



Geotechnical Engineering Report

**Indian Health Services Duplex Project – Wanblee
Wanblee, South Dakota**

May 18, 2022

Terracon Project No. 24215084B

Prepared for:

Short Elliott Hendrickson, Inc
Pueblo, Colorado

Prepared by:

Terracon Consultants, Inc.
Cheyenne, Wyoming



Revised May 18, 2022
April 27, 2022



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Attn: Mr. Jimmie Hayson, P.E. – Principal
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Re: Geotechnical Engineering Report
Indian Health Services Duplex Project – Wanblee
Wanblee, South Dakota
Terracon Project No. 24215084B

Dear Mr. Hayson:

We have completed the Geotechnical Engineering services for the project referenced above. This study was performed in general accordance with Terracon Proposal No. P24215084 dated November 17, 2021. This report has been revised from its original version, dated April 27, 2022 to incorporate comments provided by SEH, and presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs 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.

A handwritten signature in black ink, appearing to read "Kiran P. Acharya", written over a faint circular stamp.

Kiran P. Acharya, Ph.D., P.E. (TX)
Project Engineer



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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

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SUPPORTING INFORMATION

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

Geotechnical Engineering Report
Indian Health Services Duplex Project – Wanblee
Wanblee Site
Wanblee, South Dakota
Terracon Project No. 24215084B
May 18, 2022

INTRODUCTION

A geotechnical engineering report has been completed for the proposed Indian Health Services Duplex Project – Wanblee Site to be located northeast of the intersection of Camp Avenue and 2nd Avenue in Wanblee, South Dakota. Four (4) borings, designated Wanblee-1 through Wanblee-4, were performed to depths of about 20.2 to 20.5 feet below existing ground surface within the proposed duplex structure footprint. Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. Boring logs and laboratory testing data are included in the **Exploration Results** section of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Floor system design and construction
- Seismic site classification
- Lateral earth pressures

The recommendations contained in this report are based on the results of field and laboratory testing, engineering analyses, experience with similar soil and bedrock conditions and structures, and our understanding of the proposed project.

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	Wanblee site is located northeast of the intersection of Camp Avenue and 1st Avenue in Wanblee, South Dakota. Approximate coordinates near the center of the site are 43.5639° N latitude, 101.6578° W longitude. See Site Location .
Existing Improvements	The site is located in undeveloped areas. Existing housing developments are present to the west of the site.

Geotechnical Engineering Report

Indian Health Services Duplex Project – Wanblee ■ Wanblee, South Dakota
May 18, 2022 ■ Terracon Project No. 24215084B



Item	Description
Current Ground Cover	The site was covered with asphalt, grasses and weeds.
Existing Topography	Relatively level

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	<p>The following documents were provided.</p> <ul style="list-style-type: none">■ Statement of A&E Services Design for Duplex Buildings and Site Locations prepared by Indian Health Services dated October 2021■ RFP addressed to SEH prepared by Indian Health Services dated November 8, 2021■ Duplex Floor Plan (no preparer signature, no date)■ Sketches of proposed building locations for the site
Project Description	The project includes construction of new duplex structures (buildings) utilized as staff quarters.
Proposed Structure	We understand the proposed duplex buildings are planned to consist of two-stories and include a crawlspace or basement. Maximum building footprints are anticipated to be 1,800 square feet.
Building Construction	We expect the buildings will be of wood- or steel-framed construction supported on shallow, reinforced concrete, spread footing foundations with a slab-on-grade floor.
Finished Floor Elevation	Based on existing development near the sites, we assume finished floor elevation will be near (or within 2 feet of) existing ground surface elevations.
Assumed Maximum Loads	<p>Foundation loading information was not available at the time of this proposal preparation. However, based on our understanding of the project, we assume relatively light foundation loads as follows.</p> <ul style="list-style-type: none">■ Columns: 30 kips■ Walls: 2 kips per linear foot (klf)■ Slabs: 100 pounds per square foot (psf)
Grading	Based on the anticipated topography, we assume maximum cuts/fills on the order of about 1 to 2 feet may be required to develop final grades.
Below-Grade Structures	We understand a crawlspace or basement is planned for the buildings.

If project information or assumptions vary from what is described above or if location of construction changes, we should be contacted as soon as possible to confirm and/or modify our recommendations accordingly.

GEOTECHNICAL CHARACTERIZATION

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	Vegetative Soil	About 6 inches of root penetration.
2	Sand	Very loose to loose, fine to medium grained sand with varying amounts of clay and silt. Brown to light brown.
3	Clay	Soft to stiff, lean clay with varying amounts of silt and fine grained sand. Dark brown to tan.
4	Bedrock	Medium hard to very hard claystone, with varying amounts of fine grained sand. Brown.
5	Asphalt	About 1 inch of existing asphalt.

Note: Excavation difficulties are generally anticipated within Model Layer 4.

As noted in **General Comments**, this characterization is based upon widely spaced exploration points across the site, and variations are likely.

Groundwater

The boreholes were observed while drilling and shortly after completion for the presence and level of groundwater. Groundwater was not observed in any of the borings while drilling, or for the short duration the borings were allowed to remain open. This does not necessarily mean the borings terminated above groundwater. Due to the low permeability of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole. Long-term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Groundwater is not expected to affect shallow foundation construction at this site. Due to safety concerns, soil

borings were backfilled upon completion of drilling activities and subsequent groundwater measurements were not obtained. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results**.

The observations represent short-term groundwater conditions at the time of field exploration, and may not be indicative of other times, or at other locations. Groundwater levels can and should be expected to fluctuate in response to site development, irrigation demands adjacent to the streets and with varying seasonal and weather conditions. Therefore, groundwater levels during construction or at other times in the future may be higher or lower than the levels indicated on the boring logs. Seasonal fluctuations on the order of 2 to 3 feet are not uncommon; greater fluctuations are possible during extreme events.

GEOTECHNICAL OVERVIEW

Based on geotechnical conditions encountered in our test borings, the site appears suitable for the proposed construction from a geotechnical point of view provided certain precautions and design and construction recommendations presented in this report are followed. We have identified geotechnical conditions that could impact design, construction and performance of the building and other site improvements. These include low strength soils/subgrade stability with elevated moisture content near the building footprint. These conditions will require particular attention in project planning, design and during construction and are discussed in greater detail in the following sections.

Low Strength Soils/Subgrade Stability

Based on our boring and laboratory data, some of the native clayey sand, silty sand and silty clay with sand soils encountered generally exhibit comparatively low relative density and strength and elevated in-place moisture contents. Penetration resistance measurements at our boring locations indicate these soils exhibit very loose to loose relative densities and soft to stiff consistencies. Consequently, the native soils are expected to deflect and deform (pump) and create subgrade stability issues during site preparation. After removal of the vegetative soils, the contractor should expect unstable subgrades that will need to be stabilized prior to construction. Terracon recommends a contingency be provided in the construction budget to stabilize and correct weak/unstable subgrade. Further discussion regarding subgrade stabilization is presented in the **Earthwork** section of this report.

It appears feasible to support some of the buildings/structures on conventional footings and/or mat/slab foundations bearing on suitable native soils or newly placed engineered fill. However, the native soils will be easily disturbed by construction activities and may not provide a suitable working surface. To help reduce disturbance of the subgrade due to construction equipment and provide positive support of shallow footings and mat foundations, lower strength native soils may need to be removed from below the proposed shallow footings and/or mat foundations. The resulting

excavations should be brought to final grade with engineered fill placed and compacted as recommended in this report.

The site soils could become unstable with typical earthwork and construction traffic, especially after precipitation events. Effective site drainage should be completed early in the construction sequence and maintained after construction to avoid potential strength and/or stability issues. If possible, the grading should be performed during the warmer and drier time of the year. If grading is performed during the spring or winter months or wet periods, an increased risk for possible undercutting and replacement of unstable subgrade will persist.

EARTHWORK

The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project. Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include documentation of the adequate removal of existing vegetative soils, observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

Site Preparation

Site preparation should commence with removal of existing pavement, vegetation, topsoil and any loose, soft, or otherwise unsuitable material from the proposed construction areas. Stripped materials consisting of vegetation and organic materials should be wasted from the site or used to re-vegetate landscaped areas (if any) after completion of grading operations.

Although evidence of existing fills or underground facilities, such as utilities, was not observed during the site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned. Terracon should observe the excavation prior to backfill placement and/or construction.

Exposed surfaces should be free of mounds and depressions that could prevent uniform compaction. Following completion of stripping and rough grading but prior to placement of new fill, the exposed ground should be scarified, moisture conditioned as needed and re-compacted. The subgrade should then be proof rolled to help delineate weak or disturbed areas at or near the ground surface. Unsuitable areas should be improved by moisture adjustment and compaction or by undercutting and placement of suitable compacted fill.

Fill Material Types

On-site soils free of organics, debris and any other unsuitable materials or low volume change import materials approved by Terracon may be used as fill/backfill material on the site. In general, imported materials meeting the properties presented below should be acceptable for use. Other import fill material types may be suitable for use depending upon proposed application and location. However, imported soils should be evaluated and approved by the geotechnical engineer prior to delivery to the site.

Gradation/Property	Percent Finer by Weight (ASTM C136)
3-inch	100
No. 4 Sieve	30 to 100
No. 200 Sieve	50 (max.)
■ Liquid Limit (LL)	30 (max.)
■ Plasticity Index (PI)	15 (max.)

Fill Compaction Requirements

Structural and general fill/backfill should meet the following compaction requirements.

Item	Description
Fill lift thickness	<ul style="list-style-type: none"> ■ 9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used ■ 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used
Minimum Compaction requirements¹	At least 95% of the standard Proctor maximum dry density (ASTM D698)
Moisture content onsite low plasticity granular and cohesive soils^{2,3}	-2 to +2% of the optimum moisture content as determined by the standard Proctor test

1. Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. A construction disc or other suitable processing equipment will be needed to thoroughly process the materials and to aid in achieving uniform moisture content throughout the fill.
2. The contractor should expect some moisture adjustment and processing of the site soils or import materials will be needed prior to or during compaction operations.
3. Moisture conditioned cohesive soils should not be allowed to dry out. A loss of moisture within these materials will likely result in an increase of the material's swell potential. Subsequent wetting of these materials could result in undesirable movements.

Item	Description
4.	Care should be taken during the fill placement process to avoid zones of dissimilar fill. Improvements constructed over varying fill types are at a higher risk of differential movement compared to improvements over a uniform fill zone.

Excavation and Utility Trench Construction

We anticipate excavations up to about 5 to 7 feet may be necessary for utility trench construction. We believe the soils encountered in our exploratory borings can be excavated with conventional excavation equipment.

Trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. Trench backfill should consist of the on-site soils free of organic matter or approved imported materials. Trench backfill should be placed and compacted as described under **Fill Compaction Requirements**. It is strongly recommended a representative of the geotechnical engineer provide full-time observation and compaction testing of trench backfill within the building area.

Underground piping within or near the proposed building footprint should be designed and constructed so deviations in alignment do not result in breakage or distress. Utility knockouts in grade beams should be oversized to accommodate differential movements.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations in order to maintain stability of excavation sides and bottom as well as any adjacent improvements. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards. As a safety measure, it is suggested vehicles and soil piles be kept to a minimum lateral distance from the crest of the slope equal to no less than the slope height. Exposed slope faces should be protected against the elements.

The soils to be penetrated by the proposed excavations may vary significantly across the site. The soil classifications are based solely on the materials encountered in widely spaced exploratory test borings. The contractor should verify similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

Grading and Drainage

Proper drainage and surface water management is important to the performance of foundations, floor slabs, and other site improvements. The following recommendations are considered good practice for any site and should be implemented where applicable and/or to the extent possible.

Grades must be adjusted to provide positive drainage away from the building and other site improvements during construction and maintained throughout the life of the proposed facility. Infiltration of water into utility or foundation excavations must be prevented during construction.

Landscaped irrigation adjacent to the foundation system should be minimized. Plants placed close to foundation walls should be limited to those with low moisture requirements. The importance of proper irrigation practices cannot be over emphasized. Irrigation should be limited to the minimum amount needed to maintain vegetation; application of more water will increase likelihood of slab and foundation movements in excess of those described in this report.

We recommend constructing slopes of about 6 inches in the first 10 feet (5 percent slope) in landscaped areas around the building, where practical. The ground surface should be sloped in such a manner that water will not pond between or adjacent to structures and other site improvements. Concrete curbs and sidewalks may “dam” surface runoff adjacent to the building and disrupt proper flow. Use of “chase” drains or weep holes at low points in the curb should be considered to promote proper drainage.

Backfill against foundations, exterior walls and in utility and sprinkler line trenches should be well compacted and free of organics and construction debris to reduce moisture infiltration. We recommend exterior foundation wall backfill consist of on-site clayey soils or approved import materials to reduce infiltration and conveyance of surface water through the backfill. Some settlement of wall backfill should be expected even if properly compacted. Areas where backfill has settled should be repaired and re-graded immediately to maintain proper slope away from the foundation.

Flatwork will be subject to post construction movement. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond. Where paving or flatwork abuts the structure, care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Planters located adjacent to the structure (if any) should be self-contained. Sprinkler mains and spray heads should not be installed or allowed to discharge within 5 feet of foundation walls. Roof drains should be extended away from the structure well beyond the limits of the backfill zone through the use of splash blocks or downspout extensions. Downspouts and extensions should be monitored and maintained in good working condition. Generally speaking, downspouts should not be buried and extended below grade, as these systems can be difficult to monitor and maintain.

Water permitted to pond near or adjacent to the perimeter of the structure (either during or post-construction) can result in higher soil movements than those discussed in this report. As a result, estimations of potential movement described in this report cannot be relied upon if positive drainage is not obtained and maintained, and water is allowed to infiltrate the fill and/or subgrade.

After building construction and prior to project completion, we recommend verification of final grading be performed to document that positive drainage, as described in this section, has been achieved. Maintenance of surface drainage is imperative subsequent to construction and becomes the responsibility of the owner.

Earthwork Construction Considerations

As discussed in the **Geotechnical Overview** section above, the native sandy and clayey soils encountered generally exhibit comparatively low relative density and strength. Penetration resistance measurements at our boring locations indicate these soils exhibit loose to soft relative density/consistency. Consequently, the native soils are expected to deflect and deform (pump) and create subgrade stability issues during site preparation. After removal of the vegetative soils, the contractor should expect unstable subgrades that will need to be stabilized prior to construction. Terracon recommends a contingency be provided in the construction budget to stabilize and correct weak/unstable subgrade.

If unstable ground conditions develop during earthwork or subgrade preparation, some method of soil improvement or stabilization will be needed prior to construction of foundations and floor slabs. There are a number of stabilization methods that can be used to improve the subgrade and depend, in part, on the extent and severity of the unstable soils exposed during construction as well as other factors. For isolated or small areas requiring stabilization, moisture conditioning and recompaction or mechanical stabilization with granular materials and/or geosynthetics may be effective. If large areas require stabilization, chemical treatment of the soils may be a more effective alternative. In any event, we feel the appropriate method and level of stabilization should be evaluated and can best be determined on a case-by-case basis during construction once the entire subgrade and overall conditions are exposed. We are available to provide specific stabilization recommendations during construction upon your request.

Upon completion of site preparation, care should be taken to maintain the subgrade moisture content prior to construction of foundations and floor slabs. Construction traffic over the completed subgrade 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 the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and recompacted prior to fill placement or foundation, and floor slab construction.

Construction Observation and Testing

The earthwork efforts should be monitored under the guidance of Terracon. Monitoring should include documentation of adequate removal of vegetation and topsoil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation. Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts.

In areas of foundation excavations, the bearing subgrade should be evaluated under the guidance of Terracon. In the event unanticipated conditions are encountered, we should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of Terracon into the construction phase of the project provides the continuity to maintain our evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

Based on the field exploration and laboratory test results and the type of construction planned, it is our opinion the proposed building can be supported on shallow spread footings bearing on approved native soils or properly compacted engineered fills, provided the site has been prepared in accordance with the **Earthwork** section of this report. Design criteria and construction recommendations for spread footings are presented in the following table and paragraphs.

Spread Footing Design Recommendations

Item	Description	
Bearing material	On-site granular or low plasticity cohesive soils or engineered fill	
Maximum allowable soil bearing pressure ¹	1,500 psf	
Minimum dimensions	<u>Column</u>	<u>Wall Footing</u>
	24 inches	18 inches
Minimum embedment below finished grade for frost protection ²	4 feet	
Estimated post-construction movement based on assumed structural loads ³	About 1 inch	
Ultimate passive pressure ⁴	295 psf/ft	
Ultimate coefficient of sliding friction ⁴	0.33	

1. The allowable soil bearing pressure applies to dead loads plus design live load conditions and is the maximum pressure that should be transmitted to the bearing soils in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes otherwise unsuitable bearing conditions, if encountered, will be undercut and replaced with properly compacted engineered fill.

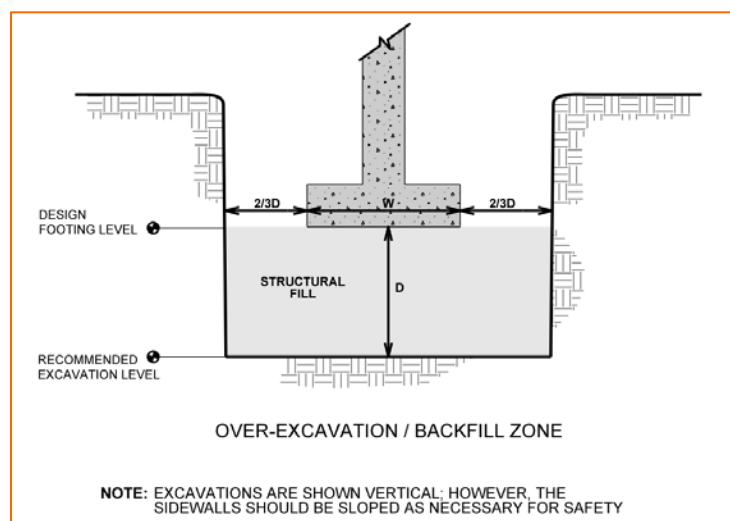
2. For perimeter footings and footings beneath unheated areas. Interior column pads in heated areas should bear at least 18 inches below the adjacent grade (or the top of the floor slab) for confinement of the bearing materials and to develop the recommended bearing pressure.

Item	Description
3.	Foundation movement will depend upon variations within the subsurface soil profile, structural loading conditions, embedment depth of footings, thickness of compacted fill, and the quality of the earthwork operations. Settlement estimates are based on the maximum allowable soil bearing pressure, assumed structural loads and resulting foundation geometry. If actual foundation loads vary significantly from those assumed, we should be contacted to review our recommendations. Additional foundation movements could occur if surface water infiltrates the foundation soils; therefore, proper drainage away from the foundation system should be provided in the final design, during construction and maintained throughout the life of the structure.
4.	The sides of the excavation for spread footings must be nearly vertical and the concrete should be placed neat against these vertical faces or backfill must be compacted to at least 95 percent of the standard Proctor maximum dry density for the passive earth pressure value to be valid. Passive pressure requires movement to generate the resistance and should only be used when movement is tolerable and the soil is well compacted and will not be removed. The passive resistance and friction factor are ultimate values. As such, appropriate factors of safety should be applied.

Footings should be proportioned to reduce differential foundation movement. Proportioning on the basis of relative constant dead-load pressure can provide a means to reduce differential movement between adjacent footings. Foundations should be detailed and reinforced as necessary to reduce the potential for distress caused by differential foundation movement.

Spread Footing Construction Considerations

Where soils are loosened during excavation or in the forming process for footings, or if low-strength soils or otherwise unsuitable bearing conditions are present, they should be removed to minimum depths determined by the Geotechnical Engineer and the resulting excavation should be backfilled up to footing base elevation with approved fill material placed and compacted as described in the **Earthwork** section of this report. Over-excavation for structural fill placement below footings (if needed) should be conducted as shown below.



The base of foundation excavations should be free of water and loose soil prior to concrete placement. Concrete should be placed soon after subgrade preparation to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete.

Completed foundation excavations should be observed and evaluated by a representative of Terracon well in advance of forming footings and placement of reinforcing steel to confirm satisfactory bearing materials are present and subsurface conditions are consistent with those encountered in our borings. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

FLOOR SLABS

All slabs-on-grade undergo some movement. Provided the site has been prepared in accordance with the **Geotechnical Overview** and **Earthwork** sections of this report. We believe risk of movement is low for the soil conditions encountered on this site and estimate settlement of slabs-on-grade constructed on properly prepared subgrade to be less than 1 inch. Where slab movement cannot be accepted or must be reduced, we are available to discuss floor movement mitigation techniques upon your request.

As discussed in the **Geotechnical Overview** section, low strength soils with elevated moisture content were encountered near the building footprint. In order to provide more uniform support across the floor slab area, we recommend the floor slab be supported on at least 12 inches of clean imported granular material compacted as described in this report.

Design Recommendations

Item	Description
Floor slab support	12-inch zone of moisture conditioned and compacted subgrade. Existing fill, where present, should be removed and re-worked.
Modulus of subgrade reaction	For limited area loads or concentrated/point loads placed directly on slabs: <ul style="list-style-type: none">■ 100 pounds per square inch per in (psi/in) for slabs supported on compacted subgrade consisting of the on-site clayey sand, silty sand, and silty clay with sand soils.■ 140 psi/in for slabs supported on at least 12 inches of compacted clean imported granular material.
Slab thickness	Slab reinforcement and thickness should be designed by a qualified engineer based on actual loads imposed and on intended slab use.

