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June 23, 2021

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Attn: Dave Lorang, AIA

Subj: Geotechnical Exploration
Proposed Building & Garage
Banner Associates
3900 N. Northview Avenue
Sioux Falls, South Dakota
GeoTek #21-851

This correspondence presents our written report of the geotechnical exploration program for the referenced project. Our work was performed in accordance with the authorization of Scott Vander Meulen with Banner Associates. 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.

*Nick Bierle*

Nick Bierle, PE
Project Engineer

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## INTRODUCTION

### Project Information

This report presents the results of the recent geotechnical exploration program for the proposed building for Banner Associates at 3900 N. Northview Avenue in Sioux Falls, South Dakota.

### Scope of Services

Our work was performed in accordance with the authorization of Scott Vander Meulen with Banner Associates. The scope of work as presented in this report is limited to the following:

1. To perform 13 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) 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 at 3900 N. Northview Avenue in Sioux Falls, South Dakota. A site location map (Figure 1) is attached showing the location of the site. The site is currently covered in

vegetation (grass). The topography of the site slopes downward from the northeast to the southwest.

**Ground Surface Elevations & Test Boring Locations**

The ground surface elevations at the test boring locations were provided by Banner Associates. The ground surface elevations at the test boring locations varied from 1,486.7 feet at test boring 13 to 1,494.3 feet at test boring 7. A site map (Figure 2) is attached at the conclusion of this report showing the relative location of the test borings.

**Subsurface Conditions**

We performed 13 test borings at the site on June 7, 2021. Of the 13 test borings, 7 test borings (test borings 1 through 7) were performed for the building and garage and the remaining 6 test borings (test borings 8 through 13) were performed in the pavement areas. The subsurface conditions encountered at the test boring locations are illustrated by means of the boring logs included in Appendix A.

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. This only pertains to the standard penetration test (SPT) borings.

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.

**Test Borings 1 Through 7 – Building & Garage**

At these test borings, the subsurface profile consisted of the following soil types: topsoil materials, existing fill materials, loess soils and glacial till soils. The topsoil materials extended to depths of ½ foot and 1 foot. The existing fill materials and loess soils were encountered

beneath the topsoil materials and extended to depths varying from 12 feet to 16 feet. The loess soils extended to the termination depth of test borings 2 and 3. The glacial till soils were encountered at test borings 1, 4, 5, 6 and 7. The glacial till soils extended to the termination depth of these test borings. A subsurface diagram (Figure 3) is attached at the conclusion of this report showing a cross-sectional view of the subsurface conditions encountered at the test borings performed for the building (east to west direction).

**Test Borings 8 Through 13 – Pavement Areas**

At these test borings, we encountered topsoil materials overlying existing fill materials and/or loess soils. The topsoil materials extended to a depth of 1 foot. The existing fill materials were encountered at test borings 8, 9 and 13 and extended to the termination depth of test boring 8. The loess soils extended to the termination depth of test borings 9, 10, 11, 12 and 13.

**Soil Types**

The topsoil materials consisted of lean clay (CL). The existing fill materials consisted of lean clay (CL) and lean clay with sand (CL). The loess soils consisted of lean clay (CL). The glacial till soils consisted of lean clay with sand (CL) and fat clay with sand (CH).

**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. Groundwater did not enter the boreholes at the time of our measurements.

The water levels 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 a new building and garage for Banner Associates at 3900 N. Northview Avenue in Sioux Falls, South Dakota. The building will be a 2-story slab-on-grade structure with an approximate area of 11,700 square feet. We understand that the finished floor elevation (FFE) of the building will be at 1,491.5 feet. We understand that the building will have an elevator with the top-of-slab elevation of the elevator pit near 1,486.0 feet. We anticipate that foundation support for the building will be provided by perimeter footings resting below frost depth and interior footings resting at or slightly below the floor slab. The maximum wall loads and column loads were provided by Banner Associates: wall loads will range from 2 kips per lineal foot (klf) to 3 klf and column loads are expected to range from 75 kips to 100 kips (exterior column pads) and 150 kips to 175 kips (interior column pads). Light floor loads are expected. Based on the existing surface grades within the footprint of the building and the FFE, filling of 1 foot (northern portion) to 3 feet (southern portion) will be needed to achieve the FFE.

In regards to the garage, we understand that the garage will be a 1-story slab-on-grade structure with an approximate area of 2,000 square feet. We understand that the FEE of the garage will be near 1,494.5 feet. Based on the existing surface grades within the footprint of the garage and the FFE, minimal cutting to filling of up to 2 feet will be needed to achieve the FFE. We also understand that the wall loads will range from 3 klf to 4 klf. We understand that the garage will be heated during the winter months.

The project will also consist of constructing pavement areas. Grade changes in the pavement areas will mostly involve cutting.

The information/assumptions detailed in the project design data section 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.

## Building & Garage

### Discussion

The test borings performed for the building and garage indicate that the existing fill materials and loess soils extended to depths varying from 12 feet to 16 feet (elevation 1,472.2 feet to 1,479.8 feet). In our opinion, it appears that portions of the existing fill materials were not placed and/or compacted in a controlled manner. Our opinion of this is based on the variable "N" values within the existing fill materials. Regarding the loess soils, the loess soils generally have low strength characteristics and are moderately compressible. In order to provide a uniform subgrade condition beneath the footings, we recommend that additional site preparation (overexcavation and backfill with granular structural fill or crushed rock) be performed beneath the footings. The depth of the overexcavation will be dependent on the type of footing and magnitude of the foundation loads.

### Site Grading

The site grading should consist of removing any vegetation and highly organic materials. Based on the test borings, a removal depth of less than 1 foot should be expected. Following the removals, we recommend placing and compacting general structural fill to an elevation of 12 inches below the bottom of the floor slab.

The subgrade within the footprint of the building or garage should not be exposed to heavy construction traffic from rubber tire vehicles. The on-site existing fill materials and loess soils are vulnerable to disturbance and can experience strength loss caused by construction traffic and/or additional moisture. If any soils become disturbed during construction, then the disturbed soils will likely need to be removed.

### Footings

As previously stated, an overexcavation should be performed beneath the footings. The overexcavation depths are based on the type of footing (continuous footing or column pads) and the magnitude of the foundation loads. Please see Table 1 for the minimum overexcavation depths. The overexcavated areas should be backfilled with granular structural fill or crushed

rock. Also, an Overexcavation Cross-Section (Figure 4) shows a cross-sectional view of the overexcavated areas.

**Table 1. Minimum Overexcavation Depths – Footing Areas**

| Footing | Minimum Overexcavation Depth, ft |
|---|---|
| Continuous Footing (0 klf to < 3 klf) | 1 |
| Continuous Footing (≥3 klf to < 5 klf) | 2 |
| Column Pad (0 kips to < 40 kips) | 1 |
| Column Pad (≥ 40 kips to < 80 kips) | 2 |
| Column Pad (≥ 80 kips to < 120 kips) | 3 |
| Column Pad (≥ 120 kips to < 180 kips) | 4 |

Note: If the load limits (5 klf or 180 kips) are exceeded, then we recommend that we be contacted to provide additional overexcavation depths.

We recommend that observations and testing (compaction tests for the fill materials) be performed on the soils exposed at the bottom of the excavations. Shallow hand auger borings should also be performed at the bottom of the excavations. Unstable areas or areas having low density may require further excavation.

If water or saturated soils are encountered at the bottom of an excavation, then we recommend placing a layer (6 inches to 12 inches) of crushed rock at the bottom of the excavation prior to the placement of the granular structural fill or footings.

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

If our recommendations are followed during site preparations, then it is our opinion that the footings of the building can be sized for a net allowable soil bearing pressure of up to 2,000 pounds per square foot (psf). If a higher net allowable soil bearing pressure is desired or the expected foundation loads on page 7 of this report are exceeded, then we recommend that we be contacted to provide additional recommendations.

