

**STRUCTURE GEOTECHNICAL REPORT
(IN HOUSE)**

BOX CULVERT

FAP 332/ ILLINOIS ROUTE 1 OVER UNNAMED CREEK

PROPOSED S.N. 051-2009

EXISTING S.N. 051-8000

LAWRENCE COUNTY

SECTION 18B

JOB NUMBER D-97-019-13

CONTRACT NUMBER: 74619

Submitted by:

BBS Foundations and Geotechnical Unit

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1.0 Project Description

The proposed structure will consist a double 12'x5' reinforced concrete box culvert with a 0° skew and will be eighty feet long along the centerline of the structure. District 7 has elected to not allow the precast method of construction on this project; therefore the box culvert will be the cast in place method of construction. The existing structure is a slab bridge with an approximate sixteen foot span. The proposed structure is much wider than the existing structure for the purpose of eliminating the need for guardrail at this location.

2.0 Subsurface Exploration and Conditions

The subsurface exploration included two borings. One was taken at Station 304+19, which is located on the south side of the proposed structure. The results of said boring show fairly weak clays ($Q_u < 0.5$ tsf), with the exception of a 4.7' thick layer of Stiff Clay ($Q_u = 1.2$ tsf) from elevation 426.34 to 421.64, underlain with sandstone. The other boring was taken at Station 304+57, which is located on the north side of the structure. This boring indicated medium stiff to stiff clays, with soft to very soft clays underneath. The soft to very soft clays began at around elevation 424.28. This boring was not taken to rock, but it is a reasonable to assume that the sandstone layer would be found at a similar elevation as the Boring for the South side shows (approx. 415.14).

The two borings consisted of Split Spoon samples taken at intervals of two and a half feet. SPT tests, moisture content test, and unconfined compression tests using a Rimac Spring Tester where taken for the samples. Rock Corings were not taken for the sandstone. While it would be preferred to have information gathered from rock corings, for the purposes of this particular structure rock corings are not required. If a strength of the sand stone is required for design purposes, a unconfined compressive strength (Q_u) of 5 tsf may be used. This represents a fairly conservative value.

Groundwater elevations where reported upon completion of the boring and 48 hours after completion of the boring. The groundwater elevation upon completion was 426.5 for the north side and 425.1 for the south side. The groundwater elevation after 48 hours was 432.3 for the north side and 432.1 for the south side. Considering that there is a creek running through the project limits, the groundwater elevation used for design purposed should be the water elevation of the creek or the top of ground elevation, whichever is less.

3.0 Geotechnical Evaluations and Recommendations

3.1 Settlement

Settlement and Differential Settlement were analyzed for the following four scenarios, the end of the box subjected to the north boring, the end of the box subjected to the south boring, the center of the box subjected to the north boring, and the center of the box subjected to the south boring. The end of the box was chosen as an area of concern due to this area not being previously loaded prior to installation of the new box; this would create the maximum amount of settlement experienced along the box culvert. The center of the box was chosen as an area due to this area having been partially loaded prior to installation of the new box culvert; this location would create the minimum amount of total settlement along the box culvert, but would create the maximum differential settlement experienced along the box culvert.

The maximum settlement without soil improvement was 2.2 inches with a maximum differential settlement of 0.6 inches. As part of our analysis, various removal and replacement depths where investigated. At 3 feet of removal and replacement the maximum settlement was reduced to 1.2 inches with a maximum

differential settlement of 0.2 inches. At 4 feet of removal and replacement the maximum settlement was reduced to 1 inch with a differential settlement of 0.3 inches. Our recommendation is to remove and replace 3 feet of unsuitable material, since going deeper than 3 feet does not reduce the settlement significantly and starts to increase the differential settlement. The differential settlement will increase with depth of undercutting after 3 feet because on the south side soft clays will be removed, but on the north side stiff clays are being removed. Results of analysis are summarized in tables 3.1 and 3.2.

Table 3.1

Location	Boring	Max. Settlement		
		Untreated	3' UC	4' UC
End of Box	South (1)	2.2"	1.2"	0.9"
End of Box	North (2)	1.6"	1.2"	1"
Center of Box	South (1)	1.7"	1"	0.7"
Center of Box	North (2)	1.3"	1"	0.9"

Table 3.2 Differential Settlement

	North-South		Center-End		Maximum
	End	Center	South	North	
Untreated	0.6"	0.4"	0.5"	0.3"	0.6"
3' UC	0"	0"	0.2"	0.2"	0.2"
4' UC	0.1"	0.2"	0.2"	0.3"	0.3"

Cross sections detailing the proposed fill limits were not available to us at the time of the report, therefore embankment settlement could not be investigated at this time.

