			R-14	60			RQD=100 Rec=100%			2 min. 2 min. 2 min. 2 min. 2 min.
	100			R-15	60			RQD=100 Rec=100%			2 min. 2 min. 2 min. 2 min. 2 min. >> ▲ Q_u = 1154.5 tsf 185.8 pcf
	105			R-16	60			RQD=100 Rec=100%			2 min. 2 min. 2 min. 2 min. 2 min. 2 min.
	110			R-17	60			RQD=100 Rec=100%			2 min. 2 min. 2 min. 2 min. 2 min. 2 min.
	115			R-18	60			RQD=100 Rec=100%			2 min. 2 min. 2 min. 2 min. 2 min.
	120			R-19	60			RQD=100			2 min.

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Professional Service Industries, Inc.
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PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

BORING B-1

Water
While Drilling 15 feet
Pre-Core (9-28-17) Not Enc.

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 / 25 / 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 / 2.0 / 4.0)	Additional Remarks
	120					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			2 min. 2 min. 2 min. >> Q_u = 1153.5 tsf 185.2 pcf 2 min.
				R-20	60			RQD=52 Rec=100%			2 min. 2 min.
	125					R-20: Fair Rock Mass Quality 125.5 to 127 ft: 75 degree fracture w/soil					2 min. 2 min. 2 min. 1 min.
				R-21	60			RQD=100 Rec=100%			2 min. 2 min. 2 min. 2 min.
	130										2 min. 2 min. 2 min. 2 min.
				R-22	60			RQD=100 Rec=100%			2 min. 2 min. 2 min. 2 min.
	135										2 min. 2 min. 2 min. 2 min.
				R-23	56			RQD=94 Rec=94%			2 min. 2 min. 3 min. >> Q_u = 2228.6 tsf 188.3 pcf
	140										3 min. 3 min. 3 min. 3 min.
				R-24	60			RQD=100 Rec=100%			3 min. 2 min. 2 min.
	145										
				R-25	60			RQD=90			
	150										

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Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION: See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	150					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			2 min.
											2 min.
											2 min.
											2 min.
						R-26: Fair Rock Mass Quality					3 min.
				R-26	60			RQD=68			
	155					154 to 155 ft: 75 degree fracture		Rec=100%			2 min.
											2 min.
											2 min.
											2 min.
											2 min.
				R-27	60			RQD=100			
	160							Rec=100%			2 min.
										>> Q_u = 1094.3 tsf	4 min.
											184.8 pcf
											2 min.
											2 min.
											2 min.
				R-28	60	R-28: Fair Rock Mass Quality		RQD=58			
	165							Rec=100%			2 min.
						162 to 173 ft: Regular 10-20 degree fractures					2 min.
											2 min.
											2 min.
											2 min.
				R-29	60	R-29: Fair Rock Mass Quality		RQD=68			
	170							Rec=100%			2 min.
											2 min.
											2 min.
											3 min.
											3 min.
				R-30	60			RQD=80			
	175							Rec=100%			3 min.
											5 min.
											6 min.
				R-31	14	10-02-17: Tooling pulled and core bit replaced; water level at 20.1 ft		RQD=100			4 min.
						10-03-17: Tooling back in borehole		Rec=100%		>> Q_u = 1332.9 tsf	
											185.4 pcf
											3 min.
	180										

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intertek psi
Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION:
See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 / 25 / 50); STRENGTH, tsf ▲ Qu ✳ Qp (0 / 2.0 / 4.0)	Additional Remarks
	180			R-32	46	**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		RQD=95 Rec=100%			3 min.
											3 min.
											3 min.
											3 min.
											3 min.
				R-33	60			RQD=100 Rec=100%			3 min.
	185										3 min.
											3 min.
											3 min.
											3 min.
											3 min.
				R-34	60			RQD=100 Rec=100%			3 min.
	190										3 min.
											4 min.
											3 min.
											3 min.
				R-35	60	R-35: Fair Rock Mass Quality		RQD=70 Rec=100%			4 min.
	195										3 min.
											5 min.
										>> ▲ Qu=828.0 tsf	3 min.
										185.8 pcf	3 min.
				R-36	60			RQD=100 Rec=100%			4 min.
	200										4 min.
											5 min.
											2 min.
											2 min.
				R-37	60			RQD=100 Rec=100%			2 min.
	205										2 min.
											2 min.
											2 min.
											3 min.
				R-38	60	R-38: Fair Rock Mass Quality		RQD=70			3 min.
	210										

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Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION: See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	210					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			3 min.
											3 min.
											4 min.
											3 min.
											4 min.
	215			R-39	60			RQD=100 Rec=100%			4 min.
											4 min.
											5 min.
											>> Q_u = 1655.6 tsf, 186.1 pcf
											4 min.
											5 min.
	220			R-40	60			RQD=100 Rec=100%			3 min.
											5 min.
						Box 13 from 207 to 222 ft end of 10-04-17					4 min.
											4 min.
											4 min.
	225			R-41	60			RQD=100 Rec=100%			4 min.
											5 min.
											6 min.
											4 min.
											7 min.
	230			R-42	60			RQD=100 Rec=100%			5 min.
											6 min.
											7 min.
											6 min.
											7 min.
	235			R-43	60			RQD=100 Rec=100%			6 min.
											5 min.
											9 min.
											>> Q_u = 1373.2 tsf, 184.1 pcf
											8 min.
											6 min.
	240			R-44	60			RQD=90			

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intertek psi
Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION:
See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	240					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			7 min.
											7 min.
											8 min.
											7 min.
											7 min.
	245			R-45	60			RQD=100 Rec=100%			7 min.
											8 min.
											9 min.
											9 min.
											8 min.
	250			R-46	60			RQD=100 Rec=100%			9 min.
											9 min.
											11 min.
											11 min.
											9 min.
	255			R-47	60			RQD=100 Rec=100%			13 min.
						256 ft: 75 degree fracture					14 min.
											12 min.
						10/4/17: Due to long coring times, driller pulled tooling to change bit which did not appear to be worn. However, it was replaced with a different core bit (RIDD#9 - Ontario, Canada).					3 min.
										>> ▲	Q_u = 1037.8 tsf 196.5 pcf 2 min.
	260			R-48	60	260.5 ft: 75 degree fracture		RQD=96 Rec=100%			1 min.
											1 min.
											2 min.
											1 min.
											2 min.
	265			R-49	60			RQD=96 Rec=100%			2 min.
											2 min.
											2 min.
											2 min.
											2 min.
	270			R-50	60			RQD=86			

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Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
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Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

BORING B-1

Water
While Drilling 15 feet
Pre-Core (9-28-17) Not Enc.

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	270					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet 270.3-270.9 ft: 75 degree fractures		Rec=100%			2 min. 2 min.
											2 min.
											2 min.
											1 min.
				R-51	60	273.9-274.6 ft: 45, 75, 105 degree fractures		RQD=86 Rec=100%			1 min.
	275									>> Q_u = 1854.6 tsf	1 min. 185.9 pcf
											2 min.
											2 min.
											2 min.
											2 min.
				R-52	60			RQD=100 Rec=100%			2 min.
	280										2 min.
											2 min.
											1 min.
											2 min.
				R-53	60			RQD=100 Rec=100%			2 min.
	285									>> Q_u = 1615.1 tsf	186.7 pcf 2 min.
											2 min.
											2 min.
											1 min.
				R-54	60			RQD=100 Rec=100%			1 min.
	290										2 min.
											2 min.
											1 min.
											1 min.
				R-55	60			RQD=100 Rec=100%			1 min.
	295									>> Q_u = 2129.3 tsf	1 min. 188.3 pcf
											2 min.
											1 min.
											1 min.
				R-56	60			RQD=100			
	300										

Continued Next Page

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION: See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture ✕ / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	300					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			2 min.
											2 min.
											2 min.
											1 min.
											1 min.
				R-57	60			RQD=100 Rec=100%			2 min.
	305										2 min.
											1 min.
											1 min.
				R-58	60			RQD=100 Rec=100%			2 min.
	310										2 min.
											2 min.
											>> Q_u = 1877.7 tsf, 188.6 pcf
											1 min.
											1 min.
				R-59	60			RQD=100 Rec=100%			2 min.
	315										2 min.
											2 min.
											2 min.
											2 min.
				R-60	60			RQD=100 Rec=100%			1 min.
	320										1 min.
											2 min.
											1 min.
											1 min.
				R-61	60	R-61: 20-30 degree fractures throughout w/ bright green mineral deposits		RQD=80 Rec=100%			2 min.
	325										2 min.
											2 min.
											1 min.
											1 min.
				R-62	60			RQD=100			
	330										

Continued Next Page

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
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Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION:
See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ Moisture × PL ✚ LL (0 / 25 / 50); STRENGTH, tsf ▲ Qu ✳ Qp (0 / 2.0 / 4.0)	Additional Remarks
	330					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			2 min.
											2 min.
										>> Q_u = 1551.0 tsf	189.3 pcf
											2 min.
											1 min.
						333.5-334 ft: 80 degree fractures					1 min.
	335			R-63	60			RQD=86 Rec=100%			1 min.
											2 min.
											2 min.
											2 min.
											1 min.
	340			R-64	60			RQD=100 Rec=100%			2 min.
											2 min.
											2 min.
											1 min.
											2 min.
	345			R-65	60			RQD=100 Rec=100%			2 min.
											2 min.
											2 min.
											1 min.
											1 min.
	350			R-66	60			RQD=100 Rec=100%			1 min.
											2 min.
										>> Q_u = 1344.8 tsf	185.9 pcf
											2 min.
											1 min.
											2 min.
	355			R-67	60			RQD=100 Rec=100%			2 min.
											1 min.
											2 min.
											1 min.
											1 min.
	360			R-68	60			RQD=100			

Continued Next Page

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-1

DATE STARTED:	9/28/17	**DRILL COMPANY:**	Eichelberger's
DATE COMPLETED:	10/5/17	**DRILLER:** M. Albright	**LOGGED BY:** M. Kauffman
COMPLETION DEPTH	365.0 ft	**DRILL RIG:**	Diedrich D50 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:**	HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:**	2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:**	Automatic
LONGITUDE:	n/a°	**EFFICIENCY**	N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	P. McMichael

REMARKS:

Water
- While Drilling — 15 feet
- Pre-Core (9-28-17) — Not Enc.

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	360					**BEDROCK** - Greenish gray to gray, **DIABASE**, slightly weathered to fresh, hard to very hard, broken to slightly broken to 62 feet		Rec=100%			2 min. 2 min. 2 min. 1 min.
				R-69	32	R-35: Poor Rock Mass Quality 20-30 degree fractures with bright green mineral deposits		RQD=47 Rec=90%			1 min. 1 min.
	365					Test Boring Terminated @ 365 ft					

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PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.


PSI #04911488
9-28-17
Geobore B-1
Box 1
Spread PPP 4 Susquehanna River (West)
Depth 0.0ft to 44.3 ft
Run | Depth | Rec | RQD
1 | 30.5 - 32.0 | 1.5 | 0.0
2 | 32.0 - 37.0 | 2.7 | 1.1
3 | 37.0 - 42.0 | 5.0 | 4.0
4 | 42.0 - 47.0 | 5.0 | 2.8
0.0
30.5
32.0
37.0
42.0
PSI 04911488 9-28-17
Bore B-1 Depth 0.0 to 44.3 ft
Spread PPP 4 Susquehanna West Bx 1


PSI # 04911488 9-28 -17
Boring B-1 Depth 44.3ft to 58.8 ft.
Spread PPP4 Susquehanna River (West)
Box 2
Run | Depth | Rec | RQD
4 | 42.0 - 47.0 | 5.0 | 2.8
5 | 47.0 - 52.0 | 5.0 | 3.1
6 | 52.0 - 57.0 | 5.0 | 2.8
7 | 57.0 - 62.0 | 5.0 | 2.3
44.3
47.0
52.0
57.0


PSI # 04911488 9-28,29-17
Boring B-1 Depth 58.8 to 72.0
Spread PPP 4 Susquehanna River (West)
Box 3
Run | Depth | Rec | RQD
7 | 57.0 - 62.0 | 5.0 | 2.3
8 | 62.0 - 67.0 | 5.0 | 3.3
9 | 67.0 - 72.0 | 5.0 | 5.0
62.0
58.8
67.0
PSI 04911488 9-28-17
Boring B-1 Depth 58.8 to 72.0
Spread PPP 4 Susquehanna River (West) Box 3

PSI 04911488 9-28 -17

Boring B-1 Depth 72.0 to 87.0

Spread PPP. 4 Susquehanna River (West)

Box 4

Run	Depth	Rec	RQD
10	72.0 - 77.0	5.0	5.0
11	77.0 - 82.0	5.0	5.0
12	82.0 - 87.0	5.0	3.0

PSI 04911488 9-28-17
Boring B-1 Depth 72.0 to 87.0
Spread PPP. 4 Susquehanna River (West) Box 4

PSI 04911488 9-28-17
Boring B-1 Depth 57.0 to 72.0
Spread PPP 4 Susquehanna River (West) Box 3


PSI 04911488 9-29-17
Boring B-1 Depth 87.0 to 102.0
Spread PPP 4 Susquehanna River (West)
Box 5
Run | Depth | Rec | RQD
13 | 87.0 - 92.0 | 5.0 | 4.3
14 | 92.0 - 97.0 | 5.0 | 5.0
15 | 97.0 - 102.0 | 5.0 | 5.0
87.0
92.0
97.0
102.0
PSI 04911488 9-29-17
Boring B-1 Depth 87.0 to 102.0
Spread PPP 4 Susquehanna River (West) Box 5


PSI 04911488 9-29-17
Boring B-1 Depth 102.0 to 117.0
Spread PPP-4 Susquehanna River (West)
Box 6
Run | Depth | Rec | RQD
16 | 102.0 - 107.0 | 5.0 | 4.2
17 | 107.0 - 112.0 | 5.0 | 5.0
18 | 112.0 - 117.0 | 5.0 | 5.0
PSI 04911488 9-29-17
Boring B-1 Depth 102.0 to 117.0
Spread PPP 4 Susquehanna River (West) Bx 6
PSI 04911488 9-29-17
Boring B-1 Depth 102.0 to 117.0
Spread PPP-4 Susquehanna River (West) Bx 4
PSI 04911488 9-29-17
Boring B-1 Depth 102.0 to 117.0
Spread PPP-4 Susquehanna River (West) Box 3


PSI 04911488 9-29-17
Boring B-1 Depth 117.0 - 132.0
Spread PPP 4 Susquehanna River (West)
Box 7
Run | Depth | Rec | RQD
19 | 117.0 - 122.0 | 5.0 | 5.0
20 | 122.0 - 127.0 | 5.0 | 2.6
21 | 127.0 - 132.0 | 5.0 | 5.0
117.0
122.0
127.0
PSI 04911488 9-29-17
Boring B-1 Depth 117.0 - 132.0
Spread PPP 4 Susquehanna River (West) Box 7


