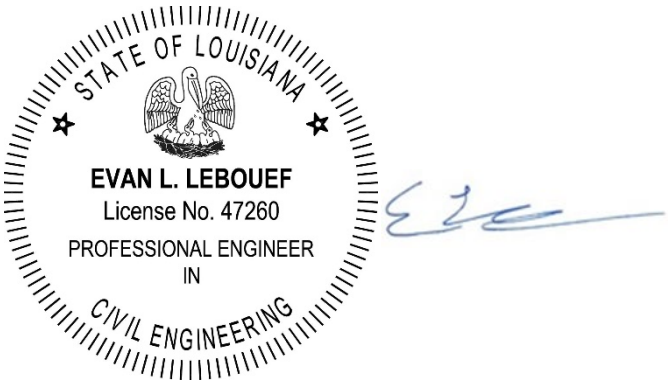
Geotechnical Evaluation Report

Restore Louisiana Homeowner Assistance Program
Proposed Residence at 1017 Carroll Street
Westlake, Louisiana

Prepared for

FCA Construction



Evan LeBouef, P.E.
Project Engineer
License Number: 47260
December 6, 2022

Project B2210849 - 1017 Carroll Street

Braun Intertec Corporation
LA Firm Registration No. EF.0005739

BRAUN INTERTEC
The Science You Build On.

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December 6, 2022

Project B2210849 - 1017 Carroll Street

Mr. Hunter Haley
FCA Construction
5609 Crawford Street, Suite A
Harahan, LA 70123

Re: Geotechnical Evaluation Report
Restore Louisiana Homeowner Assistance Program
Proposed Residence at 1017 Carroll Street
Westlake, Louisiana

Dear Mr. Haley:

We are pleased to present this Geotechnical Evaluation Report for the proposed residence to be located at the above referenced project site in Westlake, Louisiana. The attached report contains a descriptive review of available information, our field exploration program, engineering evaluation, interpretation of the results with respect to the project characteristics, our geotechnical recommendations for site preparation, foundation design, and construction guidelines for the planned project.

Thank you for making Braun Intertec Corporation your geotechnical consultant for this project. If you have any questions about this report, or if we can provide other services in support of our work to date, please contact our office.

Sincerely:

BRAUN INTERTEC CORPORATION
LA Firm Registration No. EF.0005739

Evan LeBouef, P.E.
Project Engineer

Alex Brochard, P.E.
Operations Manager/Senior Engineer

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BRAUN INTERTEC

A. Introduction

A.1. Project Description

The Restore Louisiana Program comprises new construction of residential homes at multiple locations across Louisiana that were previously damaged due to Hurricanes or other severe weather events. Based on the information provided by Mr. Hunter Haley, representing FCA Construction, Braun Intertec understands that the Client plans to construct a new single story, lightly loaded residence at 1017 Carroll Street in Westlake, Louisiana as part of the program. A geotechnical study was performed to evaluate the subsurface soil and groundwater conditions at the project site and to provide suitable foundation type, depth, and allowable loading capacity for the proposed elevated residential structure. We understand that the proposed foundation for the new residence will include a structurally suspended floor slab supported on 12-inch by 12-inch square treated timber piles.

FCA Construction provided the project information to Braun Intertec on October 25th, 2022, with a phone conversation and subsequent emails. The furnished information included a general description of the project including the project location, the Restore Louisiana Reconstruction Standards and Guidelines, and an environmental record and site evaluation.

The detailed grading information was not available during the time this report was prepared, however based on the information provided by the Client, Braun Intertec understands that the finished grade will be within one (1) foot of the existing site grade. It is also understood that the suspended floor slab for the raised building will be approximately 3 feet above finished grade.

The exact location of the new residence at the subject property is also not known at this time. Based on furnished information we understand that the footprint for the new construction will overlay the previously demolished building's footprint.

We have described our understanding of the proposed construction and site to the extent others reported it to us. Depending on the extent of available information, we may have made assumptions based on our experience with similar projects. If we have not correctly recorded or interpreted the project details, the project team should notify us. New or changed information could require additional evaluation, analyses and/or recommendations.

A.2. Purpose

The purpose of our geotechnical evaluation was to explore the subsurface soil conditions within the project site by performing soil borings at selected exploration locations, performing laboratory testing on selected soil samples to characterize the relevant engineering properties of the soil, and developing

geotechnical engineering recommendations to guide others in the design and construction of the foundations for the proposed residence.

