Report of Subsurface Exploration
and Geotechnical Evaluation

Chief Ladiga Trail
Sinkhole Evaluation
Jacksonville, Alabama

Building & Earth Project Number: BH160076

Prepared For:

The City of Jacksonville

Prepared By:

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

DATE:

April 1, 2016

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

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www.BuildingAndEarth.com

April 1, 2016

City of Jacksonville, Alabama
320 Church Avenue, SE
Jacksonville, Alabama 36265

Attn: Mr. Mark Stephens

Subject: Report of Subsurface Exploration and
Geotechnical Evaluation
Chief Ladiga Trail - Sinkhole Evaluation
Jacksonville, Alabama
Building & Earth Project No.: BH160076

Dear Mr. Stephens:

Building & Earth Sciences, Inc. has completed the authorized subsurface exploration and geotechnical engineering evaluation for the sinkhole evaluation at the Chief Ladiga Trail, located north of Warren Drive, in Jacksonville, Alabama. Our work was performed in substantial conformance with Building & Earth's Proposal No. BH180089 R1 and our Supplemental Sinkhole Exploration Proposal, dated February 29, 2016 and March 9, 2016, respectively.

The purpose of our exploration and evaluation was to determine the subsurface conditions near the dropouts that were observed at the site, and to address recommendations for remediation. The recommendations in this report are based on a physical reconnaissance of the site and observation and classification of samples obtained from seven (7) soil borings conducted at the site, as well as an Electrical Resistivity Imaging (ERI) study. The borings were located north and south of the dropout area. No borings were performed in-between the dropouts, due to access limitations.

We appreciate the opportunity to provide consultation services for the proposed project. If you have any questions regarding the information in this report or need any additional information, please call us.

Respectfully Submitted,
BUILDING & EARTH SCIENCES, INC.

Joey Jones, P.E.
Geotechnical Department Manager

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JOSEPH RAY JONES

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1.0 PROJECT AND SITE DESCRIPTION

The subject site is located on the Chief Ladiga Trail, about ½ miles north of the intersection with Warren Drive, in Jacksonville, AL. This area of the trail is bordered to the west by cleared pasture land, and to the west by a wooded area. The area generally drains to the north, where a large creek crosses the trail, approximately 1 mile to the north. A drainage ditch was observed to the east, as well as evidence of previous sinkhole activity. These dropouts were wooded and covered in leaves, indicating that sinkhole activity occurred some time ago. A photo of this area is shown below (Figure 1).

At the time of our initial visit, on February 26, 2016, sinkhole 1 and sinkhole 2 were observed present in the trial (Figures 2 and 3). Prior to our visit on March 4, 2016, when drilling was performed, sinkhole 2 had increased in size, and blocked access to the trail. Sinkhole 3 had also formed since our initial visit. A rain event had previously occurred on March 3. Photos of the sinkholes and surrounding areas are shown below.

Figure No. 1 – Previous Sinkhole Activity, located east of Ladiga Trail

Figure No. 2 – Sinkhole No. 1, looking south (03-04-16)

Figure No. 3 – Sinkholes No. 2 and 3, looking south (03-04-16)

2.0 SITE GEOLOGY

Published geologic maps indicate that the site is underlain by the Conasauga Formation. The Conasauga Formation typically consists of thin-to-medium-bedded limestone with thin partings of shale. The beds are usually folded and fractured. Weathering of this formation results in a clayey or silty-clay soil that ranges from 5 to 50+ feet in thickness. The bedrock surface is highly irregular. Pinnacles may project to the surface, and limestone boulders and fragments occur throughout the soil zone. The formation is also susceptible to vertical clay filled slots and seams.

The Conasauga Formation is primarily limestone, which is a carbonate rock, composed primarily of calcium carbonate. The calcium present within the limestone is soluble when subjected to moving water, particularly when carbon dioxide is present in the groundwater. Infiltrating groundwater will gain carbon dioxide from decaying organics at the ground surface. The rate of dissolution cannot be predicted, however it is related to the concentration of carbon dioxide and other acids present in the groundwater, and the rate of water movement.

As the dissolution process progresses, deep slots or cavities will form within the bedrock. It is common to find soft soil within the dissolution zone above the rock mass, or within the cavities or slots caused by the weathering process. Soft soil was encountered with depth at locations B-6 and B-7.

When a cavity forms in the bedrock due the physical and chemical weathering process, the overlying soil or rock can collapse or “wash” into the cavity, facilitated by surface water infiltration. When the overlying soil collapses, a sinkhole can occur. This type of failure is referred to as cover collapse. The underlying cause of the collapse occurs over geologic time, and will go through periods of stability and instability related to the regional groundwater and rainfall conditions. The ground loss at the surface may not occur for a period of time after the collapse process is initiated.

Construction activity can also trigger sinkholes, however there has been no significant constructing in the subject area. There were several periods of heavy rainfall immediately prior to the activity. Therefore, the likely cause of the observed collapse was groundwater infiltration. It is not possible to predict when or if additional activity will result in surface collapse.

The Alabama Department of Transportation Sinkhole Map for Calhoun County (1977) is shown below. The map shows the area is prone to sinkholes (shaded area), but does not indicate any known sinkholes in the vicinity.

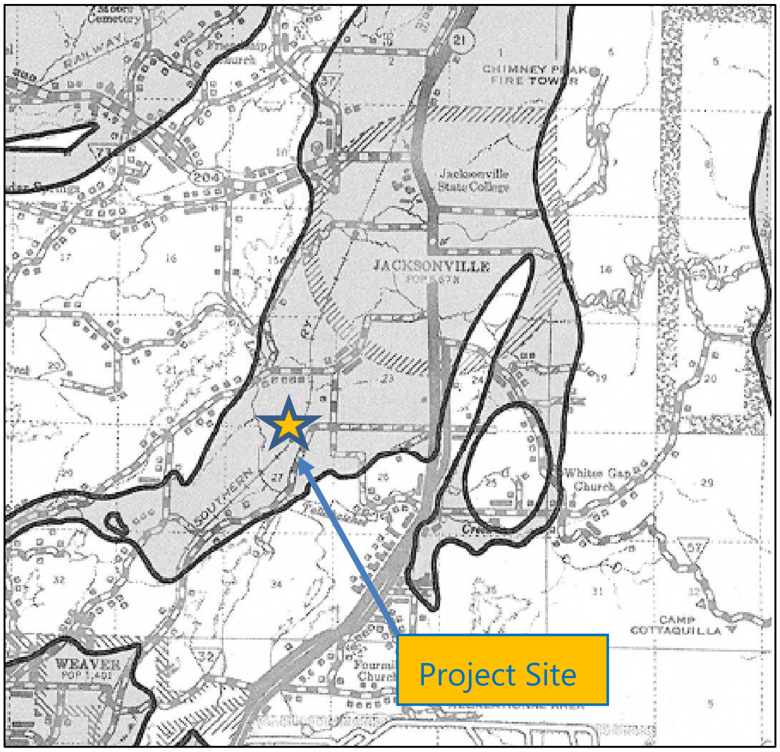


Figure No. 4 - ALDOT Calhoun County Sinkhole Map (1977)

3.0 SCOPE OF SERVICES

The purpose of the geotechnical exploration was to determine general subsurface conditions at specific soil boring locations near the collapse zones, and to gather data on which to base a geotechnical evaluation with respect to repairs of the collapsed areas. The work included soil borings, and Electronic Resistivity Imaging (ERI) survey, and geotechnical evaluation appropriate to address the site conditions. The results of the work are presented within this report that addresses:

- A description of the subsurface conditions encountered at the soil test boring locations.

- A description of the groundwater conditions observed in the boreholes during drilling. Long-term monitoring is not included in this proposal.

- Report of the ERI survey, including potential voids, water features, etc.

- Options for treating the existing collapse zones and for reducing future sinkhole risk.

4.0 SUBSURFACE EXPLORATION

The initial authorized subsurface exploration was performed on March 4, 2016. The subsurface exploration consisted of seven (7) soil test borings (B-01 through B-07). The borings were located in the paved trail, north and south of the sinkholes. The original plan included borings between the sinkholes, however our drill rig was unable to access the area in-between the sinkholes due to additional subsidence prior to the field exploration. The borings were drilled to auger refusal, which ranged from 3.5 feet to 41 feet below the existing surface.

The soil boring locations were determined in the field by a representative of our staff by measuring distances along the trail, from a fixed reference point. The surface was assigned a reference elevation of 0 for the purpose of this report. The boring locations shown on the ERI survey attached to this report should be considered approximate.

At each boring location, soil samples were obtained at standard sampling intervals with a split-spoon sampler. The borehole was first advanced to the sample depth by augering and the sampling tools were placed in the open hole. The sampler was then driven 18 inches into the ground with a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler each 6-inch increment was recorded. The initial increment is considered the “seating” blows, where the sampler penetrates loose or disturbed soil in the bottom of the borehole.