PSI 04911488 9-29-17 10-2-17
Boring B-1 Depth 132.0 to 147.0
Spread PPP 4 Susquehanna River (West)
Box 8
Run | Depth | Rec | RQD
22 | 132.0 - 137.0 | 5.0 | 5.0
23 | 137.0 - 142.0 | 4.7 | 4.7
24 | 142.0 - 147.0 | 5.0 | 5.0
132.0
142.0
147.0
PSI 04911488 9-29-17 10-2-17
Boring B-1 Depth 132.0 to 147.0
Spread PPP 4 Susquehanna River (West) Box 8a
PSI 04911488 9-29-17
Boring B-1 Depth 117.0 to 132.0
Spread PPP 4 Susquehanna River (West) Box 7


PS1049114488 10-2-17
Boring B-1 Depth 147.0 to 162.0
Spread PPP 4 Susquehanna River (West)
Box 9
Run | Depth | Rec | RQD
25 | 147.0 - 152.0 | 5.0 | 4.5
26 | 152.0 - 157.0 | 5.0 | 3.4
27 | 157.0 - 162.0 | 5.0 | 5.0
147.0
152.0
157
162.0
1049114488 10-2-17
Boring B-1 Depth 147.0 to 162.0
Spread PPP 4 Susquehanna River (West) Box 9
1049114488 9-29-17 10-1-17
Boring B-1 Depth 132.0 to 147.0
Spread PPP 4 Susquehanna River (West) Box 8
1049114488 9-29-17
Boring B-1 Depth 117.0 to 132.0
Spread PPP 4 Susquehanna River (West) Box 7

PS1049111488 10-2-17

Boring B-1 Depth 162.0-177.0

Spread PPP 4 Susquehanna River (West)

Box 10

Run	Depth	Rec	RQD
28	162.0 - 167.0	5.0	2.9
29	167.0 - 172.0	5.0	3.4
30	172.0 - 177.0	5.0	4.0

PSI 04911488 10-2-17
Boring B-1 Depth 177.0 to 192.0
Spread PPP 4 Susquehanna River (West)

Box 11

Run	Depth	Rec	RQD
31	177.0 - 178.2	1.2	1.2
32	178.2 182.0	3.8	3.6
33	182.0 - 187.0	5.0	5.0
34	187.0 - 192.0	5.0	5.0

PSI 04911488 10-2317
Boring B-1 Depth 177.0 - 192.0
Spread PPP 4 Susquehanna River (West) Box 11

PSI 04911488 10-2-17
Boring B-1 Depth 162.0 to 177.0
Spread PPP 4 Susquehanna River (West) Box 10

PSI 04911488 10-3-17

Boring B-1 Depth 192.0 to 207.0

Spread PPP 4 Susquehanna River (West)

Box 12

Run	Depth	Rec	RQD
35	192.0 - 197.0	5.0	3.5
36	197.0 - 202.0	5.0	5.0
37	202.0 - 207.0	5.0	5.0


PSI 04911488 10-2-17
Boring B-1 Depth 147.0 to 162.0
Spread PPP 4 Susquehanna River (West)
Box 9
PSI 04911488 10-3-17
Boring B-1 Depth 207.0 to 222.0
Spread PPP 4 Susquehanna River (West)
Box 13
Run | Depth | Rec | RQD
38 | 207.0 - 212.0 | 5.0 | 3.5
39 | 212.0 - 217.0 | 5.0 | 5.0
40 | 217.0 - 222.0 | 5.0 | 5.0
207.0
212.0
217.0
222.0
PSI 04911488E 10-3-17
Boring B-1 Depth 207.0 to 222.0
Spread PPP 4 Susquehanna River (West) Box 13


PSI 04911488 10-2-17
R-1 North 147.0 to 167.0
PSI 04911488 10-4-17
Boring B-1 Depth 222.0-237.0
Spread PPP 4 Susquehanna River (West)
Box 14
Run | Depth | Rec | RQD
41 | 222.0-227.0 | 5.0 | 5.0
42 | 227.0-232.0 | 5.0 | 5.0
43 | 232.0-237.0 | 5.0 | 5.0
222.0
227.0
232.0
237.0
PSI 04911488 10-4-17
Boring B-1 Depth 222.0 to 227.0 Bx 14
Spread PPP 4 Susquehanna River (West)
PSI 04911488 10-3-17
Boring B-1 Depth 207.0 to 222.0 Bx 13
Spread PPP 4 Susquehanna River (West)


PS1 04911488 10-4-17
Boring B-1 Depth 237.0 to 252.0
Spread PPP 4 Susquehanna River (West)
Box 15
Run | Depth | Rec | RQD
44 | 237.0 - 242.0 | 5.0 | 4.5
45 | 242.0 - 247.0 | 5.0 | 5.0
46 | 247.0 - 252.0 | 5.0 | 5.0
2420
2470
PS1 04911488 10-4-17
Boring B-1 Depth 237.0 to 252.0 Box 15
Spread PPP 4 Susquehanna River (West)
PS1 04911488 10-3-17
Boring B-1 Depth 2220 to 2370 Bx 14
Spread PPP 4 Susquehanna River (West)
10-3-17
Depth 2070 to 2220
Susquehanna River (West) Bx 13

PSI 04911488 10-417

Boring B-1 Depth 252.0 to 267.0

Spread PPP 4 Susquehanna River (West)

Box 16

Run	Depth	Rec	RQD
47/47	252.0 - 257.0	5.0	5.0
49/49	257.0 - 262.0	5.0	4.8
49/46	262.0 - 267.0	5.0	4.8

PSI 04911488 10-4-17
Boring B-1 Depth 252.0 to 267.0
Spread PPP 4 Susquehanna River West Box 16


PSI 04911488 10-5-17
Boring B-1 Depth 267.0 to 282.0
Spread PPP 4 Susquehanna River (West)
Box # 17
Run | Depth | Rec | RQD
50 | 267.0 - 272.0 | 5.0 | 4.3
51 | 272.0 - 277.0 | 5.0 | 4.3
52 | 277.0 - 282.0 | 5.0 | 5.0
267.0
272.0
277.0
282.0
PSI 04911488 10-5-17
Boring B-1 Depth 267.0 - 282.0
Spread PPP # 4 Susquehanna River (West) Box 17
Boring B-1 Depth 252.0 to 267.0
Spread PPP 4 Susquehanna River West Box 16


PSI 04911488 10-5-17
Boring B-1 Depth 282.0 to 297.0
Spread PPP-4 Susquehanna River (West)
Box 18
Run | Depth | Rec | RQD
53 | 282.0 - 287.0 | 5.0 | 5.0
54 | 287.0 - 292.0 | 5.0 | 5.0
55 | 292.0 - 297.0 | 5.0 | 5.0
282.0
297.0
292.0
PSI 04911488 10-5-17
Boring B-1 Depth 282.0-297.0 Box 18
Spread PPP 4 Susquehanna River (West)
Box 17
Box 16


PSI 04911488 10-5-17
Boring B-1 Depth 297.0 to 312.0
Spread PPP 4 Susquehanna River (West)
Box 19
Run | Depth | Rec | RQD
56 | 297.0 - 302.0 | 5.0 | 5.0
57 | 302.0 - 307.0 | 5.0 | 5.0
58 | 307.0 - 312.0 | 5.0 | 5.0
297.0
302.0
307.0
312.0

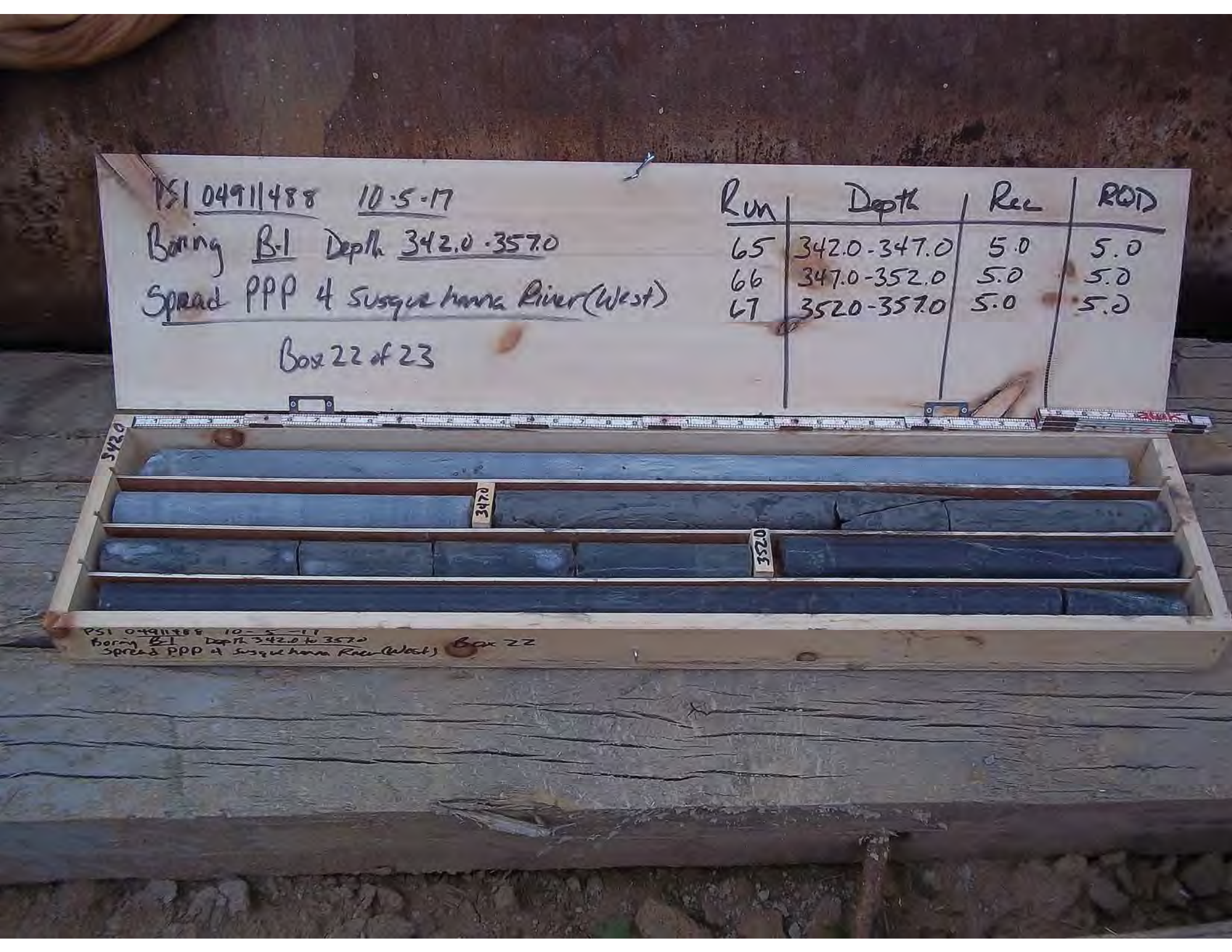

PS1 04911488 10-5-17
Boring B-1 Depth 312.0 to 327.0
Spread PPP 4 Susquehanna River (West)
Box 20
Run | Depth | Rec | RQD
59 | 312.0 - 317.0 | 5.0 | 5.0
60 | 317.0 - 322.0 | 5.0 | 5.0
61 | 322.0 - 327.0 | 5.0 | 4.0
312.0
317.0
322.0
327.0
PS1. 04911488 10-5-17
Boring B-1 Depth 312.0 to 327.0 Box 20
Spread PPP 4 Susquehanna River (West)
PS1 04911488 10-5-17
Boring B-1 Depth 297.0 to 312.0
Spread PPP 4 Susquehanna River (West) Box 19

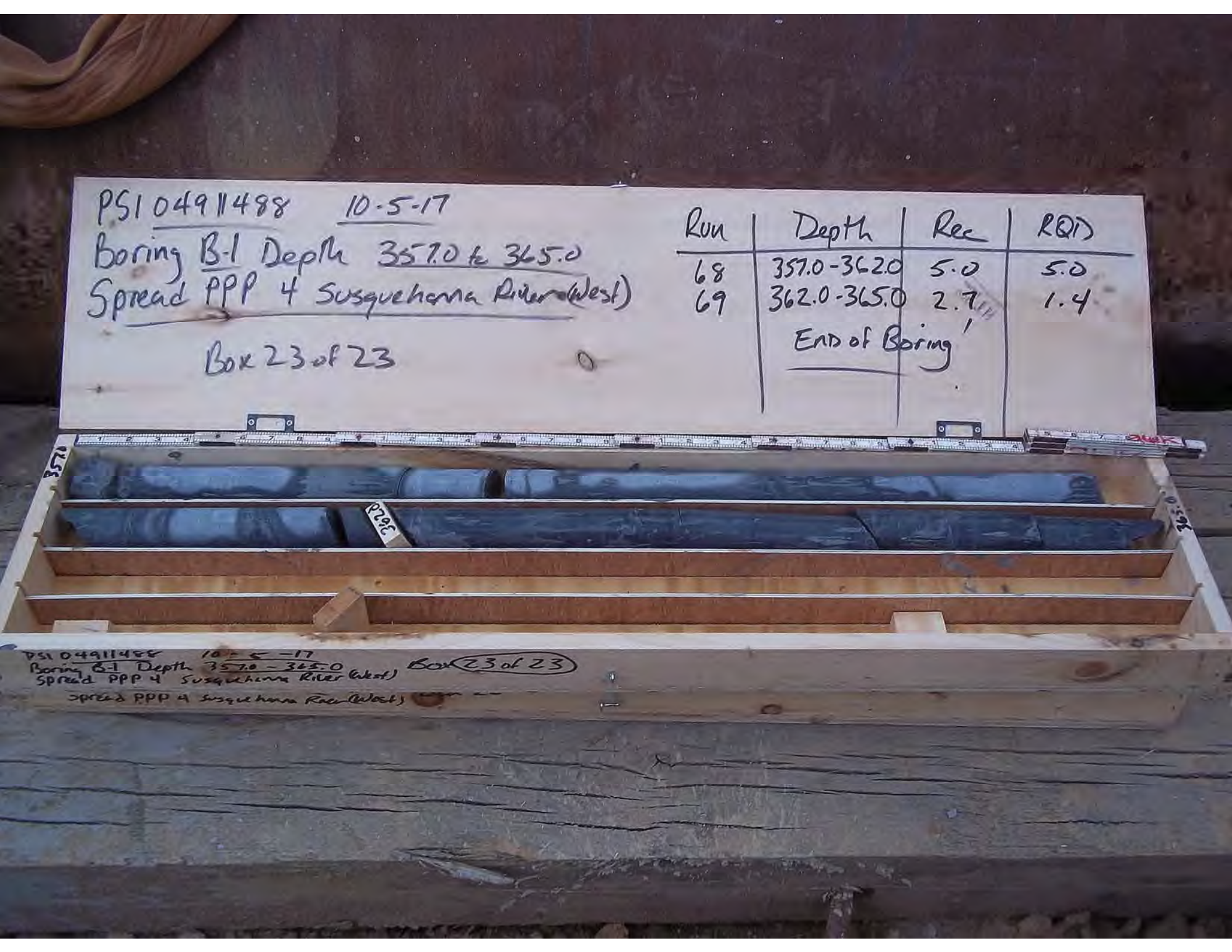

PSI 04911488 10-5-17
Boring B-1 Depth 327.0 to 342.0
Spread PPP 4 Susquehanna River (West)
Box 21 of 23
Run | Depth | Rec | RQD
62 | 327.0 - 332.0 | 5.0 | 5.0
63 | 332.0 - 337.0 | 5.0 | 4.3
64 | 337.0 - 342.0 | 5.0 | 5.0
327.0
332.0
337.0
342.0
PSI 04911488 10-5-17
Boring B-1 Depth 327.0 to 342.0
Spread PPP 4 Susquehanna River (West) Box 21
Boring B-1 Depth 312.0 to 327.0 Box 20
Spread PPP 4 Susquehanna River (West)
PSI 04911488 10-5-17
Boring B-1 Depth 297.0 to 312.0
Spread PPP 4 Susquehanna River (West) Box 19