With the expected loads and net allowable soil bearing pressure, total settlement of the footings should be less than 1 inch and differential settlement should be less than ½ inch over 50 feet. Unknown soil conditions at the site that are different from those depicted at the test boring locations could increase the amount of expected settlement.

It is our opinion that a friction factor of 0.45 can be used between the granular structural fill or crushed rock and the bottom of the concrete. The friction value is considered an ultimate value. We recommend applying a theoretical safety factor of at least 2.0.

All footing excavations should be performed with a track backhoe with a smooth edge bucket. The subgrade within the footprint of the building should not be exposed to heavy construction traffic from rubber tire vehicles.

**Floor Slab (Building & Garage)**

We recommend that 12 inches of granular structural fill be provided below the floor slab. Of the 12 inches of granular structural fill, the upper 6 inches should consist of select granular fill. Prior to the placement of the granular material, the exposed subgrade should be observed. If unstable areas are present, then these areas should be addressed. Once the subgrade is approved, the granular material should be placed and compacted up to the design elevation.

As previously stated, we understand that the garage will be heated during the winter months. With that said, if portions of the garage will not be heated during the winter months, then the granular structural fill will provide some frost protection in regards to frost heave (but not eliminate). However, if movement of the floor slab (due to potential frost heave) cannot be tolerated, then our recommendations detailed in the section "*Frost Protection – Surface Improvements*" on page 20 of this report should be followed.

If our recommendations are followed during site preparations, then it is our opinion that the floor slab of the building and garage can be designed using a soil modulus of subgrade reaction (k value) of 75 psi/inch. Also, it would be beneficial to place a vapor barrier beneath the floor slab.

**Elevator Pit Foundation**

The site preparation for the elevator pit foundation should follow the recommendations for the column pad overexcavations outlined in Table 1 found in the section entitled *"Footings"*. However, it should be noted that we recommend a minimum 2-foot overexcavation be performed below the elevator foundation.

**Dewatering – Building & Garage Footprint**

Dewatering will likely not be needed within the footprint of the building and garage. However, if dewatering is needed, then the contractor should provide appropriate dewatering methods and equipment. In areas where clay soils are encountered, it will likely be possible to remove and control water entering the excavations using normal sump pumping techniques. If waterbearing sand soils are encountered, then an extensive dewatering system will likely be needed.

**Drainage System for the Elevator Pit**

Long-term groundwater control may be needed with the elevator. We recommend placing drainage pipes beneath the elevator pit. The drainage pipes should be placed along the exterior of the elevator pit. We recommend placing the drainage pipes approximately 12 inches below the elevator pit. The drainage pipes should be surrounded by a properly graded filter that is wrapped in a geotextile filter fabric to minimize clogging. The drainage pipes should be connected to a suitable means of discharge. We also recommend that a sump pump be installed.

**Perimeter Drain Tile Recommendations**

Since the building and garage will be slab-on-grade, it is our opinion that drain tile is not needed along the perimeter of the building and garage. Again, a drain tile is recommended for the elevator pit.

**Retaining Walls**

We recommend backfilling any 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 2 shows the equivalent fluid unit weight values for the various soil types anticipated for this project.

**Table 2. Equivalent Fluid Unit Weight Values**

| Soil Type | At-Rest, pcf | | Active, pcf | | Passive, pcf | |
|---|---|---|---|---|---|---|
| | Drained | Submerged | Drained | Submerged | Drained | Submerged |
| 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 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.

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.

## Seismic Site Classification

Based on the 2018 International Building Code (IBC), it is our opinion that the site, as a whole, corresponds to a Site Class D (stiff soil) due to the underling glacial till soils. The site classification is based on the loess soils. Also, the ground acceleration values are as follows: $S_S$ = 0.092 g, $S_1$ = 0.035 g, $S_{MS}$ = 0.147 g, $S_{M1}$ = 0.085 g, $S_{DS}$ = 0.098 g, $S_{D1}$ = 0.056 g. Therefore, the seismic design category is “A”. The ground acceleration values are based on the ASCE 7-16 (referenced standard for 2018 IBC) with Risk Category II. If needed, we can provide ground acceleration values for a different design code.

**Foundation Support Alternative (Bldg.) – Rammed Aggregate Piers/Aggregate Piers**

As an alternative to the additional site preparation beneath the footings for the building, a system of rammed aggregate piers or aggregate piers could be used to support the footings of the building. With the rammed aggregate piers or aggregate piers, there are several support and sequencing options that could be considered. Discussions with the rammed aggregate pier or aggregate pier designer should be made to determine the best course of action.

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.

Rammed aggregate piers and aggregate piers are installed using 2 methods, the displacement method and the replacement method. The displacement method consists of probing equipment into the ground without removing soil (no “pre-drilling”). With the displacement method, excess pore pressures develop in soft/saturated clay soils that are displaced, which can decrease the strength and supporting characteristics of the surrounding soils and cause additional settlement. The replacement method consists of “pre-drilling” a hole, followed by replacing the removed soils with aggregate to construct the pier. With the replacement method, minimum disturbance occurs to the surrounding soils. With the soils encountered at the site, we recommend that the replacement method be used to construct the piers.

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 and aggregate piers.

Depending on the design of the rammed aggregate pier or aggregate pier system, a time delay may need to be incorporated into the project. The time delay will allow the underlying soils to compress/settle under the weight of the newly placed fill prior to the installation of the rammed aggregate piers or aggregate piers. The rammed aggregate piers or aggregate piers can be installed once any settlement has "leveled off".

We would like to point out that not all applications/systems are equivalent and each submitted design should be reviewed. In addition, the designer and installation contractor should have approximate experience (e.g., at least 5 years of experience and at least 15 or more successfully completed projects).

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.

## Pavement Areas

### Discussion

Existing fill materials and loess soils are expected to be encountered as subgrade soils in the pavement areas. The loess soils have a Unified Soils Classification System symbol of CL and an AASHTO classification of A-6.

In our opinion, the existing fill materials and loess soils have low strength characteristics and are prone to instability during freeze-thaw cycles. In addition, the existing fill materials and loess soils are prone to instability from normal construction traffic. Our opinion is based on our observations of the collected samples

We estimate California Bearing Ratio (CBR) values of 1.0 to 2.0 for the existing fill materials and loess soils. CBR values of 1.0 to 2.0 are considered low CBR values. The CBR value is a measure of the supporting value of the subgrade soils. The value can be determined from a soaked test or an unsoaked test. The value from a soaked test is used to simulate the worst

conditions (wet periods of the year and the spring thaw), while the value from an unsoaked test is used to simulate normal field conditions (summer and fall). Values from soaked tests are much lower than values from unsoaked tests. The values discussed above would represent values from soaked tests. With all this said, we would consider the subgrade condition to be a poor subgrade condition.

In order to provide a uniform and stable subgrade condition in the pavement areas, we recommend the use of subgrade reinforcement without granular subbase (option 1), subgrade reinforcement with granular subbase (option 2) or cement stabilization (option 3). The subgrade reinforcement with granular subbase (option 2) and cement stabilization (option 3) would provide an "all weather" subgrade condition once the subgrade preparation has been performed. In addition, option 2 and option 3 could be implemented early in the project after any underground utilities have been installed in order to provide an "all weather" subgrade during construction which would help reduce or minimize construction delays. Specific details for the subgrade reinforcement and cement stabilization are discussed on the following pages.

**Initial Subgrade Preparation**

The initial subgrade preparation in the pavement areas should consist of removing any vegetation and highly organic materials (a removal depth of less than 1 foot should be expected). Following the removals, the subgrade should be prepared by cutting or placing and compacting subgrade fill to the design subgrade elevations. Then, 1 of the subgrade preparation options should be performed.

**Subgrade Preparation Option 1 – Subgrade Reinforcement w/o Granular Subbase**

For the subgrade reinforcement w/o granular subbase option, a geotextile fabric should be placed beneath the aggregate base course material once the initial subgrade preparation has been performed. Regarding the geotextile fabric, we recommend using Mirafi HP 370, Propex Geotex 3x3 HF, Huesker Comtrac P 45/45 or an approved alternative.