3.2 Slope Stability

Cross Sections detailing the proposed fills were not available to us at the time of the report, however it is anticipated that the fill heights will be 8 feet or less. As per the Geotechnical Manual fills fewer than 15 feet in height do not warrant a rigorous slope stability analysis. Fills with slopes at 1V:2H or gentler built according to *Standard Specifications for Road and Bridge Construction* are anticipated to be geotechnically adequate.

3.2 Scour

Scour is not a concern on this project given the structure type (box culvert).

3.4 Seismic Consideration

Per Section 3.10.1 of *AASHTO LFRD* and current IDOT practice Seismic Considerations do not need to be considered for buried structures, such as box culverts.

4.0 Foundation Recommendations

4.1 Soil Improvement

As discussed in Section 3.1 Settlement, we recommend that 3 feet of soft clay be removed and replaced underneath the proposed box culvert. The bottom of the removal shall extend beyond the culvert footprint by 3' as well. The replacement material should meet the requirements of the District 7 Special Provision *Rockfill- Replacement* dated December 2016.

4.2 Wing walls

The type of wing walls used for this structure depends on the culvert geometry and the construction method used. Based on the design height and skew of the proposed box, along with it being cast in place construction, horizontal cantilever wingwalls are the type to be used here. Since they cantilever off the barrel of the box culvert they have no geotechnical issues.

5.0 E.W.S.E and Cofferdams

5.1 E.W.S.E

The original hydraulic survey, completed in the month of March, reported a Flowline Elevation of 431.35. Using this, a minimum streambed elevation of 430.7 (lowest invert), and a top of bank elevation of 438.16 we calculated that the E.W.S.E that should be used for this project is **432.4**. Based on this value and the cohesive nature of the soils present in the borings a water diversion system could be used to construct the box culvert and wingwalls with minimal problems.

5.2 Cofferdams

As discussed in Section 5.1 cofferdams will not be required for the construction of the Box Culvert and wingwalls.

6.0 Construction Considerations

6.1 Temporary Soil Retention

The soils present, the shallowness of rock, and the existing bridge footing, do not allow for the use of Temporary Sheet Piling designed using *Design Guide 3.13.1*. A Temporary Soil Retention System designed by the contractor will have to be used to retain soils for the staged construction.

