PRELIMINARY
GEOLOGIC-GEOTECHNICAL INVESTIGATION
FOR THE PROPOSED
LA SABANA RESIDENTIAL DEVELOPMENT
VEGA BAJA, PUERTO RICO

January 18, 2008

Geo Cim Inc. Job No. 3709-07

Geo Cim LUIS O. GARCIA & ASSOCIATES
GEOTECHNICAL ENGINEERING CONSULTANTS

Partners
Luis Oscar García, MSCE, CE, PE
Carlos García Echevarría, MSCE, PE
James A. Baigés, MSCE, PE

Associate
Alejandro E. Soto, MS, PG

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1 - INTRODUCTION

This report presents the results of a preliminary geologic-geotechnical assessment of the site of the proposed La Sabana Residential Development project in Pugnado Afuera Ward of the Municipality of Toa Alta. The purpose of the assessment was to obtain preliminary information on the geology and geotechnical features of the site for use in preliminary project design and for the preparation of environmental documents for the project. The work was performed in conformance with our proposal dated August 21, 2007 as approved by Mr. Alex Rubí of Mora Development, the Project Owner. Preliminary results of the investigation were discussed with the Client during meetings on October 9 and December 13 and a site visit on October 10, 2007.

2- PROJECT SETTING

The project site occupies an irregular-shaped parcel of approximately 335 "cuerdas" in the northern part of the Northern Puerto Rico Karst region. The property straddles the south margin of a broad plain approximately 2 km. south-southwest of the town of Vega Baja and 1.5 km. west of the valley of the Río Indio (Figure 1). Karstified limestone hills (mogotes) and ridges make up the southern and eastern parts of the property (Figure 1), whereas the northern portion is a gently undulating plain with a net northerly slope that is broken by several surface depressions that drain internally. The plain extends beyond the north property boundary where the Vega Serena Urbanization is currently under construction. The La Sabana development will consist of single-family residential structures with the appurtenant infrastructure to be constructed on the plain; excepting a northeast-trending ridge at the southwest margin of the plain and several low hills in the northeast tip of the property, the limestone highlands will remain undeveloped.

Figure 2 shows a portion of the Manatí 7.5' topographic quadrangle geologic map published by the U.S. Geological Survey (USGS)[1] that includes the project site area. The map indicates that the limestone hills and ridges consist of Aymamón Limestone (orange-colored unit identified as *Tay* on Figure 2) of Miocene age that is described as consisting of "massive to thick-bedded very pure fossiliferous limestone generally indurated by secondary cementation into finely crystalline rather dense limestone". The Aymamón is underlain by Aguada Limestone that outcrops along the base of the south side of several of the limestone hills and ridges in the eastern part of the property. The Aguada is described as thick layers of calcarenite and chalky and rubbly limestone. The strata in both formations dip gently northward. Both geologic units have undergone extensive karstification.

The northern plain area is mapped as Pleistocene Blanket deposits. These soils, common in lowland areas throughout the Aymamón and Aguada Limestone outcrop in northern Puerto Rico, consist of mixtures of clay, fine-grained quartz sand, and oxides. Within the property they are segregated into 3 units: relatively pure silica sand (*Qss* on Figure 2), sandy Blanket deposits (*QTbs*), and clayey Blanket deposits (*QTbc*). The Blanket soils are underlain by Aymamón and/or Aguada Limestone strata at depths of up to 100 feet (30 meters). The buried limestone surface is likely to exhibit relief comparable to that of the limestone hill and ridge areas to the south and east.

The USGS did not recognize any geologic faults in the vicinity of the site.

3- SITE INVESTIGATION ACTIVITIES

The following activities provided the data used in this evaluation:

1. Photointerpretation using aerial photographs of the general site area that were taken in the early 1930s, 1937, 1963, 1978, 1982, and 1997, a 60+ year span, to assess surface

[1] Monroe, W.H., 1971; *Geologic Map of the Manati Quadrangle, Puerto Rico*; USGS Misc. Geol. Investigation Map I-671; 1:20,000.

processes that may be active in the general site area. Table 1 lists the aerial photographs used.

2. Site reconnaissance of the plain area and its margins to observe the composition, distribution, and structure of the earth materials that underlie the area and any other pertinent geologic features that may influence the proposed activity.
3. Drilling seven exploratory borings within the plain to obtain information about the composition, distribution, and gross geotechnical characteristics of the subsurface materials in the area to be developed. The boring sites were flagged in the field during the site reconnaissance and were surveyed after they were drilled. The boring locations are shown on Figure 3 and Table 2 provides general information about each boring. The borings were distributed so as to sample different parts and topographic features on the plain.

    Drilling was performed using the "Hollow Stem Auger-Dry Sample" method of drilling whereby samples are collected with a standard 1.5-foot long split-spoon sampler during the performance of the Standard Penetration Test (SPT; ASTM D-1586)[2]. Samples were collected at 1.5-foot depth intervals beginning at the ground surface to a depth of 10 feet, after which sampling occurred at 5-foot depth intervals.

    The collected samples were placed in tightly closed plastic bottles and transported to the Geo Cim, Inc. laboratory in Guaynabo for routine laboratory tests including unconfined compression (determined using a spring tester and/or a pocket penetrometer) and natural moisture content determination, and for visual/manual soil description following standard laboratory procedures. Additionally, 6 representative samples were selected for classification testing to confirm the field classifications and further characterize the engineering properties of the soils encountered. The classification tests included grain size distribution analysis (ASTM D-1140) and determination of plasticity characteristics in accordance with the Atterberg Limits testing procedure (ASTM D-

[2] The SPT entails recording the number of blows required to drive the 18-in. long split-spoon sampler into the soil. The number of blows required to drive the last 12 inches of the sampler, termed the N-value, is an empirical measure of soil density and consistency.

4318; 3-Point Method). The test results, summarized in Table 3, were used to classify the soils in accordance with the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO). Detailed descriptions of the soils encountered at each boring are contained in the boring logs provided in Appendix A. Appendix B contains the Classification Test reports.

4. Data analysis and preparation of this report.

4- SITE CONDITIONS

A review of aerial photography of the site area spanning the period from the early 1930's to the present shows a variety of agricultural pursuits on the plain during this time. Crops change from orchard (reportedly grapefruit) and sugar cane in the 30's photos, sugar cane and pineapple in 1963, pineapple and pasture in 1982, and pasture in 1997. Additionally, sand extraction appears to have occurred sporadically in the west-central part of the project area. In contrast, there was little activity on the limestone hills and ridges, allowing dense forest to develop on the higher portions of the property.

The subsurface conditions observed at the site are in general agreement with the geology portrayed on the USGS geologic map. Blanket deposit soils mantle the plain extending to depths of at least 25 feet (the maximum boring depth). These were sampled as clay, silt, fine quartz sand, and clay-dominated mixtures of these, the latter making up most of the soils sampled. None of the borings penetrated the underlying limestone but the lower part of Boring B-1 sampled a mixture of recrystallized to thoroughly weathered limestone fragments and medium stiff clay with trace to little fine quartz sand that represents a transition zone between Blanket soil and limestone (Appendix A). The limestone observed along the edges of the hills and ridges exhibits features associated with mature karst that includes one large surficial solution opening. We also observed some colluvial material along the ridge-hill margins, and there is man-made garbage scattered about the property.

