DRAFT
Geotechnical Evaluation
West Segment 1

August 29, 2014

Revision 0

Southwest LRT Project Technical Report

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Contents

List of Appendices

Executive Summary

This technical memorandum presents the *Geotechnical Evaluation of West Segment 1* of the Southwest Light Rail Transit (SWLRT) project in Hennepin County. This document combines seven separate memorandums, included in the appendices, under one cover. They provide the details of the geotechnical findings and recommendations for the following areas:

- **Southwest Station Area -** This preliminary report provides general construction comments and recommendations between track STA 2064+00 to STA 2088+66 for the proposed construction of the track, Southwest Station, a parking ramp expansion, retaining walls RTW-W108 and RTW-W127, TPSS-19 and land bridges. A discussion of general civil and roadway discussion is also included. A final geotechnical report should be prepared when the full scope of the field investigation program has been completed. See Appendix A.
- **Prairie Center Drive Bridge** – This Foundation Analysis Design Recommendation (FADR) report addresses the design and construction of a multiple span bridge carrying the SWLRT alignment over Prairie Center Drive and Technology Drive in Eden Prairie. The light rail bridge will consist of an at-grade land bridge approaching pier 1 from the west, an east abutment, and 17 piers. Prestressed concrete beams are proposed to support a cast-in-place concrete deck. See Appendix B
- **Retaining Walls W110 and W111** – This preliminary report provides a summary of the soil boring information and recommendations for retaining walls RTW-W110 and RTW-W111, referred to as the Costco Hill retaining walls. A final geotechnical report should be prepared after final geotechnical design borings are completed. See Appendix C
- **General Track STA 2109+00 to STA 2139+00** – This geotechnical evaluation report addresses the proposed light rail transit line track construction between STA 2109+00 and STA 2139+00 in Eden Prairie. This area includes the Town Center Station as well as retaining walls RTW-W120, RTW-W122, RTW-W125, and RTW-W126. See Appendix D
- **Retaining Walls W113, W115 and W116** – This FADR report addresses the retaining walls RTW-W113, RTW-W115, and RTW-W116 for the west segment of the Southwest Light Rail Transit (SWLRT) alignment passing through Eden Prairie. See Appendix E
- **Bridge Over I-494** – This FADR report provides for the geotechnical evaluation for the proposed light rail bridge over I-494 parallel to existing Bridge 27762 on Flying Cloud Drive in Eden Prairie. See Appendix F
- **Retaining Walls W117, W118A, W118B, W118D, W119, W201 and W202** – This FADR report addresses the design and construction of the embankment and retaining walls RTW-W117, RTW-W118A, RTW-W118B, RTW-W118D, RTW-1119, RTW-W201, RTW-W202, and RTW-W202C between track STA 2163+25 to STA 2217+00 from the Valley View Bridge to the Nine Mile Creek Bridge. See Appendix G

This information was used in other elements of the project development including preliminary site plans, station plans, roadway improvements and traffic analysis.

Appendix A

Southwest Station Area

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August 29, 2014 Project BL-13-00213

Mr. Don Demers
Southwest Light Rail Transit Project Office
6465 Wayzata Boulevard, Suite 500
St. Louis Park, MN 55426

Re: Results of Field Exploration and Preliminary Recommendations
Proposed Southwest Station Area – 10% Design
Track STA 2064+00 to STA 2085+66
Southwest LRT, West Segment 1
Eden Prairie/Minnetonka, Minnesota

Dear Mr. Demers:

This purpose of this letter is to provide you and the design team with our soil boring results and preliminary discussions and recommendations regarding the construction of the Southwest Station area. The following preliminary report provides general construction comments and recommendations between track STA 2064+00 and STA 2088+66 for the proposed construction of the track, Southwest Platform Station, a parking ramp expansion, retaining walls RTW-W108 and RTW-W127, TPSS-19, and land bridges. A discussion of general civil and roadway discussion is also included. A final geotechnical report should be prepared when the full scope of the field investigation program has been completed.

A. Results

A.1. Exploration Logs

A.1.a. Log of Boring Sheets

Log of Boring sheets for our penetration test borings are included in the Appendix. The logs identify and describe the geologic materials that were penetrated, and present the results of penetration resistance, laboratory tests performed on penetration test samples retrieved from them, and groundwater measurements.

Strata boundaries were inferred from changes in the penetration test samples and the auger cuttings. Because sampling was not performed continuously, the strata boundary depths are only approximate. The boundary depths likely vary away from the boring locations, and the boundaries themselves may also occur as gradual rather than abrupt transitions.

A.1.b. Cone Penetration Test Sounding Logs

CPT Sounding Logs are also included in the Appendix. The CPT sounding logs report the tip resistance (Q_t), sleeve friction (F_s) and pore pressure (U_2) that was measured continuously by the cone as it was advanced, as well as the soil behavior type (SBT) inferred from established relationships between tip resistance, sleeve friction, and pore pressure. Note that the SBT should not be used to infer a soil classification based on grain size distribution. Refer to the attached CPT Descriptive Terminology in the Appendix for more information. The CPT logs also report the friction ratio, which is determined by dividing the sleeve friction by the tip resistance.

Strata boundaries, like SBT, were inferred from changes in tip resistance, sleeve friction and pore pressure, and while cone measurements were made continuously with depth, the boundaries are still only approximate, likely vary away from the sounding locations, and may also occur as gradual rather than abrupt transitions.

A.1.c. Geologic Origins

Geologic origins assigned to the materials shown on the logs and referenced within this report were based on visual classification of the various geologic material samples retrieved during the course of our subsurface exploration, penetration resistance testing performed for the project, laboratory test results, and available common knowledge of the geologic processes and environments that have impacted the site and surrounding area in the past.

A.2. Geologic Profile

The Southwest Light Rail Transit Project Office (SPO) requested subsurface soil and groundwater information in the area of the proposed Southwest Station, on parcels of land owned by MnDOT and the City of Eden Prairie. Five (5) standard penetration soil borings and six (6) cone penetration soundings were performed in this area. Logs of the borings and soundings are included in the Appendix. A Boring & Sounding Location Sketch is also included, showing the locations of borings and soundings.

A.2.a. Topsoil

The borings initially encountered about 12 inches of topsoil. The topsoil consisted of sandy lean clay and clayey sand that was dark brown to black and moist to wet.

A.2.b. Fill

Fill was encountered at the majority of the boring locations and consisted of poorly graded sand (SP), poorly graded sand with silt (SP-SM), silty sand (SM), silty clay (CL-ML), clayey sand (SC), lean clay (CL), sandy lean clay (CL), and peat (PT). Table 1 below illustrates the depth and type of fill material encountered.

Table 1. Fill Depths

Boring No.	Boring Elevation (ft)	Approximate Depth of Fill (ft)	Elevation at Bottom of Fill (ft)	Fill Composition
2093SB	849.3	28	821	SM, SC, CL
2094SB	837.7	13	824 1/2	SC, CL
2095SB	841.5	17	824 1/2	SC, CL-ML, CL
2104SB	834.3	42	792	SP, SP-SM, CL, CL
2118SB	837.8	14	824	SC, CL, CL, PT

Penetration resistances varied from 5 to 62 blows per foot (BPF), although some of the higher penetration resistances were likely influenced by encountering a rock or debris in the sampler.

A.2.c. Swamp Deposits

Beneath the fill, Borings 2094SB, 2095SB, and 2104SB encountered swamp deposited soils to depths of 17, 20, and 46 feet, respectively. The swamp deposited soils consisted of slightly organic silt (OH) and peat (PT) that was gray to black containing fibers or shells and was moist to wet.

A.2.d. Alluvium

Beneath the fill and swamp deposits, Borings 2094SB and 2118SB encountered alluvial clays to depths of 46 and 48 feet, respectively. The alluvial deposits consisted of lean clay (CL) and fat clay (CH) that were gray and wet. Penetration resistances varied from weight of hammer (WH) to 12 blows per foot (BPF), indicating the alluvial clays were very soft to rather stiff.

A.2.e. Glacial Till

Glacial till soils were encountered throughout the soil profile beneath the fill, swamp deposits and alluvial clays. The tills consisted of silty sand (SM), sandy silt (MLS), clayey sand (SC), lean clay (CL) and sandy lean clay (CLS). The till soils contained a trace to some gravel, were moist to wet or waterbearing and were brown to gray. Penetration resistances varied from 9 to 74 BPF, indicating the sands and silts were medium dense to very dense and the cohesive soils were rather stiff to hard.

A.2.f. Glacial Outwash

Glacial outwash soils were also frequently encountered throughout the soil profile. The glacial outwash soils consisted of poorly graded sand (SP) and poorly graded sand with silt (SP-SM). The sands generally contained some gravel. Penetration resistances varied from 7 to 57 BPF blows, indicating the soil was loose to very dense.

A.2.g. Sounding Logs

Based on the soil behavior type on the sounding logs, the soundings encountered a layer behaving similar to a mix composition of fairly dense sand and clay in the upper 50 feet. It appears the soundings encountered soft clay layers from 50 to 80 feet in 2109CB and again in 2105CB from 95 to 140 feet. Please refer to the sounding logs in the Appendix for a more detailed description.

A.3. Groundwater

Due to the impermeable nature of the clayey soils, and mud rotary drilling techniques, the depth of the static groundwater level was difficult to determine and the boring logs likely do not reflect the actual groundwater levels. It appears that water is perched on top of and between clayey soils and within sandy soil layers at depth. Piezometers may be needed to determine more accurate groundwater levels. Groundwater was measured or estimated to be located at the depths shown below in Table 2.

Table 2. Groundwater Summary

Location	Surface Elevation	Measured or Estimated Depth to Groundwater (ft)	Corresponding Groundwater Elevation (ft)
2093SB	849.3	40	809
2094SB	837.7	22	816
2095SB	841.5	17	825
2104SB	843.3	15	819
2118SB	837.8	NA	NA

Based on the interpretation of pore pressure on the sounding logs, it appears groundwater is estimated to be at elevations ranging from 815 to 825. These estimates appear to correlate with the groundwater observations in the borings above and from the historical information listed below.

Based on historical groundwater information pulled from previously conducted MnDOT borings, groundwater elevations seem to range from 820 to 830. A sketch of historical borings along with the approximate groundwater observations is included in the Appendix of this report.

Based on a review of the current and historic boring and sounding groundwater observations, we anticipate groundwater will be near elevations ranging from 820 to 830 feet. However, seasonal and annual fluctuations should be anticipated.

B. Southwest Station General Recommendations

B.1. Site History

The Southwest Station area in Eden Prairie has a complicated history of construction. All buildings located within the Southwest Station area are supported on driven piles, as well as a majority of the deep utility lines (sanitary sewer, water main, and storm sewer). There have been multiple utility line issues since the original site construction in the late 1990's.

The majority of the roadways and parking lots are ground supported, however, most, if not all of the roadways show signs of distress due to the soft underlying soils. Of note, the parking lot between the retail strip mall and the parking ramp contains up to 10 feet of tire chips to relieve overburden stress and reduce settlements on the soft underlying soils. We also understand that wick drains were installed across the site to promote consolidation of underlying clays during the original construction of the site.

As noted in the borings, swamp deposits were encountered to depths of 20 to 45 feet. It appears these soils were largely excavated and replaced with fill beneath the embankment for the off ramp from eastbound TH 5/TH 212. We also understand these soils were removed and replaced with granular fill beneath Technology Drive. In these areas, fill depths are anticipated to range from 15 to 40 feet, and isolated pockets of organic soils may still be present.

We understand soil corrections occurred during the original construction for the TH 212 off ramp, and the creek culvert beneath the ramp. The termination point of the soil corrections is not known at the time, and there is like a transition area, where fill may be been placed above the native organic soils.

The project team should be aware that any raises in grade on the site will result in settlement of the underlying soil and could cause collateral damage of existing structures, utilities and surface features.

B.2. General Axial and Lateral Capacities of Piles

We performed analyses on the SPT borings and CPT soundings and performed lateral analyses on 2093SB. Because the borings were not performed at specific structures, we used the following assumptions regarding the design of the piles:

- 12 3/4-inch outside diameter (OD) pile
- 1/4-inch pile wall thickness

Tables 4 and 5 below provide estimated pile embedment depths (from the ground surface) for a factored load of 140-tons, using the resistance factors noted in Table 3. We did not provide pile lengths for Boring 2105CB. The boring was offset upslope due to utility conflicts and does not represent the conditions at the bottom of the slope.

Table 3. Recommended Pile Driving Resistance Factors (ϕ_{dyn})

Specified Construction Control	ϕ_{dyn}
MnDOT Pile Formula 2012 (MPF12) for Pipe Pile Sections	0.50
Wave Equation and Pile Driving Analyzer (PDA)	0.65

Table 4. Summary of Anticipated Pile Lengths, CIP 12 ¾", $\Sigma\gamma Q_n$ = 140 Tons, PDA

Boring Number	Boring Elevation (ft)	R_n (tons)	Approximate Tip Elevation (ft)	Approximate Pile Length (ft)
2104SB	834.3	140 (430 Kips)	769	65
2106CB	837.7	140 (430 Kips)	772	66
2107CW	847.8	140 (430 Kips)	774	74
2093SB	849.3	140 (430 Kips)	792	57
2108CW	846.9	140 (430 Kips)	769	78
2109CB	840.9	140 (430 Kips)	769	72
2094SB	837.7	140 (430 Kips)	787-775*	51-63*
2110CB	840.5	140 (430 Kips)	794	47
2095SB	841.5	140 (430 Kips)	794	48
2118SB	837.8	140 (430 Kips)	778	60

Table 5. Summary of Anticipated Pile Lengths, CIP 12 ¾", $\Sigma\gamma Q_n$ = 140 Tons, MPF12

Boring Number	Boring Elevation (ft)	R_n (tons)	Approximate Tip Elevation (ft)	Approximate Pile Length (ft)
2104SB	834.3	140 (560 Kips)	750	84
2106CB	837.7	140 (560 Kips)	770-722*	68-116*
2107CW	847.8	140 (560 Kips)	769	79

Boring Number	Boring Elevation (ft)	R_n (tons)	Approximate Tip Elevation (ft)	Approximate Pile Length (ft)
2093SB	849.3	140 (560 Kips)	782	67
2108CW	846.9	140 (560 Kips)	764	83
2109CB	840.9	140 (560 Kips)	764	77
2094SB	837.7	140 (560 Kips)	774	64
2110CB	840.5	140 (560 Kips)	787	54
2095SB	841.5	140 (560 Kips)	779	63
2118SB	837.8	140 (560 Kips)	769	69

*-Pile may reach capacity at shallow elevation. Recommend PDA to confirm pile length
Abandonment of existing piles:

B.3 Lateral Pile Analyses

The following table provides the soil parameters used for the lateral pile analyses and p-y curve generation, which was performed using the computer program LPILE (2013). Based on the soils encountered in the borings, we used the default lateral modulus of subgrade reaction values included in LPILE. For the purposes of our preliminary evaluation, we used the soil parameters encountered in Boring 2093SB.

Layer Top Depth (feet)	Layer Bottom Depth (feet)	Effective Unit Weight (pcf)	Internal Angle of Friction (degrees)	Undrained Shear Strength (psf)	Material Type
0	4.0	125	NA	1000	Stiff Clay with Free Water
4.0	6.0	125	NA	2000	Stiff Clay with Free Water
6.0	9.0	120	31	NA	Sand (Reese)
9.0	14.0	125	NA	3500	Stiff Clay w/o Free Water
14.0	17.0	125	NA	2000	Stiff Clay w/o Free Water
17.0	24.0	120	32	NA	Sand (Reese)
24.0	29.0	125	NA	2500	Stiff Clay w/o Free Water
29.0	32.0	120	33	NA	Sand (Reese)
32.0	37.0	120	35	NA	Sand (Reese)
37.0	57.0	55	32	NA	Sand (Reese)
57.0	78.0	55	33	NA	Sand (Reese)
78.0	83.0	65	NA	4500	Stiff Clay w/o Free Water
83.0	101.0	58	38	NA	Sand (Reese)

For our lateral analyses, we assumed a pile top located at the ground surface. The maximum lateral load in our analyses is for a loading condition assuming one-inch of deflection at the pile top with a fixed-head condition. We assumed a pile wall thickness of 1/4-inch, a steel yield strength of 45 ksi, and concrete infill with a compressive strength of 3 ksi for our analyses. Please refer to the attachments for the shear force and bending moments within the pile at service loads of 100 tons for the 12.75-inch closed-end pipe pile.

B.4. Platform Station Construction

We understand a new platform station will be constructed in the existing Southwest Station area, in the vicinity of the western portion of the existing bus station lobby and offices. While not confirmed, we have assumed the existing lobby and office building are supported on driven pile foundations with a grade beam and structural slab supporting the first level.

Similar to the ramp, the soil conditions are anticipated to be such that new station construction will require the installation of driven pipe piles for support.

We recommend removing all debris associated with the existing structure. Depending on the design capacity of the existing piles, the proposed loads of the new structures and information such as the original driving records, the existing piles may be suitable for reuse to support the track or the platform station. If the existing piles are being considered for reuse, we recommend re-striking the pile and using PDA equipment to verify the load carrying capacity of the piles. Pile inspections are also recommended to determine if any damage occurred during building demolition.

B.5. Retaining Wall RTW-W108 and RTW-W127

Retaining walls RTW-W108 and RTW-W127 are designed to be soldier pile and lagging retaining walls supporting up to 13 feet of soil. RTW-W108 is adjacent to the track from STA 2082+30 to STA 2085+65 (approximately) while RTW-W127 is proposed to support soil adjacent to TPSS-19 on the northeast corner of the Southwest Station platform. We recommend following MnDOT guidelines when placing and compacting backfill for the walls as needed.

Soldier-pile installation depths are expected to range from 25 to 30 feet below grade assuming a pile spacing of 5 feet. The tracks adjacent to the soldier pile walls will be supported on driven pile. If embedment depths exceed 30 feet, or greater spacing is required, tiebacks should be considered. Please refer to the land bridge discussion for recommendations on the pile design.

B.6. Land Bridge

Land bridges will be used to support the tracks from STA 2064+00 to STA 2077+03 (ballast supported track) and again from STA 2081+90 to STA 2085+66 (DF supported track), where the Prairie Center Drive Bridge begins. Based on the preliminary engineering plans, spacing between pile caps for ballast supported track is approximately 35 feet and for DF supported track is approximately 50-feet.

B.7. General Civil/Roadway Construction

As part of the construction at the SW Station, several roadways will be realigned to accommodate the ramp expansion and platform station. Of note, the track will cross an existing pond at STA 2078+00, where raises in grade of at least 6 to 10 feet are expected. Additionally, a culvert carrying stormwater to the adjacent wetland will need to be extended as part of the new construction. We also understand a raise in grade of several feet may occur within the existing southern parking lot area.

The soil conditions in the area are extremely susceptible to consolidation and settlement from new loads and raises in grade. For the parking lot areas, lightweight fill in the form of tire chips or EPS foam blocks may be an option to raise grade with minimal stress increase, however, this may be an obstacle for the installation of utilities or light pole bases. Once final design parameters are known, additional measures such as surcharges or wick drains can be explored to increase the rate of consolidation. Regardless of the methods mentioned above, long term consolidation and settlement of the soil will occur and may vary in magnitude from one inch to upwards of one foot. If tight settlement tolerances exist, alternative foundation systems such as aggregate piers or reinforced pavement sections could be considered.
We recommend all structures, including the culvert and light pole bases, be supported on deep foundation systems.

We also recommend supporting all deep utilities (sanitary sewer, water main, and storm sewer) on driven piles. This area has a history of failing utility lines from consolidation of the swamp deposits and alluvial fat clays at depth.

B.8. TPSS-19

A traction power substation (TPSS) is proposed adjacent to the northeast corner of the platform station. This area is near the transition area that soil was corrected during construction, to the area of known organic deposits. We recommend further investigation of this area to determine a suitable foundation system. TPS stations are generally small, lightly loaded structures, so a limited soil correction or the use of spread footings should be considered. Further investigation should be given to the settlement tolerances of these stations as electrical conduits are running in and out of the station. If the settlement tolerances are such that damage to the conduits is probable, we recommend the use of intermediate to deep foundation systems, which may include helical anchors or driven piles.

C. Remarks

This report should be considered preliminary in nature and may be revised upon final design parameters and the completion of the full geotechnical program.

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If you have any questions about this Addendum, please contact Josh Kirk at 952.995.2222 or Ray Huber at 952.995.2260

Sincerely,

BRAUN INTERTEC CORPORATION

Professional Certification:
I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Joshua L. Kirk, PE
Associate Principal-Project Engineer
License Number: 45005

Reviewed by:

Ray A. Huber, PE
Vice President-Principal Engineer

Reviewed by:

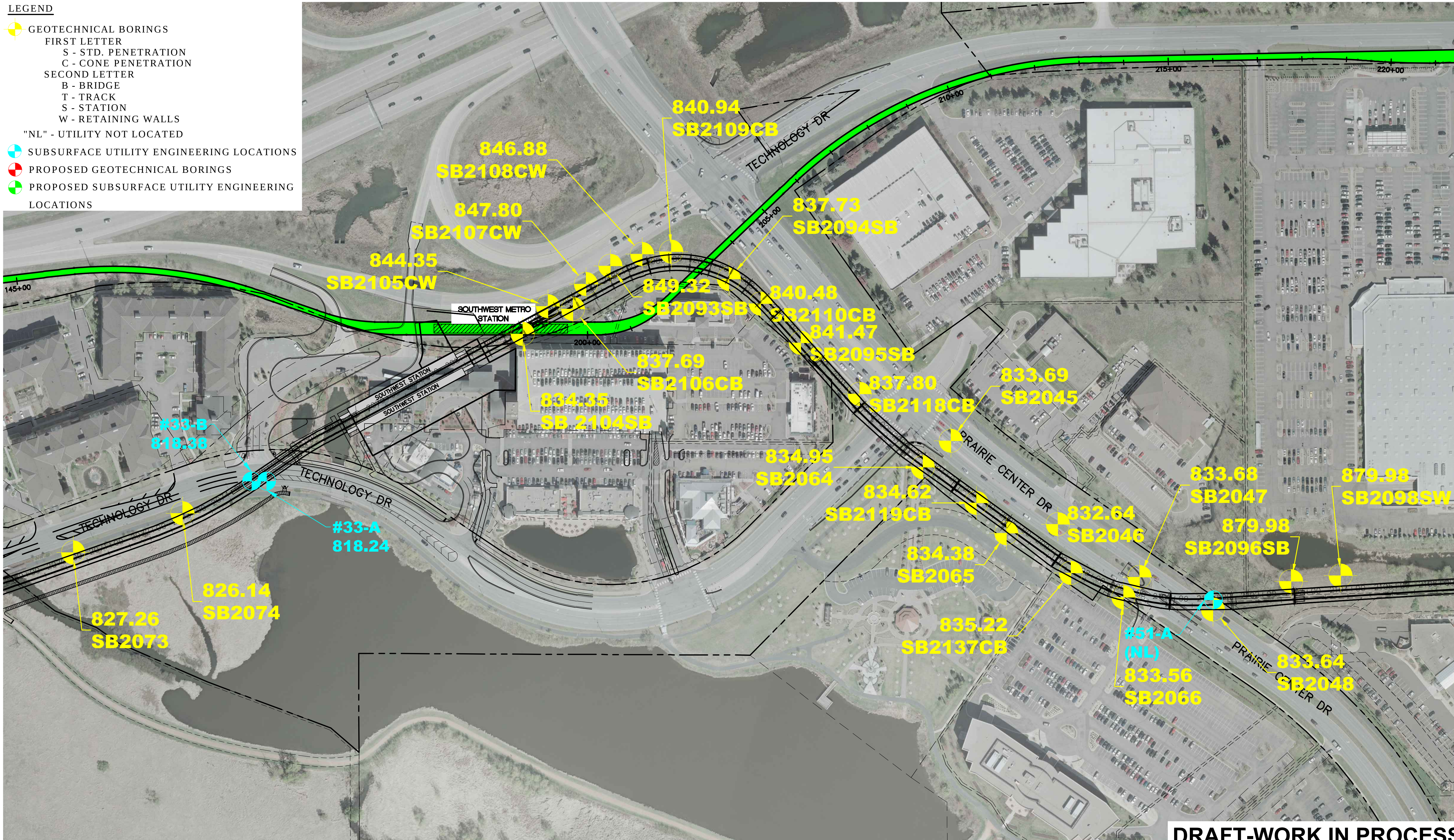
Matthew P. Ruble, PE
Principal Engineer

Appendix:
Boring Location Sketch
Preliminary Engineering Plan and Profile Pages
Standard Penetration Borings 2104SB, 2093SB, 2094SB, 2095SB, 2118SB
Cone Penetration Test Borings 2105CW, 2106CW, 2107CW, 2108CW, 2109CB, 2110CB
Nominal Resistance Graphs
Lateral Pile Analysis Results

Historical Boring Groundwater Level Sketch
SPT Descriptive Terminology
CPT Descriptive Terminology

c: Mr. Jeff Stewart: SPO
Ms. Laura Amundson: SPO

APPENDIX



SOUTHWEST Green Line LRT Extension

SOUTHWEST LIGHT RAIL

SOIL BORINGS

SHEET 3 OF 12

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Eu = 1.08"
V = 20 MPH

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Lc = 67.76'
Ls = 40'
Ea = 0.50"
Eu = 1.08"
V = 20 MPH

CURVE NO. W1A-105
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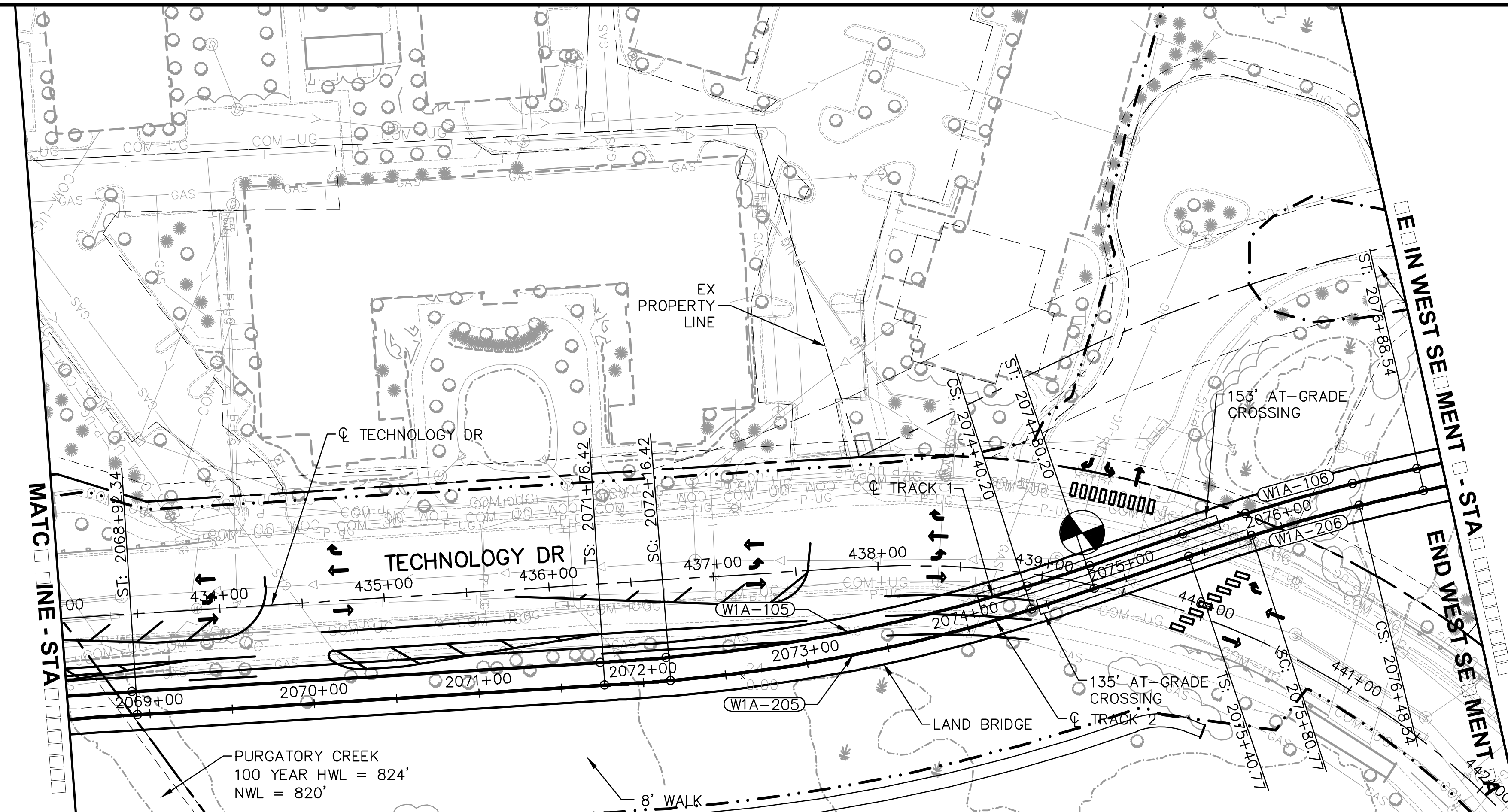

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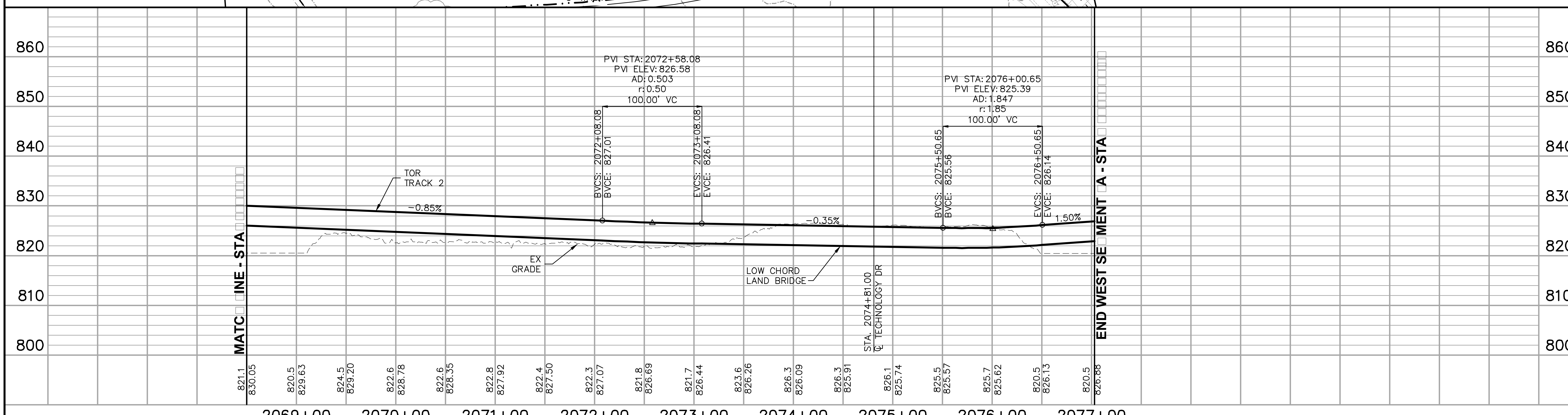

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SOUTHWEST Green Line LRT Extension

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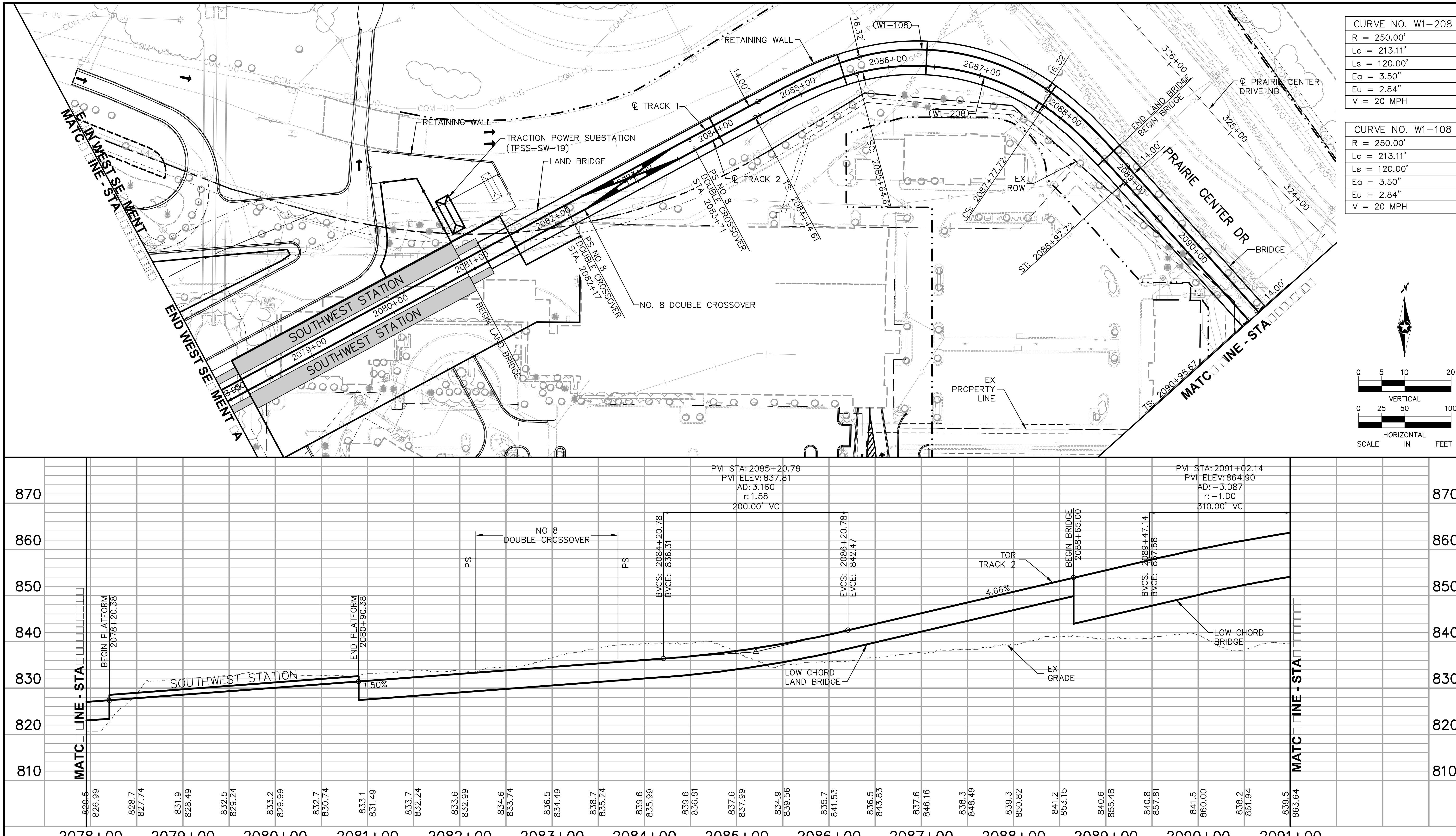

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SOUTHWEST Green Line LRT Extension

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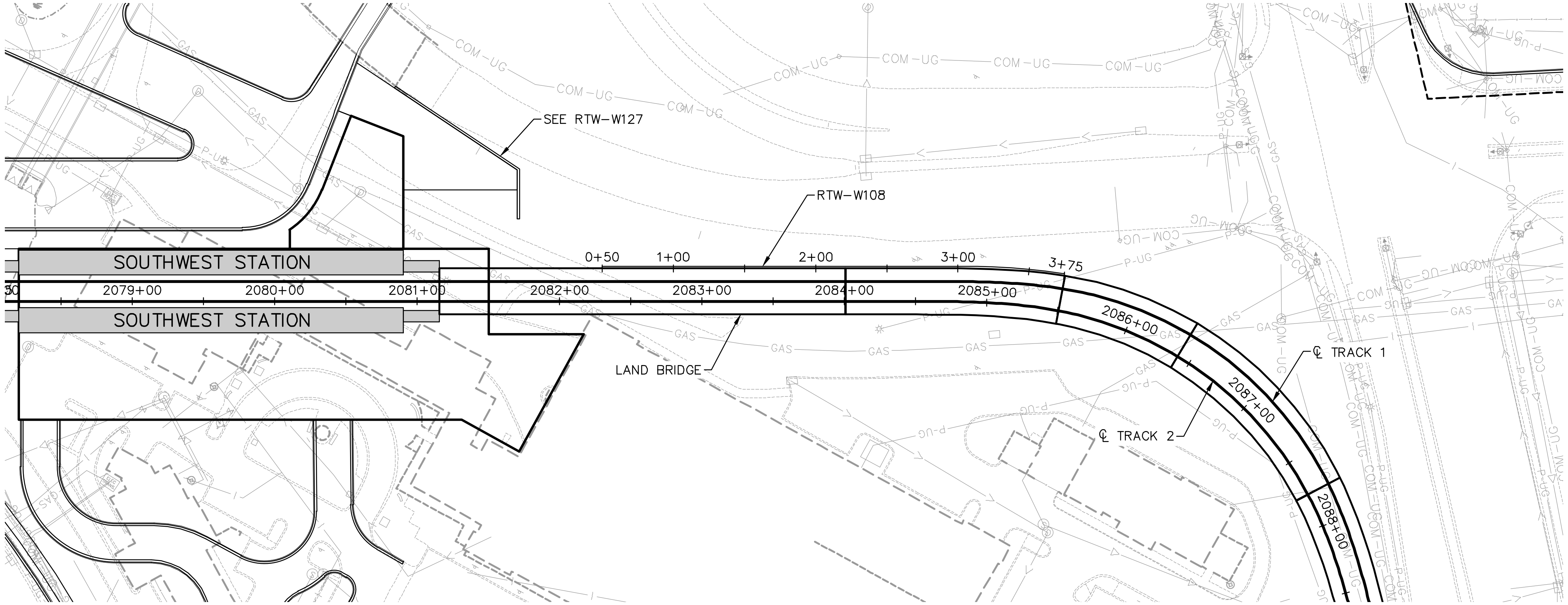
NOTE:
RTW-W108 IS ANTICIPATED TO BE A SOLDIER PILE RETAINING WALL DUE TO CLOSE PROXIMITY TO TH 212 OFF RAMP.



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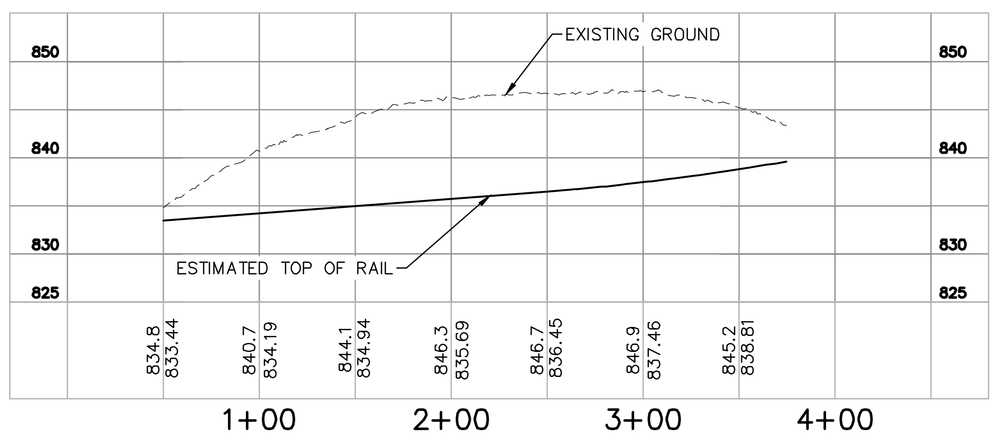
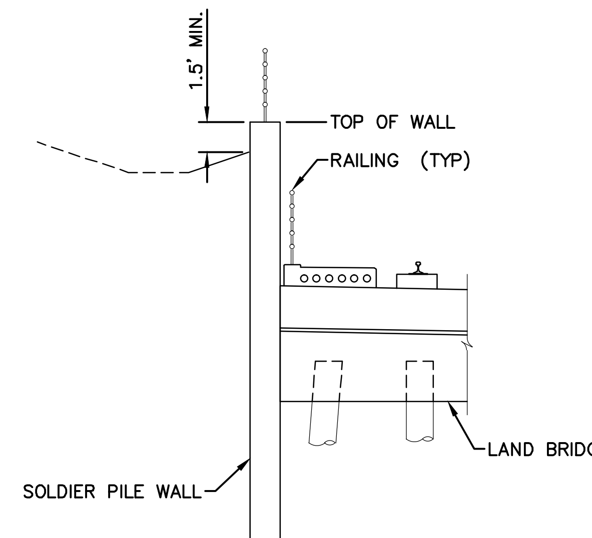
RTW-W108 PLAN



RTW-W108 PROFILE



RTW-W108 TYPICAL SECTION

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PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extention

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RTW-W108
PLAN AND PROFILE

DISCIPLINE: STRUCTURES

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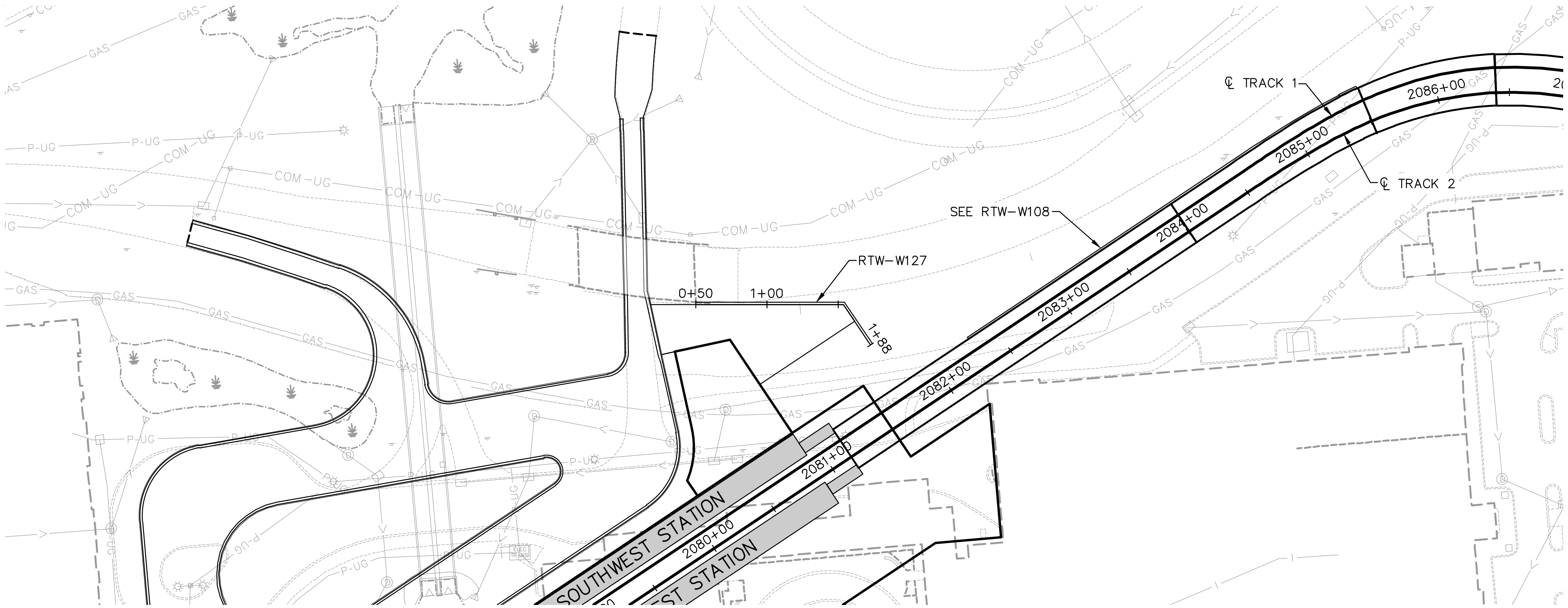
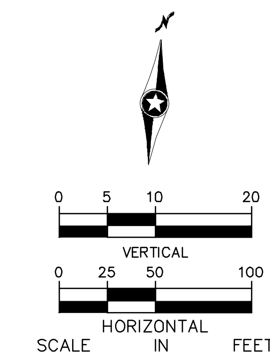
SHEET 158 OF 197

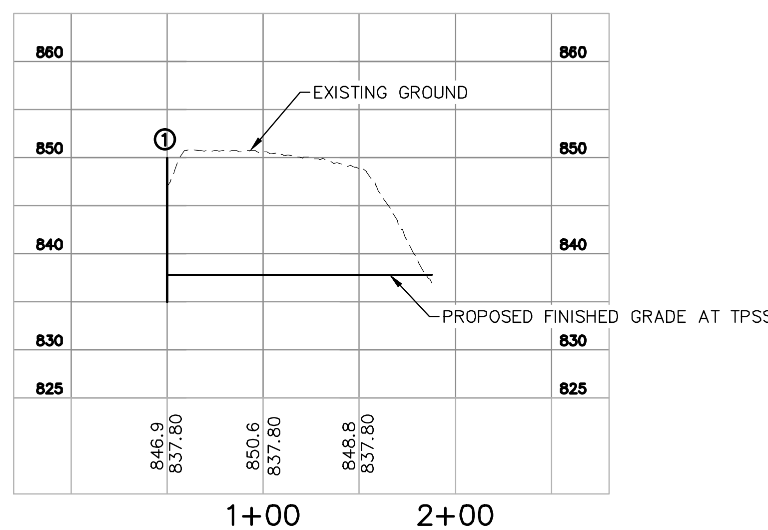
NOTE:
RTW-W127 IS ANTICIPATED TO BE A SOLDIER PILE RETAINING WALL DUE TO CLOSE PROXIMITY TO TH 212 OFF RAMP.

① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.

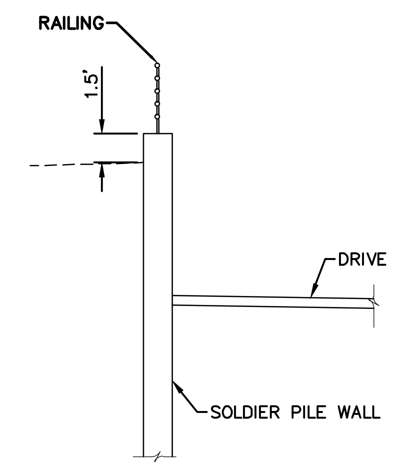




RTW-W127 PLAN



RTW-W127 PROFILE



RTW-W127 TYPICAL SECTION

Jun, 13 2014 10:57 am V:\3200_PEC-W\CAD\SEGMENT-W1\SHEET\STRUCTURES\W1-STU-RETW.dwg By: NutzmaML

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AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extention

WEST-VOLUME 2 (STRUCTURES)
SEGMENT 1
RTW-W127
PLAN AND PROFILE

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-RTW-PPFL-014

SHEET 171 OF 197

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPL(

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

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
		SWLRT	2104SB	(Surveyed)

Location: Hennepin Co. Coordinate: X= Y= (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine: 7504

Hammer: CME Automatic Calibrated

SHEET 1 of 3

Drilling Completed: 5/14/14

Depth / Elev.	Classification	Other Tests Or Remarks
1.0	SANDY LEAN CLAY, trace roots, dark brown and brown, moist. (CLS), topsoil fill	
6.0	SANDY LEAN CLAY, trace Gravel, with Sand seams, brown and gray, wet. (CLS), fill	
9.0	LEAN CLAY, with Silt lenses, gray and brown, wet. (CL), fill	DD=87 pcf
12.0	LEAN CLAY, trace fibers, gray and brown with layers of black, wet. (CL), fill	
29.0	POORLY GRADED SAND with SILT, fine- to medium-grained, brown, moist to 15 feet then waterbearing. (SP-SM), fill	P200=11% Drillers Note: Switched to mud rotary drilling method after 15-foot sample.
42.0	POORLY GRADED SAND, fine- to medium-grained, brown, waterbearing. (SP), fill	P200=2% *No sample recovery.
	SLIGHTLY ORGANIC SILT, trace shells, lenses of Lean Clay, gray with layers of black, wet. (OL), swamp deposit	OC=3%

Sample test results (in order from top):

SPT N_{60}	MC (%)
	21
6	33
7	15
7	33
15	16
18	13
16	14
4	17
9	13
15	12
8	15
3	21
6	19
*	
9	12
15	17
15	14
11	40

Water level symbol at 15 ft.

Index Sheet Code 3.0

(Continued Next Page)

BRAUN INTERTEC
This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	2104SB	(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
	46.0				10					
			SANDY LEAN CLAY, trace Gravel, gray, wet, rather stiff. (CLS), till	PD	9	21				
50				PD	15	13				
	53.0			PD						
55			POORLY GRADED SAND with SILT, fine- to medium-grained, trace Gravel, gray, waterbearing, medium dense. (SP-SM), outwash		22	11				
				PD						
60					23	25				
	63.0			PD						
65			POORLY GRADED SAND, fine- to coarse-grained, trace Gravel, gray, waterbearing, medium dense. (SP), outwahs		16	16				
				PD						
70					17	17				
				PD						
75					30	16				
	77.0			PD						
80			SANDY LEAN CLAY, trace Gravel, with frequent layers of Silt, gray, wet, hard to very stiff. (CLS), till		41	14				
				PD						
85					26	16				
				PD						
90										

(Continued Next Page)

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	2104SB	(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
			Layer of Sand encountered at 90 feet.		34	12				
				PD						
95					30	15				DD=119 pcf
				PD						
100			SANDY LEAN CLAY, trace Gravel, with frequent layers of Silt, gray, wet, hard to very stiff. (CLS), till *(continued)*		18	16				
105				PD						
110	110.0				34*					
115				PD						
120			LEAN CLAY, with Silt layers, reddish brown to gray, wet, dense. (CL), glaciofluvium		35	26				
125				PD						
130	131.0				33	26				DD=125 pcf LL=28, PL=20, PI=8

Bottom of Hole - 131 feet.
Water observed at a depth of 15 feet while drilling.
Boring immediately backfilled with bentonite grout.

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

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
		SWLRT	2093SB	849.3 (Surveyed)

Location: Hennepin Co. Coordinate: X=484621 Y=125374 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7504

Hammer CME Automatic Calibrated

Drilling Completed 5/13/14

Depth	Elev.	Classification
1.0	848.3	SANDY LEAN CLAY, trace roots, trace Gravel, black, moist. (CLS), topsoil fill
4.0	845.3	SANDY LEAN CLAY, trace roots, black and dark brown, moist. (CLS), fill
6.0	843.3	SANDY LEAN CLAY, trace Gravel, gray, moist. (CLS), fill
9.0	840.3	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist. (SM), fill
17.0	832.3	SANDY LEAN CLAY, trace Gravel, with Sand seams, gray with layers of black, moist. (CLS), fill
19.0	830.3	CLAYEY SAND, with Gravel, gray, moist. (SC), fill
22.0	827.3	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist. (SM), fill
28.0	821.3	CLAYEY SAND, with Gravel, gray, moist. (SC), fill
32.0	817.3	SILTY SAND, fine-grained, brown, wet, dense. (SM), outwash
37.0	812.3	SILTY SAND, fine- to medium-grained, with Gravel, brown, wet, very dense. (SM), outwash
		POORLY GRADED SAND with SILT, fine- to medium-grained, with Gravel, brown, wet to waterbearing, loose to medium dense. (SP-SM), outwash

SPT N60	MC (%)	Other Tests Or Remarks
	18	
8	27	
19	11	
22	12	P200=24%
32	13	
31	11	DD=123 pcf LL=25, PL=12, PI=13
18	33	
27	9	Drillers Note: Switched to mud rotary drilling method after 17 1/2-foot sample.
27	10	
27	10	DD=136 pcf
20	15	
50/6"*		50/6" (set). No sample recovery.
37	13	
74	10	P200=13%
63	12	
23	13	P200=11%
9	15	

Columns also include: COH (psf), γ (pcf), REC (%), RQD (%), ACL (ft), Core Breaks, Soil/Rock, Formation or Member, Drilling Operation (PD).

Index Sheet Code 3.0

(Continued Next Page)

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2093SB**	**849.3** *(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
			X	12	14			
			PD					
			X	19	12			
			PD					
50			X	7	17			P200=9%
			PD					
55			X	11	22			
			PD					
60			X	18	17			
		POORLY GRADED SAND with SILT, fine- to medium-grained, with Gravel, brown, wet to waterbearing, loose to medium dense. (SP-SM), outwash *(continued)*	PD					
65			X	17	17			
			PD					
70			X	21	20			
			PD					
75		Large wood chunks encountered at 75 feet.	X	16				
	78.0 / 771.3		PD					
80		SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff. (CLS), till	X	30	23			DD=104 pcf
	83.0 / 766.3		PD					
85		SILTY SAND, fine-grained, gray, waterbearing, dense. (SM), outwash	X	48	19			
	88.0 / 761.3	POORLY GRADED SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, dense to very dense. (SP),	PD					
90			X					

(Continued Next Page)

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2093SB**	**849.3** *(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
			outwash	X	41	14				
				PD						
95			POORLY GRADED SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, dense to very dense. (SP), outwash *(continued)*	X	52	23				
				PD						
100	101.0 / 748.3			X	57	19				

Bottom of Hole - 101 feet.
Water observed at 40 feet while drilling.
Boring immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2094SB	837.7 (Surveyed)

Location: Hennepin Co. Coordinate: X=484887 Y=125344 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7504

Hammer CME Automatic Calibrated

SHEET 1 of 3

Drilling Completed 5/16/14

Depth / Elev.	Classification
1.0 / 836.7	SANDY LEAN CLAY, trace roots, dark brown, wet. (CLS), topsoil fill
6.0 / 831.7	SANDY LEAN CLAY, trace Gravel, dark brown and gray, moist. (CLS), fill. With roots at 5 feet.
11.0 / 826.7	CLAYEY SAND, trace Gravel, dark gray and brown, moist. (SC), fill
13.0 / 824.7	SANDY LEAN CLAY, trace Gravel, gray, moist. (CLS), fill
17.0 / 820.7	PEAT, decomposed with fibers, with shells, black, moist. (PT), swamp deposit
28.0 / 809.7	FAT CLAY, gray, wet, medium to rather stiff. (CH), glaciofluvium
40.0 / 797.7	FAT CLAY, gray, wet, very soft. (CH), glaciofluvium
	LEAN CLAY, with frequent layers of Silt, gray, wet, medium to rather stiff. (CL), glaciofluvium

SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
	52			
9	21			qu=1 3/4 tsf
6	21			
22	11			DD=126 pcf
18	13			qu=3 tsf
10	16			
8	234			DD=21 pcf OC=50%
7	42			
8	30			
10	48			DD=75 pcf qu=1/2 tsf Switched to mud rotary drilling after 22 1/2-foot sample.
9	40			
1	71			
WOH	60			DD=69 pcf
WOH	67			
1	58			
7	18			
10	27			LL=27, PL=19, PI=8

Index Sheet Code 3.0

(Continued Next Page)

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2094SB**	**837.7** *(Surveyed)*

Depth / Elev.	Classification
46.0 / 791.7	
49.0 / 788.7	SILTY SAND, fine- to medium-grained, with Gravel, gray, waterbearing, very stiff. (SM), till
53.0 / 784.7	CLAYEY SAND, with Gravel, gray, wet, very stiff. (SC), till
63.0 / 774.7	SANDY LEAN CLAY, trace Gravel, with Sand seams, gray, wet, stiff. (CL), till
83.0 / 754.7	SILTY SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, medium dense. (SM), till
	POORLY GRADED SAND with SILT, fine- to coarse-grained, with Gravel, gray, waterbearing, medium dense to dense. (SP-SM), outwash

DEPTH (approx.)	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
46		9	26			qu=1 tsf, DD=101 pcf
48	PD	22	12			
50	PD	21	12			qu=3 tsf DD=126 pcf
55	PD	15	21			qu=1 1/4 tsf
60	PD	15	29			DD=95 pcf
65	PD	19	12			
70	PD	38	11			P200=18%
75	PD	36	20			
80	PD	37	18			
85	PD	41	13			
90	PD					

Column headers: 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

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2094SB**	**837.7** *(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
				☒	36	12				
				PD						
95				☒	38	15				
				PD						
100				☒	30	12				
105			POORLY GRADED SAND with SILT, fine- to coarse-grained, with Gravel, gray, waterbearing, medium dense to dense. (SP-SM), outwash *(continued)*	PD						
110				☒	38	20				
115				PD						
120	121.0 / 716.7			☒	42	17				

Bottom of Hole - 121 feet,
Water observed at a depth of 22 feet while drilling.
Boring immediately backfilled with betonite grout.

BRAUN INTERTEC
This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

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
		SWLRT	2095SB	841.5 (Surveyed)

Location: Hennepin Co. Coordinate: X=485048 Y=125201 (ft.)
Latitude (North)= Longitude (West)=
No Station-Offset Information Available

Drill Machine 7506
Hammer CME Automatic Calibrated

Drilling Completed 4/30/14

DEPTH	Depth / Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
	1.0 / 840.5	SANDY LEAN CLAY, dark brown, moist. (CLS), topsoil fill		16			
	4.0 / 837.5	SANDY LEAN CLAY, trace Gravel, brown and dark brown, moist. (CLS), fill	8	14			
5			12	11			
		CLAYEY SAND, trace Gravel, dark brown and gray, moist. (SC), fill	20	10			DD=125 pcf
10	12.0 / 829.5		15	12			
	14.0 / 827.5	SILTY CLAY, trace Gravel, brown, moist, (CL-ML), fill	5	16			LL=21, PL=14, PI=7
15	17.0 / 824.5	CLAYEY SAND, trace Gravel, gray and brown, moist. (SC), fill	11	12			DD=123 pcf
	20.0 / 821.5	SLIGHTLY ORGANIC SILT, with fine-grained Sand, with shells, gray and black, moist. (ML), swamp deposit	6	36			OC=3% Drillers Note: Switched to mud rotary drilling method after 17 1/2-foot sample.
20			31	14			P200=22%
		SILTY SAND, fine- to medium-grained, trace Gravel, brown, waterbearing, medium dense to dense. (SM), outwash	21	14			
25	27.0 / 814.5		33				
			31	19			P200=7%
30		POORLY GRADED SAND with SILT, fine- to medium-grained, trace Gravel, brown, waterbearing, dense to mediumd dense. (SP-SM), outwash	18	22			
			18	21			
35	36.0 / 805.5		18	20			
		POORLY GRADED SAND, fine- to medium-grained, with Gravel, brown, waterbearing, medium dense. (SP), outwash	28	11			P200=4%
40	42.0 / 799.5		16				
45		POORLY GRADED SAND, fine- to coarse-grained, with Gravel, occasional Cobbles, brown, waterbearing, medium dense. (SP), outwash	21	8			

(Continued Next Page)

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

UNIQUE NUMBER

U.S. Customary Units

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2095SB**	**841.5** *(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
				22	11			
	47.0 / 794.5		PD					
				28	12			P200=8%
			PD					
50				29	8			
			PD					
55				24	14			
			PD					
60		POORLY GRADED SAND with SILT, fine- to coarse-grained, with Gravel, occasional Cobbles, brown, waterbearing, medium dense. (SP-SM), outwash		23	9			
			PD					
65				27	11			
			PD					
70		Large Boulder and rock encountered from 70 to 72 feet.		29	13			
	73.0 / 768.5		PD					
75				39	15			P200=36%
		SILTY SAND, fine- to medium-grained, with frequent layers of Silt, brown, waterbearing, dense. (SM), outwash	PD					
80				37	16			
	83.0 / 758.5		PD					
85				30	23			DD=110 pcf
		SANDY SILT, with frequent layers of Sand, reddish brown, wet, medium dense to dense. (MLS), glaciofluvium	PD					
90								

(Continued Next Page)

BRAUN INTERTEC
This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2095SB**	**841.5** *(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
			SANDY SILT, with frequent layers of Sand, reddish brown, wet, medium dense to dense. (MLS), glaciofluvium *(continued)*	X	46	19				
	93.0 / 748.5			PD						
95			SILTY SAND, fine- to medium-grained, with frequent layers of Silt and Lean Clay, reddish brown, wet, dense. (SM), outwash	X	36	18				
				PD						
100	101.0 / 740.5			X	49	21				

Bottom of Hole - 101 feet.
Water observed at a depth of 17 feet while drilling.
Boring immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPL(

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

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
		SWLRT	2118SB	837.8 (Surveyed)

Location: Hennepin Co. Coordinate: X=485180 Y=125086 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7507

Hammer CME Automatic Calibrated

SHEET 1 of 3

Drilling Completed 5/22/14

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
	1.0 / 836.8	CLAYEY SAND, trace roots and Gravel, dark brown, moist. (SC), topsoil fill						
	5.0 / 832.8	CLAYEY SAND, trace Gravel, dark brown, moist. (SC), fill		17				
5				17				
	7.0 / 830.8	PEAT, trace shells, black, wet. (PT), fill		15				
10				8				Drillers Note: Switched to mud rotary drilling method after 10-foot sample.
	14.0 / 823.8	LEAN CLAY, trace Gravel, black, wet. (CL), fill	PD	62*				*Sampler encountered large root at 12 feet.
15			PD	10				
	19.0 / 818.8	LEAN CLAY, trace Gravel, brown and gray, wet, rather stiff. (CL), alluvium	PD	11				
20			PD	7				
			PD	12				qu=2 tsf
25			PD	8				
			PD	8				
30			PD	8				qu=1 tsf
		FAT CLAY, gray, wet, rather stiff to soft. (CH), alluvium	PD	7				
35			PD	5				
			PD	7				qu=3/4 tsf
40			PD	6				
			PD	6				
45			PD					

Index Sheet Code 3.0

(Continued Next Page)

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2118SB**	**837.8** *(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
			FAT CLAY, gray, wet, rather stiff to soft. (CH), alluvium *(continued)*		4					
				PD	6					
50				PD	3					qu=1/2 tsf
55				PD	5					
	58.0 / 779.8		SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff. (CLS), till	PD						
60					25					qu=1 1/2 tsf
65				PD	28					
70				PD	22					
	73.0 / 764.8		Cobbles or Boulder from about 76 to 79 feet. POORLY GRADED SAND, fine- to medium-grained, gray, waterbearing, medium dense to very dense. (SP), outwash	PD						
75					28					
80				PD	45*					*No sample recovery.
85				PD	54					
90				PD						

(Continued Next Page)

BRAUN INTERTEC

This boring was taken by Braun Intertec under a consultant contract for Mn/DOT

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2118SB**	**837.8** (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
			POORLY GRADED SAND, fine- to medium-grained, gray, waterbearing, medium dense to very dense. (SP), outwash *(continued)* With Gravel at 100 feet.		32					
				PD						
95					52					
				PD						
100					41					
105				PD						
	109.0 / 728.8		SANDY LEAN CLAY, trace Gravel, gray, wet, hard. (CLS), till							
110					50					
115				PD						
120	121.0 / 716.8				67					

Bottom of Hole - 121 feet.
Water level obscured due to drilling fluids used during mud rotary drilling operation.
Boring immediately backfilled with bentonite grout.

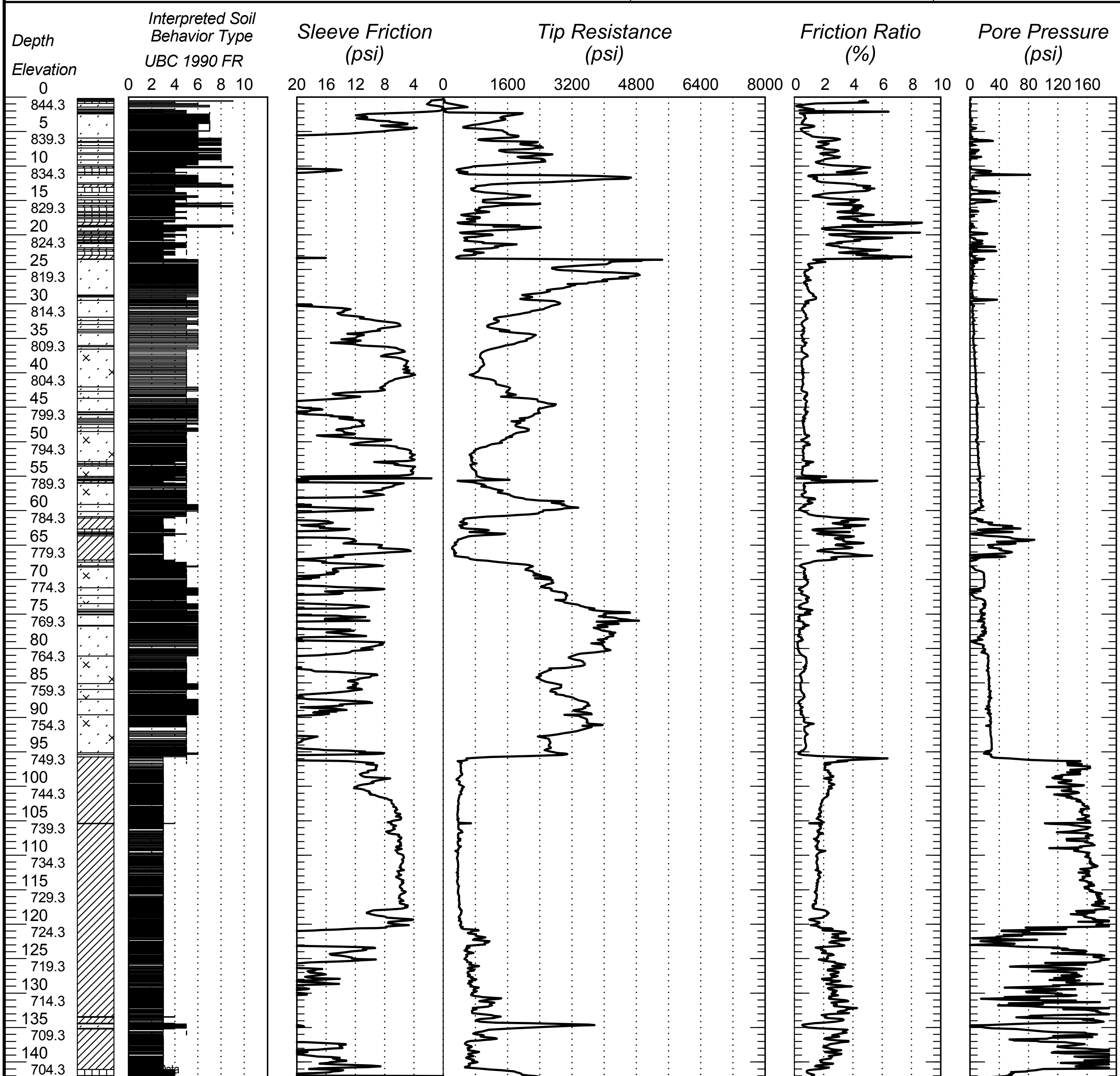
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	2105CW	844.3 (Surveyed)

Location		CPT Machine CPT-1	SHEET 1 of 2
Co. Coordinate: X=484480 Y=125283 (ft.)		CPT Operator	Date Completed
Latitude (North)=	Longitude (West)=	Hole Type CPT-STD/PWP-DISS	5/12/14
No Station-Offset Information Available			



Index Sheet Code

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METROPOLITAN COUNCIL

BRAUN INTERTEC

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	2105CW	844.3 (Surveyed)

Mn/DOT GEOTECHNICAL SECTION - CONE PENETRATION TEST RESULTS

Depth / Elevation	Interpreted Soil Behavior Type UBC 1990 FR	Sleeve Friction (psi)	Tip Resistance (psi)	Friction Ratio (%)	Pore Pressure (psi)
	0 2 4 6 8 10	20 16 12 8 4 0	1600 3200 4800 6400 8000	0 2 4 6 8 10	0 40 80 120 160

Bottom of Hole 142.41

METROPOLITAN COUNCIL

BRAUN INTERTEC

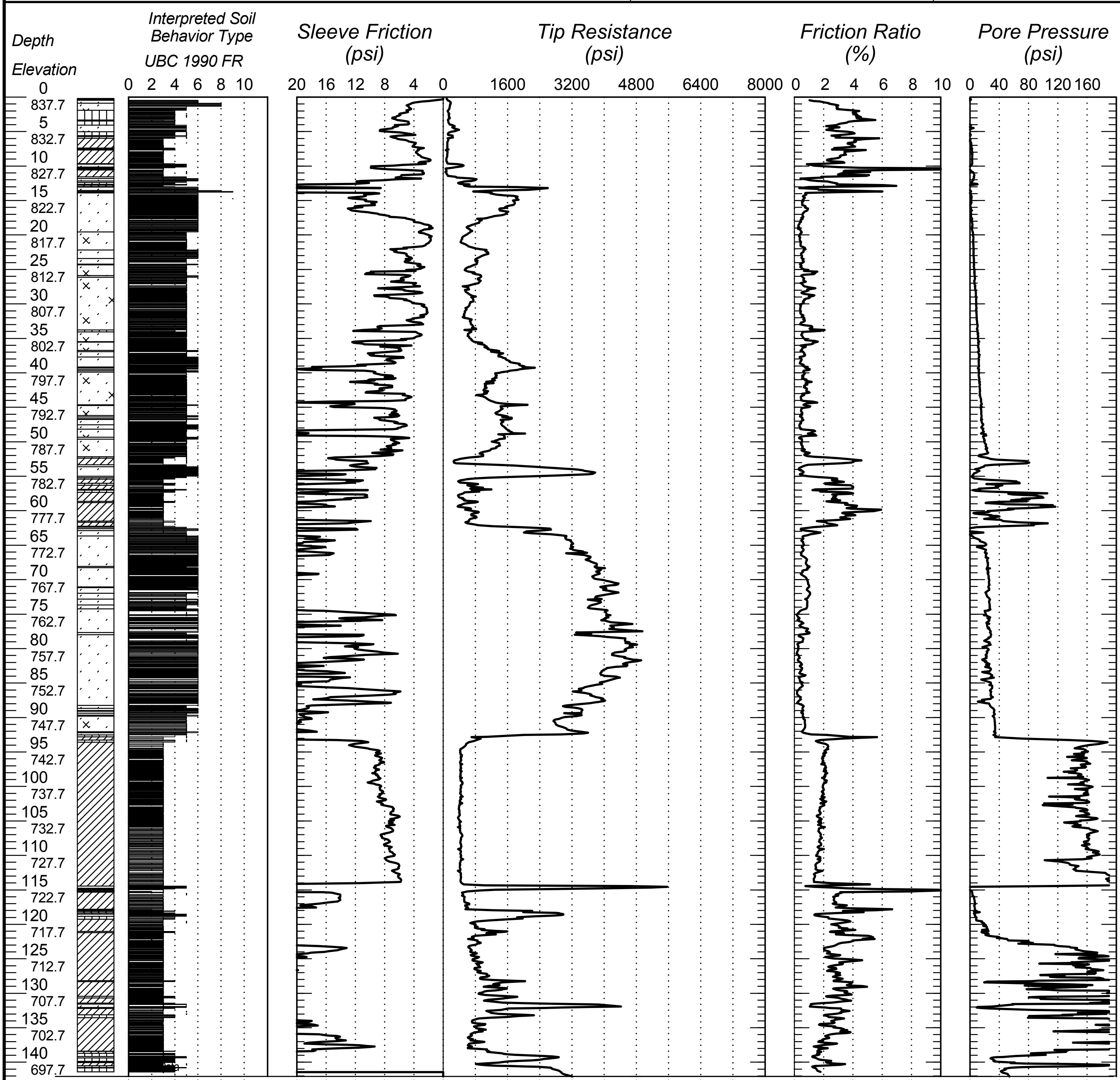
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	**2106CW**	**837.7** (Surveyed)

Location **Co. Coordinate: X=484537 Y=125277** (ft.)	CPT Machine **CPT-1**	SHEET 1 of 2
Latitude (North)= Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available	Hole Type **CPT-STD/PWP-DISS**	**5/12/14**



Index Sheet Code

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 7/28/14

N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213-MNDOT-CPT-DXF.GPJ

METROPOLITAN COUNCIL

BRAUN INTERTEC

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Sounding No.*	*Ground Elevation*
		SWLRT	**2106CW**	**837.7** *(Surveyed)*

Mn/DOT GEOTECHNICAL SECTION - CONE PENETRATION TEST RESULTS

Depth *Elevation*	*Interpreted Soil Behavior Type* *UBC 1990 FR*	*Sleeve Friction (psi)*	*Tip Resistance (psi)*	*Friction Ratio (%)*	*Pore Pressure (psi)*
	0 2 4 6 8 10	20 16 12 8 4 0	1600 3200 4800 6400 8000	0 2 4 6 8 10	0 40 80 120 160

Bottom of Hole 142.08

Soil Class: Rock Class: Edit: Date: 7/28/14
N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213-MNDOT-CPT-DXF.GPJ

METROPOLITAN COUNCIL

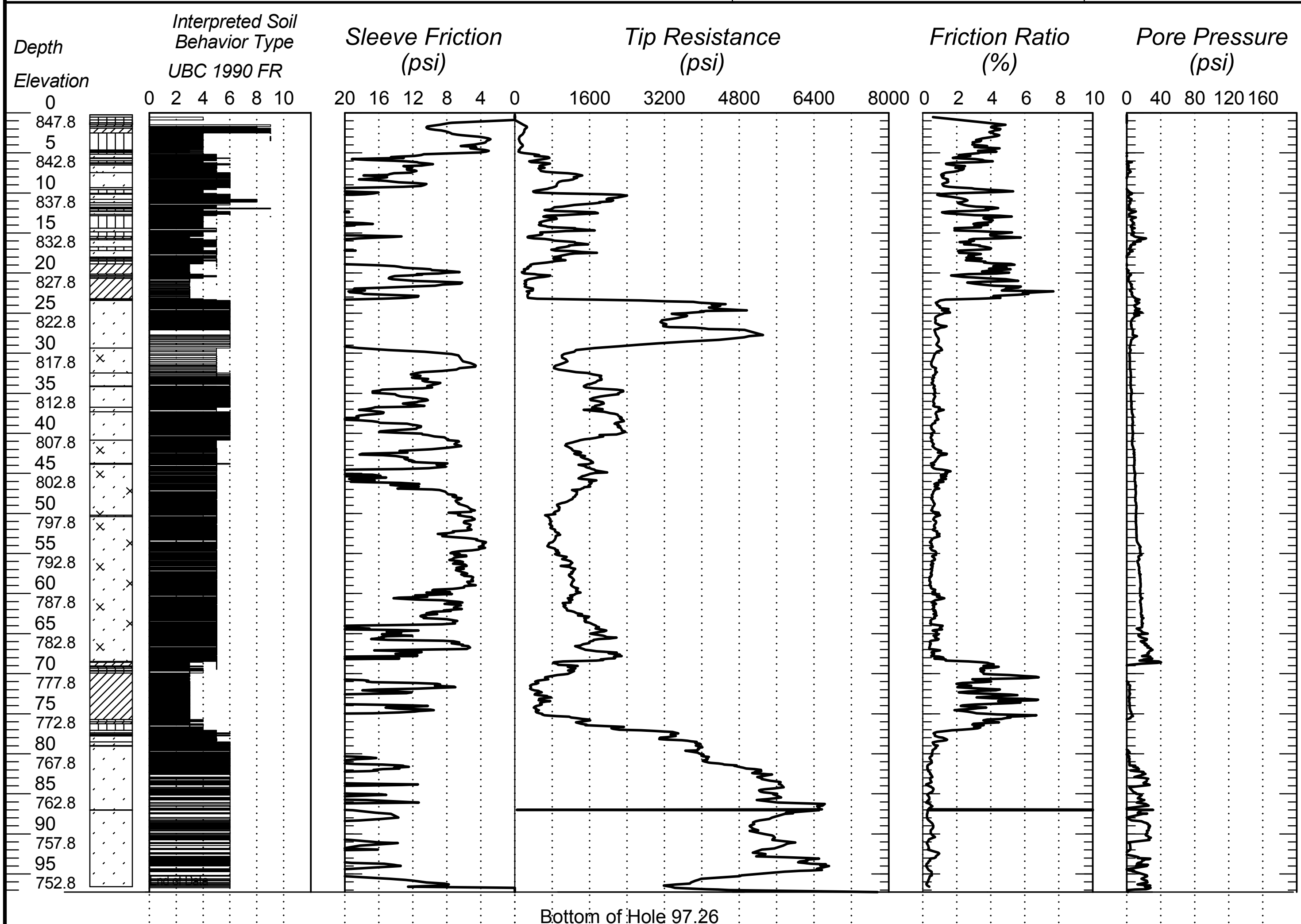
BRAUN℠ INTERTEC

MINNESOTA DEPARTMENT OF TRANSPORTATION

CONE PENETRATION TEST RESULTS
UNIQUE NUMBER
U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	2107CB	847.8 (Surveyed)

Location Co. Coordinate: X=484566 Y=125333 (ft.)	CPT Machine CPT-1	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available	Hole Type CPT-STD/PWP-DISS	5/12/14



Index Sheet Code

Soil Class: Rock Class: Edit: Date: 7/28/14
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METROPOLITAN COUNCIL

BRAUN INTERTEC℠

CONE PENETRATION TEST RESULTS

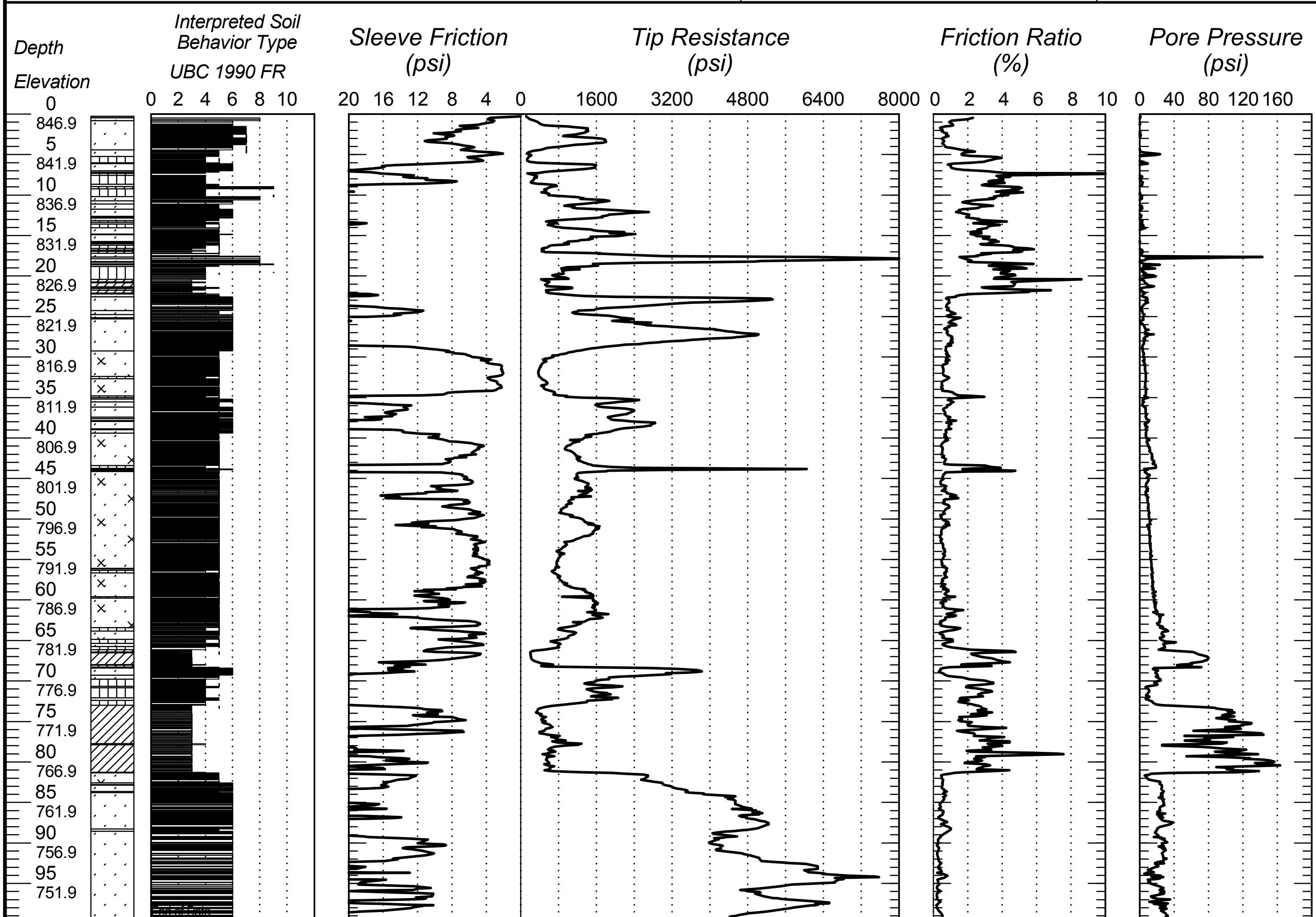
UNIQUE NUMBER

U.S. Customary Units

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	**2108CB**	**846.9** (Surveyed)

Location **Co. Coordinate: X=484692 Y=125400** (ft.)	CPT Machine **CPT-1**	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available	Hole Type **CPT-STD/PWP-DISS**	**5/12/14**



Bottom of Hole 99.83

Index Sheet Code

Soil Class: Rock Class: Edit: Date: 7/28/14
N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213-MNDOT-CPT-DXF.GPJ

METROPOLITAN COUNCIL

BRAUN INTERTEC

CONE PENETRATION TEST RESULTS

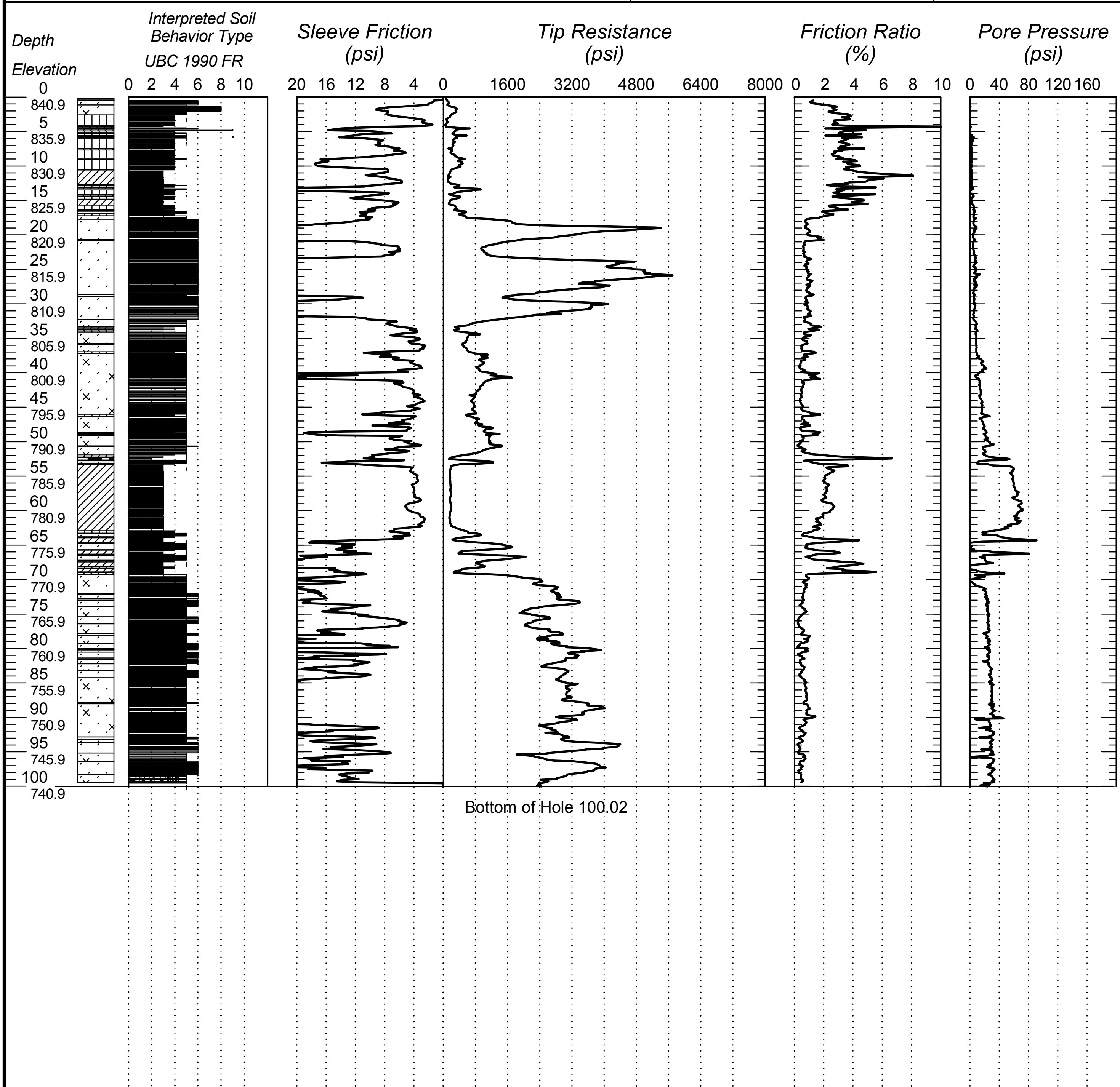
UNIQUE NUMBER

U.S. Customary Units

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	2109CB	840.9 (Surveyed)

Location				
Co. Coordinate: X=484758 Y=125406 (ft.)		CPT Machine	CPT-1	SHEET 1 of 1
Latitude (North)=	Longitude (West)=	CPT Operator		Date Completed
No Station-Offset Information Available		Hole Type	CPT-STD/PWP-DISS	5/12/14



Index Sheet Code

Soil Class: Rock Class: Edit: Date: 7/28/14

N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213-MNDOT-CPT-DXF.GPJ

METROPOLITAN COUNCIL

BRAUN[SM] **INTERTEC**

CONE PENETRATION TEST RESULTS

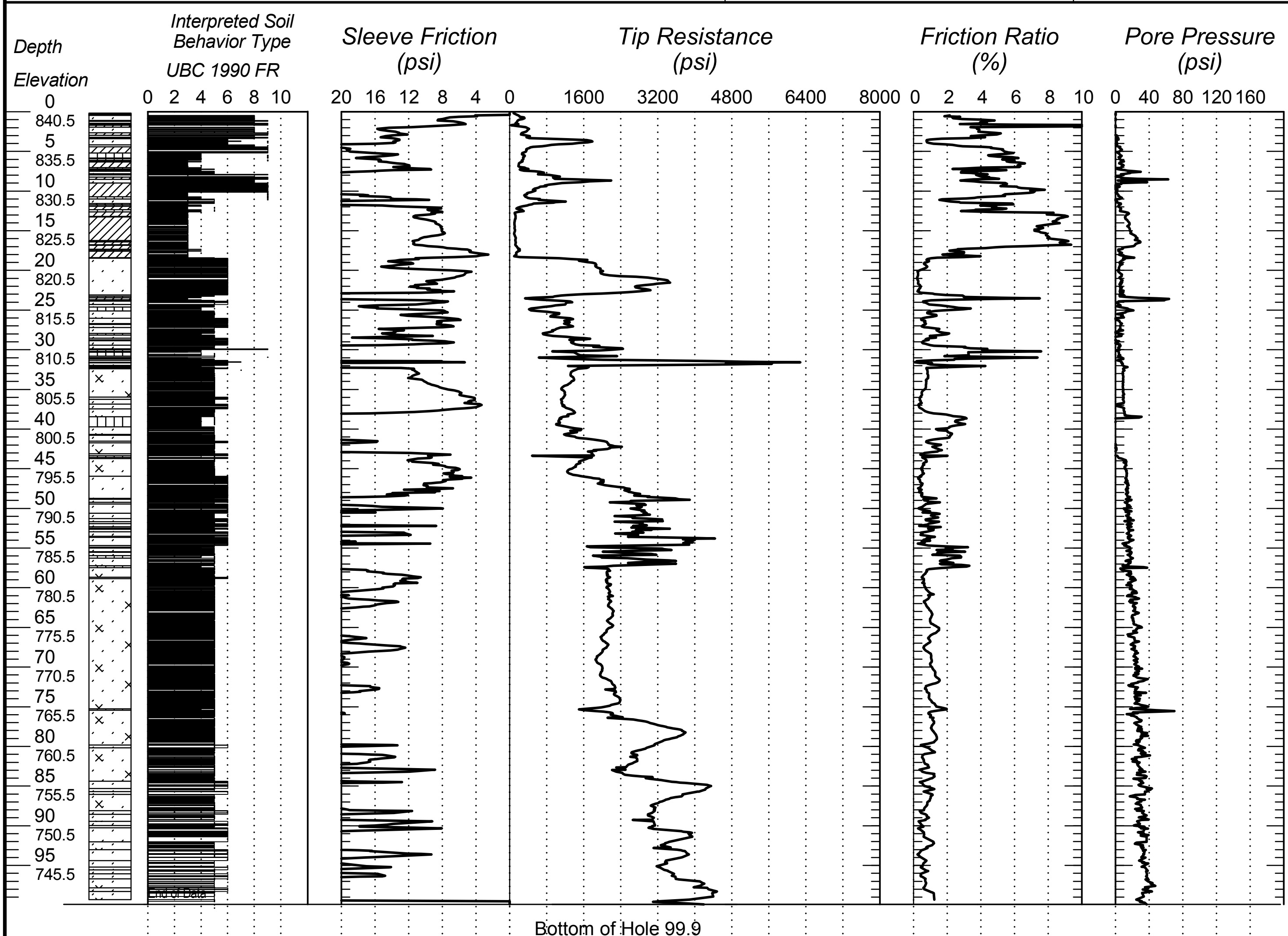
UNIQUE NUMBER

U.S. Customary Units

MINNESOTA DEPARTMENT OF TRANSPORTATION

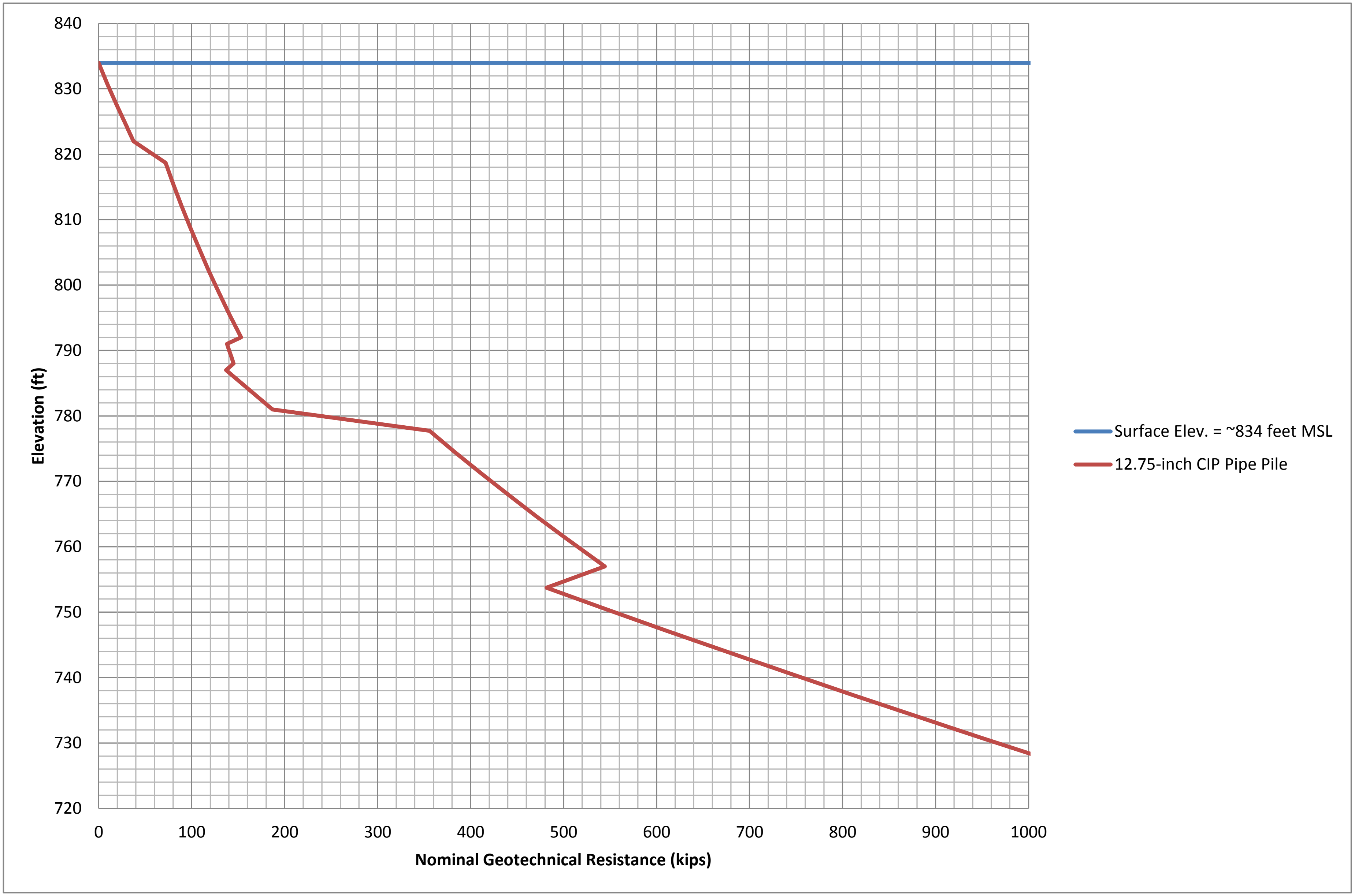
State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	**2110CB**	**840.5** *(Surveyed)*

Location **Co. Coordinate: X=484958 Y=125289** (ft.) *Latitude (North)=* *Longitude (West)=* No Station-Offset Information Available	*CPT Machine* **CPT-1** *CPT Operator* *Hole Type* **CPT-STD/PWP-DISS**	*SHEET 1 of 1* *Date Completed* **5/12/14**

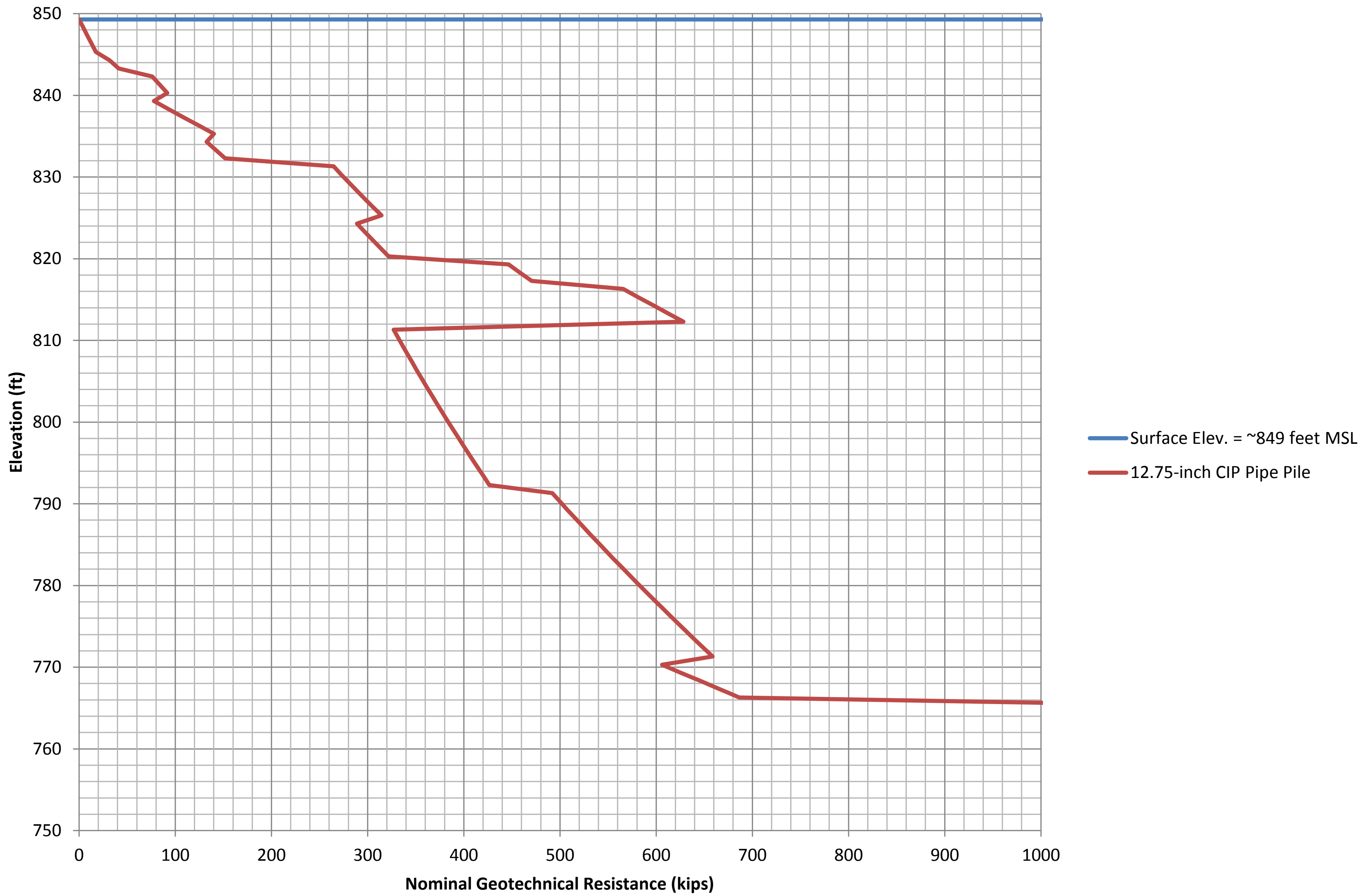


Index Sheet Code

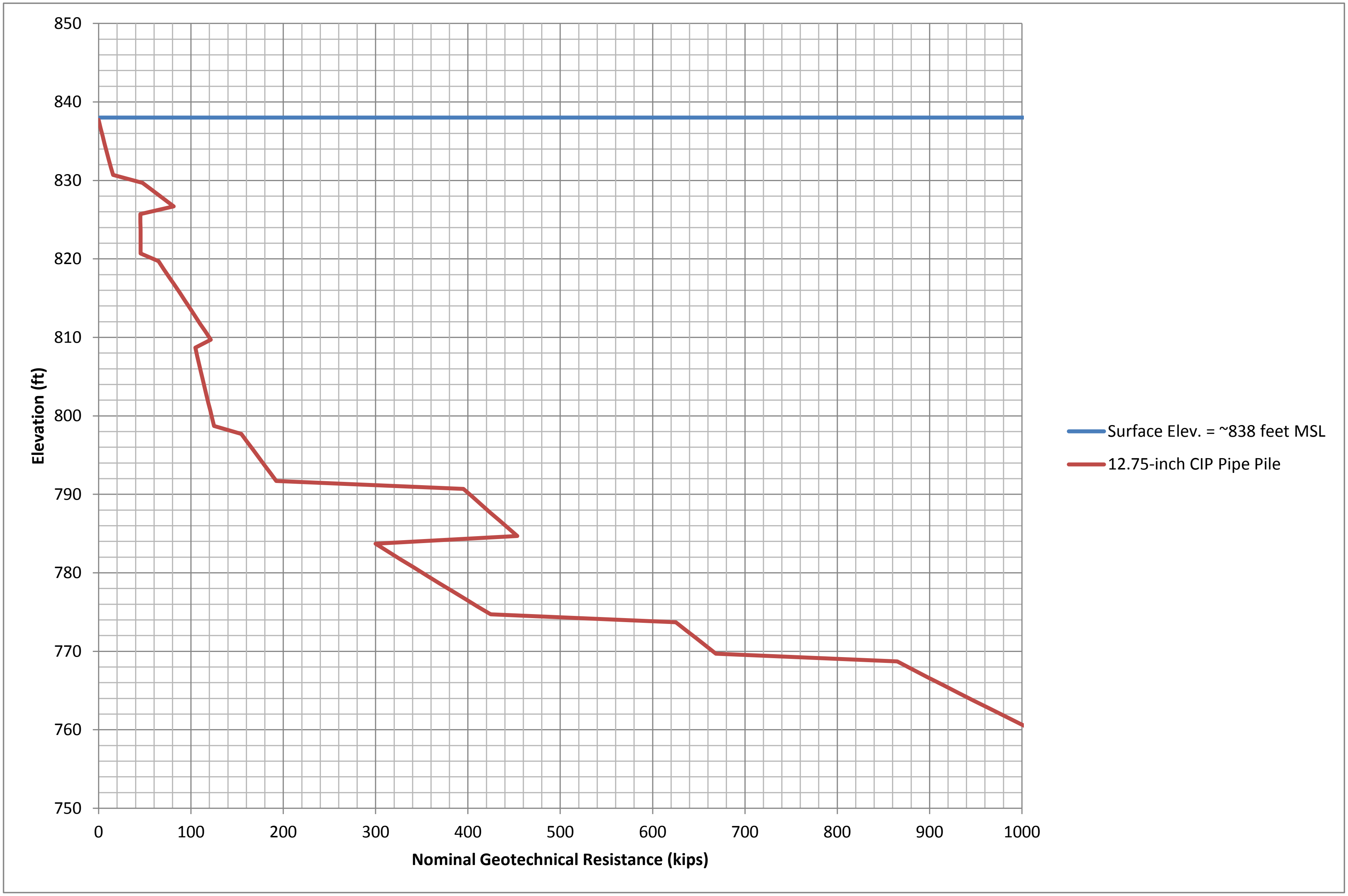
Southwest Station Area
Boring: 2104SB
12.75-inch Closed Ended Pipe Pile



Southwest Station Area
Boring: 2093SB
12.75-inch Closed Ended Pipe Pile



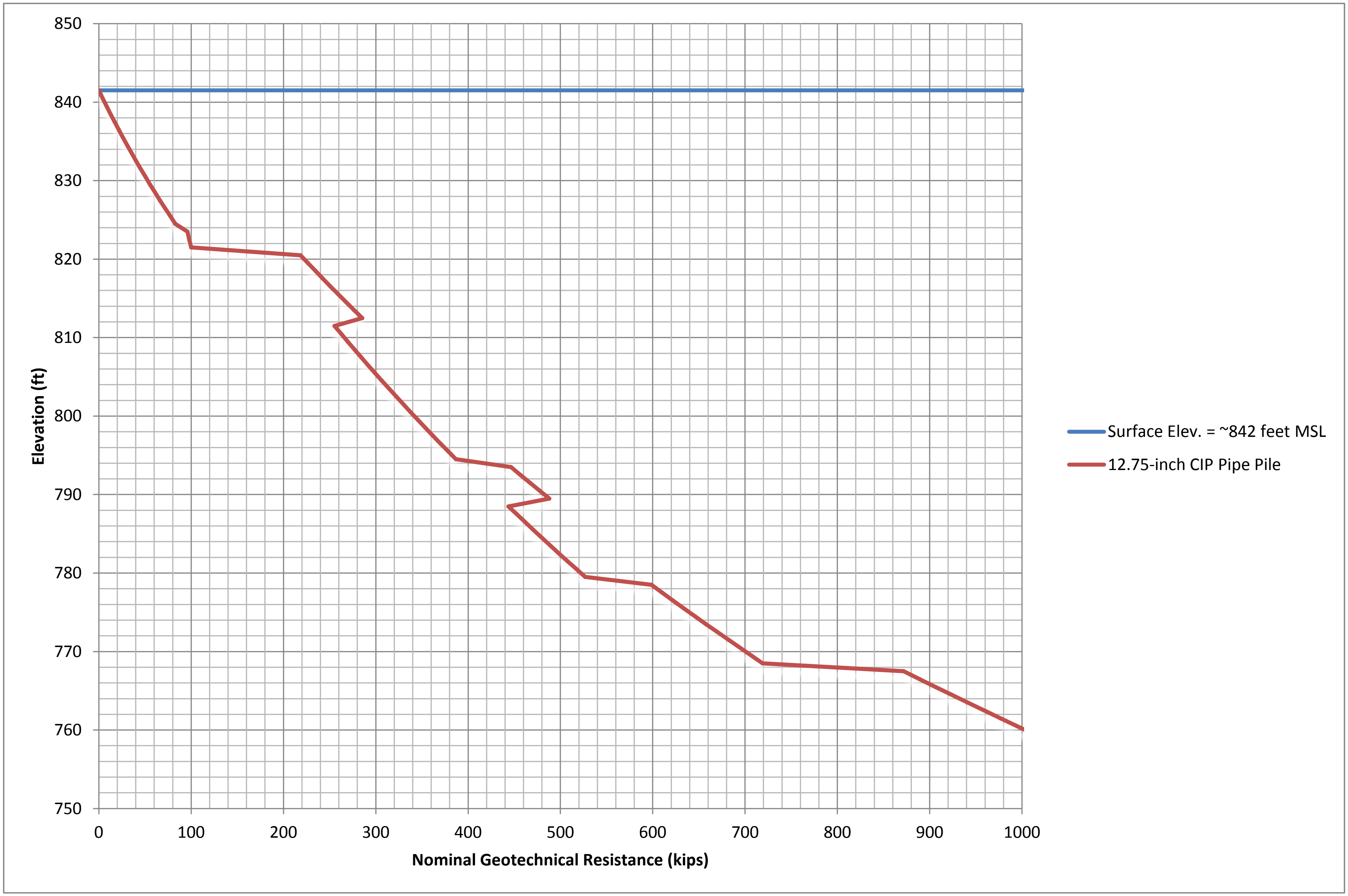
Southwest Station Area
Boring: 2094SB
12.75-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

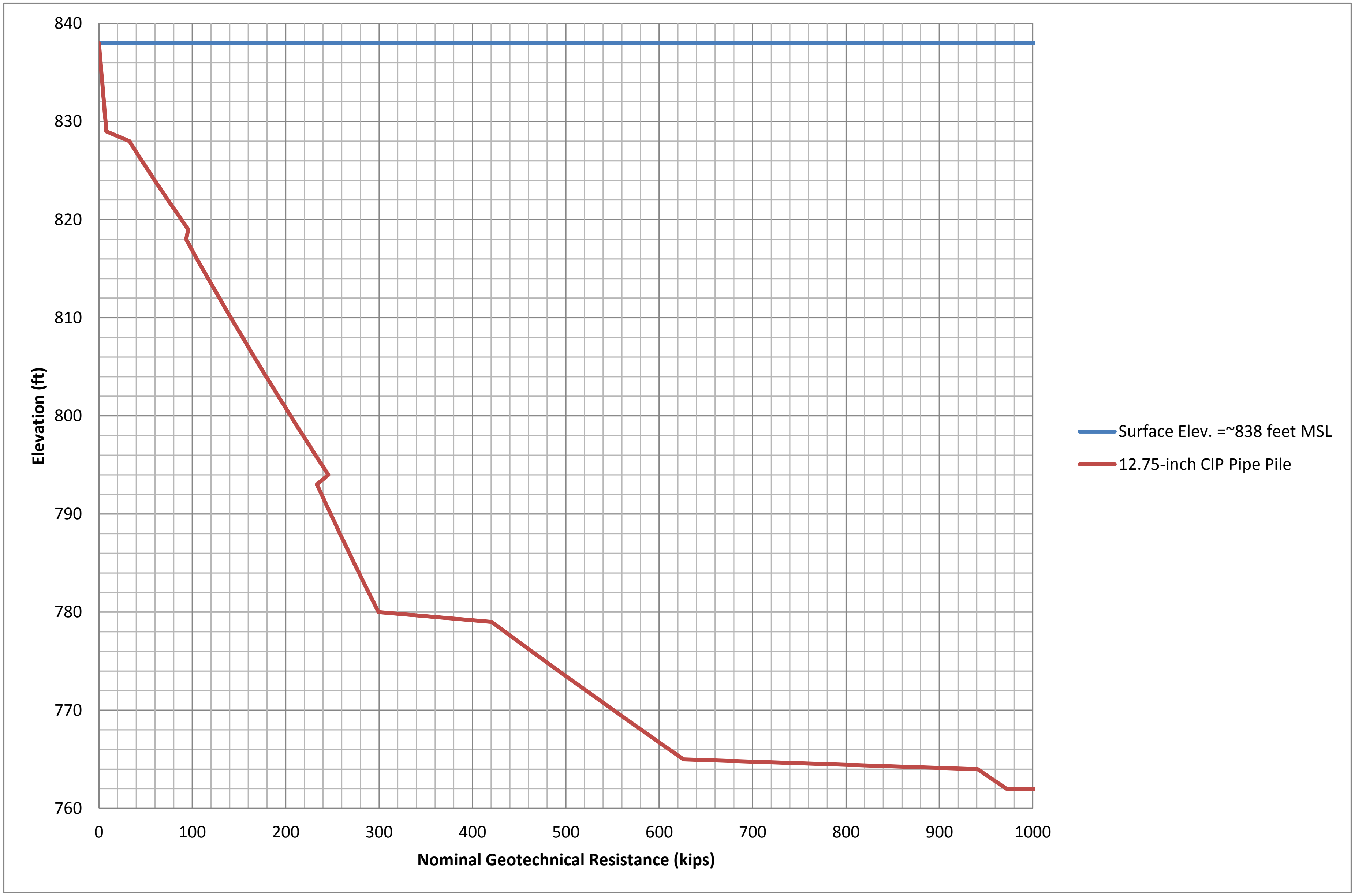
BRAUN INTERTEC

Southwest Station Area
Boring: 2095SB
12.75-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