A.3. Site Conditions and History

The project site is located at 1017 Carroll Street at the southwestern quadrant of the intersection of Gerald Washington Street and Carroll Street in Westlake, Louisiana. Available aerial imagery via Google Earth™ dating back to 1998 indicates that the project was occupied with a single-family residential dwelling at that time. Sometime following Hurricane Laura (August 2020), available imagery indicates the previous residence was demolished, removed from the project site, and replaced with a mobile home. At the time of our field exploration, the mobile home had been removed, however, remnants of the previous residence including a concrete slab was observed.

Based on our site visit at the time of field exploration and the information obtained from the Client, it is understood the proposed new building footprint will overlap the previously occupied building foundation area. During the time of our field exploration, the surficial soil appeared dry, and the ground surface topography appeared nearly level at the project site.

A.4. Scope of Services

Our scope of services for this project was to perform field exploration in general accordance with Braun Intertec's Proposal QTB168517 dated November 4, 2022. The following list describes the geotechnical tasks authorized in accordance with our authorized scope of services.

- Drilling and sampling two (2) soil borings, at accessible locations within the project site;
- Performing laboratory testing on selected soil samples collected during the field exploration program to aid in soil classification and engineering analyses;
- Preparing this report containing a boring location sketch, logs of soil borings, a summary of the soil types encountered in the borings, and results of laboratory tests; and
- Recommendations for subgrade preparation and the geotechnical recommendations for driven timber piles for support of the proposed new structure.

Our scope of services does not include environmental services. Braun Intertec personnel performing the geotechnical evaluation are not trained to provide environmental services or testing. However, we can provide these services or testing at your request.

A.5. Subsurface Exploration

The subsurface soil conditions at the project site were evaluated by drilling and sampling two soil borings to a depth of 20 feet below the existing ground surface. The approximate boring locations are shown on the Site and Boring Location Plan included in the Appendix of this report.

The soil borings were drilled with a track mounted Geoprobe drill rig using solid flight auger drilling techniques. Samples were obtained at 2 feet intervals from the ground surface to 10 feet below existing grade and at 5 feet intervals to the boring completion depth at 20 feet. The borings were sampled in general accordance with ASTM specifications. After the drilling, selected samples were placed in moisture-controlled bags and transported to our laboratory for additional testing.

A.6. Geotechnical Laboratory Testing

The soil samples obtained during the field exploration were transported to Braun Intertec's laboratory and selected soil samples were tested to determine material properties for engineering evaluation. Laboratory testing was accomplished in general accordance with ASTM procedures. Laboratory testing on selected soil samples included the following:

- *Moisture content tests (ASTM D2216)* – intended to aid in classification, evaluation of moisture condition, and estimation of engineering parameters;
- *Atterberg limits tests (ASTM D4318)* – intended to evaluate the soil plasticity, estimate whether the materials have the potential for shrink/swell, to aid in estimation of engineering parameters, and to evaluate the reusability of proposed cut/balance materials, and;
- *Unconfined compression tests (ASTM D2166)* – tests performed to measure the soil undrained shear strength.

Results of these laboratory analyses can be found on the boring logs in the Appendix.

B. Results

B.1. Geologic Overview

Braun Intertec's review of published geological information indicates the project site is mapped in an area identified as part of the Prairie Terraces Formation. Based on the geologic atlas and USGS formation description, the Prairie Terraces Formation consists of mostly light gray to brown clay, sandy clay, silt, and sand.

B.2. Soil Boring Results

The Appendix includes Log of Boring sheets for our test borings. The logs present the results of laboratory tests performed on selected soil samples with detailed descriptions of soils encountered during the time of our field exploration. A descriptive terminology key in the Appendix can be used to interpret terms used in the logs.

Stratigraphy boundaries were inferred from observations in the field, review of the samples, and laboratory test results. The boundaries selected are considered approximate and likely vary away from the specific boring locations. It should be noted that the soil strata boundaries selected may also occur as gradual rather than abrupt transitions.

Table 1 provides a generalized subsoil strata summary of the materials encountered during the subsurface exploration performed at the site.

Table 1: Subsoil Strata Summary

Strata	Soil Type - ASTM Classification	Depth (feet)[1]	Commentary and Details
Fill	SP, CL	0 - 2	▪ Moisture condition: generally dry ▪ Brown and gray in color
Lean Clay	CL	2 - 8	▪ Moisture condition: generally moist ▪ Brown and gray in color ▪ Generally medium to stiff
Fat Clay	CH	8 - 20	▪ Moisture condition: generally moist ▪ Reddish brown, brown, and gray in color ▪ Generally stiff to very stiff

Note: - 1. Reference from the existing grade at the boring locations.

B.3. Groundwater

During the time of drilling, observations were made in each borehole to determine the depth of groundwater. Groundwater was initially encountered in Boring B-1 at a depth of 13-ft and in Boring B-2 at a depth of 18 feet. After completion of drilling activities, the boreholes were immediately backfilled with auger cuttings in accordance with our scope of work. Should the project team identify a need for the determination of groundwater depth, Braun Intertec will be available to install piezometers upon request.

