Geotechnical Engineering Report

PennDOT Salt Storage Facility
East Hanover Township, Dauphin County, PA
September 28, 2021
Terracon Project No. J8215027

Prepared for:
Mimar McKissick Architects and Engineers, LLC
Harrisburg, Pennsylvania

Prepared by:
Terracon Consultants, Inc.
Blue Bell, Pennsylvania

September 28, 2021

Mimar McKissick Architects and Engineers, LLC
317 North Front Street
Harrisburg, Pennsylvania 17101

Attn: Mr. Robert A Oettl – Associate/ Project Architect
P: 717-238-6810
E: robert.oettl@mimarmckissick.com

Re: Geotechnical Engineering Report
PennDOT Salt Storage Facility
9147 Allentown Boulevard (US Route 22)
East Hanover Township, Dauphin County, PA
Terracon Project No. J8215027

Dear Mr. Oettl:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PJ8215027 dated July 19, 2021. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs and pavement for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
STEVEN DAVID THORNE
ENGINEER
No. PE044534R

Devi Tulasi P.E.
Senior Engineer

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Senior Principal/Regional Manager

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Environmental ■ Facilities ■ Geotechnical ■ Materials

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

PennDOT Salt Storage Facility
9147 Allentown Boulevard (US Route 22)
East Hanover Township, Dauphin County, PA
Terracon Project No. J8215027
September 28, 2021

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed PennDOT Salt Storage Facility to be located at 9147 Allentown Boulevard (US Route 22) in East Hanover Township, Dauphin County, PA. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Subgrade preparation and earthwork
- Pavement design and construction
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification per IBC

The geotechnical engineering Scope of Services for this project included the advancement of 9 test borings to depths ranging from approximately 6 to 13 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project site is a vacant site located at 9147 Allentown Boulevard (US Route 22), East Hanover Township, Dauphin County, PA, just south of its intersection with Sand Beach Road. The site was formerly occupied by the Grantville Diner that has been demolished. See **Site Location**
Existing Improvements	Paved parking and drive areas

Item	Description
Current Ground Cover	Pavement and the floor slab/foundation remnants of the former diner.
Geology	Geologic maps indicate that site is underlain by shale, siltstone and/or graywacke of the Hamburg Sequence Formation.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	Request for Proposal dated July 12, 2021 provided by Robert Oettl of MMA via email on July 12, 2021.
Project Description	The proposed salt storage facility consists of a small office building, a small storage shed, and a salt storage barn, along with parking and drive areas.
Proposed Structures	Detailed information regarding the structures was not available at the time of this report preparation. The footprints of the office building, storage shed, and salt storage barn shown in the RFP (based on estimates from Google Earth) are approximately 1,000, 600 and 5,000 square feet, respectively.
Finished Floor Elevation	Assumed to be established at or close to the floor level of the existing demolished structure.
Maximum Loads (assumed)	Column loads: 75 kips Wall loads: 5 kips per linear foot. Slabs: 125 pounds per square foot.
Grading/Slopes	None planned.
Below-Grade Structures	None planned.
Pavements	Paved driveway and parking with be constructed within the site. Both rigid (concrete) and flexible (asphalt) pavement sections will be considered. Anticipated traffic is as follows: ■ Autos/light trucks: 200 vehicles per day ■ Loaded Salt Trucks: 2 vehicles per week ■ Tractor-trailer truck: <1 vehicle per week The pavement design period is 20 years.

If any of the information summarized above is incorrect or changes prior to construction, Terracon should be provided the opportunity to review our conclusions and recommendations for applicability to the actual planned construction.

GEOTECHNICAL CHARACTERIZATION

Subsurface Profile

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	Fill	Silty gravel with sand
2	Sand & Clay	Medium dense to very dense clayey sand with gravel interlayered with medium stiff to very stiff lean clay with sand
3	Bedrock	Completely weathered siltstone

The fill materials (Model Layer 1) were only encountered in three of the explorations (B-3, B-6 and B-7) located relatively close to the limits of the former diner structure, so the fill presence may be associated with construction and/or demolition of that structure. These locations are all in areas that are currently proposed for pavement, but it should be understood that additional fill may be encountered between the explored locations.

Also, note that the completely weathered siltstone (Model Layer 3) was only encountered in three of the explorations (B-1, B-2 and B-9) at the locations of the proposed salt storage barn and office building. At these locations, the depth to the top of the weathered bedrock was encountered at depths ranging from 3 to 4 feet below the ground surface.

Last, please note that a layer of asphalt pavement was encountered at the ground surface in all of the explorations performed for this study. The asphalt was typically between 4 and 6 inches thick and was often underlain by a 6-inch-thick gravel base course layer. Exceptions to this were encountered at B-7 where only 2-1/2 inches of asphalt were present and at B-3, B-6 and B-7 where no base course was observed.