We recommend the following precautions be observed where slabs-on-grade are used. These precautions will not eliminate slab movement, but they tend to reduce damage when movement occurs. Additional floor slab design and construction recommendations are as follows:

- Positive separations and/or isolation joints should be provided between slabs and foundations, columns or utility lines to allow free vertical movement. This detail can reduce cracking when movement of the slab occurs. As a precautionary measure, non-bearing partition walls placed on the floor slab (if any) should be designed and constructed to allow at least 1½ inches of free vertical movement.
- Frequent control joints should be provided in slabs to control the location and extent of cracking in accordance with the American Concrete Institute (ACI). For additional recommendations refer to the *ACI Design Manual*.
- The use of a vapor retarder should be considered beneath concrete slabs on grade that will be 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/barrier, 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/barrier.
- Other design and construction considerations, as outlined in the *ACI Design Manual*, Section 302.1R are recommended.

Floor Slab Construction Considerations

Fill/backfill placed beneath slabs and next to foundation walls should be moisture conditioned and compacted as described in the **Earthwork** section of this report. Soils loosened during excavation or other construction activities should be removed or recompact as described in this report. Floor slabs should not be constructed on frozen subgrade.

Once fill is placed and the subgrade is prepared, it is important measures be planned and taken to reduce drying of the near surface materials. If the fill dries excessively prior to construction, then it will be necessary to rework the upper, drier materials just prior to installing floor slabs.

We recommend the area underlying the floor slab be carefully evaluated within 24 hours before slab construction. Particular attention should be paid to areas of existing foundation wall backfill and where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted fill. Floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report about 24 hours before placement of the base and/or concrete. The subgrade should be re-evaluated and re-approved should concrete not be placed within this time frame or should the subgrade become disturbed after construction.

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 Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil/rock 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 D**. Subsurface explorations at this site were extended to a maximum depth of 20½ 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.

CORROSIVITY

The values presented in the table below may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary									
Boring	Sample Depth (feet)	Soil Description	Sulfides (mg/kg)	Red-Ox Potential (mV)	Soluble Sulfate (mg/kg)	Chlorides (mg/kg)	Electrical Resistivity ¹ (Ω-cm)	pH	Total Salts (mg/kg)
W-2	1 to 6	Silty Clay with Sand (CL-ML)	Nil	+438	12	44	4,130	8.2	313

1. Test performed on saturated soil sample.

We recommend a certified corrosion engineer be employed to determine the need for corrosion protection and to design appropriate protective measures. The sulfate concentration measured in the sample was 12 mg/kg which equates to approximately 0.001 percent. Sulfate concentrations of less than 0.1 mg/kg indicate Class S0 exposure to sulfate attack for concrete in contact with the subsoils, according to the American Concrete Institute (ACI) *Guide to Durable Concrete*. For this level of sulfate concentrations, ACI indicates any type of cement can be used for concrete in contact with the subsoils.

Therefore, Type I Portland cement should be suitable for concrete on and below grade. However, if there is no, or minimal cost differential, use of Type II Portland cement (or equivalent) should be considered for additional sulfate resistance of construction concrete. Foundation concrete

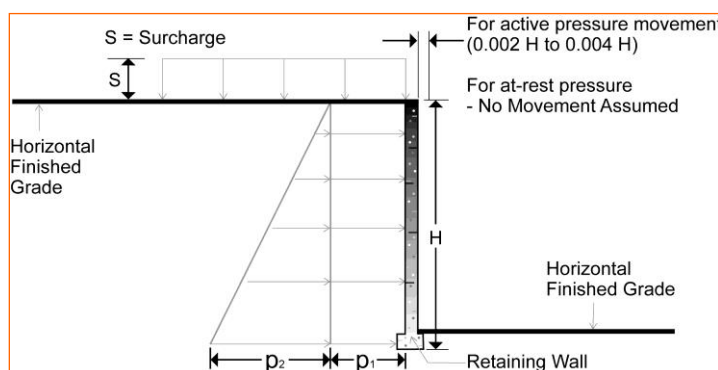
should be designed in accordance with the provisions of the *ACI Design Manual*, Section 318, Chapter 4.

LATERAL EARTH PRESSURES

We understand below-grade structures, such as a crawlspace or basement is planned for the buildings. The following sections provide recommendations and considerations for below-grade structures supporting unbalanced backfill levels. These values can also be used for lateral capacity analyses for drilled circular footings.

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters				
Earth Pressure Condition ¹	Coefficient for Backfill Type ²	Surcharge Pressure ^{3, 4, 5} p_1 (psf)	Effective Fluid Pressures (psf) ^{2, 4, 5}	
			Unsaturated ⁶	Submerged ⁶
Active (K_a)	Granular - 0.31	$(0.31)S$	$(40)H$	$(80)H$
	Fine Grained - 0.41	$(0.41)S$	$(50)H$	$(85)H$
At-Rest (K_o)	Granular - 0.47	$(0.47)S$	$(55)H$	$(90)H$
	Fine Grained - 0.58	$(0.58)S$	$(70)H$	$(95)H$

Geotechnical Engineering Report

Indian Health Services Duplex Project – Wanblee ■ Wanblee, South Dakota
May 18, 2022 ■ Terracon Project No. 24215084B



Lateral Earth Pressure Design Parameters				
Earth Pressure Condition ¹	Coefficient for Backfill Type ²	Surcharge Pressure ^{3, 4, 5} p_1 (psf)	Effective Fluid Pressures (psf) ^{2, 4, 5}	
			Unsaturated ⁶	Submerged ⁶
Passive (Kp)	Granular - 3.25	---	(390)H	(250)H
	Fine Grained - 2.46	---	(295)H	(205)H

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95% of the ASTM D 698 maximum dry density, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. To achieve "Unsaturated" conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. "Submerged" conditions are recommended when drainage behind walls is not incorporated into the design.

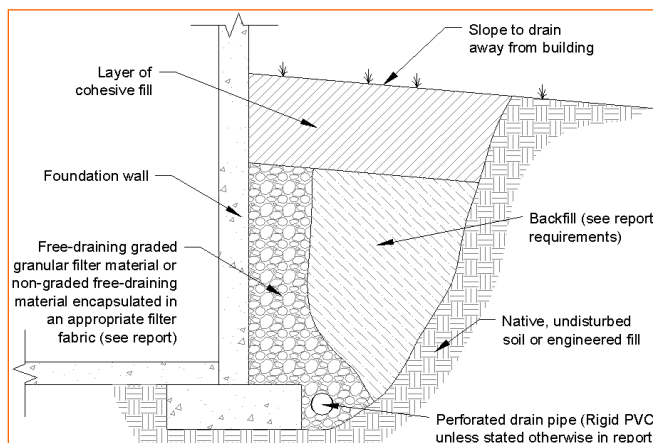
Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extended below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.

Geotechnical Engineering Report

Indian Health Services Duplex Project – Wanblee ■ Wanblee, South Dakota
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As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill.

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.

Geotechnical Engineering Report

Indian Health Services Duplex Project – Wanblee ■ Wanblee, South Dakota
May 18, 2022 ■ Terracon Project No. 24215084B



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.

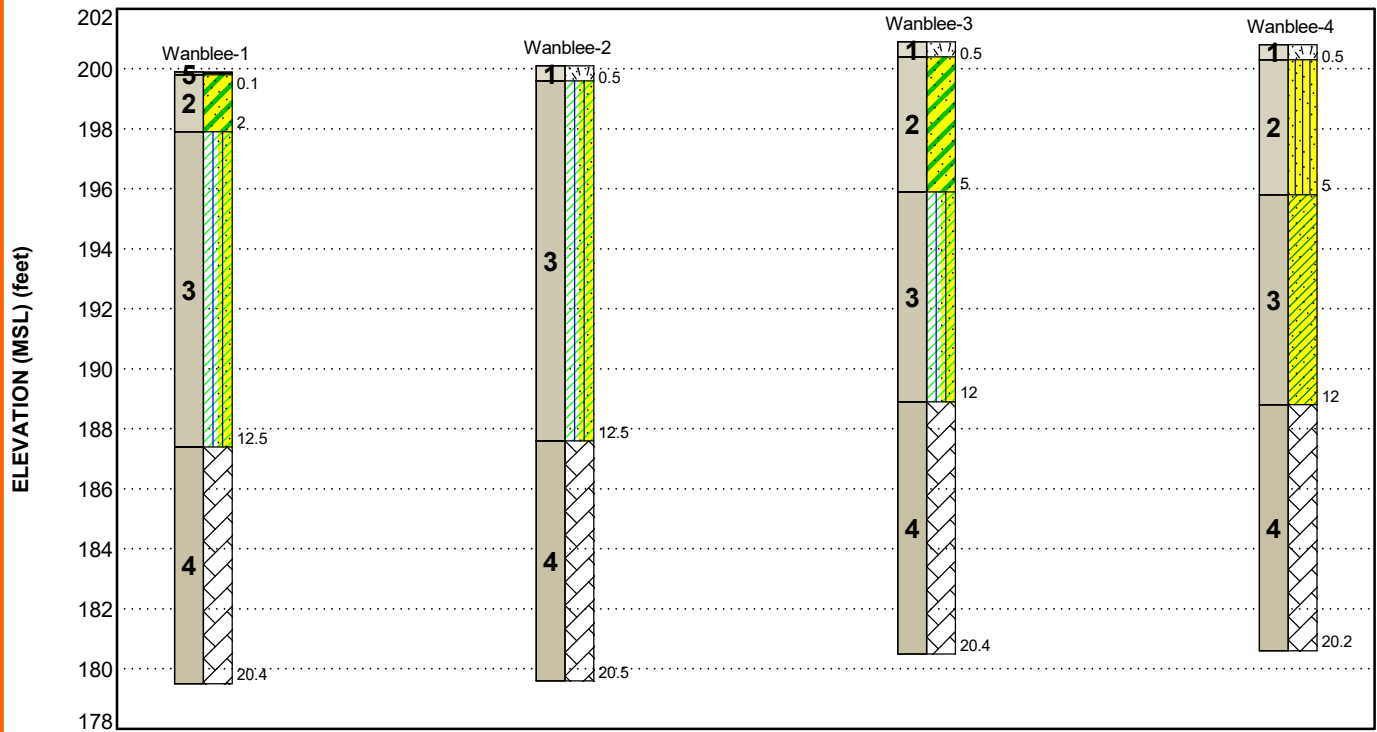
FIGURES

Contents:

GeoModel

GEOMODEL

Indian Health Services Duplex Project ■ Wanblee, South Dakota
Terracon Project No. 24215084B



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	Vegetative Soil	About 6 inches of root penetration.
2	Sand	Very loose to loose, fine to medium grained sand with varying amounts of clay and silt. Brown to light brown.
3	Clay	Loose to stiff, lean clay with varying amounts of silt and fine grained sand. Dark brown to tan.
4	Bedrock	Medium hard to very hard claystone, with varying amounts of fine grained sand. Brown.
5	Asphalt	About 1 inch of existing asphalt.

LEGEND

Asphalt	Claystone	Sandy Lean Clay
Clayey Sand	Vegetative Soil	
Silty Clay with Sand	Silty Sand	

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

Contents:

Exploration and Testing Procedures (2 pages)

Site Location and Exploration Plan (2 pages)

Exploration Results (8 pages)

Supporting Information (2 pages)

Note: All attachments are one page unless noted above.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number & Designation of Borings	Boring Depth (feet)	Planned Location
4 (Wanblee-1 through Wanblee-4)	20.2 to 20.5	Planned Building Area

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 relative ground surface elevations were measured with an engineer's level referencing a temporary benchmark. If more precise boring layout and ground surface elevations are desired, we recommend the boring locations be surveyed.

Subsurface Exploration Procedures: Soil borings were advanced with a Mobile B-57 truck-mounted drilling rig using solid-stem, continuous-flight augers. Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. Soil sampling was performed using standard split-barrel procedures and a modified California barrel. In the split-barrel sampling procedure, 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 last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. For the modified California barrel sampling procedure, a 2½-inch outer diameter ring-lined sampler is used for sampling. Modified California barrel sampling procedures are similar to standard split-barrel sampling procedures; however, blow counts are typically recorded for 6-inch intervals for a total of 12 inches of penetration. Additionally, a bulk sample of auger cuttings were obtained from boring Wanblee-2 from about 1 to 6 feet below existing ground surface. Groundwater was not encountered during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after completion of drilling.

The sampling depths, penetration distances, and other sampling information were 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.

Geotechnical Engineering Report

Indian Health Services Duplex Project – Wanblee ■ Wanblee, South Dakota
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Laboratory Testing

Samples retrieved during the field exploration were returned to the laboratory for observation by the project Geotechnical Engineer and were visually classified in general accordance with the Unified Soil Classification System described in the **Supporting Information** section of this report.

After sample review by the project engineer, an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Following completion of the laboratory testing, the field and visual descriptions were confirmed or modified as necessary, and Boring Logs were prepared. These logs are presented in the **Exploration Results** section of this report.

Selected samples were tested for the following physical and/or engineering properties:

- Moisture content
- Unit weight
- Atterberg limits
- Grain size analysis
- Swell/consolidation
- Corrosivity

Laboratory test results are indicated on the boring logs and are presented in depth in the **Exploration Results** section. The test results are used for the geotechnical engineering analyses and the development of earthwork, foundation, and floor slab recommendations. Laboratory tests are performed in general accordance with applicable local standards or other accepted standards. Procedural standards noted in this report are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgement.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are Unified Soil Classification Symbols. A brief description of this classification system as well as the General Notes can be found in the **Supporting Information** section. Classification was by visual-manual procedures. Selected samples were further classified using the result of Atterberg limit and percent fines testing. These test results are also provided in the **Exploration Results** section.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan

Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

Indian Health Services Duplex Project – Wanblee ■ Wanblee, South Dakota
May 18, 2022 ■ Terracon Project No. 24215084B

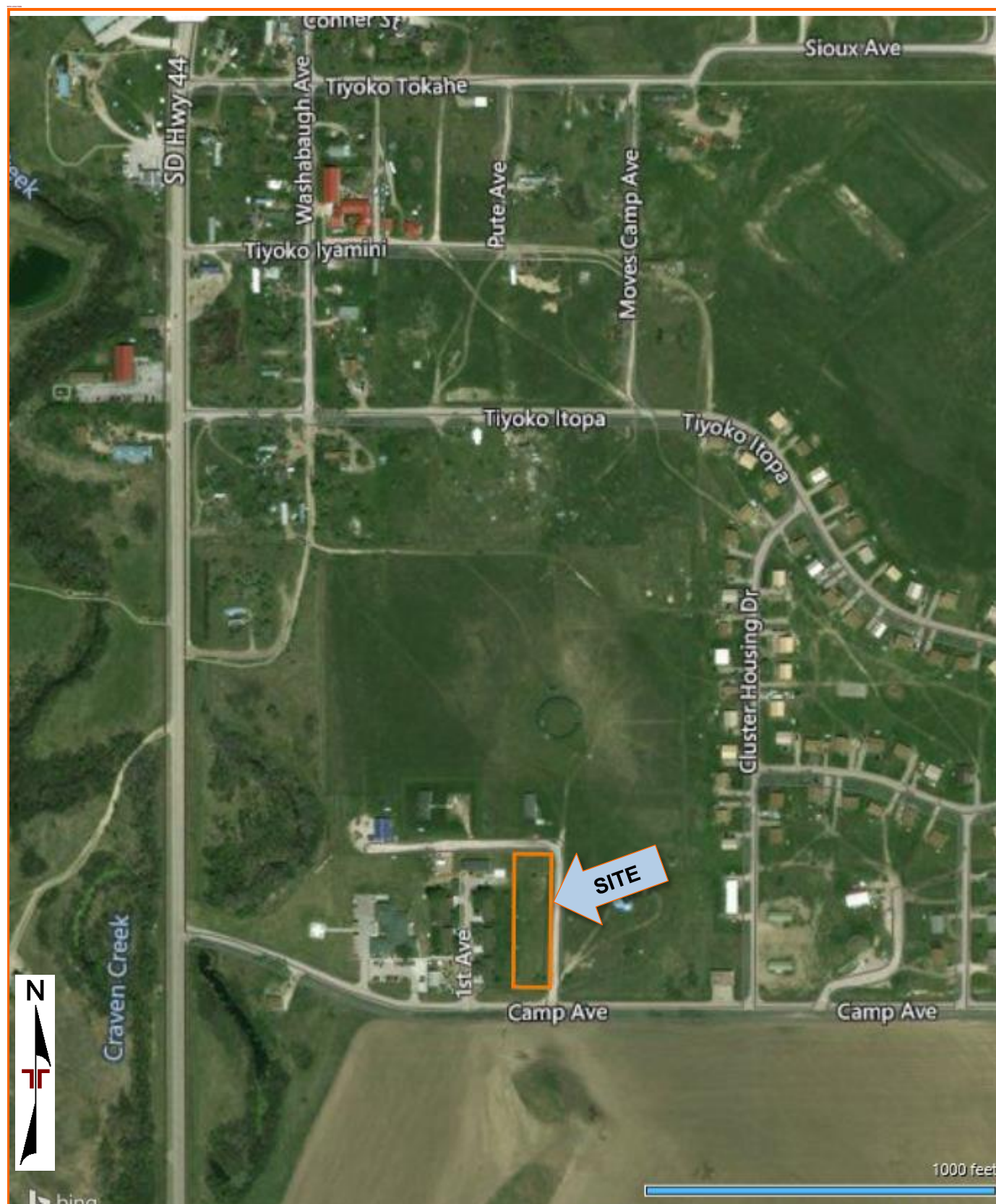


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Indian Health Services Duplex Project – Wanblee ■ Wanblee, South Dakota
May 18, 2022 ■ Terracon Project No. 24215084B



EXPLORATION RESULTS

Contents:

Boring Logs (Wanblee-1 through Wanblee-4)
Atterberg Limits
Grain Size Distribution
Swell Consolidation Test
Corrosivity

Note: All attachments are one page unless noted above.

BORING LOG NO. Wanblee-1

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Intersection of Camp and First Avenues
Wanblee, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.5643° Longitude: -101.6579° Surface Elev.: 199.9 (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL./ LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.1 / ASPHALT , about 1 inch of asphalt	200			2-1-2 N=3		16.9			
2		CLAYEY SAND (SC) , fine to medium grained sand, dark brown to brown, very loose, trace small roots	2.0								
3		SILTY CLAY WITH SAND (CL-ML) , fine grained sand, brown to light brown, medium stiff, trace small roots to about 3 feet Trace moderately cemented nodules at about 9 feet	198			2-2-4 N=6		9.1			
						2-3-4 N=7		19.8			
						4-5-7 N=12		27.3			
4		CLAYSTONE , with fine grained sand, light brown to tan, medium hard to very hard Trace strongly cemented nodules at about 14 feet	187.5			54/12"		28.2	92		
						12-22-50/5"		28.7			
		Boring Terminated at 20.4 Feet	179.5								

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

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:
Manhole rim at southeast edge of street west of W-1
Assigned TBM = 200.0 feet
See Exploration Plan

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-28-2022

Drill Rig: Mobile B-57

Project No.: 24215084B

Boring Completed: 03-28-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 24215084 INDIAN HEALTH SER GPJ TERRACON_DATATEMPLATE.GDT 4/21/22

BORING LOG NO. Wanblee-2

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Intersection of Camp and First Avenues
Wanblee, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.5641° Longitude: -101.6579° Surface Elev.: 200.1 (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL. / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.5 VEGETATIVE SOIL , about 6 inches of root penetration SILTY CLAY WITH SAND (CL-ML) , fine to medium grained sand, dark brown to tan, loose	199.5			3-2-4 N=6		11.5			
3			5			4-2-2 N=4		6.3			
						7/12"		13.1	94	26-19-7	76
			10			5-5-6 N=11		28.1			
4		12.5 CLAYSTONE , with fine grained sand, light brown, medium hard to very hard	187.5			9-16-23 N=39		30.6			
			20			10-33-48 N=81		28.9			
		20.5 Boring Terminated at 20.5 Feet	179.5								

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

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:
Manhole rim at southeast edge of street west of W-1
Assigned TBM = 200.0 feet
See Exploration Plan

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-28-2022

Drill Rig: Mobile B-57

Project No.: 24215084B

Boring Completed: 03-28-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 24215084 INDIAN HEALTH SER GPJ TERRACON_DATATEMPLATE.GDT 4/21/22

BORING LOG NO. Wanblee-3

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Intersection of Camp and First Avenues
Wanblee, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.5638° Longitude: -101.6579° Surface Elev.: 200.9 (Ft.)	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL. / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		VEGETATIVE SOIL , about 6 inches of root penetration	0.5	200.5				2-4-3 N=7		10.7			
2		CLAYEY SAND (SC) , fine to medium grained, dark brown to tan, loose											
			5.0	196	5			5-4-3 N=7		9.0			
3		SILTY CLAY WITH SAND (CL-ML) , fine grained sand, brown, stiff											
			12.0	189	10			14/12"		24.1	90		
4		CLAYSTONE , with fine grained sand, light brown, medium hard to very hard											
			20.4	180.5	15			9-14-23 N=37		29.1			
					20			12-26-50/5"		27.7			
		Boring Terminated at 20.4 Feet											

