Report of Geotechnical Exploration

NPS BADL Rehabilitate Asphalt Pullouts
Loop Road and Rim Road
Badlands National Park, South Dakota

AET Project No. P-0016010

Date:
September 28, 2022

Prepared for:

HDR Engineering, Inc.
703 Main Street, Suite 200
Rapid City, South Dakota 57701

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Forensic • Environmental
Building Technology
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September 28, 2022

HDR Engineering, Inc.
703 Main Street, Suite 200
Rapid City, South Dakota 57701

Attn: Mr. Chris Bailey, PE

RE: Report of Geotechnical Exploration
NPS BADL Rehabilitate Asphalt Pullouts
Loop Road and Rim Road
Badlands National Park, South Dakota
AET Project No. P-0016010

Dear Chris,

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for the above referenced rehabilitation project within the Badlands National Park, near Interior, South Dakota. These services were performed in general accordance with our proposal dated July 26, 2022, and written authorization to proceed provided in HDR's Geotechnical Consultant Agreement Number 1000100077581, dated August 17, 2022. We are submitting one (1) electronic copy of the report to you.

Please contact our office if you have any questions about the report. We can also be contacted to arrange observation and testing services during the construction phase of the project.

Sincerely,
American Engineering Testing, Inc.

Walt Feeger, PE
Senior Geotechnical Engineer
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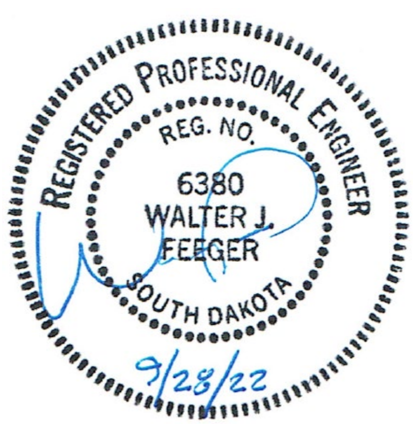

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1.0 INTRODUCTION

We understand the rehabilitation and construction of eight (8) pullouts has been proposed along Loop and Rim Roads in the Badlands National Park, near Interior, South Dakota. Please refer to Figure 1: Boring Location Map within Appendix A for the location of the site. To assist with the planning and design, American Engineering Testing, Inc. (AET) has been authorized to conduct a subsurface exploration program at the site, conduct soil laboratory testing, and perform a geotechnical engineering review for the project. This report presents the results of the above services and provides our engineering recommendations based on this data.

2.0 SCOPE OF SERVICES

AET's services were performed in general accordance with our proposal dated July 26, 2022. The authorized scope consists of the following:

- Eight (8) Standard Penetration Test (SPT) borings to depths of about 5 feet below existing grade within the areas of the existing and proposed pullouts.
- Soil laboratory testing.
- Geotechnical engineering analysis based on the gained data and preparation of this report.

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

3.0 PROJECT INFORMATION

Based on the information provided, we understand the National Park Service will be reconstructing or adding new asphalt paved parking areas/pullouts at eight (8) locations along Loop Road and Rim Road within the Badlands National Park.

The purpose of the geotechnical study will be to determine the subsurface conditions at the individual sites and to evaluate the suitability of the soils for use in constructing the proposed asphalt pavement sections.

The previously stated information represents our understanding of the proposed construction. This information is an integral part of our engineering review. It is important that you contact us if there are changes from that described so that we can evaluate whether modifications to our recommendations are appropriate.

4.0 SUBSURFACE EXPLORATION AND TESTING

4.1 Field Exploration Program

The subsurface exploration program conducted for the project consisted of eight (8) standard penetration test (SPT) borings drilled on August 30, 2022. The borings were drilled at locations selected by AET personnel based on information provided by HDR Engineering, Inc. (HDR). The logs of the borings and details of the methods used appear in Appendix A. The logs contain information concerning soil layering, soil classification, geologic origins, and moisture condition. A density description or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value).

The boring locations are shown on Figure 1: Boring Location Map included in Appendix A. Surface elevations at the boring locations were interpolated from a GoogleEarth^{tm} images of the sites.

4.2 Laboratory Testing

The laboratory test program included natural moisture content, Atterberg Limits, percent passing the #200 sieve, moisture-density relationship (proctor), and California Bearing Ratio (CBR). The test results appear in Appendix A on the individual boring logs adjacent to the samples upon which they were performed or on the data sheets following the logs.

The moisture-density relationship (modified Proctor) and California Bearing Ratio (CBR) tests, summarized below, are also included on separate sheets within Appendix A at the end of this report. The CBR test was remolded to approximately 95% of maximum dry density at the optimum moisture content for the specific boring/material.

Results are summarized as follows:

Boring	Soil Classification	Optimum Moisture Content, % [1]	Maximum Dry Density, pcf [1]	CBR Value[2]
B-2	Lean to Fat Clay (CL-CH)	14.4	108.5	1.9
B-4	Fat Clay (CH)	21.7	90.5	1.8
B-6	Silty Lean Clay (CL)	18.5	99.4	2.3
B-8	Sandy Lean Clay w/ Gravel (CL)	8.5	125.7	3.6

[1] Based on ASTM D 1698 (standard Proctor)
[2] Based on ASTM D 1883

It should be noted the bulk soil samples represents a mixture of the soils encountered within the upper 1 to 5 foot interval of the borehole. As such, the soil classification as presented on the Moisture-Density Relationship and CBR data sheets may differ from the classifications of the individual soil layers identified on the respective Subsurface Boring Log.

5.0 SITE CONDITIONS

5.1 Surface Observations

At the time of our field work, the areas of the pullouts consisted of either existing asphalt paved pullouts or vacant areas of right-of-way along Loop and Rim Roads, with these areas vegetated with native grasses and weeds.

5.2 Subsurface Soils/Geology

The subsurface soils encountered within the borings consisted firm to hard lean to fat clays, associated with the White River Group, which extended to the total depths explored in each of the borings.

The Subsurface Boring Logs included in Appendix A give a more detailed description of the soils encountered within the borings.

5.3 Groundwater

At the time of our field work, groundwater was not encountered in any of the borings drilled at the site. The lack of groundwater noted at the boring locations should not be taken as an accurate representation of the actual groundwater levels. Groundwater levels can fluctuate due to varying seasonal and annual rainfall and snow melt amounts, as well as other factors including local irrigation practices and levels of water in drainage areas. A long period of time may be required for groundwater to stabilize in the soils present at the site; this period of time is generally not available during a typical subsurface exploration program.

6.0 RECOMMENDATIONS

6.1 Discussion

The following recommendations are based on the soil conditions observed in the soil borings at the time of our exploration. The soils between the boring locations may differ significantly from those encountered at the boring locations.

Further, changes in climatic conditions between the time of exploration and the time of construction may also affect soil conditions, particularly ground water levels and the moisture content of the soils.

It is anticipated that, once the existing pavement and/or topsoil is removed along the existing/future pullout areas, the exposed subgrade will be relatively stable. However, soft, wet, and potentially unstable subgrade soils will likely develop if the clay subgrade is left open to the elements for an extended period of time. If possible, construction should take place during warmer weather months (typically May through October) which will aid in the proper processing and moisture conditioning of the exposed subgrade soils. Furthermore, we recommend the bid documents include a line item for subgrade remediation, should it be required, including the use of stabilization/separation materials such as geogrid or geo-fabric.

At this time, other than construction of new embankments associated with widening of the existing alignment to accommodate the pullouts, we do not expect any significant grade changes within the construction areas. The following recommendations are based on the soil conditions observed in the soil borings at the time of our exploration. The near surface subgrade soils consisted of clay soils which are considered fair materials for pavement support and will control the pavement design analysis. However, the soils between the boring locations may differ significantly from those encountered at the boring locations. Further, changes in climatic conditions between the time of exploration and the time of construction may also affect soil conditions, particularly groundwater levels and the moisture content of the soils.

Additionally, all imported fill material required for construction of the new roadway widening embankments should be submitted to the geotechnical engineer for approval prior to use.

6.2 Site Grading and Embankment Fill Requirements

Once the existing asphalt surfacing section and/or topsoil has been removed (where applicable), and the design grades achieved, the exposed subgrade should be scarified to a depth of at least 8-inches, the moisture content of the soils adjusted to near optimum and the material compacted to at least 95% of the maximum dry density as determined by ASTM D698 (standard Proctor).

Past experience has shown that subgrade soils under existing pavement sections are typically above the optimum moisture content, and once exposed can potentially be soft and unstable. Processing and moisture conditioning of these soils will be required to reach the required compactive effort.

Within areas to receive embankment fill for the new or extended pullouts, we recommend that all topsoil/organics, man-made debris, and other unsuitable materials be removed in their entirety from within the proposed fill areas. Stripped materials consisting of vegetation/organic and unsuitable debris should be wasted from the site. Topsoil may be stockpiled on-site to re-vegetate embankment slopes after completion of grading operations.

