Structural Geotechnical Report

IDOT PTB 204-001
Michigan City Road over I-94
Existing Bridge SN: 016-1068
Proposed Bridge SN: 016-8320
Cook County, Illinois

Prepared for

Illinois Department of Transportation (IDOT)
Contract Number: P-91-158-22

Project Design Engineer Team
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November 07, 2023

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Michigan City Road over I-94
Existing Bridge SN: 016-1068
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IDOT PTB 204-001

Dear Mr. Arif:

Attached is a copy of the Structural Geotechnical Report for the above referenced project. This report provides a brief description of the site investigation, site conditions, and foundation and construction recommendations for the above referenced project. The site investigation included advancing seven (7) soil borings to depths ranging from 60 to 110 feet. The foundation recommendations for the bridge include supporting the proposed abutments on driven piles and the piers on drilled shafts. MSE walls will also be constructed below each of the abutments.

Should you have any questions or require additional information, please call us at 630-994-2600.

Sincerely,

A. Alyousef

Abdulaziz Alyousef, E.I.T.
Staff Engineer

Dawn Edgell.

Dawn Edgell, P.E.
Sr. Project Engineer

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1.0 INTRODUCTION

GSG Consultants, Inc. (GSG) completed a geotechnical investigation for the replacement of the Michigan City Road bridge over I-94 in Cook County, Illinois. The purpose of the investigation was to explore the subsurface conditions, to determine engineering properties of the subsurface soil, and to develop design and construction recommendations for the project. The general project limits are shown in **Exhibit 1**.

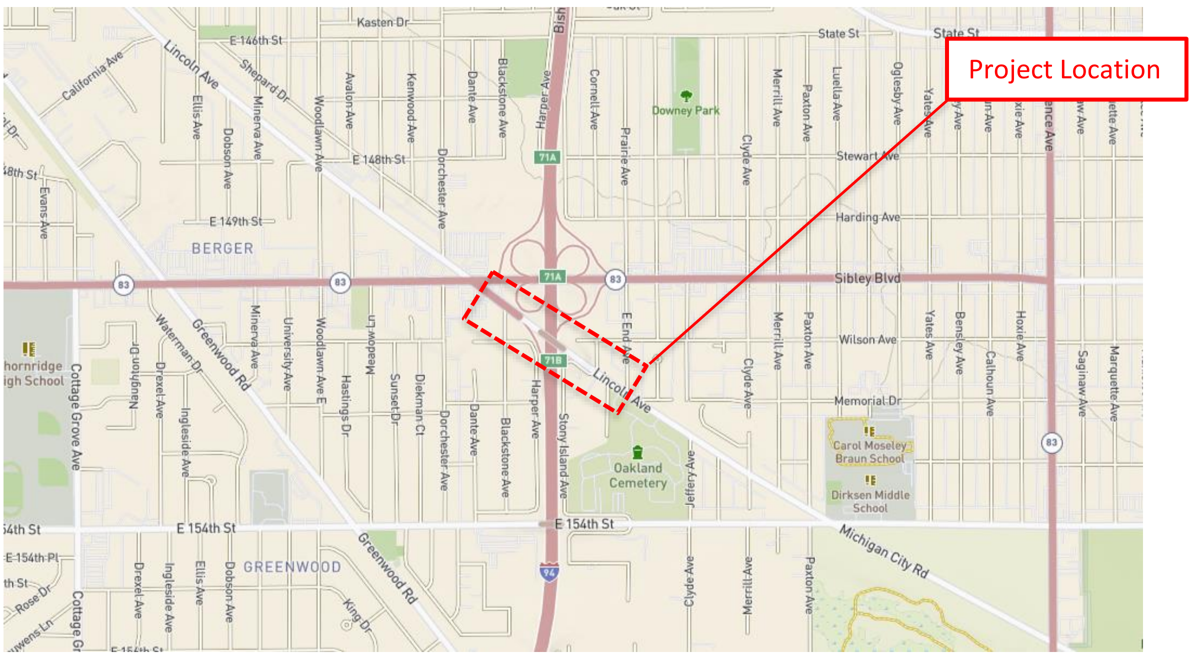


Exhibit 1 – Project Location Map
(Source: USGS Topographic Maps, usgs.gov)

1.1 Existing Bridge Information

The existing Michigan City Road bridge (SN: 016-1068) over I-94 is a 70-year-old, four-span steel beam bridge. The length of the bridge from back-to-back of the abutments is 277'-8 3/4". The out-to-out deck width of the bridge is approximately 64 feet. The entire structure is proposed to be removed and replaced. **Exhibits 2a and 2b** show the existing Michigan City Road Bridge. There is an existing sewer in the median of I-94 of the southbound road.

Exhibit 2a – Existing Site Conditions at Proposed Bridge Location Looking North

Exhibit 2b – Existing Site Conditions at Proposed Bridge Location Looking South

1.2 Proposed Bridge Information

Based on the design information and drawings provided by Delta Engineering Group, LLC. (dated 9/12/2023, Appendix A), the existing Michigan City Road over I-94 bridge will be fully reconstructed with a new two-span continuous composite steel bridge (SN: 016-8320) with a center pier and integral abutments with wrap around MSE walls at each end. It is anticipated that the new abutments will be supported on new driven piles. The center pier will be supported on drilled shafts to avoid the existing sewer below I-94. The new bridge will have a total back-to-back abutment length of 220’-0’’ and out-to-out width of 73’-0”. New MSE walls will be constructed below each of the abutments.

2.0 SITE SUBSURFACE CONDITIONS

This section describes the subsurface exploration program and laboratory testing program completed as part of this project. The proposed locations and depths of the soil borings were selected in accordance with IDOT requirements. The borings were completed in the field based on field conditions and accessibility.

2.1 Subsurface Exploration Program

The subsurface exploration program for the borings was conducted between July 23 and October 26, 2023, and included advancing seven (7) standard penetration test (SPT) borings at the proposed bridge foundation locations. Five (5) borings were completed at the proposed abutments and two (2) borings at the proposed center pier. The borings were completed per IDOT requirements, to meet 500 kips capacity or the top of bedrock, which was encountered at depths of 85 to 106 feet (El. 506.0 to 510.0 feet).

The coordinates and existing ground surface elevations shown on the soil boring logs were obtained by GSG's field crew using GPS surveying equipment and available google earth information. The as-drilled locations of the soil borings are shown on the Soil Boring Location Map and Subsurface Profile (**Appendix B**). **Table 1** presents a list of the borings completed. Copies of the Soil Boring Logs are provided in **Appendix C**.

Table 1 – Summary of Subsurface Exploration Borings

Boring ID	Location	Station[1]	Offset (ft)/ Direction	Depth (ft)	Surface Elevation (ft)
BSB-01	West Abutment	397+96.00	8.9 RT	110.0	614.5
BSB-02	West Abutment	399+00.00	42.0 LT	93.5	595.0
BSB-03	Center Pier	400+48.00	51.0 RT	97.0	596.0
BSB-04	Center Pier	399+69.68	43.0 LT	80.0	596.0
BSB-05	East Abutment	400+90.70	40.0 RT	60.0	595.0
BSB-06	East Abutment	401+77.00	14.6 RT	108.5	614.0
BSB-06A	East Abutment	401+71.66	26.6 LT	80.0	614.0

1 Based on proposed Michigan City Road Stationing.

The soil borings were drilled using truck-mounted Diedrich D-50 (hammer efficiency 99.5%), B-57 Mobile (hammer efficiency 89.0%), and CME-75 (hammer efficiency 79.8%) drill rigs, each equipped with 3¼-inch I.D. hollow stem augers and an automatic hammer. Soil sampling was performed according to AASHTO T 206, "Penetration Test and Split Barrel Sampling of Soils." Soil samples were obtained at 2.5-foot intervals to a depth of 30 feet below existing grade, and at 5-foot intervals thereafter until reaching auger refusal. Water level measurements were made in each boring when evidence of free groundwater was detected on the drill rods or in the samples. The boreholes were also checked for free water immediately after auger removal, and before filling the open boreholes with soil cuttings and surface patching with asphalt.

GSG's field representative inspected, visually classified, and logged the soil samples during the subsurface exploration activities and performed unconfined compressive strength tests on cohesive soil samples using a calibrated Rimac compression tester and a calibrated hand penetrometer in accordance with IDOT procedures and requirements. Representative soil samples collected from each sample interval, were placed in jars, and returned to the laboratory for further testing and evaluation.

2.4 Laboratory Testing Program

All samples were inspected in the laboratory to verify the field classifications. A laboratory testing program was undertaken to characterize and determine engineering properties of the subsurface soils encountered. The following laboratory tests were performed on representative soil samples:

- Moisture content ASTM D2216 / AASHTO T-265
- Atterberg Limits ASTM D4318 / AASHTO T-89 / AASHTO T-90
- Particle-Size Analysis of Soils – ASTM D422/ AASHTO T-88

The laboratory tests were performed in accordance with test procedures outlined in the most current IDOT Geotechnical Manual, and per ASTM and AASHTO requirements. Based on the laboratory test results, the soils encountered were classified according to the AASHTO and the Illinois Division of Highways (IDH) classification systems. The results of the laboratory testing program are included in the Laboratory Test Results **(Appendix D)** and are also shown along with the field test results in the Soil Boring Logs **(Appendix C)**.

2.5 Subsurface Soil Conditions

This section provides a brief description of the soils encountered in the borings performed in the vicinity of the proposed bridge. Detailed descriptions of the subsurface soils are provided in the Soil Boring Logs (**Appendix C**). The soil boring logs provide specific conditions encountered at each boring location, including soil descriptions, stratifications, penetration resistance, elevations, location of the samples, water levels (when encountered), and laboratory test data. Variations in the general subsurface soil profile were noted during the drilling activities. The stratifications shown on the boring logs represent the conditions only at the actual boring locations and represent the approximate boundary between subsurface materials; however, the actual transition may be gradual.

Borings BSB-01, BSB-06, and BSB-06A were drilled through the existing pavement and embankment for Michigan City Road with a surface elevation of 614 feet. The remaining borings were drilled on the shoulders of I-94 and had surface elevations ranging between 595 and 596 feet. Initially, borings BSB-01, BSB-06 and BSB-06A noted 10 inches of concrete. Borings BSB-02 and BSB-05 noted 14 to 15 inches of asphalt. Borings BSB-03 and BSB-04 noted 3 to 5 inches of asphalt over 9 to 10 inches of concrete. Borings BSB-01 and BSB-06A encountered 2 and 8 inches of aggregate subbase, respectively, below the concrete pavement.

Beneath the pavement section, the borings noted existing sand fill soils extending to depths between 11 and 16 feet (El. 598.0 and 603.0 feet) for borings BSB-01, BSB-06, and BSB-06A, and to 3.5 feet (El. 592.5 feet) for the remaining borings. Beneath the existing fill soils, the borings encountered loose to dense brown sand extending to depths of 6.0 and 24.0 feet (El. 589.0 to 592.5 feet). Medium stiff to very hard gray silty clay was then encountered to the termination depth of the borings; at which point highly weathered rock was encountered in borings BSB-02, BSB-03 and BSB-06. Layers of medium dense to very dense silty loam were encountered in borings BSB-01, BSB-02, BSB-04, and BSB-05 at various depths. Borings BSB-02, BSB-06, and BSB-06A encountered a hard silty clay loam layer at depths of 65.0, 68.5 and 73.5 feet, respectively. Boring BSB-06A noted a gray sand layer at a depth of 21 to 23.5 feet. Borings BSB-02, BSB-03, and BSB-06 encountered auger refusal in the weathered bedrock at depths of 93.5 to 108.5 feet (elevations 499 to 505.5 feet). Boring BSB-03 encountered cobbles at a depth of 58.8 to 60 feet, and rock fragments at 74.5 feet. Boring BSB-06A encountered rock fragments at a depth of 78.5 feet.

The native sand soil has an SPT blow count (N) values ranging from 6 to 36 blows per foot (bpf) with an average value of 19 bpf. The upper native gray silty clay had unconfined compressive strengths ranging from 0.8 to 6.0 tsf with most values over 2.5 tsf and an average strength of 3.0 tsf. The lower gray silty clay, below depths of about 43.5 to 48.5 feet, had unconfined compressive strengths ranging from 1.3 to 10.8 tsf, with an average strength of 6.4 tsf. The native gray silty loam had an SPT blow count (N) values ranging from 16 to 89 bpf with an average of 49 bpf. The native gray silty clay loam had an unconfined compressive strength of 4.5 and 10.8 tsf.

2.7 Groundwater Conditions

Water levels were checked in each boring to determine the general groundwater conditions present at the site and were measured while drilling and after each boring was completed. Mud rotary drilling techniques were utilized in the borings beginning at depths of 10 to 30 feet below grade. Groundwater was encountered in borings BSB-06 and BSB-6A at depths of 18.5 and 23.5 feet, respectively. Groundwater was not encountered prior to beginning mud rotary drilling and was obscured below these depths for the remaining borings. The borings were not left open for delayed readings and were backfilled upon completion.

Based on the color change from brown and gray to gray, it is anticipated that the long-term groundwater level could range between elevations 589.0 to 592.5 feet. Perched water may be present within the existing fill materials. Water level readings were made in the boreholes at times and under conditions shown on the boring logs and stated in the text of this report. However, it should be noted that fluctuations in groundwater level may occur due to variations in rainfall, other climatic conditions, or other factors not evident at the time measurements were made and reported herein.

3.0 GEOTECHNICAL ANALYSES

This section provides GSG's geotechnical analysis and recommendations for the design of the proposed bridge based on the results of the field exploration, laboratory testing, and geotechnical analysis. Subsurface conditions in unexplored locations may vary from those encountered at the boring locations. If structure locations, loadings, or elevations are changed, we request that GSG be contacted so that we may re-evaluate our recommendations.

3.1 Scour

The bridge structure carrying Michigan City Road over I-94 has no waterways in the vicinity; therefore, scour will not be a concern for this project.

3.2 Abutment Settlement

It is understood that the existing Michigan City Road Bridge over I-94 will be fully reconstructed and will require adding new engineered fill to raise the bridge elevation and construct the new east and west MSE walls, respectively. Based on the provide drawings (Appendix A), the average thickness of new fill behind the wall is approximately 10 feet.

An analysis was performed to evaluate the anticipated total settlement due to the new embankment construction for the alignment. Immediate settlement for cohesionless soils can typically occur during the filling operations, while the consolidation settlement for cohesive soils generally occurs over a longer period of time. The maximum estimated total settlements within the native soils were calculated as shown in **Table 2** where 90% of the total settlement is estimated to be completed within 12 to 18 months. The settlement values provided in **Table 2** do not include any potential settlement of the new constructed embankment materials as it is assumed the new embankment will be compacted and constructed per IDOT specifications.

Table 2 – Anticipated Abutment Fill Settlement

Location	Nearest Boring	Embankment				Anticipated Total Settlement (inches)
		Width (feet)	Length (feet)	Total Height (feet)	Bottom of wall Elevation (ft)	
West Abutment	BSB-02	18.0	72	24.75	591.5	0.57
East Abutment	BSB-05	18.0	72	24.5	591.5	0.55

Based on the general nature of the cohesive soils encountered below the proposed abutments and MSE walls, the estimated settlement from the new fill could be approximately 0.57 inches for the west abutment and 0.55 inches for the east abutment.

3.3 Slope Stability

The bridge will be supported on a deep foundation system that will be designed to support the substructure against lateral and slope failure. Therefore, there are no slope stability concerns anticipated for the bridge structure.

3.4 Seismic Parameters

The seismic hazard for the site was analyzed per the IDOT Geotechnical Manual, IDOT Bridge Design Manual, and AASHTO LRFD Bridge Design Specifications. The Seismic Soil Site Class was determined per the requirements of "All Geotechnical Manual Users" (AGMU) Memo 9.1, Design Guide for Seismic Site Class Determination, and the "Seismic Site Class Determination" Excel spreadsheet provided by IDOT. A global Site Class Definition was determined for this project, and was found to be Soil Site Class D. The Seismic Performance Zone (SPZ) was determined using Figure 2.3.10-2 in the IDOT Bridge Manual and was found to be Seismic Performance Zone 1.

The AASHTO Seismic Design Parameters program was used to determine the peak ground acceleration coefficient (PGA), and the short (S_{DS}) and long (S_{D1}) period design spectral acceleration coefficients for each of the proposed structures. For this section of the project, the S_{DS} and the S_{D1} were determined using 2020 AASHTO Guide Specifications as shown in **Table 3**. Given the site location and materials encountered, the potential for liquefaction is minimal.

Table 3 – Seismic Parameters

Building Code Reference	**PGA**	**S_{DS}**	**S_{D1}**
2020 AASHTO Guide for LRFD Seismic Bridge Design	0.043g	0.151g	0.09g

4.0 GEOTECHNICAL BRIDGE DESIGN RECOMMENDATIONS

The foundations for the proposed bridge must provide sufficient support to resist dead and live loads, as well as seismic loading. The foundation design recommendations presented within this section were completed per the AASHTO LRFD 9th Edition (2020). The preliminary total loads for the center bridge pier were provided by Delta as shown in **Table 4**.

Table 4 – Preliminary Total Loads – Center Pier

	Unfactored (kips)	Factored (kips)
Dead Load	2,271	2,947
Live Load	1,370	2,398
Pier Weight	700	875
Total	4,341	6,220

4.1 Bridge Foundation Recommendations

GSG evaluated potential foundation systems for the proposed bridge. GSG's evaluation included shallow spread footings, drilled shafts, and driven piles. The results of the evaluation are presented below.

4.2 Shallow Foundations

Based on the soils encountered, the new span length and the anticipated loads, shallow foundations are not anticipated to be a feasible option for the proposed substructure of the bridge. We anticipate that shallow foundations will undergo excessive settlement, or the size of the footings will be very large, and therefore will not be a feasible option and are not discussed further in the report.

4.3 Drilled Shafts

Drilled shafts are generally not recommended for integral abutments because they do not have the lateral flexibility necessary to accommodate the thermal movements for integral abutments. However, drilled shafts could be considered to support the central pier. Boring BSB-03 and BSB-04 were completed for the center pier of the Michigan City Road Bridge at an elevation of 596 feet. Boring BSB-03 encountered hard to very hard gray silty clay at an elevation of 550.0 feet extending to a depth of 499.0 feet; at which point highly weathered rock was encountered.

Boring BSB-04 encountered hard to very hard silty clay at an elevation of 557.0, dense to extremely dense gray silty loam at an elevation of 537.0 feet, and hard silty clay at 517.0 feet extending to the boring termination depth at 515.0 feet. Based on the anticipated bridge loading, drilled shafts could be extended to a minimum depth of 40 feet for the bridge pier. Design recommendations for drilled shafts are provided in *Section 4.5* of this report.

4.4 Drilled Shaft Design Recommendation

Drilled shafts are considered a feasible foundation option for the proposed center pier locations. The drilled shafts could be supported on the very hard silty clay soils encountered at a depth of 45 feet (el. 551.0 feet) below existing grade or upon weathered bedrock at an approximate depth of 90 feet (el. 506.0 feet) below existing grade. Drilled shafts should be designed in accordance with the design parameters provided in **Tables 5a and 5b**.

Table 5a – Drilled Shaft End Bearing Parameters

Bearing Elevation Depth (ft)	Soil Description	Nominal Tip Resistance (ksf)	Resistance Factor ϕ	Factored Tip Resistance (ksf)
551	Hard Gray Silty Clay	58.5	0.4	23.4
506	Weathered Bedrock	75.5	0.5	37.7

Table 5b – Drilled Shaft Side Resistance Parameters

Elevation Range (ft)	Soil Description	Nominal Side Resistance (ksf)	Side Resistance Factor ϕ	Factored Side Resistance (ksf)
593-590	Medium Dense Light Brown Sand	0.72	0.55	0.40
590-556	Very Stiff Gray Silty Clay	1.43	0.45	0.64
556-506	Hard Gray Silty Clay	2.56	0.45	1.15

We recommend designing the drilled shaft using a minimum diameter of at least 36”, and that the drilled shafts be installed with a minimum center-to-center spacing of at least 3 shaft diameters, because drilling the shafts at close spacing can reduce the total resistance of the drilled shafts.

