FOUNDATION ANALYSIS AND DESIGN REPORT

TO: Mark Bishop, PE, Kimley-Horn and Associates, Inc.

FROM: Jeffery K. Voyen, PE, American Engineering Testing, Inc.

DATE: June 25, 2014

SUBJECT: LRT Bridge over 5th Avenue N and N 7th Street
Southwest Light Rail Transit Project
Minneapolis, Minnesota
AET No. 01-05697.04

1.0 PROJECT INFORMATION

This report provides foundation analysis and recommendations for the bridge which will carry the light rail transit (LRT) tracks over 5th Avenue North and North 7th Street in Minneapolis. This new bridge will be an extension of Bridge R0646 which was recently constructed as a part of the Interchange project which includes the Target Field Station.

The new bridge will have eleven spans. The span from the south abutment to Pier 1 will be a post-tensioned slab structure, the five spans from Pier 1 to Pier 6 will have post-tensioned box girders, and the five spans from Pier 6 to the existing bridge will be a pre-stressed concrete beam structure. Current substructure data is presented in Table 1.0.

Table 1.0 – Bridge Substructure Data

Substructure	Station	Bottom of Foundation Elevation
South Abutment	2950+64.51	823.0
Pier 1	2951+49.51	823.0
Pier 2	2952+49.51	823.5
Pier 3	2953+84.51	823.5
Pier 4	2955+19.51	823.5
Pier 5	2956+54.51	817.5
Pier 6	2957+54.51	814.5
Pier 7	2958+34.51	811.5
Pier 8	2959+24.51	809.5
Pier 9	2960+14.51	810.5
Pier 10	2961+04.51	815.5
Pier 11*	2961+64.84	808.67*

*denotes existing Pier 9, Bridge R0646 (Interchange)

The plan and profile sheets from the preliminary bridge plans are attached to this report.

The south approach will begin just north of the Royalston Station and rise to a height of about 19 to 20 feet at the bridge abutment. The approach will be contained within parallel retaining walls, which will have a face-to-face width of about 30 feet.

2.0 SUBSURFACE EXPLORATION AND TESTING SUMMARY

2.1 Field Exploration Scope

The exploratory test program performed specific to this bridge and the south approach consisted of eight standard penetration test (SPT) borings and four piezocone penetration test (CPT_u) soundings. The locations of the borings and CPTs appear on attached Figure 1. The County coordinates also appear on the logs.

2.2 Laboratory Scope

During laboratory classification logging, water content tests were conducted on cohesive soil samples. In addition, the following tests were performed:

- two consolidation tests
- sixteen unconfined compression tests with density
- one sieve analysis test
- two density tests with water content

The consolidation test results appear on the data sheets following the boring logs. The remaining tests appear on the individual boring logs, opposite the samples upon which they were performed.

2.3 Methods

Logs of the SPT borings are attached. The borings were drilled using 3.25 inch diameter hollow stem augers and mud rotary drilling (plug drilling) techniques. Standard penetration test samples were taken with split-barrel samplers per ASTM: D1586, with the exception that the hammers were calibrated to near N_{60} values per MnDOT requirements. The soils were visually-manually classified per the Unified Soil Classification System. The soil group category per the AASHTO Soil Classification System is also noted on most of the logs. Please refer to the attachments entitled *Exploration/Classification Methods, Boring Log Notes, Unified Soil Classification System,* and *AASHTO Soil Classification System* for additional details. CPT testing was conducted in general accordance with ASTM:D5778; with the user notes, abbreviations, and definitions appearing on the attachment *Cone Penetration Test Index Sheet.*

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.

2.4 Geology/Soils Review

2.4.1 General Overburden Geology Review

The bridge area is underlain by Bassett Creek geologic deposits which consist of deep-water lake sediment deposited in an ice-block melt-out lake. The Bassett Creek deposit soils are primarily lean to fat clays with occasional beds of silt or fine grained sand. Most of the clays in the bridge area have been found to be firm to stiff due to apparent past overburden. Some of the borings are overlain by alluvial sands to silty sands, and considering the overconsolidated nature of the clays, we suspect most of the area has experienced natural overburden in the past. The clays become considerably softer in the lower elevation area towards the east (towards Target Station) and it appears this eastern end has not experienced the same overburden. Boring 1207 SB includes organic clay swamp deposits to about 42 feet (buried below 22 feet of uncontrolled fill).

The above described Bassett Creek deposits extend down to approximate elevations in the range of 765 feet to 745 feet. The primary soils beneath this are glacially-deposited tills, mainly consisting of clayey sands, sandy lean clays, and silty sands, with varying amounts of gravel. These soils also have increased potential to contain cobbles and boulders. These tills are sometimes underlain or interbedded with alluvial clays or sandy soil.

2.4.2 Bedrock

The elevation of the top of bedrock varies significantly. Even with this wide elevation range, the bedrock encountered will be sandstone of the St. Peter Formation. Colluvium (fallen rock pieces/residual soil) can be found just above the bedrock in some areas. The shallowest bedrock will appear on the north side of Piers 5 and 6, where CPT 1109 CB appears to have encountered denser sandstone around elevation 753 feet (several CPT attempts at that location obstructed at a similar depth). The borings reaching sandstone also suggest rising bedrock in that direction. The top of bedrock lowers considerably to the east (elevation 681 at Boring 1207 SB) and towards the southwest. Boring 1022 SB at the planned south abutment didn't reach bedrock to its termination depth around elevation 662, although colluvium appears to have been reached.

2.4.3 Upper Fill

Much of the bridge length includes a substantial thickness of uncontrolled fill over the natural soils. The fill is shallowest in the south end (about 3 to possibly 6½ feet at Boring 1022 SB at the south abutment) and increases to as much as 33 feet at Boring 1110 SB. The fill is a mixture of many soil types, both granular and cohesive. Much of the thicker fill areas include intermixing with ashes/cinders and debris, such as pieces of concrete, bituminous, wood, brick, and glass. The N-values and material quality indicate most of the fill was placed in a poorly compacted, uncontrolled manner.

2.5 Ground Water

Ground-water levels were encountered during drilling at varying elevations. The levels indicated on the logs are not necessarily stabilized levels due to the varying soil permeability properties and the waiting period allowed for stabilization at the time of measurement. Based on our interpretation of the data, it appears that the steady-state level does vary, generally within the elevation range of 798 feet to 808 feet. Water levels are expected to fluctuate both seasonally and annually.

3.0 FOUNDATION ANALYSIS

3.1 Foundation Analysis

3.1.1 Foundation Type

The new bridge will abut the existing Target Station LRT bridge, which is located at Track 2 Station 2961+63.46. New bridge Piers 7 to 10 will also be constructed adjacent to existing bridge piers located to the south for the existing tail tracks. The existing bridge is supported on HP12x53 pile which has been driven to the sandstone bedrock. We recommend continuing to use the same foundation type adjacent to the existing bridge and continuing up to and including Pier 5. Per normal MnDOT limits, this pile can be designed for a Factored Pile Bearing Resistance value (φR_n) of up to 140 tons.

As bedrock significantly lowers in elevation towards the south and as other obvious highly resistant material is not present within the bored depth, it is preferred to gain pile capacity through a combination of end bearing and side skin friction. Therefore, the use of a CIP steel pipe pile should be considered on the west/south end of the bridge. A 12-inch diameter CIP steel pipe pile is commonly used in this case and was the pile type analyzed. Per normal MnDOT limits, this pile can be designed for a Factored Pile Bearing Resistance value (φR_n) of up to 100 tons, assuming a pile wall thickness of 0.250 inches.

3.1.2 Pile Foundation Analysis Methods

Pile bearing resistance versus pile length where SPT borings were performed was analyzed using *DRIVEN* software (FHWA). This program uses the Nordlund method for granular soils and the Tomlinson method for cohesive soils. The granular soil internal friction angle used was based on its relationship to standard penetration test values as presented by Peck, Hanson, and Thorburn (1974), with the N-values being corrected for the influence of the effective overburden pressure. For cohesive soils, we estimated undrained shear strength based on the unconfined compression tests results and on correlations with the SPT data. The "ultimate capacity" determined from this *DRIVEN* analysis is considered the Nominal Resistance of Single Pile in Axial Compression (R_n) using LRFD terminology.

Pile bearing resistance versus pile length where CPT soundings were performed was analyzed using direct input of the CPT data. The data was analyzed using the computer program *UniPile5.0* (UniSoft), following the Eslami and Fellenius pile resistance method.

3.1.3 Analysis Results

The nominal resistance (ultimate capacity) needed to be demonstrated in the field depends on the Resistance Factor allowed by the "Condition/Resistance Determination Method" used. A Resistance Factor (φ) of 0.65 can be used when dynamic analysis is employed. Differing Resistance Factors are used for differing pile types when the field evaluation is based on the MPF12 driving formula (MnDOT's new formula), as follows:

- For H-pile, use a Resistance Factor (φ) of 0.60
- For steel pipe pile, use a Resistance Factor (φ) of 0.50

Where steel pipe pile is used, we recommend using dynamic analysis for pile evaluation. In the case of 12-inch diameter steel pipe pile designed for φR_n of 100 tons, a nominal resistance of 308 kips would then need to be demonstrated.

Where H-pile is used, either the MPF12 driving formula or dynamic analysis could be used; although dynamic analysis allows for better evaluation of whether or not pile damage is occurring. In the case of HP12x53 pile designed for φR_n of 140 tons, a nominal resistance of 431 kips (PDA verification) or 467 kips (MPF12 verification) would then need to be demonstrated.

The *DRIVEN* results for 12-inch diameter CIP steel pipe pile, based on the borings designated, are shown on the following figures:

Figure 3.1.3a – DRIVEN Results, Boring 1022 SB (South Abutment)

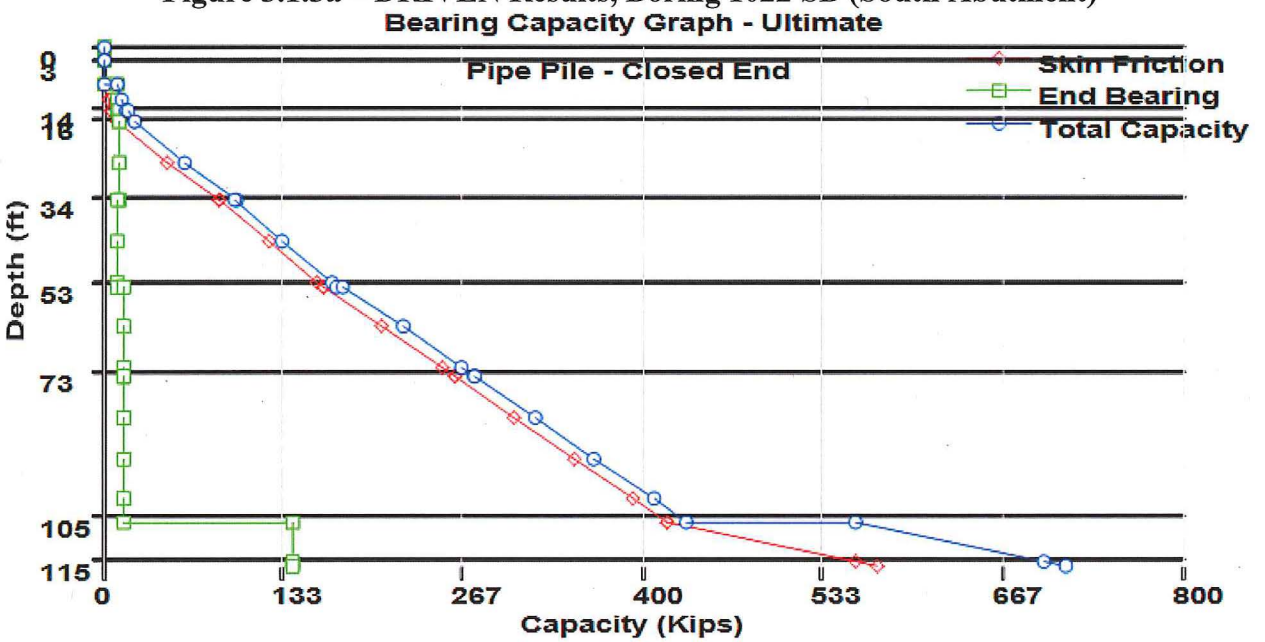


Figure 3.1.3b – DRIVEN Results, Boring 1205 SB (Between Piers 1, 2)

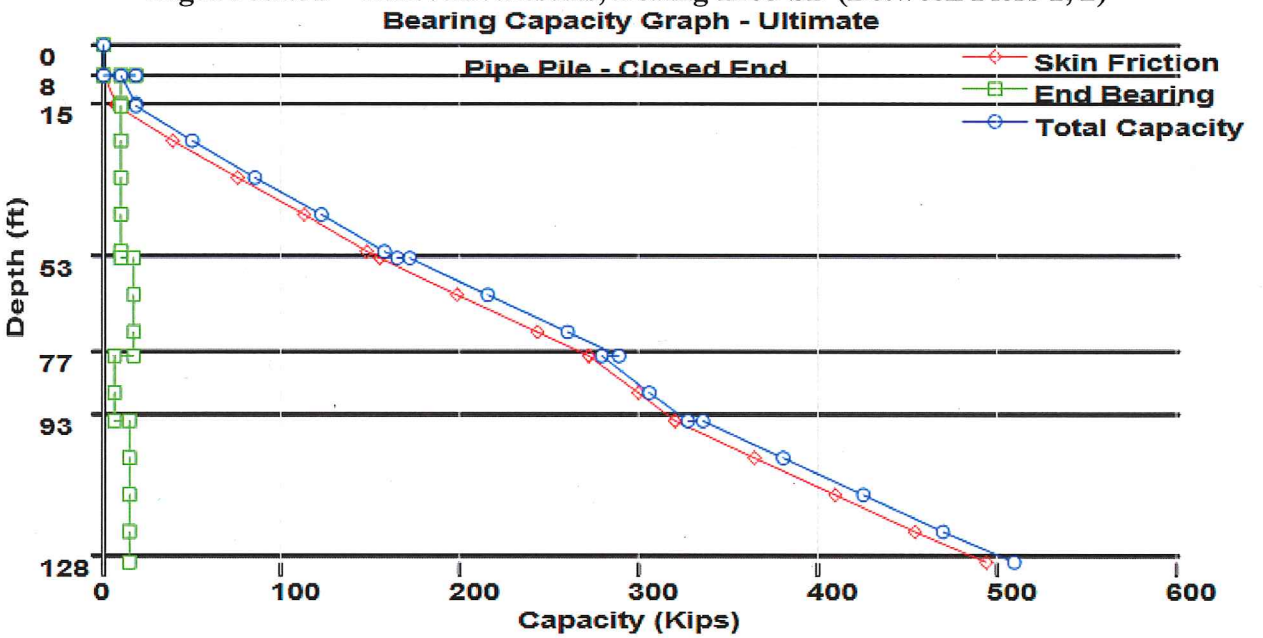


Figure 3.1.3c – DRIVEN Results, Boring 1105 SB (Between Piers 2, 3)

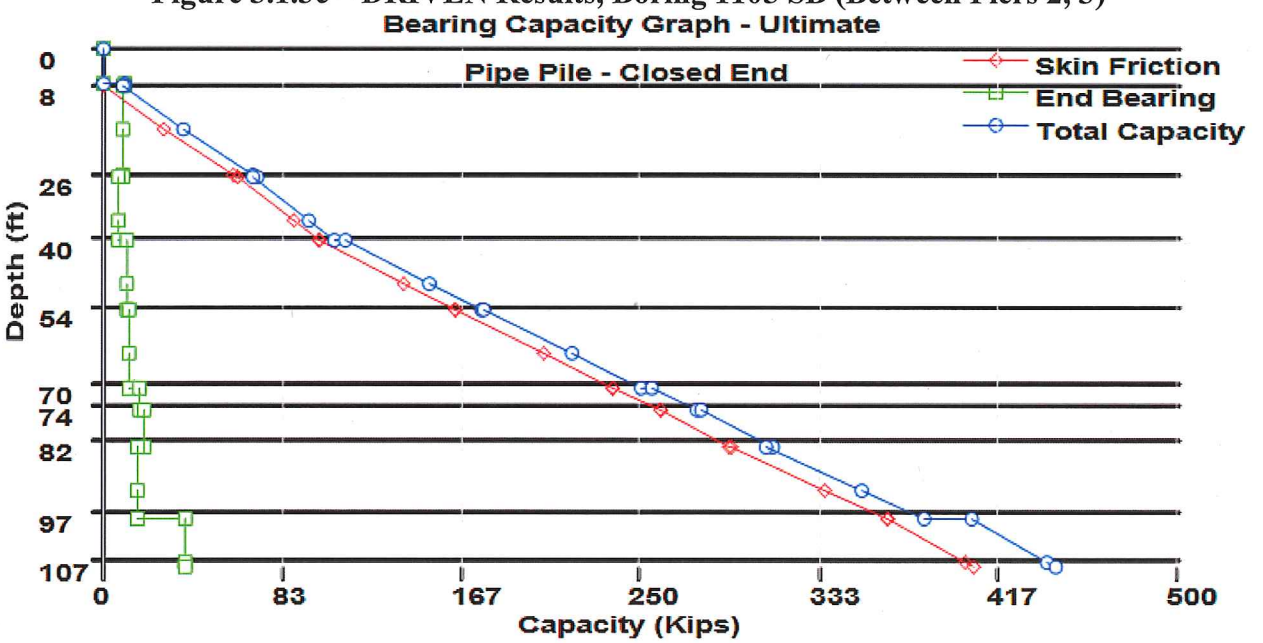
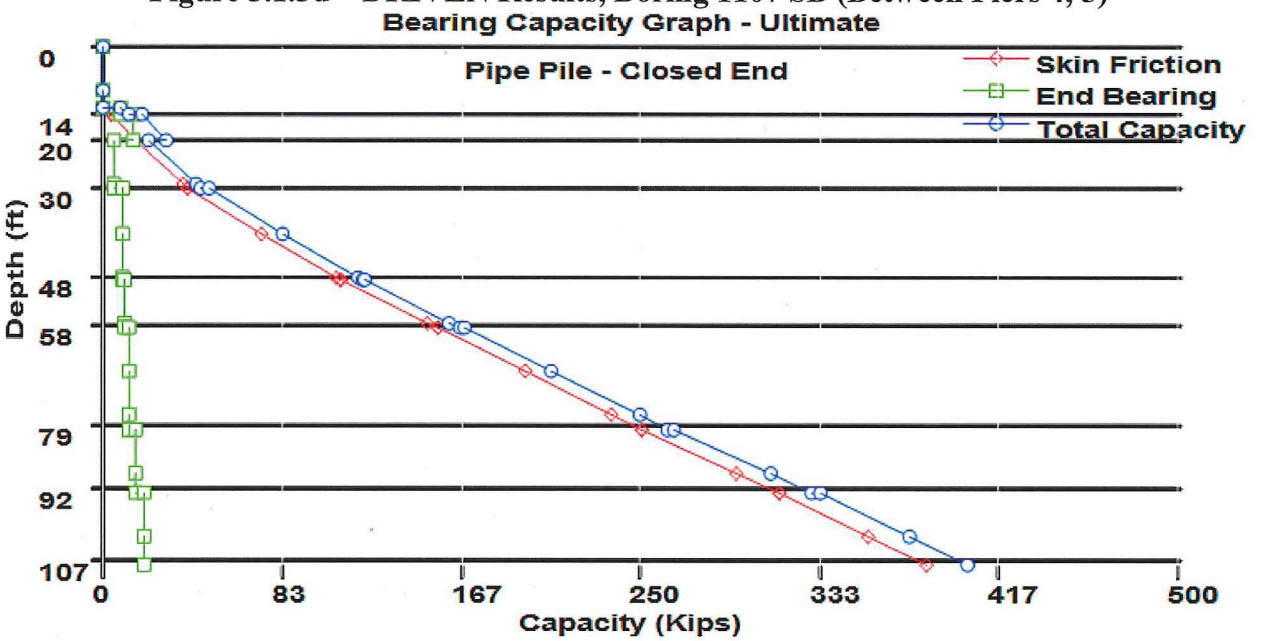


