STRUCTURE GEOTECHNICAL REPORT

IL 15 over Big Muddy Overflow

Existing S.N. 041-0024
Proposed S.N. 041-2024

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STATE OF ILLINOIS

03/20/2023
Exp. 11/30/2024

Kaskaskia
Engineering Group, LLC

TABLE OF CONTENTS

EXHIBITS

1.0　PROJECT DESCRIPTION AND SCOPE

1.1　Introduction

The geotechnical study summarized in this report was performed by Kaskaskia Engineering Group, LLC (KEG) for a proposed bridge replacement carrying IL 15 over Big Muddy Overflow. The project is located near Mt. Vernon in Jefferson County, Illinois. The purpose of this report is to document subsurface geotechnical conditions, provide analyses of anticipated site conditions as they pertain to the project described herein, and to present design and construction recommendations for the proposed structure.

1.2　Project Description

The project consists of the removal and replacement of a single span bridge carrying IL 15 over Big Muddy Overflow. The existing structure was built in 1920 and modified in 1970. The bridge is 33 ft. long and 33 ft. – 6 in. wide. The general location of the proposed structure is shown on a Location Map, Exhibit A. The project is located about 4.2 miles west of Mt. Vernon, Illinois. The site lies within the limits of the Third Principal Meridian, (T. 2S, R. 2E) within the Mt. Vernon Hill County of the Till Plains Section of the Central Lowland Province.

1.3　Proposed Structure Information

The proposed structure (SN 041-2024) will consist of a triple box culvert. The individual boxes will each measure 12' (Span) x 5' (Height). The structure will measure 38 ft. wide, and 43 ft. out-to-out headwalls. The culvert will provide two 11ft. traffic lanes with 5 ft.-6 in. paved outside shoulders. The centerline of the structure will be located at station 1223+24.00 (F.A.P. Rte. 312). Further substructure details will be based on the findings of this SGR. A General Plan & Elevation (GP&E) is included as Exhibit C.

2.0　FIELD EXPLORATION

2.1　Subsurface Exploration and Testing

The site exploration plan was developed by Illinois Department of Transportation (IDOT) District 9 geotechnical personnel. A representative of Kaskaskia Engineering Group, LLC (KEG) did not conduct a site visit or observe the drilling operations.

Two (2) standard penetration test (SPT) borings designated 1-S and 2-S were drilled on May 10, 2022, and May 11, 2022, respectively. Table 2.1 shows the borings stationing, offset and surface elevation. The boring locations are shown on the Boring Plan, Exhibit B. Detailed information regarding the nature and thickness of the soils encountered and the results of the field sampling and laboratory testing are shown on the Boring Logs, Exhibit D. The soil profile for the above-mentioned borings can be found in Subsurface Profile, Exhibit E.

Table 2.1 - Boring Stations and Offsets

Designation	Stationing	Offset (ft.)	Surface Elevation (ft.)
1-S	1223+50	11.0 RT	437.9
2-S	1222+96	11.0 LT	437.9

2.2 Subsurface Conditions

The profiles at the two (2) boring locations exhibited layers of clays, silty/sandy clays, clayey silts, tills, and shales. Boring 1-S was drilled to a depth of 54.75 ft. below Ground Surface Elevation (GSE). While boring 2-S was only drilled to a depth of 41.0 ft. below the GSE. In both borings bedrock was encountered around 40 to 45 ft below the GSE. The bedrock consisted of weathered shale with N-values between 50/2" and 50/3" followed by a more hard and dry shale with minimum strength values of 65 tsf.

N-values in the **silty clay** layers typically ranged from weight of hammer (WOH) to 7 blows per foot (bpf), with field Rimac (Qu) strength values ranging from 0.0 to 1.4 tons per square foot (tsf) and moisture contents of 16 to 38 percent. The N-value in the **sandy loam** layer was 4 bpf with a moisture content of 27 percent. The N-value in the **clay** layer was 6 bpf, with a Qu of 1.2 tsf and a moisture content of 27 percent. N-values in the **silt** layers ranged from WOH to 5 bpf, with Qu's ranging from 0.0 to 1.1 tsf and moisture contents of 20 to 28 percent. N-values in the **till** layers ranged from 5 to 27 bpf, with Qu's ranging from 1.2 to 3.6 tsf and moisture contents of 15 to 18 percent. N-values in the **clay shale** layers ranged from 50/3" to 50/2" bpf and a moisture content of 12 percent.

2.3 Groundwater

Groundwater was encountered at the time of drilling in Boring 1-S at an elevation of 420.9 ft. (17 ft. below GSE) and in Boring 2-S at an elevation of 418.4 ft. (19.5 ft. below GSE). It should be further noted that the groundwater level is subject to seasonal and climatic variations, including the level of adjacent affluents.

3.0 GEOTECHNICAL EVALUATIONS

3.1 Settlement

Based on the borings completed for the proposed culvert and the nature of the soils encountered in the borings, estimates of settlement were necessary. Although the existing soils of the current culvert have most likely consolidated and settled over time in response to the current loading conditions, the proposed culvert will result in potential settlements during and after construction completion. Borings 1-S and 2-S were used for the settlement analysis. No specific consolidation testing was completed, and empirical methods were used for estimation of the settlement.

Table 3.1 shows the results for the settlement calculations for each boring, together with the time for 50 and 90 percent of consolidation.

Table 3.1 – Settlement Results Summary

Parameter	Boring 1-S	Boring 2-S
Settlement (in)	4.15	4.46
Differential settlement	0.31	
t50 (days)	266	811
t90 (days)	1104	3491

Based on the settlement results, it is recommended a working platform extending to a minimum elevation of El. 425.0 be considered to remove the soft settlement-prone soils from below the culvert box and wingwall foundations. Calculations are attached as Exhibit F - Settlement Calculations.

3.2   Slope Stability

Stability analysis using SLOPE/W was performed using the proposed structure geometry on the TS&L and soil characteristics from both borings. Two conditions were modeled for each scenario: end-of-construction and long-term stability. A critical factor of safety (FOS) was calculated for each condition. According to current standard of practice, the target FOS is 1.5 for end-of-construction and long-term slope stability.

To model the end-of-construction condition, full cohesion, and a friction angle of 0 degrees were assumed. Nominal values for cohesion were used with full friction angle to model the long-term condition to analyze the theoretical condition where pore water pressure has dissipated. Nominal values were between 50 and 100 psf for the cohesive soils, with friction angles between 26 and 30 degrees.

The Bishop Circular Method, which generates circular-shaped failure surfaces, was used to calculate the critical failure surfaces and FOS for the proposed conditions. The FOS obtained in the analysis is shown in Table 3.2. SLOPE/W program output from this analysis can be found in SLOPE/W Slope Stability Analysis, Exhibit G.

Table 3.2 – Slope Stability Critical FOS

Location (1V:2H Slope)	Critical FOS	
	End-of Construction	Long Term
Boring 1-S	2.4	2.9
Boring 2-S	3.3	2.9

The results of the analysis, as provided in Table 3.2, indicate an acceptable FOS will exist under all two analyzed conditions at all locations.

3.3   Seismic Considerations

Per the 2015 Geotechnical Manual (Revised 2020), seismic parameters are not required for buried structures, including box culverts.

4.0   FOUNDATION EVALUATIONS AND DESIGN RECOMMENDATIONS

4.1   Bearing Resistance

The soil encountered in the borings at the anticipated bearing elevation of the culvert and wingwalls consists of a very soft to stiff silty clay. The assumed bearing elevation at the bottom of the walls and culvert is El. 426.6 +/- ft. The soil characteristics from Boring 2-S at the assumed bearing elevation has an N-value of 7 bpf and a UCS of 1.1 tsf. The calculated allowable bearing resistance, using an LRFD Factor of 0.5, at the approximate bottom elevation of the culvert (El. 426.6), is estimated to be 3,300 psf. Sliding resistance is calculated as the lessor of the cohesion or one half of the vertical stress. See Exhibit H for calculations performed.

Table 4.1 – Factored Bearing and Sliding Resistances

Factored Bearing Resistance (psf)	Factored Sliding Resistance (psf)
3,300	720

The soils are sufficient for support of the wingwalls and the proposed box culvert from a bearing resistance point of view. However, based on the settlement results, it is recommended a working platform extending to a minimum elevation of El. 425.0 be considered to remove the soft settlement-prone soils.