Where required, excavations should continue to the desired grade elevations. The site soils are suitable for use as fill material required to reach the desired pullout alignment elevations. All excavated material should be cleaned of all topsoil/organics, unsuitable materials, and aggregate/gravel greater than 3 inches in nominal size prior to re-use.

Where applicable, areas to receive fill should be scarified to a depth of at least 8-inches, the moisture content of the scarified soils adjusted to near optimum moisture content and the soils recompacted to at least 95% of maximum standard Proctor dry density (ASTM D698).

Prior to use, approved embankment fill material should be moisture conditioned to -1 to +3% for clay soils and ±3% for all granular (sand and gravel) soils. The material should be placed in maximum 8-inch loose lift thicknesses and compacted to a minimum of 95% of the maximum dry density (ATM D698). We recommend that all new embankment material be benched into the existing roadway alignment subgrade. The benching should be of sufficient width to permit operations of earthwork and compacting equipment. We recommend that the new embankment have outside slopes of 4H:1V and in no case should be steeper than 3H:1V. The slopes should be vegetated once completed to provide stability and limit the effects of erosion.

Once properly prepared and the embankment construction complete, and prior to placement of aggregate base course, the exposed subgrade should be proof rolled. Proof-rolling should be performed with a loaded tandem axle dump truck or water truck to verify a firm and unyielding subgrade has been achieved. Any areas that pump under the loaded dump truck will require remediation prior to placement of the pavement section.

Remediation consists of additional scarification and recompaction, removal of unstable material and replacement with granular material, or with the use of geotextile separation/stabilization material. Where required, the geotechnical engineer should be consulted to provide further remedial recommendations. Once the subgrade has been proof rolled and approved by the geotechnical engineer, sub-base and/or aggregate basecourse may be placed.

6.3 Pavements

6.3.1 Considerations

The following pavement section was designed based on the procedures outlined in the 1993 AASHTO Empirical Equation for Flexible Pavements and Rigid Pavements. As previously noted, it is anticipated that pavement subgrade soils along the pullouts will consist of lean to fat clays, which are considered fair materials for pavement support. For our design analysis, an average CBR value of 2.4 was utilized based on the laboratory test results. In addition to the calculated average laboratory CBR value, we have used the following design parameters;

Design Criteria	Asphalt
18-kip ESAL (20 year design life)	125,000
Overall Design Standard Deviation	0.45
Soil Resilient Modulus	CBR x 1500
Initial Serviceability	4.2
Terminal Serviceability	2.0
Reliability, %	90
Drainage Coefficient	0.75

Please note that the 18-kip ESAL value takes into consideration daily traffic to include cars, pickup trucks and Recreation Vehicles (RVs). The 20-year design period is considered to be the interval over which, with proper maintenance, the pavement will not require major repairs. A continuing regular maintenance program should be implemented to maintain satisfactory serviceability over the design life. The maintenance program should include sealing cracks and repairing minor deficiencies. Please notify us if any of the parameters used in the pavement design do not adequately define the anticipated conditions.

6.3.2 Pavement Section Recommendations

Based on the above stated information and our analysis, we recommend the following pavement section be used for this project:

Recommended Pavement Section Thickness (inches)			
Traffic Area	**Flexible (Asphalt), in.**	**Aggregate Base Course, in.**	**Total, in.**
Pullouts – Loop and Rim Roads	5	8	13

If a high modulus geotextile, such as Mirafi RS380i, or approved equivalent, is placed on the prepared subgrade, for separation and reinforcement purposes, the following pavement section may be utilized:

Traffic Area	Asphalt, inches	Aggregate Base Course, inches	Geotextile Reinforcement	Total, inches
Pullouts – Loop and Rim Roads	5	6	Mirafi RS380i	11

We recommend the asphalt be obtained from an approved mix design conforming to the South Dakota Department of Transportation (SDDOT) Class E Specifications as defined in Sections 320 and 321 of the “Standard Specifications for Road and Bridges”, current edition.

Aggregate used in the asphalt should meet SDDOT specifications under Section 880 “Aggregate for Asphalt Concrete” for quality and gradation. Mix designs should be submitted prior to construction to verify their adequacy.

6.3.3 Aggregate Base Course

Aggregate base course gravel should be moisture conditioned to within ±3% of optimum and compacted to a minimum of 95% of maximum density as determined by the standard Proctor method (ASTM D698) and should meet the requirements as outlined in Section 882 “Aggregates for Granular Bases and Surfacing” of the SDDOT specifications.

6.4 Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program.

Preventive maintenance activities are intended to slow the rate of pavement deterioration. Pavement maintenance consists of both localized maintenance (crack and joint sealing and patching) and global maintenance (surface sealing).

Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance program, additional engineering input is recommended to determine the type and extent of preventive maintenance appropriate. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Potential Difficulties

7.1.1 Soft Subgrade Soils

Depending on the time of year in which construction takes place, unstable subgrade soils could be encountered once the existing pavement section is removed. If encountered, additional conditioning of the soils may be required to obtain moisture contents which allow for firm and unyielding subgrade and/or compaction.

Localized areas of soft wet subgrades can be remedied with additional excavation to expose firmer soils, placement of coarse rock to provide a solid base on which to place additional fill and/or the use of geotextiles between the soft soils and the overlying fill and/or pavement sections. The appropriate means of subgrade stabilization should be evaluated by the geotechnical engineer at the time of construction.

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 the exposed subgrade and any 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, we have endeavored to provide our services according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, 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.”

AMERICAN
ENGINEERING TESTING

Standard Sheets

PAVEMENT IMPROVEMENT METHODS

RECONSTRUCTION

Reconstruction involves the removal of the existing pavement system and allows for improvements to the subgrade, whether for soil strength reasons or for frost/drainage improvement reasons (or both). The reconstruction approach should provide the best long-term pavement performance of the methods listed, particularly where subgrade soils are clayey or silty; and have poor stability, frost, and/or drainage properties. For frost/drainage improvement through clayey/silty soil areas, the subgrade correction would involve the placement of a sand subbase layer directly beneath the aggregate base. The degree of performance improvement in poor draining and/or frost susceptible soils is generally proportional to the sand subbase thickness placed. Incorporation of a sand subbase through poor frost/drainage soil areas also increases the likelihood that future pavement rehabilitation can be performed with less expensive methods, such as a mill and overlay.

REMOVE AND REPLACE

This procedure is essentially a reconstruction approach, although the intent is not to improve the subgrade. With this approach, it is prudent to conduct a test roll over fine grained subgrade soils and conduct local improvement of observed unstable soils which develop. With this local improvement, the approach would essentially be considered reconstruction without the incorporation of a sand subbase; and without the performance improvement that can be expected from better drainage and reduced frost susceptibility.

MILL AND OVERLAY

This procedure removes the upper portion of the existing bituminous, but leaves the lower portion in-place such that improvement to the sublayers is not possible. This approach requires sufficient thickness of bituminous such that enough bituminous remains to prevent the paving equipment from breaking through the layer; this thickness is typically considered to be at least 1½ inches, and even this depends on the bituminous condition. Note that with the mill and overlay approach, cracks from the existing pavement will reappear in the new surface layer after a short time (reflection cracking). Accordingly, this approach should be avoided for those pavements which include significant distress cracking and/or irregularity.

FULL DEPTH RECLAMATION

The full depth reclamation (FDR) process involves crushing both bituminous and aggregate base layers in-place and blending the material with the intent of creating a modified aggregate base. Additional improvement can be gained by stabilizing the modified base with emulsified asphalt (which allows for thinner new bituminous surfacing). These processes require that appropriate material types and thicknesses be in-place. A fresh bituminous layer would then be placed over the reclaimed material. These approaches will outperform the mill and overlay approach, since reflection cracking does not develop; although will not outperform a reconstruction approach if the subgrade has strength, frost, and/or drainage deficiencies. If original grades need to be maintained, excess materials will need to be removed from the site. Methods include milling the surface bituminous for removal prior to recycling or conducting the reclamation process and then removing a portion of the reclaimed material.

Appendix A

Geotechnical Field Exploration and Testing
Boring Log Notes
Unified Soil Classification System
Figure 1: Boring Location Map
Subsurface Boring Logs
Moisture-Density Relationship (Proctor) Report
California Bearing Ratio (CBR) Test Reports

Appendix A
Geotechnical Field Exploration and Testing
AET Project No. P-0016010

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling and sampling standard penetration test (SPT) borings. The locations of the borings appear on Figure 2, preceding the Subsurface Boring Logs 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.

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 LABORATORY TEST METHODS

A.5.1 Water Content Tests
Conducted per AET Procedure 01-LAB-010, which is performed in general accordance with ASTM: D2216 and AASHTO: T265.