PSI 04911488 10-5-17
Boring B-1 Depth 342.0-357.0
Spread PPP 4 Susquehanna River (West)

Box 22 of 23

Run	Depth	Rec	RQD
65	342.0-347.0	5.0	5.0
66	347.0-352.0	5.0	5.0
67	352.0-357.0	5.0	5.0




PSI 04911488 10-5-17
Boring B-1 Depth 357.0 to 365.0
Spread PPP 4 Susquehanna River (West)
Box 23 of 23
Run | Depth | Rec | RQD
68 | 357.0-362.0 | 5.0 | 5.0
69 | 362.0-365.0 | 2.7 | 1.4
End of Boring
357.0
PZ96
365.0
PSI 04911488 10-5-17
Boring B-1 Depth 357.0 - 365.0
Spread PPP 4 Susquehanna River (West)
Box 23 of 23
Spread PPP 4 Susquehanna River (West)

BORING B-2

DATE STARTED:	9/26/17	**DRILL COMPANY:** AWK Drilling
DATE COMPLETED:	9/27/17	**DRILLER:** T. Growden **LOGGED BY:** M. Wildman
COMPLETION DEPTH	160.0 ft	**DRILL RIG:** CME 55 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:** HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:** Automatic
LONGITUDE:	n/a°	**EFFICIENCY** N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:** P. McMichael

REMARKS:

Water

Pre-Core	9.2	feet
Upon Completion	23.1	feet
Post Drilling	25.7	feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ Moisture × PL ◪ LL ✚ (0 25 50) STRENGTH, tsf Qu ▲ Qp ✳ (0 2.0 4.0)	Additional Remarks
	0			S-1	11	**FILL**-Dark gray to dark brown, Poorly Graded GRAVEL with Silt and Sand, some slag, metal & concrete, dry to moist	GP-GM	8-50/4"	7		
	5			S-2	12	S2: Sand-sized Coal layer from 6 to 7 ft.		13-19-6-3 N=25	34		
	10			S-3	0	**ALLUVIUM**-Soft, Black, SILT**, trace organics, moist **Field logger visually charactized a stratum of Organic Silt (OL) between the approximate depths of 6 to 17 ft. However, the following should be noted: S2 (5 to 7 ft): The recovered material appears to have consisted of sand-sized coal material/FILL. S3 (12 to 15 ft): No Sample Recovery. S4 (15 to 17 ft): Based on oven dried vs non-oven dried Liquid Limit tests, S4 classifies as a SILT (ML) per USCS. The lab tested LOI/organic content for S4 was determined to be 6.3%. A "heavy weathered diesel odor" was noted by field logger.	ML	2-2-1-3 N=3			
	15			S-4	24			2-2-2-2 N=4	32		LL = 33 PL = 24 6.3% organics LL = 41 PL = 26
	20			S-5	10	**ALLUVIUM**-Medidum Stiff to Stiff, Light brown to brown, Sandy Silty CLAY , moist	CL-ML	4-6-8-7 N=14	24		LL = 29 PL = 22
	25			S-6	24	**ALLUVIUM**-Loose, Tan to gray, Silty SAND with Gravel, wet Weathered diesel odor from 26 to 27 feet	SM	3-3-5-5 N=8	14		Fines=19.4%
	30										

Continued Next Page

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-2

DATE STARTED:	9/26/17
DATE COMPLETED:	9/27/17
COMPLETION DEPTH	160.0 ft
BENCHMARK:	N/A
ELEVATION:	N/A
LATITUDE:	n/a°
LONGITUDE:	n/a°
STATION:	N/A
OFFSET:	N/A
REMARKS:	

DRILL COMPANY:	AWK Drilling
DRILLER:	T. Growden
LOGGED BY:	M. Wildman
DRILL RIG:	CME 55 Track Rig
DRILLING METHOD:	HSA/Rock Coring
SAMPLING METHOD:	2-in SS1.874-in Core
HAMMER TYPE:	Automatic
EFFICIENCY	N/A
REVIEWED BY:	P. McMichael

Water

Pre-Core	9.2 feet
Upon Completion	23.1 feet
Post Drilling	25.7 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	30			S-7	0	**BEDROCK**-Red-brown, **SANDSTONE**, fine grained, thinly bedded, highly to moderately weathered, soft to medium hard, RD 25-30		50/4"	3		
				R-1	29			RQD=0 Rec=92%		>>◎	1 min.
											1 min.
											1 min.
	35			R-2	60	**BEDROCK**-Red-brown, **LIMESTONE FANGLOMERATE**, thin to medium bedded, moderately weathered, medium hard, RD 20-25		RQD=34 Rec=100%			1 min.
											1 min.
										>>▲	Q_u = 99.9 tsf 147.5 pcf
											1 min.
											1 min.
	40			R-3	52			RQD=22 Rec=86%			1 min.
											1 min.
											1 min.
											2 min.
											1 min.
	45			R-4	40			RQD=0 Rec=66%			1 min.
											1 min.
											1 min.
						0.2 ' Thick soil seams, completely weathered @ 48 ft, 49 ft, 49.5 ft, 50.3 ft					2 min.
											1 min.
	50			R-5	38			RQD=24 Rec=64%			1 min.
											1 min.
						BEDROCK-Red-brown, **SANDSTONE**, fine grained, thinly bedded, completely weathered to slightly weathered, medium hard to very soft, RD 25-30					2 min.
											3 min.
											2 min.
										>>▲	Q_u = 274.2 tsf 159.2 pcf
	55			R-6	60	Completely weathered from 55 to 55.8 ft		RQD=28 Rec=100%			1 min.
											2 min.
											1 min.
											1 min.
											2 min.
	60										

Continued Next Page

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-2

DATE STARTED:	9/26/17	**DRILL COMPANY:** AWK Drilling
DATE COMPLETED:	9/27/17	**DRILLER:** T. Growden **LOGGED BY:** M. Wildman
COMPLETION DEPTH	160.0 ft	**DRILL RIG:** CME 55 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:** HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:** Automatic
LONGITUDE:	n/a°	**EFFICIENCY** N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:** P. McMichael

Water

Pre-Core	9.2	feet
Upon Completion	23.1	feet
Post Drilling	25.7	feet

BORING LOCATION: See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0, 25, 50) STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	60			R-7	60	**BEDROCK**-Red-brown, **SANDSTONE**, fine grained, thinly bedded, completely weathered to slightly weathered, medium hard to very soft, RD 25-30		RQD=36 Rec=100%			1 min. 1 min. 1 min. 1 min. 1 min.
						Completely weathered from 64 to 64.5 ft					
	65			R-8	59			RQD=34 Rec=98%			1 min. 1 min. 1 min. 1 min. 1 min.
						Some coarse Sandstone interbeds from 69.5 to 80 ft					
	70			R-9	60			RQD=68 Rec=100%		>> ▲ Q_u = 883.7 tsf 152.8 pcf	1 min. 1 min. 1 min. 1 min. 1 min.
	75			R-10	59			RQD=98 Rec=98%			1 min. 1 min. 1 min. 1 min. 1 min.
	80			R-11	59	**BEDROCK**-Red-brown to gray, **LIMESTONE FANGLOMERATE**, with coarse Sandstone interbeds, thinly to medium bedded, moderately to slightly weathered, medium hard to hard, RD 25, rock commonly grades to fine grained Sandstone		RQD=90 Rec=98%			1 min. 1 min. 1 min. 1 min. 1 min.
	85			R-12	58			RQD=56 Rec=96%		>> ▲ Q_u = 250.7 tsf 140.6 pcf	1 min. 1 min. 1 min. 1 min. 1 min.
										>> ▲ Q_u = 303.8 tsf 157.1 pcf	1 min.
	90										

Continued Next Page

intertek psi
Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622

PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-2

DATE STARTED:	9/26/17	**DRILL COMPANY:** AWK Drilling
DATE COMPLETED:	9/27/17	**DRILLER:** T. Growden **LOGGED BY:** M. Wildman
COMPLETION DEPTH	160.0 ft	**DRILL RIG:** CME 55 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:** HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:** Automatic
LONGITUDE:	n/a°	**EFFICIENCY** N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:** P. McMichael

Water

Pre-Core	9.2 feet
Upon Completion	23.1 feet
Post Drilling	25.7 feet

BORING LOCATION:
See Boring Location Plan

REMARKS:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (0 25 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 2.0 4.0)	Additional Remarks
	90			R-13	60	**BEDROCK**-Red-brown to gray, **LIMESTONE FANGLOMERATE**, with coarse Sandstone interbeds, thinly to medium bedded, moderately to slightly weathered, medium hard to hard, RD 25, rock commonly grades to fine grained Sandstone		RQD=88 Rec=100%			1 min. 1 min. 1 min. 1 min. >> Q_u = 711.6 tsf 159.6 pcf 1 min.
	95			R-14	60			RQD=90 Rec=100%			1 min. 1 min. 1 min. 1 min. 1 min.
	100			R-15	60			RQD=54 Rec=100%			1 min. 1 min. 1 min. >> Q_u = 373.0 tsf 163.9 pcf 1 min.
	105			R-16	60			RQD=100 Rec=100%			1 min. 1 min. 2 min. 1 min. 1 min. 1 min.
	110			R-17	59			RQD=98 Rec=98%			1 min. 1 min. 1 min. >> Q_u = 345.6 tsf 159.9 pcf 1 min.
	115			R-18	60			RQD=100 Rec=100%			1 min. 1 min. 1 min. 1 min. 1 min.
	120										

Continued Next Page

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PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-2

DATE STARTED:	9/26/17
DATE COMPLETED:	9/27/17
COMPLETION DEPTH	160.0 ft
BENCHMARK:	N/A
ELEVATION:	N/A
LATITUDE:	n/a°
LONGITUDE:	n/a°
STATION:	N/A
OFFSET:	N/A
REMARKS:	

DRILL COMPANY:	AWK Drilling
DRILLER:	T. Growden
LOGGED BY:	M. Wildman
DRILL RIG:	CME 55 Track Rig
DRILLING METHOD:	HSA/Rock Coring
SAMPLING METHOD:	2-in SS1.874-in Core
HAMMER TYPE:	Automatic
EFFICIENCY	N/A
REVIEWED BY:	P. McMichael

Water

Pre-Core	9.2 feet
Upon Completion	23.1 feet
Post Drilling	25.7 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf ▲ Qu ✳ Qp (0, 2.0, 4.0)	Additional Remarks
	120			R-19	60	**BEDROCK**-Red-brown to gray, **LIMESTONE FANGLOMERATE**, with coarse Sandstone interbeds, thinly to medium bedded, moderately to slightly weathered, medium hard to hard, RD 25, rock commonly grades to fine grained Sandstone		RQD=84 Rec=100%			1 min. 1 min. 2 min. 1 min. 1 min.
	125			R-20	60			RQD=80 Rec=100%			1 min. 1 min. 1 min. 1 min. 1 min.
	130			R-21	60			RQD=74 Rec=100%		>> ▲	Q_u = 324.8 tsf 160.1 pcf 1 min. 1 min. 1 min. 1 min. 1 min.
	135			R-22	60			RQD=68 Rec=100%			1 min. 1 min. 1 min. 1 min. 2 min.
	140			R-23	60			RQD=100 Rec=100%		>> ▲	1 min. 1 min. 1 min. Q_u = 312.3 tsf 164.6 pcf 2 min.
	145			R-24	59			RQD=98 Rec=98%			1 min. 1 min. 1 min. 1 min. 1 min.
	150										

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PROJECT NO.: 04911488
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-2

DATE STARTED:	9/26/17	**DRILL COMPANY:** AWK Drilling
DATE COMPLETED:	9/27/17	**DRILLER:** T. Growden **LOGGED BY:** M. Wildman
COMPLETION DEPTH	160.0 ft	**DRILL RIG:** CME 55 Track Rig
BENCHMARK:	N/A	**DRILLING METHOD:** HSA/Rock Coring
ELEVATION:	N/A	**SAMPLING METHOD:** 2-in SS1.874-in Core
LATITUDE:	n/a°	**HAMMER TYPE:** Automatic
LONGITUDE:	n/a°	**EFFICIENCY** N/A
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:** P. McMichael

REMARKS:

Water

Pre-Core	9.2 feet
Upon Completion	23.1 feet
Post Drilling	25.7 feet

BORING LOCATION:
See Boring Location Plan

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / Moisture × / PL ◪ / LL ✚ (0, 25, 50) / STRENGTH, tsf Qu ▲ / Qp ✳ (0, 2.0, 4.0)	Additional Remarks
	150			R-25	60	**BEDROCK**-Red-brown to gray, **LIMESTONE FANGLOMERATE**, with coarse Sandstone interbeds, thinly to medium bedded, moderately to slightly weathered, medium hard to hard, RD 25, rock commonly grades to fine grained Sandstone		RQD=92 Rec=100%		>> ▲ Qu=708.8 tsf	Qp=7 tsf 162.1 pcf 1 min. 1 min. 1 min. 1 min.
	155			R-26	60			RQD=74 Rec=100%			1 min. 1 min. 1 min. 1 min. 1 min.
	160			R-27	23	Test Boring Terminated @ 160 feet		RQD=95 Rec=95%			1 min. 1 min.