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

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:
Manhole rim at southeast edge of street west of W-1
Assigned TBM = 200.0 feet
See Exploration Plan

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-28-2022

Drill Rig: Mobile B-57

Project No.: 24215084B

Boring Completed: 03-28-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 24215084 INDIAN HEALTH SER GPJ TERRACON_DATATEMPLATE.GDT 4/21/22





BORING LOG NO. Wanblee-4

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Intersection of Camp and First Avenues
Wanblee, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.5636° Longitude: -101.6579° Surface Elev.: 200.8 (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL. / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.5 VEGETATIVE SOIL , about 6 inches of root penetration	200.5			2-3-1 N=4		9.7			
2		SILTY SAND (SM) , fine to medium grained, dark brown to brown, loose									
						13/12"		3.1	109		
3		5.0 SANDY LEAN CLAY (CL) , fine grained sand, brown, medium stiff	196			2-3-2 N=5		26.5			
						9/12"		23.0		41-23-18	67
4		12.0 CLAYSTONE , with fine grained sand, brown to light brown, medium hard to very hard	189			8-12-20 N=32		19.1			
						12-25-50/3"		27.2			
		20.2 Boring Terminated at 20.2 Feet	180.5								

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

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:
Manhole rim at southeast edge of street west of W-1
Assigned TBM = 200.0 feet
See Exploration Plan

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-28-2022

Drill Rig: Mobile B-57

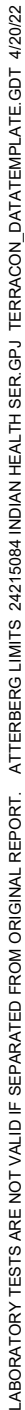
Project No.: 24215084B

Boring Completed: 03-28-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 24215084 INDIAN HEALTH SER GPJ TERRACON_DATATEMPLATE.GDT 4/21/22

ASTM D4318

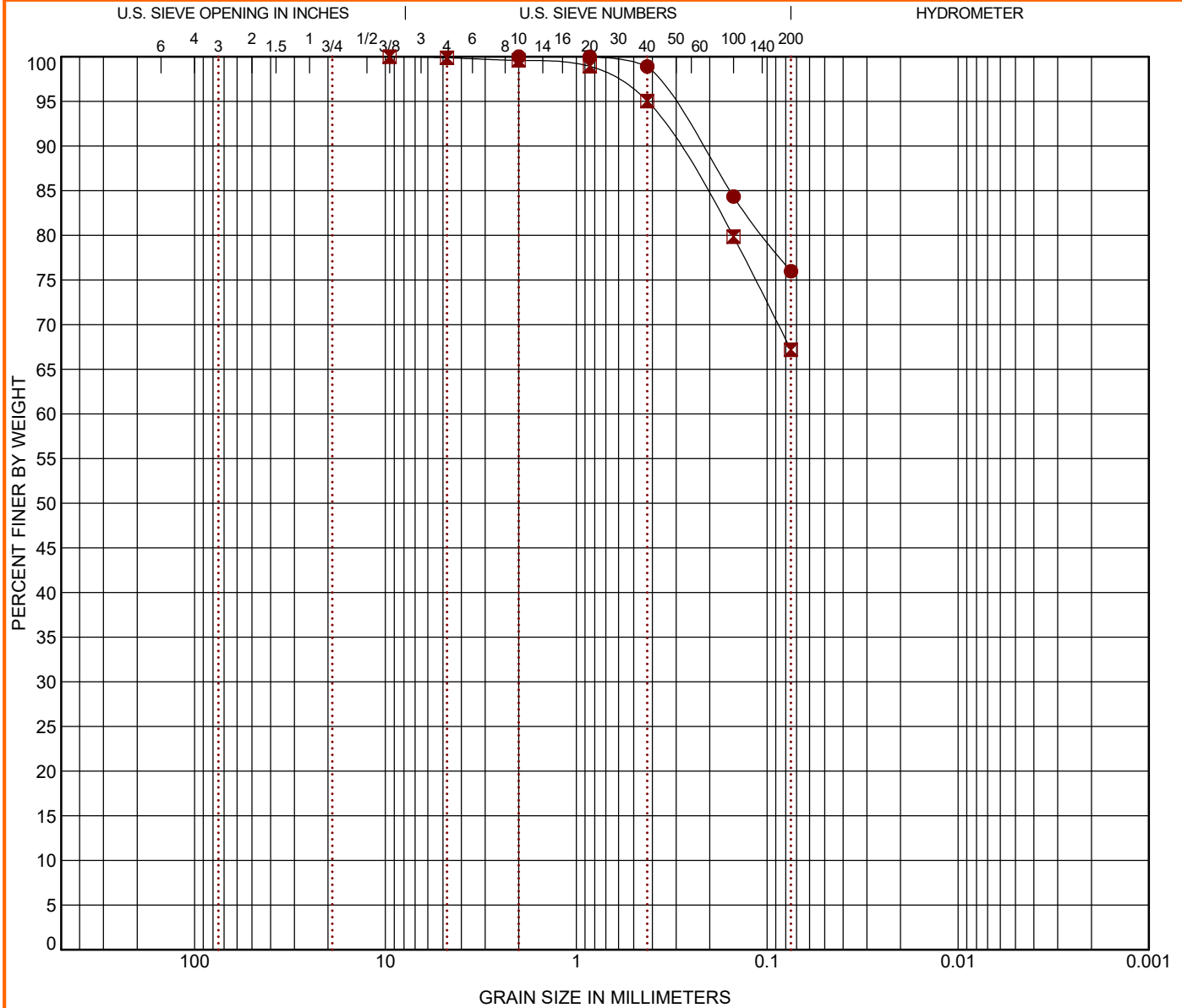


CLIENT: Short Elliott Hendrickson
Incorporated
Pueblo, Colorado

GRAIN SIZE DISTRIBUTION

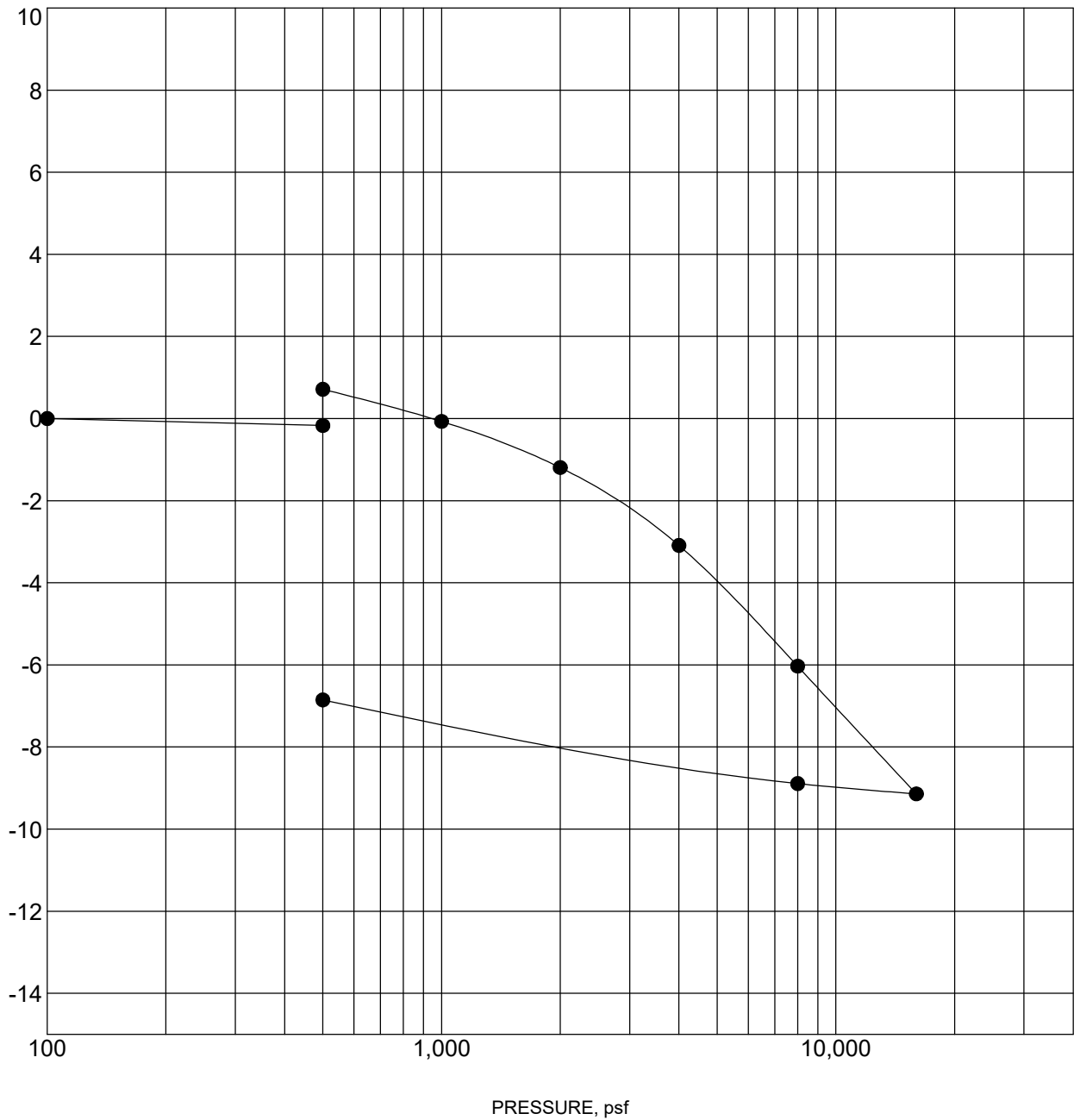
ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 24215084 INDIAN HEALTH SER.GPJ TERRACON_DATATEMPLATE.GDT 4/20/22



SWELL CONSOLIDATION TEST

AXIAL STRAIN, %



Specimen Identification		Classification	γ_d , pcf	WC, %
●	Wanblee-2 6 - 7 ft	SILTY CLAY with SAND(CL-ML)	94	16.8

NOTES: Sample exhibited 0.9 percent expansion when wetted under an applied pressure of 500 psf.

PROJECT: Indian Health Services Duplex Project

SITE: Intersection of Camp and 1st Avenues
Wanblee, South Dakota

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

PROJECT NUMBER: 24215084B

CLIENT: Short Elliott Hendrickson
Incorporated
Pueblo, Colorado

CHEMICAL LABORATORY TEST REPORT

Project Number: 24215084B

Service Date: 04/12/22

Report Date: 04/14/22

Terracon

10400 State Highway 191

Midland, Texas 79707

432-684-9600

Client

Short Elliott Hendrickson Incorporated

503 North Main Sreett Suite 225

Pueblo, CO 81003-6107

Project

Indian Health Services Duplex Project

Intersection of Camp and 1st Avenues

Wanblee, SD

<i>Sample Location</i>	W-2
<i>Sample Depth (ft.)</i>	1-6
pH Analysis, ASTM - G51-18	8.2
Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)	12
Sulfides, ASTM - D4658-15, (mg/kg)	nil
Chlorides, ASTM D 512 , (mg/kg)	44
RedOx, ASTM D-1498, (mV)	+438
Total Salts, ASTM D1125-14, (mg/kg)	313
Resistivity, ASTM G187, (ohm-cm)	4,130

Analyzed By:



Zach Robertson

Engineering Technician III

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

SUPPORTING INFORMATION

Contents:








General Notes

Unified Soil Classification System

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING	WATER LEVEL	FIELD TESTS
 Auger Cuttings  Modified California Ring Sampler  Standard Penetration Test	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Cave In Encountered <p>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.</p>	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				BEDROCK		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength Qu, (psf)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Ring Sampler Blows/Ft.	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)
Very Loose	0 - 3	0 - 5	Very Soft	less than 500	0 - 1	< 3	< 24	< 20	Weathered
Loose	4 - 9	6 - 14	Soft	500 to 1,000	2 - 4	3 - 5	24 - 35	20 - 29	Firm
Medium Dense	10 - 29	15 - 46	Medium Stiff	1,000 to 2,000	4 - 8	6 - 10	36 - 60	30 - 49	Medium Hard
Dense	30 - 50	47 - 79	Stiff	2,000 to 4,000	8 - 15	11 - 18	61 - 96	50 - 79	Hard
Very Dense	> 50	≥ 80	Very Stiff	4,000 to 8,000	15 - 30	19 - 36	> 96	> 79	Very Hard
			Hard	> 8,000	> 30	> 36			

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.

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

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

^F If soil contains $\geq 15\%$ 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 $\geq 15\%$ 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 $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

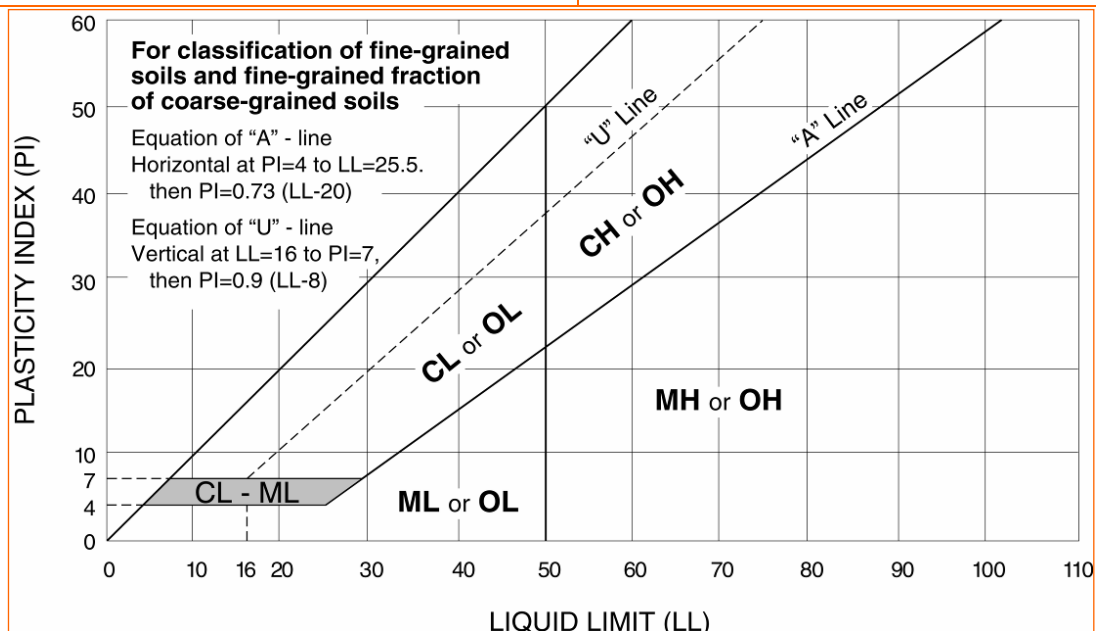
^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ 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.





Geotechnical Engineering Report

**Indian Health Services Duplex Project – Kyle
Kyle, South Dakota**

May 18, 2022

Terracon Project No. 24215084C

Prepared for:

Short Elliott Hendrickson, Inc.
Pueblo, Colorado

Prepared by:

Terracon Consultants, Inc.
Cheyenne, Wyoming



Revised May 18, 2022
April 27, 2022



Short Elliott Hendrickson, Inc.
503 North Main Street, Suite 225
Pueblo, Colorado 81003

Attn: Mr. Jimmie Hayson, P.E. – Principal
P: (719) 468-8373
E: jhayson@sehinc.com

Re: Geotechnical Engineering Report
Indian Health Services Duplex Project – Kyle
Kyle, South Dakota
Terracon Project No. 24215084C

Dear Mr. Hayson:

We have completed the Geotechnical Engineering services for the project referenced above. This study was performed in general accordance with Terracon Proposal No. P24215084 dated November 17, 2021. This report has been revised from its original version, dated April 27, 2022 to incorporate comments provided by SEH, and presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs 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.

A handwritten signature in black ink, appearing to read "Kiran P. Acharya", written over a circular embossed seal.

Kiran P. Acharya, Ph.D., P.E. (TX)
Project Engineer



REPORT TOPICS

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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

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SUPPORTING INFORMATION

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

Geotechnical Engineering Report
Indian Health Services Duplex Project – Kyle
Kyle Site
Kyle, South Dakota
Terracon Project No. 24215084C
May 18, 2022

INTRODUCTION

A geotechnical engineering report has been completed for the proposed Indian Health Services Duplex Project – Kyle Site to be located along Wapiyapi Avenue in Kyle, South Dakota. Five (5) borings, designated as Kyle-1 through Kyle-5, were performed to depths of about 15.5 to 20.5 feet below existing ground surface within the proposed duplex structure footprint. Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. Boring logs and laboratory testing data are included in the **Exploration Results** section of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Floor system design and construction
- Seismic site classification
- Lateral earth pressures

The recommendations contained in this report are based on the results of field and laboratory testing, engineering analyses, experience with similar soil and bedrock conditions and structures, and our understanding of the proposed project.

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	Kyle site is located along Wapiyapi Avenue in Kyle, South Dakota. Approximate coordinates near the center of the site are 43.4218° N latitude, 102.1865° W longitude. See Site Location .
Existing Improvements	The site is located in undeveloped areas. Existing housing developments are present to the west of the site.

Geotechnical Engineering Report

Indian Health Services Duplex Project – Kyle ■ Kyle, South Dakota

May 18, 2022 ■ Terracon Project No. 24215084C



Item	Description
Current Ground Cover	The site was covered with grasses and weeds.
Existing Topography	Relatively level

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	<p>The following documents were provided.</p> <ul style="list-style-type: none">■ Statement of A&E Services Design for Duplex Buildings and Site Locations prepared by Indian Health Services dated October 2021■ RFP addressed to SEH prepared by Indian Health Services dated November 8, 2021■ New Staff Headquarters, Kyle South Dakota Site Utility Plan prepared by Cooper Consultants, Inc. dated February 21, 2021■ Duplex Floor Plan (no preparer signature, no date)■ Sketches of proposed building locations for the site
Project Description	The project includes construction of new duplex structures (buildings) utilized as staff quarters.
Proposed Structure	We understand the proposed duplex buildings are planned to consist of two-stories and include a crawlspace or basement. Maximum building footprints are anticipated to be 1,800 square feet.
Building Construction	We expect the buildings will be of wood- or steel-framed construction supported on shallow, reinforced concrete, spread footing foundations with a slab-on-grade floor.
Finished Floor Elevation	Based on existing development near the sites, we assume finished floor elevation will be near (or within 2 feet of) existing ground surface elevations.
Assumed Maximum Loads	<p>Foundation loading information was not available at the time of this report preparation. However, based on our understanding of the project, we assume relatively light foundation loads as follows.</p> <ul style="list-style-type: none">■ Columns: 30 kips■ Walls: 2 kips per linear foot (klf)■ Slabs: 100 pounds per square foot (psf)
Grading	Based on the anticipated topography, we assume maximum cuts/fills on the order of about 1 to 2 feet may be required to develop final grades.

Item	Description
Below-Grade Structures	We understand a crawlspace or basement is planned for the buildings.

If project information or assumptions vary from what is described above or if location of construction changes, we should be contacted as soon as possible to confirm and/or modify our recommendations accordingly.

GEOTECHNICAL CHARACTERIZATION

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	Vegetative Soil	About 6 inches of root penetration.
2	Silt	Medium stiff to stiff silt, with fine grained sand. Dark brown to brown.
3	Clay	Medium stiff to hard, lean clay with varying amounts of fine grained sand. Dark brown to brown.
4	Bedrock	Hard to very hard claystone, with fine grained sand. Brown.

Note: Excavation difficulties are generally anticipated within Model Layer 4.

As noted in **General Comments**, this characterization is based upon widely spaced exploration points across the site, and variations are likely.

Groundwater

The boreholes were observed while drilling and shortly after completion for the presence and level of groundwater. Groundwater was not observed in any of the borings while drilling, or for the short duration the borings were allowed to remain open. This does not necessarily mean the borings terminated above groundwater. Due to the low permeability of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole. Long-term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Groundwater

is not expected to affect shallow foundation construction at this site. Due to safety concerns, soil borings were backfilled upon completion of drilling activities and subsequent groundwater measurements were not obtained. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results**.

The observations represent short-term groundwater conditions at the time of field exploration, and may not be indicative of other times, or at other locations. Groundwater levels can and should be expected to fluctuate in response to site development, irrigation demands adjacent to the streets and with varying seasonal and weather conditions. Therefore, groundwater levels during construction or at other times in the future may be higher or lower than the levels indicated on the boring logs. Seasonal fluctuations on the order of 2 to 3 feet are not uncommon; greater fluctuations are possible during extreme events.

GEOTECHNICAL OVERVIEW

Based on geotechnical conditions encountered in our test borings, the site appears suitable for the proposed construction from a geotechnical point of view provided certain precautions and design and construction recommendations presented in this report are followed. We have identified geotechnical conditions that could impact design, construction and performance of the building and other site improvements. These include low strength soils/subgrade stability with elevated moisture content near the building footprint. These conditions will require particular attention in project planning, design and during construction and are discussed in greater detail in the following sections.

Low Strength Soils/Subgrade Stability

Based on our boring and laboratory data, the native silt with sand and lean clay soils encountered generally exhibit comparatively medium stiff to hard consistencies and elevated in-place moisture contents. Penetration resistance measurements at our boring locations indicate these soils exhibit medium stiff relative density/consistency. Consequently, the native soils are expected to deflect and deform (pump) and create subgrade stability issues during site preparation. After removal of the vegetative soils, the contractor should expect unstable subgrades that will need to be stabilized prior to construction. Terracon recommends a contingency be provided in the construction budget to stabilize and correct weak/unstable subgrade. Further discussion regarding subgrade stabilization is presented in the **Earthwork** section of this report.