The USGS map is a relatively accurate representation of the distribution and relative proportion of clayey and sandy soil at the site. The quartz sand occurs mostly along north-trending, low ridges in the northwest part of the property. The sand is loose to medium dense with density increasing with depth. A sample from Boring B-7 was tested and found to contain close to 95% sand that based on visual examination consists almost entirely of fine, angular to subangular quartz. The rest of the plain is underlain by clayey soil that occasionally contains lenses of quartz sand.

The clayey soils are medium stiff to hard. Natural moisture contents in these soils typically fall within the 22 to 35 percent range with occasional values of 35 to 40 percent. The five samples of Blanket clayey soil tested classified as low (CL) and high (CH) plasticity clay in accordance with the USCS (Table 3).

The Blanket deposit plains of northern Puerto Rico contain numerous surface depressions that formed in response to underground erosion of Blanket soil via solution cavities in the underlying karstified limestone. Several of these depressions occur within the property. The most prominent are identified by the letters A to H on Figure 3. All but one are evident in all or most of the air photos, and all can be seen in the field. Depressions A and B located in the southwest part of the plain are the most prominent features; they are relatively deep and have relatively large, well defined runoff catchment areas. Depression C, which straddles the property boundary also has a large catchment basin but is not as deep as A and B. Though smaller, Depression E is another distinct feature. This, however, was not always the case. It does not appear in its present shape until the 1982 photos; in earlier photographs it appears as part of an irregular-shaped, shallow depression area with a northeast elongation. In the 1982 photos it has the sharp appearance of today, and seems to be surrounded by a low earth dike, suggesting it was modified with earth-moving equipment, in line with information provided by a local resident who informed us the depression was created to collect runoff from the surrounding area. In the 1997 photos there is a drainage ditch that enters the depression from the northwest and a shallow, irregular gully-like feature that appears to bring in runoff from the area of Depression D to the southwest.

Depressions D and F are irregular-shaped, low relief depressions with long axes that trend northeast to north-northeast. In some photos one can discern a distinct low point at each site but in the more recent photos the depressions are not evident or barely evident. Depression G, a shallow, east-west trending feature, is the most extensive depression within the property. As with the other depressions, it does not appear to change much from photo to photo, except in the 1982 photos where 2 distinct internal depressions, one of which appears man-made, are visible near the east margin of the feature; neither of these is evident in the 1997 photos. We also observed a small, shallow depression at H. This is the smallest of the depression features and is not evident in the aerial photographs; it is presently filled with man-made garbage.

Borings B-1, B-3, B-4, and B-5 were drilled within depressions whereas B-2, B-6, and B-7 were located outside the depressions. Excepting B-7, located on a quartz sand ridge, the soils encountered are predominantly clayey. Soil stiffness values in the vicinity of more prominent (and presumably more active) depressions are typically lower than those observed in the less pronounced depressions and at the borings drilled outside the depressions, a pattern we have observed in other plains floored by Blanket deposits.

In addition to the surface depressions observed on the plain, there is a large surface opening or shaft in limestone at the edge of the limestone ridge at location I. A man-made ditch that extends along the edge of the ridge to the shaft conducts runoff from the ridge to the opening.

Another characteristic of the Blanket soil plains of northern Puerto Rico is that they usually lack surface drainage features. Rainfall and runoff that enters the plains is lost to evapotranspiration or infiltrates underground to recharge the local groundwater system, the surface depressions acting as important runoff collection points. No groundwater was observed in the borings and we know of no wells within the property. According to the USGS[3], the regional groundwater table in the La Sabana site area occurs between elevation 15 and 30 meters above sea level. The Manatí topographic quadrangle map shows ground elevations on the plain at the site vary within an approximate range of 60 to 85 meters. The water table therefore occurs at depths in excess of 30 meters (100 feet). However, it is likely that perched water bodies form above zones of low permeability soil or rock.

[3]Renken, R.A. and others, 2002; *Geology and Hidrogeology of the Caribbean Islands Aquifer System of the Commomwealth of Puerto Rico and the U.S. Virgen Islands*, U.S. Geol. Survey Prof. Paper 1419; 139p.

5- DISCUSSION

There are 2 significant geologic-geotechnical limitations to development in most Blanket deposit plains in northern Puerto Rico, as is the case at the La Sabana project site. One is the presence of closed depressions that result from localized ground subsidence, and the potential for continued sinking of the ground. The second is the absence of surface drainage features to dispose of runoff from rainfall, which naturally exits the plains via well-integrated subterranean karst plumbing systems. As noted above, the loci of subsurface infiltration are the surface depressions so the two limitations are closely related, more so because it is the subsurface erosion of Blanket soils into cavities in the underlying limestone by percolating groundwater that causes the subsidence, a process that may occur gradually or rapidly.

These limitations can be addressed successfully with engineering measures, as evidenced by modern developments on Blanket soil plains from Vega Alta to Aguadilla. The basis for most subsidence control measures is to minimize subsurface erosion by reducing infiltration or constructing direct drainage paths to the underlying limestone such that runoff does not contact the Blanket soil. The later also addresses the drainage problem and what is typically done on projects that cover large areas with multiple depressions is to select one or several of these to develop as injection sites that process the project runoff. A critical consideration in the selection is the infiltration capacity at a given depression, which can be estimated from field tests. The injection system usually includes a retention pond that helps remove solids and regulates flow into the infiltration works. The La Sabana project will benefit from a runoff collection/injection system constructed for the Vega Serena Urbanization along the northeast property boundary. The Project Owner has indicated that part of the runoff from the La Sabana project will be conducted to the Vega Serena retention pond via drainage channels and underground pipes.

Rocks of all type weather along fractures and other discontinuities such as bedding planes that are preferential paths for groundwater flow. In most rocks this produces surficial and fracture-filling soil residues that must await removal by water or other erosive agents. In limestone, however, weathering entails dissolution of the rock and the weathering products are carried away by groundwater, leaving behind networks of solution openings through which underground water flows.

There are eight (8) Blanket soil depressions and one known open limestone shaft within the La Sabana project. Their distribution provides a glimpse of the nature of the site's subterranean plumbing system. Excepting Depression G, which is elongated in an east-west direction, the La Sabana depressions are aligned, and in some cases elongated along northeast and north-northeast trends (Figure 3). Not coincidentally, these are the orientations of limestone ridges south and east of the Blanket deposit plain (Figure 3). Taken together, these topographic lineaments point at the presence of prominent northeast to north-northeast trending fractures in the Aymamón and Aguada Limestone formations. Preferential infiltration and dissolution along these features produced the surface topography we see today and similarly oriented subterranean openings and zones of preferential groundwater migration that became expressed at the ground surface as Blanket soil eroded into the openings. The east-west elongation of Depression G coincides with the strike of the north-dipping limestone strata and is probably related to enhanced dissolution and subsurface soil erosion along bedding planes.

