STRUCTURE GEOTECHNICAL REPORT

Box Culvert Replacement
US 51 over Drainage Ditch

Existing S.N. 039-2027
Proposed S.N. 039-2030

F.A.P. ROUTE 322 (US 51)
SECTION 4B-1
JACKSON COUNTY, ILLINOIS
JOB NO. D-99-060-10
PTB 148/033
CONTRACT NO. 78204
KEG NO. 08-0060.09

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STATE OF ILLINOIS

07/19/2013
Exp. 11/30/2013

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April 2, 2013
Revised July 19, 2013

Kaskaskia
Engineering Group, LLC

EXECUTIVE SUMMARY

Box Culvert Replacement – US 51 over Drainage Ditch
F.A.P. Route 322 (US 51)
Section 4B-1
Jackson County, Illinois
Job No. D-99-060-10
PTB 148/033
Contract No. 78204
Proposed Structure No. 039-2030

This report summarizes the analysis of a proposed four-barrel box culvert for US 51 over a drainage ditch, located in Jackson County, Illinois.

Kaskaskia Engineering Group, LLC (KEG) does not anticipate settlement to be a concern for the proposed structure. The proposed loads are not expected to exceed the current applied load.

The bearing capacity of the natural soils indicates the ability to support the proposed loads. However, due to the condition of the existing soils, KEG recommends construction of a working platform immediately after excavation to provide protection against disturbance of the foundation bearing soils.

The slope stability analysis for the project was analyzed for a wingwall sideslope geometry of 1 Vertical to 2 Horizontal (1V:2H) slopes. The required FOS for the three conditions modeled were met. If the design of the wingwall sideslopes exceeds the assumed geometry, KEG should be notified to determine if the critical FOS are still met.

TABLE OF CONTENTS

TABLES

EXHIBITS

1.0 Project Description and Proposed Structure Information

1.1 Introduction

The geotechnical study summarized in this report was performed by Kaskaskia Engineering Group, LLC (KEG) for a proposed four-barrel box culvert to be constructed on US 51 over a 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 replacing the existing box culvert (S.N. 039-2027) with a four-barrel, reinforced, cast-in-place, concrete box culvert (S.N. 039-2030) located on US 51 crossing a drainage ditch in Jackson County, Illinois. The project is located approximately 0.2 miles east of Dowell, Illinois.

The general location of the structure is shown on a USGS Topographic Location Map, Exhibit A. The site lies within the limits of Third Principal Meridian, (T. 7S R. 1W Section 5) within Jackson County in the Mt. Vernon Hill Country Physiographic Region.

1.3 Proposed Structure Information

The proposed structure (S.N. 039-2030) will consist of a four-barrel, cast-in-place (C.I.P.) box culvert with horizontal cantilever wingwalls. The proposed structure will be built with no skew, 12-ft. driving lanes and 8-ft. shoulders. The culvert will consist of four, 12-ft. by 5-ft. barrels and will measure 62 ft. - 0 in. out-to-out headwalls. The proposed culvert centerline station will be 755+80.00. Channel protection is recommended at both ends of the culvert in order to maintain the future channel section. A Type, Size, and Location Plan (TS&L), as provided by Hampton, Lenzini, and Renwick, Inc. (HLR), is included in Exhibit B.

According to the TS&L, upstream and downstream flowline elevations are El. 385.55 and 385.35, respectively. The proposed design will maintain the current roadway profile with only a nominal surface overlay. The structure is to be replaced using staged construction to maintain one lane of traffic at all times.

Further substructure details will be based on the findings of this Structure Geotechnical Report (SGR).

1.4 Existing Structure Information

The original structure was built in 1922 as SBI-2, Section 4. The culvert was built as a double barrel, cast-in-place culvert. The culvert was extended in 1954, and two additional pre-cast barrels were added in 1998. The current structure is a four-barrel box culvert with two, 4-ft. by 8-ft. cast-in-place and two, 4-ft. by 10-ft. pre-cast barrels. The culvert measures 68 ft. - 0 in. out-to-out headwalls.

The Bridge Condition Report (BCR), dated April 2010, recommends complete replacement of the structure due to the current condition. The culvert is in poor condition with significant deterioration in the center two barrels. The top slab is in poor condition. Cracking and leaching are visible in the center two barrels, as well as spalling and exposed reinforcement. The sidewalls are in poor condition with cracks, delaminations, and spalls present at the construction joints.

2.0 Site Investigation, Subsurface Exploration and Generalized Subsurface Conditions

The site investigation was conducted by the Illinois Department of Transportation (IDOT). A site visit by a representative of KEG to observe all or part of the borings or to make site observations was not performed. Therefore, no observations have been made relative to existing conditions of the structure, stream, roadway, or of subsurface sample conditions.

Two Standard Penetration Test (SPT) borings, designated 1-S and 2-S, were drilled between the proposed south and north sides of the box culvert on March 15 and 16, 2010, by IDOT. The locations of the borings are shown on the TS&L Plan, Exhibit B. The boring logs as provided by IDOT are included as Exhibit C and the subsurface data profile is included as Exhibit D.

2.1 Subsurface Conditions

The profile at Boring 1-S began at El. 392.4 with an approximately 1.5-ft.-thick layer of asphalt over crushed aggregate followed by an approximately 5.5-ft.-thick layer of silty clay and silt loam. The SPT driving resistances (N-values) ranged from 2 to 3 and unconfined compressive strengths (Q_u) between 0.2 and 0.8 tons per square foot (tsf). Below El. 385.4 to approximate El. 365.4, the profile encountered layers of stiff, moist, silty clay and clay loam material, exhibiting N-values from 7 to 14. Q_u values were between 1.3 and 1.9 tsf, and moisture contents varied from 13 to 22 percent. Layers of soft to medium stiff silty or sandy clay loams were interbedded from approximate El. 375.4 to El. 370.4, with an N-value of 4. The Q_u values were between 0.4 and 0.8 tsf, and the moisture contents varied from 22 to 23 percent. The profile then continued with stiff to very stiff, moist, clay material. The N-values ranged from 5 to 12, with Q_u values between 1.1 and 2.9 tsf. The moisture contents varied from 21 to 27 percent. Hard-weathered clayey shale was encountered at El. 345. The boring was terminated in the clayey shale at El. 327.4 after two consecutive 100+ blow count samples.

Boring 2-S began at El. 392.4 with an approximately 1.5-ft. layer of asphalt over crushed aggregate. The subgrade material was followed by approximately 8 ft. of silty clay. The N-values ranged from 2 to 8, with Q_u values between 0.2 and 2.3 tsf. The moisture contents varied from 22 to 25 percent. Clay and clay loam materials were encountered from approximately El. 382.9 to El. 347.4. The N-values ranged from 3 to 11, with Q_u values between 0.8 and 1.9 tsf. The moisture contents varied from 17 to 30 percent. Clayey shale was encountered at approximately El. 347. The boring was terminated at El. 346.4.

2.2 Clayey Shale

A clayey shale material was encountered at both boring locations. Table 2.1 includes the estimated top elevations of the clayey shale.

Table 2.1 – Estimated Clayey Shale Elevations

Boring	Estimated Elevation (ft.)
1-S	344.9
2-S	347.4

2.3 Groundwater

Groundwater was encountered in Boring 1-S at El. 375.4 during drilling. At Boring 2-S, groundwater was encountered at El. 380.4 during drilling. At completion, groundwater was measured at El. 380.1 in Boring 1-S. It should be noted that the groundwater level is subject to seasonal and climatic variations. In addition, without extended periods of observation, measurements of the true groundwater level may not be possible. The high groundwater elevations may contribute to unstable subgrade conditions during construction. Surface water diversion and groundwater control may be required.

3.0 Geotechnical Evaluations

3.1 Bearing Resistance

In both borings, the upper 10 ft. of the soil profile contains material with an average Q_u of 0.5 tsf. Firmer soils were encountered approximately 10 to 12 ft. below the ground surface.

The calculated factored bearing resistance value for the box culvert was found to be 1,850 psf, using a Bearing Resistance Factor of 0.45 (2012 AASHTO LRFD) at the approximate elevation of the culvert (El. 385) and using soil characteristics from Boring 2-S with a cohesion of 700 psf. The applied bearing pressure from the four culvert barrels and horizontal wingwalls is estimated to be 350 psf.

Although the calculations indicated that the soils could support the culvert and wingwall bearing requirements, KEG recommends providing a working platform at bearing elevation during construction. It should be noted that groundwater was encountered at approximately El. 380, so excavation below this elevation may be difficult and may require dewatering efforts.

If during construction, the conditions of the foundation subgrades encountered are not representative of the conditions of the borings, KEG should be contacted.

3.2 Settlement

As previously mentioned, the upper 10 ft. of the soil profile consists of soft to medium stiff soils; however, the proposed loads are not anticipated to be greater than the existing applied loads. Therefore, if the subgrade improvement recommendations as detailed in Section 4.0 are used, total settlement resulting from construction of the proposed structure should be less than 0.5 in.

3.3 Slope Stability

A stability analysis using SLOPE-W was performed using a wingwall sideslope geometry of 1V: 2H and soil characteristics from Boring 1-S. Three conditions were modeled: end-of-construction, long-term, and a design seismic event. 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 and 1.0 for the design seismic event.

In order to model the end-of-construction condition, undrained soil parameters were used with a friction angle of 0 degrees assumed for cohesive soils. Drained soil parameters with assumed friction angles ranging from 26 to 28 degrees were used to model the long-term and seismic conditions to analyze the condition where excess pore water pressure from construction has dissipated. For cohesive materials, a nominal cohesion value of 50 psf was included in the drained strength parameters.

The Modified Bishop Method, which generates circular-arc failure surfaces, was used to calculate the critical failure surfaces and FOS for the analyzed 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	End-of-Construction	Long Term	Seismic
Wingwall Sideslope Station 755+48 (1-S)	5.0	1.9	1.2

The results of the analysis, as provided in Table 3.1, indicates an acceptable FOS will exist under all three conditions.

3.4 Seismic Considerations

As per IDOT Bridge Manual v. 2012, Section 2.3.10, seismic data is not required for buried structures, including box culverts.

3.5 Scour

The approximate invert elevation at the upstream end (TS&L, Exhibit B) is El. 385.30 and at the downstream end is El. 385.10. The design scour elevations for the proposed culvert are approximately 3 ft. below the invert elevations of the culvert. See Table 3.2 below. Class A5 stone riprap will be placed on the upstream and downstream ends of the box culvert to reduce the potential for future scour.

Table 3.2 – Design Scour Elevations

Design Scour Elevation (ft.)	Upstream	Downstream
	382.30 ft.	382.10 ft.

3.6 Mining Activity

According to the Illinois State Geological Survey (ISGS) website, coal mining has occurred in Jackson County. According to the Jackson County, Illinois Coal Mines and Underground Industrial Mines Map, dated August 17, 2009, obtained from the Illinois Geological Survey (ISGS) website (http://www.isgs.illinois.edu/maps-data-pub/coal-maps.shtml), the project site was not undermined.

The listed disclaimer indicates locations of some features on the mine map may be offset by 500 ft. or more due to errors in the original source maps, the compilation process, digitizing, or a combination of these factors.

4.0 Foundation Evaluations and Design Recommendations

4.1 Box Culvert

KEG recommends that a working platform be constructed immediately after excavation to provide protection against disturbance of the foundation bearing soils. If foundation soils are disturbed or soft pockets of material are encountered during construction, they must be removed and replaced.

Due to the potential for flooding in the project area and the potential for future scour, a precast culvert alternative is not suitable.

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 still apply.

5.2 Temporary Sheeting and Soil Retention

To accommodate stage construction, shoring will be required. The native soils indicate adequate unconfined compressive strength and densities below approximate El. 383. If the retained height is less than 15 ft. and temporary shoring depths meet or exceed the elevation noted above, IDOT Temporary Sheet Piling design charts should be feasible at this location.

If the temporary shoring is designed to terminate prior to El. 383, low strength native soils with average unconfined compressive strength of less than 0.5 tsf may be encountered. Therefore, if the retained height is greater than 15 ft., the IDOT Temporary Sheet Piling Design Guide and Charts show that a Cantilevered Sheet Piling System would not be feasible, and a Temporary Soil Retention System will be required. An Illinois-licensed structural engineer is required to seal the design of the temporary soil retention system, if deemed necessary.

5.3 Site and Soil Conditions

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

5.4 Wing Wall Types

Based on the site conditions and the proposed culvert dimensions, Horizontal Cantilever Wingwalls should be suitable for the proposed cast-in-place box culvert. The design height cannot exceed 10 ft., with a maximum wing length of 14 ft. If the design height surpasses 10 ft. and/or the maximum wing length exceeds 14 ft., an L-Type Vertical Cantilever Wingwall shall be used. As indicated from the subsurface exploration, the site soils are anticipated to be able to support the footing pressures applied from an L-Type vertical cantilever wingwall.

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 borings 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 HLR and 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 2010, 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

USGS TOPOGRAPHIC LOCATION MAP

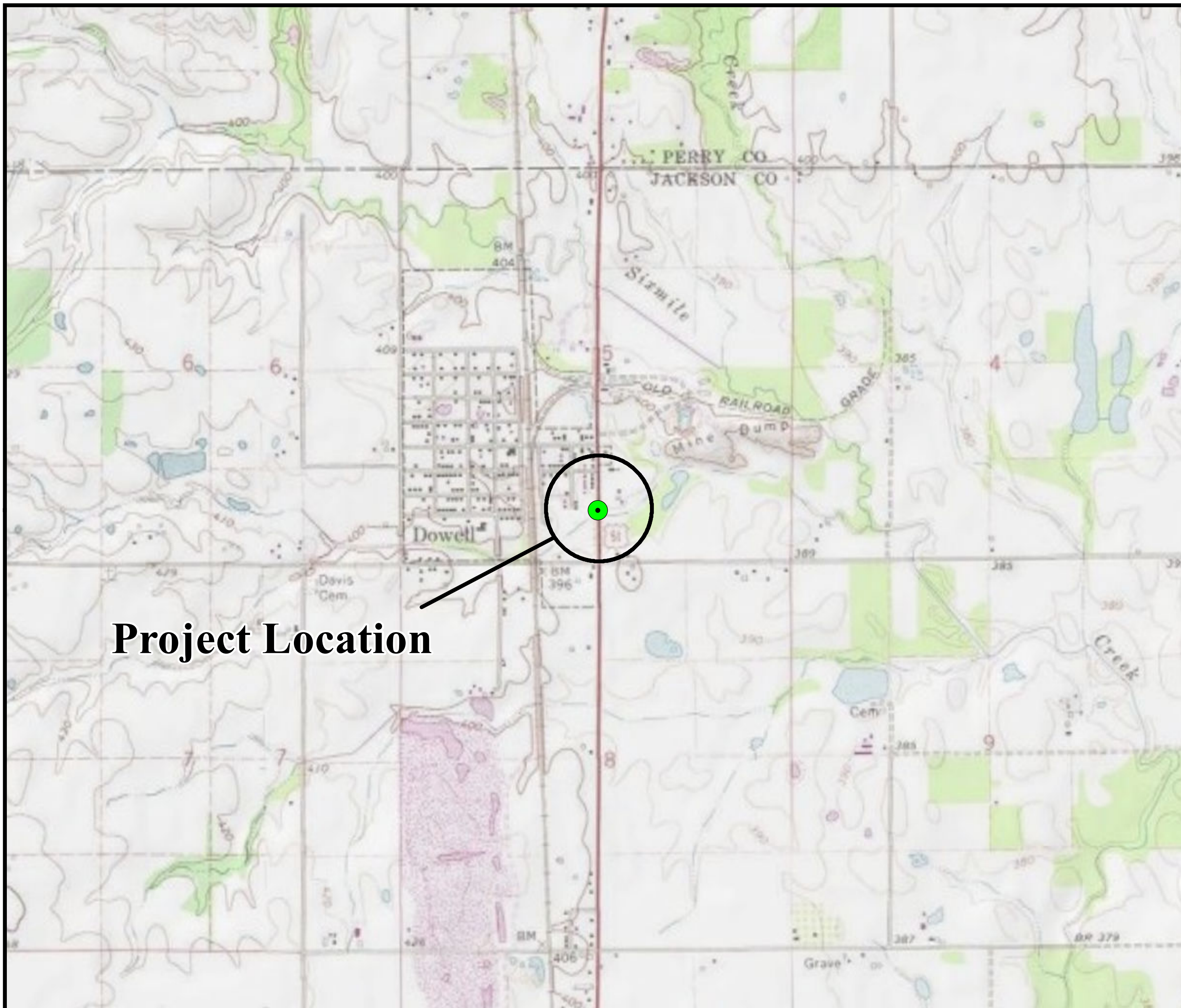


Exhibit A
Location Map
US 51 over Drainage Ditch
Jackson County, Illinois

N

0 500 1,000
Feet

Designed By: CRG
Drawn By: MMJ
Checked By: CRG
Date: 03/27/2013
Project #: 08-0060.09

Kaskaskia Engineering Group, LLC

EXHIBIT B

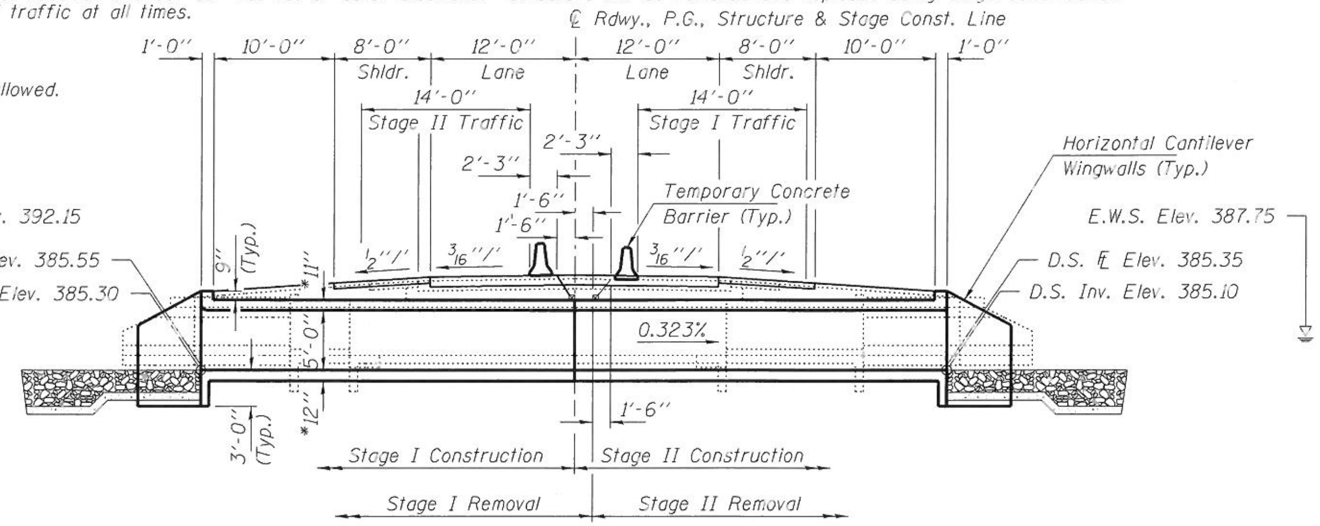
TYPE, SIZE, AND LOCATION PLAN (TS&L)

BENCHMARK: BM#392027 - Top of culvert 33' Rt., Sta. 755+91, Elev. 390.71.

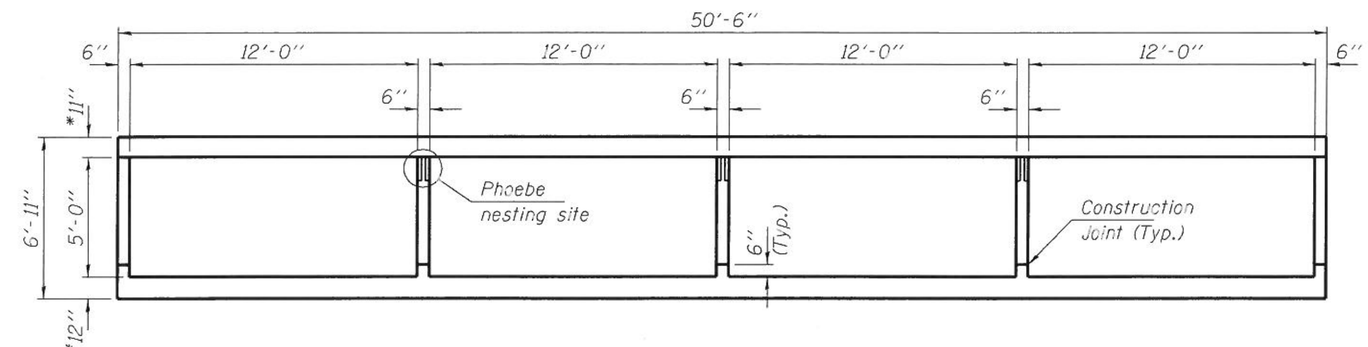
EXISTING STRUCTURE: SN 039-2027 was originally built in 1922 as SBI-2, Section 4. The culvert was extended in 1954 and two additional culvert barrels were added in 1998. The structure is a four barrel culvert with 2-4'x8' CIP and 2-4'x10' PC boxes with a length of 68'-0" o.-o. headwall and 39'-10" fc.-fc. of outer sidewalls. Structure will be removed and replaced using stage construction to maintain one lane of traffic at all times.

Salvage: None

Precast alternate not allowed.



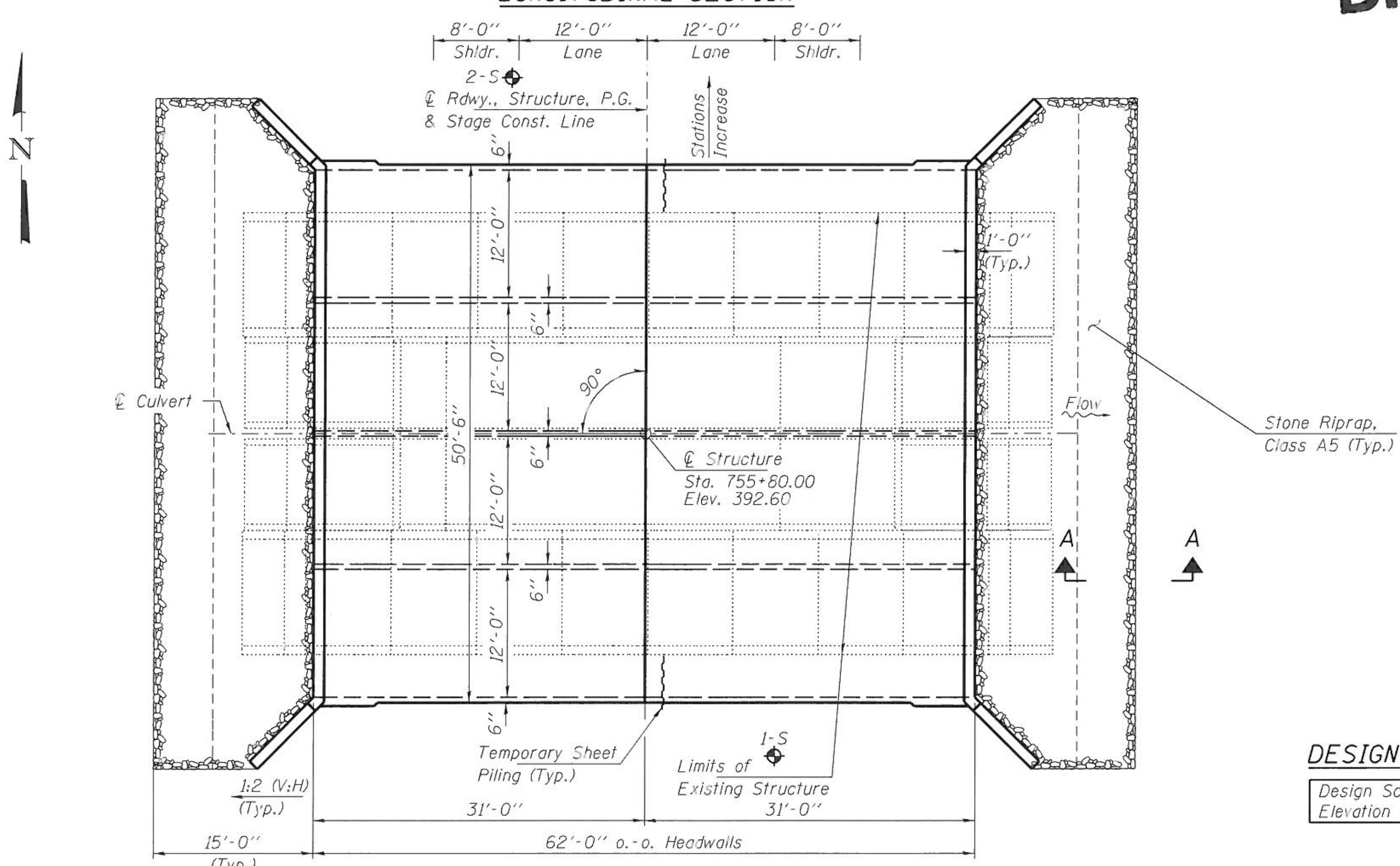
LONGITUDINAL SECTION



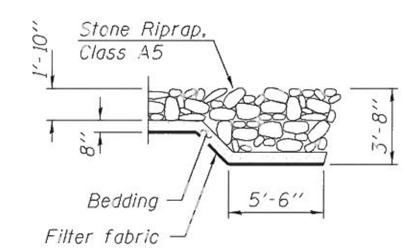
SECTION THRU BARREL

*Slab thickness may be refined in final design.

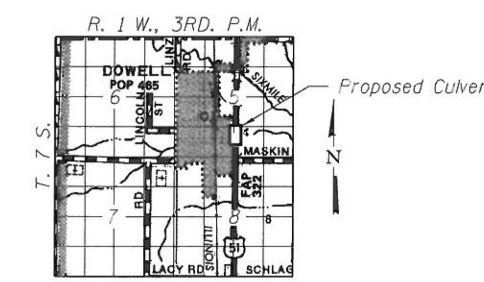
DRAFT



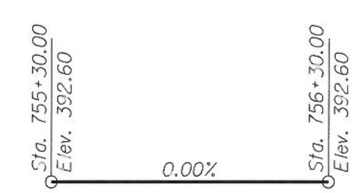
PLAN



SECTION A-A



LOCATION SKETCH



PROFILE GRADE

(along ℄ roadway)

DESIGN SCOUR ELEVATION TABLE

Design Scour Elevation (ft.)	Downstream	Upstream
	382.10	382.30

DESIGN SPECIFICATIONS

2012 AASHTO LRFD Bridge Design Specifications

LOADING HL-93

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

DESIGN STRESSES

f'c = 3,500 psi
fy = 60,000 psi (Reinf.)

HIGHWAY CLASSIFICATION

FAP Route 322 - US 51
Functional Class: minor arterial
ADT: 7200 (2011) / 7371 (2032)
ADTT: 504 / 516 (7%)
DHV: 553 (2032)
Design Speed: 55 m.p.h.
Posted Speed: 55 m.p.h.
Directional Distribution: 50% / 50%

WATERWAY INFORMATION

Drainage Area = 1.89 Sq. Mi. Proposed Low Grade Elev. 392.1 @ Sta. 753+00

Flood	Freq. Yr.	Q C.F.S.	Opening Sq. Ft.		Natural H.W.E.	Head - Ft.		Headwater El.	
			Exist.	Prop.		Exist.	Prop.	Exist.	Prop.
Exist. Overtop	10	827	130	220	391.02	1.23	0.43	392.25	391.45
Prop. Overtop	25	1120	130	220	391.66	1.07	0.71	392.73	392.37
Design	50	1360	130	220	392.15	0.79	0.59	392.94	392.74
Base	100	1600	130	220	392.61	0.49	0.37	393.10	392.98
Max. Calc.	500	2230	130	220	393.68	0.00	0.00	393.68	393.68

GENERAL PLAN
US ROUTE 51
OVER DRAINAGE DITCH
FAP ROUTE 322 - SECTION 4B-1
JACKSON COUNTY
STATION 755+80.00
STRUCTURE NUMBER 039-2030

FILE NAME = 100101-sht-culvert.dgn	USER NAME = $USER$	DESIGNED - M.D.C.	REVISED -
HAMPTON, LENZINI AND RENWICK, INC. 3085 STEVENSON DRIVE, SUITE 201 SPRINGFIELD, ILLINOIS 62703 ILLINOIS PROFESSIONAL DESIGN FIRM LS / PE / SE CORP. 184.000959		CHECKED - C.C.S.	REVISED -
	PLOT SCALE = $SCALE$	DRAWN - D.A.B.	REVISED -
	PLOT DATE = 3/29/2013	CHECKED -	REVISED -

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

GENERAL PLAN
STRUCTURE NO. 039-2030
SHEET NO. 1 OF 1 SHEETS

FAP	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
322	4B-1	JACKSON		
		CONTRACT NO. 78204		
	ILLINOIS	FED. AID PROJECT		

EXHIBIT C

BORING LOGS

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation
Boring Log

FAP 322 (US Route 51) Over drainage ditch

Sheet 1 of 2

Route: FAP 322 (US 51) Structure Number: 039-2027 Date: 3/15/2010

Section ______ Bored By: R Moberly

County: Jackson Location: SCL Dowell Checked By: R Graeff

Boring No 1-S
Station 755+48
Offset 12' Rt CL
Ground Surface 392.4 Ft

Surf Wat Elev: 387.1
Ground Water Elevation
when Drilling 375.4
At Completion 380.1
At: Hrs:

Description	Elev.	DEPTH	BLOWS	Qu tsf	W%
Asphalt over crushed aggregate	390.9				
Medium, very moist, brown and grey, Silty Clay Loam A-6			3		
			2	0.8B	24
	387.9		1		
Very soft, very moist, brown, Silt Loam A-4		5.0	WH		
			1	0.2B	26
	385.4		1		
Stiff, moist, brown, Silt Loam A-4			2		
			7	1.8B	22
	382.9		7		
Stiff, moist, grey mottled brown, Clay A7-6		10.0	1		
			3	1.9B	21
			4		
			2		
			3	1.6B	19
	377.9		4		
Stiif, moist, brown, Silty Clay A7-6		15.0	2		
			3	1.3B	21
	375.4		4		
Medium, very moist, brown, Silty Clay Loam A-6 with sand layers			1		
			2	0.8B	22
	372.9		3		
Soft, very moist, brown, Sandy Clay Loam A-4		20.0	1		
			2	0.4B	23
	370.4		2		
Stiff, moist, grey, Clay to Clay Loam A-6			5		
			6	1.8B	13
			8		
		25.0	3		
			5	1.9B	14
	365.4		7		
Stiff, moist, grey, Clay A7-6			WH		
			2	1.1B	23
			3		
		30.0	1		
			2	1.1B	21
	360.4		4		
Stiff, moist, grey, Clay A7-6			1		
			3	1.3B	23
			4		
		35.0	1		
			3	1.5B	27
			4		
			1		
			2	1.6B	24
	352.9		3		
Stiff, moist, grey, Clay A7-6		40.0	1		
			3	1.6B	22
	347.9		4		
Very stiff, moist, grey, Clay A7-6		45.0	2		
			6	2.9B	24
	344.9		7		
Hard, damp, grey, Clay A7-6 to Weathered Clay Shale	342.4	50.0	20		

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

Route: FAP 322 (US 51) **Date:** 3/15/2010

Section:

County: Jackson

Boring No: 1-S

Station: 755+48

Offset: 12' Rt CL

Ground Surface: 392.4 Ft

Description	DEPTH	BLOWS	Qu tsf	W%
Hard, dry, grey, Clay Shale		100/6"		
338.9				
Hard, dry to damp, grey, Weathered Clay Shale to Clay A7-6	55.0	7		
		22		
		32		
332.9				
Hard, dry, grey, Clay Shale	60.0	24		
		100/9"		
327.4	65.0	100/2"		
Bottom of hole = 64.7 feet				
Free water observed at 17.0 feet				
Elevation referenced to BM @ East headwall: Elev.= 390.7				
To convert "N" values to "N60" multiply by 1.25	70.0			
	75.0			

Description	DEPTH	BLOWS	Qu tsf	W%
	80.0			
	85.0			
	90.0			
	95.0			
	100.0			

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation Boring Log
Sheet 1 of 1

FAP 322 (US Route 51) Over drainage ditch

Route: FAP 322 (US 51) **Structure Number:** 039-2027 **Date:** 3/16/2010

Section:

Bored By: R Moberly

County: Jackson **Location:** SCL Dowell **Checked By:** R Graeff

Boring No 2-S
Station 756+16
Offset 14' Lt CL
Ground Surface 392.4 Ft

Surf Wat Elev: 387.1
Ground Water Elevation
when Drilling 380.4
At Completion
At: Hrs:

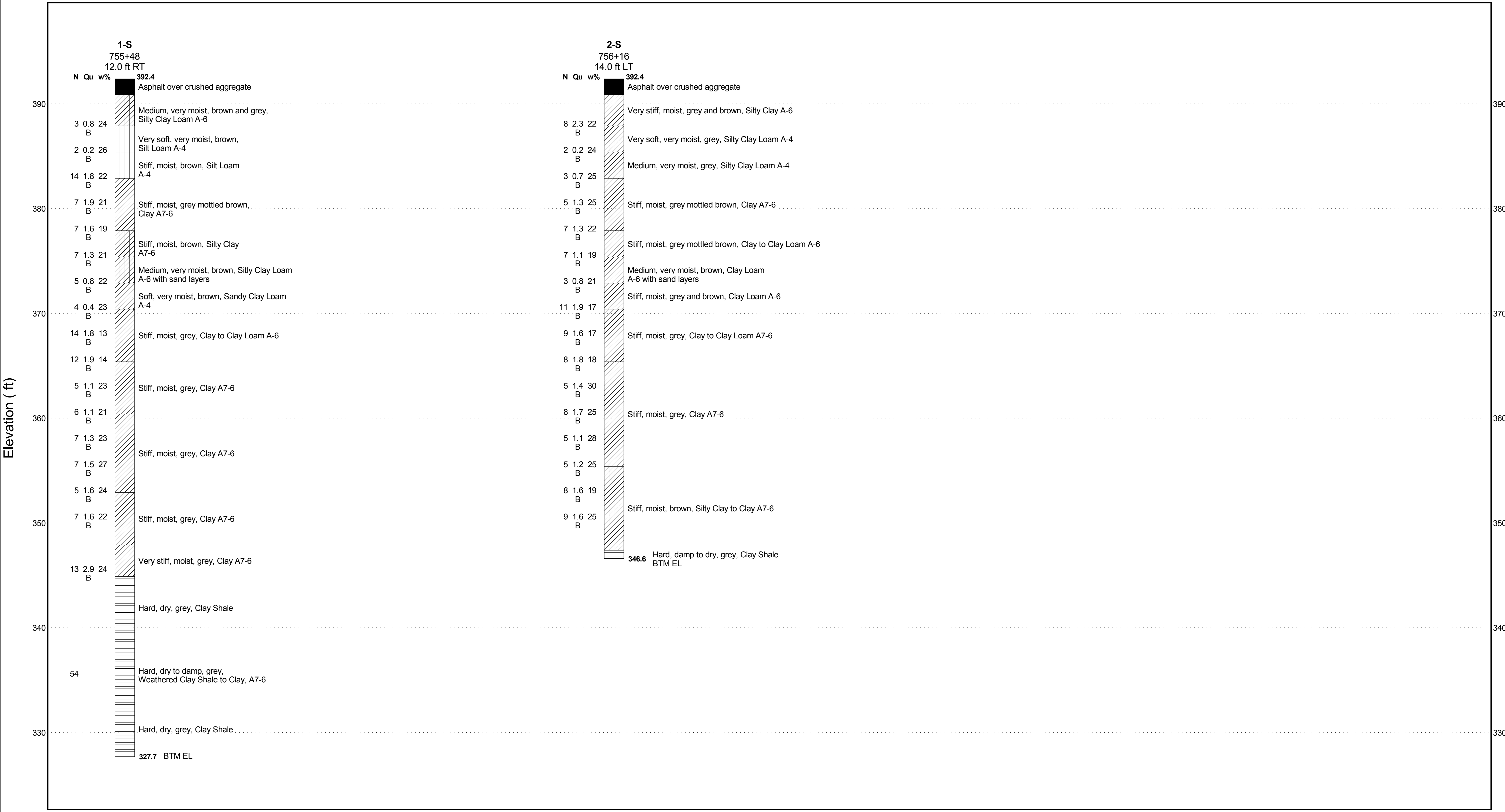
Description	DEPTH	BLOWS	Qu tsf	W%
Asphalt over crushed aggregate				
390.9				
Very stiff, moist, grey and brown, Silty Clay A-6		2		
		4	2.3B	22
		4		
387.9				
Very soft, very moist, grey, Silty Clay Loam A-4	5.0	1		
		1	0.2B	24
		1		
385.4				
Medium, very moist, grey, Silty Clay Loam A-4		WH		
		1	0.7B	25
		2		
382.9				
Stiff, moist, grey mottled brown, Clay A7-6	10.0	1		
		2	1.3B	25
		3		
		1		
		3	1.3B	22
		4		
377.9				
Stiff, moist, grey mottled brown, Clay to Clay Loam A-6	15.0	1		
		3	1.1B	19
		4		
375.4				
Medium, very moist, brown, Clay Loam A-6 with sand layers		1		
		1	0.8B	21
		2		
372.9				
Stiff, moist, grey and brown, Clay Loam A-6	20.0	3		
		5	1.9B	17
		6		
370.4				
Stiff, moist, grey, Clay to Clay Loam A7-6		2		
		4	1.6B	17
		5		
	25.0	2		

Description	DEPTH	BLOWS	Qu tsf	W%
Stiff, moist, grey, Clay to Clay Loam A7-6		3	1.8B	18
		5		
365.4				
Stiff, moist, grey, Clay A7-6		1		
		2	1.4B	30
		3		
	30.0	1		
		3	1.7B	25
		5		
		1		
		2	1.1B	28
		3		
	35.0	1		
		2	1.2B	25
		3		
355.4				
Stiff, moist, brown, Silty Clay to Clay A7-6		2		
		3	1.6B	19
		5		
	40.0	2		
		4	1.6B	25
		5		
**************************************				
To convert "N" values to "N60" multiply by 1.25				
**************************************				
347.4	45.0	14		
Hard, damp to dry, grey, Clay Shale 346.4		100/9"		
Bottom of hole = 45.8 feet				
Free water observed at 12.0 feet				
Elevation referenced to BM # East headwall: Elev.= 390.7				
	50.0			

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

EXHIBIT D

SUBSURFACE PROFILE



PRINTERMOD2 11X17 08-0060.09_US51 OVER DRAINAGE DITCH.GPJ IL_DOT.GDT 3/26/13

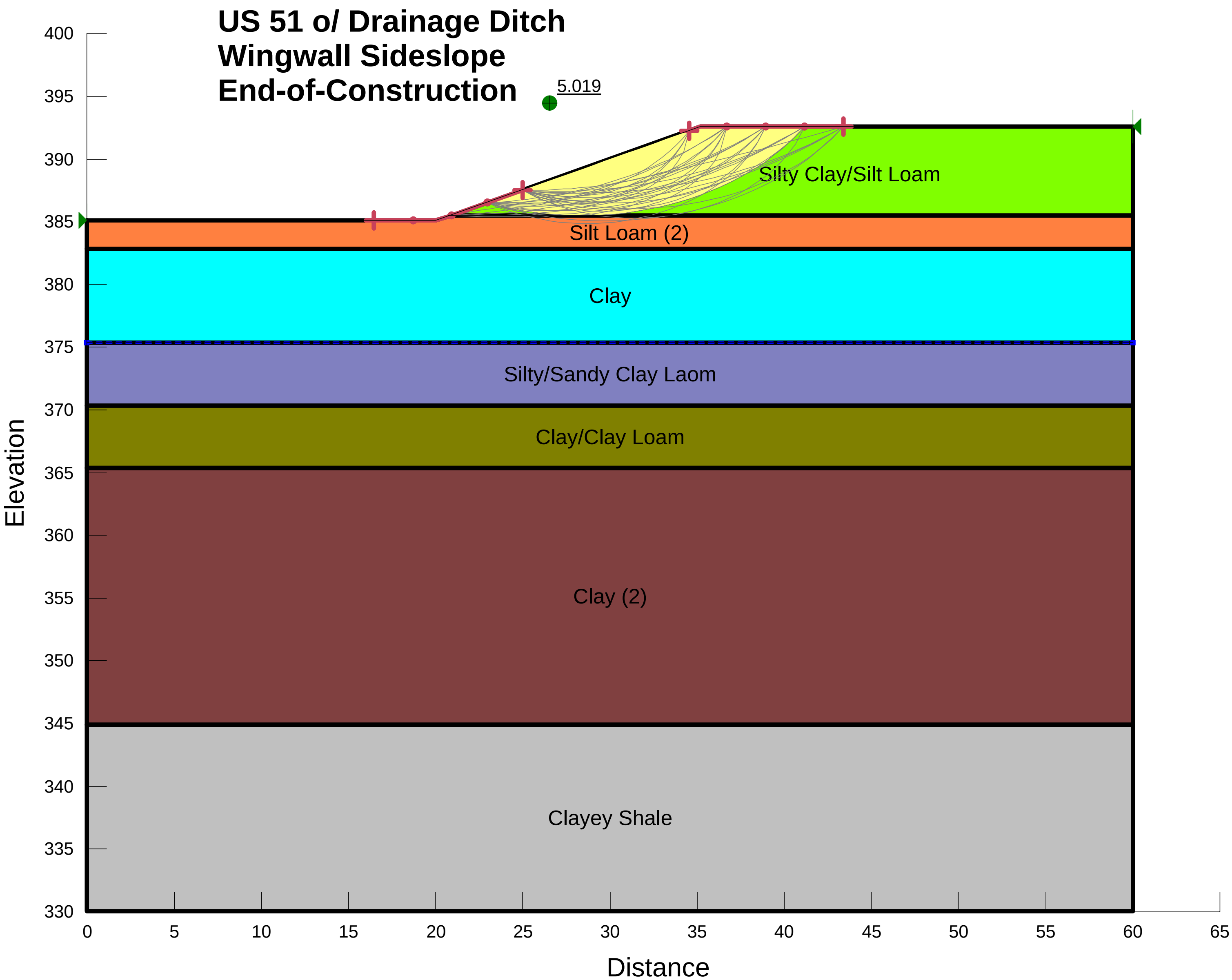
Kaskaskia Engineering Group, LLC

SUBSURFACE PROFILE :US 51 over DRAINAGE DITCH

Route: F.A.P. ROUTE 322
Section: 4B-1
County: JACKSON

EXHIBIT E

SLOPE-W SLOPE STABILITY ANALYSIS



US 51 o/ Drainage Ditch
Wingwall Sideslope
End-of-Construction
5.019
Silty Clay/Silt Loam
Silt Loam (2)
Clay
Silty/Sandy Clay Laom
Clay/Clay Loam
Clay (2)
Clayey Shale
Elevation
Distance
400
395
390
385
380
375
370
365
360
355
350
345
340
335
330
0
5
10
15
20
25
30
35
40
45
50
55
60
65

SLOPE/W Analysis

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

SLOPE/W Analysis

Description: US 51 over Drainage Ditch Culvert Wingwall Sideslopes
Kind: SLOPE/W
Method: Bishop, Ordinary and Janbu
Settings
- Apply Phreatic Correction: No
- PWP Conditions Source: Piezometric Line
- Use Staged Rapid Drawdown: No

SlipSurface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

FOS Distribution
- FOS Calculation Option: Constant

Advanced
- Number of Slices: 30
- Optimization Tolerance: 0.01
- Minimum Slip Surface Depth: 0.1 ft
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1
- Driving Side Maximum Convex Angle: 5 °
- Resisting Side Maximum Convex Angle: 1 °

Materials

Silty Clay/Silt Loam

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 500 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silt Loam (2)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 1800 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 1600 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty/Sandy Clay Laom

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 600 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay/Clay Loam

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 1800 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay (2)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 1500 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Shale

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 375 psf
Phi: 12 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (16.443049, 385.0875) ft
Left-Zone Right Coordinate: (25, 387.53649) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (34.545339, 392.26744) ft
Right-Zone Right Coordinate: (43.4, 392.59191) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 385.0875) ft
Right Coordinate: (60, 392.59191) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	0	375.35956
	60	375.35956

Regions

	Material	Points	Area (ft^2)
Region 1	Silty Clay/Silt Loam	1,2,3,4	226.44562
Region 2	Silt Loam (2)	5,6,1,4,7,8	149.90059
Region 3	Clay	8,7,9,10	450.2646
Region 4	Silty/Sandy Clay Laom	10,9,11,12	300.1764
Region 5	Clay/Clay Loam	12,11,13,14	300.1764
Region 6	Clay (2)	14,13,15,16	1225.7208
Region 7	Clayey Shale	16,15,17,18	892.191

Points

	X (ft)	Y (ft)
Point 1	20.9	385.50441
Point 2	35.2	392.59191
Point 3	60	392.59191
Point 4	60	385.50441
Point 5	0	385.0875
Point 6	20	385.0875
Point 7	60	382.86397
Point 8	0	382.86397
Point 9	60	375.35956
Point 10	0	375.35956
Point 11	60	370.35662
Point 12	0	370.35662
Point 13	60	365.35368
Point 14	0	365.35368
Point 15	60	344.925
Point 16	0	344.925
Point 17	60	330.05515
Point 18	0	330.05515

Critical Slip Surfaces

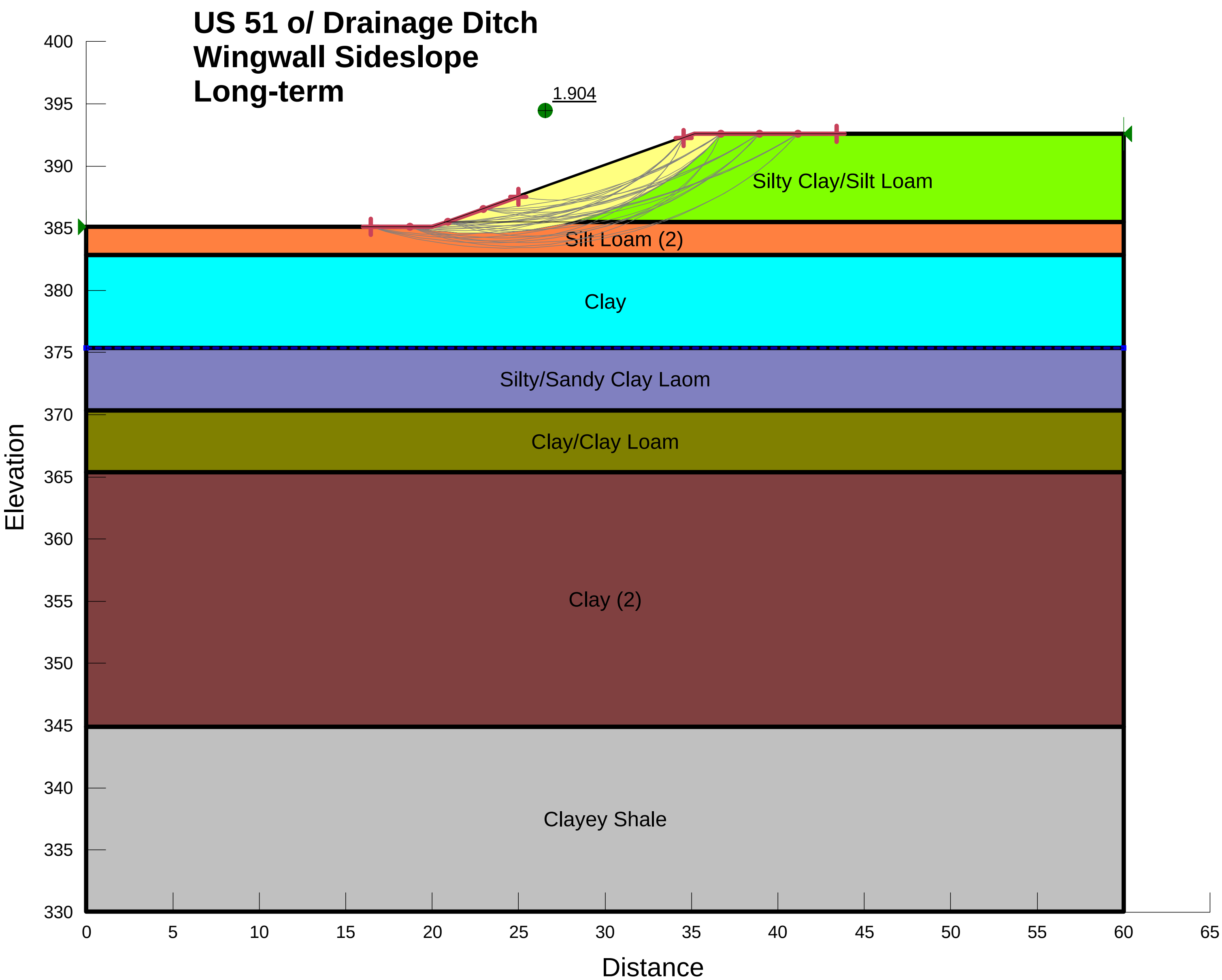
	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)

1	93	5.019	(28.399, 400.549)	15.045	(41.1673, 392.592)	(22.9561, 386.524)

Slices of Slip Surface: 93

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	93	23.255155	386.41465	-689.83188	65.823881	0	500
2	93	23.853305	386.21095	-677.1219	118.66725	0	500
3	93	24.451455	386.03475	-666.12796	168.53237	0	500
4	93	25.049605	385.8851	-656.7932	215.49754	0	500
5	93	25.647755	385.76115	-649.0628	259.62512	0	500
6	93	26.245905	385.66225	-642.89555	300.95553	0	500
7	93	26.844055	385.5879	-638.25623	339.55637	0	500
8	93	27.442205	385.53775	-635.12281	375.39767	0	500
9	93	28.040355	385.51155	-633.49002	408.54365	0	500
10	93	28.39917	385.5044	-633.03513	427.43283	0	500
11	93	28.765325	385.51185	-633.49918	445.01873	0	500
12	93	29.37815	385.5393	-635.20918	472.71873	0	500
13	93	29.990975	385.5919	-638.50111	497.4954	0	500
14	93	30.603805	385.6699	-643.37228	519.29173	0	500
15	93	31.21663	385.77375	-649.84828	538.04591	0	500
16	93	31.829455	385.90395	-657.97836	553.6589	0	500
17	93	32.442285	386.06125	-667.77955	566.04168	0	500

18	93	33.05511	386.24655	-679.33785	575.03679	0	500
19	93	33.667935	386.46085	-692.71417	580.48418	0	500
20	93	34.28076	386.7056	-707.98749	582.19246	0	500
21	93	34.893585	386.9825	-725.2727	579.92968	0	500
22	93	35.498365	387.28895	-744.39096	556.4982	0	500
23	93	36.0951	387.62635	-765.44099	511.705	0	500
24	93	36.691835	388.0012	-788.83827	462.08497	0	500
25	93	37.288565	388.41705	-814.78167	407.10697	0	500
26	93	37.8853	388.8782	-843.55763	346.10194	0	500
27	93	38.482035	389.3903	-875.5238	278.15583	0	500
28	93	39.078765	389.96085	-911.12572	202.07254	0	500
29	93	39.6755	390.6	-950.99837	116.14604	0	500
30	93	40.272235	391.3221	-996.0637	17.8213	0	500
31	93	40.86897	392.14895	-1047.6518	-96.966304	0	500


US 51 o/ Drainage Ditch
Wingwall Sideslope
Long-term
1.904
Silty Clay/Silt Loam
Silt Loam (2)
Clay
Silty/Sandy Clay Laom
Clay/Clay Loam
Clay (2)
Clayey Shale
Elevation
Distance
400
395
390
385
380
375
370
365
360
355
350
345
340
335
330
0
5
10
15
20
25
30
35
40
45
50
55
60
65

SLOPE/W Analysis

Project Settings

- Length(L) Units: feet
- Time(t) Units: Seconds
- Force(F) Units: lbf
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D

Analysis Settings

SLOPE/W Analysis

- Description: US 51 over Drainage Ditch Culvert Wingwall Sideslopes
- Kind: SLOPE/W
- Method: Bishop, Ordinary and Janbu
- Settings
  - Apply Phreatic Correction: No
  - PWP Conditions Source: Piezometric Line
  - Use Staged Rapid Drawdown: No
- SlipSurface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- FOS Distribution
  - FOS Calculation Option: Constant
- Advanced
  - Number of Slices: 30
  - Optimization Tolerance: 0.01
  - Minimum Slip Surface Depth: 0.1 ft
  - Optimization Maximum Iterations: 2000
  - Optimization Convergence Tolerance: 1e-007
  - Starting Optimization Points: 8
  - Ending Optimization Points: 16
  - Complete Passes per Insertion: 1
  - Driving Side Maximum Convex Angle: 5 °
  - Resisting Side Maximum Convex Angle: 1 °

Materials

Silty Clay/Silt Loam

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silt Loam (2)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty/Sandy Clay Laom

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay/Clay Loam

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay (2)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Shale

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 375 psf
Phi: 12 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (16.443049, 385.0875) ft
Left-Zone Right Coordinate: (25, 387.53649) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (34.545339, 392.26744) ft
Right-Zone Right Coordinate: (43.4, 392.59191) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 385.0875) ft
Right Coordinate: (60, 392.59191) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	0	375.35956
	60	375.35956

Regions

	Material	Points	Area (ft²)
Region 1	Silty Clay/Silt Loam	1,2,3,4	226.44562
Region 2	Silt Loam (2)	5,6,1,4,7,8	149.90059
Region 3	Clay	8,7,9,10	450.2646
Region 4	Silty/Sandy Clay Laom	10,9,11,12	300.1764
Region 5	Clay/Clay Loam	12,11,13,14	300.1764
Region 6	Clay (2)	14,13,15,16	1225.7208
Region 7	Clayey Shale	16,15,17,18	892.191

Points

	X (ft)	Y (ft)
Point 1	20.9	385.50441
Point 2	35.2	392.59191
Point 3	60	392.59191
Point 4	60	385.50441
Point 5	0	385.0875
Point 6	20	385.0875
Point 7	60	382.86397
Point 8	0	382.86397
Point 9	60	375.35956
Point 10	0	375.35956
Point 11	60	370.35662
Point 12	0	370.35662
Point 13	60	365.35368
Point 14	0	365.35368
Point 15	60	344.925
Point 16	0	344.925
Point 17	60	330.05515
Point 18	0	330.05515

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)

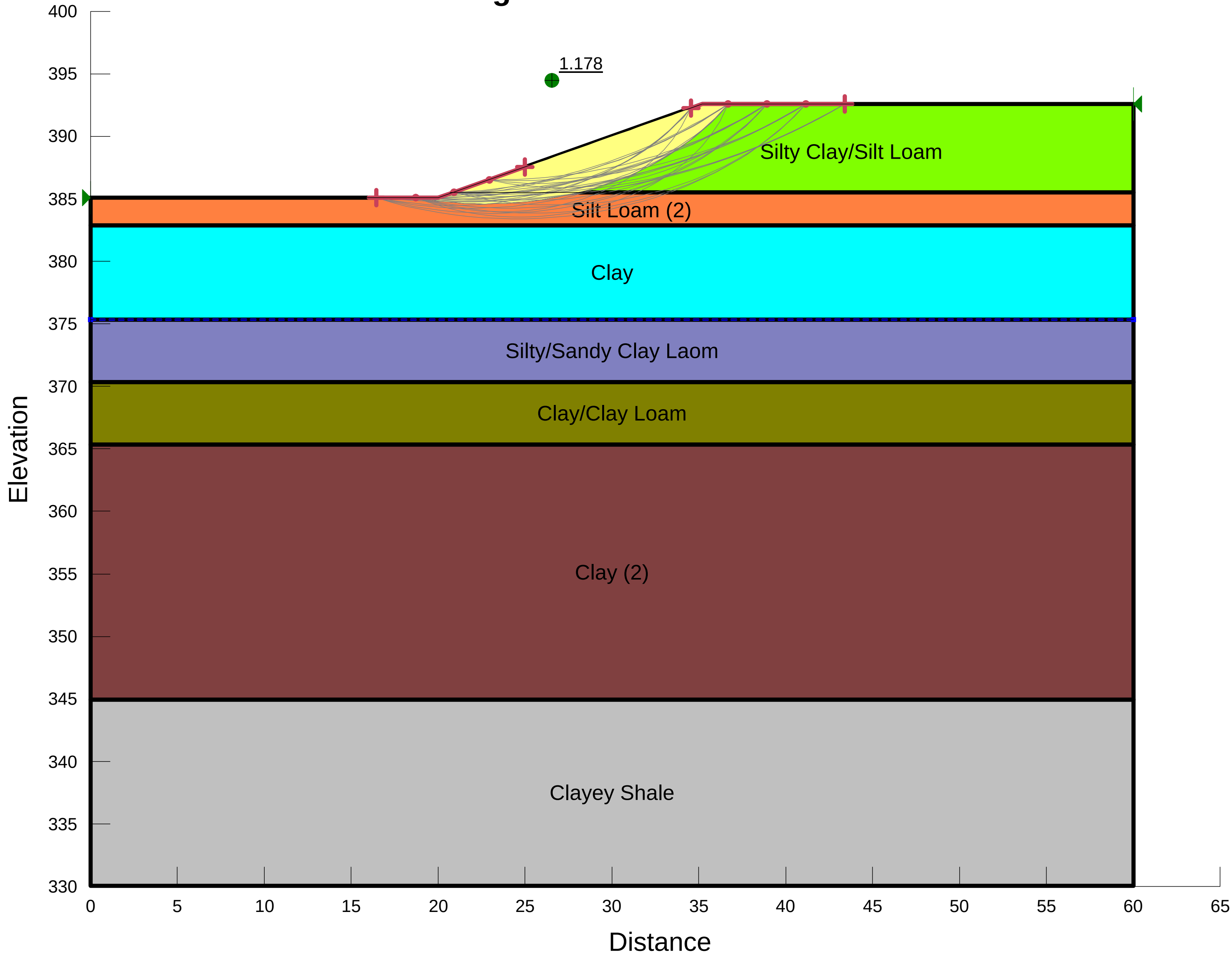
1	33	1.904	(22.706, 400.835)	16.243	(36.702, 392.592)	(18.7242, 385.087)

Slices of Slip Surface: 33

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	33	19.04318	385.01365	-602.41617	15.572434	8.2800102	50
2	33	19.68106	384.87935	-594.03458	30.525001	16.230431	50
3	33	20.225	384.78415	-588.08428	53.225822	28.300671	50
4	33	20.675	384.72105	-584.15722	84.38145	44.866413	50
5	33	21.198885	384.66485	-580.64909	119.13467	63.345027	50
6	33	21.79666	384.6202	-577.85762	156.71655	83.327667	50
7	33	22.394435	384.5977	-576.46769	190.97395	101.54265	50
8	33	22.992205	384.59725	-576.4338	222.02311	118.05178	50
9	33	23.589975	384.6188	-577.77312	249.92458	132.88726	50
10	33	24.18775	384.6625	-580.49857	274.7731	146.09945	50
11	33	24.785525	384.7285	-584.61825	296.6145	157.71273	50
12	33	25.383295	384.81705	-590.15025	315.47719	167.7422	50
13	33	25.981065	384.92855	-597.10365	331.38745	176.20183	50
14	33	26.57884	385.0635	-605.52448	344.336	183.0867	50
15	33	27.176615	385.22245	-615.44093	354.34331	188.40768	50
16	33	27.774385	385.4062	-626.90579	361.36283	192.14003	50
17	33	28.37022	385.6149	-	365.35307	194.26167	50

				639.93597			
18	33	28.964115	385.8494	-654.56673	366.2982	194.76421	50
19	33	29.558005	386.1116	-670.93285	364.13564	193.61435	50
20	33	30.1519	386.403	-689.11379	358.78749	190.77069	50
21	33	30.745795	386.72545	-709.23231	350.13216	186.16857	50
22	33	31.33969	387.0811	-731.42568	338.01769	179.72719	50
23	33	31.933585	387.47255	-755.84278	322.30559	171.37292	50
24	33	32.527475	387.9031	-782.71003	302.78036	160.99117	50
25	33	33.12137	388.37685	-812.28628	279.17618	148.44061	50
26	33	33.715265	388.899	-844.8643	251.18189	133.55578	50
27	33	34.30916	389.47625	-880.88064	218.44153	116.14742	50
28	33	34.903055	390.1175	-920.89209	180.44394	95.943747	50
29	33	35.450335	390.77245	-961.76375	130.03732	69.14207	50
30	33	35.951005	391.4425	-1003.5746	68.291046	36.310993	50
31	33	36.451675	392.1937	-1050.4494	2.8005961	1.4891033	50

US 51 o/ Drainage Ditch
Wingwall Sideslope
Seismic
Horizontal PGA 0.2481g



SLOPE/W Analysis

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

SLOPE/W Analysis

Description: US 51 over Drainage Ditch Culvert Wingwall Sideslopes
Kind: SLOPE/W
Method: Bishop, Ordinary and Janbu
Settings
- Apply Phreatic Correction: No
- PWP Conditions Source: Piezometric Line
- Use Staged Rapid Drawdown: No

SlipSurface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

FOS Distribution
- FOS Calculation Option: Constant

Advanced
- Number of Slices: 30
- Optimization Tolerance: 0.01
- Minimum Slip Surface Depth: 0.1 ft
- Optimization Maximum Iterations: 2000
- Optimization Convergence Tolerance: 1e-007
- Starting Optimization Points: 8
- Ending Optimization Points: 16
- Complete Passes per Insertion: 1
- Driving Side Maximum Convex Angle: 5 °
- Resisting Side Maximum Convex Angle: 1 °

Materials

Silty Clay/Silt Loam

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silt Loam (2)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 50 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Silty/Sandy Clay Laom

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay/Clay Loam

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clay (2)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 50 psf
Phi: 26 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Shale

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion: 375 psf
Phi: 12 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (16.443049, 385.0875) ft
Left-Zone Right Coordinate: (25, 387.53649) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (34.545339, 392.26744) ft
Right-Zone Right Coordinate: (43.4, 392.59191) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 385.0875) ft
Right Coordinate: (60, 392.59191) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
	0	375.35956
	60	375.35956

Seismic Loads

Horz Seismic Load: 0.2481

Ignore seismic load in strength: No

Regions

	Material	Points	Area (ft^2)
Region 1	Silty Clay/Silt Loam	1,2,3,4	226.44562
Region 2	Silt Loam (2)	5,6,1,4,7,8	149.90059
Region 3	Clay	8,7,9,10	450.2646
Region 4	Silty/Sandy Clay Laom	10,9,11,12	300.1764
Region 5	Clay/Clay Loam	12,11,13,14	300.1764
Region 6	Clay (2)	14,13,15,16	1225.7208
Region 7	Clayey Shale	16,15,17,18	892.191

Points

	X (ft)	Y (ft)
Point 1	20.9	385.50441
Point 2	35.2	392.59191
Point 3	60	392.59191
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Point 5	0	385.0875
Point 6	20	385.0875
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Point 8	0	382.86397
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Point 10	0	375.35956
Point 11	60	370.35662
Point 12	0	370.35662
Point 13	60	365.35368
Point 14	0	365.35368
Point 15	60	344.925
Point 16	0	344.925
Point 17	60	330.05515
Point 18	0	330.05515

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	33	1.178	(22.706, 400.835)	16.243	(36.702, 392.592)	(18.7242, 385.087)

Slices of Slip Surface: 33

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	33	19.04318	385.01365	-602.41617	20.435384	10.865686	50
2	33	19.68106	384.87935	-594.03458	34.956348	18.58662	50
3	33	20.225	384.78415	-588.08428	57.424855	30.533337	50
4	33	20.675	384.72105	-584.15722	88.473527	47.042209	50
5	33	21.198885	384.66485	-580.64909	122.69419	65.237655	50
6	33	21.79666	384.6202	-577.85762	159.19186	84.643816	50
7	33	22.394435	384.5977	-576.46769	191.92731	102.04956	50
8	33	22.992205	384.59725	-576.4338	221.06972	117.54485	50
9	33	23.589975	384.6188	-577.77312	246.78424	131.21751	50
10	33	24.18775	384.6625	-580.49857	269.209	143.14097	50
11	33	24.785525	384.7285	-584.61825	288.43512	153.36367	50
12	33	25.383295	384.81705	-590.15025	304.55429	161.93439	50
13	33	25.981065	384.92855	-597.10365	317.62401	168.88368	50
14	33	26.57884	385.0635	-605.52448	327.7	174.24118	50
15	33	27.176615	385.22245	-	334.81929	178.02658	50

				615.44093			
16	33	27.774385	385.4062	-626.90579	338.98526	180.24166	50
17	33	28.37022	385.6149	-639.93597	340.23031	180.90366	50
18	33	28.964115	385.8494	-654.56673	338.53257	180.00096	50
19	33	29.558005	386.1116	-670.93285	333.87878	177.5265	50
20	33	30.1519	386.403	-689.11379	326.24118	173.46551	50
21	33	30.745795	386.72545	-709.23231	315.56222	167.78741	50
22	33	31.33969	387.0811	-731.42568	301.73734	160.43659	50
23	33	31.933585	387.47255	-755.84278	284.67418	151.36394	50
24	33	32.527475	387.9031	-782.71003	264.22883	140.49296	50
25	33	33.12137	388.37685	-812.28628	240.26643	127.75192	50
26	33	33.715265	388.899	-844.8643	212.57756	113.02949	50
27	33	34.30916	389.47625	-880.88064	180.92542	96.199752	50
28	33	34.903055	390.1175	-920.89209	145.01091	77.103669	50
29	33	35.450335	390.77245	-961.76375	99.02071	52.650245	50
30	33	35.951005	391.4425	-1003.5746	44.268385	23.537918	50
31	33	36.451675	392.1937	-1050.4494	-12.599227	-6.6991281	50