A.5.2 Atterberg Limits Tests
Conducted per AET Procedure 01-LAB-030, which is performed in general accordance with ASTM: D4318 and AASHTO: T89, T90.

A.5.3 Sieve Analysis of Soils (thru #200 Sieve)
Conducted per AET Procedure 01-LAB-040, which is performed in general conformance with ASTM: D6913, Method A.

A.5.4 Particle Size Analysis of Soils (with hydrometer)
Conducted per AET Procedure 01-LAB-050, which is performed in general accordance with ASTM: D422 and AASHTO: T88.

A.5.5 Unconfined Compressive Strength of Cohesive Soil
Conducted per AET Procedure 01-LAB-080, which is performed in general accordance with ASTM: D2166 and AASHTO: T208.

A.5.6 Laboratory Soil Resistivity using the Wenner Four-Electrode Method
Conducted per AET Procedure 01-LAB-090, which is performed using Soil Box apparatus in the laboratory in general accordance with ASTM: G57

A.6 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.7 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≥4 and 1≤Cc≤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≥6 and 1≤Cc≤3[E]	SW	Well-graded sand[I]
			Cu<6 and 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	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	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	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	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]

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

[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.

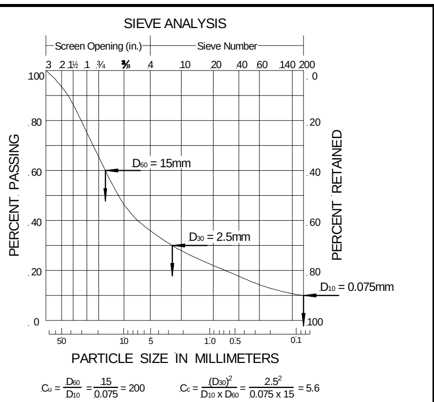
[N]PI≥4 and plots on or above "A" line.

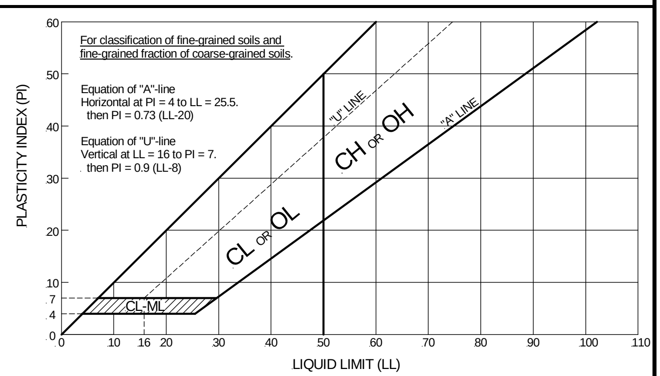
[O]PI<4 or plots below "A" line.

[P]Pl plots on or above "A" line.

[Q]Pl plots below "A" line.

[R]Fiber Content description shown below.





Plasticity Chart

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):	Absence 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.

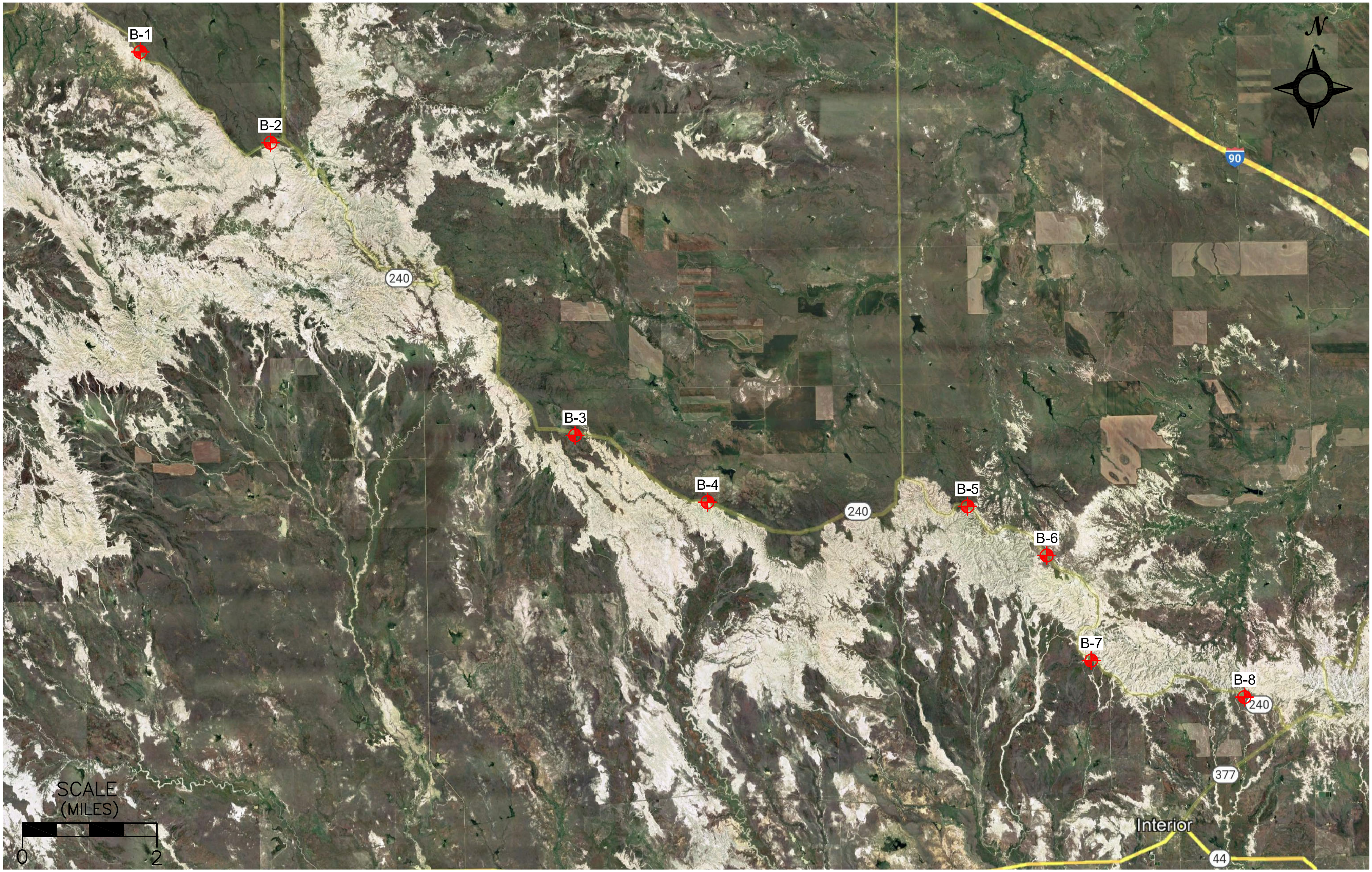
Fiber Content of Peat

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

Organic/Roots 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 soil properties. *Slightly organic* used for borderline cases.

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.



PROJECT: NPS BADL REHABILITATE ASPHALT PULLOUTS ALONG LOOP ROAD BADLANDS NATIONAL PARK, SOUTH DAKOTA		PROJECT NO. P–0016010
SUBJECT: FIGURE 1: BORING LOCATION MAP		DATE: SEPTEMBER 7, 2022
SCALE: 1 INCH = 2 MILES	DRAWN BY: JR	REVIEWED BY: WF

AMERICAN ENGINEERING TESTING

SUBSURFACE BORING LOG

AET No: **P-0016010** Log of Boring No. **B- 1 (p. 1 of 1)**

Project: **NPS BADL Rehabilitate Asphalt Pullouts; Badlands National Park, SD**

Surface Elevation **2988.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	TOPSOIL	TOPSOIL									
	LEAN CLAY, light brown, very stiff to hard (CL)	WHITE RIVER GROUP	26	M	SS	18					
1											
2											
3			34	M	SS	18	12		44	19	
4											
5											
			44	M	SS	18	21				
6											
	Bottom of Boring										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
5.0	**4" FA**	**8/30/22**	**14:33**	**6.5**	**--**	**--**	**--**	**None**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **8/30/22**

DR: **ES** LG: **SC** Rig: **Rig 106**

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

AET_CORP P-0016010.GPJ AET+CPT+WELL.GDT 9/27/22

SUBSURFACE BORING LOG

AET No: **P-0016010** Log of Boring No. **B- 2 (p. 1 of 1)**

Project: **NPS BADL Rehabilitate Asphalt Pullouts; Badlands National Park, SD**

DEPTH IN FEET	Surface Elevation 3094.0 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	TOPSOIL	TOPSOIL									
	FAT CLAY, brown, stiff to hard (CH)	WHITE RIVER GROUP	11	M	SS	18					
1											
2											
3			47	M	SS	18	21		53	24	
4											
5											
			44	M	SS	18	21				100
6											
	Bottom of Boring										

DEPTH:	DRILLING METHOD
5.0	4" FA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
8/30/22	15:34	6.5	--	--	--	None