Prior to the installation of the geotextile fabric, the upper 8 inches of the subgrade should be scarified, moisture conditioned and recompacted. The soils should be moisture conditioned to a

moisture level that is 1 percent below to 4 percent below the optimum moisture content as determined by standard Proctor (ASTM:D698). The scarification should be performed by a disc harrow and not a road grader with teeth. Following the scarification and recompaction and prior to the placement of the aggregate base course material and geotextile fabric, we recommend that a proof roll be performed on the exposed subgrade with a truck weighing 20 tons to 30 tons. During the proof roll, unstable areas in the subgrade should be delineated from stable areas. An unstable area would be considered a location with at least 1 inch of rutting or deflection. The soils within the unstable area should be removed, and either moisture-conditioned and recompacted, or replaced with suitable subgrade soils. If the unstable area will not stabilize using this method, then an alternative section will likely be needed. One (1) alternative section would consist of increasing the thickness of the aggregate base course material (thickness would be based on field conditions). Another alternative section would consist of subgrade preparation option 2 or 3.

We would like to point out that unstable areas may be encountered with this option, especially during the spring thaw, wetter periods of the year, when it is difficult to dry wet soils (late fall), areas of high groundwater or due to construction disturbance. Additionally, for Option 1 to be successful, there would likely need to be an extended period of dry weather. With all that said, Option 1 will likely take the most amount of construction time and is the most weather dependent.

**Subgrade Preparation Option 2 – Subgrade Reinforcement w/ Granular Subbase**

For the subgrade reinforcement with granular subbase option, a layer of granular subbase (see page 23 for gradation and material type) should be placed on top of a woven geotextile fabric that is overlying the subgrade once the initial subgrade preparation has been performed. Regarding the geotextile fabric, we recommend using Mirafi HP 370, Propex Geotex 3x3 HF, Huesker Comtrac P 45/45, or an approved alternative.

**Subgrade Preparation Option 3 – Cement Stabilization**

The cement stabilization should consist of blending the subgrade soils with cement to a minimum depth of 12 inches. The percentage of cement used typically ranges from 5 percent to 7

percent and should be based on a site specific mix design. However, in large cut areas, the treatment depth and percentage of cement may need to be increased in order to provide a stable subgrade condition. For bidding purposes, the percentage of cement used should be 6 percent (example: if the in-place dry density equals 100 pounds per cubic foot (pcf), then 6.0 pounds of cement should be applied to the subgrade, per square foot). We recommend that the percentage of cement used during the blending process be determined by a mix design that should be performed when the subgrade soils are exposed during construction. The mix design typically takes about 2 weeks to complete.

Once the percentage of cement is determined, the cement should be placed uniformly over the subgrade surface at the specified percentage with a truck-mounted cement spreader. In addition to the cement being placed uniformly, the truck-mounted spreader will help control the spread of cement dust. Then, a self-propelled pulvimixer/reclaimer should be used to reclaim the upper 12 inches of the subgrade along with the cement. Within 30 minutes, the reclaimed mixture of soil and cement should be initially compacted with a large (60-inch to 72-inch diameter) vibratory sheepsfoot roller to a minimum of 95 percent of the maximum dry density as determined by Moisture-Density Relations of Soil-Cement Mixtures (ASTM:D558). The moisture content of the material should be adjusted to a moisture level that is within 3 percent below to 3 percent above the optimum moisture content determined by Moisture-Density Relations of Soil-Cement Mixtures (ASTM:D558). After initial compaction, the subgrade should be graded to design elevations, rolled with a pneumatic tire roller and watered with a commercial water truck. Construction traffic should not be allowed on the subgrade for 48 hours after the final watering. This delay allows for the cement to properly hydrate without being disturbed. If at any time during or after the cement stabilization process it is determined that the subgrade is not performing as expected, then the problem should be assessed to determine the best course of action. This may include an additional application of cement.

**Pavement Section Thicknesses**

Tables 3 and 4 show the recommended pavement section thicknesses based on the subsurface conditions, subgrade preparation and anticipated traffic loads.

**Table 3. Asphalt Pavement Section Thicknesses**

| Area | Asphalt Pavement Thickness, in | Aggregate Base Course Thickness, in | Granular Subbase Thickness, in | Subgrade Reinforcement | Cement Stabilization |
|---|---|---|---|---|---|
| Light Duty (1) | 4 | 12** | * | Geotextile Fabric | * |
| Light Duty (2) | 4 | 4** | 8*** | Geotextile Fabric | - |
| Light Duty (3) | 4 | 4 | - | - | Yes**** |
| Heavy Duty (1) | 5 | 12** | * | Geotextile Fabric | * |
| Heavy Duty (2) | 5 | 4** | 8*** | Geotextile Fabric | - |
| Heavy Duty (3) | 5 | 4 | - | - | Yes**** |

Notes: The numbers are for the following sections: (1) subgrade reinforcement w/o granular subbase, (2) subgrade reinforcement w/ granular subbase and (3) cement stabilization. *Granular subbase or cement stabilization may be needed with Option 1. **The thickness of the aggregate base course may need to be increased. ***The thickness of the granular subbase may need to be increased if very poor subgrade conditions are encountered. ****The treatment depth and percentage of cement may need to be increased if very poor subgrade conditions are encountered.

**Table 4. Concrete Pavement Section Thicknesses**

| Area | Concrete Pavement Thickness, in | Aggregate Base Course Thickness, in | Granular Subbase Thickness, in | Subgrade Reinforcement | Cement Stabilization |
|---|---|---|---|---|---|
| Light Duty (1) | 5 | 12** | * | Geotextile Fabric | * |
| Light Duty (2) | 5 | 4** | 8*** | Geotextile Fabric | - |
| Light Duty (3) | 5 | 4 | - | - | Yes** |
| Heavy Duty (1) | 7 | 12** | * | Geotextile Fabric | * |
| Heavy Duty (2) | 7 | 4** | 8*** | Geotextile Fabric | - |
| Heavy Duty (3) | 7 | 4 | - | - | Yes**** |

Notes: The numbers are for the following sections: (1) subgrade reinforcement w/o granular subbase, (2) subgrade reinforcement w/ granular subbase and (3) cement stabilization. *Granular subbase or cement stabilization may be needed with Option 1. **The thickness of the aggregate base course may need to be increased. ***The thickness of the granular subbase may need to be increased if very poor subgrade conditions are encountered. ****The treatment depth and percentage of cement may need to be increased if very poor subgrade conditions are encountered.

Again, it is our opinion that unstable areas may be encountered with Option 1 during the subgrade preparation process. In regards to Option 2, it is our opinion that Option 2 will provide more uniform support (following the subgrade preparation) and a longer pavement life than

Option 1. Additionally, Option 3 will provide more reduction in construction delays as well as a more uniform subgrade condition than Options 1 and 2.

The asphalt pavement should meet the requirements of sections 320 and 321 for Class G. The concrete pavement should meet the requirements of Section 380 of the SDDOT Standard Specifications.

It should be noted that routine maintenance such as crack filling, localized patching and seal coating should be expected with all pavements in our recommendations. The design sections could be reduced if the owner is willing to assume additional maintenance costs or potentially shorter pavement life.

### Excavation – Pavement Areas

The soils within the pavement areas should not be exposed to heavy construction traffic from rubber tire vehicles. Low-ground pressure construction equipment may be needed for the project if soils with high moisture content are encountered.

The soils are vulnerable to disturbance and can experience strength loss caused by construction traffic and/or additional moisture. If any soils become disturbed during construction, then the disturbed soils will likely need to be removed.

## Frost Protection

### Footings

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 such that the bottom of the footing is a minimum of 5 feet below the finished exterior grade.

