



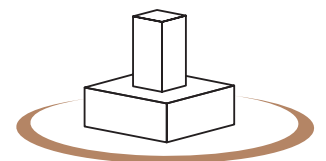
SUNOCO'S MARINER EAST 2 PIPELINE CHESTER COUNTY LIBRARY AND CHESTER VALLEY TRAIL

GEOTECHNICAL IMPACT & SINKHOLE RISK ASSESSMENT REPORT

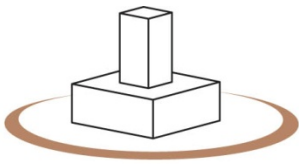
PREPARED FOR:

CHESTER COUNTY DEPT. OF FACILITIES
313 WEST MARKET STREET, STE. 5402
WEST CHESTER, PA 19380

12.21.2020



GeoStructures



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G E O T E C H N I C A L E N G I N E E R I N G C O N S U L T A N T S

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Project No. G20-265
December 21, 2020

Mr. David T. Stauffer, RLA, ASLA
Chester County Department of Facilities
313 West Market Street, Suite 5402
West Chester, PA 19380-0991

Re: Geotechnical Impact and Sinkhole Risk Assessment Report
Sunoco's Mariner East 2 Pipeline in Chester County
Chester County Library and Chester Valley Trail Properties
Exton, West Whiteland Township, Chester County, Pennsylvania

Dear Mr. Stauffer:

GeoStructures, Inc. is pleased to submit this geotechnical impact and sinkhole risk assessment report for Sunoco's Mariner East 2 Pipeline project in Chester County. This study deals exclusively with the pipeline's impact on Chester County Library and Chester Valley Trail. Our completed services are in accordance with Proposal No. P20-218 dated August 20, 2020. Based on our field exploration, USGS publications research, and review of available public records on the pipeline construction, we have identified various karst features and weaknesses in the ground and rock at the library and trail properties in the vicinity of the pipeline. In order to stabilize the ground at these two sites and mitigate the risk of sinkholes, GeoStructures recommends the geotechnical treatments outlined herein.

We appreciate being of service to Chester County Department of Facilities and look forward to assisting you with any additional investigative work or remediation. In addition to the undersigned, Daniel W. Eshete, P.G. assisted with the field exploration, geotechnical analysis, and report preparation.

Please contact us if you have any questions or need additional information.

Sincerely,

Eric J. Seksinsky, P.G., P.E.
Associate

Bashar S. Qubain, Ph.D., P.E.
President

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1. INTRODUCTION

Sunoco recently upgraded its Mariner East 1 (ME1, 8-in. diameter) pipeline to transport liquid natural gas (LNG) from production areas in Ohio and Pittsburgh to its *Marcus Hook Facility* in Delaware County. The Mariner East 2 (ME2) is an expansion of the Mariner East pipeline system and comprises the installation of two parallel 16-in. and 20-in. diameter pipes. Based on information posted on PADEP's web site, more than 80% of the 307-mile ME2 alignment will be inside the existing 50-ft wide right of way. The project calls for construction or expansion of existing pump stations and includes work outside of the existing pipeline right-of-way for site access and avoidance of environmental and cultural resources or other surface and subsurface features. ME2, also known as the PA Pipeline Project (PPP), will convey LNG product through 17 Pennsylvania counties in the southern part of the state, including Chester County.

Numerous incidents of ground subsidence and sinkholes reported along the completed sections of the pipeline through the carbonate/karst regions of Chester County have elevated the public awareness of ME2 and raised concerns over the geologic impact of ME2 and its potential risk to existing features and the public. This report by GeoStructures, Inc. is focused on the Chester County Library and the Chester Valley Trail (CVT) properties in Exton, Pennsylvania.

2. OBJECTIVES AND SCOPE OF WORK

The Chester County Department of Facilities has contracted GeoStructures to perform a geological and geotechnical engineering study of the library and trail sites in the vicinity of the ME2 pipeline project. The objectives of our work were to characterize the subsurface conditions along the right of way in order to determine whether remedial treatments are needed to protect existing features and mitigate potential risk to public safety posed by instabilities in the ground.

Our tasks included: (1) site reconnaissance; (2) researching USGS geologic records, maps and published information on geologic structures, sinkholes and surface depressions; (3) reviewing nearby reports of sinkholes and ground collapses triggered by the ongoing Sunoco pipeline installation; (4) test borings; (5) geotechnical laboratory testing and examination of selected soil and rock samples; and (6) developing remedial treatments to address the relative degree of risk to the County facilities and the public. These tasks have culminated in the preparation of this report which documents our findings and recommendations.

3. EXISTING FEATURES AND PROJECT DESCRIPTION

3.1 ME2 Pipeline Construction Methods

The ME2 pipeline alignment through the Exton area is depicted in Figure 1. Site Location Map, along with the locations of the Chester County Library and the Chester Valley Trail sites which are the subject of this study. Sunoco's contractor is using a combination of open cut trenching and horizontal boring techniques to install the ME2 pipeline. The latter includes *horizontal directional drilling (HDD)* and *conventional pipe boring* to avoid surface disruptions or underground obstacles associated with trenching methods and when the line must be installed deeper. In HDD the drill bit is steered horizontally and vertically and drilling fluid is pumped to the drill head under high pressure to lubricate and cool the drill head as it cuts through the soil and rock, and also to carry the drill cuttings back through the hole to the surface.

The conventional pipe bore method employs a hydraulically jacked tunneling drill head to advance and steer the pipeline borehole horizontally along the design profile. A steel casing is advanced behind the drill head such that the bore is continuously cased during excavation. The 20-in. (0.456-in. wall thickness) and 16-in. (0.438-in. wall thickness) pipes are inserted side by side into a single, heavy duty steel casing. Authorities and members of the community have expressed concerns over the stability of the ground, potential for future sinkholes, and level of risk to existing features and structures posed by the pipeline installation methods, especially the conventional boring methods which were employed at the Chester Valley Trail and currently underway near the Chester County Library (PADEP 2018).

3.2 Chester County Library Site

At the Chester County Library site, the Sunoco right of way parallels the east side of the building and is only 6 ft off the side of the building. Its alignment is roughly $S30^{\circ}E$. Based on the Sunoco project drawings, the pipeline installation behind the library involves a combination of open cut and direct pipe bore methods. The open cut trenching section (already installed) runs directly behind the building and extends a distance of approximately 160 ft south of the library into the open grassy lawn area. At that point, there is a switch to direct bore methods for ME2 to pass below Valley Creek. (see Drawing 1. Geotechnical Investigation Plan). Valley Creek just south of the Library building flows towards the west and southwest. On the other side of Valley Creek,

the methods revert to open cut trenching as the pipes continue towards the Chester Valley Trail intersection. The pipe cover at the library site is 4 to 5 ft based on the project profiles. In the open cut section, the pipes backfill consists of quarry aggregate.

According to an as-built First Floor and Foundation Plan prepared by Kling Lindquist, dated 01/16/1977, the library is supported on conventional strip and spread footings plus a 5-in. thick concrete slab on grade. The ground floor was cut into the hillside to accommodate a finished floor elevation of 316.0 ft. The bottom of footing elevation along the north and east sides is typically 312 ft. A study of the original grades vs. current grades indicates a maximum cut of about 22 ft along the north wall of the building. An existing retaining wall wraps around the northeast corner of the library. During construction in 1978, the contractor encountered rock protrusions or pinnacles in the north half of the footprint when excavating for the slab and footings, as documented in a blasting sketch plan dated 09/08/1978. No outcrops or pinnacles are currently visible at the ground surface of the library property, although there are some denuded or weathered dolomite boulders along the edge of the upper parking lot north of the library. It is assumed that those boulders were exhumed during construction of the pipeline earlier this year.

3.3 Chester Valley Trail Site

At the Chester Valley Trail site, the pipeline runs in the same direction as at the library, which makes it nearly perpendicular to the trail (see Drawing 1). As a previous railroad bed, the trail right of way in the area of concern is 30 ft wide and features a paved path 10 ft wide on top of a fill embankment 6 to 8 ft high and having 2H:1V to 3H:1V side slopes. The pavement surface elevation at the pipe crossing is estimated as 323.0 ft from pipeline construction plans. Conventional pipe bore methods were employed last summer along a 252-ft long section to install the 16-in. and 20-in. pipes inside of a single steel casing below the trail, a stream tributary, wetlands, and Lincoln Highway (Business Route 30). The tributary at the Trail site flows towards the northwest and empties into Valley Creek. Profiles for the project show 14 ft of ground cover above the steel casing within the trail right of way. Sunoco operates a valve station inside a fenced enclosure just north of the trail at this site. The historical Exton Hotel building occupies the area between the trail and Lincoln Highway. On the other side of Business Route 30 the method of installation reverts to open cut trenching.

4. PHYSIOGRAPHY AND GEOLOGY

4.1 Landforms and General Geologic Setting

Per the physiographic map of Pennsylvania published by PA Department of Conservation & Natural Resources (DCNR), both sites are situated within the *Piedmont Lowland Section* of the Piedmont Province (see Figure 2. Site Physiographic Map). The Piedmont is bordered by the Ridge and Valley Provinces to the north and the Appalachian Mountains. The Piedmont Lowland Section consists of broad, moderately dissected valleys separated by broad low hills. As is found in all of the Appalachian provinces, the Piedmont is generally characterized by rocks with structural trends from northeast to southwest and parallels to regional geologic structures. In Chester and Montgomery Counties, the Piedmont Lowland exists as a long, narrow valley commonly called Chester Valley with topography that has a northeast-southwest linearity.

The Piedmont Lowland is bounded on the north, east, and west by siliciclastic rocks of the Gettysburg-Newark Lowland. On the south, it is bounded by quartzite and schists of the Piedmont Upland. The Piedmont Lowland itself is underlain by folded and faulted sedimentary and metasedimentary rocks that form broad valleys separated by low hills. These valleys are drained by a combination of smaller streams that parallel the valley axes, and larger streams cut across the valleys, including the Susquehanna and Schuylkill Rivers. The drainage pattern was probably established before the present geomorphology of Chester Valley and is related to an earlier erosional surface (Bascom and Stose 1932). The topography of the basin reflects the structure of the rocks and susceptibility of the carbonate geology to erosion.

4.2 Geology, Geologic Structure and Drainage

Published information from the Geologic Map of Pennsylvania by DCNR is included as Figure 3. Site Geologic Map. Chester Valley is a regionally extensive southwest to northeast trending limestone or carbonate-based valley with a width of slightly over one mile in the Exton-Downingtown area. Its geology consists primarily of limestone and dolomite rocks with associated karst topography and features such as sinkholes, depressions and quarries. Refer to Figure 4. Surface Mines (Quarries) & Karst Features. The rocks of Chester Valley sedimentary sequence were deposited by the continental margin sedimentation in shallow and deep sea environment when the area was the eastern edge of the North American continent (Rodgers 1968). The lithologies were deformed and metamorphosed to different degrees due to tectonic

collision at the eastern edge of the North American continent that caused folding of continental shelf rocks and thrusting of oceanic sediments and other rocks west, over the basement and the clastic/carbonate rocks (Wagner and Srogi 1987). The general structure of the carbonate rocks in the valley and the non-carbonate rocks at the North Valley Hills is a south-dipping anticline. The carbonate valleys of Chester County are flanked by hills, ridges or highlands underlain by quartzite and gneiss to the north (Chickies Formation that form the North Valley Hills) and by phyllite and schist to the south (Octoraro Formation that form the South Valley Hills).

Both the library and trail sites are underlain by the bedrock of the *Ledger Formation (Cl)*, which typically consists of light-gray, locally mottled, massive, pure, coarsely crystalline dolomite, siliceous in middle part. Joints in the Ledger dolomite are blocky and well developed, moderately abundant, irregularly spaced, typically open, and steeply dipping. The Ledger dolomite underlying the subject sites is prone to sinkholes. The geologic contact with the Chickies quartzite and Harper phyllite to the north coincides with a transverse fault (see Figure 5. Geologic Structure Map). Kochanov (2016) has also indicated minor faults called the Valley Creek and Exton Faults just north and south of the subject sites. Also, described are small-scale isoclinal fold axes that run parallel to bedding strike in the valley. The adjacent geology in the south belongs to the *Conestoga Formation (oCc)*, which contains light-gray, thin-bedded, impure, contorted limestone having shale partings and conglomeratic at the base. In Chester Valley, The Conestoga Formation includes micaceous limestone in upper part, phyllite in middle, and alternating dolomite and limestone in the lower part (Berg et al. 1980).

Valley Creek south of the library and its tributary at the trail site are marked in Figure 1. In terms of drainage, both the surface water flow and the groundwater flow emanate from the hills, downwards toward the low points along the center of Chester Valley. Ground water in the valley flows west-southwest and parallel to the course of the streams (Lisa A. et al. 1997).

4.3 Sinkholes

Sinkholes are formed through a combination of carbonate bedrock weathering and overburden soil erosion due to groundwater recharge and are a part of past and future geologic conditions. Dissolution occurs as a chemical reaction due to corrosive effects of infiltrating rainwater which is mildly acidic due to dissolved carbon dioxide (carbonic acid). The initial stage of a sinkhole is

soil raveling before emerging as a ground collapse or sinkhole on surface. Based on Karst Density Map by PA DCNR, approximately 7% of Pennsylvania is underlain by carbonate bearing limestone and dolomite like those in the valleys and lowlands of south-central and southeastern Pennsylvania. Carbonate rocks weather more readily than most other types of rocks. The dissolution or dissolving away of the calcium and magnesium carbonate minerals by groundwater over long periods of time results in karst topography with voids, caves, sinkholes and surface depressions.

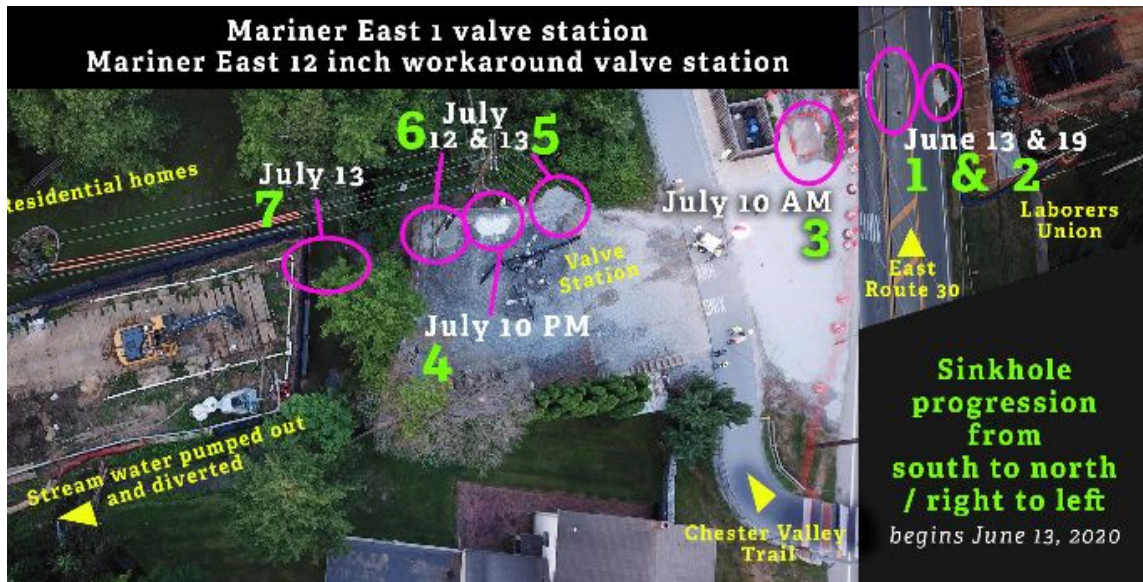
Karst features often impact public safety and health. Subsidence and water-quality problems have also been associated with karst topography for many years. In addition, karst features serve as direct recharge zones to local and regional aquifers, making these areas highly vulnerable to groundwater contamination. Per the PA Karst Density Map, the Malvern and Valley Forge Quadrangles of the USGS maps have the highest karst density in the county with 200 to more than 600 karst features per square mile locally. As marked in Figure 4, there are at least 4 recorded sinkholes on the Exton Square Mall property just west of the library.

5. RELEVANT DOCUMENTS REVIEWED

GeoStructures researched and reviewed available documents on the PADEP portal and other sites related to the Sunoco pipeline project. We also contacted PennDOT. Relevant findings are highlighted below.

- *PADEP Permit Amendment*. Based on the PADEP permitting data (HDD 400, West Whiteland Township, Chester County) dated 09/22/2020, the permit amendment modifies the installation method for the 20-inch diameter pipe. Sunoco requested to change the installation method for the 20-inch diameter pipeline from HDD to a direct pipe bore and open trench construction to minimize impacts to the environment. The direct pipe bore will go under the Exton Bypass (State Route 30), the AMTRAK and Norfolk Southern Railroad rail lines, and Wetland WL-K21. The remaining 1,269 feet are designated as open trench construction.
- *Void Mitigation Plan for Karst Terrain and Underground Mining Prepared by Tetra Tech, Inc., dated August 8, 2017*. This report provides an assessment of potential impacts and avoidance and mitigation measures that could occur during open-cut and drilling procedures for the Sunoco Pipeline project in Pennsylvania. The report discusses excavation and benching, use of flowable fill, compaction grouting, sealing off voids with drilling fluid even with wood and polymer fibers depending on the planned method of pipeline installation.

- *StateImpact Pennsylvania* (<https://stateimpact.npr.org/pennsylvania/2020/07/17/mariner-east-pipeline-construction-site-of-additional-sinkholes-in-chester-county/>), *Lincoln Highway*. This web site records sinkholes which developed alongside Mariner East construction in Chester County (by the Trail site) in their news post, dated 07/17/20. Location and dates of sinkholes around active pipelines and the valve station near Lincoln Highway are depicted in the photo below and marked in Drawing 1.



StateImpact Pennsylvania Photo showing locations of sinkholes along CVT

- *PUC Orders Sunoco Pipeline Shutdown after Sinkholes Expose Bare Pipe Near Exton; Philadelphia Inquirer (last updated 03/03/18).*
 - In March 2018 sinkholes appeared while drilling for ME2 pipelines along the 400 block of Lisa Drive in West Whiteland Township south of the U.S. Route 30 bypass and Norfolk Southern railroad tracks (see location in Figures 3, 4, and 5).
 - The ground collapse exposed the 8-in. diameter operational ME1 pipeline that was already carrying NGLs, resulting in residential evacuations due to a risk of explosion in the event that the ME1 line would rupture. One of the sinkholes measured 15 ft in diameter by 20 ft deep and only 10 ft from a house foundation.
- *PennDOT District 6-0 - Lincoln Highway Sinkholes, June and July 2020.*
 - 06/13/20: Sinkhole is documented along Mariner pipeline right of way, at edge of eastbound lane and extending into the grass; filled with Class B Flowable Fill.
 - 06/18/20: Pavement saw cut preparation work for two grout injection points in the middle of the eastbound lane near the sinkhole.

- 06/19/20: VAC truck was used to excavate to a depth of 7 ft across rectangular cut out areas; specialty contractor for Sunoco performed geotechnical sampling and installed 4-in. diameter casings inside each hole to depths of 28 to 33 ft; backfilled the upper 7 ft using Type C Flowable Fill.
- 07/18/20: Grouted through the 4-in. casings using *Hyperflex Foam* (polyurethane grout).

6. FIELD EXPLORATION

The scope of our field exploration included reconnaissance to examine the ground surface for karst features and test borings to investigate the subsurface conditions.

6.1 Test Borings

The test borings were carefully positioned to facilitate the drawing of geologic sections. The test borings were field marked and the areas scanned for buried utilities prior to drilling. Five test borings (B-1 through B-5) were drilled at the Library site at the locations marked in Drawing 1 on November 1 through 5, 2020. Three test borings (B-6 through B-8), also marked in Drawing 1, were drilled at the trail site on November 19 and 20, 2020. The purpose of the borings was to investigate the subsurface soil, rock, and groundwater conditions and check for the presence of voids, loose raveling zones, and other signs of incipient sinkholes or dissolution features within the rock mass and overburden.

GeoStructures drilled the borings using a Geoprobe 7822DT track drill rig. The drilling and sampling methods conformed to ASTM D1586 procedures for the standard penetration test (SPT). Soil samples were obtained from the overburden until reaching auger refusal on top of rock. All the borings but B-3 and B-6 were cored to retrieve rock samples to characterize the bedrock. The drilling depths range from 21 to 82 ft below existing grades.

Each SPT sample collected from the borings was visually classified in the field in accordance with the standard guidelines of ASTM D2488 and assigned a group name from the Unified Soil Classification System (USCS). Material descriptions, SPT data, pocket penetrometer readings, relative density and consistency, moisture, and groundwater are recorded in the test boring logs of Appendix A. Photos of the core boxes are also included for reference after the logs.

6.2 Site Observations

GeoStructures surveyed the ground surface of the subject sites for evidence of sinkholes, outcrops, and other karst features. Our findings are discussed below and correlated to incident reports by other sources.

Chester County Library site. As previously mentioned, no outcrops or sinkholes are visible at the ground surface of the Chester County Library property, although we were not permitted to access the Sunoco right of way at the time of our field view. Our document research also did not disclose any sinkholes on the library property. As noted earlier, however, the 1978 blasting plan for the library recorded multiple locations where karst related pinnacles were encountered during construction in the north half of the building footprint which was cut deeply into the hillside. A few weathered boulders stacked along the edge of the upper parking lot along the north side of the site were presumably exhumed during the recent, open cut trenching for the pipeline NE of the library.

Chester Valley Trail site. The Chester Valley Trail property and nearby Lincoln Highway intercept of the pipeline at the Exton Hotel are beset by numerous sinkholes features and ground collapses. As illustrated in Drawing 1 and the photos of Appendix C, there are at least 6 confirmed sinkholes exactly in line with the bored path of the ME2 pipeline plus 3 other suspect depressions in the Sunoco right of way, for total of 9 features of concern along a distance of 1654 ft. This equates to one every 18 ft of bored length.

- PADEP documents mention that flowable fill was placed to backfill 2 sinkholes which occurred inside the valve station area. The flowable fill is still visible inside the fence as 3 to 4-ft diameter spots (see Photos 1, 2 and 3 and Drawing 1). Sunoco has not released the results of their subcontracted geologic studies in connection with this incident, but apparently nothing else was done at depth to remediate the ground or mitigate against future sinkhole activity. Nonetheless, aside from minor circular cracking and concavity attributed to shrinkage of the hardened flowable fill, the features do not appear to have changed since they were filled about 6 months ago.
- During our reconnaissance of the Trail site on 09/30/20, GeoStructures discovered a new, open sinkhole at the toe of the embankment (see Photos 4 and 5 and Drawing 1). This circular ground collapse measures approximately 3 ft in diameter by 4 ft deep and is about 16 ft from the edge of the pavement (between the valve station and the trail path). This finding was initially documented in our Engineer's Field Visit Record, which was previously submitted to the County (also included in Appendix C).

- Our reconnaissance also revealed 3 suspect ground depressions in the Sunoco right of way as marked in Drawing 1. The ground does not appear to be actively moving at these spots and the largest one might be an erosional feature (see Photo 6).
- An alleged sinkhole south of the dumpster enclosure, mapped in the aforementioned *StateImpact Pennsylvania* news report, is plotted in Drawing 1. We cannot confirm whether this sinkhole was backfilled with flowable fill, as it not visible due a gravel layer at the surface and there are no signs in the field of its existence.
- The sinkhole locations which were grouted along Lincoln Highway and logged by the PennDOT Permits Department are currently visible as asphalt patches in the roadway (see Photo 7 and Drawing 1).

While on site for our field exploration we did a reconnaissance of rock exposures on the hill south of the trail site in order to obtain geologic structure measurements. These outcrops are located inside an existing stormwater basin along the entrance drive of the Laborers' District Council facility (see Figures 1 and 5 and Photos 9, 10 and 11 of Appendix C). We examined planar geologic structures such as bedding and joints/fractures. Some of the measured bedding strike angles are N87°E, N83°E, and N88°E, which is consistent with the readings posted by USGS on the Geologic Structure Map of Figure 5. The dip angles we measured are on the order of 80°SE, which is similar to the spot readings plotted in Figure 5 of 70°SE and 76°SE. Evidently, the USGS used the same outcrops in the basin for their measurements when preparing the base map. A joint was also measured as N24°W, 73°SW.

7. LABORATORY TESTING

Index tests were performed on selected soil samples in our geotechnical laboratory to verify visual classifications, and consider the potential relative magnitude of underground voids in the soil based on soil properties. The classification tests included particle-size analysis per ASTM D422, Atterberg limits per ASTM D4318, and water content per ASTM D2216. A number of other samples were tested for water content to chart moisture variations within the soil profile. The laboratory test results presented in Appendix B contain gradation curves and a summary table of the soil index properties. The rock core specimens recovered from the test borings were studied in detail in our laboratory to interpret rock structures including joints, fractures, voids, clay seams, etc.

8. SUBSURFACE CHARACTERIZATION

The subsurface conditions at each site have been characterized for risk assessment using the test boring data and geologic structure of the rock mass as well as our extensive experience with karst settings and weathering patterns in sinkhole geology. For our portrayal we prepared a total of 4 geotechnical sections—A and B at the library site (Drawing 2) + C and D at the trail site (Drawing 3). A conceptualized depiction of the conditions at each test boring was sketched and then interpolations were made between the borings to create the subsurface sections.

Sections A and D are drawn parallel to the bedding dip direction while B and C are drawn along the bedding strike (see Drawing 1). From the published mapping of Figure 5 and our own field measurements of the outcrops in the basin south of the trail we incorporated a bedding dip angle of 70°SE when drafting our geologic sections. The strike direction applied to our geotechnical analysis is N80°E. The following carbonate bedrock dissolution features were encountered by the borings in the Ledger dolomite at the library and trail sites.

- Uneven top of rock
- Rock pinnacles
- Rock ledges
- Boulders
- Slots/gouge zones
- Open voids
- Raveled zones/soil-filled voids
- Soil seams
- Weathered rock seams

8.1 Chester County Library Site

As illustrated in Sections A and B, the 5 borings drilled at the library property discovered a multitude of karst features and an uneven top of rock that slopes downwards towards the creek or to the SE—the same direction as the bedding dip but much milder at 10°. There is also the tendency for deeper weathering along the streams. The depth to rock ranges from 12.2 ft in B-1 at the upper parking lot to deeper than 53 ft in B-3. As listed in the legend of Drawing 2, the subsurface contains compacted fill and alluvial deposits, residual soil, completely weathered dolomite, raveled zones/soil-filled voids, open voids, weathered dolomite with abundant soil seams, and hard, slightly weathered dolomite.

The fill is only 2 to 3 ft thick in the lowest part of the site, south of the library building. It consists of stiff sandy silt (ML) and medium dense silty gravel with sand (GM). The alluvial deposits underlie the fill in the lowlands, extend to a maximum depth of 8 ft, and include medium to stiff silt and clay (ML and CL) plus medium dense, well-graded sand with silt and gravel (SW-SM). Rounded and sub-rounded, quartz gravel and pebbles are common in the alluvial soils. The “topographic bump” in the original grade line of geotechnical Section A appears to mark the edge of the historical floodplain and extent of the alluvial deposits. The ME2 lines next to the library were installed in the alluvial deposits and underlying residual soils.

In between the alluvial deposits and the bedrock is a stratum of residual soil and completely weathered dolomite. The residual soils at the library site are loose to medium dense, non-plastic, poorly graded sand and gravel (SP-SM), much of which has the appearance of beach sand. On the other hand, the raveled zones or soil-filled voids at the library consist mainly of soft to very soft silt (ML) and clay (CL) or clayey sand (SC). The completely weathered dolomite occurs as a residual material directly on top of the rock and within the rock mass as layers or seams of dense to very dense, sand with weathered dolomite gravel.

The rock at the library property is a complex assemblage of pinnacles with intervening slot/gouge seams and weathered zones formed by the in-place weathering and dissolution of steeply inclined dolomite beds. Based on the conditions encountered in the borings, at relatively shallow depths the rock has weathered into remnants. The cores and frequent kicking off of the augers at the top of rock interface corroborate the 70° dip measured in the outcrops to the south. Open slot voids and soil-filled slot voids (raveled zones) were intersected by B-2, B-3, and B-4, with B-4 exhibiting the greatest variability of karst features. The largest void occurs in B-2 as a slot feature over the depth range of 9.5 to 28 ft. Accounting for the bedding inclination of 70°, the estimated width of the slot in Section A is only 6 ft. Geotechnical Section A also schematically depicts the pinnacles and boulders mentioned in the 1978 blasting plan for the northern half of the building footprint.

