Soils & Engineering Services, Inc.

April 10, 2019 Project 12939.3 R07

Mr. Jeff Hanson, Project Manager
Dane Partners, LLC
901 Deming Way, Suite 203
Madison, Wisconsin 53717

Subject: Geotechnical Exploration and Analyses Report
Structure B-13-731
(IH-39/90 Northbound Bridge over Northbound Exit Ramp to USH-12/18 Westbound)
Project ID 1007-10-02/05
Illinois State Line - Madison
USH-12/18 Interchange
IH-39
Dane County, Wisconsin

Dear Mr. Hanson

We have completed the requested exploration consisting of the performance of two standard soil borings at the subject site, and the associated laboratory testing and geotechnical engineering analyses. The purpose of these soil borings was to obtain information about the soil, bedrock, and groundwater conditions at the soil boring locations. We present our findings, comments, recommendations, and analyses results in the enclosed *Geotechnical Exploration and Analyses Report* for the subject bridge.

Respectfully submitted,

SOILS & ENGINEERING SERVICES, INC.

Craig M. Bower

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CMB:DER:cmb

Enclosure

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Geotechnical Exploration and Analyses Report

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SES Project Number 12939.3

Prepared By

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Mr. Jeff Hanson, Project Manager

April 10, 2019

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I. INTRODUCTION

This *Geotechnical Exploration and Analyses Report* for Structure B-13-731 summarizes the findings of the geotechnical exploration, laboratory tests, and geotechnical engineering analyses performed for the design and construction of a new two-span bridge IH-39/90 Northbound Bridge over Northbound Exit Ramp to USH-12/18 Westbound for the northern section of the IH-39/90 reconstruction project in the Town of Blooming Grove, Dane County, Wisconsin. We completed this work under the general direction of Dane Partners, LLC who established the general scope of the work.

The intent of this report is to convey the information obtained from the soil borings, to present the results of laboratory and field tests, to provide the results of our engineering analyses, and to present our comments and recommendations for the design and construction of the proposed structure. Variations in soil conditions should be expected between or beyond the borings, or between sample intervals, the nature and extent of which might not become evident until construction is undertaken. The project geotechnical engineer, or their designated representative, should make observations at the time of construction of the structure to determine if the subsurface conditions are as indicated by the exploration performed, and to validate our comments, analyses, and recommendations presented in this report for the subject structure.

II. PROJECT INFORMATION

The subject bridge described herein is a part of the planned widening and reconstruction of Interstate Highway 39 (IH-39) in Dane County. The planned IH-39 improvement consists of the design and construction of bridges, bridge widening, retaining walls, sign structures, sound barrier walls, roadway widening, and roadway reconstruction. The portion of the IH-39 improvement in Dane County is considered the North Segment for the proposed work. Separate reports address each of the improvements involved with this project.

The subject of this report is a new IH-39/90 Northbound Bridge over Northbound Exit Ramp to USH-12/18 Westbound bridge with Structure ID B-13-731. Ayres Associates, Inc. (AAI) provided preliminary drawings dated February 13, March 12, and April 1, 2019, for use in preparing this report. Please refer to enclosed Exhibits A through E in Appendix A which present the drawings provided by AAI that we utilized in our analyses.

Based on the drawings provided, the proposed two-span bridge bridge will have a total length of approximately 192 feet and a total width of approximately 63 feet. Two abutments and one pier will provide foundation support for the two-span bridge bridge structure. The pier will be offset from the center of the length of the bridge. The southern bridge span is approximately 129 feet long and the northern bridge span is approximately 58 feet long. New north and south approach embankments will be constructed along the eastern side of the existing Southbound IH-39/90 roadway embankment. A mechanically stabilized earth (MSE) retaining wall will be constructed in front of each of the abutments to retain the new approach embankments.

III. FIELD EXPLORATION

We performed two standard soil borings, designated Borings SB-7 and SB-8 at or near the staked locations found in the field and as presented on the Location Sketches, Drawings 12939.3-7A and 12939.3-7B, enclosed in Appendix B. We adjusted the location of Boring SB-7 approximately 11 feet southwest of the staked location due to access restrictions.

We drilled and sampled borings for Structure B-13-731 to the following depths below ground surface and corresponding elevation:

Soil Boring	Substructure Unit	Ground Surface Elevation (feet)	Bottom of Boring	
			Depth (feet-inch)	Elevation (feet)
SB-7	South Abutment	870.2	99'-1"	771.1
SB-8	North Abutment	870.9	89'-6"	781.4

We used 2¼-inch-inside-diameter hollow-stem augers to maintain an open borehole as we advanced the boreholes of these borings to the last sample depth. We added water to the inside of the HSA to counteract the water pressure present during the drilling of these borings.

As we advanced the boreholes of these borings, we obtained soil samples at 2½-foot intervals starting at a depth of 1-foot below the ground surface and continued to a depth of 10 feet. We increased the sampling interval to 5 feet from a depth of 10 feet to the boring termination depth. We performed this sampling using a 2-inch-outside-diameter split-barrel sampler according to AASHTO Designation T206. We visually identified the recovered soils in general compliance with the Unified Soil Classification System (USCS).

We depict the subsoil stratification at the locations of the borings on the WisDOT Boring Logs enclosed in Appendix B. The WisDOT Boring Logs are drafted with a depth scale and the depth and respective elevation of each stratum change is denoted.

AAI staked the requested boring locations in the field. Due to drilling rig access restrictions and existing roadway embankments, and/or the presence of utility lines, we drilled Boring SB-7 at an offset from the requested location. AAI determined the coordinates and ground surface elevation of each of the soil borings after completion of the drilling and sampling and provided this information to us. The "northing" and "easting" grid coordinates, stationing, and ground surface elevations at the locations of the borings are provided on the WisDOT Boring Logs.

IV. SOIL AND BEDROCK STRATIGRAPHY

The soil stratigraphy encountered at Borings SB-7 and SB-8 can generally be characterized as topsoil and fill material overlying native soil strata. Neither of the borings encountered bedrock within the depths drilled.

We found the surficial soils at Boring SB-7 to be frozen on the day of the sampling as follows:

Boring	Ground Surface Elevation (feet)	Estimated Frost Top		Estimated Frost Bottom	
		Depth (feet-inch)	Elevation (feet)	Depth (feet-inch)	Elevation (feet)
SB-7	870.2	0'-0"	870.2	3'-0"	867.2

The borings encountered variable fill material and topsoil strata. We describe the fill material and topsoil strata encountered at the borings as follows:

- Boring SB-7 encountered 3 inches of very dark brown LEAN CLAY (CL) FILL TOPSOIL over 33 inches of brown fine to coarse SILTY SAND WITH GRAVEL (SM) FILL over 12 inches of brown SANDY LEAN CLAY (CL) FILL over 6 inches of brown fine to coarse SILTY SAND WITH GRAVEL (SM) FILL.

- Boring SB-8 encountered 7 inches of dark brown LEAN CLAY (CL) TOPSOIL.

Below the topsoil and fill material, the borings encountered a variable native soil strata. We describe the native soil strata encountered at the borings as follows:

- Boring SB-7 encountered brown fine to medium SILTY SAND WITH GRAVEL (SM) GLACIAL TILL over reddish-brown to light brown fine CLAYEY SAND WITH GRAVEL (SC) GLACIAL TILL over brown to reddish-brown fine to medium SILTY SAND WITH GRAVEL (SM) GLACIAL TILL over grayish-brown fine POORLY-GRADED SAND WITH GRAVEL (SP) over grayish-brown SANDY LEAN CLAY (CL) over brown fine to medium SILTY SAND WITH GRAVEL (SM) GLACIAL TILL with few irregular gray CLAYEY SAND (SC) lenses.

- Boring SB-8 encountered brown fine to medium SILTY SAND WITH GRAVEL (SM) GLACIAL TILL over brown fine SILTY CLAYEY SAND (SC-SM) GLACIAL TILL over brown fine to medium SILTY SAND WITH GRAVEL (SM) GLACIAL TILL over brown fine to coarse POORLY-GRADED GRAVEL WITH SILT AND SAND (GP-GM).

We note that the gravel content varied from trace to some in the GLACIAL TILL strata.

Please refer to the enclosed WisDOT Boring Logs for a further description of the topsoil, fill material, and native soil strata encountered at the locations of Borings SB-7 and SB-8.

V. GROUNDWATER

Our drilling crew found the boreholes of the borings to have a water level and were caved at or after the completion of the drilling and sampling at the borings.

We summarize the water and caved level depths and respective elevations for the borings as follows:

Boring	Ground Surface Elevation (feet)	Water Level			Caved Level		
		Depth (feet-inch)	Elevation (feet)	Comments	Depth (feet-inch)	Elevation (feet)	Comments
SB-7	870.2	3'-2"	867.0	At completion	12'-4"	857.9	At completion
SB-8	870.9	22'-4"	848.6	At completion	34'-10"	836.1	At completion
		3'-0"	867.9	Estimated based on soil samples	—	—	—

We expect the groundwater level to fluctuate as influenced by precipitation, snowmelt, surface water runoff, and other hydrological and hydrogeological factors. The groundwater level at the time of construction of the subject bridge may be higher or lower than the groundwater levels encountered on the days that we performed the borings.

VI. LABORATORY AND FIELD TESTS

We performed laboratory tests on selected split-barrel soil samples obtained from the borings to determine the physical properties of the fill material and native soil encountered at the boring locations. The laboratory tests consisted of moisture content (MC), Atterberg limits (liquid limit and plasticity index), dry densities (Dry Wt), unconfined compressive strength (q_u), percentage of soil particles passing the No. 200-mesh sieve (Fines), and particle size distribution analysis. In addition to the above tests, we tested some of the cohesive soils for approximate unconfined compressive strength (q_p) using a spring penetrometer.

The field test consisted of the standard penetration test (SPT). We performed the SPT during the sampling procedure at the boring locations. The SPT is the number of blows per foot ("N" value) needed to drive the split-barrel sampler using a 140-pound hammer free-falling for 30 inches. We determined the corrected standard penetration resistance {$(N_1)_{60}$-value} which is the N-value corrected for hammer efficiency and normalized to an effective overburden pressure at 1-atmosphere based on estimated densities for the soils encountered by the borings.

We include the laboratory and field test results obtained for this report on the WisDOT Boring Logs and/or Laboratory Test Result Records, Figures 1 through 4, enclosed in Appendix B. We used the results from the Atterberg limits, Fines, and particle size distribution tests to confirm or modify the USCS soil identifications in general compliance with USCS classification procedures as defined in ASTM Designation D2487.

The laboratory and field test results for the borings suggest the following:

- The granular fill material is in a moist relative moisture condition and in a very loose to loose state of relative density.

- The cohesive fill material is in a moist relative moisture condition and of medium consistency.

- The granular native soil strata are in a moist relative moisture condition to approximately elevation 868 feet below which they are in a wet relative moisture condition

- At Boring SB-7, the granular native soil strata are in a very loose to loose state of relative density to approximately elevation 823, medium dense state of relative density to approximately elevation 801 feet below which they are in a dense to very dense state of relative density. The SANDY LEAN CLAY (CL) stratum encountered at this boring within the granular soil strata below elevation 801 feet is of very stiff to hard consistency.

- At Boring SB-8, the granular native soil strata are in a very loose to loose state of relative density to approximately elevation 859, loose to medium dense state of relative density to approximately elevation 804 feet below which they are in a dense to very dense state of relative density.

We used the laboratory and field test results in our evaluation of the topsoil and native soil strata encountered at the boring locations to determine soil parameters to use in the design of the foundation system for the subject IH-39/90 Northbound Bridge over Northbound Exit Ramp to USH-12/18 Westbound.

VII. ANALYSES PROCEDURES, ASSUMPTIONS, & GIVEN INFORMATION

Using the information obtained from Borings SB-7 and SB-8 performed in the vicinity of the abutments of the proposed bridge structure, we performed geotechnical analyses for shallow foundations and deep driven pile foundations for the substructure units of the proposed bridge using Load and Resistance Factor Design (LRFD) procedures presented in Chapter 11 of the WisDOT *Bridge Manual* (WBM) dated January 2019, and related chapters in the AASHTO *LRFD Bridge Design Specifications for Highway Bridges, 8th Edition*.

A. Shallow Spread Footing Foundations

Per Chapter 12 of the IH-39 Project Manual, the use of a driven pile foundation for the corridor structures is preferred unless shallow spread footing foundations are placed on bedrock or other high bearing capacity material. Therefore, shallow spread footing foundations for the abutments are not being considered since bedrock was not encountered by the borings performed.

B. Deep Driven Pile Foundations

1. Existing IH-39/90 Southbound Structure B-13-461

We reviewed the WisDOT *Site Investigation Report* dated November 8, 1995, and the pile driving data for the 1997 construction of the existing IH-39/90 Southbound Bridge (Structure B-13-461) over Northbound Exit Ramp to USH-12/18 Westbound. Our review of this information is as follows:

- The WisDOT *Site Investigation Report* contained the following information:
  - The 1995 borings encountered low to moderate strength granular soil strata over moderate to high strength granular soil strata. Bedrock was not encountered within the depth explored by these borings. This is similar to the soil stratification encountered by Borings SB-7 and SB-8 for the current work.
  - Recommended 10x42 H-piles with a design bearing capacity of 55 tons or 110 kips. The report recommends a factor of safety of 2, which equates to a Rn_{dyn} of 110 tons or 220 kips for these piles.

- The recommended H-pile tip elevations for the substructure units were as follows:
  - North Abutment – 790 feet
  - Pier 1 (north) – 790 feet
  - Pier 2 (south) – 790 feet
  - South Abutment – 786 feet

- The pile driving records for existing Southbound IH-39/90 Bridge (Structure B-13-461) over Northbound Exit Ramp to USH-12/18 shows that 10x42 H-piles were driven to support the substructure units. These records indicated the following:
  - The 10x42 H-piles were designed for a bearing capacity of 55 tons or 110 kips, which equates to a Rn_{dyn} of 110 tons or 220 kips using the recommended factor of safety of 2.
  - For the North Abutment:
    - The plan length was 100 feet.
    - The cut-off lengths ranged from 83.0 to 195.6 feet with an average of 110.0 feet.
    - The estimated tip elevations ranged from 802.7 to 690.1 feet with an average of 775.7 feet. This indicates the piles drove approximately 13 feet shallower to 100 feet deeper than anticipated.
    - The Rn_{dyn} ranged from 234 to 265 kips with an average of 253 kips.
  - For the Pier 1 (north):
    - The plan length was 80 feet.
    - The cut-off lengths ranged from 44.4 to 77.7 feet with an average of 71.1 feet.
    - The estimated tip elevations ranged from 822.6 to 789.3 feet with an average of 795.9 feet. This indicates the piles drove approximately 12 feet shallower to 0 feet deeper than anticipated.
    - The Rn_{dyn} ranged from 229 to 298 kips with an average of 249 kips.
  - For the Pier 2 (south):
    - The plan length was 75 feet.
    - The cut-off lengths ranged from 68.2 to 80.0 feet with an average of 73.0 feet.
    - The estimated tip elevations ranged from 795.8 to 784.0 feet with an average of 791.0 feet. This indicates the piles drove approximately 6 feet shallower to 6 feet deeper than anticipated.
    - The Rn_{dyn} ranged from 229 to 296 kips with an average of 255 kips.

- For the South Abutment:
  - The plan length was 100 feet.
  - The cut-off lengths ranged from 86.9 to 99.4 feet with an average of 91.5 feet.
  - The estimated tip elevations ranged from 798.2 to 785.7 feet with an average of 793.6 feet. This indicates the piles drove approximately 35 feet shallower to 1-foot deeper than anticipated.
  - The Rn_{dyn} ranged from 229 to 279 kips with an average of 253 kips.

2. Groundwater Elevations

Based on the results of the borings completed for the subject bridge structure for the North Segment of the IH-39 Reconstruction project, we recommend a design groundwater elevation of 867.0 feet be used for our pile driving and ultimate capacity computations.

3. Pile-Supported Footing Base Information

AAI provided the following pile-supported footing (pile cap) base and lowest ground surface elevations at the substructure units for the subject bridge structure. Where MSE retaining walls are constructed to retain the approach embankments at substructure units, the berm elevation used in our computations is the proposed ground surface elevation in front of the MSE retaining wall.

We note that the approach embankments for this structure will be constructed on the east side of the existing southbound roadway embankment. For our computations, we used the elevations for the proposed structure at the northbound reference line.

Substructure Unit	**Nearest Boring(s)**	**Berm Elevation (feet)**	**Pile Cap Base Elevation (feet)**
South Abutment	SB-7	869.9	887.7
Pier	SB-8	873.6	862.0
North Abutment	SB-8	871.5	887.7

We anticipate the piles for the North and South Abutments will be driven after the embankment areas have been prepared and fill placed to reach the bottom elevation of the proposed MSE-retained approach embankments. Additionally, the piles will be driven prior to construction of the proposed MSE retaining walls located in front of the approach embankments.

We anticipate the piles for the Pier will be driven after the area in the vicinity of the substructure unit has been graded.

4. Pre-boring

As presented in WBM Chapter 11.3.1.6, pre-boring is required for displacement (i.e, cast-in-place or CIP) piles driven into new embankments over 10 feet in height. Based on the plans provided, pre-boring is not required for the North and South Abutments.

5. Allowable Driving Resistances

We used the computer program *APILE* to compute the ultimate skin friction and end bearing parameters and the ultimate and factored capacities of the soils encountered by the borings using static analyses.[1] We present the angle of internal friction (φ), unit weight (γ), and cohesion (c) values used in *APILE* in enclosed Table 7-1 in Appendix C and in Table A pages 10 through 14. The cohesion values are based on the approximate unconfined compressive strength readings obtained using a spring penetrometer and the laboratory unconfined compression strength test results. We estimated the density values based on: (1) wet density (γ_w) test results of selected representative samples of the various strata encountered by the borings performed; (2) the standard penetration results obtained by the borings performed; and, (3) our experience with similar material. We computed the angle of internal friction values using empirical formulas based on the $N1_{60}$-values for each soil stratum. As recommended in a 2013 WisDOT Research Program (WHRP) report written by Dr. James Long, we limited the computed maximum friction angle to 36 or 40 degrees depending upon the $N1_{60}$-values for computing skin friction and end bearing capacities for driven piles.[2] We used the percentage loss of soil strength during driving from Table 11.3-4 of the WBM based on the type of soil for each stratum for cast-in-place (CIP) pipe piles. Due to the reported over-driving of H-piles on other WisDOT bridge projects, we increase the percentage

[1]APILE. Vers. 2014. Austin, TX: Ensoft, Inc., 2014. Computer software.

[2]James H. Long, PhD, PE, Improving Agreement Between Static Method and Dynamic Formula for Driven Cast-In-Place Piles in Wisconsin. (Madison, WI: Wisconsin Department of Transportation, 2013).

Table A: Recommended Soil Design Parameters And Foundation Capacities for WisDOT Structure B-13-731 for Recommended 10¾-inch-outside-diameter, Steel CIP-Pipe Pile

		Estimated Soil Parameters			Driven Pile Parameters			
Elevation (feet)	Material Type	Moist Density, γ (pcf)	Angle of Internal Friction, Ø* (degrees)	Cohesion, c (psf)	Driving SSL** (%)	LRFD Factors***	Skin Friction† (psf)	End Bearing† (psf)
---------- Boring SB-7 located in the vicinity of South Abutment of Bridge Structure B-13-731 ----------								
889.0 to 887.7	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---	---	---
887.7 to 879.2	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---	---	---
879.2 to 870.2	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---	---	---
870.2 to 870.0	Replace existing dark brown LEAN CLAY WITH SAND (CL) FILL TOPSOIL with MSE Retaining Wall Backfill	120.0	30	0	---	---	---	---
870.0 to 868.9	Replace existing brown fine to coarse SILTY SAND WITH GRAVEL (SM) FILL with MSE Retaining Wall Backfill	120.0	30	0	---	---	---	---
868.9 to 867.4		120.0	31	0	---	---	1,170	0
867.4 to 867.2		120.0	31	0	33	0.45	70	4,100
867.2 to 867.0	***SANDY LEAN CLAY (CL)*** — *medium plasticity, brown, moist, medium consistency,* ***FILL***	125.0	0	800	50	0.35	70	5,900
867.0 to 866.2		125.0	0	800	50	0.35	70	5,700
866.2 to 865.7	***SILTY SAND WITH GRAVEL (SM)*** — *fine to coarse grained, non-plastic to low plasticity fines, brown, moist, very loose to loose relative density,* ***FILL***	120.0	31	0	33	0.45	90	6,700
865.7 to 859.2	***SILTY SAND WITH GRAVEL (SM)*** — *fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, wet, loose to very loose relative density,* ***GLACIAL TILL****, trace to some gravel*	152.0	29	0	33	0.45	140	10,300

Table Notes

The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.

* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.

** The Driving SSL values presented in Table 11.3-4 of the WisDOT Bridge Manual were used for the recommended driven cast-in-place, steel pipe piles.

*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

† The Skin Friction and End Bearing values presented above are the computed unfactored average capacities for the indicated stratum/substratum.

Table Abbreviations and Symbols

pcf = pounds per cubic foot.
SSL = soil strength loss.
psf = pounds per square foot.
NA = Not applicable.
Top = Cohesion @ top of stratum/sub-stratum.
Refusal = Steel pile will obtain capacity in indicated layer due to very dense soil or bedrock.
Bot = Cohesion @ bottom of stratum/sub-stratum.

Table A: Recommended Soil Design Parameters And Foundation Capacities for WisDOT Structure B-13-731 for Recommended 10¾-inch-outside-diameter, Steel CIP-Pipe Pile

Elevation (feet)	Material Type	Estimated Soil Parameters: Moist Density, γ (pcf)	Estimated Soil Parameters: Angle of Internal Friction, Ø* (degrees)	Estimated Soil Parameters: Cohesion, c (psf)	Driven Pile Parameters: Driving SSL** (%)	Driven Pile Parameters: LRFD Factors***	Driven Pile Parameters: Skin Friction† (psf)	Driven Pile Parameters: End Bearing† (psf)
859.2 to 853.2		152.0	29	0	33	0.45	240	13,600
853.2 to 848.2		152.0	31	0	33	0.45	390	19,600
848.2 to 838.2		152.0	29	0	33	0.45	460	13,600
838.2 to 830.7		152.0	29	0	33	0.45	620	13,300
830.7 to 823.2		152.0	29	0	33	0.45	760	13,500
823.2 to 813.2	***CLAYEY SAND WITH GRAVEL (SC)** — fine grained, medium plasticity fines, reddish-brown to light brown, wet, medium dense relative density, **GLACIAL TILL**, trace to some gravel*	146.0	31	0	33	0.45	1,080	20,500
813.2 to 803.2	***SILTY SAND WITH GRAVEL (SM)** — fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, moist to wet, medium dense relative density, **GLACIAL TILL**, trace to some gravel*	152.0	32	0	33	0.45	1,410	32,100
803.2 to 800.7	***POORLY-GRADED SAND WITH GRAVEL (SP)** — fine grained, light grayish-brown and brown, wet, medium dense relative density*	125.0	31	0	17	0.45	1,420	24,800
800.7 to 798.2	***SANDY LEAN CLAY (CL)** — medium plasticity, grayish-brown, moist, hard to very stiff consistency*	132.0	0	3,800	50	0.35	3,680	36,400
798.2 to 788.2	***SILTY SAND WITH GRAVEL (SM)** — fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, moist, dense to very dense relative density, **GLACIAL TILL**, trace to some gravel, with few irregular gray CLAYEY SAND (SC) lenses*	152.0	34	0	33	0.45	2,050	72,800

Table Notes

The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.

* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.

** The Driving SSL values presented in Table 11.3-4 of the WisDOT Bridge Manual were used for the recommended driven cast-in-place, steel pipe piles.

*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

† The Skin Friction and End Bearing values presented above are the computed unfactored average capacities for the indicated stratum/substratum.

Table Abbreviations and Symbols

pcf = pounds per cubic foot. psf = pounds per square foot. Top = Cohesion @ top of stratum/sub-stratum. Bot = Cohesion @ bottom of stratum/sub-stratum.
SSL = soil strength loss. NA = Not applicable. Refusal = Steel pile will obtain capacity in indicated layer due to very dense soil or bedrock.

Table A: Recommended Soil Design Parameters And Foundation Capacities for WisDOT Structure B-13-731 for Recommended 10¾-inch-outside-diameter, Steel CIP-Pipe Pile

		Estimated Soil Parameters			Driven Pile Parameters			
Elevation (feet)	Material Type	Moist Density, γ (pcf)	Angle of Internal Friction, Ø* (degrees)	Cohesion, c (psf)	Driving SSL** (%)	LRFD Factors***	Skin Friction† (psf)	End Bearing† (psf)
788.2 to 783.2		152.0	38 [36]	0	33	0.45	2,770	144,000
783.2 to 774.2		152.0	45 [36]	0	17	0.45	3,010	157,000
774.2 to 771.1		152.0	45 [40]	0	17	0.45	4,730	371,000
---------- End of Boring SB-7 @ Elevation 771.1 feet ----------								

Table Notes

The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.

* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.

** The Driving SSL values presented in Table 11.3-4 of the WisDOT Bridge Manual were used for the recommended driven cast-in-place, steel pipe piles.

*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

† The Skin Friction and End Bearing values presented above are the computed unfactored average capacities for the indicated stratum/substratum.

Table Abbreviations and Symbols

pcf = pounds per cubic foot.
psf = pounds per square foot.
Top = Cohesion @ top of stratum/sub-stratum.
Bot = Cohesion @ bottom of stratum/sub-stratum.
SSL = soil strength loss.
NA = Not applicable.
Refusal = Steel pile will obtain capacity in indicated layer due to very dense soil or bedrock.

Table A: Recommended Soil Design Parameters And Foundation Capacities for WisDOT Structure B-13-731 for Recommended 10¾-inch-outside-diameter, Steel CIP-Pipe Pile

Elevation (feet)	Material Type	Estimated Soil Parameters			Driven Pile Parameters			
		Moist Density, γ (pcf)	Angle of Internal Friction, Ø* (degrees)	Cohesion, c (psf)	Driving SSL** (%)	LRFD Factors***	Skin Friction† (psf)	End Bearing† (psf)
---------- Boring SB-8 located in the vicinity of North Abutment of Bridge Structure B-13-731 ----------								
889.0 to 887.7	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---	---	---
887.7 to 879.7	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---	---	---
879.7 to 871.5	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---	---	---
871.5 to 870.9	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---	510	0
870.9 to 870.3	Replace existing dark brown LEAN CLAY WITH SAND (CL) FILL TOPSOIL with MSE Retaining Wall Backfill	120.0	30	0	---	---	530	0
870.3 to 868.0	Replace existing brown fine to medium SILTY SAND WITH GRAVEL (SM) GLACIAL TILL trace to some gravel with MSE Retaining Wall Backfill	120.0	30	0	---	---	600	0
868.0 to 867.0		152.0	30	0	33	0.45	10	1,000
867.0 to 858.9		152.0	30	0	33	0.45	80	6,600
858.9 to 848.9	***SILTY SAND WITH GRAVEL (SM)** —fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, wet, loose to medium dense relative density, **GLACIAL TILL**, trace to some gravel*	152.0	29	0	33	0.45	250	13,400
848.9 to 843.9		152.0	31	0	33	0.45	460	19,700
843.9 to 836.4		152.0	29	0	33	0.45	500	13,600

Table Notes

The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.

* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.

** The Driving SSL values presented in Table 11.3-4 of the WisDOT Bridge Manual were used for the recommended driven cast-in-place, steel pipe piles.

*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

† The Skin Friction and End Bearing values presented above are the computed unfactored average capacities for the indicated stratum/substratum.

Table Abbreviations and Symbols

pcf = pounds per cubic foot.
SSL = soil strength loss.
psf = pounds per square foot.
NA = Not applicable.
Top = Cohesion @ top of stratum/sub-stratum.
Refusal = Steel pile will obtain capacity in indicated layer due to very dense soil or bedrock.
Bot = Cohesion @ bottom of stratum/sub-stratum.

Table A: Recommended Soil Design Parameters And Foundation Capacities for WisDOT Structure B-13-731 for Recommended 10¾-inch-outside-diameter, Steel CIP-Pipe Pile

		Estimated Soil Parameters			Driven Pile Parameters			
Elevation (feet)	Material Type	Moist Density, γ (pcf)	Angle of Internal Friction, Ø* (degrees)	Cohesion, c (psf)	Driving SSL** (%)	LRFD Factors***	Skin Friction† (psf)	End Bearing† (psf)
836.4 to 828.9		152.0	29	0	33	0.45	640	13,600
828.9 to 818.9		152.0	31	0	33	0.45	940	20,100
818.9 to 808.9		152.0	29	0	33	0.45	980	13,700
808.9 to 803.9		152.0	31	0	33	0.45	1,320	23,400
803.9 to 798.9	***SILTY CLAYEY SAND (SC-SM)*** *— fine grained, low plasticity fines, brown, moist, dense relative density,* ***GLACIAL TILL****, trace to some gravel*	146.0	35	0	33	0.45	1,990	103,000
798.9 to 788.9	***SILTY SAND WITH GRAVEL (SM)*** *— fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, moist, very dense relative density,* ***GLACIAL TILL****, trace to some gravel*	152.0	42 [36]	0	33	0.45	2,510	156,000
788.9 to 781.4	***POORLY-GRADED GRAVEL WITH SILT AND SAND (GP-GM)*** *— fine to coarse grained, non-plastic to low plasticity fines, brown, wet, very dense relative density*	120.0	45 [40]	0	0	0.45	4,070	404,000
---------- End of Boring SB-8 @ Elevation 781.4 feet ----------								

Table Notes

The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.

* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.

** The Driving SSL values presented in Table 11.3-4 of the WisDOT Bridge Manual were used for the recommended driven cast-in-place, steel pipe piles.

*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

† The Skin Friction and End Bearing values presented above are the computed unfactored average capacities for the indicated stratum/substratum.

Table Abbreviations and Symbols

pcf = pounds per cubic foot. psf = pounds per square foot. Top = Cohesion @ top of stratum/sub-stratum. Bot = Cohesion @ bottom of stratum/sub-stratum.
SSL = soil strength loss. NA = Not applicable. Refusal = Steel pile will obtain capacity in indicated layer due to very dense soil or bedrock.

loss of soil strength during driving values from the WBM values for H-piles. We used the Static Nominal Axial Compression Resistance Factors (φ_{stat}) from Table 11.3-1 of the WBM based on the type of soil for each stratum. The percentage loss of soil strength and φ_{stat} factors used are included in enclosed Table 7-2 in Appendix C and in Tables A on pages 10 through 14.

6. Design 'Required Driving Resistance' (Rn_{dyn}) and 'Factored Axial Compression Resistance' (P_r)

Based on the types of soils encountered by Borings SB-7 and SB-8, we evaluated driven 10¾-inch-outside-diameter, steel CIP-pipe-piles and driven 10x42 steel H-piles in our analyses of the deep foundations for the proposed substructure units for North and South Abutments. AAI requested that the minimum Rn_{dyn} for the CIP-pipe-piles be 130 tons or 260 kips.

The Design Rn_{dyn} for a selected pile type is determined by using the Design P_r for the selected pile and a dynamic resistance factor (φ_{dyn}) of 0.5 for driven piles where the modified Gates dynamic formula is planned to be used for construction driving criteria. The Design P_r and Rn_{dyn} values for the evaluated pile types, as presented in Table 11.3-5 of the WBM, are summarized as follows:

H-Pile Sizes	Maximum P_r (kips)	Maximum Rn_{dyn} (kips)
10x42	180	360

CIP Pipe Pile Sizes			
Outside Diameter (inches)	Wall Thickness (inches)	Maximum P_r (kips)	Maximum Rn_{dyn} (kips)
10¾	0.250	130	260
	0.365 or 0.500	150	300

Per Mr. Jeff Horsfall with WisDOT, all piles are driven to the Design Rn_{dyn} at the time of installation. For the subject bridge structure, the Design Rn_{dyn} equals the Maximum Rn_{dyn} for the selected CIP-pipe-piles or H-piles. Thus, we computed the Design Pile Tip Elevation for the selected CIP-pipe-pile or H-pile type based on the Design Rn_{dyn}, the static resistance factor, and the percentage loss of soil strength during driving for the soil strata encountered at each boring performed for the subject bridge structure.

7. Drivability Evaluation

We used the computer program *GRLWEAP* to perform the drivability evaluation for the selected H-piles and CIP-pipe-piles driven into the soils encountered by the borings.[3] We check drivability using the *APILE*-computed ultimate skin friction and ultimate end bearing parameters and the assigned percentage loss of soil strength for each soil stratum. We used *APILE* to create the preliminary data file for use in *GRLWEAP*.

We perform our drivability evaluation using the Delmag D16-32 and Delmag D30-32 diesel pile driving hammers. We initially determine the drivability of piles using the Delmag D16-32 pile driving hammer. If the specified pile is refused using the Delmag D16-32 above the design pile tip elevation, then we determine drivability of the specified pile using the Delmag D30-32 pile driving hammer. We define driven pile refusal as occurring when the estimated number of blows for a pile driving hammer as computed by *GRLWEAP* is equal to or greater than 120 blows per foot. The allowable steel stress is defined as 90 percent of the yield steel stress for a pile type. Per Mr. Jeff Horsfall with WisDOT, the steel stress at any time during driving should not exceed the allowable steel stress for a pile type. If the 'Driving Stress' (σ_{dr}) as computed by *GRLWEAP* for the specified piles exceeds 90 percent of the steel yield stress (35 ksi) of the shell of CIP-pipe-piles or of the steel yield stress (50 ksi) of H-piles, then the pile is overstressed and we make the following adjustments:

- For CIP-pipe-piles
  - Increase steel yield stress to 45 ksi.[4]
  - Increase shell thickness and restart the analyses process.
  - Decrease the Design Rn_{dyn} and restart the analyses process, OR switch to using H-piles.

- For H-Piles
  - Decrease the Design Rn_{dyn} and restart the analyses process.

We use the following default pile hammer cushion parameters included in *GRLWEAP* for the Delmag D16-32 and Delmag D30-32 diesel pile driving hammers equipped with a 21-inch lead size in our drivability evaluation.

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[3]GRLWEAP. Vers. 2010. Cleveland, OH: GRL Engineers, Inc. *GRLWEAP*. 2010. Computer software.

[4]Per Mr. Jeff Horsfall with WisDOT, the use of 45 ksi steel for CIP pipe piles is acceptable to WisDOT.

GRLWEAP **Default Pile Hammer Cushion Parameter**	**CIP Pipe Pile**	**H-Pile**
Cushion Material	50% Aluminum and 50% Conbest	50% Aluminum and 50% Conbest
Area (inches^2)	227	227
Elastic Modulus (ksi)	530	530
Coefficient of Restitution	0.8	0.8
Helmet Weight (kips)	1.7	1.9
Thickness (inches)	2.0	2.0

8. Downdrag Load

Per WBM Chapter 11.3.1.17.1, downdrag load, or negative shaft resistance, occurs due to settlement of the embankment caused by the additional loading imposed on the existing soils from the raising of the grade at a proposed substructure unit. WisDOT states that factored downdrag loads of 126, 168, and 294 kips are allowed in addition to the Design P_r for 10x42, 12x53, and 14x73 H-piles, respectively, driven to refusal on relatively-sound bedrock using modified Gates driving criteria to determine the Driving Rn_{dyn}. Downdrag loads on displacement piles (e.g., CIP piles) or non-end bearing H-piles reduce the Design P_r of the pile unless countermeasures are undertaken to minimize the downdrag condition.

WisDOT specifies that the provisions specified by AASHTO for downdrag should be used to compute downdrag loads. AASHTO specifies that downdrag loads should be applied if the settlement between the soil and the installed pile is 0.4 inches or greater. Soil settlement below the installed pile is ignored in these computations. We used the preliminary cross-section drawings provided by AAI to determine the maximum height of fill to be placed at each substructure unit. We use the procedures and equations presented in AASHTO Section 10.6.2.4 to estimate settlement between the soil and the installed pile to the computed maximum depth of each pile type/size analyzed.

After determining which soil strata could cause downdrag, we apply the AASHTO specified downdrag (DD) load factor to the computed unfactored skin friction load for the affected soil strata. For the driven portion of a pile, we apply a 1.4 DD load factor to the *APILE*-computed unfactored skin friction load. For the prebored portion of a pile or where embankments are constructed after piles are driven, we apply a 1.25 DD load factor to the unfactored skin friction load computed using AASHTO specified drilled shaft analyses procedures.

C. Lateral Deflection Analyses

We understand that the proposed abutments will be Type A1 (sill) abutments. We understand no lateral force analyses are required for the abutments.

VIII. ANALYSES RESULTS

A. Shallow Spread Footing Foundation Analyses

We did not perform shallow spread footing foundation analyses for the abutments or piers for the subject bridge structure for the reasons presented above in Section VII.A.

B. Deep Driven Pile Foundation Analyses

We performed the static and drivability analyses using the AASHTO and WisDOT procedures and the given and estimated information as outlined above in Section VII.B. We used *APILE* to complete the static analyses and *GRLWEAP* to complete the drivability analyses for the deep driven pile foundation for the abutments and pier for the subject bridge structure. Enclosed Table 7-2 in Appendix C and Table A on pages 10 through 14 present the average unfactored end bearing and average unfactored skin friction without soil driving loss values derived from the *APILE* static computations for the soil strata for each of the borings. Enclosed Table 7-3 in Appendix C presents the static and drivability results including the Design Pile Tip Elevations; Design, Driving, and Ultimate Rn_{dyn}; Design and Factored P_r; and estimated Maximum σ_{dr} from the *APILE* and *GRLWEAP* computations for each of the borings. Using static analyses, we used the Design Rn_{dyn} for steel CIP-pipe-piles or steel H-piles and the estimated soil driving loss for each stratum to determine the design pile tip elevation as presented in Table 7-3 in Appendix C. We used a dynamic resistance factor of 0.5 to compute the Design P_r presented in Table 7-3. Using static analyses, we computed the Factored P_r presented in Table 7-3 using the static resistance factors presented in Table 7-1 in Appendix B. Where the computed Factored P_r is higher than the Design $P_{r,}$, we recommend the Design P_r be used in designing the pile foundation layout.

The analyses' results indicate that the use of driven steel CIP-pipe-piles or steel H-piles would be acceptable to support the substructure units for the South Abutment, Pier, and North Abutment for the proposed bridge structure. Our analyses indicate that thicker wall CIP-pipe-piles with an increased steel yield stress should be used due to the presence of the very dense GLACIAL TILL soil strata. If used, the steel H-piles for this bridge structure would be functioning as a friction pile terminating in very dense GLACIAL TILL instead of an end-bearing pile due to the lack of bedrock within the depth explored by the borings. Based on the reported over-driving of H-piles functioning as friction piles for bridge structures for the South IH-39 Segment and as shown for the H-piles driven for the adjacent B-13-461 structure, we do not recommend that H-piles be considered for supporting the substructure units for the subject bridge structure due to the potential for the H-piles to over-drive to reach the design required driving capacity.

Therefore, we recommend 10¾-inch-outside-diameter, 0.500-inch-thick, 45 ksi steel, CIP-pipe-piles provide foundation support for the South Abutment, Pier, and North Abutment substructure units. Please refer to Table B on page 20 for our recommended Design Rn_{dyn}, Design P_r, Design Pile Tip Elevation, Driving Rn_{dyn}, and other pertinent design values for each substructure unit. Our drivability analyses indicate a Delmag D16-32 or similar pile driving hammer should be able to drive the recommended steel CIP-pipe-piles.