Figure 3.1.3d – DRIVEN Results, Boring 1107 SB (Between Piers 4, 5)



The *UniPile5.0* results for 12-inch diameter CIP steel pipe pile, based on the CPTs designated, are shown on the following figures:

Figure 3.1.3e – UniPile Results, CPT 1104 CB (South Abutment)

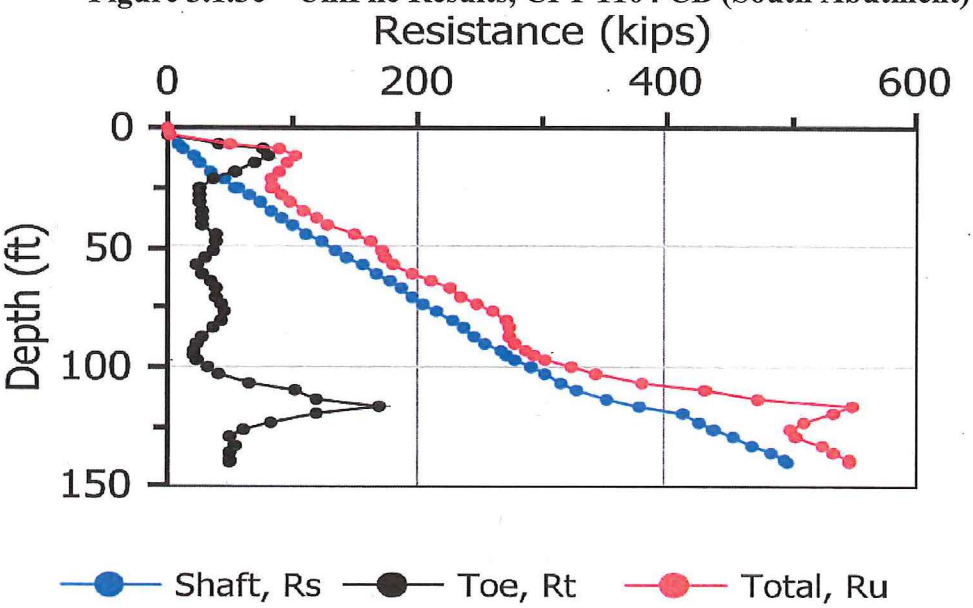
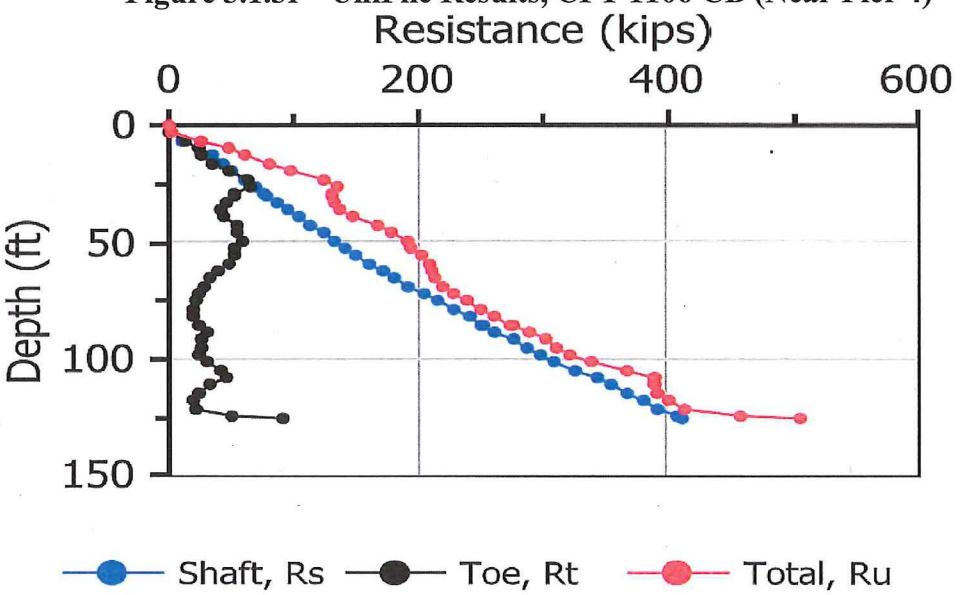


Figure 3.1.3f – UniPile Results, CPT 1106 CB (Near Pier 4)



The lengths predicted by the computer analyses in order to attain a nominal resistance of 308 kips is shown in Table 3.1.3g. This assumes a design φR_n = 100 tons and the use of dynamic analysis for the field evaluation method (allowing φ = 0.65).

Table 3.1.3g – 12-inch dia. Steel Pipe Pile Lengths from Computer Analyses

Substructure	Boring/CPT No.	Analysis Method	Proposed Bottom of Footing Elevation, ft	Estimated Tip Elevation, ft	Estimated Pile Length, ft
So. Abut	1022 SB	DRIVEN	823.0	751	72
So. Abut	1104 CB	UniPile	823.0	734	89
Between Piers 1, 2	1205 SB	DRIVEN	823.5	743	81
Between Piers 2, 3	1105 SB	DRIVEN	823.5	749	75
Near Pier 4	1106 CB	UniPile	823.5	735	89
Between Piers 4, 5	1107 SB	DRIVEN	823.5	742	82

As shown by the side-by-side boring and CPT at the South Abutment, there is a significant variation between the two pile analysis methods. In sands, it has been our experience that the

DRIVEN analyses provide more reliable results. However, in clayey soils (which do predominate the profile at this site), it has been our experience and is our opinion that the *UniPile* software program provides better prediction of the nominal resistance.

The HP12x53 piles are expected to drive to the bedrock or perhaps the colluvium just above the bedrock. HP12x53 pile driving records for the existing Target Station bridge constructed as a part of the Interchange project were also available for our review to assist estimates of potential pile lengths.

Our estimates of pile lengths at each substructure based on the above analysis and on the available pile driving records are presented later in Section 4.1.

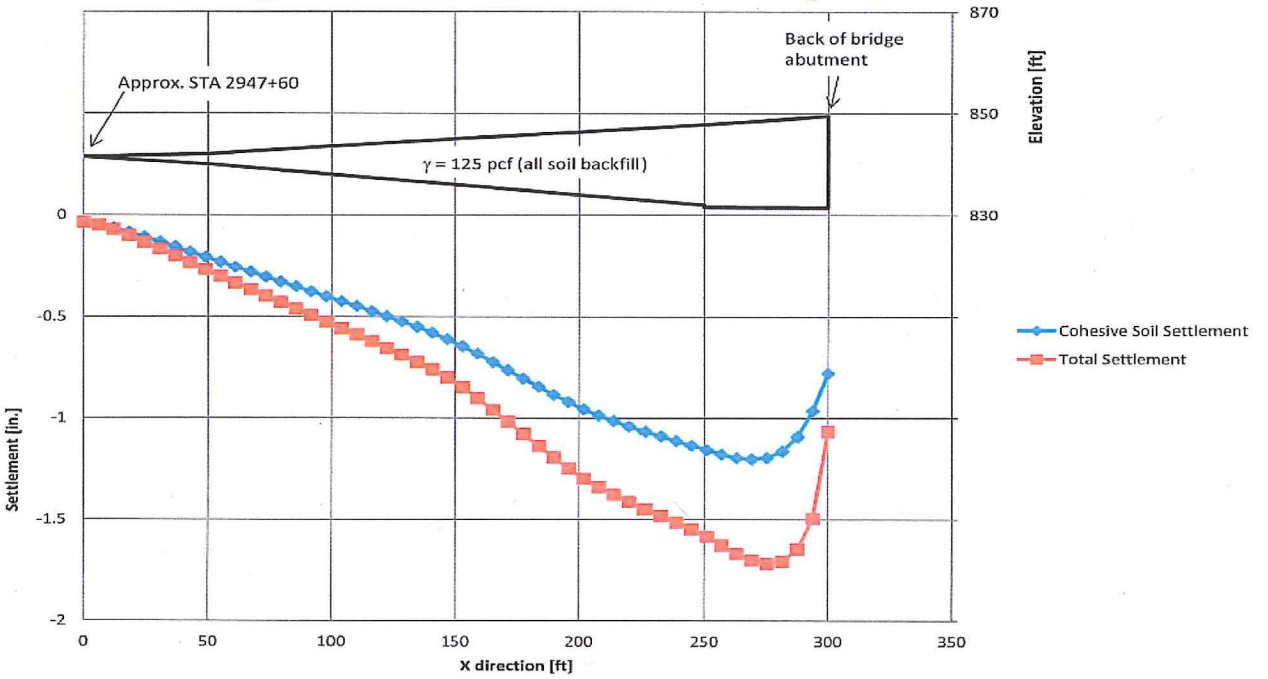
3.2 South Retained Wall Approach Settlement Review

The proposed bridge approach will raise grade by a maximum of about 20 feet, and it will be about 30 feet wide. It should be possible to support the walls on spread foundations following local correction. However, in this case, the weight of the wall backfill will need to be considered to control differential settlements and prevent downdrag (DD) loads on the abutment piles. Alternately, pile could be used to support the walls and the interior fill if needed with pile recommendations consistent with that recommended for the abutment. However, the remainder of this report presents the approach of spread footing support with interior backfill weight control to control settlement within acceptable levels.

We analyzed settlement of the underlying soils using the software program FoSSA 2.0, which utilizes conventional Boussinesq stress theory to evaluate both immediate elastic settlements and time-dependent consolidation settlements. The program allows for analysis of both two-dimensional and simplified three-dimensional embankments. The 3D option allowed us account for the abrupt end of the approach embankment at the bridge abutment. Furthermore, because the bridge abutment will be pile-supported, we assumed that the abutment pile cap will support the weight of soil backfill directly above the pile cap. Based on the consolidation test results for the alluvial clay soils, they are slightly overconsolidated, and we considered this in our analyses.

Figure 3.2a illustrates the computed settlement along the centerline of the railway approach for our "baseline" analysis. Both the total settlement and the time-dependent clay settlement are plotted. It is apparent that the greatest total settlement (about 1.7 inches) occurs just west of the bridge abutment. The maximum differential settlement is about 0.65 inch in 25 feet, which would exceed the tolerance of ½ inch in 31 feet.

Figure 3.2a – Settlement with Normal Weight Soil Backfill

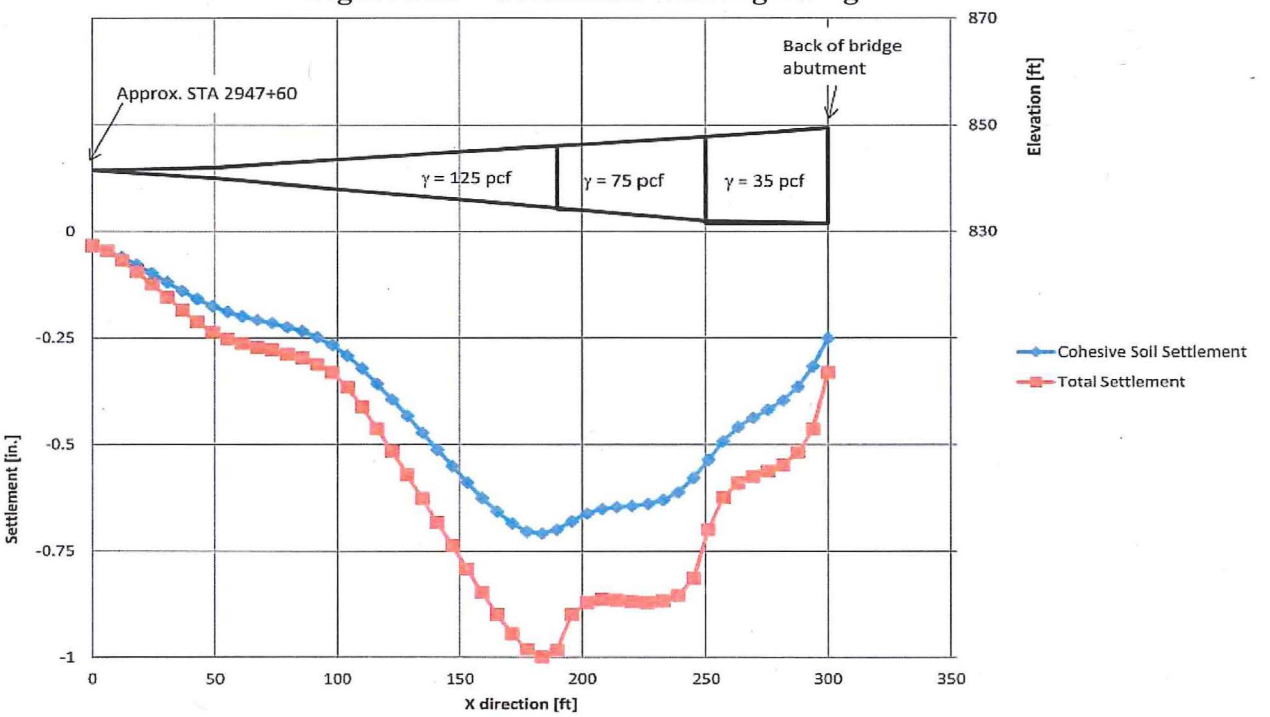


We estimate the time duration needed for 90% of the consolidation settlement to occur may range from one to two years. This time duration (and the associated uncertainty of field consolidation) and the space available likely makes a surcharge or fill/construction delay option impractical.

Given the computed settlement, it may be possible to mitigate settlement by reducing the load acting on the soils underlying the approach embankment. This could be achieved by utilizing some percentage of lightweight fill (e.g. either geofoam or cellular concrete). We evaluated the magnitude of unloading needed to meet settlement tolerances by reducing the average unit weight of the approach embankment in our FoSSA model until the settlement criterion was met.

Figure 3.2b illustrates the computed settlement along the centerline of the railway approach for an embankment that incorporates progressively more lightweight fill toward the north (i.e. toward the bridge abutment). The greatest total settlement is about 1 inch, which occurs about 120 feet west of the bridge abutment. The differential settlement meets the tolerance of ½ inch in 31 feet. Three "zones" of approach embankment fill were modeled. The first 50 feet extending from the back heel of the pile-supported bridge abutment has an average unit weight of 35 pcf; the next 60 feet to the west has an average unit weight of 75 pcf; and the average unit weight is 125 pcf for the remaining 190 feet to the west (which essentially reaches Station 2947+60, at which point embankment grade raise is about 1 foot or less).

Figure 3.2b – Settlement with Lightweight Fill



If the embankment incorporates geofoam, which has a unit weight of less than 5 pcf, that would essentially mean up to 75% replacement of soil fill with geofoam in the first zone west of the abutment, and 58% replacement with geofoam in the middle zone.

Alternatively, the denser (but still lightweight) cellular concrete (e.g. "Elastizell") could also be utilized at greater replacement proportions, perhaps approaching 100% for the first zone west of the abutment.

4.0 FOUNDATION RECOMMENDATIONS

4.1 HP12x53 Piles

The bridge foundations from Piers 6 to 10 should be supported with HP12x53 piles, meeting ASTM A572, Grade 50 (f_y = 50 ksi). The piles can be designed based on a Factored Pile Bearing Resistance (φR_n) value of up to 140 tons. The piles should be equipped with rock points.

The nominal resistance of the piles should be evaluated using the MnDOT MPF12 driving formula. With this field evaluation method, a Resistance Factor of 0.60 should be employed. For HP12x53 piles having a design φR_n value of 140 tons, this would then require demonstrating a nominal resistance of 467 kips. It is anticipated that the H-piles will establish required resistance with "refusal" upon the bedrock. Estimated tip elevations are shown in Table 4.3. During field pile analysis, we recommend discounting any skin friction contribution from any organic swamp deposits and overlying fill (e.g., at Boring 1207 SB).

A reduction factor for group effects does not need to be applied provided the pile arrangement maintains a center-to-center spacing of 3 times the flange length (i.e, 3-foot spacing for HP12x53).

All foundations should have five or more piles for redundancy purposes. With five or more piles, a reduction factor for a lack of redundancy does not need to be applied.

4.2 12-inch Diameter CIP Steel Pipe Piles

The bridge foundations from the South Abutment to Pier 5 can be supported with 12-inch diameter CIP steel pipe piles. The piles can be designed based on a Factored Pile Bearing Resistance (φR_n) value of up to 100 tons. The pipe piles should have a minimum yield strength (f_y) of 45 ksi and a minimum wall thickness of 0.250 inches. The pipe should be driven with a flat plate welded to the pile tip (closed end). The plate should have a minimum thickness of 0.75 inches and a diameter no greater than the pile diameter. The pipe piles should be inspected and concrete filled in accordance with MnDOT Specification 2452.D6. The minimum compressive strength of the concrete should be 3000 psi at 28-days.