Groundwater Conditions

Groundwater was only encountered in one of the explorations performed for this study, B-6. At this location, the water was observed in a thin clay layer at a depth of approximately 3-1/2 feet and is believed to represent a perched condition. Groundwater was not observed in the remaining borings while drilling, or for the short duration the borings could remain open.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

In general, the subsurface conditions at the site are suitable for support of the proposed salt storage barn, shed and office building on conventional shallow foundations with slabs-on-grade. As noted in the **Geotechnical Characterization** section, though, uncontrolled fill was encountered in three of the borings performed for this project. While these borings were not located within the currently proposed limits of the facility structures, it must be recognized that fill may be present between explored locations. If fill is encountered during construction within the proposed building limits it should be removed in its entirety and replaced with structural fill.

Support of new pavements on or above existing fill materials is discussed in this report. Even with the recommended construction procedures, there is inherent risk for the owner that compressible fill or unsuitable material, within or buried by the fill, will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill but can be reduced by following the recommendations contained in this report. To take advantage of the cost benefit of not removing the entire amount of undocumented fill, the owner must be willing to accept the risk associated with constructing pavements over the undocumented fills following the recommended reworking of the material.

The **Shallow Foundations** section addresses support of the building bearing on the native soils or weathered rock, or on structural fill placed over these soils. The **Floor Slabs** section addresses slab-on-grade support of the building. The site preparation recommendations, including subgrade improvement and fill placement, are provided in the **Earthwork** section.

Both flexible Asphaltic Concrete (AC) and rigid pavement Portland Cement Concrete (PCC) pavement system can be used at this site. The **Pavements** section addresses the design of pavement systems.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations and floor slabs.

Site Preparation

Prior to subgrade preparation operations for the new construction, any foundation/slab remnants associated with the former diner structure, as well as any other abandoned subsurface structures should be removed from the site in their entirety. In addition, any subsurface utilities, if present, that conflict with the new construction should be relocated and/or removed from the proposed construction area, and the existing asphalt, concrete sidewalks and curbs, (assuming they will not be reused) should be stripped. The stripped asphalt and concrete are not suitable for reuse as structural fill/backfill and should be disposed in a suitable manner.

Following these initial demolition and clearing activities, the uncontrolled fill materials identified in our study should then be removed in their entirety from within and at least 5 feet beyond the limits of the proposed structure, where encountered. A Terracon representative should be present to confirm that unsuitable materials have been removed and to assist the contractor in avoiding removal of suitable materials.

Subgrade Preparation

<u>Office Building, Storage Shed and Salt Storage Barn:</u> The exposed subgrades within the proposed building footprint should be proofrolled and densified with at least 6 passes of a large, self-propelled compactor with a static drum weight of at least 12,000 pounds under the observation of a qualified geotechnical engineer. Proofrolling in a static mode will likely be required if subgrades consist of the lean clay materials occasionally encountered in Model Layer 2. Any soft or unstable materials encountered during proofrolling should be excavated to the surface of stable soils and replaced with structural fill in the manner discussed below.

<u>Pavement area:</u> Assuming the risks associated with leaving fill material in place are understood and accepted by the owner, the exposed subgrade within the proposed pavement areas should be proofrolled with at least six passes of a large, self-propelled vibratory compactor with a static drum weight of at least 12,000 pounds under the observation of a qualified geotechnical engineer. Any soft or unstable materials encountered during proofrolling should be excavated to the surface of stable soils and replaced with structural fill in the manner discussed below.

After the preparations described above have been completed, structural fill may then be placed to design subgrade elevations as needed. Completed subgrades will still be susceptible to disturbance from construction traffic and inclement weather and should be protected by the contractor prior to the placement of any additional structural fill or foundation elements.

Construction traffic over completed subgrades should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If any subgrades should become frozen, wet, or disturbed, the affected materials should be removed to the surface of stable soils and replaced with controlled compacted fill, or if conditions permit may be scarified, moisture conditioned as necessary, and recompacted in place under the observation of the geotechnical engineer.

Excavation Safety

As a minimum, temporary excavations should be sloped or braced, as required by Occupational Health and Safety Administration (OSHA) regulations, to provide stability and safe working conditions. The contractor should shore, slope or bench the sides of all temporary excavations, as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, State and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Reuse of Materials

Materials generated during the excavation operations for foundations and utilities are expected to consist of sandy fill containing, native sands and clays, and weathered siltstone bedrock. The fill materials can be reused as structural fill from a geotechnical perspective, provided they are free of concentrations of deleterious materials; however, the use of the on-site fill soils should be verified with the project's environmental consultant. The native sand and clay materials will be difficult to reuse due to the high fines content (they may require significant moisture conditioning efforts to properly compact and will be susceptible to disturbance when wet). The sandier layers would be somewhat easier to reuse, but it may be difficult to segregate the thin layers of clay from the sand during excavation. If the efforts required to reuse these materials are judged to be excessive, consideration should be given to importing more suitable materials. If excavations need to extend into the weathered bedrock, the excavated siltstone materials may be reused, provided they are crushed into a well-graded blend of sand and/or gravel-sized materials with a maximum dimension no greater than 6 inches.

All structural fill materials should be free of any deleterious materials (i.e., materials that can degrade with time or are highly compressible, such as wood, vegetation, topsoil, etc.) and have a maximum particle size of 6 inches. The reuse of fill materials containing durable foreign materials such as concrete would be acceptable, provided the materials are well mixed in a matrix of soil to prevent the formation of voids and are no larger than 6 inches.