The blows required to penetrate the final two (2) increments are added together and are referred to as the Standard Penetration Test (SPT) N-Value. The N-Value, when properly evaluated, gives an indication of the soil’s strength and ability to support structural loads. Many factors can affect the SPT N-Value, so this result cannot be used exclusively to evaluate soil conditions. SPT testing was performed in general accordance with ASTM D-1586.

A Mobile HD-45 drill rig equipped with an automatic hammer was used for drilling the borings. Automatic hammers deliver higher energy efficiency (90 to 99 percent) than the standard hammer (safety hammer, 60 percent efficient). Therefore, an energy correction factor of 1.3 was applied to the recorded field N-values for the purpose of our evaluation. The N-values discussed or mentioned in this report and shown on the boring logs are recorded field values.

Samples retrieved from the boring locations were labeled and stored in plastic bags at the jobsite before being transported to our laboratory for analysis. The project engineer prepared Boring Logs summarizing the subsurface conditions at the boring location. The Boring Logs are attached to this report.

The ERI survey was performed on March 17, 2016 as a part of our supplemental proposal. The ERI study included one (1) 498 ft. long ERI array oriented parallel to the trail, and crossed both sinkholes. The array included 84 electrodes spaced at 6 feet. The maximum depth of the investigation using this configuration was approximately 120 feet.

5.0 SUBSURFACE CONDITIONS

The subsurface conditions at the site were evaluated by observation and classification of soil samples obtained from seven (7) soil borings and the ERI Survey. Due to geologic conditions at the site, highly variable conditions could be encountered over short horizontal distances.

A generalized subsurface profile has been constructed using data from the soil borings. The profile graphically depicts the general soil conditions and strata type encountered at the specific soil boring locations. However, due to the variability of the soils at the site, the profile may not depict all conditions and strata changes within the subject area.

The ERI investigation includes one ERI model showing variable resistivity values in the subsurface strata. These values are used to interpret subsurface conditions at the site including delineation of subsurface voids and variable geology. The ERI study was performed by GeoWave Solutions, Inc. working as a subcontractor to Building & Earth. The ERI report and diagram are included in the Appendix.

5.1 EXISTING SURFACE CONDITIONS

The borings were located within the bike path. About 2 inches of asphalt underlain by 6 to 8 inches of base material were observed at the boring locations. The surface conditions surrounding the trail consisted of leaves and underbrush in the wooded areas. At the time of our exploration, the surrounding surface soils were wet, due to recent rains. Drainage ditches were present along both sides of the bike path, and it appeared that water had been recently flowing in the ditches.

5.2 RESIDUAL SOILS

Residual soils, materials formed by the in-place weathering of the parent bedrock, were encountered in the boring locations beneath the pavement section. The residual soils consisted primarily of fat clay (CH). The fat clay was generally red in color, with varying consistencies. Some low consistency layers were encountered in borings B-03, B-06, and B-07. Blow counts of 0 were encountered in borings B-06, at a depth of 18 to 25 feet, indicating very soft material, likely disturbed by past migration of the surrounding soil into cavities or dissolution of the bedrock surface. The soil samples were generally moist, and became wet or saturated with increasing depth.

5.3 AUGER REFUSAL

Auger refusal is the drilling depth at which the borehole can no longer be advanced using soil drilling procedures. All of the borings were advanced to auger refusal. Auger refusal was encountered at relatively shallow depths in the borings located north of the sinkholes. The refusal depths in this area ranged from about 3.5 to 5 feet below the surface, with the exception of B-03, which refused at about 10 feet. Borings B-01 and B-03 were offset and re-drilled, with similar refusal depths. The borings located south of the sinkholes refused at depths of 22 to 41 feet. The following table indicates the auger refusal depths in the boring locations.

BORING LOCATION	**APPROXIMATE AUGER REFUSAL DEPTH (FT)**
B-01	5.5
B-02	5
B-03	10
B-04	3.5
B-05	22
B-06	41
B-07	38

Table 1: Auger Refusal Depths

The depth to continuous rock does not necessarily correspond to the practical refusal depths. In order to determine the depth to continuous rock, additional equipment would be required.

A sample of limestone bedrock was taken from one of the sinkholes, and can be seen in the photo below. The rock sample is relatively lightweight and porous, with many voids present.

Figure No. 5 – Photo of limestone sampled from Sinkhole No. 1

5.4 GROUNDWATER

Groundwater was not encountered in the boring locations at the time of our exploration. Long term monitoring of groundwater was not included as a part of our subsurface exploration. Fluctuations in the water level can occur due to variations in the seasonal rainfall or other factors. Water levels as observed during subsurface exploration are accurate for only the time and date of the exploration. The soil borings were backfilled the same day with grout, in order to avoid facilitating additional surface water entering the ground near the disturbed areas.

5.5 ELECTRICAL RESISTIVTY IMAGING (ERI) RESULTS

The ERI survey indicated four general subsurface strata in the area of the sinkholes. The strata are described in the ERI report included in the appendix and summarized below.

In the upper 5 feet lies a layer of wet clay, indicated by a relatively high conductivity.

Beneath the upper soil layer, lies a layer of highly weathered rock. This layer is highly resistive, and consists of an upper interface with the soil. Based on the boring logs, competent rock is sporadic in this layer and may only have rock fragments remaining due to the advanced weathering of the layer. Of the remnant competent rock that is remaining, high resistivity values are common which possibly indicate the presence of air-filled voids. This layer of rock extends to a depth of about 20 to 25 feet.

The middle layer of rock is mostly conductive, consisting of highly weathered rock with cavities back-filled with mud and saturated sediment. **Two of the three large conductive anomalies in this layer lie directly below the collapse sinks observed on the surface.** It is likely that surface water and sediment are migrating from the surface down into these zones. **We suspect that the conductive zone, located approximately 90 to 150 feet south of sinkhole no. 2 is a possible location for a future collapse to emerge.** The prominent cavities are located at depths of about 25 to 30 feet, and extend to depths of about 50 to 60 feet.

The lower strata of rock at depths of 50 to 60 feet is moderately conductive and relatively consistent, indicating competent rock, with fewer weathering features.

A more detailed discussion of the interpreted subsurface conditions using the ERI survey is included in the appendix.

6.0 SITE REMEDIATION

The intent of the remediation process is to repair the existing dropouts, and to mitigate the risk of additional sinkhole development. While the options discussed below should minimize the risk of additional dropout in the repair area, there is no way to guarantee that additional future dropouts will not occur.

Building & Earth has evaluated several options for the remediation of the sinkholes. The options considered included:

- Excavation and backfill
- Structurally spanning the disturbed area
- Relocating the trail
- Remediation grouting

The options are briefly discussed below:

6.1 EXCAVATION/ BACKFILL

The Excavation/Backfill option would involve excavating in the disturbed soils in the vicinity of the existing dropouts to expose the breach in the underlying rock which allowed the soils to collapse. The excavation would them be backfilled with an "inverted filter" system. This system includes (from bottom to top) geogrid or geotextile, boulders, gravel, and clay cover. The ERI survey indicates potential mud filled voids underneath the dropouts, which extend to depths of about 55 feet. An excavation could potentially punch into this zone, creating a much larger and deeper repair. The existing side slopes along the trail and narrow right of way prevent adequate room to properly remediate the dropout zones using this approach.

6.2 STRUCTURAL SPAN

The Structural Span option would entail construction of a platform at grade, supported on a deep foundation system bearing on competent bedrock. Additional geotechnical evaluation, including rock coring would be required to further develop this recommendation. This option was not pursued due to the potential cost of the deep foundation system required to support the platform.

6.3 RELOCATING THE TRAIL

Relocating the trail around the dropouts could be considered. However, this would require the acquisition of additional right of way, as well as extensive grading to construct the new trail. The geologic conditions which caused the disturbance in the existing trail are present throughout the region, and evidence of past subsidence in the area was observed. Therefore, the same potential for future dropouts would remain if the trail is relocated.

6.4 REMEDIATION GROUTING

We believe the most feasible remediation option is to implement a remediation grouting program. The recommended grouting process is intended utilize Low Mobility Grout (LMG) to form a grout cap over the upper rock zone, and improve the consistency of the overlying material by compaction grouting.

A typical grouting program would be initiated on a 10 to 15 foot spacing in the vicinity of the known sinkholes. Depending on the grout take and pressures in the primary injection, secondary or tertiary grout holes may be required. The total size of the treated area will depend on the conditions encountered during the grouting process.

Below are typical grouting parameters regarding the casing advancement and pumping:

A 4" to 6" casing will be advanced through the soil profile using percussion or rotary drilling methods to the bottom of the treatment zone, presumably refusal upon bedrock. LMG will be injected into the casing as the casing is extracted to the surface in 1 to 2 foot lifts. Grouting will begin at the target depth, with the following limiting criteria during the LMG injection:

a. A maximum gage pressure of 250 psi; for the baseline < 6" slump grout mix.
b. A maximum quantity injected of 10 CY at the soil/bedrock interface.
c. A maximum quantity injected of 0.5 CY per 2 foot interval.
d. Grout communication to the surface.
e. Excessive heave or structural movement.
f. As directed by the engineer.