The nominal resistance of the piles should be evaluated using high strain dynamic (PDA) testing, which will allow the Resistance Factor of 0.65. The dynamic testing should meet the minimum requirements listed in Section 10.5.5 of the *AASHTO LRFD Bridge Design Specifications, 2012*. This approach includes Quality Control of non-tested pile by calibrated wave equation analyses.

We refer you to Table 4.3 for the pile lengths predicted to achieve a nominal resistance of 308 kips.

If the lightweight interior fill approach presented herein is used for the retained wall system, it is our opinion that down drag (DD) load does not need to be considered in the pile design. The amount of settlement expected is less than the acceptable settlement tolerance of the pile.

A reduction factor for group effects does not need to be applied provided the pile arrangement maintains a center-to-center spacing of 3 times the pile diameter.

All foundations should have five or more piles for redundancy purposes. With five or more piles, a reduction factor for a lack of redundancy does not need to be applied.

4.3 Estimated Pile Lengths

Based on the *DRIVEN* and *UniPile* analyses, the past pile driving records, and our experience, the piles lengths shown in Table 4.3 are estimated.

Table 4.3 – Estimated Pile Lengths

Substructure	Bottom of Foundation Elevation	Recommended Pile Type	Estimated Pile Tip Elevation, ft	Estimate Pile Length, ft
South Abutment	823.0	12" dia. pipe	734	89
Pier 1	823.0	12" dia. pipe	734	89
Pier 2	823.5	12" dia. pipe	734	90
Pier 3	823.5	12" dia. pipe	734	90
Pier 4	823.5	12" dia. pipe	735	89
Pier 5	817.5	12" dia. pipe	738	80
Pier 6	814.5	HP12x53	725	90
Pier 7	811.5	HP12x53	714	98
Pier 8	809.5	HP12x53	694	116
Pier 9	810.5	HP12x53	680	131
Pier 10	815.5	HP12x53	682	134
Pier 11*	808.67*	HP12x53	684.5 (actual)	124

*denotes existing Pier 9, Bridge R0646 (Interchange)

The pile lengths shown are based on the varying analysis methods discussed with assumed soil parameters, and the soil layer variations make accurate pile length predictions difficult. It is common for actual pile resistance to differ from the theoretical resistance. The actual pile lengths must be confirmed at the time of driving, and lengths may be more or less than that shown.

If piles do not achieve the required resistance at desired depths, pile driving can be stopped and time can be given to allow pile "set-up" to occur. The increase in resistance can then be rechecked with a re-strike on the following day. This will likely need to occur during driving and evaluation of the steel pipe pile.

Boulders or rock slabs may potentially be present within the profile. If pile penetration appears to be obstructed at abnormally variable depths (due to apparent boulders/slabs), additional pile and foundation review may be needed.

4.4 Approach Retaining Wall Foundation Support

Borings 1022 SB and 1103 SS indicate granular soils are present in the upper 16 to 19½ feet of the profile. At a foundation frost depth of 4½ feet at Boring 1022 SB, the soils exposed at foundation grade are silty sands, which may either be alluvium or possibly fill. The boring does show the presence of natural sand with silt having an N-value of 3 below 6½ feet. These looser sands should be densified. To allow spread foundation support of the wall in this area, the soils

should be subcut to 3 feet below foundation grade (presumed to be about 7½ feet deep), and then surface compacted with a vibratory roller compactor. The excavation bottom should be laterally oversized beyond the planned footing edges at a 1:1 ratio (i.e., 3 feet in the case of a 3-foot subcut). No special subcutting should be necessary in the area of Boring 1103 SS, although surface compaction at foundation grade is recommended.

Engineered fill placed to establish foundation grade should meet the requirements of MnDOT Specification 3149.2B2, Select Granular Borrow.

The granular fill should be placed and compacted in accordance with MnDOT Specification 2105. Compaction should meet the Specified Density Method, with the modification that the entire thickness of the new fill below the footing be compacted to a minimum of 100% of the Standard Proctor density.

If spread foundation support is used (in lieu of pile support continuation from the abutment), additional testing and analysis should be performed with regards to this element of the bridge design during the final design stage of the project. This should include additional borings to better determine soil correction needs. LRFD foundation analysis considering Bearing Resistance in the strength and service limit states, sliding resistance, and global stability should be evaluated. For preliminary price evaluation, a 3000 psf allowable bearing pressure (using ASD methods) can be assumed.

4.5 Abutment/Retaining Wall Backfilling

The imbalanced abutment walls and retaining walls must be designed to resist the lateral pressures exerted. Where lightweight fill is not used, the backfill material should consist of Select Granular Borrow (MnDOT 3149.2B2), which is modified to containing less than 10% by weight passing the #200 sieve. Typical "Select Granular Borrow 10% Modified" geometry is shown on attached MnDOT *Diagram F-1*. However, all excavation backsloping must also meet OSHA requirements. For proper track approach performance, frost tapering of the Select Granular Borrow over frost susceptible soils should be maintained at no steeper than 1V:20H within the frost zone (assume a frost zone of 4.5 feet). The backfill should be compacted per the Specified Density Method (MnDOT 2105.3F1).

The use of lightweight fill can significantly reduce lateral loads on the wall. These loads can be provided as the design develops.

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

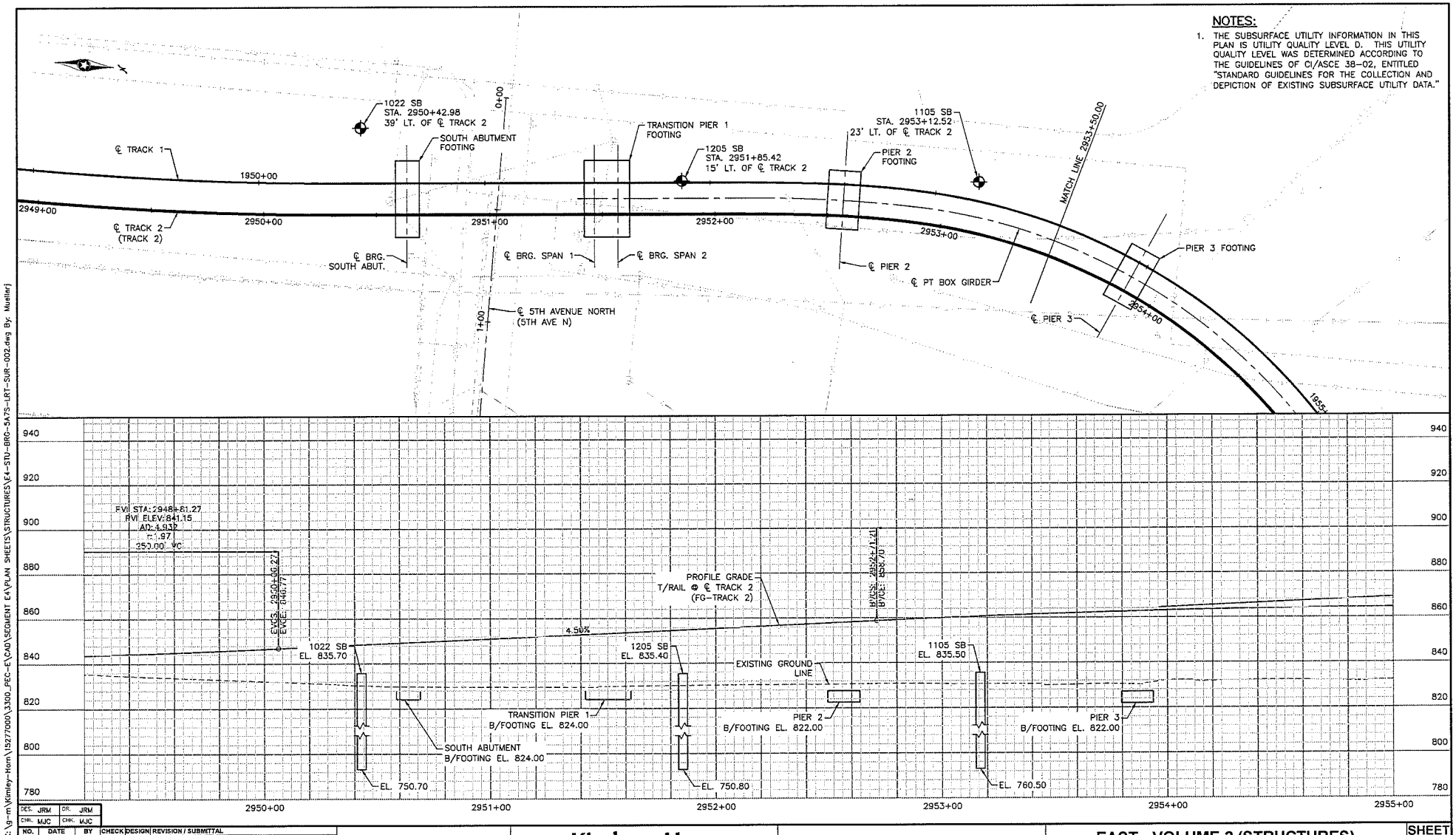
Name: Jeffery K. Voyen
Jeffery K. Voyen

Date: 6/25/14 **License #: 15928**

Report Reviewed By: Joseph G. Bentler
Joseph G. Bentler, PE, Senior Geotechnical Engineer

Attachments:

- Preliminary Bridge Plan-Profile Sheets
- Figure 1 – Boring/CPT Locations
- Subsurface Boring Logs
- Cone Penetration Test Logs
- Consolidation Test Results
- Exploration/Classification Methods
- Boring Log Notes
- Unified Soil Classification System
- AASHTO Soil Classification System
- Cone Penetration Test Index Sheel
- MnDOT Diagram F-1



DES. JRM	DR. JRM
CHK. MJC	CHK. MJC

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

Kimley»Horn
TKDA
PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
5TH AVENUE AND 7TH STREET
BRIDGE XXXXX (LRT)
BORINGS (1 OF 8)

DISCIPLINE: STRUCTURES
SHEET NAME: E4-STU-BRG-5A7S-LRT-SUR-002

SHEET 185 OF 277

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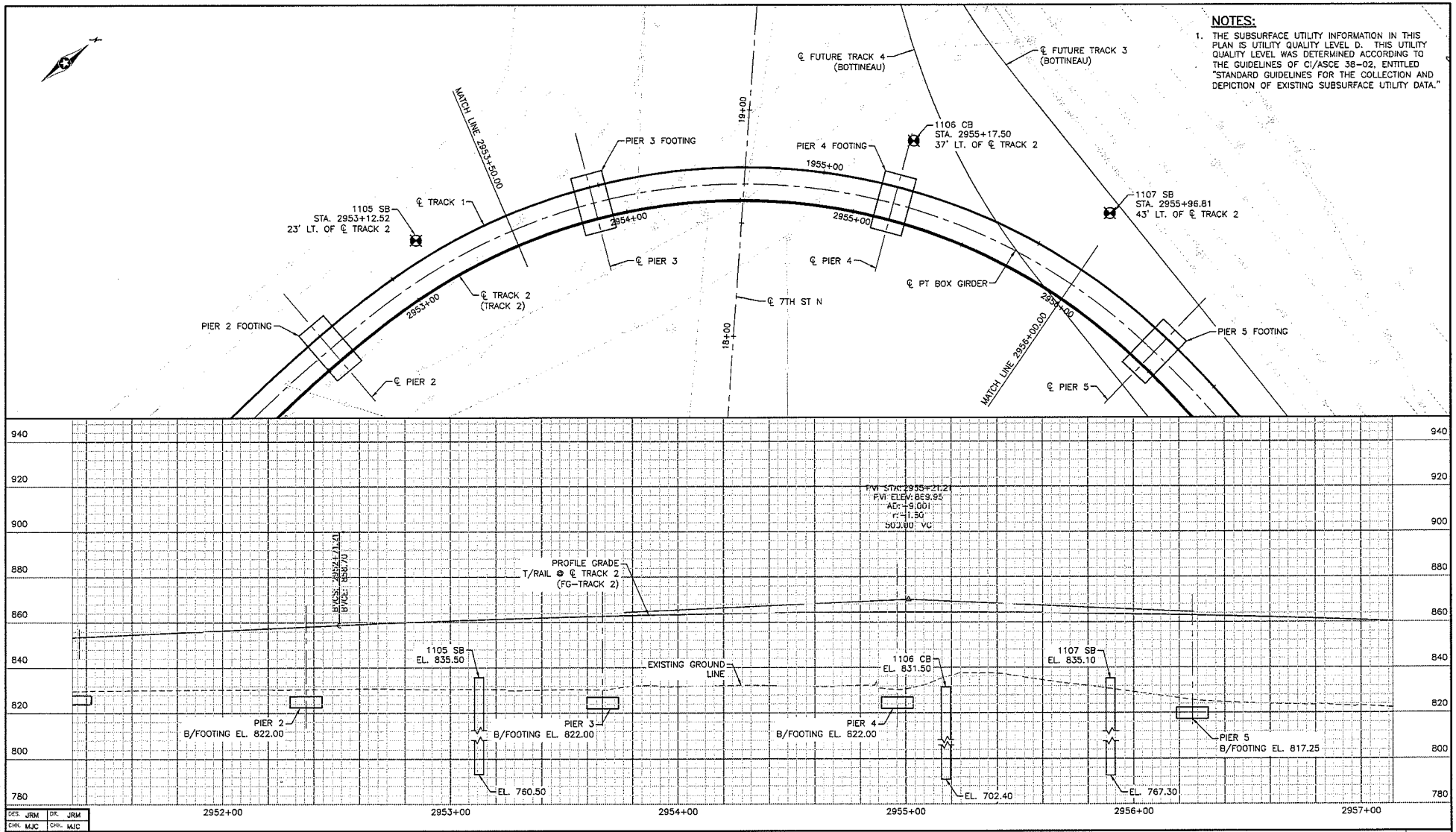

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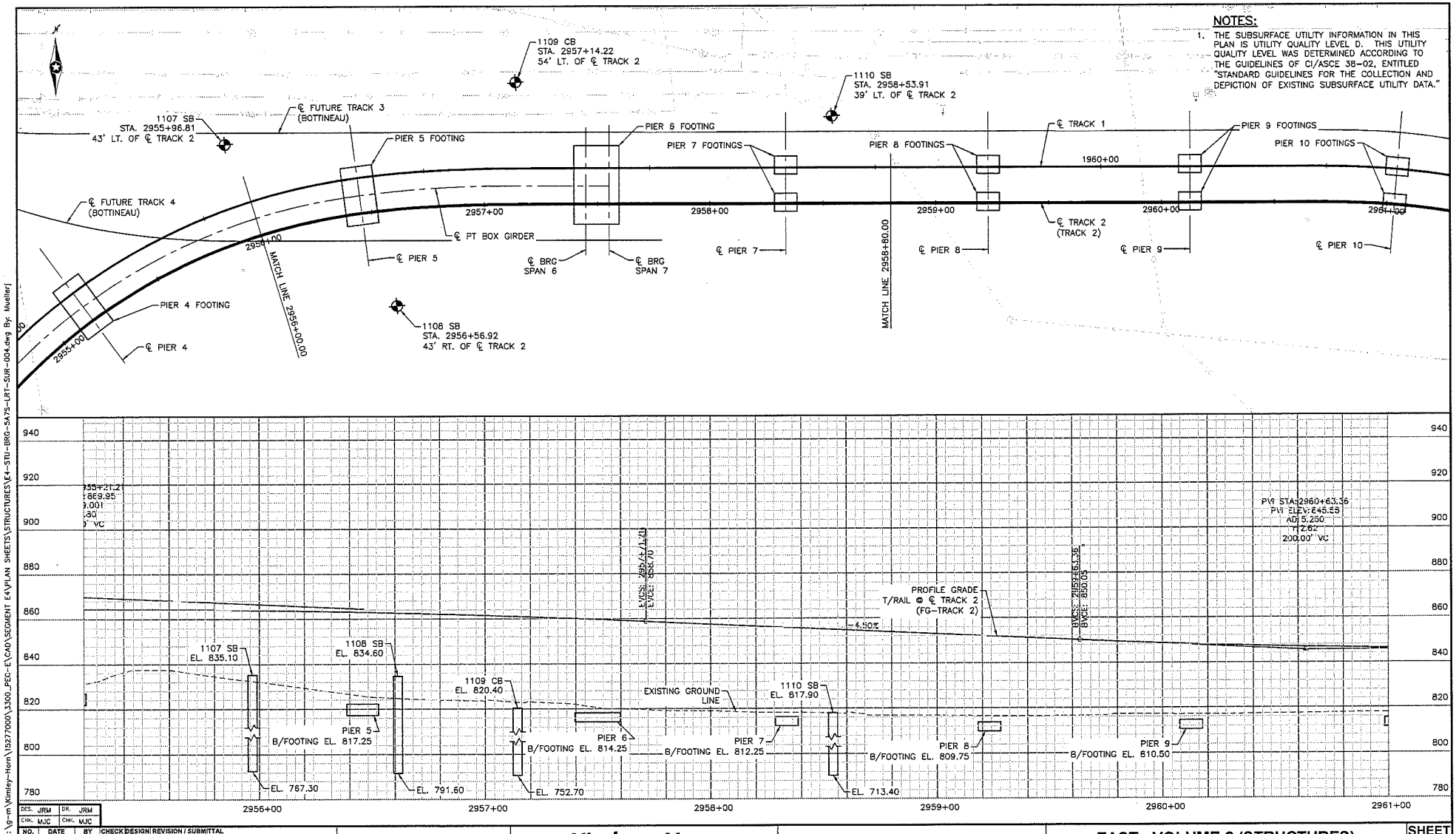
TKDA
PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
5TH AVENUE TO 7TH STREET
BRIDGE XXXXX (LRT)
BORINGS (2 OF 8)

