SUNOCO PIPELINE
An ENERGY TRANSFER Company

535 Fritztown Road
Sinking Spring, PA 19608

August 5, 2019

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

Re: DEP HDD Re-Evaluation Report – Request for Additional Information
Lewisberry Road Crossing 16" Horizontal Directional Drill (S2-0260-16)
Permit No. E67-920
Fairview Township, York County

Dear Mr. Williamson:

In compliance with the Corrected Stipulated Order dated August 10, 2017 a Re-Evaluation Report for the above-referenced horizontal directional drill (HDD) was submitted to the Pennsylvania Department of Environmental Protection (Department) on February 20, 2019. In a letter dated May 23, 2019, the Department requested further information, please accept this letter as a response. Your requests are bolded below followed by Sunoco Pipeline, LP (SPLP) responses.

1. **As required by Paragraph 4 and 5 of the Environmental Hearing Board's August 10, 2017 Corrected Stipulated Order (Order), SPLP failed to fully utilize information gathered during the HDD of the 20-inch pipeline as part of the HDD Re-evaluation for the 16-inch pipeline. While SPLP made changes to the proposed 16-inch pipeline profile based on information gathered during the 20-inch pipeline, the HDD re-evaluation doesn't adequately tie the 20-inch information into a geologic analysis. SPLP identifies that they possess a complete geologic profile from the 20-inch HDD. However, the complete geologic profile or representation of such is not included within the report. Please submit a detailed geologic map, complete with profiles, along with a detailed narrative describing how the "complete geologic profile from the drilling of the 20-inch pipeline and vertical geotechnical data" were used to help determine the proposed 16-inch HDD profile location. The proposed 16-inch design seems to rely on the 20-inch "as-built", however there is no description of how the "as-built" was used in determining the proposed 16-inch HDD path. The re-evaluation should describe how the 20-inch "as-built" was used in determining the proposed 16-inch HDD path.**

   The loss of returns (LOR) and flowback to the drill pit needs to be analyzed and described in detail as part of the re-evaluation. Inclusion of incident reports a11d photographs would be appropriate as part of the demonstration. Please gather geologic and drilling information collected by various site personnel during the 20-inch bore which can be used to synthesize a comprehensive evaluation of the loss of return. The HDD re-evaluation report should discuss

the operational or geologic cause of each LOR, and the drilling procedure or technique used to progress the boring. The type of information described above, and any other relevant data gained in the intervening time period since the 20-inch HDD began to present, should be used to describe and support why the chosen bore path for the 16-inch pipeline was determined and how such information has been used to minimize the potential for IRs or the potential for water supply impacts to occur. Part of the discussion of construction alternatives, including why HDD activity is still the preferred methodology for pipeline construction at this location should be included in the re-evaluation report.

The type of information described above, and any other relevant data gained in the intervening time period since the 20-inch HDD began to present, should be used to describe and support why the chosen bore path for the 16-inch pipeline was determined and how such information has been used to minimize the potential for IRs or the potential for water supply impacts to occur. Part of the discussion of construction alternatives, including why HDD activity is still the preferred methodology for pipeline construction at this location should be included in the re-evaluation report.

Information Used from Drilling of the 20-Inch HDD

SPLP utilized all the information obtained during drilling of the 20-inch HDD in our internal assessment and evaluation of the 16-inch HDD profile, and as required by paragraph 5 of the Order, described and presented the results of this study in the HDD Reevaluation Report. However, as the Department is aware, cuttings generated at the returns pit are arriving after traveling along the bore path and the length of time is variable depending on the tool location, pumping rate, fluid viscosity and carrying capacity, etc. Further, the cuttings are a conglomeration of cuttings both from the face, as well as from cuttings that had dropped out of the drilling fluid while traveling back to the returns pit and then being re-entrained into the drilling fluid flow when the borehole was swabbed, or the drill string was tripped out of the boring. Therefore, it is not possible to specifically identify the location along the profile the observed cuttings originated from with accuracy or to generate a detailed geologic profile of the boring as one would be able to with a vertical boring.

It should be noted that the Lewisberry Road 20-inch HDD pilot hole and over half of the 30-inch ream pass were completed prior to the collection of drill cutting samples at 5-foot intervals, but the drill cuttings were examined multiple times throughout each day. The cuttings observed by the Pennsylvania Professional Geologist present during the completion of the 20-inch HDD confirmed the bedrock cuttings observed were consistent with the geology described in the revised Geologic Report (Report) primarily of sedimentary rocks (quartz conglomerate with a red sand matrix) with some limestone and dolomite pebbles within a quartz sand matrix and metamorphosed sedimentary rocks surrounding the igneous intrusion (i.e. diabase). Figure 1 in Attachment 2 represents a graphical presentation of the plan and cross section views of conditions encountered during the completion of this HDD. This figure presents the reality of events occurring during this HDD in relation to the depth of profile and allowed for correlation to monitoring data collected during active drilling. The bedrock surface elevations on this figure are based on data obtained from the 2014 and 2017 geotechnical investigations.

Temporary Loss of Returns

Two temporary, partial LORs were reported during the completion of the 20-inch HDD, the first one occurring on September 30, 2017 and the second one occurred a few days later on October 3, 2017. Both temporary LORs occurred as a result of the annular space behind the 22-inch reamer becoming clogged with cuttings as evidenced by the diversion of drilling fluid flow to the eastern returns pit, which is located at a higher elevation than the western returns pit. When each temporary LOR occurred, the drilling contractor swabbed the borehole to remove the blockage and eventually re-establish partial returns to the western entry/exit point. The swabbing of the borehole had some limited effect as evidenced by drilling fluid starting to flow back into the western entry/exit point, but it wasn't until October 5, 2017 that full returns were finally re-established. To reduce the potential of temporary, LORs during the completion of the 16-inch HDD, SPLP will instruct the drilling contractor to swab the boring more frequently and to adjust the carrying capacity of the drilling fluid to minimize the potential for a blockage behind the drilling tool.

The daily drilling logs (i.e., penetration rate, annular and mud pressure, drilling fluid usage, etc.), geotechnical investigations, and daily HDD inspection reports were internally reviewed by SPLP following the completion of the 20-inch HDD to determine if the permitted 16-inch HDD would be susceptible to LORs or inadvertent returns (IRs). Based on the results of this review process, it was determined that the 16-inch HDD should be redesigned to reduce the potential for LORs or IRs. As part of this process the bedrock data collected from the 2017 geotechnical boring B-2 was project across the portion of the profile to be completed within diabase bedrock. To reduce the risk of LORs and IRs during construction of the 16-inch HDD, the eastern and western entry/exit angles were increased to advance the drilling tools more quickly through the unconsolidated material and weathered bedrock. The total depth and overall horizontal length of the boring have also been increased by 56 and 385 feet, respectively. This will place the bore path in bedrock with rock quality designation (RQD) values ranging from 78 to 100 (good to excellent).

Selection of the Bore Path

As mentioned in the Alternative Analysis of the Horizontal Direction Drill Analysis Lewisberry Road Crossing (Analysis), the HDD methodology was confirmed to be the preferred installation method because it will ultimately cause the least amount of direct impact to the residents and the environment. Changing the installation technique to an open cut would result in disturbance to recreational activities at Roof Park and potential damage and disruption of service to existing utility services. Re-routing the pipeline is not a viable option at this location because no other existing utility corridors are located to the north or south that provide a practical alternative route. Further, a re-routing would result in the creation of a new greenfield corridor through existing woodlands and would potential impact streams and wetlands prior to rejoining the current route. Further, re-routing the pipeline could lead to more direct impact to residential properties which will be avoided by the HDD installation technique.

After review of all the data related to drilling and installation of the 20-inch pipeline, the first decision by the drilling specialist is to accept or reject the current permitted design for the 16-inch HDD profile.

The original design was rejected. The shallower depth of profile would place more of the profile in weaker bedrock structure, and the reduced angles of entry and exit had a higher risk of IRs over a greater distance of the profile compared to the "as-built" 20-inch. For redesign of the 16-inch profile, the first assessment is the limiting factors for establishment of potential revised entry and exit points. At this HDD, the western HDD entry location has forested lands with a stream and wetlands to the west; therefore, the existing HDD entry was maintained in the redesign. Based upon a targeted profile bottom of 20-ft below the installed 20-inch pipeline to establish the bottom of the 16-inch below a noted weakness in the bedrock, a back calculation of the entry tangent using a 2,000-radius resulted in the 14° angle of entry. Several variations of the exit radius were studied before setting the exit point at 120 ft east of the 20-inch exit. This targeted exit maintains a reasonable distance from a stream further to the east to buffer any potential for impacts should a "punch out" IR occur during any drilling phase. in a 14° exit angle. The exit angle takes into account the falling slope east of the exit point, and the allowable break over radius for the pulling of the HDD pipeline segment into the prepared profile.

Alternatives Analysis

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

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

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

SPLP's construction contractors have successfully completed one (1) Direct Pipe Bore approximately 925 ft in extent on the Mariner Pipeline project. The Lewisberry Road HDD length, however, is 1,470 ft, which exceeds the limits of Direct Pipe bore technology. Due to the presence of surface development, adjacent utility lines, and natural resources, there are no feasible entry-exit point's subset within the length of this HDD to employ this technology that would not result in greater direct affects to existing surface developments by conventional construction to interconnect with a direct bore segment. Based on the analysis of all alternatives, SPLP has concluded that the HDD method remains the preferred construction method for this location.

2. Relating to the overall HDD Re-evaluation Analysis and the Geology and Hydrogeological Evaluation Report:

a. There is no evaluation of the data and no data-based correlation for why the revised 16-inch pathway was chosen. Please provide a discussion of how the data presented was used in designing and as support for this proposed HDD bore path and profile.

The response to Item 1 above provides information on the data utilized to redesign the 16-inch HDD profile, and limitations to further modifications.

The bedrock qualities for the 20-inch profile were generally considered good; and are equal or better for the 16-inch profile. Based upon the 2017 geotechnical investigation projected to the HDD profile, competent rock will be encountered at 40-45 feet below ground surface (bgs). Except for the interval between 90 to 95 feet bgs, below 40 ft bgs, recovery values are generally in the 97-100% range, and RQD values range from 75 to 100. The interval between 90 to 95 feet bgs had 100% recovery; however, because the bedrock in that interval was very broken, the RQD value was 0. The 16-inch HDD was redesigned to be installed in the competent bedrock located beneath the broken zone encountered between 90 to 95 feet bgs.

b. Between the <u>Horizontal Directional Drill Analysis</u>, the <u>Geologic Report</u>, and the maps included with this submission, the western portion of the HDD is variously described as being underlain by diabase, quartz conglomerate, and quartz fanglomerate. Please accurately and consistently describe the bedrock underlying the HDD.

The Analysis and Report have been revised to reflect the correct and same bedrock geology underlying the HDD. Copies of the Analysis and Report are attached.

c. <u>Section 1.0 Introduction</u> of the Geologic Report states that HDD 52-0260 is located within the Piedmont Upland Section of the Piedmont Physiographic Province, while Section 2.0 Geology and Soils states that the HDD is in the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. Please clarify.

Section 1.0 of the Report has been revised to reflect that HDD S2-0260 is located within the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. A copy of the revised geologic report is attached.

d. Section 5.0 Geotechnical Evaluation:

di. The section ends with the statement Skelly and Loy and RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework of the analysis of the proposed 16-inch drill at HDD S2-0260-16 for this report. Please specify where this data was incorporated into the re-evaluation. The data is presented but is not further discussed.

The data from the 2014 and 2017 geotechnical investigations were evaluated by SPLP to determine the potential for an occurrence of IRs during the completion of the 16-inch HDD. Based on this data evaluation, and other HDD design factors as discussed above, the 16-inch HDD profile was redesigned by the drilling specialists and pipeline engineers.

Skelly and Loy and RETTEW incorporates the published geologic information and geotechnical investigation data into the analysis and opinion of IR risk as provided in closing of the Hydrogeologic Report.

dii. Additionally, this section of the report presents information and data, but no evaluation of the data and information is made in relation to the re-design of the proposed 16-inch bore path.

The evaluation of how the geotechnical investigations was utilized in the re-design of the 16-inch HDD is detailed in the responses to Items 1 and 2a above.

diii. The description of SB-01 does not match the attached log. The description states the total depth of SB-01 was 7.2 ft. BGS, yet groundwater was encountered at 142 ft BGS. The graphical depiction of SB-01 on the left margins of both the permitted and redesigned 16-inch HDD plan/profile maps is not consistent with the log for SB-01, as it leaves out the cored section from 20-28 ft BGS that was collected after auger refusal at 19.7 ft BGS. Please revise.

The description of boring SB-01 has been revised to accurately reflect the data gathered during the 2014 geotechnical investigation. The total depth of the boring was 28 feet bgs, with auger refusal occurring at a depth of 20 feet bgs. The cores consisted of unconsolidated silts with fine sands to a depth of 8 feet bgs and sand with silts and weathered sandstone from 8 to 20 feet bgs. The rock cores collected between 20 and 28 feet consisted of weathered sandstone bedrock. The graphical representation of boring SB-01 on the permitted and redesigned 16-inch HDD profile have been revised to include the bedrock core descriptions.

div. The description of SB-03 calls the "total depth of the boring" at 22.8 ft BGS, however the drilling log for SB-03 calls refusal at 18.5 ft BGS. Please revise.

The Report has been revised to reflect the correct depth for boring SB-03.

dv. The section describes the results of core borings B-1 and B-2, however, a boring log and core photos were only included for B-2. None of the maps contain any reference to B-1, except for Figure 2 Boring Location Plan, where it is listed as "ON-HOLD**". Please explain the disposition of core boring B-1.**

Boring B-1 was not completed and therefore no logs, photographs were generated, and the location was not included on any of the Report or figures.

dvi. Boring SB-01 is located approximately 150 feet southeast of core boring B-I, as depicted on Figure 2 Boring Location Plan. SB-01 hit refusal in sandstone at 19.7 ft and then cored sandstone from 20 ft to 28 ft, while core boring B-1 is described as encountering diabase from 12 ft to 114 ft. The location of B-1 as depicted on Figure 2 Boring Location Plan is mapped as being underlain by Gettysburg Formation Quartz Fanglomerate. Please explain.

Boring B-1 was not completed at the Lewisberry HDD location. Therefore, the provided lithologic description is not accurate and has been deleted. Further the description for Boring B-2 has been revised to reflect the correct lithology and depth for the boring. A revised Report is attached.

dvii. The section states "the compressive strength of a portion of the bedrock core at a depth of 36.5 feet was 550 pounds per square inch . . . ". There is no indication as to which boring this data comes from, although it must have come from either B-i or B-2, since none of the SB-borings extend to 36 ft. The type of bedrock is not identified. In neither B-1 nor B-2, is the profile depth near 36 ft below grade. Please clarify and revise the report as applicable.

As previously mentioned, boring B-1 was not completed at this location so the reported compressive strength is not for that location. Further, as illustrated in the table below, a sample was collected from B-2 at a depth of 36 feet bgs; however, the reported compressive strength is 1754.48 tons per square foot (27,291.91 pounds per square inch). The Report has been revised to reflect location from which the sample was collected and the correct compressive strength and is attached.

Boring	Sample Depth (feet bgs)	Compressive Strength (tons per square foot)
B-2	17	368.07
B-2	36	1,754.48
B-2	44.2	921.57
B-2	52.6	1259.32
B-2	67	1395.20
B-2	77	416.69
B-2	89	694.01
B-2	103	379.88
B-2	114	985.69

e. Section 7.0 Geophysical Survey Considerations:

ei. States "the only limestone conglomerate mapped in the area of the site is located approximately 2,000 feet NW of the HDD bore path." Skelly and Loy's Figure 2 Geology Map shows Gettysburg Formation Limestone Conglomerate underlying the east-central portion of the path, between the Gettysburg Formation Quartz Fanglomerate to the west and diabase to the east. Please clarify or revise.

The Report has been revised to include the Gettysburg Limestone Conglomerate along the east-central portion of the HDD profile. The revised report is attached.

eii. If the bore path is not within a karst setting, it appears that geophysics may be useful in detecting fractures and soft spots, thereby providing useful data to aide in this HDD pathway design. Please further explain why geophysical data were not collected and reconsider whether its use could be beneficial to preventing IRs, LORs and water supply impacts at this site.

The Gettysburg Limestone Conglomerate does underlie the east-central profile of the HDD profile; however, this conglomerate consists of limestone and dolomite fragments and pebbles interbedded with shale fanglomerate contained within a fine-grained matrix of red quartz. This formation does not exhibit the solution channels and/or voids typically associated with other karst forming limestone units. No evidence of karst features (i.e., prolonged loss of drilling fluid circulation, tool drops, IRs, etc.) or bedrock fractures were identified during the completion of the 20-inch HDD. Further, the temporary LORs that did occur on September 30, 2017 and October 3, 2017 were the result of the annulus becoming clogged with cuttings which diverted the flow of drilling fluids to the eastern returns pit. Once the blockage was removed, full returns were re-established at the western returns pit. Field reconnaissance completed around the HDD did not reveal any karst features or evidence of subsurface karst features.

Finally, no karst features have been mapped near the Lewisberry HDD. Based on this information, the utilization of geophysics would not add any additional value or information that could be used to evaluate the potential for IRs, LORs or impacts to water supplies.

f. *Analysis of geologic strength at profile depth*:
RQDs are provided on the core boring logs and one unconfined compressive strength test was run on an unknown core section, but the data is never used to justify the revised 16-inch HDD profile location. There is no analysis in the re-evaluation report specifically tying the revised drill path to any specific zones noted on the core boring logs as having high RQDs, or why the revised 16-inch path was chosen. Please identify the core section where a compressive strength test was run and provide a discussion addressing the use of this data in designing the bore path.

The section Conclusions states "...Sunoco will employ the following HDD best management practices… SPLP will provide the drilling crew and company inspectors the location(s) data on potential zones of higher risk for fluid loss and IRs, including areas of potential zones of fracture concentration identified by the fracture trace analysis, so the monitoring can be enhanced when drilling through these locations." If this information is available, please include it in the revision for DEP review.

