FOUNDATION ANALYSIS AND DESIGN REPORT

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

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

DATE: August 28, 2014

SUBJECT: LRT, Freight, and Trail Bridges over Louisiana Avenue South
Southwest Light Rail Transit Project
St. Louis Park, Minnesota
AET No. 01-05697.07

1.0 PROJECT INFORMATION

This report provides foundation analysis and recommendations for the bridges which will carry the light rail transit (LRT) tracks, the realigned freight rail track, and Cedar Lake Trail over Louisiana Avenue South in St. Louis Park, Minnesota.

1.1 Bridge Information

Each of the three new bridges will be two-span structures; the spans having a length of approximately 70 feet, resulting in total bridge lengths of about 140 feet. Out-to-out bridge widths and deck structure types are planned as follows:

- LRT bridge: 36'-4", prestressed concrete beams
- Freight bridge: 19'-8", steel welded plate girders
- Trail bridge: 18'-6", prestressed concrete beams

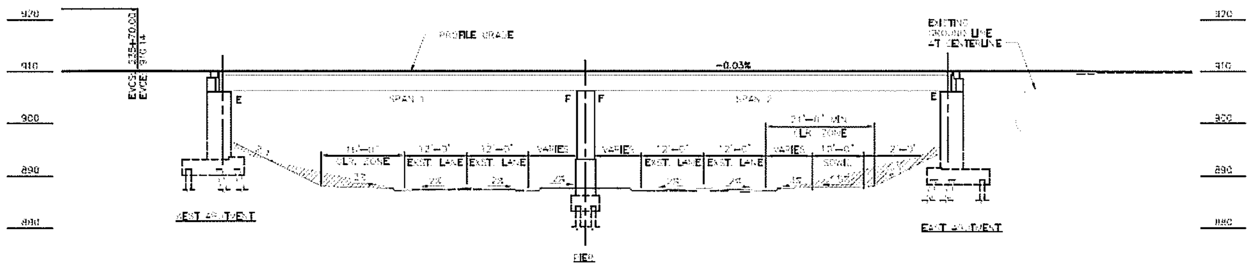
The preliminary bottom of foundation elevations are 888.0 feet for the abutments and 886.0 feet for the center piers.

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

1.2 Approach Information

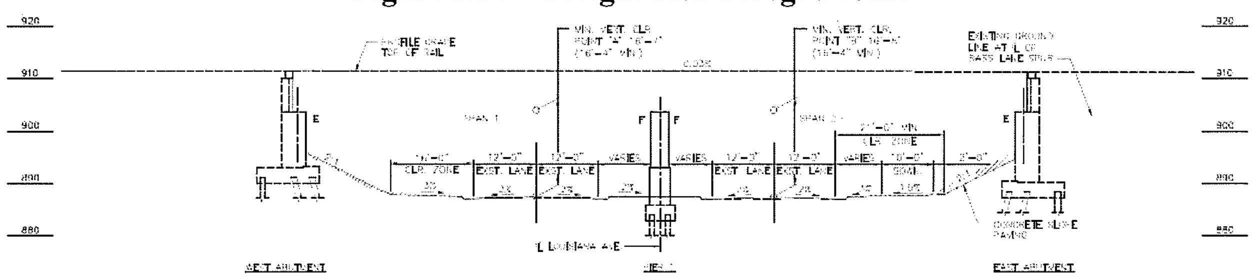
The existing trail and freight tracks are built upon a raised embankment. The new LRT tracks will veer to the south off of the embankment, with the angled bridge located to the south of the existing bridge and embankment (see attached Figure 1). The new trail approach will have a profile grade similar to the existing grade as shown on Figure 1.2a. Due to changes in bridge configuration, new wedges of fill will be placed behind the parapet abutments; although considering the geometry, much of this new fill load will be carried by the abutments.

Figure 1.2a – Trail Bridge Profile



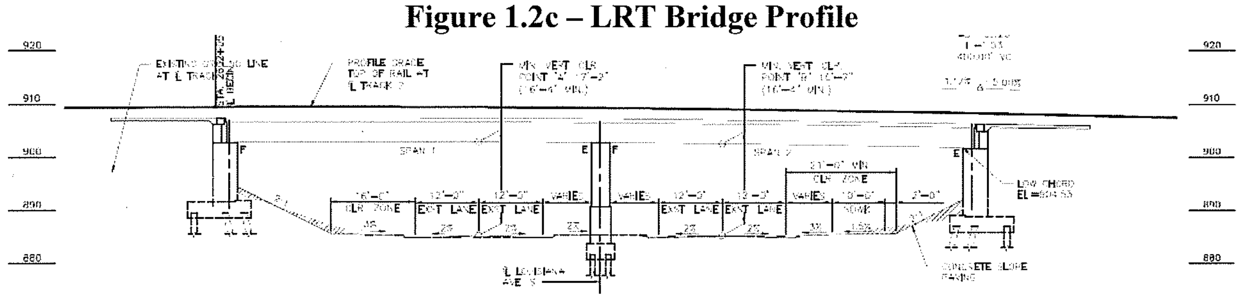
The profile view of the freight rail bridge is shown on Figure 1.2b. This shows that up to 5 feet of approach grade raise is planned (and greater in the "abutment wedge" area). Therefore, significant new load will be imposed on the underlying soils if mineral soils were to be placed.

Figure 1.2b – Freight Rail Bridge Profile



With the LRT tracks veering to the south off the embankment, up to about 20 feet or more of new fill is needed for the new approaches, as shown in Figure 1.2c. Current plans are to retain the south edge of the approach on both the west and east sides with a structured retaining wall, with the fill on the north side abutting up to the existing embankment.

Figure 1.2c – LRT Bridge Profile



2.0 SUBSURFACE EXPLORATION AND TESTING SUMMARY

2.1 Field Exploration Scope

The exploratory test program performed specific to these bridges consisted of six standard penetration test (SPT) "foundation" borings. The locations of the borings 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, two consolidation tests, three unconfined compression tests with density, one density test, one Atterberg Limits test, and four organic content tests were performed. The test results appear on the individual boring logs, opposite the samples upon which they were performed, or on the data sheets following the boring logs (consolidation tests).

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 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.

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

The generalized geologic profile consists of fill overlying organic swamp deposits which overlie both water-deposited (alluvium) and glacially deposited (till) soils. Bedrock is about 66 feet to 88 feet below Louisiana Avenue.

2.4.1 Bedrock

The bedrock at the boring locations ranges in depth from 66.7 feet to 109 feet (corresponding to elevation 800.0 feet to 821.8 feet). The bedrock encountered in the southwest and south central portion of the area where top of rock is shallower (elevation 820.1 feet and 821.8 feet) was limestone of the Platteville Formation. The Platteville was eroded away at the remaining locations where the top of bedrock was in the elevation range of 800 feet to 810.8 feet. The bedrock in these areas was sandstone of the St. Peter Formation. Shale of the Glenwood

Formation would be interbedded between the Platteville and St. Peter formations, but remains below the limestone cap at the boring locations where the limestone is still present.

2.4.2 Natural Overburden Soils

The generalized natural soil profile consists of swamp deposits over alluvium (water-deposited soils) and then glacially-deposited till soils, although granular alluvium is sometimes interbedded in the till.

The swamp deposits are 15 feet to 32½ feet thick. The areas of lesser thickness are below the existing raised embankment where the swamp has been more compressed. The swamp consists of peats and organic clays.
The alluvium is mostly granular, mainly consisting of sand and sand with silt having varying gravel content. In some areas, lean clay alluvium is present at the top of the alluvial deposit, directly beneath the swamp deposits.

The till mostly consists of clayey sand, sandy lean clay, and silty sand, again having varying gravel content.

2.4.3 Upper Fill

Borings 1011 SB and 1012 SB were drilled on the existing raised embankment. At these locations, the fill was 36½ feet and 41½ feet thick; although lower zones could be alluvial soils which deposited over the swamp. At the lower elevation borings, the fill thickness is about 6½ to 9 feet thick. The fill is primarily a mixture of sandy soils (sands to silty sands and clayey sands), although occasionally includes intermixing with organic fines, ash/cinders, and wood.

2.5 Ground Water

Ground-water levels were encountered during drilling. Several of the measured levels were at lower elevations that we feel were not stabilized levels. Based on review of the data, it appears the ground-water level at the time of drilling was in the elevation range of 882½ feet to 884½ feet. Water levels are expected to fluctuate both seasonally and annually.

3.0 FOUNDATION ANALYSIS

The following analysis uses Load and Resistance Factor Design (LRFD) methodology. In the future, it may be determined that freight rail bridge foundation analyses needs to follow AREMA standards which use Allowable Stress Design (ASD) methodology. If this is determined to be the case, the report will need to be modified using the preferred methodology during advanced design.

3.1 Foundation Analysis

3.1.1 Foundation Type

The swamp deposits are highly compressible and spread foundation support cannot be considered. Supporting the bridge on driven piles is considered the most economical approach, and is the foundation type analyzed and recommended.

If piles were to gain reasonable nominal resistance prior to reaching the bedrock, the resistance would likely need to be met with a combination of tip resistance and side friction. A typical pile type for this case is a 12-inch diameter CIP steel pipe pile. We conducted an analysis of this pile type at Boring 1213 SB where the alluvial/till deposits are the thickest. If this case shows pile lengths at or approaching the bedrock are needed for typical resistance needs, then the use of H-pile driven to bedrock would be considered the appropriate pile type.

