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April 17, 2019

FourFront Design, Inc.
517 7th Street
Rapid City, South Dakota 57701

Attn: Joel Simonyak

Subj: Geotechnical Exploration
Proposed SPS Addition – Building 5
VA Medical Center
Sioux Falls, South Dakota
GeoTek #19-225

This correspondence presents our written report of the geotechnical exploration program for the referenced project. Our work was performed in accordance with your authorization. We are transmitting an electronic copy of our report for your use.

We thank you for the opportunity of providing our services on this project and look forward to continued participation during the design and construction phases. If you have any questions regarding this report, please contact our office at (605) 335-5512.

Respectfully Submitted,
GeoTek Engineering & Testing Services, Inc.

Brennen Ahlers

Brennen Ahlers, PE
Project Manager

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GEOTECHNICAL EXPLORATION
PROPOSED SPS ADDITION – BUILDING 5
VA MEDICAL CENTER
SIOUX FALLS, SOUTH DAKOTA
GEOTEK #19-225

INTRODUCTION

Project Information

This report presents the results of the recent geotechnical exploration program for the proposed SPS Addition to Building 5 at the existing VA Medical Center in Sioux Falls, South Dakota.

Scope of Services

Our work was performed in accordance with the authorization of Joel Simonyak with FourFront Design, Inc. The scope of work as presented in this report is limited to the following:

1. To perform four (4) standard penetration test (SPT) borings to gather data on the subsurface conditions at the site.

2. To perform laboratory tests that include moisture content, dry density, Atterberg limits (liquid and plastic limits), sieve analysis (#200 sieve wash), standard Proctor, resistivity and unconfined compressive strength.

3. To prepare an engineering report that includes the results of the field and laboratory tests as well as our earthwork and foundation recommendations for design and construction.

The scope of our work was intended for geotechnical purposes only. This scope of work did not include determining the presence or extent of environmental contamination at the site or to characterize the site relative to wetlands status.

SITE & SUBSURFACE CONDITIONS

Site Location & Description

The site is located on the south side of Building 5 at the existing VA Medical Center in Sioux Falls, South Dakota. The current site features include the following: a building, a concrete parking lot, sidewalks, vegetated areas and trees.

Ground Surface Elevations & Test Boring Locations

The ground surface elevations at the test boring locations were determined by using the finished floor (ground level) of Building 5 (south wing) as a benchmark. An arbitrary elevation of 100.0 feet was used for the benchmark. Based on the benchmark datum, the ground surface elevations at the test boring locations varied from 102.5 feet at test boring 4 to 106.7 feet at test boring 1. A site map is attached at the conclusion of this report showing the relative location of the test borings.

Subsurface Conditions

Four (4) test borings were performed at the site on March 18 and March 20, 2019. The subsurface conditions encountered at the test boring locations are illustrated by means of the boring logs included in Appendix A.

The subsurface profile at the test boring locations consisted of the following layers: existing fill materials, topsoil materials, loess soils, glacial outwash soils and glacial till soils. The existing fill materials and topsoil materials extended to depths varying from 2 feet to 7 feet. The loess soils were encountered beneath the existing fill materials and topsoil materials and extended to depths varying from 12 feet to 24 ½ feet. The glacial outwash soils and glacial till soils were encountered beneath the loess soils. The glacial till soils extended to the termination depth of the test borings. The glacial outwash soils were only encountered at test boring 4 from 12 feet to 19 ½ feet.

The existing fill materials consisted of lean clay soils and lean clay with sand soils. The topsoil materials and loess soils consisted of lean clay soils. The glacial outwash soils consisted of sandy lean clay soils. The glacial till soils consisted of lean clay with sand soils and fat clay with sand soils.

The consistency or relative density of the soils is indicated by the standard penetration resistance ("N") values as shown on the boring logs. A description of the soil consistency or relative density based on the "N" values can be found on the attached Soil Boring Symbols and Descriptive Terminology data sheet.

We wish to point out that the subsurface conditions at other times and locations at the site may differ from those found at our test boring locations. If different conditions are encountered during construction, then it is important that you contact us so that our recommendations can be reviewed.

Water Levels

Measurements to record the groundwater levels were made at the test boring locations. The time and level of the groundwater readings are recorded on the boring logs. A groundwater measurement was not made at test boring 3 due to the presence of drilling fluid that was used to advance the deep test boring. Groundwater was measured at depths of 19 feet (test boring 1) and 21 feet (test boring 2). Groundwater did not enter the borehole at test boring 4 at the time of our measurement.

The water levels indicated on the boring logs may or may not be an accurate indication of the depth or lack of subsurface groundwater. The limited length of observation restricts the accuracy of the measurements. Long term groundwater monitoring was not included in our scope of work.

ENGINEERING REVIEW & RECOMMENDATIONS

Project Design Data

We understand that the project will consist of constructing an addition to Building 5 at the existing VA Medical Center in Sioux Falls, South Dakota. The addition will be constructed on the south and west sides of the south wing of Building 5. The addition will be a one-story or two-story slab-on-grade structure. The addition will match the ground level (lower level) of Building

5. With that said, the foundation walls of the addition will be below-grade walls that act as retaining walls. Wall and column loads were not available at the time of this report. We anticipate light floor slab loads. A grading plan was also not available; however, we assume that grade changes will consist of mostly cutting to achieve the design elevation. The project will also consist of some reconstruction within the existing building. We understand that the reconstruction will consist of removing load bearing walls and transferring those loads from the load bearing walls to new columns. We understand that moderate to heavy column loads are anticipated for the new columns.

The information/assumptions detailed in this section of the report are important factors in our review and recommendations. If there are any corrections or additions to the information detailed in this section, then it is important that you contact us so that we can review our recommendations with regards to the revised plans.

Discussion

The test borings indicate that existing fill materials and topsoil materials extended to depths varying from 2 feet to 7 feet. It is our opinion that the existing fill materials and topsoil materials are not suitable for support of the footings of the proposed addition.