6.2 Top of Box Soil Retention

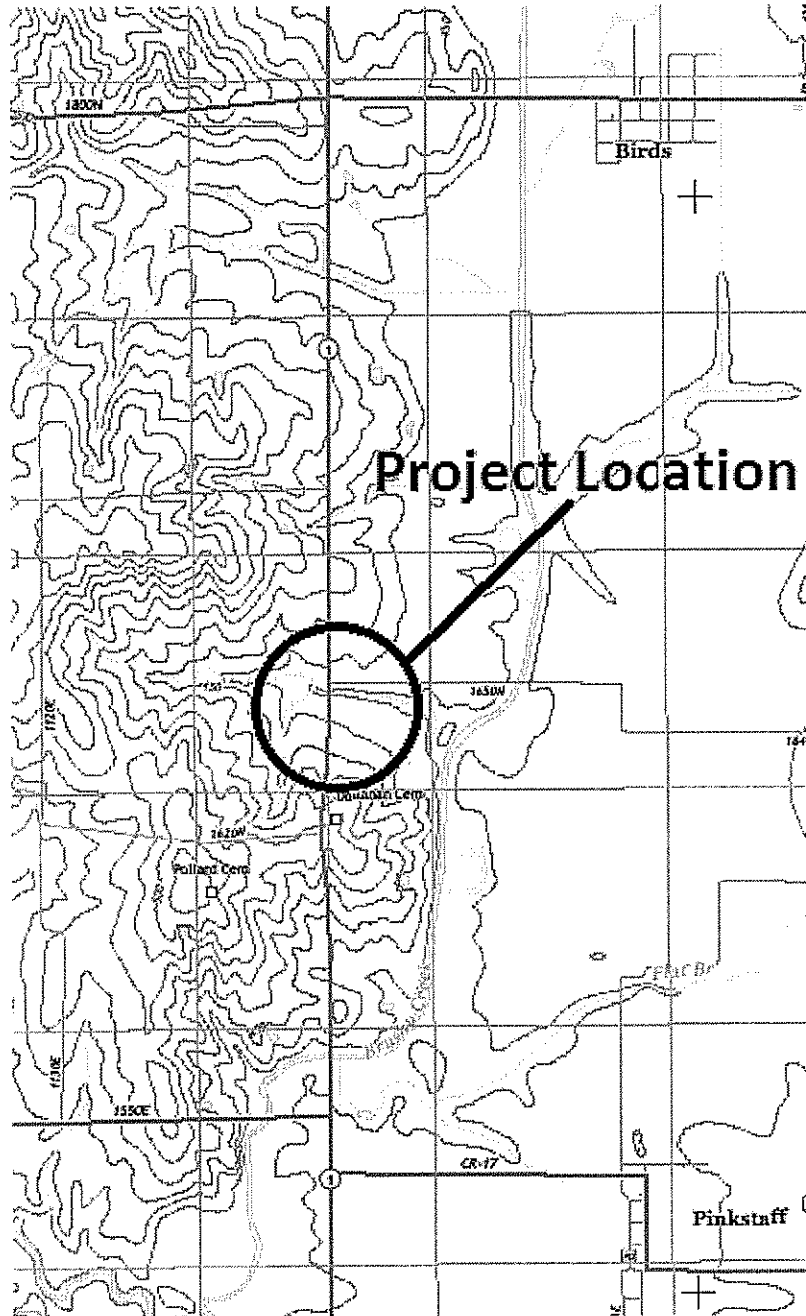
The anticipated retained height on top of the box culvert will be less than one foot, 9 inches to be exact. Therefore, a railroad tie or a similar non-structural headwall can be added to help retain the soil.

6.3 Temporary Slopes

Based on our analysis, continuous temporary slopes should be cut no steeper than 1V: 1.5H in order to maintain a factor of safety of 1.5. If the cut is benched 4 feet once every 4 vertical feet, then a 1V:1H slope could be used, however this method does not save on excavation quantity.