If the drilled shafts extend into the silty loam soils encountered in BSB-04 below depths of 55 feet, then the drilled shafts should be straight shaft, with no bell. Geotechnical losses due to downdrag were not included in the drilled shaft calculations. A protective casing may also be required for any shafts extending through the silty loam materials. Construction of drilled shafts should be following the recommendations in Section 6.4.

4.5 Driven Pile Foundations

Piles considered for this site include metal shell piles, concrete piles, and H-piles. Concrete piles are not recommended for this site because the pile lengths cannot be readily adjusted to accommodate variability in soil conditions. Metal shell piles and H-piles are a feasible option for the construction of the abutments and center piers for the proposed bridge structures. Design recommendations for driven piles are provided in *Section 4.6* of this report.

4.6 Driven Pile Foundation Design Recommendation

The Modified IDOT static method-excel spreadsheet was used to estimate the pile lengths at various axial geotechnical resistances for driven piles per IDOT AGMU Memo 10.2. The factored resistance includes a reduction of 0.55 for the geotechnical resistance for the pile installation. The geotechnical losses due to down drag or liquefaction were not included in the axial pile resistance calculations.

Due to the MSE wall construction below the abutments, the top of the pile foundations for the abutments will extend through new embankment materials which will require corrugated steel pipes to be installed within the wall select backfill. The steel pipes may be filled full-depth with clean sand.

According to AASHTO Section 3.11.8-Downdrag, the pile should be designed to resist the downdrag if the ground settlement is 0.4 inches or greater. The nominal geotechnical resistance available to resist the structure load plus the downdrag load is estimated by considering only the positive side resistance and tip resistance below the lowest layer contributing to the downdrag. Based on the proposed fill heights at the bridge abutments, it is anticipated that settlement will be greater than 0.4 inches; therefore, downdrag will be discussed further in this report.

4.7 Pile Design with Downdrag

This section presents pile design recommendations including the effect of downdrag due to the downward movement of the soil relative to the piles if the new embankment in the area of the bridge and approach is constructed after pile installation. According to AASHTO Section 3.11.8- Downdrag, the pile should be designed to resist the downdrag if the ground settlement is 0.4 inches or greater. For the purpose of this report about 9.5 feet of downdrag was estimated. The nominal geotechnical resistance available to resist the structure load plus the downdrag load is estimated by considering only the positive side resistance and tip resistance below the lowest layer contributing to the downdrag.

Tables 6a and 6b summarize the estimated maximum pile lengths for representative pile sections along with the factored resistance available for the piles that are feasible for the proposed substructures. The complete IDOT Pile Design Tables, including factored resistance available (RF) and nominal required bearing (R_N), are included in **Appendix E**.

The estimated pile lengths shown in **Table 6a and 6b** and in **Appendix E** are based on the pile cut off elevations estimated from the preliminary plans and noted below each table. The actual pile length and resistance should be evaluated based on test piles installed in accordance with the specifications provided in Section 512.15 of IDOT Standard Specifications for Road and Bridge Construction. Per section 3.10.1.11 of the IDOT Bridge Manual (2023), the minimum pile spacing should be 3 pile diameters, and the maximum pile spacing should not be more than 3.5 times the effective footing thickness plus one foot, not to exceed a total of 8 feet.

Table 6a – West Abutment Pile Design (BSB-02) – with Downdrag

Pile Section	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (FT)	Pile End Bearing Stratum
Metal Shell 14’’ Φ w/0.25’’ walls (Max. R_N = 459 Kips)	267	60	44	Very Stiff Silty Clay
	338	99	49	Hard Silty Clay
	447	159	54	Hard Silty Clay
Metal Shell 16’’ Φ w/0.312’’ walls (Max. R_N = 654 Kips)	313	73	44	Very Stiff Silty Clay
	397	119	49	Hard Silty Clay
	529	192	54	Hard Silty Clay
HP10x42 (Max. R_N = 335 Kips)	204	72	49	Hard Silty Clay
	264	105	59	Very Hard Silty Clay
	281	114	64	Hard Silty Clay
HP12x53 (Max. R_N = 418 Kips)	258	93	49	Hard Silty Clay
	328	132	59	Very Hard Silty Clay
	350	144	64	Hard Silty Clay
HP14x73 (Max. R_N = 578 Kips)	537	238	84	Hard Silty Clay
	552	246	89	Hard Silty Clay
	567	254	94	Hard Silty Clay

NOTES:
Pile cut off elevation = 609.3 feet (preliminary TS&L)
Ground surface elevation against pile during driving = 591.5 feet (preliminary TS&L)
Downdrag influence to elevation 582 feet

Table 6b – East Abutment Pile Design (BSB-06) – with Downdrag

Pile Section	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (FT)	Pile End Bearing Stratum
Metal Shell 14'' Φ w/0.25'' walls (Max. R_N = 459 Kips)	220	5	41	Stiff Silty Clay
	289	43	46	Very Stiff Silty Clay
	358	81	51	Hard Silty Clay
Metal Shell 16'' Φ w/0.312'' walls (Max. R_N = 654 Kips)	258	9	41	Stiff Silty Clay
	340	55	46	Very Stiff Silty Clay
	420	99	51	Hard Silty Clay
HP10x42 (Max. R_N = 335 Kips)	254	73	56	Hard Silty Clay
	275	85	61	Very Stiff Silty Clay
	277	86	71	Hard Silty Clay
HP12x53 (Max. R_N = 418 Kips)	281	75	51	Hard Silty Clay
	319	95	56	Hard Silty Clay
	340	107	71	Hard Silty Clay
HP14x73 (Max. R_N = 578 Kips)	546	206	86	Hard Silty Clay
	561	214	91	Hard Silty Clay
	576	222	96	Extremely Dense Silty Loam

NOTES:
Pile cut off elevation = 610.07 feet (preliminary TS&L)
Ground surface elevation against pile during driving = 591.5 feet (preliminary TS&L)
Downdrag influence to elevation 582 feet

4.8 Pile Design with Downdrag Mitigation (Precore)

This section presents pile design recommendations including the effect of downdrag induced due to the downward movement of the soil relative to the piles if the embankment is constructed after pile installation. According to AASHTO Section 3.11.8-Downdrag, the pile should be designed to resist the downdrag if the ground settlement is 0.4 inches or greater. The nominal geotechnical resistance available to resist the structure load plus the downdrag load is estimated by considering only the positive side resistance and tip resistance below the lowest layer contributing to the downdrag. Based on the subsurface profile, the soil layer below the depth where the settlement is less than 0.4 inches can be considered relatively incompressible, where no downdrag will occur. This depth is anticipated at an elevation of 582 feet for both abutments. GSG utilized the Modified IDOT static method-excel spreadsheet to estimate the pile resistance with this downdrag load applied. It was found that only the H piles with largest sections can provide a certain amount of resistance when the pile bears on bedrock, below 200 kips. This will likely lead to an uneconomically long pile length, large pile numbers and pile sections. Therefore, it is recommended to mitigate the downdrag influence.

There are several mitigation measures to resist the downdrag forces for driven piles. This includes soil surcharging and preloading, ground improvement, increasing the pile section, using a larger pile diameter, increasing the number of piles, restrike piles after primary settlement completes and precoring. Soil preloading and surcharging or ground improvement are not viable options due to the existing site conditions. Although restriking the pile after primary settlement completes can regain the side resistance within the downdrag influence depth, it has similar scheduling concerns as the preloading option, and it is uncertain how much the resistance can be regained or included in the design. Therefore, the preferred alternative is to precore the pile location to the depth where settlement will be less than 0.4 inches to eliminate the downdrag effects. This is anticipated at a depth of 582 feet for both abutments. Considering the potential caving at depth when encountering sandy/silty soils, pile sleeves or temporary casing could be used to keep the precored hole open. The void between the plie sleeves/ casing and the piles should be filled with clean sand below the elevation at the bottom of the MSE wall. The advantage of this process includes the reduction or elimination of downdrag forces; disadvantages include increased costs, construction time and longer pile lengths.

GSG utilized the Modified IDOT static method-excel spreadsheet to estimate the pile lengths at various axial geotechnical resistances for driven piles with precoring per IDOT AGMU Memo 10.2. Precoring was simulated in the design by removing the soil within the precored depth in the spreadsheet. No additional geotechnical losses due to downdrag or liquefaction were included in the axial pile resistance calculations.

Tables 7a through 7b summarizes the estimated maximum pile lengths for representative pile sections along with the factored resistance available for piles that are feasible for the proposed substructures.

Due to the MSE wall construction below the abutments and new embankment below the approach slabs, the top of the pile foundations for the abutments will extend through new embankment materials. According to ABD Memo 19.8, pile sleeves of either corrugated metal pipe shall be placed around each pile, for the full height of the MSE select backfill. The void between the pile and the pile sleeve shall be filled with sand within the MSE wall height. The estimated pile lengths for the proposed abutments shown in **Tables 7a and 7b** include the length of pile within this pipe, as necessary.

The estimated pile lengths shown in **Tables 7a** and **7b** and in Appendix E are based on the pile cut off elevations shown on the preliminary TSL and noted below each table. The actual pile length and resistance should be evaluated based on test piles installed in accordance with the specifications provided in Section 512.15 of IDOT Standard Specifications for Road and Bridge Construction. Per section 3.10.1.11 of the IDOT Bridge Manual (2023), the minimum pile spacing should be 3 pile diameters, and the maximum pile spacing should not be more than 3.5 times the effective footing thickness plus one foot, not to exceed a total of 8 feet.

Table 7a – West Abutment Pile Design (BSB-02) – with Precore to 582 feet

Pile Section	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (FT)	Pile End Bearing Stratum
Metal Shell 14'' Φ w/0.25'' walls (Max. R_N = 459 Kips)	215	118	44	Very Stiff Silty Clay
	286	157	49	Hard Silty Clay
	394	217	54	Hard Silty Clay
Metal Shell 16'' Φ w/0.312'' walls (Max. R_N = 654 Kips)	337	185	49	Very Stiff Silty Clay
	469	258	54	Hard Silty Clay
	614	338	59	Hard Silty Clay
HP10x42 (Max. R_N = 335 Kips)	312	172	69	Hard Silty Clay
	315	173	79	Very Hard Silty Clay
	326	179	84	Hard Silty Clay
HP12x53 (Max. R_N = 418 Kips)	386	213	69	Hard Silty Clay
	394	217	79	Very Hard Silty Clay
	407	224	84	Hard Silty Clay
HP14x73 (Max. R_N = 578 Kips)	517	284	89	Hard Silty Clay
	532	293	94	Hard Silty Clay
	544	299	98	Hard Silty Clay

NOTES:
Pile cut off elevation = 609.3 feet (preliminary TS&L)

Ground surface elevation against pile during driving = 591.5 feet (preliminary TS&L)
Precore to 582.0 feet

Table 7b – East Abutment Pile Design (BSB-06) – with Precore to 582.0 feet

Pile Section	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (FT)	Pile End Bearing Stratum
Metal Shell 14'' Φ w/0.25'' walls (Max. R_N = 459 Kips)	134	74	41	Stiff Silty Clay
	203	112	46	Very Stiff Silty Clay
	272	150	51	Hard Silty Clay
Metal Shell 16'' Φ w/0.312'' walls (Max. R_N = 654 Kips)	242	133	46	Very Stiff Silty Clay
	323	177	51	Hard Silty Clay
	582	320	56	Hard Silty Clay
HP10x42 (Max. R_N = 335 Kips)	308	169	86	Hard Silty Clay
	318	175	91	Hard Silty Clay
	329	181	96	Extremely Dense Silty Loam
HP12x53 (Max. R_N = 418 Kips)	385	212	86	Hard Silty Clay
	398	219	91	Hard Silty Clay
	410	226	96	Extremely Dense Silty Loam
HP14x73 (Max. R_N = 578 Kips)	506	278	96	Extremely Dense Silty Loam
	567	312	102	Extremely Dense Silty Loam
	578	318	105	Weathered Bedrock

NOTES:
Pile cut off elevation = 610.07 feet (preliminary TS&L)
Ground surface elevation against pile during driving = 591.5 feet (preliminary TS&L)
Precore to 582.0 feet

4.9 Pile Driving Considerations

The subsurface conditions appear to be consistent throughout the soil boring locations. The soil borings were completed within the proposed substructure locations. Therefore, the subsurface soil conditions during the pile driving would be fairly predictable. Based on the general consistency of the soils for the abutments, test piles should be considered at alternating substructure locations.

Driving shoes for the piles, in accordance with Section 1006.05 (e) of the IDOT Standard Specifications for Road and Bridge Construction (SSRBC), should be considered if the piles are to be driven through cobbles or dense to very dense sand and gravel. For metal shell piles, a wall thickness of 0.25” or greater is recommended to minimize potential damage during driving with a conical tip welded to the pile to avoid abrupt overstress.

Pile setup is a consideration that can contribute to an increase to long-term pile resistance of displacement piles (i.e. driven pile). This increase in resistance is referred to as pile setup which is the gain in pile resistance over time that occurs mainly due to dissipation of pore water pressures and healing of the distorted and remolded soils immediately surrounding the pile. The magnitude of soil setup is function of pile type as well as soil type and consistency. A greater magnitude of soil setup is generally expected for soft clays, dense granular deposits, and displacement type piles than for stiff clays, loose granular deposits, and non-displacement type piles. However, pile setup consideration should not be included in the pile resistance during the design phase of the project, but this may be considered during the construction phase if a pile does not achieve the required bearing during installation. Based on the subsurface soil conditions, we do not anticipate any setup for the driven piles.

4.10 Lateral Load Resistance

Lateral loadings applied to pile foundations are typically resisted by battering selected piles, the soil/structure interaction, pile flexure, or a combination of these factors. Section 3.10.1.10 of the 2023 IDOT Bridge Manual requires performing detailed structure interaction analysis if the factored lateral loading per pile exceeds 3 kips. The analysis shall determine actual pile moment and deflection to determine the selected pile adequacy for the proposed loadings. **Table F-1** in **Appendix F** provides generalized soil parameters for the entire site and includes recommended lateral soil modulus and soil strain parameters that can be used for laterally loaded pile analysis via the p-y curve method based on the encountered subsurface conditions.

5.0 GEOTECHNICAL WALL DESIGN RECOMMENDATIONS

This section provides GSG's geotechnical recommendations for the design of the proposed abutment retaining walls based on the results of the field exploration, laboratory testing, and geotechnical analyses.

Based on the design drawings, MSE walls are proposed to retain the embankment fill below the bridge abutments. MSE walls are typically associated with fill wall construction and consist of facing such as segmental precast units, dry block concrete or CIP concrete facing units connected to horizontal steel strips, bars or geosynthetic to create a reinforced soil mass. The reinforcement is typically placed in horizontal layers between successive layers of granular backfill. A free draining backfill is required to provide adequate performance of the wall. MSE walls can be used in cut situations as well. The additional cost of the excavations for a MSE wall is usually offset by the savings in construction costs and schedule as compared to a CIP wall on spread footings.

The design of MSE walls for internal stability is the Contractor's responsibility and will need to be designed by a licensed Structural Engineer in the State of Illinois. The length of the reinforced soil mass from the outside face should be a minimum of 8 feet, but not less than 70% of the wall height. The length should be determined to satisfy the eccentricity and sliding criteria and provide adequate length to prevent structural failure with respect to pullout and rupture of reinforcement. The MSE wall could be designed using a unit weight of 125 pcf and a friction angle of 34 degrees for the reinforced backfill soils.

GSG evaluated the global and external stabilities (sliding and overturning) to determine the suitability of a MSE retaining wall system for this project.

5.1 MSE Wall Design Recommendations

The engineering analyses performed for evaluation of the retaining wall options followed the current AASHTO Load and Resistance Factor Design (LRFD) Methodology as required by IDOT. LRFD methodology incorporates the use of load factors and resistance factors to account for uncertainty in applied loads and load resistance of structure elements separately. The AASHTO LRFD Bridge Design Specifications outline load factors and combinations for various strength, extreme event, service, and fatigue limit states. Section 11, which outlines geotechnical criteria for retaining walls, of the AASHTO Specifications requires the evaluation of bearing resistance failure, lateral sliding, and overturning at the strength limit state and excessive vertical displacement, excessive lateral displacement, and overall stability at the service limit state. **Table 8** outlines the load factors used in evaluation of the retaining walls in accordance with Tables 3.4.1-1 and 3.4.1-2.

Table 8 – LRFD Load Factors for Retaining Wall Analyses

	Type of Load	Sliding and Eccentricity Strength Ia	Bearing Resistance Strength Ib	Sliding and Eccentricity Extreme IIa	Bearing Resistance Extreme IIb	Settlement Service I
Load Factors for Vertical Loads	Dead Load of Structural Components (DC)	0.90	1.25	0.90	1.25	1.00
	Vertical Earth Pressure Load (EV)	1.00	1.35	1.00	1.35	1.00
	Earth Surcharge Load (ES)		1.50			
	Live Load Surcharge (LS)		1.75			1.00
Load Factors for Horizontal Loads	Horizontal Earth Pressure Load (EH) Active At-Rest AEP for anchored walls	1.50	 1.50 1.35 1.35	1.00	1.00	1.00
	Earth Surcharge (ES)		1.50			
	Live Load Surcharge (LS)	1.75	1.75			1.00
Load Factor for Vehicular Collision				1.00	1.00	

5.2 Lateral Earth Pressures and Loading

The walls shall be designed to withstand earth and live lateral earth pressures. The lateral earth pressures on MSE walls should be determined in accordance with AASHTO 3.11.5.8. Earth loads of retained soils behind the MSE walls may be calculated using an active earth pressure coefficient, K_a, calculated using the Rankine Theory. **Table F-1** in **Appendix F** presents the soil design properties for the retaining wall for the anticipated soil types at the site and provide recommended lateral soil modulus and soil strain parameters that can be used for laterally loaded pile analysis via the p-y curve method based on the encountered subsurface conditions.

Traffic and other surcharge loads should be included in the design of the retaining walls. A live load surcharge shall be applied where vehicular load is expected to act on the surface of the backfill within a distance equal to one-half the wall height behind the back face of the wall in accordance with AASHTO 3.11.6.4. The live load surcharge may be estimated as a uniform horizontal earth pressure due to an equivalent height (H_{eq}) as shown in **Table 9** for vehicular loading perpendicular to traffic.

Table 9 - Equivalent Height of Soil for Vehicular Loading on Abutments Perpendicular to Traffic

Abutment Height (feet)	H_{eq} (feet)
5	4.0
10	3.0
⩾20	2.0

Reference: AASHTO LRFD Table 3.11.6.4-1

The retaining walls should be designed with free draining material as reinforced soil mass and the discharging water should be collected within the reinforced fill and drained away from the wall system. This will allow movement of any water behind the wall panel, and no hydrostatic (seepage) pressures will develop in the active soil wedge behind the wall panel. The backfill should be placed in accordance with the IDOT SSRBC. Heavy compaction equipment should not be allowed closer than five (5) feet to the retaining wall to prevent inducing high lateral earth pressures and causing wall yielding and/or other damage. The passive lateral earth pressure coefficient (K_p) from the upper 3.5 feet of level backfill at the toe of the wall should be neglected, unless the soil is confined or protected by a concrete slab or well drained pavement. The passive lateral earth pressure coefficient from the upper 3.5 feet of soil for a descending slope at the wall toe should also be neglected, regardless of any surface protection.

5.3 Bearing Resistance

Bearing resistance for the retaining walls founded on a granular fill leveling slab shall be evaluated at the strength limit state using load factors (see **Table 10**), and factored bearing resistances. The bearing resistance factor, ϕ_b, for a MSE wall is 0.65 per AASHTO Table 11.5.7-1. The bearing resistance shall be checked for the extreme event limit state with a resistance factor of 1.0. **Table 10** presents the proposed bearing elevations and recommended bearing resistances of suitable materials to support the wall systems.