It appears feasible to support some of the buildings/structures on conventional footings and/or mat/slab foundations bearing on suitable native soils/bedrock or newly placed engineered fill. However, the native soils will be easily disturbed by construction activities and may not provide a suitable working surface. To help reduce disturbance of the subgrade due to construction equipment and provide positive support of shallow footing and mat foundations, lower strength native soils may need to be removed from below the proposed shallow footing and/or mat foundations. The resulting

excavations should be brought to final grade with engineered fill placed and compacted as recommended in this report.

The site soils could become unstable with typical earthwork and construction traffic, especially after precipitation events. Effective site drainage should be completed early in the construction sequence and maintained after construction to avoid potential strength and/or stability issues. If possible, the grading should be performed during the warmer and drier time of the year. If grading is performed during the spring or winter months or wet periods, an increased risk for possible undercutting and replacement of unstable subgrade will persist.

EARTHWORK

The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project. Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include documentation of the adequate removal of existing vegetative soils, observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

Site Preparation

Site preparation should commence with removal of existing pavement, vegetation, topsoil and any loose, soft, or otherwise unsuitable material from the proposed construction areas. Stripped materials consisting of vegetation and organic materials should be wasted from the site or used to re-vegetate landscaped areas (if any) after completion of grading operations.

Although evidence of existing fills or underground facilities, such as utilities, was not observed during the site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned. Terracon should observe the excavation prior to backfill placement and/or construction.

Exposed surfaces should be free of mounds and depressions that could prevent uniform compaction. Following completion of stripping and rough grading but prior to placement of new fill, the exposed ground should be scarified, moisture conditioned as needed and re-compacted. The subgrade should then be proof rolled to help delineate weak or disturbed areas at or near the ground surface. Unsuitable areas should be improved by moisture adjustment and compaction or by undercutting and placement of suitable compacted fill.

Fill Material Types

On-site soils free of organics, debris and any other unsuitable materials or low volume change import materials approved by Terracon may be used as fill/backfill material on the site. In general, imported materials meeting the properties presented below should be acceptable for use. Other import fill material types may be suitable for use depending upon proposed application and location. However, imported soils should be evaluated and approved by the geotechnical engineer prior to delivery to the site.

Gradation/Property	Percent Finer by Weight (ASTM C136)
3-inch	100
No. 4 Sieve	30 to 100
No. 200 Sieve	50 (max.)
■ Liquid Limit (LL)	30 (max.)
■ Plasticity Index (PI)	15 (max.)

Fill Compaction Requirements

Structural and general fill/backfill should meet the following compaction requirements.

Item	Description
Fill lift thickness	<ul style="list-style-type: none"> ■ 9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used ■ 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used
Minimum Compaction requirements¹	At least 95% of the standard Proctor maximum dry density (ASTM D698)
Moisture content onsite low plasticity granular and cohesive soils^{2,3}	-2 to +2% of the optimum moisture content as determined by the standard Proctor test

1. Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. A construction disc or other suitable processing equipment will be needed to thoroughly process the materials and to aid in achieving uniform moisture content throughout the fill.
2. The contractor should expect some moisture adjustment and processing of the site soils or import materials will be needed prior to or during compaction operations.

Item	Description
3.	Moisture conditioned cohesive soils should not be allowed to dry out. A loss of moisture within these materials will likely result in an increase of the material's swell potential. Subsequent wetting of these materials could result in undesirable movements.
4.	Care should be taken during the fill placement process to avoid zones of dissimilar fill. Improvements constructed over varying fill types are at a higher risk of differential movement compared to improvements over a uniform fill zone.

Excavation and Utility Trench Construction

We anticipate excavations up to about 5 to 7 feet may be necessary for utility trench construction. We believe the soils encountered in our exploratory borings can be excavated with conventional excavation equipment.

Trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. Trench backfill should consist of the on-site soils free of organic matter or approved imported materials. Trench backfill should be placed and compacted as described under **Fill Compaction Requirements**. It is strongly recommended a representative of the geotechnical engineer provide full-time observation and compaction testing of trench backfill within the building area.

Underground piping within or near the proposed building footprint should be designed and constructed so deviations in alignment do not result in breakage or distress. Utility knockouts in grade beams should be oversized to accommodate differential movements.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations in order to maintain stability of excavation sides and bottom as well as any adjacent improvements. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards. As a safety measure, it is suggested vehicles and soil piles be kept to a minimum lateral distance from the crest of the slope equal to no less than the slope height. Exposed slope faces should be protected against the elements.

The soils to be penetrated by the proposed excavations may vary significantly across the site. The soil classifications are based solely on the materials encountered in widely spaced exploratory test borings. The contractor should verify similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

Grading and Drainage

Proper drainage and surface water management is important to the performance of foundations, floor slabs, and other site improvements. The following recommendations are considered good practice for any site and should be implemented where applicable and/or to the extent possible.

Grades must be adjusted to provide positive drainage away from the building and other site improvements during construction and maintained throughout the life of the proposed facility. Infiltration of water into utility or foundation excavations must be prevented during construction.

Landscaped irrigation adjacent to the foundation system should be minimized. Plants placed close to foundation walls should be limited to those with low moisture requirements. The importance of proper irrigation practices cannot be over emphasized. Irrigation should be limited to the minimum amount needed to maintain vegetation; application of more water will increase likelihood of slab and foundation movements in excess of those described in this report.

We recommend constructing slopes of about 6 inches in the first 10 feet (5 percent slope) in landscaped areas around the building, where practical. The ground surface should be sloped in such a manner that water will not pond between or adjacent to structures and other site improvements. Concrete curbs and sidewalks may “dam” surface runoff adjacent to the building and disrupt proper flow. Use of “chase” drains or weep holes at low points in the curb should be considered to promote proper drainage.

Backfill against foundations, exterior walls and in utility and sprinkler line trenches should be well compacted and free of organics and construction debris to reduce moisture infiltration. We recommend exterior foundation wall backfill consist of on-site clayey soils or approved import materials to reduce infiltration and conveyance of surface water through the backfill. Some settlement of wall backfill should be expected even if properly compacted. Areas where backfill has settled should be repaired and re-graded immediately to maintain proper slope away from the foundation.

Flatwork will be subject to post construction movement. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond. Where paving or flatwork abuts the structure, care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Planters located adjacent to the structure (if any) should be self-contained. Sprinkler mains and spray heads should not be installed or allowed to discharge within 5 feet of foundation walls. Roof drains should be extended away from the structure well beyond the limits of the backfill zone through the use of splash blocks or downspout extensions. Downspouts and extensions should be monitored and maintained in good working condition. Generally speaking, downspouts should not be buried and extended below grade, as these systems can be difficult to monitor and maintain.

Water permitted to pond near or adjacent to the perimeter of the structure (either during or post-construction) can result in higher soil movements than those discussed in this report. As a result, estimations of potential movement described in this report cannot be relied upon if positive drainage is not obtained and maintained, and water is allowed to infiltrate the fill and/or subgrade.

After building construction and prior to project completion, we recommend verification of final grading be performed to document that positive drainage, as described in this section, has been achieved. Maintenance of surface drainage is imperative subsequent to construction and becomes the responsibility of the owner.

Earthwork Construction Considerations

As discussed in the **Geotechnical Overview** section above, the native silt with sand and lean clay soils encountered generally exhibit comparatively low relative density/consistency and strength. Penetration resistance measurements at our boring locations indicate these soils exhibit medium stiff relative density/consistency. Consequently, the native soils are expected to deflect and deform (pump) and create subgrade stability issues during site preparation. After removal of the vegetative soils, the contractor should expect unstable subgrades that will need to be stabilized prior to construction. Terracon recommends a contingency be provided in the construction budget to stabilize and correct weak/unstable subgrade.

If unstable ground conditions develop during earthwork or subgrade preparation, some method of soil improvement or stabilization will be needed prior to construction of foundations and floor slabs. There are a number of stabilization methods that can be used to improve the subgrade and depend, in part, on the extent and severity of the unstable soils exposed during construction as well as other factors. For isolated or small areas requiring stabilization, moisture conditioning and recompaction or mechanical stabilization with granular materials and/or geosynthetics may be effective. If large areas require stabilization, chemical treatment of the soils may be a more effective alternative. In any event, we feel the appropriate method and level of stabilization should be evaluated and can best be determined on a case-by-case basis during construction once the entire subgrade and overall conditions are exposed. We are available to provide specific stabilization recommendations during construction upon your request.

Upon completion of site preparation, care should be taken to maintain the subgrade moisture content prior to construction of foundations and floor slabs. Construction traffic over the completed subgrade 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 the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and recompacted prior to fill placement or foundation, and floor slab construction.

Construction Observation and Testing

The earthwork efforts should be monitored under the guidance of Terracon. Monitoring should include documentation of adequate removal of vegetation and topsoil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation. Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts.

In areas of foundation excavations, the bearing subgrade should be evaluated under the guidance of Terracon. In the event unanticipated conditions are encountered, we should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of Terracon into the construction phase of the project provides the continuity to maintain our evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

Based on the field exploration and laboratory test results and the type of construction planned, it is our opinion the proposed building can be supported on shallow spread footings bearing on approved native soils or properly compacted engineered fills, provided the site has been prepared in accordance with the **Earthwork** section of this report. Design criteria and construction recommendations for spread footings are presented in the following table and paragraphs.

Spread Footing Design Recommendations

Item	Description	
Bearing material	On-site soils or engineered fill	
Maximum allowable soil bearing pressure ¹	2,000 psf	
Minimum dimensions	<u>Column</u>	<u>Wall Footing</u>
	24 inches	18 inches
Minimum embedment below finished grade for frost protection ²	4 feet	
Estimated post-construction movement based on assumed structural loads ³	About 1 inch	
Ultimate passive pressure ⁴	295 psf/ft	
Ultimate coefficient of sliding friction ⁴	0.33	

Item	Description
1.	The allowable soil bearing pressure applies to dead loads plus design live load conditions and is the maximum pressure that should be transmitted to the bearing soils in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes otherwise unsuitable bearing conditions, if encountered, will be undercut and replaced with properly compacted engineered fill.
2.	For perimeter footings and footings beneath unheated areas. Interior column pads in heated areas should bear at least 18 inches below the adjacent grade (or the top of the floor slab) for confinement of the bearing materials and to develop the recommended bearing pressure.
3.	Foundation movement will depend upon variations within the subsurface soil profile, structural loading conditions, embedment depth of footings, thickness of compacted fill, and the quality of the earthwork operations. Settlement estimates are based on the maximum allowable soil bearing pressure, assumed structural loads and resulting foundation geometry. If actual foundation loads vary significantly from those assumed, we should be contacted to review our recommendations. Additional foundation movements could occur if surface water infiltrates the foundation soils; therefore, proper drainage away from the foundation system should be provided in the final design, during construction and maintained throughout the life of the structure.
4.	The sides of the excavation for spread footings must be nearly vertical and the concrete should be placed neat against these vertical faces or backfill must be compacted to at least 95 percent of the standard Proctor maximum dry density for the passive earth pressure value to be valid. Passive pressure requires movement to generate the resistance and should only be used when movement is tolerable and the soil is well compacted and will not be removed. The passive resistance and friction factor are ultimate values. As such, appropriate factors of safety should be applied.

Footings should be proportioned to reduce differential foundation movement. Proportioning on the basis of relative constant dead-load pressure can provide a means to reduce differential movement between adjacent footings. Foundations should be detailed and reinforced as necessary to reduce the potential for distress caused by differential foundation movement.

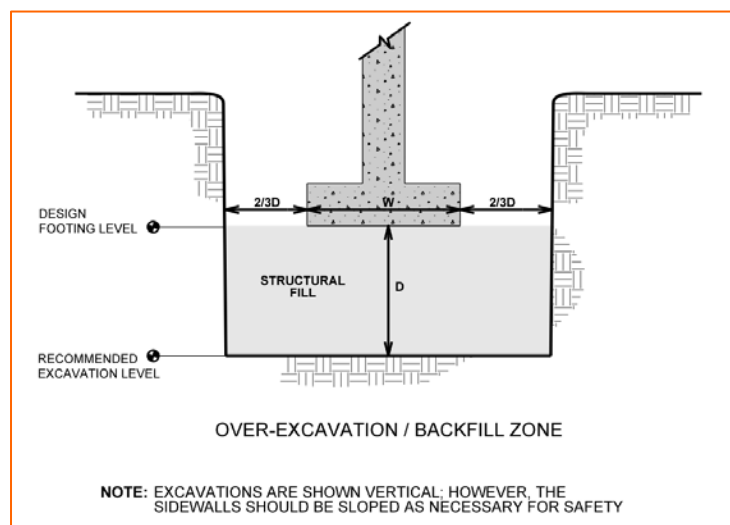
Spread Footing Construction Considerations

Where soils are loosened during excavation or in the forming process for footings, or if low-strength soils or otherwise unsuitable bearing conditions are present, they should be removed to minimum depths determined by the Geotechnical Engineer and the resulting excavation should be backfilled up to footing base elevation with approved fill material placed and compacted as described in the **Earthwork** section of this report. Over-excavation for structural fill placement below footings (if needed) should be conducted as shown below.

Geotechnical Engineering Report

Indian Health Services Duplex Project – Kyle ■ Kyle, South Dakota

May 18, 2022 ■ Terracon Project No. 24215084C



The base of foundation excavations should be free of water and loose soil prior to concrete placement. Concrete should be placed soon after subgrade preparation to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete.

Completed foundation excavations should be observed and evaluated by a representative of Terracon well in advance of forming footings and placement of reinforcing steel to confirm satisfactory bearing materials are present and subsurface conditions are consistent with those encountered in our borings. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

FLOOR SLABS

All slabs-on-grade undergo some movement. Provided the site has been prepared in accordance with the **Geotechnical Overview** and **Earthwork** sections of this report. We believe risk of movement is low for the soil conditions encountered on this site and estimate settlement of slabs-on-grade constructed on properly prepared subgrade to be less than 1 inch. Where slab movement cannot be accepted or must be reduced, we are available to discuss floor movement mitigation techniques upon your request.

As discussed in the **Geotechnical Overview** section, low strength soils with elevated moisture content were encountered near the building footprint. In order to provide more uniform support across the floor slab area, we recommend the floor slab be supported on at least 12 inches of clean imported granular material compacted as described in this report.

Design Recommendations

Item	Description
Floor slab support	12-inch zone of moisture conditioned and compacted subgrade. Existing fill, where present, should be removed and re-worked.
Modulus of subgrade reaction	For limited area loads or concentrated/point loads placed directly on slabs: <ul style="list-style-type: none"> ■ 100 pounds per square inch per in (psi/in) for slabs supported on compacted subgrade consisting of the on-site silt with sand and lean clay soils. ■ 140 psi/in for slabs supported on at least 12 inches of compacted clean imported granular material.
Slab thickness	Slab reinforcement and thickness should be designed by a qualified engineer based on actual loads imposed and on intended slab use.

We recommend the following precautions be observed where slabs-on-grade are used. These precautions will not eliminate slab movement, but they tend to reduce damage when movement occurs. Additional floor slab design and construction recommendations are as follows:

- Positive separations and/or isolation joints should be provided between slabs and foundations, columns or utility lines to allow free vertical movement. This detail can reduce cracking when movement of the slab occurs. As a precautionary measure, non-bearing partition walls placed on the floor slab (if any) should be designed and constructed to allow at least 1½ inches of free vertical movement.
- Frequent control joints should be provided in slabs to control the location and extent of cracking in accordance with the American Concrete Institute (ACI). For additional recommendations refer to the *ACI Design Manual*.
- The use of a vapor retarder should be considered beneath concrete slabs on grade that will be 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/barrier, 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/barrier.
- Other design and construction considerations, as outlined in the *ACI Design Manual*, Section 302.1R are recommended.

Floor Slab Construction Considerations

Fill/backfill placed beneath slabs and next to foundation walls should be moisture conditioned and compacted as described in the **Earthwork** section of this report. Soils loosened during excavation or other construction activities should be removed or recompacted as described in this report. Floor slabs should not be constructed on frozen subgrade.

Once fill is placed and the subgrade is prepared, it is important measures be planned and taken to reduce drying of the near surface materials. If the fill dries excessively prior to construction, then it will be necessary to rework the upper, drier materials just prior to installing floor slabs.

We recommend the area underlying the floor slab be carefully evaluated within 24 hours before slab construction. Particular attention should be paid to areas of existing foundation wall backfill and where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted fill. Floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report about 24 hours before placement of the base and/or concrete. The subgrade should be re-evaluated and re-approved should concrete not be placed within this time frame or should the subgrade become disturbed after construction.

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 Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil/rock 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 D**. Subsurface explorations at this site were extended to a maximum depth of 20½ 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.

CORROSIVITY

The values presented in the table below may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary									
Boring	Sample Depth (feet)	Soil Description	Sulfides (mg/kg)	Red-Ox Potential (mV)	Soluble Sulfate (mg/kg)	Chlorides (mg/kg)	Electrical Resistivity ¹ (Ω-cm)	pH	Total Salts (mg/kg)
K-2	1 to 6	Silty Clay with Sand (CL-ML)	Nil	+433	77	56	1,549	8.3	653

1. Test performed on saturated soil sample.

We recommend a certified corrosion engineer be employed to determine the need for corrosion protection and to design appropriate protective measures. The sulfate concentration measured in the sample was 77 mg/kg which equates to approximately 0.01 percent. Sulfate concentrations of less than 0.1 mg/kg indicate Class S0 exposure to sulfate attack for concrete in contact with the subsoils, according to the American Concrete Institute (ACI) *Guide to Durable Concrete*. For this level of sulfate concentrations, ACI indicates any type of cement can be used for concrete in contact with the subsoils.

Therefore, Type I Portland cement should be suitable for concrete on and below grade. However, if there is no, or minimal cost differential, use of Type II Portland cement (or equivalent) should be considered for additional sulfate resistance of construction concrete. Foundation concrete should be designed in accordance with the provisions of the *ACI Design Manual*, Section 318, Chapter 4.

LATERAL EARTH PRESSURES

We understand below-grade structures, such as a crawlspace or basement is planned for the buildings. The following sections provide recommendations and considerations for below-grade structures supporting unbalanced backfill levels. These values can also be used for lateral capacity analyses for drilled circular footings.

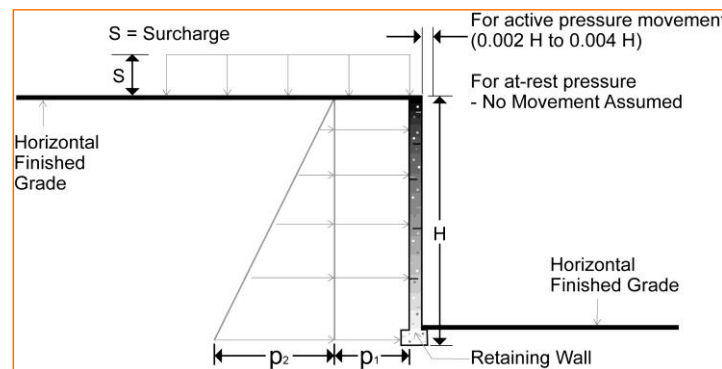
Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).

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Indian Health Services Duplex Project – Kyle ■ Kyle, South Dakota

May 18, 2022 ■ Terracon Project No. 24215084C



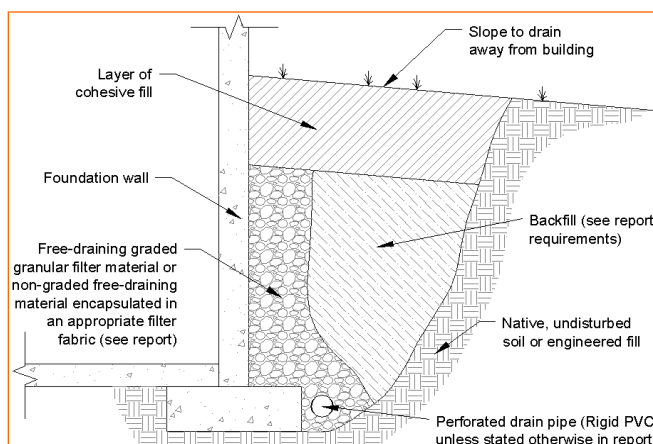
Lateral Earth Pressure Design Parameters				
Earth Pressure Condition ¹	Coefficient for Backfill Type ²	Surcharge Pressure ^{3, 4, 5} p_1 (psf)	Effective Fluid Pressures (psf) ^{2, 4, 5}	
			Unsaturated ⁶	Submerged ⁶
Active (K_a)	Granular - 0.31	$(0.31)S$	$(40)H$	$(80)H$
	Fine Grained - 0.41	$(0.41)S$	$(50)H$	$(85)H$
At-Rest (K_o)	Granular - 0.47	$(0.47)S$	$(55)H$	$(90)H$
	Fine Grained - 0.58	$(0.58)S$	$(70)H$	$(95)H$
Passive (K_p)	Granular - 3.25	---	$(390)H$	$(250)H$
	Fine Grained - 2.46	---	$(295)H$	$(205)H$

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H , where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95% of the ASTM D 698 maximum dry density, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. To achieve "Unsaturated" conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. "Submerged" conditions are recommended when drainage behind walls is not incorporated into the design.

