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May 14, 2021

Banner Associates
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Attn: Kristin Bisgard, PE

Subj: Geotechnical Exploration
Proposed WEB Water Treatment Plant Expansion
29698 135th Street
Near Selby, South Dakota
GeoTek #20-J18

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.

Jared Haskins

Jared Haskins, PE
Geotechnical Manager

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29698 135TH STREET
NEAR SELBY, SOUTH DAKOTA
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INTRODUCTION

Project Information

This report presents the results of the recent geotechnical exploration program for the proposed expansion of the existing WEB Water Treatment Plant near Selby, South Dakota.

Scope of Services

Our work was performed in accordance with the authorization of Kristin Bisgard with Banner Associates. The authorized scope of services included the following:

1. To perform 15 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 existing treatment plant is located along the north side of 135th Street (west of 297th Avenue) in Walworth County, South Dakota. The address of the treatment plant is 29698 135th Street. A site location map (Figure 1) is attached showing the location of the treatment plant. The town of

Selby is located 9 miles east and 5 miles north of the treatment plant. The Missouri River is located approximately 3 miles west of the treatment plant. The current site features include the following: the main building, several treatment buildings and tanks, 3 retention ponds on the west side of the main building, pavement areas, gravel surfaced areas, trees and vegetated areas.

Ground Surface Elevations & Test Boring Locations

The ground surface elevations at the test boring locations were provided by Banner Associates and varied from 1,996.1 feet at test boring 12 to 2,001.0 feet at test borings 1 and 2. A site map (Figure 2) is attached at the conclusion of this report showing the relative location of the test borings.

Subsurface Conditions

Fifteen (15) test borings were performed at the site on November 2, November 3 and November 4, 2020. 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 soil types: existing fill materials, topsoil materials, fine alluvium soils and glacial till soils. The existing fill materials were encountered at all of the test borings and extended to depths varying from 2 feet to 14 ½ feet (fill thicknesses of 7 feet to 9 ½ feet were encountered at the majority of the test borings). The topsoil materials were only encountered at test boring 4 from 7 feet to 8 ½ feet. The fine alluvium soils were encountered beneath the existing fill materials and topsoil materials at the majority of the test borings (fine alluvium soils were not encountered at test borings 10 and 14). The glacial till soils were encountered beneath the existing fill materials and fine alluvium soils at all of the test borings. The glacial till soils extended to the termination depth of the test borings.

The existing fill materials consisted of lean clay (CL), fat clay (CH), lean clay with sand (CL), fat clay with sand (CH), sandy lean clay (CL) and clayey sand (SC). The topsoil materials consisted of lean clay (CL). The fine alluvium soils consisted of lean clay (CL) and fat clay (CH). The glacial till soils consisted of fat clay with sand (CH) and sandy lean clay (CL).

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, 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 test borings 1, 2 and 4 through 15. 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. The time and level of the groundwater readings are recorded on the boring logs. Also, a summary of the groundwater levels is shown in Table 1.

Table 1. Groundwater Levels

Test Boring	Ground Surface Elevation, ft	Groundwater Level, ft	Elevation of Groundwater, ft
1	2,001.0	Dry to the Termination Depth*	---
2	2,001.0	11	1,990.0
3	2,000.4	N/A**	---
4	2,000.9	10 ½	1,990.4
5	1,997.7	8	1,989.7
6	2,000.5	10	1,990.5
7	1,999.9	Dry to the Termination Depth*	---
8	2,000.3	14	1,986.3
9	2,001.0	Dry to the Termination Depth*	---
10	1,998.9	Dry to the Termination Depth*	---
11	2,000.4	Dry to the Termination Depth*	---
12	1,996.1	Dry to the Termination Depth*	---
13	1,997.2	Dry to the Termination Depth*	---
14	1,996.7	Dry to the Termination Depth*	---
15	1,996.9	12 ½	1,984.4

Note – *If these boreholes were allowed to stay open for an extended period of time, then a similar water level as measured in the other boreholes would be expected. **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.

The water levels indicated on the boring logs may or may not be an accurate indication of the depth or lack of subsurface groundwater. Delayed groundwater readings were taken at several of the test borings. 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

Overall Project Design Data

We understand that the project will consist of expanding the existing WEB Water Treatment Plant. The new structures include the following: 2 storage tanks, a wash water recovery basin, a water treatment building and a clear well.

Storage Tanks (Borings 1 – 4)

Design Data

The storage tanks will be located within the south retention pond and will likely have a diameter of 57 feet and a capacity of approximately 750,000 gallons. The storage tanks will either be prestressed concrete tanks or steel tanks. We understand that the storage tanks will be supported by spread footing/ringwall foundation systems. The finished grade around the storage tanks may be near elevation 2,002 feet. With the bottom of the south retention pond near elevation 1,996 feet, filling of about 6 feet will be needed to achieve the finished grade around the storage tanks. We anticipate moderate to moderately heavy foundation/floor loads for the storage tanks.

Discussion

Test borings 1 through 4 were performed just outside of the footprint of the storage tanks. These test borings indicated that existing fill materials and topsoil materials extended to depths varying from 7 feet to 9 ½ feet (elevation 1,994.0 feet to 1,991.5 feet). Fine alluvium soils were encountered beneath the existing fill materials and topsoil materials and extended to depths varying from 12 feet to 19 ½ feet (elevation 1,989.0 feet to 1,981.4 feet). Glacial till soils were encountered beneath the fine alluvium soils.

In our opinion, the existing fill materials and topsoil materials are not suitable for support of the storage tanks. In addition, the majority of the fine alluvium soils have low strength characteristics and are not suitable for support of the storage tanks. Therefore, unsuitable soils (existing fill materials, topsoil materials and soft fine alluvium soils) extend to depths varying from 12 feet to about 19 ½ feet (elevation 1,989.0 feet to 1,981.4 feet). In our opinion, a complete removal of the unsuitable soils is not practical. A deep foundation system could be considered for support of the storage tanks, but it is usually cost prohibitive. With that said, we recommend that an intermediate foundation system be used for support of the storage tanks. The intermediate foundation system could consist of rammed aggregate piers or aggregate piers.

About 6 feet of fill will be needed to achieve the finished grade around the storage tanks. A time delay is recommended in areas requiring more than 4 feet of fill to allow the underlying soils to compress/settle under the weight of the newly placed fill. The rammed aggregate piers and aggregate piers should not be installed until the majority of the settlement has occurred in these areas.

Initial Site Preparation – Storage Tanks

Prior to the installation of the rammed aggregate piers or aggregate piers, we recommend removing any vegetation, organic materials and debris. The removals should extend a minimum of 15 feet outside of the edges of the storage tanks.

