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FORENSIC GEOTECHNICAL EXPLORATION

HILPERT RESIDENCE
10464 Cranston Street
Spring Hill, Florida 34608

Universal Project No. 0830.1000350.0000
Citizens Property Insurance Corporation Claim No. 351934

Prepared For:

Citizens Property Insurance Corporation
3802 Coconut Palm Drive
Tampa, Florida 33619

Prepared By:

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October 22, 2010

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October 22, 2010

Timothy Smartt
Citizens Property Insurance Corporation
3802 Coconut Palm Drive
Tampa, Florida 33619

Reference: ***Forensic Geotechnical Exploration***
Hilpert Residence
10464 Cranston Street
Spring Hill, Florida 34608
Universal Project No. 0830.1000350.0000
Citizens Property Insurance Corporation Claim No. 351934

Dear Mr. Smartt:

Universal Engineering Sciences, Inc. has completed a forensic geotechnical exploration of the Hilpert residence in Spring Hill, Florida. The scope of our services was performed in general accordance with the principles and practices of the local community and with the intent to satisfy the purpose for such a study described in Florida Statute §627.707. We refer the reader to the report for specific discussion, opinions, and recommendations as appropriate.

We appreciate the opportunity to have assisted you. Please contact us if you have any questions or if we may further assist you.

Respectfully submitted,

UNIVERSAL ENGINEERING SCIENCES, INC.
Certificate of Authorization No. 549/GB33

Candace Delarue for

Zane Pierson
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Meagen Gonzalez, P.G.
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EXECUTIVE SUMMARY

Universal Engineering Sciences (Universal) was requested by Citizens Property Insurance Corporation to perform a forensic geotechnical evaluation of the Hilpert residence located at 10464 Cranston Street in Spring Hill, Florida in general accordance with Florida Statutes §627.707 and §627.7072.

As reported to us by the homeowner, the insurance claim was filed due to cracks in the interior and exterior walls of the house, cracks in concrete flatwork, and sinkhole claims being filed in the neighborhood.

Our analysis indicates that sinkhole conditions were interpreted to be present within the subsurface borings conducted as part of the exploration. Therefore, sinkhole activity is considered a cause of distress for settlement related issues.

A portion of the reported cosmetic distress to the structure is related to commonplace conditions, inadequate embedment of the foundation, post-construction settlement, and normal aging or performance of building components. Each reported condition is discussed in section 3.2, Reported/Observed Distress Overview.

To remediate sinkhole conditions encountered during this exploration, we recommend that the soils beneath the perimeter of the residence be treated by low slump grouting. Preliminarily, we estimate a total of 40 grout injection points surrounding the residence, a total of 2,100 lineal feet of grout injection point piping, and approximately 400-420 cubic yards of low slump grout.

In addition, Universal also recommends the shallow soils around the perimeter of the residence be treated with high density polyurethane material. Preliminarily we estimate a total of 79 injection points surrounding the residence requiring approximately 2,000 lbs of polyurethane material.

The following is an estimate for stabilization costs for treating the Hilpert Residence. The estimate contains a range value for each item provided in our attached Grout Program Recommendations based on commonly seen unit prices. To begin the remedial grouting repairs bids from qualified grout contractors will need to be secured.

Contractor Remediation Services				
Description	**Estimated Quantity**	**Unit**	**Unit Price Range**	**Total**
Mobilization / Demobilization	1	lump sum	$2,000 - $3,000	$2,000 - $3,000
Grout Injection Point Piping	2100	lineal foot	$15 - $18	$31,500 - $37,800
Compaction Grout Material	400 - 420	cubic yard	$160 - $180	$64,000 - $75,600
Mobilization and 500 lbs Material	1	lump sum	$7,000 - $9,000	$7,000 - $9,000
Material Beyond 500 lbs	1500	pound	$12 - $14	$18,000
			Estimated Cost Range for Remediation Services	**$122,500 - $125,400**

Professional Services During Remediation Operations				
Description	**Estimated Quantity**	**Unit**	**Unit Rate**	**Total**
Sr. Engineering Technician Grouting Monitor	100	hour	$50	$5,000
Sr. Engineering Technician Polyurethane Mon.	8	hour	$50	$400
Forensic Project Manager	11	hour	$90	$990
Grout Completion Report Preparation	1	report	$250	$250
Senior Engineer [PE]	2	hour	$120	$240
			Estimated Cost for Professional Services	**$6,880**

Estimated Cost Range for Project Remediation	**$129,380 - $132,280**

We refer the reader to the information contained within the report for specific discussion, opinions and recommendations as appropriate.

1.0 PURPOSE AND SCOPE OF SERVICES

1.1 General Purpose and Scope

Florida Statute §627.706 requires that "Every insurer authorized to transact property insurance in this state shall make available coverage for a catastrophic ground cover collapse and shall make available, for an appropriate additional premium, coverage for sinkhole losses on any structure, including contents of personal property contained therein, to the extent provided in the form to which the sinkhole coverage attaches."

Florida Statute §627.707 states that "Upon receipt of a claim for a *sinkhole loss*...the insurer must...make an inspection of the insured's premises to determine if there has been physical damage to the structure which may be the result of sinkhole activity." "Following the insurer's initial inspection, insurer shall engage a professional engineer or professional geologist to conduct testing as provided in §627.7072."

"*Sinkhole loss*" is defined as "structural damage to the building, including the foundation, caused by sinkhole activity." "Sinkhole activity" is defined as "settlement or systematic weakening of the earth supporting such property only when such settlement or systematic weakening results from movement or raveling of soils, sediments, or rock materials into subterranean voids created by the effect of water on limestone or similar rock formation."

In this report we present the results of the forensic geotechnical exploration of the Hilpert residence located at 10464 Cranston Street, Spring Hill, Florida. The purpose of our services was to perform a sinkhole evaluation of the site in general accordance with the spirit and intent of the standards for investigation and reporting described within Florida Statute §627.707. The recovered soil samples were not examined, either visually or analytically, for chemical composition or environmental hazards.

The general scope of services consisted of the following:

- gather pertinent information about the property and structure through review of available reference material, direct observations, and interviews with the homeowner or their representative;
- conduct shallow and deep subsurface exploration around the building and site improvements as appropriate, using non-intrusive and intrusive methodology;
- interpret the accumulation of information to include or eliminate sinkhole activity as a potential contributory cause of distress or damage;
- determine the most probable cause of the distress or damage to the structure and/or other improvements; and
- provide general remedial recommendations if our interpretation indicates that sinkhole activity cannot be ruled out as a contributory cause of the observed or reported distress to the structure.

1.2 Field Methods

Our field evaluation consisted of a series of coordinated tasks in an attempt to maximize the usefulness of the data gathered. The methods used to perform our evaluation are briefly listed below:

- An initial site reconnaissance was conducted to document the observable condition of the structure and property and to determine accessibility of potential boring locations for our drilling equipment.

- An interview was conducted with the homeowner and/or their designated representative to gather historical information and distress location points along with a time-line.

- A relative elevation survey of the structure's interior floor systems and/or pertinent exterior flatwork was performed.

- A geophysical survey was conducted consisting of a Ground Penetrating Radar (GPR) survey to attempt identification of interpretable subsurface features of interest.

- Four (4) test pits were excavated adjacent to the perimeter of the foundation to obtain dimensional and embedment information.

- Thirty-one (31) hand cone penetrometer (HCP) resistance probes were advanced to evaluate shallow soil relative strength.

- Three (3) shallow (hand auger) borings were completed to obtain shallow soil composition information.

- Four (4) Standard Penetration Test (SPT) borings were advanced to obtain deeper soil strength and composition information.

1.3 Laboratory Methods

The recovered soil samples were transported to our laboratory and reviewed under the direction of a professional geologist.

Since all the recovered soil samples were identifiable for purposes of this study, no laboratory testing was deemed necessary at this time.

2.0 FINDINGS

2.1 Literature Review

We reviewed commonly available references for general information about the subject property. A Site Location Map and Site Topographic Map are included in **Appendix A-1** and **A-2.**

General Site Setting

The Hilpert residence is located at 28°30'18" N and 82°32'44" W within Section 7 of Township 23 South and Range 18 East. The property is within the Coastal Lowlands geomorphic and physiographic regions of Florida. The property is located in the Spring Hill Unit 18 subdivision, a relatively flat residential neighborhood approximately 7.3 miles east of the Gulf of Mexico in southwest Hernando County.

Topography

The photorevised 1988 U.S.G.S topographic quadrangle titled "Port Richey NE, Florida" indicates that the property elevation is approximately 30 to 40 feet above N.G.V.D. The Google Earth® "Terrain" layers list the property elevation as 38 feet above sea level. The terrain surrounding the property is relatively flat.

Flood and Wind Zones

According to the Generalized Flood Zones of Hernando County, Florida map, the property is not located within a designated flood zone. The State of Florida Wind-Borne Debris region map indicates that the residence is within a designated area where the basic wind speed may reach 110 to 120 miles per hour.

Surface Soils

The USDA Soil Conservation Service-Soil Survey of Hernando County lists the surficial soil series as Candler fine sand, 0 to 5 percent slopes. Candler fine sand is described as nearly level to gently sloping, excessively drained, sandy marine deposits on very large to small areas on uplands. The series contains 0 to 5 percent slopes with convex down slope and convex across slope shapes. The depth to water is greater than 80 inches below land surface (in bls).

The soil profile for Candler is as follows:

- 0 – 4 in bls, dark grayish brown fine sand;
- 4 – 9 in bls, brown fine sand;
- 9 – 20 in bls, light yellowish brown fine sand;
- 20 – 48 in bls, brownish yellow fine sand; and
- 48 – 80 in bls, pale brown fine sand containing lamellae of brown loamy fine sand.

Geology

The surficial soils underlying the site and the general vicinity are comprised of undifferentiated Quaternary sands deposited in former near shore marine environments. These surficial sands extend to depths of approximately 10 to 50 feet.

The surficial sands in this area are generally underlain by mid-Miocene clays. The contact between the upper sands and underlying clayey strata are oftentimes gradational in nature and may vary in thickness due to underlying bedrock geology.

The Oligocene Suwannee Limestone generally lies below the Hawthorn Group sediments in the region. The upper portion of the limestone bedrock is highly variable due to weathering and contacts between the Hawthorn clayey sediments and the underlying Suwannee Limestone are highly variable. It is not uncommon for limestone to be found at shallow depths in the area.

Hydrogeology

The Floridan aquifer is confined in this area of Hernando County. The Floridan aquifer is comprised of limestone and dolomite strata with thicknesses ranging between 250 to 300 feet. The Floridan aquifer is comprised of the upper aquifer and the lower aquifer which are separated by a unit of lower permeability. Groundwater flow is usually from the center of the state towards the coast.

Per available potentiometric surface maps, the average potentiometric surface of the Floridan aquifer is ten to twenty feet above sea level in this area.

2.2 Brief Description of Property and Structure

The Hilpert residence is located at 10464 Cranston Street in Spring Hill, Hernando County, Florida. The residence was built in 1989 and the current owner purchased the property in 2008.

The residence is located on a rectangular shaped lot that encompasses 0.36 acres. The ground surface surrounding the home appears nearly level with a slight slope away from the house for drainage purposes.

The one-story residence is a masonry structure supported by a thickened edge monolithic slab. The exterior perimeter walls of the residence are covered with stucco, wood siding, and rock.

The main living space of the structure occupies 2 016 square feet. A 1,422 square foot garage and garage addition are attached to the north side of the house. A 512 square foot screened porch is attached to the south side of the house. A 30 square foot front porch is attached to the north side of the house at the front entrance.

A concrete driveway connects the garage entrance to Cranston Street. A concrete walkway connects the driveway to the front porch. Another concrete sidewalk connects the driveway to access doors on the garage and west side of the house. The septic system is located in front of the house. Vegetation on the property includes trees, bushes, and a grass lawn.

A Site Location Map of the site and vicinity is included in **Appendix A-1** and a Site Topographic Map can be found in **Appendix A-2**.

2.3 Interview and Observations

A Universal field crew performed a site inspection of the property on August 12, 2010. Each reported condition is listed below and illustrated on the Reported/Observed Distress Location Plan included in **Appendix A-3**.

A. Hairline cracks in the stucco were noted on the exterior masonry walls (Photographs 5 through 10).

B. Joint cracks/separations were noted in the drywall and ceiling of the house (Photographs 11 through 20).

C. Cracks were noted in concrete flatwork (Photographs 21 through 28).

Please refer to Site Photographs, **Appendix A-4** for pertinent visual observations.

According to the Fred Hilpert, the interior and exterior wall cracks, and ceiling cracks were first noticed 1 to 2 months ago. The concrete cracks were first noticed 1 to 2 years ago. The interior and exterior of the house were last painted in 2008. No plumbing or roof leaks were noted.

The homeowner indicated that no past geotechnical investigations or repairs have been conducted on the residence. A review of Hernando County building permits did not reveal any geotechnical related permits.

2.4 Floor Slab Relative Elevation Survey

A floor slab relative elevation survey (FSRES) of the residence was conducted prior to the subsurface boring operations. The interior floor slab and garage floor slab were surveyed separately. A contour map of the FSRES is presented in **Appendix B-1.** The data collection and analytical methods are presented in the Description of Evaluation Methods, **Appendix C-1**.

<u>Interior Floor Slab</u>

The maximum elevational difference between the lowest point and highest point of the interior slab was 1.4 inches. The lowest points of the floor slab, based on our FSRES, were recorded along the south side of the house and in the northeast corner of the house. The highest location of the floor slab, based on our FSRES, was recorded centrally in the house. The maximum elevation gradient across the interior of the slab is approximately 1.4 inch in ten feet. This magnitude of gradient is considered outside the customarily accepted threshold for residential slab construction of 1.25 inches within ten feet, as noted in ACI-117-90 (FL=10). Distress to the residence is minor and architectural in nature. There has been no diminution of use of the floor slab. However, minor post-construction settlement may have occurred.

<u>Garage Floor Slab</u>

The garage floor was constructed as a non-living area slab. Typically, non-living area ground supported slabs are finished with a drainage slope to direct surface water away from the interior portions of the structure. The garage slab is sloped toward the north in general conformance with this typical construction practice.

<u>Garage Addition Floor Slab</u>

The garage addition floor was constructed as a non-living area slab. Typically, non-living area ground supported slabs are finished with a drainage slope to direct surface water away from the interior portions of the structure. The garage addition slab is sloped toward the north in general conformance with this typical construction practice.

2.5 Ground Penetrating Radar

The GPR survey was conducted along transect lines established around the perimeter of the structure, as shown on the GPR Exploration Plan, **Appendix B-2.** The limitations and methodology of the GPR survey and analysis are presented in **Appendix C-2**. A RAMAC X2M integrated radar with a 250-megahertz antenna with a time window of 220 nanoseconds (ns) was used to perform the GPR survey outside the house. A total of twenty-five transects were completed in continuous mode. The equipment settings for, and date of the GPR data collection, are included on the GPR Exploration Plan.

Across the property, the virtual GPR profiles provided a primary reflector in the subsurface at approximately 44 ns. This two-way travel time correlates with interpreted depth of approximately 10 ft bls in unsaturated conditions and are interpreted as a transition to clayey soil.

The GPR profiles also provided an anomalous feature southwest of the structure. A break is seen in the reflective feature. The location of the anomalies is seen in **Appendix B-2**.