Note that the observation periods were relatively short, and project planning can expect groundwater levels to fluctuate in response to rainfall, flooding, irrigation, seasonal cycles, surface drainage modifications, and other factors. We recommend that the Contractor determine the actual groundwater levels at the area at the particular time of a given construction activity.

C. Recommendations

C.1. Demolition Considerations

As discussed previously, it is understood that the project site was previously occupied by an existing residence, which was demolished and removed from the site. Based on the information provided by the Client, Braun Intertec understands that the proposed new building footprint will overlap the existing old building foundation area and that demolition activities of the existing foundations may affect the new foundation design and construction. During demolition, removal of existing underground structures could disturb the surrounding subgrade soils and cause detrimental effects on construction of the proposed new residence at this site. Demolition activities at this site may result in pockets of loose soils or deleterious materials that remain below grade. Care should be exercised during site development to identify loose or disturbed soils and to remove and replace them with properly compacted fill.

The demolition activities should include the removal of the existing floor slab and grade beam system and other shallow below grade components such as underground utilities, if encountered. It is recommended that the existing shallow foundation system be removed in its entirety. For any existing pile or deeper foundation system, the pile portions of the existing foundations should be sawcut at least 24 inches below final grade and the site be graded and cleaned, as required. Voids left by removal of the below grade components should be backfilled with properly compacted fill soils. It is understood that a structurally suspended slab supported on timber piles will be used for the new foundation. Therefore, any existing deep foundation system should be identified so that the new foundation system does not interfere with the existing system.

C.2. Site Preparation

As discussed earlier, we understand that a raised structurally suspended floor slab supported on treated timber piles will be utilized for support of the proposed residence. It is understood that the elevation of the suspended floor slab for the new building will be approximately 3 feet above the elevation of the finished site grade. As there will be no grade supported structure, no significant site preparation is anticipated other than general site grading.

We do anticipate that some general site preparation will be required including stripping and removal of any topsoil, organic, demolition debris, existing foundation slabs/footings, utilities, and other deleterious materials from the construction area. The appropriate stripping depth should be determined by a representative of the Geotechnical Engineer at the time of construction.

Once subgrade preparation and observation have been completed, fill placement may begin as required to achieve final design grades. Adequate grades should be established within the proposed structure footprint to promote drainage away from the foundation areas, as ponding water could weaken the upper soils gradually over time.

Should more than one (1) foot of fill be placed within the footprint of the proposed structure, Braun Intertec should be notified to reevaluate the recommendations contained in this report. The fill should be placed in loose lifts not exceeding 8-inches per lift. The first layer of fill should be placed in a relatively uniform horizontal lift and be adequately keyed into the stripped and scarified subgrade soils. Compaction criteria may be waived in timber pile supported areas, but the fill should be compacted to near the density (approximately 100 to 110 pounds per cubic foot) of the existing near surface soils.

C.3. Rainwater Management

The initial step to prepare the construction site is to account for potential rainfall during construction. We recommend maintaining construction grades to intercept surface water flow into the area and drain water from the area to an appropriate collection point. Sumps and pumps may be required to remove rainwater from ditches and excavations. After grading, the contractor should compact the soil surface with a smooth drum roller to attempt to lower the infiltration potential of the compacted soil. After rain events, the contractor should limit construction traffic until the surface is dry enough that construction traffic will not mix accumulated surface water into lower portions of the soil.

The near surface soils encountered at the site are subject to reduction in shear strength, erosion, washout, and excessive settlement should these soils be allowed to become saturated. Therefore, Braun Intertec recommends adequate permanent drainage be provided to collect all rainfall away from the proposed foundation.

The contractor should also note that the on-site native clay soils are highly susceptible to rutting, disturbance, and a loss of shear strength due to moisture intrusion and repeated construction traffic. Disturbance of these soils may cause areas that were previously prepared, or that were suitable for structure support, to become unstable and require moisture conditioning and compaction.

C.4. Foundation Recommendations

C.4.a. Driven Timber Pile Foundations

Analyses have been made to estimate allowable compressive and tensile load capacities for various embedments of 12-inch square, treated timber piles for support of the proposed residence. The

estimated allowable compressive and tensile (or uplift) capacities for the 12-inch square timber piles are provided in Table 2. These capacities neglect skin friction for the uppermost 2-feet of pile penetration due to lateral movements and construction activities that would potentially reduce contact between the pile and supporting soil. Further, the pile capacities do not consider the weights of the piles. The net load of the pile material is considered negligible for timber piles.