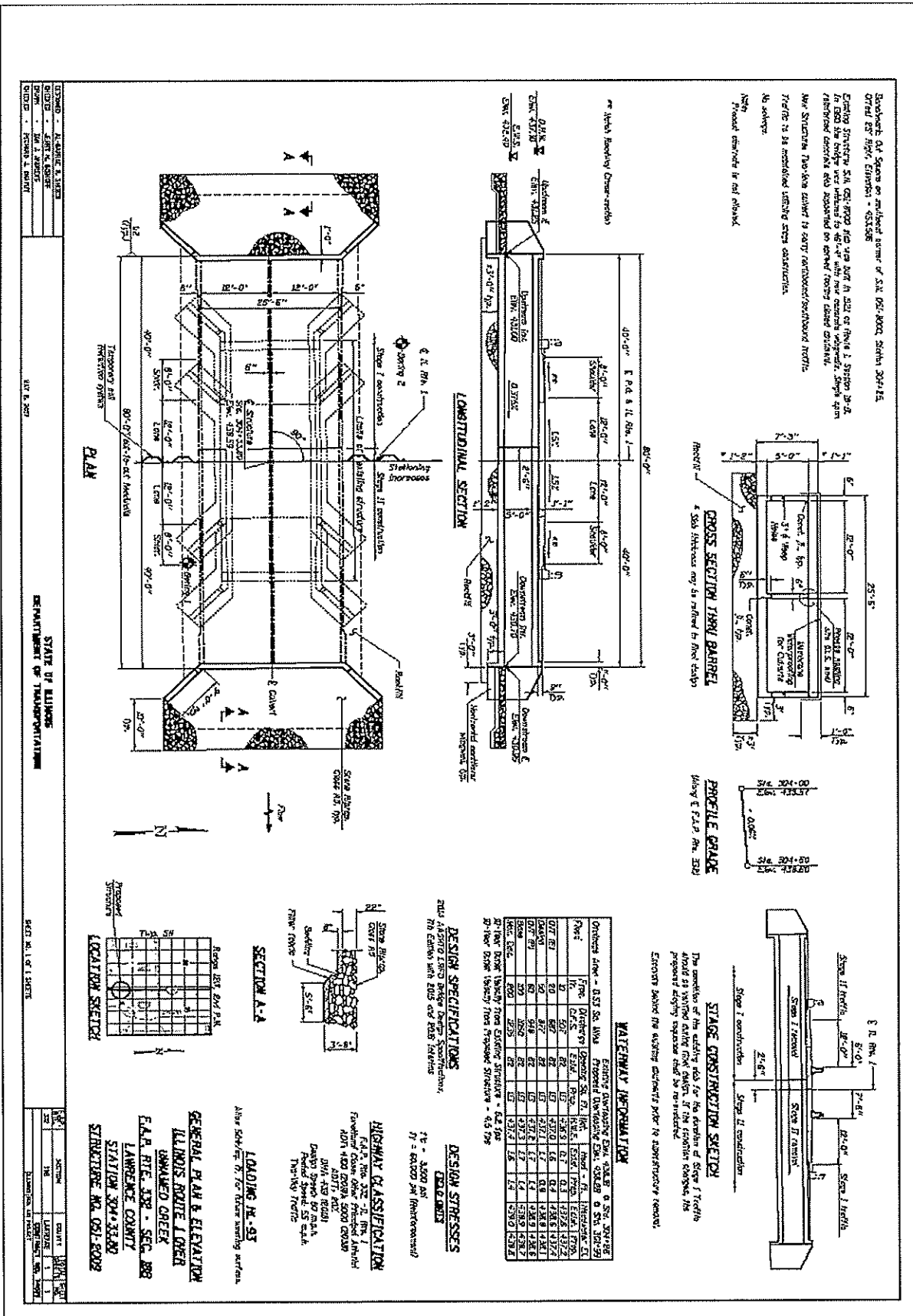
Appendix A

Location Map



Appendix B

Current Version of TSL (Dated May 2, 2017)