DISCIPLINE: STRUCTURES
SHEET NAME: E4-STU-BRG-5A7S-LRT-SUR-003

SHEET 186 OF 277



DES. JRM	DR. JRM
CHK. MJC	CHK. MJC

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

Kimley»Horn

TKDA

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

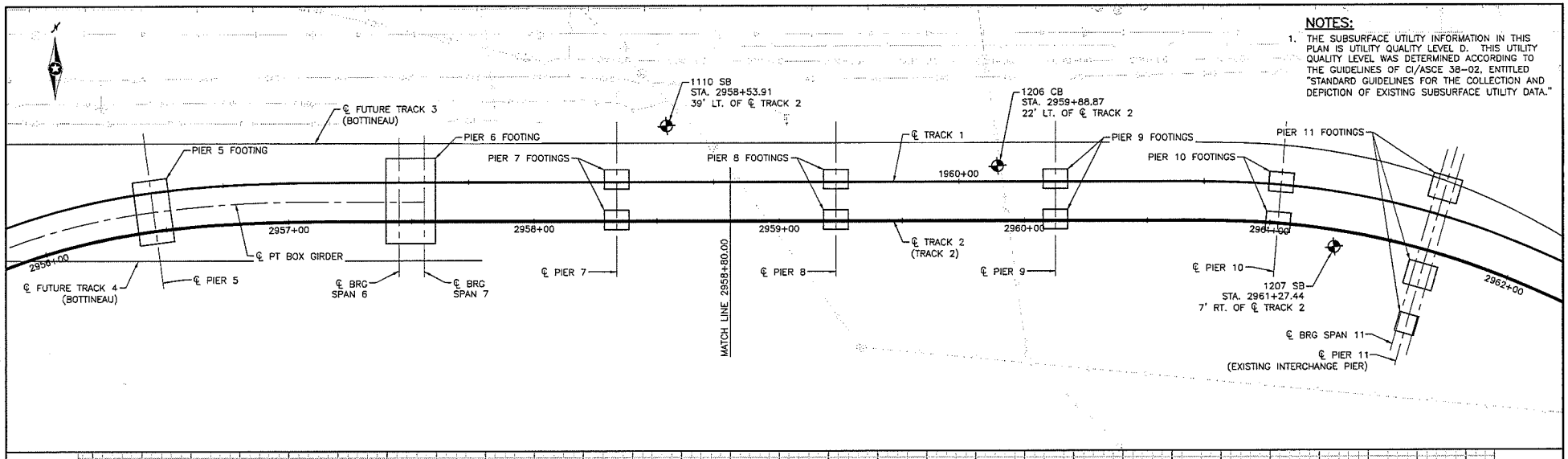
SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
5TH AVENUE AND 7TH STREET
BRIDGE XXXXX (LRT)
BORINGS (3 OF 8)

DISCIPLINE: STRUCTURES

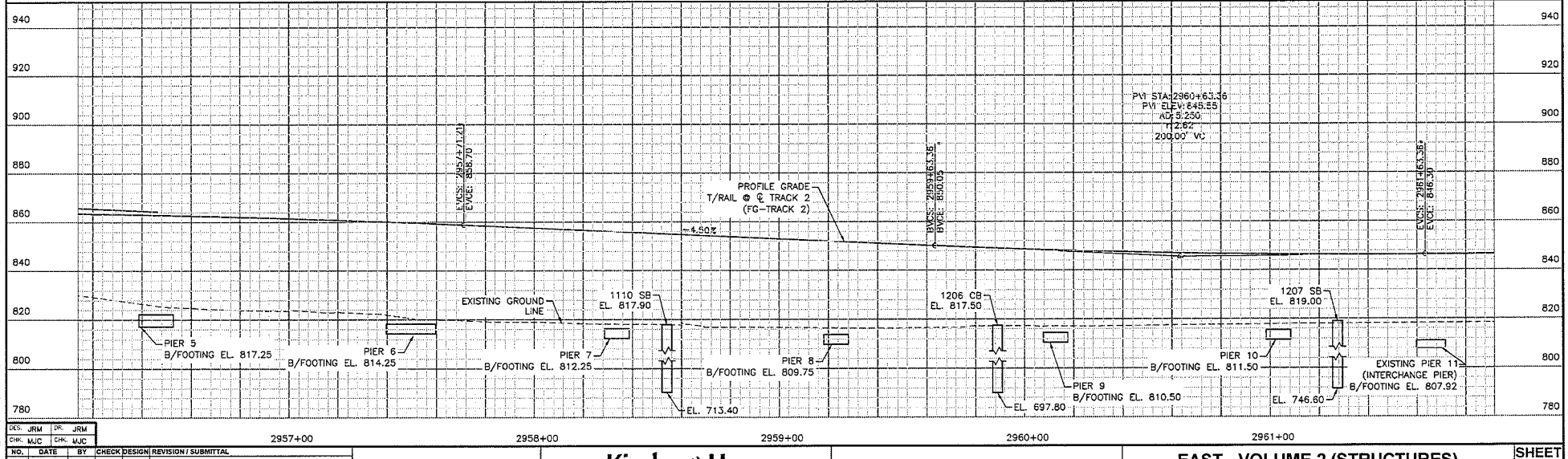
SHEET NAME: E4-STU-BRG-5A7S-LRT-SUR-004

SHEET 187 OF 277



NOTES:

1. THE SUBSURFACE UTILITY INFORMATION IN THIS PLAN IS UTILITY QUALITY LEVEL D. THIS UTILITY QUALITY LEVEL WAS DETERMINED ACCORDING TO THE GUIDELINES OF CI/ASCE 38-02, ENTITLED "STANDARD GUIDELINES FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA."



DES.	JRM	DR.	JRM
CHK.	MJC	CHK.	MJC

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

Kimley»Horn
TKDA

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

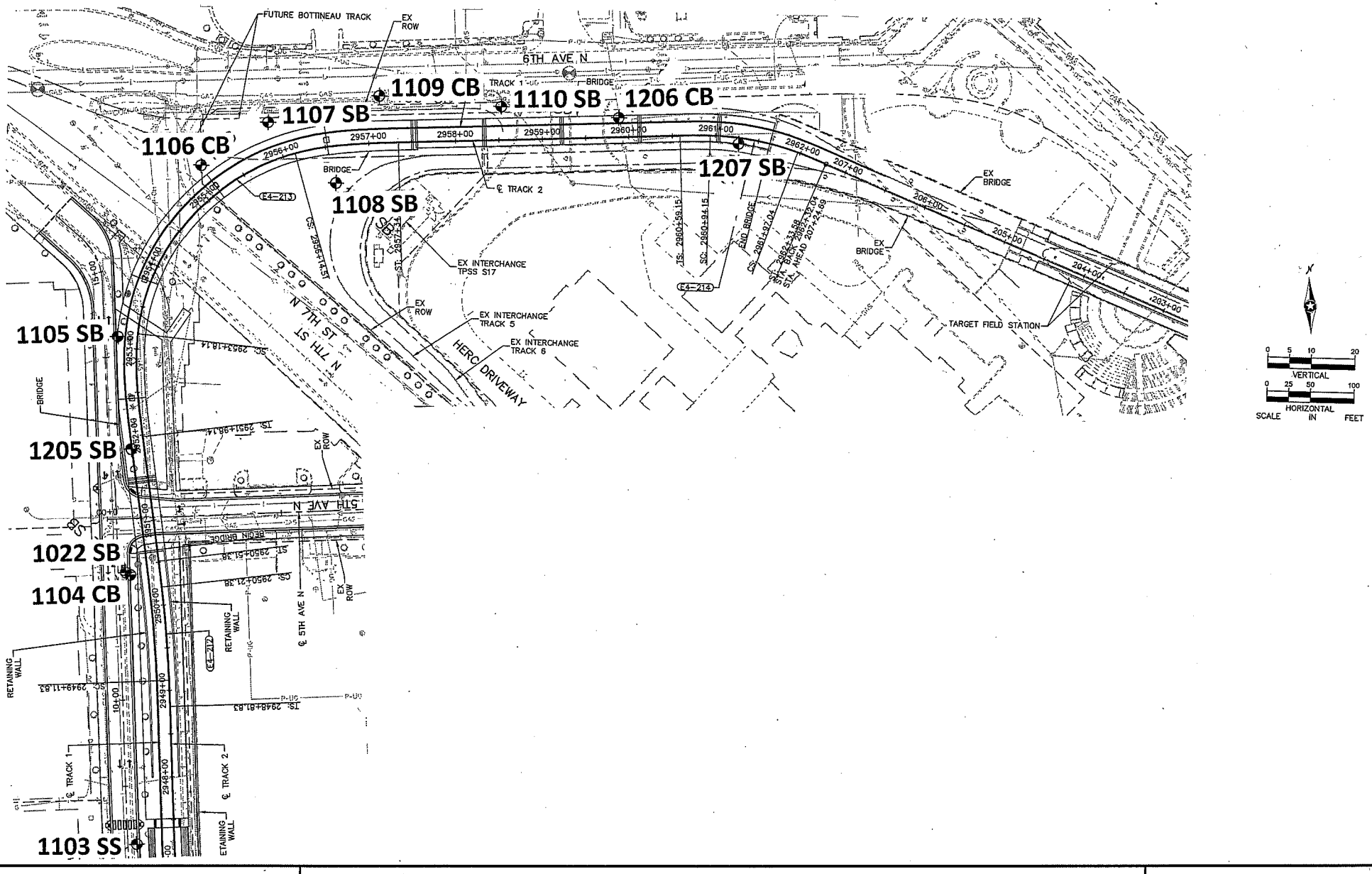
SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
5TH AVENUE AND 7TH STREET
BRIDGE XXXXX (LRT)
BORINGS (4 OF 8)

DISCIPLINE: STRUCTURES

SHEET NAME: E4-STU-BRG-5A7S-LRT-SUR-005

SHEET 188 OF 277



AMERICAN ENGINEERING TESTING, INC.	**PROJECT** SWLRT Bridge over 5th Ave N and N 7th Street		**AET NO.** 01-05697
	SUBJECT Boring/CPT Locations		**DATE** May 15, 2014
	SCALE 1" = 160'±	**PREPARED BY** KHA	**CHECKED BY** JV-	**FIGURE 1**

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1022 SB**	**831.3** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=525925 Y=169859 (ft.)

Latitude (North)=44.9826644 Longitude (West)=-93.2831487

Drill Machine **91C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 5

Drilling Completed **4/11/13**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
					REC (%)	RQD (%)	ACL (ft)	Core Breaks		
	3.0 / 828.3		Clayey sand with organic fines, a little silty sand, trace roots, black, dark brown and brown (A-2-4) fill		14					Hammer Calibration: 68% efficiency with 110 lb. hammer, 5/27/14
					18					
5	6.5 / 824.8		SILTY SAND, fine grained, dark brown to brown, moist, medium dense to loose (SM) (A-2-4) alluvium or fill		6					
					3					
10	11.5 / 819.8		SAND WITH SILT, fine grained, brown, moist, very loose to loose (SP-SM) (A-3) alluvium		5					
	14.0 / 817.3		SAND WITH SILT, a little gravel, medium to fine grained, brown, a little dark brown, moist, loose, a lens of clayey sand (SP-SM) (A-1-b) alluvium		6					
15	16.5 / 814.8		SAND WITH SILT, fine to medium grained, brown, a little dark brown, moist, medium dense, a lens of silty sand (SP-SM) (A-2-4) alluvium		11					
					11	29				
20						29	1795	123		
					10	28				
25			FAT CLAY, grayish brown and brownish gray, a little light tan and gray, stiff, laminations of silt (CH) (A-7-6) alluvium			34		118		Consolidation test
						33	1755	121		
					9	28				
30						24	1860	126		
					11	25				
35	34.0 / 797.3		LEAN CLAY, grayish brown to brownish gray, a little gray, stiff, laminations of silt (CL) (A-7-6) alluvium			28	1045	127		
	37.0 / 794.3				11	25				
40			LEAN CLAY, grayish brown, a little brown and gray, stiff, laminations of sandy silt, silt and fine silty sand (CL) (A-7-6) alluvium			23	1385	128		

Index Sheet Code

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1022 SB	831.3 (Surveyed)

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
45			LEAN CLAY, grayish brown, a little brown and gray, stiff, laminations of sandy silt, silt and fine silty sand (CL) (A-7-6) alluvium *(continued)*		9	23				
						24	1700	126		Consolidation test
					10	26				
50						24	1760	128		
	53.0 778.3									
55			SILTY CLAY, grayish brown, a little brown, very stiff, a lens of fat clay, laminations of silt (CL-ML) (A-4) alluvium		23	24				
	58.0 773.3									
60			LEAN CLAY, dark grayish brown, a little brown, stiff, laminations of sandy silt (CL) (A-7-6) alluvium		*	21				*dropped rods - no N-value
65					13	25				
	68.0 763.3									
70			LEAN CLAY, brownish gray, a little gray, stiff, laminations of fat clay (CL) (A-6) alluvium		15	26				
	73.0 758.3									
75			SANDY LEAN CLAY, a little gravel, grayish brown, very stiff (CL) (A-6) till		22	15				
	78.0 753.3									
80			CLAYEY SAND, a little gravel, brown and brownish gray, very stiff to stiff (SC) (A-6) till		19	15				

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1022 SB	831.3 (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60}	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
					REC (%)	RQD (%)	ACL (ft)	Core Breaks		
85			CLAYEY SAND, a little gravel, brown and brownish gray, very stiff to stiff (SC) (A-6) till *(continued)*		11	14				
	88.0 / 743.3			PD						
90			SANDY LEAN CLAY, brown, stiff (CL) (A-6) till		15	18				
	93.0 / 738.3			PD						
95			CLAYEY SAND, a little gravel, brownish gray, stiff (SC) (A-6) till		15	18				
	98.0 / 733.3			PD						
100			CLAYEY SAND, grayish brown, very stiff (SC/SM) (A-2-4) till		20	14				
105	105.0 / 726.3			PD						
110			SILTY SAND, a little gravel, grayish brown, very dense (SM/SC) (A-4) till		64	14				
115	115.0 / 716.3			PD						
120			CLAYEY SAND, a little gravel, apparent cobbles from 122' to 125', brownish gray to brown, hard to very stiff (SC) (A-6) till		39	17				
125				PD						

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1022 SB	831.3 (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Soil	Other Tests Or Remarks
				REC (%)	RQD (%)	ACL (ft)	Core Breaks	Rock	Formation or Member	
130			CLAYEY SAND, a little gravel, apparent cobbles from 122' to 125', brownish gray to brown, hard to very stiff (SC) (A-6) till *(continued)*	PD	26	15				
135	135.0 696.3			PD						
140			LEAN CLAY WITH SAND, dark brownish gray, very stiff (CL) (A-6) till		20	25				
145	145.0 686.3			PD						
150			SANDY LEAN CLAY, a little gravel, brownish gray, very stiff (CL) (A-6) till		20	18				
155				PD						
	157.0 674.3									
160					100/.1	14				
			GRAVELLY SILTY SAND, apparent cobbles, brownish gray, very dense (SM/SC) (A-2-4) till	PD						
165										

Only gravel retrieved in

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1022 SB	831.3 (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 (%)	MC (%)	COH (psf)	γ (pcf)	Soil	Other Tests Or Remarks
					REC (%)	RQD (%)	ACL (ft)	Core Breaks	Rock	Formation or Member
170	169.8 / 661.5		GRAVELLY SILTY SAND, apparent cobbles, brownish gray, very dense (SM/SC) (A-2-4) till *(continued)* **END OF BORING**	PD	375/.3					bottom sample, but drill tool action similar in lower zone

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1103 SS	842.6 (Surveyed)

Location , , ft. LT

Co. Coordinate: X=525927 Y=169543 (ft.)

Latitude (North)=44.9817977 Longitude (West)=-93.2831424

Drill Machine 33C

Hammer CME Automatic Calibrated

SHEET 1 of 1

Drilling Completed 11/11/10

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
	1.0 841.6		SILTY SAND, with organic fines, trace roots, fine grained, black, moist, loose (SM) topsoil		6					Hammer Calibration: 69% efficiency with 105 lb. hammer, 9/17/13
	2.0 840.6		CLAYEY SAND, trace roots, brown, firm (SC) alluvium		12					-#200 = 9.5%
5	5.5 837.1		SAND WITH SILT, fine grained, brown, moist, medium dense to loose (SP-SM) alluvium		9					
	6.5 836.1		SAND WITH SILT, fine grained, light grayish brown, moist, loose (SP-SM) alluvium		14					
	9.0 833.6		SAND, a little gravel, fine to medium grained, light grayish brown, moist, medium dense, laminations of silt (SP) alluvium		22					
10			SAND, a little gravel, medium to fine grained, brownish gray, moist, medium dense (SP) alluvium		17					
	14.0 828.6		SAND, medium to fine grained, brownish gray, moist, medium dense (SP) alluvium		13					
15	16.5 826.1		SAND, fine grained, light grayish brown, moist, medium dense (SP) alluvium		15					
	18.0 824.6		SAND, fine grained, brown, a little dark brown, moist, medium dense, laminations of silt (SP) alluvium			28				
	19.5 823.1		LEAN CLAY, grayish brown, a little brown, stiff, laminations of sand with silt (CL) alluvium		13	27				
20	20.0 822.6		FAT CLAY, gray, a little light brownish gray, stiff, laminations of silt (CH) alluvium							
	21.0 821.6		END OF BORING							

Index Sheet Code

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1105 SB	831.0 (Surveyed)

Location , , ft. LT

Co. Coordinate: X=525925 Y=170134 (ft.)

