GEOTEK ENGINEERING
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January 25, 2019

City of Flandreau
1005 W. Elm Avenue
Flandreau, South Dakota 57028

Attn: Jeff Pederson, City Administrator

Subj: Geotechnical Exploration
Proposed Safe Room #2
210 W. Prospect Avenue
Flandreau, South Dakota
GeoTek #19-030

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 any electronic copy of our report for your use. An additional copy is also being sent as noted below.

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

Cc: Banner Associates, Inc., Attn: Dave Lorang

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APPENDIX

GEOTECHNICAL EXPLORATION
PROPOSED SAFE ROOM #2
210 W. PROSPECT AVENUE
FLANDREAU, SOUTH DAKOTA
GEOTEK #19-030

INTRODUCTION

Project Information

This report presents the results of the recent geotechnical exploration program for the proposed Safe Room #2 for the City of Flandreau in Flandreau, South Dakota.

Scope of Services

Our work was performed in accordance with the authorization of Jeff Pederson with the City of Flandreau. 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 included sieve analyses (#200 sieve wash).
3. To prepare an engineering report that includes the results of the field and laboratory tests as well as our earthwork and foundation recommendations for design and construction.

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

SITE & SUBSURFACE CONDITIONS

Site Location & Description

The site is located northeast of the intersection of W. Prospect Avenue and N. Henry Street in Flandreau, South Dakota. The address to the property is 210 W. Prospect Avenue. The site is currently vacant and covered with snow. We understand that a residence structure was previously located on the site. The topography of the site is relatively flat.

Ground Surface Elevations & Test Boring Locations

The ground surface elevations at the test boring locations were estimated based off of elevations on the site plan. The estimated ground surface elevations at the test boring locations were 1,539.5 feet at test boring 1 and 1,539.7 feet at test boring 2. A site map (Figure 2) 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 January 14, 2019. The subsurface conditions encountered at the test boring locations are illustrated by means of the boring logs included in the appendix.

The subsurface conditions at the test boring locations consisted of 2 feet of topsoil overlying mixed alluvium soils and coarse alluvium soils. The topsoil consisted of sandy lean clay soils. The mixed alluvium soils consisted of clayey sand soils. The coarse alluvium soils consisted of sand with silt soils.

The consistency/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/relative density based on the "N" values can be found on the attached Soil Boring Symbols and Descriptive Terminology data sheet.

We wish to point out that the subsurface conditions at other times and locations at the site may differ from those found at our test boring locations. If different conditions are encountered

during construction, then it is important that you contact us so that our recommendations can be reviewed.

Water Levels

Measurements to record the groundwater levels were made at the test boring locations. The time and level of the groundwater readings are recorded on the boring logs. Groundwater did not enter the bore hole at the test boring locations at the time of our measurements.

ENGINEERING REVIEW & RECOMMENDATIONS

Project Design Data

We understand that the project will consist of constructing Safe Room #2. We understand that the safe room will consist of a slab-on-grade building structure with approximate dimensions of 22 feet by 30 feet. The safe room will have 10-foot masonry walls with a precast roof. We understand that the finished floor elevation of the safe room will be near 1,543.5 feet; therefore, approximately 4 feet of fill is needed to achieve the design elevation. We anticipate light foundation and floor loads. We understand that the building will not be heated during the winter months.

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

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 building after the recommended site preparation is performed. It is our opinion that the topsoil materials are not suitable for support of the footings and floor slab of the proposed building. Regarding the mixed alluvium soils and coarse alluvium soils, it is our opinion that these soils are suitable for support of the footings and floor slab of the proposed safe room structure.

Site Preparation

We recommend that the site preparation in the entire footprint of the proposed structure consist of removing the topsoil in order to expose the mixed alluvium soils and/or coarse alluvium soils. If encountered, the removals should also consist of removing the remnants of the previous structure. If the excavation required to expose the mixed alluvium soils and coarse alluvium soils extends below the bottom-of-footing or bottom of slab elevation, then we recommend placing and compacting granular structural fill up to the bottom-of-footing elevation. The final 6 inches of granular structural 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 – Building Footprint

Test Boring Number	Ground Surface Elevation, ft	Anticipated Excavation Depth, ft	Approximate Excavation Elevation, ft
1	1,539.5	2	1,537.5
2	1,539.7	2	1,537.7

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 granular structural fill or footings.

Where crushed rock or granular structural fill 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 crushed rock or granular structural fill 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 foundations of the proposed building can be sized for a net allowable soil bearing pressure of up to 3,000 pounds per square foot (psf). We estimate total settlement to be less than 1 inch and differential settlement to 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 Slabs

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 150 psi/inch.

Frost Protection

Footings

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 slabs. 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.