Imported Fill Materials

In the event that imported fill is needed to complete the backfill or site grading, we recommend that the material consist of inorganic, readily compactable, well-graded granular soils with no more than 15 percent fines (no more than 15 percent passing the No. 200 sieve). Additionally, we recommend excluding gradations greater than 6 inches.

Structural Fill Placement

Structural fill should be installed in controlled layers uniformly compacted to at least 95 percent of the fill material's maximum dry density, as determined by ASTM D1557 test procedures. The moisture content of the fill material should be controlled as needed to achieve the required compaction (generally this needs to be within approximately 2 to 3 percent of the optimum moisture content) by wetting, aeration, or blending. The layer thickness should be adjusted as needed depending on the type of compaction equipment used and the condition of the fill materials at the time of construction but should be no greater than 12 inches in loose thickness. It should be expected that thinner lifts will be required to achieve the required compaction in confined areas where portable compaction equipment is used. Lean concrete or nominally compacted clean crushed stone could be used in lieu of structural fill soil.

SHALLOW FOUNDATIONS

The following shallow foundation design parameter recommendations assume that the site has been prepared in accordance with the requirements noted in **Earthwork**.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing pressure [1, 2]	3,000 pounds per square foot (psf)
Required Bearing Stratum [3]	Native sand or clay soils, weathered bedrock, or Structural Fill placed over these materials.
Minimum Foundation Dimensions	Columns: 30 inches Continuous: 18 inches
Ultimate Passive Resistance [4] **(equivalent fluid pressures)**	350 pounds per cubic foot (pcf) - granular backfill
Ultimate Coefficient of Sliding Friction [5]	0.35
Minimum Embedment below Finished Grade [6]	Exterior footings, or interior footings in unheated areas: 36 inches

Item	Description
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch
Estimated Differential Settlement [2, 7]	About 1/2 of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in **Project Description**. Note that higher design bearing pressures may be possible for foundations bearing directly on the weathered rock. Given the variability of rock depths at the site and the relatively light design loads, though, this report assumes that higher design pressures would either not be practical to employ or not needed. If this is not the case, we would be pleased to discuss alternative recommendations once the layout and loads of the structures are finalized.
3. Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork**.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.
6. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
7. Differential settlements are as measured over a span of 50 feet.

Foundation Construction Considerations

The footing excavations should be evaluated under the direction of the geotechnical engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with the International Building Code (IBC). Based on the soil properties encountered at the site and as described on the exploration logs and results, it is our professional opinion that the **Seismic Site Classification is C**. Subsurface explorations at this site were extended to a maximum depth of approximately 13 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

FLOOR SLABS

The following design parameters for floor slabs assume the requirements for **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the floor slab.

Floor Slab Design Parameters

Item	Description
Floor Slab Support [1]	Minimum 6 inches of a well-graded sand-gravel material such as PennDOT 2A, compacted to at least 95% of the maximum dry density (ASTM D1557) [2]
Estimated Modulus of Subgrade Reaction [2]	150 pounds per cubic inch (pci) for point loads
Modulus Correction Factor	$K_c = k \times \left(\frac{b+1}{2b}\right)^2$

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in **Earthwork**, and the floor slab support as noted in this table. It is provided for point loads. It is common to reduce the k-value to account for dimensional effects of large loaded areas using the modulus correction factor provided, where kc is the corrected or design modulus value and b is the mat width (short dimension) or tributary loaded area.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Floor Slab Construction Considerations

Immediately prior to placement of the granular base and concrete, we recommend the area underlying the floor slab be proofrolled again with at least six passes of a minimum 4-ton (static weight) compactor operating in static mode. In areas with limited access, a double-drum walk-behind compactor may be used. Attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located, and manual probes should be performed by Terracon to confirm the stability of these areas. Areas with unsuitable conditions should be repaired by removing and replacing the affected material with properly compacted fill.

We estimate that floor slabs supported by the subgrade soils and/or controlled compacted fill prepared in accordance with the recommendations presented in this report will experience post construction settlement on the order of 1/2-inch or less. Most of this movement will occur during initial load application.

PAVEMENTS

Pavement subgrades should be prepared as discussed in the Earthwork section of this report. However, they should also be carefully evaluated for disturbance or softening from construction activities or weather as the time for pavement construction approaches. Unless the procedures recommended above are conducted immediately prior to paving, the subgrades should be rechecked and proofrolled prior to placing the pavement base course with a loaded tandem-axle dump truck. Attention should be paid to high traffic areas that were rutted and disturbed, to areas where backfilled trenches are located, and to areas of in-situ fill materials or other site improvements. Areas where unsuitable conditions are located should be repaired by replacing the materials with properly compacted fill. When proofrolling/subgrade stabilization has been completed to the satisfaction of the geotechnical engineer, base may be placed.