As mentioned in the response to item 2d vii, compressive core strengths were collected from boring B-2. The results of the compressive strength testing, along with the RQD values, were evaluated while re designing the 16-inch HDD profile. An interval of weaker bedrock was identified near the diabase and conglomerate and the profile was designed to avoid this interval. Even though higher compressive strength bedrock was identified slightly deeper in the profile, the maximum depth of the profile was restricted by the bend allowances (pipe stress) for the product pipe and other limiting factors as discussed above and the final depth was set to intersect bedrock containing higher RQD values.

3. Relating to the *Analysis of well production zones* and use of information obtained during construction of the 20-inch pipeline;

The re-evaluation report fails to include evaluation of the data and information collected for the nine private water supplies within 450 feet of the proposed HDD, the water supplies that are in the vicinity (beyond 450 feet) of the proposed HDD, and the water supply complaint that SPLP received at this HDD site. It is also unclear about whether any of the private water supplies identified within 450 feet are the same as any of the water supplies within 0.5 miles that were identified from the PaGWIS database.

In addition, Attachment 3 *Well Location Map* has a parcel marked as "Public Water Supply/Landowner Confirmed No Well" on Bradley Circle, just west of Roof Park. More recent aerial photography shows a new house in that location. Please update the private water supply inventory and ensure this residence is contacted.

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

Per the Order, SPLP conducted a survey of water supply wells located within 450 feet of the Lewisberry Road HDD. A total of nine (9) water wells and one (1) spring were identified within the 450-foot search radius. Additionally, SPLP identified a total of seven (7) residence near the Lewisberry Road HDD that had water supply wells. All of the identified locations are represented on Attachment 3 of the Report.

Water samples were collected from the 16 water wells and 1 spring location illustrated on Attachment 3 of the Report during various phases (i.e., pre, during, and post- construction) of the completion of the 20-inch HDD. Pre-construction samples could not be collected from all of the identified locations because construction of the 20-inch HDD started prior to the Order being implemented. A review of the analytical results from these sampling events did not identify any changes in water quality, other than changes associated with seasonal fluctuations.

Some of the sampled locations contained concentrations of various parameters at concentrations exceeding their respective Department's established secondary drinking water standards. However, these locations did not show elevated concentrations of all of the parameters (suspended solids, turbidity, iron, manganese) typically associated with drilling fluid impacts. Therefore, the detection of these parameters above Departmental standards and the wide spread nature of these detections, are likely the result of natural groundwater quality and not reflective of drilling fluid impacts. One well (WL-09010217-609-03) was sampled for the presence of residual bentonite in the form of clay minerals during the post-construction sampling event. Clay minerals were identified in the analyzed samples; however, the source of the bentonite is still under investigation as the home owners reported observing bentonite being placed around the new surface casing when the well casing was extended in 2018. This would be a more logical source of the bentonite since no other parameters (i.e., suspended solids, turbidity, iron and manganese) were detected at elevated concentrations or above their respective Departmental secondary standards, if applicable. Based on these findings, no impacts to groundwater quality have been associated with the 20-inch HDD. Summary tables of the analytical results from the water quality sampling events are attached.

To date, only one water well complaint has been received by SPLP relative to the completion of the Lewisberry Road HDD. The complaint was received in April 2019 after the homeowners had their well independently analyzed for bacterial contamination and elevated concentrations were identified.

Samples were collected from the residence on April 25, 2019 and results of the analysis did identify Total Coliform at a concentration of 14.40 MPN/100 ml (most probably number per 100 milliliters). It should be noted that the residence was switched to public sewer in 2018 and the former septic system is a potential source of the Total Coliform if it was not properly "closed". The well complaint is still being investigated by a Pennsylvania Professional Geologist (PG) and following the completion of the investigation, a report with the PG's conclusions will be submitted to the Department.

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

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

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

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

All the information and stress assessment procedures discussed above are incorporated into the profile design and implemented in analysis of the drilling profile to ensure the integrity of the pipeline as installed. Specific items concerning the design of the revised profile for the 16-inch HDD were provided in the response to Item 1and 2f above.

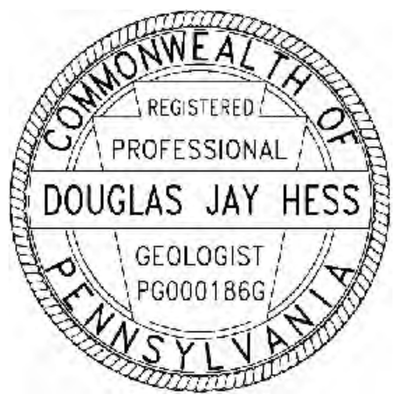
SPLP submits that we have been, and are, in complete compliance with the agreed terms and analysis requirements of the Order, as agreed to by the Department, and that no further analysis is required for the Department to consent to the start of this HDD. SPLP requests that the Department approve the Re-evaluation Report for Lewisberry Road Crossing HDD (S2-0260-16) as soon as possible.

Sincerely,

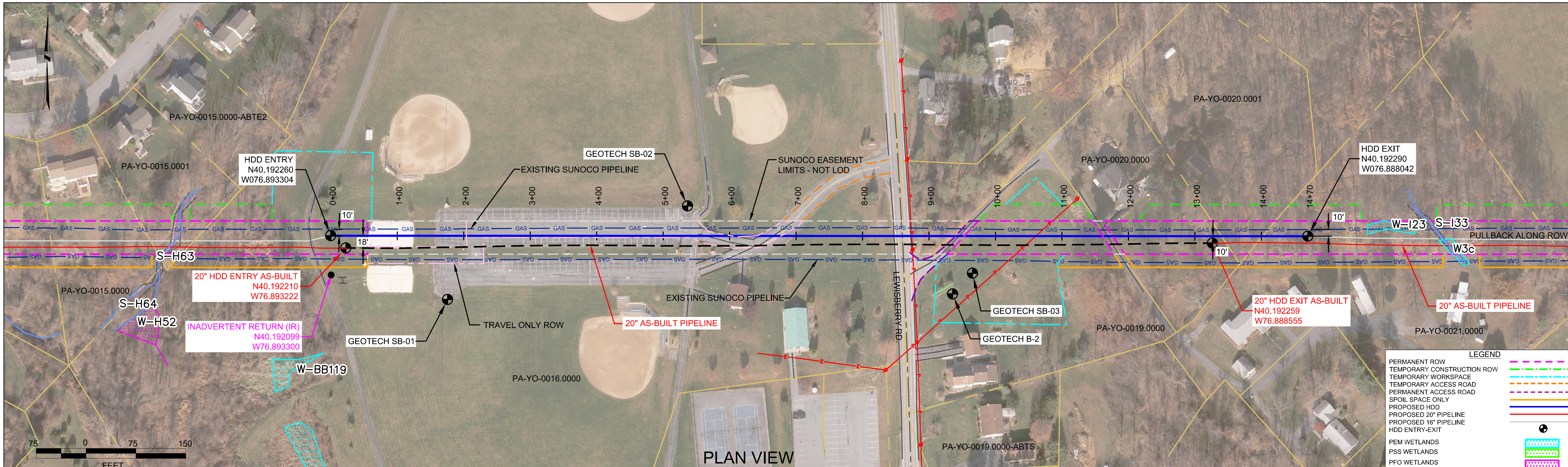
Larry J. Gremminger, CWB
Vice-President – Environmental, Health & Safety
Energy Transfer Partners
Mariner East 2 Pipeline Project

Pertaining to the practice of geology and information conveyed.

______________________ 8-5-2019
Douglas J. Hess, P.G. Date
License No. PG-000186-G
Skelly and Loy, Inc.
Director of Groundwater
and Site Characterization
Geo-Environmental Services

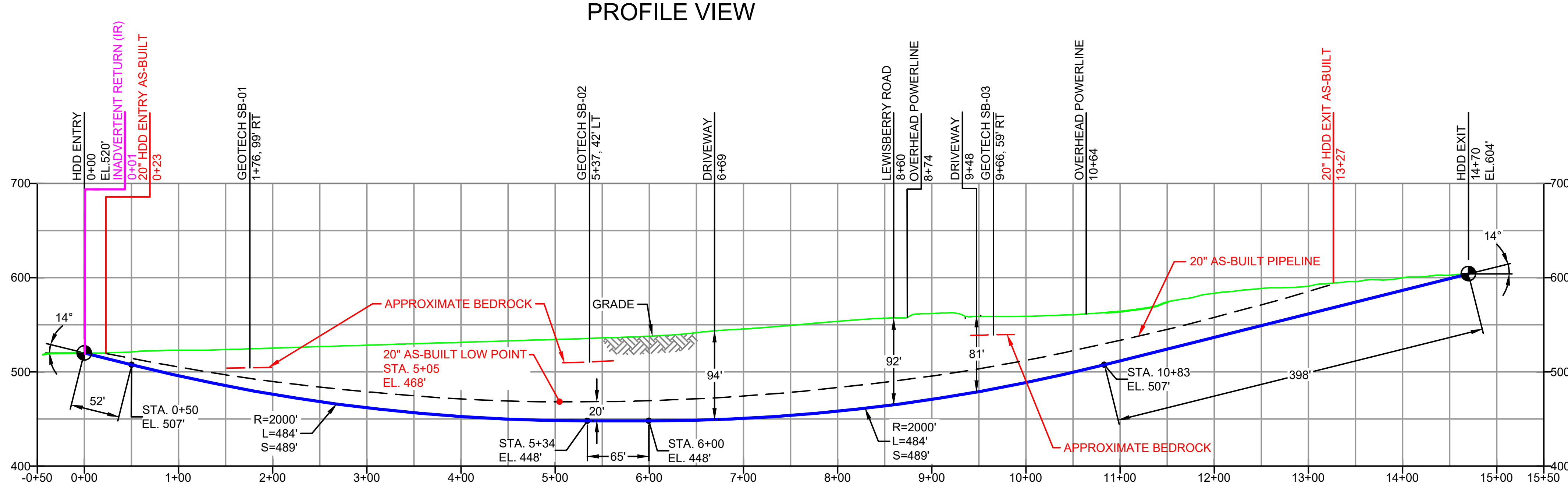


Attachments as stated



YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP
S2-0260-16

PROFILE VIEW



GEOTECH SB-01

- NG EL. 523'
- TOPSOIL (0' - 0.3')
- ML (0.3' - 11.5')
- GROUNDWATER (14.2')
- SM (11.5' - 19.7')
- AUGER REFUSAL (19.7')
- SANDSTONE (19.7' - 28.0')
- COMPLETION DEPTH EL. 495'

GEOTECH SB-02

- NG EL. 535'
- TOPSOIL (0' - 0.5')
- GROUNDWATER (14.0')
- SM (0.5' - 25.0')
- AUGER REFUSAL (25.0')
- SANDSTONE (25.0' - 33.0')
- COMPLETION DEPTH EL. 502'

GEOTECH SB-03

- NG EL. 557'
- TOPSOIL (0' - 0.7')
- SM (0.7' - 8.5')
- SM (11.5' - 18.5')
- GROUNDWATER (15.5')
- AUGER REFUSAL (18.5')
- COMPLETION DEPTH EL. 541'

NOTE: REFER TO TEST BORING LOG S2-0260 FOR COMPLETE SOIL MATERIAL DESCRIPTION

GEOTECH B-2

- NG EL. 557'
- TOPSOIL (0' - 0.3')
- FILL (0.3' - 3.5')
- RESIDIUUM-SILTY SAND SM (3.5' - 8.5')
- RESIDUUM LEAN CLAY W/ SAND CL (8.5' - 10.0')
- GROUNDWATER (23.0')
- DIABASE (10.0' - 96.5')
- CONGLOMERATE (96.5' - 115.0')
- BORING TERMINATED EL.442'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PROJECT #04911463 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=): 1470'
   HDD PIPE LENGTH (S=): 1493'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGH FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

NOTES

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-4.04	TO	ES-4.04	EROSION & SEDIMENT PLAN
SHEET 3	TO	SHEET 3	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP4	REVISED GEOTECH SB-01 INFORMATION	MRS	08/05/19	RMB	08/05/19	AMC	08/05/19
EP3	DESIGN CHANGE - INCREASED DEPTH AND LENGTH OF DRILL, ADDED GEOTECH DATA	MRS	12/14/18	RMB	12/14/18	AMC	12/14/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/09/16	RMB	05/09/16	AAW	05/09/16
EP		JTW	03/15/16	RMB	03/15/16	AAW	03/15/16
B	ADDED GEOTECH INFO	MRS	09/16/15	RMB	09/16/15	AAW	09/16/15

Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
LEWISBERRY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150'   DWG. NO: PA-YO-0016.0000-RD-16

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June 28, 2019

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

Re: Sunoco PA Pipeline Project Mariner East II, Lewisberry Road HDD S2-0260, PA-YO-0016.0000-RD-16
Hydrogeological Re-Evaluation Report for the 16-Inch Pipeline
Fairview Township, York County, Pennsylvania
Rettew Project No. 096302011

EXECUTIVE SUMMARY

1. The completed 20-inch and proposed 16-inch Lewisberry Road Horizontal Directional Drills (HDD) S2-0260 are included in the Corrected Stipulated Order of August 10, 2017, requiring re-evaluation, including a geologic report.

2. The Lewisberry Road 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 Formation 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 weathered zone at the top 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, HDD operations have been completed at the Lewisberry Road site for the 20-inch pipeline. The 20-inch product pipe pull was completed on April 11, 2018.

6. Based on the hydro-structural characteristics of the underlying geology and the proposed HDD profiles within shallow unconsolidated soil materials and shallow bedrock, the proposed 16-inch HDD is susceptible to the inadvertent return (IR) of drilling fluids during HDD operations. A redesigned 16-inch HDD profile (Attachment 2, Figure 2) and Best Management Practices (BMPs) during drilling operations will be used to reduce the risk of an IR. The inclination of the entry and exit angles has been increased as a means to install the 16-inch pipe through protective 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 Lewisberry Road (S2-0260) HDD location on the Sunoco Pipeline, L.P. (SPLP) Pennsylvania Pipeline Project-Mariner East II (PPP-ME2) Project. The Lewisberry Road HDD (the site) is located in Fairview Township, York County, Pennsylvania. The site is located approximately 2 miles northeast of the Village of Lisburn and approximately 0.8 mile south of the Pennsylvania Turnpike (I-76). The HDD was designed to be drilled under portions of Roof Park, Lewisberry Road, and several residential driveways (refer to **Figure 1**). Although no IRs occurred during HDD operations for the 20-inch pipeline, temporary losses of returns (LORs) attributed to changes in drilling fluid circulation patterns between the entry pit and pit locations were reported. In accordance with the Corrected Stipulated Order of August 10, 2017, this Hydrogeologic Re-Evaluation Report was prepared to address the potential for the IR of drilling fluids during the proposed 16-inch HDD operations.

HDD S2-0260 is located within the Gettysburg-Newark Lowland Section of the Piedmont 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 in the vicinity of the site from approximately 500 feet above mean sea level (AMSL) to 565 feet AMSL (GoogleEarth, 2017). The site is drained by a shallow, unnamed tributary stream situated immediately adjacent to the western HDD entry point. The unnamed tributary flows 1.5 miles to the northwest before discharging to the Yellow Breeches Creek. The area surrounding the HDD profile consists predominantly of a combination of open and forested semi-rural land bounded by suburban residential properties.

The proposed redesigned 16-inch HDD crosses under two driveways at depths ranging from 81 to 94 feet below ground surface (bgs) and Lewisberry Road at 92 feet bgs. The proposed 16-inch HDD is located between Stations 10897+80 and 10910+20 on the pipeline, for an overall horizontal length of 1,470 feet and a pipe length/bore path length of 1,493 feet. The existing 20-inch and proposed 16-inch S2-0260 HDD locations are shown on **Figure 1**.

2.0 GEOLOGY AND SOILS

The Pennsylvania Department of Conservation and Natural Resources (2000) reported that the S2-0260 HDD site is situated in the northern portion of the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province. The dominant topography is rolling lowlands, shallow valleys, and isolated hills with low to moderate relief. The predominant rock type consists mainly of red shale, siltstone, and sandstone with some conglomerate and diabase. The predominant geologic structure within this physiographic section consists of a half-graben having low, monoclinal, northwest-dipping beds. The surface drainage pattern is both dendritic and trellis. The general structure of the Newark Group is a north-northwestward dipping homocline. Typical dip directions are north or northwest and range from 20° to 40° (Newport, 1971). Intrusive diabase has been mapped near the eastern entry/exit point of the HDD (**Figure 2**).

According to Google Earth (2017), four geologic formations occur within a ½-mile radius of HDD S2-0260. These include the Triassic age Gettysburg Formation Quartz Fanglomerate (Trgfq), Gettysburg Formation Limestone Conglomerate (Trglc), Gettysburg Formation (Trg), and the younger Jurassic age Diabase (Jd). These geologic units are identified on the geologic mapping included as **Figure 2**.

The Gettysburg Formation Quartz Fanglomerate is described as coarse, quartz conglomerate containing rounded pebbles and cobbles in a matrix of red sand (Geyer and Wilshusen, 1982). This formation underlies the majority of the proposed 16-inch HDD bore path as shown on **Figure 2**.

The Gettysburg Formation Limestone Conglomerate is described as chiefly yellow-gray to light medium-gray limestone and dolomite pebbles and fragments with angular fragments up to 8 inches in diameter with interbeds of shale fanglomerate in a very fine-grained red quartz matrix (Geyer and Wilshusen, 1982). While this formation is identified on **Figure 2**, it is important to note that this formation underlies only approximately 250 feet of the east-central portion of the proposed 16-inch HDD bore path beginning approximately 400 feet west of the eastern HDD entry/exit point.

The Gettysburg Formation is composed of reddish-brown to maroon, silty mudstone and shale containing thin red sandstone interbeds with several thin beds of impure limestone. According to Geyer and Wilshusen (1982), the Gettysburg Formation is moderately to well bedded with individual beds ranging from thin to flaggy (sandstone, siltstone and shale) and thick to massive (quartz conglomerate-fanglomerate, and limestone conglomerate) 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 fair to poor due to 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 (where the baked rock is harder and the drilling rate is slower).