Groundwater measurements in the library borings ranged from 5 to 13 ft below the surface, corresponding to elevations 302 to 303.6 ft. It is noted that based on these groundwater levels in

the library borings, Valley Creek is categorized as an *influent stream*, with a normal flow elevation of approximately 306 ft—higher than the groundwater levels in the vicinity. This is consistent with streams in karst geologic settings where the flow infiltrates into the ground and recharges the underlying aquifer. Typical streams in relatively humid climates such as Pennsylvania's are categorized as effluent streams where the groundwater levels in the stream banks are generally higher than the normal water flow in the stream.

8.2 Chester Valley Trail Site

As illustrated in Sections C and D, the 3 borings drilled along the trail disclosed a remarkably uniform top of rock for a carbonate setting (18.0 to 19.5 ft; elevation range of 303.5 to 305 ft). The embankment penetrated by the 3 trail borings consists of relatively poorly compacted clay (CL), clayey sand (SC) and well-graded gravel (GW) fill extending to a maximum depth of 8 ft. The underlying residual soils are generally stiff, plastic silt (ML) and lean clay (CL) with some lower zones of slightly plastic silty sand (SM) above the rock. Notwithstanding the uniform top of rock, the trail site was found to have an abundance of pinnacles, open slot voids, soil-filled slot voids (raveled zones), and other karst features. Boring B-6 shows the most severe raveling (12 to 19.5 ft) and slot features. Accounting for bedding inclination, the soil-filled slot at B-6 has an estimated width of approximately 3 ft. B-8 only hit an open void over the depth range of 22 to 25.7 ft and B-7 did not intercept any voids.

Groundwater below the trail is at a depth of 10 to 12 ft in B-6 and B-7, which corresponds to elevation 311 to 313 ft. The water level at a depth of 6 ft in B-8 is believed to be perched water at the fill/residual soil interface.

9. SINKHOLE RISK ASSESSMENT

9.1 General

Both of the investigated sites show evidence of karst features and extensive sinkhole activity due to weathering and dissolution of the underlying carbonate, dolomite bedrock. Based on the character of overburden and rock mass, as depicted in Sections A through D, we evaluated the sinkhole risk assessment, accounting for the sensitivity and use of the County's existing features. General geologic risk findings, applicable to both sites, are summarized below while site-specific risks and hazards are discussed in the following two sections.

- The bedding 70° dip of the rock is favorable because a steep inclination of the beds shields the vulnerable joint fractures from receiving the full effects of infiltration. Sites underlain by horizontally bedded limestone or dolomite can be subject to excessive widening and dissolution along the joints (Sowers, 1996), while the library and trail sites are considered to have a *low risk of large caverns or openings* developing in the rock.
- The above finding can be inferred from the geotechnical sections, which display relatively narrow slots. Moreover, it is backed up by the relatively small size of the sinkholes at the Chester Valley Trail site and Lincoln Highway, which have a maximum diameter of about 4 ft.
- The alignment of the gas pipeline perpendicular rather than parallel to the strike orientation of the slot features is favorable in that the maximum length of unsupported pipe length is limited by the width rather than the length of the slots.
- Considering the history of construction related sinkholes alongside ME2, it appears that the pipe boring methods are triggering more sinkholes than open cut trenching.
- The influent or groundwater recharging nature of Valley Creek and its tributary is a driving factor or causative effect in sinkhole formation.

9.2 Chester County Library Site

- Based on the good condition of the Chester County Library structure with no reports of structural distress, its shallow foundation and slab on grade seem to be functioning adequately to date in spite of the slot features and raveled zones indicated by the test borings. This may be attributed to the finding that the solution features decrease with greater distance from the stream (see Section A). So it is possible that much of the library is supported on relatively stable ground.
- The east exterior wall of the library runs perpendicular to the strike or trend of the slots, which is favorable. Despite this observation, the pipeline along the east side is very close to the building and could adversely impact its foundations. Specifically, the aggregate backfill around the pipes may retain perched water which could infiltrate into the slot features and accelerate subsurface erosion and sinkhole activity.
- The stiff silt and clay and medium dense sand and gravel alluvial soils in the low lying area of the library property provide a buffer in that sinkholes must propagate through it in order to reach the surface.
- In terms of sinkhole progression, the predominance of loose to medium dense, non-plastic, residual soils are not conducive to sudden collapse; gradual raveling and subsidence of the overburden are more likely.
- The impact of the pipe boring method at the south end of the library will become evident after construction is completed of that section which passes under the stream. Fortunately, the boring operation begins at a distance of 160 ft from the library so even if sinkholes appear as a result of the that work, the risk to the library is very low.

9.3 Chester Valley Trail Site

- The causative effect of the boring method on sinkhole formation is clear at this site; the sinkholes align exactly with the pipeline.
- The stiff, plastic silt and lean clay component of the residual soils is more conducive to sudden dropouts than the non-plastic, sandy, residual soils of the library site.
- It is favorable that there is no sign of additional movement or subsidence of the ground at the repaired sinkholes along Lincoln Highway, so the grouting appears to have been successful under traffic loadings.
- The collapses inside the valve station which were backfilled with lean concrete do not appear to have changed, but without knowing whether they were remediated at depth and lacking subsurface data it is difficult to confirm that they will remain stable. In any event, those 2 features as well as the 3 suspect depressions and the feature south of the dumpster pad are all outside the right of way and beyond the trail embankment, so their risk to the trail is low.
- The open sinkhole discovered by GeoStructures at the toe of the embankment poses a *low to moderate* safety risk to the trail if it were to advance towards the paved path. If this were to happen, the progression is expected to be gradual considering that it must propagate all the way through the embankment fill before it impacts the trail.
- Similarly, the slot feature at B-6 poses a *low to moderate* safety risk to the trail.

10. CONCLUSIONS AND RECOMMENDATIONS

Considering the subsurface soil and geologic conditions documented in this report, the potential for future disrupting sinkholes resulting from the Sunoco pipelines still exist. However, this is considered a *low risk*, given the relatively small void sizes associated with the steeply dipping bedrock. Evidently, the ground collapses that occurred during and after the pipeline installation are relatively small.

That said, protective, remedial measures are prudent and recommended for limited areas of the library building and trail as indicated in Drawing 1. Specifically, the east side of the library is very close to the pipeline and its foundation bearing conditions may be compromised from water infiltrating through the aggregate backfill around the pipeline into the existing slots below the footings. Also, the two trail areas as marked in Drawing 1 should be stabilized to improve their subsurface conditions and safeguard against potential ground collapses or sinkholes.

For the library and the smaller area of the trail around B-6, the optimal stabilization measure is *compaction grouting*. To accomplish that, grout injection pipes are drilled into the underlying bedrock at a predetermined spacing across the area of concern. Then, low-slump or very stiff cement grout is injected into the drilled holes and the casing is lifted in 2-ft increments while maintaining a specified maximum pressure or volume cutoff during each increment. The process is repeated until sealing the top of rock and stabilizing the overburden soils in order to minimize the risk of future soil erosion and raveling into the pre-existing bedrock slots and joints.

Unlike the previous two areas, compaction grouting is not suitable for stabilizing the larger cross-hatched area of the trail in Drawing 1. As shown, the Sunoco pipelines run through its center and may be adversely impacted by the drilling and high injection pressures associated with compaction grouting. Therefore, excavation and bridging is the recommended method of mitigating the sinkhole risk and preventing a sudden dropout where the Sunoco pipelines pass below the trail. This technique consists of excavating the designated area to a depth of 3 ft or so below the surface of the trail and then backfilling with a well-graded stone such as PennDOT 2A aggregate and installing layers of geogrid reinforcement to act as a bridge in the event that a sinkhole would propagate upwards. This may not completely avoid pavement deflection or distress but would eliminate the obvious safety risks associated with a sudden dropout.

11. LIMITATIONS

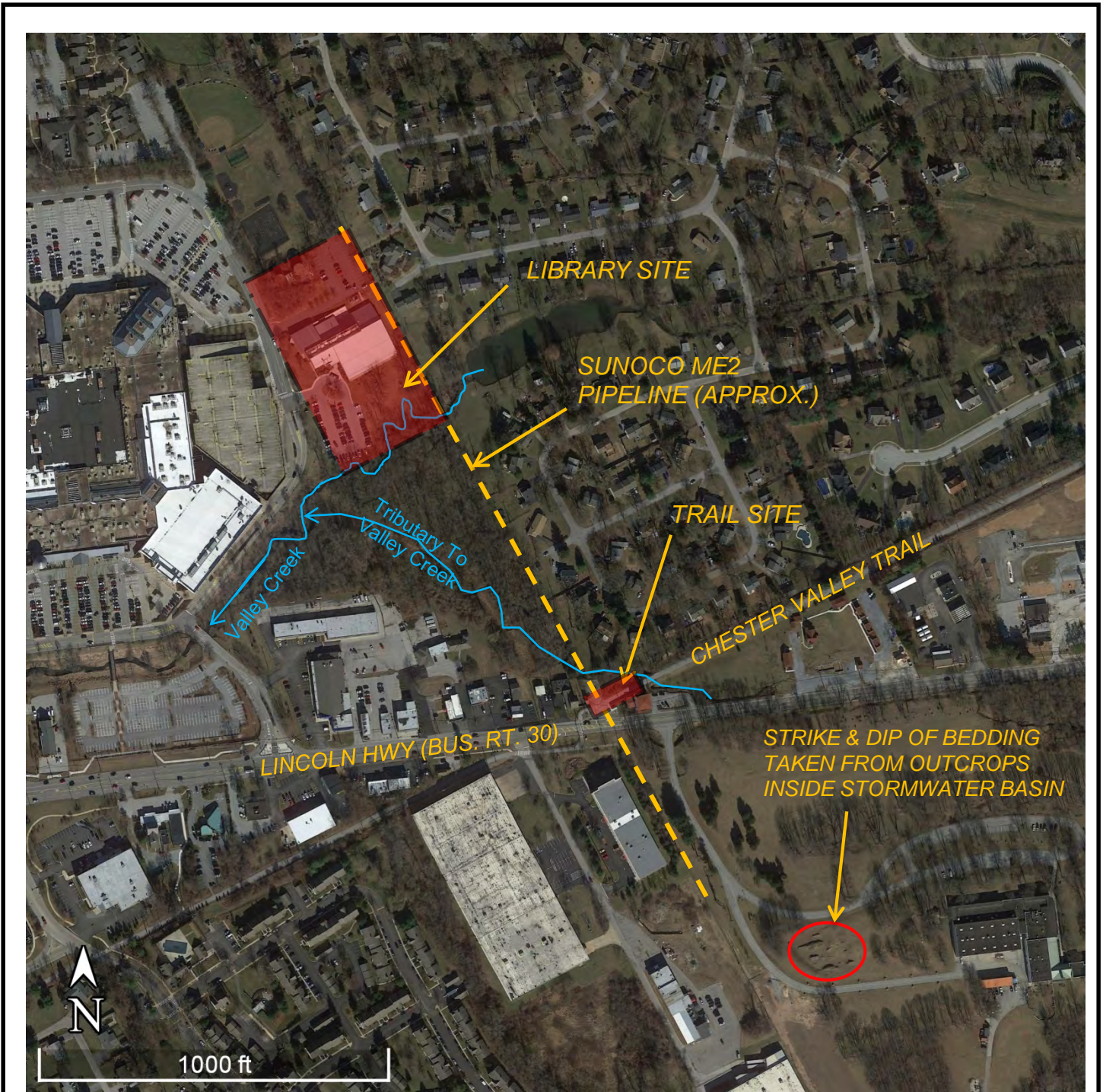
The geotechnical risk assessment and associated findings and recommendations are based on the researched data, field reconnaissance, and test borings at the locations marked in the geotechnical investigation plan (Drawing 1). The field explorations have been supplemented by laboratory testing to properly characterize the subsurface conditions and evaluate sinkhole risks. This idealization is strictly for engineering and geologic analyses and it is not implied in this report that the conditions depicted in the Geotechnical Sections of Drawings 2 and 3 are identical to what will be encountered during implementation of the remedial recommendations.

12. REFERENCES

1. Bascom, Florence, and Stose, G.W., (1932), *Description of the Coatesville and West Chester quadrangles (Pennsylvania and Delaware)*: U.S. Geological Survey Geologic Atlas, Folio 223, 15 p.

2. Berg, T. M., Edmunds, W. E., Geyer, A. R., and others, compilers (1980), *Geologic map of Pennsylvania (2nd ed.)*: Pennsylvania Geological Survey, 4th ser., Map 1, 3 sheets.
3. Kochanov, W. E., (2016). *Geology of Part of the Chester Valley Area, Chester, Delaware, Montgomery, and Philadelphia Counties, Pennsylvania, PA*. Geol. Surv., 4th Ser., Open-File Geologic Atlas 16-01.0.
4. Lisa A. Senior, Ronald A. Sloto, and Andrew G. Reif (1997), *Hydrogeology and Water Quality of the West Valley Creek Basin, Chester County, Pennsylvania*: U.S. Geological Survey, Water-Resources Investigations Report 94-4137.
5. PA Department of Conservation & Natural Resources (DCNR), Bureau of Topographic and Geologic Survey, <http://dcnr.state.pa.us/topogeo/publications/pgspub/map/index.htm>
6. PADEP site portal for Mariner East 2 Pipeline project, <https://www.dep.pa.gov/Business/ProgramIntegration/Pennsylvania-Pipeline-Portal/Pages/Mariner-East-II.aspx>
7. Rodgers, John, (1968), *The eastern edge of the North American continent during the Cambrian and early Ordovician*, in Zen, E., White, W.S., Hadley, J.B., and Thompson, J.B., Jr., *Studies of Appalachian Geology*: New York, Interscience Publishers, p. 141-149.
8. Sowers, George F. (1996). *Building on Sinkholes – Design and Construction of Foundations in Karst Terrain*. ASCE Press.
9. Wagner, M.E., and Srogi, Leeann, (1987), *Early Paleozoic metamorphism at two crustal levels and a tectonic model for the Pennsylvania-Delaware piedmont*: Geological Society America Bulletin, v. 99, p. 113-126.

Figures and Drawings



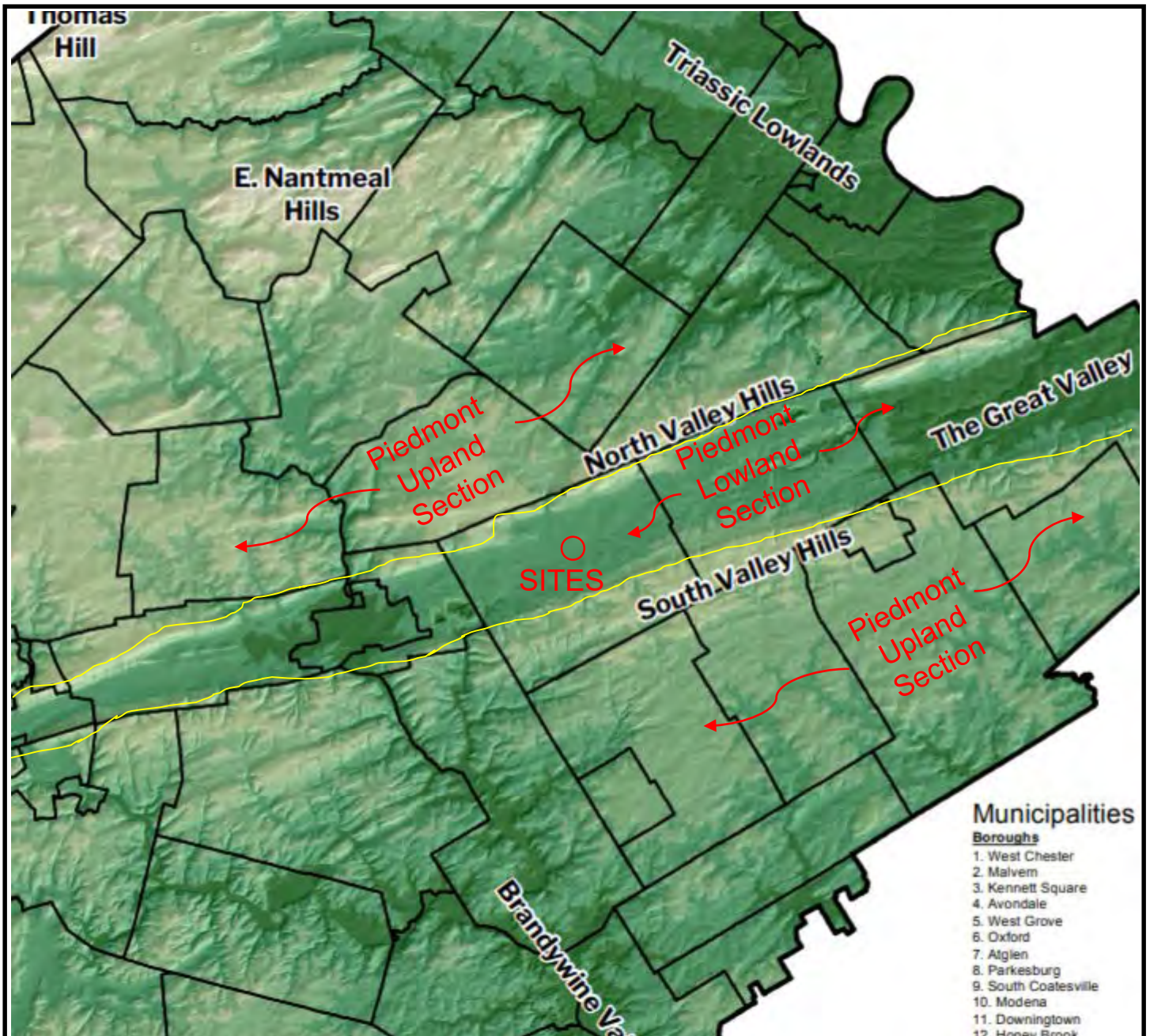
Source:

"Google Maps in Google Earth." *Google Maps in Google Earth*. N.p., n.d. Web. 12/18/2020. <<http://ge-map-overlays.appspot.com/google-maps/road>>.



FIGURE 1. SITE LOCATION MAP

SUNOCO MARINER EAST 2 PIPELINE GEOTECHNICAL IMPACT
EXTON, CHESTER COUNTY, PENNSYLVANIA



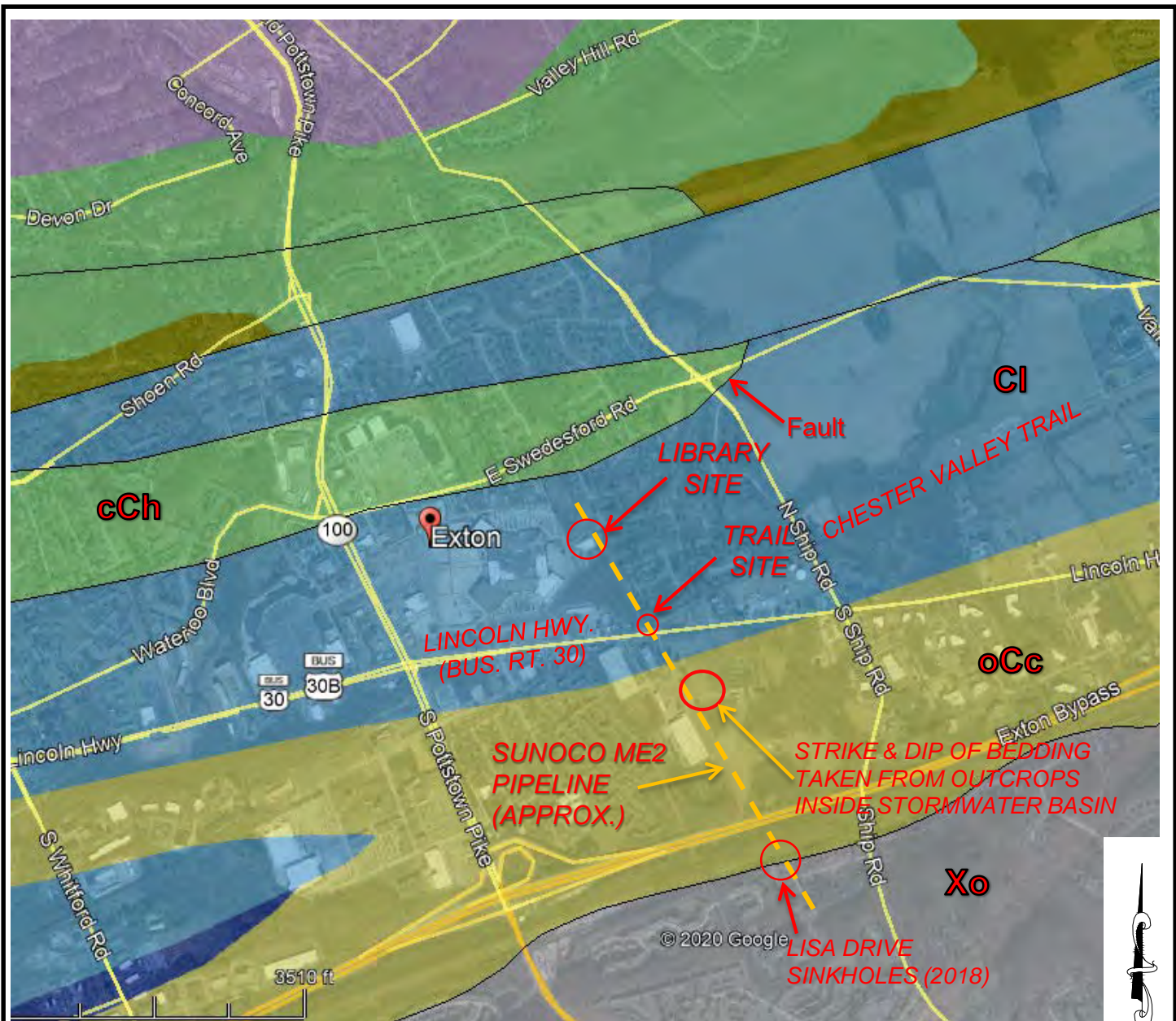
Source:

"Bing Maps in Google Earth." *Bing Maps in Google Earth*. N.p., n.d. Web. 12/18/2020. <<http://ge-map-overlays.appspot.com/bing-maps/road>>.



FIGURE 2. SITE PHYSIOGRAPHIC MAP

SUNOCO MARINER EAST 2 PIPELINE GEOTECHNICAL IMPACT
EXTON, CHESTER COUNTY, PENNSYLVANIA



CI: Ledger Formation (Cambrian):

Light-gray, locally mottled, massive, pure, coarsely crystalline dolomite; siliceous in middle part.

oCc: Conestoga Formation (Ordovician and Cambrian):

Light-gray, thin-bedded, impure, contorted limestone having shale partings; conglomeratic at base; in Chester Valley, includes micaceous limestone in upper part, phyllite in middle, and alternating dolomite and limestone in lower part.

cCh: Chickies Formation (Cambrian):

Light-gray, hard, massive, Scolithus-bearing quartzite and quartz schist; thin, interbedded dark slate at top; conglomerate (Hellam Member) at base.

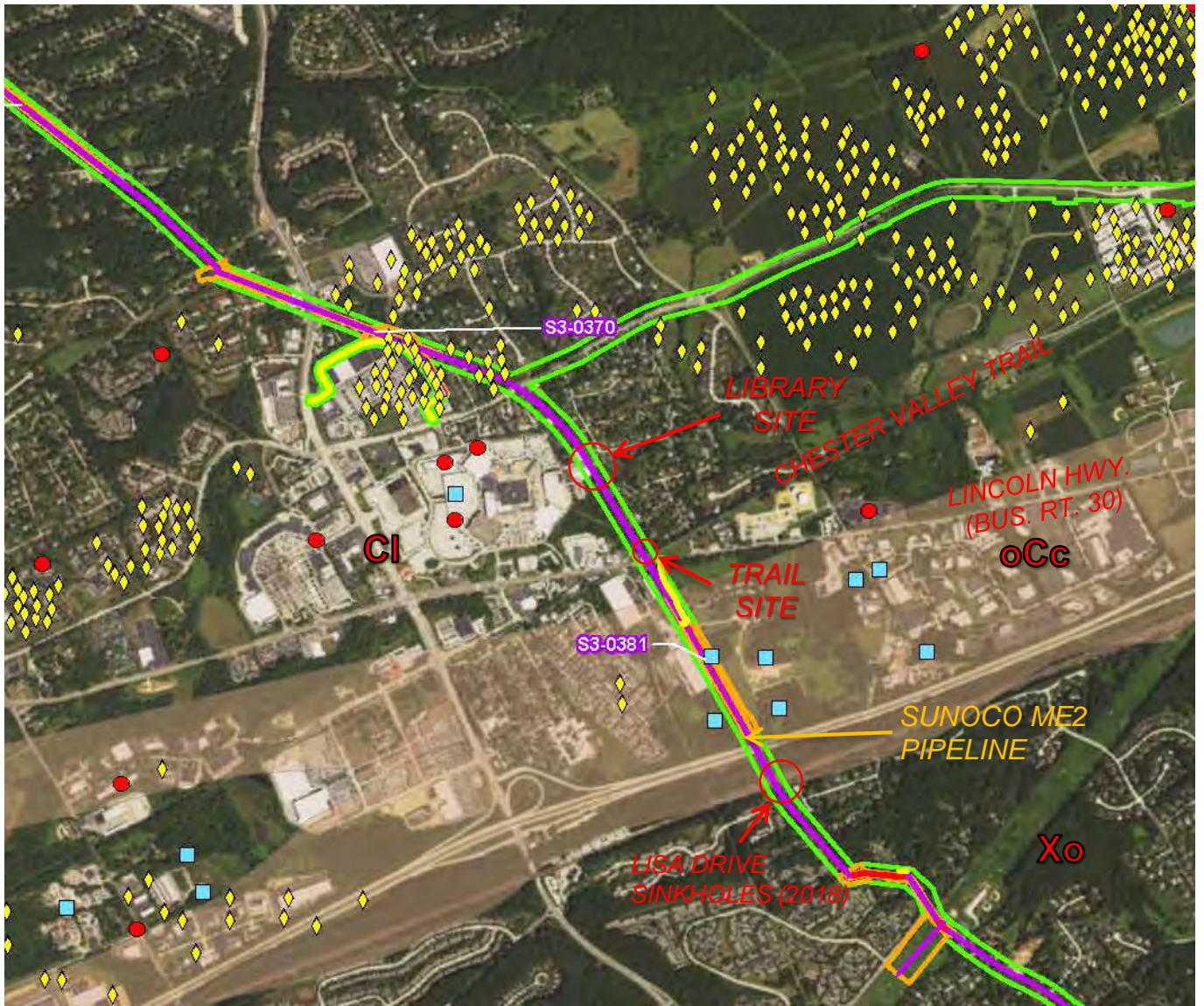
Sources:

- (1) Google Maps in Google Earth. N.p., n.d. Web. 12/18/2020. <<http://ge-map-overlays.appspot.com/google-maps/road>>.
- (2) Bedrock Geologic Map of Pennsylvania by Socolow, A.A. & Berg, T.M., 1980.



FIGURE 3. SITE GEOLOGIC MAP

SUNOCO MARINER EAST 2 PIPELINE GEOTECHNICAL IMPACT
EXTON, CHESTER COUNTY, PENNSYLVANIA



APPROXIMATE SCALE = 1" = 2000'



Source:

Void Mitigation Plan for Karst Terrain and Underground Mining Prepared by Tetra Tech, Inc., 2017.

