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REPORT OF GEOTECHNICAL EXPLORATION AND REVIEW

Beach Stabilization Project
Sibley State Park

New London, Minnesota

Report No. 08-11538

Date:

July 9, 2014

Prepared for:

MN/DNR
Management Resources Bureau
261 Highway 15 South
New Ulm, MN 56073

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July 9, 2014

Mr. Jared DeMaster
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MN/DNR
Management Resources Bureau
261 Highway 15 South
New Ulm, MN 56073

RE: Geotechnical Exploration and Review
Sibley State Park
Beach Stabilization Project
New London, Minnesota
Report No. 08-11538

Dear Mr. DeMaster:

American Engineering Testing, Inc. (AET) is pleased to present the results of our geotechnical exploration for your proposed Beach Stabilization Project at Sibley State Park near New London, Minnesota.

We are submitting one (1) hard copy and one (1) electronic copy of the report to you.

We have enjoyed working with you on this phase of the project. If you have any questions regarding this report or we can be of further assistance, please contact us. I can also be contacted for arranging construction observation and testing services during the earthwork phase of the project.

Sincerely,
American Engineering Testing, Inc.

Steven J. Ruesink, PE
Regional Manager
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SJR/lmh

SIGNATURE PAGE

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I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under Minnesota Statute Section 326.02 to 326.15

Date: 7/9/14 **License #: 19431**

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1.0 INTRODUCTION

This report presents the results of a subsurface exploration program and engineering review for the proposed beach stabilization project at Sibley State Park in New London, Minnesota.

2.0 SCOPE OF SERVICES

The scope of our work consists of the following:

- Four (4) standard penetration test (SPT) soil borings to a depth of 21 feet.
- Laboratory water content testing.
- Geotechnical engineering analysis based on the above data and preparation of this report.

These services are intended for geotechnical purposes. The scope is not intended to explore for the presence or extent of environmental contamination.

3.0 PROJECT INFORMATION

The following is our understanding of the proposed project. If our understanding is incorrect, then contact us for additional recommendations.

We understand that you are planning to construct a 300 foot long retaining wall along the north shoreline of Lake Andrew at Sibley State Park. We understand the proposed wall will be either cast-in-place concrete or modular block. We were provided the Feasibility Plan Sheet A which indicated the soil boring locations, general configuration of the retaining wall and some cross-sections showing grade changes at locations along the wall. We understand an existing retaining wall is present that will be demolished for new wall construction. Portions of the wall will have two tiers with access walkways to the lake. We understand the wall height will vary from 2 to 6 feet. We do not have any specific structural loading information. Based on the height of the wall we estimate wall loads to be relatively light.

4.0 SUBSURFACE EXPLORATION AND TESTING

Our subsurface exploration program for this project consisted of four (4) SPT soil borings. The soil borings were drilled on June 9, 2014 at the approximate locations shown on Figure 2. Surface elevations at the borings were measured by AET personnel using a level and survey rod. Elevations were referenced to a temporary benchmark located on the concrete pad north of the existing beach house. The reference bench mark elevation was taken as 100.0 feet.

4.1 SPT Borings

The logs of the SPT borings and details of the methods used are presented in Appendix A. The logs contain information concerning soil layering, soil classification, geologic description, and moisture condition. Relative density or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value).

We drilled the SPT borings using 3¼-inch inside diameter hollow stem augers. Refer to Appendix A for details on the drilling and sampling methods, the classification methods and the water level measurement methods.

4.2 Laboratory Testing

The laboratory test program included water content using the direct measurement method. The test results appear in Appendix A on the individual boring logs adjacent to the samples upon which they were performed.

5.0 SUBSURFACE CONDITIONS

5.1 Subsurface Soils/Geology

The general soil profile consists of six (6) main soil units.

1. A 2 to 4 ½ feet thick layer of black silty sand, existing fill soil at the ground surface at borings B-3 and B-4.
2. A 2' layer of black silty to clayey sand, topsoil at the ground surface at borings B-1 and B-2.
3. A layer of very loose to medium dense, coarse alluvial, sand with silt and silty sand, extending from 2 to 14 ½ feet in depth.
4. A layer of swamp deposits, consisting of soft multi-colored organic clay, from 12 to 19 ½ feet in depth at borings B-2 and B-3.
5. A layer of very soft to very stiff, fine and mixed alluvium including lean clay, sandy lean clay, fat clay and clayey sand that extends from 7 to 21 feet in depth.
6. A deposit of stiff to firm glacial till below the mixed alluvial deposits to a depth of about 9 ½ to 21 feet at boring B-1.

A discussion of the various soil units is given below.

5.1.1 Surficial Layers

Based on the soil borings, the upper 2 to 4 ½ feet of the soil profile consists of organic topsoil and existing fill soil. In our opinion, these soils are not suitable for support of the retaining wall.

5.1.2 Coarse Alluvium Deposits

Between the surficial unsuitable layer and about 2 to 14 ½ feet depth, a very loose to medium dense coarse alluvial sand with silt and silty sand is found. Based on the SPT and laboratory testing in this zone, it is our opinion this soil would be suitable for compacted fill and/or retaining wall support after surface densification.