Considering the above, any of the existing depressions is potentially a good site to locate a structure to conduct runoff to the subterranean karst drainage. Unfortunately, and excepting the limestone shaft at I, the entrance to the underground network is covered by clay-rich Blanket soil that slows infiltration (recall that none of our borings reached limestone). We visited the site early in the morning of October 29th following 4 days of rain during which precipitation in the area was on the order of 3 to 4 inches (7.5 to 10 cm.), a significant, though not extraordinary event. Only Depressions A and B had standing water (small pools less than a foot deep); all the others were dry so runoff was able to infiltrate underground. There is evidence of ponding (including standing water) at the bottom of Depressions A an B in all of the air photos. Ponding is also apparent at the other large depressions (C and G) in some of the photos, most notably those from 1982 that appear to have been taken following a significant a rain event (bare erosion gullies are seen on some of the depression walls and elsewhere in the property)[4]. This is not

[4] The 1982 edition of the USGS topographic quadrangle map (Figure 1) shows Depression A as under water. The pond is not shown in an earlier (1946) map edition. Furthermore, the 1982 photos are the only ones that show a significant portion of the depression under water. Area residents state there has never been a permanent lake or pond at the site. The topographic quadrangle maps are revised using photogrametry; the 1982 map revisions are based on unspecified aerial photographs taken in 1977; it is interesting to note that Depression A is dry in the 1978 photos.

surprising since large volumes of runoff reach the low parts of these depressions, and once there, it must infiltrate through low permeability clayey soil. Furthermore, the runoff carries fine soil eroded from the depression walls that is deposited on the depression floor further retarding percolation. At the same time, eroded soil can accumulate in the underlying limestone solution openings causing temporary or long-term obstructions to groundwater movement.

Nevertheless, high permeability zones occur in the underlying limestone, and it is reasonable to assume that these are more extensive below the larger depressions, making them prime targets for additional subsurface exploration and field testing to identify injection sites and design the injection works. Depression E is another site that should be evaluated. The fact it was once deepened and runoff from other drainage cells was diverted to it suggest it has a good infiltration capacity. This is also true for the open limestone shaft at I, which at first glance looks like it should be capable of handling large volumes of water. Both sites should be evaluated to determine the role they can play in the project's drainage system.

Ground settlement due to subterranean erosion is also greater at the larger depressions; that's why they're wider and deeper. Settlement may occur gradually or rapidly. We witnessed an example of the latter when a roughly 10-foot (3-meter) deep, 15-foot (4.5-meter) wide hole formed in Depression A, about 100 feet (30 meters) south-southwest of the depression low point. The missing soil escaped via a tortuous cavity about 2 feet (0.6 meter) wide that angled down and away from the floor below the north wall of the new depression. The walls of the hole and drainage cavity consisted of Blanket soil. No one saw the ground collapse but it probably occurred in a matter of minutes during a strong, short-duration rain event.

This is the only documented instance of sudden ground subsidence at the site that we know of. Local residents professed no knowledge of other events, and there is no indication of rapid collapse in the air photos. Depressions A, B, and C don't change much from photo to photo. Minor variations in surface configuration are visible in the vicinity of the other depressions but these could be caused by differences in vegetation height or density or they could have been created by human activity. There is evidence that this may be the case with the changes observed at Depressions E and G in the 1982 photos.

Future collapse events could occur at all the depressions, but the potential for this is greater at the large depressions (A, B, C, and to a lesser extent G), where they are likely to have occurred in the past, than at the smaller ones that could have formed by slow subsidence. Our experience with ground subsidence in the Blanket soil plains is that collapse events typically occur at or in the vicinity of previous collapse failures. On this basis, the potential is greater at Depression A than at other depressions. Nevertheless, the recurrence of collapse events at any depression may take tens to hundreds of years; the air photo data suggest the Depression A event followed more than 70 years of inactivity, and the other depressions appear not to have experienced any events during this period. Furthermore, humans can influence the occurrence of these events. Activities that increase subsurface erosion result in more frequent collapses; the highest collapse frequencies we have seen occur in areas with many septic tanks that provide a constant subsurface erosive flow. Conversely, reducing or eliminating infiltration greatly reduces the likelihood of collapse.

6- PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

We have found no geologic or geotechnical feature that would preclude the proposed development. The Blanket deposit soils that underlie the site will generally provide adequate bearing support for single-family residential structures and community facilities, which can be founded on conventional shallow foundations. The critical geologic-geotechnical issues for the project revolve around controlling surface drainage. The development will render large tracts that are paved over impervious. Paved areas will not infiltrate and the resulting runoff must flow directly into the project storm drain system. Non-paved areas must be graded so runoff moves quickly to collection points connected to the system. Good surface drainage decreases infiltration, reducing subsurface erosion and the potential for rapid ground subsidence. It also increases discharge at disposal sites, which must transfer runoff to the underground limestone drainage network without itself inducing subsurface erosion of the Blanket soils.

Although a portion of the runoff that will be generated within the La Sabana project area will be conducted to the runoff collection/injection system constructed for the Vega Serena Urbanization, specific details of the project drainage system will not be known until the conclusion of additional geotechnical and hydrologic-hydraulic studies that are necessary to complete project design. Several critical issues that these studies must address are listed below.

1. Depressions A, B, E, and G and the limestone shaft at I have the best potential for development as injection sites and should be studied for this purpose. The infiltration structures will have to bypass the Blanket soils and discharge into limestone of adequate permeability.
2. In addition to providing foundation and earthwork recommendations, the project geotechnical study should:
   a. Evaluate the presence of open cavities in the Blanket soil within the depressions that portend sudden collapse settlement; the assessment should combine exploratory borings and electrical resistivity surveys.
   b. Delineate areas of weaker soil that may require engineering measures to provide suitable foundation support; these will typically occur within depression areas.
   c. Identify areas of potentially expansive soil. Three of the Blanket soil samples tested classified as high plasticity clay (CH) in accordance with the USCS. High plasticity clays are likely to experience large volume changes in response to moisture content variations, expanding (swelling) with moisture intake and shrinking as they dry up. These so-called expansive soils can cause severe cracking in buildings whose foundations undergo large differential shrink-swell motion. A typical engineering solution is to construct a 3-foot thick special fill pad directly under each proposed structure using non-expansive fill material, thereby removing the expansive soil from the zone of significant, weather-related moisture variations.
3. It is likely that project grading will include cut and fill operations. The Blanket soils will generally be suitable for use in the construction of engineered fill that may be needed. However, clayey soils are likely to require significant reworking in the field in order to attain the optimum moisture content needed to achieve the compaction levels required for engineered fills. The quartz sands present in the west-central part of the project area will be suitable for use in engineering fill, but could also be marketed for other uses such as glass manufacturing. All fills should be constructed as engineered fills placed in 8- to 10-

inch thick layers and each layer shall be compacted to 95% of the maximum dry density of the fill material measured in the Modified Proctor Test (ASTM D-1557).

4. Excavation into the Blanket soils can typically be performed using conventional earth-moving equipment such as bulldozers and excavators. Based on our experience in other projects with similar geologic settings, any excavation into the limestone hills and ridges that may be required could necessitate the use of rock excavating methods.

We request to be consulted should there be any questions as to the intent and general scope of these recommendations. Likewise, we also request to be informed of any changes in the scope of the project that may require a revision of our conclusions and recommendations.

Respectfully Submitted,

GEO CIM – LUIS O. GARCIA & ASSOCIATES

Alejandro E. Soto, P.G.
Associate

Carlos García Echevarría, P.E.
Principal

Geo Cim, Inc. Job No. 3709-07
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Year	*Photo ID*	*Approximate Scale*	*Stereo Coverage*
Early 1930s	T-W-8-13 and T-W-8-14	1:10,000	Most of property excepting easternmost portion.
1937	K-84-74 and K-84-75	1:18,000	Entire property.
1963	ELT-3DD-57 to ELT-3DD-59	1:20,000	Most of property excepting northernmost margen.
1978	78-ACPR-LIN-5 Nos. 115 and 116	1:20,000	Entire property.
1982	Nos. 277 to 279	1:10,000	Entire property.
1997	ACT-OFG-97-01 Nos. 163 and 164	1:20,000	Entire property.

TABLE 1 - Air Photo Information

Boring No.	*Depth (feet)*	*Coordinates(ms.)*		*Topographic Expression*
		East	*North*	
B-1	25.5	156,294.1	65,042.3	Located near visual low point in area of Depression D.
B-2	25.5	156,542.0	65,169.4	Located approximately 15 meters from the surface limestone solution opening at H.
B-3	25.5	156,415.1	65,302.6	Located within Depression E.
B-4	25.5	155,946.5	64,950.9	Located near visual low point of Depression B.
B-5	25.5	155,681.2	64,850.9	Located near visual low point of Depression A.
B-6	25.5	155,743.0	65,100.1	Located on east side of north-south trending low ridge.
B-7	25.5	155,736.1	65,259.7	Located near north tip of sand ridge.

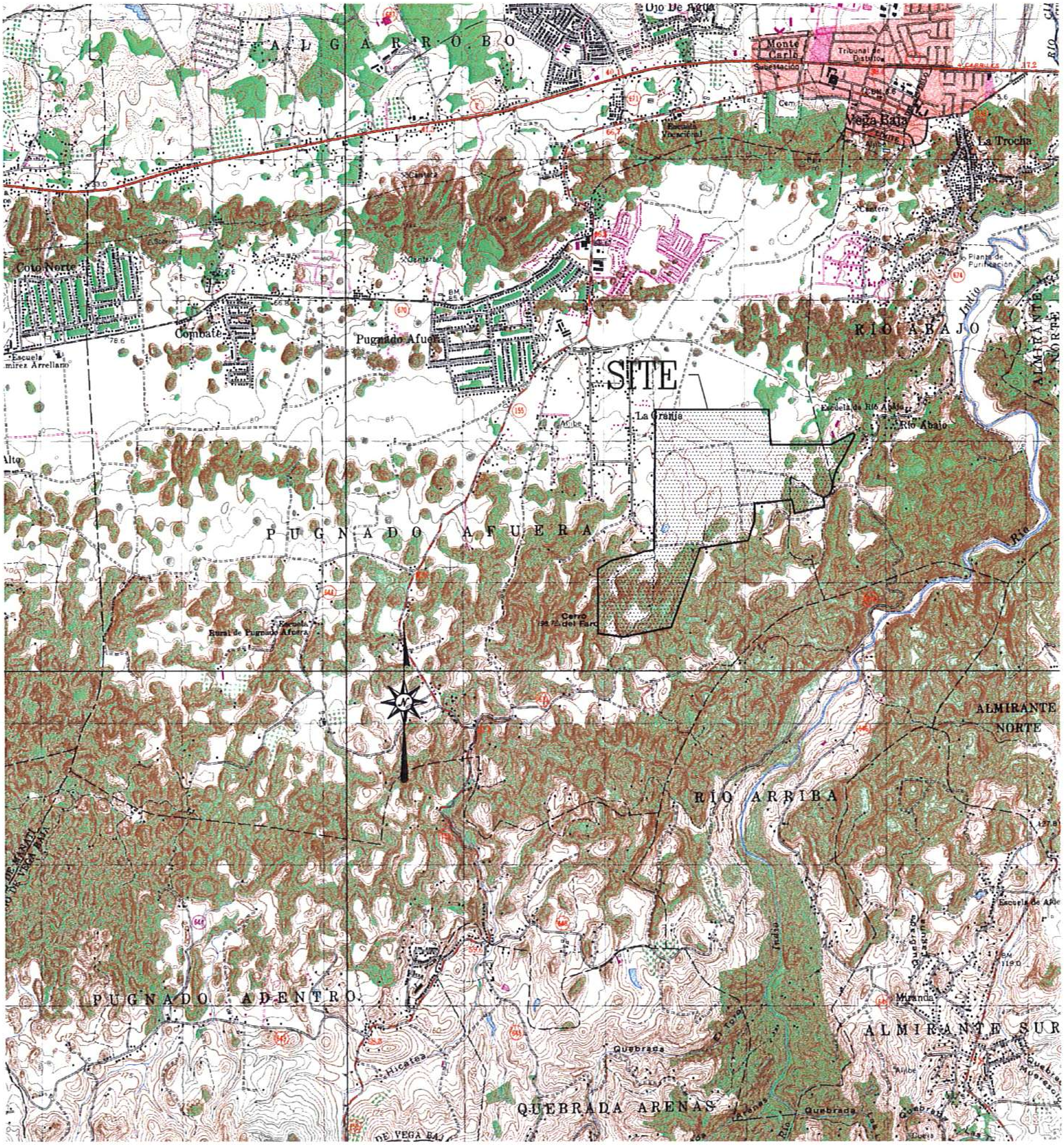
TABLE 2 - Exploratory Boring Information; topographic features referred to are shown on Figure 3.

Boring No.	Sample Depth (ft)	Natural Moisture Content (%)	% (by weight) passing #200 Sieve	Liquid Limit (%)	Plasticity Index (%)	USCS[1] Category	AASHTO[2] Classification
B-1	5.0-6.5	25.1	73.4	64.1	39.6	CH	A-7-6(30)
B-2	5.0-6.5	27.2	82.4	48.1	22.7	CL	A-7-6(20)
B-3	10.0-11.5	24.5	84.0	47.5	20.8	CL	A-7-6(19)
B-4	10.0-11.5	30.6	74.7	59.0	33.9	CH	A-7-6(26)
B-5	10.0-11.5	39.6	78.4	55.9	30.0	CH	A-7-6(25)
B-7	7.5-9.0	3.2	5.3	NP[3]	NP[3]	SP-SM	A-3

Notes:

1. USCS - Unified Soil Classification System
2. AASHTO - American Association of State Highway and Transportation Officials
3. NP - Non Plastic

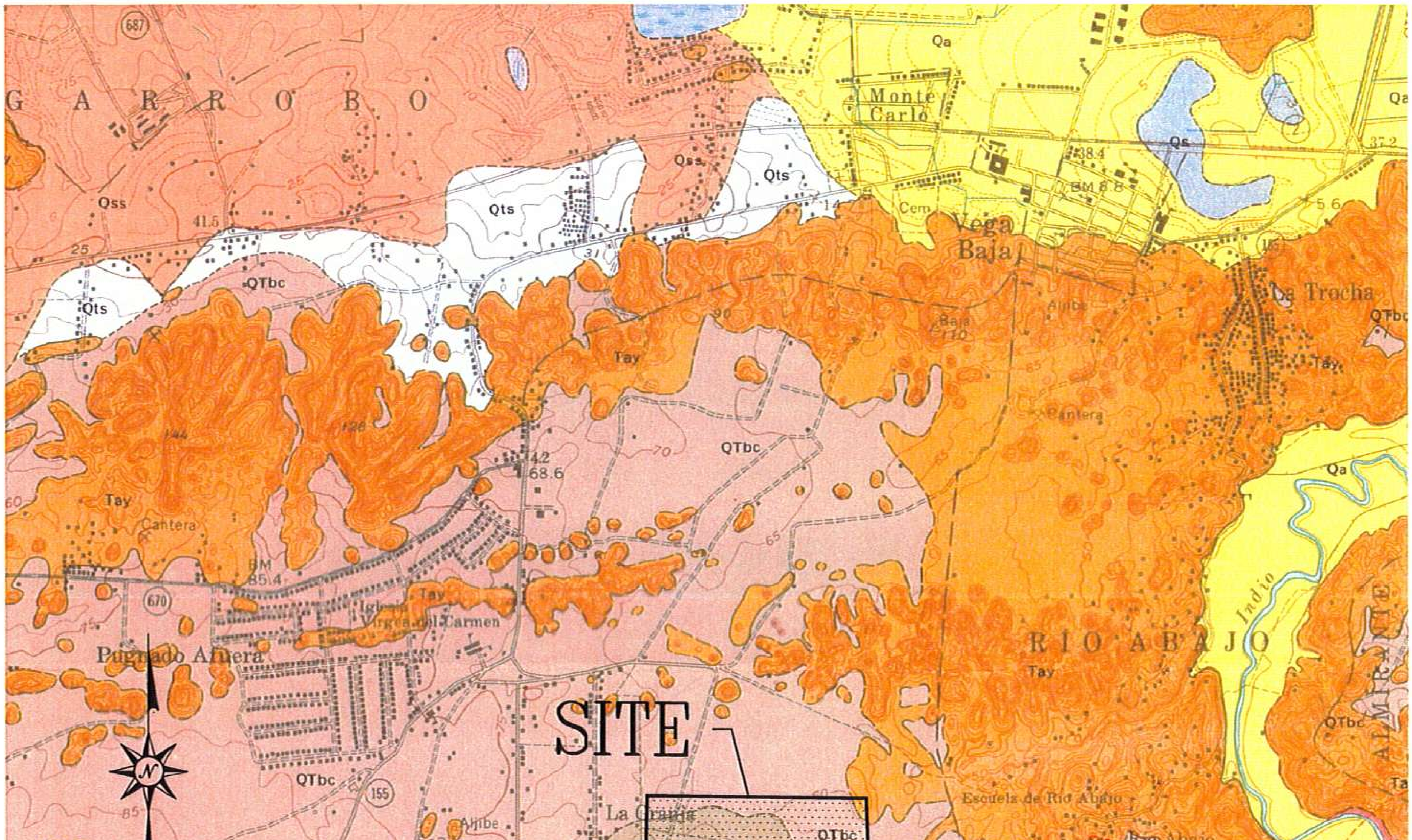
TABLE 3 - Soil Classification Test Results



N:\AUTOCAD\DRAWINGS\3709-07\FIGURE 3 Google Earth Photo

GeoCim
LUIS O. GARCIA & ASSOCIATES

SITE LOCATION AND TOPOGRAPHIC MAP					
LA SABANA RESIDENTIAL DEVELOPMENT, VEGA BAJA, P.R.					
DRW. BY: G.ORTEGA	CKD. BY: JB	SCALE: N.T.S.	DATE: 11/07/07	JOB. NO: 3709-07	FIGURE NO: 1



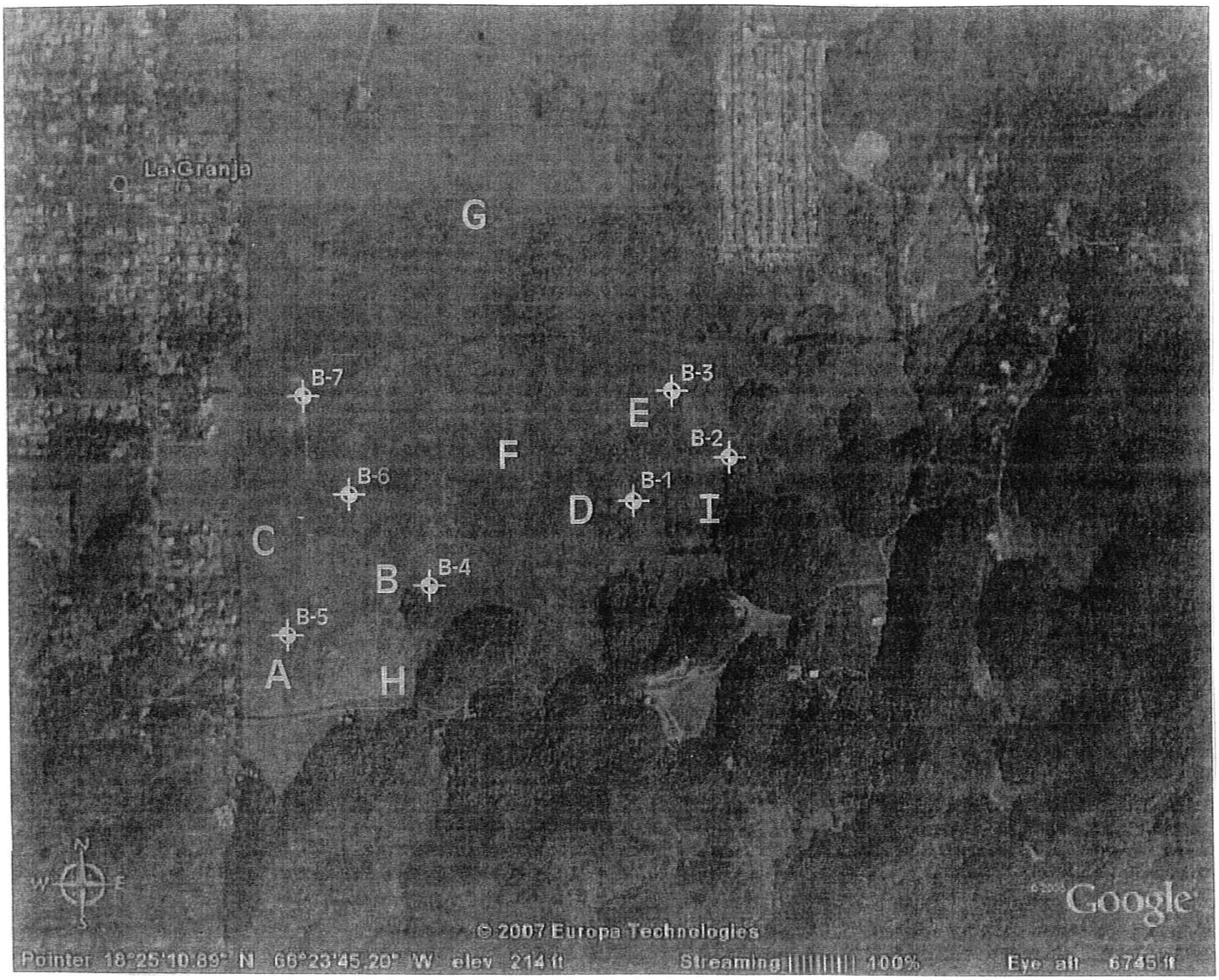
GEOLOGY OF THE PROJECT SITE AREA

LA SABANA RESIDENTIAL DEVELOPMENT, VEGA BAJA, P.R.