Legend

PA DCNR Karst Points

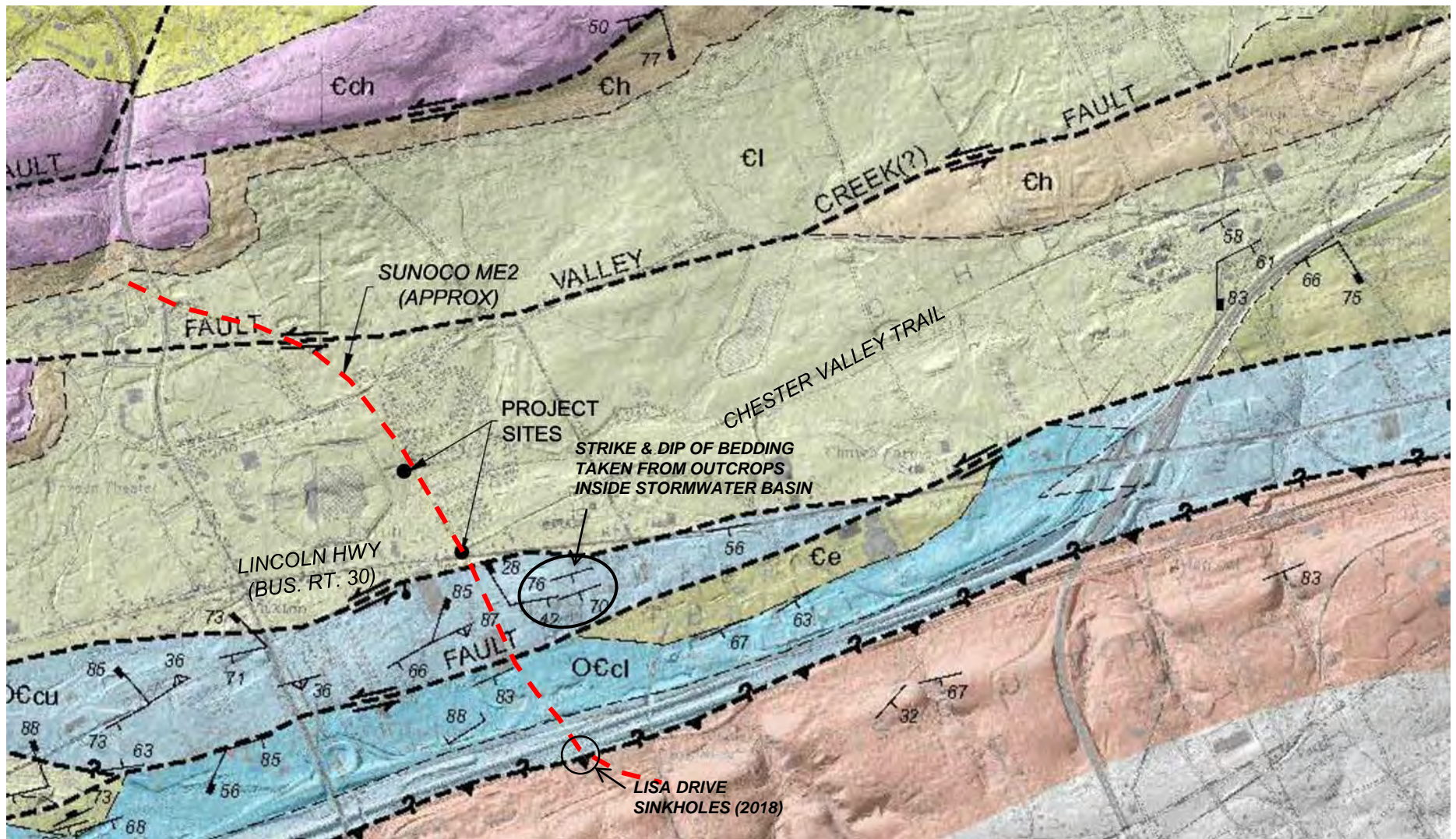
- Sinkhole
- ◆ Surface Depression
- Surface Mine
- Alignment Centerline
- Access Road
- HDD Centerline
- Limit of Disturbance
- Centerline Buffer (100-ft)

Geology

- Limestone



FIGURE 4. SURFACE MINES (QUARRIES) & KARST FEATURES
 SUNOCO MARINER EAST 2 PIPELINE GEOTECHNICAL IMPACT
 EXTON, CHESTER COUNTY, PENNSYLVANIA



Source:

Bedrock Geologic Map of Part of the Chester Valley Area , Pennsylvania by Kochanov, W., 2016.



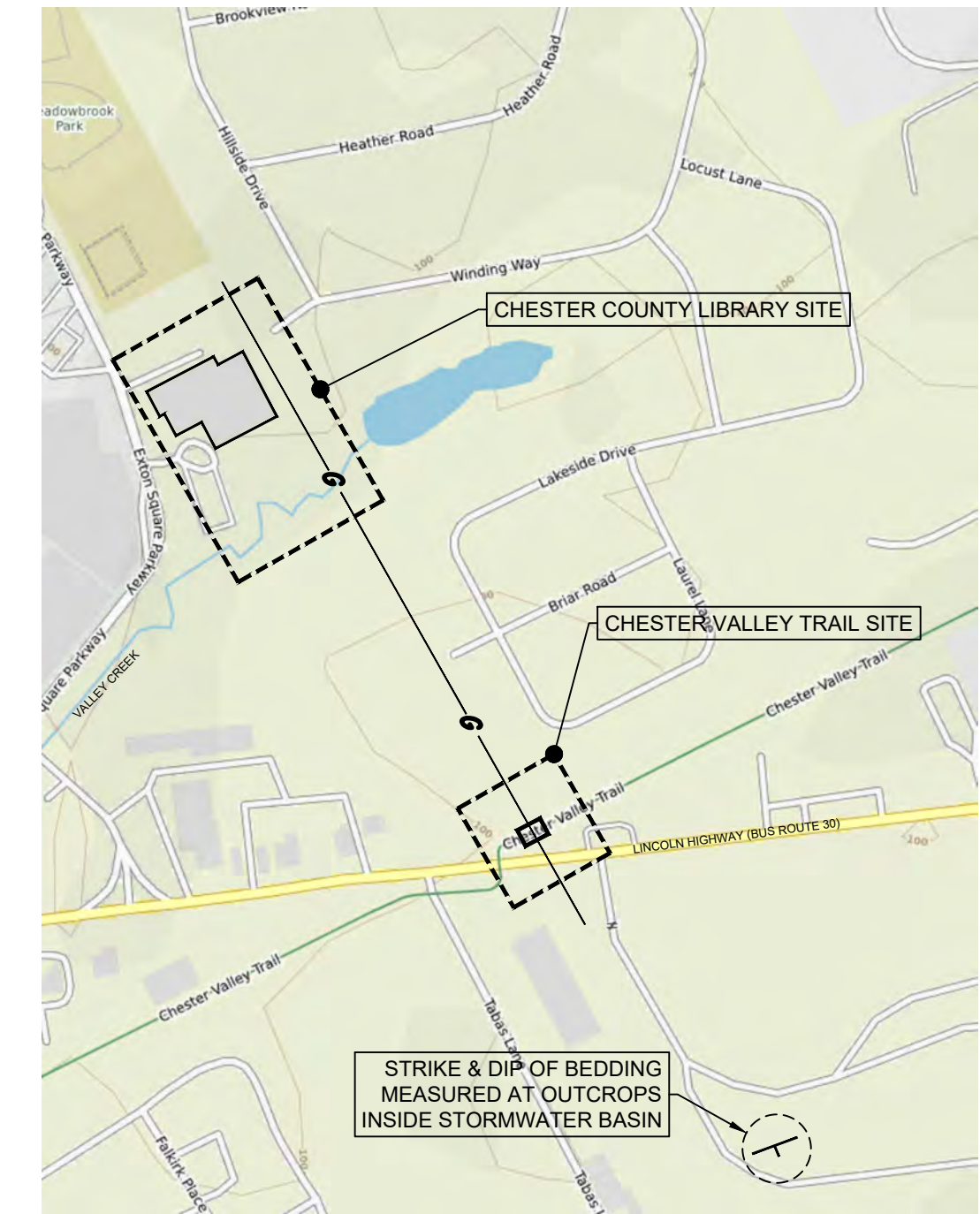
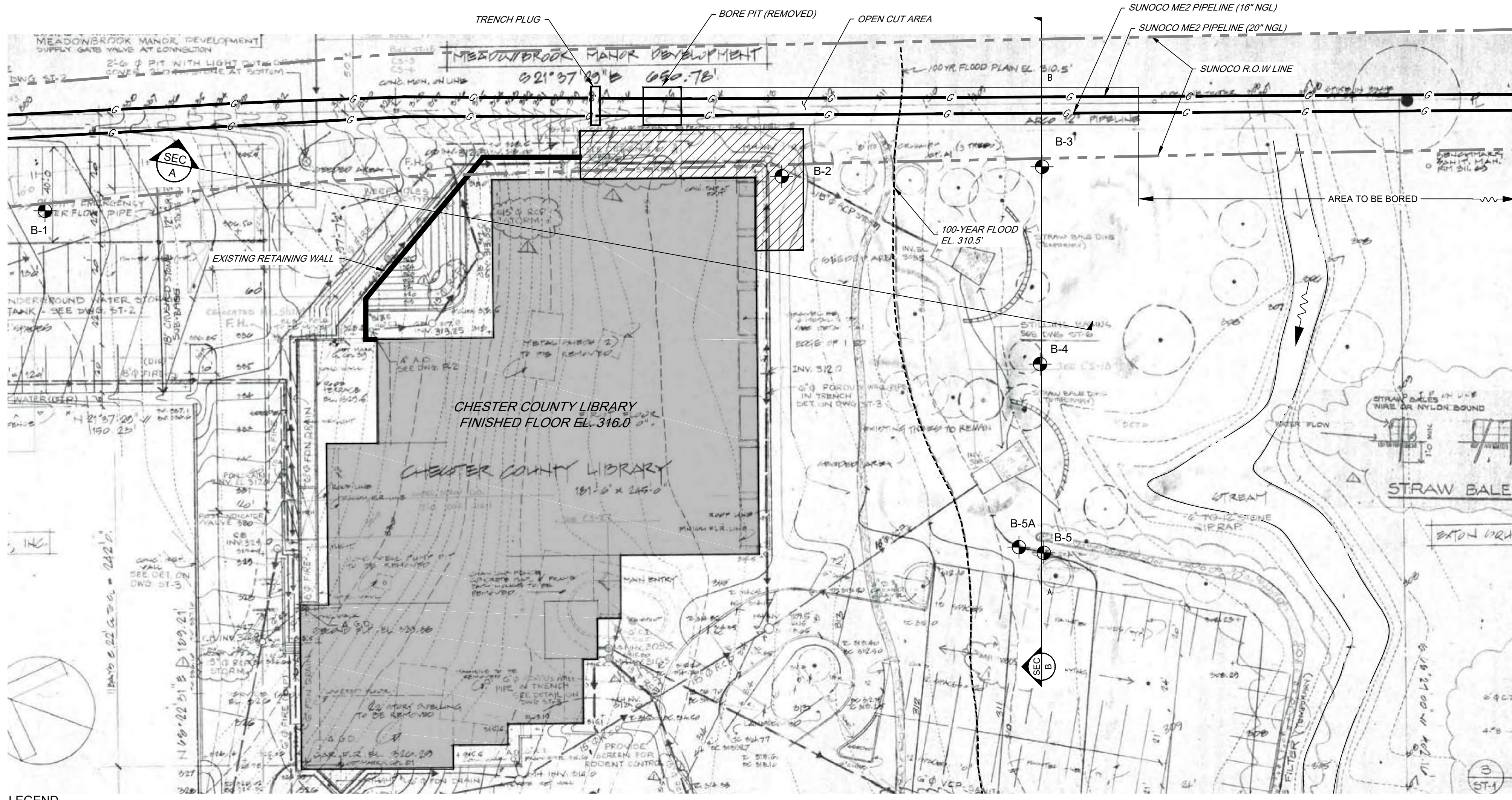
FIGURE 5. GEOLOGIC STRUCTURE MAP

SUNOCO MARINER EAST 2 PIPELINE GEOTECHNICAL IMPACT
EXTON, CHESTER COUNTY, PENNSYLVANIA



GeoStructures, Inc.
1000 West 9th Avenue
King of Prussia, PA 19406

Phone: 610.265.1818
Fax: 610.265.1833
www.geostructures.net

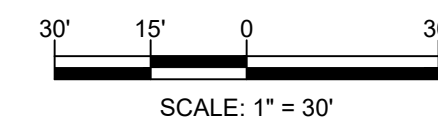


KEY PLAN
SCALE: 1" = 400'

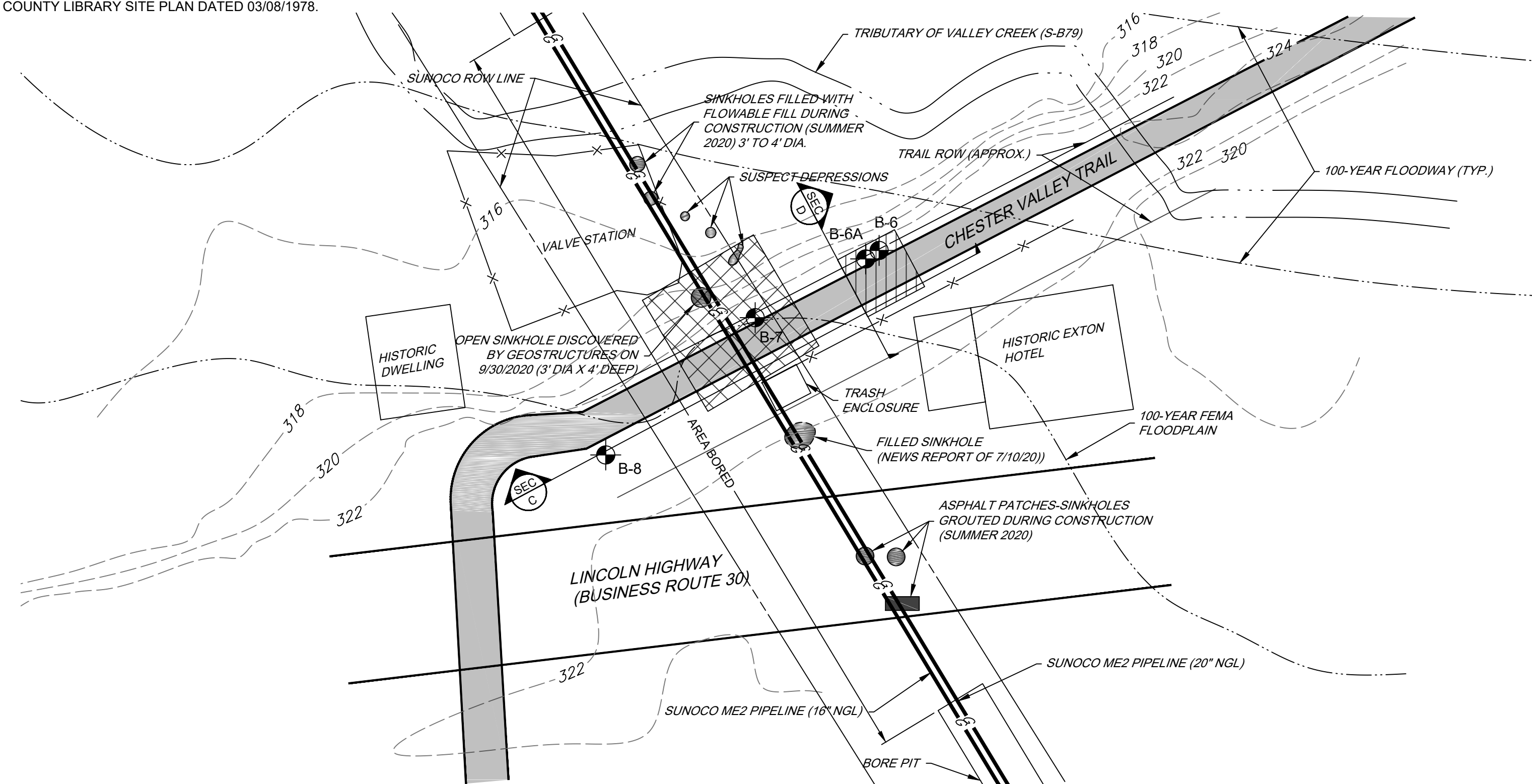
LEGEND

- TEST BORING
- AREA TO BE GROUTED

CHESTER COUNTY LIBRARY



NOTE: THIS DRAWING IS BASED ON THE AS BUILT CHESTER COUNTY LIBRARY SITE PLAN DATED 03/08/1978.



CHESTER VALLEY TRAIL



LEGEND

- TEST BORING
- AREA TO BE STABILIZED (BY EXCAVATION AND BRIDGING)
- AREA TO BE GROUTED

NOTE: THIS DRAWING IS BASED ON EROSION & SEDIMENT CONTROL & SITE RESTORATION PLAN PREPARED BY TETRA TECH DATED 2/6/17.

GEOTECHNICAL INVESTIGATION PLAN

SUNOCO MARINER EAST 2 PIPELINE GEOTECHNICAL IMPACT ON
CHESTER COUNTY LIBRARY AND CHESTER VALLEY TRAIL

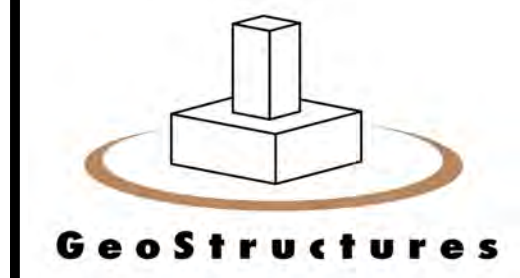
DRAWING NO.

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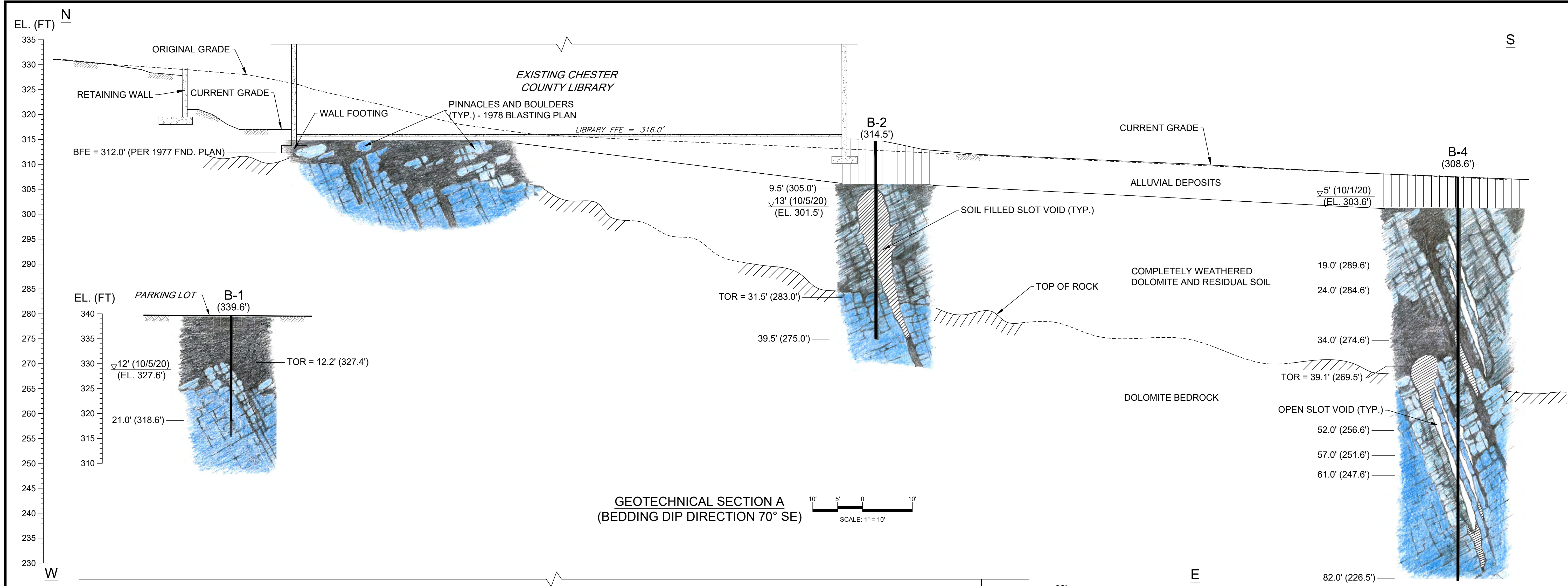
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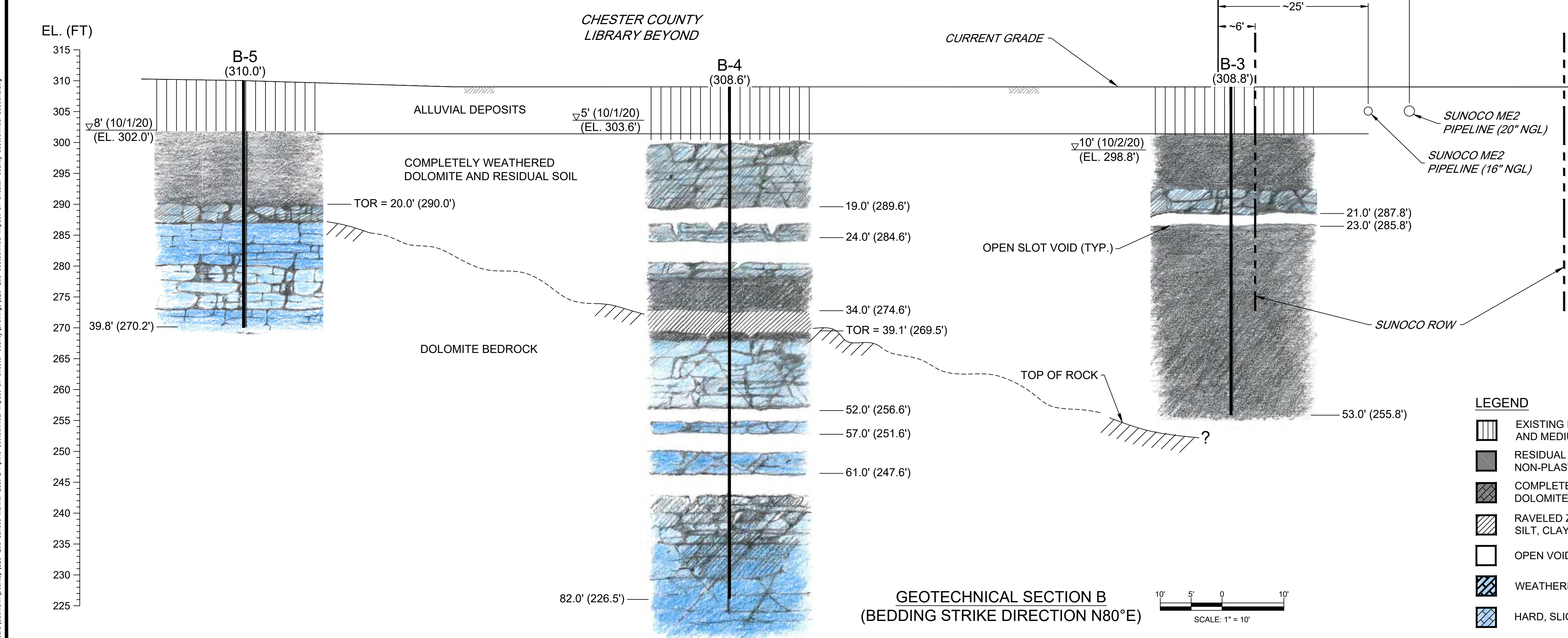
CHECKED: EJS SHEET: 1 of 3



GeoStructures, Inc.
1000 West 9th Avenue
King of Prussia, PA 19406
Phone: 610.265.1818
Fax: 610.265.1833
www.geostructures.net



GEOTECHNICAL SECTION A
(BEDDING DIP DIRECTION 70° SE)



GEOTECHNICAL SECTION B
(BEDDING STRIKE DIRECTION N80°E)

NOTES:

1. TEST BORINGS WERE DRILLED OVER THE PERIOD FROM 10/01 THROUGH 10/21/2020.
2. SURFACE ELEVATIONS WERE ESTIMATED FROM TOPOGRAPHIC CONTOURS SHOWN ON AVAILABLE PLANS.
3. OTHER GAS LINES WITHIN SUNOCO R.O.W. ARE NOT SHOWN IN SECTIONS.
4. THE VOIDS, SLOTS, SOIL SEAMS, PINNACLES, SOUND ROCK AND OTHER FEATURES ENCOUNTERED IN THE BORINGS HAVE BEEN CONCEPTUALIZED BASED ON NEARBY STRIKE AND DIP MEASUREMENTS OF OUTCROPS AS WELL AS THE WEATHERING CHARACTERISTICS OF THE LEDGER FORMATION AND OUR EXPERIENCE WITH KARST GEOLOGY.

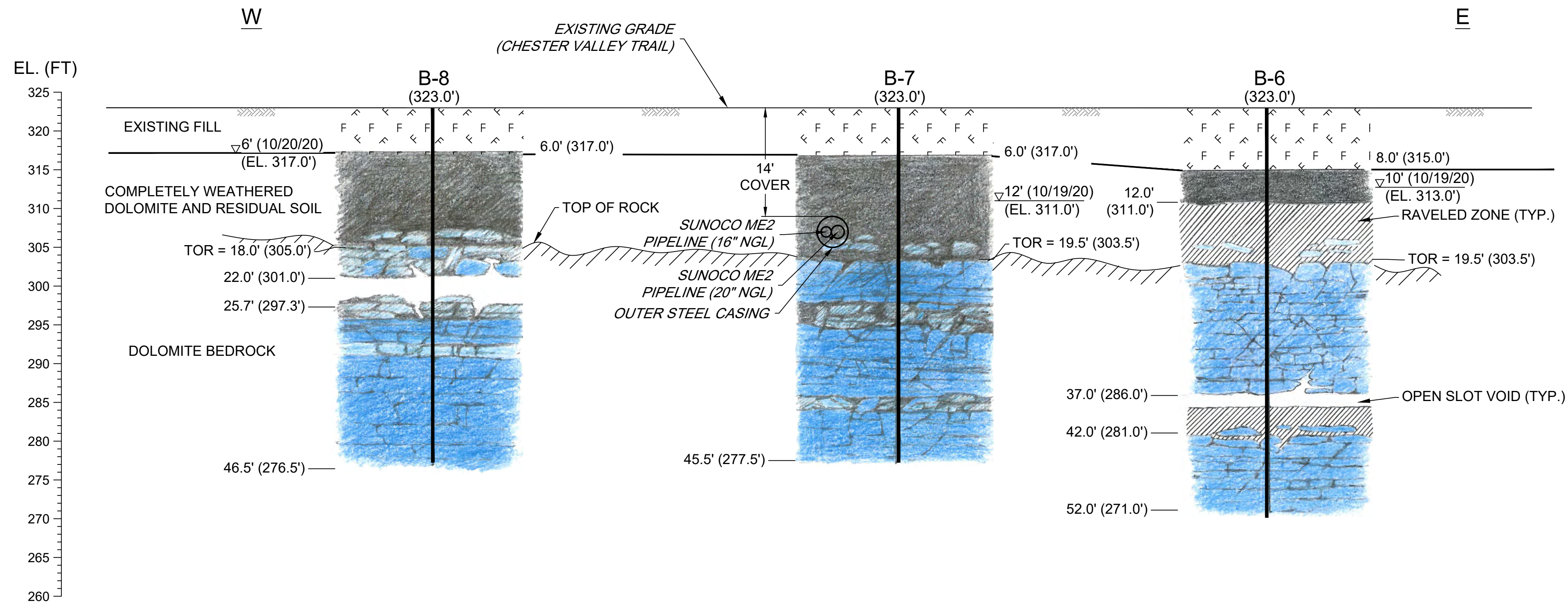
LEGEND

- EXISTING FILL & ALLUVIAL DEPOSITS: STIFF SILT AND CLAY AND MEDIUM DENSE SAND WITH SILT AND GRAVEL.
- RESIDUAL SOIL / SOIL SEAM: LOOSE TO MEDIUM DENSE, NON-PLASTIC SAND AND GRAVEL.
- COMPLETELY WEATHERED DOLOMITE: DENSE TO VERY DENSE, SAND WITH DOLOMITE GRAVEL, HAS RELICT BEDDING STRUCTURE AND FRACTURING.
- RAVELED ZONE/SOIL FILLED VOID: SOFT TO VERY SOFT, SILT, CLAY AND CLAYEY SAND.
- OPEN VOID
- WEATHERED DOLOMITE W/ ABUNDANT SOIL SEAMS
- HARD, SLIGHTLY WEATHERED DOLOMITE.