5.1.3 Swamp Deposits

Between the coarse and fine alluvial soils, soft organic clay swamp deposits were encountered from 12 to 19 ½ feet below the surface. These soils are low strength materials that will compress over time with the added load applied where a raise in grade occurs at the wall alignment as well as the area of the reinforced soil zone.

5.1.4 Fine/Mixed Alluvium Deposits

Below the coarse alluvium and swamp deposits, very soft to very stiff fine and mixed alluvial lean clay, sandy lean clay, fat clay and clayey sand deposits are found that extend from 7 to 21 feet in depth. The softer portions of these soils are also low strength materials that may compress over time with the added load applied where a raise in grade occurs at the wall alignment as well as the area of the reinforced soil zone.

5.1.5 Glacial Till Deposits

Below the upper deposits to the boring termination depth at boring B-1 a deposit of firm to stiff sandy lean clay glacial till deposits are found. These deposits have moderate strength and would generally be fairly incompressible under the anticipated loads.

5.2 Groundwater

Water was observed at the soil boring locations as shallow as 5.8 feet at the time our field work was performed. Because of the clayey soils in the subsurface, the measured water levels are probably not at steady state levels. In order to accurately measure water table in clay soils, installation and long-term monitoring of piezometers would be required.

6.0 ENGINEERING REVIEW AND RECOMMENDATIONS

6.1 Approach Discussion

In our opinion, the surficial layer of topsoil and fill soil is not suitable for support of the retaining wall foundation. We recommend that these layers (approximately 2 to 4 ½ feet thick) be fully excavated from under the wall and reinforced backfill zone and replaced with compacted select granular fill. Further discussion on this soil correction is given in Section 6.2 below.

Compressible soils are present at all the boring locations at depth. In our opinion, differential settlements of 1 inch or more could occur, depending on variations in wall height and thickness of compressible organic clay soils at depth. It is also our opinion that modular block retaining walls can tolerate differential settlement better than reinforced concrete retaining walls. For that reason, the design recommendations, given in the following sections, are applicable to modular block retaining walls. If you decide to use reinforced concrete walls, then contact us for additional recommendations.

6.2 Soil Correction Recommendations

We recommend that the topsoil, existing fill soil and any existing retaining wall foundation and wall elements be excavated from below the retaining wall foundation and the reinforced backfill zone area plus a 1 to 1 lateral oversize. The reinforced backfill zone consists of the area behind the modular block wall that contains horizontal layers of geogrid reinforcement.

The depth of the required excavation at the soil boring locations is as follows:

Boring Location	Surface Elevation (ft)	*Excavation Depth (ft)	*Approximate Excavation Elevation (ft)
B-1	99.7	2	97 ½
B-2	99.0	2	97
B-3	100.4	4 ½	96
B-4	99.6	2	97 ½

*Estimated to the nearest half-foot.

At other locations in the excavation, the depths may vary depending on actual conditions encountered in the field. We recommend that a geotechnical engineer observe the excavation bottom to confirm that all unsuitable soils have been fully excavated.

The sands exposed at the bottom of the excavation should be surfaced compacted with several passes of a moderately heavy, vibratory compactor prior to placement of new fill or construction of the wall elements. If the exposed sands are saturated, they will be sensitive to disturbance and we do not suggest surface compaction.

6.3 Fill Placement and Compaction

We recommend that the excavation below the retaining wall foundation and associated oversizing be backfilled with a crushed aggregate base material meeting the gradation requirements of Mn/DOT Class 5. This aggregate base layer should be a minimum of 12" in thickness. We recommend that the aggregate base be compacted to 95% of the Standard Proctor density (ASTM: D698).

Fill placed as retaining wall backfill (retained zone) should be compacted in thin horizontal lifts, such that the entire lift achieves a minimum compaction level of 95% of the *standard maximum dry unit weight* per ASTM:D698 (standard Proctor test). The retaining wall backfill materials should at least meet the requirement of a Select Granular Borrow per Mn/DOT specification

3149.2B2. This refers to sand containing less than 12% by weight passing the #200 sieve. The retained zone is backfill behind the reinforced soil zone. Recommendations for backfill materials within the reinforced zone are given in Section 6.5, below.

If the wall design does not include a reinforced zone (e.g. low height walls without geogrid reinforcement), then we recommend that the wall backfill consist of free-draining backfill, as discussed in Section 6.5, below.

The sand with silt and sand with silt and gravel encountered on-site may be suitable for use as retained zone wall backfill.

6.4 Foundation Design

Based on the conditions encountered and provided the modular block wall foundation is supported on the aggregate base layer discussed above, it is our opinion the foundations can be designed based on a net maximum allowable soil bearing pressure of 3,000 psf. It is our judgment this design pressure will have a factor of safety of at least 3 against localized shear or base failure.

Due to the compressible soils at depth, we judge that total settlements under this loading will exceed 1 inch. Limiting the amount of grade increase should limit the total long term settlement observed. A modular block wall should be able to incorporate these types of settlements.

6.5 Retaining Wall Backfilling and Drainage

Wall backfill in the reinforced zone should consist of free draining sand with less than 40% passing the #40 sieve and 5% passing the No. 200 sieve.

The backfill should be placed in lifts and compacted to a minimum of 95% of standard Proctor density (ASTM:D698). For this level of compaction, we recommend that lateral earth pressures be computed assuming a friction angle of 34 degrees and a total unit weight of 125 pcf.