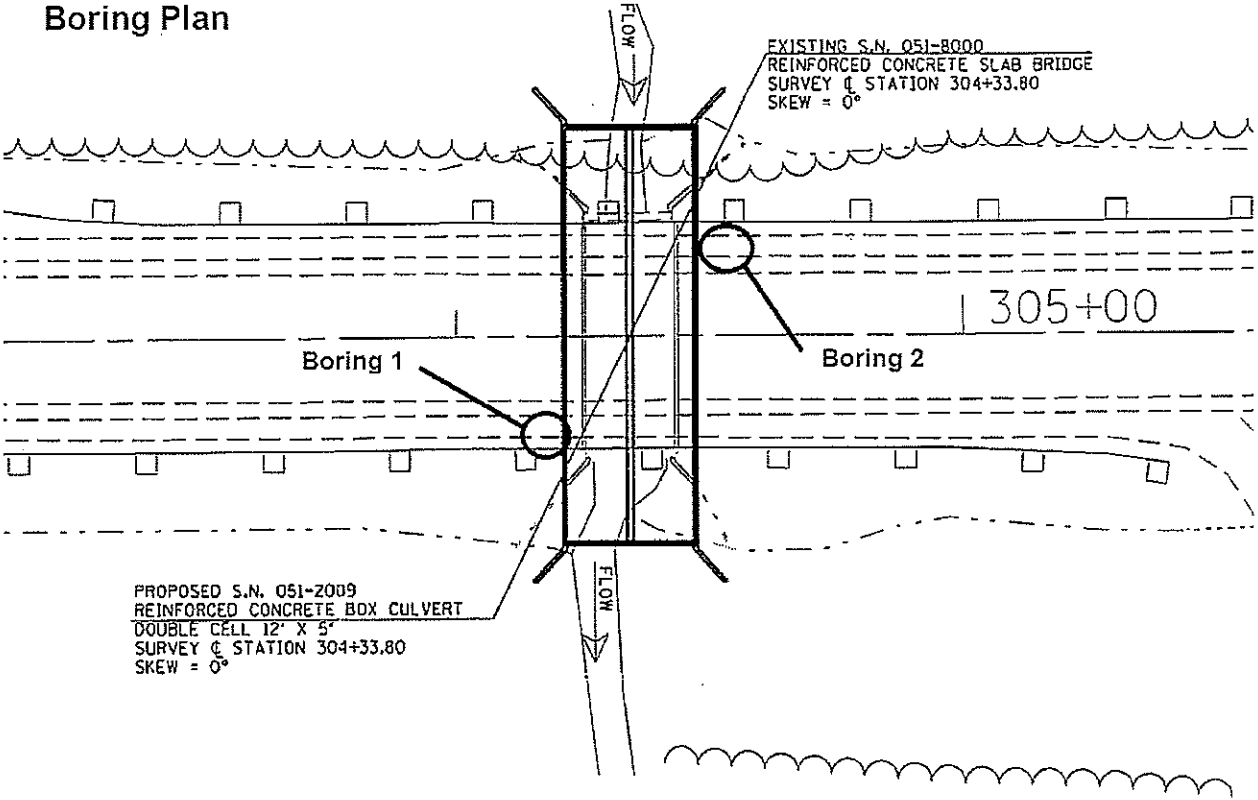


Appendix C

Boring Plan



Boring Plan

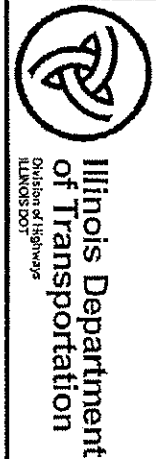
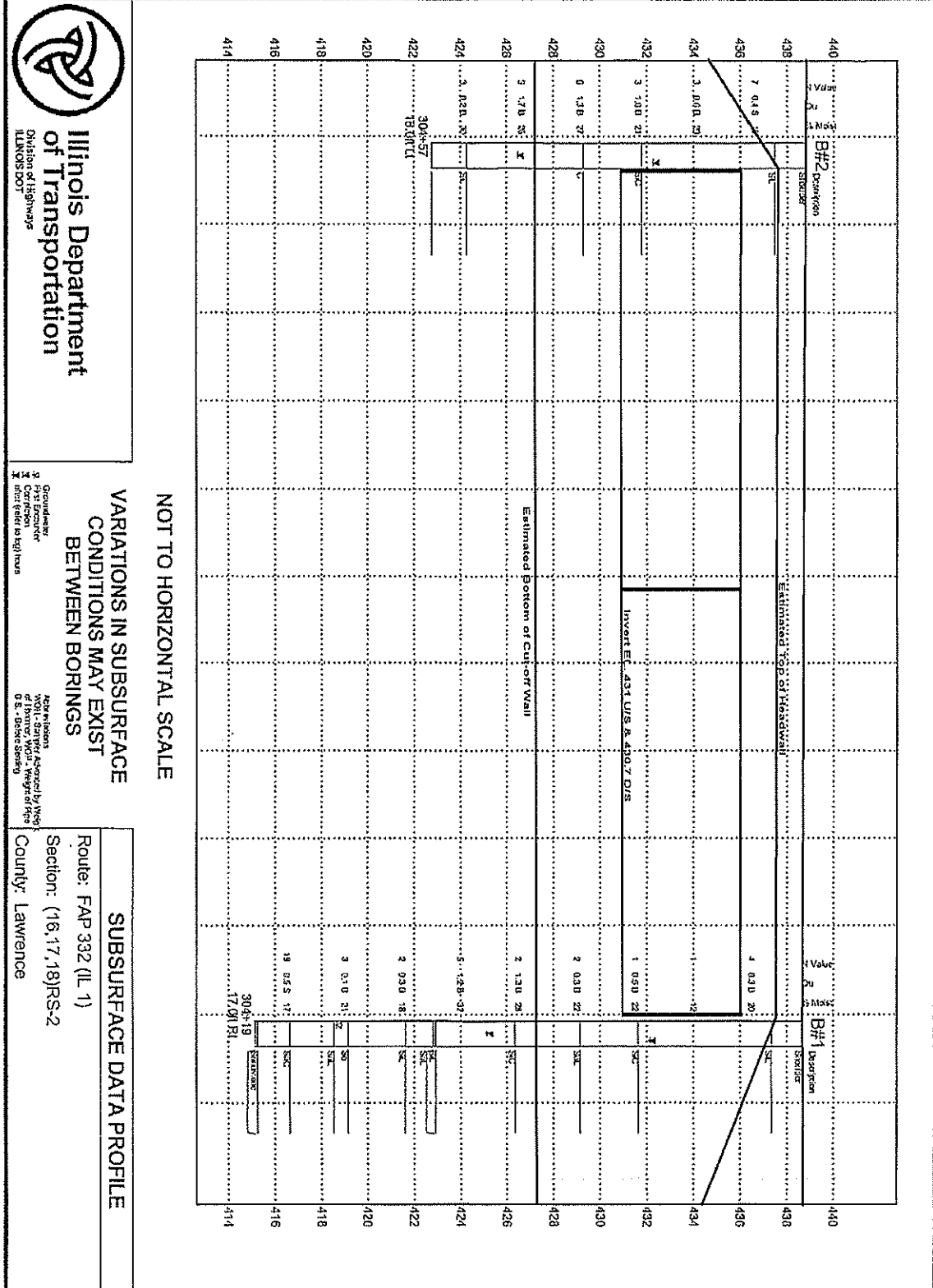