Latitude (North)=44.9834186 Longitude (West)=-93.2831473

Drill Machine 33C

Hammer CME Automatic Calibrated

SHEET 1 of 4

Drilling Completed 11/8/10

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
	2.0 829.0		Silty sand, a little gravel and clayey sand, trace roots, grayish brown and brown, fill		6					Hammer Calibration: 69% efficiency with 105 lb. hammer, 9/17/13
5			Sand, a little gravel, sandy lean clay and silty sand, light brown and brown, a little brownish gray, fill		18 8					
	8.0 823.0		FAT CLAY, trace roots, brown and light brown, a little gray, firm, laminations of silt and sandy lean clay (CH) alluvium		8	30				
10	11.0 820.0					34 30 29	1135	122		
15			FAT CLAY, brownish gray, a little brown and light grayish brown, stiff to firm, laminations of sandy lean clay and silt (CH) alluvium		11 10 8	27 35				
20						29				
25	26.0 805.0				10 9	23 25 29				Water level measured at 26.2' deep with SS to 26.5' deep
	29.5		FAT CLAY, brownish gray, stiff to firm, a lens of wet silt at 26' (CH) alluvium		7	25				
30	801.5 32.0		LEAN CLAY, brownish gray, a little gray, firm, laminations of silt and fat clay (CL) alluvium		8	26				
	799.0				7	22				
35			SILTY CLAY, brownish gray, firm (CL-ML) alluvium		7 7	21 22				
	39.5									
40	791.5 42.0		SILTY CLAY, brownish gray, a little dark brownish gray, very stiff, laminations of fat clay (CL-ML) alluvium		16	23				

Index Sheet Code

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1105 SB	831.0 (Surveyed)

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
	789.0									
45			SILTY CLAY, brownish gray, very stiff to stiff, a lens of fat clay at 49' (CL-ML) alluium	LM	20	23				
				PD	11	21				
50				PD	9	29				
	51.5 / 779.5		SILTY CLAY, brownish gray, a little dark brownish gray, stiff, laminations of fat clay (CL-ML) alluvium	PD	11	27				
	54.0 / 777.0		FAT CLAY, dark brownish gray, a little brownish gray, very stiff to stiff, laminations of silty clay (CH) alluvium	PD	16	33				
55				PD	14	28				
				PD	14	26				
60	61.5 / 769.5			PD	15	25				
			LEAN CLAY, brownish gray, a little dark brownish gray, stiff to very stiff, laminations of silt and fat clay (CL) alluvium	PD	14	28				
65				PD	13	24				
				PD	21	26				
70	71.5 / 759.5		SILTY CLAY, brownish gray, very stiff, a lens of fat clay below 74', laminations of wet silt (CL-ML) alluvium	PD	20	26				
	74.5 / 756.5		CLAYEY SAND, a little gravel, grayish brown, very stiff (SC) till	PD	22	28 / 15				
75										
	79.0 / 752.0		SANDY LEAN CLAY, a little gravel, brownish gray, very stiff, laminations of fat clay (CL) till	PD	23	17				
80	82.0 / 749.0		FAT CLAY, grayish brown, very stiff (CH) alluvium							

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

SHEET 3 of 4

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1105 SB	831.0 (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Soil	Other Tests Or Remarks
					REC (%)	RQD (%)	ACL (ft)	Core Breaks	Rock	Formation or Member
85				X	21	31				
				PD						
90			FAT CLAY, grayish brown, very stiff (CH) alluvium *(continued)*	X	18	21				
				PD						
95				X	19	23				
	97.0 734.0			PD						
100				X	36	9				
			CLAYEY SAND WITH GRAVEL, grayish brown, hard (SC/SM) till	PD						
105				X	50	10				
				PD						
110	110.0 721.0			X	25					No recovery
			CLAYEY SAND, grayish brown, very stiff (SC) till	PD						
115				X	16	16				
	117.5 713.5			PD						
120			FAT CLAY, grayish brown, very stiff (CH) alluvium	X	20	31				
				PD						
	123.0 708.0									
125			CLAYEY SAND WITH GRAVEL, brown, very stiff (SC) till	X	29	10				
				PD						

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Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1105 SB**	**831.0** *(Surveyed)*

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
	128.0 703.0		CLAYEY SAND WITH GRAVEL, brown, very stiff (SC) till *(continued)*	PD						
130					35	28				
				PD						
135			FAT CLAY, grayish brown, hard to very stiff (CH) alluvium		23	22				
				PD						
140					21	22				
	142.2 688.8		Top of Bedrock	PD						ST. PETER FORMATION
					50/0.2					
145			SANDSTONE, fresh to weathered, light brownish gray	PD						
					*					*43/0.5+75/0.5
150	150.0 681.0		**END OF BORING**							

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1107 SB	830.1 (Surveyed)

Location , , ft. LT
Co. Coordinate: X=526107 Y=170379 (ft.)
Latitude (North)=44.9840899 Longitude (West)=-93.2824428

Drill Machine 68C
Hammer CME Automatic Calibrated

SHEET 1 of 4
Drilling Completed 11/2/10

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
	1.0 829.1		Sandy lean clay, slightly organic, a little gravel and lean clay, trace roots, dark brownish gray and black, fill		9	18 18				Hammer Calibration: 68% efficiency with 110 lb. hammer, 6/9/14
			Sandy lean clay, a little gravel, pieces of brick, concrete, glass and cinders, trace roots, dark brownish gray and dark grayish brown, fill (petroleum-type odor below 2')		14	20 23				
5	5.5 824.6				11	32 23				
			Mixture of lean clay and sandy lean clay, a little gravel, pieces of concrete and wood, trace roots, gray, brownish gray and brown, fill (petroleum-type odor from approximately 8' to 10½')		11	26 19				
10					9	21 17				
	14.0 816.1				24	26 28				
15			SILTY SAND, fine grained, brown, gray, moist, medium dense to loose, lenses of fat clay, laminations of lean clay (SM), alluvium (petroleum-type odor)		16 9					
	19.5 810.6		SILTY CLAY, brownish gray, firm (CL-ML) alluvium (petroleum-type odor)		6	20 25				
20	20.5 809.6		FAT CLAY, brownish gray, a little light brownish gray, firm, laminations of silt (CH) alluvium (petroleum-type odor)			27				
	22.0 808.1		SILTY CLAY, brownish gray, firm (CL-ML) alluvium (petroleum-type odor)		8	24				
25	23.0 807.1		FAT CLAY, brownish gray, a little light brownish gray, firm, laminations of silt (CH) alluvium (petroleum-type odor)		8	28 23				
	24.5 805.6		SILTY CLAY, brownish gray, firm (CL-ML) alluvium (petroleum-type odor)			26				
	28.0 802.1		LEAN CLAY, gray, a little light gray, firm, laminations of silt (CL) alluvium		5	24				
30	29.5 800.6		FAT CLAY, brownish gray, lenses of lean clay and silty sand, laminations of silt (CH) alluvium			24 25	1198	129		
	33.0 797.1		FAT CLAY, brownish gray, stiff, lenses and laminations of wet silt (CL-ML) alluvium		11	23 29				
	34.5 795.6		FAT CLAY, brownish gray, a little light brownish gray, stiff, laminations of silt (CH) alluvium		10	37 26				
35	35.0 795.1		SILTY CLAY, brownish gray, stiff, laminations of wet silt (CL-ML) alluvium							
	37.0 793.1		FAT CLAY, gray, a little brownish gray, stiff, laminations of wet silt (CH) alluvium		11	31 28				
	39.0 791.1		SILTY CLAY, brownish gray, stiff, lenses and laminations of wet silt (CL-ML) alluvium			23				
40	41.0 789.1		FAT CLAY, dark brownish gray and brownish gray,			24 25		125		Water level measured at

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Index Sheet Code

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1107 SB	830.1 (Surveyed)

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
	42.0 788.1		laminations of silt (CH) alluvium		13					41.7' deep with HSA to 42' deep
45			SILTY CLAY, brownish gray, a little dark brownish gray, stiff, laminations of fat clay (CL-ML) alluvium		12					
	48.0 782.1				12					
50			SILTY SAND, fine grained, brownish gray, wet, medium dense to loose (SM) alluvium		7					
	53.0 777.1			PD						
55			SILT, brownish gray, wet, very dense (ML) alluvium		51					
	59.0 771.1			PD						
60			FAT CLAY, gray, a little brownish gray to brownish gray to grayish brown, stiff, laminations of silt (CH) alluvium		13	30				
				PD						
					12	32				
				PD						
65					15	34				
				PD						
					14	35				
				PD						
70					11	31				
				PD						
					15	23				
	74.0 756.1			PD						
75			LEAN CLAY WITH SAND, brown, stiff to very stiff (CL) aluvium		15	22				
				PD						
					16	22				
	79.0 751.1			PD						
80			CLAYEY SAND WITH GRAVEL, grayish brown, very stiff (SC) till		18	12				
				PD						
					28	9				
				PD						

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Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1107 SB	830.1 (Surveyed)

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
85			CLAYEY SAND WITH GRAVEL, grayish brown, very stiff (SC) till *(continued)*	PD	16	11				
	86.5 / 743.6		CLAYEY SAND, brown, stiff (SC) till	PD	13	17				
	89.0 / 741.1		SANDY LEAN CLAY, a little gravel, brownish gray, very stiff (CL) till	PD	18	20				
90				PD	22					
	93.0 / 737.1		CLAYEY SAND, a little gravel, grayish brown, very stiff (SC) till	PD	16	15				1" recovery
95				PD						
	96.5 / 733.6		CLAYEY SAND, grayish brown, very stiff (SC/SM) till	PD	20	16				
	99.0 / 731.1		CLAYEY SAND, a little gravel, brownish gray to grayish brown, very stiff (SC) till	PD	23	13				
100				PD						
	103.0 / 727.1		GRAVEL WITH CLAY AND SAND, brownish gray and reddish brown, moist, very dense (GP-GC) till	PD	60	13				
	104.0 / 726.1		CLAYEY SAND, a little gravel, gray and brown mottled, very stiff (SC) till	PD	21	14				
105				PD						
110				PD	26	18				
	113.0 / 717.1		FAT CLAY WITH SAND, brownish gray, very stiff (CH) till	PD	19	26				
115				PD						
	117.0 / 713.1		SAND WITH SILT, possible cobbles, fine to medium grained, brown, waterbearing, very dense (SP-SM) alluvium	PD	77					
120				PD						
	123.0 / 707.1		SAND WITH SILT, fine grained, brown, waterbearing, very dense (SP-SM) alluvium	PD	84					
125										

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1107 SB**	**830.1** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	128.0 702.1		SAND WITH SILT, fine grained, brown, waterbearing, very dense (SP-SM) alluvium *(continued)*	PD						
130			SAND WITH SILT, a little gravel, fine to medium grained, brown, waterbearing, very dense (SP-SM) alluvium	PD	*					*46/0.5+50/0.1
	134.5		Top of Bedrock							**40/0.5+50/0.4
135	695.6		SANDSTONE, weathered to fresh, light gray		**					ST. PETER FORMATION
	135.4 694.7		**END OF BORING**							

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1108 SB	829.2 (Surveyed)

Location , , ft. LT
Co. Coordinate: X=526183 Y=170307 (ft.)
Latitude (North)=44.9838922 Longitude (West)=-93.2821495

Drill Machine 68C
Hammer CME Automatic Calibrated

SHEET 1 of 3
Drilling Completed 11/2/10

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
	2.0 827.2		Gravelly clayey sand, pieces of limestone, trace roots, dark brown and brownish gray, fill		13					Hammer Calibration: 68% efficiency with 110 lb. hammer, 6/9/14
			Sandy lean clay, a little gravel, trace roots, dark brown and brownish gray, fill (chemical-type odor)		6	18 13				
5	5.5 823.7		Clayey sand, a little gravel and silty sand, trace roots, dark brownish gray and grayish brown, fill		9	13 14				
	7.5 821.7 8.0 821.2		Sandy lean clay, a little gravel, brownish gray, fill (petroleum-type odor) Weathered concrete, light grayish brown, fill		43	21				
10	9.5 819.7		Lean clay, a little gravel and sand with silt, trace roots, gray, brownish gray and brown, fill		9	31 22 21				
	11.5 817.7		Mixture of silty sand, sand with silt and clayey sand, a little gravel, pieces of brick and wood, dark brownish gray and black, a little brown, fill (chemical-type odor)		20	21				
15	14.5 814.7		Silty sand, dark brown, grayish brown and brown, fill (chemical-type odor)		5					
	17.0 812.2		Sand with silt, brown and light brown, fill (chemical-type odor)		9					
20					8					
	22.0 807.2		Sand, a little gravel and fat clay, brown and brownish gray, fill		7					
	24.5									
25	804.7 26.0 803.2		SAND, a little gravel, medium grained, gray, a little light gray, moist, medium dense, a lens of fine grained (SP) alluvium		12					
			FAT CLAY, trace roots, brownish gray, a little light gray, stiff, laminations of silt (CH) alluvium (chemical-type odor)		9	27				
30	30.5 798.7		FAT CLAY, brownish gray, a little light gray, stiff, laminations of silt (CH) alluvium			23 22				
▼	33.5 795.7				10	33 26				Water level measured at 32.2' deep with SS to 34' deep (rose from 33.2' deep 10 minutes earlier)
35			LEAN CLAY, brownish gray, a little light grayish brown, laminations of silt (CL) alluvium			22				
	38.0 791.2		SILTY CLAY, brownish gray, a little light grayish brown, laminations of silt (CL-ML) alluvium		5	22 23				
40	41.5					23 23		130		

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Soil Class: Rock Class: Edit: Date: 8/25/14
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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1108 SB	829.2 (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	787.7		LEAN CLAY, brownish gray, a little light gray, laminations of silt (CL) alluvium *(continued)*		9	22				
	44.0					25				
45	785.2		SILTY CLAY, brownish gray, a little gray, stiff, lenses of fat clay, laminations of silt (CL-ML) alluvium			24				
	47.0									
	782.2		LEAN CLAY, brownish gray, stiff (CL) alluvium		10	26				
	48.0		SANDY SILT, brownish gray, wet, loose (ML) alluvium							
	781.2									
50	49.5		FAT CLAY, brownish gray, a little light grayish brown, laminations of silt (CH) alluvium			27				
	779.7					25				
	51.0		LEAN CLAY, brownish gray, laminations of fat clay and silt (CL) alluvium			26				
	778.2				12					
	53.0					28				
	776.2									
55			LEAN CLAY, brownish gray, a little dark brownish gray, stiff, laminations of fat clay and silt (CL) alluvium			28				
						25				
					14					
						23				
	59.5									
60	769.7		FAT CLAY, dark brownish gray, a little light grayish brown, laminations of silt (CH) alluvium			27				
	62.0			PD		23				
	767.2		LEAN CLAY, brownish gray, a little light grayish brown, laminations of silt (CL) alluvium		20	26				
	64.0			PD						
65	765.2		SANDY LEAN CLAY, a little gravel, brown, very stiff (CL) till		27	12				
	66.5			PD						
	762.7				19	14				
				PD						
70					25	13				
				PD						
			CLAYEY SAND, a little gravel, brown to brown and gray mottled, very stiff (SC) till		27	13				
				PD						
75					19	16				
				PD						
					20	14				
	79.0			PD						
	750.2		CLAYEY SAND, a little gravel, brown, very stiff, a lens of wet silty sand (SC) till		23	10				
80	81.5			PD						
	747.7		LEAN CLAY WITH SAND, brown, very stiff (CL) till or alluvium		18	21				
	84.0			PD						

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1108 SB**	**829.2** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60}	MC (%)	COH (psf)	γ (pcf)	Soil	Other Tests Or Remarks
					REC (%)	RQD (%)	ACL (ft)	Core Breaks	Rock	Formation or Member
	745.2		SANDY LEAN CLAY, a little gravel, brown, a little gray,	PD						
85	85.5		hard, laminations of wet silty sand (CL) till		72	16				
	743.7		GRAVELLY CLAYEY SAND, grayish brown, hard (SC/SM) till			10				
	86.0									
	743.2		**END OF BORING**							

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1110 SB	817.9 (Surveyed)

Location , , ft. LT
Co. Coordinate: X=526376 Y=170390 (ft.)
Latitude (North)=44.9841192 Longitude (Westl)=-93.2814032

Drill Machine 33C
Hammer CME Automatic Calibrated

SHEET 1 of 3
Drilling Completed 10/28/10

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
					REC (%)	RQD (%)	ACL (ft)	Core Breaks		
	2.0 / 815.9		Mixture of clayey sand and lean clay, a little gravel, dark brownish gray and gray, fill		18	13				Hammer Calibration: 69% efficiency with 105 lb. hammer, 9/17/13
5			Sand with silt, a little gravel, pieces of brick and wood, grayish brown and black, fill (petroleum-type odor below about 7')		19					
					8					
					5					
10					3					
	12.0 / 805.9		Silty sand, black, a little gray, fill		5					
	14.5 / 803.4		Sand with silt, a little silty sand, gray, a little brownish gray, fill		7					
15					9					
	19.5 / 798.4		Sand, brown and gray, fill		9					Water level measured at 20.8' deep with HSA to 24.5' deep (rose from 21.3' deep 10 minutes earlier)
20 ▼										
	23.0 / 794.9		Sand with silt, trace roots, dark gray, fill		2					
25					PD					
	28.0 / 789.9		Sand, a little gravel, a nail, dark gray and gray, fill		6					
30					PD					
	33.0 / 784.9		SAND, a little gravel, medium to fine grained, dark gray, waterbearing, loose (SP) alluvium or fill		7					
35					PD					
	37.5 / 780.4		SAND, a little gravel, medium to fine grained, gray, waterbearing, medium dense, lenses of fine grained (SP) alluvium		11					
40					PD					

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

SHEET 2 of 3

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1110 SB	817.9 (Surveyed)

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
	42.5 775.4			PD						
45			LEAN CLAY, brownish gray, stiff, laminations of fat clay (CL) alluvium	X	15	22				
	48.0 769.9			PD						
50			SILT, brownish gray, wet, medium dense (ML) alluvium	X	16	24				
	52.0 765.9			PD						
55			FAT CLAY, brownish gray, a little gray, very stiff, laminations of silt (CH) alluvium	X	17	23				
	57.0 760.9			PD						
60			LEAN CLAY, brownish gray, stiff (CL) alluvium	X	15	30				
	62.0 755.9			PD						
65			FAT CLAY, brownish gray, a little gray, stiff, laminations of lean clay (CH) alluvium	X	13	35				
				PD						
70				X	15	36				
	73.0 744.9			PD						
75				X	26	14				
			CLAYEY SAND, a little gravel, brown, very stiff, laminations of waterbearing sand below 77' (SC) till	PD						
80				X	22	18				
				PD						

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Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1110 SB**	**817.9** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
85	87.0 730.9		CLAYEY SAND, a little gravel, brown, very stiff, laminations of waterbearing sand below 77' (SC) till *(continued)*		23	23				
			CLAYEY SAND, a little gravel, brownish gray, very stiff (SC) till	PD						
90	91.5 726.4				27	20				
			No sample recovery - driller note: possible cobbles/boulders, possible colluvium	PD						
95	98.0 719.9				18					
			REDEPOSITED SANDSTONE, brownish gray, [Textural classification: Sand, a little gravel, fine grained, waterbearing, very dense (SP)] colluvium or alluvium	PD	100/.4					
100	101.5 716.4		Top of Bedrock							ST. PETER FORMATION
	104.5 713.4		SANDSTONE, fresh, a lens of shaly sandstone, gray, a little light brown **END OF BORING**	PD	100/.5					

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1205 SB**	**830.8** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=525936 Y=170003 (ft.)