For lateral resistance of the retaining wall against sliding, we recommend using a friction factor of 0.35 between the bottom of the reinforced zone and the soil subgrade. Passive resistance against the embedded portion of the wall should be ignored due to frost action.

We recommend that the wall design include internal drainage consisting of a 1 foot wide gravel drain directly behind the modular blocks that is drained with a perforated PVC drain line at footing level. Gradation of the gravel should meet filter criteria against the reinforced zone backfill material. For example, if reinforced zone backfill meets MnDOT specification 3149.2J (Fine Filter Aggregate), the gravel zone should meet MnDOT specification 3149.2H (Coarse Filter Aggregate).

We recommend capping the backfill with a 1' layer of clay or other low permeability material which slopes away from the structure to minimize surface water infiltration.

6.6 Pavements

6.6.1 Definitions

The ensuing sections use the following words or phrases, which have the following definitions:

> ***Top of grading grade*** is defined as the grade which contacts the bottom of the aggregate base layer.
>
> ***Sand subbase*** is a uniform thickness sand layer placed as the top of subgrade (directly below top of grading grade) which is intended to improve the frost and drainage characteristics of the pavement system by better draining excess water in the aggregate base and subbase, by reducing and "bridging" frost heaving, and by reducing spring thaw weakening effects.

Granular Material shall be a pit-run or crusher-run product which shall all pass a 3-inch sieve, and of the portion passing a 1-inch sieve, not more than 10% by weight will pass a #200 sieve and not more than 50% by weight will pass a #40 sieve.

Compaction Subcut is the construction of a uniform thickness subcut below a designated grade to provide uniformity and compaction within the subcut zone. Replacement fill can be the inorganic materials subcut, although the reused soils should be blended to a uniform soil condition and re-compacted to at least of 95% of the standard Proctor density (ASTM:D698). Compaction may need to be higher in order to pass a test roll.

Test roll is a means of evaluating the near-surface stability of subgrade soils (usually non-granular). Suitability is determined by the depth of rutting or deflection caused by passage of heavy rubber-tired construction equipment, such as a loaded dump truck, over the test area. Yielding of less than 1-inch is normally considered acceptable, although engineering judgment may be applied depending on equipment used and soil conditions present.

Organic soils are those soils which have sufficient organic content such that engineering properties/stability are affected (generally more than 3% organic content).

6.6.2 Subgrade Preparation

As a background to this section, we refer you to the attached data sheet entitled "Bituminous Pavement Subgrade Preparation and Design," which presents considerations and recommendations for pavement subgrade preparation.

To prepare the subgrade for new pavement, we recommend removing the organic soil as previously defined. The stability of the exposed soils should them be evaluated using a test roll procedure, as described on the attached sheet. Soils found to be unstable should either be moisture conditioned and compacted back into place, or they should be removed and replaced with compacted fill.

The on-site inorganic soils can be used for subgrade fill. The use of granular materials encountered on-site is preferred. Compaction of new fill supporting pavements should meet the requirements of Mn/DOT Specification 2105.3F1 (Specified Density Method). This specification requires soils placed within the upper 3' of the subgrade be compacted to a minimum of 100% of the Standard Proctor Density (ASTM:D698). The soil placed below the upper 3' zone can have a reduced minimum compaction level of 95%.

It is our judgment that the existing site soils should be able to provide pavement support if they are stable and compacted. Any upper organic soils should be removed from the subgrade exposing the native sand with silt coarse alluvium. Non-organic soils should be removed if found to be unstable under a test roll. We refer you to the attached sheet entitled "Bituminous Pavement Subgrade Preparation and Design" for general information on pavement design and subgrade preparation, including items such as test roll evaluation, subgrade drainage and compaction recommendations. Fill which is placed or reworked in the pavement areas should be compacted to a minimum of 100% of standard Proctor density in the upper 3' of subgrade and to 95% below the upper 3' zone.

6.6.3 Section Thicknesses

We are presenting pavement designs based on two potential traffic situations (light and standard duty). The light duty design refers to parking areas which are intended only for automobiles and passenger truck/ vans. The standard duty design is intended for pavements which will experience the heavier truck traffic at relatively light volumes. Bituminous pavement thickness designs for the on-site granular soils are provided in the following table B.

Table B – Pavement Thickness Designs

Pavement Material	Light Duty	Standard Duty
Bituminous Wear	1 ½"	1 ½"
Bituminous Base	1 ½"	2"
*Class 5 Aggregate Base	5"	7"

*If granular materials are not encountered at subgrade elevations, a minimum 1' sand subbbase layer should be provided.

The above designs could be reduced if the project owner is willing to assume the additional maintenance costs. Also, the site conditions are suited for the use of an engineering fabric and some reduction in the pavement section may be possible depending on the subgrade conditions encountered and the amount of sand subbase provided.