In regards to the loess soils, it is our opinion that these soils have low strength characteristics and limited bearing capacity. The loess soils are only considered suitable for indirect support of light foundation loads. Light foundations loads would consist of wall loads less than or equal to 4 kips per lineal foot (klf) and column loads less than or equal to 100 kips. Additional site preparation will be needed with the loess soils. The additional site preparation would consist of performing an overexcavation below the footings. A net allowable soil bearing capacity of up to 2,000 pounds per square foot (psf) could be expected for the loess soils.

For moderate to heavy loads, wall loads that exceed 4 klf and column loads that exceed 100 kips, it is our opinion that the loess soils are not suitable for direct or indirect support of the footings. Due to the thickness of the loess soils, it is our opinion that a complete removal of the loess soils would not be practical. With that said, an alternative foundation support system would be needed for the moderately and heavily loaded footings. The alternative foundation support system would likely consist of an intermediate foundation system of rammed aggregate piers, aggregate piers or helical piers. The rammed aggregate piers, aggregate piers or helical piers could also be used to support the footings where wall loads are less than or equal to 4 klf and column loads are less than or equal to 100 kips. In addition, due to the loads associated with the new columns within the reconstruction of the existing building, a system of helical piers will likely be needed to support the new columns.

Footing Areas – Wall Loads ≤ 4 KLF & Column Loads ≤ 100 Kips

Site Preparation

The initial site preparation in the footing areas where the wall loads are less than or equal to 4 klf and column loads are less than or equal to 100 kips should consist of removing the existing fill materials and topsoil materials in order to expose the loess soils. Following the removals, we recommend that the overexcavation be performed below the footings. For continuous footings, the overexcavation should extend to a minimum depth of 1 footing width beneath the bottom-of-footing elevation (example: at a minimum a 3-foot-wide continuous footing would require a 3-foot overexcavation). For individual column pad footings, the overexcavation should extend to a minimum depth of one-half of the column pad width below the bottom-of-footing elevation (example: at a minimum a 5-foot by 5-foot column pad would require a 2 ½ foot overexcavation). Due to the moisture content levels of the loess soils, we recommend placing a minimum of 12 inches of crushed drainage rock at the bottom of the overexcavations. The remaining portion of the overexcavated areas could be backfilled with granular structural fill or crushed drainage rock. The overexcavations may extend to a greater depth if the existing fill materials and topsoil materials are not completely removed.

Where granular structural fill or crushed drainage rock is needed below the footings, the bottom of the excavations should be laterally oversized 1 foot beyond the edges of the footings for each vertical foot of granular structural fill or crushed drainage rock needed below the footings (1 horizontal : 1 vertical).

Foundation Loads & Settlement

For this site preparation option (wall loads less than or equal to 4 klf and column loads less than or equal to 100 kips supported indirectly by the loess soils), it is our opinion that the footings can be sized for a net allowable soil bearing pressure of up to 2,000 psf. If our recommendations are followed during site preparations, then we estimate that total settlement of the footings should be less than 1 inch and differential settlement should be less than ½ inch. At least a portion of the anticipated total settlement may appear as differential with respect to the existing building. Unknown soil conditions at the site that are different from those depicted at the test boring locations could increase the amount of expected settlement.

Footing Areas – Wall Loads >4 KLF & Column Loads >100 Kips

Rammed Aggregate Piers & Aggregate Piers

We recommend that the rammed aggregate piers or aggregate piers be designed by a licensed professional engineer specializing in the design of rammed aggregate piers or aggregate piers. The designer will typically provide a net allowable soil bearing pressure and estimated settlements. The rammed aggregate piers or aggregate piers should be installed by an experienced licensed rammed aggregate pier or aggregate pier contractor. Testing of the rammed aggregate piers and aggregate piers should be performed at the beginning of the work and during production to confirm the design parameters. We can provide contact information of rammed aggregate pier and aggregate pier designers.

Protection of the rammed aggregate piers and aggregate piers will need to be considered before, during and after installation. The tops of the rammed aggregate piers and aggregate piers should be protected from construction traffic. Excavations performed within close proximity of a rammed aggregate pier or aggregate pier can affect the integrity of the rammed aggregate pier or aggregate pier. With that said, excavation work for underground utility installation, maintenance or future repair should be considered prior to the installation of the rammed aggregate piers or aggregate piers. Excavation work for future construction, maintenance or repairs should also take into account any risks that may affect the integrity of any rammed aggregate piers or aggregate piers.

Some site preparation may need to be performed prior to the installation of the rammed aggregate piers or aggregate piers. The site preparation may consist of removing any organic materials, followed by placing and compacting a clay or granular material up to the design elevations. The designer of the rammed aggregate piers or aggregate piers should provide the specifics regarding the site preparation.

Helical Piers

The helical piers should extend down to competent soils (glacial till soils). We recommend that the helical piers be designed by a licensed professional engineer specializing in the design of helical piers. The designer will typically provide a capacity and estimated settlements. The helical piers should be installed by an experienced contractor. Testing of the helical piers should be performed to confirm the design capacities. The helical piers could also be used to support the light foundation loads. A deep test boring was performed for the design of the helical piers. In our opinion, helical piers will likely be needed to support the new columns within the existing building.

Coefficient of Friction

A friction factor of 0.45 can be used between the crushed drainage rock or granular structural fill and the bottom of the concrete. The majority of the footings will rest on crushed drainage rock or granular structural fill. The friction value is considered an ultimate value. We recommend applying a theoretical safety factor of at least 2.0. If rammed aggregate piers or aggregate piers are used, then the designer of the rammed aggregate piers or aggregate piers should be able to provide a friction value.

Seismic Site Classification

Based on the 2015 International Building Code (IBC), it is our opinion that the site, as a whole, corresponds to a Site Class D (stiff soil). Also, the ground acceleration values are as follows: S_S = 0.09 g, S_1 = 0.035 g, S_{MS} = 0.144 g, S_{M1} = 0.084 g, S_{DS} = 0.096 g, S_{D1} = 0.056 g. Therefore, the seismic design category is “A”. The ground acceleration values are also based on the 2015

IBC with Risk Category IV. If needed, we can provide ground acceleration values for a different design code.