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LOCATION: Susquehanna River (PPP4) Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

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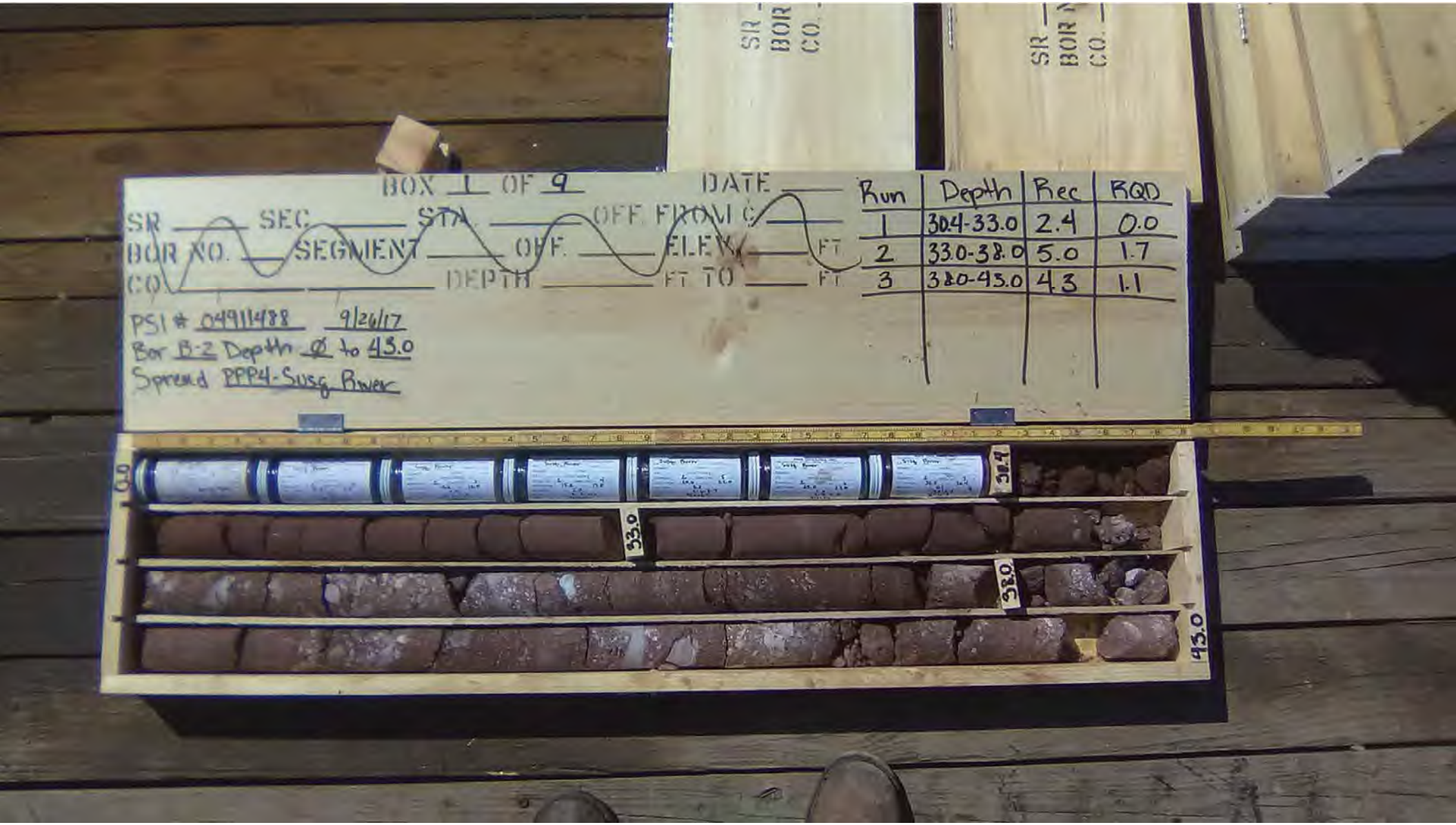
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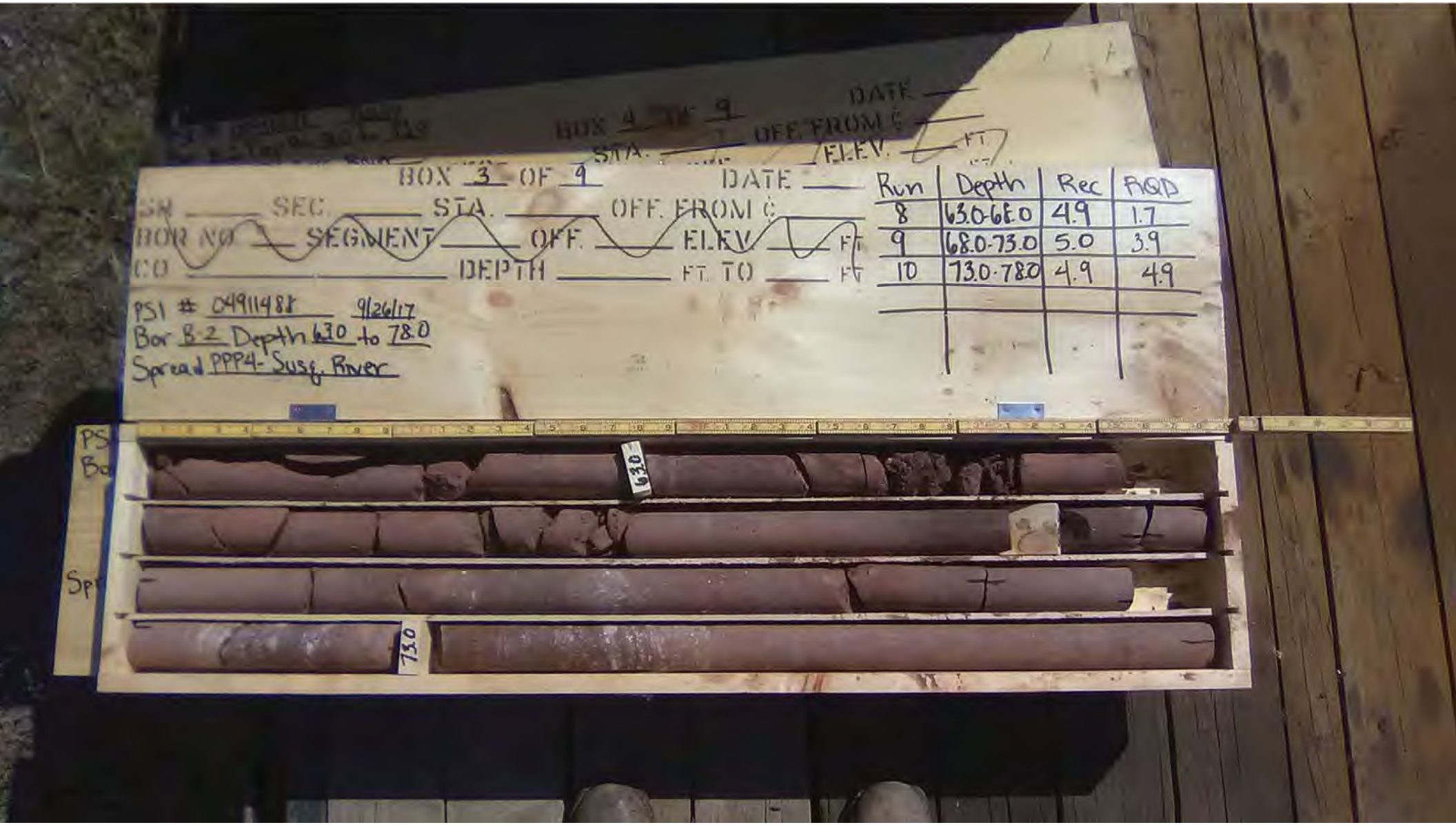
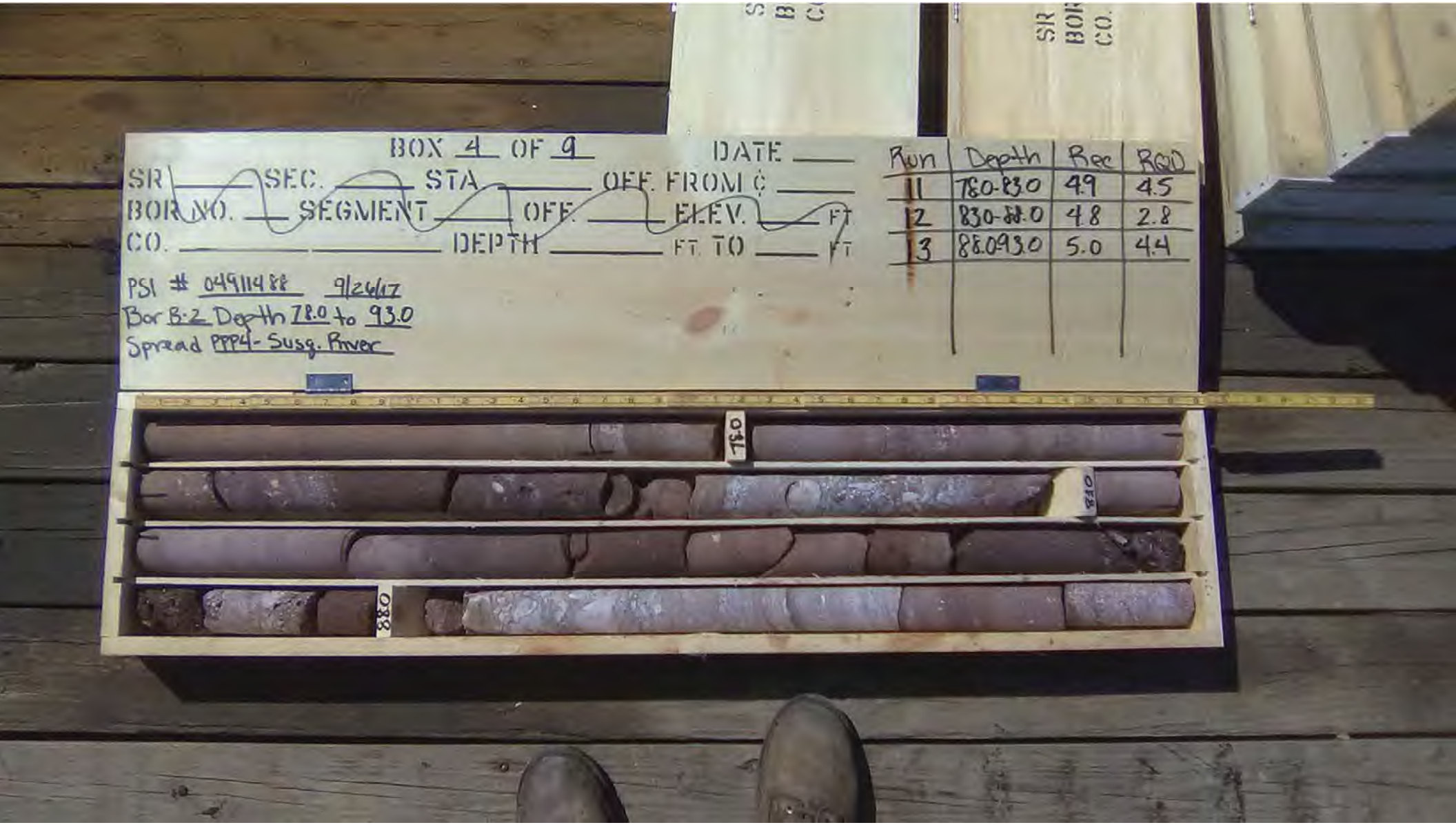
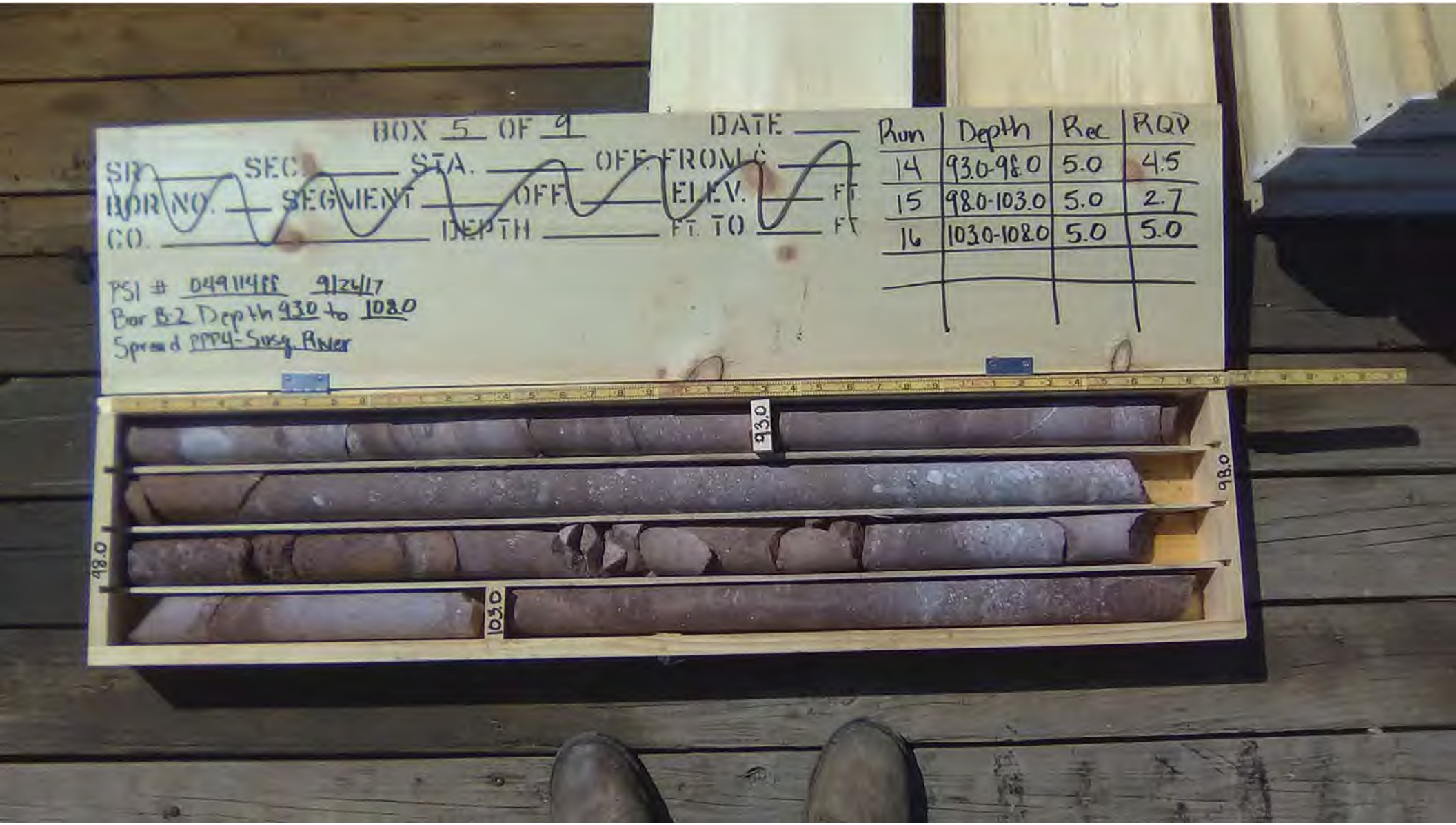
DATE
SR SEC STA OFF FROM ℄
BOR NO. SEGMENT OFF ELEV FT
CO DEPTH FT TO FT
PSI # 04911488 9/26/17
Bor B-2 Depth ℄ to 43.0
Spread PPP4-Susq Power
Run | Depth | Rec | RQD
1 | 30.4-33.0 | 2.4 | 0.0
2 | 33.0-38.0 | 5.0 | 1.7
3 | 38.0-43.0 | 4.3 | 1.1
33.0
38.0
43.0