Table 2: Timber Pile Capacities

Estimated Allowable Single Pile Capacity[1]		
Pile Embedment Length (feet)[2]	**Treated 12-inch Square Timber Piles**	
	Compression	**Tension**
10	13 – kips	5½ - kips
15	18½ - kips	9½ – kips
20	24 - kips	13 – kips

[1] *Capacities are soil-pile related capacities and consideration should be given to the structural integrity of the pile.*
[2] *Pile lengths are referenced from the existing site grade, and additional length should be added to the presented length to account for height of the structure. Piles driven to firm embedment into the stiff to very stiff clay stratum.*

C.4.b. Factor of Safety

The estimated pile capacities presented in Table 2 include minimum design factors of safety of two (2) in compression and three (3) in tension. These factors of safety assumes that static load testing and/or pile installation monitoring will not be conducted as part of the construction and installation of piles and foundations.

C.4.c. Lateral Loading Considerations

Analyses for lateral capacities of the timber piles are not included in our current scope of work. The structural engineer of record should determine lateral capacities once additional information including pile layout is known. Lateral loading due to anticipated wind loads may govern the required embedment depth of the piles. Braun Intertec should be retained to provide soil parameters for lateral capacity analysis.

C.4.d. Timber Pile Assumptions

The presented pile embedment lengths were evaluated for 12-inch square treated (non-tapered) timber piles to support the proposed residence. The treated timber piles should conform to the treatment and quality criteria outlined in ASTM D25.

Braun Intertec anticipates the timber piles utilized for support of the proposed structure will derive the majority of their capacity through friction in the underlying stiff clay deposits. Note, variations in the clays could be encountered; therefore, piles should be installed by experienced personnel. Field personnel installing piles should monitor the penetration resistances/log all job piles during installation and driveability characteristics should be evaluated with respect to the conditions encountered in the soil borings.

The timber piles should meet the American Wood Preservers Association Standards regarding quality as outlined in Section 1014 of the Louisiana Standard Specifications for Roads and Bridges, 2016 edition (LSSRB). Treatment of the piles should also follow Section 812 where applicable. The capacities presented herein are based on a soil-pile relationship. The structural capacity of the piles themselves and their ability to withstand the associated capacities have not been evaluated. A structural engineer should evaluate the piles for their structural integrity to maintain the capacities presented.

C.4.e. Timber Pile Installation

Pile driving hammers used to drive foundation piles should be selected according to pile type, length, size, and weight of pile, as well as potential vibrations resulting from pile driving operations. Care should be taken to assure that the hammer selected is capable of achieving the desired penetration without causing damage to the piles. Generally, the local contractor will select a hammer based on their localized experience. Driving large timber piles should be limited to the refusal rate of 25 blows per foot using a Vulcan No. 1 hammer or similar. In lieu of the Vulcan No. 1, a single acting air hammer having a manufacturer's rating of 15,000 ft-lbs. per blow may also be considered. These recommendations are provided to minimize the risk of damaging the piles during installation.

It is recommended that probe type piles be driven at the site to establish driving characteristics and pile lengths. While it is believed the piles could be driven several feet into the stiff clay deposits without severe damage, the piles should be closely observed and if "refusal" or little or no penetration under several successive blows occurs, driving should be ceased. Probe piles should be of the same type and size as the job piles and should be installed with the same equipment and techniques that would be used to install the production piles.

Each pile should be driven to the desired tip elevation and driving resistance should be monitored without interruption in the driving operations. Driving of the center piles first will better facilitate driving operations. Accurate records of the final tip elevation and driving resistances should be obtained during the pile driving operations. Some pile heaving may be experienced during installation of adjacent displacement type piles. It is therefore recommended that the Contractor record and monitor pile elevations, and if significant heave is noted after driving subsequent piles, provisions must be made for reseating them.

Predrilling and/or prepunching generally not recommended for driving the piles. However, predrilling or prepunching may be required if buried hard objects or debris are encountered at relatively shallow depths. Predrilling may also be needed to reduce vibration which may cause damage to the nearby existing structures. In either case, the drill bit or punch diameter should not exceed the size of the pile tip. Predrilling should be ceased as soon as the debris or buried hard object is fully bypassed and the piles then driven with normal driving effort to the desired pile tip depth. Predrilling should be ceased at least six feet above the desired tip depth and the piles then driven with normal driving effort to the desired pile tip depth. If predrilling or prepunching is utilized Braun Intertec should be notified to reevaluate the provided allowable pile load capacities.

C.4.f. Pile Installation Monitoring

We recommend the piles be monitored during installation. Braun Intertec can provide these services at your request. Hammer blows and performance of the hammer are both important variables that need to be examined during driving. Poor hammer performance can result in premature refusal before a pile has reached a competent bearing layer.