The diabase is described as a medium- to coarse-grained, quartz-normative tholeiitic basalt composed of labradorite and various pyroxenes and occurs as dikes, sheets, and a few small flows. The rocks of the Newark Basin generally dip an average of 20° to the north-northwest. As previously referenced, the geologic structure of the Newark Group rocks present in the Gettysburg-Newark Lowland Physiographic Province consist principally of a north-northwestward dipping homocline (Newport, 1971). The igneous diabase that occurs in the Gettysburg-Newark Lowland is dark gray to black, with high silica content and a dense, very fine to coarsely crystalline, non-granular lithologic fabric forming narrow dikes and sheets. The diabase is highly resistant to weathering and commonly weathers to form large, massive, spheroidal boulders (Geyer and Wilshusen, 1982; Low, et al., 2002). Joints are well-developed, abundant, and open providing a very low secondary porosity. The overlying soil is thin. Dikes typically form narrow ridges, and larger intrusions form hills of moderate relief. Excavation and/or drilling are classified as slow due to the density and hardness of the rock. This formation is mapped as underlying only the last 150 feet of the proposed 16-inch HDD bore path beginning approximately 150 feet west of the eastern HDD entry/exit point.

According to the United States Department of Agriculture Soil Survey of York County, Pennsylvania, soils within approximately 600 feet of the drill path for HDD S2-0260 consist of five soil types primarily composed of channery silt loam with lesser amounts of loam, silt loam, channery sandy loam, and channery loam. A site map showing the spatial distribution of the various soils along with the soil profile descriptions is included as **Attachment 1**.

Fifteen available published and online references were reviewed to evaluate the hydrogeology and soils present in the vicinity of the proposed Lewisberry Road HDD location (S2-0260). Detailed descriptions of the soils and bedrock geology underlying S2-0260 are included in the following section.

3.0 HYDROGEOLOGY

Bedrock geology ultimately influences the storage, transmission, and use of ground-water. 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, et al. (2002), groundwater within the clastic rocks of the Gettysburg Formation within York County 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 aquifer and under confined or semiconfined conditions in the deeper portions of the aquifer. The groundwater flow system 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 (i.e., hydraulically interconnected) 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 discharges toward points of regional groundwater discharge such as the Susquehanna River. Groundwater divides may be different for each zone of groundwater flow and therefore may not coincide with surface water divides.

According to Google Earth (2017), The Pennsylvania Bureau of Topographic and Geologic Survey (2001), and Wood (1980), the Gettysburg Formation Quartz Fanglomerate is the uppermost rock unit underlying the majority of the HDD bore path with the Gettysburg Limestone Conglomerate and diabase underlying the last 400 feet of the bore path near the eastern HDD entry/exit point (**Figure 2**). Based on the initial phase of geotechnical drilling performed during October and November 2014, and documented in the Tetra Tech geotechnical report, groundwater was encountered at 14.2 feet bgs (SB-01), 14 feet bgs (SB-02), and 15.5 feet bgs (SB-03). Based on results of more recent geotechnical drilling performed in September 2017 and referenced in a geotechnical report prepared by Intertek Professional Service Industries Inc., Boring B-2, located near the eastern HDD entry/exit point, identified groundwater at a depth of 5 feet bgs while advancing the rock core and was measured at 23 feet bgs upon completion of the boring. Both geotechnical reports are included in **Attachment 2**.

The direction of groundwater flow within the clastic rocks of the Gettysburg Formation in York County 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 the strike of the rock beds. The potential for well interference related to pumping is generally greatest for wells aligned parallel to the strike, rather than in wells drilled in the direction of bedding dip (i.e., perpendicular to the 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 S2-0260.

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 lacks bedding planes or consistent foliation and therefore possesses very low primary porosity and hydraulic conductivity. Although abundant, joint openings within the diabase provide very low secondary porosity (low permeability) and, combined with the corresponding low hydraulic conductivity, there is minimal pore space. 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 from the Pennsylvania Department of Conservation and Natural Resources (PA DCNR) Pennsylvania Groundwater Information System (PaGWIS) database were reviewed to identify domestic water supply and other wells located within a ½-mile radius of the proposed HDD right-of-way (ROW) boundary (PaGWIS, 2017). The search identified 48 wells within the ½-mile radius of the HDD. These wells consist of 30 domestic supply wells, 13 abandoned wells, 2 unused/observation wells, 1 institutional well, and 2 wells identified as “other”. A map showing the well locations relative to the proposed HDD location is included as **Figure 3**. Based on the PaGWIS database (**Figure 3**), it appears that the majority of the identified wells were completed as 6-inch-diameter open-rock wells at depths ranging from 100 to 400 feet bgs. Based solely on the PaGWIS database, the depth to bedrock ranges from 0 to 92 feet, and well construction consists of 5 to 105 feet of steel casing with the open-rock portions of the wells extending from 5 feet to 400 feet bgs. Reported well yields range from 0 to 60 gpm. Static water level measurements were recorded and range from 6 to 175 feet bgs. Based on the PaGWIS database, the majority of the wells identified above were completed in the diabase.

As a condition of the Corrected Stipulated Order, other Sunoco subcontractors researched private water supplies located within a 450-foot radius of the Lewisberry Road HDD. From January to February 2019, nine water supply wells and one spring were identified within the 450-foot radius and seven additional water wells were identified outside the search radius. The reported well depths range from 65 feet bgs to 325 feet bgs. A depth to water of 60 feet bgs was known and recorded for only one well. A figure depicting these well and spring locations is included with **Attachment 3**.

4.0 FRACTURE TRACE ANALYSIS

Fracture traces are natural linear features that are unaffected by local topographic relief and, as a result, are considered surface manifestations of concentrated high-angle bedrock fracturing. Fracture traces may be observed on aerial photographs as linear topography, straight stream segments, vegetation, or variable soil tonal alignments. The occurrence of fracture traces underlying, or in close proximity to, the site were analyzed 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. Five series of historical aerial photographs were analyzed that included photography dated September 1937, May 1958, August 1971, December 2000, and February 2004 (Pennsylvania Spatial Data Access [PASDA], 2017, and Google Earth Pro, 2017). Since the site area is generally developed to semi-rural with numerous residential properties, the older, leaf off, higher-resolution photography from 1937 and 1958 were the most useful for fracture trace evaluation. These older photos were used to confirm three of four fracture traces mapped by Wood (1980) and McGlade and Geyer (1976). The fourth fracture trace is located approximately 2,000 feet southwest of the HDD entry point. No additional fracture traces were identified on the more recent photography due to the reduced image quality of the on-line photos, and lack of black and white leaf off images.

Four fracture traces were identified northeast, southeast, and southwest of the HDD bore path. 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** and the Groundwater Well Location Map presented as **Figure 3**. Two of these mapped fracture traces are roughly perpendicular to the HDD bore path and trend northwest (NW)-southeast (SE) at a low angle approximately 2,000 feet (0.4 mile) and 400 feet southwest of the western entry/exit point. A third fracture trace is mapped as trending northeast (NE)-southwest (SW) in the area approximately 2,000 feet (0.4 mile) northeast of the eastern entry/exit point. A fourth fracture trace is mapped as trending NW-SE in the area approximately 1,650 feet (0.3 mile) SE of the eastern entry/exit point. Although none of the identified fracture traces cross the HDD bore path, the identified fracture traces are related to the primary geologic structure in the vicinity of the HDD site. The general surface drainage patterns near the HDD site are characterized by the linear stream reaches of the Yellow Breeches Creek and several smaller surface streams generally trending NW-SE and NE-SW which appear to reflect the local geologic structure.

5.0 GEOTECHNICAL EVALUATION

Two phases of geotechnical investigation have been completed at the Lewisberry Road HDD S2-0260 site. Three geotechnical borings were completed from October 26 through November 4, 2014 during the preliminary investigation and prior to initiating HDD operations. One additional boring (B-2) was completed in September of 2017. The borings were completed to investigate soil and bedrock conditions using hollow-stem augers with split spoons for soil sampling and a core barrel/bit for rock coring. **Attachment 2** presents a map depicting the boring locations, boring logs, and geotechnical reports for the two studies.

SB-01 was located near the western HDD entry/exit point, SB-02 was located just east of Yellow Breeches Creek and an associated wetland, and SB-03 was located near the easternmost entry/exit point. The generalized subsurface profile observed in SB-01 through SB-03 is described as follows.

- **SB-01**: Clays and silts from ground surface to 11.5 feet bgs; sand with some trace silt and weathered sandstone from 11.5 to 20 feet bgs and highly fractured and weathered sandstone from 20 feet bgs to the total depth of the boring at 28 feet bgs. Groundwater was encountered at 14.2 feet bgs.

- **SB-02**: Sand from ground surface to 23 feet bgs; partially weathered sandstone and highly fractured and degraded sandstone with oxidation from 23 feet bgs to the total boring depth of 33 feet bgs. Groundwater was encountered at 14 feet bgs.

- **SB-03**: Sands, silts and clays from ground surface to the total depth of the boring at 18.5 feet bgs. Groundwater was encountered at 15.5 feet bgs.

The boring logs indicate that the soil/bedrock interface ranges from approximately 18.5 feet (SB-03) to 23 feet (SB-02) bgs. The bedrock was described in SB-01 as highly fractured and weathered sandstone in SB-01 and highly fractured and weathered sandstone with oxidation in SB-02.

One additional soil boring (B-2) was completed during September 2017, as part of the second phase of the geotechnical investigation. B-2 was drilled near the eastern HDD entry/exit point. The generalized subsurface profile observed in B-2 is described as follows.

- **B-2**: Fill material, clays, and sands were encountered from the ground surface to approximately 15 feet bgs; diabase bedrock was encountered from 15 to 96.5 feet bgs; and conglomerate was found from 96.5 to the total depth of the borehole at 115 feet bgs. Groundwater was encountered at approximately 5 feet bgs during drilling and 23 feet bgs following completion of Boring B-2.

The bedrock in Boring B-2 was described as ranging from moderately hard to extremely hard and broken to massive. Photographs of the cores obtained from boring B-2 are included in **Attachment 2**. Unconfined compressive strength testing was performed on core samples from Boring B-2, and the results are summarized in the table below.

Boring	Sample Depth (feet bgs)	Compressive Strength (tons per square foot)
B-2	17	368.07
B-2	36	1,754.48
B-2	44.2	921.57
B-2	52.6	1259.32

Boring	Sample Depth (feet bgs)	Compressive Strength (tons per square foot)
B-2	67	1395.20
B-2	77	416.69
B-2	89	694.01
B-2	103	379.88
B-2	114	985.69

Please note that Skelly and Loy or RETTEW did not oversee or direct the geotechnical drilling programs associated with HDD S2-0260, including but not limited to, the selection of boring locations, determination of location, determination of surface elevation, target depths, observations of rock cores during drilling operations, or preparation of boring logs. The geotechnical reports, boring logs, and core photographs that resulted from these programs were generated by other Sunoco Pipeline, L.P. contractors. Skelly and Loy and RETTEW relied on these reports and incorporated their data into the general geologic and hydrogeologic framework of the analysis of HDD S2-0260 for this report.

6.0 FIELD OBSERVATIONS

Site reconnaissance activities performed by Skelly and Loy geologists from June 26 through July 15, 2017 identified the closest bedrock exposure to the HDD bore path to be a cut slope of weathered diabase located in the HDD exit point mud pit. Additional bedrock exposures occur in the surrounding area along Yellow Breeches Creek and on top of nearby ridges that consist predominantly of the Gettysburg conglomerate. No structural geologic measurements could be obtained from the mud pit exposure due to the metamorphosed crystalline nature of the massive diabase outcrop. Exposures of the Gettysburg Formation were not accessible due to their locations on private property. 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 which is also consistent with the field observations and geologic measurements of the Gettysburg Formation nearly ½-mile southwest, south, southeast, and east of the HDD trace.

According to available geologic mapping, the western three quarters of the HDD bore path is underlain by bedrock mapped as the Gettysburg Formation Quartz Fanglomerate and the eastern quarter of the HDD bore path is underlain by Gettysburg Limestone Conglomerate and diabase. This mapping is consistent with Skelly and Loy's field observations. The rocks proximate to the diabase ridge near the HDD exit point comprise a baked zone that has been metamorphosed, crystallized, and hardened by the intrusive diabase. In addition to the Yellow Breeches Creek and identified private water supplies, no additional potential environmental receptors of concern were identified within the defined ½-mile HDD buffer area.

On June 3, 2017, during reaming of the 20-inch pilot hole, groundwater flowback overflowed the entry mud pit, passed through the erosion control devices, and entered an adjacent storm drain. This release of groundwater to the storm drain occurred during the night; however, no evidence of erosion was reported. Drilling operations continued while containment measures were implemented in the entry mud pit. The location of the entry mud pit is shown on **Figures 1 through 3**.

On September 30, 2017, Pretec reported nearly 100% loss of returns (LOR) for approximately 10 minutes during 22-inch reaming when the reamer bit was located approximately 190 feet from the east pit. Pretec moved the reamer back and forth along the borehole and reestablished approximately 40% return. After about one hour, drill returns were observed at the exit pit (at higher elevation than entry pit). Pretec suspended reaming and pumping drilling fluid until a vacuum truck was available to shuttle water from the east pit to the west pit. All drilling fluid was contained within the pits and there were no IRs identified.

On October 3, 2017, a second LOR event was reported when the returns at the west pit diminished for about 25 minutes, but were still over 50%, and then suddenly diminished to a nearly 100% loss. As a result, Pretec shut down pumping drilling fluid and reaming immediately. Water started flowing into the exit pit about 7 minutes later. Two vacuum trucks were set up to shuttle water from the east pit to the west pit. Pretec then continued to ream and work the reamer along the borehole to try and clear the blockage. All drilling fluid was contained within the pits and no IRs were identified. The 20-inch pipe was pulled through on April 11, 2018.

7.0 GEOPHYSICAL SURVEY CONSIDERATIONS

Although some thin-bedded limestone fanglomerate units are mapped approximately 2,000 feet NW of the HDD bore path, and the limestone conglomerate underlying the east-central portion of the HDD profile consists of carbonate (limestone and dolomite) fragments and pebbles interbedded with shale fanglomerate in a very fine-grained matrix of red quartz, these rocks do not exhibit solution channels and voids characteristic of thickly bedded carbonate units typified by karst terrain. As a result, no karst geology was observed during the field reconnaissance or is mapped as being present at this HDD location. Although the Corrected Stipulated Order states that the use of geophysical surveys should be considered in karst areas, based on the lack of karst geologic features and extensively fractured carbonate bedrock, the use of geophysical surveys during re-evaluation was considered but was ultimately not implemented at the Lewisberry Road HDD location 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 terrain 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 trace 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 additional information on the formational thickness, interbedded sandstone, shale, diabase, and thin beds of quartz conglomerate-fanglomerate and limestone conglomerate at depths greater than 50 feet bgs along the HDD profile. As such, geophysical survey data would not enhance the evaluation or reduce the risk of an IR.

8.0 CONCEPTUAL HYDROGEOLOGIC MODEL

Groundwater occurring in the watershed occupied by the Lewisberry Road 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 Yellow Breeches Creek located approximately 4,200 feet west of the western entry/exit point. Based on these limited site-specific data, it appears that the groundwater table also occurs within the unconsolidated overburden near the soil/bedrock interface. The available data suggest that the groundwater table proximate to the HDD path is relatively shallow and may exist in some areas of the overburden soils that contribute flow to the local shallow groundwater discharge zone. 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 October 2014 through September 2017 indicate that the soil thickness near HDD S2-0260 ranges from approximately 18.5 to 23 feet and consists of various soil types ranging from clay, silt, and sand with trace gravel to weathered sandstone. Recorded descriptions of the bedrock cores include weathered sandstone, diabase and conglomerate. Data tabulated for supply wells found in the PaGWIS database (**Figure 3**) within a ½-mile radius of the HDD trace recorded measured water levels in the bedrock aquifer ranging from 6 to 175 feet bgs. Groundwater was encountered in all three of the shallow geotechnical soil borings (SB-01, 14.2 feet bgs; SB-02, 14 feet bgs; and SB-03, 15.5 feet bgs) completed in the soil regolith. Depth to water measurements ranged from 5 feet bgs during drilling to 23 feet bgs upon completion of geotechnical core Boring B-2.

This formation is highly anisotropic, with the predominant groundwater flow direction parallel to bedrock strike. The transport of groundwater 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 the HDD profile. 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 west toward the unnamed tributary discharging to Yellow Breeches Creek. The Yellow Breeches Creek is sustained by local shallow groundwater flow discharges. 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 measured depths to water ranging from 5 (B-2) feet bgs to 14 (SB-02) feet bgs. As stated above, measured water levels in private supply wells located within ½-mile of the site range from 6 to 175 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 S2-0260 Lewisberry Road HDD location is underlain by clastic sedimentary rocks (conglomerate, sandstone, siltstone, quartz conglomerate-fanglomerate, and limestone conglomerate) 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) 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, and diabase. Because the limestone conglomerate consists of carbonate (limestone and dolomite) fragments and pebbles interbedded with shale fanglomerate in a very fine-grained matrix of red quartz, these rocks do not exhibit solution channels and voids characteristic of thickly bedded carbonate units typified by karst terrain. 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 Yellow Breeches Creek.

The proposed 16-inch HDD profile extends entirely within both the shallow unconsolidated regolith materials and weathered to unweathered bedrock. Based on the hydrostructural characteristics of the underlying geology described in this report and the known HDD profile through shallow soils and bedrock, the Lewisberry Road HDD site is susceptible to the inadvertent return of drilling fluids during HDD operations. The inclination of the entry and exit angles for the proposed 16-inch pipeline has been increased as a means to install the pipe through these protective soils and bedrock in closer proximity to the entry and exit points than the original, shorter profile. From a geologic perspective, the laterally adjusted, longer and deeper profile, in conjunction with the proposed proactive engineering controls and/or drilling BMPs, will be used to reduce the risk of LORs or IRs. Drilling BMPs are described in the Horizontal Directional Drill Analysis component of the overall re-evaluation package.