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extended below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill.

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.

Geotechnical Engineering Report

Indian Health Services Duplex Project – Kyle ■ Kyle, South Dakota

May 18, 2022 ■ Terracon Project No. 24215084C



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.

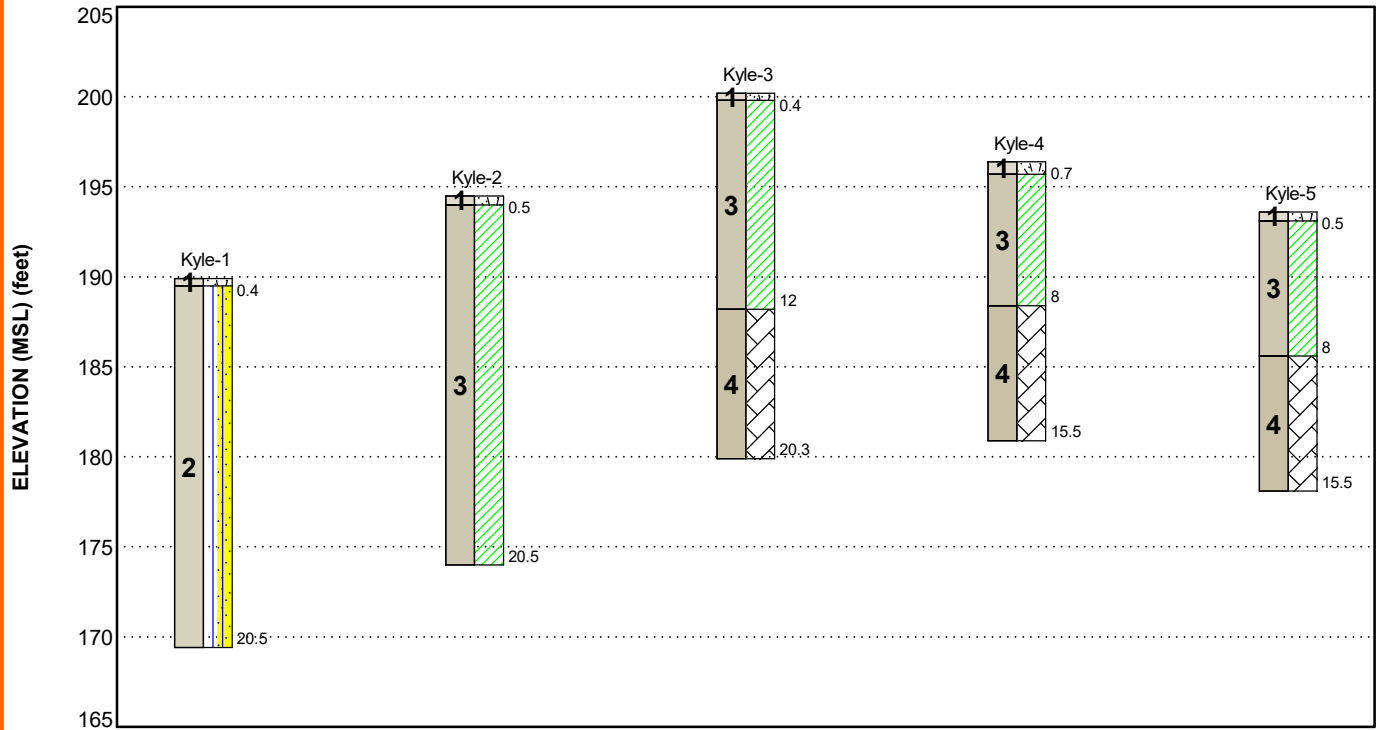
FIGURES

Contents:

GeoModel

GEOMODEL

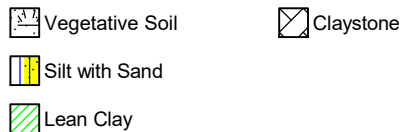
Indian Health Services Duplex Project ■ Kyle, South Dakota
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This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Vegetative Soil	About 6 inches of root penetration
2	Silt	Medium stiff to stiff silt, with fine grained sand. Dark brown to brown.
3	Clay	Medium stiff to hard, lean clay with varying amounts of fine grained sand. Dark brown to brown.
4	Bedrock	Hard to very hard claystone, with fine grained sand. Brown.

LEGEND



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

Contents:

Exploration and Testing Procedures (2 pages)

Site Location and Exploration Plan (2 pages)

Exploration Results (10 pages)

Supporting Information (2 pages)

Note: All attachments are one page unless noted above.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number & Designation of Borings	Boring Depth (feet)	Planned Location
5 (Kyle-1 through Kyle-5)	15.5 to 20.5	Planned Building Areas

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 relative ground surface elevations were measured with an engineer's level referencing a temporary benchmark. If more precise boring layout and ground surface elevations are desired, we recommend the boring locations be surveyed.

Subsurface Exploration Procedures: Soil borings were advanced with a Mobile B-57 truck-mounted drilling rig using solid-stem, continuous-flight augers. Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. Soil sampling was performed using standard split-barrel procedures and a modified California barrel. In the split-barrel sampling procedure, 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 last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. For the modified California barrel sampling procedure, a 2½-inch outer diameter ring-lined sampler is used for sampling. Modified California barrel sampling procedures are similar to standard split-barrel sampling procedures; however, blow counts are typically recorded for 6-inch intervals for a total of 12 inches of penetration. Additionally, a bulk sample of auger cuttings were obtained from boring Kyle-1 from about 1 to 6 feet below existing ground surface. Groundwater was not encountered during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after completion of drilling.

The sampling depths, penetration distances, and other sampling information were 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

Geotechnical Engineering Report

Indian Health Services Duplex Project – Kyle ■ Kyle, South Dakota

May 18, 2022 ■ Terracon Project No. 24215084C



Laboratory Testing

Samples retrieved during the field exploration were returned to the laboratory for observation by the project Geotechnical Engineer and were visually classified in general accordance with the Unified Soil Classification System described in the **Supporting Information** section of this report.

After sample review by the project engineer, an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Following completion of the laboratory testing, the field and visual descriptions were confirmed or modified as necessary, and Boring Logs were prepared. These logs are presented in the **Exploration Results** section of this report.

Selected samples were tested for the following physical and/or engineering properties:

- Moisture content
- Unit weight
- Atterberg limits
- Grain size analysis
- Swell/consolidation
- Corrosivity

Laboratory test results are indicated on the boring logs and are presented in depth in the **Exploration Results** section. The test results are used for the geotechnical engineering analyses and the development of earthwork, foundation, and floor slab recommendations. Laboratory tests are performed in general accordance with applicable local standards or other accepted standards. Procedural standards noted in this report are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgement.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are Unified Soil Classification Symbols. A brief description of this classification system as well as the General Notes can be found in the **Supporting Information** section. Classification was by visual-manual procedures. Selected samples were further classified using the result of Atterberg limit and percent fines testing. These test results are also provided in the **Exploration Results** section.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan

Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

Indian Health Services Duplex Project – Kyle ■ Kyle, South Dakota
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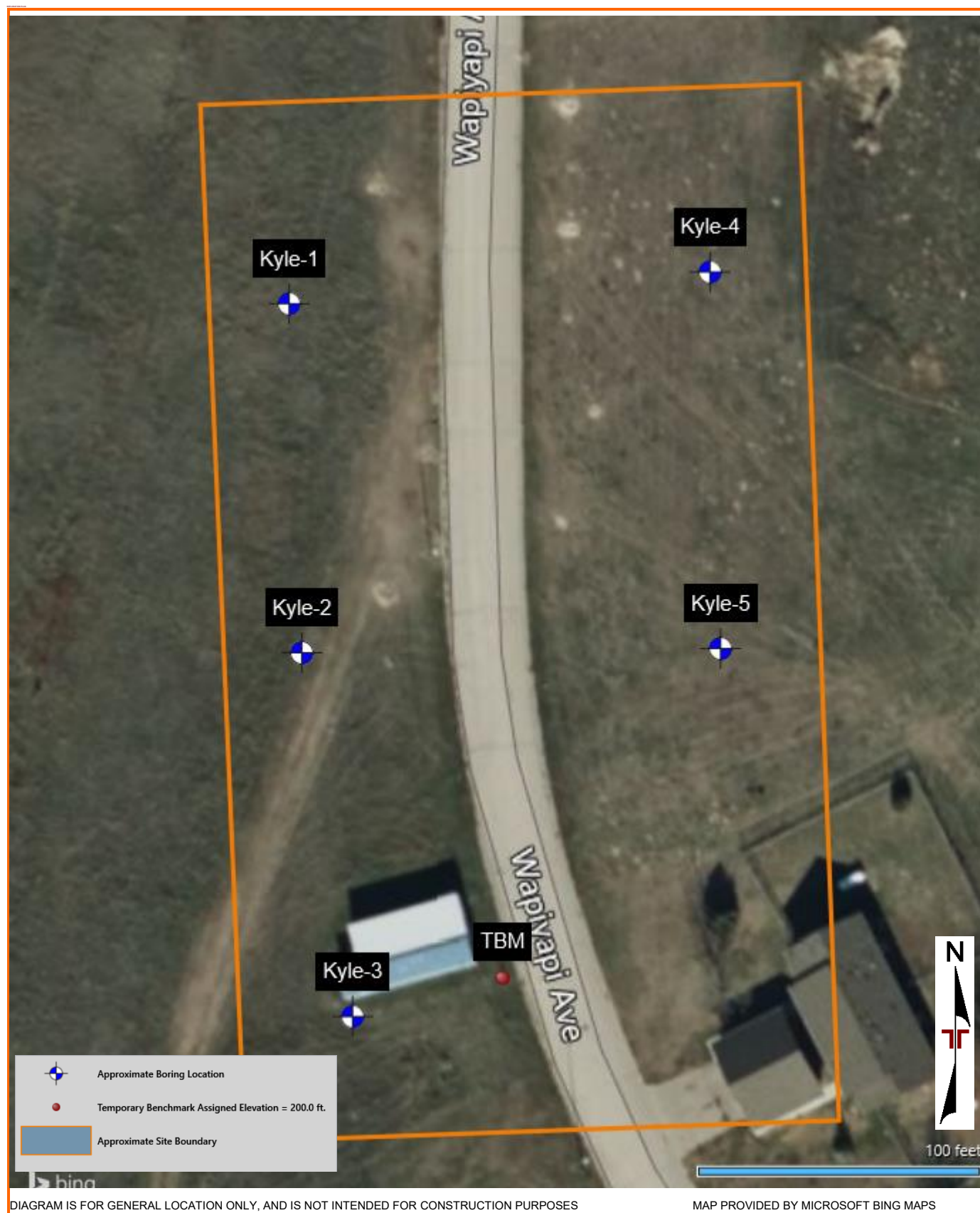
DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

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EXPLORATION RESULTS

Contents:

Boring Logs (Kyle-1 through Kyle-5)
Atterberg Limits
Grain Size Distribution
Swell Consolidation Test (2 pages)
Corrosivity

Note: All attachments are one page unless noted above.

Page 1 of 1

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

[illegible]

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Project No.: 24215084C

BORING LOG NO. Kyle-2

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Various Locations
Fort Thompson, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.4218° Longitude: -102.1868° Surface Elev.: 194.5 (Ft.) DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.5 VEGETATIVE SOIL , about 6 inches of root penetration LEAN CLAY (CL) , varies to silt, trace fine grained sand, dark brown to brown, medium stiff to stiff Color changes from light brown to brown at about 3 feet Color changes from brown to dark brown at about 8 feet Varies to SILTY CLAYEY SAND at about 12 feet Trace moderately cemented nodules at about 19 feet 20.5	194		X	3-4-7 N=11		19.7			
			5		X	15/12"		17.1	92		
			10		X	3-2-3 N=5		15.1			
			15		X	4-3-4 N=7		16.0			
			20		X	4-5-7 N=12		13.5		31-22-9	90
					X	4-4-5 N=9		16.9			
		Boring Terminated at 20.5 Feet									

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

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of
symbols and abbreviations.

Elevations were measured in the field using an
engineer's level and grade rod.

Notes:

Top bolt of fire hydrant east of K-3

Assigned TBM = 200.0 feet

See Exploration Plan

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon

1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-29-2022

Drill Rig: Mobile B-57

Project No.: 24215084C

Boring Completed: 03-29-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL_24215084 INDIAN HEALTH SER GPJ TERRACON_DATATEMPLATE.GDT 4/26/22

BORING LOG NO. Kyle-3

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Various Locations
Fort Thompson, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.4214° Longitude: -102.1867° Surface Elev.: 200.2 (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.4 VEGETATIVE SOIL , about 5 inches of root penetration	200			2-3-4 N=7		22.9			
3		LEAN CLAY (CL) , varies to silt, trace fine grained sand, light brown to brown, medium stiff to stiff, trace small roots to about 3 feet				4-4-4 N=8		14.1			
			5			3-5-5 N=10		12.0			
			10			8/12"		15.2	83		
4		12.0 CLAYSTONE , fine grained sand, light brown, very hard	188			17-30-50/6"		16.0			
			15			31-37-50/4"		20.4			
		20.3 Boring Terminated at 20.3 Feet	180								

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

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

Elevations were measured in the field using an engineer's level and grade rod.

Notes:

Top bolt of fire hydrant east of K-3

Assigned TBM = 200.0 feet

See Exploration Plan

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon

1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-29-2022

Drill Rig: Mobile B-57

Project No.: 24215084C

Boring Completed: 03-29-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL_24215084 INDIAN HEALTH SER.GPJ TERRACON_DATATEMPLATE.GDT 4/26/22




BORING LOG NO. Kyle-4

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PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Various Locations
Fort Thompson, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.4222° Longitude: -102.1862° Surface Elev.: 196.4 (Ft.) DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.7 VEGETATIVE SOIL , about 8 inches of root penetration 195.5				3-3-4 N=7		17.4			
3		LEAN CLAY (CL) , varies to silt, trace fine grained sand, dark brown to brown, medium stiff to stiff, trace small roots to about 3 feet Color changes from brown to light brown at about 2 feet 8.0 188.5	5			11/12"		9.4	89		
4		CLAYSTONE , with fine grained sand, light brown, hard 15.5 181	10			3-4-4 N=8		20.3			
			15			10-23-30 N=53		21.7			
						11-25-39 N=64		20.3			
		Boring Terminated at 15.5 Feet									

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

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

Elevations were measured in the field using an engineer's level and grade rod.

Notes:

Top bolt of fire hydrant east of K-3

Assigned TBM = 200.0 feet

See Exploration Plan

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-29-2022

Drill Rig: Mobile B-57

Project No.: 24215084C

Boring Completed: 03-29-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL_24215084 INDIAN HEALTH SER.GPJ TERRACON_DATATEMPLATE.GDT 4/26/22




BORING LOG NO. Kyle-5

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PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Various Locations
Fort Thompson, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.4218° Longitude: -102.1862° Surface Elev.: 193.6 (Ft.) DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.5 VEGETATIVE SOIL , about 8 inches of root penetration LEAN CLAY (CL) , varies to silt, trace fine grained sand, dark brown to brown, stiff to hard, trace small roots to about 2 feet Color changes from brown to light brown at about 2 feet	193		X	2-5-7 N=12		21.0			
3		Trace moderately cemented nodules at about 6 feet	5		X	3-5-7 N=12		16.8			
					XX	49/12"		21.2	88		
4		8.0 CLAYSTONE , with fine grained sand, light brown, hard to very hard Trace strongly cemented nodules at about 9.5 feet	185.5		X	25-50/4"		15.8			
			15		X	11-26-39 N=65		21.6			
		15.5 Boring Terminated at 15.5 Feet	178								

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

Hammer Type: Automatic, Hammer Efficiency = 93.8%, N60 Correction Factor = 1.6

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

Elevations were measured in the field using an engineer's level and grade rod.

Notes:

Top bolt of fire hydrant east of K-3

Assigned TBM = 200.0 feet

See Exploration Plan

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon

1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-29-2022

Drill Rig: Mobile B-57

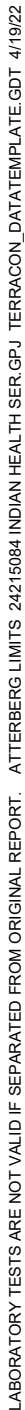
Project No.: 24215084C

Boring Completed: 03-29-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL_24215084 INDIAN HEALTH SER.GPJ TERRACON_DATATEMPLATE.GDT 4/26/22

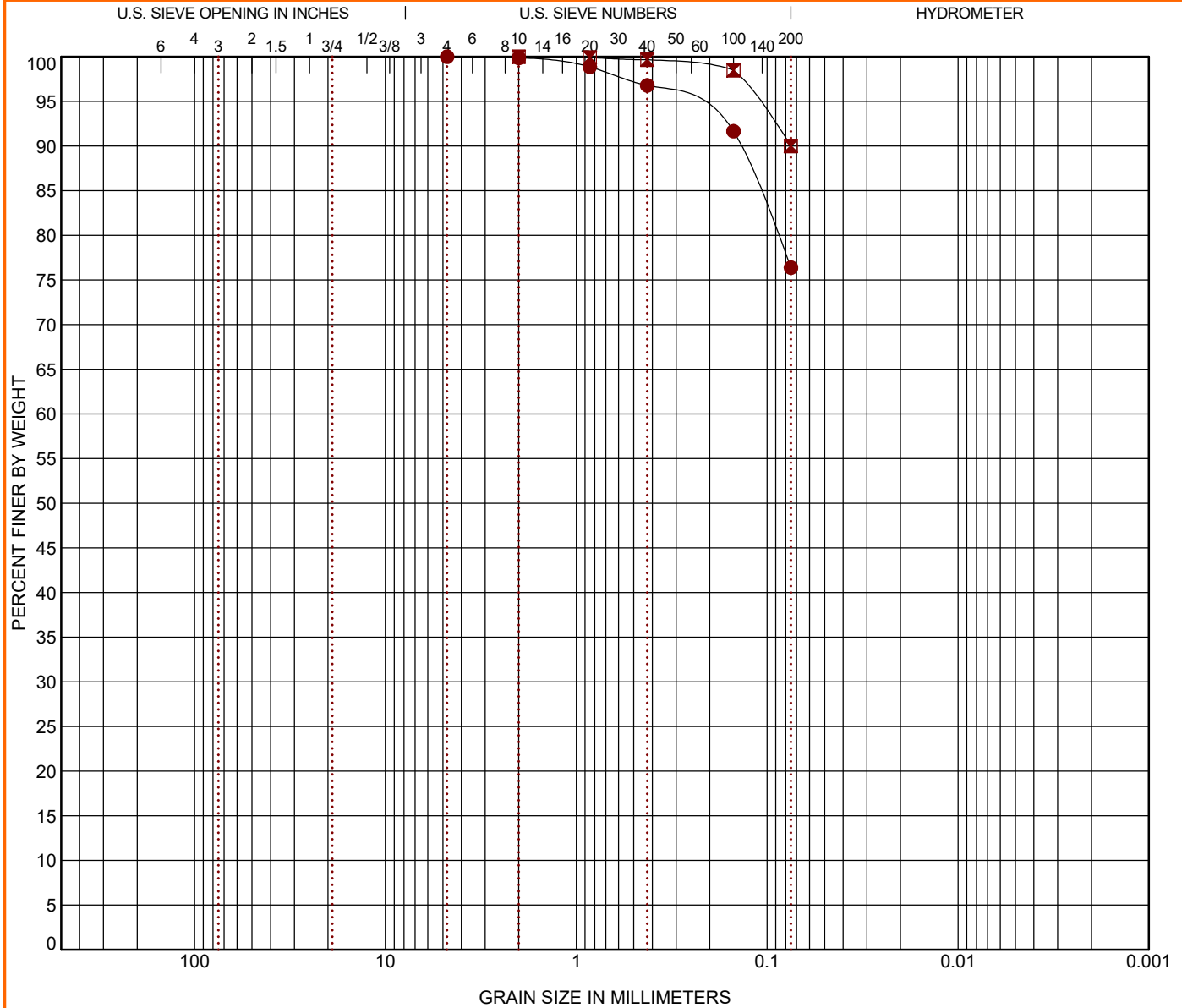
ASTM D4318



CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth (Ft)	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
● Kyle-1	6 - 7	SILT with SAND (ML)	13.7	33	25	8		
✕ Kyle-2	14 - 15.5	LEAN CLAY (CL)	13.5	31	22	9		

Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
● Kyle-1	6 - 7	4.75				0.0	0.0	23.6		76.4	
✕ Kyle-2	14 - 15.5	2				0.0	0.0	10.0		90.0	