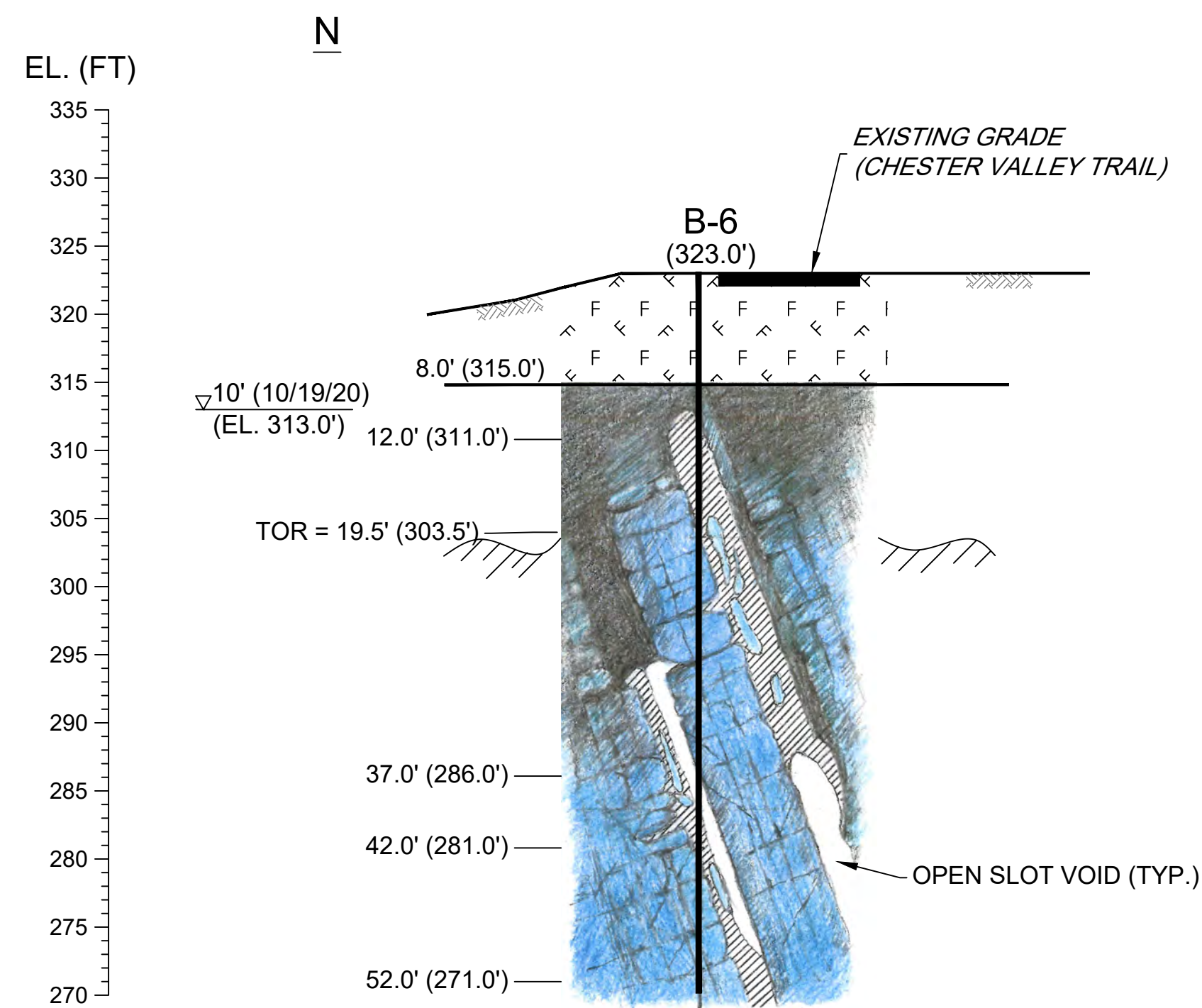
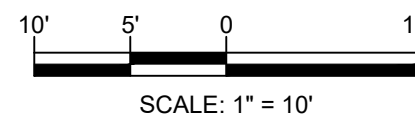
GEOTECHNICAL SECTIONS A AND B
 SUNOCO MARINER EAST 2 PIPELINE GEOTECHNICAL IMPACT ON
 CHESTER COUNTY LIBRARY

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CHECKED: EJS	SHEET: 2 of 3

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GEOTECHNICAL SECTION C
(BEDDING DIP DIRECTION 70° SE)



GEOTECHNICAL SECTION D
(BEDDING STRIKE DIRECTION N80°E)



NOTES:

1. TEST BORINGS WERE DRILLED OVER THE PERIOD FROM 10/01 THROUGH 10/21/2020.
2. SURFACE ELEVATIONS WERE ESTIMATED FROM TOPOGRAPHIC CONTOURS SHOWN ON AVAILABLE PLANS.
3. OTHER GAS LINES WITHIN SUNOCO R.O.W. ARE NOT SHOWN IN SECTIONS.
4. THE VOIDS, SLOTS, SOIL SEAMS, PINNACLES, SOUND ROCK AND OTHER FEATURES ENCOUNTERED IN THE BORINGS HAVE BEEN CONCEPTUALIZED BASED ON NEARBY STRIKE AND DIP MEASUREMENTS OF OUTCROPS AS WELL AS THE WEATHERING CHARACTERISTICS OF THE LEDGER FORMATION AND OUR EXPERIENCE WITH KARST GEOLOGY.

LEGEND

- EXISTING TRAIL EMBANKMENT FILL: LOOSE TO MEDIUM DENSE, SAND, GRAVEL AND CLAYEY SAND WITH SUBLAYERS OF SOFT TO STIFF CLAY.
- RESIDUAL SOIL / SOIL SEAM: STIFF SILT AND CLAY WITH SUBLAYERS OF SILTY SAND.
- COMPLETELY WEATHERED DOLOMITE: DENSE TO VERY DENSE, SAND WITH DOLOMITE GRAVEL, HAS RELICT BEDDING STRUCTURE AND FRACTURING.
- RAVELED ZONE/SOIL FILLED VOID: SOFT TO VERY SOFT, SILT, CLAY AND CLAYEY SAND.
- OPEN VOID
- WEATHERED DOLOMITE W/ ABUNDANT SOIL SEAMS
- HARD, SLIGHTLY WEATHERED DOLOMITE.

GEOTECHNICAL SECTIONS C AND D

SUNOCO MARINER EAST 2 PIPELINE GEOTECHNICAL IMPACT ON CHESTER VALLEY TRAIL

DRAWING NO.

3

DATE: 12/21/2020 PROJECT NO. G20-265

DRAWN: KN SCALE: AS SHOWN

CHECKED: EJS SHEET: 3 of 3

SHEET NUMBER: DRAWING 3
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Appendix A
Test Boring Logs



TEST BORING LOG

Test Boring: B-1
 Sheet: 1 of 2
 Elevation (ft): 339.60

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 Date: 10/05/20 - 10/05/20

Location: Chester County Library Twp.: W Whiteland County: Chester State: PA

Driller/Company: L. Davis/GeoStructures, Inc. Rig Type: Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. Logged By: JMR

Water Depth ∇: 12' During drilling (10/05/20) Water Depth : Checked By: EJS

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
339.60	0.0											Asphalt.	0.3	4" of asphalt.	
335	2.0	S-1	S-1	0.0-2.0	13-12-11-9	30	0.9/45					Medium dense, black to light gray, well-graded gravel with silt and sand (GW-GM), very moist (RESIDUAL).	3.5		
	4.0	S-2	S-2	2.0-4.0	5-5-4-4	11	0.6/30					Medium dense, red. bn, silty sand (SM), moist to v. moist (RESIDUAL).	4.0		
	6.0	S-3	S-3	4.0-6.0	5-3-2-2	6	0.6/30					Loose, yellowish brown, poorly graded sand with silt (SP-SM), damp to moist (RESIDUAL).	6.0		
	8.0	S-4	S-4	6.0-8.0	3-2-3-1	6	0.4/20					Loose to med. dense, reddish brown, poorly graded sand with gravel (SP), moist to very moist, contains angular gravel (RESIDUAL).			
330	10.0	S-5	S-5	8.0-10.0	2-2-2-2	5	0.4/20								
	11.0	S-6	S-6	10.0-11.3	5-6-50/4"	74	0.4/31	8.2							
	12.2	S-7	S-7	12.0-12.2	50/2"		0.2/100						V. dense, light brown to white, poorly graded sand with gravel (SP), damp, contains angular rock fragments (RESIDUAL).	12.2	∇ Grades to well-graded gravel with sand (GW), wet at 12.0' (Perched). Top of Rock at 12.2' (EL. 327.4'). Highly fractured. Low water return. Orange coloring on fracture surfaces. Increase of closely spaced fractures from 17' to 21'.
325	14.0	R-1	R-1	12.2-17.0	0.7/15		2.3/47						LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).	15.0	
	16.0												LEDGER FM. DOLOMITE, gray, medium hard, moderately weathered, medium to closely spaced fractures (RD 0°, 45°, 60°, and 90°).		
320	18.0	R-2	R-2	17.0-21.0	1.8/45		4.0/100								

SAMPLE LEGEND		GENERAL NOTES
☐	SPT Sample	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.
☒	Rock Core	
■	Bulk Sample	
■	Shelby Tube	

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20-265 chester county geologic study (library).gpj | Date and Time: 12/11/20 16:04.



TEST BORING LOG

Test Boring: B-1
 Sheet: 2 of 2
 Elevation (ft): 339.60

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
		X										▨	Bottom of borehole at 21.0'.	21.0	

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> <input type="checkbox"/> SPT Sample <input checked="" type="checkbox"/> Rock Core <input type="checkbox"/> Bulk Sample <input type="checkbox"/> Shelby Tube 	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.



TEST BORING LOG

Test Boring: B-2
Sheet: 1 of 2
Elevation (ft): 314.50

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 | Path: g:\field\joint program & project data\project\g20-265 chester county geologic study (library).gpx | Date and Time: 12/11/20 16:04

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 **Date:** 10/05/20 - 10/05/20

Location: Chester County Library **Twp.:** W Whiteland **County:** Chester **State:** PA

Driller/Company: L. Davis/GeoStructures, Inc. **Rig Type:** Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. **Logged By:** JMR

Water Depth ∇ : 13' During drilling (10/05/20) **Water Depth** : **Checked By:** EJS

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
314.50	0.0												Topsoil.	0.3	4" of topsoil.
312.50	2.0	S-1	S-1	0.0-2.0	2-2-5-5	9	0.9/45				3.5	FILL	Stiff, reddish brown, sandy silt (ML), damp to moist, contains trace, subrounded gravel (FILL).	2.0	
310.50	4.0	S-2	S-2	2.0-4.0	6-10-10-11	26	0.6/30				4.25		Stiff to very stiff, dark grayish brown, sandy silt (ML), damp to moist, contains subrounded quartz gravel (ALLUVIAL).	4.0	Quartz gravel at 4'.
308.50	6.0	S-3	S-3	4.0-6.0	7-7-5-6	15	1.1/55				1.75		Stiff, light reddish brown, sandy silt (ML) to sandy lean clay (CL), moist, contains subrounded quartz gravel (ALLUVIAL).	6.0	Plant material in S-4.
306.50	8.0	S-4	S-4	6.0-8.0	4-4-4-6	10	0.8/38	16.4	30 / 20	CL	1.75			8.0	More wet at 8'.
304.50	10.0	S-5	S-5	8.0-10.0	5-7-3-1	13	0.3/15	18.1					Medium to stiff, yellowish brown, sandy silt (ML), very moist to wet to saturated, contains angular quartz gravel (RESIDUAL).	9.5	Weak raveled zone starting at S-5.
302.50	12.0	S-6	S-6	10.0-12.0	WOH-1- WOH-WOH	1	0.2/10						Soft to very soft, yellowish brown, sandy, lean clay with gravel (CL) and clayey sand with gravel (SC), wet to saturated, contains angular sand and gravel (RAVELED ZONE).		
300.50	14.0	S-7	S-7	12.0-14.0	WOH-1- WOH-2	1	0.4/20								∇ Wet at 13'.
298.50	16.0	S-8	S-8	14.0-16.0	1-2-2-1	5	NR								Sandy at 14'.
296.50	18.0	S-9	S-9	16.0-18.0	1-1-1-1	2	0.3/15								
294.50	20.0	S-10	S-10	18.0-20.0	1-2-2-2	5	1.0/50	19.2	32 / 21	SC	0.25				

SAMPLE LEGEND		GENERAL NOTES	
	SPT Sample	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.	
	Rock Core		
	Bulk Sample		
	Shelby Tube		

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (library).gpj | Date and Time: 12/11/20 16:04



TEST BORING LOG

Test Boring: B-2
Sheet: 2 of 2
Elevation (ft): 314.50

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
22		S-11		20.0-22.0	2-1-1-WOH	2	NR						Soft to very soft, yellowish brown, sandy, lean clay with gravel (CL) and clayey sand with gravel (SC), wet to saturated, contains angular sand and gravel (RAVELED ZONE). <i>(continued)</i>	24.0	Wet, clayey with subrounded quartz grains at 23'.
		S-12		22.0-24.0	1-WOH-1-WOH	1	0.6/30								
24		S-13		24.0-26.0	WOH-5-7-2	15	0.3/15						Loose to v. loose, light gray, poorly graded sand with silt and gravel (SP-SM), damp to moist, contains angular gravel (RAVELED ZONE).	28.0	
26		S-14		26.0-28.0	1-1-1-WOH	2	NR								
28		S-15		28.0-30.0	10-21-27-13	63	1.1/55						Same SP-SM as above except dense to very dense (COMPLETELY WEATHERED DOLOMITE).	30.5	Spoon came out bent; might be glancing, thus blow count is not representative; hitting rock just shy of 30'. Driller will core into the rock. Missing recovery is from the top of the run; Top of Rock at 31.5' (EL. 283.0').
285		S-16		30.0-30.6	5-50/1"		0.2/33	9.0	NP / NP	GM					
30													Very dense, light gray to yellowish white, well-graded gravel (GW), wet, contains angular weathered dolomite fragments and quartz sand (COMPLETELY WEATHERED DOLOMITE).	31.5	
32		R-1		31.5-34.5	0.9/30		1.6/53						LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).	32.9	Mottled dark spots throughout. Few fractures; top of run is highly weathered with quartz gravel, but the intact core below is only slightly weathered. RD near 90°
34		R-2		34.5-39.5	2.8/56		3.8/76						LEDGER FM. DOLOMITE, gray, medium hard to hard, slightly weathered with soft, highly weathered seams, especially in the upper 3.0'. massive, very widely fractured (RD 0°, 30°, and 90°).		
280													Bottom of borehole at 39.5'.	39.5	Contains more fractures and broken pieces in bottom 0.5' of run Orange oxidation banding on fractured surfaces. Highly weathered and closely spaced fractures at 39'.

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> SPT Sample Rock Core Bulk Sample Shelby Tube 	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.



TEST BORING LOG

Test Boring: B-3
 Sheet: 1 of 3
 Elevation (ft): 308.80

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 | Path: g:\field\gint program & project data\projects\g2020\g20-265 chester county geologic study (library).gpi | Date and Time: 12/11/20 16:04

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 Date: 10/02/20 - 10/02/20

Location: Chester County Library Twp.: W Whiteland County: Chester State: PA

Driller/Company: L. Davis/GeoStructures, Inc. Rig Type: Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. Logged By: JMR

Water Depth ∇: 10' During drilling (10/02/20) Water Depth : Checked By: EJS

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
308.80	0.0										1.75		Topsoil.	0.3	4" of topsoil.
305	2.0	S-1	S-1	0.0-2.0	3-2-4-5	7	0.8/38						Medium, dark brown, lean clay (CL), moist, contains woody plant material, trace mica, and quartz sand (ALLUVIAL).	2.0	
	4.0	S-2	S-2	2.0-4.0	9-10-12-12	29	0.8/40						Medium dense, reddish to yellowish brown, well-graded sand with silt and gravel (SW-SM), damp, contains subrounded sand and gravel (ALLUVIAL).	4.0	
	6.0	S-3	S-3	4.0-6.0	7-5-5-5	13	0.4/20						Medium dense, light yellowish brown to reddish brown, well-graded sand with silt and gravel (SW-SM), wet to saturated, contains subrounded quartz gravel and sand (ALLUVIAL).	7.5	
	8.0	S-4	S-4	6.0-8.0	WOH-10-10-14	26	0.6/30						Medium dense, pale yellow, poorly graded sand with silt and gravel (SP-SM), very moist to wet to saturated, contains angular fragments of quartz and dolomite gravel (RESIDUAL).	11.0	∇ Wet to saturated at 10' to 17'.
300	10.0	S-5	S-5	8.0-10.0	10-13-13-12	34	1.2/60						Same SP-SM as above except loose (RESIDUAL).	14.0	
	12.0	S-6	S-6	10.0-12.0	5-5-4-3	11	0.5/25						Same SP-SM as above except medium dense to dense (RESIDUAL)	17.0	
295	14.0	S-7	S-7	12.0-14.0	3-1-1-2	2	0.7/35								
	16.0	S-8	S-8	14.0-16.0	4-4-15-21	25	1.2/60								
	18.0	S-9	S-9	16.0-18.0	20-22-30-35	69	1.3/63								
290	18.0	S-10	S-10	18.0-18.2	50/2"		0.2/100	9.0	NP / NP	GM					Completely weathered dolomite at 17' to 18.16'.
	18.2	R-1	R-1	18.2-21.0	0/0		0.3/11								

SAMPLE LEGEND		GENERAL NOTES
	SPT Sample	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.
	Rock Core	
	Bulk Sample	
	Shelby Tube	

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (library).gpi | Date and Time: 12/11/20 16:04



TEST BORING LOG

Test Boring: B-3
Sheet: 2 of 3
Elevation (ft): 308.80

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
		X										○	Very dense, pale yellow to white, well-graded gravel with sand (GW), moist, contains angular, weathered, and slightly oxidized fragments of dolomite (COMPLETELY WEATHERED DOLOMITE). <i>(continued)</i>	21.0	Void. Small spoon used from 21' to end of boring.
	22		S-11	21.0-23.0	WOH-1-8-4	11	NR					▽		23.0	
285	24		S-12	23.0-25.0	12-13-13-12	34	1.1/55					○	Void.		Wet at 25.0'. Wet at 30.0'
	26		S-13	25.0-27.0	3-3-3-8	7	1.4/70					○	Loose to medium dense, pale yellow to white or light brownish gray, poorly graded sand with silt (SP-SM), and silty sand (SM), moist to vwet, contains angular fragments of weathered dolomite gravel (RESIDUAL).		
	28		S-14	27.0-29.0	2-4-13-13	22	1.1/55	14.0	NP / NP	SM		○			
280	30		S-15	29.0-31.0	12-4-2-3	7	0.8/40					○			
	32		S-16	31.0-33.0	4-8-13-13	27	2.0/100					○			
275	34		S-17	33.0-35.0	5-8-9-27	22	2.0/100					○			
	36		S-18	35.0-37.0	8-9-8-8	22	1.1/55					○			
	38		S-19	37.0-39.0	9-11-10-4	27	0.7/35					○			
270	40		S-20	39.0-41.0	5-6-6-18	15	1.1/55					○		Medium dense, pale yellow, poorly graded sand with silt and gravel (SP-SM), moist to very moist, contains angular fragments of weathered dolomite gravel (RESIDUAL).	
	42		S-21	41.0-43.0	25-10-3-1	17	1.3/63					○			
												○			43.0
265												○			

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> SPT Sample Rock Core Bulk Sample Shelby Tube 	<p>Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.</p>

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (library).gpi | Date and Time: 12/11/20 16:04



TEST BORING LOG

Test Boring: B-3
Sheet: 3 of 3
Elevation (ft): 308.80

Elevation (ft)	Depth (ft)	Sample Type Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
		S-22	43.0-45.0	8-13-5-5	23	0.7/35						Medium dense to dense, yellow to white, poorly graded sand with silt (SP-SM), very moist, contains angular fragments of gravel (RESIDUAL). <i>(continued)</i>	49.0	Rocks in casing at 45'. Core barrel is following casing with blows at 47'. 47' to 49': Pushed casing 1' (no sample), then cleared to 49'.
	46	S-23	45.0-47.0	7-7-26-15	43	2.0/100								
260		S-24	49.0-51.0	6-5-8-6	17	0.8/38	9.0	NP / NP	GM		Medium dense, pale yellow to white, well-graded gravel with silt and sand (GW-GM), wet to saturated, contains angular, weathered fragments of dolomite (RESIDUAL).	53.0	At 53': Too much sand in casing; acquired what was needed; ended boring at 53'.	
	52	S-25	51.0-53.0	11-6-6-19	15	1.3/63			GM					
													Bottom of borehole at 53.0'.	

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> <input type="checkbox"/> SPT Sample <input type="checkbox"/> Rock Core <input type="checkbox"/> Bulk Sample <input type="checkbox"/> Shelby Tube 	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.



TEST BORING LOG

Test Boring: B-4
 Sheet: 1 of 4
 Elevation (ft): 308.60

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 | Path: g:\field\joint program & project data\project\g20-265 chester county geologic study (library).gpj | Date and Time: 12/11/20 16:05

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 Date: 10/01/20 - 10/01/20

Location: Chester County Library Twp.: W Whiteland County: Chester State: PA

Driller/Company: L. Davis/GeoStructures, Inc. Rig Type: Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. Logged By: EJS

Water Depth ∇: 5' During drilling (10/01/20) Water Depth : Checked By: EJS

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
308.60	0												Dark grayish brown, silty topsoil.	1.5	
307.5	2												Very stiff, olive gray, sandy silt (ML), moist (ALLUVIAL).	2.5	
305.5	4	S-2	S-2	2.0-4.0	4-10-11-9	27	1.7/85				3.5		Medium dense, brown, silty sand with gravel (SM) and silty gravel with sand (GM), trace phyllite, abundant subrounded quartz gravel, moist (ALLUVIAL).	5.0	∇ S-3 wet spoon. Loose zone at GW level.
304.5	6	S-3	S-3	4.0-6.0	9-11-3-3	18	0.4/20						Same SM and GM as above except loose and wet (ALLUVIAL).	7.0	
303.5	8	S-4	S-4	6.0-8.0	WOH-5-30-23	46	0.9/45						Dense to very dense, pale yellow and yellowish brown, poorly graded sand with silt (SP-SM) and silty sand (SM), contains zones of weathered dolomite, wet (RESIDUAL).		Completely weathered dolomite with highly weathered zones.
302.5	10	S-5	S-5	8.0-10.0	13-16-19-27	46	1.8/90								
301.5	12	S-6	S-6	10.0-12.0	27-33-34-27	89	2.0/100	17.4	NP / NP	SM					
300.5	12	S-7	S-7	12.0-12.4	50/5"		NR								
299.5	14														
298.5	16	S-8	S-8	15.0-17.0	12-14-15-17	38	1.2/60								Starting from S-8, used 1.75" (O.D.) spoon inside core barrel.
297.5	18	S-9	S-9	17.0-18.8	10-15-20-50/4"	46	1.8/100								Advanced casing to 19', cleaned out to 17' and took S-9.
296.5	19.0												Apparent open void (casing dropped abruptly).		

SAMPLE LEGEND		GENERAL NOTES	
	SPT Sample	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.	
	Rock Core		
	Bulk Sample		
	Shelby Tube		



TEST BORING LOG

Test Boring: B-4
 Sheet: 2 of 4
 Elevation (ft): 308.60

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\git program & project data\projects\g20\g20-265 chester county geologic study (library).gpi | Date and Time: 12/11/20 16:05.

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
285	22	S-10	21.0-22.0	WOH-WOH-2-17/0"	2	1.8/180					0.25		Very soft, olive to yellowish brown, sandy lean clay (CL), wet (RAVELED ZONE).	20.5	
	22	S-11	22.0-24.0	15-12-13-19	33	2.0/100							Dense, dark grayish brown, silty gravel with sand (GM), wet (RESIDUAL).	21.5	
	24	S-12	24.0-26.0	2-1-WOH-1	1	NR							Raveled zone/Void.	24.0	Possibly very soft clay 24' - 27.5' (no recovery).
	26	S-13	26.0-28.0	2-1-2-15	3	1.2/60							Dense to very dense, dark grayish brown, silty gravel with sand (GM), wet (RESIDUAL).	27.5	
	28	S-14	28.0-28.6	5-50/1"		0.6/100							Intermittent, silty gravel with sand (GM) and soft to very stiff lean clay with sand (CL), wet (RESIDUAL WITH RAVELED ZONES).	29.0	Advanced casing to 29.0'.
	30	S-15	29.0-31.0	2-WOH-5-2	6	0.7/35							Very soft, brown and light gray, low plasticity silt (ML), wet (RAVELED ZONE).	30.0	
	32	S-16	31.0-33.0	7-6-5-1	14	0.9/45							Medium dense, pale yellow to white, poorly graded sand with silt (SW-SM), contains angular fragments of dolomite gravel (RESIDUAL).	32.0	Casing refusal at 32.0' (possibly "clipping" edge of pinnacle). Went back in with core barrel. 32'-35': Recovered 15" of dolomite core when cleaning out casing with core barrel (Evidence of pinnacle and slot). S-18 & S-19: smaller diameter spoon.
	34	S-17	33.0-35.0	5-4-1-6	6	1.5/75							Very dense, yellowish brown to light gray, well-graded gravel with sand (GW), contains fragmented dolomite pieces (RESIDUAL).	35.0	
	36	S-18	35.0-37.0	WOH		1.3/65	44.8	37 / 27	ML				LEDGER FM. DOLOMITE, light gray, medium hard to hard, slightly weathered with a few completely weathered seams, closely spaced fractures (RD 70° and 45°), massive.	37.0	Top of Rock at 39.1' (EL. 269.5'). Dark gray, soft and moderately weathered around fracture faces. 42'-42.6': very closely fractured.
	38	S-19	37.0-39.0	9-14-6-6	26	1.1/55							Very dense, yellowish brown to light gray, well-graded gravel with sand (GW), contains fragmented dolomite pieces (RESIDUAL).	39.0	
	39.1	S-20	39.0-39.1	50/1"		0.0/10	9.0	NP / NP	GM				Very dense, yellowish brown to light gray, well-graded gravel with sand (GW), contains fragmented dolomite pieces (RESIDUAL).	39.1	
	40	R-1	39.1-42.0	0.7/24		2.3/78							LEDGER FM. DOLOMITE, light gray, medium hard to hard, slightly weathered with a few completely weathered seams, closely spaced fractures (RD 70° and 45°), massive.	42.0	
	42														
	265														

SAMPLE LEGEND		GENERAL NOTES	
	SPT Sample	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.	
	Rock Core		
	Bulk Sample		
	Shelby Tube		

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (library).gpi | Date and Time: 12/11/20 16:05



TEST BORING LOG

Test Boring: B-4
Sheet: 3 of 4
Elevation (ft): 308.60

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
260	46		R-2	42.0-47.0	0.3/6		1.5/30						LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring). <i>(continued)</i>	45.5	No drill water return throughout.
	47.0												LEDGER FM. DOLOMITE, light gray, medium hard to hard, slightly weathered with a few completely weathered seams, closely spaced fractures (RD 70° and 45°), massive.	47.0	
	48												LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).	50.3	
	50	R-3		47.0-52.0	0.75/15		1.7/34						LEDGER FM. DOLOMITE, light gray, medium hard to hard, slightly weathered with a few completely weathered seams, closely spaced fractures (RD 70° and 45°), massive.	52.0	
	52												Open void	53.0	
255	54	R-4		52.0-57.0	2.1/42		3.6/72						LEDGER FM. DOLOMITE, light gray, medium hard to hard, slightly weathered widely spaced fractures.	57.0	
	56												Open void	58.0	
250	58												LEDGER FM. DOLOMITE, light gray, medium hard to hard, slightly weathered widely spaced fractures.	61.0	
	60	R-5		57.0-62.0	0/0		1.7/34						Open void	62.0	
245	62												LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).		
	64	R-6		62.0-67.0	0/0		NR								
	66														

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> SPT Sample Rock Core Bulk Sample Shelby Tube 	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\gint program & project data\projects\g20\g20-265 chester county geologic study (library).gpi | Date and Time: 12/11/20 16:05



TEST BORING LOG

Test Boring: B-4
Sheet: 4 of 4
Elevation (ft): 308.60

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
240	70		R-7	67.0-72.0	0.4/8		1.8/35					[Symbol]	LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring). <i>(continued)</i>	70.2	69'-71': Highly weathered with near vertical fractures. 72.5'-75.5': Highly weathered and with weathered seams.
72												[Symbol]	LEDGER FM. DOLOMITE, light gray, soft, highly to completely weathered with some medium hard, slightly weathered, intact rock, closely spaced fractures (RD 70° and 45°), massive.	72.0	
235	74		R-8	72.0-77.0	0.3/6		1.2/24					[Symbol]	LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).	75.8	
76												[Symbol]	LEDGER FM. DOLOMITE, light gray, soft, highly to completely weathered with some medium hard, slightly weathered, intact rock, closely spaced fractures (RD 70° and 45°), massive.	77.0	
230	78		R-9	77.0-82.0	4.5/90		4.8/95					[Symbol]	LEDGER FM. DOLOMITE, light gray, medium hard to hard, slightly weathered, widely spaced fractures.	82.0	
82													Bottom of borehole at 82.0'.		

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> SPT Sample Rock Core Bulk Sample Shelby Tube 	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.



TEST BORING LOG

Test Boring: B-5
Sheet: 1 of 2
Elevation (ft): 310.00

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\git program & project data\projects\g2020\g20-265 chester county geologic study (library).gpl | Date and Time: 12/11/20 16:05.