Floor Slab – Site Preparation

The site preparation for the floor slab should consist of removing the existing fill materials and topsoil materials in order to expose the loess soils, or excavating to a minimum depth of 12 inches below the bottom-of-floor elevation, whichever is greater. We recommend backfilling the overexcavated areas with a minimum of 12 inches of select granular fill. If elevated moisture content levels are encountered within the loess soils, then crushed drainage rock may need to be used lieu of the select granular fill. The crushed drainage rock would provide better drainage characteristics.

Floor Slab – Design

If our recommendations are followed during site preparations, then it is our opinion that the floor slab can be designed using a soil modulus of subgrade reaction (k value) of 75 psi/inch.

Drainage System for the Lower Level Floor Slabs

Long-term groundwater control should be expected with the addition. We recommend placing drainage pipes beneath the lower level floor slab. The drainage pipes should have a maximum spacing of 25 feet between pipes. The drainage pipes should be surrounded by a properly graded rock filter that is wrapped in a geotextile filter fabric to minimize clogging. The drainage pipes should also be connected to a suitable means of discharge.

Below-Grade & Retaining Walls

We recommend backfilling any below-grade or retaining walls with free-draining sand. The active lateral earth pressures may be employed only if movement of the walls can be tolerated to reach the active state. A horizontal movement of approximately 1/500 of the height of the wall would be required to develop the active state for granular soils. If the above movement cannot be tolerated, then we recommend using the at-rest lateral earth pressures to design the walls. The zone of the sand backfill should extend a minimum of 2 feet outside the bottom of the foundation and then extend upward and outward at a slope no steeper than 1:1 (horizontal to vertical). Also, we recommend capping the sand backfill section with 1 foot to 2 feet of clayey soil in areas that will not have asphalt or concrete surfacing to minimize infiltration of surface waters. Table 1 shows the equivalent fluid unit weight values for the various soil types anticipated for this project.

Table 1. Equivalent Fluid Unit Weight Values

Soil Type	At-Rest, pcf		Active, pcf		Passive, pcf	
	Drained	Submerged	Drained	Submerged	Drained	Submerged
Lean Clay	-	-	-	-	220*	115*
Free-Draining Sand (SP)	50	90	35	80	460*	230*

*Value below frost depth – 0 pcf above frost depth

The passive resistance in front of a below-grade or retaining wall should not be used in an analysis unless the wall extends well below the depth of frost penetration due to loss of strength upon thawing. In addition, development of passive lateral earth pressure in the soil in front of a wall requires a relatively large rotation or outward displacement of the wall. Therefore, we do not recommend using passive resistance in front of the wall for the analysis.

We recommend that backfill drainage systems be provided for the below-grade and retaining walls to collect and remove water and to prevent hydrostatic pressure on the walls. The drainage systems should consist of slotted or perforated drainage pipes located at the bottom of the backfill trench. The drainage systems should be connected to a suitable means of discharge.

During backfill operations, bracing and/or shoring of the walls may be needed. Only hand-operated compaction equipment should be used directly adjacent to the walls. Prior to backfilling, we recommend that damp/waterproofing be applied on the exterior side of the below-grade walls.

Frost Protection

We recommend that all footings be placed at a sufficient depth for frost protection. The perimeter footings for heated buildings should be placed such that the bottom of the footing is a minimum of 4 feet below finished exterior grade. Interior footings in heated buildings can be placed beneath the floor slab. Footings for unheated areas and canopies, or footings that are not protected from frost during freezing temperatures, should be placed at a minimum depth of 5 feet below the lowest adjacent grade.

Material Types & Compaction Levels

Granular Structural Fill – The granular structural fill should consist of a pit-run or processed sand or gravel having a maximum particle size of 3 inches with less than 15 percent by weight passing the #200 sieve.

Crushed Drainage Rock – The crushed drainage rock should be washed and meet the gradation specifications shown in Table 2.

Table 2. Crushed Drainage Rock Gradation Specifications

Sieve Size	Percent Passing
1 ½-inch	100
1-inch	70 – 90
¾-inch	25 – 50
3/8-inch	0 – 5

Select Granular Fill – The select granular fill should consist of a medium to coarse grained, free-draining sand or rock having a maximum particle size of 1 inch with less than 5 percent by weight passing the #200 sieve.

Free-Draining Sand – The free-draining sand should have a maximum particle size of 1 inch with less than 5 percent by weight passing the #200 sieve. The exterior foundation wall backfill for below-grade walls should consist of free-draining sand. In areas that will not have asphalt or concrete surfacing, we recommend capping the free-draining sand with at least 1 foot to 2 feet of clay soils to minimize the infiltration of surface water.

Recommended Compaction Levels – The recommended compaction levels listed in Table 3 are based on a material's maximum dry density value, as determined by a standard Proctor (ASTM: D698) test.

Table 3. Recommended Compaction Levels

Placement Location	Compaction Specifications
Below Footings	95%
Below Floor Slabs	95%
Behind Below-Grade & Retaining Walls	95% - 98%
Non-Structural Areas	90%

Note: Compaction specifications are not applicable with the drainage rock.

Recommended Moisture Levels – The moisture content of the clay backfill materials, when used as backfill around the exterior of a foundation should be maintained within a range of plus 1 percent to minus 4 percent of the materials' optimum moisture content. When the clay backfill materials are used below a pavement area, or as site grading, the materials' moisture content should be maintained within a range of minus 1 percent to minus 4 percent of the materials' optimum moisture content. The optimum moisture content should be determined using a standard Proctor (ASTM: D698) test.

The moisture content of the granular backfill materials should be maintained at a level that will be conducive for vibratory compaction.

Recommended Lift Sizes – Typically, as backfill is placed, the loose lift thickness should not exceed 8 inches for granular structural backfill or 6 inches for clay backfill material. Lift sizes may be increased if the equipment used for compaction is large enough to fully compact a thicker lift.

Corrosive Potential

Soil samples were collected from test borings 2 and 4 and submitted for resistivity testing. Based on the soil resistivity test results, the soils are considered highly corrosive. The results of the laboratory tests are shown in Table 4.