Assuming the pavement subgrades have been prepared in accordance with these recommendations, Asphaltic Concrete pavement sections may be designed using an estimated CBR value of 8, and Portland Cement Concrete sections may be designed using an estimated modulus of subgrade reaction of 150 pounds per cubic inch. The values were empirically derived based upon our experience with the described soil type subgrade soils and our understanding of the quality of the subgrade as prescribed herein. Since these values are highly dependent on variations in subgrade materials and in the subgrade conditions at the time of construction, it is critical that Terracon be present to confirm that these parameters reflect the actual conditions prior to paving.

Last, please note that pavement performance is affected by its surroundings especially by presence of water. Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. The civil engineer should consider the following drainage recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2 percent;
- The subgrade and pavement surface should have a minimum 2 percent slope to promote proper surface drainage;
- Install below pavement drainage systems surrounding areas anticipated for frequent wetting;
- Install joint sealant and seal cracks immediately;
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils;
- Place compacted, low permeability backfill against the exterior side of curbs and gutters.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the geotechnical engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

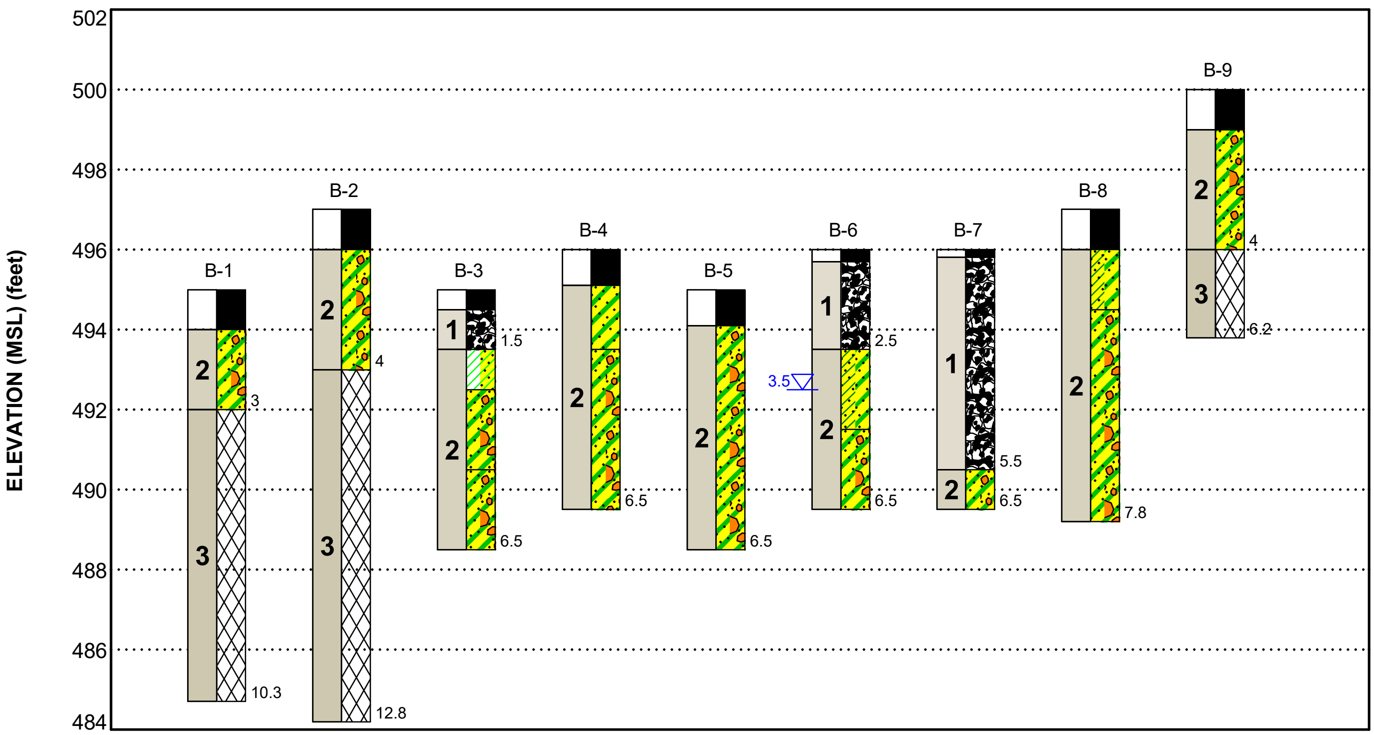
FIGURES

Contents:

GEOMODEL

PennDOT Salt Storage Facility ■ Grantville, PA
Terracon Project No. J8215027

Terracon GeoReport



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Fill	Silty Gravel with Sand
2	Sand & Clay	Medium dense to very dense clayey sand with gravel interlayered with medium stiff to very stiff lean clay with sand
3	Bedrock	Completely weathered Siltstone

LEGEND

- Asphalt
- Fill
- Sandy Lean Clay/Clayey Sand
- Clayey Sand with Gravel
- Lean Clay with Sand
- Highly Weathered Shale
- Clayey Sand

▽ First Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Locations	Type of Exploration (Borings/Test Pits)	Explored Depth (feet) [1]	Location [2]
9	Borings	6.2 to 12.8	Buildings and pavement areas

