

**Retaining Wall
Subsurface Information**

U-4756

Cumberland Co.

C202135



April 23, 2008

Mr. Kevin Austin, P.E.
Mulkey Engineers and Consultants
6750 Tryon Road
Cary, NC 27511

Re: Geotechnical Subsurface Exploration Report Addendum
Retaining Walls along Morganton Road
Cumberland County, NC
Tierra Project No.: 6211-07-018

Dear Mr. Austin:

As requested, Tierra North Carolina Inc. (Tierra) has performed additional geotechnical test borings for the proposed retaining walls at the above referenced site and prepared the following addendum to our original report (Tierra Project No. 6211-07-018, dated May 1, 2007). These additional services were performed in general accordance with our proposal (Tierra Proposal No. TR-07-017a, dated August 17, 2007). The following addendum presents field exploration and laboratory testing results, and the results of our analysis for the proposed retaining structures.

Project Description

Based upon our review of the plans provided by Mulkey Engineers and Consultants (Mulkey), dated April 2008, we understand the proposed project will consist of constructing 2:1 (horizontal to vertical) or flatter embankment slopes and three retaining walls associated with the roadway widening along Morganton Road between Glensford Drive and Sycamore Dairy Road in Fayetteville, North Carolina. Details of the project are provided below.

- Retaining Wall No. 1 (RW1): located between Stations 36+20 and 39+09 -L-, at offsets of approximately 75 to 100 feet left. The wall heights range from approximately 4 to 6 feet with 2:1 slopes above the wall, resulting in up to 18 feet of retained fill. A soldier pile and lagging wall system will be utilized for RW1.
- Retaining Wall No. 2 (RW2): located between Stations 49+59 and 54+45 -L-, at offsets of approximately 60 to 100 feet left. The wall heights range from approximately 4 to 8 feet with 2:1 slopes or flatter above the wall, resulting in up to 16 feet of retained fill. A soldier pile and lagging wall system will be utilized for RW2. The wall crosses over an elliptical 95-inch diameter RCP near Station 53+37 -L-.
- Retaining Wall No. 3 (RW3): located between Stations 50+60 and 54+65 -L-, at an offset of approximately 75 feet right. The wall heights range from approximately 3 feet to 10 feet with 2:1 slopes above the wall, resulting in up to 14 feet of retained fill. A soldier pile and lagging wall system will be utilized.
- Embankment Slopes: 2:1 or flatter slope construction is anticipated between Stations 34+50 and 55+50 -L-, on both sides of the roadway, except in the proposed retaining wall (RW1 through

RW3) locations and the bridge structure. The slopes will tie into the existing embankment and have heights ranging from approximately 1 to 29 feet.

Subsurface Conditions

A total of fifteen (15) standard penetration test (SPT) borings (B-1 through B-15) were drilled near the proposed retaining structures and embankment slopes and extended to depths ranging from 15 to 50 feet below existing ground surface. The SPT Borings were advanced using a CME 45B track mounted drill rig with a manual hammer and mud rotary drilling techniques. Boring locations were established in the field by a qualified staff professional in accordance with the plans provided by Mulkey (refer to the attached Boring Location Plan). Ground surface elevations for the borings were estimated from the site topographic map provided by Mulkey.

In general, the soils beneath the proposed slopes and retaining structures consist of artificial fills underlain by coastal plain materials. Artificial fills were encountered at the ground surface and consist of approximately 3 to 12 feet of loose to very dense silty sand and medium stiff to hard sandy clay (A-2-4, A-6, and A-7-6). Coastal plain materials were encountered underneath artificial fills and extended to the boring termination depths, consisting of very loose to very dense sands and medium stiff to hard clays (A-2-4, A-2-6, A-3, A-6, and A-7).

The subsurface soil stratification is generalized to highlight major subsurface stratification features and material classifications. Specific details concerning subsurface conditions and materials encountered at each test location may be obtained from the soil test boring logs and cross sections in the attachments. The depths of strata indicated in the boring logs represent approximate boundaries between soil types of significantly different engineering properties; however, the actual transition may be gradual.

Groundwater Conditions

Groundwater measurements were obtained at the boring locations using a weighted 100-foot tape from a reference location at the top of each boring. Measurements were recorded immediately after boring completion and after a 24-hour waiting period at some locations. Groundwater was encountered at depths ranging from approximately 1 to 9 feet below ground surface immediately following boring completion and at some locations at depths of approximately 10 to 16 feet after a 24-hour period following drilling. However, it should be noted that due to mud rotary drilling techniques, during which water and bentonite are added to the borehole while drilling, the above water levels may not represent stabilized groundwater conditions.

Laboratory Testing

Representative split- spoon samples were selected from soil test borings to verify visual field classification and determine soil index properties. All testing was performed in general accordance with AASHTO, NCDOT and ASTM Standards. A total of seven (7) samples were analyzed in our laboratory for Atterberg limits, grain size analysis, and natural moisture content determination. The results of these tests are summarized in Table 1 in the Attachments. The test results indicate that the samples tested had AASHTO classifications ranging from A-2-6 to A-7-6, liquid limits ranging from non-plastic to 92 and plasticity indices ranging from non-plastic to 71. In addition, the samples had moisture contents ranging from 10 to 53 percent.

Embankment Slope Construction

Based upon the plans provided, it is our understanding that embankment slope construction is proposed with slopes of 2:1 or flatter. Based upon our field exploration, and our previous experience on similar projects we anticipate that 2:1 or flatter slope construction will be suitable for the project. Embankment construction shall be performed in accordance with NCDOT Specifications

In addition, construction of new fills on existing embankment slopes will need to include benching into the existing slopes in accordance with NCDOT Specifications to reduce the potential for creating a weak plane at the interface of the new fills and the existing soils. The proposed construction sequencing for the fill slope should include fill placement from the bottom to top of the existing slopes. Finished slopes shall be properly seeded or vegetated and maintained in accordance with NCDOT Specifications to reduce the potential for erosion.

A drainage system to improve the internal and external drainage of the new fill slope may also be installed. An underdrain may be constructed at the back of the lowest compaction bench and graded to remove water away from the new fill. The drain should consist of a 4-inch diameter perforated pipe and be construction in accordance with NCDOT Specifications. The drainage system should slope to allow for gravity drainage and tie into a collection system or outfall to direct water away from the slope.

Retaining Wall Analysis

As discussed above, three retaining structures (RW1, RW2 and RW3) will be constructed at the site using a soldier pile and lagging wall system. The retaining walls were analyzed using the following soil parameters:

Soil Type	Approximate Soil Unit Weight (pcf)		Effective Soil Angle of Internal Friction (degrees)	Effective Cohesion (psf)	Equivalent Active Fluid Pressure (pcf)	
	γ_{sat}	$\gamma_{effective}$			Level Backfill	Sloping Backfill
Existing/Proposed Embankment Fill	120	57.6	30	0	43	58
Coastal Plain Soil	120	57.6	30	0	43	58

To account for groundwater fluctuations in the coastal plain, groundwater levels were assumed to be at the ground surface at the base of the retaining wall. However, the active fluid pressure values assume that the backfill behind the retained portion of the wall is fully drained and that hydrostatic pressure does not develop.

The intent of the soldier beam and lagging wall is to provide continuous support for the new embankment fill, as construction proceeds. The wall is constructed by drilling shafts and embedding steel piles in the shafts. Precast concrete lagging is inserted between the beams to retain the soil.

Presented below in Table 3 is a summary of the proposed wall locations and associated design criteria. The pile embedments and spacings provided below are based upon a factor of safety of 1.5 using AASHTO design procedures. Sample calculations for the design are provided in the Attachments.

TABLE 3: SOLDIER PILE AND LAGGING WALL SUMMARY								
Wall No.	Station	Max. Exposed Wall Height (ft)	Preliminary Minimum Pile Size ⁽¹⁾	Drilled Pile Diameter (ft)	Pile Spacing (ft)	Drilled Pile Embedment Depth ⁽²⁾ (ft)	Deflection (in)	Max. Moment (kip-ft)
1	36+20 ~ 39+09 -L-	6	HP 12x53	2	10	22	0.3	125
2	49+60 ~ 54+45 -L-	8	HP 12x53	2	10	23	0.5	180
2	95" RCP (53+29 ~ 53+45 -L-)	10	W 30x99	3	16	35	0.4	360
3	50+60 ~ 53+50 -L-	10	HP 14x73	2	8	30	0.5	290
3	53+50 ~ 54+00 -L-	8	HP 12x53	2	10	23	0.5	180
3	54+00 ~ 54+65 -L-	6	HP 12x53	2	10	22	0.3	125

(1) Preliminary pile size estimated from Geotechnical Analysis. Final pile size to be determined by structural engineer.
(2) Depth is below the finished grade in front of the wall.

When drilling shafts, a temporary casing, which is removed when concrete is placed, should be utilized to prevent collapse of the overburden and infiltration of the groundwater in accordance with NCDOT Specifications. Drilled shaft construction techniques shall conform to NCDOT Specifications.

The soldier beam wall should be designed to provide drainage behind the wall, consisting of a minimum 1-foot wide free-draining granular backfill zone and weep holes through the wall. Alternatively, the installation of a prefabricated drainage composite behind the wall may be used. In addition, any voids between the wall and slope should be backfilled with gravel. Weep pipes should be placed through the wall at the lowest elevation that will allow gravity drainage.

General Retaining Wall Considerations


It is important that the retaining wall designs and construction conform to the specifications provided by NCDOT and AASHTO. The existing soils shall be cut back beyond the base of the foundation at a slope of 1H:1V or flatter as required by OSHA, and backfilled with compacted select material.


Hand guided compaction equipment should be used within 5 feet of the wall. In addition, the precast concrete panels should be monitored during backfilling to verify that the construction operations are not damaging the panels. Site grades should be designed to provide positive surface drainage away from the proposed structures.

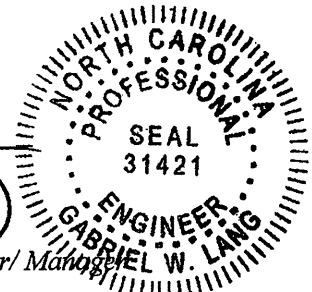
Tierra should be provided the opportunity to review the parameters used in designing the retaining wall to ensure that they are consistent with our report. In addition, the wall foundations should be evaluated by NCDOT or a geotechnical engineer to confirm the design.

If you have any questions concerning the contents of this addendum or need additional information, please do not hesitate to contact our office.