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11.0 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.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
DOUGLAS JAY HESS
GEOLOGIST
NO. PG000186G

Douglas J. Hess, P.G.
License No. PG-000186-G

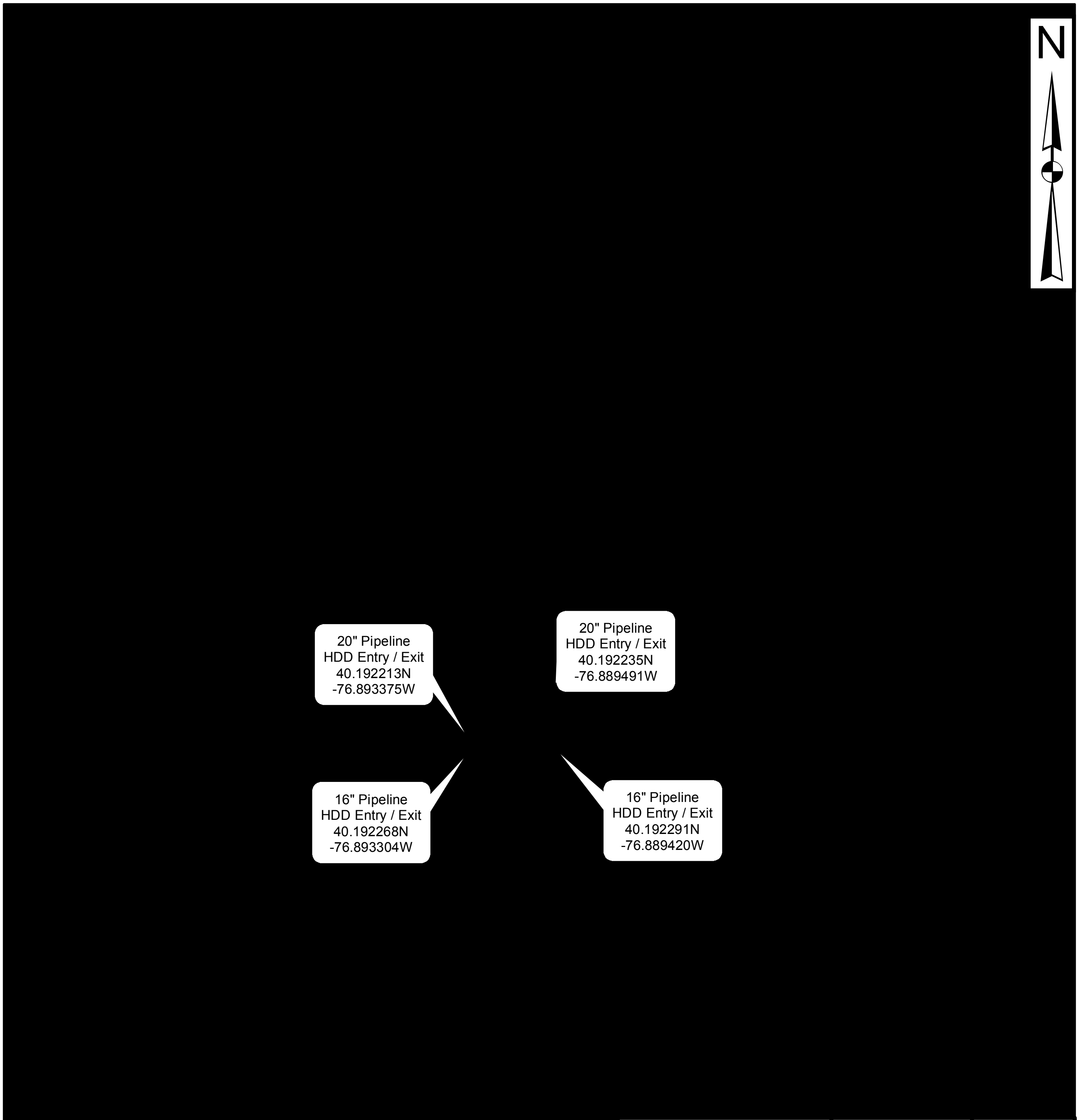
Sincerely yours,

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-Lewisberry Road_DJH (2019-2-15) - MASTER2 REV DJH_GAA edits- DJH Rev 6.11.19.docx

FIGURES



SKELLY and LOY, Inc.	December 2017	Figure 1

Sunoco Pipeline

PROJECT LOCATION MAP

Fairview Township
York County, Pennsylvania

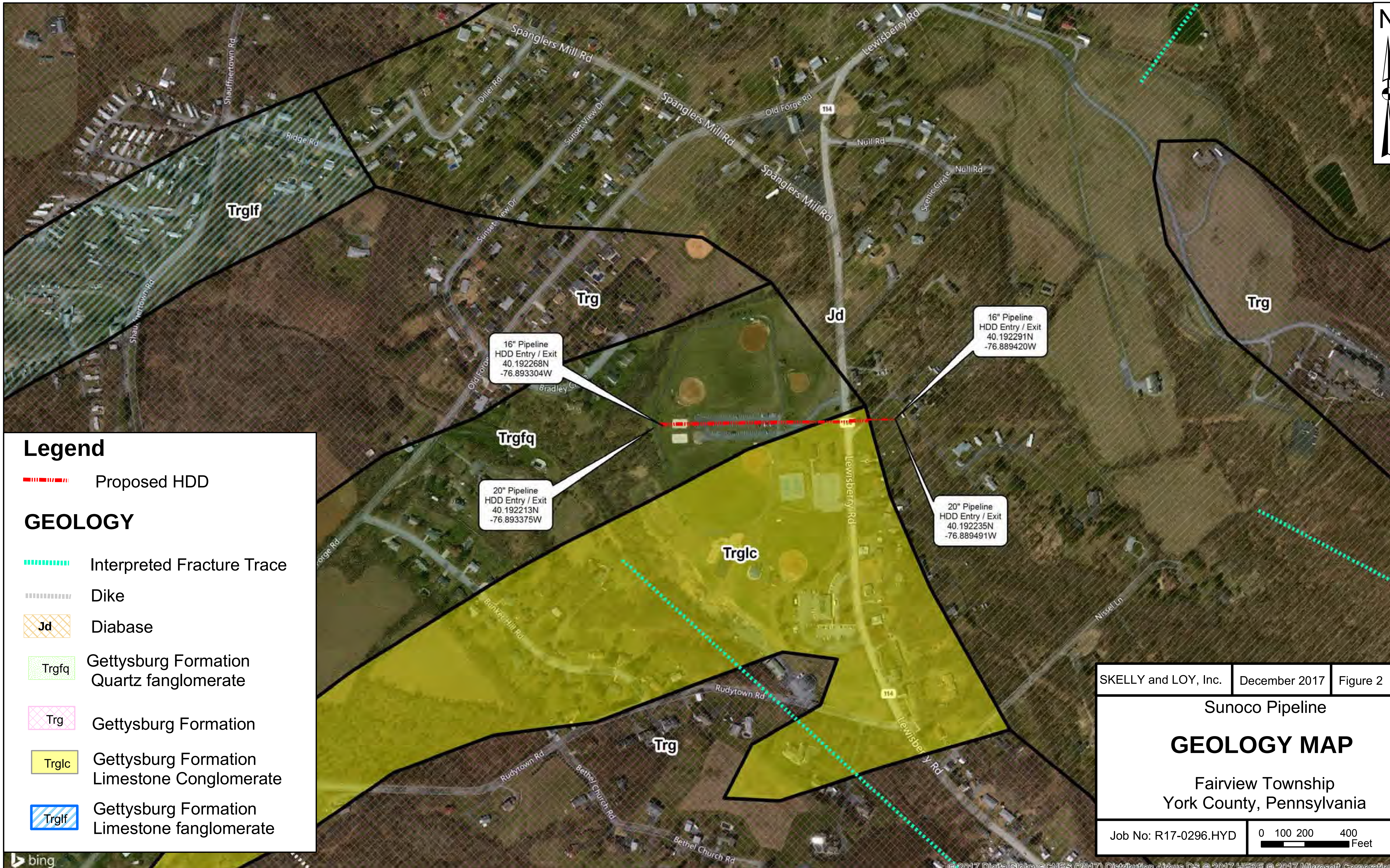
R17-0296.HYD

0 500 1,000 2,000 Feet

LEGEND

- ● HDD Entry / Exit
- HDD Bore

Source: U.S.G.S. 7.5' Quadrangle - LEMOYNE, PENNSYLVANIA.



Legend
Proposed HDD
GEOLOGY
Interpreted Fracture Trace
Dike
Jd Diabase
Trgfq Gettysburg Formation Quartz fanglomerate
Trg Gettysburg Formation
Trglc Gettysburg Formation Limestone Conglomerate
Trglf Gettysburg Formation Limestone fanglomerate
16" Pipeline HDD Entry / Exit 40.192268N -76.893304W
20" Pipeline HDD Entry / Exit 40.192213N -76.893375W
16" Pipeline HDD Entry / Exit 40.192291N -76.889420W
20" Pipeline HDD Entry / Exit 40.192235N -76.889491W
Trglf
Trg
Jd
Trgfq
Trglc
Trg
Trg
Spanglers Mill Rd
Lewisberry Rd
Old Forge Rd
Null Rd
Rudytown Rd
Bethel Church Rd
Nissel Ln
Ridge Rd
N
SKELLY and LOY, Inc.
December 2017
Figure 2
Sunoco Pipeline
GEOLOGY MAP
Fairview Township
York County, Pennsylvania
Job No: R17-0296.HYD
0 100 200 400 Feet
bing
© 2017 DigitalGlobe ©CNES (2017) Distribution Airbus DS © 2017 HERE © 2017 Microsoft Corporation

20" Pipeline
HDD Entry / Exit
40.192213N
-76.893375W
20" Pipeline
HDD Entry / Exit
40.192235N
-76.889491W
16" Pipeline
HDD Entry / Exit
40.192268N
-76.893304W
16" Pipeline
HDD Entry / Exit
40.192291N
-76.889420W
35121
156581
156583
157249
632902
156649
156357
156402
156615
156414
156366
156587
156471
156359
617145
156422
156329
35118
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259661
156375
156377
643383
156459
156451
156383
156437
617627
624917
156401
35117
156455
624441
620751
624440
620752
636993
624439
624702
260377
624438
624703
624655
156785
630357
476660
156381
422511
N
Legend
Proposed HDD
.5 Mile Buffer of Proposed HDD
Parcel Boundary and Map ID
1234
Well Location and Well ID
Interpreted Fracture Trace
SKELLY and LOY, Inc.
December 2017
Figure 3
Sunoco Pipeline
WELL LOCATION MAP
Fairview Township
York County, Pennsylvania
Job No: R17-0296.HYD
0 175 350 700
Feet
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ATTACHMENTS

ATTACHMENT 1 - SOILS

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

York County, Pennsylvania

SUNOCO HDD LEWISBERRY RD

October 26, 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.

Soil Map

Map Scale: 1:3,950 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 150, 300, 600, 900

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

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

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

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

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

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

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

Soil Survey Area: York County, Pennsylvania
Survey Area Data: Version 10, Sep 19, 2016

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

Date(s) aerial images were photographed: Aug 23, 2013—Feb 22, 2017

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Cm	Codorus silt loam	4.9	7.4%
LeB	Lansdale loam, 3 to 8 percent slopes	6.7	10.1%
LfC	Lansdale channery loam, 8 to 15 percent slopes	2.2	3.4%
LhB	Lehigh channery silt loam, 3 to 8 percent slopes	7.0	10.7%
MdB	Mount Lucas silt loam, 3 to 8 percent slopes	0.1	0.1%
NaB	Neshaminy channery silt loam, 3 to 8 percent slopes	25.7	39.0%
NaC	Neshaminy channery silt loam, 8 to 15 percent slopes	3.9	5.9%
NdB	Neshaminy channery silt loam, 0 to 8 percent slopes, extremely bouldery	4.6	6.9%
NdD	Neshaminy channery silt loam, 8 to 25 percent slopes, extremely bouldery	7.2	10.9%
StD	Steinsburg channery sandy loam, 15 to 25 percent slopes	2.8	4.2%
WbB	Watchung silt loam, 0 to 8 percent slopes, extremely bouldery	0.9	1.3%
Totals for Area of Interest		**66.0**	**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.

York County, Pennsylvania

Cm—Codorus silt loam

Map Unit Setting

National map unit symbol: l6vp
Elevation: 200 to 2,000 feet
Mean annual precipitation: 35 to 50 inches
Mean annual air temperature: 45 to 57 degrees F
Frost-free period: 120 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Codorus

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from gneiss and/or alluvium derived from mica schist

Typical profile

Ap - 0 to 12 inches: silt loam
Bw - 12 to 48 inches: silt loam
C - 48 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 72 to 99 inches to lithic bedrock
Natural drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.5 inches)

Interpretive groups

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

Minor Components

Hatboro

Percent of map unit: 8 percent
Landform: Flood plains

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

Glenville

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

Baile

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

LeB—Lansdale loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l6x8
Elevation: 300 to 1,000 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 160 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Lansdale

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 sandstone and/or residuum weathered from conglomerate

Typical profile

Ap - 0 to 8 inches: loam
Bt - 8 to 34 inches: channery sandy loam
C - 34 to 46 inches: channery sandy loam
R - 46 to 50 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 42 to 60 inches to lithic bedrock
Natural drainage class: 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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.1 inches)

Interpretive groups

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

Minor Components

Reaville

Percent of map unit: 8 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope, summit
Landform position (three-dimensional): Base slope, interfluve
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

LfC—Lansdale channery loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: l6x9
Elevation: 250 to 1,400 feet
Mean annual precipitation: 36 to 55 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 130 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Lansdale, channery loam, and similar soils: 75 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lansdale, Channery 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 sandstone and/or residuum weathered from conglomerate

Typical profile

H1 - 0 to 10 inches: channery loam
H2 - 10 to 17 inches: channery loam
H3 - 17 to 30 inches: channery sandy loam
H4 - 30 to 42 inches: channery loamy sand
H5 - 42 to 47 inches: channery loamy sand
H6 - 47 to 57 inches: bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 40 to 60 inches to lithic bedrock
Natural drainage class: 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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.4 inches)

Interpretive groups

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

Minor Components

Penn, silt loam

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

Klinesville

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

Readington

Percent of map unit: 3 percent
Landform: Hillslopes, swales
Landform position (two-dimensional): Footslope, backslope, toeslope
Landform position (three-dimensional): Base slope, head slope, side slope
Down-slope shape: Concave, linear, convex
Across-slope shape: Concave, linear, convex
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

Steinsburg

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

Reaville

Percent of map unit: 2 percent
Landform: Hillsides, hillslopes
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Side slope, interfluve, base slope
Down-slope shape: Convex, concave, linear
Across-slope shape: Convex, concave, linear
Hydric soil rating: No

LhB—Lehigh channery silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: l6xg
Elevation: 300 to 2,000 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 150 to 220 days
Farmland classification: All areas are prime farmland

Map Unit Composition

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

Description of Lehigh

Setting

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
Parent material: Residuum weathered from porcellanite

Typical profile

H1 - 0 to 8 inches: channery silt loam
H2 - 8 to 30 inches: channery silt loam
H3 - 30 to 42 inches: extremely channery silt loam
H4 - 42 to 52 inches: bedrock

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 40 to 60 inches to lithic bedrock
Natural drainage class: Somewhat poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 6 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.8 inches)

Interpretive groups

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

Minor Components

Reaville

Percent of map unit: 10 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope, summit
Landform position (three-dimensional): Interfluve, base slope
Down-slope shape: Concave, linear
Across-slope shape: Concave, 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

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

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

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

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

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: Hillslopes, hillsides
Landform position (two-dimensional): Footslope, backslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, concave, convex
Across-slope shape: Concave, linear, convex
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

NdB—Neshaminy channery silt loam, 0 to 8 percent slopes, extremely bouldery

Map Unit Setting

National map unit symbol: l6yd
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: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Neshaminy, Extremely Bouldery

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: 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: 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): 7s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Legore

Percent of map unit: 5 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

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

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

Mount lucas, very bouldery
Percent of map unit: 3 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

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

StD—Steinsburg channery sandy loam, 15 to 25 percent slopes

Map Unit Setting

National map unit symbol: l6zm
Elevation: 300 to 1,500 feet
Mean annual precipitation: 36 to 50 inches
Mean annual air temperature: 46 to 57 degrees F
Frost-free period: 130 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Steinsburg

Setting

Landform: Hillsides
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from conglomerate and/or residuum weathered from sandstone

Typical profile

H1 - 0 to 10 inches: channery sandy loam
H2 - 10 to 20 inches: channery sandy loam
H3 - 20 to 26 inches: very channery loamy sand
H4 - 26 to 36 inches: bedrock

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: 24 to 40 inches to lithic bedrock
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Lansdale

Percent of map unit: 5 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

Lewisberry

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

Klinesville

Percent of map unit: 5 percent
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

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

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

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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ATTACHMENT 2 -
GEOTECHNICAL REPORT

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Figure 1: Site Vicinity Map

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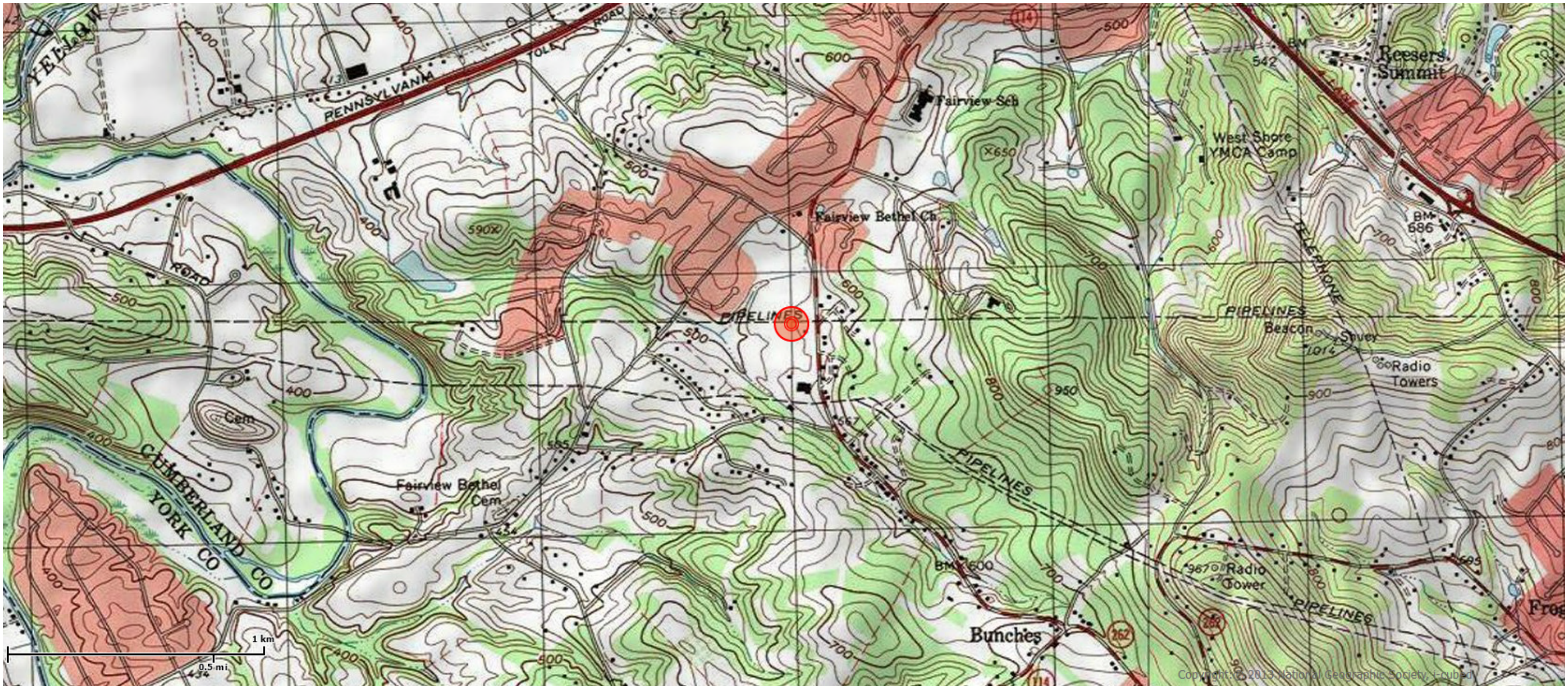