3.1.2 Pile Foundation Analysis Methods

Pile bearing resistance versus pile length 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 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.

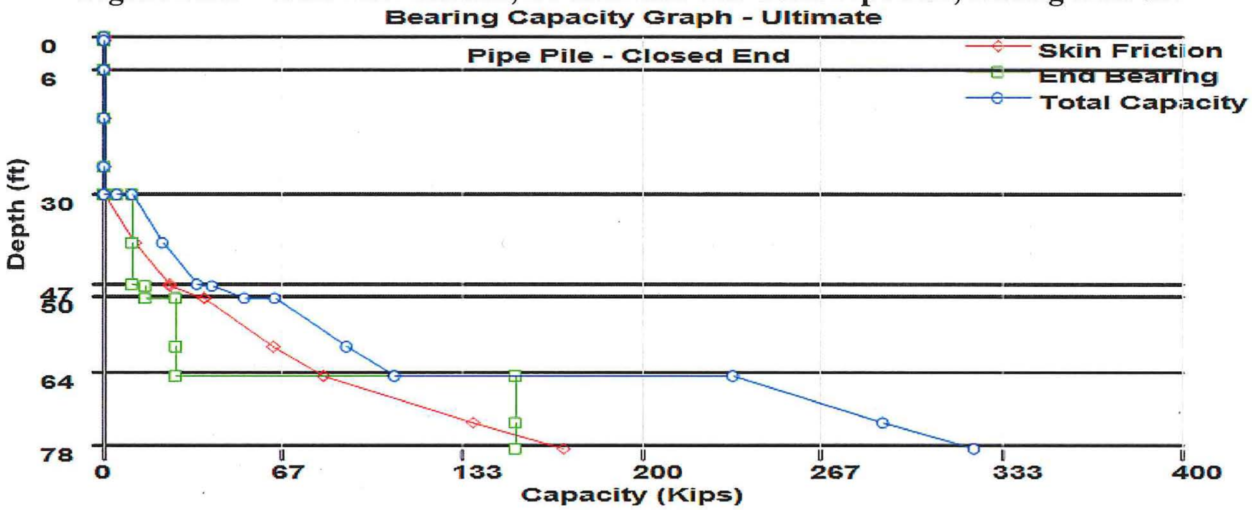
DRIVEN does not specifically address bedrock resistance (other than allowing input of very high values of cohesion). However, it is expected that if nominal resistance needs are not met prior to reaching the bedrock, high tip resistance will be gained with minimal penetration into the bedrock. Therefore, the *DRIVEN* analysis performed only evaluates whether resistance is met before reaching the highly resistant bedrock.

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. Assuming a design φR_n of 100 tons for the 12-inch diameter CIP steel pipe pile, a nominal resistance of 308 kips would need to be demonstrated in the field.

The *DRIVEN* results for 12-inch diameter CIP steel pipe pile based on Boring 1213 SB is presented on Figure 3.1.3.

Figure 3.1.3 – DRIVEN Results, 12-inch dia. CIP Steel Pipe Pile, Boring 1213 SB



As shown, nominal resistance needs were met within a foot or so of the top of bedrock. As the overburden thickness between the swamp deposits and bedrock is similar or less than the demonstrated case throughout the remainder of the bridge area, it is our opinion that driving H-pile to refusal on the bedrock is the appropriate pile type on this project. Upon reaching bedrock, it is expected that tip resistance will be significantly increased to the point of meeting nominal resistance requirements. Some minor penetration into more highly weathered bedrock zones may occur, but it is expected resistance needs will be quickly gained with this rock penetration.

The lengths predicted at each boring location are shown in Table 3.1.3. These lengths are based on reaching the bedrock and should generally be similar for all H-pile sizes.

Table 3.1.3 – Estimated Pile Lengths

Bridge	Substructure	Boring No.	Proposed Bottom of Footing Elevation, ft	Estimated Tip Elevation, ft	Estimated Pile Length, ft
Freight/Trail	West Abutment	1011 SB	888	800	88
	Pier	1203 SB	886	809	77
	East Abutment	1012 SB	888	809	79
LRT	West Abutment	1211 SB	888	820	68
	Pier	1212 SB	886	821	65
	East Abutment	1213 SB	888	810	78

3.2 Approach Settlement Review

If not supported on structure, the planned grade raise required for the LRT approaches off the existing embankment is estimated to induce settlement on the order of 4½ feet if mineral soil fill were to be used. Because of the extreme settlements expected, the retaining walls on the south side will need to be supported structurally on driven piling. Although the piled wall will support overlying fill, the additional fill placed to the north of the wall foundation (up to the existing embankment) would impose load upon the swamp and would then result in significant settlement.

The profile shows the freight bridge approaches will be filled up to 5 feet above current grade. The swamp deposits have undergone primary settlement under the fill loading condition, although the grade raise will induce additional settlement. We estimate this additional primary settlement will be on the order of 3 inches.

4.0 FOUNDATION RECOMMENDATIONS

4.1 HP12x53 Piles

The bridge foundations can be supported on H-piles, meeting ASTM A572, Grade 50 (f_y = 50 ksi). The piles should be equipped with rock points. Various sizes of H-piles can be considered, as listed below. These piles can be designed based on the maximum Factored Pile Bearing Resistance (φR_n) values shown for each size.

- HP12x53, 140 tons
- HP12x84, 215 tons
- HP14x73, 190 tons
- HP14x89, 225 tons
- HP14x102, 260 tons
- HP14x117, 300 tons

The nominal resistance of the piles can be evaluated using either high strain dynamic (PDA) testing or the MnDOT MPF12 driving formula, although dynamic analysis allows for better evaluation of whether or not damage is occurring. 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. Resistance Factors of 0.65 or 0.60 should be employed for PDA or MPF12 field analysis methods, respectively. It is anticipated that all H-piles sizes would establish required resistance with "refusal" upon the bedrock. Estimated tip elevations are shown in Table 3.1.3.

If the approach fill was allowed to impose loads on the swamp in the vicinity of the abutments such that settlement occurred around the piles, downdrag (DD) loads would need to be considered in the foundation design. Based on the *DRIVEN* analysis at Boring 1213 SB, this downdrag load would be on the order of 25 tons. However, as settlement will need to be mitigated to meet differential settlement requirements between the approach and the pile supported bridge, the settlement needed to create the DD loads are not expected to occur. In this case, it is our opinion that downdrag (DD) loads would not need to be considered in the pile design.

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.

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.

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

We recommend that the LRT approach retaining walls be structurally supported on a pile foundation system, consistent with that recommended for the bridge. In order to support the tracks between the wall and the existing embankment to the north, the wall foundation system should extend far enough to the north such that the new fill system is supported on this foundation; or lightweight fill (e.g., geofoam) could be placed to control settlement. Design of either of these approaches should be done during the advanced project design phase.

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).

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

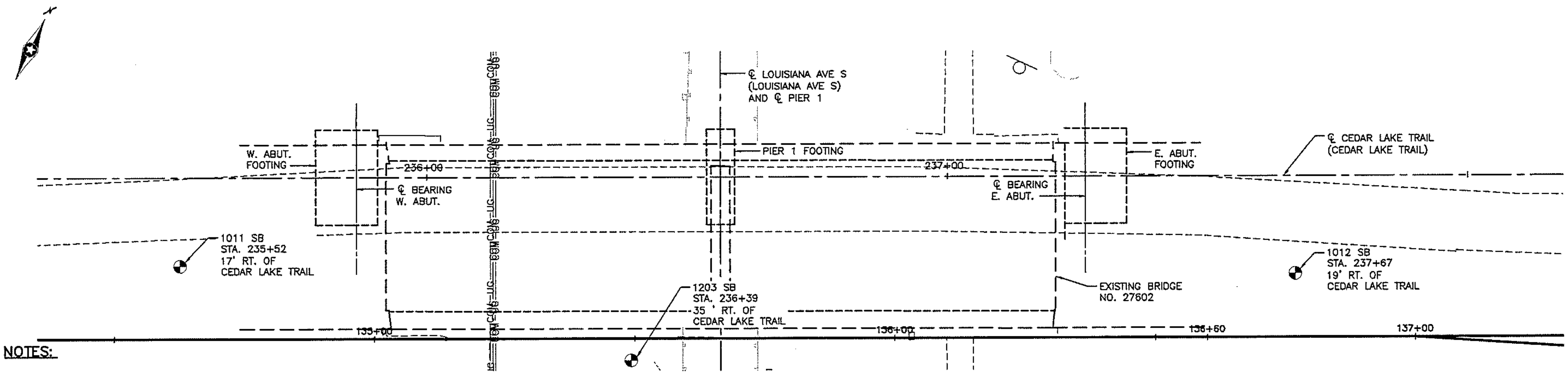
Name: ______________________
Jeffery K. Voyen

Date: 8/28/14 **License #: 1592[illegible]**

Report Reviewed By: ______________________
Gregory R. Reuter, PE, PG, Principal Engineer