Latitude (North)=44.9840721 Longitude (West)=-93.2808816

Drill Machine **33C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 5

Drilling Completed **12/18/13**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	1.0 829.8		Silty sand with organic fines, trace roots, dark brown, frozen (A-4) fill							Hammer Calibration: 69% efficiency with 105 lb. hammer, 9/17/13
	2.0 828.8		Silty sand, a little gravel and clayey sand, pieces of brick, trace roots, brown, a little dark brown (A-2-4) fill		24					
5			Sand with silt, a little gravel and silty sand, pieces of brick, trace roots (A-3, A-2-4) fill		12					
	9.0 821.8				13					
10	11.5 819.3		Sand with silt, a little silty sand, trace roots, light brown, a little brown (A-3) fill		10					
	15.0 815.8		Sand with silt, brown to dark brown (A-1-b) fill		9					
15	16.5 814.3		FAT CLAY, brown and gray mottled, firm, laminations of silt (CH) (A-7-6) alluvium		7	32				
	19.0 811.8		LEAN CLAY, gray and brown mottled, stiff, laminations of silt (CL) (A-7-6) alluvium		10	29				
20			FAT CLAY, brownish gray to gray, a little grayish brown, stiff, laminations of silt (CH) (A-7-6) alluvium			29	1245	124		
	24.0 806.8				11	27				
25			LEAN CLAY, grayish brown to brownish gray, a little light grayish brown, stiff, laminations of silt (CL) (A-7-6) alluvium			26	1760	126		
	29.0 801.8				9	24				
30	31.5 799.3		SILT, brownish gray, wet (ML) (A-4) alluvium			23				
	34.0 796.8		SILTY CLAY, brownish gray, stiff, a lens of silt (CL-ML) (A-4) alluvium		13	27				
35			LEAN CLAY, brownish gray and grayish brown, stiff, laminations of silt (CL) (A-7-6) alluvium			22	1310	128		
	40.5 790.3				14	25				
40			FAT CLAY, dark brownish gray, a little grayish brown, stiff, laminations of silt (CH) (A-7-6) alluvium			26	1410	129		

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1205 SB	830.8 (Surveyed)

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
45			FAT CLAY, dark brownish gray, a little grayish brown, stiff, laminations of silt (CH) (A-7-6) alluvium *(continued)*		12	31				
						31	1095	119		
	46.5 / 784.3									
▼			LEAN CLAY, brownish gray, stiff (CL) (A-6) alluvium		9	23				Water level measured at 47.2' deep with HSA to 59.5' deep (rose from 58.2' deep 17 minutes earlier)
	49.0 / 781.8									
50			SILT, gray, moist, laminations of lean clay (ML) (A-4) alluvium			24	1410	130		
	53.0 / 777.8									
55			SILTY CLAY, brownish gray to grayish brown, very stiff (CL-ML) (A-4) alluvium		24	22				
60	60.5 / 770.3									No recovery
				PD						
65			LEAN CLAY, grayish brown, a little brownish gray, very stiff, laminations of fat clay and sandy silt (CL) (A-7-6) alluvium		20	27				
				PD						
70					16					1" recovery
	72.0 / 758.8			PD						
75			SILTY CLAY, brownish gray, very stiff, laminations of fat clay (CL-ML) (A-4) alluvium		17	26				
	77.0 / 753.8			PD						
80			CLAYEY SAND, grayish brown, stiff (SC) (A-6) till		11	18				
	82.0 / 748.8			PD						
			CLAYEY SAND, brown, firm to stiff (SC) (A-2-6) till							

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1205 SB**	**830.8** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
85			CLAYEY SAND, brown, firm to stiff (SC) (A-2-6) till *(continued)*	X	7	17				
				PD						
90				X	6	19				
				PD						
95	95.0 / 735.8			X	14	18				
			CLAYEY SAND, grayish brown, stiff to very stiff (SC) (A-6) till	PD						
100				X	17	19				
	102.0 / 728.8			PD						
105			CLAYEY SAND, a little gravel, brown and grayish brown, stiff (SC) (A-6) till	X	15	16				
				PD						
110				X	15	17				
	112.5 / 718.3			PD						
115			CLAYEY SAND, a little gravel, brownish gray to grayish brown, very stiff, laminations of sand (SC) (A-6) till	X	17	14				
				PD						
120				X	18	14				
				PD						
125				X	18	17				
				PD						

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1205 SB**	**830.8** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60}	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
	127.5 703.3			PD						
130			SILTY SAND WITH GRAVEL, possible cobbles, brown, dense to very dense (SM/SC) (A-1-b) till		46					
				PD						
135					90/.9					
				PD						
	138.0 692.8									
140			CLAYEY SAND, a little gravel, brownish gray and grayish brown, very stiff (SC) (A-6) till		26	17				
				PD						
145					29	13				
				PD						
	148.0 682.8									
150			SANDY LEAN CLAY, brownish gray, very stiff to hard (CL) (A-6) till		26	23				
				PD						
155					31	22				
	157.5 673.3		Top of Bedrock	PD						ST. PETER FORMATION
160			SANDSTONE, highly weathered, grayish brown		85					
	162.0 668.8			PD						
165			SANDSTONE, fresh, light brown		50/.1					
				PD						

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Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1205 SB**	**830.8** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Soil	Other Tests Or Remarks
					REC (%)	RQD (%)	ACL (ft)	Core Breaks	Rock	Formation or Member
	169.1 / 661.7		SANDSTONE, fresh, light brown *(continued)*	PD	100/.05					
170			**END OF BORING**							

Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1207 SB	817.9 (Surveyed)

Location , , ft. LT

Co. Coordinate: X=526648 Y=170339 (ft.)

Latitude (North)=44.9841563 Longitude (West)=-93.2800274

Drill Machine 68C

Hammer CME Automatic Calibrated

SHEET 1 of 4

Drilling Completed 11/4/10

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
0														Hammer Calibration: 68% efficiency with 110 lb. hammer, 6/9/14
			Mixture of clayey sand, sandy lean clay and silty sand, with gravel, pieces of brick, trace roots, dark brown and brown, fill		17		16							
					25		15							
5					14		24							
	7.0 / 810.9													
			Silty sand, pieces of concrete and wood, brownish gray and black, fill (petroleum-type odor)		23									
▼10					9									Water level measured at 9.9' deep with HSA to 14.5' deep (rose from 10.2' deep 10 minutes earlier)
	12.0 / 805.9													
			Silty sand, a little gravel and clayey sand, pieces of bituminous and wood, cinders, clinkers and ash, dark brown and gray, fill (petroleum-type odor)		7									
15					4									
					4									
	19.5 / 798.4													
20			Silty sand, a little gravel and organic silt, pieces of bituminous, trace roots, gray and dark gray, fill (petroleum-type odor)		6									
	22.0 / 795.9													
			ORGANIC CLAY, trace roots, grayish brown, firm (OL/OH) swamp deposit		8		203							
25					5		118							
	27.0 / 790.9													
			ORGANIC CLAY, grayish brown, soft (OL/OH) swamp deposit		4		109							
30					4		122							
							114							
	33.5 / 784.4													
35			ORGANIC CLAY, trace roots, brownish gray, soft (OL/OH) swamp deposit		4		108							
					3		103							
	39.0 / 778.9													
40			ORGANIC CLAY, dark gray, a little gray, soft (OL/OH) swamp deposit		3		51							
	41.5													

Index Sheet Code

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Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1207 SB	817.9 (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
	776.4		LEAN CLAY, trace roots, gray, a little light gray, laminations of silt (CL) alluvium (petroleum-type odor) *(continued)*			28	890	115		
	43.5 / 774.4		SAND WITH SILT, fine grained, gray, wet (SP-SM) alluvium (petroleum-type odor)			40				
45	44.5 / 773.4		SAND, a little gravel, fine to medium grained, gray, waterbearing, loose (SP) alluvium (petroleum-type odor)		7					
	48.0 / 769.9			PD						
50			SAND, fine grained, gray, waterbearing, medium dense to dense (SP) alluvium		22					
				PD						
55					36					
	58.0 / 759.9			PD						
60			SAND WITH SILT, a little gravel, fine to medium grained, gray, a little black, waterbearing, medium dense (SP-SM) alluvium (petroleum-type odor)		20					
	63.0 / 754.9			PD						
65			SAND, a little gravel, medium grained, gray, waterbearing, dense (SP) alluvium		31					
	67.0 / 750.9		SILTY CLAY, brownish gray, stiff (CL-ML) alluvium (petroleum-type odor)	PD						
70	70.0 / 747.9		FAT CLAY, brownish gray, very stiff, laminations of wet silt (CH) alluvium (petroleum-type odor)		19	23 / 26				
	73.0 / 744.9			PD						
75			SILTY CLAY, brownish gray, very stiff (CL-ML) alluvium		19	23				
	78.0 / 739.9			PD						
80			LEAN CLAY, a little dark gray, very stiff, laminations of fat clay (CL) alluvium		23	29				
	82.0 / 735.9		FAT CLAY, gray, a little brownish gray, stiff, laminations of wet silt (CH) alluvium	PD	14	31				

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	Southwest LRT, PEC East	1207 SB	817.9 (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
85	85.0			PD						
	732.9		LEAN CLAY, brownish gray, very stiff (CL) alluvium		20	31 29				
	86.5			PD						
	731.4		FAT CLAY, gray, a little brownish gray mottled, stiff (CH) alluvium		13	37				
	89.0			PD						
90	728.9		SILTY CLAY, brownish gray, very stiff, laminations of wet silt (CL-ML) alluvium		24	24				
	91.5			PD						
	726.4		SILTY CLAY, brownish gray, a little gray, very stiff, laminations of fat clay (CL-ML) alluvium		22	28				
	94.0			PD						
	723.9				20	14 16				
95				PD						
					16	18				
100			SANDY LEAN CLAY, a little gravel, brown and gray mottled to brown, very stiff (CL) till	PD						
					28	15				
105				PD						
	108.0									
	709.9				57	19				
110			CLAYEY SAND, a little gravel, brown, hard, laminations of waterbearing sand (SC) till	PD						
					41	20				
115				PD						
	118.0									
	699.9				23	19				
120			SANDY LEAN CLAY, a little gravel, brown and gray mottled, very stiff (CL) till	PD						
	123.0									
	694.9				23	19				
125			CLAYEY SAND, a little gravel, brown and gray mottled, very stiff (SC) till							

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Soil Class: Rock Class: Edit: Date: 8/25/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	5th Ave N/7th Street	**Southwest LRT, PEC East**	**1207 SB**	**817.9** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
					REC (%)	RQD (%)	ACL (ft)	Core Breaks		
130			CLAYEY SAND, a little gravel, brown and gray mottled, very stiff (SC) till *(continued)*	PD						
					24	18				
	133.0 / 684.9			PD						
135			SANDSTONE SAND [Textural Classification: Sand with silt, a little gravel, fine grained, brown, very dense (SP-SM)] colluvium or residual soil		59					
	137.0 / 680.9		Top of Bedrock	PD						ST. PETER FORMATION
140			Apparent Fresh SANDSTONE, based on drilling action (no samples retrieved)		100/0.1					
				PD						
	144.6 / 673.3		END OF BORING		100/0.1					

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

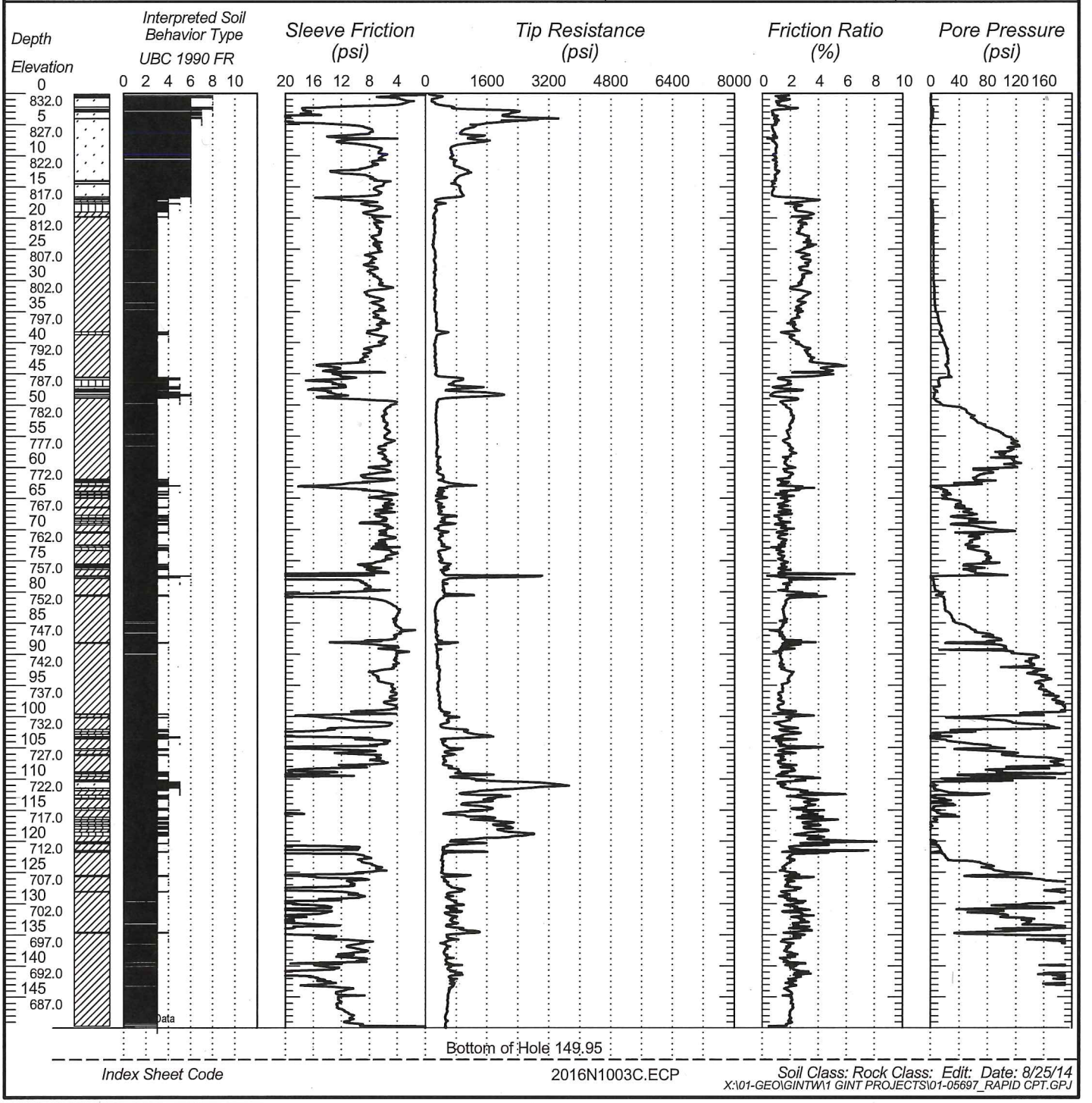
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	5th Ave N/ 7th St	Southwest LRT, PEC East	1104CB	832.0 (Surveyed)

Location	CPT Machine	
Hennepin Co. Coordinate: X=525930 Y=169856 (ft.)	20	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator Adams	Date Completed
No Station-Offset Information Available	Hole Type CPT-SEISMIC	11/16/10



Index Sheet Code 2016N1003C.ECP

Soil Class: Rock Class: Edit: Date: 8/25/14

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AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

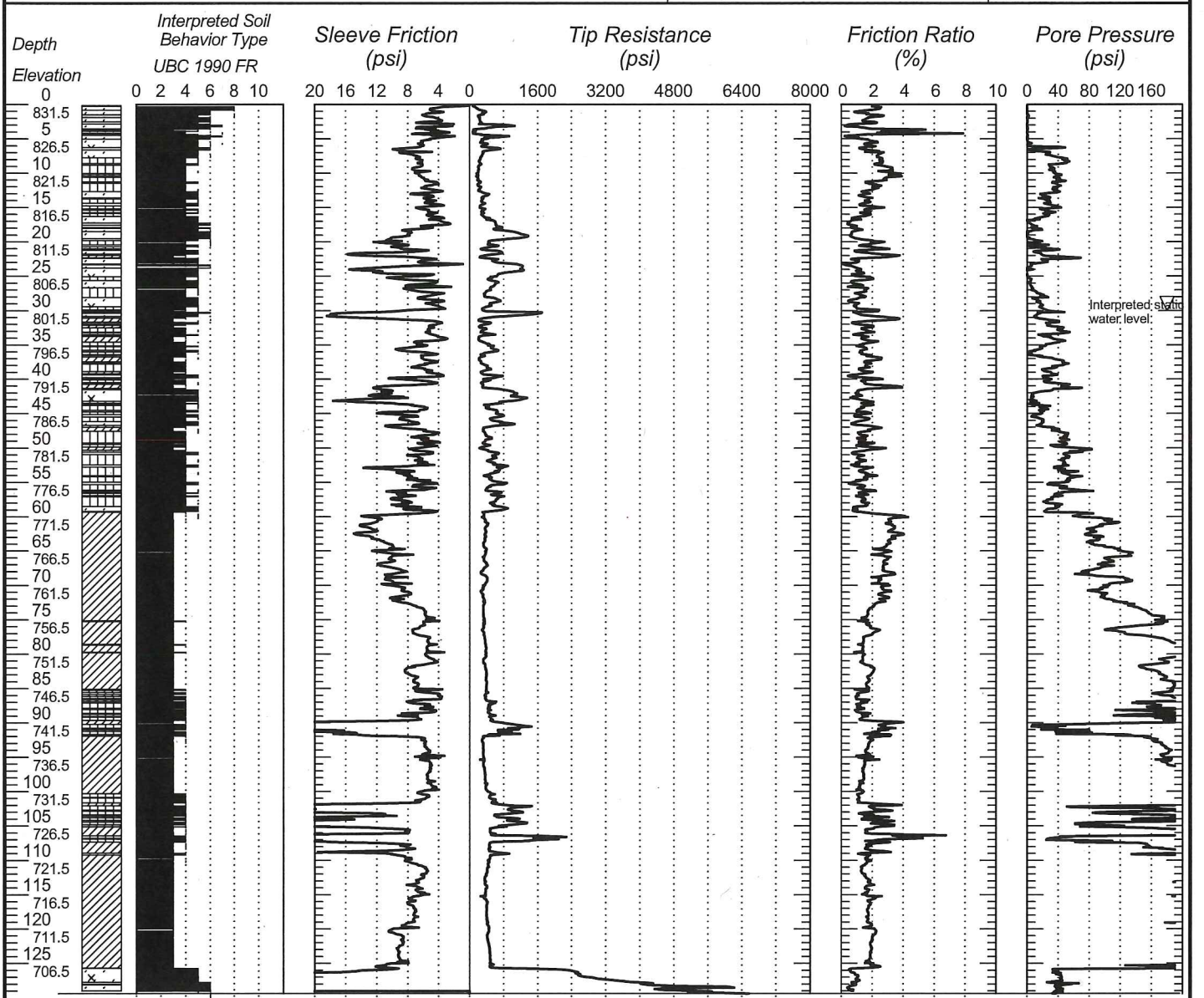
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	5th Ave N/ 7th St	Southwest LRT, PEC East	1106CB	831.5 (Surveyed)