BORING COMPLETED: **8/30/22**

DR: **ES** LG: **SC** Rig: **Rig 106**

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

SUBSURFACE BORING LOG

AMERICAN ENGINEERING TESTING

AET No: **P-0016010** Log of Boring No. **B- 3 (p. 1 of 1)**

Project: **NPS BADL Rehabilitate Asphalt Pullouts; Badlands National Park, SD**

Surface Elevation **2805.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	ASPHALT, 5-inches	PAVEMENT									
	AGGREGATE BASE COURSE, 8-inches		12	M	SS	18					
1	**SILTY LEAN CLAY**, brown, firm to stiff, trace sand present (CL)	WHITE RIVER GROUP									
2											
3			7	M	SS	18	17				
4											
5											
			12	M	SS	18	15				
6											
	Bottom of Boring										

DEPTH:	DRILLING METHOD
5.0	4" FA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
8/30/22	13:44	6.5	--	--	--	None

BORING COMPLETED: **8/30/22**

DR: **ES** LG: **SC** Rig: **Rig 106**

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

AET_CORP P-0016010.GPJ AET+CPT+WELL.GDT 9/27/22

SUBSURFACE BORING LOG

AMERICAN ENGINEERING TESTING

AET No: **P-0016010** Log of Boring No. **B- 4 (p. 1 of 1)**

Project: **NPS BADL Rehabilitate Asphalt Pullouts; Badlands National Park, SD**

Surface Elevation **2682.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	TOPSOIL	TOPSOIL									
	FAT CLAY, brown, very stiff to hard, bentonitic (CH)	WHITE RIVER GROUP	19	M	SS	18					
1											
2											
3			21	M	SS	18	22				99
4											
5											
			55	M	SS	18	23		80	27	
6											
	Bottom of Boring										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
5.0	**4" FA**	**8/30/22**	**13:06**	**6.5**	**--**	**--**	**--**	**None**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **8/30/22**

DR: **ES** LG: **SC** Rig: **Rig 106**

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

AET_CORP P-0016010.GPJ AET+CPT+WELL.GDT 9/27/22

SUBSURFACE BORING LOG

AET No: **P-0016010** Log of Boring No. **B- 5 (p. 1 of 1)**

Project: **NPS BADL Rehabilitate Asphalt Pullouts; Badlands National Park, SD**

DEPTH IN FEET	Surface Elevation 2685.0 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	TOPSOIL	TOPSOIL									
	SILTY LEAN to FAT CLAY, light brown to light grey, very stiff to hard (CL-CH)	WHITE RIVER GROUP	19	M	SS	18					
1											
2											
3			30	M	SS	18	11				
4											
5											
			58	M	SS	18	14				
6											
	Bottom of Boring										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
5.0	**4" FA**	**8/30/22**	**12:33**	**6.5**	**--**	**--**	**--**	**None**

BORING COMPLETED: **8/30/22**

DR: **ES** LG: **SC** Rig: **Rig 106**

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

AET_CORP P-0016010.GPJ AET+CPT+WELL.GDT 9/27/22

SUBSURFACE BORING LOG

AET No: **P-0016010** Log of Boring No. **B- 6 (p. 1 of 1)**

Project: **NPS BADL Rehabilitate Asphalt Pullouts; Badlands National Park, SD**

Surface Elevation **2688.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	TOPSOIL	TOPSOIL									
	SILTY LEAN CLAY, light brown, soft to firm, sand present (CL)	WHITE RIVER GROUP	8	M	SS	18					
1											
2											
3			5	M	SS	18	31				86
4											
5											
			4	M	SS	18	35				
6											
	Bottom of Boring										

DEPTH:	DRILLING METHOD
5.0	4" FA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
8/30/22	**12:01**	**6.5**	**--**	**--**	**--**	**None**

BORING COMPLETED: **8/30/22**

DR: **ES** LG: **SC** Rig: **Rig 106**

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

AET_CORP P-0016010.GPJ AET+CPT+WELL.GDT 9/27/22

SUBSURFACE BORING LOG

AET No: **P-0016010** Log of Boring No. **B- 7 (p. 1 of 1)**

Project: **NPS BADL Rehabilitate Asphalt Pullouts; Badlands National Park, SD**

Surface Elevation **2463.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	TOPSOIL	TOPSOIL									
1	**SILTY LEAN CLAY**, light brown, firm to stiff (CL)	WHITE RIVER GROUP	10	M	SS	18					
2											
3			8	M	SS	18	17				
4											
5											
6	**SILTY LEAN CLAY with SAND**, light grey, soft (CL)		2	M	SS	18	30		44	17	
	Bottom of Boring										

DEPTH:	DRILLING METHOD
5.0	4" FA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
8/30/22	11:20	6.5	--	--	--	None

BORING COMPLETED: **8/30/22**

DR: **ES** LG: **SC** Rig: **Rig 106**

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

SUBSURFACE BORING LOG

AMERICAN ENGINEERING TESTING

AET No: **P-0016010** Log of Boring No. **B- 8 (p. 1 of 1)**

Project: **NPS BADL Rehabilitate Asphalt Pullouts; Badlands National Park, SD**

Surface Elevation **2431.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	TOPSOIL	TOPSOIL									
1	**SANDY LEAN CLAY with GRAVEL**, brown, firm to hard (CL)	WHITE RIVER GROUP	34	M	SS	18					
2											
3			12	M	SS	18	8				
4											
5	**SILTY LEAN CLAY**, light brown, firm (CL)										
6			7	M	SS	18	30				
	Bottom of Boring										

DEPTH:	DRILLING METHOD
5.0	4" FA

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
8/30/22	10:41	6.5	--	--	--	None

BORING COMPLETED: **8/30/22**

DR: **ES** LG: **SC** Rig: **Rig 106**

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

AET_CORP P-0016010.GPJ AET+CPT+WELL.GDT 9/27/22

American Engineering Testing, Inc.
Rapid City
1745 Samco Road
Rapid City, SD 57702
(605) 388-0029
www.teamAET.com

Report No: PTR:AET-080168-S1

Proctor Report

Client: HDR Engineering, Inc.

CC:

Project: NPS BADL Rehabilitate Asphalt Pullouts
Badlands National Park

near Interior SD

Job No: P-0016010

Date of Issue: 9/1/2022

Sample Details

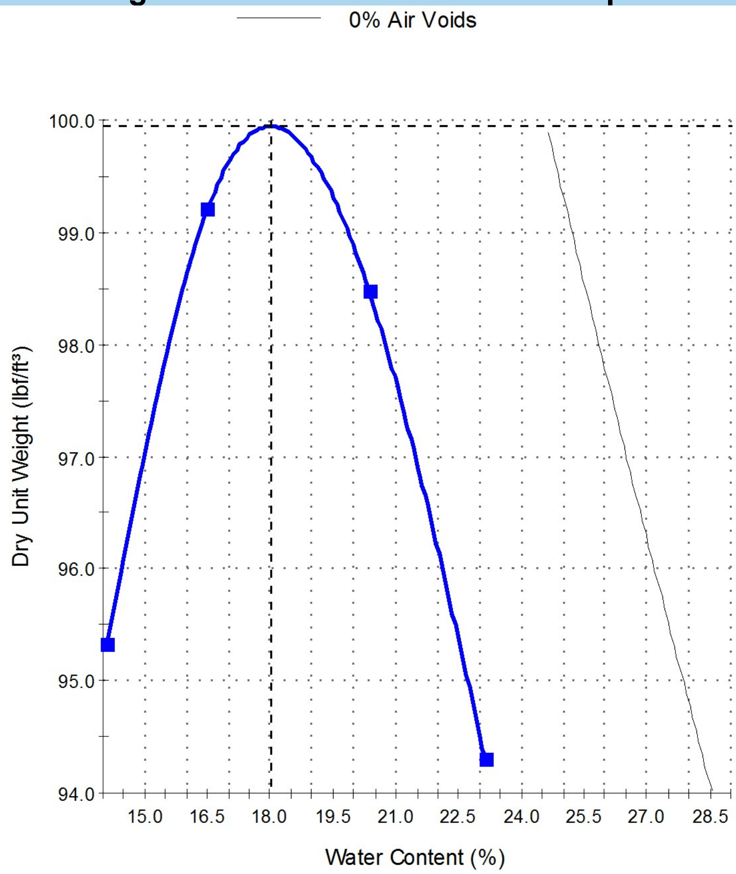
Sample ID: AET-080168-S1 **Field ID:** Bulk B-2 1-5'

Date Sampled: 8/30/2022

Material: Lean to Fat Clay (CL-CH)

Location: Boring B-2

Dry Unit Weight - Water Content Relationship



Test Results

ASTM D 698

Maximum Dry Unit Weight (lbf/ft³):	**99.9**
Optimum Water Content (%):	**18.0**
Method:	A
Preparation Method:	Moist
Specific Gravity (Fines):	2.65
Specific Gravity Method:	Assumed
Retained Sieve No 4 (4.75mm) (%):	20
Passing Sieve No 4 (4.75mm) (%):	80
Tested By:	Christine Olson
Date Tested:	9/1/2022

ASTM D 4718

Corrected Maximum Dry Unit Weight (lbf/ft³):	**108.5**
Corrected Optimum Water Content (%):	**14.4**
Specific Gravity (Oversize):	2.65
Sieve Size (Oversize):	No 4
Oversize Particles (%):	20

Comments

American Engineering Testing, Inc.
Rapid City
1745 Samco Road
Rapid City, SD 57702
(605) 388-0029
www.teamAET.com

Report No: PTR:AET-080168-S2

Proctor Report

Client: HDR Engineering, Inc.