SR
BOR NO.
CO.
SR
BOR NO.
CO.
BOX 2 OF 9
DATE
SR SEC STA OFF. FROM ℄
BOR NO. SEGMENT OFF. ELEV. FT.
CO DEPTH FT. TO FT.
PSI at 0499114PP 9/26/17
Bor B-2 Depth 43.0 to 63.0
Spread PPP9-Susq. River
Run | Depth | Rec. | RQD
4 | 43.0-48.0 | 3.3 | 0.0
5 | 48.0-53.0 | 3.2 | 1.2
6 | 53.0-58.0 | 5.0 | 1.4
7 | 58.0-63.0 | 5.0 | 1.8
43.0
48.0
53.0
58.0
58.0


BOX 4 OF 9
DATE
OFF. FROM ℄
STA.
ELEV.
FT.
BOX 3 OF 9
DATE
SR
SEC.
STA.
OFF. FROM ℄
BOR NO
SEGMENT
OFF.
ELEV
FT
CO
DEPTH
FT. TO
FT
PSI # 04911488 9/26/17
Bor B-2 Depth 630 to 780
Spread PPP4- Susq. River
Run | Depth | Rec | RQD
8 | 63.0-68.0 | 4.9 | 1.7
9 | 68.0-73.0 | 5.0 | 3.9
10 | 73.0-78.0 | 4.9 | 4.9
630
730


BOX 4 OF 9
DATE
SR
SEC.
STA
OFF. FROM ℄
BOR NO.
SEGMENT
OFF.
ELEV.
FT
CO.
DEPTH
FT. TO
FT
PSI # 04911488 9/26/17
Bor B-2 Depth 78.0 to 93.0
Spread PPP4 - Susq. River
Run | Depth | Rec | RQD
11 | 78.0-83.0 | 4.9 | 4.5
12 | 83.0-88.0 | 4.8 | 2.8
13 | 88.0-93.0 | 5.0 | 4.4
78.0
83.0
88.0


BOX 5 OF 9
DATE
SR
SEC.
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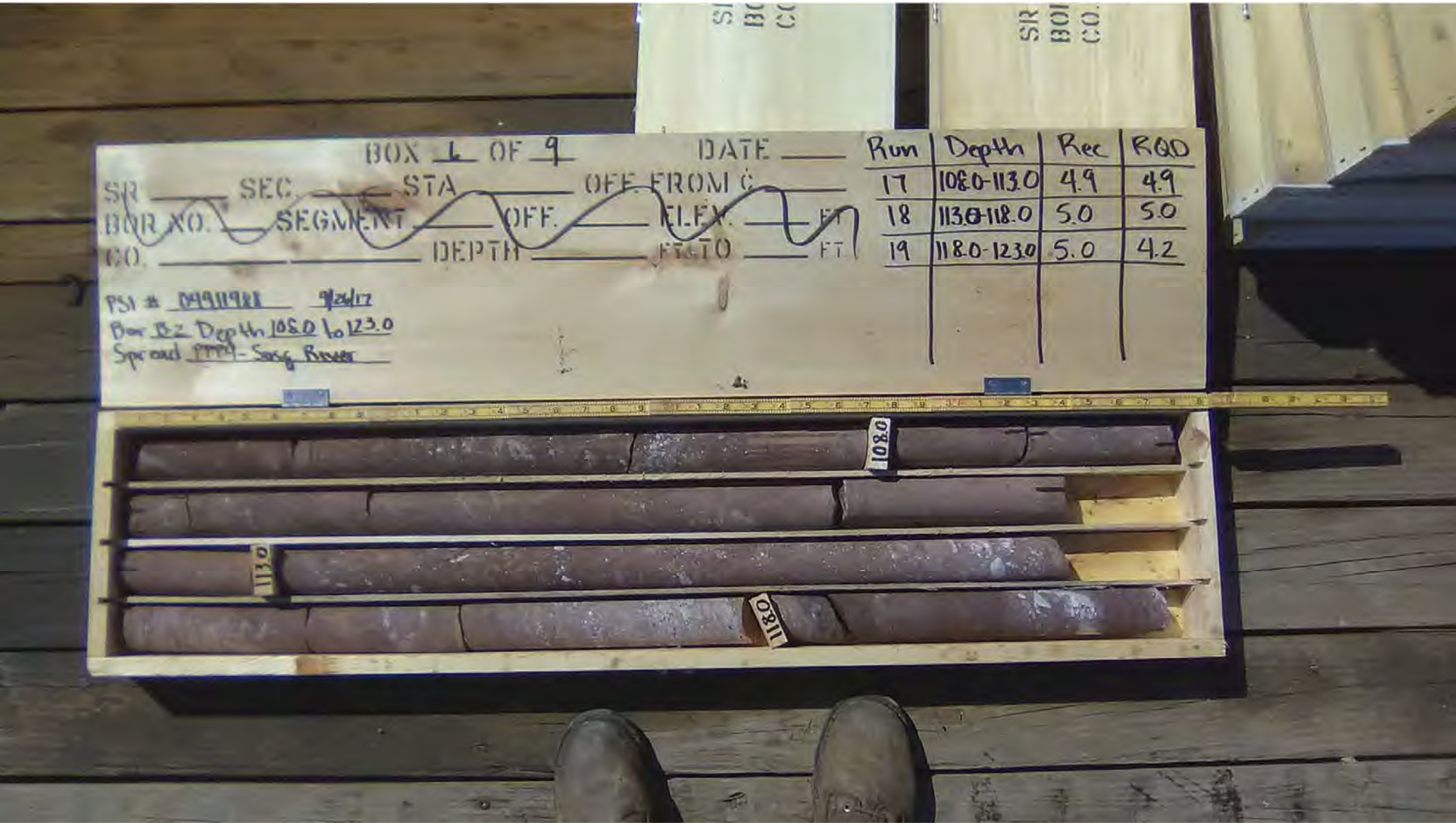
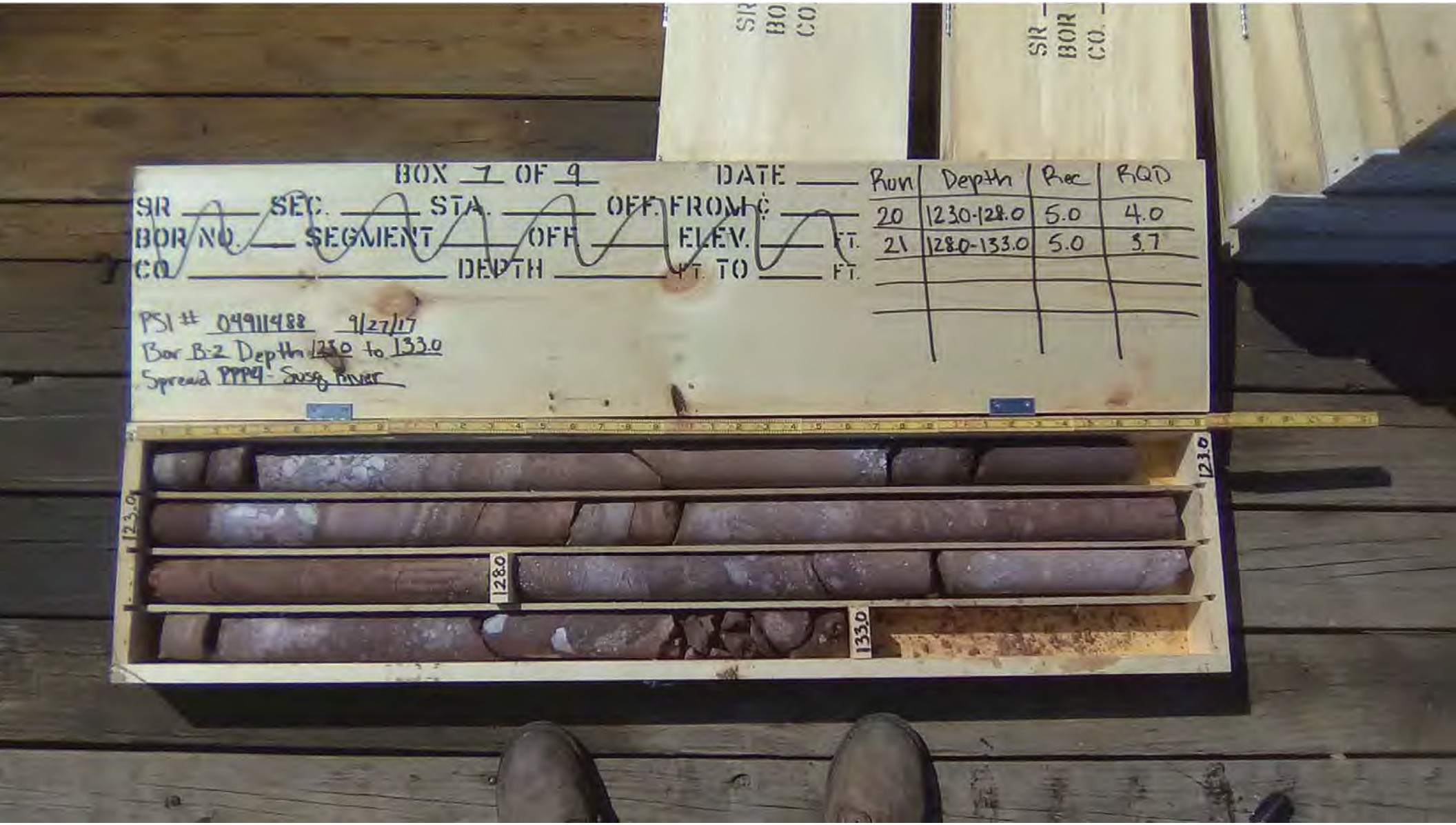
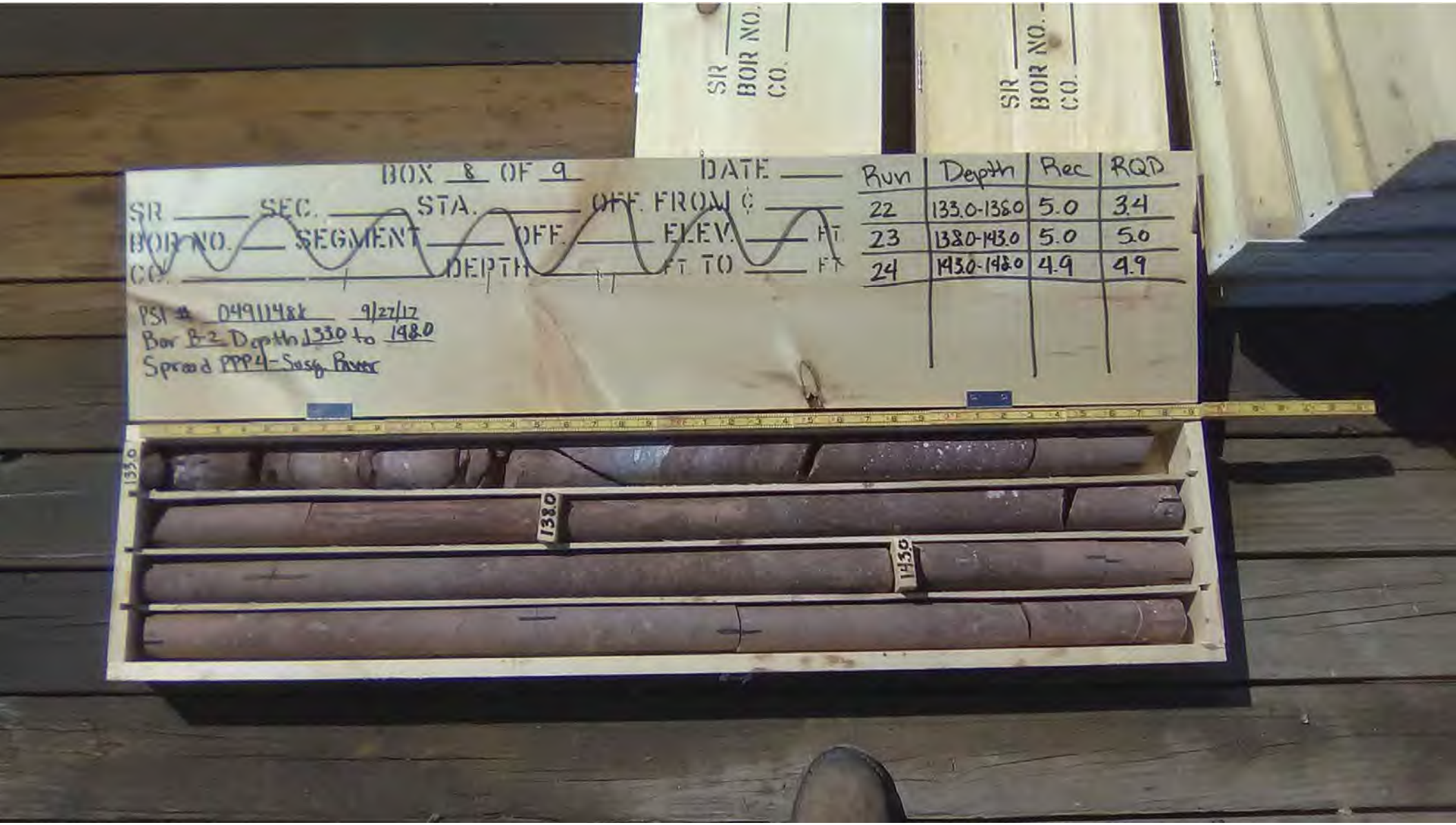
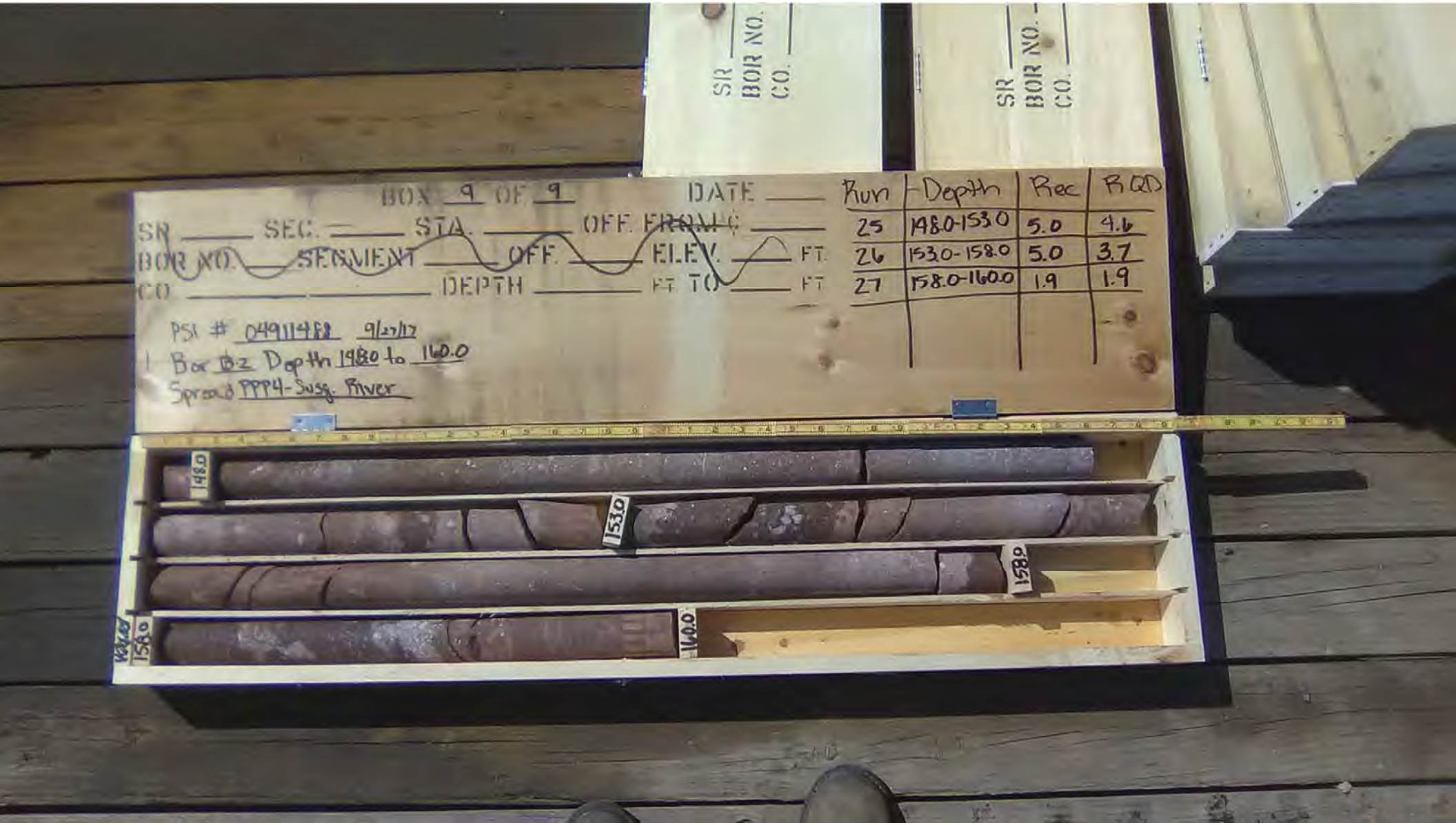
OFF.
FROM ℄
BOR NO.
SEGMENT
OFF.
EL.EV.
FT
CO.
DEPTH
FT. TO
FT
PSI # 04911488 9/24/17
Bor B-2 Depth 930 to 1080
Spread PPP4-Susq. River
Run | Depth | Rec | RQD
14 | 93.0-98.0 | 5.0 | 4.5
15 | 98.0-103.0 | 5.0 | 2.7
16 | 103.0-108.0 | 5.0 | 5.0
93.0
98.0
103.0
108.0