Table 10 – Recommended Bearing Resistance

Location	Elevation* (feet)	Nominal Resistance (ksf)	Factored Bearing Resistance (ksf)	Bearing** Resistance for 1.0-inch Settlement Service Limit (ksf)	Bearing** Resistance for 2.0-inch Settlement Service Limit (ksf)	Anticipated Bearing Soil
West Abutment	591.5	8.8	6.0	4.2	5.8	New Engineering Granular Fill
East Abutment	591.5	8.8	6.0	4.5	6.0	New Engineering Granular Fill

*Elevations estimated from design cross section drawings provided by Delta

** Based on the existing soil profile with undercuts in **Table 11**.

The minimum depth of the wall foundations should be 3.5 feet below the final exterior grade to alleviate the effects of frost. The subgrade soils encountered at the bearing elevations should be cleared of any unsuitable material, such as topsoil. Based on the results of the subsurface exploration, we anticipate the walls would be supported upon the soil types noted in **Table 10.**

5.4 Subgrade Undercut Areas

Based on the soil conditions along the wall alignments, it is anticipated that high moisture content/loose sand materials may be encountered near the bearing elevations. These soils are not generally considered suitable for foundation bearing as they will not provide adequate bearing resistance. **Table 11** provides anticipated undercut depths along the bridge abutments.

Table 11 – Potential Undercuts Summary for MSE walls

Location	Soil Borings	Wall Height (feet)	Soil Description	Remedial Undercut	
				Start[1] Elevation (feet)	Depth (feet)
West Abutment	BSB-02	24.75	Brown Sand	591.5	2.5
East Abutment[2]	BSB-05	24.5	Brown Sand	591.5	2.5

1 The bottom of leveling pad of MSE walls is assumed at 591.5 feet based on the TSL Plans.

2 If the sand at the bottom of the wall can be dried at the east abutment, there is no need to undercut.

Undercut areas should be replaced with granular structural fill in accordance with IDOT standard construction requirements. The lateral limit of the structural fill should extend a minimum of 1 foot beyond the edge of the MSE wall footing, then an additional 1 foot laterally for every 2 feet of structural fill depth as depicted in **Exhibit 3** below. With 2.5 feet of undercut and replacement, we recommend that the horizontal limits of the proposed treatment be extended 2 feet beyond the wall footprints for the abutments. The granular structural fill should be placed and compacted to a minimum of 95% of the maximum dry density, as determined by AASHTO T-180: Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures (ASTM D1557) in accordance with IDOT standard construction requirements.

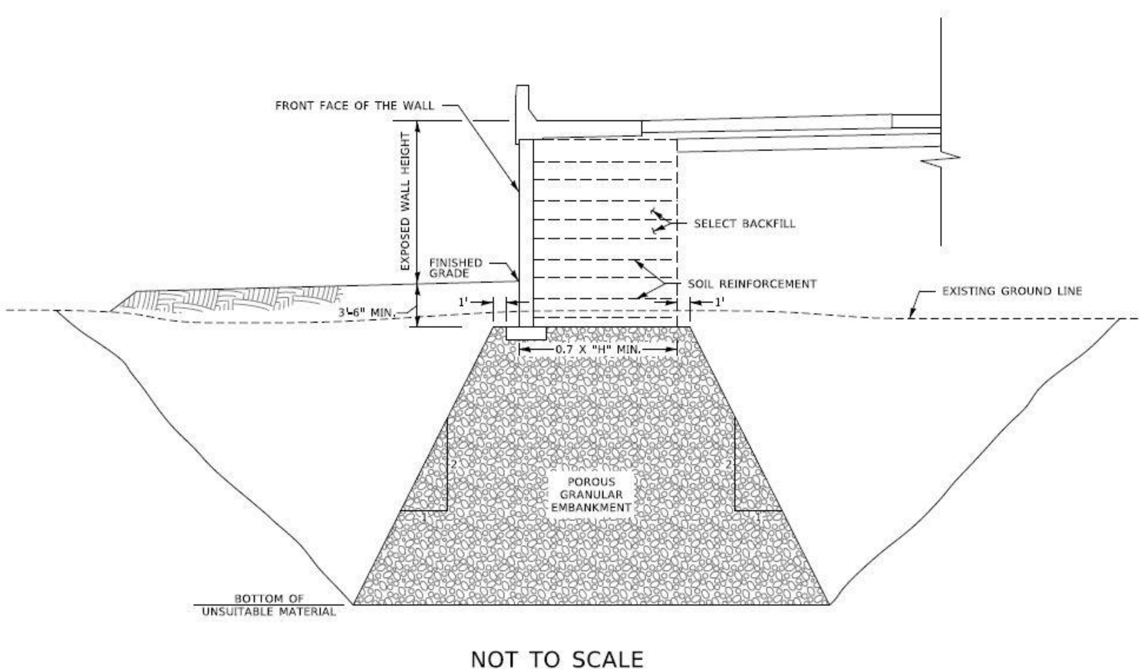


Exhibit 3 - Structural Fill Placement below MSE Wall Footing

5.5 Sliding and Overturning Stability

The wall base width should be sufficient to resist sliding. The frictional resistance shall include the friction between granular backfill for the wall and supportive cohesive or granular soils, and the friction between the wall foundation and bearing soils.

The factored resistance against sliding should be calculated using equation 10.6.3.4-1 in the AASHTO LRFD manual. A sliding resistance factor, ϕ, of 1.0 (Table 11.5.7-1) shall be applied to the nominal sliding resistance of soil on soil beneath the MSE walls. A maximum nominal frictional coefficient of 0.53 (tan 28 degrees) could be used for determining the sliding resistance for the soil to soil in-fill interfaces. The width of the MSE wall (length of reinforcing) must be wide enough to resist overturning forces. The location of the resultant of the forces shall be within the middle two thirds of the MSE base width.

5.6 Wall and Embankment Settlement

Settlement of the MSE walls depends on the foundation sizes and bearing pressures, as well as the strength and compressibility characteristics of the underlying bearing soils. Assuming the foundation subgrades have been prepared as recommended above and the service bearing pressures for the west and east abutments as mentioned in **Table 10** are used, the settlement of the MSE walls will be on the order of 1.0 to 2.0 inches. Differential settlement between two points of 100 feet apart along the length of the walls will be ½ inch or less. AASHTO 11.10.4.1 provides guidelines regarding the maximum total and differential tolerable settlements for various facing of MSE walls. The allowable settlement of MSE walls shall be established based on the longitudinal deformability of the facing. It is recommended to provide a vertical full-height slip joints if large differential settlements over short horizontal distances is anticipated.

5.7 Overall Stability

Based on the preliminary information provided by Delta Engineering, the retaining walls should be designed for external stability of the wall system as well as internal stability behind the wall facing. The following parameters were used to evaluate the overall stability of the walls.

Table 12 – West and East Abutment MSE Retaining Wall Descriptions

Maximum height of the retaining wall (H)*	24.75 feet
Minimum length of reinforcement 0.7xH	18.0 feet
Unit weight of the retained soil (embankment)	120 pcf
Unit weight of the reinforced soil mass	120 pcf

*Maximum wall height is measured from the top of pavement to the top of leveling pad.

The actual wall width and total height of the walls should be based on structural analysis performed by a Licensed Structural Engineer in the State of Illinois.

5.8 Slope Stability Results

Slide2 program was used to evaluate the global slope stability of the proposed MSE walls for the project based on the limit equilibrium method. The proposed wall systems were analyzed based on the preliminary grading, cross sections as shown in the TSL plans and the soils encountered at the site. Circular failure analyses were evaluated using the simplified Bishop analysis method for the proposed wall and slope geometries.

A circular analysis was evaluated for both a short term (undrained) and long term (drained) conditions for the proposed retaining walls. Based on the TSL plans, the MSE walls for the bridge have a maximum exposed height of 24.75 feet. Geometries of the cross sections for the maximum exposed heights were used in the slope stability analysis. Generalized soil profiles at two (2) different boring locations were analyzed. The bottoms of the MSE walls were assumed to be at elevation 591.5 feet; the elevations of the final new bridge slab surfaces will be near elevation 616.0 feet. The results of the analyses are shown in **Table 13**.

Table 13 –Stability Analyses Results

Analysis Exhibit	Cross Section	Soil Profile	Failure Type	Factor of Safety	Required Minimum Factor of Safety
Exhibit A	West Abutment	Borings BSB-01 & BSB-02	Circular – Short Term	2.4	1.5
Exhibit B			Circular – Long Term	2.2	1.5
Exhibit C	East Abutment	Borings BSB-05 & BSB-06A	Circular – Short Term	2.3	1.5
Exhibit D			Circular – Long Term	2.2	1.5

Based on the analyses performed, the proposed retaining walls meet the minimum factor of safety of 1.5. Copies of the Slope Stability analyses exhibits are included in **Appendix G**.

5.9 Drainage Recommendations

The walls should be designed to prevent the buildup of hydrostatic forces. This can be done with the construction of a base drain and back drain to collect and remove surface water away from the face of the MSE walls.

6.0 CONSTRUCTION CONSIDERATIONS

All work performed for the proposed project should conform to the requirements in the IDOT Standard Specifications for Road and Bridge Construction (2022). Any deviation from the requirements in the manuals above should be approved by the design engineer.

6.1 Existing Utilities

Based on the existing site conditions, significant utilities may exist along the project corridor that may interfere with construction of the proposed bridge and walls. Before proceeding with construction, all existing utility lines that will interfere with construction should be completely relocated from the proposed construction areas.

Where possible, existing utility lines that are to be abandoned in place should be removed and/or plugged with a minimum of 2 feet of cement grout. All excavations resulting from underground utilities removal activities should be cleaned of loose and disturbed materials, including all previously placed backfill, and backfilled with suitable fill materials in accordance with the requirements of this section. During the clearing and stripping operations, positive surface drainage should be maintained to prevent the accumulation of water.

6.2 Site Excavation

The contractor will be responsible for providing a safe excavation during the construction activities of the project. All excavations should be conducted in accordance with applicable federal, state, and local safety regulations, including, but not limited to the Occupational Safety and Health Administration (OSHA) excavation safety standards. Excavation stability and soil pressures on temporary shoring are dependent on soil conditions, depth of excavations, installation procedures, and the magnitude of any surcharge loads on the ground surface adjacent to the excavation. Excavation near existing structures and underground utilities should be performed with extreme care to avoid undermining existing structures. Excavations should not extend below the level of adjacent existing foundations or utilities unless underpinning or other support is installed. It is the responsibility of the contractor for field determinations of applicable conditions and providing adequate shoring for all excavation activities.

6.3 Borrow Material and Compaction Requirements

If borrow material is to be used for onsite construction, it should conform to Section 204 “Borrow and Furnished Excavation” of the current IDOT Construction Manual. The fill material should be free of organic matter and debris. Earth-moving operations should be avoided during excessively cold or wet weather to avoid freezing of softening subgrade soils.

6.4 Drilled Shafts Construction

The drilled shaft construction should be completed in accordance with Section 516, Drilled Shafts, in the IDOT SSRBC. A wet construction method may be necessary for the drilled shafts installation. Temporary casing may be required due to the observed water table elevation and the non-cohesive soil layers encountered in the soil borings. Water should be removed from the base of the drilled shaft base prior to placing any concrete. The placement method of concrete for the drilled shaft foundation should be based on the amount of water present at the base of the shaft just prior to placing the concrete. Concrete may be placed using the free fall method, provided less than 2 inches of water is present at the base of the shaft at the time the concrete is being placed. If more than 2 inches of water is present, a tremie should be used in an effort to displace the water to the surface for removal.

6.5 Pile Installation

IDOT standard practice requires driving one (1) test pile for each substructure element. The test-piles are installed based on the preliminary driving criteria in order to evaluate site conditions and are inspected in accordance with the IDOT Standard for Road and Bridge Construction. All pile installation should be completed in accordance with the IDOT SSRBC Section 512.15.

6.6 Groundwater Management

Based on the color change from brown and gray to gray, it is anticipated that the long-term groundwater level could range between elevations 589 to 592.5 feet. GSG does not anticipate any significant groundwater related issues occur during construction activity, however perched water may be encountered within the existing fill materials. If rainwater run-off or groundwater is accumulated at the base of excavations, the contractor should remove accumulated water using conventional sump pit and pump procedures and maintain a dry and stable excavation. The location of the sump should be determined by the contractor based on field conditions. During earthmoving activities at the site, grading should be performed to ensure that drainage is maintained throughout the construction period. Water should not be allowed to accumulate in the foundation area either during or after construction. Undercut and excavated areas should be sloped toward one corner to facilitate the removal of any collected rainwater or surface run-off. Grades should be sloped away from the excavations to minimize runoff from entering.

6.7 Temporary Earth Retention Systems

Temporary soil retention systems (TSRS) will be required for the installation of either drilled shaft or driven piles, as shown on the preliminary TSL plans. Based on the soil profile, a cantilevered sheet pile system could be used. The sheet pile retaining system should be designed in accordance with the IDOT Bridge Design Manual, Section 3.13.1, Temporary Sheet Piling Design, Temporary Soil Retention Systems. The design of the TSRS is the responsibility of the contractor.

The IDOT Temporary Sheet Piling Design procedures include limitations if the required embedment depths fall below soil layers with a Qu value larger than 4.5 tsf or N-values larger than 45 blows or rock, because the sheet piling may not penetrate these layers. Refer to the soil boring logs for the elevations to the hard stratum. If adequate retained heights cannot be obtained using the IDOT Temporary Sheet Piling Design Guide, then a Temporary Soil Retention System shall be designed by the Contractor. The Temporary Soil Retention Systems should include surcharge loads from the excavated materials, construction equipment and truck traffic as necessary. The retention system should extend to a sufficient depth below excavation bottom to provide the required lateral passive resistance if the active case is used for the design. Embedment depths should be determined based on the principles of force and moment equilibrium.

The retention system shall be designed by an Illinois licensed structural engineer in accordance with the IDOT Bridge Design Manual. The design of the temporary soil retention system (TSRS) is the responsibility of the contractor. The contractor should submit the TSRS plans to the structural design team for review prior to commencing construction of the TSRS.

7.0 LIMITATIONS

This report has been prepared for the exclusive use of the Illinois Department of Transportation (IDOT) and its Design Section Engineer consultant. The recommendations provided in the report are specific to the project described herein and are based on the information obtained at the soil boring locations. The analyses have been performed, and the recommendations have been provided based on subsurface conditions determined at the location of the borings. This report may not reflect all variations that may occur between boring locations or at some other time, the nature and extent of which may not become evident until during the time of construction. If variations in subsurface conditions become evident after submission of this report, it will be necessary to evaluate their nature and review the recommendations presented herein.

APPENDIX A

GENERAL PLAN, ELEVATION AND DETAILS

Bench Mark: Chiseled square cut in Northeast corner of wingwall at Northwest corner of Michigan City Road deck Elev. 613.98.

Existing Structures: S.N. 016-1068, originally built in 1948 as FA Route 122, Section 0606.2-HB. In 1983 as part of Contract 35912, a portion of the beam currently designated as Beam 10 was replaced and over Pier 3 due to a vehicle impact. In 1990 as part of Contract 80290, the existing concrete deck was replaced and widened from 56'-0" to 64'-0". The widening included one new rolled steel beam on each side of the bridge and widening of the abutments and piers. The existing wing walls were removed to accommodate the abutment widening and new wing walls constructed. 2" Neoprene expansion joints were provided at each abutment. The steel handrail replaced with pedestrian railing on a concrete barrier. Concrete slopes wall were provided in each end span. The existing steel beams were raised and several beams were repaired. In 1994 as part of Contract 82595, steel repairs were performed due to a vehicle impact on Beam 10 just east of the field splice in Span 2. In 2012 as part of Contract 60P60, bridge deck sealing was performed. In 2015 as part of Contract 62A17, steel repairs were performed due to a vehicle impact on Beam 11 in Span 3. The back to back abutment length is 277'-8 3/4" and the out to out bridge width is 64'-0". Existing structure is to be removed and replaced. Traffic will be maintained utilizing stage construction.

Salvage: None

LOADING HL-93

Allow 50#/sq. ft. for future wearing surface.

DESIGN SPECIFICATIONS

2020 AASHTO LRFD Bridge Design Specifications, 9th Edition
Live Load Deflection Limit Span/1000

HIGHWAY CLASSIFICATION

Michigan City Road
Functional Class: Other Principal Arterial
ADT: 9,300 (2014); 9,579 (2032)
ADTT: 279 (2014); 287 (2032)
DHV: 930 (2014)
Design Speed: 35 m.p.h.
Posted Speed: 35 m.p.h.
Two-Way Traffic
Directional Distribution: 50:50

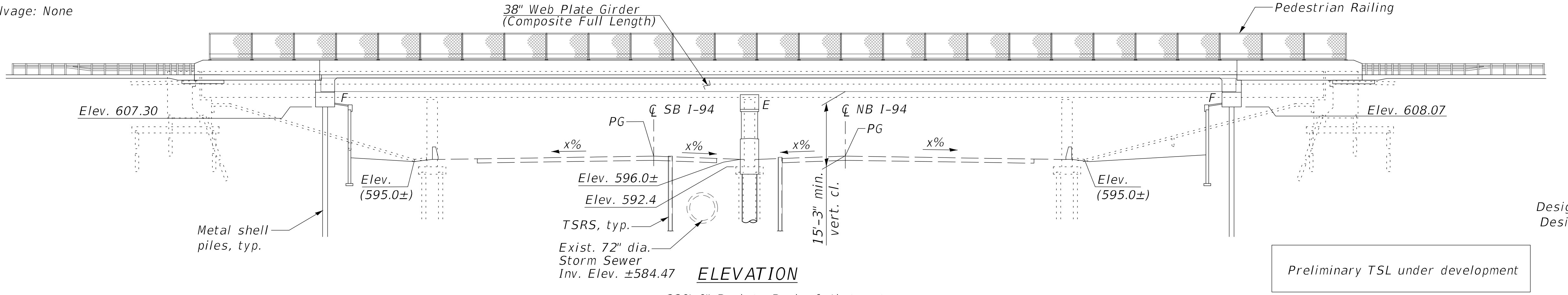
DESIGN STRESSES

FIELD UNITS

f'c = 4,000 psi (Superstructure)
f'c = 3,500 psi (Substructure)
fy = 60,000 psi (Reinforcement)
fy = 50,000 psi (M270 Grade 50)

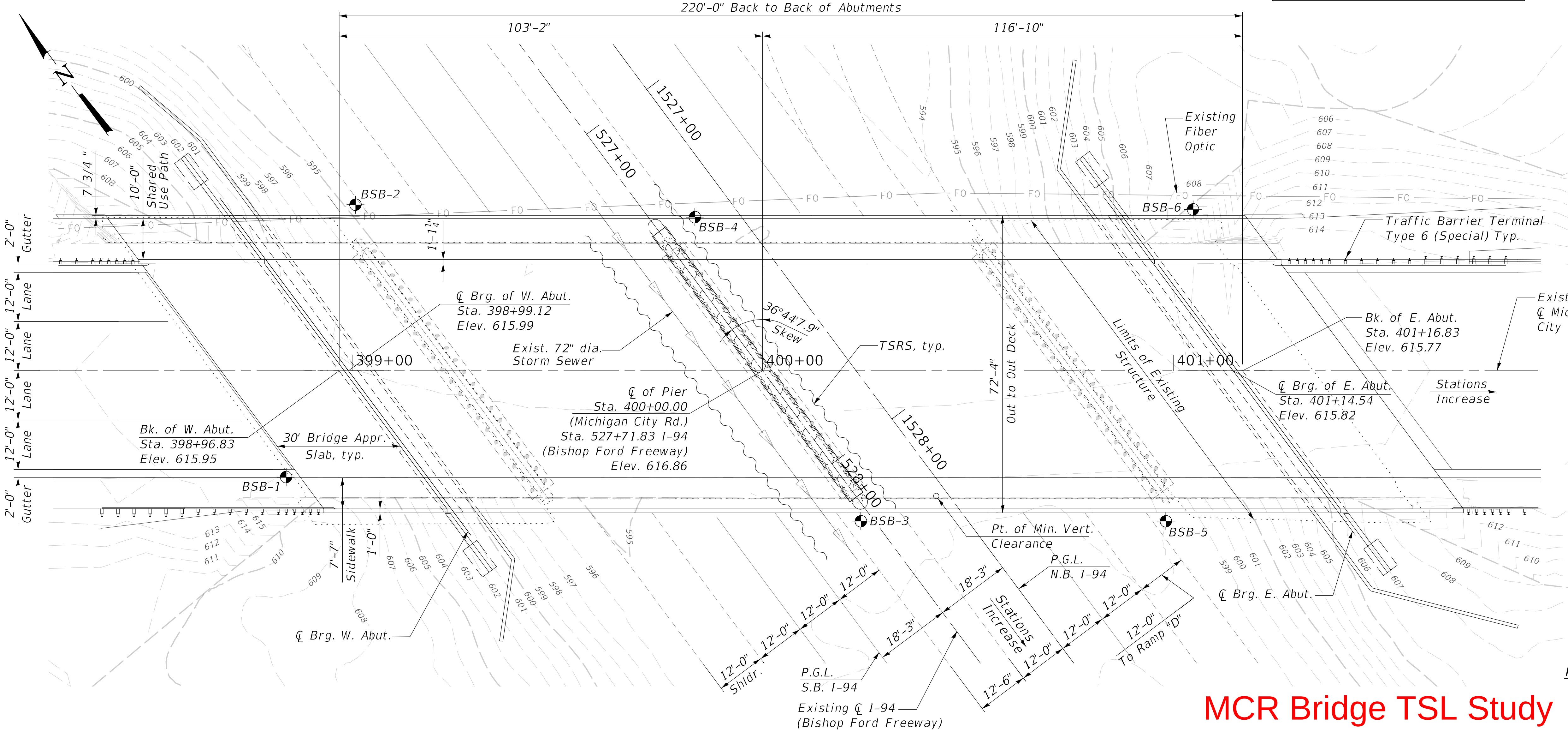
SEISMIC DATA

Seismic Performance zone (SPZ) = B
Design Spectral Acceleration at 1.0 sec. (SD1) - 0.099
Design Spectral Acceleration at 0.2 sec. (SD2) - 0.13
Soil Site Class = D

