Minnesota Department of Transportation

Office of Materials
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Date: February 20, 2009

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Metro District

From: Derrick Dasenbrock, Foundations Geomechanics Engineer
Foundations Unit

Digitally signed by Derrick Dasenbrock
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Date: 2009.02.24 10:14:44 -06'00'

Phone: 651.366.5597

Concur: Gary Person, Foundations Engineer
Foundations Unit

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Subject: S.P. 1907-68
Reinforced Soil Slope (for the protection of Oak Trees associated with the DNR SNA)
TH 52, Roadway Station 217+00 to 222+25
Foundation Investigation and Recommendations

REF: Note that this report covers only the investigation and recommendations for the proposed reinforced soil slope portion of the project; refer to earlier reports for recommendations associated with BR 19035 and the proposed stormwater detention chambers.

Project Description

This project involves the construction of a reinforced soil slope which will replace a natural soil slope in an area where a new frontage road is being constructed. The slope area is adjacent to a Department of Natural Resources (DNR) Scientific and Natural Area (SNA) and there is interest in preserving a grove of Oak trees located at the top of the existing slope. The existing slope is currently vegetated with small trees and grass.

There is insufficient space to construct the new frontage road and preserve the existing slope. Additionally, the existing slope is fairly steep and there is insufficient space to excavate into the existing hillside and install traditional “bottom up” retaining wall systems (including cantilever or MSE types). Figure 1 shows the in-place slope. The project stakeholders indicated that a retaining system with a vegetated face was highly preferred. Vegetated slopes or wall systems with vegetated facing were selected as possible solutions to allow construction of the frontage road while reducing the impact to the oak trees on Mn/DOT ROW and the DNR SNA.

At a series of meetings in the summer of 2007, several alternative concepts were considered. It was determined that a ‘typical’ soil nailed wall would be presented in the project plan with accompanying special provisions to guide contractor designs. Detailed plans and construction documents would be left to the contractor to develop; these designs would then be submitted for review and approval. Alternate construction techniques, provided they met the same design requirements would be allowed.

Construction of the new slope is complicated by the need for protection of the oak trees, the

replacement of a city water line, construction of the roadway, and the realignment of Excel Energy high tension lines in the immediate area of the slope.

Collaboration between the Foundations Unit and Metro Design has been ongoing through the project process; the project plan sheets, project cross sections, and project special provisions (Section S-61) are consistent with the information included in this report. The details referring to the slope are described in the project documents as “Reinforced Soil Slope Special” (RSSS).

Figure 1. The reinforced soil slope is necessary to minimize impact to the DNR Scientific and Natural Area and support the trees at the top of the existing hill. Many of the trees are on Mn/DOT ROW. The new frontage road will encroach significantly on the existing toe of the embankment.

Field Investigation and Foundation Conditions

Fourteen CPT soundings were advanced in March of 2007. The soundings showed predominantly sandy soils with intermittent layers of cohesive materials. Two borings were taken in September of 2008 for purposes of recovering samples for direct shear testing and grain size analysis, anticipating the desire for these parameters for use in the reinforced soil slope design. In most cases, the slope soils had very good strength properties except in the near surface areas and in some intermittent weaker strata. The soil strength generally increased with depth. Overall the sandy materials were generally medium dense to very dense through the soil profile. The CPT and boring data suggested that the soils were damp and unsaturated. Water was not encountered while drilling.

Four gradation tests and four series of Direct Shear tests were performed on four samples from each boring T11 and T12 (eight samples total). The results of the Direct Shear tests are presented on the boring logs. The grain size analysis reports are available as PDF files from our office on request.

Please refer to the attached CPT sounding and soil boring logs for a more detailed description of the foundation soils. Information is presented in U.S. Customary Units. Index sheets for CPT soundings and soil borings are attached.

Foundation Analysis

Overall, the site was found to be very well suited to the construction of a reinforced soil slope or retaining wall system to support the hillside and oak trees. The dense sandy soils are expected to provide good bearing and stable support for the new slope. Consolidation settlement is not expected to be a concern and the material are dense and granular in nature and the site will be unloaded by the removal of material in most areas.

Construction of the new steepened slope or retaining wall system may be difficult due to the dense nature of the in-place soils, and 'stand up time' (needed for some "top down" construction methods) may be limited due to the granular nature of most of the materials in the existing slope. At the time of the investigation, a water table was not encountered.

The reinforced soil slope will be vendor designed by a professional engineer who will be responsible for ensuring the stability of the system. The submittal will be reviewed by our office. The soil borings and CPT soundings will be made available to contractors for bidding and to the firms designing and constructing the system.

Tree Support Alternatives

The proposed road geometry and the need to protect the oak trees and the DNR SNA, created an unusual situation at this location. Traditional "bottom up" retaining wall systems including cantilever walls and Mechanically Stabilized Earth (MSE) required a large amount of excavation behind the proposed wall system which would result in the loss of the trees of interest. In order to preserve the trees in the limited space, several alternatives were considered including:

1) Pile and Lagging Systems
2) Permanent Sheetpiling
3) Soil Nails
4) Earth/Ground Anchors
5) Launched Soil Nails or Reticulated Mini-Piles (or similar)
6) Shored MSE Systems

Soil Nailing and Earth/Ground Anchoring systems were determined to be the most reasonable solution to the wall construction problem based on the project size, application, and anticipated cost. A vegetated face is required.

Through a series of meetings with the project stakeholders it was determined that a performance-based design specification would be developed and used for this portion of the work. This would allow contractors to develop the most cost effective solutions for the reinforced slope while minimizing Mn/DOT design involvement.

A line and grade for the soil slope will be provided in the contract plans as well as detailed project special provisions detailing the design and construction requirements. The contractor

would then be responsible for providing a design and ensuring that the wall construction was consistent with that design. Although the Soil Nailing and Earth/Ground Anchoring systems are believed to be the most competitive systems, alternate designs will also be considered, provided they meet the project specifications of supporting the hillside and the oak trees (including the requirement for the vegetated face).

Site Area for RSSS

The Reinforced Soil Slope Special (RSSS) is to be located in the area where the slope adjacent to the new east frontage road will be steeper than 2H : 1V., from STA 217+00 to 222+25. The estimated face area of the slope is 1667 square yards and the slope is expected to vary from 2H : 1V to 1H : 1V along the length of the slope.

Typical Plan Details for RSSS

Several plan sheets and cross sections have been developed in collaboration with Metro Design to detail the basic outline for the slope construction. The plan sheets provide a plan view and a typical cross section. A layout of the spacing of reinforcing elements is presented, as are suggested details for the mesh facing and slope dressing.

The Reinforced Soil Slope Special (RSSS) is to be located in the area where the slope adjacent to the new east frontage road will be steeper than 2H : 1V., from STA 217+00 to 222+25. The estimated face area of the slope is 1667 square yards and the slope is expected to vary from 2H : 1V to 1H : 1V along the length of the slope.

Additional details related to tree preservation, including special root treatments, cover soils, protective fencing, watering, etc… are addressed in the portions of the plan developed by the Office of Environmental Services.

Recommendations

Based on the existing conditions along with an analysis of the project soils, we recommend:

1. The existing hillside be reinforced using a “top down” construction technique to provide adequate support and stabilization as the slope is steepened to accommodate a new frontage road at the base while maintaining the crest of the hill at a condition very close to the in-place condition. The preferred construction options include the use of soil nails, earth anchors, ground anchors, or related systems with a vegetated final facing (as opposed to panels, shotcrete, textured concrete, or similar. Alternative system could include structural pile and lagging, sheetpiling, shored MSE systems, or similar types, provided these systems provide a vegetated face.

2. The system be referred to as the Reinforced Soil Slope Special (RSSS) for purposes of this project.

3. The reinforced slope system be installed in those areas where the slope will be steeper than 2H : 1V, from STA 217+00 to 222+25. A line and grade will be provided for the slope (or wall) system. It is preferred that a single system be used for the length of the steepened area.

4. A soil nail wall/slope system will be presented in the project plans. Alternate wall/slope systems will be considered if the alternate system meets or exceeds the design requirements. Alternate systems must be approved by Mn/DOT. The CPT soundings and soil borings, as well as related soil testing, should be made available to interested bidders and the design and construction contractors who will be responsible for the design and construction of the work.

5. The project plans will include estimated quantities for the wall, a typical nail pattern, a typical cross section, cross sections in the construction area, ROW, and sheets detailing the DNR SNA tree protection (as developed by the Office of Environmental Services) for the Environmentally Sensitive Area.

6. The slope will be designed by a registered professional engineer; the factor of safety (for internal, external, and compound stability) is 1.3.

7. The slope system will be designed to accommodate a vegetated face with a minimum 8 inch thick layer of soil suitable for establishing and maintaining vegetation on the slope. Depending on the type of construction methods and materials, special attention must be given to ensure the surface topsoil remains in place. It may be necessary to use mesh reinforcing materials or similar treatments to retain the topsoil along the face of the slope. Benches, tiers, baskets, or other containing systems may be needed to help retain soil on the face (and prevent local sliding or slumping) and prevent it from migrating down the slope due to the steepness of the face. For conventional RSS applications a fabric wrapped face is typically employed; depending on the nature of the facing, this may also be appropriate for this type of wall, if the fabric can be adequately secured to the reinforcing system.

8. The slope system may have overland flow approaching the system from the top; if necessary, a drainage system will be installed to prevent deleterious effects to the vegetated face. The drainage system will not adversely affect the oak trees in the designated preservation area.

9. The contractor performing the work for soil nailed or earth/ground anchored slopes/walls must meet pre-qualification requirements to ensure they are familiar with this type of specialty construction.

10. A pre-construction conference among those involved in the design, construction, and acceptance of the reinforced slope system is strongly encouraged prior to beginning the work for this portion of the project. Contractor Qualification and Design System submittals (including a QC/QA plan) are required for review and acceptance by Mn/DOT.

11. A minimum 2 year warranty is required.

12. The contractor should be made aware of constraints in the project area including Excel Energy power lines, a city water main that will be reconstructed below the east frontage road, and any other utilities or conflicts.

Note that a copy of the suggested language for the project special provisions (which

incorporates the above recommendations) is attached with this report. This has been previously transmitted to Metro Design and is in the project documents in section S-61.

Please contact our office if you have any questions or require any additional information regarding this portion of the project.

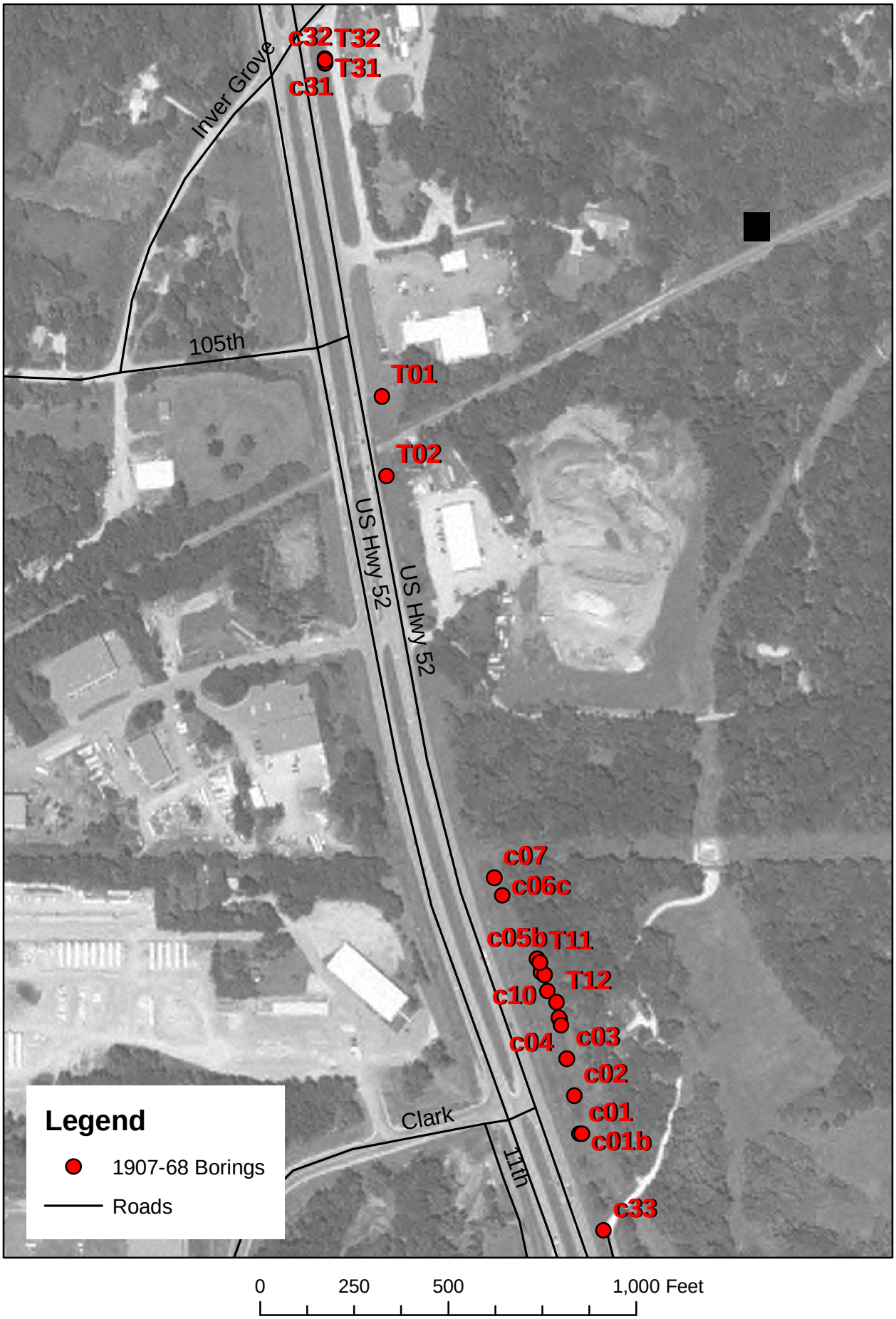
Attachments:

Boring Layout (note that the layout also shows the borings and soundings taken for a bridge and proposed stormwater detention chambers soil slope on this project)
Boring Layout of immediate RSSS area
CPT Index Sheet
CPT Sounding c01 – c10b (Unique Number 68653, and 68498 - 68511)
SPT Index sheet
SPT Boring: T11, T12 (Unique Number 60924, 60925)
CPT Fence Diagram
Suggested Special Provision Language (1907-68 Reinforced Soil Slope Special)

Copies of the Direct Shear Test Results and the Grain Size Analysis reports are available electronically as PDF files from our office on request.

cc: G. Engstrom
B. Timerson
D. Palmquist
A. Azarshin
E. Boytim

File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T32
T31
c31
Inver Grove
105th
T01
T02
US Hwy 52
US Hwy 52
c07
c06c
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T11
T12
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c04
c03
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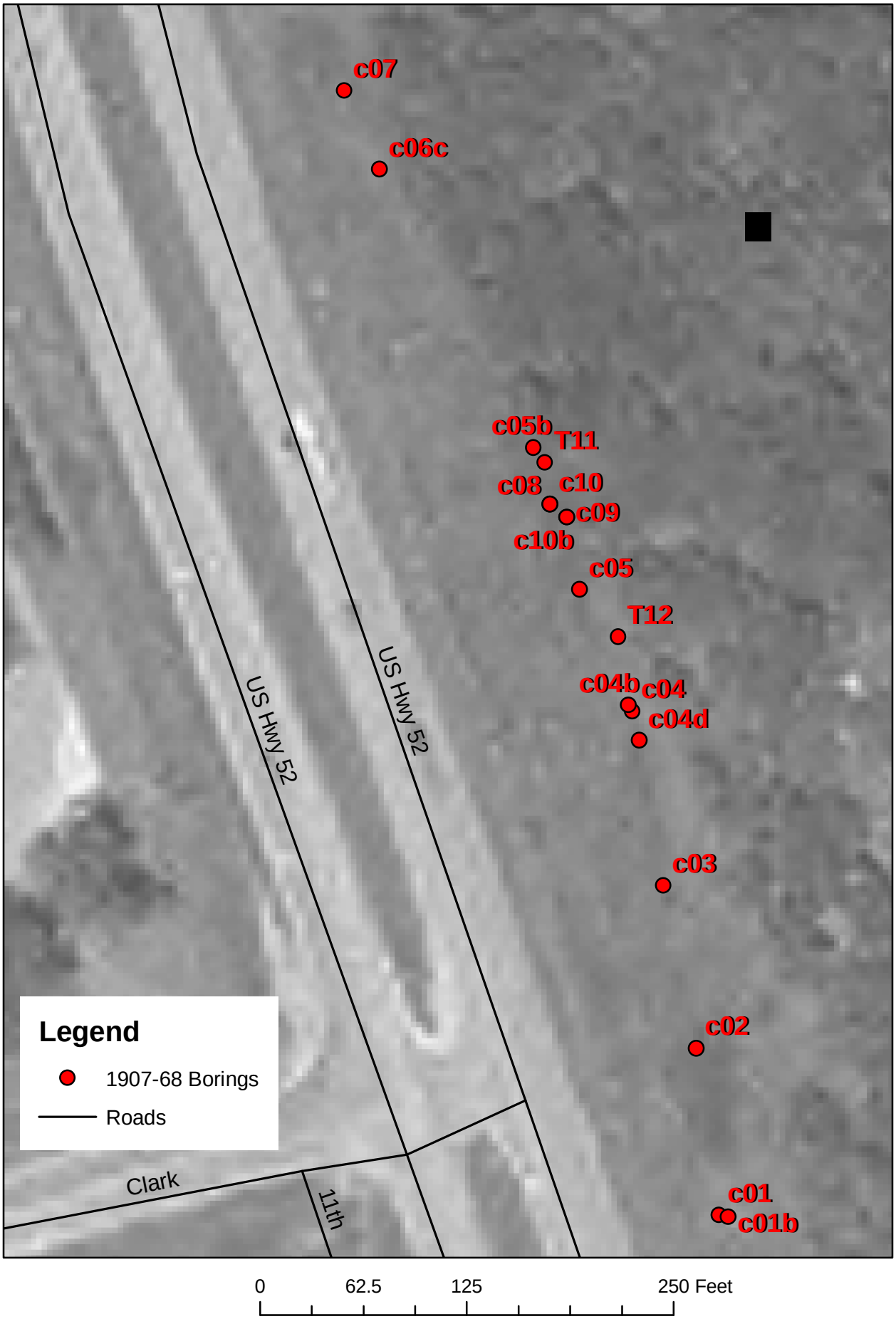
Clark
11th
c33
Legend
1907-68 Borings
Roads
0
250
500
1,000 Feet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c10b
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T12
c04b
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c04d
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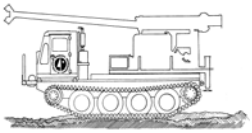
c01b
US Hwy 52
US Hwy 52
Clark
11th
Legend
1907-68 Borings
Roads
0
62.5
125
250 Feet

Minnesota Department of Transportation
Geotechnical Section
Cone Penetration Test Index Sheet 1.0 (CPT 1.0)



USER NOTES, ABBREVIATIONS AND DEFINITIONS

This Index sheet accompanies Cone Penetration Test Data. Please refer to the Boring Log Descriptive Terminology Sheet for information relevant to conventional boring logs.

This Cone Penetration Test (CPT) Sounding follows ASTM D 5778 and was made by ordinary and conventional methods and with care deemed adequate for the Department's design purposes. Since this sounding was not taken to gather information relating to the construction of the project, the data noted in the field and recorded may not necessarily be the same as that which a contractor would desire. While the Department believes that the information as to the conditions and materials reported is accurate, it does not warrant that the information is necessarily complete. This information has been edited or abridged and may not reveal all the information which might be useful or of interest to the contractor. Consequently, the Department will make available at its offices, the field logs relating to this sounding.

Since subsurface conditions outside each CPT Sounding are unknown, and soil, rock and water conditions cannot be relied upon to be consistent or uniform, no warrant is made that conditions adjacent to this sounding will necessarily be the same as or similar to those shown on this log. Furthermore, the Department will not be responsible for any interpretations, assumptions, projections or interpolations made by contractors, or other users of this log.

Water pressure measurements and subsequent interpreted water levels shown on this log should be used with discretion since they represent dynamic conditions. Dynamic Pore water pressure measurements may deviate substantially from hydrostatic conditions, especially in cohesive soils. In cohesive soils, water pressures often take extended periods of time to reach equilibrium and thus reflect their true field level. Water levels can be expected to vary both seasonally and yearly. The absence of notations on this log regarding water does not necessarily mean that this boring was dry or that the contractor will not encounter subsurface water during the course of construction.

CPT Terminology

CPT ..... Cone Penetration Test
CPTU..... Cone Penetration Test with Pore Pressure measurements
SCPTU..... Cone Penetration Test with Pore Pressure and Seismic measurements
Piezocone...Common name for CPTU test

(Note: This test is not related to the Dynamic Cone Penetrometer DCP)

q_T TIP RESISTANCE

The resistance at the cone corrected for water pressure. Data is from cone with 60 degree apex angle and a 10 cm^2 end area.

f_s SLEEVE FRICTION RESISTANCE

The resistance along the sleeve of the penetrometer.

FR Friction Ratio

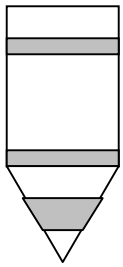
Ratio of sleeve friction over corrected tip resistance.
FR = fs/qt

V_s Shear Wave Velocity

A measure of the speed at which a siesmic wave travels through soil/rock.

PORE WATER MEASUREMENTS

Pore water measurements reported on CPT Log are representative of water pressures measured at the U2 location, just behind the cone tip, prior to the sleeve, as shown in the figure below. These measurements are considered to be dynamic water pressures due to the local disturbance caused by the cone tip. Dynamic water pressure decay and Static water pressure measurements are reported on a Pore Water Pressure Dissipation Graph.



SBT SOIL BEHAVIOR TYPE

Soil Classification methods for the Cone Penetration Test are based on correlation charts developed from observations of CPT data and conventional borings. Please note that these classification charts are meant to provide a guide to Soil Behavior Type and should not be used to infer a soil classification based on grain size distribution.

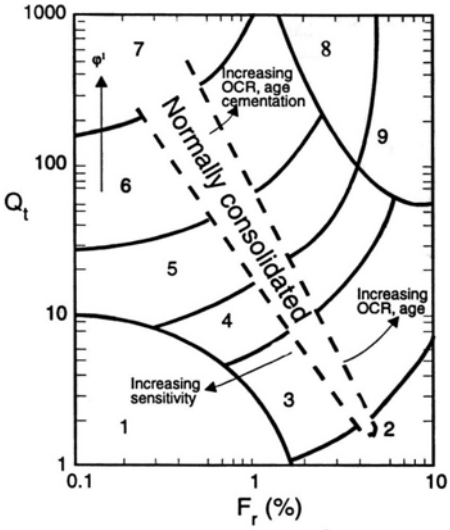
The numbers corresponding to different regions on the charts represent the following soil behavior types:

1. Sensitive, Fine Grained
2. Organic Soils - Peats
3. Clays - Clay to Silty Clay
4. Silt Mixtures - Clayey Silt to Silty Clay
5. Sand Mixtures - Silty Sand to Sandy Silt
6. Sands - Clean Sand to Silty Sand
7. Gravelly Sand to Sand
8. Very Stiff Sand to Clayey Sand
9. Very Stiff, Fine Grained

Note that engineering judgment, and comparison with conventional borings is especially important in the proper interpretation of CPT data in certain geo-materials.

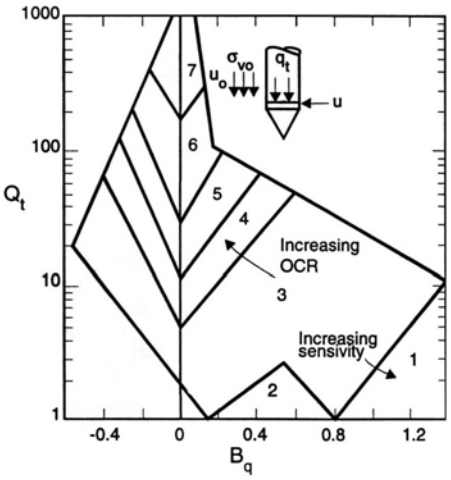
The following charts are used to provide a Soil Behavior Type for the CPT Data.

Robertson CPT 1990
Soil Behavior type based on friction ratio



$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \qquad F_r = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$$

Robertson CPTU 1990
Soil Behavior type based on pore pressure



$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \qquad B_q = \frac{u_2 - u_o}{q_t - \sigma_{vo}}$$

where ...

Q_T..... normalized cone resistance
B_q ..... pore pressure ratio
F_r ..... Normalized friction ratio
σ_{vo} ..... overburden pressure
σ'_{vo} ..... effective over burden pressure
u_2 ..... measured pore pressure
u_0 ..... equilibrium pore pressure

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

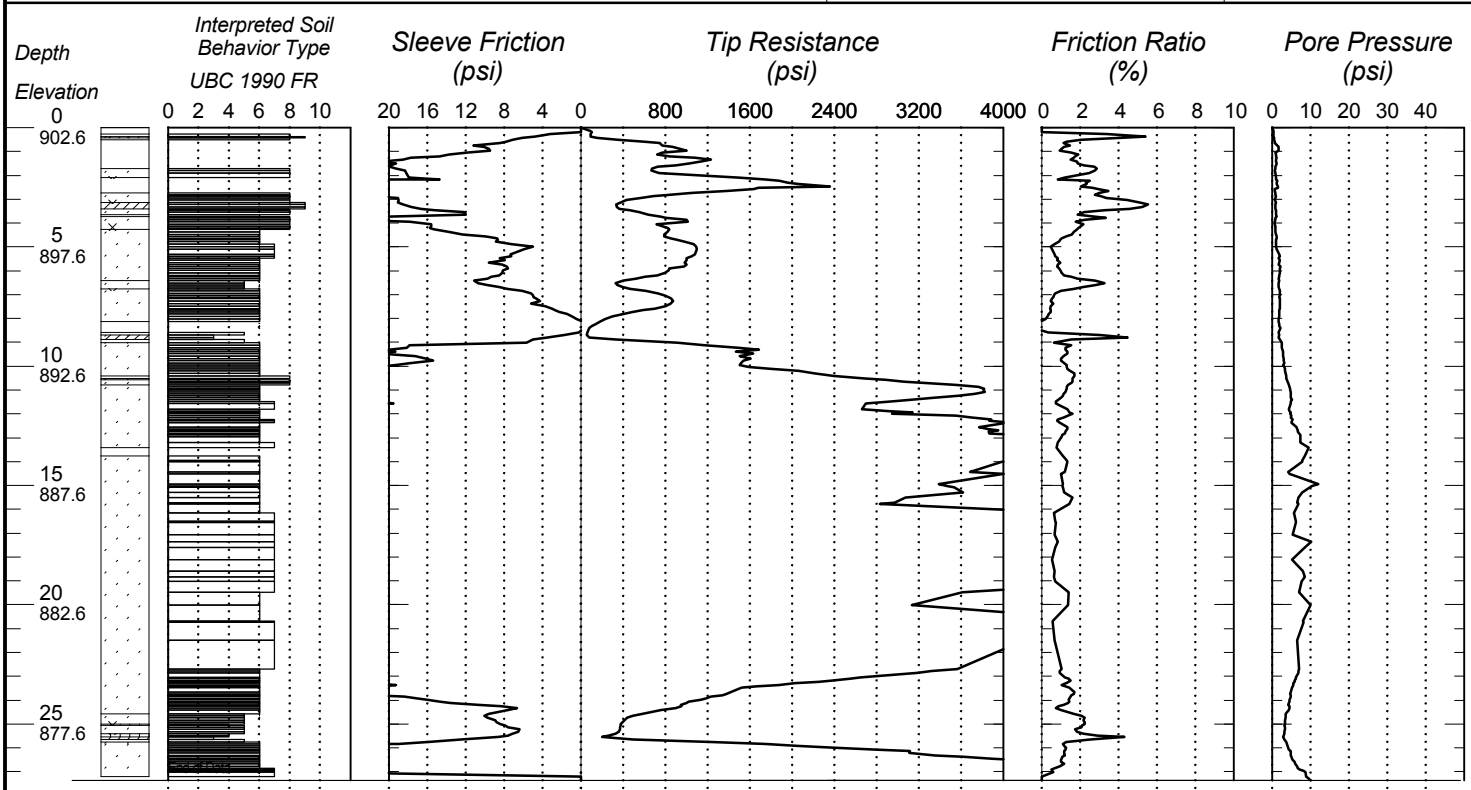
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68498