Table 4. Laboratory Test Results

Test Boring	Depth (ft)	Soil Type	Resistivity (ohm-cm) (as-received)	Resistivity (ohm-cm) (saturated)	Moisture Content	Dry Unit Weight
2	7 to 8 ½	Lean Clay (Loess)	1,375	---	24.2	93.7
4	4 ½ to 6	Lean Clay (Loess)	1,350	---	27.5	95.7

Note: The samples were received in a saturated condition (resistivity testing).

Building Excavation

If an excavation adjacent to the existing building is to extend below the existing foundations, then we recommend that the excavation extend approximately 2 feet outside the bottom of the existing foundation and then extend downward and outward at a slope no steeper than 1:1 (horizontal to vertical). This may not apply if caving soils are encountered beneath the existing foundations. In this case, temporary shoring or underpinning may be needed.

All excavations within the footprint of the addition should be performed with a track backhoe with a smooth edge bucket. The subgrade within the addition should not be exposed to heavy construction traffic from rubber tire vehicles. The soils are extremely susceptible to disturbance and can experience strength loss caused by construction traffic and/or additional moisture.

We recommend extreme caution be exercised while excavating adjacent to an existing building to prevent undermining of the existing foundations. The excavation adjacent to the existing building should be performed in small sections such that only a limited area of the foundation soils supporting the existing structure is exposed for a short period of time.

Drainage

Proper drainage should be maintained during and after construction. The general site grading should direct surface run-off waters away from the excavations. Water which accumulates in the excavations should be removed in a timely manner.

Finished grades around the perimeter of the structure should be sloped such that positive drainage away from the structure is provided. Also, a system to collect and channel roof run-off waters away from the structure is suggested.

CONSTRUCTION CONSIDERATIONS

Groundwater & Surface Water

Water may enter the excavations due to subsurface water, precipitation or surface run off. Any water that accumulates in the bottom of the excavations should be immediately removed and surface drainage away from the excavations should be provided during construction.

Disturbance of Soils

The soils encountered at the test boring locations are susceptible to disturbance and can experience strength loss caused by construction traffic and/or additional moisture. Precautions will be required during earthwork activities in order to reduce the risk of soil disturbance.

Cold Weather Precautions

If site preparation and construction is anticipated during cold weather, we recommend all foundations, slabs and other improvements that may be affected by frost movements be insulated from frost penetration during freezing temperatures. If filling is performed during freezing temperatures, all frozen soils, snow and ice should be removed from the areas to be filled prior to placing the new fill. The new fill should not be allowed to freeze during transit, placement and compaction. Concrete should not be placed on frozen subgrades. Frost should not be allowed to penetrate below the footings. If floor slab subgrades freeze, we recommend the frozen soils be removed and replaced, or completely thawed, prior to placement of the floor slab. The subgrade soils will likely require reworking and recompacting due to the loss of density caused by the freeze/thaw process.

Excavation Sideslopes

The excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, “Excavations and Trenches”. This document states that the excavation safety is the responsibility of the contractor. Reference to this OSHA requirement should be included in the project specifications.

Observations & Testing

This report was prepared using a limited amount of information for the project and a number of assumptions were necessary to help us develop our conclusions and recommendations. It is recommended that our firm be retained to review the geotechnical aspects of the final design plans and specifications to check that our recommendations have been properly incorporated into the design documents.

The recommendations submitted in this report have been made based on the subsurface conditions encountered at the test boring locations. It is possible that there are subsurface conditions at the site that are different from those represented by the test borings. As a result, on-site observation during construction is considered integral to the successful implementation of the recommendations. We believe that qualified field personnel need to be on-site at the following times to observe the site conditions and effectiveness of the construction.

Excavation

We recommend that a geotechnical engineer or geotechnical engineering technician working under the direct supervision of a geotechnical engineer observe all excavations for foundations, slabs and pavements. These observations are recommended to determine if the exposed soils are similar to those encountered at the test boring locations, if unsuitable soils have been adequately removed and if the exposed soils are suitable for support of the proposed construction. These observations should be performed prior to placement of fill or foundations.

Testing

After the subgrade is observed by a geotechnical engineer/technician and approved, we recommend a representative number of compaction tests be taken during the placement of the structural fill and backfill placed below foundations, slabs and pavements, beside foundation walls and behind retaining walls. The tests should be performed to determine if the required compaction has been achieved. As a general guideline, we recommend at least one (1) test be taken for every 2,000 square feet of structural fill placed in building and pavement areas, at least one (1) test for every 75 feet to 100 feet in trench fill, and for every 2-foot thickness of fill or backfill placed. The actual number of tests should be left to the discretion of the geotechnical engineer. Samples of proposed fill and backfill materials should be submitted to our laboratory for testing to determine their compliance with our recommendations and project specifications.

If installed, we recommend that a geotechnical engineer or a geotechnical engineering technician working under the direct supervision of a geotechnical engineer monitor the installation of the rammed aggregate piers, aggregate piers or helical piers. Detailed records should be kept during installation.

SUBSURFACE EXPLORATION PROCEDURES

Test Borings

We performed four (4) SPT borings on March 18 and March 20, 2019 with a truck rig equipped with hollow-stem auger. Soil sampling was performed in accordance with the procedures described in ASTM:D1586. Using this procedure, a 2-inch O.D. split barrel sampler is driven into the soil by a 140-pound weight falling 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as the penetration resistance, or “N” value. The “N” value is an index of the relative density of cohesionless soils and the consistency of cohesive soils. In addition, thin walled tube samples were obtained according to ASTM:D1587, where indicated by the appropriate symbol on the boring logs.

The test borings were backfilled with on-site materials and some settlement of these materials can be expected to occur. Final closure of the holes is the responsibility of the client or property owner.

The soil samples collected from the test boring locations will be retained in our office for a period of one (1) month after the date of this report and will then be discarded unless we are notified otherwise.

Soil Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief according to ASTM:D2488. Representative portions of all samples were then sealed and returned to the laboratory for further examination and for verification of the field classification. In addition, select samples were then submitted to a program of laboratory tests. Where laboratory classification tests (sieve analysis and Atterberg limits) have been performed, classifications according to ASTM:D2487 are possible. Logs of the test borings indicating the depth and identification of the various strata, the "N" value, the laboratory test data, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are also attached in Appendix A. Charts illustrating the soil classification procedures, the descriptive terminology and the symbols used on the boring logs are also attached in Appendix A.