Following the removals, we recommend placing and compacting general structural fill up to the design elevations. If water or saturated soils are encountered at the bottom of the excavation, then we recommend placing a layer (6 inches to 12 inches) of drainage rock at the bottom of the excavation prior to the placement of the general structural fill. We expect that some drainage rock will be needed at the bottom of the excavation.

Time Delay

As previously stated, about 6 feet of fill will be needed to achieve the finished grade around the storage tanks. With that said, a time delay should be incorporated into the project. The time delay will allow the underlying soils to compress/settle under the weight of the newly placed fill. We recommend waiting 2 to 3 weeks to allow the majority of the settlement to take place in the areas requiring more than 4 feet of fill. The site filling should extend up to the finished grade. The rammed aggregate piers or aggregate piers should not be installed until the majority of the settlement has occurred. Several settlement plates or rods could be installed at the beginning stages of earthwork activities to monitor the rate of settlement after the fill has been in place.

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.

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 soft/wet fine alluvium soils encountered at test borings 1 through 4, 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.

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 appropriate experience (e.g., at least 5 years of experience and at least 15 or more successfully completed similar projects).

The designer of the rammed aggregate piers or aggregate piers should be able to provide a coefficient of friction for foundation design. Also, a layer (6 inches to 12 inches) of select granular fill should be provided beneath the slabs of the storage tanks.

Wash Water Recovery Basin (Borings 5 – 7) & Clear Well (Borings 13 – 15)

Design Data

The wash water recovery basin will be a cast-in-place concrete structure with approximate dimensions of 40 feet by 45 feet. The top-of-slab elevation for the basin will be near 1,984.0 feet. The base slab will have a thickness of approximately 2 feet (bottom-of-slab elevation near 1,982.0 feet).

The clear well will either be a cast-in-place concrete structure with approximate dimensions of 55 feet by 100 feet or a prestressed concrete structure. The top-of-slab elevation for the clear well will be near 1,985.0 feet. If the structure is cast-in-place, then the base slab would likely have a thickness of approximately 2 feet (bottom-of-slab elevation near 1,983.0 feet).

Discussion

Test borings 5 through 7 were performed for the wash water recovery basin and test borings 12 through 15 were performed for the clear well. These test borings indicated that existing fill materials extended to depths varying from 2 feet to 14 ½ feet (elevation 1,994.9 feet to 1,982.7 feet). Fine alluvium soils were encountered beneath the existing fill materials (except at test boring 14) and extended to depths varying from 9 ½ feet to 16 feet (elevation 1,988.5 feet to

1,981.2 feet). Glacial till soils were encountered beneath the fine alluvium soils and existing fill materials.

Based on the anticipated depth of the structures and the soils encountered at test borings 5 through 7 and 12 through 15, glacial till soils are anticipated at the bottom of the excavations for the structures. In our opinion, the glacial till soils have suitable strength to support the wash water recovery basin and clear well. However, the glacial till soils consist of fat clay with sand soils. In our opinion, the fat clay with sand soils have a moderate potential for expansion. In order to control or minimize the potential effects of the fat clay with sand soils, we recommend providing a buffer, typically 2 feet, of non-expansive soil (rock or granular material) between the fat clay with sand soils and the base slabs of the structures.

Our groundwater measurements at test borings 5, 6 and 12 indicate that the groundwater levels are above the slab elevations of the wash water recovery basin and clear well. As previously stated, glacial till soils are anticipated at the bottom of the excavations. With that said, it will likely be possible to remove and control water entering the excavations using normal sump pumping techniques due to the low permeable characteristics of the glacial till soils. However, lenses or layers of waterbearing sand soils could be encountered within the glacial till soils. If waterbearing sand soils are encountered, then a more extensive dewatering system will likely be needed to handle the high volume of water. The dewatering procedures will need to be maintained during construction of the wash water recovery basin and clear well.

Site Preparation

The site preparation for the base slabs of the wash water recovery basin and clear well should consist of removing the existing fill materials and fine alluvium soils in order to expose the glacial till soils. Following the removals, we recommend that an overexcavation be performed to a minimum depth of 2 feet below the bottom-of-slab elevation. The overexcavated areas should be backfilled with a minimum of 2 feet of drainage rock up to the bottom-of-slab elevation.

Dewatering

As previously stated, dewatering procedures will need to be maintained during construction of the wash water recovery basin and clear well. Where predominately clayey soils are encountered, it will likely be possible to remove and control water entering the excavations using normal sump pumping techniques (several sump pits). Where waterbearing sand soils are encountered, a more extensive dewatering procedure will be needed. The groundwater should be controlled to some depth within the drainage rock layer. The contractor should provide appropriate dewatering methods and equipment.

Laterally Oversized Excavations

Where drainage rock is needed below the base slabs, the bottom of the excavations should be laterally oversized 1 foot beyond the edges of the base slabs for each vertical foot of drainage rock required below the base slabs (1 horizontal : 1 vertical).

Foundation Loads & Settlement

If our recommendations are followed during site preparations, then it is our opinion that the base slabs of the wash water recovery basin and clear well can be sized for a net allowable soil bearing pressure of up to 3,000 pounds per square foot (psf). With the recommended site preparation, anticipated foundation loads and net allowable soil bearing pressure, total settlement of the base slabs 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.

Soil Modulus of Subgrade Reaction – Base Slabs

If a k value (soil modulus of subgrade reaction) is needed for the design of the base slabs, then it is our opinion that a value of 200 psi/inch could be used. The k value is based on our recommendations (minimum of 2 feet of drainage rock overlying glacial till soils).

Coefficient of Friction

A friction factor of 0.45 can be used between the drainage 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.

Foundation Backfill

It is our opinion that the compacted backfill over the foundation can be assigned a total unit weight of 120 pounds per cubic foot (pcf) above the groundwater level and a submerged unit weight of 58 pcf below the groundwater level. These values provide the ultimate resistance to uplift and moment loads. We recommend using a theoretical safety factor of at least 1.25 to resist the uplift and moment loads.

Below-Grade Walls & Retaining Walls

The lateral earth pressure used for the design of the below-grade walls and retaining walls will depend on the material used to backfill the walls. The active and passive lateral earth coefficients 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, while a horizontal movement of approximately 1/50 of the height of the wall would be required to develop the active state for cohesive soils. If the above movements cannot be tolerated, then we recommend using the at-rest lateral earth coefficients to design the walls. Table 2 shows the lateral earth coefficients and Table 3 shows the equivalent fluid unit weight values for the various soil types anticipated for this project.