**Surface Improvements**

It is our opinion that on-site loess soils have a high frost susceptibility. Surface improvements, such as pavements, patios and sidewalks), constructed on clay soils are potentially subject to both cosmetic and structural damage caused by frost heaving. The surface improvements should be designed to accommodate the potential frost movements, or non-frost susceptible drainage fill should be placed beneath the surface improvements. If movement cannot be tolerated, then we recommend placing non-frost susceptible drainage fill beneath the surface improvements. The non-frost susceptible drainage fill should extend to a depth of 4 feet below the surface improvements. If it is desired to reduce (but not eliminate) the amount of potential frost heave, then we recommend consideration be given to placing 2 feet of non-frost susceptible drainage fill beneath the surface improvements.

**Material Types & Compaction Levels**

**General Structural Fill** – The general structural fill should consist of either a granular or clay material. If a granular material is used, then it should consist of a pit-run or processed sand or gravel having a maximum particle size of 3 inches. The granular material can be placed in lifts of up to 1 foot in thickness. If a clay material is selected, then it should consist of a non-organic clay having a liquid limit less than 45. Scrutiny on the clay material's moisture content should be made prior to the acceptance and use. The clay fill should be placed in lifts of up to 6 inches in thickness. The on-site topsoil materials should not be used as general structural fill.

**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. The granular structural fill should be placed in lifts of up to 1 foot in thickness.

**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. The select granular fill should be placed in lifts of up to 1 foot in thickness.

**Crushed Rock** – The crushed rock should be washed and meet the gradation specifications shown in Table 5.

**Table 5. Crushed Rock Gradation Specifications**

| Sieve Size | Percent Passing |
|---|---|
| 1 1/2-inch | 100 |
| 1-inch | 70 – 90 |
| 3/4-inch | 25 – 50 |
| 3/8-inch | 0 – 5 |

**Free-Draining Sand** – The free-draining sand should contain no more than 5 percent by weight passing the #200 sieve. The free-draining sand should be placed in lifts of up to 1 foot in thickness.

**Exterior Foundation Wall Backfill for Slab-on-Grade Structures** – The exterior foundation wall backfill for slab-on-grade structures should consist of a similar material as described for the general structural fill. If granular soils are used in areas that will not have asphalt or concrete surfacing, then we recommend capping the granular soils with at least 1 foot to 2 feet of clay soils to minimize infiltration of surface water. The exterior backfill should be placed in lifts of up to 1 foot in thickness.

**Interior Foundation Wall Backfill for Slab-on-Grade Structures** – We recommend that granular structural fill be used to backfill the interior side of the foundation walls. The interior backfill should be placed in lifts of up to 1 foot in thickness.

**Subgrade Fill** – The subgrade fill should consist of a similar material as discussed for general structural fill.

**Aggregate Base Course Material** – We recommend the aggregate base course materials meet the requirements of Sections 260 and 882 of the SDDOT Standard Specifications.

**Granular Subbase** – The granular subbase should consist of crushed quartzite, recycled concrete or a crushed pit-run material meeting the gradation specifications shown in Table 6.

**Table 6. Granular Subbase Gradation Specifications**

| Sieve Size | Percent Passing |
|---|---|
| 4-inch | 100 |
| 3-inch | 70 – 90 |
| 2-inch | 60 – 80 |
| 1-inch | 40 – 70 |
| #4 | 10 – 50 |
| #40 | 5 – 20 |
| #200 | 0 – 8 |

**Recommended Compaction Levels** – The recommended compaction levels listed in Table 7 are based on a material's maximum dry density value, as determined by a standard Proctor (ASTM: D698) test.

**Table 7. Recommended Compaction Levels**

| Placement Location | Compaction Specifications |
|---|---|
| Below Footings | 97% |
| Below Floor Slabs | 95% |
| Exterior Foundation Wall Backfill for Slab-on-Grade Structures | 95% |
| Behind Retaining Walls | 95% - 98% |
| Subgrade Fill in Pavement Areas | 95% |
| Aggregate Base Course in Pavement Areas | 97% |
| Granular Subbase in Pavement Areas | 97% |
| Non-Structural Areas | 90% |

Notes: Compaction specifications are not applicable with the crushed rock. Compaction testing may not be practical for the granular subbase due to the large aggregate.

**Recommended Moisture Levels** – The moisture content of the clay backfill materials should be maintained within a range of plus 2 percent to minus 2 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.

**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, then 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, then 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 and asphalt should not be placed on frozen subgrades. Frost should not be allowed to penetrate below the footings. If floor slab subgrades freeze, then 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 1 test be taken for every 2,000 square feet of structural fill placed in building and pavement areas, at least 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.

## SUBSURFACE EXPLORATION PROCEDURES

**Test Borings**

We performed 13 SPT borings on June 7, 2021 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. Also, we also performed 8 test borings using hand-operated equipment.

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 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 boring locations. Fluctuations occur due to varying seasonal and yearly rainfall amounts and snowmelt, as well as other factors. It is possible that the subsurface groundwater levels during or after construction could be significantly different than the time the test borings were performed.

**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 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.

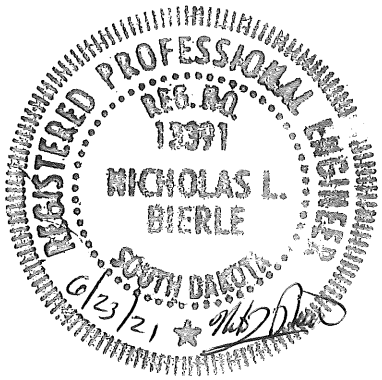
This report is for the exclusive use of the addressee and its representatives for use in design of the proposed project described herein and preparation of construction documents. Without written approval, we assume no responsibility to other parties regarding this report. Our conclusions, opinions and 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.