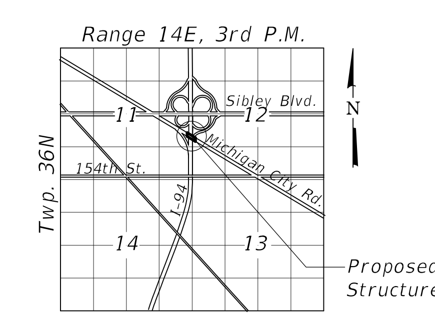


ELEVATION

Preliminary TSL under development



PLAN



LOCATION SKETCH

GENERAL PLAN & ELEVATION
MICHIGAN CITY ROAD OVER I-94
(BISHOP FORD FREEWAY)
F.A.I. RTE. 94 SEC. 0606(2HB)R-86
COOK COUNTY
STATION 400+00.00
STRUCTURE NO. 016-8320

MCR Bridge TSL Study
09/12/2023

BRIDGE TSL STUDY

MODEL: $MODELNAME$
FILE NAME: $FILE$

DELTA ENGINEERING GROUP, LLC
CONSULTING ENGINEERS, CONSTRUCTION MANAGERS, SURVEYORS
111 W JACKSON BLVD, SUITE 910
CHICAGO, IL 60604
T 312.377.7700, F 312.427.6145

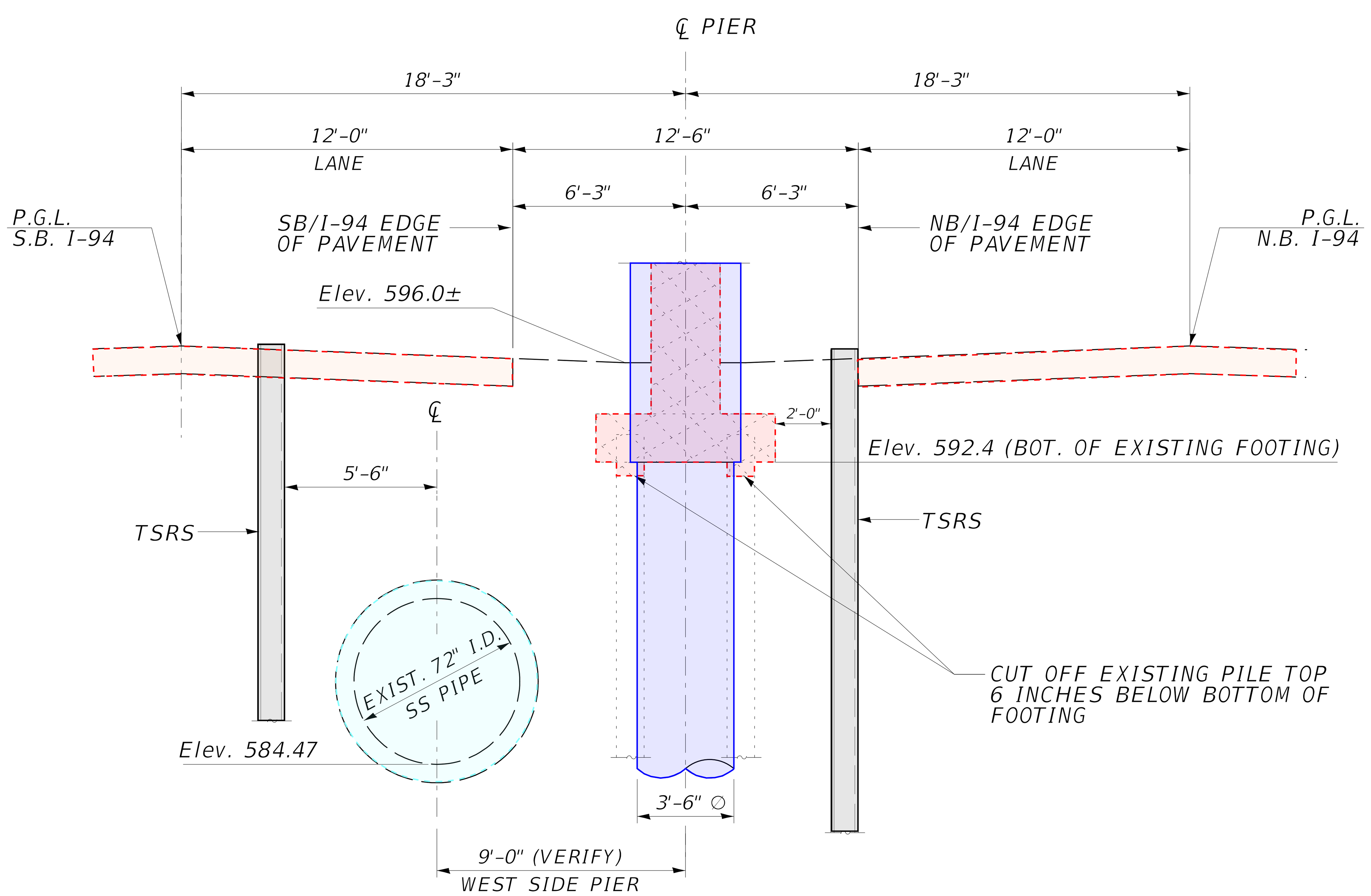
USER NAME = $USER$	DESIGNED -	REVISED -
	DRAWN -	REVISED -
PLOT SCALE = $SCALE$	CHECKED -	REVISED -
PLOT DATE = $DATE$	DATE - 5/15/2023	REVISED -

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SCALE: | SHEET OF SHEETS | STA. | TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
I-94	XXXXXXXXXXX	COOK	3	1
		CONTRACT NO. XXXX		
	ILLINOIS	FED. AID PROJECT		

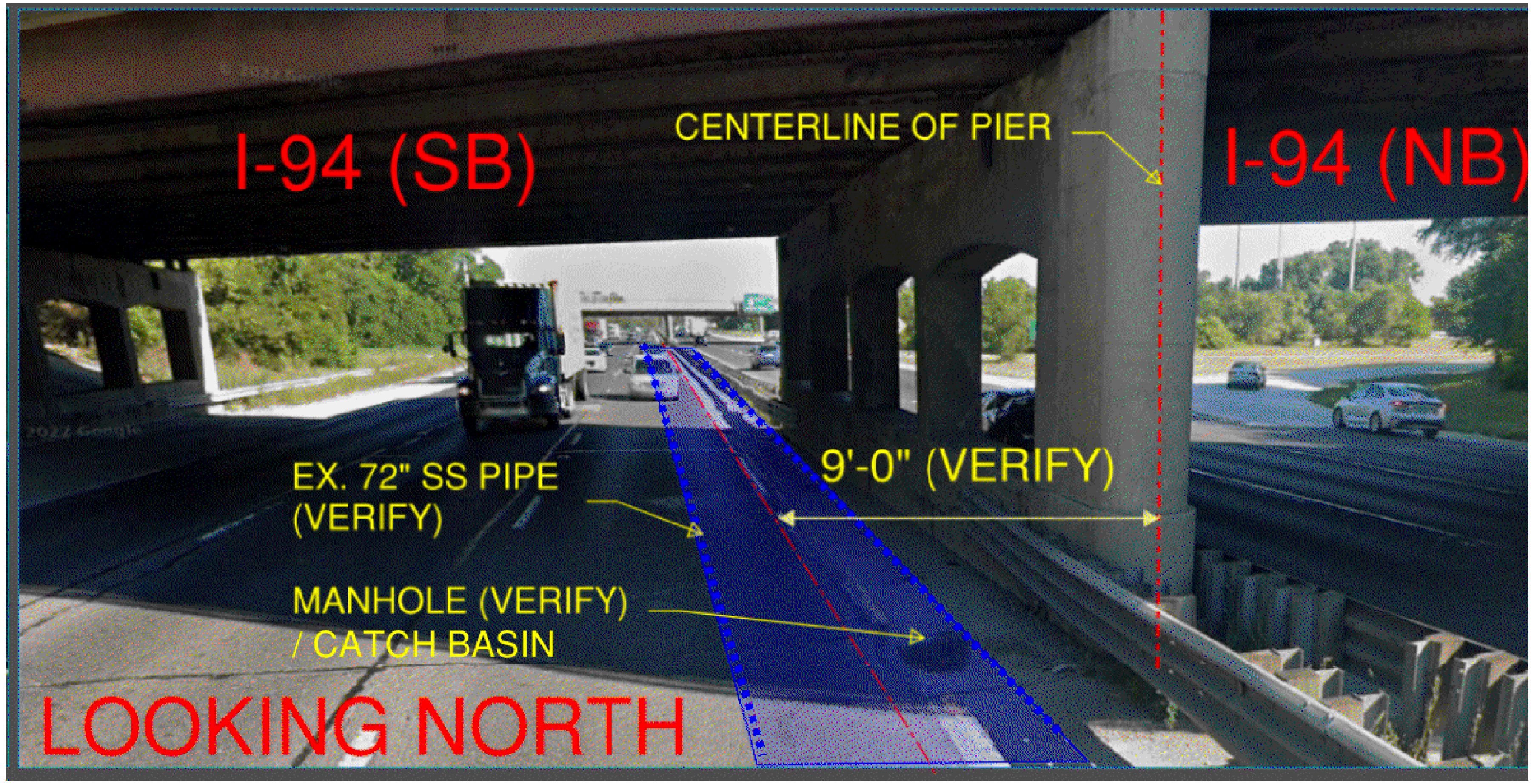
PLAN

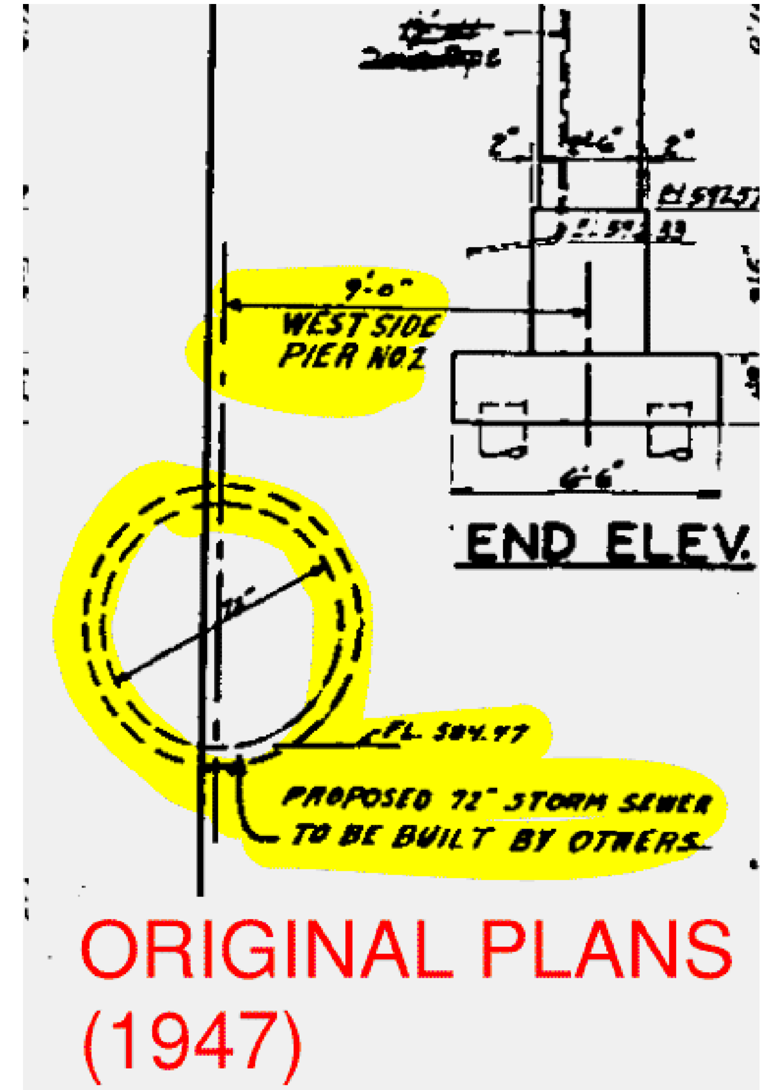


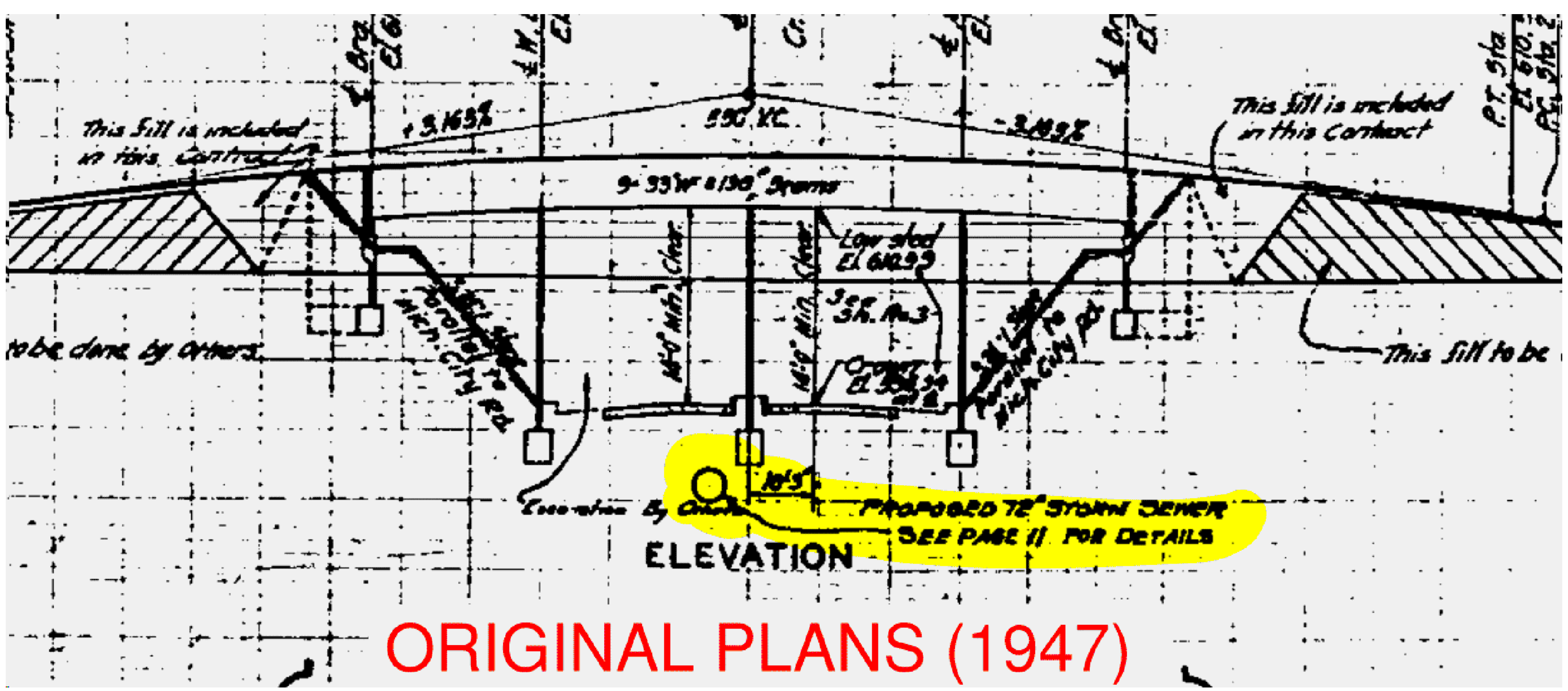
PIER ELEVATION
(LOOKING NORTH)