If after final design the bearing elevation changes, KEG should be informed to review that the above recommendations still apply.

5.0   CONSTRUCTION CONSIDERATIONS

5.1   Construction Activities

Construction activities should be performed in accordance with the current IDOT Standard Specifications for Road and Bridge Construction and any pertinent Special Provisions or Policies.

Should any design considerations assumed by KEG change, KEG should be contacted to determine if the recommendations stated in this report still apply.

5.2   Temporary Sheeting and Soil Retention

Temporary shoring may be required at various stages of this project, due to the proposed staged-construction layout shown in the TS&L. Temporary Soil Retention Systems may be required for support of any required Stage construction for retained heights greater than 15 feet and the pay item for Temporary Soil Retention System should be included in the plans.

5.3   Site and Soil Conditions

Provisions of the Standard Specifications should adequately address site and soil conditions.

6.0   COMPUTATIONS

Computations and analyses for specific circumstances, if any, are included as exhibits. Please refer to each section of the report for reference to the exhibit containing any such calculations or analysis used.

7.0   GEOTECHNICAL DATA

Soil boring logs can be found in Exhibit D. The Subsurface Profiles can be found in Exhibit E.

8.0   LIMITATIONS

The recommendations provided herein are for the exclusive use of Veenstra & Kimm Inc. and the Illinois Department of Transportation (IDOT) District 9. They are specific only to the project described and are based on the subsurface information obtained by IDOT at two boring locations within the structure area, KEG's understanding of the project as described herein, and geotechnical engineering practice consistent with the standard of care. No other warranty is expressed or implied. KEG should be contacted if conditions encountered during construction are not consistent with those described.

EXHIBIT A

LOCATION MAP
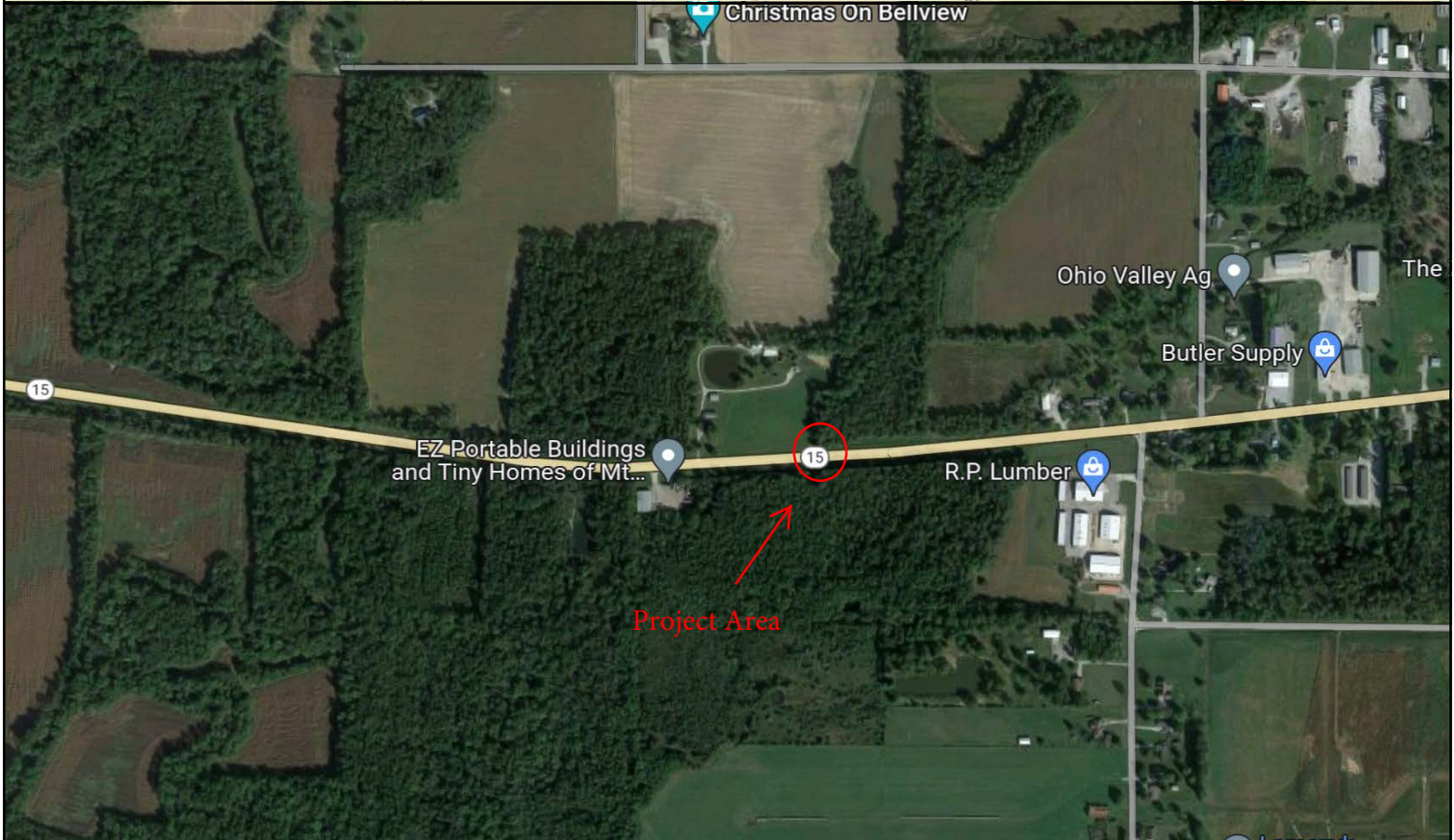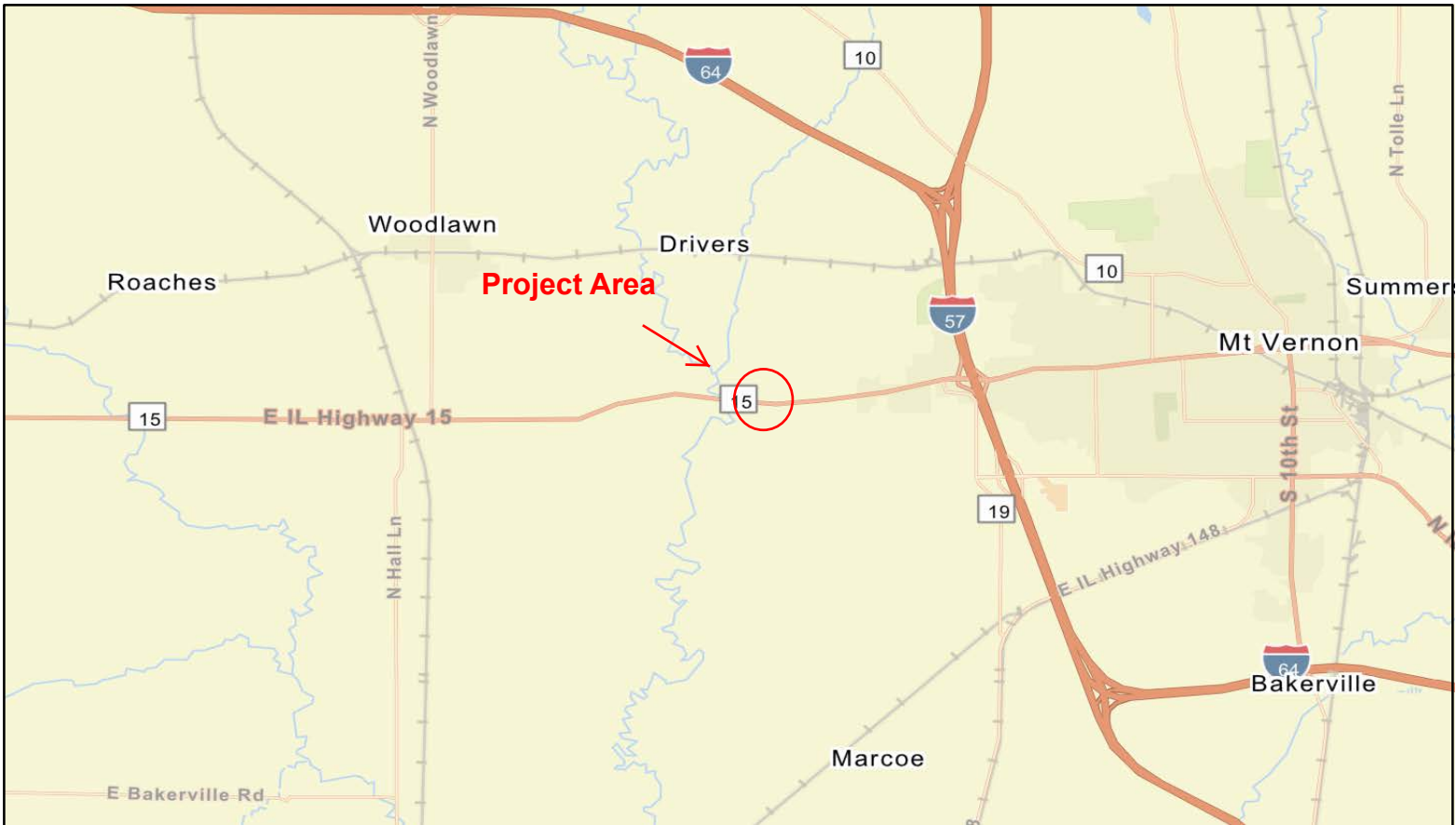
Project Area