Estimated Subgrade R-Value

No actual R-value testing was conducted to define subgrade soil strength. However, based on our experience we estimate a conservative R-value for the pavement section thickness design of about 40 for the granular soils on site. If you desire additional field and laboratory testing can be performed to better define the R-value for the soils present. Any additional sand provided would increase the estimated R-value or could be accounted for by assigning a granular equivalent (GE) value of about 0.5.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Excavation Backsloping

If excavation faces are not retained, the excavations should maintain maximum allowable slopes in accordance with *OSHA Regulations (Standards 29 CFR), Part 1926, Subpart P, "Excavations"* (can be found on www.osha.gov). Even with the required OSHA sloping, water seepage or surface runoff can potentially induce sideslope erosion or running which could require slope maintenance.

7.2 Observation and Testing

The recommendations in this report are based on the subsurface conditions found at our test boring locations. Since the soil conditions can be expected to vary away from the soil boring locations, we recommend on-site observation by a geotechnical engineer/technician during construction to evaluate these potential changes. Soil density testing should also be performed on new fill placed in order to document that project specifications for compaction have been satisfied.

8.0 LIMITATIONS

Within the limitations of scope, budget, and schedule, our services have been conducted according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, either expressed or implied, is intended.

Important information regarding risk management and proper use of this report is given in Appendix B entitled "Geotechnical Report Limitations and Guidelines for Use."

Appendix A

Geotechnical Field Exploration and Testing
Boring Log Notes
Unified Soil Classification System
Figure 1 – Site Location
Figure 2 – Soil Boring Locations
SPT Boring Logs

Appendix A
Geotechnical Field Exploration and Testing
Report No. 08-11538

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling and sampling four (4) standard penetration test borings and three cone penetration test soundings. The locations of the borings/soundings are shown on Figure 1 in this appendix.

A.2 SAMPLING METHODS

A.2.1 Split-Spoon Samples (SS) - Calibrated to N_{60} Values

Standard penetration (split-spoon) samples were collected in general accordance with ASTM: D1586 with one primary modification. The ASTM test method consists of driving a 2-inch O.D. split-barrel sampler into the in-situ soil with a 140-pound hammer dropped from a height of 30 inches. The sampler is driven a total of 18 inches into the soil. After an initial set of 6 inches, the number of hammer blows to drive the sampler the final 12 inches is known as the standard penetration resistance or N-value. Our method uses a modified hammer weight, which is determined by measuring the system energy using a Pile Driving Analyzer (PDA) and an instrumented rod.

In the past, standard penetration N-value tests were performed using a rope and cathead for the lift and drop system. The energy transferred to the split-spoon sampler was typically limited to about 60% of its potential energy due to the friction inherent in this system. This converted energy then provides what is known as an N_{60} blow count.

The most recent drill rigs incorporate an automatic hammer lift and drop system, which has higher energy efficiency and subsequently results in lower N-values than the traditional N_{60} values. By using the PDA energy measurement equipment, we are able to determine actual energy generated by the drop hammer. With the various hammer systems available, we have found highly variable energies ranging from 55% to over 100%. Therefore, the intent of AET's hammer calibrations is to vary the hammer weight such that hammer energies lie within about 60% to 65% of the theoretical energy of a 140-pound weight falling 30 inches. The current ASTM procedure acknowledges the wide variation in N-values, stating that N-values of 100% or more have been observed. Although we have not yet determined the statistical measurement uncertainty of our calibrated method to date, we can state that the accuracy deviation of the N-values using this method is significantly better than the standard ASTM Method.

A.2.2 Disturbed Samples (DS)/Spin-up Samples (SU)

Sample types described as "DS" or "SU" on the boring logs are disturbed samples, which are taken from the flights of the auger. Because the auger disturbs the samples, possible soil layering and contact depths should be considered approximate.

A.2.3 Sampling Limitations

Unless actually observed in a sample, contacts between soil layers are estimated based on the spacing of samples and the action of drilling tools. Cobbles, boulders, and other large objects generally cannot be recovered from test borings, and they may be present in the ground even if they are not noted on the boring logs.

Determining the thickness of "topsoil" layers is usually limited, due to variations in topsoil definition, sample recovery, and other factors. Visual-manual description often relies on color for determination, and transitioning changes can account for significant variation in thickness judgment. Accordingly, the topsoil thickness presented on the logs should not be the sole basis for calculating topsoil stripping depths and volumes. If more accurate information is needed relating to thickness and topsoil quality definition, alternate methods of sample retrieval and testing should be employed.

A.3 CLASSIFICATION METHODS

Soil descriptions shown on the boring logs are based on the Unified Soil Classification (USC) system. The USC system is described in ASTM: D2487 and D2488. Where laboratory classification tests (sieve analysis or Atterberg Limits) have been performed, accurate classifications per ASTM: D2487 are possible. Otherwise, soil descriptions shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

Visual-manual judgment of the AASHTO Soil Group is also noted as a part of the soil description. A chart presenting details of the AASHTO Soil Classification System is also attached.

The boring logs include descriptions of apparent geology. The geologic depositional origin of each soil layer is interpreted primarily by observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

A.4 WATER LEVEL MEASUREMENTS

The ground water level measurements are shown at the bottom of the boring logs. The following information appears under "Water Level Measurements" on the logs:

- Date and Time of measurement
- Sampled Depth: lowest depth of soil sampling at the time of measurement
- Casing Depth: depth to bottom of casing or hollow-stem auger at time of measurement
- Cave-in Depth: depth at which measuring tape stops in the borehole
- Water Level: depth in the borehole where free water is encountered
- Drilling Fluid Level: same as Water Level, except that the liquid in the borehole is drilling fluid

The true location of the water table at the boring locations may be different than the water levels measured in the boreholes. This is possible because there are several factors that can affect the water level measurements in the borehole. Some of these factors include: permeability of each soil layer in profile, presence of perched water, amount of time between water level readings, presence of drilling fluid, weather conditions, and use of borehole casing.