Exterior Surface Improvements & Floor Slab

It is our opinion that clay soils have moderate frost susceptibility. Surface improvements (pavements and sidewalks) and floor slabs in unheated building on clay soils are potentially subject to both cosmetic and structural damage caused by frost heaving. We anticipate the heave for clay soils to potentially be on the order of 0.2 inch to 0.4 inch for each foot of frost penetration within the soil, which would translate to over 1 inch of total movement. The heave could be even greater if free water is available, resulting in a buildup of ice lenses. If movement cannot be tolerated, then we recommend placing granular structural fill beneath the surface improvements and floor slabs. The granular structural fill should extend to a depth of 4 feet below the finished exterior grade. If it is desired to reduce (but not eliminate) the amount of potential frost heave, then we recommend consideration be given to placing 2 feet of granular structural fill beneath the surface improvements and floor slab. Based on the design elevations, a minimum of 5 feet of granular structural fill will be placed beneath the floor slab.

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 5 percent by weight passing the #200 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.

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

Table 2. Crushed Drainage Rock Gradation Specifications

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

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

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 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 Foundations	97%
Below Floor Slabs	97%
Exterior Wall Backfill (Slab-on-Grade)	95%
Non-Structural Areas	90%

Notes: Compaction specifications are not applicable with the crushed 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 2 percent to minus 2 percent of the materials' optimum moisture content. The optimum moisture content should be determined using a standard Proctor (ASTM: D698) test.

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

Coefficient of Friction

A friction factor of 0.45 can be used between the mixed alluvium soils, coarse alluvium soils and granular structural fill or the crushed drainage rock and the bottom of the concrete.

Excavation

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

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 building should be sloped such that positive drainage away from the building is provided. Also, a system to collect and channel roof run-off waters away from the building 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 foundations. 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 granular 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 paved 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) SPT borings on January 14, 2019 with a truck rig equipped with hollow-stem auger. Soil sampling was performed in accordance with the procedures described in ASTM:D1586. Using this procedure, a 2-inch O.D. split barrel sampler is driven into the soil by a 140-pound weight falling 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as the penetration resistance, or "N" value. The "N" value is an index of the relative density of cohesionless soils and the consistency of cohesive soils. In addition, thin walled tube samples were obtained according to ASTM:D1587, where indicated by the appropriate symbol on the boring logs.

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

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

Soil Classification

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

Water Level Measurements

Subsurface groundwater levels should be expected to fluctuate seasonally and yearly from the groundwater readings recorded at the test borings. Fluctuations occur due to varying seasonal and yearly rainfall amounts and snowmelt, as well as other factors. 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 sieve analysis (#200 sieve wash). 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.

