STRUCTURE GEOTECHNICAL REPORT

FAP RTE 312 Culvert – IL. Route 3 Over Drainage Ditch

Existing S.N. 039-2034

FAU 312
SECTION 123B-6
JACKSON COUNTY, ILLINOIS
JOB NO. D-99-036-17
PTB 184/034
CONTRACT NO. 78790
KEG NO. 17-1095.08

LICENSED PROFESSIONAL ENGINEER
MATTHEW DENNIS MASTERSON
062-061885
STATE OF ILLINOIS

12/13/2021
Exp 02/28/2022

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May 5, 2021
REVISED December 13, 2021

Kaskaskia
Engineering Group, LLC

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TABLES

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 the replacement of a double barrel reinforced concrete box culvert for IL-3 over Drainage Ditch in Jackson 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 replacement of a double barrel reinforced concrete box culvert (existing SN 039-2014) located at IL-3 over Drainage Ditch in Jackson County, Illinois.

The general location of the proposed structure is shown on a Location Map, Exhibit A. The project is located approximately 2.8 miles northwest of IL-151 in Rockwood, Illinois. The site lies within the limits of the Third Principal Meridian (T. 8S R. 4W) within the Shawnee Hills Section of the Interior Low Plateaus Province.

1.3 Proposed Structure Information

The proposed structure will consist of a cast-in-place (C.I.P.) double box culvert with L-Type cantilever wingwalls on each end of the culvert. The proposed structure will be built on a 25-degree skew and will provide 13 ft.-wide driving lanes and 7 ft.-wide shoulders. The proposed culvert centerline station will be 345+42.00. The culvert will consist of two 8 ft. by 9 ft. barrels and will measure 43 ft. out-to-out of headwalls. A Type, Size, and Location Plan (TS&L) is included in Exhibit B. Class A5 stone riprap will be placed at both ends of the culvert.

Further substructure details will be based on the findings of this SGR.

2.0 Field Exploration

2.1 Subsurface Exploration and Testing

The site exploration plan was developed and completed by IDOT. Two standard penetration test (SPT) borings, designated 1-S and 2-S were drilled April 9, 2020. 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 C. The soil profile for the above mentioned borings can be found in Subsurface Profile, Exhibit D.

2.2 Subsurface Conditions

The profiles at the two boring locations exhibited layers of clays and silts. The borings were terminated at 21 ft. below ground surface elevation (GSE). Boring 1-S has an estimated GSE of 385.6 ft. and 2-S has an estimated GSE of 385.7 ft. In general, the lithologic succession is as follows:

Clay - Boring 1-S encountered 6 ft. of clay below the pavement at ground surface elevation (GSE). The driving resistance (N-values) ranged from 5 to 7 blows per foot (bpf), with unconfined compressive strength (Q_u) values between 0.8 to 1.6 tons per square foot (tsf). The moisture contents varied from 22 to 27 percent.

Silt - Below the clay layer in Boring 1-S, and below the pavement in Boring 2-S, silt was encountered between 1 and 7 ft. below GSE, extending to the termination of the borings at 21 ft. below GSE. The N-values ranged from 0 bpf to 16 bpf, with Q_u values between 0.1 tsf and 0.9 tsf, and moisture contents of 22 percent to 30 percent.

Groundwater was encountered in Boring 1-S at 12 ft. below GSE and in Boring 2-S at 19 ft. below GSE. Stream bed elevations were noted to be approximately 9 ft. below GSE for both 1-S and 2-S, respectively. It should be noted that the groundwater level is subject to seasonal and climatic variations, including the flow of the Tributary. In addition, without extended periods of observation, measurement of true groundwater levels may not be possible. Bedrock was not encountered in either boring.

3.0 Geotechnical Evaluations

3.1 Settlement

Due to the presence of soft soils in the vicinity of the proposed upstream (El. 376.10) and downstream (El. 375.45) inverts and the possibility of remaining materials from the existing structure, settlement calculations were necessary.

Based on our analysis, the proposed new culvert and wingwalls with up to 2 feet of new roadbed fill and pavement section could experience settlements of up to 8 inches if the culvert bears on the existing soils. Differential settlement between the main box and proposed L Type wingwalls was estimated to be a maximum of 1.5 inches. KEG recommends the removal and disposal of unsuitable material is necessary for proper support of the new construction. In addition, IDOT recommends that horizontal cantilever wingwalls and/or wingwall extensions be used for construction and support of the proposed wingwalls and reductioin of applied pressures. KEG recommends overexcavation of the soils a minimum of 3 feet to El. 371.0. The horizontal limits of removal shall extend to 3 feet beyond the outer limits of the culvert and wingwall footprints. The overexcavation and replacement of the soft soils are necessary for proper support of the new construction.

3.2 Slope Stability

A stability analysis using SLOPE/W was performed using the proposed roadway and culvert geometry on the TS&L and soil characteristics from Boring 1-S and 2-S. 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. The slope stability analyses indicated that the required minimum FOS for all conditions were met.

In order 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 a friction angle of 26 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 3.1. SLOPE/W program output from this analysis can be found in SLOPE/W Slope Stability Analysis, Exhibit E.

Table 3.1 – Slope Stability Critical FOS

Location (2H:1V Slope)	Critical FOS	
	End-of Construction	Long Term
Northwest Culvert Wingwall	1.5	2.2
Southeast Culvert Wingwall	2.4	3.1

3.3 Scour

The approximate elevation at the upstream invert (TS&L, Exhibit B) is El. 375.85, and at the downstream invert is El. 375.45. Class A5 stone dumped riprap will be placed on both the upstream and downstream end of the double box culvert to reduce the potential for future scour.

3.4 Seismic Considerations

As per IDOT Geotechnical Manual v. 2020, Section 7.4.5.4, seismic data is not required for buried structures, including box culverts.

4.0 Foundation Evaluations and Design Recommendations

AASHTO Table 12.5.5-1 and Article 12.11 do not require box culverts to be designed for bearing capacity. Culverts weigh less than the soil around them and tend to “float” in the soil medium and are supported by the soil on the sides and below.

The soil encountered in the borings at the anticipated bearing elevation of the culvert consist of a very soft to medium-stiff silt material. The soil characteristics from Borings 1-S and 2-S at the assumed bearing elevation have a Qu value range of 0.1 to 0.9 tsf. The total applied bearing pressure from the culvert box, including the proposed 2 feet of roadbed fill and pavement is estimated to be 696 psf. The applied bearing pressure from just the wingwalls is estimated to be 507 psf for each of the 14.5-ft.-long walls, and 525 psf for each of the 22.25-ft-long walls. Based on these estimates, the service bearing pressures will be satisfied, however, settlement of up to 8 inches is estimated.

While this analysis shows the proposed L-type wingwalls to be feasible, other wingwall types may be considered, such as apron supported walls or horizontal cantilever walls. Horizontal cantilever wingwalls will provide lower applied pressure compared to the L-type wingwalls, and may reduce any differential settlement resulting from the walls bearing on some previously unloaded material. As indicated above, IDOT also recommends horizontal cantilever wingwalls and/or wingwall extensions be considered to reduce the potential for differential settlement.

If after final design the bearing elevation changes, KEG should be informed to review that the above information is still accurate.

4.1 Box Culvert

Varying depths of existing stream bed will require excavation and removal to reach the proposed bottom elevation of the box culvert (El. 374+/-). Typically, excavations to these depths will result in suitable bearing soils for construction. As indicated above, KEG recommends the removal and disposal of unsuitable material a minimum of 3 feet below proposed bearing elevation of the culvert to El. 371.0 for proper support of the new construction. In addition, care must be taken during excavation to prevent disturbing the final bearing surface soils. If the foundation soils are disturbed or soft pockets of material are encountered during construction, they must also be removed and replaced.

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 versus Temporary Shoring, depending upon the surcharge loading and retained heights required to be supported during construction. An Illinois-licensed Structural Engineer is required to seal the design of Temporary Soil Retention Systems, if deemed necessary.

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 special 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 C. The Subsurface Profile can be found in Exhibit D.

8.0 Limitations

The recommendations provided herein are for the exclusive use of Veenstra & Kimm, Inc and the Illinois Department of Transportation (IDOT). 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 in 2020, 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

Kaskaskia Engineering Group, LLC

LOCATION MAP
IL 3 (FAP 312) over Drainage Ditch
Section 123B-6
Existing SN 039-2014
Proposed SN 039-2034
Jackson County, Illinois

Exhibit No.

A

KEG JOB #17-1095.08

EXHIBIT B

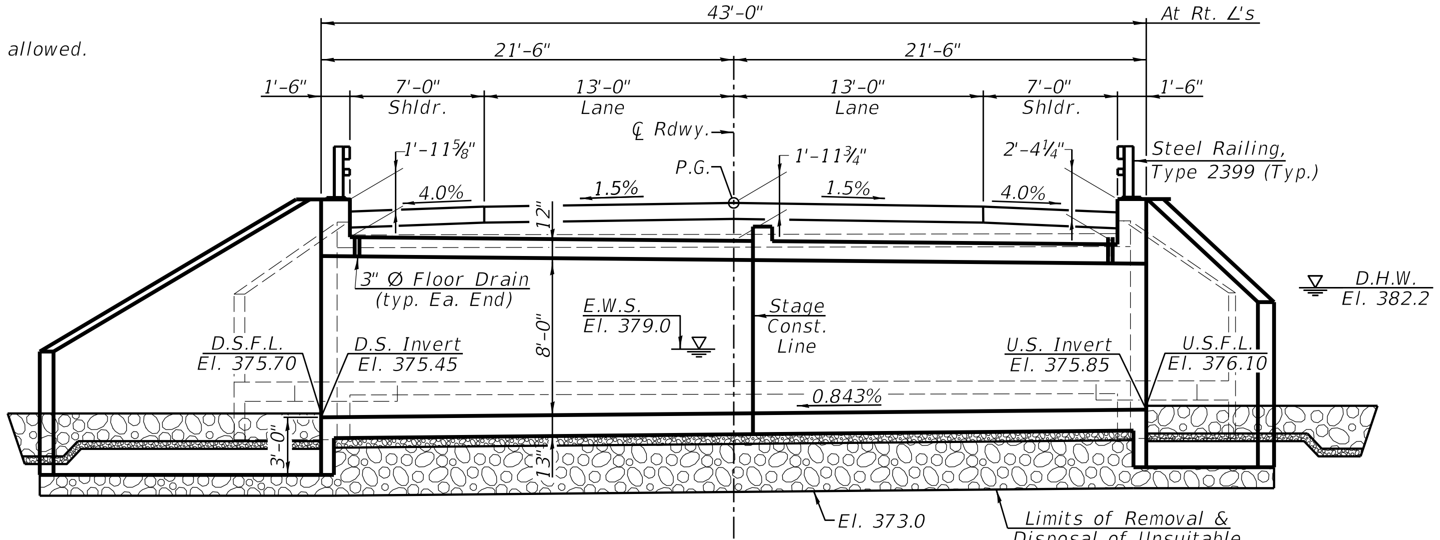
TYPE, SIZE, AND LOCATION PLAN (TS&L)

B.M. 1004 Top of exposed rebar on the southeast corner of headwall on Structure No. 039-2014 along IL Route 3. Elev. 385.758

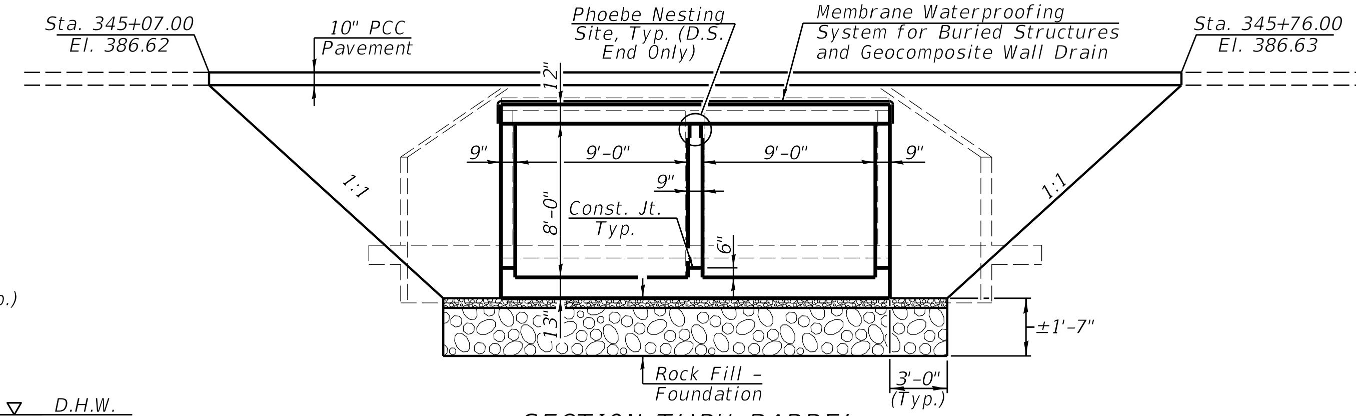
Existing Structure: S.N. 039-2014 originally built under SBI Route 150 under Section 123 in 1933. The structure is a double barrel reinforced box culvert (9'-0"W x 7'-0"H) 41'-4" out-out of headwalls, 45'-7¼" along centerline of culvert. 25° skew Rt. Fwd. The structure will be replaced utilizing stage construction. ℄ Structure Sta. 345+42.

No Salvage.

Precast option is not allowed.



LONGITUDINAL SECTION



SECTION THRU BARREL

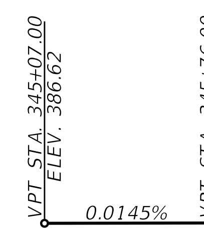
(Culvert top and bottom slab thickness is subject to refinement during final design.)
(Existing bridge foundation within the limits of the proposed construction to be removed.)

WATERWAY INFORMATION

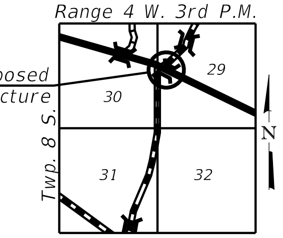
Drainage Area = 0.8 Sq. Mi.
Exist. Overtopping Elev. = 386.8 @ Sta. 345+50
Prop. Overtopping Elev. = 386.8 @ Sta. 345+50

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	671	75	103	381.8	2.3	1.0	384.1	382.8
Design	50	1,140	83	110	382.2	2.9	2.5	385.1	384.7
Base	100	1,360	83	110	382.2	3.2	2.9	385.4	385.1
Overtop Exist.	N/A								
Overtop Prop.	N/A								
Max. Calc.	500	1,910	88	115	382.5	3.3	3.2	385.8	385.7

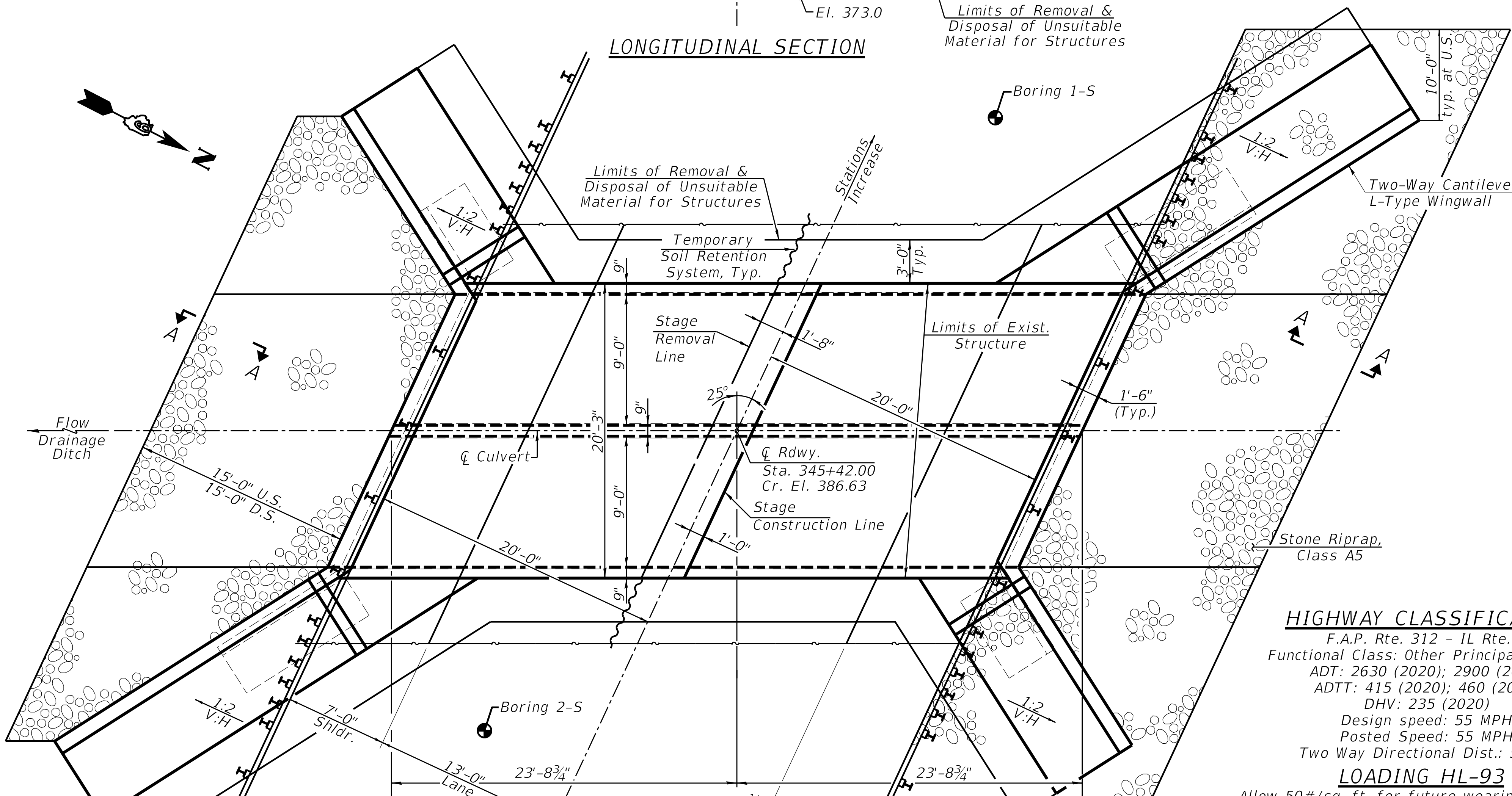
10 Yr. Outlet Velocity through Exist. Structure = 8.9 ft/s
10 Yr. Outlet Velocity through Prop. Structure = 6.5 ft/s



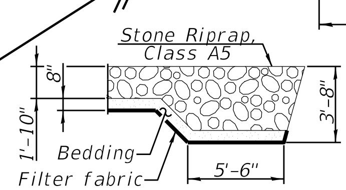
PROFILE GRADE
(Along ℄ IL Rte. 3)



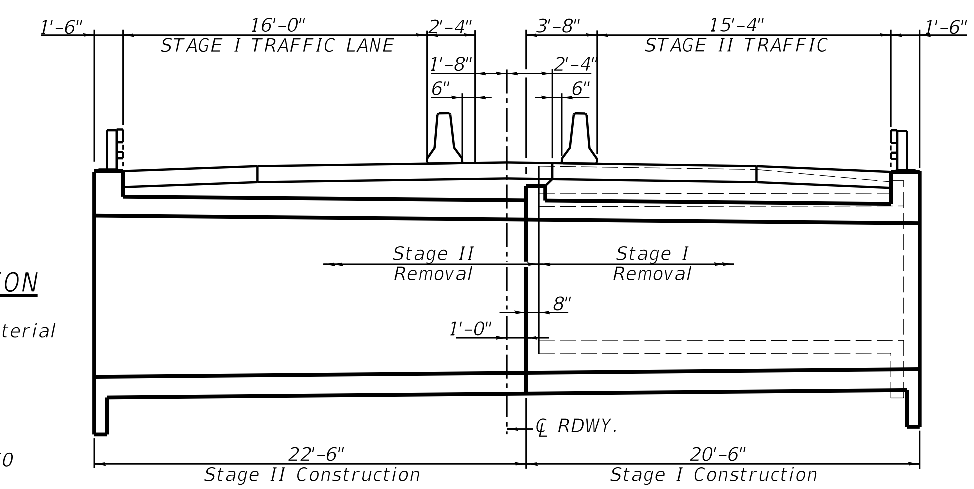
LOCATION SKETCH



PLAN



SECTION A-A



STAGE CONSTRUCTION SKETCH

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
fy = 60,000 psi (Reinforcement)

GENERAL PLAN & ELEVATION
IL. ROUTE 3 OVER DRAINAGE DITCH
F.A.P. RTE 312 - SECTION 123B-6
JACKSON COUNTY
STATION 345+42
STRUCTURE NO. 039-2034

VEENSTRA & KIMM INC. Springfield, IL. Phone: (217)544-8033 IL. Design Firm No. 184-001939	USER NAME = _	DESIGNED - KS	REVISED - _	STATE OF ILLINOIS DEPARTMENT OF TRANSPORTATION	GENERAL PLAN & ELEVATION STRUCTURE NO. 039-2034	
		CHECKED - TRC	REVISED - _			
	PLOT SCALE = _	DRAWN - JRP	REVISED - _			
	PLOT DATE = 10/28/2021	CHECKED - _	REVISED - _		SHEET NO. 1 OF 1 SHEETS	

F.A.P. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
312	123B-6	JACKSON	_	_
		CONTRACT NO. 78790		
		ILLINOIS FED. AID PROJECT		

EXHIBIT C

BORING LOGS

Illinois Department of Transportation
Division of Highways
District 9

SOIL BORING LOG

Date 4/9/20

ROUTE IL 3 **DESCRIPTION** Box culvert over drainage ditch **LOGGED BY** L. Estel

SECTION 123B-6 **LOCATION** 0.1 mi. SE of Raddle Rd, **SEC.** 29, **TWP.** 8S, **RNG.** 4W, 3 **PM**

COUNTY Jackson **DRILLING METHOD** Hollow stem auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb

STRUCT. NO. 039-2014
Station 345+42

BORING NO. 1-S
Station 345+69
Offset 7.0ft Right
Ground Surface Elev. 385.6 ft

Surface Water Elev. ____ ft
Stream Bed Elev. 376.2 ft

Groundwater Elev.:
▽ **First Encounter** 373.6 ft
▼ **Upon Completion** ____ ft
▼ **After** ____ **Hrs.** ____ ft

Description	Elev.	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
Cored Pavement, 2.5" HMA over 9.5" PCC	384.60				
M. Stiff Brown, Moist CLAY			1		
			3	0.8	27
			2	B	
(Stiff)		-5	1		
			2	1.6	22
			5	B	
	378.60				
V. Soft Brown, Moist to Wet SILT			WOH		
			1	0.2	28
			1	B	
		-10	WOH		
			WOH	0.1	28
			WOH	B	
▽			WOH		
			WOH	0.1	26
			WOH	B	
		-15	WOH		
			WOH	0.1	26
			WOH	B	
			WOH		
			WOH	0.1	30
			WOH	B	
		-20	WOH		
V. Soft Brown, Moist to Wet SILT *(continued)*			WOH	0.1	28
	364.60		WOH	B	
		-25			
		-30			
Bottom of hole @ 21.0 ft					
		-35			
		-40			

Elevation referenced to BM 1003, Cut Square on top of SE HDWL of SN 039-2014; EL. 384.85

To convert "N" values to "N60", multiply by 1.5

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)

File Name S:\MATERIALS GEOTECHNICAL UNIT\GINT\PROJECTS\PROJECTS FILE\JACKSON\STRUCTURES\039-2014 IL 3 OVER DRAINAGE DITCH\039-2014 IL 3 OVER DRAINAGE DITCH 2020.GPJ Data Template D6TEMPLT.GDT Date Printed 4/23/20
Latitude 37 48 11.14 Longitude 89 34 45.36 Datum NAD83 Job Number

Illinois Department of Transportation
Division of Highways
District 9

SOIL BORING LOG

Date 4/9/20

ROUTE IL 3 **DESCRIPTION** Box culvert over drainage ditch **LOGGED BY** L. Estel

SECTION 123B-6 **LOCATION** 0.1 mi. SE of Raddle Rd, **SEC.** 29, **TWP.** 8S, **RNG.** 4W, 3 **PM**

COUNTY Jackson **DRILLING METHOD** Hollow stem auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb

STRUCT. NO. 039-2014
Station 345+42

BORING NO. 2-S
Station 345+16
Offset 7.0ft Left
Ground Surface Elev. 385.7 ft

Surface Water Elev. ft
Stream Bed Elev. 376.2 ft

Groundwater Elev.:
First Encounter 366.2 ft
Upon Completion ft
After Hrs. ft

Description	Elev.	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
Cored Pavement, 2.5" HMA over 9.5" PCC	384.70				
M. Stiff Brown, Moist SILT			3		
			5	0.8	22
			11	B	
		-5	1		
			2	0.7	26
			3	B	
			WOH		
			1	0.6	23
			3	B	
		-10	WOH		
			1	0.7	25
			2	B	
			1		
			3	0.9	23
			3	B	
	371.20				
V. Soft Brown, Moist SILT		-15	WOH		
			WOH	0.2	27
			WOH	B	
▽			WOH		
		-20	1	0.2	26
V. Soft Brown, Moist SILT *(continued)*	364.70		1	B	
		-25			
Bottom of hole @ 21.0 ft		-30			
		-35			
		-40			

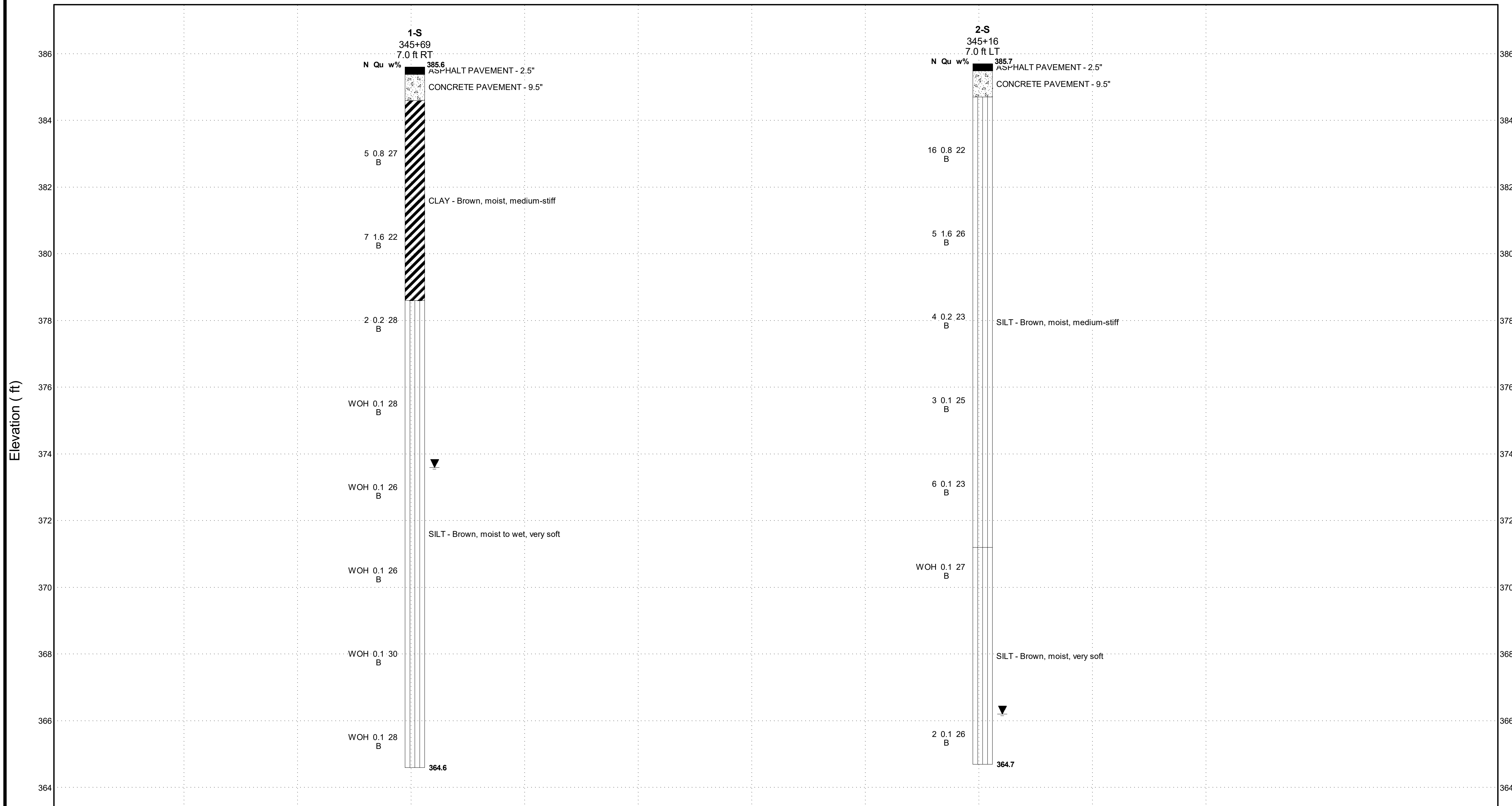
Elevation referenced to BM 1003, Cut Square on top of SE HDWL of SN 039-2014; EL. 384.85

To convert "N" values to "N60", multiply by 1.5

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)

EXHBIT D

SUBSURFACE PROFILE



PRINTERMOD2 11X17 17-1095.08 IL RT 3 OVER DRAINAGE DITCH.GPJ IL_DOT.GDT 4/8/21

Illinois Department of Transportation
Division of Highways

NOT TO HORIZONTAL SCALE

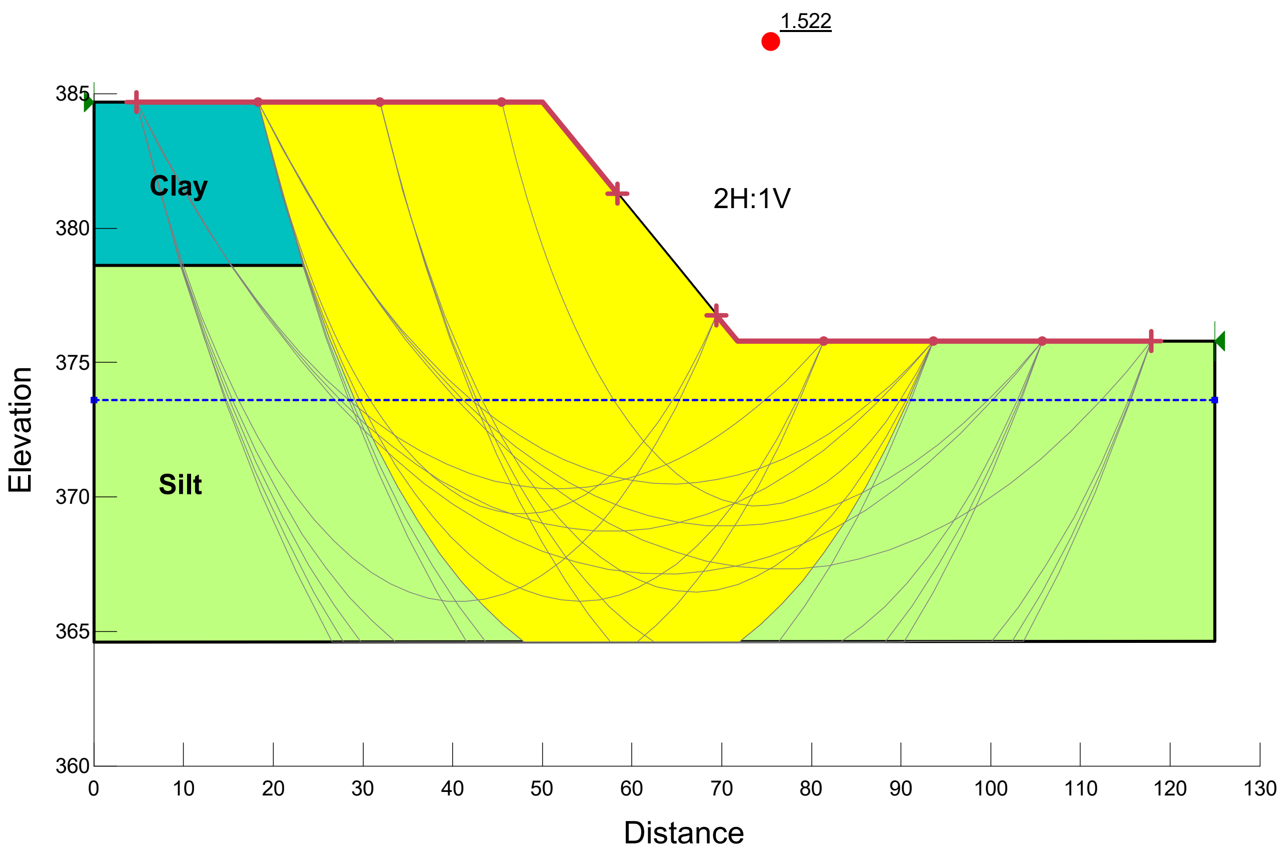
SUBSURFACE DATA PROFILE

Route: FAP RTE 312
Section: 123B-6
County: Jackson County, IL

EXHIBIT E

SLOPE/W SLOPE STABILITY ANALYSIS

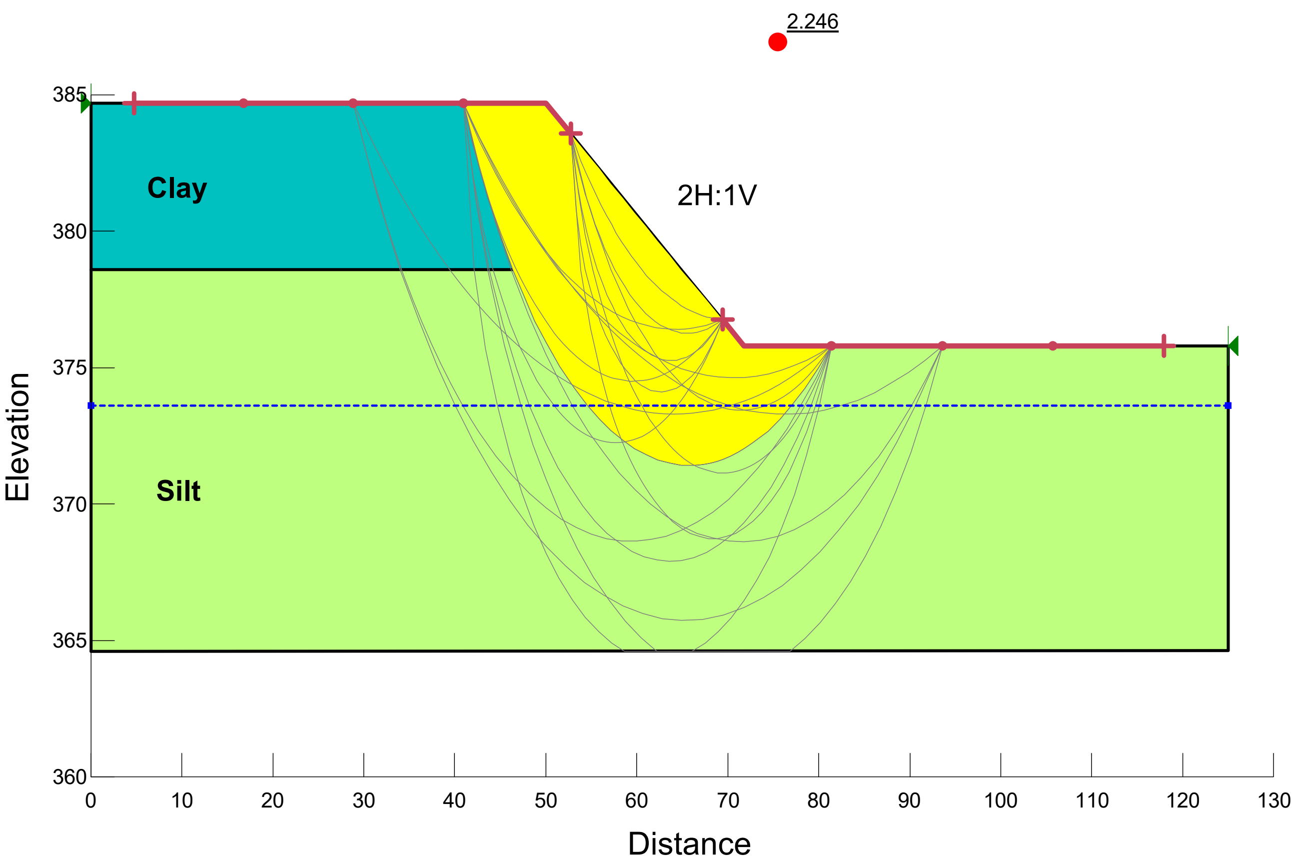
IL 3 Over Drainage Ditch
SN 039-2014 Northwest Wingwall - Boring 1-S
End-of-Construction (Undrained Analysis)



Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 1,200 psf
Phi': 0 °
Phi-B: 0 °
Piezometric Line: 1

Name: Silt
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 150 psf
Phi': 0 °
Phi-B: 0 °
Piezometric Line: 1

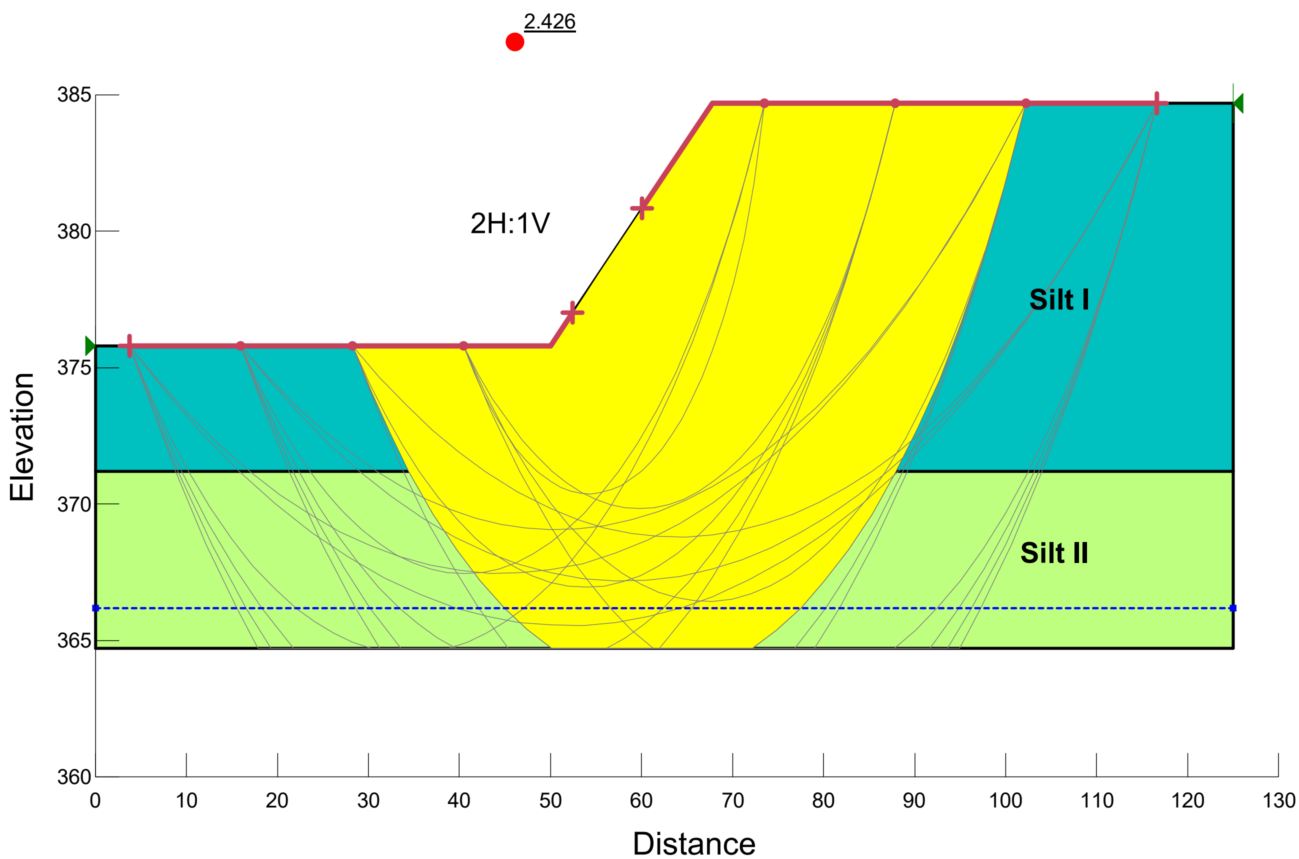
IL 3 Over Drainage Ditch
SN 039-2014 Northwest Wingwall - Boring 1-S
Long Term (Drained Analysis)



Name: Clay
Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 100 psf
Phi': 26 °
Phi-B: 0 °
Piezometric Line: 1

Name: Silt
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 50 psf
Phi': 26 °
Phi-B: 0 °
Piezometric Line: 1

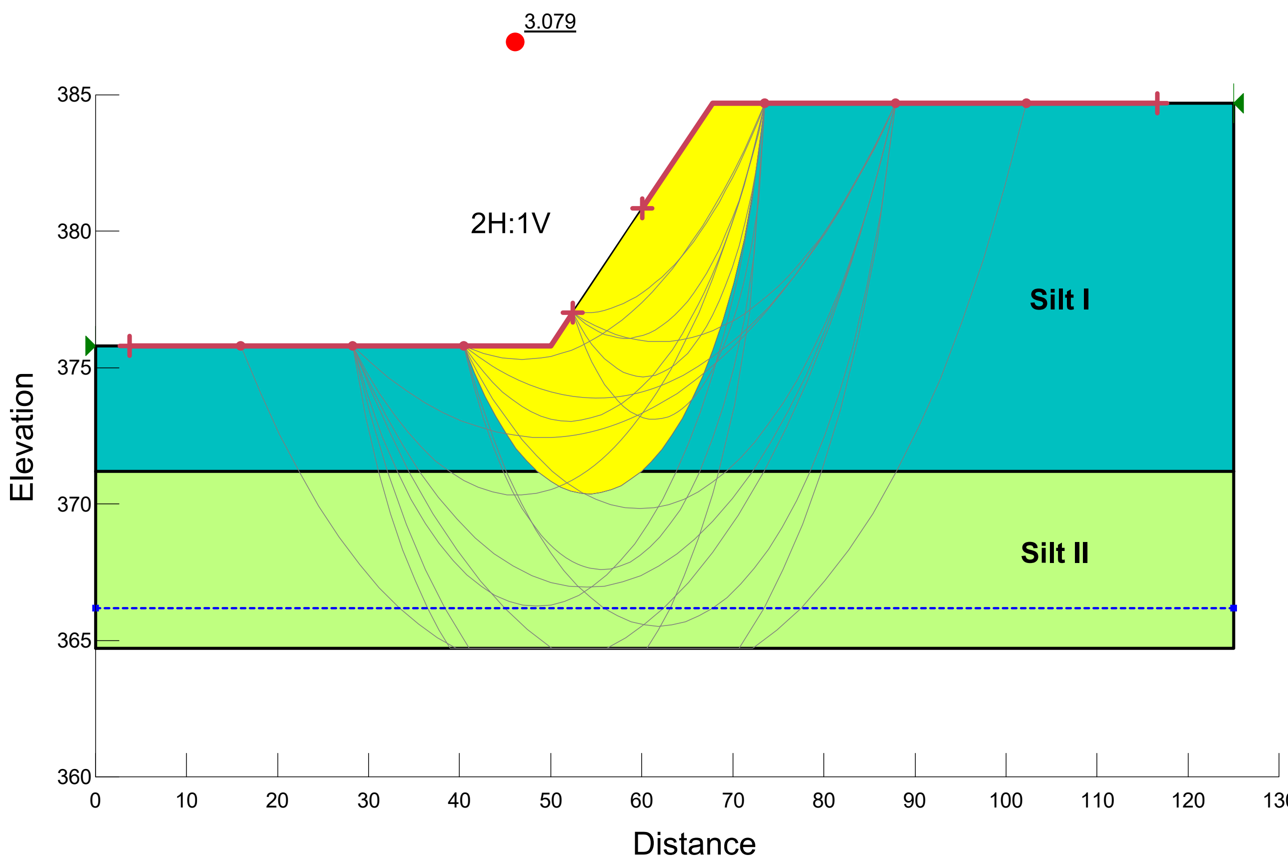
IL 3 Over Drainage Ditch
SN 039-2014 Southeast Wingwall - Boring 2-S
End-of-Construction (Undrained Analysis)



Name: Silt I
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 740 psf
Phi': 0 °
Phi-B: 0 °
Piezometric Line: 1

Name: Silt II
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 0 °
Phi-B: 0 °
Piezometric Line: 1

IL 3 Over Drainage Ditch
SN 039-2014 Southeast Wingwall - Boring 2-S
Long Term (Drained Analysis)



Name: Silt I
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 200 psf
Phi': 26 °
Phi-B: 0 °
Piezometric Line: 1

Name: Silt II
Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 50 psf
Phi': 26 °
Phi-B: 0 °
Piezometric Line: 1