A.5 TEST STANDARD LIMITATIONS

Field and laboratory testing is done in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

A.6 SAMPLE STORAGE

Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
AR:	Sample of material obtained from cuttings blown out the top of the borehole during air rotary procedure.
B, H, N:	Size of flush-joint casing
CAS:	Pipe casing, number indicates nominal diameter in inches
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
DP:	Direct push drilling; a 2.125 inch OD outer casing with an inner 1½ inch ID plastic tube is driven continuously into the ground.
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PQ:	PQ wireline core barrel
RDA:	Rotary drilling with compressed air and roller or drag bit.
RDF:	Rotary drilling with drilling fluid and roller or drag bit
REC:	In split-spoon (see notes), direct push and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
SS:	Standard split-spoon sampler (steel; 1.5" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after "falling" through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
▽:	Estimated water level based solely on sample appearance

TEST SYMBOLS

Symbol	Definition
CONS:	One-dimensional consolidation test
DEN:	Dry density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q_p:	Pocket Penetrometer strength, tsf (approximate)
q_c:	Static cone bearing pressure, tsf
q_u:	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remolded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES
(Calibrated Hammer Weight)

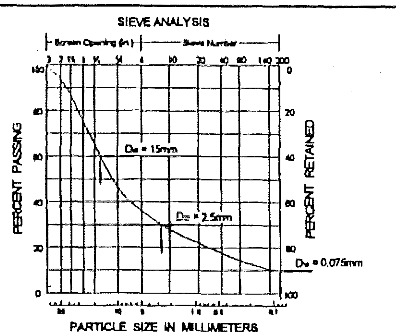
The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N_{60} values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

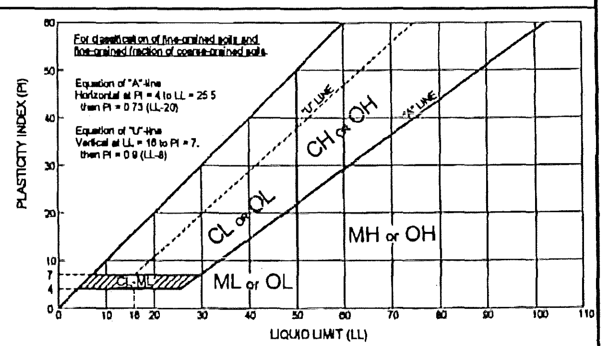
UNIFIED SOIL CLASSIFICATION SYSTEM
ASTM Designations: D 2487, D2488

AMERICAN ENGINEERING TESTING, INC.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines more than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly-graded sand[I]
		Sands with Fines more than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve (see Plasticity Chart below)	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit–oven dried / Liquid limit – not dried <0.75	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	Liquid limit–oven dried / Liquid limit – not dried <0.75	OH	Organic clay[K,L,M,P] Organic silt[K,L,M,Q]
Highly organic soil			Primarily organic matter, dark in color, and organic in odor	PT	Peat[R]



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{2.5^2}{0.075 \times 15} = 5.6$



Plasticity Chart

Notes

[A] Based on the material passing the 3-in (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$, $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot is hatched area, soils is a CL-ML silty clay.
[K] If soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.
[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.
[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI≥4 and plots on or above "A" line.
[O] PI<4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.
[R] Fiber Content description shown below.

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size

Term	Particle Size
Boulders	Over 12"
Cobbles	3" to 12"
Gravel	#4 sieve to 3"
Sand	#200 to #4 sieve
Fines (silt & clay)	Pass #200 sieve

Gravel Percentages

Term	Percent
A Little Gravel	3% - 14%
With Gravel	15% - 29%
Gravelly	30% - 50%

Consistency of Plastic Soils

Term	N-Value, BPF
Very Soft	less than 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	*Greater than 30*

Relative Density of Non-Plastic Soils

Term	N-Value, BPF
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Greater than 50

Moisture/Frost Condition
(MC Column)

- D (Dry): Absense of moisture, dusty, dry to touch.
- M (Moist): Damp, although free water not visible. Soil may still have a high water content (over "optimum").
- W (Wet/ Waterbearing): Free water visible intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.
- F (Frozen): Soil frozen

Layering Notes

- Laminations: Layers less than ½" thick of differing material or color.
- Lenses: Pockets or layers greater than ½" thick of differing material or color.