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c01b**	**902.6** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
Dakota Co. Coordinate: X=572955 Y=216721 (ft.)	*CPT Operator* **R Winter**	*Date Completed*
Latitude (North)=44°47'30.25" *Longitude (West)=93°02'08.41"*	*Hole Type* **CPT-STD**	**3/22/07**



Bottom of Hole 27.35684

Index Sheet Code 3.0 D22M0712C.DAT *Soil Class: Rock Class: Edit: Date: 7/25/07*

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68499

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c02**	**917.5** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
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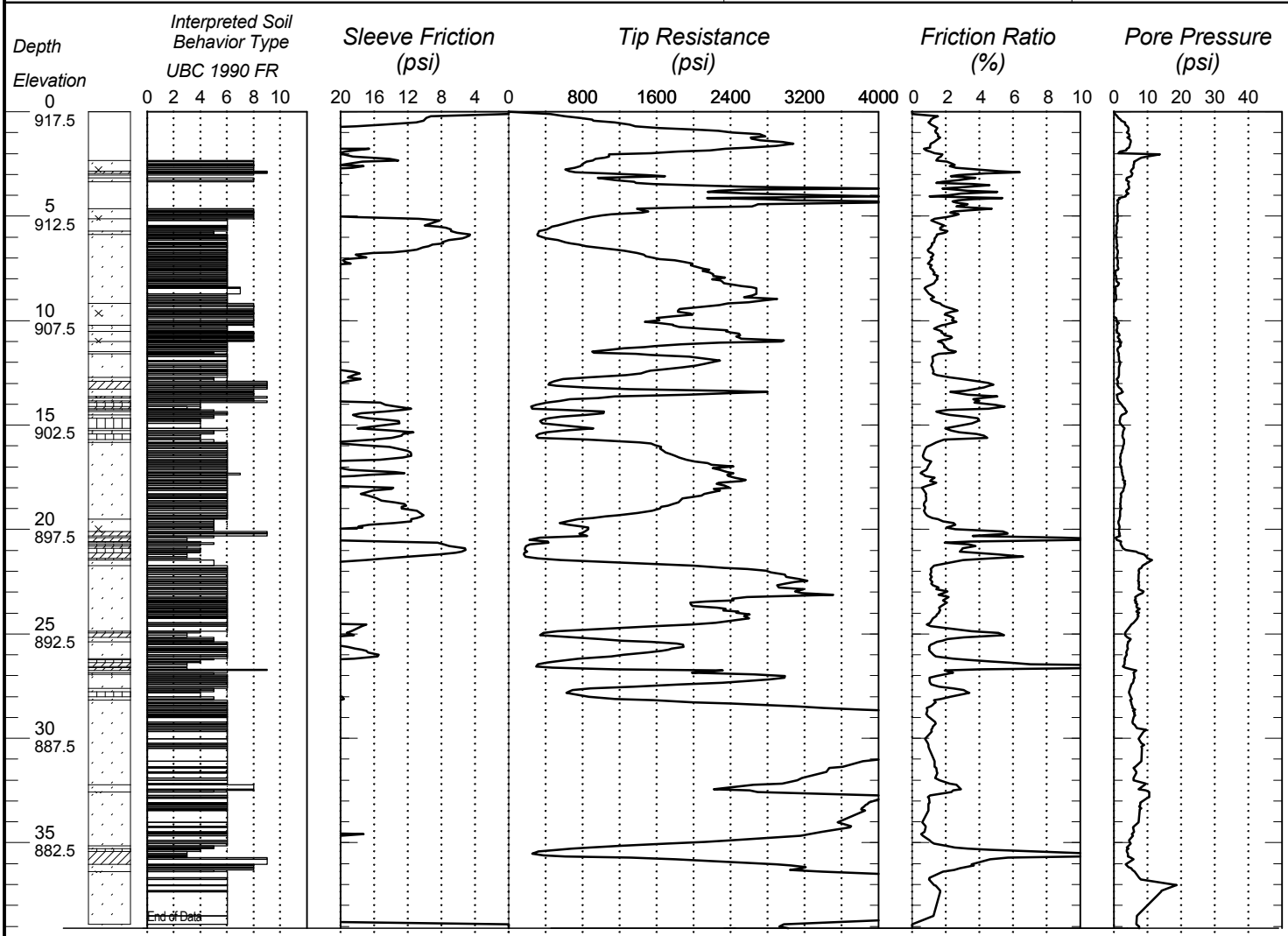

Bottom of Hole 39.08344

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68500

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c03**	**926.1** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
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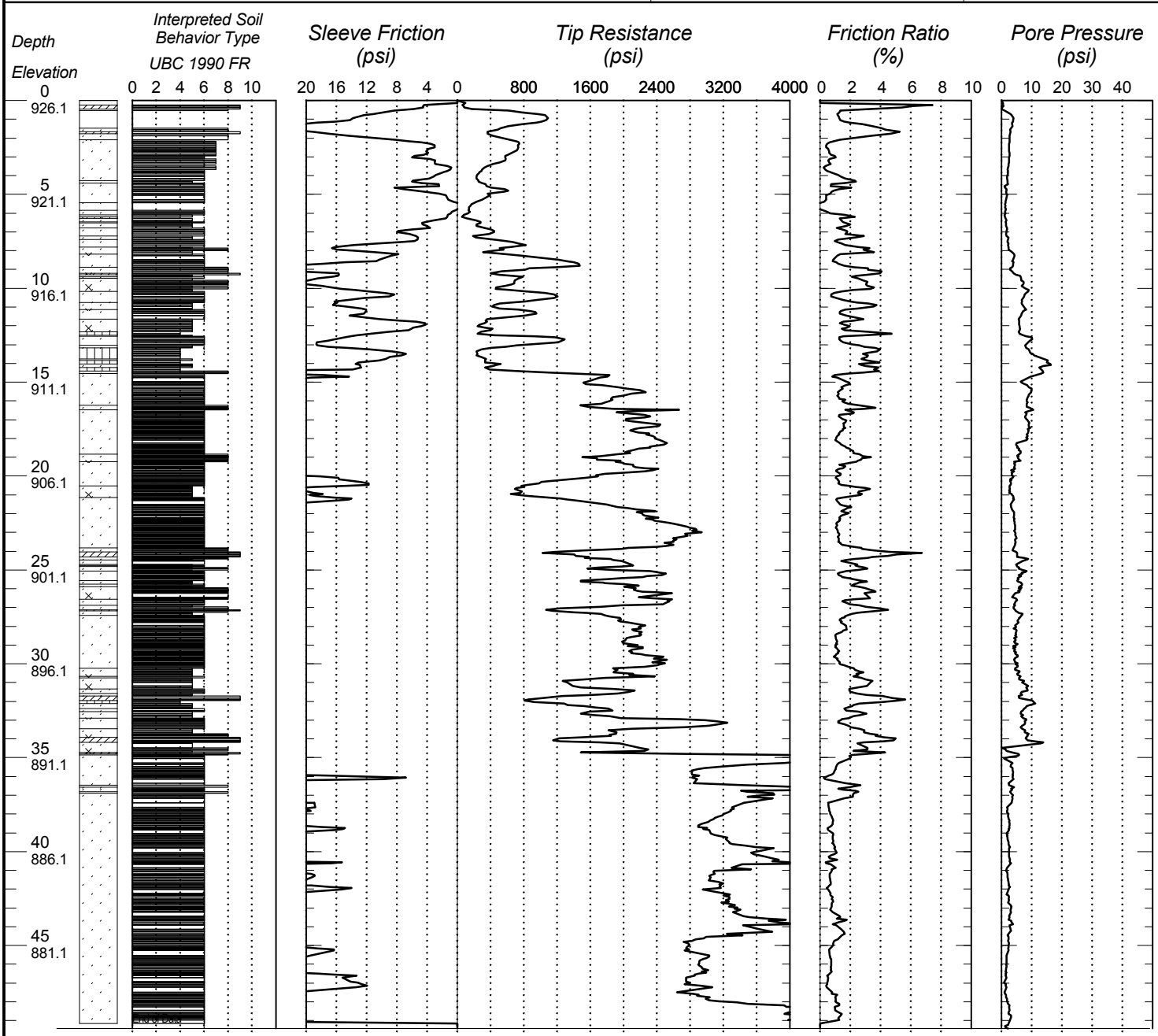

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68501

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c04**	**936.3** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
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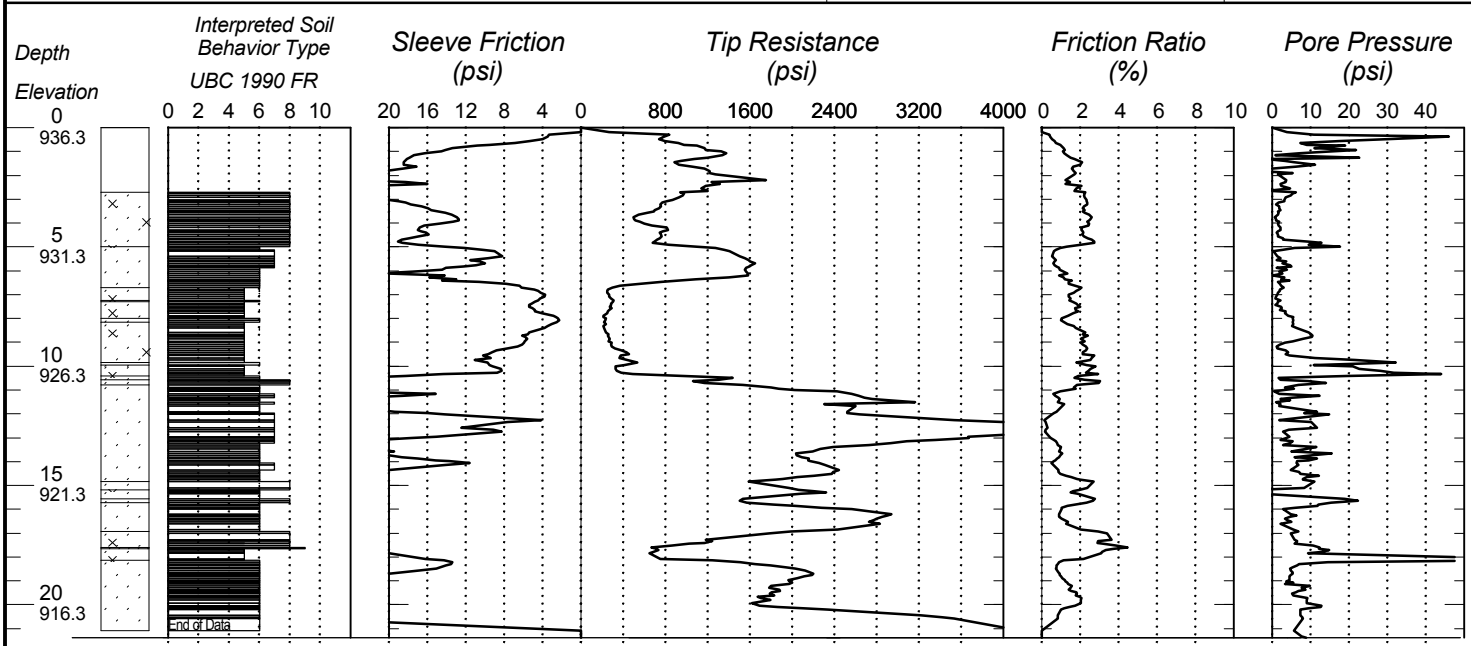