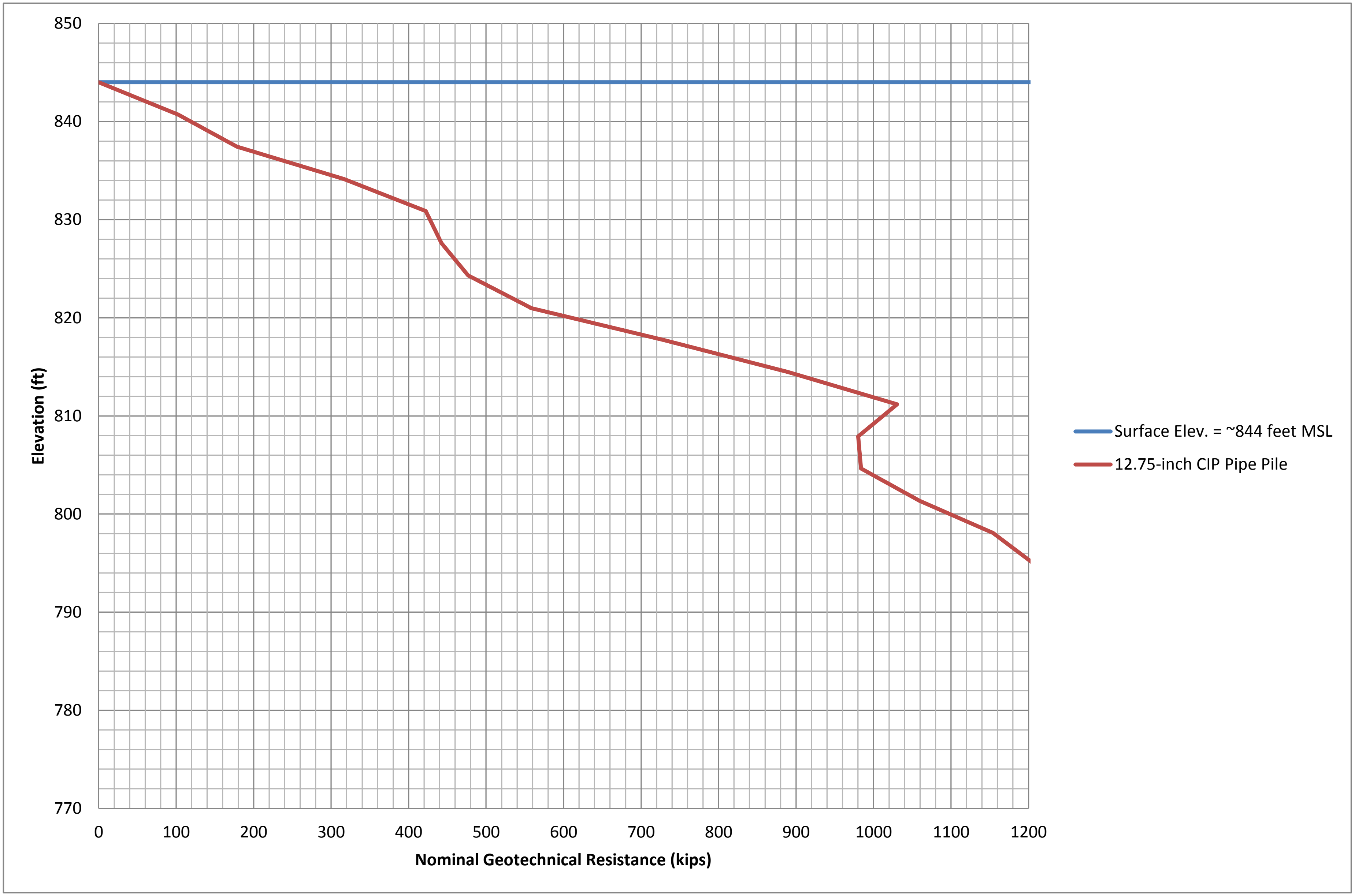
Southwest Station Area
Boring: 2118SB
12.75-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

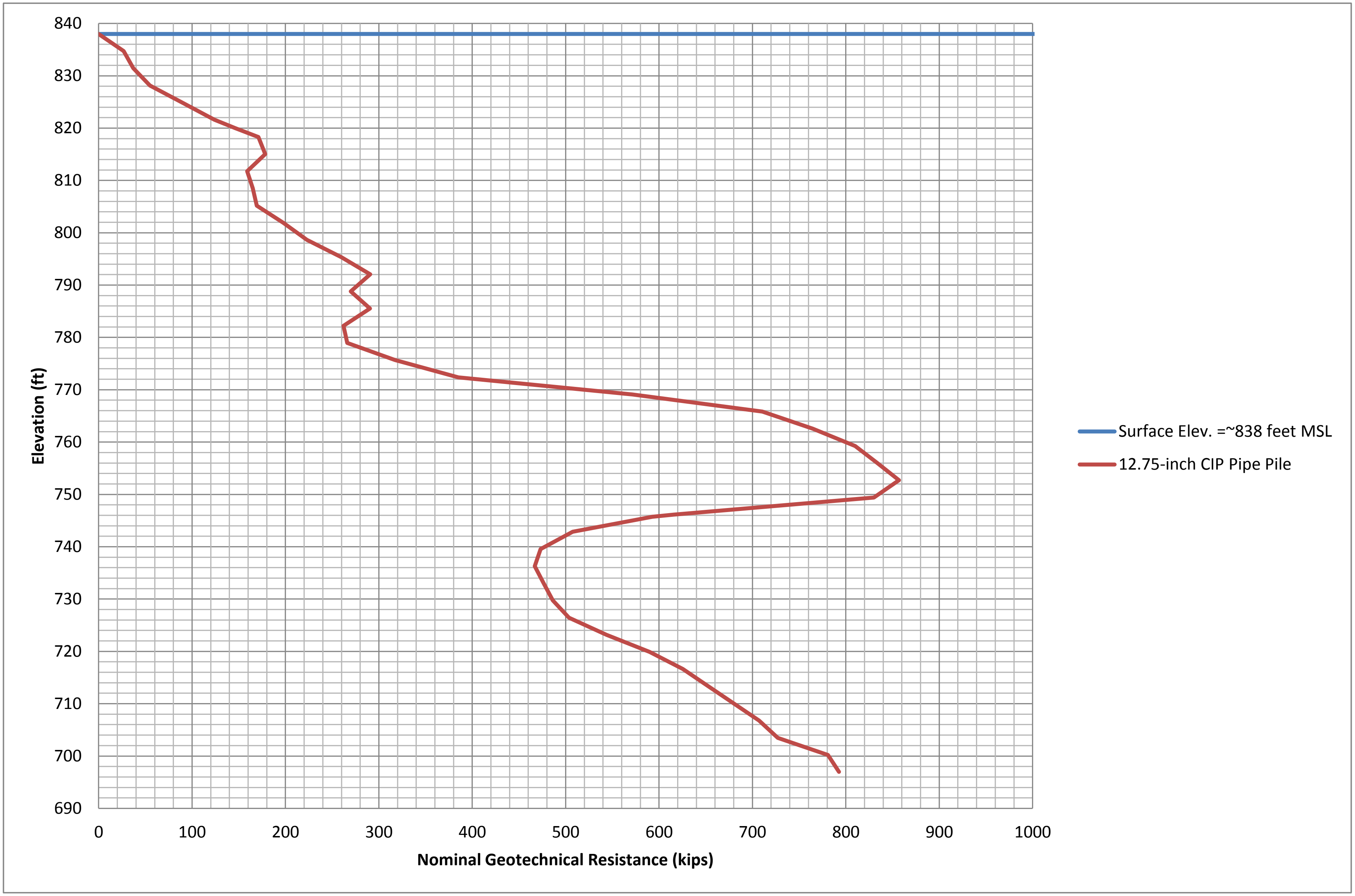
BRAUN INTERTEC

Southwest Station Area
Sounding: 2105CB
12.75-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

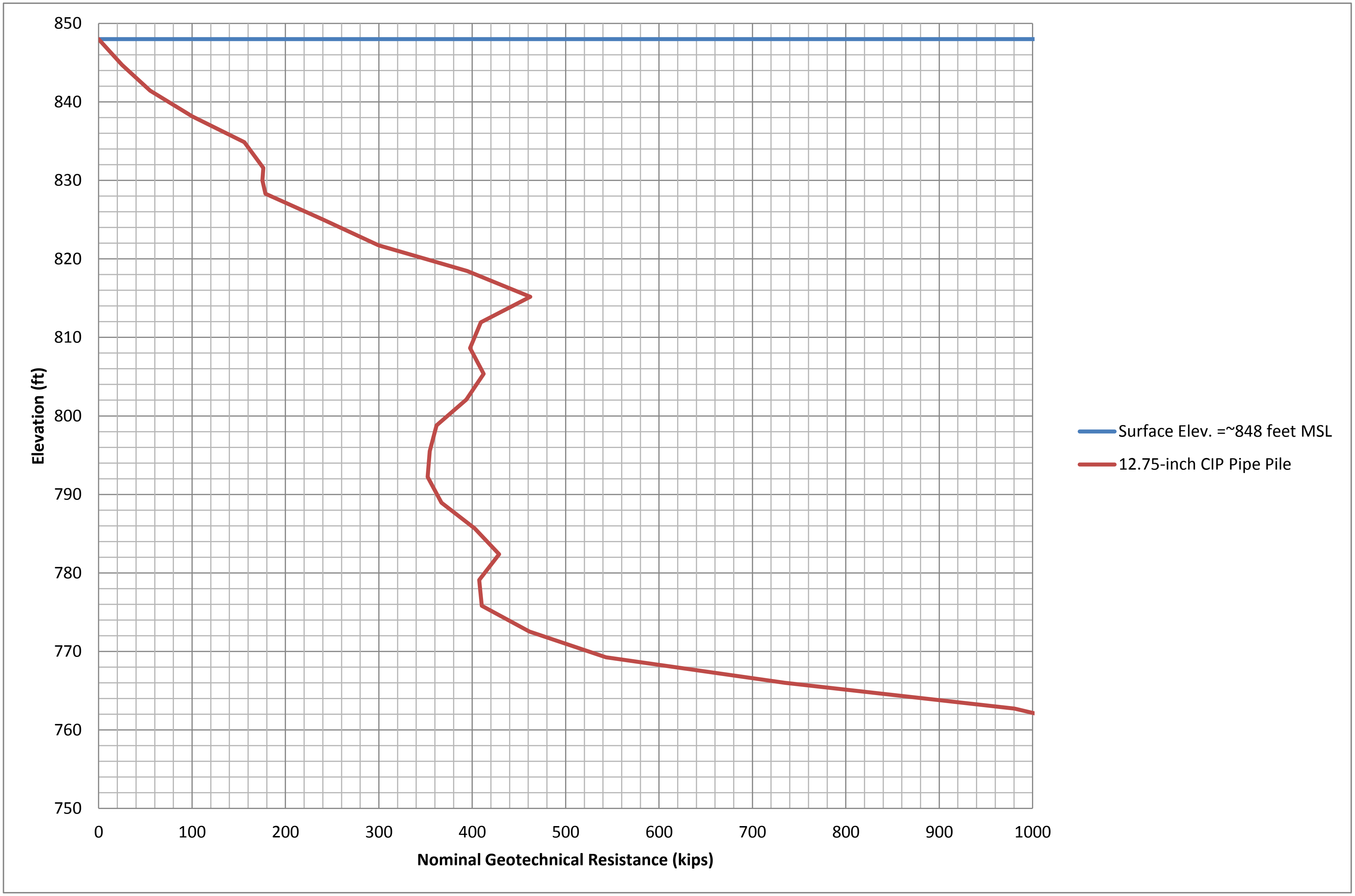
Southwest Station Area
Sounding: 2106CB
12.75-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

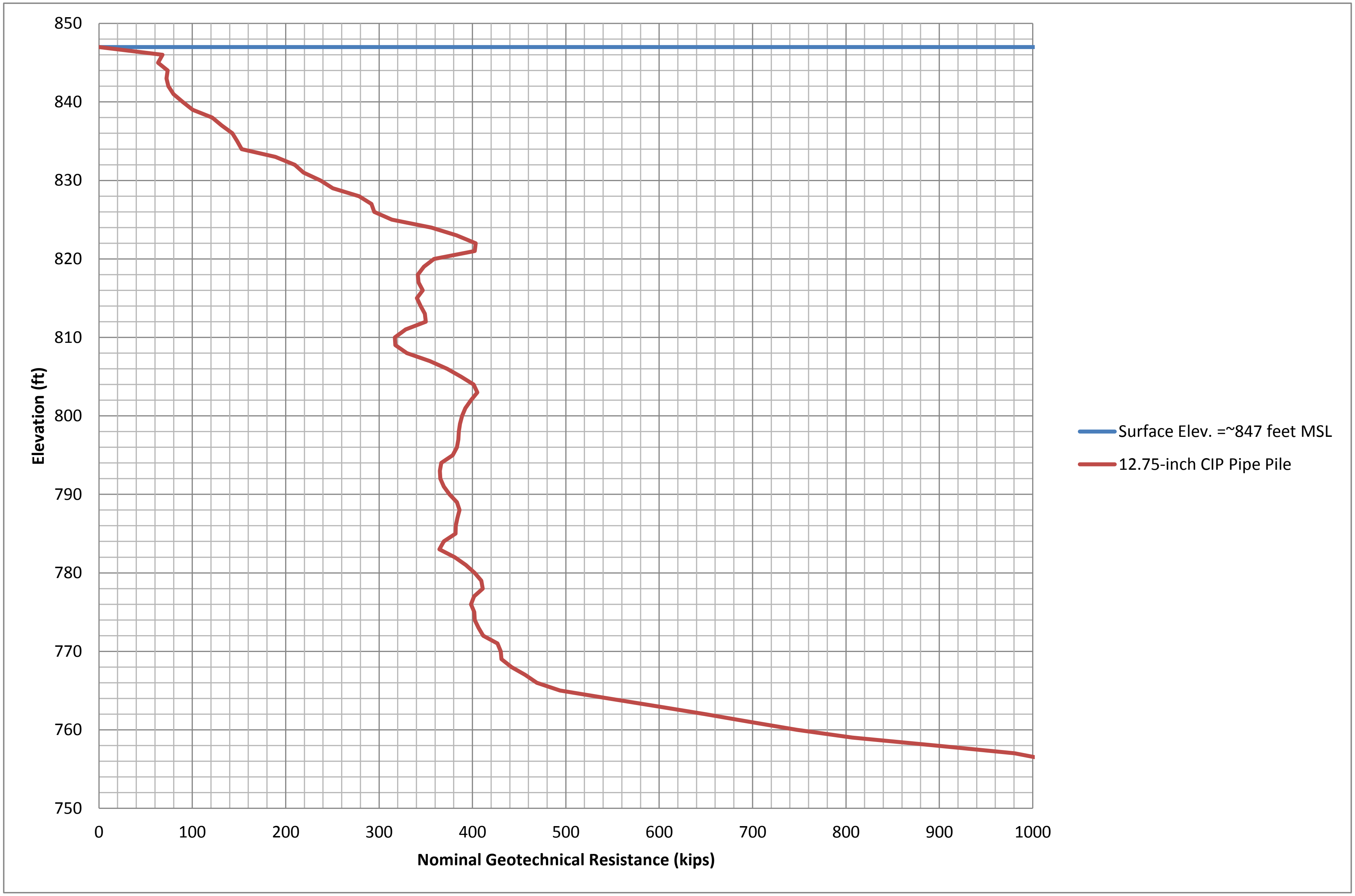
BRAUN INTERTEC

Southwest Station Area
Sounding: 2107CB
12.75-inch Closed Ended Pipe Pile



BRAUN INTERTEC

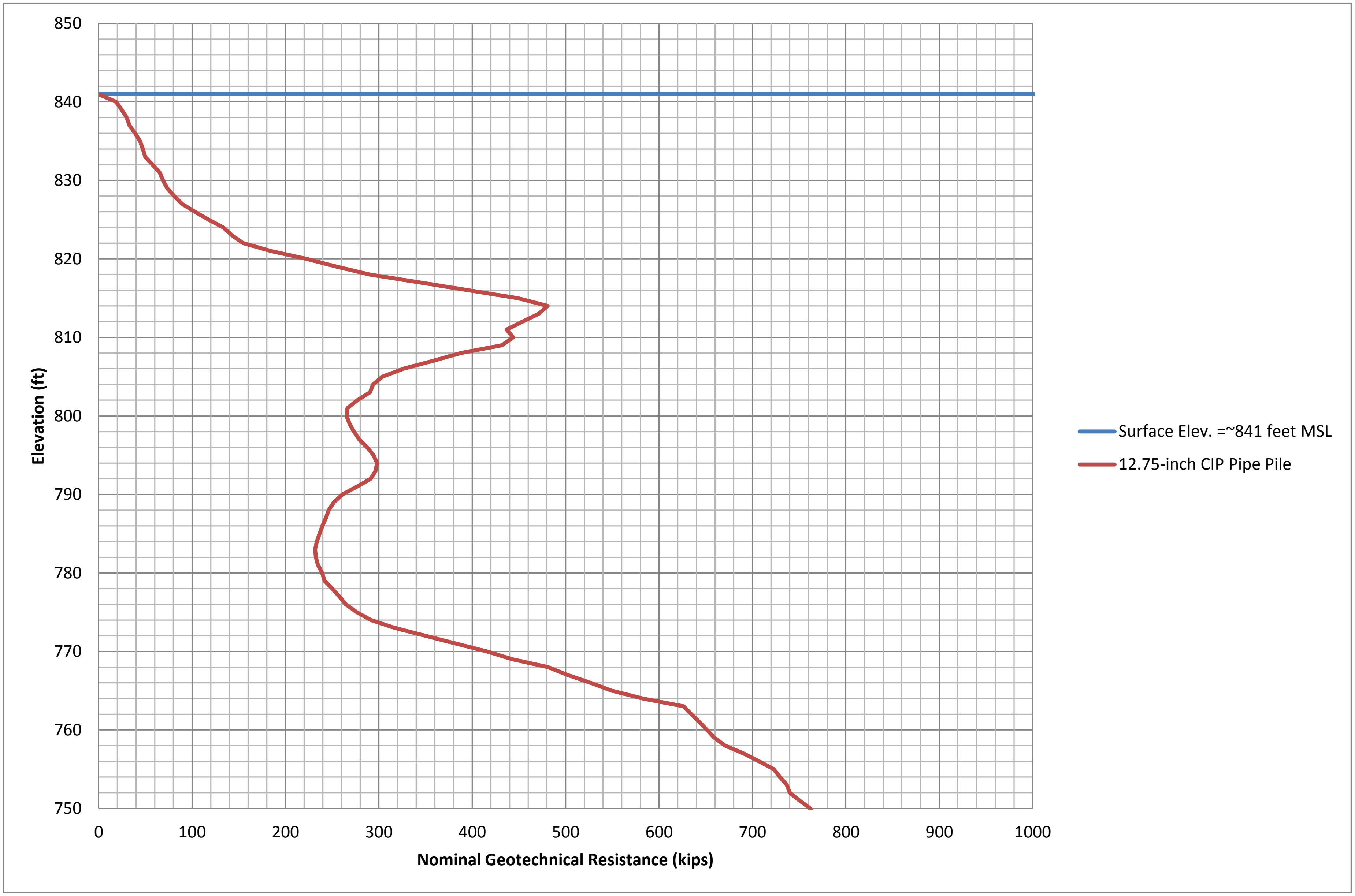
Southwest Station Area
Sounding: 2108CW
12.75-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

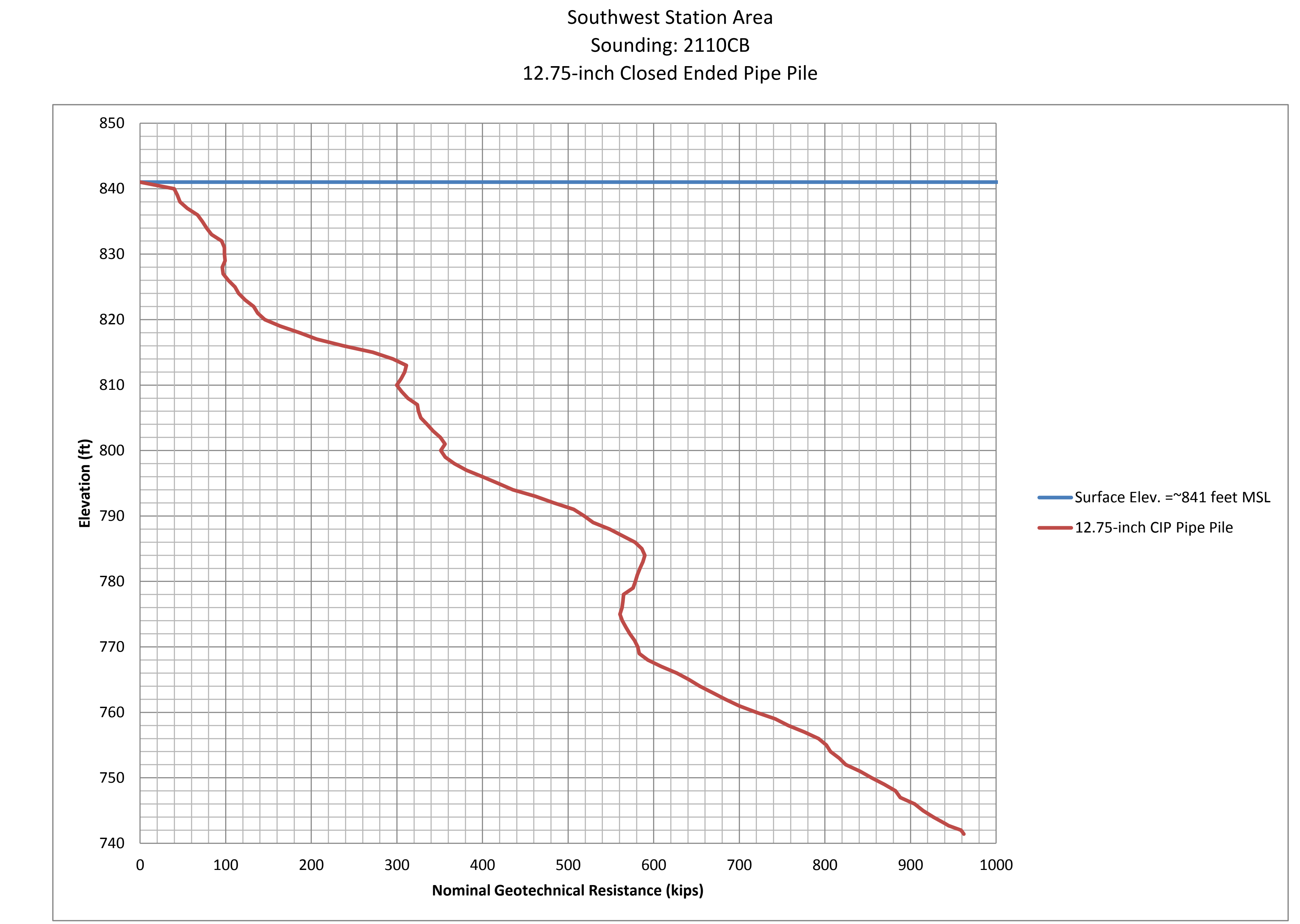
BRAUN INTERTEC

Southwest Station Area
Sounding: 2109CB
12.75-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

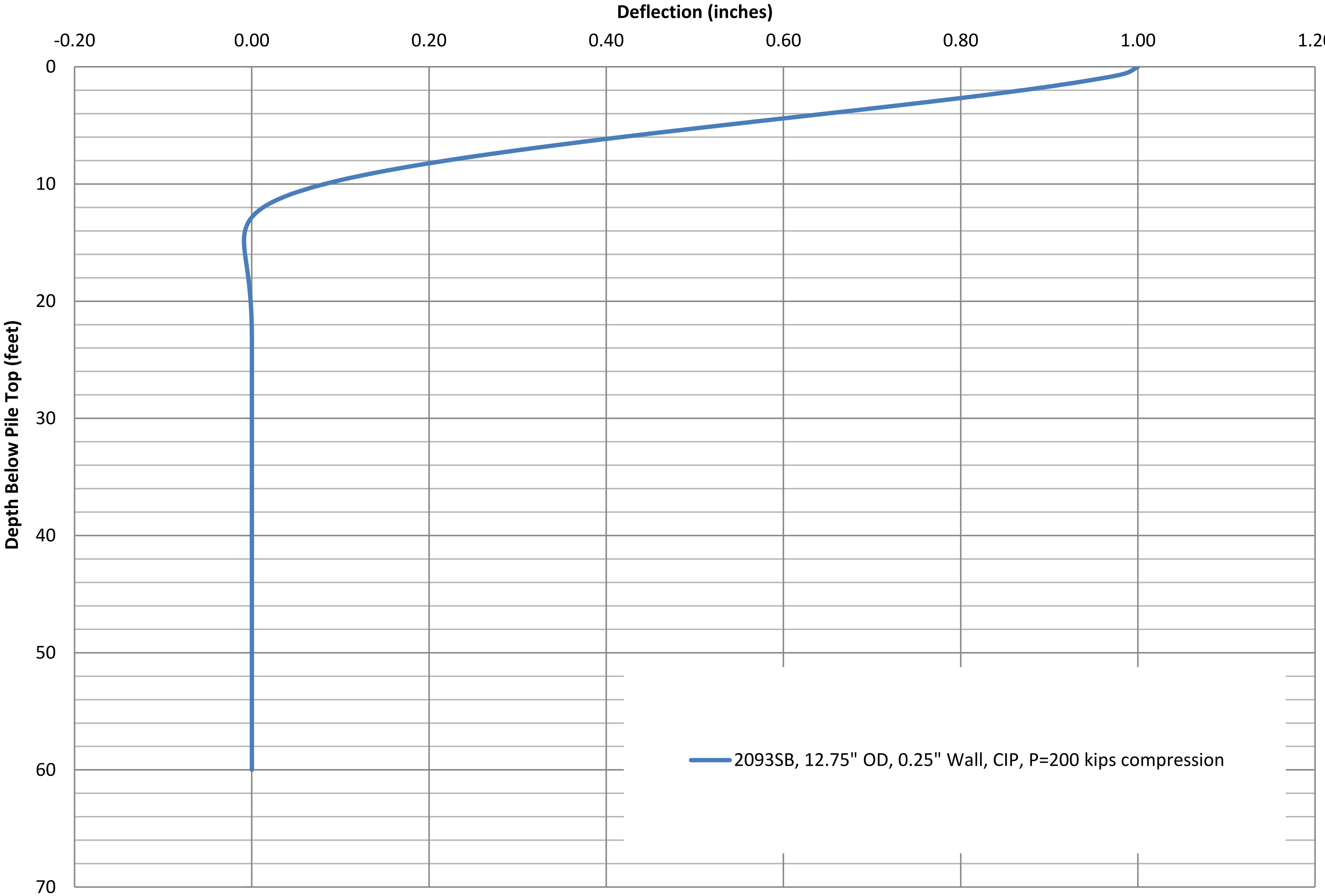
BRAUN INTERTEC

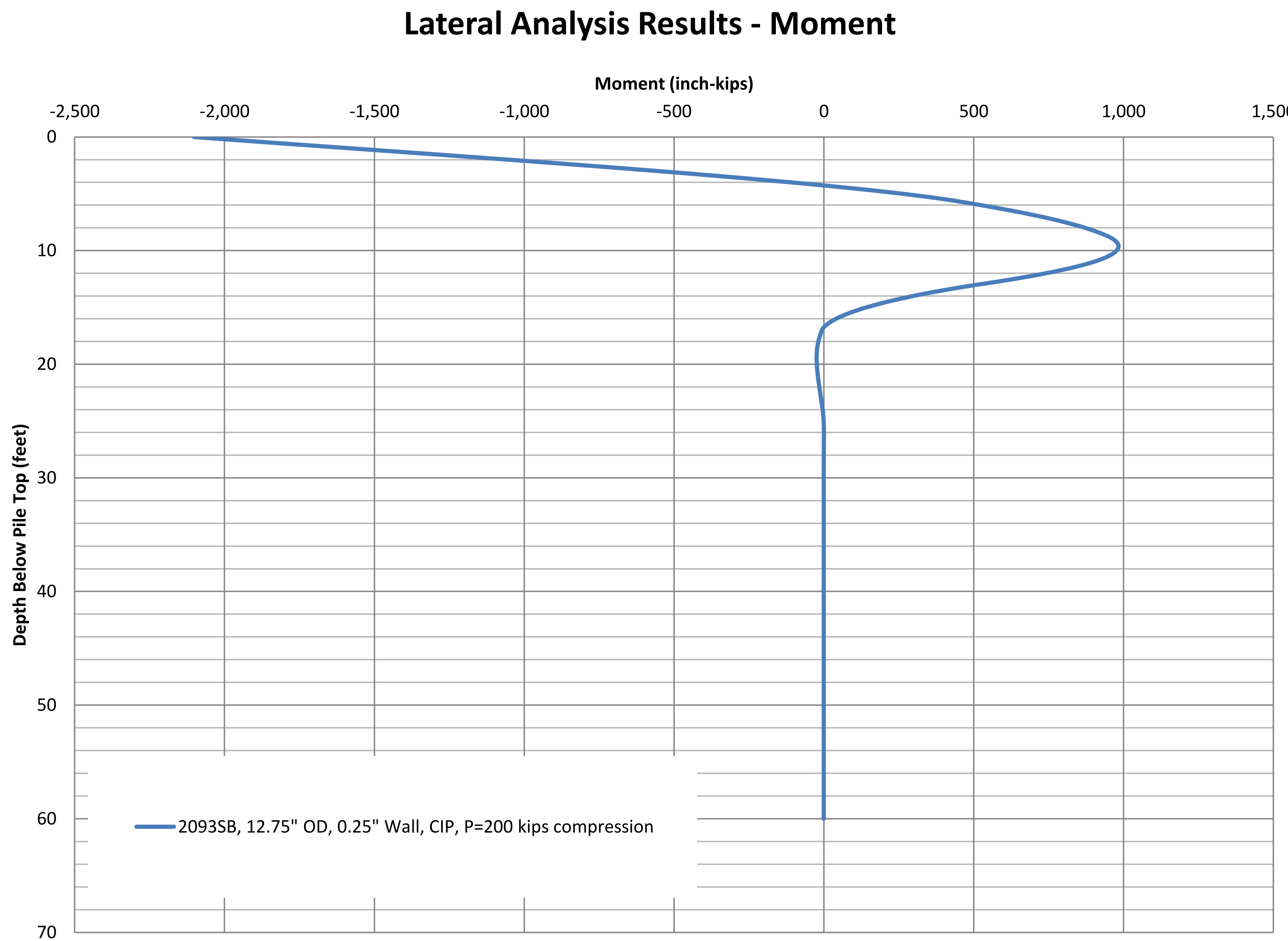


Braun Project No. BL-13-00213

BRAUN INTERTEC

Lateral Analysis Results - Deflection



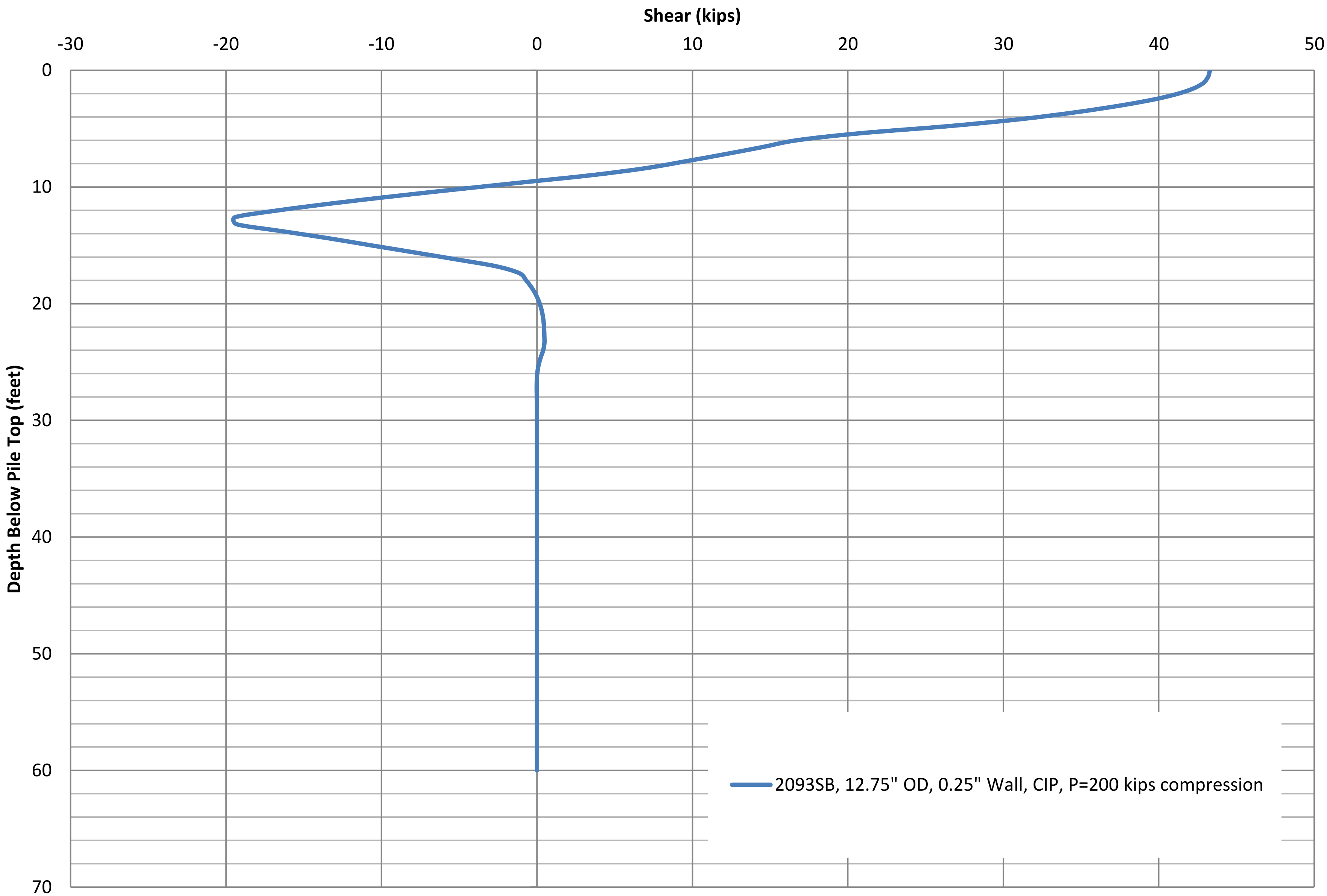


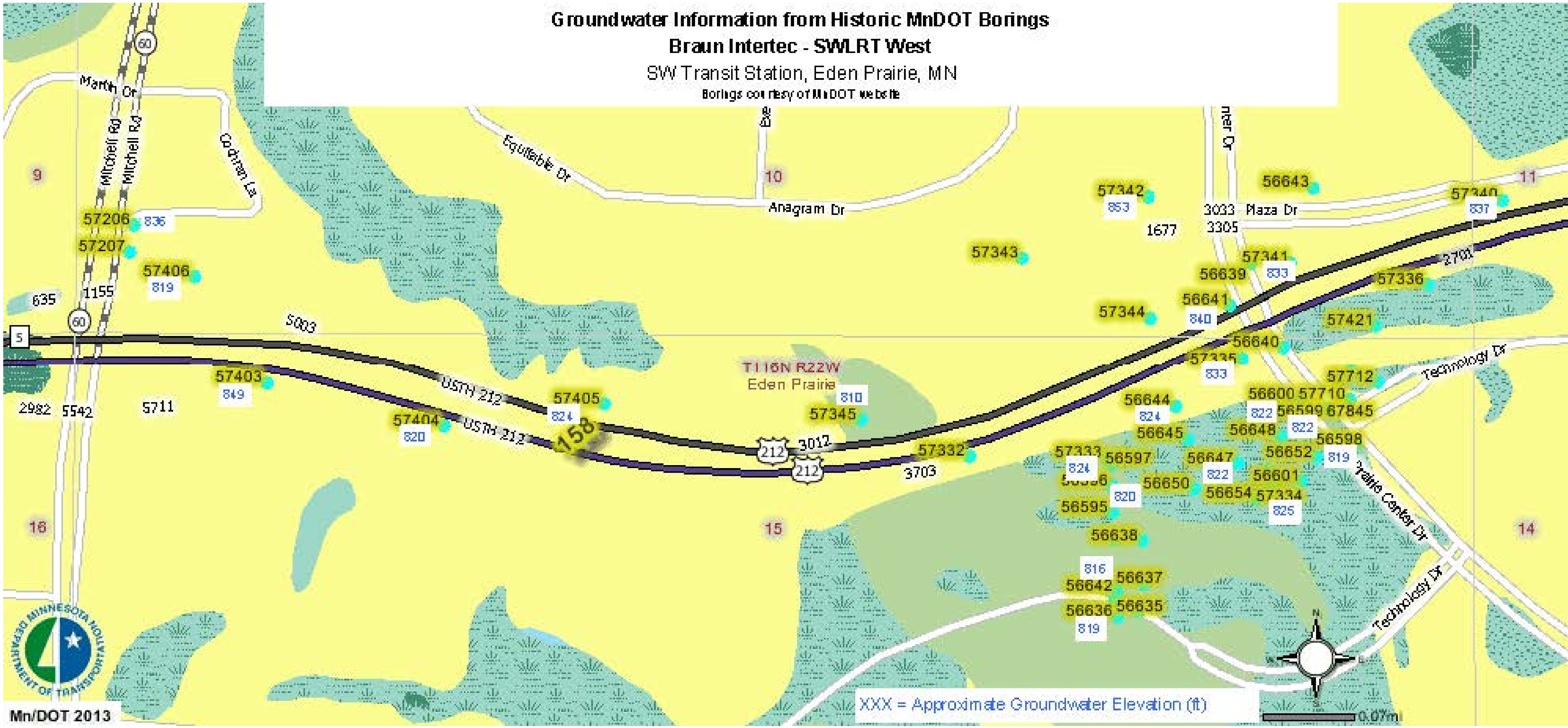
BL-13-00213
7/25/2014

SWLRT
SW Station

BRAUN INTERTEC

Lateral Analysis Results - Shear




Groundwater Information from Historic MnDOT Borings
Braun Intertec - SWLRT West
SW Transit Station, Eden Prairie, MN
Borings courtesy of MnDOT website
XXX = Approximate Groundwater Elevation (ft)
Mn/DOT 2013
0.07mi
T116N R22W
Eden Prairie
Martin Dr
Mitchell Rd
Mitchell Rd
Cochran La
Equitable Dr
Anagram Dr
Plaza Dr
Technology Dr
Prairie Center Dr
USTH 212
USTH 212
57206
836
57207
57406
819
57403
849
57405
824
57404
820
57345
810
57332
57342
853
57343
57344
56643
57340
837
57341
833
56639
56641
840
57336
57421
56640
57335
833
57712
56600
57710
822
56599
67845
56644
824
56645
56648
822
56598
57333
824
56597
56647
822
56652
819
56650
820
56654
56601
57334
825
56595
56638
816
56642
56637
56636
56635
819
9
10
11
16
15
14
5003
3012
3703
2701
3033
3305
1677
1155
635
2982
5542
5711

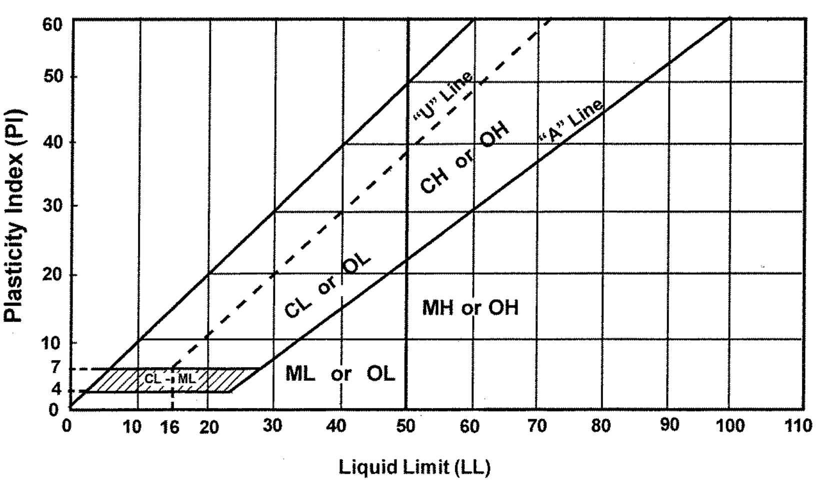
BRAUN INTERTEC

Descriptive Terminology of Soil

Standard D 2487 - 00
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels 5% or less fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands 5% or less fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	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]
				OL	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]
				OH	Organic silt [k l m q]
Highly Organic Soils		Primarily organic matter, dark in color and organic odor		PT	Peat

a. Based on the material passing the 3-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. 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
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines" to group name.
h. If soil contains ≥ 15% gravel, add "with gravel" to group name.
i. 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
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 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.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcf	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liqiuid limit, %	**C**	Cohesion, psf
PL	Plastic limit, %	∅	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders .... over 12"
Cobbles .... 3" to 12"
Gravel
Coarse .... 3/4" to 3"
Fine .... No. 4 to 3/4"
Sand
Coarse .... No. 4 to No. 10
Medium .... No. 10 to No. 40
Fine .... No. 40 to No. 200
Silt ....< No. 200, PI< 4 or below "A" line
Clay ....< No. 200, PI≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose .... 0 to 4 BPF
Loose .... 5 to 10 BPF
Medium dense .... 11 to 30 BPF
Dense .... 31 to 50 BPF
Very dense .... over 50 BPF

Consistency of Cohesive Soils

Very soft .... 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff .... 17 to 30 BPF
Hard .... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers unless noted otherwise, Jetting water was used to clean out auger prior to sampling only where indicated on logs. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous-flight, solid-stem augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface and are, therefore, somewhat approximate. Power auger borings are designated by the prefix "B."

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn. Hand auger borings are indicated by the prefix "H."

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

BRAUN INTERTEC

Descriptive Terminology
Cone Penetration Test

This document accompanies Cone Penetration Test Data. Please refer to the Boring Log Descriptive Terminology Sheet for information relevant to conventional v. Cone Penetration Test (CPT) boring logs.

Cone Penetration Test (CPT) sounding was performed in general accordance with ASTM D 5778 and consistent with the ordinary degree of care and skill used by reputable practitioners of the same discipline currently practicing under similar circumstances and in the same locality. No warranty, express or implied, is made.

Since subsurface conditions outside each CPT sounding are unknown, and soil, rock and pore water conditions cannot be relied upon to be consistent or uniform, no warranty is made that conditions adjacent to each sounding will necessarily be the same as or similar to those shown on this log. Braun Intertec is not responsible for any interpretations, assumptions, projections or interpolations of the data made by others.

Pore water pressure measurements and subsequently interpreted water levels shown on CPT logs should be used with discretion as they represent dynamic conditions. Dynamic pore water pressure measurements may deviate substantially from hydrostatic conditions, especially in cohesive soils. In cohesive soils, pore water pressures often take an extended time to reach equilibrium and thus reflect their true field level. Groundwater levels can be expected to vary both seasonally and yearly. The absence of notations on this log regarding water does not necessarily mean that groundwater is not present to the depth explored, or that a contractor will not encounter groundwater during excavation or 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
Q_T........................normalized cone resistance
B_q........................pore pressure ratio
F_r..........................normalized friction ratio
σ_{vo}........................overburden pressure
σ'_{vo}.......................effective overburden pressure

q_T TIP RESISTANCE

The resistance at the cone corrected for water pressure. Data is from cone with a 60 degree apex angle and a 15 cm^2 end area.

f_s SLEEVE FRICTION RESISTANCE

The resistance along the sleeve of the penetrometer.

F_r Friction Ratio

Ratio of sleeve friction over corrected tip resistance.
$F_r = f_s/q_t$

V_s Shear Wave Velocity

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

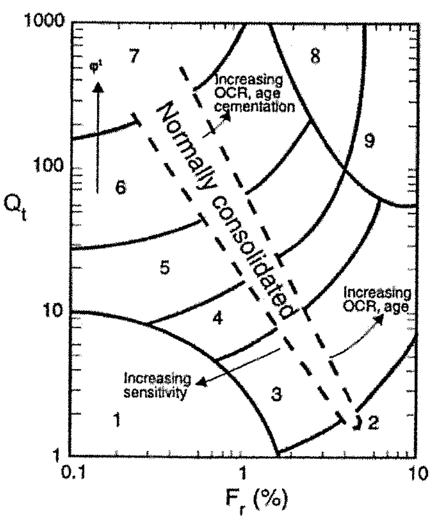
SBT SOIL BEHAVIOR TYPE

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

Engineering judgment and comparison with augered borings is especially important in the proper interpretation of CPT data in certain geo-materials.

The following charts provide a Soil Behavior Type for the CPT Data. The numbers corresponding to different regions on the charts represent the following soil behavior types:

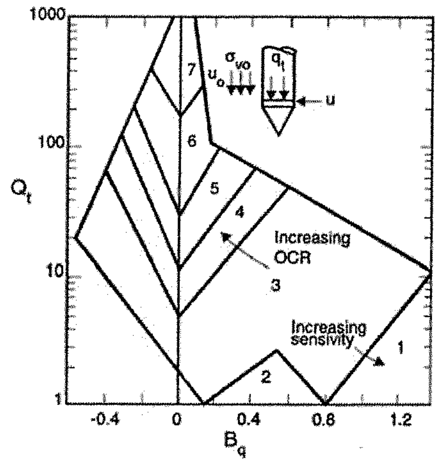
Soil Behavior Type based on friction ratio



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

Robertson CPT 1990

Soil Behavior Type based on pore pressure



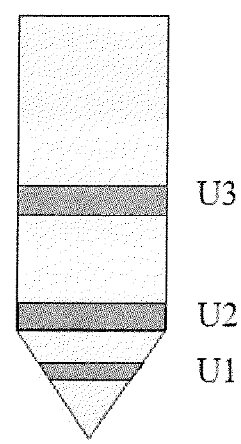
$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \qquad B_q = \frac{u_2 - u_o}{q_t - \sigma_{vo}}$$

Robertson CPT 1990

1 Sensitive, Fine Grained
2 Organic Soils - Peat
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

U2 PORE WATER MEASUREMENTS

Pore water measurements reported on CPT logs are representative of pore 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 represent dynamic pore water pressures due to the local disturbance caused by the cone tip. Dynamic pore water pressure decay and static pore water pressure measurements are reported on a Pore Water Pressure Dissipation Graph.



Appendix B

Prairie Center Drive Bridge

BRAUN INTERTEC

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August 29, 2014 Project BL-13-00213

Mr. Don Demers
Southwest Light Rail Transit Project Office
6465 Wayzata Boulevard, Suite 500
St. Louis Park, MN 55426

Re: Foundation Analysis Design Recommendation Report
Prairie Center Drive Bridge – 75% Design
STA 2085+51 to STA 2102+53
Southwest LRT, West Segment 1
Eden Prairie, Minnesota

Dear Mr. Demers:

Braun Intertec has completed the geotechnical evaluation for the proposed light rail bridge over Prairie Center Drive and Technology Drive near TH 212 in Eden Prairie, Minnesota. The following sections provide our recommendations for the design and construction of bridge foundations.

This report is part of a larger series of reports for the west segment of the Southwest Light Rail Transit (SWLRT) project. Recommendations for the land bridge approaching west end, abutment,the east approach embankment, retaining walls RTW-W108, RTW-W110 and RTW-W111, general track construction, and pole foundations for the Overhead Contact System (OCS) will be addressed in separate reports.

A. Project information

The west segment of the SWLRT project is proposing to construct a light rail transit line through the cities of Hopkins, Minnetonka, and Eden Prairie, Minnesota. This report considers the design and construction of a multiple span bridge carrying the SWLRT alignment over Prairie Center Drive and Technology Drive in Eden Prairie, Minnesota. The light rail bridge will consist of an at-grade land bridge approaching pier 1 from the west, an east abutment, and 17 piers. Prestressed concrete beams are proposed to support a cast-in-place concrete deck.

A.1. Type of Structures

This design report provides recommendations for foundations for the bridge carrying light rail vehicles over Prairie Center Drive and Technology Drive. The east abutment and piers are anticipated to be supported on cast-in-place concrete pipe piles. The west approach will consist of a land bridge supported on cast-in-place concrete pipe piles, with the north side supported by retaining wall RTW-W108. The east approach will consist of an earth embankment with sides supported by retaining walls RTW-W110 and RTW-W111.. Design recommendations for the land bridge, east approach embankment, and retaining walls will be addressed in separate reports.

A.2. Location of Bridge

The bridge is proposed to carry the LRT tracks over Prairie Center Drive and Technology Drive approximately 0.1 miles southeast of the intersection of TH 212 and Prairie Center Drive in Eden Prairie, Minnesota. The west bridge approach will be located on the west side of Prairie Center Drive, approximately 0.1 miles north of Technology Drive. The east abutment will be located on the east side of Prairie Center Drive, approximately 0.2 miles south of Technology Drive. 17 bridge piers will be located between the west bridge approach and east abutment, with span lengths ranging from approximately 45 to 140 feet. The overall length of the bridge is approximately 1,716 feet between the west approach and east abutment.

A.3. Other Information

The design team discussed the use of spread footing foundations to support the new structure. However, due to depth of fill and buried organic soils along a portion of the alignment, we have recommended supporting the structure on driven piles.

To construct the bridge, embankment grade increases of 10 to 20 feet for the east bridge abutment will be necessary. Grade raises of this magnitude will influence the design and construction of the proposed bridge foundation types. The effects of the embankment stresses are accounted for in our foundation design recommendations.

B. Subsurface Investigation Summary

B.1. Summary of Borings Taken

Braun Intertec completed standard penetration test (SPT) borings and cone penetration test (CPT) soundings near the proposed bridge structures on the project. Further details of the structure location and corresponding SPT borings and CPT soundings performed are as follows:

Structure Location and Corresponding SPT Boring and CPT Soundings

Structure	Approximate Track Stationing	Corresponding SPT Borings	Corresponding CPT Soundings
Pier 1	2085+66	-	2108CB
Pier 2	2086+11	-	2109CB
Pier 3	2086+56	-	2109CB
Pier 4	2087+01	2094SB	-
Pier 5	2087+46	2094SB	-
Pier 6	2087+91	2094SB	-
Pier 7	2088+36	-	2110CB
Pier 8	2088+81	-	2110CB
Pier 9	2090+21	2095SB	-
Pier 10	2091+61	2118SB	-
Pier 11	2093+01	2064SB	-
Pier 12	2094+41	2119SB	-
Pier 13	2095+81	2065SB	-
Pier 14	2097+21	2137SB	-
Pier 15	2098+61	2066SB	-
Pier 16	2100+00	2047SB	-
Pier 19	2101+40	2048SB	-
East Abutment	2102+82	2096SB	-

Please note that not all of the structure locations have been drilled as of the date of this report due to property boundaries, utility conflicts, and realignment of some pier locations. The Appendix includes copies of the SPT and CPT logs, a generalized soil profile, and a boring location sketch.

B.2. Description of Foundation Soil and Rock Conditions

The borings conducted for the bridge piers and abutments generally revealed a surficial layer of topsoil fill underlain by additional fill over mixed layers of glacial soils (outwash and tills). Swamp deposits were noted in Borings 2094SB (Piers 4, 5 and 6), 2095SB (Pier 9), 2064SB (Pier 11), 2119SB (Pier 12), 2065SB (Pier 13), and 2137SB (Pier 14), between the fill and underlying glacial soils. The following paragraphs discuss the encountered soils in more detail at each substructure location.

B.2.a. Pavements

Borings 2048SB and 2066SB were located within or near existing pavement areas. The borings encountered various amounts of bituminous or concrete pavement and/or aggregate base. A summary of the encountered pavement section is provided in the following table.

Encountered Pavement Section

Boring	Approximate Track Stationing	Bituminous Thickness (inches)	Aggregate Base Thickness (inches)
2048SB	2100+96	7	1 1/2
2066SB	2098+95	4” of Concrete	

B.2.b. Topsoil Fill

A surficial layer of topsoil fill was encountered at all boring locations, with the exception of Borings 2048SB, 2066SB, and 2096SB. The topsoil fill ranged in thickness from a few inches to 2 feet and consisted of clayey sand (SC), lean clay (CL), lean clay with sand (CL), and sandy lean clay (CL).

B.2.c. Fill

Immediately below the topsoil fill or pavements, the borings encountered fill soils consisting of a mixture of silty sand (SM), clayey sand, silty clay (CL-ML), sandy lean clay, and peat (PT) to varying depths, ranging from approximately 6 to 28 feet below existing grade, corresponding to elevations 831 to 816 feet.

B.2.d. Swamp Deposits

Swamp deposits were encountered directly below the fill in Borings 2064SB, 2064SB, 2094SB, 2095SB, 2119SB, and 2137SB. Swamp deposits consisted of peat, organic clay (OL), and organic silt (OH). The swamp deposits extended to variable depths ranging from 6 to 48 feet below existing grade, corresponding to elevations 830 to 787 feet.

B.2.e. Alluvial Soils

Just beneath the topsoil, fill and swamp deposits, Borings 2094SB, 2118SB, 2064SB, and 2065SB encountered alluvium layers of lean clay, sandy lean clay, and fat clay (CH) extending to depths ranging from 27 to 58 feet below existing grade, corresponding to elevations 807 to 780 feet MSL.

B.2.f. Glacial Soils

Glacial soils were encountered below the fill and swamp deposits to boring termination depths. The glacial soils consisted of till and outwash with classifications including gravel, poorly graded sand (SP), poorly graded sand with silt (SP-SM), silty sand, silt (ML), silt with sand (ML), sandy silt(MLS), clayey sand, lean clay, lean clay with sand, sandy lean clay, and fat clay. Glacial soils have the potential to contain cobbles and boulders.

B.2.g. Penetration Resistance Testing

The results of our penetration resistance testing from the borings are summarized below. Comments are provided to qualify the significance of the results.

Penetration Resistance Data

Geologic Material	Classification	Range of Penetration Resistances*	Comments
Fill	SM, SC, CL-ML, CL, PT	5 to 62 BPF	Variable compaction
Swamp Deposits	OL, OH, PT	3 to 16 BPF	Slightly to moderately consolidated
Alluvial Soils	CL and CH	WH to 12 BPF	Locally very soft to rather stiff, generally rather soft to rather stiff
Glacial Soils	GP, SP-SM, SP, SM, ML, MLS	7 to 100+ BPF	Locally loose to very dense, generally medium dense to dense
	CL, SC	7 to 74 BPF	Locally rather medium to hard, generally stiff to hard

*BPF-Blows per Foot, WH –weight of hammer

Where the CPT soundings penetrated into the underlying glacial soils, we recorded tip resistances generally ranging from less than 100 to over 5,000 psi. These tip resistances also indicate soils are generally loose to very dense and appear consistent to the SPT borings performed concurrently on the project

B.3. Summary of Water Level Measurements

Groundwater elevations were noted on the boring logs between elevations of about 805 to 825 feet above Mean Sea Level (MSL). Seasonal and annual fluctuations of groundwater, however, should be anticipated.

B.4. Interpretation of Water Level

The water level measurements in the borings indicated groundwater elevations between 805 and 825 feet. Historical borings in the area indicate the normal water level in the area is near 820-825, corresponding to the water level in the Purgatory Creek wetland. Based on the anticipated bottom-of-footing/pile-cap elevations for the bridge substructures and the recorded water levels, groundwater may influence foundation construction of the pile caps. The estimated water level and anticipated design may require the placement of 1 to 2 feet of crushed rock to aid in controlling groundwater seepage with sumps and pumps. In addition, a working platform for construction of the pile caps may be required.

C. Foundation Analysis

Based on the soil conditions encountered in the borings and soundings and the loads anticipated on the bridge, we recommend the proposed bridge abutment and piers be supported on pile foundations.

C.1. Embankments and Slopes

The proposed bridge is a new structure and will require the construction of a new approach embankment at the east abutment. The west abutment will transition to a land bridge, thus no embankment construction is anticipated on the west end of the proposed bridge. The eastern approach embankment will be approximately 10 to 20 feet tall and will utilize two walls, RTW-W110 and RTW-W111, to retain embankment backfill material (design and construction of embankment and walls covered under separate reports).

C.1.a. Settlement

Please refer to the RTW-W110 and RTW-W111 Report.

C.1.b. Time Rate of Settlement

Please refer to the RTW-W110 amd RTW-W111 Report.

C.2. Pile Foundations

C.2.a. Nominal Resistance at Given Tip Elevations (Compression)

For bridge support, we calculated the nominal resistance of the piles in compression. Please refer to the Nominal Resistance Graphs and Section C.3.c.1 for the calculation method.

C.2.b. Calculate and Consider Downdrag and Lateral Squeeze

Based on the proposed east abutment location and lack of anticipated raise in grade in the area of the west abutment and bridge piers, we do not anticipate downdrag forces will contribute additional load to the piles.

Lateral squeeze can occur if the unit weight of the fill multiplied by the fill height is greater than three times the undrained shear strength of the subgrade soils. Due to the general granular nature of the soil encountered at the east embankment, we do not anticipate that lateral squeeze will be an issue.

C.2.c. Lateral Pile Analyses

The following table provides the soil parameters used for the lateral pile analyses and p-y curve generation, which was performed using the computer program LPILE (2013). Based on the soils encountered in the borings, we utilized the default lateral modulus of subgrade reaction values included in LPILE. For the purposes of our preliminary evaluation, we modeled the soil conditions encountered in Borings 2093SB and 2066SB. 2093SB is not associated with an abutment or pier for the bridge, but is representative of the conditions that will be encountered near the west end of the bridge. We have included boring 2093SB in the Appendix for reference.

Soil Parameters for p-y Curve Generation – Boring 2093SB

Layer Top Depth (feet)	Layer Bottom Depth (feet)	Effective Unit Weight (pcf)	Internal Angle of Friction (degrees)	Undrained Shear Strength (psf)	Material Type
0	4.0	125	NA	1000	Stiff Clay with Free Water
4.0	6.0	125	NA	2000	Stiff Clay with Free Water
6.0	9.0	120	31	NA	Sand (Reese)
9.0	14.0	125	NA	3500	Stiff Clay w/o Free Water
14.0	17.0	125	NA	2000	Stiff Clay w/o Free Water
17.0	24.0	120	32	NA	Sand (Reese)
24.0	29.0	125	NA	2500	Stiff Clay w/o Free Water
29.0	32.0	120	33	NA	Sand (Reese)
32.0	37.0	120	35	NA	Sand (Reese)
37.0	57.0	55	32	NA	Sand (Reese)
57.0	78.0	55	33	NA	Sand (Reese)
78.0	83.0	65	NA	4500	Stiff Clay w/o Free Water
83.0	101.0	58	38	NA	Sand (Reese)

Soil Parameters for p-y Curve Generation – Boring 2066SB (Pier 15)

Layer Top Depth below Pile Top (feet)	Layer Bottom Depth below Pile Top (feet)	Effective Unit Weight (pcf)	Internal Friction Angle (degrees)	Undrained Shear Strength (psf)	Material Type
0	0.5	120	NA	1250	Stiff Clay with Free Water
0.5	13.5	125	NA	1900	Stiff Clay w/o Free Water
13.5	19.5	53	32	NA	Sand (Reese)
19.5	34.5	56	33	NA	Sand (Reese)
34.5	44.5	65	34	NA	Sand (Reese)
44.5	59.5	68	35	NA	Sand (Reese)
59.5	64.5	58	35	NA	Sand (Reese)
64.5	72.5	60	35	NA	Sand (Reese)

For our lateral analyses, we assumed a pile top located 5 feet below the ground surface. The maximum lateral load in our analyses is for a loading condition assuming one-inch of deflection at the pile top with a fixed-head condition. We assumed a pile wall thickness of 0.25 inches for both the 12.0-inch and the 16.0-inch outside diameter pipe piles. We assumed a steel yield strength of 45 ksi and concrete infill with a compressive strength of 3 ksi for our analyses. Please refer to the attachments for the shear force and bending moments within the pile, which were generated at service loads of 120 tons (240 kips) for the 12.0-inch pipe pile and 140 tons (280 kips) for the 16.0-inch closed-end pipe pile.

C.2.d. Tip Elevation

We recommend driving the proposed pipe pile sections to the elevations shown in the anticipated pile length tables and the attached resistance graphs for driven pile in the Appendix of this report. The table below shows approximate bottom-of-pile-cap elevations based on plans provided by SPO.

Substructure	Anticipated Bottom-of-Pile-Cap Elevation (feet)
Bottom of Grade Beam	832 – 838*
Pier 1	834
Pier 2	836
Pier 3	838
Pier 5	840
Pier 6	844
Pier 7	846
Pier 8	837
Pier 9	831
Pier 10	829
Pier 12	827
Pier 13	827
Pier 14	825
Pier 15	826
Pier 16	825
Pier 17	828
East Abutment	862

*The range given represents the approximate bottom of grade beam elevation for the screen wall located between piers 1 through 8.

C.3. Summarize Design Assumptions

C.3.a. Bridge Loading Information (Axial and Horizontal)

Please refer to Section D.1 and D.4 for anticipated pile loads and resistances.

C.3.b. Design Methodologies – Pile-Supported Structures

C.3.b.1. Pile Capacity – LRFD (Prairie Center Drive Bridge)

We used the computer program UniPile, version 5.0.0.33, to estimate the static nominal geotechnical resistance (R_n) of the 10.0-, 12.0-,- and 16.0-inch outside-diameter, 1/4-inch thick wall, closed-ended pipe piles for support of the bridge abutments and piers. UniPile software was developed by UniSoft Geotechnical Solutions Ltd. and can calculate pile resistance using a variety of methods.

For our analysis, we utilized the Beta-method, an effective stress method, to estimate the static geotechnical resistance for these piles. This method determines shaft resistance using Bjerrum-Burland beta coefficients (β), which are based on soil type and effective friction angle. We estimated the β values for each layer using Figure 9.20 from the Federal Highway Administration (FHWA) Publication No. NHI-05-042, Design and Construction of Driven Pile Foundations, April 2006. The Beta-method determines end bearing resistance using toe bearing capacity factors (N_t), which are also based on soil type and effective friction angle. We estimated the N_t values from Table 9-6 of the April 2006 FHWA publication identified previously.

C.3.b.2. Downdrag

We do not expect downdrag will act on the piling based on the anticipated east embankment construction method and lack of anticipated raise in grade in the areas of the west abutment and the proposed piers.

C.4. Construction Considerations

C.4.a. Design of Temporary and Permanent Slopes

The existing foundation/embankment soils consist of a mixture of cohesive soils and sand with angles of internal friction of 28 degrees or greater. The permanent slopes can match the existing slopes, except they must be not steeper than 1V:2H. The granular borrow is anticipated have an angle of internal friction of approximately 30 degrees. This soil could be temporarily placed at a slope of 1V:1.5H, but must be limited to 1V:2H or flatter for the permanent condition.

C.4.b. Subcut Recommendations and Backfill Requirements

C.4.b.1. Prairie Center Drive Bridge

We recommend removing the topsoil fill along the east approach embankment. The excavations to remove these soils are anticipated to be limited and are estimated to be about 1 to 2 feet below grade at the east embankment. The extent of the excavation should extend horizontally beyond the embankment limits a distance equal to the depth of the subcut, or 1 foot, whichever is greater. As the bridge piers are to be constructed within a cut, we do not anticipate a need for subcutting below the substructure since a driven-pile foundation system will support the structure.

Based on the anticipated bottom-of-pile-cap substructure elevations, groundwater will not likely be encountered within the bottom excavations. If encountered, temporary dewatering may be needed along with the placement of crushed rock to help control groundwater seepage with sumps. A stable working platform also may need to be provided during construction.

We recommend backfilling below the substructures and constructing embankment fills with Granular Borrow or Select Granular Borrow. We also recommend compacting the soils to meet the requirements from MnDOT Specifications 2451 or 2105, as appropriate for backfill and fill, respectively. The compaction should be evaluated using the Specified Density Method defined in MnDOT Specification 2105.3 F1. Soils placed as backfill may not be saturated or frozen at time of placement. Do not place new backfill material on frozen soil.

We recommend using Select Granular Modified 10 percent for Structure Backfill. Select Granular Modified 10% shall comply with Specification 3149.2B2, modified to 10 percent or less passing the 0.075 mm (#200) sieve.

C.4.c. Construction Staging Requirements

Due to the anticipated cuts at the pier substructure locations, a waiting period is not necessary at these substructure locations. Please refer to the RTW-W110 and RTW-W111 Report for recommendations regarding construction of the east embankment.

C.4.d. Demolition

All existing pavement, structures, and associated deleterious material where proposed structures and oversize areas are to be located should be fully removed and replaced with suitable engineered fill.

D. Foundation Recommendations – Deep Foundations

D.1. Bearing Resistances and Associated Resistance/Safety Factors

Please refer to the Appendix for nominal bearing resistances for driven pile for bridge abutment and pier support. For situations where subsurface exploration and static calculations have been completed, we recommend that the following φ_{dyn} factors be used for LRFD Design.

Recommended Pile Driving Resistance Factors (ϕ_{dyn})

Specified Construction Control	ϕ_{dyn}
MnDOT Pile Formula 2012 (MPF12) for Pipe Pile Sections	0.50
Wave Equation and Pile Driving Analyzer (PDA)	0.65

D.2. Uplift Capacity/Resistance

Currently, a tension resistance line is not provided on the Nominal Bearing Resistance Graphs attached to this report. If piles will experience tension loads, we will revise our recommendations accordingly.

D.3. Recommended Design Soil Parameters (e.g., Coefficient of Friction, Lateral Earth Pressure Coefficients, etc.)

We recommend soil parameters to be used for design are as follows:

Soil Type	Angle of Internal Friction (degrees)	Effective unit Weight (pcf)	Coefficient of Sliding Friction Rough Concrete	Active Earth Pressure Coefficient	At-Rest Earth Pressure Coefficient
Select Granular Borrow	35	120	0.6	0.27	0.43
Granular Borrow	30	120	0.5	0.33	0.50
Existing Non-organic Granular Fill	30	125	0.5	0.33	0.50
Existing Clay Fill	28	130	0.4	0.36	0.53

D.4. Recommended Pile Size, Length, and Tip Elevation

D.4.a. Bridge Abutments and Piers

We have constructed two tables which summarize the anticipated pile depths based on the factored load ($\Sigma\gamma Q_n$) for 10.0-, 12.0- and 16.0-inch, outside-diameter pipe piles with a wall thickness of 1/4 inch. The tables provide a PDA length (i.e., φ_{dyn} of 0.65) and a MPF12 formula length (i.e., φ_{dyn} of 0.50) for each location. We assumed a cutoff elevation of about 1 foot above the anticipated bottom-of-pile-cap elevation. Please refer to the nominal bearing resistance graphs and the anticipated pile length tables using PDA Analysis and the MPF 12 for a detailed profile of pile resistances and anticipated pile lengths.

D.5. Waiting Periods for Embankments

Not used. Please refer to the RTW-W110 and RTW-W111 Report for the east abutment embankment construction.

D.6. Surcharge Systems Recommendations

Not used. Please refer to the RTW-W110 and RTW-W111 Report for the east abutment embankment construction.

D.7. Temporary Slopes and Shoring Limits

Temporary slopes in the Granular Borrow or Select Granular Borrow backfill are recommended to be constructed at 1V:1.5H or shallower. Temporary slopes constructed in natural material are recommended to be constructed at 1V:2H or shallower. In a temporary condition; these slopes have a Factor of Safety against global failure in excess of 1.3.

E. Material Classification and Testing

E.1. Visual and Manual Classification

The geologic materials encountered were visually and manually classified in accordance with ASTM Standard Practice D 2488. A chart explaining the classification system is attached. Samples were placed in jars or bags and returned to our facility for review and storage.

E.2. Laboratory Testing

The results of the laboratory tests performed on geologic material samples are noted on the appropriate attached exploration logs. The tests were performed in accordance with ASTM procedures and follow MnDOT guidelines.

E.3. Groundwater Measurements

The drillers checked for groundwater as the penetration test borings were advanced. The boreholes were then backfilled or sealed with bentonite grout.

F. Qualifications

F.1. Variations in Subsurface Conditions

F.1.a. Material Strata

Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth, and therefore, strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions, and can be expected to vary in depth, elevation and thickness away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed, or construction commences. If any such variations are revealed, our recommendations should be re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

F.1.b. Groundwater Levels

Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications, and other seasonal and annual factors.

F.2. Continuity of Professional Responsibility

F.2.a. Plan Review

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

F.2.b. Construction Observations and Testing

It is recommended that we be retained to perform observations and tests during construction. This will allow correlation of the subsurface conditions encountered during construction with those encountered by the borings, and provide continuity of professional responsibility.

F.3. Use of Report

This report is for the exclusive use of Southwest Light Rail Transit. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

G. General

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If there are questions regarding these bridge foundation recommendations, please call Josh Kirk at 952.995.2222 or Ray Huber at 952.995.2260.

Sincerely,

BRAUN INTERTEC CORPORATION

Professional Certification:
I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Joshua L. Kirk, PE
Associate Principal - Project Engineer
License Number: 45005
July 21, 2014

Reviewed by:

Ray A. Huber, PE
Vice President-Principal Engineer

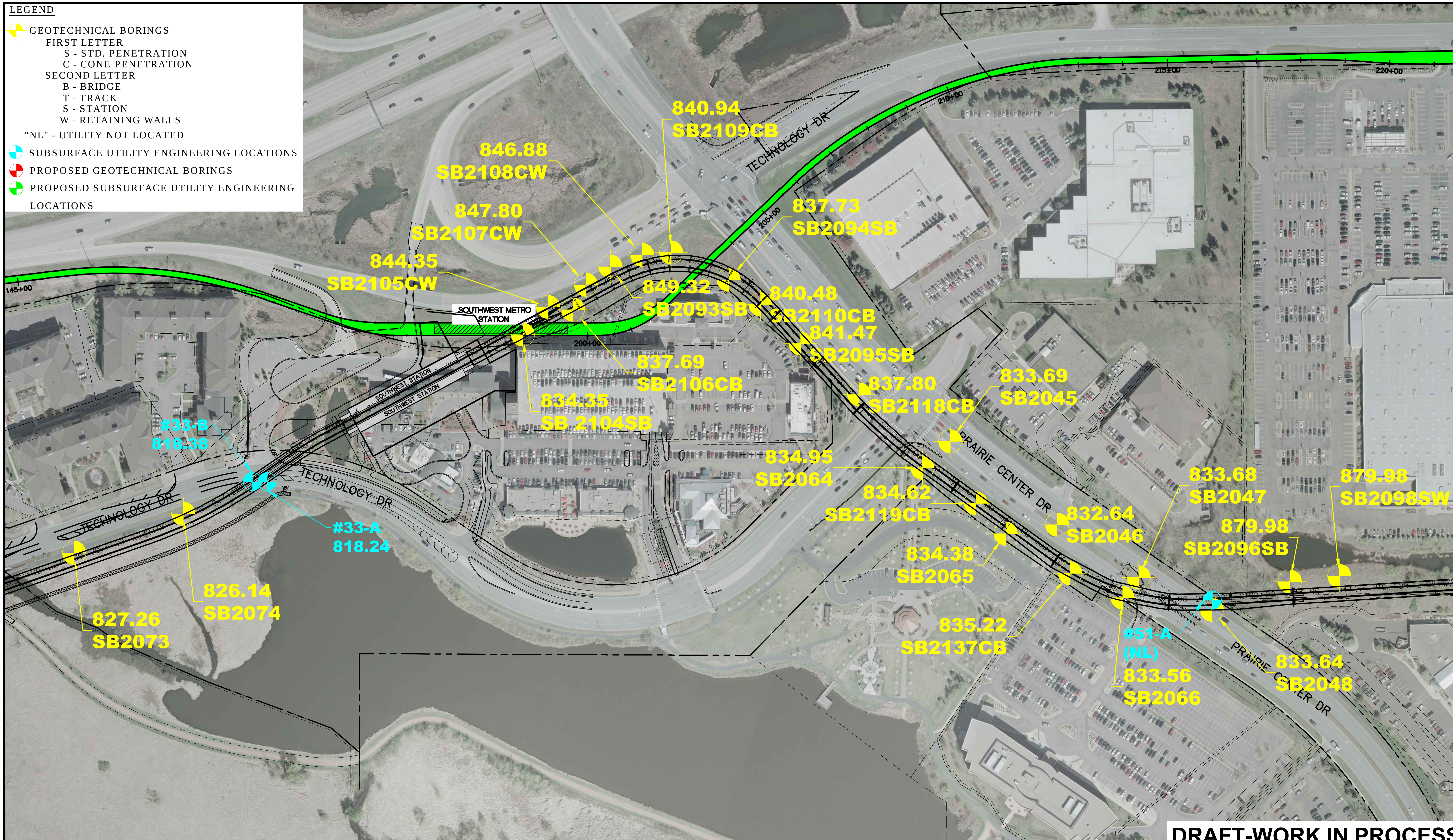
Reviewed by:

Matthew P. Ruble, PE
Principal Engineer

Appendix:
- Boring Location Sketch
- Preliminary Engineering Plan and Profile Sheets – Prairie Center Drive Bridge
- SPT Logs: (2047SB, 2048SB, 2064SB, 2065SB, 2066SB, 2093SB,2094SB, 2095SB, 2096SB, 2118SB, 2119SB, 2137SB)
- CPT Logs: (2108CB, 2109CB, 2110CB)
- Summary of Anticipated Pile Lengths – PDA Analysis

- Summary of Anticipated Pile Lengths – MPF12 Analysis
- Summary of Anticipated Pile Lengths - Screenwalls
- Nominal Geotechnical Resistance Graphs
- Lateral Pile Analysis Results
- MnDOT SPT Descriptive Terminology
- MnDOT CPT Descriptive Terminology

APPENDIX



SOUTHWEST Green Line LRT Extension

SOUTHWEST LIGHT RAIL

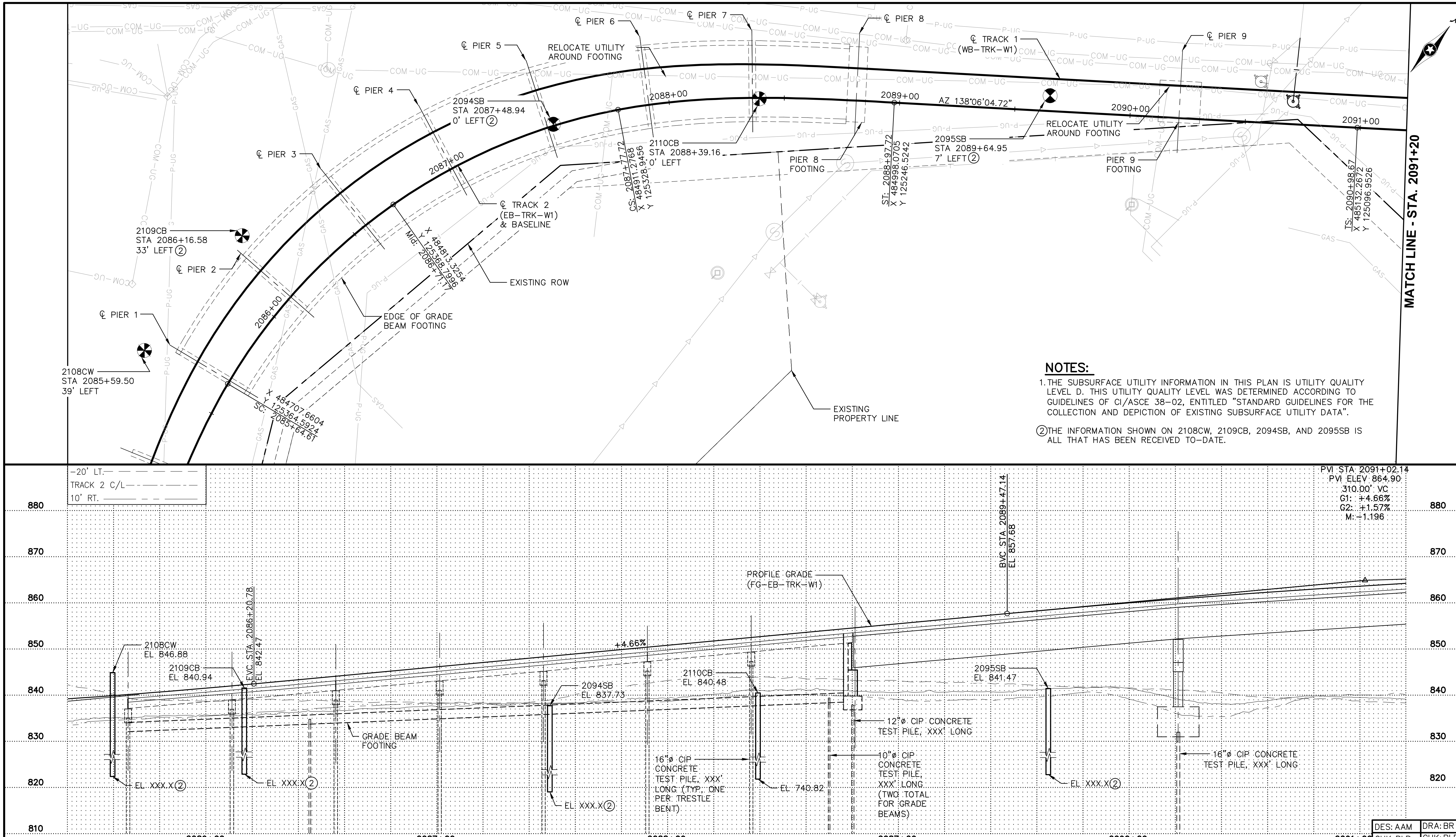
SOIL BORINGS
SHEET 3 OF 12

IRT: N/A
REV: 0
DATE: 06/30/2014

NORTH
0 50 100 200

METROPOLITAN COUNCIL
AECOM
SRF Consulting Group, Inc.

Aug. 28 2014 11:30 am V:\3200_PEC-W\CAD\OVERALL\EXHIBITS\CIVIL\EXHB-CIV-SOIL BORINGS.dwg By: Boscha



NOTES:

1. 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".
2. THE INFORMATION SHOWN ON 2108CW, 2109CB, 2094SB, AND 2095SB IS ALL THAT HAS BEEN RECEIVED TO-DATE.

DES: AAM	DRA: BR
CHK: PLR	CHK: PLR

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

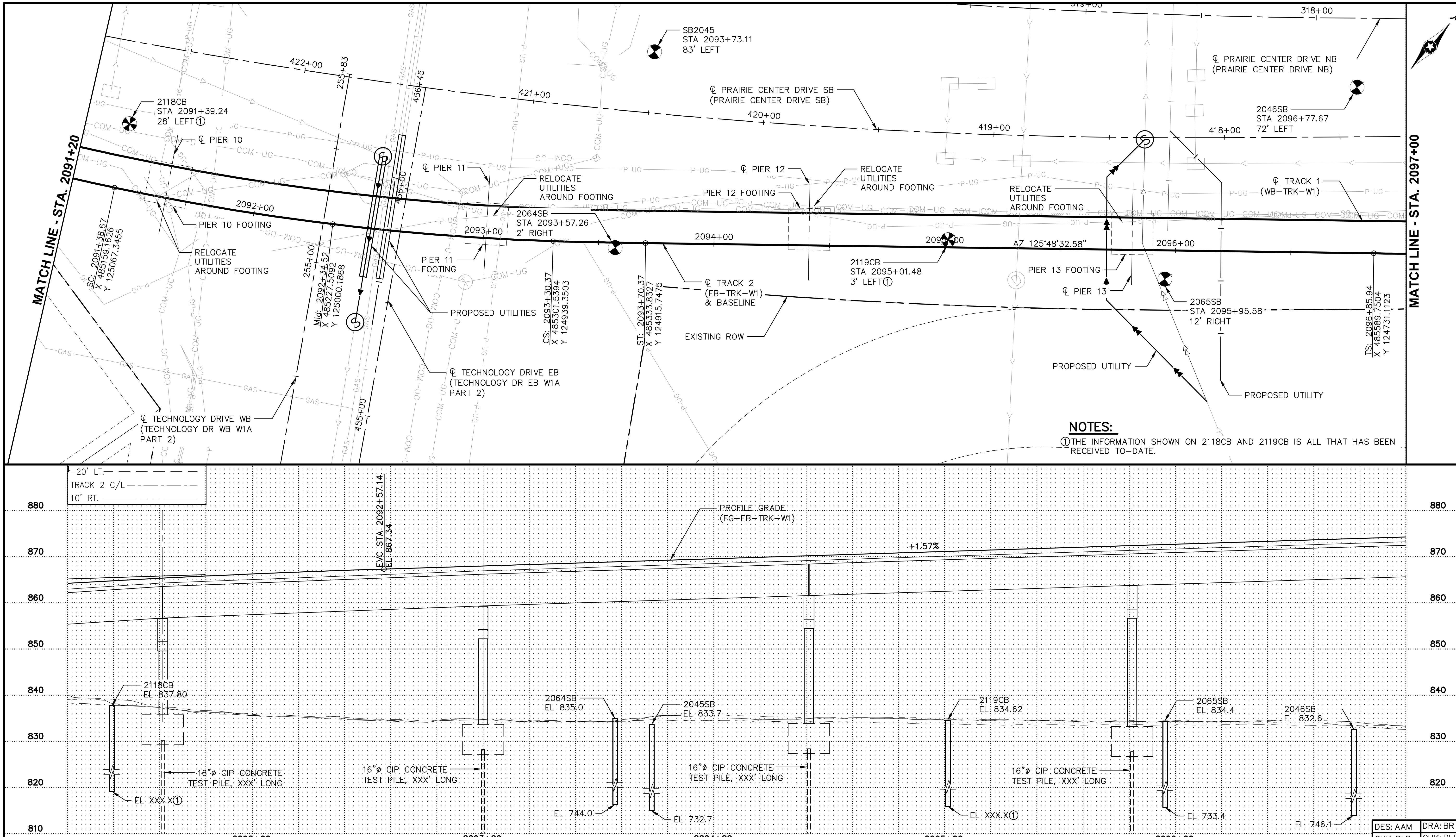
SOUTHWEST Green Line LRT Extension

WEST - VOLUME 2 (STRUCTURES)
PRAIRIE CENTER DRIVE
BRIDGE XXXXX (LRT)
BORINGS

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-BRG-PRCD-LRT-SUR-BOR-001

SHEET 22 OF 203



DES: AAM | DRA: BR
CHK: PLR | CHK: PLR

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

WEST - VOLUME 2 (STRUCTURES)
PRAIRIE CENTER DRIVE
BRIDGE XXXXX (LRT)
BORINGS

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-BRG-PRCD-LRT-SUR-BOR-002

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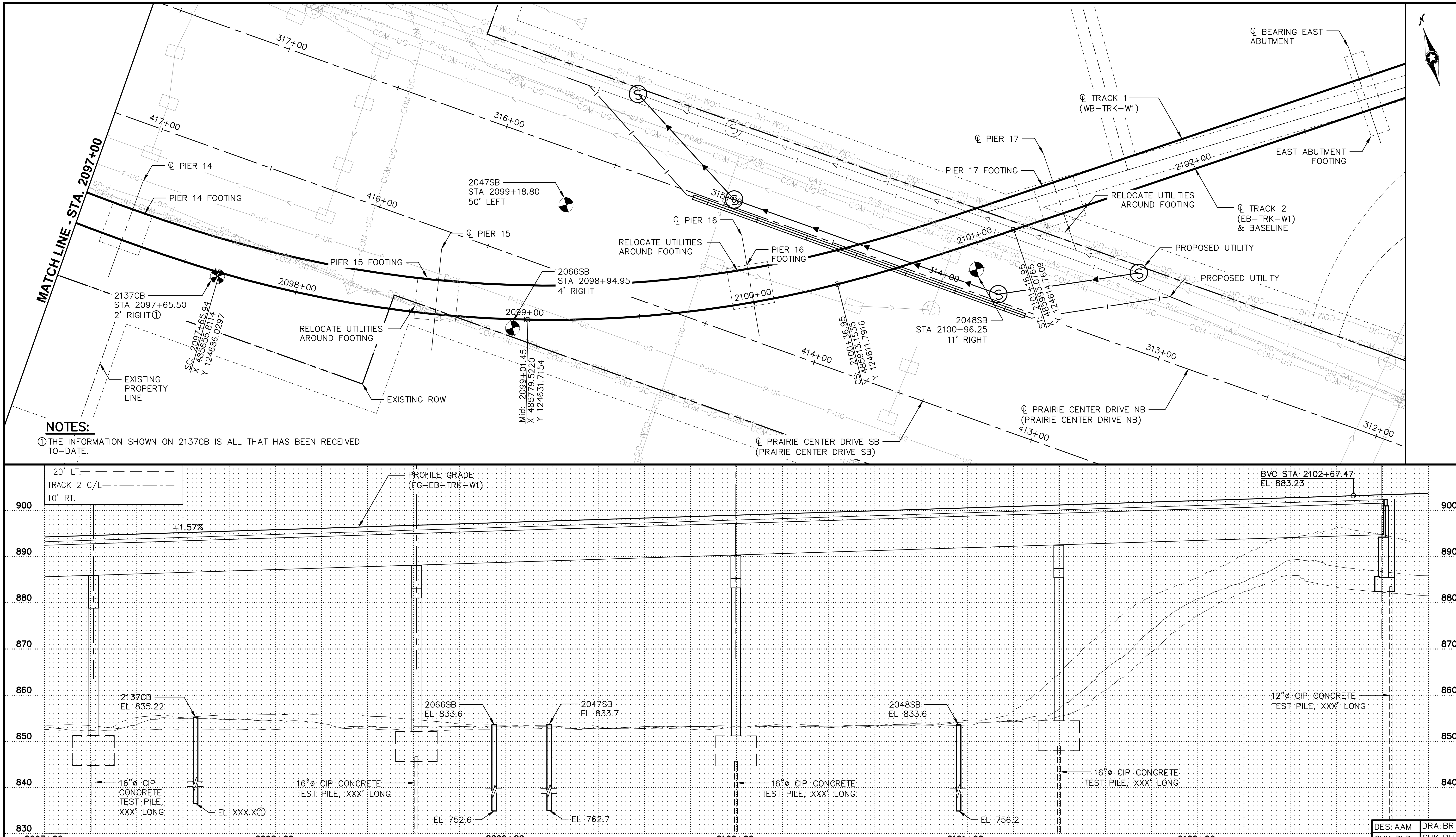


NOTES:

① THE INFORMATION SHOWN ON 2137CB IS ALL THAT HAS BEEN RECEIVED TO-DATE.

DES: AAM	DRA: BR
CHK: PLR	CHK: PLR

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

WEST - VOLUME 2 (STRUCTURES)
PRAIRIE CENTER DRIVE
BRIDGE XXXXX (LRT)
BORINGS

DISCIPLINE: **STRUCTURES**

SHEET NAME: W1-STU-BRG-PRCD-LRT-SUR-BOR-003

SHEET 24 OF 203

Jul, 30 2014 03:48 pm V:\3200_PEC-W\CAD\SEGMENT-W1\SHEET\STRUCTURES\W1-STU-BRG-PRCD-SUR-BOR.dwg By: rieckmanb

Elevation scale (left and right): 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720, 710, 700, 690, 680, 670

2045SB
Elevation 833.7

Coh N60

N60: 26, 17, 12, 19, 12, 12, 15, 11, 9, 10, 10, 9, 10, 10, 13, 14, 10, 12, 16, 19, 23, 35, 46, 44, 50, 47, 70, 51, 62, 63

- 3 inches of Bituminous over 2 inches of Aggregate Base.
- FILL: Silty Sand, with Gravel, trace bituminous, occasional Lean Clay lenses, brown, moist.
- SANDY LEAN CLAY, trace Gravel, brown, wet.
- LEAN CLAY, trace Gravel, gray, wet, rather stiff to stiff.
- Poorly Graded Sand and Silt lenses at 17 feet.
- SANDY LEAN CLAY, trace Gravel, with occaisonal Sand lenses, gray, wet, rather stiff.
- Sand lense at 32 feet.
- LEAN CLAY, with occasional Sandy Lean Clay layers, gray, wet, rather stiff to stiff.
- SANDY LEAN CLAY, trace Gravel, gray, wet, rather stiff to very stiff.
- LEAN CLAY, with occasional Silt lenses, bluish gray, wet, very stiff to hard.
- SILTY CLAY, with waterbearing fine Sand lenses, gray, wet, hard.

END OF BORING.
Water observed at 17 feet with 17 feet of hollow-stem auger in the ground.
Boring immediately backfilled with bentonite grout.
Bottom of Borehole at 101 ft

2046SB
Elevation 832.6

Coh N60

N60: 24, 21, 25, 19, 8, 4, 2, 3, 8, 6, 7, 8, 13, 12, 14, 16, 18, 17, 22, 25, 25, 26, 31, 37, 79, 50/3"

- LEAN CLAY, black, moist.
- FILL: Poorly Graded Sand, fine- to medium-grained, brown, moist.
- FILL: Sandy Lean Clay, with Sand lenses, brown and gray, wet. Silty Clay layer at 7 feet. Sand layer at 8 feet.
- CLAYEY SAND, fine- to medium-grained, with black, Lean Clay lenses, with Sand lenses, gray and black, wet.
- ORGANIC SILT, brown, wet.
- ORGANIC CLAY, with shells and fibers, gray, wet.
- LEAN CLAY, with fibers at 22 feet, gray, wet, soft to medium.
- LEAN CLAY with SAND, trace Gravel, gray, wet, rather stiff to hard.
- Waterbearing Sand lense at 65 feet.

Auger refusal at 86 1/2 feet.
Boring Immediately backfilled with bentonite grout.
Bottom of Borehole at 86.5 ft

2047SB
Elevation 833.7

Coh N60

N60: 20, 24, 20, 27, 25, 10, 12, 15, 19, 24, 28, 33, 31, 36, 29, 25, 27, 30, 31, 39, 42, 53, 50/5", 50/6"

- LEAN CLAY, black, wet.
- FILL: Clayey Sand, fine- to medium-grained, with Gravel, brown, moist.
- FILL: Sandy Lean Clay, trace Gravel, brown, moist.
- FILL: Silty Sand, fine- to medium-grained, with Lean Clay lenses, brown, moist.
- FILL: Silty Sand, fine- to medium-grained, trace Gravel, brown to 12 feet then gray, moist.
- SANDY LEAN CLAY, trace Gravel, gray, wet, rather stiff.
- POORLY GRADED SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, medium dense.
- CLAYEY SAND, fine- to medium-grained, trace Gravel, gray, wet, medium dense to dense.
- SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff.
- SILTY SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, medium dense.
- SILT, brown and gray, waterbearing, dense.
- POORLY GRADED SAND, fine-grained, with occasional Silty Sand lenses, gray, waterbearing, very dense.

END OF BORING.
Water observed at 20 feet with 20 feet of hollow-stem auger in the ground.
Boring immediately backfilled with bentonite grout.
Bottom of Borehole at 71 ft

NOTES:
THE MATERIAL DESCRIPTIONS ARE CLASSIFIED ACCORDING TO THE UNIFIED SOIL CLASSIFICATION SYSTEM. DETAILS ON THE SYSTEM CAN BE FOUND IN THE FADR AND IN ASTM: D2488.

DES: N/A	DRA: BR
CHK: N/A	CHK: PLR

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

WEST - VOLUME 2 (STRUCTURES)
PRAIRIE CENTER DRIVE
BRIDGE XXXXX (LRT)
BORINGS

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-BRG-PRCD-LRT-SUR-BOR-004

Elevation scale: 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720, 710, 700, 690, 680, 670

2048SB
Elevation 833.6

Coh | N60: 16, 11, 36, 16, 20, 17, 18, 15, 20, 26, 21, 25, 22, 23, 22, 26, 33, 37, 42, 36, 37, 34, 47, 69, 68, 74

- 7 Inches of Bituminous over 1 1/2 inches of Aggregate Base.
- FILL: Sandy Lean Clay, trace Gravel, with frequent Sand seams, brown, wet.
- SANDY LEAN CLAY, trace Gravel, brown, moist, stiff.
- SILT with SAND, light brown to brown, moist, medium dense.
- POORLY GRADED SAND, fine-grained, light brown to brown, moist to 27 feet then waterbearing, medium dense.
- SILTY SAND, fine-grained, brown, waterbearing, medium dense.
- POORLY GRADED SAND, fine- to medium-grained, brown to 65 feet then gray, waterbearing, dense to very dense.
- SANDY LEAN CLAY, with Gravel, with frequent coarse Sand layers, brown, wet, hard.

END OF BORING.
Water observed at 27 feet with 27 feet of hollow-stem auger in the ground.
Boring immediately backfilled with bentonite grout.
Bottom of Borehole at 81 ft

2064SB
Elevation 835.0

Coh | N60: 13, 5, 15, 12, 9, 16, 3, 7, 10, 9, 4*, 2, 4, 7, 14*, 14*, 15*, 17, 16, 17, 19, 25*, 23, 37, 36, 44*, 65*

- CLAYEY SAND, trace roots, black and brown, frozen.
- FILL: Silty Sand, fine-grained, trace Gravel, grayish brown, frozen to moist.
- FILL: Sandy Lean Clay, trace Gravel and fibers, brown and black, moist.
- FILL: Sandy Lean Clay, trace fibers, gray, brown and black, moist.
- ORGANIC CLAY, with shells, light gray, moist.
- SANDY LEAN CLAY, trace Gravel, brown and gray, wet, soft.
- FAT CLAY, gray, moist to wet, rather soft to soft.
- SANDY LEAN CLAY, trace Gravel, gray, moist, stiff to very stiff.
- CLAYEY SAND, with Gravel, gray, waterbearing, very stiff.
- SANDY LEAN CLAY, with Gravel, gray, moist, very stiff to hard.
- CLAYEY SAND, with Gravel, gray, waterbearing, hard.
- Heavy Gravel encountered at 78 feet.
- POORLY GRADED GRAVEL, with medium-grained Sand, with frequent cobbles, gray, waterbearing, dense to very dense.

END OF BORING.
Water observed at 17 feet while drilling.
Boring then backfilled with bentonite grout.
Bottom of Borehole at 91 ft

2065SB
Elevation 834.4

Coh | N60: 21, 11, 16, 12, 15, 8, 10, 7, 9, 9, 11, 14, 13, 11, 12, 14, 16, 18, 20, 20, 18, 23, 20, 34, 42, 49, 41, 52, 58, 68

- SANDY LEAN CLAY, trace roots, black, frozen.
- FILL: Clayey Sand, trace Gravel, brown, frozen.
- FILL: Sandy Lean Clay, trace Gravel, brown and black, frozen to 5 feet then moist.
- FILL: Sandy Lean Clay, with frequent Silt layers, gray to black, moist.
- PEAT, trace fibers, black, moist.
- ORGANIC SILT, with shells, trace fibers, gray, black, wet.
- LEAN CLAY, with layers of fat Clay, gray, moist, rather stiff to medium.
- SANDY LEAN CLAY, trace Gravel, gray, moist, rather stiff to stiff.
- SANDY LEAN CLAY, with Gravel, gray, moist, very stiff.
- CLAYEY SAND, with Gravel, gray, waterbearing, medium dense.
- SANDY LEAN CLAY, trace Gravel, with frequent layers of Fat Clay, gray, wet, very stiff.
- FAT CLAY, gray, wet, very stiff to hard.
- CLAYEY SAND, with Gravel, with Sand layers, gray, wet, dense to very dense.

END OF BORING.
Water observed at 22 feet while drilling.
Boring immediately backfilled with bentonite grout.
Bottom of Borehole at 101 ft

NOTES:

THE MATERIAL DESCRIPTIONS ARE CLASSIFIED ACCORDING TO THE UNIFIED SOIL CLASSIFICATION SYSTEM. DETAILS ON THE SYSTEM CAN BE FOUND IN THE FADR AND IN ASTM: D2488.

DES: N/A	DRA: BR
CHK: N/A	CHK: PLR

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

WEST - VOLUME 2 (STRUCTURES)
PRAIRIE CENTER DRIVE
BRIDGE XXXXX (LRT)
BORINGS

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-BRG-PRCD-LRT-SUR-BOR-005

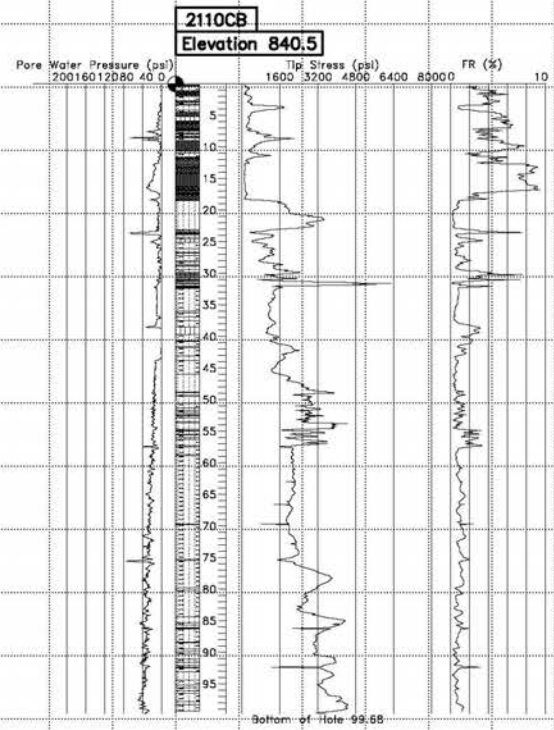
SHEET 26 OF 203

2066SB
Elevation 833.6

N60	Description
	4 Inches of Concrete.
47	FILL: Clayey Sand, trace Gravel, brown, frozen to moist.
15	FILL: Sandy Lean Clay, trace Gravel, brown and gray, moist.
22, 19	FILL: Clayey Sand, with Sand seams, with Gravel, brown and gray, moist.
15, 11	CLAYEY SAND, with layers of Lean Clay, gray, moist, stiff to rather stiff.
9, 11*	SANDY LEAN CLAY, with Sand seams, gray, moist to 20 feet then wet, rather stiff.
11, 12, 24, 34, 31	POORLY GRADED SAND, fine- to medium-grained, with Gravel, gray, waterbearing, medium dense to dense. Layers of Lean Clay at 40 feet.
32, 37, 44, 52, 62	SILTY SAND, with Gravel, with layers of Lean Clay, gray, waterbearing, hard. Silty Sand layers at 65 feet.
28	POORLY GRADED SAND, fine- to coarse-grained, with Gravel, with layers of Lean Clay, gray, waterbearing, medium dense.
49, 75	SILT, with Sand, gray, wet, dense to very dense.

Coh: (no values shown). Water level symbol (∇) at 20 feet.

END OF BORING.
Water observed at 20 feet while drilling.
Boring immediately backfilled with bentonite grout.
Bottom of Borehole at 81 ft



Elevation scale: 850, 840, 830, 820, 810, 800, 790, 780, 770, 760, 750, 740, 730, 720, 710, 700, 690, 680

NOTES:

THE MATERIAL DESCRIPTIONS ARE CLASSIFIED ACCORDING TO THE UNIFIED SOIL CLASSIFICATION SYSTEM. DETAILS ON THE SYSTEM CAN BE FOUND IN THE FADR AND IN ASTM: D2488.

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

DES: N/A | DRA: BR | CHK: N/A | CHK: PLR

AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL | SOUTHWEST Green Line LRT Extension

WEST - VOLUME 2 (STRUCTURES)
PRAIRIE CENTER DRIVE
BRIDGE XXXXX (LRT)
BORINGS

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-BRG-PRCD-LRT-SUR-BOR-006

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	2047SB	833.7 (Surveyed)

Location: Hennepin Co. Coordinate: X=485809 Y=124676 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine

Hammer **CME Automatic Calibrated**

SHEET 1 of 2

Drilling Completed **11/18/13**

Depth	Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
1.0	832.7	LEAN CLAY, black, wet, (CL), topsoil fill					
4.0	829.7	CLAYEY SAND, Sand, fine- to medium-grained, with Gravel, brown, moist, (SC), fill	20				
7.0	826.7	SANDY LEAN CLAY, trace Gravel, brown, moist, (CL), fill	24	12			
9.0	824.7	SILTY SAND, fine- to medium-grained, with Lean Clay lenses, brown, moist, (SM), fill	20				
14.0	819.7	SILTY SAND, fine- to medium-grained, trace Gravel, brown to 12 feet then gray, moist, (SM), fill	27	7			
			25				
19.0	814.7	SANDY LEAN CLAY, trace Gravel, gray, wet, rather stiff, (CL), till	10	16			qp=1 1/2 tsf
			12				qp=3 tsf
27.0	806.7	POORLY GRADED SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, medium dense, (SP), outwash	15				Switched to mud rotary drilling method after 20-foot sample.
			19				
			24				
37.0	796.7	CLAYEY SAND, fine- to medium-grained, trace Gravel, gray, wet, very stiff to hard, (SC), till	28	14			P200=38%
			33				
			31	14			
			36				
44.0	789.7	SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff, (CL), till	29				
			25				
			27	15			DD=121 pcf 116 pcf

Water level symbol at 20 ft depth.

Index Sheet Code 3.0

(Continued Next Page)

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	2047SB	833.7 (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
	47.0 / 786.7		SILTY SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, medium dense, (SM), till *(continued)*		30	16			P200=20%
				PD					
					31				
50				PD					
					39				
			SILT, brown and gray, waterbearing, dense, (ML), till						
55					42	24			P200=90%
	59.0 / 774.7			PD					
60					53				
				PD					
65			POORLY GRADED SAND, fine-grained, with occasional Silty Sand lenses, gray, waterbearing, very dense, (SP), outwash		*				*50 blows per 5-inch set.
				PD					
70	70.4 / 763.3				*				*50 blows per 5-inch set.

Bottom of Hole - 70.4 feet.
Water observed at 20 feet with 20 feet of hollow-stem auger in the ground.
Boring Immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	2048SB	833.6 (Surveyed)

Location: Hennepin Co. Coordinate: X=485973 Y=124602 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7507

Hammer CME Automatic Calibrated

SHEET 1 of 2

Drilling Completed 11/21/13

Depth / Elev.	Classification	SPT N60	MC (%)	Other Tests Or Remarks
0.6 / 833.0	7 inches of Bituminous.			
0.8 / 832.8	1 1/2 inches of Aggregate Base.			
9.0 / 824.6	SANDY LEAN CLAY, trace Gravel, with frequent Sand seams, brown, wet, (CLS), fill	16, 11, 36	15	
12.0 / 821.6	SANDY LEAN CLAY, trace Gravel, brown, moist, stiff, (CLS), till	16		
19.0 / 814.6	SILT with SAND, light brown to brown, moist, medium, dense, (ML), till	20, 17, 18	9	P200=78%
37.0 / 796.6	POORLY GRADED SAND, fine-grained, light brown to brown, moist to 27 fee then waterbearing, medium dense, (SP), outwash	15, 20, 26, 21*, 25, 22, 23	2	P200=5% Switched to mud rotary drilling operation to mud rotary drilling method after 25-foot sample. *No recovery sample recovery. P200=26%
42.0 / 791.6	SILTY SAND, fine-grained, brown, waterbearing, medium dense, (SM), till	22, 26	27	
	POORLY GRADED SAND, fine- to medium-grained, brown to 65 feet then gray, waterbearing, dense to very dense, (SP), outwash	33		

Index Sheet Code 3.0

(Continued Next Page)

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2048SB**	**833.6** *(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
			POORLY GRADED SAND, fine- to medium-grained, brown to 65 feet then gray, waterbearing, dense to very dense, (SP), outwash *(continued)*		37					
				PD						
					42					
50				PD						
					36					
				PD						
55					37					
				PD						
60					34					
				PD						
65					47					
				PD						
70					69					
				PD						
	74.0 / 759.6		SANDY LEAN CLAY, with Gravel, with frequent coarse Sand layers, brown, wet, hard, (CLS), till							
75					68					
				PD						
80	81.0 / 752.6				74					

Bottom of Hole - 81 feet.
Water observed at 27 feet with 27 feet of hollow-stem auger in the ground.
Boring immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2064SB	835.0 (Surveyed)

Location: Hennepin Co. Coordinate: X=485322 Y=124922 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7507

Hammer CME Automatic Calibrated

Drilling Completed 2/10/14

DEPTH	Depth / Elev.	Classification	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Other Tests Or Remarks / Formation or Member
	0.7 / 834.3	CLAYEY SAND, trace roots, black and brown, frozen, (SC), topsoil fill					
	6.0 / 829.0	SILTY SAND, fine-grained, trace Gravel, grayish brown, frozen to moist, (SM), fill	13				
5			5				
	9.0 / 826.0	SANDY LEAN CLAY, trace Gravel and fibers, brown and black, moist, (CL), fill	15				
10			12	40			DD=76 pcf
	14.0 / 821.0	SANDY LEAN CLAY, trace fibers, gray, brown and black, moist, (CL), fill	9				
15			16	38			DD=86 pcf; OC=2%
▼	17.0 / 818.0	ORGANIC CLAY, with shells, light gray, moist, (OL), marl/swamp deposit					
	19.0 / 816.0	SANDY LEAN CLAY, trace Gravel, brown and gray, wet, soft, (CL), alluvium	3				
20			7	43			qp=1/4 tsf; LL=64, PL=24, PI=40
			10	41			qp=2 tsf; DD=78 pcf
25			9				qp= 3/4 tsf
		FAT CLAY, gray, wet, rather stiff to soft, (CH), alluvium	4*				*No sample recovery.
30			2				qp=1/2 tsf
			4				qp=1/2 tsf
35			7				qp=3/4 tsf
	37.0 / 798.0		14*				*No sample recovery.
40		SANDY LEAN CLAY, trace Gravel, gray, wet, stiff to very stiff, (CL), till	14*				*Switched to mud rotary drilling method at 40-foot sample.
		PD	15*				*No sample recovery.
45		PD					

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Soil Class:J. Kirk Rock Class: Edit: Date: 7/28/14

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Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2064SB**	**835.0** *(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
			SANDY LEAN CLAY, trace Gravel, gray, wet, stiff to very stiff, (CL), till *(continued)*		17	24			qp=1 3/4 tsf; DD-101 pcf
				PD					
					16				qp=2 1/4 tsf
50				PD					
					17	21			qp=2 tsf; DD=107 pcf
	53.0 782.0								
			CLAYEY SAND, with Gravel, gray, waterbearing, very stiff, (SC), till	PD					
55					19				
				PD					
60	60.0 775.0		SANDY LEAN CLAY, with Gravel, gray, wet, very stiff to hard, (CL), till		25*				*Lost 3 feet of hole at 60 feet. No sample recovery.
				PD					
65					23				
				PD					
70					37	16			DD=116 pcf
	73.0 762.0		CLAYEY SAND, with Gravel, gray, waterbearing, hard, (SC), till	PD					
75					36				
	78.0 757.0		POORLY GRADED GRAVEL, with medium-grained Sand, with frequent Cobbles, gray, waterbearing, dense to very dense, (GP), outwash	PD					Heavy Gravel encountered at 78 feet.
80					44*				*Used full tank of mud from 80 to 85 feet.
				PD					
85					65*				*Lost 8 feet of hole after 85-foot sample.
				PD					
90									

(Continued Next Page)

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2064SB**	**835.0** *(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
	91.0			PD						
	744.0		Bottom of Hole - 91 feet. Water observed at 17 feet while drilling. Boring then backfilled with bentonite grout.							

BRAUN INTERTEC

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
		SWLRT	2065SB	834.4 (Surveyed)

Location: Hennepin Co. Coordinate: X=485509 Y=124774 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7507

Hammer CME Automatic Calibrated

Drilling Completed 2/12/14

Depth (ft)	Depth / Elev.	Classification	SPT N60	MC (%)	Other Tests Or Remarks
	0.5 / 833.9	SANDY LEAN CLAY, trace roots, black, frozen, (CL), topsoil fill			
	4.0 / 830.4	CLAYEY SAND, trace Gravel, brown, frozen, (SC), fill	21		
5	9.0 / 825.4	SANDY LEAN CLAY, trace Gravel, brown and black, frozen to 5 feet then moist, (CL), fill	11		
			16	17	DD=75 pcf
10	12.5 / 821.9	SANDY LEAN CLAY, with frequent Silt layers, gray to black, moist, (CLS), fill	12		
	14.0 / 820.4	PEAT, trace fibers, black, moist, (PT), swamp deposit	15		
15	17.0 / 817.4	ORGANIC SILT, with shells, trace fibers, gray, black, wet, (OH), swamp deposit	8	53	
			10		
20	27.0 / 807.4	LEAN CLAY, with frequent layers of Fat Clay, gray, moist, rather stiff to medium, (CL), alluvium	7		
			9		LL=49 PL=17
25			9	26	DD=99 pcf
	44.0 / 790.4	SANDY LEAN CLAY, trace Gravel, gray, moist, rather stiff to stiff, (CL), till	11		
30			14		
			13	19	DD=111 pcf
35			11		
			12		
40			14		
			16		
45					

Water level symbol (▼) at approximately 22 ft.

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2065SB**	**834.4** *(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
			SANDY LEAN CLAY, with Gravel, gray, moist, very stiff, (CL), till *(continued)*		18					
					20					
50					20	15				DD=117 pcf
	53.0 / 781.4		CLAYEY SAND, with Gravel, gray, wet, very stiff, (SC), till							
55					18					
	58.0 / 776.4		SANDY LEAN CLAY, trace Gravel, with frequent layers of Fat Clay, gray, wet, very stiff, (CL), till							
60					23					
65					20	29				DD=91 pcf LL=56 PL=17 PI=33
70					34					
	73.0 / 761.4		CLAYEY SAND, with Gravel, with Sand layers, gray, wet, hard, (SC), till							
75					42					
80					49					DD=123 pcf
						14				
85					41					
90										

(Continued Next Page)

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2065SB**	**834.4** *(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
					52					
95			CLAYEY SAND, with Gravel, with Sand layers, gray, wet, hard, (SC), till *(continued)*		58					
100	101.0 / 733.4				68					

Bottom of Hole - 101 feet.
Water observed at 22 feet while drilling.
Boring immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2066SB	833.6 (Surveyed)

Location: Hennepin Co. Coordinate: X=485772 Y=124630 (ft.)
Latitude (North)= Longitude (West)=
No Station-Offset Information Available

Drill Machine 7504
Hammer CME Automatic Calibrated

SHEET 1 of 2

Drilling Completed 2/25/14

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
	0.3 / 833.3		4 inches of Concrete.							
	4.0 / 829.6		CLAYEY SAND, trace Gravel, brown, frozen to moist, (SC), fill		47					
5	6.0 / 827.6		SANDY LEAN CLAY, trace Gravel, brown and gray, moist, (CLS), fill		15	23				
10	12.0 / 821.6		CLAYEY SAND, with Sand seams, with Gravel, brown and gray, moist, (SC), fill		22					
					19	10				
15	17.0 / 816.6		CLAYEY SAND, with layers of Lean Clay, gray, moist, stiff to rather stiff, (SC), till		15					
					11					
20 (water level)	22.0 / 811.6		SANDY LEAN CLAY, with Sand seams, gray, moist to 20 feet then wet, rather stiff, (CLS), till		9					
					11*	12				*Switched to mud rotary drilling method after 20-foot sample.
				PD	11					
25				PD	12					P200=4%
30				PD		19				
					24					
35			POORLY GRADED SAND, fine- to medium-grained, with Gravel, gray, waterbearing, dense to dense, (SP), outwash	PD	34					
40	43.0 / 790.6			PD	31					Layers of Lean Clay at 40 feet.
45			SILTY SAND, with Gravel, with layers of Lean Clay, gray, waterbearing, dense to very dense, (SM), till	PD						

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2066SB**	**833.6** *(Surveyed)*

DEPTH	Depth / Elev.	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
		SILTY SAND, with Gravel, with layers of Lean Clay, gray, waterbearing, dense to very dense, (SM), till *(continued)*	X	32				
			PD					
50			X	37				P200=25%
			PD		12			
55			X	44				
			PD					
60			X	52				
			PD					
65			X	62				Layers of Silty Sand at 65 feet.
	68.0 / 765.6	POORLY GRADED SAND, fine- to coarse-grained, with Gravel, with layers of Lean Clay, gray, waterbearing, medium dense, (SP), outwash	PD					
70			X	28				
	73.0 / 760.6	SILT, with Sand, gray, wet, dense to very dense, (ML), till	PD					
75			X	49				P200=86%
			PD		12			
80	81.0 / 752.6		X	75				

Bottom of Hole - 81 feet.
Water observed at 20 feet while drilling.
Boring immediately backfilled with bentonite grout.