2.6 Foundation Characteristics

Four (4) test pits, TP-1 through TP-4, were excavated to obtain dimensional and embedment characteristics of the foundation under the residence. TP-1 was excavated beneath the north side of the house, TP-2 was excavated beneath the east side of the house, TP-3 was excavated beneath the south side of the screened porch, and TP-4 was excavated beneath the west side of the garage. The locations of the test pits are illustrated on the Soil Testing Location Plan in **Appendix B-3.**

Based on observations made within the test pits, the foundation supporting the residence consists of a thickened edge monolithic slab-on-grade. The approximate thickness and embedment of the thickened edge at TP-1 were 12 and 4 inches, respectively. The approximate thickness and embedment of the thickened edge at TP-2 were 12 and 3 inches, respectively. The approximate thickness and embedment of the screened porch slab at TP-3 were 8 and 2 inches, respectively. The approximate thickness and embedment of the thickened edge at TP-4 were 12 and 11 inches, respectively. Test Pit Details can be found in **Appendix B-4.**

2.7 Shallow Soil Conditions

Hand Cone Penetrometers

We performed thirty-one (31) Hand Cone Penetrometer (HCP) resistance probes, P-1 through P-31, as part of the subsurface exploration. The locations of HCP resistance probes are illustrated on the Soil Testing Location Plan in **Appendix B-3.**

Typically, readings less than 5 indicate very loose materials, readings between 5 and 13 indicate loose materials, and 14 or above indicate medium-dense and above material (for sands). The letter "R" represents refusal which means the penetrometer would not move past that depth. The HCP data are presented in a table and as Hand Cone Penetrometer Graphs in **Appendix B-5.**

Significant observations made during the penetrometer tests are listed below:

- Refusal of the penetrometer was encountered at or above 36 in bls at all penetrometer test locations.

Shallow (Hand Auger) Borings

Three (3) hand auger borings, HA-1 through HA-3, were completed to obtain shallow soil composition characteristics. Detailed subsurface conditions are illustrated on the boring logs in **Appendix B-6**. The classifications and descriptions shown on the boring logs are based upon visual classification of the recovered soil samples. A soil classification chart is presented in **Appendix B-8.**

HA-1 was completed near the southeast corner of the house, HA-2 was completed near the southwest corner of the house, and HA-3 was completed east of the garage. The locations of the borings are illustrated on the Soil Testing Location Plan presented in **Appendix B-3.**

The soil stratigraphy for the hand auger borings is as follows:

- Soils in **HA-1** were comprised of sand from 0 to 10 ft bls. Groundwater was not encountered in the boring.

- Soils in **HA-2** were comprised of sand from 0 to 10 ft bls. Groundwater was not encountered in the boring.

- Soils in **HA-3** were comprised of sand from 0 to 10 ft bls. Groundwater was not encountered in the boring.

Lithology was consistent between the borings and no anomalous conditions were noted.

2.8 Deep Subsurface Conditions

Four (4) standard penetration test (SPT) borings, B-1 through B-4, were completed to obtain deeper soil strength and composition characteristics. Detailed subsurface conditions are illustrated on the boring logs in **Appendix B-7**. The classifications and descriptions shown on the boring logs are based upon visual classification of the recovered soil samples. A soil classification chart is presented in **Appendix B-8.**

Boring B-1 was completed near the northeast corner of the house, B-2 was completed south of the screened porch, B-3 was completed near the northeast corner of the garage, and B-4 was completed west of the house. The locations of the borings are illustrated on the Soil Testing Location Plan presented in **Appendix B-3.**

The soil stratigraphy for the SPT borings is as follows:

- Soils in **B-1** were comprised of very loose and loose sand from 0 to 15 ft bls. Medium dense sand with clay was encountered from 15 to 25 ft bls. Medium dense sand was encountered from 25 to 30 ft bls. Medium dense sand with clay was encountered from 30 to 50 ft bls. Limestone with N-values ranging from 21 to greater than 50 blows per foot (bpf) was encountered from 50 ft bls to boring terminus, 61.5 ft bls.

- Soils in **B-2** were comprised of loose sand from 0 to 15 ft bls. Medium dense sand with clay was encountered from 15 to 20 ft bls. Medium dense sand was encountered from 20 to 30 ft bls. Medium dense and loose sand with clay was encountered from 30 to 45 ft bls. Limestone with N-values ranging from 29 to greater than 50 bpf was encountered from 45 ft bls to boring terminus, 55.1 ft bls.

- Soils in **B-3** were comprised of loose sand from 0 to 7.5 ft bls. Loose sand with clay was encountered from 7.5 to 15 ft bls. Medium dense sand was encountered from 15 to 35 ft bls. Loose sand with clay was encountered from 35 to 40 ft bls. Loose sand was encountered from 40 to 45 ft bls. Very loose sand and clay was encountered from 45 to 54 ft bls. Limestone with N-values ranging from 31 to greater than 50 bpf was encountered from 54 ft bls to boring terminus, 65.1 ft bls.

- Soils in **B-4** were comprised of very loose sand from 0 to 8.5 ft bls. Loose to medium dense sand and clay was encountered from 8.5 to 20 ft bls. Medium dense sand was encountered from 20 to 30 ft bls. Medium dense sand with clay was encountered from 30 to 35 ft bls. Loose to very loose clayey sand was encountered from 35 to 46 ft bls. Limestone with N-values ranging from 4 to greater than 50 bpf was encountered from 46 ft bls to boring terminus, 60.1 ft bls.

Groundwater was not encountered above ten feet bls in the SPT borings.

Significant observations made during the time of drilling operations are listed below:

Boring B-1:

- No significant observations.

Boring B-2:

- No significant observations.

Boring B-3:

- A weight of rod (WOR) event occurred from 45 to 54 ft bls.
- Drilling fluid loss of circulation (LOC) was recorded at 37 ft bls.

Boring B-4:

- A weight of hammer (WOH) event occurred from 4.5 t 8.5 ft bls.
- A WOR event occurred from 40 to 46 ft bls.
- Drilling fluid LOC was recorded at 39 ft bls.

The descriptions and stratum changes shown on the boring logs are based on the information taken from the field boring logs and visual classification of retained samples. The boring logs do not reflect subtle variations which may occur and the fact that compositional changes between strata are generally more gradual than can be depicted on the logs. Also, variations in material composition and density at locations other than the borings are expected.

3.0 ANALYSIS AND OPINION

3.1 Geologic and Geotechnical Review

Based on analysis of the data collected during this exploration, it is our opinion that sinkhole conditions were found in the SPT borings performed as part of this exploration.

The following site specific conditions encountered during the exploration may be associated with sinkhole activity:

- The WOH and WOR occurrences encountered in borings B-3 and B-4 are interpreted as raveling, erosion or subsidence of the overlying sand/clay cover into deeper zones. Also, the WOR events occurred at the limestone/overburden interface and may represent dissolution of limestone in that area.
- The drilling fluid LOC in boring B-3 and B-4 occurred before the WOH/WOR events and may have been lost due to loose zones or voids in those areas.

Based on the information gathered during this exploration, the shallow embedment of the foundation system must be considered in the evaluation of settlement related distress to the structure. The monolithic thickened edge slab supporting the load bearing walls of the residence was embedded 3 to 11 inches. Current building codes call for a minimum depth of embedment of 12 inches. Inadequate embedment of a monolithic slab can result in settlement due to the lack of confining soils resulting in a localized shear failure of the bearing soils.

3.2 Reported/Observed Distress Overview

Evidence of sinkhole activity was found during the exploration and therefore is considered a potential contributory factor that may affect the structure *for settlement related issues solely*.

Each individual reported/observed condition is listed below with a description of distress and our opinion of the cause of the described condition:

A. Hairline cracks in the stucco were noted on the exterior masonry walls (Photographs 5 through 10).

> *Cracks will generally form in masonry due to very small differential settlements of the foundation system which can be exacerbated by inadequate embedment. Thermal and material expansion/contraction from normal temperature changes and dissimilar materials, and workmanship issues may cause typical cracks in masonry. Typical foundation settlement will occur and result in minor cracks of the masonry walls. The standard construction industry generally allows 1 inch of total settlement and ½ of an inch differential settlement. This can result in cracks less than ¼ of an inch in width in masonry structures.*
> *As indicators of sinkhole activity were encountered within the borings advanced at the site; sinkhole activity cannot be ruled out as a potential contributory factor in the observed settlement related distresses.*

B. Joint cracks/separations were noted in the drywall and ceiling of the house (Photographs 11 through 20).

Cracks will form in drywall due to very small differential movements. These differential movements may be a result of temperature or humidity related shrinking and swelling of the gypsum board or wood framing components, differential movement of dissimilar abutting materials, differential movement of connections at adjoining framing materials, or minor differential settlement of the building's foundation or roof truss system.

As settlement-related movement of the building structure may be a contributing cause of the observed distresses and indicators of sinkhole activity were encountered within the borings advanced at the site; sinkhole activity cannot be ruled out as a potential contributory factor in the observed distresses

C. Cracks were noted in concrete flatwork (Photographs 21 through 28).

The cracks in the slabs are generally associated with normal concrete shrinkage, a material property of poured or cast-in-place concrete flatwork. The cracks originate from tensile stress generated from the shrinkage of the concrete materials with evaporation of mix water, curing, and age. The cracks do not appear to show vertical offset and therefore are not considered settlement related.

3.3 Summary of Opinion and Declaration

Based on analysis of the data gathered for this study, it is our opinion that commonly associated indicators of sinkhole activity were interpreted from the borings when placed within the site specific geologic setting.

In accordance with Florida Statute, Section 627.7073, the following is hereby declared.

- The individuals responsible for conducting this study are Ms. Meagen Gonzalez, P.G., licensed under the rules of Florida Statute, Chapter 492, as a Professional Geologist and Mr. Mark K. Hardy, P.E., licensed under the rules of Florida Statute, Chapter 471, as a Professional Engineer, in the discipline of Civil (Geotechnical) Engineering.
- Based on the results of our study, we opine within a reasonable professional probability that sinkhole related activity was encountered in the borings conducted at the site and sinkhole activity is included as a potential contributory cause of distress to the structure and improvements.

4.0 RECOMMENDATIONS

To remediate sinkhole conditions encountered during this exploration, we recommend that the soils beneath the perimeter of the residence be treated by low slump grouting. The grout injection pipes should be spaced on 8 to 10 foot centers around the perimeter of the building. The grouting pipes should be inserted to the top of relatively hard limestone. We estimate this depth to be 50 to 55 ft bls across the site. Within heavily weathered limestone areas, grout injection pipes may be installed deeper at the discretion of the Geotechnical Engineer.

Preliminarily, we estimate a total of 40 grout injection points surrounding the residence. We estimate a total of 2,100 lineal ft of grout injection point piping and approximately 400 to 420 cubic yards of low slump grout. This quantity could vary dependent upon actual conditions at locations other than the borings.

The drilling and grouting operations should be monitored by a representative of Universal to document installation depths, to record grout quantities, and to modify recommendations if conditions vary from those anticipated.

In addition to low slump grouting and to treat loose surface soils, we recommend that the shallow soils beneath the perimeter of the residence and a portion of the driveway be treated by polyurethane injection. The injection pipes should be spaced on 4 foot centers around the perimeter of the residence. The injection pipes should be inserted to a depth of 3 to 10 ft bls. Injection pipes may be installed deeper at the discretion of the Geotechnical Engineer.

Preliminarily, we estimate a total of 79 polyurethane injection points surrounding the residence. We estimate a total of 2,000 pounds of polyurethane material will be used. This quantity could vary dependent upon actual conditions at each location.

The remediation operations should be monitored by a representative of Universal to document installation depths, to record material quantities, and to modify recommendations if conditions vary from those anticipated.

Remediation program recommendations are presented in **Appendix D-1** and the Preliminary Low Slump Grout Injection Point Location Plan is presented in **Appendix D-2** and the Preliminary Polyurethane Injection Point Location Plan is presented in **Appendix D-3**.

5.0 LIMITATIONS

We note that subsurface grouting causes alteration of the hydrogeologic and geotechnical regimes beneath the site. Sometimes the temporary effects of such alterations can create imbalances that result in unanticipated ground subsidence and unintended damage to the structure or improvements.

We also note that measures such as subsurface grouting are intended to treat, in a practical and cost-effective manner, potentially detrimental subsurface conditions which could affect the structure during its remaining useful life. However, the effectiveness of treatment is subject to inference and interpretation of the end result and cannot be evaluated or predicted with certainty.

Because of the natural limitations inherent in working with the subsurface, it is not possible for geotechnical/geologic professionals to anticipate and predict all possible subsurface variations and their potential affect on the subject of this study.

An ASFE publication, "Important Information about Your Geotechnical Engineering Report" appears in **Appendix E**, and will help explain the nature of geotechnical issues.

APPENDICES

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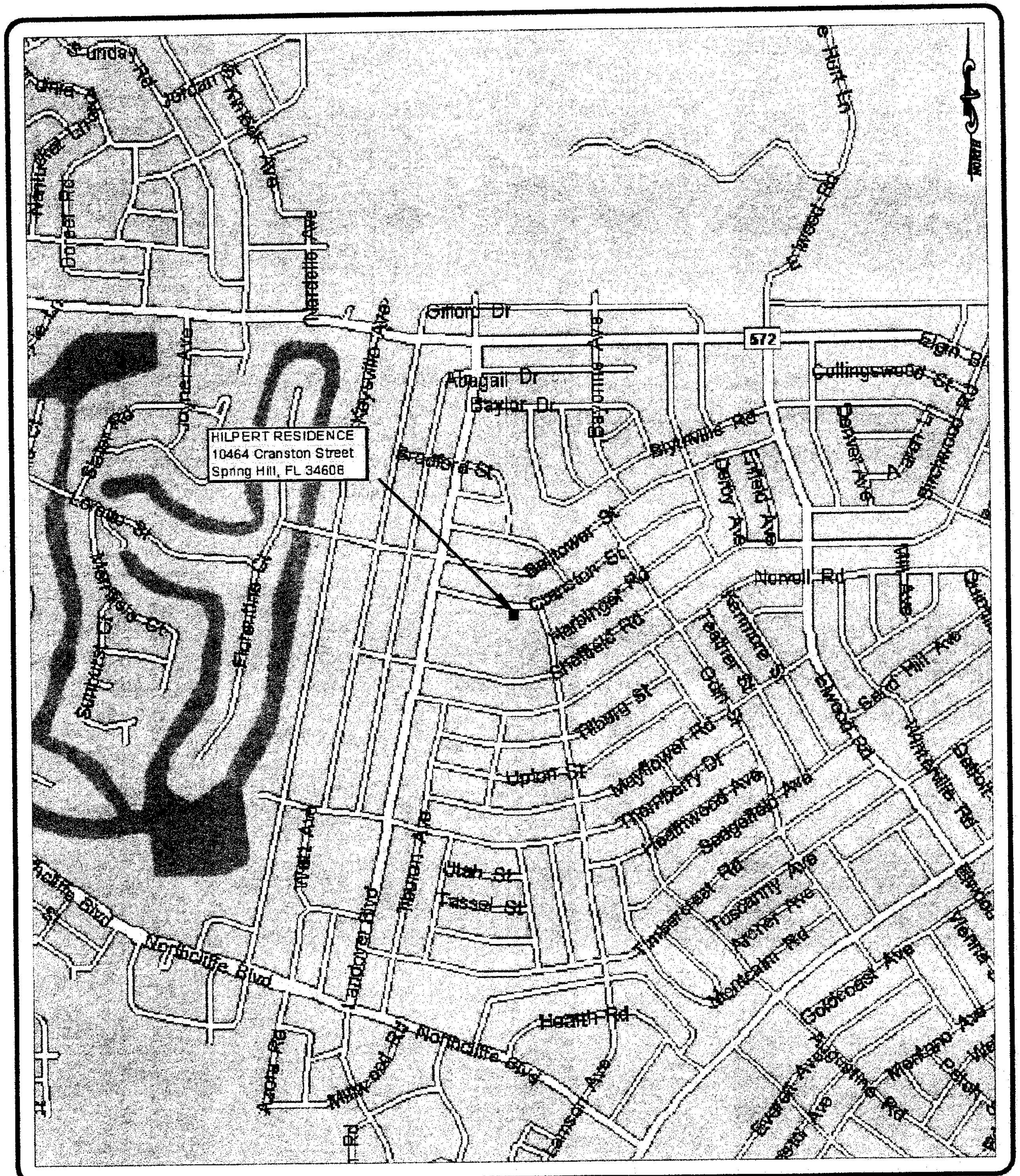
Tampa, Florida 33619
(813) 740-8506