1. Below ground surface
2. See **Exhibit E**

Boring Layout and Elevations: Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±20 feet) and approximate elevations were obtained by interpolation from Google Earth^{TM}. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted, rotary drill rig using hollow stem continuous flight augers. Four to five samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, performed at the site, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the middle 12 inches of a normal 24-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a geotechnical engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the geotechnical engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a geotechnical engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the

materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the geotechnical engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data to understand the engineering properties of the various soil strata, as necessary, for this project. The laboratory testing program included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

PennDOT Salt Storage Facility ■ East Hanover Township, Dauphin County, PA
September 28, 2021 ■ Terracon Project No. J8215027

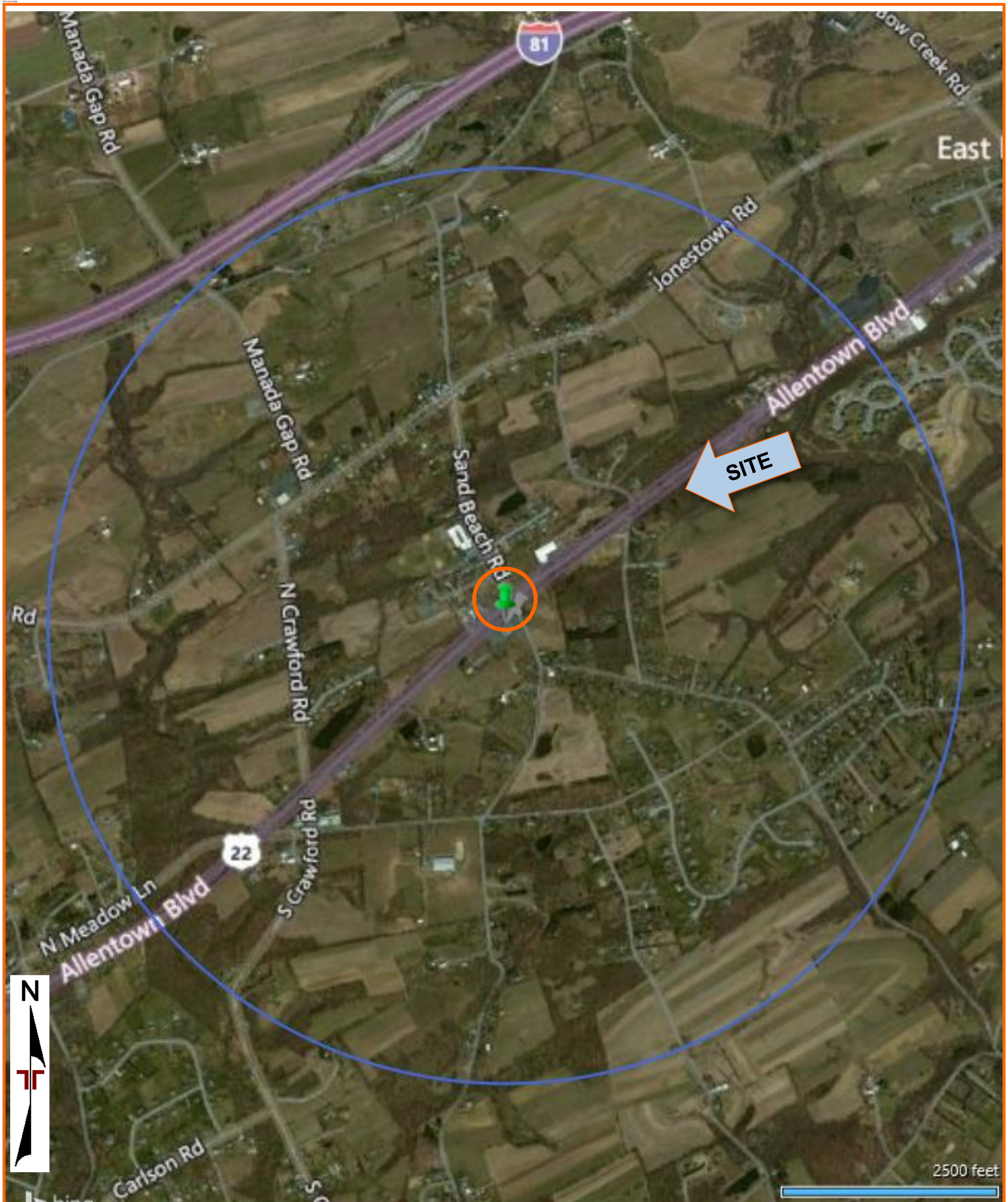


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

PennDOT Salt Storage Facility ■ East Hanover Township, Dauphin County, PA
September 28, 2021 ■ Terracon Project No. J8215027