Appendix D

Subsurface Plot

Structure Number 051-8000 Brushy Fork Creek
 Located in the R. 12 W - Sec 1 - E. 1/2, R 11 W - Sec 6 - W 1/2 of Section , Township 4 N, Range of the 3 P.M.

TEST FENCE 2 051-8000 SOIL 2011.GPJ D6TEMPLT.GDT 11/08/16



NOT TO HORIZONTAL SCALE

VARIATIONS IN SUBSURFACE CONDITIONS MAY EXIST BETWEEN BORINGS

Geotechnical Corporation
 1111 North 1st Street
 Chicago, IL 60610

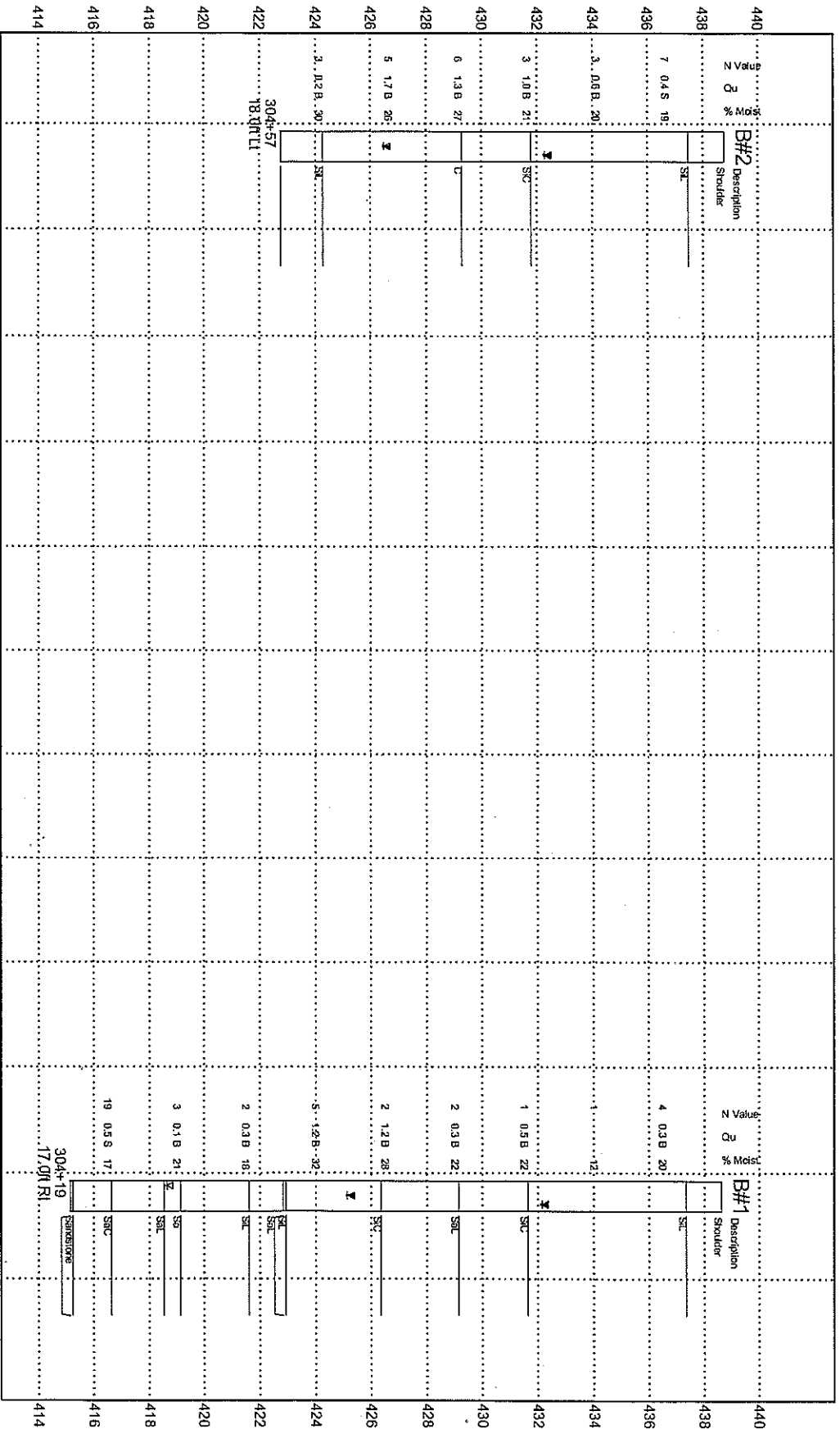
Approved by: [Signature]
 Date: 11/08/16