GeoCim
LUIS O. GARCIA & ASSOCIATES

DRW. BY:	CKD. BY:	SCALE:	DATE:	JOB. NO:	FIGURE NO:
G.ORTEGA	A.S.	N.T.S.	11/07/07	3709-07	2

N:\AUTOCAD\DRAWINGS\3709-07\FIGURE 3 Google Earth Photo



Explanation:

B-1 - Boring location and number

A to H - Surface depression

I - Limestone shaft

GeoCim LUIS O. GARCIA & ASSOCIATES	GOOGLE EARTH IMAGE SHOWING DEPRESSION AND APPROXIMATE BORING LOCATIONS				
	LA SABANA RESIDENTIAL DEVELOPMENT, VEGA BAJA, P.R.				
	DRW. BY: G.ORTEGA	CKD. BY: JB	SCALE: N.T.S.	DATE: 11/07/07	JOB. NO: 3709-07	FIGURE NO: 3

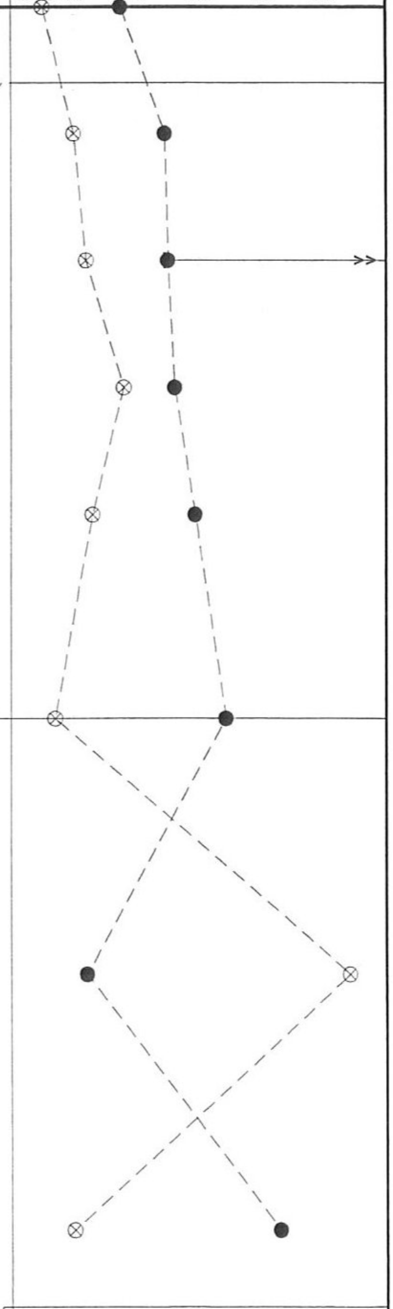
N:\CAD\DRAWINGS\3709-07\FIGURE 3 Google Earth Photo

APPENDIX A

BORING LOGS

BORING LOG No: **B-1**

DEPTH M FT	BLOWS ON SAMPLER	N	q_u	w_n	LL	PI	Symbol	DESCRIPTION
	3-3-2	5	(4.5)	17.6				BLANKET DEPOSITS: Fine quartz sand, little clay, trace roots; medium stiff, dark brown.
	4-5-5	10		24.6				CLAY, trace fine sand; trace roots; stiff; red.
5	4-5-7	12	10.27	25.1	64.1	39.6		-little silt, trace oxide nodules; CH; 73.4% finer than #200 sieve; AASHTO classification: A-7-6(30).
	7-8-10	18	(4.5+)	26.1				-no roots or nodules; very stiff; red.
10	5-6-7	13	7.74	29.3				-stiff.
	4-4-3	7		34.1				TRANSITION ZONE: Mixture of limestone fragments and terrigenous clay; trace sand; many small solution openings; loose; strong brown, white, and pale yellow.
15								
20	14-25-29	54		12.1				-crystalline limestone, broken, no clay; very dense; pinkish white.
25	4-5-5	10		42.7				-limestone fragments, numerous solution openings, trace terrigenous clay; loose to medium dense; white and yellowish brown.
								END OF BORING NO. B-1 AT 25.5 FEET DEPTH. Notes: 1. No groundwater observed during drilling.



DATE HOLE STARTED **10-1-07** COMPLETED **10-1-07**

ELEVATION TOP OF HOLE

ELEVATION GROUND WATER

LOCATION (Coordinates or Station) **N 65,042.3 E 156,294.1**

NAME OF DRILLER **Rubén Nieves** DRILLING EQUIPMENT **CME-55** /METHOD **SPT**

w_n	WATER CONTENT IN %	q_u	( ) PENETROMETER, TSF
N	BLOWS FROM S. P. T. (ASTM D-1586)	LL	LIQUID LIMIT IN %
q_u	UNCONFIED COMPRESSIVE STRENGTH, TSF	PL	PLASTIC LIMIT IN %
▼	WATER TABLE OR PHREATIC LEVEL	PI	PLASTICITY INDEX IN %

GeoCim

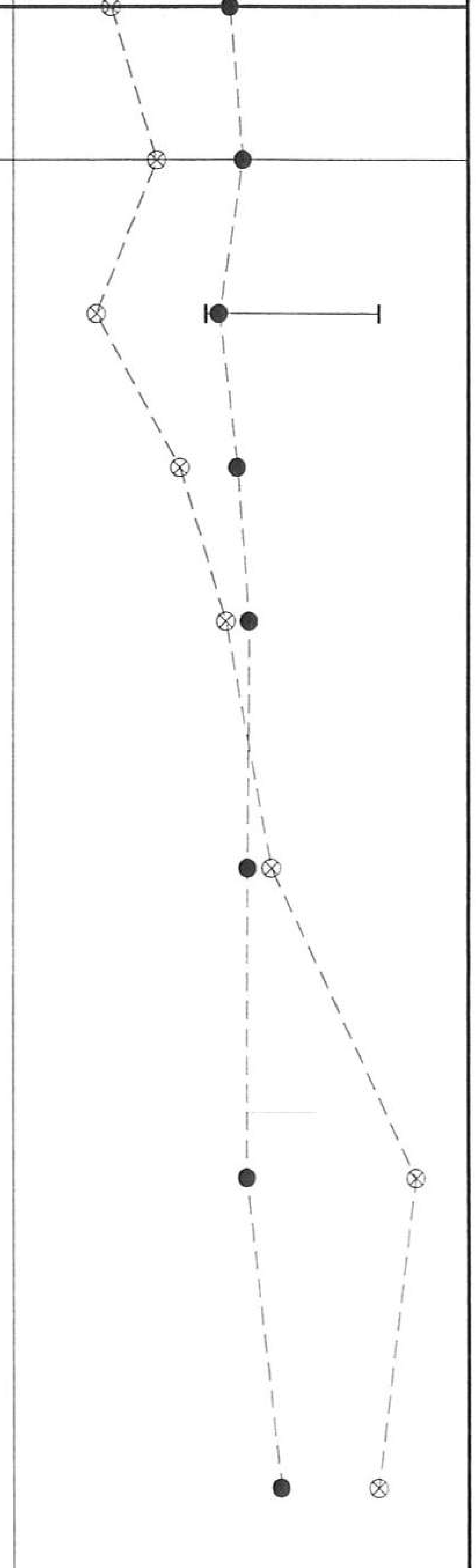
GEOTECNIA Y CIMIENTOS
GEOTECHNICAL TESTING SERVICES
P.O. BOX 10872, SAN JUAN, P.R. 00922-0872

LA SABANA RESIDENTIAL DEVELOPMENT, VEGA BAJA, PR

APPROVED | JOB No. **3709-07** | **1** OF **1** SHEETS | BORING No. **B-1**

BORING LOG No: **B-2**

DEPTH M FT	BLOWS ON SAMPLER	N	q_u	w_n	LL	PI	Symbol	DESCRIPTION
	4-6-7	13		28.7				FILL: Clay, trace to little limestone gravel; trace roots; stiff; reddish yellow and dark yellowish brown.
	5-9-10	19	(4.5+)	30.3				BLANKET DEPOSITS: CLAY; trace fine quartz sand and roots; very stiff; yellowish red.
5	4-5-6	11	(4.5+)	27.2	48.1	22.7		-stiff; CL; 82.4% finer than #200 sieve; AASHTO classification: A-7-6(20).
	5-9-13	22	(4.5+)	29.6				-very stiff; brownish yellow.
10	9-12-16	28	(4.5+)	31.1				-no roots; brownish yellow and red.
15	11-14-20	34	(4.5+)	30.9				-hard; light gray, brownish yellow and red.
20	12-18-35	53	(4.5+)	30.7				-no sand.
25	13-20-28	48	11.06	35.2				-red and brownish yellow.
								END OF BORING NO. B-2 AT 25.5 FEET DEPTH. Notes: 1. No groundwater observed during drilling.