CC:

Project: NPS BADL Rehabilitate Asphalt Pullouts
Badlands National Park

near Interior SD

Job No: P-0016010

Date of Issue: 9/6/2022

Sample Details

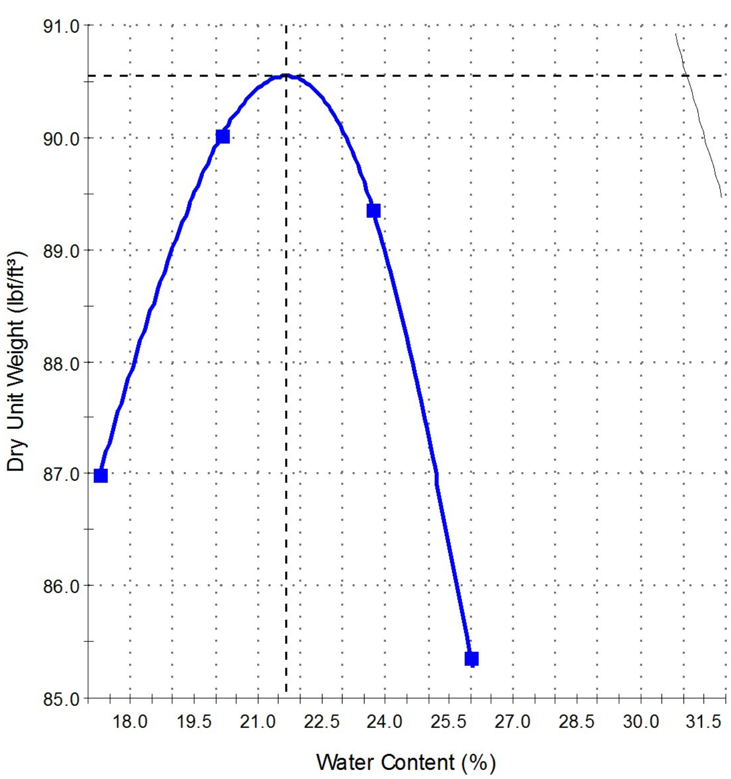
Sample ID: AET-080168-S2 **Field ID:** Bulk B-4 1-5'

Date Sampled: 8/30/2022

Material: Fat Clay (CH)

Location: Boring B-4

Dry Unit Weight - Water Content Relationship



Test Results

ASTM D 698

Maximum Dry Unit Weight (lbf/ft³):	**90.5**
Optimum Water Content (%):	**21.7**
Method:	A
Preparation Method:	Moist
Specific Gravity (Fines):	2.65
Specific Gravity Method:	Assumed
Retained Sieve No 4 (4.75mm) (%):	4
Passing Sieve No 4 (4.75mm) (%):	96
Tested By:	Christine Olson
Date Tested:	9/1/2022

Comments

American Engineering Testing, Inc.
Rapid City
1745 Samco Road
Rapid City, SD 57702
(605) 388-0029
www.teamAET.com

Report No: PTR:AET-080168-S3

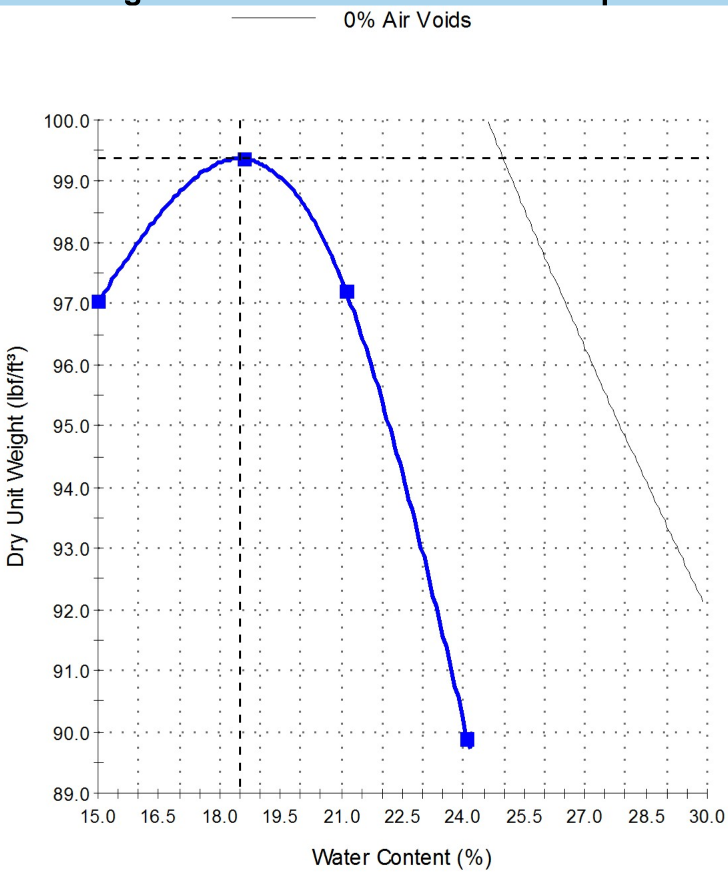
Proctor Report

Client:	HDR Engineering, Inc.	**CC:**	
Project:	NPS BADL Rehabilitate Asphalt Pullouts Badlands National Park near Interior SD		
Job No:	P-0016010	Date of Issue:	9/2/2022

Sample Details

Sample ID:	AET-080168-S3	**Field ID:**	Bulk B-6 1-5'
Date Sampled:	8/30/2022		
Material:	Silty Lean Clay (CL)		
Location:	Boring B-6		

Dry Unit Weight - Water Content Relationship



Test Results

ASTM D 698

Maximum Dry Unit Weight (lbf/ft³):	**99.4**
Optimum Water Content (%):	**18.5**
Method:	A
Preparation Method:	Moist
Specific Gravity (Fines):	2.65
Specific Gravity Method:	Assumed
Tested By:	Christine Olson
Date Tested:	9/1/2022

Comments

American Engineering Testing, Inc.
Rapid City
1745 Samco Road
Rapid City, SD 57702
(605) 388-0029
www.teamAET.com

Proctor Report

Report No: PTR:AET-080168-S4

Client: HDR Engineering, Inc.

CC:

Project: NPS BADL Rehabilitate Asphalt Pullouts
Badlands National Park

near Interior SD

Job No: P-0016010

Date of Issue: 9/2/2022

Sample Details

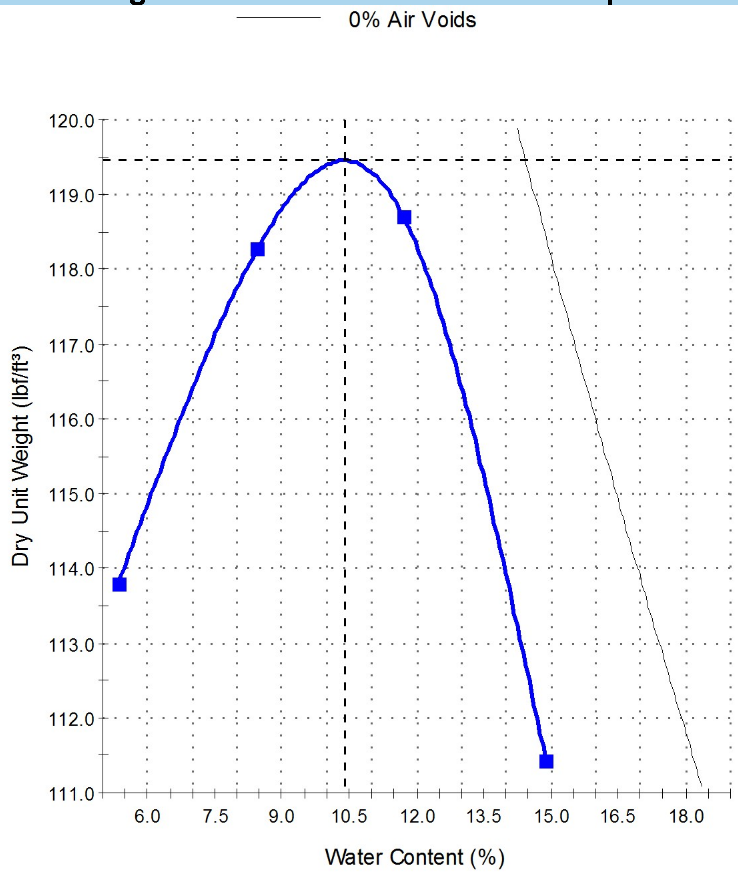
Sample ID: AET-080168-S4 **Field ID:** Bulk B-8 1-5'

