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January 5, 2017

Banner Associates, Inc.
2307 W. 57th Street, Suite 102
Sioux Falls, South Dakota 57108

Attn: Kristin Bisgard

Subj: Geotechnical Exploration
Proposed MCWC Service Line Meter Building
Lewis & Clark Regional Water System
Sioux Falls, South Dakota
GeoTek #16-F06

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

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

Respectfully Submitted,
GeoTek Engineering & Testing Services, Inc.

Brennen Ahlers

Brennen Ahlers, PE
Project Manager

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GEOTECHNICAL EXPLORATION
PROPOSED MCWC SERVICE LINE METER BUILDING
LEWIS & CLARK REGIONAL WATER SYSTEM
SIOUX FALLS, SOUTH DAKOTA
GEOTEK #16-F06

INTRODUCTION

Project Information

This report presents the results of the recent geotechnical exploration program for the proposed meter building for the Lewis & Clark Regional Water System in Sioux Falls, South Dakota.

Scope of Services

Our work was performed in accordance with the authorization of Tim Conner with Banner Associates, Inc. The scope of work as presented in this report is limited to the following:

1. To perform two (2) standard penetration test (SPT) borings to gather data on the subsurface conditions at the project site.
2. To perform laboratory tests that include moisture content, dry density 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 project site is located southwest of the intersection of S. Six Mile Road and E. 39^{th} Street in Sioux Falls, South Dakota. The site is currently vacant and is relatively flat.

Ground Surface Elevations & Test Boring Locations

The ground surface elevations at the test boring locations were furnished by Banner Associates, Inc. The ground surface elevations at the test boring locations varied from 1,489.7 feet at test boring 1 to 1,489.3 feet at test boring 2. A site map is attached at the conclusion of this report showing the relative location of the test borings.

Subsurface Conditions

Two (2) test borings were performed at the project site on December 14, 2016. The subsurface conditions encountered at the test boring locations are illustrated by means of the boring logs included in Appendix A.

The subsurface conditions encountered at the test boring locations consisted of 2 feet of topsoil materials overlying fine alluvium soils and glacial till soils. The topsoil materials and fine alluvium soils consisted of lean clay soils. The glacial till soils consisted of lean clay soils and lean clay with sand soils.

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

Water Levels

Measurements to record the groundwater levels were made at the test boring locations. The time and level of the groundwater readings are recorded on the boring logs. Groundwater was measured at depths of 12 feet (elevation 1,477.7 feet) at test boring 1 and 8.5 feet (elevation 1,480.8 feet) at test boring 2.

ENGINEERING REVIEW & RECOMMENDATIONS

Project Design Data

We understand that the project will consist of constructing a new meter building for the Lewis & Clark Regional Water System in Sioux Falls, South Dakota. The new meter building will be a slab-on-grade structure. We understand that the finished floor of the meter building will be near elevation 1,492.0 feet. We also assume that foundation support for the meter building will be provided by perimeter footings resting below frost depth and interior footings resting at or slightly below the floor slab. Light foundation loads are expected for the meter building. We assume that the meter building will be heated during the winter months.

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

Discussion

Typically, spread footings are the most cost effective type of foundation system. It is our opinion that a spread footing foundation system can be used for support of the proposed meter building after the recommended site preparation has been performed.

It is our opinion that the topsoil materials are not suitable for support of the footings or floor slab of the proposed meter building.

Site Preparation

The site preparation for the entire footprint of the meter building should consist of removing the topsoil materials in order to expose the fine alluvium soils or glacial till soils. If the excavation required to expose the fine alluvium soils or glacial till soils extends below the bottom-of-footing/bottom-of-slab elevation, then we recommend placing and compacting structural fill up to the bottom-of-footing/bottom-of-slab elevation. The final 6 inches of fill beneath the floor slab should consist of select granular fill. Please refer to Table 1 for a summary of the anticipated minimum excavation depths to remove the unsuitable soils encountered at the test boring locations. The depth of the excavations will likely vary between the test boring locations.