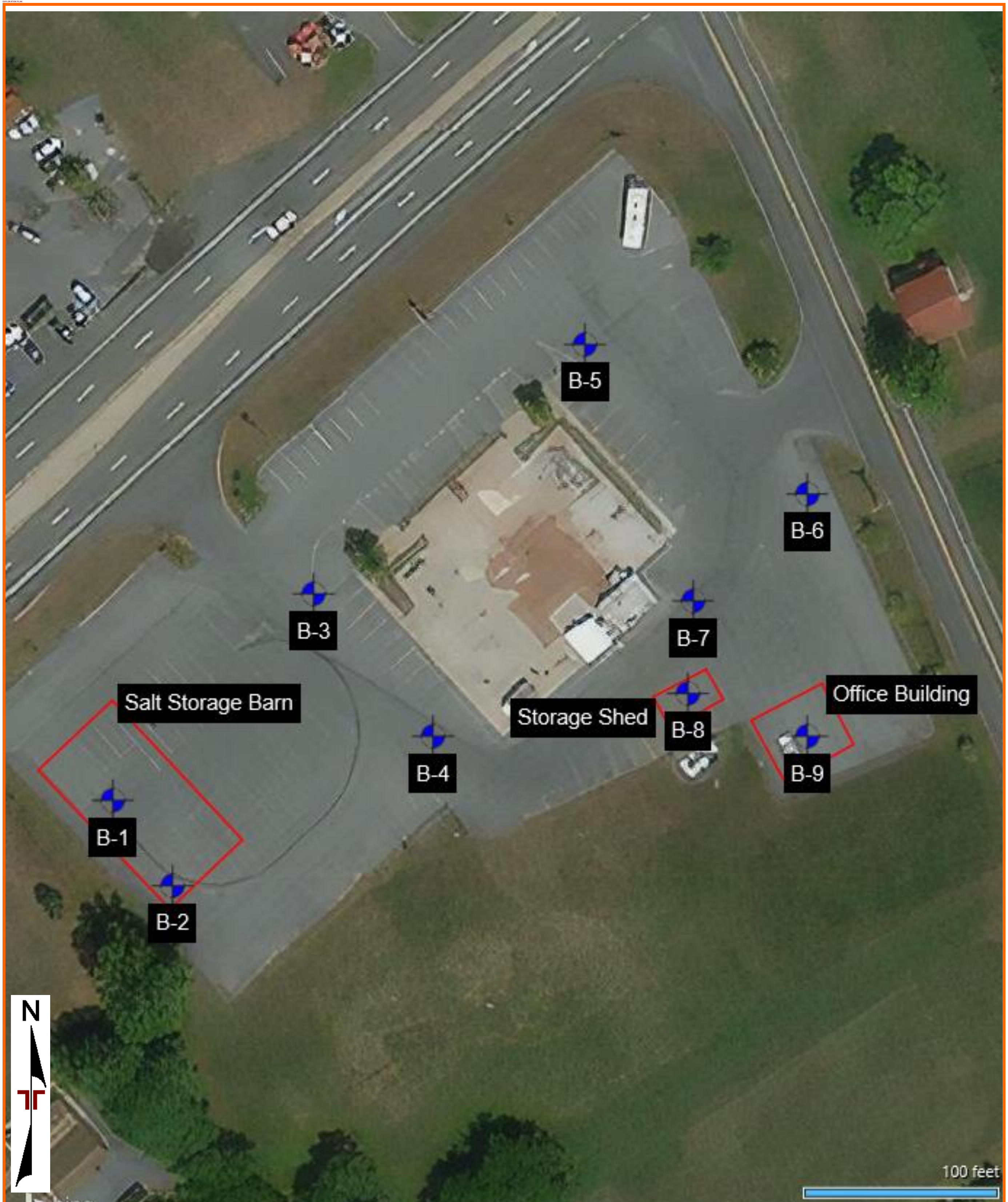


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: PennDOT Salt Storage Facility

CLIENT: Mimar McKissick Architects & Engineers LLC
Harrisburg, PA

SITE: 9147 Allentown Boulevard US
Grantville, PA

LOCATION See Exploration Plan

Latitude: 40.3582° Longitude: -76.6732°

Approximate Surface Elev.: 495 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
		ASPHALT, 6" Asphalt, 6" Gravel base — 1.0	494+/-					
2		**CLAYEY SAND WITH GRAVEL (SC)**, with siltstone fragments, light gray, dense				X	18	5-19-22-21 N=41
		3.0	492+/-					
3		**COMPLETELY WEATHERED SILTSTONE**, light gray				X	16	3-13-21-31 N=34
				5		X	14	5-25-21-51 N=46
						X	16	11-18-28-53 N=46
		10.3	484.5+/-	10		X	12	13-46-50/3"
		Spoon Refusal at 10.3 Feet						

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

BORING LOG NO. B-2

PROJECT: PennDOT Salt Storage Facility

**CLIENT: Mimar McKissick Architects & Engineers LLC
Harrisburg, PA**

**SITE: 9147 Allentown Boulevard US
Grantville, PA**

LOCATION See Exploration Plan

Latitude: 40.3580° Longitude: -76.6731°

Approximate Surface Elev.: 497 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
		1.0	**ASPHALT**, 6" Asphalt, 6" Gravel base	496+/-					
2		4.0	**CLAYEY SAND WITH GRAVEL (SC)**, with siltstone fragments, light gray, medium dense	493+/-			X	14	6-11-16-14 N=27
							X	14	5-9-35-55 N=44
3		12.8	**COMPLETELY WEATHERED SILTSTONE**, light gray	484+/-	5		X	14	9-37-47-57 N=84
							X	16	7-17-24-21 N=41
					10		X	18	8-14-16-20 N=30
							X	6	14-50/3"
			Spoon Refusal at 12.8 Feet						