Sincerely,
TIERRA


Pu (Paul) Zhang, Ph.D., P.E.
Geotechnical Engineer

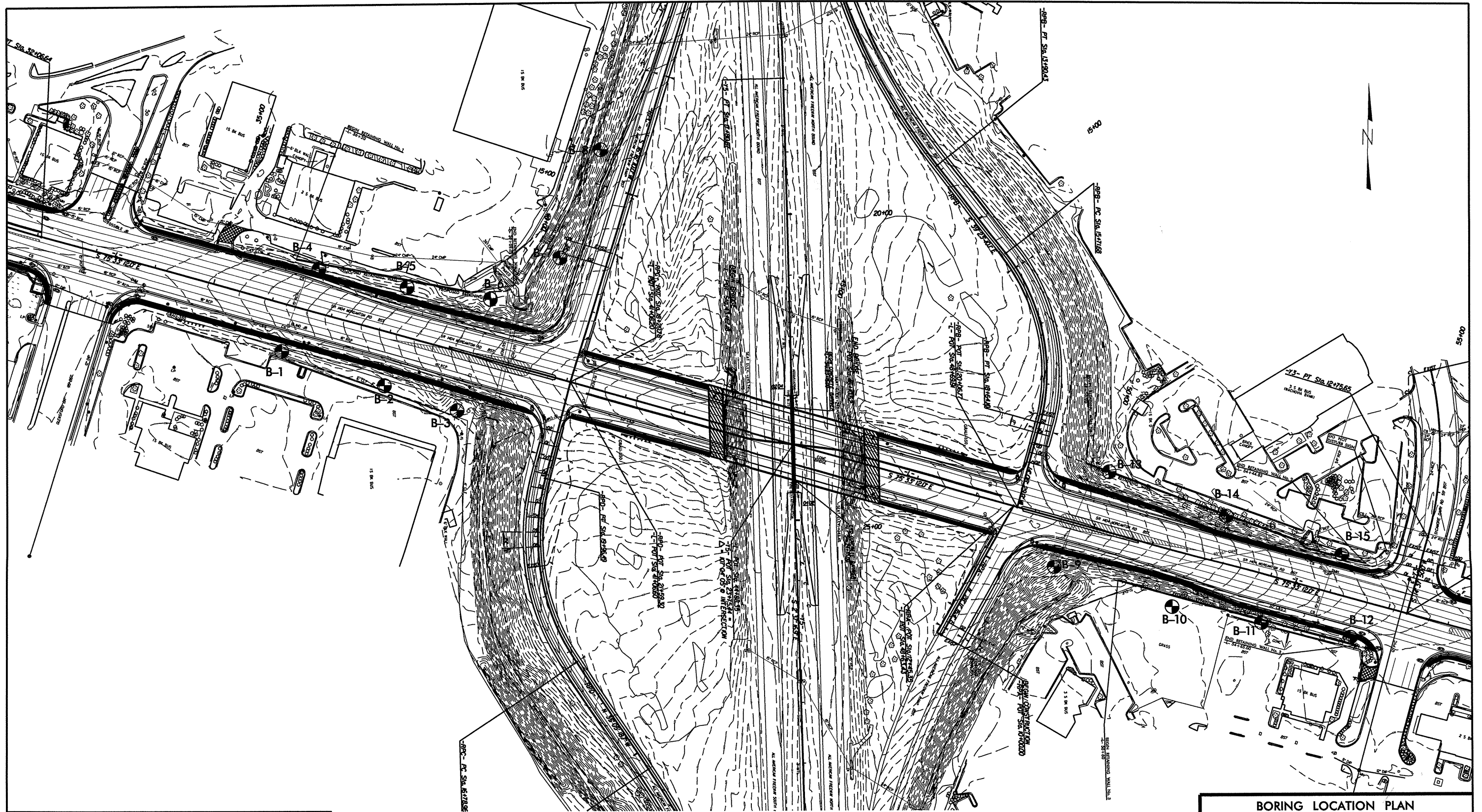

Gabriel W. Lang, P.E.
Sr. Geotechnical Engineer/Manager


4-23-08

Attachments: Boring Location Plan
Subsurface Cross Sections (Sheets 1 through 3)
Boring Logs (B-1 through B-15)
Legend
Table 1: Summary of Classification Test Results
Sample Retaining Wall Calculations

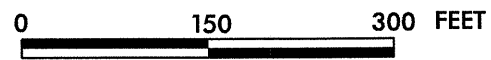
ATTACHMENTS

- **BORING LOCATION PLAN**
- **SUBSURFACE CROSS SECTIONS (SHEETS 1 THROUGH 3)**
- **BORING LOGS (B-1 THROUGH B-15)**
- **LEGEND**
- **TABLE 1: SUMMARY OF CLASSIFICATION TEST RESULTS**
- **SAMPLE RETAINING WALL CALCULATIONS**



NOTES:

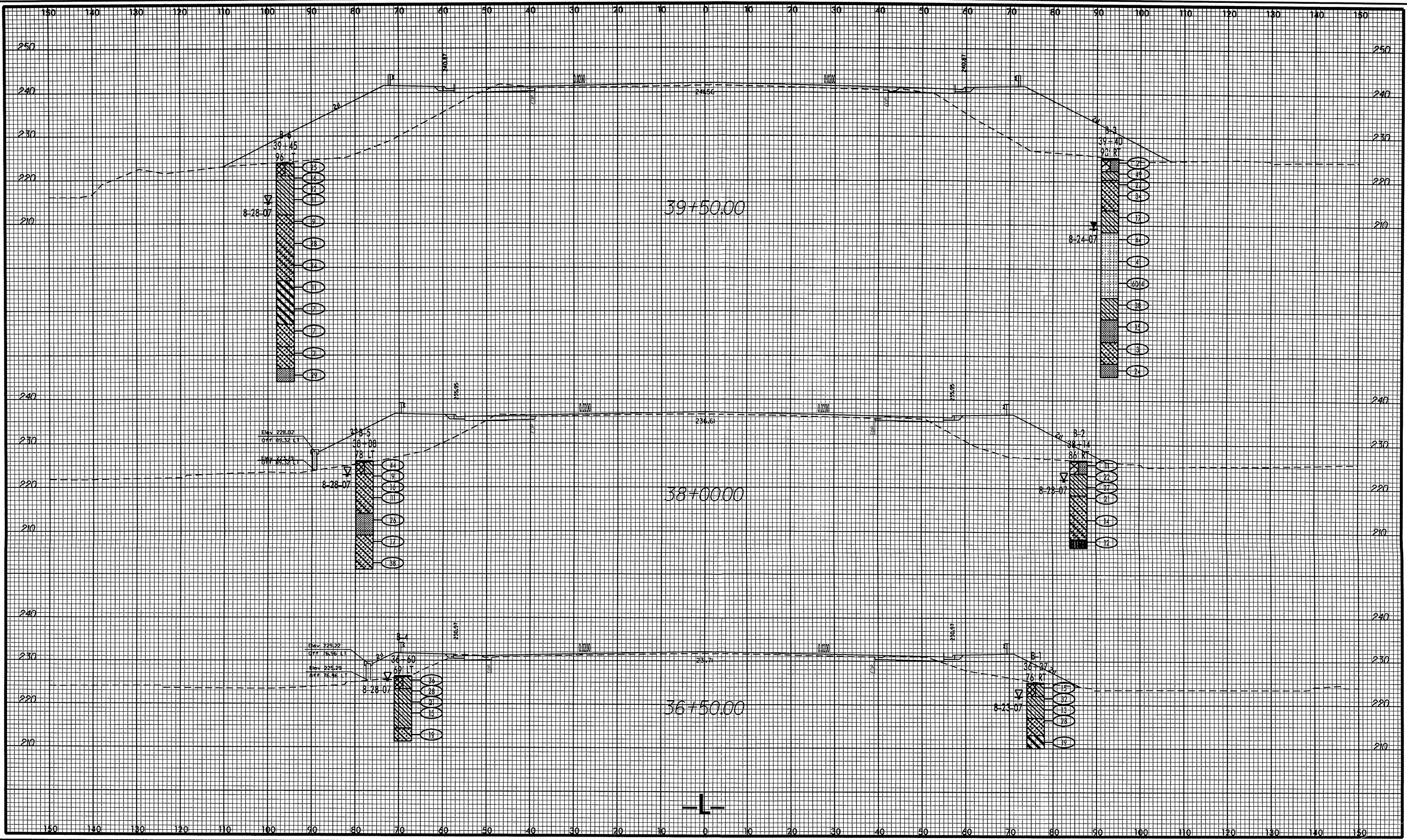
- APPROXIMATE SPT BORING LOCATION
- PLANS ADOPTED FROM FILES RECEIVED FROM MULKEY ENGINEERS & CONSULTANTS, DATED APRIL 2008.



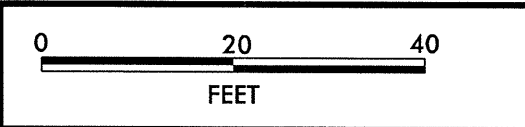
BORING LOCATION PLAN

RETAINING WALLS ALONG MORGANTON ROAD
CUMBERLAND COUNTY, NORTH CAROLINA
TIERRA PROJECT NO.: 6211-07-018

 <p>TIERRA GEO-TECHNICAL • MATERIALS ENGINEERING</p>	<p>TIERRA 2736 ROWLAND RD. RALEIGH, NC 27615 PHONE (919) 871-0800 FAX (919) 871-0803</p>
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NOTES:
 • PLANS ADOPTED FROM FILES RECEIVED FROM MULKEY ENGINEERS & CONSULTANTS, DATED APRIL 2008.