Table 1. Estimated Excavation Depths – Footprint of the Meter Building

Test Boring Number	Ground Surface Elevation, ft	Anticipated Excavation Depth, ft	Approximate Excavation Elevation, ft
1	1,489.7	2	1,487.7
2	1,489.3	2	1,487.3

If groundwater or saturated soils are encountered at the bottom of the 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 structural fill or footings. We expect that crushed rock will be needed at the bottom of the excavations, even during drier periods of the year.

Where 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 structural fill or crushed rock required below the footings (1 horizontal : 1 vertical).

Foundation Loads & Settlement

If our recommendations are followed during site preparations, then it is our opinion that the footings can be sized for a net allowable soil bearing pressure of up to 2,000 pounds per square foot (psf). Total settlement of the meter building should be less than 1 inch and differential settlement should be less than ½ inch. Unknown soil conditions at the site that are different from those depicted at the test boring locations could increase the amount of expected settlement.

Floor Slab

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

Backfilling/Lateral Pressures – Below-Grade & Retaining Walls

If there are below-grade walls or retaining walls, then the lateral earth pressure used for the design of below-grade or retaining walls will depend on the material used to backfill the walls.

The active and passive 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, 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 movements cannot be tolerated, then we recommend using the at-rest lateral earth pressures to design the walls. 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	95	110	90	105	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 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.

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). 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.

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.

Frost Protection

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

Material Types & Compaction Levels

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

Crushed Rock – The crushed rock should be washed and have 100 percent by weight passing the 1-inch sieve and no more than 5 percent by weight passing the #4 sieve.

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

Free-Draining Sand – The free-draining sand should have a maximum particle size of 1 inch with less than 5 percent by weight passing the #200 sieve.

Exterior Backfill / Slab-on-Grade Backfill – 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, we recommend capping the granular soils with at least 1 foot to 2 feet of clay soils to minimize infiltration of surface water.

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

Table 3. Recommended Compaction Levels

Placement Location	Compaction Specifications
Below Footings	95%*
Below Floor Slabs	95%
Exterior Wall Backfill (Slab-on-Grade)	95%
Behind Below-Grade & Retaining Walls	95% - 98%
Non-Structural Areas	90%

*Does not apply to the crushed rock.

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

Recommended Moisture Levels – The moisture content of 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. The optimum moisture content should be determined using a standard Proctor (ASTM: D698) test.

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

Excavation

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

Coefficient of Friction

It is our opinion that a friction factor of 0.35 can be used between the clay soils and the bottom of the concrete. A friction factor of 0.45 can be used between the crushed rock or structural fill the bottom of the concrete. The friction values are considered ultimate values. We recommend applying a theoretical safety factor of at least 2.0.

Drainage

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

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

CONSTRUCTION CONSIDERATIONS

Groundwater & Surface Water

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

Disturbance of Soils

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

Cold Weather Precautions

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

Excavation Sideslopes

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

Observations & Testing

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

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

Excavation

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

Testing

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

SUBSURFACE EXPLORATION PROCEDURES

Test Borings

We performed two (2) test borings on December 14, 2016 with a truck rig and tractor rig equipped with hollow-stem auger. Soil sampling was performed in accordance with the procedures described in ASTM:D1586. Using this procedure, a 2-inch O.D. split barrel sampler is driven into the soil by a 140-pound weight falling 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as the penetration resistance, or “N” value. The “N” value is an index of the relative density of cohesionless soils and the consistency of cohesive soils. In addition, thin walled tube samples were obtained according to ASTM:D1587, where indicated by the appropriate symbol on the boring logs.