Nick Bierle, PE
Project Engineer



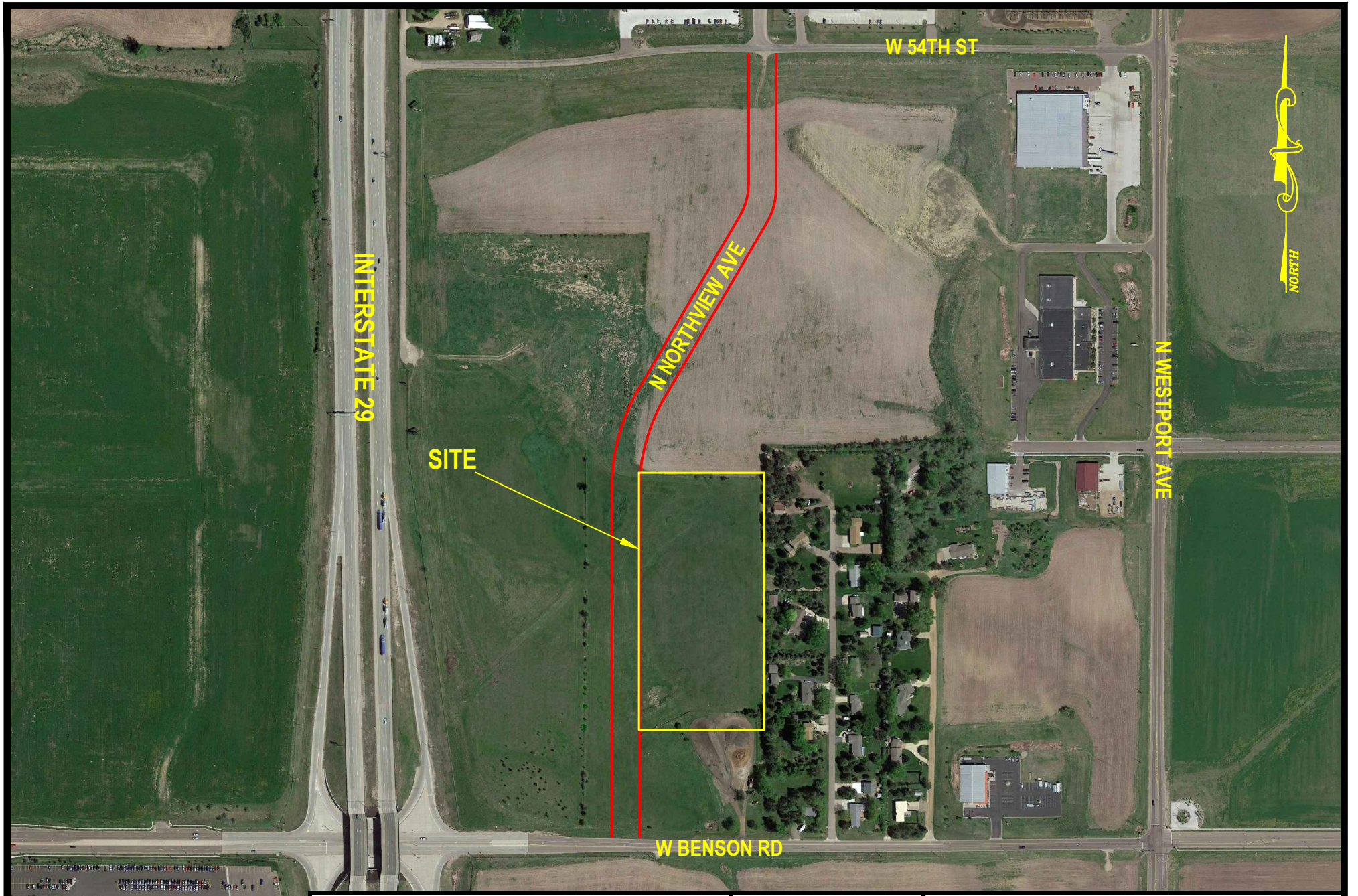



FIGURE 1
SITE LOCATION MAP
PROPOSED BUILDING & GARAGE
BANNER ASSOCIATES
3900 N NORTHVIEW AVENUE
SIOUX FALLS, SD

ACAD/GEOTEK/NICK/21-851

PROJECT#: 21-851

DRAWN BY: MAB

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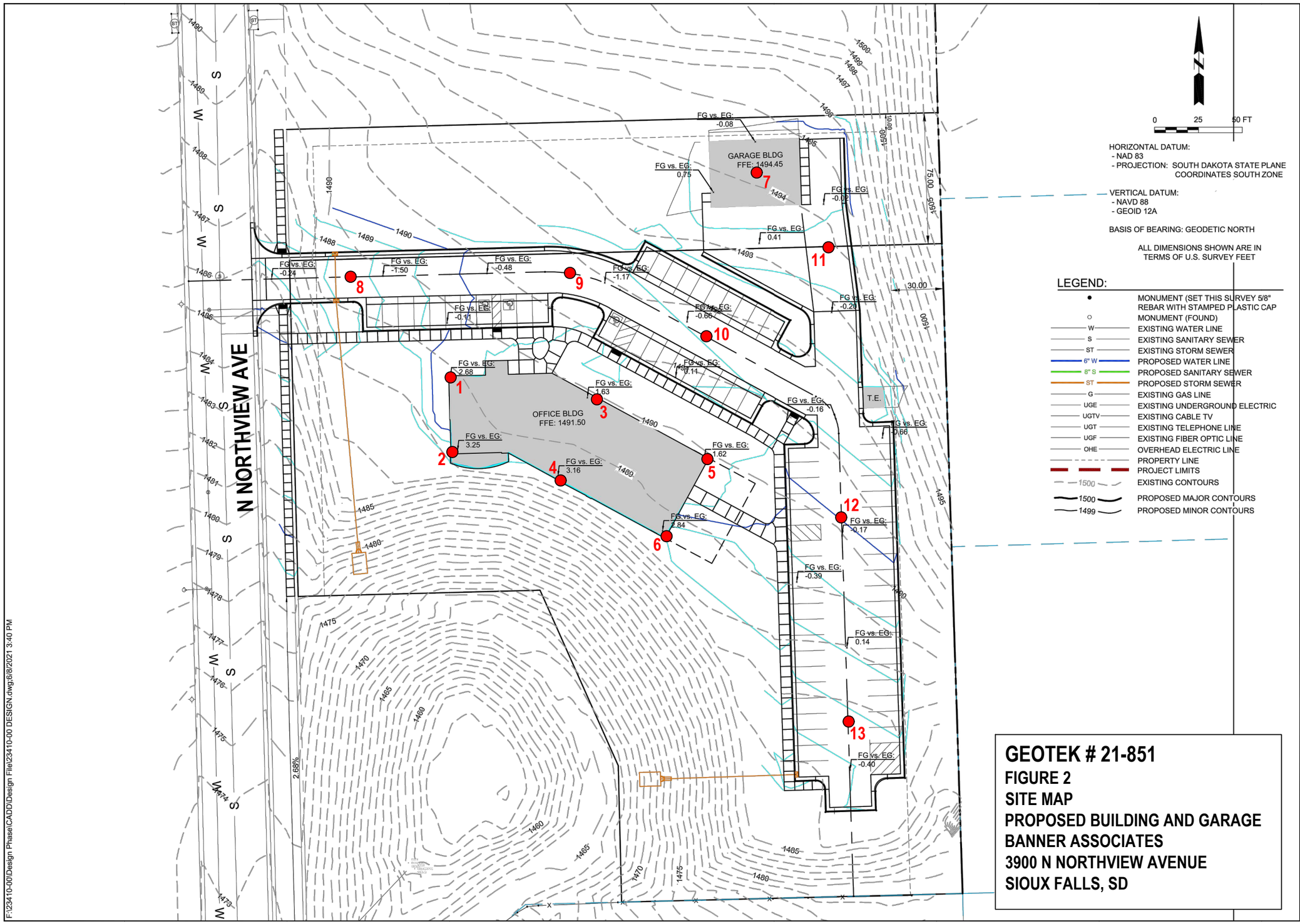
Sioux Falls, South Dakota 57104
605-335-5512 Fax 605-335-0773




HORIZONTAL DATUM:
- NAD 83
- PROJECTION: SOUTH DAKOTA STATE PLANE COORDINATES SOUTH ZONE

VERTICAL DATUM:
- NAVD 88
- GEOID 12A

BASIS OF BEARING: GEODETIC NORTH

ALL DIMENSIONS SHOWN ARE IN TERMS OF U.S. SURVEY FEET

LEGEND:

- MONUMENT (SET THIS SURVEY 5/8" REBAR WITH STAMPED PLASTIC CAP
- MONUMENT (FOUND)
- W — EXISTING WATER LINE
- S — EXISTING SANITARY SEWER
- ST — EXISTING STORM SEWER
- 6" W — PROPOSED WATER LINE
- 8" S — PROPOSED SANITARY SEWER
- ST — PROPOSED STORM SEWER
- G — EXISTING GAS LINE
- UGE — EXISTING UNDERGROUND ELECTRIC
- UGTV — EXISTING CABLE TV
- UGT — EXISTING TELEPHONE LINE
- UGF — EXISTING FIBER OPTIC LINE
- OHE — OVERHEAD ELECTRIC LINE
- PROPERTY LINE
- PROJECT LIMITS
- 1500 — EXISTING CONTOURS
- 1500 — PROPOSED MAJOR CONTOURS
- 1499 — PROPOSED MINOR CONTOURS

**GEOTEK # 21-851**
**FIGURE 2**
**SITE MAP**
**PROPOSED BUILDING AND GARAGE**
**BANNER ASSOCIATES**
**3900 N NORTHVIEW AVENUE**
**SIOUX FALLS, SD**

BANNER engineering a better community
www.bannerassociates.com - Toll Free: 1.855.323.6342

PROJECT / SHEET TITLE :
BANNER SIOUX FALLS OFFICE
OVERALL SITE PLAN
SIOUX FALLS, SOUTH DAKOTA

| REV. | DATE | DESCRIPTION |
|---|---|---|
| | | |

FOR REVIEW ONLY
NOT FOR CONSTRUCTION

| | |
|---|---|
| JOB No.: | 23410.00 |
| DATE: | FEB 2021 |
| DESIGNED BY: | NCE |
| CHECKED BY: | RSU |
| DRAWN BY: | SS |