SUBSURFACE DATA PROFILE

Route: FAP 332 (IL 1)
 Section: (16, 17, 18)RS-2
 County: Lawrence

TEST FENCE 2 051-8000 SOIL 2011.GPJ D6TEMPLT.GDT 11/08/16

Structure Number 051-8000 Brushy Fork Creek
 Located in the R 12 W - Sec 1 - E 1/2, R 11 W - Sec 6 - W 1/2 of Section , Township 4 N, Range of the 3 P.M.



NOT TO HORIZONTAL SCALE

VARIATIONS IN SUBSURFACE
 CONDITIONS MAY EXIST
 BETWEEN BORINGS

SUBSURFACE DATA PROFILE

Route: FAP 332 (IL 1)

Section: (16,17,18)RS-2

County: Lawrence

Groundwater
 Completion
 after (refer to log) hours

Aberrations
 of Hammer, WCP, Weight of Pen
 B.S. - Before Sealing



Illinois Department
 of Transportation
 Division of Highways
 ILLINOIS DOT

Appendix E

Soil Boring Logs



SOIL BORING LOG

ROUTE FAP 332 (IL 1) DESCRIPTION Brushy Fork Creek LOGGED BY E. Sandschafer
SECTION (16,17,18)RS-2 LOCATION R 12 W - Sec 1 - E 1/2, R 11 W - Sec 6 - W 1/2, SEC., TWP. 4 N, RNG. 3 PM
COUNTY Lawrence DRILLING METHOD Hollow stem auger & split spoon HAMMER TYPE Auto 140#

STRUCT. NO. Station	BORING NO. Station	Offset	Ground Surface Elev. (ft)	D E P T H (ft)	B L O W S (/ft)	U C S Qu (tsf)	M O I S T (%)	Surface Water Elev.		Groundwater Elev.:		D E P T H (ft)	B L O W S (/ft)	U C S Qu (tsf)	M O I S T (%)
								432.83 ft	431.91 ft	First Encounter	Upon Completion				
051-8000 304+37	1 (South) 304+19	17.0ft Rt	438.64 ft						418.6 ft	425.1 ft	432.1 ft				
16" aggregate shoulder.									Gray, fine grained, SAND. 12% passing #200 sieve. (continued)		418.54	1	0.1	21	
437.34									Very soft, very damp, gray, SANDY LOAM.			2	B		
Soft, damp, gray, SILTY LOAM.					1						416.64				
					2	0.3	20					5			
					2	B					415.24	6	0.5	17	
									Brown, SANDSTONE.		415.14	13	S		
									Extent of exploration.						
					-5	0					-25				
					0		12								
					1				Benchmark: BM 445 chiseled square on the SE wingwall of existing SN 051-8000 = 439.46' elevation.						
431.64					0										
Medium, damp, gray marbled reddish brown, SILTY CLAY.					0	0.5	22								
					1	B									
429.14															
Soft, damp, red marbled gray, SANDY LOAM.					-10	0					-30				
					1	0.3	22								
					1	B									
426.34															
Stiff, damp, gray marbled reddish brown, SILTY CLAY.					0	1.2	28								
					1	B									
					-15	1					-35				
					2	1.2	32								
422.94					3	B									
Very soft, very damp, gray, SILTY LOAM.															
422.84															
Gray, SANDY LOAM.															
421.64															
Soft, damp, gray, SILTY LOAM.					0	0.3	18								
					1	B									
					1										
419.14															
					-20	1					-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)