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

The soil samples collected from the test boring locations will be retained in our office for a period of one 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

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

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

Laboratory Tests

Laboratory tests were performed on select samples to aid in determining the index and strength properties of the soils. The index tests consisted of moisture content and dry density. The strength tests consisted of unconfined compressive strength. The laboratory tests were performed in accordance with the appropriate ASTM procedures. The results of the laboratory tests are shown on the boring logs opposite the samples upon which the tests were performed or on the data sheets included in the Appendix.

LIMITATIONS

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

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

STANDARD OF CARE

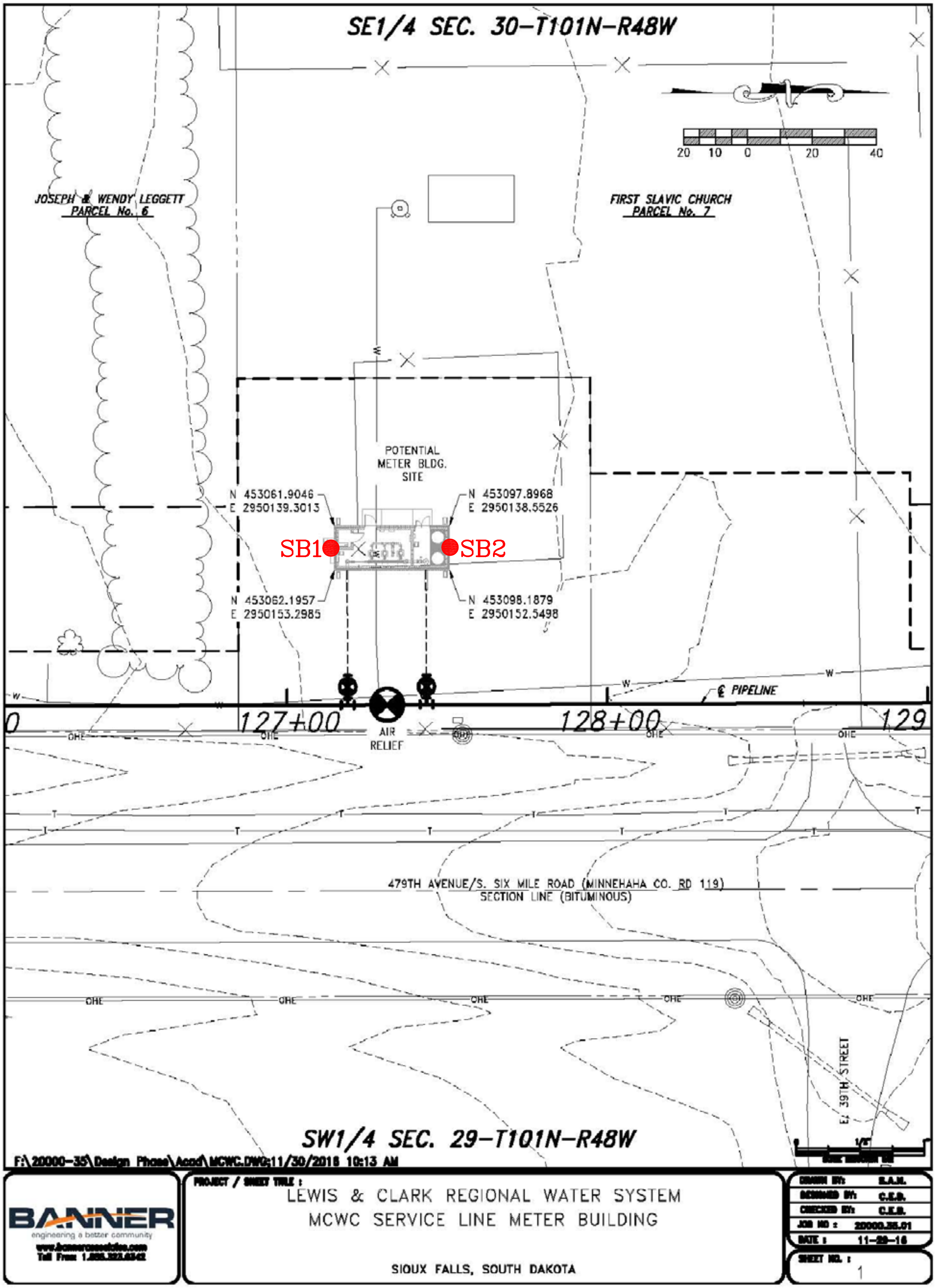
The recommendations submitted in this report represent our professional opinions. Our services for your project were performed in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering profession currently practicing at this time and area.