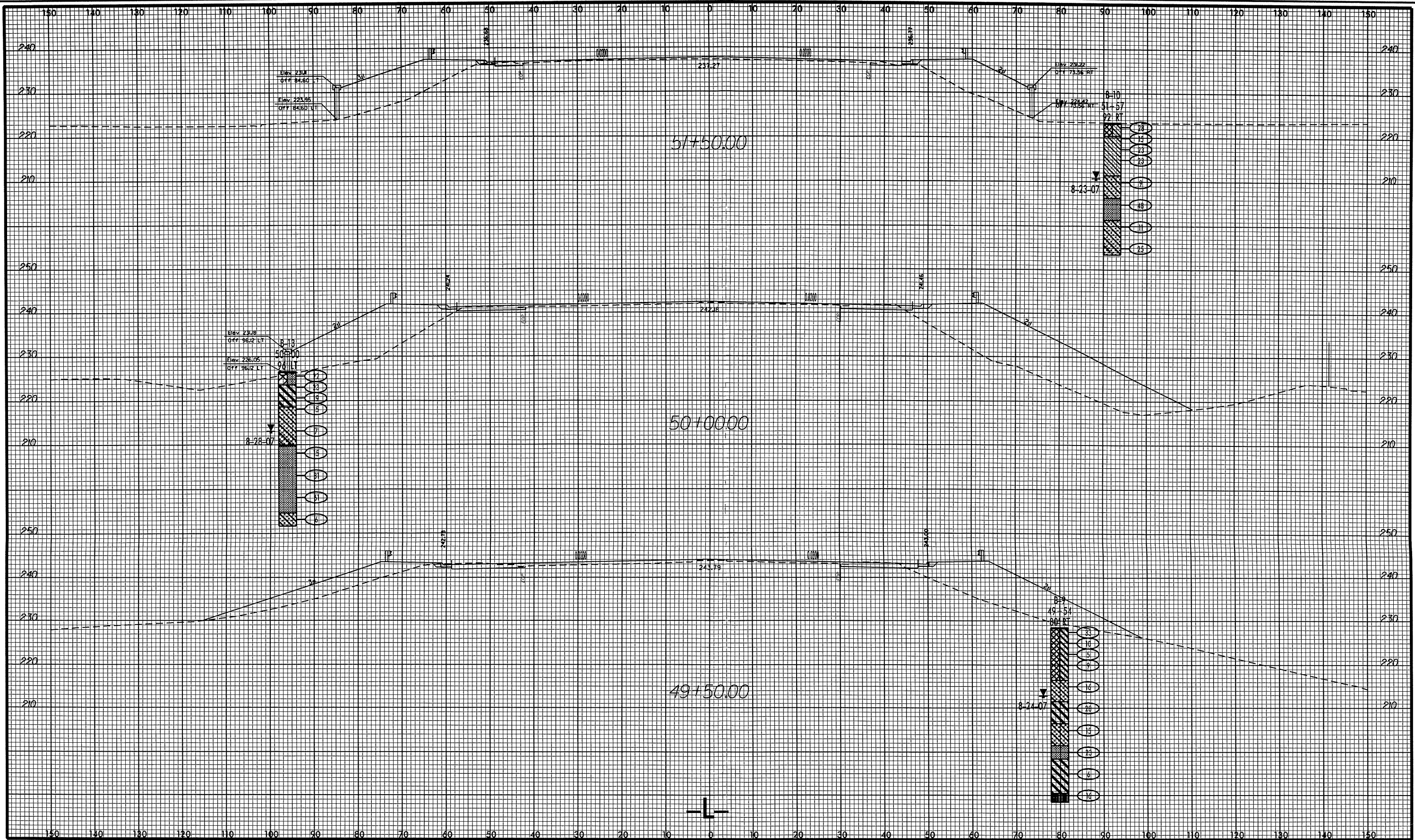


SUBSURFACE CROSS SECTION
 SHEET 1 OF 3

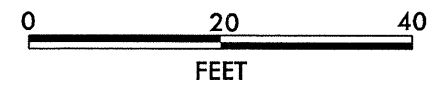
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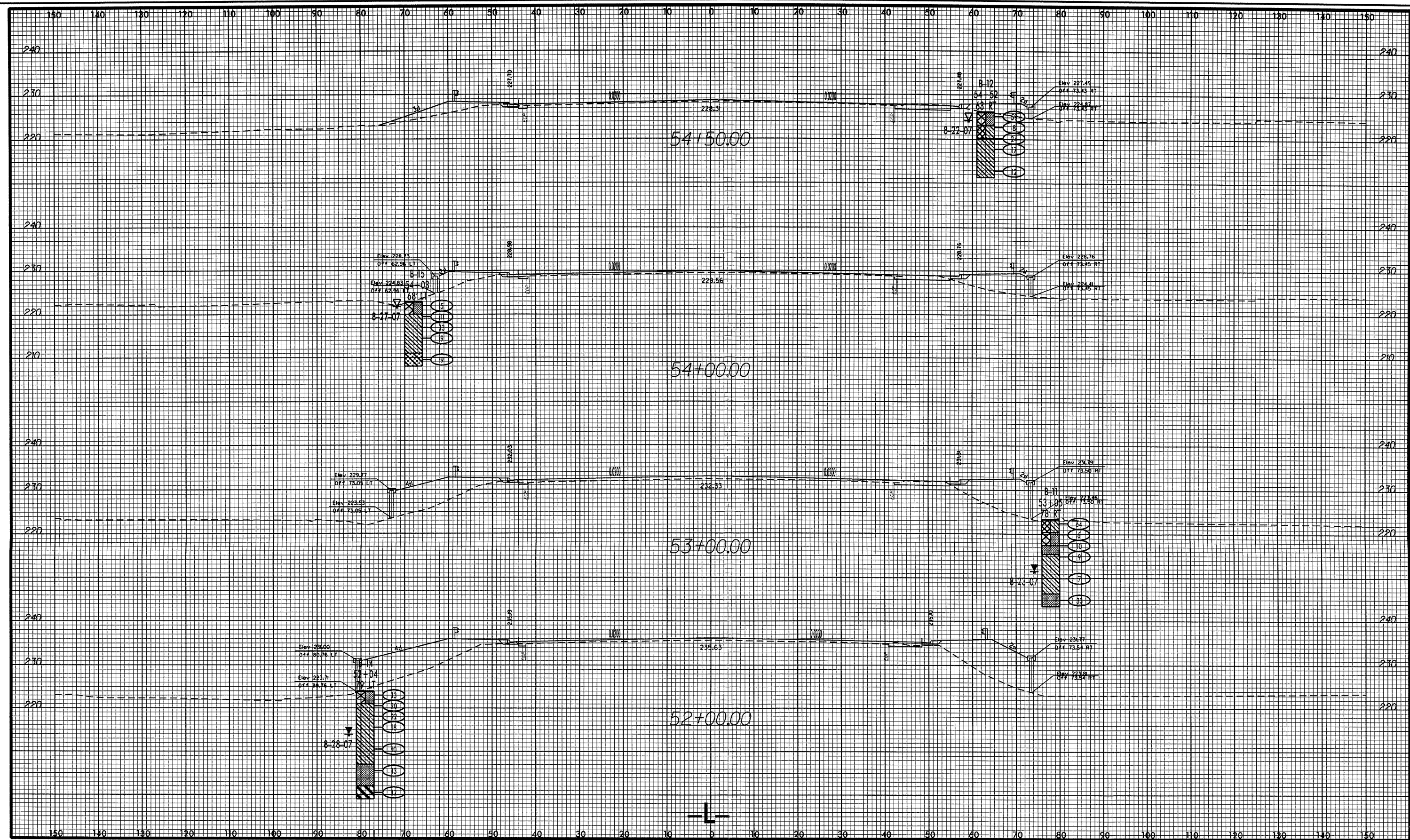


SUBSURFACE CROSS SECTION
 SHEET 2 OF 3

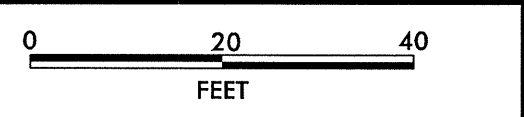
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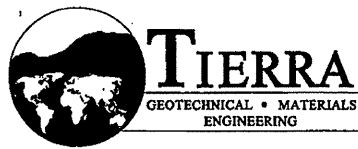


SUBSURFACE CROSS SECTION
 SHEET 3 OF 3

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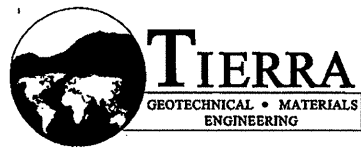
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N.C.D.O.T. GEOTECHNICAL UNIT
 BORING LOG

SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.	COUNTY CUMBERLAND		GEOLOGIST P. ZHANG									
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS						GROUND WATER (ft)								
BORING NO. B-1	BORING LOCATION 36+37		OFFSET 76' RT	ALIGNMENT -L-	0 HR.	3.2								
COLLAR ELEV. 225 ft	NORTHING 479,948.5		EASTING 2,012,289.8		24 HR. CAVE @	13.4								
TOTAL DEPTH 15.0 ft	DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL									
DATE STARTED 8-23-07		COMPLETED 8-23-07		SURFACE WATER DEPTH N/A										
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	MOI	L O G	SOIL AND ROCK DESCRIPTION	
		0.5ft	0.5ft	0.5ft	0	20	40	60	80	100				
225.0														EXISTING GROUND
	1.0	9	8	7							SS-1	10%		225.0
	3.5	9	13	19							SS-2	M		224.8
220	6.0	5	11	2							SS-3	M		222.0
	8.5	9	14	14							SS-4	W		217.0
215	13.5	6	6	13							SS-5	W		213.0
210														210.0
														BORING TERMINATED AT 15.0' BELOW EXISTING GROUND

NCDOT_BORE 07-018 RETAINING WALLS.GPJ NCDOT.GDT 9/9/07



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 BORING LOG

SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.	COUNTY CUMBERLAND		GEOLOGIST P. ZHANG										
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS						GROUND WATER (ft)									
BORING NO. B-2		BORING LOCATION 38+14		OFFSET 86' RT	ALIGNMENT -L-	0 HR. 4.4									
COLLAR ELEV. 226.5 ft		NORTHING 479,894.6		EASTING 2,012,458.8		24 HR. CAVE @ 10									
TOTAL DEPTH 20.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL									
DATE STARTED 8-23-07		COMPLETED 8-23-07		SURFACE WATER DEPTH N/A											
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION			
		0.5ft	0.5ft	0.5ft	0	20	40	60	80				100		
226.5													EXISTING GROUND		
	1.0	8	4	7									226.5	0.0	ROOTMAT
225	3.5	9	10	12							SS-1	D	226.3	0.2	FILL: TAN AND GRAY, MED. DENSE, SILTY SAND (A-2-4)
	6.0										SS-2	W	223.5	3.0	CP: TAN, GRAY AND REDDISH BROWN, V. STIFF, SANDY CLAY (A-6)
220	8.5	9	11	10							SS-3	M			
	13.5	5	6	8							SS-4	M	218.5	8.0	CP: GRAY AND PURPLE, MED. DENSE, CLAYEY SAND (A-2-6)
215															
	18.5	4	5	7							SS-5	W			
210															
											SS-6	W	208.5	18.0	CP: TAN AND WHITE, MED. DENSE, SLIGHTLY SILTY SAND (A-1-b)
													206.5	20.0	BORING TERMINATED AT 20.0' BELOW EXISTING GROUND