Project Area

	LOCATION MAP	**Exhibit No.**
Kaskaskia Engineering Group, LLC	IL 15 over Big Muddy Overflow SN 041-0024 (Ex.) Section: 13B-3 Jefferson County, Illinois	**A** KEG JOB #22-1060.02

EXHIBIT B

BORING PLAN

2-S

1-S

15

15

15

BORING PLAN
IL 15 over Big Muddy Overflow
SN 041-0024 (Ex.)
Section: 13B-3
Jefferson County, Illinois

Exhibit No.

B

KEG JOB #22-1060.02

EXHBIT C

GENERAL PLAN AND ELEVATION (GP&E)

LONGITUDINAL SECTION

43'-0"

21'-6" | 21'-6"

1'-6" | 3'-6" | 5'-6" Shldr. | 11'-0" Lane | 11'-0" Lane | 5'-6" Shldr. | 3'-6" | 1'-6"

22'-0" | 21'-0"

Stage II Construction | Stage I Construction

Stage II Removal | Stage I Removal

9"

P.G. — ℄ Rdwy.

14.5"

4.0% | 1.5% | 1.5% | 4.0%

Steel Railing, Type CO-10 (Typ.)

U.S.F.L. El. 430.90
U.S. Invert El. 430.65
Stage Removal Line
Stage Construction Line
D.S. Invert El. 430.25
D.S.F.L. El. 430.50

5'-0"

Limits of Removal & Disposal of Unsuitable Material for Structures

SECTION THRU BARREL

Sta. 1223+94 El. 438.08
10" PCC Pavement
Phoebe Nesting Site, Typ. (D.S. End Only)
Membrane Waterproofing System for Buried Structures and Geocomposite Wall Drain
Sta. 1223+54 El. 438.08

6" | 12'-0" | 6" | 12'-0" | 6" | 12'-0" | 6"

5'-0"

Const. Jt. Typ.

1:1 | 1:1

Rock Fill – Foundation

3'-0" Typ.

(Culvert top and bottom slab thickness is subject to refinement during final design.)
(Existing bridge foundation within the limits of the proposed construction to be removed.)
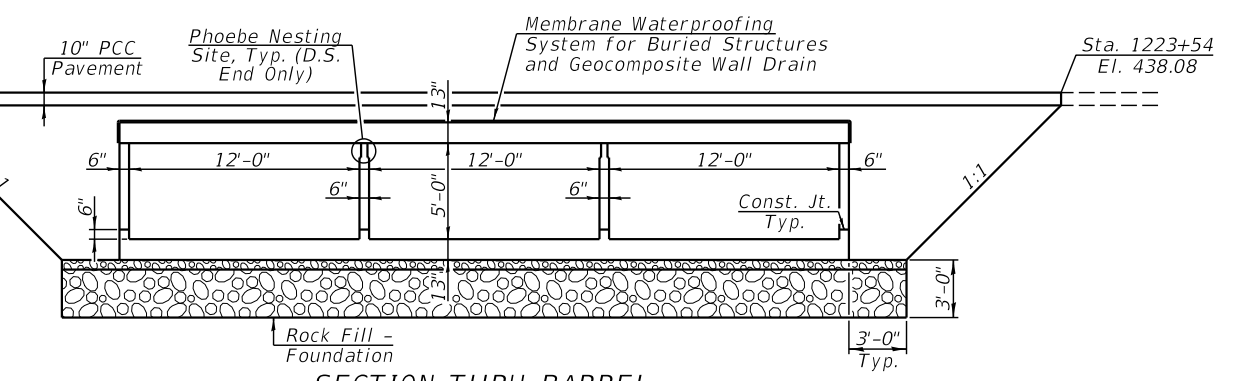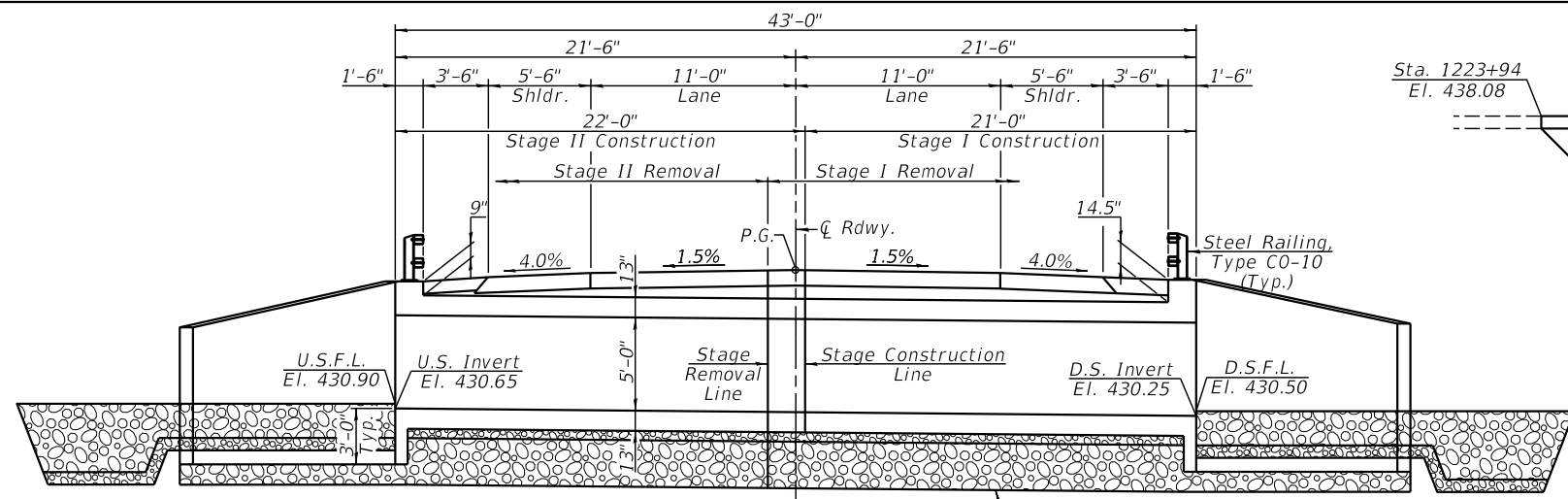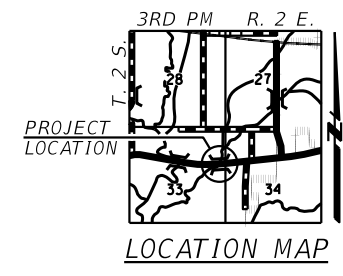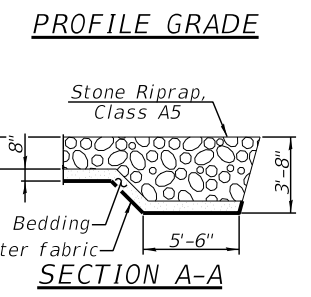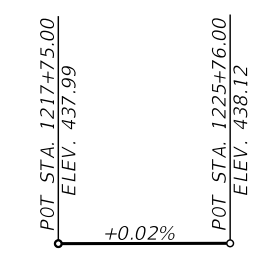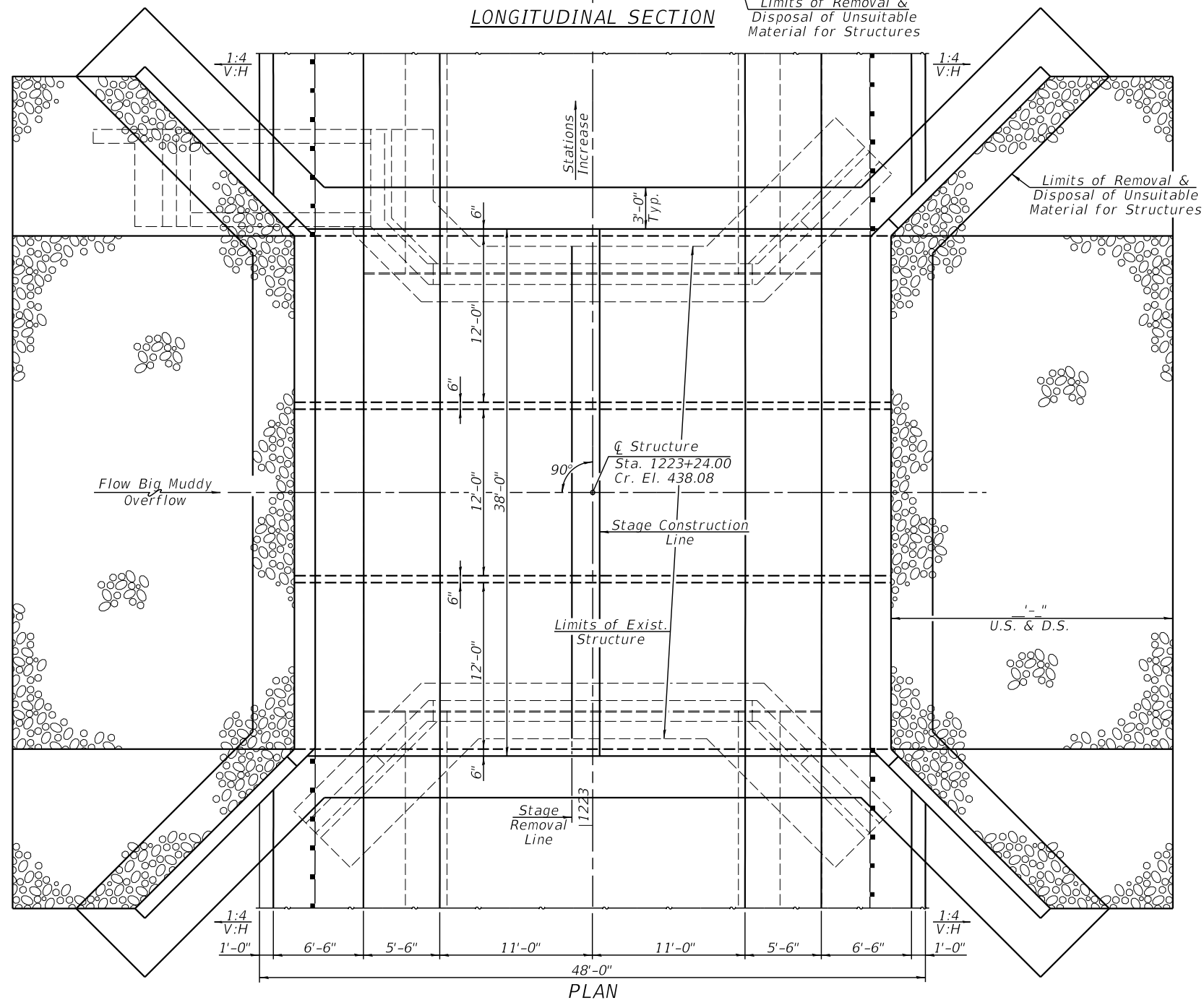
WATERWAY INFORMATION

Drainage Area = ___ Sq. Mi.

Exist. Overtopping Elev. = ____ @ Sta. _____
Prop. Overtopping Elev. = ____ @ Sta. _____

Flood	Freq. Yr.	Q C.F.S.	Opening Sq. Ft. Exist.	Opening Sq. Ft. Prop.	Nat. H.W.E.	Head – Ft. Exist.	Head – Ft. Prop.	Headwater El. Exist.	Headwater El. Prop.
	10								
Design	50								
Base	100								
Overtop Exist.	N/A								
Overtop Prop.	N/A								
Max. Calc.	500								

10 Yr. Outlet Velocity through Exist. Structure = ___ ft/s
10 Yr. Outlet Velocity through Prop. Structure = ___ ft/s

PLAN

1:4 V:H | 1:4 V:H

Stations Increase

3'-0" Typ.

12'-0"
6"
12'-0"
6"
12'-0"

38'-0"

Limits of Removal & Disposal of Unsuitable Material for Structures

Flow Big Muddy Overflow

℄ Structure
Sta. 1223+24.00
Cr. El. 438.08

90°

Stage Construction Line

Limits of Exist. Structure

U.S. & D.S.

Stage Removal Line

1223

1:4 V:H | 1:4 V:H

1'-0" | 6'-6" | 5'-6" | 11'-0" | 11'-0" | 5'-6" | 6'-6" | 1'-0"

48'-0"

PROFILE GRADE

POT STA. 1217+75.00 ELEV. 437.99
POT STA. 1225+76.00 ELEV. 438.12

+0.02%

SECTION A-A

Stone Riprap, Class A5

8"
1'-10"
3'-8"

Bedding
Filter fabric

5'-6"

LOCATION MAP

3RD PM   R. 2 E.
T. 2 S.
PROJECT LOCATION
34

HIGHWAY CLASSIFICATION

F.A.P. Rte. 312 – IL Rte. 3
Functional Class: Other Principal Arterial
ADT: 2630 (2020); 2900 (2030)
ADTT: 415 (2020); 460 (2030)
DHV: 235 (2020)
Design speed: 55 MPH
Posted Speed: 55 MPH
Two Way Directional Dist.: 50/50

LOADING HL-93

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

DESIGN SPECIFICATIONS

2020 AASHTO LRFD Bridge Design Specifications, 9th Edition

DESIGN STRESSES

FIELD UNITS

f'c = 3,500 psi
f'c = 4,500 psi (Top Slab & Headwalls)
fy = 60,000 psi (Reinforcement)

GENERAL PLAN & ELEVATION
IL. ROUTE 15 OVER
BIG MUDDY OVERFLOW
F.A.P. RTE 821 – SECTION
JEFFERSON COUNTY
STATION 1223+24
STRUCTURE NO.

USER NAME = ___		
PLOT SCALE = ___		
PLOT DATE = ___		

DESIGNED – ___	REVISED – ___
CHECKED – ___	REVISED – ___
DRAWN – ___	REVISED – ___
CHECKED – ___	REVISED – ___

**STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION**

GENERAL PLAN & ELEVATION

SHEET NO. ___ OF ___ SHEETS

F.A.P. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
821		JEFFERSON		

CONTRACT NO.

ILLINOIS FED. AID PROJECT

EXHIBIT D

BORING LOGS

Illinois Department of Transportation

Division of Highways
District 9

SOIL BORING LOG

Date 5/10/22

ROUTE IL 15   **DESCRIPTION** IL 15 over Big Muddy Overflow   **LOGGED BY** L. Estel

SECTION 13B-3   **LOCATION** 9 miles E of Washington Co. Line (Near E. Abut.), **SEC.** 33, **TWP.** 2S, **RNG.** 2E, **PM**

COUNTY Jefferson   **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE=86.5%)

STRUCT. NO. 041-0024
Station 1223+24

BORING NO. 1-S
Station 1223+50
Offset 11.0ft Rt
Ground Surface Elev. 437.9 ft

Surface Water Elev. _____ ft
Stream Bed Elev. 430.6 ft

Groundwater Elev.:
▽ **First Encounter** 420.9 ft
▼ **Upon Completion** _____ ft
▼ **After** _____ **Hrs.** _____ ft

DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)	Description	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
				Cored Pavement		1 / 2	0.9 B	26
				M. Stiff Brown with spots of Grey, Moist SILTY CLAY (continued)				
436.65								
				Stiff Grey, Moist SILT				
	1 / 3 / 2	1.1 B	20			1 / 1 / 2	0.7 B	27
433.40					413.40			
-5	WOH / WOH / WOH	0.15 B	27	V. Soft Grey, V. Moist SILT 80% Fines <#200, LL 26, PI 7 (Estimated based on visual ID and historical database)	-25	1 / 2 / 3	1.4 B	24
				Stiff Brown with specks of Red, Moist SILTY CLAY				
	WOH / WOH / WOH	0 B	28			1 / 2 / 3	1.2 B	22
					408.40			
-10	1 / 2 / 2	0.2 S	27		-30	WOH / WOH / WOH	0.5 B	28
				M. Stiff Grey, Moist SILT 80% Fines <#200, LL 26, PI 7 (Estimated based on visual ID and historical database)				
425.90					405.90			
	1 / 1 / 3	1.2 B	24	Stiff Grey and mottled Brown, Moist SILTY CLAY		1 / 2 / 4	1.2 B	27
				Stiff Grey, Moist CLAY				
423.40					403.40			
-15	WOH / 1 / 1	0.2 B	25	V. Soft Grey and mottled Brown, Moist SILTY CLAY	-35	1 / 2 / 2		27
				V. Loose dark Grey, Moist SANDY LOAM 4% f. GRAVEL & c. SAND, 16% m. SAND, 46% f. SAND, 24% SILT, 10% CLAY, LL = 23, PI = 6 (Lab 32)				
▽ 420.90					400.90			
	1 / 1 / 2	0 B	23	V. Soft Brown and dark Brown, V. Moist SILT 80% Fines <#200, LL 26, PI 7 (Estimated based on visual ID and historical database)				
				(Washed - 6 ft of blow in) M. Stiff Grey, V. Moist SILTY CLAY		1 / 1 / 3	0.8 B	38
418.40					398.40			
-20	1				-40	1		

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206) BBS, from 137 (Rev. 8-99)

Illinois Department of Transportation

Division of Highways
District 9

SOIL BORING LOG

Date 5/10/22

ROUTE IL 15   **DESCRIPTION** IL 15 over Big Muddy Overflow   **LOGGED BY** L. Estel

SECTION 13B-3   **LOCATION** 9 miles E of Washington Co. Line (Near E. Abut.), **SEC.** 33, **TWP.** 2S, **RNG.** 2E, **PM**

COUNTY Jefferson   **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE=86.5%)

STRUCT. NO. 041-0024					
Station 1223+24					

Surface Water Elev. _____ ft
Stream Bed Elev. 430.6 ft

BORING NO. 1-S
Station 1223+50
Offset 11.0ft Rt
Ground Surface Elev. 437.9 ft

Groundwater Elev.:
▽ **First Encounter** 420.9 ft
▼ **Upon Completion** _____ ft
▼ **After** _____ **Hrs.** _____ ft

DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
M. Stiff Grey, Moist SILTY CLAY with a 4" dark Grey SAND Layer *(continued)*	2 / 2	0.8 B	16
393.40 / 393.15 — Hard Grey, Dry CLAY SHALE — -45	50/3"		
Borehole continued with rock coring.			
Bottom of hole @ 54.75 ft			
To convert "N" values to "N60", multiply by 1.44; Hammer Efficiency = 86.5%			
Ground surface elevation referenced to IP&C 4100243 at Sta 1223+45, 22 ft Lt; EL. 436.72			

Depth markers: -45, -50, -55, -60

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206) BBS, from 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
District 9

ROCK CORE LOG

Date __5/10/22__

ROUTE __IL 15__   **DESCRIPTION** __IL 15 over Big Muddy Overflow__   **LOGGED BY** __L. Estel__

SECTION __13B-3__   **LOCATION** __9 miles E of Washington Co. Line (Near E. Abut.)__, **SEC.** 33, **TWP.** 2S, **RNG.** 2E, **PM**

COUNTY __Jefferson__   **CORING METHOD** __Conventional rotary with polymer modified water__

STRUCT. NO. __041-0024__
Station __1223+24__

BORING NO. __1-S__
Station __1223+50__
Offset __11.0ft Rt__
Ground Surface Elev. __437.9__ ft

CORING BARREL TYPE & SIZE __NV3 5FT NWJ__
Core Diameter __1.78__ in
Top of Rock Elev. __393.15__ ft
Begin Core Elev. __393.15__ ft

Description	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Hard Grey, Dry CLAY SHALE 393.15	-45	1	89	34	26	
						65
388.15	-50	2	100	98	21	87.7
						199.9
						223.6
Hard Grey, Dry CLAY SHALE 383.15	-55					226.2
	-60					

Bottom of hole @ 54.75 ft

To convert "N" values to "N60", multiply by 1.44; Hammer Efficiency = 86.5%

Ground surface elevation referenced to IP&C 4100243 at Sta 1223+45, 22 ft Lt; EL. 436.72

Color pictures of the cores __Yes, attached__
Cores will be stored for examination until __5 Years after Construction__
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)
RQD is the ratio of the total length of sound core specimens >4" to total length of core run

BBS, form 138 (Rev. 8-99)

Illinois Department of Transportation
District Nine Materials
Unconfined Compressive Strength

Route:	15	**Lab#:**	34	
County:	Jefferson	**Date Drilled:**	5/10/2022	
Structure:	041-0024	**Boring:**	1-S	

Boring	Specimen #	Thickness (in.)	L/D Ratio	Depth	Load (lbs)	USC (psi)
1-S	1	3.9	2.2	48'	2,245	903
1-S	2	3.9	2.2	50'-6"	3,030	1,218
1-S	3	3.8	2.1	51'-6"	6,905	2,776
1-S	4	3.9	2.2	53'-6"	7,725	3,106
1-S	5	3.9	2.2	54'-3"	7,815	3,142

*Desirable specimen length to diameter (L/D) ratios are between 2.0:1 and 2.5:1. The results may differ from results obtained from a test specimen that meets the requirements.

Core diameter = 1.78 in.

Illinois Department of Transportation
Division of Highways — District 9

SOIL BORING LOG

Date 5/11/22

ROUTE IL 15 **DESCRIPTION** IL 15 over Big Muddy Overflow **LOGGED BY** L. Estel

SECTION 13B-3 **LOCATION** 9 miles E of Washington Co. Line (Near W. Abut.), **SEC.** 33, **TWP.** 2S, **RNG.** 2E, **PM**

COUNTY Jefferson **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE=86.5%)

STRUCT. NO. 041-0024
Station 1223+24

BORING NO. 2-S
Station 1222+96
Offset 11.0ft Lt
Ground Surface Elev. 437.9 ft

Surface Water Elev. _____ ft
Stream Bed Elev. 430.6 ft

Groundwater Elev.:
▽ **First Encounter** 418.4 ft
▼ **Upon Completion** _____ ft
▼ **After** _____ **Hrs.** _____ ft

Left column

DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)	Description
				Cored Pavement
				436.65
	1			Soft Brown and Tan, Moist SILTY CLAY
	1	0.3 B	25	
	1			
				433.40
-5	WOH			V. Soft Brown and Tan, V. Moist SILTY CLAY
	WOH	0 B	29	
	WOH			
	WOH			
	WOH	0 B	29	
	WOH			
				428.40
-10	1			M. Stiff Grey, Moist SILT
	1	0.8 B	22	80% Fines <#200, LL 26, PI 7
	3			(Estimated based on visual ID and historical database)
				425.90
	1			Stiff Grey with specks of Brown, Moist SILTY CLAY
	3	1.1 B	22	
	4			
				423.40
-15	1			Soft Grey and Brown, Moist SILTY CLAY
	2	0.25 B	25	
	3			
	WOH			
	WOH	0.25 B	26	
	2			
▽				418.40
-20	1			

Right column

DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)	Description
	1	0.5 B	26	M. Stiff Brown and Grey, Moist SILTY CLAY (continued)
	2			
	WOH			
	1	0.7 B	26	
	2			
				413.40
-25	WOH			Stiff Brown and Grey, Moist SILTY CLAY
	1	1.0 B	22	
	3			
				410.90
	WOH			Soft Brown and Grey, Moist SILTY CLAY
	1	0.4 B	20	
	2			
				408.40
-30	1			Stiff Grey, Moist CLAY - CLAY TILL with GRAVEL
	3	1.2 B	17	
	4			
	WOH			
	2	1.2 B	18	
	3			
				403.40
-35	5			V. Stiff Grey, Moist CLAY - CLAY TILL
	7	3.1 B	17	
	10			
	6			
	15	3.6 S	15	
	12			
-40	16			397.90

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206) BBS, from 137 (Rev. 8-99)

Illinois Department of Transportation

Division of Highways
District 9

SOIL BORING LOG

Date 5/11/22

ROUTE IL 15 **DESCRIPTION** IL 15 over Big Muddy Overflow **LOGGED BY** L. Estel

SECTION 13B-3 **LOCATION** 9 miles E of Washington Co. Line (Near W. Abut.), **SEC.** 33, **TWP.** 2S, **RNG.** 2E, **PM**

COUNTY Jefferson **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE=86.5%)

STRUCT. NO. 041-0024
Station 1223+24

BORING NO. 2-S
Station 1222+96
Offset 11.0ft Lt
Ground Surface Elev. 437.9 ft

Surface Water Elev. _____ ft
Stream Bed Elev. 430.6 ft

Groundwater Elev.:
▽ **First Encounter** 418.4 ft
▽ **Upon Completion** _____ ft
▽ **After** ____ **Hrs.** _____ ft

Description	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
Hard Grey, Dry weathered CLAY SHALE		40 50/2"		12
	-45			
Bottom of hole @ 41.0 ft				
To convert "N" values to "N60", multiply by 1.44; Hammer Efficiency = 86.5%				
Ground surface elevation referenced to IP&C 4100243 at Sta 1223+45, 22 ft Lt; EL. 436.72				
	-50			
	-55			
	-60			
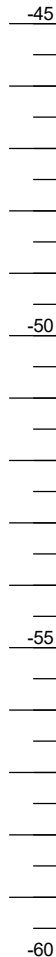
The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206) BBS, from 137 (Rev. 8-99)

EXHIBIT E

SUBSURFACE PROFILE

Elevation (ft)

1-S

N Value	Qu	%m	

Cored Pavement

5 .1 .1 .20 B — Stiff Grey, Moist SILT

0 .2 27 B

430.25

0 .0 .0 .28 B — V. Soft Grey, V. Moist SILT
80% Fines <#200, LL 26, PI 7
(Estimated based on visual ID and historical database)

4 0.2 27 S

4 .1 .2 .24 B — Stiff Grey and mottled Brown, Moist SILTY CLAY

2 0.2 25 B — V. Soft Grey and mottled Brown, Moist SILTY CLAY

3 .0 .0 .23 B — V. Soft Brown and dark Brown, V. Moist SILT
80% Fines <#200, LL 26, PI 7
(Estimated based on visual ID and historical database)

3 0.9 26 B — M. Stiff Brown with spots of Grey, Moist SILTY CLAY

.3 .0 .7 .27 B

5 1.4 24 B — Stiff Brown with specks of Red, Moist SILTY CLAY

.5 .1 .2 .22 B

0.5 28 B — M. Stiff Grey, Moist SILT
80% Fines <#200, LL 26, PI 7
(Estimated based on visual ID and historical database)

.6 .1 .2 .27 B — Stiff Grey, Moist CLAY

4 27 — V. Loose dark Grey, Moist SANDY LOAM4% f. GRAVEL & c. SAND, 16%
m. SAND, 46% f. SAND, 24%
SILT, 10% CLAY, LL = 23, PI = 6 (Lab 32)

.4 .0.8 .38 B — (Washed - 6 ft of blow in) M. Stiff Grey, V. Moist SILTY CLAY

4 0.8 16 B

M. Stiff Grey, Moist SILTY CLAY with a 4" dark Grey SAND Layer

Hard Grey, Dry CLAY SHALE

Hard Grey, Dry CLAY SHALE

Hard Grey, Dry CLAY SHALE

1223+50
11.0 ft RT

2-S

N Value	Qu	%m	

Cored Pavement

2 .0 .3 .25 B — Soft Brown and Tan, Moist SILTY CLAY

0 .0 29 B

430.65

V. Soft Brown and Tan, V. Moist SILTY CLAY

.0 .0 .29 B

4 0.8 22 B — M. Stiff Grey, Moist SILT
80% Fines <#200, LL 26, PI 7
(Estimated based on visual ID and historical database)

7 .1 .1 .22 B — Stiff Grey with specks of Brown, Moist SILTY CLAY

5 0.3 25 B

.0 .3 .26 B — Soft Grey and Brown, Moist SILTY CLAY

3 0.5 26 B

.3 .0 .7 .26 B

4 1.0 22 B — Stiff Brown and Grey, Moist SILTY CLAY

3 .0.4 .20 B — Soft Brown and Grey, Moist SILTY CLAY

7 1.2 17 B — Stiff Grey, Moist CLAY - CLAY TILL with GRAVEL

5 .1.2 .18 B

17 3.1 17 B — V. Stiff Grey, Moist CLAY - CLAY TILL
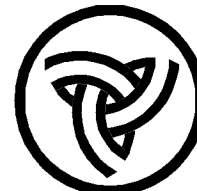
27 -3.6 .15. S

12 — Hard Grey, Dry weathered CLAY SHALE

1222+96
11.0 ft LT

**Approximate Invert
Elevation of Culvert**

NOT TO HORIZONTAL SCALE

Illinois Department
of Transportation
Division of Highways

SUBSURFACE PROFILE

Route: F.A.P. 812 (IL 15)
Section: 13B-3
County: Jefferson

EXHIBIT F

SETTLEMENT CALCULATIONS

SETTLEMENT CALCULATIONS FOR IL 15 OVER BIG MUDDY OVERFLOW

Layer	H (ft)	type of soil	zcl (ft)	γ (pcf)	LL	p'o (psf)	ΔP' (psf)	p'o + ΔP' (psf)	eo	Cc	Δi (in)
				Boring 1-S - 3ft Excavation							
2	2.5	Silty Clay	1.25	120	24	150	710.61	860.61	0.648	0.126	1.740
3	2.5	Silty Clay	3.75	120	25	450	598.69	1048.69	0.675	0.135	0.888
4	2.5	Silt	6.25	110	26	659.5	512.04	1171.54	0.702	0.144	0.633
5	2.5	Silty Clay	8.75	120	26	791	443.40	1234.40	0.702	0.144	0.491
6	2.5	Silty Clay	11.25	120	27	935	388.01	1323.01	0.729	0.153	0.400
										Σ=	4.15

Time Rate of consolidation

Without wick drains

Cv (in²/min)=	8.37E-03		
H (ft)=	10.55		
	days	months	years
t50	266	9	1
t90	1104	37	3

With Wick Drains

Cv hor. (in²/min)=	1.67E-02		
Triangular spacing(ft)=	5.0		
de(ft)=	5.3		
	days	months	years
t50	65.9	2.20	0.18
t90	273.3	9.11	0.75

Multilayer Calculations Method B

Layer	cv(in²/sec)	H eq(ft)
silt	2.87E-03	0.55
silty clay	1.40E-04	10
Σ=		10.55

Layer	H (ft)	type of soil	zcl (ft)	γ (pcf)	LL	p'o (psf)	ΔP' (psf)	p'o + ΔP' (psf)	eo	Cc	Δi (in)
				Boring 2-S - 3ft Excavation							
2	2.5	Silty Clay	1.25	120	22	150	733.24	883.24	0.594	0.108	1.565
3	2.5	Silty Clay	3.75	120	25	450	652.47	1102.47	0.675	0.135	0.941
4	2.5	Silty Clay	6.25	120	26	750	584.36	1334.36	0.702	0.144	0.635
5	2.5	Silty Clay	8.75	120	26	972	526.39	1498.39	0.702	0.144	0.477
6	2.5	Silty Clay	11.25	120	26	1116	476.64	1592.64	0.702	0.144	0.392
7	2.5	Silty Clay	13.75	120	22	1260	433.63	1693.63	0.594	0.108	0.261
8	2.5	Silty Clay	16.25	120	20	1404	396.20	1800.20	0.54	0.09	0.189
										Σ=	4.46

Time Rate of consolidation

Without wick drains

Cv (in²/min)=	7.44E-03		
H (ft)=	17.50		
	days	months	years
t50	811	27	2
t90	3491	116	10

With Wick Drains

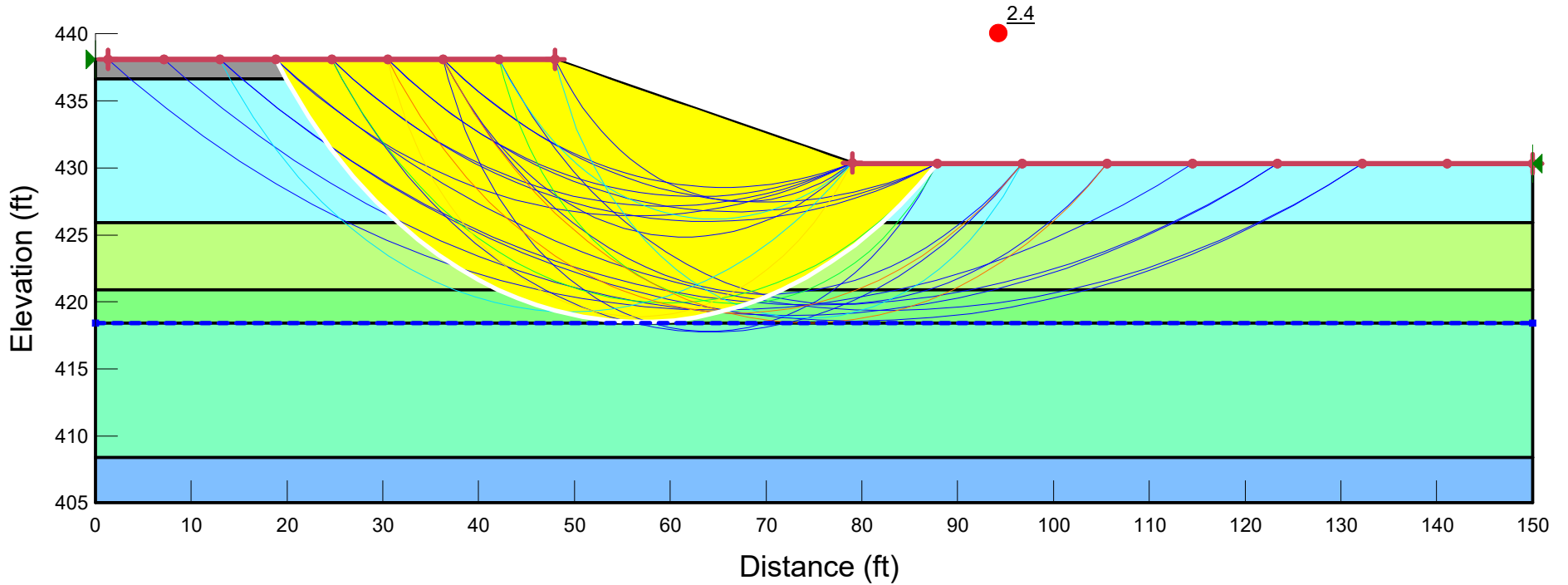|			
Cv hor. (in²/min)=	1.49E-02		
Triangular spacing(ft)=	5.0		
de(ft)=	5.3		
	days	months	years
t50	73.0	2.43	0.20
t90	314.2	10.47	0.86

EXHIBIT G

SLOPE W SLOPE STABILITY ANALYSIS

IL 15 over Big Muddy Overflow
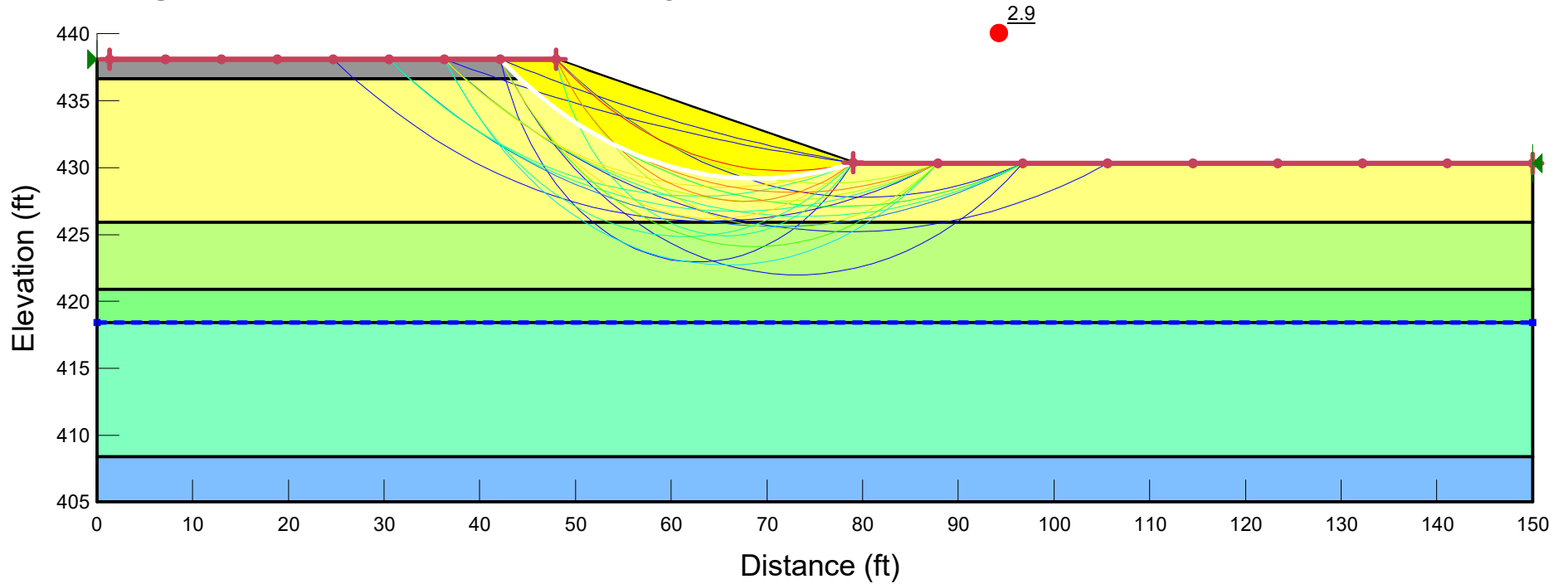# Boring 1-S
Short Term Condition (Undrained Analyisis)

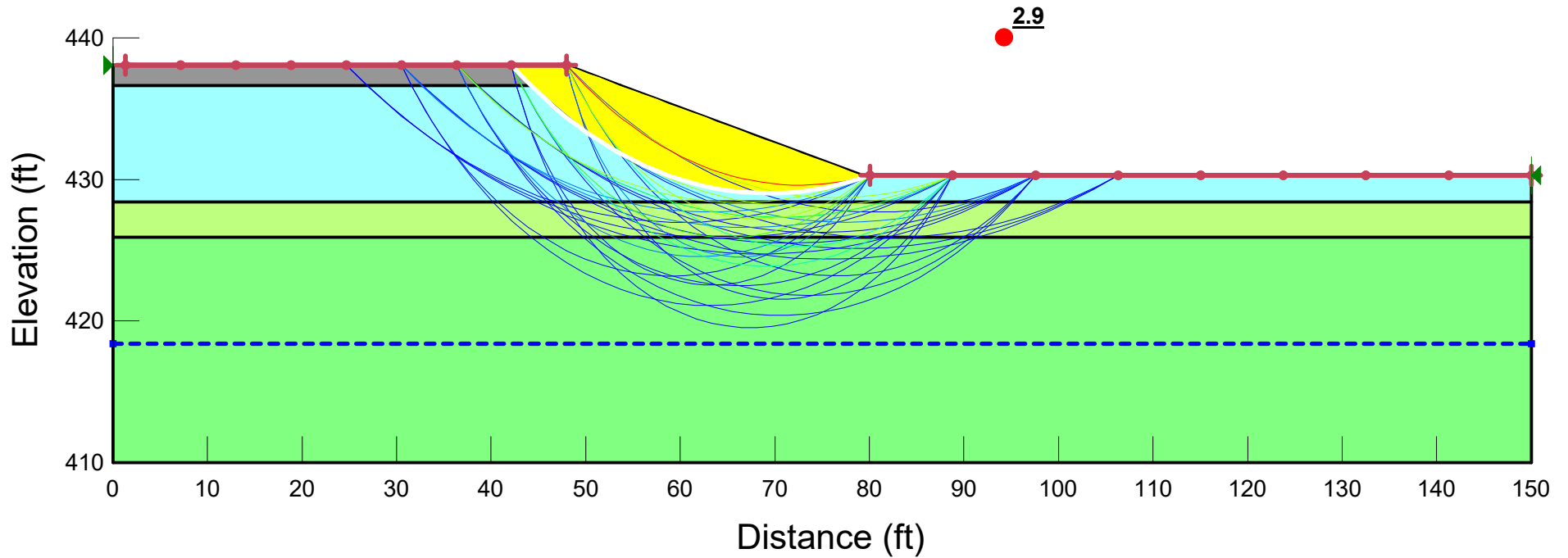| Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Pavement	Mohr-Coulomb	130	0	34
	Silt I	Mohr-Coulomb	110	360	0
	Silt II	Mohr-Coulomb	110	0	0
	Silt III	Mohr-Coulomb	110	500	0
	Silty Clay I	Mohr-Coulomb	120	700	0
	Silty Clay II	Mohr-Coulomb	120	1,050	0

IL 15 over Big Muddy Overflow
Boring 1-S
Long Term Condition (Drained Analyisis)

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Pavement	Mohr-Coulomb	130	0	34
	Silt I	Mohr-Coulomb	110	50	26
	Silt II	Mohr-Coulomb	110	50	26
	Silt III	Mohr-Coulomb	110	50	26
	Silty Clay I	Mohr-Coulomb	120	50	26
	Silty Clay II	Mohr-Coulomb	120	100	26

IL 15 over Big Muddy Overflow
Boring 2-S
Short Term Condition (Undrained Analyisis)
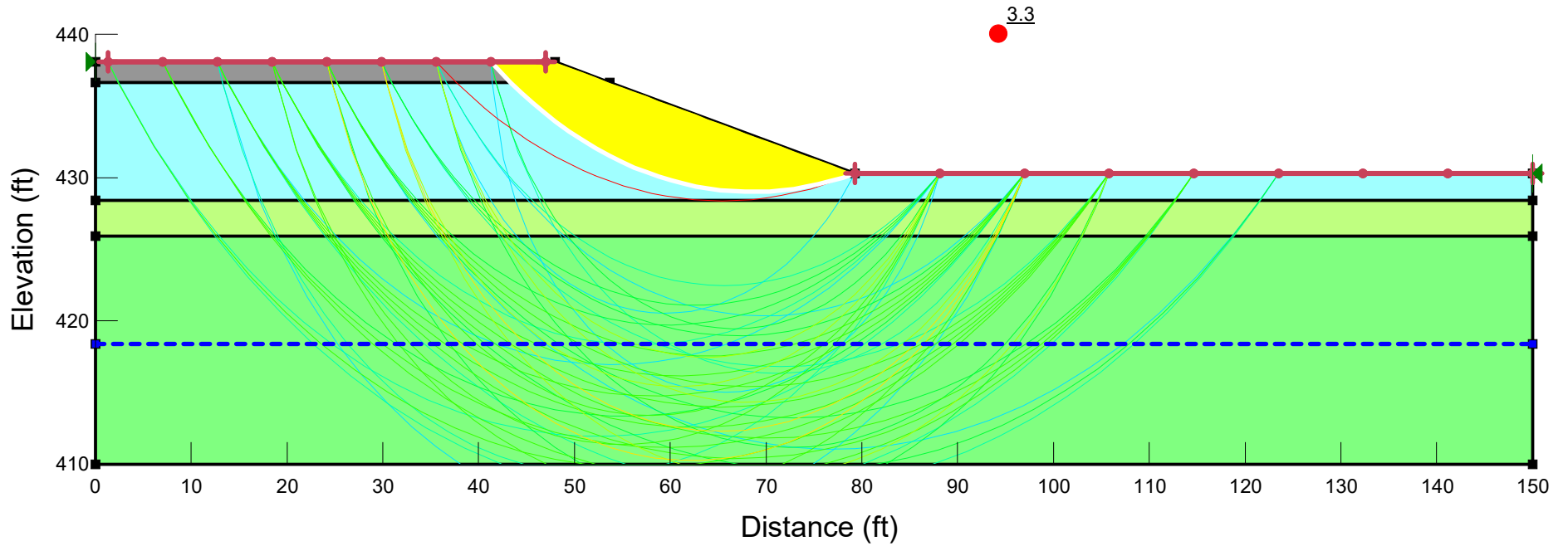
| Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
■ (gray)	Pavement	Mohr-Coulomb	130	0	34
■ (light green)	Silt I	Mohr-Coulomb	110	800	0
■ (cyan)	Silty Clay I	Mohr-Coulomb	120	300	0
■ (green)	Silty Clay II	Mohr-Coulomb	120	600	0

IL 15 over Big Muddy Overflow
Boring 2-S
Long Term Condition (Drained Analyisis)

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Pavement	Mohr-Coulomb	130	0	34
	Silt I	Mohr-Coulomb	110	100	26
	Silty Clay I	Mohr-Coulomb	120	50	26
	Silty Clay II	Mohr-Coulomb	120	100	26

EXHIBIT H

BEARING RESISTANCE CALCULATIONS

- **Culvert Weight**
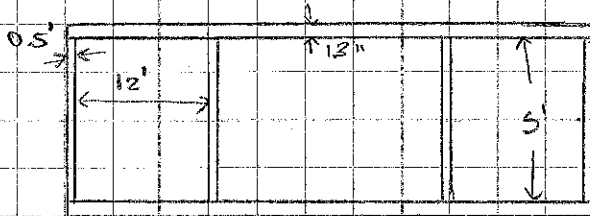
$$A_c = 13/12 \times 38 \times 2 + 0.5 \times 5 \times 4$$
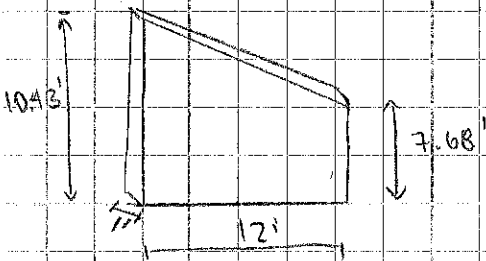$$= 92.3 \ ft^2$$

$$V_c = A_c \ L_c = 92.3 \times 43$$
$$= 3970.3$$

$$W_c = \gamma_{concrete} \times V_c = 150 \times 3970.3$$
$$= 595,550.00 \ lbs$$

- **Weight of Wingwalls**

Assumed dimensions

$$A_w = \frac{10.43 + 7.68}{2} \times 12 \times 4 = 434.64 \ ft^2$$

$$V_w = 434.64 \times 1 = 434.64 \ ft^3$$

$$W_w = 150 \times 434.64 = 65,196.00 \ lbs$$

- **Foundation Fill**

$$V_F = 3 \times 43 \times 38 = 4902 \ ft^3$$

$$W_F = \gamma_{fill} \times V_f = 125 \times 4902 = 612750 \ lbs$$

$$\text{Total Weight} = W_c + W_w + W_f = 1273496 \ lbs$$

$$\text{Bearing Pressure} = W_T/A = \frac{1273496}{38 \times 43} = 779.37 \ psf$$

Kaskaskia
Engineering Group, LLC

208 E. Main Street
Suite 100
Belleville, Illinois 62220
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618.233.5977 *fax*
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Project Title: IL 15 over Big Muddy Sheet: 2 of 2
Project Number: 22-1060.02
Calculated By: TG Date: 3/15/22
Checked By: MDM Date: 03/17/2023
Comments: Bearing Capacity

- Bearing Capacity for continuous footing

$q_{ult} = cN_c + \gamma D_f N_q + 0.5 \gamma' B N_\gamma$ Boring 2-5

$= 1100(5.7) + 120(3)(1)$ Silty Clay layer → $\gamma = 120$ pcf
$c' = 1100$ psf
$= 6630$ psf $D_f = 3$ ft
$\phi = 0$
$q_a = 0.5(6630) = 3315$ psf $N_c = 5.7$
$N_q = 1$
$N_\gamma = 0$

$q_a = 3315$ psf > 779.37 psf ✓ ok

Sliding Resistance — Using Boring 2-5

Assumed H = 12 ft, Bearing in Silty Clay → 120 pcf, c' 1100 psf

Lesser of ½ vertical stress or cohesion

$\frac{1}{2} \sigma_v = \frac{1}{2}(120)(12) = 720$ psf $< c = 1100$ psf

Sliding Resistance = 720 psf