MCR Bridge TSL Study
09/12/2023

MICHIGAN CITY ROAD BRIDGE
CENTER PIER FOOTING - STUDY



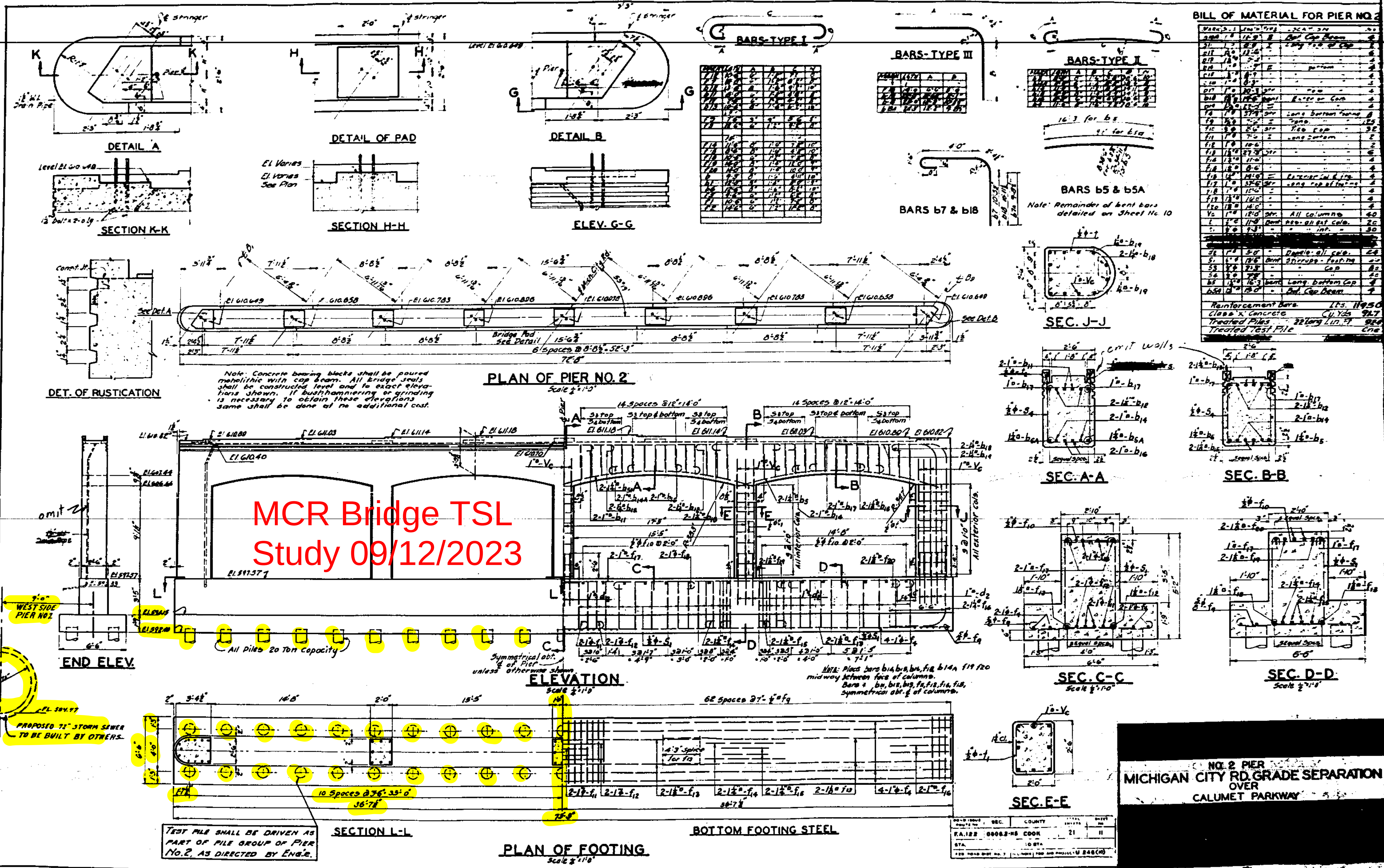




MCR Bridge TSL Study
09/12/2023

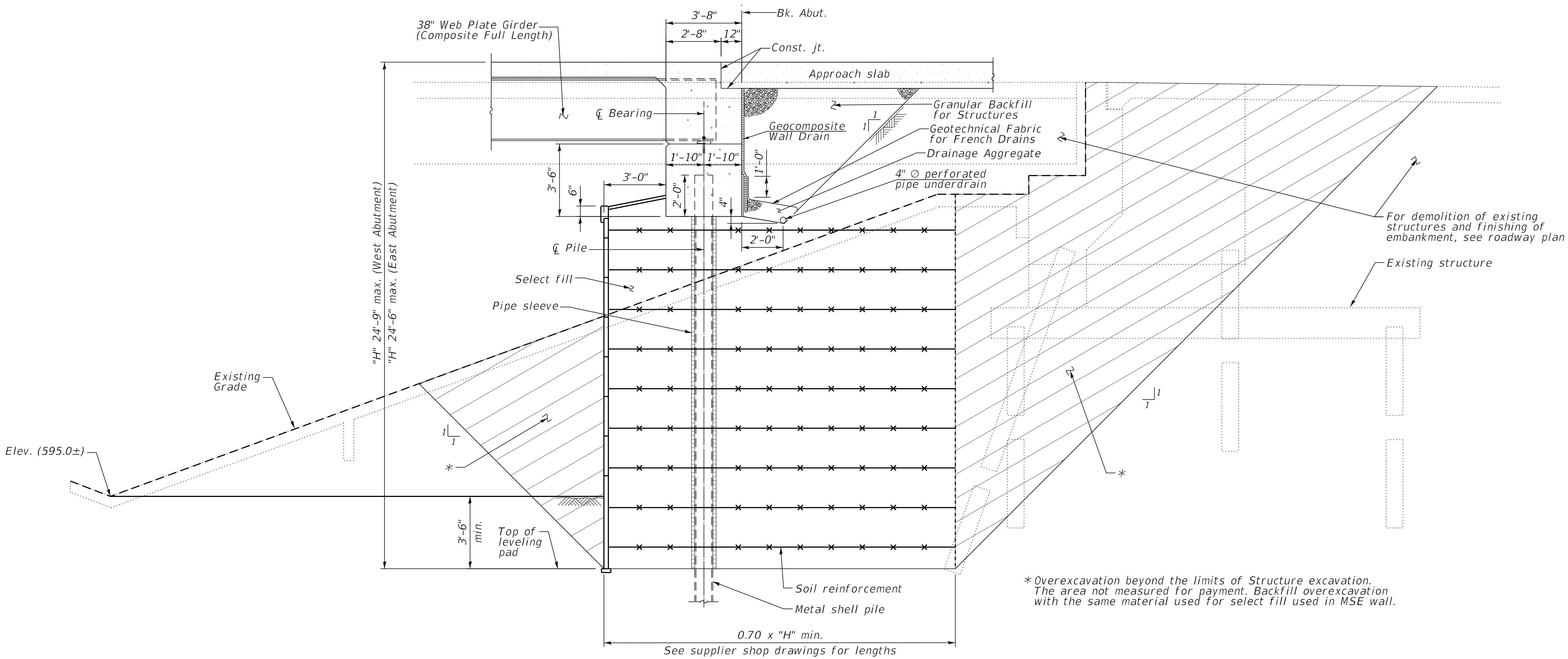
MICHIGAN CITY ROAD BRIDGE

CENTER PIER FOOTING – STUDY



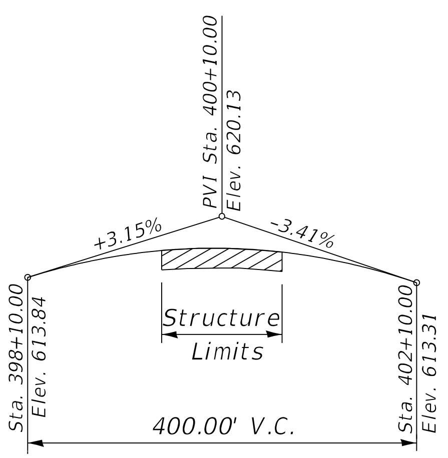
MCR Bridge TSL
Study 09/12/2023

CENTER PIER_FOR REFERENCE ONLY



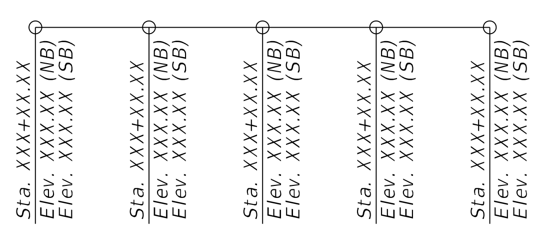
SECTION THRU INTEGRAL ABUTMENT

(Horiz. dim. @ Rt. ∠'s)



FROFILE GRADE

(Along Michigan City Road)



FROFILE GRADE

(Along P.G.'s of I-94)

8-30-2023

BRIDGE TSL STUDY

DETAILS
MICHIGAN CITY ROAD OVER I-94
(BISHOP FORD FREEWAY)
F.A.I. RTE. 94 SEC. 0606(2HB)R-86
COOK COUNTY
STATION 400+00.00
STRUCTURE NO. 016-1068

MODEL: $MODELNAME$
FILE NAME: $FILEL$

DELTA ENGINEERING GROUP, LLC
CONSULTING ENGINEERS, CONSTRUCTION MANAGERS, SURVEYORS
111 W JACKSON BLVD, SUITE 910
CHICAGO, IL 60604
T 312.377.7700, F 312.427 6145

USER NAME = $USER$	DESIGNED -	REVISED -	
	DRAWN -	REVISED -	
PLOT SCALE = $SCALE$	CHECKED -	REVISED -	
PLOT DATE = $DATE$	DATE - 5/15/2023	REVISED -	

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

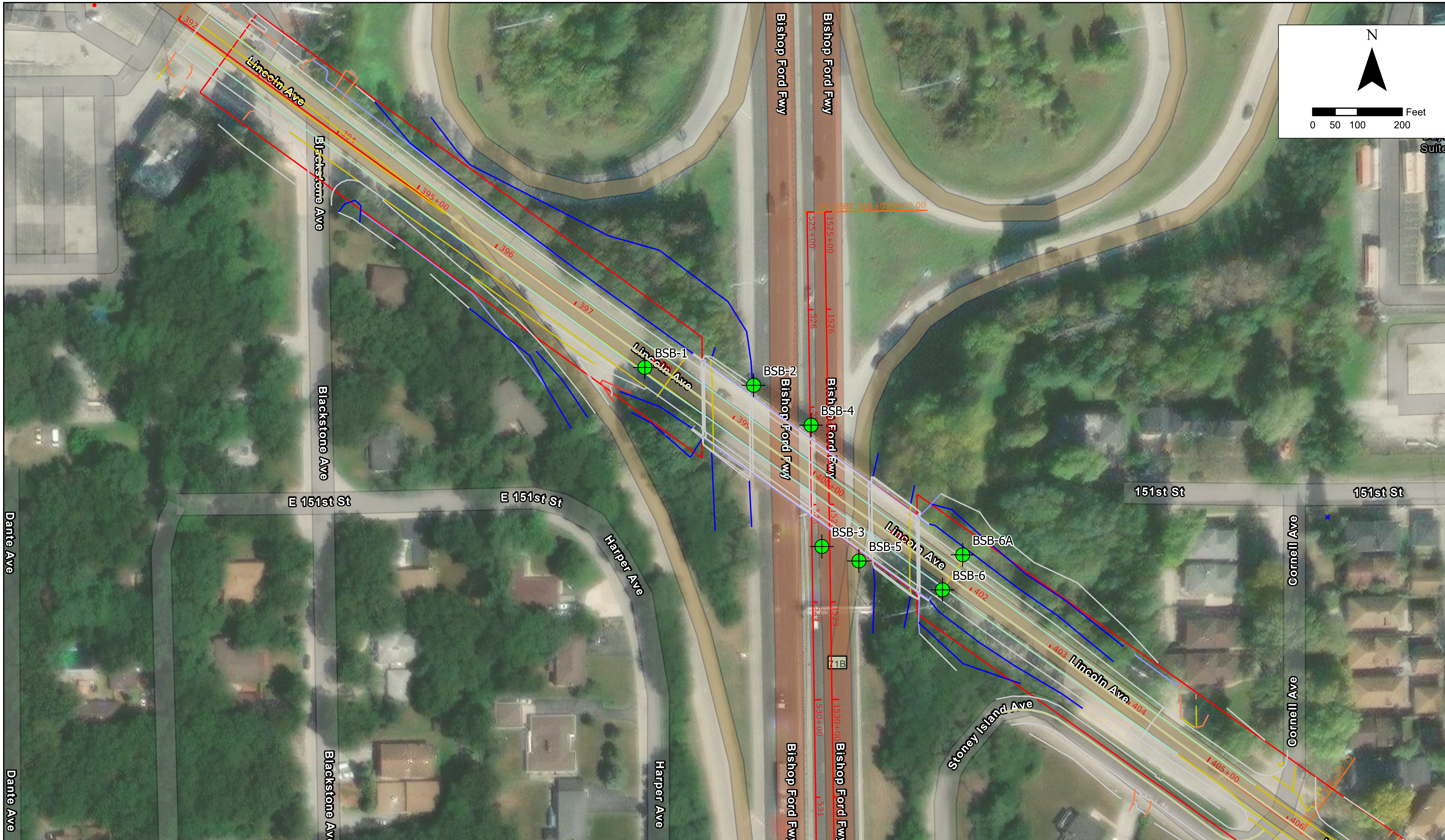
SCALE: | SHEET OF SHEETS | STA. | TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
I-94	XXXXXXXXXXX	COOK	4	3
		CONTRACT NO. XXXX		
	ILLINOIS	FED. AID PROJECT		

APPENDIX B

SOIL BORING LOCATION PLAN

AND SUBSURFACE PROFILE



DRAWN BY	KN	***DATE***	10/30/2023
CHECKED BY	MZ	***DATE***	10/30/2023

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

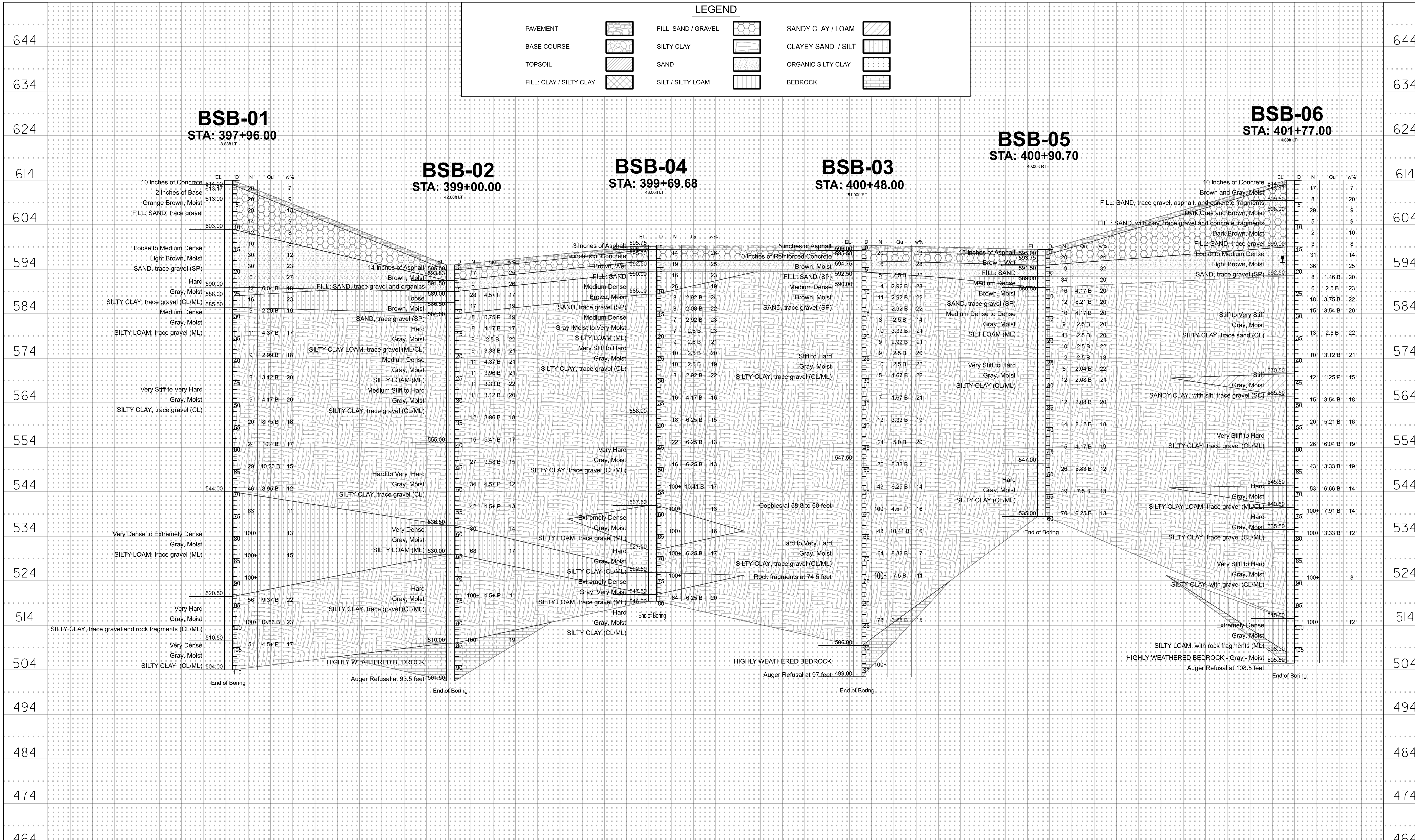
Illinois Department of Transportation

DELTA ENGINEERING GROUP

MICHIGAN CITY ROAD OVER I-94

EXHIBIT 1: BRIDGE BORING LOCATION PLAN

SHEET NO.
-



GSG CONSULTANTS, INC.
735 E. REMINGTON RD, SCHAUMBURG, IL 60173
TEL: +1630.994.2600 | WWW.GSG-CONSULTANTS.COM

USER NAME	= $USER$	DESIGNED	-
SHEET SIZE	= 17x11 (in.)	DRAWN	-
PLOT SCALE	= 0.610 m / in.	CHECKED	-
PLOT DATE	= 9/28/2023	DATE	-

DELTA ENGINEERING 204-001

SUBSURFACE PROFILES

MICHIGAN CITY ROAD OVER I-94

SCALE: ____ SHEET OF SHEETS STA. TO STA.

F.A. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
		CONTRACT NO.		
	ILLINOIS	FED. AID PROJECT		

FILE NAME =
PLOT DATE = 9/28/2023
TIME = 1:25:33 PM
SHEET SIZE = 17x11 (in.)
PLOT SCALE = 0.610 m / in.
USER NAME = $USER$

APPENDIX C

SOIL BORING LOGS

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/26/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** TS

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6212571, Longitude -87.5795654

COUNTY COOK **DRILLING RIG** CME 75 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 79.8

STRUCT. NO. ______
Station ______

BORING NO. BSB-01
Station 397+96.00
Offset 8.90ft RT
Ground Surface Elev. 614.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A Hrs. N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
10 inches of Concrete	613.17				
2 inches of Base	613.00		11		
Orange Brown, Moist FILL: SAND, trace gravel			15		7
			13		
			9		
			11		9
		-5	9		
			8		
			14		13
			15		
			8		
			8		9
		-10	6		
	603.00				
Loose to Medium Dense Light Brown, Moist SAND, trace gravel (SP)			4		
			5		8
			7		
			5		
			5		8
		-15	5		
			10		
			14		12
			16		
			14		
			13		23
		-20	17		

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Loose to Medium Dense Light Brown, Moist SAND, trace gravel (SP) *(continued)*			5		
			4		27
			2		
			3		
	590.00				
Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)			5	6.0	18
		-25	7	B	
	588.00				
Medium Dense Gray, Moist SILTY LOAM, trace gravel (ML)			5		
			10		23
			6		
	585.50				
Very Stiff to Very Hard Gray, Moist SILTY CLAY, trace gravel (CL)			3		
			4	2.3	19
		-30	5	B	
			4		
			6	4.4	17
		-35	5	B	
			4		
			4	3.0	18
		-40	5	B	

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/26/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** TS

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6212571, **Longitude** -87.5795654

COUNTY COOK **DRILLING RIG** CME 75 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 79.8

STRUCT. NO.
Station

BORING NO. BSB-01
Station 397+96.00
Offset 8.90ft RT
Ground Surface Elev. 614.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Stiff to Very Hard Gray, Moist SILTY CLAY, trace gravel (CL) *(continued)*				
	-45	3 3 5	3.1 B	20
	-50	4 4 5	4.2 B	20
	-55	6 9 11	8.8 B	16
	-60	9 11 13	10.4 B	17
Very Stiff to Very Hard Gray, Moist SILTY CLAY, trace gravel (CL) *(continued)*				
	-65	9 12 17	10.2 B	15
544.00	-70	12 17 29	9.0 B	12
Very Dense to Extremely Dense Gray, Moist SILTY LOAM, trace gravel (ML)				
	-75	24 26 37		11
	-80	50/4"		13

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/26/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** TS

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6212571, Longitude -87.5795654

COUNTY COOK **DRILLING RIG** CME 75 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 79.8

STRUCT. NO. ______
Station ______

BORING NO. BSB-01
Station 397+96.00
Offset 8.90ft RT
Ground Surface Elev. 614.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Dense to Extremely Dense Gray, Moist SILTY LOAM, trace gravel (ML) *(continued)*				
		19		
		39		15
	-85	50/5"		
		50/2"		
	-90			
520.50				
Very Hard Gray, Moist SILTY CLAY, trace gravel and rock fragments (CL/ML)		10		
		17	9.4	22
	-95	39	B	
		10		
		25	10.8	23
	-100	50/3"	B	

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Hard Gray, Moist SILTY CLAY, trace gravel and rock fragments (CL/ML) *(continued)*				
510.50				
Very Dense Gray, Moist SILTY CLAY (CL/ML)		15		
		24	4.5	17
	-105	27	P	
504.00	-110			
End of Boring				
	-115			
	-120			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 8/2/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** TS

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.62120421, **Longitude** -87.57915855

COUNTY COOK **DRILLING RIG** CME 75 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 79.8

STRUCT. NO.
Station

BORING NO. BSB-02
Station 399+00.00
Offset 42.00ft LT
Ground Surface Elev. 595.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
14 inches of Asphalt	593.83				
Brown, Moist FILL: SAND, trace gravel and organics			3 8 9		25
	591.50				
Loose Brown, Moist SAND, trace gravel (SP)		-5	2 6 3		26
	589.00				
Hard Gray, Moist SILTY CLAY LOAM, trace gravel (ML/CL)			4 12 16	4.5 P	17
	586.50				
Medium Dense Gray, Moist SILTY LOAM (ML)		-10	7 9 8		19
	584.00				
Medium Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)			3 3 5	0.8 P	19
		-15	1 4 4	4.2 B	17
			2 4 5	2.5 B	22
		-20	2 4 5	3.3 B	21

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Medium Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*			2 5 6	4.4 B	21
		-25	3 5 6	4.0 B	21
			3 4 7	3.3 B	22
		-30	3 4 7	3.1 B	20
		-35	3 6 6	4.0 B	18
	555.00	-40	5 7 8	5.4 B	17

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 8/2/23

ROUTE	Michigan City Rd	**DESCRIPTION**	Bridge Boring	**LOGGED BY**	TS
SECTION	Michigan City Rd	**LOCATION**	, SEC. , TWP. , RNG. , Latitude 41.62120421, Longitude -87.57915855		
COUNTY	COOK	**DRILLING RIG**	CME 75	**HAMMER TYPE**	AUTO
		DRILLING METHOD	HSA	**HAMMER EFF (%)**	79.8