Location	CPT Machine	SHEET 1 of 1
Hennepin Co. Coordinate: X=526028 Y=170332 (ft.)	CPT Operator Adams	
Latitude (North)= Longitude (West)=		Date Completed
No Station-Offset Information Available	Hole Type CPT-SEISMIC	11/17/10



Index Sheet Code 2017N1001C.ECP Soil Class: Rock Class: Edit: Date: 8/25/14

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CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

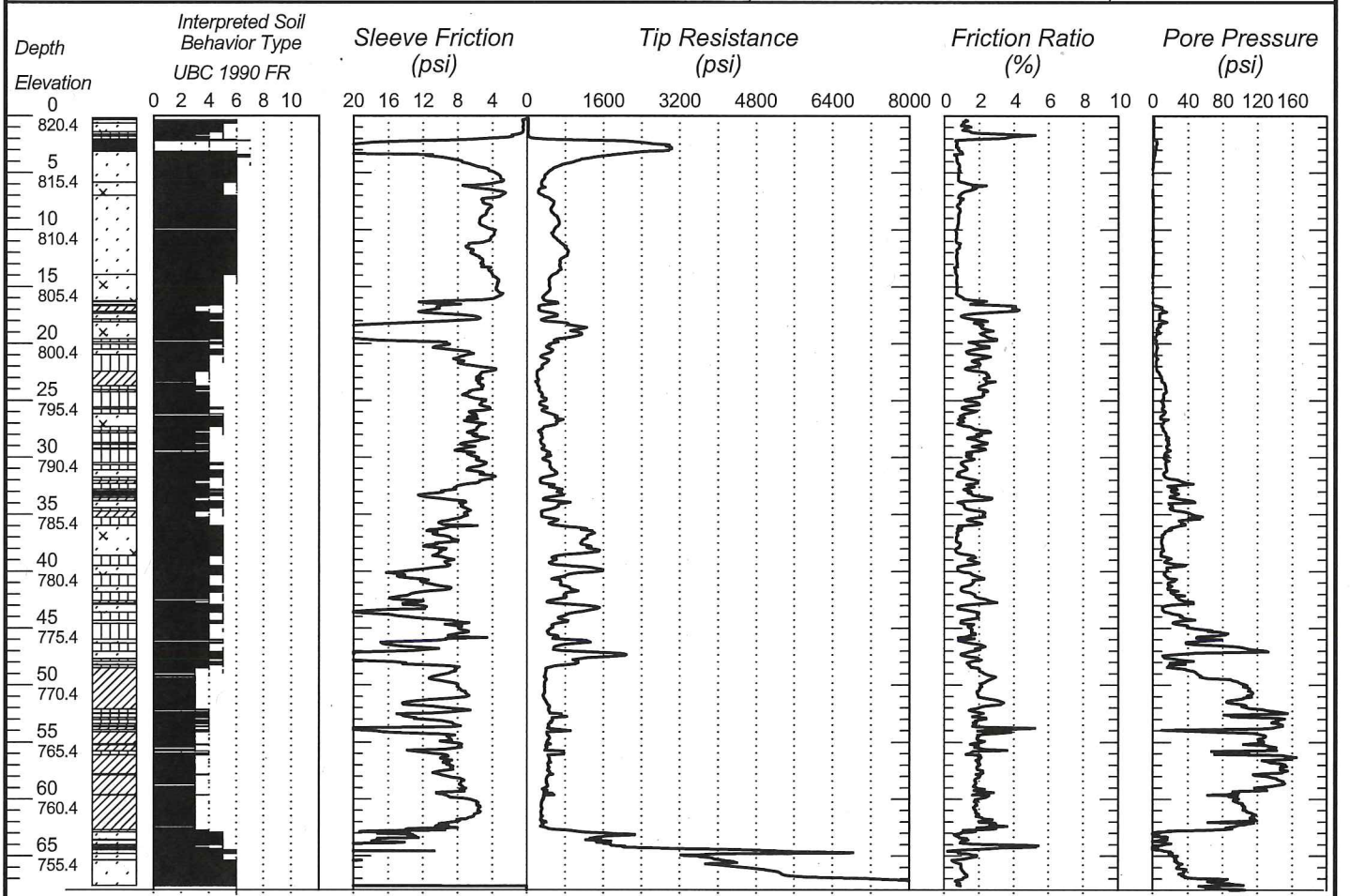
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	5th Ave N/ 7th St	Southwest LRT, PEC East	1109CB	820.4 (Surveyed)

Location	CPT Machine	
Hennepin Co. Coordinate: X=526236 Y=170406 (ft.)	20	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator Adams	Date Completed
No Station-Offset Information Available	Hole Type CPT-SEISMIC	11/16/10



Bottom of Hole 67.98

Index Sheet Code 2016N1002C.ECP

Soil Class: Rock Class: Edit: Date: 8/25/14

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AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

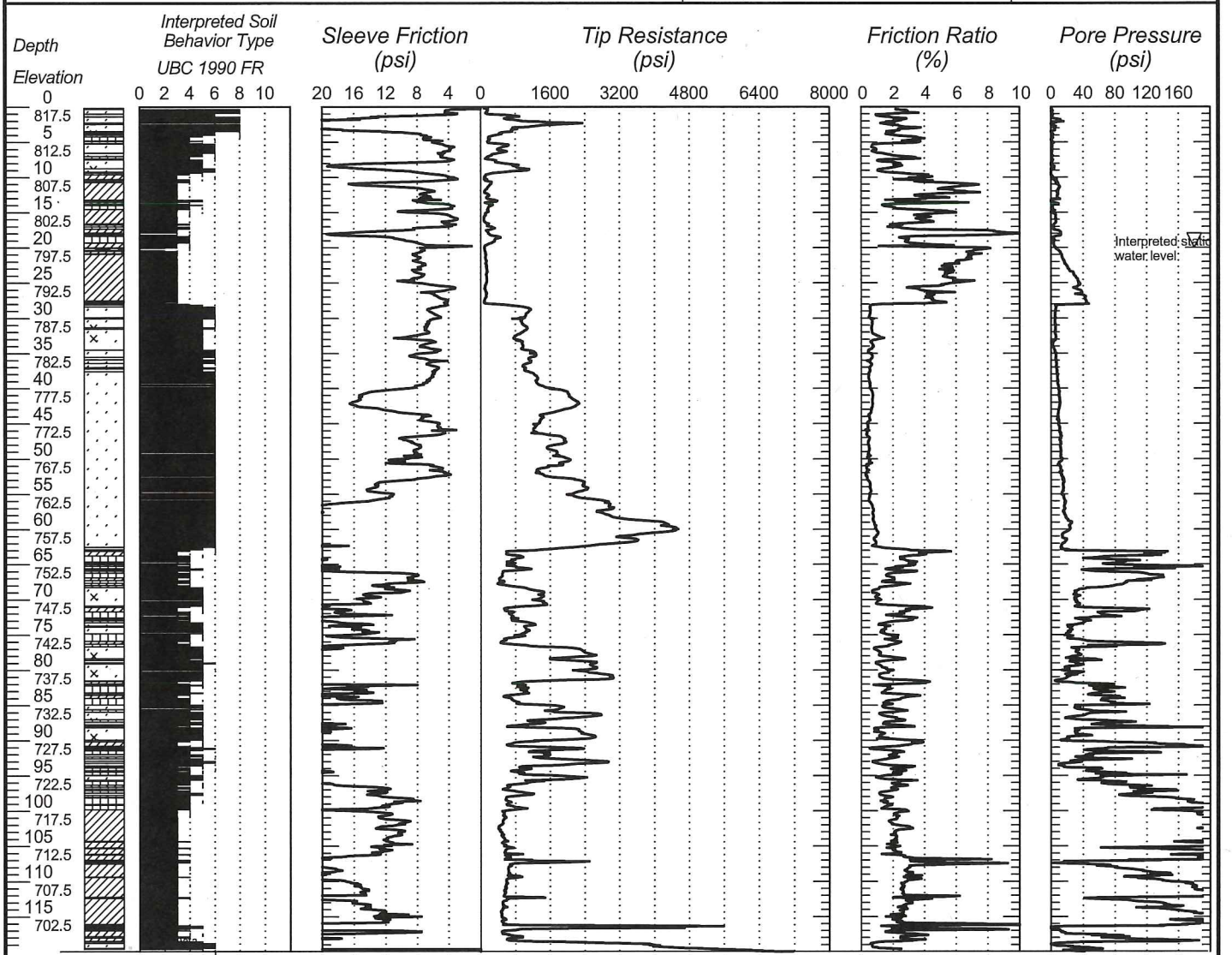
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	5th Ave N/ 7th St	Southwest LRT, PEC East	1206CB	817.5 (Surveyed)

Location	CPT Machine	
Hennepin Co. Coordinate: X=526511 Y=170373 (ft.)	20	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator Adams	Date Completed
No Station-Offset Information Available	Hole Type CPT-SEISMIC	10/28/10



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Soil Class: Rock Class: Edit: Date: 8/25/14

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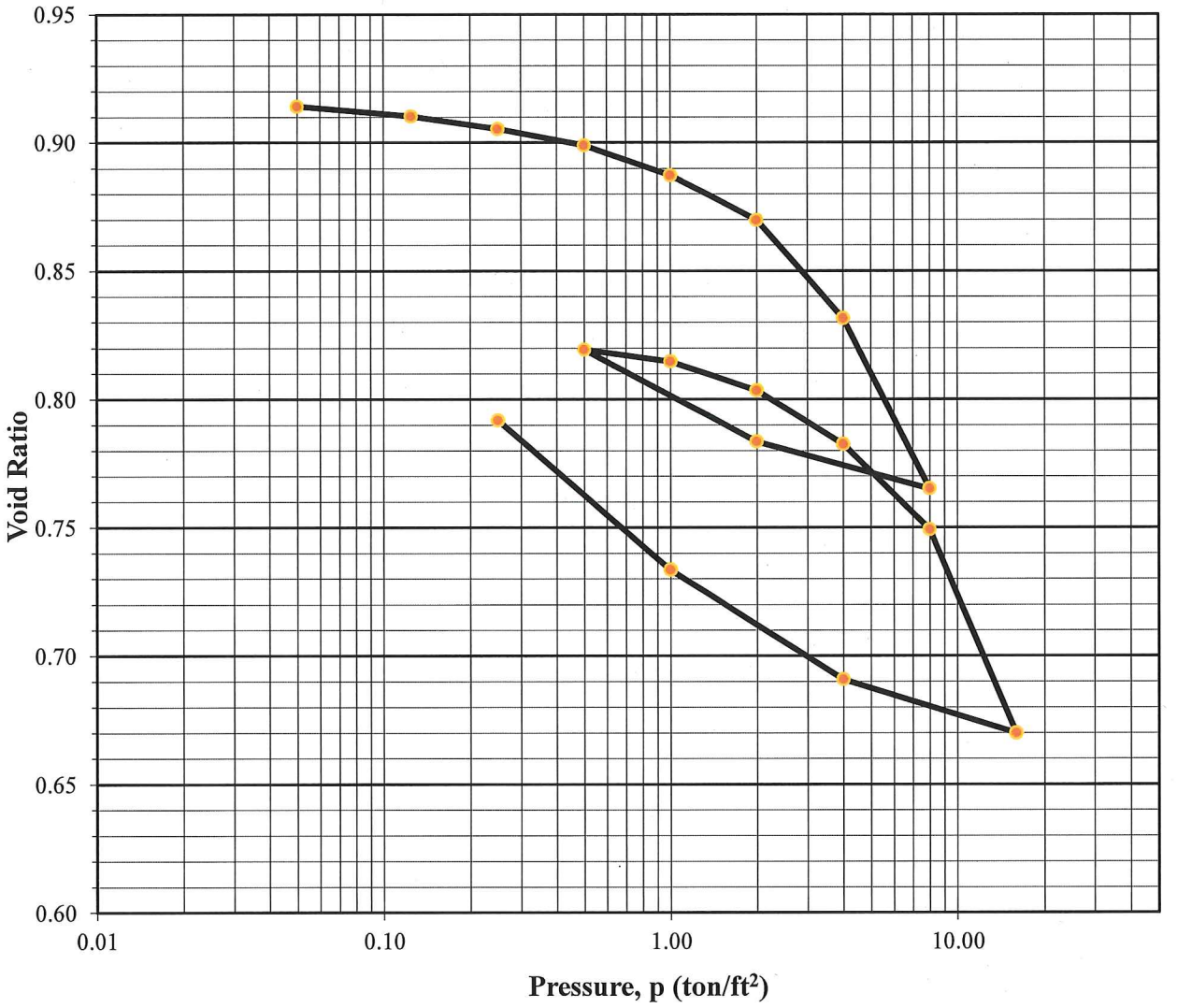
AMERICAN ENGINEERING TESTING, INC.

Consolidation Test Results: Void Ratio vs. Pressure

Project: SW Light Rail Transit
Minneapolis to Hopkins, MN

AET No.: 01-05697

Date: 5/20/2013



	Before	After	Liquid Limit (%):	60	Test Date: 4/22/2013
Water Content (%):	33.57	30.98	Plastic Limit (%):	22	
Dry Density (pcf):	87.89	93.88	Plasticity Index (%):	38	
Saturation (%):	98.76	105.15			
Void Ratio:	0.9166	0.7939	Specific Gravity:	2.70	Assumed

Sample Description: Fat Clay, Gray-Brown (CH)

Boring Number: SB-1022 **Depth:** 24.5'-26.5'

Remarks: Test conducted in general accordance with ASTM D2435

Soil Parameters:
Preconsolidation Pressure (Pc): 3.1 tsf
Compression Index (Cc): 0.272
Recompression Index (Cr): 0.047

Tested By: Benjamin Pomroy

Reviewed By: Jeff Voyen

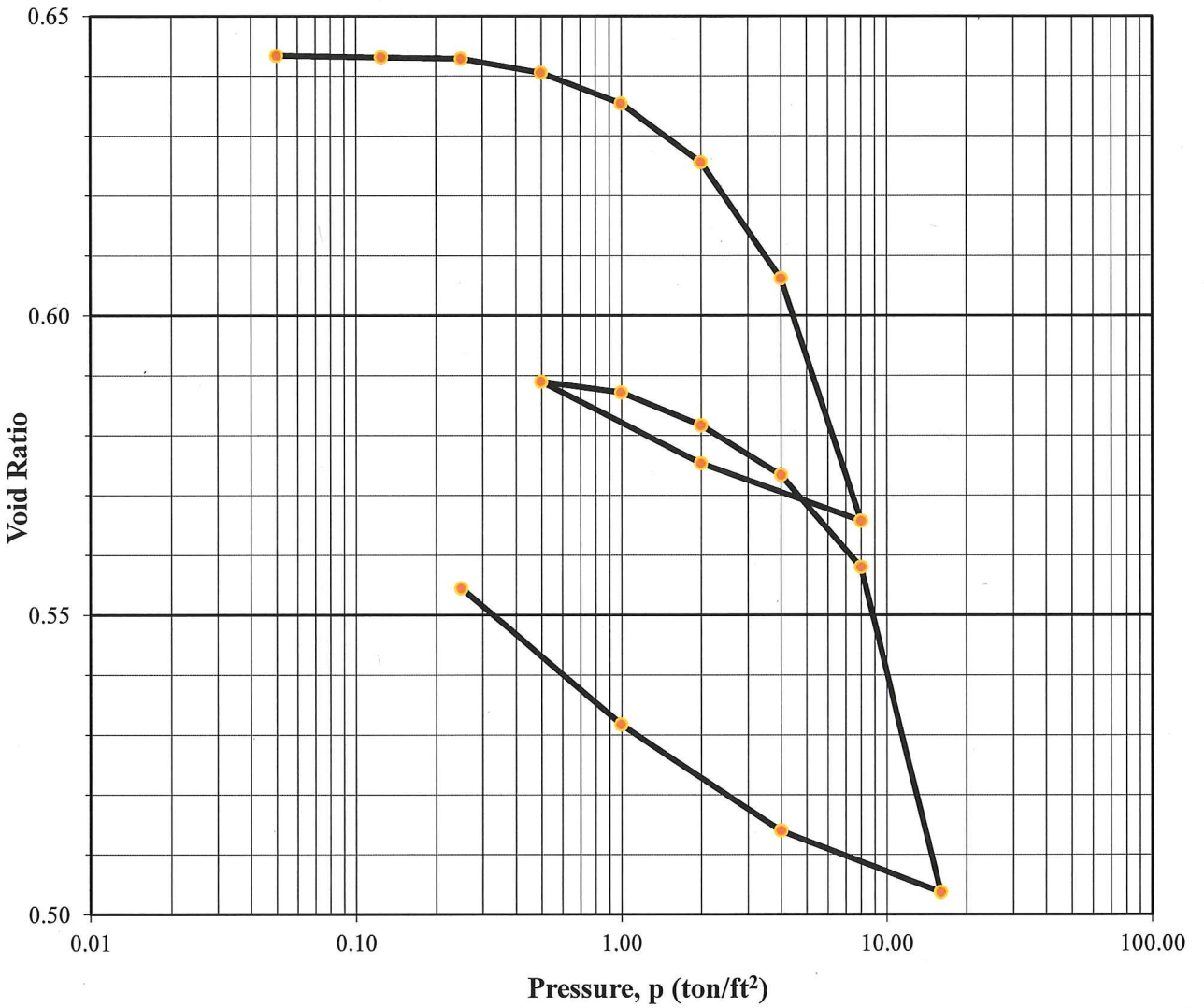
AMERICAN ENGINEERING TESTING, INC.