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	2093SB	849.3 (Surveyed)

Location: Hennepin Co. Coordinate: X=484621 Y=125374 (ft.)
Latitude (North)= Longitude (West)=
No Station-Offset Information Available

Drill Machine 7504
Hammer CME Automatic Calibrated

Drilling Completed 5/13/14

Depth / Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
1.0 / 848.3	SANDY LEAN CLAY, trace roots, trace Gravel, black, moist. (CLS), topsoil fill		18			
4.0 / 845.3	SANDY LEAN CLAY, trace roots, black and dark brown, moist. (CLS), fill	8	27			
6.0 / 843.3	SANDY LEAN CLAY, trace Gravel, gray, moist. (CLS), fill	19	11			
9.0 / 840.3	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist. (SM), fill	22	12			P200=24%
17.0 / 832.3	SANDY LEAN CLAY, trace Gravel, with Sand seams, gray with layers of black, moist. (CLS), fill	32	13			
		31	11			DD=123 pcf LL=25, PL=12, PI=13
		18	33			
19.0 / 830.3	CLAYEY SAND, with Gravel, gray, moist. (SC), fill	27	9			Drillers Note: Switched to mud rotary drilling method after 17 1/2-foot sample.
22.0 / 827.3	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist. (SM), fill	27	10			
28.0 / 821.3	CLAYEY SAND, with Gravel, gray, moist. (SC), fill	27	10			DD=136 pcf
		20	15			
		50/6"*				50/6" (set). No sample recovery.
32.0 / 817.3	SILTY SAND, fine-grained, brown, wet, dense. (SM), till	37	13			
37.0 / 812.3	SILTY SAND, fine- to medium-grained, with Gravel, brown, wet, very dense. (SM), till	74	10			P200=13%
		63	12			
	POORLY GRADED SAND with SILT, fine- to medium-grained, with Gravel, brown, wet to 40 feet then waterbearing, loose to medium dense. (SP-SM), outwash	23	13			P200=11%
		9	15			

Drilling Operation: PD (pilot drilling) between samples from 19 ft; water level symbol at 40 ft.

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2093SB**	**849.3** *(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
					12	14				
				PD						
					19	12				
				PD						
50					7	17				P200=9%
				PD						
55					11	22				
				PD						
60					18	17				
			POORLY GRADED SAND with SILT, fine- to medium-grained, with Gravel, brown, wet to 40 feet then waterbearing, loose to medium dense. (SP-SM), outwash *(continued)*	PD						
65					17	17				
				PD						
70					21	20				
				PD						
75			Large wood chunks encountered at 75 feet.		16					
	78.0 / 771.3			PD						
80			SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff. (CLS), till		30	23				DD=104 pcf
	83.0 / 766.3			PD						
85			SILTY SAND, fine-grained, gray, waterbearing, dense. (SM), till		48	19				
	88.0 / 761.3		POORLY GRADED SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, dense to very dense. (SP),	PD						
90										

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2093SB**	**849.3** *(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
			outwash		41	14				
				PD						
95			POORLY GRADED SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, dense to very dense. (SP), outwash *(continued)*		52	23				
				PD						
100	101.0				57	19				
	748.3		Bottom of Hole - 101 feet. Water observed at 40 feet while drilling. Boring immediately backfilled with bentonite grout.							

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2094SB	837.7 (Surveyed)

Location: Hennepin Co. Coordinate: X=484887 Y=125344 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7504

Hammer CME Automatic Calibrated

Drilling Completed 5/16/14

DEPTH	Depth / Elev.	Classification	SPT N60 (REC %)	MC (%) (RQD %)	COH (psf) (ACL ft)	γ (pcf) (Core Breaks)	Other Tests Or Remarks (Formation or Member)
	1.0 / 836.7	SANDY LEAN CLAY, trace roots, dark brown, wet. (CLS), topsoil fill		52			
		SANDY LEAN CLAY, trace Gravel, dark brown and gray, moist. (CLS), fill With roots at 5 feet.	9	21			qp=1 3/4 tsf
5	6.0 / 831.7		6	21			
		CLAYEY SAND, trace Gravel, dark gray and brown, moist. (SC), fill	22	11			DD=126 pcf
10	11.0 / 826.7		18	13			qp=3 tsf
	13.0 / 824.7	SANDY LEAN CLAY, trace Gravel, gray, moist. (CLS), fill	10	16			
15	17.0 / 820.7	PEAT, decomposed with fibers, with shells, black, moist. (PT), swamp deposit	8	234			DD=21 pcf OC=50%
		FAT CLAY, gray, wet, medium to rather stiff. (CH), glaciofluvium	7	42			
20			8	30			
			10	48			DD=75 pcf qp=1/2 tsf Switched to mud rotary drilling after 22 1/2-foot sample.
25	28.0 / 809.7		9	40			
30		FAT CLAY, gray, wet, very soft. (CH), glaciofluvium	1	71			
			WOH	60			DD=69 pcf
35			WOH	67			
	40.0 / 797.7		1	58			
40		LEAN CLAY, with frequent layers of Silt, gray, wet, medium to rather stiff. (CL), glaciofluvium	7	18			
45			10	27			LL=27, PL=19, PI=8

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2094SB**	**837.7** (Surveyed)

Depth	Elev.	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
46.0	791.7			9	26			qp=1 tsf, DD=101 pcf
		SILTY SAND, fine- to medium-grained, with Gravel, gray, waterbearing, very stiff. (SM), till	PD	22	12			
49.0	788.7	CLAYEY SAND, with Gravel, gray, wet, very stiff. (SC), till	PD	21	12			qp=3 tsf DD=126 pcf
53.0	784.7	SANDY LEAN CLAY, trace Gravel, with Sand seams, gray, wet, stiff. (CL), till	PD	15	21			qp=1 1/4 tsf
			PD	15	29			DD=95 pcf
63.0	774.7	SILTY SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, medium dense. (SM), till	PD	19	12			
			PD	38	11			P200=18%
			PD	36	20			
			PD	37	18			
83.0	754.7	POORLY GRADED SAND with SILT, fine- to coarse-grained, with Gravel, gray, waterbearing, medium dense to dense. (SP-SM), outwash	PD	41	13			
			PD					

Depth scale: 50, 55, 60, 65, 70, 75, 80, 85, 90

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Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2094SB**	**837.7** *(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
					36	12				
				PD						
95					38	15				
				PD						
100					30	12				
105			POORLY GRADED SAND with SILT, fine- to coarse-grained, with Gravel, gray, waterbearing, medium dense to dense. (SP-SM), outwash *(continued)*	PD						
110					38	20				
115				PD						
120	121.0 / 716.7				42	17				

Bottom of Hole - 121 feet,
Water observed at a depth of 22 feet while drilling.
Boring immediately backfilled with betonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2095SB	841.5 (Surveyed)

Location: Hennepin Co. Coordinate: X=485048 Y=125201 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7506

Hammer CME Automatic Calibrated

SHEET 1 of 3

Drilling Completed 4/30/14

Depth / Elev.	Classification	SPT N60	MC (%)	Other Tests Or Remarks
1.0 / 840.5	SANDY LEAN CLAY, dark brown, moist. (CLS), topsoil fill		16	
4.0 / 837.5	SANDY LEAN CLAY, trace Gravel, brown and dark brown, moist. (CLS), fill	8	14	
12.0 / 829.5	CLAYEY SAND, trace Gravel, dark brown and gray, moist. (SC), fill	12	11	
		20	10	DD=125 pcf
		15	12	
14.0 / 827.5	SILTY CLAY, trace Gravel, brown, moist, (CL-ML), fill	5	16	LL=21, PL=14, PI=7
17.0 / 824.5	CLAYEY SAND, trace Gravel, gray and brown, moist. (SC), fill	11	12	DD=123 pcf
20.0 / 821.5	SLIGHTLY ORGANIC SILT, with fine-grained Sand, with shells, gray and black, moist. (OH), swamp deposit	6	36	OC=3% Drillers Note: Switched to mud rotary drilling method after 17 1/2-foot sample. P200=22%
27.0 / 814.5	SILTY SAND, fine- to medium-grained, trace Gravel, brown, waterbearing, medium dense to dense. (SM), till	31	14	
		21	14	
		33		
36.0 / 805.5	POORLY GRADED SAND with SILT, fine- to medium-grained, trace Gravel, brown, waterbearing, dense to medium dense. (SP-SM), outwash	31	19	P200=7%
		18	22	
		18	21	
		18	20	
42.0 / 799.5	POORLY GRADED SAND, fine- to medium-grained, with Gravel, brown, waterbearing, medium dense. (SP), outwash	28	11	P200=4%
		16		
	POORLY GRADED SAND, fine- to coarse-grained, with Gravel, occasional Cobbles, brown, waterbearing, medium dense. (SP), outwash	21	8	

Index Sheet Code 3.0

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2095SB**	**841.5** *(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
				X	22	11				
	47.0 / 794.5			PD						P200=8%
				X	28	12				
50				PD						
				X	29	8				
				PD						
55				X	24	14				
				PD						
60			POORLY GRADED SAND with SILT, fine- to coarse-grained, with Gravel, occasional Cobbles, brown, waterbearing, medium dense. (SP-SM), outwash	X	23	9				
				PD						
65				X	27	11				
				PD						
70			Large Boulder and rock encountered from 70 to 72 feet.	X	29	13				
	73.0 / 768.5			PD						
75				X	39	15				P200=36%
			SILTY SAND, fine- to medium-grained, with frequent layers of Silt, brown, waterbearing, dense. (SM), till	PD						
80				X	37	16				
	83.0 / 758.5			PD						
85			SANDY SILT, with frequent layers of Sand, reddish brown, wet, medium dense to dense. (ML), till	X	30	23				DD=110 pcf
				PD						
90										

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2095SB**	**841.5** *(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
	93.0 / 748.5		SANDY SILT, with frequent layers of Sand, reddish brown, wet, medium dense to dense. (ML), till *(continued)*	X	46	19				
95			SILTY SAND, fine- to medium-grained, with frequent layers of Silt and Lean Clay, reddish brown, wet, dense. (SM), till	PD						
				X	36	18				
				PD						
100	101.0 / 740.5			X	49	21				

Bottom of Hole - 101 feet.
Water observed at a depth of 17 feet while drilling.
Boring immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	2096SB	880.0 (Surveyed)

Location: Hennepin Co. Coordinate: X= Y= (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7506

Hammer CME Automatic Calibrated

Drilling Completed 4/25/14

Depth	Elev.	Classification
0.9	879.1	LEAN CLAY with SAND, trace roots, dark brown, moist, (CLwS), topsoil
5.0	875.0	LEAN CLAY with SAND, trace Gravel, brown, moist, rather stiff, (CLwS), till
13.0	867.0	SILTY SAND, fine- to medium-grained, with Gravel, brown, moist, medium dense, (SM), till
20.0	860.0	POORLY GRADED SAND, fine- to medium-grained, with Gravel, light brown to brown, moist, dense to medium dense, (SP), outwash Layer of Lean Clay at 17 feet.
22.0	858.0	POORLY GRADED SAND with SILT, fine- to medium-grained, trace Gravel, brown, moist, medium dense, (SP-SM), outwash
35.0	845.0	SANDY LEAN CLAY, fine- to medium-grained, trace Gravel, brown, moist, very stiff to hard, (CLS), till
37.0	843.0	CLAYEY SAND, trace Gravel, brown, moist, hard, (SC), till
40.0	840.0	SILTY SAND, fine-grained, brown, moist, medium dense, (SM), till
		POORLY GRADED SAND, fine- to medium-grained, light brown to 70 feet then brown, moist to 75 feet then wet, medium dense to dense, (SP), outwash

SPT N60	Other Tests Or Remarks
10	
17	
17	
19	
10	
7	
11	
12	
35	
20	
38*	*No sample recovery.
34	
18	
39	
23	
19	
18	

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Soil Class:J. Kirk Rock Class: Edit: Date: 7/28/14

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2096SB**	**880.0** *(Surveyed)*

DEPTH	Depth / Elev.	Classification	SPT N60	Other Tests Or Remarks
47			28	
48.5			25	
50			26	
55			34	
60		POORLY GRADED SAND, fine- to medium-grained, light brown to 70 feet then brown, moist to 75 feet then wet, medium dense to dense, (SP), outwash *(continued)*	32	
65			32	
70			27	
75 (water level ▼)			30*	*Switched to mud rotary drilling method after 75-foot sample.
80	80.0 / 800.0		47	
85		POORLY GRADED SAND with SILT, fine- to medium-grained, with Gravel, gray, waterbearing, dense, (SP-SM), outwash	47	
90	90.0			

Drilling Operation: split-spoon samples alternating with auger (to 75 ft) and PD (below 75 ft).

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2096SB**	**880.0** *(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
	790.0				31					
			SILT with SAND, with frequent layers of Fat Clay, gray, wet, dense, (MLwS), glaciofluvium	PD						
95	96.0 784.0				41					

Bottom of Hole - 96 feet.
Water observed at 75 feet while drilling.
Boring immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2118SB	837.8 (Surveyed)

Location: Hennepin Co. Coordinate: X=485180 Y=125086 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7507

Hammer CME Automatic Calibrated

Drilling Completed 5/22/14

Depth / Elev.	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
1.0 / 836.8	CLAYEY SAND, trace roots and Gravel, dark brown, moist. (SC), topsoil fill			13			
	CLAYEY SAND, trace Gravel, dark brown, moist. (SC), fill		17	14			
5.0 / 832.8							
7.0 / 830.8	PEAT, trace shells, black, wet. (PT), fill		17	34			
	LEAN CLAY, trace Gravel, black, wet. (CL), fill		15	27			
		PD	8	22			Switched to mud rotary drilling method after 10-foot sample.
14.0 / 823.8		PD	62*	101			*Sampler encountered large root at 12 feet.
	LEAN CLAY, trace Gravel, brown and gray, wet, rather stiff. (CL), alluvium	PD	10	24			
19.0 / 818.8		PD	11	18			
	FAT CLAY, gray, wet, rather stiff to soft. (CH), alluvium	PD	7	44			DD=112 pcf
		PD	12	35			qp=2 tsf
		PD	8	46			
		PD	8	38			qu=2760 psf DD=82 pcf
		PD	8	50			qp=1 tsf qp=1 tsf
		PD	7	41			
		PD	5	47			
		PD	7	42			qp=3/4 tsf
		PD	6	55			DD=66 pcf
		PD	6	52			

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Soil Class:J. Kirk Rock Class: Edit: Date: 7/28/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2118SB**	**837.8** *(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
			FAT CLAY, gray, wet, rather stiff to soft. (CH), alluvium *(continued)*	X	4	60				
				PD						
				X	6	72				
				PD						
50				X	3	64				qp=1/2 tsf
				PD						
55				X	5	34				
	58.0 / 779.8		SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff. (CL), till	PD						
60				X	25	12				qp=1 1/2 tsf
				PD						
65				X	28	16				DD=124 pcf
				PD						
70				X	22	12				qu=4560 psf DD=129 pcf
	73.0 / 764.8		POORLY GRADED SAND, fine- to medium-grained, gray, waterbearing, medium dense to very dense. (SP), outwash	PD						
75				X	28	21				Cobbles or Boulder from about 76 to 79 feet.
				PD						
80				X	45*					*No sample recovery.
				PD						
85				X	54	19				
				PD						
90										

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2118SB**	**837.8** *(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
			POORLY GRADED SAND, fine- to medium-grained, gray, waterbearing, medium dense to very dense. (SP), outwash *(continued)*	X	32	15				
				PD						
95				X	52	18				
				PD						
100				X	41	12				Gravel encountered at 100 feet.
105				PD						
	109.0 / 728.8									
110			SANDY LEAN CLAY, trace Gravel, gray, wet, hard. (CL), till	X	50	13				DD=122 pcf
115				PD						
120				X	67	13				
	121.0 / 716.8		Bottom of Hole - 121 feet. Water level obscured due to drilling fluids used during mud rotary drilling operation. Boring immediately backfilled with bentonite grout.							

Soil Class:J. Kirk Rock Class: Edit: Date: 7/28/14

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2119SB	834.6 (Surveyed)

Location: Hennepin Co. Coordinate: X=485442 Y=124842 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine: 7506

Hammer: CME Automatic Calibrated

SHEET 1 of 3

Drilling Completed: 5/5/14

Depth (ft)	Elev.	Classification	Other Tests Or Remarks
0.2	834.4	SANDY LEAN CLAY, trace Gravel, black, moist. (CLS), topsoil fill	
6.0	828.6	CLAYEY SAND, trace Gravel, with frequent layers of Lean Clay, brown, wet. (SC), fill	DD=112 pcf
9.0	825.6	ORGANIC CLAY, trace roots, trace shells, with wood pieces, black, moist. (OL), swamp deposit	DD=85 pcf OC=5%
12.0	822.6	CLAYEY SAND, trace Gravel, brown, wet, very stiff. (SC), till	Drillers Note: Switched to mud rotary drilling method after 10-foot sample.
14.0	820.6	SANDY LEAN CLAY, with Gravel, with Sand seams, gray, moist, very stiff. (CL), till	
29.0	805.6	LEAN CLAY, with layers of Fat Clay, gray, wet, rather stiff to stiff. (CL), till	DD=104 pcf LL=35, PL=12, PI=23
42.0	792.6	SANDY LEAN CLAY, trace Gravel, gray, wet, rather stiff to stiff. (CL), till	DD=114 pcf LL=36, PL=12, PI=24
		CLAYEY SAND, with Gravel, gray, wet, stiff to hard. (SC), till	DD=125 pcf

Water level symbol at approx. 10 ft.

Approx. Depth (ft)	Drilling Operation	SPT N_{60}	MC (%)
0–2			24
2.5		6	17
5		16	12
7.5		16	33
10		14	14
12.5	PD	24	26
15	PD	10	28
17.5	PD	12	25
20	PD	10	22
22.5	PD	11	29
25	PD	11	23
27.5	PD	15	23
30	PD	11	18
32.5	PD	15	23
35	PD	10	17
37.5	PD	14	15
40	PD	11	21
42.5	PD	13	12

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2119SB**	**834.6** *(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
		CLAYEY SAND, with Gravel, gray, wet, stiff to hard. (SC), till *(continued)*		40	10			
	47.0 / 787.6		PD	18	15			
50			PD	19	16			
		FAT CLAY, trace Gravel, gray, moist, very stiff. (CH), till	PD					
55				22	24			DD=102 pcf LL=55, PL=18, PI=37
	58.0 / 776.6		PD					
60				12	13			DD=121 pcf
		CLAYEY SAND, trace Gravel, gray, wet, rather stiff to stiff. (SC), till	PD					
65				14*				*No sample recovery.
	68.0 / 766.6		PD					
70				100*				*No sample recovery. Rock in tip.
			PD					
75				59	12			
		SILTY SAND, fine- to medium-grained, with Gravel, gray, wet, very dense. (SM), till	PD					
80				67	9			P200=14%
			PD					
85				58	18			
			PD					
90								

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2119SB**	**834.6** *(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
			SILTY SAND, fine- to medium-grained, with Gravel, gray, wet, very dense. (SM), till *(continued)*	X	80	14				
				PD						
95	96.0 / 738.6			X	55	10				
			Bottom of Hole - 96 feet.							

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2137SB	835.2 (Surveyed)

Location: Hennepin Co. Coordinate: X=485655 Y=124685 (ft.)
Latitude (North)= Longitude (West)=
No Station-Offset Information Available

Drill Machine 7506
Hammer CME Automatic Calibrated

Drilling Completed 5/7/14

DEPTH	Depth / Elev.	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
	0.2 / 835.0	SANDY LEAN CLAY, trace roots, trace Gravel, dark brown, moist. (CLS), topsoil fill			19				
	4.0 / 831.2	SANDY LEAN CLAY, trace Gravel, trace roots, dark brown and black, moist. (CLS), fill		9	22				
5				19	23				
				29	9				
10 (water level ▼)	14.0 / 821.2	CLAYEY SAND, with Gravel, with lenses of Lean Clay, brown and gray, moist to 10 feet then wet. (SC), fill		16					Drillers Note: Switched to mud rotary drilling method after 10-foot sample.
			PD	22	13				
15	17.0 / 818.2	SANDY LEAN CLAY, with Gravel, occasional Cobbles, brown and gray, wet. (CLS), fill	PD	37*	3				
	19.0 / 816.2	CLAYEY SAND, with Gravel, with lenses of Lean Clay, gray and brown, wet. (SC), fill	PD	16	13				
20			PD	3	54				OC=3%
			PD	5	80				
25			PD	4					
			PD	3	144				
30		SLIGHTLY ORGANIC to ORGANIC SILT, with shells, trace fibers, trace roots, gray with layers of black, wet. (OL), swamp deposit	PD	3	104				OC=10%
			PD	3	116				
35			PD	3	99				
	39.0 / 796.2		PD	4	84				*Rock in tip of sampler.
40			PD	4	63				
		SLIGHTLY ORGANIC SILT, trace roots, with shells, with wood pieces, dark gray and black, wet. (OL), swamp deposit	PD	5	47				OC=3%
45			PD						

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2137SB**	**835.2** *(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
			SLIGHTLY ORGANIC SILT, trace roots, with shells, with wood pieces, dark gray and black, wet. (OL), swamp deposit *(continued)*		3					
	48.0 / 787.2			PD	9	30				
50	50.0 / 785.2		CLAYEY SAND, with Gravel, gray, wet, rather stiff. (SC), till	PD	10	44				LL=61; PL=24; PI=37
55			FAT CLAY, trace Gravel, gray, wet, rather stiff to very stiff. (CH), till	PD	15					
60				PD	17	23				
65	63.0 / 772.2		SANDY LEAN CLAY, with Gravel, gray, wet, very stiff. (CL), till	PD	21	24				
70				PD	26					
75	73.0 / 762.2		CLAYEY SAND, with Gravel, with frequent lenses of Lean Clay, gray, wet, medium dense to very dense. (SC), till	PD	30	11				
80				PD	36					
85				PD	35	11				
90				PD						

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2137SB**	**835.2** *(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
			Sand layer encountered at 90 feet.		54	13				
	93.0 / 742.2		CLAYEY SAND, with Gravel, with frequent lenses of Lean Clay, gray, wet, medium dense to very dense. (SC), till *(continued)*	PD						
95	98.0 / 737.2		SANDY SILT, gray, wet, very dense. (ML), glaciofluvium	PD	53					
100					77	23				
105			SILTY SAND, fine- to medium-grained, with Gravel, brown and gray, waterbearing, very dense to dense. (SM), till	PD						
110	111.0 / 724.2				48	19				

Bottom of Hole - 111 feet.
Water not observed while drilling.
Boring immediately backfilled with bentonite grout.

METROPOLITAN COUNCIL

BRAUN INTERTEC

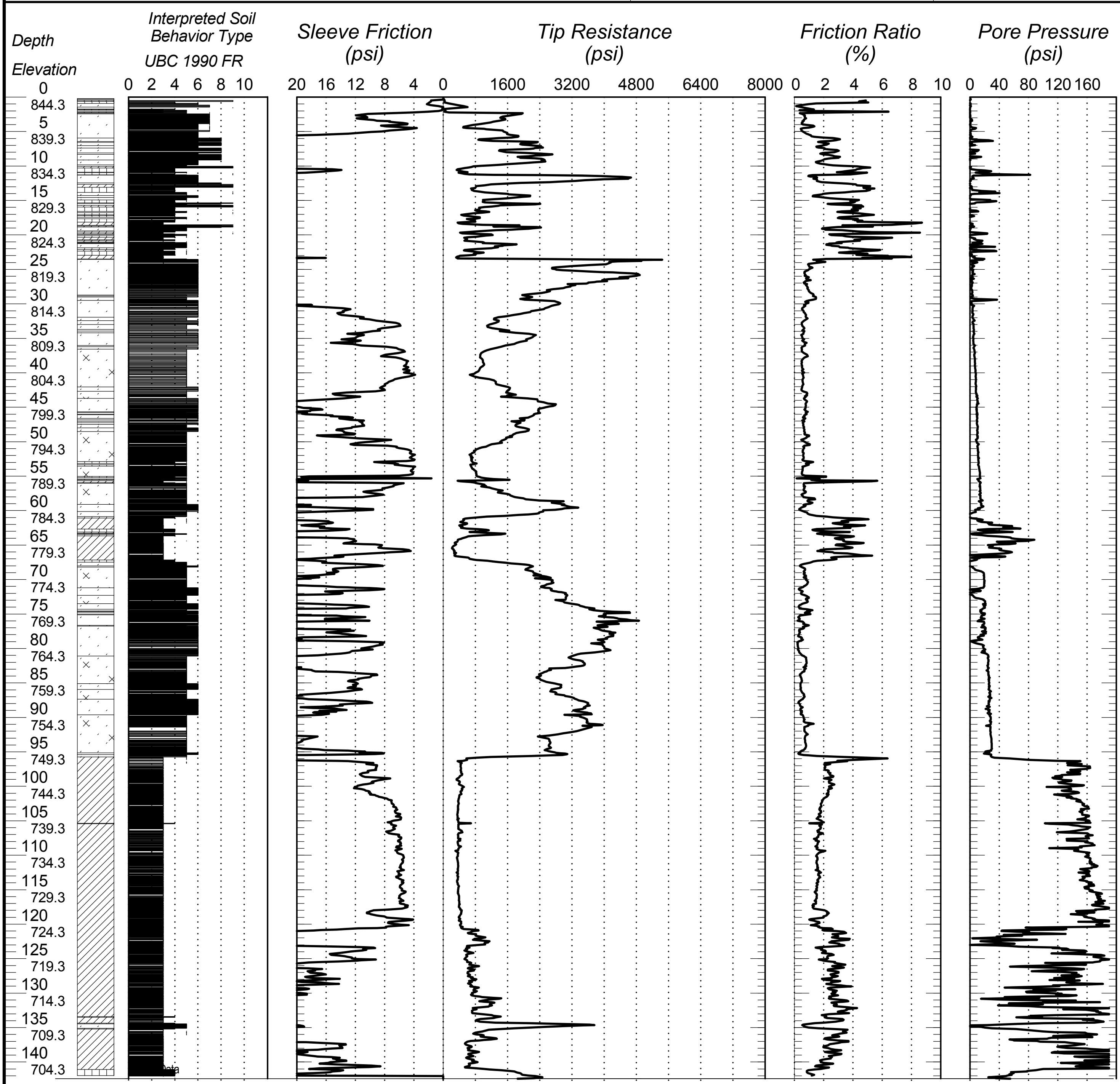
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	2105CW	844.3 (Surveyed)

Location: Co. Coordinate: X=484480 Y=125283 (ft.)		CPT Machine CPT-1	SHEET 1 of 2
Latitude (North)=	Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available		Hole Type CPT-STD/PWP-DISS	5/12/14



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METROPOLITAN COUNCIL

BRAUN INTERTEC

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Sounding No.*	*Ground Elevation*
		SWLRT	**2105CW**	**844.3** *(Surveyed)*

Mn/DOT GEOTECHNICAL SECTION - CONE PENETRATION TEST RESULTS

Depth *Elevation*	*Interpreted Soil Behavior Type* *UBC 1990 FR*	*Sleeve Friction (psi)*	*Tip Resistance (psi)*	*Friction Ratio (%)*	*Pore Pressure (psi)*
	0 2 4 6 8 10	20 16 12 8 4 0	1600 3200 4800 6400 8000	0 2 4 6 8 10	0 40 80 120 160

Bottom of Hole 142.41

Soil Class: Rock Class: Edit: Date: 8/4/14
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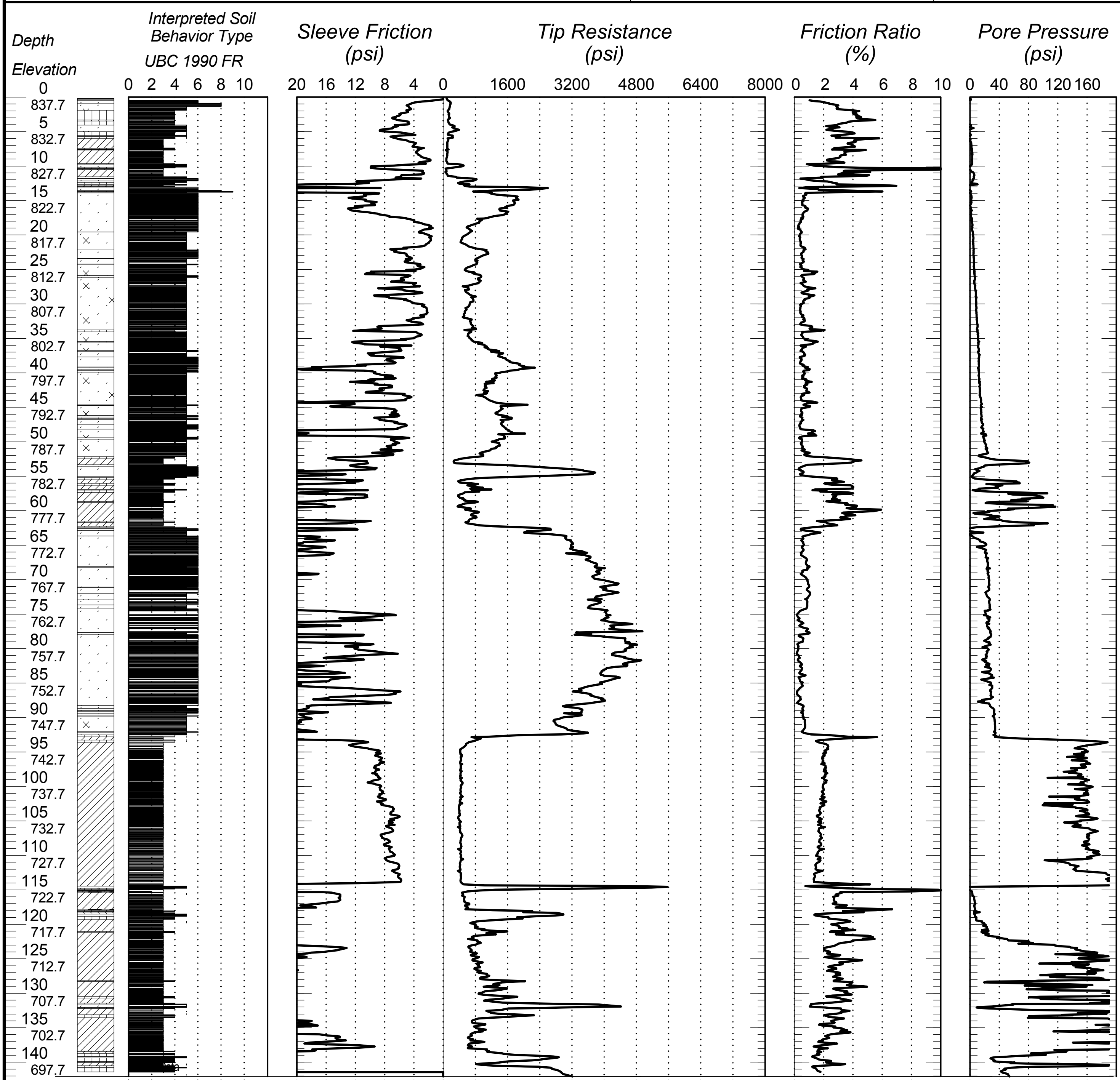
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	2106CW	837.7 (Surveyed)

Location Co. Coordinate: X=484537 Y=125277 (ft.)	CPT Machine CPT-1	SHEET 1 of 2
Latitude (North)= Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available	Hole Type CPT-STD/PWP-DISS	5/12/14



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Soil Class: Rock Class: Edit: Date: 8/4/14
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METROPOLITAN COUNCIL

BRAUN INTERTEC

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Sounding No.*	*Ground Elevation*
		SWLRT	**2106CW**	**837.7** *(Surveyed)*

Mn/DOT GEOTECHNICAL SECTION - CONE PENETRATION TEST RESULTS

Depth *Elevation*	*Interpreted Soil Behavior Type* *UBC 1990 FR*	*Sleeve Friction (psi)*	*Tip Resistance (psi)*	*Friction Ratio (%)*	*Pore Pressure (psi)*
	0 2 4 6 8 10	20 16 12 8 4 0	1600 3200 4800 6400 8000	0 2 4 6 8 10	0 40 80 120 160

Bottom of Hole 142.08

Soil Class: Rock Class: Edit: Date: 8/4/14
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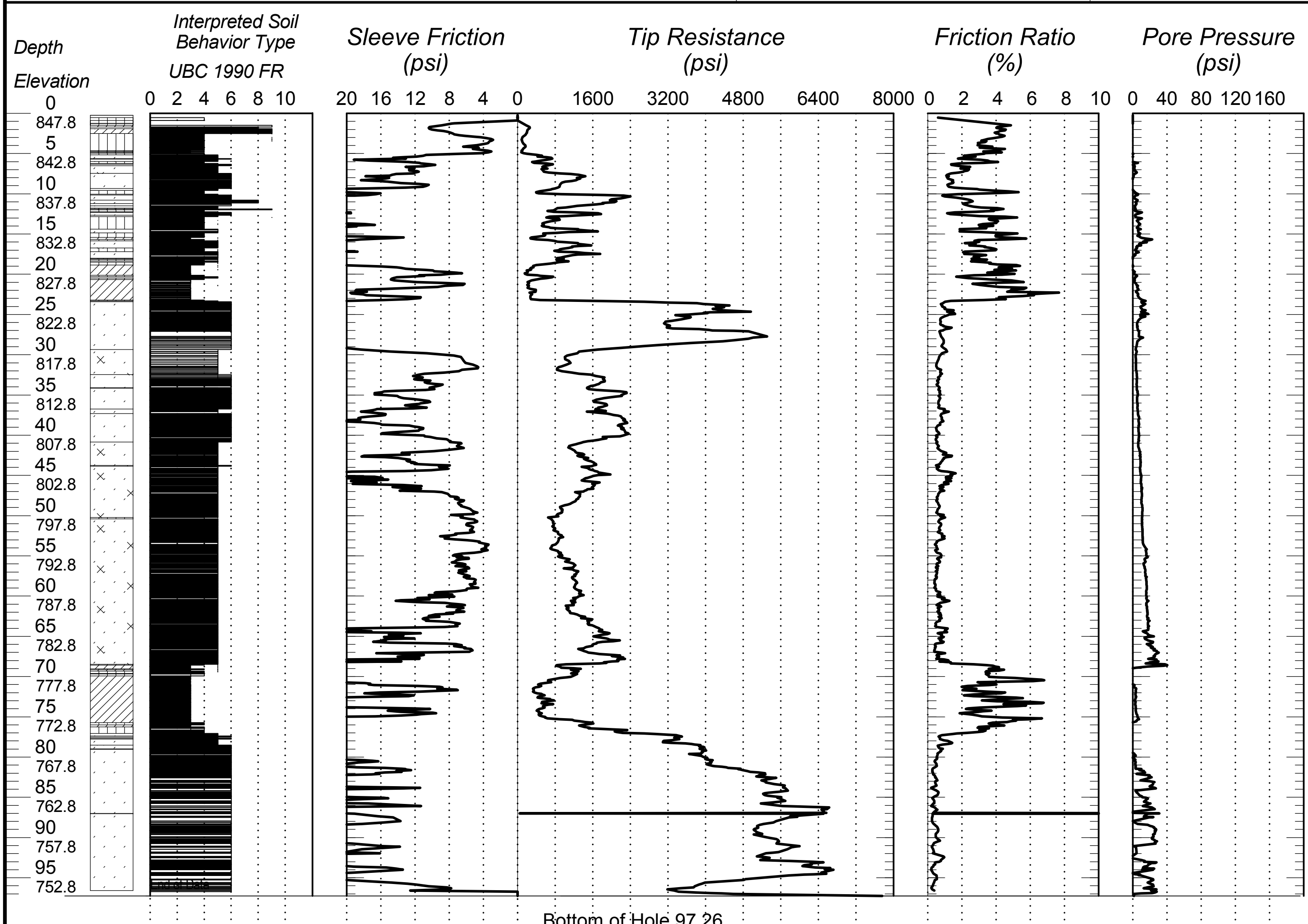
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	**2107CB**	**847.8** (Surveyed)

Location **Co. Coordinate: X=484566 Y=125333** (ft.)	CPT Machine **CPT-1**	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available	Hole Type **CPT-STD/PWP-DISS**	**5/12/14**



Index Sheet Code

Soil Class: Rock Class: Edit: Date: 8/4/14
N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213-MNDOT-CPT-DXF.GPJ

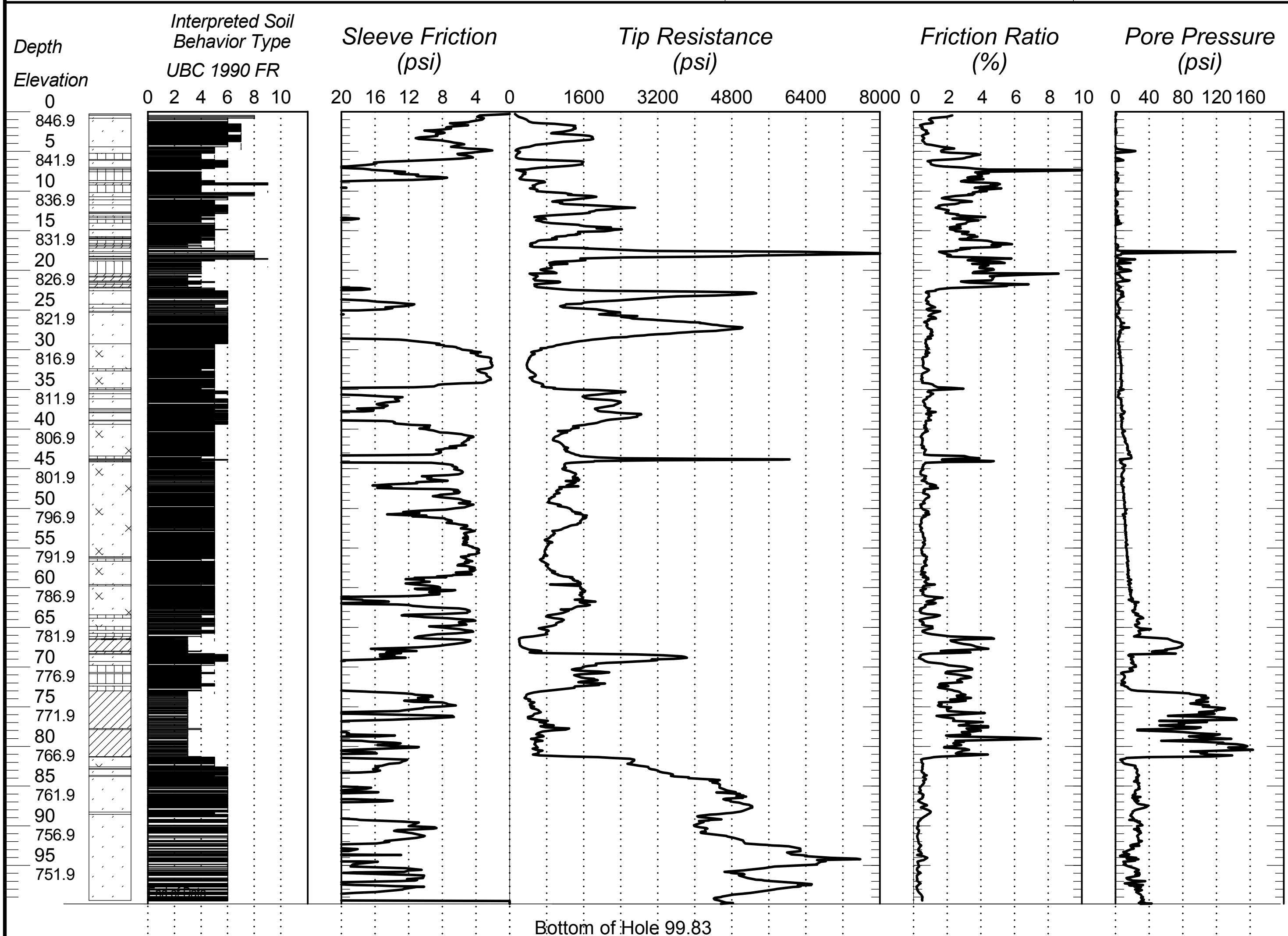
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	**2108CB**	**846.9** (Surveyed)

Location **Co. Coordinate: X=484692 Y=125400** (ft.)	CPT Machine **CPT-1**	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available	Hole Type **CPT-STD/PWP-DISS**	**5/12/14**



Index Sheet Code

METROPOLITAN COUNCIL

BRAUN INTERTEC

MINNESOTA DEPARTMENT OF TRANSPORTATION

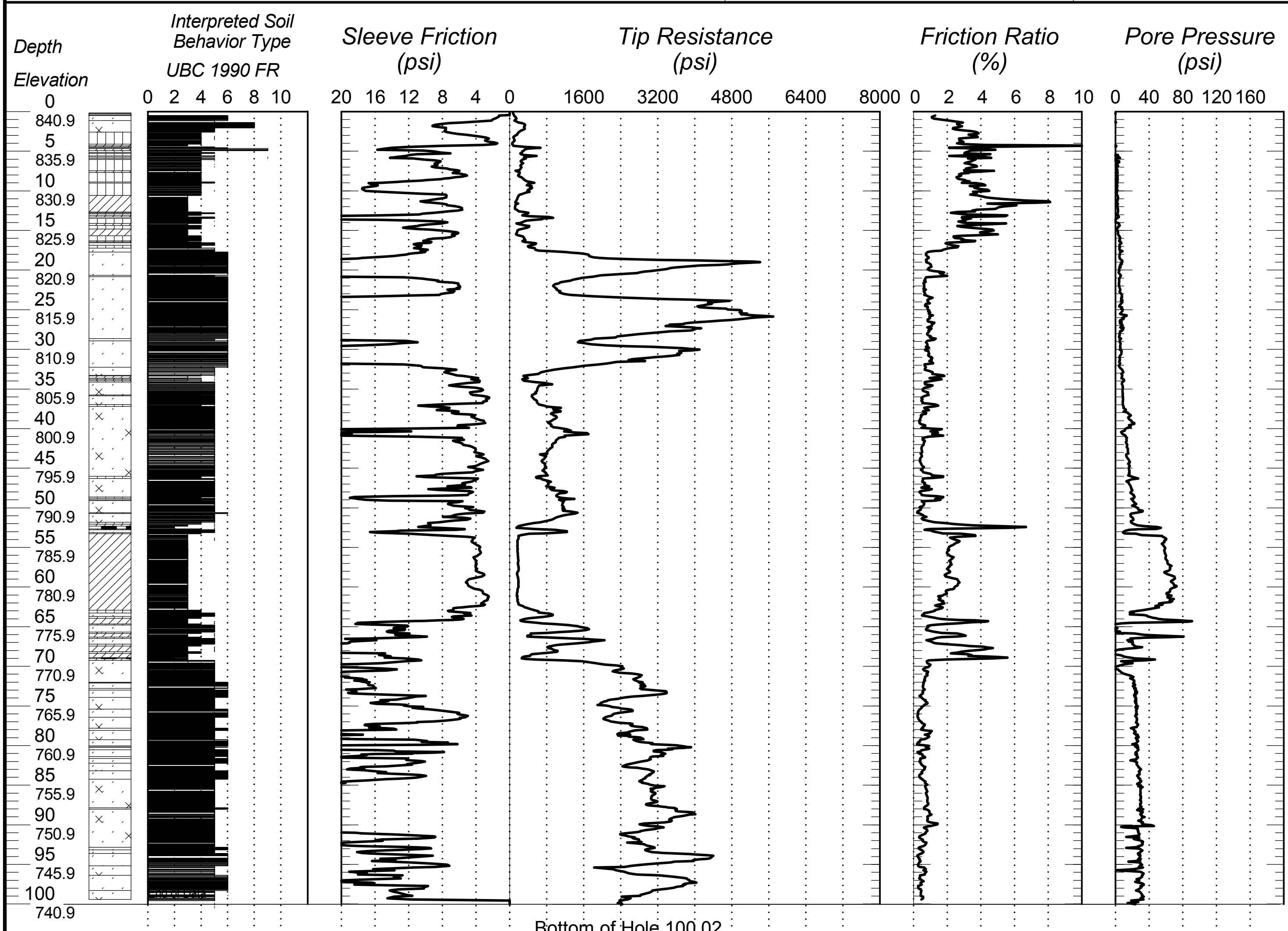
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	2109CB	840.9 (Surveyed)

Location Co. Coordinate: X=484758 Y=125406 (ft.)	CPT Machine CPT-1	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available	Hole Type CPT-STD/PWP-DISS	5/12/14



Index Sheet Code

Soil Class: Rock Class: Edit: Date: 8/4/14

N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213-MNDOT-CPT-DXF.GPJ

METROPOLITAN COUNCIL

BRAUN INTERTEC

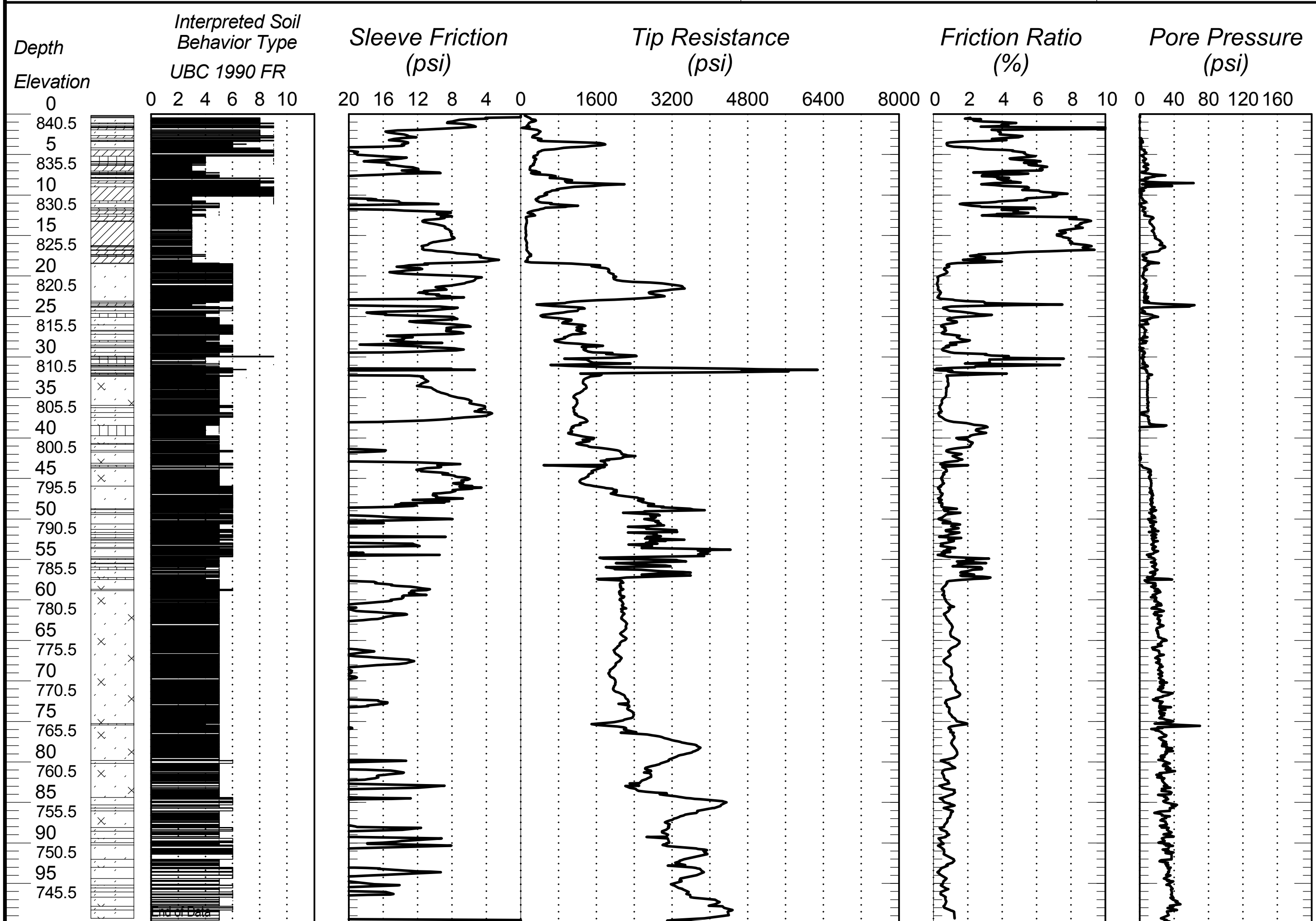
CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
		SWLRT	**2110CB**	**840.5** (Surveyed)

Location **Co. Coordinate: X=484958 Y=125289** (ft.)	CPT Machine **CPT-1**	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator	Date Completed
No Station-Offset Information Available	Hole Type **CPT-STD/PWP-DISS**	**5/12/14**



Bottom of Hole 99.9

Index Sheet Code

Soil Class: Rock Class: Edit: Date: 8/4/14

N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213-MNDOT-CPT-DXF.GPJ

Summary of Anticipated Pile Lengths – Abutment and Piers - PDA Analysis

Boring/Substructure	Anticipated Cutoff Elevation (feet)	Factored Load $\Sigma\gamma Q_n$ (tons)	Nominal Resistance R_n (tons)	O.D. of Pipe Pile (inches)	Approximate Tip Elevation (feet)	Approximate Pile Length (feet)
2108CB (Pier 1)	835	120	185 [370 kips]	16.0	791	45
		140	215 [430 kips]	16.0	776	60
2109CB (Pier 2)	837	120	185 [370 kips]	16.0	772	65
		140	215 [430 kips]	16.0	767	70
2109CB (Pier 3)	839	120	185 [370 kips]	16.0	772	70
		140	215 [430 kips]	16.0	767	75
2094SB (Pier 4 and Pier 5	841	120	185 [370 kips]	16.0	785	55
		140	215 [430 kips]	16.0	780	60
2094SB (Pier 6)	845	120	185 [370 kips]	16.0	785	60
		140	215 [430 kips]	16.0	780	65
2110CB (Pier 7)	847	120	185 [370 kips]	16.0	807	40
		140	215 [430 kips]	16.0	797	50
2110CB (Pier 8)	838	120	185 [370 kips]	12.0	793	45
		140	215 [430 kips]	12.0	788	50
2095SB (Pier 9)	832	120	185 [370 kips]	16.0	802	30
		140	215 [430 kips]	16.0	792	40
2118SB (Pier 10)	830	120	185 [370 kips]	16.0	775	55
		140	215 [430 kips]	16.0	770	60

Summary of Anticipated Pile Lengths – Abutment and Piers - PDA Analysis
Continued

Boring/Substructure	Anticipated Cutoff Elevation (feet)	Factored Load $\Sigma\gamma Q_n$ (tons)	N Nominal Resistance R_n (tons)	O.D. of Pipe Pile (inches)	Approximate Tip Elevation (feet)	Approximate Pile Length (feet)
2064SB (Pier 11)	828	120	185 [370 kips]	16.0	783	45
		140	215 [430 kips]	16.0	778	50
2119SB (Pier 12)	828	120	185 [370 kips]	16.0	780	40
		140	215 [430 kips]	16.0	783	45
2065SB (Pier 13)	828	120	185 [370 kips]	16.0	788	40
		140	215 [430 kips]	16.0	783	45
2137SB (Pier 14)	826	120	185 [370 kips]	16.0	766	60
		140	215 [430 kips]	16.0	761	65
2066SB (Pier 15)	827	120	185 [370 kips]	16.0	797	30
		140	215 [430 kips]	16.0	792	35
2047SB (Pier 16)	829	120	185 [370 kips]	16.0	794	35
		140	215 [430 kips]	16.0	784	45
2048SB (Pier 17)	829	120	185 [370 kips]	16.0	799	30
		140	215 [430 kips]	16.0	794	35
2096SB (East Abutment)	863	120	185 [370 kips]	12.0	833	30
		140	215 [430 kips]	12.0	828	35

Summary of Anticipated Pile Lengths – Abutment and Piers – MPF12 Analysis

Boring/Substructure	Anticipated Cutoff Elevation (feet)	Factored Load $\Sigma\gamma Q_n$ (tons)	Nominal Resistance R_n (tons)	O.D. of Pipe Pile (inches)	Approximate Tip Elevation (feet)	Approximate Pile Length (feet)
2108CB (Pier 1)	835	120	240 [480 kips]	16.0	766	70
		140	280 [560 kips]	16.0	761	75
2109CB (Pier 2)	837	120	240 [480 kips]	16.0	767	70
		140	280 [560 kips]	16.0	762	75
2109CB (Pier 3)	839	120	240 [480 kips]	16.0	767	75
		140	280 [560 kips]	16.0	762	80
2094SB (Pier 4 and Pier 5)	841	120	240 [480 kips]	16.0	775	65
		140	280 [560 kips]	16.0	770	70
2094SB (Pier 6)	845	120	240 [480 kips]	16.0	775	70
		140	280 [560 kips]	16.0	770	75
2110CB (Pier 7)	847	120	240 [480 kips]	16.0	797	50
		140	280 [560 kips]	16.0	792	55
2110CB (Pier 8)	838	120	240 [480 kips]	12.0	788	50
		140	280 [560 kips]	12.0	763	75
2095SB (Pier 9)	832	120	240 [480 kips]	16.0	792	40
		140	280 [560 kips]	16.0	787	45
2118SB (Pier 10)	830	120	240 [480 kips]	16.0	775	55
		140	280 [560 kips]	16.0	770	60
2064SB (Pier 11)	828	120	240 [480 kips]	16.0	778	50
		140	280 [560 kips]	16.0	773	55

Summary of Anticipated Pile Lengths – Abutment and Piers – MPF12 Analysis
Continued

Boring/Substructure	Anticipated Cutoff Elevation (feet)	Factored Load $\Sigma\gamma Q_n$ (tons)	Nominal Resistance R_n (tons)	O.D. of Pipe Pile (inches)	Approximate Tip Elevation (feet)	Approximate Pile Length (feet)
2119SB (Pier 12)	828	120	240 [480 kips]	16.0	783	45
		140	280 [560 kips]	16.0	778	50
2065SB (Pier 13)	828	120	240 [480 kips]	16.0	783	45
		140	280 [560 kips]	16.0	778	50
2137SB (Pier 14)	826	120	240 [480 kips]	16.0	761	65
		140	280 [560 kips]	16.0	756	70
2066SB (Pier 15)	827	120	240 [480 kips]	16.0	797	30
		140	280 [560 kips]	16.0	792	35
2047SB (Pier 16)	829	120	240 [480 kips]	16.0	784	45
		140	280 [560 kips]	16.0	779	50
2048SB (Pier 17)	829	120	240 [480 kips]	16.0	799	30
		140	280 [560 kips]	16.0	794	35
2096SB (East Abutment)	863	120	280 [560 kips]	12.0	833	30
		140	280 [560 kips]	12.0	823	40

Summary of Anticipated Pile Lengths – Screen Wall – PDA Analysis

Boring/Sounding	Anticipated Bottom of Grade Beam Elevation (feet)	Factored Load $\Sigma\gamma Q_n$ (tons)	Nominal Resistance R_n (tons)	O.D. of Pipe Pile (inches)	Approximate Tip Elevation (feet)	Approximate Pile Length (feet)
2108CB	832	100	154 [307 kips]	10.0	762	70
2109CB	834	100	154 [307 kips]	10.0	769	65
2094SB	836	100	154 [307 kips]	10.0	776	60
2110CB	838	100	154 [307 kips]	10.0	793	45

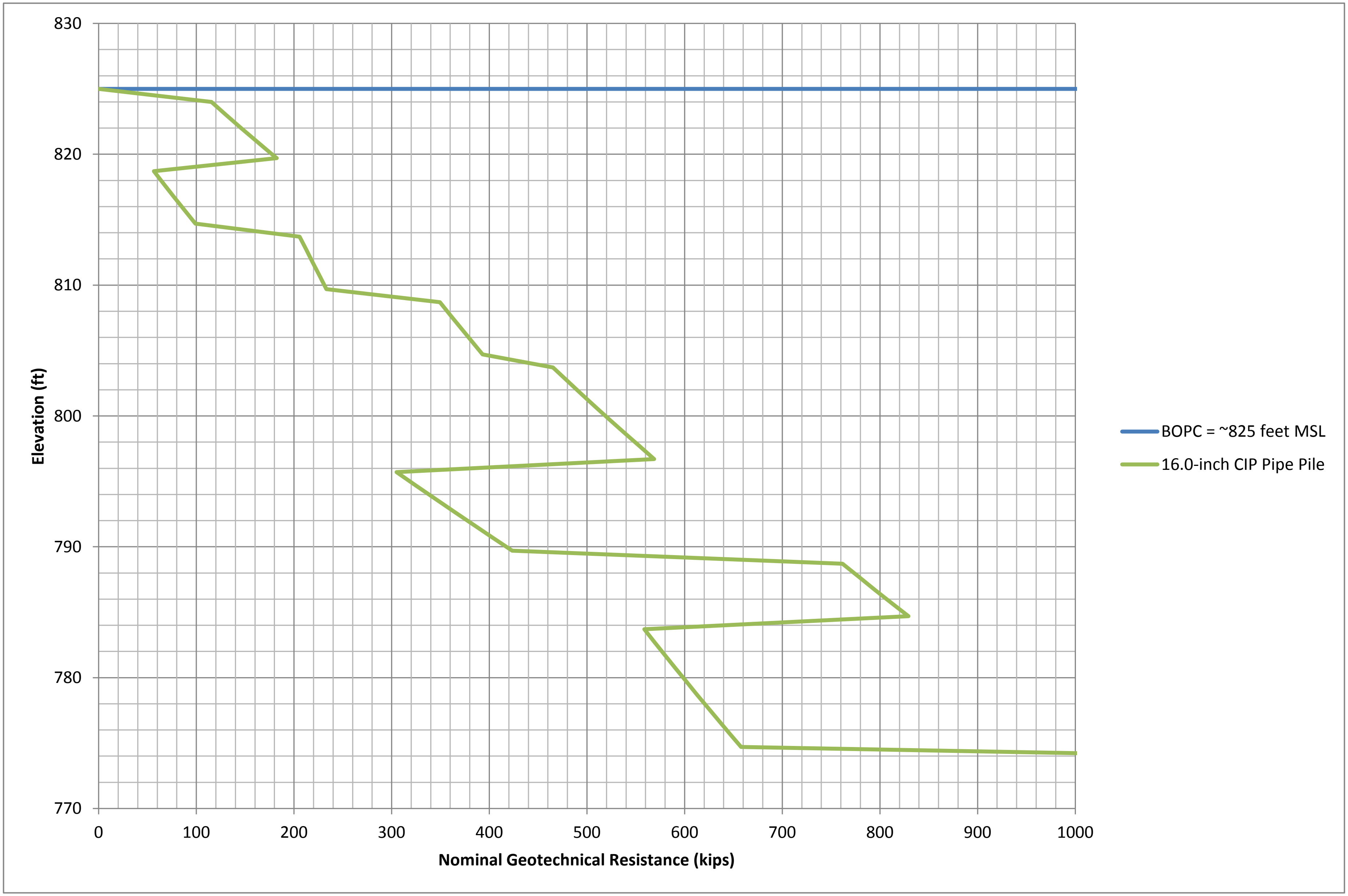
Summary of Anticipated Pile Lengths – Screen Wall – MPF12 Analysis

Boring/Sounding	Anticipated Bottom of Grade Beam Elevation (feet)	Factored Load $\Sigma\gamma Q_n$ (tons)	Nominal Resistance R_n (tons)	O.D. of Pipe Pile (inches)	Approximate Tip Elevation (feet)	Approximate Pile Length (feet)
2108CB	832	100	200 [400 kips]	10.0	757	75
2109CB	834	100	200 [400 kips]	10.0	764	70
2094SB	836	100	200 [400 kips]	10.0	771	65
2110CB	838	100	200 [400 kips]	10.0	768	70

Prairie Center Drive Bridge - Pier 17 North

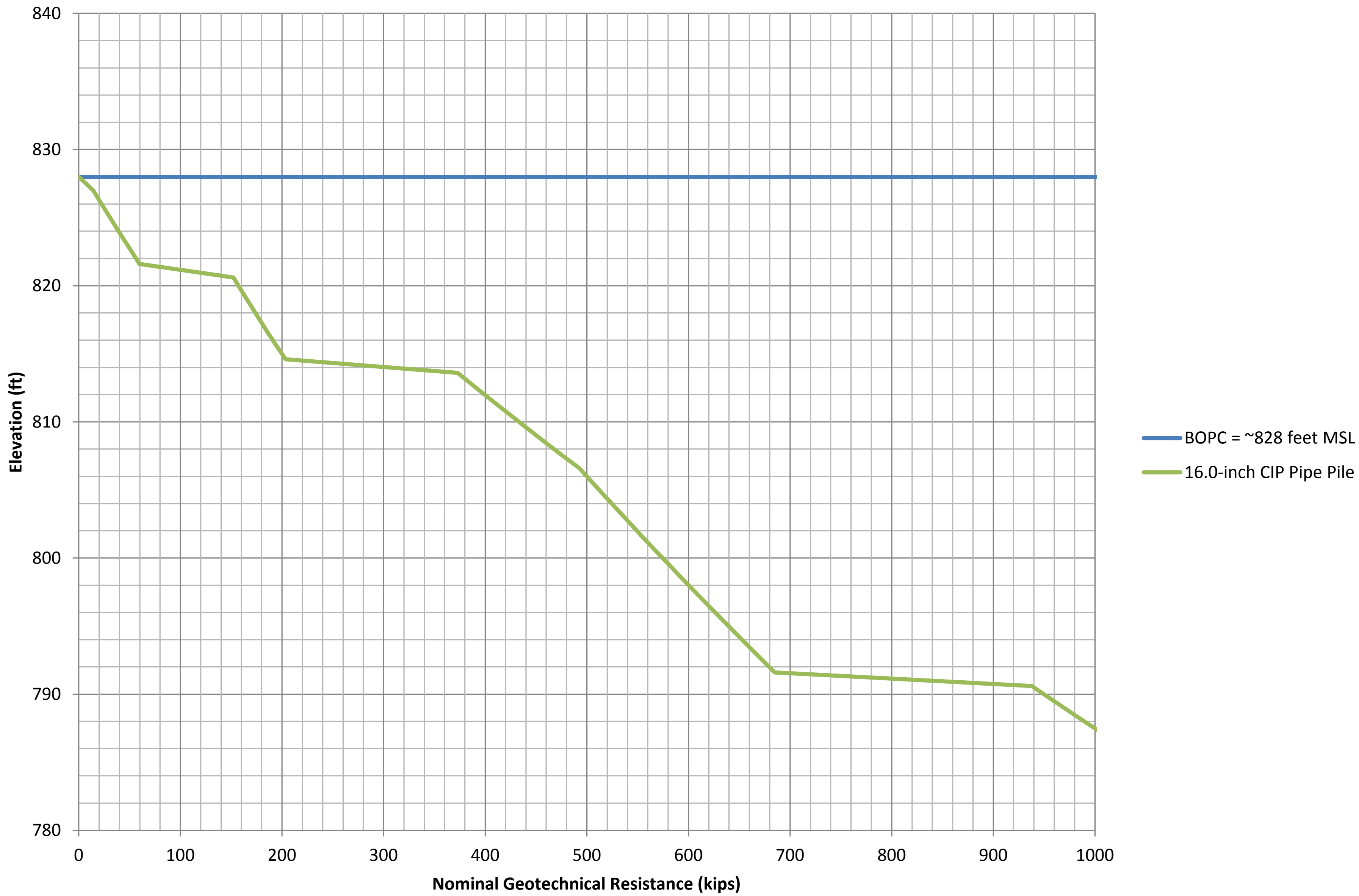
Boring: 2047SB

16.0-inch Closed Ended Pipe Pile



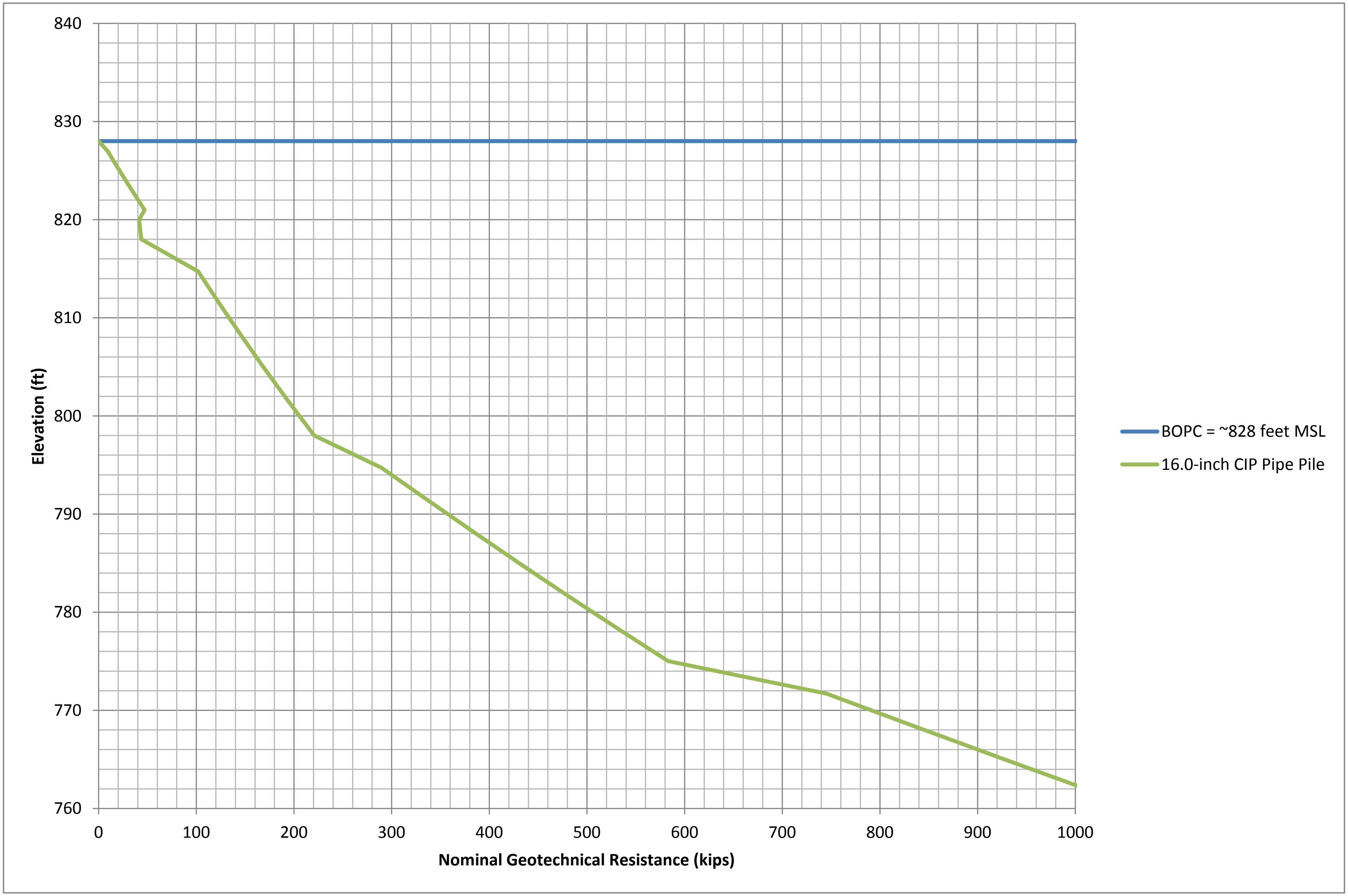
Braun Project No. BL-13-00213

Prairie Center Drive Bridge - Pier 19
Boring: 2048SB
16.0-inch Closed Ended Pipe Pile



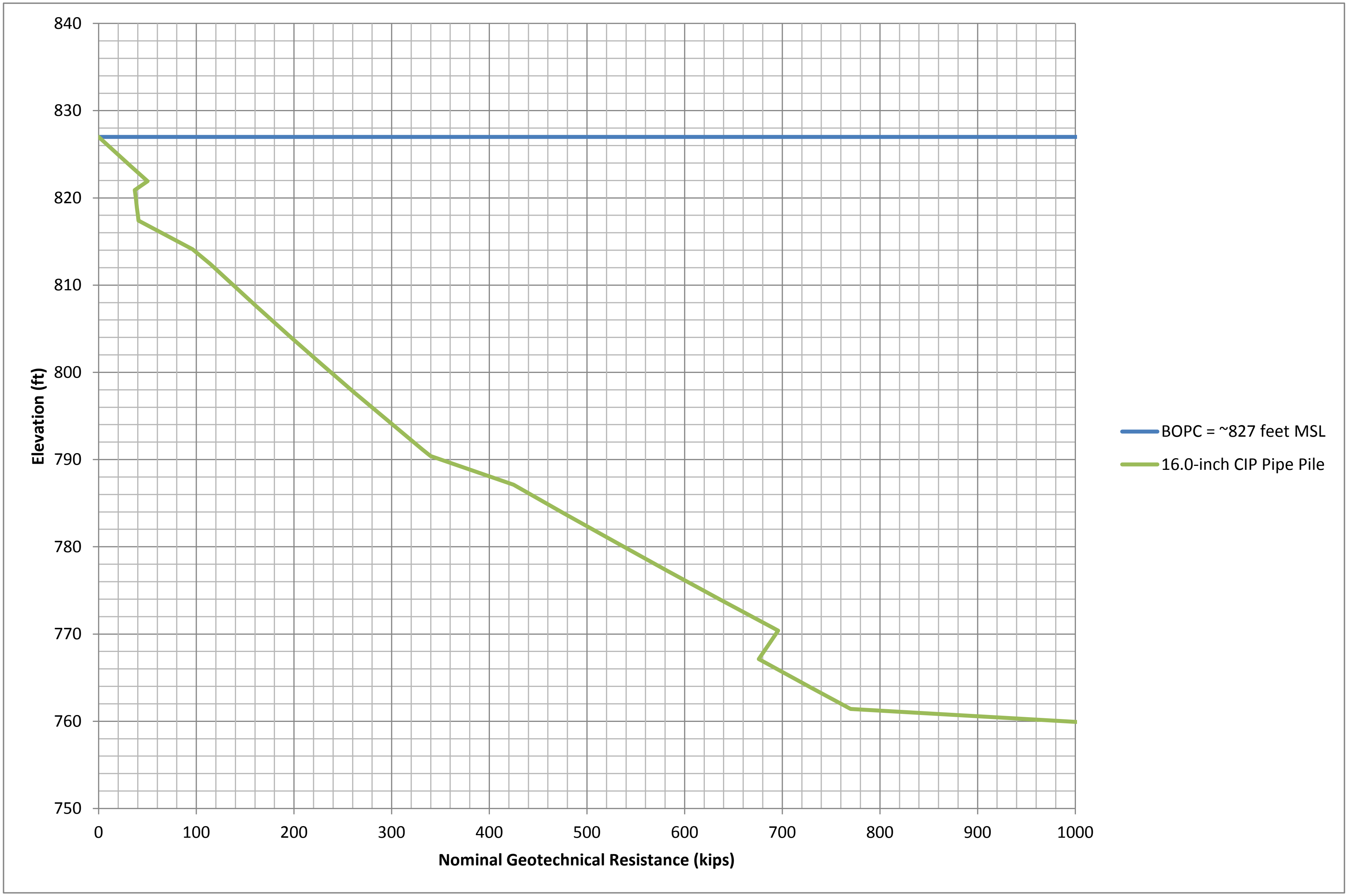
BRAUN INTERTEC

Prairie Center Drive Bridge - Pier 12
Boring: 2064SB
16.0-inch Closed Ended Pipe Pile



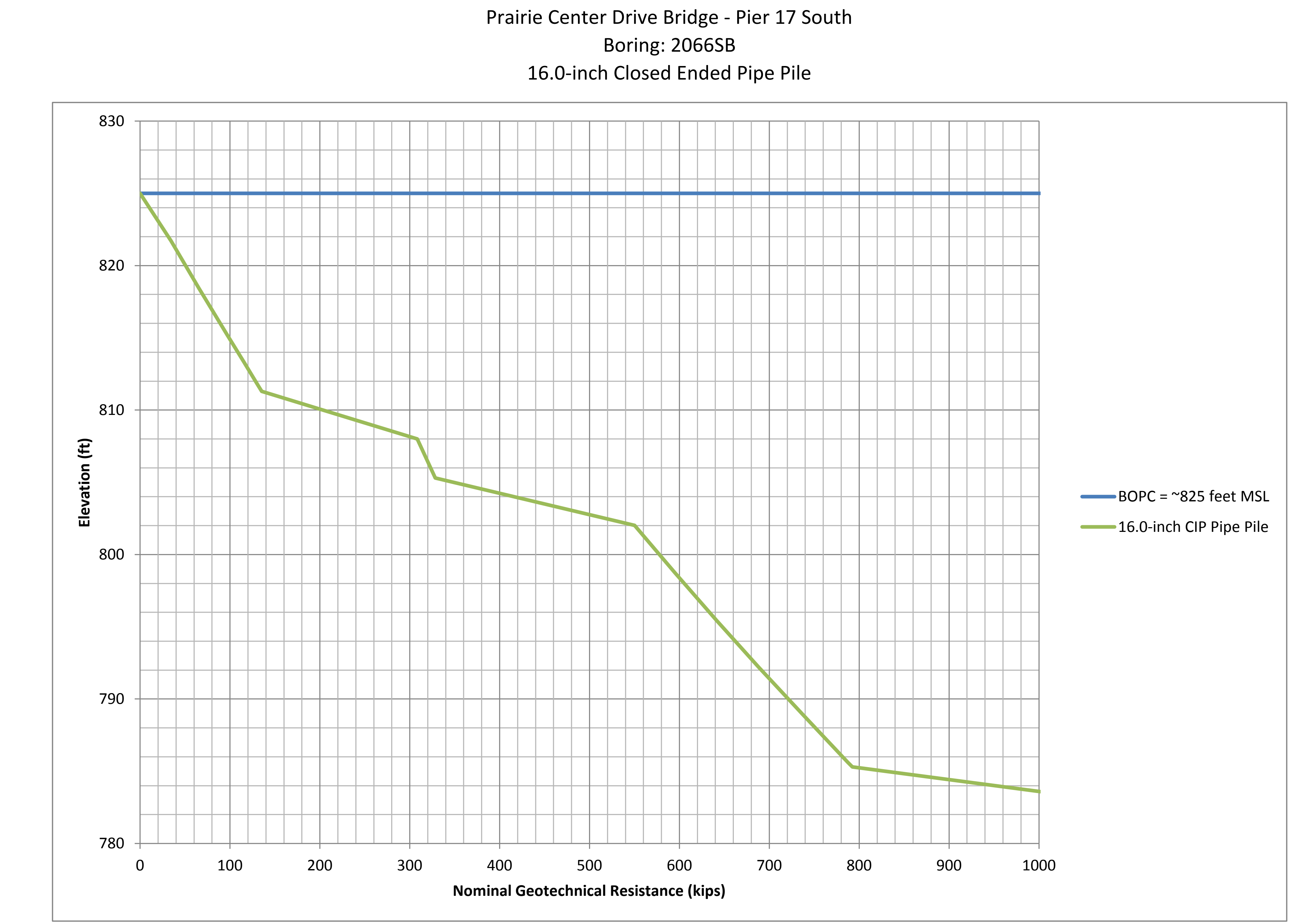
Braun Project No. BL-13-00213

Prairie Center Drive Bridge - Pier 14
Boring: 2065SB
16.0-inch Closed Ended Pipe Pile

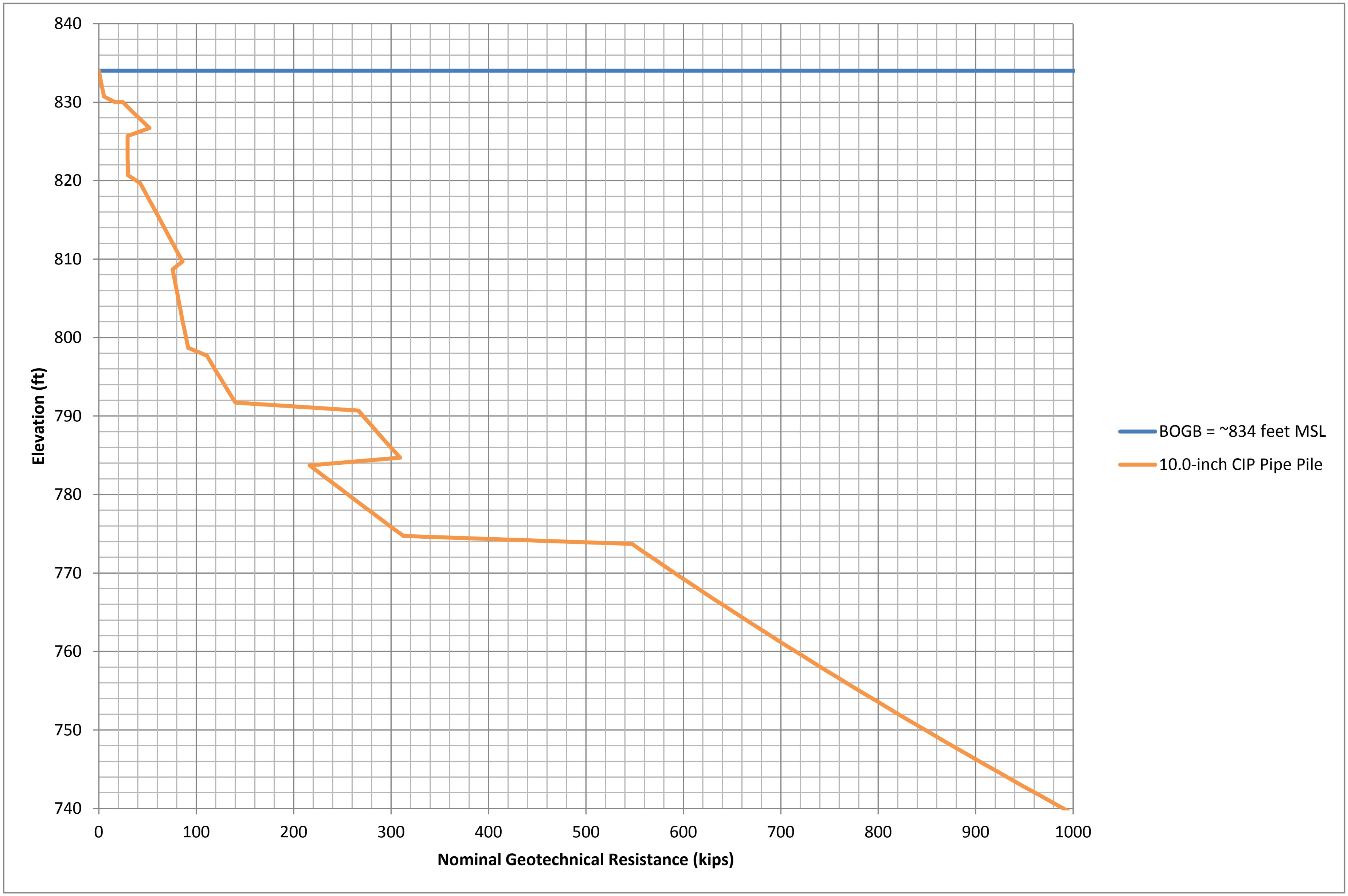


Braun Project No. BL-13-00213

BRAUN INTERTEC

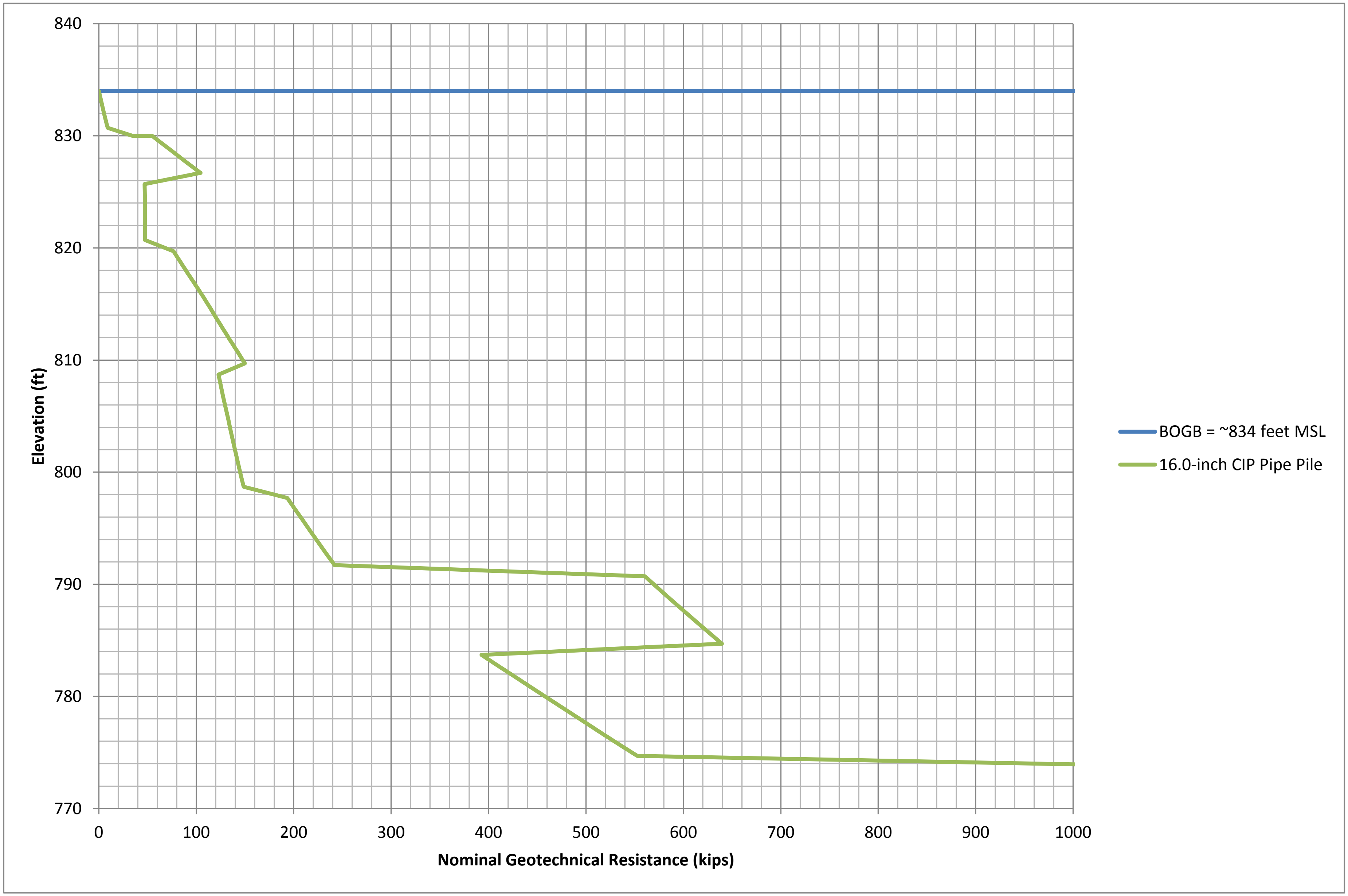

Prairie Center Drive Bridge - Pier 17 South
Boring: 2066SB
16.0-inch Closed Ended Pipe Pile
830
820
810
800
790
780
Elevation (ft)
0
100
200
300
400
500
600
700
800
900
1000
Nominal Geotechnical Resistance (kips)
BOPC = ~825 feet MSL
16.0-inch CIP Pipe Pile

Prairie Center Drive Bridge - Grade Beam
Boring: 2094SB
10.0-inch Closed Ended Pipe Pile

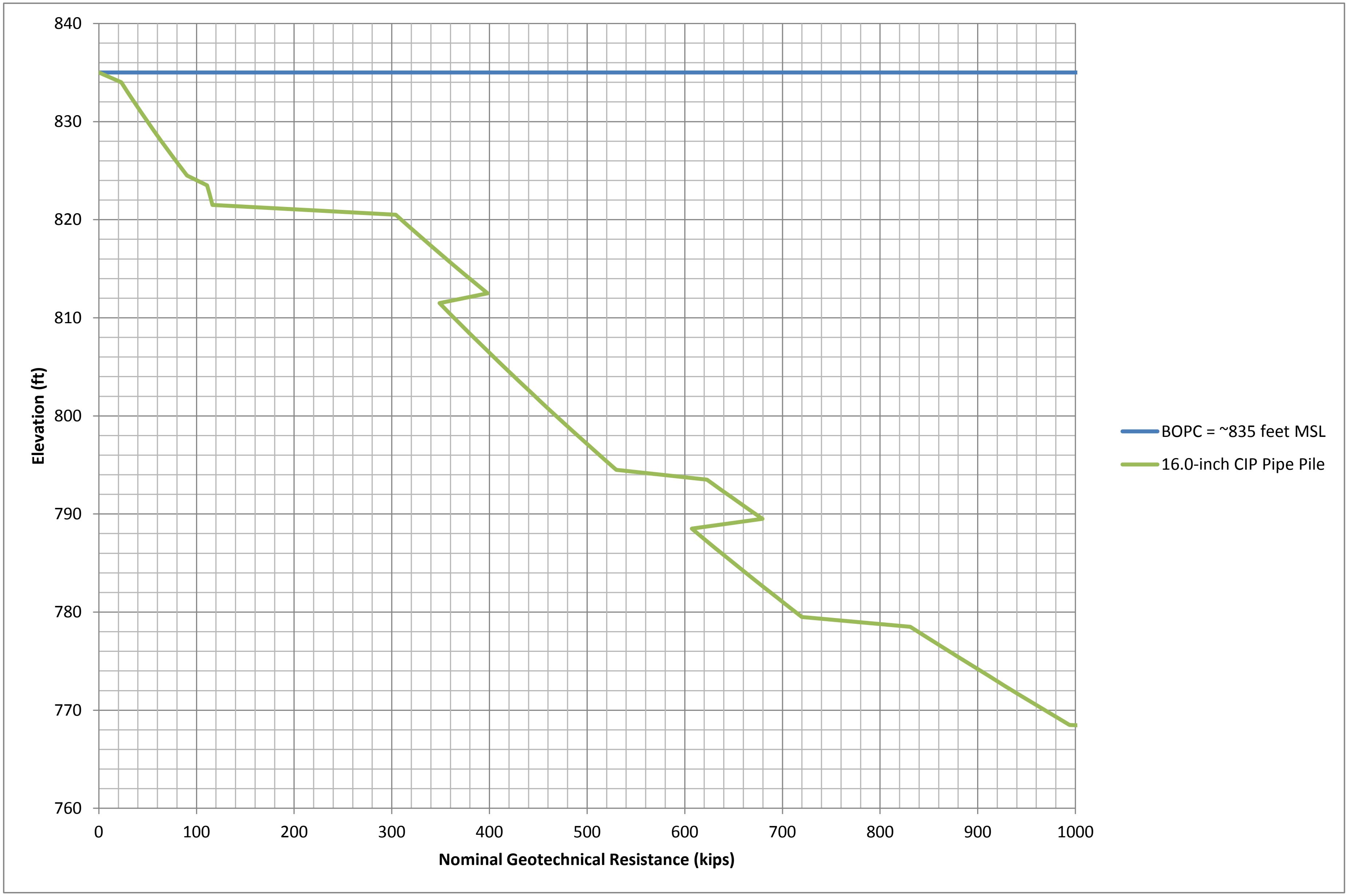


Braun Project No. BL-13-00213

Prairie Center Drive Bridge - Pier 5 and 6
Boring: 2094SB
16.0-inch Closed Ended Pipe Pile



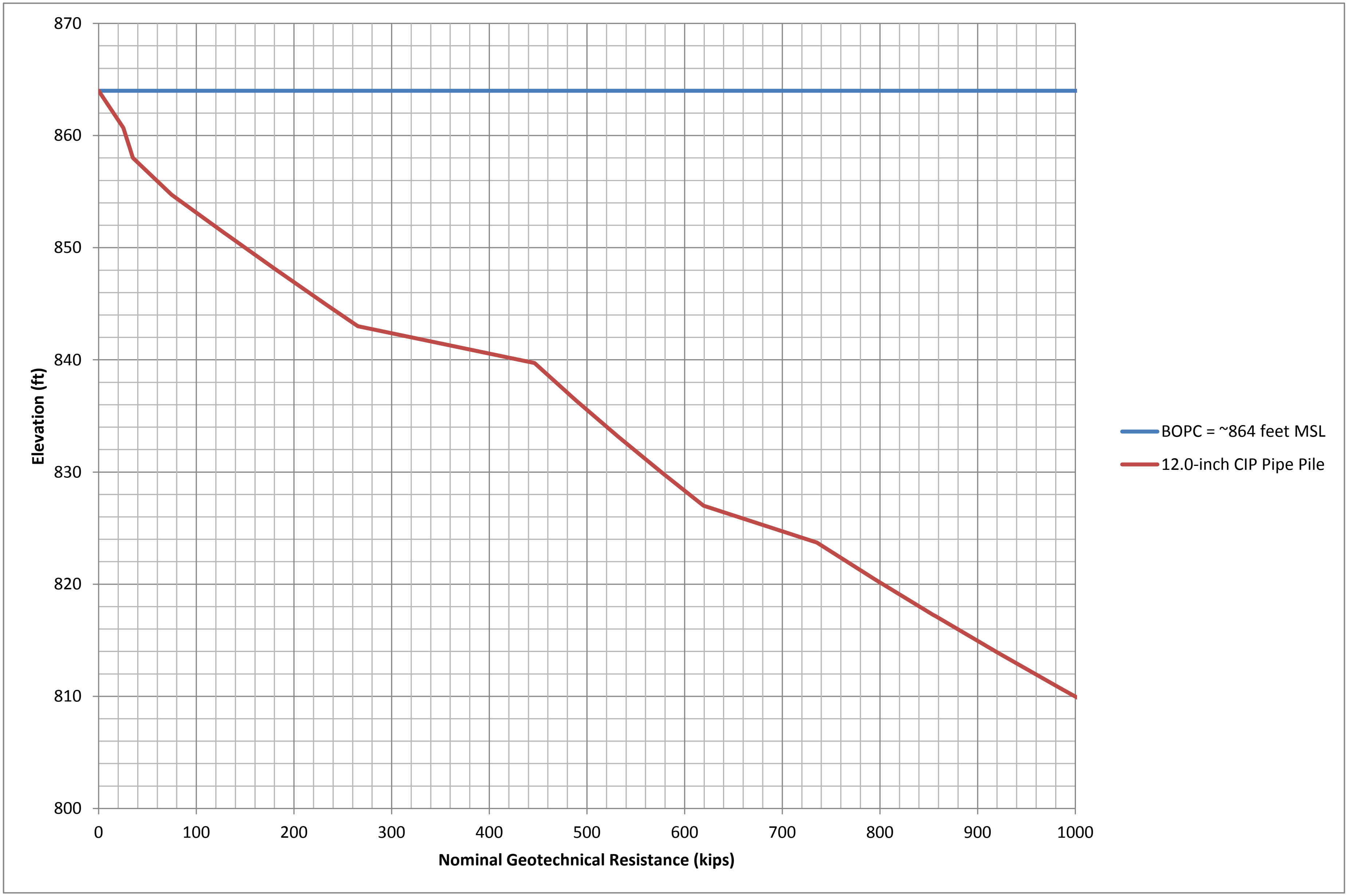
Prairie Center Drive Bridge - Pier 9
Boring: 2095SB
16.0-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

BRAUN INTERTEC

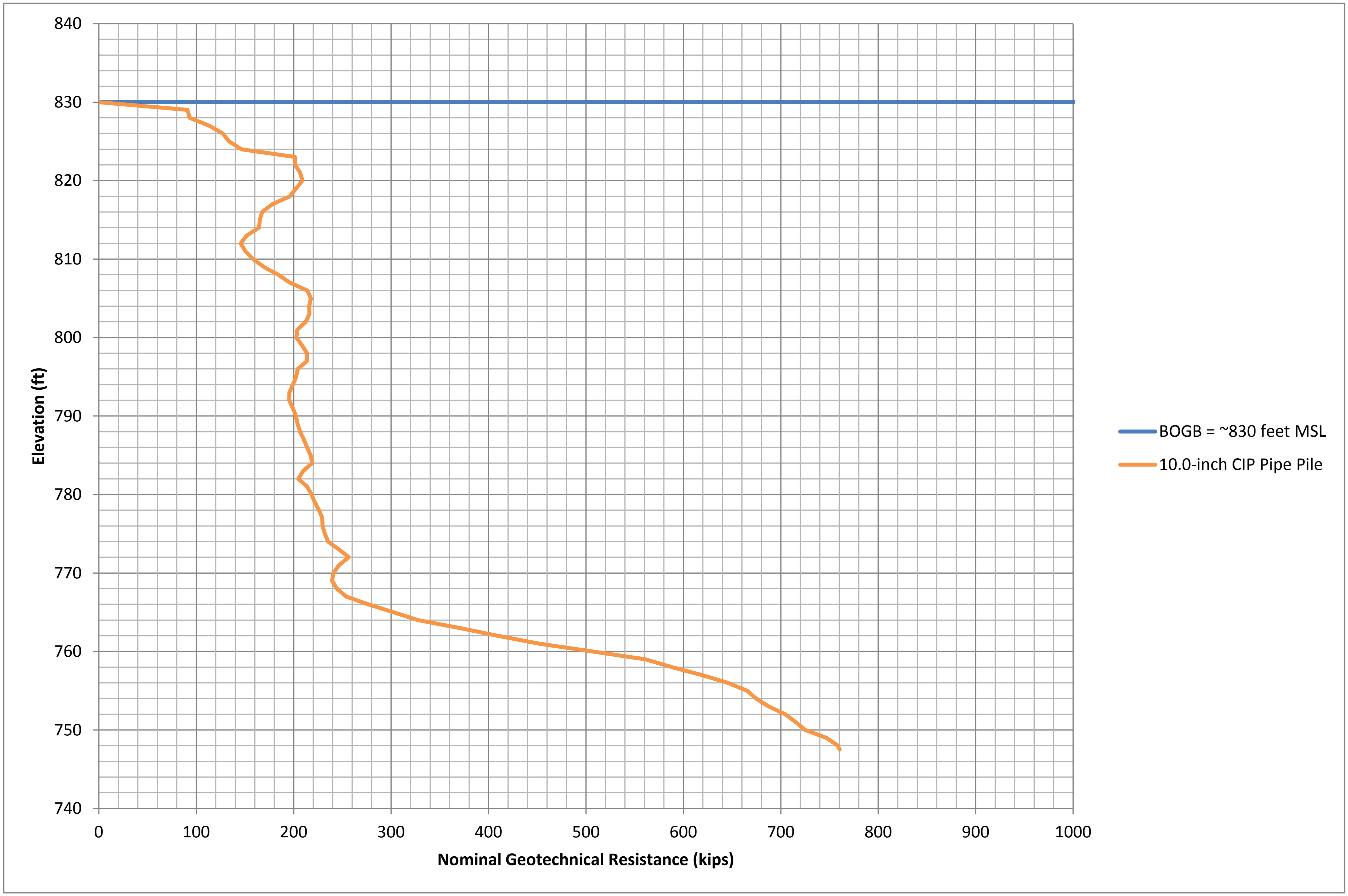
Prairie Center Drive Bridge - East Abutment
Boring: 2096SB
12.0-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

BRAUN INTERTEC

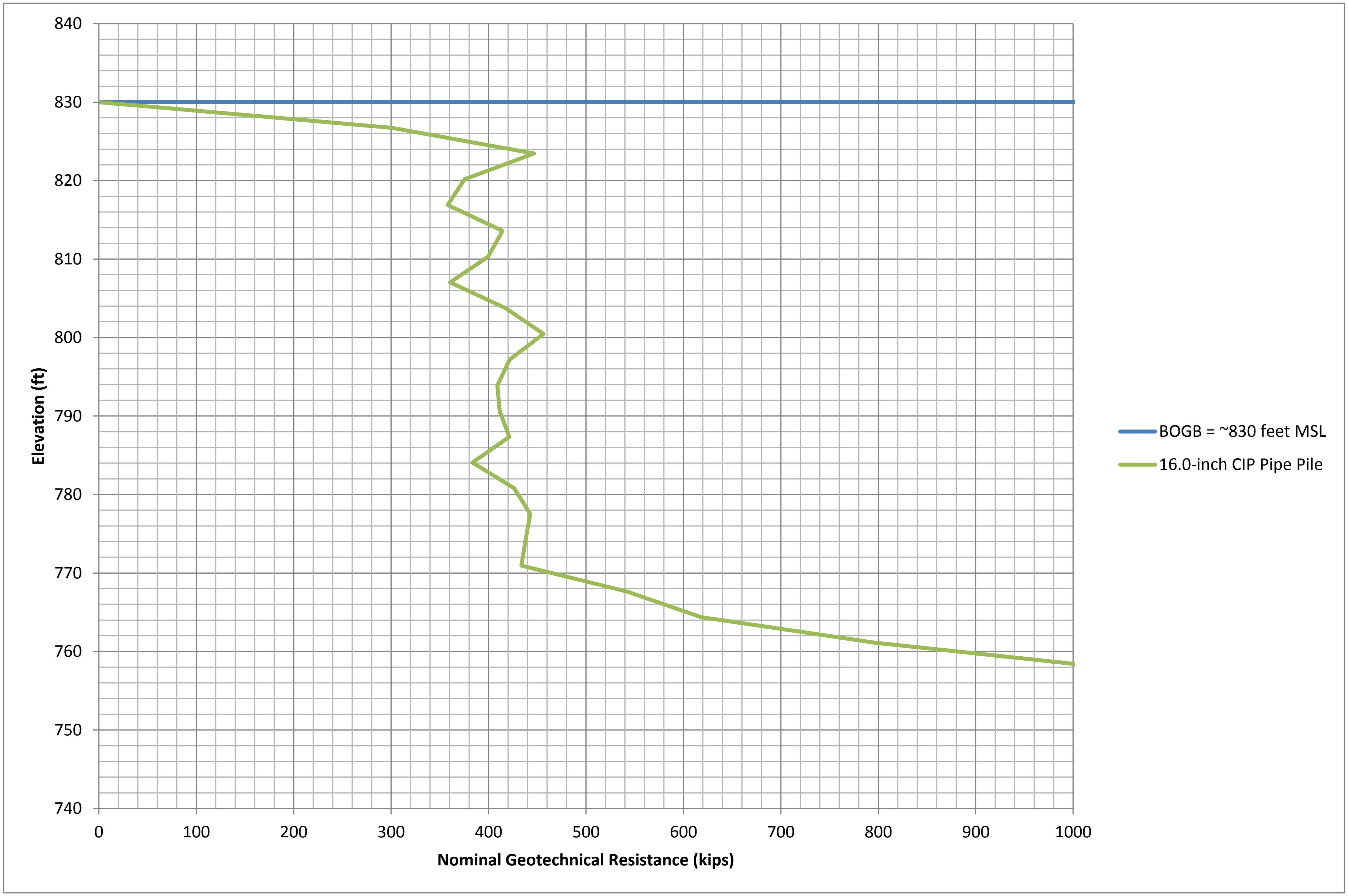
Prairie Center Drive Bridge - Grade Beam
Sounding 2108CW
10.0-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

BRAUN INTERTEC

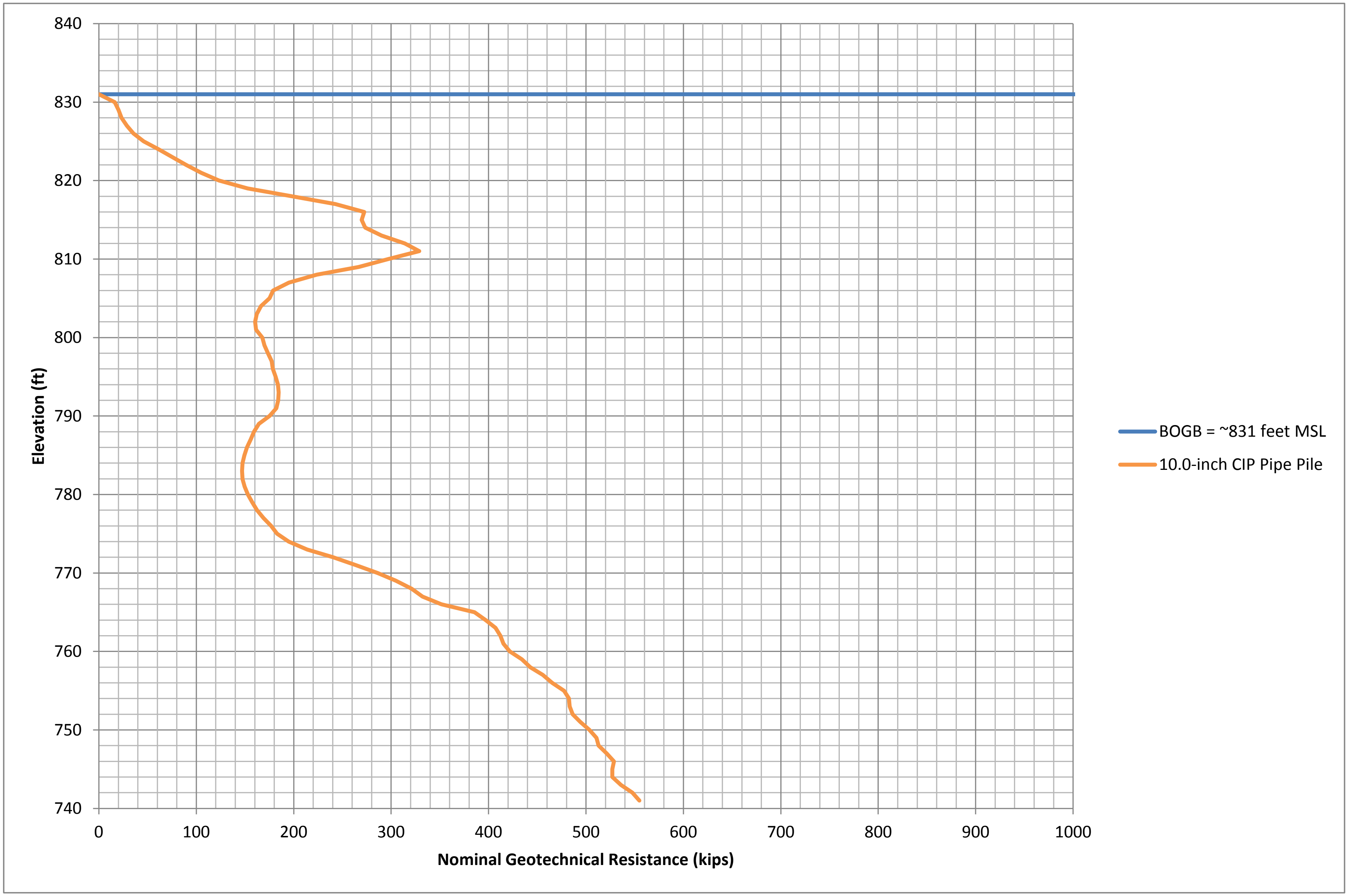
Prairie Center Drive Bridge - Pier 1
Sounding 2108CB
16.0-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

BRAUN INTERTEC

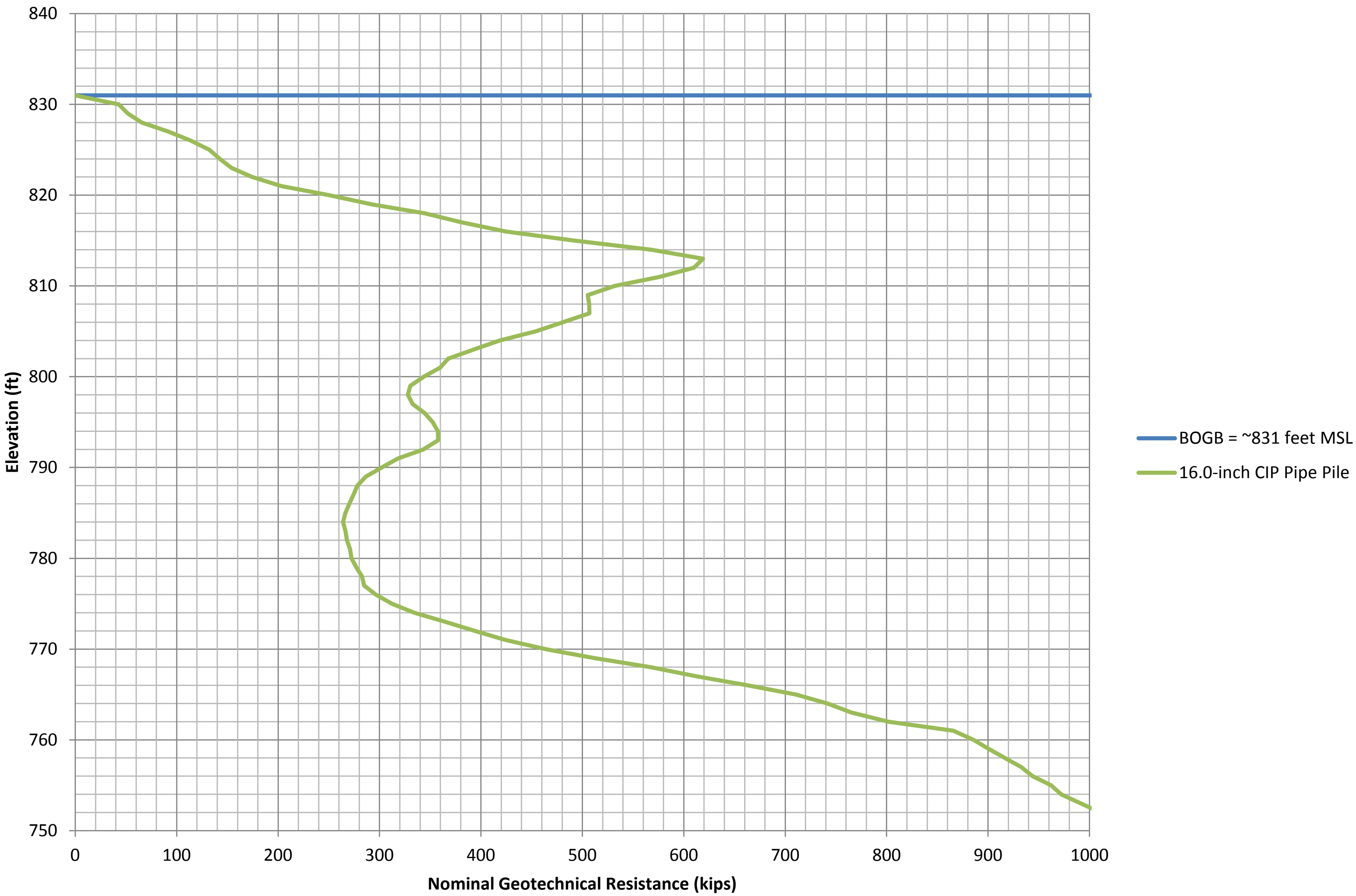
Prairie Center Drive Bridge - Grade Beam
Sounding: 2109CB
10.0-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

BRAUN INTERTEC

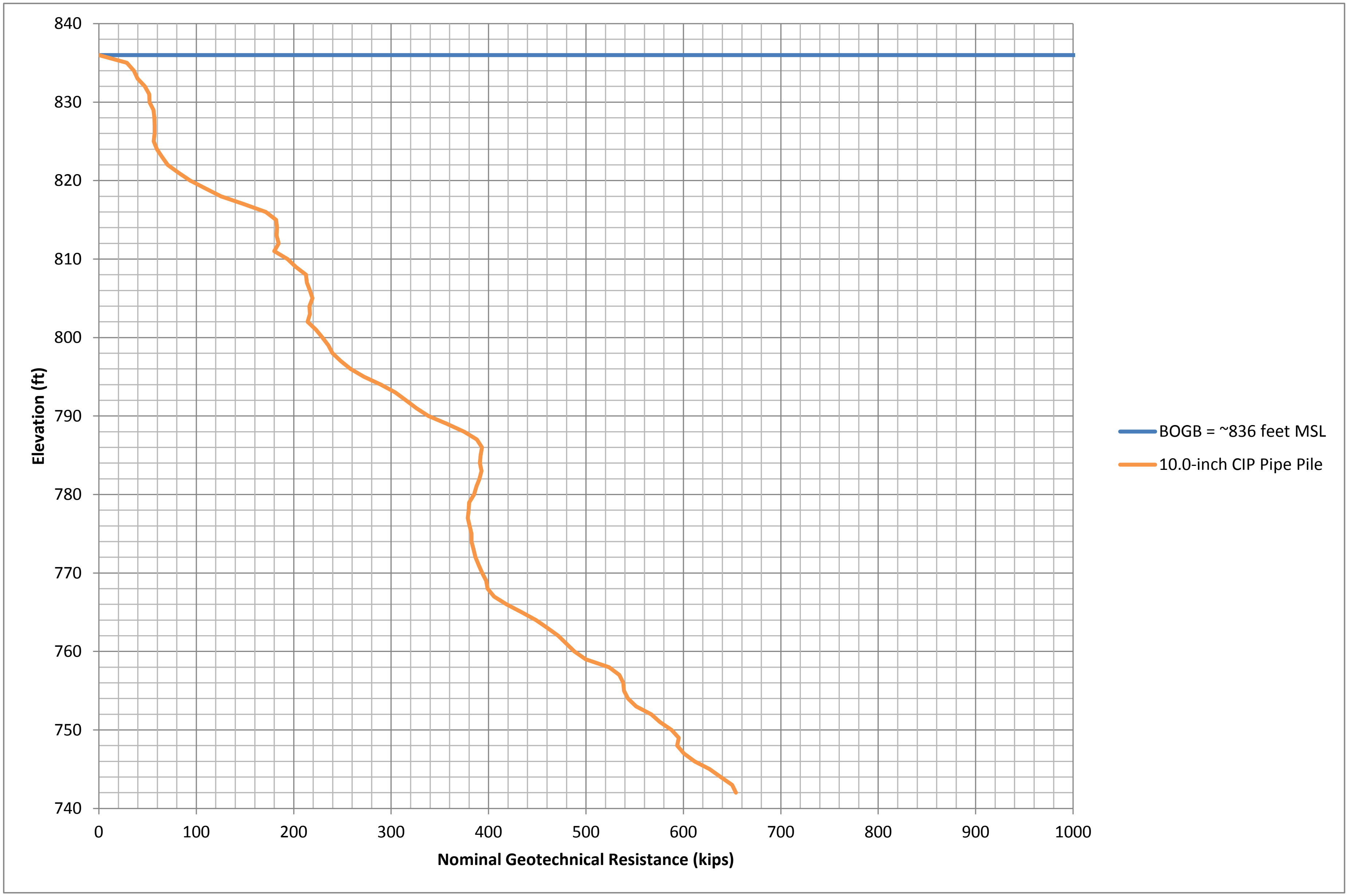
Prairie Center Drive Bridge - Pier 2 and 3
Sounding: 2109CB
16.0-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