STRUCT. NO. ______
Station ______

BORING NO. BSB-02
Station 399+00.00
Offset 42.00ft LT
Ground Surface Elev. 595.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Hard to Very Hard Gray, Moist SILTY CLAY, trace gravel (CL)		8		
		12	9.6	15
	-45	15	B	
		15		
		17	4.5	12
	-50	17	P	
		19		
		19	4.5	13
	-55	23	P	
536.50				
Very Dense Gray, Moist SILTY LOAM (ML)		24		
		36		14
	-60	44		

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Dense Gray, Moist SILTY LOAM (ML) *(continued)*		25		
		32		17
530.00	-65	36		
Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)				
	-70			
		45		
		50/3"	4.5	11
	-75		P	
	-80			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 8/2/23

ROUTE Michigan City Rd DESCRIPTION Bridge Boring LOGGED BY TS

SECTION Michigan City Rd LOCATION , SEC. , TWP. , RNG. ,
Latitude 41.62120421, Longitude -87.57915855

COUNTY COOK DRILLING RIG CME 75 HAMMER TYPE AUTO
DRILLING METHOD HSA HAMMER EFF (%) 79.8

STRUCT. NO.
Station

BORING NO. BSB-02
Station 399+00.00
Offset 42.00ft LT
Ground Surface Elev. 595.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A Hrs. N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*			50/4"		
					19
	510.00	-85			
HIGHLY WEATHERED BEDROCK					
		-90			
Auger Refusal at 93.5 feet	501.50				
End of Boring					
		-95			
		-100			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, form 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/26/23

ROUTE	Michigan City Rd	**DESCRIPTION**	Bridge Boring	**LOGGED BY**	EH
SECTION	Michigan City Rd	**LOCATION**	, SEC. , TWP. , RNG. , Latitude 41.620749, Longitude -87.578908		
COUNTY	COOK	**DRILLING RIG**	Mobile B57	**HAMMER TYPE**	AUTO
		DRILLING METHOD	HSA	**HAMMER EFF (%)**	89.0

STRUCT. NO.		**Surface Water Elev.**	N/A ft
Station		**Stream Bed Elev.**	N/A ft
BORING NO.	BSB-03	**Groundwater Elev.:**	
Station	400+48.00	**First Encounter**	None ft
Offset	51.00ft RT	**Upon Completion**	N/A ft
Ground Surface Elev.	596.00 ft	**After** N/A **Hrs.**	N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
5 inches of Asphalt	595.58				
10 inches of Reinforced Concrete	594.75				
Brown, Moist FILL: SAND (SP)	592.50		7 9 11		13
Medium Dense Brown, Moist SAND, trace gravel (SP)	590.00	-5	5 9 7		28
Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)			2 2 3	2.5 B	22
		-10	2 4 10	2.9 B	23
			5 5 6	2.9 B	22
		-15	2 4 6	2.9 B	22
			2 4 4	2.5 B	14
		-20	3 4 6	3.3 B	21

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*		3 4 5	2.9 B	21
	-25	3 3 6	2.5 B	20
		3 3 7	2.5 B	22
	-30	2 2 3	1.7 B	22
	-35	1 2 5	1.7 B	21
	-40	3 5 8	3.3 B	19

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/26/23

ROUTE Michigan City Rd DESCRIPTION Bridge Boring LOGGED BY EH

SECTION Michigan City Rd LOCATION , SEC. , TWP. , RNG. ,
Latitude 41.620749, Longitude -87.578908

COUNTY COOK DRILLING RIG Mobile B57 HAMMER TYPE AUTO
DRILLING METHOD HSA HAMMER EFF (%) 89.0

STRUCT. NO. ______
Station ______

BORING NO. BSB-03
Station 400+48.00
Offset 51.00ft RT
Ground Surface Elev. 596.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A Hrs. N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*				
		6 11 10	5.0 B	20
	-45			
547.50				
Hard to Very Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)		11 10 15	8.3 B	12
	-50			
		21 21 22	6.3 B	14
	-55			
Cobbles at 58.8 to 60 feet		50/5.5"	4.5 P	16
	-60			

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Hard to Very Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*				
		15 16 27	10.4 B	16
	-65			
		18 24 37	8.3 B	17
	-70			
Rock fragments at 74.5 feet		38 29 50/3"	7.5 B	11
	-75			
	-80			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/26/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** EH

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.620749, **Longitude** -87.578908

COUNTY COOK **DRILLING RIG** Mobile B57 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 89.0

STRUCT. NO.
Station

BORING NO. BSB-03
Station 400+48.00
Offset 51.00ft RT
Ground Surface Elev. 596.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Hard to Very Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*			25 28 50	6.3 B	15
		-85			
	506.00	-90			
HIGHLY WEATHERED BEDROCK			50/1"		
		-95			
Auger Refusal at 97 feet	499.00				
End of Boring		-100			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, form 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/24/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** EH

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.62109073, **Longitude** -87.57894435

COUNTY COOK **DRILLING RIG** Mobile B57 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 89.0

STRUCT. NO.
Station

BORING NO. BSB-04
Station 399+69.68
Offset 43.00ft LT
Ground Surface Elev. 596.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	Elev. (ft)	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
3 inches of Asphalt	595.75				
9 inches of Concrete	595.00				
Brown, Wet FILL: SAND			7 5 9		26
	592.50				
Medium Dense Brown, Moist SAND, trace gravel (SP)		-5	3 9 10		25
	590.00				
Medium Dense Gray, Moist to Very Moist SILTY LOAM (ML)			7 7 9		23
		-10	6 12 14		19
	585.00				
Very Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL)			4 3 5	2.9 B	24
		-15	2 4 4	2.1 B	22
			3 3 4	2.9 B	23
		-20	2 3 4	2.5 B	23
Very Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL) *(continued)*			2 4 5	2.5 B	21
		-25	2 4 6	2.5 B	20
			3 5 5	2.5 B	19
		-30	3 3 5	2.9 B	22
		-35	4 6 10	4.2 B	16
	558.00				
Very Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)		-40	6 8 10	6.3 B	15

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/24/23

ROUTE Michigan City Rd DESCRIPTION Bridge Boring LOGGED BY EH

SECTION Michigan City Rd LOCATION , SEC. , TWP. , RNG. ,
Latitude 41.62109073, Longitude -87.57894435

COUNTY COOK DRILLING RIG Mobile B57 HAMMER TYPE AUTO
DRILLING METHOD HSA HAMMER EFF (%) 89.0

STRUCT. NO.
Station

BORING NO. BSB-04
Station 399+69.68
Offset 43.00ft LT
Ground Surface Elev. 596.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A Hrs. N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*		8 9 13	6.3 B	13
	-45			
		8 8 8	6.3 B	13
	-50			
		15 50/5.5"	10.4 B	17
	-55			
537.50				
Extremely Dense Gray, Moist SILTY LOAM, trace gravel (ML)		48 50/4"		13
	-60			

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Extremely Dense Gray, Moist SILTY LOAM, trace gravel (ML) *(continued)*		24 36 50/5"		16
	-65			
527.50				
Hard Gray, Moist SILTY CLAY (CL/ML)		13 41 50/5"	6.3 B	17
	-70			
522.50				
Extremely Dense Gray, Very Moist SILTY LOAM, trace gravel (ML)		50/3"		
	-75			
517.50				
Hard Gray, Moist SILTY CLAY (CL/ML)		13 34 30	6.3 B	20
516.00	-80			

End of Boring

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/23/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** EH

SECTION Michigan City Rd **LOCATION** , **SEC.** , **TWP.** , **RNG.** ,
Latitude 41.62070743, **Longitude** -87.57876953

COUNTY COOK **DRILLING RIG** Mobile B57 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 89.0

STRUCT. NO.
Station

BORING NO. BSB-05
Station 400+90.70
Offset 40.00ft RT
Ground Surface Elev. 595.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
15 inches of Asphalt 593.75 Brown, Wet FILL: SAND		4 9 11		24
591.50 Medium Dense Brown, Moist SAND, trace gravel (SP)	-5	5 9 10		32
589.00 Medium Dense to Dense Gray, Moist SILT LOAM (ML)		7 15 19		20
586.50 Very Stiff to Hard Gray, Moist SILTY CLAY (CL/ML)	-10	9 9 7	4.2 B	20
		4 4 8	5.2 B	20
	-15	4 5 5	4.2 B	20
		3 4 5	2.5 B	20
	-20	4 5 6	2.5 B	20

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Stiff to Hard Gray, Moist SILTY CLAY (CL/ML) *(continued)*		3 4 6	2.5 B	22
	-25	3 5 7	2.5 B	18
		2 3 5	2.0 B	22
	-30	0 6 6	2.1 B	21
	-35	4 5 7	2.1 B	20
	-40	4 5 9	2.1 B	18

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/23/23

ROUTE Michigan City Rd   DESCRIPTION Bridge Boring   LOGGED BY EH

SECTION Michigan City Rd   LOCATION , SEC. , TWP. , RNG. ,
Latitude 41.62070743, Longitude -87.57876953

COUNTY COOK   DRILLING RIG Mobile B57   HAMMER TYPE AUTO
DRILLING METHOD HSA   HAMMER EFF (%) 89.0

STRUCT. NO.
Station

BORING NO. BSB-05
Station 400+90.70
Offset 40.00ft RT
Ground Surface Elev. 595.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter None ft
Upon Completion N/A ft
After N/A Hrs. N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Stiff to Hard Gray, Moist SILTY CLAY (CL/ML) *(continued)*			3 6 9	4.2 B	19
		-45			
	547.00				
Hard Gray, Moist SILTY CLAY (CL/ML)			11 11 15	5.8 B	12
		-50			
			15 23 26	7.5 B	13
		-55			
			18 30 40	6.3 B	13
	535.00	-60			

End of Boring

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/31/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** DV/EH

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6206242, **Longitude** -87.5784571

COUNTY COOK **DRILLING RIG** D-50 ATV **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 91.5

STRUCT. NO.
Station

BORING NO. BSB-06
Station 401+77.00
Offset 14.60ft RT
Ground Surface Elev. 614.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 595.5 ft ▼
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
10 inches of Concrete — 613.17				
Brown and Gray, Moist FILL: SAND, trace gravel, asphalt, and concrete fragments		9 / 9 / 8		7
— 609.50	-5	5 / 4 / 4		20
Dark Gray and Brown, Moist FILL: SAND, with clay, trace gravel and concrete fragments — 608.00				
Dark Brown, Moist FILL: SAND, trace gravel		7 / 14 / 15		9
	-10	5 / 3 / 2		9
		2 / 1 / 1		10
— 599.00	-15	1 / 1 / 2		8
Loose to Medium Dense Light Brown, Moist SAND, trace gravel (SP)		11 / 14 / 17		14
▼	-20	9 / 18 / 18		25
Loose to Medium Dense Light Brown, Moist SAND, trace gravel (SP) *(continued)* — 592.50		5 / 4 / 4	1.5 B	20
Stiff to Very Stiff Gray, Moist SILTY CLAY, trace sand (CL)	-25	2 / 2 / 4	2.5 B	23
		4 / 6 / 12	3.8 B	22
	-30	4 / 7 / 8	3.5 B	20
	-35	3 / 6 / 7	2.5 B	22
	-40	3 / 4 / 6	3.1 B	21

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/31/23

ROUTE Michigan City Rd DESCRIPTION Bridge Boring LOGGED BY DV/EH

SECTION Michigan City Rd LOCATION , SEC. , TWP. , RNG. ,
Latitude 41.6206242, Longitude -87.5784571

COUNTY COOK DRILLING RIG D-50 ATV HAMMER TYPE AUTO
DRILLING METHOD HSA HAMMER EFF (%) 91.5

STRUCT. NO. ______
Station ______

BORING NO. BSB-06
Station 401+77.00
Offset 14.60ft RT
Ground Surface Elev. 614.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 595.5 ft ▼
Upon Completion N/A ft
After N/A Hrs. N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Stiff to Very Stiff Gray, Moist SILTY CLAY, trace sand (CL) *(continued)*				
570.50				
Stiff Gray, Moist SANDY CLAY, with silt, trace gravel (SC)		2		
		5	1.3	15
	-45	7	P	
565.50				
Very Stiff to Hard SILTY CLAY, trace gravel (CL/ML)		3		
		6	3.5	18
	-50	9	B	
		5		
		8	5.2	16
	-55	12	B	
		7		
		11	6.0	19
	-60	15	B	

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Stiff to Hard SILTY CLAY, trace gravel (CL/ML) *(continued)*				
		9		
		18	3.3	19
	-65	25	B	
545.50				
Hard Gray, Moist SILTY CLAY LOAM, trace gravel (ML/CL)		15		
		21	6.7	14
	-70	32	B	
540.50				
Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)		20		
		34	7.9	14
	-75	50/4"	B	
535.50				
Very Stiff to Hard Gray, Moist SILTY CLAY, with gravel (CL/ML)		50/5"		
			3.3	12
	-80		B	

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 7/31/23

ROUTE	Michigan City Rd	**DESCRIPTION**	Bridge Boring	**LOGGED BY**	DV/EH
SECTION	Michigan City Rd	**LOCATION**	, **SEC.** , **TWP.** , **RNG.** , **Latitude** 41.6206242, **Longitude** -87.5784571		
COUNTY	COOK	**DRILLING RIG**	D-50 ATV	**HAMMER TYPE**	AUTO
		DRILLING METHOD	HSA	**HAMMER EFF (%)**	91.5

STRUCT. NO.	
Station	
BORING NO.	BSB-06
Station	401+77.00
Offset	14.60ft RT
Ground Surface Elev.	614.00 ft
Surface Water Elev.	N/A ft
Stream Bed Elev.	N/A ft
Groundwater Elev.:	
First Encounter	595.5 ft ▼
Upon Completion	N/A ft
After N/A **Hrs.**	N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Stiff to Hard Gray, Moist SILTY CLAY, with gravel (CL/ML) *(continued)*					
		-85			
			50/3"		8
		-90			
		-95			
	515.50				
			50/4"		12
		-100			

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Extremely Dense Gray, Moist SILTY LOAM, with rock fragments (ML) *(continued)*					
		-105			
	508.00				
HIGHLY WEATHERED BEDROCK - Gray - Moist					
Auger Refusal at 108.5 feet	505.50				
End of Boring					
		-110			
		-115			
		-120			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
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SOIL BORING LOG

Date 10/26/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** DV

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6207222, **Longitude** -087.5783806

COUNTY COOK **DRILLING RIG** Mobile B57 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 89.0

STRUCT. NO. ____
Station ____

BORING NO. BSB-6A
Station 401+71.66
Offset 26.64ft LT
Ground Surface Elev. 614.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 590.5 ft ▼
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	Elev. (ft)	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
10 inches of Concrete	613.17				
8 inches of Aggregate Base	612.50		10 15 13		9
Brown, Moist FILL: SAND, with gravel	610.50				
Brown, Moist FILL: SAND, trace gravel		-5	5 7 7		8
			3 5 6		10
		-10	4 8 4		6
			1 1 1		8
	599.00	-15	1 1 2		9
Medium Dense to Dense Light Brown, Moist to Wet SAND, trace gravel (SP)			6 8 13		9
		-20	12 19 16		22
	593.00				
Medium Dense Gray, Wet SAND, trace gravel (SP)			11 8 3		25
	590.50 ▼				
Very Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)		-25	3 5 10	4.4 B	20
			5 5 9	5.0 B	19
		-30	4 4 7	5.8 B	20
		-35	5 7 10	4.2 B	20
		-40	3 4 7	3.5 B	20

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 10/26/23

ROUTE Michigan City Rd **DESCRIPTION** Bridge Boring **LOGGED BY** DV

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6207222, **Longitude** -087.5783806

COUNTY COOK **DRILLING RIG** Mobile B57 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 89.0

STRUCT. NO.
Station

BORING NO. BSB-6A
Station 401+71.66
Offset 26.64ft LT
Ground Surface Elev. 614.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 590.5 ft ▼
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Very Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*				
		3		
		4	3.8	21
	-45	5	B	
		3		
		5	3.5	17
	-50	6	B	
		5		
		6	5.0	16
	-55	10	B	
555.00		9		
		16	7.5	14
	-60	15	B	

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Hard Gray, Moist SILTY CLAY LOAM, trace gravel (ML/CL) *(continued)*				
550.50				
Hard to Very Hard		6		
Gray, Moist		8	5.0	18
SILTY CLAY, trace gravel (CL/ML)	-65	9	B	
		10		
		11	10.0	13
	-70	14	B	
540.50				
Very Hard		15		
Gray, Moist		33	10.8	13
SILTY CLAY LOAM, trace gravel (ML/CL)	-75	40	B	
Push Rock at 78.5 feet		50		
534.00	-80			
End of Boring				

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

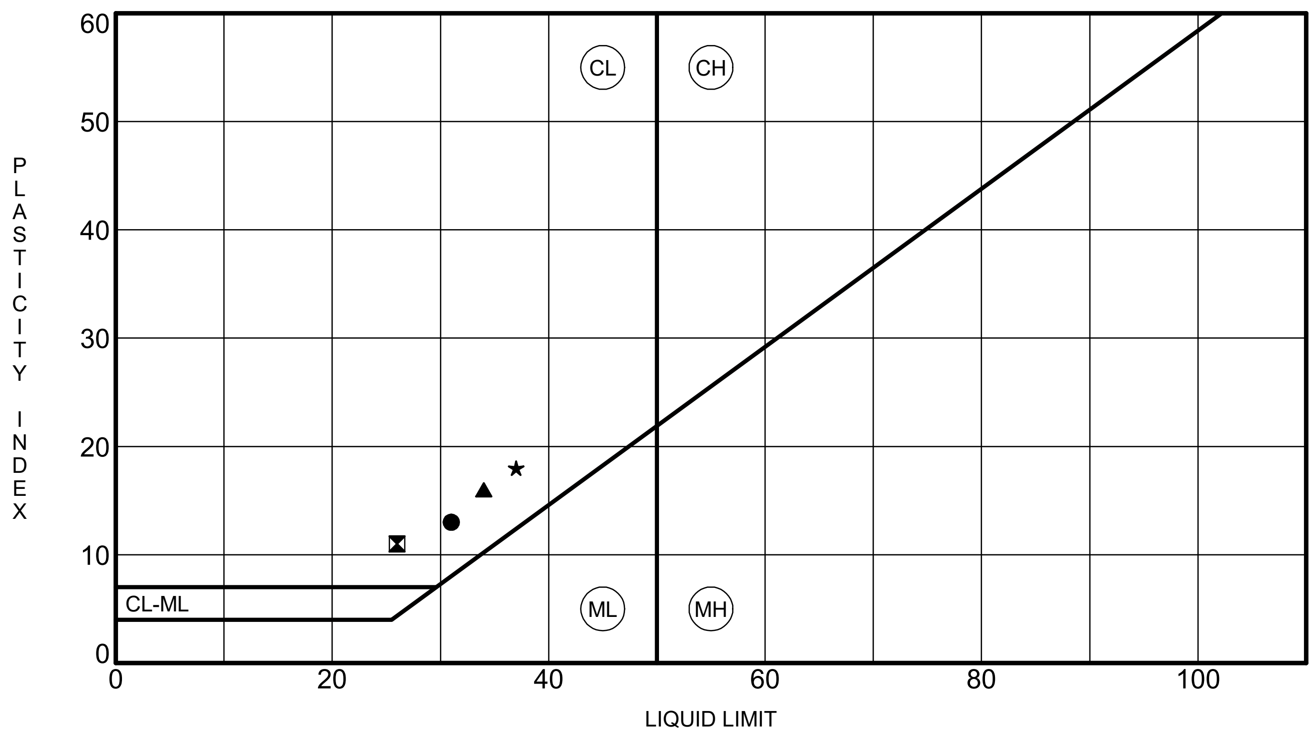
APPENDIX D

LABORATORY TEST RESULTS

& SUMMARY

Test Results – Atterberg Limits

Boring ID	Sample Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Soil Classification
BSB-01	28.5-30.0	31.0	18.0	13.0	CL/ML
BSB-02	43.5-45.0	26.0	15.0	11.0	CL/ML
BSB-04	13.5-15.0	34.0	18.0	16.0	CL/ML
BSB-06	21.0-22.5	37.0	19.0	18.0	CL/ML