PROJECT: Indian Health Services Duplex Project

SITE: Wapiyapi Avenue
Kyle, South Dakota



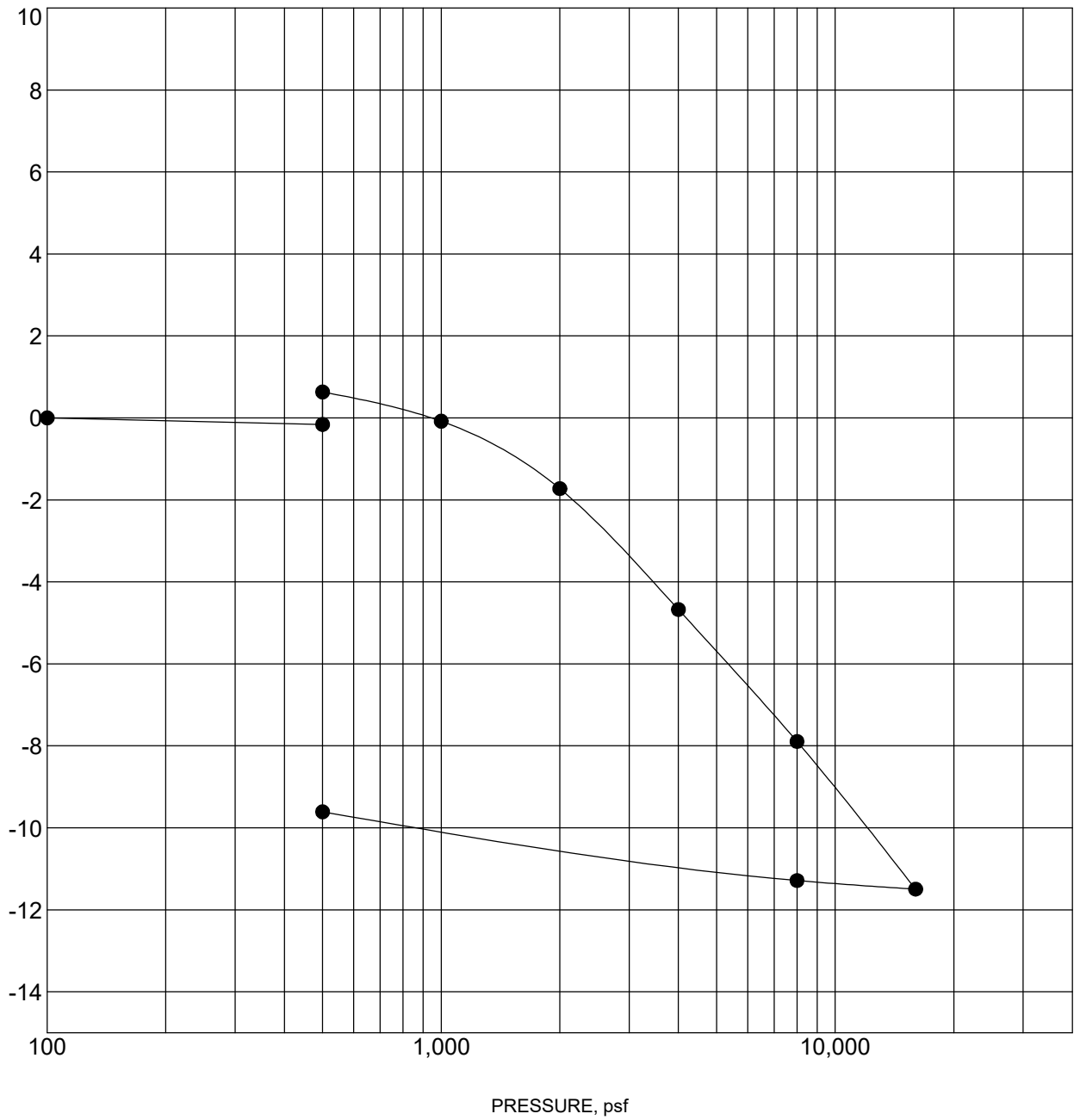
PROJECT NUMBER: 24215084C

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 24215084 INDIAN HEALTH SER.GPJ TERRACON_DATATEMPLATE.GDT 4/19/22

SWELL CONSOLIDATION TEST

AXIAL STRAIN, %



Specimen Identification			Classification	γ_d , pcf	WC, %
●	Kyle-1	6 - 7 ft	SILT with SAND(ML)	84	12.9

NOTES: Sample exhibited 0.8 percent expansion when wetted under an applied pressure of 500 psf.

PROJECT: Indian Health Services Duplex Project

SITE: Wapiyapi Avenue
Kyle, South Dakota

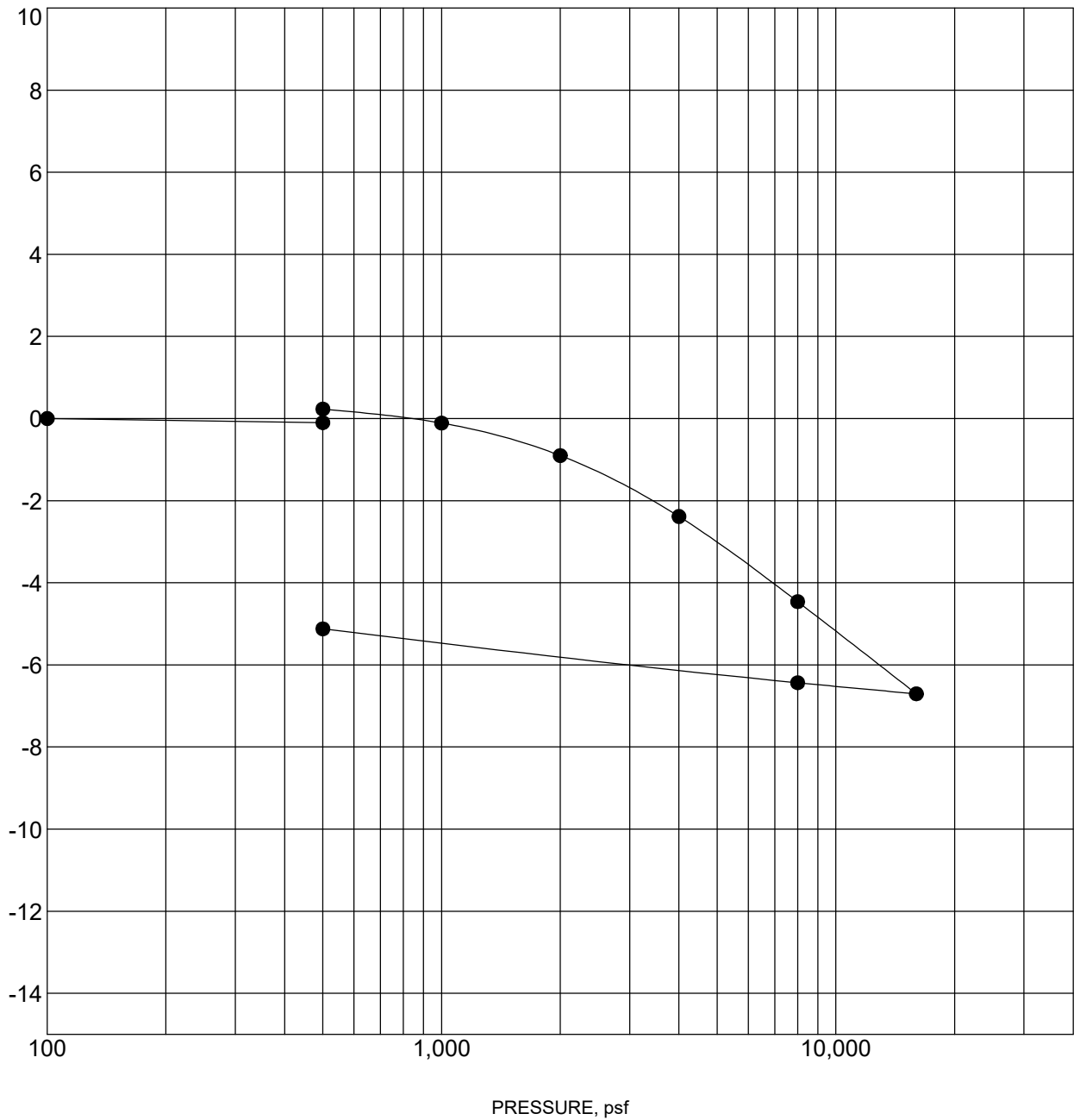
Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

PROJECT NUMBER: 24215084C

CLIENT: Short Elliott Hendrickson
Incorporated
Pueblo, Colorado

SWELL CONSOLIDATION TEST

AXIAL STRAIN, %



Specimen Identification			Classification	γ_d , pcf	WC, %
●	Kyle-3	9 - 10 ft	LEAN CLAY	83	15.2

NOTES: Sample exhibited 0.3 percent expansion when wetted under an applied pressure of 500 psf.

PROJECT: Indian Health Services Duplex Project

SITE: Wapiyapi Avenue
Kyle, South Dakota

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

PROJECT NUMBER: 24215084C

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

CHEMICAL LABORATORY TEST REPORT

Project Number: 24215084C

Service Date: 04/12/22

Report Date: 04/14/22

Terracon

10400 State Highway 191

Midland, Texas 79707

432-684-9600

Client

Short Elliott Hendrickson Incorporated

503 North Main Sreett Suite 225

Pueblo, CO 81003-6107

Project

Indian Health Services Duplex Project

Wapiyapi Avenue

Kyle, SD

<i>Sample Location</i>	<i>K-1</i>
<i>Sample Depth (ft.)</i>	<i>1-6</i>
pH Analysis, ASTM - G51-18	8.3
Water Soluble Sulfate (SO ₄), ASTM C 1580 (mg/kg)	77
Sulfides, ASTM - D4658-15, (mg/kg)	nil
Chlorides, ASTM D 512 , (mg/kg)	56
RedOx, ASTM D-1498, (mV)	+433
Total Salts, ASTM D1125-14, (mg/kg)	653
Resistivity, ASTM G187, (ohm-cm)	1,549

Analyzed By:



Zach Robertson

Engineering Technician III

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

SUPPORTING INFORMATION

Contents:








General Notes

Unified Soil Classification System

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING	WATER LEVEL	FIELD TESTS
 Auger Cuttings  Modified California Ring Sampler  Standard Penetration Test	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Cave In Encountered <p>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.</p>	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				BEDROCK		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength Qu, (psf)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Ring Sampler Blows/Ft.	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)
Very Loose	0 - 3	0 - 5	Very Soft	less than 500	0 - 1	< 3	< 24	< 20	Weathered
Loose	4 - 9	6 - 14	Soft	500 to 1,000	2 - 4	3 - 5	24 - 35	20 - 29	Firm
Medium Dense	10 - 29	15 - 46	Medium Stiff	1,000 to 2,000	4 - 8	6 - 10	36 - 60	30 - 49	Medium Hard
Dense	30 - 50	47 - 79	Stiff	2,000 to 4,000	8 - 15	11 - 18	61 - 96	50 - 79	Hard
Very Dense	> 50	≥ 80	Very Stiff	4,000 to 8,000	15 - 30	19 - 36	> 96	>79	Very Hard
			Hard	> 8,000	> 30	> 36			

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.

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

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

^F If soil contains $\geq 15\%$ 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 $\geq 15\%$ 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 $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

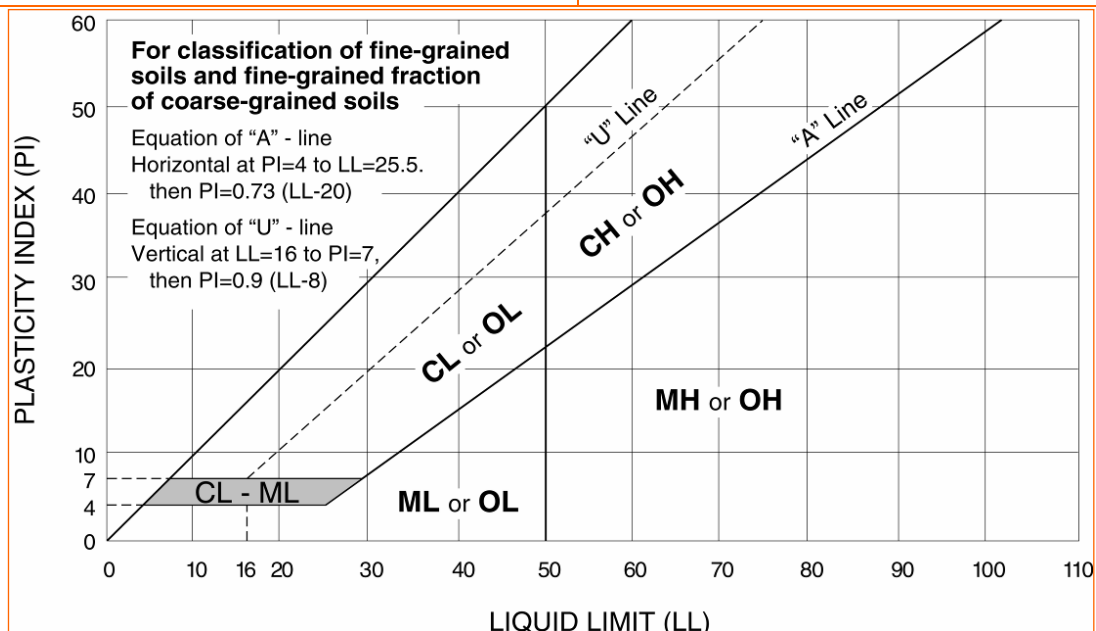
^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ 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.





Geotechnical Engineering Report

**Indian Health Services Duplex Project – Pine Ridge
Pine Ridge, South Dakota**

May 18, 2022

Terracon Project No. 24215084D

Prepared for:

Short Elliott Hendrickson, Inc.
Pueblo, Colorado

Prepared by:

Terracon Consultants, Inc.
Cheyenne, Wyoming



Revised May 18, 2022
April 27, 2022



Short Elliott Hendrickson, Inc.
503 North Main Street, Suite 225
Pueblo, Colorado 81003

Attn: Mr. Jimmie Hayson, P.E. – Principal
P: (719) 468-8373
E: jhayson@sehinc.com

Re: Geotechnical Engineering Report
Indian Health Services Duplex Project – Pine Ridge
Pine Ridge, South Dakota
Terracon Project No. 24215084D

Dear Mr. Hayson:

We have completed the Geotechnical Engineering services for the project referenced above. This study was performed in general accordance with Terracon Proposal No. P24215084 dated November 17, 2021. This report has been revised from its original version, dated April 27, 2022 to incorporate comments provided by SEH, and presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

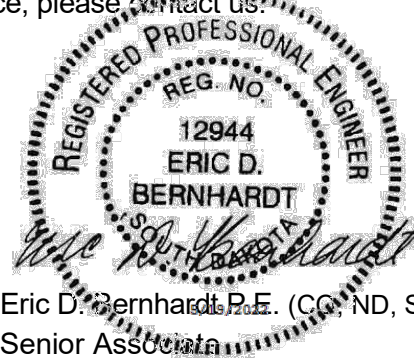
We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.

A handwritten signature in black ink, appearing to read "Kiran P. Acharya", written over a faint circular stamp.

Kiran P. Acharya, Ph.D., P.E. (TX)
Project Engineer



Eric D. Bernhardt, P.E. (CO, ND, SD WY)
Senior Associate

REPORT TOPICS

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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

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SUPPORTING INFORMATION

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

Geotechnical Engineering Report
Indian Health Services Duplex Project – Pine Ridge
Pine Ridge Site
Pine Ridge, South Dakota
Terracon Project No. 24215084D
May 18, 2022

INTRODUCTION

A geotechnical engineering report has been completed for the proposed Indian Health Services Duplex Project – Pine Ridge Site to be located southeast of the intersection of Antelope Drive and Pejuta Road, in Pine Ridge, South Dakota. Three (3) borings, designated as PR-1 through PR-3, were performed to depths of about 15.5 to 17.4 feet below existing ground surface within the proposed duplex structure footprint. Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. Boring logs and laboratory testing data are included in the **Exploration Results** section of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Floor system design and construction
- Seismic site classification
- Lateral earth pressures

The recommendations contained in this report are based on the results of field and laboratory testing, engineering analyses, experience with similar soil and bedrock conditions and structures, and our understanding of the proposed project.

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	Pine Ridge site is located southeast of the intersection of Antelope Drive and Pejuta Road, in Pine Ridge, South Dakota. Approximate coordinates near the center of the site are 43.0217° N latitude, 102.5426° W longitude. See Site Location .
Existing Improvements	The site is located in undeveloped areas. Existing housing developments are present to the north, south and west of the site.

Item	Description
Current Ground Cover	The site was covered with grasses and weeds.
Existing Topography	Relatively level

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	<p>The following documents were provided.</p> <ul style="list-style-type: none">■ Statement of A&E Services Design for Duplex Buildings and Site Locations prepared by Indian Health Services dated October 2021■ RFP addressed to SEH prepared by Indian Health Services dated November 8, 2021■ Pine Ridge Staff Quarters Plan and Profile prepared by Louis L. Weller, Architects, PC dated April 19, 1991■ Duplex Floor Plan (no preparer signature, no date)■ Sketches of proposed building locations for the site
Project Description	The project includes construction of new duplex structures (buildings) utilized as staff quarters.
Proposed Structure	We understand the proposed duplex buildings are planned to consist of two-stories and include a crawlspace or basement. Maximum building footprints are anticipated to be 1,800 square feet.
Building Construction	We expect the buildings will be of wood- or steel-framed construction supported on shallow, reinforced concrete, spread footing foundations with a slab-on-grade floor.
Finished Floor Elevation	Based on existing development near the sites, we assume finished floor elevation will be near (or within 2 feet of) existing ground surface elevations.
Assumed Maximum Loads	<p>Foundation loading information was not available at the time of this report preparation. However, based on our understanding of the project, we assume relatively light foundation loads as follows.</p> <ul style="list-style-type: none">■ Columns: 30 kips■ Walls: 2 kips per linear foot (klf)■ Slabs: 100 pounds per square foot (psf)
Grading	Based on the anticipated topography, we assume maximum cuts/fills on the order of about 1 to 2 feet may be required to develop final grades.
Below-Grade Structures	We understand a crawlspace or basement is planned for the buildings.

If project information or assumptions vary from what is described above or if location of construction changes, we should be contacted as soon as possible to confirm and/or modify our recommendations accordingly.

GEOTECHNICAL CHARACTERIZATION

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	Vegetative Soil	About 6 inches of root penetration.
2	Clay	Stiff to very stiff, lean clay with varying amounts of fine grained sand. Dark brown to brown.
3	Bedrock	Hard to very hard, Sandstone/Siltstone. Light brown.

Note: Excavation difficulties are generally anticipated within Model Layer 3.

As noted in **General Comments**, this characterization is based upon widely spaced exploration points across the site, and variations are likely.

Groundwater

The boreholes were observed while drilling and shortly after completion for the presence and level of groundwater. Groundwater was not observed in any of the borings while drilling, or for the short duration the borings were allowed to remain open. This does not necessarily mean the borings terminated above groundwater. Due to the low permeability of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole. Long-term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Groundwater is not expected to affect shallow foundation construction at this site. Due to safety concerns, soil borings were backfilled upon completion of drilling activities and subsequent groundwater measurements were not obtained. The water levels observed in the boreholes can be found on the boring logs in **Exploration Results**.

The observations represent short-term groundwater conditions at the time of field exploration, and may not be indicative of other times, or at other locations. Groundwater levels can and should be

expected to fluctuate in response to site development, irrigation demands adjacent to the streets and with varying seasonal and weather conditions. Therefore, groundwater levels during construction or at other times in the future may be higher or lower than the levels indicated on the boring logs. Seasonal fluctuations on the order of 2 to 3 feet are not uncommon; greater fluctuations are possible during extreme events.

GEOTECHNICAL OVERVIEW

Based on geotechnical conditions encountered in our test borings, the site appears suitable for the proposed construction from a geotechnical point of view provided certain precautions and design and construction recommendations presented in this report are followed. We have identified geotechnical conditions that could impact design, construction and performance of the building and other site improvements. These include potential low subgrade stability with elevated moisture content near the building footprint and relatively high moisture content throughout the explored depth. These conditions will require particular attention in project planning, design and during construction and are discussed in greater detail in the following sections.

Elevated Moisture Content Soils/Subgrade Stability

Based on our boring and laboratory data, the native lean clay with sand soils encountered generally exhibit elevated moisture content near the building footprint and relatively high moisture content throughout the explored depth. Although penetration resistance measurements at our boring locations indicate these soils exhibit stiff to very stiff consistencies, the native soils are expected to possibly deflect and deform (pump) and create subgrade stability issues during site preparation due to relatively high moisture content. After removal of the vegetative soils, the contractor should expect unstable subgrades that will need to be stabilized prior to construction. Terracon recommends a contingency be provided in the construction budget to stabilize and correct weak/unstable subgrade. Further discussion regarding subgrade stabilization is presented in the **Earthwork** section of this report.

It appears feasible to support some of the buildings/structures on conventional footings and/or mat/slab foundations bearing on suitable native soils/bedrock or newly placed engineered fill. However, the native soils will be easily disturbed by construction activities and may not provide a suitable working surface. To help reduce disturbance of the subgrade due to construction equipment and provide positive support of shallow footing and mat foundations, lower strength native soils may need to be removed from below the proposed shallow footing and/or mat foundations. The resulting excavations should be brought to final grade with engineered fill placed and compacted as recommended in this report.

The site soils could become unstable with typical earthwork and construction traffic, especially after precipitation events. Effective site drainage should be completed early in the construction sequence and maintained after construction to avoid potential strength and/or stability issues. If

possible, the grading should be performed during the warmer and drier time of the year. If grading is performed during the spring or winter months or wet periods, an increased risk for possible undercutting and replacement of unstable subgrade will persist.

EARTHWORK

The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project. Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include documentation of the adequate removal of existing vegetative soils, observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

Site Preparation

Site preparation should commence with removal of existing vegetation, topsoil and any loose, soft, or otherwise unsuitable material from the proposed construction areas. Stripped materials consisting of vegetation and organic materials should be wasted from the site or used to re-vegetate landscaped areas (if any) after completion of grading operations.