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68502

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c04b**	**936.4** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
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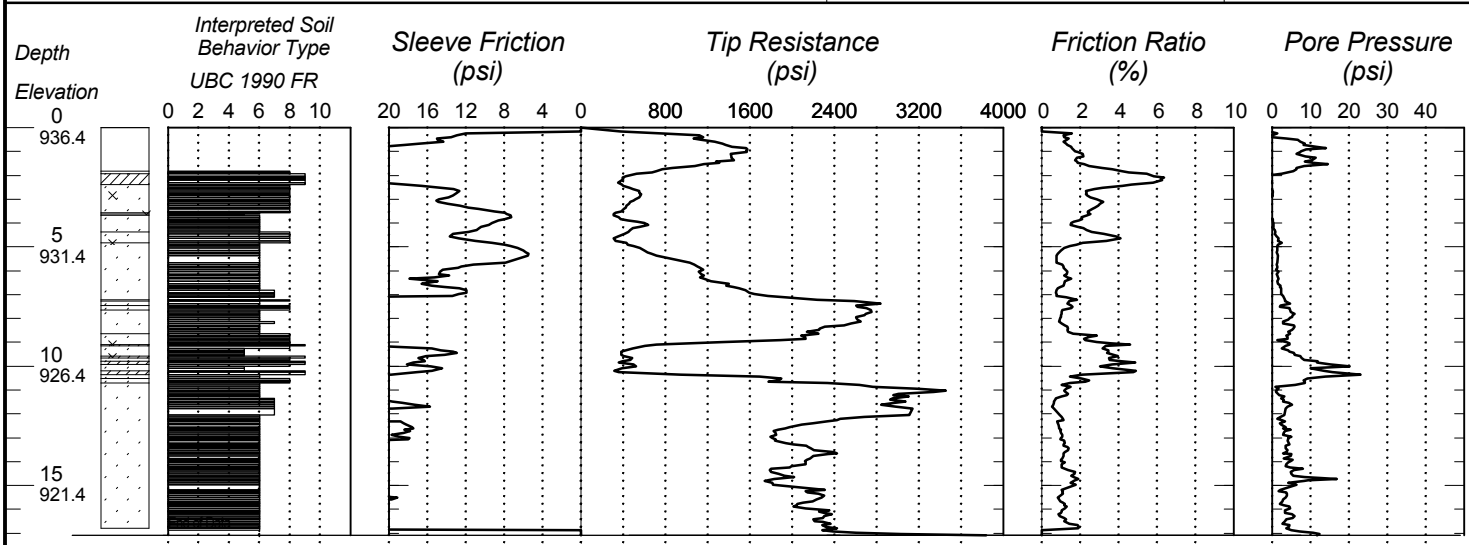

Bottom of Hole 17.10159

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68503

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c04d**	**935.3** (DTM)

Location **, , ft. LT**	CPT Machine **99649 CPT Track**	SHEET 1 of 1
Dakota Co. Coordinate: X=572900 Y=217009 (ft.)	CPT Operator **R Winter**	Date Completed
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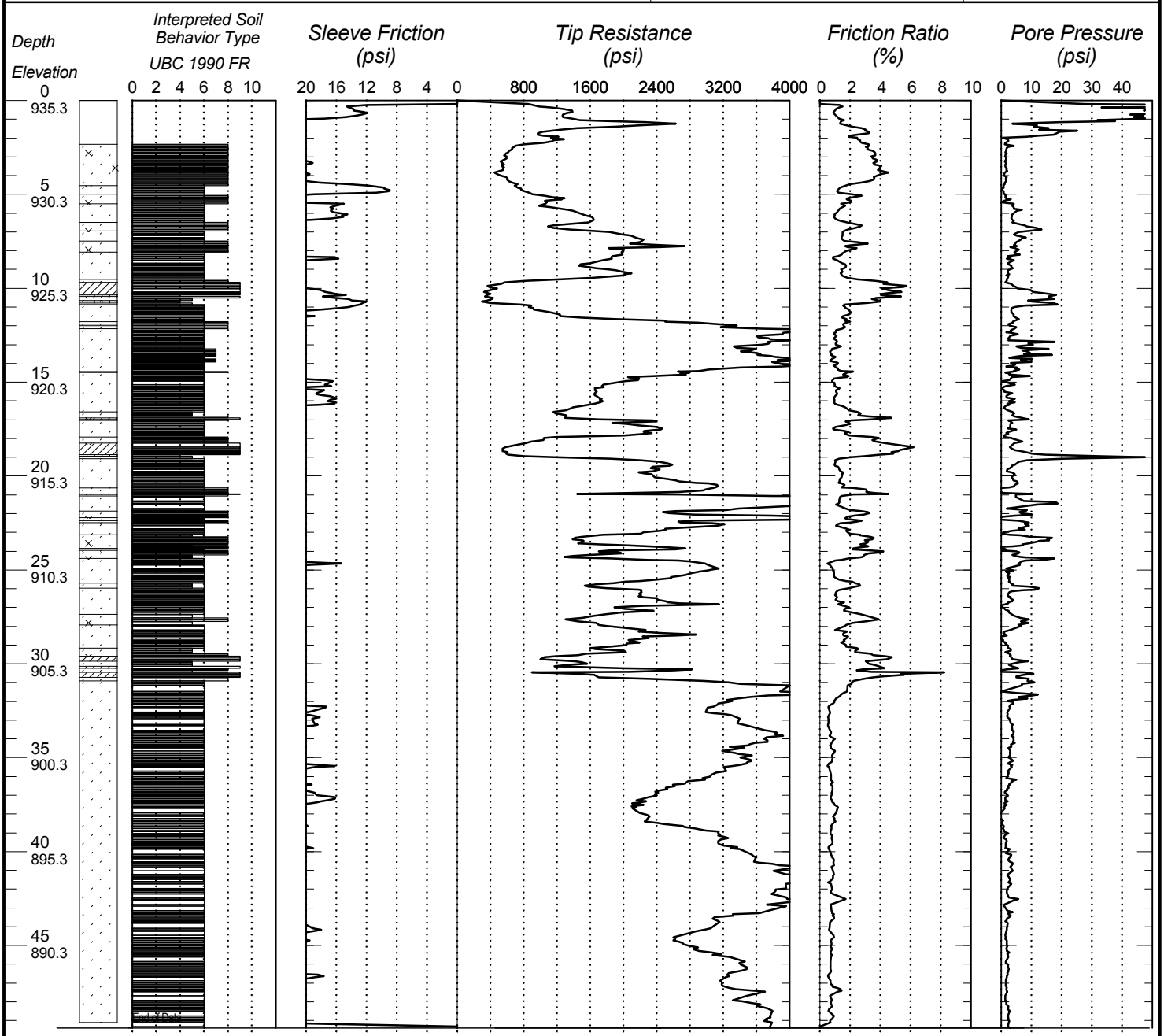

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

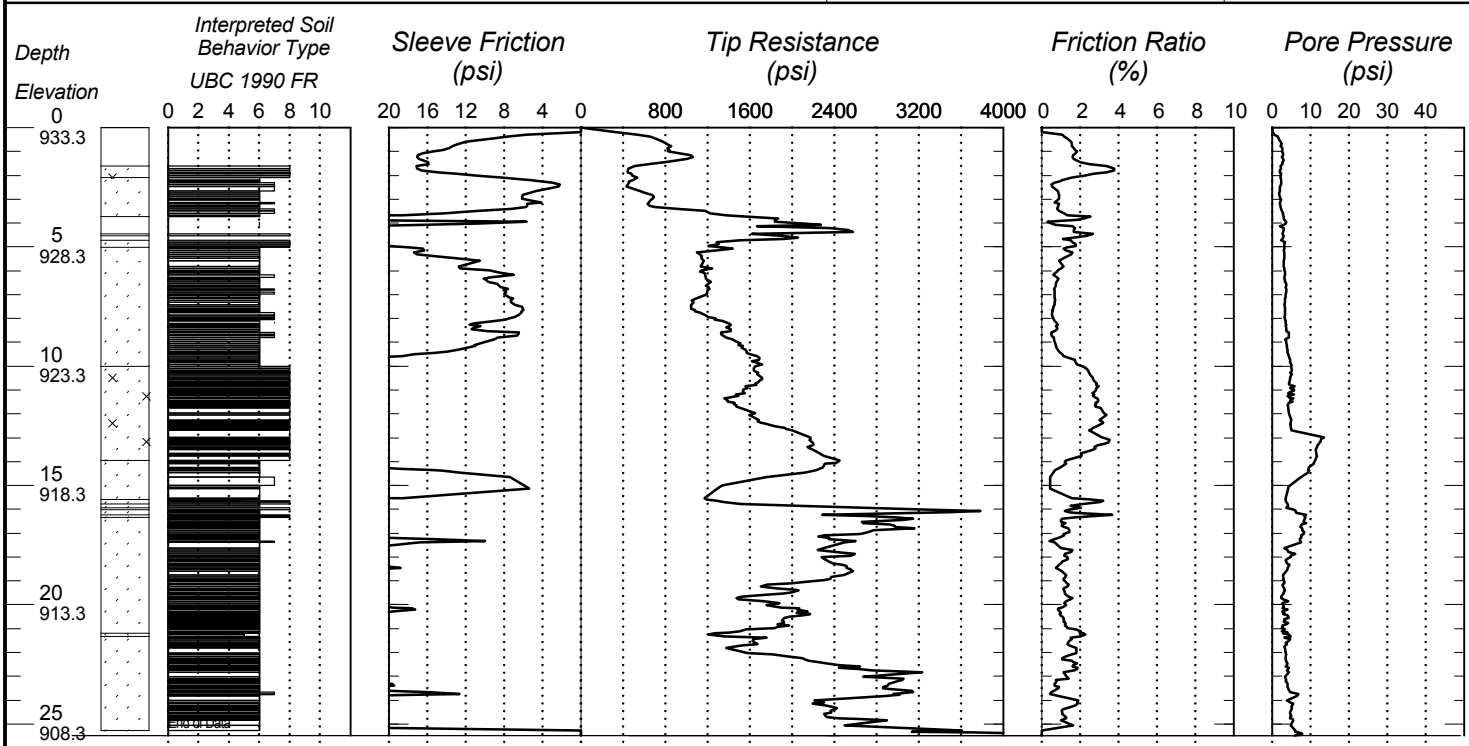
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68504

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c05**	**933.3** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
Dakota Co. Coordinate: X=572863 Y=217100 (ft.)	*CPT Operator* **R Winter**	*Date Completed*
Latitude (North)=44°47'34" *Longitude (West)=93°02'09.66"*	*Hole Type* **CPT-STD**	**3/22/07**



Index Sheet Code 3.0 D22M0703C.DAT *Soil Class: Rock Class: Edit: Date: 7/25/07*

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

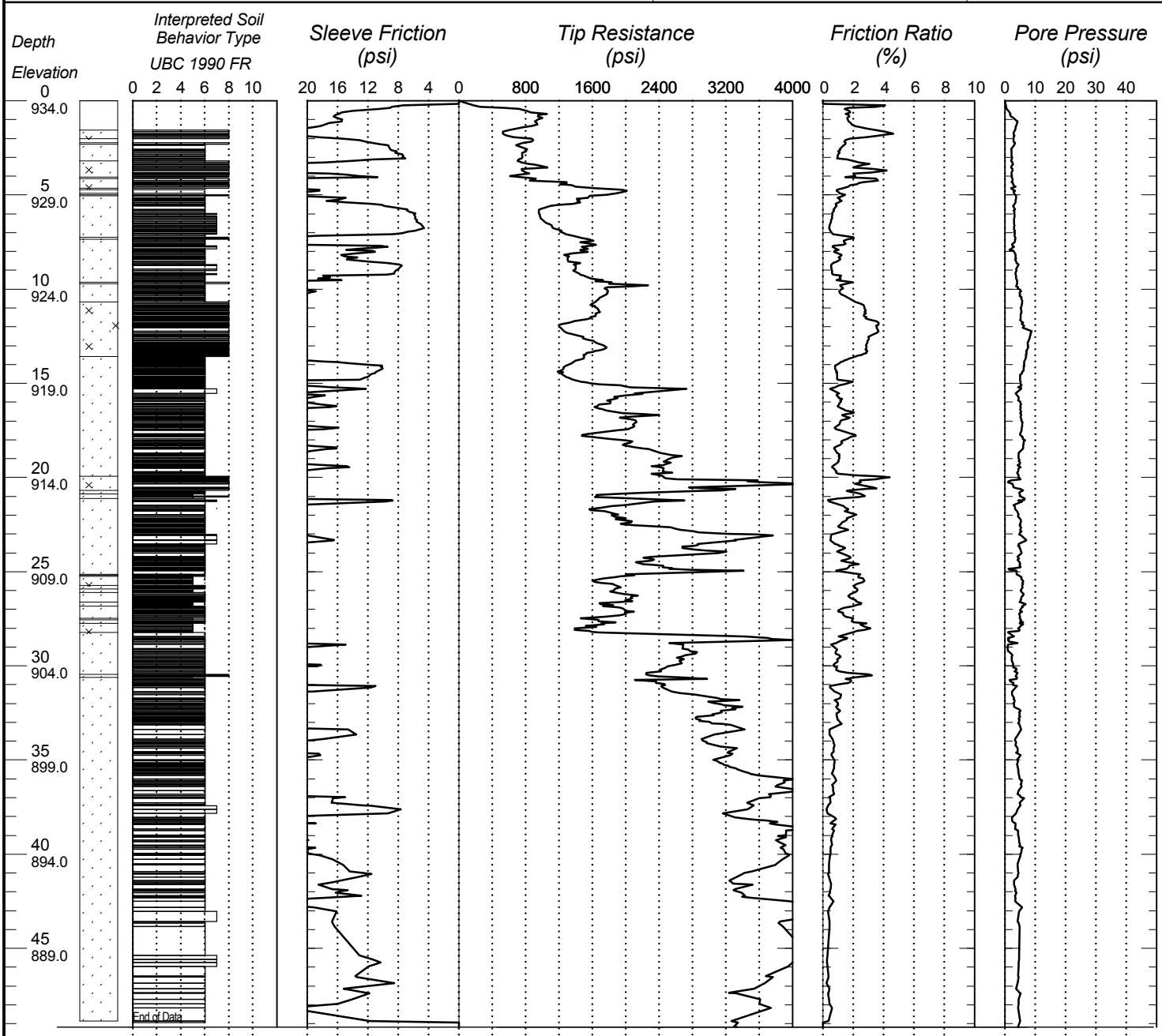
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68505

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c05b**	**934.0** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
Dakota Co. Coordinate: X=572835 Y=217186 (ft.)	*CPT Operator* **R Winter**	*Date Completed*
Latitude (North)=44°47'34.85" *Longitude (West)=93°02'10.05"*	*Hole Type* **CPT-STD**	**3/22/07**



