

STRUCTURE GEOTECHNICAL REPORT

US 40 over Embarras River

Proposed Structure No. 018-0068

Existing Structure No. 018-0008

Route: US-40

Section: (FXX-B)B

County: Cumberland

Contract No. 74595

Job Number: P-97-045-12

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Foundations and Geotechnical Unit
Bureau of Bridges and Structures
Illinois Department of Transportation

Prepared for:

Bridge Planning Unit and Bridge Design Section
Illinois Department of Transportation

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Illinois Department of Transportation

Bureau of Bridges and Structures • 2300 South Dirksen Parkway • Springfield, IL 62764

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1 Project Description and Scope of Work

In this report are included the results and recommendations of the geotechnical investigation performed by the Illinois Department of Transportation (IDOT) for the proposed Project. The Project consists of the replacement of a 6-span bridge, Structure Number (SN) 018-0008, with a 4-span bridge, SN 018-0068.

The existing structure, which was built on 1946, is to be replaced with no salvage. The Project is located in District 7, Cumberland County and carries US-40 over Embarras River. The site area is shown the location maps included in Appendix A.

The existing bridge has a superstructure consisting of non-composite W36 steel beams with a reinforced concrete deck, supported on solid concrete piers and stub abutments. The abutments, as well as Piers 3 through 5 are supported by timber piles, while Piers 1 and 2 are supported by spread footings. The structure is 456'-9" long from back to back of abutments and is 32'-1 1/2" wide, with a 12 degrees skew.

The proposed bridge will have 50" deep web plate girders, supported by column-webwall bent piers and integral abutments. The abutments will be supported by H-Piles driven to rock, while the piers will be supported by drilled shafts. The structure will be 479'-8 1/4" long from face to face to face of abutments and 34'-10" wide, with a 7 degrees skew.

The proposed profile will be raised by approximately 1.5 ft according to the Plan and Profile. A structure sketch is attached to this report, in Appendix B, as well as a Plan and Profile, in Appendix C.

Preliminary factored loads were provided by our Planning Unit and are summarized in the table below:

Table 1: Preliminary Factored Loads

Substructure	Preliminary Factored Loads (kips)
West Abutment	1266
East Abutment	1406
Pier 1	3477
Pier 2	3612
Pier 3	3304

2 Field Exploration

2.1 Subsurface Exploration and Testing

Five Standard Penetration Test (SPT) logs were provided by personnel of IDOT District 7. These borings were taken on June, September and October of 2020 for substructure exploration of the existing structure. SPTs and Unconfined Compressive Strength Tests were conducted, and moisture content was reported for all samples. Grain Size Analyses were performed on some samples.

The borings were denominated Boring 1 through 5, located near the proposed substructures, from West to East. These borings were advanced to depths ranging from 45 ft to 65 ft, approximately. Borings 1 and 3 were continued with rock coring, and Boring 5 was drilled without sampling, to determine the top of rock elevation. Since the borings were taken at different times of the year, groundwater was encountered at different elevations, ranging from 517.9 ft to 506.5 ft.

Since no borings were drilled near Pier 1, the historical boring logs from the existing structure were used to supplement the data gathered in the new borings and to estimate the top of rock elevation near Piers 1 and 2. The boring logs are included in Appendix D and the location of the borings is shown on the TSL drawing included in Appendix B.

2.2 Subsurface Conditions

The soil profile consists mainly of sandy loams and silty clays over sand. Bedrock (identified as sandy clay shale) was encountered at various elevations throughout the site, tapering down towards the East side of the structure. The estimated top of rock elevations at the substructures were calculated using both the new borings and historical borings (B-1h, 2h, 4h and 6h). The elevations are shown in the table below.

Table 2: Estimated Top of Rock Elevations

Substructure	Estimated Top of Rock Elevation (ft)
West Abutment	506.6
Pier 1	502.4
Pier 2	487.2
Pier 3	471.5
East Abutment	471.9

The Unconfined Compressive Strength tests results show that most of the cohesive soils have Unconfined Compressive Strength (Q_u) values of 1.5 tsf or less, with some exceptions and blow counts ranging from 3 to 12. On average, the sands encountered below the cohesive soils have blow counts ranging from 10 to 25. From the two rock core logs, the encountered shale has Q_u values ranging from 45 tsf to 141 tsf. For detailed information, refer to the attached boring logs and laboratory tests results in Appendix D.

3 Geotechnical Evaluations and Recommendations

3.1 Settlement

According to the Plan and Profile, the grade will be raised by approximately 6 inches at the West abutment and 1.5 ft at the East abutment; therefore, no significant settlement is expected.

3.2 Slope Stability

As mentioned in the previous section, the road profile will be raised by approximately 1.5 feet at the East abutment, and the proposed embankment will have a 2H: 1V slope, as the existing. Static and seismic slope analyses were conducted, and the calculated factors of safety are 1.5 and greater for the static cases and greater than 1.1 for the seismic cases. The seismic analyses assume 1-2 inches of permanent displacement are acceptable. The seismic analyses diagrams are included in Appendix E.

3.3 Scour

The design scour elevations for the proposed structure are shown in Table 2 below. The total predicted raw scour values for Q100 and Q200 are 12.6 ft and 13.2 ft, respectively. The design scour elevations were calculated by taking the scour depths from the thalweg elevation at all three piers. This is based on both the Hydraulic Report and Hydraulic Unit's assertion that the stream is prone to migrating significantly over the life of the structure.

Scour reduction was applied at Pier 1 due to bedrock being very close to the surface at that location; however, due to the encountered granular soils, as well as deeper bedrock elevations, no scour reductions were applied at the locations of Piers 2 and 3.

Class A5 stone riprap will be used at the abutment slopes location, extending to the streambed elevation at the West abutment.

Table 3: Design Scour Table

Event/Limit State	Design Scour Elevations (ft.)					Item 113
	W. Abut.	Pier 1	Pier 2	Pier 3	E. Abut.	
Q100	537.9	501.2	490.2	490.2	529.2	5
Q200	537.9	501.1	489.6	489.6	529.2	
Design	537.9	501.2	490.2	490.2	529.2	
Check	537.9	501.1	489.6	489.6	529.2	

3.4 Seismic Considerations

The soils encountered in this site correspond to a Soil Site Class D. The seismic data is summarized in the table below.

Table 4: Seismic Data

Seismic Performance Zone (SPZ)	2
SDS	0.428g
SD1	0.195g
Soil Site Class	D

This project is located in SPZ 2; therefore, liquefaction analyses were conducted. Since all soil layers were found either non-liquefiable or have factors of safety greater than 1, no remedial treatment is required, and liquefaction was not taken into account when calculating the foundation resistances.

4 Foundation Recommendations

4.1 Driven Piles

Driven piles are a geotechnically adequate foundation treatment for the abutments as well as for Pier 3; however, they are not recommended for Piers 1 and 2. As shown on Table 2, the estimated top of rock elevation is 487.2 ft, only 3 ft below the design scour elevation at that location. That would leave the driven piles only 3 ft of embedment over shale. H-piles are expected to penetrate shale, but the achievable embedment depths are unknown. For this reason, driven piles at this specific location are not recommended.

One test pile per substructure is recommended.

The corresponding pile factored resistances and estimated lengths are shown in the table below.

Table 5: Design Pile Table

East Abutment			
Pile Section	Nominal Required Bearing (kips)	Factored Resistance Available (kips)	Estimated Pile Length (ft)
HP 12 X 74	589	324	67
HP 14 X 73	578	318	65
HP 14 X 89	705	388	67
HP 14 X 102	810	445	69
HP 14 X 117	929	511	70
West Abutment			
Pile Section	Nominal Required Bearing (kips)	Factored Resistance Available (kips)	Estimated Pile Length (ft)
HP 12 X 74	589	324	41
HP 14 X 73	578	318	39
HP 14 X 89	705	388	41
HP 14 X 102	810	445	43
HP 14 X 117	929	511	44

Pier 3			
Pile Section	Nominal Required Bearing (kips)	Factored Resistance Available (kips)	Estimate d Pile Length (ft)
HP 12 X 74	589	298	56
HP 14 X 73	578	288	54
HP 14 X 89	705	358	56
HP 14 X 102	810	416	58
HP 14 X 117	929	480	59

4.2 Spread Footings

Since shale was encountered close to the surface towards the West side of the structure, the use of a spread footing to support Pier 1 is feasible. Shale provides enough bearing capacity to support the spread footing; however, the bottom of footing shall be at Elevation 498.9 ft or keyed a minimum of 3.5 ft into rock, whichever is deeper. We estimate that factored bearing resistance is greater than 15 ksf. To protect the shale during construction, a mud slab seal needs to be utilized. In addition to maintain the shale's integrity, it will also provide resistance to sliding. For additional details, refer to Section 5.3 of this SGR.

4.3 Drilled Shafts

Drilled shafts are feasible at all three piers and appear to be the most practical option for Pier 2. Using drilled shafts could avoid the use of cofferdams if drilled shaft bents with permanent casings and web walls are able to be constructed without cofferdams (this would depend on the elevation of the web wall). If shaft bents with solid wall encasements are used for any of the piers, the cofferdam needed would use a much smaller footprint than what would be needed for a shaft supported footing or a spread footing in rock. It should be noted that Pier 1 would not need such a large excavation in rock nor a mud slab.

Utilizing Rock Core No. 3, the estimated factored unit side and tip resistances would be 14 ksf and 160 ksf, respectively.

5 Construction Considerations

5.1 Soil Retention

As per the Structure Report, the traffic will be maintained by a road closure and a detour; however, should stage construction be implemented, cantilever temporary sheet piles could be used, thereby using the *Temporary Sheet Piling* pay item. To construct the proposed structure, excavations of approximately 10 feet would be required.

5.2 Cofferdams

An Estimated Water Surface Elevation (EWSE) of 513.14 feet was provided by the IDOT Planning Unit. Since shaft bents with webwalls will be utilized at all three piers, cofferdams are not required. Should the piers be supported by footings, Piers 1 and 2 would require the use of cofferdams and since the EWSE is over 6 ft above the bottom of the footings at both locations, Type 2 cofferdams would be required.

If a spread footing were to be used at Pier 1, a mud slab would be required (see next section for details).

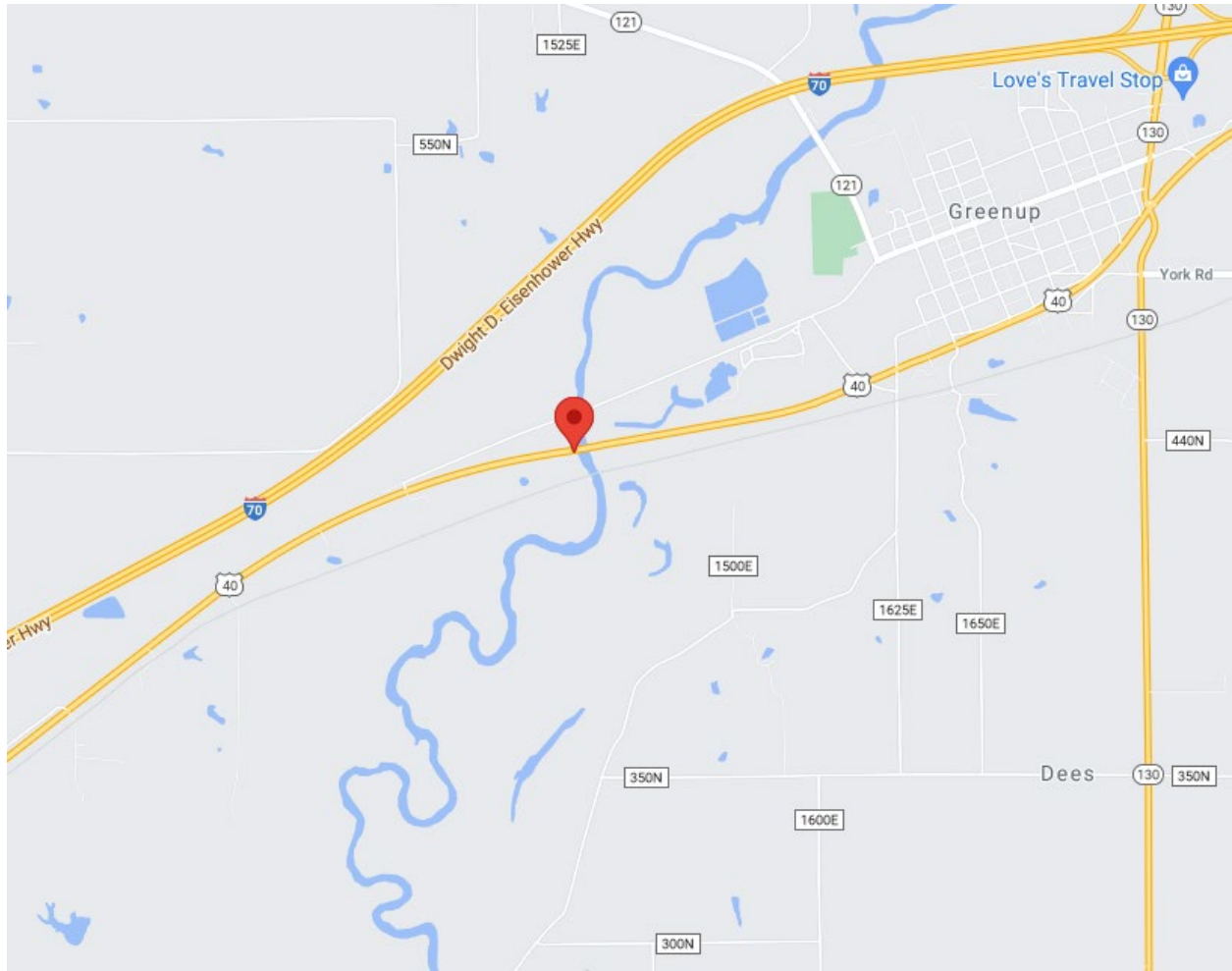
5.3 Mud Slab Seal

If a spread footing were to be used to support Pier 1, a mud slab seal would need to be utilized below said spread footing . This would protect the integrity of the shale and provide sliding resistance to the footing. The following note would need to be added to the plans:

The footing excavation shall be undercut by 6 in. and immediately filled with seal coat concrete to prevent degradation of the exposed foundation material surface.

Appendices

Appendix A: Site Location Map



Site Location¹

¹ Image retrieved from Google Maps 2021.

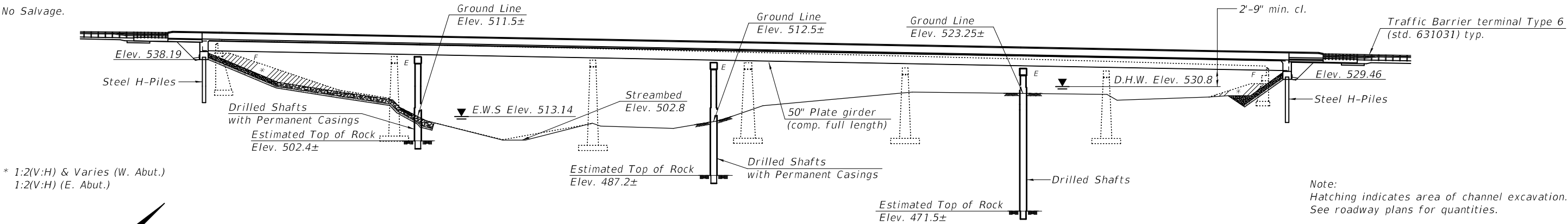
Appendix B: Type, Size & Location (TSL)

Bench Mark: BM 201: Chiseled square on wingwall at northwest corner of SN: 018-0008
Station 1724+56, 15.6' Left, Elevation = 542.27

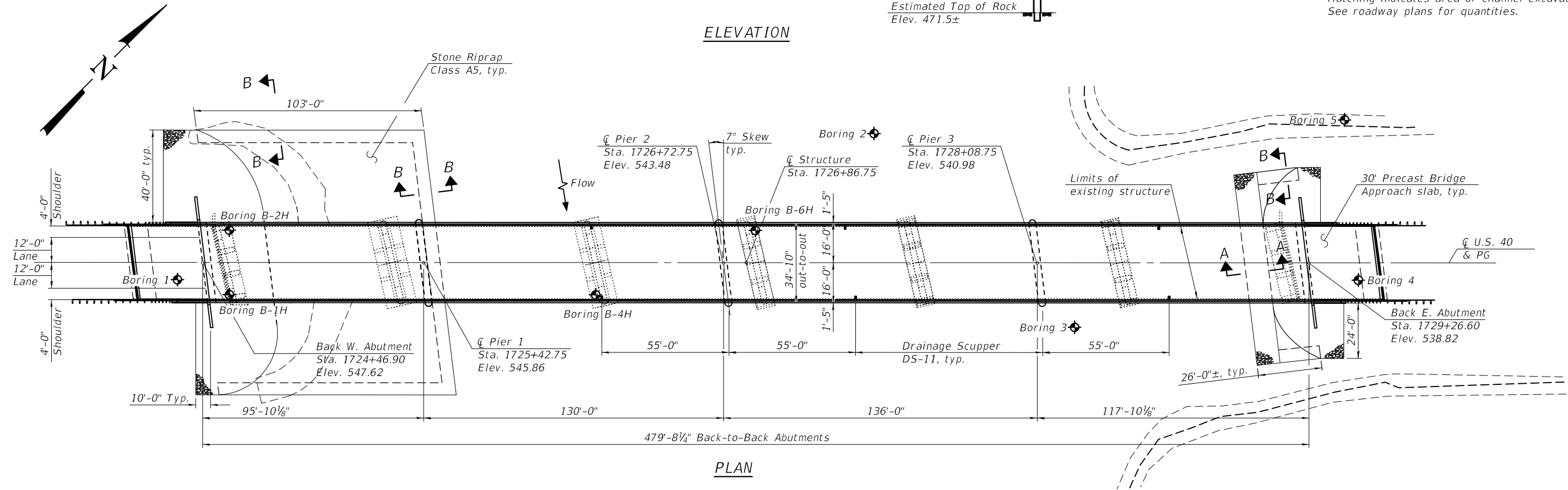
Existing Structure: Structure No. 018-0008 was originally constructed in 1946 under F.A. Rte. 12(S.B.I. RT II), Section F-X-BF at station 726+91.75. The superstructure consists of a 6 span continuous non-composite W36 steel beams, with a 7" reinforced concrete deck, all supported on solid concrete piers and stub abutments over timber piles. In 1984, a new 1½" bituminous wearing surface with waterproofing membrane was added as well as a new bridge rail. The deck was patched, joints were reconstructed, and beam ends over pier 3 were repaired and/or replaced.

Road Closure with marked route detour for maintenance of traffic.

No Salvage.



* 1:2(V:H) & Varies (W. Abut.)
1:2(V:H) (E. Abut.)



HIGHWAY CLASSIFICATION

F.A.S. Route 1707 - U.S. 40
Functional Class: Major Collector
ADT: 1600 (2024); 1950 (2044)
ADTT: 226 (2024); 275 (2044)
DHV: 184 (2024); 224 (2044)
Design Speed: 60 m.p.h.
Posted Speed: 55 m.p.h.
2-Way Traffic
Directional Distribution: 51/49

DESIGN STRESSES

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

All structural steel shall be metalized

DESIGN SPECIFICATIONS

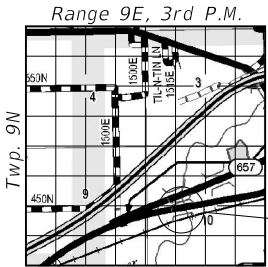
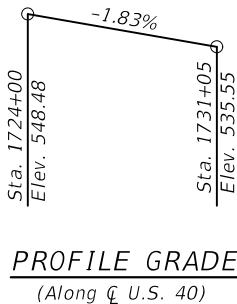
2020 AASHTO LRFD Bridge Design
Specifications, 9th Edition

LOADING HL-93

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

SEISMIC DATA

Seismic Performance Zone (SPZ) = 2
Design Spectral Acceleration at 1.0 sec. (SD1) = 0.195g
Design Spectral Acceleration at 0.2 sec. (SDS) = 0.428g
Soil Site Class = D



GENERAL PLAN & ELEVATION
U.S. 40 OVER EMBARRAS RIVER
F.A.S. Rte. 1707-SEC. (FXX-B)B

CUMBERLAND COUNTY
STATION 1726+86.75
STRUCTURE NO. 018-0068

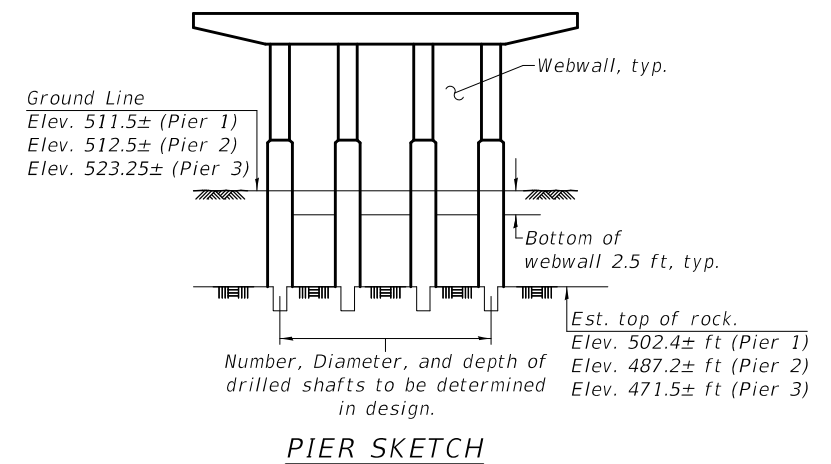
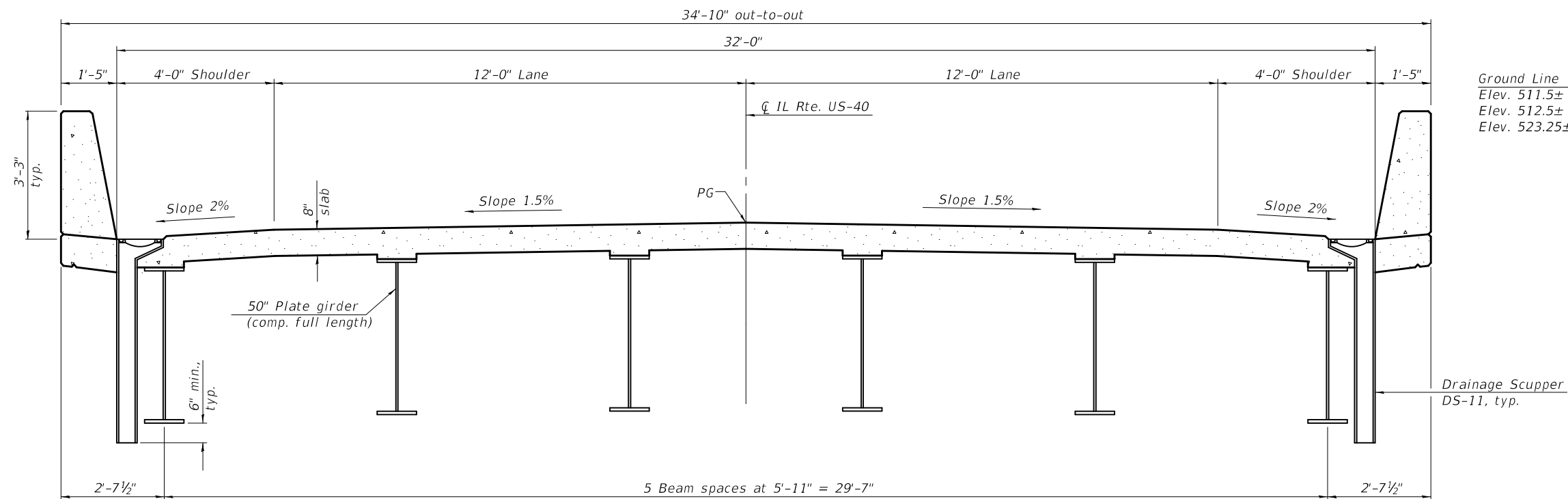
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET 1 OF 2 SHEETS

F.A.S. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
1707	(FXX-B)B	CUMBERLAND	2	1
CONTRACT NO. 74595				
ILLINOIS FED. AID PROJECT				

MODEL: 0180068-74595-TSL-001
FILE NAME: pw:\idiot-pw\benley.com\FWIDOT\Documents\IDOT Offices\Bureau of Bridges and Structures\Projects\0180068\CADD Plans\0180068-74595.dgn

4/26/2022 - 3:23:55 PM



CROSS SECTION

APPROVED

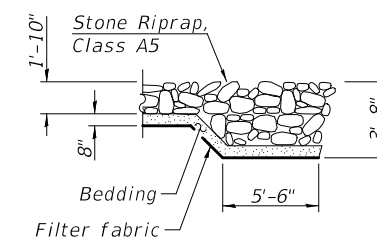
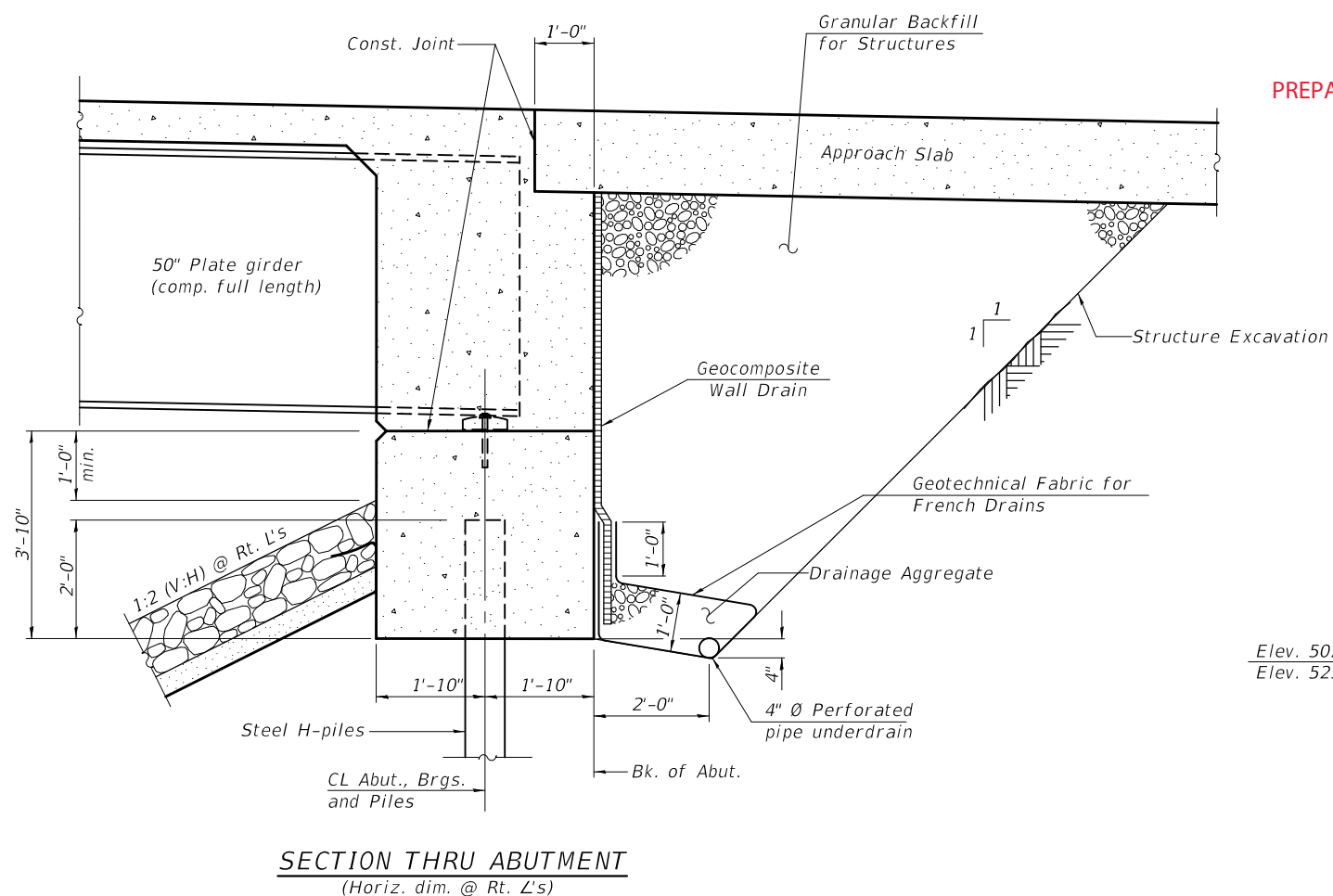
APRIL 27, 2022

AS A BASIS FOR
PREPARATION OF DETAILED PLANS

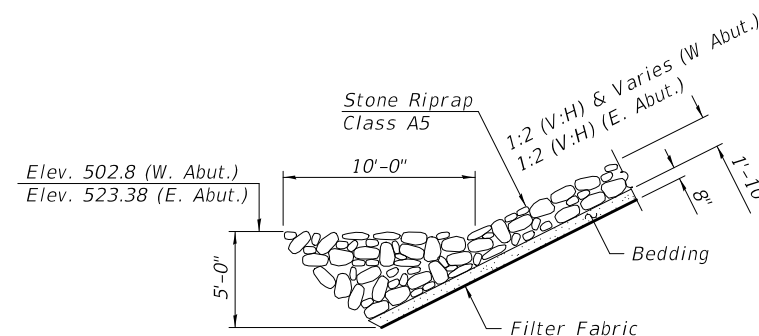
WATERWAY INFORMATION

Existing Overtopping Elev. = 532.64 at Sta. 1755+96 Proposed Overtopping Elev. = 532.64 at Sta. 1755+96 Drainage Area = 1021.0 sq. mi.									
Flood	Freq. Yr.	Disch. Ft³/s	Opening Ft²		Nat. H.W.E.	Head - Ft.		Headwater El.	
			Exist.	Prop.		Exist.	Prop.	Exist.	Prop.
	10	17,830	4,440	4,660	528.5	0.2	0.1	528.7	528.6
Design	50	26,620	5,290	5,290	530.8	0.5	0.4	531.3	531.2
Base	100	30,360	5,630	5,990	531.6	0.6	0.5	532.2	532.1
Scour Design Check	200	34,200	5,850	6,370	532.5	0.6	0.5	533.1	533.0
Max. Calc.	500	39,200	6,270	6,990	533.6	0.8	0.7	534.4	534.3

10 year velocity through existing bridge = 4.0 ft/s
10 year velocity through proposed bridge = 3.8 ft/s



SECTION B-B



SECTION A-A

DESIGN SCOUR ELEVATION TABLE

Event / Limit	Design Scour Elevations (ft.)					Item 113
State	West Abut.	Pier 1	Pier 2	Pier 3	E. Abut.	
Q100	538.19	501.2	490.2	490.2	529.46	5
Q200	538.19	501.1	489.6	489.6	529.46	
Design	538.19	501.2	490.2	490.2	529.46	
Check	538.19	501.1	489.6	489.6	529.46	

DETAILS
U.S. 40 OVER EMBARRAS RIVER
F.A.S. Rte. 1707-SEC. (FXX-B)B
CUMBERLAND COUNTY
STATION 1726+86.75
STRUCTURE NO. 018-0068

Appendix C: Plan and Profile



Bridge Opening / Cross Section
Along C/P.G US 40

Appendix D: Boring Logs

Page 1 of 3

Date 6/2/20

SOIL BORING 018-0008(E), -0068(P) SOIL ROCK 2020.GPJ IL DOT.GDT 12/16/20

BBS, form 137 (Rev. 8-99)



BBS, form 137 (Rev. 8-99)

Field Rock Core Log

Date: 6-2-20Structure #: 018-0008Boring #: B1 W. ABUTRock Core #: C1Rock Core #: C2Depth: 45⁰

RQD

5.25

1.00

1.75

.50

.50

8.00

1

2

3

4

Grey
SANDY
clay

S

H

A

L
E

CORE to TEST

0.1630J

1.600J

2.250J

2.750J

Depth: 50⁰Core Time: 11:50Recovery: 64%RQD: 64Logged By: Eric SandschaferDepth: 50⁰

Grey

SANDY

clay

S

H

A

L

E

0.120J

0.910J

1.100J

1.220J

1.650J

1.850J

2.180J

CORE TO TEST

48.75

3.150J

3.400J

3.570J

3.830J

4.87

Depth: 55⁰Core Time: 12:57Recovery: 100%RQD: 81.25%

RQD

11.25

9.00

4.00

12.00

12.50

Field Rock Core Log

Date: 6-2-20Structure #: 018-0008Boring #: B1 W. ABUTRock Core #: C3

Rock Core #: _____

Depth: 55'

Depth: _____

0.15' 0J
0.37' 0J

Grey

SANDY

1.60' 0J

CLAY

2.62' 0J

S

H

3.48' 0J

A

L

E

CORE
TO
TESTDepth: 60'

Depth: _____

Core Time: 11:40

Core Time: _____

Recovery: 100%

Recovery: _____

RQD: 91.25

RQD: _____

Logged By: Eric Sandschafer

Page 1 of 2

Date 10/1/20

BBS, form 137 (Rev. 8-99)



SOIL BORING LOG

ROUTE FAS 1707 DESCRIPTION US 40 over Embarras River LOGGED BY E. Sandschafer

SECTION (FXX-B)B LOCATION E 1/2, SEC. 10, TWP. 9N, RNG. 9E, 3rd PM,
Latitude N 39.237503, Longitude W 88.186506

COUNTY Cumberland DRILLING METHOD Hollow stem auger & split spoon HAMMER Auto ETR = 91.8% @ 57.4 bpm

STRUCT. NO. 018-0008 (Existing)
018-0068 (Proposed)
Station 1726+91.75

BORING NO. 2 (Middle Pier)
Station 1727+38
Offset 56.0 ft LT
Ground Surface Elev. 523.55 ft

D E P T H	B L O W S	U C S Qu	M O I S T
(ft)	(/6")	(tsf)	(%)

Surface Water Elev.	<u>510.34</u>	ft
Stream Bed Elev.	<u>506.34</u>	ft
Groundwater Elev.:		
First Encounter	<u>509.1</u>	ft ▼
Upon Completion	<u>511.6</u>	ft ▼
After <u>24</u> Hrs.	<u>511.6</u>	ft ▼

Medium, wet, brown, coarse,
SAND with 1/8 "-5/8" rounded
gravel

8			6
8			

Grey, fine
9.7% passing #200.

-45	8		
	8		16
	8		

11.9% passing #200.

-50	12		
	13		13
	11		

471.05
Very dense, moist, grey, SHALE 470.35

	20		
	50		7

Benchmark: BM 202 - Permanent
Survey Marker on wingwall at
southeast corner of Structure No.
018-0008.
End of Boring

	1-5/8"		
	50		
-55	-1/16"		

SOIL BORING 018-0008(E), -0068(P) SOIL ROCK 2020.GPJ IL DOT.GDT 12/16/20

Page 1 of 3

Date 9/30/20

BBS, form 137 (Rev. 8-99)

[illegible]

BBS, form 137 (Rev. 8-99)

Field Rock Core Log

Date: 9-30-20Structure #: 018-6008Boring #: B3Rock Core #: C1Rock Core #: C2

Depth:

53'CORE
TO
TEST

0.05 0J
0.10 0J
0.35 0J
0.50 0J
0.55 0J
1.07 0J
1.74 0J
1.93 0J
2.10 0J
2.40 0J

RQD

6.125

7.875

2

14

60

0.233

3

x100

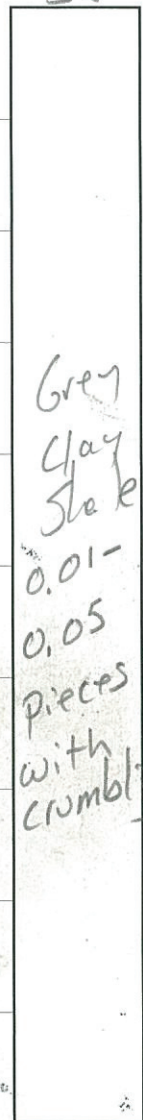
23.333

4

Note:
Was hard to flow
water. Also pea gravel
was in core barrel
tearing up
the CORE

Depth: 58'Core Time: 21:18Recovery: 50%RQD: 23.333Logged By: Eric Sandschafer

Depth:

58'

Grey
Clay
Shale

0.01-
0.05
pieces
with
crumbling

Note:
we overloaded
Rock Core Barrel.
All the Shale
is broken and
NOT Representative
of the subgrade
conditions.

RQD

0

Depth: 63'Core Time: 18:22Recovery: 100%RQD: 0%

Page 1 of 2

Date 6/1/20

BBS, form 137 (Rev. 8-99)



BBS, form 137 (Rev. 8-99)



SOIL BORING LOG

ROUTE FAS 1707 DESCRIPTION US 40 over Embarras River LOGGED BY E. Sandschafer

SECTION (FXX-B)B LOCATION E 1/2, SEC. 10, TWP. 9N, RNG. 9E, 3rd PM,
Latitude N 39.237677, Longitude W 88.185779

COUNTY Cumberland DRILLING METHOD Hollow stem auger & split spoon **HAMMER** Auto ETR = 91.8% @ 57.4 bpm

STRUCT. NO. 018-0008 (Existing)
018-0068 (Proposed)
Station 1726+91.75

BORING NO. 5 (East Abutment)
Station 1729+42
Offset 62.0 ft LT
Ground Surface Elev. 521.40 ft

D E P T H (ft)	B L O W S (/6")	U C S Qu (tsf)	M O I S T (%)	Surface Water Elev. <u>510.34</u> ft	Stream Bed Elev. <u>506.34</u> ft	D E P T H (ft)	B L O W S (/6")	U C S Qu (tsf)	M O I S T (%)
				Groundwater Elev.:					
				First Encounter <u>NA</u> ft					
				Upon Completion <u>NA</u> ft					
				After <u> </u> Hrs. <u>NA</u> ft					

No sampling - Boring advanced to
determine top of rock elevation.

No sampling - Boring advanced to
determine top of rock elevation.

501.40 -20

481.40 -40

SOIL BORING 018-0008(E), -0068(P) SOIL ROCK 2020.GPJ IL_DOT.GDT 12/16/20

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

BBS, form 137 (Rev. 8-99)



SOIL BORING LOG

ROUTE FAS 1707 DESCRIPTION US 40 over Embarras River LOGGED BY E. Sandschafer

SECTION (FXX-B)B LOCATION E 1/2, SEC. 10, TWP. 9N, RNG. 9E, 3rd PM,
Latitude N 39.237677, Longitude W 88.185779

COUNTY Cumberland DRILLING METHOD Hollow stem auger & split spoon **HAMMER** Auto ETR = 91.8% @ 57.4 bpm

STRUCT. NO. 018-0008 (Existing)
018-0068 (Proposed)
Station 1726+91.75

BORING NO. 5 (East Abutment)
Station 1729+42
Offset 62.0 ft LT
Ground Surface Elev. 521.40 ft

D E P T H	B L O W S	U C S	M O I S T
(ft)	(/6")	(tsf)	(%)

Surface Water Elev.	<u>510.34</u>	ft
Stream Bed Elev.	<u>506.34</u>	ft
Groundwater Elev.:		
First Encounter	<u>NA</u>	ft
Upon Completion	<u>NA</u>	ft
After <u> </u> Hrs.	<u>NA</u>	ft

No sampling - Boring advanced to determine top of rock elevation.

Very dense, grey, pokerchipped, silty, clay, SHALE

Benchmark: BM 202 - Permanent Survey Marker on wingwall at southeast corner of Structure No. 018-0008.
End of Boring

-45			
473.90	32		
	50		9
471.90	3-9/16"		
	50 2"		
-50			
-55			
-60			

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



Yellow Silt
& Sand

Yellow Sand

Yellow Sand
& Gravel

77.8

87

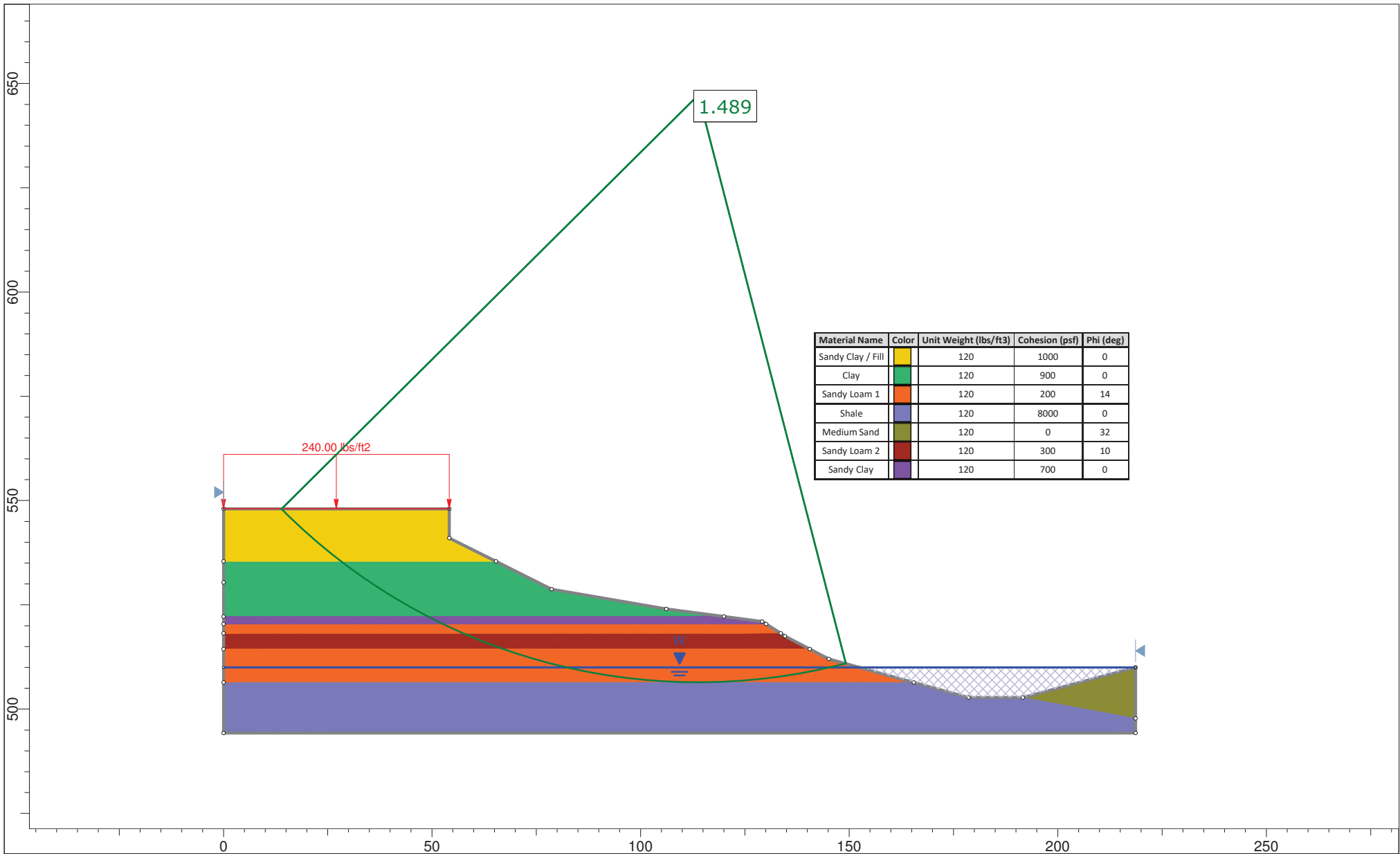
729-0368

STRESSSES
for 100 $\frac{W}{G}$ (Super)
for 200 $\frac{W}{G}$ (S24)
for 2000 $\frac{W}{G}$ (Rm)
for 1000 $\frac{W}{G}$ (Rock)
ms 10

STRENGTHS

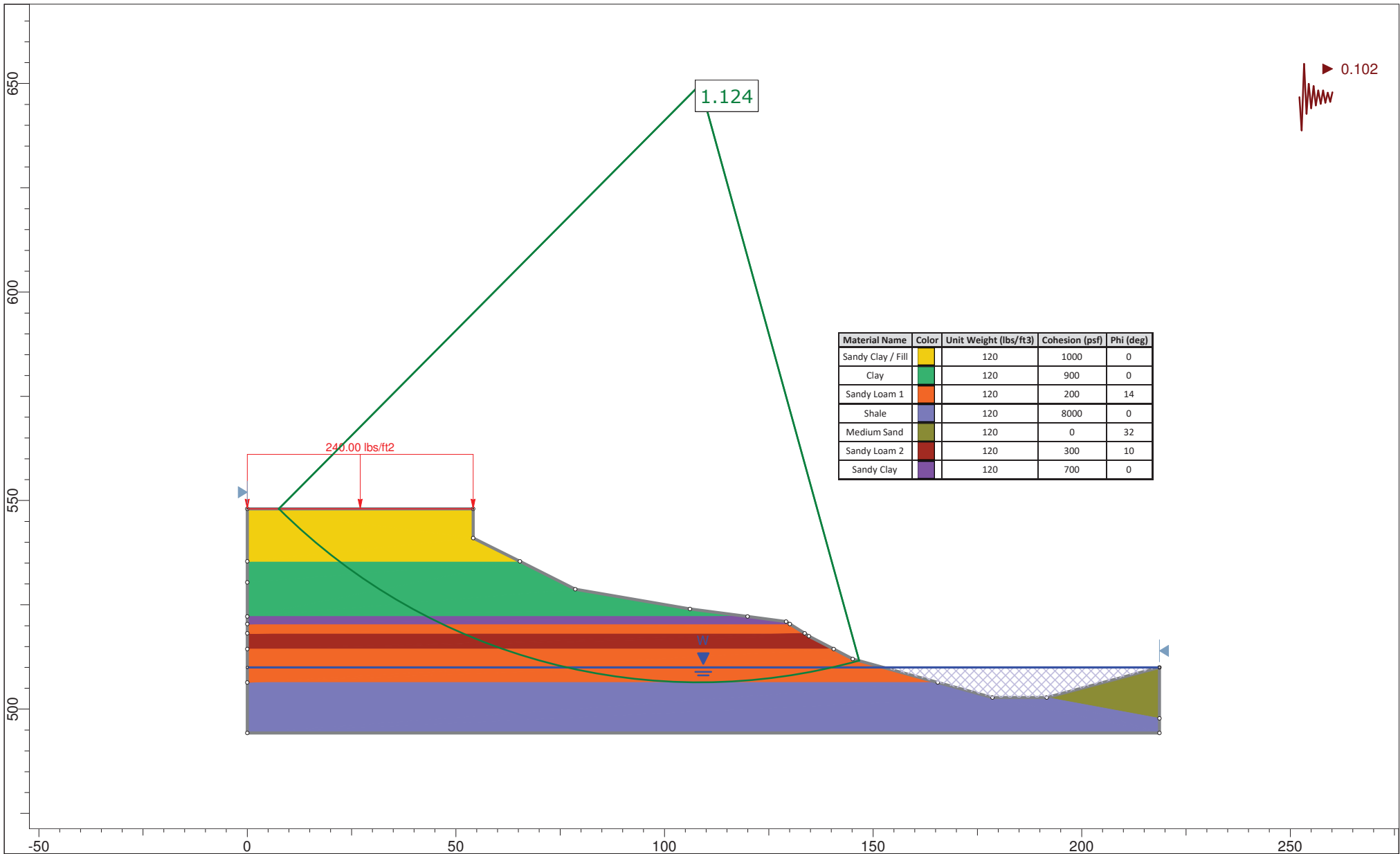
U-20-S16-44 Loading

Appendix E: Slope Stability Analyses



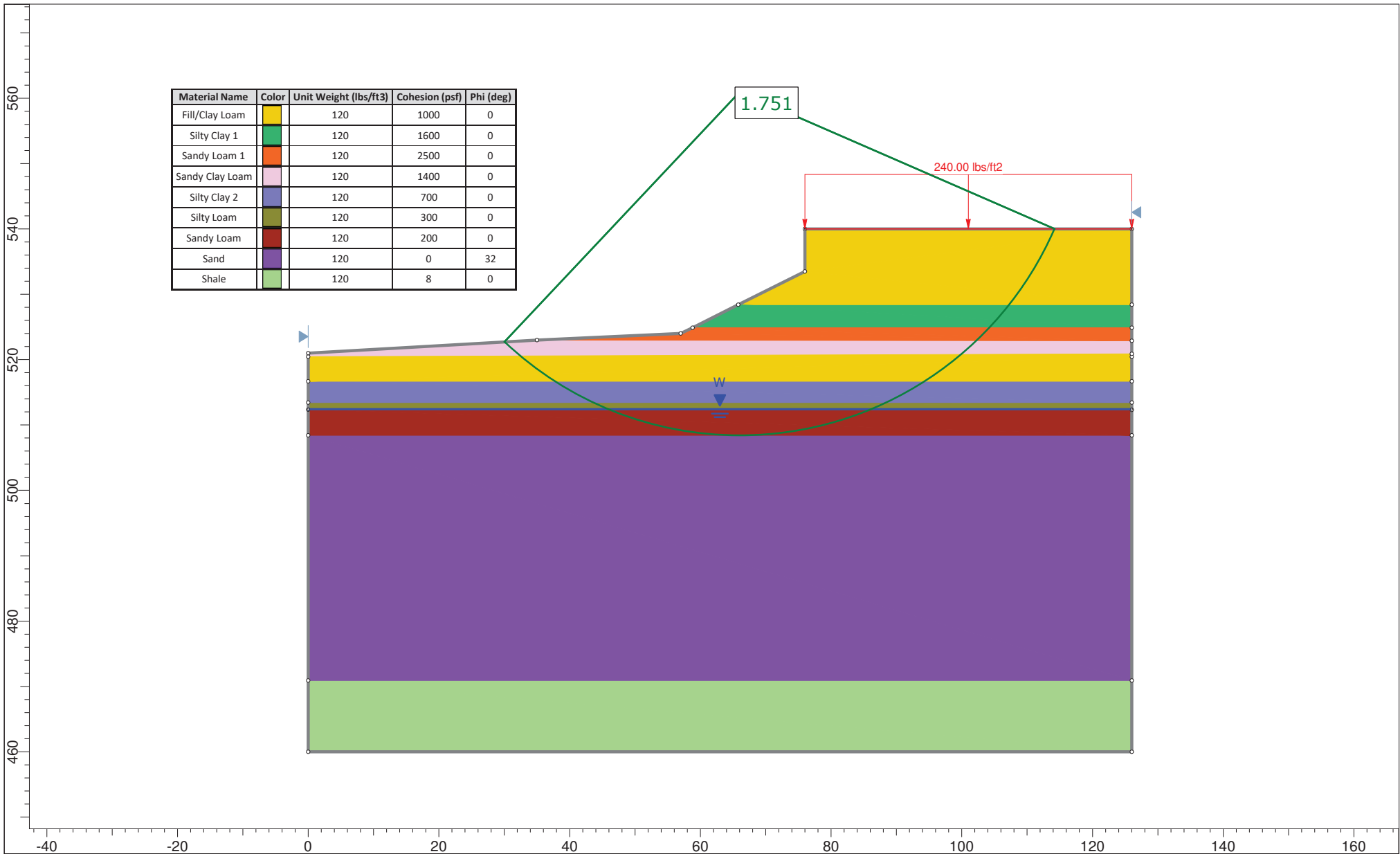
SLIDEINTERPRET 9.008

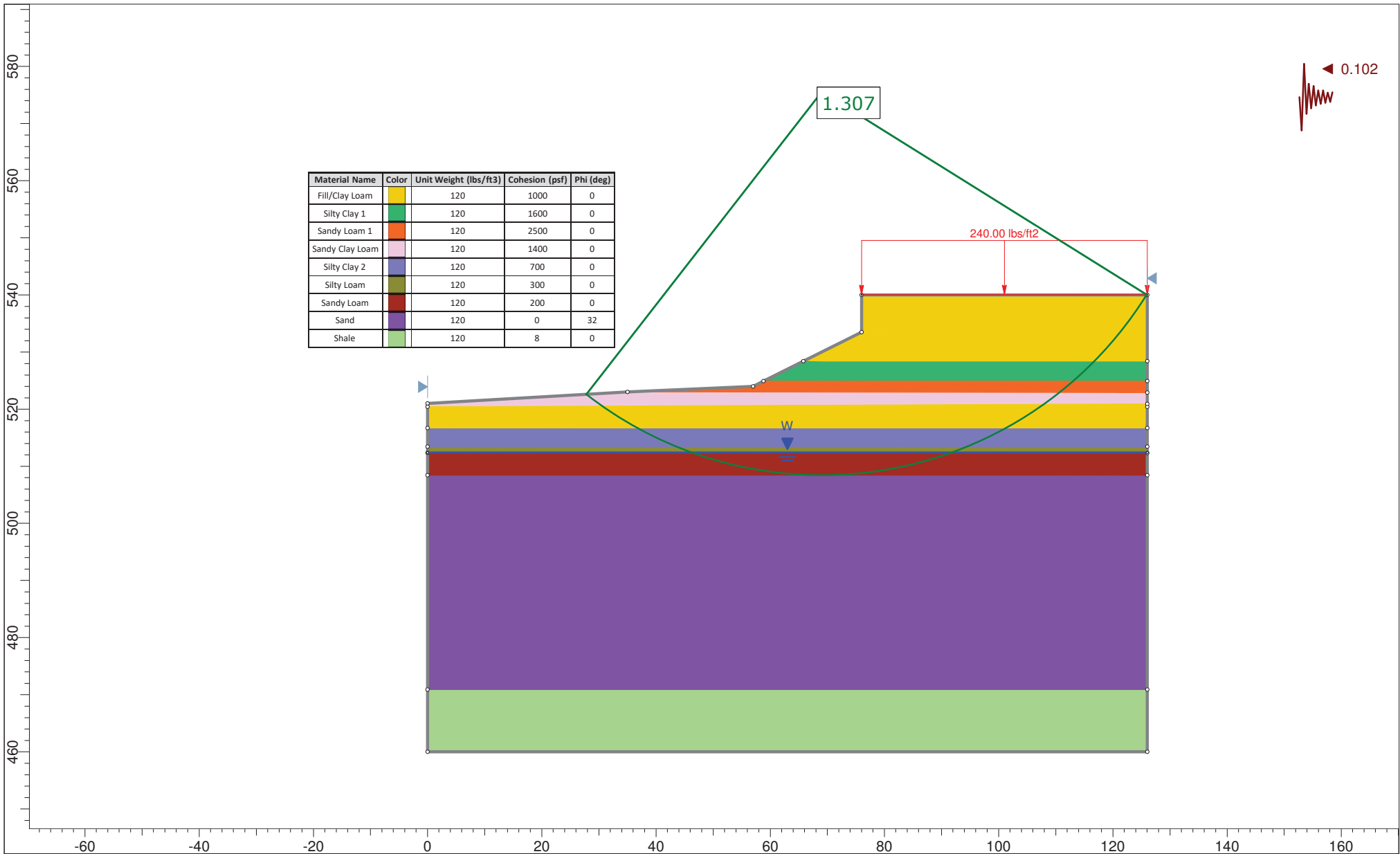
Project			
SLIDE - An Interactive Slope Stability Program			
Group		Scenario	
Group 1		Master Scenario	
Drawn By		Company	
Date		File Name	
6/28/2021, 2:06:59 PM		W. Embankment End Slope.slmd	



SLIDEINTERPRET 9.008

Project			
SLIDE - An Interactive Slope Stability Program			
Group	Group 1		Scenario
			Master Scenario
Drawn By			Company
Date	6/28/2021, 2:06:59 PM		File Name
			W. Embankment End Slope.slmd





Appendix F: Liquefaction Spreadsheets



LIQUEFACTION ANALYSIS

REFERENCE BORING NUMBER ===== W. Abut / B-1
ELEVATION OF BORING GROUND SURFACE ===== 547.41 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ===== 29.51 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ===== 17.75 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.376
EARTHQUAKE MOMENT MAGNITUDE ===== 4.9
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ===== 9.71 FT. (Fill Height)
HAMMER EFFICIENCY===== 73 %
BOREHOLE DIAMETER===== 8 IN.
SAMPLING METHOD===== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = 2.581

AVG. SHEAR WAVE VELOCITY (top 40')
 $V_{s,40'} = 384$ FT./SEC.

PGA CALCULATOR

Earthquake Moment Magnitude = 4.9
Source-To-Site Distance, R (km) = 10
Ground Motion Prediction Equations = CEUS
PGA = 0.244

BORING DATA								CONDITIONS DURING DRILLING						CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE	BORING DEPTH	SPT N VALUE	UNCONF. COMPR. STR., Q _u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w _c (%)	EFFECTIVE UNIT WT. (KCF.)	VERT. STRESS (KSF.)	CORR. SPT N VALUE (N ₁) ₆₀	EQUIV. CLN. SAND SPT N VALUE (N ₁) _{60CS}	CRR RESIST. MAG 7.5 CRR _{7.5}	EFFECTIVE UNIT WT. (KCF.)	VERT. STRESS (KSF.)	TOTAL VERT. STRESS (KSF.)	OVER-BURDEN CORR. FACT. (Ks)	CORR. RESIST. CRR _{7.5} CRR	SOIL MASS PART. FACTOR (r _d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR	
545.41	2	5	0.7					0.117	0.234	9.690	9.690	0.110	0.117	1.399	1.399	1.100	0.313	0.745	0.182	N.L. (1)	
541.91	5.5	5	0.7					0.117	0.644	8.445	8.445	0.100	0.117	1.809	1.809	1.036	0.266	0.657	0.161	N.L. (1)	
540.66	6.75	5	0.7					0.117	0.790	8.075	8.075	0.097	0.117	1.955	1.955	1.018	0.254	0.627	0.153	N.L. (1)	
538.16	9.25	3	0.5		11	30	12	0.114	1.075	4.753	4.753	0.070	0.052	2.085	2.160	1.003	0.182	0.568	0.144	N.L. (2)	
535.41	12	7	1.5		11	30	15	0.126	1.421	10.796	10.796	0.120	0.064	2.261	2.508	0.985	0.306	0.508	0.138	N.L. (2)	
532.91	14.5	5	1		11	30	13	0.122	1.726	7.457	7.457	0.091	0.060	2.411	2.814	0.973	0.229	0.460	0.131	N.L. (2)	
530.41	17	3	0.8		11	30	25	0.119	2.024	4.304	4.304	0.067	0.057	2.553	3.113	0.963	0.167	0.418	0.125	N.L. (2)	
527.91	19.5	4	0.9		11	30	21	0.120	2.324	5.495	5.495	0.076	0.058	2.698	3.414	0.952	0.186	0.383	0.118	N.L. (2)	
525.41	22	5	1.7		11	30	17	0.128	2.644	6.537	6.537	0.084	0.066	2.863	3.735	0.939	0.203	0.353	0.112	N.L. (2)	
522.91	24.5	3	0.8		11	30	24	0.119	2.941	3.747	3.747	0.063	0.057	3.006	4.033	0.933	0.152	0.328	0.108	N.L. (2)	
520.41	27	3	0.7		11	30	16	0.117	3.234	3.583	3.583	0.062	0.055	3.143	4.327	0.924	0.148	0.309	0.104	N.L. (2)	
518.16	29.25	3	0.2		11	30	19	0.104	3.468	3.461	3.461	0.061	0.042	3.238	4.561	0.919	0.145	0.294	0.101	N.L. (2)	
514.41	33	3	0.3		11	30	19	0.046	3.640	3.386	3.386	0.061	0.046	3.410	4.968	0.909	0.143	0.276	0.098	N.L. (2)	
509.41	38	3	0.2		11	30	23	0.042	3.850	3.296	3.296	0.060	0.042	3.620	5.490	0.898	0.140	0.259	0.096	N.L. (2)	
506.61	40.8	13	0.2		11	30	11	0.042	3.968	14.074	14.074	0.151	0.042	3.738	5.782	0.864	0.337	0.253	0.096	N.L. (2)	

* FACTOR OF SAFETY DESCRIPTIONS

N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION

N.L. (2) = NOT LIQUEFIABLE, $PI \geq 12$ OR $w_c/LL \leq 0.85$

N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$

(C) = CONTRACTIVE SOIL TYPES

(D) = DILATIVE SOIL TYPES



LIQUEFACTION ANALYSIS

REFERENCE BORING NUMBER ===== B-2 / Pier 2
ELEVATION OF BORING GROUND SURFACE ===== 523.55 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ===== 11.45 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ===== 0.00 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.376
EARTHQUAKE MOMENT MAGNITUDE ===== 4.9
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ===== -21.30 FT. (Cut Depth)
HAMMER EFFICIENCY===== 73 %
BOREHOLE DIAMETER===== 8 IN.
SAMPLING METHOD===== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = 2.581

AVG. SHEAR WAVE VELOCITY (top 40')
 $V_{s,40'} = 746$ FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 4.9
Source-To-Site Distance, R (km) = 10
Ground Motion Prediction Equations = CEUS
PGA = 0.244

BORING DATA								CONDITIONS DURING DRILLING					CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE	BORING DEPTH	SPT N VALUE	UNCONF. STR., Q _u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w _c (%)	EFFECTIVE UNIT WT. (KCF.)	VERT. STRESS (KSF.)	CORR. SPT N VALUE (N ₁) ₆₀	EQUIV. CLN. SAND SPT N VALUE (N ₁) _{60cs}	CRR RESIST. MAG 7.5 CRR _{7.5}	EFFECTIVE UNIT WT. (KCF.)	VERT. STRESS (KSF.)	TOTAL STRESS (KSF.)	OVER-BURDEN CORR. FACT. (Ks)	CORR. RESIST. CRR _{7.5} CRR	SOIL MASS PART. FACTOR (r _d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
521.55	2	7						0.114	0.228	13.815	13.815	0.148								
519.05	4.5	7						0.114	0.513	12.404	12.404	0.135								
516.8	6.75	7	0.5		10	40	16	0.114	0.770	11.373	11.373	0.125								
514.3	9.25	4	0.8		10	40	23	0.119	1.067	6.351	6.351	0.082								
511.55	12	3	0.6		10	40	23	0.053	1.213	4.884	4.884	0.071								
509.05	14.5	6	0.5		10	40	21	0.051	1.340	9.838	9.838	0.112								
506.8	16.75	7						0.058	1.471	11.399	11.399	0.126								
504.3	19.25	8						0.059	1.618	12.831	12.831	0.139								
501.8	21.75	14						0.064	1.778	22.961	22.961	0.256	0.064	0.029	0.057	1.500	0.992	1.000	0.482	2.058 (D)
499.3	24.25	13						0.063	1.936	20.502	20.502	0.222	0.063	0.186	0.370	1.500	0.858	0.998	0.485	1.769 (D)
496.8	26.75	20						0.067	2.103	32.398	32.398	0.859	0.067	0.354	0.694	1.500	3.327	0.995	0.477	N.L. (3)
494.3	29.25	18						0.066	2.268	27.697	27.697	0.359	0.066	0.519	1.015	1.500	1.391	0.992	0.474	N.L. (3)
490.55	33	21						0.068	2.523	31.377	31.377	0.609	0.068	0.774	1.504	1.445	2.271	0.986	0.468	N.L. (3)
487.2	36.35	18						0.066	2.744	25.140	25.140	0.295	0.066	0.995	1.934	1.280	0.973	0.978	0.464	N.L. (3)

* FACTOR OF SAFETY DESCRIPTIONS

N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION

N.L. (2) = NOT LIQUEFIABLE, $PI \geq 12$ OR $w_c/LL \leq 0.85$

N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$

(C) = CONTRACTIVE SOIL TYPES

(D) = DILATIVE SOIL TYPES



LIQUEFACTION ANALYSIS

REFERENCE BORING NUMBER ===== Pier 3 / B-3
ELEVATION OF BORING GROUND SURFACE ===== 523.45 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ===== 13.20 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ===== 13.00 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.376
EARTHQUAKE MOMENT MAGNITUDE ===== 4.9
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ===== -4.20 FT. (Cut Depth)
HAMMER EFFICIENCY===== 73 %
BOREHOLE DIAMETER===== 8 IN.
SAMPLING METHOD===== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = 2.581

AVG. SHEAR WAVE VELOCITY (top 40')
 $V_{s,40'} = 482$ FT./SEC.

PGA CALCULATOR

Earthquake Moment Magnitude = 4.9
Source-To-Site Distance, R (km) = 10
Ground Motion Prediction Equations = CEUS
PGA = 0.244

BORING DATA								CONDITIONS DURING DRILLING						CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE	BORING DEPTH	SPT N VALUE	UNCONF. COMPR. STR., Q _u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w _c (%)	EFFECTIVE UNIT WT. (KCF.)	VERT. STRESS (KSF.)	CORR. SPT N VALUE (N ₁) ₆₀	EQUIV. CLN. SAND SPT N VALUE (N ₁) _{60cs}	CRR RESIST. MAG 7.5 CRR _{7.5}	EFFECTIVE UNIT WT. (KCF.)	VERT. STRESS (KSF.)	TOTAL STRESS (KSF.)	OVER-BURDEN CORR. FACT. (Ks)	CORR. RESIST. CRR _{7.5} CRR	SOIL MASS PART. FACTOR (r _d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR	
519.2	4.25	2	0.5				21	0.114	0.485	3.555	3.555	0.062	0.114	0.006	0.006	1.500	0.240	1.000	0.244	N.L. (1)	
516.45	7	5	0.8				20	0.119	0.812	8.022	8.022	0.096	0.119	0.333	0.333	1.500	0.372	0.976	0.238	N.L. (1)	
513.95	9.5	4	1				21	0.122	1.117	6.308	6.308	0.082	0.122	0.638	0.638	1.284	0.272	0.951	0.232	N.L. (1)	
511.45	12	8	1.7				20	0.128	1.437	12.291	12.291	0.134	0.128	0.958	0.958	1.216	0.420	0.920	0.225	N.L. (1)	
508.95	14.5	2	0.3				25	0.046	1.552	3.110	3.110	0.059	0.108	1.228	1.228	1.115	0.170	0.884	0.216	N.L. (1)	
506.45	17	1	0.2				28	0.042	1.657	1.560	1.560	0.051	0.104	1.488	1.488	1.073	0.141	0.844	0.206	N.L. (1)	
503.95	19.5	7						0.058	1.802	10.771	10.771	0.120	0.058	1.633	1.776	1.064	0.329	0.800	0.212	1.552 (D)	
501.45	22	20						0.067	1.969	32.971	32.971	1.211	0.067	1.800	2.100	1.063	3.323	0.752	0.214	N.L. (3)	
499.2	24.25	10						0.061	2.107	14.723	14.723	0.157	0.061	1.938	2.378	1.024	0.416	0.707	0.212	1.962 (D)	
496.7	26.75	11						0.062	2.262	15.884	15.884	0.169	0.062	2.093	2.689	1.003	0.438	0.658	0.206	2.126 (D)	
494.2	29.25	15						0.065	2.424	21.717	21.717	0.238	0.065	2.255	3.007	0.981	0.603	0.610	0.199	3.030 (D)	
488.95	34.5	25						0.069	2.786	36.346	36.346	-0.162	0.069	2.617	3.697	0.920	-0.384	0.519	0.179	N.L. (3)	
485.45	38	25						0.069	3.028	34.657	34.657	-1.270	0.069	2.859	4.157	0.891	-2.920	0.469	0.167	N.L. (3)	
480.45	43	21						0.068	3.368	26.604	26.604	0.328	0.068	3.199	4.809	0.871	0.737	0.415	0.152	N.L. (3)	
475.45	48	17						0.066	3.698	19.824	19.824	0.213	0.066	3.529	5.451	0.861	0.474	0.378	0.143	3.315 (D)	
471.45	52	19						0.067	3.966	21.486	21.486	0.235	0.067	3.797	5.968	0.838	0.508	0.358	0.137	3.708 (D)	

* FACTOR OF SAFETY DESCRIPTIONS

N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION

N.L. (2) = NOT LIQUEFIABLE, $PI \geq 12$ OR $w_c/LL \leq 0.85$

N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$

(C) = CONTRACTIVE SOIL TYPES

(D) = DILATIVE SOIL TYPES



LIQUEFACTION ANALYSIS

REFERENCE BORING NUMBER ===== E. Abut / B-4
ELEVATION OF BORING GROUND SURFACE ===== 535.43 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ===== 23.03 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ===== 14.55 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.376
EARTHQUAKE MOMENT MAGNITUDE ===== 4.9
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ===== 6.23 FT. (Fill Height)
HAMMER EFFICIENCY===== 73 %
BOREHOLE DIAMETER===== 8 IN.
SAMPLING METHOD===== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR

(MSF) = 2.581

AVG. SHEAR WAVE VELOCITY (top 40')

$V_{s,40'}$ = 375 FT./SEC.

PGA CALCULATOR

Earthquake Moment Magnitude = 4.9
Source-To-Site Distance, R (km) = 10
Ground Motion Prediction Equations = CEUS
PGA = 0.244

BORING DATA								CONDITIONS DURING DRILLING						CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE	BORING SAMPLE	SPT N	UNCONF. COMPR.	% FINES < #200	PLAST. INDEX	LIQUID LIMIT	MOIST. CONTENT	EFFECTIVE UNIT	VERT.	CORR. SPT N	EQUIV. CLN. SAND SPT	CRR RESIST.	EFFECTIVE UNIT	VERT.	TOTAL VERT.	OVER- BURDEN	CORR. RESIST.	SOIL MASS PART.	EQ	FACTOR OF	
DEPTH (FT.)	VALUE (BLOWS)	STR., Q _u (TSF.)			PI	LL	w _c (%)	WT. (KCF.)	STRESS (KSF.)	VALUE (N ₁) ₆₀	N VALUE (N ₁) _{60CS}	MAG 7.5 CRR _{7.5}	WT. (KCF.)	STRESS (KSF.)	STRESS (KSF.)	CORR. FACT. (Ks)	CRR _{7.5} CRR	FACTOR (r _d)	INDUCED CSR	SAFETY * CRR/CSR	
533.43	2	7						0.114	0.228	13.815	13.815	0.148	0.114	0.976	0.976	1.219	0.467	0.821	0.201	N.L. (1)	
528.43	7	4	1.3					0.125	0.853	6.339	6.339	0.082	0.125	1.601	1.601	1.060	0.225	0.693	0.169	N.L. (1)	
526.18	9.25	9	1.6		11	35	16	0.127	1.139	14.189	14.189	0.152	0.065	1.747	1.805	1.051	0.412	0.636	0.161	N.L. (2)	
524.93	10.5	9	2.5		11	35	23	0.133	1.305	13.963	13.963	0.150	0.071	1.836	1.972	1.038	0.401	0.605	0.159	N.L. (2)	
522.93	12.5	6	1.4		11	35	19	0.125	1.555	9.036	9.036	0.105	0.063	1.962	2.222	1.018	0.275	0.558	0.154	N.L. (2)	
520.93	14.5	12	1		11	35	13	0.122	1.799	18.060	18.060	0.192	0.060	2.082	2.467	1.005	0.499	0.514	0.149	N.L. (2)	
518.43	17	6	0.9		11	35	17	0.120	2.099	8.469	8.469	0.100	0.058	2.227	2.768	0.989	0.255	0.464	0.141	N.L. (2)	
516.18	19.25	3	0.7		11	35	28	0.117	2.362	4.082	4.082	0.065	0.055	2.350	3.032	0.980	0.165	0.424	0.134	N.L. (2)	
513.43	22	3	0.7		11	35	28	0.117	2.684	3.892	3.892	0.064	0.055	2.502	3.355	0.967	0.160	0.383	0.125	N.L. (2)	
512.43	23	2	0.3		10	30	26	0.108	2.792	2.553	2.553	0.056	0.046	2.548	3.464	0.964	0.139	0.370	0.123	1.130 (C)	
511.18	24.25	2	0.3		11	30	26	0.046	2.850	2.538	2.538	0.056	0.046	2.605	3.599	0.960	0.138	0.355	0.120	1.150 (C)	
508.43	27	2	0.2		11	30	24	0.042	2.965	2.505	2.505	0.055	0.042	2.721	3.886	0.951	0.136	0.326	0.114	N.L. (2)	
506.18	29.25	1					26	0.043	3.062	1.237	1.237	0.050	0.043	2.817	4.123	0.945	0.122	0.307	0.110	1.109 (C)	
502.43	33	16					11	0.065	3.306	19.569	19.569	0.210	0.065	3.061	4.601	0.899	0.487	0.283	0.104	4.683 (D)	
497.43	38	19						0.067	3.641	22.435	22.435	0.248	0.067	3.396	5.248	0.864	0.554	0.261	0.098	5.653 (D)	
492.43	43	29						0.071	3.996	34.385	34.385	-2.348	0.071	3.751	5.915	0.803	-4.867	0.248	0.095	N.L. (3)	
487.43	48	16						0.065	4.321	16.689	16.689	0.178	0.065	4.076	6.552	0.836	0.383	0.239	0.094	4.074 (D)	
482.43	53	26						0.069	4.666	27.317	27.317	0.347	0.069	4.421	7.209	0.779	0.699	0.234	0.093	N.L. (3)	
479.93	55.5	26						0.069	4.838	26.628	26.628	0.328	0.069	4.594	7.538	0.772	0.654	0.233	0.093	N.L. (3)	
470.93	64.5	35						0.072	5.486	34.135	34.135	-7.170	0.072	5.242	8.747	0.707	-13.090	0.219	0.089	N.L. (3)	

* FACTOR OF SAFETY DESCRIPTIONS

N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION

N.L. (2) = NOT LIQUEFIABLE, $PI \geq 12$ OR $w_c/LL \leq 0.85$

N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$

(C) = CONTRACTIVE SOIL TYPES

(D) = DILATIVE SOIL TYPES

Appendix G: Pile Length Estimate Spreadsheets

SUBSTRUCTURE===== West Abutment
REFERENCE BORING ===== B-1
LRFD or ASD or SEISMIC ===== LRFD
PILE CUTOFF ELEV. ===== 539.92 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 537.92 ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ===== None
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ===== ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) ===== ft

TOTAL FACTORED SUBSTRUCTURE LOAD ===== 1266 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)===== 35.09 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ===== 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ===== 288.63 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ===== 108.24 KIPS

MAX. REQUIRED BEARING & RESISTANCE for Selected Pile, Soil Profile, & Losses

Maximum Nominal Req'd Bearing of <u>Pile</u>	Maximum Nominal Req'd Bearing of <u>Boring</u>	Maximum Factored Resistance Available in <u>Boring</u>	Maximum Pile Driveable Length in <u>Boring</u>
810 KIPS	790 KIPS	435 KIPS	42 FT.

PILE TYPE AND SIZE ===== Steel HP 14 X 102

Plugged Pile Perimeter===== 4.800 FT. Unplugged Pile Perimeter===== 7.058 FT.
Plugged Pile End Bearing Area===== 1.439 SQFT. Unplugged Pile End Bearing Area===== 0.208 SQFT.

BOT. OF LAYER ELEV. (FT.)	LAYER THICK. (FT.)	UNCONF. COMPR. STRENGTH (TSF.)	S.P.T. N VALUE (BLOWS)	GRANULAR OR ROCK LAYER DESCRIPTION	NOMINAL PLUGGED			NOMINAL UNPLUG'D			NOMINAL REQ'D BEARING (KIPS)	FACTORED GEOTECH. LOSS FROM SCOUR or DD (KIPS)	FACTORED GEOTECH. LOSS LOAD FROM DD (KIPS)	FACTORED RESISTANCE AVAILABLE (KIPS)	ESTIMATED PILE LENGTH (FT.)
					SIDE RESIST. (KIPS)	END BRG. RESIST. (KIPS)	TOTAL RESIST. (KIPS)	SIDE RESIST. (KIPS)	END BRG. RESIST. (KIPS)	TOTAL RESIST. (KIPS)					
535.41	2.51	1.50			11.6		31.8	17.0		20.0	20	0	0	11	5
533.16	2.25	1.00			7.7	20.2	35.4	11.3	2.9	30.7	31	0	0	17	7
530.41	2.75	0.80			7.8	16.1	45.2	11.5	2.3	42.4	42	0	0	23	10
528.16	2.25	0.90			7.0	18.1	68.4	10.4	2.6	55.1	55	0	0	30	12
525.66	2.50	1.70			12.6	34.3	62.8	18.5	5.0	71.0	63	0	0	35	14
522.91	2.75	0.80			7.8	16.1	68.6	11.5	2.3	82.1	69	0	0	38	17
520.41	2.50	0.70			6.3	14.1	64.8	9.3	2.0	90.0	65	0	0	36	20
518.16	2.25	0.20			1.8	4.0	68.6	2.6	0.6	92.9	69	0	0	38	22
514.41	3.75	0.30			4.4	6.0	70.9	6.4	0.9	99.0	71	0	0	39	26
509.41	5.00	0.20			3.9	4.0	74.9	5.8	0.6	104.8	75	0	0	41	31
506.61	2.80	0.20			2.2	4.0	252.3	3.2	0.6	133.4	133	0	0	73	33
505.61	1.00			Shale	59.8	179.2	312.1	87.9	25.9	221.3	221	0	0	122	34.3
504.61	1.00			Shale	59.8	179.2	371.9	87.9	25.9	309.2	309	0	0	170	35.3
503.61	1.00			Shale	59.8	179.2	431.7	87.9	25.9	397.2	397	0	0	218	36.3
502.61	1.00			Shale	59.8	179.2	491.5	87.9	25.9	485.1	485	0	0	267	37.3
501.61	1.00			Shale	59.8	179.2	551.3	87.9	25.9	573.0	551	0	0	303	38.3
500.61	1.00			Shale	59.8	179.2	611.1	87.9	25.9	660.9	611	0	0	336	39.3
499.61	1.00			Shale	59.8	179.2	670.9	87.9	25.9	748.9	671	0	0	369	40.3
498.61	1.00			Shale	59.8	179.2	730.7	87.9	25.9	836.8	731	0	0	402	41.3
497.61	1.00			Shale	59.8	179.2	790.5	87.9	25.9	924.7	790	0	0	435	42.3
496.61	1.00			Shale	59.8	179.2	850.2	87.9	25.9	1012.6	850	0	0	468	43.3
495.61	1.00			Shale	59.8	179.2	910.0	87.9	25.9	1100.6	910	0	0	501	44.3
494.61	1.00			Shale	59.8	179.2	969.8	87.9	25.9	1188.5	970	0	0	533	45.3
493.61	1.00			Shale	59.8	179.2	1029.6	87.9	25.9	1276.4	1030	0	0	566	46.3
492.61	1.00			Shale	59.8	179.2	1089.4	87.9	25.9	1364.4	1089	0	0	599	47.3
491.61	1.00			Shale		179.2			25.9						



IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE=====East Abutment
REFERENCE BORING =====B-4
LRFD or ASD or SEISMIC =====LRFD
PILE CUTOFF ELEV. =====531.17 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 529.17 ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) =====None
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD =====ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) =====ft

MAX. REQUIRED BEARING & RESISTANCE for Selected Pile, Soil Profile, & Losses

Maximum Nominal Req'd Bearing of <u>Pile</u>	Maximum Nominal Req'd Bearing of <u>Boring</u>	Maximum Factored Resistance Available in <u>Boring</u>	Maximum Pile Driveable Length in <u>Boring</u>
578 KIPS	578 KIPS	318 KIPS	65 FT.

TOTAL FACTORED SUBSTRUCTURE LOAD =====1406 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)=====35.09 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE =====1
Approx. Factored Loading Applied per pile at 8 ft. Cts =====320.55 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts =====120.21 KIPS

PILE TYPE AND SIZE =====Steel HP 14 X 73

Plugged Pile Perimeter=====4.700 FT. Unplugged Pile Perimeter=====6.975 FT.
Plugged Pile End Bearing Area=====1.379 SQFT. Unplugged Pile End Bearing Area=====0.149 SQFT.

BOT. OF LAYER ELEV. (FT.)	LAYER THICK. (FT.)	UNCONF. COMPR. STRENGTH (TSF.)	S.P.T. N VALUE (BLOWS)	GRANULAR OR ROCK LAYER DESCRIPTION	NOMINAL PLUGGED			NOMINAL UNPLUG'D			NOMINAL REQ'D BEARING (KIPS)	FACTORED GEOTECH. LOSS FROM SCOUR or DD (KIPS)	FACTORED GEOTECH. LOSS LOAD FROM DD (KIPS)	FACTORED RESISTANCE AVAILABLE (KIPS)	ESTIMATED PILE LENGTH (FT.)
					SIDE RESIST. (KIPS)	END BRG. RESIST. (KIPS)	TOTAL RESIST. (KIPS)	SIDE RESIST. (KIPS)	END BRG. RESIST. (KIPS)	TOTAL RESIST. (KIPS)					
528.43	0.74	1.30			3.0		33.9	4.5		7.8	8	0	0	4	3
524.93	3.50	1.60			16.5	30.9	67.9	24.5	3.3	34.2	34	0	0	19	6
522.93	2.00	2.50			12.7	48.3	59.3	18.8	5.2	50.7	51	0	0	28	8
520.93	2.00	1.40			8.6	27.1	60.2	12.8	2.9	62.7	60	0	0	33	10
518.43	2.50	1.00			8.3	19.3	66.6	12.4	2.1	74.9	67	0	0	37	13
516.18	2.25	0.90			6.9	17.4	69.6	10.2	1.9	84.7	70	0	0	38	15
513.43	2.75	0.70			6.8	13.5	68.7	10.1	1.5	94.0	69	0	0	38	18
512.43	1.00	0.30			1.1	5.8	67.9	1.7	0.6	95.4	68	0	0	37	19
508.43	4.00	0.20			3.1	3.9	70.6	4.6	0.4	100.0	71	0	0	39	23
506.18	2.25		1	Fine Sand	0.2	3.4	122.3	0.3	0.4	105.8	106	0	0	58	25
502.43	3.75		16	Fine Sand	4.8	55.0	137.4	7.2	5.9	114.1	114	0	0	63	29
497.43	5.00		19	Fine Sand	7.6	65.3	179.4	11.3	7.0	129.1	129	0	0	71	34
492.43	5.00		29	Fine Sand	11.7	99.6	146.4	17.3	10.7	141.6	142	0	0	78	39
487.43	5.00		16	Fine Sand	6.4	55.0	187.2	9.6	5.9	154.9	155	0	0	85	44
484.93	2.50		26	Fine Sand	5.2	89.3	192.4	7.8	9.6	162.7	163	0	0	89	46
479.93	5.00		26	Fine Sand	10.5	89.3	233.8	15.5	9.6	181.5	182	0	0	100	51
474.93	5.00		35	Fine Sand	15.0	120.2	248.8	22.2	13.0	203.7	204	0	0	112	56
470.93	4.00		35	Fine Sand	12.0	120.2	312.3	17.8	13.0	227.0	227	0	0	125	60
469.93	1.00			Shale	58.5	171.8	370.8	86.9	18.5	313.9	314	0	0	173	61.2
468.93	1.00			Shale	58.5	171.8	429.4	86.9	18.5	400.8	401	0	0	220	62.2
467.93	1.00			Shale	58.5	171.8	487.9	86.9	18.5	487.7	488	0	0	268	63.2
466.93	1.00			Shale	58.5	171.8	546.5	86.9	18.5	574.6	546	0	0	301	64.2
465.93	1.00			Shale	58.5	171.8	605.0	86.9	18.5	661.5	605	0	0	333	65.2
464.93	1.00			Shale	58.5	171.8	663.6	86.9	18.5	748.4	664	0	0	365	66.2
463.93	1.00			Shale	58.5	171.8	722.1	86.9	18.5	835.2	722	0	0	397	67.2
462.93	1.00			Shale	58.5	171.8	780.7	86.9	18.5	922.1	781	0	0	429	68.2
461.93	1.00			Shale	58.5	171.8	839.2	86.9	18.5	1009.0	839	0	0	462	69.2
460.93	1.00			Shale		171.8			18.5						



IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE===== Pier 3
REFERENCE BORING ===== B-3
LRFD or ASD or SEISMIC ===== LRFD
PILE CUTOFF ELEV. ===== 520.25 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 519.25 ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ===== Scour
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ===== 490.20 ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) ===== ft

TOTAL FACTORED SUBSTRUCTURE LOAD ===== 3304 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)===== 35.09 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ===== 2
Approx. Factored Loading Applied per pile at 8 ft. Cts ===== 376.63 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ===== 141.24 KIPS

MAX. REQUIRED BEARING & RESISTANCE for Selected Pile, Soil Profile, & Losses

Maximum Nominal Req'd Bearing of <u>Pile</u>	Maximum Nominal Req'd Bearing of <u>Boring</u>	Maximum Factored Resistance Available in <u>Boring</u>	Maximum Pile Driveable Length in <u>Boring</u>
578 KIPS	551 KIPS	273 KIPS	54 FT.

PILE TYPE AND SIZE ===== Steel HP 14 X 73

Plugged Pile Perimeter===== 4.700 FT. Unplugged Pile Perimeter===== 6.975 FT.
Plugged Pile End Bearing Area===== 1.379 SQFT. Unplugged Pile End Bearing Area===== 0.149 SQFT.

BOT. OF LAYER ELEV. (FT.)	LAYER THICK. (FT.)	UNCONF. COMPR. STRENGTH (TSF.)	S.P.T. N VALUE (BLOWS)	GRANULAR OR ROCK LAYER DESCRIPTION	NOMINAL PLUGGED			NOMINAL UNPLUG'D			NOMINAL REQ'D BEARING (KIPS)	FACTORED GEOTECH. LOSS FROM SCOUR or DD (KIPS)	FACTORED GEOTECH. LOSS LOAD FROM DD (KIPS)	FACTORED RESISTANCE AVAILABLE (KIPS)	ESTIMATED PILE LENGTH (FT.)
					SIDE RESIST. (KIPS)	END BRG. RESIST. (KIPS)	TOTAL RESIST. (KIPS)	SIDE RESIST. (KIPS)	END BRG. RESIST. (KIPS)	TOTAL RESIST. (KIPS)					
516.45	2.80	0.80			7.8		27.1	11.5		13.6	14	4	0	3	4
513.95	2.50	1.00			8.3	19.3	49.0	12.4	2.1	27.5	27	9	0	6	6
511.45	2.50	1.70			12.3	32.9	34.2	18.3	3.5	42.8	34	16	0	3	9
508.95	2.50	0.30			2.8	5.8	35.1	4.2	0.6	46.8	35	17	0	2	11
506.45	2.50	0.20			1.9	3.9	57.2	2.9	0.4	51.9	52	18	0	10	14
503.95	2.50		7	Clean Coarse Sand	1.6	24.0	103.5	2.4	2.6	59.1	59	19	0	13	16
501.45	2.50		20	Medium Sand	4.3	68.7	73.5	6.4	7.4	61.8	62	22	0	12	19
499.20	2.25		10	Fine Sand	1.8	34.4	78.7	2.7	3.7	64.8	65	23	0	13	21
496.70	2.50		11	Fine Sand	2.2	37.8	94.7	3.3	4.1	69.6	70	24	0	15	24
494.20	2.50		15	Fine Sand	3.0	51.5	132.0	4.5	5.6	77.8	78	25	0	17	26
490.20	4.00		25	Fine Sand	8.1	85.9	140.1	11.9	9.3	89.7	90	30	0	20	30
488.95	1.25		25	Fine Sand	2.5	85.9	142.6	3.7	9.3	93.4	93	30	0	22	31
485.45	3.50		25	Fine Sand	7.0	85.9	135.9	10.5	9.3	102.4	102	30	0	27	35
480.45	5.00		21	Medium Sand	9.0	72.1	131.2	13.3	7.8	114.3	114	30	0	33	40
475.45	5.00		17	Medium Sand	7.3	58.4	145.3	10.8	6.3	125.8	126	30	0	39	45
471.45	4.00		19	Medium Sand	6.5	65.3	258.3	9.7	7.0	147.0	147	30	0	51	49
470.45	1.00			Shale	58.5	171.8	316.9	86.9	18.5	233.8	234	30	0	99	49.8
469.45	1.00			Shale	58.5	171.8	375.4	86.9	18.5	320.7	321	30	0	147	50.8
468.45	1.00			Shale	58.5	171.8	434.0	86.9	18.5	407.6	408	30	0	194	51.8
467.45	1.00			Shale	58.5	171.8	492.5	86.9	18.5	494.5	493	30	0	241	52.8
466.45	1.00			Shale	58.5	171.8	551.1	86.9	18.5	581.4	551	30	0	273	53.8
465.45	1.00			Shale	58.5	171.8	609.6	86.9	18.5	668.3	610	30	0	305	54.8
464.45	1.00			Shale	58.5	171.8	668.2	86.9	18.5	755.2	668	30	0	338	55.8
463.45	1.00			Shale	58.5	171.8	726.7	86.9	18.5	842.1	727	30	0	370	56.8
462.45	1.00			Shale	58.5	171.8	785.3	86.9	18.5	929.0	785	30	0	402	57.8
461.45	1.00			Shale	58.5	171.8	843.8	86.9	18.5	1015.8	844	30	0	434	58.8
460.45	1.00			Shale	58.5	171.8	902.4	86.9	18.5	1102.7	902	30	0	466	59.8
459.45	1.00			Shale	58.5	171.8	960.9	86.9	18.5	1189.6	961	30	0	499	60.8
458.45	1.00			Shale	58.5	171.8	1019.5	86.9	18.5	1276.5	1019	30	0	531	61.8
457.45	1.00			Shale	58.5	171.8	1078.0	86.9	18.5	1363.4	1078	30	0	563	62.8
456.45	1.00			Shale		171.8			18.5						