Peat Description

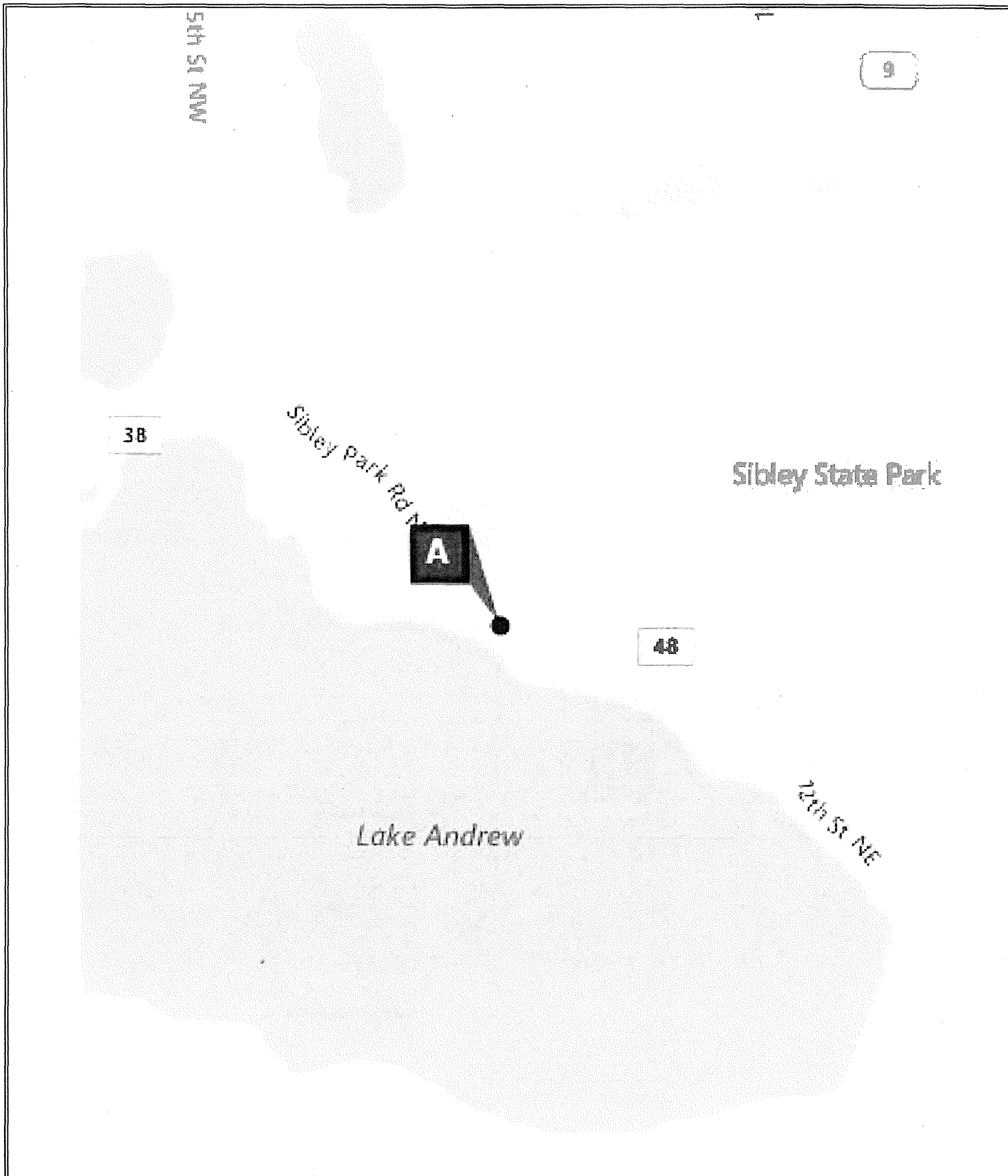
Term	Fiber Content (Visual Estimate)
Fibric Peat:	Greater than 67%
Hemic Peat:	33 – 67%
Sapric Peat:	Less than 33%

Organic Description (if no lab tests)

Soils are described as *organic*, if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. *Slightly organic* used for borderline cases.