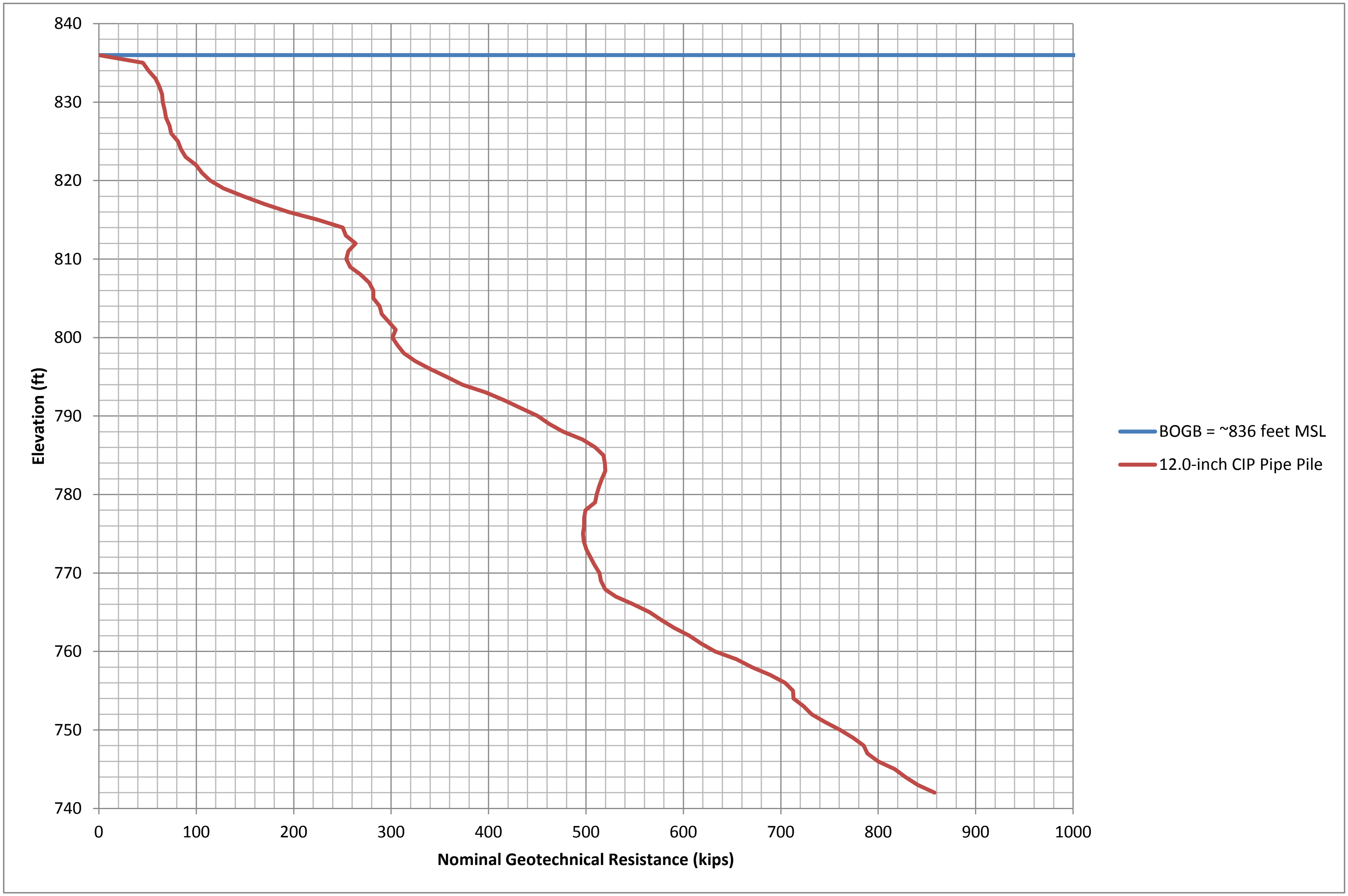
BRAUN INTERTEC

Prairie Center Drive Bridge - Grade Beam
Sounding: 2110CB
10.0-inch Closed Ended Pipe Pile

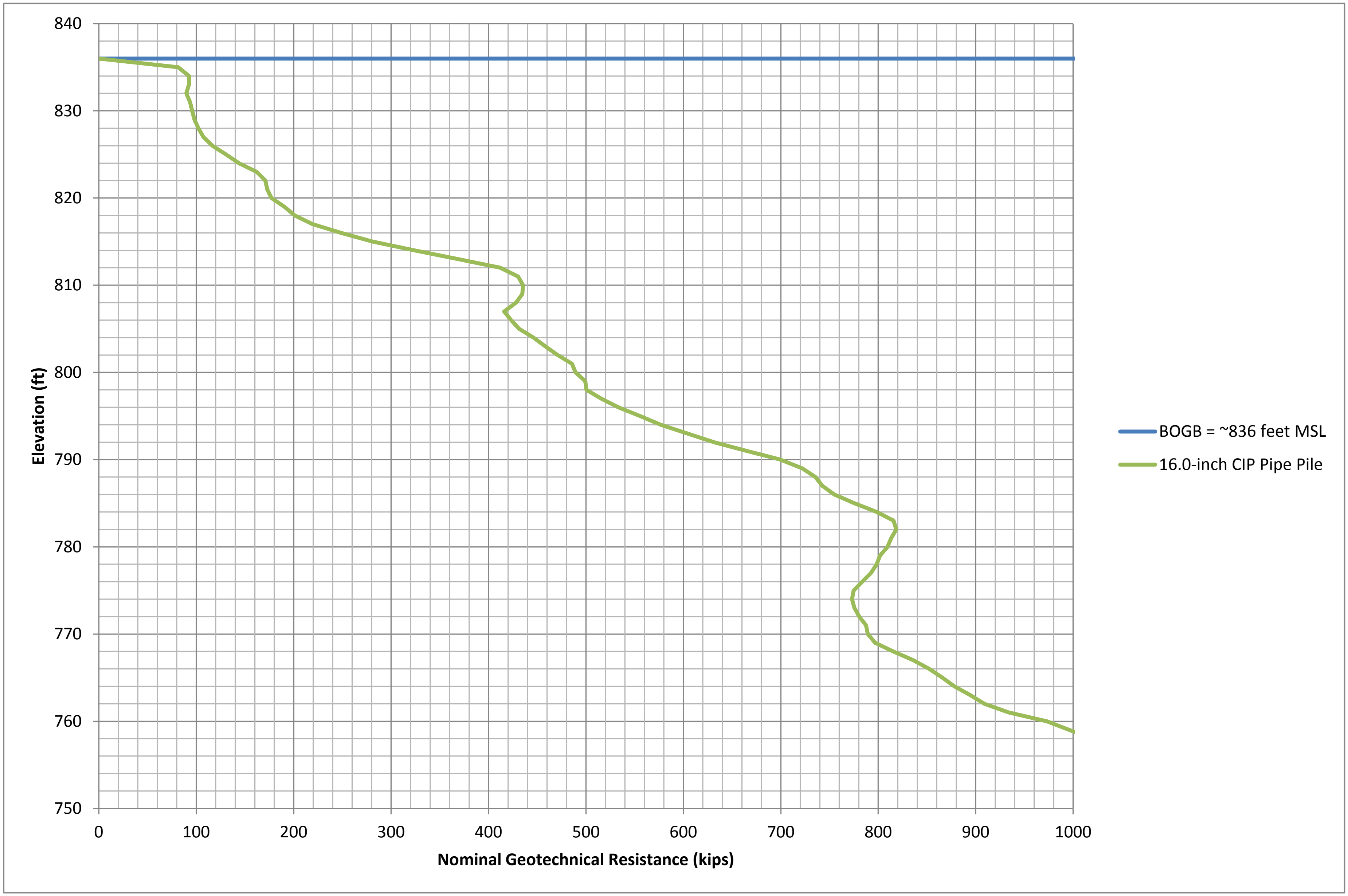


Braun Project No. BL-13-00213

Prairie Center Drive Bridge - Pier 8
Sounding: 2110CB
12.0-inch Closed Ended Pipe Pile



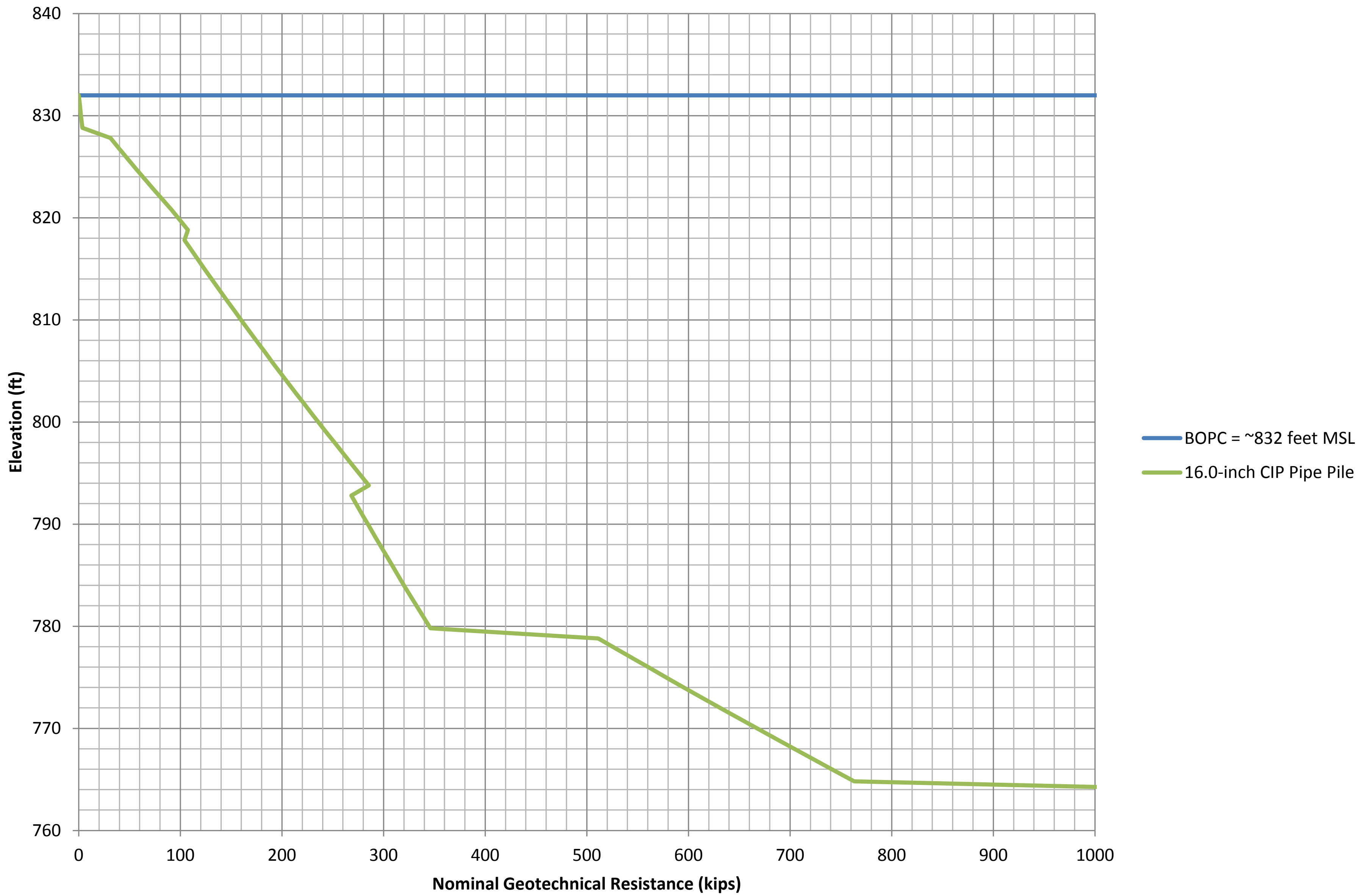
Prairie Center Drive Bridge - Pier 7
Sounding: 2110CB
16.0-inch Closed Ended Pipe Pile



Braun Project No. BL-13-00213

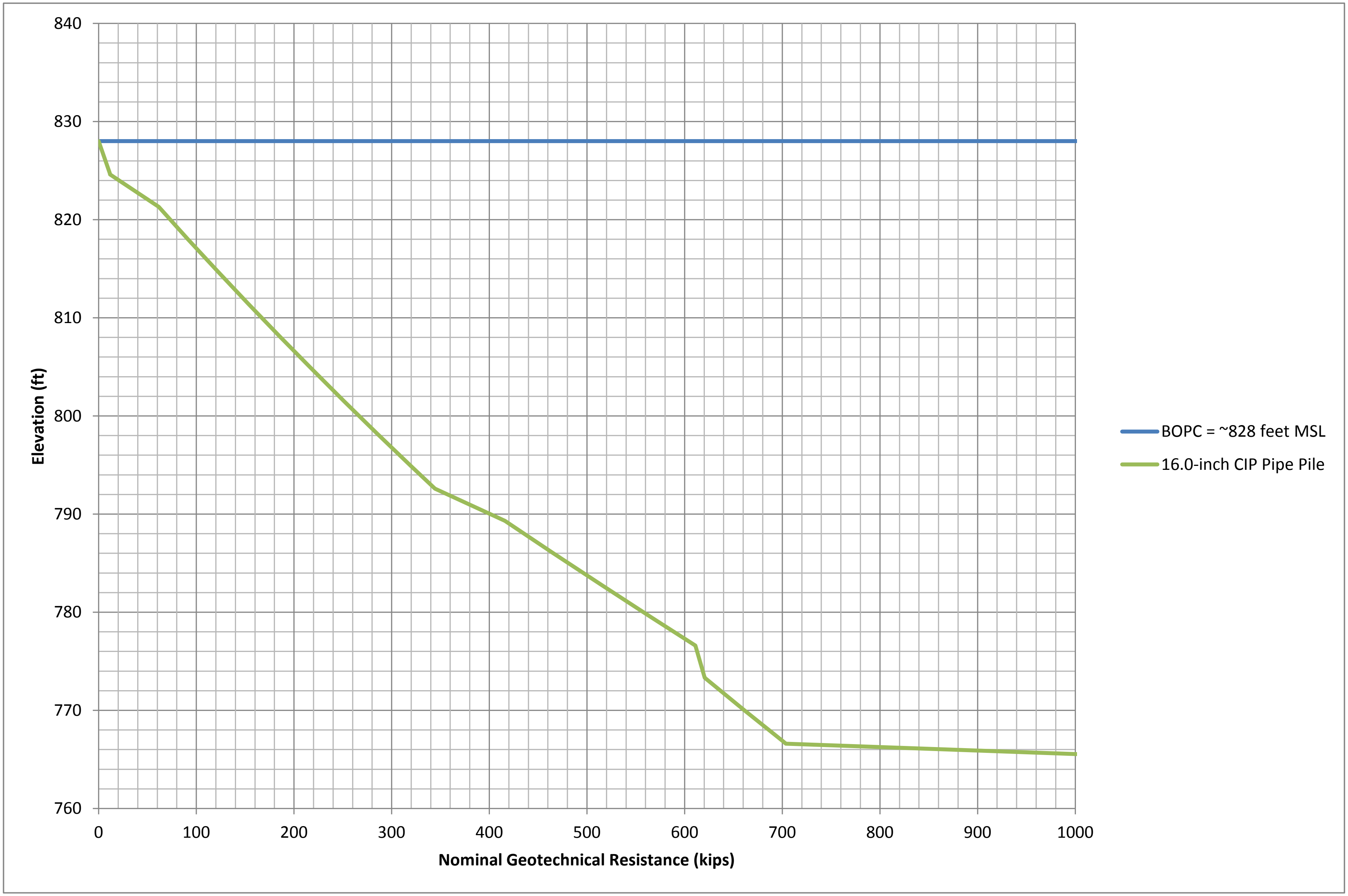
BRAUN INTERTEC

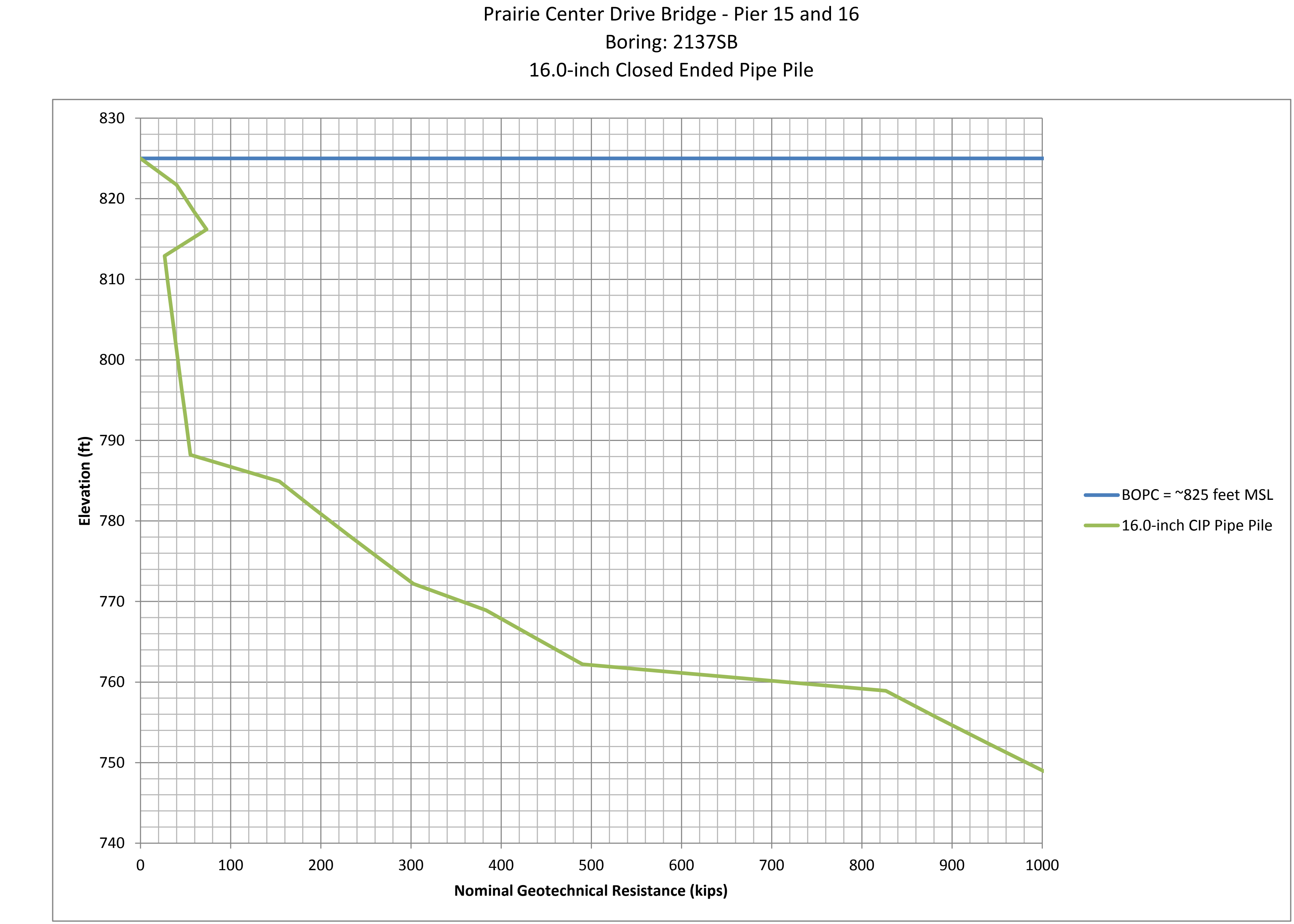
Prairie Center Drive Bridge - Pier 10
Boring: 2118SB
16.0-inch Closed Ended Pipe Pile



BRAUN INTERTEC

Prairie Center Drive Bridge - Pier 13
Boring: 2119SB
16.0-inch Closed Ended Pipe Pile

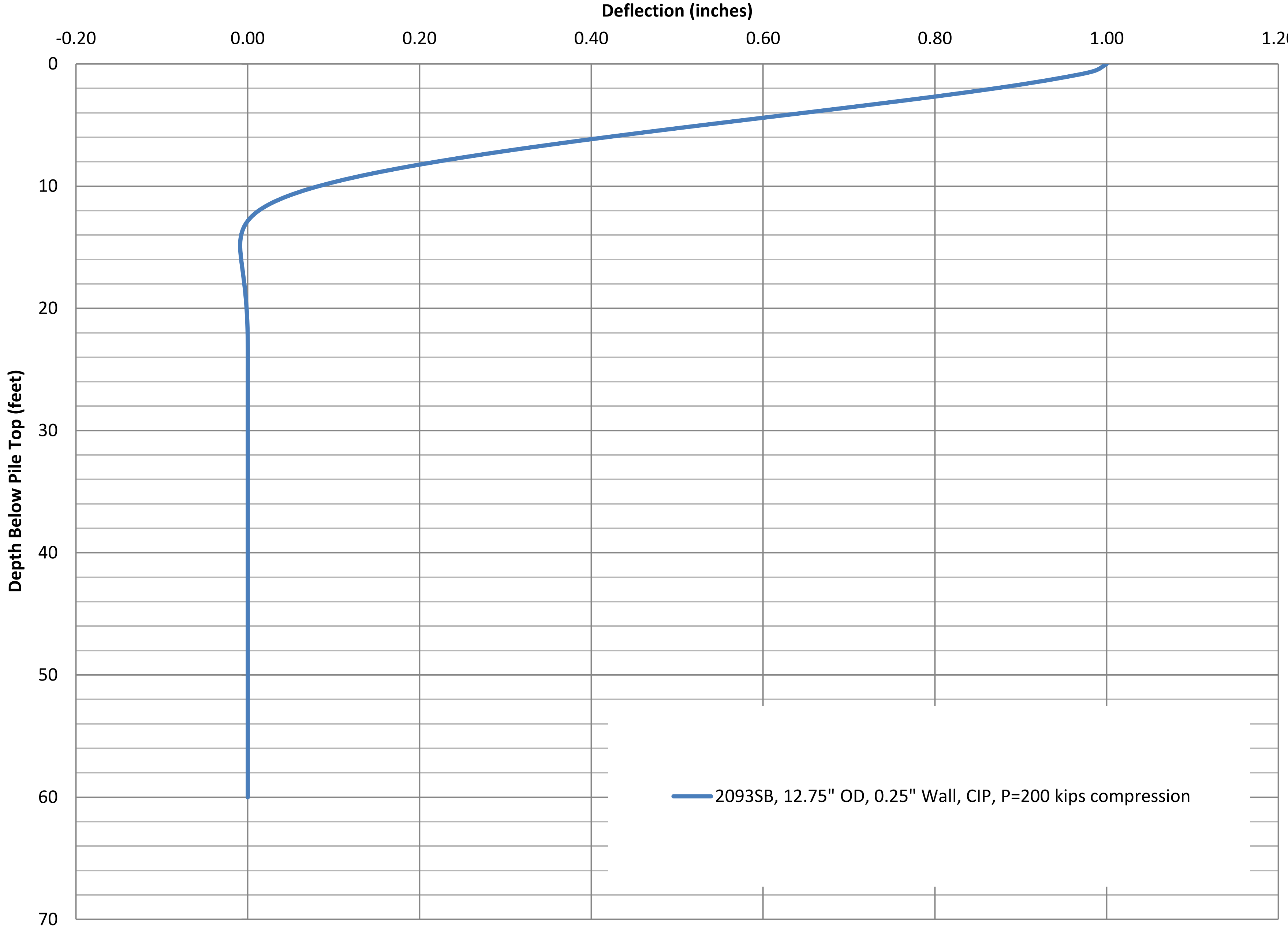




Braun Project No. BL-13-00213

Lateral Analysis Results - Deflection

Boring: 2093SB

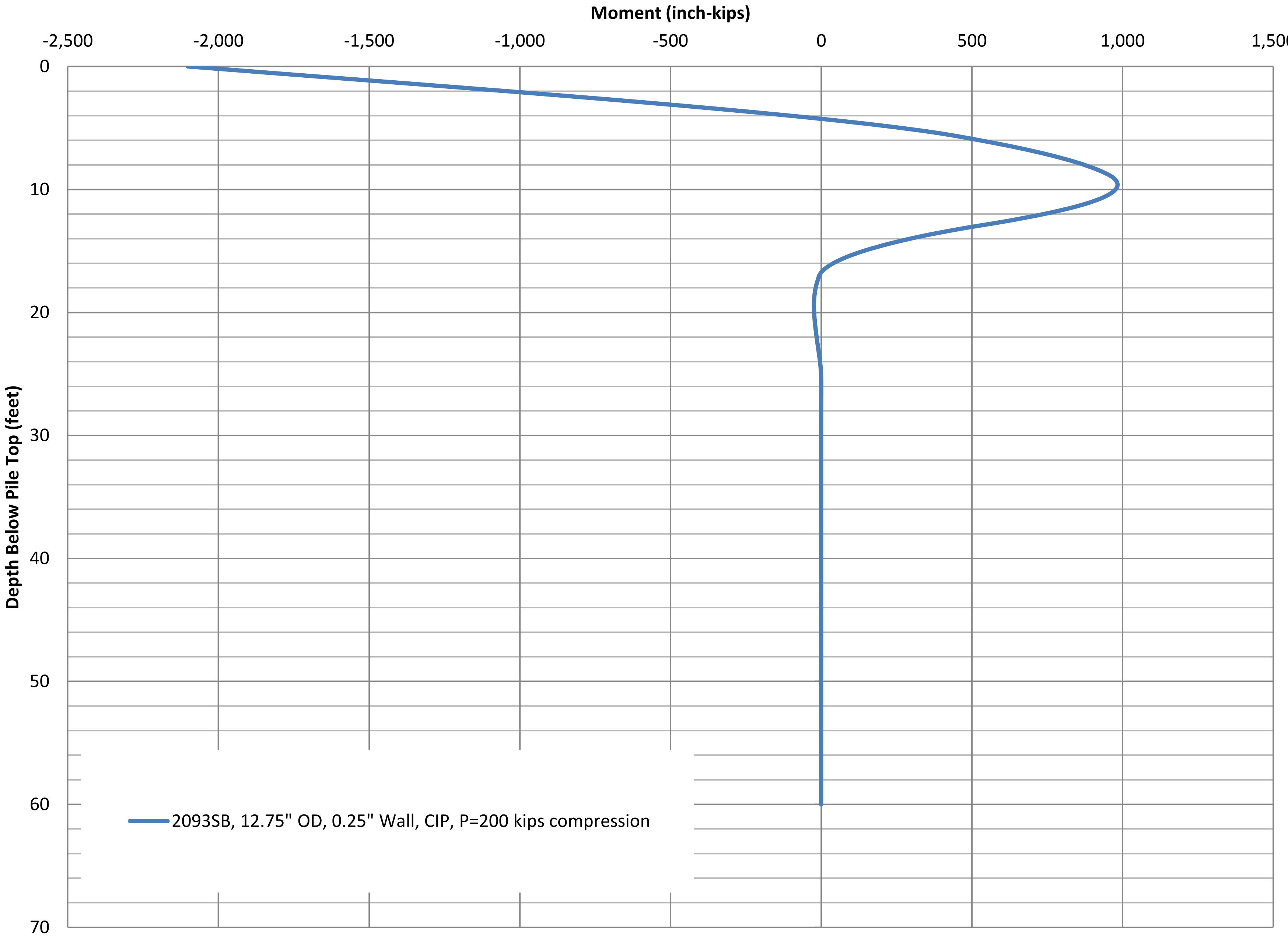


Braun Project No. BL-13-00213

BRAUN INTERTEC

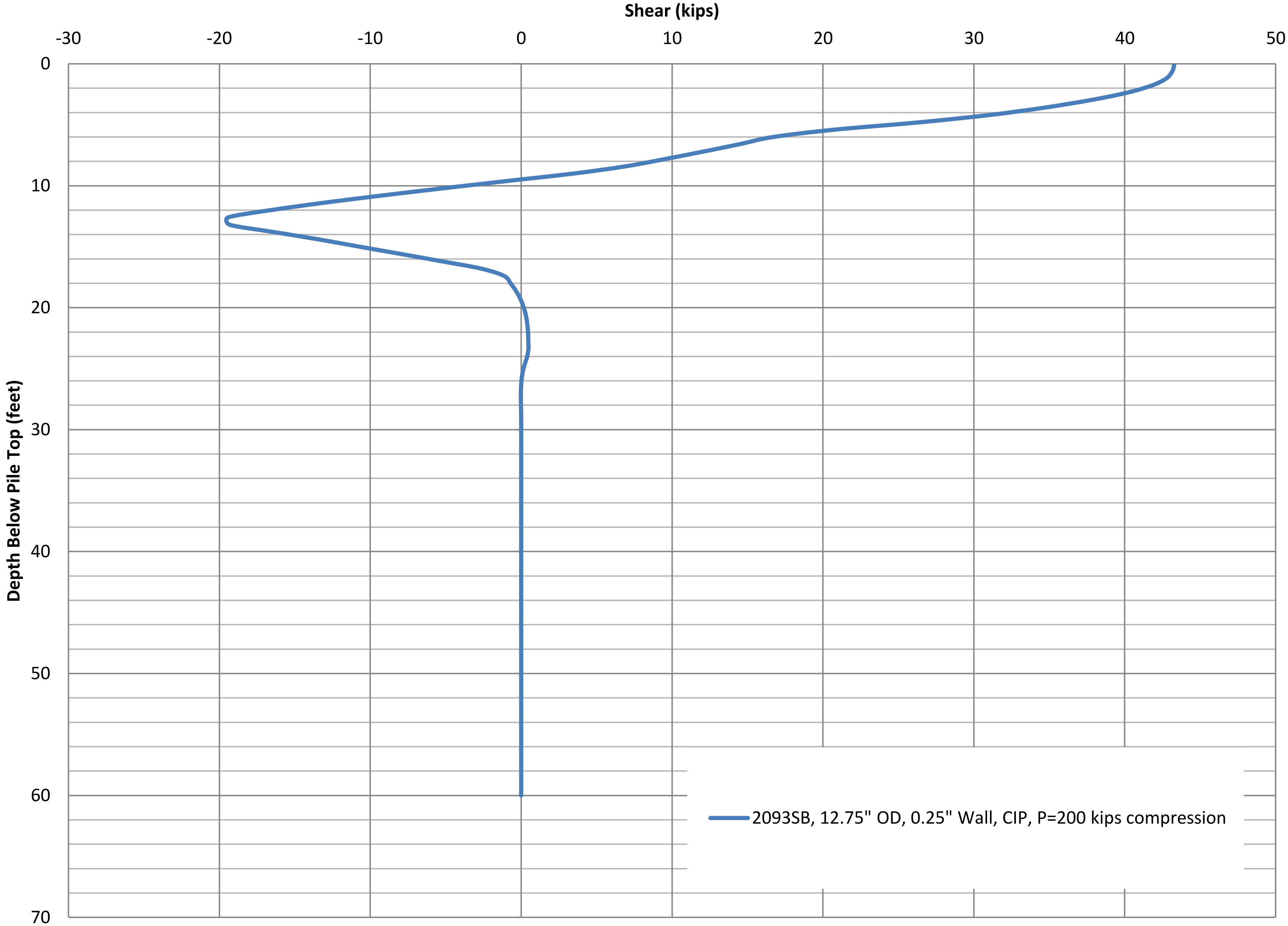
Lateral Analysis Results - Moment

Boring: 2093SB



Lateral Analysis Results - Shear

Boring: 2093SB

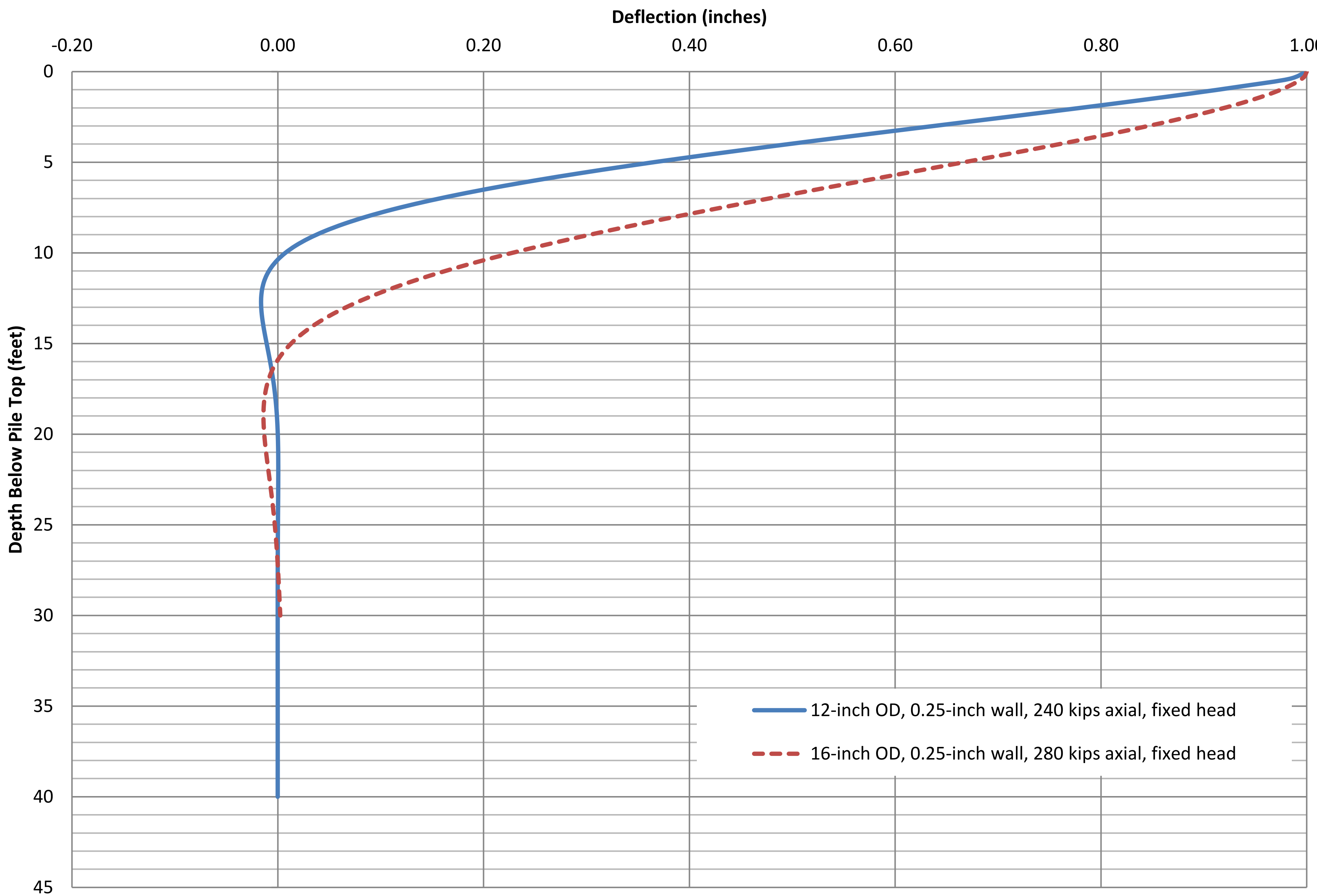


Braun Project No. BL-13-00213

BRAUN INTERTEC

Lateral Analysis Results - Deflection

Boring: 2066SB

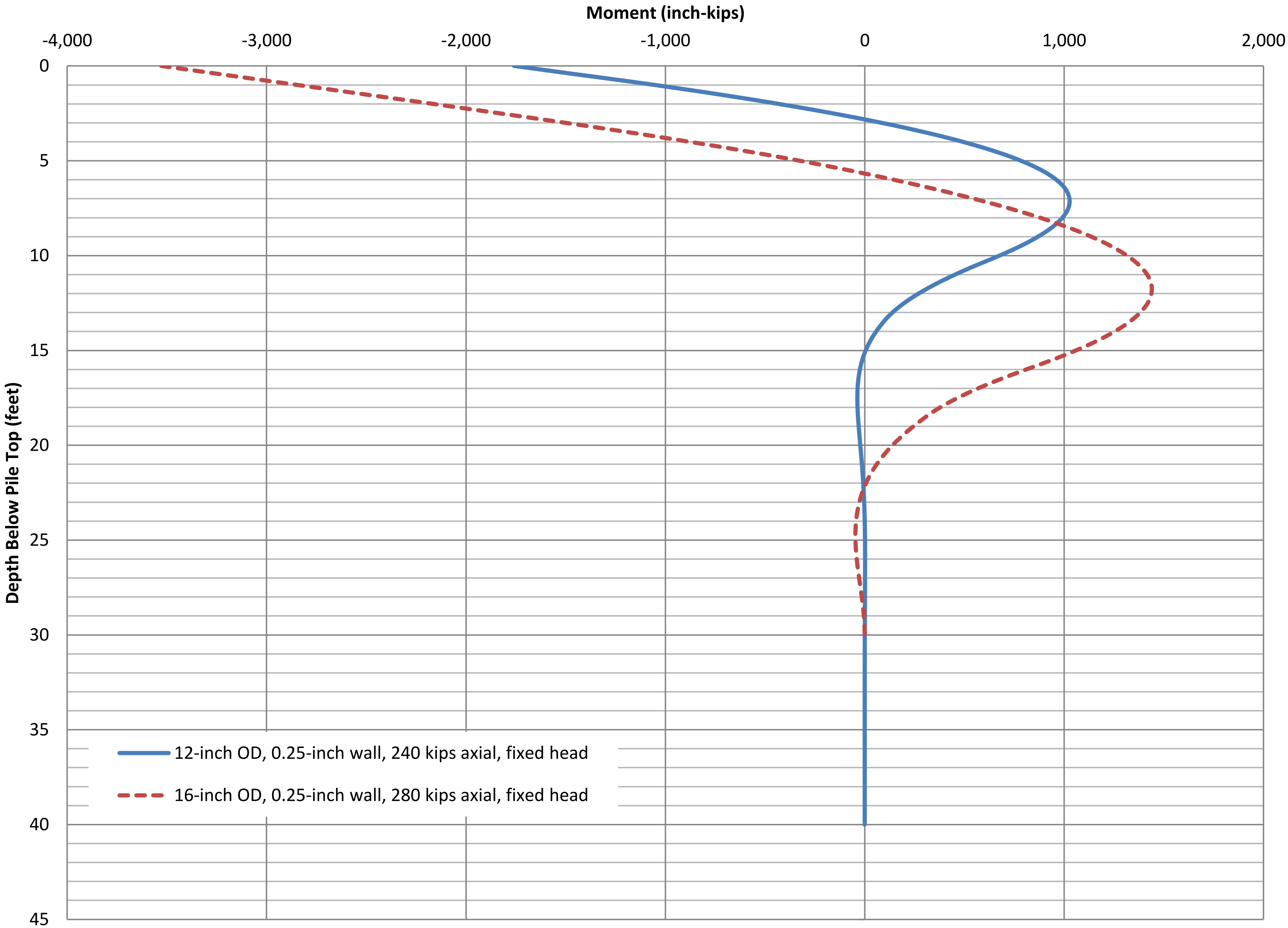


Braun Project No. BL-13-00213

BRAUN INTERTEC

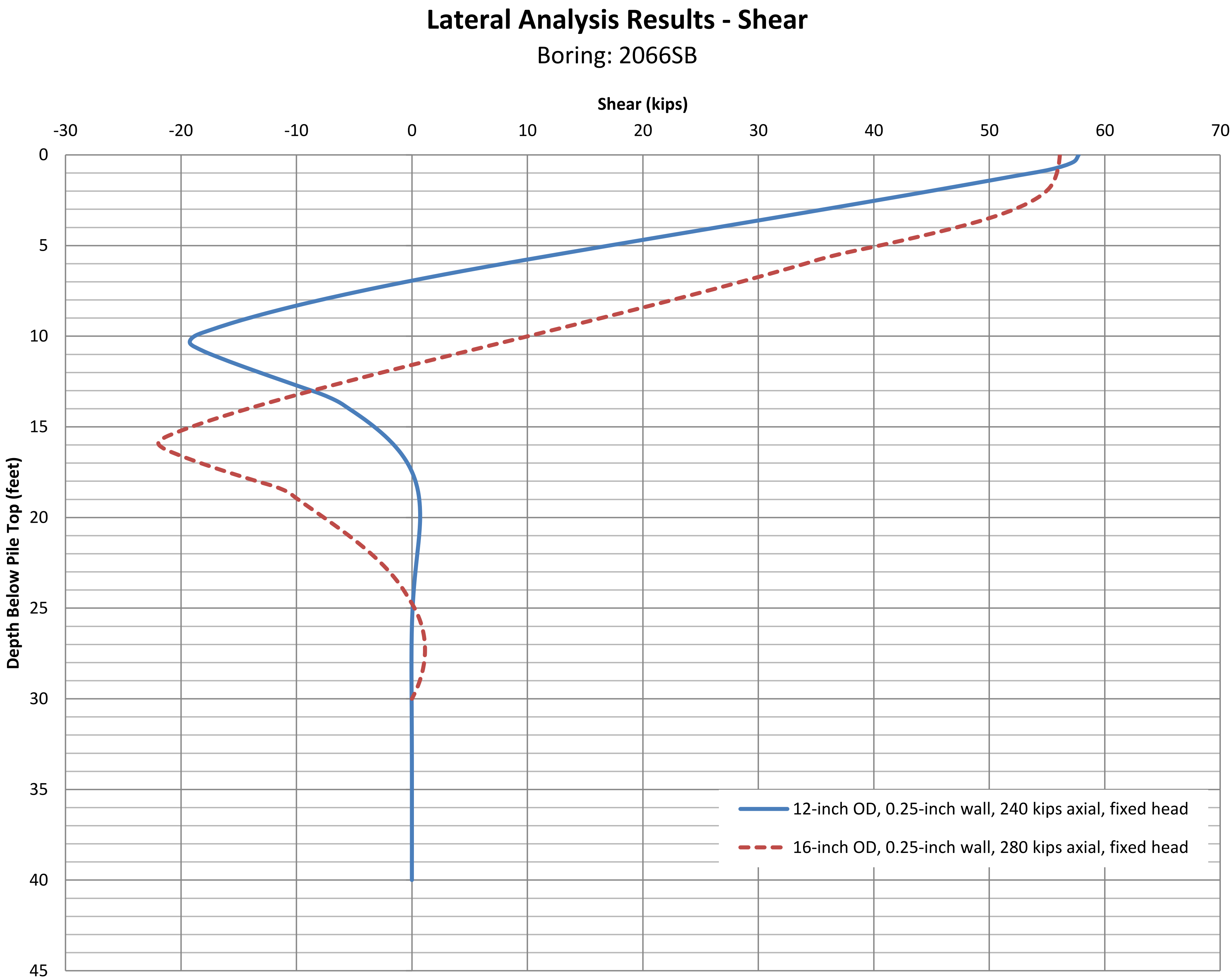
Lateral Analysis Results - Moment

Boring: 2066SB



Braun Project No. BL-13-00213

BRAUN INTERTEC



Braun Project No. BL-13-00213

BRAUN INTERTEC

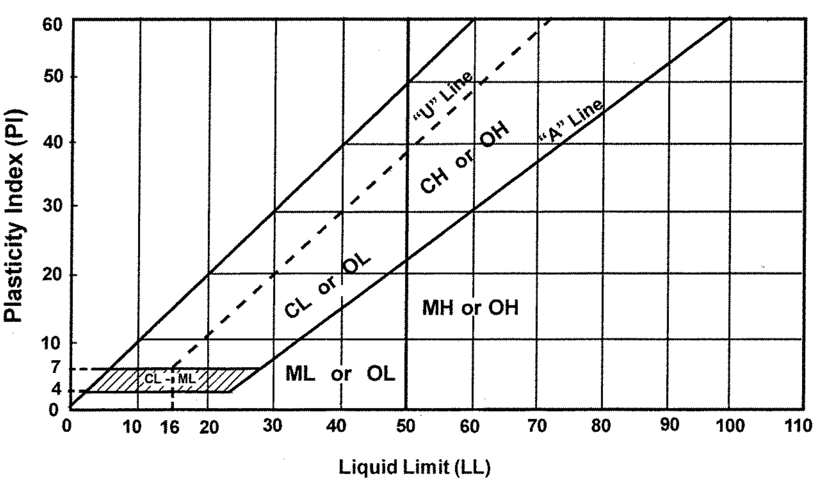
BRAUN INTERTEC

Descriptive Terminology of Soil

Standard D 2487 - 00
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels 5% or less fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands 5% or less fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	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]
				OL	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]
				OH	Organic silt [k l m q]
Highly Organic Soils		Primarily organic matter, dark in color and organic odor		PT	Peat

a. Based on the material passing the 3-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. 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
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines" to group name.
h. If soil contains ≥ 15% gravel, add "with gravel" to group name.
i. 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
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 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.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcf	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liqiuid limit, %	**C**	Cohesion, psf
PL	Plastic limit, %	**∅**	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders	over 12"
Cobbles	3" to 12"
Gravel	
Coarse	3/4" to 3"
Fine	No. 4 to 3/4"
Sand	
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Silt	< No. 200, PI < 4 or below "A" line
Clay	< No. 200, PI ≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose	0 to 4 BPF
Loose	5 to 10 BPF
Medium dense	11 to 30 BPF
Dense	31 to 50 BPF
Very dense	over 50 BPF

Consistency of Cohesive Soils

Very soft	0 to 1 BPF
Soft	2 to 3 BPF
Rather soft	4 to 5 BPF
Medium	6 to 8 BPF
Rather stiff	9 to 12 BPF
Stiff	13 to 16 BPF
Very stiff	17 to 30 BPF
Hard	over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers unless noted otherwise, Jetting water was used to clean out auger prior to sampling only where indicated on logs. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous-flight, solid-stem augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface and are, therefore, somewhat approximate. Power auger borings are designated by the prefix "B."

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn. Hand auger borings are indicated by the prefix "H."

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

BRAUN INTERTEC

Descriptive Terminology Cone Penetration Test

This document accompanies Cone Penetration Test Data. Please refer to the Boring Log Descriptive Terminology Sheet for information relevant to conventional v. Cone Penetration Test (CPT) boring logs.

Cone Penetration Test (CPT) sounding was performed in general accordance with ASTM D 5778 and consistent with the ordinary degree of care and skill used by reputable practitioners of the same discipline currently practicing under similar circumstances and in the same locality. No warranty, express or implied, is made.

Since subsurface conditions outside each CPT sounding are unknown, and soil, rock and pore water conditions cannot be relied upon to be consistent or uniform, no warranty is made that conditions adjacent to each sounding will necessarily be the same as or similar to those shown on this log. Braun Intertec is not responsible for any interpretations, assumptions, projections or interpolations of the data made by others.

Pore water pressure measurements and subsequently interpreted water levels shown on CPT logs should be used with discretion as they represent dynamic conditions. Dynamic pore water pressure measurements may deviate substantially from hydrostatic conditions, especially in cohesive soils. In cohesive soils, pore water pressures often take an extended time to reach equilibrium and thus reflect their true field level. Groundwater levels can be expected to vary both seasonally and yearly. The absence of notations on this log regarding water does not necessarily mean that groundwater is not present to the depth explored, or that a contractor will not encounter groundwater during excavation or 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
Q_T........................normalized cone resistance
B_q.........................pore pressure ratio
F_r..........................normalized friction ratio
σ_{vo}........................overburden pressure
σ'_{vo}.......................effective overburden pressure

q_T TIP RESISTANCE

The resistance at the cone corrected for water pressure. Data is from cone with a 60 degree apex angle and a 15 cm^2 end area.

f_s SLEEVE FRICTION RESISTANCE

The resistance along the sleeve of the penetrometer.

F_r Friction Ratio

Ratio of sleeve friction over corrected tip resistance.
$F_r = f_s/q_t$

V_s Shear Wave Velocity

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

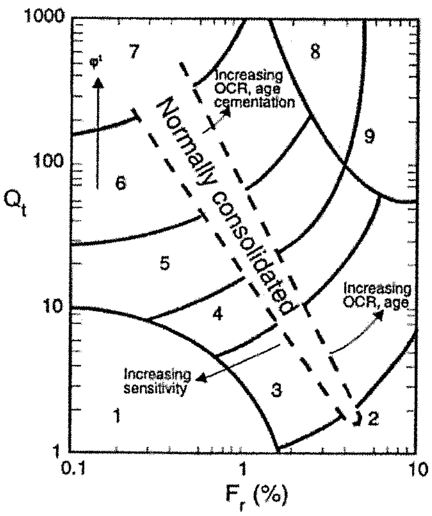
SBT SOIL BEHAVIOR TYPE

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

Engineering judgment and comparison with augered borings is especially important in the proper interpretation of CPT data in certain geo-materials.

The following charts provide a Soil Behavior Type for the CPT Data. The numbers corresponding to different regions on the charts represent the following soil behavior types:

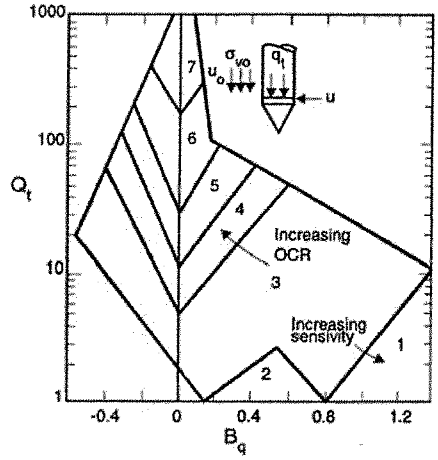
Soil Behavior Type based on friction ratio



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

Robertson CPT 1990

Soil Behavior Type based on pore pressure



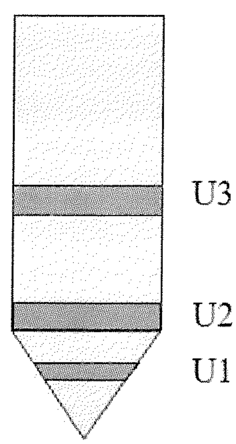
$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$ $B_q = \frac{u_2 - u_o}{q_t - \sigma_{vo}}$

Robertson CPT 1990

1 Sensitive, Fine Grained
2 Organic Soils - Peat
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

U2 PORE WATER MEASUREMENTS

Pore water measurements reported on CPT logs are representative of pore 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 represent dynamic pore water pressures due to the local disturbance caused by the cone tip. Dynamic pore water pressure decay and static pore water pressure measurements are reported on a Pore Water Pressure Dissipation Graph.



Appendix C

Retaining Walls W110 and W111

BRAUN INTERTEC

Braun Intertec Corporation
11001 Hampshire Avenue S
Minneapolis, MN 55438

Phone: 952.995.2000
Fax: 952.995.2020
Web: braunintertec.com

August 29, 2014 Project BL-13-00213

Mr. Don Demers
Southwest Light Rail Transit Project Office
6545 Wayzata Boulevard, Suite 500
Wayzata, MN 55426

Re: Summary of Boring Information and Preliminary Retaining Wall Recommendations
Proposed Retaining Walls 110 and 111 - 30% Design
STA 2102+80 to STA 2109+00
Eden Prairie, Minnesota

Dear Mr. Demers:

This purpose of this letter is to provide you and the design team with a summary of our preliminary soil boring information in the area of retaining walls RTW-W110 and RTW-W111, referred to as the Costco Hill retaining walls, to provide preliminary retaining wall design information. A final geotechnical report should be prepared after final geotechnical design borings are completed.

A. Subsurface Investigation Summary

A.1. Summary of Historical Boring Information

Due to site terrain and vegetation, final design soil borings have not been completed. Due to the steep slope in the area, we were only able to complete three (3) soil borings at this time. The table below provides information on the borings including numbering, track stationing, and the ground surface elevation at the boring location:

Table 1. Soil Boring Information near the Proposed Retaining Walls

Boring	Approximate Track Station	Surface Elevation at Boring Location (ft)
2096SB	2102+75	880.0
2098SW	2303+80	880.0
2102SW	2309+25	884.8

A.2. Description of Foundation Soil Conditions

A.2.a. General Soil Profile

As mentioned previously, a limited number of borings were performed at the proposed wall locations. The following paragraphs describe the soils encountered at the drilled boring locations.

A.2.b. Topsoil

Lean clay and sandy lean clay topsoil was encountered at Borings 2096SB and 2102SW and ranged in thickness from approximately 3 to 12 inches thick.

A.2.c. Fill

Fill soil was encountered at the surface of Boring 2098SW and extended to a depth of 12 feet beneath the surface. The fill consisted of sandy lean clay. Of the 12 feet of fill, the lower 5 feet (from 7 to 12 feet) were slightly organic.

The penetration resistances in the fill ranged from 6 to 15 Blows per Foot (BPF).

A.2.d. Glacial Deposits

Beneath the fill and topsoil, the borings encountered glacially deposited soils to the termination depth of the borings. The soils encountered included poorly graded sand, poorly graded sand with silt, silty sand, silt, clayey sand, lean clay with sand, and sandy lean clay.

Penetration resistances within the clayey soils ranged from 7 to 45 BPF, indicated medium to hard consistencies. Penetration resistances with the sandy and silt soils ranged from 6 to 51 BPF, indicating loose to very dense relative densities.

A.2.e. Groundwater

Groundwater was encountered at a depth of 75 feet while drilling Boring 2096SB. Groundwater was not observed in the shallower borings. We anticipate groundwater will generally be deep and will not influence construction of the retaining walls; however, perched groundwater within sandy layers could be encountered during periods of high precipitation or during spring thaw.

B. Design and Construction Considerations

We were provided with cross sections of the design configuration of the two retaining walls. The general track elevation ranges from approximately 880 to 885, resulting in wall heights of up to 28 feet. In addition, an existing MSE (mechanically stabilized earth) wall is present near the bottom of footing elevation of wall RTW-W111. The wall retains soil for the driveway of a commercial property to the south of the track alignment. Based on the information provided to us, it appears the location of the footings for retaining wall RTW-W111 will be as close as 10 to 15 feet from the back of the MSE wall.

The following design and construction criteria were considered and will be addressed in our preliminary evaluation. We recommend a final geotechnical program be established and performed upon final design of the retaining walls:

- Based on the cross sections we were provided, we anticipate wall heights will range from 13 to 28 feet in height.
- This report will discuss wall construction using cast-in-place walls with spread footing foundations with an allowable bearing capacity, as well as construction utilizing soldier piling and lagging with tieback between STA 2103+00 and STA 2106+00.
- For the preliminary solider pile wall design of the retaining wall, we assumed a uniform sandy soil with slightly increasing density below the excavation. We assume a surcharge from the AW4 weight light-rail train of 34 kips per axle spreading 5 feet 7 inches along the length of rail and across the width of the tie.
- Should a soldier pile retaining system with tiebacks be utilized, stray electrical currents from grounding rods may affect the corrosion potential of buried metal materials.
- As the south wall (RTW-W111) approaches the MSE wall on Bachmann's property, we may encounter fill soils and a reinforcement system behind the MSE Wall. To avoid placing additional stresses on the MSE wall, we recommend removing the MSE wall and the fill soil behind it. The MSE wall should be re-constructed. A temporary retention system may be needed to create a stable slope when removing the fill soils. Alternatively an intermediate or deep foundation system could be used to support the track and avoid temporary retention system problems. However any additional stresses or vibration may cause damage to the MSE wall. We recommend planning to reconstruct the MSE wall at this time to avoid problems during construction.
- Care should be taken during construction to prevent surficial and deep stability problems of the hill. The contractor may need to use temporary retention systems to protect the stability of the

hill during construction. Multiple retention systems may be needed in parallel on the hill.

- Our analysis shows that, as currently designed near the Bachmann's wall, new wall RTW-W111 will settle about three inches with lateral displacement near the top of the wall of about six inches. Thus we recommend against using a spread footing to support wall RTW-W111.
- Piles could be used to support wall RTW-W111 but will be subjected to significant downdrag loads unless the embankment is pre-loaded. It will be difficult to construct a pre-load condition due to the geometry of the hills.
- Even with a pile supported wall RTW-W111 the embankment near the wall could exhibit post-construction settlement around 8 inches. A construction delay would be needed to reduce post-construction settlement. Lightweight fill could be used to reduce embankment settlement.
- The design team and owner may want to consider extending the Prairie Center Drive (PCD) Bridge further along the Costco Hill to avoid the embankment and wall settlement concerns, stability concerns, reduce the risk of working around the Bachmann's wall, and for ease of construction.

A preliminary global stability analysis was performed during this preliminary evaluation in the area of the Bachmann's wall. We recommend another stability analysis of the final wall design be performed upon completion of the soil boring program and final design to re-evaluate the temporary and permanent stability conditions.

B.1.a. Precautions Regarding Changed Information

We have attempted to describe our understanding of the proposed construction to the extent it was reported to us by others. Depending on the extent of available information, assumptions may have been made based on our experience. If we have not correctly recorded or interpreted the project details, we should be notified. New or changed information could require additional evaluation, analyses and/or recommendations.

C. Preliminary Recommendations

The following preliminary recommendations are based our preliminary soil boring program in the vicinity of the proposed walls.

C.1. Cast-In-Place Concrete Retaining Walls

As mentioned in the discussion section of this report, we recommend against using a spread footing to support RTW-W111 due to settlement concerns around the Bachmann's wall. This section provides suggestions for construction of wall RTW-W111 away from the Bachmann's wall and for wall RTW-W110.

For retaining wall design, we recommend using the MnDOT CIP Retaining Wall Standards wall loading case: 2-foot live load surcharge for design.

Based on our preliminary analysis, it appears a tie-rod or beam connecting the two walls may be required to reduce the size of the walls. Consideration should also be given to designing a large enough foundation system to counteract the active pressure of the retained soils behind the walls.

C.1.a. Excavations

In general, we recommend removing the topsoil and fill from beneath the base of the new retaining walls. Based on our borings, the fill soils range from 1 to 12 feet below the ground surface. From there, the footings can either be placed on the native soils, or engineered fill can be placed and compacted to achieve design elevations. However, since the borings were offset along the proposed alignment and in the area of the proposed walls, it is possible the fill soils do not extend to the same depth under the current alignment. As the south wall approaches the MSE Wall on Bachman's property we may encounter fill soils and a reinforcement system behind the MSE Wall. To avoid placing additional stresses on the MSE wall, we recommend removing the MSE wall and the fill soil behind it. The MSE wall should be re-constructed. A temporary retention system may be needed to create a stable slope when removing the fill soils. Alternatively, an intermediate or deep foundation system could be used to support the track and avoid temporary retention system problems. However, any additional stresses or vibration may cause damage to the MSE wall. We recommend planning to reconstruct the MSE wall at this time to avoid problems during construction. Even if the PCD Bridge is extended past the Bachmann's wall, we recommend budgeting to replace the wall. The wall could be very susceptible to any vibrations, construction loads, and precipitation. Based on the presumed age of the wall (estimated to be about 20 years) and the more limited design methodology and experience of contractors of walls at that time, we do not know what the life expectancy of the wall is or if the wall currently has an adequate factor of safety for bearing and slope stability.

To provide lateral support to replacement backfill placed beneath the foundations, additional required fill, and the structural loads they will support, we recommend oversizing (widening) the excavations 1 foot horizontally beyond the outer edges of the retaining wall foundations for each foot the excavations extend below bottom-of-footing subgrade elevations.

Excavation depths will vary between the borings and the actual wall location. Portions of the excavations may also be deeper than indicated by the borings. Contractors should also be prepared to extend excavations in wet or fine-grained soils to remove disturbed bottom soils.

Excavations on slopes should also be benched, or keyed into the slope to provide a flat surface for the placement of fill to reduce the potential for fill instability.

C.1.b. Selection, Placement and Compaction of Backfill.

We recommend referencing the following specification sections in Table 2 below from the 2014 MnDOT Standard Specifications for Construction when considering the material and compaction specifications for the embankment material beneath the wall, level pad material, and retaining wall backfill material.

Table 2. Material and Compaction Specifications for Retaining Walls.

Material	Material Specification	Compaction Specification
Embankment Fill	2105.2B2	2105.3F
Leveling Pad Beneath Footings	2211.2A	2211.3C
Retaining Wall Backfill	3149.2D2	2105.3F

C.1.c. Net Allowable Bearing Pressure

Based on MnDOT's cast-in place concrete retaining wall criteria, the above recommendations, and the soils encountered at the wall locations, we anticipate the soils will be suitable for support of the walls. Because several feet of the stem wall height is buried for frost protection, the maximum exposed wall height is near 23 feet. We recommend further analysis and borings at the proposed wall locations to confirm soil conditions.

C.2. Pile Supported Wall RTW-W111

A spread footing cannot be used to support RTW-W111 near the existing Bachmann's wall due to excess settlement. We recommend considering using piles to support RTW-W111. The piles should be extended to near STA 2105+00. Spread footings could be used to support RTW-W111 to the east of this station.

C.3. Light Weight Fill

Even with using piles to support wall RTW-W111, the proposed track embankment near the wall near the Bachmann's wall location could settle around eight inches. Lightweight fill could be used to reduce settlement to tolerable levels.

C.4. Extended Prairie Center Bridge

We recommend the design team and owner consider extending the PCD Bridge to STA 2105+00. There are multiple benefits and reasons to consider extending the PCD Bridge including:

- A spread footing cannot be used to support wall RTW-W111 near the Bachmann's wall due to settlement.
- Even with a pile supported RTW-W111, there is a significant risk of damage to the existing Bachmann's wall during construction. While extending the PCD Bridge will not eliminate the risk of damage to the Bachmann's wall, it would significantly reduce the risk.
- It is possible the existing Bachman's wall could remain in place if the bridge is extended. Additional surveying may be needed to more accurately determine if this is possible.
- Temporary shoring may be eliminated. Temporary shoring may be needed to replace the Bachmann's wall. Additional shoring may be needed to construct wall RTW-W111 (and protect the slope above. Shoring may also be needed to protect the existing pond at the top of the hill.
- There is less risk of the existing pond on top of the hill affecting construction and the performance of the track and structures after construction.
- An extended bridge could be easier to construct than retaining walls and an embankment.

C.5. Preliminary Soldier Pile Wall Design

We performed a preliminary soldier pile and lagging design analysis as an alternative wall design based on preliminary boring information provided and assumed soil conditions provided in Table 3 below.

Table 3. Assumed Soil Conditions

Geologic Material	Saturated Unit Weight (pcf)	Friction Angle (degrees)
Fill Soils and/or Retained Soils	125	33
Below Grade Soils	115	30

Our preliminary analysis used the assumed soil conditions noted above to evaluate piles at various track stationing, for various wall heights, and various grades and slopes that were provided to us on preliminary track cross sections. Table 4 below provides preliminary sizing for use in preliminary cost estimation.

Table 4. Preliminary Soldier Pile Design Information

Retaining Wall Stationing	Retaining Wall	Exposure Height (ft)	Pile Spacing (ft)	Pile Length (ft)	Number of Tiebacks rows	Horizontal Tieback Spacing (ft)
0+00 to 6+63	RTW-W110	12	8	25	1	8
0+00 to 3+20	RTW-W111	23	8	40	2	8
3+20 to 4+00	RTW-W111	18	8	40	2	8
4+00 to 6+65	RTW-W111	9	8	25	1	8

C.6. Existing MSE Wall

Based on the plans provided to us, the existing MSE wall will be influenced by the proposed construction. The walls and rail embankment will impart additional loads on the existing wall, which we anticipate was not accounted for during the design of the wall.

Design drawings of the retaining wall were not available at the time of this report, however, we anticipate the wall contains geogrid reinforcement within the retained area of the wall, extending behind the wall a length equal to approximately 80 percent of the wall height. It is possible the reinforced zone behind the wall will extend beneath the footings of RTW-W111.

We recommend provisions be made to analyze the existing design of the wall. Based on discussion with the design team, provisions are being made to reconstruct this wall. Further analysis can be completed when a more detailed design of the wall has been completed.

C.7. Corrosion Potential

The construction of the proposed retaining walls may include the use of tiebacks or driven soldier piles. While the soils in the areas are not considered corrosive, a grounding system for the overhead contact system, used to power the light rail trains, may introduce electrical currents into the soil, and may interact with metal structures installed into the ground. We recommend accounting for this potential in the design of any retaining system.

D. General

This report should be considered preliminary in nature and will be revised upon final design parameters and the completion of the full geotechnical program. In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If you have any questions about this report, please contact Matt Ruble at 952.995.2224.

Sincerely,

BRAUN INTERTEC CORPORATION

Professional Certification:
I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

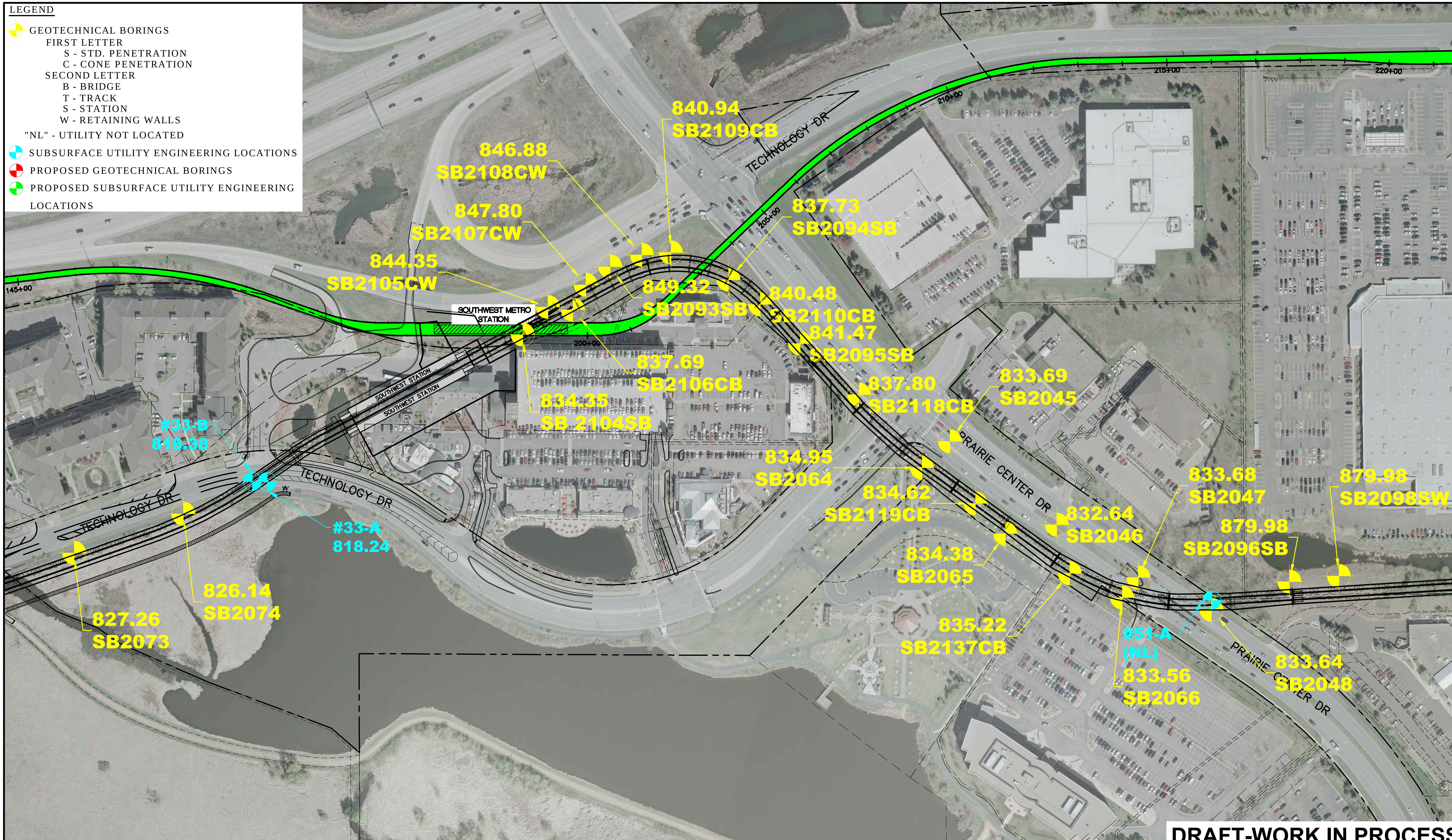
Matthew P. Ruble, PE
Principal Engineer
License Number: 40935

Ray A. Huber, PE
Vice President – Principal Engineer

Appendix:
Soil Boring Location Sketch
Preliminary Engineering Plan and Profile Sheets for Retaining Walls RTW-W110 and RTW-W111
Soil Borings 2096SB, 2098SW, and 2102SW
Analytical Graphics: RTW-W111 Stability at Sta. 2013+50

c: Mr. Jeff Stewart, SPO
Ms. Laura Amundson, Parsons Brinkerhoff

APPENDIX



SOUTHWEST LIGHT RAIL

SOIL BORINGS
SHEET 3 OF 12

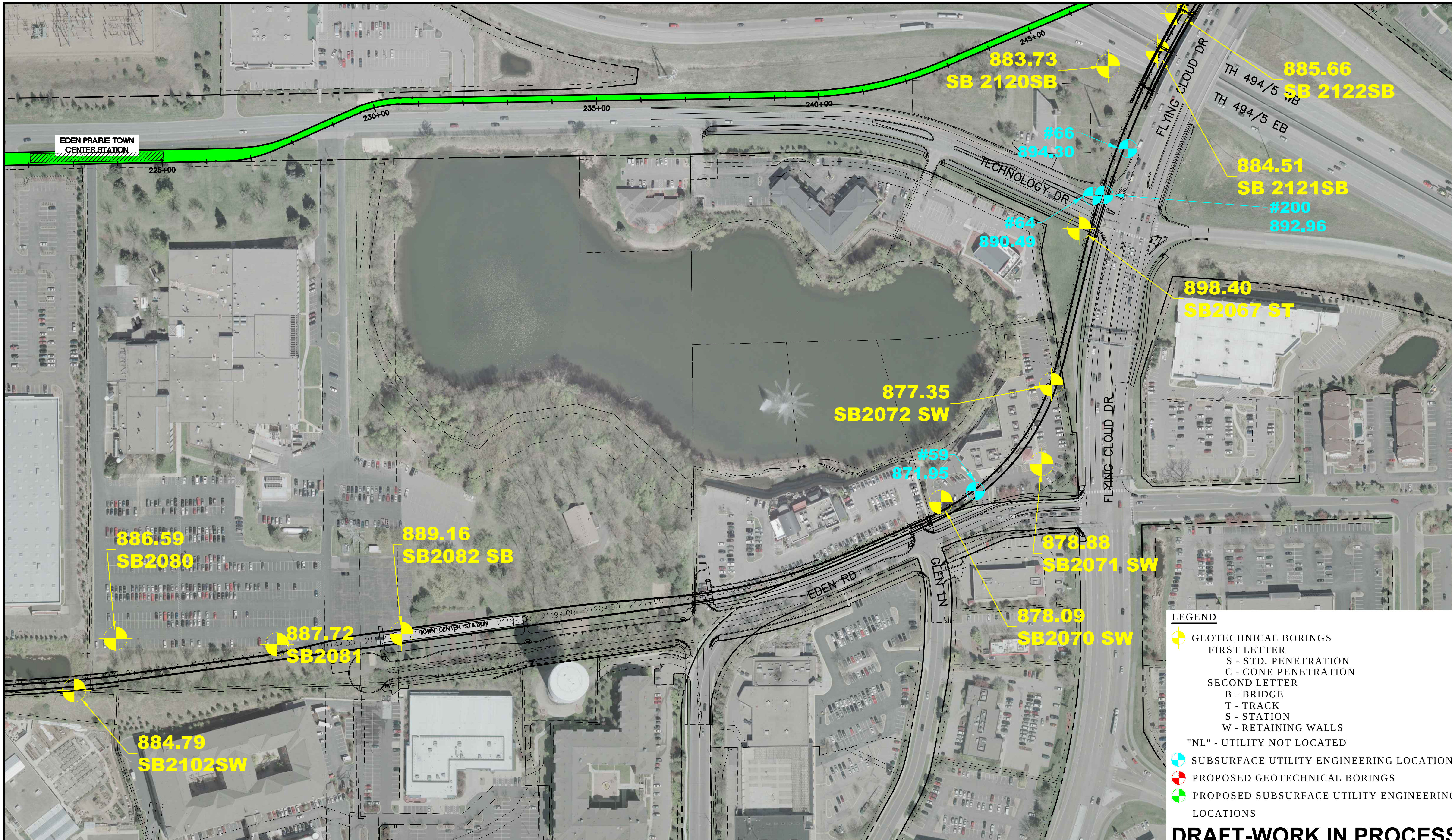
IRT: N/A
REV: 0
DATE: 06/30/2014

NORTH
0 50 100 200

SOUTHWEST Green Line LRT Extention

METROPOLITAN COUNCIL
AECOM
SRF Consulting Group, Inc.

Aug. 28 2014 11:30 am V:\3200_PEC-W\CAD\OVERALL\EXHIBITS\CIVIL\EXHB-CIV-SOIL BORINGS.dwg By: Boscha



SOUTHWEST Green Line LRT Extention

SOUTHWEST LIGHT RAIL

SOIL BORINGS

SHEET 4 OF 12

IRT: N/A

REV: 0

DATE: 06/30/2014

NORTH

0 50 100 200

METROPOLITAN COUNCIL

AECOM

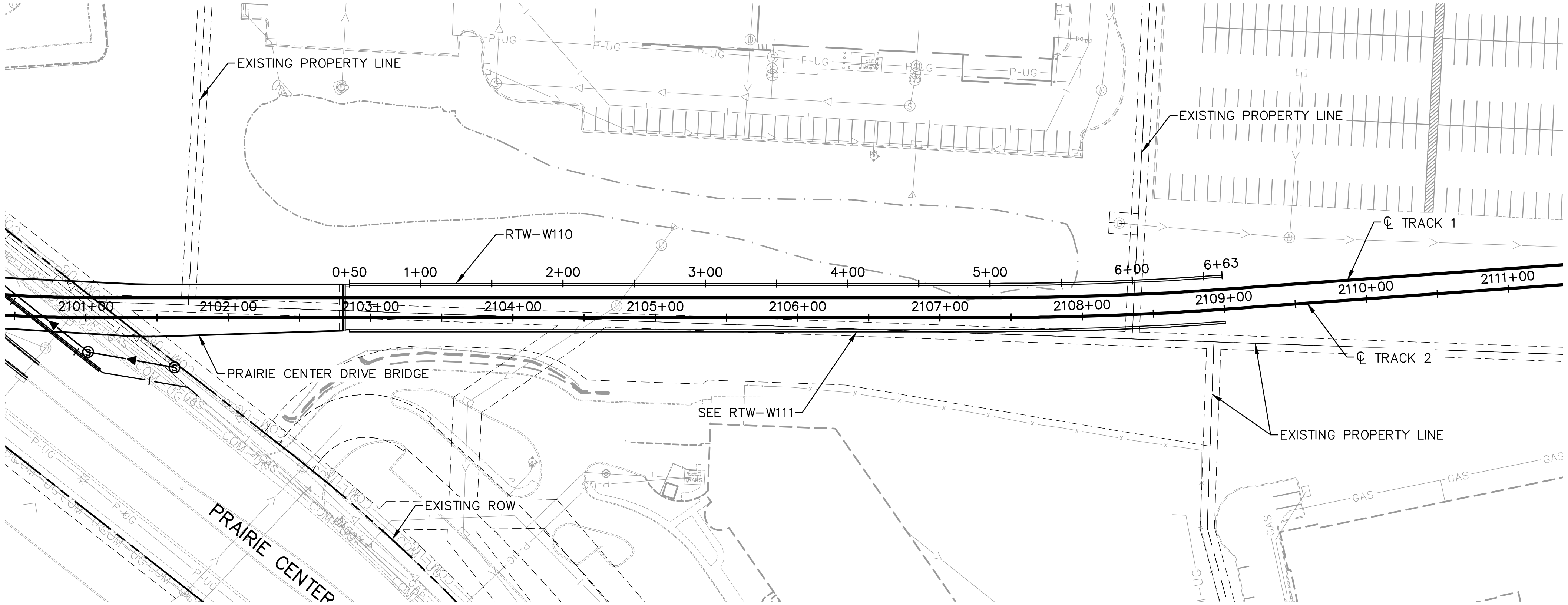
SRF Consulting Group, Inc.

Aug. 28 2014 11:30 am V:\3200_PEC-W\CAD\OVERALL\EXHIBITS\CIVIL\EXHB-CIV-SOIL BORINGS.dwg By: Boscha

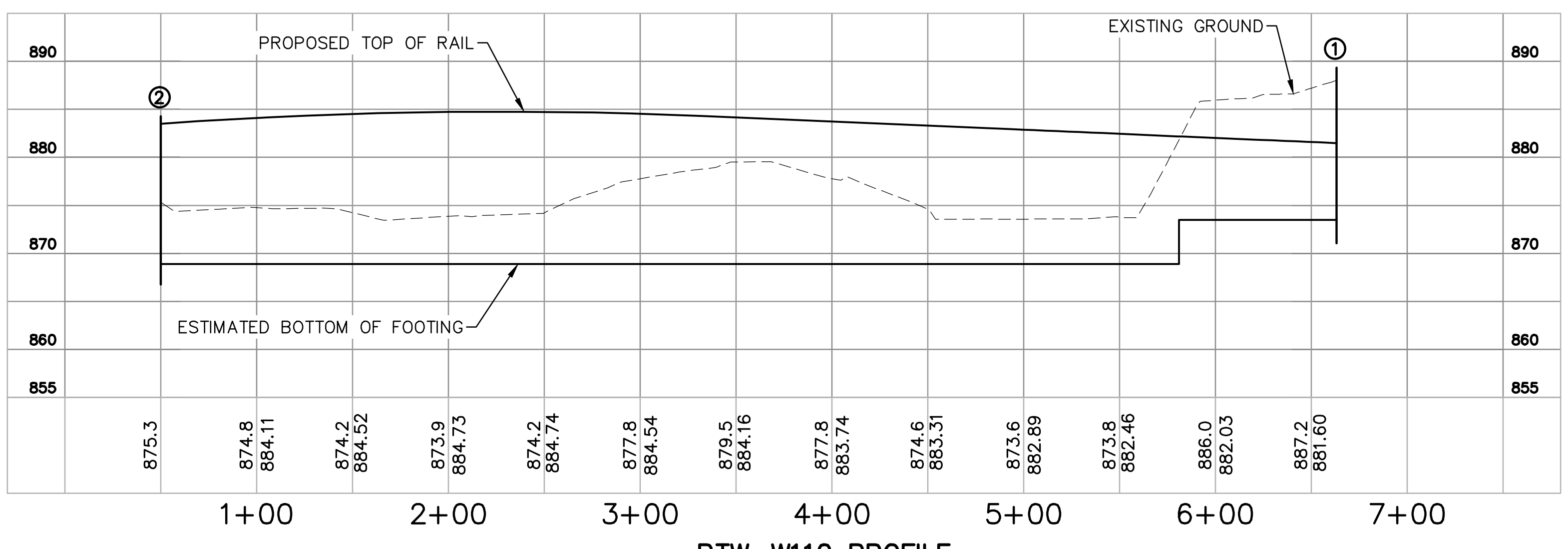
NOTE:
RTW-W110 IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL ON SPREAD FOOTINGS.

① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.

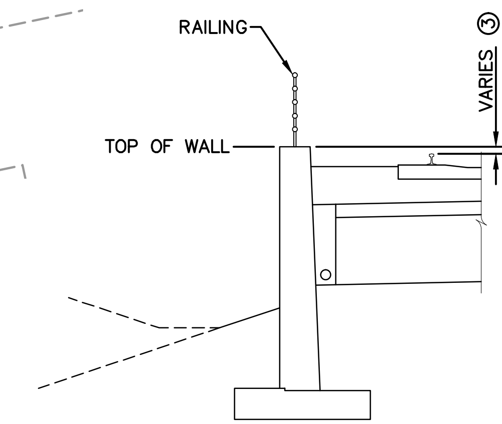
② JOINT LOCATION BETWEEN RETAINING WALL AND BRIDGE WINGWALL.



RTW-W110 PLAN

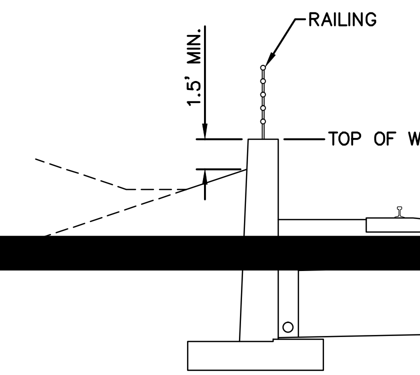


RTW-W110 PROFILE

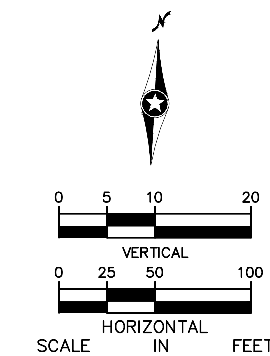


③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES & SPIRALS

RTW-W110 TYPICAL SECTION
STA. 0+50 TO STA. 5+82



RTW-W110 TYPICAL SECTION
STA. 5+82 TO STA. 6+63



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AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extention

WEST-VOLUME 2 (STRUCTURES)
SEGMENT 1
RTW-W110
PLAN AND PROFILE

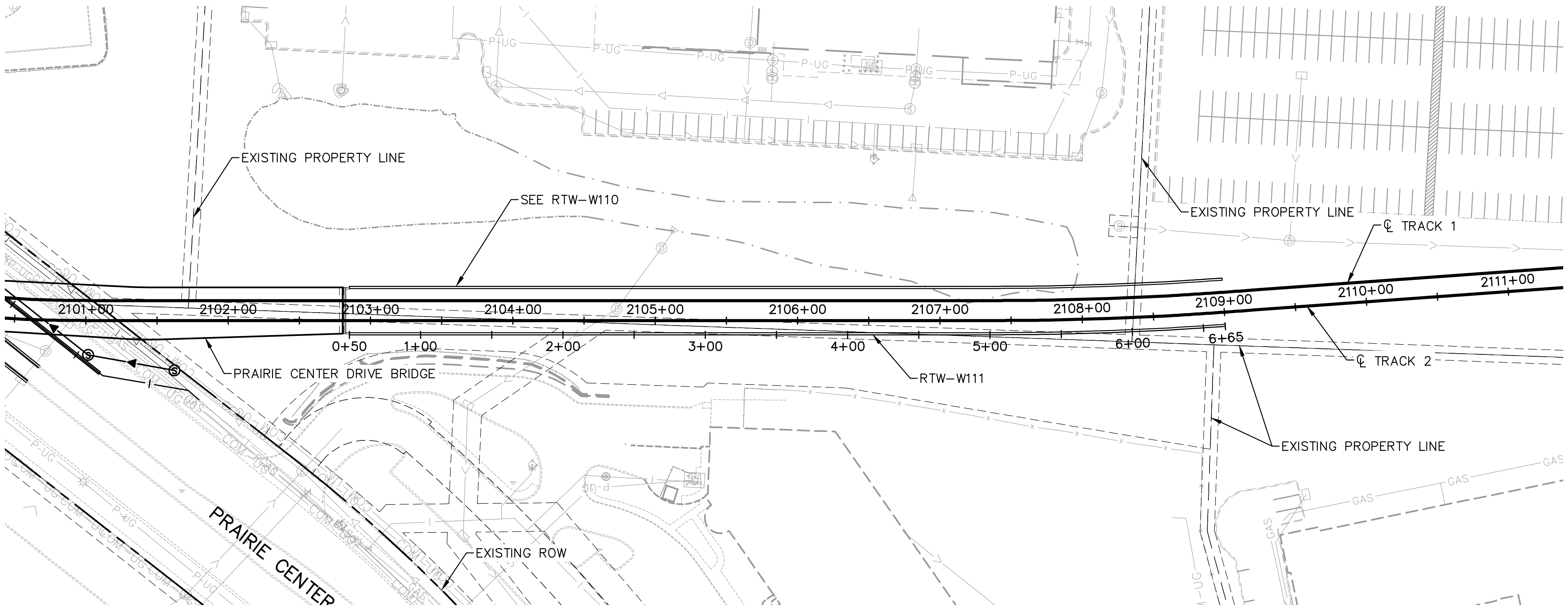
DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-RTW-PPFL-002

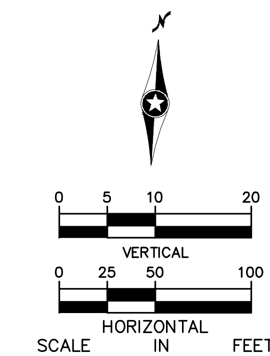
NOTE:
RTW-W111 IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL ON SPREAD FOOTINGS.

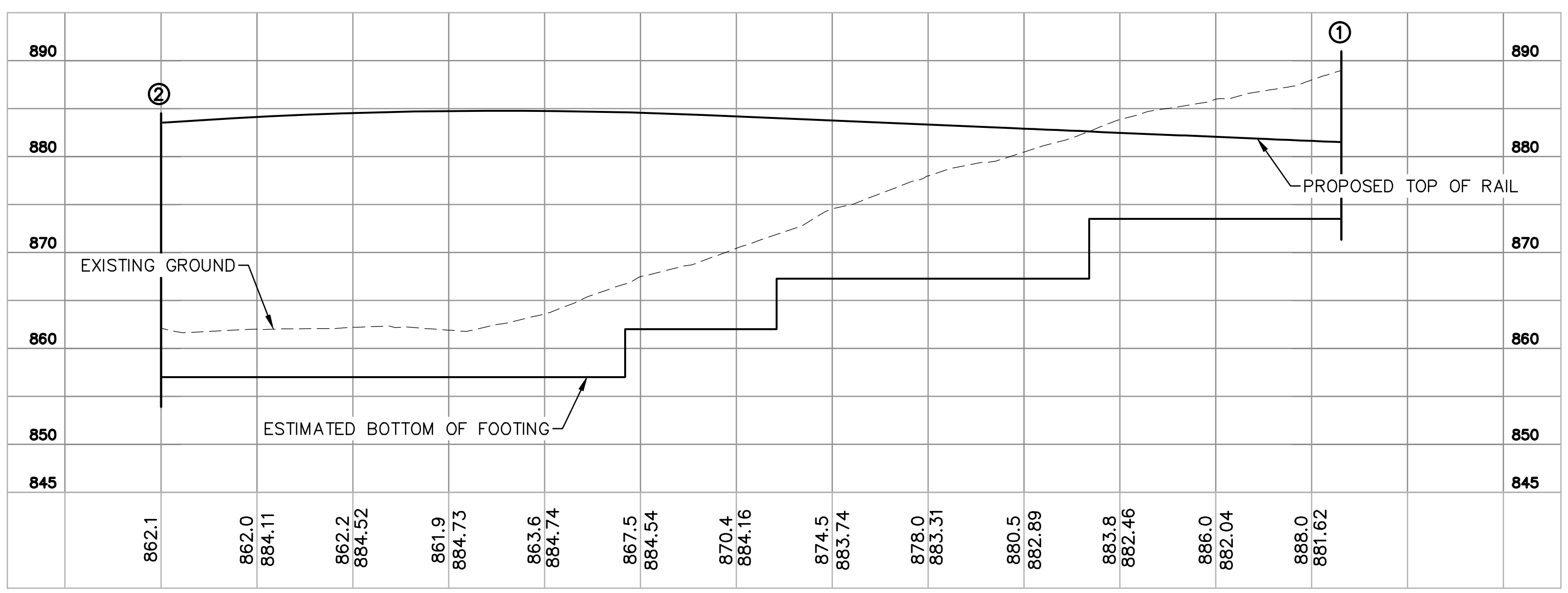
① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.

② JOINT LOCATION BETWEEN RETAINING WALL AND BRIDGE WINGWALL.

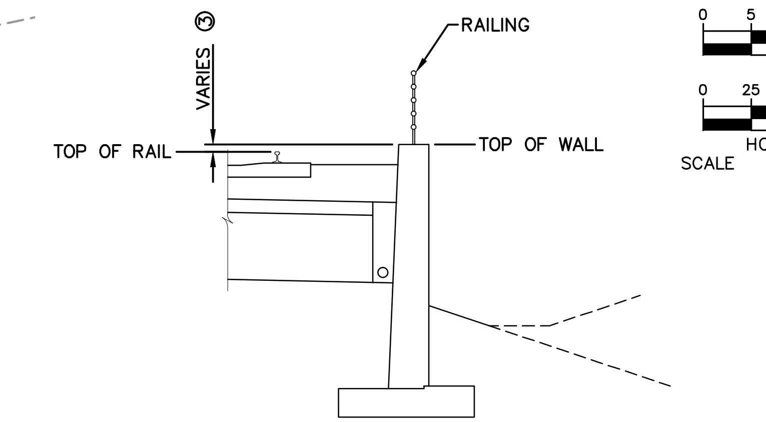


RTW-W111 PLAN



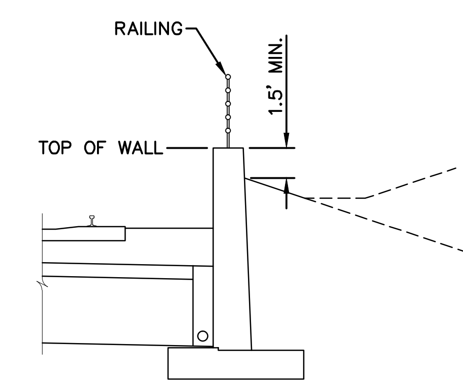


RTW-W111 PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES & SPIRALS

RTW-W110 TYPICAL SECTION
STA. 0+50 TO STA. 5+34



RTW-W110 TYPICAL SECTION
STA. 5+34 TO STA. 6+65

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AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extention

WEST-VOLUME 2 (STRUCTURES)
SEGMENT 1
RTW-W111
PLAN AND PROFILE

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-RTW-PPFL-003

BRAUN INTERTEC

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2096SB LOCATION: N: 124666.2; E: 486148.2; Offset 43' N of stake. See attached sketch.

DRILLER: B. Kammermeier	METHOD: 3 1/4" HSA, Autohammer	DATE: 4/25/14	SCALE: 1" = 4'

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 880.0	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
879.1	0.9	CL	LEAN CLAY with SAND, trace roots, dark brown, moist. (Topsoil)			17	
875.0	5.0	CL	LEAN CLAY with SAND, trace Gravel, brown, moist, rather stiff. (Glacial Till)	10		15	
867.0	13.0	SM	SILTY SAND, fine- to medium-grained, with Gravel, brown, moist, medium dense. (Glacial Outwash)	17		10	
				17		7	
				19		9	
				10		8	
860.0	20.0	SP	POORLY GRADED SAND, fine- to medium-grained, with Gravel, light brown to brown, moist, loose to medium dense. (Glacial Outwash)	7		2	
			Layer of Lean Clay at 17 feet.	11		13	
858.0	22.0	SP-SM	POORLY GRADED SAND with SILT, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	12		9	
848.0	32.0	CL	SANDY LEAN CLAY, trace Gravel, brown, wet, very stiff to hard. (Glacial Till)	35		14	
				20		14	
				38*			*No sample recovery.
				34		14	DD=111 pcf

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/3/14 15:25

LOG OF BORING

BRAUN INTERTEC

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2096SB (cont.)**

LOCATION: N: 124666.2; E: 486148.2; Offset 43' N of stake. See attached sketch.

DRILLER: B. Kammermeier | METHOD: 3 1/4" HSA, Autohammer | DATE: **4/25/14** | SCALE: **1" = 4'**

Elev. feet 848.0	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
		ML	SILT, with layers of Sand, brown, moist, medium dense. (Glacial Till)	18		19	
845.0	35.0	SC	CLAYEY SAND, trace Gravel, brown, moist, hard. (Glacial Till)	39		11	
843.0	37.0	SM	SILTY SAND, fine-grained, brown, moist, medium dense. (Glacial Outwash)	23		5	
840.0	40.0	SP	POORLY GRADED SAND, fine- to medium-grained, light brown to 70 feet then brown, moist to 75 feet then waterbearing, medium dense to dense. (Glacial Outwash)	19		2	
				18		2	
				28		1	
				25		1	
				26		1	
				34		1	
				32		2	

(See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BL-13-00213 **GEOTECHNICAL EVALUATION** **SWLRT** **Minnetonka, Minnesota**		BORING: **2096SB (cont.)** LOCATION: N: 124666.2; E: 486148.2; Offset 43' N of stake. See attached sketch.	
DRILLER: B. Kammermeier	METHOD: 3 1/4" HSA, Autohammer	DATE: **4/25/14**	SCALE: **1" = 4'**

Elev. feet 816.0	Depth feet 64.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
			POORLY GRADED SAND, fine- to medium-grained, light brown to 70 feet then brown, moist to 75 feet then waterbearing, medium dense to dense. (Glacial Outwash) *(continued)*	32		1	
				27		1	An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while drilling.
				30	▽	18	Switched to mud rotary drilling method after 75-foot sample.
800.0	80.0	SP-SM	POORLY GRADED SAND with SILT, fine- to medium-grained, with Gravel, gray, waterbearing, dense. (Glacial Outwash)	47		23	
				47		31	
790.0	90.0	ML	SILT with SAND, with frequent layers of Fat Clay, gray, wet, dense. (Glaciofluvium)	31		29	DD=95 pcf *Water observed at 75 feet while drilling. Boring immediately backfilled with bentonite grout.
				41		25	
784.0	96.0		END OF BORING at 96 feet.				

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING

BRAUN INTERTEC

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2098SW**

LOCATION: N: 124678.9;; E: 486259.2.
See attached sketch.

DRILLER: M. Barber | METHOD: 3 1/4" HSA, Autohammer | DATE: **4/30/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 880.0	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
		FILL	FILL: Sandy Lean Clay, dark brown and brown, moist.	6		23	
				15			
873.0	7.0	FILL	FILL: Sandy Lean Clay, slightly organic, trace Gravel, dark gray and black, moist.	19		20	OC=3%
				15			
868.0	12.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	26		10	
				22			
863.0	17.0	SC	CLAYEY SAND, trace Gravel, brown, moist, very stiff. (Glacial Till)	29			
861.0	19.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	25			
				26			
856.0	24.0	SP-SM	POORLY GRADED SAND with SILT, fine- to medium-grained, with Gravel, with lenses of Lean Clay, brown, moist, medium dense. (Glacial Outwash)	17			
853.0	27.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	29			
851.0	29.0	SC	CLAYEY SAND, trace Gravel, brown, moist, very stiff. (Glacial Till)	29			

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BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2098SW (cont.) LOCATION: N: 124678.9;; E: 486259.2. See attached sketch.

DRILLER: M. Barber	METHOD: 3 1/4" HSA, Autohammer	DATE: 4/30/14	SCALE: 1" = 4'

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 848.0	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
846.0	34.0		CLAYEY SAND, trace Gravel, brown, moist, very stiff. (Glacial Till) *(continued)*	24			
838.0	42.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	24 28 27			
834.0	46.0	SM	SILTY SAND, fine-grained, light brown, moist, dense to medium dense. (Glacial Outwash)	38 27			
			END OF BORING. Water not observed with 44 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth of 28 feet immediately after withdrawal of auger. Boring immediately backfilled with bentonite grout.				

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BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2102SW LOCATION: N: 124650.1; E: 486674.2. See attached sketch.

DRILLER: B. Kammemeier	METHOD: 3 1/4" HSA, Autohammer	DATE: 4/24/14	SCALE: 1" = 4'

Elev. feet 884.8	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
884.6	0.2	CL	SANDY LEAN CLAY, trace roots, dark brown, moist. (Topsoil)				
		CL	SANDY LEAN CLAY, trace Gravel, brown, moist, medium to stiff. (Glacial Till)	7			
				7		11	
				13		15	DD=114 pcf
874.8	10.0	SP	POORLY GRADED SAND, fine- to medium-grained, light brown, moist, loose to medium dense. (Glacial Outwash)	6		11	
			Gravel at 12 feet.	6			
				11			
				14			
				22			
862.8	22.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, dense. (Glacial Outwash)	43			
				45		7	
857.8	27.0	SM	SILTY SAND, fine- to medium-grained, with Gravel, with lenses of lean Clay, brown, moist, medium dense to dense. (Glacial Till)	36		10	
				24		11	

(See Descriptive Terminology sheet for explanation of abbreviations)

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BRAUN℠ INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2102SW (cont.)**
LOCATION: N: 124650.1; E: 486674.2.
See attached sketch.

DRILLER: B. Kammemeier	METHOD: 3 1/4" HSA, Autohammer	DATE: **4/24/14**	SCALE: **1" = 4'**

Elev. feet 852.8	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
			SILTY SAND, fine- to medium-grained, with Gravel, with lenses of lean Clay, brown, moist, medium dense to dense. (Glacial Till) *(continued)*	47		11	
849.8	35.0	SP	POORLY GRADED SAND, fine-grained, brown to light brown, moist, dense to very dense. (Glacial Outwash)	45		9	
				51		5	
844.8	40.0	SC	CLAYEY SAND, with Gravel, brown, moist, hard. (Glacial Till)	45		12	
842.8	42.0	SP	POORLY GRADED SAND, fine- to medium-grained, with Gravel, light brown, moist, dense. (Glacial Outwash)	40		4	
				35		5	
838.8	46.0		END OF BORING. Water not observed while drilling. Water not observed with 44 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth at 19 feet immediately after withdrawal of auger. Boring immediately backfilled with bentonite grout.				

(See Descriptive Terminology sheet for explanation of abbreviations)

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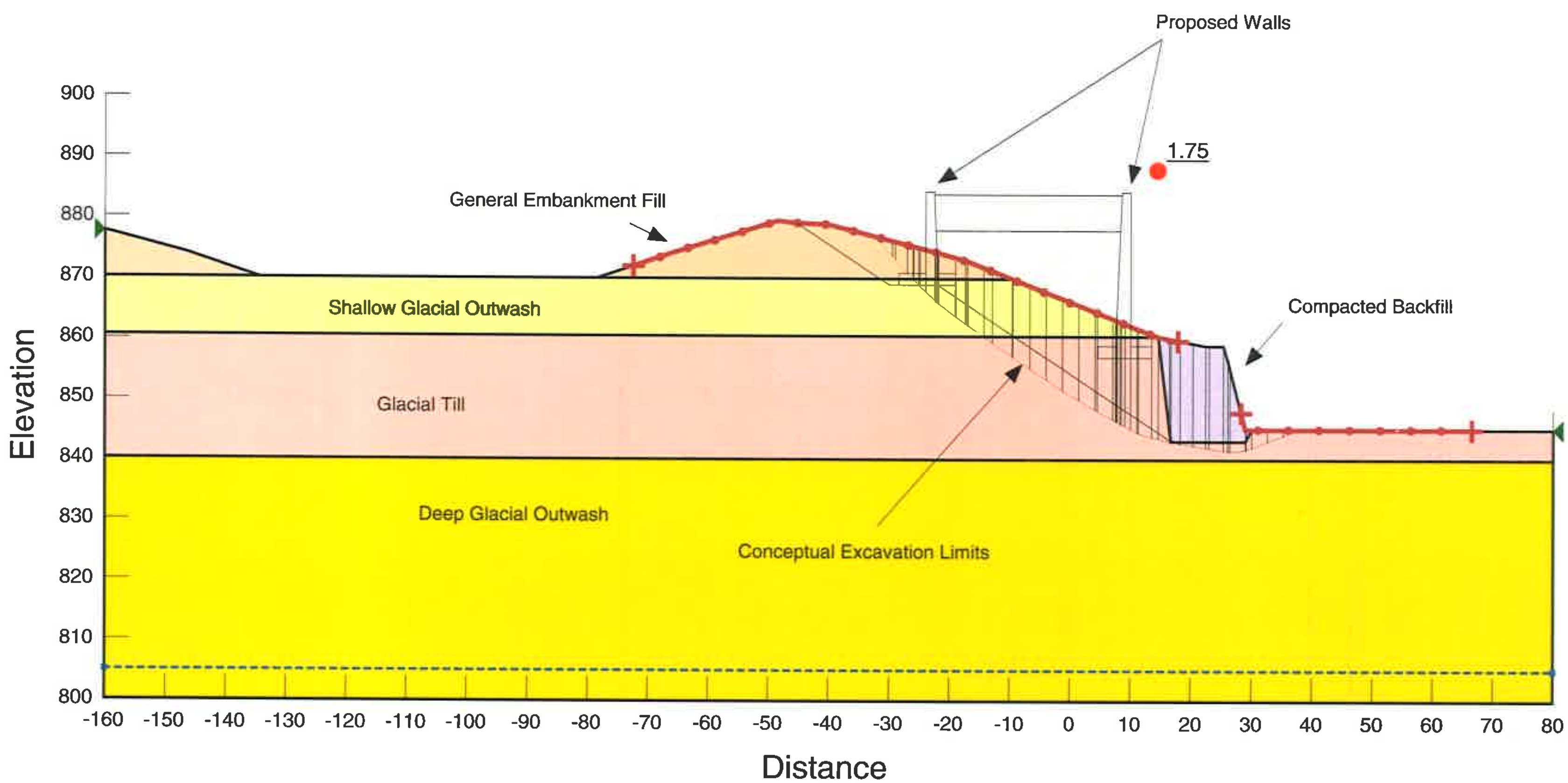
BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

LE Stability of Existing Condition
Effective Stress Analysis

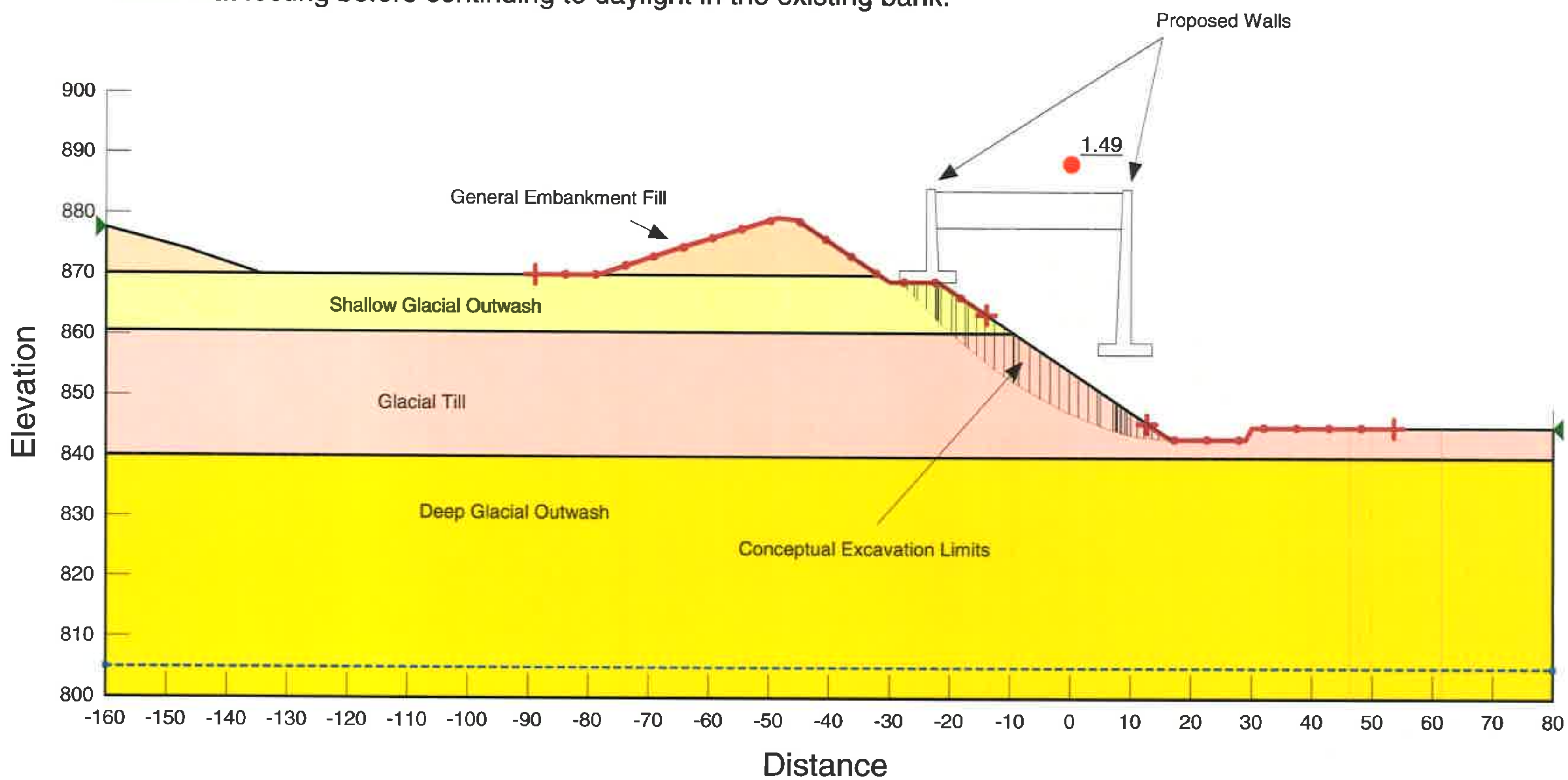
The purpose of this analysis being to calibrate to the extent possible the parameters assigned to the materials - mainly overconsolidated glacial soils - of which the cross section is comprised.



BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

LE Excavation Stability
Effective Stress Analysis

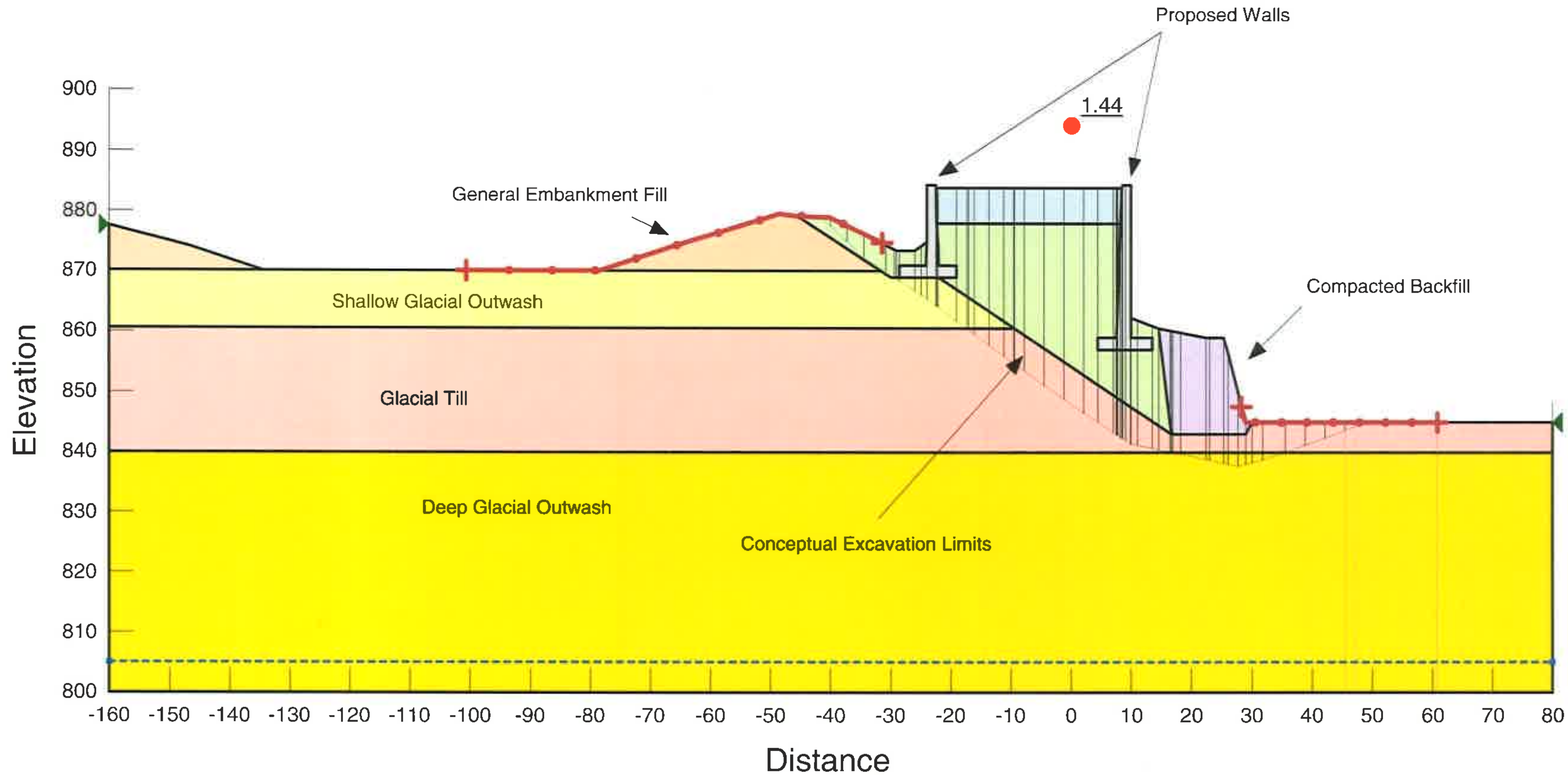
Excavation assumed cut up and back from bottom rear of existing MSE wall's reinforced zone at a 1 1/2:1 (horizontal:vertical) gradient to near an elevation consistent with the bottom of the upslope or WB wall footing, then benched below that footing before continuing to daylight in the existing bank.



BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

Global LE Stability - Spread Footing Construction
Effective Stress Analysis

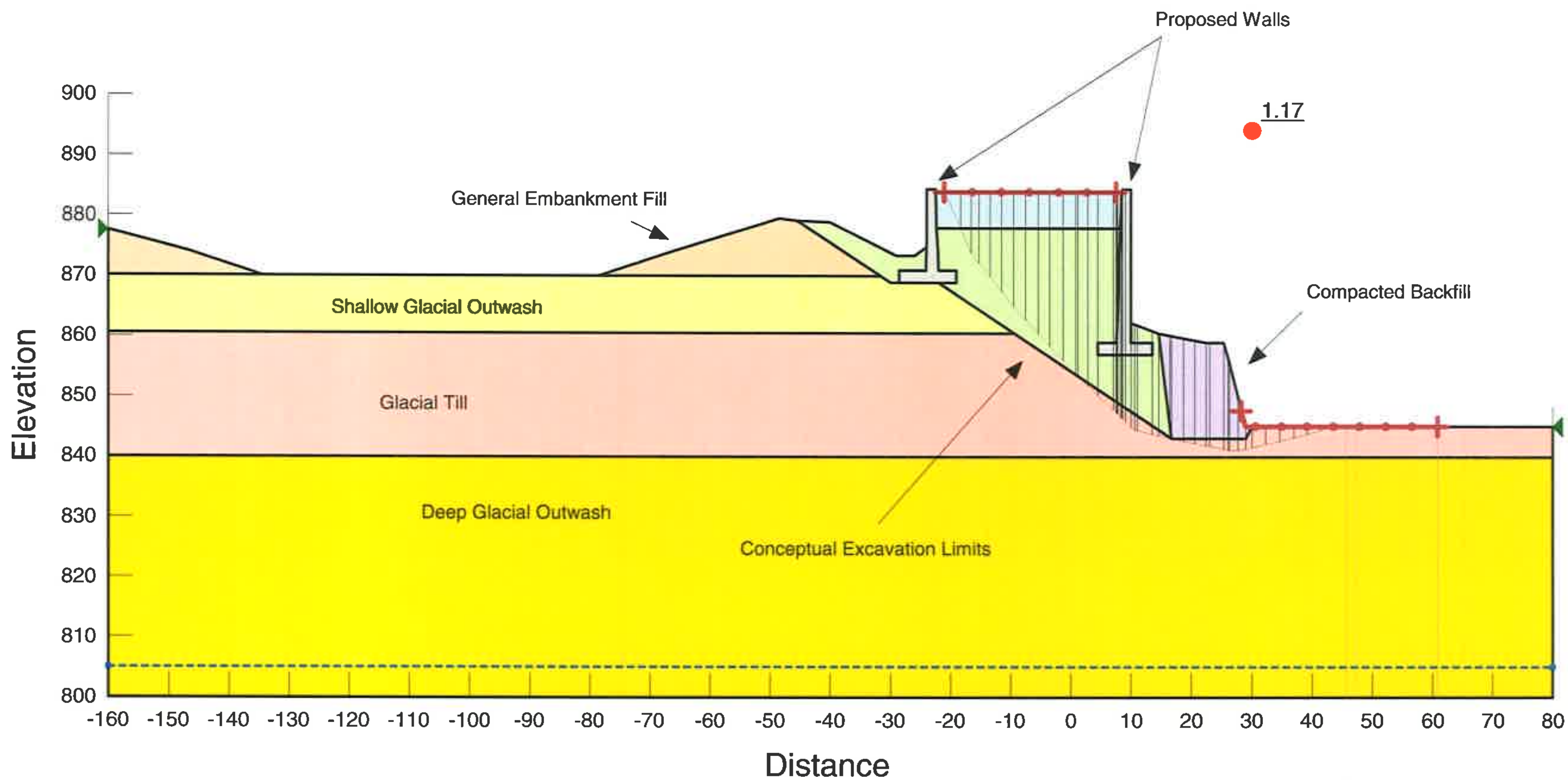
From a global perspective, the composite wall/backfill section could be shown to meet FOS requirements, the strength parameters for the materials identified in the section being reasonably conservative).



BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

Local LE Stability - Spread Footing Construction
Effective Stress Analysis

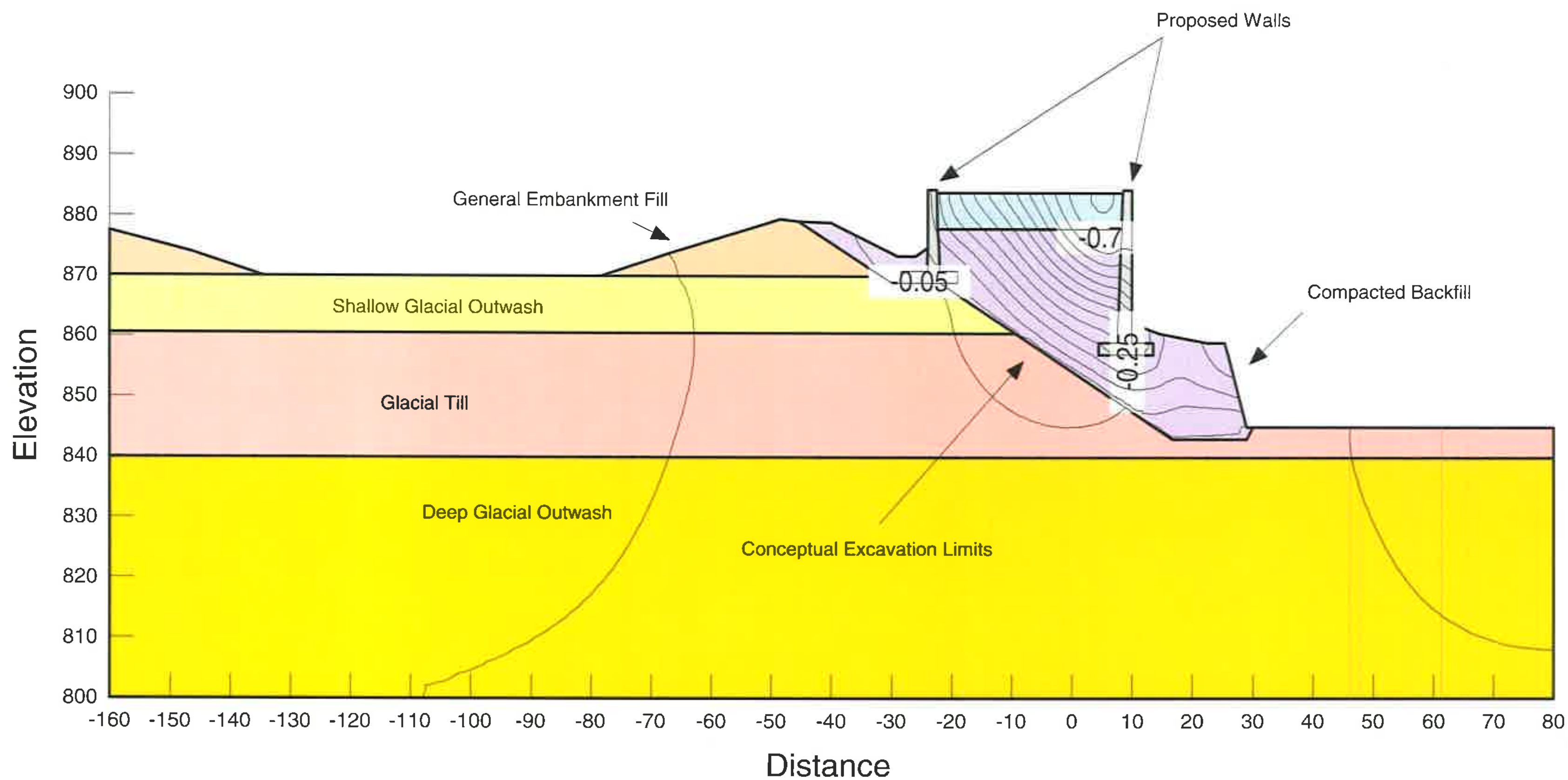
From a local perspective, however, if one looks at the walls as separate structural components, the downslope or EB wall and existing MSE wall below are challenged to support the driving forces generated by the backfill.



BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

Settlement Associated with Spread Footing Construction

Settlement of the downslope or EB wall could approach 0.25 feet, or 3 inches, if supported on a spread footing. In this example, the footings and backfill are placed as one, which also then predicts even more settlement within the backfill. Still, this example shows how settlement, in addition to stability, impacts spread footing construction. (Note that settlement of the upslope or WB wall is limited in contrast.)



BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

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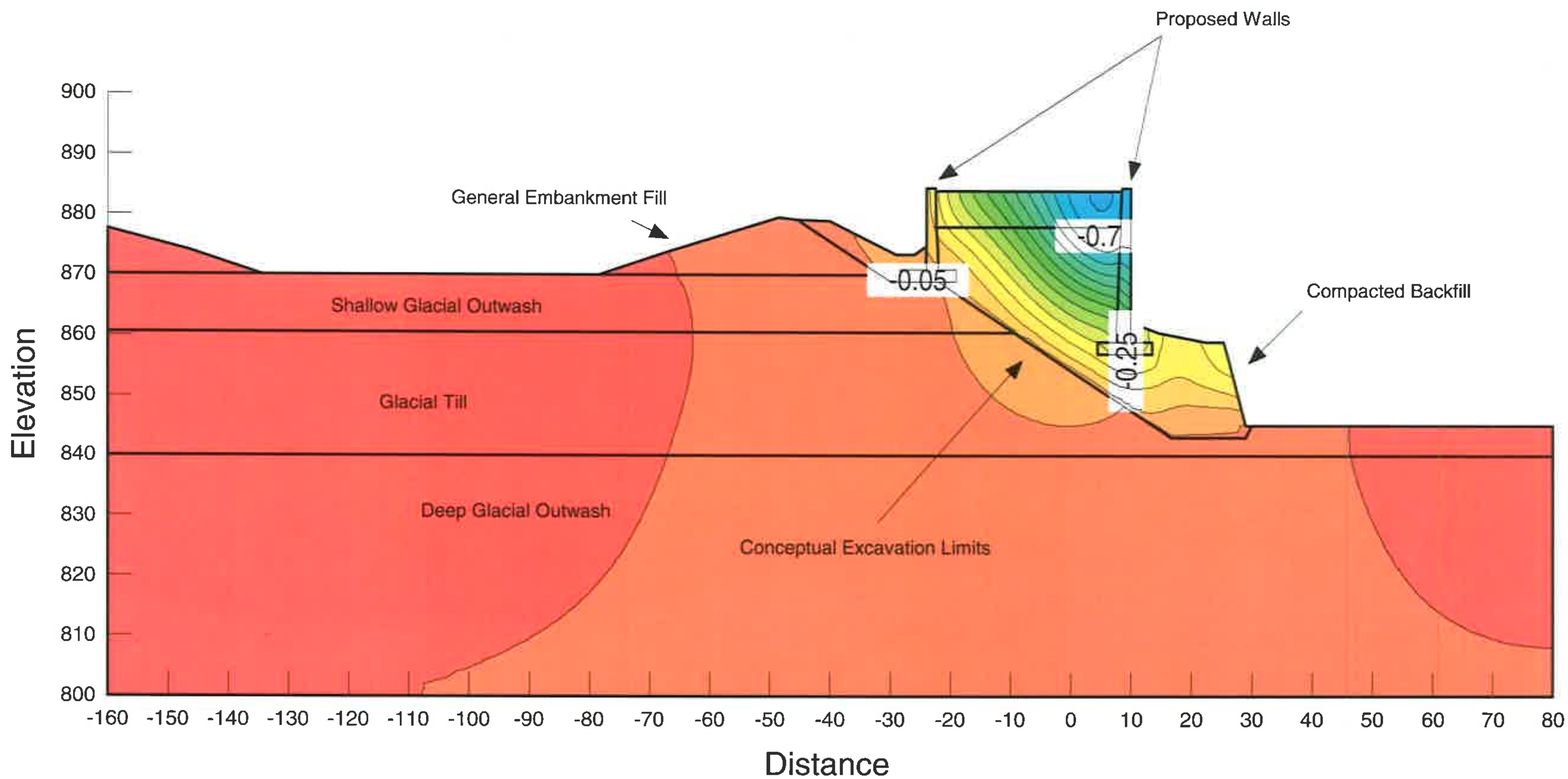
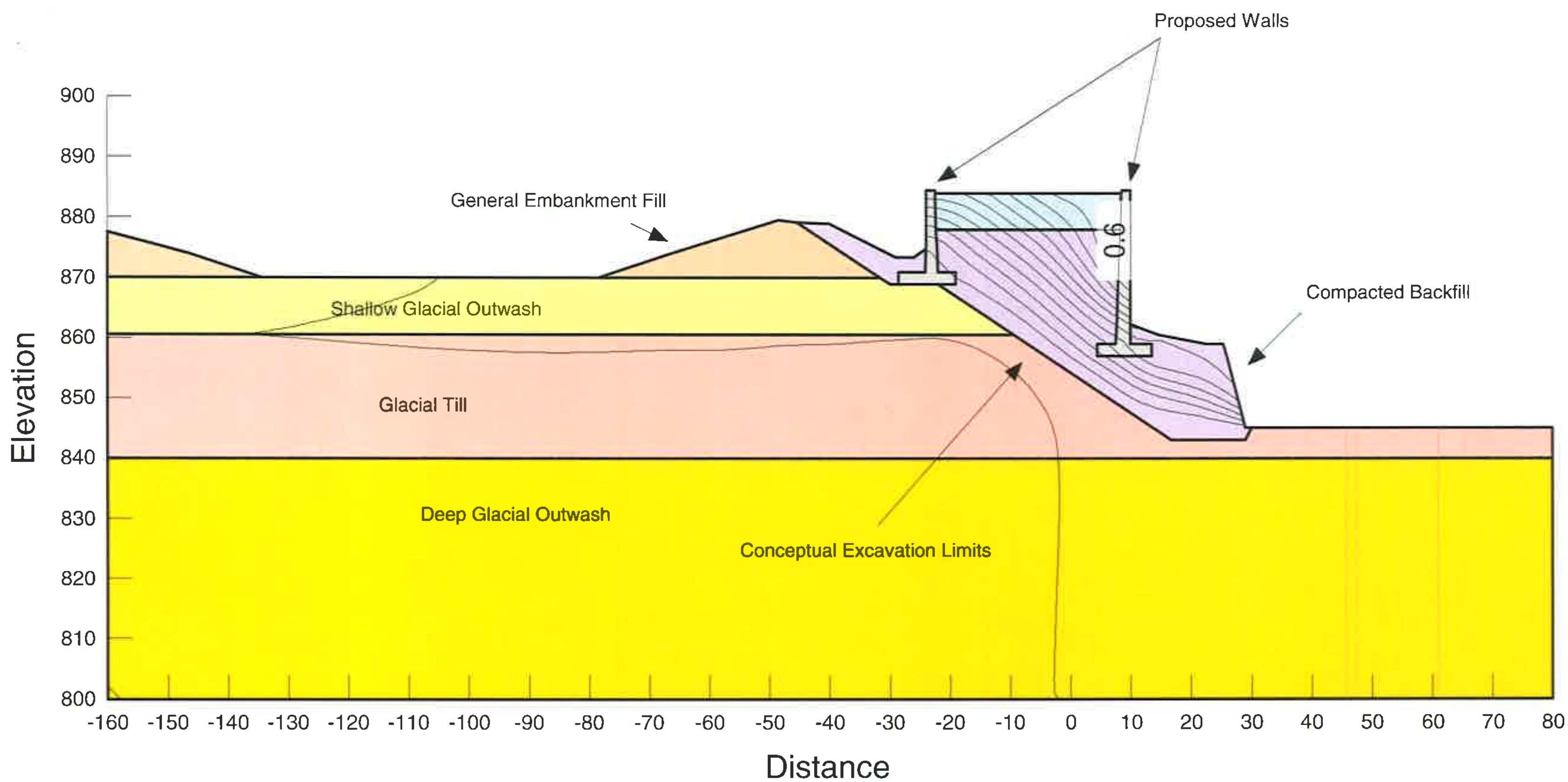


BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

Lateral Displacement Associated with Spread Footing Construction

Perhaps more importantly, if the two walls are built as independent structures and the downslope or EB wall allowed to rotate about its footing, lateral displacement could exceed settlement, in this case approaching 0.6 feet or 7 inches. Regardless of foundation design, this result suggests that the walls need to be tied together, or that the downslope wall at least needs to be tied back.



BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

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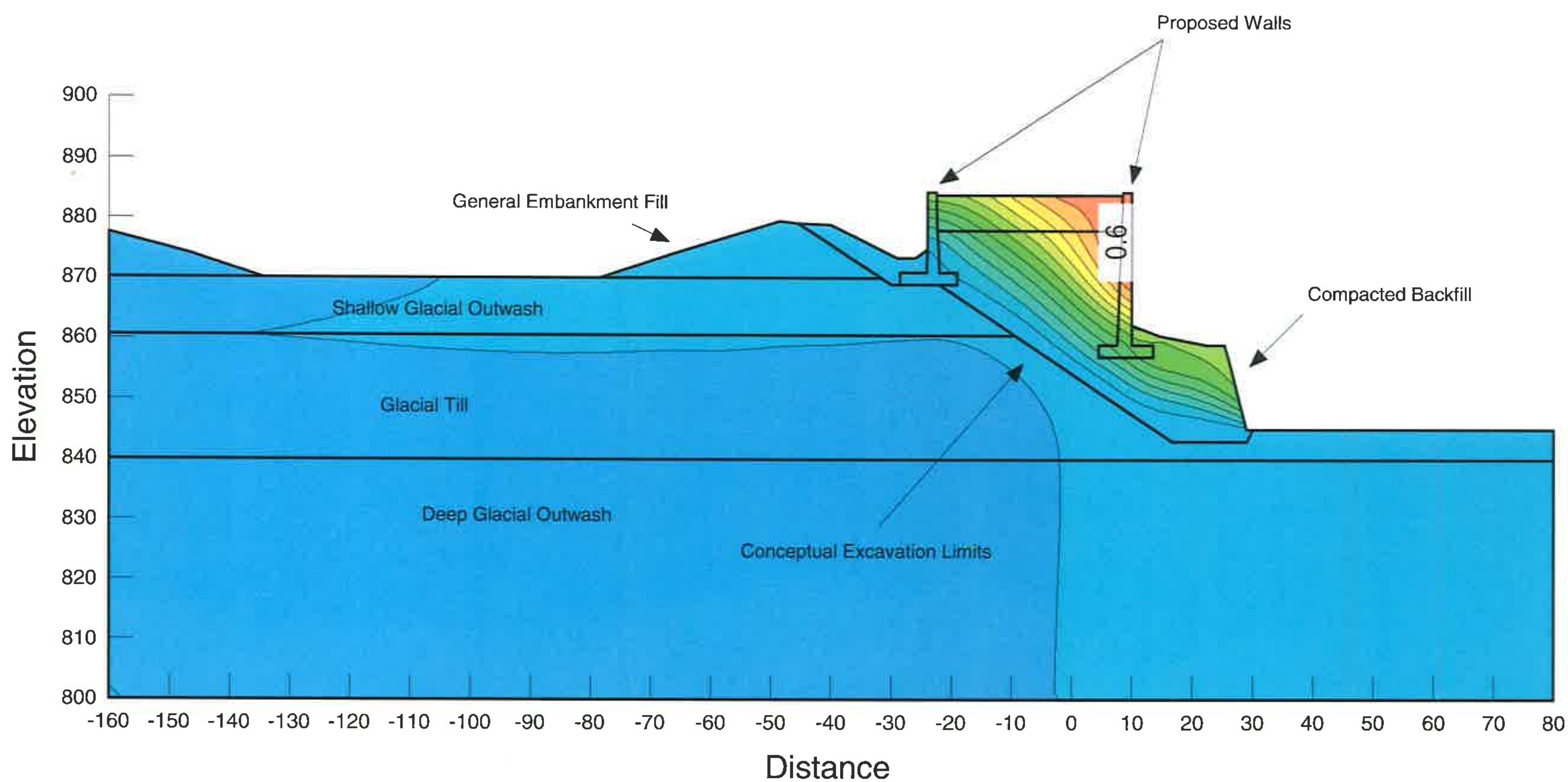
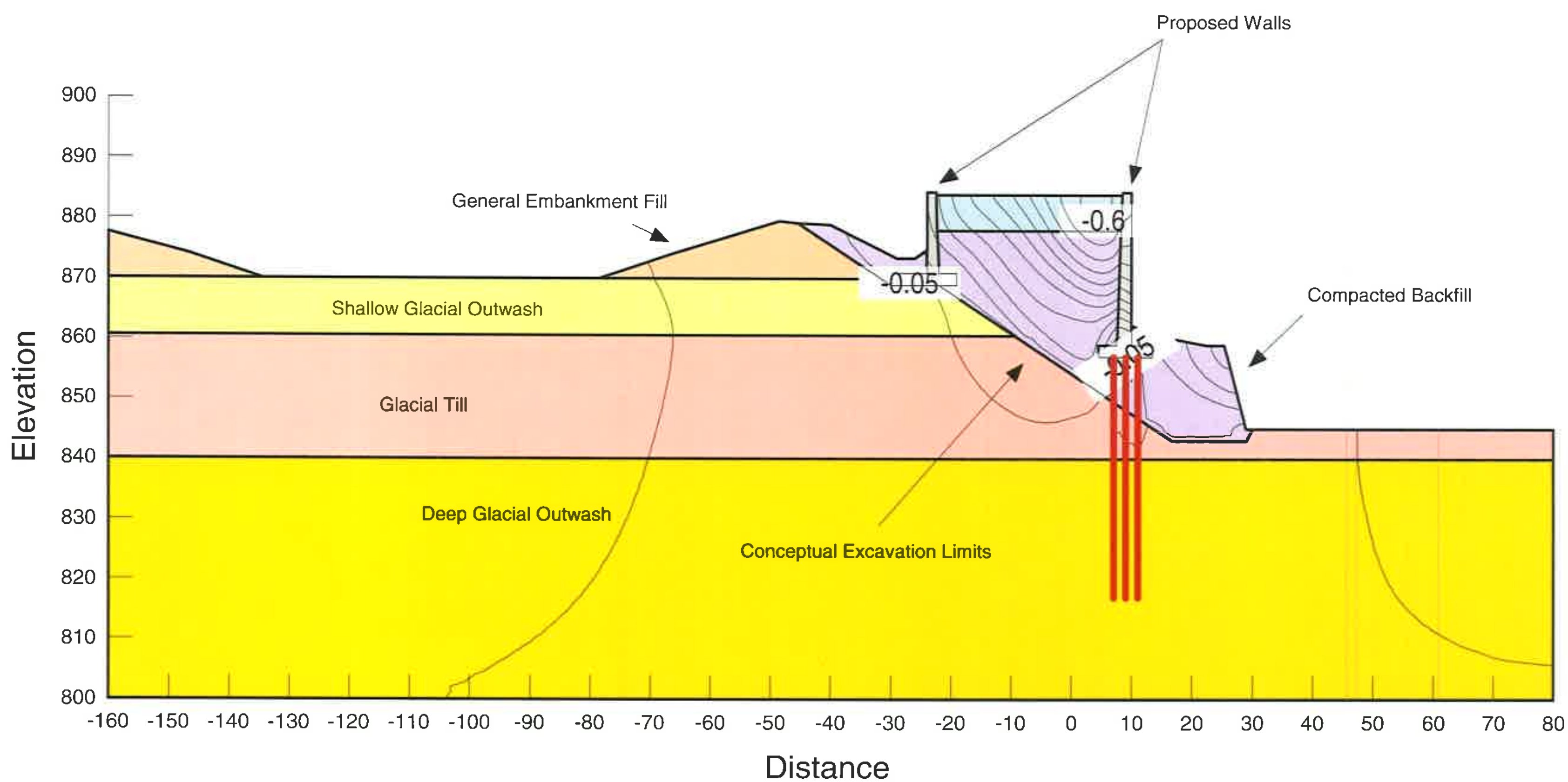


BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

Settlement Associated with Deep Foundation Construction

Settlement of the downslope or EB wall could be reduced to less than 1 inch (0.05 feet) if the wall is supported on deep foundations (in this case 40-foot long pile elements shown extending into the glacial soils below the wall). Settlement of the downslope and upslope walls is also comparable in this case, suggesting that the upslope or WB wall need not be similarly supported.



BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

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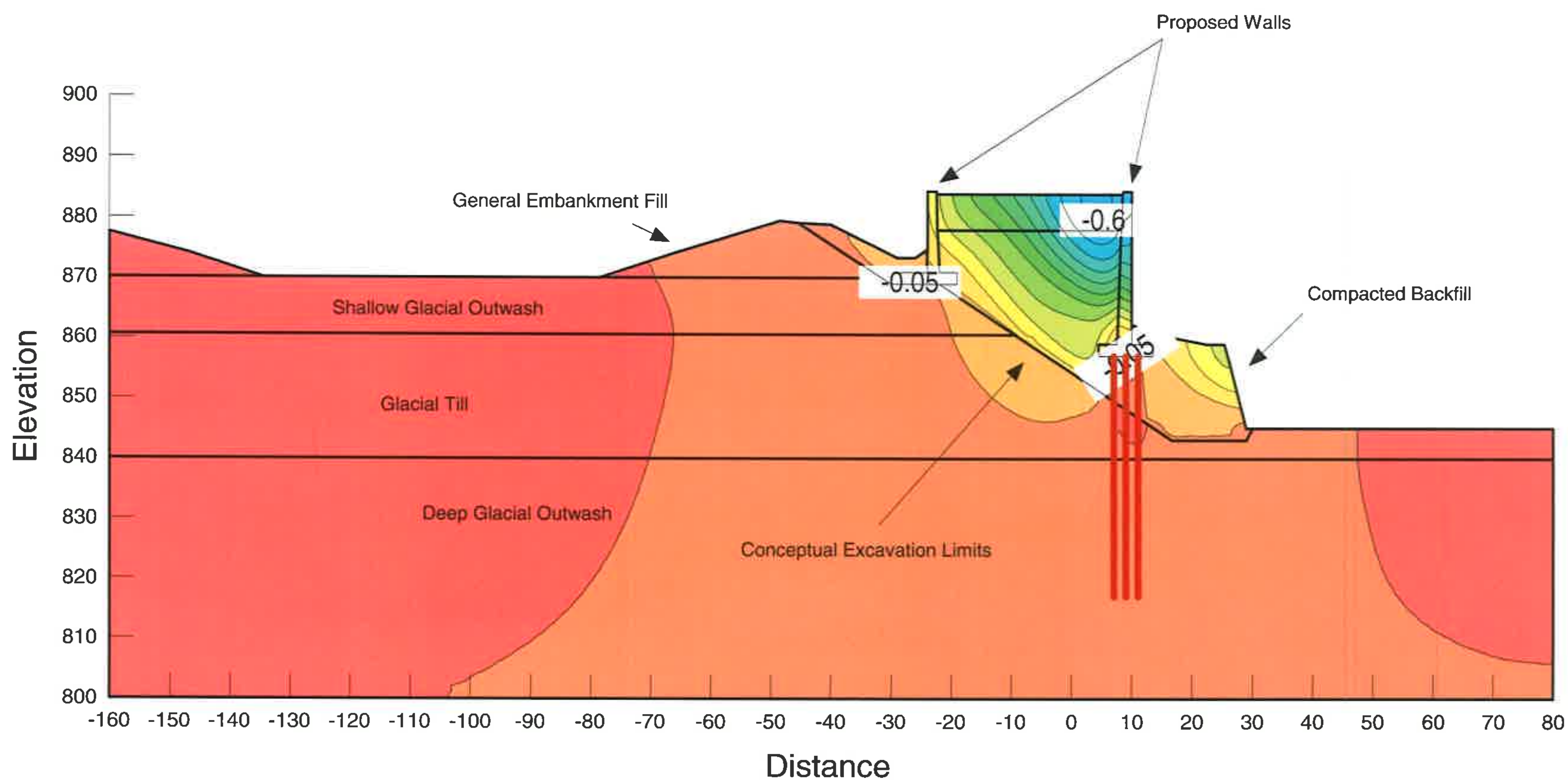
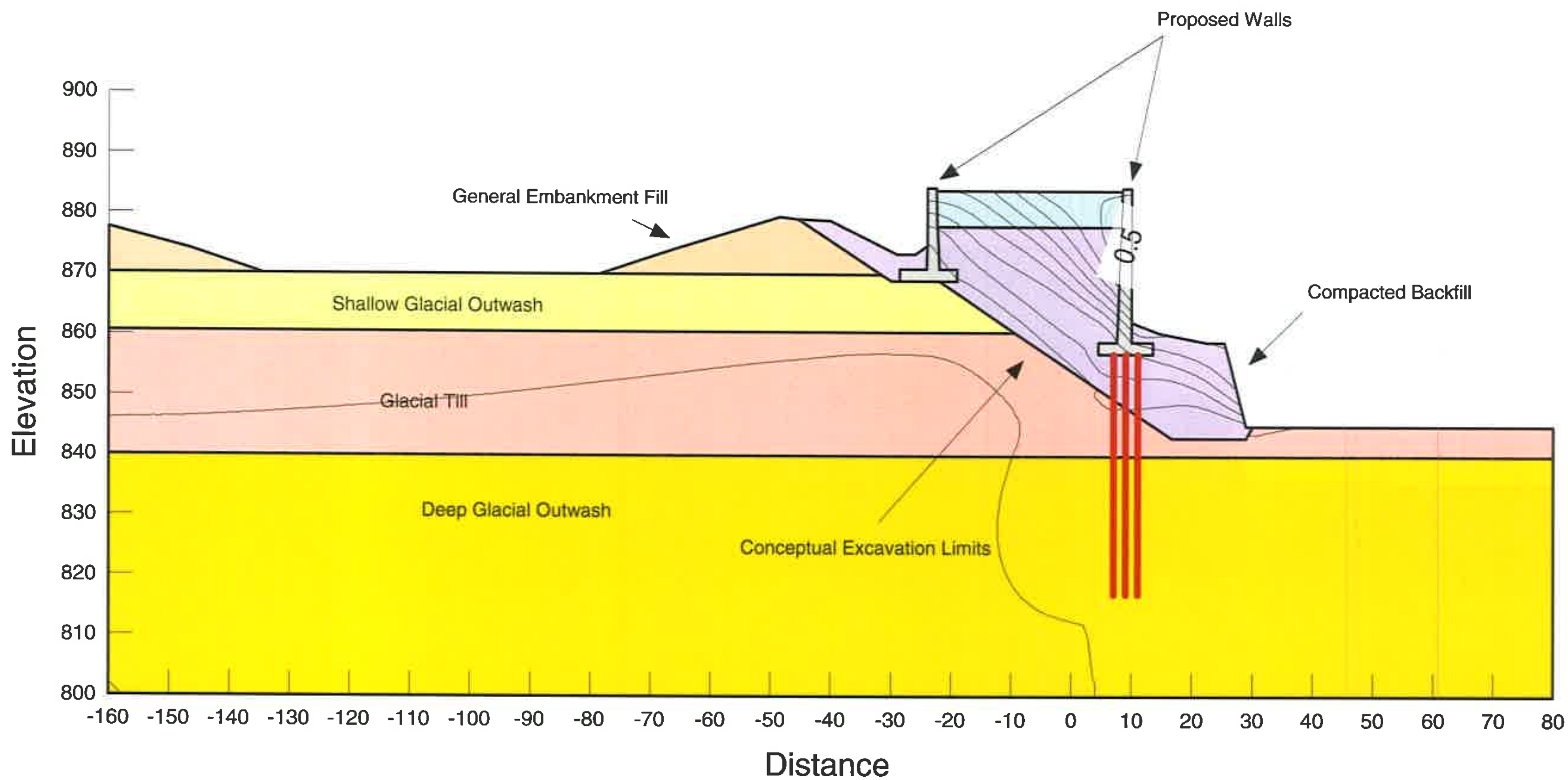
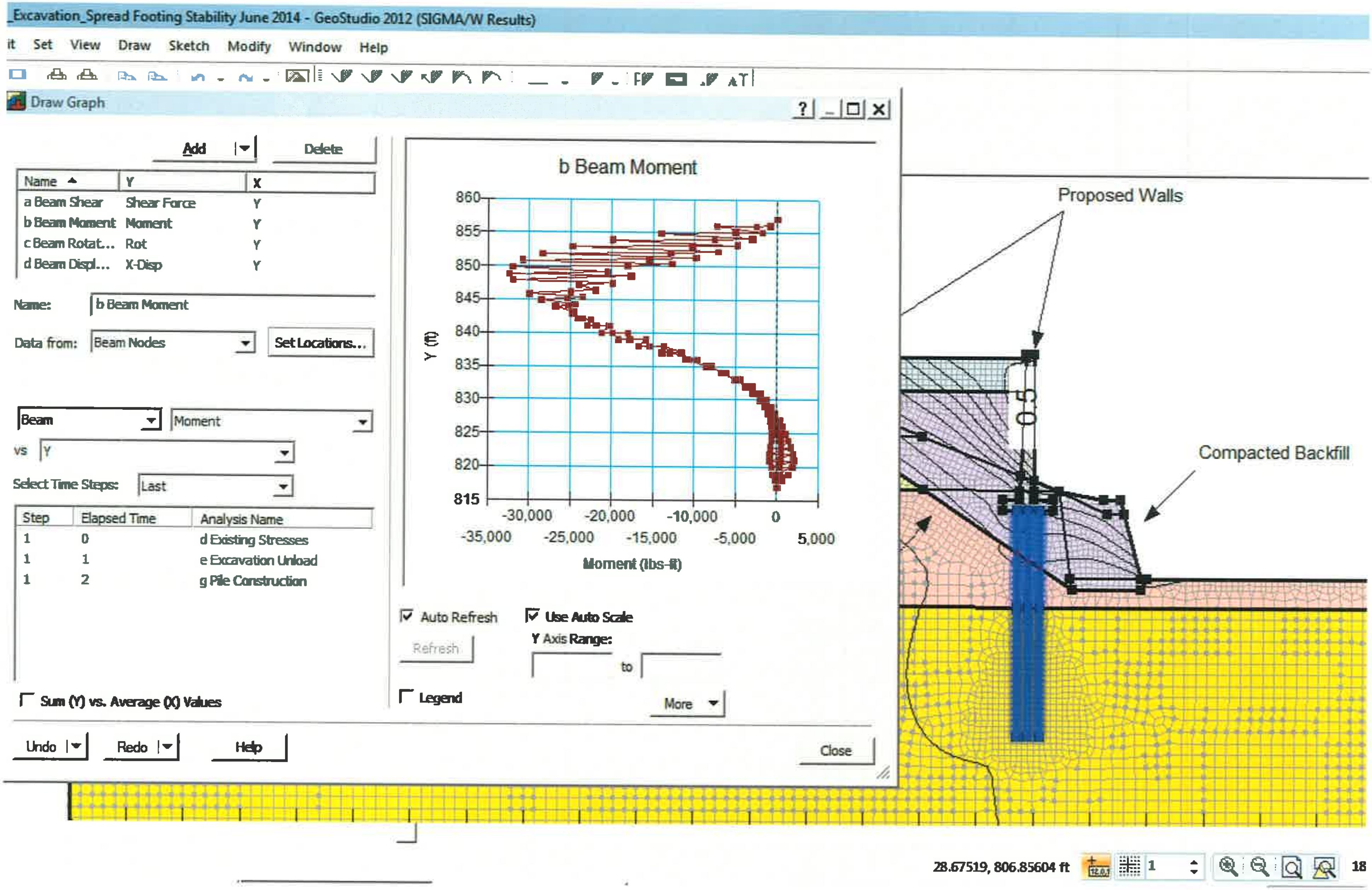


BL-13-00213: Southwest Light Rail RTW 111
vic. Prairie Center Drive, Eden Prairie, Minnesota

Lateral Displacement Associated with Deep Foundation Construction

This graphic shows again how, regardless of foundation design, rotation of the downslope or EB wall could approach 6 inches (0.5 feet) if the two walls are not tied together or the downslope wall tied back.





While the piles in this example do not constitute a probable design, the graph shows the relative magnitude of bending moment in the structural members.

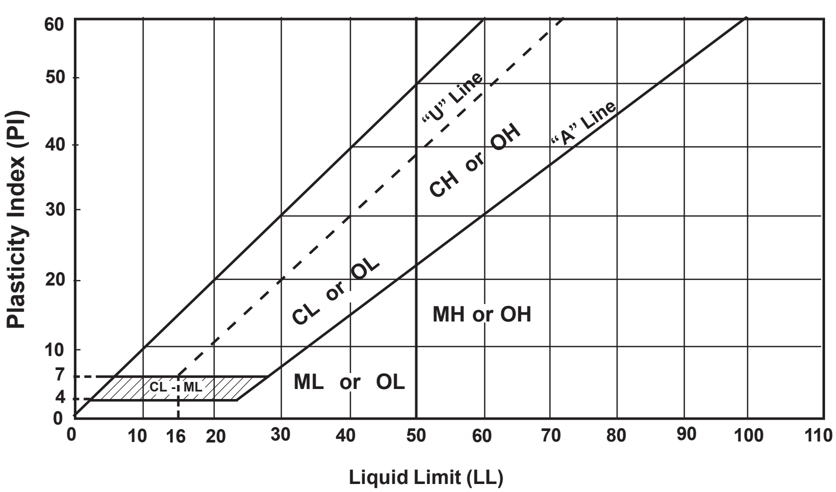
BRAUN INTERTEC

Descriptive Terminology of Soil

Standard D 2487 - 00
Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels** 5% or less fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	**GW**	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	**GP**	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	**GM**	Silty gravel [d f g]
			Fines classify as CL or CH	**GC**	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands** 5% or less fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	**SW**	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	**SP**	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	**SM**	Silty sand [f g h]
			Fines classify as CL or CH	**SC**	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	**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]
				OL	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]
				OH	Organic silt [k l m q]
Highly Organic Soils			Primarily organic matter, dark in color and organic odor	**PT**	Peat

a. Based on the material passing the 3-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. 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
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines" to group name.
h. If soil contains ≥ 15% gravel, add "with gravel" to group name.
i. 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
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 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.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcf	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liqiuid limit, %	**C**	Cohesion, psf
PL	Plastic limit, %	∅	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders .... over 12"
Cobbles .... 3" to 12"
Gravel
 Coarse .... 3/4" to 3"
 Fine .... No. 4 to 3/4"
Sand
 Coarse .... No. 4 to No. 10
 Medium .... No. 10 to No. 40
 Fine .... No. 40 to No. 200
Silt .... < No. 200, PI < 4 or below "A" line
Clay .... < No. 200, PI ≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose .... 0 to 4 BPF
Loose .... 5 to 10 BPF
Medium dense .... 11 to 30 BPF
Dense .... 31 to 50 BPF
Very dense .... over 50 BPF

Consistency of Cohesive Soils

Very soft .... 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff .... 17 to 30 BPF
Hard .... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers unless noted otherwise, Jetting water was used to clean out auger prior to sampling only where indicated on logs. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous-flight, solid-stem augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface and are, therefore, somewhat approximate. Power auger borings are designated by the prefix "B."

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn. Hand auger borings are indicated by the prefix "H."

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

Appendix D

General Track STA 2019+00 to STA 2139+00

BRAUN INTERTEC

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August 29, 2014 Project BL-13-00213

Mr. Don Demers
Southwest Light Rail Transit Project Office
6465 Wayzata Boulevard, Suite 500
St. Louis Park, MN 55426

Re: Preliminary Geotechnical Evaluation
General Track, Station Platform and Retaining Wall Construction
STA 2109+00 to STA 2139+00 – 75% Design
Southwest LRT, West Segment 1
Eden Prairie, Minnesota

Dear Mr. Demers:

Braun Intertec has completed the preliminary geotechnical evaluation for the proposed track construction between STA 2109+00 and STA 2139+00 as well as the Town Center station platform located between STA 2115+00 to STA 2118+00. The following sections provide information regarding our opinions, methods and recommendations for general track, station platform and retaining wall construction in this area.

This report is part of a larger series of reports for the west segment of the Southwest Light Rail Transit (SWLRT) project. Recommendations for pole foundations for the Overhead Contact System (OCS) will be addressed in a separate report.

A. Project Description

This Geotechnical Evaluation Report addresses the proposed light rail transit line track construction between STA 2109+00 and STA 2139+00 in Eden Prairie, Minnesota. This area includes the Town Center station platform as well as retaining walls RTW-W120, RTW-W122, RTW-W125, and RTW-W126.

To facilitate our evaluation, we were provided with or reviewed the following information or documents:

- Aerial images from Google Earth™
- Preliminary Engineering Plans provided by AECOM, dated 6/30/2014.

Based on images from Google Earth™, the site appears to be located in parking lots and grassy areas along Eden Road in Eden Prairie, Minnesota. The area described in this report is bounded by retaining walls RTW-W110 and RTW-W111 associated with the east abutment of the Bridge over Prairie Center and Technology Drive and the south abutment of the Bridge of I-494.

B. Subsurface Investigation Summary

B.1. Geologic Profile

Braun Intertec performed seven (7) soil borings within the boundaries noted above (2067ST, 2070ST, 2071ST, 2072ST, 2080ST, 2081ST, and 2082ST). Logs of the borings are included in the Appendix, along with a boring location sketch showing their locations.

A description of the soils encountered is described below, starting at the surface.

B.1.a. Pavements and Topsoil Fill

Borings 2071ST, 2072ST, 2080ST, 2081ST, and 2082ST encountered parking lot pavement sections consisting of 4 to 7 inches of bituminous over 4 to 11 inches of aggregate base fill. Borings 2067ST encountered 12 inches of topsoil fill at the surface, consisting of sandy lean clay.

B.1.b. Fill

Fill was encountered beneath the pavements and topsoil fill at Borings 2067ST, 2071ST, 2072ST and 2082ST. Fill was encountered at the surface of Boring 2070ST. The fill consisted of sandy lean clay (CL), silty sand (SM), clayey sand (SC), poorly graded sand (SP), and poorly graded sand with silt (SP-SM). Table 1 below illustrates the depth and elevations of fill materials encountered.

Table 1. Fill Depths at Boring Locations

Boring	Boring Elevation (ft)	Approximate Depth of Fill (ft)	Elevation at Bottom of Fill (ft)
2067ST	898.4	14	884 ½
2070SW	878.1	20	858
2071SW	878.9	4	875

Boring	Boring Elevation (ft)	Approximate Depth of Fill (ft)	Elevation at Bottom of Fill (ft)
2072SW	877.4	17	860 ½
2082SW	889.2	3	886 ½

Of note, Boring 2070ST encountered buried concrete and bituminous debris to depths of 12 to 17 feet beneath the surface.

Penetration resistances varied from 8 to over 50 blows per foot (BPF), although some of the higher penetration resistances were likely influenced by frost.

B.1.c. Glacial Deposits

Glacially deposited soils were encountered beneath the pavement section, topsoil, and fill at all of the boring locations, extending to the termination depth of the borings. The glacial deposits consisted of lean clay with sand, sandy lean clay, clayey sand, silty sand, and poorly graded sand. The till soils contained traces of gravel, while the sands generally contained gravel. Penetration resistances varied from 10 to over 50 BPF, indicating the cohesive soils were rather stiff to hard, while the sandy soils were medium dense to very dense.

B.2. Summary of Water Level Measurements

The boring logs noted water levels during drilling ranging from 838 1/2 to 847 feet above mean sea level (MSL). Seasonal and annual fluctuations of groundwater, however, should be anticipated.

C. Basis for Recommendations

C.1. Design Details

C.1.a. Anticipated Grade Changes

Based on the plan and profile drawings, existing ground surface elevations are within approximately 14 feet of the proposed top of rail elevations. Cuts on the order of 14 feet and fills of less than 5 feet are anticipated to construct the tracks.

C.1.b. Station Platform Construction

The Town Center Station is proposed to be constructed between STA 2115+00 to STA 2118+00, in an area where approximately 4 to 10 feet of soil is to be removed to achieve top of rail elevation. While soils borings were not performed specifically for the station, we anticipate native soils will be encountered at platform subgrade elevations.

C.1.c. Retaining Wall Construction

The proposed retaining walls in the area generally range in height from 5 to 13 feet. It appears the majority of the walls will be cut to grade walls supporting existing slopes. While soil borings were not performed specifically for the walls at this time, we anticipate fill soils will be encountered near the surface with native soils near footing elevations.

C.1.d. Precautions Regarding Changed Information

We have attempted to describe our understanding of the proposed construction to the extent it was reported to us by others. Depending on the extent of available information, assumptions may have been made based on our experience with similar projects. If we have not correctly recorded or interpreted the project details, we should be notified. New or changed information could require additional evaluation, analyses and/or recommendations.

C.2. Design and Construction Considerations

It appears the track and the Town Center Station will be cut into native soils between STA 2109+00 to STA 2128+00. Fill soils were encountered at several boring locations, mainly between STA 2128+00 and STA 2139+00 and ranged in depth from 3 to 20 feet beneath the surface. While the majority of the fill soils appear to have been previously compacted based on the blow counts, the fill encountered near STA 2128+00 encountered concrete, bituminous, and traces of wood debris to depths of 17 feet. There is an inherent risk of potential instability in fill containing debris, as it may shift or consolidate under new loads. However, it appears there will be minimal grade changes through this area.

D. Recommendations

In accordance with our findings, we prepared the following preliminary recommendations for the design and construction of the proposed track, station platform and retaining walls. Supplementary borings will be required for final design.

D.1. Subgrade Preparation

Throughout the track profile and beneath the station platform, a five-foot subcut is anticipated for construction of the Guideway. The following subsections provide preliminary recommendations to prepare the subgrades for the track, station platform and retaining walls. Additional borings will be required for final design recommendations.

D.1.a. Excavations

D.1.a.1. Track Construction

We recommend excavating the soils down to the proposed bottom of subgrade elevation. We expect native soils will be encountered between STA 2109+00 to approximately STA 2122+00. Between STA 2122+00 to STA 2126+00 we expect shallow fills, with the fill soils extending deeper as you approach STA 2128+00 through STA 2139+00.

We recommend removing all vegetation, topsoil, and any soft or wet soils encountered at the surface. If soft or otherwise unsuitable soils are encountered at subgrade elevations, additional excavations may be necessary. This should be evaluated in the field on a case by case basis.

We expect to encounter fill soils at proposed subgrade elevations between STA 2122+00 to STA 2139+00. Due to the expected minimal (less than 2 feet) raises in overall grade, we do not anticipate settlement in excess of one inch from the existing fill soils, however, the condition of the fill soils will vary between the soil borings. We recommend excavating the soil to bottom of subgrade elevation, and evaluating the condition of the fill during construction. Additional subcuts may be necessary.

D.1.a.2. Station Platform

Cuts on the order of 5 to 10 feet are expected at the station platform. We expect to encounter native glacial soils at anticipated subgrade elevations. Should soft or otherwise unsuitable soils be encountered, additional subcuts may be necessary, and should be determined in the field at the time of construction.

D.1.a.3. General Retaining Wall Construction (Preliminary)

As mentioned previously, it appears the proposed retaining walls will largely be cut into existing slopes. Based on this condition and the expected wall heights ranging from 5 to 13 feet, we anticipate the soils encountered at proposed footing subgrades will likely be suitable to support the proposed walls. Limited subcuts may be required in areas where fill or otherwise unsuitable soils are present.

Excavation depths will vary. Portions of the excavations may also be deeper than indicated by the boring logs. Contractors should be prepared to extend excavations in wet or fine-grained soils, or where unsuitable fill soils may be encountered to remove disturbed or otherwise unsuitable soils.

To provide lateral support to replacement backfill, additional required fill, and the structural loads they will support, we recommend oversizing (widening) the excavations 1 foot horizontally beyond the outer edges of the retaining wall footings for each foot the excavations extend below bottom-of-footing.

D.1.b. Excavation Dewatering

We recommend removing groundwater from the excavations. Sumps and pumps can be considered for excavations in low-permeability silt- and clay-rich soils, or where groundwater can be drawn down 2 feet below the bottoms of excavations in more permeable sands. In large excavations, or where groundwater must be drawn down more than 2 feet, a well contractor should review our logs to determine if wells are required, how many will be required, and to what depths they will need to be installed.

We expect any groundwater encountered will be perched within sandy layers of soils encountered during the excavation process. Seasonal and annual precipitation will influence the amount and extent of groundwater that will be encountered.

D.1.c. Selecting Excavation Backfill and Additional Required Fill

D.1.c.1. General Subgrade Fill

We initially recommend backfilling over wet or submerged excavation bottoms with at least 2 feet of coarse sand having less than 50 percent of the particles by weight passing a #40 sieve, and less than 5 percent of the particles passing a #200 sieve. We anticipate that this material will need to be imported.

On-site soils free of organic soil and debris can be considered for reuse as subgrade backfill and fill. The clays, however, being fine-grained, will be more difficult to compact if wet or allowed to become wet, or if spread and compacted over wet surfaces.

Imported material needed to replace excavation spoils or balance cut and fill quantities, may consist of sand, silty sand, clayey sand, sandy lean clay or lean clay. We recommend, however, that the plastic index of these materials not exceed 20.

D.1.c.2. Guideway and Station Platform Fill

Based on the proposed design sections, the Guideway will be composed of 40-inch thick layer of granular material, over a minimum of 12-inches of subballast material. We recommend specifying Guideway fill to meet the requirements of the Minnesota Department of Transportation (MnDOT) 3149.2B2 (Select Granular Borrow) for the granular material, and 3138 (Aggregate Base) for the subballast.

D.1.c.3. Retaining Wall Fill

Fill placed beneath the retaining walls may consist of onsite soils free of debris and organic material. The clays, however, being fine-grained, will be more difficult to compact if wet or allowed to become wet, or if spread and compacted over wet surfaces.

If a leveling pad is used beneath the retaining wall footings, we recommend specifying material meeting the guidelines of MnDOT 3138 for aggregate base.

Retained soil (retaining wall backfill) should meet the specifications of MnDOT 3149.2B2, modified to 10 percent or less passing the 0.075 mm (#200) sieve.

D.1.d. Placement and Compaction of Backfill and Fill

We recommend spreading backfill and fill in loose lifts of approximately 6 to 12 inches. We recommend compacting backfill and fill in accordance with the criteria presented below in Table 2. The relative compaction of utility backfill should be evaluated based on the structure below which it is installed, and vertical proximity to that structure.

Table 2. Material and Compaction Specification for Backfill and Fill

Material	Material Specification	Compaction Specification
Subgrade Fill	Onsite Material Free of Debris and Organic Material	100% of standard Proctor Density (ASTM D698)
Leveling Pad Beneath Footings	MnDOT 3138	MnDOT 2211.3C
Retaining Wall Backfill	MnDOT 3149.2D2	MnDOT 2105.3F
Guideway Select Granular Layer	MnDOT 3149.2B2	100% of standard Proctor Density (ASTM D698)
Guideway Subballast	MnDOT 3138	MnDOT 2211.3C

D.1.e. Drainage Control

We recommend installing subdrains behind the retaining walls, adjacent to the wall footings, and at low points of the Guideway. Preferably the subdrains should consist of perforated pipes embedded in washed gravel, which in turn is wrapped in filter fabric. Perforated pipes encased in a filter “sock” and embedded in washed gravel, however, may also be considered.

We recommend routing the subdrains to a storm sewer or sump and pump capable of routing any accumulated groundwater to a storm sewer or other suitable disposal site, if available.

D.1.f. Recommended Design Parameters (e.g., Coefficient of Friction, Lateral Earth Pressure Coefficients, etc.)

The recommended soil parameters to be used for design are as follows:

Table 3. Recommended Soil Design Parameters

Soil Type	Angle of Internal Friction (degrees)	Effective Unit Weight (pcf)	Coefficient of Sliding Friction Rough Concrete	Active Earth Pressure Coefficient	At-Rest Earth Pressure Coefficient
Select Granular Borrow Modified 10%	35	120	0.6	0.27	0.43
Granular Borrow	30	120	0.5	0.33	0.50

D.2. Exterior Slabs

Though not necessarily designed to accommodate dead and live load surcharges or vehicles, exterior slabs can be subjected to both. Settlement of exterior slabs on poorly compacted foundation backfill, utility backfill and other compressible naturally deposits, soils or fills can also contribute to unfavorable surface drainage conditions and frost-related damage to the slabs and adjacent structures and pavements. Subgrades supporting exterior slabs should therefore consist of non-organic compacted fill or native soils. To accommodate the potential for exterior slabs bearing unanticipated traffic loads, we recommend using the compaction criteria provided in Section D.1.d. We anticipate that a majority of exterior slabs associated with station construction will be placed on the Guideway fill section. For exterior slabs not supported by the Guideway fill such as sidewalks, we recommend a transition zone of at least 5:1 (H:V) to reduce the effects of differential frost heave away from the station.

D.2.a. General

Some of the exterior slabs will be underlain with lean clay, which are considered to be moderately to highly frost susceptible. Soils of the type can retain moisture and heave upon freeing. In general, this characteristic is not an issue unless these soils become saturated due to surface runoff or infiltration or are excessively wet in-situ. Once frozen, unfavorable amounts of general and isolated heaving of the soils and the surface structures supported on them could develop. This type of heaving could impact design drainage patterns and the performance of exterior slabs, isolated footings and piers, and pavements. To address most of the heave related issues, we recommend the general site grades and grades for surface features be set to direct surface drainage away from buildings, across large paved areas and away from walkways to limit the potential for saturation of the subgrade and any subsequent heaving. General grades should also have enough “slope” shown to tolerate potential larger areas of heave which may not fully settle when thawed.

D.2.b. Exterior Slabs

Even small amounts of frost-related differential movement at walkway joints or cracks can create tripping hazards. Several subgrade improvement options can be explored to address this condition. The most conservative and potentially most costly subgrade improvement option to help limit the potential for heaving, but not eliminate it, would be to remove any frost-susceptible soils present below the exterior slabs’ “footprint” down to the bottom-of-footing grades or to a maximum depth of 5 feet below subgrade elevations, whichever is less. We recommend the resulting excavation then be refilled with sand or sandy gravel having less than 50 percent of the particles by weight passing the #40 sieve and less than 5 percent of the particles by weight passing a #200 sieve.

Another subgrade improvement option would be to build in a transition zone between those soils considered to be frost-susceptible and those that are not to somewhat control where any differential movement may occur. Such transitions could exist between exterior slabs and pavements, between entry way slabs and sidewalks, and along the sidewalks themselves. For this option, the frost-susceptible soils in critical areas would be removed to a depth of at least 4 feet below grade as discussed above. The excavation below the footprint of the sidewalks or other slabs would then be sloped upward at a gradient no steeper than 3:1 (horizontal : vertical) toward the less critical areas. The bottom of the excavation should then be sloped toward the center so that any water entering the excavation could be quickly drained to the deepest area for removal. In the deepest areas of the excavation, a series of perforated drainpipes will need to be installed to collect and dispose of surface water infiltration and/or groundwater that could accumulate within the backfill. The piping would need to be connected to a storm sewer or a sump to remove any accumulated water. If the water is not removed, it is our opinion this option will not be effective in controlling heave.

Regardless of what is done to the walkway or pavement area subgrade, it will be critical the end-user develop a detailed maintenance program to seal and/or fill any cracks and joints that may develop during the useful life of the various surface features. Concrete and bituminous will experience episodes of normal thermo-expansion and thermo-contraction during its useful life. During this time, cracks may develop and joints may open up, which will expose the subgrade and allow any water flowing overland to enter the subgrade and either saturate the subgrade soils or to become perched atop it. This occurrence increases the potential for heave due to freezing conditions in the general vicinity of the crack or joint. This type of heave has the potential to become excessive if not addressed as part of a maintenance program. Special attention should be paid to areas where dissimilar materials abut one another, where construction joints occur and where shrinkage cracks develop.

D.2.c. Isolated Footing and Piers

Soils classified as being "clayey" or "silty" have the potential for adhering to poured concrete or masonry block features built through the normal frost zone. In freezing conditions, this soil adhesion could result in the concrete or masonry construction being lifted out of the ground. This lifting action is also known as heave due to adfreezing. The potential for experiencing the impacts of adfreezing increases with poor surface drainage in the area of below grade elements, in areas of poorly compacted clayey or silty soils and in areas of saturated soils. To limit the impacts of adfreeze, we recommend placing a low friction separation barrier, such as high density insulation board, between the backfill and the element. Extending isolated piers deeper into the frost-free zone, enlarging the bottom of the piers and then providing tension reinforcement can also be considered. Recommendations for specific foundation conditions can be provided as needed.

D.3. Construction Quality Control

D.3.a. Excavation Observations

We recommend having a geotechnical engineer observe all excavations related to subgrade preparation for spread footing, Guideway and retaining wall construction. The purpose of the observations is to evaluate the competence of the geologic materials exposed in the excavations, and the adequacy of required excavation oversizing.

D.3.b. Materials Testing

We recommend density tests be taken in excavation backfill and additional required fill placed below retaining walls footings, behind retaining walls, and for Guideway and Station Platform construction.

We also recommend slump, air content, and strength tests of Portland cement concrete.

D.3.c. Cold Weather Precautions

If site grading and construction is anticipated during cold weather, all snow and ice should be removed from cut and fill areas prior to additional grading. No fill should be placed on frozen subgrades. No frozen soils should be used as fill.

Concrete delivered to the site should meet the temperature requirements of ASTM C 94. Concrete should not be placed on frozen subgrades. Concrete should be protected from freezing until the necessary strength is attained. Frost should not be permitted to penetrate below footings.

E. Procedures

E.1. Penetration Test Borings

The penetration test borings were drilled with core and auger drill equipped with hollow-stem auger mounted on an off-road carrier. The borings were performed in accordance with ASTM D 1586. Penetration test samples were taken at 2 1/2- or 5-foot intervals. Actual sample intervals and corresponding depths are shown on the boring logs.

Penetration test boreholes that met the Minnesota Department of Health (MDH) Environmental Borehole criteria were sealed with an MDH-approved grout. A sealing record (or Sealing records) for those boreholes will be forwarded to the Minnesota Department of Health Well Management Section. A copy of the sealing record follows (or Copies of the sealing records follow) the Log of Boring sheets in the Appendix.

E.2. Material Classification and Testing

E.2.a. Visual and Manual Classification

The geologic materials encountered were visually and manually classified in accordance with ASTM Standard Practice D 2488. A chart explaining the classification system is attached. Samples were placed in jars or bags and returned to our facility for review and storage.

E.2.b. Laboratory Testing

The results of the laboratory tests performed on geologic material samples are noted on or follow the appropriate attached exploration logs. The tests were performed in accordance with ASTM procedures.

E.3. Groundwater Measurements

The drillers checked for groundwater as the penetration test borings were advanced, and again after auger withdrawal. The boreholes were then backfilled or allowed to remain open for an extended period of observation as noted on the boring logs.

F. Qualifications

F.1. Variations in Subsurface Conditions

F.1.a. Material Strata

Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth, and therefore strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions, and can be expected to vary in depth, elevation and thickness away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed, or construction commences. If any such variations are revealed, our recommendations should be re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

F.1.b. Groundwater Levels

Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

F.2. Continuity of Professional Responsibility

F.2.a. Plan Review

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

F.3. Use of Report

This report is for the exclusive use of Southwest Light Rail Transit. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

F.4. General

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If there are questions regarding these recommendations, please call Josh Kirk at 952.995.2222 (jkirk@braunintertec.com) or Ray Huber at 952.995.2260 (rhuber@braunintertec.com) at your convenience.

Sincerely,

BRAUN INTERTEC CORPORATION

Professional Certification:
I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Joshua L. Kirk, PE
Associate-Project Engineer
License Number: 45005

Reviewed by:

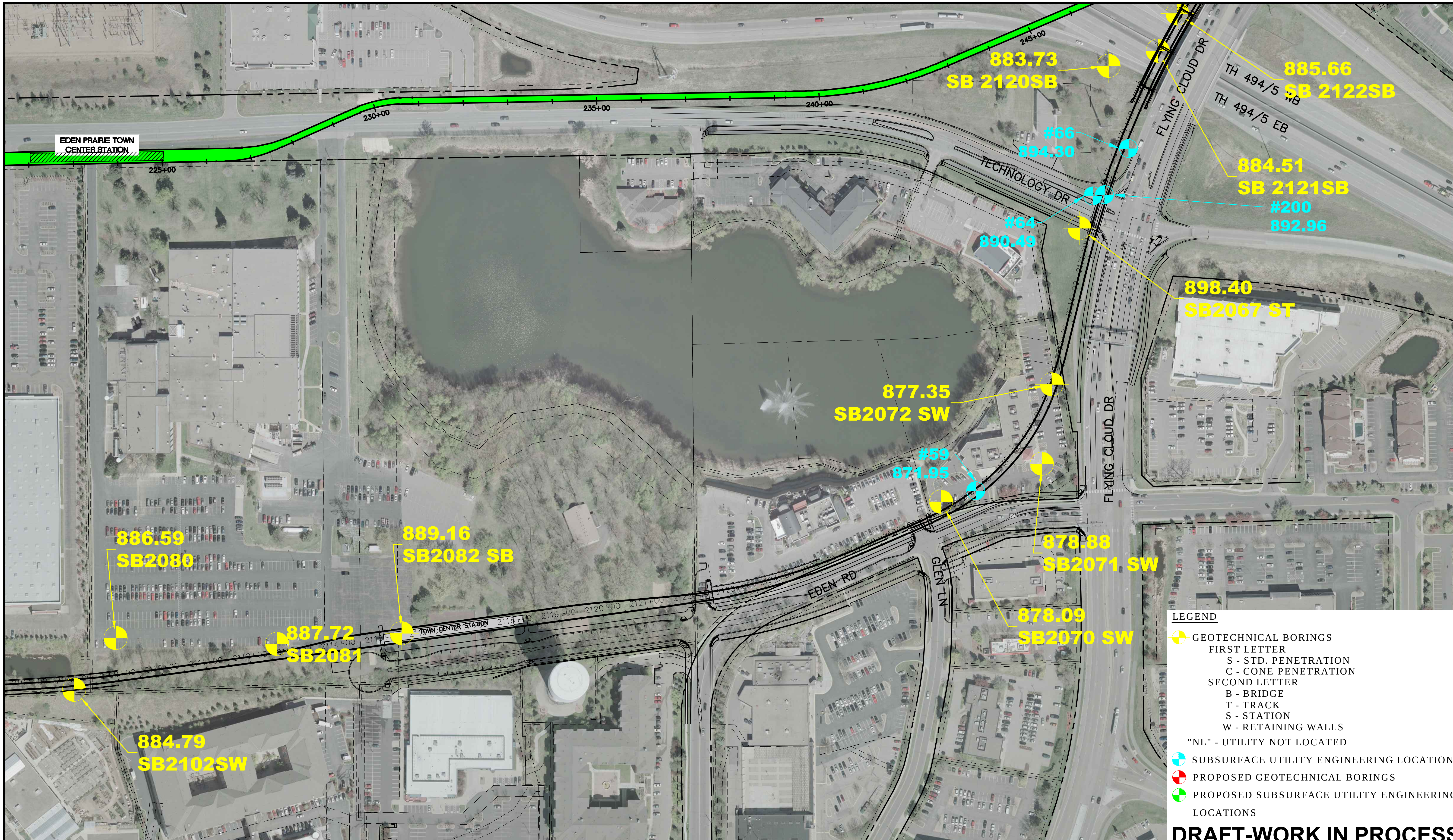
Ray A. Huber, PE
Vice President-Principal Engineer

Reviewed by:

Matthew P. Ruble, PE
Principal Engineer

Appendix:
Soil Boring Location Sketch
Preliminary Engineering Plan and Profile Sheets - W1-TRK-PPFL-003 through 006
Soil Boring Logs 2067ST, 2070ST, 2071ST, 2072ST, 2080ST, 2081ST, 2082ST
Descriptive Terminology of Soil

APPENDIX



SOUTHWEST Green Line LRT Extention

SOUTHWEST LIGHT RAIL

SOIL BORINGS

SHEET 4 OF 12

IRT: N/A

REV: 0

DATE: 06/30/2014

NORTH

0 50 100 200

METROPOLITAN COUNCIL

AECOM

SRF Consulting Group, Inc.

Aug. 28 2014 11:30 am V:\3200_PEC-W\CAD\OVERALL\EXHIBITS\CIVIL\EXHB-CIV-SOIL BORINGS.dwg By: Boscha

CURVE NO. W1-211
R = 2000'
Lc = 84.50'
Ls = 60'
Ea = 1.00"
Eu = 1.43"
V = 35 MPH

CURVE NO. W1-111
R = 2000'
Lc = 84.50'
Ls = 60'
Ea = 1.00"
Eu = 1.43"
V = 35 MPH

CURVE NO. W1-112
R = 750'
Lc = 46.79'
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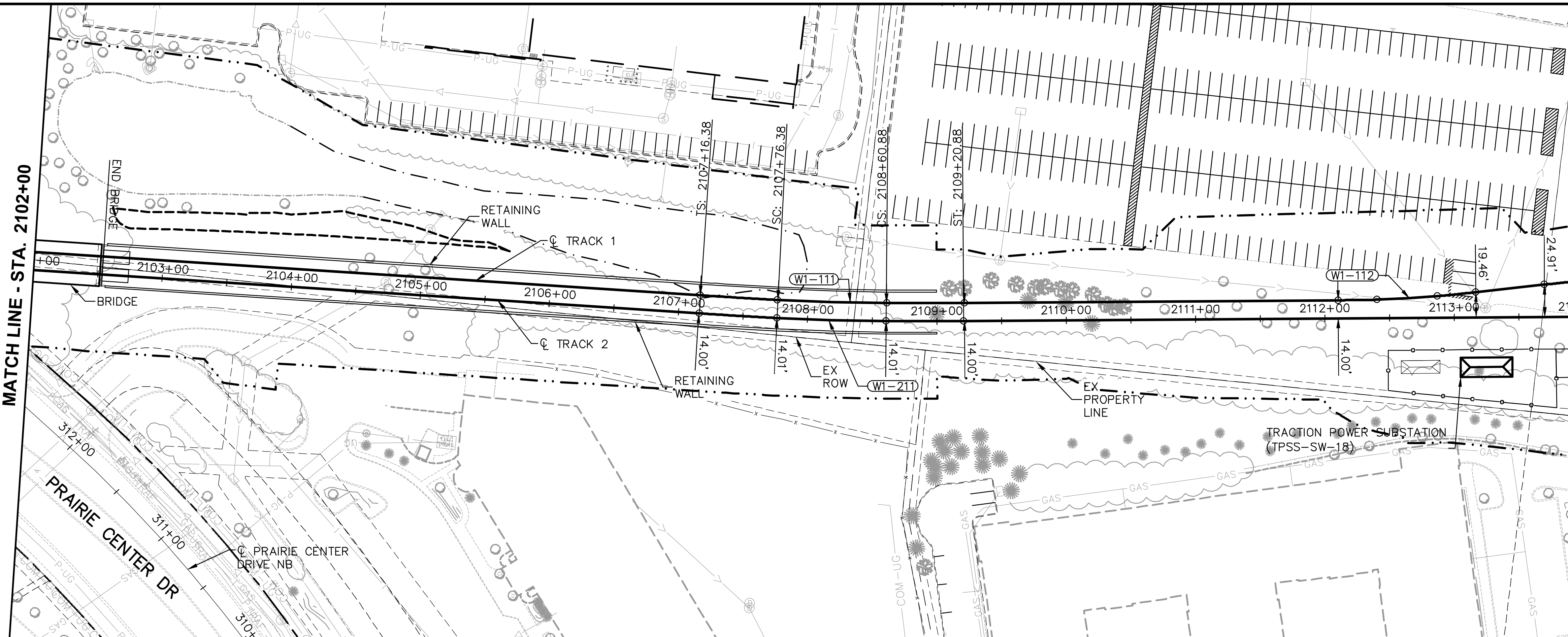
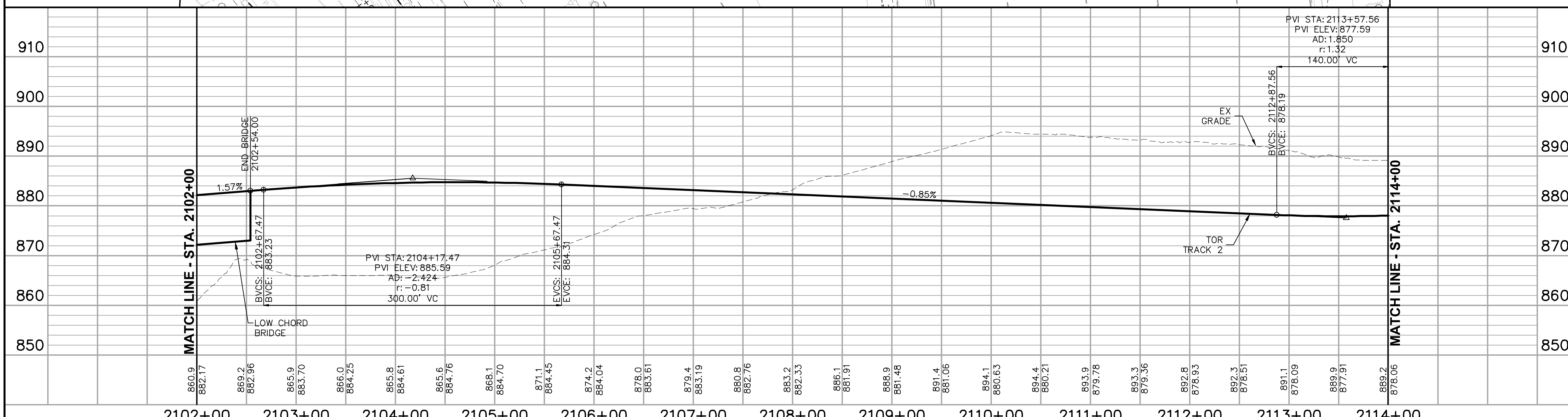
Eu = 0.94"
V = 15 MPH





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AECOM

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

WEST- VOLUME 1 (CIVIL) - SEGMENT 1
TRACK
PLAN AND PROFILE
STA. 2102+00 TO STA. 2114+00

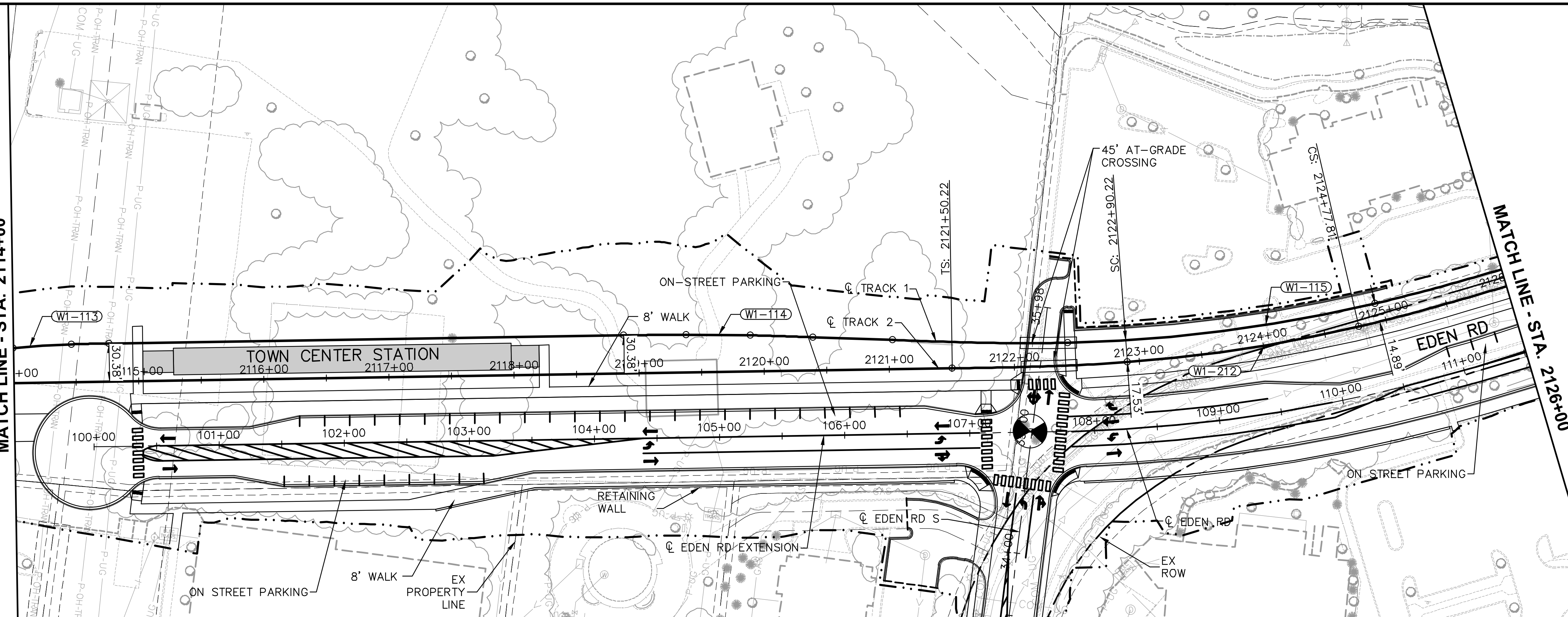
DISCIPLINE: TRACK

SHEET NAME: W1-TRK-PPFL-003

SHEET 31 OF 66

CURVE NO. W1-113
R = 750'
Lc = 46.79
Ls = 30'
Ea = 0.75"
Eu = 0.44"
V = 15 MPH

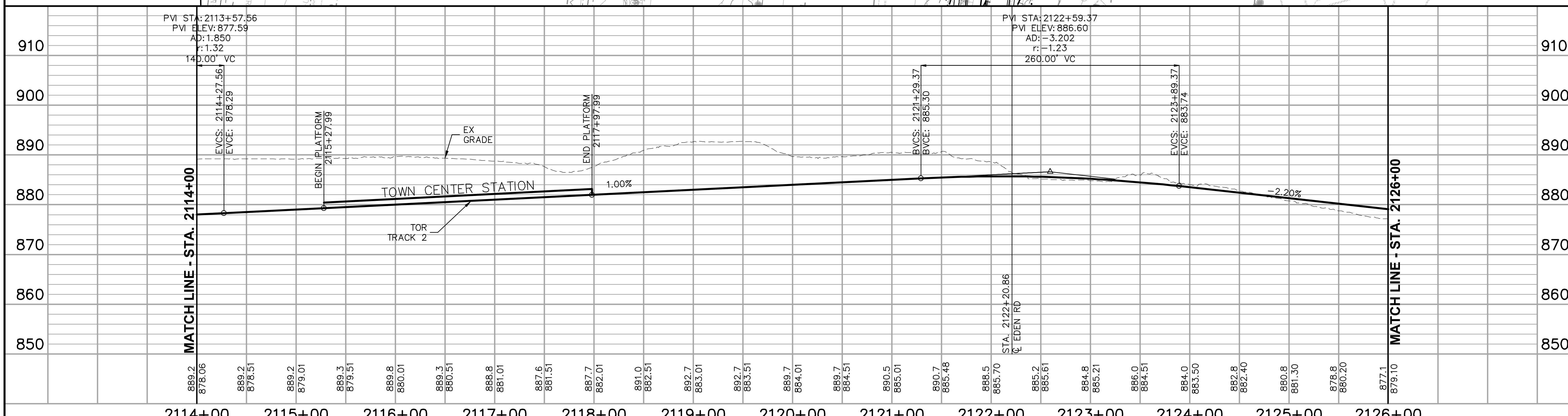
CURVE NO. W1-114
R = 2000'
Lc = 51.23'
Ls = 50'
Ea = 1.00"
Eu = 0.78"
V = 30 MPH



CURVE NO. W1-212
R = 1200'
Lc = 187.59'
Ls = 140'
Ea = 1.00"
Eu = 3.04"
V = 35 MPH

CURVE NO. W1-115
R = 1200'
Lc = 248.33'
Ls = 140'
Ea = 1.00"
Eu = 3.04"
V = 35 MPH

0 5 10 20
VERTICAL
0 25 50 100
HORIZONTAL
SCALE IN FEET



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PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

WEST- VOLUME 1 (CIVIL) - SEGMENT 1
TRACK
PLAN AND PROFILE
STA. 2114+00 TO STA. 2126+00

DISCIPLINE: TRACK

SHEET NAME: W1-TRK-PPFL-004

SHEET 32 OF 66

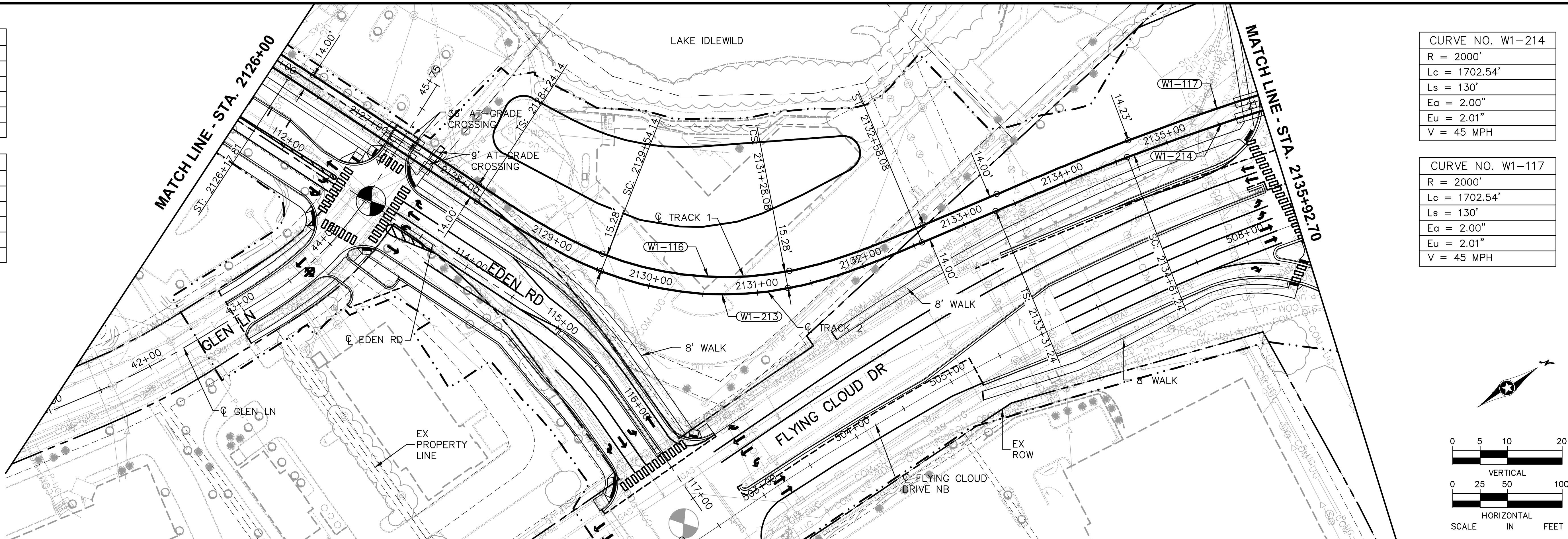
Jun. 13 2014 11:48 am V:\3200_PEC-W\CAD\SEGMENT-W1\SHEET\TRACK\W1-TRK-PLN.dwg By: Boscha

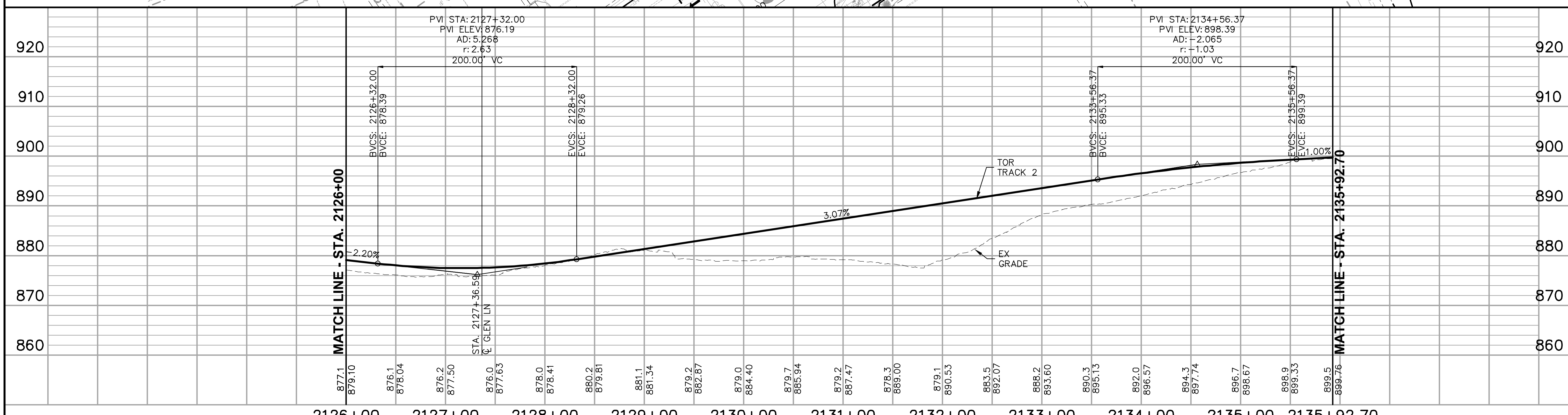
CURVE NO. W1-213
R = 310'
Lc = 173.93'
Ls = 130'
Ea = 3.75"
Eu = 4.23"
V = 25 MPH

CURVE NO. W1-116
R = 310'
Lc = 173.93'
Ls = 130'
Ea = 3.75"
Eu = 4.23"
V = 25 MPH

CURVE NO. W1-214
R = 2000'
Lc = 1702.54'
Ls = 130'
Ea = 2.00"
Eu = 2.01"
V = 45 MPH

CURVE NO. W1-117
R = 2000'
Lc = 1702.54'
Ls = 130'
Ea = 2.00"
Eu = 2.01"
V = 45 MPH





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PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

WEST- VOLUME 1 (CIVIL) - SEGMENT 1
TRACK
PLAN AND PROFILE
STA. 2126+00 TO STA. 2135+92.70

DISCIPLINE: TRACK

SHEET NAME: W1-TRK-PPFL-005

SHEET 33 OF 66

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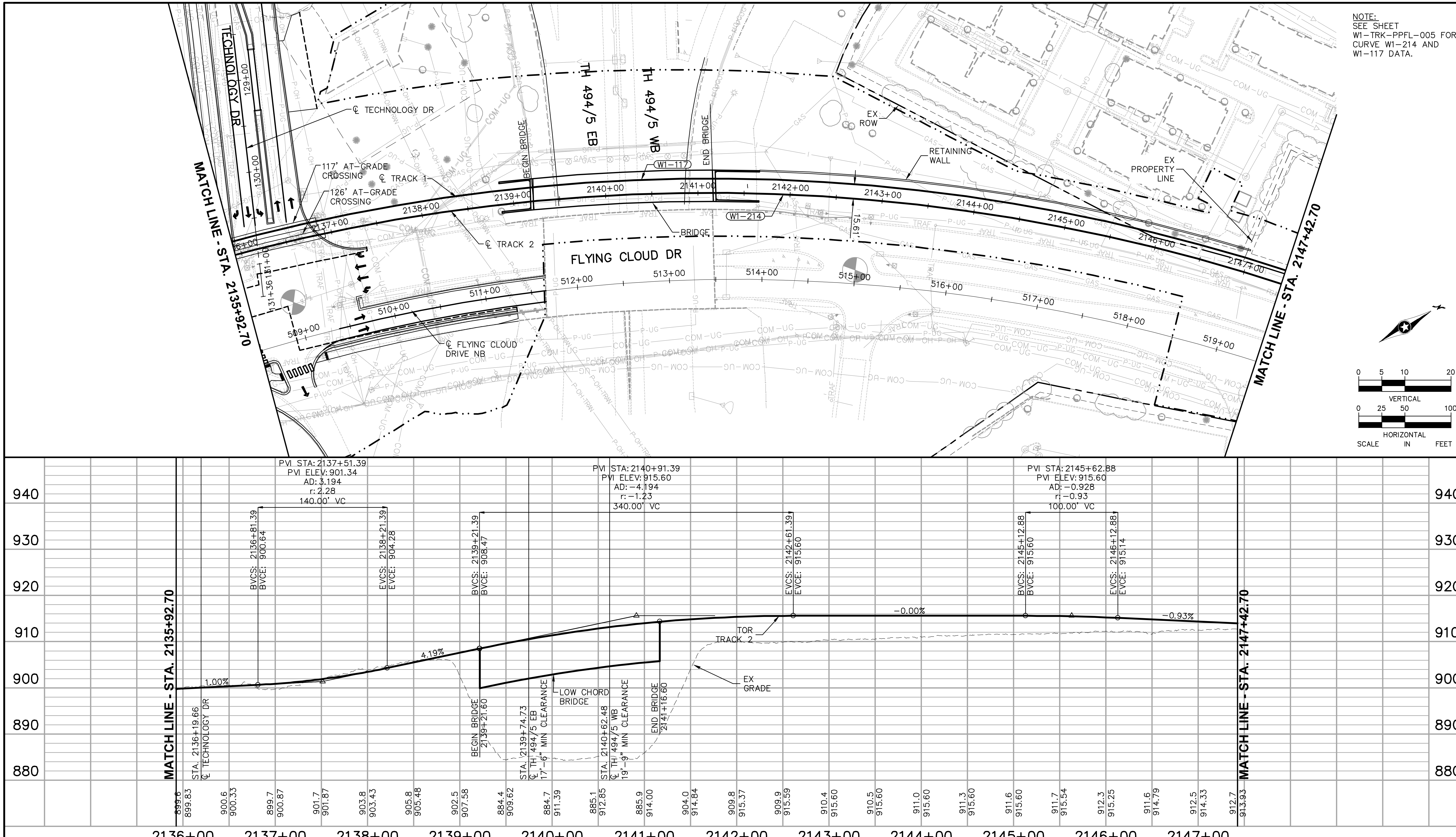

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PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

WEST- VOLUME 1 (CIVIL) - SEGMENT 1
TRACK
PLAN AND PROFILE
STA. 2135+92.70 TO STA. 2147+42.70

DISCIPLINE: TRACK

SHEET NAME: W1-TRK-PPFL-006

SHEET 34 OF 66

LOG OF BORING

BRAUN INTERTEC

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2067ST**

LOCATION: N: 125688.7; E: 488934.2; Lat.: 445141.60987; Long.: -932533.62235. See attached sketch.

DRILLER: K. Keck	METHOD: 3 1/4" HSA, Autohammer	DATE: **2/26/14**	SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 898.4	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
897.4	1.0	CL	SANDY LEAN CLAY, trace Gravel, dark brown, frozen. (Topsoil/Fill)				
		FILL	FILL: Silty Sand, fine- to medium-grained, with Gravel, with occasional Cobbles and Clay lenses, brown, frozen to moist.	65			
				8		10	P200=33%
891.4	7.0						
		FILL	FILL: Clayey Sand, trace Gravel, brown and gray, moist.	24		11	
889.4	9.0						
		FILL	FILL: Poorly Graded Sand, fine- to medium-grained, trace Gravel, brown, moist.	42			
886.4	12.0						
		FILL	FILL: Sandy Lean Clay, with Gravel, gray and brown, moist.	34		10	
884.4	14.0						
		SM	SILTY SAND, fine- to medium-grained, with Gravel, brown, moist, very dense to dense. (Glacial Till)	45			
				50/2"*			*50/2" (set). No sample recovery.
				38			
876.4	22.0						
		SC	CLAYEY SAND, fine- to medium-grained, with Gravel, brown, moist, dense to medium dense. (Glacial Till)	33			
				30			*Water not observed with 29 1/2 feet of hollow-stem auger in the ground.
870.4	28.0						Water not observed to cave-in depth of 25 feet immediately after withdrawal of auger.
		SP	POORLY GRADED SAND, fine- to medium-grained, light brown, moist, medium dense. (Glacial Outwash)	21			
867.4	31.0						Boring immediately backfilled with bentonite grout.
			END OF BORING.*				

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:24

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2070SW**

LOCATION: N: 125073.1; E: 488623.2; Lat.: 445135.52981; Long.: -932537.93479. See attached sketch.

DRILLER: M. Takada | METHOD: 3 1/4" HSA, Autohammer | DATE: **3/6/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 878.1	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
877.1	1.0	FILL	FILL: Clayey Sand, fine- to medium-grained, dark brown, frozen.					
		FILL	FILL: Sandy Lean Clay, trace Gravel, gray and brown, frozen to 3 feet then wet.					Frozen to 3 feet, no sample recovered.
			Trace wood debris at 5 feet.	22				
				17		21		
				8			1 1/2	
			With large amounts of concrete and bituminous debris from 12 to 17 feet.	43				Limited sample recovery.
861.1	17.0			38				
858.1	20.0	FILL	FILL: Poorly Graded Sand with Silt, fine- to medium-grained, with concrete debris, brown, moist.	30				
856.1	22.0	CL	SANDY LEAN CLAY, trace Gravel, brown and gray, wet, rather stiff. (Glacial Till)	10				
		SC	CLAYEY SAND, fine- to medium-grained, trace Gravel, gray, wet, rather stiff to stiff. (Glacial Till)	11		13		
				12			3 1/2	
			With waterbearing Sand seam at 30 feet.	13	▽			An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:26

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2070SW (cont.) LOCATION: N: 125073.1; E: 488623.2; Lat.: 445135.52981; Long.: -932537.93479. See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: 3/6/14	SCALE: 1" = 4'

Elev. feet 846.1	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
			CLAYEY SAND, fine- to medium-grained, trace Gravel, gray, wet, rather stiff to stiff. (Glacial Till) *(continued)*	15				drilling. Groundwater levels fluctuate.
839.1	39.0	CL	SANDY LEAN CLAY, trace Gravel, gray, wet, rather stiff. (Glacial Till)	12				
837.1	41.0		END OF BORING. Water observed at 30 feet with 30 feet of hollow-stem auger in the ground. Water not observed with 39 1/2 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.					

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:26

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2071SW**

LOCATION: N: 125158.5; E: 488850;
Lat.: 445136.37450; Long.: -932534.78791.
See attached sketch.

DRILLER: M. Takada | METHOD: 3 1/4" HSA, Autohammer | DATE: **3/6/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 878.9	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
878.1	0.8	PAV	4 inches of bituminous over 4 inches of aggregate base.				
876.9	2.0	FILL	FILL: Silty Sand, fine- to medium-grained, with Gravel, frozen.				
874.9	4.0	FILL	FILL: Silty Sand, fine- to medium-grained, with Gravel, brown, frozen.	50/3"			
869.9	9.0	CL	SANDY LEAN CLAY, trace Gravel, brown, frozen to 5 feet then wet, very stiff. (Glacial Till)	42			Frozen soil to 5 feet.
				25		13	
866.9	12.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Till)	23			
		SC	CLAYEY SAND, fine- to medium-grained, trace Gravel, brown to 25 feet then gray, moist, rather stiff to very stiff. (Glacial Till)	22		32	P200=9%
				24			
				23			
				24			
				26			
				15			
				35			

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BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2071SW (cont.) LOCATION: N: 125158.5; E: 488850; Lat.: 445136.37450; Long.: -932534.78791. See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: 3/6/14	SCALE: 1" = 4'

Elev. feet 846.9	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
844.9	34.0						
		SP	POORLY GRADED SAND, fine- to medium-grained, with Gravel, brown, moist, medium dense to dense. (Glacial Outwash)	38			
837.9	41.0			16			
			END OF BORING. Water not observed with 39 1/2 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.				

(See Descriptive Terminology sheet for explanation of abbreviations)

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LOG OF BORING

BRAUN INTERTEC

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2072SW**

LOCATION: N: 125337.6; E: 488872;
Lat.: 445138.14247; Long.: -932534.48368.
See attached sketch.

DRILLER: M. Takada | METHOD: 3 1/4" HSA, Autohammer | DATE: 3/7/14 | SCALE: 1" = 4'

Elev. feet 877.4	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
876.4	1.0	PAV	5 inches of bituminous over 7 inches of aggregate base.					
		FILL	FILL: Clayey Sand, fine- to medium-grained, with Gravel, gray and dark brown, frozen to 5 feet then moist.	50/4"		13		Frozen soil to 5 feet, no sample recovered.
				27				
			With Gravel at 10 feet.	21				
				15		15		
860.4	17.0			15				
		CL	LEAN CLAY with SAND, gray, moist, rather stiff. (Glacial Till)	11		22	2 1/4	
855.4	22.0			10				
		CL	SANDY LEAN CLAY, trace Gravel, brown, wet, stiff. (Glacial Till)	16				
848.4	29.0			14				
		SC	CLAYEY SAND, fine- to medium-grained, trace Gravel, brown to 35 feet then gray, moist, very stiff. (Glacial Till)	18				

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:27

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2072SW (cont.) LOCATION: N: 125337.6; E: 488872; Lat.: 445138.14247; Long.: -932534.48368. See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: 3/7/14	SCALE: 1" = 4'

Elev. feet 845.4	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
			CLAYEY SAND, fine- to medium-grained, trace Gravel, brown to 35 feet then gray, moist, very stiff. (Glacial Till) *(continued)*	19				
838.4	39.0	SP	POORLY GRADED SAND, fine- to medium-grained, with Gravel, dark brown, waterbearing, dense. (Glacial Outwash)	39	▽			An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while drilling. Groundwater levels fluctuate.
836.4	41.0		END OF BORING. Water observed at 39 feet with 39 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2080SW**

LOCATION: N: 124766.7; E: 486767.4; Lat.: 445132.49433; Long.: -932603.69484. See attached sketch.

DRILLER: S. McLean	METHOD: 3 1/4" HSA, Autohammer	DATE: **2/14/14**	SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 886.6	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
885.5	1.1	PAV	5 inches of Bituminous over 9 inches of Aggregate Base.				
877.6	9.0	CL	SANDY LEAN CLAY, trace Gravel, brown, frozen to moist, hard to very stiff. (Glacial Till)	40*			*Frozen soils to 3 feet.
				21		---	
				25		---	
872.6	14.0	SP	POORLY GRADED SAND, fine- to medium-grained, brown, moist, medium dense. (Glacial Outwash)	12			P200=
				12			
867.6	19.0	SP	POORLY GRADED SAND, fine- to medium-grained, with Gravel, brown, moist, medium dense. (Glacial Outwash)	16			
				17			
858.6	28.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Till)	24			
				21			
				22			
		SC	CLAYEY SAND, trace Gravel, brown, moist, dense. (Glacial Till)	38			

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BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2080SW (cont.)**

LOCATION: N: 124766.7; E: 486767.4; Lat.: 445132.49433; Long.: -932603.69484. See attached sketch.

DRILLER: S. McLean	METHOD: 3 1/4" HSA, Autohammer	DATE: 2/14/14	SCALE: 1" = 4'

Elev. feet 854.6	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
853.6	33.0						
		SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, dense. (Glacial Till)	55			
				46			
845.6	41.0		END OF BORING. Water not observed while drilling. Water not observed with 39 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth of 33 feet immediately after withdrawal of auger. Boring then backfilled.				

(See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2081SW**

LOCATION: N: 124753.4; E: 487130.7;
Lat.: 445132.36455; Long.: -932558.65223.
See attached sketch.

DRILLER: S. McLean	METHOD: 3 1/4" HSA, Autohammer	DATE: **2/14/14**	SCALE: **1" = 4'**

Elev. feet 887.8	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
886.9	1.0	PAV	7 inches of Bituminous over 11 inches of Aggregate Base.				
881.8	6.0	CL	SANDY LEAN CLAY, trace Gravel, brown, frozen to moist, very stiff. (Glacial Till)	48*			*Frozen soils to 3 feet.
				18		---	
875.8	12.0	SP	POORLY GRADED SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	13			P200=
				13			
873.8	14.0	SP	POORLY GRADED SAND, fine- to medium-grained, with Gravel, brown, moist, medium dense. (Glacial Outwash)	16			
		SP	POORLY GRADED SAND, fine- to medium-grained, brown, moist, medium dense. (Glacial Outwash)	14			
				17			
				14			
				17*			*No sample recovery.
			Layer of Silty Sand encountered at 25 feet.	18			
				19			

(See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2081SW (cont.)**

LOCATION: N: 124753.4; E: 487130.7;
Lat.: 445132.36455; Long.: -932558.65223.
See attached sketch.

DRILLER: S. McLean	METHOD: 3 1/4" HSA, Autohammer	DATE: **2/14/14**	SCALE: **1" = 4'**

Elev. feet 855.8	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
			POORLY GRADED SAND, fine- to medium-grained, brown, moist, medium dense. (Glacial Outwash) *(continued)*				
				22			
849.8	38.0	SM	SILTY SAND, fine- to medium-grained, brown, moist, medium dense. (Glacial Till)				
				26			
846.8	41.0		END OF BORING. Water not observed while drilling. Water not observed with 39 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth of 32 1/2 feet of hollow-stem auger in the ground. Boring immediately backfilled.				

(See Descriptive Terminology sheet for explanation of abbreviations)

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BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2082SW**

LOCATION: N: 124777.6; E: 487410.7; Lat.: 445132.60526; Long.: -932554.76534. See attached sketch.

DRILLER: S. McLean	METHOD: 3 1/4" HSA, Autohammer	DATE: **2/14/14**	SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 889.2	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
887.9	1.3	PAV	4 inches of Bituminous over 12 inches of Aggregate Base.				
886.2	3.0	FILL	FILL: Sandy Lean Clay, trace Gravel, dark brown, frozen to moist.	32*			*Frozen soils to 3 feet.
880.2	9.0	CL	LEAN CLAY with SAND, trace Gravel, brown, moist, very stiff to hard. (Glacial Till)	19		---	
				37		---	
875.2	14.0	SC	CLAYEY SAND, trace Gravel, brown, moist, medium dense. (Glacial Till)	16			P200=
			Sand layer encountered at 12 feet.	12			
		SP	POORLY GRADED SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	17			
				20			
				14			
				14			
				19			
			Lenses of Lean Clay encountered at 30 feet.	21			

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2082SW (cont.) LOCATION: N: 124777.6; E: 487410.7; Lat.: 445132.60526; Long.: -932554.76534. See attached sketch.

DRILLER: S. McLean	METHOD: 3 1/4" HSA, Autohammer	DATE: 2/14/14	SCALE: 1" = 4'

Elev. feet 857.2	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
856.2	33.0						
		SC	CLAYEY SAND, with Gravel, brown, moist, medium dense. (Glacial Till)	26			
				27			
848.2	41.0		END OF BORING. Water not observed while drilling. Water not observed with 39 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth of 31 feet immediately after withdrawal of auger. Boring immediately backfilled.				

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:31

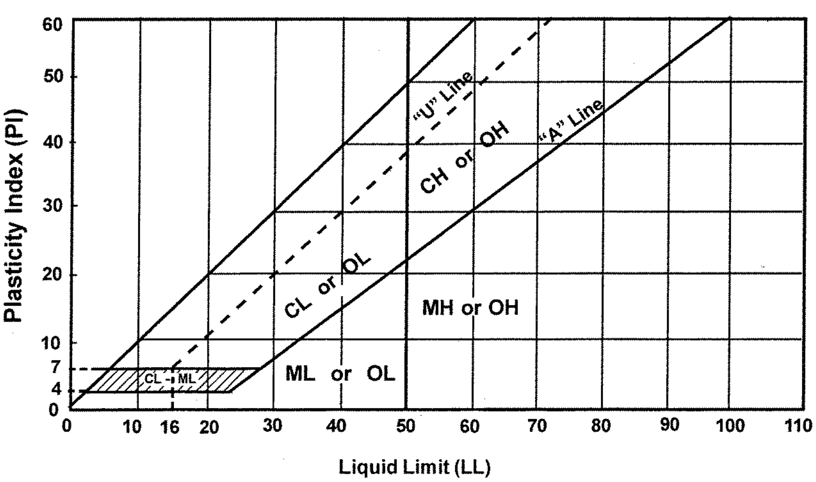
BRAUN INTERTEC

Descriptive Terminology of Soil

Standard D 2487 - 00
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels** 5% or less fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands** 5% or less fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	**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]
				OL	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]
				OH	Organic silt [k l m q]
Highly Organic Soils	Primarily organic matter, dark in color and organic odor			PT	Peat

a. Based on the material passing the 3-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
d. If soil contains≥15% sand, add "with sand" to group name.
e. 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
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines" to group name.
h. If soil contains ≥ 15% gravel, add "with gravel" to group name.
i. 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
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 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.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcf	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liqiuid limit, %	**C**	Cohesion, psf
PL	Plastic limit, %	∅	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders .... over 12"
Cobbles .... 3" to 12"
Gravel
  Coarse .... 3/4" to 3"
  Fine .... No. 4 to 3/4"
Sand
  Coarse .... No. 4 to No. 10
  Medium .... No. 10 to No. 40
  Fine .... No. 40 to No. 200
Silt .... < No. 200, PI < 4 or below "A" line
Clay .... < No. 200, PI ≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose .... 0 to 4 BPF
Loose .... 5 to 10 BPF
Medium dense .... 11 to 30 BPF
Dense .... 31 to 50 BPF
Very dense .... over 50 BPF

Consistency of Cohesive Soils

Very soft .... 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff .... 17 to 30 BPF
Hard .... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers unless noted otherwise, Jetting water was used to clean out auger prior to sampling only where indicated on logs. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous-flight, solid-stem augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface and are, therefore, somewhat approximate. Power auger borings are designated by the prefix "B."

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn. Hand auger borings are indicated by the prefix "H."

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

Appendix E

Retaining Walls W113, W115 and W116

BRAUN INTERTEC

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August 29, 2014 Project BL-13-00213

Mr. Don Demers
Southwest Light Rail Transit Project Office
6465 Wayzata Boulevard, Suite 500
St. Louis Park, MN 55426

Re: Foundation Analysis Design Recommendation Report
Retaining Walls 113, 115, 116 and General Track Construction – 90% Design
STA 2141+52 to STA 2155+62
Southwest LRT, West Segment
Eden Prairie, Minnesota

Dear Mr. Demers:

Braun Intertec Corporation has completed the geotechnical evaluation for the retaining walls RTW-W113, RTW-W115, and RTW-W116 for the west segment of the Southwest Light Rail Transit (SWLRT) alignment passing through Eden Prairie, Minnesota. The following sections provide information regarding our opinions, methods, and recommendations for general track construction retaining wall foundation, associated embankments and general track construction in this area.

A. Project information

The west segment of the SWLRT project is proposing to construct a light rail transit line through the cities of Hopkins, Minnetonka, and Eden Prairie, Minnesota. This design report addresses general track construction, as well as the design and construction of three retaining walls that will support the track embankment along Flying Cloud Drive in Eden Prairie.

A.1. Type of Structure

Cast-in-place (CIP) concrete and modular block retaining walls will be utilized for wall design. The proposed CIP concrete walls will be supported by spread footing foundations founded at least 4 ½ feet below the lowest finished grade along the toe of the wall. The walls will be designed and constructed by others.

A.2. Location of Walls

We were provided with drawings showing the plan and profile for each of the three walls. The locations and additional information for the walls are provided below.

A.2.a. Wall RTW-W113

Wall RTW-W113 is proposed to be a modular block retaining wall located along the north side of the proposed SWLRT alignment, extending from about STA 2141+52 to STA 2146+79, for a length of about 534 feet and connects to the north abutment of the 494 Bridge. The wall height (from bottom of footing to top of rail) will be about 17 feet except for the east-most 140 feet where the footing will step up resulting in a wall height of about 12 feet.

A.2.b. Wall RTW-W115

Wall RTW-W115 is located along the north side of the proposed SWLRT alignment, extending from about STA 2152+92 to STA 2155+62, for a length of about 272 feet. The wall height (from bottom of footing to top of rail) will vary from about 7 feet at the west edge to about 24 feet at the east edge, with the greater height due to the approach for the Valley View Bridge.

A.2.c. Wall RTW-W116

Wall RTW-W116 is located along the south side of the proposed SWLRT alignment, extending from about STA 2152+77 to STA 2155+62, for a length of about 284 feet. The wall will be parallel to and across the tracks from Wall RTW-W115. The wall height (from bottom of footing to top of rail) will vary from about 8 feet at the west edge to about 22 feet at the east edge, with the greater height due an increase in top elevation for the abutment of the Valley View Bridge.

A.3. Embankment Construction

To construct the walls along the proposed alignment, embankment grade increases of up to 20 feet will be necessary. Grade raises of this magnitude will influence the design and construction of the proposed wall foundation types. However, the effects of the embankment stresses are accounted for in our foundation design recommendations.

B. Subsurface Investigation Summary

B.1. Summary of Borings Taken

Braun Intertec performed 10 SPT (standard penetration test) borings (2049SW, 2050SW, 2051ST 2052SW, 2053SW, 2054SB, 2123SW, 2124SW, 2127SW, and 2128SW) and two CPT (cone penetration test) soundings (2125CW and 2126CW) in the vicinity of the proposed wall alignments. Logs of the wall borings and soundings are included in the Appendix. A Boring & Sounding Location Sketch is also included, showing the locations of such wall borings and soundings.

B.2. Description of Foundation Soil and Conditions

The proposed retaining walls are generally underlain with sandy lean clay fill, followed by glacially deposited sands and clays to the termination depth of the borings. A more detailed description is provided below.

B.2.a. Topsoil

The borings initially encountered about 4 to 30 inches of topsoil. The topsoil consisted of sandy lean clay that was dark brown to black and moist.

B.2.b. Fill

Fill was encountered at the majority of the boring locations and consisted of sandy lean clay (CL), sandy silt (ML), and poorly graded sand (SP). Table 1 below illustrates the depth and type of fill material encountered.

Table 1. Fill Depths Beneath Retaining Walls 113, 115, and 116

Boring No.	Boring Elevation (ft)	Approximate Depth of Fill (ft)	Elevation at Bottom of Fill (ft)	Fill Composition
2123SW	901.5	27	874 ½	Sandy Lean Clay, Sandy Silt
2049SW	902.8	14	889	Sandy Lean Clay
2050SW	903.1	9	894	Sandy Lean Clay
2124SW	903.9	9	895	Sandy Lean Clay
2127SW	914.6	6	908 ½	Sandy Lean Clay
2128SW	914.8	5	910	Sandy Lean Clay
2151ST	912.4	4	908	Poorly Graded Sand with Silt
2052SW	909.2	7	902	Poorly Graded Sand
2053SW	914.1	½	913 ½	Topsoil
2054SW	899.1	½	989 ½	Topsoil

Note: No fill was encountered at Borings 2053SW and 2054SW

Penetration resistances varied from 3 to 27 blows per foot (BPF), although some of the higher penetration resistances were likely influenced by encountering a rock in the sampler.

B.2.c. Glacial Till

Glacial till soils were encountered throughout the soil profile across the lengths of the walls. The till consisted of lean clay with sand, sandy lean clay, clayey sand, silty sand, and silt. The till soils contained a trace to some gravel, were moist to wet or waterbearing, and were brown. Penetration resistances varied from 9 to 42 BPF indicating the cohesive soils were rather stiff to hard.

B.2.d. Glacial Outwash

Glacial outwash soils were also frequently encountered throughout the soil profile. The glacial outwash soils consisted of poorly graded sand and poorly graded sand with silt. The sands generally contained some gravel. Penetration resistances varied from 8 BPF to 50 blows per 4 inches of penetration, indicating the soil was loose to very dense.

B.3. Summary of Water Level Measurements

SPT boring logs note water levels during drilling ranging from approximate 844 to 895 feet above mean sea level (MSL). This large range in elevation indicates the groundwater encountered was in a perched condition. Temporary water level indicators installed several hundred feet down-track have been periodically monitored and noted groundwater near an elevation of 841. We expect static groundwater levels to be near 841. Seasonal and annual fluctuations of groundwater, however, should be anticipated.

C. Foundation Analysis

Based on the soil conditions encountered in the borings and loads anticipated on the wall, we recommend the use of spread footing foundations for support of the CIP walls and a leveling pad consisting of coarse filter aggregate wrapped in geotextile fabric to support the facing of the modular block wall. An optional concrete leveling pad could also be placed. Based on the depth of fill, portions of the footings for RTW-W113 will bear in the fill. Based on the borings and soundings, and our calculations, the fill appears to be competent for wall and embankment support, however, there is inherent uncertainty in fill soils.

To reduce the potential for settlement exceeding the service limit, we recommend undercutting foundations a minimum of five feet, or extending through the fill, whichever is less. We also recommend preloading the areas of the walls where new embankment heights will exceed 10 feet from existing grades to reduce the potential of settlement exceeding one-inch due to the embankment loads. A second option for reducing settlement at RTW-W113 is to support the wall and embankment with rammed aggregate piers.

The wall suitability will be controlled by the service limit state (settlement). A maximum total settlement of one-inch is specified for the CIP retaining wall structures. Total settlement is defined as the sum of primary consolidation and secondary consolidation.

C.1. Embankment and Slopes

The track embankments associated with the walls will consist of retaining wall backfill. The MSE wall backfill will also contain geogrid reinforcement. Preparation will include topsoil removal, limited removal of fill beneath the footings, and backfilling and filling with the proposed track section.

C.1.a. Settlement

There are two known existing utilities currently beneath RTW-W113 which include a gas main and a water force main. Existing large utilities remaining below the walls and associated embankments have not been considered for settlement since details of such utilities are unknown at this stage, and it is assumed utilities will be re-routed from beneath the proposed track area. We assume that small utilities will be rerouted from beneath the walls and embankments.

The settlement ranges noted below are a combination of both settlements from the retaining walls loads as well as settlement from the raise in grade for the embankment.

C.1.a.1. Wall RTW-W113

Based on the Plan and Profile Drawings provided to us, about 3 to 11 feet of new fill will be required to construct the embankments. Based on this, we estimate total settlement to range from about ¾ inches to approximately 1 ¾ inches. With the recommended soil correction, preloading, or aggregate pier support, overall settlement will be less than one-inch.

C.1.a.2. Walls RTW-W115 and RTW-W116

Based on the Plan and Profile Drawings provided to us, about 3 to 18 feet of fill will be required to construct the embankments. Based on this, we estimate total settlement will be less than one-inch.

C.1.b. Bearing Capacity

Based on our calculations and assumptions for the CIP Walls, the soil conditions identified in the borings and soundings are anticipated to provide a bearing resistance in excess of the required capacity shown on the attached Minnesota Department of Transportation (MnDOT) Retaining Wall Standard Plant Sheet for a 2-foot live load surcharge. However, a limited subcut will be required for several hundred feet along the western portion of RTW-W113.

C.1.c. Global Stability

Based on the proposed wall heights, slope angles, and the competent native soils encountered in the borings and soundings, the factor of safety is anticipated to exceed the required minimum value of 1.5. Local stability of the walls and associated reinforced embankments, which is separate from the global stability, will be determined by the retaining wall engineer.

C.2. Spread Footing Foundations

C.2.a. Cast-in-Place Concrete Walls

Settlements were calculated based on three methods. The first is the Hough method with Boussinesq and Westergaard stress distributions, which utilizes the standard penetration test (SPT) values from the soil borings. The second is the CPT method or Constrained Modulus method, which utilizes the in place elastic modulus of the soil that is calculated from cone readings that were taken in the field. The third is the Menard method, which is based on pressuremeter determinations of soil parameters that were collected in the field or modified from the SPT values from the soil borings. For the Menard Method, where pressuremeter testing was not performed, conservative correlations were used to estimate pressuremeter values based on N_{60} factors provided in Federal Highway Administration (FHWA) Publication No. FHWA-IP-89-008. Tables 5 and 6 from this publication are in the Appendix for reference. After these three methods were evaluated, the results were averaged.

Terzhagi's strength limit state is also included on the nominal bearing graphs in the Appendix, for reference. The strength limit state (bearing) will not control design.

The service limit state (settlement) will control the design and the average service limit state should be used for design of Bridge substructures. A maximum settlement of one-inch is specified for this project.

C.2.b. Modular Block Walls

The spread footings (concrete leveling pads) are not true footings in that the vertical and horizontal loads are not carried only by the footings but also by the reinforced earth behind the wall. Assuming a minimum "footing" width of 0.7H (wall height), it is our opinion the backfill and native granular soils will have adequate bearing capacity for support of the wall. The global stability assumption in these soils confirms the adequacy of the bearing capacity of the "footing." The typical leveling pad, detailed on the attached MSEW-1 sheet in the Appendix, will be adequate for the intended purposes of the pad.