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 Date: 10/01/20 - 10/01/20

Location: Chester County Library Twp.: W Whiteland County: Chester State: PA

Driller/Company: L. Davis/GeoStructures, Inc. Rig Type: Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. Logged By: EJS

Water Depth ∇ : 8' During drilling (09/30/20) Water Depth : Checked By: EJS

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
305	0.0	S-1	0.0-2.0	2-7-14-9	27	1.3/65						☀	Dark grayish brown, silty topsoil.	0.5	Crushed dolomite-quartz aggregate.
2	2.0	S-2	2.0-4.0	8-7-12-18	25	1.0/50						☀	Medium dense, light grayish brown, silty gravel with sand (GM), damp (FILL).	3.0	
4	4.0	S-3	4.0-6.0	9-11-12-18	30	1.5/75						☀	Medium dense to dense, silty sand with gravel (SM), and silty gravel with sand (GM), trace phyllite, abundant subrounded quartz gravel, damp (ALLUVIAL).	7.0	
6	6.0	S-4	6.0-8.0	16-15-21-28	47	1.7/85	4.3	NP / NP	GM			☀	Very dense, yellowish brown, silty sand with gravel (SM), very moist (ALLUVIAL).	8.0	
8	8.0	S-5	8.0-10.0	6-4-6-5	13	0.2/9						☀	Medium dense, light gray and pale yellow, poorly graded sand with silt (SP-SM), wet (RESIDUAL).	11.5	
10	10.0	S-6	10.0-12.0	5-5-5-12	13	1.2/59						☀	Same SP-SM as above except has dense sublayers, which contain weathered dolomite fragments (RESIDUAL).	15.0	
12	12.0	S-7	12.0-14.0	15-16-31-19	62	2.0/100	15.5					☀		16.0	
14	14.0	S-8	14.0-16.0	9-7-3-3	13	NR						☀		17.0	
16	16.0	S-9	16.0-18.0	17-27-9-8	47	1.0/50						☀		18.0	
18	18.0	S-10	18.0-20.0	6-12-15-17	35	1.8/88						☀		20.0	

SAMPLE LEGEND	
	SPT Sample
	Rock Core
	Bulk Sample
	Shelby Tube

GENERAL NOTES

Unable to continue boring due to angled borehole and offset at B-5A.
 Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (library).gpj | Date and Time: 12/11/20 16:05.



TEST BORING LOG

Test Boring: B-5
 Sheet: 2 of 2
 Elevation (ft): 310.00

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
	22	R-1		20.0-22.0	0/0		1.0/50						Buff silty gravel with sand (GM), weathered dolomite fragments (HIGHLY TO COMPLETELY WEATHERED DOLOMITE). DOLOMITE, buff, medium hard, moderately weathered, massive, closely spaced fractures. Bottom of borehole at 22.0'.	21.5 22.0	19'-20', deflecting Auger refusal at 20.0'. Top of Rock at 20.0' (EL. 290.0'). Unable to continue boring due to angled borehole.

SAMPLE LEGEND		GENERAL NOTES	
	SPT Sample	Unable to continue boring due to angled borehole and offset at B-5A. Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.	
	Rock Core		
	Bulk Sample		
	Shelby Tube		



TEST BORING LOG

Test Boring: B-5A
Sheet: 1 of 2
Elevation (ft): 310.00

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 **Date:** 10/01/20 - 10/01/20

Location: Chester County Library **Twp.:** W Whiteland **County:** Chester **State:** PA

Driller/Company: L.Davis/GeoStructures, Inc. **Rig Type:** Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. **Logged By:** EJS

Water Depth ∇ : During drilling (01/07/00) **Water Depth** : **Checked By:** EJS

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
305	2												Vibrated 3" ID steel casing to 20', used roller bit to clean out the soil plug, then sampled at 20.5'.		
300	10														S-5: wet spoon.
295	16														
290	18														

SAMPLE LEGEND		GENERAL NOTES	
<input type="checkbox"/>	SPT Sample	B-5A is offset towards north 4' from B-5, augered to 20.5' and started sampling. Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.	
<input checked="" type="checkbox"/>	Rock Core		
<input type="checkbox"/>	Bulk Sample		
<input type="checkbox"/>	Shelby Tube		

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\gint program & project data\projects\g20\g20-265 chester county geologic study (library).gpi | Date and Time: 12/11/20 16:05.



TEST BORING LOG

Test Boring: B-5A
 Sheet: 2 of 2
 Elevation (ft): 310.00

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\gint program & project data\projects\g2020\g20-265 chester county geologic study (library).gpi | Date and Time: 12/11/20 16:05.

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
22		S-1	20.5-22.5	25-20-12-16	42	1.6/80							Dense to very dense, buff, gravelly, poorly graded sand with silt (SP-SM), wet (RESIDUAL), gravel is weathered dolomite fragments.	20.5	
		S-2	22.5-23.3	29-50/3"		0.8/100	11.4							23.0	Top of Rock at 23.0' (EL. 287.0').
24		R-1	23.0-25.0	1/50		2.0/100							DOLOMITE, buff, medium hard, moderately weathered, massive, closely fractured (RD 70°).	24.0	Denuded or weathered fracture surface.
285		R-2	25.0-30.0	3.7/74		5.0/100							DOLOMITE, gray, hard, slightly to moderately weathered, massive but has undulating black mineral banding (RD 70°), medium to widely spaced fractures (RD 70°), few fractures at RD 20°.		Crystalline, mottled Dolomite.
280		R-3	30.0-32.5	0/0		2.3/92							DOLOMITE, buff, soft to medium hard, moderately to highly weathered, massive, closely fractured (Random).	30.0	Numerous, highly weathered fractures.
275		R-4	32.5-35.3	0/0		2.8/100									
		R-5	35.3-36.3	0/0		1.0/100								37.0	Soil seams (SP-SM), 35.0'-35.8', 36.25'-37.0', sand blockage prevented longer coring runs.
		R-6	36.3-39.8	2/57		3.5/100							DOLOMITE, gray to buff, medium hard to hard, slightly to moderately weathered, massive, closely to medium spaced fractures (RD 70° and 20°).		
														39.8	Bottom of borehole at 39.8'.

SAMPLE LEGEND

- SPT Sample
- Rock Core
- Bulk Sample
- Shelby Tube

GENERAL NOTES

B-5A is offset towards north 4' from B-5, augered to 20.5' and started sampling.
 Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.



TEST BORING LOG

Test Boring: B-6
 Sheet: 1 of 2
 Elevation (ft): 323.00

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 | Date and Time: 12/14/20 11:47. | Path: g:\field\git program & project data\project\g20-265 chester county geologic study (trail).gpl

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 Date: 10/19/20 - 10/19/20

Location: Chester Valley Trail Twp.: W. Whiteland County: Chester State: PA

Driller/Company: L. Davis/GeoStructures, Inc. Rig Type: Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. Logged By: JMR

Water Depth ∇ : 10' During drilling (10/19/20) Water Depth : Checked By: DWE

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
320	2	S-1	0.0-2.0	4-4-5-5	11	1.0/50						F <	Loose, blk. to lt. gy., well-graded gravel with sand (GW), dry to damp, contains angular pieces of gravel, cinders, and asphalt (FILL).	2.5	Interval for S-3 is only 1.5' because want to avoid bending spoon; will run auger down; there was a layer of dense sand with gravel, as captured in jar S-3.
	4	S-2	2.0-4.0	1-1-2-25	3	1.3/65					0.75	F <	Soft, dk. reddish brn. to brn., lean clay (CL) damp to moist, contains tr. angular rock gravel, degraded plant material, and randomly distributed layers of approximately 1"-thick poorly graded sand (FILL).		
	6	S-3	4.0-5.5	4-6-7	17	0.5/33	26.8	36 / 22	CL			F <			
315	8	S-4	6.0-8.0	2-1-2-3	3	1.7/84					1.5	F <		8.0	More gravel at the bottom of S-5.
	10	S-5	8.0-10.0	5-9-11-15	26	1.1/54					1.5	F <	Stiff to v. stiff, grayish brn. to yellowish brn., lean clay (CL), moist to v. moist, contains angular quartz gravel (RESIDUAL).	10.0	
	12	S-6	10.0-12.0	17-14-7-3	27	1.3/63						F <	Med. dense, brn. to lt. gy., well-graded sand with gravel (SW), damp, contains angular gravel (RESIDUAL).	12.0	Wet spoon at 10'.
310	14	S-7	12.0-14.0	1-2-2-2	5	1.0/50					1.0	F <	Soft, orange-brn., lean clay (CL), moist to v. moist, contains sand and gravel (RAVELED).		Raveled zones 12' to 24'.
	16	S-8	14.0-16.0	WOH		NR						F <		16.0	
	18	S-9	16.0-18.0	WOH-4-3-4	9	2.0/100	31.2	36 / 26	ML			F <	V. loose, olive yellow, poorly graded sand (SP), damp to moist. Has moist to wet, sandy silt (ML) sublayers (RAVELED).		
305	18	S-10	18.0-20.0	2-1-2-3	3	NR						F <			

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> SPT Sample Rock Core Bulk Sample Shelby Tube 	<p>B-6 was abandoned at 24.8' and offset 23'. Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.</p>

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (trail).gpi | Date and Time: 12/14/20 11:47.



TEST BORING LOG

Test Boring: B-6
Sheet: 2 of 2
Elevation (ft): 323.00

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
			S-11	20.0-22.0	3-5-4-10	11	NR						V. loose, olive yellow, poorly graded sand (SP), damp to moist. Has moist to wet, sandy silt (ML) sublayers (RAVELED). <i>(continued)</i>		
300	22		S-12	22.0-24.0	WOH-WOH-WOH-2	WOH	NR								
	24		S-13	24.0-24.8	6-50/4"		0.2/21						Dense to v. dense, yellowish brn. to dk. gy., poorly graded sand with gravel (SP), wet to saturated, contains angular fragments of gravel (COMPLETELY WEATHERED DOLOMITE). Bottom of borehole at 24.8'.	24.5 24.8	Spear head lost down hole at 24.8'. See adjacent B-6A log.

SAMPLE LEGEND	GENERAL NOTES
<input type="checkbox"/> SPT Sample <input checked="" type="checkbox"/> Rock Core <input type="checkbox"/> Bulk Sample <input type="checkbox"/> Shelby Tube	B-6 was abandoned at 24.8' and offset 23'. Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.



TEST BORING LOG

Test Boring: B-6A
Sheet: 1 of 3
Elevation (ft): 323.00

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 | Date and Time: 12/14/20 11:47: | Path: g:\field\gint program & project data\projects\g2020\g20-265 chester county geologic study (trail).gpl

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 **Date:** 10/20/20 - 10/20/20
Location: Chester Valley Trail **Twp.:** W. Whiteland **County:** Chester **State:** PA

Driller/Company: L. Davis/GeoStructures, Inc. **Rig Type:** Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. **Logged By:** JMR

Water Depth : **Water Depth :** **Checked By:** DWE

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks	
320	2												Unsampled (See B-6 log).		Continuation of aborted B-6 at offset location.	
315	4															
310	6															
305	8															
	10															
	12															
	14															
	16															
	18															
	19.5	X										//		19.5		Auger refusal and

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> <input type="checkbox"/> SPT Sample <input checked="" type="checkbox"/> Rock Core <input type="checkbox"/> Bulk Sample <input type="checkbox"/> Shelby Tube 	<p>B-6A starts at 19.5' and is offset 3' from B-6.</p> <p>Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.</p>

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (trail).gpj | Date and Time: 12/14/20 11:47.



TEST BORING LOG

Test Boring: B-6A
Sheet: 2 of 3
Elevation (ft): 323.00

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
300	22	X	R-1	19.5-21.5	0/0		1.5/75					▨	LEDGER FM. DOLOMITE, dk. gy. to lt. gy., med. hard to hard, slightly weathered to moderately weathered, med. to closely spaced fractures (RD 50° to horizontal). <i>(continued)</i>		Top of Rock at 19.5' (EL. 303.5'); Continued adjacent to B-6. 19.5' to 22': orange zones of oxidation along fracture surfaces Dark gray, mottled appearance throughout core. Completely fractured at approximately 22' to 26'.
	24		R-2	21.5-26.0	0.5/11		3.5/78					▨			
	26	X	R-3	26.0-26.5	0/0		0.5/100					▨			
295	28		R-4	26.5-32.0	1.75/32		5.0/91					▨			Orange oxidation stains on fracture surfaces from 26.5' to 32'.
	30														
290	32		R-5	32.0-37.0	2.9/58		4.4/88					▨			
	34														
	36											v	37.0	Void at 37' to 38.5'.	
	38											v	38.5		
285	40		R-6	38.5-42.0	0/0		NR					▨	Highly to completely weathered dolomite with raveled soil seams and possible void zones (washed away during coring).		38.5' to 42': Nothing substantial while drilling; suggested gravelly zones and voids.
	42														
280												▨			

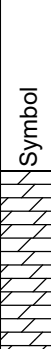

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> SPT Sample Rock Core Bulk Sample Shelby Tube 	<p>B-6A starts at 19.5' and is offset 3' from B-6. Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.</p>





Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\project\g20\g20-265 chester county geologic study (trail).gpj | Date and Time: 12/14/20 11:47.



TEST BORING LOG

Test Boring: B-6A
 Sheet: 3 of 3
 Elevation (ft): 323.00

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
46			R-7	42.0-47.0	0.83/17		3.6/72						LEDGER FM. DOLOMITE, dark to light gray, medium hard to hard, slightly to moderately weathered, med. to closely spaced fractures (RD 50° to horizontal), microcrystalline texture. (continued)		
275	48		R-8	47.0-52.0	1.17/23		3.2/63								
52													Bottom of borehole at 52.0'.	52.0	End of boring at 52'.

SAMPLE LEGEND		GENERAL NOTES	
	SPT Sample	B-6A starts at 19.5' and is offset 3' from B-6. Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.	
	Rock Core		
	Bulk Sample		
	Shelby Tube		



TEST BORING LOG

Test Boring: B-7
 Sheet: 1 of 3
 Elevation (ft): 323.00

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\git program & project data\project\g20-265 chester county geologic study (trail)\gpl | Date and Time: 12/14/20 11:47.

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 Date: 10/19/20 - 10/19/20

Location: Chester Valley Trail Twp.: W. Whiteland County: Chester State: PA

Driller/Company: L. Davis/GeoStructures, Inc. Rig Type: Geoprobe 7822DT, Automatic Safety Hammer.

Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. Logged By: JMR

Water Depth ∇ : 12' During drilling (10/19/20) Water Depth : Checked By: DWE

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
320	2	S-1	0.0-2.0	5-4-4-6	10	0.6/29						F < E	Loose, lt. gy. to blk., well-graded gravel with sand (GW), dry to damp, contains angular gravel cinders and sand (FILL).	3.5	Quartz gravel and sand observed in S-3.
	4	S-2	2.0-4.0	4-3-3-4	7	1.0/50					1.5	F < E			
	6	S-3	4.0-6.0	4-3-4-3	9	0.6/29	13.7	35 / 24	SC	1.0		F < E	Loose, reddish brn., clayey sand with gravel (SC), damp to moist, contains angular coarse sand, mica flakes, and plant material (FILL).	6.0	
315	8	S-4	6.0-8.0	2-2-2-2	5	0.7/34	23.7	34 / 25	ML	0.75		F < E	Med., brn., silt with sand (ML), moist to v. moist, contains mica flakes and tr. angular gravel (RESIDUAL).	8.5	Increased sand and gravel and 10'. Wet spoon at 12'.
	10	S-5	8.0-10.0	4-5-8-9	17	2.0/100						F < E	Med. dense to dense, brownish gy., silty sand with gravel (SM), moist to v. moist, micaceous, contains tr. angular gravel (RESIDUAL).		
	12	S-6	10.0-12.0	8-15-16-16	41	1.0/50	9.3					F < E			
310	14	S-7	12.0-14.0	12-5-5-6	13	1.5/75					2.0	F < E	Medium dense, brn., well-graded sand with gravel (SW), wet to saturated (RESIDUAL).	13.0	
	16	S-8	14.0-16.0	4-4-4-5	10	0.5/25	23.3	33 / 28	SM	1.0		F < E	Stiff, yellowish orange, lean clay (CL), moist, micaceous, contains tr. angular quartz gravel (RESIDUAL).	14.0	Relict banding and black gravel observed from 17' to 18'. Bent spoon,
	18	S-9	16.0-18.0	5-4-6-50	13	1.3/63					3.5	F < E	Medium dense, yellowish orange, silty sand with gravel (SM), wet to saturated, micaceous, contains tr. angular quartz gravel (RESIDUAL).	18.0	
305	19.5	S-10	18.0-19.5	12-20-50	93	1.5/100	17.5					F < E	Very stiff, yellowish orange, silt (ML), wet to saturated, micaceous, contains tr. angular quartz gravel (RESIDUAL).	19.0	

SAMPLE LEGEND SPT Sample Rock Core Bulk Sample Shelby Tube		GENERAL NOTES Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.
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Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g2020\g20-265 chester county geologic study (trail).gpj | Date and Time: 12/14/20 11:47.



TEST BORING LOG

Test Boring: B-7
Sheet: 2 of 3
Elevation (ft): 323.00

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
			R-1	19.5-21.5	1.25/63		1.8/88					[Symbol]	Dense to v. dense, white to black., poorly graded sand (SP), moist (RESIDUAL).		decided to core. Top of Rock 19.5' (EL. 303.5').
300	22		R-2	21.5-25.0	0.5/14		2.6/74					[Symbol]	LEDGER FM. DOLOMITE, gray to white, medium hard to hard, slightly to moderately weathered, with local highly weathered zones, medium to closely spaced fractures (RD 0° and 60° to vertical). (continued)		Highly weathered, dark gray region at 22'. Gray, mottled texture and color throughout core.
	24											[Symbol]		25.0	
	26		R-3	25.0-29.3	0/0		1.8/43					[Symbol]	LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).		Fragment of highly weathered rock at 26'.
295	28											[Symbol]	LEDGER FM. DOLOMITE, gray to white, medium hard to hard, slightly to moderately weathered, with local highly weathered zones, medium to closely spaced fractures (RD 0° and 60° to vertical).	27.5	
	30		R-4	29.3-31.5	0.92/42		2.0/91					[Symbol]			In R-4, increased weathered, dark gray sections that occur on opposite side of fractures.
	32											[Symbol]			
290	34		R-5	31.5-37.0	1.58/29		4.1/74					[Symbol]			In R-5, fewer fractures and no highly weathered pieces.
	36											[Symbol]			
	38		R-6	37.0-40.5	0.42/12		1.8/52					[Symbol]	LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).		
285	40											[Symbol]	LEDGER FM. DOLOMITE, gray to white, medium hard to hard, slightly to moderately weathered, with local highly weathered zones, medium to closely spaced fractures (RD 0° and 60° to vertical).	37.0	
	42											[Symbol]			Highly fractured (closely spaced, with RD near vertical).
280			R-7	40.5-45.5	1.16/23		4.6/92					[Symbol]		38.7	

SAMPLE LEGEND	
☐	SPT Sample
☒	Rock Core
■	Bulk Sample
■	Shelby Tube

GENERAL NOTES
 Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.



TEST BORING LOG

Test Boring: B-7
Sheet: 3 of 3
Elevation (ft): 323.00

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (trail).gpj | Date and Time: 12/14/20 11:47.

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
		X										▨	Bottom of borehole at 45.5'.	45.5	End of boring at 45.5'.

SAMPLE LEGEND	GENERAL NOTES
<ul style="list-style-type: none"> <input type="checkbox"/> SPT Sample <input checked="" type="checkbox"/> Rock Core <input type="checkbox"/> Bulk Sample <input type="checkbox"/> Shelby Tube 	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.



TEST BORING LOG

Test Boring: B-8
 Sheet: 1 of 3
 Elevation (ft): 323.00

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 | Date and Time: 12/14/20 11:47. | Path: g:\field\joint program & project data\project\g20-265 chester county geologic study (trail).gpj

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact Project No: G20-265 Date: 10/20/20 - 10/21/20
 Location: Chester Valley Trail Twp.: W. Whiteland County: Chester State: PA
 Driller/Company: L. Davis/GeoStructures, Inc. Rig Type: Geoprobe 7822DT, Automatic Safety Hammer.
 Drilling Methods: 3-1/4" I.D. Hollow Stem Auger, NQ2 Solid Rock Core Barrel. Logged By: JMR
 Water Depth ∇ : 6' During drilling (10/20/20) Water Depth : Checked By: DWE

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RQD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
320	2	S-1	0.0-2.0	22-10-9-8	25	0.8/38						F <	Med. dense, blk. to lt. gy., well-graded gravel with sand (GW), dry to damp, contains angular pieces of cinders, sand, and asphalt (FILL).	2.3	
	4	S-2	2.0-4.0	4-6-13-4	25	1.3/63					1.5	F <	Stiff, reddish brn. to tan, sandy lean clay (CL), damp to moist, contains angular gravel pieces and sand (FILL).	4.0	At 3.5': 3" layer of sandy gravel observed.
	6	S-3	4.0-6.0	WOH-1-2-2	3	NR						F <	Same CL as above except soft to v. soft (FILL).	6.0	Wet spoon at 6' (perched water at base of fill).
315	8	S-4	6.0-8.0	4-4-5-6	11	0.8/42					1.75	F <	Stiff, yellowish brn., silt (ML), damp to moist, contains tr. mica and sand grains (RESIDUAL).	8.0	More moist at 8'.
	10	S-5	8.0-10.0	5-5-5-5	13	1.3/67		24.4	35 / 25	ML	2.0	F <		10.0	Increased sand at 10'.
	12	S-6	10.0-12.0	2-2-1-1	3	1.6/79					0.25	F <	Soft, brn. to yellowish brn., sandy silt (ML), v. moist to wet to saturated, contains mica and angular sand and gravel (RESIDUAL).	12.0	
310	14	S-7	12.0-14.0	2-1-10-18	14	1.1/54						F <		13.0	
	16	S-8	14.0-16.0	18-5-3-2	10	0.7/34						F <	Med. dense, gy. to yellowish brn., well-graded sand with silt and gravel (SW-SM), wet to saturated, contains gravel-sized fragments of angular weathered rock (RESIDUAL).	16.0	
	18	S-9	16.0-18.0	5-6-9-18	19	0.8/42						F <		18.0	Started to core.
305	18	S-10	18.0-18.0	50/0"		NR						F <		18.0	Top of Rock at 18.0' (EL. 305.0').

SAMPLE LEGEND		GENERAL NOTES	
	SPT Sample	B-8 is offset to avoid power lines.	
	Rock Core	Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.	
	Bulk Sample		
	Shelby Tube		

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (trail).gpj | Date and Time: 12/14/20 11:47.



TEST BORING LOG

Test Boring: B-8
Sheet: 2 of 3
Elevation (ft): 323.00

Elevation (ft)	Depth (ft)	Sample Type Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
300	22	R-1	18.0-22.0	2.08/52		2.6/65						LEDGER FM. DOLOMITE, dark gray, medium to hard, slightly to moderately weathered with soft highly weathered seams, v. widely spaced fractures (RD 45° to 90°). <i>(continued)</i>	22.0	Dark gray, mottled appearance very prominent from 18' to 22'. Fractured surfaces show slight discoloration from oxidation at 21'. Void from 22' to 25.7'.
	24	R-2	22.0-27.0	1.08/22		1.3/26						Void.	25.7	
295	28	R-3	27.0-30.8	0/0		2.0/53						LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).	27.5	R-2 sample recovery came from end of the tube. Oxidation discoloration on fracture surfaces from 25.7' to 27'.
	30											LEDGER FM. DOLOMITE, dark gray, medium hard to hard, moderately to highly weathered, v. closely to widely spaced fractures (RD 60°, 70°, 90°, and horizontal).	30.8	
290	32	R-4	30.8-33.0	0/0		1.3/58						LEDGER FM. DOLOMITE, soft to very soft, highly to completely weathered (washed away during coring).	31.7	Becomes highly weathered and very closely fractured (rubble) at 30.75'. Increased rock quality with depth from 33' to 37'.
	34											LEDGER FM. DOLOMITE, dark gray, medium hard to hard, moderately to highly weathered, v. closely to widely spaced fractures (RD 60°, 70°, 90°, and horizontal).		
	36	R-5	33.0-37.0	0.92/23		3.8/94								Heavily oxidized fracture surfaces at 36'. Polygonal hairline fracture patterns on core surfaces. Fracture surfaces are slick, healed with minerals, and/or oxidized.
285	38	R-6	37.0-41.5	1.79/40		3.5/78								
280	42													

SAMPLE LEGEND

- SPT Sample
- Rock Core
- Bulk Sample
- Shelby Tube

GENERAL NOTES

B-8 is offset to avoid power lines.
 Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.

Project Name: Sunoco Mariner East 2 Pipeline Geotechnical Impact | Project Number: G20-265 | Path: g:\field\joint program & project data\projects\g20\g20-265 chester county geologic study (trail).gpj | Date and Time: 12/14/20 11:47.



TEST BORING LOG

Test Boring: B-8
Sheet: 3 of 3
Elevation (ft): 323.00

Elevation (ft)	Depth (ft)	Sample Type	Sample No.	Sample Interval (ft)	SPT Blows or RGD (ft/%)	SPT N ₆₀	Recovery (ft/%)	W _c (%)	LL/PL (%)	USCS/AASHTO	Strength (tsf)	Symbol	Material Description	Strata Div. (ft)	Remarks
	46	R-7		41.5-46.5	1.92/38		5.0/100						LEDGER FM. DOLOMITE, dark gray, medium hard to hard, moderately to highly weathered, v. closely to widely spaced fractures (RD 60°, 70°, 90°, and horizontal). (continued) Bottom of borehole at 46.5'.	46.5	Core is lighter in color towards the bottom of R-7, with yellow-orange oxidized fracture surfaces. End of boring at 46.5'.

SAMPLE LEGEND		GENERAL NOTES	
	SPT Sample	B-8 is offset to avoid power lines. Surface elevations are estimated from E&S and Utility Plan by The Kling Partnership dated 3/8/78 and E&S Plan prepared by TetraTech, dated 2/6/17.	
	Rock Core		
	Bulk Sample		
	Shelby Tube		



Photo 1. Cores of B-2 & B-1



Photo 3. Cores of B-5 & B-5A (R-1 to R-4)



ROCK CORE BOX PHOTO

CHESTER COUNTY LIBRARY
EXTON, CHESTER COUNTY, PENNSYLVANIA



Photo 2. Cores of B-5A (R-5 to R-6) & B-4 (R-1 to R-3)



Photo 3. Cores of B-4 (R-4 to R-9)



ROCK CORE BOX PHOTO

CHESTER COUNTY LIBRARY
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Photo 1. Cores of B-7 (R-1 to R-5)



Photo 2. Cores of B-7 (R-6 to R-7) & B-6A (R-1 to R-4)



ROCK CORE BOX PHOTO

CHESTER VALLEY TRAIL
EXTON, CHESTER COUNTY, PENNSYLVANIA



Photo 3. Cores of B-6A (R-4 to R-8)



Photo 3. Cores of B-6A (R-8) & B-8 (R-1 to R-5)



ROCK CORE BOX PHOTO

CHESTER VALLEY TRAIL
EXTON, CHESTER COUNTY, PENNSYLVANIA



Photo 3. Cores of B-8 (R-5 to R-7)



ROCK CORE BOX PHOTO

CHESTER VALLEY TRAIL
EXTON, CHESTER COUNTY, PENNSYLVANIA

Appendix B
Geotechnical Laboratory Testing Results

Summary of Index Properties

Boring	Sample	Depth (ft)	Water Content ¹	Ave.	Type	LL ²	PI ²	USCS ³
B-2	S-3 & S-4	4.0 - 8.0	16.4%	17.3%	Alluvial	30	10	CL
B-2	S-5	8.0 - 10.0	18.1%					
B-5	S-2 to S-4	3.0 - 7.0	4.3%	4.3%	Alluvial	N.P.	N.P.	GM
B-2	S-10 & S-12	18.0 - 24.0	19.2%	32.0%	Residual	32	11	SC
B-4	S-18	35.0 - 37.0	44.8%			37	10	ML
B-1	S-6	10.0 - 11.0	8.2%	10.4%	Residual			
B-3	S-14 & S-18	27.0 - 37.0	14.0%			N.P.	N.P.	SM
Composite*		16.0 - 53.0	9.0%			N.P.	N.P.	GM
B-4	S-5 & S-6	8.0 - 12.0	17.4%	14.8%	Residual	N.P.	N.P.	SM
B-5	S-7	12.0 - 14.0	15.5%					
B-5A	S-2	22.5 - 23.3	11.4%					

¹ ASTM D2216.

² ASTM D4318.

³ Upper case denotes classification per ASTM D2487; lower case is visual classification per ASTM D2488.

* Composite sample: B-2 S-16 (30.0'-30.6'), B-3 S-9 & S-10 (16.0' - 18.2'), B-3 S-24 & S-25 (49.0 - 53.0'), B-4 S-20 (39.0'-39.1').