Created using PA DCNR Map Viewer

Map created on Sun Sep 17 2017

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Figure 3: Site Geology Map

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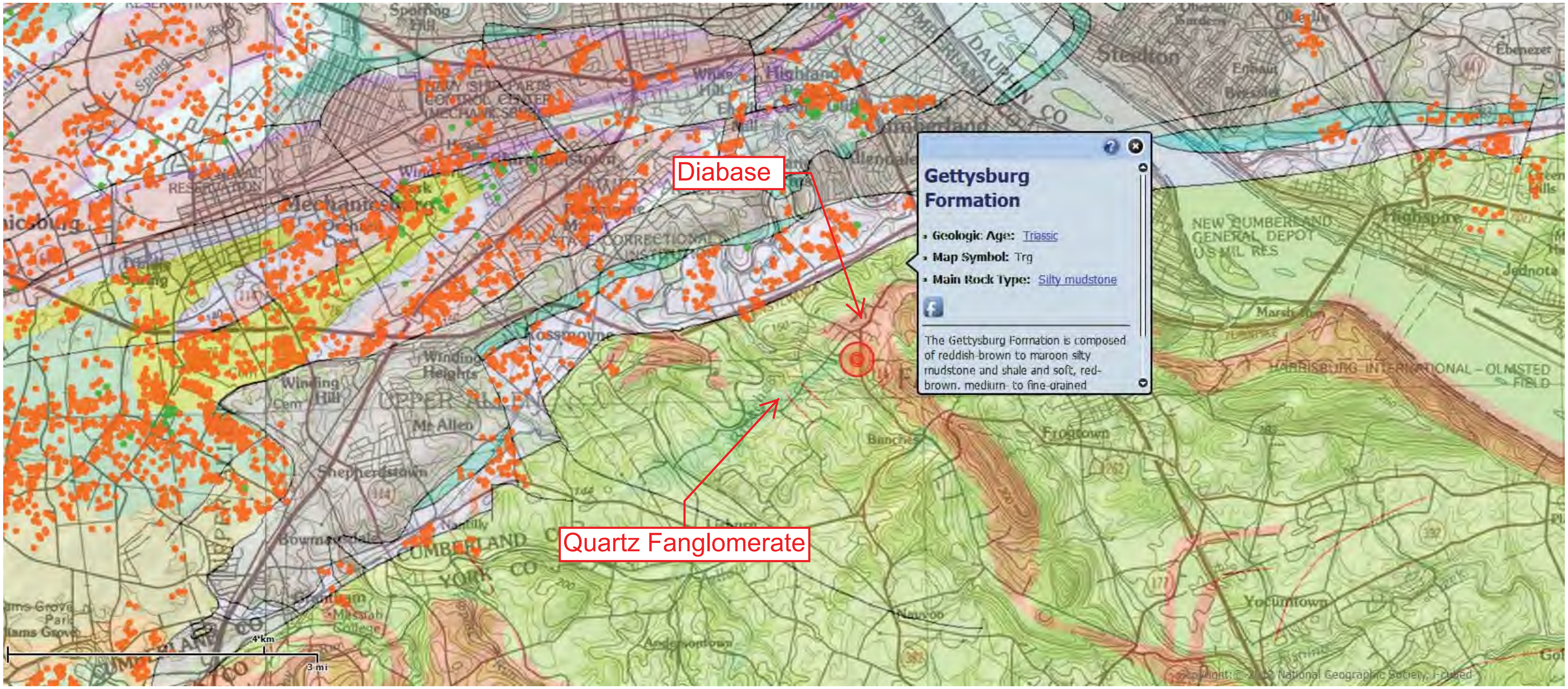
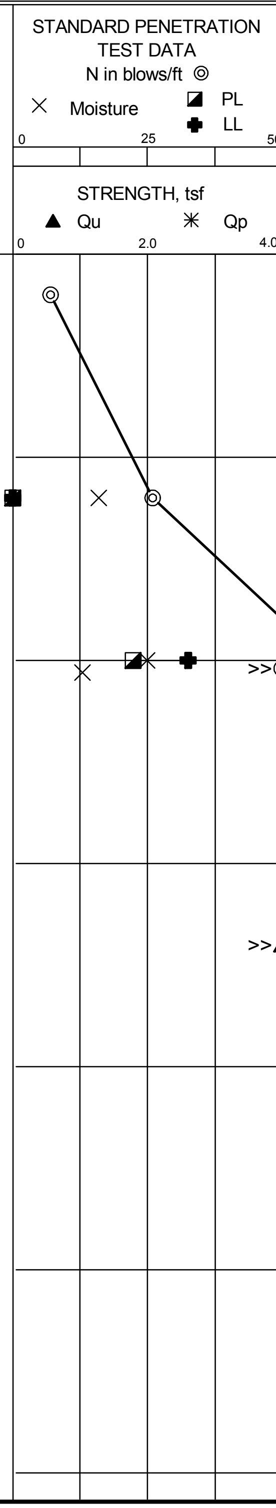


Created using PA DCNR Map Viewer

Map created on Sun Sep 17 2017

DATE STARTED: 9/8/17	**DRILL COMPANY:** Eichelberger's, Inc.		**BORING B-2**
DATE COMPLETED: 9/8/17	**DRILLER:**	**LOGGED BY:** L. Proczko	Water: While Drilling 5 feet
COMPLETION DEPTH 115.0 ft	**DRILL RIG:** Diedrich D-120		Upon Completion 23 feet
BENCHMARK: N/A	**DRILLING METHOD:** Casing/Rock Coring		
ELEVATION: N/A	**SAMPLING METHOD:** 2-in SS1.874-in Core		
LATITUDE: n/a°	**HAMMER TYPE:** Automatic		**BORING LOCATION:**
LONGITUDE: n/a°	**EFFICIENCY** N/A		See Boring Location Plan
STATION: N/A **OFFSET:** N/A	**REVIEWED BY:** F. Hoffman		
REMARKS:			

Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS) RQD & Recovery % (NX)	Moisture, %	Additional Remarks
0			4 inches topsoil				
	S-1	7	**FILL**-Limited recovery consisted of gravel-sized brick fragments and dark gray-brown silt		5-4-3-3 N=7		
5	S-2	8	**Probable RESIDUUM**-Medium Dense, Brown, Silty SAND, trace Gravel, moist/wet	SM	17-12-14-16 N=26	16	Non-Plastic Fines=44.9%
			RESIDUUM-Gray-brown, Lean CLAY with Sand, trace Gravel, moist/wet	CL			
10	S-3	5	**Highly Weathered DIABASE Sampled as Soil**-Very Dense, Dark gray-brown, Silty SAND, trace Gravel, moist/wet	SM	50/5"	25 13	LL = 32 PL = 22
	R-1	6	**Highly/Completely Weathered ROCK**-Recovery from this core run consisted of 6 inches of clay suggesting the remainder of the core run washed away during coring activities		RQD=0 Rec=11%		
15	R-2	56	**DIABASE**-Gray to dark gray-brown, Fine grained, Weathered to Highly Weathered, very broken to slightly broken, hard to very hard Multiple soil seams from 15 to 20 feet.		RQD=28 Rec=93%		1 min. 2 min. Q_u = 368.1 tsf 179.6 pcf 1 min. 1 min. 1 min.
20	R-3	60			RQD=15 Rec=100%		1 min. 2 min. 2 min. 1 min. 1 min.
25	R-4	60	**DIABASE**-Gray to dark gray, Fine grained, Weathered to Slightly Weathered, broken to massive, hard to very hard		RQD=47 Rec=100%		2 min. 2 min. 1 min. 1 min.
30							



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BORING B-2

DATE STARTED:	9/8/17	**DRILL COMPANY:**	Eichelberger's, Inc.
DATE COMPLETED:	9/8/17	**DRILLER:**	**LOGGED BY:** L. Proczko
COMPLETION DEPTH	115.0 ft	**DRILL RIG:**	Diedrich D-120
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/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:**	F. Hoffman
REMARKS:			

Water

▽	While Drilling	5 feet
▼	Upon Completion	23 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			R-5	60	**DIABASE**-Gray to dark gray-brown, Fine grained, Weathered to Highly Weathered, very broken to slightly broken, very hard **DIABASE**-Dark gray-brown to gray to black, Fine grained, Slightly Weathered, very broken to massive, very hard		RQD=44 Rec=100%			1 min. 2 min. 1 min. 1 min. 1 min. 2 min.
	35			R-6	60	Weathered layer @ 36.8 feet (~ 3-1/4 inches thick)		RQD=49 Rec=100%		>>▲	1 min. Q_u = 1754.5 tsf 188.1 pcf 2 min. 1 min. 1 min. 1 min.
	40			R-7	60			RQD=82 Rec=100%		>>▲	2 min. 2 min. 2 min. 3 min. Q_u = 921.6 tsf 187.4 pcf 2 min.
	45			R-8	60			RQD=90 Rec=100%			2 min. 2 min. 2 min. 2 min. 2 min.
	50			R-9	60			RQD=88 Rec=100%		>>▲	3 min. 1 min. Q_u = 1259.3 tsf 1 min. 191.0 pcf 1 min. 1 min.
	55			R-10	60			RQD=93 Rec=100%			2 min. 2 min. 1 min. 1 min.
	60										

Continued Next Page

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Harrisburg, PA 17104
Telephone: (717) 230-8622

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PROJECT NO.: 04911463
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Lewisberry RD (PPP4)
York Co., PA
PA-YO-0016.0000-RD/PO#20170824

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

DATE STARTED: 9/8/17	**DRILL COMPANY:** Eichelberger's, Inc.	**BORING B-2**	
DATE COMPLETED: 9/8/17	**DRILLER:** **LOGGED BY:** L. Proczko	**Water** ▽ While Drilling	5 feet
COMPLETION DEPTH 115.0 ft	**DRILL RIG:** Diedrich D-120	▼ Upon Completion	23 feet
BENCHMARK: N/A	**DRILLING METHOD:** Casing/Rock Coring	▽	
ELEVATION: N/A	**SAMPLING METHOD:** 2-in SS1.874-in Core		
LATITUDE: n/a°	**HAMMER TYPE:** Automatic	**BORING LOCATION:**	
LONGITUDE: n/a°	**EFFICIENCY** N/A	See Boring Location Plan	
STATION: N/A **OFFSET:** N/A	**REVIEWED BY:** F. Hoffman		
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					**DIABASE**-Dark gray-brown to gray to black, Fine grained, Slightly Weathered, very broken to massive, very hard					1 min. 2 min. 1 min. 1 min. 1 min.
				R-11	60			RQD=75 Rec=100%			
	65					Nearly vertical calcite seam from 65.5 to 66.6 feet.				>>▲	1 min. 1 min. 1 min. Qu = 1395.2 tsf 190.0 pcf 1 min. 1 min.
				R-12	60			RQD=97 Rec=100%			
	70										1 min. 1 min. 1 min. 1 min. 1 min.
				R-13	60			RQD=96 Rec=100%			
	75									>>▲	1 min. 2 min. 1 min. Qu = 416.7 tsf 187.3 pcf 1 min. 1 min.
				R-14	60			RQD=88 Rec=100%			
	80										1 min. 2 min. 1 min. 1 min. 1 min.
				R-15	58			RQD=75 Rec=97%			
	85										1 min. 2 min. 1 min. 1 min.
				R-16	60	Nearly vertical fractures from 87 to 88.5 feet.		RQD=77 Rec=100%		>>▲	1 min. Qu = 694.0 tsf 187.1 pcf
	90										

Continued Next Page

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Telephone: (717) 230-8622

PROJECT NO.: 04911463
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Lewisberry RD (PPP4)
York Co., PA
PA-YO-0016.0000-RD/PO#20170824

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

BORING B-2

DATE STARTED:	9/8/17	**DRILL COMPANY:**	Eichelberger's, Inc.
DATE COMPLETED:	9/8/17	**DRILLER:**	**LOGGED BY:** L. Proczko
COMPLETION DEPTH	115.0 ft	**DRILL RIG:**	Diedrich D-120
BENCHMARK:	N/A	**DRILLING METHOD:**	Casing/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:**	F. Hoffman
REMARKS:			

Water

∇	While Drilling	5 feet
▼	Upon Completion	23 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
	90					**DIABASE**-Gray to black, Fine grained, Weathered to Slightly Weathered, very broken to massive, very hard					1 min.
											2 min.
											1 min.
				R-17	60			RQD=0 Rec=100%			1 min.
											1 min.
	95										2 min.
											2 min.
						CONGLOMERATE-Dark gray-brown to light gray to dark green-gray, Fine to very coarse grained, Slightly Weathered, broken to massive, very hard to extremely hard					1 min.
				R-18	60			RQD=78 Rec=100%			2 min.
											2 min.
	100										2 min.
											2 min.
											2 min.
				R-19	60			RQD=84 Rec=100%		>> ▲	Q_u = 379.9 tsf 178.9 pcf
											3 min.
											2 min.
	105										2 min.
											2 min.
											2 min.
				R-20	60	Trace pits and vugs from 105 to 110 feet.		RQD=98 Rec=100%			2 min.
											2 min.
	110										2 min.
											2 min.
											2 min.
				R-21	60			RQD=100 Rec=100%			1 min.
										>> ▲	Q_u = 985.7 tsf 170.3 pcf
											2 min.
	115					Test boring terminated @ 115 feet					2 min.

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PROJECT NO.: 04911463
PROJECT: Energy Transfer HDD (DPS)
LOCATION: Lewisberry RD (PPP4)
York Co., PA
PA-YO-0016.0000-RD/PO#20170824

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


PPP#4
04911463
B-2
9.8.17
10-30
Box 1 of 1
Lewisberry Rd.
Run | Depth (ft.) | Rec (in.) | RQD (in.)
R-1 | 10-15 | 6" | —
R-2 | 15-20 | 56 | 17
R-3 | 20-25 | 60 | 11
R-4 | 25-30 | 60 | 34
30


PPP#4
049/1463
B-2
9.8.17
30-44.9
Box 2 of
Lewisberry Rd.
RUN Depth(ft.) Rec(in.) RQD(in.)
R-5 30-35 60 26.5
R-6 35-40 60 25.5
R-7 40-45 60 51.5
30
35
40


B-2
9-8-17
Box 3 of
Lewisberry Rd.
Run | Depth (ft.) | Rec (in.) | RQD (in.)
R-8 | 45-50 | 60 | 54
R-9 | 50-55 | 60 | 53
R-10 | 55-60 | 60 | 55.5
45
50
55


PPP#4
04911463
B2
9.8.17
58.8-73.1
Box 4 of
Lewisberry Rd.
RUN | Depth (ft.) | Rec (in.) | RQD (in.)
R-11 | 60-65 | 60 | 45
R-12 | 65-70 | 60 | 58
R-13 | 70-75 | 60 | 57.5
58.8
60
65
70
73.1


PPP#4
04911463
B-2
9-8-17
73.1-87
Box 5 of
Lewisberry Rd.
RUN | Depth (ft.) | Rec (in.) | RQD (in.)
R-14 | 75-80 | 60 | 53
R-15 | 80-85 | 58 | 45
R-16 | 85-90 | 60 | 46
73.1
75
80
85
87


04911463
B-2
9.8.17
87-101
Box 6 of
Lewisberry Rd.
RUN
Depth (ft.)
REC (in.)
RQD (in.)
R-17
90-95
60
0
R-18
95-100
60
47
R-19
100-105
60
87
90
95
100
101


FPP#4
04911463
B-2
9.8.17
101-115
Box 7 of
Lewisberry Rd.
RUN
Depth(ft.)
Rec(in.)
RQD (in.)
R-20
105-110
60
59
R-21
110-115
60
60
105
110

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%

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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

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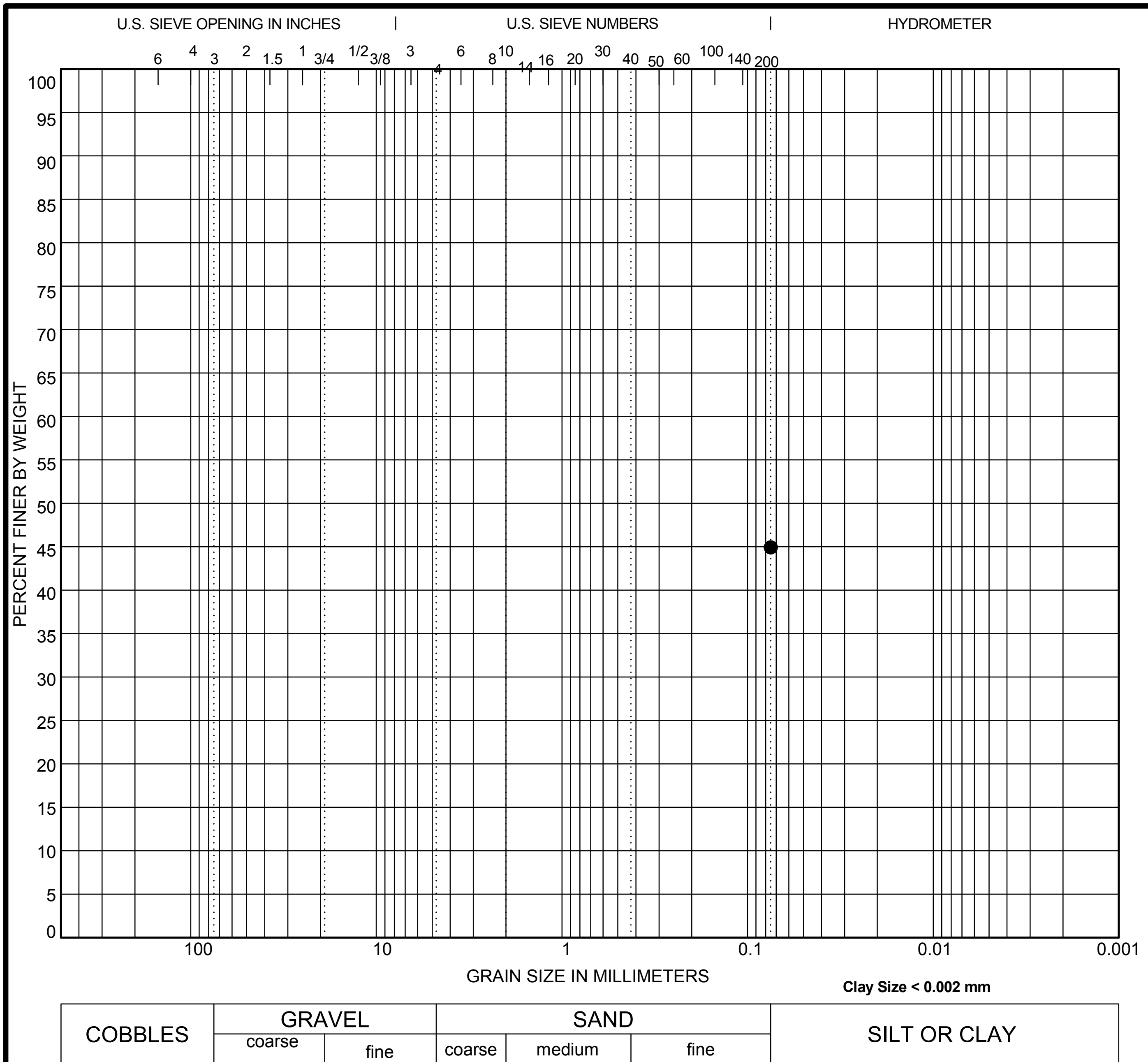
Table 4–3 Hardness and unconfined compressive strength of rock materials

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.



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-2	6.0	Silty SAND (SM)	NP	NP	NP		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-2	6.0	0.075				0.0	0.0	44.9	

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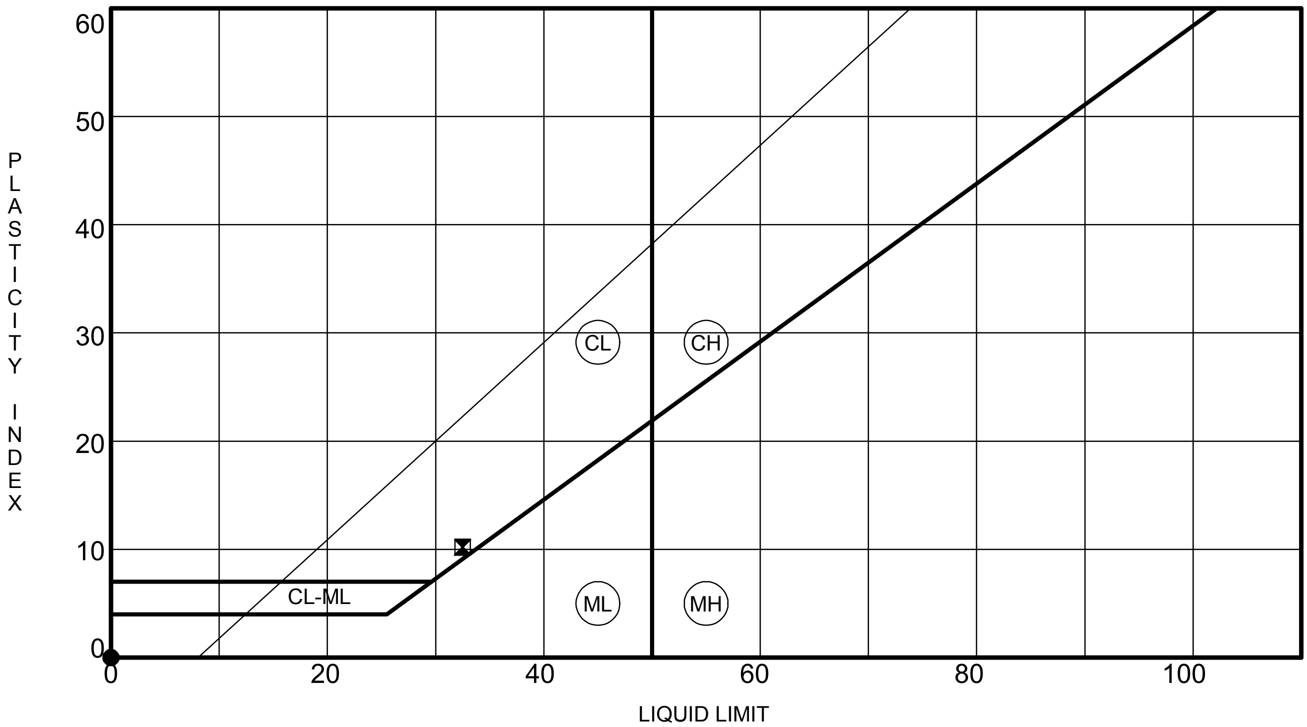
GRAIN SIZE DISTRIBUTION

Project: Energy Transfer HDD (DPS)
PSI Job No.: 04911463
Location: Lewisberry RD (PPP4)
York Co., PA



	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**B-2**	**6.0**	**NP**	**NP**	**NP**	**44.9**	**Silty SAND (SM)**
⧗	**B-2**	**10.0**	**32**	**22**	**10**		**Lean CLAY with Sand (CL)**

Professional Service Industries, Inc.
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Harrisburg, PA 17104
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ATTERBERG LIMIT RESULTS

PSI Job No.: 04911463
Project: Energy Transfer HDD (DPS)
Location: Lewisberry RD (PPP4)
York Co., 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-2	6	0	0	0		44.9%		16			
B-2	10	32	22	10				25			
B-2	10.3							13			
B-2	17				368.07						
B-2	36				1754.48						
B-2	44.2				921.57						
B-2	52.6				1259.32						
B-2	67				1395.20						
B-2	77				416.69						
B-2	89				694.01						
B-2	103				379.88						
B-2	114				985.69						

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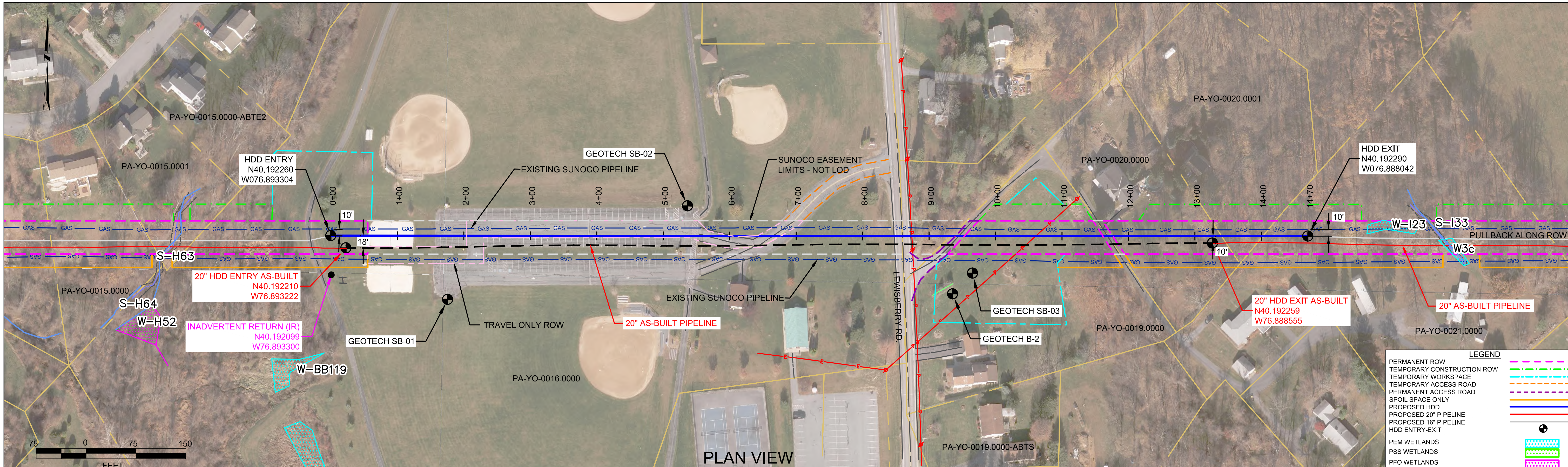
Summary of Laboratory Results

PSI Job No.: 04911463
Project: Energy Transfer HDD (DPS)
Location: Lewisberry RD (PPP4)
York Co., PA
PA-YO-0016.0000-RD/PO#20170824

PLAN VIEW



YORK COUNTY, PENNSYLVANIA - FAIRVIEW TOWNSHIP
S2-0260-16

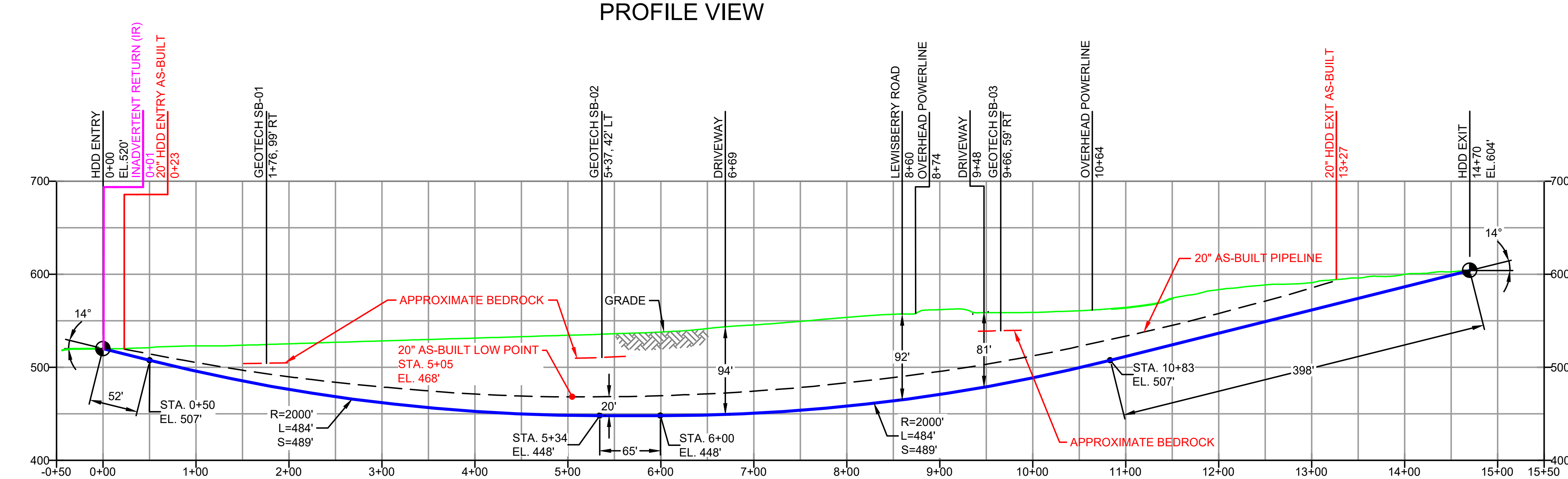
PROFILE VIEW

GEOTECH SB-01
- NG EL. 523'
- TOPSOIL (0' - 0.3')
- ML (0.3' - 11.5')
- GROUNDWATER (14.2')
- SM (11.5' - 19.7')
- AUGER REFUSAL (19.7')
- SANDSTONE (19.7' - 28.0')
- COMPLETION DEPTH EL. 495'

GEOTECH SB-02
- NG EL. 535'
- TOPSOIL (0' - 0.5')
- GROUNDWATER (14.0')
- SM (0.5' - 25.0')
- AUGER REFUSAL (25.0')
- SANDSTONE (25.0' - 33.0')
- COMPLETION DEPTH EL. 502'

GEOTECH SB-03
- NG EL. 557'
- TOPSOIL (0' - 0.7')
- SM (0.7' - 8.5')
- SM (11.5' - 18.5')
- GROUNDWATER (15.5')
- AUGER REFUSAL (18.5')
- COMPLETION DEPTH EL. 541'

NOTE: REFER TO TEST BORING LOG S2-0260 FOR COMPLETE SOIL MATERIAL DESCRIPTION



GEOTECH B-2
- NG EL. 557'
- TOPSOIL (0' - 0.3')
- FILL (0.3' - 3.5')
- RESIDIUUM-SILTY SAND SM (3.5' - 8.5')
- RESIDUUM LEAN CLAY W/ SAND CL (8.5' - 10.0')
- GROUNDWATER (23.0')
- DIABASE (10.0' - 96.5')
- CONGLOMERATE (96.5' - 115.0')
- BORING TERMINATED EL.442'

NOTE: REFER TO TEST BORING LOG B-2 INTERTEK PROJECT #04911463 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=): 1470'
   HDD PIPE LENGTH (S=): 1493'
   16" x 0.438" W.T., X-70, API5L, PSL2, ERW, BFW
   COATING: 14-16 MILS FBE WITH 30-35 MIL ARO (POWERCRETE OR ENGINEER APPROVED EQUAL)
5. INTERNAL DESIGN PRESSURE 2100 PSIG (SEAM FACTOR 1.0, DESIGN FACTOR 0.50).
6. INSTALLATION METHOD: HORIZONTAL DIRECTIONAL DRILL (HDD).
7. PIPELINE WARNING MARKERS SHALL BE INSTALLED ON BOTH SIDES OF ALL ROAD, RAILWAY, AND STREAM CROSSINGS.
8. CARRIER PIPE NOT ENCASED.
9. PIPE / AMBIENT TEMPERATURE MUST BE NO LESS THAN 30°F DURING PULLBACK WITHOUT PRIOR WRITTEN APPROVAL FROM THE ENGINEER.
10. CONDUCT 4-HOUR PRE-INSTALLATION HYDROTEST OF HDD PIPE STRING TO MINIMUM 2625 PSIG.
11. SEE SUNOCO PENNSYLVANIA PIPELINE PROJECT ESRI WEBMAP FOR ACCESS ROAD ALIGNMENT.
12. SUNOCO PIPELINE, L.P.'S HORIZONTAL DIRECTIONAL DRILL INADVERTENT RETURN CONTINGENCY PLAN WILL BE IMPLEMENTED AT ALL TIMES.
13. SUNOCO PIPELINE, L.P.'S EROSION AND SEDIMENTATION CONTROL PLAN WILL BE IMPLEMENTED AT ALL TIMES.

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

REF. DRAWING

DWG NO		DWG NO	DESCRIPTION
ES-4.04	TO	ES-4.04	EROSION & SEDIMENT PLAN
SHEET 3	TO	SHEET 3	AERIAL SITE PLAN

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK	DATE	APP	DATE
EP4	REVISED GEOTECH SB-01 INFORMATION	MRS	08/05/19	RMB	08/05/19	AMC	08/05/19
EP3	DESIGN CHANGE - INCREASED DEPTH AND LENGTH OF DRILL, ADDED GEOTECH DATA	MRS	12/14/18	RMB	12/14/18	AMC	12/14/18
EP2	REVISED PER PADEP COMMENTS RECEIVED 09-06-16	MRS	10/07/16	RMB	10/07/16	AAW	10/07/16
EP1	REVISED PER PADEP COMMENTS	MRS	05/09/16	RMB	05/09/16	AAW	05/09/16
EP		JTW	03/15/16	RMB	03/15/16	AAW	03/15/16
B	ADDED GEOTECH INFO	MRS	09/16/15	RMB	09/16/15	AAW	09/16/15

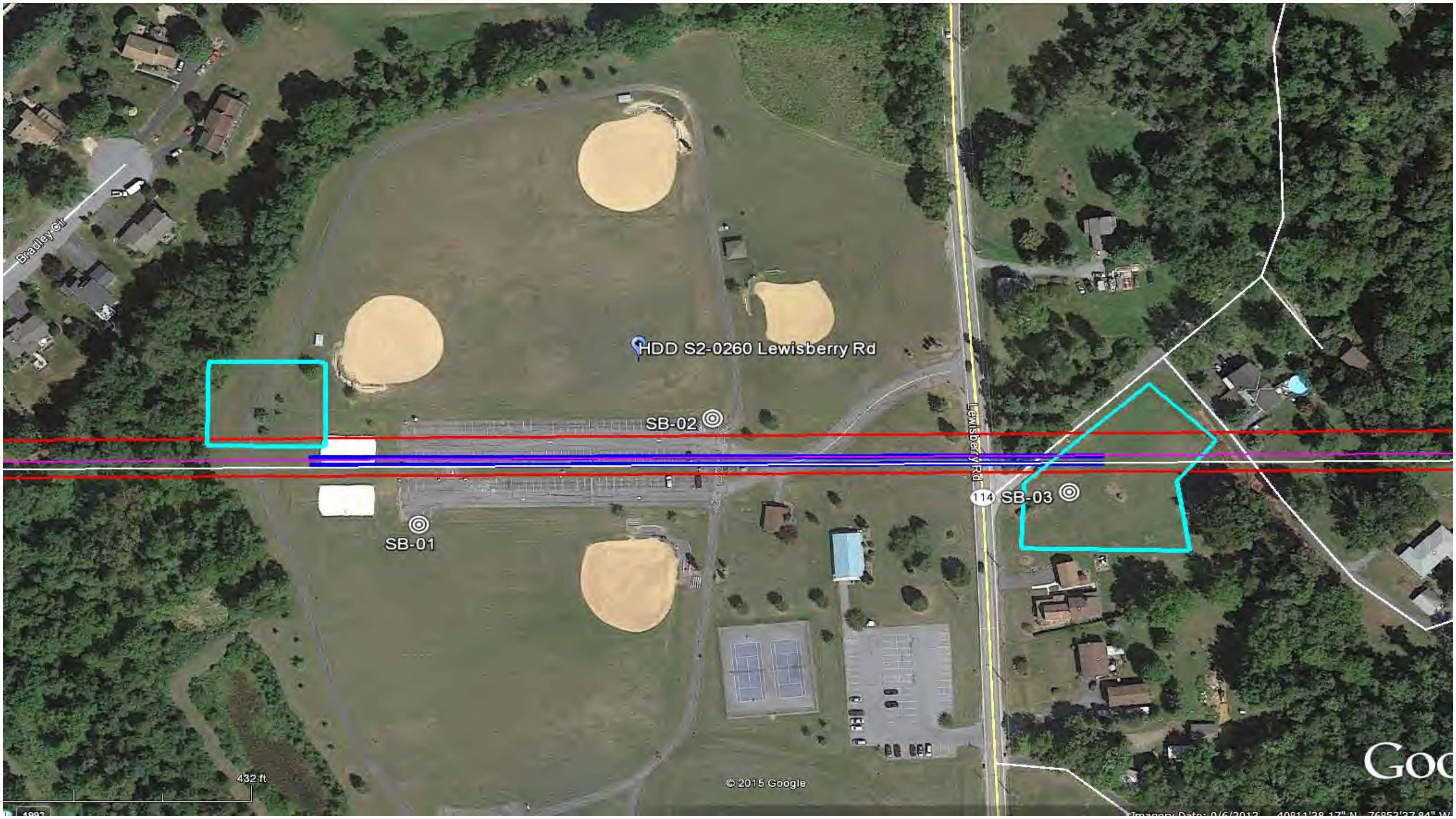
Sunoco Logistics Partners L.P.

TETRA TECH ROONEY
(303) 792-5911

SUNOCO PIPELINE, L.P.

HORIZONTAL DIRECTIONAL DRILL
LEWISBERRY ROAD
PENNSYLVANIA PIPELINE PROJECT

SCALE: 1"=150' | DWG. NO: PA-YO-0016.0000-RD-16



LEGEND:

Geotechnical Soil Boring (SB) Locations

TETRA TECH

GEOTECHNICAL BORING LOCATIONS
HDD S2-0260
YORK COUNTY, FAIRVIEW TOWNSHIP, PA
SUNOCO PENNSYLVANIA PIPELINE PROJECT

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT		Project No.: 103IP3406
Project Location:	ROOF PARK, LEWISBERRY ROAD, NEW CUMBERLAND, PA		Page 1 of 1
HDD No.:	S2-0260	Dates(s) Drilled: 10-27-14	Inspector: E. WATT
Boring No.:	SB-01	Drilling Method: SPT - ASTM D1586	Driller: S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 14.2	Total Depth (ft): 28.0

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
			0.0	0.3			TOPSOIL (4")					
			0.3	3.5		ML	GRAY SILT WITH A LITTLE FINE SAND.					
1	3.0	5.0	3.5			ML	MOTTLED BROWN AND ORANGE BROWN SILT AND FINE SAND	2	4	6	7	**10**
						ML	(USCS: ML)					
2	8.0	10.0		11.5		ML	MOTTLED BROWN TO GREENISH BROWN SILT AND FINE SAND.	3	10	11	10	**21**
3	13.0	15.0	11.5			SM	DR WEATHERED TO A VARI-COLORED FINE SAND WITH SOME SILT	3	6	8	16	**14**
						SM	AND TRACE OF UNWEATHERED FINE SANDSTONE GRAVEL.					
4	18.0	18.6				SM	DR WEATHERED TO A VARI-COLORED F-M SAND WITH SOME SILT	18	50/1"			**>50**
				19.7		SM	AND TRACE OF UNWEATHERED FINE SANDSTONE GRAVEL.					
5	19.7	20.0	19.7	20.0			PARTIALLY WEATHERED SANDSTONE.	50/4"				**>50**
							AUGER REFUSAL AT 19.7'.					
							ROCK CORING					
RUN 1	20.0	22.0	20.0		24	ROCK	GRAY HIGHLY FRACTURED AND WEATHERED SANDSTONE.	TCR: 100%, SCR: 0%, RQD: 0%				
RUN 2	22.0	25.0			36	ROCK	GRAY HIGHLY FRACTURED AND WEATHERED SANDSTONE.	TCR: 100%, SCR: 0%, RQD: 0%				
RUN 2	25.0	28.0		28.0	33	ROCK	GRAY HIGHLY FRACTURED AND WEATHERED SANDSTONE.	TCR: 92%, SCR: 7%, RQD: 0%				
							WATER LEVEL THROUGH AUGERS AT 14.2'.					
							CAVED AT 19.5'.					

Notes/Comments:

Pocket Pentrometer Testing
S1: 2 TSF
S2: 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.

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:	ROOF PARK, LEWISBERRY ROAD, NEW CUMBERLAND, PA			Page 1 of 1	
HDD No.:	S2-0260	Dates(s) Drilled: 10-27 and 11-04-14		Inspector:	E. WATT
Boring No.:	SB-02	Drilling Method: SPT - ASTM D1586		Driller:	S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 14.0		Total Depth (ft):	33.0

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (in)	Strata	Description of Materials	6" Increment Blows *				N
	From	To	From	To		(USCS)						
			0.0	0.5			TOPSOIL (6")					
1	3.0	5.0	0.5		19		GREENISH BROWN TO GRAYISH BROWN FINE SAND WITH SOME	3	8	9	12	**17**
							SILT.					
2	8.0	10.0			16		YELLOWISH BROWN TO LIGHT BROWN FINE TO MEDIUM SAND WITH	4	20	39	50	**59**
							SOME SILT, TRACE FINE GRAVEL.					
3	13.0	13.9			9	SM	YELLOWISH BROWN TO LIGHT BROWN FINE TO MEDIUM SAND WITH	7	50/5"			**>50**
							SOME SILT, TRACE FINE GRAVEL.					
4	18.0	18.9			10		BROWN TO YELLOWISH BROWN MEDIUM TO COARSE SAND WITH	3	50/5"			**>50**
							SOME SILT, AND A LITTLE FINE GRAVEL.					
5	20.0	20.8			5		LIGHT BROWN TO YELLOWISH BROWN F-M SAND WITH A LITTLE	2	50/4"			**>50**
							SILT.					
6	23.0	23.3			3		PARTIALLY WEATHERED SANDSTONE.	50/4"				**>50**
							AUGER REFUSAL AT 25'.					
							<u>ROCK CORING</u>					
RUN 1	25.0	28.0	25.0		12		GRAY HIGHLY FRACTURED AND DEGRADED SANDSTONE, WITH	TCR: 33%, SCR: 0%, RQD: 0%				
							OXIDATION.					
RUN 2	29.0	33.0			26		GRAY HIGHLY FRACTURED AND DEGRADED SANDSTONE, WITH	TCR: 54%, SCR: 0%, RQD: 0%				
				33.0			OXIDATION.					
							BORING COLLAPSED AFTER REMOVING COE BAREL AFTER RUN 1.					
							AUGERED BACK DOWN TO 29'. EACH CORE RUN TOOK SEVERAL					
							ATTEMPTS BECAUSE SANDSTONE FRAGMENTS KEPT COLLAPSING					
							INTO BOREHOLE.					
							REFUSAL MATERIAL MAY BE A RESULT OF BOULDERY CONDITIONS.					

Notes/Comments:

<u>Pocket Pentrometer Testing</u>

DR: DECOMPOSED ROCK

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

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

TETRA TECH

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

TEST BORING LOG

Project Name:	SUNOCO PENNSYLVANIA PIPELINE PROJECT			Project No.: 103IP3406
Project Location:	ROOF PARK, LEWISBERRY ROAD, NEW CUMBERLAND, PA			Page 1 of 1
HDD No.:	S2-0260	Dates(s) Drilled: 10-26-14	Inspector:	E. WATT
Boring No.:	SB-03	Drilling Method: SPT - ASTM D1586	Driller:	S. HOFFER
Drilling Contractor:	HAD DRILLING	Groundwater Depth (ft): 15.5	Total Depth (ft):	18.5

Sample No.	Sample Depth (ft)		Strata Depth (ft)		Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *				N
	From	To	From	To								
			0.0	0.7			TOPSOIL (7")					
1	3.0	5.0	0.7		21	SM	MOTTLED ORANGE BROWN AND LIGHT BROWN FINE TO MEDIUM	1	6	5	10	**11**
				8.5			SAND AND SILT (USCS: SM).					
2	8.0	10.0	8.5		24	SC/ SM	DR WEATHERED TO A GREENISH BROWN TO GRAYISH BROWN FINE	2	12	15	20	**27**
							TO MEDIUM SAND WITH A LITTLE SILTY CLAY, TRACE F-GRAVEL.					
3	13.0	13.8			9		DR WEATHERED TO A GREENISH BROWN TO GRAYISH BROWN FINE	20	50/3"			**>50**
							TO MEDIUM SAND WITH A LITTLE SILTY CLAY, TRACE F-GRAVEL.					
4	18.0	18.2			3		DR WEATHERED TO A LIGHT BROWN TO YELLOWISH BROWN	50/3"				**>50**
							MEDIUM TO COARSE SAND WITH A LITTLE SILTY CLAY.					
5	18.5	18.5		18.5	0		NO RETURN.	50/0"				
							AUGER REFUSAL AT 18.5'.					
							REFUSAL MATERIAL MAY BE A RESULT OF EITHER BOULDERY OR					
							CONGLOMERATE SUBSURFACE CONDITIONS.					

Notes/Comments:

Pocket Pentrometer Testing

DR: DECOMPOSED ROCK

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

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

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0260

HDD No.	Test Boring No.	Sample No.	Depth of Sample (ft.)		Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
			From	To			Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
S2-0260	SB-01	1	3.0	5.0	17.4	53.1	39	37	2	ML
		2	8.0	10.0	32.2	53.8	-	-	-	-
		3	13.0	15.0	22.5	26.2	-	-	-	-
		4	18.0	18.6	6.6	21.4	-	-	-	-
		5	19.7	20.0	9.1	22.8	-	-	-	-
	SB-02	1	3.0	5.0	9.1	27.5	-	-	-	-
		2	8.0	10.0	7.0	24.0	-	-	-	-
		3	13.0	13.9	8.5	26.1	-	-	-	-
		4	18.0	18.9	12.9	22.8	-	-	-	-
		6	23.0	23.3	6.1	14.0				
	SB-03	1	3.0	5.0	15.2	36.8	29	22	7	SM
		2	8.0	10.0	12.2	19.3	-	-	-	-
		3	13.0	13.8	5.3	12.6	-	-	-	-
		4	18.0	18.2	4.4	14.1	-	-	-	-

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

REGIONAL GEOLOGY SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
HDD S2-0260

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
S2-0260	Lewisberry Road	SB-01	**Quartz Fanglomerate** - consists of coarse conglomerate containing rounded cobbles and boulders of quartzite, sandstone, quartz, and some metarhyolite in a matrix of red sand.	Gently sloping to level upland (suburban)	Quartz fanglomerate	Conglomerate-sandstone		31-64	
		SB-02							
		SB-03	**Gettysburg conglomerate** is a coarse quartz conglomerate containing rounded pebbles and cobbles in a matrix of red sand. **Diabase** - occurs primarily as dikes and sheets and forms a complex igneous network that extensively intrudes sedimentary rocks in the Gettysburg basin.		Gettysburg Conglomerate with diabase sheets to the east	Quartz conglomerate with sand to occasional diabase dikes and sheets	7,300	15-31	

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 S2-0260

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					
S2-260	SB-1	1	20	22	100	0	0	20	28	Moderately to heavily	Coarse sandstone	Massive	Light gray	Extremely heavily fractured, ranging from 0° to 90°; no pieces large or intact enough for compression testing
S2-260	SB-1	2	22	25	100	0	0							
S2-260	SB-1	3	25	28	92	7	0							
S2-260	SB-2	1	25	28	33	0	0	25	28	Moderate	Sandstone	Massive	Red	Poor recovery, fractures ranging from 0° to 45°
S2-260	SB-2	2	29	33	54	0	0	29	33	Heavily	Sandstone	Massive	Gray	Heavily fractured, ranging from 0° to 90°

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).

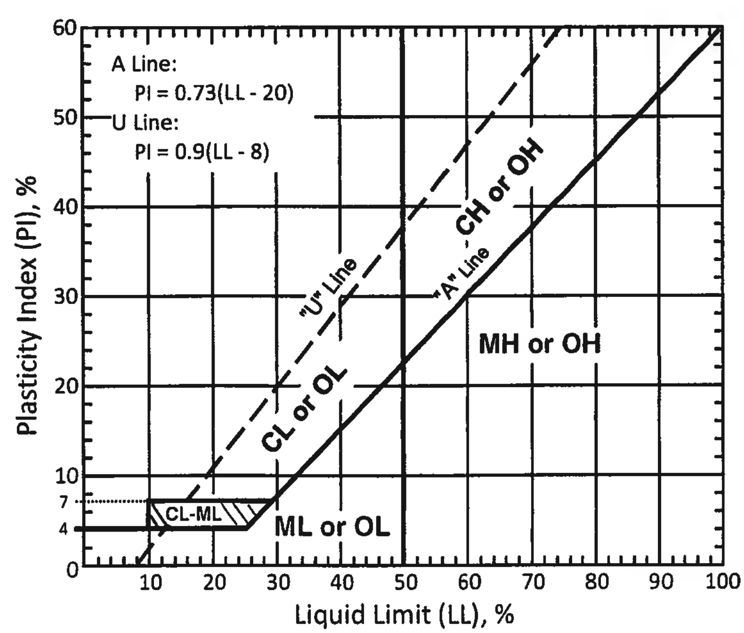
Groundwater observations were made at the times indicated. Groundwater elevations fluctuate throughout a given year, depending on actual field porosity and variations in seasonal and annual precipitation.

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 size	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

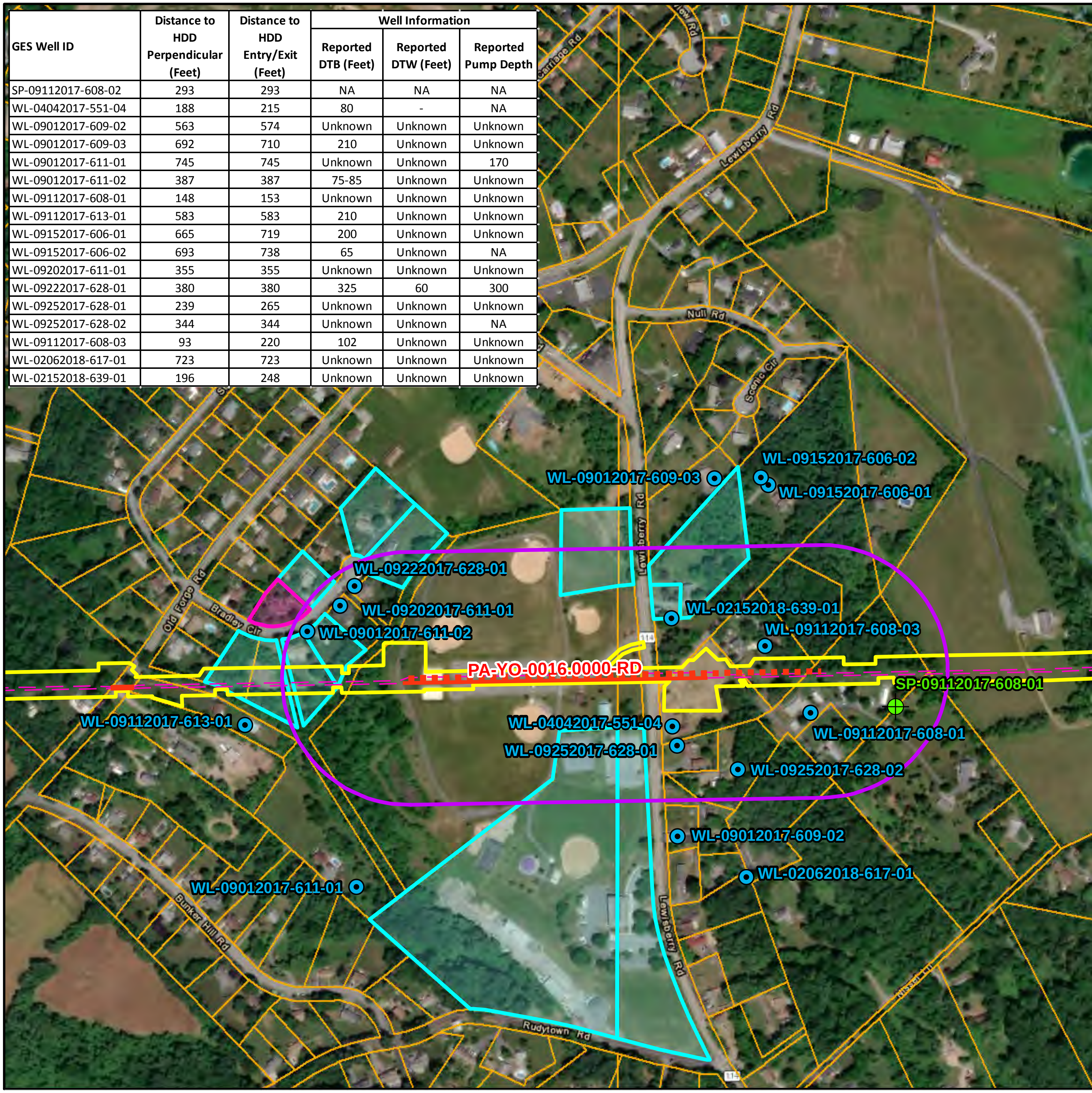
For soils plotting nearly on A line use dual symbols i.e ., I_p = 29.5, w_L=60 gives CH-MH. When w_L is near 50 use CL-CH or ML-MH. Take near as ± 2 percent.



(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.