Table 2. Lateral Earth Coefficients

Soil Type	Wet Unit Weight, pcf	Effective Unit Weight, pcf	Friction Angle, Degrees	Active Earth Pressure (Ka)	At-Rest Earth Pressure (Ko)	Passive Earth Pressure (Kp)
On-Site Clay Soils	125	58*	17	0.55	0.71	1.83
Free-Draining Sand	125	63*	35	0.27	0.43	3.69

*The effective unit weight is the weight below the water table.

Table 3. Equivalent Fluid Unit Weight Values

Soil Type	At-Rest, pcf		Active, pcf		Passive, pcf	
	Drained	Submerged*	Drained	Submerged*	Drained	Submerged*
On-Site Clay Soils	89	107	69	97	229**	115**
Free-Draining Sand (SP)	54	89	34	79	461**	232**

*If clay soils are used, then a submerged or high groundwater condition should be considered for the design of the walls. **Value below frost depth – 0 pcf above frost depth.

Prior to backfilling the below-grade walls or retaining walls, the contractor should verify what soil type could be used to backfill the walls. If clay can be used to backfill the below-grade walls and retaining walls, then the clay backfill can consist of the on-site existing fill materials, fine alluvium soils and glacial till soils. The sand backfill should consist of imported free-draining sand. If sand soils are selected as backfill, then 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). With the sand soils, we recommend capping the sand backfill section with 1 foot to 2 feet of clayey soil in areas that will not have asphalt concrete or concrete surfacing to minimize infiltration of surface waters.

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.

Water Control & Buoyancy Forces

We expect that the wash water recovery basin and clear well will either have drainage systems incorporated into the design or the structures will be designed to resist buoyant uplift forces due to groundwater. If the structures are designed to resist buoyant uplift forces, then we assume that water stops and water barriers will be incorporated into the design of the structures. If the structures are not designed to resist buoyant uplift forces, then a drainage system should be installed beneath the structures. The drainage system should be connected to a suitable means of discharge. We understand that some of the existing structures at the site have drainage systems that are connected to an existing manhole (located north of the site). The drainage systems for the wash water recovery basin and clear well could also be connected to the manhole.

Water Treatment Building (Borings 8 – 11)

Design Data

We expect that the water treatment building will be a pre-engineered slab-on-grade structure with approximate dimensions of 50 feet by 165 feet. The water treatment building will be constructed next to an existing building. The water treatment building will be supported by a spread footing foundation system that rests 5 feet to 6 feet below the finished grade. The finished floor elevation of the building will likely be near 2,001.0 feet. Several tanks will be located within the building. The tanks will have a depth of 4 feet to 8 feet.

Discussion

Test borings 8 through 11 were performed for the water treatment building. These test borings indicated that existing fill materials extended to depths varying from 7 feet to 14 ½ feet (elevation 1,993.4 feet to 1,985.8 feet). Fine alluvium soils were encountered beneath the existing fill materials (except at test boring 10) and extended to depths varying from 12 feet to 19 feet (elevation 1,989.0 feet to 1,981.3 feet). Glacial till soils were encountered beneath the fine alluvium soils and existing fill materials.

In our opinion, the existing fill materials are not suitable for support of the footings, floor slab or tanks of the water treatment building. In addition, the majority of the fine alluvium soils have low strength characteristics and are not suitable for support of the footings of the building. Therefore, unsuitable soils (existing fill materials and soft fine alluvium soils) extend to depths varying from 7 feet to 19 feet (elevation 1,991.9 feet to 1,981.3 feet). In our opinion, a complete removal of the unsuitable soils is not practical and likely difficult next to the existing building. Therefore, we recommend that an intermediate foundation system be used for support of the footings, floor slab and tanks of the water treatment building. The intermediate foundation system could consist of rammed aggregate piers or aggregate piers.

Portions of the existing fill materials and fine alluvium soils and all of the glacial till soils consist of fat clay soils and fat clay with sand soils. In our opinion, the fat clay soils and fat clay with sand soils have a moderate potential for expansion. In order to control or minimize the potential effects of the fat clay soils and fat clay with sand soils, we recommend providing a buffer, typically 2 feet, of non-expansive soil (rock or granular material) between the fat clay soils and fat clay with sand soils and the footings, floor slab and tanks of the water treatment building. The overexcavations (due to the presence of expansive soils) will still be needed even though rammed aggregate piers or aggregate piers are installed beneath the footings, floor slab and tanks of the water treatment building.

Initial Site Preparation

Prior to the installation of the rammed aggregate piers or aggregate piers, we recommend removing any vegetation, organic materials and debris from the footprint of the water treatment building. The removals should extend a minimum of 10 feet outside of the edges of the building. Following the removals, we recommend placing and compacting general structural fill up to the design elevations.

Rammed Aggregate Piers & Aggregate Piers

See the section entitled *Rammed Aggregate Piers & Aggregate Piers* (on pages 9 and 10 of this report) for information regarding the rammed aggregate piers and aggregate piers.

Floor Slab & Tanks – Soil Modulus of Subgrade Reactions

We recommend placing a minimum of 12 inches of granular structural fill beneath the on-grade floor slab of the water treatment building. Of the 12 inches of granular structural fill, the upper 6 inches should consist of select granular fill. For tanks within the water treatment building, we recommend placing a minimum of 12 inches of drainage rock beneath the tanks. The thickness of the granular structural fill and drainage rock will need to be increased if expansive soils are encountered (see section entitled *Overexcavation Due to Expansive Soils* – on page 17 of this report). Regarding a k value, the rammed aggregate pier or aggregate pier designer should be able to provide a value as the floor slab and tanks will be supported by rammed aggregate piers or aggregate piers.

Overexcavation Due to Expansive Soils

In areas where fat clay soils or fat clay with sand soils are encountered within 2 feet of the bottom-of-foundation/bottom-of-slab elevation, we recommend that an overexcavation be performed to a minimum depth of 2 feet below the bottom-of-foundation/bottom-of-slab elevation. Observations and hand auger borings should be performed at the bottom of the excavations to determine whether or not an overexcavation is required due to the presence of expansive soils. The overexcavated areas should be backfilled with a minimum of 2 feet of granular structural fill or drainage rock. The overexcavations can be performed before or after the rammed aggregate piers or aggregate piers are installed.

Dewatering

Dewatering may be needed during construction of the water treatment building. Where predominately clayey soils are encountered, it will likely be possible to remove and control water entering the excavations using normal sump pumping techniques (several sump pits). Where waterbearing sand soils are encountered, a more extensive dewatering procedure will be needed. The contractor should provide appropriate dewatering methods and equipment.

Laterally Oversized Excavations

Where granular structural fill or drainage 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).