C.4.g. Pile Driving Hammer Selection and PDA Testing

Selection of an appropriate hammer depends on several factors such as hammer performance, cushion type and size, pile type, pile size and length, pile weight, predicted or required pile capacity, soil resistance, etc.

The selected hammer must be able to drive the pile to the required capacity or length without damaging the pile. Generally, experience of local contractor is often the primary source for the selection of the hammer. Wave equation analysis of piles (WEAP) may be used to aid in hammer selection. In the field, dynamic testing using a Pile Dynamic Analyzer (PDA) can be used on the test piles to select a proper hammer, predict driving resistance, evaluate the stresses in the piles, and estimate ultimate capacity of the piles during pile installation. However, it is the responsibility of the contractor to select the proper hammer type that will provide enough energy to drive the pile to bearing. Once the design is finalized, Braun Intertec can be contacted to perform further analysis, assist with hammer selection, and perform the PDA testing services.

C.4.h. Pile Settlement from Structural Loads

No detailed settlement analyses were made since design structural loads, pile length, pile layout, etc. are not known at the present time. However, settlements of the proposed structure supported on a timber pile foundation system using the recommended pile load capacities in single widely spaced rows may settle ½ to 1 inch under sustained structural loading.

The spacing between driven piles can affect the capacities and settlements presented in this report. Piles must maintain a center-to-center spacing of 3 times the side dimension of the pile. Closer spacing will require reductions in the skin friction values. The published results indicate that the efficiency factor of a single isolated pile in a group may range from 0.5 to 1.0 depending on the number of piles in a group or their spacing.

D. Qualifications

D.1. Variations in Subsurface Conditions

Braun Intertec has developed our evaluation, analyses, and recommendations from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth. Therefore, we must infer strata boundaries and thicknesses to some extent. Strata boundaries may also be gradual transitions, and project planning should expect the strata to vary in depth, elevation, and thickness, away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until performing additional exploration work or starting construction. If future activity for this project reveals any such variations, you should notify us so that we may reevaluate our recommendations. Such variations could increase construction costs, and we recommend including a contingency to accommodate them.

D.2. Continuity of Professional Responsibility

D.2.a. Plan Review

We based this report on a limited amount of information, and we made a number of assumptions to help us develop our recommendations. Braun Intertec should be retained to review all geotechnical aspects of the designs and specifications. This review will allow us to evaluate whether we anticipated the design correctly, if any design changes affect the validity of our recommendations, and if the design and specifications correctly interpret and implement our recommendations.

D.2.b. Construction Observations and Testing

We recommend retaining Braun Intertec to perform the required observations and testing during construction as part of the ongoing geotechnical evaluation. This will allow us to correlate the subsurface conditions exposed during construction with those encountered by the borings and provide professional continuity from the design phase to the construction phase. If we do not perform observations and testing during construction, it becomes the responsibility of others to validate the assumption made during the preparation of this report and to accept the construction-related geotechnical engineer-of-record responsibilities.