Although evidence of existing fills or underground facilities, such as utilities, was not observed during the site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned. Terracon should observe the excavation prior to backfill placement and/or construction.

Exposed surfaces should be free of mounds and depressions that could prevent uniform compaction. Following completion of stripping and rough grading but prior to placement of new fill, the exposed ground should be scarified, moisture conditioned as needed and re-compacted. The subgrade should then be proof rolled to help delineate weak or disturbed areas at or near the ground surface. Unsuitable areas should be improved by moisture adjustment and compaction or by undercutting and placement of suitable compacted fill.

Fill Material Types

On-site soils free of organics, debris and any other unsuitable materials or low volume change import materials approved by Terracon may be used as fill/backfill material on the site. In general, imported materials meeting the properties presented below should be acceptable for use. Other import fill material types may be suitable for use depending upon proposed application and location. However, imported soils should be evaluated and approved by the geotechnical engineer prior to delivery to the site.

Geotechnical Engineering Report

Indian Health Services Duplex Project – Pine Ridge ■ Pine Ridge, South Dakota
May 18, 2022 ■ Terracon Project No. 24215084D



Gradation/Property	Percent Finer by Weight (ASTM C136)
3-inch	100
No. 4 Sieve	30 to 100
No. 200 Sieve	50 (max.)
■ Liquid Limit (LL)	30 (max.)
■ Plasticity Index (PI)	15 (max.)

Fill Compaction Requirements

Structural and general fill/backfill should meet the following compaction requirements.

Item	Description
Fill lift thickness	<ul style="list-style-type: none">■ 9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used■ 4 to 6 inches in loose thickness when hand-guided equipment (i.e. jumping jack or plate compactor) is used
Minimum Compaction requirements¹	At least 95% of the standard Proctor maximum dry density (ASTM D698)
Moisture content onsite clay soils^{2,3}	-1 to +3% of the optimum moisture content as determined by the standard Proctor test
Moisture content low plasticity clayey soils or LVC materials or imported soils²	-2 to +2% of the optimum moisture content as determined by the standard Proctor test

1. Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. A construction disc or other suitable processing equipment will be needed to thoroughly process the materials and to aid in achieving uniform moisture content throughout the fill.
2. The contractor should expect some moisture adjustment and processing of the site soils or import materials will be needed prior to or during compaction operations.
3. Moisture conditioned cohesive soils should not be allowed to dry out. A loss of moisture within these materials will likely result in an increase of the material's swell potential. Subsequent wetting of these materials could result in undesirable movements.
4. Care should be taken during the fill placement process to avoid zones of dissimilar fill. Improvements constructed over varying fill types are at a higher risk of differential movement compared to improvements over a uniform fill zone.

Excavation and Utility Trench Construction

We anticipate excavations up to about 5 to 7 feet may be necessary for utility trench construction. We believe the soils encountered in our exploratory borings can be excavated with conventional excavation equipment.

Trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. Trench backfill should consist of the on-site soils free of organic matter or approved imported materials. Trench backfill should be placed and compacted as described under **Fill Compaction Requirements**. It is strongly recommended a representative of the geotechnical engineer provide full-time observation and compaction testing of trench backfill within the building area.

Underground piping within or near the proposed building footprint should be designed and constructed so deviations in alignment do not result in breakage or distress. Utility knockouts in grade beams should be oversized to accommodate differential movements.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations in order to maintain stability of excavation sides and bottom as well as any adjacent improvements. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards. As a safety measure, it is suggested vehicles and soil piles be kept to a minimum lateral distance from the crest of the slope equal to no less than the slope height. Exposed slope faces should be protected against the elements.

The soils to be penetrated by the proposed excavations may vary significantly across the site. The soil classifications are based solely on the materials encountered in widely spaced exploratory test borings. The contractor should verify similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

Grading and Drainage

Proper drainage and surface water management is important to the performance of foundations, floor slabs, and other site improvements. The following recommendations are considered good practice for any site and should be implemented where applicable and/or to the extent possible.

Grades must be adjusted to provide positive drainage away from the building and other site improvements during construction and maintained throughout the life of the proposed facility. Infiltration of water into utility or foundation excavations must be prevented during construction.

Landscaped irrigation adjacent to the foundation system should be minimized. Plants placed close to foundation walls should be limited to those with low moisture requirements. The importance of proper irrigation practices cannot be over emphasized. Irrigation should be limited to the minimum amount needed to maintain vegetation; application of more water will increase likelihood of slab and foundation movements in excess of those described in this report.

We recommend constructing slopes of about 6 inches in the first 10 feet (5 percent slope) in landscaped areas around the building, where practical. The ground surface should be sloped in such a manner that water will not pond between or adjacent to structures and other site improvements. Concrete curbs and sidewalks may “dam” surface runoff adjacent to the building and disrupt proper flow. Use of “chase” drains or weep holes at low points in the curb should be considered to promote proper drainage.

Backfill against foundations, exterior walls and in utility and sprinkler line trenches should be well compacted and free of organics and construction debris to reduce moisture infiltration. We recommend exterior foundation wall backfill consist of on-site clayey soils or approved import materials to reduce infiltration and conveyance of surface water through the backfill. Some settlement of wall backfill should be expected even if properly compacted. Areas where backfill has settled should be repaired and re-graded immediately to maintain proper slope away from the foundation.

Flatwork and pavements will be subject to post construction movement. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond. Where paving or flatwork abuts the structure, care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Planters located adjacent to the structure (if any) should be self-contained. Sprinkler mains and spray heads should not be installed or allowed to discharge within 5 feet of foundation walls. Roof drains should discharge on pavements or be extended away from the structure well beyond the limits of the backfill zone through the use of splash blocks or downspout extensions. Downspouts and extensions should be monitored and maintained in good working condition. Generally speaking, downspouts should not be buried and extended below grade, as these systems can be difficult to monitor and maintain.

Water permitted to pond near or adjacent to the perimeter of the structure (either during or post-construction) can result in higher soil movements than those discussed in this report. As a result, estimations of potential movement described in this report cannot be relied upon if positive drainage is not obtained and maintained, and water is allowed to infiltrate the fill and/or subgrade.

After building construction and prior to project completion, we recommend verification of final grading be performed to document that positive drainage, as described in this section, has been achieved. Maintenance of surface drainage is imperative subsequent to construction and becomes the responsibility of the owner.

Earthwork Construction Considerations

As discussed in the **Geotechnical Overview** section above, the native lean clay soils encountered generally exhibit elevated moisture contents near the building footprint and moisture content is high through the explored depth. Consequently, the native soils are expected to possibly deflect and deform (pump) and create subgrade stability issues during site preparation. After removal of the vegetative soils, the contractor should expect unstable subgrades that will need to be stabilized prior to construction. Terracon recommends a contingency be provided in the construction budget to stabilize and correct weak/unstable subgrade.

If unstable ground conditions develop during earthwork or subgrade preparation, some method of soil improvement or stabilization will be needed prior to construction of foundations and floor slabs. There are a number of stabilization methods that can be used to improve the subgrade and depend, in part, on the extent and severity of the unstable soils exposed during construction as well as other factors. For isolated or small areas requiring stabilization, moisture conditioning and recompaction or mechanical stabilization with granular materials and/or geosynthetics may be effective. If large areas require stabilization, chemical treatment of the soils may be a more effective alternative. In any event, we feel the appropriate method and level of stabilization should be evaluated and can best be determined on a case-by-case basis during construction once the entire subgrade and overall conditions are exposed. We are available to provide specific stabilization recommendations during construction upon your request.

Upon completion of site preparation, care should be taken to maintain the subgrade moisture content prior to construction of foundations and floor slabs. Construction traffic over the completed subgrade 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 the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and recompacted prior to fill placement or foundation, and floor slab construction.

Construction Observation and Testing

The earthwork efforts should be monitored under the guidance of Terracon. Monitoring should include documentation of adequate removal of vegetation and topsoil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation. Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts.

In areas of foundation excavations, the bearing subgrade should be evaluated under the guidance of Terracon. In the event unanticipated conditions are encountered, we should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of Terracon into the construction phase of the project provides the continuity to maintain our evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

Based on the field exploration and laboratory test results and the type of construction planned, it is our opinion the proposed building can be supported on shallow spread footings bearing on approved native soils or properly compacted engineered fills, provided the site has been prepared in accordance with the **Earthwork** section of this report. Design criteria and construction recommendations for spread footings are presented in the following table and paragraphs.

Spread Footing Design Recommendations

Item	Description	
Bearing material	On-site soils or engineered fill	
Maximum allowable soil bearing pressure ¹	2,500 psf	
Minimum dimensions	<u>Column</u>	<u>Wall Footing</u>
	24 inches	18 inches
Minimum embedment below finished grade for frost protection ²	4 feet	
Estimated post-construction movement based on assumed structural loads ³	About 1 inch	
Ultimate passive pressure ⁴	295 psf/ft	
Ultimate coefficient of sliding friction ⁴	0.33	

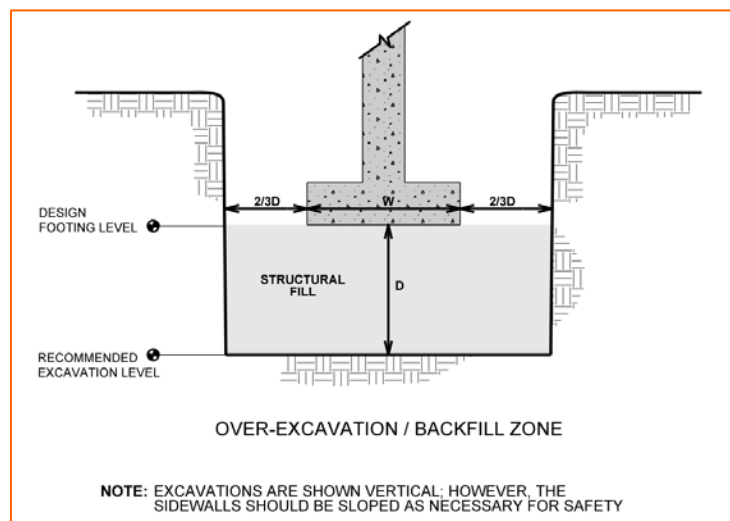
1. The allowable soil bearing pressure applies to dead loads plus design live load conditions and is the maximum pressure that should be transmitted to the bearing soils in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes otherwise unsuitable bearing conditions, if encountered, will be undercut and replaced with properly compacted engineered fill.
2. For perimeter footings and footings beneath unheated areas. Interior column pads in heated areas should bear at least 18 inches below the adjacent grade (or the top of the floor slab) for confinement of the bearing materials and to develop the recommended bearing pressure.
3. Foundation movement will depend upon variations within the subsurface soil profile, structural loading conditions, embedment depth of footings, thickness of compacted fill, and the quality of the earthwork operations. Settlement estimates are based on the maximum allowable soil bearing pressure, assumed structural loads and resulting foundation geometry. If actual foundation loads vary significantly from those assumed, we should be contacted to review our recommendations. Additional foundation movements could occur if surface water infiltrates the foundation soils; therefore, proper drainage away from the foundation

Item	Description
	system should be provided in the final design, during construction and maintained throughout the life of the structure.
4.	The sides of the excavation for spread footings must be nearly vertical and the concrete should be placed neat against these vertical faces or backfill must be compacted to at least 95 percent of the standard Proctor maximum dry density for the passive earth pressure value to be valid. Passive pressure requires movement to generate the resistance and should only be used when movement is tolerable and the soil is well compacted and will not be removed. The passive resistance and friction factor are ultimate values. As such, appropriate factors of safety should be applied.

Footings should be proportioned to reduce differential foundation movement. Proportioning on the basis of relative constant dead-load pressure can provide a means to reduce differential movement between adjacent footings. Foundations should be detailed and reinforced as necessary to reduce the potential for distress caused by differential foundation movement.

Spread Footing Construction Considerations

Where soils are loosened during excavation or in the forming process for footings, or if low-strength soils or otherwise unsuitable bearing conditions are present, they should be removed to minimum depths determined by the Geotechnical Engineer and the resulting excavation should be backfilled up to footing base elevation with approved fill material placed and compacted as described in the **Earthwork** section of this report. Over-excavation for structural fill placement below footings (if needed) should be conducted as shown below.



The base of foundation excavations should be free of water and loose soil prior to concrete placement. Concrete should be placed soon after subgrade preparation to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete.

Completed foundation excavations should be observed and evaluated by a representative of Terracon well in advance of forming footings and placement of reinforcing steel to confirm satisfactory bearing materials are present and subsurface conditions are consistent with those encountered in our borings. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

FLOOR SLABS

All slabs-on-grade undergo some movement. Provided the site has been prepared in accordance with the **Geotechnical Overview** and **Earthwork** sections of this report. We believe risk of movement is low for the soil conditions encountered on this site and estimate settlement of slabs-on-grade constructed on properly prepared subgrade to be less than 1 inch. Where slab movement cannot be accepted or must be reduced, we are available to discuss floor movement mitigation techniques upon your request.

As discussed in the **Geotechnical Overview** section, soils with elevated moisture content were encountered near the building footprint. In order to provide more uniform support across the floor slab area, we recommend the floor slab be supported on at least 12 inches of clean imported granular material compacted as described in this report.

Design Recommendations

Item	Description
Floor slab support	12-inch zone of moisture conditioned and compacted subgrade. Existing fill, where present, should be removed and re-worked.
Modulus of subgrade reaction	For limited area loads or concentrated/point loads placed directly on slabs: <ul style="list-style-type: none">■ 100 pounds per square inch per in (psi/in) for slabs supported on compacted subgrade consisting of the on-site silt with sand and lean clay soils.■ 140 psi/in for slabs supported on at least 12 inches of clean imported granular material.
Slab thickness	Slab reinforcement and thickness should be designed by a qualified engineer based on actual loads imposed and on intended slab use.

We recommend the following precautions be observed where slabs-on-grade are used. These precautions will not eliminate slab movement, but they tend to reduce damage when movement occurs. Additional floor slab design and construction recommendations are as follows:

- Positive separations and/or isolation joints should be provided between slabs and foundations, columns or utility lines to allow free vertical movement. This detail can reduce cracking when movement of the slab occurs. As a precautionary measure, non-bearing

partition walls placed on the floor slab (if any) should be designed and constructed to allow at least 1½ inches of free vertical movement.

- Frequent control joints should be provided in slabs to control the location and extent of cracking in accordance with the American Concrete Institute (ACI). For additional recommendations refer to the *ACI Design Manual*.
- The use of a vapor retarder should be considered beneath concrete slabs on grade that will be 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/barrier, 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/barrier.
- Other design and construction considerations, as outlined in the *ACI Design Manual*, Section 302.1R are recommended.

Floor Slab Construction Considerations

Fill/backfill placed beneath slabs and next to foundation walls should be moisture conditioned and compacted as described in the **Earthwork** section of this report. Soils loosened during excavation or other construction activities should be removed or recompact as described in this report. Floor slabs should not be constructed on frozen subgrade.

Once fill is placed and the subgrade is prepared, it is important measures be planned and taken to reduce drying of the near surface materials. If the fill dries excessively prior to construction, then it will be necessary to rework the upper, drier materials just prior to installing floor slabs.

We recommend the area underlying the floor slab be carefully evaluated within 24 hours before slab construction. Particular attention should be paid to areas of existing foundation wall backfill and where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted fill. Floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report about 24 hours before placement of the base and/or concrete. The subgrade should be re-evaluated and re-approved should concrete not be placed within this time frame or should the subgrade become disturbed after construction.

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 Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil/rock 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 D**. Subsurface explorations at this site were extended to a maximum depth of 15½ 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.

CORROSIVITY

The values presented in the table below may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary									
Boring	Sample Depth (feet)	Soil Description	Sulfides (mg/kg)	Red-Ox Potential (mV)	Soluble Sulfate (mg/kg)	Chlorides (mg/kg)	Electrical Resistivity ¹ (Ω-cm)	pH	Total Salts (mg/kg)
PR-2	1 to 6	Lean Clay with Sand (CL)	Nil	+440	646	200	465	7.9	2,255

1. Test performed on saturated soil sample.

We recommend a certified corrosion engineer be employed to determine the need for corrosion protection and to design appropriate protective measures. The sulfate concentration measured in the sample was 646 mg/kg which equates to approximately 0.06 percent. Sulfate concentrations of less than 0.1 mg/kg indicate Class S0 exposure to sulfate attack for concrete in contact with the subsoils, according to the American Concrete Institute (ACI) *Guide to Durable Concrete*. For this level of sulfate concentrations, ACI indicates any type of cement can be used for concrete in contact with the subsoils.

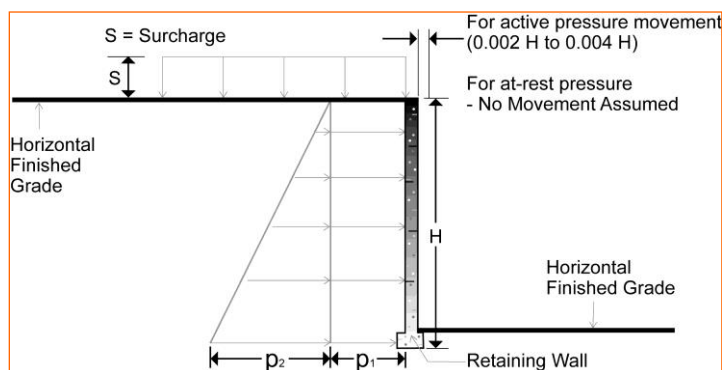
Therefore, Type I Portland cement should be suitable for concrete on and below grade. However, if there is no, or minimal cost differential, use of Type II Portland cement (or equivalent) should be considered for additional sulfate resistance of construction concrete. Foundation concrete should be designed in accordance with the provisions of the *ACI Design Manual*, Section 318, Chapter 4.

LATERAL EARTH PRESSURES

We understand below-grade structures, such as a crawlspace or basement is planned for the buildings. The following sections provide recommendations and considerations for below-grade structures supporting unbalanced backfill levels. These values can also be used for lateral capacity analyses for drilled circular footings.

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters				
Earth Pressure Condition ¹	Coefficient for Backfill Type ²	Surcharge Pressure ^{3, 4, 5} p_1 (psf)	Effective Fluid Pressures (psf) ^{2, 4, 5}	
			Unsaturated ⁶	Submerged ⁶
Active (K_a)	Granular - 0.31	$(0.31)S$	$(40)H$	$(80)H$
	Fine Grained - 0.41	$(0.41)S$	$(50)H$	$(85)H$
At-Rest (K_o)	Granular - 0.47	$(0.47)S$	$(55)H$	$(90)H$
	Fine Grained - 0.58	$(0.58)S$	$(70)H$	$(95)H$
Passive (K_p)	Granular - 3.25	---	$(390)H$	$(250)H$
	Fine Grained - 2.46	---	$(295)H$	$(205)H$

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95% of the ASTM D 698 maximum dry density, rendering a maximum unit weight of 120 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.

Lateral Earth Pressure Design Parameters				
Earth Pressure Condition ¹	Coefficient for Backfill Type ²	Surcharge Pressure ^{3, 4, 5} p_1 (psf)	Effective Fluid Pressures (psf) ^{2, 4, 5}	
			Unsaturated ⁶	Submerged ⁶

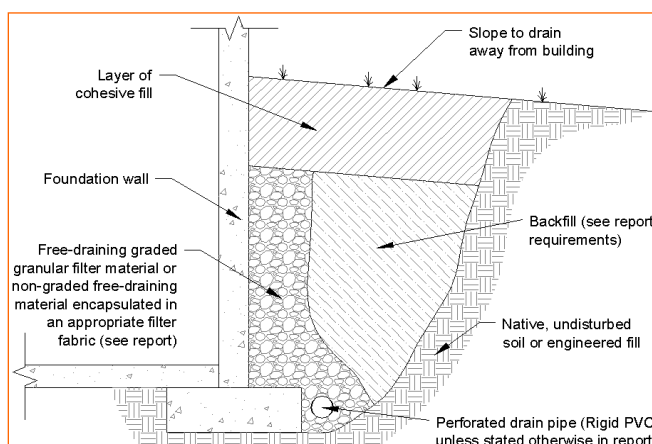
5. No safety factor is included in these values.

6. To achieve “Unsaturated” conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. “Submerged” conditions are recommended when drainage behind walls is not incorporated into the design.

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extended below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill.

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.