Date Sampled: 8/30/2022

Material: Sandy Lean Clay with Gravel

Location: (CL) Boring B-8

Dry Unit Weight - Water Content Relationship



Test Results

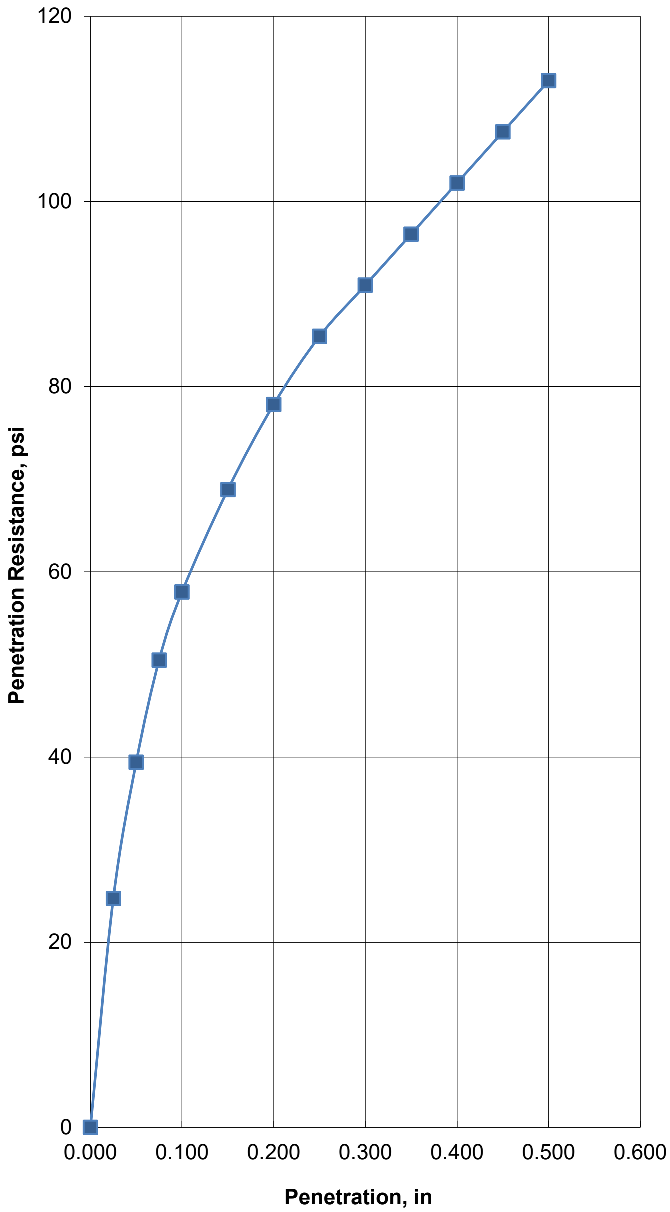
ASTM D 698

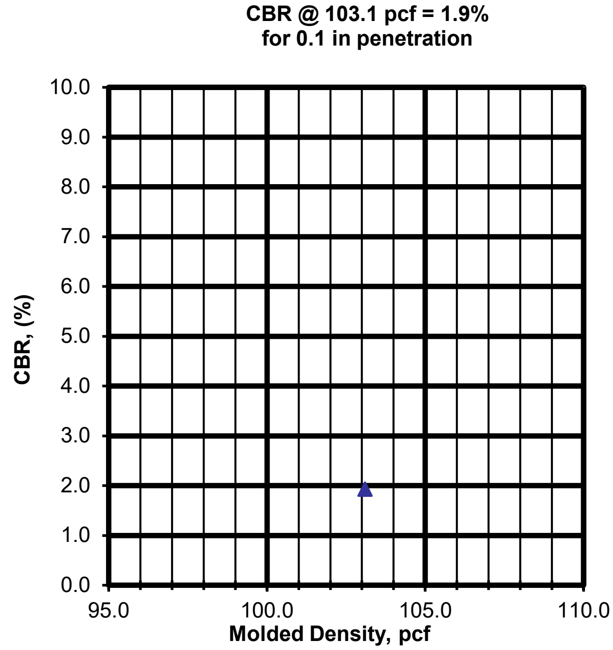
Maximum Dry Unit Weight (lbf/ft³):	**119.5**
Optimum Water Content (%):	**10.4**
Method:	A
Preparation Method:	Moist
Specific Gravity (Fines):	2.65
Specific Gravity Method:	Assumed
Retained Sieve No 4 (4.75mm) (%):	18
Passing Sieve No 4 (4.75mm) (%):	82
Tested By:	Christine Olson
Date Tested:	9/1/2022

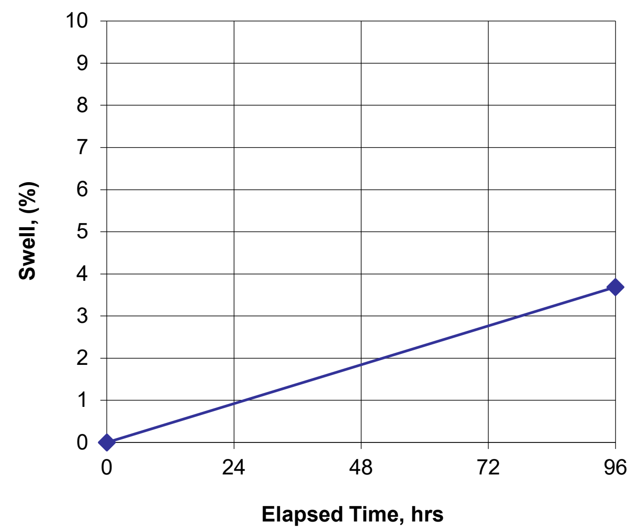
ASTM D 4718

Corrected Maximum Dry Unit Weight (lbf/ft³):	**125.7**
Corrected Optimum Water Content (%):	**8.5**
Specific Gravity (Oversize):	2.65
Sieve Size (Oversize):	No 4
Oversize Particles (%):	18

Comments







Molded			Soaked			CBR, (%)		Pen.	Swell
Dens.	% Max.	% Moisture	Dens.	% Max.	% Moisture	0.1 in	0.2 in	Surcharge	%
103.1	95.0	14.4	99.6	91.8	22.6	1.9	1.7	10lb	3.7
MATERIAL DESCRIPTION					USCS	Max. Dens.	Opt. Mois.	LL	PI
Lean to Fat Clay (CL-CH)					CL-CH	108.5	14.4		

Project No: P-0016010 Bulk B-2 1-5'