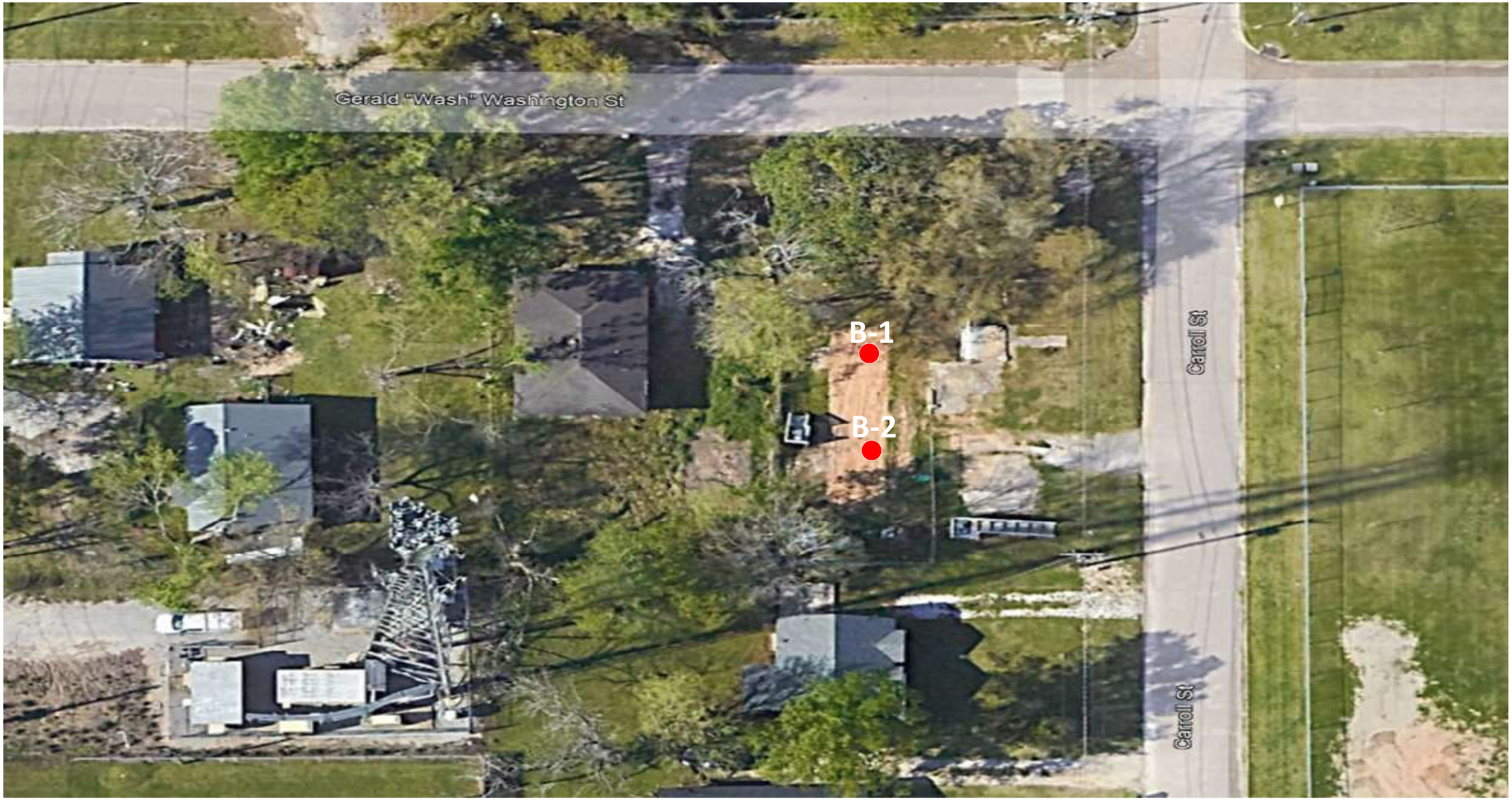
D.3. Use of Report

This report is for the exclusive use of the addressed parties. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

D.4. Standard of Care

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Appendix



● DENOTES APPROXIMATE LOCATIONS OF THE 20-FT SOIL BORINGS

NOTE: - PROPOSED BORING LOCATIONS ARE NOT TO SCALE
- BORINGS ADVANCED TO NOMINAL DEPTHS OF 20-FEET BELOW EXISTING GRADE

BRAUN INTERTEC The Science You Build On.	LOCATION: WESTLAKE, LOUISIANA	
	PROJECT NO. B2210849	
PROJECT NAME: LOUISIANA RESTORE PROGRAM - CAROLL STREET		
DRAWN BY: E.L.	CHECKED BY: E.M.	DATE: 11/23/22

BRAUN INTERTEC
The Science You Build On.

LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2210849
Geotechnical Evaluation
Restore Louisiana Program
Carroll Street
Westlake, Louisiana

BORING: **B-1**
LOCATION: See attached sketch
DATUM: WGS 84
LATITUDE: 30.24566 LONGITUDE: -93.26568
DRILLER: K. Currie LOGGED BY: K. Currie START DATE: 11/10/22 END DATE: 11/10/22
SURFACE ELEVATION: NA RIG: Ardco-1 METHOD: SSA SURFACING: Grass WEATHER: Sunny

Elev./ Depth ft	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (Blows/ft) Recovery	q_p tsf	MC %	%Pass No. 200	Atterberg Limits LL	PL	PI	Dry Unit Wt. pcf	Un. Com. Str. tsf	Tests or Remarks
2.0	FILL: SANDY LEAN CLAY (CL), brown and gray, very stiff		SH	4.50	10							
4.0	SANDY LEAN CLAY (CL), gray, medium		5-3-5 (8)		19							
	LEAN CLAY (CL), brown and gray, stiff		3-5-7 (12)		18					111		
8.0			SH	2.00	22		47	14	33	105	1.84	
	FAT CLAY (CH), reddish brown and gray, stiff		SH	2.50								
			SH	2.00			77	23	54			
18.0												
20.0	FAT CLAY (CH), gray, very stiff		SH	4.00	18					112	2.38	
	END OF BORING											
	Boring immediately backfilled											

Water observed at 13.0 feet while drilling.