C.3. Track Construction

Throughout the track profile, cuts of approximately 2 to 12 feet and fills of 2 to 17 feet are anticipated for construction of the Guideway Section below the track. Based on the proposed design sections, the Guideway will be composed of a minimum of 12-inches of subballast material, over a 40-inch thick layer of granular material.

C.4. Summary of Design Assumptions

C.4.a. Embankment Heights, Unit Weights, Side Slopes, and End slopes

The wet unit weight of the anticipated compacted fill soils has been assumed as 120 pounds per cubic foot (pcf). The top surface behind all walls will be the associated tracks for the SWLRT and will be relatively flat. The slope in front of all walls will be 1:4 (V:H) or flatter. Information regarding the walls is provided in Table 2.

Table 2: Design Information for Walls

Retaining Wall Location	Existing Grade Elevations (ft)	Corresponding Proposed Wall Heights (ft)	Approximate Footing Elevation (ft)
RTW-W113	904-912	9 to 16	898-904
RTW-W115	900-915	7 to 22	895-905
RTW-W116	901-909	6 to 20	897-904

C.4.b. Retaining Wall Loading Information

A 2-foot live load surcharge will be used for the design of all CIP walls supporting track embankments. For the CIP concrete walls we recommend the design loads and anticipated footing widths be based on anticipated wall heights and the MnDOT standard plans included in the *Cast-in-Place Retaining Wall Details* section of the Appendix.

C.4.c. Design Methodologies

The LRFD (Load and Resistance Factor Design Method) was used for design of the retaining wall foundations supported on shallow foundations. Resistance factors were obtained from the Sixth Edition of the AASHTO (American Association of State Highway and Transportation Officials) LRFD Bridge Design Specifications (6th edition with 2013 interim revisions).

The ASD (Allowable Strength Design Method) was referenced for design of the retaining wall footings supported on shallow foundations. Strength design and safety factors were taken from the MnDOT design criteria for retaining walls with a 2-foot live load surcharge.

C.4.d. Modular Block Wall Loading Information

It is assumed a level fill will be used for the design of the MSE abutment walls.

C.5. Construction Considerations

C.5.a. Design of Temporary Slopes and Shoring Limits

We recommend that permanent slopes match the existing slopes, except they should not be steeper than 1V:2H. Select Granular Borrow is anticipated have an angle of internal friction greater than 30 degrees. This soil could be temporarily placed at a slope of 1V:1 ½ H, but if not retained by a CIP embankment, must be limited to 1V:2H or flatter for the permanent condition.

C.5.b. Subcut Recommendations and Backfill Requirements

To reduce the potential for settlement exceeding the service limit, we recommend subcutting fill soils present beneath the foundations a minimum five feet, or until native soils are encountered, whichever is less. Based on proposed elevations, the natural glacial soils will not be encountered until STA 4+00 on RTW-W113. We anticipate native soils will be encountered at footing elevations which will not require a subcut throughout RTW-W115 and RTW-W116.

The extent of the excavation required for the walls should extend horizontally beyond the embankment limits/footing dimensions a distance equal to the depth of the subcut. Exposed excavation bottoms, deemed suitable by a Geotechnical Engineer, should be surface compacted by a large vibratory sheepsfoot compactor prior to fill or footing placement.

We recommend the use of engineered fill to establish slope subgrade or backfill for any subcuts of marginal soils under the proposed CIP spread foundation foundations, oversize areas, or reinforced zones. Please refer to Table 3 below for material and compaction specifications based on the 2014 MnDOT Standard Specification for Construction.

Table 3. Material and Compaction Specification for Backfill and Fill

Material	Material Specification	Compaction Specification
Subgrade Fill	Onsite Material Free of Debris and Organic Material	100% of standard Proctor Density (ASTM D698)
Leveling Pad Beneath Footings/Block Facing	MnDOT 3138	MnDOT 2211.3C
Modular Block Wall Leveling Pad	MnDOT 3149.2H	MnDOT 2211.3C
Retaining Wall Backfill	MnDOT 3149.2D2	MnDOT 2105.3F
Guideway Select Granular Layer	MnDOT 3149.2B2	100% of standard Proctor Density (ASTM D698)
Guideway Subballast	MnDOT 3138	MnDOT 2211.3C

We recommend backfill material be placed in uniform layers approximately parallel to the profile, extending the full width of the retaining structures. We recommend backfill material be placed in lift thicknesses not exceeding 12 inches.

C.5.c. Construction Staging Requirements

Based on the borings and soundings, and the estimated settlements, which are estimated to exceed one-inch at RTW-W113, we recommend a short waiting period for the portions of the embankment that extend higher than 10 feet at RTW-W113. Please refer to Section D.4 of this report for details related to the recommended waiting period and staging requirements and the Appendix for a typical preload embankment sketch at each retaining wall location.

C.5.d. Rammed Aggregate Pier for Wall and Embankment Construction

An alternative method to support the walls and embankment at RTW-W113 is the use of aggregate piers (i.e. stone columns). Aggregate piers are composed of densely compacted, well-graded aggregates such as highway/roadway base course. They are constructed by drilling a shaft or advancing a mandrel through the looser or softer soil, densifying and pre-stressing the soil at the base of the hole with a proprietary high-energy impact compactor, and backfilling the hole with thin lifts of aggregate compacted to about 100 percent of its maximum modified Proctor dry density, ASTM D 1557.

High capacity side friction is developed in aggregate pier foundation elements, caused by build-up of lateral soil stresses during compaction of the aggregate. In addition to the side friction provided by the undulating sides of the aggregate piers and the increased lateral soil stresses, the bottoms of the aggregate piers are supported by a combination of pre-stressing and densification of the subsoils at the bottom of aggregate pier cavities during compaction. This develops aggregate "bulbs" at the bottom of the aggregate piers.

This process creates a series of very stiff, very dense foundation elements that reduce settlement from structural or embankment loads. Conventional footing foundations and embankments constructed over the aggregate pier-reinforced soil accomplish the load transfer.

In our opinion, the clayey fill soils beneath the RTW-W113 from STA 0+00 to STA 4+00 (approximately) can be improved with rammed aggregate piers. If the adjacent 494 Bridge abutment or neighboring structures are sensitive to vibrations, we would recommend vibrations be further evaluated and the licensed design/build contractor be consulted to provide further information in regards to vibration. Since rammed aggregate piers are a proprietary system, the design should be customized for this project by a licensed design/build contractor.

Backfill placed for the embankment and walls should follow the recommendations from Table 2 above.

If rammed aggregate piers are used to support the wall and embankment, we recommend extending the piers past the end of the embankment for RTW-W113 to include the north abutment for the 494 Bridge. Please refer to the report for the Bridge over I-494 for soils conditions and recommendations associated with the bridge construction.

C.5.e. Track Construction

Existing ground surface elevations vary between STA 2142+00 to STA 2155+50 with respect to the proposed top of rail elevation. Cuts on the order of 12 feet and fills of up to 17 feet will be required to construct the track embankment.

We recommend excavating down to the proposed bottom of subgrade for the Guideway section. We expect a combination of native soils and fill will be encountered. We recommend removing all vegetation, topsoil, and any soft or wet soils encountered at subgrade elevations. We do not recommend removing the entire depth of the fill soils if they appear suitable to support the proposed track construction. Additional excavations may be necessary beyond what is noted in the boring logs. This should be evaluated in the field on a case by case basis.

After the fill has been evaluated, and any additional corrections made, the subgrade soils should be surface compacted with a large, vibratory sheepsfoot compactor prior to the placement of fill or before construction of the Guideway begins. Please refer to Table 2 in Section C.5.b for the compaction specifications and guidelines.

D. Retaining Wall Foundation Recommendations

D.1. Bearing Capacities and Associated Resistance Factors/Factors of Safety

Based on the soil conditions, recommended soil corrections, or aggregate pier construction, the service limit bearing pressure exceeds the anticipated soil loading based on the MnDOT Standard Plan for CIP and Modular Block Retaining Walls Associated factors of safety are also provided on the attached plan.

D.2. Recommended Lateral Design Soil Parameters

The recommended lateral soil parameters to be used for design are provided in Table 4.

Table 4: Lateral Soil Parameters

Soil Type	Angle of Internal Friction (degrees)	Effective unit Weight (pcf)	Coefficient of Sliding Friction Rough Concrete	Active Earth Pressure Coefficient	At-Rest Earth Pressure Coefficient
Select Granular Borrow	35	120	0.6	0.27	0.43
Granular Borrow	30	120	0.5	0.33	0.50
Onsite Sandy Lean Clay	28	125	0.4	0.36	0.53

D.3. Recommended Foundation Types, Sizes and Embedment Depths

We recommend that the walls be supported on spread footings, following the MnDOT standard plans included in the *Cast-in-Place Retaining Wall Details and Modular Block Retaining Wall* sections of the Appendix. The size of these footings shall be determined based upon the stem wall or wall height by the wall designer. If stem wall heights/footing sizes change during retaining wall design, we should be notified to confirm that bearing capacity and settlement criteria are within the recommended tolerances. We recommend that the footings be embedded at least 4-1/2 feet below grade (bottom of footing) for frost protection.

D.4. Waiting Periods for Embankments

In areas of RTW-W113 where the fill height will exceed 10 feet, we recommend an estimated embankment waiting period of one to two months once the embankment preload has been constructed or until settlement has essentially ceased. To control the settlement of the underlying soil, we recommend the preload be constructed near final grade of the track alignment. The waiting period should reduce the majority of the settlement of the foundation soils due to the embankment raise in grade as discussed in Section C.1. The embankment preload should be constructed with, at a minimum, a top trapezoidal width and length that is the vertical projection of the retaining wall footing dimension (width) with side slopes that extend at a 1V:1 ½ H slope or flatter. A typical preload embankment cross section sketch along each wall is included in the Appendix of this report.

Settlement plates are recommended be installed every 100 feet along the retaining wall preload embankment and monitored to evaluate the rate and amount of settlement. The geotechnical engineer will review the monitoring data and make the determination of when the end of the waiting period will be. The settlement plates should be surveyed daily for one week after construction, and every other day for two additional weeks. Beyond the initial three weeks, we recommend surveying the plates bi-weekly. Settlement plates should be surveyed until settlement has leveled off to an acceptable limit to where the contractor can proceed with removal of the preload embankment and construction of the footings.

The waiting period can likely be reduced with the use of rammed aggregate piers. The extent of the waiting period will be determined upon design of the aggregate pier system.

D.5. Subexcavations

To reduce the potential for settlement exceeding the service limit, we recommend subcutting the soils beneath the foundations a minimum of five feet or extending through the fill, whichever is less. Based on proposed elevations, the natural till soils will not be encountered above the proposed subcut elevation until approximately STA 4+00 of RTW-W113. Native soils are expected to be encountered at bottom of footing elevations for the remaining areas of RTW-W113, and throughout RTW-W115 and RTW-W116. Subexcavations will not be required in these areas. According to the cross sections, it appears that topsoil and fill will be excavated beneath the track during construction of the retaining walls.

The extent of the excavation required for the track or walls should extend horizontally beyond the embankment limits/footing dimensions a distance equal to the depth of the subcut. Exposed excavation bottoms, deemed suitable by a Geotechnical Engineer, should be surface-compacted by a large vibratory sheepsfoot compactor prior to fill or footing placement.

The Geotechnical Engineer should observe and evaluate the bottoms of the excavations for the track, embankments and foundations to confirm the soils are similar to those encountered in the soil borings and CPT soundings. The Geotechnical Engineer should determine the need for excavation of poor soils and replacement with compacted fill. The evaluation may include test pits, hand-auger borings, dynamic cone penetrometer soundings, and possibly other tests.

To provide lateral support to replacement backfill, additional required fill and the structural loads they will support in areas of native mineral soils, we recommend oversizing (widening) the excavation 1 foot horizontally beyond the outer edges of the footing for each foot the excavations extend below bottom-of-footing subgrade elevations. The excavation shall be backfilled with Select Granular Borrow in accordance with the Specified Density Method (2105.1A7).

D.6. Temporary Slopes and Shoring Limits

Temporary slopes in Select Granular Borrow can be constructed at 1V:1 ½ H or shallower. Temporary slopes constructed in granular borrow or natural granular material encountered at the site are recommended to be constructed at 1V:1.5H or shallower. In a temporary condition; these slopes have a Factor of Safety against global failure in excess of 1.3.

E. Material Classification and Testing

E.1. Visual and Manual Classification

The geologic materials encountered were visually and manually classified in accordance with ASTM International Standard Practice D 2488. A chart explaining the classification system is attached. Samples were sealed in jars or bags and returned to our facility for review and storage

E.2. Laboratory Testing

The results of the laboratory tests performed on geologic material samples are noted on or follow the appropriate attached exploration logs. The tests were performed in accordance with ASTM procedures.

E.3. Groundwater Measurements

The drillers checked for groundwater as the penetration test borings were advanced, and again after auger withdrawal. The boreholes were then backfilled or sealed with bentonite grout.

F. Qualifications

F.1. Variations in Subsurface Conditions

F.1.a. Material Strata

Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth, and therefore, strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions, and can be expected to vary in depth, elevation and thickness away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed, or construction commences. If any such variations are revealed, our recommendations should be re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

F.1.b. Groundwater Levels

Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

F.2. Continuity of Professional Responsibility

F.2.a. Plan Review

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

F.2.b. Construction Observations and Testing

It is recommended that we be retained to perform observations and tests during construction. This will allow correlation of the subsurface conditions encountered during construction with those encountered by the borings, and provide continuity of professional responsibility.

F.3. Use of Report

This report is for the exclusive use of Southwest Light Rail Transit. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

G. General

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If there are questions regarding these bridge foundation recommendations, please call Josh Kirk at 952.995.2222 or Ray Huber at 952.995.2260.

Sincerely,

BRAUN INTERTEC CORPORATION

Professional Certification:
I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

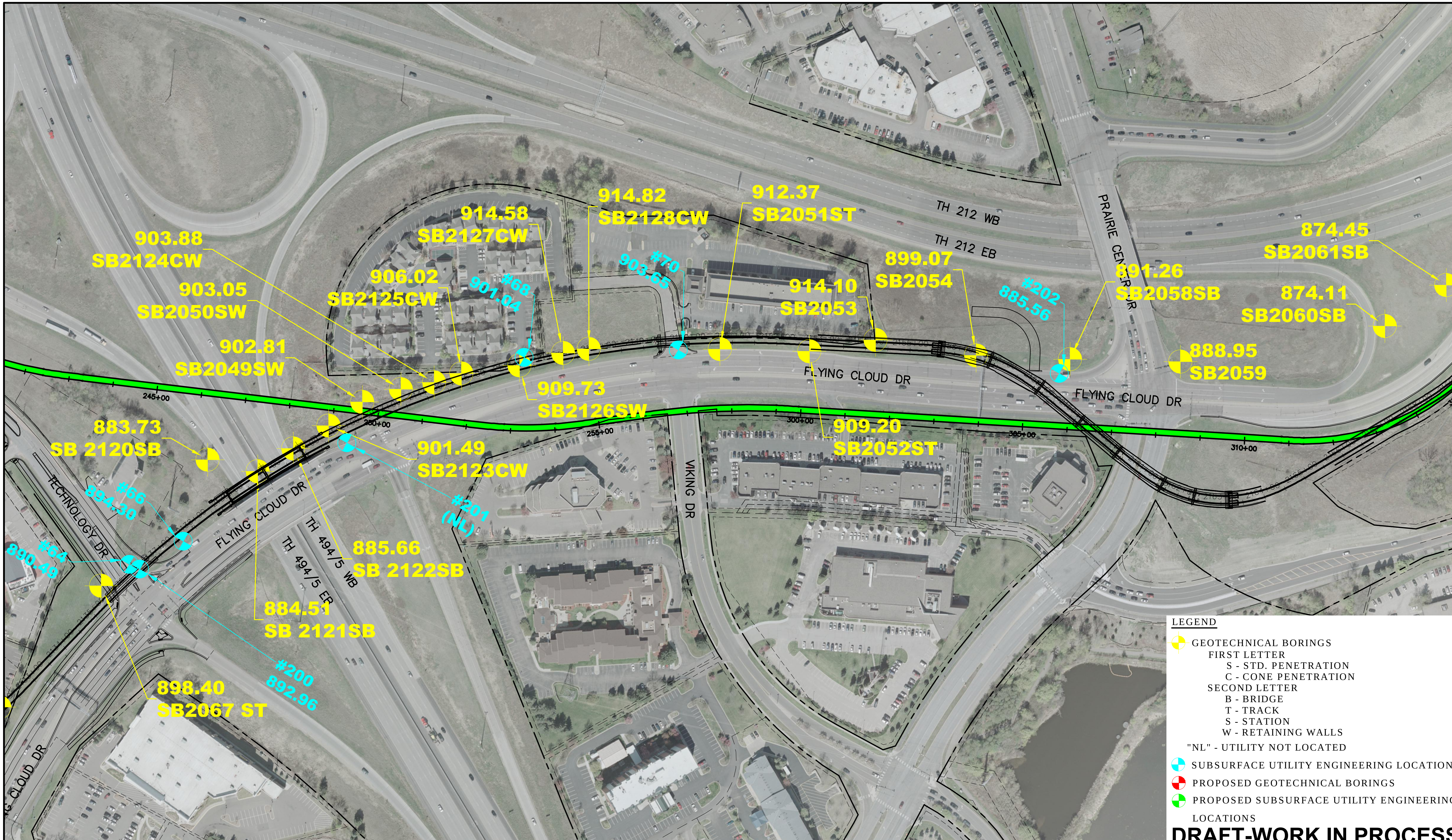
Joshua L. Kirk, PE
Associate Principal-Project Engineer
License Number: 45005

Reviewed by:

Ray A. Huber, PE
Vice President-Principal Engineer

Appendix:
Boring Location Sketch
Retaining Wall RTW-W113, RTW-W115, RTW-W116 Plan and Profile Sheet
Standard Penetration Boring Logs 2049SW, 2050SW, 2051ST, 2052SW, 2053SW, 2054SW, 2123SW, 2124SW, 2127SW, and 2128SW
CPT Sounding Logs 2125CW and 2126CW
Limit State Graphs for Walls RTW-W113 and RTW-W115/116
MnDOT Standard Sheet No. 5-297.632, 1 of 4 (2’ LL Surcharge, Spread Footing Supported Retaining Walls)
MnDOT Standard Sheet No. 5-297-641 (Modular Block Retaining Wall, Soil Reinforcement for level fill, Case 1)
Publication No. FHWA-IP-89-008 N60 Correlation Tables
MnDOT Standard Preload Plan Sheet 297.233
SPT Descriptive Terminology
CPT Descriptive Terminology

APPENIDX



SOUTHWEST Green Line LRT Extention

SOUTHWEST LIGHT RAIL

SOIL BORINGS
SHEET 5 OF 12

IRT: N/A

REV: 0

DATE: 06/30/2014

NORTH

0 50 100 200

METROPOLITAN COUNCIL

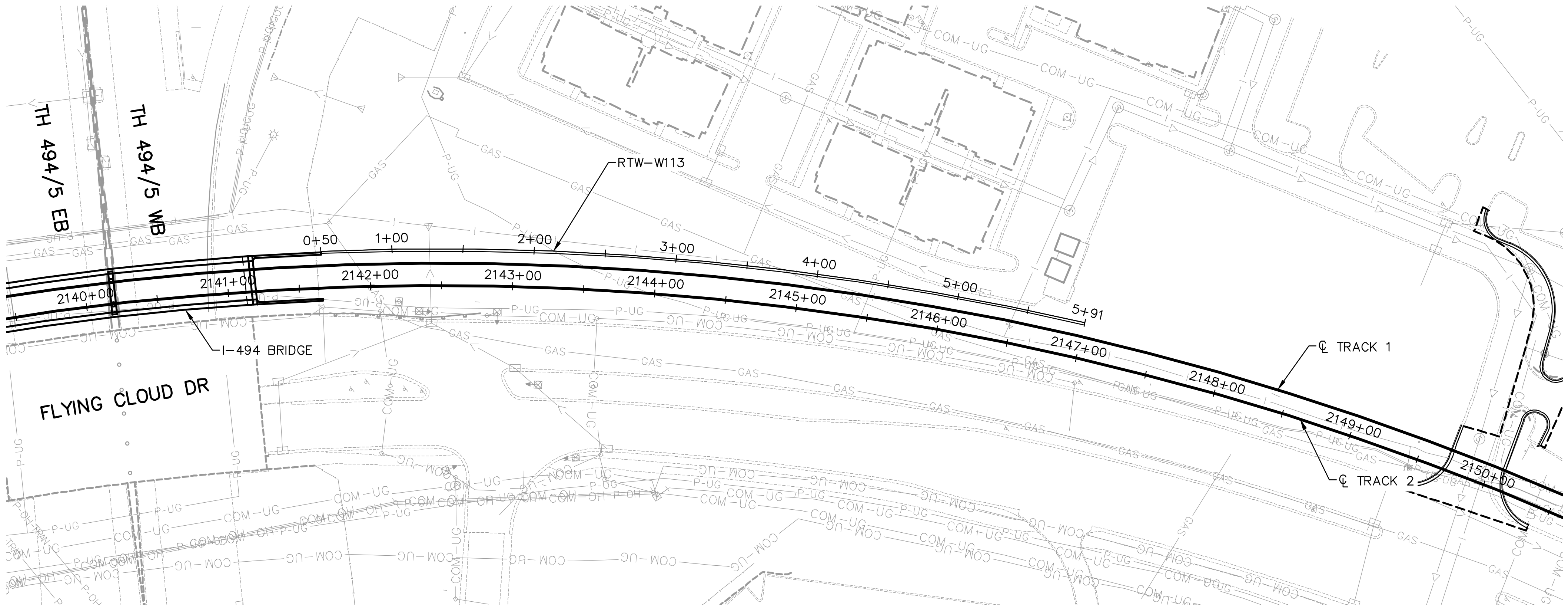
AECOM

SRF Consulting Group, Inc.

Aug. 28 2014 11:30 am V:\3200_PEC-W\CAD\OVERALL\EXHIBITS\CIVIL\EXHB-CIV-SOIL BORINGS.dwg By: Boscha

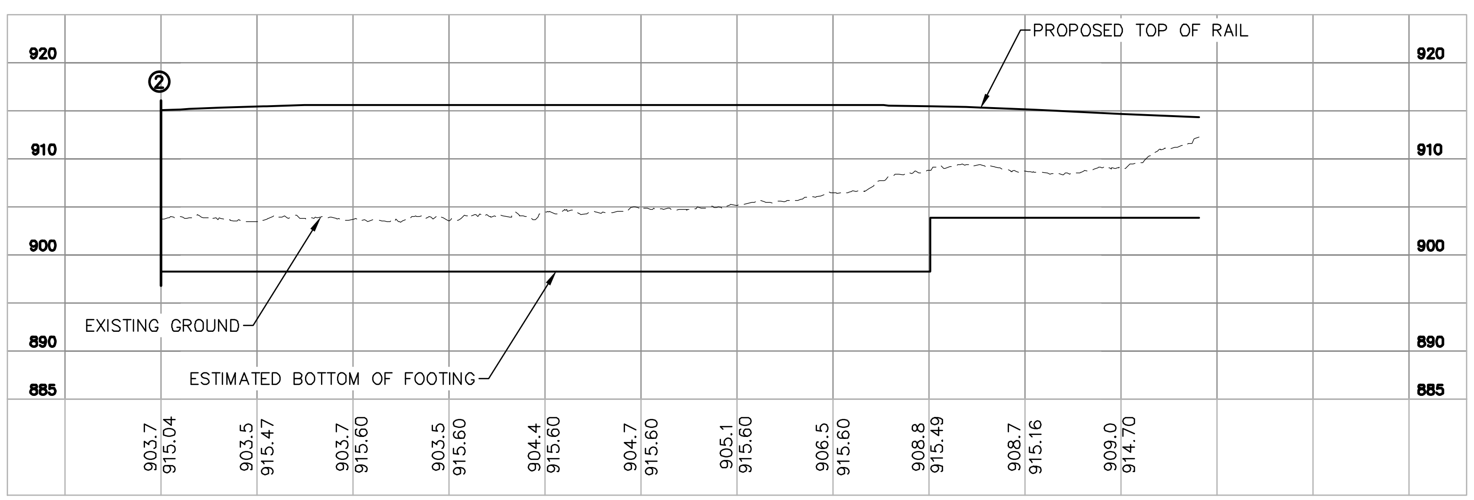
NOTE:
RTW-W113 IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL ON SPREAD FOOTINGS.

② JOINT LOCATION BETWEEN RETAINING WALL AND BRIDGE WINGWALL.

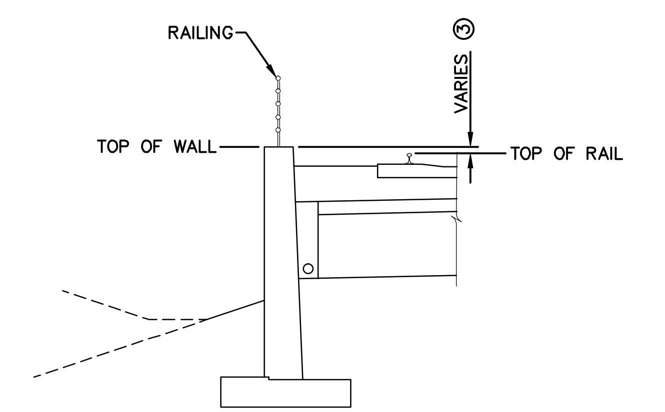


SCALE IN FEET: VERTICAL 0 5 10 20; HORIZONTAL 0 25 50 100

RTW-W113 PLAN



RTW-W113 PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW-W113 TYPICAL SECTION

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CORRECTED BY: DATE:
REVIEWED BY: DATE:

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PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extention

WEST-VOLUME 2 (STRUCTURES)
SEGMENT 1
RTW-W113
PLAN AND PROFILE

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-RTW-PPFL-004

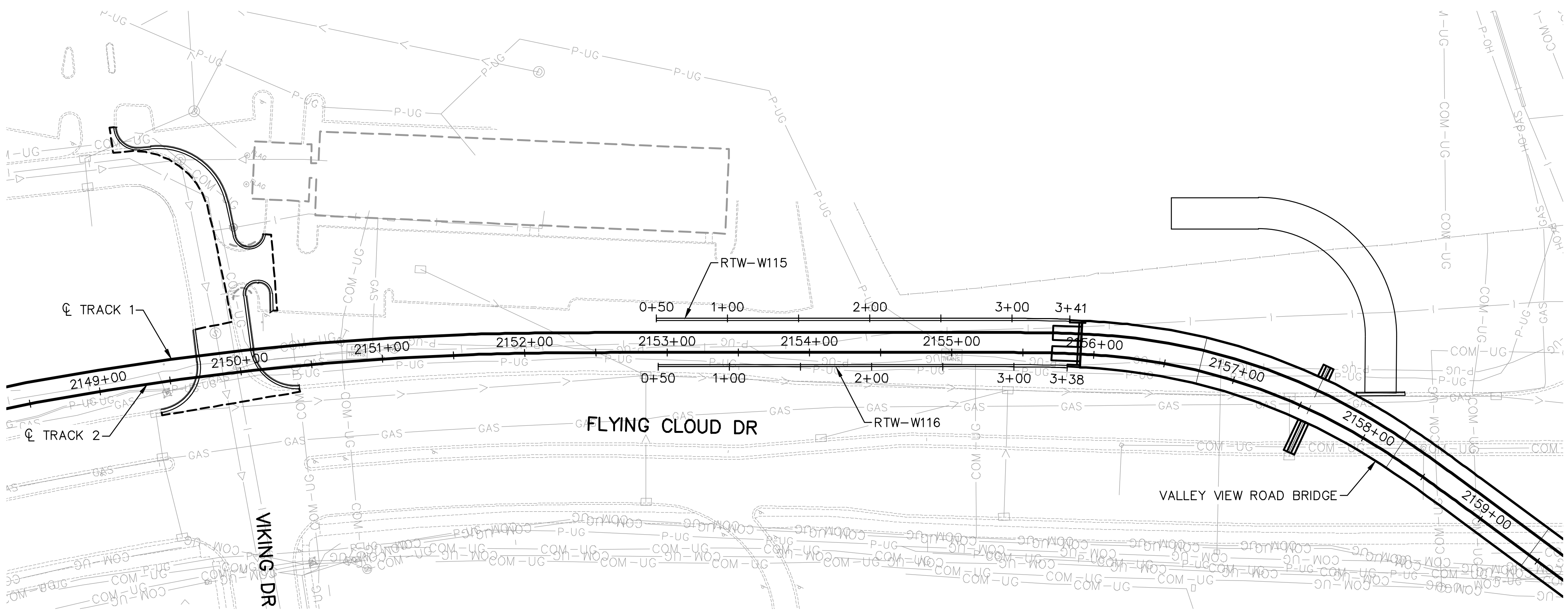
SHEET 161 OF 197

Jun, 13 2014 10:54 am V:\3200_PEC-W\CAD\SEGMENT-W1\SHEET\STRUCTURES\W1-STU-RETW.dwg By: NutzmaML

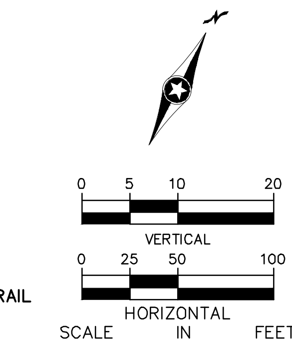
Jun. 13 2014 10:54 am V:\3200_PEC-W\CAD\SEGMENT-W1\SHEET\STRUCTURES\W1-STU-RETW.dwg By: NutzmaML

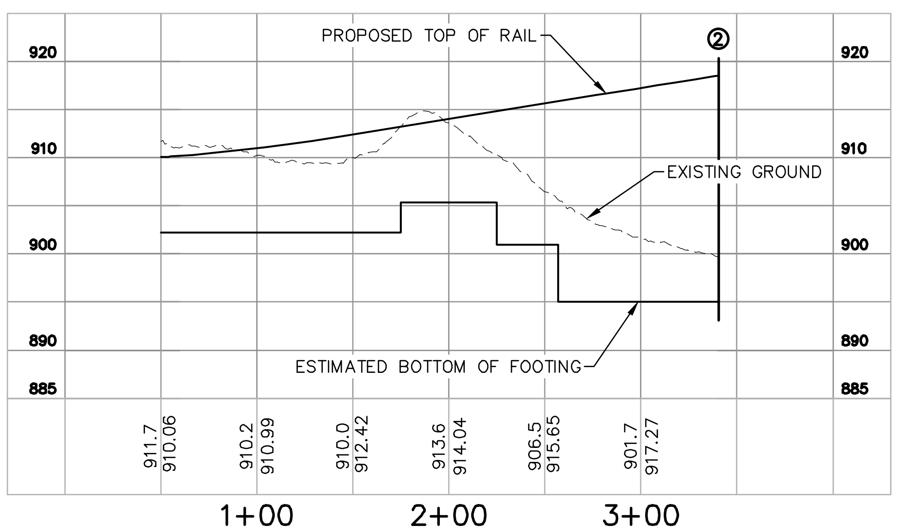
NOTE:
RTW-W115 AND RTW-W116 ARE ANTICIPATED TO BE CAST-IN-PLACE RETAINING WALLS ON SPREAD FOOTINGS.

② JOINT LOCATION BETWEEN RETAINING WALL AND BRIDGE WINGWALL.

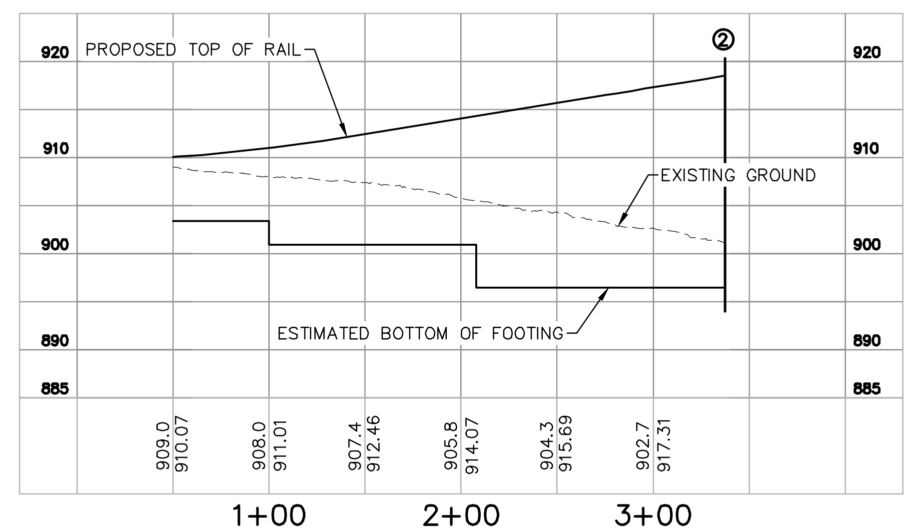


RTW-W115 & RTW-W116 PLAN

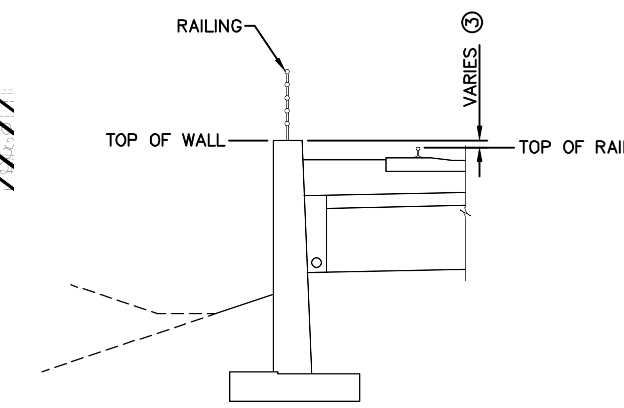




RTW-W115 PROFILE

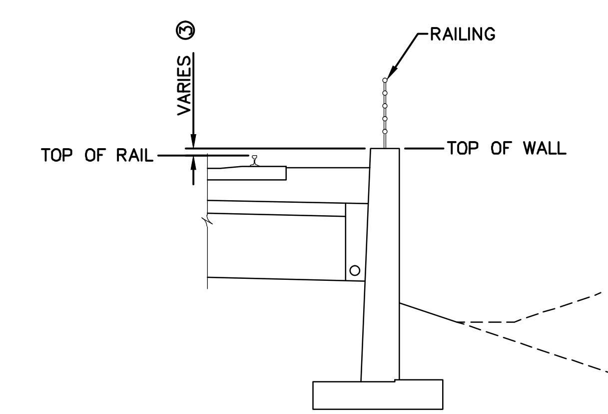


RTW-W116 PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW-W115 TYPICAL SECTION



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW-W116 TYPICAL SECTION

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PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extention

WEST-VOLUME 2 (STRUCTURES)
SEGMENT 1
RTW-W115 & RTW-W116
PLAN AND PROFILE

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-RTW-PPFL-005

LOG OF BORING

BRAUN INTERTEC

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2049SW**

LOCATION: See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: 11/22/13	SCALE: 1" = 4'

Elev. feet 902.8	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
902.2	0.6	CL	Sandy Lean Clay, with roots, dark brown, moist. (Topsoil)					
		FILL	FILL: Sandy Lean Clay, brown, moist.					
				12		9		
				23		9		
				27				Pushed rock.
				9				
			Trace of fibers at 12 feet.	10				
888.8	14.0	CL	LEAN CLAY with SAND, trace Gravel, brown, wet, rather stiff to very stiff. (Glacial Till)	12		24	3	
				18				
				25			3 1/4	
				23		17		DD=116 pcf
			Waterbearing sand lense at 25 feet.	30				
873.8	29.0	SM	SILTY SAND, fine- to medium-grained, with some Gravel, brown, wet to 30 feet then waterbearing, dense to very dense. (Glacial Outwash)	62	▽			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 2/5/14 16:46

LOG OF BORING

BRAUN INTERTEC

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2049SW (cont.)**

LOCATION: See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/22/13**	SCALE: **1" = 4'**

Elev. feet 870.8	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
			SILTY SAND, fine- to medium-grained, with some Gravel, brown, wet to 30 feet then waterbearing, dense to very dense. (Glacial Outwash) *(continued)*					
				34				P200=
861.8	41.0			38				
			END OF BORING. Water observed at 30 feet with 30 feet of hollow-stem auger in the ground. Water not observed to cave-in depth of 24 feet immediately after withdrawal of auger. Boring immediately backfilled with bentonite grout.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2050SW**

LOCATION: See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/22/13**	SCALE: **1" = 4'**

Elev. feet 903.1	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
902.2	1.0	CL	SANDY LEAN CLAY, with roots, black, moist. (Topsoil)					
894.1	9.0	FILL	FILL: Sandy Lean Clay, trace Gravel, brown, moist to 7 feet then wet.	17		8		
				11		11		
				10				
889.1	14.0	CL	SANDY LEAN CLAY, trace Gravel, brown, wet, stiff to very stiff. (Glacial Till)	17		26	3	
				13				
884.1	19.0	SC	CLAYEY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Till)	15				
				17				
		SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist to 30 feet then waterbearing, medium dense. (Glacial Till)	20				
				25		13		P200=40%
				26				
				20	▽			

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2050SW (cont.) LOCATION: See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: 11/22/13	SCALE: 1" = 4'

Elev. feet 871.1	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
			SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist to 30 feet then waterbearing, medium dense. (Glacial Till) *(continued)*					
				21				
864.1	39.0	CL	SANDY LEAN CLAY, trace Gravel, with Sand lenses, brown, wet, very stiff. (Glacial Till)					
				24				
862.1	41.0		END OF BORING. Water observed at 30 feet with 30 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2052ST**

LOCATION: N: 126940.9; E: 490049.5;
Lat.: 445153.97917; Long.: -932518.14675.
See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: 11/27/13	SCALE: 1" = 4'

Elev. feet 909.2	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
908.5	0.8	CL	LEAN CLAY, black, moist. (Topsoil)			
		FILL	FILL: Poorly Graded Sand, fine- to medium-grained, with Gravel, dark brown, moist.	11		
			Occasional Lean Clay lenses at 5 feet.	14		
902.2	7.0	CL	SANDY LEAN CLAY, with Gravel, brown, wet, stiff to hard. (Glacial Till)	42		
				24		
				50/6"		No recovery. Rock encountered. Offset & redrilled from 12 1/2 feet.
				16		
				19		
				16		No recovery at 20 feet.
				39		
			Occasional Clayey Sand lenses at 25 feet.	47		
880.2	29.0	SC	CLAYEY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Till)	30		

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:18

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2052ST (cont.)**

LOCATION: N: 126940.9; E: 490049.5;
Lat.: 445153.97917; Long.: -932518.14675.
See attached sketch.

DRILLER: M. Takada	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/27/13**	SCALE: **1" = 4'**

Elev. feet 877.2	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
			CLAYEY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Till) *(continued)*	19		
870.2	39.0	CL	SANDY LEAN CLAY, trace Gravel, brown, wet, very stiff. (Glacial Till)	21		
868.2	41.0		END OF BORING. Water not observed with 39 1/2 feet of hollow-stem auger in the ground. Boring immediately backfilled.			

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:18

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2053SW LOCATION: N: 127037.7; E: 490165.8; Lat.: 445154.93526; Long.: -932516.53315. See attached sketch.

DRILLER: M. Barber	METHOD: 3 1/4" HSA, Autohammer	DATE: 11/27/13	SCALE: 1" = 4'

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 914.1	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
913.9	0.3	CL	SANDY LEAN CLAY, trace roots, dark brown, wet. (Topsoil)					
		CL	SANDY LEAN CLAY, trace Gravel, brown, moist, stiff. (Glacial Till)	13		8	2 1/2	
910.1	4.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	26		7		P200=32%
				25				
			Sandy Lean Clay layer at 10 feet.	27				
902.1	12.0	ML	SANDY SILT, with occasional Silt lenses, brown, moist, dense. (Glacial Outwash)	33				
				31		12		
897.1	17.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash)	24				
				33				
				29				
				28				
				28				

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 4/1/14 15:43

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2053SW (cont.)**

LOCATION: N: 127037.7; E: 490165.8; Lat.: 445154.93526; Long.: -932516.53315. See attached sketch.

DRILLER: M. Barber | METHOD: 3 1/4" HSA, Autohammer | DATE: **11/27/13** | SCALE: **1" = 4'**

Elev. feet 882.1	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	qp tsf	Tests or Notes
			SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Outwash) *(continued)*					
			Sandy Lean Clay lenses at 35 feet.	25				
875.1	39.0	CL	SANDY LEAN CLAY, trace Gravel, gray, wet, stiff. (Glacial Till)	15				
873.1	41.0		END OF BORING. Water not observed with 39 1/2 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.					

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 4/1/14 15:43

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2054SB LOCATION: N: 127120.4; E: 490379; Lat.: 445155.75238; Long.: -932513.57316. Offset 10' North of stake. See attached sketch.

DRILLER: M. Belch	METHOD: 3 1/4" HSA, Autohammer	DATE: 11/27/13	SCALE: 1" = 4'

Elev. feet 899.1	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
899.0	0.2	SM	SILTY SAND, fine- to medium-grained, drak brown, moist. (Topsoil)			
		SM	SILTY SAND, fine- to medium-grained, with Gravel, with occasional Lean Clay lenses, brown, moist, medium dense. (Glacial Outwash)	38		
				15		
892.1	7.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown to 20 feet then gray, moist, medium dense. (Glacial Outwash)	16		
				15		
				16		Direct Shear: Ø=30 degrees.
				14		
				17		
				13		
878.1	21.0	SP	POORLY GRADED SAND, fine- to coarse-grained, with Gravel, brown, moist, medium dense to dense. (Glacial Outwash)			
				TW		
				31		
				36		

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:19

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2054SB (cont.)**

LOCATION: N: 127120.4; E: 490379;
Lat.: 445155.75238; Long.: -932513.57316.
Offset 10' North of stake. See attached sketch.

DRILLER: M. Belch	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/27/13**	SCALE: **1" = 4'**

Elev. feet 867.1	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
			POORLY GRADED SAND, fine- to coarse-grained, with Gravel, brown, moist, medium dense to dense. (Glacial Outwash) *(continued)*	32		
				24		
862.1	37.0	SP	POORLY GRADED SAND, fine-grained, brown, moist, medium dense. (Glacial Outwash)	26		
860.1	39.0	SP	POORLY GRADED SAND, fine- to medium-grained, brown, moist to 56 feet then waterbearing, loose to dense. (Glacial Outwash)	27		
				8		
				30		
				29		Switched to mud rotary drilling at 48 feet.
			Coarse-grained at 50 feet.	40		
				32	▽	
				11		

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2054SB (cont.) LOCATION: N: 127120.4; E: 490379; Lat.: 445155.75238; Long.: -932513.57316. Offset 10' North of stake. See attached sketch.

DRILLER: M. Belch	METHOD: 3 1/4" HSA, Autohammer	DATE: 11/27/13	SCALE: 1" = 4'

Elev. feet 835.1	Depth feet 64.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
			POORLY GRADED SAND, fine- to medium-grained, brown, moist to 56 feet then waterbearing, loose to dense. (Glacial Outwash) *(continued)*	23		No recovery.
				10		
				25		
				44		
				42		
810.1	89.0	ML	SILT, with fine Sand layers, gray, waterbearing, dense to very dense. (Glacial Outwash)	39		
				52		

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 3/28/14 15:19

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: **2054SB (cont.)** LOCATION: N: 127120.4; E: 490379; Lat.: 445155.75238; Long.: -932513.57316. Offset 10' North of stake. See attached sketch.

DRILLER: M. Belch	METHOD: 3 1/4" HSA, Autohammer	DATE: **11/27/13**	SCALE: **1" = 4'**

Elev. feet 803.1	Depth feet 96.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
798.1	101.0		SILT, with fine Sand layers, gray, waterbearing, dense to very dense. (Glacial Outwash) *(continued)*	54		
			END OF BORING. Water observed at 55 feet with 50 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.			

(See Descriptive Terminology sheet for explanation of abbreviations)

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2123SW**

LOCATION: N: 126256; E: 489196.7; See attached sketch.

DRILLER: K. Keck | METHOD: 3 1/4" HSA, Autohammer | DATE: **5/8/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 901.5	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
900.5	1.0	FILL	FILL: Lean Clay with Sand, trace roots, dark brown, moist. (Topsoil Fill)			34	
894.5	7.0	FILL	FILL: Sandy Lean Clay, brown and dark brown, wet.	7		17	
				10		18	
884.5	17.0	FILL	FILL: Sandy Lean Clay, trace Gravel, brown and gray, wet.	15		18	
				10		22	
				12		15	DD=115 pcf
				23		26	
882.5	19.0	FILL	FILL: Sandy Lean Clay, brown and white with layers of black, moist.	7		19	
879.5	22.0	FILL	FILL: Sandy Lean Clay, brown and dark brown, moist.	6		19	
877.5	24.0	FILL	FILL: Sandy Lean Clay, slightly organic, dark brown and black, moist.	6		27	OC=3%
874.5	27.0	FILL	FILL: Sandy Silt, with frequent layers of Silt, dark brown, moist to 25 feet then waterbearing.	13	▽	18	An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while drilling. Groundwater levels fluctuate.
872.5	29.0	CL-ML	SILTY CLAY, brown, waterbearing, rather stiff. (Glaciofluvium)	12		22	LL=20, PL=16, PI=4
		CL	SANDY LEAN CLAY, trace Gravel, brown, wet, stiff to very stiff. (Glacial Till)	13		15	

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/5/14 11:35

Braun Project BL-13-00213 GEOTECHNICAL EVALUATION SWLRT Minnetonka, Minnesota	BORING: 2123SW (cont.) LOCATION: N: 126256; E: 489196.7; See attached sketch.
DRILLER: K. Keck — METHOD: 3 1/4" HSA, Autohammer	DATE: 5/8/14 — SCALE: 1" = 4'

Elev. feet 869.5	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
867.5	34.0		SANDY LEAN CLAY, trace Gravel, brown, wet, stiff to very stiff. (Glacial Till) *(continued)*	22		14	
862.5	39.0	CL	SANDY LEAN CLAY, trace Gravel, with Sand seams, gray, wet, very stiff to hard. (Glacial Till)	23 35		16 17	
860.5	41.0	ML	SANDY SILT, gray brown, moist, very dense. (Glaciofluvium)	52		16	
			END OF BORING. Water observed at a depth of 26 feet while drilling. Water not observed with 39 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth of 39 1/2 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.				

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/5/14 11:35

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2124SW**

LOCATION: N: 126458.7; E: 489354;
See attached sketch.

DRILLER: K. Keck | METHOD: 3 1/4" HSA, Autohammer | DATE: **5/9/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 903.9	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
902.9	1.0	FILL	FILL: Sandy Lean Clay, dark brown, moist. (Topsoil Fill)				
		FILL	FILL: Sandy Lean Clay, trace Gravel, brown and dark brown, moist.	10		13	
				4			An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while drilling. Groundwater levels fluctuate.
894.9	9.0			4	▽	16	
891.9	12.0	SP-SM	POORLY GRADED SAND with SILT, fine- to medium-grained, brown, wet, medium dense. (Glacial Outwash)	14		13	P200=12%
		SM	SILTY SAND, fine- to medium-grained, with frequent layers of Lean Clay, brown, moist, medium dense to very dense. (Glacial Outwash)	28		15	
				31			
				35		9	P200=20%
881.9	22.0			52			
879.9	24.0	SM	SILTY SAND, fine-grained, brown, moist, dense. (Glacial Outwash)	37			
		SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist to 39 feet then waterbearing, medium dense. (Glacial Outwash)	20			
				26			
				28			

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/5/14 11:24

BRAUN℠ INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2124SW (cont.)**

LOCATION: N: 126458.7; E: 489354;
See attached sketch.

DRILLER: K. Keck	METHOD: 3 1/4" HSA, Autohammer	DATE: **5/9/14**	SCALE: **1" = 4'**

Elev. feet 871.9	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
			SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist to 39 feet then waterbearing, medium dense. (Glacial Outwash) *(continued)*	22			
				22			
				28			
					▼		
862.9	41.0			22			
			END OF BORING. Water observed at a depth of 9 feet while drilling. Water observed at 39 feet with 39 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth of 30 1/2 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.				

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/5/14 11:24

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2127SW**

LOCATION: N: 126660.8; E: 489572.1;
See attached sketch.

DRILLER: K. Keck	METHOD: 3 1/4" HSA, Autohammer	DATE: **5/8/14**	SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 914.6	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
912.1	2.5	FILL	FILL: Sandy Lean Clay, trace roots, dark brown, moist. (Topsoil Fill)				
908.6	6.0	FILL	FILL: Sandy Lean Clay, trace Gravel, dark brown, moist.	5		17	
				16		14	
904.6	10.0	SP	POORLY GRADED SAND, fine- to medium-grained, with frequent Silt layers, brown, moist, medium dense. (Glacial Outwash)	15			
900.6	14.0	SM	SILTY SAND, fine- to medium-grained, with Gravel, light brown, moist, dense. (Glacial Till)	22		5	P200=14%
				31			
894.6	20.0	SP	POORLY GRADED SAND, fine- to medium-grained, with Gravel, with frequent Silt layers, light brown to brown, moist, medium dense. (Glacial Outwash)	23			
				28		6	
		SM	SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Till)	28			
				28		8	P200=31%
				26			
				25			
				24			

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/13/14 13:36

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213 **GEOTECHNICAL EVALUATION** **SWLRT** **Minnetonka, Minnesota**	BORING: **2127SW (cont.)** LOCATION: N: 126660.8; E: 489572.1; See attached sketch.
DRILLER: K. Keck	METHOD: 3 1/4" HSA, Autohammer
DATE: **5/8/14**	SCALE: **1" = 4'**

Elev. feet 882.6	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	Tests or Notes
			SILTY SAND, fine- to medium-grained, trace Gravel, brown, moist, medium dense. (Glacial Till) *(continued)*	25			
				22			
878.6	36.0						
		SC	CLAYEY SAND, with Gravel, brown and gray, moist, stiff to very stiff. (Glacial Till)	16			
			Sand layer encountered at 40 feet.	22			
873.6	41.0						
			END OF BORING. Water not observed while drilling. Water not observed with 39 1/2 feet of hollow stem auger in the ground. Water not observed to cave-in depth of 31 1/2 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.				

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/13/14 13:36

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2128SW**

LOCATION: N: 126697.6; E: 489617.6. See attached sketch.

DRILLER: K. Keck | METHOD: 3 1/4" HSA, Autohammer | DATE: **5/7/14** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 914.8	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
912.8	2.0	FILL	FILL: Sandy Lean Clay, trace roots, dark brown, moist. (Topsoil Fill)			
909.8	5.0	FILL	FILL: Sandy Lean Clay, trace roots, dark brown to brown, moist.	3		
902.8	12.0	CL	SANDY LEAN CLAY, trace Gravel, with Sand seams, brown, moist, very stiff to rather stiff. (Glacial Till) Layer of Sand encountered at 8 feet.	19 11 10		
900.8	14.0	CL	LEAN CLAY with SAND, with Silt lenses, brown, moist, very stiff. (Glacial Till)	20		
895.8	19.0	SM	SILTY SAND, fine- to medium-grained, with frequent layers of Lean Clay, brown, moist, medium dense. (Glacial Till)	17 30		
882.8	32.0	SP	POORLY GRADED SAND, fine- to coarse-grained, with Gravel, occasional Cobbles, light brown to brown, moist, very dense to medium dense. (Glacial Outwash) Layer of Lean Clay encountered at 27 feet.	50/4" 50/0"* 54 46 34		*50/0" (set). No sample recovery. Auger met refusal at the 22 1/2-foot depth. Boring then offset 5 feet North of staked location and redrilled to 24 1/2 feet.

LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/3/14 15:11

BRAUN INTERTEC

LOG OF BORING

Braun Project BL-13-00213
GEOTECHNICAL EVALUATION
SWLRT
Minnetonka, Minnesota

BORING: **2128SW (cont.)**

LOCATION: N: 126697.6; E: 489617.6. See attached sketch.

DRILLER: K. Keck | METHOD: 3 1/4" HSA, Autohammer | DATE: 5/7/14 | SCALE: 1" = 4'

Elev. feet 882.8	Depth feet 32.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
880.8	34.0	SM	SILTY SAND, fine- to medium-grained, trace Gravel, with Silt lenses, brown, moist, dense. (Glacial Till)	42		
877.8	37.0	ML	SILT with SAND, gray to brown, moist, medium dense. (Glaciofluvium)	30		
875.8	39.0	SC	CLAYEY SAND, trace Gravel, brown, moist, rather stiff. (Glacial Till)	12	▽	An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while drilling. Groundwater levels fluctuate.
873.8	41.0	CL	SANDY LEAN CLAY, trace Gravel, brown, wet, rather stiff. (Glacial Till)	9		
			END OF BORING. Water observed at 38 feet with 36 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth of 32 feet immediately after withdrawal of auger. Boring immediately backfilled with bentonite grout.			

(See Descriptive Terminology sheet for explanation of abbreviations)

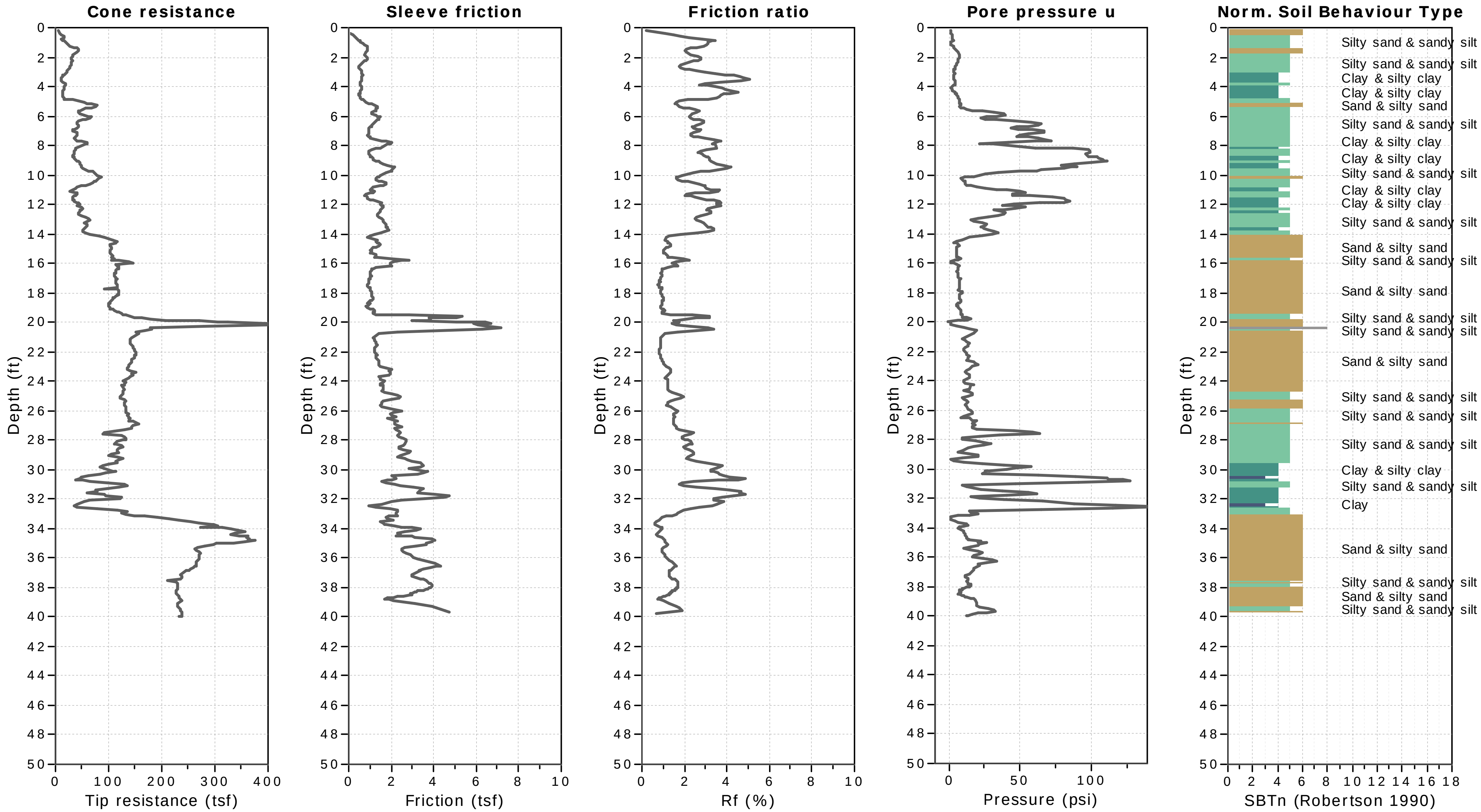
LOG OF BORING N:\GINT\PROJECTS\MINNEAPOLIS\2013\00213.GPJ BRAUN_V8_CURRENT.GDT 6/3/14 15:11

BRAUN INTERTEC

Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

CPT: 2125CW
Total depth: 39.99 ft, Date: 5/8/2014
Surface Elevation: 906.02 ft
Coords: X:489397.16, Y:126506.72
Cone Type: SCPTu
Cone Operator: Reich/Holmbo

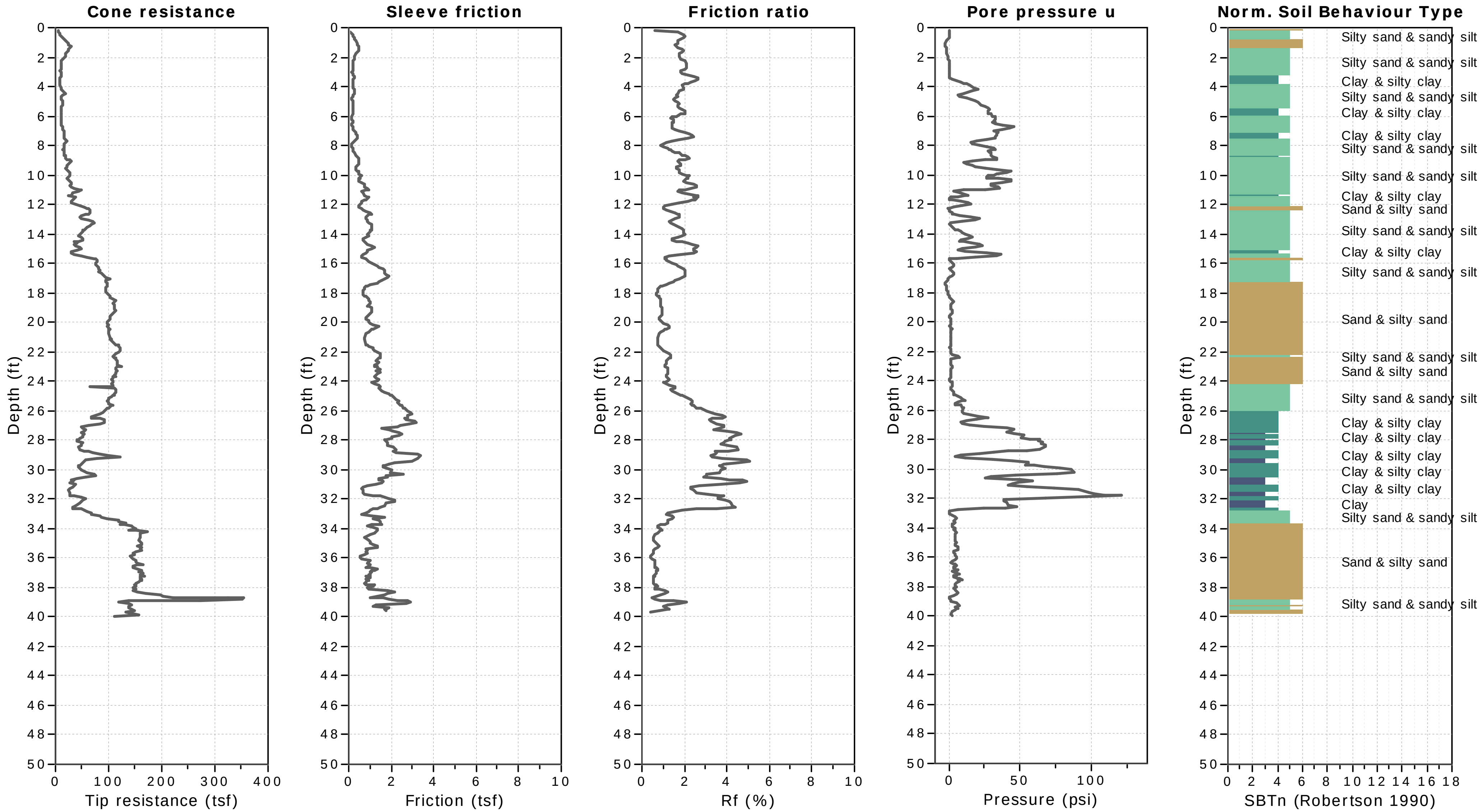
Project: SWLRT
Location: Hopkins, MN
Project Number: BL-13-00213



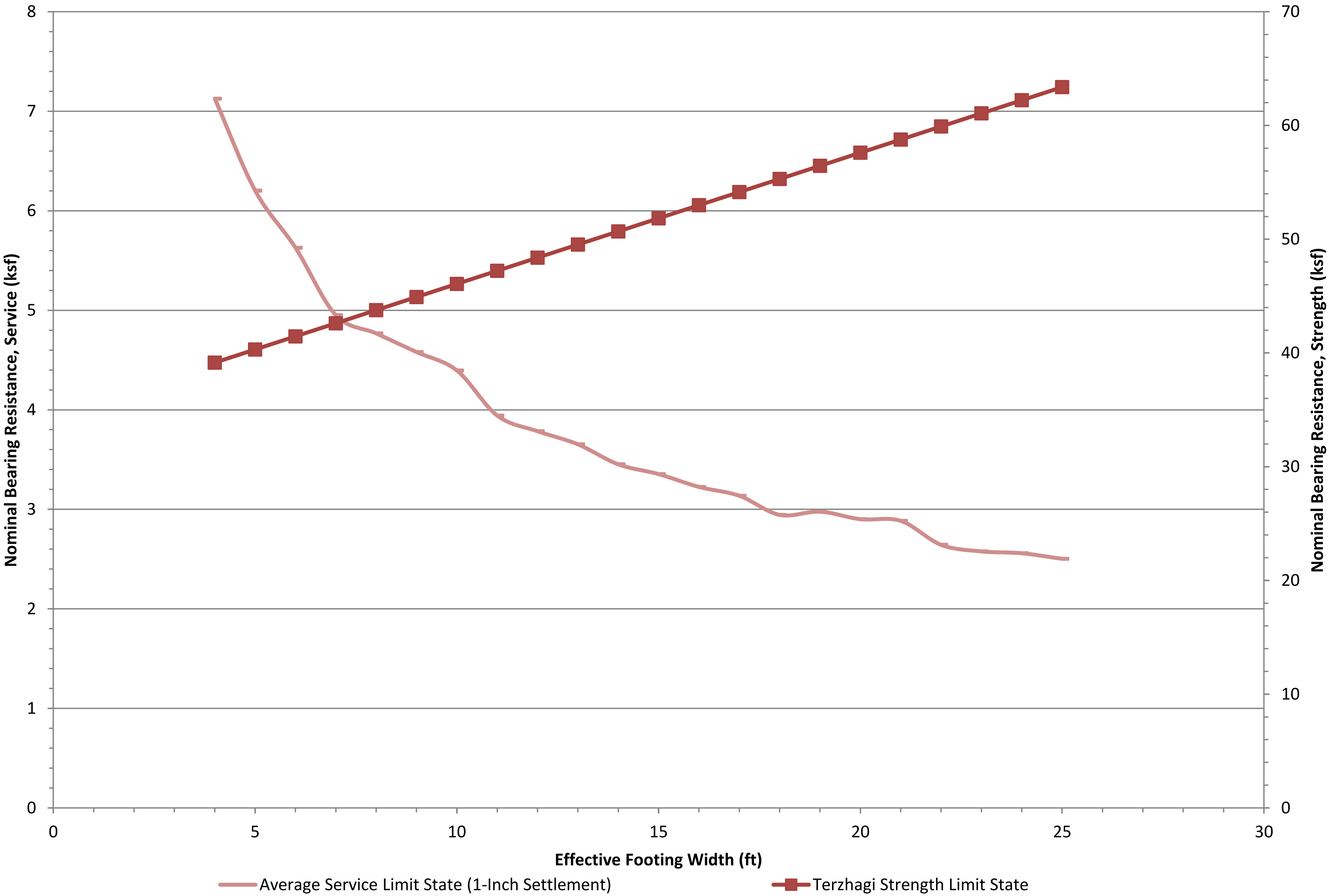
Braun Intertec Corporation
11001 Hampshire Ave S
Minneapolis, MN 55438
952-995-2000

Project: SWLRT
Location: Hopkins, MN
Project Number: BL-13-00213

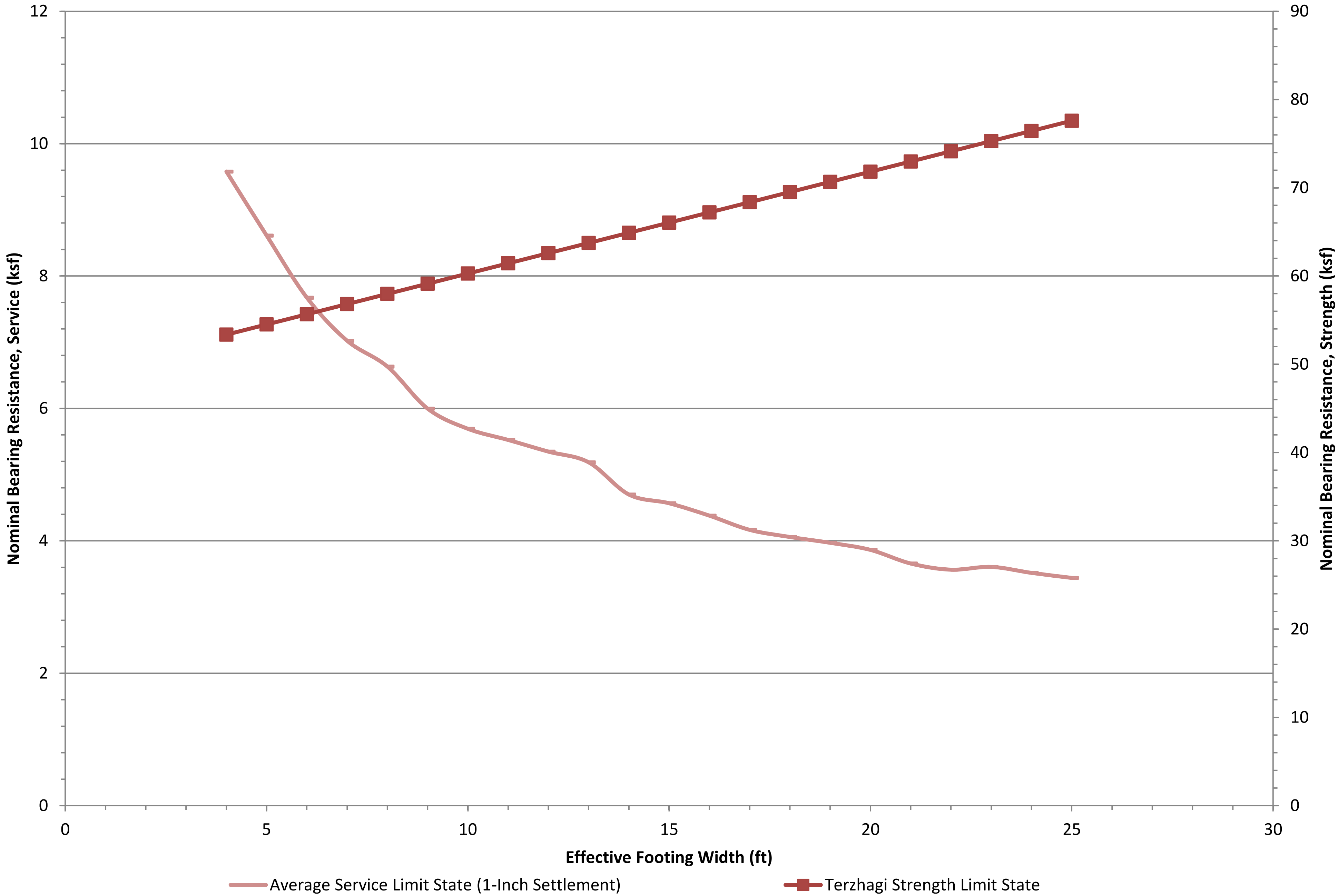
CPT: 2126CW
Total depth: 39.96 ft, Date: 5/8/2014
Surface Elevation: 909.73 ft
Coords: X:489500.76, Y:126587.68
Cone Type: SCPTu
Cone Operator: Reich/Holmbo



Limit State Shallow Foundation Analysis
Wall RTW-113 - 1-inch Settlement



Limit State Shallow Foundation Analysis
Wall RTW-115 & 116 - 1-inch Settlement

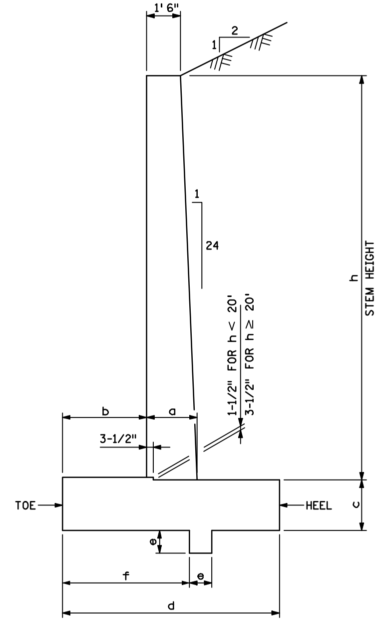


WALL LOADING CASE:
1:2 SLOPED FILL

WALL GEOMETRICS AND DATA - SPREAD FOOTING							QUANTITIES PER FOOT - SPREAD FOOTING				WALL DETAILING SCHEME ①	BASE PRESSURE KIPS/SQ. FT.	
							STRUCTURAL CONCRETE		REINFORCEMENT				
STEM HEIGHT h	STEM WIDTH a	TOE WIDTH b	FOOTING THICKNESS c	FOOTING WIDTH d	SHEAR KEY SIZE e	SHEAR KEY LOCATION f	1A43 CU. YD. FOOTING	3Y43 CU. YD. STEM	PLAIN POUND	EPOXY POUND		TOE	HEEL
5	1'-8 1/2"	0'-9"	1'-5"	3'-0"	N/A	N/A	0.163	0.296	12.07	30.56	SHORT	1.471	0.319
6	1'-9"	0'-10"	1'-5"	3'-9"	N/A	N/A	0.198	0.360	15.90	34.13	SHORT	1.672	0.415
7	1'-9 1/2"	1'-0"	1'-5"	4'-6"	N/A	N/A	0.233	0.425	19.70	37.74	SHORT	1.800	0.550
8	1'-10"	1'-2"	1'-5"	5'-3"	N/A	N/A	0.269	0.492	23.61	41.28	SHORT	1.931	0.679
9	1'-10 1/2"	1'-4"	1'-5"	6'-0"	N/A	N/A	0.304	0.561	25.18	45.80	SHORT	2.073	0.806
10	1'-11"	1'-6"	1'-5"	6'-9"	N/A	N/A	0.340	0.631	29.02	49.28	SHORT	2.210	0.936
11	1'-11 1/2"	1'-10"	1'-5"	7'-0"	1'-0"	3'-5 1/8"	0.390	0.703	29.54	53.21	SHORT	2.376	0.960
12	2'-0"	2'-2"	1'-5"	7'-3"	1'-0"	3'-9 5/8"	0.403	0.776	35.44	62.52	MEDIUM	2.536	0.937
13	2'-0 1/2"	2'-4"	1'-5"	7'-6"	1'-0"	4'-0 1/8"	0.415	0.851	39.38	67.15	MEDIUM	2.835	0.855
14	2'-1"	2'-8"	1'-5"	8'-0"	1'-0"	4'-4 5/8"	0.440	0.928	45.02	71.80	MEDIUM	2.924	0.916
15	2'-1 1/2"	2'-10"	1'-5"	8'-6"	1'-0"	4'-7 1/8"	0.464	1.006	49.08	76.62	MEDIUM	3.139	0.941
16	2'-2"	3'-2"	1'-5"	9'-0"	1'-0"	4'-11 5/8"	0.489	1.085	56.33	81.25	MEDIUM	3.232	0.997
17	2'-2 1/2"	3'-4"	1'-5"	9'-6"	1'-0"	5'-2 1/8"	0.513	1.166	54.95	110.81	TALL	3.446	1.022
18	2'-3"	3'-8"	1'-6"	10'-0"	1'-0"	5'-6 3/4"	0.611	1.249	56.75	106.46	TALL	3.712	1.004
19	2'-3 1/2"	4'-0"	1'-6"	10'-6"	1'-0"	5'-11 1/4"	0.640	1.333	60.82	123.67	TALL	3.809	1.053
20	2'-4"	4'-2"	1'-6"	11'-0"	1'-0"	6'-1 3/4"	0.696	1.417	75.05	130.82	TALL	4.051	1.069
21	2'-4 1/2"	4'-6"	1'-9"	11'-6"	1'-0"	6'-6 3/8"	0.834	1.504	66.66	161.18	TALL	4.325	1.041
22	2'-5"	4'-10"	1'-9"	12'-0"	1'-0"	6'-10 7/8"	0.870	1.593	82.13	170.00	TALL	4.427	1.085
23	2'-5 1/2"	5'-2"	2'-0"	12'-6"	1'-2"	7'-3 1/2"	1.035	1.683	80.16	209.34	TALL	4.707	1.059
24	2'-6"	5'-6"	2'-3"	13'-0"	1'-4"	7'-8 1/8"	1.212	1.775	95.80	221.64	TALL	4.991	1.029
25	2'-6 1/2"	5'-10"	2'-3"	13'-6"	1'-6"	8'-0 5/8"	1.274	1.868	101.18	277.08	TALL	5.097	1.078
26	2'-7"	6'-2"	2'-6"	14'-0"	1'-9"	8'-5 1/4"	1.479	1.963	103.31	289.67	TALL	5.383	1.052
27	2'-7 1/2"	6'-6"	2'-9"	14'-6"	2'-0"	8'-9 7/8"	1.698	2.059	116.46	304.69	TALL	5.672	1.026
28	2'-8"	6'-10"	3'-0"	15'-3"	2'-0"	9'-2 1/2"	1.920	2.157	126.16	388.20	TALL	5.843	1.139
29	2'-8 1/2"	7'-2"	3'-0"	16'-0"	2'-3"	9'-7"	2.046	2.257	129.90	400.20	TALL	5.835	1.351
30	---	---	---	---	---	---	---	---	---	---	---	---	---

NOTE:
EPOXY REINFORCEMENT QUANTITY ASSUMES AN EXPANSION JOINT IS USED ON BOTH PANEL ENDS. THE QUANTITY MUST BE ADJUSTED WHEN CONSTRUCTION JOINTS ARE USED.

① SEE STANDARD PLANS 5-297.621 TO .623 FOR REINFORCING DETAILS.



TYPICAL SECTION

DESIGN CRITERIA

1992 A.A.S.H.T.O. DESIGN SPECIFICATIONS
DESIGN METHOD:
WORKING STRESS - STABILITY, FOUNDATIONS
LOAD FACTOR DESIGN - REINFORCED CONCRETE
f'c = 4,000 PSI
fy = 60,000 PSI

FACTOR OF SAFETY OVERTURNING: 2.0 MINIMUM
FACTOR OF SAFETY SLIDING: 1.5 MINIMUM
LOCATION OF RESULTANT: MIDDLE 1/3 OF FOOTING NEGLECTING SOIL IN FRONT OF WALL.

SEE FOUNDATION REPORT FOR ALLOWABLE BEARING PRESSURE AND COEFFICIENT OF FRICTION.

BACKFILL CHARACTERISTICS:
INTERNAL ANGLE OF FRICTION: 35°
= 44 PCF EQUIVALENT FLUID PRESSURE ACTIVE STATE
= 71 PCF EQUIVALENT FLUID PRESSURE AT REST STATE
βe = 1.0
COEFFICIENT OF FRICTION: 0.55
UNIT WEIGHT: 125 PCF

REVISED:
APPROVED: MAY 31, 2006
[signature]
STATE BRIDGE ENGINEER

STANDARD SHEET NO. 5-297.631 (1 OF 4)	TITLE: RETAINING WALL (1:2 SLOPED FILL) SPREAD FOOTING GEOMETRY AND DATA
STANDARD APPROVED: MAY 31, 2006	
STATE PROJ. NO.	(TH) SHEET NO. OF SHEETS

WALL LOADING CASE:
2' - LIVE LOAD SURCHARGE

WALL GEOMETRICS AND DATA - SPREAD FOOTING							QUANTITIES PER FOOT - SPREAD FOOTING				WALL DETAILING SCHEME ①	BASE PRESSURE KIPS/SQ. FT.	
							STRUCTURAL CONCRETE		REINFORCEMENT				
STEM HEIGHT h	STEM WIDTH a	TOE WIDTH b	FOOTING THICKNESS c	FOOTING WIDTH d	SHEAR KEY SIZE e	SHEAR KEY LOCATION f	1A43 (CU.YD.) FOOTING	3Y43 (CU.YD.) STEM	PLAIN (POUND)	EPOXY (POUND)		TOE	HEEL
5	1'-8 1/2"	1'-0"	1'-5"	3'-6"	N/A	N/A	0.187	0.296	15.38	38.16	SHORT	1.670	0.070
6	1'-9"	1'-2"	1'-5"	4'-0"	N/A	N/A	0.211	0.360	16.43	41.74	SHORT	1.820	0.090
7	1'-9 1/2"	1'-4"	1'-5"	4'-6"	N/A	N/A	0.235	0.425	19.70	45.34	SHORT	1.970	0.120
8	1'-10"	1'-6"	1'-5"	5'-0"	N/A	N/A	0.259	0.492	20.75	48.89	SHORT	2.110	0.150
9	1'-10 1/2"	1'-8"	1'-5"	5'-6"	N/A	N/A	0.283	0.561	24.13	52.69	SHORT	2.250	0.180
10	1'-11"	1'-9"	1'-5"	6'-0"	N/A	N/A	0.306	0.631	25.18	62.49	MEDIUM	2.446	0.199
11	1'-11 1/2"	2'-0"	1'-5"	6'-6"	N/A	N/A	0.331	0.703	31.28	66.85	MEDIUM	2.536	0.239
12	2'-0"	2'-3"	1'-5"	6'-9"	1'-0"	3'-10 5/8"	0.380	0.776	35.38	72.23	MEDIUM	2.758	0.156
13	2'-0 1/2"	2'-6"	1'-5"	7'-0"	1'-0"	4'-2 1/8"	0.393	0.851	40.30	76.82	MEDIUM	2.986	0.013
14	2'-1"	2'-9"	1'-6"	7'-8"	1'-0"	4'-5 3/4"	0.477	0.928	40.49	81.74	MEDIUM	3.147	0.078
15	2'-1 1/2"	3'-0"	1'-6"	8'-2"	1'-0"	4'-9 1/4"	0.506	1.006	40.10	99.57	TALL	3.239	0.111
16	2'-2"	3'-3"	1'-9"	8'-8"	1'-0"	5'-0 7/8"	0.615	1.085	41.38	105.97	TALL	3.494	0.056
17	2'-2 1/2"	3'-6"	1'-9"	9'-2"	1'-0"	5'-4 3/8"	0.649	1.166	49.02	111.90	TALL	3.586	0.089
18	2'-3"	3'-9"	1'-9"	9'-8"	1'-0"	5'-7 7/8"	0.682	1.249	50.52	129.74	TALL	3.679	0.121
19	2'-3 1/2"	4'-0"	2'-0"	10'-2"	1'-0"	5'-11 1/2"	0.810	1.333	54.26	137.41	TALL	3.935	0.066
20	2'-4"	4'-3"	2'-0"	10'-8"	1'-0"	6'-3"	0.875	1.417	61.38	165.51	TALL	4.056	0.080
21	2'-4 1/2"	4'-6"	2'-0"	11'-2"	1'-0"	6'-6 1/2"	0.916	1.504	71.34	174.30	TALL	4.151	0.122
22	2'-5"	4'-9"	2'-3"	11'-8"	1'-0"	6'-10 1/8"	1.064	1.593	85.93	183.51	TALL	4.407	0.067
23	2'-5 1/2"	5'-0"	2'-6"	12'-2"	1'-0"	7'-1 3/4"	1.221	1.683	84.82	224.49	TALL	4.663	0.012
24	2'-6"	5'-3"	2'-9"	12'-9"	1'-0"	7'-5 3/8"	1.396	1.775	94.03	234.03	TALL	4.872	0.020
25	2'-6 1/2"	5'-6"	2'-9"	13'-3"	1'-0"	7'-8 7/8"	1.449	1.868	100.13	288.16	TALL	4.967	0.052
26	2'-7"	5'-10"	3'-0"	13'-9"	1'-0"	8'-1 1/2"	1.631	1.963	102.26	299.67	TALL	5.189	0.000
27	2'-7 1/2"	6'-2"	3'-3"	14'-4"	1'-0"	8'-6 1/8"	1.832	2.059	127.34	315.84	TALL	5.364	0.000
28	2'-8"	6'-6"	3'-3"	15'-0"	1'-0"	8'-10 5/8"	1.916	2.157	140.92	394.98	TALL	5.334	0.140
29	2'-8 1/2"	6'-10"	3'-6"	15'-6"	1'-0"	9'-3 1/4"	2.123	2.257	148.00	407.90	TALL	5.558	0.077
30	---	---	---	---	---	---	---	---	---	---	---	---	---

NOTE:
EPOXY REINFORCEMENT QUANTITY ASSUMES AN EXPANSION JOINT IS USED ON BOTH PANEL ENDS. THE QUANTITY MUST BE ADJUSTED WHEN CONSTRUCTION JOINTS ARE USED. QUANTITIES ON THIS SHEET DO NOT INCLUDE RAILING. SEE RAILING SHEETS FOR RAIL REINFORCEMENT (EPOXY) AND RAIL CONCRETE (3Y46).

① SEE STANDARD PLANS 5-297.621 TO .623 FOR REINFORCING DETAILS.

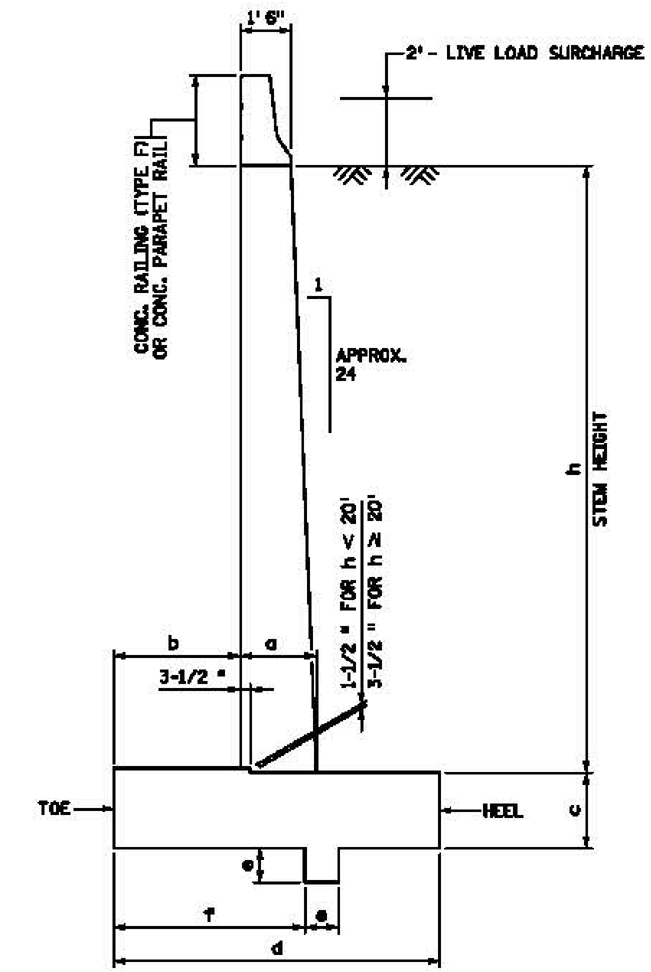
DESIGN CRITERIA

1992 A.A.S.H.T.O. DESIGN SPECIFICATIONS
DESIGN METHOD:
WORKING STRESS - STABILITY, FOUNDATIONS
LOAD FACTOR DESIGN - REINFORCED CONCRETE
f'c = 4,000 PSI
fy = 60,000 PSI

FACTOR OF SAFETY OVERTURNING: 2.0 MINIMUM
FACTOR OF SAFETY SLIDING: 1.5 MINIMUM
LOCATION OF RESULTANT: MIDDLE 1/3 OF FOOTING NEGLECTING SOIL IN FRONT OF WALL.

SEE FOUNDATION REPORT FOR ALLOWABLE BEARING PRESSURE AND COEFFICIENT OF FRICTION.

BACKFILL CHARACTERISTICS:
INTERNAL ANGLE OF FRICTION: 35°
= 33 PCF EQUIVALENT FLUID PRESSURE ACTIVE STATE
= 53 PCF EQUIVALENT FLUID PRESSURE AT REST STATE
βe = 1.0
COEFFICIENT OF FRICTION: 0.55
UNIT WEIGHT: 125 PCF



TYPICAL SECTION

REVISED:
APPROVED: MAY 31, 2006
STATE BRIDGE ENGINEER

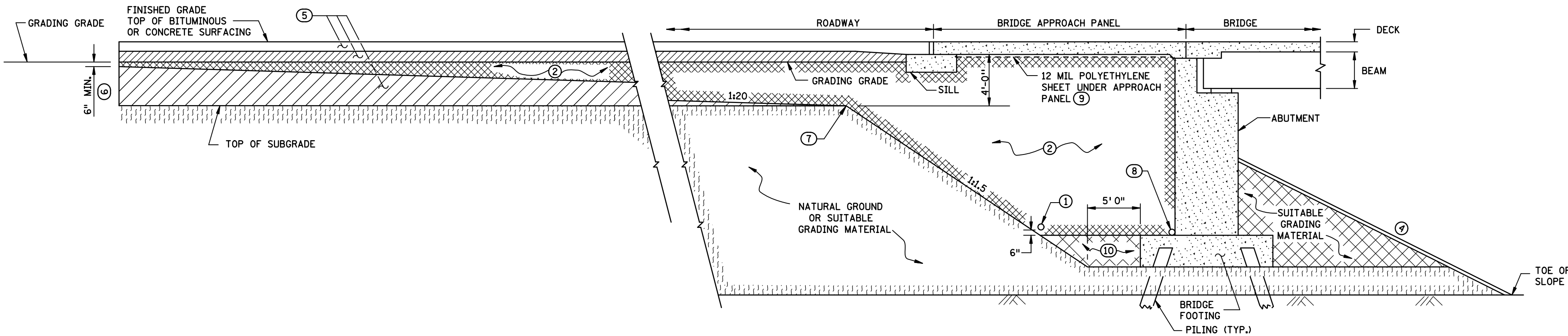
STANDARD SHEET NO. 5-297.632 (1 OF 4)
STANDARD APPROVED: MAY 31, 2006
TITLE: RETAINING WALL (LIVE LOAD SURCHARGE) SPREAD FOOTING GEOMETRY AND DATA
STATE PROJ. NO. (TH) SHEET NO. OF SHEETS

Table 5. Correlation results for sand. (Column A = Number in Table x Row B.)

A \ B	E_o tsf	E_R tsf	p^*_L tsf	q_c tsf	f_s tsf	N bl/ft
E_o tsf	1	0.125	8	1.15	57.5	4
E_R tsf	8	1	64	6.25	312.5	22.7
p^*_L tsf	0.125	0.0156	1	0.11	5.5	0.5
q_c tsf	0.87	0.16	9	1	50	5
f_s tsf	0.0174	0.0032	0.182	0.02	1	0.1
N bl/ft	0.25	0.044	2	0.2	10	1

Table 6. Correlation results for clay. (Column A = Number in Table x Row B.)

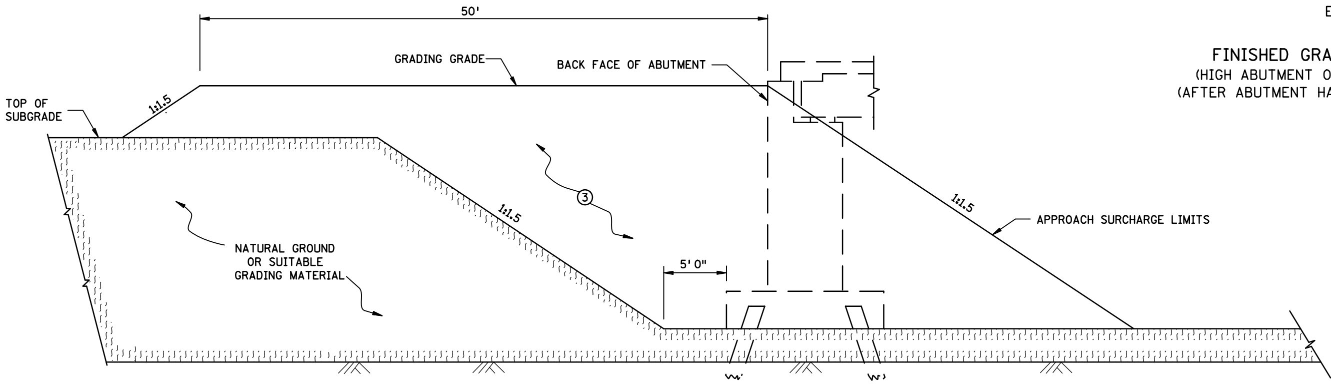
A \ B	E_o tsf	E_R tsf	p^*_L tsf	q_c tsf	f_s tsf	S_u tsf
E_o tsf	1	0.278	14	2.5	56	100
E_R tsf	3.6	1	50	13	260	300
p^*_L tsf	0.071	0.02	1	0.2	4	7.5
q_c tsf	0.40	0.077	5	1	20	27
f_s tsf	0.079	0.0038	0.25	0.05	1	1.6
S_u tsf	0.010	0.0033	0.133	0.037	0.625	1



ELEVATION

FINISHED GRADING SECTION

(HIGH ABUTMENT ON PILING SHOWN)
(AFTER ABUTMENT HAS BEEN CONSTRUCTED)



ELEVATION

ROUGH GRADING SECTION

(PRIOR TO ABUTMENT CONSTRUCTION)

NOTES:

1. SUBSURFACE PIPE DRAIN. SEE GRADING PLAN FOR DETAILS. FURNISH AND INSTALL IF SHOWN IN GRADING PLAN.
2. QUANTITY OF SELECT GRANULAR MATERIAL MODIFIED 10% IS BASED ON DIMENSIONS SHOWN, AND PAYMENT IS BASED ON THIS QUANTITY. SELECT GRANULAR MATERIAL MODIFIED 10% SHALL COMPLY WITH SPEC. 3149.2B2, MODIFIED TO 10% OR LESS PASSING THE NUMBER 200 SIEVE. SEE GRADING PLAN FOR QUANTITY. IF THE CONTRACTOR CHOOSES TO INCREASE DIMENSIONS IN ORDER TO FACILITATE CONSTRUCTION OPERATIONS, ANY QUANTITY INCREASES SHALL BE CONSIDERED INCIDENTAL.
3. PLACE ABUTMENT APPROACH SURCHARGE MATERIAL PRIOR TO ABUTMENT CONSTRUCTION. AFTER COMPLETION OF SURCHARGE WAITING PERIOD, REMOVE SURCHARGE AND EXISTING NATURAL GROUND OR SUITABLE GRADING MATERIAL TO THE LIMITS SHOWN IN "ROUGH GRADING SECTION" ABOVE, PRIOR TO ABUTMENT CONSTRUCTION. SEE BRIDGE PLANS AND SPECIAL PROVISIONS FOR ABUTMENT APPROACH SURCHARGE REQUIREMENT AND PAYMENTS.
4. SEE BRIDGE PLANS FOR SLOPE AND SLOPE PROTECTION.
5. SEE GRADING PLANS FOR TYPE OF MATERIAL.
6. GRADING TO BE SQUARED OFF ON SKEWED BRIDGES.
7. TOP OF 1:1.5 SLOPE (FORMS A LINE PARALLEL TO END OF BRIDGE).
8. SUBSURFACE PIPE DRAIN. FURNISH AND INSTALL AT TOP OF BRIDGE FOOTING IF BRIDGE DETAIL B910 IS INCLUDED ON BRIDGE PLAN.
9. IF THE APPROACH PANEL IS TIED TO THE ABUTMENT WITH REINFORCEMENT BARS, PLACE 12 MIL POLYETHYLENE SHEETING (OR TWO LAYERS OF OF 6 MIL) UNDER THE LIMITS OF THE APPROACH PANEL TO ALLOW THE PANEL TO MOVE LONGITUDINALLY ON THE GRADE. SHEETING IS INCIDENTAL.
10. SUITABLE GRADING MATERIAL SHALL HAVE SUITABLE MOISTURE CONTENT DURING PLACEMENT AND SHALL BE COMPACTED PER SPEC. 2105. SELECT GRANULAR MATERIAL MODIFIED 10% MAY BE USED IN LIEU OF SUITABLE GRADING MATERIAL.

STANDARD SHEET NO.: 5-297.233 (1 OF 2)	TITLE: BRIDGE ABUTMENT APPROACH TREATMENT FOR ABUTMENT ON FOOTING
STANDARD APPROVED: AUGUST 1, 2011	
STATE PROJ. NO.	(TH) SHEET NO. OF SHEETS

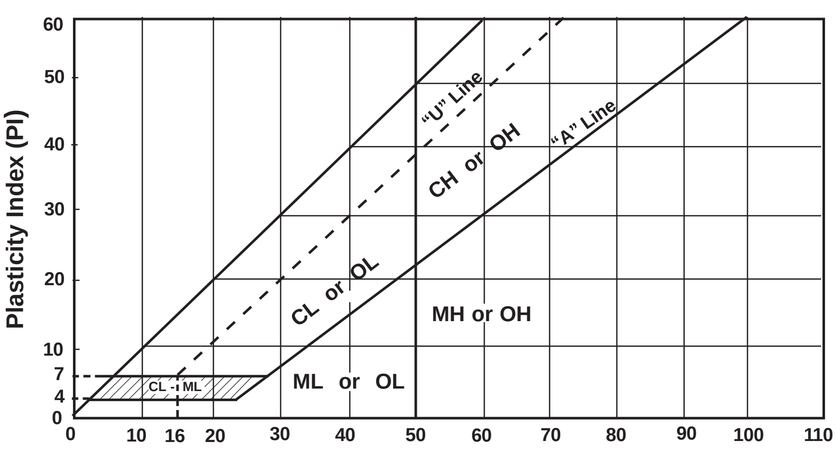
BRAUN INTERTEC

Descriptive Terminology of Soil

Standard D 2487 - 00
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels** 5% or less fines [e]	$C_u \ge 4$ and $1 \le C_c \le 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands** 5% or less fines [i]	$C_u \ge 6$ and $1 \le C_c \le 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	**Silts and Clays** Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line [j]	CL	Lean clay [k l m]
			PI < 4 or plots below "A" line [j]	ML	Silt [k l m]
		Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL OL	Organic clay [k l m n] Organic silt [k l m o]
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [k l m]
			PI plots below "A" line	MH	Elastic silt [k l m]
		Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH OH	Organic clay [k l m p] Organic silt [k l m q]
Highly Organic Soils		Primarily organic matter, dark in color and organic odor		PT	Peat

a. Based on the material passing the 3-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $\quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. 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
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines" to group name.
h. If soil contains ≥15% gravel, add "with gravel" to group name.
i. 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
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 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.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcf	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liqiuid limit, %	**C**	Cohesion, psf
PL	Plastic limit, %	∅	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders .... over 12"
Cobbles .... 3" to 12"
Gravel
  Coarse .... 3/4" to 3"
  Fine .... No. 4 to 3/4"
Sand
  Coarse .... No. 4 to No. 10
  Medium .... No. 10 to No. 40
  Fine .... No. 40 to No. 200
Silt .... < No. 200, PI < 4 or below "A" line
Clay .... < No. 200, PI ≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose .... 0 to 4 BPF
Loose .... 5 to 10 BPF
Medium dense .... 11 to 30 BPF
Dense .... 31 to 50 BPF
Very dense .... over 50 BPF

Consistency of Cohesive Soils

Very soft .... 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff .... 17 to 30 BPF
Hard .... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers unless noted otherwise, Jetting water was used to clean out auger prior to sampling only where indicated on logs. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous-flight, solid-stem augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface and are, therefore, somewhat approximate. Power auger borings are designated by the prefix "B."

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn. Hand auger borings are indicated by the prefix "H."

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

BRAUN INTERTEC

Descriptive Terminology
Cone Penetration Test

This document accompanies Cone Penetration Test Data. Please refer to the Boring Log Descriptive Terminology Sheet for information relevant to conventional v. Cone Penetration Test (CPT) boring logs.

Cone Penetration Test (CPT) sounding was performed in general accordance with ASTM D 5778 and consistent with the ordinary degree of care and skill used by reputable practitioners of the same discipline currently practicing under similar circumstances and in the same locality. No warranty, express or implied, is made.

Since subsurface conditions outside each CPT sounding are unknown, and soil, rock and pore water conditions cannot be relied upon to be consistent or uniform, no warranty is made that conditions adjacent to each sounding will necessarily be the same as or similar to those shown on this log. Braun Intertec is not responsible for any interpretations, assumptions, projections or interpolations of the data made by others.

Pore water pressure measurements and subsequently interpreted water levels shown on CPT logs should be used with discretion as they represent dynamic conditions. Dynamic pore water pressure measurements may deviate substantially from hydrostatic conditions, especially in cohesive soils. In cohesive soils, pore water pressures often take an

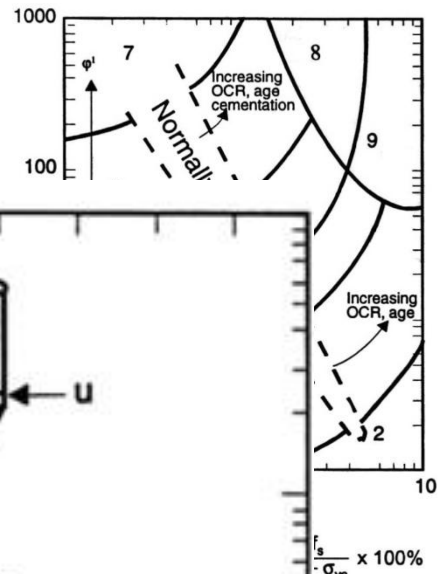
SBT SOIL BEHAVIOR TYPE

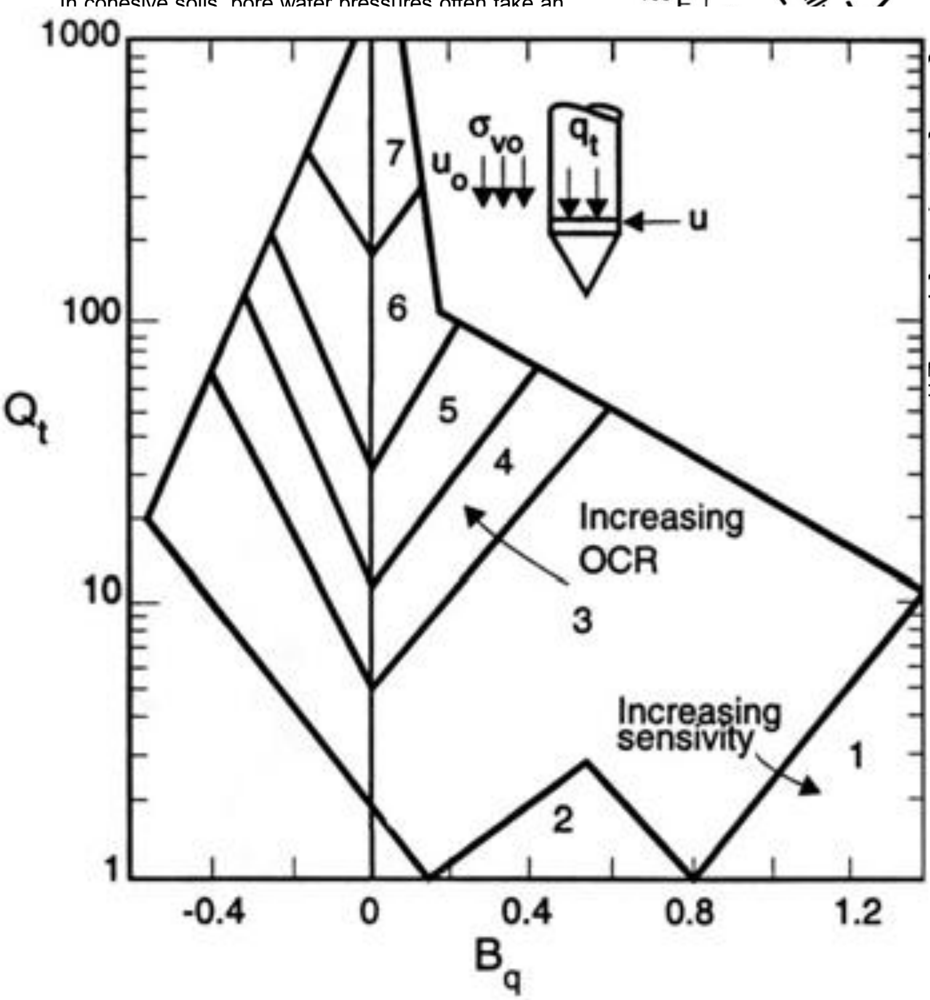
Soil Identification methods for the Cone Penetration Test are based on correlation charts developed from observations of CPT data and conventional borings. Please note that these identification charts are provided as a guide to Soil Behavior Type and should not be used to infer a soil classification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

Engineering judgment and comparison with augered borings is especially important in the proper interpretation of CPT data in certain geo-materials.

The following charts provide a Soil Behavior Type for the CPT Data. The numbers corresponding to different regions on the charts represent the following soil behavior types:

Soil Behavior Type based on friction ratio





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

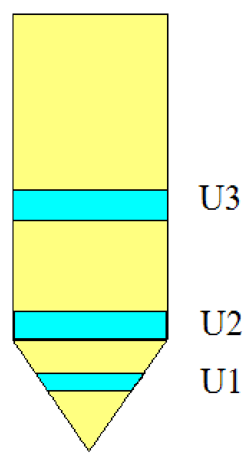
Soil Behavior Type based on pore pressure

Robertson CPT 1990

1 Sensitive, Fine Grained
2 Organic Soils - Peat
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

U2 PORE WATER MEASUREMENTS

Pore water measurements reported on CPT logs are representative of pore 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 represent dynamic pore water pressures due to the local disturbance caused by the cone tip. Dynamic pore water pressure decay and static pore water pressure measurements are reported on a Pore Water Pressure Dissipation Graph.



Appendix F

Bridge over I-494

BRAUN INTERTEC

Braun Intertec Corporation
11001 Hampshire Avenue S
Minneapolis, MN 55438

Phone: 952.995.2000
Fax: 952.995.2020
Web: braunintertec.com

August 29, 2014 Project BL-13-00213

Mr. Don Demers
Southwest Light Rail Transit Project Office
6465 Wayzata Boulevard, Suite 500
St. Louis Park, MN 55426

Re: Foundation Analysis Design Recommendation Report
Bridge over I-494 – 90% Design
STA 2139+21 to STA 2141+14
Southwest LRT, West Segment 1
Eden Prairie, Minnesota

Dear Mr. Demers:

Braun Intertec has completed the requested drilling and geotechnical evaluation for the proposed light rail bridge over I-494 parallel to existing Bridge 27762 on Flying Cloud Drive in Eden Prairie, Minnesota. The following sections include bridge foundation and approach embankment support, discussions, and recommendations.

This report is part of a larger series of reports for the west segment of the Southwest Light Rail Transit (SWLRT) project. Recommendations for retaining wall (RTW-113), general track construction, and pole foundations for the Overhead Contact System (OCS) will be addressed in separate reports.

A. Project information

The proposed bridge over I-494 consists of a multi-span bridge for use by light rail trains over I-494 and parallel to existing Bridge 27762 on Flying Cloud Drive in Eden Prairie, Minnesota.

The light rail bridge will consist of two abutments with one center pier. Prestressed concrete beams are proposed to support a cast-in-place concrete deck. The bridge is planned to be approximately 34 feet wide. The existing bridge is approximately 186 feet long, and the preliminary engineering plans show the light rail bridge to be approximately 195 feet long.

A.1. Type of Structures

This design report includes recommendations for bridge foundation and approach embankment support for the bridge carrying light rail trains over I-494. The abutments and center pier are anticipated to be supported on cast-in-place concrete filled pipe piles.

A.2. Location of Bridge

The bridge is proposed to span I-494 approximately 0.2 miles east of the Junction of I-494 and Trunk Highway (TH) 212 in Eden Prairie, Minnesota.

A.3. Other Information

We understand the light rail bridge will not be structurally connected to the existing bridge, but will be within approximately 10 feet of the existing bridge.

Temporary shoring of embankments adjacent to the existing bridge structure will be required to facilitate construction.

The design team discussed the use of spread footing foundations to support the new structure. While the soils appear suitable to support the anticipated loads, the proximity and design of the abutment will result in a loading condition that will negatively influence the existing battered piles of the adjacent bridge. Therefore, alternative foundation support methods are being explored.

To construct the bridge, embankment grade increases of 15 to 20 feet for the abutments will be necessary. Grade raises of this magnitude will influence the design and construction of the proposed bridge foundation types. The effects of the embankment stresses are accounted for in our foundation design recommendations.

B. Subsurface Investigation Summary

B.1. Summary of Borings Taken

Three foundation borings (2120SB, 2121SB, and 2122SB) were completed in the vicinity of the proposed bridge abutments and center pier by Braun Intertec. The number, function, and approximate track station of the soils borings are provided in the table below. Copies of the Log of Borings are included in the Appendix of this report.

Table 1. Soil Boring Location and Function

Boring	Soil Boring Function	Approximate Track Stationing
2120SB	South Abutment	2139+40
2121SB	Center Pier	2140+10
2122SB	North Abutment	2141+00

B.2. Description of Foundation Soil and Rock Conditions

South Abutment Boring:

Boring 2120SB was performed at the south abutment at elevation 883.7 and was offset approximately 50 feet west of the existing bridge due to overhead and underground utility conflicts. The boring encountered approximately 1/2-foot of topsoil over glacial clays to a depth of 29 feet below the ground surface. Beneath the clay, glacially deposited sands and silts were encountered to the termination depth of the boring at 66 feet. The glacial soils consisted of poorly graded sand, poorly graded sand with silt, silty sand, sandy silt, lean clay with sand, and sandy lean clay.

Center Pier:

Boring 2121SB was performed at the center pier at elevation 884.5. The boring encountered 5 inches of bituminous over a mix of sand fill to a depth of 12 feet below the ground surface. Beneath the fill, glacially deposited sands and silts with occasional layers of clay were encountered to the termination depth of the boring at 76 feet. The fill consisted of poorly graded sand with silt and silty sand. The glacial soils consisted of poorly graded sand, poorly graded sand with silt, silty sand, sandy silt, lean clay and sandy lean clay.

North Abutment Boring:

Boring 2122SB was performed at the north abutment at elevation 885.7. The boring encountered approximately 2 feet of topsoil over fill to a depth of 19 feet below the ground surface. This may be a result of deep utilities in the area. A layer of organic clay was encountered from 12 to 17 feet. Beneath the fill, glacial clays were encountered to a depth of 37 feet. Below the clays, glacially deposited sands and silts with an occasional layer of clay were encountered to the termination depth of the boring at 76 feet. The fill consisted of poorly graded sand, poorly graded sand with silt, clayey sand, sandy lean clay, and organic clay. The glacial soils consisted of poorly graded sand, poorly graded sand with silt, clayey sand, lean clay, and sandy lean clay.

Penetration Resistance Values:
Penetration resistance values recorded in the fill ranged from 3 to 16 blows per foot (BPF), indicating the fill soils were variably compacted. Penetration resistance values recorded in the glacial clays ranged from 3 to 70 BPF, indicating the soils were soft to hard (generally rather stiff to hard). Penetration resistance values recorded in the glacial sands and silts ranged from 28 to 103 BPF, indicating the soils were medium dense to very dense.

B.3. Summary of Water Level Measurements

Groundwater was only measured at Boring 2120SB and was observed at a depth of 42 feet, or elevation 842 feet above Mean Sea Level (MSL). Seasonal and annual fluctuations of groundwater, however, should be anticipated.

Waterbearing sands were encountered 38 feet below grade at Boring 2121SB corresponding to an elevation of 846 1/2. Pockets of water are likely trapped on top and between dense, low permeability soils.

B.4. Interpretation of Water Level

Groundwater was only encountered in one boring during drilling operations. The boreholes were only open for a short period of time and groundwater was likely not able to reach its static elevation prior to the conclusion of drilling activities.

However, based on the assumed pile cap elevations and the encountered groundwater from the soil borings, we do not anticipate that groundwater will affect construction activities.

C. Foundation Analysis

Poor soils were encountered to a depth of 22 to 26 feet below the surface at Boring 2122SB corresponding to an elevation of 864 to 859 1/2. This elevation is appreciably below the bottom of the north abutment and wing walls which have bottom of pile cap elevations varying from 881 to 888.

A new embankment, resulting in a grade increase of 15 to 20 feet is anticipated near the north and south abutments of the proposed bridge. Based on the fill heights, a soil load of this magnitude will produce settlements within the existing soils, causing a downdrag condition on the existing battered piles beneath the roadway bridge. MnDOT discourages the placement of additional loads next to existing battered piles. Therefore, an embankment constructed of soil will not be possible. Alternative methods of supporting the abutments were evaluated including lightweight fill, a structurally supported bridge deck creating a "hollow box" for the abutments, or reconfiguring the locations of piers and abutments to redistribute the bridge loads.

Based on the soil conditions encountered in the borings and the proximity of the existing bridge to the proposed light rail bridge, the current preferred foundation option for the proposed bridge abutments, piers and wing walls is pile foundations.

C.1. Embankment and Slopes – Bridge and Abutments

The proposed light rail bridge will require the construction of approach embankments and wing walls. These walls are proposed to be Cast-In-Place (CIP) concrete walls used to retain embankment backfill material placed at or near the north and south sides of the proposed bridge.

C.1.a. Embankment Settlement

Based on the anticipated fill heights of up to 15 to 20 feet for the north and south embankments, total settlement magnitudes will exceed 1/2-inch using imported granular fill, which will result in adding downdrag forces on the existing piles. Therefore, to reduce settlement from new loads on the underlying soils, alternative methods to construct the embankment will be required. Please refer to Section C.6.b of this report.