We computed a settlement of approximately 1¼ inches between the existing soil strata and the total length of an installed pile due to the construction of the south and north approach embankments. Per AASHTO, downdrag load should be considered when computed settlements between existing soil strata and the total length of an installed pile are greater than or equal to 0.4 inches. We compute elevations 838.2 feet and 836.4 feet, respectively for the south and north approach embankment, to be the elevation below which the estimated settlement between the soil and the installed pile will be less than 0.4 inches. The soil strata above these elevations contribute to downdrag loading of the installed pile.

Due to the minor changes in the ground surface elevation at the Pier substructure unit, downdrag load due to settlement between the existing soil strata and the total length of installed pile is estimated to less than 0.4 inches.

Based on the computed settlement between the soil and the total length of installed pile due to the south and north approach embankments and per AASHTO and the WBM, we computed the Factored Downdrag Load presented in Table B due to soils above elevation 838.2 feet at Boring SB-7 and above elevation 836.4 feet at Boring SB-8. We recommend the reduction of the Design P_r by the Factored Downdrag Load presented in Table B for the recommended 10¾-inch-outside-diameter, 0.500-inch-thick, 45 ksi steel, CIP-pipe-piles. Alternatively, the downdrag load could be countered by: (1) pre-boring through the existing soil strata to the specified elevations [or lower] and leaving a permanent pipe sleeve, (2) coating the pile with bitumen to the specified elevations [or lower], or (3) removing the existing soil strata

Table B: Recommended Driven Steel CIP-pipe-pile Information for Structure B-13-731‡

Substructure Unit	South Abutment	Pier	North Abutment
Nearest Boring	SB-7	SB-8	SB-8
Pile Cap Base Elevation (feet)	887.7	862.0	887.7
CIP Diameter (inches)	10¾	10¾	10¾
CIP Shell Thickness (inches)	0.500	0.500	0.500
CIP Steel Yield Stress (ksi)	45	45	45
Design Rn_{dyn} (kips)	300	300	300
Design P_r (kips)	150	150	150
Factored Downdrag Load (kips)*	54	0	60
Design Pile Tip Elevation (feet)	784.9	772.9	772.9
Computed Pile Length (feet)	102.8	89.1	114.8
Recommended Plan Pile Length (feet)†	87	76	98
Driving Rn_{dyn} (kips)	300	300	300
Hammer Type	Delmag D16-32	Delmag D16-32	Delmag D16-32

‡ See attached Table 7-3 in Appendix B for additional driven pile drivability results.
† Please refer to page 21 for an explanation of the recommended plan pile lengths.
* Per WBM 11.3.1.17.1, the recommended Design P_r should be reduced by the recommended Factored Downdrag Load for the recommended CIP-pipe-piles unless countermeasures are taken.

to the specified elevations [or lower] within the footprint of the substructure unit and replacing with WisDOT structural fill material.

Some of the newer bridges along the I-39 Corridor were constructed with either H-piles or CIP piles. We were informed that the H-piles are typically driving deeper than the computed depths in soils and the CIP piles are typically reaching capacity at shallower than computed depths, although some piles are driving deeper and shallower within the same substructure. For bridge Structure B-53-323 (Avalon

Road), H-piles for the abutments drove significantly deeper than computed and CIP were driven in the median to depths 3 to 6 feet shallower than computed.

Based on the reported shallower pile tip depth of driven CIP-pipe-piles for the I-39 Corridor and as indicated by Borings SB-7 and SB-8 that the thickness and type of soil overburden is variable, we recommend an average of approximately 15 percent be subtracted from the computed pile lengths as presented in Table B on page 20 for the recommended 10¾-inch-outside-diameter, 0.500-inch-thick, 45 ksi steel, CIP-pipe-piles installed at the substructure units for the South and North Abutments for the subject bridge structure to allow for the anticipated soil overburden variability.

Although Borings SB-7 and SB-8 did not encounter any cobbles or boulders in the GLACIAL TILL strata, it is known that GLACIAL TILL soils can contain a variable quantity of these large particles and that these large particles can be erratically located within the GLACIAL TILL soil matrix. Therefore, we recommend conical pile points be used for the CIP-pipe-piles due to the potential to encounter cobbles and/or boulders within the very dense GLACIAL TILL soils. The conical pile points help to evenly distribute the driving stresses to the steel shell of these piles which will help to reduce the potential of damage to the piles during driving.

C. Lateral Deflection Analyses

We did not perform lateral deflection analyses for any of the substructure units for the subject bridge structure.

IX. BRIDGE CONSTRUCTION

We offer the following comments and recommendations regarding the construction of the two-span bridge for the North Segment of the IH-39 Reconstruction Project.

A. Shallow Foundations

Shallow spread footing foundations are not being considered for the abutments and piers for the subject bridge structure for the reasons presented above in Section VII.A.

B. Deep Foundations

We recommend a deep foundation system consisting of 10¾-inch-outside-diameter, 0.500-inch-thick, 45 ksi steel, CIP-pipe-piles driven in accordance with the WisDOT *Standard Specifications for Highway and Structure Construction* and relevant special provisions to support the proposed substructure units for the South and North Abutments and the Pier for the subject bridge reconstruction.

Using the proposed pile cap base elevations as presented on Exhibit A and the recommended plan pile lengths as presented in Table B on page 20, we estimate the recommended steel CIP-pipe-piles will achieve the Design Rn_{dyn} of 300 kips in very dense GLACIAL TILL in the vicinity of the following estimated pile tip elevations:

Substructure Unit	Nearest Boring(s)	Estimated Pile Tip Elevation (feet)
South Abutment	SB-7	800
Pier	SB-8	786
North Abutment	SB-8	789

Please refer to Table B on page 20 for a summary of the analyses results for the recommended steel H-piles. Additional static and drivability analyses' results information is presented in Tables 7-2 and 7-3 in Appendix C.

The final driven length of the steel CIP-pipe-piles will depend on: (1) the variability of the soil overburden thickness, (2) the variability of the soil overburden density, and (3) the selected pile hammer type. Therefore, variations in the installed length of steel CIP-pipe-piles should be anticipated.

C. General Comments and Recommendations

We recommend that all work associated with the selected foundation system at the project site be performed in accordance with the WisDOT *Standard Specifications for Highway and Structure Construction* and relevant special provisions.

Slope protection should be provided in the vicinity of and around all substructure foundation units as required by WisDOT standards to reduce the potential for erosion.

X. CLOSING COMMENTS

Soils & Engineering Services, Inc. prepared this report for the exclusive use of Dane Partners, LLC and the Wisconsin Department of Transportation to aid in the design of the proposed Illinois State Line - Madison for the North Segment of the IH-39 Reconstruction Project in the Town of Blooming Grove, in Dane County, Wisconsin. The recommendations in this report are based on the project information provided to our office. Soils & Engineering Services, Inc. should review any changes in the nature, design, or location of the proposed bridge after submittal of this *Geotechnical Exploration and Analyses Report* for Structure B-13-731 to revise the recommendations in the report, if necessary. The nature and extent of soil or groundwater variations between the boring locations may not become evident until the time of excavation or construction of the subject bridge. If soil or groundwater variations are evident at the time of excavation or construction, it will be necessary for Soils & Engineering Services, Inc. to re-evaluate the soil and groundwater, and other site conditions, which may result in the revision of our recommendations in this report.

Soils & Engineering Services, Inc. should review the final design and specification documents for this project to verify that our recommendations regarding the foundation system are interpreted correctly and implemented in the design of the subject bridge as they are intended. It is further recommended that the project geotechnical engineer be present at the time of pile installation for the proposed bridge structure to observe compliance with the design concept and specifications, and to provide recommendations to modify the design if subsurface conditions differ from those anticipated prior to construction. It is important that the pile load capacity, soil strength, bedrock integrity, degree of compaction, and other soil properties required be confirmed and/or determined at the time of excavation and construction activities for the subject bridge.

The recommendations provided in this report are based on our identification/classification and interpretation of the soils and information given on the WisDOT Boring Logs, and may not be based solely on the contents of the driller's field logs.

Soils & Engineering Services, Inc. prepared this report for the subject bridge in accordance with generally accepted geotechnical engineering practices at this time. Soils & Engineering Services, Inc. offers no other expressed or implied warranty.

Soils & Engineering Services, Inc. will store the soil samples obtained from the soil borings performed for this project for a period of 60 calendar days after the date of this report. Please advise us if we should extend this period.

We recommend that this *Geotechnical Exploration and Analyses Report*, in its entirety, for Proposed Structure B-13-731 be made available to bidding contractors or subcontractors for information purposes. The Appendices, WisDOT Boring Logs, and other attachments referenced in this report should not be separated from the text of this report. This report should be considered invalid if used for purposes other than those described herein.

Safety precautions, such as those required by OSHA and the Wisconsin Department of Safety and Professional Services, should be followed throughout the entire construction of the proposed project. They include, but are not limited to, the proper sloping and/or support of excavation sidewalls and adjacent embankments, roadways, sidewalks, railroad lines, utility lines, and/or buildings.

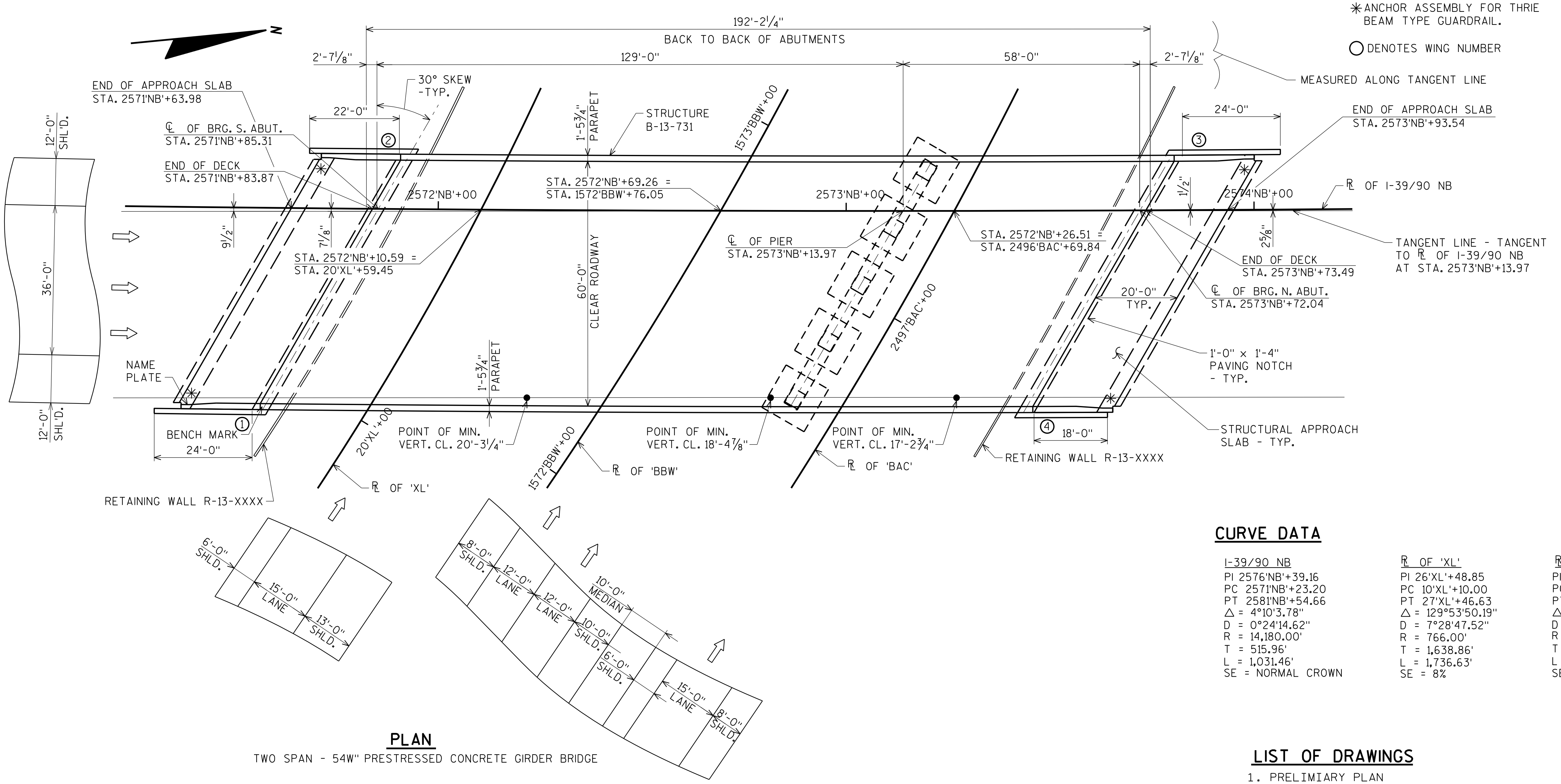
Soils & Engineering Services, Inc. respectfully submits this *Geotechnical Exploration and Analyses Report*, dated April 10, 2019, for Proposed Structure B-13-731 to **Dane Partners, LLC** and the **Wisconsin Department of Transportation**.

Appendix A

B-13-731 Preliminary Plan Sheet 1 of 4, Exhibit A
60% Plan Cross-Section Sheet PRE-93, Exhibit B
60% Plan Cross-Section Sheet PRE-94, Exhibit C
R-13-352 General Plan Sheet, Exhibit D
R-13-353 General Plan Sheet, Exhibit E

STATE PROJECT NUMBER

1007-12-78



PLAN

TWO SPAN - 54W" PRESTRESSED CONCRETE GIRDER BRIDGE

CURVE DATA

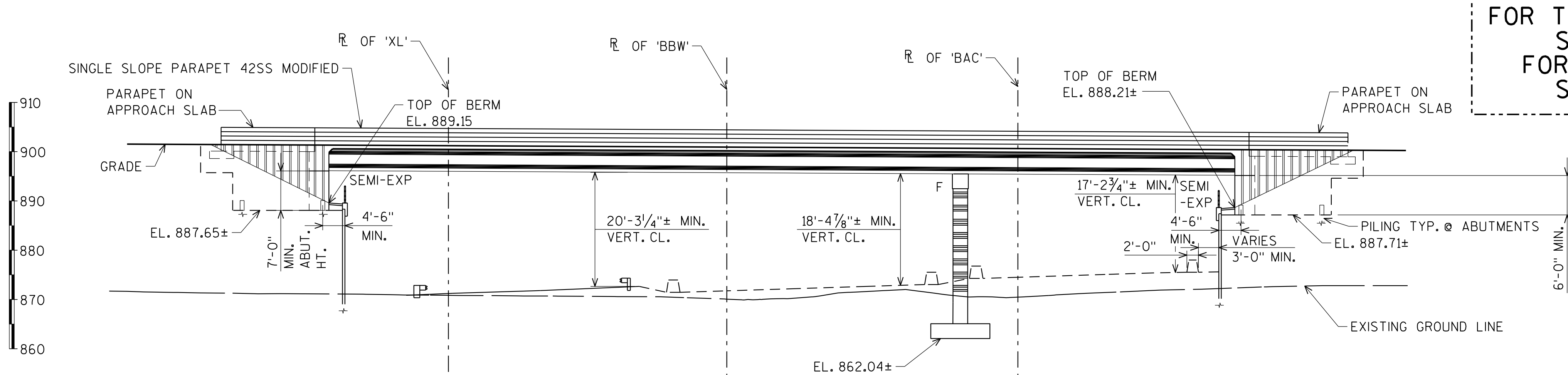
I-39/90 NB	℞ OF 'XL'	℞ OF 'BBW'	℞ OF 'BAC'
PI 2576'NB'+39.16	PI 26'XL'+48.85	PI 1586'BBW'+65.30	PI 2493'BAC'+24.20
PC 2571'NB'+23.20	PC 10'XL'+10.00	PC 1561'BBW'+51.94	PC 2486'BAC'+40.18
PT 2581'NB'+54.66	PT 27'XL'+46.63	PT 1586'BBW'+35.91	PT 2498'BAC'+66.23
△ = 4°10'3.78"	△ = 129°53'50.19"	△ = 134°15'54.45"	△ = 63°17'8.61"
D = 0°24'14.62"	D = 7°28'47.52"	D = 5°24'18.94"	D = 5°9'42.41"
R = 14,180.00'	R = 766.00'	R = 1,060.00'	R = 1,110.00'
T = 515.96'	T = 1,638.86'	T = 2,513.36'	T = 684.02'
L = 1,031.46'	L = 1,736.63'	L = 2,483.97'	L = 1,226.04'
SE = NORMAL CROWN	SE = 8%	SE = 6%	SE = 6%

EXHIBIT A

LIST OF DRAWINGS

1. PRELIMIARY PLAN
2. TYPICAL SECTIONS
3. DESIGN DATA AND QUANTITIES
4. GENERAL NOTES AND PROFILES
5. SUBSURFACE EXPLORATION

FOR TYPICAL SECTIONS, SEE SHEET 2
FOR DESIGN DATA, SEE SHEET 3



ELEVATION

(NORMAL TO ℞ OF EXISTING AND POTENTIAL OFF-RAMP TO USH 12/18 WB AND CD ROAD)

BRIDGE OFFICE CONTACT:
WILLIAM DREHER
(608)-266-8489

CONSULTANT CONTACT:
CHRIS MCMAHON
(715)-834-3161

NO.	DATE	REVISION	BY

ORIGINAL PLANS PREPARED BY
AYRES ASSOCIATES
3433 Oakwood Hills Parkway
Eau Claire, WI 54701
www.AyresAssociates.com

STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION

ACCEPTED ________
CHIEF STRUCTURES DESIGN ENGINEER   DATE

STRUCTURE B-13-731

I-39/90 NB OVER RAMP TO USH-12/18 WB

COUNTY: DANE
TOWN/~~CITY/VILLAGE~~: BLOOMING GROVE

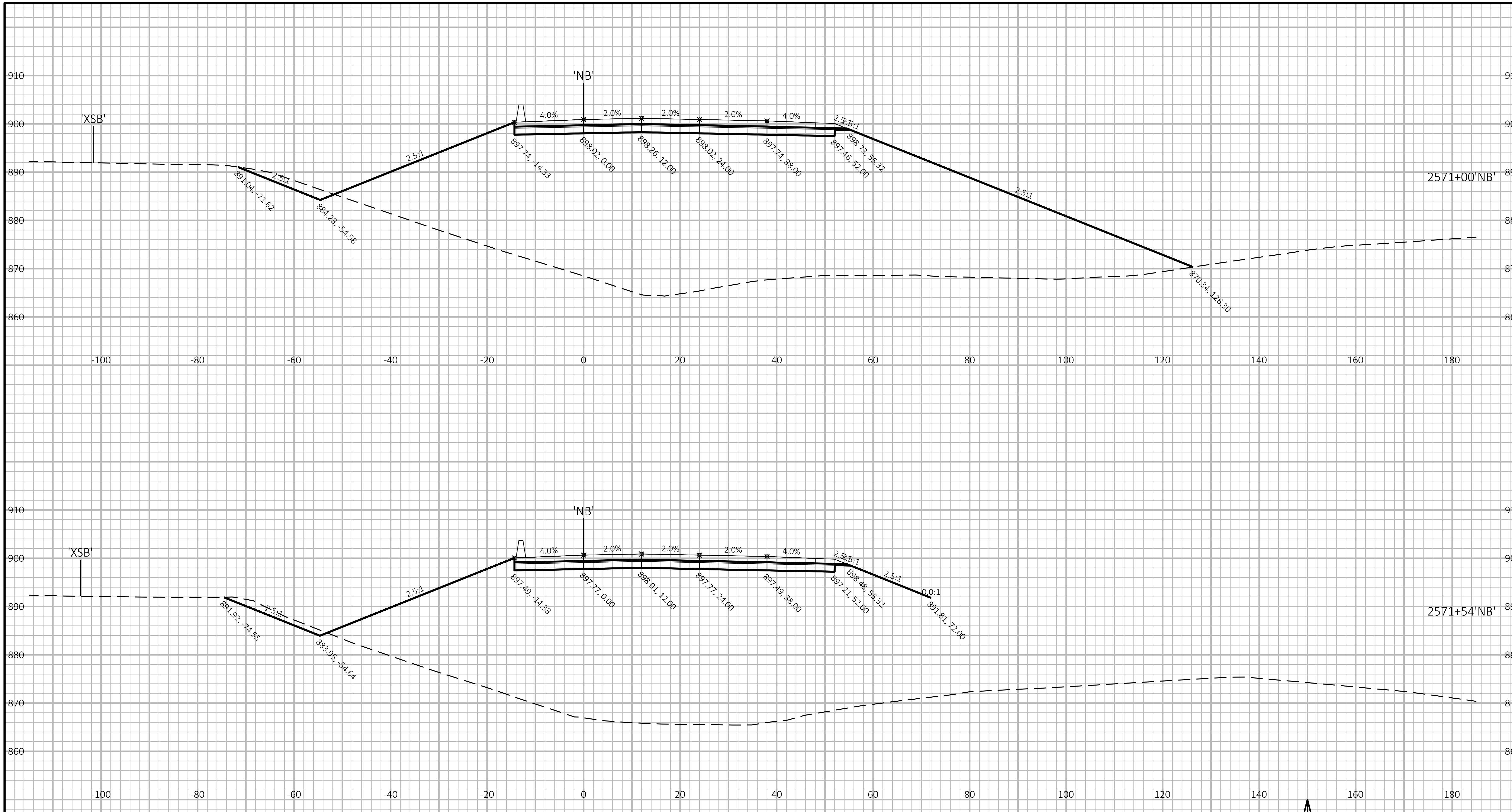
DESIGN SPEC.
AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS

DESIGNED BY: CBM | DESIGN CK'D.: | DRAWN BY: JLB | PLANS CK'D.:

PRELIMINARY PLAN

SHEET 1 OF 5

8



BEGIN BRIDGE DECK
STRUCTURE NO. B-13-731
STA. 2571+54'NB'

EXHIBIT B

9

PROJECT NO: 1007-12-78	HWY: IH 39	COUNTY: DANE	CROSS SECTIONS: IH 39 NB	SHEET	E

PRE_93

FILE NAME : P:\2019 PROJECTS\5019001 - BIC\CIVIL3D\SHEETSPLAN\10071278\0902_XS_NB.DWG
LAYOUT NAME - 21
PLOT DATE : 2/13/2019 4:14 PM PLOT BY : KYLE CORNELIUS PLOT NAME : PLOT SCALE : 1 IN:20 FT HORZ. / 1 IN:20 FT VERT.
WISDOT/CADDS SHEET 49

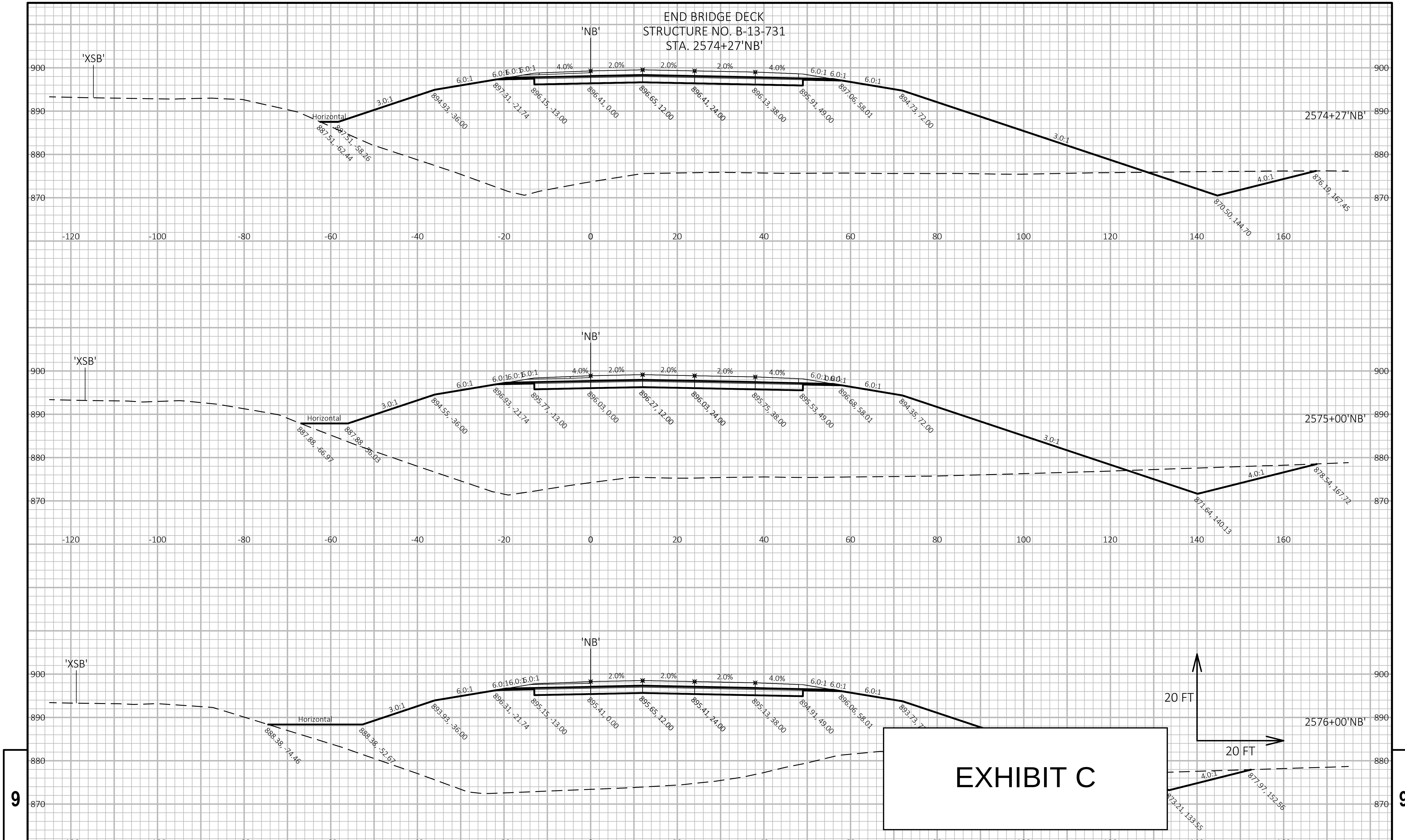


EXHIBIT C

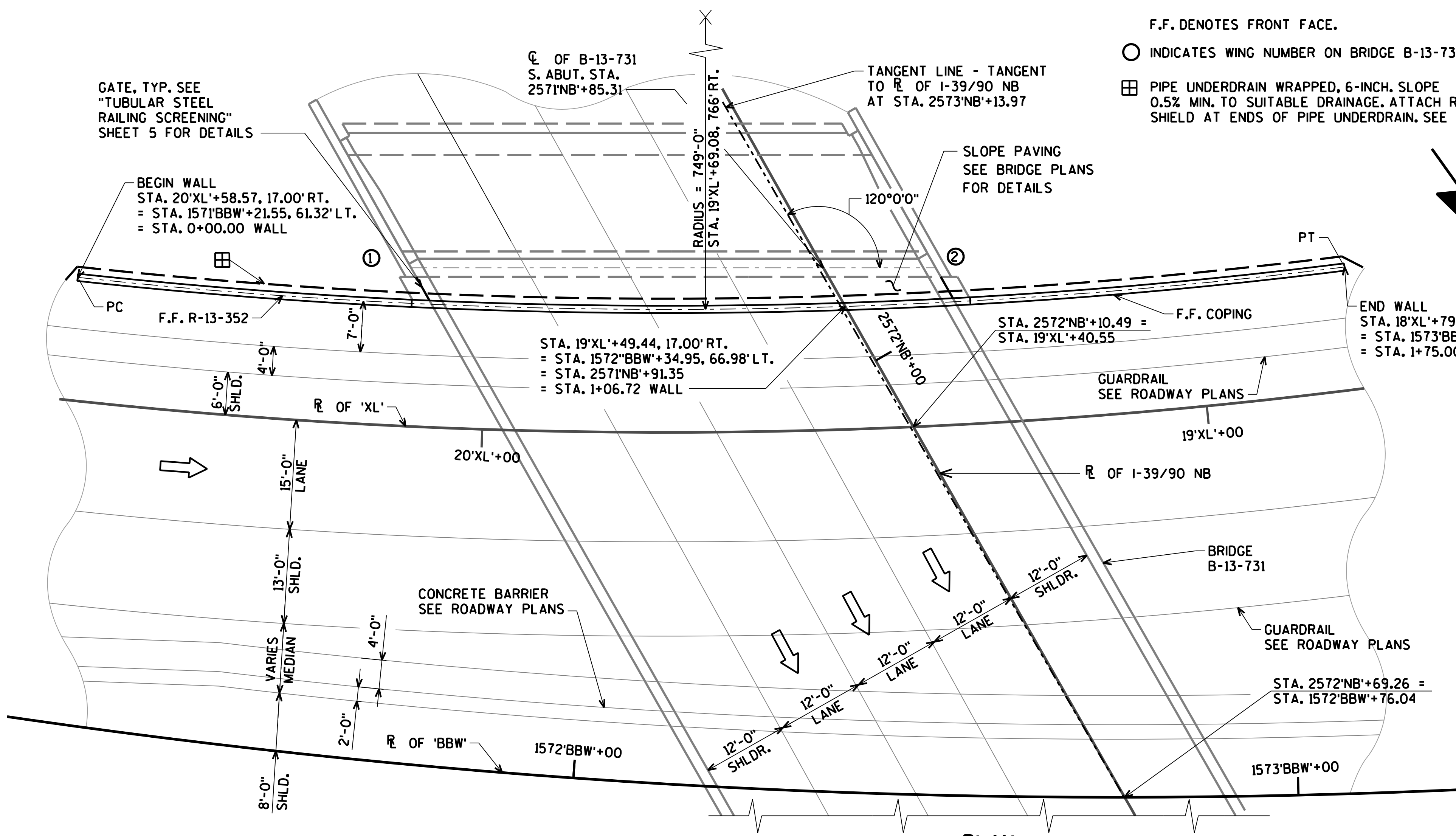
PROJECT NO: 1007-12-78	HWY: IH 39	COUNTY: DANE	CROSS SECTIONS: IH 39 NB	SHEET E

FILE NAME : P:\2019 PROJECTS\5019001 - BIC\CIVIL3D\SHEETSPLAN\10071278\0902_XS_NB.DWG
LAYOUT NAME - 22
PLOT DATE : 2/13/2019 4:14 PM
PLOT BY : KYLE CORNELIUS
PLOT NAME :
PLOT SCALE : 1 IN:20 FT HORZ. / 1 IN:20 FT VERT.

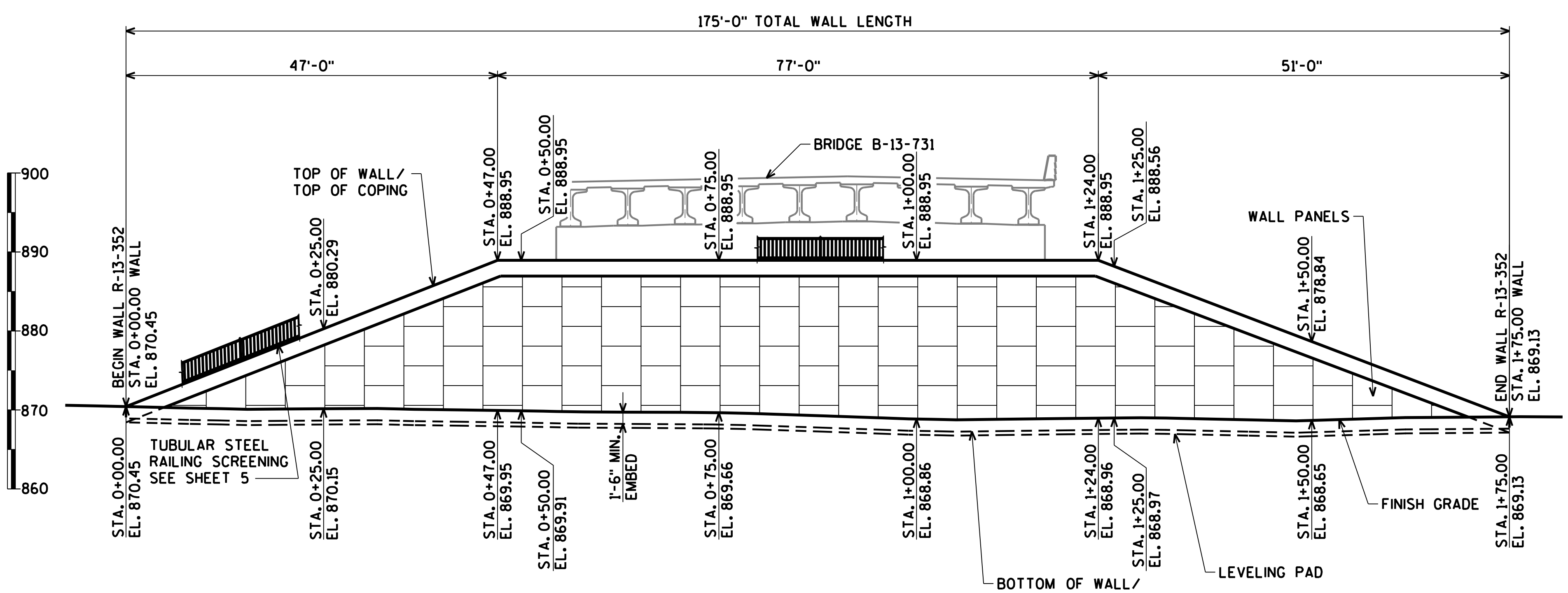
F.F. DENOTES FRONT FACE.

○ INDICATES WING NUMBER ON BRIDGE B-13-731

⊞ PIPE UNDERDRAIN WRAPPED, 6-INCH, SLOPE 0.5% MIN. TO SUITABLE DRAINAGE. ATTACH RODENT SHIELD AT ENDS OF PIPE UNDERDRAIN. SEE SHEET 3.



PLAN
MSE RETAINING WALL



ELEVATION
LOOKING SOUTH AT F.F. WALL

ALLOWABLE WALL SYSTEMS

WALL CONCRETE PANEL MSE

MATERIAL PROPERTIES

CONCRETE MASONRY (COPING) ______ f'_c = 3,500 P.S.I.

BAR STEEL REINFORCEMENT (GRADE 60) ______ f_y = 60,000 p.s.i.

GENERAL NOTES

DRAWINGS SHALL NOT BE SCALED.

BEVEL ALL EXPOSED EDGES OF CONCRETE ¾" UNLESS NOTED OTHERWISE.

BAR STEEL REINFORCEMENT SHALL HAVE 2" CLEAR COVER UNLESS OTHERWISE SHOWN OR NOTED.

ALL WALL STATIONING AND OFFSETS ARE GIVEN AT THE FRONT FACE OF THE WALL R-13-352.

THE EXISTING GROUND LINE IS THE UPPER LIMIT OF EXCAVATION FOR STRUCTURES.

COORDINATE THE CONSTRUCTION OF RETAINING WALL R-13-352 WITH THE SOUTH ABUTMENT OF BRIDGE B-13-731.

ALL BAR STEEL REINFORCEMENT IN CAST-IN-PLACE CONCRETE IS TO BE EPOXY COATED.

THE PLAN QUANTITY FOR THE ITEM "WALL CONCRETE PANEL MECHANICALLY STABILIZED EARTH" IS BASED ON A WALL HEIGHT MEASURED FROM THE TOP OF WALL TO A CONSTANT DEPTH OF 1'-6" BELOW FINISHED GRADE.

THE QUANTITY OF CONCRETE MASONRY, COATED REINFORCING STEEL, AND RUBBERIZED MEMBRANE WATERPROOFING FOR THE CAST-IN-PLACE COPING IS INCIDENTAL TO BID ITEM "WALL CONCRETE PANEL MECHANICALLY STABILIZED EARTH".

LIST OF DRAWINGS

EXHIBIT D

NO.	DATE	REVISION	BY

ORIGINAL PLANS PREPARED BY
AYRES ASSOCIATES
3433 Oakwood Hills Parkway
Eau Claire, WI 54701
www.AyresAssociates.com

STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION

ACCEPTED ______ CHIEF STRUCTURES DESIGN ENGINEER ______ DATE

STRUCTURE R-13-352

MSE WALL ALONG B-13-731 S. ABUT.

COUNTY DANE | TOWN/~~CITY/VILLAGE~~ BLOOMING GROVE

DESIGN SPEC. AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS

DESIGNED BY | DESIGN CK'D. | DRAWN BY JLB | PLANS CK'D.

GENERAL PLAN

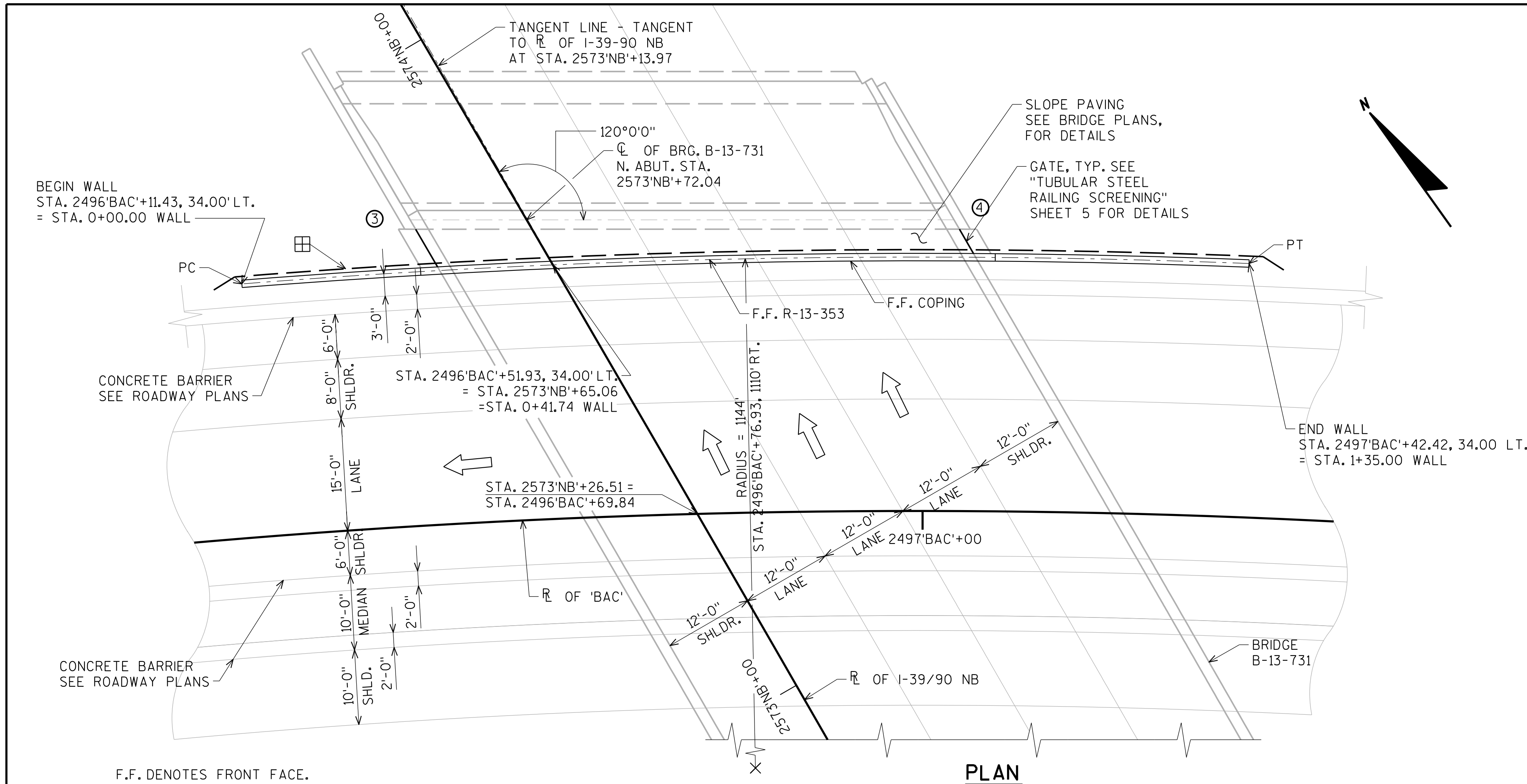
SHEET 1 OF 6

BRIDGE OFFICE CONTACT:
WILLIAM DREHER
(608)-266-8489

CONSULTANT CONTACT:
CHRIS MCMAHON
(715)-834-3161

CHECKED BY: DATE:
BACK CHECKED BY: DATE:
CORRECTED BY: DATE:

$PRFNAME$
U:±41-0660.0X - IH-39 Dane Partners General Bridge Information±RETAINING WALLS±B-13-731±R-13-352 SOL

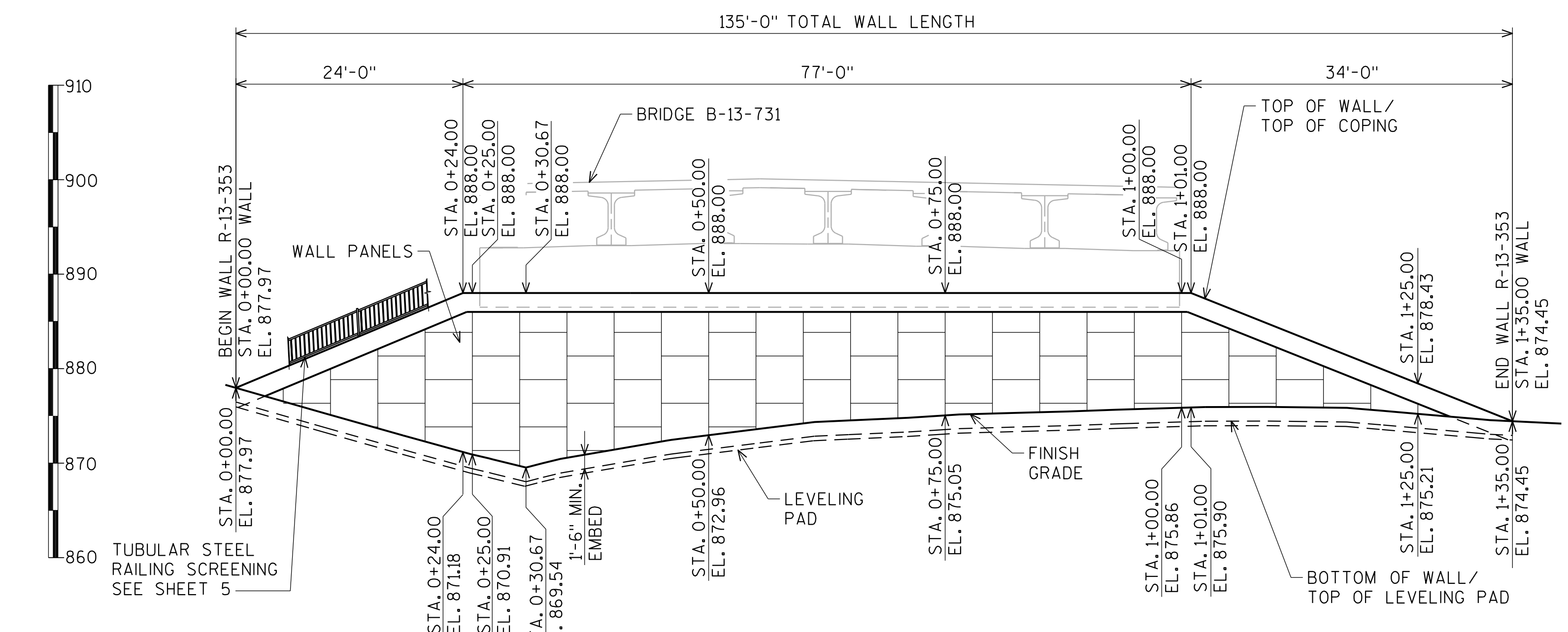


PLAN
MSE RETAINING WALL

F.F. DENOTES FRONT FACE.

○ INDICATES WING NUMBER ON BRIDGE B-13-731

⊞ PIPE UNDERDRAIN WRAPPED, 6-INCH. SLOPE 0.5% MIN. TO SUITABLE DRAINAGE. ATTACH RODENT SHIELD AT ENDS OF PIPE UNDERDRAIN. SEE SHEET 3.



ALLOWABLE WALL SYSTEMS
WALL CONCRETE PANEL MSE

MATERIAL PROPERTIES

CONCRETE MASONRY (COPING) ________________ f'_c = 3,500 P.S.I.

BAR STEEL REINFORCEMENT (GRADE 60) _______ f_y = 60,000 p.s.i.

GENERAL NOTES

DRAWINGS SHALL NOT BE SCALED.

BEVEL ALL EXPOSED EDGES OF CONCRETE ¾" UNLESS NOTED OTHERWISE.

BAR STEEL REINFORCEMENT SHALL HAVE 2" CLEAR COVER UNLESS OTHERWISE SHOWN OR NOTED.

ALL WALL STATIONING AND OFFSETS ARE GIVEN AT THE FRONT FACE OF THE WALL R-13-353.

THE EXISTING GROUND LINE IS THE UPPER LIMIT OF EXCAVATION FOR STRUCTURES.

COORDINATE THE CONSTRUCTION OF RETAINING WALL R-13-353 WITH THE NORTH ABUTMENT OF BRIDGE B-13-731.

ALL BAR STEEL REINFORCEMENT IN CAST-IN-PLACE CONCRETE IS TO BE EPOXY COATED.

THE PLAN QUANTITY FOR THE ITEM "WALL CONCRETE PANEL MECHANICALLY STABILIZED EARTH" IS BASED ON A WALL HEIGHT MEASURED FROM THE TOP OF WALL A CONSTANT DEPTH OF 1'-6" BELOW FINISHED GRADE.

THE QUANTITY OF CONCRETE MASONRY, COATED REINFORCING STEEL, AND RUBBERIZED MEMBRANE WATERPROOFING FOR THE CAST-IN-PLACE COPING IS INCIDENTAL TO BID ITEM "WALL CONCRETE PANEL MECHANICALLY STABILIZED EARTH".

LIST OF DRAWINGS

EXHIBIT E

BRIDGE OFFICE CONTACT:
WILLIAM DREHER
(608)-266-8489

CONSULTANT CONTACT:
CHRIS MCMAHON
(715)-834-3161

NO.	DATE	REVISION	BY

ORIGINAL PLANS PREPARED BY
AYRES ASSOCIATES
3433 Oakwood Hills Parkway
Eau Claire, WI 54701
www.AyresAssociates.com

STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION

ACCEPTED ________ CHIEF STRUCTURES DESIGN ENGINEER ________ DATE

STRUCTURE R-13-353

MSE WALL ALONG B-13-731 N. ABUT.

COUNTY DANE | TOWN/~~CITY/VILLAGE~~ BLOOMING GROVE

DESIGN SPEC. AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS

DESIGNED BY | DESIGN CK'D. | DRAWN BY JLB | PLANS CK'D.

GENERAL PLAN

SHEET 1 OF 6

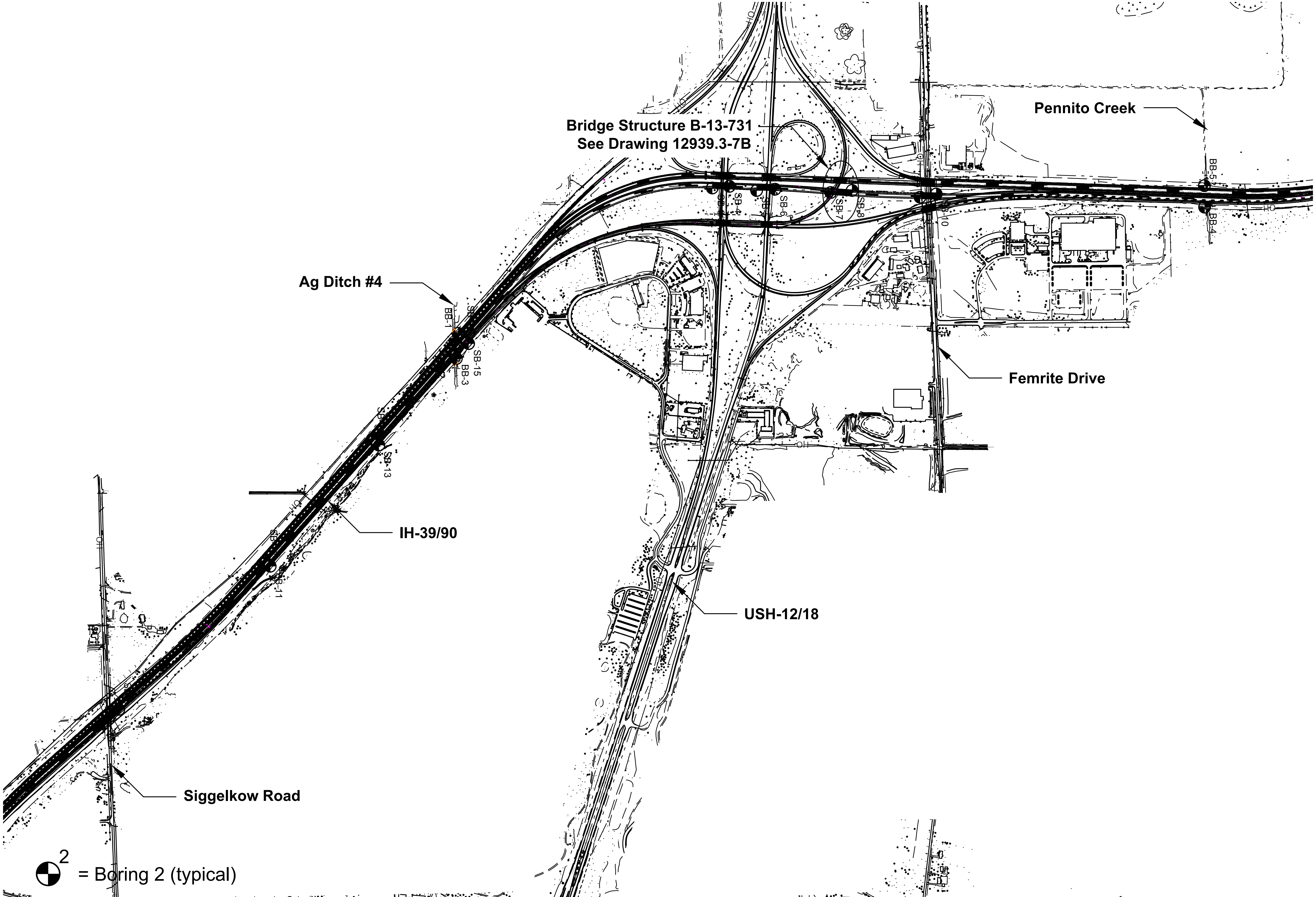
I.D. DATE:

CHECKED BY: DATE:
BACK CHECKED BY: DATE:
CORRECTED BY: DATE:

$PRFNAME$
U:±41-0660.0X - IH-39 Dane Partners General Bridge Information±RETAINING WALLS±B-13-731±R-13-353 NOR

Appendix B

Boring Location Sketch, Drawing 12939.3-7A and 12939.3-7B
WisDOT Boring Logs for Borings SB-7 and SB-8
Laboratory Test Result Records, Figures 1 through 4



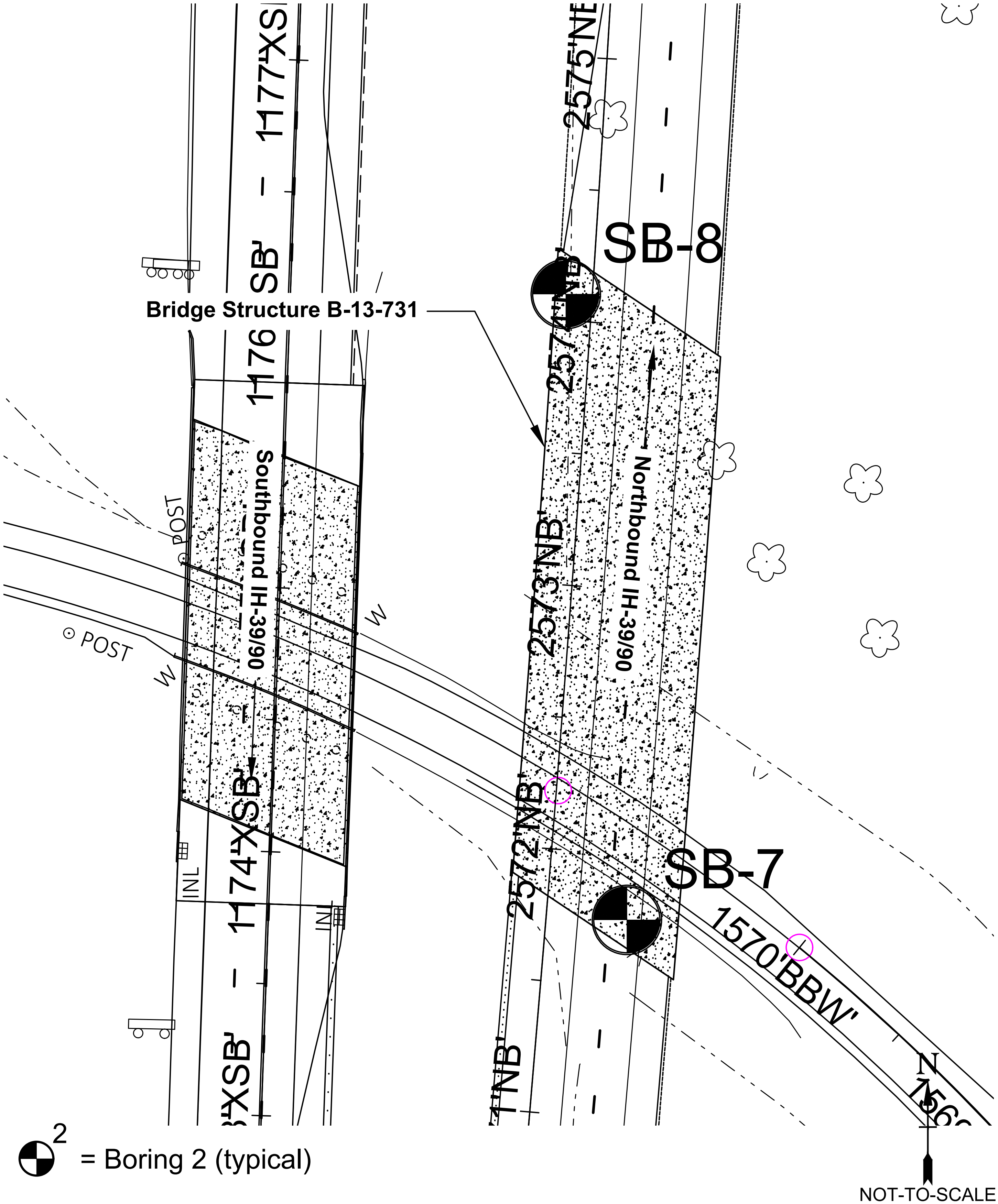
NOT-TO-SCALE

DRAWING
12939.3-7A

LOCATION SKETCH
IH-39 North Segment
IH-39/90 NB Bridge Over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Soils & Engineering Services, Inc.
1102 STEWART STREET • MADISON, WISCONSIN 53713
Phone: 608-274-7600 • 888-866-SOIL (7645)
Fax: 608-274-7511 • Email: soils@soils.ws
CONSULTING CIVIL ENGINEERS SINCE 1966

Created on 04/10/2019 Revised on



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CONSULTING CIVIL ENGINEERS SINCE 1966

LOCATION SKETCH
IH-39 North Segment
IH-39/90 NB Bridge Over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

DRAWING
12939.3-7B

Created on 04/10/2019 Revised on

WI Dept. of Transportation
3502 Kinsman Blvd.
Madison, WI 53704

WISDOT PROJECT ID: 1007-10-02/05	WISDOT STRUCTURE ID: B-13-731	BORING ID: SB-7	PAGE NO: 1 of 3
WISDOT PROJECT NAME: IH-39 North Segment	CONSULTANT: Dane Partners, LLC	CONSULTANT PROJECT NO:	LATITUDE: / LONGITUDE:
ROADWAY NAME: Bridge over NB Exit to USH-12/18 WB	DRILLING CONTRACTOR: Soils & Engineering Services, Inc.	DRILLING CONTRACTOR PROJECT NO: 12939.3	NORTHING: 473463.3 / EASTING: 849766.54
DATE STARTED: 1/10/19	CREW CHIEF: S. Hunger	DRILL RIG: CME 550X	COORDINATE SYSTEM: WCCS
DATE COMPLETED: 1/10/19	LOGGED BY: G. Prior	HOLE SIZE: 5.6 in	HORIZONTAL DATUM: WCCS Dane / VERTICAL DATUM: MSL
COUNTY: Dane	LOG QC BY: C. Bower	HAMMER TYPE: Automatic	STREAMBED ELEVATION: NA
STATION: 2571+75.52 'NB (OES)' / OFFSET: 30.595' R	TOWNSHIP: 7N / RANGE: 10E / SECTION: 23	1/4 SECTION: SW / 1/4 1/4 SECTION: SE	SURFACE ELEVATION: 870.19 ft

SAMPLE TYPE NUMBER	RECOVERY (in) (RQD)	Moisture	BLOW COUNTS (N VALUE)	Depth (ft)	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	Elev.	USCS / AASHTO	Strength Qp (tsf)	Liquid Limit (%)	Plasticity Index (%)	Boulders	Drilling Method	Notes
GS		F		0.3	LEAN CLAY WITH SAND, very dark brown, frozen, medium plasticity, fill topsoil. Frozen, 0' to 3'	869.9	CL					HSA	2¼"-inside-diameter continuous flight hollow-stem augers
SPT 1	14	F, F	7-11-8 (19)	3.0	SILTY SAND WITH GRAVEL, brown, fine to coarse grained, frozen, non-plastic to low plasticity, fill	867.2	SM						N1$_{60}$=43
				4.0	SANDY LEAN CLAY, brown, moist, medium, medium plasticity, fill	866.2	CL	0.9, 0.8					
SPT 2	16	M, M, W	2-3-22 (25)	4.5	SILTY SAND WITH GRAVEL, brown, fine to coarse grained, moist, very loose to loose, non-plastic to low plasticity, fill	865.7	SM						Drove Stone N1$_{60}$=4-6-42/6"
					SILTY SAND WITH GRAVEL, brown, fine to medium grained, wet, loose to very loose, non-plastic to low plasticity, trace to some gravel, glacial till		SM						
SPT 3	6	W	3-2-3 (5)										N1$_{60}$=9
SPT 4	8	W	2-1-2 (3)	10									N1$_{60}$=5
SPT 5	18	W 0	2-2-3 (5)	15					NP	NP			Fines = 29% MC = 12.9% N1$_{60}$=7
SPT 6	18	W	4-4-5 (9)	20			SM						N1$_{60}$=12
SPT 7	18	W	3-2-4 (6)	25									N1$_{60}$=8
SPT 8	18	W	2-2-2 (4)	30									N1$_{60}$=6
SPT 9	18	W 14	1-2-3 (5)										Dry Wt = 141 pcf MC = 13.8%

WATER LEVEL & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: NMR	CAVE - IN DEPTH AT COMPLETION: 12.33ft. WET ☐ DRY ☐
WATER LEVEL AT COMPLETION: 3.17ft.	CAVE - IN DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐

NOTES: 1) Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.
2) NE = Not Encountered; NMR = No Measurement Recorded

SAMPLE TYPE NUMBER	RECOVERY (in) (RQD)	Moisture	BLOW COUNTS (N VALUE)	Depth (ft)	Graphic	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Strength Qp (tsf)	Liquid Limit (%)	Plasticity Index (%)	Boulders	Drilling Method	Notes
						SILTY SAND WITH GRAVEL, brown, fine to medium grained, wet, loose to very loose, non-plastic to low plasticity, trace to some gravel, glacial till	SM						$N1_{60}$=6
SPT 10	18	W	2-3-5 (8)	40									$N1_{60}$=9
SPT 11	16	W	7-3-3 (6)	45									$N1_{60}$=6
				47.0		823.2 CLAYEY SAND WITH GRAVEL, reddish brown to light brown, fine grained, wet, medium dense, medium plasticity, trace to some gravel, glacial till	SC						
SPT 12	6	W	5-6-8 (14)	50									$N1_{60}$=14
SPT 13	12	M	3-5-6 (11)	55									$N1_{60}$=11
				57.0		813.2 SILTY SAND WITH GRAVEL, brown to reddish brown, fine to medium grained, moist to wet, medium dense, non-plastic to low plasticity, trace to some gravel, glacial till	SM						
SPT 14	4	M-W	7-8-8 (16)	60								HSA	2¼"-inside-diameter continuous flight hollow-stem augers and water $N1_{60}$=14
SPT 15	16	M-W	7-11-12 (23)	65									$N1_{60}$=20
				67.0		803.2 POORLY GRADED SAND WITH GRAVEL, grayish brown, poorly graded, fine grained, wet, medium dense	SP						
SPT 16	16	W / M	6-8-10 (18)										$N1_{60}$=15
				69.5		800.7 SANDY LEAN CLAY, grayish brown, moist, hard to very stiff, medium plasticity	CL	4.5+, 3.0					
				70									
				72.0		798.2 SILTY SAND WITH GRAVEL, brown, fine to medium grained, moist, dense to very dense, non-plastic to low plasticity, trace to some gravel, glacial till, with few irregular gray CLAYEY SAND (SC) lenses with few irregular gray CLAYEY SAND (SC) lenses	SM						
SPT 17	16	M	7-11-20 (31)	75									$N1_{60}$=25
SPT 18	14	M	12-12-17 (29)	80									$N1_{60}$=22

SAMPLE TYPE NUMBER	RECOVERY (in) (RQD)	Moisture	BLOW COUNTS (N VALUE)	Depth (ft)	Graphic	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Strength Qp (tsf)	Liquid Limit (%)	Plasticity Index (%)	Boulders	Drilling Method	Notes
						SILTY SAND WITH GRAVEL, brown, fine to medium grained, moist, dense to very dense, non-plastic to low plasticity, trace to some gravel, glacial till, with few irregular gray CLAYEY SAND (SC) lenses with few irregular gray CLAYEY SAND (SC) lenses							
SPT 19	16	M	15-25-29 (54)	85									$N1_{60}$=40
SPT 20	14	M	26-49-25/2"	90			SM						$N1_{60}$=19-35-18/2"
SPT 21	10	M	44-56/5"	95									$N1_{60}$=31-39/5"
SPT 22	6	M	73-27/1"	99.1		771.1							$N1_{60}$=51-19/1"

End of Boring at 99.1 ft.

N:\PROJECTS\12900 PROJECTS\12939.I-39 SEGMENTS\12939.3.I-39 NORTH\12939.3.BRS\731.NB BR.NB XRAMP\DRAWINGS\12939.3.I39N.NB BR.NB XRAMP.TN BLOOMG GROVE.DANE CO.1007-10-02.R07 WISDOT LOGS B-13-731.GPJ IH-39 North Segment 04/10/19

WI Dept. of Transportation
3502 Kinsman Blvd.
Madison, WI 53704

WISDOT PROJECT ID: **1007-10-02/05**			**BORING ID: SB-8**
WISDOT STRUCTURE ID: **B-13-731**			PAGE NO: 1 of 3
WISDOT PROJECT NAME: IH-39 North Segment	CONSULTANT: Dane Partners, LLC	CONSULTANT PROJECT NO:	LATITUDE: / LONGITUDE:
ROADWAY NAME: 90 NB Bridge over NB Exit to USH-12/18 WB	DRILLING CONTRACTOR: Soils & Engineering Services, Inc.	DRILLING CONTRACTOR PROJECT NO: 12939.3	NORTHING: 473700.32 / EASTING: 849743.38
DATE STARTED: 1/09/19	CREW CHIEF: S. Hunger	DRILL RIG: CME 550X	COORDINATE SYSTEM: WCCS
DATE COMPLETED: 1/09/19	LOGGED BY: G. Prior	HOLE SIZE: 5.6 in	HORIZONTAL DATUM: WCCS Dane / VERTICAL DATUM: MSL
COUNTY: Dane	LOG QC BY: C. Bower	HAMMER TYPE: Automatic	STREAMBED ELEVATION: NA
STATION: 2574+10 'NB (OES)' / OFFSET: 10' L	TOWNSHIP: 7N / RANGE: 10E / SECTION: 23	1/4 SECTION: SW / 1/4 1/4 SECTION: SE	SURFACE ELEVATION: 870.9 ft

SAMPLE TYPE NUMBER	RECOVERY (in) (RQD)	Moisture	BLOW COUNTS (N VALUE)	Depth (ft)	Graphic	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Strength Qp (tsf)	Liquid Limit (%)	Plasticity Index (%)	Boulders	Drilling Method	Notes
GS		M		0.6		LEAN CLAY, dark brown, moist, medium plasticity, topsoil (870.3)	CL					HSA	2¼"-inside-diameter continuous flight hollow-stem augers
SPT 1 / AU	0	M	4-5-5 (10)			SILTY SAND WITH GRAVEL, brown, fine to medium grained, moist to wet, loose to very loose, non-plastic to low plasticity, trace to some gravel, glacial till							$N1_{60}$=22
SPT 2	16	W	2-3-2 (5)	5									$N1_{60}$=10
SPT 3	14	W 13	3-3-3 (6)				SM						Dry Wt = 141 pcf MC = 12.7% $N1_{60}$=10
SPT 4	18	W	2-2-2 (4)	10									$N1_{60}$=8
				12.0		(858.9) SILTY SAND WITH GRAVEL, brown, fine to medium grained, wet, loose to medium dense, non-plastic to low plasticity, trace to some gravel, glacial till							
SPT 5	18	W	2-3-4 (7)	15									$N1_{60}$=9
SPT 6	18	W	2-3-3 (6)	20									$N1_{60}$=8
SPT 7	14	W	3-3-9 (12)	25			SM						$N1_{60}$=15
SPT 8	18	W	2-2-3 (5)	30									$N1_{60}$=7
SPT 9	18	W	3-4-5 (9)										$N1_{60}$=10

WATER LEVEL & CAVE-IN OBSERVATION DATA

WATER ENCOUNTERED DURING DRILLING: NMR	CAVE - IN DEPTH AT COMPLETION: 34.83ft. WET ☐ DRY ☐
WATER LEVEL AT COMPLETION: 22.33ft.	CAVE - IN DEPTH AFTER 0 HOURS: NMR WET ☐ DRY ☐

NOTES: 1) Stratification lines between soil types represent the approximate boundary; gradual transition between in-situ soil layers should be expected.
2) NE = Not Encountered; NMR = No Measurement Recorded

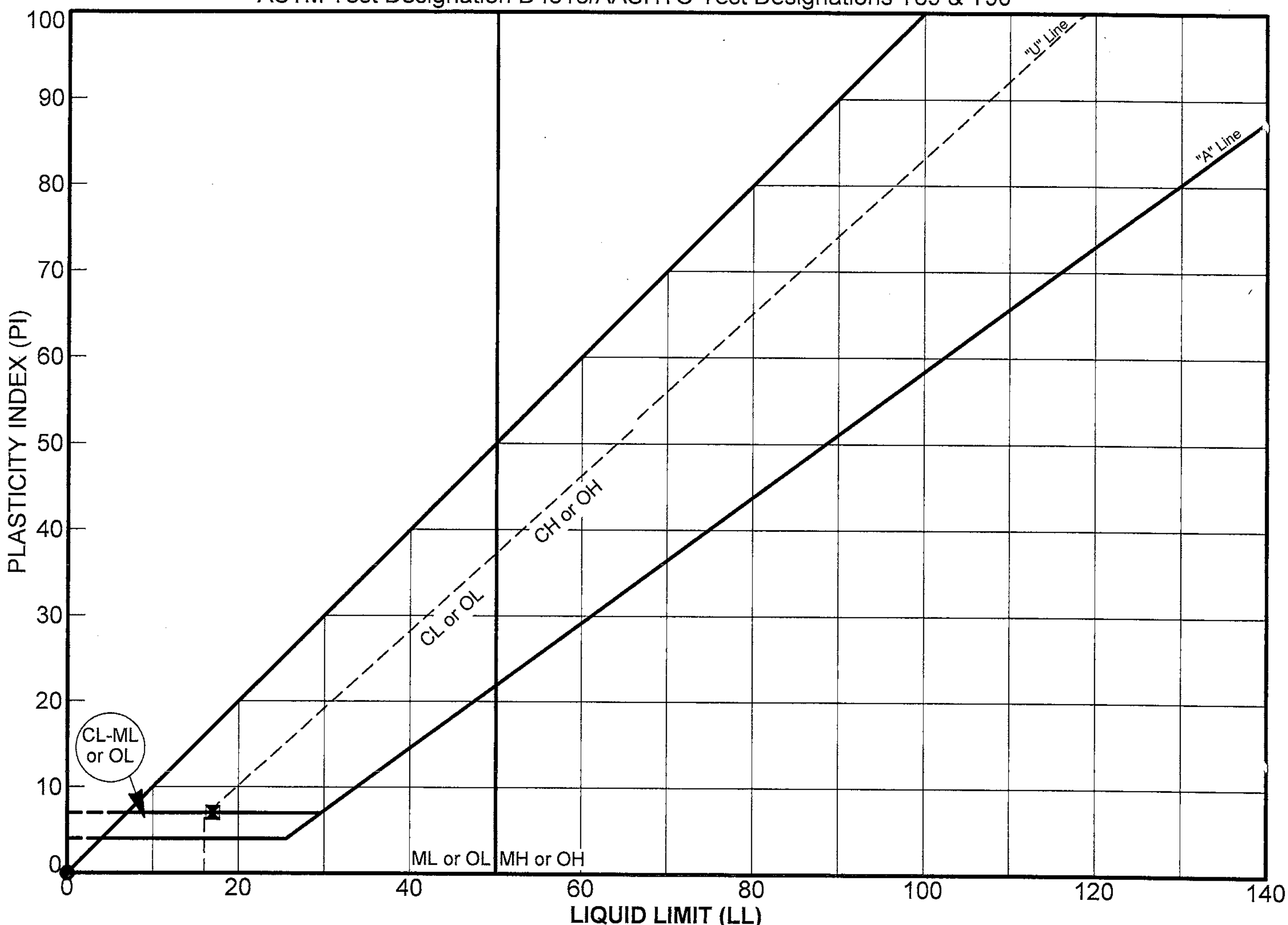
SAMPLE TYPE NUMBER	RECOVERY (in) (RQD)	Moisture	BLOW COUNTS (N VALUE)	Depth (ft)	Graphic	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Strength Qp (tsf)	Liquid Limit (%)	Plasticity Index (%)	Boulders	Drilling Method	Notes
						SILTY SAND WITH GRAVEL, brown, fine to medium grained, wet, loose to medium dense, non-plastic to low plasticity, trace to some gravel, glacial till							
SPT 10	14	W	2-3-3 (6)	40									$N1_{60}$=6
SPT 11	14	W	4-6-8 (14)	45									$N1_{60}$=14
SPT 12	18	W	5-7-7 (14)	50			SM						$N1_{60}$=12
SPT 13	0		3-3-3 (6)	55									$N1_{60}$=6
SPT 14	14	W	5-3-4 (7)	60		with probable wet POORLY-GRADED SAND (SP) seams, 60' to 67'							$N1_{60}$=6
SPT 15	0		6-6-8 (14)	65									$N1_{60}$=12
				67.0		SILTY CLAYEY SAND, brown, fine grained, moist, dense, low plasticity, trace to some gravel, glacial till (elev. 803.9)							
SPT 16	16	M M 9	11-15-18 (33)	70			SC-SM	4.5, 4.0 4.9	17	7		HSA	Dry Wt = 134 pcf Fines = 47% 2¼"-inside-diameter continuous flight hollow-stem augers and water MC = 8.9% q_u=2.04 tsf $N1_{60}$=27
				72.0		SILTY SAND WITH GRAVEL, brown, fine to medium grained, moist, very dense, non-plastic to low plasticity, trace to some gravel, glacial till (elev. 798.9)							
SPT 17	16	M M	20-30-42 (72)	75			SM						$N1_{60}$=57
SPT 18	18	M	24-33-34 (67)	80									$N1_{60}$=51

SAMPLE TYPE NUMBER	RECOVERY (in) (RQD)	Moisture	BLOW COUNTS (N VALUE)	Depth (ft)	Graphic	Soil / Rock Description and Geological Origin for Each Major Unit / Comments	USCS / AASHTO	Strength Qp (tsf)	Liquid Limit (%)	Plasticity Index (%)	Boulders	Drilling Method	Notes
						82.0 — 788.9	SM						
SPT 19	6	W 9	64-36/3"			POORLY GRADED GRAVEL WITH SILT AND SAND, brown, poorly graded, fine to coarse grained, wet, very dense, non-plastic to low plasticity							Fines = 7% MC = 9.0% $N1_{60}$=47-27/3"
				85			GP-GM						
SPT 20	12	W	28-72			89.5 — 781.4							$N1_{60}$=20-53

End of Boring at 89.5 ft.

ATTERBERG LIMITS TEST REPORT

ASTM Test Designation D4318/AASHTO Test Designations T89 & T90



	Specimen Identification	LL	PL	PI	Sample Classification
●	**Boring SB-7, 14'-9" Depth**	**NP**	**NP**	**NP**	***SILTY SAND (SM)*** — *7% gravel, 64% sand, 29.1% fines, fine to medium grained, non-plastic fines, light brown, wet, loose relative density,* ***GLACIAL TILL****, few gravel*
⊠	**Boring SB-8, 69'-7" Depth**	**17**	**10**	**7**	***SILTY CLAYEY SAND (SC-SM)*** — *6% gravel, 47% sand, 47.4% fines, fine grained, low plasticity fines, grayish-brown, moist,* ***GLACIAL TILL****, few gravel*

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LABORATORY TEST RESULT RECORD
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

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FIGURE 1

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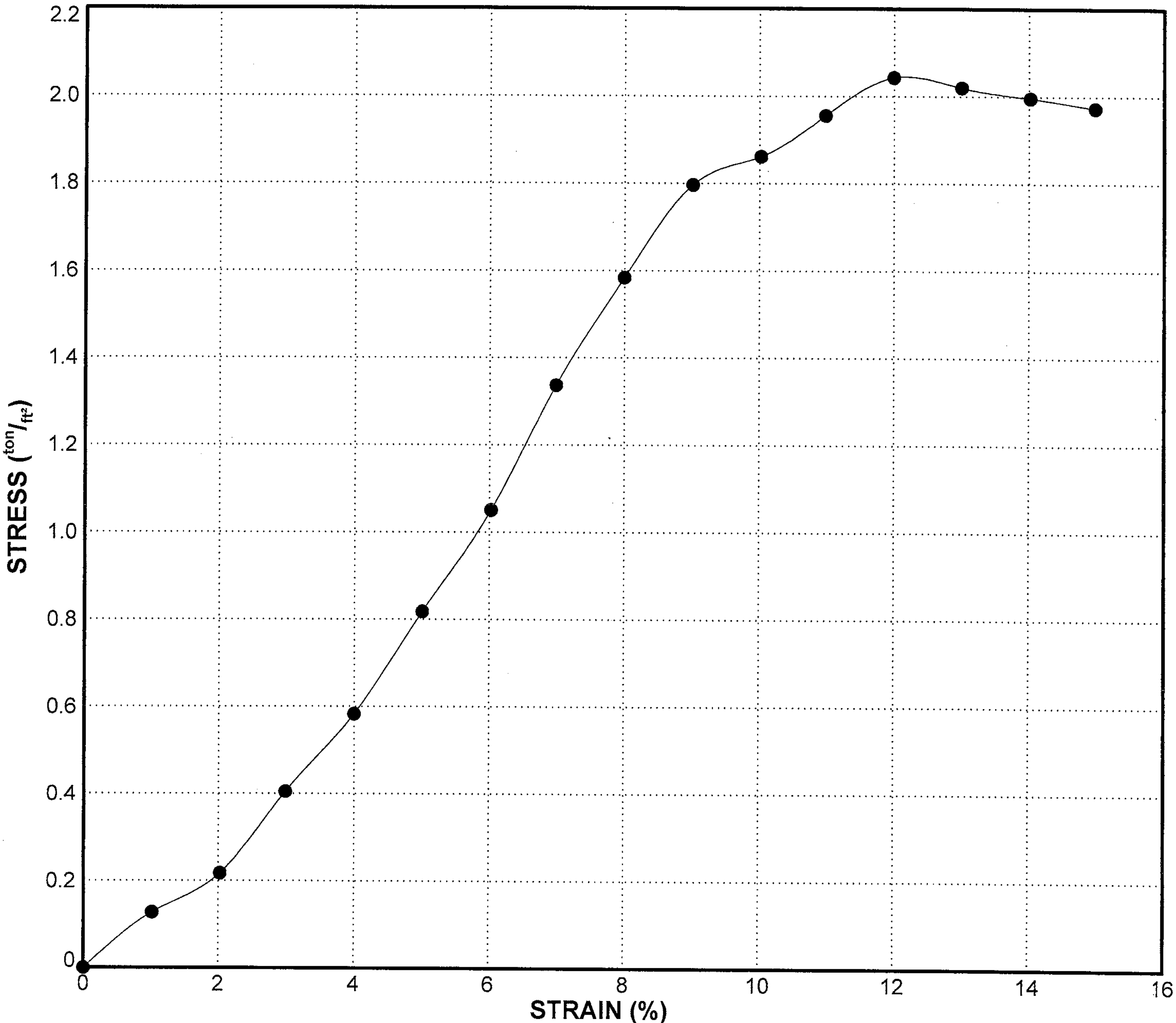
UNCONFINED COMPRESSION TEST REPORT

ASTM Test Designation D2166



Unconfined Compression Test Results for **Boring SB-8**

	Sample			Diameter (inches)	Height (inches)	H:D Ratio	Wet Density (lb/ft³)	Dry Density (lb/ft³)	MC (%)	Failure Stress (ton/ft²)	Failure Strain (%)
	Identification	Classification	Type								
●	**69'-7" Depth**	***SILTY CLAYEY SAND (SC-SM) GLACIAL TILL***	**SS2**	**1.534**	**1.976**	**1.3**	**146.4**	**134.4**	**8.9**	**2.04**	**12.0**