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

Brennen Ahlers, PE
Project Manager

REGISTERED PROFESSIONAL ENGINEER
REG. NO.
12056
BRENNEN W.
AHLERS
SOUTH DAKOTA
1/5/17

16-F06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JOSEPH & WENDY LEGGETT
PARCEL No. 6
FIRST SLAVIC CHURCH
PARCEL No. 7
POTENTIAL
METER BLDG.
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127+00
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SECTION LINE (BITUMINOUS)
E. 39TH STREET
SW1/4 SEC. 29-T101N-R48W
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BANNER
engineering a better community
PROJECT / SHEET TITLE :
LEWIS & CLARK REGIONAL WATER SYSTEM
MCWC SERVICE LINE METER BUILDING
SIOUX FALLS, SOUTH DAKOTA
DRAWN BY: E.A.H.
DESIGNED BY: C.E.B.
CHECKED BY: C.E.B.
JOB NO : 20000.35.01
DATE : 11-29-18
SHEET NO. : 1

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **16-F06**   BORING NO. **1 (1 of 1)**

PROJECT **Proposed Meter Building, Lewis & Clark Regional Water System, Sioux Falls, SD**

DEPTH in FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1489.7 ft)	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	LEAN CLAY: black, frozen to moist, (CL)	TOPSOIL			1	HSA					
2	**LEAN CLAY**: brown, moist, firm, (CL)	FINE ALLUVIUM	7		2	SPT	29	90			
4½	**LEAN CLAY WITH SAND**: a trace of gravel, mottled brown and gray, moist, firm, (CL)	GLACIAL TILL	5		3	SPT	22	103			
			6		4	SPT					
9½	**LEAN CLAY WITH SAND**: a little gravel, brown, moist, firm to stiff, (CL)	GLACIAL TILL	5		5	SPT					
				▼							
			6		6	SPT					
			9		7	SPT					
16	Bottom of borehole at 16 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
12-14-16	10:15 am	16	--	14	▼ 12.0
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 12-14-16   COMPLETE 12-14-16 10:15 am

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Roy Hanson

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **16-F06**

BORING NO. **2 (1 of 1)**

PROJECT **Proposed Meter Building, Lewis & Clark Regional Water System, Sioux Falls, SD**

SURFACE ELEVATION 1489.3 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	LEAN CLAY: black, frozen to moist, (CL)	TOPSOIL			1	HSA					
2	**LEAN CLAY**: brown, dry, firm, (CL)	FINE ALLUVIUM	5		2	SPT	26	95			
4½	**LEAN CLAY WITH SAND**: a trace of gravel, mottled brown and gray, moist, firm, (CL)	GLACIAL TILL	8		3	SPT	21	106			3600
			6	▼	4	SPT					
9½	**LEAN CLAY WITH SAND**: a little gravel, brown, moist, firm, (CL)	GLACIAL TILL	6		5	SPT					
12	**LEAN CLAY**: brown and gray, moist, firm, (CL)	GLACIAL TILL	7		6	SPT					
13½	**LEAN CLAY WITH SAND**: a little gravel, brown, moist, stiff, (CL)	GLACIAL TILL	11		7	SPT					
16	Bottom of borehole at 16 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
12-14-16	9:30 am	16	--	14	--
12-14-16	10:15 am	16	--	14	▼ 8.5
--	--	--	--	--	--
--	--	--	--	--	--

START 12-14-16 COMPLETE 12-14-16 9:30 am

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

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%