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N.C.D.O.T. GEOTECHNICAL UNIT
 BORING LOG

SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.	COUNTY CUMBERLAND	GEOLOGIST P. ZHANG									
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS					GROUND WATER (ft)								
BORING NO. B-3	BORING LOCATION 39+40	OFFSET 93' RT	ALIGNMENT -L-	0 HR.	9.2								
COLLAR ELEV. 225.5 ft	NORTHING 479,856.6	EASTING 2,012,578.7	24 HR.		16.2								
TOTAL DEPTH 50.0 ft	DRILL MACHINE CME 45B	DRILL METHOD MUD ROTARY	HAMMER TYPE MANUAL										
DATE STARTED 8-23-07	COMPLETED 8-23-07	SURFACE WATER DEPTH N/A											
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION	
		0.5ft	0.5ft	0.5ft	0	20	40	60	80	100			
225.5													EXISTING GROUND
225	1.0	6	7	14							SS-1	D	ROOTMAT
	3.5	11	22	27							SS-2	W	FILL: TAN AND GRAY, MED. DENSE, SILTY SAND (A-2-4)
220	6.0	9	11	16							SS-3	W	CP: TAN AND REDDISH BROWN, HARD, SANDY CLAY (A-6) WITH ROOTS
	8.5	8	14	20							SS-4	W	CP: TAN AND PURPLE, MED. DENSE TO DENSE, CLAYEY SAND (A-2-6)
215	13.5	7	8	9							SS-5	W	CP: GRAY AND PURPLE, V. STIFF, SANDY CLAY (A-6)
210	18.5	17	19	25							SS-6	W	CP: PURPLE, GRAY AND TAN, DENSE TO V. DENSE, SAND (A-3)
205	23.5	28	24	17							SS-7	W	
200	28.5	60/4									SS-8	W	
195	33.5	18	23	15							SS-9	W	CP: TAN, HARD, SANDY CLAY (A-6)
190	38.5	5	6	9							SS-10	W	CP: TAN AND GRAY, MED. DENSE, SILTY SAND (A-2-4)
185	43.5	2	1	2							SS-11	W	CP: DARK GRAY, V. LOOSE, CLAYEY SAND (A-2-6)
180	48.5	8	9	15							SS-12	W	CP: DARK GRAY, MED. DENSE, SILTY SAND (A-2-4)
													BORING TERMINATED AT 50.0' BELOW EXISTING GROUND

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SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.	COUNTY CUMBERLAND	GEOLOGIST P. ZHANG											
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS					GROUND WATER (ft)										
BORING NO. B-4	BORING LOCATION 36+60	OFFSET 69' LT	ALIGNMENT -L-	0 HR.	0.9										
COLLAR ELEV. 226.5 ft	NORTHING 480,083.8	EASTING 2,012,348.5	24 HR.		BACKFILL										
TOTAL DEPTH 15.0 ft	DRILL MACHINE CME 45B	DRILL METHOD MUD ROTARY	HAMMER TYPE MANUAL												
DATE STARTED 8-28-07	COMPLETED 8-28-07	SURFACE WATER DEPTH N/A													
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION			
		0.5ft	0.5ft	0.5ft	0	20	40	60	80	100					
226.5					EXISTING GROUND										
	1.0	15	17	19									226.5	0.0	ROOTMAT
	3.5	13	14	14									226.3	0.2	FILL: TAN, GRAY AND BROWN, HARD, SANDY CLAY (A-6) WITH ORGANICS
	6.0	8	9	12									223.5	3.0	CP: TAN AND GRAY, V. STIFF, SANDY CLAY (A-6)
	8.5	7	8	7											
	13.5	8	7	12									214.5	12.0	CP: TAN AND GRAY, MED. DENSE, CLAYEY SAND (A-2-6)
													211.5	15.0	BORING TERMINATED AT 15.0' BELOW EXISTING GROUND

NCDOT_BORE_07-018 RETAINING WALLS.GPJ NCDOT.GDT 9/27/07



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 BORING LOG

SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.	COUNTY CUMBERLAND		GEOLOGIST P. ZHANG												
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS					GROUND WATER (ft)												
BORING NO. B-5		BORING LOCATION 38+08		OFFSET 78' LT	ALIGNMENT -L-	0 HR. 3.2											
COLLAR ELEV. 226 ft		NORTHING 480,055.6		EASTING 2,012,493.5		24 HR. BACKFILL											
TOTAL DEPTH 25.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL											
DATE STARTED 8-28-07		COMPLETED 8-28-07		SURFACE WATER DEPTH N/A													
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION					
		0.5ft	0.5ft	0.5ft	0	20	40	60	80	100							
226.0		EXISTING GROUND											226.0	0.0			
225	1.0	14	19	25						SS-1	D	ROOTMAT	0.2				
	3.5	3	3	6						SS-2	W	FILL: DARK GRAY, TAN AND RED, HARD, SANDY CLAY (A-6)	3.0				
220	6.0	5	7	9						SS-3	W	CP: TAN AND GRAY, LOOSE TO MED. DENSE, CLAYEY SAND (A-2-6)					
	8.5	8	5	6						SS-4	W						
215	13.5	5	12	14						SS-5	W	CP: TAN AND GRAY, MED. DENSE, SILTY SAND (A-2-4)	12.0				
210	18.5	8	12	5						SS-6	W	CP: PURPLE, TAN AND GRAY, MED. DENSE TO DENSE, CLAYEY SAND (A-2-6)	17.0				
205	23.5	11	23	15						SS-7	W						
															201.0	25.0	BORING TERMINATED AT 25.0' BELOW EXISTING GROUND

NCDOT_BORE_07-018 RETAINING WALLS.GPJ NCDOT.GDT 9/27/07



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N.C.D.O.T. GEOTECHNICAL UNIT
 BORING LOG

SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.		COUNTY CUMBERLAND		GEOLOGIST P. ZHANG							
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS						GROUND WATER (ft)							
BORING NO. B-7		BORING LOCATION 16+32		OFFSET 76' RT		ALIGNMENT -RPC-							
COLLAR ELEV. 227 ft		NORTHING 480,107.8		EASTING 2,012,742.8		0 HR. 2.9							
TOTAL DEPTH 15.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		24 HR. CAVE @ 6							
DATE STARTED 8-27-07		COMPLETED 8-27-07		SURFACE WATER DEPTH N/A									
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION	
		0.5ft	0.5ft	0.5ft	0	20	40	60	80				100
227.0													EXISTING GROUND
	1.0	8	13	13									226.8 ROOTMAT FILL: BROWN AND DARK GRAY, MED. DENSE, SILTY SAND (A-2-4)
225	3.5	8	9	13									224.0 CP: GRAY AND TAN, MED. DENSE, CLAYEY SAND (A-2-6)
	6.0	5	5	5									222.0 CP: TAN, GRAY AND REDDISH BROWN, STIFF, SANDY CLAY (A-6)
220	8.5	4	3	7									219.0 CP: GRAY AND TAN, LOOSE TO MED. DENSE, CLAYEY SAND (A-2-6)
	13.5	6	7	11									212.0 BORING TERMINATED AT 15.0' BELOW EXISTING GROUND

NCDOT_BORE 07-018 RETAINING WALLS.GPJ NCDOT.GDT 9/19/07



2736 ROWLAND ROAD
 RALEIGH, NORTH CAROLINA 27615
 Phone (919) 871-0800 Fax (919) 871-0803

N.C.D.O.T. GEOTECHNICAL UNIT
 BORING LOG

SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.		COUNTY CUMBERLAND		GEOLOGIST P. ZHANG							
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS							GROUND WATER (ft)						
BORING NO. B-8		BORING LOCATION 14+45		OFFSET 64' RT		ALIGNMENT -RPC-							
COLLAR ELEV. 225.5 ft		NORTHING 480,284.3		EASTING 2,012,806.6		0 HR. 2.2							
TOTAL DEPTH 15.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL							
DATE STARTED 8-27-07		COMPLETED 8-27-07		SURFACE WATER DEPTH N/A									
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION	
		0.5ft	0.5ft	0.5ft	0	20	40	60	80				100
225.5													EXISTING GROUND
225	1.0	8	12	10									225.5 0.0
													225.3 0.2
													ROOTMAT
													FILL: TAN AND REDDISH BROWN, MED. DENSE, SILTY SAND (A-2-4) WITH CLAY SEAMS AND ORGANICS
	3.5	10	10	10									222.5 3.0
													CP: TAN AND GRAY, MED. DENSE, CLAYEY SAND (A-2-6)
220	6.0	7	6	7									220.5 5.0
													CP: TAN AND REDDISH BROWN, MED. DENSE, SILTY SAND (A-2-4)
	8.5	3	3	3									217.5 8.0
													CP: TAN AND GRAY, MED. STIFF, SANDY CLAY (A-6)
215													213.5 12.0
													CP: TAN, MED. DENSE, CLAYEY SAND (A-2-6)
	13.5	4	7	15									210.5 15.0
													BORING TERMINATED AT 15.0' BELOW EXISTING GROUND

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 BORING LOG

SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.		COUNTY CUMBERLAND		GEOLOGIST P. ZHANG									
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS							GROUND WATER (ft)								
BORING NO. B-10		BORING LOCATION 51+57		OFFSET 92' RT		ALIGNMENT -L-									
0 HR.		4.7		24 HR.		12.7									
COLLAR ELEV. 223 ft		NORTHING 479,554.3		EASTING 2,013,758.0											
TOTAL DEPTH 30.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL									
DATE STARTED 8-22-07		COMPLETED 8-22-07		SURFACE WATER DEPTH N/A											
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	L O G	SOIL AND ROCK DESCRIPTION			
		0.5ft	0.5ft	0.5ft	0	20	40	60	80				100		
223.0													EXISTING GROUND		
	1.0	9	16	12									223.0	0.0	ROOTMAT
													222.8	0.2	FILL: DARK BROWN, V. STIFF, SANDY CLAY (A-6)
	3.5	4	6	9									220.0	3.0	CP: TAN, GRAY AND RED, STIFF TO V. STIFF, SANDY CLAY (A-6)
	6.0														
	8.5	8	11	12											
	13.5	5	4	5									211.0	12.0	CP: TAN, GRAY AND PURPLE, LOOSE, CLAYEY SAND (A-2-6)
	18.5	12	25	23									206.0	17.0	CP: TAN AND GRAY, DENSE, SILTY SAND (A-2-4)
	23.5	5	6	5									201.0	22.0	CP: PURPLE, TAN AND GRAY, MED. DENSE, CLAYEY SAND (A-2-6)
	28.5	9	9	16									193.0	30.0	BORING TERMINATED AT 30.0' BELOW EXISTING GROUND