C.2. Embankment and Slopes – Walls (RTW-W113)

The retaining wall (RTW-W113) associated with the roadway embankments will be addressed in a separate report.

C.3. Pile Foundations – Bridge Abutment, Piers and Wing Walls

C.3.a. Nominal Resistance at Given Tip Elevations (Compression)

For bridge and wing wall support, we calculated the nominal resistance of the piles in compression. Currently, a tension resistance line is not provided on the Nominal Bearing Graphs attached to this report. If piles will experience tension loads, please let us know and we'll revise our recommendations accordingly. Please refer to the Nominal Resistance Graphs and Section C.4.b.1 for the calculation method.

C.3.b. Calculate and Consider Downdrag and Lateral Squeeze

Based on the alternative embankment recommendations in Section C.6.b for the abutments and no raise in grade anticipated in the area of the proposed piers, we do not anticipate downdrag forces will contribute additional load to the piles.

Lateral squeeze can occur if the unit weight of the fill multiplied by the fill height is greater than three times the undrained shear strength of the subgrade soils. Due to the general granular and dense nature of the soil encountered at the north and south embankments, we do not anticipate that lateral squeeze will be an issue.

C.3.c. Lateral Earth Pressure Calculations for P-Y Curves and Lateral Earth Forces

The following tables provide earth pressure soil parameters for lateral pile analysis and p-y curve generation using the current version of the computer program LPILE. Based on the soils encountered in Boring 2122SB, we recommend using the default lateral modulus of subgrade reaction values included in LPILE. We assumed a bottom-of-pile-cap (BOPC) elevation of 881 feet, as shown in the table.

Table 2. Soil Parameters for p-y Curve Generation – North Abutment

Layer Top Depth Below BOPC Elevation (feet)	Layer Bottom Depth Below BOPC Elevation (feet)	Effective Unit Weight (pounds per cubic foot)	Internal Angle of Friction (degrees)	Undrained Shear Strength (pounds per square foot)	Material Type
0	2	120	30	NA	Sand (Reese)
2	7	126	NA	750	Soft Clay
7	12	110	NA	500	Soft Clay
12	22	120	NA	500	Soft Clay
22	32	135	NA	1500-3300	Stiff Clay w/o free water
32	42	70	40	NA	Sand (Reese)
42	59	58	38	NA	Sand (Reese)
59	63	65	40	NA	Sand (Reese)
63	68	60	NA	8300	Stiff Clay with free water
68	71	65	40	NA	Sand (Reese)

C.3.d. Tip Elevation, Casing Requirement, Estimates of Overdrive

We recommend driving the proposed pipe pile sections to elevations shown in Section D.4 and the attached resistance graphs for driven pile. The table below shows approximate bottom-of pile-cap elevations based on plans provided by SPO.

Table 3. Estimated Bottom of Pile Cap Elevations

Substructure	Approximate Bottom-of-Pile-Cap Elevation (feet)
South Abutment	882
South Abutment Wing Wall	887
Center Pier	878
North Abutment	881
North Abutment Wing Wall	886

C.4. Summarize Design Assumptions – Driven Piles

C.4.a. Bridge Loading Information (Axial and Horizontal)

Please refer to Section D.1 and D.4 for anticipated pile loads and resistances.

C.4.b. Design Methodologies – Pile-Supported Structures

C.4.a.1. Pile Capacity – LRFD (I-494 Bridge)

We used the computer program UniPile, version 5.0.0.33, to estimate the static nominal geotechnical resistance (R_n) of the 12.0-inch outside-diameter, 1/4-inch thick wall, closed-ended pipe piles for support of the bridge abutments and pier. UniPile software was developed by UniSoft Geotechnical Solutions Ltd. and can calculate pile resistance using a variety of methods.

For our analysis, we utilized the Beta-method, an effective stress method, to estimate the static geotechnical resistance for these pile. This method determines shaft resistance using Bjerrum-Burland beta coefficients (β), which are based on soil type and effective friction angle. We estimated the β values for each layer using Figure 9.20 from the Federal Highway Administration (FHWA) Publication No. NHI-05-042, Design and Construction of Driven Pile Foundations, April 2006. The Beta-method determines end bearing resistance using toe bearing capacity factors (N_t), which are also based on soil type and effective friction angle. We estimated the N_t values from Table 9-6 of the April 2006 FHWA publication identified previously.

C.4.a.2. Downdrag

We do not expect down drag will act on the existing or new piles for the abutments and piers as no raise in grade or embankment construction is anticipated in the areas of the proposed structures.

C.5. Summarize Design Assumptions – Abutment Construction

C.5.a. Embankment Heights, Unit Weights, Side Slopes, and End Slopes

Based on the preliminary design information, finished grade at the north and south bridge abutments will be 15 to 20 feet above existing grades. Soil loads of this magnitude will produce settlements in excess of 1/2-inch, which will produce downdrag forces on the existing battered piles. To reduce settlement and down drag potential, alternative foundation methods are being explored and will be discussed further in Section C.6 of this report.

C.5.b. Wall Loading Information

Bridge abutments and wing walls are assumed to be pile supported.

C.6. Construction Considerations

C.6.a. Design of Temporary and Permanent Slopes

The existing foundation/embankment soils are generally sandy with angles of internal friction of 28 degrees or greater. The permanent slopes can match the existing slopes, except they must be not steeper than 1V:2H. The granular borrow is anticipated to have an angle of internal friction of approximately 30 degrees. This soil could be temporarily placed at a slope of 1V:1.5H, but must be limited to 1V:2H or flatter for the permanent condition.

C.6.b. Embankment Construction Recommendations

Based on settlement limitations due to the existing piles, the light rail bridge abutments must provide a negligible stress increase in the underlying soils. To achieve this condition, the following embankment construction options are discussed.

C.6.b.1. Lightweight Fill

By replacing conventional granular fill material weighing 120 pcf with blocks of Expanded Polystyrene, know as EPS, or more commonly known as Geofoam, weighing 1.5 pcf, the approach embankment can be constructed according to plan without producing significant settlement causing downdrag on the existing battered piles. The EPS should be wrapped in poly to protect it from fuel and chemicals which may break down the polystyrene. Additionally, a layer of sand and aggregate should be placed on top of the EPS to provide a working platform for the placement of concrete. Typical thicknesses of this layer are approximately two feet, but can vary. The placement of EPS should extend the full length of the embankment.

C.6.c. Structurally Supported Bridge Deck

An alternative to using lightweight fill would be to span the abutments with a concrete deck to carry the bridge loads and transfer them to the wing walls, leaving a void space beneath the deck (where soil or lightweight fill would commonly be placed). This approach would create a zero increase in the underlying soils and eliminate the potential downdrag on the existing piles. The top span of the bridge should be designed to sufficiently support the design loads and may require a structural connection to the wing walls. Consideration should also be given to sealing all joints associated with this construction so soil, debris, or animals cannot enter the interior of the structure over time.

C.6.d. Construction Staging Requirements

Based on the close proximity of the north bridge abutment and retaining wall RTW-113, final staging is to be determined once final design and foundation designs for both the abutments and walls are concluded.

C.6.e. Demolition

All existing pavement and structures, associated fill subgrades, and associated deleterious material where proposed structures and oversize areas are to be located must be fully removed and replaced with suitable engineered fill.

D. Foundation Recommendations – Deep Foundations

D.1. Bearing Resistances and Associated Resistance/Safety Factors

Please refer to Appendix B for nominal bearing resistances for driven pile for bridge abutment and pier support. For situations where subsurface exploration and static calculations have been completed, we recommend that the following φ_{dyn} factors be used for LRFD Design.

Table 4. Recommended Pile Driving Resistance Factors (ϕ_{dyn})

Specified Construction Control	ϕ_{dyn}
MnDOT Pile Formula 2012 (MPF12) for Pipe Pile Sections	0.50
Wave Equation and Pile Driving Analyzer (PDA)	0.65

D.2. Uplift Capacity/Resistance

Currently, a tension resistance line is not provided on the Nominal Bearing Graphs attached to this report. If piles will experience tension loads, please let us know and we'll revise our recommendations accordingly.

D.3. Recommended Design Soil Parameters (e.g., Coefficient of Friction, Lateral Earth Pressure Coefficients, etc.)

The recommended soil parameters to be used for design are as follows:

Table 5. Recommended Design Soil Parameters

Soil Type	Angle of Internal Friction (degrees)	Effective unit Weight (pcf)	Coefficient of Sliding Friction Rough Concrete	Active Earth Pressure Coefficient	At-Rest Earth Pressure Coefficient
Select Granular Borrow	35	120	0.6	0.27	0.43
Granular Borrow	30	120	0.5	0.33	0.50
Existing Non-organic granular Fill	30	125	0.5	0.33	0.50
Existing Clay Fill	28	130	0.5	0.36	0.53

D.4. Recommended Pile Size, Length, and Tip Elevation

D.4.a. Bridge Abutments, Pier and Wing Walls

The following tables summarize the anticipated pile depths based on the factored load ($\Sigma\gamma Q_n$) for 12.0-inch, outside-diameter pipe pile with a wall thickness of 1/4-inch. The tables provide a PDA length (i.e., φ_{dyn} of 0.65) and a MPF12 formula length (i.e., φ_{dyn} of 0.50) for each location. We assumed a cutoff elevation of about 1 foot above the anticipated bottom-of-pile-cap elevation. Please refer to the attached nominal bearing resistance graphs for a detailed profile of pile resistances as a function of depth.

Table 6. Summary of Anticipated Pile Lengths, CIP 12.0" x 1/4", $\Sigma\gamma Q_n$=140 tons, PDA

Substructure	Boring	Anticipated Cutoff Elevation (feet)	R_n (tons)	Approximate Tip Elevation (feet)	Approximate Pile Length (feet)
South Abutment	2120SB	883	215 [430 kips]	853	30
South Abutment Wing Walls	2120SB	887	215 [430 kips]	853	35
Center Pier	2121SB	879	215 [430 kips]	844	35
North Abutment	2122SB	882	215 [430 kips]	847	35
North Abutment Wing Walls	2122SB	886	215 [430 kips]	847	40

Table 7. Summary of Anticipated Pile Lengths CIP 12.0" x 1/4", $\Sigma\gamma Q_n$= 140 tons, MPF12

Substructure	Boring	Anticipated Cutoff Elevation (feet)	R_n (tons)	Approximate Tip Elevation (feet)	Approximate Pile Length (feet)
South Abutment	2120SB	883	280 [560 kips]	853	30
South Abutment Wing Walls	2120SB	887	280 [560 kips]	853	35
Center Pier	2121SB	879	280 [560 kips]	839	40
North Abutment	2122SB	882	280 [560 kips]	847	35
North Abutment Wing Walls	2122SB	886	280 [560 kips]	847	40

We evaluated the lateral resistance of the pile under the strength limit state using a factored axial load of 140 tons (280 kips) and a factored lateral load resistance (ϕR_{nh}) of 12 tons (24 kips) for a 12.0-inch closed ended pile section with a 1/4-inch wall thickness. Please refer to the Appendix for the resulting moments within the pile at the factored loads. Under the reported factored loads, the anticipated lateral deflection of the pile top is less than 1 inch. Therefore, we expect the lateral pile top deflection under service loads will also be less than 1 inch.

D.5. Recommended Slope Angles

We recommend designing permanent side and end slopes of approximately 1:3 or 1:2 (V:H), respectively. With the proposed slope protection, these slopes have a Factor of Safety against global failure in excess of 1.5.

D.6. Temporary Slopes and Shoring Limits

Temporary shoring is noted on the plans at the north and south abutment on the south side of the proposed bridge. Temporary slopes are recommended to be constructed at 1V:1.5H or shallower. Temporary slopes constructed in natural material are recommended to be constructed at 1V:2H or shallower. In a temporary condition; these slopes have a Factor of Safety against global failure in excess of 1.3. Please refer to our soil parameters in Section D.3.

D.7. Topsoil, Fill, and Poor Soil Excavations

In accordance with MnDOT Standard Specification 2105, we recommend stripping existing vegetation, organic topsoil, and non-mineral debris prior to placement of the abutments and wing walls. The slopes must be benched where they are steeper than 1:4 to a bottom that is flatter than 1:4.

D.8. Trench Excavation Slopes

Please refer to Section D.6 Temporary Slopes and Shoring Limits.

D.9. Temporary Slopes and Shoring Limits

Please refer to Section D.6 Temporary Slopes and Shoring Limits.

E. Material Classification and Testing

E.1. Visual and Manual Classification

The geologic materials encountered were visually and manually classified in accordance with ASTM Standard Practice D 2488. A chart explaining the classification system is attached. Samples were placed in jars or bags and returned to our facility for review and storage.

E.2. Laboratory Testing

The results of the laboratory tests performed on geologic material samples are noted on or follow the appropriate attached exploration logs. The tests were performed in accordance with ASTM or AASHTO procedures.

E.3. Groundwater Measurements

The drillers checked for groundwater as the penetration test borings were advanced. The boreholes were then backfilled or sealed with bentonite grout as noted on the boring logs.

F. Qualifications

F.1. Variations in Subsurface Conditions

F.1.a. Material Strata

Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth, and therefore, strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions, and can be expected to vary in depth, elevation and thickness away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed, or construction commences. If any such variations are revealed, our recommendations should be re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

F.1.b. Groundwater Levels

Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

F.2. Continuity of Professional Responsibility

F.2.a. Plan Review

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

F.2.b. Construction Observations and Testing

It is recommended that we be retained to perform observations and tests during construction. This will allow correlation of the subsurface conditions encountered during construction with those encountered by the borings, and provide continuity of professional responsibility.

F.3. Use of Report

This report is for the exclusive use of Southwest Light Rail Transit. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

G. General

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If there are questions regarding these bridge foundation recommendations, please call Joshua Kirk at 952.995.2222 or jkirk@braunintertec.com or Ray Huber at 952.995.2260 or rhuber@braunintertec.com.

Sincerely,

BRAUN INTERTEC CORPORATION

Professional Certification:
I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Joshua L. Kirk, PE
Associate Principal - Project Engineer
License Number: 45005

Reviewed by:

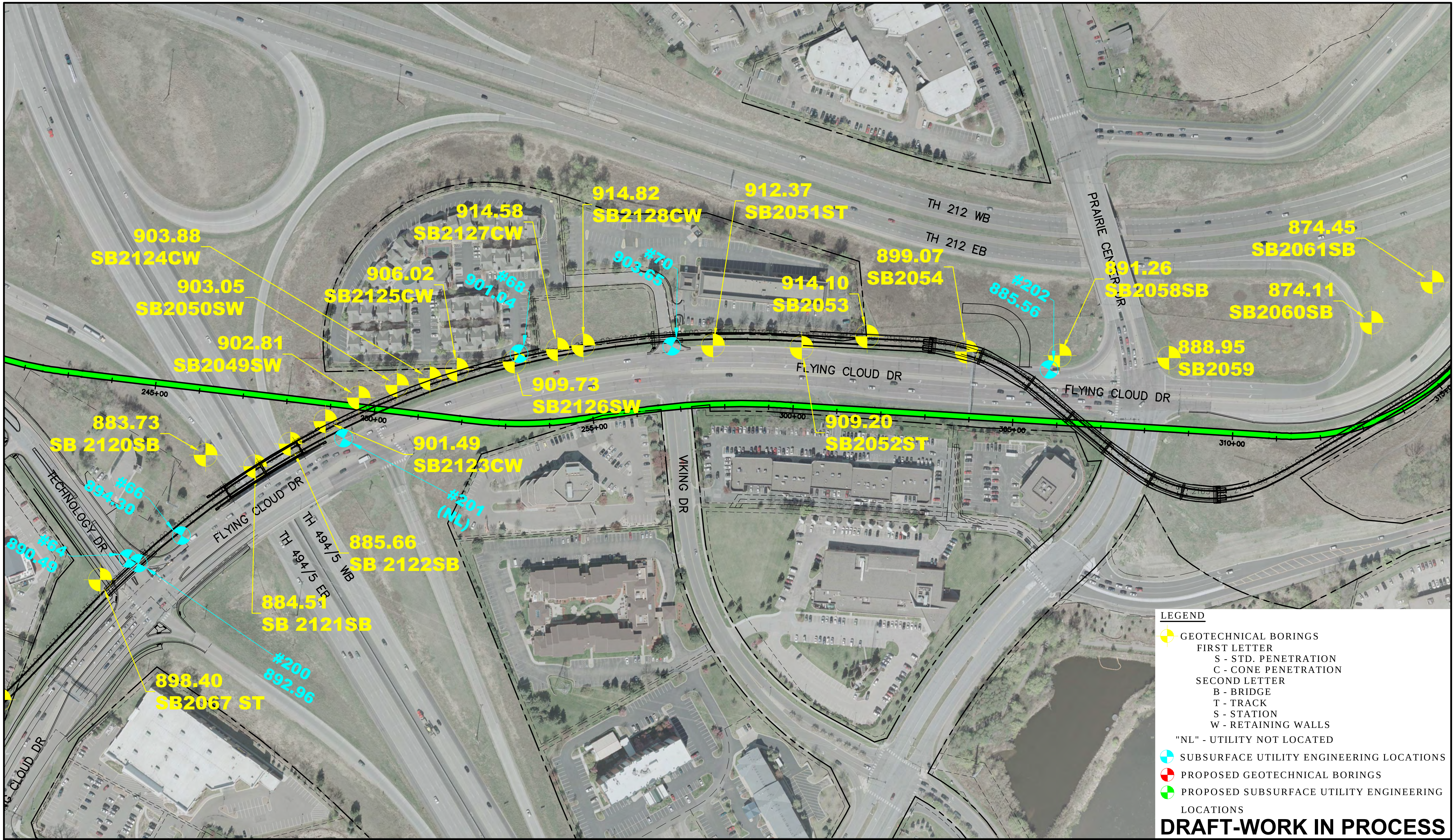
Ray A. Huber, PE
Vice President - Principal Engineer

Reviewed by:

Matthew P. Ruble, PE
Principal Engineer

Appendix:
Boring Location Sketch
Preliminary Engineering Plan and Profile Sheets - Bridge over I-494
Standard Penetration Test Borings (2120SB, 2121SB, 2122SB)
Nominal Resistance Graphs
Lateral Pile Analysis Results
Publication No. FHWA-IP-89-008 N_{60} Correlation Tables
SPT Descriptive Terminology

APPENDIX



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SOUTHWEST Green Line LRT Extension

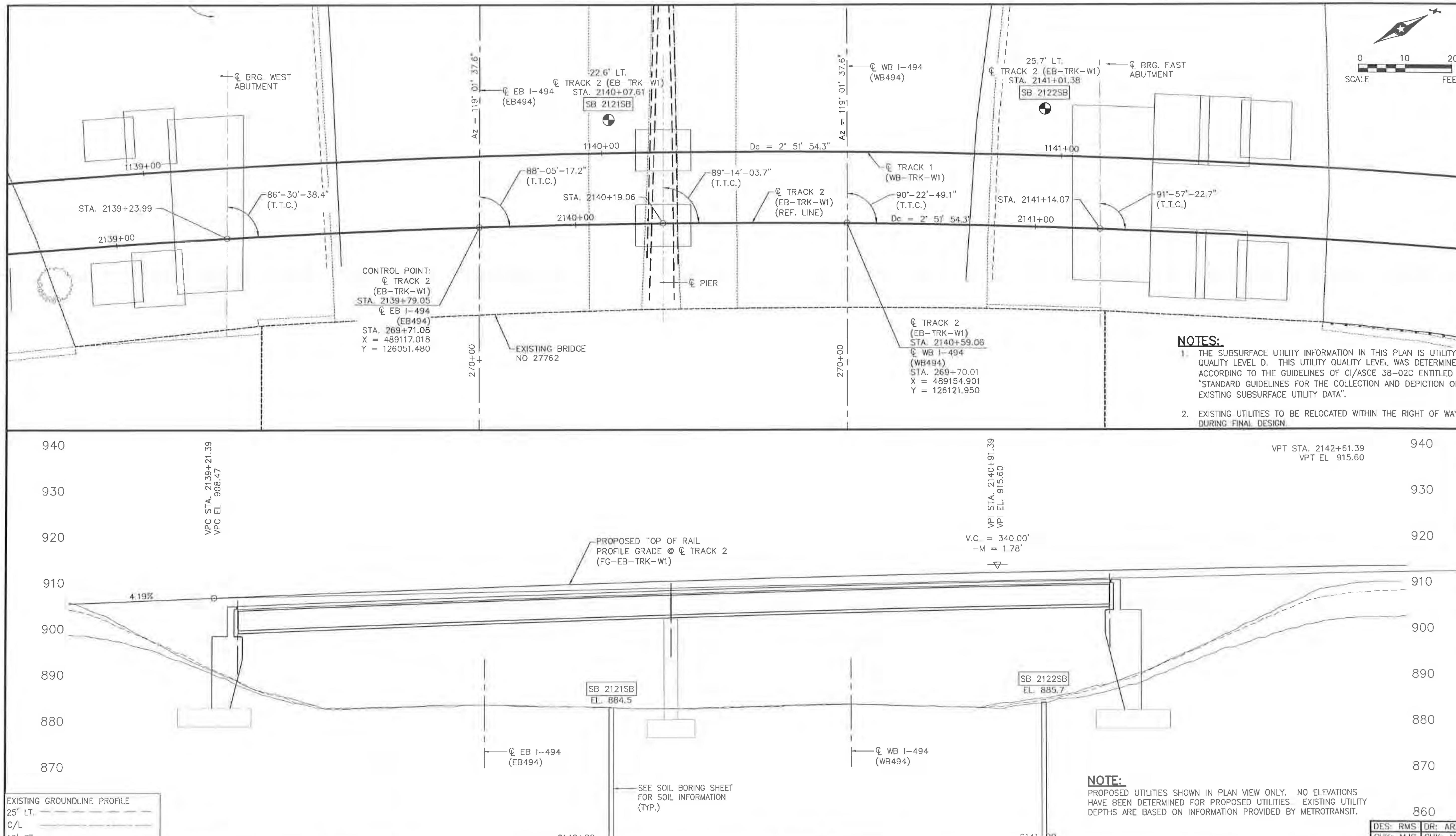
SOUTHWEST LIGHT RAIL

SOIL BORINGS
SHEET 5 OF 12

IRT: N/A
REV: 0
DATE: 06/30/2014

NORTH
0 50 100 200

METROPOLITAN COUNCIL
AECOM
SRF Consulting Group, Inc.



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DES: RMS	DR: ARH
CHK: MJC	CHK: MJC

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

AECOM SRF Consulting Group, Inc.

PERLIMINARY ENGINEERING

METROPOLITAN COUNCIL SOUTHWEST Green Line LRT Extension

WEST SEGMENT 1
BRIDGE OVER I-494
BRIDGE XXXXX (LRT)
PLAN AND PROFILE

DISCIPLINE: STRUCTURES

SHEET NAME: W1-STU-BRG-BOR

SHEET 29 OF 197

920
915
910
905
900
895
890
885
880
875
870
865
860
855
850
845
840
835

BORINGS IN PROGRESS

NOTES:

THE MATERIAL DESCRIPTIONS ARE CLASSIFIED ACCORDING TO THE UNIFIED SOIL CLASSIFICATION SYSTEM. DETAILS ON THE SYSTEM CAN BE FOUND IN THE FADR AND IN ASTM:D2488. THE SOIL GROUP CATEGORY PER THE AASHTO SOIL CLASSIFICATION SYSTEM IS ALSO SHOWN.

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

DES: RMS | DR: ARH
CHK: MJC | CHK: MJC

AECOM
SRF Consulting Group, Inc.

PERLIMINARY ENGINEERING

METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extension

WEST SEGMENT 1
BRIDGE OVER I-494
BRIDGE XXXXX (LRT)
SOIL BORINGS

DISCIPLINE: STRUCTURES
SHEET NAME: W1-STU-BRG-BOR

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2120SB	883.7 (Surveyed)

Location: Hennepin Co. Coordinate: X=489000 Y=126054 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7506

Hammer CME Automatic Calibrated

Drilling Completed 5/29/14

DEPTH	Depth / Elev.	Classification	Drilling Operation	SPT N60	MC (%)	Other Tests Or Remarks
	0.4 / 883.3	SANDY LEAN CLAY, trace roots, dark brown, moist, (CL), topsoil			19	
		LEAN CLAY with SAND, trace Gravel, with frequent layers of Sand and Silt, brown and gray with iron stains, moist to 12 feet then wet, very stiff to hard, (CL), till		21	13	
5				29	15	
				17	20	LL=23; PL=15; PI=8
10				19	19	Switched to mud rotary drilling method after 10-foot sample.
		Layer of Silt encountered at 12 feet.	PD	33	24	
	14.0 / 869.7	SANDY LEAN CLAY, trace Gravel, brownish gray to 17 feet then gray, moist to wet, very stiff to hard, (CL), till	PD			
15				23	17	
			PD	37	14	qu=2 1/4 tsf
20			PD	32	14	After 20-foot sample, switched back to auger.
				33	12	DD=127 pcf
25				57	15	qu=3 1/2 tsf
				40	12	
	29.0 / 854.7	SILTY SAND, fine- to medium-grained, trace Gravel, with frequent layers of Lean Clay and Silt, brown, moist, very dense, (SM), till				
30				53	16	
				60	9	P200=29%
35	35.0 / 848.7	POORLY GRADED SAND, fine- to medium-grained, trace Gravel, brown, moist, very dense to dense, (SP), outwash		57	6	
				46	6	
40				39	12	
▼	42.0 / 841.7	SANDY SILT, with frequent layers of Silty Sand, brown, waterbearing, dense, (ML), till		33		
45						

Other column headings: COH (psf), γ (pcf), Soil; REC (%), RQD (%), ACL (ft), Core Breaks, Rock, Formation or Member.

Index Sheet Code 3.0

(Continued Next Page)

Soil Class:J. Kirk Rock Class: Edit: Date: 8/21/14

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2120SB**	**883.7** *(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
	47.0 / 836.7		SANDY SILT, with frequent layers of Silty Sand, brown, waterbearing, dense, (ML), till *(continued)*		38	26				
	49.0 / 834.7		POORLY GRADED SAND, fine- to medium-grained, brownish gray, moist, very dense, (SP), outwash		53	22				P200=4%
50					57	20				
55	58.0 / 825.7		SANDY SILT, with frequent layers of Silty Sand, brownish gray, wet, very dense, (ML), till		51	21				DD=111 pcf
60	63.0 / 820.7		SILTY SAND, fine- to medium-grained, brown, wet, very dense, (SM), till		51	23				
65	66.0 / 817.7		SANDY SILT, with frequent layers of Silty Sand, brownish gray, wet, dense, (ML), till		46	21				DD=115 pcf; LL=17; PL=14; PI=3

Bottom of Hole - 66 feet.
Water observed at a depth of 42 feet while drilling.
Boring immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2121SB	884.5 (Surveyed)

Location: Hennepin Co. Coordinate: X=489110 Y=126087 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7514

Hammer CME Automatic Calibrated

SHEET 1 of 2

Drilling Completed 5/21/14

DEPTH	Depth / Elev.	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
	0.4 / 884.1	5 inches of bituminous.			7			Full flight sampling was utilized due to restricted work zone hours.
	2.0 / 882.5	SILTY SAND, fine- to medium-grained, with Gravel, dark brown, moist, (SM), fill						
	4.0 / 880.5	POORLY GRADED SAND with SILT, fine-grained, brown, moist, (SP-SM), fill						
5				16	11			P200=19%
10	12.0 / 872.5	SILTY SAND, fine- to medium-grained, trace Gravel, dark brown and gray, moist, (SM), possible fill		8	12			
15				16	12			
20				28	13			Switched to mud rotary drilling method after 20-foot sample.
			PD					
25				19	17			P200=20%
			PD					
30				16	17			
	33.0 / 851.5	SILTY SAND, fine- to medium-grained, brown, moist to 25 feet then wet, medium dense, (SM), till	PD					
35				12	22			DD=109 pcf
	38.0 / 846.5	SANDY LEAN CLAY, trace Gravel, with Sand seams, brown, wet, rather stiff, (CL), till	PD					
40				53	13			
			PD					
45		POORLY GRADED SAND with SILT, fine- to medium-grained, brown, waterbearing, very dense to medium dense, (SP-SM), outwash						

Index Sheet Code 3.0

(Continued Next Page)

Soil Class:J. Kirk Rock Class: Edit: Date: 8/21/14

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BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2121SB**	**884.5** *(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
			POORLY GRADED SAND with SILT, fine- to medium-grained, brown, waterbearing, very dense to medium dense, (SP-SM), outwash *(continued)*	X	23	17				
				PD						
50				X	48	20				
				PD						
	53.0 / 831.5		POORLY GRADED SAND to POORLY GRADED SAND with SILT, fine- to medium-grained, gray, waterbearing, dense to very dense, (SP / SP-SM), outwash							
55				X	50	17				P200=8%
				PD						
60				X	79	21				
				PD						
	63.0 / 821.5		SANDY SILT, brown and gray, waterbearing, very dense, (ML), till							
65				X	79	21				DD=112 pcf; P200=12%
				PD						
	68.0 / 816.5		POORLY GRADED SAND, fine-grained, gray, waterbearing, very dense, (SP), outwash							
70				X	68	23				
				PD						
	74.0 / 810.5		LEAN CLAY, with frequent Fat Clay layers, gray and brown, wet, hard, (CL) till							
75				X	70	32				
	76.0 / 808.5		Bottom of Hole - 76 feet. Boring immediately backfilled with bentonite grout.							

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2122SB	885.6 (Surveyed)

Location: Hennepin Co. Coordinate: X=489154 Y=126172 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine 7514

Hammer CME Automatic Calibrated

Drilling Completed 5/15/14

Depth / Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
2.0 / 883.6	CLAYEY SAND, trace roots, dark brown, moist. (SC), topsoil fill		16			
4.0 / 881.6	POORLY GRADED SAND with SILT, fine- to medium-grained, brown, moist. (SP-SM), fill	6	6			
7.0 / 878.6	POORLY GRADED SAND, fine- to medium-grained, brown, moist. (SP), fill	6	4			
12.0 / 873.6	SANDY LEAN CLAY, trace Gravel, brown and gray, wet. (CL), fill	6	20			DD=106 pcf
		6	19			
17.0 / 868.6	ORGANIC CLAY, black, wet. (OL), fill	5	32			
		13	23			DD=101 pcf; OC=14%
19.0 / 866.6	CLAYEY SAND, trace Gravel, brown and gray, moist. (SC), fill	3	15			
22.0 / 863.6	LEAN CLAY, with frequent Silt layers, gray, wet, soft. (CL), till	3	30			DD=95 pcf; LL=32; PL=19; PI=13
24.0 / 861.6	SANDY LEAN CLAY, trace Gravel, brown and gray, moist, medium. (CL), till	6	18			
29.0 / 856.6	CLAYEY SAND, fine- to medium-grained, trace Gravel, brown, wet, medium to very stiff. (SC), till	7	13			DD=120 pcf
		17	17			
32.0 / 853.6	SANDY LEAN CLAY, trace Gravel, gray, wet, rather stiff. (CLS), till	9	15			
37.0 / 848.6	CLAYEY SAND, fine- to medium-grained, trace Gravel, gray, moist to wet, very stiff. (SC), till	22	12			
		22				
42.0 / 843.6	POORLY GRADED SAND with SILT, fine- to medium-grained, brown, wet, very dense. (SP-SM), outwash	51	13			DD=132 pcf
		101	16			P200=7%
	POORLY GRADED SAND, fine- to medium-grained, brown, wet, very dense to dense. (SP), outwash	103	13			

Index Sheet Code 3.0

(Continued Next Page)

Soil Class:J. Kirk Rock Class: Edit: Date: 8/21/14

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

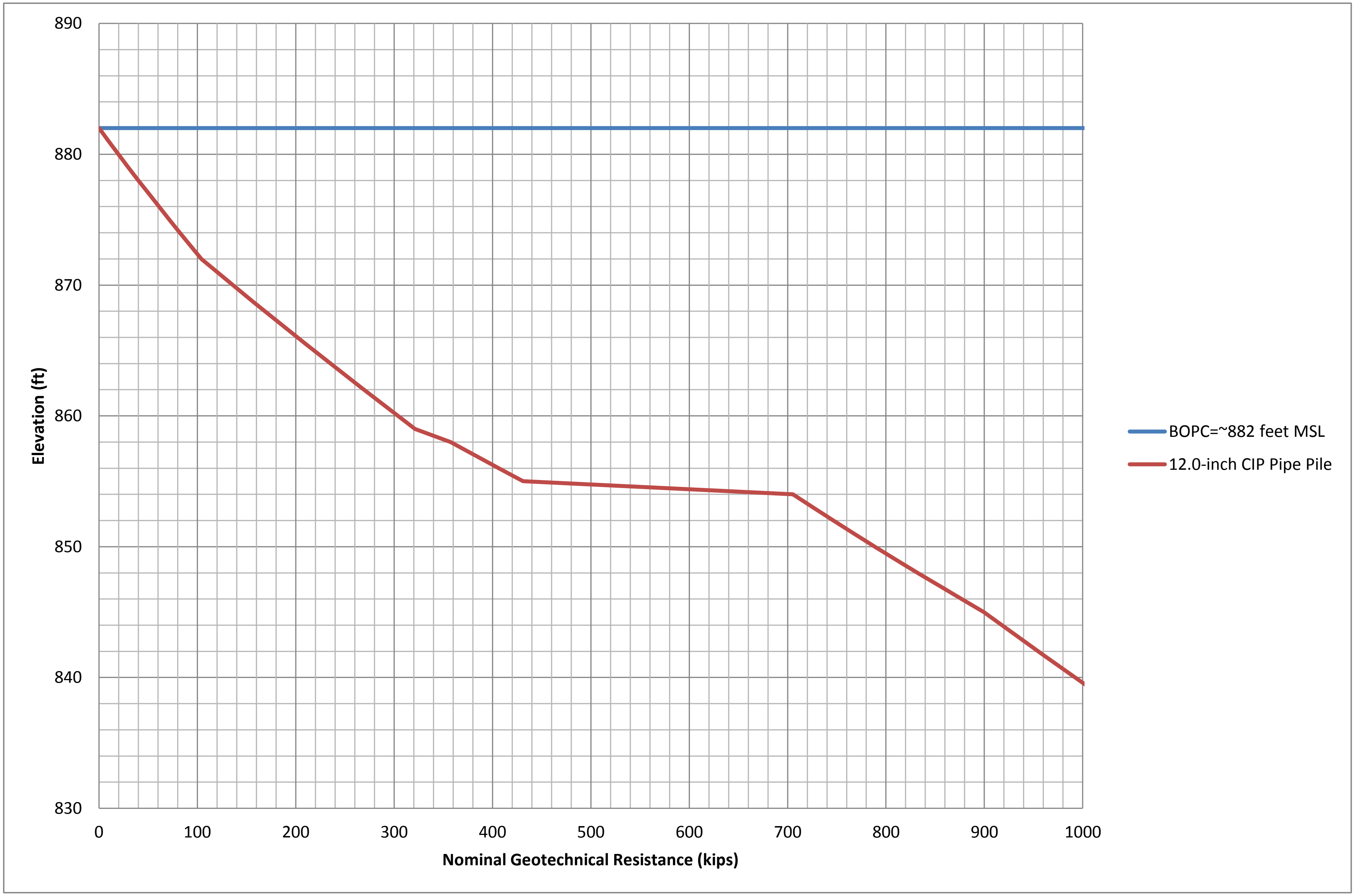
MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2122SB**	**885.6** *(Surveyed)*

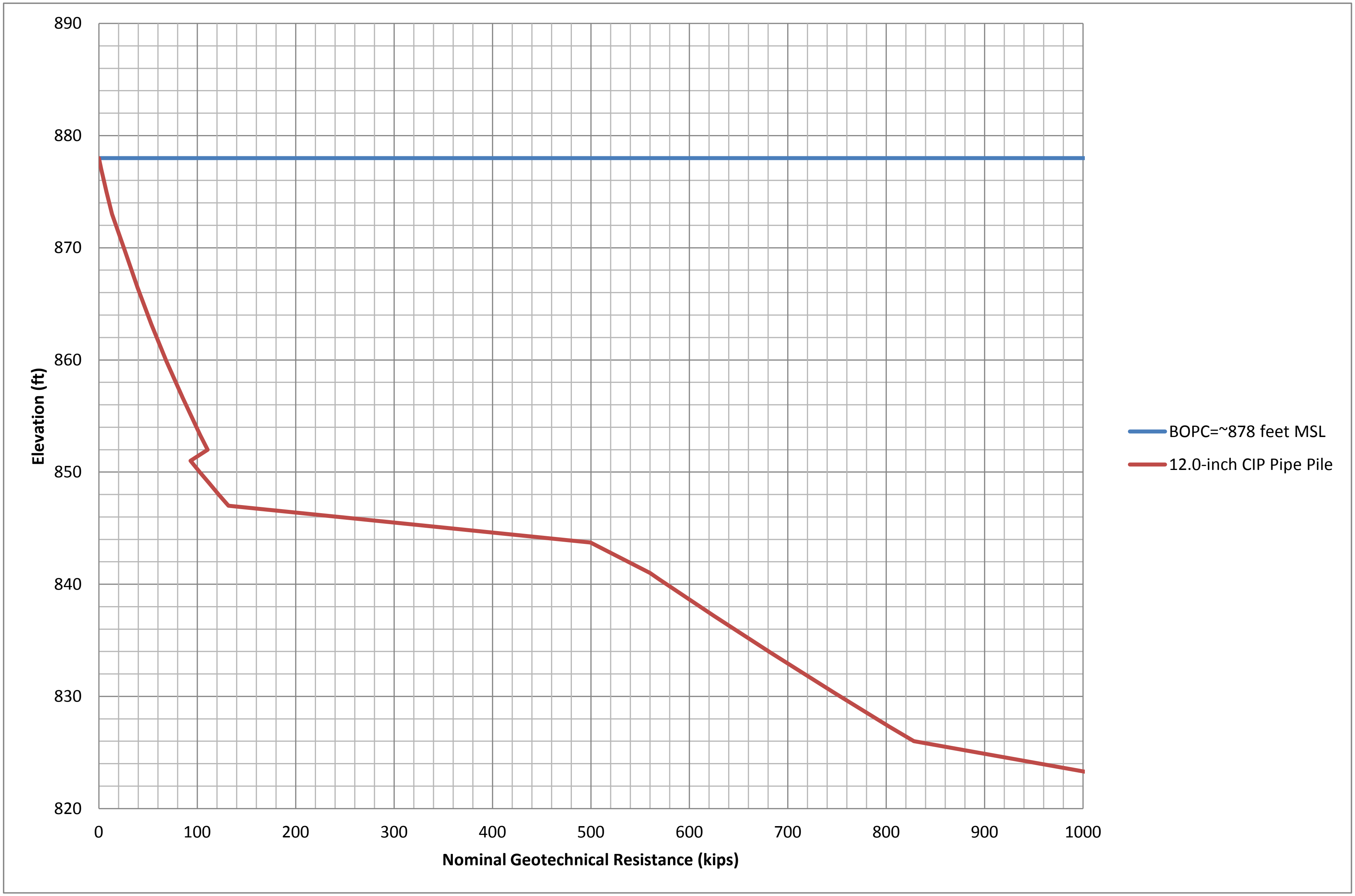
DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
					109	11				
			POORLY GRADED SAND, fine- to medium-grained, brown, wet, very dense to dense. (SP), outwash *(continued)*		49	15				
50					36	17				
	53.0 / 832.6									
55			POORLY GRADED SAND, fine-grained, brown, wet, medium dense. (SP), outwash		40	20				
	58.0 / 827.6									
60			POORLY GRADED SAND, fine- to medium-grained, trace Gravel, brown to gray, wet, medium dense to dense. (SP), outwash		28	12				P200=4%
65					76	16				
	68.0 / 817.6									
70			LEAN CLAY, gray, moist, hard. (CL), till		66	31				DD=93 pcf
	73.0 / 812.6									
75			POORLY GRADED SAND, fine- to medium-grained, with Gravel, brown, wet, very dense. (SP), outwash		76	18				
	76.0 / 809.6		Bottom of Hole - 76 feet. Water not observed while drilling. Boring immediately backfilled with bentonite grout.							

Bridge over I-494 - South Abutment
Boring: 2120SB
12.0-inch Closed Ended Pipe Pile



BRAUN INTERTEC

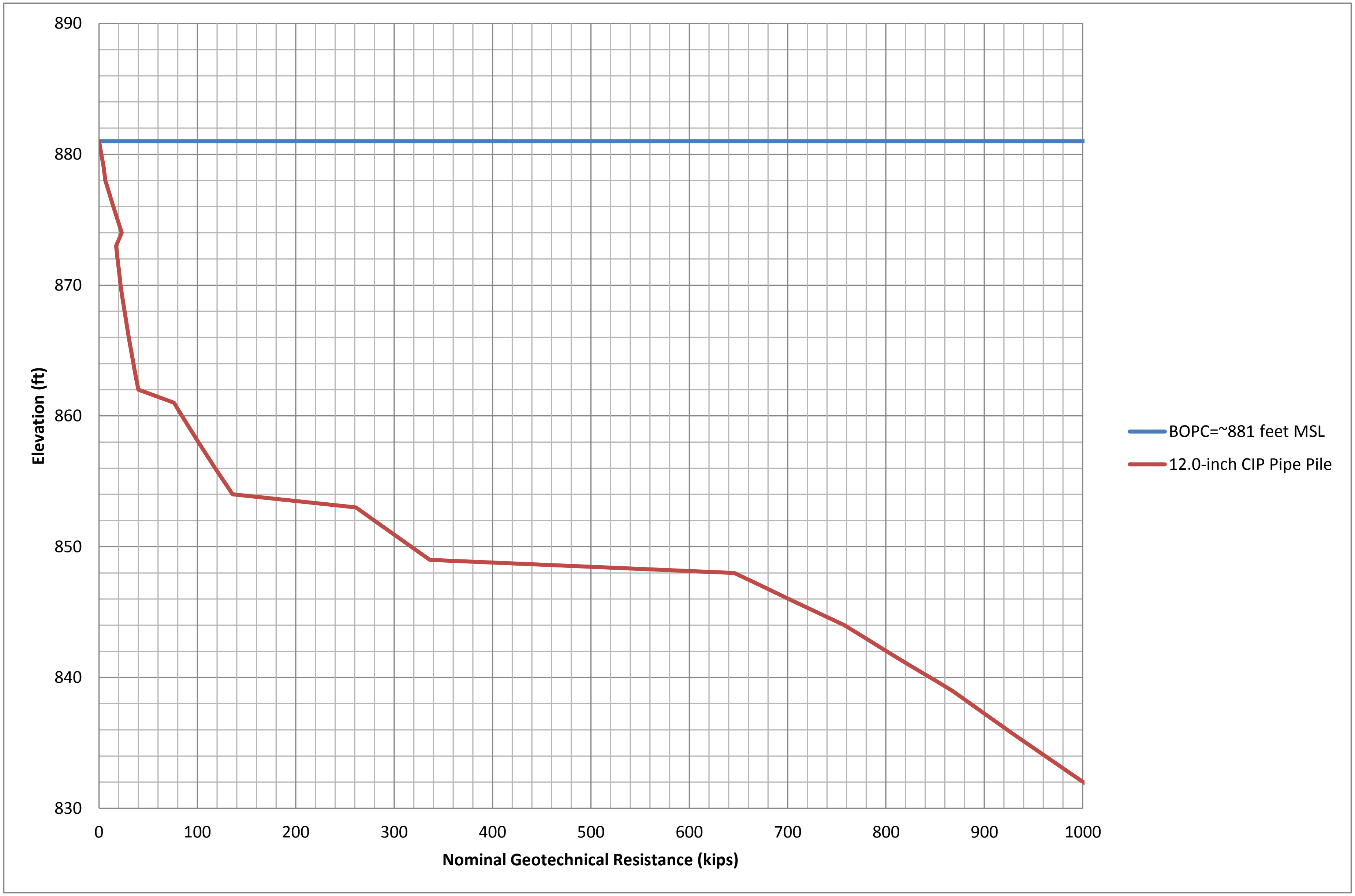
Bridge over I-494 - Center Pier
Boring: 2121SB
12.0-inch Closed Ended Pipe Pile



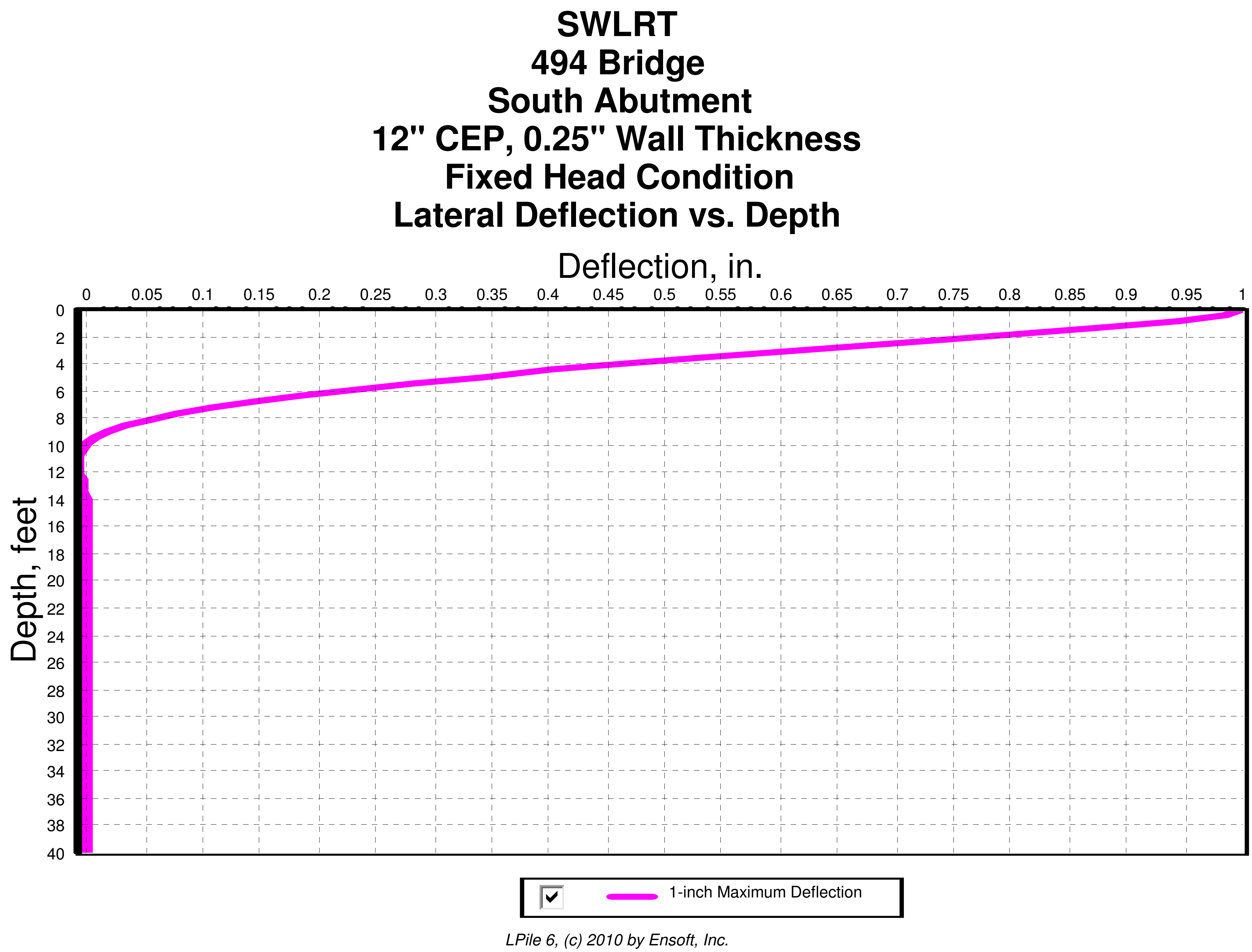
Braun Project No. BL-13-00213

BRAUN INTERTEC

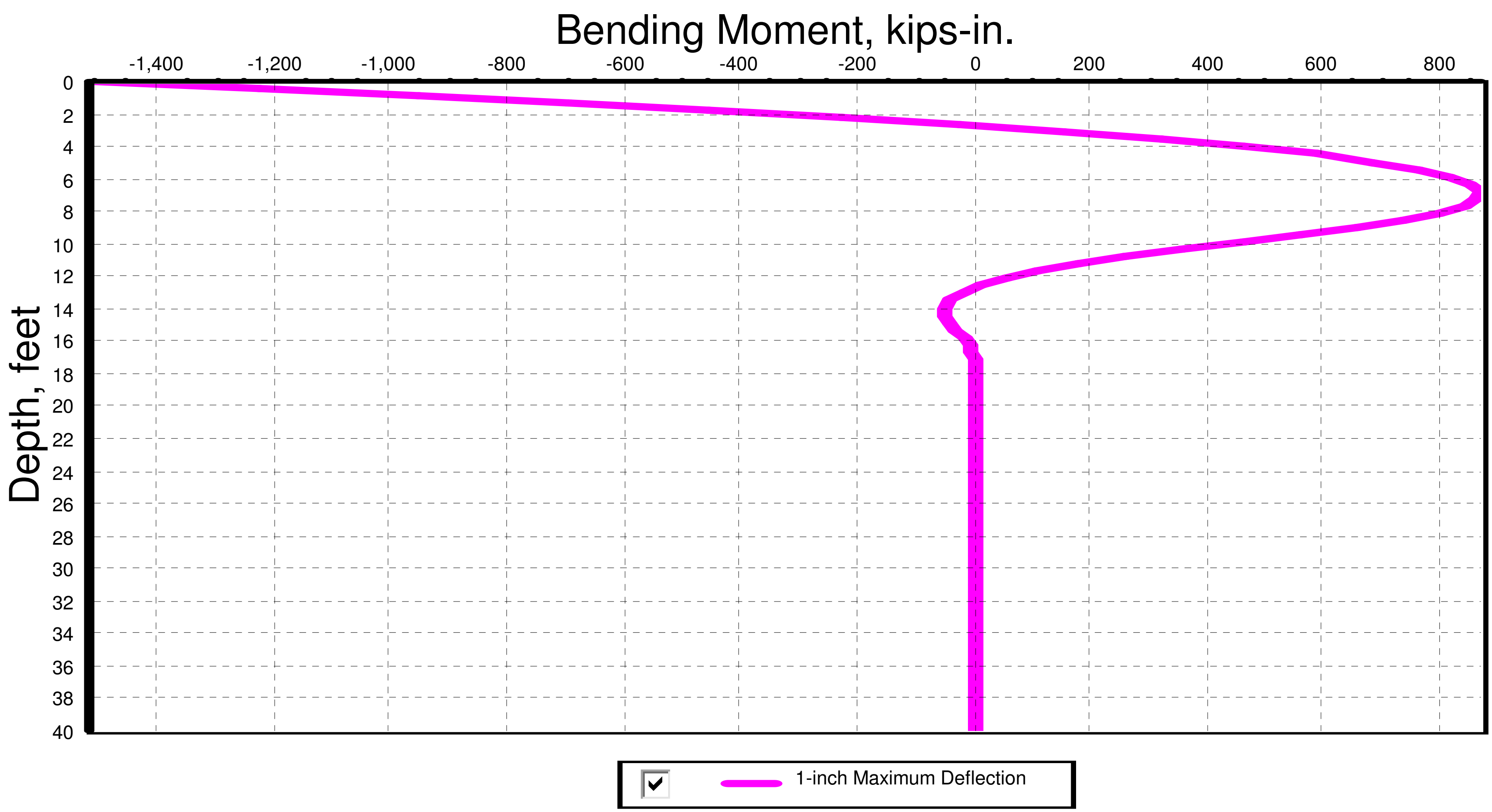
Bridge over I-494 - North Abutment
Boring: 2122SB
12.0-inch Closed Ended Pipe Pile



BRAUN INTERTEC

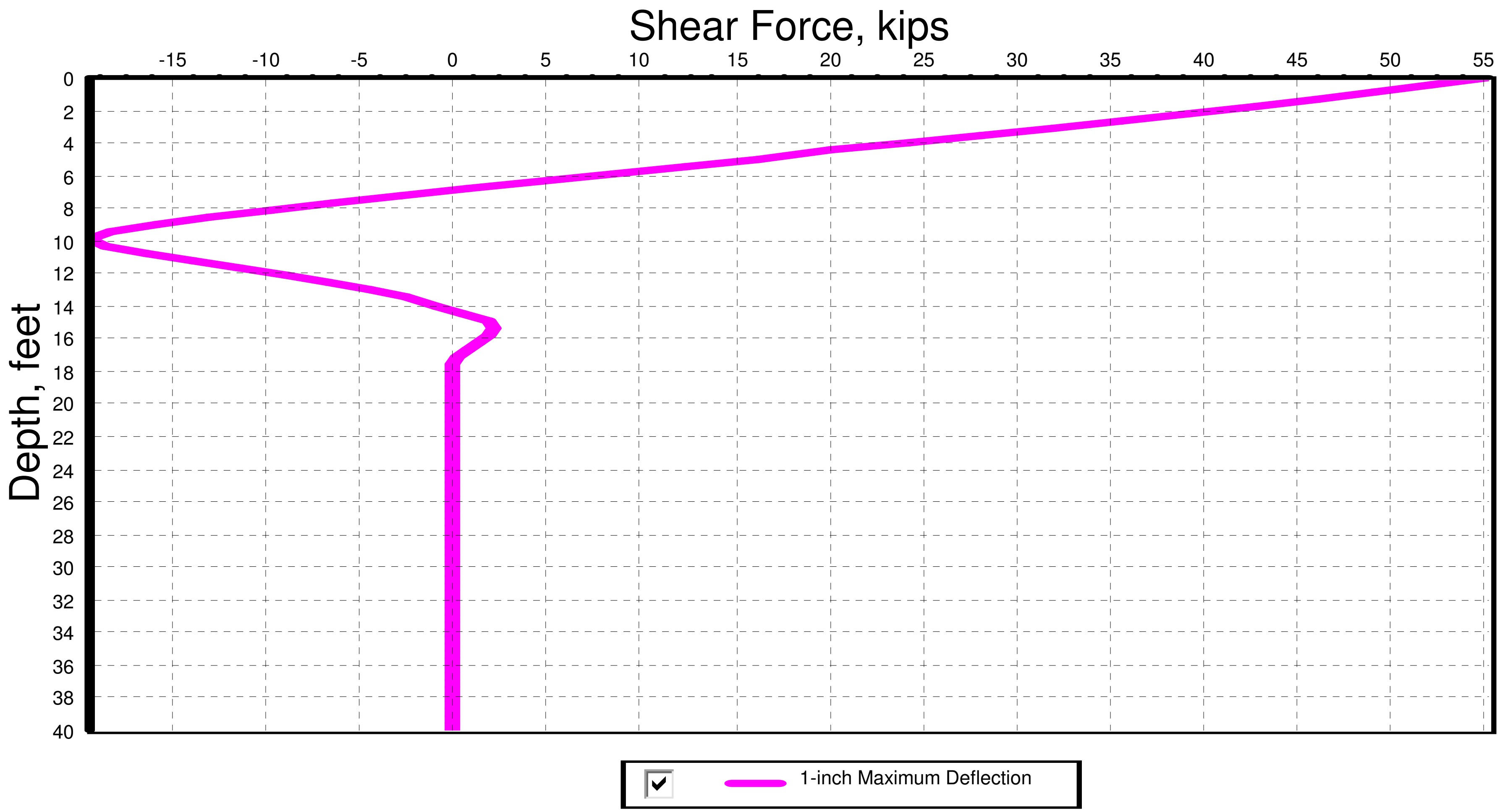

SWLRT
494 Bridge
South Abutment
12" CEP, 0.25" Wall Thickness
Fixed Head Condition
Lateral Deflection vs. Depth
Deflection, in.
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1
Depth, feet
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
1-inch Maximum Deflection
LPile 6, (c) 2010 by Ensoft, Inc.

SWLRT
494 Bridge
South Abutment
12" CEP, 0.25" Wall Thickness
Fixed Head Condition
Bending Moment vs. Depth



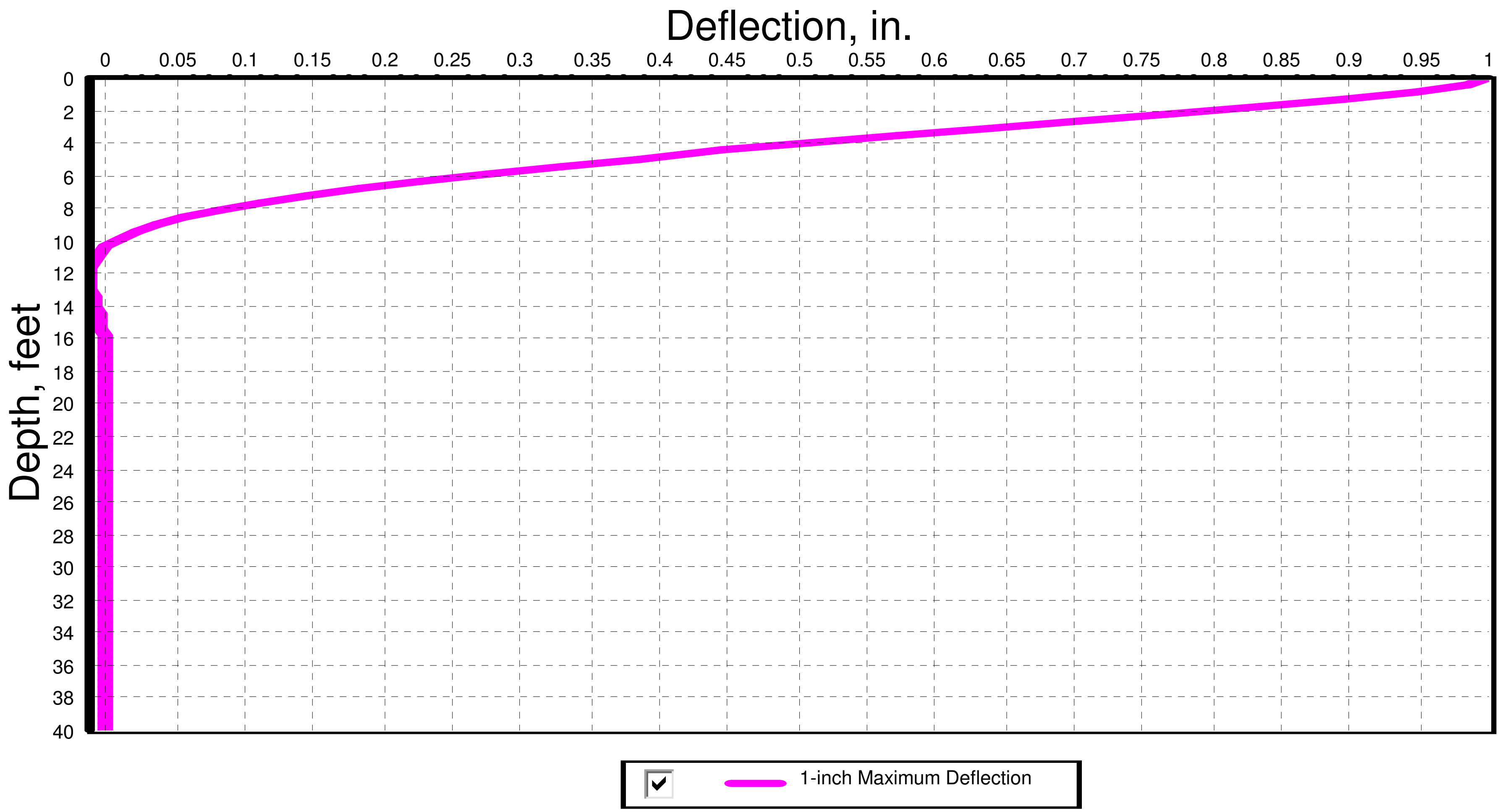
LPile 6, (c) 2010 by Ensoft, Inc.

SWLRT
494 Bridge
South Abutment
12" CEP, 0.25" Wall Thickness
Fixed Head Condition
Shear Force vs. Depth



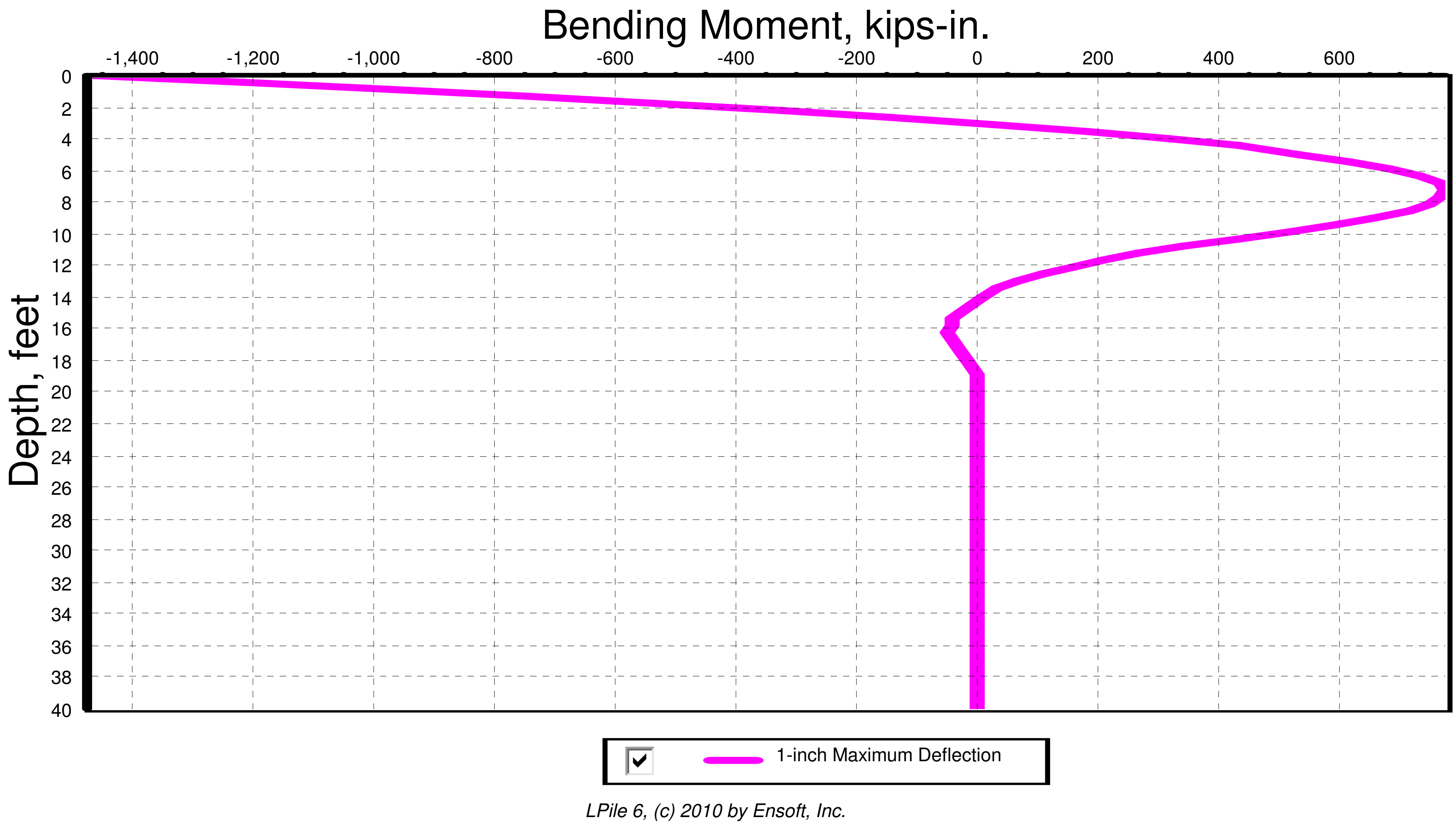
LPile 6, (c) 2010 by Ensoft, Inc.

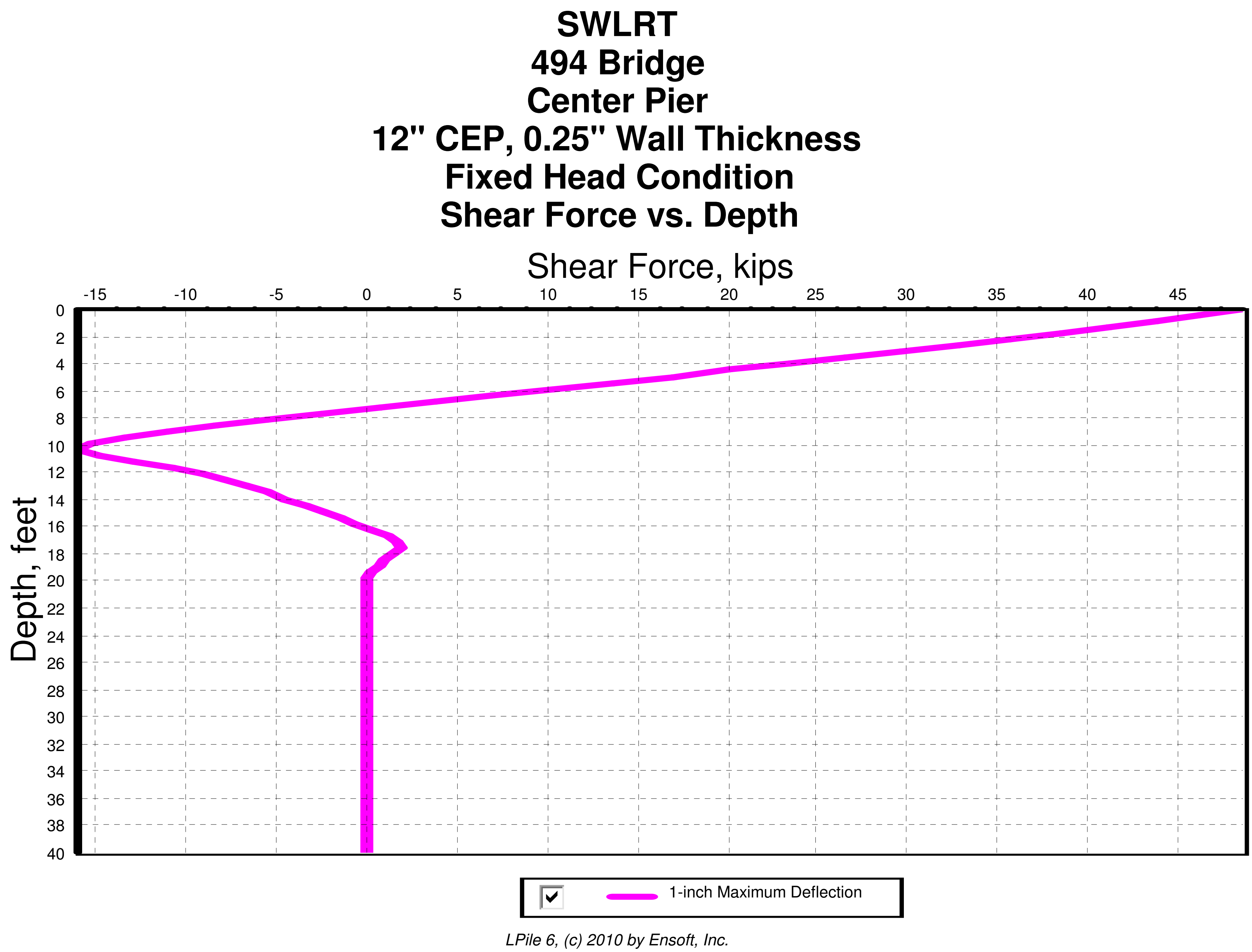
SWLRT
494 Bridge
Center Pier
12" CEP, 0.25" Wall Thickness
Fixed Head Condition
Lateral Deflection vs. Depth

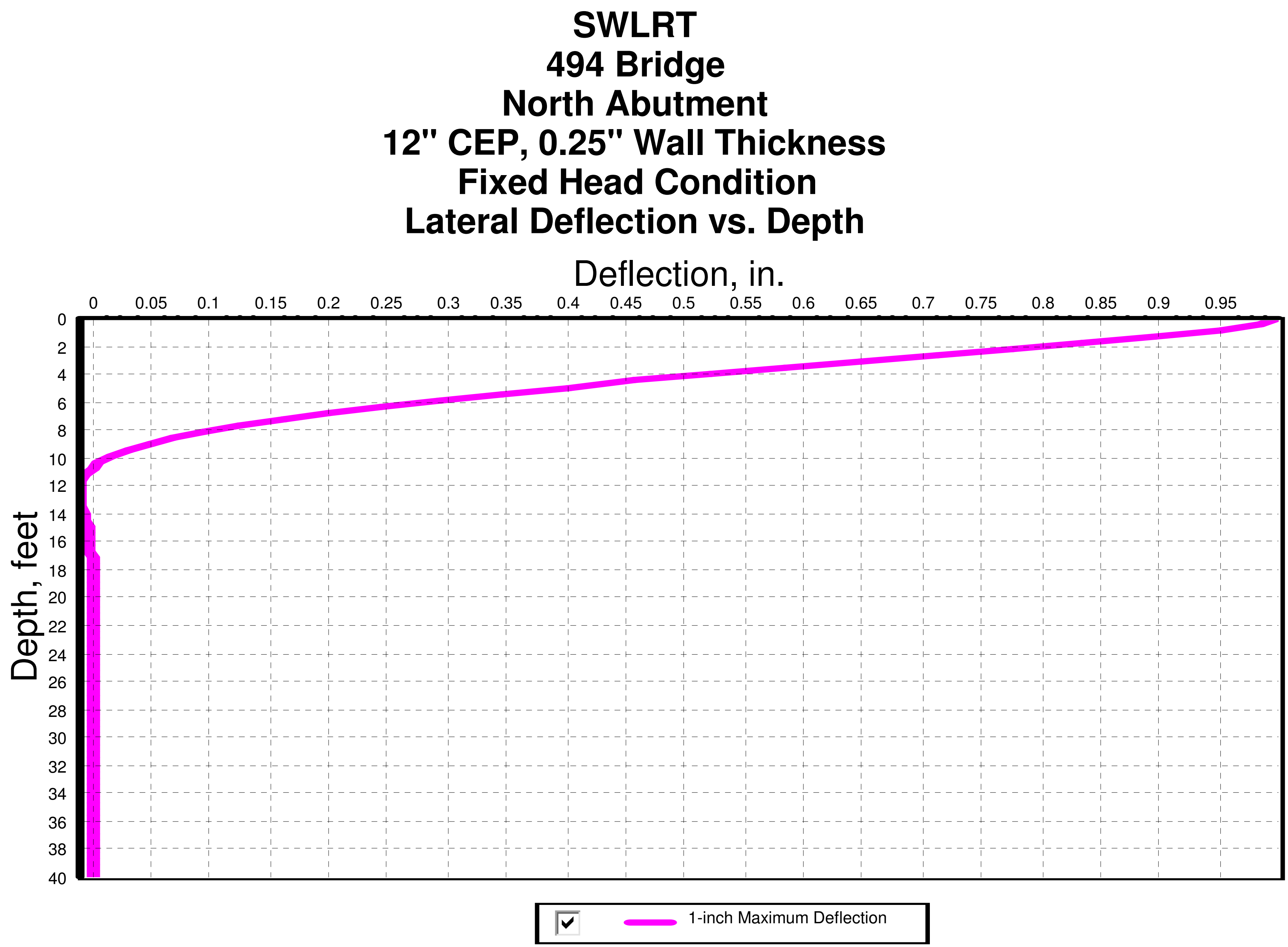


LPile 6, (c) 2010 by Ensoft, Inc.

SWLRT
494 Bridge
Center Pier
12" CEP, 0.25" Wall Thickness
Fixed Head Condition
Bending Moment vs. Depth

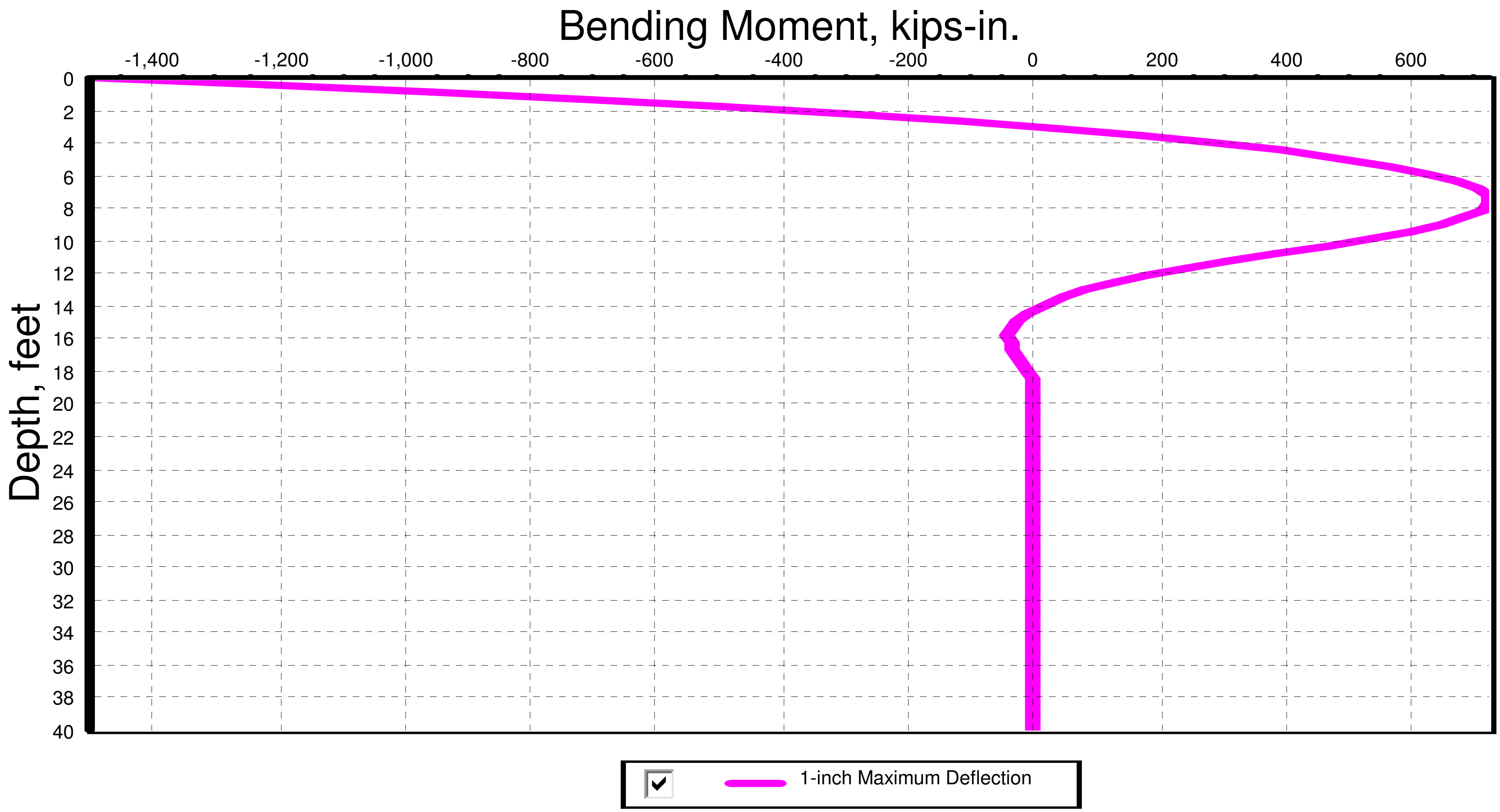



SWLRT
494 Bridge
Center Pier
12" CEP, 0.25" Wall Thickness
Fixed Head Condition
Shear Force vs. Depth
Shear Force, kips
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
Depth, feet
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
1-inch Maximum Deflection
LPile 6, (c) 2010 by Ensoft, Inc.



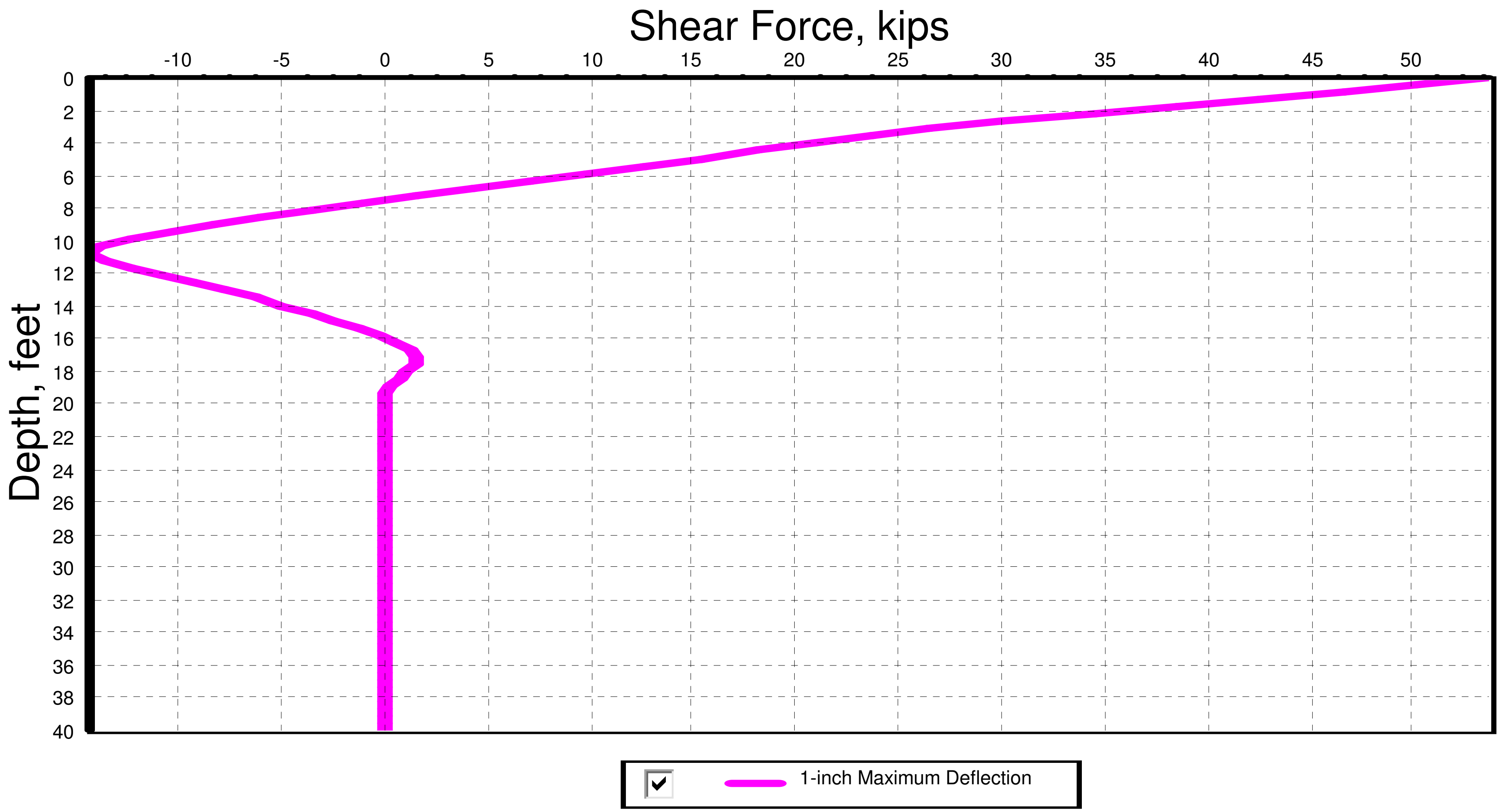
LPile 6, (c) 2010 by Ensoft, Inc.

SWLRT
494 Bridge
North Abutment
12" CEP, 0.25" Wall Thickness
Fixed Head Condition
Bending Moment vs. Depth



LPile 6, (c) 2010 by Ensoft, Inc.

SWLRT
494 Bridge
North Abutment
12" CEP, 0.25" Wall Thickness
Fixed Head Condition
Shear Force vs. Depth



LPile 6, (c) 2010 by Ensoft, Inc.

Table 5. Correlation results for sand.
(Column A = Number in Table
x Row B.)

A \ B	E_o tsf	E_R tsf	p^*_L tsf	q_c tsf	f_s tsf	N bl/ft
E_o tsf	1	0.125	8	1.15	57.5	4
E_R tsf	8	1	64	6.25	312.5	22.7
p^*_L tsf	0.125	0.0156	1	0.11	5.5	0.5
q_c tsf	0.87	0.16	9	1	50	5
f_s tsf	0.0174	0.0032	0.182	0.02	1	0.1
N bl/ft	0.25	0.044	2	0.2	10	1

Table 6. Correlation results for clay.
(Column A = Number in Table
x Row B.)

A \ B	E_o tsf	E_R tsf	p^*_L tsf	q_c tsf	f_s tsf	S_u tsf
E_o tsf	1	0.278	14	2.5	56	100
E_R tsf	3.6	1	50	13	260	300
p^*_L tsf	0.071	0.02	1	0.2	4	7.5
q_c tsf	0.40	0.077	5	1	20	27
f_s tsf	0.079	0.0038	0.25	0.05	1	1.6
S_u tsf	0.010	0.0033	0.133	0.037	0.625	1

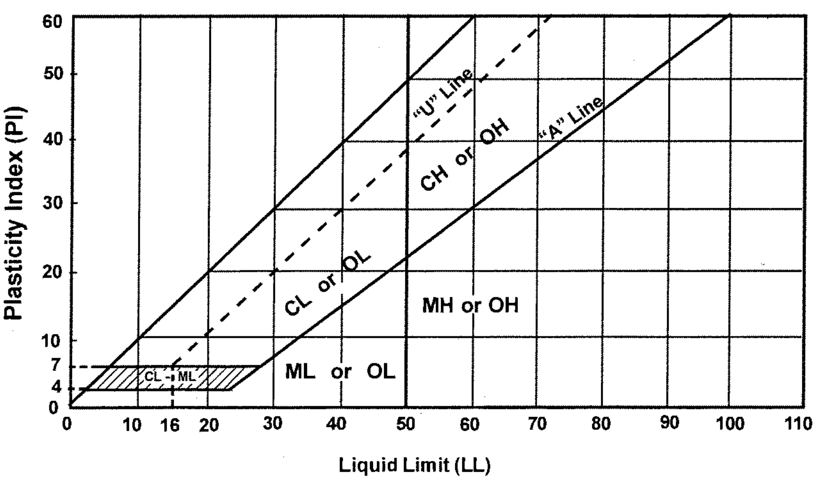
BRAUN INTERTEC

Descriptive Terminology of Soil

Standard D 2487 - 00
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels 5% or less fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands 5% or less fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	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]
				OL	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]
				OH	Organic silt [k l m q]
Highly Organic Soils		Primarily organic matter, dark in color and organic odor		PT	Peat

a. Based on the material passing the 3-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. 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
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines" to group name.
h. If soil contains ≥ 15% gravel, add "with gravel" to group name.
i. 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
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 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.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcf	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liqiuid limit, %	**C**	Cohesion, psf
PL	Plastic limit, %	**∅**	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders .... over 12"
Cobbles .... 3" to 12"
Gravel
  Coarse .... 3/4" to 3"
  Fine .... No. 4 to 3/4"
Sand
  Coarse .... No. 4 to No. 10
  Medium .... No. 10 to No. 40
  Fine .... No. 40 to No. 200
Silt .... < No. 200, PI < 4 or below "A" line
Clay .... < No. 200, PI ≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose .... 0 to 4 BPF
Loose .... 5 to 10 BPF
Medium dense .... 11 to 30 BPF
Dense .... 31 to 50 BPF
Very dense .... over 50 BPF

Consistency of Cohesive Soils

Very soft .... 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff .... 17 to 30 BPF
Hard .... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers unless noted otherwise, Jetting water was used to clean out auger prior to sampling only where indicated on logs. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous-flight, solid-stem augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface and are, therefore, somewhat approximate. Power auger borings are designated by the prefix "B."

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn. Hand auger borings are indicated by the prefix "H."

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

Appendix G

Retaining Walls, W117, W118A, W118B, W118D, W119, W201 and W202

BRAUN INTERTEC

Braun Intertec Corporation
11001 Hampshire Avenue S
Minneapolis, MN 55438

Phone: 952.995.2000
Fax: 952.995.2020
Web: braunintertec.com

August 29, 2014 Project BL-13-00213

Mr. Don Demers
Southwest Light Rail Transit Project Office
6465 Wayzata Boulevard, Suite 500
St. Louis Park, MN 55426

Re: Preliminary Foundation Analysis Design Recommendation Report – 50% Design
Retaining Walls RTW-W117, RTW-118A, RTW-W118B, RTW-W118D, RTW-W119, RTW-W201, RTW-W202, RTW-W202C and Track Embankment
STA 2163+25 to STA 2217+00
Southwest LRT, West Segment 1 and 2
Eden Prairie, Minnesota

Dear Mr. Demers:

Braun Intertec Corporation has completed this preliminary geotechnical evaluation for the retaining walls and the track embankment for the west segment of the Southwest Light Rail Transit (SWLRT) alignment in Eden Prairie, Minnesota between the Valley View Bridge and the 9-Mile Creek Bridge. The following sections provide information regarding our opinions, methods, and recommendations for the retaining wall foundations and associated embankments.

This report is part of a larger series of reports for the west segment of the Southwest Light Rail Transit (SWLRT) project. Recommendations for pole foundations for the Overhead Contact System (OCS) will be address in a separate report.

A. Project Information

SWLRT is proposing to construct a light rail transit line through the cities of Hopkins, Minnetonka, and Eden Prairie, Minnesota. This design report addresses the design and construction of the embankment and retaining walls RTW-W117, RTW-W118A, RTW-W118B, RTW-W118D, RTW-1119, RTW-W201, RTW-W202, and RTW-W202C between STA 2163+25 and STA 2217+00 from the Valley View Bridge to the Nine Mile Creek Bridge.

A.1. Type of Structures

Cast-in-place (CIP) concrete will be used to construct the retaining walls (with the exception to walls RTW-W119, a portion of RTW-W201, and RTW-202C). The proposed CIP concrete walls will be supported by spread footing foundations founded at least 4 ½ feet below the lowest finished grade along the toe of the wall. However, RTW-W119 is planned to be a Mechanically Stabilized Earth (MSE) wall and a portion of RTW-W201 and RTW-W202C will be supported on driven pile foundations.

A.2. Location of Walls

We used the preliminary engineering plans and available cross sections to perform our analysis. The locations and additional information for the walls are provided below.

A.2.a. Wall RTW-W117

Wall RTW-W117 will be constructed off the northwest corner of the north abutment of the Valley View Bridge, extending from STA 2163+27 to STA 2163+99. The wall height (top of footing to top of rail) varies from 15 to 19 feet approximately with an overall length of approximately 66 feet.

A.2.b. Wall RTW-W118A

Wall RTW-W118A will be constructed off the northwest corner of the north abutment of the Valley View Bridge, extending from STA 2163+25 to STA 2163+98. The wall height (top of footing to top of rail) varies from 15 to 19 feet approximately with an overall length of approximately 76 feet.

A.2.c. Wall RTW-W118B

Wall RTW-W118B is located along the east side of the proposed SWLRT alignment, extending from about STA 2165+73 to STA 2166+73 for a length of about 100 feet. The wall height (bottom of footing to top of rail) varies from 9 to 15 feet with a total stem height of 7 to 14 feet, approximately.

A.2.d. Wall RTW-W118D

Wall RTW-W118D is located along the east side of the proposed SWLRT alignment, extending from about STA 2178+23 to STA 2181+00, for a length of about 277 feet. The wall height (bottom of footing to top of rail) varies from 8 to 12 feet with a total stem height of 6 to 11 feet, approximately.

A.2.e. Wall RTW-W119 and RTW-W201

Wall RTW-W119 is located along the west side of the proposed SWLRT alignment, extending from about STA 2165+73 to STA 2181+00 where it becomes retaining wall RTW-W201, and extends from STA 2210+00 to STA 2216+90. The combined walls have a length of 2235 feet. The wall height (bottom of footing to top of rail) varies from about 15 feet to almost 34 feet. The wall is tallest near STA 2172+00.

Walls RTW-W119 is planned to be a MSE wall and RTW-201 is planned to be founded on spread footings foundations from STA 2165+73 to STA 2211+80, and on pile-supported foundations from Stations STA 2211+80 to STA 2216+90.

A.2.f. Wall RTW-W202

Retaining wall RTW-W202 is located on the south or east side of the alignment extending from STA 2210+00 to STA 2210+50. The total length of the wall is approximately 50 feet. The wall height (bottom of footing to top of rail) varies from 7 to 8 feet, approximately.

A.2.g. Wall RTW-W202C

Retaining wall RTW-W202C is located on the east side of the alignment from STA 2215+00 to STA 2216+90. The length of the wall is 185 feet, with wall heights (top of footing to top of wall) ranging from 8 to 19 feet. The wall is proposed to be supported on driven pile foundations.

A.3. Embankment Construction

To construct the walls along the proposed alignment, embankment grade increases of up to 20 feet will be necessary. Grade raises of this magnitude will influence the design and construction of the proposed wall foundation types. However, the effects of the embankment stresses are accounted for in our foundation design recommendations.

B. Subsurface Investigation Summary

B.1. Summary of Borings Taken

Braun Intertec performed five SPT (standard penetration test) borings (2055SW, 2056SW, 2057SW, 2012SB, and 2027SB) as part of our preliminary investigation. Logs of the wall borings are included in the Appendix. A Boring Location Sketch is also included in the Appendix.

B.2. Description of Foundation Soil and Conditions

The general soil profile in the area consists of surficial topsoil and shallow fill deposits, underlain by glacially deposited soils. The exception to this is Boring 2027SB, where swamp deposits were encountered beneath a layer of fill. A more detailed description is provided below.

B.2.a. Topsoil

The borings initially encountered about 3 to 18 inches of topsoil. The topsoil consisted of sandy lean clay and clayey sand that was dark brown and moist to wet.

B.2.b. Fill

Fill was encountered at four of the five boring locations and consisted of Poorly Graded Sand (SP), Poorly Graded Sand with Silt (SP-SM), Silty Sand (SM), and Clayey Sand (SC). Table 1 below illustrates the depth and type of fill material encountered.

Table 1. Fill Depths at Boring Locations

Boring No.	Boring Elevation (ft)	Approximate Depth of Fill (ft)	Elevation at Bottom of Fill (ft)	Fill Composition
2055SW	868.4	Not Encountered	868	Not Encountered
2056SW	869.2	7		Clayey Sand
2057SW	869.0	12		Poorly Graded Sand
2012SB	856.7	12	844 1/2	Silty Sand and Clayey Sand
2027SB	859.3	20	839	Clayey Sand, Poorly Graded Sand with Silt

Penetration resistances varied from 2 to 23 blows per foot (BPF).

B.2.c. Swamp Deposits

Swamp deposit soils consisting of peat, organic lean clay, silt, and silty sand were encountered in Boring 2027SB beneath the fill to a depth of 54 feet, or elevation 805. The swamp deposits are associated with the 9 Mile Creek floodplain. Penetration resistance values in the peat and organic lean clay ranged from 3 to 6 BPF, while penetration resistances in the silt and silty sand ranged from 7 to 13 BPF.

B.2.d. Glacial Till

Glacial till soils were encountered throughout the soil profile across the lengths of the walls beneath the fill and topsoil. The till consisted of sandy lean clay, clayey sand, silty sand, and silt. The till soils contained gravel, were gray, and were wet to waterbearing. Penetration resistances varied from 3 to 71 BPF indicating the clayey soils were soft to hard while the sand and silt soils were loose to very dense.

B.2.e. Glacial Outwash

Glacial outwash soils were also encountered throughout the profile beneath the fill and topsoil. The glacial outwash soils consisted of poorly graded sand. The sands generally contained some gravel. Penetration resistances varied from 4 BPF to 82 BPF, indicating the soil was very loose to very dense. The lower penetration resistances were likely due to hydrostatic pressures impacting the samples and the higher penetration resistances may indicate cobbles or boulders are located within the soil.

B.3. Summary of Water Level Measurements

SPT boring logs note water levels during drilling ranging from approximate 823 to 847 feet above mean sea level (MSL). Temporary water level indicators installed closer to TH 212 near Valley View Road noted groundwater near an elevation of 841. The last recorded normal water level from the Minnesota DNR for nearby Bryant Lake was near 851 ½. The water level of 9 Mile Creek near Flying Cloud Drive is expected to be near 840 and 845.

Perched water conditions are prevalent along many other sections of the alignment away from the currently completed boring locations. Seasonal and annual fluctuations of groundwater, however, should be anticipated.

C. Foundation Analysis

Based on the soil conditions encountered in the borings and loads anticipated on the wall, we recommend the use of spread footing foundations for support of the CIP walls after the removal of any existing fill soils for the majority of the wall locations. After the soil corrections and embankment construction procedures provided below, we anticipate the service limit state for settlement of one-inch can be achieved.

The exception to this is near Boring 2027SB, affecting RTW-W201 and RTW-W202C from track STA 2214+00 to STA 2217+00. In this area, deep fills over organic soils were noted to depths of 54 feet. When the proposed embankment consisting of more than 20 feet of new soil is placed in this area, the service limit state for settlement will be exceeded. While measures such as the use of lightweight fill and preloading the embankments may reduce the magnitude of the settlement, long term consolidation of the underlying organic deposits will make a soil supported embankment extremely difficult with regard to maintaining the service limit state of one-inch of total settlement. Extending the length of the 9-Mile Creek Bridge and the use of a driven pile foundation system appears to be the most economical solution.

C.1. Embankment and Slopes

The track embankments associated with the walls are proposed to be constructed with vertical CIP concrete and or MSE walls. Portions of the embankment will also be constructed on the existing soil embankments associated with Highway 212. Preparation will include topsoil removal, removal of fill beneath the footings, and backfilling and filling with the proposed track section.

C.1.a. Settlement

The settlement ranges noted below are a combination of both settlements from the retaining walls loads as well as settlement from the raise in grade for the embankment.

C.1.a.1. Walls RTW-117 and RTW-W118A

Borings were not performed in the area of these walls, and final borings will be needed to more accurately estimate settlement. However, based on historical boring information and nearby borings, we anticipate settlement from the walls and embankments will be less than one-inch, provided soils corrections are performed to remove any fill or soft soils that may be encountered.

C.1.a.2. Wall RTW-W119

Final borings will be needed to more accurately estimate settlement. However, based on our preliminary borings along RTW-W119 (2055SW, 2056SW, and 2057SW) it appears settlement from the walls and embankments will be less than one-inch with the removal of the fill soil and soft and/or loose native soils encountered just below the fill.

C.1.a.3. Wall RTW-118B

Soil borings were not performed in the area of RTW-W118B. It is our best estimate that spread footings can be used to support this wall. Based on the proposed embankment heights, we expect settlement will remain within the service limit and preloading will not be necessary.

C.1.a.4. Wall RTW-118D

Based on the preliminary engineering plans, preliminary cross sections, and Borings 2057SW and 2012SB, we anticipate spread footings can be used to support the walls and the service limit state for settlement can be achieved upon removal of the topsoil and fill.

C.1.a.5. Wall RTW-W201

Based on our preliminary borings, we anticipate RTW-201 could be constructed on spread footings and stay within the service limit state after soil corrections are performed to remove the existing fill, and a preload of the embankment is placed to allow for consolidation of the underlying soils from the new embankment load. We anticipate this type of construction can be performed between STA 2210+00 and STA 2214+00.

The poor soil conditions, accompanied by the large raise in grade will not allow the current design to stay within the service limit state if spread footings are used to support RTW-W201 between STA 2214+00 and STA 2217+00. We recommend extending the 9-Mile Creek Bridge to span the poor soils, eliminating the need for the large embankment and retaining wall at this location.

The final design of the 9-Mile Creek Bridge is under discussion at the time of this report and there is a possibility the bridge will be extended to near STA 2214+00. Any changes to the bridge length and placement of the west abutment with regard to RTW-W201 should be addressed during final design.

C.1.a.6. Wall RTW-W202

We do not have adequate boring information to verify if subexcavation is needed to support retaining wall RTW-W202. We anticipate similar conditions to RTW-W201 between STA 2210+00 and STA 2214+00 will be encountered, and similar construction techniques should be used.

C.1.a.7. Wall RTW-W202C

Based on the poor soils encountered near STA 2217+00 at the current abutment location for the Nine Mile Creek Bridge, we recommend extending the bridge, eliminating the need for this wall. Please refer to the discussion in section C.1.a.5 with regard to foundation support and settlement between STA 2214+00 and STA 2217+00.

C.2. Spread Footing Foundations

Settlements were calculated based on two methods. The first is the Hough method with Boussinesq and Westergaard stress distributions, which utilizes the standard penetration test (SPT) values from the soil borings. The second is the Menard method, which is based on pressuremeter determinations of soil parameters that were collected in the field or modified from the SPT values from the soil borings. For the Menard Method, where pressuremeter testing was not performed, conservative correlations were used to estimate pressuremeter values based on N_{60} factors provided in Federal Highway Administration (FHWA) Publication No. FHWA-IP-89-008. Tables 5 and 6 from this publication are in the Appendix for reference. After these two methods were evaluated, the results were averaged.

C.3. Summary of Design Assumptions

C.3.a. Embankment Heights, Unit Weights, Side Slopes, and End slopes

The wet unit weight of the anticipated compacted fill soils has been assumed as 120 pounds per cubic foot (pcf). The top surface behind all walls will be the associated tracks for the SWLRT and will be relatively flat. Information regarding the walls is provided in Table 2.

Table 2: Design Information for Walls

Retaining Wall Location	Existing Grade Elevations (ft)	Corresponding Proposed Wall Heights (ft)	Approximate Footing Elevation (ft)
RTW-W117	891	15 to 19	886
RTW-W118A	891	15 to 19	887
RTW-W118B	895-905	7 to 14	890
RTW-W118D	877-880	6 to 11	868-873
RTW-W119	865-893	13 to 32	862 to 880
RTW-W201	850-868	13 to 26	844 to 860
RTW-202	877	7 to 8	869
RTW-W202C	858-868	8 to 19	854-863

C.3.b. Retaining Wall Loading Information

We assume a 2-foot live load surcharge will be used for the design of all walls supporting track embankments. For the CIP concrete walls we recommend the design loads and anticipated footing widths be based on anticipated wall heights and the MnDOT standard plans included in the *Cast-in-Place Retaining Wall Details* section of the Appendix.

C.3.c. Soil Design Parameters

The soil parameters below are recommended to be used for design:

Table 3. Recommend Soil Design Parameters

Soil Type	Angle of Internal Friction (degrees)	Effective unit Weight (pcf)	Coefficient of Sliding Friction Rough Concrete	Active Earth Pressure Coefficient	At-Rest Earth Pressure Coefficient
Select Granular Borrow	35	120	0.6	0.27	0.43
Granular Borrow	30	120	0.5	0.33	0.50
Fill: Sands	30	120	0.5	0.33	0.50
Fill: Lean Clay	22	115	0.4	0.45	0.63
Fill: Clayey Sand	28	130	0.4	0.36	0.53
Native Sands	32	130	0.5	0.31	0.47
Native Lean Clay	27	130	0.35	0.38	0.55
Native Clayey Sand	28	135	0.4	0.36	0.53

C.3.d. Design Methodologies

The Allowable Stress Design (ASD) methodology was used for design of the CIP retaining walls supported on shallow foundations. Safety Factors were obtained from the MnDOT Standard Plan for CIP Retaining Walls included in the Appendix.

C.4. Construction Considerations

C.4.a. Design of Temporary Slopes and Shoring Limits

We recommend that permanent slopes match the existing slopes, except they should not be steeper than 1V:2H. Select Granular Borrow is anticipated to have an angle of internal friction of 35 degrees. This soil could be temporarily placed at a slope of 1V:1 ½ H, but if not retained by a CIP embankment, must be limited to 1V:2H or flatter for the permanent condition.

C.4.b. Subcut Recommendations and Backfill Requirements

To reduce the potential for settlement exceeding the service limit, we recommend subcutting all existing fill soils present beneath the foundations and embankments. We also recommend removing the very loose native soils encountered at Boring 2056SW. Excavation depths beneath footing elevations are expected to be near 5 feet, but may vary away from our borings and will be revised upon completion of the final boring program.

The extent of the excavation required for the walls should extend horizontally beyond the embankment limits/footing dimensions a distance equal to the depth of the subcut. Exposed excavation bottoms, deemed suitable by a Geotechnical Engineer, should be surface compacted by a large vibratory sheepsfoot compactor prior to fill or footing placement.

We recommend the use of engineered fill to establish slope subgrade or backfill for any subcuts of marginal soils under the proposed CIP spread or leveling pad foundations, oversize areas, or reinforced zones. Please refer to Table 4 below for material and compaction specifications based on the 2014 MnDOT Standard Specification for Construction.

Table 4. Recommended Fill and Compaction Specifications.

Material	Material Specification	Compaction Specification
Fill Placed Beneath Footings	2105.1A7	2105.3F
Leveling Pad Beneath Footings	3138.2B	2211.3C
Retaining Wall Backfill	3149.2D2	2105.3F

Backfill placed for all wall embankments should consist of Select Granular Modified 10% and compacted to meet the requirements of 2105.3F1. Select Granular Modified 10% shall comply with Specification 3149.2B2, modified to having 10 percent or less passing the 0.075 mm (#200) sieve. We recommend backfill material be placed in uniform layers approximately parallel to the profile, extending the full width of the retaining structures. We recommend backfill material be placed in lift thicknesses not exceeding 12 inches.

C.4.c. Construction Staging Requirements

Based on the results of the borings and the estimated settlements, which are estimated to exceed one-inch for portions of RTW-W201 between STA 2212+00 and STA 2214+00, we recommend a short waiting period (anticipated to be up to 8 weeks) prior to construction. Please refer the Appendix for a typical preload embankment sketch at each retaining wall location.

C.5. Track Construction

C.5.a. Subgrade Preparation

We anticipate the track subgrade soils will consist of a mixture of native soils and engineered fill associated with the construction of the embankment. Should previously placed fill be encountered at track subgrade elevations, we recommend evaluating the fill to determine its suitability to support the proposed track construction. Fill soils judged to be unsuitable for track support should be removed and replaced with engineered fill.

After the subgrade has been evaluated, and any additional corrections made, the subgrade soils should be surface compacted with vibratory sheepsfoot compactor, taking into consideration the integrity of the retaining walls, prior to the placement of fill or before construction of the Guideway begins. Please refer to Table 5 below for the compaction specifications and guidelines for the Guideway.

C.5.b. Guideway and Platform Station Fill

Based on the proposed design sections, the Guideway will be composed of 40-inch thick layer of granular material, over a minimum of 12-inches of subballast material. We recommend specifying Guideway fill to meet the requirements of the Minnesota Department of Transportation (MnDOT) 3149.2B2 (Select Granular Borrow) for the granular material, and 3138 (Aggregate Base) for the subballast. Table 5 below provides material and compaction specifications for the Guideway.

Table 5. Material and Compaction Specification for Backfill and Fill

Material	Material Specification	Compaction Specification
Subgrade Fill	Onsite Material Free of Debris and Organic Material	100% of standard Proctor Density (ASTM D698)
Guideway Select Granular Layer	MnDOT 3149.2B2	100% of standard Proctor Density (ASTM D698)
Guideway Subballast	MnDOT 3138	MnDOT 2211.3C

C.6. Drainage Control

We recommend installing subdrains behind the retaining walls, adjacent to the wall footings, and at low points of the Guideway. Preferably the subdrains should consist of perforated pipes embedded in washed gravel, which in turn is wrapped in filter fabric. Perforated pipes encased in a filter “sock” and embedded in washed gravel, however, may also be considered.

We recommend routing the subdrains to a storm sewer or sump and pump capable of routing any accumulated groundwater to a storm sewer or other suitable disposal site, if available.

D. Material Classification and Testing

D.1. Visual and Manual Classification

The geologic materials encountered were visually and manually classified in accordance with ASTM International Standard Practice D 2488. A chart explaining the classification system is attached. Samples were sealed in jars or bags and returned to our facility for review and storage

D.2. Laboratory Testing

The results of the laboratory tests performed on geologic material samples are noted on or follow the appropriate attached exploration logs. The tests were performed in accordance with ASTM procedures.

D.3. Groundwater Measurements

The drillers checked for groundwater as the penetration test borings were advanced, and again after auger withdrawal. The boreholes were then backfilled or sealed with bentonite grout.

E. Qualifications

E.1. Variations in Subsurface Conditions

E.1.a. Material Strata

Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth, and therefore, strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions, and can be expected to vary in depth, elevation and thickness away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed, or construction commences. If any such variations are revealed, our recommendations should be re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

E.1.b. Groundwater Levels

Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

E.2. Continuity of Professional Responsibility

E.2.a. Plan Review

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

E.2.b. Construction Observations and Testing

It is recommended that we be retained to perform observations and tests during construction. This will allow correlation of the subsurface conditions encountered during construction with those encountered by the borings, and provide continuity of professional responsibility.

E.3. Use of Report

This report is for the exclusive use of Southwest Light Rail Transit. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

F. General

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

If there are questions regarding these bridge foundation recommendations, please call Josh Kirk at 952.995.2222 or jkirk@braunintertec.com or Matt Ruble at 952.995.2224 or mruble@braunintertec.com.