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
1/25/19

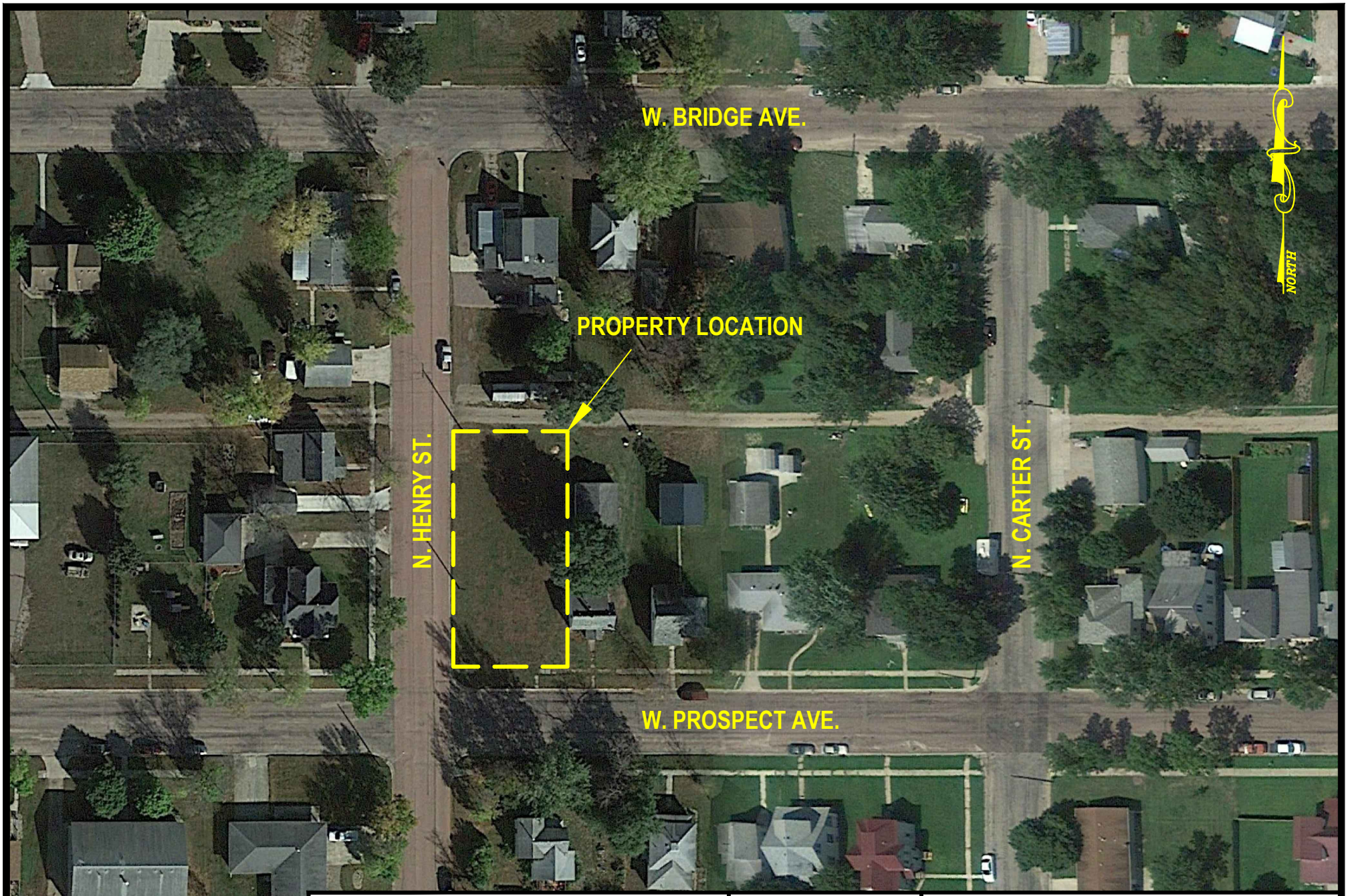

FIGURE 1
PROPERTY LOCATION MAP
PROPOSED SAFE ROOM #2
210 W. PROSPECT AVE.
FLANDREAU, SD

ACAD/GEOTEK/BRENNEN/19-030

PROJECT#: 19-030

DRAWN BY: PLH

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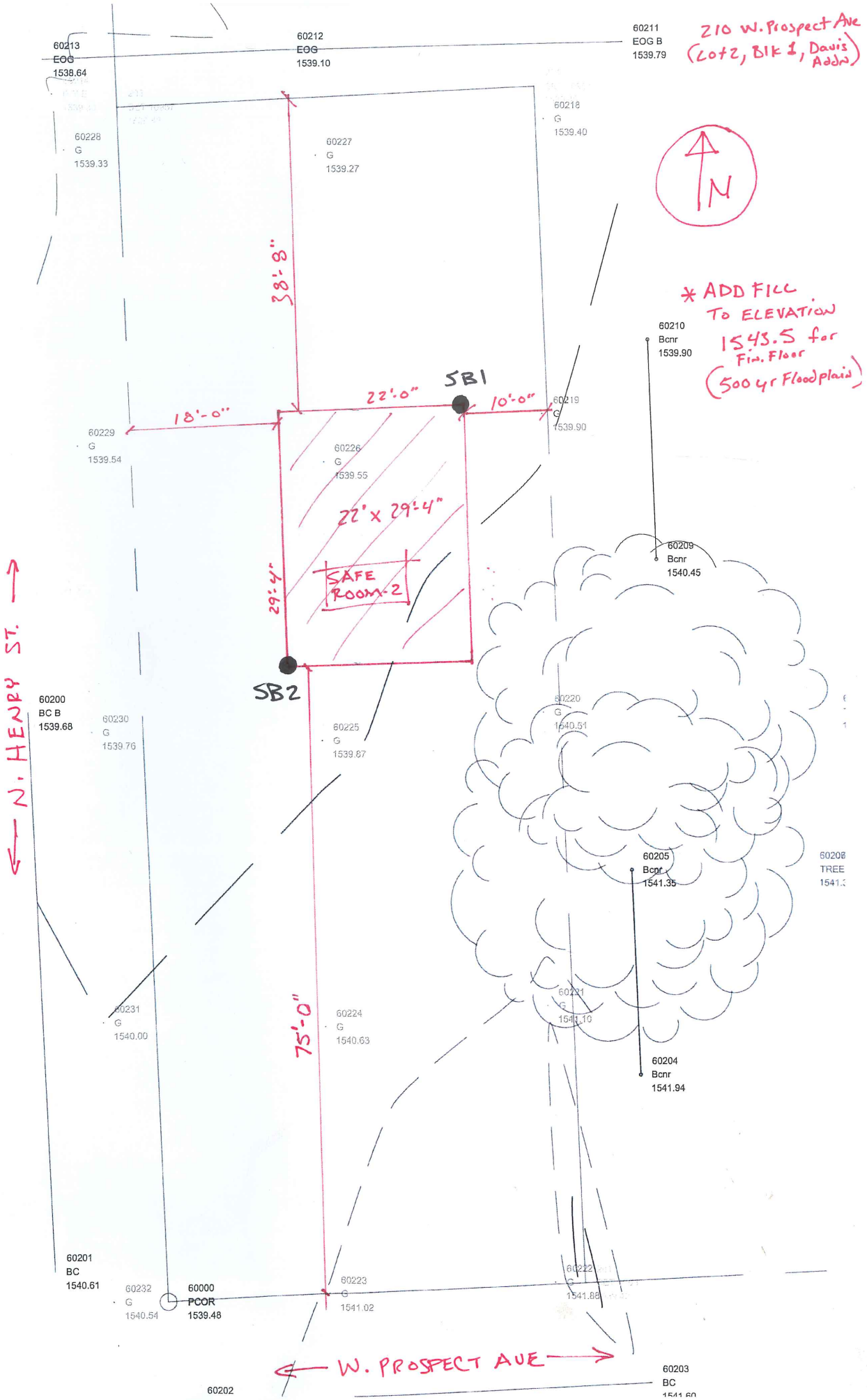
210 W. Prospect Ave
(Lot 2, Blk 1, Davis Addn)
60211
EOG B
1539.79
60212
EOG
1539.10
60213
EOG
1538.64
60218
G
1539.40
60228
G
1539.33
60227
G
1539.27
N
38'-8"
* ADD FILL
TO ELEVATION
1543.5 for
Fin. Floor
(500 yr Floodplain)
60210
Bcnr
1539.90
SB1
22'-0"
10'-0"
18'-0"
60219
G
1539.90
60229
G
1539.54
60226
G
1539.55
22' x 29'-4"
SAFE ROOM-2
29'-4"
60209
Bcnr
1540.45
SB2
60200
BC B
1539.68
60230
G
1539.76
60220
G
1540.51
60225
G
1539.87
N. HENRY ST.
60205
Bcnr
1541.35
60208
TREE
1541.3
60231
G
1540.00
75'-0"
60224
G
1540.63
60221
G
1541.10
60204
Bcnr
1541.94
60201
BC
1540.61
60232
G
1540.54
60000
PCOR
1539.48
60223
G
1541.02
60222
G
1541.88
W. PROSPECT AVE
60202
60203
BC
1541.60