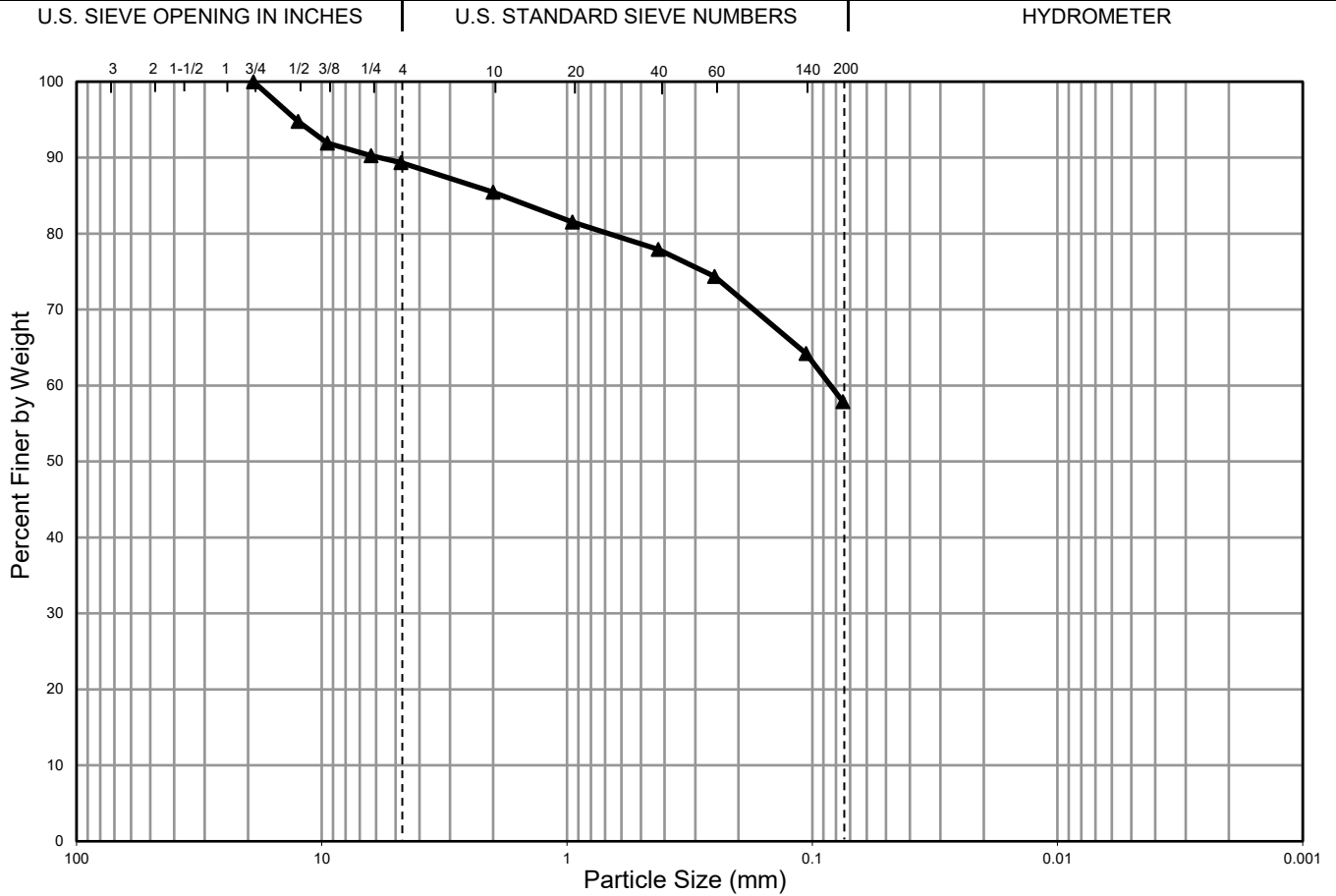
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Library

GeoStructures Project No: G20-265

Prepared By: VM

10/21/2020

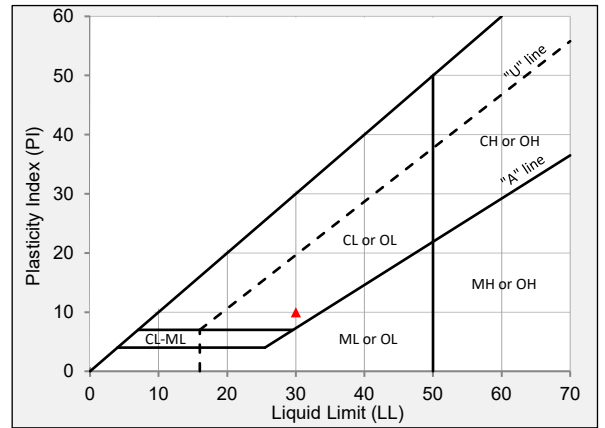
PARTICLE SIZE ANALYSIS OF SOILS



%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	10.6		31.5			57.9

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	
3/4"	100.0
1/2"	94.8
3/8"	91.9
1/4"	90.3
No. 4	89.4
No. 10	85.4
No. 20	81.5
No. 40	77.9
No. 60	74.3
No. 140	64.2
No. 200	57.9

Stratum	▲
Boring	B-2
Sample	S-3 & S-4
Depth (ft)	4.0 - 8.0
C _u	
C _c	
w (%)	16.4
LL	30
PL	20
PI	10
USCS	CL



▲	Color	USCS Group Name
	Brown	Sandy lean clay



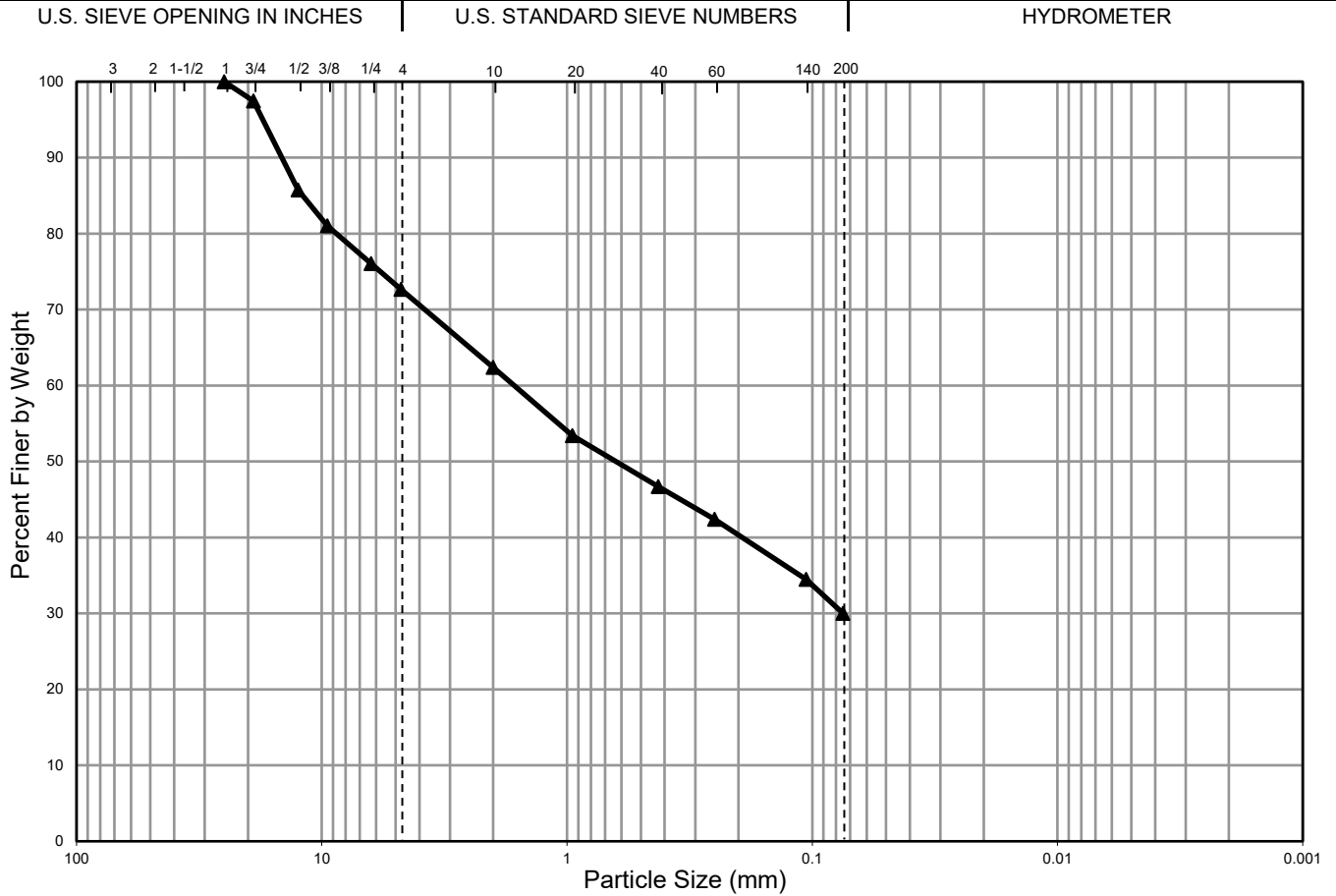
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Library

GeoStructures Project No.: G20-265

Tested By: VM

10/21/2020

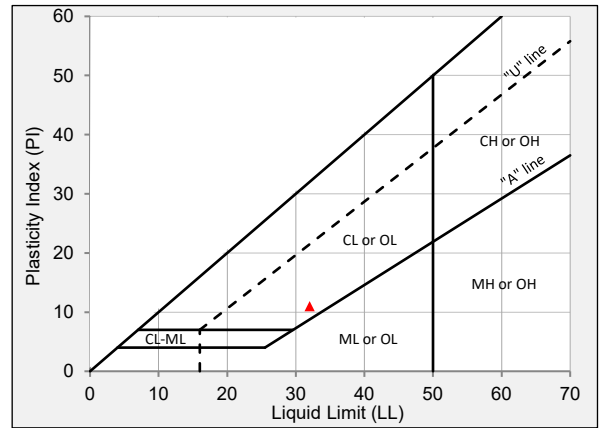
PARTICLE SIZE ANALYSIS OF SOILS



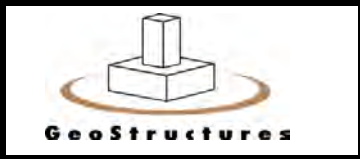
%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	27.3		42.6			30.0

Sieve	Percent Finer ▲
3"	
2"	
1-1/2"	
1"	100.0
3/4"	97.5
1/2"	85.8
3/8"	81.0
1/4"	76.1
No. 4	72.7
No. 10	62.4
No. 20	53.4
No. 40	46.7
No. 60	42.4
No. 140	34.5
No. 200	30.0

Stratum	▲ 3
Boring	B-2
Sample	S-10 & S-12
Depth (ft)	18.0 - 24.0
C _u	
C _c	
w (%)	19.2
LL	32
PL	21
PI	11
USCS	SC

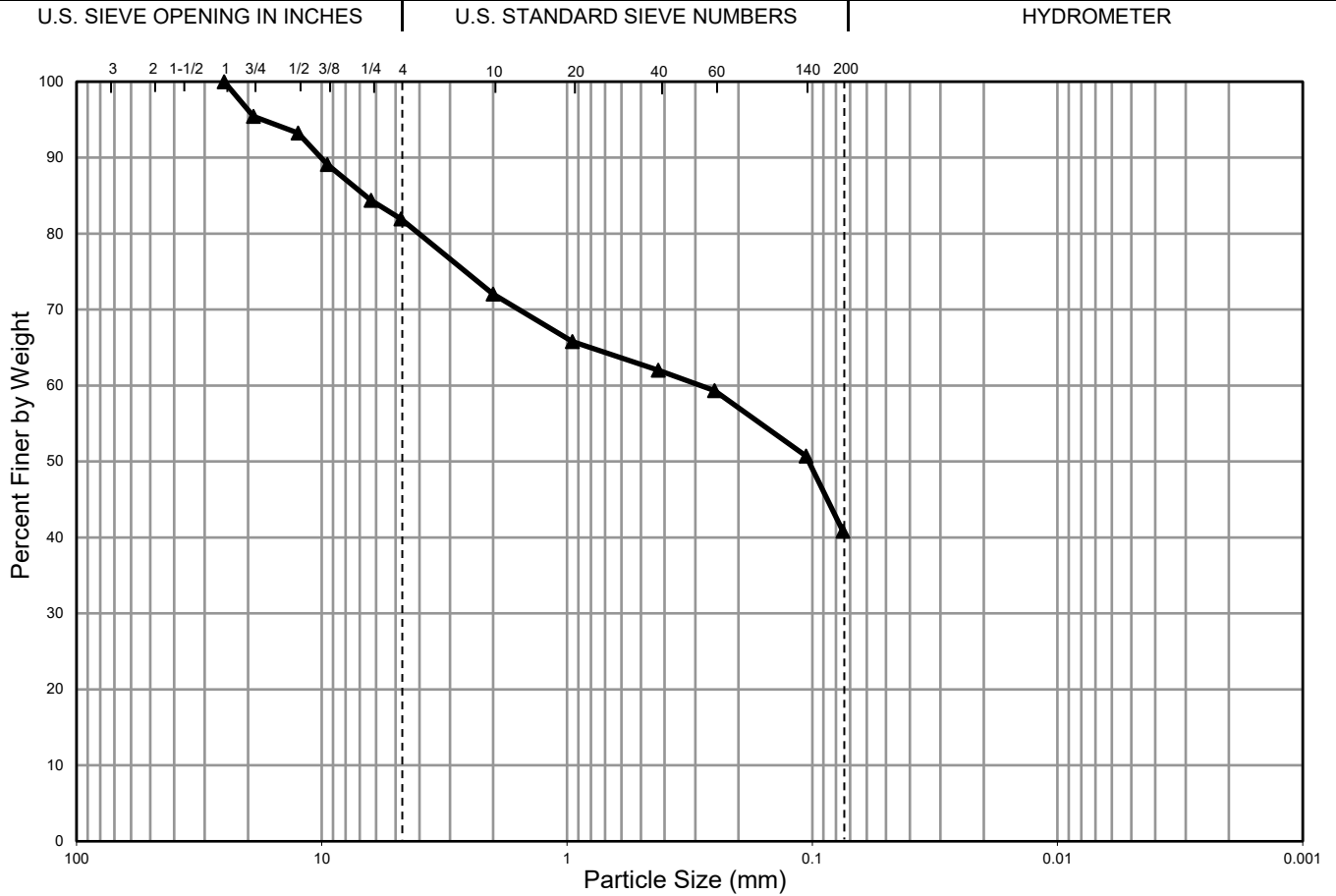


▲	Color	USCS Group Name
	Brown	Clayey sand with gravel



Sunoco Mariner East 2 Pipeline Geotechnical Impact - Library		
GeoStructures Project No.: G20-265	Tested By: VM	10/21/2020

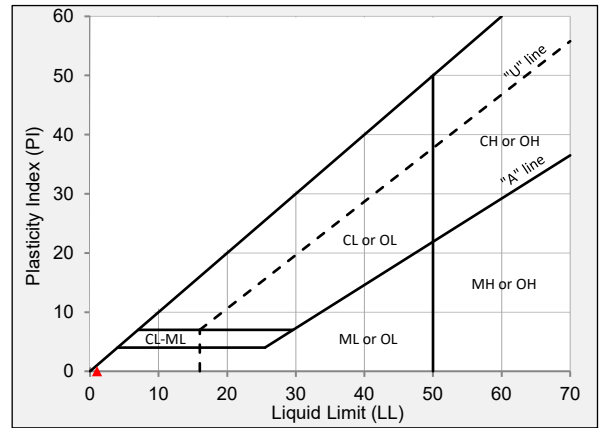
PARTICLE SIZE ANALYSIS OF SOILS



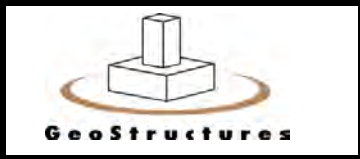
%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	18.1		41.1			40.8

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	100.0
3/4"	95.4
1/2"	93.2
3/8"	89.1
1/4"	84.4
No. 4	81.9
No. 10	72.1
No. 20	65.8
No. 40	62.0
No. 60	59.3
No. 140	50.7
No. 200	40.8

Stratum	▲
Boring	B-3
Sample	S-14 & S-18
Depth (ft)	27.0 - 37.0
C_u	
C_c	
w (%)	14.0
LL	N.P.
PL	N.P.
PI	N.P.
USCS	SM



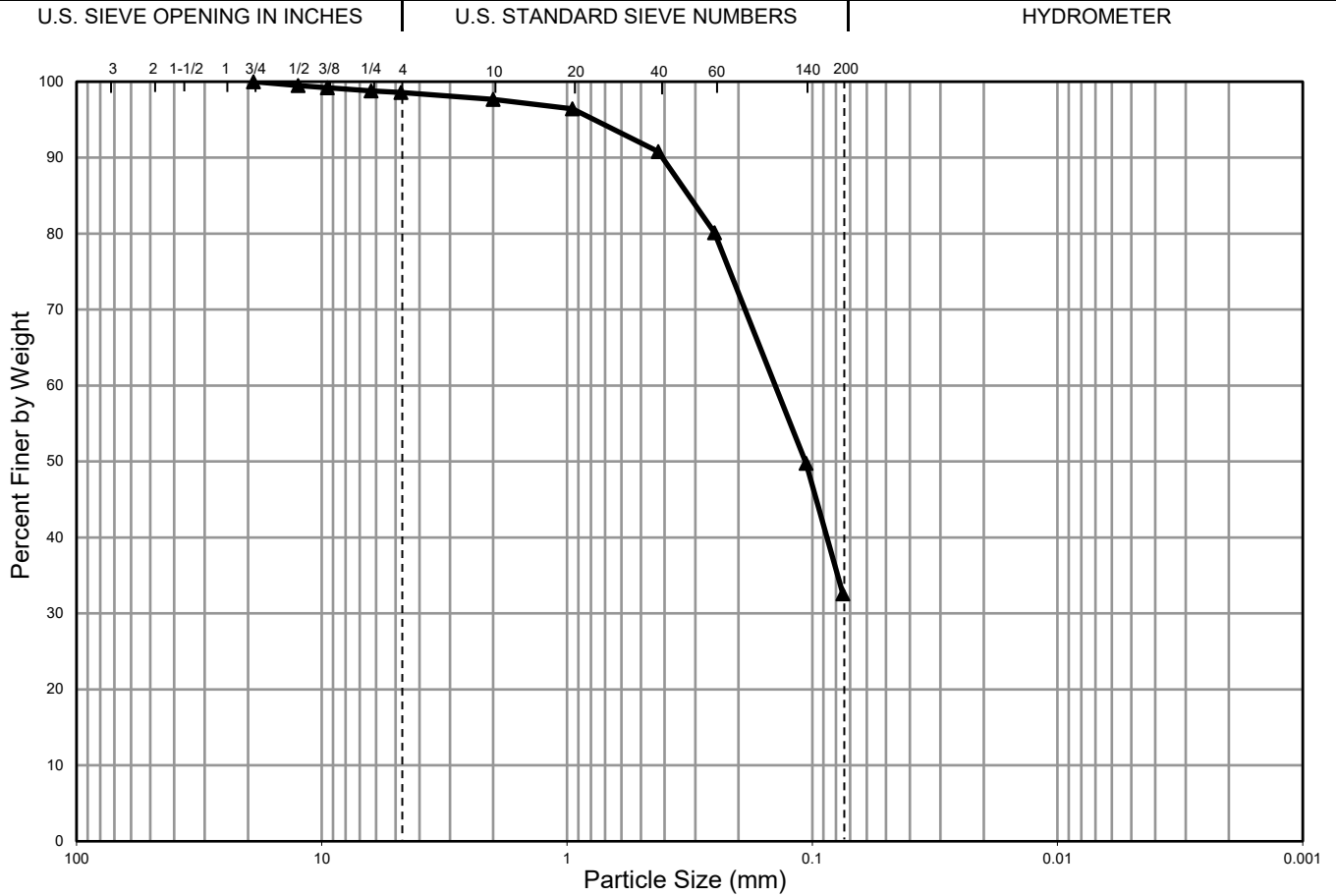
▲	Color Light whitish brown	USCS Group Name Silty sand with gravel
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Sunoco Mariner East 2 Pipeline Geotechnical Impact - Library

GeoStructures Project No.: G20-265	Tested By: VM	10/20/2020
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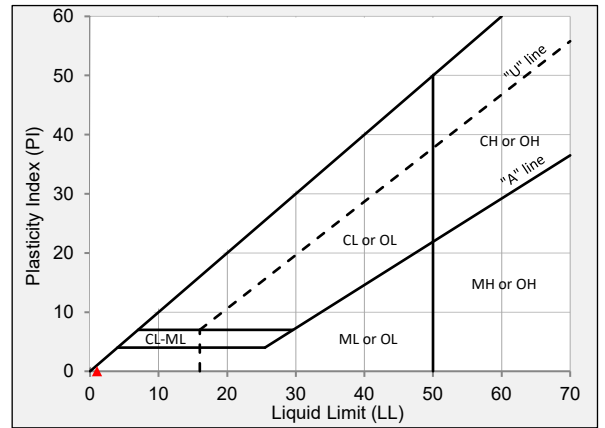
PARTICLE SIZE ANALYSIS OF SOILS



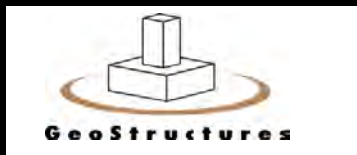
%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	1.4		66.0			32.6

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	
3/4"	100.0
1/2"	99.5
3/8"	99.2
1/4"	98.8
No. 4	98.6
No. 10	97.6
No. 20	96.4
No. 40	90.8
No. 60	80.1
No. 140	49.8
No. 200	32.6

Stratum	▲ 4B
Boring	B-4
Sample	S-5 & S-6
Depth (ft)	8.0 - 12.0
C _u	
C _c	
w (%)	17.4
LL	N.P.
PL	N.P.
PI	N.P.
USCS	SM



▲	Color	USCS Group Name
	Light yellowish brown	Silty sand



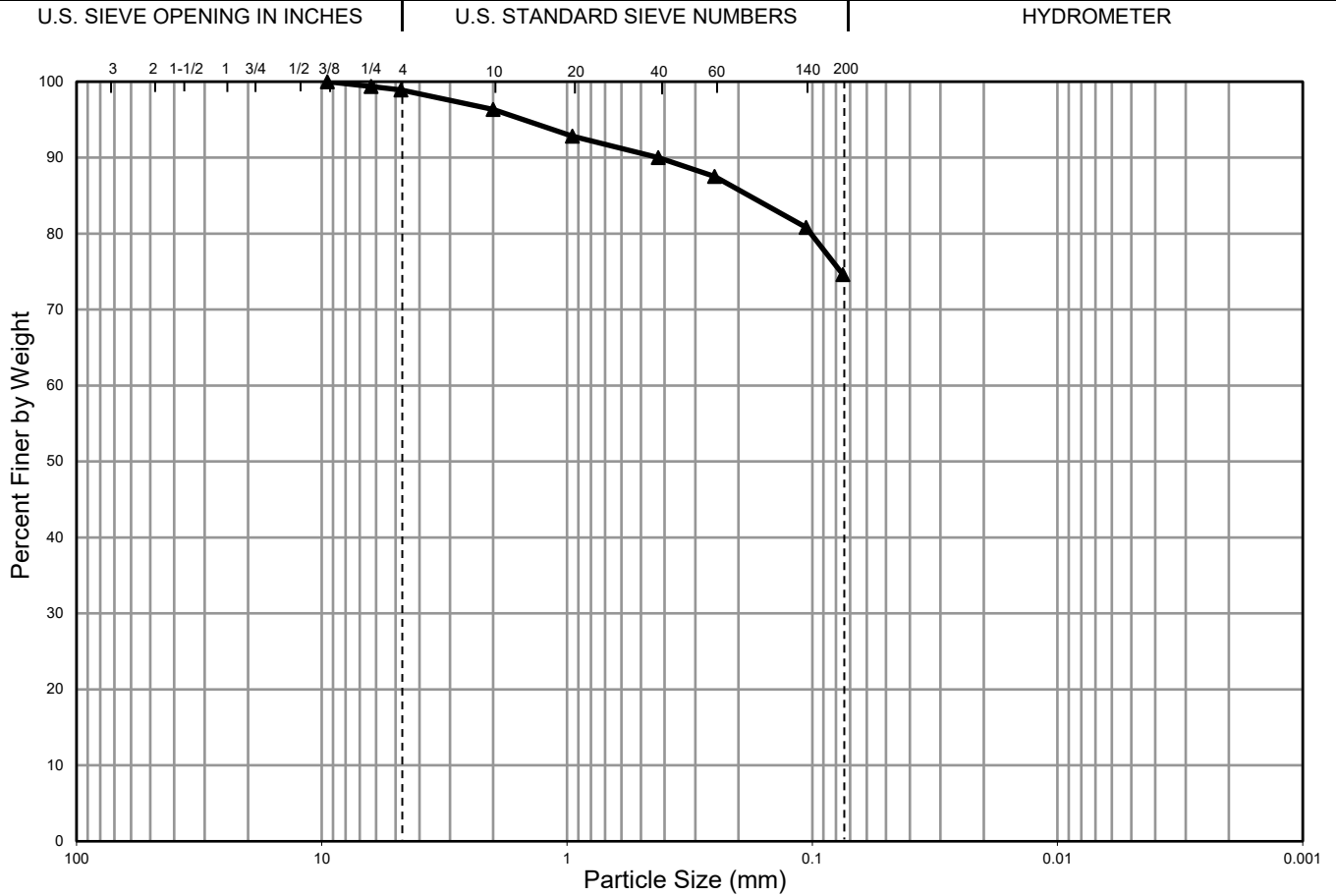
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Library

GeoStructures Project No.: G20-265

Tested By: VM

10/20/2020

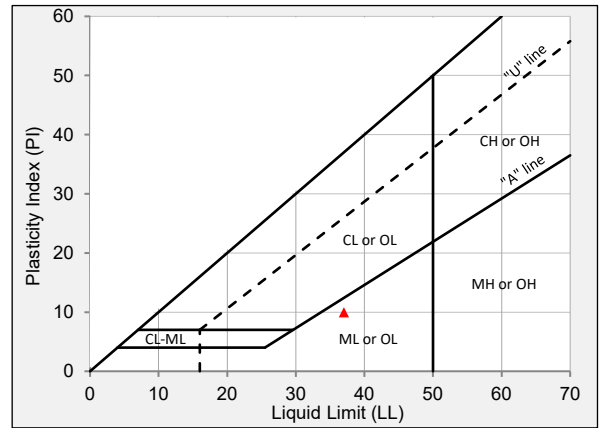
PARTICLE SIZE ANALYSIS OF SOILS



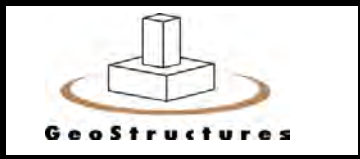
%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	1.1		24.3			74.6

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	
3/4"	
1/2"	
3/8"	100.0
1/4"	99.4
No. 4	98.9
No. 10	96.3
No. 20	92.8
No. 40	90.0
No. 60	87.5
No. 140	80.8
No. 200	74.6

Stratum	▲
Boring	B-4
Sample	S-18
Depth (ft)	35.0 - 37.0
C _u	
C _c	
w (%)	44.8
LL	37
PL	27
PI	10
USCS	ML