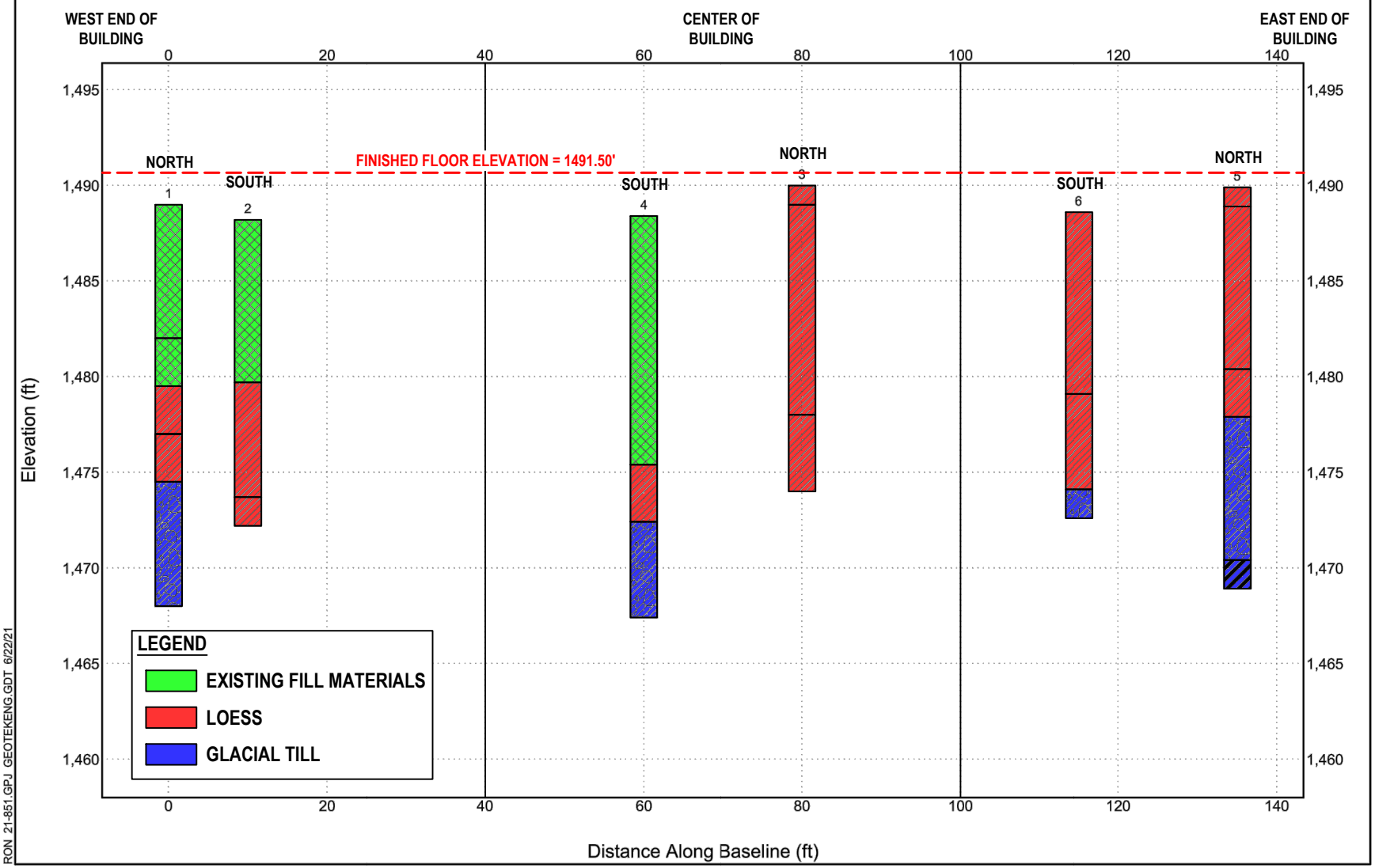
0 1/2" 1"
SCALE REDUCTION BAR

SHEET No. :
2

F:\23410-00\Design Phase\CADD\Design File\23410-00 DESIGN.dwg\6/8/2021 3:40 PM

# SUBSURFACE DIAGRAM
# FIGURE 3

**CLIENT** BANNER ASSOCIATES
**PROJECT NUMBER** 21-851
**PROJECT NAME** Proposed Building & Garage
**PROJECT LOCATION** Sioux Falls, SD




RON 21-851.GPJ GEOTEKENG.GDT 6/22/21

*NOTE: OVEREXCAVATION DEPTHS ARE BASED ON THE TYPE OF FOOTING AND MAGNITUDE OF THE FOUNDATION LOADS (SEE TABLE 1 IN THE REPORT)