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BSB-01**	**28.50**	**31.0**	**18.0**	**13.0**		
⧗	**BSB-02**	**43.50**	**26.0**	**15.0**	**11.0**		
▲	**BSB-04**	**13.50**	**34.0**	**18.0**	**16.0**		
★	**BSB-06**	**21.00**	**37.0**	**19.0**	**18.0**		

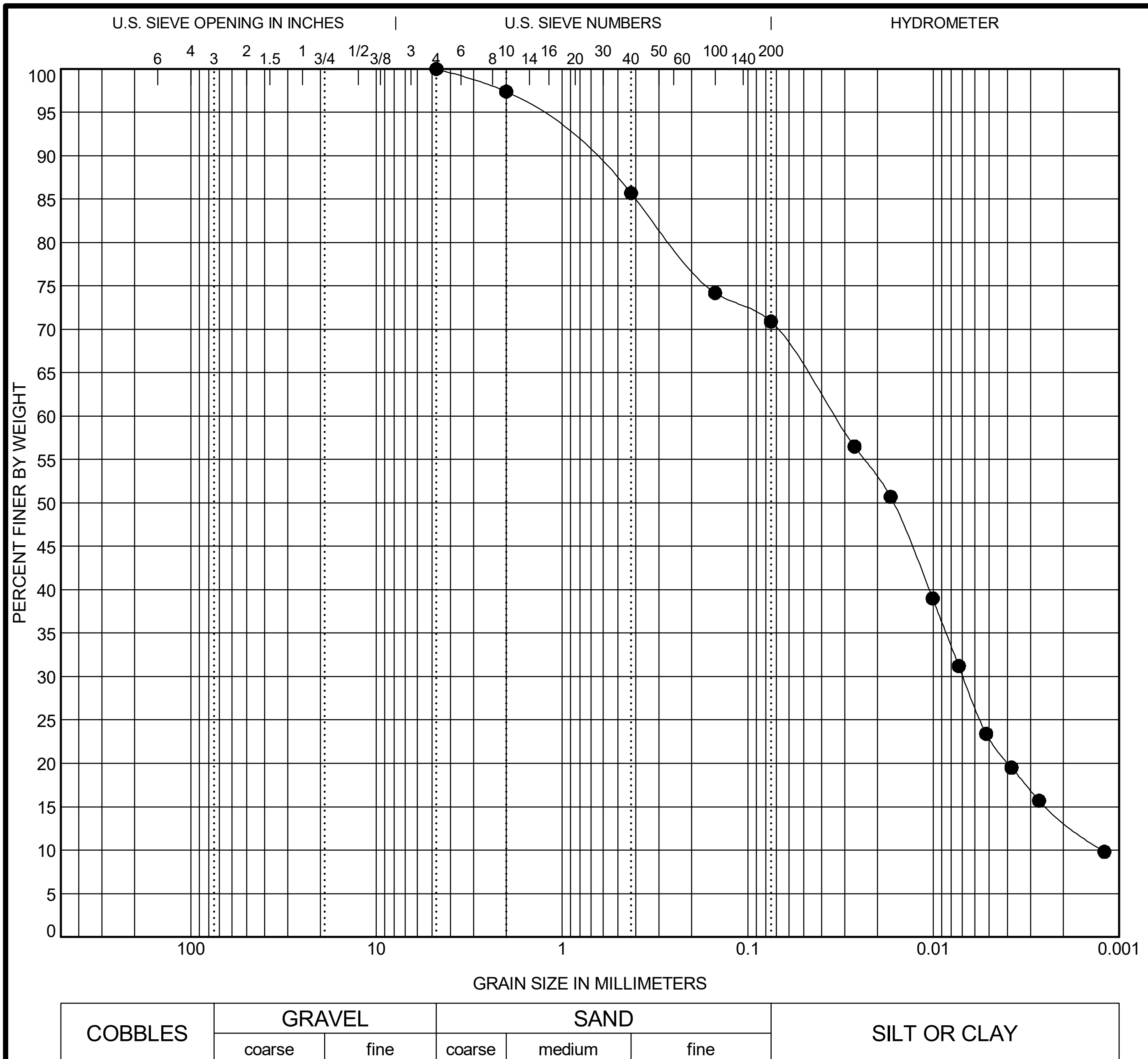
Illinois Department of Transportation
Division of Highways
GSG Consultants, Inc.

ATTERBERG LIMITS' RESULTS

Route: Michigan City Rd

Section: Michigan City Rd

County: COOK



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**BSB-01**	**73.50**	**SILTY LOAM**				**1.14**	**27.74**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BSB-01**	**73.50**	**4.75**	**0.034**	**0.007**	**0.001**	**0.0**	**29.1**	**70.9**	

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GRAIN SIZE DISTRIBUTION

Route: Michigan City Rd
Section: Michigan City Rd
County: COOK

GRAIN SIZE PTB 204-001 MICHIGAN CITY RD - NEW.GPJ IL DOT.GDT 9/14/23

APPENDIX E

IDOT PILE DESIGN TABLES

Pile Design Table for West Abutment utilizing Boring #BSB-02 with Downdrag

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Metal Shell 12"Φ w/.25" walls			
	161	14	37
	178	23	39
	196	34	42
	223	48	44
	282	81	49
	369	129	54
Metal Shell 14"Φ w/.25" walls			
	194	20	37
	213	30	39
	234	42	42
	267	60	44
	338	99	49
	447	159	54
Metal Shell 14"Φ w/.312" walls			
	194	20	37
	213	30	39
	234	42	42
	267	60	44
	338	99	49
	447	159	54
	566	224	59
Metal Shell 16"Φ w/.312" walls			
	202	12	34
	230	27	37
	250	38	39
	274	51	42
	313	73	44
	397	119	49
	529	192	54
Metal Shell 16"Φ w/.375" walls			
	202	12	34
	230	27	37
	250	38	39
	274	51	42
	313	73	44
	397	119	49
	529	192	54
	675	272	59
	767	322	64
Steel HP 8 X 36			
	90	16	37
	98	21	39
	108	26	42
	124	35	44
	159	54	49
	209	82	59
	221	88	64
	260	110	69
	268	114	79

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 10 X 42			
	97	13	34
	117	24	37
	126	29	39
	138	35	42
	159	47	44
	204	72	49
	264	105	59
	281	114	64
Steel HP 10 X 57			
	99	13	34
	120	25	37
	129	30	39
	141	36	42
	163	48	44
	209	74	49
	270	107	59
	287	117	64
	346	149	69
	348	150	79
	359	156	84
	369	162	89
	380	168	94
	413	186	99
	452	207	104
	454	208	108
Steel HP 12 X 53			
	116	15	34
	145	31	37
	159	39	39
	173	46	42
	201	62	44
	258	93	49
	328	132	59
	350	144	64
Steel HP 12 X 63			
	119	16	34
	148	32	37
	161	39	39
	175	47	42
	203	62	44
	260	94	49
	331	133	59
	354	145	64
	428	186	79
	441	193	84
	454	200	89
	466	207	94
Steel HP 12 X 74			
	121	17	34

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 12 X 84			
	123	17	34
	152	33	37
	166	41	39
	180	49	42
	209	65	44
	269	97	49
	341	137	59
	365	150	64
	441	192	79
	454	199	84
	467	207	89
	481	214	94
	526	239	99
	574	265	104
	664	315	108
Steel HP 14 X 73			
	141	20	34
	175	39	37
	199	51	39
	214	60	42
	250	80	44
	321	119	49
	402	163	59
	432	180	64
	520	228	69
	522	229	79
	537	238	84
	552	246	89
	567	254	94
Steel HP 14 X 89			
	112	3	32
	144	21	34
	179	40	37
	201	52	39
	217	61	42
	253	81	44
	326	121	49
	408	166	59
	438	182	64
	529	232	69
	529	233	79
	544	241	84
	559	249	89
	575	258	94
	634	290	99
	689	321	104
	705	329	108
Steel HP 14 X 102			
	114	4	32

Pile Design Table for West Abutment utilizing Boring #BSB-02 with Downdrag

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
	277	119	84		150	33	37		146	21	34
	285	124	89		164	40	39		181	40	37
					177	48	42		204	53	39
					206	64	44		220	62	42
					265	96	49		257	82	44
					336	135	59		331	123	49
					359	148	64		413	168	59
					435	189	79		443	185	64
					448	196	84		534	235	69
					461	203	89		536	236	79
					473	211	94		552	244	84
					518	235	99		567	253	89
					566	261	104		582	261	94
					589	274	108		642	294	99
									698	325	104
									810	386	108
								Steel HP 14 X 117			
									116	4	32
									149	22	34
									184	41	37

Pile Design Table for East Abutment utilizing Boring #BSB-06 with Downdrag

Pile	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Metal Shell 12"Φ w/.25" walls			
	183	2	41
	240	33	46
	298	65	51
Metal Shell 14"Φ w/.25" walls			
	220	5	41
	289	43	46
	358	81	51
Metal Shell 14"Φ w/.312" walls			
	220	5	41
	289	43	46
	358	81	51
	564	194	56
Metal Shell 16"Φ w/.312" walls			
	258	9	41
	340	55	46
	420	99	51
Metal Shell 16"Φ w/.375" walls			
	258	9	41
	340	55	46
	420	99	51
	680	242	56
Steel HP 8 X 36			
	106	4	41
	140	23	46
	173	41	51
	199	55	56
	215	64	61
	221	67	71
	265	91	76
	273	96	81
	282	101	86

Pile	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 10 X 42			
	136	8	41
	181	33	46
	222	56	51
	254	73	56
	275	85	61
	277	86	71
Steel HP 10 X 57			
	139	9	41
	185	34	46
	228	58	51
	260	75	56
	282	87	61
	283	88	71
	344	121	76
	354	127	81
	365	133	86
	376	139	91
	386	145	96
	421	164	102
	454	182	105
Steel HP 12 X 53			
	172	14	41
	229	46	46
	281	75	51
	319	95	56
	340	107	71
Steel HP 12 X 63			
	174	15	41
	232	47	46
	284	76	51
	322	97	56
	343	108	71
	423	152	76
	436	159	81
	449	166	86
	461	173	91
	474	180	96
Steel HP 12 X 74			
	176	15	41
	235	48	46
	289	77	51
	327	98	56
	348	110	71
	430	155	76
	443	162	81
	456	169	86
	468	176	91
	481	183	96
	529	209	102

Pile	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 12 X 84			
	179	16	41
	239	49	46
	294	79	51
	332	100	56
	353	112	71
	436	157	76
	449	164	81
	462	172	86
	475	179	91
	488	186	96
	537	213	102
	664	283	105
Steel HP 14 X 73			
	151	-12	36
	214	23	41
	287	63	46
	351	98	51
	395	122	56
	413	132	71
	516	189	76
	531	197	81
	546	206	86
	561	214	91
	576	222	96
Steel HP 14 X 89			
	153	-12	36
	217	23	41
	291	64	46
	356	100	51
	400	124	56
	418	134	71
	523	192	76
	538	200	81
	554	209	86
	569	217	91
	584	225	96
	646	259	102
	705	292	105
Steel HP 14 X 102			
	155	-12	36
	220	24	41
	295	66	46
	361	102	51
	406	126	56
	423	136	71
	530	195	76
	546	203	81
	561	212	86
	576	220	91

Pile Design Table for East Abutment utilizing Boring #BSB-06 with Downdrag

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
					589	242	105		591	228	96
									655	263	102
									792	339	105
								Steel HP 14 X 117			
									157	-12	36
									223	25	41
									300	67	46
									366	104	51
									411	128	56
									428	138	71
									537	198	76
									553	206	81
									568	215	86
									584	223	91
									599	232	96
									663	267	102
									806	345	105
								Precast 14"x 14"			
									215	-29	36

Pile Design Table for West Abutment utilizing Boring #BSB-02 with Precore

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Metal Shell 12"Φ w/.25" walls			
	64	35	32
	94	52	34
	116	64	37
	133	73	39
	151	83	42
	178	98	44
	237	130	49
	324	178	54
Metal Shell 14"Φ w/.25" walls			
	52	29	29
	81	44	32
	117	64	34
	142	78	37
	161	88	39
	182	100	42
	215	118	44
	286	157	49
	394	217	54
Metal Shell 14"Φ w/.312" walls			
	52	29	29
	81	44	32
	117	64	34
	142	78	37
	161	88	39
	182	100	42
	215	118	44
	286	157	49
	394	217	54
	513	282	59
Metal Shell 16"Φ w/.312" walls			
	64	35	29
	98	54	32
	142	78	34
	170	93	37
	190	104	39
	214	118	42
	253	139	44
	337	185	49
	469	258	54
	614	338	59
Metal Shell 16"Φ w/.375" walls			
	64	35	29
	98	54	32
	142	78	34
	170	93	37
	190	104	39
	214	118	42
	253	139	44
	337	185	49

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 10 X 42			
	61	33	34
	85	47	37
	102	56	39
	113	62	42
	135	74	44
	179	99	49
	240	132	59
	256	141	64
	312	172	69
	315	173	79
	326	179	84
Steel HP 10 X 57			
	63	35	34
	87	48	37
	104	57	39
	116	64	42
	138	76	44
	184	101	49
	245	135	59
	262	144	64
	321	176	69
	323	178	79
	333	183	84
	344	189	89
	355	195	94
	363	200	98
	388	213	99
	427	235	104
	454	250	108
Steel HP 12 X 53			
	73	40	34
	102	56	37
	128	71	39
	143	79	42
	171	94	44
	228	125	49
	299	164	59
	321	176	64
	386	213	69
	394	217	79
	407	224	84
Steel HP 12 X 63			
	75	41	34
	104	57	37
	131	72	39
	145	80	42
	173	95	44
	231	127	49
	302	166	59

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 12 X 84			
	78	43	34
	108	59	37
	134	74	39
	150	82	42
	179	98	44
	238	131	49
	311	171	59
	334	184	64
	405	223	69
	411	226	79
	424	233	84
	437	240	89
	450	247	94
	460	253	98
	496	273	99
	544	299	104
	664	365	108
Steel HP 14 X 73			
	58	32	32
	89	49	34
	123	68	37
	155	85	39
	179	98	42
	212	117	44
	281	155	49
	363	200	54
	367	202	59
	397	218	64
	468	257	69
	487	268	79
	502	276	84
	517	284	89
	532	293	94
	544	299	98
Steel HP 14 X 89			
	60	33	32
	91	50	34
	126	69	37
	158	87	39
	182	100	42
	216	119	44
	286	157	49
	370	203	54
	372	205	59
	402	221	64
	476	262	69
	494	272	79
	509	280	84
	524	288	89

Pile Design Table for West Abutment utilizing Boring #BSB-02 with Precore

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
	469	258	54		324	178	64		539	297	94
	614	338	59		395	217	69		551	303	98
	707	389	64		398	219	79		598	329	99
Steel HP 8 X 36					411	226	84		654	360	104
	78	43	39		424	233	89		705	388	108
	88	48	42		437	240	94	**Steel HP 14 X 102**			
	104	57	44		447	246	98		61	34	32
	139	76	49		481	264	99		93	51	34
	189	104	59	**Steel HP 12 X 74**					128	71	37
	201	111	64		77	42	34		160	88	39
	240	132	69		106	58	37		184	101	42
	248	136	79		133	73	39		218	120	44
	257	141	84		147	81	42		289	159	49
	265	146	89		176	97	44		375	206	54
	274	151	94		234	129	49		377	207	59
	281	154	98		306	168	59		408	224	64
					329	181	64		482	265	69
					400	220	69		501	275	79
					405	223	79		516	284	84
					418	230	84		531	292	89
					430	237	89		546	300	94
					443	244	94		559	307	98
					454	249	98		606	334	99
					488	268	99		662	364	104
					535	294	104		810	445	108
					589	324	108	**Steel HP 14 X 117**			
									63	35	32
									96	53	34
									131	72	37
									162	89	39
									187	103	42
									222	122	44
									294	162	49
									382	210	54
									382	210	59
									413	227	64
									490	270	69
									507	279	79
									523	287	84
									538	296	89
									553	304	94
									566	311	98
									615	338	99
									671	369	104
									834	459	108
								Precast 14"x 14"			
									66	36	29
									103	56	32

Pile Design Table for East Abutment utilizing Boring #BSB-06 with Precore

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Metal Shell 12"Φ w/.25" walls				**Steel HP 10 X 42**				**Steel HP 12 X 84**			
	70	38	36		52	28	36		68	37	36
	110	60	41		83	46	41		105	58	41
	167	92	46		127	70	46		160	88	46
	225	124	51		173	95	51		223	123	51
	384	211	56		205	113	56		271	149	56
Metal Shell 14"Φ w/.25" walls					226	124	61		292	161	71
	60	33	31		227	125	71		375	206	76
	83	46	36		287	158	76		388	214	81
	134	74	41		297	163	81		401	221	86
	203	112	46		308	169	86		414	228	91
	272	150	51		318	175	91		427	235	96
Metal Shell 14"Φ w/.312" walls					329	181	96		476	262	102
	60	33	31	**Steel HP 10 X 57**					577	317	105
	83	46	36		53	29	36	**Steel HP 14 X 73**			
	134	74	41		85	47	41		35	19	31
	203	112	46		130	71	46		81	45	36
	272	150	51		178	98	51		120	66	41
	478	263	56		210	116	56		184	101	46
Metal Shell 16"Φ w/.312" walls					232	128	61		258	142	51
	74	41	31		233	128	71		325	179	56
	98	54	36		293	161	76		343	189	71
	160	88	41		304	167	81		446	246	76
	242	133	46		315	173	86		461	254	81
	323	177	51		326	179	91		476	262	86
	582	320	56		336	185	96		491	270	91
Metal Shell 16"Φ w/.375" walls					371	204	102		506	278	96
	74	41	31		454	250	105		567	312	102
	98	54	36	**Steel HP 12 X 53**					578	318	105
	160	88	41		65	36	36	**Steel HP 14 X 89**			
	242	133	46		99	55	41		36	20	31
	323	177	51		152	83	46		82	45	36
	582	320	56		213	117	51		123	68	41
Steel HP 8 X 36					260	143	56		188	103	46
	66	36	41		281	155	71		263	144	51
	100	55	46		360	198	76		330	181	56
	133	73	51		373	205	81		347	191	71
	159	88	56		385	212	86		453	249	76
	175	96	61		398	219	91		468	257	81
	181	100	71		410	226	96		483	266	86
	225	123	76	**Steel HP 12 X 63**					498	274	91
	233	128	81		66	36	36		513	282	96
	242	133	86		102	56	41		575	316	102
	250	138	91		155	85	46		678	373	105
	259	142	96		218	120	51	**Steel HP 14 X 102**			
	283	156	102		263	144	56		38	21	31
	286	157	105		284	156	71		83	46	36
					364	200	76		125	69	41
					376	207	81		190	105	46
					389	214	86		266	146	51

Pile Design Table for East Abutment utilizing Boring #BSB-06 with Precore

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)		Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
					402	221	91		334	184	56
					415	228	96		352	193	71
					461	254	102		459	252	76
					497	273	105		474	261	81
				Steel HP 12 X 74					489	269	86
					67	37	36		505	278	91
					103	57	41		520	286	96
					157	87	46		583	321	102
					221	121	51		687	378	105
					267	147	56	**Steel HP 14 X 117**			
					288	158	71		39	22	31
					369	203	76		84	46	36
					382	210	81		127	70	41
					395	217	86		194	107	46
					408	224	91		270	149	51
					421	232	96		339	186	56
					468	258	102		356	196	71
					569	313	105		465	256	76
									480	264	81
									496	273	86
									511	281	91
									527	290	96
									591	325	102
									700	385	105
								Precast 14"x 14"			
									76	42	31
									106	58	36
									171	94	41
									259	142	46