Consolidation Test Results: Void Ratio vs. Pressure

Project: Southwest Light Rail Transit
Minneapolis to Hopkins, MN

AET No.: 01-05697

Date: 5/20/2013



	Before	After			
Water Content (%):	23.56	21.04	**Liquid Limit (%):**	41	**Test Date:** 4/22/2013
Dry Density (pcf):	102.35	107.94	**Plastic Limit (%):**	15	
Saturation (%):	98.35	101.15	**Plasticity Index (%):**	26	
Void Ratio:	0.6435	0.5541	**Specific Gravity:**	2.70	Assumed

Sample Description: Lean Clay, Gray-Brown (CL)

Boring Number: 1022 SB **Depth:** 44.5'-46.5'

Remarks: Test conducted in general accordance with ASTM D2435

Soil Parameters:
Preconsolidation Pressure (Pc): 3.1 tsf
Compression Index (Cc): 0.122
Recompression Index (Cr): 0.020

Tested By: Benjamin Pomroy

Reviewed By: Jeff Voyen

SAMPLING METHODS

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" O.D. split-barrel sampler into the in-situ soil with a 140-pound hammer dropped from a height of 30". The sampler is driven a total of 18" into the soil. After an initial set of 6", the number of hammer blows to drive the sampler the final 12" 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.

Most of today's 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". 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 deviations of the N-values using this method are significantly better than the standard ASTM Method.

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.

CLASSIFICATION METHODS

Soil classifications 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 classifications shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

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

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

WATER LEVEL MEASUREMENTS

The ground-water level measurements/comments are shown on the boring logs in the remarks section. 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.

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
PD:	Plug Drilling (same as RDF)
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
COH:	Cohesion, psf (0.5 x q_u)
CONS:	One-dimensional consolidation test
γ:	Wet density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
MC:	Moisture Content, %
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
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES
(Calibrated Hammer Weight)

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

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

UNIFIED SOIL CLASSIFICATION SYSTEM
ASTM Designations: D 2487, D2488

AMERICAN ENGINEERING TESTING, INC.

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

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

[F] If soil contains ≥15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot is hatched area, soils is a CL-ML silty clay.

[K] If soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.

[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.

[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

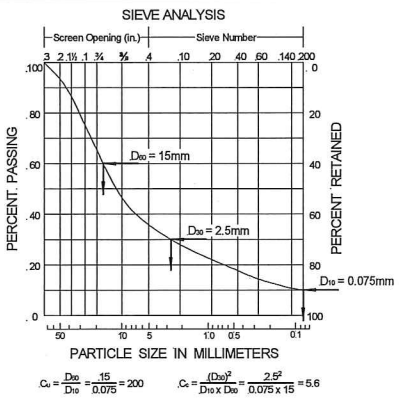
[N] PI≥4 and plots on or above "A" line.

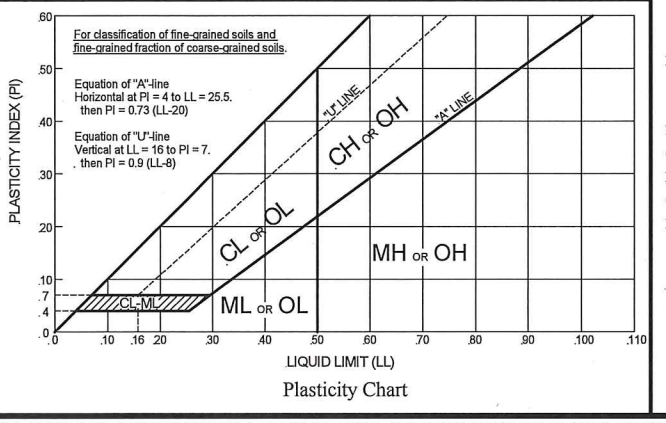
[O] PI<4 or plots below "A" line.

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

[Q] PI plots below "A" line.

[R] Fiber Content description shown below.





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.

Peat Description

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

Organic Description (if no lab tests)

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

Root Inclusions

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

AASHTO SOIL CLASSIFICATION SYSTEM

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

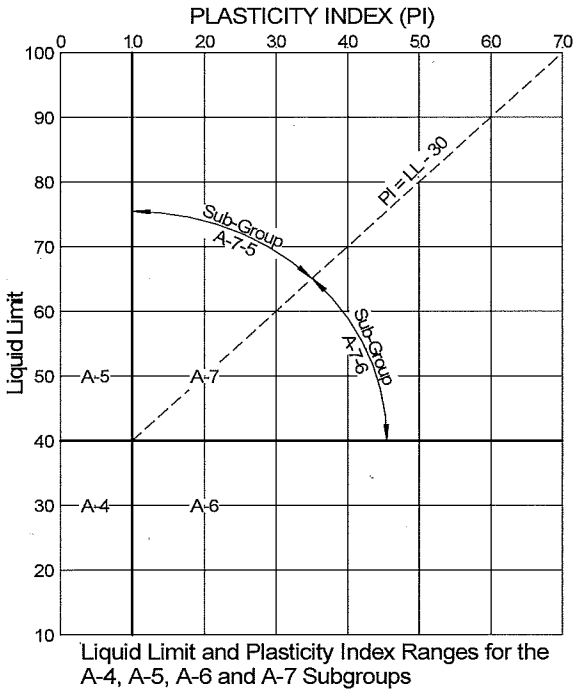
Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35% or less passing No. 200 sieve)							Silt-Clay Materials (More than 35% passing No. 200 sieve)			
Group Classification	A-1			A-2							A-7
	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 A-7-6
Sieve Analysis, Percent passing:											
No. 10 (2.00 mm)	50 max.	....	....	....	....	....	....	....	....	....	....
No. 40 (0.425 mm)	30 max.	50 max.	51 min.	....	....	....	....	....	....	....	....
No. 200 (0.075 mm)	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of Fraction Passing No. 40 (0.425 mm)											
Liquid limit	....		....	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		N.P.	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Ratings as Subgrade	Excellent to Good							Fair to Poor			

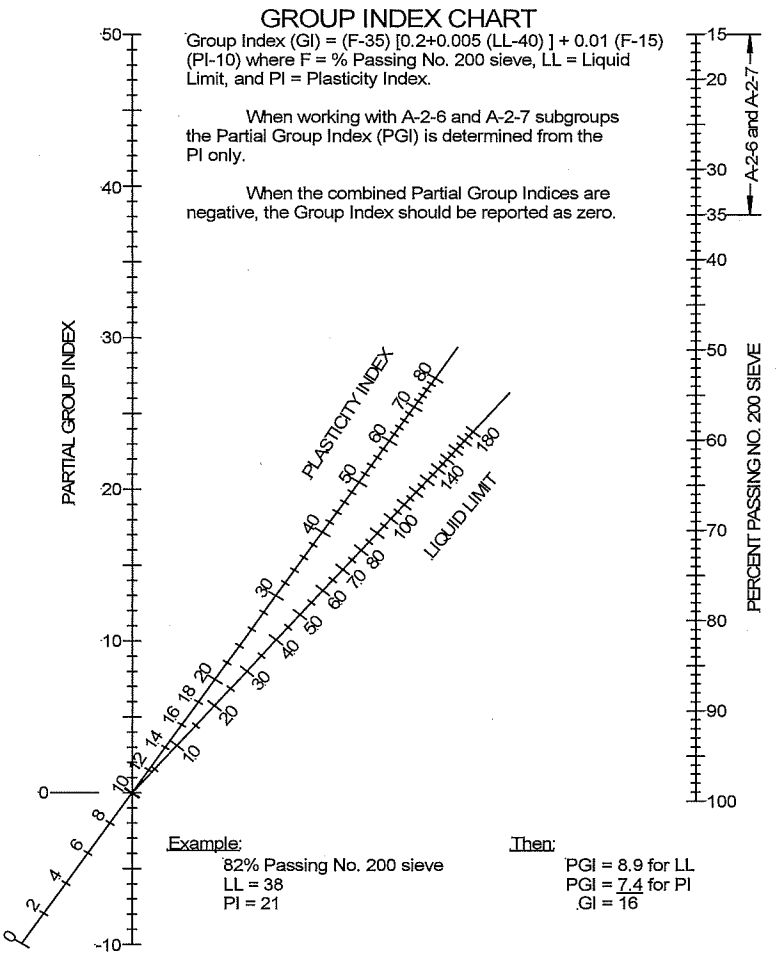
The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

Group A-8 soils are organic clays or peat with organic content >5%.



Liquid Limit and Plasticity Index Ranges for the A-4, A-5, A-6 and A-7 Subgroups



Example:
82% Passing No. 200 sieve
LL = 38
PI = 21

Then:
PGI = 8.9 for LL
PGI = 7.4 for PI
GI = 16

Definitions of Gravel, Sand and Silt-Clay

The terms "gravel", "coarse sand", "fine sand" and "silt-clay", as determinable from the minimum test data required in this classification arrangement and as used in subsequent word descriptions are defined as follows:

GRAVEL - Material passing sieve with 3-in. square openings and retained on the No. 10 sieve.

COARSE SAND - Material passing the No. 10 sieve and retained on the No. 40 sieve.

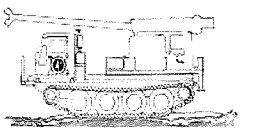
FINE SAND - Material passing the No. 40 sieve and retained on the No. 200 sieve.

COMBINED SILT AND CLAY - Material passing the No. 200 sieve

BOULDERS (retained on 3-in. sieve) should be excluded from the portion of the sample to which the classificaiton is applied, but the percentage of such material, if any, in the sample should be recorded.

The term "silty" is applied to fine material having plasticity index of 10 or less and the term "clayey" is applied to fine material having plasticity index of 11 or greater.

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)

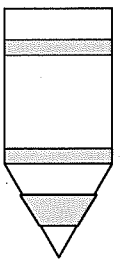
q_T TIP RESISTANCE
The resistance at the cone corrected for water pressure. Data is from cone with 60 degree apex angle and a 10 cm² end area.

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.

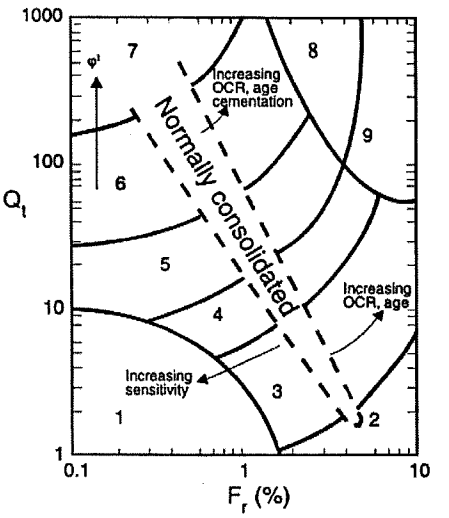
The numbers corresponding to different regions on the charts represent the following soil behavior types:

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.

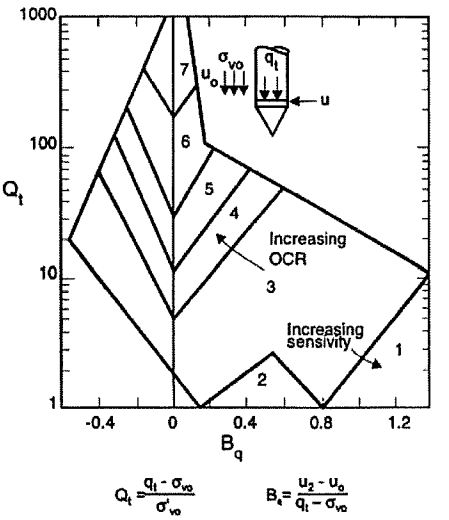
The following charts are used to provide a Soil Behavior Type for the CPT Data.

Robertson CPT 1990
Soil Behavior type based on friction ratio



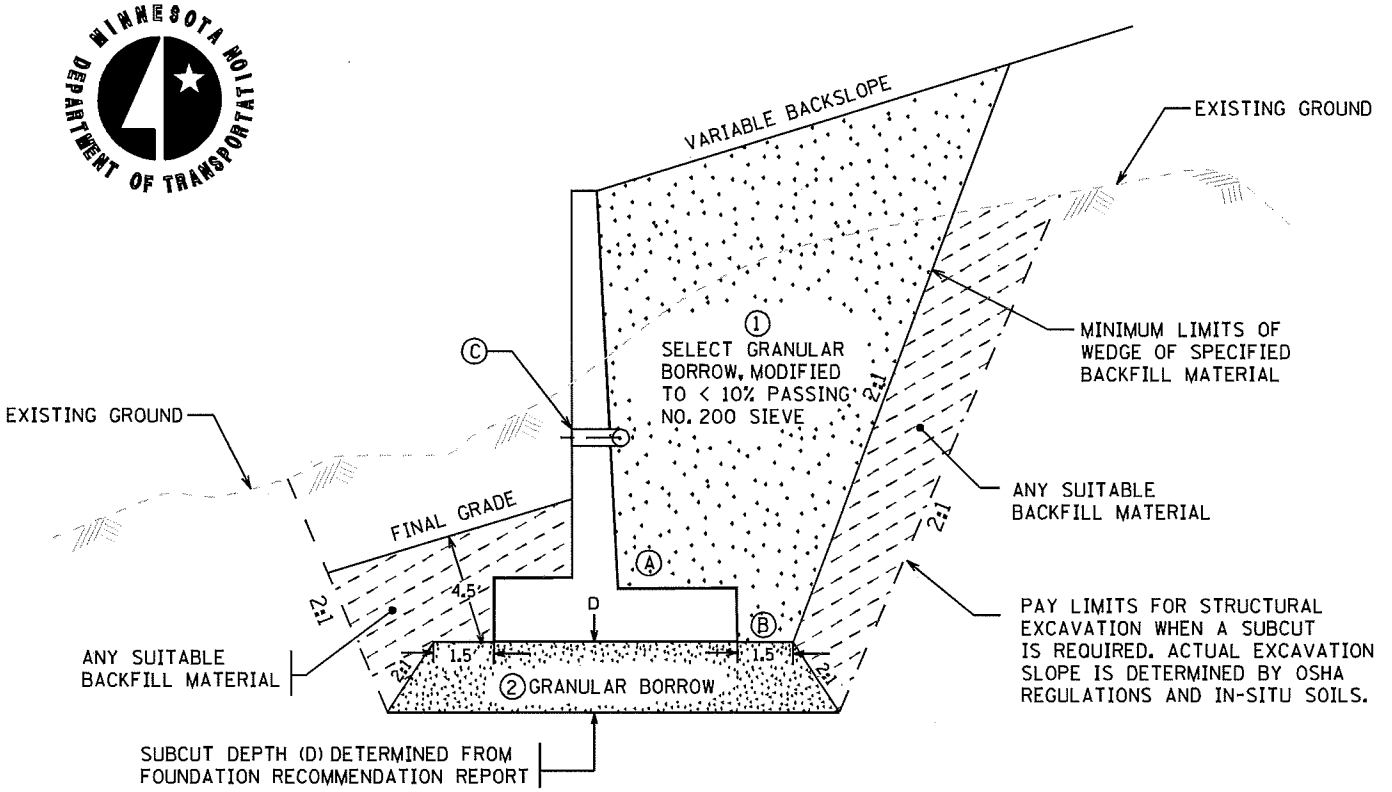
$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \qquad F_r = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$$

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 ...
QT..... normalized cone resistance
Bq..... pore pressure ratio
Fr ..... Normalized friction ratio
σvo ..... overburden pressure
σ'vo ..... effective over burden pressure
U2 ..... measured pore pressure
U0 ..... equilibrium pore pressure



NOT TO SCALE

All slope dimensions shown as V:H

THE RECOMMENDATIONS MAY BE MODIFIED AS PER THE ATTACHED FOUNDATIONS INVESTIGATION AND RECOMMENDATION REPORT

EXCAVATION AND BACKFILL NOTES:

① Mn/DOT SPEC. 3149.2B2 MODIFIED TO 10% PASSING THE NO. 200 SIEVE COMPACT BACKFILL TO SPECIFIED DENSITY METHOD Mn/DOT SPEC. 2105.3F1

② IF SUBCUT IS REQUIRED, BACKFILL WITH GRANLAR BORROW, Mn/DOT SPEC. 3149.2B1. COMPACT BACKFILL TO 100% OF STANDARD PROCTOR (T-99). REFER TO FOUNDATION RECOMMENDATION LETTER FOR SUBCUT DEPTHS.

DRAINAGE SYSTEM NOTES:

PROVIDE WALL DRAINAGE SYSTEM A, B OR C

Ⓐ Ⓑ PLACE A 6 IN. I.D. NON-STEEL PERFORATED PIPE(Mn/DOT SPEC. 3245) WRAPPED WITH A TYPE I GEOTEXTILE FABRIC (Mn/DOT SPEC. 3733) RUNNING THE ENTIRE LENGTH OF THE WALL AND LAID A MINIMUM OF 2 IN. ABOVE THE TOP OF FOOTING (OPTION A) OR BOTTOM ELEVATION OF THE FOOTING (OPTION B). STRUCTURAL BACKFILL MATERIALS SHALL COMPLETELY SURROUND THE PIPE. AT ALL TIMES, THE SLOPE OF THE PIPE SHALL BE CHECKED TO ENSURE POSITIVE DRAINAGE. FREQUENT TIES (SPACED APPROXIMATELY 200 FT. APART) SHALL BE MADE FROM THE PIPE TO THE INPLACE OR PROPOSED DRAINAGE SYSTEM.

Ⓒ PROVIDE WEEP HOLES AS SPECFIED IN THE BRIDGE STANDARD PLANS MANUAL, STANDARD SHEET 5-297.621 TO 5-297.623.

STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION
STRUCTURAL BACKFILL, FOOTING SUBCUT & DRAINAGE SYSTEM TREATMENT
(STANDARD CANTILEVER RETAINING WALL DESIGN)

DIAGRAM NO.
F–1

November 2005

PREPARED BY THE FOUNDATIONS UNIT
GEOTECHNICAL ENGINEERING SECTION – OFFICE OF MATERIALS