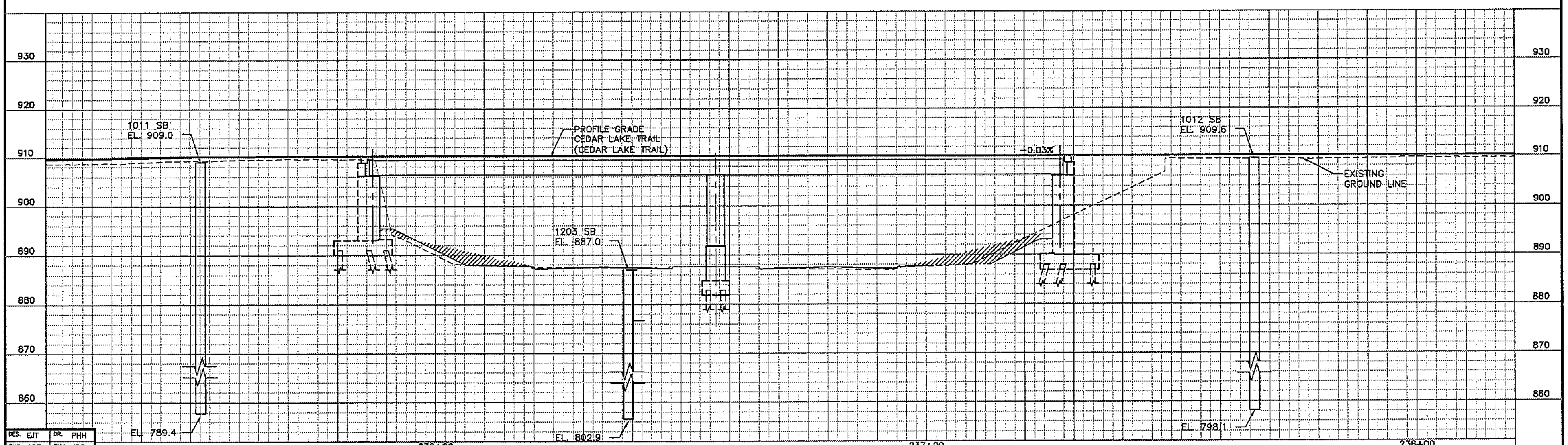
Attachments:

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



NOTES:

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



DES. EJT	DR. PHH
CHK. CPE	CHK. JDP

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

Kimley»Horn

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

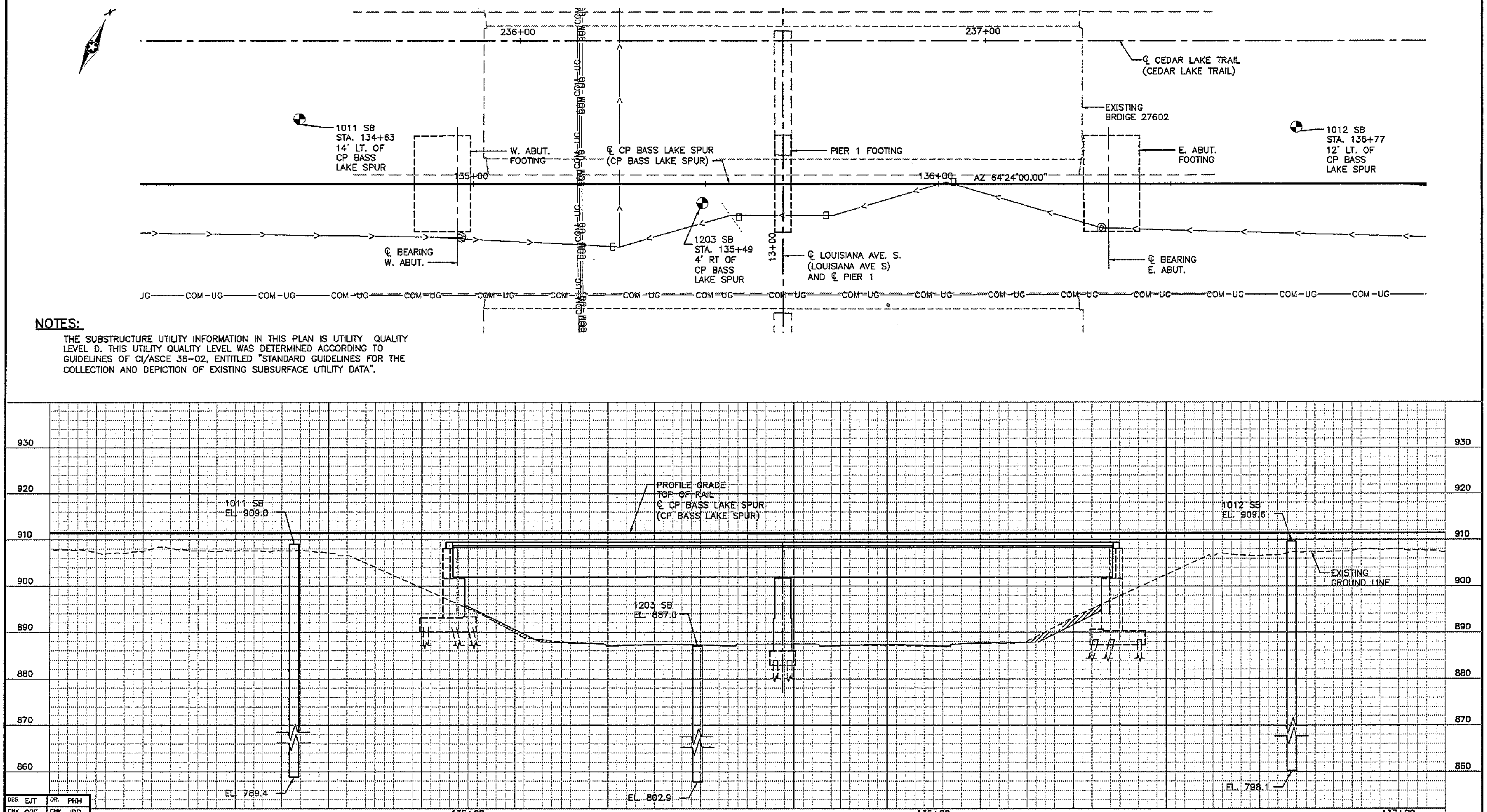
EAST - VOLUME 2 (STRUCTURES)
LOUISIANA AVENUE S.
BRIDGE XXXXX (TRL)
BORINGS (1 OF 2)

DISCIPLINE: STRUCTURES

SHEET NAME: E2-STU-BRG-LOIS-TRL-BOR-001

SHEET 59 OF 277

Jun, 20 2014 12:15 pm V:\3300_pec-e\CAD\segment e2\plan sheets\structures\E2-STU-BRG-LOIS-TRL-SUR-002.dwg By: Katie.Ellis



NOTES:

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

DES. EJT	DR. PHH
CHK. CPE	CHK. JDP

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

Kimley»Horn

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

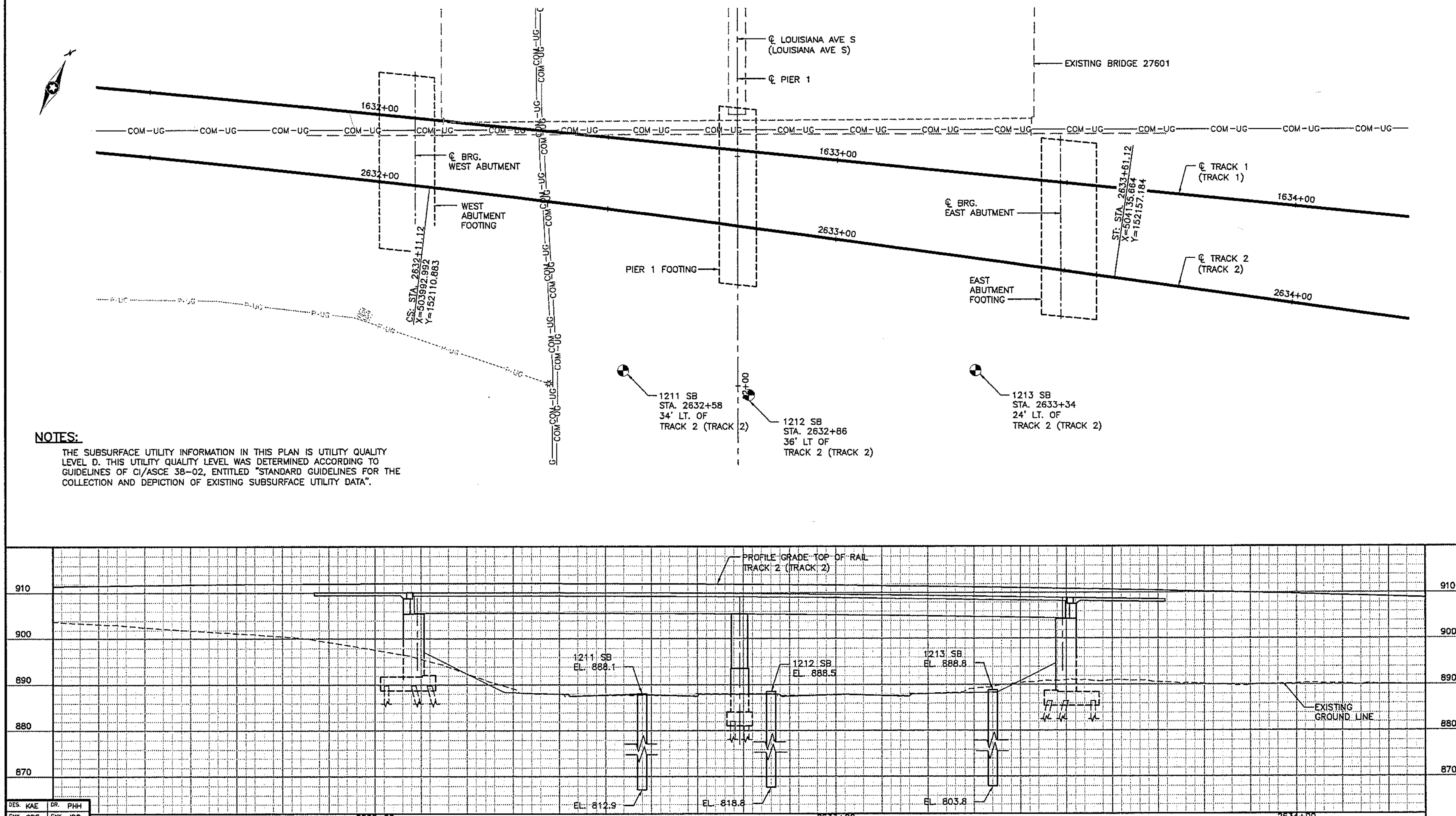
SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
LOUISIANA AVENUE S.
BRIDGE XXXXX (FRT)
BORINGS (1 OF 2)