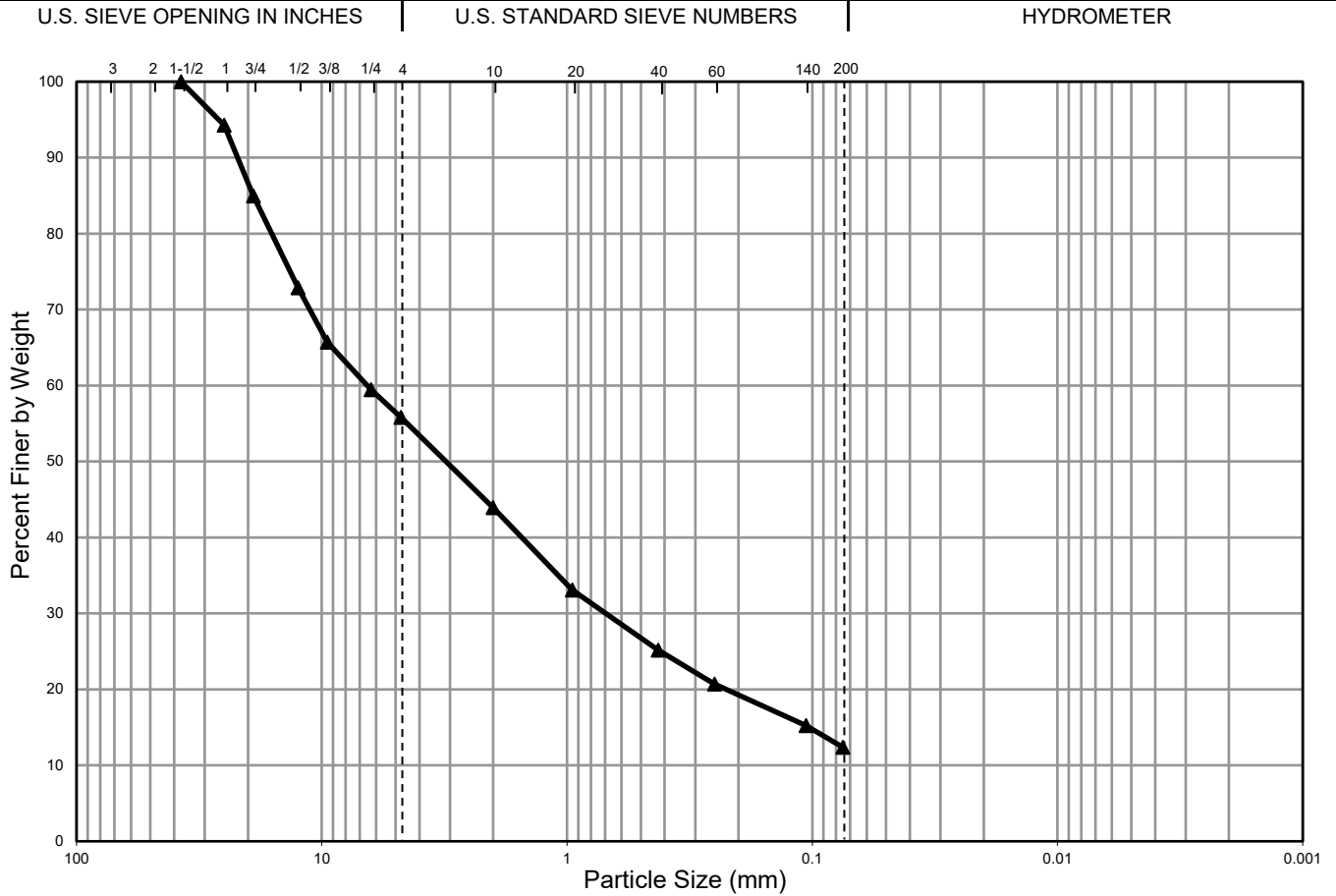


	Color	USCS Group Name
▲	Brown	Silt with sand



Sunoco Mariner East 2 Pipeline Geotechnical Impact - Library		
GeoStructures Project No.: G20-265	Tested By: VM	10/21/2020

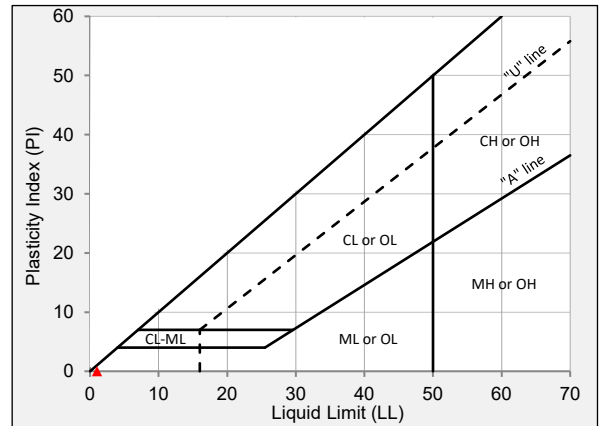
PARTICLE SIZE ANALYSIS OF SOILS



%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	44.2		43.4			12.4

Sieve	Percent Finer
	▲
3"	
2"	
1.5"	100.0
1"	94.3
0.75"	84.9
0.5"	72.8
0.375"	65.7
0.25"	59.4
No. 4	55.8
No. 10	43.9
No. 20	33.1
No. 40	25.2
No. 60	20.7
No. 140	15.2
No. 200	12.4

Stratum	▲ 2A
Boring	B-5
Sample	S-2 to S-4
Depth (ft)	3.0 - 7.0
C _u	
C _c	
w (%)	4.3
LL	N.P.
PL	N.P.
PI	N.P.
USCS	GM



▲	Color	USCS Group Name
	Brown	Silty gravel with sand



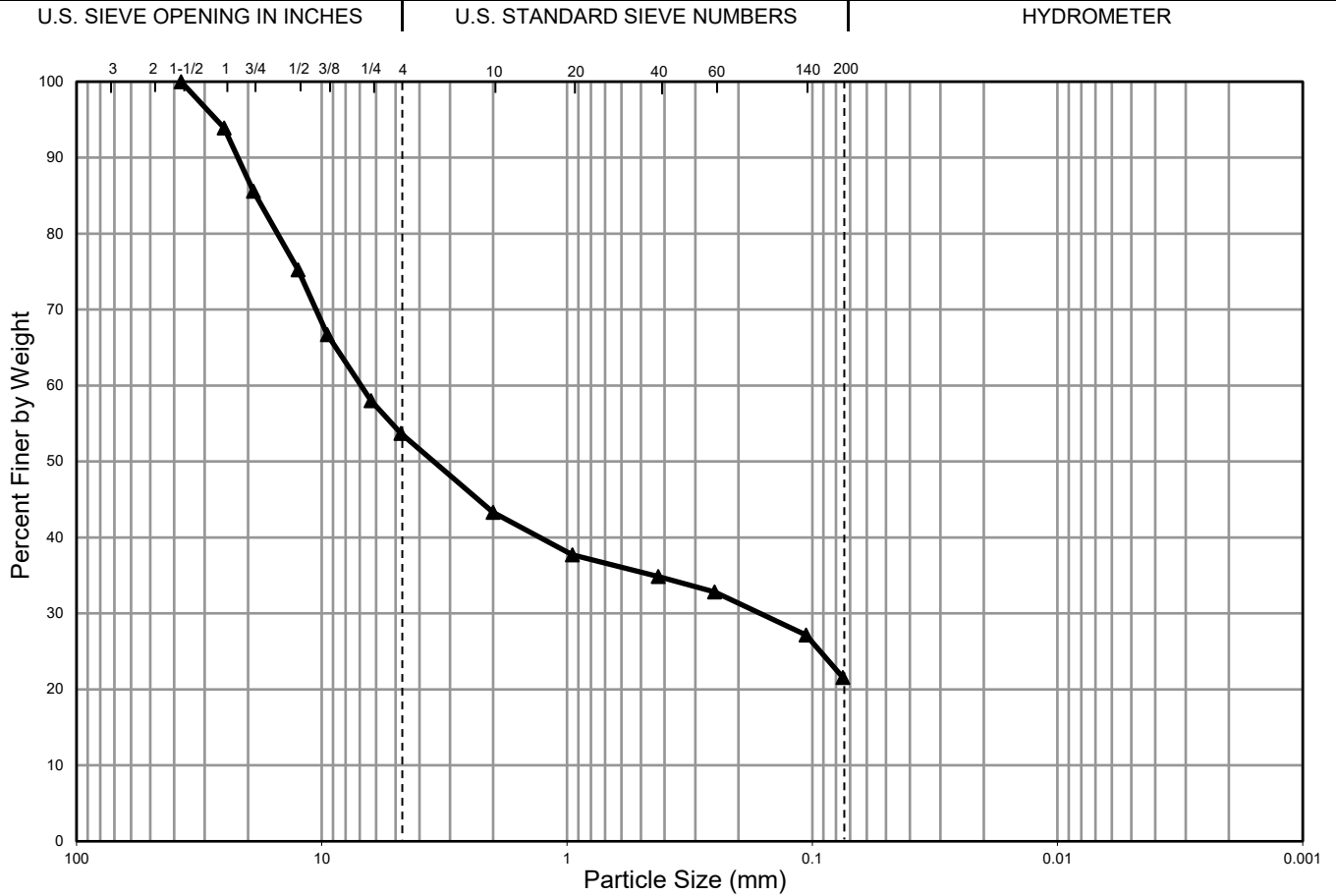
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Library

GeoStructures Project No.: G20-265

Tested By: VM

10/20/2020

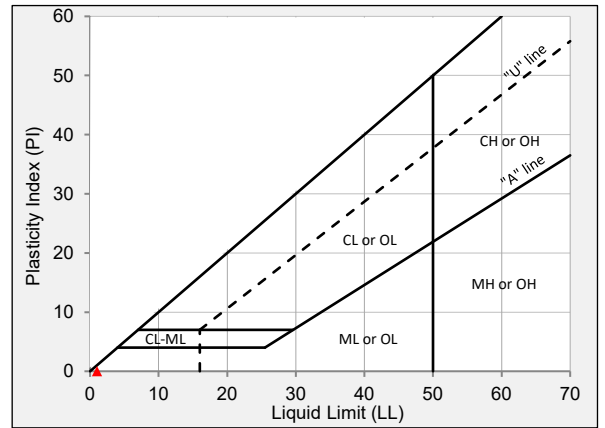
PARTICLE SIZE ANALYSIS OF SOILS



%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	46.3		32.1			21.6

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	100.0
1"	93.9
3/4"	85.6
1/2"	75.2
3/8"	66.7
1/4"	58.0
No. 4	53.7
No. 10	43.3
No. 20	37.7
No. 40	34.8
No. 60	32.8
No. 140	27.2
No. 200	21.6

Stratum	▲
Boring	Composite
Sample Depth (ft)	16.0 - 53.0
C _u	
C _c	
w (%)	9.0
LL	N.P.
PL	N.P.
PI	N.P.
USCS	GM



▲	Color	USCS Group Name
	Light yellowish brown	Silty gravel with sand



Sunoco Mariner East 2 Pipeline Geotechnical Impact - Library

GeoStructures Project No.: G20-265

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10/20/2020

Summary of Index Properties

Boring	Sample	Depth (ft)	Water Content ¹	Ave.	Type	LL ²	PI ²	USCS ³
B-6	S-2 & S-4	2.0 - 8.0	26.8%	21.6%	Alluvial	36	14	CL
B-7	S-2 & S-3	2.0 - 6.0	13.7%			35	11	SC
B-8	S-4 & S-5	6.0 - 10.0	24.4%			35	10	ML
B-6	S-9	16.0 - 18.0	31.2%	31.2%	Residual	36	10	ML
B-7	S-10	18.0 - 19.5	17.5%	20.4%	Residual			SM
B-7	S-8 & S-9	14.0 - 18.0	23.3%			33	5	SM
B-7	S-4	6.0 - 8.0	23.7%	15.5%	Residual	34	9	ML
B-7	S-5 & S-6	8.0 - 12.0	9.3%					SM
B-8	S-8 & S-9	14.0 - 18.0	13.4%					SM

¹ ASTM D2216.

² ASTM D4318.

³ Upper case denotes classification per ASTM D2487; lower case is visual classification per ASTM D2488.



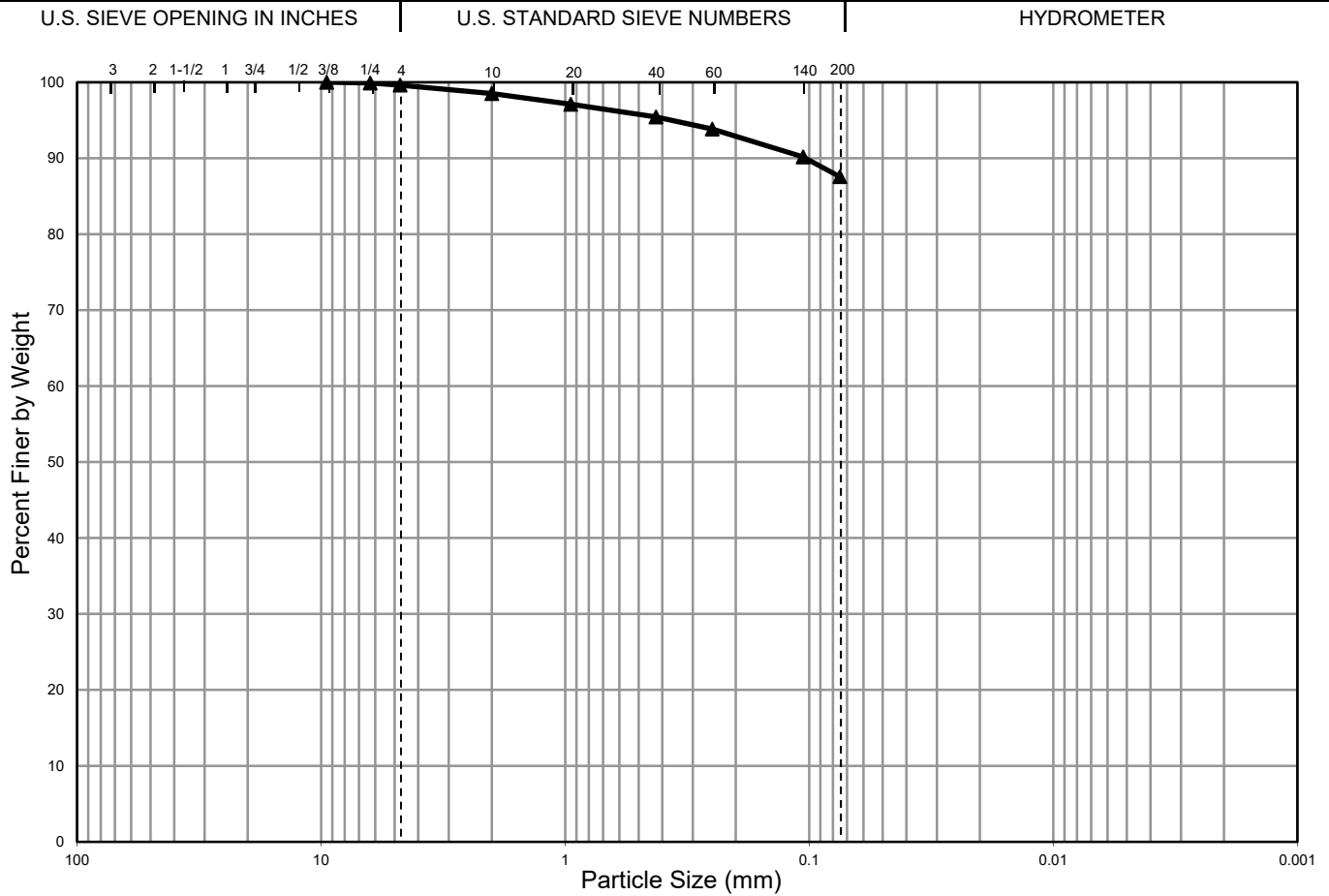
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Valley Trail

GeoStructures Project No: G20-265

Prepared By: VM

11/15/2020

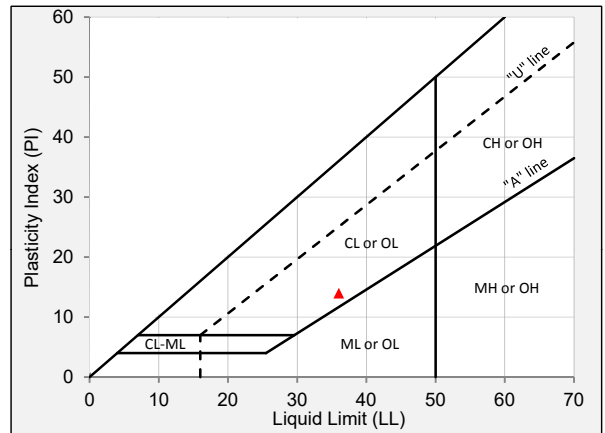
PARTICLE SIZE ANALYSIS OF SOILS



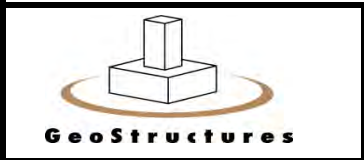
%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	0.4		12.1			87.6

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	
3/4"	
1/2"	
3/8"	100.0
1/4"	99.9
No. 4	99.6
No. 10	98.5
No. 20	97.1
No. 40	95.4
No. 60	93.8
No. 140	90.2
No. 200	87.6

Stratum	▲
Boring	B-6
Sample	S-2 & S-4
Depth (ft)	2.0 - 8.0
C_u	
C_c	
w (%)	26.8
LL	36
PL	22
PI	14
USCS	CL



	Color	USCS Group Name
▲	Brown	Lean clay



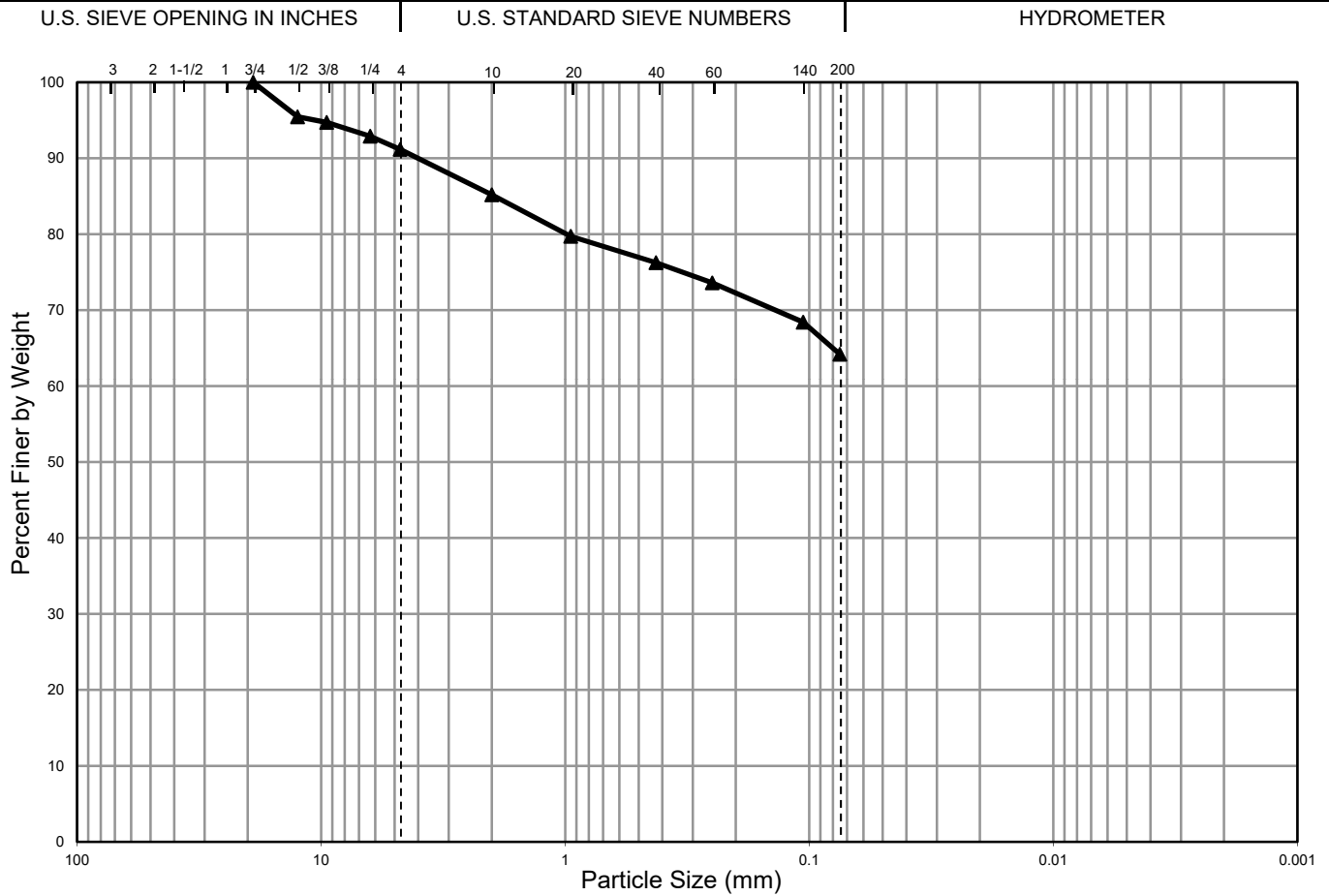
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Valley Trail

GeoStructures Project No.: G20-265

Tested By: VM

11/15/2020

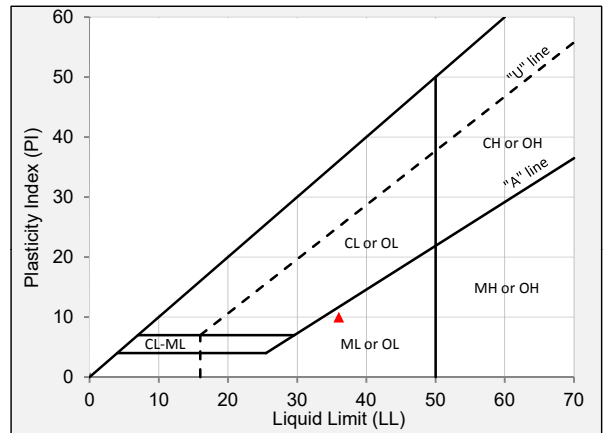
PARTICLE SIZE ANALYSIS OF SOILS



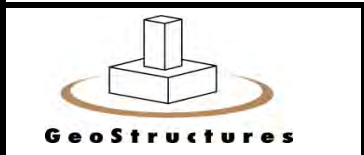
%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	8.8		27.0			64.2

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	
3/4"	100.0
1/2"	95.4
3/8"	94.7
1/4"	92.9
No. 4	91.2
No. 10	85.2
No. 20	79.7
No. 40	76.2
No. 60	73.6
No. 140	68.4
No. 200	64.2

Stratum	▲
Boring	B-6
Sample	S-9
Depth (ft)	16.0 - 18.0
C _u	
C _c	
w (%)	31.2
LL	36
PL	26
PI	10
USCS	ML



	Color	USCS Group Name
▲	Yellowish brown	Sandy silt



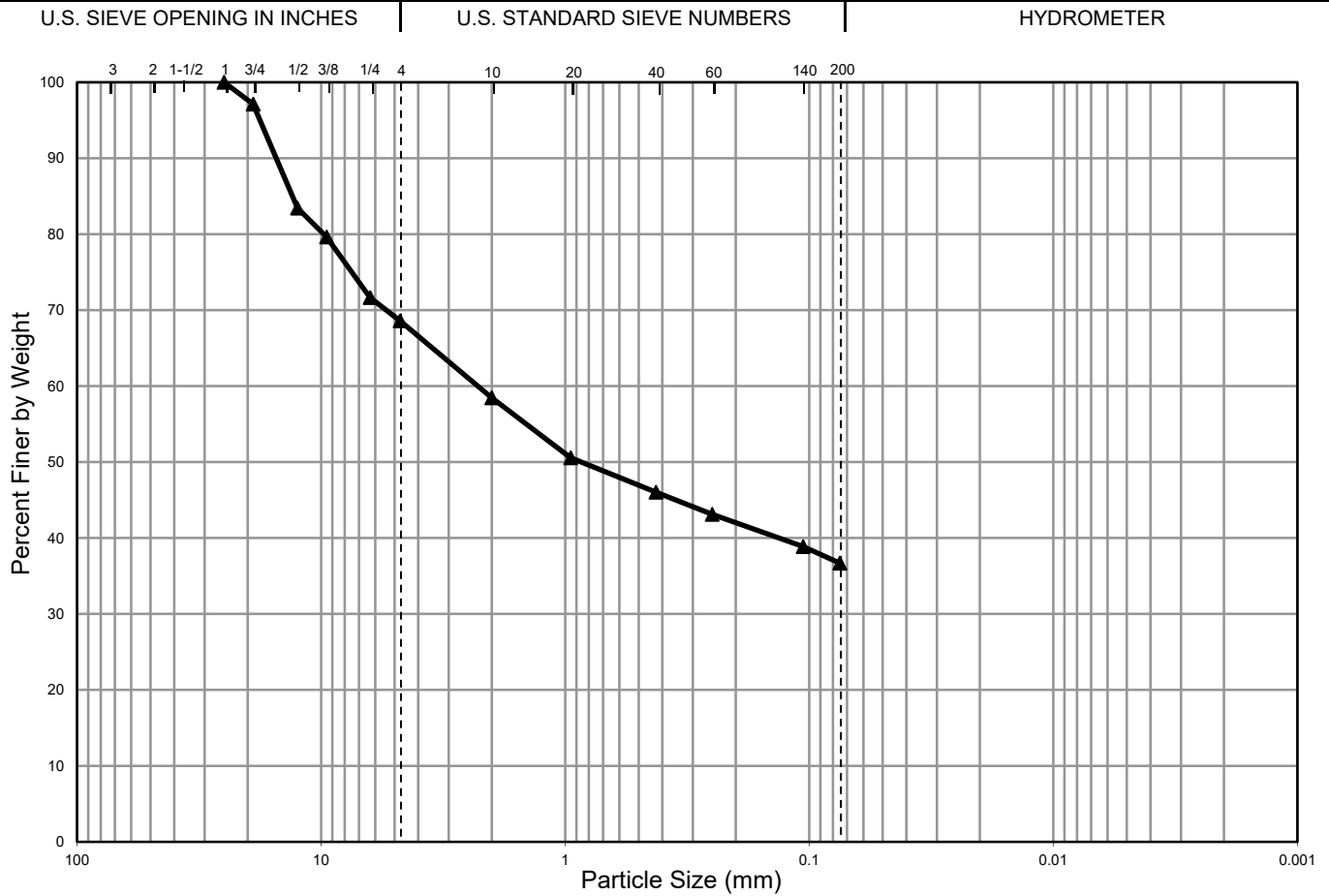
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Valley Trail

GeoStructures Project No.: G20-265

Tested By: VM

11/15/2020

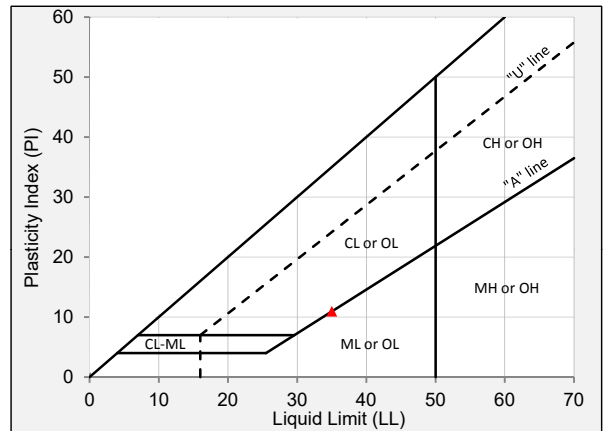
PARTICLE SIZE ANALYSIS OF SOILS



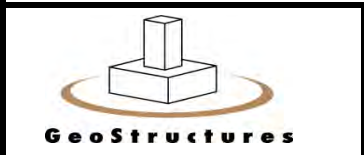
%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	31.4		31.9			36.7

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	100.0
3/4"	97.1
1/2"	83.4
3/8"	79.6
1/4"	71.7
No. 4	68.6
No. 10	58.5
No. 20	50.6
No. 40	46.0
No. 60	43.1
No. 140	38.9
No. 200	36.7

Stratum	▲
Boring	B-7
Sample	S-2 & S-3
Depth (ft)	2.0 - 6.0
C _u	
C _c	
w (%)	13.7
LL	35
PL	24
PI	11
USCS	SC



	Color	USCS Group Name
▲	Reddish brown	Clayey sand with gravel



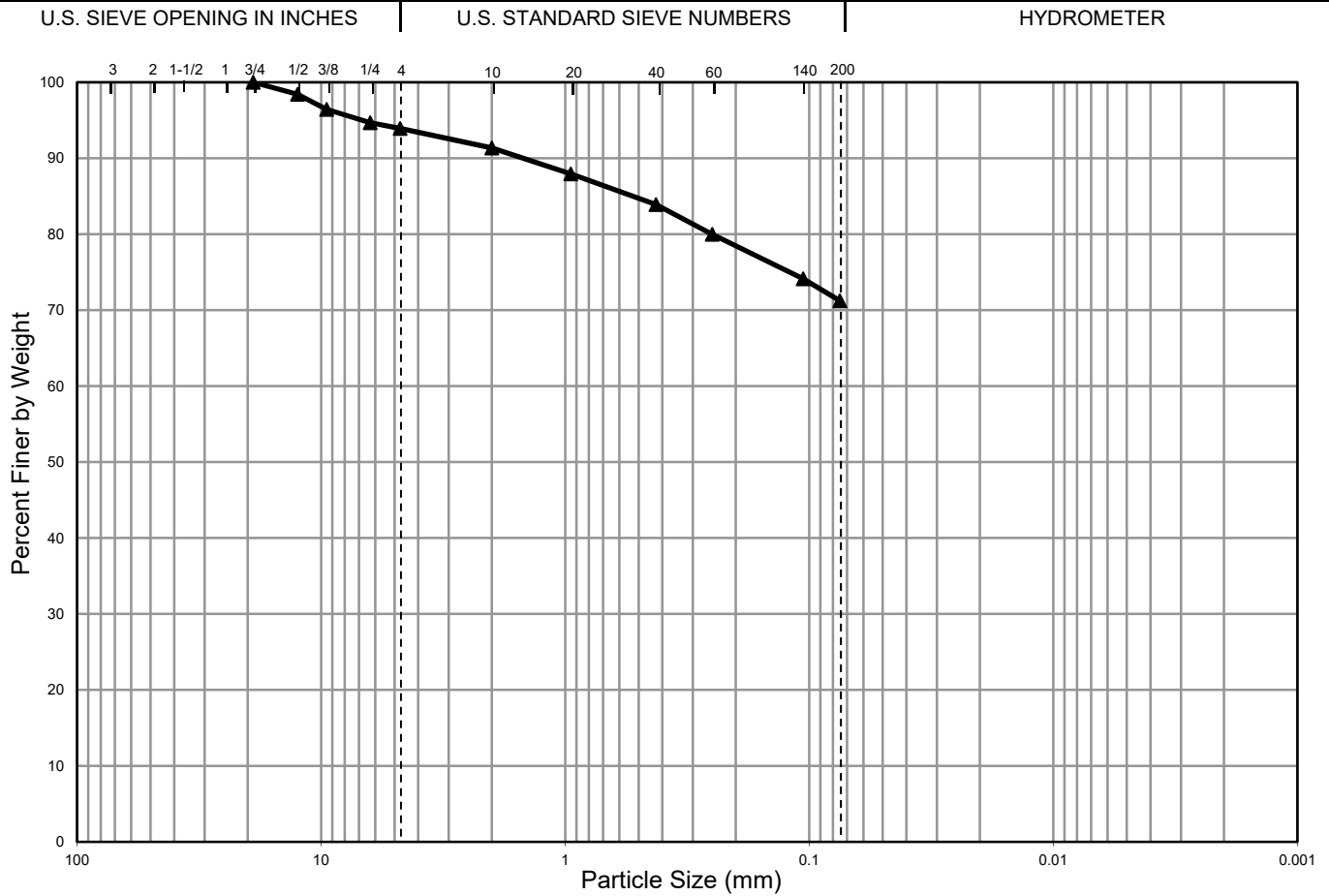
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Valley Trail