BOX 1 OF 9
DATE
SR SEC STA OFF. FROM ℄
BOR NO. SEGMENT OFF. ELEV. FT
CO. DEPTH FT TO FT
PSI # 0499119881 9/26/17
Bor B2 Depth 108.0 to 123.0
Spread 9999 - Saco River
Run | Depth | Rec | RQD
17 | 108.0-113.0 | 4.9 | 4.9
18 | 113.0-118.0 | 5.0 | 5.0
19 | 118.0-123.0 | 5.0 | 4.2
108.0
113.0
118.0


BOX 7 OF 9
DATE
SR SEC. STA. OFF. FROM ℄
BOR NO. SEGMENT OFF ELEV. FT.
CO DEPTH FT. TO FT.
PSI # 04911488 9/27/17
Bor B-2 Depth 1230 to 1330
Spread PPP4 - Susq River
Run | Depth | Rec | RQD
20 | 1230-1280 | 5.0 | 4.0
21 | 1280-1330 | 5.0 | 3.7
1230
1280
1330


SR
BOR NO.
CO.
SR
BOR NO.
CO.
BOX 8 OF 9
DATE
SR SEC. STA. OFF. FROM ℄
BOR NO. SEGMENT OFF. ELEV. FT
CO. DEPTH FT TO FT
PSI # 049114&k 9/27/17
Bor B-2 Depth 1330 to 1980
Spread PPP4-Susq. River
Run | Depth | Rec | RQD
22 | 133.0-138.0 | 5.0 | 3.4
23 | 138.0-143.0 | 5.0 | 5.0
24 | 143.0-148.0 | 4.9 | 4.9
1330
1380
1430


SR
BOR NO.
CO.
SR
BOR NO.
CO.
BOX 9 OF 9
DATE
SR SEC. STA. OFF. ELEV.
BOR NO. SEGMENT OFF. FT.
CO DEPTH FT TO FT
PSI # 049111488 9/27/17
1 Bor B2 Depth 1980 to 160.0
Spread PPP4-Susq. River
Run | Depth | Rec | RQD
25 | 148.0-153.0 | 5.0 | 4.6
26 | 153.0-158.0 | 5.0 | 3.7
27 | 158.0-160.0 | 1.9 | 1.9
148.0
153.0
158.0
160.0
158.0

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
RC: Rock Core
TC: Texas Cone
BS: Bulk Sample
PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
Q_u: Unconfined compressive strength, TSF
Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
w%: Moisture/water content, %
LL: Liquid Limit, %
PL: Plastic Limit, %
PI: Plasticity Index = (LL-PL),%
DD: Dry unit weight, pcf
▼,▽,⧩ Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

Degree of Brokeness

Characteristic	Description
Less than 1 inch	Very Broken
1 inch to 3 inches	Broken
3 inches to 6 inches	Slightly Broken
Greater than 6 inches	Massive

DEGREE OF WEATHERING

Slightly Weathered: Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.

Weathered: Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.

Highly Weathered: Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

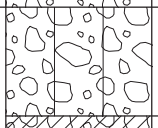
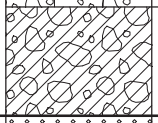
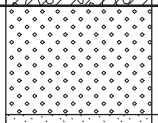
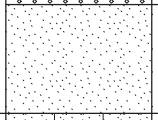
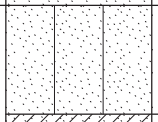
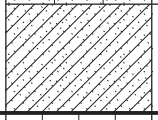
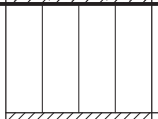
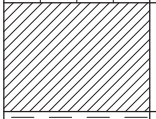
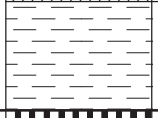
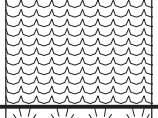
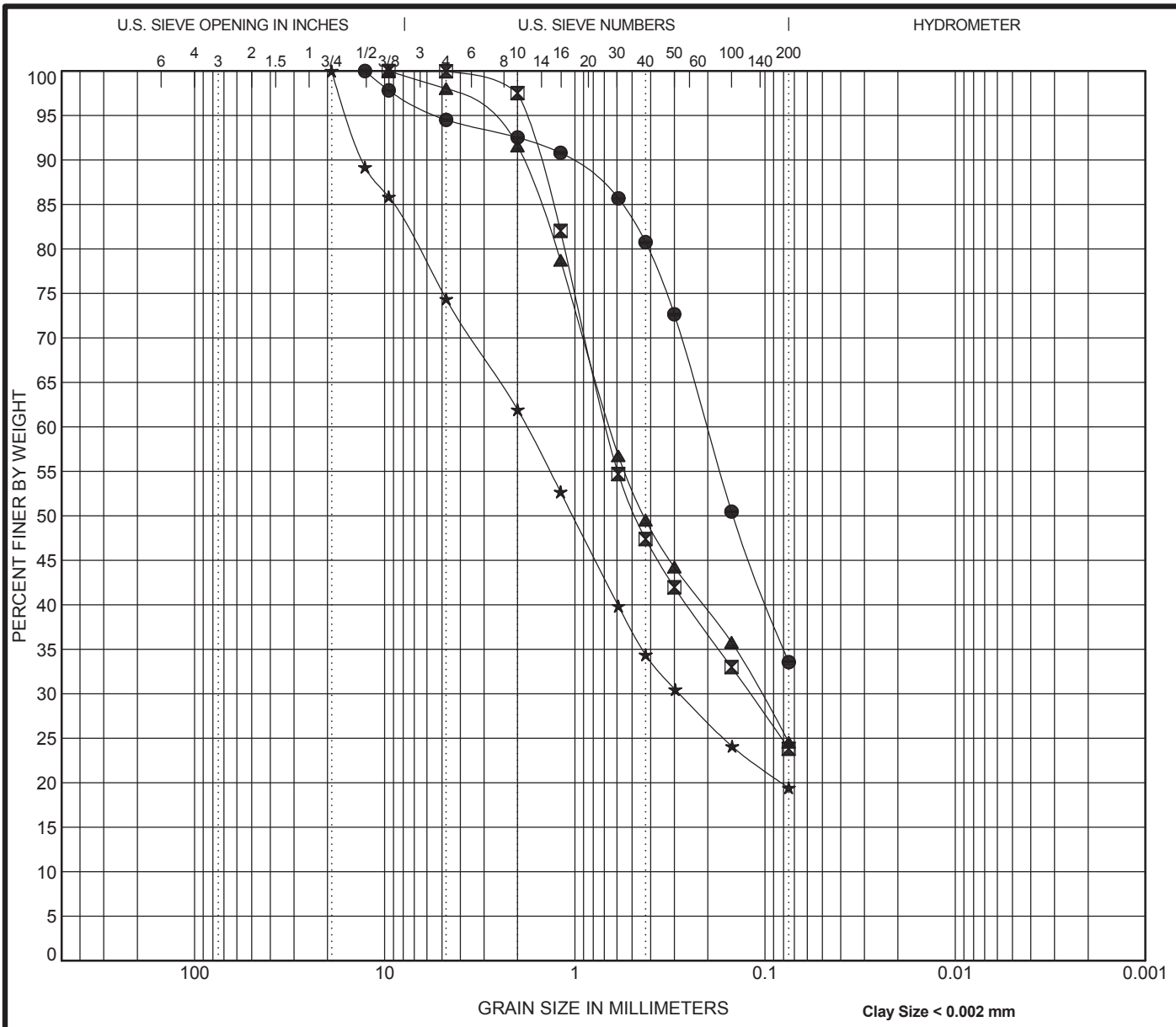
MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	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 SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

Table 4–3 Hardness and unconfined compressive strength of rock materials

Hardness category	Typical range in unconfined compressive strength (MPa)	Strength value selected (MPa)	Field test on sample	Field test on outcrop
Soil*	< 0.60		Use USCS classifications	
Very soft rock or hard, soil-like material	0.60–1.25		Scratched with fingernail. Slight indentation by light blow of point of geologic pick. Requires power tools for excavation. Peels with pocket knife.	
Soft rock	1.25–5.0		Permits denting by moderate pressure of the fingers. Handheld specimen crumbles under firm blows with point of geologic pick.	Easily deformable with finger pressure.
Moderately soft rock	5.0–12.5		Shallow indentations (1–3 mm) by firm blows with point of geologic pick. Peels with difficulty with pocket knife. Resists denting by the fingers, but can be abraded and pierced to a shallow depth by a pencil point. Crumbles by rubbing with fingers.	Crumbles by rubbing with fingers.
Moderately hard rock	12.5–50		Cannot be scraped or peeled with pocket knife. Intact handheld specimen breaks with single blow of geologic hammer. Can be distinctly scratched with 20d common steel nail. Resists a pencil point, but can be scratched and cut with a knife blade.	Unfractured outcrop crumbles under light hammer blows.
Hard rock	50–100		Handheld specimen requires more than one hammer blow to break it. Can be faintly scratched with 20d common steel nail. Resistant to abrasion or cutting by a knife blade, but can be easily dented or broken by light blows of a hammer.	Outcrop withstands a few firm blows before breaking.
Very hard rock	100–250		Specimen breaks only by repeated, heavy blows with geologic hammer. Cannot be scratched with 20d common steel nail.	Outcrop withstands a few heavy ringing hammer blows but will yield large fragments.
Extremely hard rock	> 250		Specimen can only be chipped, not broken by repeated, heavy blows of geologic hammer.	Outcrop resists heavy ringing hammer blows and yields, with difficulty, only dust and small fragments.

Method used to determine consistency or hardness (check one):
Field assessment: _____ Uniaxial lab test: _____ Other: _____ Rebound hammer (ASTM D5873): _____
* See NEH631.03 for consistency and density of soil materials. For very stiff soil, SPT N values = 15 to 30. For very soft rock or hard, soil-like material, SPT N values exceed 30 blows per foot.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

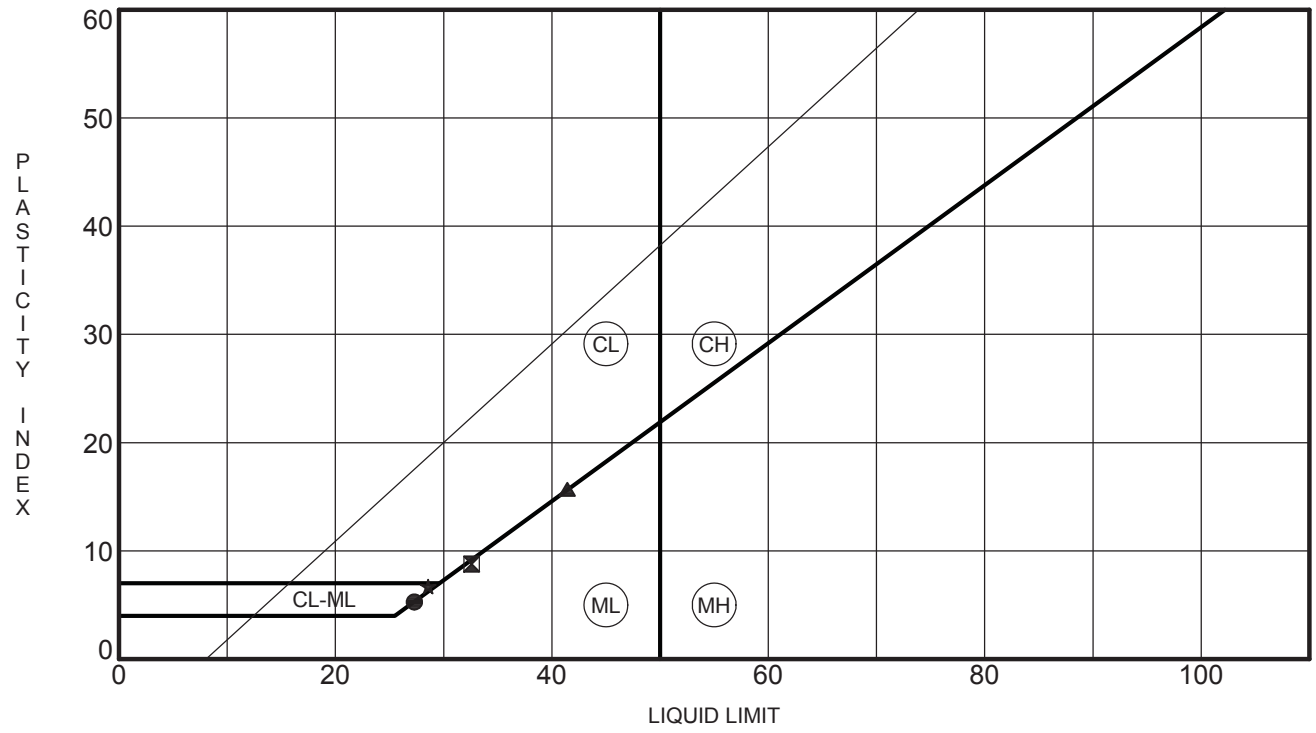
	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-1	11.0	Silty SAND (SM)					
⊠	B-1	21.0	Silty Clayey SAND (SC-SM)					
▲	B-1	26.0	Silty SAND (SM)					
★	B-2	26.0	Silty SAND with Gravel (SM)					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	11.0	12.7	0.202			5.5	60.9	33.6	
⊠	B-1	21.0	9.525	0.676	0.12		0.0	76.1	23.8	
▲	B-1	26.0	9.525	0.655	0.105		2.0	73.5	24.5	
★	B-2	26.0	19.05	1.794	0.282		25.6	54.9	19.4	