BRAUN INTERTEC
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LOG OF BORING

See Descriptive Terminology sheet for explanation of abbreviations

Project Number B2210849
Geotechnical Evaluation
Restore Louisiana Program
Carroll Street
Westlake, Louisiana

BORING: **B-2**
LOCATION: See attached sketch
DATUM: WGS 84
LATITUDE: 30.24558 LONGITUDE: -96.26569
DRILLER: K. Currie LOGGED BY: K. Currie START DATE: 11/10/22 END DATE: 11/10/22
SURFACE ELEVATION: NA RIG: Ardco-1 METHOD: SSA SURFACING: Grass WEATHER: Sunny

Elev./ Depth ft	Water Level	Description of Materials (Soil-ASTM D2488 or 2487; Rock-USACE EM 1110-1-2908)	Sample	Blows (Blows/ft) Recovery	q_p tsf	MC %	%Pass No. 200	Atterberg Limits LL	PL	PI	Dry Unit Wt. pcf	Un. Com. Str. tsf	Tests or Remarks
		FILL: POORLY GRADED SAND (SP), brown and gray, loose		2-3-2 (5)		15							
2.0		SANDY LEAN CLAY (CL), gray, medium		2-3-4 (7)		16					104		
4.0		LEAN CLAY (CL), brown and gray, stiff		SH	2.50	17		47	13	34	111	2.5	
				SH	3.00	22							
8.0		FAT CLAY with SAND (CH), brown and gray, stiff		SH	1.50			57	17	40			
				SH	3.00	32					91	1.32	
	▽			SH	2.50	28					100	2.04	
20.0		END OF BORING Boring immediately backfilled											

Water observed at 18.0 feet while drilling.

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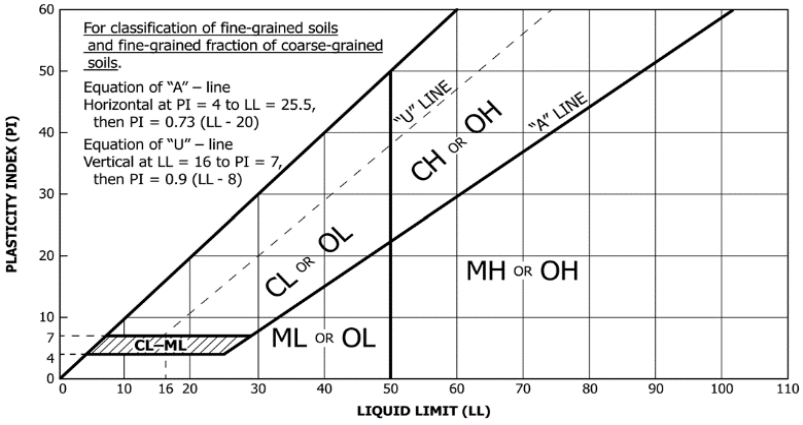
Descriptive Terminology of Soil

Based on Standards ASTM D2487/2488
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse-grained Soils (more than 50% retained on No. 200 sieve)	Gravels (More than 50% of coarse fraction retained on No. 4 sieve)	Clean Gravels (Less than 5% fines[C])	$C_u \geq 4$ and $1 \leq C_c \leq 3$[D]	GW	Well-graded gravel[E]
			$C_u < 4$ and/or ($C_c < 1$ or $C_c > 3$)[D]	GP	Poorly graded gravel[E]
		Gravels with Fines (More than 12% fines[C])	Fines classify as ML or MH	GM	Silty gravel[E F G]
			Fines Classify as CL or CH	GC	Clayey gravel[E F G]
	Sands (50% or more coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5% fines[H])	$C_u \geq 6$ and $1 \leq C_c \leq 3$[D]	SW	Well-graded sand[I]
			$C_u < 6$ and/or ($C_c < 1$ or $C_c > 3$)[D]	SP	Poorly graded sand[I]
		Sands with Fines (More than 12% fines[H])	Fines classify as ML or MH	SM	Silty sand[F G I]
			Fines classify as CL or CH	SC	Clayey sand[F G I]
Fine-grained Soils (50% or more passes the No. 200 sieve)	Silts and Clays (Liquid limit less than 50)	Inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K L M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K L M]
		Organic	Liquid Limit – oven dried / Liquid Limit – not dried <0.75	OL	Organic clay[K L M N] / Organic silt[K L M O]
	Silts and Clays (Liquid limit 50 or more)	Inorganic	PI plots on or above "A" line	CH	Fat clay[K L M]
			PI plots below "A" line	MH	Elastic silt[K L M]
		Organic	Liquid Limit – oven dried / Liquid Limit – not dried <0.75	OH	Organic clay[K L M P] / Organic silt[K L M Q]
Highly Organic Soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