DISCIPLINE: STRUCTURES

SHEET NAME: E2-STU-BRG-LOIS-FRT-BOR-001

SHEET 67 OF 277



NOTES:

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

DES. KAE	DR. PHH
CHK. CPE	CHK. JDP

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

Kimley»Horn

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

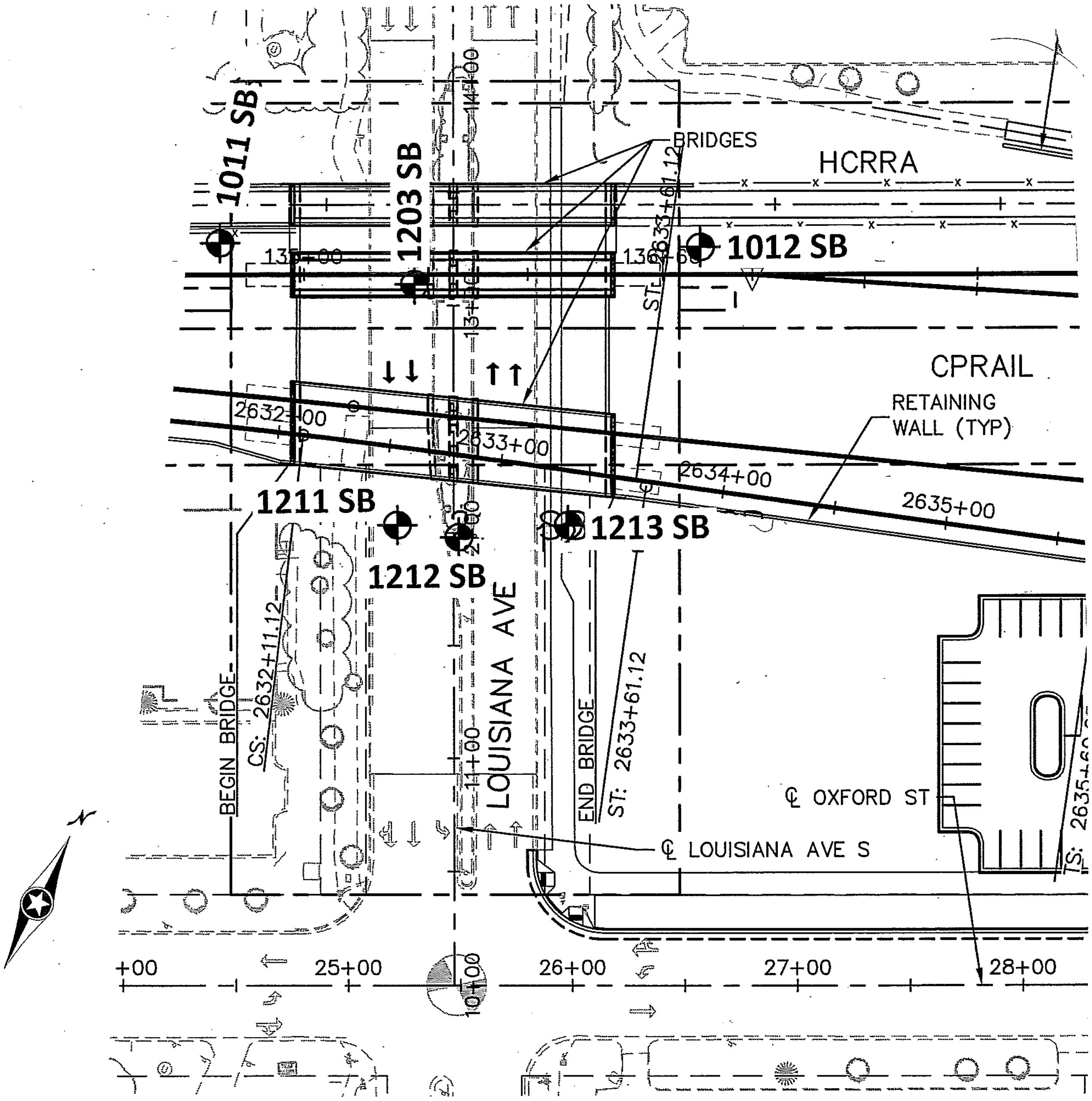
SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
LOUISIANA AVENUE S.
BRIDGE XXXXX (LRT)
BORINGS (1 OF 2)

DISCIPLINE: STRUCTURES

SHEET NAME: E2-STU-BRG-LOIS-LRT-BOR-001

SHEET 73 OF 277



AMERICAN ENGINEERING TESTING, INC.	**PROJECT** Bridges over Louisiana Avenue N			**AET NO.** 01-05697.07
	SUBJECT Boring Locations			**DATE** June 17, 2014
	SCALE 1" = 73'±	**DRAWN BY** KHA/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
	Louisiana Avenue	**Southwest LRT, PEC East**	**1011 SB**	**909.0** (Surveyed)

Location **, , ft. LT**

Co. Coordinate: X=503923 Y=152171 (ft.)

Latitude (North)=44.9341962 Longitude (West)=-93.3681860

Drill Machine **1C**

Hammer **CME Automatic Calibrated**

Drilling Completed **4/15/13**

Depth	Elev.	Classification	SPT N60	MC (%)	Other Tests Or Remarks
0.6	908.4	Clayey sand with gravel, trace roots, dark brown (A-2-4) fill	22	15	Hammer Calibration: 66% efficiency with 105 lb. hammer, 9/18/13
2.0	907.0	Sand with silt and gravel, light brown (A-1-b) fill	19		
6.5	902.5	Mixture of silty sand and sand with silt, with gravel, ash/cinders, black, dark brown and light brown (A-2-4) fill	14		
14.0	895.0	Mixture of sand and sand with silt, with gravel, a little clayey sand, light brown and brown, a little dark brown (A-1-b) fill	14, 13, 17		
16.5	892.5	Mixture of sand with silt and silty sand, with gravel, a little clayey sand, light brown and black (A-2-4) fill	15		
24.0	885.0	Mixture of sand and sand with silt with gravel, a little clayey sand, light brown and brown (A-1-b) fill	21, 15, 9		Water level measured at 24.5' deep with HSA to 24.5' deep
26.5	882.5	Silty sand, a little gravel and ashes/cinders, pieces of wood, dark brown and light brown (A-2-4) fill	4		
31.5	877.5	Mixture of clayey sand with organic fines and sand with silt, with gravel, trace roots, black and brown, a little gray (A-6 and A-1-b) fill	6, 13	19	
34.0	875.0	SAND WITH SILT, a little gravel, medium to fine grained, brown, waterbearing, loose, a lens of fine to medium grained sand (SP-SM) (A-1-b) alluvium or fill	8		
39.0	870.0	SAND WITH GRAVEL, pieces of wood at 37½', medium grained, dark gray to gray, waterbearing, loose (SP) (A-1-b) alluvium or fill	10, 10		
41.5	867.5	GRAVEL WITH SAND, gray, waterbearing, medium dense (GP) (A-1-a) alluvium or fill	13		
44.0	865.0	HEMIC PEAT, black (PT) (A-8) swamp deposits	18	281	
49.0	860.0	ORGANIC CLAY, trace roots, brownish gray, stiff (OL/OH) (A-8) swamp deposits	15, 11	145, 167	Organic Content = 25.8%

Index Sheet Code

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1011 SB**	**909.0** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Other Tests Or Remarks / Formation or Member
			ORGANIC CLAY, trace roots and shells, black to dark brownish gray, firm to very stiff (OL/OH) (A-8) swamp deposits *(continued)*		6	109			
				PD					
					16	182			
				PD					
55					15	201			
				PD					
	59.0				13	107			Organic Content = 16.8%
	850.0		LEAN CLAY, slightly organic, dark brownish gray, stiff (CL) (A-6) alluvium	PD					
60	60.5 / 848.5		LEAN CLAY, brownish gray, stiff (CL) (A-6) alluvium		12	58 / 25			
	63.0 / 846.0		GRAVELLY SAND WITH SILT, medium grained, dark brownish gray, waterbearing, medium dense (SP-SM) (A-1-b) alluvium	PD					
65					18				
				PD					
70					12				
	73.0 / 836.0		CLAYEY SAND, a little gravel, dark brownish gray, very stiff (SC) (A-6) till	PD					
75					16	17			
				PD					
80					26	13			
	83.0 / 826.0		CLAYEY SAND WITH GRAVEL, brownish gray, very stiff (SC/SM) (A-2-4) till	PD					
85					18	11			
	88.0 / 821.0		SAND, medium grained, a little gravel, brownish gray, waterbearing, medium dense (SP) (A-1-b) alluvium	PD					
90					21				
	93.0 / 816.0		GRAVEL WITH SILT AND SAND, dark brown, waterbearing, medium dense (GP-GM) (A-1-b) alluvium	PD					
95					29				
	98.0 / 811.0		CLAYEY SAND, a little gravel, brown, hard (SC) (A-6) till	PD					
100									

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1011 SB**	**909.0** (Surveyed)

DEPTH	Depth / Elev.	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Other Tests Or Remarks / Formation or Member
				44	13			
105		CLAYEY SAND, a little gravel, brown, hard (SC) (A-6) till *(continued)*	PD					
	109.0 / 800.0	Top of Bedrock						
110	110.0 / 799.0	SHALEY SANDSTONE, fresh, gray		100/.1				ST. PETER FORMATION
			PD					
115		SANDSTONE, fresh, light brownish gray		100/.2				
			PD					
	119.6 / 789.4	**END OF BORING**		100/.1				

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

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1012 SB**	**909.6** (Surveyed)

Location **, , ft. LT**

Co. Coordinate: X=504117 Y=152262 (ft.)