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622
Fax: (717) 230-8626

GRAIN SIZE DISTRIBUTION

Project: Energy Transfer HDD (DPS)
PSI Job No.: 04911488
Location: Susquehanna River (PPP4)
Dauphin & York COs., PA



	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**B-1**	**6.0**	**27**	**22**	**5**		**SILT with Sand (ML)**
⊠	**B-2**	**16.0**	**33**	**24**	**9**		**SILT (ML)**
▲	**B-2**	**16.1**	**41**	**26**	**15**		**SILT (ML)**
★	**B-2**	**21.0**	**29**	**22**	**7**		**Sandy Silty CLAY (CL-ML)**

Professional Service Industries, Inc.
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622
Fax: (717) 230-8626

ATTERBERG LIMIT RESULTS

PSI Job No.: 04911488
Project: Energy Transfer HDD (DPS)
Location: Susquehanna River (PPP4)
Dauphin & York COs., PA

Laboratory Summary Sheet

Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-1	1							18			
B-1	6	27	22	5				21			
B-1	11					33.6%		29			
B-1	16							40			
B-1	21					23.8%		35			
B-1	26					24.5%		12			
B-1	30.5							11			
B-1	41.5				950.51						
B-1	54.5				591.69						
B-1	67.2				1369.74						
B-1	77.1				1064.40						
B-1	91.5				1051.44						
B-1	103.5				1154.45						
B-1	123				1153.53						
B-1	142.6				2228.58						
B-1	161				1094.26						
B-1	178.3				1332.87						
B-1	198				828.02						
B-1	217.4				1655.56						
B-1	237.3				1373.21						
B-1	258.5				1037.77						
B-1	275				1854.56						
B-1	285.3				1615.11						
B-1	295.5				2129.32						
B-1	312.4				1877.71						
B-1	331.3				1551.04						
B-1	351.5				1344.79						
B-2	0.5							7			
B-2	6							34			
B-2	16	33	24	9				32			
B-2	16.1	41	26	15							
B-2	21	29	22	7				24			
B-2	26					19.4%		14			
B-2	30							3			
B-2	37.5				99.92						
B-2	54.3				274.19						
B-2	71.8				883.69						
B-2	86.5				250.67						
B-2	88.5				303.75						
B-2	93.7				711.56						
B-2	103.5				372.97						
B-2	114				345.58						

intertek PSI

Professional Service Industries
1707 S. Cameron Street, Suite B
Harrisburg, PA 17104
Telephone: (717) 230-8622
Fax: (717) 230-8626

Summary of Laboratory Results

PSI Job No.: 04911488
Project: Energy Transfer HDD (DPS)
Location: Susquehanna River (PPP4)
Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

Laboratory Summary Sheet

Borehole	Approx. Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#200 Sieve	Est. Specific Gravity	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-2	129.8				324.80						
B-2	143.4				312.28						
B-2	150.5				708.76						

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Summary of Laboratory Results

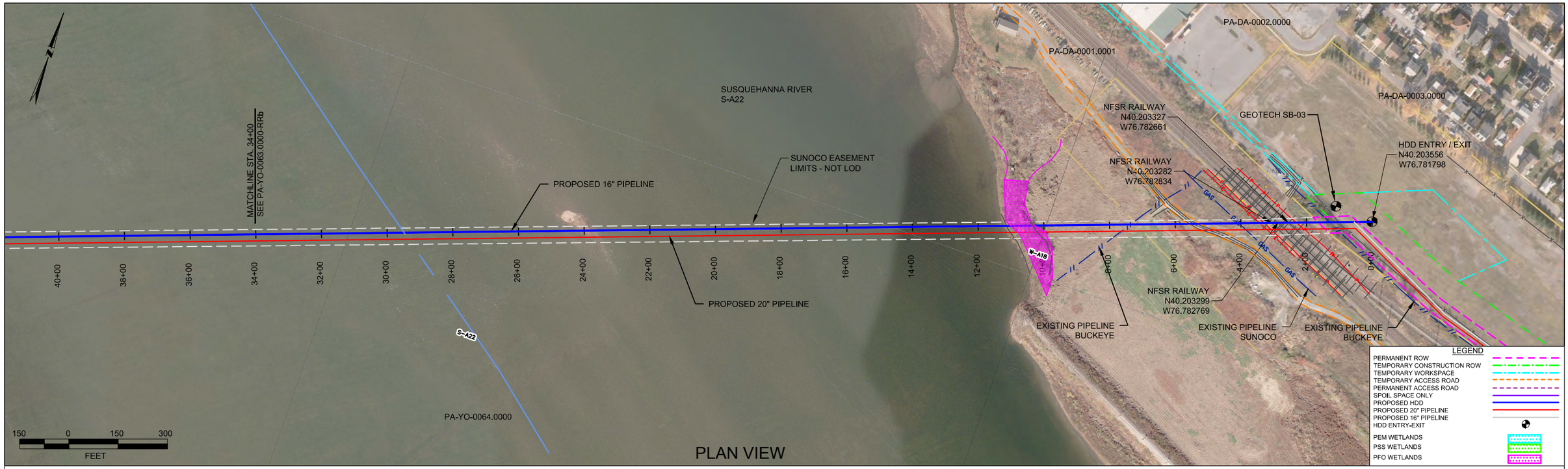
PSI Job No.: 04911488
Project: Energy Transfer HDD (DPS)
Location: Susquehanna River (PPP4)
Dauphin & York COs., PA
PA-YO-0063.0000-RRa&b/PO#20170926

FID	PA WellID	County	Municipali	QuadName	WellAddres	Well ZipCod	DateDrille	TypeOfActi	Latitude DD	Longitude D	Driller	Original Ow	WellUse	Water Use	Well Depth_	TopOf Casin	Bottom OfCa	Casing Diam	Depth ToBed	Bedrock Not	Well Yield_	Static Wate	Water Level	Length OfTe	Yield Measu	Saltwater Z	Formation N	Paper Image	Remark
0	156643	YORK	FAIRVIEW TWP.	STEELTON			1991-10-01	NEW WELL	40.1964	-76.80111	HARRISBURG'S KOHL BROS INC	BEAVERS HOMES	WITHDRAWAL	DOMESTIC	200	0	21	6	3	False	30	60	200	1	ESTIMATED		DIABASE DIKES AND SILLS		ROCK TYPE = IRONSTONE
1	425209	YORK	FAIRVIEW TWP.		248 MARSH RUN ROAD	17070	2008-08-20	NEW WELL	40.2	-76.81333	EICHELBERGERS INC.	SANTIAGO	WITHDRAWAL	DOMESTIC	300	0	40	6	21	False	3	40	240	30	VOLUMETRIC WATCH & BUCKET				
2	636500	DAUPHIN	HIGHSPIRE BORO		686 SECOND STREET	17034	2004-12-03	WELL ABANDONMENT	40.2028	-76.7725	EICHELBERGERS INC.	SICO - TURKEY HILL #125	ABANDONED	UNUSED	22	0	0	0	0	False	0	0							SEALING MATERIALS: 188lbs cement; 16.67lbs Bentonite; 12gallons water.SEALING METHOD: Pumping through tremie pipe at well bottom.
3	636499	DAUPHIN	HIGHSPIRE BORO		686 SECOND STREET	17034	2004-12-03	WELL ABANDONMENT	40.2028	-76.7725	EICHELBERGERS INC.	SICO - TURKEY HILL #125	ABANDONED	UNUSED	22	0	0	0	0	False	0	0							SEALING MATERIALS: 188lbs cement; 16.67lbs Bentonite; 12gallons water.SEALING METHOD: Pumping through tremie pipe at well bottom.
4	637132	DAUPHIN	HIGHSPIRE BORO		686 SECOND STREET	17034	2004-12-03	WELL ABANDONMENT	40.2028	-76.7725	EICHELBERGERS INC.	SICO - TURKEY HILL #125	ABANDONED	UNUSED	22	0	0	0	0	False	0	0							SEALING MATERIALS: 188lbs cement; 16.67lbs Bentonite; 12gallons water.SEALING METHOD: Pumping through tremie pipe at well bottom.
5	17839	DAUPHIN	LOWER SWATARA TWP.	STEELTON			1934-01-01		40.2006	-76.77444	UNKNOWN	PENNSY SUPPLY	WITHDRAWAL	INDUSTRIAL	700	0	40	10	0	False	450	20	140				GETTYSBURG FORMATION		
6	17586	DAUPHIN	HIGHSPIRE BORO	STEELTON			1934-01-01		40.2061	-76.78639	UNKNOWN	ABITIBI	UNUSED	INDUSTRIAL	200	0	0	8	0	False	100	0					GETTYSBURG FORMATION		
7	17574	DAUPHIN	LOWER SWATARA TWP.	STEELTON			1934-01-01		40.1994	-76.77722	UNKNOWN	HARRISBURG INTERNATI	DESTROYED	UNUSED	225	0	0	6	0	False	200	20	23				GETTYSBURG FORMATION		
8	17840	DAUPHIN	LOWER SWATARA TWP.	STEELTON			1934-01-01		40.2006	-76.77444	UNKNOWN	PENNSY SUPPLY	WITHDRAWAL	INDUSTRIAL	500	0	40	8	0	False	200	20					GETTYSBURG FORMATION		

HORIZONTAL DIRECTIONAL DRILL ANALYSIS
SUSQUEHANNA RIVER CROSSING
PADEP SECTION 105 PERMIT NOS.: E67-920 and E22-619
PA-YO-0063.0000-RR-16
(SPLP HDD No. S2-0280)

ATTACHMENT 2

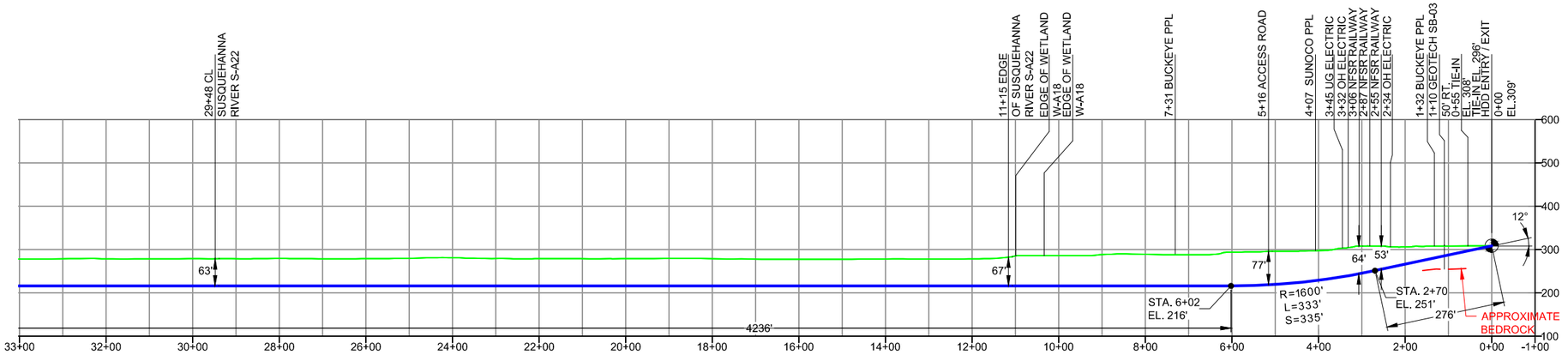
HORIZONTAL DIRECTIONAL DRILL PLAN AND PROFILES



PLAN VIEW

PROFILE VIEW

YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP
DAUPHIN COUNTY, PENNSYLVANIA - LOWER SWATARA TOWNSHIP
S2-0280A-16



GEOTECH SB-03

-NG EL. 308'
-FILL (0.0' - 14.7')
-CL (14.7' - 37.0')
-SILTSTONE \ SANDSTONE (37.0' - 43.2')
-MAROON SANDSTONE (43.2' - 53.0')
-COMPLETION DEPTH EL. 255'

NOTE: REFER TO TEST BORING LOG S2-0280 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:
1. CONTRACTOR SHALL FIELD VERIFY DEPTH OF ALL EXITING UTILITIES SHOWN OR NOT SHOWN ON THIS DRAWING.
2. THE MINIMUM SEPARATION DISTANCE FROM EXISTING SUBSURFACE UTILITIES SHALL NOT BE LESS THAN 10 FEET AS MEASURED FROM THE OUTSIDE EDGE OF THE UTILITY TO OUTSIDE OF PROPOSED PIPELINE.
3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):6706'
   HDD PIPE LENGTH (S=):6735'
   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 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 1850 PSIG.
11. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.
13. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

Figure 1. Original 16-Inch HDD Plan and Profile

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

REF. DRAWING

ES-4.20	TO	ES-4.04	EROSION & SEDIMENT PLAN	
SHEET 13	TO	SHEET 2	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP3	REVISED PER PADEP COMMENTS RECEIVED 01-30-17	DLM	02/01/17	RMB	02/01/17	CAG	02/01/17
3	DESIGN CHANGE - RELOCATED DRILL ENTRY/EXIT	MRS	01/06/17	RMB	01/06/17	AAW	01/06/17
2	REVISED PER ENGINEERING COMMENTS	MRS	08/31/16	RMB	08/31/16	AAW	08/31/16
1	REVISED PER COMMENTS FROM REI REVIEW	MRS	02/19/16	RMB	02/19/16	AAW	02/19/16
0	ISSUED FOR CONSTRUCTION	MRS	01/19/16	RMB	01/19/16	AAW	01/19/16

Sunoco Logistics Partners L.P.