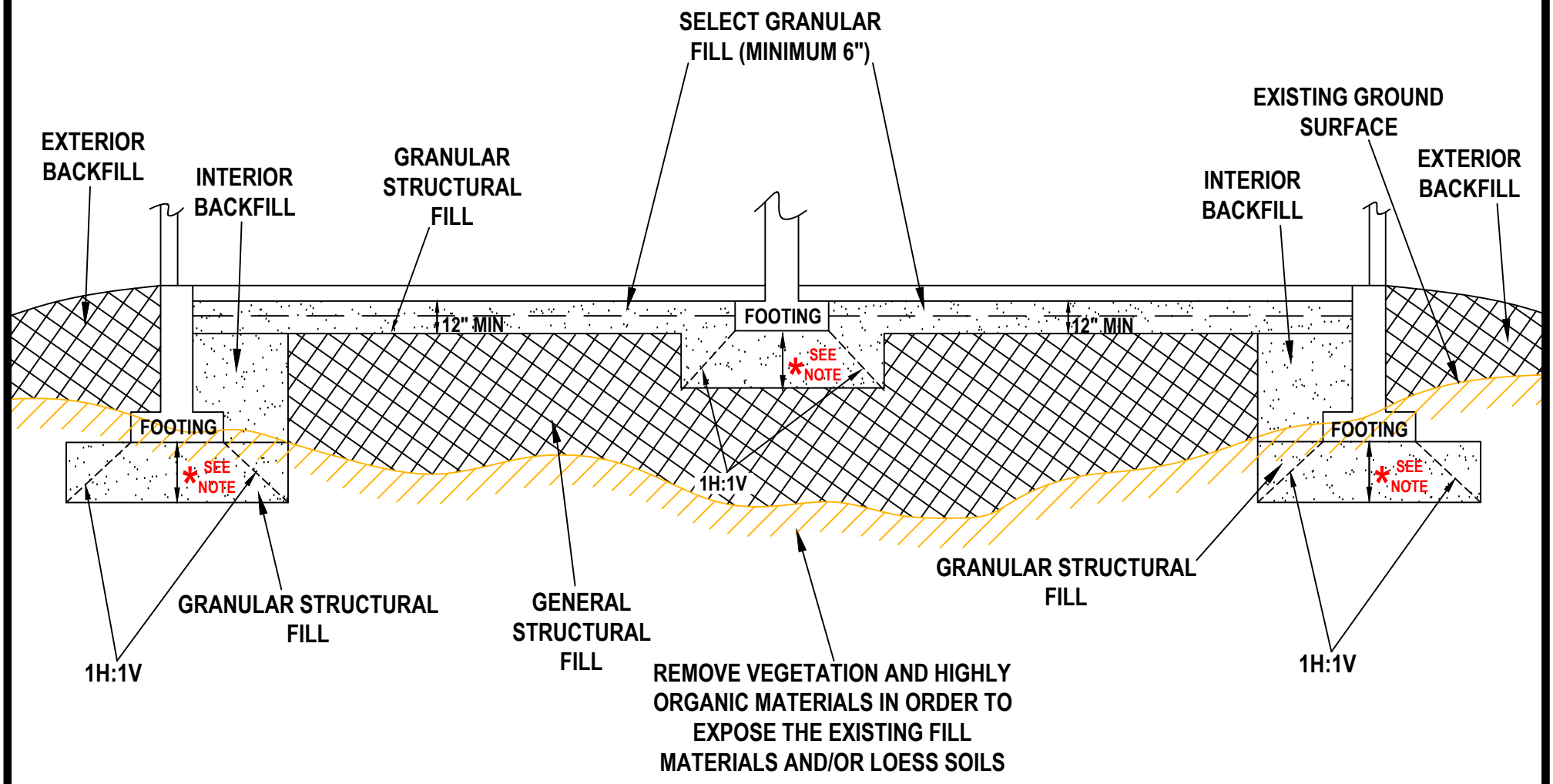



FIGURE 4
OVEREXCAVATION CROSS-SECTION
PROPOSED BUILDING & GARAGE
3900 N. NORTHVIEW AVENUE
SIOUX FALLS, SD

ACAD/GEOTEK/NICK/21-851

PROJECT#: 21-851

DRAWN BY: MAB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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **1 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1489.0 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FILL, MOSTLY LEAN CLAY**: brown, dry to moist, 12" of topsoil at the surface. | FILL | | | 1 | HSA | | | | | |
| | | | 10 | | 2 | SPT | 12 | 111 | | | |
| | | | 9 | | 3 | SPT | 12 | 117 | 37 | 18 | |
| 7 | **FILL, MOSTLY LEAN CLAY WITH SAND**: a little gravel, brown and gray, moist | FILL | 8 | | 4 | SPT | 18 | | | | |
| 9½ | **LEAN CLAY**: brown and gray, moist, firm, (CL) | LOESS | 5 | | 5 | SPT | 17 | 105 | | | |
| 12 | **LEAN CLAY**: grayish brown, moist, firm, (CL) | LOESS | 6 | | 6 | SPT | 22 | | | | |
| 14½ | **LEAN CLAY WITH SAND**: a trace of gravel, brown, moist, firm to stiff, (CL) | GLACIAL TILL | 8 | | 7 | SPT | | | | | |
| | | | 11 | | 8 | SPT | | | | | |
| 21 | Bottom of borehole at 21 feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

START 6-7-21 COMPLETE 6-7-21 10:08 am

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 21 | -- | 12 | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **2 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1488.2 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LAB WC | LAB D | LAB LL | LAB PL | LAB QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FILL, MOSTLY LEAN CLAY**: brown, dry to moist, 12" of topsoil at the surface. | FILL | | | 1 | HSA | | | | | |
| | | | 10 | | 2 | SPT | 15 | 107 | | | |
| | | | 7 | | 3 | SPT | 13 | 102 | 38 | 20 | |
| | | | 6 | | 4 | SPT | 19 | 109 | | | |
| 8½ | **LEAN CLAY**: brown, moist, soft to firm, (CL) | LOESS | | | | | | | | | |
| | | | 4 | | 5 | SPT | 17 | 107 | | | |
| | | | 6 | | 6 | SPT | 17 | | | | |
| 14½ | **LEAN CLAY**: grayish brown, moist, firm, (CL) | LOESS | | | | | | | | | |
| | | | 6 | | 7 | SPT | 24 | | | | |
| 16 | Bottom of borehole at 16 feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

START 6-7-21 COMPLETE 6-7-21 10:33 am

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 16 | -- | 13 | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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nbierle@geotekeng.com

# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **3 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

SURFACE ELEVATION 1490.0 ft

| DEPTH in FEET | DESCRIPTION OF MATERIAL | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **LEAN CLAY**: dark brown, dry to moist, 6" of topsoil at the surface. (CL) | LOESS | | | 1 | HSA | | | | | |
| | **LEAN CLAY**: brown, dry to moist, firm, (CL) | LOESS | 6 | | 2 | SPT | 11 | 96 | | | |
| | | | 6 | | 3 | SPT | 10 | | | | |
| | | | 6 | | 4 | SPT | 16 | 99 | 34 | 19 | |
| | | | 7 | | 5 | SPT | 17 | | | | |
| 12 | **LEAN CLAY**: brownish gray, moist, firm, (CL) | LOESS | 6 | | 6 | SPT | 19 | 99 | | | |
| | | | 8 | | 7 | SPT | 22 | | | | |
| 16 | Bottom of borehole at 16 feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 16 | -- | 12 | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

START 6-7-21 COMPLETE 6-7-21 11:28 am

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **4 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1488.4 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FILL, MOSTLY LEAN CLAY**: brown, dry to moist, 12" of topsoil at the surface. | FILL | | | 1 | HSA | | | | | |
| | | | 8 | | 2 | SPT | 13 | 109 | | | |
| | | | 8 | | 3 | SPT | 11 | 101 | | | |
| | | | 3 | | 4 | SPT | 13 | 98 | | | |
| | | | 5 | | 5 | SPT | 20 | 100 | | | |
| 13 | **LEAN CLAY**: grayish brown, moist, soft, (CL) | LOESS | 6 | | 6 | SPT | 13 | 109 | | | |
| | | | 4 | | 7 | SPT | 24 | | | | |
| 16 | **LEAN CLAY WITH SAND**: a trace of gravel, brown, moist, stiff, (CL) | GLACIAL TILL | | | | | | | | | |
| | | | 9 | | 8 | SPT | 19 | 108 | | | 4900 |
| 21 | Bottom of borehole at 21 feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 21 | -- | 14 | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

START 6-7-21 COMPLETE 6-7-21 11:02 am

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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nbierle@geotekeng.com

# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **5 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1489.9 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **LEAN CLAY**: dark brown, dry to moist, 6" of topsoil at the surface. (CL) | LOESS | | | | | | | | | |
| | **LEAN CLAY**: brown, moist, (CL) | LOESS | | | 1 | HSA | | | | | |
| | | | 6 | | 2 | SPT | 13 | 95 | | | |
| | | | 6 | | 3 | SPT | 15 | | | | |
| | | | 7 | | 4 | SPT | 20 | | | | |
| 9½ | **LEAN CLAY**: grayish brown, moist, firm, (CL) | LOESS | 6 | | 5 | SPT | 21 | 102 | | | |
| 12 | **LEAN CLAY WITH SAND**: a trace of gravel, brown, moist, stiff to very stiff, (CL) | GLACIAL TILL | 11 | | 6 | SPT | 19 | | | | |
| | | | 12 | | 7 | SPT | 21 | 108 | | | |
| 19½ | **FAT CLAY WITH SAND**: brown, moist, very stiff, (CH) | GLACIAL TILL | 18 | | 8 | SPT | 17 | | | | |
| 21 | Bottom of borehole at 21 feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

START 6-7-21 COMPLETE 6-7-21 12:00 pm

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 21 | -- | 11 | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

**GEOTEK ENGINEERING**
**& TESTING SERVICES, INC.**
909 E 50th St N
SIOUX FALLS, SD 57104
(605) 335-5512 Fax (605) 335-0773
nbierle@geotekeng.com

# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **6 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1488.6 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **LEAN CLAY**: brown, dry to moist, firm, 12" of topsoil at the surface. (CL) | LOESS | | | 1 | HSA | | | | | |
| | | | 6 | | 2 | SPT | 9 | 97 | | | |
| | | | 6 | | 3 | SPT | 11 | | | | |
| | | | 7 | | 4 | SPT | 21 | 97 | | | |
| 9½ | **LEAN CLAY**: grayish brown, moist, firm, (CL) | LOESS | 8 | | 5 | SPT | 21 | | | | |
| | | | 8 | | 6 | SPT | 17 | | | | |
| 14½ | **LEAN CLAY WITH SAND**: a trace of gravel, brown, moist, stiff, (CL) | GLACIAL TILL | 9 | | 7 | SPT | 19 | | | | |
| 16 | Bottom of borehole at 16 feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