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

BORING LOG NO. B-3

PROJECT: PennDOT Salt Storage Facility

CLIENT: Mimar McKissick Architects & Engineers LLC Harrisburg, PA

SITE: 9147 Allentown Boulevard US Grantville, PA

LOCATION See Exploration Plan

Latitude: 40.3585° Longitude: -76.6729°

Approximate Surface Elev.: 495 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
1		0.5	**ASPHALT**, 6" Asphalt	494.5+/-					
1		1.5	**FILL -** , silty gravel with sand, gray	493.5+/-			X	14	9-12-9-15 N=21
2		2.5	**LEAN CLAY WITH SAND (CL)**, brown, very stiff	492.5+/-					
2		4.5	**CLAYEY SAND WITH GRAVEL (SC)**, brown, medium dense	490.5+/-			X	14	8-6-11-13 N=17
2		6.5	**CLAYEY SAND WITH GRAVEL (SC)**, with siltstone fragments, brown, dense	488.5+/-	5		X	16	19-16-14-15 N=30

Boring Terminated at 6.5 Feet

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

BORING LOG NO. B-4

PROJECT: PennDOT Salt Storage Facility

CLIENT: Mimar McKissick Architects & Engineers LLC Harrisburg, PA

SITE: 9147 Allentown Boulevard US Grantville, PA

LOCATION See Exploration Plan

Latitude: 40.3583° Longitude: -76.6727°

Approximate Surface Elev.: 496 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
	0.9	**ASPHALT**, 5" Asphalt, 6" Gravel base	495+/-					
2	2.5	**CLAYEY SAND (SC)**, brown, medium dense	493.5+/-			X	16	3-5-5-8 N=10
2	6.5	**CLAYEY SAND WITH GRAVEL (SC)**, with siltstone fragments, brown, medium dense	489.5+/-	5		X	16	8-12-12-16 N=24
						X	16	5-12-12-16 N=24

Boring Terminated at 6.5 Feet

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

BORING LOG NO. B-5

PROJECT: PennDOT Salt Storage Facility

CLIENT: Mimar McKissick Architects & Engineers LLC
Harrisburg, PA

SITE: 9147 Allentown Boulevard US
Grantville, PA

LOCATION See Exploration Plan

Latitude: 40.3588° Longitude: -76.6724°

Approximate Surface Elev.: 495 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
		ASPHALT, 5" Asphalt, 6" Gravel base 0.9	494+/-					
2		**CLAYEY SAND WITH GRAVEL (SC)**, with siltstone fragments, brown, medium dense to dense				X	16	9-14-17-19 N=31
						X	16	14-13-14-14 N=27
		6.5	488.5+/-	5		X	16	14-10-11-17 N=21
		Boring Terminated at 6.5 Feet						

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

BORING LOG NO. B-6

PROJECT: PennDOT Salt Storage Facility

CLIENT: Mimar McKissick Architects & Engineers LLC
Harrisburg, PA

SITE: 9147 Allentown Boulevard US
Grantville, PA

LOCATION See Exploration Plan

Latitude: 40.3586° Longitude: -76.6720°

Approximate Surface Elev.: 496 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
	0.3	**ASPHALT**, 4"	495.5+/-					
1	2.5	**FILL -** , silty gravel with sand, gray	493.5+/-			X	10	3-3-6-8 N=9
2	4.5	**SANDY LEAN CLAY (CL)**, brown, very stiff perched water at 3.5'	491.5+/-		▽	X	14	7-9-7-13 N=16
	6.5	**CLAYEY SAND WITH GRAVEL (SC)**, brown, medium dense	489.5+/-	5		X	14	12-11-16-17 N=27

Boring Terminated at 6.5 Feet

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *perched water*

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

BORING LOG NO. B-7

PROJECT: PennDOT Salt Storage Facility

CLIENT: Mimar McKissick Architects & Engineers LLC Harrisburg, PA

SITE: 9147 Allentown Boulevard US Grantville, PA

LOCATION See Exploration Plan

Latitude: 40.3584° Longitude: -76.6722°

Approximate Surface Elev.: 496 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
1	0.2	**ASPHALT**, 2.5"	496+/-					
1		**FILL -** , silty gravel with sand, gray				X	14	6-11-13-20 N=24
						X	16	6-7-6-5 N=13
	5.5		490.5+/-	5		X	13	8-21-30-31 N=51
2	6.5	**CLAYEY SAND WITH GRAVEL (SC)**, with siltstone fragments, brown, very dense	489.5+/-					
		Boring Terminated at 6.5 Feet						