APPENDIX A

A-1: Site Location Map
A-2: Site Topographic Map
A-3: Reported/Observed Distress Location Plan
A-4: Site Photographs



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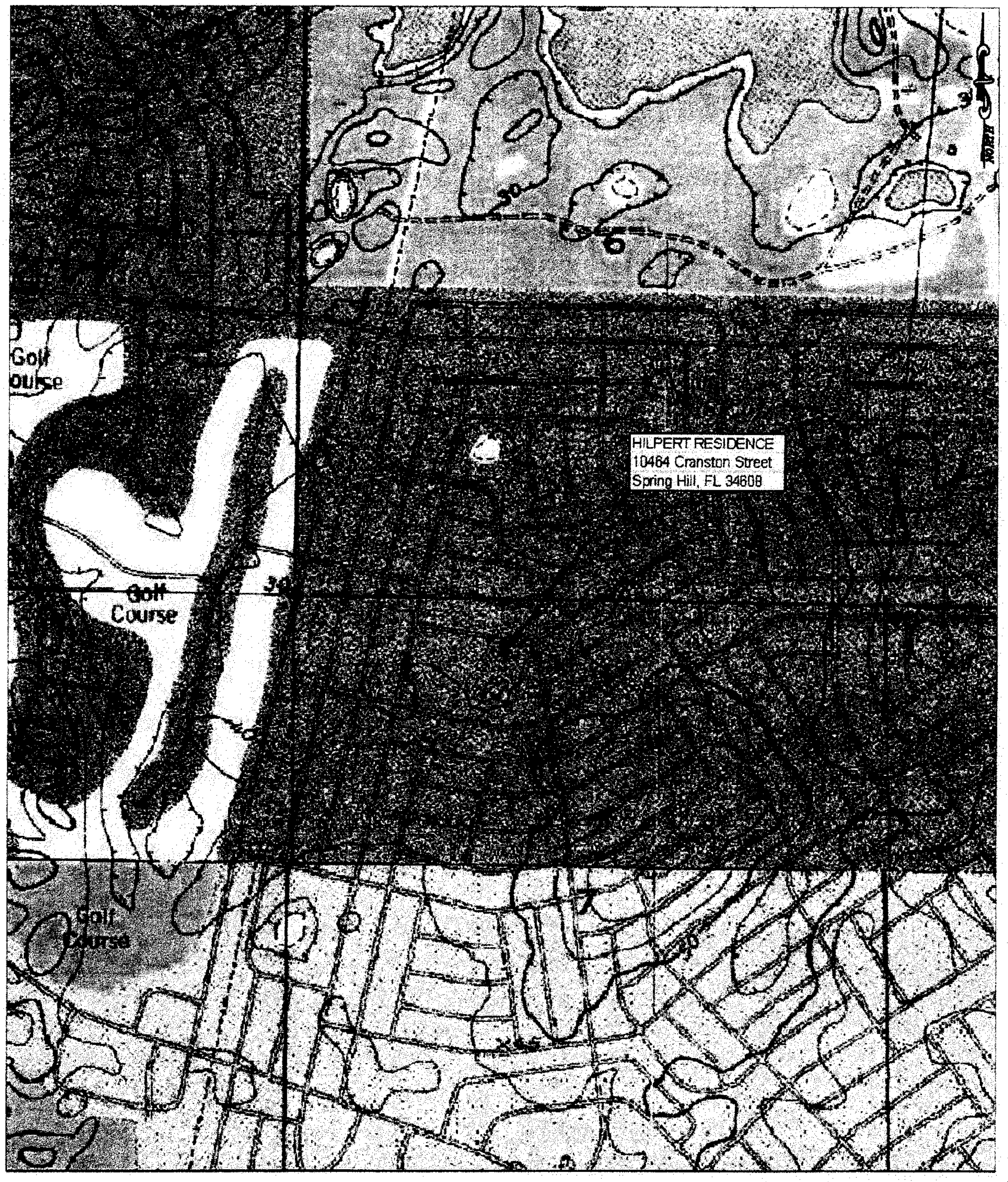
10464 CRANSTON STREET
SPRING HILL, HERNANDO COUNTY, FLORIDA

SITE LOCATION MAP

DRAWN BY: SB	DATE: OCT 12, 2010	REVIEWED BY: MG	DATE: OCT 12, 2010
SCALE: NOT TO SCALE	PROJECT NO: 0830.1000350.0000		APPENDIX: A-1



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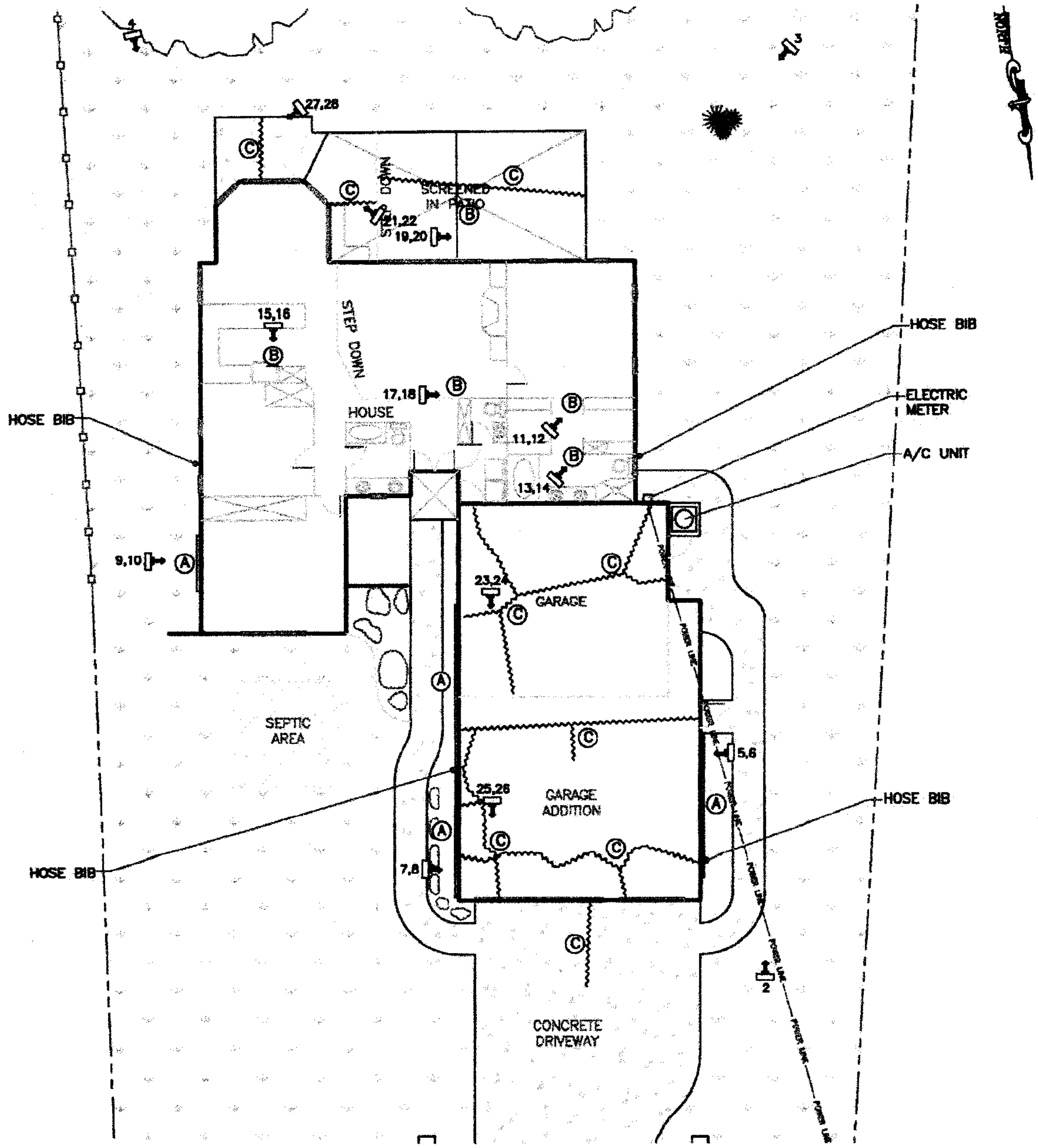
SITE TOPOGRAPHIC MAP

DRAWN BY: SB	DATE: OCT 12, 2010	REVIEWED BY: MG	DATE: OCT 12, 2010
SCALE: NOT TO SCALE	PROJECT NO: 0830.1000350.0000		APPENDIX: A-2



LEGEND:

- Ⓐ Cracks in perimeter walls.
- Ⓑ Cracks in interior walls and ceiling.
- Ⓒ Cracks in concrete.

1 Approximate photograph location

NOTE:
REFER TO SECTION 2.3 FOR DESCRIPTION OF EACH REPORTED / OBSERVED CONDITION.

GRAPHIC SCALE
0 5 10 20
(IN FEET)

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REPORTED / OBSERVED DISTRESS LOCATION PLAN

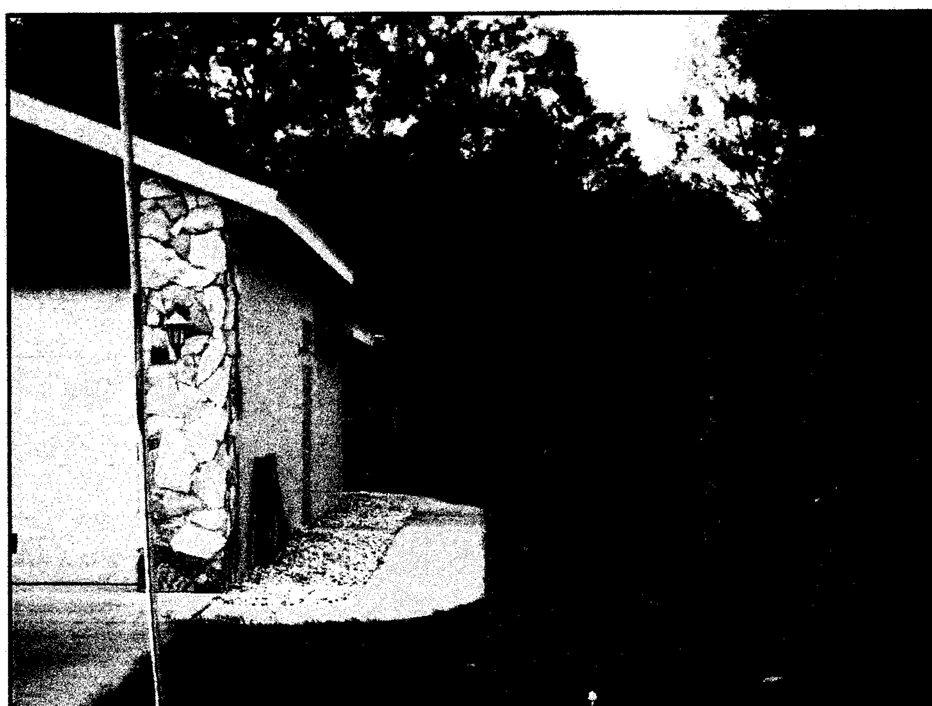
DRAWN BY: SB	DATE: OCT 12, 2010	REVIEWED BY: MH	DATE: OCT 12, 2010
SCALE: 1" = 20'	PROJECT NO: 0830.1000350.0000		APPENDIX: A-3

Appendix A-4

Citizens Property Insurance Corp. / Hilpert Residence (10464 Cranston street, Spring Hill, FL 34608)

SITE PHOTOGRAPHS

Photograph 1: The front of the house looking south.

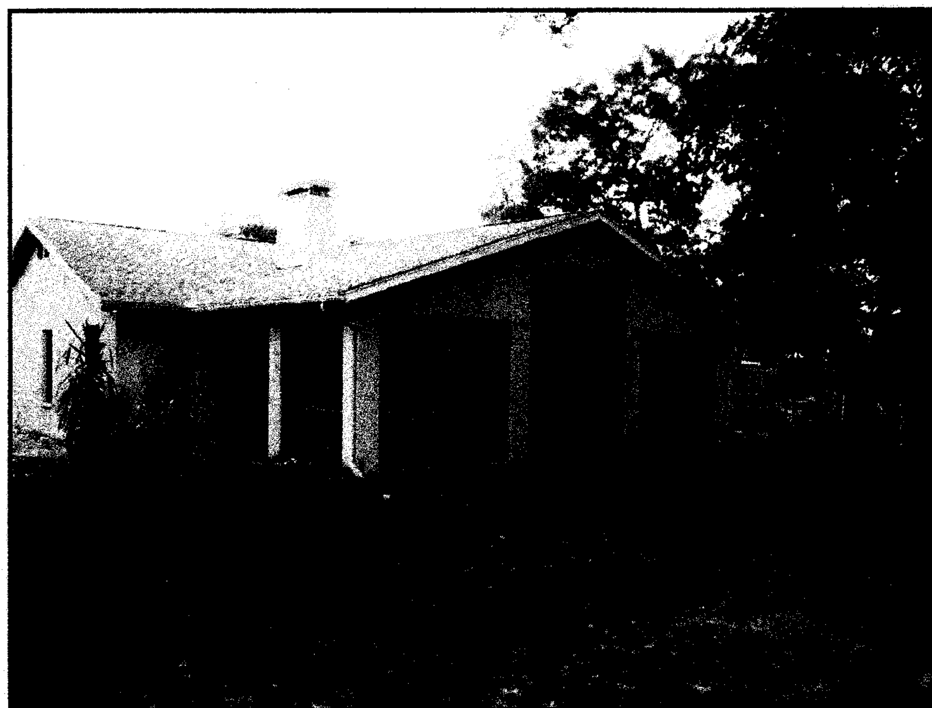


Photograph 2: The east side of the house looking south.

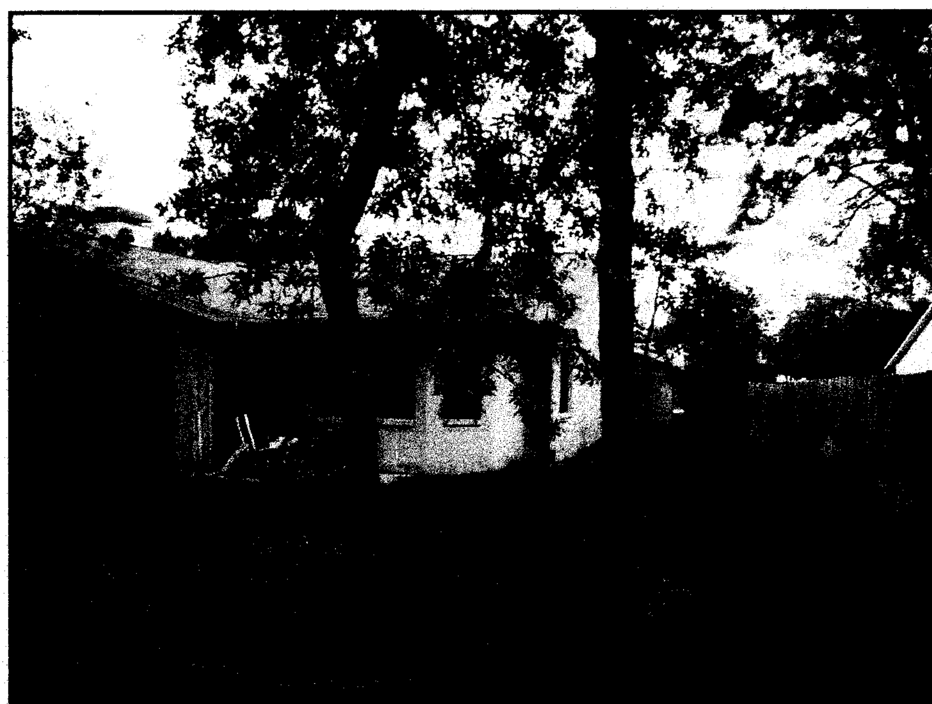
Appendix A-4

Citizens Property Insurance Corp. / Hilpert Residence (10464 Cranston street, Spring Hill, FL 34608)

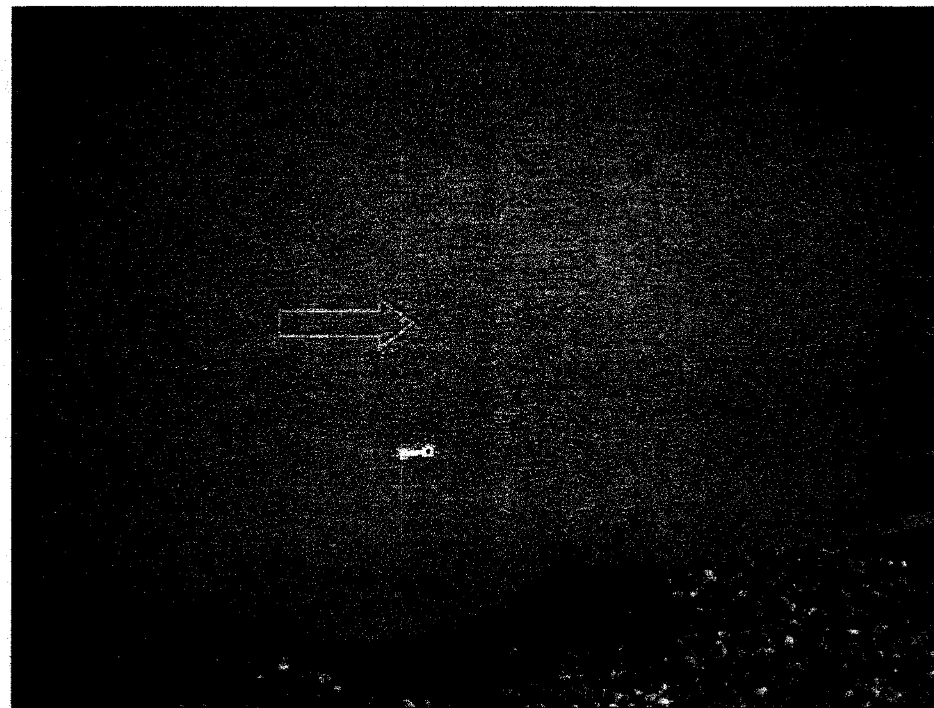
SITE PHOTOGRAPHS



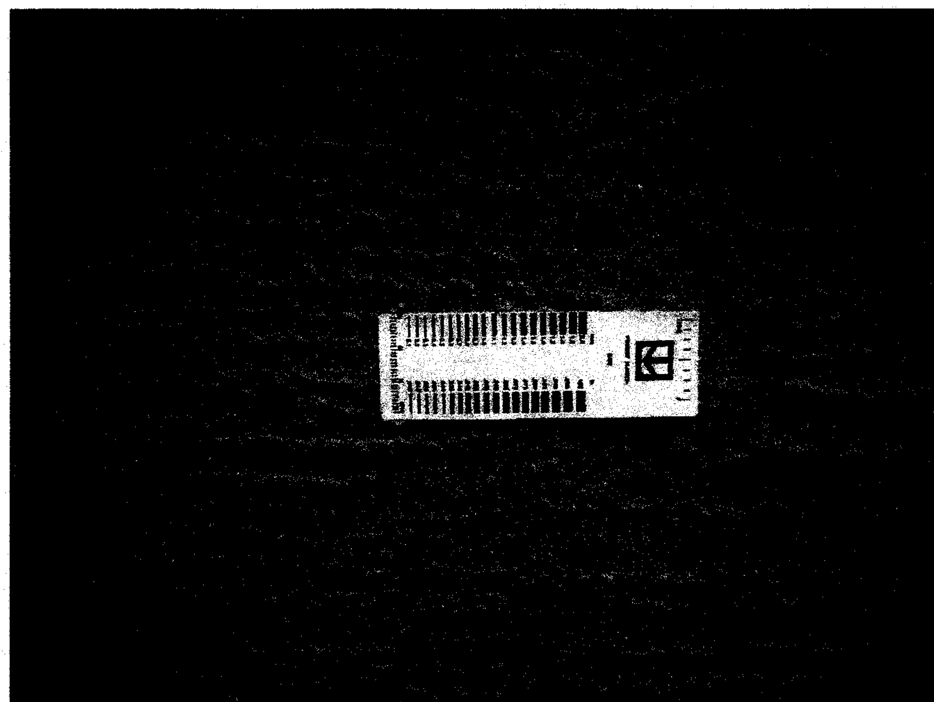
Photograph 3: The south side of the house looking northeast



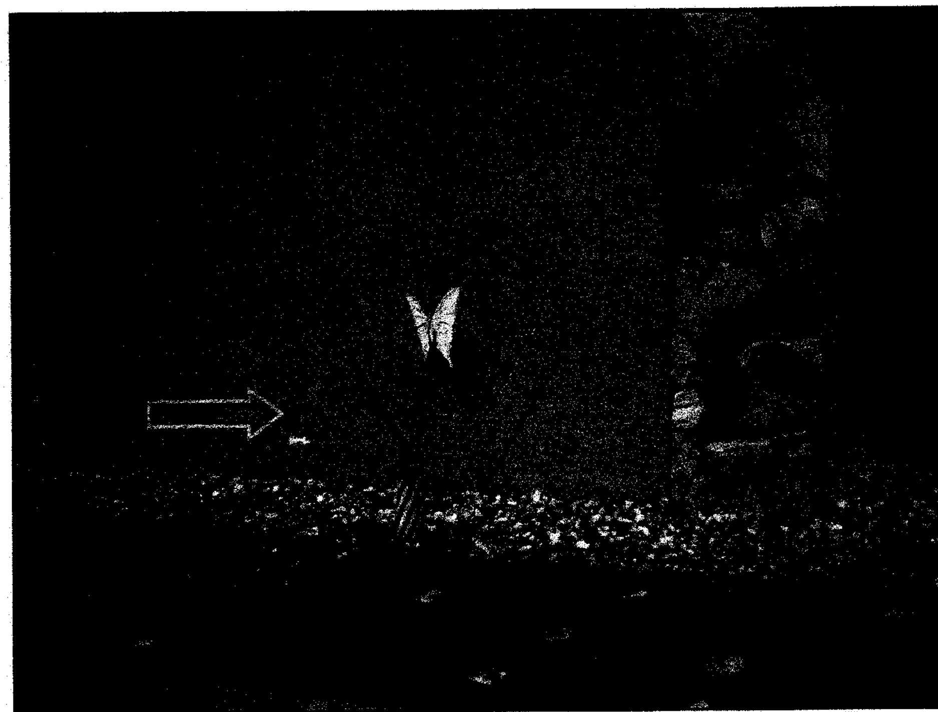
Photograph 4: The west side of the house looking north.



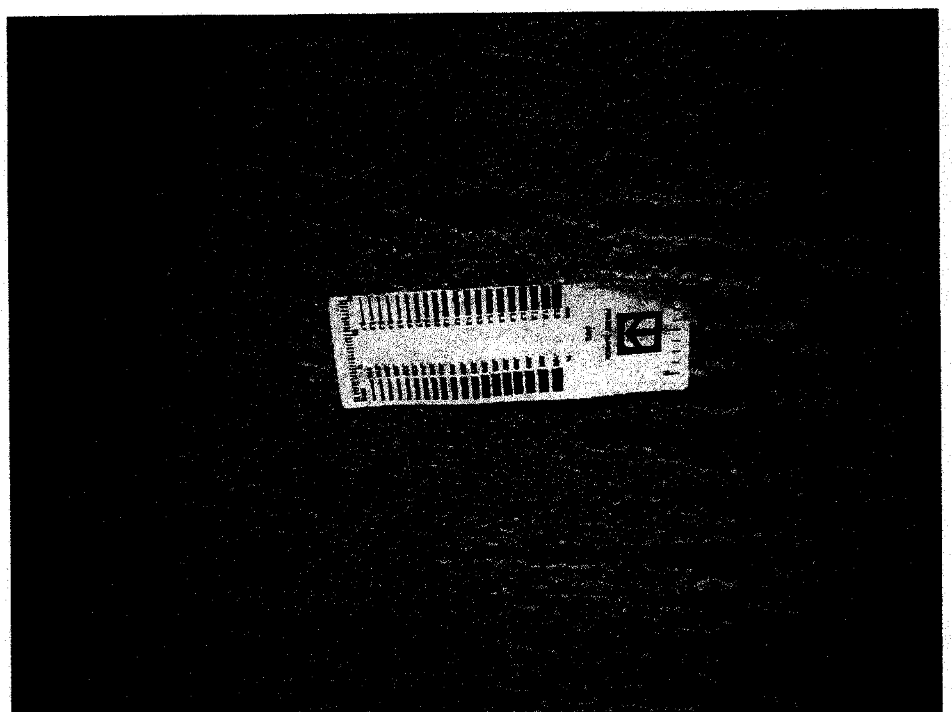
Photograph 5: A hairline crack in perimeter wall. **(A)**



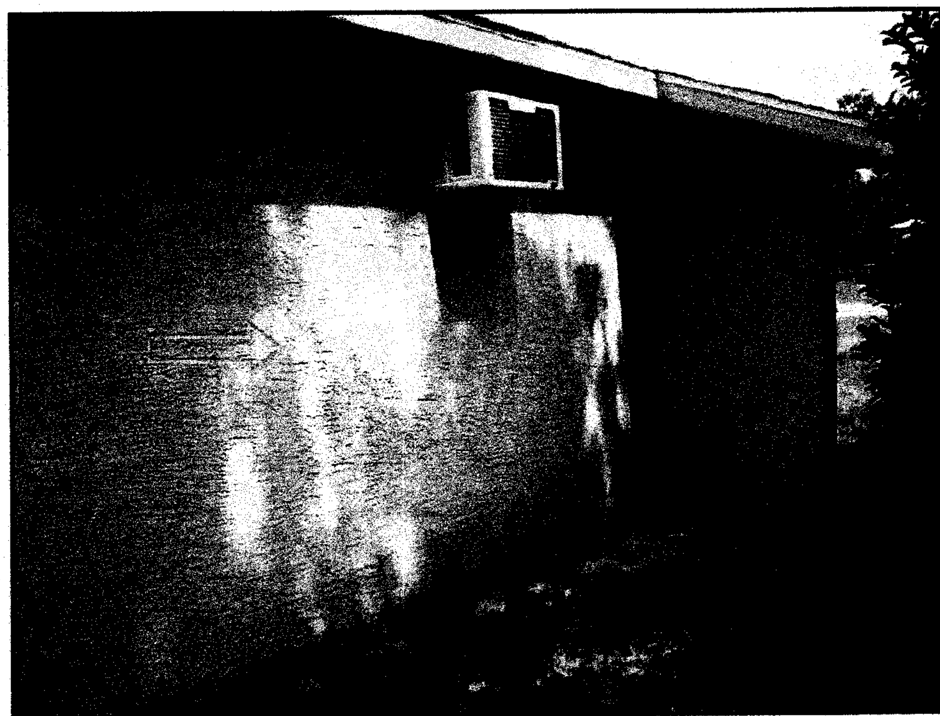
Photograph 6: A close-up view of Photograph 5. **(A)**



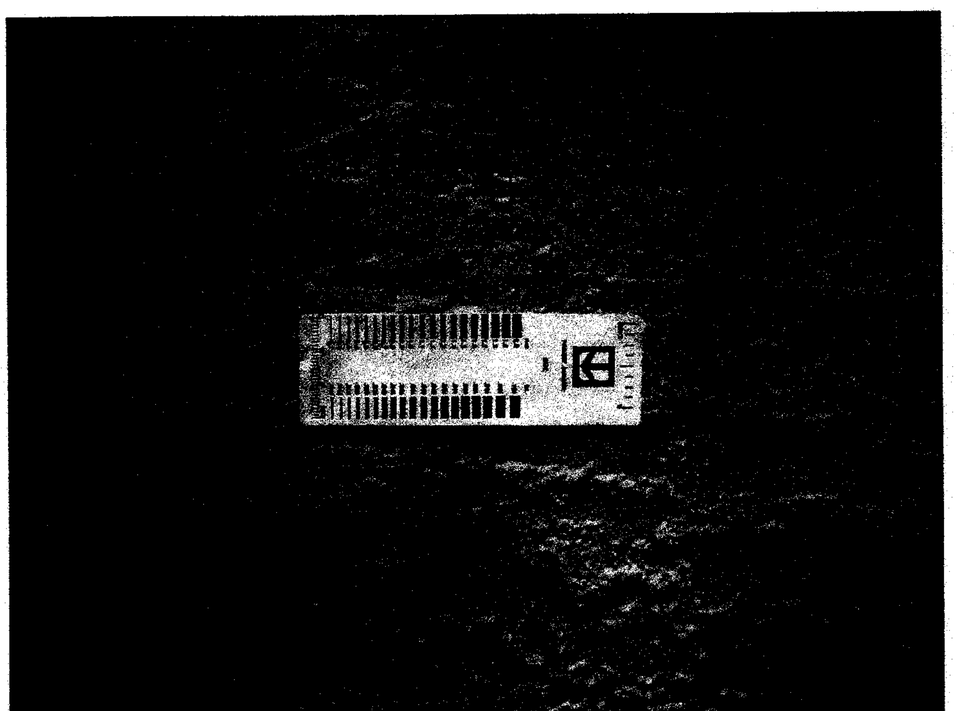
Photograph 7: Additional hairline crack in perimeter wall. **(A)**



Photograph 8: A close-up view of Photograph 7. **(A)**



Photograph 9: Additional hairline crack in perimeter wall. **(A)**

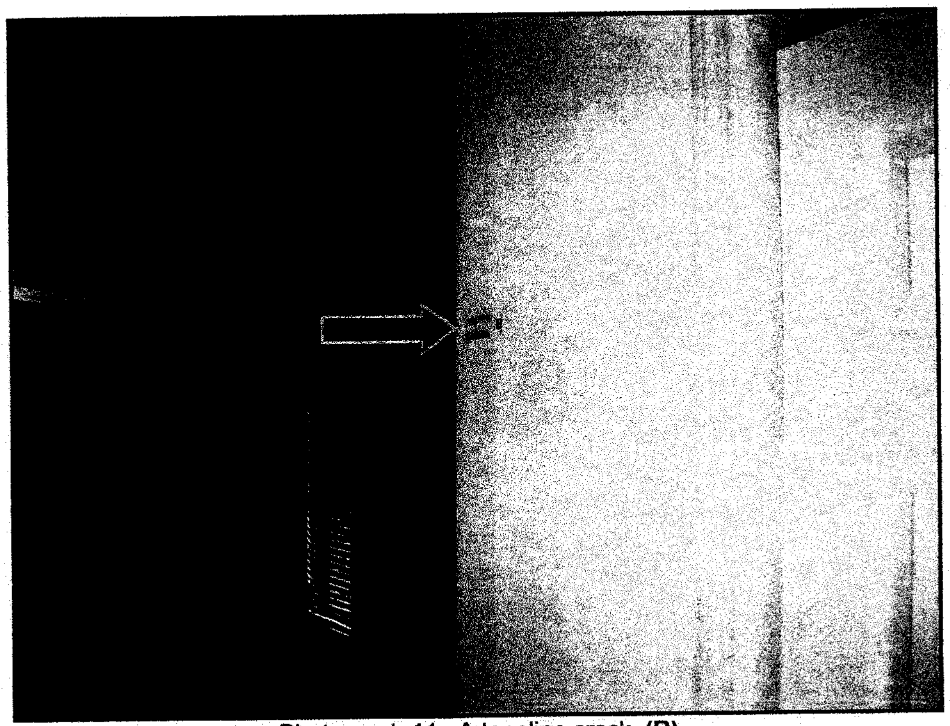


Photograph 10: A close-up view of Photograph 9. **(A)**

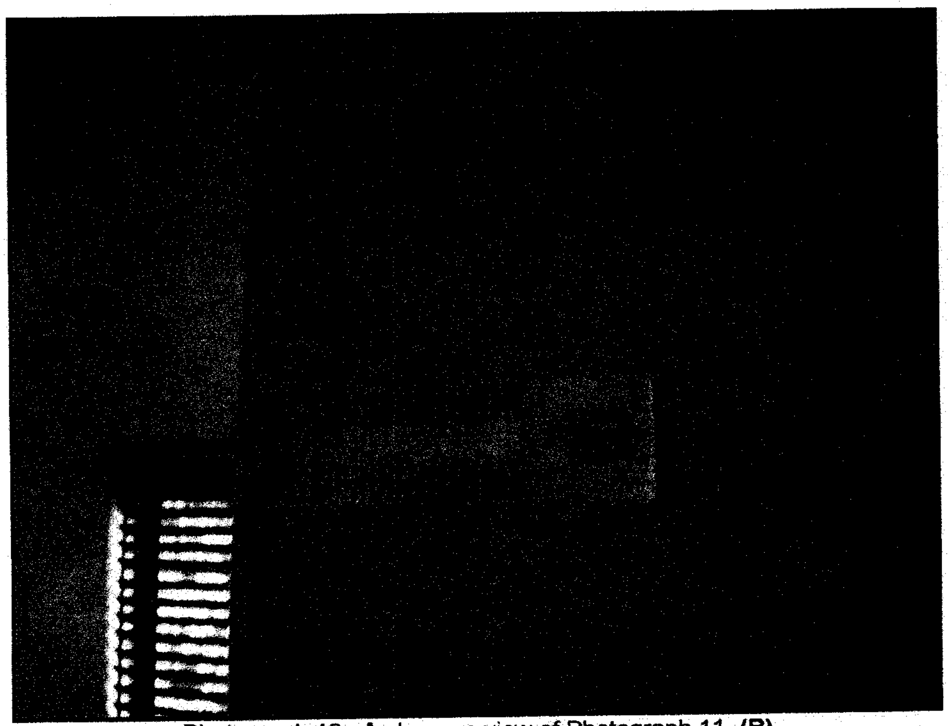
Appendix A-4

Citizens Property Insurance Corp. / Hilpert Residence (10464 Cranston street, Spring Hill, FL 34608)

SITE PHOTOGRAPHS

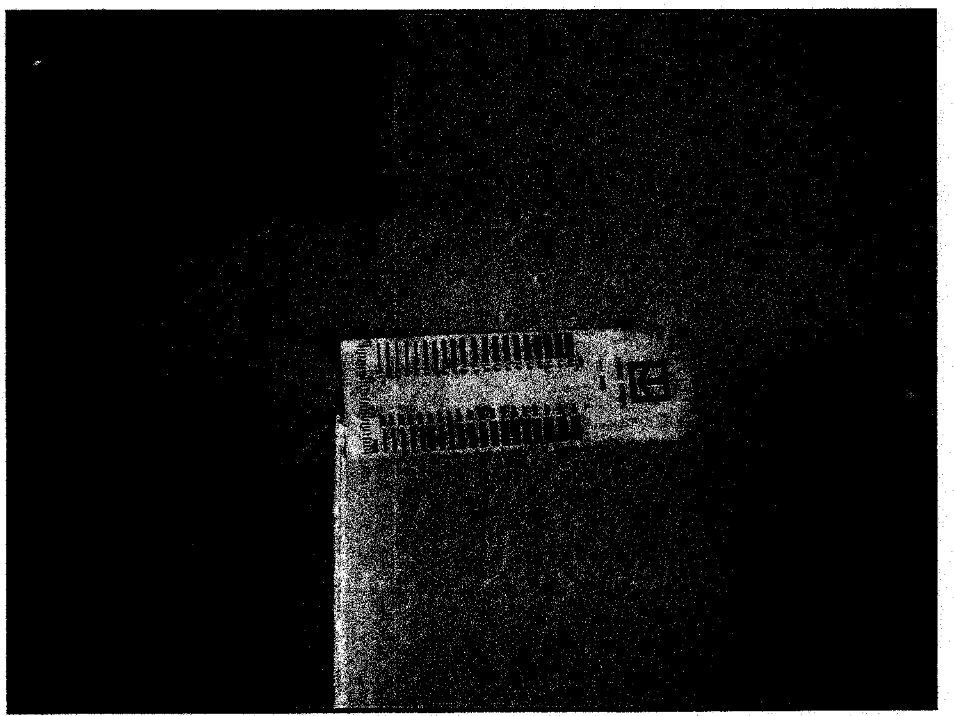


Photograph 11: A tapeline crack. **(B)**

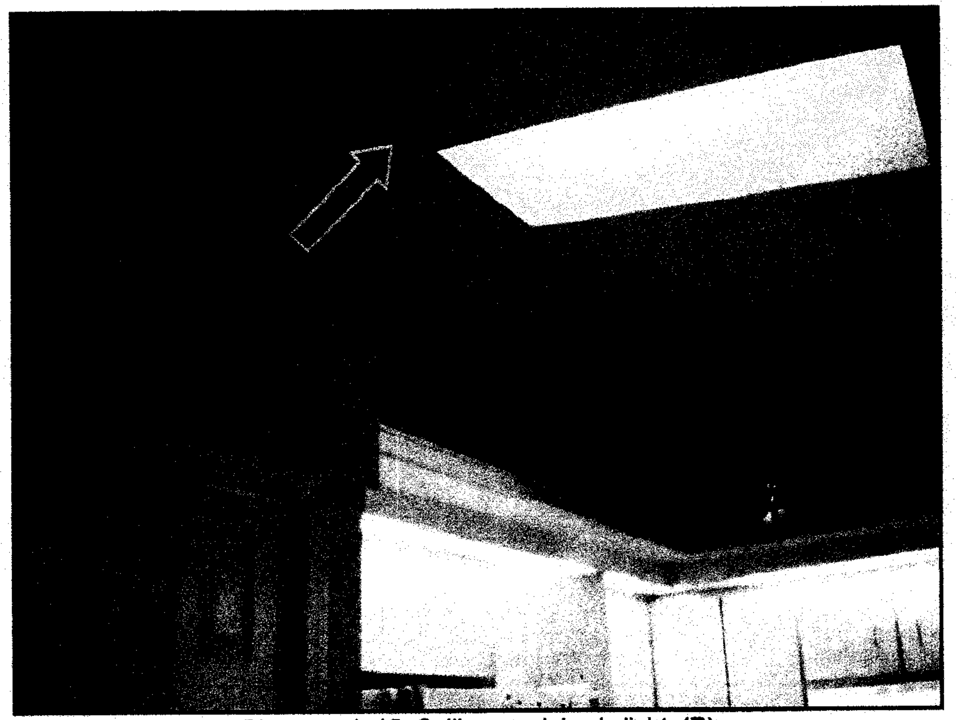


Photograph 12: A close-up view of Photograph 11. **(B)**

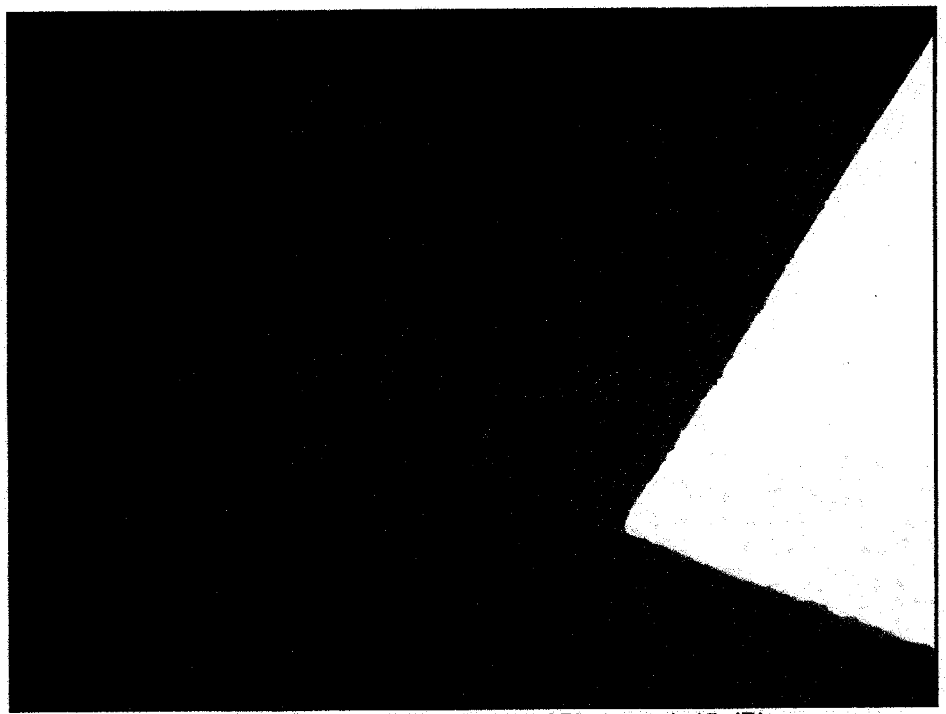
Photograph 13: Construction joint crack above a doorway. **(B)**



Photograph 14: A close-up view of Photograph 13. **(B)**

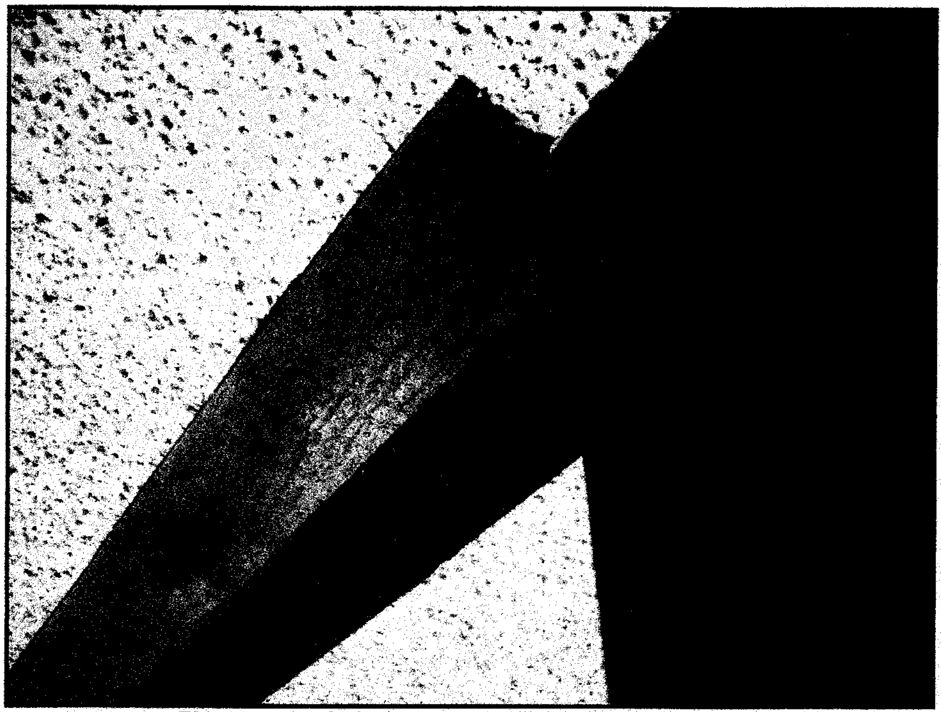


Photograph 15: Ceiling crack in skylight. **(B)**

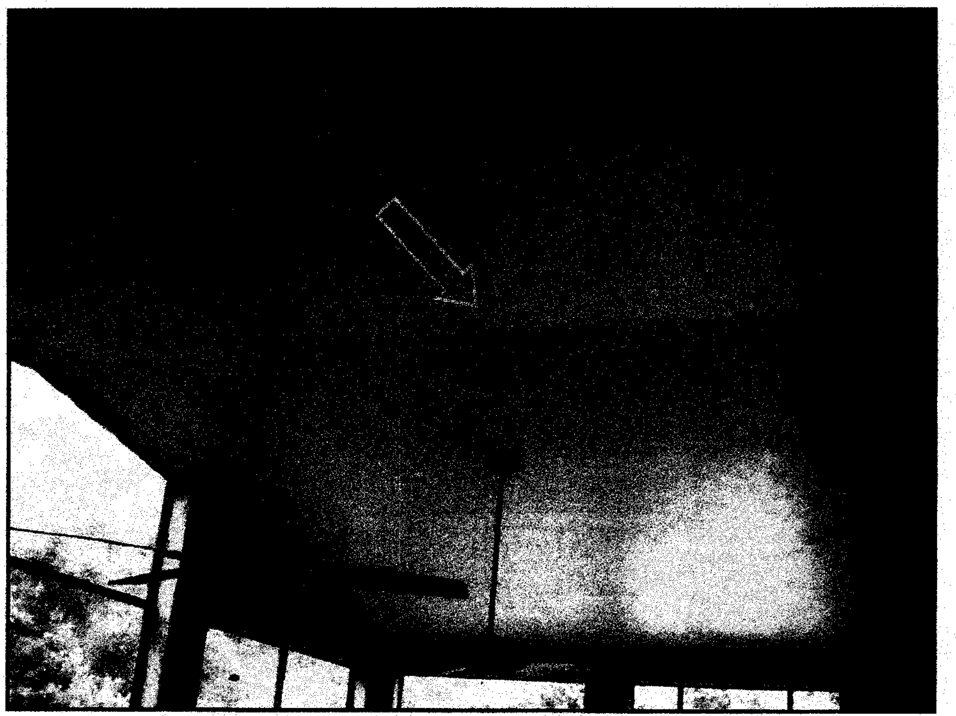


Photograph 16: A close-up view of Photograph 15. **(B)**

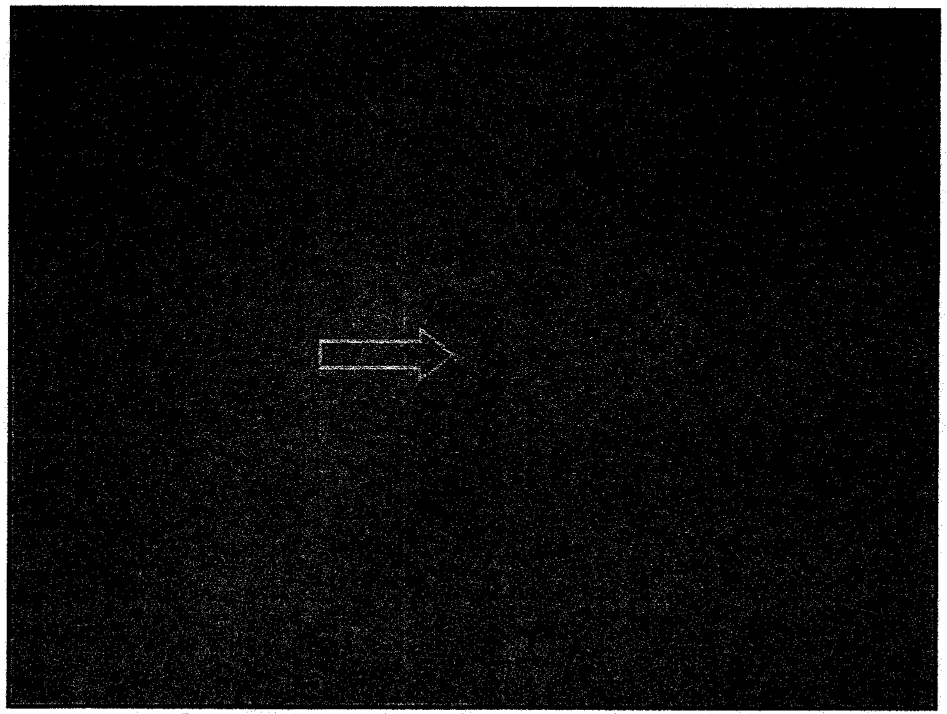
Photograph 17: Wood separation of ceiling joint. **(B)**



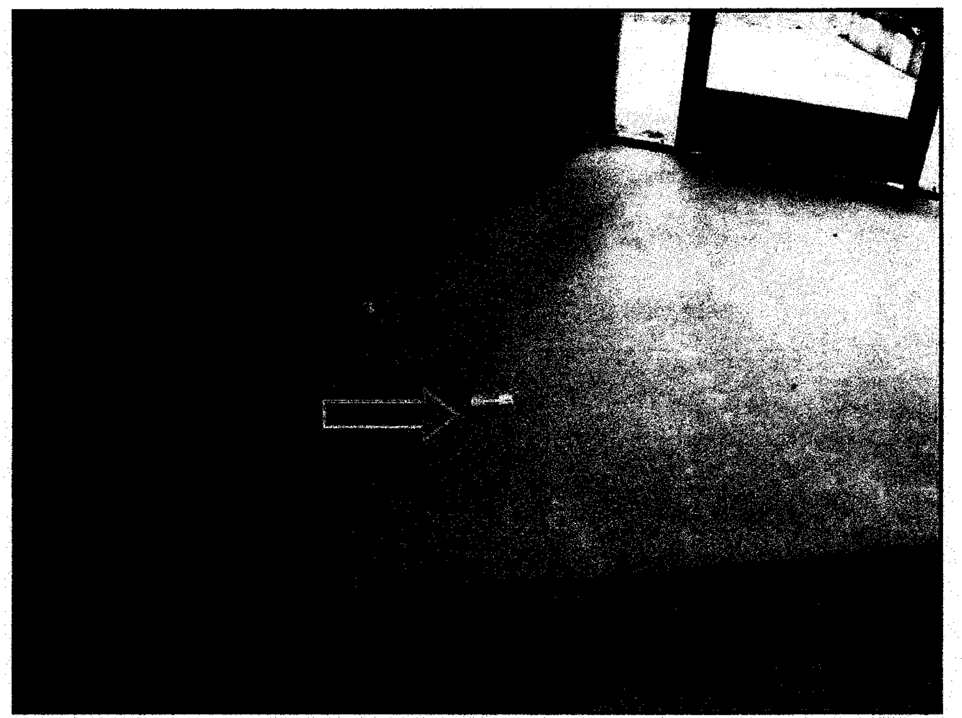
Photograph 18: A close-up view of Photograph 17. **(B)**



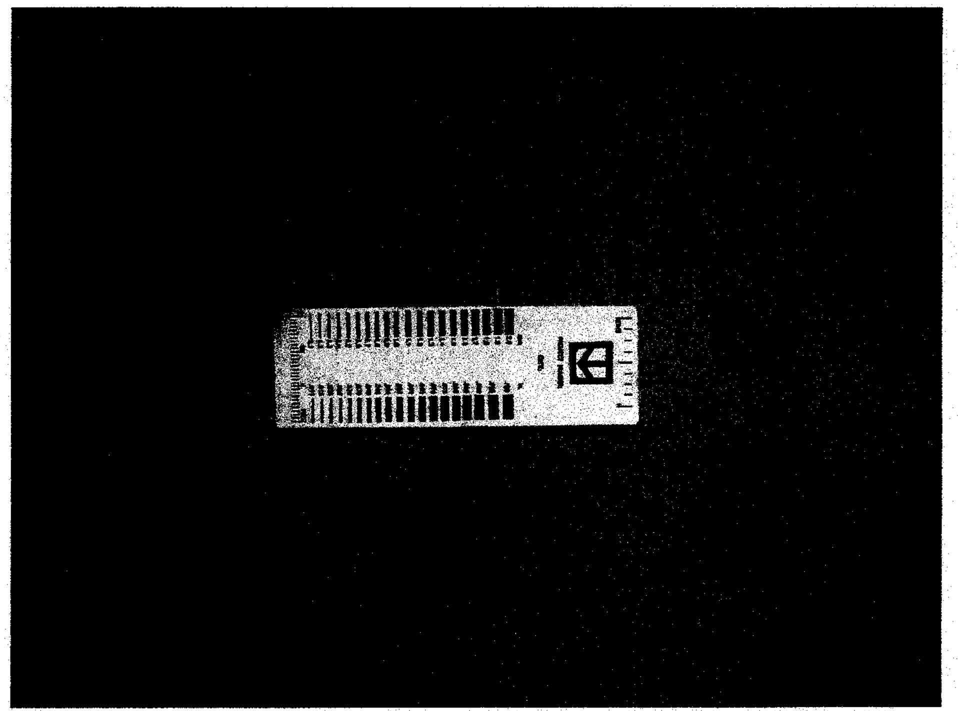
Photograph 19: A crack in ceiling vault. **(B)**



Photograph 20: A close-up view of Photograph 19. **(B)**



Photograph 21: Crack in concrete. **(D)**

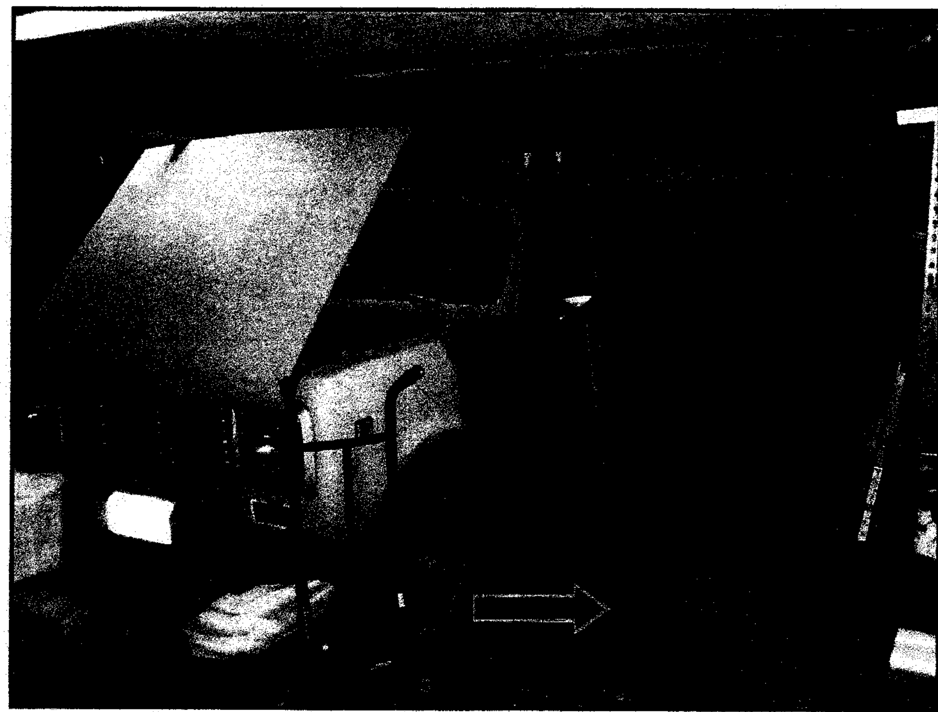


Photograph 22: A close-up view of Photograph 21. **(D)**

Appendix A-4

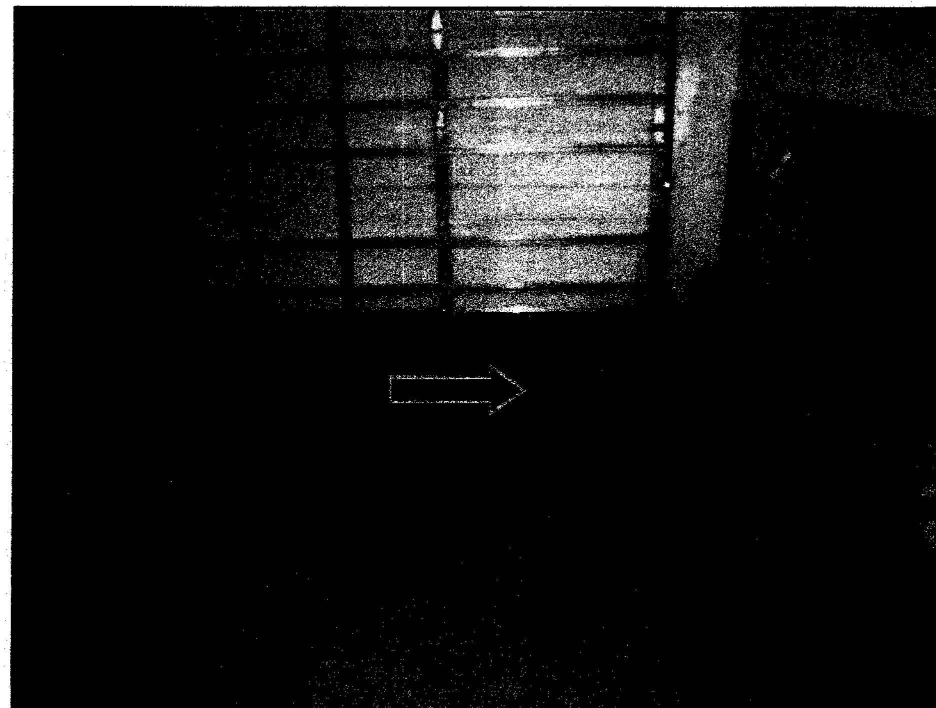
Citizens Property Insurance Corp. / Hilpert Residence (10464 Cranston street, Spring Hill, FL 34608)

SITE PHOTOGRAPHS

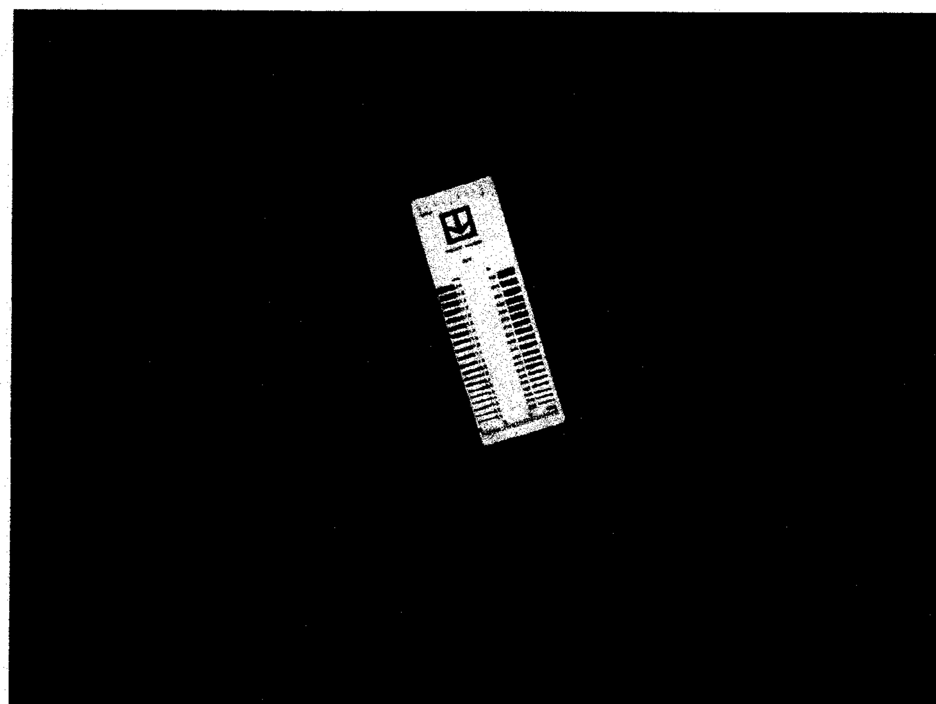


Photograph 23: Cracks in garage floor. **(C)**

Photograph 24: A close-up view of Photograph 23. **(C)**

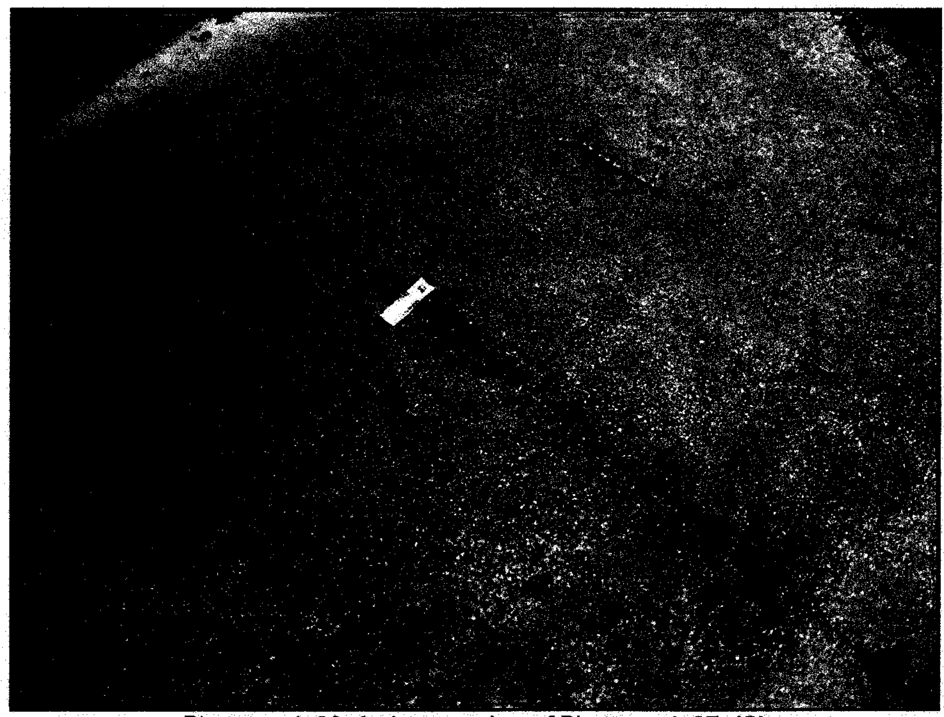


Photograph 25: Crack in garage floor. **(C)**



Photograph 26: A close-up view of Photograph 25. **(C)**

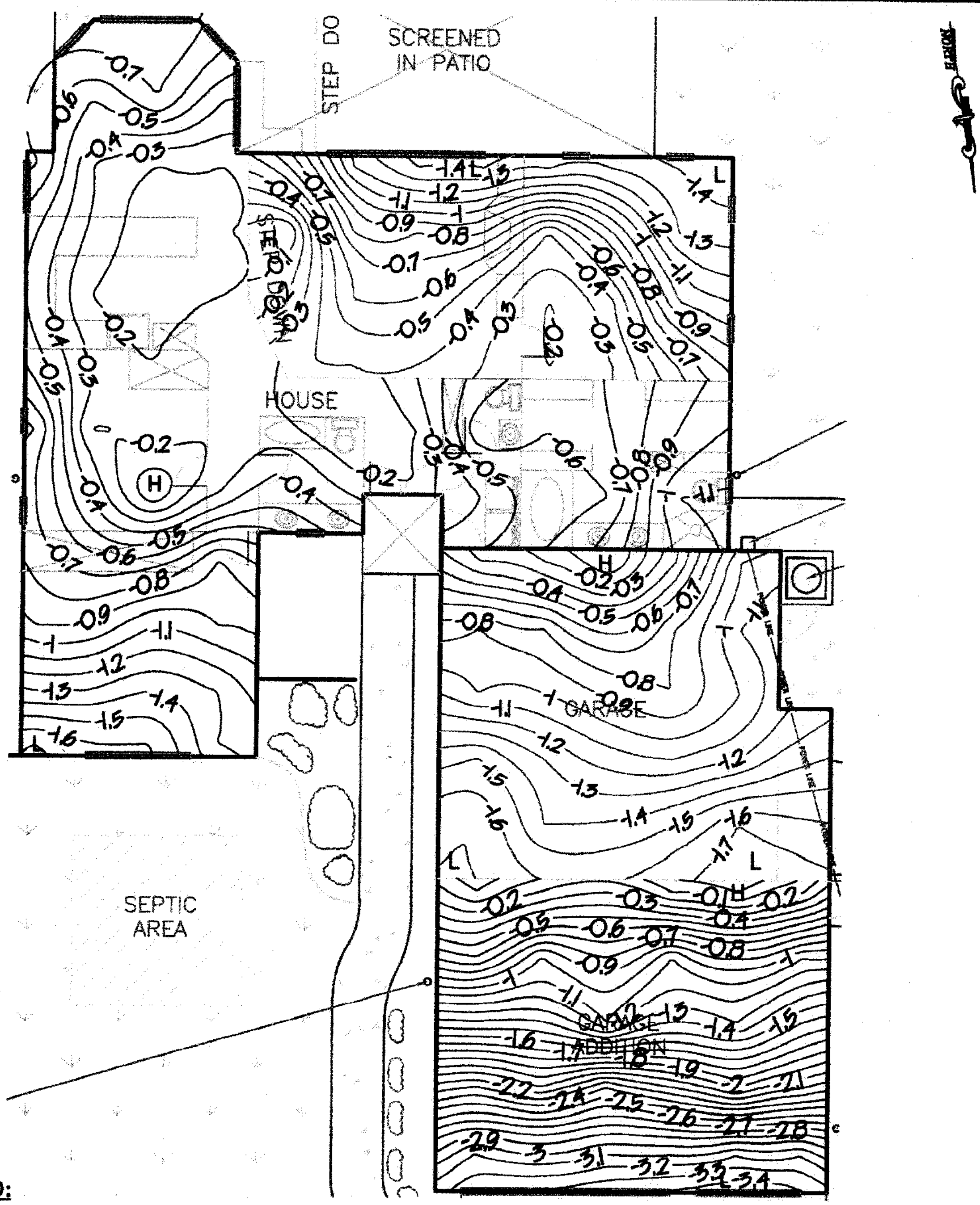
Photograph 27: A crack in concrete patio slab. **(C)**



Photograph 28: A close-up view of Photograph 27. **(C)**

APPENDIX B

B-1: Floor Slab Relative Elevation Survey
B-2: Geophysical (GPR) Exploration Plan
B-3: Soil Testing Location Plan
B-4: Test Pit Details
B-5: Hand Cone Penetrometer Readings / Graphs
B-6: Shallow (Hand Auger) Boring Logs
B-7: SPT Boring Logs
B-8: Soil Classification Chart



LEGEND:

—0.1— FLOOR SLAB CONTOUR ELEVATION [in]

H/L HIGHEST/LOWEST AREAS SURVEYED

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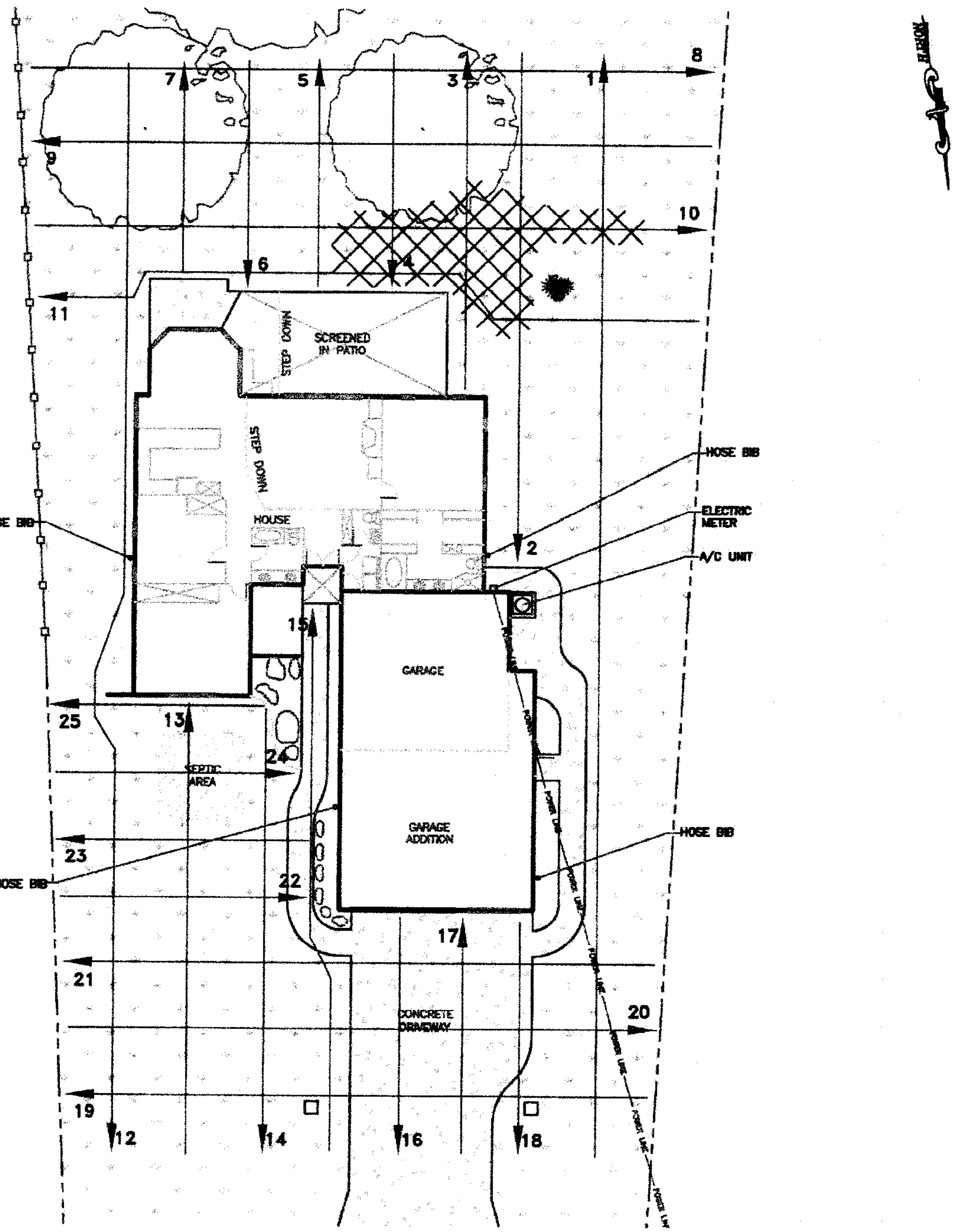
FLOOR SLAB RELATIVE ELEVATION SURVEY

DRAWN BY: SB	DATE: OCT 12, 2010	SURVEYED BY: JC/PR	DATE: AUG 12, 2010
SCALE: 1" = 12'	PROJECT NO: 0830.1000350.0000		APPENDIX: B-1



LEGEND:

GPR TRANSECT (250MHz – TIME WINDOW = 220ns)

GPR ANOMALIES ILLUSTRATED IN RED

GRAPHIC SCALE

0 25

(IN FEET)

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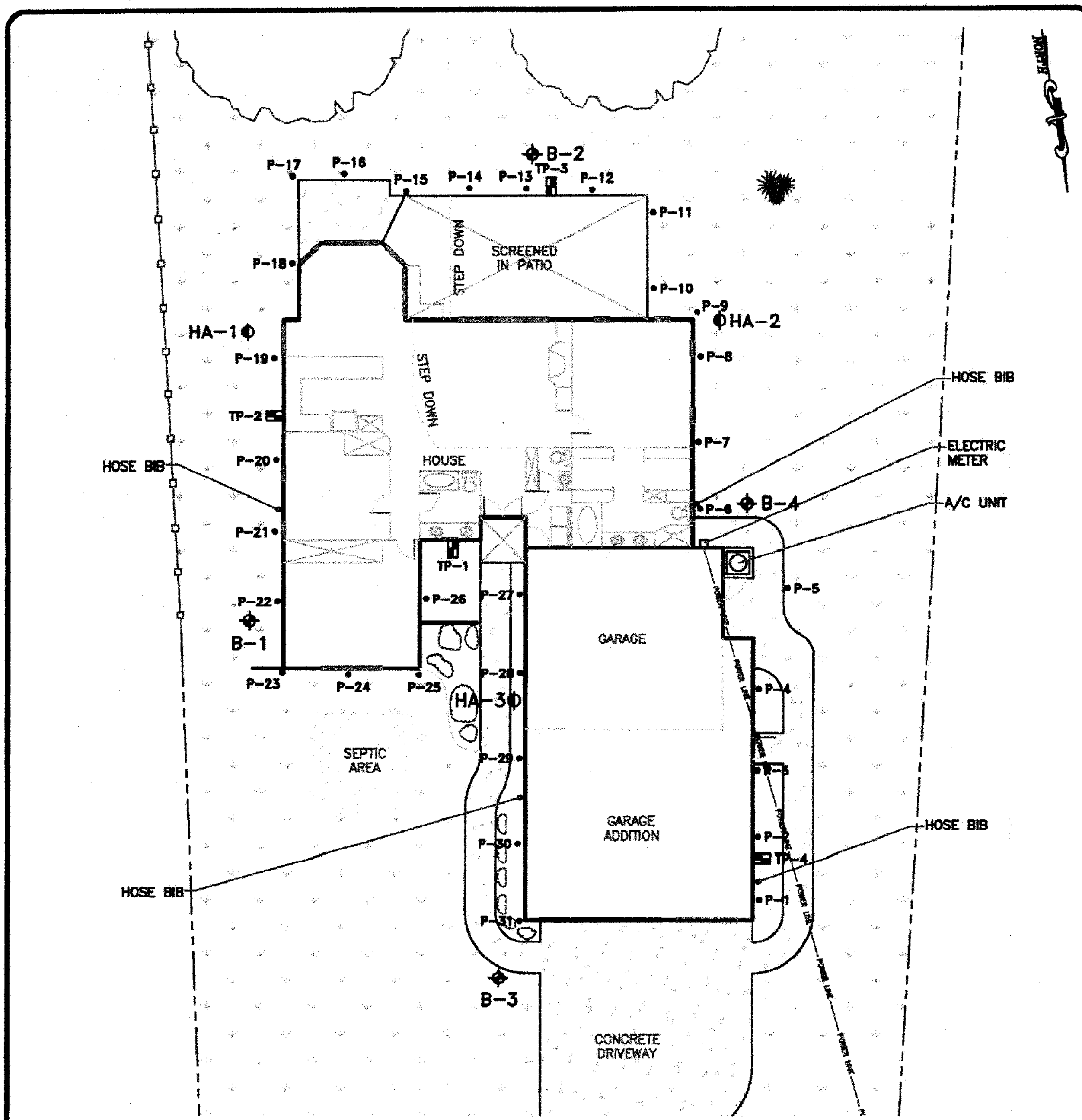
GEOPHYSICAL (GPR) EXPLORATION PLAN

DRAWN BY: SB	DATE: OCT 12, 2010	SURVEYED BY: JC/PR	DATE: AUG 12, 2010
SCALE: 1" = 25'	PROJECT NO: 0830.1000350.0000		APPENDIX: B–2



LEGEND:

- B-1 Approximate SPT boring location
- HA-1 Approximate Hand Auger location
- P-1 Approximate Hand Penetrometer location
- TP-1 Approximate Test Pit location

GRAPHIC SCALE
0 5 10 20
(IN FEET)

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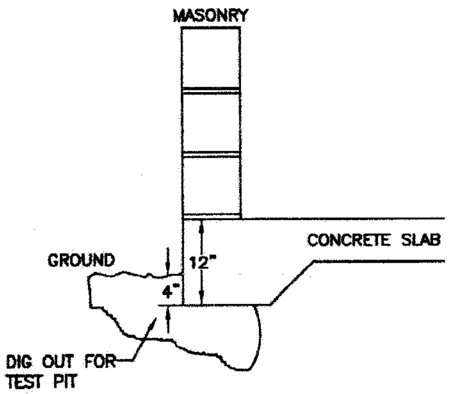
SOIL TESTING LOCATION PLAN

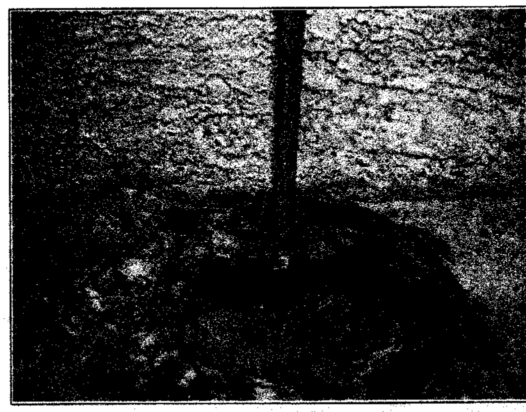
DRAWN BY: SB	DATE: OCT 12, 2010	REVIEWED BY: MG	DATE: OCT 12, 2010
SCALE: 1" = 20'	PROJECT NO: 0830.1000350.0000		APPENDIX: B-3

TEST PIT DETAILS / PHOTOGRAPHS

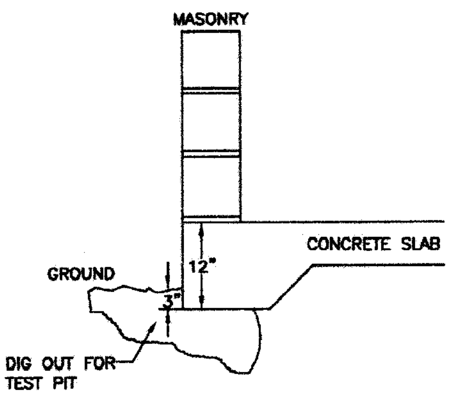
TP–1



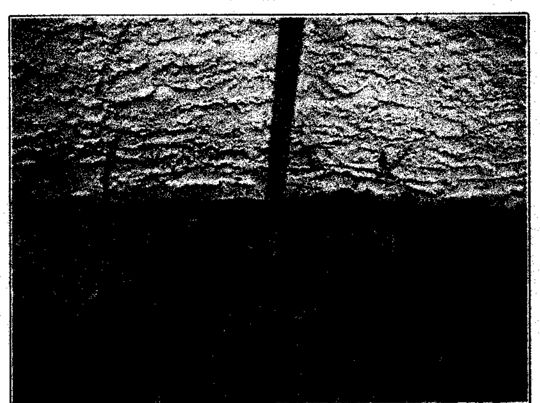
TP–1



TP–2



TP–2



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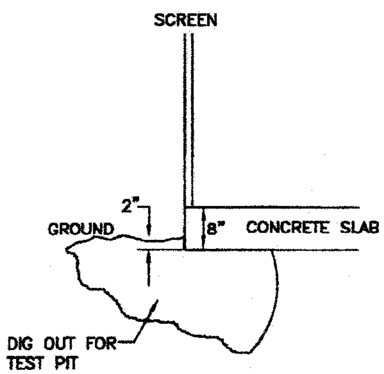
TEST PIT DETAILS