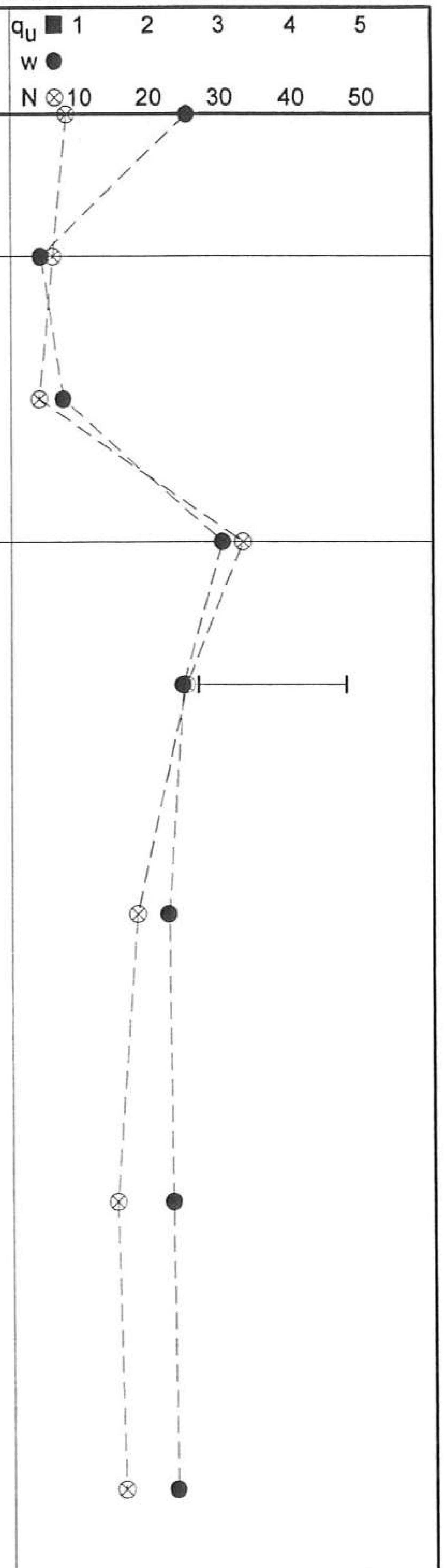


DATE HOLE STARTED 9-25-07 COMPLETED 9-25-07	GEOTECNIA Y CIMIENTOS GEOTECHNICAL TESTING SERVICES P.O. BOX 10872, SAN JUAN, P.R. 00922-0872
ELEVATION TOP OF HOLE	
ELEVATION GROUND WATER	
LOCATION (Coordinates or Station) N 65,169.4 E 156,542.0	LA SABANA RESIDENTIAL DEVELOPMENT, VEGA BAJA, PR
NAME OF DRILLER **Rubén Nieves** DRILLING EQUIPMENT **CME-55** /METHOD **SPT**	
	APPROVED — JOB No. **3709-07** — BORING No. **B-2** — **1** OF **1** SHEETS

w_n	WATER CONTENT IN %	q_u	( ) PENETROMETER, TSF
N	BLOWS FROM S. P. T. (ASTM D-1586)	LL	LIQUID LIMIT IN %
q_u	UNCONFIED COMPRESSIVE STRENGTH, TSF	PL	PLASTIC LIMIT IN %
▼	WATER TABLE OR PHREATIC LEVEL	PI	PLASTICITY INDEX IN %

BORING LOG No: **B-3**

DEPTH M FT	BLOWS ON SAMPLER	N	q_u	w_n	LL	PI	Symbol	DESCRIPTION
	4-4-4	8		25.2				BLANKET DEPOSITS: Fine SANDY CLAY; trace roots; medium stiff to stiff; yellowish red.
	2-3-3	6		4.2				Fine angular quartz SAND, trace clay and roots; loose; yellowish brown.
5	2-2-2	4		7.5				-no roots; very loose to loose.
	9-13-20	33		30.1				CLAY; trace fine quartz sand, hard; red.
10	10-12-13	25		24.5	47.5	20.8		-very stiff; CL; 84% finer than #200 sieve; AASHTO classification: A-7-6(19).
15	7-9-9	18		22.4				-little silt, yellowish red.
20	9-7-8	15		22.9				-stiff to very stiff; red.
25	10-9-7	16		23.3				-stiff.
								END OF BORING NO. B-3 AT 25.5 FEET DEPTH. Notes: 1. No groundwater observed during drilling.



DATE HOLE	STARTED 9-25-07	COMPLETED 9-25-07
ELEVATION TOP OF HOLE		
ELEVATION GROUND WATER		
LOCATION (Coordinates or Station)	N 65,302.6 E 156,415.1	
NAME OF DRILLER **Rubén Nieves**	DRILLING EQUIPMENT **CME-55**	/METHOD **SPT**

w_n	WATER CONTENT IN %	q_u	( ) PENETROMETER, TSF
N	BLOWS FROM S. P. T. (ASTM D-1586)	LL	LIQUID LIMIT IN %
q_u	UNCONFIED COMPRESSIVE STRENGTH, TSF	PL	PLASTIC LIMIT IN %
▼	WATER TABLE OR PHREATIC LEVEL	PI	PLASTICITY INDEX IN %

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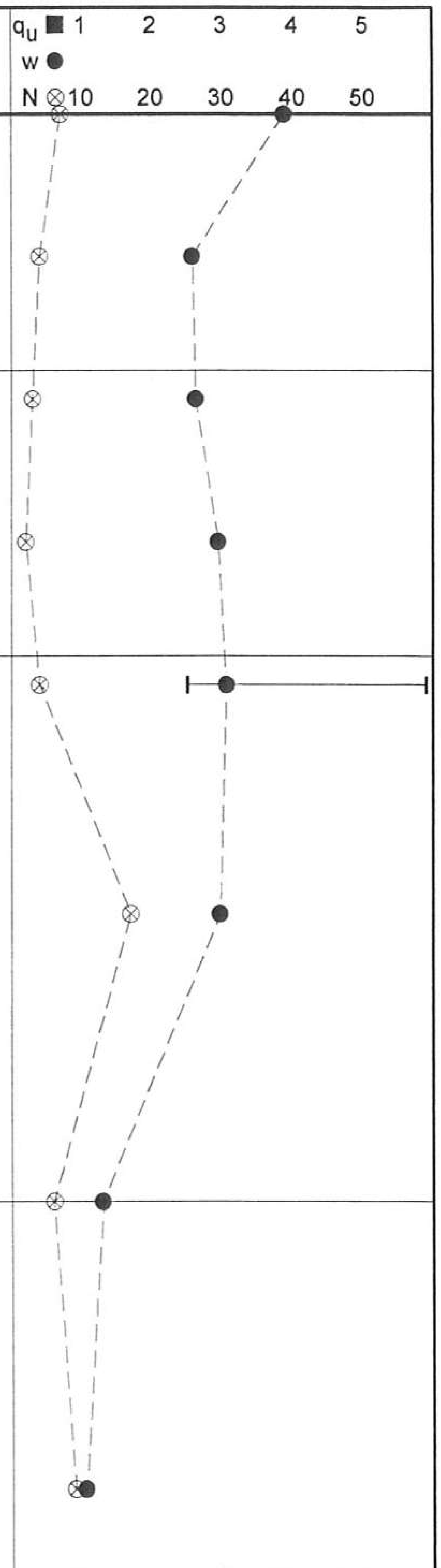
LA SABANA RESIDENTIAL DEVELOPMENT, VEGA BAJA, PR