SS2=2-inch-outside-diameter, split-barrel sampler

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IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
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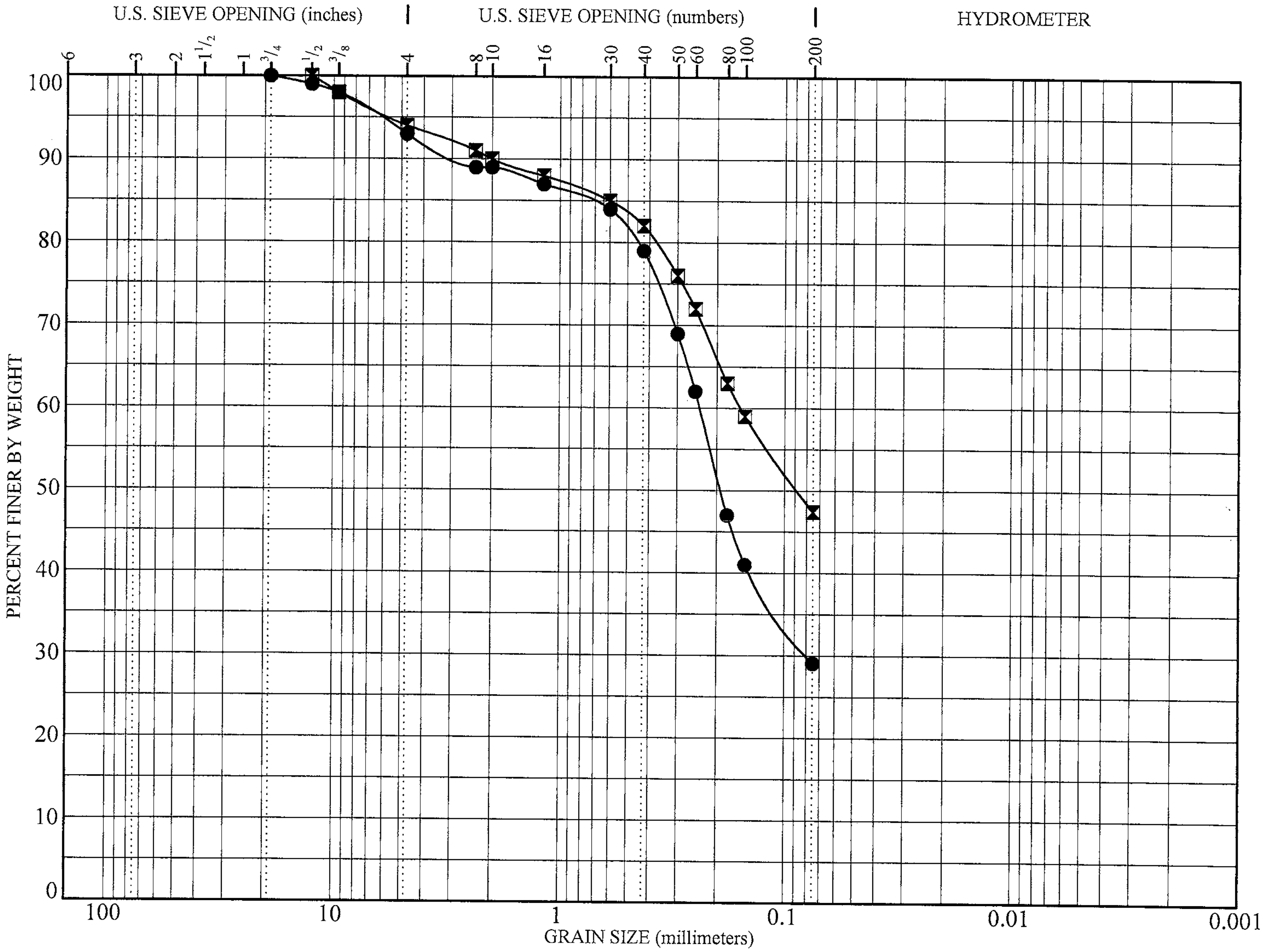
FIGURE 2

PARTICLE SIZE DISTRIBUTION ANALYSIS REPORT



	COBBLES (%)	GRAVEL (%) coarse	GRAVEL (%) fine	SAND (%) coarse	SAND (%) medium	SAND (%) fine	FINES (%) SILT (%)	FINES (%) CLAY (%)
●	0	7		64			29.1	
⧗	0	6		47			47.4	

Sieve Size	Percent Finer ●	Percent Finer ⧗	
3/4-inch	100		
1/2-inch	99	100	
3/8-inch	98	98	
#4	93	94	
#8	89	91	
#10	89	90	
#16	87	88	
#30	84	85	
#40	79	82	
#50	69	76	
#60	62	72	
#80	47	63	

Sieve Size	Percent Finer ●	Percent Finer ⧗	
#100	41	59	
#200	29.1	47.4	

	Grain Size (mm) D_{60}	Grain Size (mm) D_{30}	Grain Size (mm) D_{10}	Coefficients C_c	Coefficients C_u
●	0.24	0.079			
⧗	0.16				

	Sample Information
●	Boring SB-7, 14'-9" Depth: ***SILTY SAND (SM)*** *— fine to medium grained, non-plastic fines (LL=NP, PL=NP), light brown, wet, loose relative density,* ***GLACIAL TILL****, few gravel*
⧗	Boring SB-8, 69'-7" Depth: ***SILTY CLAYEY SAND (SC-SM)*** *— fine grained, low plasticity fines (LL=17, PL=10), grayish-brown, moist,* ***GLACIAL TILL****, few gravel*

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LABORATORY TEST RESULT RECORD
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

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FIGURE 3

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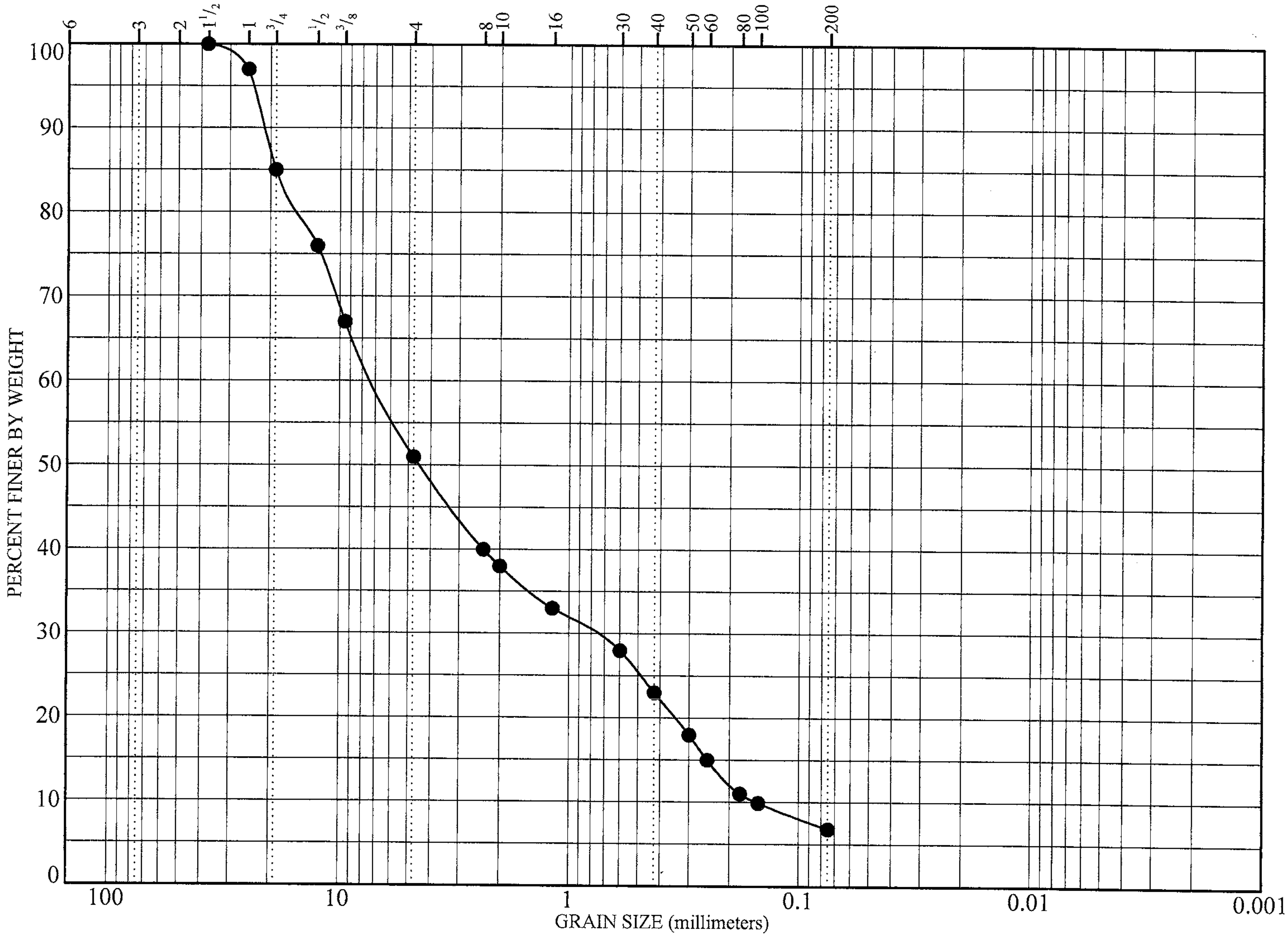
PARTICLE SIZE DISTRIBUTION ANALYSIS REPORT



	COBBLES (%)	GRAVEL (%) coarse	GRAVEL (%) fine	SAND (%) coarse	SAND (%) medium	SAND (%) fine	FINES (%) SILT (%)	FINES (%) CLAY (%)
●	0	49		44			6.8	

Sieve Size	Percent Finer ●		
1 1/2-inch	100		
1-inch	97		
3/4-inch	85		
1/2-inch	76		
3/8-inch	67		
#4	51		
#8	40		
#10	38		
#16	33		
#30	28		
#40	23		
#50	18		

Sieve Size	Percent Finer ●		
#60	15		
#80	11		
#100	10		
#200	6.8		

	Grain Size (mm) D_{60}	D_{30}	D_{10}	Coefficients C_c	C_u
●	7.0	0.78	0.15	0.58	47

	Sample Information
●	Boring SB-8, 83'-9" Depth: ***POORLY-GRADED GRAVEL WITH SILT AND SAND (GP-GM)*** — *fine to coarse grained, non-plastic to low plasticity fines, brown, wet, very dense relative density*

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LABORATORY TEST RESULT RECORD
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

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FIGURE 4

Appendix C

Table 7-1: Recommended Soil Design Parameters
Table 7-2: Deep Driven Pile Foundation Analyses' Results; *APILE* Static Analyses' Average Unfactored Soil Design Parameters
Table 7-3: Deep Driven Pile Foundation Analyses' Results; *APILE* Static and *GRLWEAP* Drivability Analyses' Results

Table 7-1: RECOMMENDED SOIL DESIGN PARAMETERS
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Elevation (feet)	Material Type	Estimated Soil Parameters* Moist Density, γ (pcf)	Estimated Soil Parameters* Angle of Internal Friction, Ø* (degrees)	Estimated Soil Parameters* Cohesion, c (psf)	Driven Pile Parameters Driving SSL** (%)	Driven Pile Parameters LRFD Factors***
	--------- Boring SB-7 located in the vicinity of South Abutment of Bridge Structure B-13-731 ---------					
889.0 to 887.7	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---
887.7 to 879.2	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---
879.2 to 870.2	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---
870.2 to 870.0	Replace existing dark brown LEAN CLAY WITH SAND (CL) FILL TOPSOIL with MSE Retaining Wall Backfill	120.0	30	0	---	---
870.0 to 868.9	Replace existing brown fine to coarse SILTY SAND WITH GRAVEL (SM) FILL with MSE Retaining Wall Backfill	120.0	30	0	---	---
868.9 to 867.4		120.0	31	0	---	---
867.4 to 867.2		120.0	31	0	33 [67]	0.45
867.2 to 867.0	***SANDY LEAN CLAY (CL)** — medium plasticity, brown, moist, medium consistency, **FILL***	125.0	0	800	50 [83]	0.35
867.0 to 866.2		125.0	0	800	50 [83]	0.35
866.2 to 865.7	***SILTY SAND WITH GRAVEL (SM)** — fine to coarse grained, non-plastic to low plasticity fines, brown, moist, very loose to loose relative density, **FILL***	120.0	31	0	33 [67]	0.45
865.7 to 859.2	***SILTY SAND WITH GRAVEL (SM)** — fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, wet, loose to very loose relative density, **GLACIAL TILL**, trace to some gravel*	152.0	29	0	33 [67]	0.45
859.2 to 853.2		152.0	29	0	33 [67]	0.45
853.2 to 848.2		152.0	31	0	33 [67]	0.45
848.2 to 838.2		152.0	29	0	33 [67]	0.45
838.2 to 830.7		152.0	29	0	33 [67]	0.45
830.7 to 823.2		152.0	29	0	33 [67]	0.45
823.2 to 813.2	***CLAYEY SAND WITH GRAVEL (SC)** — fine grained, medium plasticity fines, reddish-brown to light brown, wet, medium dense relative density, **GLACIAL TILL**, trace to some gravel*	146.0	31	0	33 [67]	0.45

Table Notes

* The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.
* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.
** The presented Driving SSL values from Table 11.3-4 of the WisDOT Bridge Manual are used for driven cast-in-place, steel pipe piles. The increased Driving SSL values shown in brackets ([]) are used for driven steel H-piles based on feedback from pile driving contractors.
*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

Table Abbreviations and Symbols

pcf = pounds per cubic foot.
SSL = soil strength loss.
psf = pounds per square foot.
NA = Not applicable.
Top = Cohesion @ top of stratum/sub-stratum.
Bot = Cohesion @ bottom of stratum/sub-stratum.

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Table 7-1: RECOMMENDED SOIL DESIGN PARAMETERS
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

		Estimated Soil Parameters*			Driven Pile Parameters	
Elevation (feet)	**Material Type**	**Moist Density, γ (pcf)**	**Angle of Internal Friction, Ø* (degrees)**	**Cohesion, c (psf)**	**Driving SSL** (%)**	**LRFD Factors*****
813.2 to 803.2	***SILTY SAND WITH GRAVEL (SM)*** *—fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, moist to wet, medium dense relative density,* ***GLACIAL TILL****, trace to some gravel*	152.0	32	0	33 [67]	0.45
803.2 to 800.7	***POORLY-GRADED SAND WITH GRAVEL (SP)*** *—fine grained, light grayish-brown and brown, wet, medium dense relative density*	125.0	31	0	17 [50]	0.45
800.7 to 798.2	***SANDY LEAN CLAY (CL)*** *— medium plasticity, grayish-brown, moist, hard to very stiff consistency*	132.0	0	3,800	50 [83]	0.35
798.2 to 788.2	***SILTY SAND WITH GRAVEL (SM)*** *—fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, moist, dense to very dense relative density,* ***GLACIAL TILL****, trace to some gravel, with few irregular gray CLAYEY SAND (SC) lenses*	152.0	34	0	33 [67]	0.45
788.2 to 783.2		152.0	38 [36]	0	33 [67]	0.45
783.2 to 774.2		152.0	45 [36]	0	17 [50]	0.45
774.2 to 771.1		152.0	45 [40]	0	17 [17]	0.45
	---------- End of Boring SB-7 @ Elevation 771.1 feet ----------					

Table Notes

* The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.

* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.

** The presented Driving SSL values from Table 11.3-4 of the WisDOT Bridge Manual are used for driven cast-in-place, steel pipe piles. The increased Driving SSL values shown in brackets ([]) are used for driven steel H-piles based on feedback from pile driving contractors.

*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

Table Abbreviations and Symbols

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SSL = soil strength loss.
psf = pounds per square foot.
NA = Not applicable.
Top = Cohesion @ top of stratum/sub-stratum.
Bot = Cohesion @ bottom of stratum/sub-stratum.

Table 7-1: RECOMMENDED SOIL DESIGN PARAMETERS
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Elevation (feet)	Material Type	Estimated Soil Parameters*: Moist Density, γ (pcf)	Estimated Soil Parameters*: Angle of Internal Friction, Ø* (degrees)	Estimated Soil Parameters*: Cohesion, c (psf)	Driven Pile Parameters: Driving SSL** (%)	Driven Pile Parameters: LRFD Factors***
--------- Boring SB-8 located in the vicinity of North Abutment of Bridge Structure B-13-731 ---------						
889.0 to 887.7	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---
887.7 to 879.7	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---
879.7 to 871.5	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---
871.5 to 870.9	Construct new embankment with MSE Retaining Wall Backfill	120.0	30	0	---	---
870.9 to 870.3	Replace existing dark brown LEAN CLAY WITH SAND (CL) FILL TOPSOIL with MSE Retaining Wall Backfill	120.0	30	0	---	---
870.3 to 868.0	Replace existing brown fine to medium SILTY SAND WITH GRAVEL (SM) GLACIAL TILL trace to some gravel with MSE Retaining Wall Backfill	120.0	30	0	---	---
868.0 to 867.0		152.0	30	0	33 [67]	0.45
867.0 to 858.9		152.0	30	0	33 [67]	0.45
858.9 to 848.9	***SILTY SAND WITH GRAVEL (SM)*** *—fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, wet, loose to medium dense relative density,* ***GLACIAL TILL****, trace to some gravel*	152.0	29	0	33 [67]	0.45
848.9 to 843.9		152.0	31	0	33 [67]	0.45
843.9 to 836.4		152.0	29	0	33 [67]	0.45
836.4 to 828.9		152.0	29	0	33 [67]	0.45
828.9 to 818.9		152.0	31	0	33 [67]	0.45
818.9 to 808.9		152.0	29	0	33 [67]	0.45
808.9 to 803.9		152.0	31	0	33 [67]	0.45
803.9 to 798.9	***SILTY CLAYEY SAND (SC-SM)*** *—fine grained, low plasticity fines, brown, moist, dense relative density,* ***GLACIAL TILL****, trace to some gravel*	146.0	35	0	33 [67]	0.45
798.9 to 788.9	***SILTY SAND WITH GRAVEL (SM)*** *—fine to medium grained, non-plastic to low plasticity fines, brown to reddish-brown, moist, very dense relative density,* ***GLACIAL TILL****, trace to some gravel*	152.0	42 [36]	0	33 [67]	0.45

Table Notes

* The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.

* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.

** The presented Driving SSL values from Table 11.3-4 of the WisDOT Bridge Manual are used for driven cast-in-place, steel pipe piles. The increased Driving SSL values shown in brackets ([]) are used for driven steel H-piles based on feedback from pile driving contractors.

*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

Table Abbreviations and Symbols

pcf = pounds per cubic foot. psf = pounds per square foot. Top = Cohesion @ top of stratum/sub-stratum. Bot = Cohesion @ bottom of stratum/sub-stratum.
SSL = soil strength loss. NA = Not applicable.

Table 7-1: RECOMMENDED SOIL DESIGN PARAMETERS
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Elevation (feet)	Material Type	Estimated Soil Parameters*			Driven Pile Parameters	
		Moist Density, γ (pcf)	Angle of Internal Friction, Ø* (degrees)	Cohesion, c (psf)	Driving SSL** (%)	LRFD Factors***
788.9 to 781.4	***POORLY-GRADED GRAVEL WITH SILT AND SAND (GP-GM)*** — *fine to coarse grained, non-plastic to low plasticity fines, brown, wet, very dense relative density*	120.0	45 [40]	0	0 [0]	0.45
	---------- End of Boring SB-8 @ Elevation 781.4 feet ----------					

Table Notes
* The Moist Density, Angle of Internal Friction, Cohesion, Driving SSL, and LRFD Static Resistance Factor values are considered estimates based on the soils encountered at the indicated boring.
* The computed Angle of Internal Friction, Ø, for each soil stratum or sub-stratum is presented. For driven pile computations, computed Øs greater than 36° are reduced to 36° or 40° depending upon the $N1_{60}$-value for the indicated stratum/sub-stratum. The reduced driven pile Øs are shown in brackets ([]). Please refer to geotechnical report for further explanation.
** The presented Driving SSL values from Table 11.3-4 of the WisDOT Bridge Manual are used for driven cast-in-place, steel pipe piles. The increased Driving SSL values shown in brackets ([]) are used for driven steel H-piles based on feedback from pile driving contractors.
*** LRFD Static Resistance Factors and LRFD Load Factors are presented in this column. The LRFD Static Resistance Factors from the WisDOT Bridge Manual Table 11.3-1 or Table 11.3-8 are presented. For soil strata contributing to downdrag, LRFD Load Factors from the AASHTO LRFD Bridge Design Specifications Table 3.4.1-2 are presented in brackets ([]). Please see report for further definition of the LRFD Factors presented.