Latitude (North)=44.9344457 Longitude (West)=-93.3674369

Drill Machine **1C**

Hammer **CME Automatic Calibrated**

Drilling Completed **4/16/13**

DEPTH	Depth / Elev.	Classification	SPT N60 (REC %)	MC (%) (RQD %)	COH (psf) (ACL ft)	γ (pcf) (Core Breaks)	Other Tests Or Remarks / Formation or Member
	0.5 / 909.1	Clayey sand with organic fines, a little gravel and sand with silt, trace roots (A-6) fill	17	23			Hammer Calibration: 66% efficiency with 105 lb. hammer, 9/18/13
	2.0 / 907.6	Crushed limestone base, a little sand with silt, light brown (A-1-b) fill	29				
5		Sand with silt and gravel, a little ashes/cinders, brown, light brown, dark brown and black (A-1-b) fill	20				
			16				
10	11.5 / 898.1		23				
		Mixture of sand with silt, silty sand and sand, with gravel, a little clayey sand, sandy lean clay and ashes/cinders, brown and light brown, a little dark brown (A-1-b) fill	17				
15			19				
			27				
20			11				
	24.0 / 885.6		6				
▼25	26.5 / 883.1	Silty sand, a little gravel, pieces of wood, brown (A-2-4) fill	8				Water level measured at 25.3' deep with HSA to 27' deep (rose from 25.5' deep 13 minutes earlier)
		Sand with gravel, a little clayey sand, brown (A-1-b) fill	10				
30	32.0 / 877.6		16				
	34.0 / 875.6	SANDY LEAN CLAY, slightly organic, a little gravel, black, stiff (CL) (A-6) alluvium or fill	10	29			
35	36.5 / 873.1	SAND WITH GRAVEL, medium grained, brown, a little black, waterbearing, medium dense, laminations of clayey sand (SP) (A-1-b) alluvium or fill	15				
	39.0 / 870.6	HEMIC PEAT, brown and black (PT) (A-8) swamp deposits	27	243			
40	41.5 / 868.1	SAPRIC PEAT, trace roots, dark brownish gray, laminations of silty sand (PT) (A-8) swamp deposits		121	1215	80	
	44.0 / 865.6	ORGANIC CLAY, trace shells and roots, black to dark brown, stiff (OH) (A-8) swamp deposits	13	144			
45	46.5 / 863.1	ORGANIC SILT, dark brown (OH) swamp deposits		58		95	LL=94%, PL=63%, PI=31% Organic Content =7.6%
		ORGANIC CLAY, trace shells and roots, dark brownish gray, stiff (OH) (A-8) swamp deposits	13	164			
50							

Index Sheet Code

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1012 SB**	**909.6** (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
	51.5 / 858.1					129		80		
55	54.0 / 855.6		LEAN CLAY, slightly organic, trace roots, dark brownish gray, firm (CL) (A-4/A-6) alluvium	PD	7	33				
	58.0 / 851.6		LEAN CLAY, trace shells, brownish gray, stiff, a lens of waterbearing fine grained sand (CL) (A-4) alluvium	PD	10	23				
60, 65	65.5 / 844.1		GRAVELLY SAND, medium grained, gray and dark gray, waterbearing, medium dense (SP) (A-1-b) alluvium	PD	20, 11					
70	74.0 / 835.6		GRAVEL WITH SAND, gray, waterbearing, medium dense (GP) (A-1-a) alluvium	PD	21					
75	80.0 / 829.6		GRAVELLY CLAYEY SAND, gray, very stiff (SC/SM) (A-2-4) till	PD	24					
80	85.0 / 824.6		CLAYEY SAND, a little gravel, gray, hard (SC) (A-6) till	PD	34	28				
85	90.5 / 819.1		GRAVELLY SILTY SAND, gray, wet, dense (SM) (A-2-4) till	PD	35	13				
90	95.0 / 814.6		CLAYEY SAND, a little gravel, apparent cobbles, brown, hard (SC) (A-6) till	PD	38	21				
95			SAND WITH SILT AND GRAVEL, fine to medium grained, brown, waterbearing, very dense (SP-SM) (A-1-b) alluvium	PD	52					
100										

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1012 SB**	**909.6** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil: Other Tests Or Remarks / Rock: Formation or Member
	100.5		Top of Bedrock	PD					ST. PETER FORMATION
	809.1		SHALEY SANDSTONE, weathered, gray, a little light gray		100/.7				
	104.5 / 805.1			PD					
105			SANDSTONE, fresh, gray		100/.2				
				PD					
110									
	111.6 / 798.0		**END OF BORING**		100/.1				

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1203 SB**	**887.0** (Surveyed)

Location **, , ft. LT**

Co. Coordinate: X=504009 Y=152192 (ft.)

Latitude (North)=44.9794990 Longitude (West)=-93.2826866

Drill Machine **33C**

Hammer **CME Automatic Calibrated**

Drilling Completed **1/24/14**

Depth	Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
1.3	885.8	15" Concrete pavement with significant rebar					Hammer Calibration: 69% efficiency with 105 lb. hammer, 9/17/13
4.0	883.0	Silty sand with gravel, grayish brown, frozen (A-2-4) fill					
9.0	878.0	Sand with silt and gravel, grayish brown and dark brownish gray (A-1-b) fill	16				
			42				
14.0	873.0	HEMIC PEAT, dark brown to black (PT) (A-8) swamp deposits	6	328			
			6	362			
31.5	855.5	SAPRIC PEAT, dark brown, a little light gray and brown, laminations of hemic peat (PT) (A-8) swamp deposits	5	192			
			5	180			Water level measured at 18.6' deep with HSA to 47' deep (HSA advanced to 51' deep and water level remained at 18.6' deep the next morning)
			6	182			
			5	159			
			5	175			
			4	128			
			5	192			
36.5	850.5	SAPRIC PEAT, black (PT) (A-8) swamp deposits	5	224			
			6	221			
39.0	848.0	SAPRIC PEAT, trace shells, dark brown (PT) (A-8) swamp deposits	5	135			
41.5	845.5	ORGANIC CLAY, brownish gray, a little black, firm, laminations of hemic peat (OH) (A-8) swamp deposits	5	44			
49.5		SAND, a little gravel, coarse grained, waterbearing, loose (SP) (A-1-b) alluvium	7				
			9				
			9				

Index Sheet Code

(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

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	Southwest LRT, PEC East	1203 SB	887.0 (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Other Tests Or Remarks / Formation or Member
	837.5 / 52.0		GRAVEL WITH SAND, gray, waterbearing, very dense (GP) (A-1-b) alluvium *(continued)*		50/.4				
55	835.0		SAND WITH GRAVEL, medium grained, gray, waterbearing, very dense (SP) (A-1-b) alluvium	PD	58				
60	57.0 / 830.0		SANDY LEAN CLAY, a little gravel, gray, very stiff, a lens of gravel (CL) (A-6) till	PD	24	13			
65	62.0 / 825.0		SANDY LEAN CLAY WITH GRAVEL, brownish gray, hard (CL) (A-6) till	PD	46	11			
	67.0 / 820.0		CLAYEY SAND, a little gravel, grayish brown, very stiff (SC) (A-2-4) till	PD	20	11			
70, 75	70.0 / 817.0		CLAYEY SAND, a little gravel, possible cobble at 79', grayish brown, very stiff (SC) (A-2-4) till Top of Bedrock	PD	50/0				
80	78.0 / 809.0		SANDSTONE, fresh	PD	100/.1 100/.1				ST. PETER FORMATION
	84.1 / 802.9		**END OF BORING**						

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

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1211 SB**	**888.1** (Surveyed)

Location **, , ft. LT**

Co. Coordinate: X=504048 Y=152093 (ft.)