Project: NPS BADL Rehabilitate Asphalt Pullouts
Badlands National Park, SD

Date: 9/23/2022

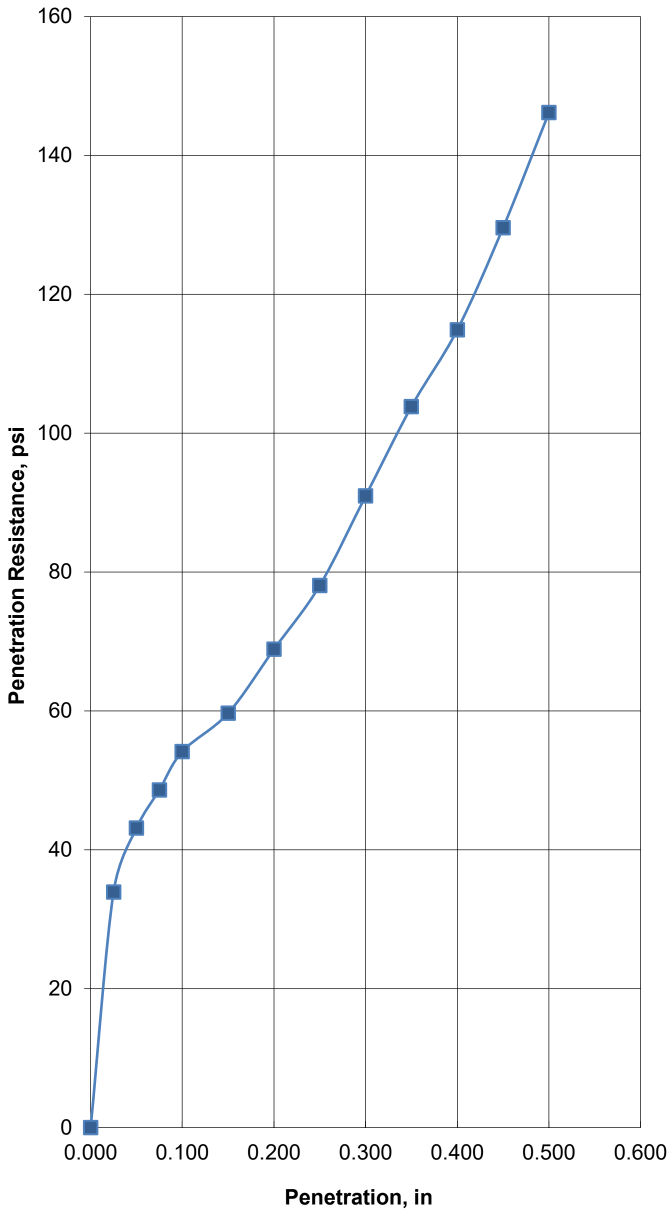
Test Descr. / Remarks

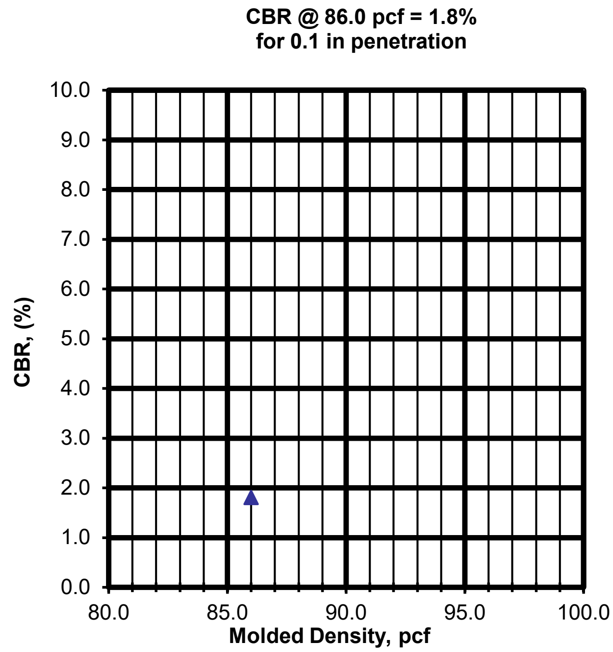
CBR: ASTM: D1883

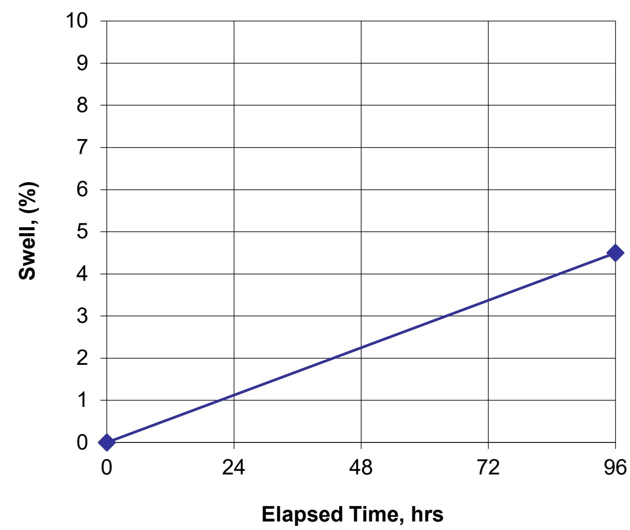
Proctor: ASTM: D698

AMERICAN ENGINEERING TESTING

BEARING RATIO TEST REPORT







Molded			Soaked			CBR, (%)		Pen.	Swell
Dens.	% Max.	% Moisture	Dens.	% Max.	% Moisture	0.1 in	0.2 in	Surcharge	%
86.0	95.0	21.7	82.4	91.1	25.0	1.8	1.5	10lb	4.5
MATERIAL DESCRIPTION					USCS	Max. Dens.	Opt. Mois.	LL	PI
Fat Clay					CH	90.5	21.7		

Project No: P-0016010 Bulk B-4 1-5'

Project: NPS BADL Rehabilitate Asphalt Pullouts
Badlands National Park, SD

Date: 9/23/2022

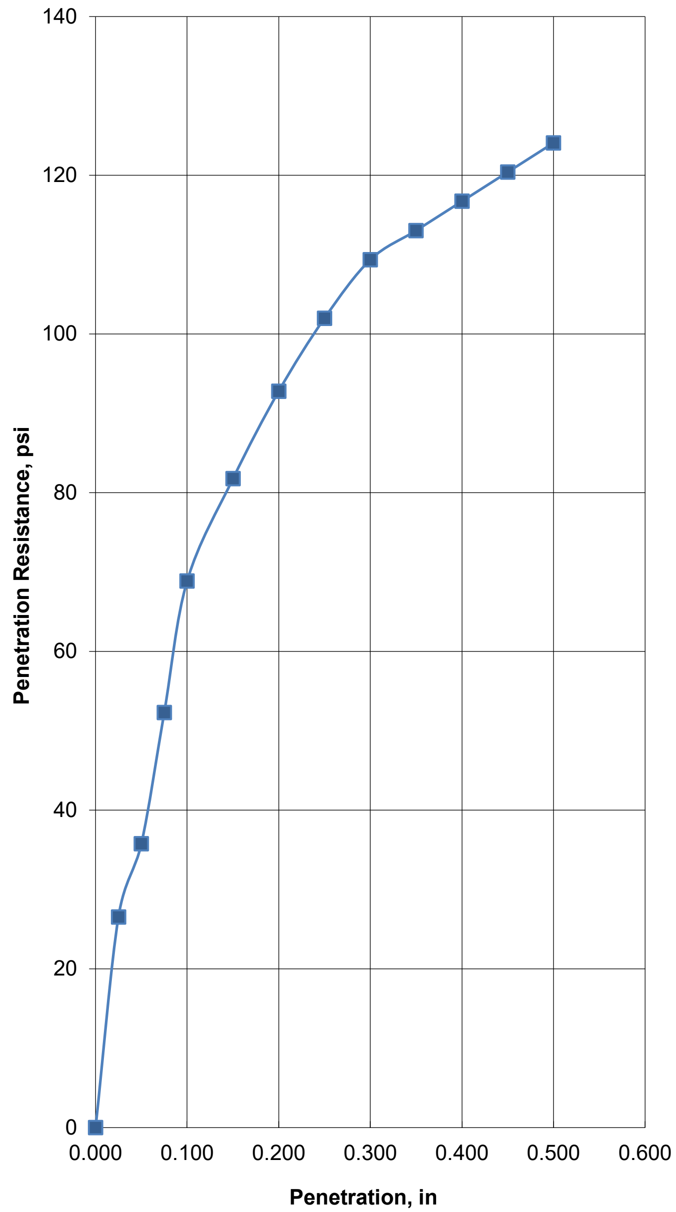
AMERICAN ENGINEERING TESTING

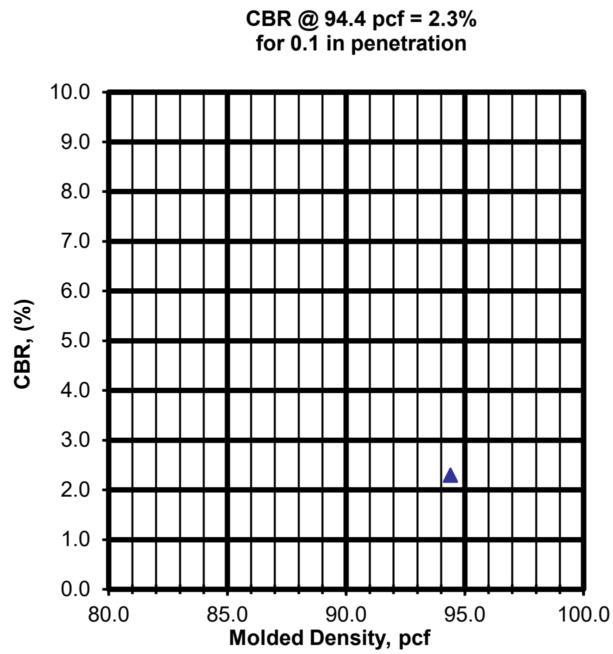
BEARING RATIO TEST REPORT

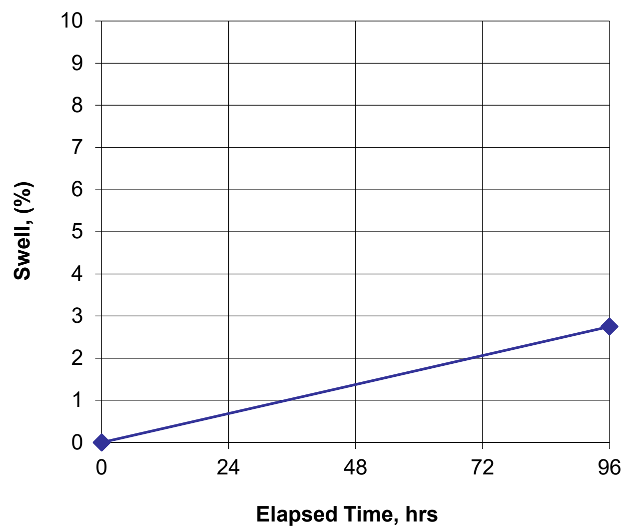
Test Descr. / Remarks

CBR: ASTM: D1883

Proctor: ASTM: D698







Molded			Soaked			CBR, (%)		Pen.	Swell
Dens.	% Max.	% Moisture	Dens.	% Max.	% Moisture	0.1 in	0.2 in	Surcharge	%
94.4	95.0	18.5	92.0	92.5	22.1	2.3	2.1	10lb	2.8