Below-Grade Walls & Retaining Walls

See the section entitled *Below-Grade Walls & Retaining Walls* (on pages 13 and 14 of this report) for detailed information regarding the below-grade walls and retaining walls.

Water Control & Buoyancy Forces

We expect that the tanks of the water treatment building will either have a drainage system incorporated into the design or the tanks will be designed to resist buoyant uplift forces due to groundwater. If the tanks are designed to resist buoyant uplift forces, then we assume that water stops and water barriers will be incorporated into the design of the structure. If the tanks are not designed to resist buoyant uplift forces, then a drainage system should be installed beneath the tanks. The drainage system should be connected to a suitable means of discharge. We understand that some of the existing structures at the site have drainage systems that are connected to an existing manhole. The drainage system for the tanks of the water treatment building could also be connected to the manhole.

Excavation & Temporary Shoring

All excavations for the structures should be performed with a track backhoe with a smooth-edged bucket. The subgrade should not be exposed to heavy construction traffic from rubber tire vehicles. 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.

If an excavation adjacent to an existing structure is to extend below the existing foundation, then we recommend that the excavation extend 1 foot to 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 foundation. In this case, temporary shoring or underpinning will likely be needed.

We recommend extreme caution be exercised while excavating adjacent to any existing structure to prevent undermining of the existing foundation. The excavations adjacent to any existing structure 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.

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). Also, the ground acceleration values are as follows: S_S = 0.074 g, S_1 = 0.027 g, S_{MS} = 0.118 g, S_{M1} = 0.064 g, S_{DS} = 0.079 g, S_{D1} = 0.043 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/III. If needed, we can provide ground acceleration values for a different design code.

Frost Protection

We recommend that all foundations be placed at a sufficient depth for frost protection. The perimeter foundations for heated buildings should be placed such that the bottom of the foundation is a minimum of 4 feet below the finished exterior grade. Interior foundations in heated buildings can be placed beneath the floor slab. Foundations for unheated areas and canopies, or foundations that are not protected from frost during freezing temperatures, should be placed such that the bottom of the foundation is a minimum of 5 feet below the finished exterior grade. The foundations could be placed at a shallower depth, provided the foundations are placed on a sufficient depth of granular structural fill that is not susceptible to frost heave.

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

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 50. Fat clay soils and fat clay with sand soils should not be used as general structural fill within the footprint of the structures. The fat clay soils and fat clay with sand soils could be used as general fill outside of the footprint of the structures. Scrutiny on the material's moisture content should be made prior to the acceptance and use. The clay material should be placed in maximum 6-inch lifts. Some of the on-site soils could be used as general structural fill. We expect that the majority of the on-site soils used as general structural fill will require drying prior to their use. Organic soils should not be used as general structural fill.

Drainage Rock – The drainage rock should be crushed, washed and meet the gradation specifications shown in Table 4.

Table 4. Drainage 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

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.

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 free-draining sand should be placed in lifts of up to 1 foot in thickness.

Exterior Foundation Wall Backfill for Slab-on-Grade Structures – We recommend either clay or granular soils be used. Debris, organic material, or over-sized material should not be used as backfill. 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 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.

Recommended Compaction Levels – The recommended compaction levels listed in Table 5 are based on a material's maximum dry density value, as determined by a standard Proctor (ASTM: D698) test.

Table 5. Recommended Compaction Levels

Placement Location	Compaction Specifications
Below Storage Tanks & Buildings	97%
Exterior Foundation Wall Backfill for Slab-on-Grade Structures	95%
Behind Retaining Walls	95% - 98%
Non-Structural Areas	90%

Notes: 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 moisture content of the trench backfill soils should be adjusted to a moisture level that is within plus or minus 2 percent of the 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.

Corrosive Potential

Soil samples were collected from test borings 5 and 12 and were submitted for resistivity, pH, chloride content and sulfate content testing. The results of the laboratory tests are shown in Table 6.

Table 6. Laboratory Test Results

Boring	Depth (ft)	Soil Type	Resistivity (ohm-cm) (as-received)	Resistivity (ohm-cm) (saturated)	pH	Chloride (mg/kg)	Sulfate (mg/kg)
5	14 to 19	Fat Clay w/ Sand (GT)	510	*	7.9	220	1330
12	7 to 12	Lean Clay (FA)	1070	*	8.1	14	71

Note: *Sample received in a saturated condition. FA – fine alluvium soils and GT – glacial till soils.

Generally, soils are considered mildly corrosive if the chloride content and sulfate content levels are below 100 mg/kg and 200 mg/kg, respectively, for soils with pH levels between 5 and 10.

Soils are generally considered corrosive if the chloride content and sulfate content levels are higher than the levels discussed on the previous page. Based on the chloride content and sulfate content levels, the glacial till soils are considered corrosive and the fine alluvium soils are considered mildly corrosive. Due to the high sulfate content (glacial till soils), we recommend using Type II cement in the concrete mix design for the project. Regarding the resistivity test results, the glacial till soils are considered extremely corrosive and the fine alluvium soils are considered highly corrosive.

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 structures should be sloped such that positive drainage away from the structures is provided. Also, a system to collect and channel roof run-off waters away from the structures 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.

We recommend 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 and aggregate piers. Detailed records should be kept during installation.

SUBSURFACE EXPLORATION PROCEDURES

Test Borings

We performed 15 SPT borings on November 2, November 3 and November 4, 2020 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 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 test 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.