APPROVED	JOB No. **3709-07**	BORING No.
	1 OF **1** SHEETS	**B-3**

BORING LOG No: **B-4**

DEPTH M FT	BLOWS ON SAMPLER	N	q_u	w_n	LL	PI	Symbol	DESCRIPTION
	3-3-4	7	(3.75)	38.8				BLANKET DEPOSITS: CLAYEY SILT, trace roots; medium stiff; dark brown.
	3-2-2	4	(4.0)	25.9				-no roots; trace fine quartz sand; soft to medium stiff.
5	2-2-1	3	(1.75)	26.3				SILT, little clay and fine quartz sand; soft brown.
	2-1-1	2		29.5				-very soft to soft; red.
10	2-2-2	4	(4.5)	30.6	59.0	33.9		CLAY, little silt, trace fine sand; soft to medium stiff; CH; 74.7% finer than #200 sieve; AASHTO classification: A-7-6(26).
15	4-8-9	17	(4.5+)	29.7				-very stiff; red and black spots.
20	3-3-3	6	(3.25)	13.0				Fine quartz SAND; little clay, loose; red.
25	3-4-5	9	(2.0)	10.5				-trace silt; loose; dark brown.
								END OF BORING NO. B-4 AT 25.5 FEET DEPTH. Notes: 1. No groundwater observed during drilling.



DATE HOLE STARTED 10-1-07 COMPLETED 10-1-07

ELEVATION TOP OF HOLE

ELEVATION GROUND WATER

LOCATION (Coordinates or Station) N 64,950.9 E 155,946.5

NAME OF DRILLER **Rubén Nieves** DRILLING EQUIPMENT **CME-55** /METHOD **SPT**

w_n	WATER CONTENT IN %	q_u	() PENETROMETER, TSF
N	BLOWS FROM S. P. T. (ASTM D-1586)	LL	LIQUID LIMIT IN %
q_u	UNCONFIED COMPRESSIVE STRENGTH, TSF	PL	PLASTIC LIMIT IN %
▼	WATER TABLE OR PHREATIC LEVEL	PI	PLASTICITY INDEX IN %

GeoCim

GEOTECNIA Y CIMIENTOS
GEOTECHNICAL TESTING SERVICES
P.O. BOX 10872, SAN JUAN, P.R. 00922-0872

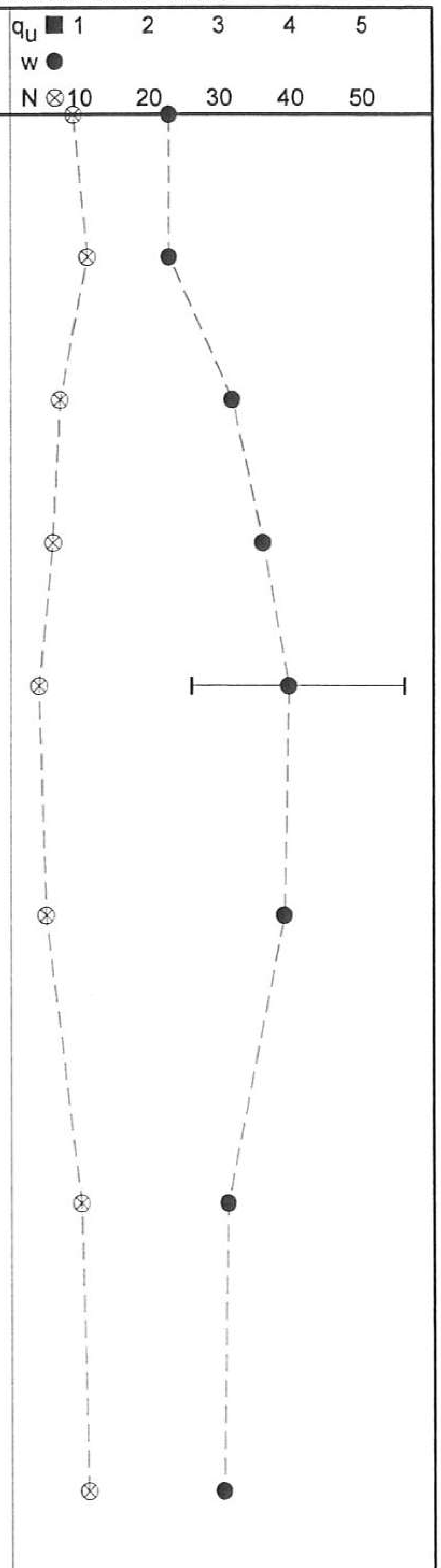
LA SABANA RESIDENTIAL DEVELOPMENT, VEGA BAJA, PR

APPROVED | JOB No. **3709-07** | BORING No. **B-4**

1 OF **1** SHEETS

BORING LOG No: **B-5**

DEPTH M FT	BLOWS ON SAMPLER	N	q_u	w_n	LL	PI	Symbol	DESCRIPTION
	4-4-5	9		22.8				BLANKET DEPOSITS: CLAY; little silt and fine sand, trace roots; stiff; strong brown.
	4-5-6	11	(4.5)	22.8				-brown.
5	3-3-4	7		31.7				-trace sand; no roots; medium stiff.
	3-3-3	6		36.0				
10	2-2-2	4		39.6	55.9	30.0		-soft to medium stiff; dark yellowish brown; CH; 78.4% finer than #200 sieve; AASHTO classification: A-7-6(25).
15	2-2-3	5	(1.0)	38.9				-medium stiff.
20	3-4-6	10	(3.5)	30.9				-stiff; red.
25	4-5-6	11		30.2				-trace to little fine quartz sand.
								END OF BORING NO. B-5 AT 25.5 FEET DEPTH. Notes: 1. No groundwater observed during drilling.



DATE HOLE STARTED **9-25-07** COMPLETED **9-25-07**	GeoCim
ELEVATION TOP OF HOLE	GEOTECNIA Y CIMIENTOS
ELEVATION GROUND WATER	GEOTECHNICAL TESTING SERVICES
LOCATION (Coordinates or Station) **N 64,850.9 E 155,681.2**	P.O. BOX 10872, SAN JUAN, P.R. 00922-0872
NAME OF DRILLER **Rubén Nieves** DRILLING EQUIPMENT **CME-55** /METHOD **SPT**	**LA SABANA RESIDENTIAL DEVELOPMENT, VEGA BAJA, PR**

w_n	WATER CONTENT IN %	q_u	( ) PENETROMETER, TSF
N	BLOWS FROM S. P. T. (ASTM D-1586)	LL	LIQUID LIMIT IN %
q_u	UNCONFIED COMPRESSIVE STRENGTH, TSF	PL	PLASTIC LIMIT IN %
▼	WATER TABLE OR PHREATIC LEVEL	PI	PLASTICITY INDEX IN %

APPROVED	JOB No. **3709-07**	BORING No.
	1 OF **1** SHEETS	**B-5**