MATERIAL DESCRIPTION	USCS	Max. Dens.	Opt. Mois.	LL	PI
Silty Lean Clay	CL	99.4	18.5		

Project No: P-0016010 Bulk B-6 1-5'

Project: NPS BADL Rehabilitate Asphalt Pullouts
Badlands National Park, SD

Date: 9/23/2022

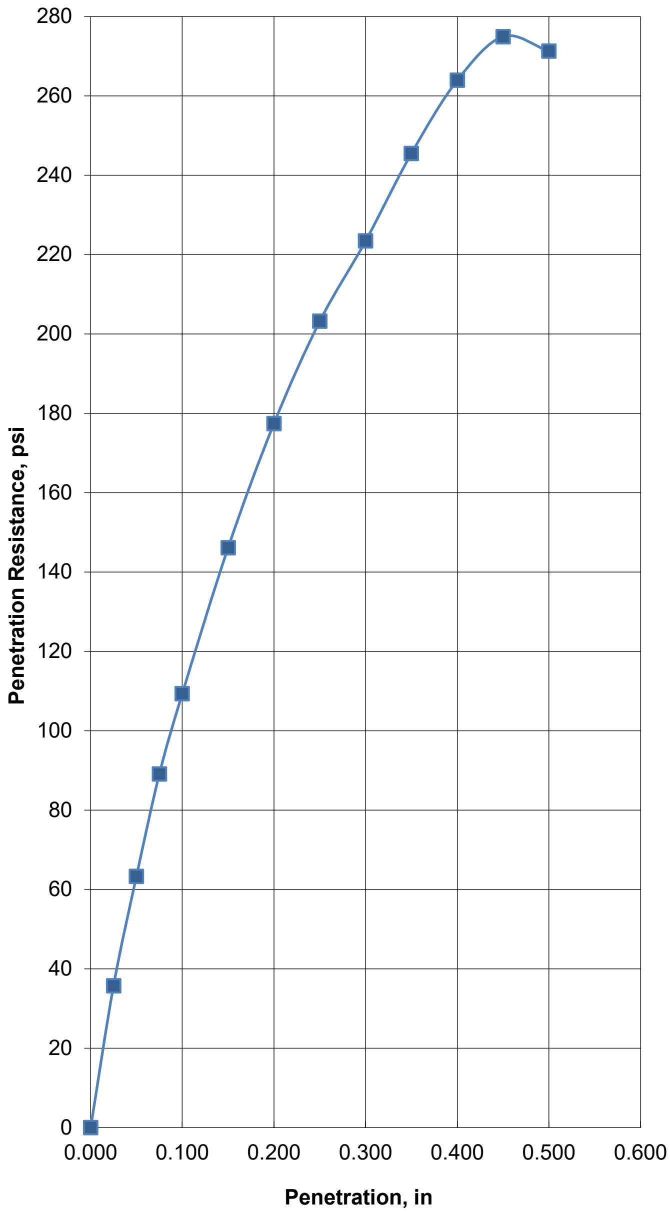
AMERICAN ENGINEERING TESTING

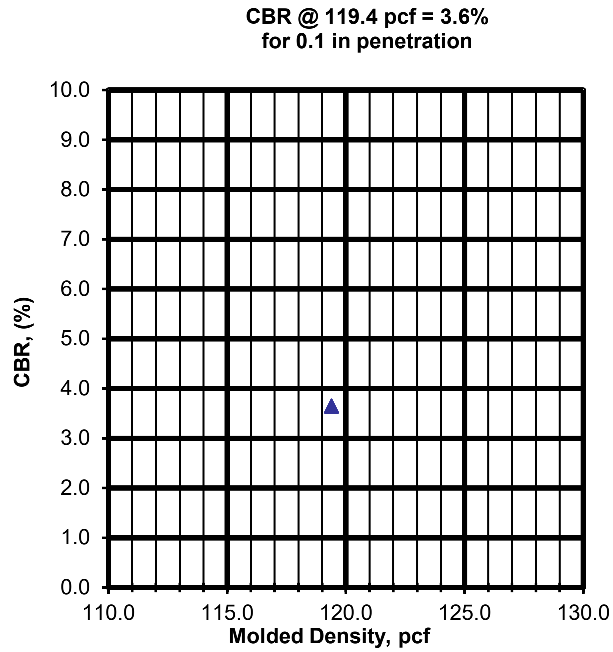
BEARING RATIO TEST REPORT

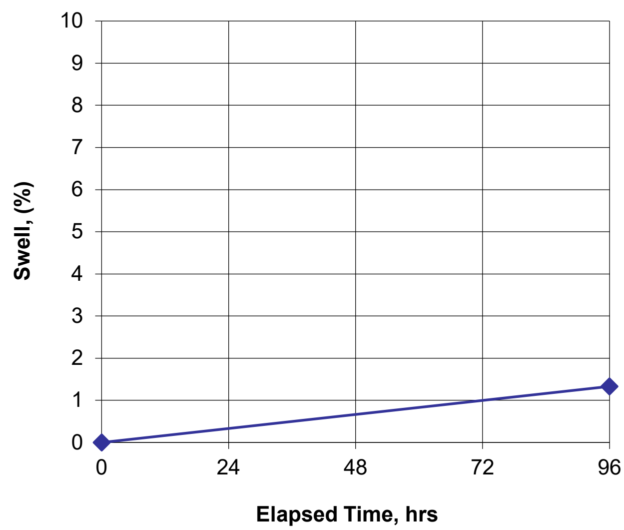
Test Descr. / Remarks

CBR: ASTM: D1883

Proctor: ASTM: D698







Molded			Soaked			CBR, (%)		Pen.	Swell
Dens.	% Max.	% Moisture	Dens.	% Max.	% Moisture	0.1 in	0.2 in	Surcharge	%
119.4	95.0	8.5	118.0	93.9	9.4	3.6	3.9	10lb	1.3

MATERIAL DESCRIPTION	USCS	Max. Dens.	Opt. Mois.	LL	PI
Sandy Lean Clay with Gravel	CL	125.7	8.5		

Project No: P-0016010 Bulk B-8 1-5'

Project: NPS BADL Rehabilitate Asphalt Pullouts
Badlands National Park, SD

Date: 9/23/2022

Test Descr. / Remarks

CBR: ASTM: D1883

Proctor: ASTM: D698

AMERICAN ENGINEERING TESTING

BEARING RATIO TEST REPORT

Appendix B

Geotechnical Report Limitations and Guidelines for Use

Appendix B
Geotechnical Report Limitations and Guidelines for Use
AET Project No. P-0016010

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 GBA[1], of which, we are a member firm.

B.2 RISK MANAGEMENT INFORMATION

B.2.1 Understand the Geotechnical Engineering Services Provided for this Report

Geotechnical engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical engineering services is typically a geotechnical engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

B.2.2 Geotechnical Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client.

Likewise, geotechnical engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do <u>not</u> rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. If you are the least bit uncertain about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

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1 Geoprofessional Business Association, 1300 Piccard Drive, LL14, Rockville, MD 20850
Telephone: 301/565-2733: www.geoprofessional.org, 2019

B.2.3 Read the Full Report

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. Read and refer to the report in full.

B.2.4 You Need to Inform Your Geotechnical Engineer About Change
Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, always inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

B.2.5 Most of the "Findings" Related in This Report Are Professional Opinions
Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed. The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

B.2.6 This Report's Recommendations Are Confirmation-Dependent
The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations only after observing actual subsurface conditions exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.

B.2.7 This Report Could Be Misinterpreted
Other design professionals' misinterpretation of geotechnical engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

B.2.8 Give Constructors a Complete Report and Guidance
Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical engineering report, along with any attachments or appendices, with your contract documents, but be certain to note conspicuously that you have included the material for information purposes only. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, only from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to and be sure to allow enough time to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

B.2.9 Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. 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.2.10 Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical engineering study. For that reason, a geotechnical engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated subsurface environmental problems have led to project failures. If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

B.2.11 Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. Geotechnical engineers are not building-envelope or mold specialists.