Jared Haskins, PE
Geotechnical Manager

REGISTERED PROFESSIONAL ENGINEER
REG. NO. 10971
JARED E. HASKINS
SOUTH DAKOTA
12-14-21

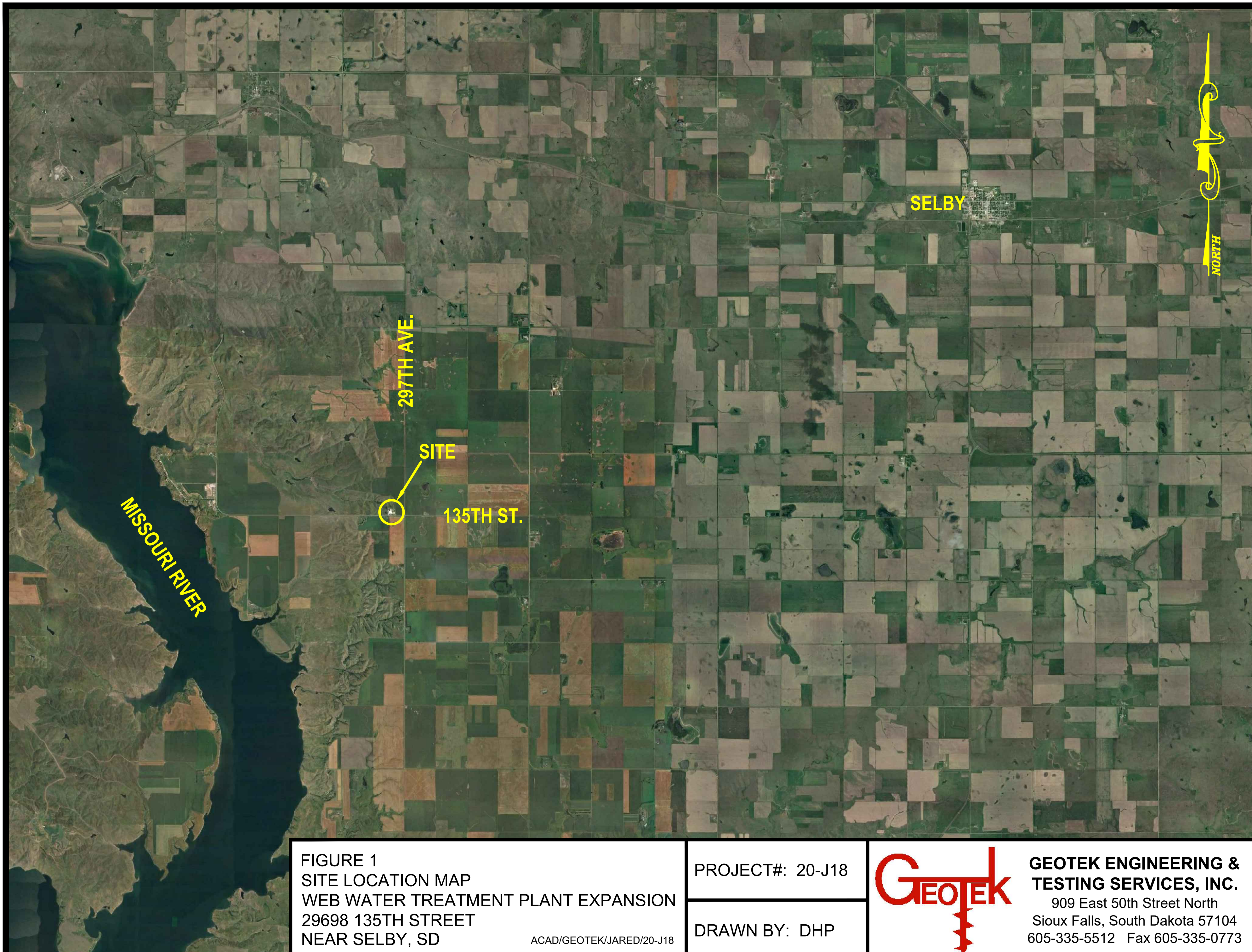


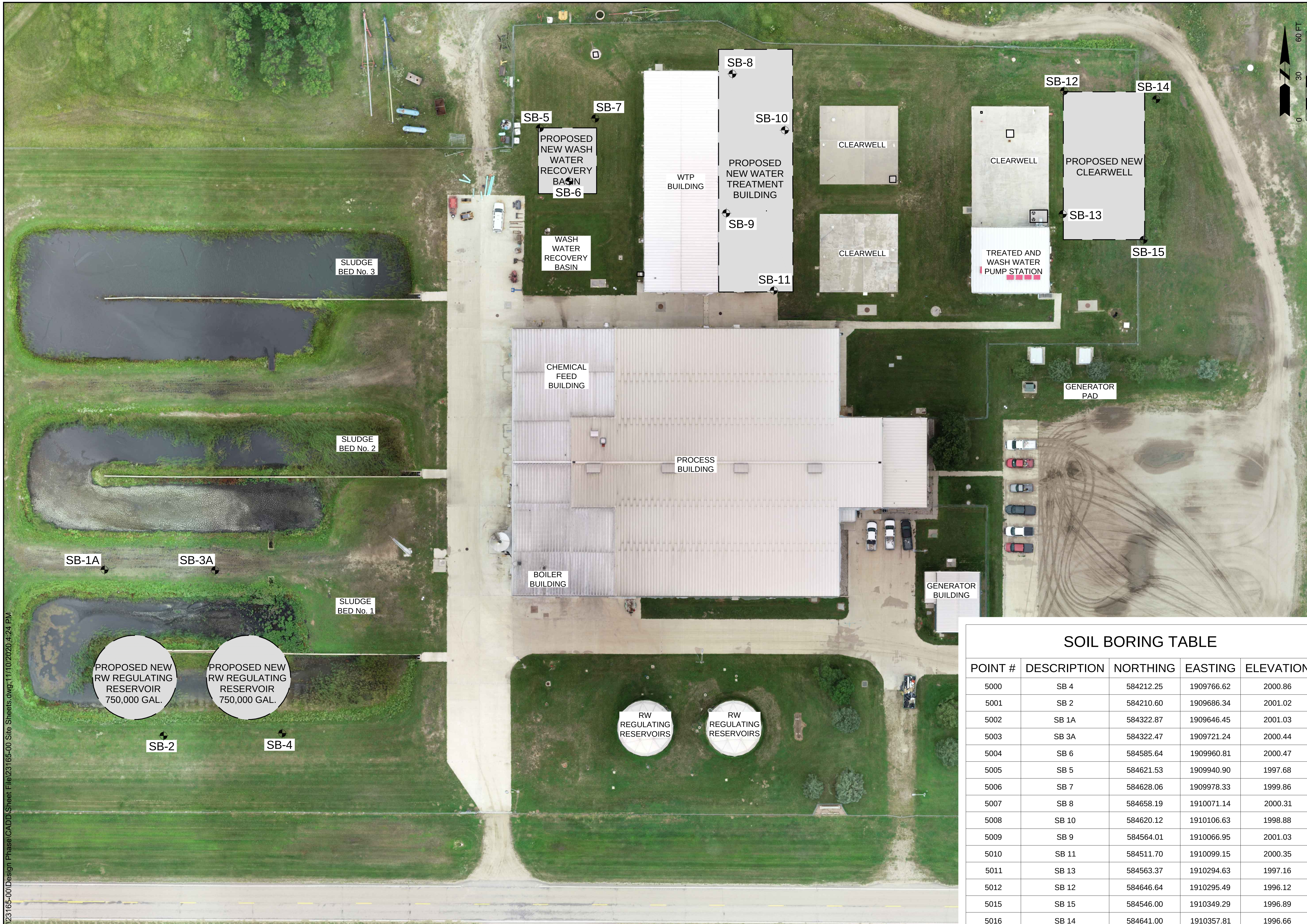
FIGURE 1
SITE LOCATION MAP
WEB WATER TREATMENT PLANT EXPANSION
29698 135TH STREET
NEAR SELBY, SD