In situations where no back pressure is observed (grouting into open void conditions), on secondary locations, or if settlement is observed while grouting, additional grout may be required. It should be noted that high grout takes are possible during the initial phase of the primary injection, or when injecting into open voids, if encountered. It is our experience that the grout volumes generally reduce below maximum quantity as the grouting program progresses.

During injection, the pressure, volume, and surface movement are monitored and recorded on the grout log. The pressure will be monitored through the use of a gauge saver type system located in the grout line. The volume is monitored from a mechanical stroke counter located on the grout pump. All observation and data obtained will be recorded on the approved grout log.

Based on our conversations with a specialty contractor we anticipate the cost of the LMG program to be in the range of $100,000 to $150,000 which includes mobilization, grouting, etc. The cost could vary depending on the amount of grouting required.

We also recommend that the area north of sinkhole No. 1 be further evaluated during the grouting process to determine if the near surface anomalies identified on the ERI survey are actually air-filled voids as identified in the study. If voids are encountered, then additional grouting will be required in those areas.

6.5 ONGOING EVALUATION

The conductive zone identified by the ERI survey south of the known sinkholes appears to have the same potential for future disturbance as the current dropouts. However, it is likely that similar conditions are present at other locations along the trail within the same geologic setting. It will be important to maintain positive drainage along the trail to avoid concentrating infiltration of surface water.

We recommend that areas outside the known dropouts be monitored, and if any subsidence such as shallow depressions occur, then the areas be evaluated by a geotechnical engineer to help determine if subsurface remediation is advisable.

7.0 CONSTRUCTION MONITORING

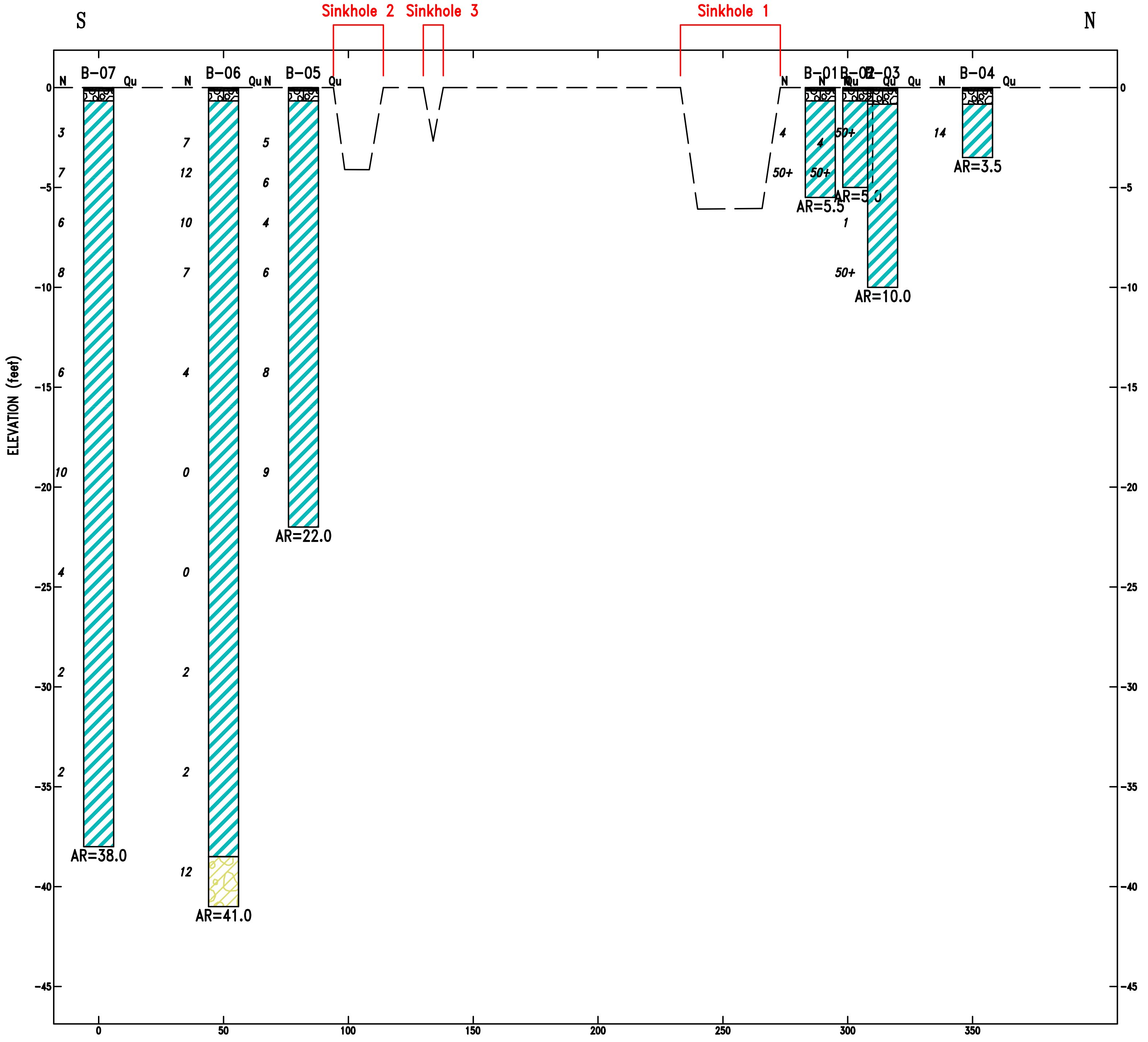
The recommendations presented in this report are based on information obtained from seven (7) soil test borings and the ERI survey. Field verification of site conditions is an essential part of the services provided by the geotechnical consultant. In order to confirm our recommendations, it will be necessary for Building & Earth personnel to make periodic visits to the site during site remediation. We can prepare a proposal for construction monitoring services based on the construction schedule and your risk management preferences.

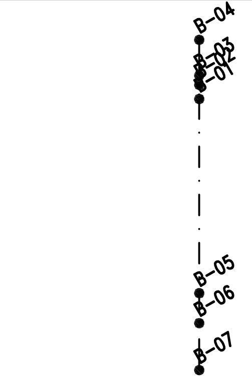
8.0 CLOSING

This report was prepared for the City of Jacksonville, for specific application to the sinkhole remediation on the Chief Ladiga Trail, in Jacksonville, Alabama. The information in this report is not transferable. This report should not be used for a different development on the same property without first being evaluated by the engineer. The recommendations in this report were based on the information obtained from our field exploration and engineering judgment regarding conditions between soil borings. It will be necessary to confirm the anticipated subsurface conditions during construction.

This report is intended for use during design and preparation of specifications and may not address all conditions at the site during construction. Contractors reviewing this information should acknowledge that this document is for design information only.

An article published by the Geoprofessional Business Association (GBA), titled *Important Information About Your Geotechnical Report*, has been included in the Appendix. We encourage all individuals to become familiar with the article to help manage risk.





Site Map Scale 1 inch equals 220 feet

Explanation

BT=Boring Termination

AR=Auger Refusal

PPqu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)

N=Standard Penetration Test N-Value

■ Asphalt

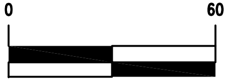
▨ Aggregate Base Material

▨ USCS High Plasticity Clay

▨ USCS Clayey Gravel

▽ Water Level Reading at time of drilling.

▼ Water Level Reading after drilling.



Horizontal Scale (feet)
Vertical Exaggeration: 8x

Building & Earth Sciences, Inc.
13159 Middletown Industrial Blvd
Loiusville, KY 40223

Section Name A-A'
Subsurface Profile

Chief Ladiga Trail Sinkhole
Jacksonville, AL

JOB NUMBER	PLATE NUMBER	DATE
BH160076	Plate A-1	3/28/16

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-01

Sheet 1 of 1

5545 Derby Drive
Birmingham, AL 35210
Office: (205) 836-6300
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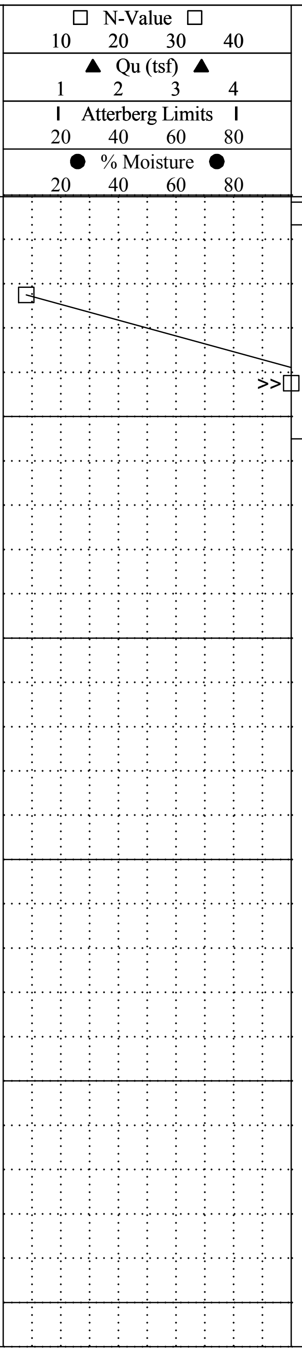
Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 15' North of Sinkhole 1

Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	0				0.2 Asphalt = 2" -0.2		Boring offset 5' north, auger refusal at 3'
					0.7 Base = 6" -0.7		
					FAT CLAY (CH): firm, red, moist		
		☒	1	2-2-2			
		☒	2	2-1-50/5	hard, wet		
5	-5				5.5 -5.5		
					Auger Refusal at 5.5'		
10	-10						
15	-15						
20	-20						
25	-25						Groundwater not encountered at time of drilling. Boring backfilled with grout on 3/4/16.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

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Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-02

Sheet 1 of 1

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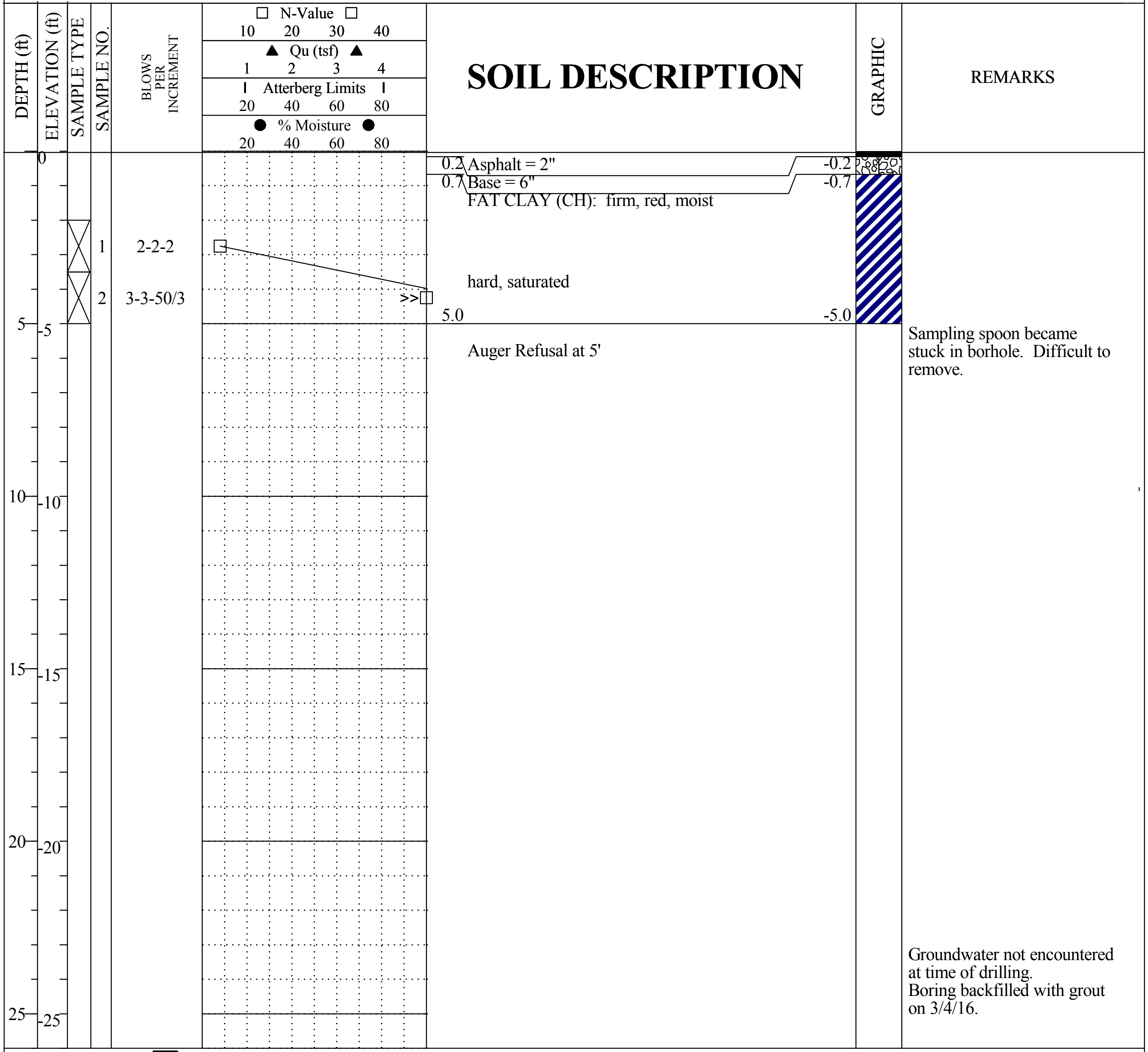
Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 30' North of Sinkhole 1

Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ



SAMPLE NO.	BLOWS PER INCREMENT
1	2-2-2
2	3-3-50/3

SOIL DESCRIPTION

Depth	SOIL DESCRIPTION	Elevation
0.2	Asphalt = 2"	-0.2
0.7	Base = 6"	-0.7
	FAT CLAY (CH): firm, red, moist	
	hard, saturated	
5.0		-5.0
	Auger Refusal at 5'	

REMARKS

Sampling spoon became stuck in borhole. Difficult to remove.

Groundwater not encountered at time of drilling.
Boring backfilled with grout on 3/4/16.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

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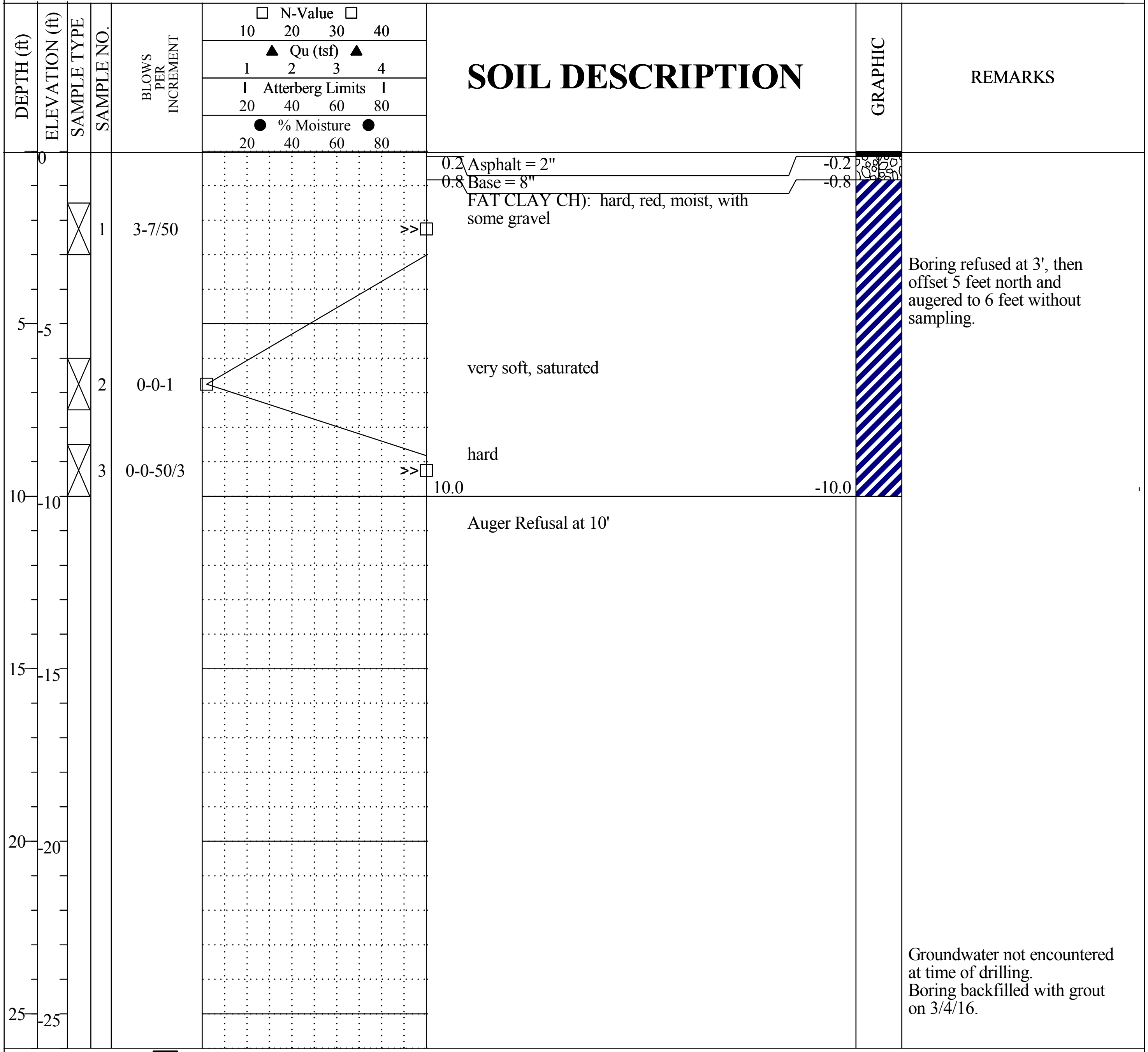
LOG OF BORING

Designation: B-03

Sheet 1 of 1

Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 40' North of Sinkhole 1

Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	REMARKS
0	0				0.2 Asphalt = 2" -0.2	
					0.8 Base = 8" -0.8	
					FAT CLAY CH): hard, red, moist, with some gravel	
		☒	1	3-7/50		Boring refused at 3', then offset 5 feet north and augered to 6 feet without sampling.
5	-5					
		☒	2	0-0-1	very soft, saturated	
		☒	3	0-0-50/3	hard	
10	-10				10.0 -10.0	
					Auger Refusal at 10'	
15	-15					
20	-20					
25	-25					Groundwater not encountered at time of drilling. Boring backfilled with grout on 3/4/16.

SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
$\underline{\nabla}$ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING
Designation: B-04
Sheet 1 of 1

5545 Derby Drive
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Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 78' North of Sinkhole 1

Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	□ N-Value □ 10 20 30 40 ▲ Qu (tsf) ▲ 1 2 3 4 I Atterberg Limits I 20 40 60 80 ● % Moisture ● 20 40 60 80	SOIL DESCRIPTION	GRAPHIC	REMARKS
0	0					0.2 Asphalt = 2" -0.2		
						0.8 Base = 8" -0.8		
		☒	1	6-7-7	□	FAT CLAY (CH): very stiff, red, with limestone fragments, wet	▨	
						3.5 -3.5		
						Auger Refusal at 3.5'		
5	-5							
10	-10							
15	-15							
20	-20							
25	-25							Groundwater not encountered at time of drilling. Boring backfilled with grout on 3/4/16.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING
Designation: B-05
Sheet 1 of 1

5545 Derby Drive
Birmingham, AL 35210
Office: (205) 836-6300
Fax: (205) 836-9007
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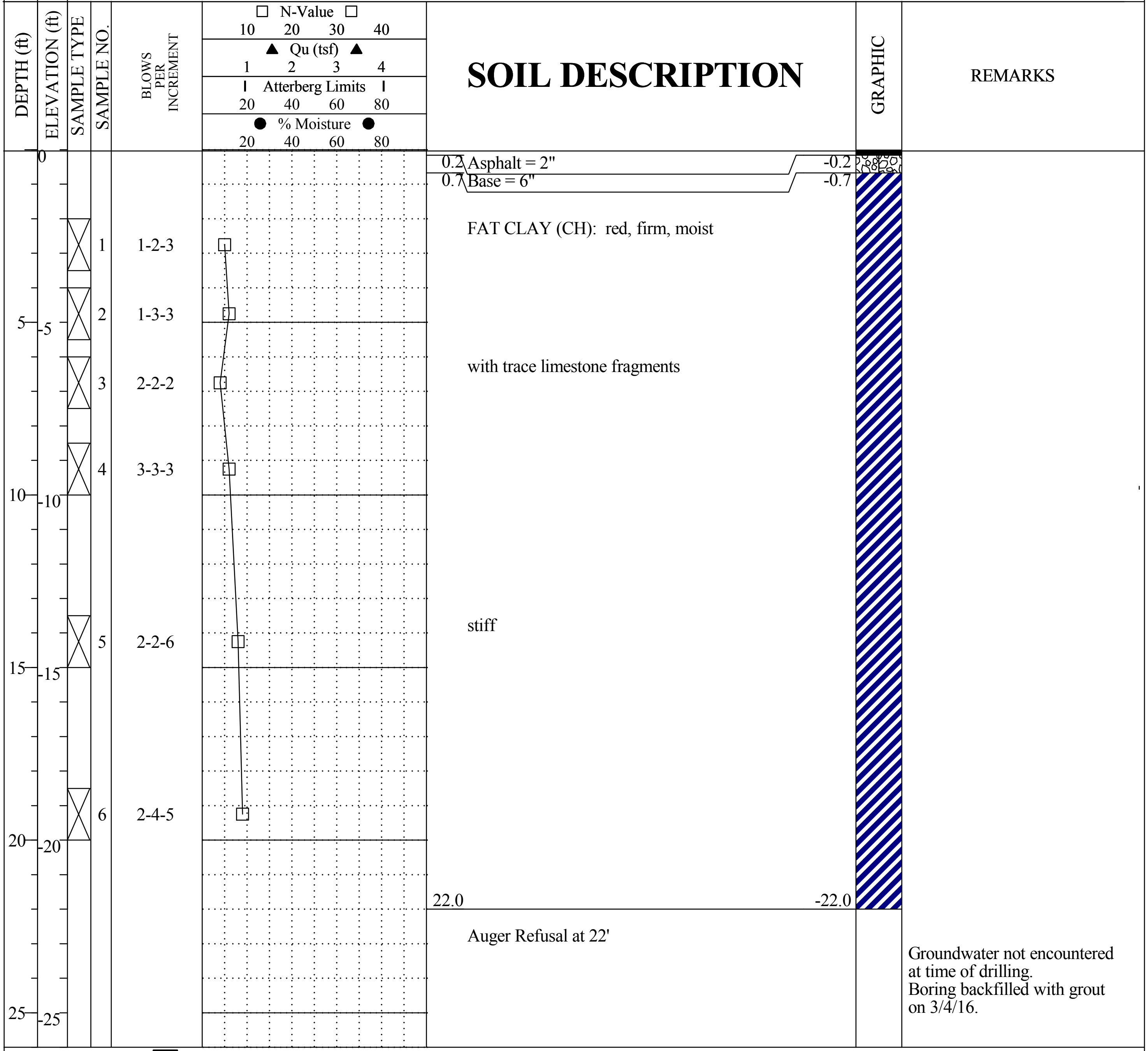
Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 12' South of Sinkhole 2

Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ



SAMPLE NO.	BLOWS PER INCREMENT
1	1-2-3
2	1-3-3
3	2-2-2
4	3-3-3
5	2-2-6
6	2-4-5

Depth	Soil Description	Elevation
0.2	Asphalt = 2"	-0.2
0.7	Base = 6"	-0.7
	FAT CLAY (CH): red, firm, moist	
	with trace limestone fragments	
	stiff	
22.0		-22.0
	Auger Refusal at 22'	

Groundwater not encountered at time of drilling.
Boring backfilled with grout on 3/4/16.

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

BUILDING & EARTH
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LOG OF BORING

Designation: B-06

Sheet 1 of 2

5545 Derby Drive
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Office: (205) 836-6300
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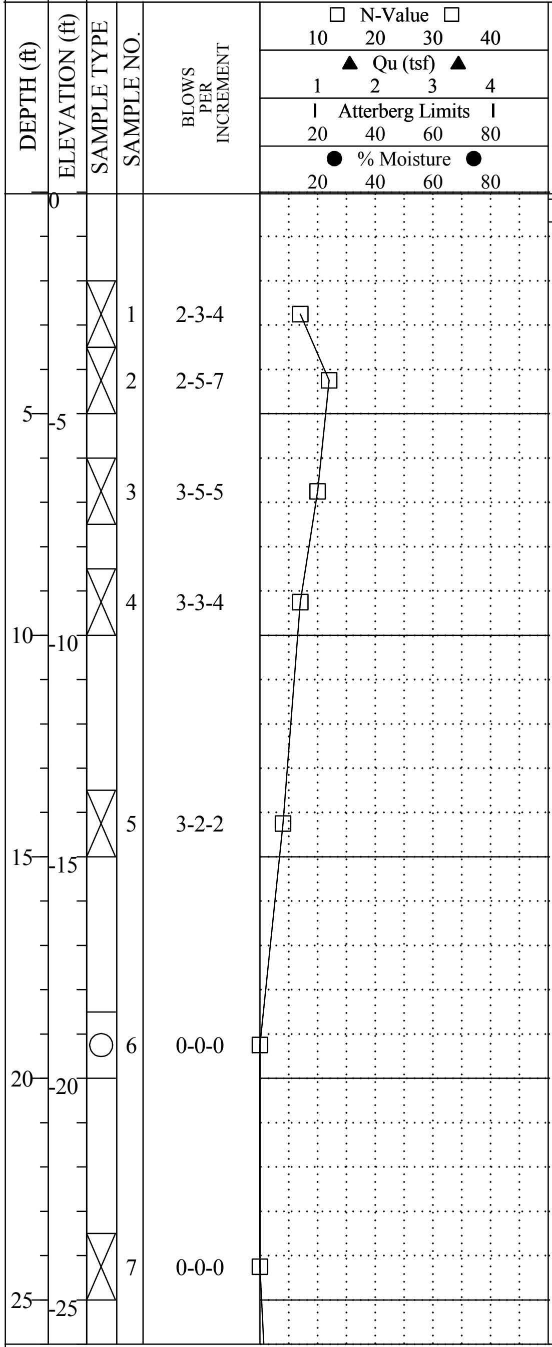
Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 44' South of Sinkhole 2

Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	REMARKS
0.2	-0.2				Asphalt = 2"	
0.7	-0.7				Base = 6"	
					FAT CLAY (CH): stiff, red, moist	
		☒	1	2-3-4		
		☒	2	2-5-7	very stiff	
		☒	3	3-5-5	stiff, with limestone fragments	
		☒	4	3-3-4		
		☒	5	3-2-2	firm, wet	
		○	6	0-0-0	very soft	No recovery, possible void 18 to 23 feet
		☒	7	0-0-0	with some gravel, little recovery	Groundwater not encountered at time of drilling. Boring backfilled on 3/4/16.