Latitude (North)=44.9340014 Longitude (West)=-93.3675992

Drill Machine **91C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 2

Drilling Completed **5/6/14**

Depth / Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
1.2 / 886.9	14.5" Concrete Pavement					Hammer Calibration: 68% efficiency with 110 lb. hammer, 5/27/14
1.6 / 886.6	4" Void					
6.5 / 881.6	Sand with silt, a little gravel and clayey sand, brown and gray (A-1-b) fill	5				Water level measured at 4.5' deep with HSA to 4.5' deep (SS to 6' deep)
		12				
21.5 / 866.6	ORGANIC CLAY, trace shells and roots, dark brown, soft to very soft, lenses and laminations of sapric peat (OH) (A-8) swamp deposits	1	180			
		2	175			
		WH	201			
		2	103			
		3	137			
		3	172			
36.5 / 851.6	ORGANIC CLAY, trace shells and roots, dark brown to black, a little brown and light gray, soft, laminations of silt and hemic peat (OH) (A-8) swamp deposits	4	165			
		4	220			
		2	184			
		3	269			
		3	276			
		3	125			
39.0 / 849.1	ORGANIC CLAY, pieces of wood around 37.5', dark brownish gray, very soft (OH) (A-8) swamp deposits	1	68			
42.0 / 846.1	LEAN CLAY, brownish gray, stiff (CL) (A-6) alluvium	9	26			
44.0 / 844.1	No sample taken at 42' due to blow up in hole (left advanced HSA in ground overnight)					
	GRAVELLY SAND, medium grained, brownish gray, waterbearing, medium dense to loose (SP) (A-1-b) alluvium	12				
		11				

Index Sheet Code

(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

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1211 SB**	**888.1** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 (REC %)	MC (%) (RQD %)	COH (psf) (ACL ft)	γ (pcf) (Core Breaks)	Other Tests Or Remarks (Soil) / Formation or Member (Rock)
			GRAVELLY SAND, medium grained, brownish gray, waterbearing, medium dense to loose (SP) (A-1-b) alluvium *(continued)*		7				
	53.0 / 835.1			PD					
55			GRAVELLY SAND, medium to coarse grained, brownish gray, waterbearing, loose (SP) (A-1-b) alluvium		9				
	58.0 / 830.1			PD					
60					18	14			
			CLAYEY SAND, a little gravel, grayish brown, very stiff (SC) (A-6) till	PD					
65					25	15			
	68.0 / 820.1		Top of Bedrock	PD					
70					*				PLATTEVILLE FORMATION *23/.5 + 50/.5 + 100/.4
			LIMESTONE, weathered, gray	PD					
75	75.2 / 812.9		**END OF BORING**		200/.7				

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1212 SB**	**888.5** (Surveyed)

Location , , ft. LT
Co. Coordinate: X=504075 Y=152100 (ft.)
Latitude (North)=44.9340727 Longitude (West)=-93.3674370

Drill Machine 1C
Hammer CME Automatic Calibrated

Drilling Completed 5/2/14

DEPTH	Depth / Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
	0.7 / 887.8	Lean clay, slightly organic, trace roots, black (A-6) fill	5	27			Hammer Calibration: 66% efficiency with 105 lb. hammer, 9/18/13
	2.0 / 886.5	Clayey sand, a little gravel, grayish brown (A-2-6) fill		9			
5	6.5 / 882.0	Mixture of sand and sand with silt and gravel, brown and grayish brown (A-1-b) fill	23 12				Water level measured at 6.2' deep with HSA to 7' deep
10, 15	16.5 / 872.0	ORGANIC CLAY, trace roots, brownish gray to black, very soft to soft (OH) (A-8) swamp deposits	1 2 2 2	194 168 181			 No recovery
	19.0 / 869.5	HEMIC PEAT, dark brown (PT) (A-8) swamp deposits	2	197			
20	21.5 / 867.0	ORGANIC CLAY, trace shells and roots, dark grayish brown, soft, laminations of sand (OH) (A-8) swamp deposits	3	64			
25, 30	31.5 / 857.0	SAPRIC PEAT, dark brownish gray and black (PT) (A-8) swamp deposits	2 3 2 4	229 235 346 199			
	34.0 / 854.5	ORGANIC CLAY, trace roots, dark brownish gray, soft (OH) (A-8) swamp deposits	2	111			
35	36.5 / 852.0	LEAN CLAY, slightly organic, dark brownish gray, soft (CL) (A-6) till	3	56 38			 Organic content = 1.9%
40	42.0 / 846.5	GRAVELLY SAND, medium to coarse grained, gray, waterbearing, loose (SP) (A-1-b) alluvium	6 10				
45	46.5 / 842.0	SAND WITH GRAVEL, medium grained, gray, waterbearing, medium dense to loose (SP) (A-1-b) alluvium	11 10				
50		GRAVELLY SAND, medium grained, gray, waterbearing, medium dense to loose (SP) (A-1-b) alluvium	13				

Index Sheet Code

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1212 SB**	**888.5** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Other Tests Or Remarks / Formation or Member
			GRAVELLY SAND, medium grained, gray, waterbearing, medium dense to loose (SP) (A-1-b) alluvium *(continued)*		7				
	53.0 / 835.5			PD					
55			CLAYEY SAND, a little gravel, gray to grayish brown, hard to very stiff (SC) (A-6) till		37	13			
				PD					
60	60.5 / 828.0				24	11			
	63.0 / 825.5		SILTY SAND, a little gravel, brown, a little black, medium dense, a lens of clayey sand (SM) (A-2-4) till	PD					
65	65.5 / 823.0		SANDY LEAN CLAY WITH GRAVEL, brown and gray mottled, hard (CL) (A-6) till		40	19			
	66.7 / 821.8		GRAVEL WITH SILT AND SAND, brown, waterbearing, dense (GP-GM) (A-1-b) alluvium						
	69.7 / 818.8		Top of Bedrock LIMESTONE, weathered, gray	WS	100/.2				PLATTEVILLE FORMATION
			END OF BORING						

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1213 SB**	**888.8** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=504117 Y=152126 (ft.)

Latitude (North)=44.9256426 Longitude (West)=-93.3929230

Drill Machine **1C**

Hammer **CME Automatic Calibrated**

Drilling Completed **5/1/14**

Depth / Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
1.0 / 887.8	Clayey sand with gravel, a little sandy lean clay, trace roots, dark brown and black (A-1-b) fill	9	12			Hammer Calibration: 66% efficiency with 105 lb. hammer, 9/18/13
6.5 / 882.3	Sand with silt and gravel, a little sandy lean clay, brown, a little black (A-1-b) fill	23				
		4				
20.0 / 868.8	ORGANIC CLAY, trace roots and shells, brownish gray, dark brown and black, soft, lenses of hemic and sapric peat (OH) (A-8) swamp deposits	2	177			
			204	505	76	
			190		75	
		2	200			
		2	182			
		2	108			
			76	340	95	
24.0 / 864.8	SAPRIC PEAT, black, a little dark brownish gray (PT) (A-8) swamp deposits	4	251			
30.0 / 858.8	ORGANIC CLAY, trace roots, black to brownish gray, soft (CL) (A-8) swamp deposits	2	261			
		2	51			
44.5 / 844.3	SAND WITH GRAVEL, possible cobbles, medium grained, gray, waterbearing, medium dense to loose, lenses of sand with silt (SP) (A-1-b) alluvium	9				
		5				
		14				
		7				
		6				
47.0 / 841.8	SAND WITH GRAVEL, medium to coarse grained, gray, waterbearing, loose (SP) (A-1-b) alluvium	6				
49.5	SANDY LEAN CLAY, little gravel, gray, very stiff (CL) (A-6) till	18	14			

Index Sheet Code

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Louisiana Avenue	**Southwest LRT, PEC East**	**1213 SB**	**888.8** (Surveyed)

DEPTH	Depth / Elev.	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks / Formation or Member
	839.3	GRAVEL WITH SAND, apparent cobbles, brown, waterbearing, medium dense (GP) (A-1-b) alluvium *(continued)*	X	25				
	53.0 / 835.8		PD					
55		SAND, a little gravel, medium grained, brownish gray, waterbearing, medium dense (SP) (A-1-b) alluvium	X	11				
	58.0 / 830.8		PD					
60		GRAVELLY SAND, medium grained, grayish brown, waterbearing, medium dense (SP) (A-1-b) alluvium	X	20				
	61.0 / 827.8		PD					
65		SAND WITH SILT, a little gravel, fine grained, brown, waterbearing, dense, a lens of sand (SP-SM) (A-3) alluvium	X	37				
	68.0 / 820.8		PD					
70		GRAVEL WITH CLAY AND SAND, brown, waterbearing, very dense (GP-GC) (A-1-b) alluvium or colluvium	X	53				
			PD					
75		GRAVEL WITH CLAY AND SAND, brown, waterbearing, very dense (GP-GC) (A-1-b) alluvium or colluvium Top of Bedrock	X	43				
	78.0 / 810.8		PD					ST. PETER FORMATION
80		SHALEY SANDSTONE, highly weathered to weathered, gray	X	25				
	82.8 / 806.0		PD					
		SANDSTONE, fresh, gray	X	270/.5				
85	85.0 / 803.8	END OF BORING						