ACAD/GEOTEK/JARED/20-J18

PROJECT#: 20-J18

DRAWN BY: DHP

GEOTEK ENGINEERING & TESTING SERVICES, INC.
909 East 50th Street North
Sioux Falls, South Dakota 57104
605-335-5512 Fax 605-335-0773



SOIL BORING TABLE

POINT #	DESCRIPTION	NORTHING	EASTING	ELEVATION
5000	SB 4	584212.25	1909766.62	2000.86
5001	SB 2	584210.60	1909686.34	2001.02
5002	SB 1A	584322.87	1909646.45	2001.03
5003	SB 3A	584322.47	1909721.24	2000.44
5004	SB 6	584585.64	1909960.81	2000.47
5005	SB 5	584621.53	1909940.90	1997.68
5006	SB 7	584628.06	1909978.33	1999.86
5007	SB 8	584658.19	1910071.14	2000.31
5008	SB 10	584620.12	1910106.63	1998.88
5009	SB 9	584564.01	1910066.95	2001.03
5010	SB 11	584511.70	1910099.15	2000.35
5011	SB 13	584563.37	1910294.63	1997.16
5012	SB 12	584646.64	1910295.49	1996.12
5015	SB 15	584546.00	1910349.29	1996.89
5016	SB 14	584641.00	1910357.81	1996.66

F:\23165-00\Design Phase\CADD\Sheet File\23165-00 Site Sheets.dwg,11/10/2020 4:24 PM

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

PROJECT / SHEET TITLE :
WEB WATER TREATMENT PLANT IMPROVEMENTS
SOIL BORING LOCATIONS
NEAR MOBRIDGE, SOUTH DAKOTA

REV.	DATE	DESCRIPTION

FOR REVIEW ONLY
NOT FOR CONSTRUCTION

JOB No.: 23165.01.00
DATE: FEBRUARY 2021
DESIGNED BY: JML
CHECKED BY: KLB
DRAWN BY: AME

0 1/2" 1"
SCALE REDUCTION BAR

SHEET No. :
FIGURE 1

GEOTEK ENGINEERING
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GEOTECHNICAL TEST BORING LOG

Boring for tanks
*Finished grade around new tanks will be near 2004'
**Existing grade in the pond is near 1996'

GEOTEK # **20-J18** BORING NO. **1 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 2001.0 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and dark brown, dry to moist	FILL			1	HSA					
			14		2	SPT					
7	**LEAN CLAY**: brown and gray, wet, firm, (CL)	FINE ALLUVIUM	7		3	SPT					
			6		4	SPT	29	102	36	19	400
12	**SANDY LEAN CLAY**: a little gravel, brown, moist, firm, (CL)	GLACIAL TILL	8		5	SPT	21	106			
14½	**FAT CLAY WITH SAND**: a little gravel, brown, moist, firm to very stiff, (CH)	GLACIAL TILL	8		6	SPT	27	93			2400
			12		7	SPT					
			16		8	SPT					
31			16		9	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-4-20	12:55 pm	31	--	29	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 11-4-20 COMPLETE 11-4-20 12:55 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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& TESTING SERVICES, INC.
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jhaskins@geotekeng.com

GEOTECHNICAL TEST BORING LOG

Boring for tanks

*Finished grade around new tanks will be near 2004'

**Existing grade in the pond is near 1996'

GEOTEK # **20-J18** BORING NO. **2 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 2001.0 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and dark brown, dry to moist	FILL			1	HSA					
			15		2	SPT					
			18		3	SPT					
9½	**FAT CLAY**: very dark gray, moist, stiff, (CH)	FINE ALLUVIUM	10	▼	4	SPT					
12	**FAT CLAY**: brown and gray, moist, stiff, (CH)	FINE ALLUVIUM	10		5	SPT	24	101			3600
14½	**LEAN CLAY**: brown and gray, wet, firm, (CL)	FINE ALLUVIUM	5		6	SPT	31				
19½	**FAT CLAY WITH SAND**: a little gravel, brown, moist, stiff, (CH)	GLACIAL TILL	10		7	SPT	28	95			2700
			14		8	SPT					
			14		9	SPT					
31	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-4-20	11:40 am	31	--	28	12
11-4-20	4:07 pm	31	--	18	▼ 11
--	--	--	--	--	--
--	--	--	--	--	--

START 11-4-20 COMPLETE 11-4-20 11:40 am

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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& TESTING SERVICES, INC.
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GEOTECHNICAL TEST BORING LOG

Boring for tanks

*Finished grade around new tanks will be near 2004'

**Existing grade in the pond is near 1996'

GEOTEK # **20-J18** BORING NO. **3 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 2000.4 ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and dark brown, dry to moist	FILL			1	FA					
			11		2	SPT					
7	**LEAN CLAY**: brown and gray, wet, soft to firm, percent passing the #200 sieve = 97% (at 15') (CL)	FINE ALLUVIUM	4		3	SPT	31	89			
			3		4	SPT	32				
			6		5	SPT	29	94			
19	**FAT CLAY WITH SAND**: a little gravel, brown, moist, stiff, (CH)	GLACIAL TILL	15		6	SPT					
			13		7	SPT	31	92	68	24	3600
29	**FAT CLAY WITH SAND**: a little gravel, grayish brown, moist, stiff to very stiff, (CH)	GLACIAL TILL	15		8	SPT					
			15		9	SPT					
			20		10	SPT					
44	**FAT CLAY WITH SAND**: a little gravel, grayish brown and dark gray, moist, very stiff, (CH)	GLACIAL TILL	21		11	SPT					
			24		12	SPT					
51	Bottom of borehole at 51 feet.										