Index Sheet Code 3.0 D22M0704C.DAT *Soil Class: Rock Class: Edit: Date: 7/25/07*

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

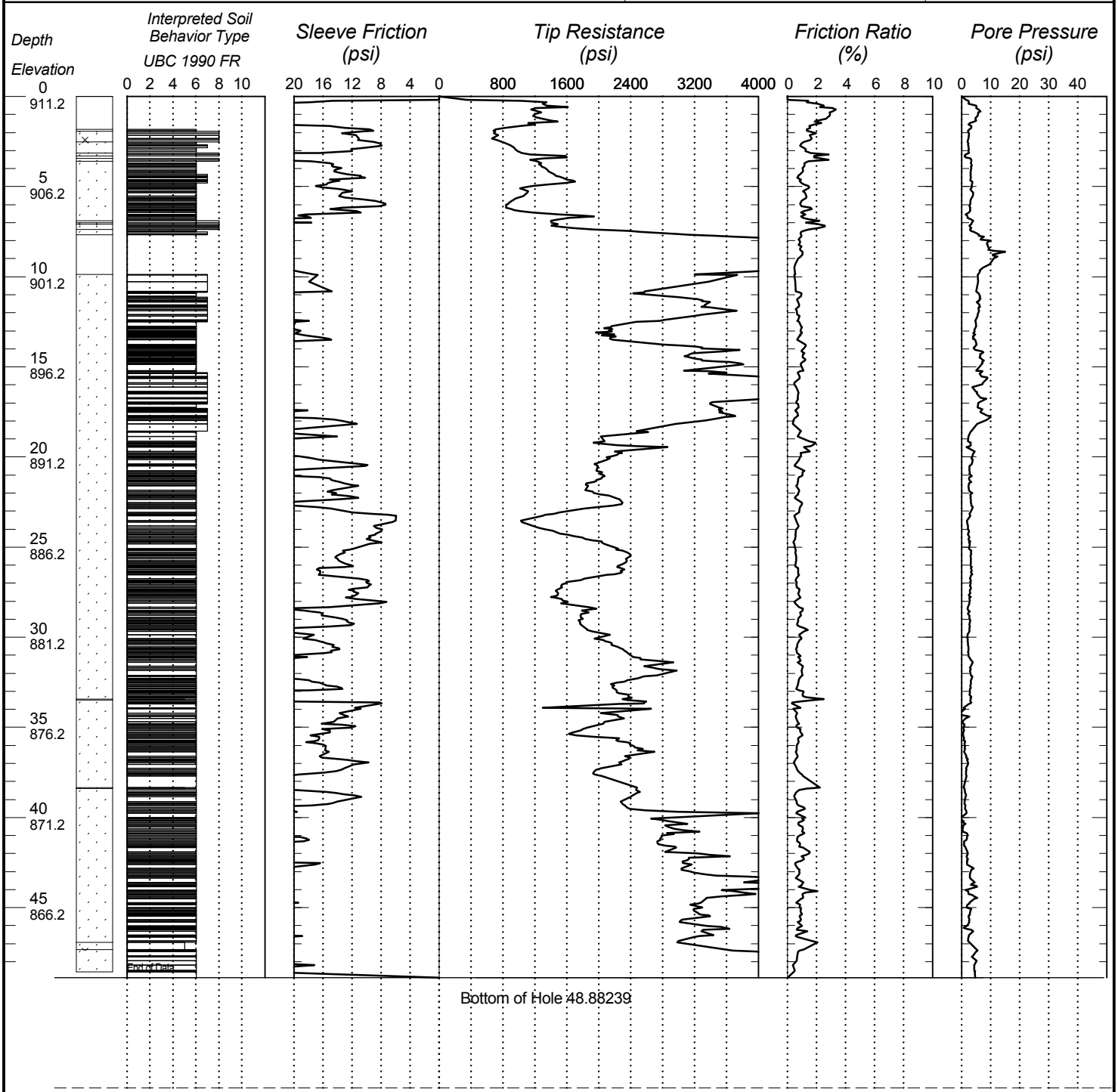
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68506

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c06c**	**911.2** (DTM)

Location **, , ft. LT**	CPT Machine **99649 CPT Track**	SHEET 1 of 1
Dakota Co. Coordinate: X=572741 Y=217354 (ft.)	CPT Operator **R Winter**	Date Completed
Latitude (North)=44°47'36.51" Longitude (West)=93°02'11.34"	Hole Type **CPT-STD**	**3/21/07**



Index Sheet Code 3.0 D21M0706C.DAT Soil Class: Rock Class: Edit: Date: 7/25/07

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

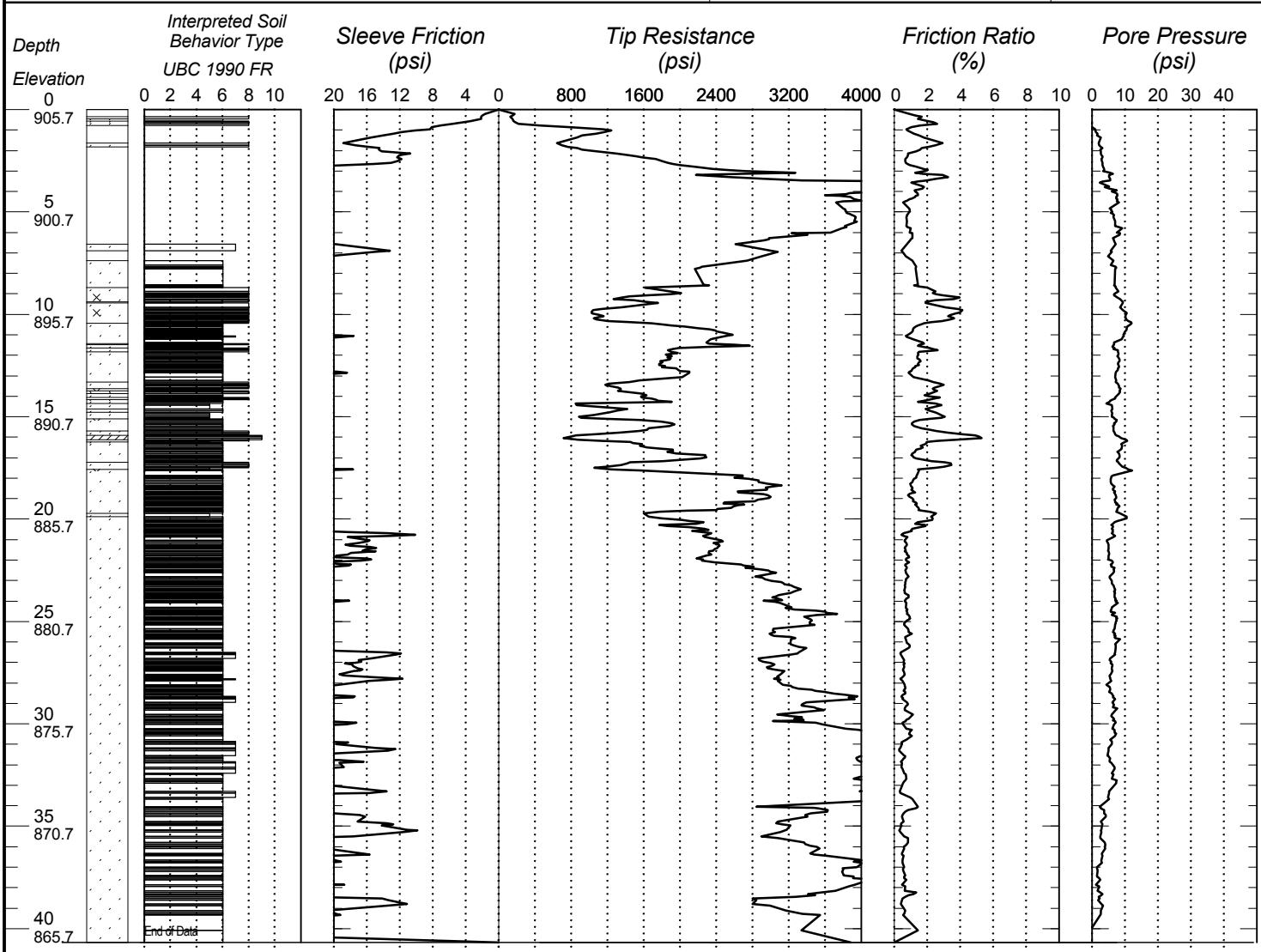
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68507

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c07**	**905.7** (DTM)

Location **, , ft. LT**	CPT Machine **99649 CPT Track**	SHEET 1 of 1
Dakota Co. Coordinate: X=572720 Y=217402 (ft.)	CPT Operator **R Winter**	Date Completed
Latitude (North)=44°47'36.98" Longitude (West)=93°02'11.64"	Hole Type **CPT-STD**	**3/21/07**



Index Sheet Code 3.0 D21M0703C.DAT Soil Class: Rock Class: Edit: Date: 7/25/07

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

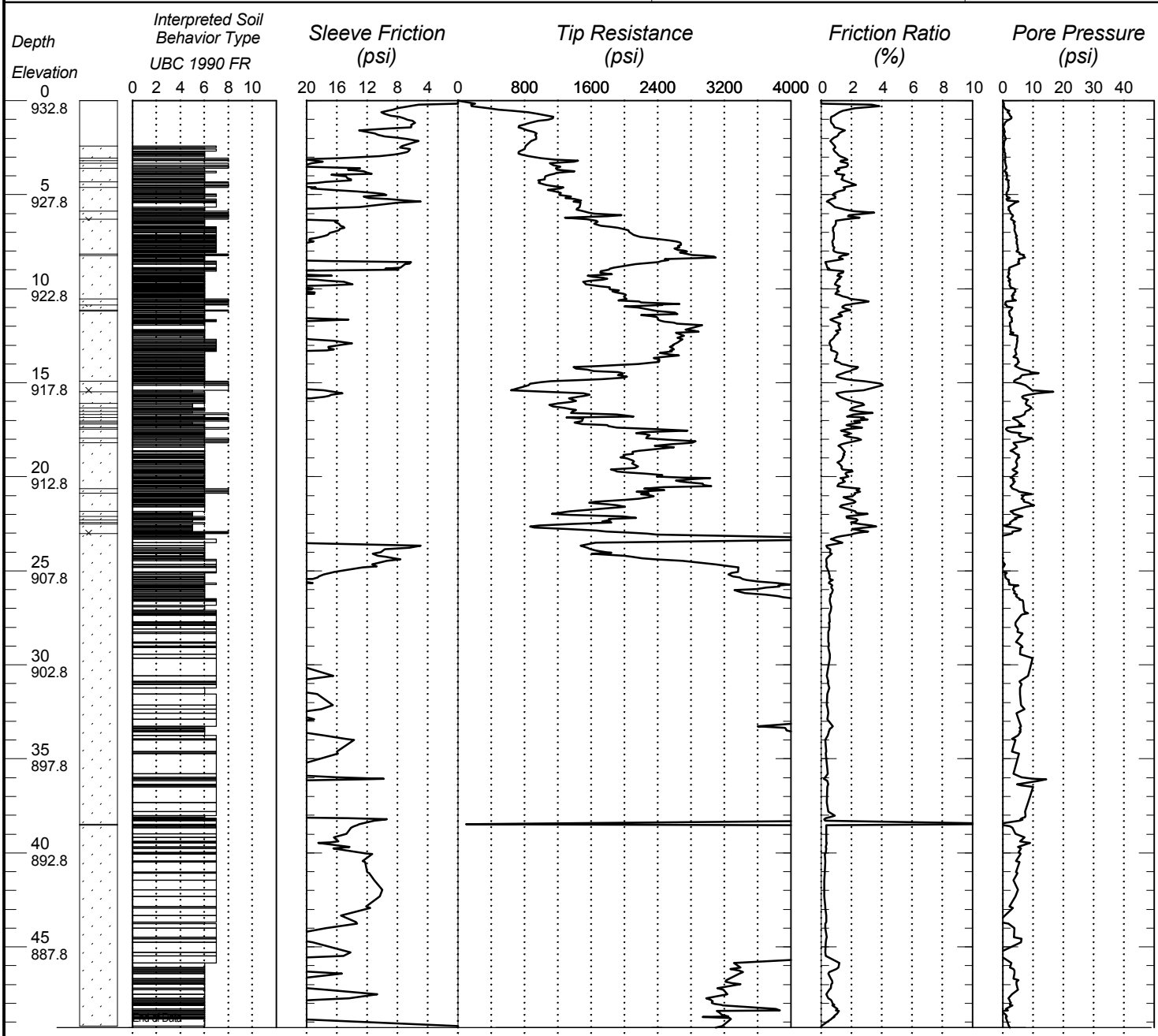
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68508

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c08**	**932.8** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
Dakota Co. Coordinate: X=572845 Y=217152 (ft.)	*CPT Operator* **R Winter**	*Date Completed*
Latitude (North)=44°47'34.51" *Longitude (West)=93°02'09.91"*	*Hole Type* **CPT-STD**	**3/21/07**



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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