Water Level Measurements

Subsurface groundwater levels should be expected to fluctuate seasonally and yearly from the groundwater readings recorded at the test borings. Fluctuations occur due to varying seasonal and yearly rainfall amounts and snowmelt, as well as other factors.

Laboratory Tests

Laboratory tests were performed on select samples to aid in determining the index and strength properties of the soils. The index tests consisted of moisture content, dry density, sieve analysis (#200 sieve wash), standard Proctor, resistivity and Atterberg limits (liquid and plastic limits). The strength tests consisted of unconfined compressive strength. The laboratory tests were performed in accordance with the appropriate ASTM procedures. The results of the laboratory tests are shown on the boring logs opposite the samples upon which the tests were performed or on the data sheets included in the Appendix.

LIMITATIONS

The recommendations and professional opinions submitted in this report were based upon the data obtained through the sampling and testing program at the test boring locations. We wish to point out that because no exploration program can totally reveal the exact subsurface conditions for the entire site, conditions between test borings and between samples and at other times may differ from those described in our report. Our exploration program identified subsurface conditions only at those points where samples were retrieved or where water was observed. It is not standard engineering practice to continuously retrieve samples for the full depth of the borings. Therefore, strata boundaries and thicknesses must be inferred to some extent. Additionally, some soils layers present in the ground may not be observed between sampling intervals. If the subsurface conditions encountered at the time of construction differ from those represented by our test borings, it is necessary to contact us so that our recommendations can be reviewed. The variations may result in altering our conclusions or recommendations regarding site preparation or construction procedures, thus, potentially affecting construction costs.

This report is for the exclusive use of the addressee and its representatives for use in design of the proposed project described herein and preparation of construction documents. Without written approval, we assume no responsibility to other parties regarding this report. Our conclusions, opinions and recommendations may not be appropriate for other parties or projects.

STANDARD OF CARE

The recommendations submitted in this report represent our professional opinions. Our services for your project were performed in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering profession currently practicing at this time and area.

This report was prepared by:
GeoTek Engineering & Testing Services, Inc.