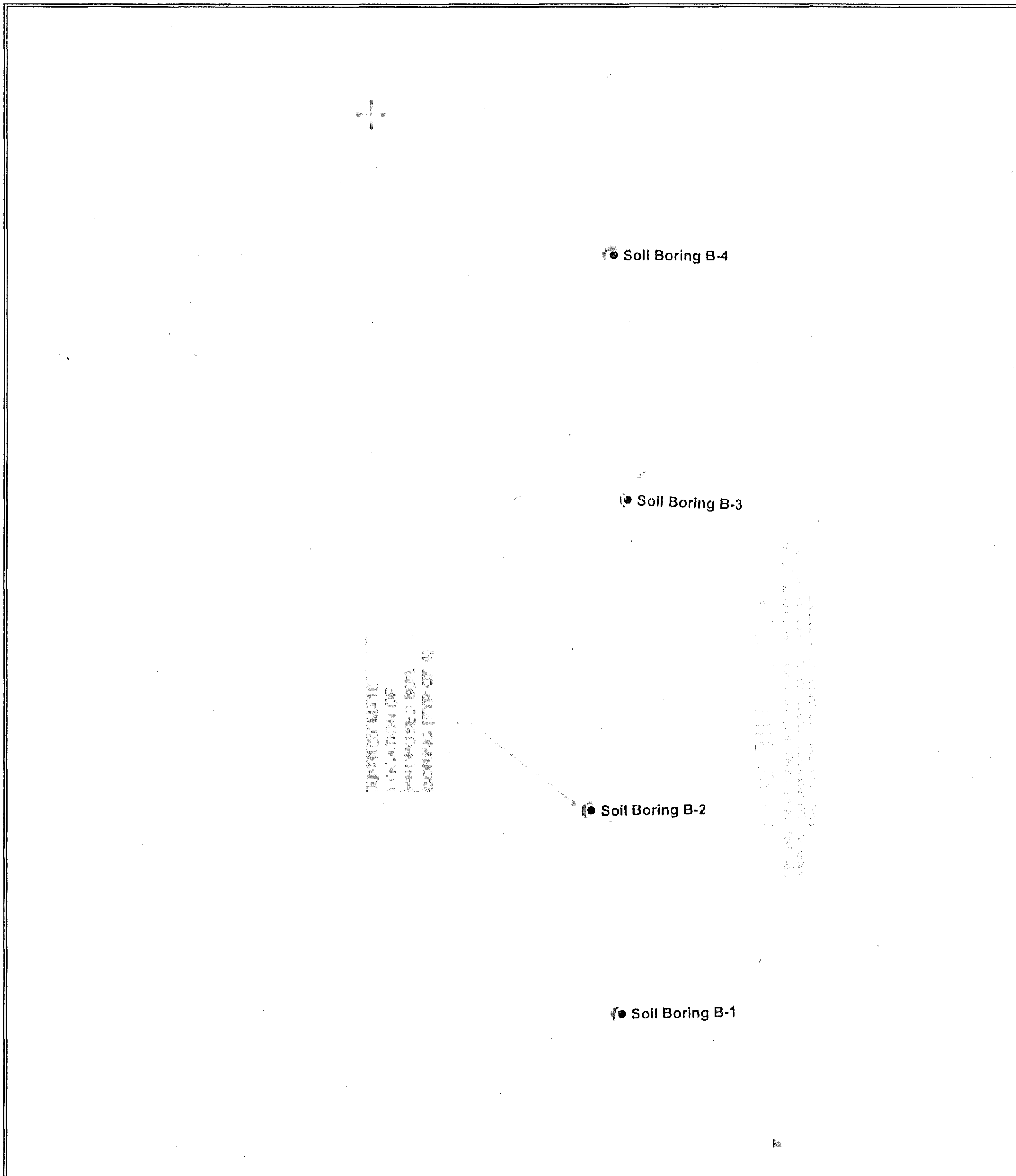
Root Inclusions

- With roots: Judged to have sufficient quantity of roots to influence the soil properties.
- Trace roots: Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.



AMERICAN ENGINEERING TESTING, INC.

Project: Sibley State Park – Beach Stabilization Project New London, Minnesota			AET Job No. 08-11538
Subject: Site Location			Date: June 30, 2014
Scale: NTS	Drawn By: SJR	Checked By: GG	Figure: 1



American Engineering Testing, Inc.	Project: Sibley State Park – Beach Stabilization Project New London, Minnesota			AET Job No. 08-11538
	Subject: Boring Locations			Date: June 30, 2014
	Scale: NTS	Drawn By: SJR	Checked By: GG	Figure: 2

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **08-11538** LOG OF BORING NO. **B-1 (p. 1 of 1)**

PROJECT: **Sibley State Park Beach Stablization Project; New London, Minnesota**

DEPTH IN FEET	SURFACE ELEVATION: 99.7' MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	qp
0–2	CLAYEY SAND with visible organics, black	TOPSOIL	6	M	SS	10					
2–4.5	SAND WITH SILT, a little gravel, medium to coarse grained, brown, loose (SP-SM)	COARSE ALLUVIUM	7	M	SS	14					
4.5–7	SAND WITH SILT AND GRAVEL, medium to fine grained, gray, medium dense (SP-SM)		24	M	SS	14					
7–9.5	CLAYEY SAND, a little gravel, gray, stiff (SC)	MIXED ALLUVIUM	9	M	SS	16	12				
9.5–21	SANDY LEAN CLAY, light gray and brown mottled, firm to stiff (CL)	TILL	8	M	SS	16	17				
			13	M	SS	18	14				
			18	M	SS	18	11				
			19	M	SS	18	12				
21	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-19½'	3.25" HSA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
6/9/14		21'	19.5'	19.5'	None	None

BORING COMPLETED: **6/9/14**

DR: **BP** LG: **TW** Rig: **24R**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 11538.GPJ AET+CPT+WELL.GDT 7/9/14

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **08-11538** LOG OF BORING NO. **B-2 (p. 1 of 1)**

PROJECT: **Sibley State Park Beach Stablization Project; New London, Minnesota**

DEPTH IN FEET	SURFACE ELEVATION: 99.0' MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS WC	DEN	LL	PL	qp
0–2	SILTY SAND with visible organics, black	TOPSOIL	4	M	SS	10					
2–7	SAND WITH SILT, a little gravel, medium to fine grained, gray, waterbearing below 3.9', medium dense (SP-SM)	COARSE ALLUVIUM	15	M	SS	12					
			17	W	SS	12					
7–12	SILTY SAND, fine grained, gray, loose, waterbearing (SM)		9	W	SS	16					
			7	W	SS	14					
12–14.5	ORGANIC LEAN CLAY with sand lenses, black and gray, soft (OL/OH)	SWAMP DEPOSIT	2	W	SS	12	52				
14.5–19.5	LEAN CLAY, gray, very soft (CL)	FINE ALLUVIUM	WH	W	SS	12	36				
19.5–21	FAT CLAY, gray, soft (CH)		2	W	SS	12	72				
21	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-19½'	**3.25" HSA**							
		6/9/14		**6'**	**4.4'**	**4.4'**	**None**	**3.9'**
		6/9/14		**21'**	**19.5'**	**18.6'**	**None**	**12.6'**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **6/9/14**