SAMPLE TYPE ☒ Split Spoon ○ No Recovery

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING

Designation: B-06

Sheet 2 of 2

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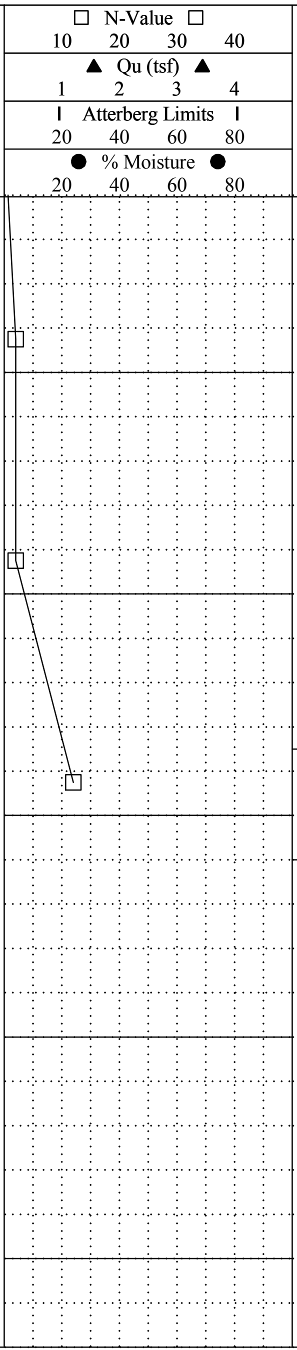
Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 44' South of Sinkhole 2

Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	GRAPHIC	REMARKS
		☒	8	5-1-1	soft, with limestone fragments, little recovery	▨	
30	-30					▨	
		☒	9	1-1-1		▨	
35	-35					▨	
38.5	-38.5						
		☒	10	4-6-6	CLAYEY GRAVEL (GC): medium dense, grey, wet		
40	-40						
41.0	-41.0						
					Auger Refusal at 41'		
45	-45						
50	-50						



SAMPLE TYPE ☒ Split Spoon ○ No Recovery

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

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LOG OF BORING
Designation: B-07
Sheet 1 of 2

5545 Derby Drive
Birmingham, AL 35210
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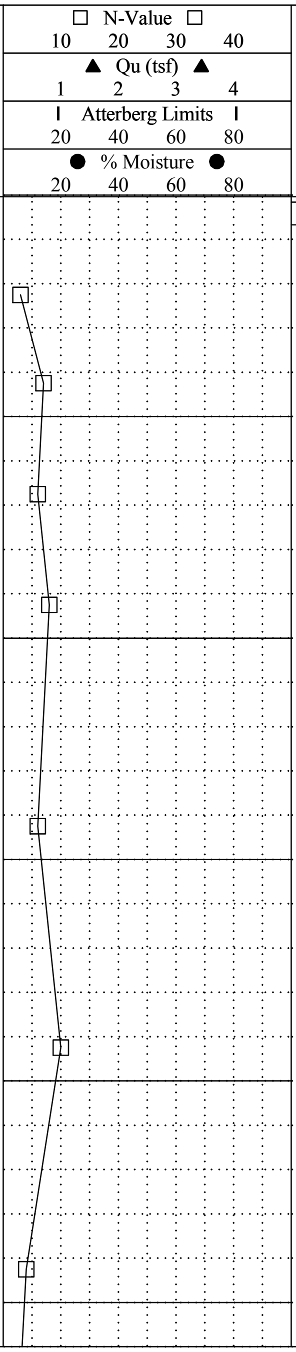
www.BuildingAndEarth.com

Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 94' South of Sinkhole 2

Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ



DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION		GRAPHIC	REMARKS
0	0				0.2 Asphalt = 2"	-0.2		
					0.7 Base = 6"	-0.7		
					FAT CLAY (CH): soft, red, moist			
		☒	1	2-1-2				
		☒	2	2-3-4	stiff			
5	-5							
		☒	3	3-3-3	with trace limestone fragments			
		☒	4	2-4-4				
10	-10							
		☒	5	2-3-3	with limestone fragments			
15	-15							
		☒	6	4-4-6	with limestone fragments			
20	-20							
		☒	7	2-2-2	firm, with limestone fragments			Groundwater not encountered at time of drilling. Boring backfilled with grout on 3/4/16.
25	-25							

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (AASHTO T-206)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

LOG OF BORING
Designation: B-07
Sheet 2 of 2

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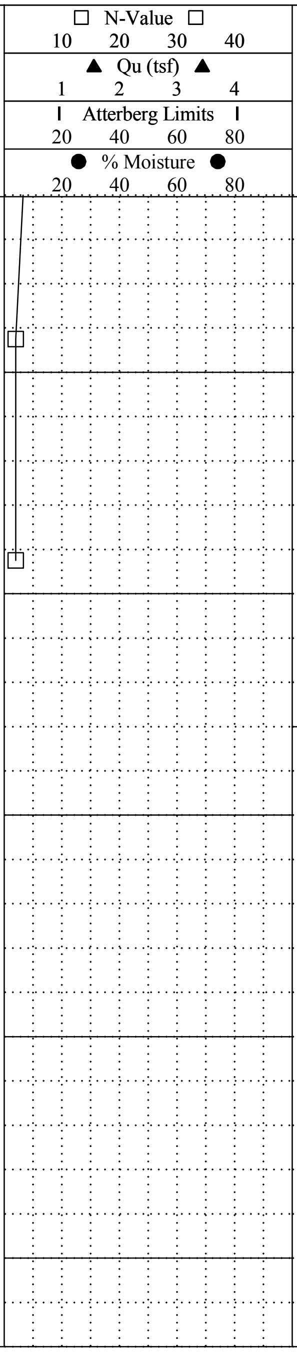
Project Name: Chief Ladiga Trail Sinkhole
Project Number: BH160076
Drilling Method: HS Auger
Equipment Used: Mobile HD-45 (Truck)
Hammer Type: Automatic
Boring Location: 94' South of Sinkhole 2

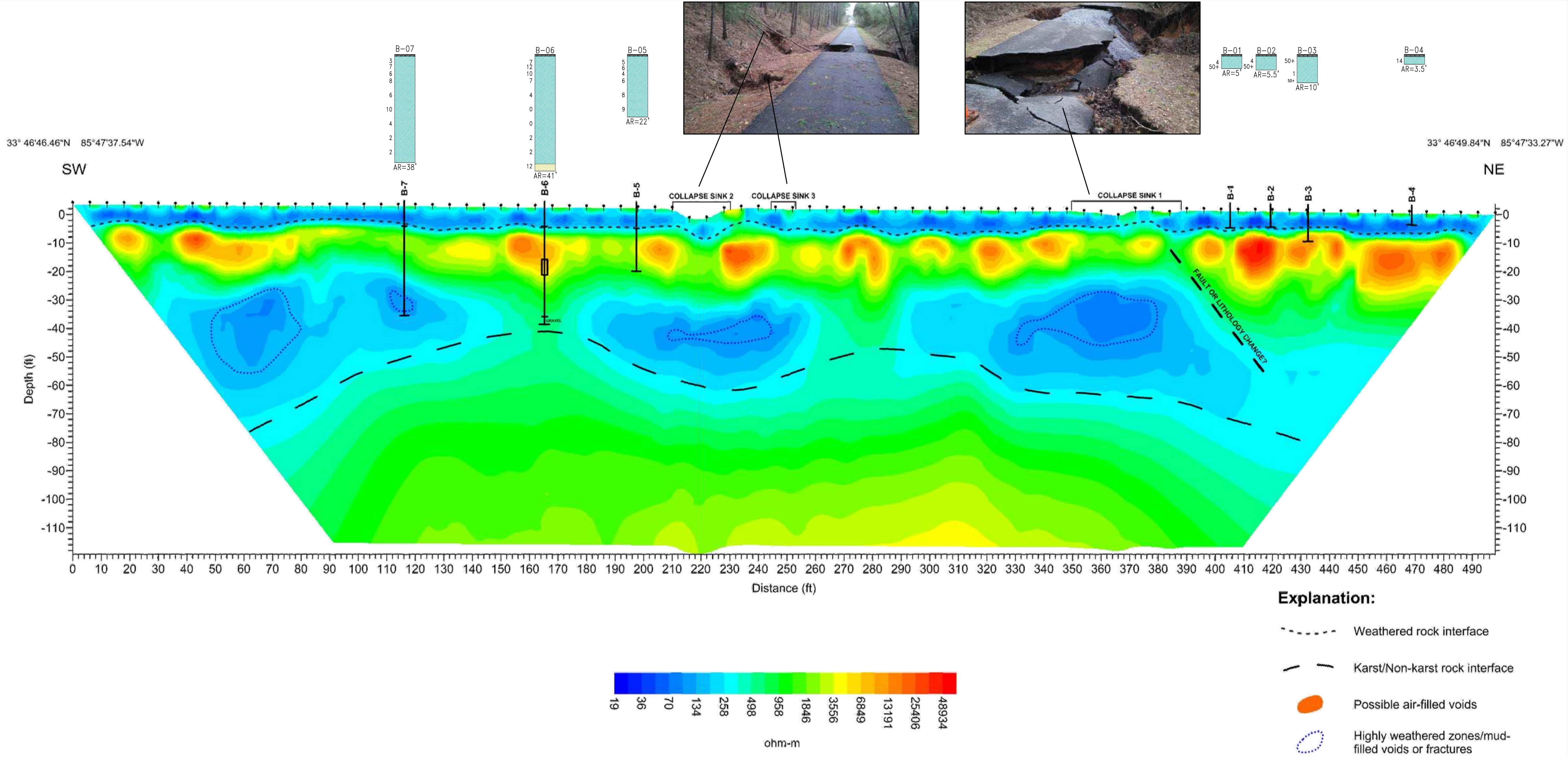
Project Location: Jacksonville, AL
Date Drilled: 3/4/16
Weather Conditions: Cloudy/cool
Surface Elevation: 0
Drill Crew: South Bros
Logged By: JJ