A. Based on the material passing the 3-inch (75-mm) sieve.
B. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
C. Gravels with 5 to 12% fines require dual symbols:
   GW-GM well-graded gravel with silt
   GW-GC well-graded gravel with clay
   GP-GM poorly graded gravel with silt
   GP-GC poorly graded gravel with clay
D. $C_u = D_{60} / D_{10}$ $C_c = (D_{30})^2 / (D_{10} \times D_{60})$
E. If soil contains ≥ 15% sand, add "with sand" to group name.
F. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
G. If fines are organic, add "with organic fines" to group name.
H. Sands with 5 to 12% fines require dual symbols:
   SW-SM well-graded sand with silt
   SW-SC well-graded sand with clay
   SP-SM poorly graded sand with silt
   SP-SC poorly graded sand with clay
I. If soil contains ≥ 15% gravel, add "with gravel" to group name.
J. If Atterberg limits plot in hatched area, soil is CL-ML, silty clay.
K. If soil contains 15 to < 30% plus No. 200, add "with sand" or "with gravel", whichever is predominant.
L. If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
M. If soil contains ≥ 30% plus No. 200 predominantly gravel, add "gravelly" to group name.
N. PI ≥ 4 and plots on or above "A" line.
O. PI < 4 or plots below "A" line.
P. PI plots on or above "A" line.
Q. PI plots below "A" line.



Laboratory Tests

DD	Dry density, pcf	**q_p**	Pocket penetrometer strength, tsf
WD	Wet density, pcf	**q_U**	Unconfined compression test, tsf
P200	% Passing #200 sieve	**LL**	Liquid limit
MC	Moisture content, %	**PL**	Plastic limit
OC	Organic content, %	**PI**	Plasticity index

Particle Size Identification

Boulders..... over 12"
Cobbles..... 3" to 12"
Gravel
  Coarse..... 3/4" to 3" (19.00 mm to 75.00 mm)
  Fine..... No. 4 to 3/4" (4.75 mm to 19.00 mm)
Sand
  Coarse..... No. 10 to No. 4 (2.00 mm to 4.75 mm)
  Medium..... No. 40 to No. 10 (0.425 mm to 2.00 mm)
  Fine..... No. 200 to No. 40 (0.075 mm to 0.425 mm)
Silt..... No. 200 (0.075 mm) to .005 mm
Clay..... < .005 mm

Relative Proportions[L, M]

trace..... 0 to 5%
little..... 6 to 14%
with..... ≥ 15%

Inclusion Thicknesses

lens..... 0 to 1/8"
seam..... 1/8" to 1"
layer..... over 1"

Apparent Relative Density of Cohesionless Soils

Very loose ..... 0 to 4 BPF
Loose ..... 5 to 10 BPF
Medium dense..... 11 to 30 BPF
Dense..... 31 to 50 BPF
Very dense..... over 50 BPF

Consistency of Cohesive Soils	Blows Per Foot	Approximate Unconfined Compressive Strength
Very soft	0 to 1 BPF	< 0.25 tsf
Soft	2 to 4 BPF	0.25 to 0.5 tsf
Medium	5 to 8 BPF	0.5 to 1 tsf
Stiff	9 to 15 BPF	1 to 2 tsf
Very Stiff	16 to 30 BPF	2 to 4 tsf
Hard	over 30 BPF	> 4 tsf

Moisture Content:

Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp but no visible water.
Wet: Visible free water, usually soil is below water table.

Drilling Notes:

Blows/N-value: Blows indicate the driving resistance recorded for each 6-inch interval. The reported N-value is the blows per foot recorded by summing the second and third interval in accordance with the Standard Penetration Test, ASTM D1586.

Partial Penetration: If the sampler could not be driven through a full 6-inch interval, the number of blows for that partial penetration is shown as #/x" (i.e. 50/2"). The N-value is reported as "REF" indicating refusal.

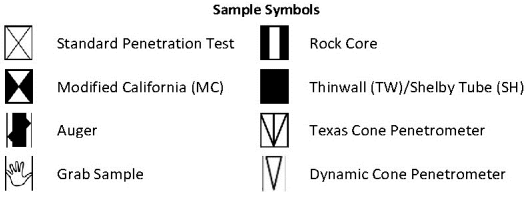
Recovery: Indicates the inches of sample recovered from the sampled interval. For a standard penetration test, full recovery is 18", and is 24" for a thinwall/shelby tube sample.

WOH: Indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WOR: Indicates the sampler penetrated soil under weight of rods alone; hammer weight and driving not required.

Water Level: Indicates the water level measured by the drillers either while drilling (▽), at the end of drilling (▼), or at some time after drilling (▼).

Sample Symbols



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