DR: **BP** LG: **TW** Rig: **24R**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 11538.GPJ AET+CPT+WELL.GDT 7/9/14

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **08-11538** LOG OF BORING NO. **B-3 (p. 1 of 1)**

PROJECT: **Sibley State Park Beach Stablization Project; New London, Minnesota**

SURFACE ELEVATION: **100.4'**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	qp
0–4	FILL, silty sand, black, mixed with areas of silty sand with gravel and visible organics, brown	FILL	10	M	SS	10					
			7	M	SS	6					
4–9	SAND WITH SILT, medium to fine grained, gray, medium dense, waterbearing below 5.8' (SP-SM)	COARSE ALLUVIUM	11	M	SS	12					
			9	W	SS	12					
9–11.5	SILTY SAND, fine to medium grained, brown, loose to very loose, waterbearing (SM)		5	W	SS	10					
11.5–14	SILTY SAND, fine grained, gray, very loose, lense of silt, waterbearing (SM)		2	W	SS	10					
14–19.5	ORGANIC CLAY, dark brown with white shells, soft (OH)	SWAMP DEPOSIT	2	W	SS	10	81				
19.5–21	FAT CLAY, gray, soft (CH)	FINE ALLUVIUM	2	W	SS	18	60				
21	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-19½'	**3.25" HSA**							
		6/9/14		**10'**	**8.5'**	**6.9'**	**None**	**5.8'**
		6/9/14		**21'**	**19.5'**	**19'**	**None**	**15.5'**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **6/9/14**

DR: **BP** LG: **TW** Rig: **24R**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 11538.GPJ AET+CPT+WELL.GDT 7/9/14

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: **08-11538** LOG OF BORING NO. **B-4 (p. 1 of 1)**

PROJECT: **Sibley State Park Beach Stablization Project; New London, Minnesota**

DEPTH IN FEET	SURFACE ELEVATION: **99.6'** MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	qp
0–2	FILL, silty sand with visible organics, black, pieces of asphalt	FILL	10	M	SS	8					
2–7	SAND WITH SILT, a little gravel, medium to fine grained, light gray, loose (SP-SM)	COARSE ALLUVIUM	24	M	SS	6					
			9	M/W	SS	12					
7–9	SAND WITH SILT, fine to medium grained, gray, loose, waterbearing (SP-SM)		4	W	SS	14					
9–12	CLAYEY SAND, black and gray, very soft (SC)	MIXED ALLUVIUM	1	W	SS	12	32				
12–14.5	SANDY LEAN CLAY, gray, soft (CL)	FINE ALLUVIUM	3	W	SS	14	25				
14.5–21	CLAYEY SAND, a little gravel, gray, very stiff to hard (SC)	MIXED ALLUVIUM	17	W	SS	16	14				
			32	W	SS	0					
21	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-19½'	**3.25" HSA**							
		6/9/14		**10'**	**8.5'**	**7.4'**	**None**	**6.5'**
		6/9/14		**21'**	**19.5'**	**19'**	**None**	**16.4'**

BORING COMPLETED: **6/9/14**

DR: **BP** LG: **TW** Rig: **24R**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 11538.GPJ AET+CPT+WELL.GDT 7/9/14

Appendix B

Geotechnical Report Limitations and Guidelines for Use

Appendix B
Geotechnical Report Limitations and Guidelines for Use
Report No. 08-11538

B.1 REFERENCE

This appendix provides information to help you manage your risks relating to subsurface problems which are caused by construction delays, cost overruns, claims, and disputes. This information was developed and provided by ASFE[1], of which, we are a member firm.

B.2 RISK MANAGEMENT INFORMATION

B.2.1 Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. And no one, not even you, should apply the report for any purpose or project except the one originally contemplated.

B.2.2 Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

B.2.3 A Geotechnical Engineering Report is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typically factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, always inform your geotechnical engineer of project changes, even minor ones, and request an assessment of their impact. Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.

B.2.4 Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. Do not rely on a geotechnical engineering report whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

1 ASFE, 8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733: www.asfe.org

B.2.5 Most Geotechnical Findings Are Professional Opinions
Site exploration identified subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

B.2.6 A Report's Recommendations Are Not Final
Do not overrely on the construction recommendations included in your report. Those recommendations are not final, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.

B.2.7 A Geotechnical Engineering Report Is Subject to Misinterpretation
Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

B.2.8 Do Not Redraw the Engineer's Logs
Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognizes that separating logs from the report can elevate risk.

B.2.9 Give Contractors a Complete Report and Guidance
Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In the letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

B.2.10 Read Responsibility Provisions Closely
Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their report. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

B.2.11 Geoenvironmental Concerns Are Not Covered
The equipment, techniques, and personnel used to perform a geoenvironmental study differ significantly from those used to perform a geotechnical study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated environmental problems have led to numerous project failures. If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. Do not rely on an environmental report prepared for someone else.