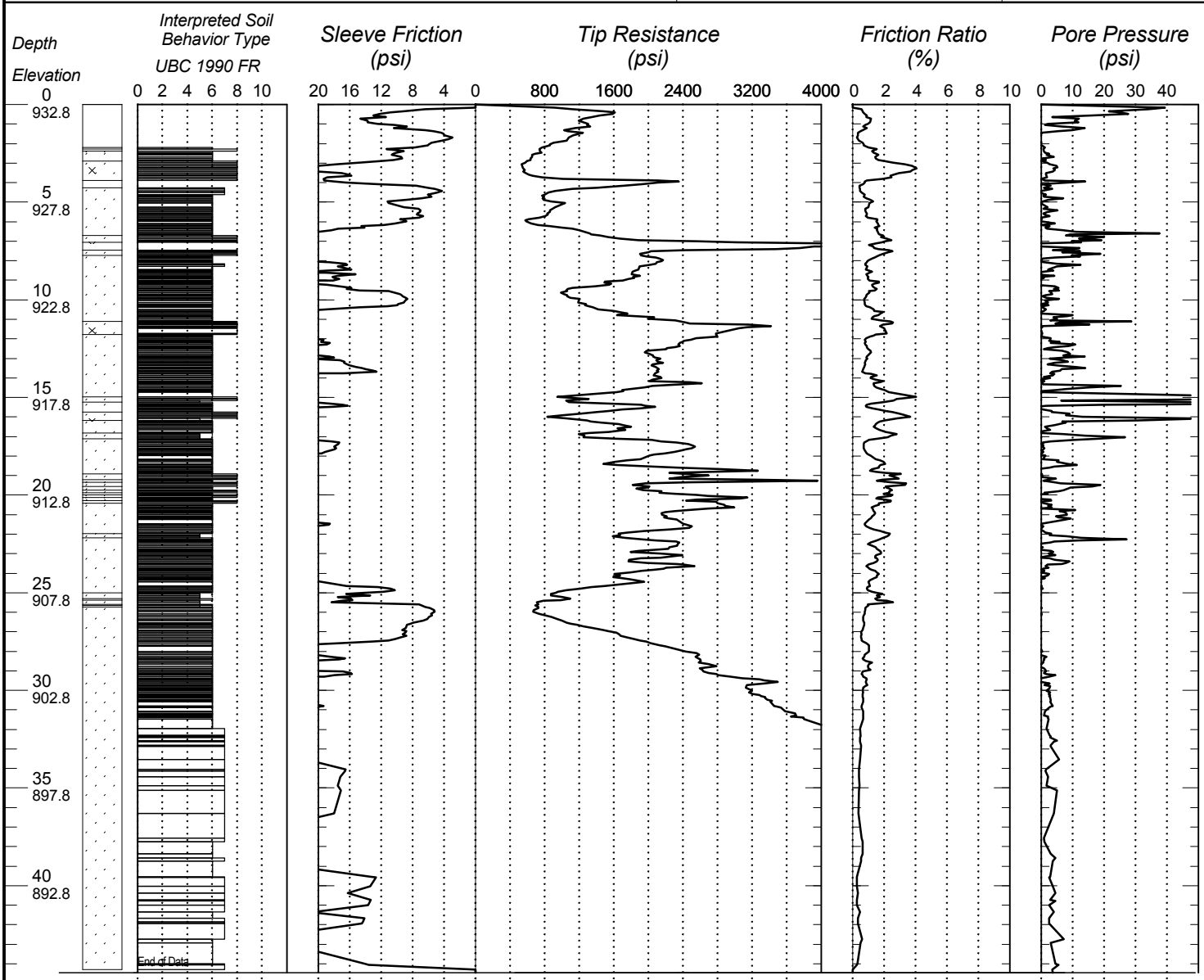
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68509

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c09**	**932.8** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
Dakota Co. Coordinate: X=572855 Y=217144 (ft.)	*CPT Operator* **R Winter**	*Date Completed*
Latitude (North)=44°47'34.43" *Longitude (West)=93°02'09.77"*	*Hole Type* **CPT-STD**	**3/21/07**



Index Sheet Code 3.0 D21M0701C.DAT *Soil Class: Rock Class: Edit: Date: 7/25/07*

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

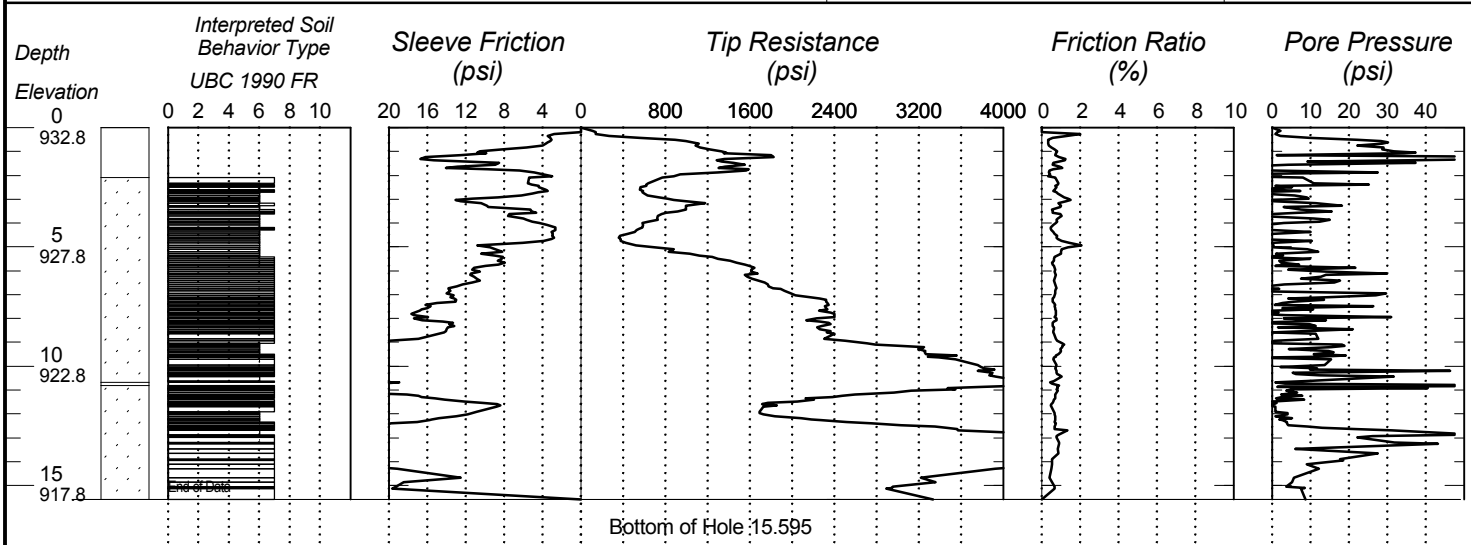
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68510

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c10**	**932.8** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
Dakota Co. Coordinate: X=572845 Y=217152 (ft.)	*CPT Operator* **R Winter**	*Date Completed*
Latitude (North)=44°47'34.51" *Longitude (West)=93°02'09.91"*	*Hole Type* **CPT-STD**	**3/22/07**



Index Sheet Code 3.0 D22M0701C.DAT *Soil Class: Rock Class: Edit: Date: 7/25/07*

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

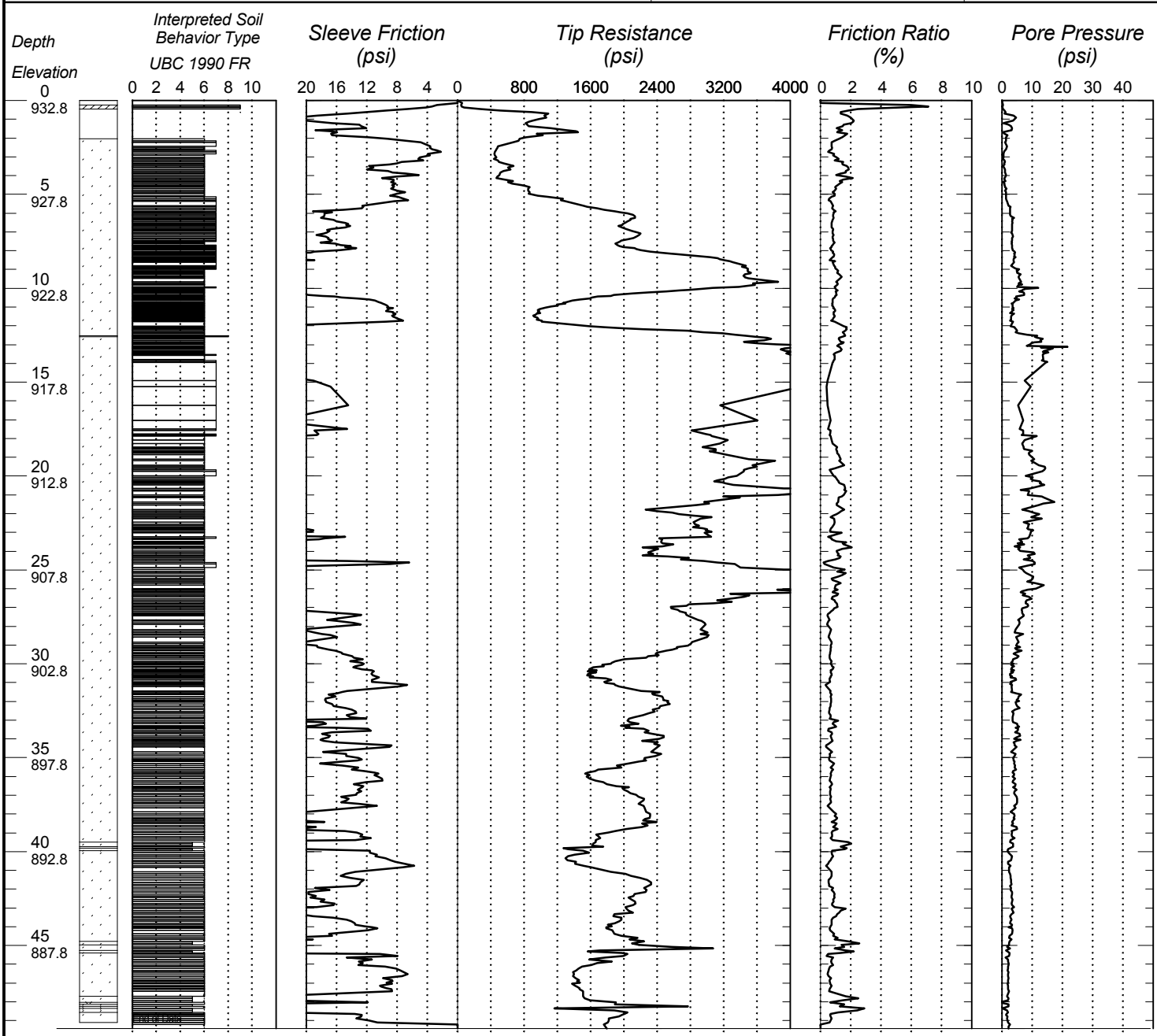
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68511

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c10b**	**932.8** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
Dakota Co. Coordinate: X=572855 Y=217144 (ft.)	*CPT Operator* **R Winter**	*Date Completed*
Latitude (North)=44°47'34.43" *Longitude (West)=93°02'09.77"*	*Hole Type* **CPT-STD**	**3/22/07**



Index Sheet Code 3.0 D22M0702C.DAT *Soil Class: Rock Class: Edit: Date: 7/25/07*

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

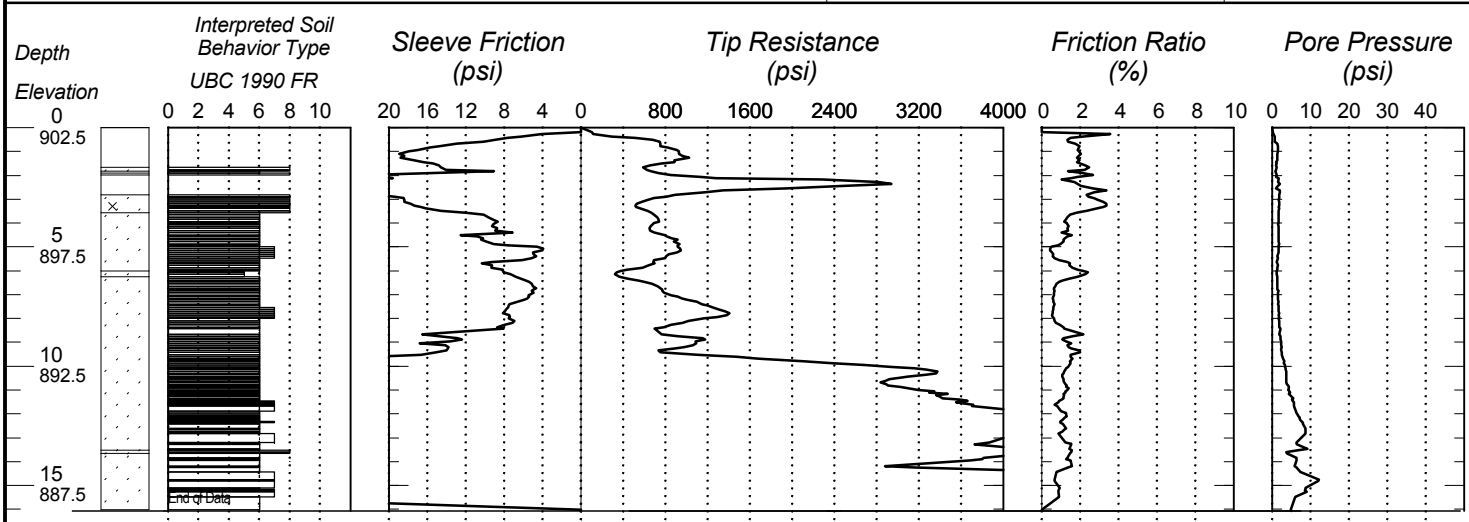
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 68653

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
1907-68		**TH 52**	**c01**	**902.5** *(DTM)*

Location **, , ft. LT**	*CPT Machine* **99649 CPT Track**	*SHEET 1 of 1*
Dakota Co. Coordinate: X=572949 Y=216722 (ft.)	*CPT Operator* **R Winter**	*Date Completed*
Latitude (North)=44°47'30.26" *Longitude (West)=93°02'08.49"*	*Hole Type* **CPT-STD**	**3/22/07**



Bottom of Hole 16.07446

Index Sheet Code 3.0 D22M0711C.DAT *Soil Class: Rock Class: Edit: Date: 7/25/07*

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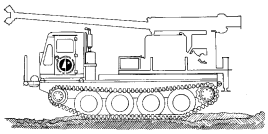
Minnesota Department of Transportation
Geotechnical Section
Boring Log Descriptive Terminology (English Units)



USER NOTES, ABBREVIATIONS AND DEFINITIONS - Additional information available in Geotechnical Manual.