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SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.		COUNTY CUMBERLAND		GEOLOGIST P. ZHANG									
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS							GROUND WATER (ft)								
BORING NO. B-11		BORING LOCATION 53+05		OFFSET 78' RT		ALIGNMENT -L-									
0 HR.		2.4		24 HR.		11.9									
COLLAR ELEV. 223.5 ft		NORTHING 479,530.5		EASTING 2,013,904.7											
TOTAL DEPTH 20.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL									
DATE STARTED 8-22-07		COMPLETED 8-22-07		SURFACE WATER DEPTH N/A											
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	L O G	SOIL AND ROCK DESCRIPTION			
		0.5ft	0.5ft	0.5ft	0	20	40	60	80				100		
223.5													EXISTING GROUND		
	1.0	9	31	33									223.5	0.0	ROOTMAT
	3.5	3	3	3						SS-1	⊕		223.3	0.2	FILL: DARK BROWN, TAN AND RED, HARD, SANDY CLAY (A-6)
220	6.0	3	4	6						SS-2	M		220.5	3.0	FILL: DARK GRAY, LOOSE, SILTY SAND (A-2-4)
	8.5	4	4	5						SS-3	M		217.5	6.0	CP: TAN AND GRAY, LOOSE, SILTY SAND (A-2-4)
215	13.5	3	3	4						SS-4	W		215.5	8.0	CP: GRAY, TAN AND PURPLE, STIFF TO MED. STIFF, SANDY CLAY (A-6)
210	18.5	6	15	18						SS-5	W		206.5	17.0	CP: TAN AND PINK, DENSE, SILTY SAND (A-2-4)
205										SS-6	W		203.5	20.0	BORING TERMINATED AT 20.0' BELOW EXISTING GROUND

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SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.	COUNTY CUMBERLAND		GEOLOGIST P. ZHANG											
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS						GROUND WATER (ft)										
BORING NO. B-12		BORING LOCATION 54+52		OFFSET 63' RT	ALIGNMENT -L-	0 HR. 1.9										
COLLAR ELEV. 226.5 ft		NORTHING 479,508.9		EASTING 2,014,050.3		24 HR. CAVE @ 12.9										
TOTAL DEPTH 15.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL										
DATE STARTED 8-22-07		COMPLETED 8-22-07		SURFACE WATER DEPTH N/A												
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION				
		0.5ft	0.5ft	0.5ft	0	20	40	60	80	100						
226.5		EXISTING GROUND											226.5	0.0		
	1.0	14	28	31										226.3	0.2	ROOTMAT
225	3.5	3	4	4							SS-1	W		223.5	3.0	FILL: TAN AND BROWN, V. DENSE, SILTY SAND (A-2-4)
	6.0	8	10	14							SS-2	W		220.5	6.0	FILL: TAN, MED. STIFF, SANDY CLAY (A-6)
220	8.5	6	8	9							SS-3	W				CP: RED, TAN AND GRAY, V. STIFF TO STIFF, SANDY CLAY (A-6)
	13.5	6	5	7							SS-4	W				
215											SS-5	W		211.5	15.0	BORING TERMINATED AT 15.0' BELOW EXISTING GROUND

NCDOT_BORE_07-018_RETAINING_WALLS.GPJ NCDOT.GDT 9/9/07



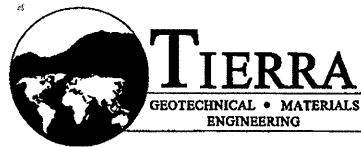
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SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.	COUNTY CUMBERLAND	GEOLOGIST P. ZHANG											
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS					GROUND WATER (ft)										
BORING NO. B-13	BORING LOCATION 50+00	OFFSET 96' LT	ALIGNMENT -L-	0 HR.	4.6										
COLLAR ELEV. 226.5 ft	NORTHING 479,743.8	EASTING 2,013,735.5		24 HR.	13.6										
TOTAL DEPTH 35.0 ft	DRILL MACHINE CME 45B	DRILL METHOD MUD ROTARY	HAMMER TYPE MANUAL												
DATE STARTED 8-27-07	COMPLETED 8-27-07	SURFACE WATER DEPTH N/A													
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION			
		0.5ft	0.5ft	0.5ft	0	20	40	60	80	100					
226.5													EXISTING GROUND		
	1.0												226.5	0.0	
225		11	14	8							SS-1	D	226.3	0.2	ROOTMAT FILL: TAN AND BROWN, MED. DENSE, SILTY SAND (A-2-4)
	3.5	6	9	14							SS-2	W	223.5	3.0	CP: TAN, GRAY AND REDDISH BROWN, V. STIFF, SANDY CLAY (A-7-6)
220		7	8	11							SS-3	W	218.5	8.0	CP: TAN AND GRAY, MED. DENSE TO LOOSE, CLAYEY SAND (A-2-6)
	8.5	5	8	7							SS-4	W			
215															
	13.5	3	3	4							SS-5	W			
210															
	18.5	12	8	7							SS-6	W	209.5	17.0	CP: TAN, GRAY AND PINK, MED. DENSE TO V. DENSE, SILTY SAND (A-2-4)
205															
	23.5	5	8	23							SS-7	W			
200															
	28.5	16	41	20							SS-8	W			
195															
	33.5	4	3	3							SS-9	W	194.5	32.0	CP: TAN AND PURPLE, LOOSE, CLAYEY SAND (A-2-6)
													191.5	35.0	BORING TERMINATED AT 35.0' BELOW EXISTING GROUND

NCDOT_BORE_07-018_RETAINING_WALLS.GPJ NCDOT.GDT 9/9/07



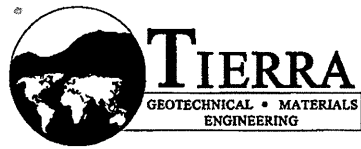
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SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.		COUNTY CUMBERLAND		GEOLOGIST P. ZHANG									
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS							GROUND WATER (ft)								
BORING NO. B-14		BORING LOCATION 52+04		OFFSET 79' LT		ALIGNMENT -L-									
COLLAR ELEV. 224 ft		NORTHING 479,707.7		EASTING 2,013,846.3		0 HR.	3.3								
TOTAL DEPTH 25.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL									
DATE STARTED 8-27-07		COMPLETED 8-27-07		SURFACE WATER DEPTH N/A											
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION		
		0.5ft	0.5ft	0.5ft	0	20	40	60	80					100	
224.0					EXISTING GROUND										
	1.0	5	9	4									224.0	0.0	
	3.5												223.8	0.2	ROOTMAT
	6.0												221.0	3.0	FILL: TAN AND BROWN, MED. DENSE, SILTY SAND (A-2-4)
	8.5														CP: RED, TAN AND GRAY, V. STIFF TO STIFF, SANDY CLAY (A-6)
	13.5														
	18.5														
	23.5														
													207.0	17.0	CP: TAN, GRAY AND PINK, MED. DENSE, SILTY SAND (A-2-4)
													202.0	22.0	CP: TAN, GRAY AND PINK, STIFF, SANDY CLAY (A-7)
													199.0	25.0	BORING TERMINATED AT 25.0' BELOW EXISTING GROUND

NCDOT_BORE_07-018_RETAINING_WALLS.GPJ NCDOT.GDT 9/9/07



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SHEET 1 OF 1

PROJECT NO. 6211-07-018		ID.		COUNTY CUMBERLAND		GEOLOGIST P. ZHANG									
SITE DESCRIPTION MORGANTON ROAD RETAINING WALLS							GROUND WATER (ft)								
BORING NO. B-15		BORING LOCATION 54+03		OFFSET 68' LT		ALIGNMENT -L-									
COLLAR ELEV. 223 ft		NORTHING 479,647.5		EASTING 2,014,036.1		0 HR. 1.2									
TOTAL DEPTH 15.0 ft		DRILL MACHINE CME 45B		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL									
DATE STARTED 8-27-07		COMPLETED 8-27-07		SURFACE WATER DEPTH N/A											
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION			
		0.5ft	0.5ft	0.5ft	0	20	40	60	80				100		
223.0					EXISTING GROUND										
	1.0	3	1	4									223.0	0.0	
	3.5	4	6	5									222.8	0.2	ROOTMAT
	6.0	5	5	8									220.0	3.0	FILL: DARK BROWN, LOOSE, CLAYEY SILTY SAND (A-2-4)
	8.5	4	5	4											CP: TAN, GRAY AND RED, STIFF, SANDY CLAY (A-6)
	13.5	3	5	4									211.0	12.0	CP: TAN AND GRAY, LOOSE, CLAYEY SAND (A-2-6)
													208.0	15.0	

NCDOT_BORE 07-018 RETAINING WALLS.GPJ NCDOT.GDT 9/9/07

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
 DIVISION OF HIGHWAYS
 GEOTECHNICAL ENGINEERING UNIT
 SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS

SOIL DESCRIPTION										GRADATION									
SOIL IS CONSIDERED TO BE THE UNCONSOLIDATED, SEMI-CONSOLIDATED, OR WEATHERED EARTH MATERIALS THAT CAN BE PENETRATED WITH A CONTINUOUS FLIGHT POWER AUGER, AND YIELD LESS THAN 100 BLOWS PER FOOT ACCORDING TO STANDARD PENETRATION TEST (AASHTO T295, ASTM D-1586). SOIL CLASSIFICATION IS BASED ON THE AASHTO SYSTEM. BASIC DESCRIPTIONS GENERALLY SHALL INCLUDE: CONSISTENCY, COLOR, TEXTURE, MOISTURE, AASHTO CLASSIFICATION, AND OTHER PERTINENT FACTORS SUCH AS MINERALOGICAL COMPOSITION, ANGULARITY, STRUCTURE, PLASTICITY, ETC. EXAMPLE: <i>VERY STIFF, GRAY, SILTY CLAY, MOST WITH INTERBEDDED FINE SAND LAYERS, HIGHLY PLASTIC, A-7-6</i>										WELL GRADED - INDICATES A GOOD REPRESENTATION OF PARTICLE SIZES FROM FINE TO COARSE. UNIFORM - INDICATES THAT SOIL PARTICLES ARE ALL APPROXIMATELY THE SAME SIZE. (ALSO POORLY GRADED) GAP-GRADED - INDICATES A MIXTURE OF UNIFORM PARTICLES OF TWO OR MORE SIZES.									
SOIL LEGEND AND AASHTO CLASSIFICATION										MINERALOGICAL COMPOSITION									
GENERAL CLASS. GRANULAR MATERIALS (<= 35% PASSING #200) SILT-CLAY MATERIALS (> 35% PASSING #200) ORGANIC MATERIALS										MINERAL NAMES SUCH AS QUARTZ, FELDSPAR, MICA, TALC, KAOLIN, ETC. ARE USED IN DESCRIPTIONS WHENEVER THEY ARE CONSIDERED OF SIGNIFICANCE.									
GROUP CL. ASS. A-1, A-1-b, A-2, A-2-4, A-2-5, A-2-6, A-2-7, A-4, A-5, A-6, A-7, A-7-5, A-7-6, A-3, A-4, A-5, A-6, A-7										COMPRESSIONIBILITY									
SYMBOL										SLIGHTLY COMPRESSIBLE LIQUID LIMIT LESS THAN 31 MODERATELY COMPRESSIBLE LIQUID LIMIT EQUAL TO 31-50 HIGHLY COMPRESSIBLE LIQUID LIMIT GREATER THAN 50									
% PASSING # 10, # 40, # 200										PERCENTAGE OF MATERIAL									
LIQUID LIMIT, PLASTIC INDEX, GROUP INDEX										ORGANIC MATERIAL, SILT-CLAY SOILS, OTHER MATERIAL									
USUAL TYPES OF MAJOR MATERIALS										GROUND WATER									
GEN. RATING AS A SUBGRADE										MISCELLANEOUS SYMBOLS									
CONSISTENCY OR DENSENESS										ABBREVIATIONS									
TEXTURE OR GRAIN SIZE										EQUIPMENT USED ON SUBJECT PROJECT									
SOIL MOISTURE - CORRELATION OF TERMS										PLASTICITY									
COLOR										DESCRIPTIONS MAY INCLUDE COLOR OR COLOR COMBINATIONS (TAN, RED, YELLOW-BROWN, BLUE-GRAY). MODIFIERS SUCH AS LIGHT, DARK, STREAKED, ETC. ARE USED TO DESCRIBE APPEARANCE.									

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
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 SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS

ROCK DESCRIPTION		TERMS AND DEFINITIONS	
<p>HARD ROCK IS NON-COASTAL PLAIN MATERIAL THAT IF TESTED, WOULD YIELD SPT REFUSAL, AN INFERRED ROCK LINE INDICATES THE LEVEL AT WHICH NON-COASTAL PLAIN MATERIAL WOULD YIELD SPT REFUSAL. SPT REFUSAL IS PENETRATION BY A SPLIT SPOON SAMPLER EQUAL TO OR LESS THAN 60 BLOWS. IN NON-COASTAL PLAIN MATERIAL, THE TRANSITION BETWEEN SOIL AND ROCK IS OFTEN REPRESENTED BY A ZONE OF WEATHERED ROCK. ROCK MATERIALS ARE TYPICALLY DIVIDED AS FOLLOWS:</p>		<p>ALLUVIUM (ALLUV.) - SOILS THAT HAVE BEEN TRANSPORTED BY WATER. AQUIFER - A WATER BEARING FORMATION OR STRATA. ARENACEOUS - APPLIED TO ROCKS THAT HAVE BEEN DERIVED FROM SAND OR THAT CONTAIN SAND. ARGILLACEOUS - APPLIED TO ALL ROCKS OR SUBSTANCES COMPOSED OF CLAY MINERALS, OR HAVING A NOTABLE PROPORTION OF CLAY IN THEIR COMPOSITION, AS SHALE, SLATE, ETC. ARTESIAN - GROUND WATER THAT IS UNDER SUFFICIENT PRESSURE TO RISE ABOVE THE LEVEL AT WHICH IT IS ENCOUNTERED, BUT WHICH DOES NOT NECESSARILY RISE TO OR ABOVE THE GROUND SURFACE. CALCAREOUS (CALC.) - SOILS THAT CONTAIN APPRECIABLE AMOUNTS OF CALCIUM CARBONATE. COLLUVIUM - ROCK FRAGMENTS MIXED WITH SOIL DEPOSITED BY GRAVITY ON SLOPE OR AT BOTTOM OF SLOPE. CORE RECOVERY (REC.) - TOTAL LENGTH OF ALL MATERIAL RECOVERED IN THE CORE BARREL DIVIDED BY TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE. DIKE - A TABULAR BODY OF IGNEOUS ROCK THAT CUTS ACROSS THE STRUCTURE OF ADJACENT ROCKS OR CUTS MASSIVE ROCK. DIP - THE ANGLE AT WHICH A STRATUM OR ANY PLANAR FEATURE IS INCLINED FROM THE HORIZONTAL. DIP DIRECTION (DIP AZIMUTH) - THE DIRECTION OR BEARING OF THE HORIZONTAL TRACE OF THE LINE OF DIP, MEASURED CLOCKWISE FROM NORTH. FAULT - A FRACTURE OR FRACTURE ZONE ALONG WHICH THERE HAS BEEN DISPLACEMENT OF THE SIDES RELATIVE TO ONE ANOTHER PARALLEL TO THE FRACTURE. FISSILE - A PROPERTY OF SPLITTING ALONG CLOSELY SPACED PARALLEL PLANES. FLOAT - ROCK FRAGMENTS ON SURFACE NEAR THEIR ORIGINAL POSITION AND DISLOGGED FROM PARENT MATERIAL. FLOOD PLAIN (FP) - LAND BORDERING A STREAM, BUILT OF SEDIMENTS DEPOSITED BY THE STREAM. FORMATION (FM) - A MAPPABLE GEOLOGIC UNIT THAT CAN BE RECOGNIZED AND TRACED IN THE FIELD. JOINT - FRACTURE IN ROCK ALONG WHICH NO APPRECIABLE MOVEMENT HAS OCCURRED. LEDGE - A SHELF-LIKE RIDGE OR PROJECTION OF ROCK WHOSE THICKNESS IS SMALL COMPARED TO ITS LATERAL EXTENT. LENS - A BODY OF SOIL OR ROCK THAT THINS OUT IN ONE OR MORE DIRECTIONS. MOTTLED (MOT.) - IRREGULARLY MARKED WITH SPOTS OF DIFFERENT COLORS. MOTTLING IN SOILS USUALLY INDICATES POOR AERATION AND LACK OF GOOD DRAINAGE. PERCHED WATER - WATER MAINTAINED ABOVE THE NORMAL GROUND WATER LEVEL BY THE PRESENCE OF AN INTERVENING IMPERVIOUS STRATUM. RESIDUAL (RES.) SOIL - SOIL FORMED IN PLACE BY THE WEATHERING OF ROCK. ROCK QUALITY DESIGNATION (RQD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE. SAPROLITE (SAP) - RESIDUAL SOIL THAT RETAINS THE RELIC STRUCTURE OR FABRIC OF THE PARENT ROCK. SILL - AN INTRUSIVE BODY OF IGNEOUS ROCK OF APPROXIMATELY UNIFORM THICKNESS AND RELATIVELY THIN COMPARED WITH ITS LATERAL EXTENT, THAT HAS BEEN EMPLACED PARALLEL TO THE BEDDING OR SCHISTOSITY OF THE INTRUDED ROCKS. SLICKENSIDE - POLISHED AND STRIATED SURFACE THAT RESULTS FROM FRICTION ALONG A FAULT OR SLIP PLANE. STANDARD PENETRATION TEST (PENETRATION RESISTANCE) (SPT) - NUMBER OF BLOWS (N OR BPF) OF A 140 LB. HAMMER FALLING 30 INCHES REQUIRED TO PRODUCE A PENETRATION OF 1 FOOT INTO SOIL WITH A 2 INCH OUTSIDE DIAMETER SPLIT SPOON SAMPLER. SPT REFUSAL IS PENETRATION EQUAL TO OR LESS THAN 60 BLOWS. STRATA CORE RECOVERY (SREC) - TOTAL LENGTH OF STRATA MATERIAL RECOVERED DIVIDED BY TOTAL LENGTH OF STRATUM AND EXPRESSED AS A PERCENTAGE. STRATA ROCK QUALITY DESIGNATION (SROQ) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS WITHIN A STRATUM EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF STRATA AND EXPRESSED AS A PERCENTAGE. TOPSOIL (TS) - SURFACE SOILS USUALLY CONTAINING ORGANIC MATTER.</p>	
<p>WEATHERED ROCK (WR)</p> 	<p>NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT N VALUES > 100 BLOWS PER FOOT IF TESTED.</p>	<p>ARGILLACEOUS (ARG.) - APPLIED TO ALL ROCKS OR SUBSTANCES COMPOSED OF CLAY MINERALS, OR HAVING A NOTABLE PROPORTION OF CLAY IN THEIR COMPOSITION, AS SHALE, SLATE, ETC.</p>	<p>ARTESIAN - GROUND WATER THAT IS UNDER SUFFICIENT PRESSURE TO RISE ABOVE THE LEVEL AT WHICH IT IS ENCOUNTERED, BUT WHICH DOES NOT NECESSARILY RISE TO OR ABOVE THE GROUND SURFACE.</p>
<p>CRYSTALLINE ROCK (CR)</p> 	<p>FINE TO COARSE GRAIN IGNEOUS AND METAMORPHIC ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES GRANITE, GNEISS, GABBRO, SCHIST, ETC.</p>	<p>COLLUVIUM - ROCK FRAGMENTS MIXED WITH SOIL DEPOSITED BY GRAVITY ON SLOPE OR AT BOTTOM OF SLOPE.</p>	<p>CORE RECOVERY (REC.) - TOTAL LENGTH OF ALL MATERIAL RECOVERED IN THE CORE BARREL DIVIDED BY TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE.</p>
<p>NON-CRYSTALLINE ROCK (NCRI)</p> 	<p>FINE TO COARSE GRAIN METAMORPHIC AND NON-COASTAL PLAIN SEDIMENTARY ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES PHYLLITE, SLATE, SANDSTONE, ETC.</p>	<p>DIKE - A TABULAR BODY OF IGNEOUS ROCK THAT CUTS ACROSS THE STRUCTURE OF ADJACENT ROCKS OR CUTS MASSIVE ROCK.</p>	<p>DIP - THE ANGLE AT WHICH A STRATUM OR ANY PLANAR FEATURE IS INCLINED FROM THE HORIZONTAL.</p>
<p>COASTAL PLAIN SEDIMENTARY ROCK (CPI)</p> 	<p>COASTAL PLAIN SEDIMENTS CEMENTED INTO ROCK, BUT MAY NOT YIELD SPT REFUSAL. ROCK TYPE INCLUDES LIMESTONE, SANDSTONE, CEMENTED SHELL BEDS, ETC.</p>	<p>FAULT - A FRACTURE OR FRACTURE ZONE ALONG WHICH THERE HAS BEEN DISPLACEMENT OF THE SIDES RELATIVE TO ONE ANOTHER PARALLEL TO THE FRACTURE.</p>	<p>FISSILE - A PROPERTY OF SPLITTING ALONG CLOSELY SPACED PARALLEL PLANES.</p>
<p>WEATHERING</p>		<p>FLOOD PLAIN (FP) - LAND BORDERING A STREAM, BUILT OF SEDIMENTS DEPOSITED BY THE STREAM.</p>	
<p>FRESH</p>	<p>ROCK FRESH, CRYSTALS BRIGHT, FEW JOINTS MAY SHOW SLIGHT STAINING. ROCK RINGS UNDER HAMMER IF CRYSTALLINE.</p>	<p>FORMATION (FM) - A MAPPABLE GEOLOGIC UNIT THAT CAN BE RECOGNIZED AND TRACED IN THE FIELD.</p>	
<p>VERY SLIGHT (V SL.)</p>	<p>ROCK GENERALLY FRESH, JOINTS STAINED, SOME JOINTS MAY SHOW THIN CLAY COATINGS IF OPEN. CRYSTALS ON A BROKEN SPECIMEN FACE SHINE BRIGHTLY. ROCK RINGS UNDER HAMMER BLOWS IF OF A CRYSTALLINE NATURE.</p>	<p>JOINT - FRACTURE IN ROCK ALONG WHICH NO APPRECIABLE MOVEMENT HAS OCCURRED.</p>	
<p>SLIGHT (SL.)</p>	<p>ROCK GENERALLY FRESH, JOINTS STAINED AND DISCOLORATION EXTENDS INTO ROCK UP TO 1 INCH. OPEN JOINTS MAY CONTAIN CLAY. IN GRANITOID ROCKS SOME OCCASIONAL FELDSPAR CRYSTALS ARE DULL AND DISCOLORED. CRYSTALLINE ROCKS RING UNDER HAMMER BLOWS.</p>	<p>LEDGE - A SHELF-LIKE RIDGE OR PROJECTION OF ROCK WHOSE THICKNESS IS SMALL COMPARED TO ITS LATERAL EXTENT.</p>	
<p>MODERATE (MOD.)</p>	<p>SIGNIFICANT PORTIONS OF ROCK SHOW DISCOLORATION AND WEATHERING EFFECTS. IN GRANITOID ROCKS, MOST FELDSPARS ARE DULL AND DISCOLORED, SOME SHOW CLAY. ROCK HAS DULL SOUND UNDER HAMMER BLOWS AND SHOWS SIGNIFICANT LOSS OF STRENGTH AS COMPARED WITH FRESH ROCK.</p>	<p>LENS - A BODY OF SOIL OR ROCK THAT THINS OUT IN ONE OR MORE DIRECTIONS.</p>	
<p>MODERATELY SEVERE (MOD. SEV.)</p>	<p>ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. IN GRANITOID ROCKS, ALL FELDSPARS DULL AND DISCOLORED AND A MAJORITY SHOW KAOLINIZATION. ROCK SHOWS SEVERE LOSS OF STRENGTH AND CAN BE EXCAVATED WITH A GEOLOGIST'S PICK. ROCK GIVES "CLUNK" SOUND WHEN STRUCK. IF TESTED, WOULD YIELD SPT REFUSAL.</p>	<p>MOTTLED (MOT.) - IRREGULARLY MARKED WITH SPOTS OF DIFFERENT COLORS. MOTTLING IN SOILS USUALLY INDICATES POOR AERATION AND LACK OF GOOD DRAINAGE.</p>	
<p>SEVERE (SEV.)</p>	<p>ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC CLEAR AND EVIDENT BUT REDUCED IN STRENGTH TO STRONG SOIL. IN GRANITOID ROCKS ALL FELDSPARS ARE KAOLINIZED TO SOME EXTENT. SOME FRAGMENTS OF STRONG ROCK USUALLY REMAIN. IF TESTED, YIELDS SPT N VALUES > 100 BPF.</p>	<p>PERCHED WATER - WATER MAINTAINED ABOVE THE NORMAL GROUND WATER LEVEL BY THE PRESENCE OF AN INTERVENING IMPERVIOUS STRATUM.</p>	
<p>VERY SEVERE (V SEV.)</p>	<p>ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC ELEMENTS ARE DISCERNIBLE BUT THE MASS IS EFFECTIVELY REDUCED TO SOIL STATUS, WITH ONLY FRAGMENTS OF STRONG ROCK REMAINING. SAPROLITE IS AN EXAMPLE OF ROCK WEATHERED TO A DEGREE SUCH THAT ONLY MINOR VESTIGES OF THE ORIGINAL ROCK FABRIC REMAIN. IF TESTED, YIELDS SPT N VALUES < 100 BPF.</p>	<p>RESIDUAL (RES.) SOIL - SOIL FORMED IN PLACE BY THE WEATHERING OF ROCK.</p>	
<p>COMPLETE</p>	<p>ROCK REDUCED TO SOIL. ROCK FABRIC NOT DISCERNIBLE, OR DISCERNIBLE ONLY IN SMALL AND SCATTERED CONCENTRATIONS. QUARTZ MAY BE PRESENT AS DIKES OR STRINGERS. SAPROLITE IS ALSO AN EXAMPLE.</p>	<p>ROCK QUALITY DESIGNATION (RQD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE.</p>	
<p>ROCK HARDNESS</p>		<p>SAPROLITE (SAP) - RESIDUAL SOIL THAT RETAINS THE RELIC STRUCTURE OR FABRIC OF THE PARENT ROCK.</p>	
<p>VERY HARD</p>	<p>CANNOT BE SCRATCHED BY KNIFE OR SHARP PICK. BREAKING OF HAND SPECIMENS REQUIRES SEVERAL HARD BLOWS OF THE GEOLOGIST'S PICK.</p>	<p>SILL - AN INTRUSIVE BODY OF IGNEOUS ROCK OF APPROXIMATELY UNIFORM THICKNESS AND RELATIVELY THIN COMPARED WITH ITS LATERAL EXTENT, THAT HAS BEEN EMPLACED PARALLEL TO THE BEDDING OR SCHISTOSITY OF THE INTRUDED ROCKS.</p>	
<p>HARD</p>	<p>CAN BE SCRATCHED BY KNIFE OR PICK ONLY WITH DIFFICULTY. HARD HAMMER BLOWS REQUIRED TO DETACH HAND SPECIMEN.</p>	<p>SLICKENSIDE - POLISHED AND STRIATED SURFACE THAT RESULTS FROM FRICTION ALONG A FAULT OR SLIP PLANE.</p>	
<p>MODERATELY HARD</p>	<p>CAN BE SCRATCHED BY KNIFE OR PICK. GOUGES OR GROOVES TO 0.25 INCHES DEEP CAN BE EXCAVATED BY HARD BLOW OF A GEOLOGIST'S PICK. HAND SPECIMENS CAN BE DETACHED BY MODERATE BLOWS.</p>	<p>STANDARD PENETRATION TEST (PENETRATION RESISTANCE) (SPT) - NUMBER OF BLOWS (N OR BPF) OF A 140 LB. HAMMER FALLING 30 INCHES REQUIRED TO PRODUCE A PENETRATION OF 1 FOOT INTO SOIL WITH A 2 INCH OUTSIDE DIAMETER SPLIT SPOON SAMPLER. SPT REFUSAL IS PENETRATION EQUAL TO OR LESS THAN 60 BLOWS.</p>	
<p>MEDIUM HARD</p>	<p>CAN BE GROOVED OR GOUGED 0.05 INCHES DEEP BY FIRM PRESSURE OF KNIFE OR PICK POINT. CAN BE EXCAVATED IN SMALL CHIPS TO PIECES 1 INCH MAXIMUM SIZE BY HARD BLOWS OF THE POINT OF A GEOLOGIST'S PICK.</p>	<p>STRATA CORE RECOVERY (SREC) - TOTAL LENGTH OF STRATA MATERIAL RECOVERED DIVIDED BY TOTAL LENGTH OF STRATUM AND EXPRESSED AS A PERCENTAGE.</p>	
<p>SOFT</p>	<p>CAN BE GROOVED OR GOUGED READILY BY KNIFE OR PICK. CAN BE EXCAVATED IN FRAGMENTS FROM CHIPS TO SEVERAL INCHES IN SIZE BY MODERATE BLOWS OF A PICK POINT. SMALL, THIN PIECES CAN BE BROKEN BY FINGER PRESSURE.</p>	<p>STRATA ROCK QUALITY DESIGNATION (SROQ) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS WITHIN A STRATUM EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF STRATA AND EXPRESSED AS A PERCENTAGE.</p>	
<p>VERY SOFT</p>	<p>CAN BE CARVED WITH KNIFE. CAN BE EXCAVATED READILY WITH POINT OF PICK. PIECES 1 INCH OR MORE IN THICKNESS CAN BE BROKEN BY FINGER PRESSURE. CAN BE SCRATCHED READILY BY FINGER NAIL.</p>	<p>TOPSOIL (TS) - SURFACE SOILS USUALLY CONTAINING ORGANIC MATTER.</p>	
<p>FRACTURE SPACING</p>		<p>BEDDING</p>	
<p>TERM</p>	<p>SPACING</p>	<p>TERM</p>	<p>THICKNESS</p>
<p>VERY WIDE</p>	<p>MORE THAN 10 FEET</p>	<p>VERY THICKLY BEDDED</p>	<p>> 4 FEET</p>
<p>WIDE</p>	<p>3 TO 10 FEET</p>	<p>THICKLY BEDDED</p>	<p>1.5 - 4 FEET</p>
<p>MODERATELY CLOSE</p>	<p>1 TO 3 FEET</p>	<p>THINLY BEDDED</p>	<p>0.16 - 1.5 FEET</p>
<p>CLOSE</p>	<p>0.16 TO 1 FEET</p>	<p>VERY THINLY BEDDED</p>	<p>0.03 - 0.16 FEET</p>
<p>VERY CLOSE</p>	<p>LESS THAN 0.16 FEET</p>	<p>THICKLY LAMINATED</p>	<p>0.008 - 0.03 FEET</p>
		<p>THINLY LAMINATED</p>	<p>< 0.008 FEET</p>
<p>INDURATION</p>			
<p>FOR SEDIMENTARY ROCKS, INDURATION IS THE HARDENING OF THE MATERIAL BY CEMENTING, HEAT, PRESSURE, ETC.</p>			
<p>FRIABLE</p>	<p>RUBBING WITH FINGER FREES NUMEROUS GRAINS; GENTLE BLOW BY HAMMER DISINTEGRATES SAMPLE.</p>		
<p>MODERATELY INDURATED</p>	<p>GRAINS CAN BE SEPARATED FROM SAMPLE WITH STEEL PROBE; BREAKS EASILY WHEN HIT WITH HAMMER.</p>		
<p>INDURATED</p>	<p>GRAINS ARE DIFFICULT TO SEPARATE WITH STEEL PROBE; DIFFICULT TO BREAK WITH HAMMER.</p>		
<p>EXTREMELY INDURATED</p>	<p>SHARP HAMMER BLOWS REQUIRED TO BREAK SAMPLE; SAMPLE BREAKS ACROSS GRAINS.</p>		
<p>BENCH MARK:</p>		<p>ELEVATION: FT.</p>	
<p>NOTES:</p>			
<p>GROUND SURFACE ELEVATIONS FOR THE TEST BORINGS ARE ESTIMATED FROM SITE TOPOGRAPHIC MAPS PREPARED BY OTHERS.</p>			