DEPTH (ft)	ELEVATION (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	GRAPHIC	REMARKS
		☒	8	1-1-1	soft, wet	▨	
30	-30					▨	
		☒	9	1-1-1		▨	
35	-35					▨	
38.0	-38.0				Auger Refusal at 38'		
40	-40						
45	-45						
50	-50						



SAMPLE TYPE ☒ Split Spoon

N-VALUE STANDARD PENETRATION RESISTANCE (AASHTO T-206)
% MOISTURE PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE
Qu UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST
REC RECOVERY
RQD ROCK QUALITY DESIGNATION
UD UNDISTURBED



GeoWave Solutions, Inc.
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www.geowavesolutions.com

Chief Ladiga Trail

Jacksonville, Alabama

Building & Earth Sciences, Inc.

Electrical Resistivity Imaging Investigation

March 21, 2016

Project Manager: S. Hurd

ERI-1

March 28, 2016

Mr. Joey Jones, P.E.
Building & Earth Sciences, Inc.
5545 Derby Drive
Birmingham, Alabama 35210

Subject: Results of Electrical Resistivity Imaging Investigation
Chief Ladiga Trail
Jacksonville, Alabama

Dear Mr. Jones:

GeoWave Solutions, Inc. has completed the geophysical subsurface investigation that was requested along the Chief Ladiga Trail near Jacksonville, Alabama. The purpose of this study was to map subsurface conditions around the areas of sinkhole collapse on the trail. This report describes the site conditions, specifies the project's scope, discusses the techniques used to collect and reduce the data, and presents our findings.

Site Description

The project site is along the popular walking/biking Chief Ladiga Trail between Jacksonville and Weaver, Alabama. Formally, the trail was a railroad grade with this section falling within a cut excavation and having steeply sloped embankments on both sides of the alignment. At the time of our fieldwork, two areas of sinkhole collapses had emerged approximately 100 feet apart. In both areas, sink collapses were large enough to encompass the whole width of the asphalt trail as well as shallow drainage ditches on either side. In the area of Sink Collapses 2 and 3, evidence of a new sinkhole is present on the northwestern side of the trail with soil slumping in the acclivity over the sinkhole.

The site lies within the Valley and Ridge physiographic province of eastern Alabama. Rock at the project site has been classified as the Cambrian-aged Conasauga Formation and is described as a thinly bedded, argillaceous limestone with interbedded shale. Below this predominantly limestone unit lies the lower Conasauga shale facies which is mostly shale with a few limestone interbeds. Despite the significant presence of clay, the upper Conasauga Formation is known to have karst characteristics due to solution weathering which can create sinkholes at the ground surface. No rock was observed in the excavation cut along the trail alignment; however, both competent, as well as highly weathered limestone was identified within Sink Collapse 1.

Scope

Electrical resistivity imaging (ERI) was selected as the optimal geophysical method to define the areas around the existing sinkholes. One ERI array 498 feet long was conducted along the southeastern side of the trail alignment using 84 electrodes a 6-foot spacing. The maximum depth of investigation for this configuration was close to 120 feet. Endpoints of the lines are designated by survey paint and survey staking while latitude/longitude coordinates of each line were obtained using a GPS unit and are noted on the model.

Instrumentation and Field/Analysis Techniques

The electrical resistivity imaging method is used for measuring the conductive and resistive properties of the subsurface. It is often used to understand subsurface geology such as mapping strata, fracture zones, various karst features, etc. or to define cultural subsurface anomalies such as landfill boundaries, leachate plumes and buried tanks and pipes. This method utilizes electrical current introduced into the earth by two electrodes. The resistivity of the subsurface is obtained by measuring the potential (drop) between two other electrodes. The depth of investigation is proportional to the current electrode separation and ultimately the length of the array on the surface. By varying the electrode separations, different depths and locations can be sampled allowing a profile of subsurface resistivity to be developed.

For this study, an Advanced Geosciences, Inc. SuperSting R1/IP resistivity system was employed. The SuperSting is a resistivity meter, data logger, and a switching box that configures the various electrodes used during the data acquisition process. Data were collected using a Dipole-Dipole resistivity array and were processed using a forward modeling subroutine for calculating apparent resistivity values and a least-squares optimization inversion process to create the models.

Results

The data collected from the resistivity imaging array were processed to create a two-dimensional model showing subsurface conditions below the surface array. The model shows the relative surface topography along the top of the section with contouring below indicating resistive/conductive changes in the subsurface. Colors toward the red and orange end of the ohm-meter scale can indicate areas of higher resistivity such as competent rock, dry soils/sands, and air-filled voids in some cases. Colors toward the blue end of the scale are representative of more conductive conditions such as wet soils and clays, weathered or discontinuous bedrock within a saturated zone, water-filled voids, and metallic materials, in some cases. An interpretation of the geologic conditions has been added using annotation based on the ERI results and available boring logs. Refer to the Explanation below the model for a description of the annotated boundaries that have been added to the profile.

As with most electrical or magnetic imaging geophysical methods, the results are viewed and analyzed for anomalous changes from the surrounding background levels. In a true homogeneous setting, results will typically be displayed as fairly uniform resistivity levels across the model. If conditions are variable due to changes from cultural influences or variations in the geologic characteristics, findings will generally produce more discontinuous measurements forming odd-shaped anomalies.

It is also important to note that electrical resistivity imaging as well as all other surface geophysical surveys have deceasing resolution with depth. Resolution detail of subsurface conditions is higher in the upper half of each model than the lower half. With increasing depth, more lateral averaging occurs from environments offset from the surface array as electrical current travels out farther laterally to the sides. Therefore, except for larger sized features, resistivity levels in the lower third of the models are characterized by more average resistivity values for the vicinity.

Interpretation

The model created from the ERI data can be generally interpreted into four distinct layers: 1) upper conductive layer, 2) upper resistive layer, 3) middle conductive layer and 4) lower resistive layer.

UPPER CONDUCTIVE LAYER

This thin, conductive layer extends from the surface to approximately 5 feet in depth. Its conductive nature is the result of a clay-rich soil retaining moisture. Small pockets of increased clay/increased moisture content are identified in areas where darker blue contours are present. For the most part, soil conditions beneath the collapse sinks are less conductive than many other areas on the model. This is likely due to the soils being well-drained at the collapse areas and the less consolidated nature of the sediment below the sinkholes.

UPPER RESISTIVE LAYER

The upper resistive layer extends from approximately 5 feet to 20-25 feet in the southwestern four-fifths of the model. This layer appears to increase significantly to approximately 35 feet in the northeastern end. It contains the highest resistivity interpreted in our testing with numerous areas of orange and red contours. Based on ERI interpretation and boring logs, this layer consists of the upper interface of rock. However, due to the highly weathered nature of this unit, much of it is no longer a competent bedrock and is fairly easily penetrated with auger borings. Competent rock areas that do remain in this layer are generally short, discontinuous segments of remnant rock with many areas that have pockets of high resistivity of over 10,000 ohm-meters assigned to them (orange and red contours). These high resistivity values are likely the result of air-filled voids or fractures since competent, unfractured limestone typically is below 5,000 ohm-meters.