This boring was made by ordinary and conventional methods and with care deemed adequate for the Department's design purposes. Since this boring was not taken to gather information relating to the construction of the project, the data noted in the field and recorded may not necessarily be the same as that which a contractor would desire. While the Department believes that the information as to the conditions and materials reported is accurate, it does not warrant that the information is necessarily complete. This information has been edited or abridged and may not reveal all the information which might be useful or of interest to the contractor. Consequently, the Department will make available at its offices, the field logs relating to this boring.

Since subsurface conditions outside each borehole are unknown, and soil, rock and water conditions cannot be relied upon to be consistent or uniform, no warrant is made that conditions adjacent to this boring will necessarily be the same as or similar to those shown on this log. Furthermore, the Department will not be responsible for any interpretations, assumptions, projections or interpolations made by contractors, or other users of this log.

Water levels recorded on this log should be used with discretion since the use of drilling fluids in borings may seriously distort the true field conditions. Also, water levels in cohesive soils often take extended periods of time to reach equilibrium and thus reflect their true field level. Water levels can be expected to vary both seasonally and yearly. The absence of notations on this log regarding water does not necessarily mean that this boring was dry or that the contractor will not encounter subsurface water during the course of construction.

WR . . . . . Weight of Rod
Mud . . . . . Drilling Fluids in Sample
CS . . . . . Continuous Sample

SOIL/CORE TESTS

SPT N_{60} . . . . . ASTM D1586 Modified Blows per foot with 140 lb. hammer and a standard energy of 210 ft-lbs. This energy represents 60% of the potential energy of the system and is the average energy provided by a Rope & Cathead system.
MC . . . . . Moisture Content
COH . . . . . Cohesion
(. . . . . Sample Density
LL . . . . . Liquid Limit
PI . . . . . Plasticity Index
F . . . . . Phi Angle
REC . . . . . Percent Core Recovered
RQD . . . . . Rock Quality Description (Percent of total core interval consisting of unbroken pieces 4 inches or longer)
ACL . . . . . Average Core Length (Average length of core that is greater than 4 inches long)
Core Breaks . Number of natural core breaks per 2-foot interval.

DISCONTINUITY SPACING

Fractures	Distance	Bedding
Very Close	<2 inches	Very Thin
Close	2-12 inches	Thin
Mod. Close	12-36 inches	Medium
Wide	>36 inches	Thick

RELATIVE DENSITY

Compactness - Granular Soils	BPF
very loose	0-4
loose	5-10
medium dense	11-24
dense	25-50
very dense	>50

Consistency - Cohesive Soils	BPF
very soft	0-1
soft	2-4
firm	5-8
stiff	9-15
very stiff	16-30
hard	31-60
very hard	> 60

COLOR

blk	Black	**wht**	White
grn	Green	**brn**	Brown
orng	Orange	**yel**	Yellow
dk	Dark	**lt**	Light
IOS	Iron Oxide Stained		

GRAIN SIZE /PLASTICITY

VF	Very Fine	**pl**	Plastic
F	Fine	**slpl**	Slightly Plastic
Cr	Coarse		

SOIL/ROCK TERMS

C	Clay	**Lmst**	Limestone
L	Loam	**Sst**	Sandstone
S	Sand	**Dolo**	Dolostone
Si	Silt	**wx**	weathered

G . . . . . Gravel (No. 10 Sieve to 3 inches)
Bldr . . . Boulder (over 3 inches)
T . . . . . till (unsorted, nonstratified glacial deposits)

WATER MEASUREMENT

AB . . . . . After Bailing
AC . . . . . After Completion
AF . . . . . After Flushing
w/C . . . . . with Casing
w/M . . . . . with Mud
WSD . . . . . While Sampling/Drilling
w/AUG . . . . . with Hollow Stem Auger

MISCELLANEOUS

NA . . . . . Not Applicable
w/ . . . . . with
w/o . . . . . with out
sat . . . . . saturated

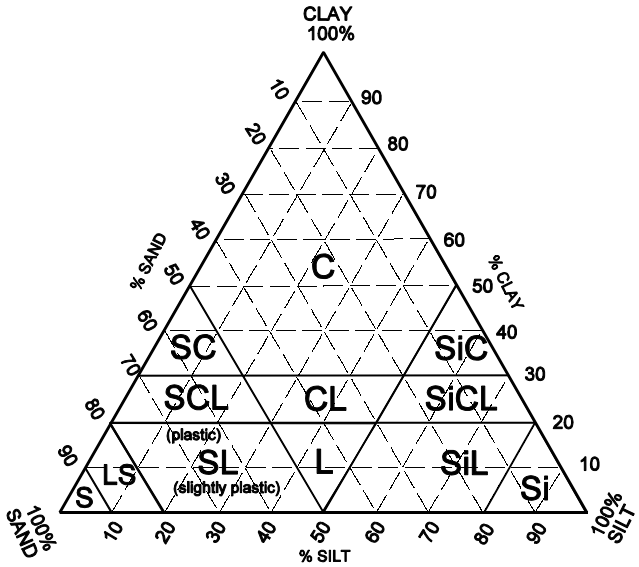
DRILLING OPERATIONS

AUG . . . . . Augered
CD . . . . . Core Drilled
DBD . . . . . Disturbed by Drilling
DBJ . . . . . Disturbed by Jetting
PD . . . . . Plug Drilled
ST . . . . . Split Tube (SPT test)
TW . . . . . Thinwall (Shelby Tube)
WS . . . . . Wash Sample
NSR . . . . . No Sample Retrieved
WH . . . . . Weight of Hammer

DRILLING SYMBOLS

- Vane Shear Test
- WS — **Washed Sample** Collected during plug drilling
- Augered
- PD — **Plug Drilled** (Rotary drilled with fluid)
- **Split Tube Sample** (SPT N_{60} with 2 in. split tube with liners)
- **Thin Wall Sample** (3 inch Thin Wall Tube)
- **Core Drilled** (NV Core Barrel, unless otherwise noted)
- CS — **Continuous Soil Sample**
- A/P — **Augered and Plug Drilled**
- Jet — **Jetted**
- A/J — **Augered and Jetted**

Mn/DOT TRIANGULAR TEXTURAL CLASSIFICATION SYSTEM



Index Sheet No. 3.0 July 1997

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 69024

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
1907-68	**RSS (special)**	**US Highway TH 52**	**T11**	**937.7** (DTM)

Location **, , ft. LT**

Dakota Co. Coordinate: X=572842 Y=217177 (ft.)

Latitude (North)=44°47'34.76" Longitude (West)=93°02'09.95"

Drill Machine **205120 CME(LC55) Track**

Hammer **CME Automatic Calibrated**

SHEET 1 of 2

Drilling Completed **9/10/07**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
			slightly organic Loamy Sand and Gravel with a few roots, dark brown and moist			9				
	2.5 / 935.2				11	10				
5					19	3				
					19	1				
			Fine Sand to Sand with a little Gravel, light brown and damp							
10					94	4				
					38	3				
15					51	4				
	16.5 / 921.2									
			Sand with a little Gravel, brown and damp		40	6				
20	20.0 / 917.7				31	3				
					35	3				
25			Sand with some Gravel and a few stone chips, light brown and damp		25	2				
					16	2				
30										

Index Sheet Code 3.0

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Soil Class:DSB Rock Class: Edit: Date: 2/10/09

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 69024

U.S. Customary Units

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS *SHEET 2 of 2*

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
1907-68	**RSS (special)**	**US Highway TH 52**	**T11**	**937.7** *(DTM)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
					33	2				
					26	2				
35					22	1				
			Sand with some Gravel and a few stone chips, light brown and damp *(continued)*		46	1				
40					47	1				Addl. Lab Test: Grain Size Analysis on Bag Sample 40 ft., DS test series: phi = 37.6, c= 377 psf
					36	1				Addl. Lab Test: Grain Size Analysis on Bag Sample 43 ft., DS test series: phi = 38.9, c= 172 psf
	44.0 / 893.7									
45					60	5				Addl. Lab Test: Grain Size Analysis on Bag Sample 46 ft., DS test series: phi = 37.4, c= 272 psf
			Sand with a little Gravel and stone pieces, brown and damp		77	5				Addl. Lab Test: Grain Size Analysis on Bag Sample 48 ft., DS test series: phi = 38.6, c= 78 psf
50					63	6				
	51.0 / 886.7									

Bottom of Hole - 51.0'
No water encountered or measured during drilling

Soil Class:DSB Rock Class: Edit: Date: 2/10/09
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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 69025

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
1907-68	**RSS (special)**	**US Highway TH 52**	**T12**	**939.9** (DTM)

Location **, , ft. LT**

Dakota Co. Coordinate: X=572887 Y=217072 (ft.)

Latitude (North)=44°47'33.72" Longitude (West)=93°02'09.34"

Drill Machine **205120 CME(LC55) Track**

Hammer **CME Automatic Calibrated**

SHEET 1 of 2

Drilling Completed **9/11/07**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
			slightly organic Loamy Sand with some Gravel, roots and grass; dark brown and moist			10				
	2.5 / 937.4				7	18				
5			Sand and Gravel with a few seams of slightly plastic Sandy Loam, browns, moist to damp		10	3				
					48	7				
	9.0 / 930.9									
10			Loamy Fine Sand with a few pebbles, seam of plastic Fine Sandy Loam; light browns and damp		14	11				
	12.5 / 927.4		Sand and Gravel, light brown and damp		41	6				
	14.0 / 925.9									
15					26	9				
					41	6				
20					39	7				
			Loamy Sand with some Gravel, browns and damp		32	8				
25					43	6				
					53	8				
30										

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Soil Class:DSB Rock Class: Edit: Date: 2/10/09

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MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 69025

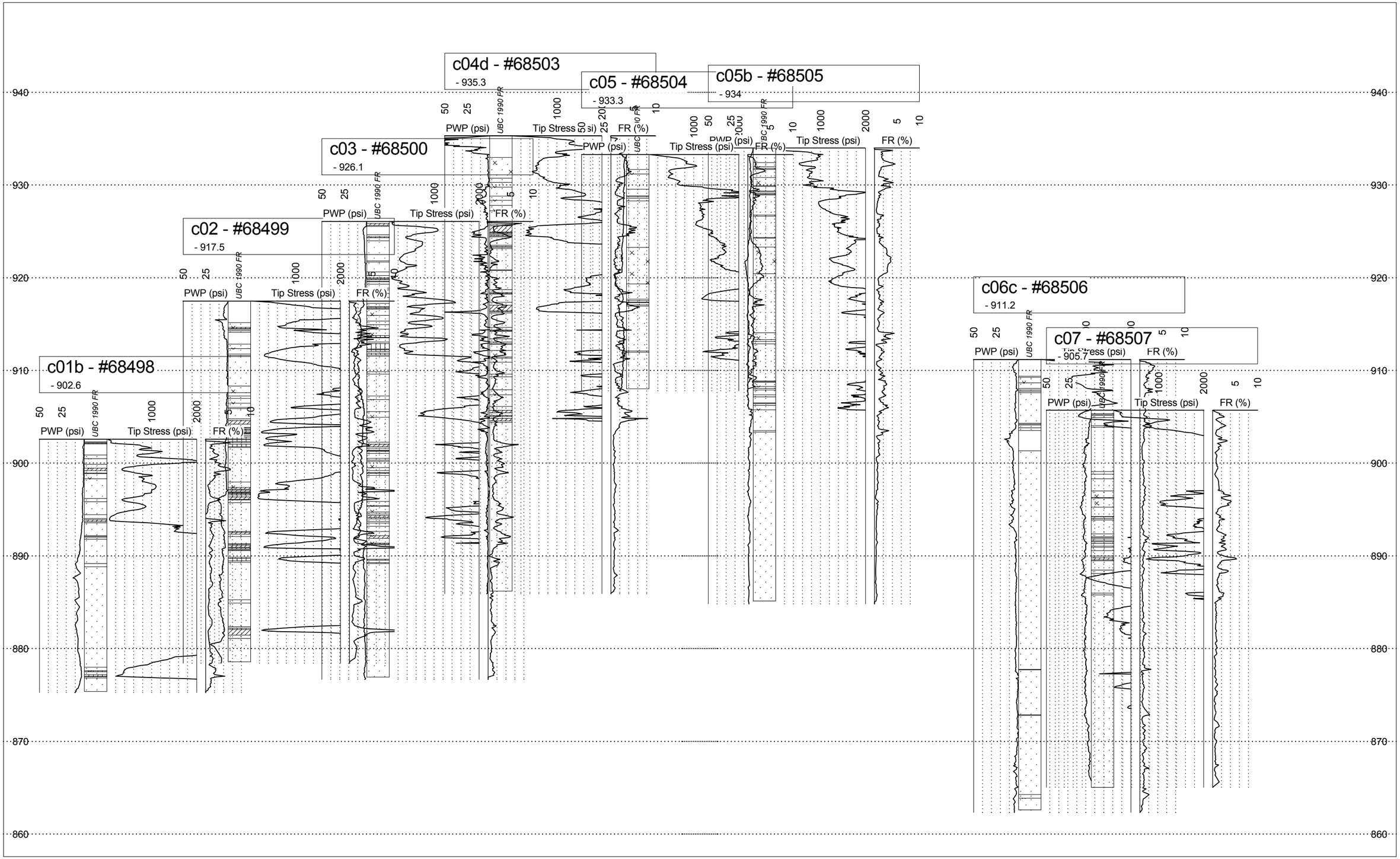
U.S. Customary Units

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS *SHEET 2 of 2*

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
1907-68	**RSS (special)**	**US Highway TH 52**	**T12**	**939.9** *(DTM)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
			Loamy Sand with some Gravel, browns and damp *(continued)*		47	8				
	31.5 / 908.4									
			Sand and Gravel, brown and damp		37	3				
	34.0 / 905.9									
35			Sand with Gravel, brown and damp		34	5				
					56	5				Addl. Lab Test: Grain Size Analysis on Bag Sample 38 ft., DS test series: phi = 38.0, c= 167 psf
	39.0 / 900.9									
40			Sand and Gravel with a few stone pieces, brown and damp		50	3				
	41.5 / 898.4									
					42	5				Addl. Lab Test: Grain Size Analysis on Bag Sample 43 ft., DS test series: phi = 41.0, c= 204 psf
45					44	2				
			Sand with some Gravel, a few stone pieces; brown and damp							Addl. Lab Test: Grain Size Analysis on Bag Sample 47 ft., DS test series: phi = 38.3, c= 370 psf
					30	2				Addl. Lab Test: Grain Size Analysis on Bag Sample 49 ft., DS test series: phi = 40.6, c= 139 psf
50					21	2				
	51.0 / 888.9									

Bottom of Hole - 51.0'
No water encountered or measured during drilling


c01b - #68498
- 902.6
c02 - #68499
- 917.5
c03 - #68500
- 926.1
c04d - #68503
- 935.3
c05 - #68504
- 933.3
c05b - #68505
- 934
c06c - #68506
- 911.2
c07 - #68507
- 905.7
PWP (psi)
Tip Stress (psi)
FR (%)
UBC 1990 FR
940
930
920
910
900
890
880
870
860

SP 1907-68
Special Provisions for
Reinforced (Earth Anchored) Slope Special

A. Reinforced (Earth Anchored) Slope Description

As part of the Work, between roadway STA 217+00 and 222+50, a reinforced slope is to be constructed in order to preserve a grove of oak trees associated with the DNR SNA. A number of the trees to be protected are on Mn/DOT ROW. Due to space constraints limiting the amount of excavation in this area, a top-down system of construction, consisting of an earth anchoring system with a vegetated face is specified to construct the reinforced soil slope at this location. Traditional bottom-up MSE systems are not anticipated to be appropriate for most or all of the slope system in the vicinity of the designated tree protection area.