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **19-030** BORING NO. **1 (1 of 1)**

PROJECT **Proposed Safe Room #2, 210 W. Prospect Avenue, Flandreau, SD**

SURFACE ELEVATION 1539.5 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	WC	D	LL	PL	QU
	SANDY LEAN CLAY: very dark brown, frozen to 1.5' then moist, firm, (CL)	TOPSOIL			1	HSA					
2	**CLAYEY SAND**: a little gravel, fine to medium grained, very dark brown, moist, loose, 16% passing the #200 sieve from 2' to 3.5' (SC)	MIXED ALLUVIUM	6		2	SPT					
4½	**SAND**: a little gravel, medium to coarse grained, brown, moist, loose to dense, (SP-SM)	COARSE ALLUVIUM	6		3	SPT					
			13		4	SPT					
			29		5	SPT					
			22		6	SPT					
			22		7	SPT					
16	Bottom of borehole at 16 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
1-14-19	12:04 pm	16	--	--	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 1-14-19 COMPLETE 1-14-19 12:04 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Mike Wagner

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GEOTECHNICAL TEST BORING LOG

GEOTEK # **19-030** BORING NO. **2 (1 of 1)**

PROJECT **Proposed Safe Room #2, 210 W. Prospect Avenue, Flandreau, SD**

SURFACE ELEVATION 1539.7 ft

DEPTH in FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS WC	D	LL	PL	QU
	SANDY LEAN CLAY: very dark brown, frozen to 1.5' then moist, firm, 1.5' of frost (CL)	TOPSOIL			1	HSA					
2	**CLAYEY SAND**: a little gravel, fine to medium grained, very dark brown, moist, loose, 16% passing the #200 sieve from 2' to 3.5' (SC)	MIXED ALLUVIUM	6		2	SPT					
5	**CLAYEY SAND**: a little gravel, fine to medium grained, brown, moist, loose, 18% passing the #200 sieve from 4.5' to 6' (SC)	MIXED ALLUVIUM	6		3	SPT					
7	**SAND WITH SILT**: a little gravel, medium to coarse grained, brown, moist, very loose to dense, (SP-SM)	COARSE ALLUVIUM	4		4	SPT					
			32		5	SPT					
			29		6	SPT					
			29		7	SPT					
16	Bottom of borehole at 16 feet.										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	WATER LEVEL
1-14-19	12:49 pm	16	--	--	none
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

START 1-14-19 COMPLETE 1-14-19 12:49 pm

METHOD
3.25" ID Hollow Stem Auger

CREW CHIEF Mike Wagner

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	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
	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%