Sincerely,

BRAUN INTERTEC CORPORATION

Professional Certification:
I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Joshua L. Kirk, PE
Associate-Project Engineer
License Number: 45005

Reviewed by:

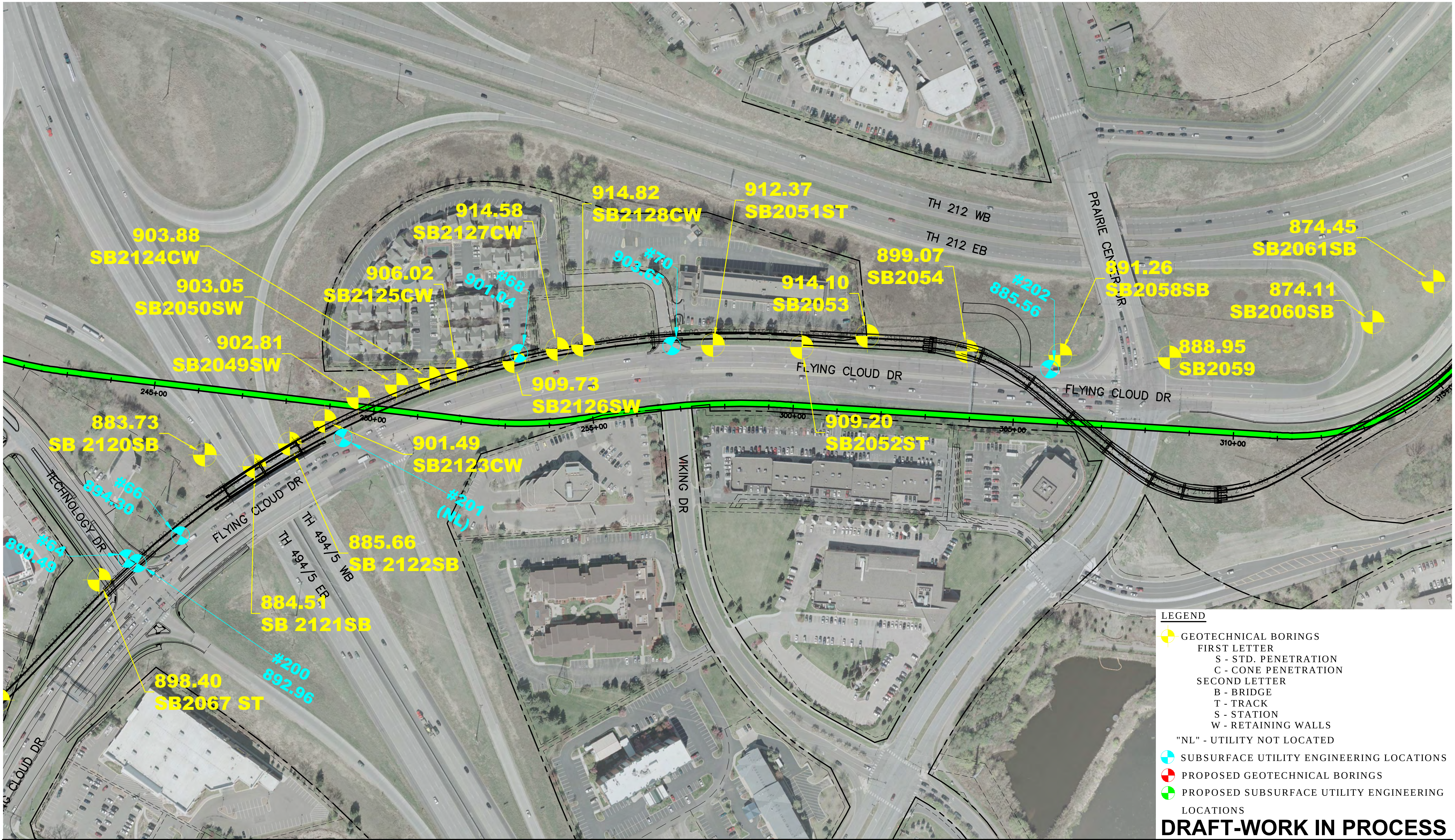
Ray A. Huber, PE
Vice President-Principal Engineer

Reviewed by:

Matthew P. Ruble, PE
Principal Engineer

Appendix:
Boring Location Sketch
Preliminary Engineering Plan and Profile Sheets
Standard Penetration Boring Logs (2055SW, 2056SW, 2057SW, 2012SW, and 2027SW)
Nominal Geotechnical Resistance Graphs
MnDOT Standard Sheet No. 5-297.632, 1 of 4 (2' LL Surcharge, Spread Footing Supported Retaining Walls)
Publication No. FHWA-IP-89-008 N60 Correlation Tables
MnDOT Standard Sheet No. 297.233 - Preload
SPT Descriptive Terminology

APPENDIX



SOUTHWEST LIGHT RAIL

SOIL BORINGS

SHEET 5 OF 12

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SOUTHWEST Green Line LRT Extension

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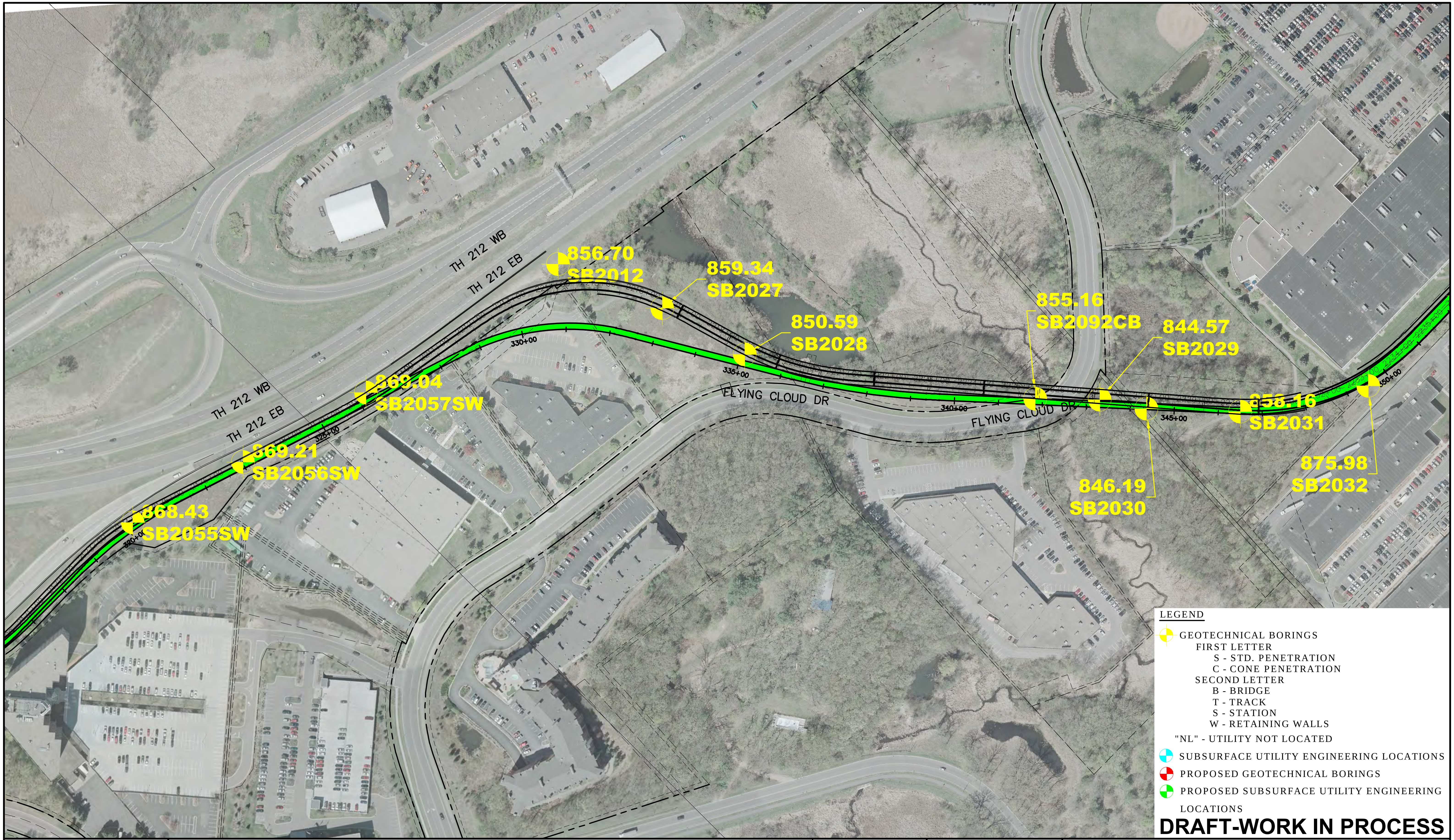

SOUTHWEST Green Line LRT Extention

SOUTHWEST LIGHT RAIL

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Lc = 213.60'
Ls = 140'
Ea = 3.00"
Eu = 2.46"
V = 20 MPH

CURVE NO. W1–119
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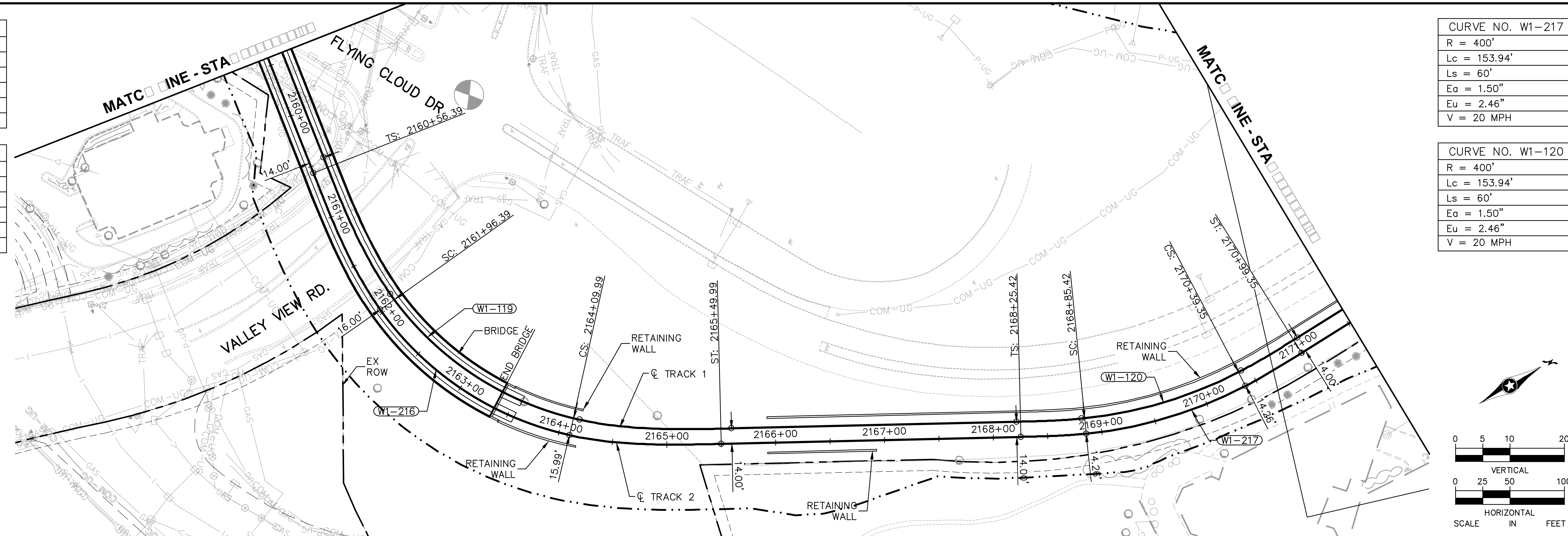
Lc = 213.60'
Ls = 140'
Ea = 3.00"
Eu = 2.46"
V = 20 MPH



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Ls = 60'
Ea = 1.50"
Eu = 2.46"
V = 20 MPH

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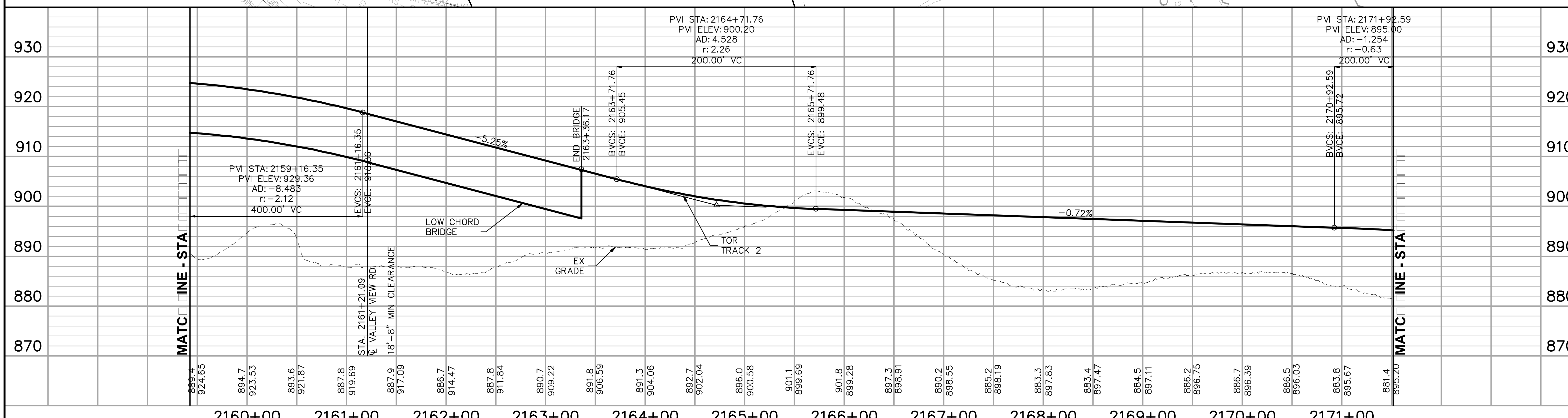
Ls = 60'
Ea = 1.50"
Eu = 2.46"
V = 20 MPH



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SOUTHWEST Green Line LRT Extension

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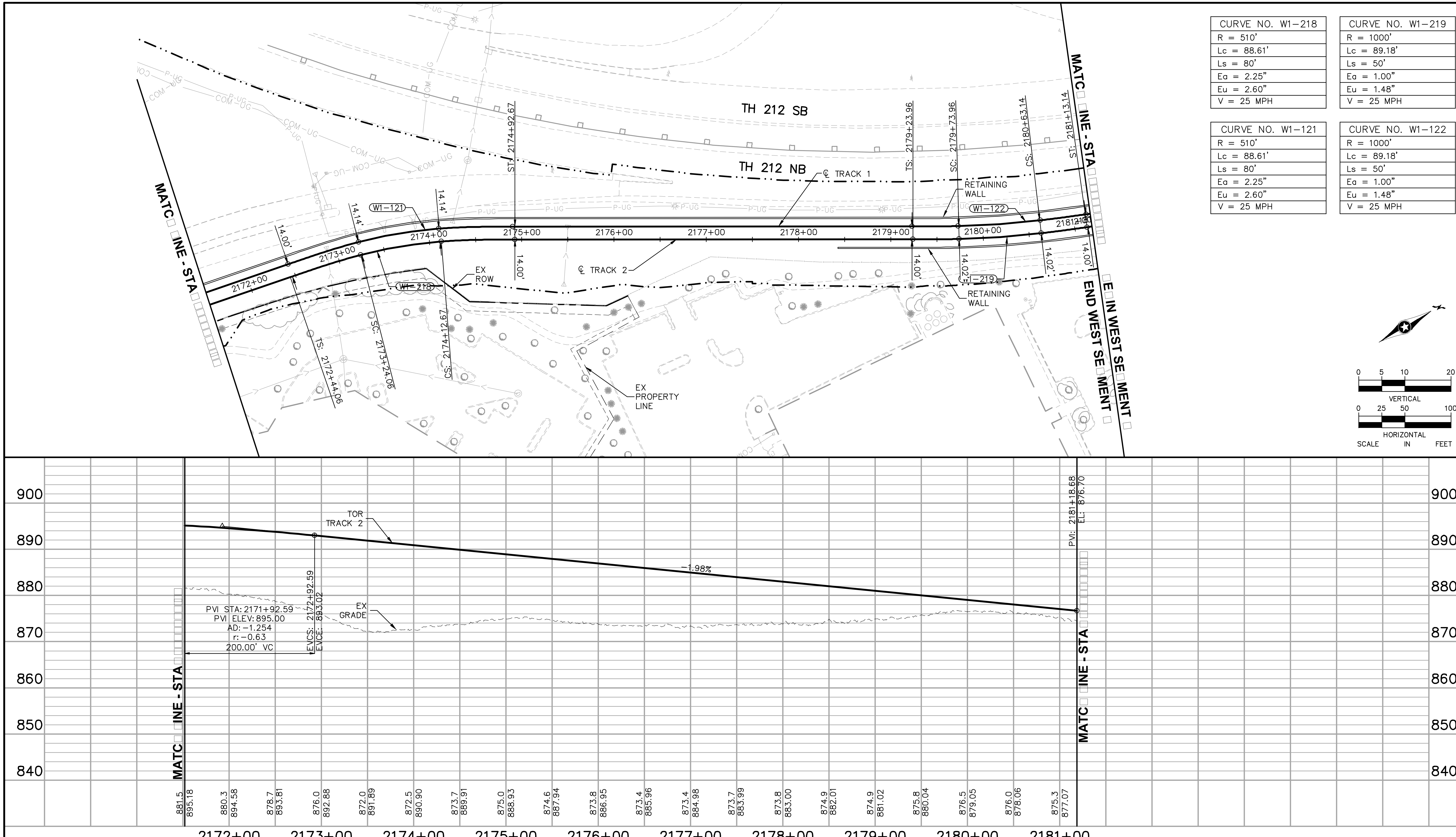

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Ls = 80'
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Eu = 2.60"
V = 25 MPH

CURVE NO. W1-219
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Lc = 89.18'
Ls = 50'
Ea = 1.00"
Eu = 1.48"
V = 25 MPH

CURVE NO. W1-121
R = 510'
Lc = 88.61'
Ls = 80'
Ea = 2.25"
Eu = 2.60"
V = 25 MPH

CURVE NO. W1-122
R = 1000'
Lc = 89.18'
Ls = 50'
Ea = 1.00"
Eu = 1.48"
V = 25 MPH

NO.	DATE		CHECK	DESIGN	REVISION / SUBMITTAL

PRELIMINARY ENGINEERING

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METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

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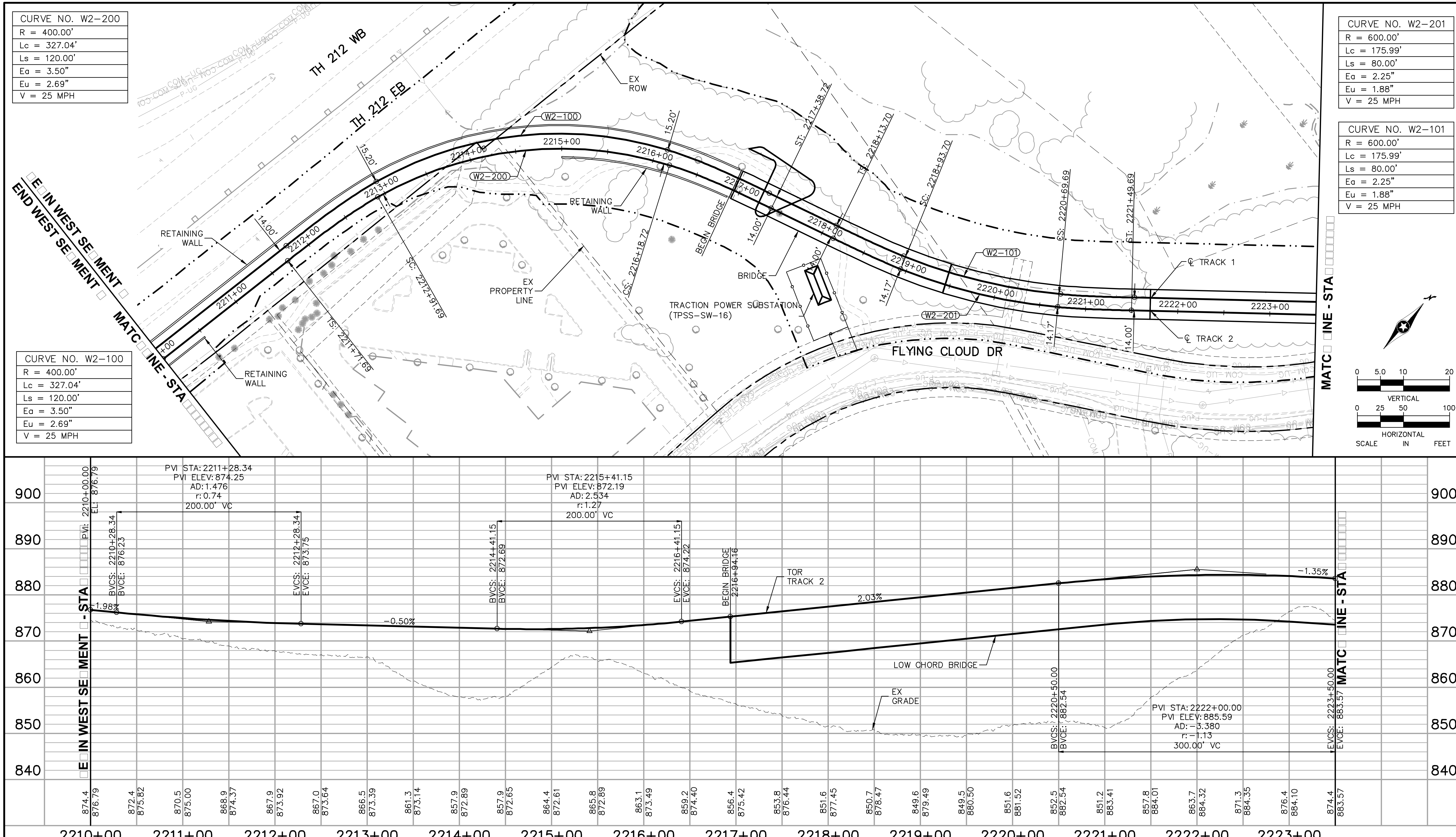
DISCIPLINE: TRACK

SHEET NAME: W□-TRK-PPF□-□□□

SHEET □□ OF □□

Jun. 13 2014 11:54 am V:\3200_PEC-W\CAD\SEGMENT-W1\SHEET\TRACK\W1-TRK-PLN.dwg By: Boscha



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METROPOLITAN COUNCIL — SOUTHWEST Green Line LRT Extension

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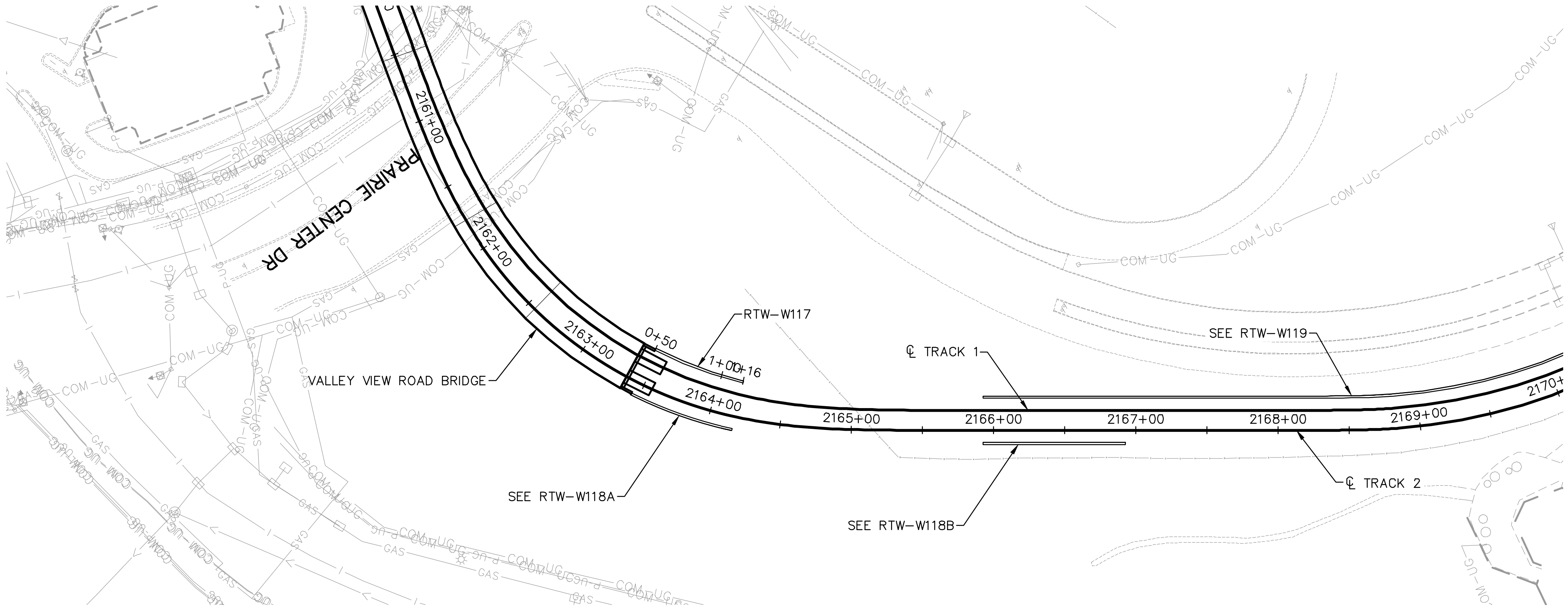
Jun. 13 2014 12:32 pm V:\3200_PEC-W\CAD\SEGMENT-W2\SHEET\TRACK\W2-TRK-PLN.dwg By: Konenji



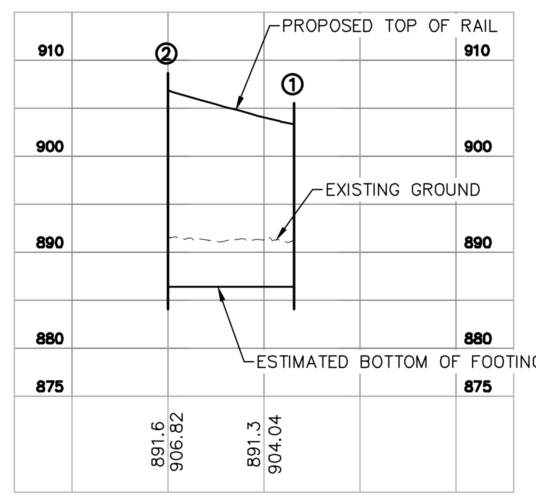
RTW-W117 PLAN

NOTE:
RTW-W117 IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL ON SPREAD FOOTINGS.

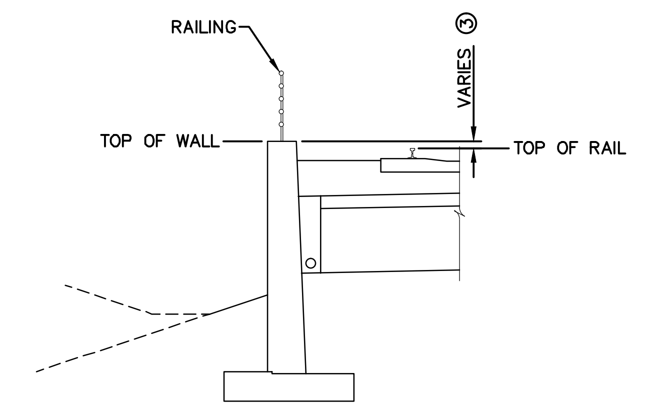
① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.

② JOINT LOCATION BETWEEN RETAINING WALL AND BRIDGE WINGWALL.

0 5 10 20
VERTICAL
0 25 50 100
HORIZONTAL
SCALE IN FEET



RTW-W117 PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW-W117 TYPICAL SECTION

Jun. 13 2014 10:55 am V:\3200_PEC-W\CAD\SEGMENT-W1\SHEET\STRUCTURES\W1-STU-RETW.dwg By: NutzmaML

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METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extention

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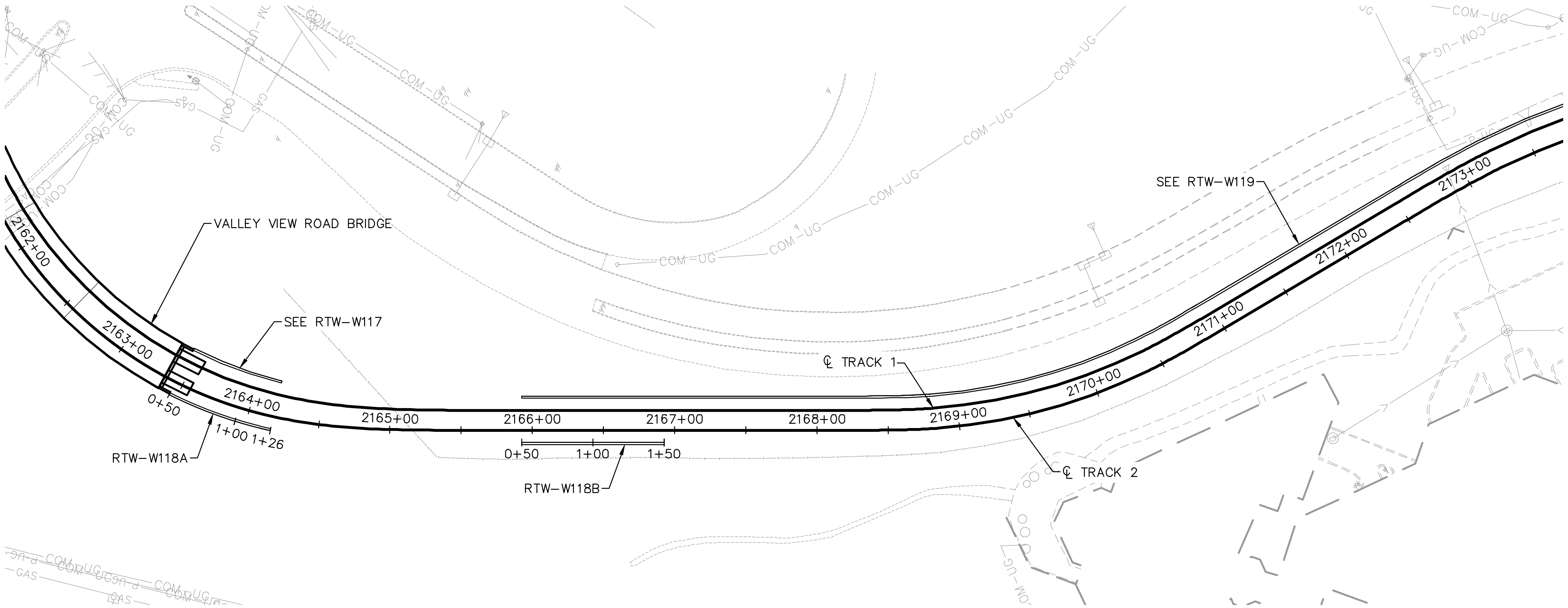
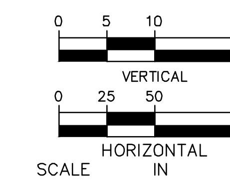


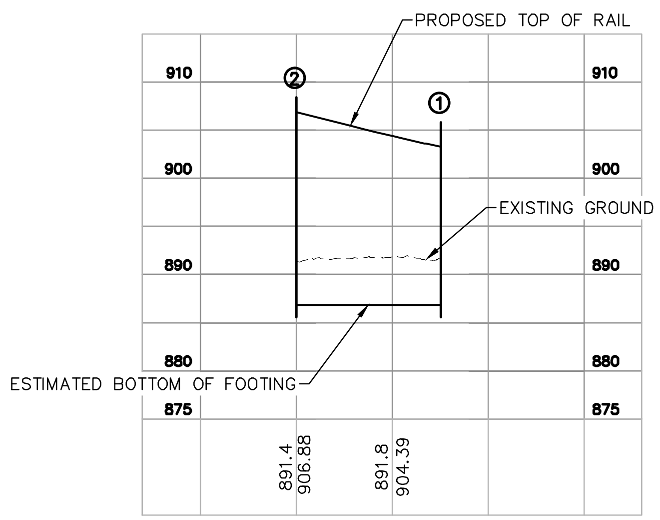
RTW-W118A & RTW-W118B PLAN

NOTE:
RTW-W118A AND RTW-W118B ARE ANTICIPATED TO BE CAST-IN-PLACE RETAINING WALLS ON SPREAD FOOTINGS.

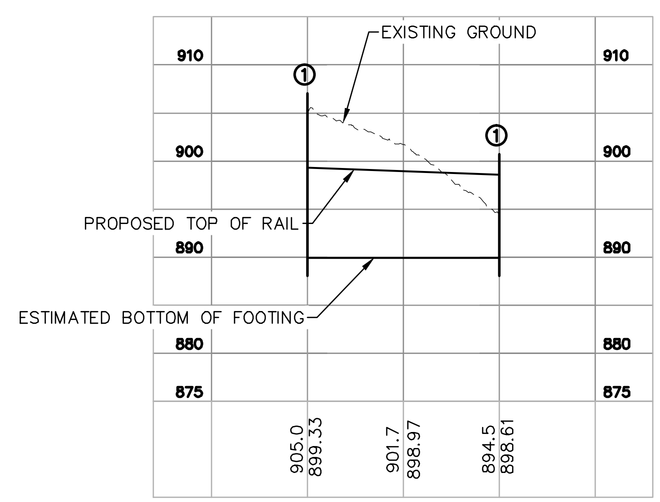
① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.

② JOINT LOCATION BETWEEN RETAINING WALL AND BRIDGE WINGWALL.

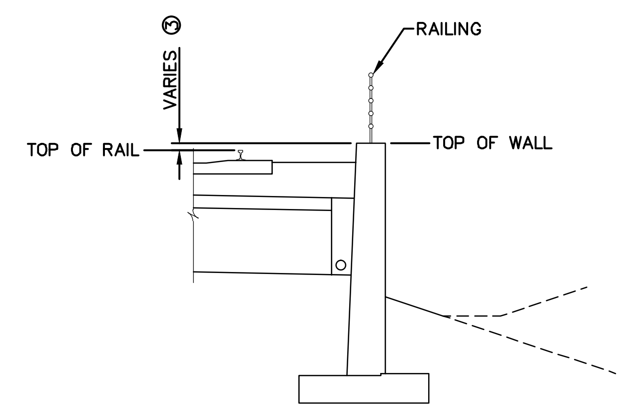




RTW-W118A PROFILE

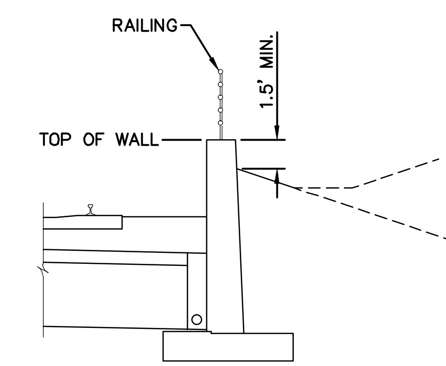


RTW-W118B PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW-W118A & RTW-118B TYPICAL SECTION
RTW-W118B STA. 1+20 TO STA. 1+50



RTW-W118B TYPICAL SECTION
STA. 0+50 TO STA. 1+20

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METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extention

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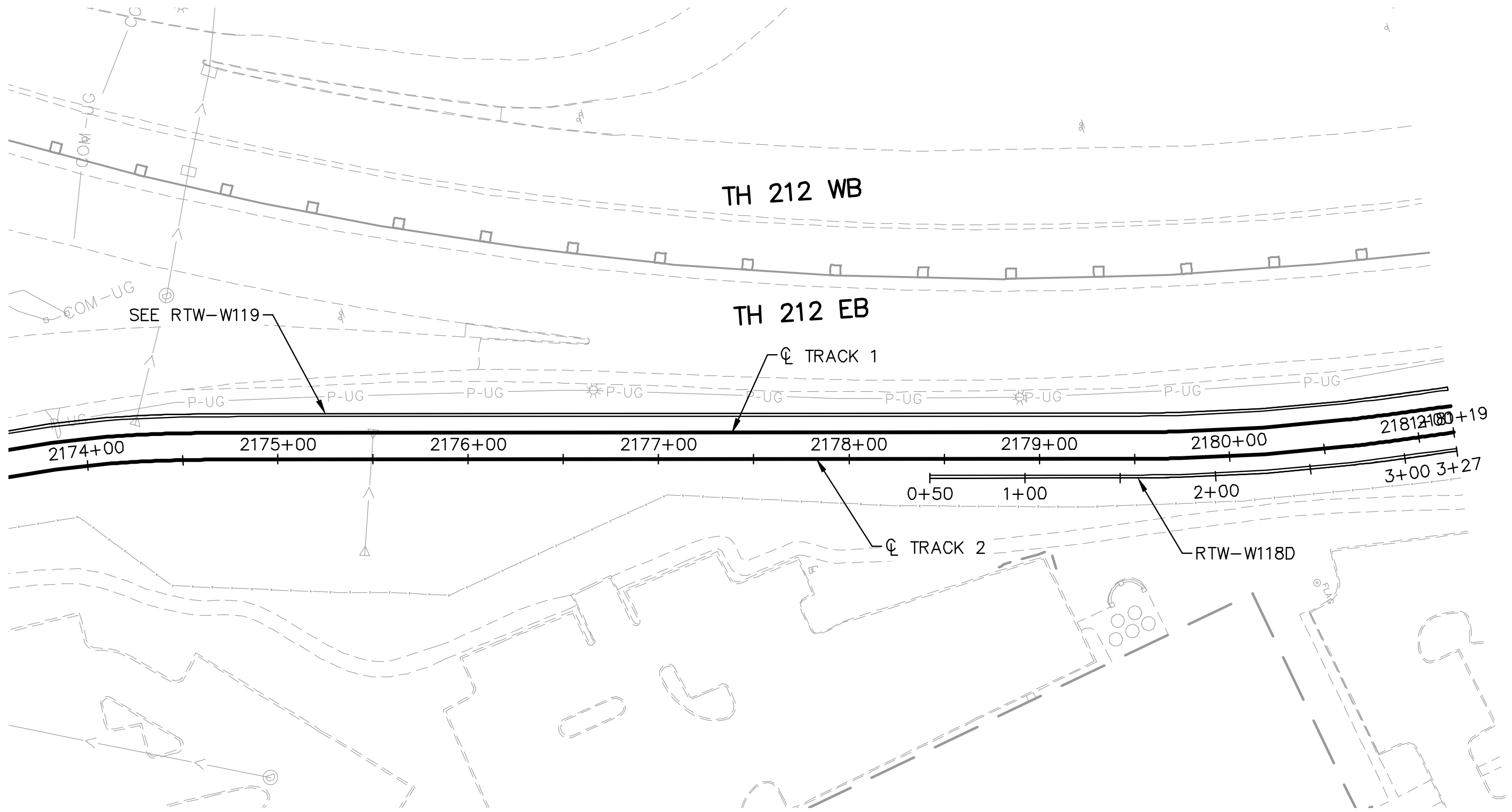
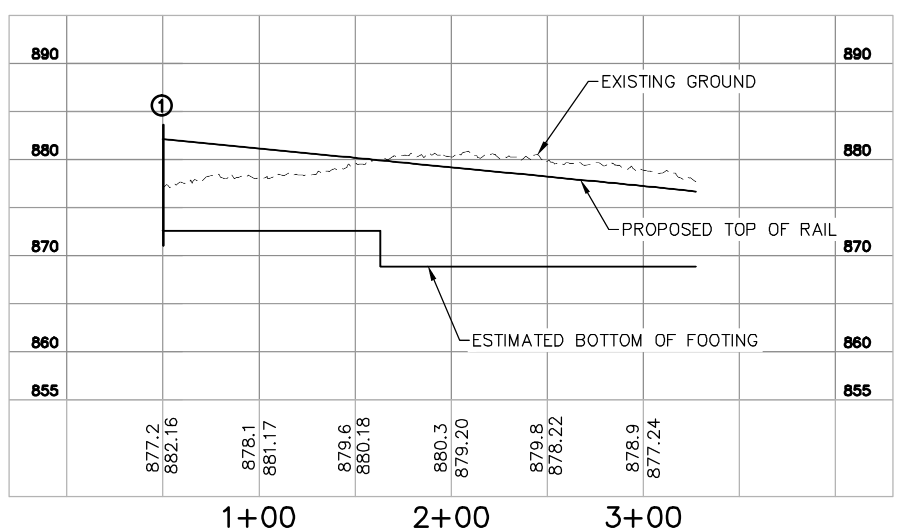
Jun. 13 2014 10:55 am V:\3200_PEC-W\CAD\SEGMENT-W1\SHEET\STRUCTURES\W1-STU-RETW.dwg By: NutzmaML

NOTE:
RTW-W118D IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL ON SPREAD FOOTINGS.

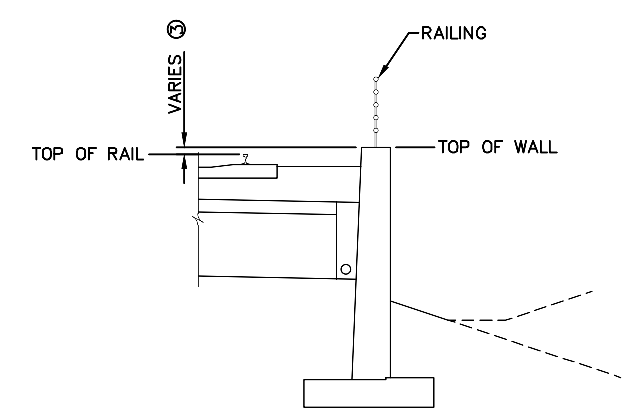
① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.



RTW-W118D PLAN

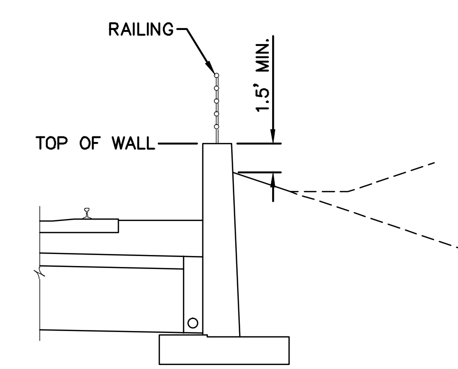


RTW-W118D PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW-W118D TYPICAL SECTION
STA. 0+50 TO STA. 1+63



RTW-W118D TYPICAL SECTION
STA. 1+63 TO STA. 3+27

0 5 10 20
VERTICAL
0 25 50 100
HORIZONTAL
SCALE IN FEET

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METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extention

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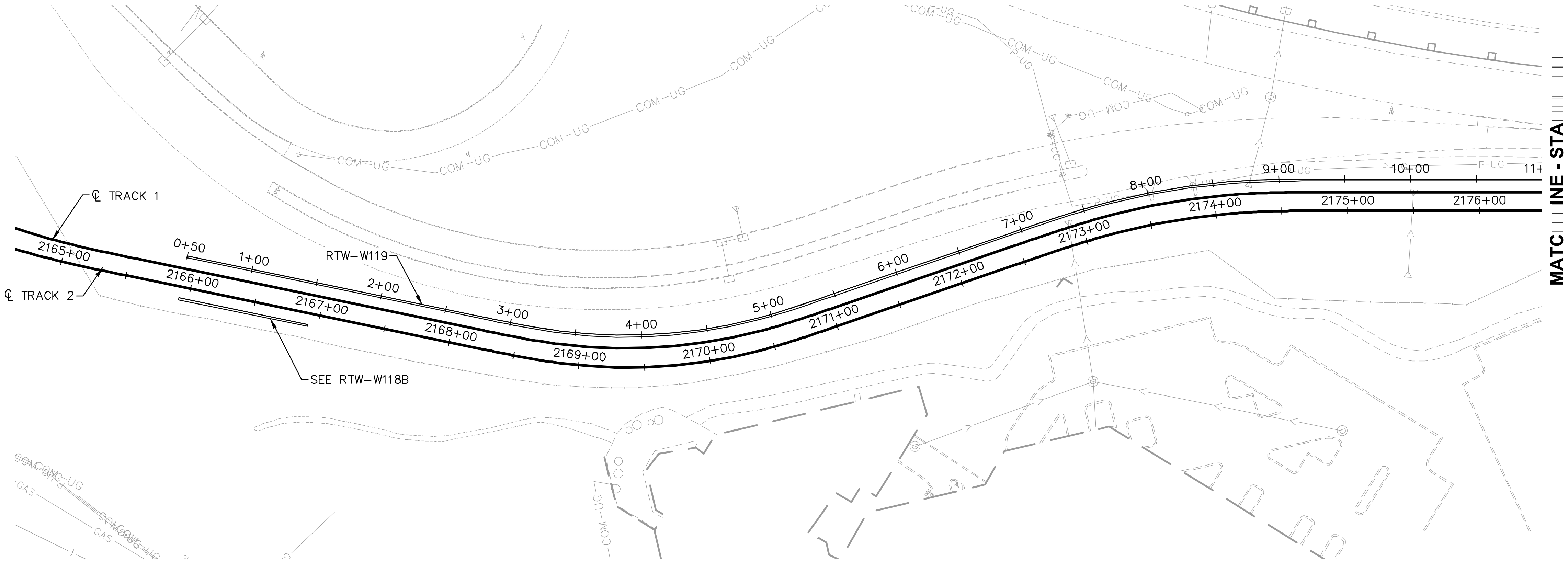
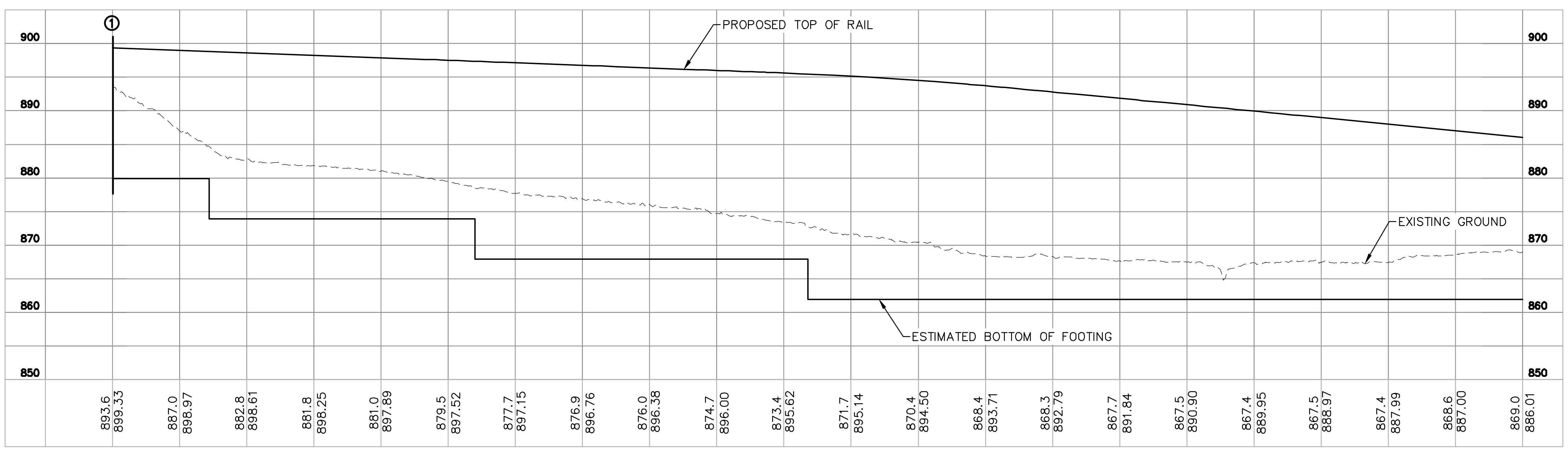
NOTE:
RTW–W119 IS ANTICIPATED TO BE A CAST–IN–PLACE RETAINING WALL ON SPREAD FOOTINGS.

① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.

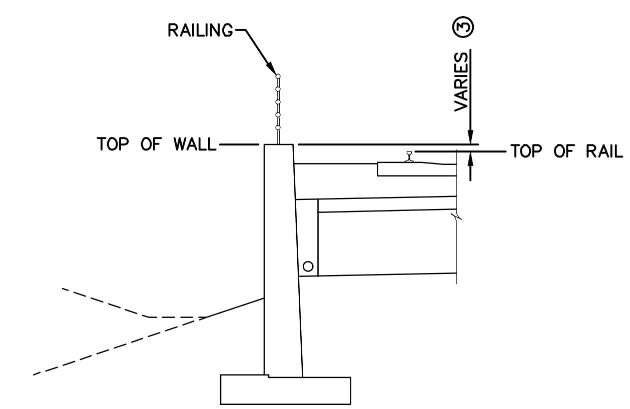


RTW–W119 PLAN

SCALE IN FEET — VERTICAL: 0, 5, 10, 20 — HORIZONTAL: 0, 25, 50, 100



RTW–W119 PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW–W119 TYPICAL SECTION

NO.	DATE		CHECK	DESIGN	REVISION / SUBMITTAL

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METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extention

WEST-SOME STRUCTURES
SEGMENT - RTW-W
PLAN AND PROFILE
STA TO STA

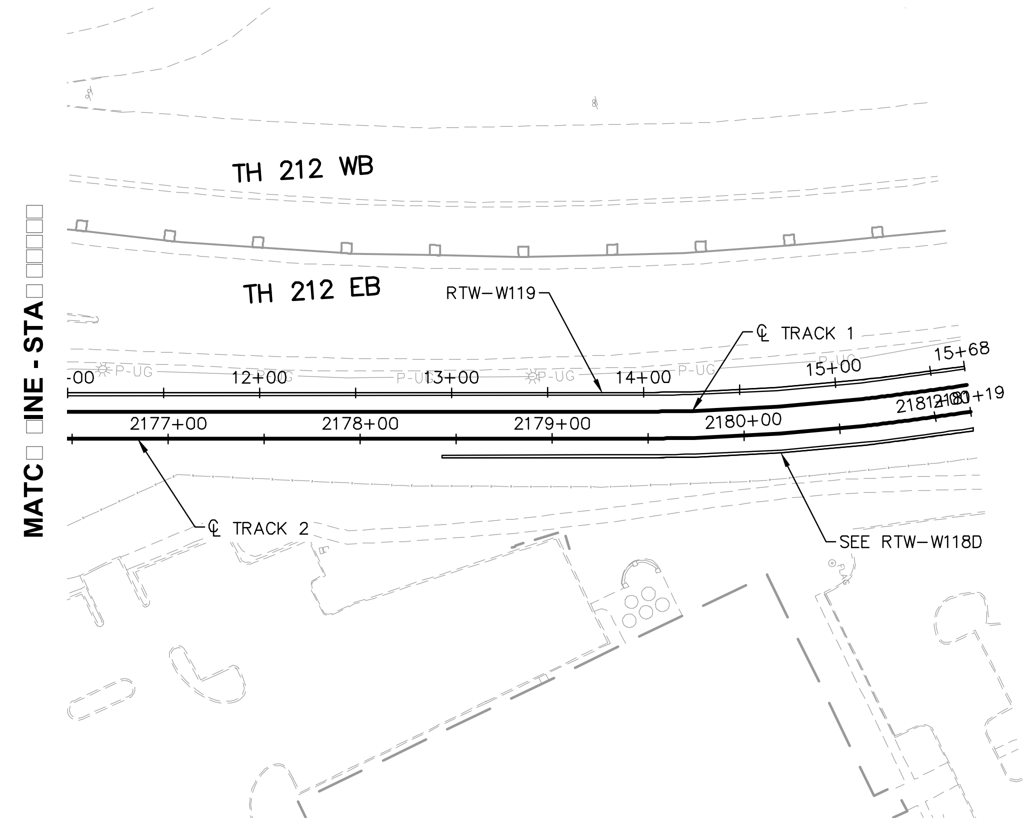
DISCIPLINE: STRUCTURES
SHEET NAME: W-ST-RTW-PPF-

SHEET
OF

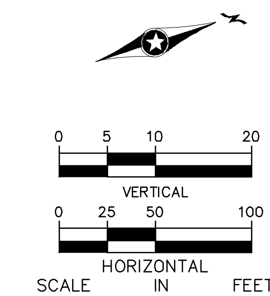
Jun, 13 2014 10:56 am V:\3200_PEC–W\CAD\SEGMENT–W1\SHEET\STRUCTURES\W1–STU–RETW.dwg By: NutzmaML

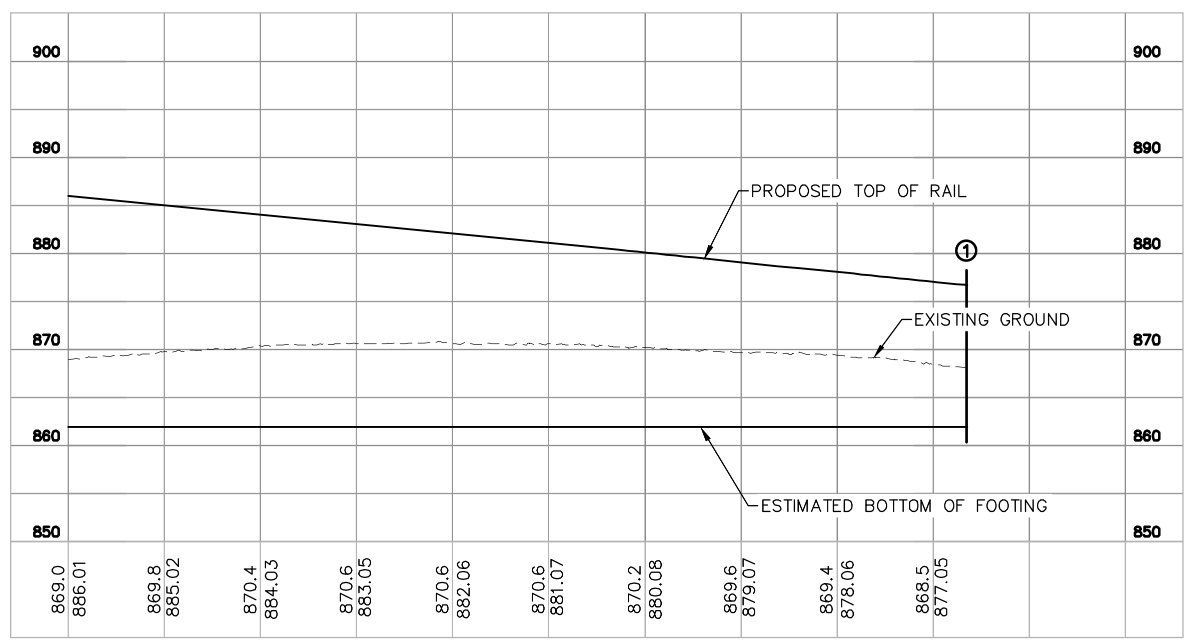
NOTE:
RTW–W119 IS ANTICIPATED TO BE A CAST–IN–PLACE RETAINING WALL ON SPREAD FOOTINGS.

① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.

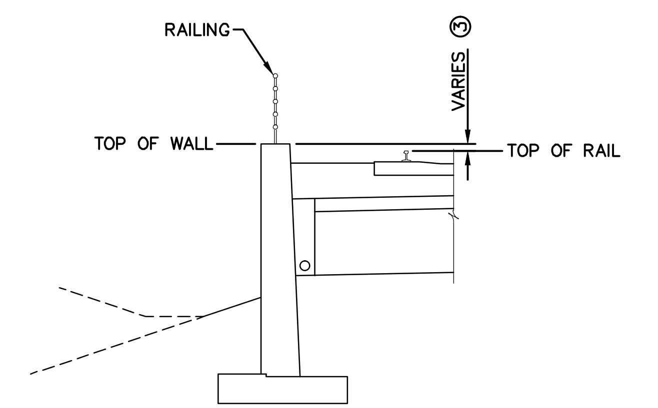


RTW–W119 PLAN





RTW–W119 PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW–W119 TYPICAL SECTION

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METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extension

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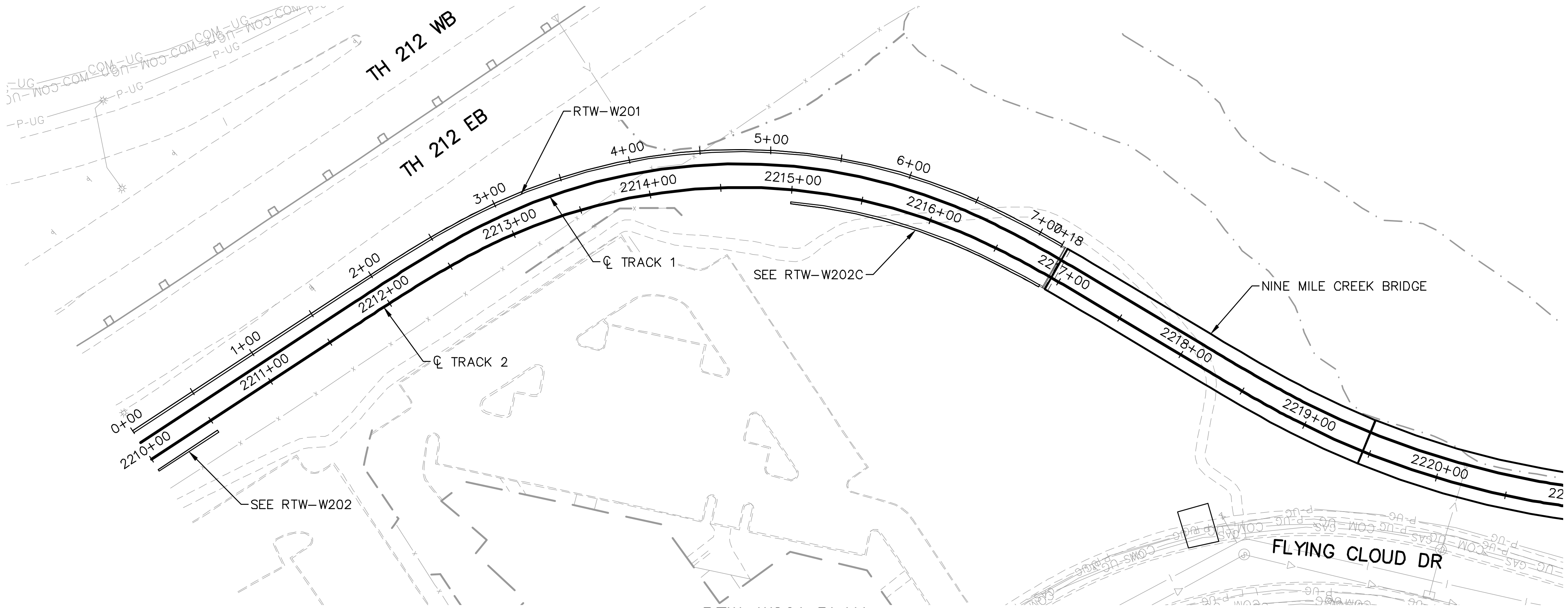
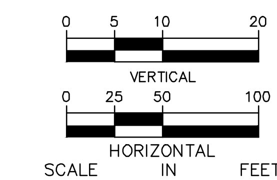
NOTE:
RTW-W201 IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL ON SPREAD FOOTINGS FROM STA. 2210+00 TO STA. 2211+80.

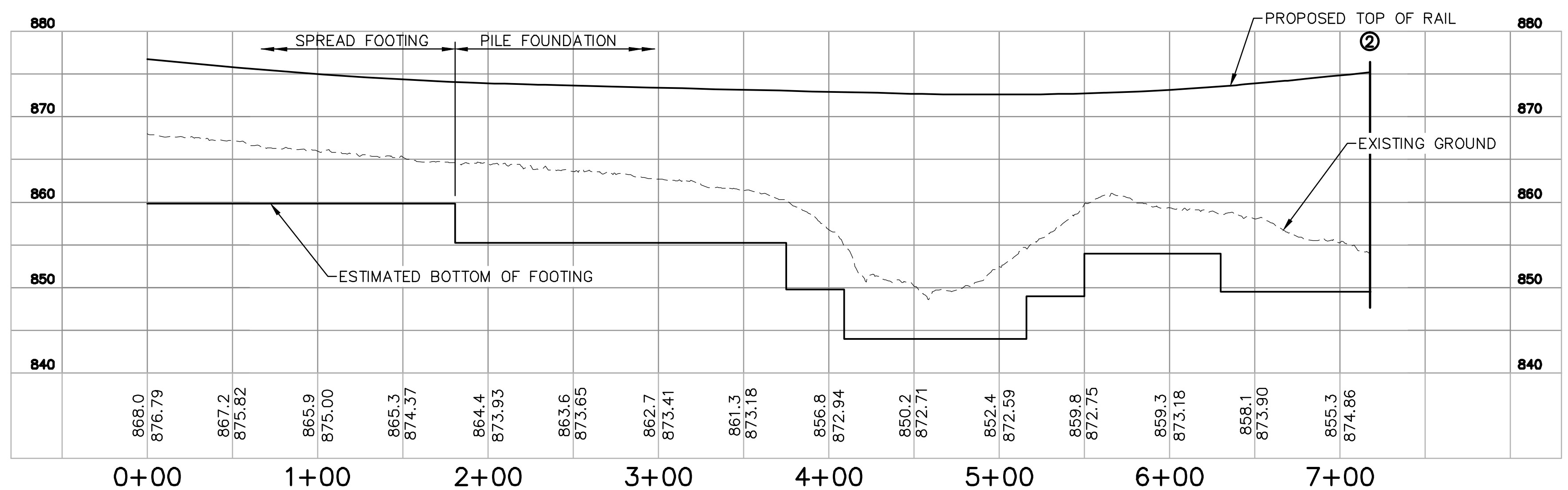
THE REMAINDER OF RTW-W201 IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL ON A PILE SUPPORTED FOUNDATION.

② JOINT LOCATION BETWEEN RETAINING WALL AND BRIDGE WINGWALL.

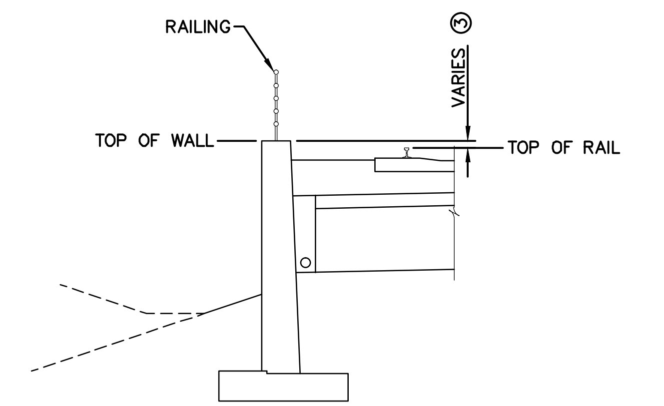


RTW-W201 PLAN





RTW-W201 PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW-W201 TYPICAL SECTION

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METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extention

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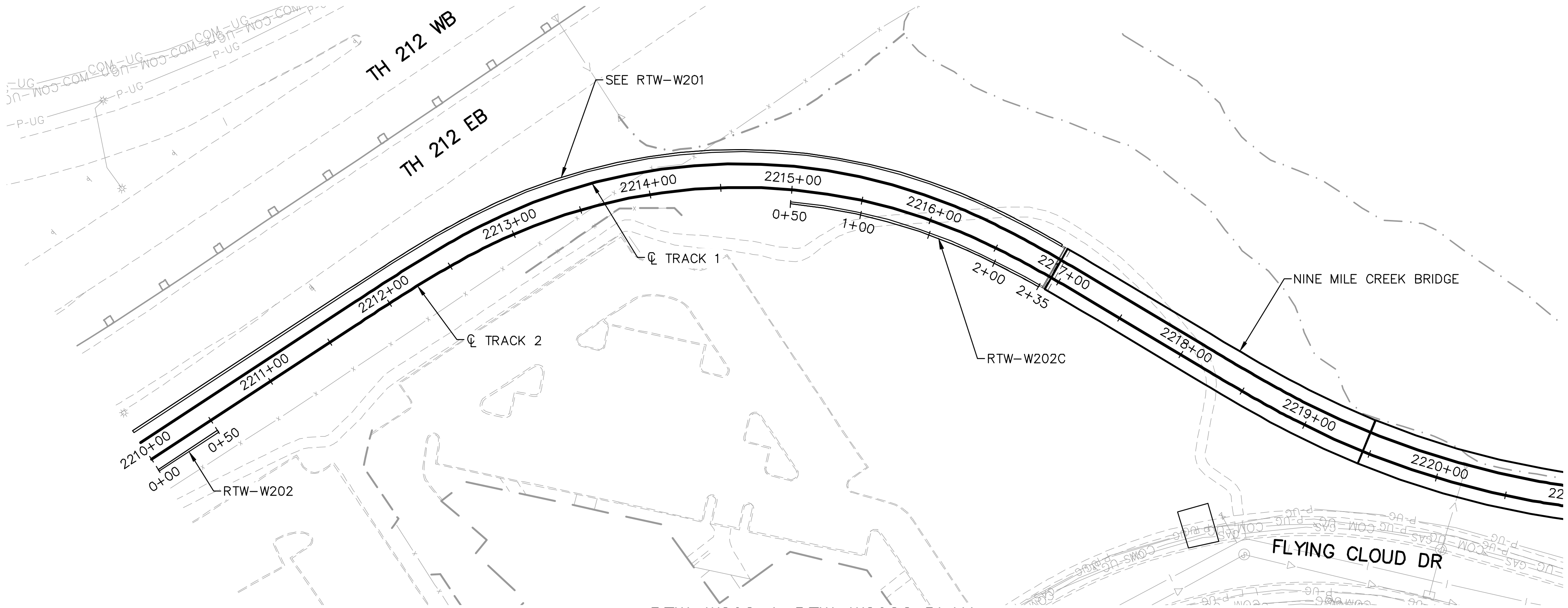
NOTE:
RTW-W202 IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL ON SPREAD FOOTINGS.

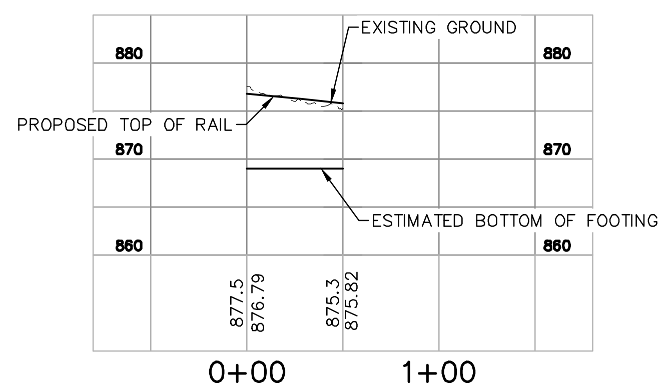
RTW-W202C IS ANTICIPATED TO BE A CAST-IN-PLACE RETAINING WALL WITH A PILE SUPPORTED FOUNDATION.

① PROPOSED GROUND LINE AT 2H:1V MAXIMUM SLOPE AT WALL TERMINATION NOT SHOWN.

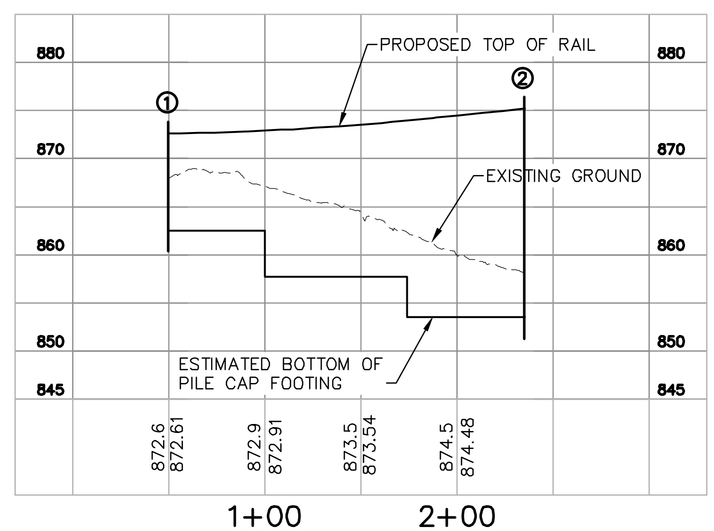
② JOINT LOCATION BETWEEN RETAINING WALL AND BRIDGE WINGWALL.



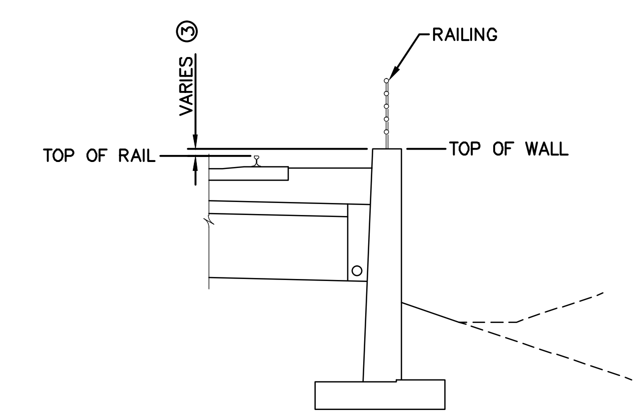
RTW-W202 & RTW-W202C PLAN



RTW-W202 PROFILE



RTW-W202C PROFILE



③ TOP OF WALL = TOP OF RAIL THROUGH TANGENTS
TOP OF WALL = TOP OF RAIL + SUPERELEVATION THROUGH CURVES

RTW-W202 & RTW-W202C TYPICAL SECTION

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METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extention

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2055SW	868.4 (Surveyed)

Location: Hennepin Co. Coordinate: X=491380 Y=128106 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine

Hammer CME Automatic Calibrated

SHEET 1 of 2

Drilling Completed 11/26/13

DEPTH	Depth / Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
	0.5 / 867.9	SANDY LEAN CLAY, with Gravel, dark brown, wet, (CLS), topsoil fill		11			
		SILTY SAND, fine- to medium-grained, with Gravel, gray, wet, medium dense, (SM) till	14	11			
5			21	10			P200=39%
			19	11			
10			21	11			
	13.0 / 855.4	POORLY GRADED SAND, fine- to medium-grained, with Gravel, brown, moist to 40 feet then waterbearing, (SP), outwash	65	12			Gravel encountered at 13 feet.
15			39	2			
			24	3			P200=3%
20			82	3			
			43	2			
25			39	2			
30			30	2			
35			25	4			
40 ▼			14	20			
45							

Index Sheet Code 3.0

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2055SW**	**868.4** *(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
	46.0			X	9	22				
	822.4		Bottom of Hole - 46 feet. Water observed to 40 feet with 40 feet of hollow-stem auger in the ground. Water observed to 42 feet with 44 1/2 feet of hollow-stem auger in the ground. Water not observed to cave-in depth immediately after withdrawal of auger. Boring immediately backfilled with bentonite grout.							

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	**2056SW**	**869.2** (Surveyed)

Location: Hennepin Co. Coordinate: X=491549 Y=128380 (ft.)

Latitude (North)= Longitude (West)=

No Station-Offset Information Available

Drill Machine

Hammer **CME Automatic Calibrated**

SHEET 1 of 1

Drilling Completed **11/26/13**

Depth / Elev.	Classification	SPT N60	MC (%)	Other Tests Or Remarks
0.5 / 868.7	SANDY LEAN CLAY, with Gravel, dark brown, wet, (CLS), topsoil fill		16	
7.0 / 862.2	FILL: Clayey Sand, fine- to medium-grained, trace roots, dark brown to brown, wet, (SC), fill	16	13	
		20	12	
12.0 / 857.2	CLAYEY SAND, trace Gravel, brown, moist, rather soft to soft, (SC), till	4	14	qp=1 tsf
		3	13	P200=29%
19.0 / 850.2	POORLY GRADED SAND, fine- to coarse-grained, with Gravel, brown, moist, very loose to dense, (SP), outwash	4	4	
		10	4	qp=4 tsf P200=3% P200=3%
		36	7	
22.0 / 847.2	SILT, with occasional Poorly Graded Sand lenses, brown, wet, medium dense, (ML), till	21	24	
29.0 / 840.2	LEAN CLAY, with Silt and Poorly Graded Sand lenses, brown, wet, stiff to hard, (CL), till	15	25	
		31	22	
31.0 / 838.2	POORLY GRADED SAND, fine- to medium-grained, brown, moist, dense, (SP), outwash	36	3	

Bottom of Hole - 31 feet.
Water not observed with 29 1/2 feet of hollow-stem auger in the ground.
Water not observed to cave-in depth of 22 feet immediately after withdrawal of auger.
Boring immediately backfilled with bentonite grout.

Column headings (no data recorded): COH (psf), γ (pcf), Soil, REC (%), RQD (%), ACL (ft), Core Breaks, Rock, Formation or Member, Drilling Operation, Lithology.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	**2057SW**	**869.0** (Surveyed)

Location Hennepin Co. Coordinate: X=491545 Y=128690 (ft.)

Latitude (North)= *Longitude (West)=*

No Station-Offset Information Available

Drill Machine

Hammer **CME Automatic Calibrated**

Drilling Completed **11/27/13**

DEPTH	Depth / Elev.	Lithology	Classification	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Other Tests Or Remarks / Formation or Member
	0.2 / 868.8		CLAYEY SAND, with Gravel, dark brown, moist, (SC), topsoil fill	12	12			
				11				
5			POORLY GRADED SAND, fine- to medium-grained, trace Gravel, with occasional Lean Clay lenses, brown, moist, (SP), fill	3				
				4				P200=4%
10	12.0 / 857.0			5				Trace of Clay at 10 feet.
				3				
15			POORLY GRADED SAND, fine- to medium-grained, trace Gravel, with occasional Silt lenses, brown, moist, medium dense, (SP), outwash	2				P200=3%
				26				Silt layer at 17 feet.
20	22.0 / 847.0			12				Gravel encountered at 20 feet.
	24.0 / 845.0		POORLY GRADED SAND, fine-grained, light brown, moist, dense, (SP), outwash	2				
25	29.0 / 840.0		SILT, with Sand and Clay lenses, brown and dark brown, moist, medium dense, (ML), till	20				
30	31.0 / 838.0		SILTY SAND, fine- to medium-grained, trace Gravel, gray, wet, medium dense, till, (SM), till	8				

Bottom of Hole - 31 feet.
Water not observed with 29 1/2 feet of hollow stem auger in the ground.
Water not observed to cave-in depth of 16 feet after withdrawal of auger.
Boring immediately backfilled with bentonite grout.

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	**2012SB**	**856.7** (Surveyed)

Location: Hennepin Co. Coordinate: X=491648 Y=12904 (ft.)

Latitude (North)= *Longitude (West)=*

No Station-Offset Information Available

Drill Machine **7507**

Hammer **CME Automatic Calibrated**

Drilling Completed **7/19/13**

Depth / Elev.	Classification	SPT N60	MC (%)	Other Tests Or Remarks
1.5 / 855.2	CLAYEY SAND, trace roots, dark brown, moist, (SC), topsoil fill		12	
4.0 / 852.7	SILTY SAND, fine- to medium-grained, trace Gravel, with Clay inclusions, dark gray and brown, moist, (SM), fill	12	11	
7.0 / 849.7	CLAYEY SAND, trace Gravel, dark brown and gray, wet, (SC), fill	8	14	
12.0 / 844.7	SILTY SAND, fine- to medium-grained, trace Gravel, dark brown, moist to 10 feet then waterbearing, (SM), fill	4	18	
		10	16	
19.0 / 837.7	SILTY SAND, fine- to coarse-grained, trace Gravel, with Clay lenses and seams, brown, waterbearing, loose to medium dense, (SM) till	10	20	
		16	25	
		16	11	
34.0 / 822.7	SANDY LEAN CLAY, trace Gravel, gray, wet, stiff to hard, (CL), till	18	10	qp=2 tsf
		13	16	qp=2 tsf
		20	12	qp=1 1/2 tsf
		32	16	qp=2 1/2 tsf
		15	11	
		20	18	qp=1 1/2 tsf
42.0 / 814.7	POORLY GRADED SAND, fine- to coarse-grained, trace Gravel, gray, waterbearing, medium dense, (SP), outwash	15	15	
		15*	15	
		20	12	*No sample recovery. Switched to mud rotary drilling method after 40-foot sample.
	SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff, (CL), till	21	16	qp=1 1/2 tsf

Water level symbol at 10 ft. Drilling operation: PD below 38 ft.

Index Sheet Code 3.0

(Continued Next Page)

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
		SWLRT	**2012SB**	**856.7** *(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
		SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff, (CL), till *(continued)*	X	23	14			qp=2 tsf
			PD					
	49.0 / 807.7		X	20	17			
50		POORLY GRADED SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, medium dense to dense, (SP), outwash	PD					
			X	32	12			
			PD					
55			X	38	12			
			PD					
	59.0 / 797.7	SILTY SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, dense, (SM), till						
60			X	48	13			
			PD					
	64.0 / 792.7	CLAYEY SAND, trace Gravel, gray, wet, hard, (SC), till						
65			X	47	9			qp=4 tsf
			PD					
	69.0 / 787.7	SILTY SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, dense, (SM), till						
70			X	54	11			
			PD					
	74.0 / 782.7	CLAYEY SAND, trace Gravel, gray, wet, hard, (SC), till						
75			X	41	12			
			PD					
80			X	46	14			
			PD					
	84.0 / 772.7	SANDY LEAN CLAY, trace Gravel, gray, wet hard, (CL), till						
85			X	45	17			
			PD					
90								

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2012SB**	**856.7** *(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
			SANDY LEAN CLAY, trace Gravel, gray, wet hard, (CL), till *(continued)*	PD	44	17				
95	96.0 / 760.7		Bottom of Hole - 96 feet. Water observed at 10 feet with 9 1/2 feet of hollow-stem auger in the ground. Boring then sealed with bentonite grout.							

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

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
		SWLRT	2027SB	859.3 (Surveyed)

Location	Hennepin Co. Coordinate: X=491886 Y=129301 (ft.)
	Latitude (North)= Longitude (West)=
	No Station-Offset Information Available
Drill Machine	7504
Hammer	CME Automatic Calibrated
SHEET 1 of 3	
Drilling Completed	9/10/13

Depth / Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks
0.5 / 858.8	LEAN CLAY, brown, moist, (CL), topsoil fill					
5.0 / 854.3	LEAN CLAY, brown, moist, (CL), fill	23				
7.0 / 852.3	CLAYEY SAND, fine- to medium-grained, with Gravel, brown, moist to wet, (SC), fill	11				
14.0 / 845.3	CLAYEY SAND, trace Gravel, brown, wet, (SC), fill	6	13			
		10	12			P200=31%
		2				Sand lenses at 12 feet.
20.0 / 839.3	POORLY GRADED SAND with SILT, fine- to medium-grained, with Lean Clay lenses at 15 feet, gray, waterbearing, (SP-SM), fill	4				
		2				
27.0 / 832.3	PEAT, with fibers and roots, black, wet, (PT), swamp deposit	3				
		TW				
		5				Trace fibers at 25 feet.
						Occasional Sand lenses at 26 feet.
	LEAN CLAY, with fibers and shells, black, wet, (CL), swamp deposit.	6	68			OC=7%
		6				
		5				
		TW				Su=1,545 psf; WD=79 pcf
		6	94			OC=14%; LL=91; PL=82, PI=9
		3				Occasional layers of Peat at 44 feet.

Depth scale: 5, 10, 15 (water level ▼), 20, 25, 30, 35, 40, 45

Index Sheet Code 3.0

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2027SB**	**859.3** *(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
			LEAN CLAY, with fibers and shells, black, wet, (CL), swamp deposit. *(continued)*		5					
	47.0 / 812.3		SILTY SAND, fine- to medium-grained, trace Gravel, gray, waterbearing, (SM), swamp deposit		13					
50	49.0 / 810.3		SILT, trace roots and organics, gray, waterbearing, (ML), swamp deposit	PD	7					Switched to mud rotary drilling method after 50-foot sample.
55	54.0 / 805.3		SILTY SAND, fine- to medium-grained, with Gravel, gray to 60 feet then brown, waterbearing, medium dense to very dense, (SM), till	PD	22					
60				PD	71	12				P200=13%
65	64.0 / 795.3		SILTY CLAY, with Silt layers, gray, wet, hard, (CL-ML), till	PD	47	23				LL=26; PL=20; PI=6
70	69.0 / 790.3		POORLY GRADED SAND, fine- to coarse-grained, with Gravel, gray, waterbearing, very dense, (SP), outwash	PD	79					
75	74.0 / 785.3		SANDY LEAN CLAY, trace Gravel, gray, wet, very stiff, (CLS), till	PD	19					qp=2 tsf
80				PD	24					qp=1 1/2 tsf
85	84.0 / 775.3		CLAYEY SAND, with Sand lenses from 85 to 95 feet, gray, wet, very stiff to hard, (SC), till	PD	27	12				P200=36%
90										

(Continued Next Page)

BRAUN INTERTEC

UNIQUE NUMBER

U.S. Customary Units

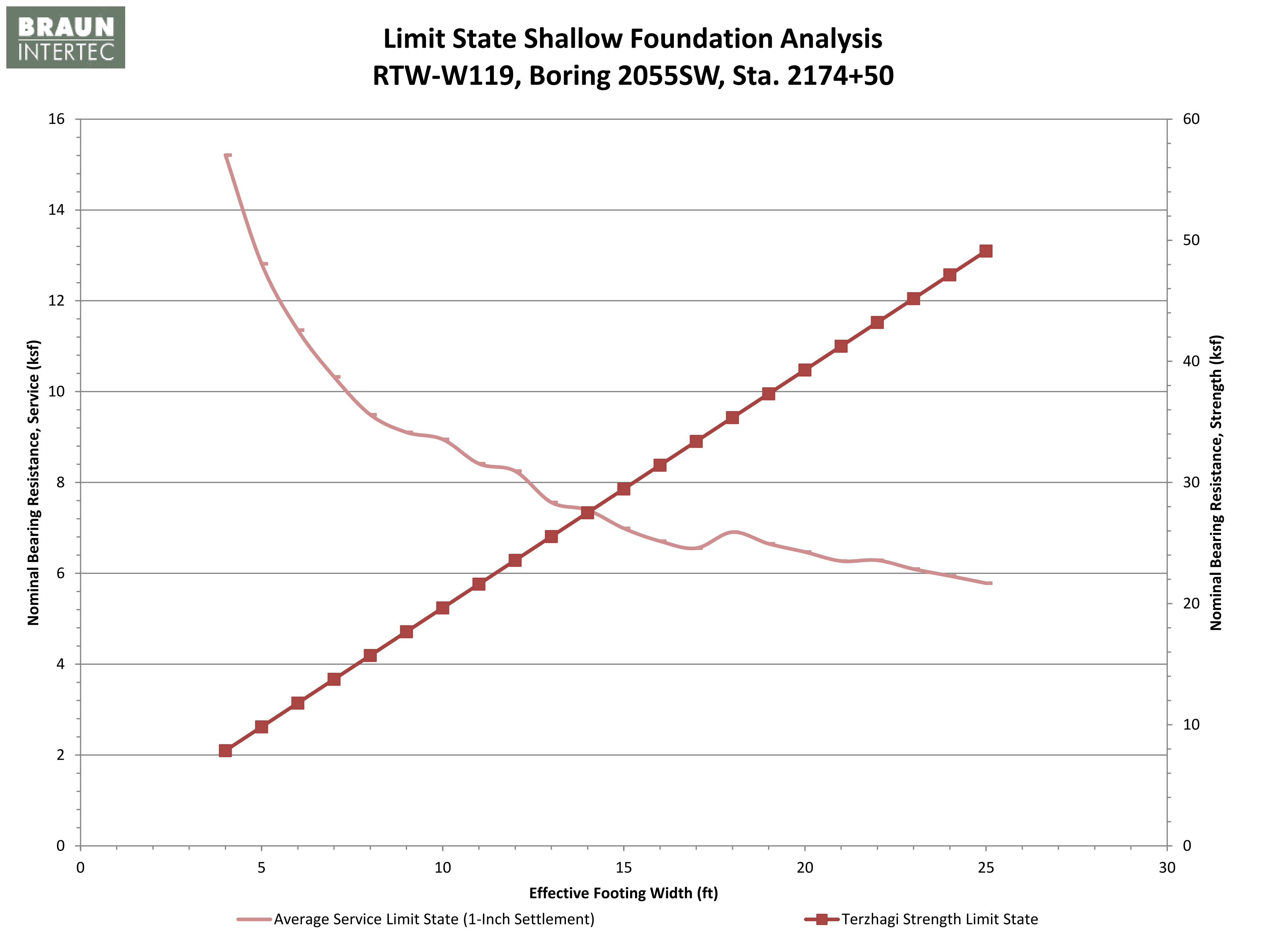
METROPOLITAN COUNCIL

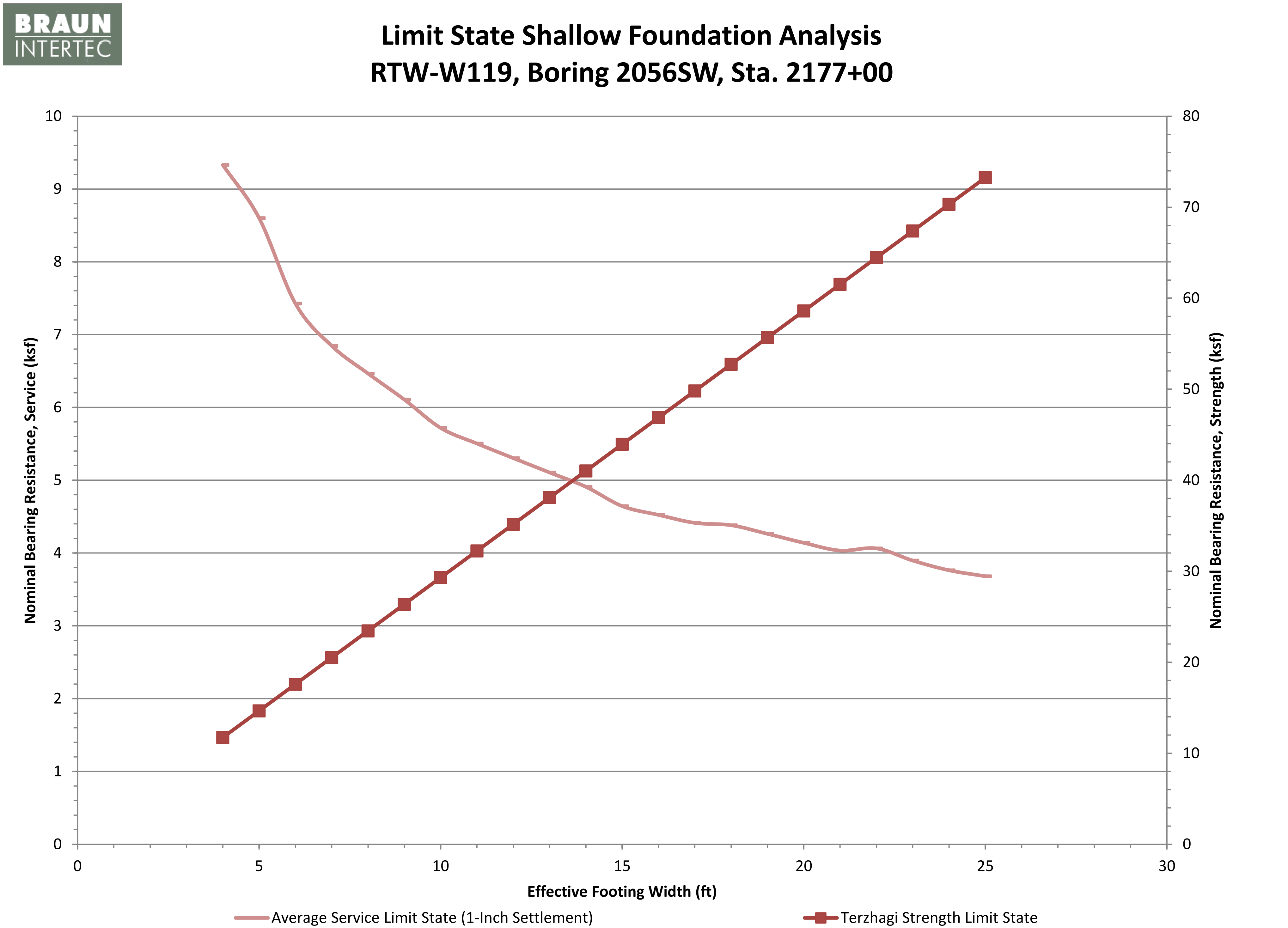
MINNESOTA DEPARTMENT OF TRANSPORTATION

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS

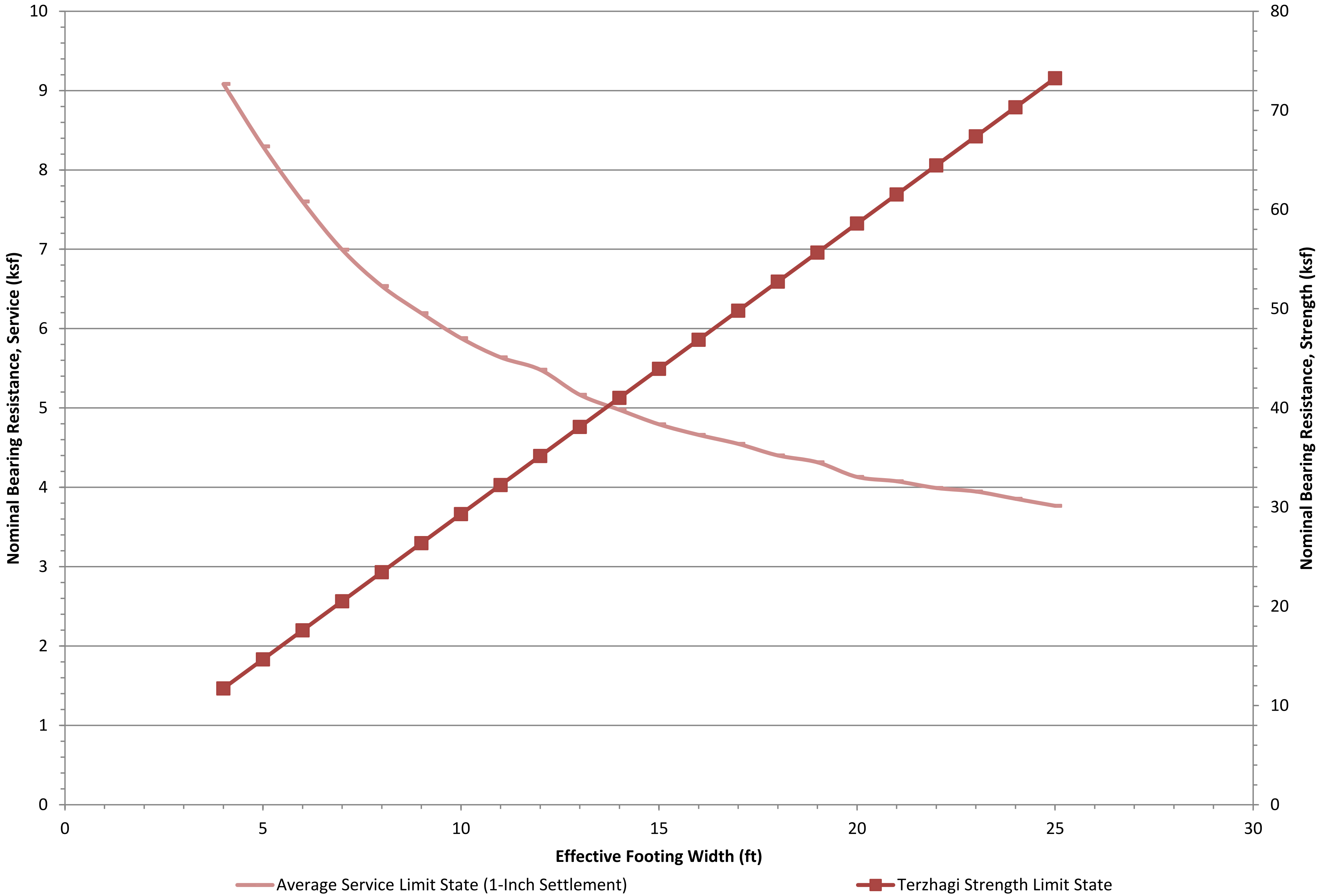
State Project	*Bridge No. or Job Desc.*	*Trunk Highway/Location*	*Boring No.*	*Ground Elevation*
		SWLRT	**2027SB**	**859.3** *(Surveyed)*

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
			CLAYEY SAND, with Sand lenses from 85 to 95 feet, gray, wet, very stiff to hard, (SC), till *(continued)*	X	51					
				PD						
95				X	20					
				PD						
100				X	18					
105				PD						
	109.0 / 750.3									
110			SILTY SAND, fine- to medium-grained, with Gravel, brown, waterbearing, medium dense to dense, (SM), till	X	36					
115				PD						
120				X						
	121.0 / 738.3		Bottom of Hole - 121 feet. Water observed at 15 feet with 15 feet of hollow-stem auger in the ground. Boring immediately backfilled with bentonite grout.							


BRAUN
INTERTEC
Limit State Shallow Foundation Analysis
RTW-W119, Boring 2055SW, Sta. 2174+50
Nominal Bearing Resistance, Service (ksf)
Nominal Bearing Resistance, Strength (ksf)
Effective Footing Width (ft)
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
Average Service Limit State (1-Inch Settlement)
Terzhagi Strength Limit State

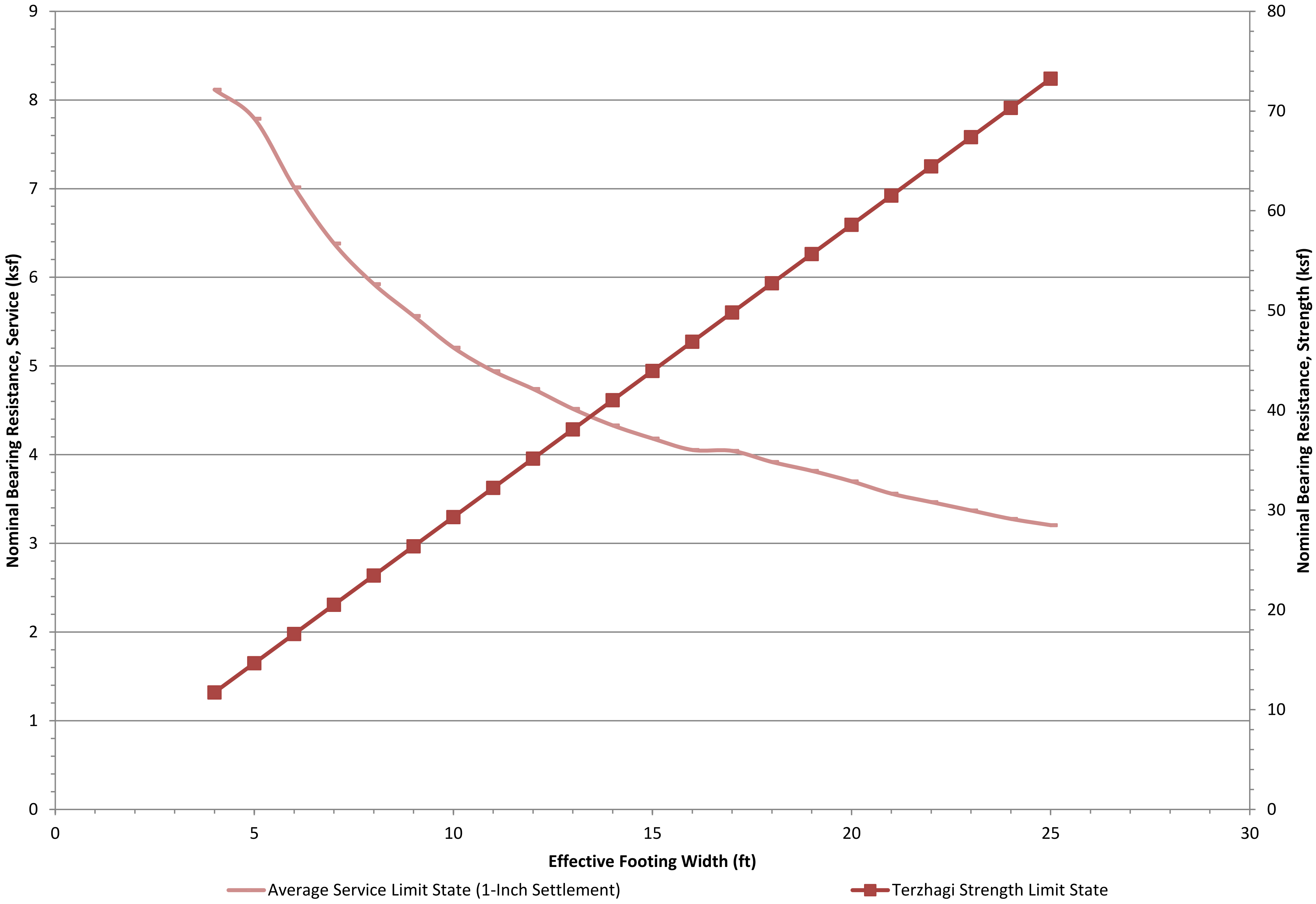

BRAUN INTERTEC
Limit State Shallow Foundation Analysis
RTW-W119, Boring 2056SW, Sta. 2177+00
Nominal Bearing Resistance, Service (ksf)
Nominal Bearing Resistance, Strength (ksf)
Effective Footing Width (ft)
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25
30
Average Service Limit State (1-Inch Settlement)
Terzhagi Strength Limit State

Limit State Shallow Foundation Analysis
RTW-W119, Boring 2057SW, Sta. 2180+50



BRAUN INTERTEC

Limit State Shallow Foundation Analysis
RTW-W119, Boring 2056SW, Sta. 2177+00



WALL LOADING CASE:
2' - LIVE LOAD SURCHARGE

WALL GEOMETRICS AND DATA - SPREAD FOOTING							QUANTITIES PER FOOT - SPREAD FOOTING					BASE PRESSURE KIPS/SQ. FT.	
							STRUCTURAL CONCRETE		REINFORCEMENT				
STEM HEIGHT h	STEM WIDTH a	TOE WIDTH b	FOOTING THICKNESS c	FOOTING WIDTH d	SHEAR KEY SIZE e	SHEAR KEY LOCATION f	1A43 (CU.YD.) FOOTING	3Y43 (CU.YD.) STEM	PLAIN (POUND)	EPOXY (POUND)	WALL DETAILING SCHEME ①	TOE	HEEL
5	1'-8½"	1'-0"	1'-5"	3'-6"	N/A	N/A	0.187	0.296	15.38	38.16	SHORT	1.670	0.070
6	1'-9"	1'-2"	1'-5"	4'-0"	N/A	N/A	0.211	0.360	16.43	41.74	SHORT	1.820	0.090
7	1'-9½"	1'-4"	1'-5"	4'-6"	N/A	N/A	0.235	0.425	19.70	45.34	SHORT	1.970	0.120
8	1'-10"	1'-6"	1'-5"	5'-0"	N/A	N/A	0.259	0.492	20.75	48.89	SHORT	2.110	0.150
9	1'-10½"	1'-8"	1'-5"	5'-6"	N/A	N/A	0.283	0.561	24.13	52.69	SHORT	2.250	0.180
10	1'-11"	1'-9"	1'-5"	6'-0"	N/A	N/A	0.306	0.631	25.18	62.49	MEDIUM	2.446	0.199
11	1'-11½"	2'-0"	1'-5"	6'-6"	N/A	N/A	0.331	0.703	31.26	66.85	MEDIUM	2.536	0.239
12	2'-0"	2'-3"	1'-5"	6'-9"	1'-0"	3'-10⅝"	0.360	0.776	35.38	72.23	MEDIUM	2.758	0.156
13	2'-0½"	2'-6"	1'-5"	7'-0"	1'-0"	4'-2⅛"	0.393	0.851	40.30	76.82	MEDIUM	2.986	0.013
14	2'-1"	2'-9"	1'-6"	7'-8"	1'-0"	4'-5¾"	0.477	0.928	40.49	81.74	MEDIUM	3.147	0.078
15	2'-1½"	3'-0"	1'-6"	8'-2"	1'-0"	4'-9¼"	0.506	1.006	40.10	99.57	TALL	3.239	0.111
16	2'-2"	3'-3"	1'-9"	8'-8"	1'-0"	5'-0⅞"	0.615	1.085	41.38	105.97	TALL	3.494	0.056
17	2'-2½"	3'-6"	1'-9"	9'-2"	1'-0"	5'-4⅜"	0.649	1.166	49.02	111.90	TALL	3.566	0.089
18	2'-3"	3'-9"	1'-9"	9'-8"	1'-0"	5'-7⅞"	0.682	1.249	50.52	129.74	TALL	3.679	0.121
19	2'-3½"	4'-0"	2'-0"	10'-2"	1'-0"	5'-11½"	0.810	1.333	54.26	137.41	TALL	3.935	0.066
20	2'-4"	4'-3"	2'-0"	10'-8"	1'-0"	6'-3"	0.875	1.417	61.38	165.51	TALL	4.056	0.090
21	2'-4½"	4'-6"	2'-0"	11'-2"	1'-0"	6'-6½"	0.916	1.504	71.34	174.30	TALL	4.151	0.122
22	2'-5"	4'-9"	2'-3"	11'-8"	1'-0"	6'-10⅛"	1.064	1.593	65.93	183.51	TALL	4.407	0.067
23	2'-5½"	5'-0"	2'-6"	12'-2"	1'-0"	7'-1¾"	1.221	1.683	84.82	224.49	TALL	4.663	0.012
24	2'-6"	5'-3"	2'-9"	12'-9"	1'-0"	7'-5⅜"	1.396	1.775	94.03	234.03	TALL	4.872	0.020
25	2'-6½"	5'-6"	2'-9"	13'-3"	1'-0"	7'-8⅞"	1.449	1.868	100.13	288.16	TALL	4.967	0.052
26	2'-7"	5'-10"	3'-0"	13'-9"	1'-0"	8'-1½"	1.631	1.963	102.26	299.67	TALL	5.189	0.000
27	2'-7½"	6'-2"	3'-3"	14'-4"	1'-0"	8'-6⅛"	1.832	2.059	127.34	315.84	TALL	5.364	0.000
28	2'-8"	6'-6"	3'-3"	15'-0"	1'-0"	8'-10⅝"	1.916	2.157	140.92	394.98	TALL	5.334	0.140
29	2'-8½"	6'-10"	3'-6"	15'-6"	1'-0"	9'-¾"	2.123	2.257	148.00	407.90	TALL	5.558	0.077
30	---	---	---	---	---	---	---	---	---	---	---	---	---

NOTE:
EPOXY REINFORCEMENT QUANTITY ASSUMES AN EXPANSION JOINT IS USED ON BOTH PANEL ENDS. THE QUANTITY MUST BE ADJUSTED WHEN CONSTRUCTION JOINTS ARE USED. QUANTITIES ON THIS SHEET DO NOT INCLUDE RAILING. SEE RAILING SHEETS FOR RAIL REINFORCEMENT (EPOXY) AND RAIL CONCRETE (3Y46).

① SEE STANDARD PLANS 5-297.621 TO .623 FOR REINFORCING DETAILS.

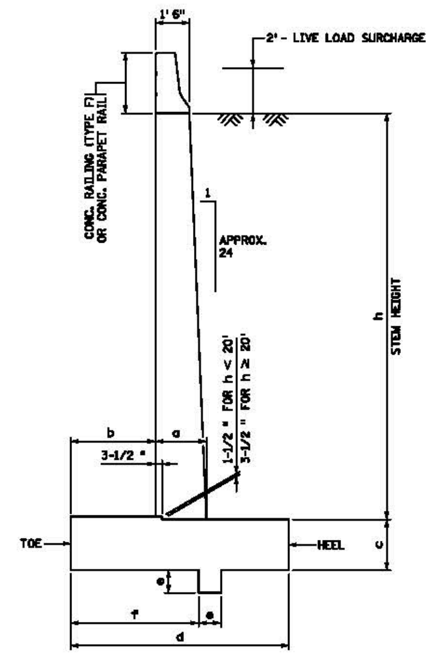
DESIGN CRITERIA

1992 A.A.S.H.T.O. DESIGN SPECIFICATIONS
DESIGN METHOD:
WORKING STRESS - STABILITY, FOUNDATIONS
LOAD FACTOR DESIGN - REINFORCED CONCRETE
f'c = 4,000 PSI
fy = 60,000 PSI

FACTOR OF SAFETY OVERTURNING: 2.0 MINIMUM
FACTOR OF SAFETY SLIDING: 1.5 MINIMUM
LOCATION OF RESULTANT: MIDDLE 1/3 OF FOOTING NEGLECTING SOIL IN FRONT OF WALL.

SEE FOUNDATION REPORT FOR ALLOWABLE BEARING PRESSURE AND COEFFICIENT OF FRICTION.

BACKFILL CHARACTERISTICS:
INTERNAL ANGLE OF FRICTION: 35°
= 33 PCF EQUIVALENT FLUID PRESSURE ACTIVE STATE
= 53 PCF EQUIVALENT FLUID PRESSURE AT REST STATE
βe = 1.0
COEFFICIENT OF FRICTION: 0.55
UNIT WEIGHT: 125 PCF



TYPICAL SECTION

REVISED:
APPROVED: MAY 31, 2006
STATE BRIDGE ENGINEER

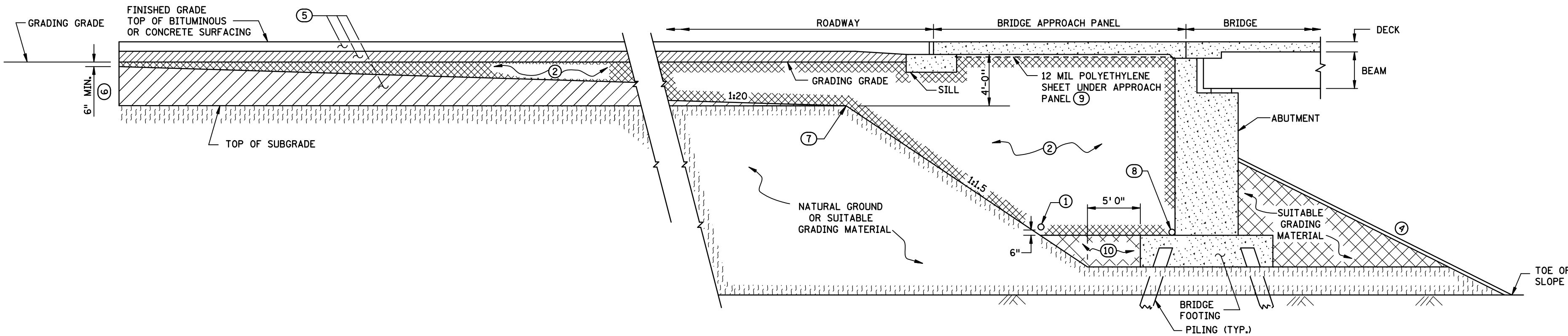
STANDARD SHEET NO. 5-297.632 (1 OF 4)
STANDARD APPROVED: MAY 31, 2006
TITLE: RETAINING WALL (LIVE LOAD SURCHARGE) SPREAD FOOTING GEOMETRY AND DATA
STATE PROJ. NO. (TH) SHEET NO. OF SHEETS

Table 5. Correlation results for sand. (Column A = Number in Table x Row B.)

A \ B	E_o tsf	E_R tsf	p^*_L tsf	q_c tsf	f_s tsf	N bl/ft
E_o tsf	1	0.125	8	1.15	57.5	4
E_R tsf	8	1	64	6.25	312.5	22.7
p^*_L tsf	0.125	0.0156	1	0.11	5.5	0.5
q_c tsf	0.87	0.16	9	1	50	5
f_s tsf	0.0174	0.0032	0.182	0.02	1	0.1
N bl/ft	0.25	0.044	2	0.2	10	1

Table 6. Correlation results for clay. (Column A = Number in Table x Row B.)

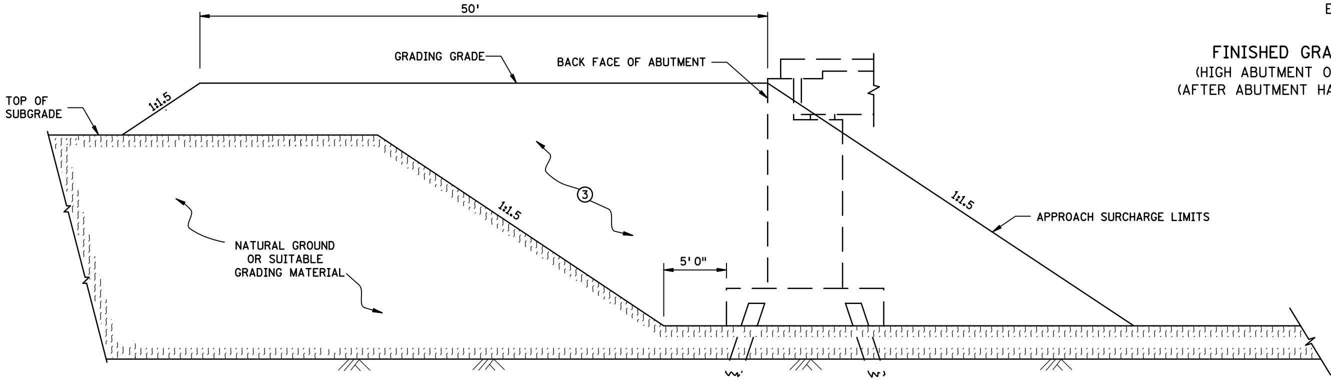
A \ B	E_o tsf	E_R tsf	p^*_L tsf	q_c tsf	f_s tsf	S_u tsf
E_o tsf	1	0.278	14	2.5	56	100
E_R tsf	3.6	1	50	13	260	300
p^*_L tsf	0.071	0.02	1	0.2	4	7.5
q_c tsf	0.40	0.077	5	1	20	27
f_s tsf	0.079	0.0038	0.25	0.05	1	1.6
S_u tsf	0.010	0.0033	0.133	0.037	0.625	1



ELEVATION

FINISHED GRADING SECTION

(HIGH ABUTMENT ON PILING SHOWN)
(AFTER ABUTMENT HAS BEEN CONSTRUCTED)



ELEVATION

ROUGH GRADING SECTION

(PRIOR TO ABUTMENT CONSTRUCTION)

NOTES:

(1) SUBSURFACE PIPE DRAIN. SEE GRADING PLAN FOR DETAILS. FURNISH AND INSTALL IF SHOWN IN GRADING PLAN.

(2) QUANTITY OF SELECT GRANULAR MATERIAL MODIFIED 10% IS BASED ON DIMENSIONS SHOWN, AND PAYMENT IS BASED ON THIS QUANTITY. SELECT GRANULAR MATERIAL MODIFIED 10% SHALL COMPLY WITH SPEC. 3149.2B2, MODIFIED TO 10% OR LESS PASSING THE NUMBER 200 SIEVE. SEE GRADING PLAN FOR QUANTITY. IF THE CONTRACTOR CHOOSES TO INCREASE DIMENSIONS IN ORDER TO FACILITATE CONSTRUCTION OPERATIONS, ANY QUANTITY INCREASES SHALL BE CONSIDERED INCIDENTAL.

(3) PLACE ABUTMENT APPROACH SURCHARGE MATERIAL PRIOR TO ABUTMENT CONSTRUCTION. AFTER COMPLETION OF SURCHARGE WAITING PERIOD, REMOVE SURCHARGE AND EXISTING NATURAL GROUND OR SUITABLE GRADING MATERIAL TO THE LIMITS SHOWN IN "ROUGH GRADING SECTION" ABOVE, PRIOR TO ABUTMENT CONSTRUCTION. SEE BRIDGE PLANS AND SPECIAL PROVISIONS FOR ABUTMENT APPROACH SURCHARGE REQUIREMENT AND PAYMENTS.

(4) SEE BRIDGE PLANS FOR SLOPE AND SLOPE PROTECTION.

(5) SEE GRADING PLANS FOR TYPE OF MATERIAL.

(6) GRADING TO BE SQUARED OFF ON SKEWED BRIDGES.

(7) TOP OF 1:1.5 SLOPE (FORMS A LINE PARALLEL TO END OF BRIDGE).

(8) SUBSURFACE PIPE DRAIN. FURNISH AND INSTALL AT TOP OF BRIDGE FOOTING IF BRIDGE DETAIL B910 IS INCLUDED ON BRIDGE PLAN.

(9) IF THE APPROACH PANEL IS TIED TO THE ABUTMENT WITH REINFORCEMENT BARS, PLACE 12 MIL POLYETHYLENE SHEETING (OR TWO LAYERS OF OF 6 MIL) UNDER THE LIMITS OF THE APPROACH PANEL TO ALLOW THE PANEL TO MOVE LONGITUDINALLY ON THE GRADE. SHEETING IS INCIDENTAL.

(10) SUITABLE GRADING MATERIAL SHALL HAVE SUITABLE MOISTURE CONTENT DURING PLACEMENT AND SHALL BE COMPACTED PER SPEC. 2105. SELECT GRANULAR MATERIAL MODIFIED 10% MAY BE USED IN LIEU OF SUITABLE GRADING MATERIAL.

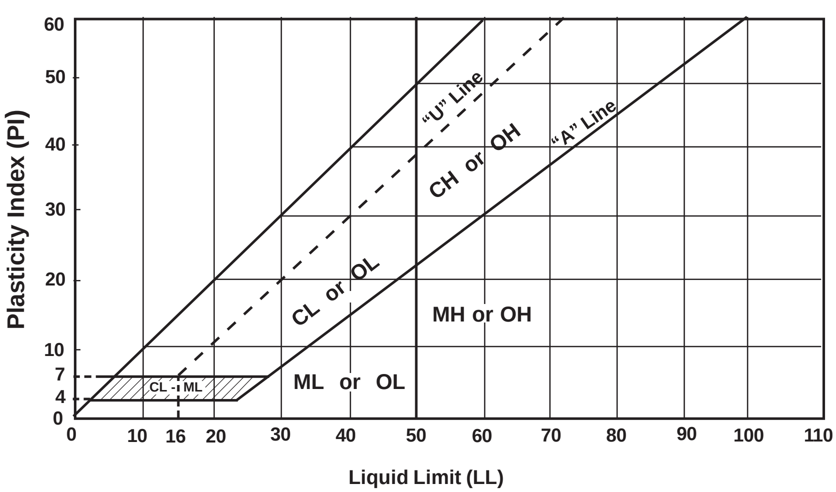
STANDARD SHEET NO. 5-297.233 (1 OF 2)	TITLE: BRIDGE ABUTMENT APPROACH TREATMENT FOR ABUTMENT ON FOOTING
STANDARD APPROVED: AUGUST 1, 2011	
STATE PROJ. NO.	(TH) SHEET NO. OF SHEETS

Descriptive Terminology of Soil

Standard D 2487 - 00
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels** 5% or less fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	**GW**	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	**GP**	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	**GM**	Silty gravel [d f g]
			Fines classify as CL or CH	**GC**	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands** 5% or less fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	**SW**	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	**SP**	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	**SM**	Silty sand [f g h]
			Fines classify as CL or CH	**SC**	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	**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]
				OL	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]
				OH	Organic silt [k l m q]
Highly Organic Soils	Primarily organic matter, dark in color and organic odor			**PT**	Peat

a. Based on the material passing the 3-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. 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
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines" to group name.
h. If soil contains ≥15% gravel, add "with gravel" to group name.
i. 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
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 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.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcf	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liqiuid limit, %	**C**	Cohesion, psf
PL	Plastic limit, %	∅	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders .... over 12"
Cobbles .... 3" to 12"
Gravel
  Coarse .... 3/4" to 3"
  Fine .... No. 4 to 3/4"
Sand
  Coarse .... No. 4 to No. 10
  Medium .... No. 10 to No. 40
  Fine .... No. 40 to No. 200
Silt .... < No. 200, PI < 4 or below "A" line
Clay .... < No. 200, PI ≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose .... 0 to 4 BPF
Loose .... 5 to 10 BPF
Medium dense .... 11 to 30 BPF
Dense .... 31 to 50 BPF
Very dense .... over 50 BPF

Consistency of Cohesive Soils

Very soft .... 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff .... 17 to 30 BPF
Hard .... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers unless noted otherwise, Jetting water was used to clean out auger prior to sampling only where indicated on logs. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous-flight, solid-stem augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface and are, therefore, somewhat approximate. Power auger borings are designated by the prefix "B."

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn. Hand auger borings are indicated by the prefix "H."

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.