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

BORING LOG NO. B-8

PROJECT: PennDOT Salt Storage Facility

CLIENT: Mimar McKissick Architects & Engineers LLC Harrisburg, PA

SITE: 9147 Allentown Boulevard US Grantville, PA

LOCATION See Exploration Plan

Latitude: 40.3583° Longitude: -76.6722°

Approximate Surface Elev.: 497 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
		1.0	**ASPHALT**, 6" Asphalt, 6" Gravel base	496+/-					
2		2.5	**SANDY LEAN CLAY (CL)**, brown, medium stiff	494.5+/-			X	12	2-2-2-3 N=4
2		7.8	**CLAYEY SAND WITH GRAVEL (SC)**, with siltstone fragments, brown, medium dense to very dense	489+/-	5		X	12	3-3-8-8 N=11
							X	12	8-40-48-50 N=88
							X	8	21-47-50/3"

Spoon Refusal at 7.8 Feet

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

BORING LOG NO. B-9

PROJECT: PennDOT Salt Storage Facility

CLIENT: Mimar McKissick Architects & Engineers LLC
Harrisburg, PA

SITE: 9147 Allentown Boulevard US
Grantville, PA

LOCATION See Exploration Plan

Latitude: 40.3583° Longitude: -76.6720°

Approximate Surface Elev.: 500 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
		ASPHALT, 6" Asphalt, 6" Gravel base — 1.0 — 499+/-					
2		**CLAYEY SAND WITH GRAVEL (SC)**, with siltstone fragments, light brown, dense to very dense — 4.0 — 496+/-			X	16	13-31-41-33 N=72
					X	12	6-21-32-50/2" N=53
3		**COMPLETELY WEATHERED SILTSTONE**, light brown — 6.2 — 494+/-	5		X	12	12-40-50-50/2"
		Spoon Refusal at 6.2 Feet					

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

Hammer Type: Automatic

Advancement Method:
HSA

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
844 N Lenola Rd, Ste 1
Moorestown, NJ

Boring Started: 08-27-2021	Boring Completed: 08-27-2021
Drill Rig: Geoprobe	Driller: Brandon C.
Project No.: J8215027	

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

PennDOT Salt Storage Facility ■ Grantville, PA

Terracon Project No. J8215027

Terracon GeoReport

SAMPLING

Standard Penetration Test

WATER LEVEL

- **Water Initially Encountered**
- **Water Level After a Specified Period of Time**
- **Water Level After a Specified Period of Time**
- **Cave In Encountered**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
UC	**Unconfined Compressive Strength**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ and/or [$Cc<1$ or $Cc>3.0$] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	SW	Well-graded sand [I]
			$Cu < 6$ and/or [$Cc<1$ or $Cc>3.0$] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A” line	CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line	CH	Fat clay [K, L, M]
			PI plots below “A” line	MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

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

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

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

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

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

[F] If soil contains ≥ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ≥ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.

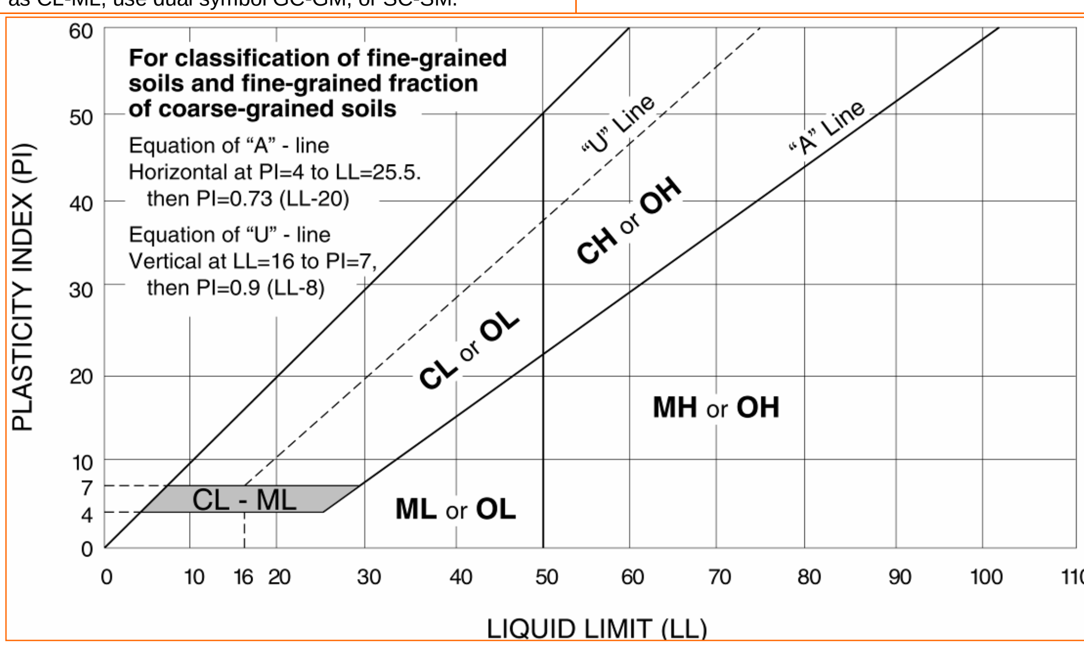
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ≥ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



DESCRIPTION OF ROCK PROPERTIES

Terracon GeoReport

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements