STRUCTURE
GEOTECHNICAL REPORT

Proposed S.N. 070-2020

Existing S.N. 070-0027

IL 133 over Jonathan Branch
5.67 Miles South of IL Rte. 36
FAP Route 749
Section (119BR-1)B-1
Moultrie County

PTB 160 – Item 016
IDOT Job No. P-97-013-10
Contract No.74436

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Date Prepared: January 9, 2015

Date Revised: March 31, 2015

April 16, 2015

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Exhibits:
1) Location Map
2) Boring Locations
3) Subsurface Data profile
4) Boring Logs
5) Slope Stability Output

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March 28, 2017

MEMORANDUM

Mr. D. Carl Puzey, Engineer of Bridges and Structures
Bureau of Bridges and Structures
Illinois Department of Transportation
2300 South Dirksen Parkway
Springfield, IL 62764

Attn: Mr. William Kramer
Foundations & Geotechnical Engineer

RE: Proposed S.N. 070-2020
FAP 749 (IL 133) over Jonathan Branch
Moultrie County
Contract No. 74436
PTB 160-016

The purpose of this technical memo is to provide further geotechnical guidance in regards to the drilled soldier pile wingwalls that will be used for the subject culvert, beyond that which was provided in the Structure Geotechnical Report revised April 16, 2015.

For the purpose of pile design, we recommend measuring the design height from the proposed ground line at the back face of the wall to the bottom of the cast-in-place facing. As shown on the preliminary plans received from the design consultant, the bottom of the cast-in-place facing will be located 3 feet below the invert elevation at each end of the culvert. A live load surcharge should be applied as necessary in accordance with AASHTO LRFD Bridge Design Specifications section 3.11.6.4 when considering the construction and final conditions. A maximum deflection of 1% of the height, measured from the top of the soldier pile to the bottom of the cast-in-place facing, is suggested when investigating the Service Limit States.

The soil boring logs indicate the presence of a very soft sandy loam within the anticipated drilled shaft installation depths at both ends of the culvert, which could necessitate the use of temporary casings for installation of drilled soldier piles. The construction of drilled soldier piles is addressed in Section 522 of the 2016 Standard Specifications for Road and Bridge Construction. Section 516 details drilled shafts and the drilling methods used to maintain the shaft excavation during the various phases of shaft excavation and concrete placement as appropriate for the site conditions encountered.

Sincerely,

LIN ENGINEERING, LTD.

Michael T. Haley, PE, SE
Structural Manager

vpt Technical Memo_032817.pdf

Project Description and Proposed Structure Information

This project consists of replacing an existing single span precast channel beam bridge that carries IL 133 over Jonathan Branch at station 138+54.22 with a double barrel 9'x8' cast-in-place box culvert. The structure will carry one lane of traffic in each direction. The proposed structure is 9'x8' double barrel reinforced concrete box culvert, 44'-6 ¼" out to out headwalls measured along culvert centerline with 15 degrees left ahead skew. The proposed structure design will follow the LRFD Design Specifications. Complete removal of the existing structure will be required for construction.

Construction will be done in one stage and traffic will be maintained using a detour route during construction. The maximum fill height is approximately 3'-0" above the proposed culvert. The structure will have 15'-0" and 19'-6" long solder pile wingwalls that will retain a 1:2 (V:H) embankment slope. On the USGS Saline Mines quadrangle map, the project area falls on the border of Section 30 and 31 of township 15 N and Range 6E of the 3rd PM. A location map is presented in Exhibit 1.

Existing Information

The existing bridge is located at station 138+54.22. The single-span precast channel beam bridge on closed abutments is supported by spread footings on untreated timber piles. The bridge has a length of 18'-7½" from inside face to inside face of the abutments, an out-to-out width of 41'-3", and a 14˚-56'-30" left ahead skew. Stationing along the roadway increases from west to east.

Site Investigation, Subsurface Exploration and Generalized Subsurface Conditions

The site is located in a rural area approximately 2.6 miles east of IL 32. The tributary flows from north to south. Flat agriculture fields are on both sides of the structure. There is an aerial electric line on the north side of the structure.

IDOT District 7 personnel provided boring data. Two borings drilled in July/September of 2014 are associated with the proposed culvert location. Boring 1 East was drilled at station 138+76 approximately 14.5 ft north of the centerline. Boring 2 West was drilled at station 138+31 approximately 15.5 ft south of the centerline. Both borings were terminated at a depth of 36 ft below ground surface. Boring locations relative to the culvert location are shown in Exhibit 2.

At each boring location, a standard penetration test (SPT) was conducted every 2.5 ft according to AASHTO T 206 using a hollow stem auger drill. Borings 1 East and 2 West encountered water during drilling at depths of 12 ft and 24.53 ft, respectively and after completion had water depths of 20 ft and 20.03 ft, respectively. Both borings were backfilled so no data was collected on the water depths after 24 hours. Boring 1 East encountered a soft to stiff gray clay with silt directly below the surface to a depth of 12ft, with Q_u values from 0.41 to 1.24 tsf, STP (N) values ranging from 4 to 6 blows per foot, and moisture contents ranging between 19% and 28%. Below the layer of clay is approximately 7.5 ft of very soft to medium gray sandy loam with gravel with a Q_u value of 0.3 tsf, STP (N) values ranging from 17 to 34 blows per foot, and moisture contents ranging between 10% and 23%. Below the sandy loam is approximately 15 ft of hard

gray clay loam till with Q_u values from 5.98 to 8.04 tsf, STP (N) values ranging from 28 to 32 blows per foot, and the moisture content of 10%. Boring 2 West encountered soft dark gray silty clay directly below the surface to a depth of 7 ft, with Q_u values from 0.33 to 0.37 tsf, STP (N) values ranging from 3 to 4, and moisture contents ranging between 28% and 30%. Below the silty clay is approximately 5 ft of medium to stiff gray clay with Q_u values from 0.62 to 1.65 tsf, a STP (N) value of 5 blows per foot, and moisture contents ranging from 24% to 25%. Below the clay is approximately 2.5 ft of very stiff brown sandy clay with a Q_u value of 2.89 tsf, a STP (N) value of 28 blows per foot, and a moisture content of 4%. Below the sandy clay is approximately 2.5 ft of very stiff gray clay loam till with a Q_u value of 2.89 tsf, a STP (N) value of 15 blows per foot, and a moisture content of 12%. Below the clay loam till is approximately 2.5 ft of very soft gray sandy loam and gravel with a STP (N) value of 33 blows per foot, and a moisture content of 15%. Below the sandy loam and gravel is approximately 16.5 ft of very stiff to hard gray clay loam till with Q_u values from 1.5 to 4.5 tsf, STP (N) values ranging from 15 to 49 blows per foot, and moisture contents ranging from 11% to 13%.

Geotechnical Evaluations

Settlement: No significant changes in profile are proposed at the culvert location. The proposed culvert will have a slab footing. There will be an increase in pressure down the center of the culvert due to the change in footing type from the existing structure. In order to prevent differential settlement over ½" it is recommended to remove the weaker layers of soil; the soil should be excavated to an elevation of 672.25 and replaced with rockfill. Soil improvements below culvert barrel will eliminate significant differential settlements along the length of the culvert. It is assumed that there will be no settlement over the existing piles and only settlement under the center of culvert will occur. However, with the soil improvements discussed, settlement is less than ½" so differential settlement will not be an issue along the width of the culvert.

Slope Stability: Preliminary stability analyses using Bishop's method were performed for the structure at both boring locations using a 1:1 (V:H) slope. Boring 1 East rendered a factor of safety of 1.79, and boring 2 West rendered a factor of safety of 5.19. The maximum excavation required is 12.6 ft.

Seismic Considerations: As per AASHTO LRFD Bridge Manual Seventh Edition, 2014, Section 3.10.1 seismic data for box culverts and buried structures need not to be considered, except where crossing active faults.

Mining Activity: According to the Illinois State Geological Survey (ISGS) "Coal Mines in Illinois Viewer," The culvert is not in the proximity of any underground mines. The closest mine proximity region is over 1.6 miles west of the structure. The closest underground mine is approximately 2 miles west of the structure.

Liquefaction: Liquefaction analysis was performed and no liquefiable soils were found at the structure's location.

Box Culvert Evaluations and Design Recommendations

Culvert Barrel: Based on hydraulic requirements and size limitations, a 3-sided structure is not a viable option.

Due to the District's preference the precast culvert option is not recommended.

With the large foundation area and proposed soil improvement at the culvert base, the bearing capacity at the base of the foundation was found to be more than adequate for resistance of estimated bearing pressures.

Wingwalls: There are several feasible options for selection of wingwalls. The wall type selection should be performed considering but not limited to soil conditions, length and economy.

Per IDOT Culvert Manual Figure 3.1.5-2, based on the 15˚ skew, 1:2 (V:H) slope behind the wingwall, and an H_L of 12'-5", the wingwall length chart shows lengths of 15'-0" and 19'-6" with angles of 52.5˚ and 37.5˚ respectively. However, per IDOT Culvert Manual Figure 3.1.5-3, based on the 15˚ skew, 1:1.5 (V:H) slope behind the wingwall, and an H_L of 12'-5", the wingwall length chart shows lengths of 10'-9" and 14'-0" with angles of 52.5˚ and 37.5˚ respectively.

The horizontal cantilever wingwalls and horizontal cantilever wingwalls with extensions are not feasible due to the large design height. The design height is 11'-9¼" and according to the Culvert Manual it is not feasible to have horizontal cantilever wingwalls if the design height distance is greater than 10 feet.

Permanent sheet piling is a feasible option. Depending on the required embedment depth, deeper borings may be required. Permanent sheet piles may also require an anchorage system to limit deflection or reduce the required section modulus of the sheet pile. Possible options for an anchorage system include use of deadman, helical anchors, or permanent ground anchors. A Geotechnical Design Memorandum will be required in the design phase if the permanent sheet pile option with anchorage system is chosen. The existing footings for the wingwalls will require complete removal for this option.

Vertical Cantilever T-type wingwalls is also a feasible option. The soil under the north wingwalls shall be removed to an elevation of 670.10 and replaced with rockfill. The recommended active earth pressure as an equivalent fluid pressure on the cantilever wingwalls according to the proposed design is 57 pcf. A coefficient of friction for sliding of 0.4 is recommended. Factored bearing resistance available is 7 ksf.

Soldier pile wall is a feasible option. The short term undrained and long term drained soil parameters for the North wingwalls are presented in table 1 and for the South wingwalls the soil parameters are presented in table 2. The long term drained soil parameters are recommended for Coulomb's earth pressure analysis, and the short term undrained soil parameters are recommended for laterally loaded pile analysis. The parameters were determined based on the soil conditions encountered in the soil borings. Both drilled soldier pile and driven soldier pile walls are feasible options. Drilled piles have fewer limitations in spacing and section modulus than driven piles. The proposed piles need to be spaced in order to miss the existing piles. A Geotechnical Design Memorandum will be required in the design phase if the soldier pile wall option is chosen.

Soil Type	Elev. At Bottom of Layer	Moist Unit Wt. (pcf)	Shear Strength Properties			k (pci)	Soil Strain E50
			Short Term		Long Term		
			c (pcf)	Friction Angle (deg)	Friction Angle (deg)		
Soft to Stiff Gray Clay	675.10	118	750	-	26	100	0.01
Very Soft to Medium Gray Sandy Loam with Gravel	667.60	122	-	35	35	50	-
Very Stiff to Hard Gray Clay Loam Till	651.10	145	6700	-	30	2000	0.004

Table 1 – North Wingwalls

Soil Type	Elev. At Bottom of Layer	Moist Unit Wt. (pcf)	Shear Strength Properties			k (pci)	Soil Strain E50
			Short Term		Long Term		
			c (psf)	Friction Angle (deg)	Friction Angle (deg)		
Soft Silty Clay	680.13	110	350	-	25	30	0.02
Stiff Clay	675.13	122	1150	-	27	500	0.007
Very Stiff Sandy Clay	672.63	134	2900	-	30	1000	0.005
Very Stiff Clay Loam Till	670.13	134	2900	-	30	1000	0.005
Dense Sandy Loam w/ gravel	667.63	134	-	37	37	125	-
Very Stiff to Hard Gray Clay Loam Till	651.13	134	3000	-	30	1000	0.005

Table 2 – South Wingwalls

Gabion baskets appear to be feasible and can be constructed easily and quickly with traditional labor equipment. This wall can be labor intensive and expensive if a nearby stone source is not available. Factored bearing resistance available is 7 ksf. The recommended coefficient of friction for sliding is 0.4 and an active earth pressure as an equivalent fluid pressure is 57 pcf.

Construction Considerations

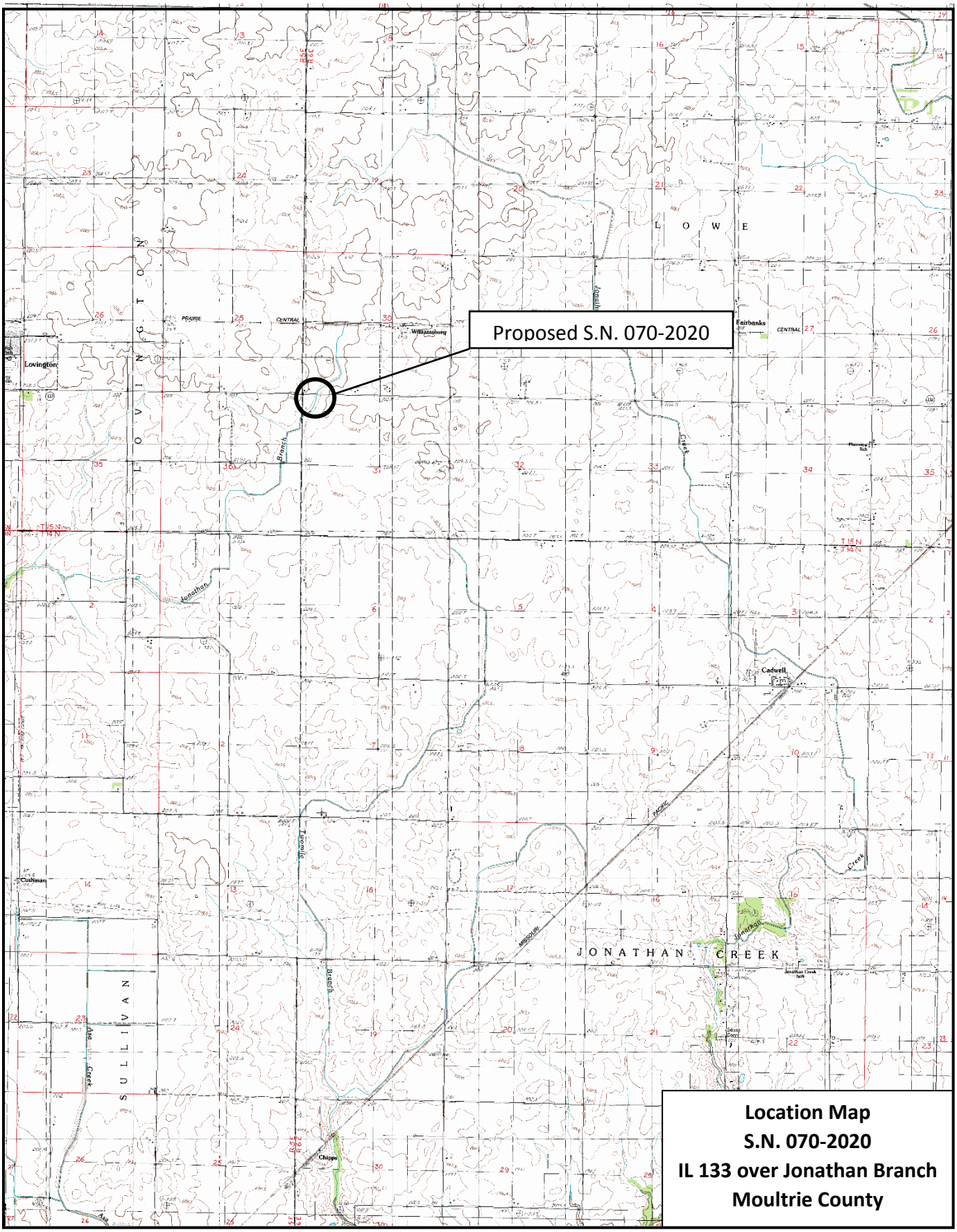
Cofferdams: In order to maintain a dry construction area, dewatering techniques may be necessary. However, based on hydraulic conditions, a temporary cofferdam is not expected to be necessary.

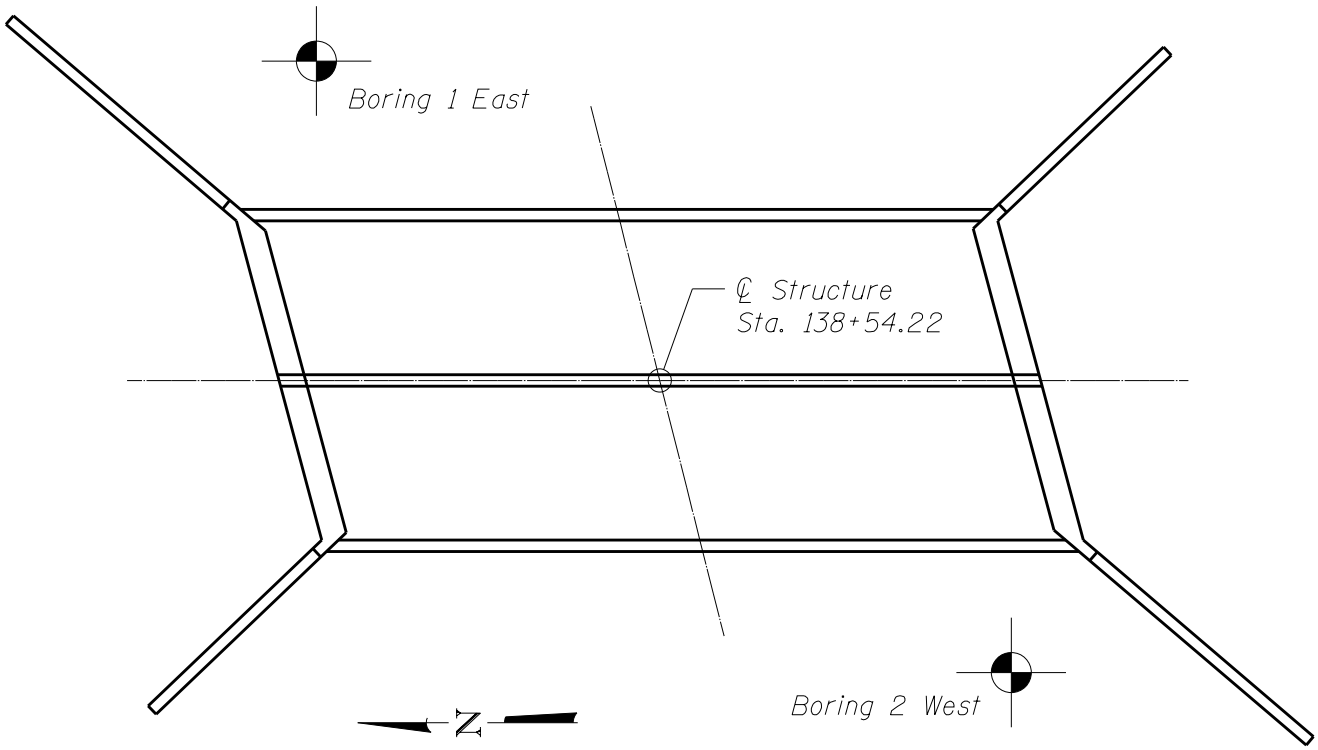
Excavation: A 1:1 (V:H) temporary excavation slope for construction clearance has an adequate factor of safety for slope stability. The factor of safety is limited to 1:1 slopes and any steeper slopes should not be used. An alternative would be to use temporary sheet piling along both sides of the culvert.

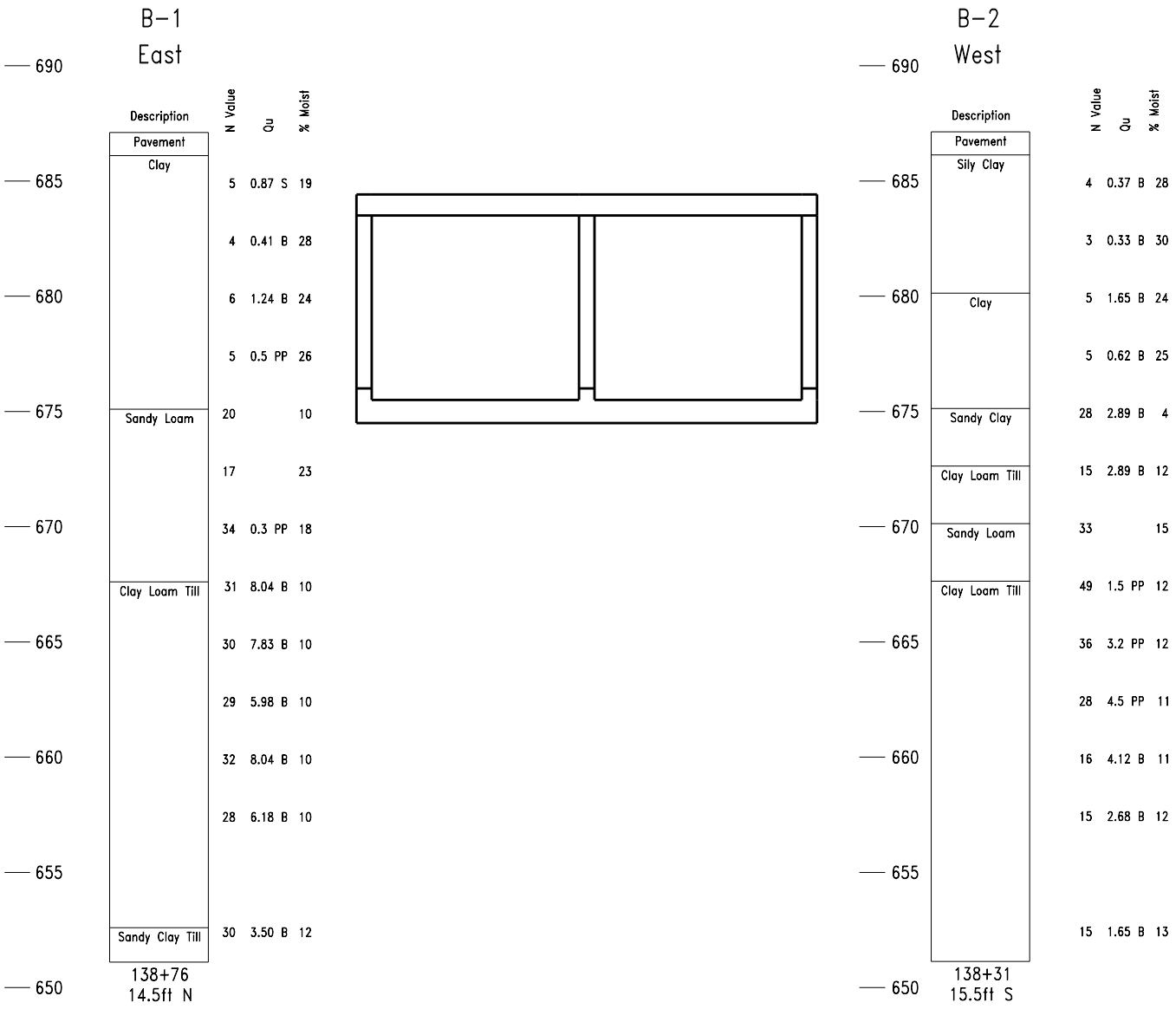
Ground Improvement: It is recommended to have the weaker soil excavated down to an elevation of 670.10 on the north half of the culvert, replaced with rockfill and have a 1:1 slope under the centerline of the roadway. The pay limits shall extend 1 foot outside the limits of the barrel.

Limitations

The recommendations provided herein are for the exclusive use of IDOT and ESCA Consultants, Inc. They are specific only to the project described, and are based on subsurface information obtained at boring locations within the bridge area, our understanding of the project as described herein, and geotechnical engineering practice consistent with the standard of care. No other warranty is expressed or implied. Lin Engineering, Ltd. should be contacted if conditions encountered during construction are not consistent with those described.


Proposed S.N. 070-2020
LOVINGTON
SULLIVAN
LOWE
JONATHAN CREEK
Lovington
Fairbanks
Cadwell
Cushman
Chippe
Location Map
S.N. 070-2020
IL 133 over Jonathan Branch
Moultrie County


Boring 1 East
℄ Structure
Sta. 138+54.22
Boring 2 West
N


B-1
East
690
685
680
675
670
665
660
655
650
Description
N Value
Qu
% Moist
Pavement
Clay
5 0.87 S 19
4 0.41 B 28
6 1.24 B 24
5 0.5 PP 26
Sandy Loam
20 10
17 23
34 0.3 PP 18
Clay Loam Till
31 8.04 B 10
30 7.83 B 10
29 5.98 B 10
32 8.04 B 10
28 6.18 B 10
Sandy Clay Till
30 3.50 B 12
138+76
14.5ft N
B-2
West
690
685
680
675
670
665
660
655
650
Description
N Value
Qu
% Moist
Pavement
Sily Clay
4 0.37 B 28
3 0.33 B 30
Clay
5 1.65 B 24
5 0.62 B 25
Sandy Clay
28 2.89 B 4
Clay Loam Till
15 2.89 B 12
Sandy Loam
33 15
Clay Loam Till
49 1.5 PP 12
36 3.2 PP 12
28 4.5 PP 11
16 4.12 B 11
15 2.68 B 12
15 1.65 B 13
138+31
15.5ft S

Illinois Department of Transportation
Division of Highways
IDOT

SOIL BORING LOG

Date 7/15/14

ROUTE FAP 749 (IL 133) **DESCRIPTION** Jonathan Branch **LOGGED BY** E. Sandschafer

SECTION (119BR-1)B-1 **LOCATION** Sec 30 - SW 1/4, Sec 31 - NW 1/4, **SEC.** , **TWP.** 15 N, **RNG.** 6 E, 3 **PM**

COUNTY Moultrie **DRILLING METHOD** Hollow stem auger & split spoon **HAMMER TYPE** Auto 140#

STRUCT. NO. 070-2020
Station 138+54.22

BORING NO. 1 East
Station 138+76
Offset 14.5ft N
Ground Surface Elev. 687.10 ft

Surface Water Elev. 676.42 ft
Stream Bed Elev. 676.16 ft

Groundwater Elev.:
▽ **First Encounter** 675.1 ft
▽ **Upon Completion** 667.1 ft
▼ **After** ____ **Hrs.** Backfilled ft

DEPTH (ft)	BLOWS /6"	UCS Qu (tsf)	MOIST (%)	Description
				8.25" asphalt pavement on 4" gravel subbase.
				686.10
				Soft to Stiff, damp, gray, sticky, CLAY w/ Silt.
	2			
	3	0.87	19	
	2	S		
-5	2			
	1	0.41	28	
	3	B		
	2			
	3	1.24	24	
	3	B		
-10	1			
	2	0.5	26	
	3	PP		
				▽ 675.10
	6			Very soft to medium, water bearing, gray, SANDY LOAM w/ Gravel.
	13		10	
	7			
-15	7			
	7		23	
	10			
				Low recoveries due to gravel and cobbles.
	11			
	15	0.3	18	
	19	PP		
				667.60
-20	12			▼

DEPTH (ft)	BLOWS /6"	UCS Qu (tsf)	MOIST (%)	Description
	13	8.04	10	Hard, damp, gray, CLAY LOAM TILL. *(continued)*
	18	B		
	8			
	13	7.83	10	
	17	B		
-25	8			
	12	5.98	10	
	17	B		
	9			
	14	8.04	10	
	18	B		
-30	9			
	12	6.18	10	
	16	B		
				652.60
-35	7			Very stiff, damp, gray, SANDY CLAY TILL.
	11	3.50	12	
	19	B		
				651.10
				Extent of exploration.
				Benchmark: BM 201 Cut square on SW wingwall of existing structure Sta 138+36 Rt 22.3' = 686.95'
-40				

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)

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Illinois Department of Transportation
Division of Highways
IDOT

SOIL BORING LOG

Date 9/10/14

ROUTE FAP 749 (IL 133) **DESCRIPTION** Jonathan Branch **LOGGED BY** E. Sandschafer

SECTION (119BR-1)B-1 **LOCATION** Sec 30 - SW 1/4, Sec 31 - NW 1/4, **SEC.** , **TWP.** 15 N, **RNG.** 6 E, 3 **PM**

COUNTY Moultrie **DRILLING METHOD** Hollow stem auger & split spoon **HAMMER TYPE** Auto 140#

STRUCT. NO. 070-2020
Station 138+54.22

BORING NO. 2 West
Station 138+31
Offset 15.5ft S
Ground Surface Elev. 687.13 ft

Surface Water Elev. 676.42 ft
Stream Bed Elev. 676.16 ft

Groundwater Elev.:
▽ **First Encounter** 662.6 ft
▽ **Upon Completion** 667.1 ft
▼ **After** ____ **Hrs.** Backfilled ft

DEPTH (ft)	BLOWS /6"	UCS Qu (tsf)	MOIST (%)	Description
				12.25" asphalt pavement.
686.13				
				Soft, damp, dark gray, sticky, SILTY CLAY.
	1			
	2	0.37	28	
	2	B		
-5	1			
	1	0.33	30	
	2	B		
680.13				
	2			Stiff to medium, damp, gray, CLAY.
	2	1.65	24	
	3	B		
-10	1			
	2	0.62	25	
	3	B		
675.13				
	9			Very stiff, moist, brown, SANDY CLAY. *Sample powdered.*
	15	2.89	4	
	13	B		
672.63				
-15	9			Very stiff, damp, gray, CLAY LOAM TILL.
	8	2.89	12	
	7	B		
670.13				
	15			Very soft, wet, gray, SANDY LOAM and GRAVEL.
	15		15	
	18			
667.63				
▽ 667.13 -20	24			

DEPTH (ft)	BLOWS /6"	UCS Qu (tsf)	MOIST (%)	Description
	24	1.5	12	Hard to very stiff, damp, gray, CLAY LOAM TILL. *Rock in sampler shoe, low recovery.*
	25	PP		
	18			
	17	3.2	12	*Rock in sampler shoe, low recovery.*
	19	PP		
▽				
-25	12			
	13	4.5	11	*Rock in sampler shoe, low recovery.*
	15	PP		
	5			
	7	4.12	11	
	9	B		
-30	5			
	7	2.68	12	
	8	B		
-35	7			
	7	1.65	13	
651.13	8	B		
				Extent of exploration.
				Benchmark: BM 201 Cut square on SW wingwall of existing structure Sta 138+36 Rt 22.3' = 686.95'
-40				

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
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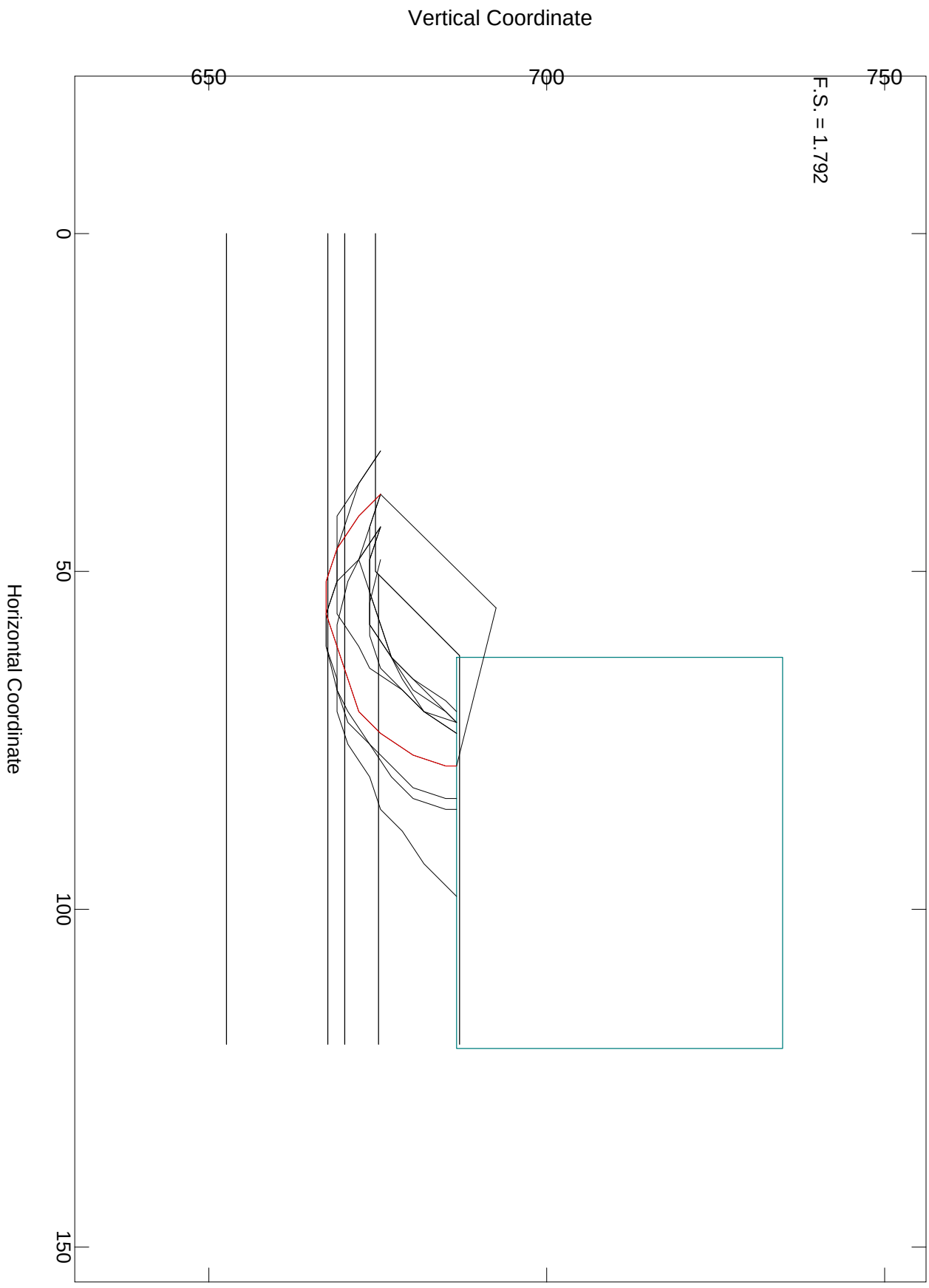
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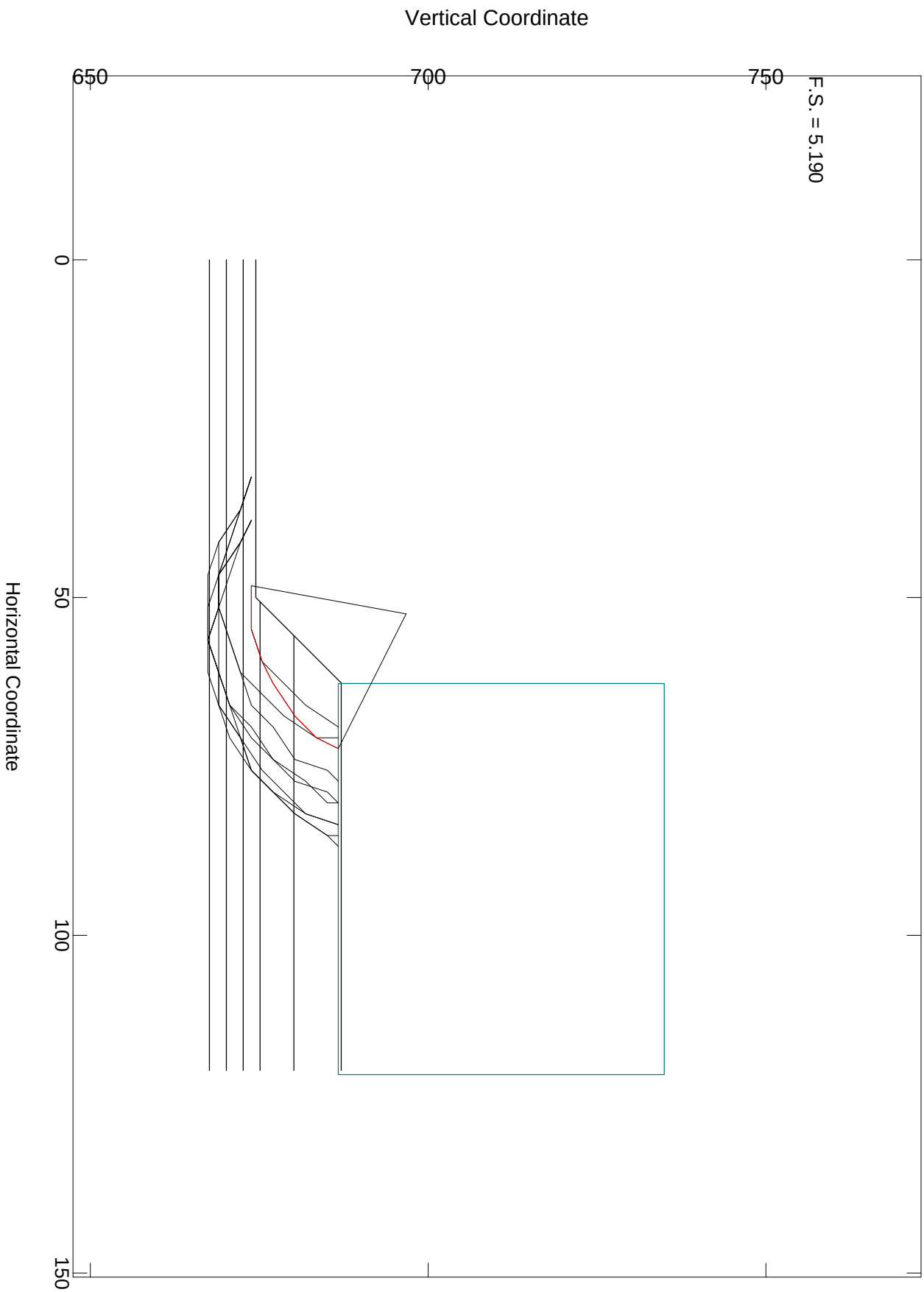
700
750
F.S. = 1.792
0
50
100
150
Horizontal Coordinate


Vertical Coordinate
650
700
750
F.S. = 5.190
0
50
100
150
Horizontal Coordinate