The design and construction shall accommodate both the preservation of the designated trees (and associated root systems, which shall be delineated prior to the Work) and the installation of a vegetated fascia system at the front of the wall. The tree protection area is indicated on the project plan sheets (Plan Pages XXX to XXX) for the wall area and on the relevant cross sections (X-Sec Pages XXX to XXX).

As described in the contract documents, Mn/DOT (or the contractor for Mn/DOT) will install fencing and demarcation boundaries around the trees and root areas that are not to be disturbed by either the slope construction itself or associated construction equipment. Mn/DOT will also provide the seed mixtures, and the seed, for use in the vegetated fascia system. The slope construction contractor shall provide initial quick-growth seeding as part of their design. The system shall be designed so as to contain a minimum nominal 8 inch thick layer of soil suitable for establishing and maintaining vegetation on the slope.

A line and grade for the wall system are provided in the project plans. The reinforced slope system shall be installed in all areas where the slope is in excess of 1V: 2H (26.6 degrees).

For purposes of this specification, “earth anchoring” may be taken to describe a number of earth/soil reinforcing systems including, but not limited to, soil nails (launched or grouted), micro-piles, mini-piles, piles, and other reinforcing systems and not specifically permanent “earth anchors” or “ground anchors.” Refer to the section on alternate designs for additional information.

B. Reinforced (Earth Anchored) Slope Design Requirements

The wall vendor/contractor/designer shall be responsible for the engineering design and analysis of the reinforced (earth anchored) slope system. Analysis shall include internal, external (global), and compound stability (if applicable), of the slope system. Materials and components selected shall meet a 75 year design life or as directed in the contract documents. Designs shall include consideration of appropriate loadings, geometry, and material properties associated with the native soil, backfill [if applicable], reinforcement, connections, facing, vegetation, and other design elements. Safety factors for the internal, external (global), and compound (if applicable) stability of the system should be a minimum FS of 1.3. Evaluation of slope stability shall be performed by a registered professional engineer using accepted state-of-practice hand-methods or computer software. Static equilibrium and/or finite element methods incorporating reinforcing elements are acceptable.

The site shall be evaluated for overland flow approaching the slope system; if necessary a drainage system shall be installed at the top of the slope system to prevent deleterious effects on the vegetated face.

Shop/installation drawings shall be submitted by the designer to Mn/DOT for review at least 28 days prior to beginning the slope construction. The design should be prepared, reviewed, signed and stamped by a licensed [registered] professional engineer.

Soil borings and Cone Penetration Test (CPT) soundings in the vicinity of the proposed slope construction are included with the project documentation. A copy of the wall design report is available from the Mn/DOT Foundations Unit [contact Gary Person, Foundations Engineer at 651.366.5598].

It is preferred that a single system be employed for the construction of the whole slope area for ease of construction. Soil Nailing, Permanent Ground Anchoring, and Reticulated Micropiles are anticipated to meet the design needs at this site. Alternately, use of Shored MSE systems or sheeting/shoring wall systems with vegetated MSE slopes in front of them, may also be considered; refer to section H, below. The system(s) shall be designed so as to contain a minimum nominal 8 inch thick layer of soil suitable for establishing and maintaining vegetation on the slope.

Designs shall be prepared in accordance with appropriate FHWA and AASHOTO design guides and specifications, where applicable, including "Geotechnical Engineering Circular #4, Ground Anchors and Anchored Systems" FHWA IF-99-015; "Geotechnical Engineering Circular # 7, Soil Nail Walls" FHWA IF-03-017; "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Design and Construction Guidelines", FHWA NHI-00-043 ; "Micropile Design and Construction", FHWA NHI-05-039; Design and Construction of Driven Pile Foundations" FHWA NHI-05-042.

Where FHWA or AASHTO design guidelines are not available (e.g. launched soil nails, reticulated micropiles) the designer must provide sample slope stability computations, detailed design information [based on geometry and soil properties for this site], methodologies, and assumptions, working drawings, installation details, and a complete QC/QA inspection and testing program as part of the submittal package for review. These systems must be submitted, reviewed and approved by Mn/DOT prior to construction of the slope system.

C. Construction Requirements

Slope construction shall consist of excavating soil materials in the prescribed area (in appropriate benched to preserve slope stability), limiting impact to the protected DNR trees, and installing a reinforced (earth anchored) slope system (including but not limited to, drainage, reinforcement, connections, facing, and all related construction. All proprietary items used in the structure shall be installed in accordance with the manufacturer’s recommendations.

A qualified engineer or engineering technician, experienced in the design and construction of the selected type of retaining structure construction, shall be present to observe and monitor the installation process. The slope construction shall be actively inspected for quality assurance and control. Materials used in construction and construction methods shall be inspected, sampled, and tested for compliance, in accordance with the Mn/DOT schedule for materials control, with design specifications. Materials that do not meet or exceed design specifications will be rejected.

The Mn/DOT project engineer shall authorize a stoppage of work and conduct appropriate corrections if installation is unsatisfactory, if materials are inconsistent with design specifications, or if other conditions are present that would result in inappropriate construction or safety concerns.

The slope construction contractor shall determine the geometry of the slope system in the design process and prepare working/shop drawings accordingly. Deviation from the design batter and horizontal alignment for the face when measured along a ten foot straight edge shall not exceed 4 inches, at time of construction.

Construction shall be staged such that the risk of local and global slope failures is minimized, particularly in the vicinity of the protected trees. Excavation benches shall be limited to a maximum of 6 feet. Stand-up time of open faces shall be evaluated and excavations limited to prevent loss of ground.

The drainage systems at the top of the slope and any systems integrated into the fascia system shall be developed so as to be compatible with long term success of the native vegetation to be established on the face. Seed mixtures for the vegetated face shall be developed in coordination with the Mn/DOT Office of Environmental Services in cooperation with the Minnesota DNR.

D. Contractor's Experience Requirements

The Contractor is advised that the reinforced (earth anchored) slope is a specialty geotechnical structure, requiring both experience and specialty expertise in both design and construction.

The Contractor or Subcontractor performing the Work shall have competed at least 5 projects within the last 5 years involving the construction of retaining walls or soil slopes using the elected methodology to be used on this project (e.g. grouted soil nails, launched soil nails, reticulated micropiles, permanent earth anchors, etc…). At least 2 of the projects shall be of a scope equal or greater than the Work described herein with a minimum of 500 total successfully installed reinforcing elements on each structure. On site supervisors shall have a minimum of 2 years of experience installing permanent slope systems of the design used here (soil nails, earth anchors, etc…) and shall be present during the complete installation of the system.

E. Preconstruction Conference

A reinforced (earth anchored) slope preconstruction conference shall be held at least 5 working days prior to the Contractor beginning any permanent work at the site to discuss the construction plan, construction procedures, personnel, and equipment to be used. If there are any significant revisions to the approved installation plan, and additional conference shall be held after the revisions are reviewed and accepted.

F. Submittals

Work shall not begin until the Engineer has approved all of the required submittals. The contractor shall submit the following information prior to the pre-construction meeting:

1) A brief description of each project satisfying the Contractors Experience Requirements with the Project Owner's name and current phone number.
2) A list identifying key personnel assigned to the project and their experience with the slope system.
3) The proposed detailed construction procedure that includes: excavation methods, reinforcing installation equipment and methods, general geometry of reinforcement, reinforcing element properties, grout information (if applicable), drainage information, connection details, facing details, turf establishment details.
4) Proposed QC/QA program* and related information on deflection tolerance control and in-situ or lab testing of reinforcing and/or, connection, and facing material properties.

At a minimum of 28 calendar days prior to the beginning of the construction of the slope, the contractor shall submit a detailed plan for the slope.
The detailed plan shall include:

1) The actual lengths for the proposed reinforcement elements and the locations of each proposed element.
2) Proposed construction method including proposed forming systems (if any), types of equipment to be used, and proposed construction sequence. A layout and description of the construction stages and installation layers/benches.
3) Details of the vegetated facing including connections, components, and materials used to attach the facing system to the earth anchoring system. Facing properties shall be provided as well as details related to the vegetation and turf establishment procedures.
4) A general plan for remediation of the wall system in the event of installation difficulties associated with the reinforcing elements, connections, or vegetated facing system.
5) QC/QA program* and related information on deflection tolerance control and in-situ or lab testing of reinforcing elements (proof/verification) and/or, connection, and facing material properties.

- Note that the QA/QC program shall be in general conformity with FHWA design and construction guidelines for the work. Where these guidelines do not exist, the contractor shall develop and include a QA/QC plan for review and acceptance which satisfies the following criteria:

The QA/QC plan shall validate:

1) design assumptions for strength of the reinforcing elements. The contractor shall also provide documentation that assumptions in the design are valid (strength and/or deflection properties of the soil or reinforcement are satisfied)
2) connection strength is appropriate
3) installed component strength is appropriate
4) deflection tolerances at the vegetated facing are less than 4 inches from the design locations due to bulging or other deformation.

G. Warranty

A minimum 2 year warranty on the wall system shall be required for the Work. The warranty includes structural defects (including, but not limited to pull-out of reinforcing elements, connection deficiencies, bulging at the face, vegetation die-off, and distress to the system caused by groundwater at the rear of the facing system or overland flow across the facing system. If deflections of the front face are greater than 6 inches from the original design over more than 25% of the slope area, the system shall be deemed out-of-tolerance and shall be wholly replaced. If more than 10% of the connections or reinforcing elements are found to be broken, deformed, or in severe distress, the system shall be deemed out-of-tolerance and shall be wholly replaced. If the entire slope system is determined to be failing through a defect in either internal stability or global stability, the slope system shall be wholly replaced. Lesser impacts shall be repaired or replaced where identified to the satisfaction of the Engineer. Small impact areas, when repaired, shall have a new warranty associated with that work of 2 years from the date of repair. This warranty local repair work shall be at no additional cost to Mn/DOT. In the event of a full warranty replacement due to a structural or geotechnical failure, the new factor of safety for the revised/replacement slope design will be 1.5, with a new warranty period of 3 years. This warranty full replacement work shall be at no additional cost to Mn/DOT.

H. Alternate Wall/Slope Systems

Alternate wall or slope systems may be considered for use in the construction of the proposed reinforced (earth anchored) slope system. If alternate systems are used, a complete design based on these alternate systems must be submitted for approval [refer to the previous paragraphs for design and inspection requirements]. Use of alternate system without an appropriate design, analysis, and accompanying engineering documentation [by a licensed professional engineer] will not be considered. Note that alternate systems must also provide protection to the tree preservation area during construction and long-term, as well as have a vegetated face, similar to the specified system; alternate wall or slope types, not meeting these criteria, will not be considered.

Alternate designs, if proposed, must meet or exceed the design and construction (including QA/QC and inspection/acceptance) requirements of the system indicated in the plan. Aesthetic, turf establishment, strength, and related structural properties of any proposed alternates must meet or exceed appropriate AASHTO and Mn/DOT specifications, and any special provisions detailed for this project. All systems must include a 2 minimum year warranty for both turf establishment and deformation tolerances.

I. System Approval

The Engineer shall approve the soil reinforcement system prior to construction. A system may be disallowed if the contractor fails to submit design or construction information, or if proposed techniques (documentation/submittals, design, construction, QA/QC [proof/validation] testing, inspection) are not consistent with the requirements established in the special provisions, plans, or are determined not to meet the current standard of practice for the construction of the proposed Work.

J. Payment

Payment shall be made under the pay items as described in the Special Provisions S-XX? (Reinforced [Earth Anchor] Soil Slope Special)

Pay Items include payment for all portions of each slope system, including, but not limited to, engineering design, analysis, and testing, associated earthwork and backfill, subcuts and foundation treatments, reinforcement, drainage, anchoring, connections, facing and fascia treatments, turf establishment (where appropriate), formwork, and all related materials, labor, inspection, construction, installation, warranty, and warranty correction associated with the slope systems.

Pay items are based on wall area of exposed finished slope height (horizontal face width x vertical face height). [Note that this is a projection of the slope surface area on a vertical plane running through the slope toe; units are square feet].