START 6-7-21 COMPLETE 6-7-21 12:25 pm

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 16 | -- | 12 | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **7 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1494.3 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **LEAN CLAY**: dark brown, dry, (CL) | TOPSOIL | | | | | | | | | |
| | **LEAN CLAY**: brown, moist, firm, (CL) | LOESS | | | 1 | HSA | | | | | |
| | | | 5 | | 2 | SPT | 17 | 99 | | | |
| | | | 6 | | 3 | SPT | 19 | | | | |
| | | | 7 | | 4 | SPT | 18 | 101 | | | |
| | | | 6 | | 5 | SPT | 23 | | | | |
| 12 | **LEAN CLAY**: mottled brown and gray, moist, firm, (CL) | LOESS | 7 | | 6 | SPT | 24 | 100 | | | |
| 14½ | **LEAN CLAY WITH SAND**: a trace of gravel, brown, moist, firm to stiff, (CL) | GLACIAL TILL | 8 | | 7 | SPT | 21 | | | | |
| | | | 9 | | 8 | SPT | | | | | |
| 21 | Bottom of borehole at 21 feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

START 6-7-21 COMPLETE 6-7-21 12:59 pm

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 21 | -- | 12 | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **8 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1489.5 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LAB WC | LAB D | LAB LL | LAB PL | LAB QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FILL, MOSTLY LEAN CLAY**: brown, dry to moist, 12" of topsoil at the surface. | FILL | 10 | | 1 | SPT | 11 | 103 | | | |
| | | | 8 | | 2 | SPT | 12 | 112 | | | |
| | | | 11 | | 3 | SPT | 12 | | | | |
| | | | 12 | | 4 | SPT | | | | | |
| 8½ | Bottom of borehole at 8½ feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 8.5 | -- | -- | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

START 6-7-21 COMPLETE

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **9 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1491.7 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LAB WC | LAB D | LAB LL | LAB PL | LAB QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FILL, MOSTLY LEAN CLAY**: light brown, dry to moist, 12" of topsoil at the surface. | FILL | 11 | | 1 | SPT | 13 | 104 | | | |
| 2 | **LEAN CLAY**: brown, moist, firm, (CL) | LOESS | 7 | | 2 | SPT | 14 | 99 | | | |
| | | | 8 | | 3 | SPT | 9 | | | | |
| | | | 8 | | 4 | SPT | | | | | |
| 8½ | Bottom of borehole at 8½ feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 8.5 | -- | -- | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

START 6-7-21 COMPLETE

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **10 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL<br>SURFACE ELEVATION 1491.5 ft | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **LEAN CLAY**: brown, dry to moist, firm, 12" of topsoil at the surface. (CL) | LOESS | 7 | | 1 | SPT | 11 | 96 | | | |
| | | | 5 | | 2 | SPT | 15 | 91 | | | |
| | | | 7 | | 3 | SPT | 15 | | | | |
| | | | 8 | | 4 | SPT | | | | | |
| 8½ | Bottom of borehole at 8½ feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 8.5 | -- | -- | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

START 6-7-21 COMPLETE

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **11 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL<br>SURFACE ELEVATION 1493.6 ft | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **LEAN CLAY**: brown, dry to moist, firm to stiff, 12" of topsoil at the surface. (CL) | LOESS | 9 | | 1 | SPT | 11 | 93 | | | |
| | | | 8 | | 2 | SPT | 11 | 97 | | | |
| | | | 6 | | 3 | SPT | 14 | | | | |
| | | | 7 | | 4 | SPT | | | | | |
| 8½ | Bottom of borehole at 8½ feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 8.5 | -- | -- | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

START 6-7-21 COMPLETE

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **12 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL<br>SURFACE ELEVATION 1490.3 ft | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **LEAN CLAY**: brown, dry to moist, firm, 12" of topsoil at the surface. (CL) | LOESS | 8 | | 1 | SPT | 15 | 101 | | | |
| | | | 5 | | 2 | SPT | 12 | 98 | | | |
| | | | 6 | | 3 | SPT | 14 | | | | |
| | | | 7 | | 4 | SPT | | | | | |
| 8½ | Bottom of borehole at 8½ feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 8.5 | -- | -- | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

START 6-7-21 COMPLETE

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

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# GEOTECHNICAL TEST BORING LOG

GEOTEK # **21-851** BORING NO. **13 (1 of 1)**

PROJECT **Proposed Building & Garage, Banner Associates, 3900 N. Northview Avenue, Sioux Falls, SD**

| DEPTH in FEET | DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1486.7 ft) | GEOLOGIC ORIGIN | N | WL | SAMPLE NO. | SAMPLE TYPE | LABORATORY TESTS WC | D | LL | PL | QU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FILL, MOSTLY LEAN CLAY**: brown, dry to moist, 12" of topsoil at the surface. | FILL | 10 | | 1 | SPT | 12 | 104 | | | |
| 3 | **LEAN CLAY**: brown, moist, firm to stiff, (CL) | LOESS | 8 | | 2 | SPT | 17 | 99 | | | |
| | | | 9 | | 3 | SPT | 12 | | | | |
| | | | 8 | | 4 | SPT | | | | | |
| 8½ | Bottom of borehole at 8½ feet. | | | | | | | | | | |

WATER LEVEL MEASUREMENTS

| DATE | TIME | SAMPLED DEPTH | CASING DEPTH | CAVE-IN DEPTH | WATER LEVEL |
|---|---|---|---|---|---|
| 6-7-21 | -- | 8.5 | -- | -- | none |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- |

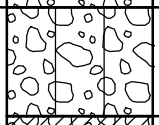
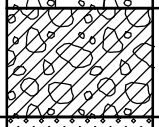
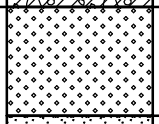
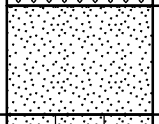
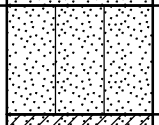
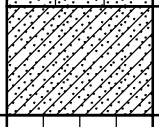
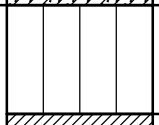
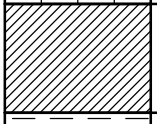
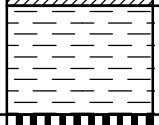
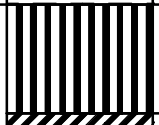
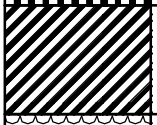
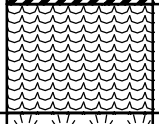
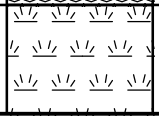
START 6-7-21 COMPLETE

METHOD
6.25" ID Hollow Stem Auger

CREW CHIEF Scott Schumacher

GEOTECHNICAL TEST BORING 21-851.GPJ GEOTEKENG.GDT 6/22/21

# SOIL CLASSIFICATION CHART

| MAJOR DIVISIONS | | | SYMBOLS | | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|---|
| | | | GRAPH | LETTER | |
| COARSE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE | GRAVEL AND GRAVELLY SOILS<br>MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE | CLEAN GRAVELS<br>(LITTLE OR NO FINES) |  | GW | WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES |
| | | |  | GP | POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES |
| | | GRAVELS WITH FINES<br>(APPRECIABLE AMOUNT OF FINES) |  | GM | SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES |
| | | |  | GC | CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES |
| | SAND AND SANDY SOILS<br>MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE | CLEAN SANDS<br>(LITTLE OR NO FINES) |  | SW | WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES |
| | | |  | SP | POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES |
| | | SANDS WITH FINES<br>(APPRECIABLE AMOUNT OF FINES) |  | SM | SILTY SANDS, SAND - SILT MIXTURES |
| | | |  | SC | CLAYEY SANDS, SAND - CLAY MIXTURES |
| FINE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE | SILTS AND CLAYS<br>LIQUID LIMIT LESS THAN 50 | |  | ML | INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY |
| | | |  | CL | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS |
| | | |  | OL | ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY |
| | SILTS AND CLAYS<br>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 | | Consistency |
|---|---|---|
| Term | N-Value | 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 |

## 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 |

## 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 |

## GRAVEL PERCENTAGES

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