TIERRA

2736 ROWLAND ROAD RALEIGH NC 27615

RETAINING WALLS ALONG MORGANTON ROAD

CUMBERLAND COUNTY, NORTH CAROLINA

TIERRA PROJECT NO. 6211-07-018

TABLE 1: SUMMARY OF CLASSIFICATION TEST RESULTS

BORING #		SAMPLE #	NATURAL MOISTURE CONTENT	TOTAL SAMPLE			ATTERBERG LIMIT		
AASHTO Classification				PERCENT PASSING			LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX
STATION #	OFFSET (FEET)	DEPTH (FEET)	#10	#40	#200				
B-1		SS-1	9.8%	100	87	54	28	13	15
A-6									
36+37 -L-	76' RT	1.0-2.5							
B-3		SS-7	N/A	100	76	7	NP	NP	NP
A-3									
39+40 -L-	93' RT	23.5-25.0							
B-5		SS-4	N/A	100	80	35	37	17	20
A-2-6									
38+08 -L-	78' LT	8.5-10.0							
B-6		SS-4	24.2%	100	97	67	37	21	16
A-6									
39+45 -L-	96' LT	8.5-10.0							
B-6		SS-9	53.0%	100	99	94	92	21	71
A-7-6									
39+45 -L-	96' LT	33.5-35.0							
B-9		SS-3	22.6%	99	82	48	43	18	25
A-7-6									
49+54 -L-	80' RT	6.0-7.5							
B-13		SS-3	23.6%	98	81	51	47	25	22
A-7-6									
50+00 -L-	96' LT	6.0-7.5							

Developed by Dr. Pu Zhang, Tierra, Inc.

Soldier Pile Lagging Wall (per AASHTO 5.6)

Project ID: Morganton Road RW# 3 Station 50+60 ~ 53+50

Input Wall Dimensions

Wall Height H= 10 ft
 Soldier Pile Spacing L= 8 ft
 Effective Pile Width b= 2 ft
 Soil Arching Factor N= 3 * AASHTO N=3, Caltrans N=0.08*Φ for granular, N=1~2 for cohesive.
 Embedment Depth D= 21.7219583 ft
 Backfill angle Beta= 26.6 degree
 Consider Soil Disturbance @ Excavation yes

Retaining Soil Parameters

Cohesion c= 0 lb/ft²
 Friction angle Φ= 30 deg
 Unit weight Gamma= 120 lb/ft³

Base Soil Parameters

Cohesion c= 0 lb/ft²
 Friction angle Phi= 30 deg
 Unit weight Gamma= 120 lb/ft³

Surcharge

Uniform surcharge q= lb/ft²

Run Solver under Tools menu

0.00 = 0 Moments about F.
 -102438.04 = 0 Zero Shear Plan.

Steel Yield Strength Fy= 50 ksi
 Allowable Bending Stress Fb= 30 ksi
 Section Modulus S= 0.00 in³
 = 0.6Fy

Required Embedment Depth Dj= 21.7 ft
 Design Embedment Depth D= 30 = 1.4D_o

Gamma water= 62.4 lb/ft³
 Total H= 10.00 ft

Active Earth Pressure

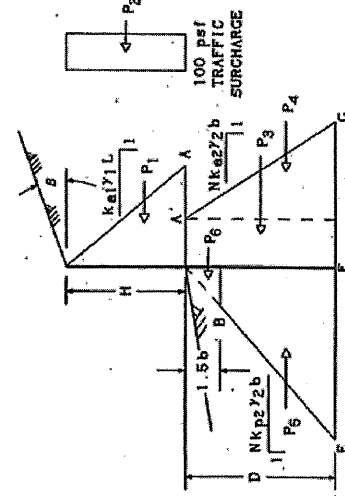
Ka1= 0.538
 PA= 5162.95
 P1h= 23082.36
 P1v= 11558.79
 Surcharge P2= 0.00
 Ka2= 0.538
 PA'= 3872.21 ** Assume Groundwater is at the bottom of excavation.
 PG= 4037.38
 P3h= 75209.11
 P3v= 37661.92
 P4h= 39208.54
 P4v= 19634.18

Passive Earth Pressure

Kp2= 3.00
 PB= 3110.4
 PE= 22521.33
 P6= 4665.60
 P5= 244603.66

Moments about F:

Active Source	Force	Arm	Moment
P1	23082.36	25.06	578335.30
P2	0.00	26.72	0.00
P3	75209.11	10.86	816844.63
P4	39208.54	7.24	283895.44
P6	4665.60	19.72	92014.77
Sum	142165.62		1771090.14
Resistance Source			
P5	244603.66	7.24	1771090.14



LPILE+ 4.0 INPUT SHEET:

UNIT : 2

Designer: PZ Checker: GL

Project Title		
Proj. #:	6211-07-018	Station: RW3 51+00
County:	Cumberland	

File Properties		
Total Pile Length	444.0	(in)
Increments (recommend 50 to 100)	100	
Distance from Top of Pile to Ground	120.0	(in)
Combined Ground Slope & Batter Angles	0	(degrees)

Pile Sections					
Section #	Depth (in)	Diameter (in)	Mom. of Inertia (in4)	Area (in2)	Modulus (psi)
1	0	14	729	21.46	30000000
2	120.0	14	729	21.46	30000000
3	120.0	24	16286	452	38000000
4 (Tip)	444	24	16286	452	38000000

Distributed Lateral Load Intensity		
Point No.	Depth (in)	Distr. Load lbs/in
1	0	0
2	108	346

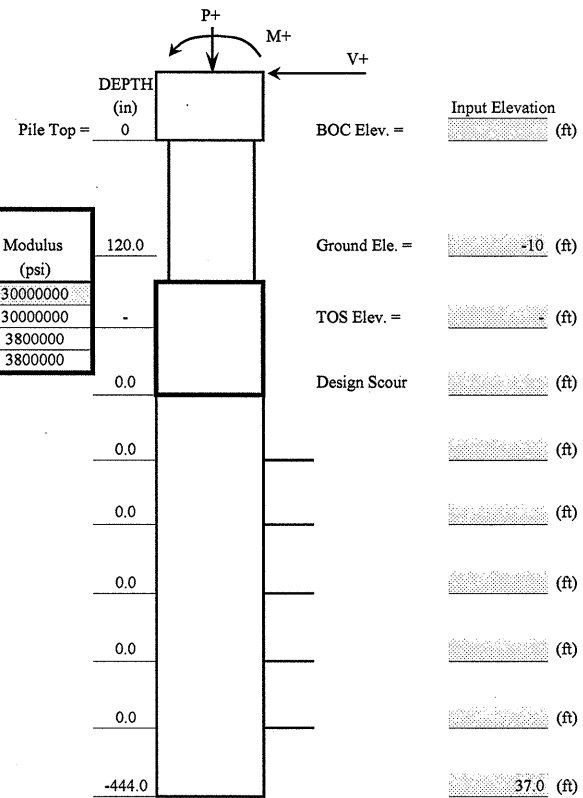
File-Head Boundary Conditions & Loading			
Pile-Head B.C.	V (Shear) (lbs)	M (Moment) (lbs-in)	P (Axial) (lbs)
Shear & Moment	0	0	0
Shear & Slope			

Soil Layers			
Layer #	Internal Soil Type	x-top (in)	x-bottom (in)
1	4	120.0	444.0
2		444	0.0
3		0	0.0
4		0	0.0
5		0	0.0
6			

- #1 = Soft Clay Criteria (Matlock)
- #2 = Stiff Clay with Free Water
- #3 = Stiff Clay without Free Water
- #4 = Sand (Reese, 1974)
- #5 = Linear Interp. p-y curves
- #6 = Strong Rock (Vuggy Limestone)
- #7 = Silt (Cemented c-phi soil)
- #8 = API Sand (O'Neill)
- #9 = Weak Rock (Reese, 1977)

SOIL and ROCK PROPERTIES					
Non-rock Soil Types	Eff. Unit Wt. (pci)	p-y Modulus (pci)	Cohesive Str. (psi)	Friction Angle ϕ (degrees)	Soil Strain ϵ_{50}
4	0.033	20		30	
Weak Rock Properties					
Weak Rock	Eff. Unit Wt. (pci)	Young's Mod.* (psi)	Uniax. Comp. Str. (psi)	RQD (%)	k _{rm} (0.0005 to .00005)
Strong Rock Properties (Vuggy Limestone)					
Strong Rock Properties (Vuggy Limestone)	Eff. Unit Wt. (pci)	Uniax. Comp. Str. (psi)			

* Young's Modulus of Rock = 200 to 500 X Comp. Strength of Rock (RULE OF THUMB)



DEFLECTION @ PILE TOP = Δ_{TOP}		
Δ_{TOP}	Max. Neg.	Pile Length
0.54	373	444.0
(in)	(in)	(in)

COMMENTS:

POINT OF FIXITY EL. =	(ft)
TIP NO HIGHER THAN =	