WATER LEVEL MEASUREMENTS

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

START 11-4-20 COMPLETE 11-4-20 3:45 pm

METHOD
Rotary Mud Drilling

CREW CHIEF Roy Hanson

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& TESTING SERVICES, INC.
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GEOTECHNICAL TEST BORING LOG

Boring for tanks

*Finished grade around new tanks will be near 2004'

**Existing grade in the pond is near 1996'

GEOTEK # **20-J18** BORING NO. **4 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 2000.9 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY WITH SAND: a trace of gravel, brown and black, dry to moist	FILL			1	HSA					
			16		2	SPT					
7			9		3	SPT					
8½	**LEAN CLAY**: black, moist, stiff, (CL)	TOPSOIL	10		4	SPT					
11	**LEAN CLAY**: dark brown, wet, soft, (CL)	FINE ALLUVIUM	2	▼	5	SPT	35	87			
	LEAN CLAY: brown and gray, wet, soft to firm, (CL)	FINE ALLUVIUM	3		6	SPT	31				
19			6		7	SPT	29	96			
24	**FAT CLAY WITH SAND**: a little gravel, brown, moist, stiff, (CH)	GLACIAL TILL	15		8	SPT	28	95			
	FAT CLAY WITH SAND: a little gravel, brown and dark brown, moist, very stiff, (CH)	GLACIAL TILL	16		9	SPT					
31			17		10	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-4-20	10:25 am	31	--	28	11
11-4-20	4:06 pm	31	--	20	▼ 10.5
--	--	--	--	--	--
--	--	--	--	--	--

START 11-4-20 COMPLETE 11-4-20 10:25 am

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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GEOTECHNICAL TEST BORING LOG

Boring for water recovery basin

GEOTEK # **20-J18** BORING NO. **5 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 1997.7 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and gray, dry to moist	FILL			1	HSA					
			8		2	SPT					
7			11		3	SPT					
9½	**LEAN CLAY**: brown and gray, wet, soft, (CL)	FINE ALLUVIUM	3	▼	4	SPT					
	FAT CLAY WITH SAND: a little gravel, brown and gray, moist, firm to stiff, (CH)	GLACIAL TILL	8		5	SPT					
			11		6	SPT					
	*Anticipated Foundation Depth (1982') Water Recovery Basin		12		7	SPT					
19	**FAT CLAY WITH SAND**: a little gravel, dark grayish brown, moist, very stiff, (CH)	GLACIAL TILL	16		8	SPT	28	91	68	22	6800
			16		9	SPT					
31			17		10	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-3-20	9:00 am	31	--	29	none
11-5-20	8:22 am	31	--	8	▼ 8
--	--	--	--	--	--
--	--	--	--	--	--

START 11-3-20 COMPLETE 11-3-20 9:00 am

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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GEOTECHNICAL TEST BORING LOG

Boring for water recovery basin

GEOTEK # **20-J18**　　　　BORING NO. **6 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 2000.5 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY FAT CLAY: a trace of gravel, brown and black, dry to moist	FILL			1	HSA					
			18		2	SPT					
			16		3	SPT					
7	**LEAN CLAY**: grayish brown, wet, soft, (CL)	FINE ALLUVIUM	2		4	SPT					
			2	▼	5	SPT					
12	**FAT CLAY WITH SAND**: a little gravel, brown and gray, moist, stiff, (CH)	GLACIAL TILL	10		6	SPT					
	*Anticipated Foundation Depth (1982') Water Recovery Basin		12		7	SPT	29	94			
19	**FAT CLAY WITH SAND**: a little gravel, dark grayish brown, moist, stiff to very stiff, (CH)	GLACIAL TILL	12		8	SPT					
			17		9	SPT					
31			18		10	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-3-20	10:20 am	31	--	29	none
11-5-20	8:22 am	31	--	11.5	▼ 10
--	--	--	--	--	--
--	--	--	--	--	--

START 11-3-20　COMPLETE 11-3-20 10:20 am

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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jhaskins@geotekeng.com

GEOTECHNICAL TEST BORING LOG

Boring for water recovery basin

GEOTEK # **20-J18** BORING NO. **7 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 1999.9 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY FAT CLAY WITH SAND: a trace of gravel, brown and dark brown, dry to moist	FILL			1	HSA					
			18		2	SPT					
			9		3	SPT					
7	**FILL, MOSTLY LEAN CLAY**: brown and gray, wet	FILL	7		4	SPT					
9½	**LEAN CLAY**: brown and gray, wet, soft, (CL)	FINE ALLUVIUM	3		5	SPT					
			4		6	SPT	28	97			
14½	**FAT CLAY WITH SAND**: a little gravel, grayish brown, moist, firm to stiff, (CH)	GLACIAL TILL	8		7	SPT					
	*Anticipated Foundation Depth (1982') Water Recovery Basin										
			11		8	SPT	29	95	52	24	
			12		9	SPT					
31			13		10	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-2-20	4:25 pm	31	--	28	none
11-5-20	8:23 am	31	--	5	none
--	--	--	--	--	--
--	--	--	--	--	--

START 11-2-20 COMPLETE 11-2-20 4:25 pm

METHOD 3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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& TESTING SERVICES, INC.
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GEOTECHNICAL TEST BORING LOG

Boring for water treatment building

GEOTEK # **20-J18** BORING NO. **8 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 2000.3 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY WITH SAND: a trace of gravel, brown and dark brown, dry to moist	FILL			1	HSA					
			12		2	SPT					
4½	**FILL, MOSTLY CLAYEY SAND**: a trace of gravel, fine to medium grained, brown, dry	FILL	22		3	SPT					
			12		4	SPT					
8½	**FILL, MOSTLY FAT CLAY**: a trace of gravel, brown and dark brown, moist to wet *Anticipated Foundation Depth (1995') Water Treatment Building	FILL	8		5	SPT	26				
			9	▼	6	SPT	32				
14½	**LEAN CLAY**: brown and gray, wet, firm, (CL)	FINE ALLUVIUM	8		7	SPT	33	80			900
19	**FAT CLAY WITH SAND**: a little gravel, brown, moist, stiff, (CH)	GLACIAL TILL	14		8	SPT	33	87			3800
24	**FAT CLAY WITH SAND**: a little gravel, brown and dark brown, moist, very stiff, (CH)	GLACIAL TILL	18		9	SPT					
26	Bottom of borehole at 26 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-3-20	2:35 pm	26	--	23	none
11-5-20	8:30 am	26	--	15	▼ 14
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--	--	--	--	--	--

START 11-3-20 COMPLETE 11-3-20 2:35 pm

METHOD 3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

GEOTEK ENGINEERING
& TESTING SERVICES, INC.
909 E 50th St N
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GEOTECHNICAL TEST BORING LOG

Boring for water treatment building

GEOTEK # **20-J18** BORING NO. **9 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 2001.0 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY FAT CLAY: a trace of gravel, brown and black, dry to moist	FILL			1	HSA					
			13		2	SPT					
4½	**FILL, MOSTLY CLAYEY SAND**: a trace of gravel, fine to medium grained, brown, dry	FILL	9		3	SPT					
			6		4	SPT					
8½	**LEAN CLAY**: brown and gray, wet, soft, (CL)	FINE ALLUVIUM	4		5	SPT	28	95			
12	**FAT CLAY WITH SAND**: a little gravel, grayish brown, moist, firm to stiff, (CH)	GLACIAL TILL	8		6	SPT	27	96			
	*Anticipated Foundation Depth (1995') Water Treatment Building		11		7	SPT	29	92	68	23	5200
19	**FAT CLAY WITH SAND**: a little gravel, gray, moist, very stiff, (CH)	GLACIAL TILL	17		8	SPT	27	97			
			17		9	SPT					
26	Bottom of borehole at 26 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-3-20	1:20 pm	26	--	23	none
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START 11-3-20 COMPLETE 11-3-20 1:20 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 20-J18.GPJ GEOTEKENG.GDT 12/9/20