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

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

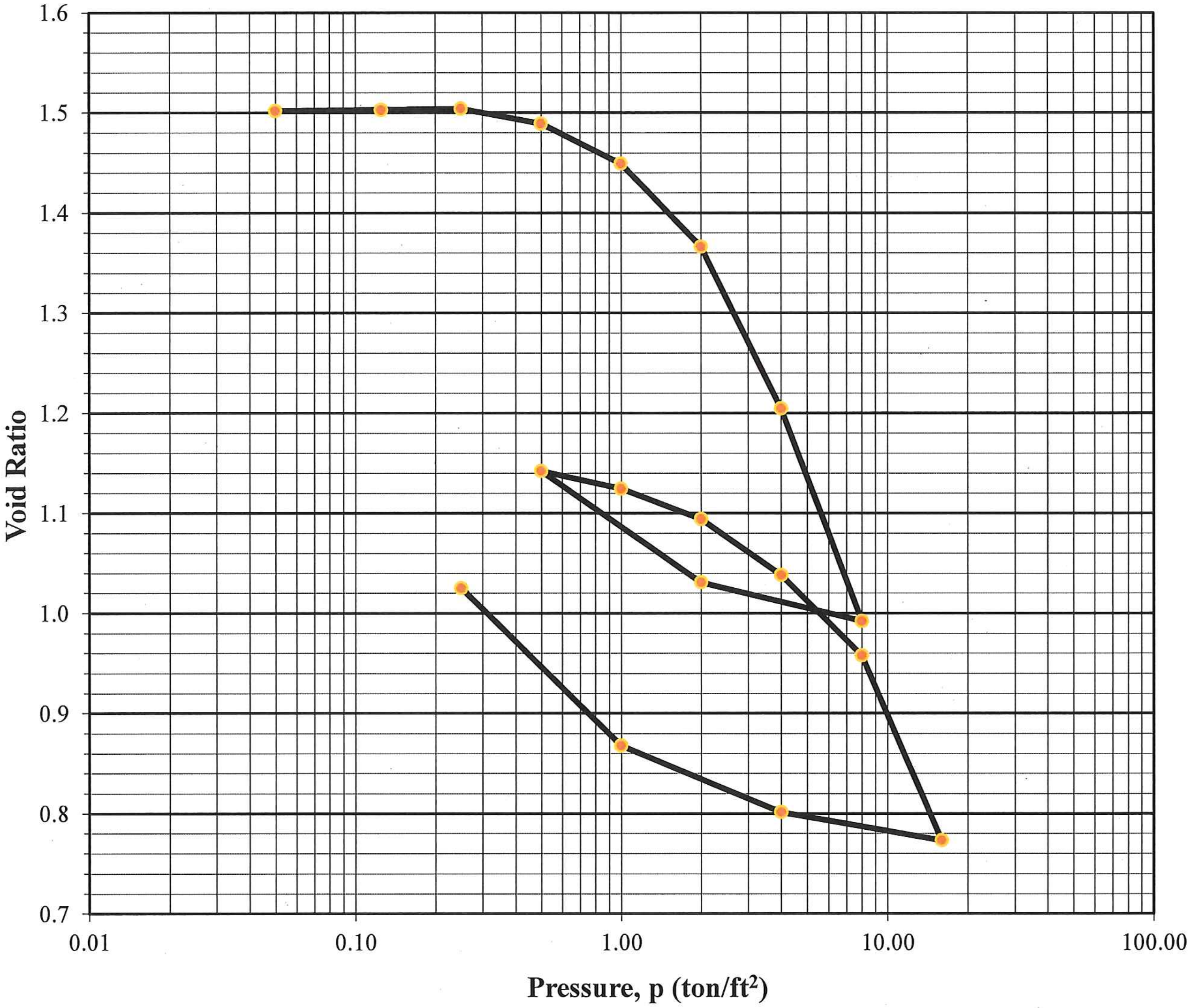
American Engineering Testing, Inc.

Consolidation Test Results: Void Ratio vs. Pressure

Project: SW Light Rail Transit
Minneapolis to Hopkins

AET No.: 01-05697

Date: 6/24/2013



	Before	After	Liquid Limit (%):	94	Test Date: 5/23/13
Water Content (%):	57.49	54.39	**Plastic Limit (%):**	63	
Dry Density (pcf):	59.79	67.87	**Plasticity Index (%):**	31	
Saturation (%):	91.62	108.09			
Void Ratio:	1.5026	1.0261	**Specific Gravity:**	2.40	Measured

Sample Description: Organic Silt (OH)

Boring Number: B-1012 **Depth:** 44.5-46.5'

Remarks: Test conducted in general accordance with ASTM D2435

Soil Parameters:
Preconsolidation Pressure (Pc): 1.7 tsf
Compression Index (Cc): 0.715
Recompression Index (Cr): 0.135

Tested By: Benjamin Pomroy **Reviewed By:** Jeff Voyen

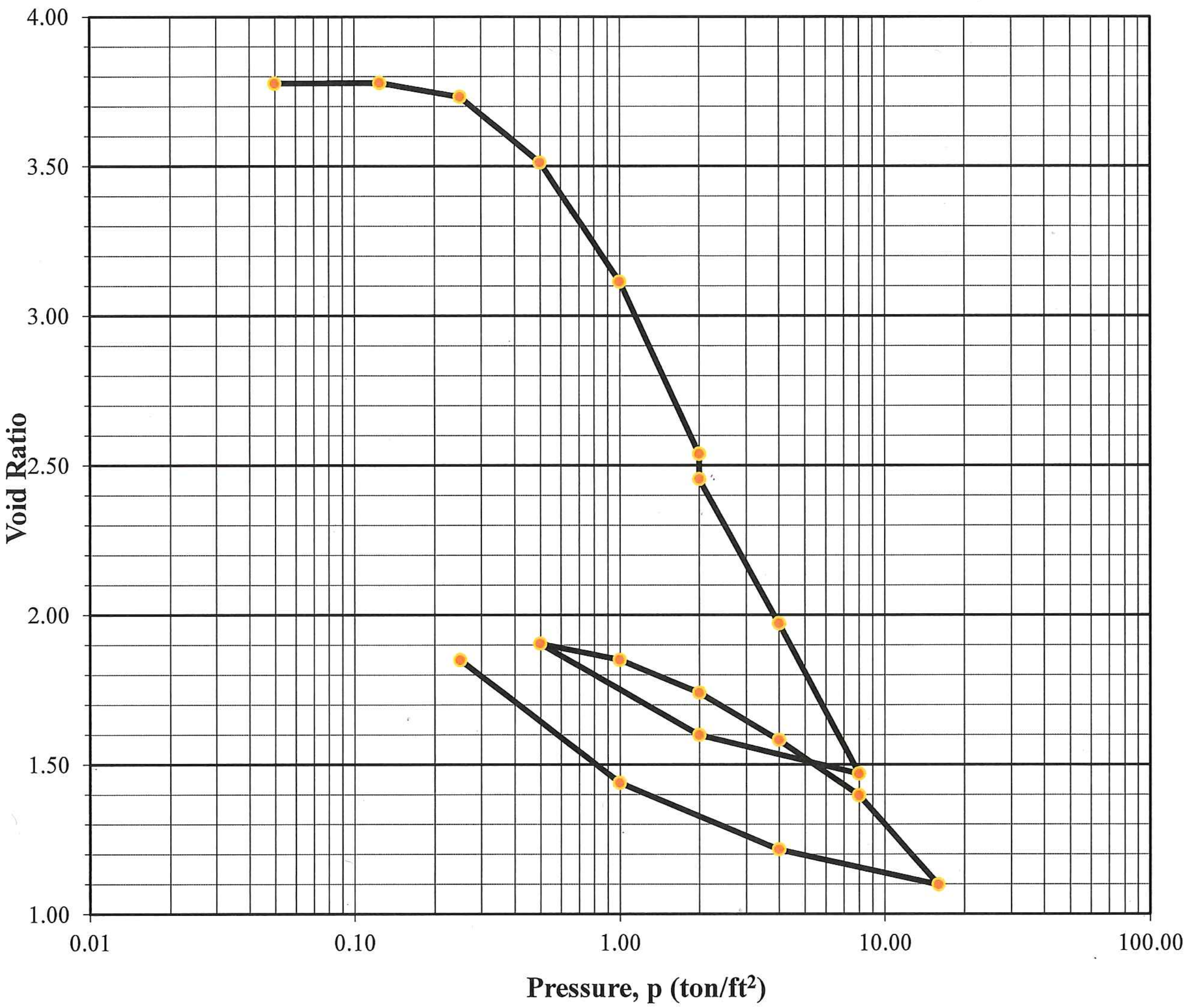
American Engineering Testing, Inc.

Consolidation Test Results: Void Ratio vs. Pressure

Project: Southwest LRT
Hopkins to Minneapolis, MN

AET No.: 01-05697

Date: 6/19/2014



	Before	After	Liquid Limit (%):		Test Date:
Water Content (%):	189.45	111.01	**Plastic Limit (%):**		
Dry Density (pcf):	25.64	39.50	**Plasticity Index (%):**		
Saturation (%):	98.33	103.59			
Void Ratio:	3.7861	2.1058	**Specific Gravity:**	1.967	Measured

Sample Description: Peat

Boring Number: 1213 SB **Depth:** 9'-11'

Remarks: Test conducted in general accordance with ASTM D2435

Soil Parameters:
Preconsolidation Pressure (Pc): 0.5 tsf
Compression Index (Cc): 1.860
Recompression Index (Cr): 0.383

Tested By: Benjamin Pomroy **Reviewed By:** Jeff Voyen

EXPLORATION/CLASSIFICATION METHODS

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)

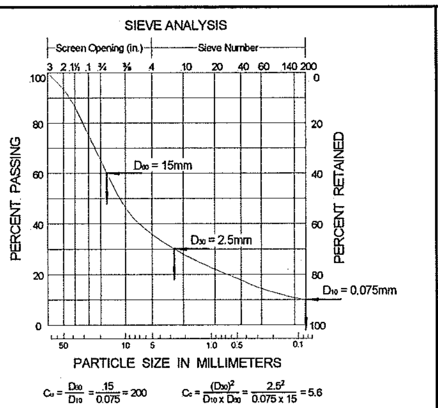
The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N_{60} values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), 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.