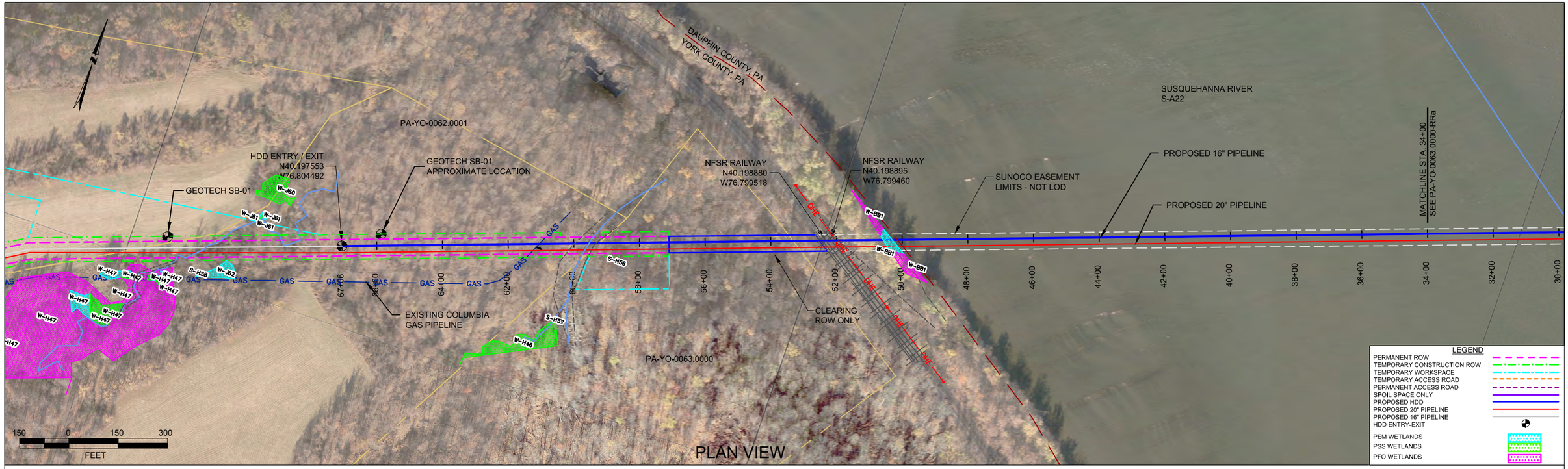
TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

16-INCH HORIZONTAL DIRECTIONAL DRILL
SUSQUEHANNA RIVER
PENNSYLVANIA PIPELINE PROJECT

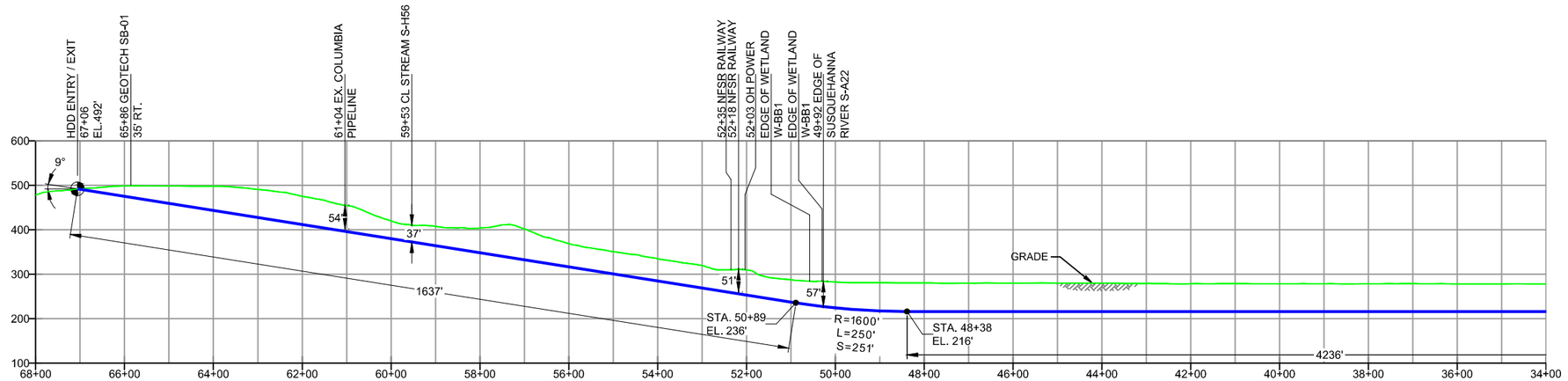
SCALE: 1"=300'

DWG. NO: PA-YO-0063.0000-RRa-16

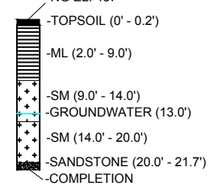


YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP
DAUPHIN COUNTY, PENNSYLVANIA - LOWER SWATARA TOWNSHIP
S2-0280B-16

PROFILE VIEW



GEOTECH SB-01



NOTE: REFER TO TEST BORING LOG S2-0280 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

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   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 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
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11. PIPELINE AND CROSSING TO BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH LAST APPROVED AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION SPECIFICATIONS FOR PIPELINES CONVEYING FLAMMABLE AND NON-FLAMMABLE SUBSTANCES.
12. BLASTING NOT PERMITTED.
13. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.

Figure 2. Original 16-Inch HDD Plan and Profile

NOTES

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

REF. DRAWING

ES-4.20	TO	ES-4.04	EROSION & SEDIMENT PLAN	
SHEET 13	TO	SHEET 2	AERIAL SITE PLAN	
DWG NO		DWG NO	DESCRIPTION	

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
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Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
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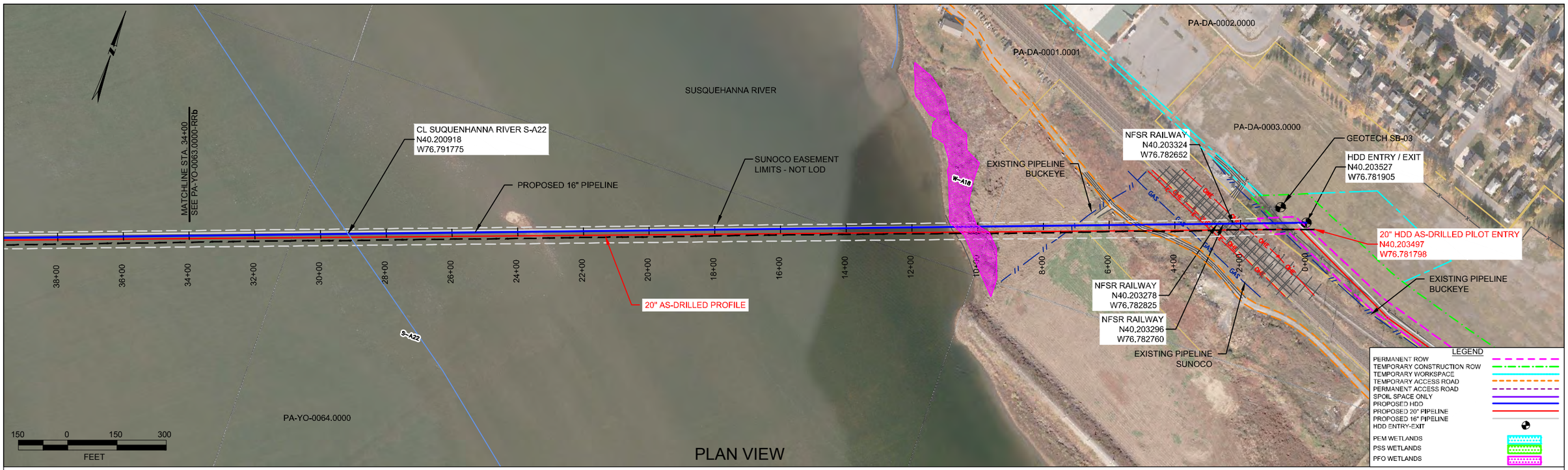
SUNOCO PIPELINE, L.P.

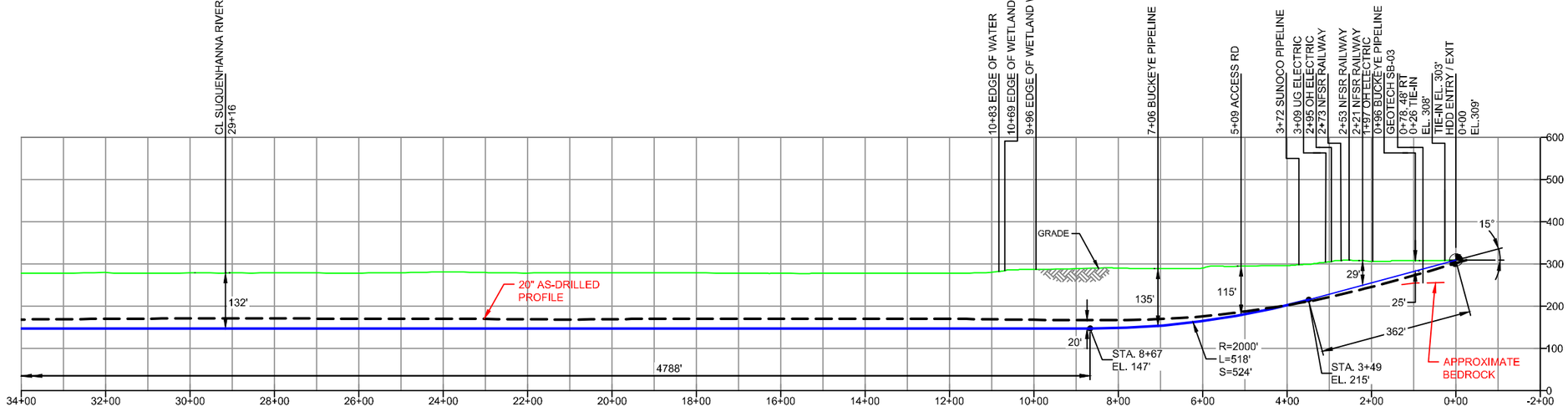
16-INCH HORIZONTAL DIRECTIONAL DRILL
SUSQUEHANNA RIVER
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300' | DWG. NO: PA-YO-0063.0000-RRb-16



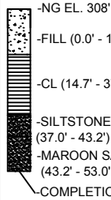
PLAN VIEW

PROFILE VIEW



YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP
DAUPHIN COUNTY, PENNSYLVANIA - LOWER SWATARA TOWNSHIP
S2-0280-16

GEOTECH SB-03



NOTE: REFER TO TEST BORING LOG S2-0280 FOR COMPLETE SOIL MATERIAL DESCRIPTION

DESIGN AND CONSTRUCTION:

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3. DESIGNED IN ACCORDANCE WITH CFR 49 195 & ASME B31.4
4. CROSSING PIPE SPECIFICATION:
   HDD HORZ. LENGTH (L=):7380'
   HDD PIPE LENGTH (S=):7436'
   16" x 0.438" W.T., X-70, APISL, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 40 MILS MIN. ARO (POWERCRETE R95)
5. INTERNAL DESIGN PRESSURE 1480 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50 (HOOP STRESS)).
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12. BLASTING NOT PERMITTED.
13. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
14. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
15. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

Figure 3. Revised 16-Inch HDD Plan and Profile

NOTES

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REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-4.20	TO	ES-4.04	EROSION & SEDIMENT PLAN
SHEET 13	TO	SHEET 2	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
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TETRA TECH ROONEY
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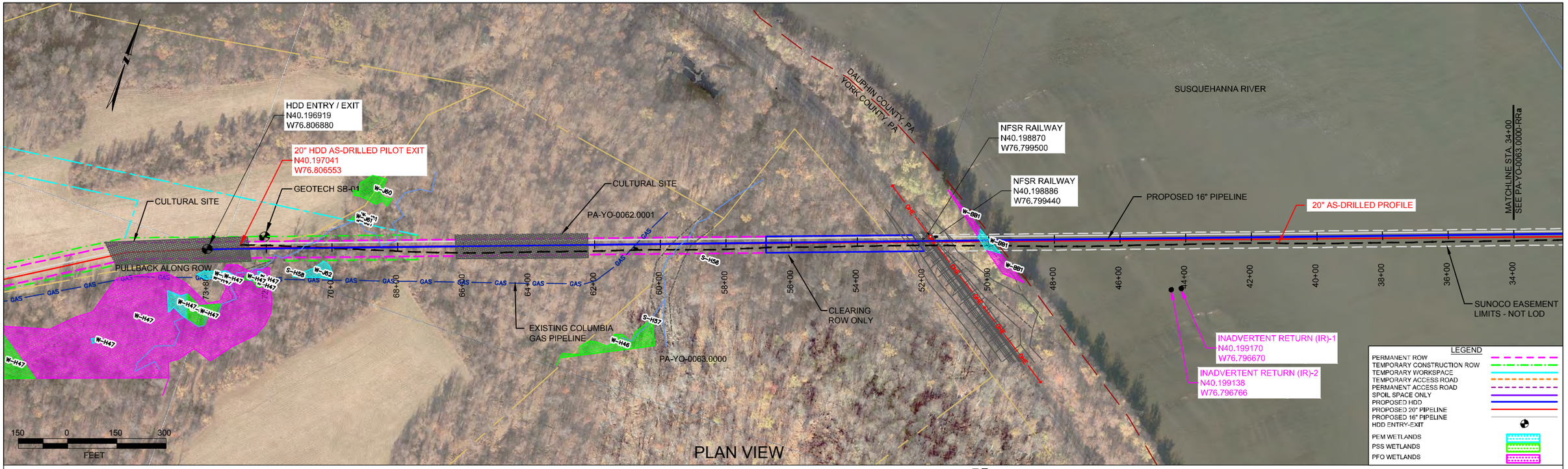
SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
SUSQUEHANNA RIVER
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=300'

DWG. NO: PA-YO-0063.0000-RRa-16



PLAN VIEW

YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP
DAUPHIN COUNTY, PENNSYLVANIA - LOWER SWATARA TOWNSHIP
S2-0280-16

PROFILE VIEW

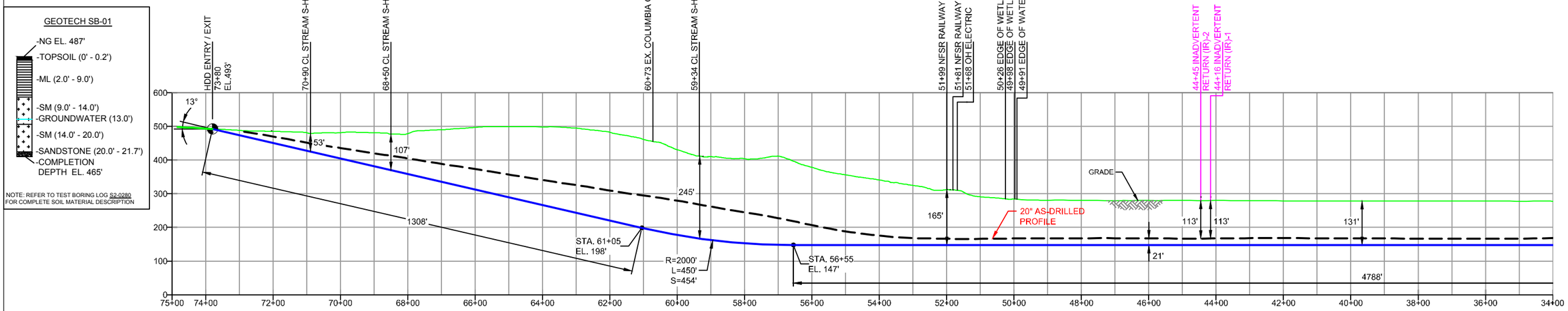


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Figure 4. Revised 16-Inch HDD Plan and Profile

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