APPENDIX F

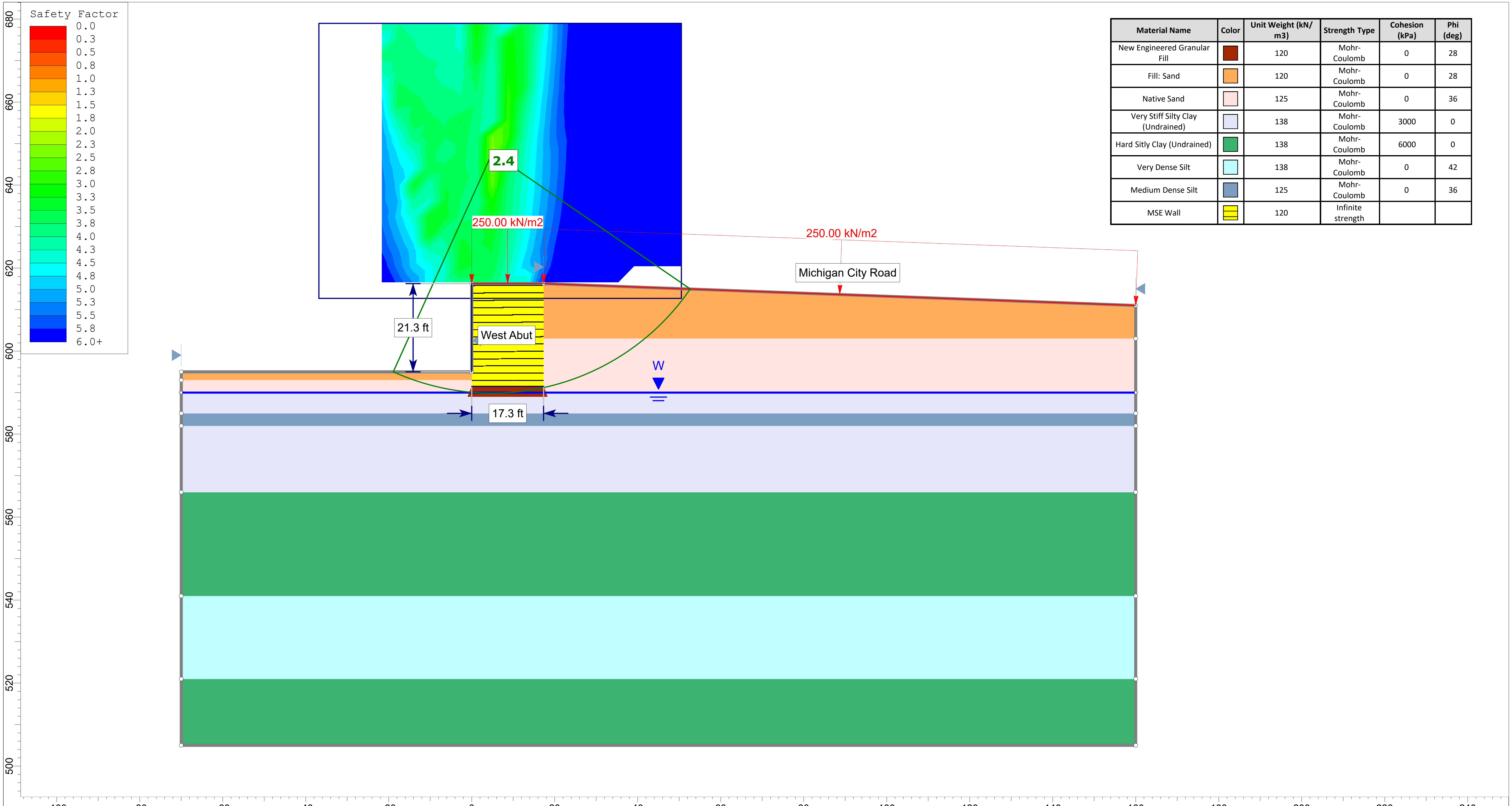
SOIL PARAMETER TABLE

Table G: Summary of Soil Parameters

Elevation Range (ft)	Soil Description	In situ Unit Weight γ (pcf)	Undrained		Drained		Active Earth Pressure Coefficient (K_a)	Passive Earth Pressure Coefficient (K_p)	At Rest Earth Pressure Coefficient (K_o)	Lateral Modulus of Subgrade Reaction (pci)	Soil Strain (ε_{50})
			Cohesion c (psf)	Friction Angle ϕ (°)	Cohesion c (psf)	Friction Angle ϕ (°)					
	New Engineered Clay Fill	125	1,000	0	100	28	0.41	2.46	0.58	500	0.007
	New Engineered Granular Fill	120	0	28	0	28	0.33	3.00	0.50	90	N/A
613.0-602.0	FILL: Brown Sand	120	0	28	0	28	0.36	2.77	0.53	60	N/A
602.0-590	Loose to Dense Light Brown Sand	125	0	36	0	36	0.26	3.85	0.41	60	N/A
590.0-566.0	Gray Medium Stiff to Hard Silty Clay	138	3,000	0	300	28	0.36	2.77	0.53	1,000	0.005
566.0-509.0	Gray Hard to Very Hard Silty Clay	138	6,000	0	600	28	0.36	2.77	0.53	2,000	0.004
608.0-606.5 **BSB-04 & BSB-05 Only**	Gray Medium Dense to Dense Silty Loam	131	0	41	0	41	0.25	4.02	0.40	90	N/A
589.0-585.0 **BSB-01, BSB-02 & BSB-04 Only**	Gray Medium Dense Silty Loam	125	0	36	0	36	0.31	3.25	0.46	60	N/A
537.0-528.0 **BSB-02 & BSB-04 Only**	Gray Very Dense Silty Loam	138	0	42	0	42	0.20	5.04	0.33	125	N/A
544.0-520.5 **BSB-01 Only**	Gray Very Dense Silty Loam	138	0	42	0	42	0.20	5.04	0.33	125	N/A
522-517.5 **BSB-04 Only**	Gray Very Dense Silty Loam	137	0	42	0	42	0.22	4.60	0.36	125	N/A

APPENDIX G

SLOPE STABILITY ANALYSES EXHIBITS



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Engineered Granular Fill		120	Mohr-Coulomb	0	28
Fill: Sand		120	Mohr-Coulomb	0	28
Native Sand		125	Mohr-Coulomb	0	36
Very Stiff Silty Clay (Undrained)		138	Mohr-Coulomb	3000	0
Hard Sitly Clay (Undrained)		138	Mohr-Coulomb	6000	0
Very Dense Silt		138	Mohr-Coulomb	0	42
Medium Dense Silt		125	Mohr-Coulomb	0	36
MSE Wall		120	Infinite strength		

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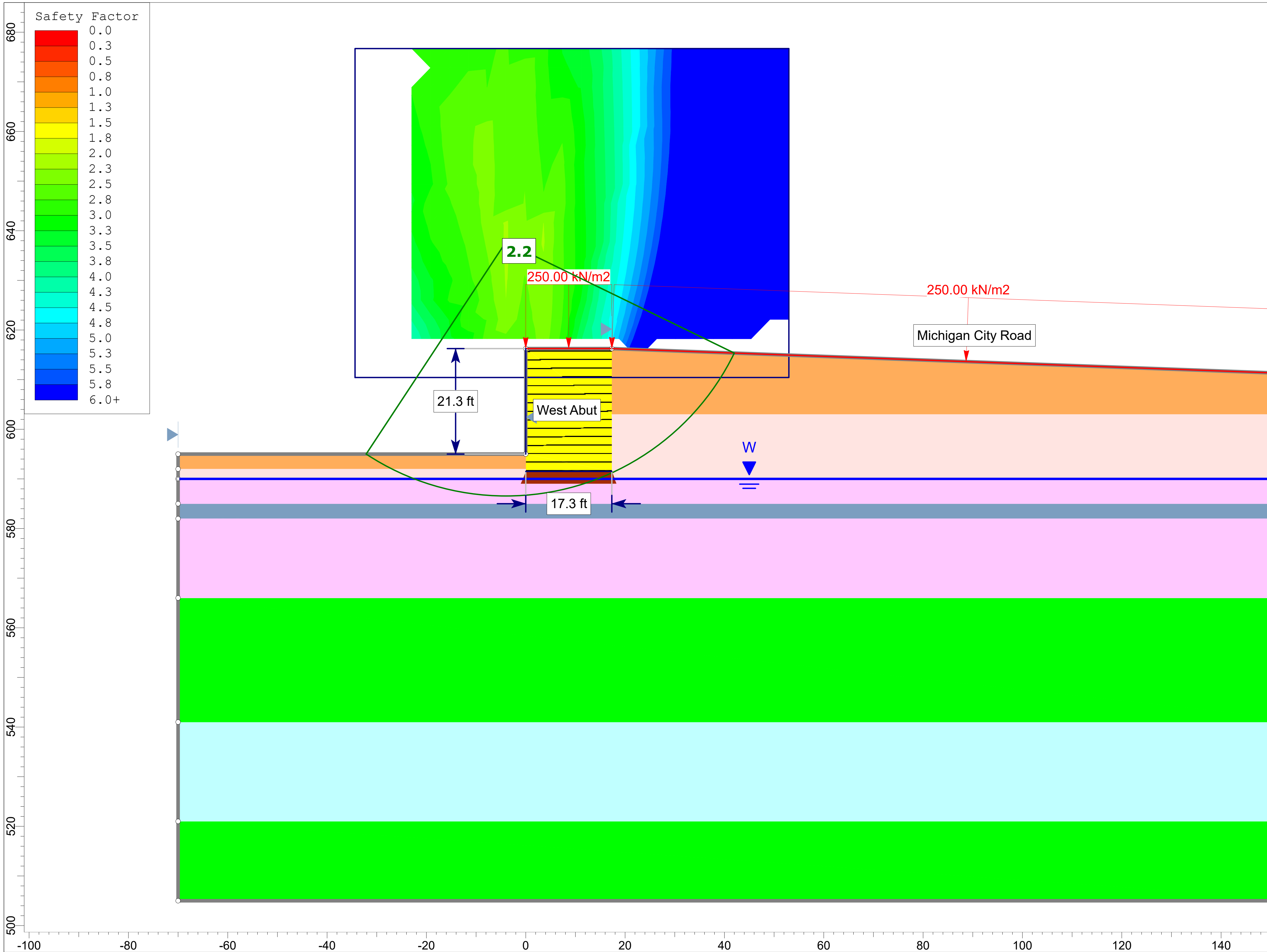
SLIDEINTERPRET 9.018

Project	Michigan City Road - West Retaining Wall		
Analysis Description	Exhibit A - Circular Failure - Undrained - Abutment		
Drawn By	AA	Company	GSG Consultants, Inc.
Date	8/31/2023, 8:33:02 AM	File Name	RW_West_Abut.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Engineered Granular Fill		120	Mohr-Coulomb	0	28
Fill: Sand		120	Mohr-Coulomb	0	28
Native Sand		125	Mohr-Coulomb	0	36
Very Dense Silt		138	Mohr-Coulomb	0	42
Medium Dense Silt		125	Mohr-Coulomb	0	36
Very Stiff Silty Clay (Drained)		138	Mohr-Coulomb	300	28
Hard Silty Clay (Drained)		138	Mohr-Coulomb	600	28
MSE Wall		120	Infinite strength		

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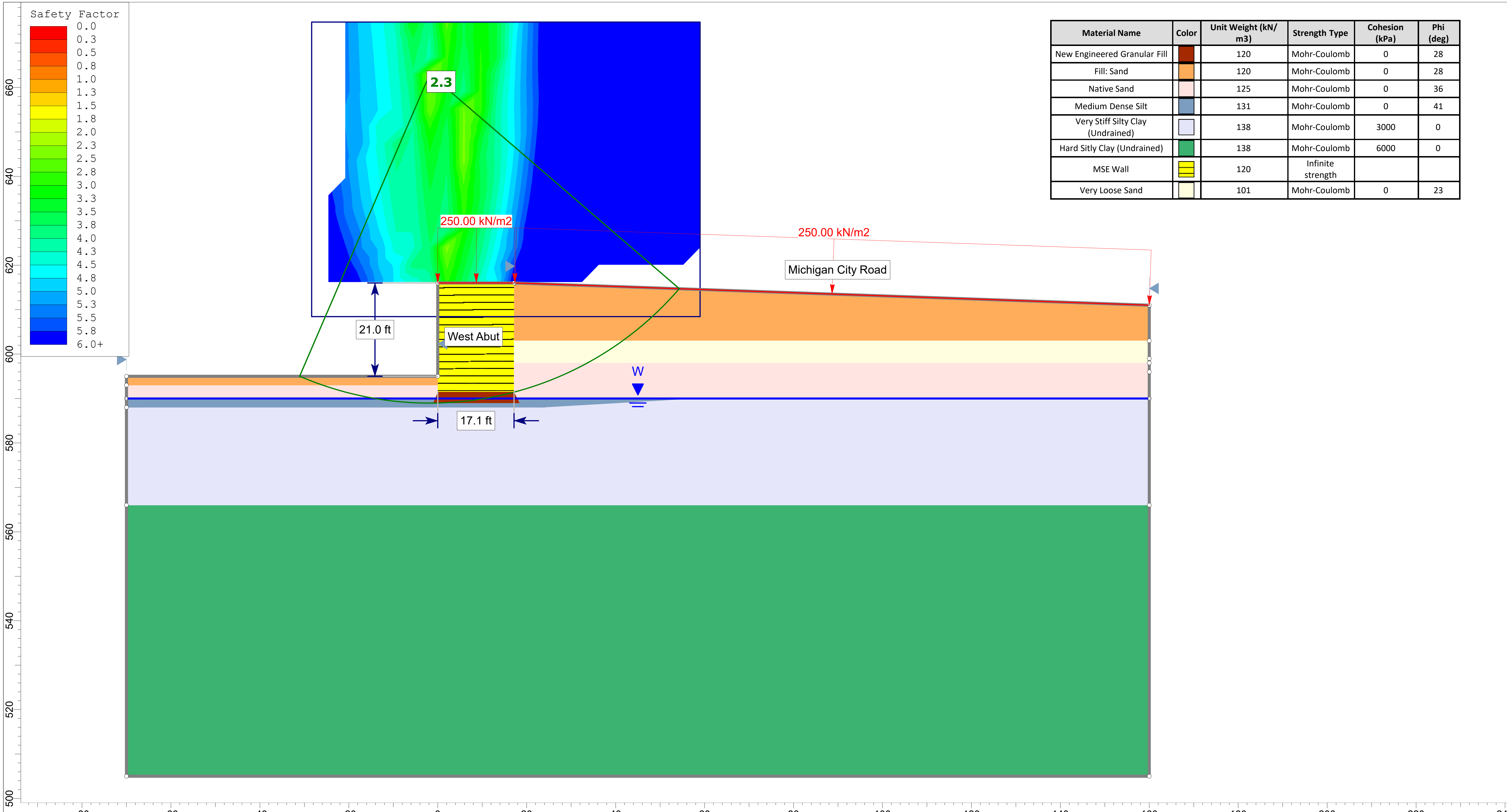
Project	Michigan City Road - West Retaining Wall		
Analysis Description	Exhibit B - Circular Failure - Drained - Abutment		
Drawn By	AA	Company	GSG Consultants, Inc.
Date	8/31/2023, 8:33:02 AM	File Name	RW_West_Abut.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Engineered Granular Fill		120	Mohr-Coulomb	0	28
Fill: Sand		120	Mohr-Coulomb	0	28
Native Sand		125	Mohr-Coulomb	0	36
Medium Dense Silt		131	Mohr-Coulomb	0	41
Very Stiff Silty Clay (Undrained)		138	Mohr-Coulomb	3000	0
Hard Sitly Clay (Undrained)		138	Mohr-Coulomb	6000	0
MSE Wall		120	Infinite strength		
Very Loose Sand		101	Mohr-Coulomb	0	23

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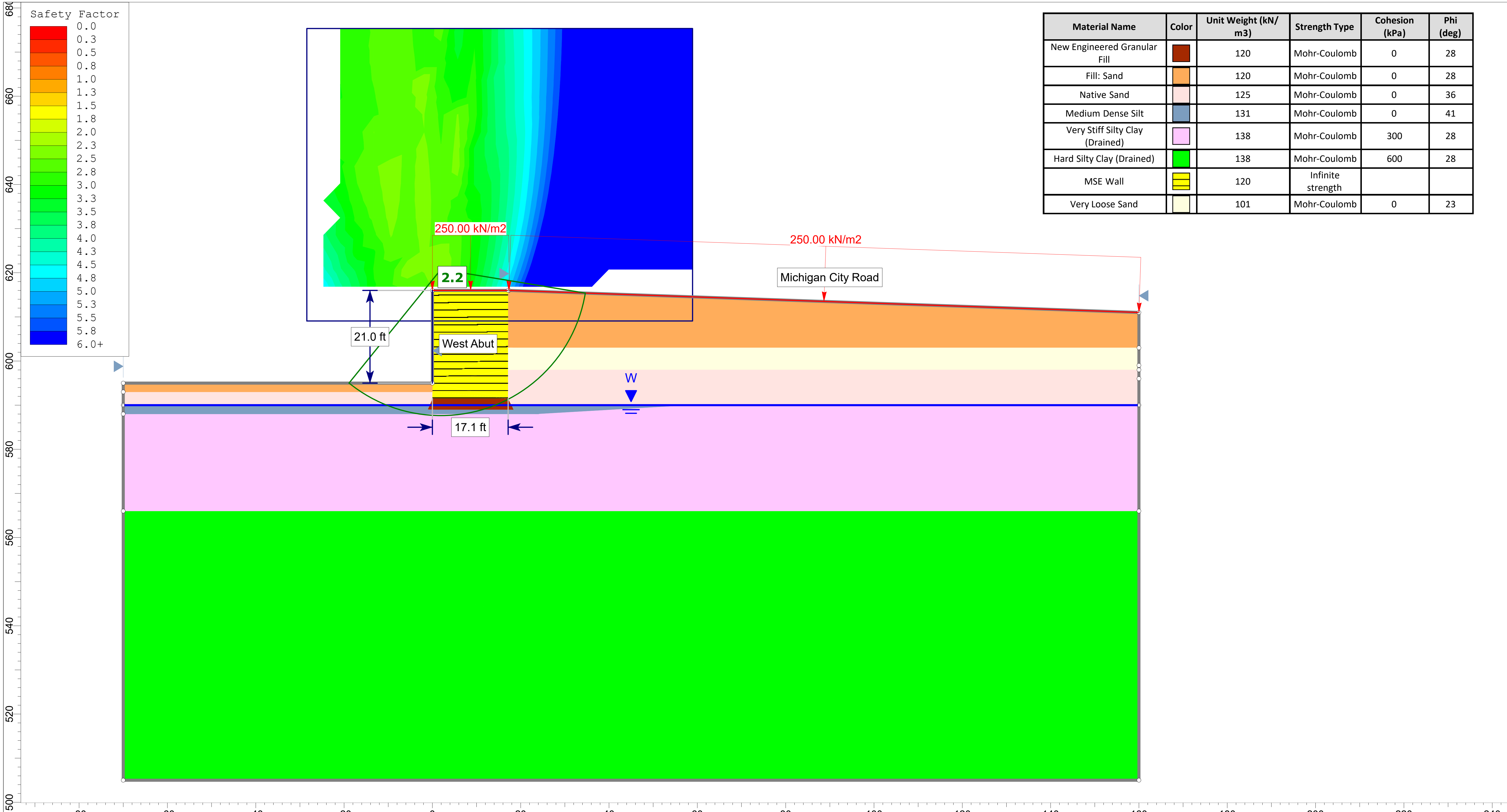
SLIDEINTERPRET 9.018

Project	Michigan City Road - East Retaining Wall
Analysis Description	Exhibit C - Circular Failure - Undrained - East Abutment
Drawn By	AA
Company	GSG Consultants, Inc.
Date	8/31/2023, 8:33:02 AM
File Name	RW_East_Abut.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Engineered Granular Fill		120	Mohr-Coulomb	0	28
Fill: Sand		120	Mohr-Coulomb	0	28
Native Sand		125	Mohr-Coulomb	0	36
Medium Dense Silt		131	Mohr-Coulomb	0	41
Very Stiff Silty Clay (Drained)		138	Mohr-Coulomb	300	28
Hard Silty Clay (Drained)		138	Mohr-Coulomb	600	28
MSE Wall		120	Infinite strength		
Very Loose Sand		101	Mohr-Coulomb	0	23

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SLIDEINTERPRET 9.018

Project	Michigan City Road - East Retaining Wall		
Analysis Description	Exhibit D - Circular Failure - Drained - East Abutment		
Drawn By	AA	*Company*	GSG Consultants, Inc.
Date	8/31/2023, 8:33:02 AM	*File Name*	RW_East_Abut.slmd