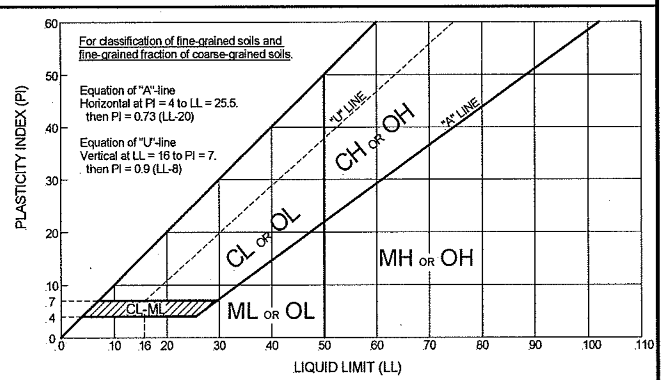
The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered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





Plasticity Chart

Notes

[A]Based on the material passing the 3-in (75-mm) sieve.

[B]If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C]Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

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

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

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

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

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

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

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

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

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

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

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

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

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

[Q]PI plots below "A" line.

[R]Fiber Content description shown below.

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size

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

Gravel Percentages

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

Consistency of Plastic Soils

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

Relative Density of Non-Plastic Soils

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

Moisture/Frost Condition (MC Column)

D (Dry):	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

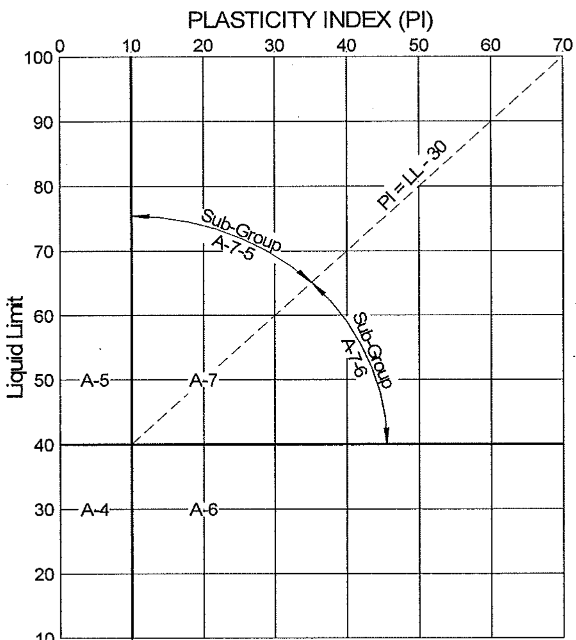
Classification of Soils and Soil-Aggregate Mixtures

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

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.

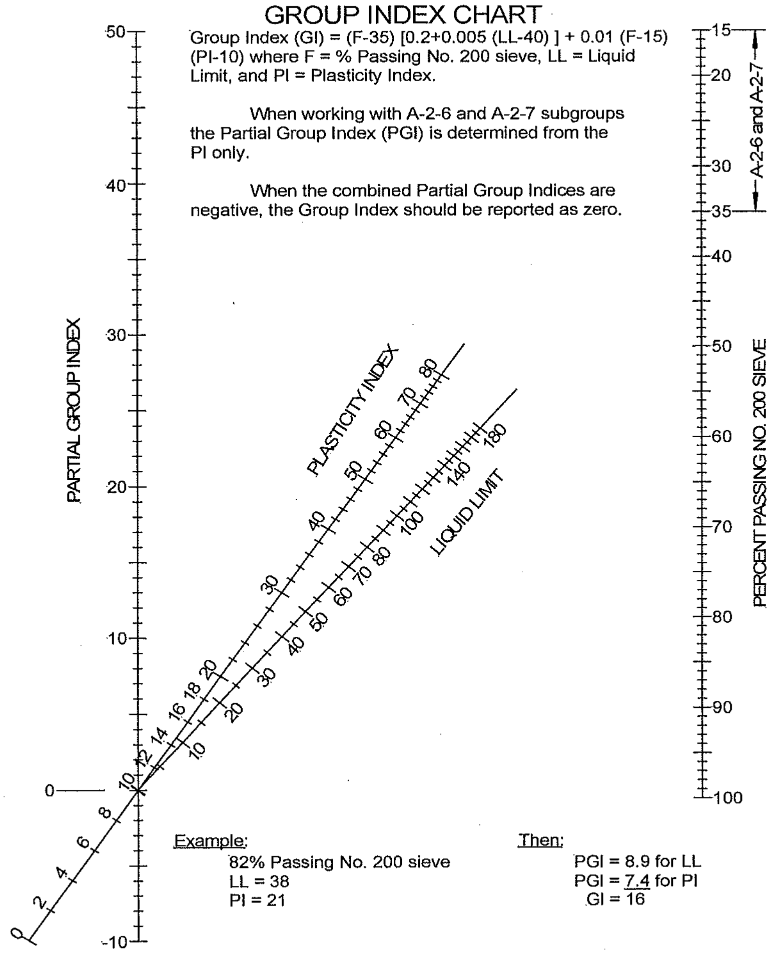
The term "silty" is applied to fine material having plasticity index of 10 or less and the term "clayey" is applied to fine material having plasticity index of 11 or greater.

GROUP INDEX CHART

Group Index (GI) = (F-35) [0.2+0.005 (LL-40)] + 0.01 (F-15) (PI-10) where F = % Passing No. 200 sieve, LL = Liquid Limit, and PI = Plasticity Index.

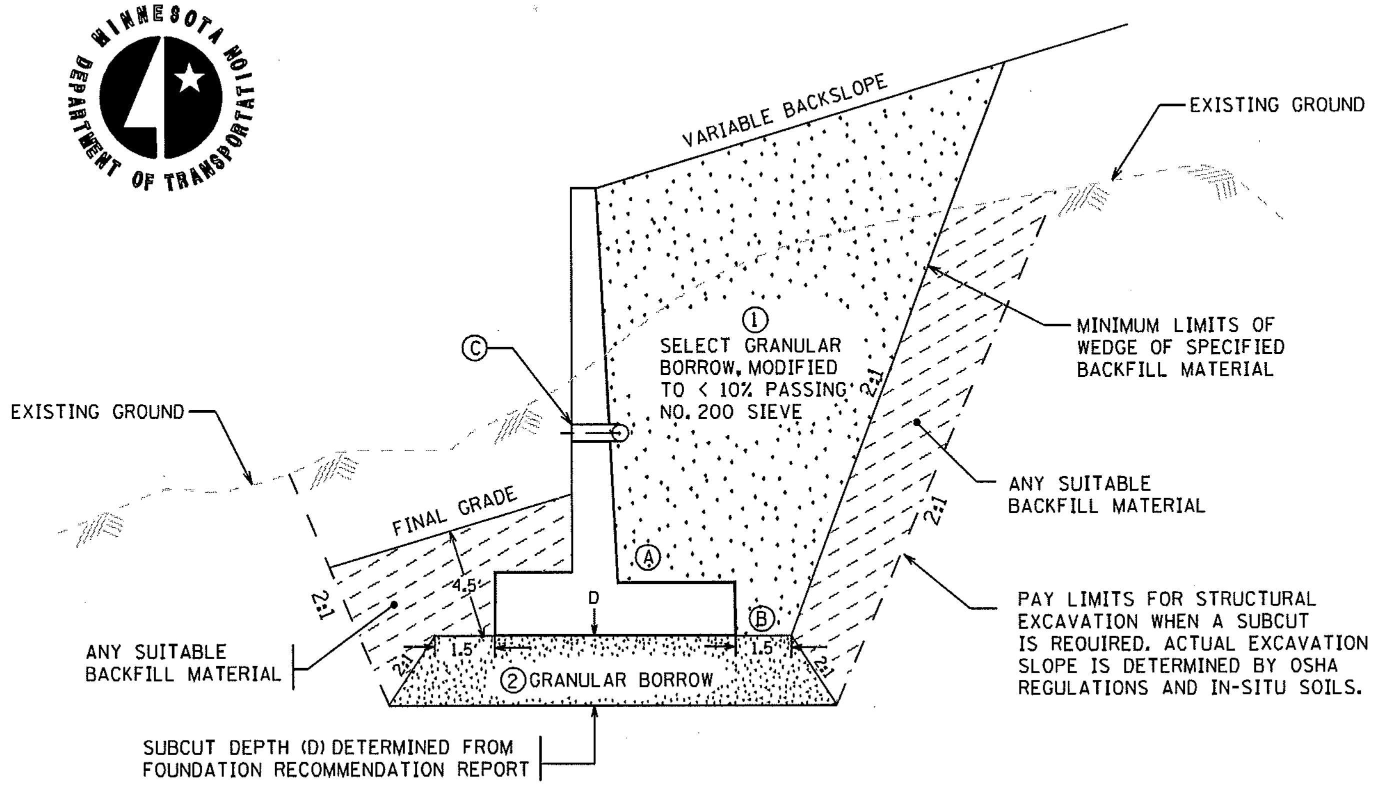
When working with A-2-6 and A-2-7 subgroups the Partial Group Index (PGI) is determined from the PI only.

When the combined Partial Group Indices are negative, the Group Index should be reported as zero.



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

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



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	