Brennen Ahlers, PE
Project Manager

REGISTERED PROFESSIONAL ENGINEER
REG. NO. 12056
BRENNEN W. AHLERS
SOUTH DAKOTA

4/17/19

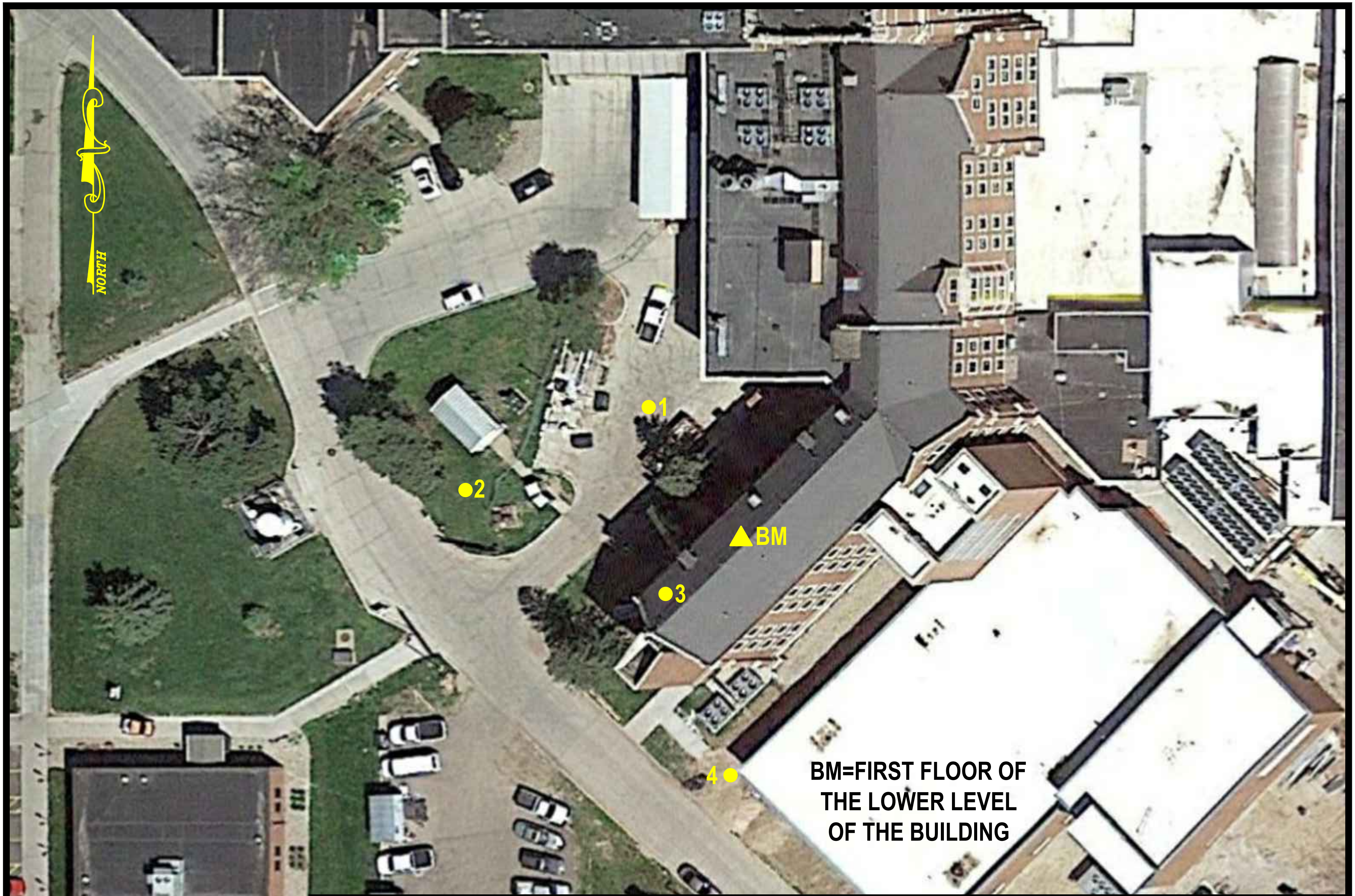

FIGURE 1
TEST BORING LOCATION MAP
PROPOSED SPS ADDITION - BUILDING 5
VA MEDICAL CENTER
SIOUX FALLS, SD

ACAD/GEOTEK/BRENNEN/19-225

PROJECT#: 19-225

DRAWN BY: DHP

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **19-225**

BORING NO. **1 (1 of 1)**

PROJECT **Proposed SPS Addition - Building 5, VA Medical Center, Sioux Falls, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 106.7 ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LAB WC	LAB D	LAB LL	LAB PL	LAB QU
	FILL, MOSTLY LEAN CLAY WITH SAND: a little gravel, brown, frozen, 8" of concrete at the surface	FILL			1	HSA					
2	**FILL, MOSTLY CLAYEY SAND**: with gravel, medium grained, brown, dry	FILL	26		2	SPT					
			7		3	SPT					
7	**LEAN CLAY**: mottled brown and gray, moist to wet, firm, 98.9% passing #200 sieve from 12'-13.5' (CL)	LOESS	6		4	SPT	18	103			
			6		5	SPT					
			8		6	SPT					
			6		7	SPT	27		36	22	
				▼							
			5		8	SPT	30				
24½	**FAT CLAY WITH SAND**: a little gravel, mottled brown and gray, moist, stiff, (CL)	GLACIAL TILL	13		9	SPT	21	107			5600
26	Bottom of borehole at 26 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
3-18-19	3:00 pm	26	--	19	▼ 19
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 3-18-19 COMPLETE 3-18-19 2:39 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Mike Wagner

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www.geotekeng.com

GEOTECHNICAL TEST BORING LOG

GEOTEK # **19-225** BORING NO. **2 (1 of 1)**

PROJECT **Proposed SPS Addition - Building 5, VA Medical Center, Sioux Falls, SD**

SURFACE ELEVATION 104.7 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: brown, frozen to 2' then moist	FILL			1	HSA					
			7		2	SPT					
5	**LEAN CLAY**: very dark brown to black, moist, firm, (CL)	TOPSOIL	8		3	SPT	31	87			
7	**LEAN CLAY**: mottled brown and gray, moist to wet, soft to firm, (CL)	LOESS	8		4	SPT					
			7		5	SPT					
			7		6	SPT	26	97			
			6		7	SPT					
			3	▼	8	SPT					
24½	**LEAN CLAY WITH SAND**: a little gravel, mottled brown and gray, moist, stiff, (CL)	GLACIAL TILL	11		9	SPT					
26	Bottom of borehole at 26 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
3-19-19	9:37 am	26	--	21	▼ 21
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 3-18-19 COMPLETE 3-18-19 4:08 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Mike Wagner

GEOTECHNICAL TEST BORING 19-225.GPJ GEOTEKENG.GDT 4/10/19

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **19-225** BORING NO. **3 (1 of 2)**

PROJECT **Proposed SPS Addition - Building 5, VA Medical Center, Sioux Falls, SD**

SURFACE ELEVATION 104.8 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: dark brown, frozen to 2' then moist	FILL			1	HSA					
3	**LEAN CLAY**: very dark brown to black, moist, firm, (CL)	TOPSOIL	5		2	SPT					
4½	**LEAN CLAY**: brown, moist, stiff, (CL)	LOESS	11		3	SPT					
7	**LEAN CLAY**: mottled brown and gray, moist to wet, soft to firm, (CL)	LOESS	6		4	SPT	22	100			
			6		5	SPT					
			4		6	SPT					
19½	**LEAN CLAY WITH SAND**: a little gravel, mottled brown and gray, moist, stiff, (CL)	GLACIAL TILL	9		7	SPT	24	103			
			15		8	SPT					
29½	**FAT CLAY WITH SAND**: a little gravel, mottled brown and dark gray, moist, stiff to very stiff, (CH)	GLACIAL TILL	16		9	SPT					
			17		10	SPT	21	111			5200
39½	**LEAN CLAY WITH SAND**: a little gravel, brown, moist, very stiff to hard, (CL)	GLACIAL TILL	21		11	SPT					

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 3-19-19 COMPLETE 3-20-19 3:31 pm

METHOD
Rotary Mud Drilling

CREW CHIEF Mike Wagner

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **19-225** BORING NO. **3 (2 of 2)**

PROJECT **Proposed SPS Addition - Building 5, VA Medical Center, Sioux Falls, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 104.8 ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	LEAN CLAY WITH SAND: a little gravel, brown, moist, very stiff to hard, (CL) *(Continued from previous page)*	GLACIAL TILL									
			25		12	SPT					
			25		13	SPT					
			38		14	SPT					
			36		15	SPT	18	118			5100
			41		16	SPT					
			43		17	SPT					
			35		18	SPT					
81			39		19	SPT					
	Bottom of borehole at 81 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 3-19-19 COMPLETE 3-20-19 3:31 pm

METHOD
Rotary Mud Drilling

CREW CHIEF Mike Wagner

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **19-225** BORING NO. **4 (1 of 1)**

PROJECT **Proposed SPS Addition - Building 5, VA Medical Center, Sioux Falls, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 102.5 ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: brown, frozen	FILL			1	HSA					
2	**LEAN CLAY**: mottled brown and gray, moist to wet, firm, 98.6 feet passing #200 sieve from 7' to 8.5' (CL)	LOESS	8		2	SPT	31	90			
			6		3	SPT	28				
			5		4	SPT	27				
			5		5	SPT					
12	**SANDY LEAN CLAY**: a few lenses of gravel, brown, moist, stiff to very stiff, (CL)	GLACIAL OUTWASH	24		6	SPT					
			15		7	SPT					
19½	**LEAN CLAY WITH SAND**: a little gravel, mottled brown and gray, moist, very stiff, (CL)	GLACIAL TILL	17		8	SPT	21	101			7000
24½	**FAT CLAY WITH SAND**: a little gravel, mottled brown and gray, moist, very stiff, (CH)	GLACIAL TILL	20		9	SPT					
26	Bottom of borehole at 26 feet.										