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GEOTECHNICAL TEST BORING LOG

Boring for water treatment building

GEOTEK # **20-J18** BORING NO. **10 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1998.9 ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY FAT CLAY: a trace of gravel, brown and black, dry to moist	FILL			1	HSA					
			8		2	SPT					
	*Anticipated Foundation Depth (1995') Water Treatment Building		11		3	SPT					
7	**FAT CLAY WITH SAND**: a little gravel, grayish brown, moist, stiff, (CH)	GLACIAL TILL	10		4	SPT					
			11		5	SPT	31	89	74	24	4800
			12		6	SPT					
			14		7	SPT					
19	**FAT CLAY WITH SAND**: a little gravel, brown and dark brown, moist, very stiff, (CH)	GLACIAL TILL	17		8	SPT					
26			17		9	SPT					
	Bottom of borehole at 26 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-3-20	3:40 pm	26	--	24	none
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--	--	--	--	--	--

START 11-3-20 COMPLETE 11-3-20 3:40 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **20-J18**　　BORING NO. **11 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 2000.4 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
2	**FILL, MOSTLY SANDY LEAN CLAY**: brown and black, dry	FILL			1	HSA					
7	**FILL, MOSTLY FAT CLAY**: a trace of gravel, brown and black, dry to moist *Anticipated Foundation Depth (1995') Water Treatment Building	FILL	10		2	SPT					
			10		3	SPT					
12	**LEAN CLAY**: brown and gray, wet, firm, (CL)	FINE ALLUVIUM	5		4	SPT					
			6		5	SPT	29	103			200
14½	**FAT CLAY**: grayish brown, moist, stiff, (CH)	FINE ALLUVIUM	9		6	SPT	30	90	68	26	6000
26	**FAT CLAY WITH SAND**: a little gravel, grayish brown, moist, stiff, (CH)	GLACIAL TILL	10		7	SPT	33	88			
			12		8	SPT					
			12		9	SPT					

Bottom of borehole at 26 feet.

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-3-20	11:25 am	26	--	24	none
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--	--	--	--	--	--
--	--	--	--	--	--

START 11-3-20　　COMPLETE 11-3-20 11:25 am

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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GEOTECHNICAL TEST BORING LOG

Boring for clear well

GEOTEK # **20-J18** BORING NO. **12 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1996.1 ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown and black, dry to moist	FILL			1	HSA					
			12		2	SPT					
6			11		3	SPT					
	LEAN CLAY: brown and gray, moist to wet, firm, (CL)	FINE ALLUVIUM	8		4	SPT					
			6		5	SPT					
			8		6	SPT					
13½	**LEAN CLAY WITH SAND**: a little gravel, grayish brown, moist, stiff, (CH) *Anticipated Foundation Depth (1983') Clear Well	GLACIAL TILL	15		7	SPT	26	97	65	23	6300
			14		8	SPT	30	93			
			14		9	SPT					
31			15		10	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-4-20	9:10 am	31	--	29	none
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START 11-4-20 COMPLETE 11-4-20 9:10 am

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

GEOTECHNICAL TEST BORING 20-J18.GPJ GEOTEKENG.GDT 12/9/20

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **20-J18** BORING NO. **13 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 1997.2 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY FAT CLAY: a trace of gravel, brown and black, dry to moist	FILL			1	HSA					
			9		2	SPT					
			8		3	SPT					
			8		4	SPT					
			8		5	SPT					
	*Anticipated Foundation Depth (1983') Clear Well		5		6	SPT					
14½	**LEAN CLAY**: brown and gray, moist, firm, (CL)	FINE ALLUVIUM	8		7	SPT					
16	**FAT CLAY WITH SAND**: a little gravel, grayish brown, moist, stiff to very stiff, (CH)	GLACIAL TILL									
			14		8	SPT	29	94			
			16		9	SPT					
31			17		10	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-3-20	4:45 pm	31	--	29	none
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START 11-3-20 COMPLETE 11-3-20 4:45 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **20-J18** BORING NO. **14 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 1996.7 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	FILL, MOSTLY LEAN CLAY: a trace of gravel, brown, dry	FILL			1	HSA					
			9		2	SPT					
4½	**FAT CLAY WITH SAND**: a little gravel, grayish brown, moist, stiff, (CH)	GLACIAL TILL	9		3	SPT					
			10		4	SPT					
			10		5	SPT					
			10		6	SPT					
	*Anticipated Foundation Depth (1983') Clear Well		10		7	SPT	30		57	23	
			14		8	SPT	31	91			
24	**FAT CLAY WITH SAND**: a little gravel, brown and dark brown, moist, stiff to very stiff, (CH)	GLACIAL TILL	15		9	SPT					
31			19		10	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-2-20	1:50 pm	31	--	29	none
11-5-20	8:31 am	31	--	27	none
--	--	--	--	--	--
--	--	--	--	--	--

START 11-2-20 COMPLETE 11-2-20 1:50 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **20-J18** BORING NO. **15 (1 of 1)**

PROJECT **Proposed WEB Water Treatment Plant Expansion, 29698 135th Street, Near Selby, SD**

SURFACE ELEVATION 1996.9 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
2	**FILL, MOSTLY FAT CLAY**: black, moist	FILL			1	HSA					
4½	**FAT CLAY**: very dark brown, moist, stiff, (CH)	FINE ALLUVIUM	11		2	SPT					
	LEAN CLAY: brown and gray, moist, firm to stiff, (CL)	FINE ALLUVIUM	9		3	SPT					
			5		4	SPT					
11			7		5	SPT					
	FAT CLAY WITH SAND: a little gravel, brown, moist, stiff, (CH)	GLACIAL TILL	9	▼	6	SPT					
	*Anticipated Foundation Depth (1983') Clear Well										
			10		7	SPT					
			10		8	SPT	32				
			14		9	SPT					
31			14		10	SPT					
	Bottom of borehole at 31 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
11-2-20	3:00 pm	31	--	29	none
11-5-20	8:30 am	31	--	15	▼ 12.5
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START 11-2-20 COMPLETE 11-2-20 3:00 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
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%