ATTACHMENT 3 -
PAGWIS AND 450-FOOT RADIUS WELL MAPS

GES Well ID	Distance to HDD Perpendicular (Feet)	Distance to HDD Entry/Exit (Feet)	Well Information		
			Reported DTB (Feet)	Reported DTW (Feet)	Reported Pump Depth
SP-09112017-608-02	293	293	NA	NA	NA
WL-04042017-551-04	188	215	80	-	NA
WL-09012017-609-02	563	574	Unknown	Unknown	Unknown
WL-09012017-609-03	692	710	210	Unknown	Unknown
WL-09012017-611-01	745	745	Unknown	Unknown	170
WL-09012017-611-02	387	387	75-85	Unknown	Unknown
WL-09112017-608-01	148	153	Unknown	Unknown	Unknown
WL-09112017-613-01	583	583	210	Unknown	Unknown
WL-09152017-606-01	665	719	200	Unknown	Unknown
WL-09152017-606-02	693	738	65	Unknown	NA
WL-09202017-611-01	355	355	Unknown	Unknown	Unknown
WL-09222017-628-01	380	380	325	60	300
WL-09252017-628-01	239	265	Unknown	Unknown	Unknown
WL-09252017-628-02	344	344	Unknown	Unknown	NA
WL-09112017-608-03	93	220	102	Unknown	Unknown
WL-02062018-617-01	723	723	Unknown	Unknown	Unknown
WL-02152018-639-01	196	248	Unknown	Unknown	Unknown



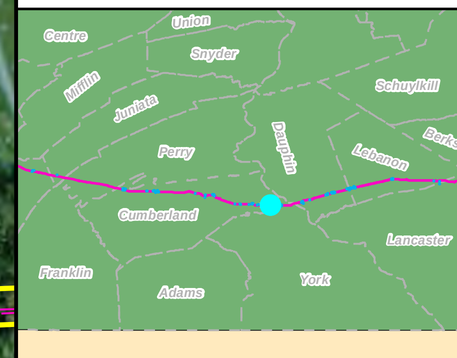
Legend

- LOD
- Parcel
- PPP Centerline
- PPP 1 HDD
- Proposed PPP 2 HDD Redesign
- 450 foot buffer of HDD alignment
- Public Water Supply/Landowner Confirmed No Well
- Testing Refused

**Testing locations current as of 02/01/2019

- GES Testing Location
- GES Spring Testing Location

Location



N

0 250 500 Feet

Well Location Map
HDD# PA-YO-0016.0000-RR
York County, PA.

Prepared By: [redacted]

Date: 2/1/2019

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

Coordinate System: NAD 83 Stateplane, PA South, Feet

WELLS WITHIN 0.5 MILES OF PROPOSED HDD TRACE - SUNOCO LEWISBERRY ROAD
FROM PAGWIS DATABASE 10/26/17

PAWellID	County	Municipali	QuadName	WellAddres	WellZipCod	DateDrille	TypeOfActi	LatitudeDD	LongitudeD	Driller	OriginalOw	WellUse	WaterUse
636993	YORK	FAIRVIEW TWP.		824 RUDYTOWN ROAD	17070	2003-12-10	NEW WELL	40.18861	-76.8925	EICHELBERGERS INC.	JOE BRESKI	WITHDRAWAL	DOMESTIC
156581	YORK	FAIRVIEW TWP.	LEMOYNE			1988-12-01	NEW WELL	40.19806	-76.88778	EICHELBERGERS INC.	McCULLOUGH THOMAS	UNUSED	DOMESTIC
156383	YORK	FAIRVIEW TWP.	LEMOYNE			1983-12-01	NEW WELL	40.19	-76.89583	EICHELBERGERS INC.	PURVIS J	WITHDRAWAL	DOMESTIC
617145	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2006-11-15	WELL ABANDONMENT	40.19417	-76.89444	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
156381	YORK	FAIRVIEW TWP.	LEMOYNE			1983-11-01	NEW WELL	40.18611	-76.89167	EICHELBERGERS INC.	HANNA WM	WITHDRAWAL	DOMESTIC
476660	YORK	FAIRVIEW TWP.		620 LEWISBERRY ROAD	17070	2008-10-31	NEW WELL	40.1875	-76.88861	EICHELBERGERS INC.	SCHNETZKA	WITHDRAWAL	DOMESTIC
156402	YORK	FAIRVIEW TWP.	LEMOYNE			1982-10-11	NEW WELL	40.19639	-76.89306	EICHELBERGERS INC.	YOHE D	WITHDRAWAL	DOMESTIC
156583	YORK	FAIRVIEW TWP.	LEMOYNE			1987-10-01	NEW WELL	40.19722	-76.9	EICHELBERGERS INC.	JUSTH WILLIAM	WITHDRAWAL	DOMESTIC
156377	YORK	FAIRVIEW TWP.	LEMOYNE			1983-10-01	NEW WELL	40.19167	-76.89417	EICHELBERGERS INC.	THAWLEY J	WITHDRAWAL	DOMESTIC
156422	YORK	FAIRVIEW TWP.	LEMOYNE			1980-10-01	NEW WELL	40.19417	-76.89556	EICHELBERGERS INC.	BARTLEY J	WITHDRAWAL	DOMESTIC
156459	YORK	FAIRVIEW TWP.	LEMOYNE			1977-09-16	NEW WELL	40.19167	-76.88389	PERRY COUNTY WATER WELL DRILLING	KISHBAUGH BRUCE	WITHDRAWAL	DOMESTIC
156451	YORK	FAIRVIEW TWP.	LEMOYNE			1977-09-10	NEW WELL	40.19056	-76.88444	PERRY COUNTY WATER WELL DRILLING	KISHBAUGH B	UNUSED	
156437	YORK	FAIRVIEW TWP.	LEMOYNE			1977-09-05	NEW WELL	40.18972	-76.885	PERRY COUNTY WATER WELL DRILLING	KISHBAUGH B	UNUSED	
156587	YORK	FAIRVIEW TWP.	LEMOYNE			1990-09-01	NEW WELL	40.19444	-76.88972	EICHELBERGERS INC.	BONNER P.	WITHDRAWAL	DOMESTIC
156615	YORK	FAIRVIEW TWP.	LEMOYNE			1986-09-01	NEW WELL	40.19556	-76.88472	EICHELBERGERS INC.	ESHENAURS FUELS INC	WITHDRAWAL	DOMESTIC
156414	YORK	FAIRVIEW TWP.	LEMOYNE			1981-09-01	NEW WELL	40.195	-76.89944	EICHELBERGERS INC.	KARNS W	WITHDRAWAL	DOMESTIC
643383	YORK	FAIRVIEW TWP.	LEMOYNE	566 Lewisberry Road	17070	2016-08-22	NEW WELL	40.19149	-76.88632	EICHELBERGERS INC.	Bissette	WITHDRAWAL	DOMESTIC
156329	YORK	FAIRVIEW TWP.	LEMOYNE			1979-08-20	NEW WELL	40.19306	-76.895	EICHELBERGERS INC.	BUTLER D JR	WITHDRAWAL	DOMESTIC
259661	YORK	FAIRVIEW TWP.	LEMOYNE	289 Bradley Circle		1998-08-19	NEW WELL	40.19245	-76.89523		Ort		OTHER
156359	YORK	FAIRVIEW TWP.	LEMOYNE			1979-08-16	NEW WELL	40.19417	-76.89472	EICHELBERGERS INC.	COOK B	WITHDRAWAL	DOMESTIC
260377	YORK	FAIRVIEW TWP.	LEMOYNE	838 Rudytown Rd.		1998-08-10	NEW WELL	40.18824	-76.89417		Molesevich		OTHER
624917	YORK	FAIRVIEW TWP.		794 NISSELL LANE	17055	2001-08-01	NEW WELL	40.18944	-76.88389	EICHELBERGERS INC.	DEPASTINO	OBSERVATION	UNUSED
156366	YORK	FAIRVIEW TWP.	LEMOYNE			1980-08-01	NEW WELL	40.19472	-76.88889	EICHELBERGERS INC.	ACRI C	WITHDRAWAL	DOMESTIC
617627	YORK	FAIRVIEW TWP.		794 NISSELL LANE	17055	2001-07-31	NEW WELL	40.18944	-76.88389	EICHELBERGERS INC.	DEPASTINO	OBSERVATION	UNUSED
156455	YORK	FAIRVIEW TWP.	LEMOYNE			1978-06-17	NEW WELL	40.18917	-76.88667	PERRY COUNTY WATER WELL DRILLING	HOMMEL G	WITHDRAWAL	DOMESTIC
156785	YORK	FAIRVIEW TWP.	LEMOYNE			1988-06-01	NEW WELL	40.1875	-76.9	G & R WESTBROOK WELL DRILLING INC.	FOGEL DARYL	WITHDRAWAL	DOMESTIC
156401	YORK	FAIRVIEW TWP.	LEMOYNE			1982-06-01	NEW WELL	40.18944	-76.90167	EICHELBERGERS INC.	REICHWEIN J	WITHDRAWAL	DOMESTIC
156375	YORK	FAIRVIEW TWP.	LEMOYNE			1981-06-01	NEW WELL	40.19167	-76.89694	EICHELBERGERS INC.	MOODY R	WITHDRAWAL	DOMESTIC
630357	YORK	FAIRVIEW TWP.	LEMOYNE	860 RUDYTOWN ROAD	17070	2002-05-31	NEW WELL	40.18749	-76.89639	EICHELBERGERS INC.	S and A HOMES	WITHDRAWAL	DOMESTIC
156471	YORK	FAIRVIEW TWP.	LEMOYNE			1985-05-15	NEW WELL	40.19444	-76.89944	EICHELBERGERS INC.	MCCONAUGHEY D	WITHDRAWAL	DOMESTIC
632902	YORK	FAIRVIEW TWP.		522 LEWISBERRY RD.	17070	2002-05-03	NEW WELL	40.19694	-76.88889	EICHELBERGERS INC.	ASSOCIATION OF BAPTISTS (ABWE)	WITHDRAWAL	DOMESTIC
156649	YORK	FAIRVIEW TWP.	LEMOYNE			1989-05-01	NEW WELL	40.19667	-76.88694	FUNKS DRILLING INC	McCOLLOUGH TOM JR.	WITHDRAWAL	DOMESTIC
156357	YORK	FAIRVIEW TWP.	LEMOYNE			1978-04-05	NEW WELL	40.19639	-76.90083	EICHELBERGERS INC.	HARING G	WITHDRAWAL	DOMESTIC
620751	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.88889	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
624438	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.88889	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
624439	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.88888	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
624440	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.88888	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
624702	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.8889	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
624655	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.8889	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
620752	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.88889	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
624441	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.88889	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
624703	YORK	FAIRVIEW TWP.	LEMOYNE	599 LEWISBERRY RD.	17070	2007-03-12	WELL ABANDONMENT	40.18778	-76.88889	EICHELBERGERS INC.	FAIRVIEW TWP	ABANDONED	UNUSED
156480	YORK	FAIRVIEW TWP.	LEMOYNE			1985-01-28	NEW WELL	40.1925	-76.89611	EICHELBERGERS INC.	BRINLEY C	WITHDRAWAL	DOMESTIC
422511	YORK	FAIRVIEW TWP.		639 LEWISBERRY ROAD		2008-01-16	NEW WELL	40.18583	-76.88528	MYERS BROS DRILLING CONTRACTORS INC	SGAGIAS	WITHDRAWAL	DOMESTIC
35118	YORK	FAIRVIEW TWP.	LEMOYNE			1974-01-01		40.1925	-76.88972	HARRISBURG'S KOHL BROS INC	SCHOFIELD B L	WITHDRAWAL	DOMESTIC
35117	YORK	FAIRVIEW TWP.	LEMOYNE			1971-01-01		40.18944	-76.89111	HARRISBURG'S KOHL BROS INC	FAIRVIEW TOWNSHIP	WITHDRAWAL	DOMESTIC
157249	YORK	FAIRVIEW TWP.	LEMOYNE			1966-01-01	NEW WELL	40.19694	-76.89417	HARRISBURG'S KOHL BROS INC	TAHOE CONST CO	WITHDRAWAL	DOMESTIC
35121	YORK	FAIRVIEW TWP.	LEMOYNE			1962-01-01		40.19944	-76.88806	YORK DRILLING COMPANY INC	FAIRVIEW SCHOOL	WITHDRAWAL	INSTITUTIONAL

PAWellID	WellDepth_	TopOfCasin	BottomOfCa	CasingDiam	DepthToBed	BedrockNot	WellYield_	StaticWate	WaterLevel	LengthOfTe	YieldMeasu	FormationN	Remark
636993	360	0	60	6	19	False	7	110	230	30	VOLUMETRIC WATCH & BUCKET		
156581	400	0	42	6	17	False	0					DIABASE DIKES AND SILLS	ROCK TYPE = WEATHERED ZONES WITH IRONSTONE
156383	200	0	83	6	60	False	7	97	190	0.5	VOLUMETRIC WATCH & BUCKET	EPLER FORMATION	RT=SS CGL
617145	120	0	0	0	0	False	0						
156381	340	0	54	6	36	False	5	175	330	0.5	VOLUMETRIC WATCH & BUCKET	EPLER FORMATION	RT=RED SH
476660	300	0	60	6	46	False	2	50	230	30	VOLUMETRIC WATCH & BUCKET		
156402	125	0	105	6	39	False	20		72	0.5	VOLUMETRIC WATCH & BUCKET	GETTYSBURG SHALE UPPER MEMBER	RT=LS CGL
156583	100	0	40	6	24	False	25	30	80	0.5	VOLUMETRIC WATCH & BUCKET	GETTYSBURG FORMATION	DWBZ = 1)3 2)25 /ROCK TYPE = RED CONGLOMERATE
156377	300	0	42	6	31	False	3	37	290	0.5	VOLUMETRIC WATCH & BUCKET	EPLER FORMATION	RT=HORNFELS;LOT#5;DEV=FAIRVIEW
156422	150	0	60	6	53	False	7	60			VOLUMETRIC WATCH & BUCKET	HEIDLERSBURG MEM OF GETTY	WBZ4=134;RT=HORNFELS + SS
156459	400	0	21	6	17	False	1	15				DIABASE DIKES AND SILLS	CM=STEEL;C M=ROTARY
156451	300	0	0	6	10	False	0					DIABASE DIKES AND SILLS	
156437	150	0	0	6	15	False	0					DIABASE DIKES AND SILLS	
156587	160	0	42	0	32	False	15	40	140	0.5	ESTIMATED	DIABASE DIKES AND SILLS	DWBZ = 1)6 2)15 /ROCK TYPE = IRONSTONE
156615	300	0	0	6	0	False	5	50	290	0.5	VOLUMETRIC WATCH & BUCKET	DIABASE DIKES AND SILLS	DWBZ = 1)5 /RT=DIABASE /ORIGINAL DEPTH OF WELL = 120'
156414	150	0	42	6	9	False	15	60	140	0.5	VOLUMETRIC WATCH & BUCKET	HEIDLERSBURG MEM OF GETTY	WBZ4=148;RT=SS W/CGL BEDS
643383	800	0	38	6	18	False	2	131		30	VOLUMETRIC WATCH & BUCKET		
156329	450	0	44	6	31	False	3				VOLUMETRIC WATCH & BUCKET	EPLER FORMATION	WBZ4=416;LOT#6;DEV=NORMANDY MANOR
259661	160	0	80	6	64	False	25	50	140		VOLUMETRIC WATCH & BUCKET		
156359	100	0	46	6	27	False	8				VOLUMETRIC WATCH & BUCKET	HEIDLERSBURG MEM OF GETTY	LOT#6;DEV=NORMANDY MANOR
260377	300	0	60	6	19	False	8	65	280		VOLUMETRIC WATCH & BUCKET		
624917	35	0	5	2	1	False	0						WELL ID: MW3
156366	150	0	0	6	0	False	12	82			VOLUMETRIC WATCH & BUCKET	DIABASE DIKES AND SILLS	RE-DRILL FROM 102'
617627	40	0	10	2	26	False	0						WELL ID: MW2
156455	323	0	21	6	15	False	1	6		0.5	VOLUMETRIC WATCH & BUCKET	DIABASE DIKES AND SILLS	
156785	125	0	65	6	50	False	20				VOLUMETRIC WATCH & BUCKET	GETTYSBURG FORMATION	
156401	275	0	40	6	34	False	8	110	265	0.5	VOLUMETRIC WATCH & BUCKET	NEW OXFORD FORMATION	RT=SILTSTONE W/SS
156375	250	0	42	6	27	False	5	95	240	0.5	VOLUMETRIC WATCH & BUCKET	EPLER FORMATION	RT=RED ROCK + SS
630357	300	0	100	6	92	False	12	70	210	30	VOLUMETRIC WATCH & BUCKET		SNYDER JOB
156471	175	0	30	6	9	False	40	37	165	0.5	VOLUMETRIC WATCH & BUCKET	GETTYSBURG FORMATION	RT=HORNFELS
632902	303	0	52	8	9	False	16	12		30	ESTIMATED		WELL ID: WELL #1
156649	302	0	31	6	19	False	5		20		ESTIMATED	DIABASE DIKES AND SILLS	DWBZ = 4)255 /ROCK TYPE = IRONSTONE
156357	400	0	60	6	60	False	2				VOLUMETRIC WATCH & BUCKET	HEIDLERSBURG MEM OF GETTY	
620751	20	0	0	0	0	False	0						
624438	44	0	0	0	0	False	0						
624439	51	0	0	0	0	False	0						
624440	44	0	0	0	0	False	0						
624702	38	0	0	0	0	False	0						
624655	52	0	0	0	0	False	0						
620752	20	0	0	0	0	False	0						
624441	39	0	0	0	0	False	0						
624703	42	0	0	0	0	False	0						
156480	200	0	40	6	32	False	10	9	190	0.5	VOLUMETRIC WATCH & BUCKET	GETTYSBURG FORMATION	WBZ4=188;RT=MULTI-COLORED SS
422511	300	0	60	6	38	False	3				VOLUMETRIC WATCH & BUCKET		
35118	100	0	29	6	0	False	12	10	100	1		DIABASE DIKES AND SILLS	
35117	120	0	47	6	0	False	28	35	106	24		GETTYSBURG FORMATION	
157249	118	0	39	6	30	False	60	35		1	UNKNOWN	GETTYSBURG FORMATION	
35121	257	0	0	6	0	False	30	90				DIABASE DIKES AND SILLS	