GeoStructures Project No.: G20-265

Tested By: VM

11/15/2020

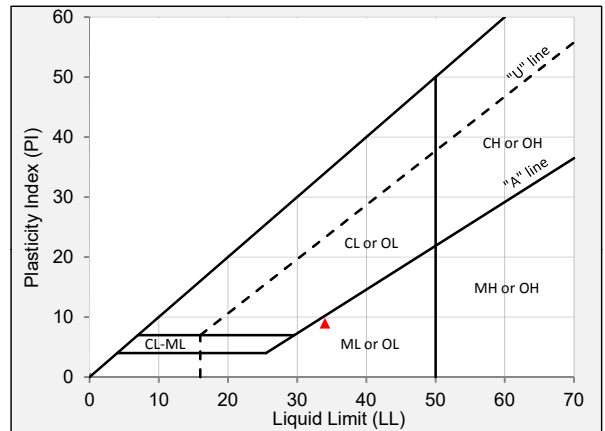
PARTICLE SIZE ANALYSIS OF SOILS



%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	6.1		22.7			71.2

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	
3/4"	100.0
1/2"	98.4
3/8"	96.4
1/4"	94.7
No. 4	93.9
No. 10	91.3
No. 20	87.9
No. 40	83.9
No. 60	80.0
No. 140	74.1
No. 200	71.2

Stratum	▲
Boring	B-7
Sample	S-4
Depth (ft)	6.0 - 8.0
C _u	
C _c	
w (%)	23.7
LL	34
PL	25
PI	9
USCS	ML



	Color	USCS Group Name
▲	Brown	Silt with sand



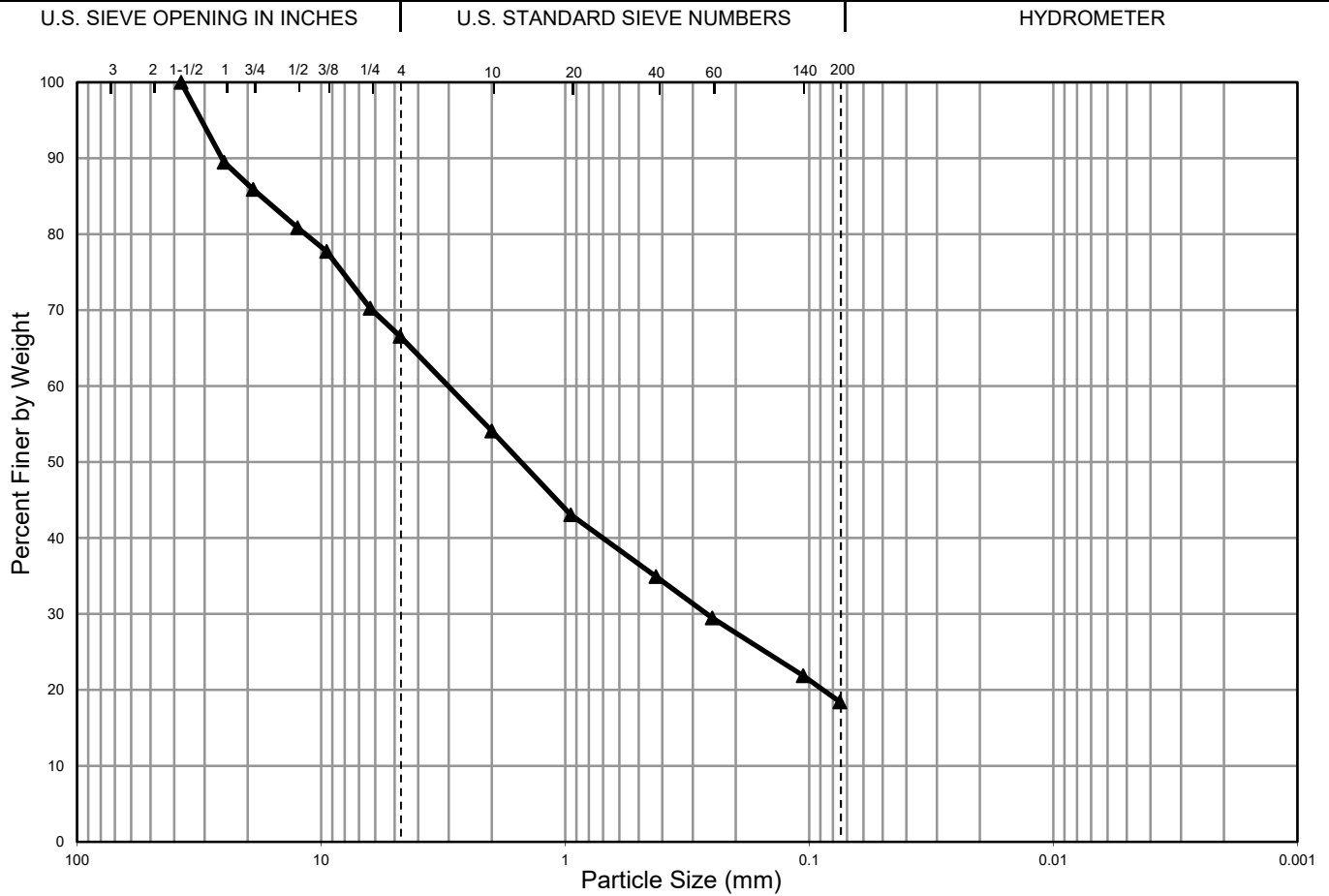
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Valley Trail

GeoStructures Project No.: G20-265

Tested By: VM

11/15/2020

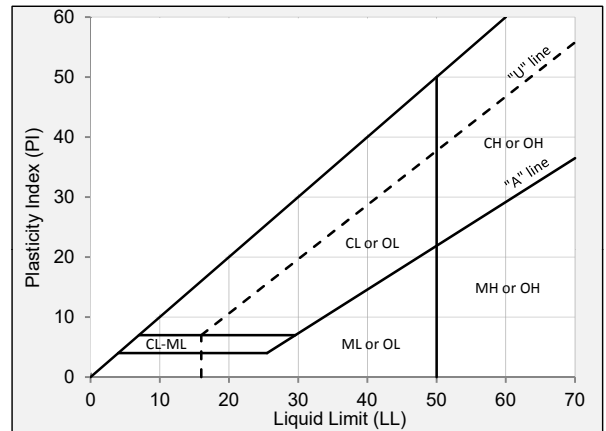
PARTICLE SIZE ANALYSIS OF SOILS



%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	33.4		48.1			18.4

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	100.0
1"	89.5
3/4"	85.9
1/2"	80.9
3/8"	77.7
1/4"	70.3
No. 4	66.6
No. 10	54.1
No. 20	43.1
No. 40	34.9
No. 60	29.5
No. 140	21.9
No. 200	18.4

Stratum	▲
Boring	4A
Sample	S-5 & S-6
Depth (ft)	9.0 - 12.0
C _u	
C _c	
w (%)	9.3
LL	
PL	
PI	
USCS	SM



	Color	USCS Group Name
▲	Brown	Silty sand with gravel



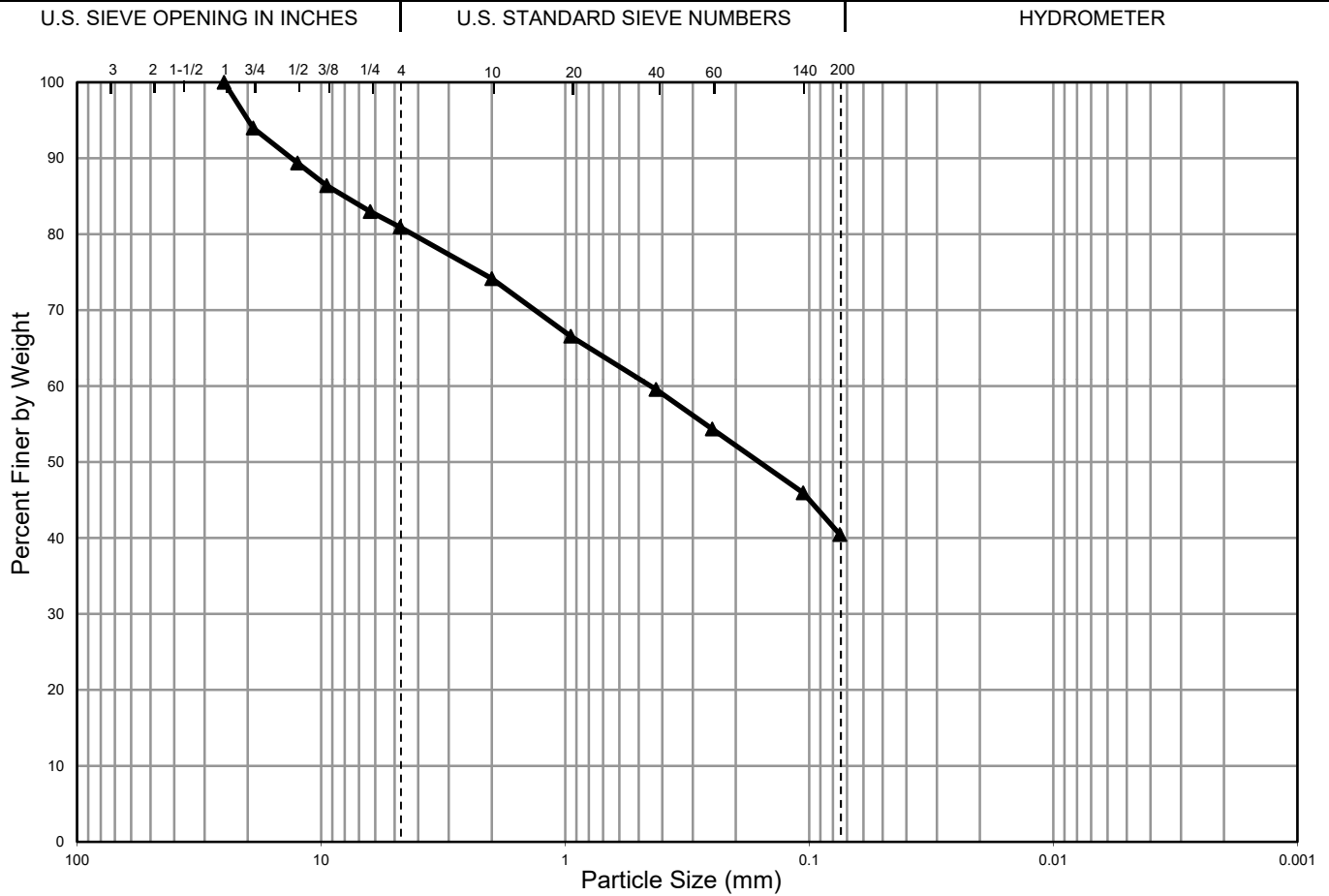
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Valley Trail

GeoStructures Project No.: G20-265

Tested By: VM

11/12/2020

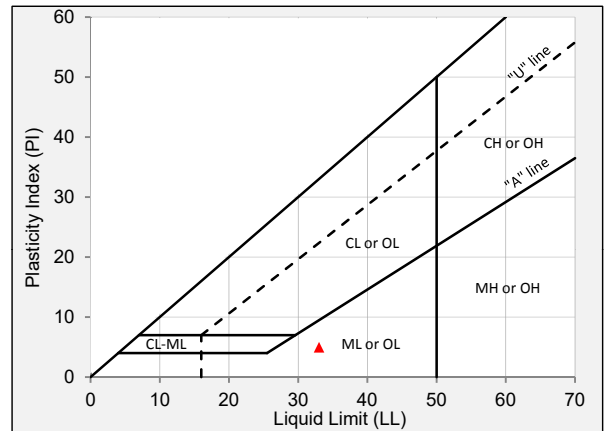
PARTICLE SIZE ANALYSIS OF SOILS



%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	19.1		40.5			40.5

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	100.0
3/4"	94.0
1/2"	89.4
3/8"	86.4
1/4"	83.0
No. 4	80.9
No. 10	74.2
No. 20	66.6
No. 40	59.6
No. 60	54.4
No. 140	45.9
No. 200	40.5

Stratum	▲ 4A
Boring	B-7
Sample	S-8 & S-9
Depth (ft)	14.0 - 18.0
C_u	
C_c	
w (%)	23.3
LL	33
PL	28
PI	5
USCS	SM



	Color	USCS Group Name
▲	Yellowish brown	Silty sand with gravel



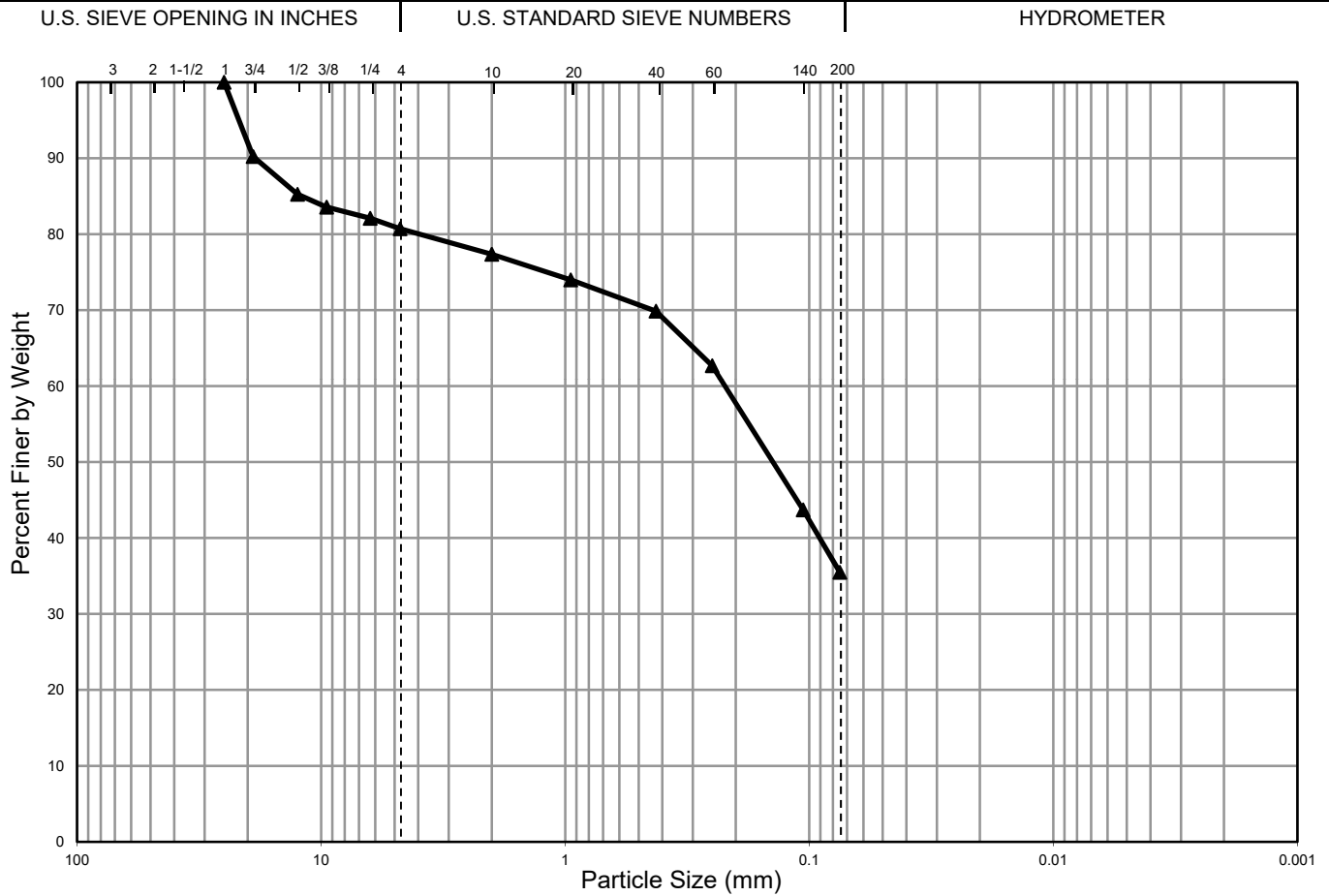
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Valley Trail

GeoStructures Project No.: G20-265

Tested By: VM

11/15/2020

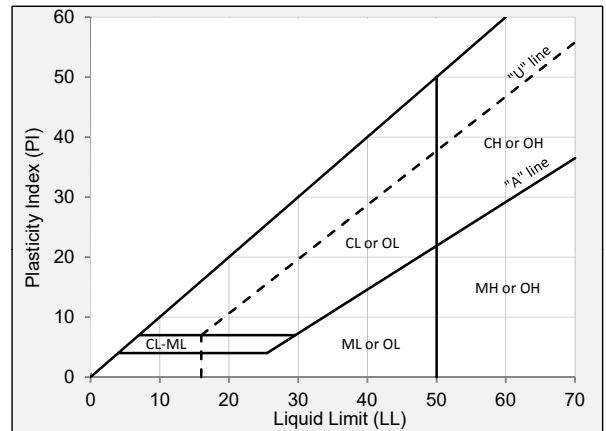
PARTICLE SIZE ANALYSIS OF SOILS



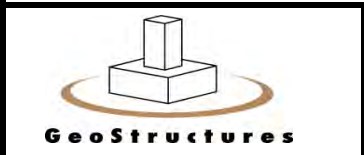
%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	19.3		45.2			35.5

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	
1"	100.0
3/4"	90.2
1/2"	85.2
3/8"	83.6
1/4"	82.1
No. 4	80.7
No. 10	77.4
No. 20	74.0
No. 40	69.9
No. 60	62.7
No. 140	43.7
No. 200	35.5

Stratum	▲
Boring	B-7
Sample	S-10
Depth (ft)	18.0 - 19.5
C _u	
C _c	
w (%)	17.5
LL	
PL	
PI	
USCS	SM



	Color	USCS Group Name
▲	Brown	Silty sand with gravel



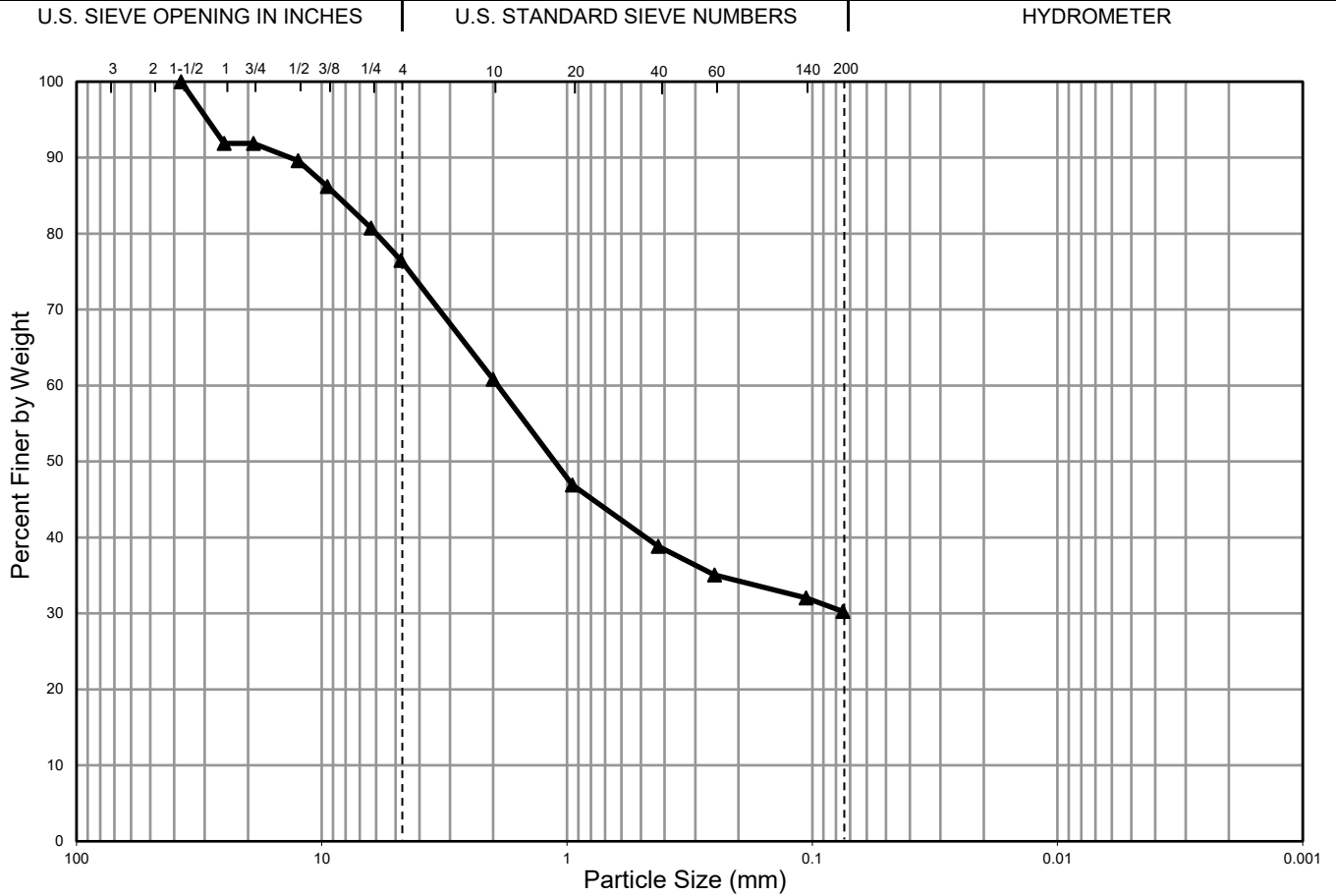
Sunoco Mariner East 2 Pipeline Geotechnical Impact - Valley Trail

GeoStructures Project No.: G20-265

Tested By: VM

11/12/2020

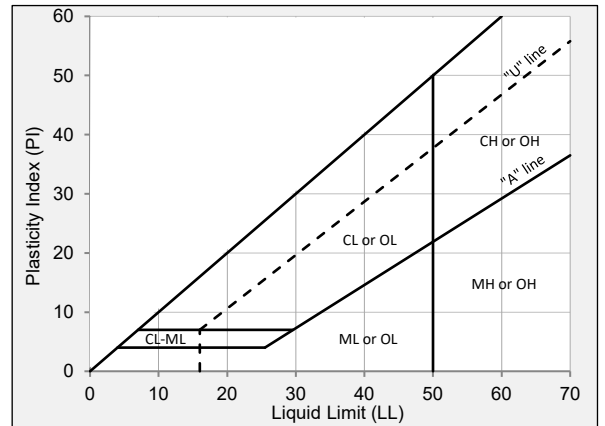
PARTICLE SIZE ANALYSIS OF SOILS



%	Cobbles	Gravel		Sand			Fines (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	
▲	0.0	23.5		46.2			30.3

Sieve	Percent Finer
	▲
3"	
2"	
1-1/2"	100.0
1"	91.9
3/4"	91.9
1/2"	89.6
3/8"	86.2
1/4"	80.7
No. 4	76.5
No. 10	60.8
No. 20	46.9
No. 40	38.8
No. 60	35.0
No. 140	32.0
No. 200	30.3

Stratum	▲
Boring	4A
Sample	B-8
Depth (ft)	S-8 & S-9
C _u	14.0 - 18.0
C _c	
w (%)	13.4
LL	
PL	
PI	
USCS	SM



	Color	USCS Group Name
▲	Light brown	Silty sand with gravel



Chester County Trail, Exton, PA

GeoStructures Project No.: G20-265

Tested By: VM

11/12/2020

Appendix C
Field Observations



ENGINEER'S FIELD VISIT PHOTOS

Project	Mariner East 2 Pipeline at Chester Valley Trail	Sheet No.	1 of 1
Location	West Whiteland Twp., Chester Co.	Project No.	G20-265
Client	The County of Chester	Date	9/30/2020
		Weather	Sunny 75°F

Field Observations and Findings

GeoStructures visited the trail site to check utilities and perform an initial reconnaissance for the upcoming test borings. The ground surface in the vicinity of the valve station was examined for evidence of sinkhole activity. Our findings are presented in the attached plan. The observed features include 2 sinkholes inside the fence which were backfilled with flowable fill during pipeline construction activities earlier this year + 2 suspicious circular ground depressions just outside of the fence. Of greatest concern is a 3' dia. x 4' deep circular ground collapse at the toe of the trail embankment about 16' from the edge of pavement (Photos 1 + 2). This feature appears very recent. Finally, there is a potential sinkhole (old) noted and mapped just outside of the R.O.W. line, NE of the recent collapse (Photo 3).



Photo 1. Recent 3' dia. x 4' deep sinkhole at toe of embankment.



Photo 2. Close view of the recent sinkhole.

Distribution			
	Engineer (PE): Eric J. Seksinsky, PG, PE	Date	9/30/2020



ENGINEER'S FIELD VISIT PHOTOS

Project	Mariner East 2 Pipeline at Chester Valley Trail	Sheet No.	1 of 2
Location	West Whiteland Twp., Chester Co.	Project No.	G20-265
Client	The County of Chester	Date	9/30/2020
		Weather	Sunny 75°F




Field Observations and Findings

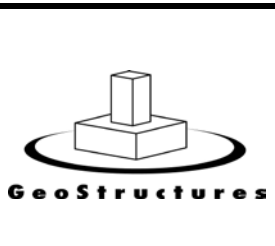


Photo 3. Potential (old) sinkhole just outside of the R.O.W.

Distribution	Engineer (PE): Eric J. Seksinsky, PG, PE	Date	9/30/2020

LEGEND

-  SINKHOLES FILLED WITH FLOWABLE FILL DURING PIPELINE CONSTRUCTION
-  2' DIA. X 9" DP. SUSPICIOUS GROUND DEPRESSIONS OBSERVED ON 09/30/20
-  PROPOSED TEST BORING



SINKHOLE PLAN - CHESTER VALLEY TRAIL

CHESTER VALLEY TRAIL AT LINCOLN HIGHWAY
WEST WHITELAND TWP., CHESTER CO., PA

SCALE: 1" = 30'	DRAWN: EJS	DRAWING NO. 1
DATE: 09/30/20	CHECKED:	

GeoStructures, Inc. 1000 West 9th Avenue
King of Prussia, PA 19406

Note: This plan is based on aerial photos and a Tetra Tech plan of the pipeline right of way.



Photo 1. Sunoco valve station by the Chester Valley Trail site.



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Photo 2. Recent sinkhole repaired using flowable fill inside the Sunoco valve station by the Chester Valley Trail site.



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EXTON, CHESTER COUNTY, PENNSYLVANIA



Photo 3. Second sinkhole repaired using flowable fill inside the Sunoco valve station by the Chester Valley Trail site.



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Photo 4. New, open sinkhole discovered by GeoStructures along the edge of the trail embankment on 09/30/20.



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Photo 5. Close view of the new sinkhole.



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Photo 6. The largest of the 3 suspect features.



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Photo 7. Sinkholes repaired along Lincoln Highway.



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Area of sinkhole
feature at B-6

Photo 8. Chester Valley Trail looking northeast.



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Photo 9. Rock outcrop in basin near Laborers' District Council facility south of Trail site.



Photo 10. Small-scale isoclinal fold (near Laborers' District Council facility south of Trail site).



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Photo 11. Dipping bed near Laborers' District Council facility south of Trail site.



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