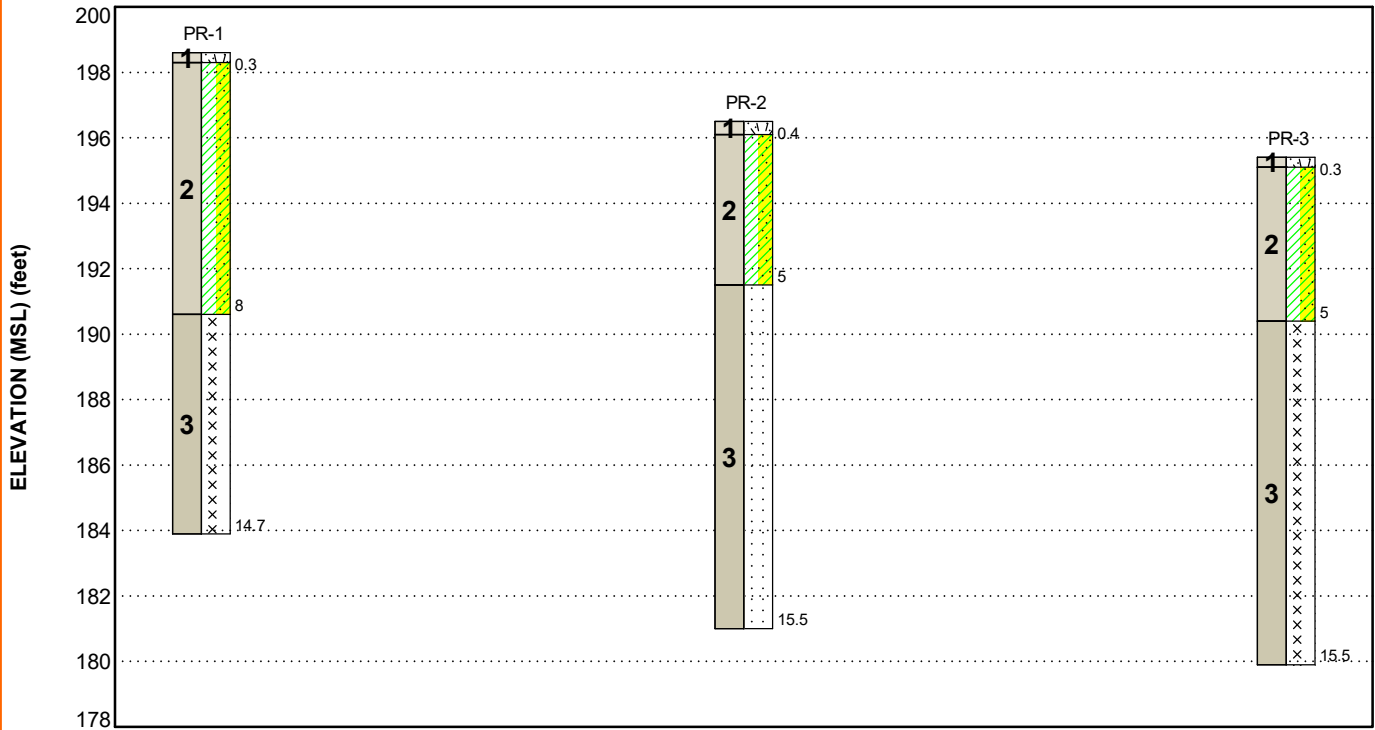
FIGURES

Contents:

GeoModel

GEOMODEL

Indian Health Services Duplex Project ■ Pine Ridge, South Dakota
Terracon Project No. 24215084D



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	Vegetative Soil	About 6 inches of root penetration.
2	Clay	Stiff to very stiff, lean clay with varying amounts of fine grained sand. Dark brown to brown.
3	Bedrock	Hard to very hard, Sandstone/Siltstone. Light brown.

LEGEND

	Vegetative Soil		Sandstone
	Lean Clay with Sand		
	Siltstone		

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

Contents:

Exploration and Testing Procedures (2 pages)

Site Location and Exploration Plan (2 pages)

Exploration Results (6 pages)

Supporting Information (2 pages)

Note: All attachments are one page unless noted above.

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number & Designation of Borings	Boring Depth (feet)	Planned Location
3 (PR-1 through PR-3)	14.7 to 15.5	Planned Building Area

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 relative ground surface elevations were measured with an engineer's level referencing a temporary benchmark. If more precise boring layout and ground surface elevations are desired, we recommend the boring locations be surveyed.

Subsurface Exploration Procedures: Soil borings were advanced with a Mobile B-57 truck-mounted drilling rig using solid-stem, continuous-flight augers. Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. Soil sampling was performed using standard split-barrel procedures and a modified California barrel. In the split-barrel sampling procedure, 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 last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. For the modified California barrel sampling procedure, a 2½-inch outer diameter ring-lined sampler is used for sampling. Modified California barrel sampling procedures are similar to standard split-barrel sampling procedures; however, blow counts are typically recorded for 6-inch intervals for a total of 12 inches of penetration. Additionally, a bulk sample of auger cuttings were obtained from boring PR-2 from about 1 to 6 feet below existing ground surface. Groundwater was not encountered during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after completion of drilling.

The sampling depths, penetration distances, and other sampling information were 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

Samples retrieved during the field exploration were returned to the laboratory for observation by the project Geotechnical Engineer and were visually classified in general accordance with the Unified Soil Classification System described in the **Supporting Information** section of this report.

After sample review by the project engineer, an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Following completion of the laboratory testing, the field and visual descriptions were confirmed or modified as necessary, and Boring Logs were prepared. These logs are presented in the **Exploration Results** section of this report.

Selected samples were tested for the following physical and/or engineering properties:

- Moisture content
- Unit weight
- Atterberg limits
- Grain size analysis
- Corrosivity

Laboratory test results are indicated on the boring logs and are presented in depth in the **Exploration Results** section. The test results are used for the geotechnical engineering analyses and the development of earthwork, foundation, and floor slab recommendations. Laboratory tests are performed in general accordance with applicable local standards or other accepted standards. Procedural standards noted in this report are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgement.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are Unified Soil Classification Symbols. A brief description of this classification system as well as the General Notes can be found in the **Supporting Information** section. Classification was by visual-manual procedures. Selected samples were further classified using the result of Atterberg limit and percent fines testing. These test results are also provided in the **Exploration Results** section.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan

Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

Indian Health Services Duplex Project – Pine Ridge ■ Pine Ridge, South Dakota
May 18, 2022 ■ Terracon Project No. 24215084D

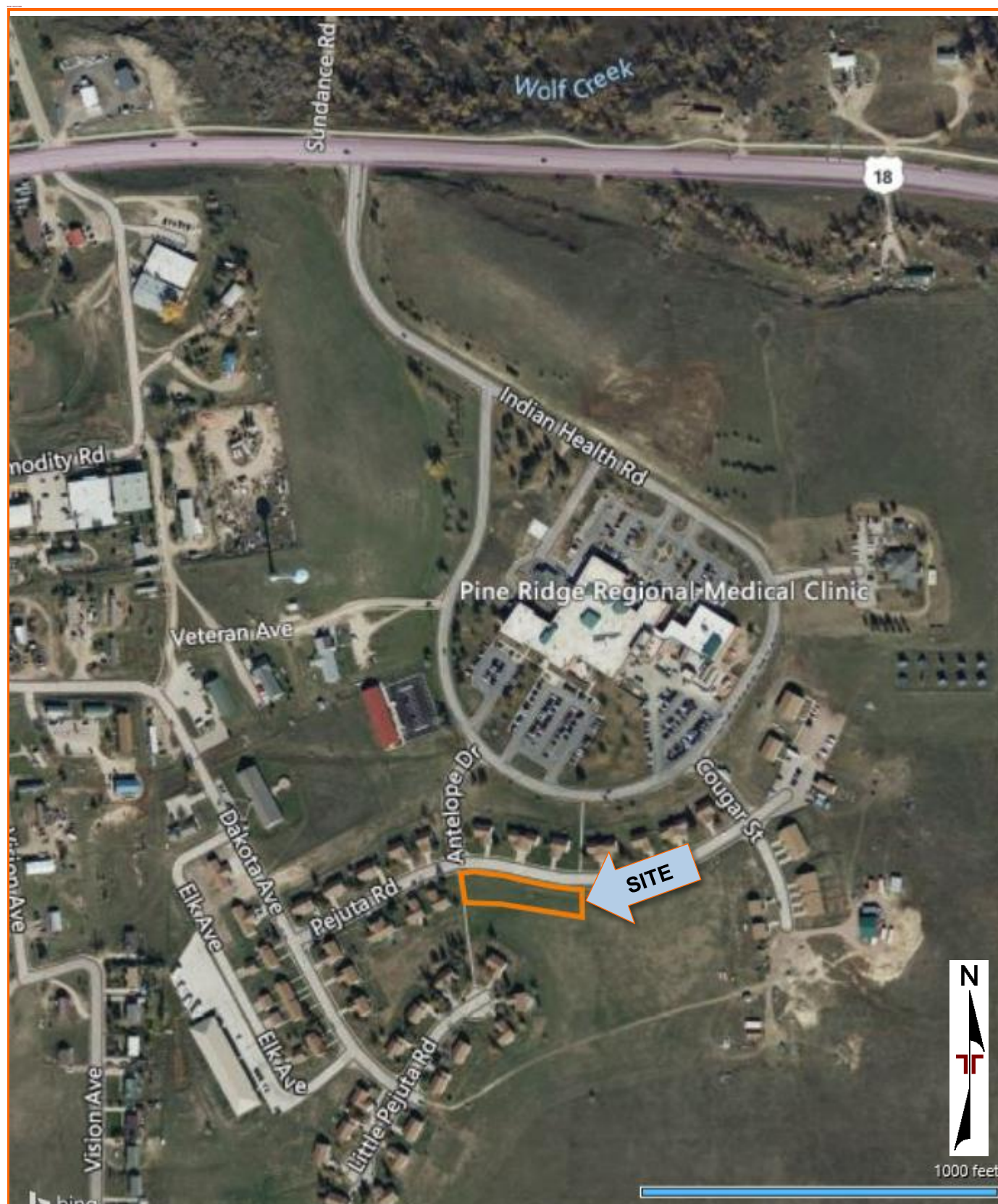


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Indian Health Services Duplex Project – Pine Ridge ■ Pine Ridge, South Dakota
May 18, 2022 ■ Terracon Project No. 24215084D



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

EXPLORATION RESULTS

Contents:

Boring Logs (PR-1 through PR-3)
Atterberg Limits
Grain Size Distribution
Corrosivity

Note: All attachments are one page unless noted above.




BORING LOG NO. PR-1

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Various Locations
Fort Thompson, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.0217° Longitude: -102.5426° Surface Elev.: 198.6 (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL. / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.3 VEGETATIVE SOIL , about 4 inches of root penetration	198.5		X	3-5-8 N=13		15.1			
2		LEAN CLAY WITH SAND (CL) , fine grained sand, dark brown to brown, stiff to very stiff, trace small roots to about 3 feet			✖	22/12"		12.8	95		
			5								
					X	2-3-10 N=13		15.0			
3		8.0 SILTSTONE , with fine grained sand, light brown, medium hard to very hard Trace moderately cemented nodules at about 9 feet	190.5		X	14-16-28 N=44		23.8			
			10								
					X	28-50/2"		18.0			
		14.7 Boring Terminated at 14.7 Feet	184								

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

Hammer Type: Automatic

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-29-2022

Drill Rig: Mobile B-57

Project No.: 24215084D

Boring Completed: 03-29-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL. 24215084D PINE RIDGE INDIAN HEALTH SERVICES GPJ TERRACON_DATATEMPLATE.GDT 5/23/22

BORING LOG NO. PR-2

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Various Locations
Fort Thompson, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.0216° Longitude: -102.5422° Surface Elev.: 196.5 (Ft.)	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL. / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		VEGETATIVE SOIL , about 5 inches of root penetration	0.4	196				3-6-7 N=13		15.6			
2		LEAN CLAY WITH SAND (CL) , fine grained sand, dark brown to brown, stiff, trace small roots to about 3 feet						7-8-5 N=13		12.4			
			5.0	191.5	5			52/12"		15.6		38-32-6	40
3		SANDSTONE/SILTSTONE , light brown, medium hard to very hard Trace moderately cemented nodules at about 6 feet						9-20-31 N=51		23.8			
			15.5	181	15			10-42-38 N=80		21.5			
		Boring Terminated at 15.5 Feet											

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

Hammer Type: Automatic

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-29-2022

Drill Rig: Mobile B-57

Project No.: 24215084D

Boring Completed: 03-29-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL_ 24215084D PINE RIDGE INDIAN HEALTH SER.GPJ TERRACON_DATATEMPLATE.GDT 5/23/22

BORING LOG NO. PR-3

Page 1 of 1

PROJECT: Indian Health Services Duplex Project

CLIENT: Short Elliott Hendrickson Incorporated
Pueblo, Colorado

SITE: Various Locations
Fort Thompson, South Dakota

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 43.0216° Longitude: -102.5418° Surface Elev.: 195.4 (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL-CONSOL. / LOAD, (% / psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.3 VEGETATIVE SOIL , about 4 inches of root penetration	195			3-5-9 N=14		18.5			
2		LEAN CLAY WITH SAND (CL) , fine grained sand, dark brown to brown, stiff to very stiff, trace small roots to about 3 feet				7-8-10 N=18		12.4			
		5.0	190.5			8-18-32 N=50		18.6			
3		SILTSTONE , with fine grained sand, light brown, hard to very hard				13-16-37 N=53		18.8			
		15.5	180			15-30-50/6"		20.7		32-26-6	65
		Boring Terminated at 15.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
3 1/4 inch diameter, solid-stem auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.
Elevations were measured in the field using an engineer's level and grade rod.

Notes:

WATER LEVEL OBSERVATIONS

None encountered after completion of drilling.

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

Boring Started: 03-29-2022

Drill Rig: Mobile B-57

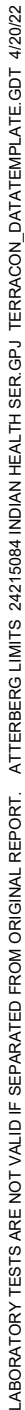
Project No.: 24215084D

Boring Completed: 03-29-2022

Driller: FMG Engineering, Inc.

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 24215084D PINE RIDGE INDIAN HEALTH SER.GPJ TERRACON_DATATEMPLATE.GDT 5/23/22

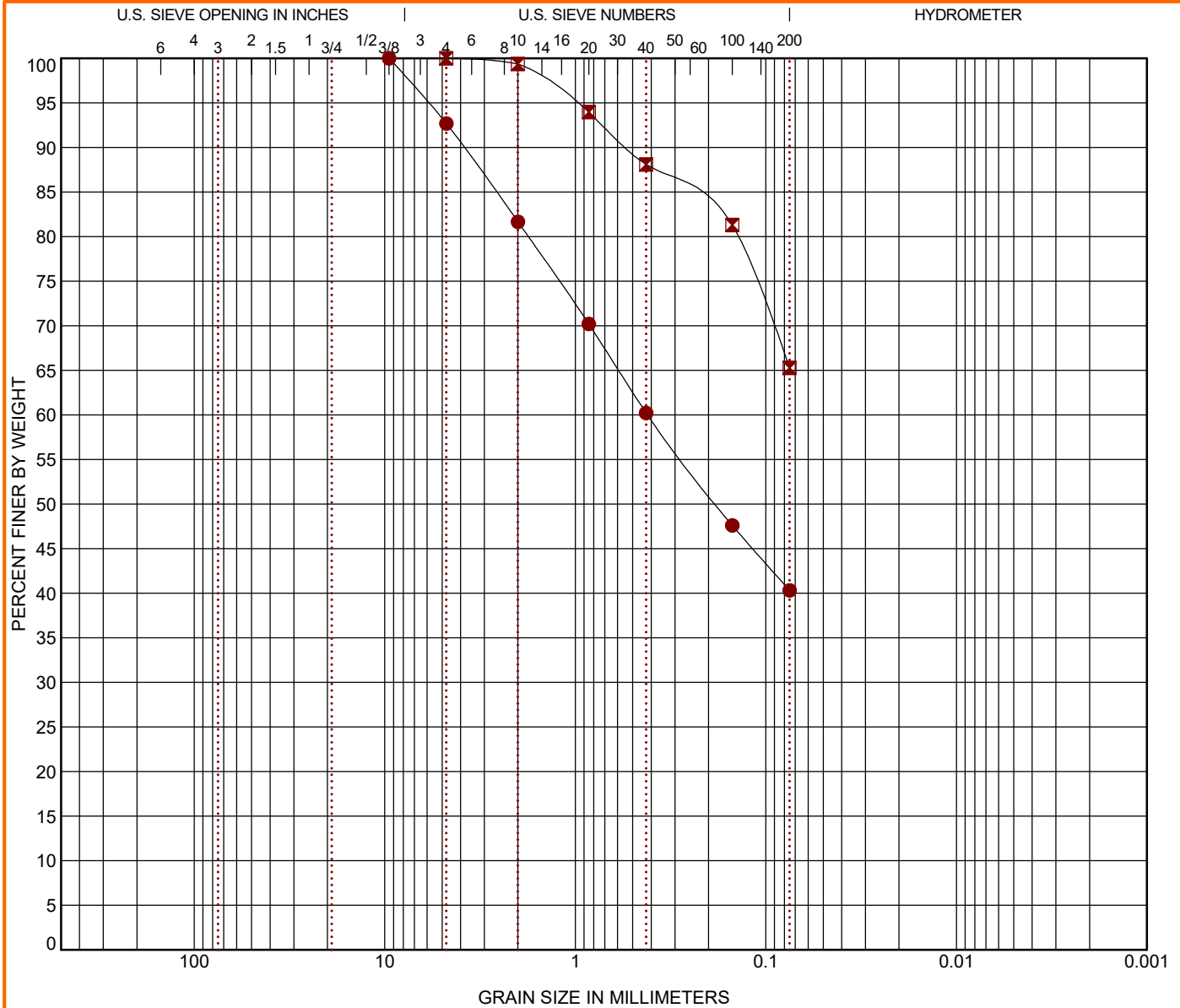
ASTM D4318



CLIENT: Short Elliott Hendrickson
Incorporated
Pueblo, Colorado

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth (Ft)	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
PR-2	6 - 7	SILTY SAND (SM)	15.6	38	32	6		
PR-3	14 - 15.5	SILTSTONE	20.7	32	26	6		

Boring ID	Depth (Ft)	D ₁₀₀	D ₆₀	D ₃₀	D ₁₀	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
PR-2	6 - 7	9.5	0.418			0.0	7.3	52.4		40.3	
PR-3	14 - 15.5	4.75				0.0	0.0	34.7		65.3	

PROJECT: Indian Health Services Duplex Project

SITE: Pejuta Road
Pine Ridge, South Dakota

Terracon
1505 Old Happy Jack Rd
Cheyenne, WY

PROJECT NUMBER: 24215084D

CLIENT: Short Elliott Hendrickson
Incorporated
Pueblo, Colorado

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 24215084 INDIAN HEALTH SER.GPJ TERRACON_DATATEMPLATE.GDT 4/20/22

CHEMICAL LABORATORY TEST REPORT

Project Number: 24215084D

Service Date: 04/12/22

Report Date: 04/14/22

Terracon

10400 State Highway 191

Midland, Texas 79707

432-684-9600

Client

Short Elliott Hendrickson Incorporated

503 North Main Sreett Suite 225

Pueblo, CO 81003-6107

Project

Indian Health Services Duplex Project

Pejuta Road

Pine Ridge, SD

<i>Sample Location</i>	PR-2
<i>Sample Depth (ft.)</i>	1-6
pH Analysis, ASTM - G51-18	7.9
Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)	646
Sulfides, ASTM - D4658-15, (mg/kg)	nil
Chlorides, ASTM D 512 , (mg/kg)	200
RedOx, ASTM D-1498, (mV)	+440
Total Salts, ASTM D1125-14, (mg/kg)	2,255
Resistivity, ASTM G187, (ohm-cm)	465

Analyzed By:



Zach Robertson

Engineering Technician III

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

SUPPORTING INFORMATION

Contents:








General Notes

Unified Soil Classification System

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING	WATER LEVEL	FIELD TESTS
 Auger Cuttings  Modified California Ring Sampler  Standard Penetration Test	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Cave In Encountered <p>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.</p>	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				BEDROCK		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength Qu, (psf)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Ring Sampler Blows/Ft.	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)
Very Loose	0 - 3	0 - 5	Very Soft	less than 500	0 - 1	< 3	< 24	< 20	Weathered
Loose	4 - 9	6 - 14	Soft	500 to 1,000	2 - 4	3 - 5	24 - 35	20 - 29	Firm
Medium Dense	10 - 29	15 - 46	Medium Stiff	1,000 to 2,000	4 - 8	6 - 10	36 - 60	30 - 49	Medium Hard
Dense	30 - 50	47 - 79	Stiff	2,000 to 4,000	8 - 15	11 - 18	61 - 96	50 - 79	Hard
Very Dense	> 50	≥ 80	Very Stiff	4,000 to 8,000	15 - 30	19 - 36	> 96	>79	Very Hard
			Hard	> 8,000	> 30	> 36			

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.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A					Soil Classification	
					Group Symbol	Group Name ^B
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels:	Cu ≥ 4 and 1 ≤ Cc ≤ 3 ^E		GW	Well-graded gravel ^F
			Less than 5% fines ^C		GP	Poorly graded gravel ^F
		Gravels with Fines:	Fines classify as ML or MH		GM	Silty gravel ^{F,G,H}
			More than 12% fines ^C		GC	Clayey gravel ^{F,G,H}
	Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands:	Cu ≥ 6 and 1 ≤ Cc ≤ 3 ^E		SW	Well-graded sand ^I
			Less than 5% fines ^D		SP	Poorly graded sand ^I
		Sands with Fines:	Fines classify as ML or MH		SM	Silty sand ^{G,H,I}
			More than 12% fines ^D		SC	Clayey sand ^{G,H,I}
Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit less than 50	Inorganic:	PI > 7 and plots on or above “A”		CL	Lean clay ^{K,L,M}
			PI < 4 or plots below “A” line ^J		ML	Silt ^{K,L,M}
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay ^{K,L,M,N}
			Liquid limit - not dried		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	< 0.75	OH	Organic clay ^{K,L,M,P}
			Liquid limit - not dried		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

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

^F If soil contains $\geq 15\%$ 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 $\geq 15\%$ 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 $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ 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.