START 3-18-19 COMPLETE 3-18-19 12:18 pm

METHOD
3.25" ID Hollow Stem Auger

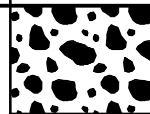
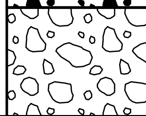
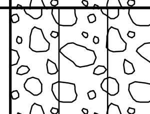
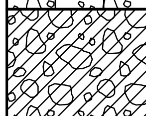
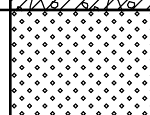
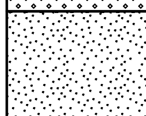
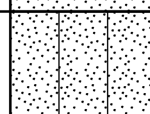
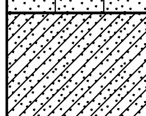
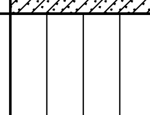
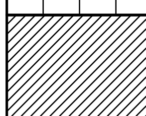
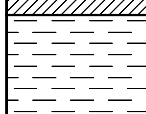
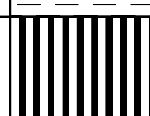
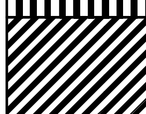
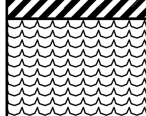
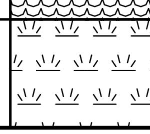
CREW CHIEF Mike Wagner

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
3-18-19	5:15 pm	26	--	19	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

GEOTECHNICAL TEST BORING 19-225.GPJ GEOTEKENG.GDT 4/10/19

SOIL CLASSIFICATION CHART

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

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

BORING LOG SYMBOLS AND DESCRIPTIVE TERMINOLOGY

SYMBOLS FOR DRILLING AND SAMPLING

Symbol	Definition
Bag	Bag sample
CS	Continuous split-spoon sampling
DM	Drilling mud
FA	Flight auger; number indicates outside diameter in inches
HA	Hand auger; number indicates outside diameter in inches
HSA	Hollow stem auger; number indicates inside diameter in inches
LS	Liner sample; number indicates outside diameter of liner sample
N	Standard penetration resistance (N-value) in blows per foot
NMR	No water level measurement recorded, primarily due to presence of drilling fluid
NSR	No sample retrieved; classification is based on action of drilling equipment and/or material noted in drilling fluid or on sampling bit
SH	Shelby tube sample; 3-inch outside diameter
SPT	Standard penetration test (N-value) using standard split-spoon sampler
SS	Split-spoon sample; 2-inch outside diameter unless otherwise noted
WL	Water level directly measured in boring
▼	Water level symbol

SYMBOLS FOR LABORATORY TESTS

Symbol	Definition
WC	Water content, percent of dry weight; ASTM:D2216
D	Dry density, pounds per cubic foot
LL	Liquid limit; ASTM:D4318
PL	Plastic limit; ASTM:D4318
QU	Unconfined compressive strength, pounds per square foot; ASTM:D2166

DENSITY/CONSISTENCY TERMINOLOGY

Density Term	N-Value	Consistency Term
Very Loose	0-4	Soft
Loose	5-8	Firm
Medium Dense	9-15	Stiff
Dense	16-30	Very Stiff
Very Dense	Over 30	Hard

DESCRIPTIVE TERMINOLOGY

Term	Definition
Dry	Absence of moisture, powdery
Frozen	Frozen soil
Moist	Damp, below saturation
Waterbearing	Pervious soil below water
Wet	Saturated, above liquid limit
Lamination	Up to ½" thick stratum
Layer	½" to 6" thick stratum
Lens	½" to 6" discontinuous stratum

PARTICLE SIZES

Term	Particle Size
Boulder	Over 12"
Cobble	3" – 12"
Gravel	#4 – 3"
Coarse Sand	#10 – #4
Medium Sand	#40 – #10
Fine Sand	#200 – #40
Silt and Clay	passes #200 sieve

GRAVEL PERCENTAGES

Term	Range
A trace of gravel	2-4%
A little gravel	5-15%
With gravel	16-50%

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MOISTURE - DENSITY TEST REPORT

REPORTED TO:

FourFront Design Inc.
Joel Simonyak
517 7th Street
Rapid City, SD 57701

PROJECT: 19-225

Proposed SPS Addition -
Building 5
VA Medical Center
Sioux Falls, SD

COPIES TO:

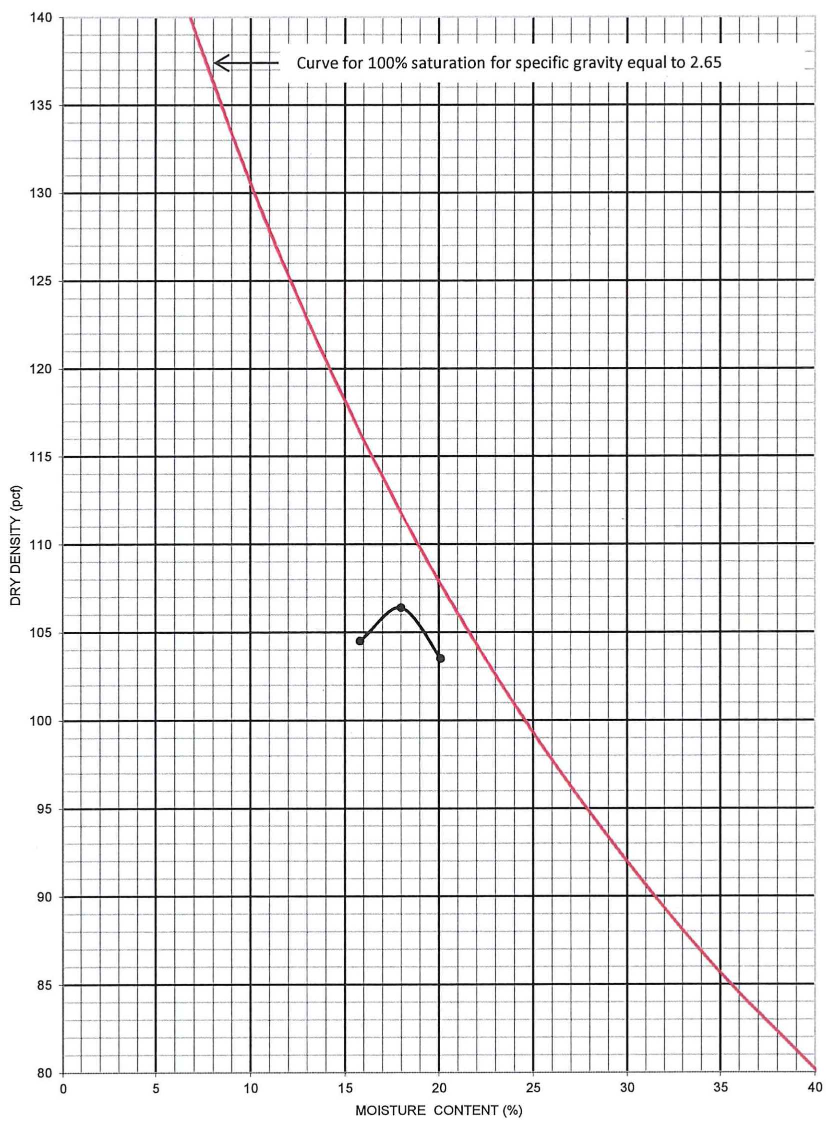
DATE REPORTED: 3/25/2019

SAMPLE DATA

Sample No.: 1
ASTM Test Method: D698B Manual
Soil Classification: Lean Clay, Brown (CL) - 1
Remarks: SB1 (7' - 12')

Date Received: 3/22/2019
Date Tested: 3/22/2019

TEST DATA



Maximum Density, pcf:	106.4
Optimum Moisture, %:	18.0
Percent Passing, %:	
3/4":	100
3/8":	100
#4:	100
#200:	98.9

Atterberg Limits (ASTM: D4318):
Liquid Limit:
Plastic Limit:
Plasticity Index:

Paul Miles, Construction Materials Lab Supervis

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MOISTURE - DENSITY TEST REPORT

REPORTED TO:

FourFront Design Inc.
Joel Simonyak
517 7th Street
Rapid City, SD 57701

PROJECT: 19-225

Proposed SPS Addition -
Building 5
VA Medical Center
Sioux Falls, SD

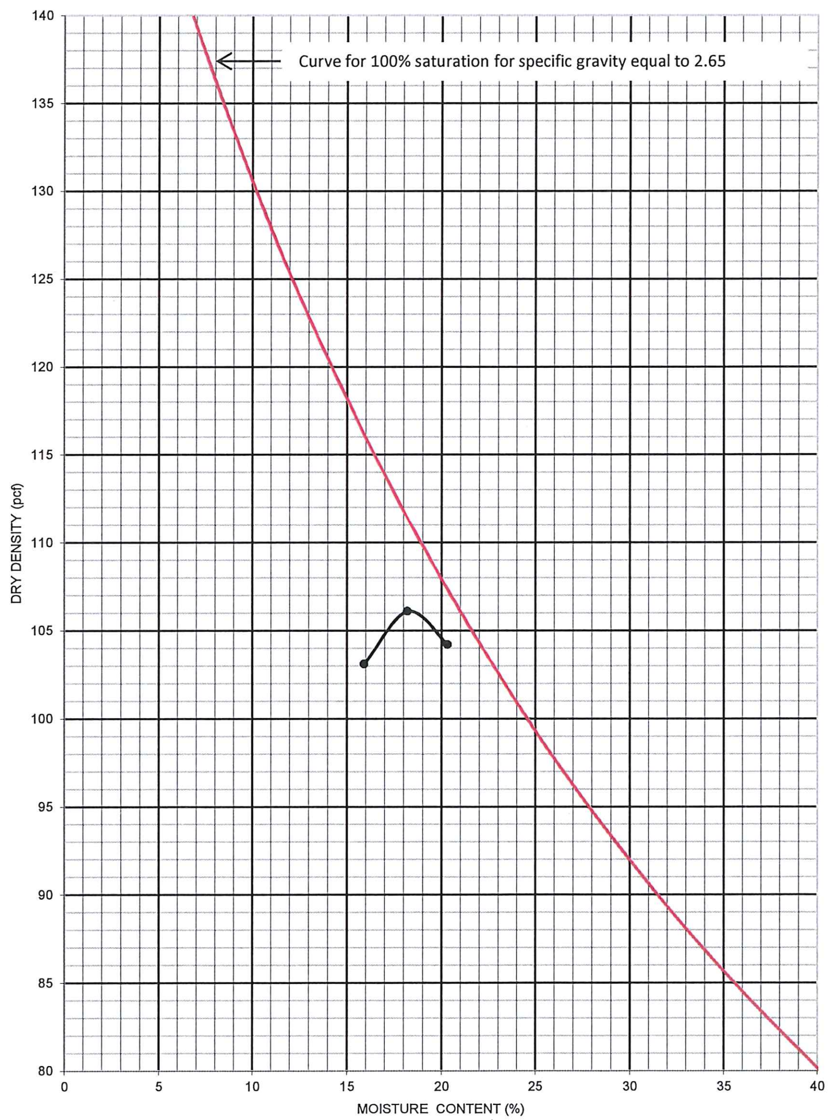
COPIES TO:

DATE REPORTED: 3/25/2019

SAMPLE DATA

Sample No.:	2	**Date Received:**	3/22/2019
ASTM Test Method:	D698B Manual	**Date Tested:**	3/22/2019
Soil Classification:	Lean Clay, Brown (CL) - 2		
Remarks:	SB4 (2' - 6')		

TEST DATA



Maximum Density, pcf:	106.1
Optimum Moisture, %:	18.2
Percent Passing, %:	
3/4":	100
3/8":	100
#4:	100
#200:	98.6
Atterberg Limits (ASTM: D4318):	
Liquid Limit:	
Plastic Limit:	
Plasticity Index:	

Paul Miles, Construction Materials Lab Supervis