The upper resistive layer on the northeast end of the model exhibits different characteristics than the southwestern four-fifths. Boring data indicate auger refusal at a consistently shallow depth of around 5 to 6 feet. In addition, ERI results show a thicker resistive layer extending to approximately 35 feet and a higher concentration of high resistivity anomalies. It appears that this area contains more continuously competent rock with less overall weathering. However, we interpret the high resistivity areas in the rock above 10,000 ohm-meters to be the result of air-filled voids. As is typical with limestone weathering, the upper rock interface of this layer consists of competent limestone while solution weathering inside the rock has created well-protected voids that have been mostly immune to back-filling from the upper soil layer. Given the change of character for this upper rock layer, we suspect faulting or a facies change is occurring very near Collapse Sink 1.

MIDDLE CONDUCTIVE LAYER

Extending from approximately 20-25 to 50-60 feet lies the middle conductive layer. It is characterized by three prominent conductive zones (blue contours) centered at approximately 65/115 feet, 225 feet and 360 feet along the ERI model. While this layer is well within the limestone unit, solution weathering has created larger scale conductive anomalies that are likely the influence of back-filled, mostly saturated, sediment in the rock. Based on boring results and auger refusals, the competency of the rock in this layer is probably highly variable with competent rock remnants existing adjacent to intensely weathered limestone.

Not surprisingly, Collapse Sink 1 and Collapse Sinks 2/3 are centered above two of these conductive zones in the middle conductive layer. It's probable that surface water and sediment from the surface collapse sinks are eventually migrating down into these zones. The third conductive zone in the southwestern end of the model does not have any surface subsidence associated with it; however, given it's similar properties to the other two conductive zones that do have surface collapses associated with them, a surface collapse in this area may potentially occur (or possibly has occurred and been back-filled/regraded in the past).

LOWER RESISTIVE LAYER

The deepest layer in the ERI model consists of moderate resistivity levels that increase gradually with depth starting at 40-60 feet and extending to the total depth of investigation. This layer is composed of rock and does not show any evidence of karst solution weathering. It may be that the limestone is less susceptible to chemical weathering or the lithology of the rock changes from limestone to shale in the lower Conasauga Formation.

This report reflects subsurface conditions found along the test alignment. Because abrupt changes in the subsurface are common, the attached model may not be representative of subsurface conditions in adjacent areas. The interpretations made in this report are based on the results of the resistivity imaging investigation and the supplied boring logs. It is suggested that more geotechnical drilling be used to substantiate and corroborate all interpretations of the subsurface conditions that are proposed in this report.

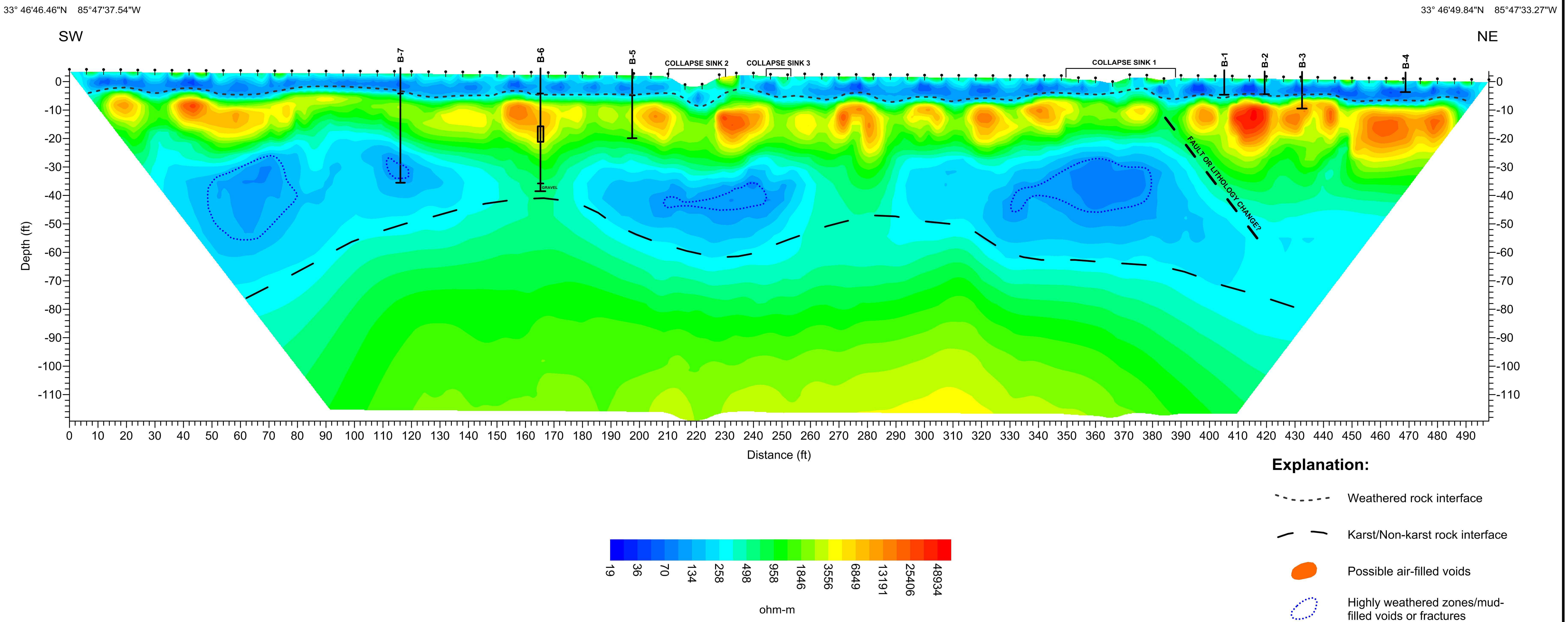
Should you have any questions regarding this investigation or require additional services please feel free to contact us. We have enjoyed working with you on this project and look forward to working with you again in the future.

Sincerely,

Steve A. Hurd

Steven A. Hurd, P.G.
GeoWave Solutions, Inc.

ERI-1



Explanation:

Weathered rock interface

Karst/Non-karst rock interface

Possible air-filled voids

Highly weathered zones/mud-filled voids or fractures

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Chief Ladiga Trail

Jacksonville, Alabama

Building & Earth Sciences, Inc.

Electrical Resistivity Imaging Investigation

March 21, 2016

Project Manager: S. Hurd

ERI-1

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	●	GW	WELL - GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			○	GP	POORLY - GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	○	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			▨	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	◇	SW	WELL - GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			∴	SP	POORLY - GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	∴	SM	SILTY SANDS, SAND - SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▤	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▥	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY
			≈	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			⁂	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

BORING LOG DESCRIPTION

Building & Earth Sciences, Inc. uses the gINT software program to prepare the attached boring logs. The gINT program provides the flexibility to custom design the boring logs to include the pertinent information from the subsurface exploration and results of our laboratory analysis. The soil and laboratory information included on our logs is summarized below:

Depth
The depth below the ground surface is shown.

Sample Type
The method used to collect the sample is shown. The typical sampling methods include Split Spoon Sampling, Shelby Tube Sampling, Grab Samples, and Rock Core. A key is provided at the bottom of the log showing the graphic symbol for each sample type.

Sample Number
Each sample collected is numbered sequentially

Blows per 6", REC%, RQD%
When Standard Split Spoon sampling is used, the blows required to drive the sampler each 6-inch increment are recorded and shown in column 4. When rock core is obtained the recovery ration (REC%) and Rock Quality Designation (RQD%) is recorded.

Soil Data
Column 5 is a graphic representation of 4 different soil parameters. Each of the parameters use the same graph, however, the values of the graph subdivisions vary with each parameter. Each parameter presented on column 5 is summarized below:

- **N-Value**- The Standard Penetration Test N-Value, obtained by adding number of blows required to drive the sampler the final 12 inches, is recorded. The graph labels range from 0 to 50.
- **Qu** – Unconfined Compressive Strength estimate from the Pocket Penetrometer test in tons per square foot (tsf). The graph labels range from 0 to 5 tsf.
- **Atterberg Limits** – The Atterberg Limits are plotted with the plastic limit to the left, and liquid limit to the right, connected by a horizontal line. The difference in the plastic and liquid limits is referred to as the Plasticity Index. The Atterberg Limits test results are also included in the Notes column on the far right column of the boring log. The Atterberg Limits graph labels range from 0 to 100.
- **% Moisture** – The Natural Moisture Content of the soil sample as determined in our laboratory.

Soil Description
The soil description prepared in accordance with ASTM D 2488, Visual Description of Soil Samples. The Munsel Color chart is used to determine the soil color. Strata changes are indicated by a solid line, with the depth of the change indicated on the left side of the line. If subtle changes within a soil type occur, a broken line is used. The Boring Termination or Auger Refusal depth is shown as a solid line at the bottom of the boring.

Graphic
The graphic representation of the soil type is shown. The graphic used for each soil type is related to the Unified Soil Classification chart. A chart showing the graphic associated with each soil classification is included.

Remarks
Remarks regarding borehole observations, and additional information regarding the laboratory results and groundwater observations.

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GEOTECHNICAL
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