Table Abbreviations and Symbols
pcf = pounds per cubic foot.
SSL = soil strength loss.
psf = pounds per square foot.
NA = Not applicable.
Top = Cohesion @ top of stratum/sub-stratum.
Bot = Cohesion @ bottom of stratum/sub-stratum.

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Table 7-2: DEEP PILE FOUNDATION ANALYSES' RESULTS
Static Analyses' Average Unfactored Soil Design Parameters
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Boring ==>	SB-7 located in the vicinity of South Abutment of Bridge Structure B-13-731				
Substructure Unit Foundation Bottom Elev ==>	887.7 feet	**Design Ultimate GWL Elev ==>**	867.0 feet	**Design Contraction Scour Elev ==>**	NA
Design Driving GS Elev ==>	867.4 feet	**Design Driving/Restrike GWL Elev ==>**	867.0 feet	**Design Local Scour Elev ==>**	NA
Design Ultimate GS Elev ==>	868.9 feet	**Design Pre-Boring Elev ==>**	NA		

Pile Type and Size ==>	10¾Ø CIP		HP 10x42											
Elevation (feet)	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**
889.0 to 887.7	0	0	0	0										
887.7 to 879.2	230	0	230	0										
879.2 to 870.2	460	0	460	0										
870.2 to 869.9	540	0	540	0										
869.9 to 868.9	590	0	590	0										
868.9 to 867.4	1,170	0	1,170	0										
867.4 to 867.2	70	4,100	90	3,800										
867.2 to 867.0	70	5,900	90	5,600										
867.0 to 866.2	70	5,700	100	5,900										
866.2 to 865.7	90	6,700	120	6,800										
865.7 to 859.2	140	10,300	190	10,300										
859.2 to 853.2	240	13,600	310	13,600										
853.2 to 848.2	390	19,600	510	19,400										
848.2 to 838.2	460	13,600	610	13,700										
838.2 to 830.7	620	13,300	830	13,300										
830.7 to 823.2	760	13,500	1,010	13,500										
823.2 to 813.2	1,080	20,500	1,410	20,500										
813.2 to 803.2	1,410	32,100	1,830	32,000										
803.2 to 800.7	1,420	24,800	1,860	25,400										
800.7 to 798.2	3,680	36,400	3,770	36,900										
798.2 to 788.2	2,050	72,800	2,630	72,800										
788.2 to 783.2	2,770	144,000	3,480	143,000										
783.2 to 774.2	3,010	157,000	3,780	158,000										

Table Abbreviations and Symbols
HP = Steel H-pile.
NA = Not applicable.
NR = Not recommended.
psf = pounds per square foot.
Ø CIP = -inch-outside-diameter, cast-in-place, steel pipe pile.
⌀ PCP = -inch-square, precast concrete pile.
Refusal = Steel pile will obtain capacity in indicated layer due to very dense soil or bedrock.
Elev = Elevation.
GS = Ground Surface.
GWL = Groundwater Level.

The **End Bearing & Skin Friction** values presented above are the computed unfactored average for the indicated stratum.

Printed on 4/10/2019

Table 7-2: DEEP PILE FOUNDATION ANALYSES' RESULTS
Static Analyses' Average Unfactored Soil Design Parameters
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Boring ==>	SB-7 located in the vicinity of South Abutment of Bridge Structure B-13-731				
Substructure Unit Foundation Bottom Elev ==>	887.7 feet	**Design Ultimate GWL Elev ==>**	867.0 feet	**Design Contraction Scour Elev ==>**	NA
Design Driving GS Elev ==>	867.4 feet	**Design Driving/Restrike GWL Elev ==>**	867.0 feet	**Design Local Scour Elev ==>**	NA
Design Ultimate GS Elev ==>	868.9 feet	**Design Pre-Boring Elev ==>**	NA		

Pile Type and Size ==>	10¾Ø CIP		HP 10x42											
Elevation (feet)	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**
774.2 to 771.1	4,730	371,000	5,760	365,000										

Table Abbreviations and Symbols
HP = Steel H-pile.
NA = Not applicable.
NR = Not recommended.
psf = pounds per square foot.

Ø CIP = -inch-outside-diameter, cast-in-place, steel pipe pile.
Ø PCP = -inch-square, precast concrete pile.
Refusal = Steel pile will obtain capacity in indicated layer due to very dense soil or bedrock.

Elev = Elevation.
GS = Ground Surface.
GWL = Groundwater Level.

The **End Bearing & Skin Friction** values presented above are the computed unfactored average for the indicated stratum.

Printed on 3/10/2019

Table 7-2: DEEP PILE FOUNDATION ANALYSES' RESULTS
Static Analyses' Average Unfactored Soil Design Parameters
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Boring ==>	SB-8 located in the vicinity of North Abutment of Bridge Structure B-13-731				
Substructure Unit Foundation Bottom Elev ==>	887.7 feet	**Design Ultimate GWL Elev ==>**	867.0 feet	**Design Contraction Scour Elev ==>**	NA
Design Driving GS Elev ==>	868.0 feet	**Design Driving/Restrike GWL Elev ==>**	867.0 feet	**Design Local Scour Elev ==>**	NA
Design Ultimate GS Elev ==>	871.5 feet	**Design Pre-Boring Elev ==>**	NA		

Pile Type and Size ==>	10¾Ø CIP		HP 10x42											
Elevation (feet)	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**	**Skin Friction (psf)**	**End Bearing (psf)**
889.0 to 887.7	0	0	0	0										
887.7 to 879.7	230	0	230	0										
879.7 to 871.5	450	0	450	0										
871.5 to 870.9	510	0	510	0										
870.9 to 870.3	530	0	530	0										
870.3 to 868.0	600	0	600	0										
868.0 to 867.0	10	1,000	10	900										
867.0 to 858.9	80	6,600	110	6,600										
858.9 to 848.9	250	13,400	330	13,500										
848.9 to 843.9	460	19,700	600	19,500										
843.9 to 836.4	500	13,600	670	13,700										
836.4 to 828.9	640	13,600	850	13,600										
828.9 to 818.9	940	20,100	1,230	20,100										
818.9 to 808.9	980	13,700	1,300	13,800										
808.9 to 803.9	1,320	23,400	1,730	23,700										
803.9 to 798.9	1,990	103,000	2,550	102,000										
798.9 to 788.9	2,510	156,000	3,150	157,000										
788.9 to 781.4	4,070	404,000	4,960	403,000										

Table Abbreviations and Symbols
HP = Steel H-pile.
NA = Not applicable.
NR = Not recommended.
psf = pounds per square foot.
Ø CIP = -inch-outside-diameter, cast-in-place, steel pipe pile.
Ø PCP = -inch-square, precast concrete pile.
Refusal = Steel pile will obtain capacity in indicated layer due to very dense soil or bedrock.
Elev = Elevation.
GS = Ground Surface.
GWL = Groundwater Level.

The **End Bearing** & **Skin Friction** values presented above are the computed unfactored average for the indicated stratum.

Printed on 4/10/2019

Table 7-3: DEEP DRIVEN PILE FOUNDATION ANALYSES' RESULTS
APILE Static and *GRLWEAP* Drivability Analyses' Results
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Boring ==> SB-7 located in the vicinity of South Abutment of Bridge Structure B-13-731

Substructure Unit Foundation Bottom Elev ==>	887.7 feet	**Design Ultimate GWL Elev ==>**	867.0 feet	**Design Contraction Scour Elev ==>**	NA
Design Driving GS Elev ==>	867.4 feet	**Design Driving/Restrike GWL Elev ==>**	867.0 feet	**Design Local Scour Elev ==>**	NA
Design Ultimate GS Elev ==>	868.9 feet	**Design Pre-Boring Elev ==>**	NA		

Pile Type and Size	WisDOT Maximum Rn_{dyn} (kips)	Design Steel Yield Stress (ksi)	Design Rn_{dyn} (kips)	Design P_r (kips)	Design Pile Tip Elevation* (feet)	Vertical Piles Driven to Design Rn_{dyn} At Time of Installation: Pile Driving Hammer	Pile Tip Elevation* (feet)	Pile Refusal** (Yes/No)	Soil Resistance During Driving* (kips)	Max Steel Stress During Driving* (ksi)	Ultimate Static Capacity*** (kips)
Factored Embankment Settlement Downdrag Load = 54 kips for 10¾Ø CIP.											
Per WBM Chapter 11.3.1.17.1, the Design P_r should be reduced by the Factored Embankment Settlement Downdrag Load for 10¾Ø CIP unless countermeasures are taken.											
10¾Ø CIP 0.250Ŧ	260	35	260	130	781.4	D16-32	783.4	Yes *Not recommended. Pile refused above the design pile tip elevation.*			
10¾Ø CIP 0.250Ŧ	260	35	260	130	781.4	D30-32	781.4	No	260	47.9 *Not recommended. Max Stress > 90% Yield Stress*	
10¾Ø CIP 0.250Ŧ	260	45†	260	130	781.4	D30-32	781.4	No	260	47.9 *Not recommended. Max Stress > 90% Yield Stress*	
10¾Ø CIP 0.365Ŧ	300	35	300	150	775.4	D16-32	775.4	Yes	300	31.6 *Not recommended. Max Stress > 90% Yield Stress*	
10¾Ø CIP 0.365Ŧ	300	45†	300	150	775.4	D16-32	775.4	Yes	300	31.6	407
10¾Ø CIP 0.500Ŧ	300	35	300	150	775.4	D16-32	775.4	No	300	29.2	407
10¾Ø CIP 0.500Ŧ	300	45†	300	150	775.4	D16-32	775.4	No	300	29.2	407
Factored Embankment Settlement Downdrag Load = 81 kips for 10x42 HP.											
Per WBM Chapter 11.3.1.17.1, the Design P_r should be reduced by the Factored Embankment Settlement Downdrag Load for 10x42 HP unless countermeasures are taken.											
10x42 HP	360	50	360	180	769.8	D16-32	769.8	No	360	29.9	712

Table Notes
* Elevation, Soil Resistance During Driving, and Max(imum) Steel Stress During Driving values are considered estimates based on the soils encountered at the indicated boring.
** Pile Refusal = Specified pile driving hammer is estimated to require more than 120 blows per foot to drive the indicated steel pile.
*** Ultimate Static Capacity is the estimated capacity using static analyses that the indicated pile could achieve after pile set-up. The Design Rn_{dyn} and Design P_r should be used for design.
‡ Pile driven through upper dense layer(s) to reach design pile tip elevation. Maximum Computed Driving Rn_{dyn} {shown within brackets} for the upper dense layer(s) is less than or equal to the WisDOT Maximum Rn_{dyn} for the indicated pile.
★ Pile Tip Elevation for indicated pile was controlled by recommended 10-foot minimum pile embedment below pre-bore depth.
† Per Mr. Jeff Horsfall with WisDOT, the use of steel with a yield stress of 45 ksi for the shell of CIP pipe piles is acceptable to WisDOT.
✘ Design P_r was reduced due to low strength soil strata below the Design Pile Tip Elevation or due to a Design Ultimate GS Elevation that is less than the Design Driving GS Elevation.

Table Abbreviations and Symbols
NA = Not applicable.
ksi = kips per square inch.
HP = Steel H-pile.
f'_c = ultimate concrete strength in ksi.
Ŧ = -inch wall thickness.
P_r = Factored Axial Compression Resistance.
Ø CIP = -inch-outside-diameter, cast-in-place, steel pipe pile.
Ø PCP = -inch-square, precast concrete pile.
Rn_{dyn} = Required Driving Resistance.

Printed on 4/10/2019

Table 7-3: DEEP DRIVEN PILE FOUNDATION ANALYSES' RESULTS
APILE Static and *GRLWEAP* Drivability Analyses' Results
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Boring ==>	SB-8 located in the vicinity of Pier of Roadway Structure B-13-731				
Substructure Unit Foundation Bottom Elev ==>	862.0 feet	**Design Ultimate GWL Elev ==>**	867.0 feet	**Design Contraction Scour Elev ==>**	NA
Design Driving GS Elev ==>	873.6 feet	**Design Driving/Restrike GWL Elev ==>**	867.0 feet	**Design Local Scour Elev ==>**	NA
Design Ultimate GS Elev ==>	873.6 feet	**Design Pre-Boring Elev ==>**	NA		

Pile Type and Size	WisDOT Maximum Rn_{dyn} (kips)	Design Steel Yield Stress (ksi)	Design Rn_{dyn} (kips)	Design P_r (kips)	Design Pile Tip Elevation* (feet)	Vertical Piles Driven to Design Rn_{dyn} At Time of Installation: Pile Driving Hammer	Pile Tip Elevation* (feet)	Pile Refusal** (Yes/No)	Soil Resistance During Driving* (kips)	Max Steel Stress During Driving* (ksi)	Ultimate Static Capacity*** (kips)
10¾Ø CIP 0.250Ŧ	260	35	260	130	790.2	D16-32	790.2	Yes	260	35.5 *Not recommended. Max Stress > 90% Yield Stress*	
10¾Ø CIP 0.250Ŧ	260	45†	260	130	790.2	D16-32	790.2	Yes	260	35.5	339
10¾Ø CIP 0.365Ŧ	300	35	300	150	789.4	D16-32	789.4	No	300	32.1 *Not recommended. Max Stress > 90% Yield Stress*	
10¾Ø CIP 0.365Ŧ	300	45†	300	150	789.4	D16-32	789.4	No	300	32.1	392
10¾Ø CIP 0.500Ŧ	300	35	300	150	789.4	D16-32	789.4	No	300	29.8	392
10¾Ø CIP 0.500Ŧ	300	45†	300	150	789.4	D16-32	789.4	No	300	29.8	392
10x42 HP	360	50	360	180	783.8	D16-32	783.8	No	360	30.1	619

Table Notes
* Elevation, Soil Resistance During Driving, and Max(imum) Steel Stress During Driving values are considered estimates based on the soils encountered at the indicated boring.
** Pile Refusal = Specified pile driving hammer is estimated to require more than 120 blows per foot to drive the indicated steel pile.
*** Ultimate Static Capacity is the estimated capacity using static analyses that the indicated pile could achieve after pile set-up. The Design Rn_{dyn} and Design P_r should be used for design.
‡ Pile driven through upper dense layer(s) to reach design pile tip elevation. Maximum Computed Driving Rn_{dyn} {shown within brackets} for the upper dense layer(s) is less than or equal to the WisDOT Maximum Rn_{dyn} for the indicated pile.
★ Pile Tip Elevation for indicated pile was controlled by recommended 10-foot minimum pile embedment below pre-bore depth.
† Per Mr. Jeff Horsfall with WisDOT, the use of steel with a yield stress of 45 ksi for the shell of CIP pipe piles is acceptable to WisDOT.
✖ Design P_r was reduced due to low strength soil strata below the Design Pile Tip Elevation or due to a Design Ultimate GS Elevation that is less than the Design Driving GS Elevation.

Table Abbreviations and Symbols
NA = Not applicable.
ksi = kips per square inch.
HP = Steel H-pile.
f'_c = ultimate concrete strength in ksi.
Ŧ = -inch wall thickness.
P_r = Factored Axial Compression Resistance.
Ø CIP = -inch-outside-diameter, cast-in-place, steel pipe pile.
⌀ PCP = -inch-square, precast concrete pile.
Rn_{dyn} = Required Driving Resistance.

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Table 7-3: DEEP DRIVEN PILE FOUNDATION ANALYSES' RESULTS
APILE Static and *GRLWEAP* Drivability Analyses' Results
IH-39 North Segment
IH-39/90 NB Bridge over NB Exit to USH-12/18 WB
Illinois State Line - Madison
USH-12/18 Interchange
Town of Blooming Grove, Dane County, Wisconsin
WisDOT State ID 1007-10-02/05

Boring ==>	SB-8 located in the vicinity of North Abutment of Bridge Structure B-13-731				
Substructure Unit Foundation Bottom Elev ==>	887.7 feet	**Design Ultimate GWL Elev ==>**	867.0 feet	**Design Contraction Scour Elev ==>**	NA
Design Driving GS Elev ==>	868.0 feet	**Design Driving/Restrike GWL Elev ==>**	867.0 feet	**Design Local Scour Elev ==>**	NA
Design Ultimate GS Elev ==>	871.5 feet	**Design Pre-Boring Elev ==>**	NA		

Pile Type and Size	WisDOT Maximum Rn_{dyn} (kips)	Design Steel Yield Stress (ksi)	Design Rn_{dyn} (kips)	Design P_r (kips)	Design Pile Tip Elevation* (feet)	Vertical Piles Driven to Design Rn_{dyn} At Time of Installation: Pile Driving Hammer	Pile Tip Elevation* (feet)	Pile Refusal** (Yes/No)	Soil Resistance During Driving* (kips)	Max Steel Stress During Driving* (ksi)	Ultimate Static Capacity*** (kips)
Factored Embankment Settlement Downdrag Load = 60 kips for 10¾Ø CIP.											
Per WBM Chapter 11.3.1.17.1, the Design P_r should be reduced by the Factored Embankment Settlement Downdrag Load for 10¾Ø CIP unless countermeasures are taken.											
10¾Ø CIP 0.250Ŧ	260	35	260	130	786.2	D16-32	786.2	No	260	31.6 *Not recommended. Max Stress > 90% Yield Stress*	
10¾Ø CIP 0.250Ŧ	260	45†	260	130	786.2	D16-32	786.2	No	260	31.6	355
10¾Ø CIP 0.365Ŧ	300	35	300	150	785.6	D16-32	785.6	No	300	32.0 *Not recommended. Max Stress > 90% Yield Stress*	
10¾Ø CIP 0.365Ŧ	300	45†	300	150	785.6	D16-32	785.6	No	300	32.0	397
10¾Ø CIP 0.500Ŧ	300	35	300	150	785.6	D16-32	785.6	No	300	29.6	397
10¾Ø CIP 0.500Ŧ	300	45†	300	150	785.6	D16-32	785.6	No	300	29.6	397
Factored Embankment Settlement Downdrag Load = 85 kips for 10x42 HP.											
Per WBM Chapter 11.3.1.17.1, the Design P_r should be reduced by the Factored Embankment Settlement Downdrag Load for 10x42 HP unless countermeasures are taken.											
10x42 HP	360	50	360	180	778.4	D16-32	778.4	No	360	30.2	613

Table Notes
* Elevation, Soil Resistance During Driving, and Max(imum) Steel Stress During Driving values are considered estimates based on the soils encountered at the indicated boring.
** Pile Refusal = Specified pile driving hammer is estimated to require more than 120 blows per foot to drive the indicated steel pile.
*** Ultimate Static Capacity is the estimated capacity using static analyses that the indicated pile could achieve after pile set-up. The Design Rn_{dyn} and Design P_r should be used for design.
‡ Pile driven through upper dense layer(s) to reach design pile tip elevation. Maximum Computed Driving Rn_{dyn} {shown within brackets} for the upper dense layer(s) is less than or equal to the WisDOT Maximum Rn_{dyn} for the indicated pile.
★ Pile Tip Elevation for indicated pile was controlled by recommended 10-foot minimum pile embedment below pre-bore depth.
† Per Mr. Jeff Horsfall with WisDOT, the use of steel with a yield stress of 45 ksi for the shell of CIP pipe piles is acceptable to WisDOT.
✖ Design P_r was reduced due to low strength soil strata below the Design Pile Tip Elevation or due to a Design Ultimate GS Elevation that is less than the Design Driving GS Elevation.

Table Abbreviations and Symbols
NA = Not applicable.
ksi = kips per square inch.
HP = Steel H-pile.
f'_c = ultimate concrete strength in ksi.
Ŧ = -inch wall thickness.
P_r = Factored Axial Compression Resistance.
Ø CIP = -inch-outside-diameter, cast-in-place, steel pipe pile.
⌀ PCP = -inch-square, precast concrete pile.
Rn_{dyn} = Required Driving Resistance.