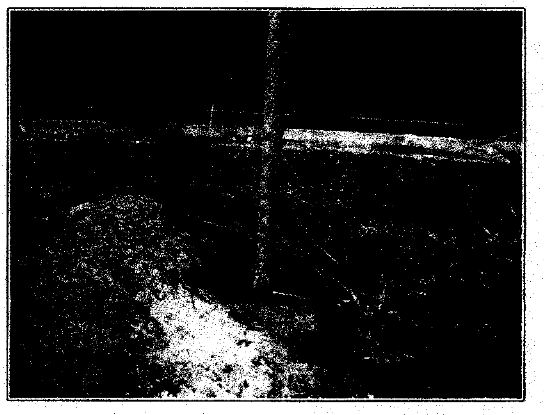
DRAWN BY: SB	DATE: OCT 12, 2010	REVIEWED BY: MH	DATE: OCT 12, 2010
SCALE: NOT TO SCALE	PROJECT NO: 0830.1000350.0000		APPENDIX: B–4

TEST PIT DETAILS / PHOTOGRAPHS

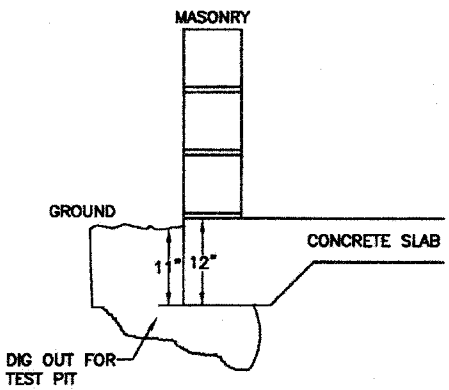
TP–3



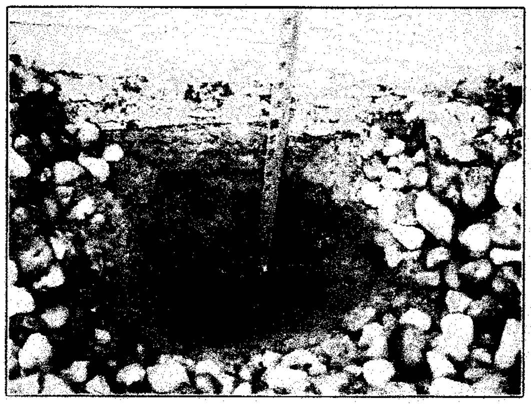
TP–3



TP–4



TP–4



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TEST PIT DETAILS

DRAWN BY: SB	DATE: OCT 12, 2010	REVIEWED BY: MH	DATE: OCT 12, 2010
SCALE: NOT TO SCALE	PROJECT NO: 0830.1000350.0000		APPENDIX: B–4

APPENDIX B-5

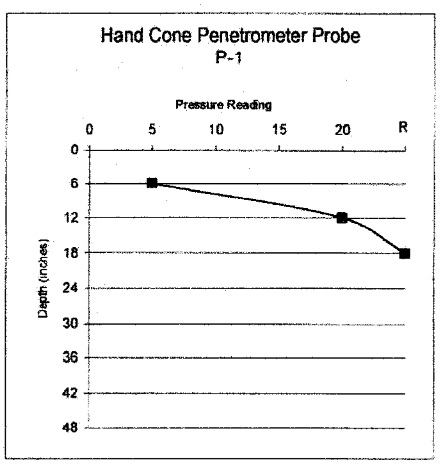
Hand Cone Penetrometer Graphs - Hilpert Residence - 10464 Cranston Street, Spring Hill, Florida

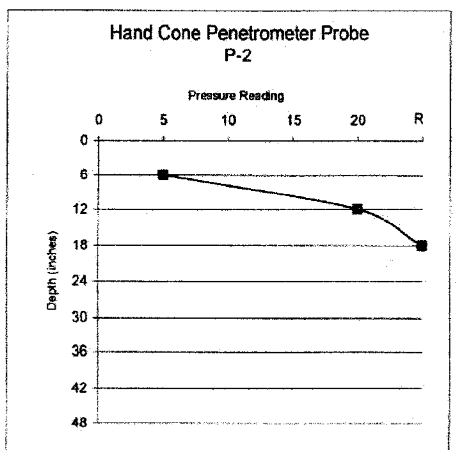
Penetrometer Readings

Test Location / Depth	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11
6"	5	5	5	20	20	20	10	20	10	10	10
12"	20	20	20	20	R	R	20	R	10	10	10
18"	R	R	R	R			R		20	10	20
24"									R	10	R
30"										20	
36"										R	
42"											
48"											

Test Location / Depth	P-12	P-13	P-14	P-15	P-16	P-17	P-18	P-19	P-20	P-21	P-22
6"	10	10	10	10	10	10	20	20	5	10	20
12"	10	10	10	20	20	20	R	R	5	20	R
18"	10	10	10	R	R	R			20	R	
24"	20	20	10						20		
30"	R	R	20						20		
36"			R						R		
42"											
48"											

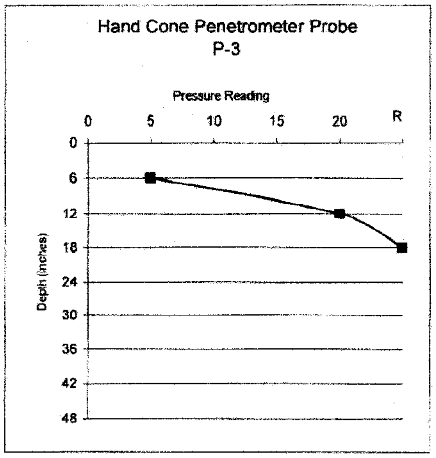
Test Location / Depth	P-23	P-24	P-25	P-26	P-27	P-28	P-29	P-30	P-31
6"	20	20	20	5	20	10	5	5	5
12"	R	R	R	5	R	20	20	20	20
18"				R		R	R	R	R
24"									
30"									
36"									
42"									
48"									

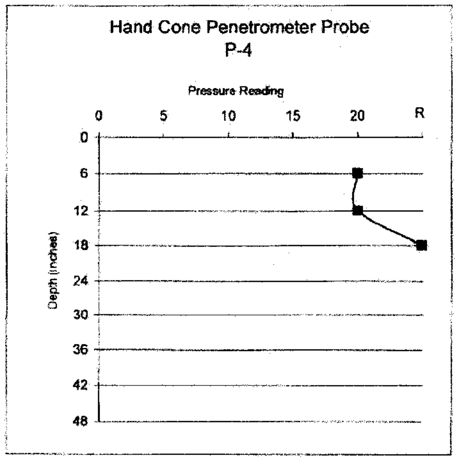


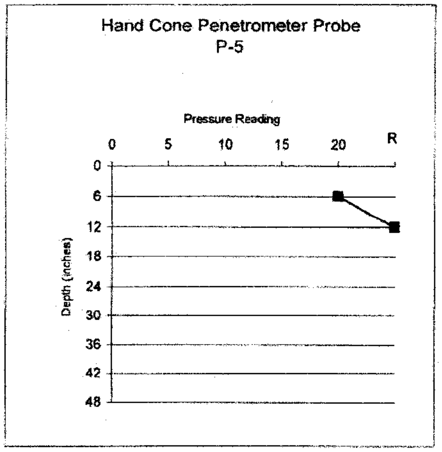


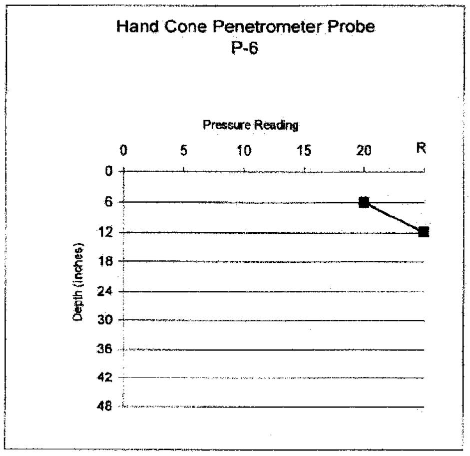
APPENDIX B-5

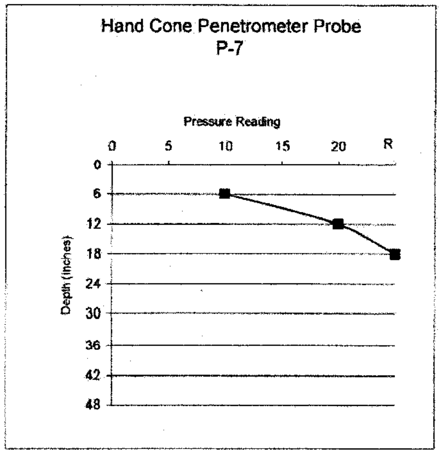
Hand Cone Penetrometer Graphs - Hilpert Residence - 10464 Cranston Street, Spring Hill, Florida

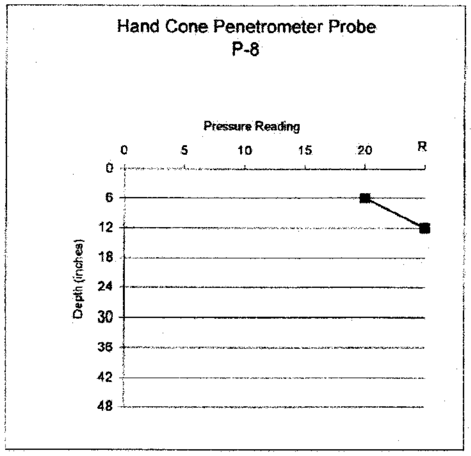






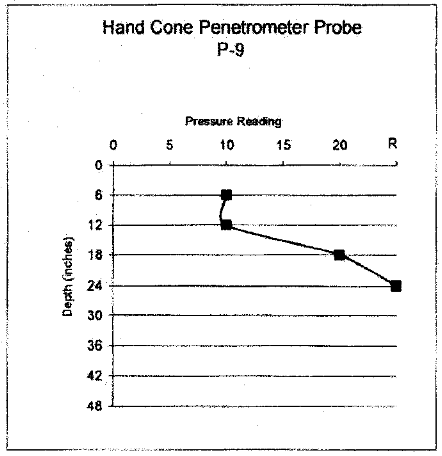


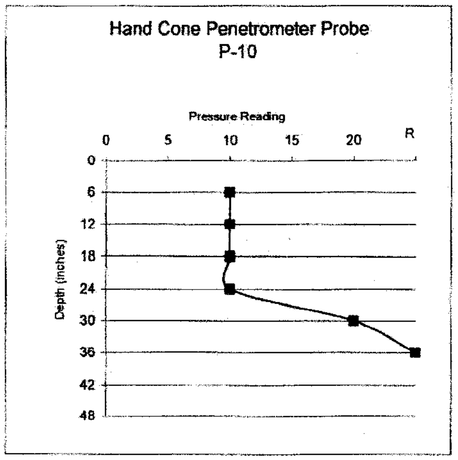


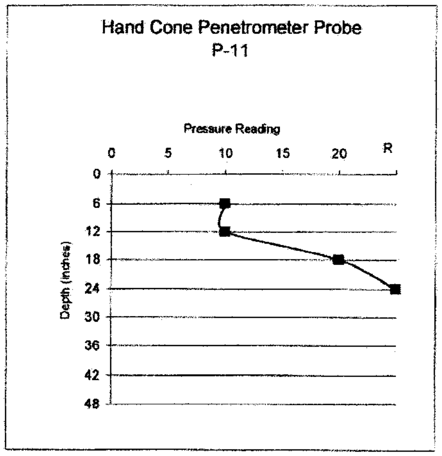


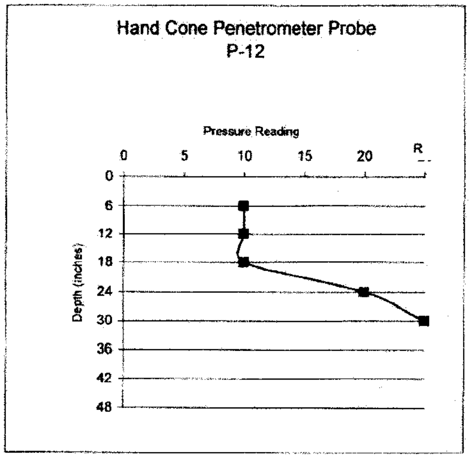
APPENDIX B-5

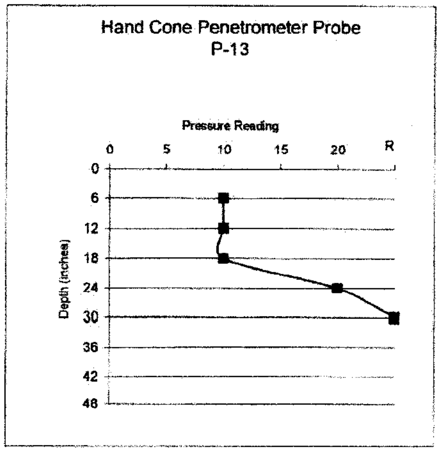
Hand Cone Penetrometer Graphs - Hilpert Residence - 10464 Cranston Street, Spring Hill, Florida

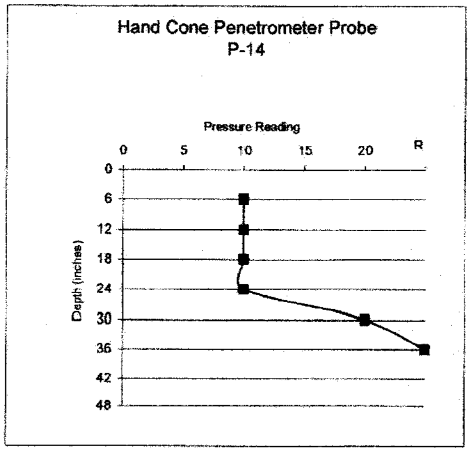






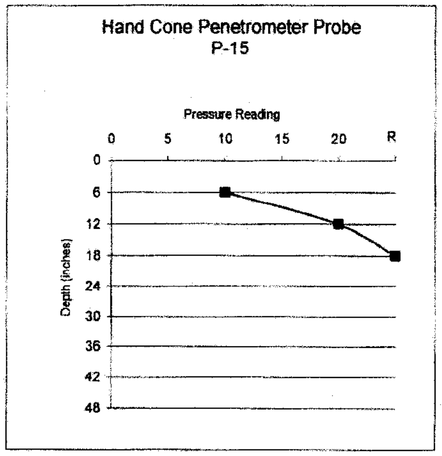


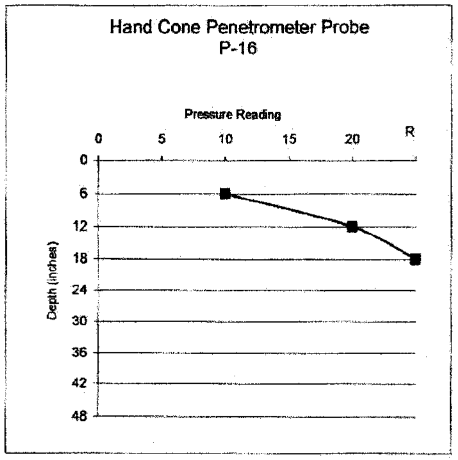


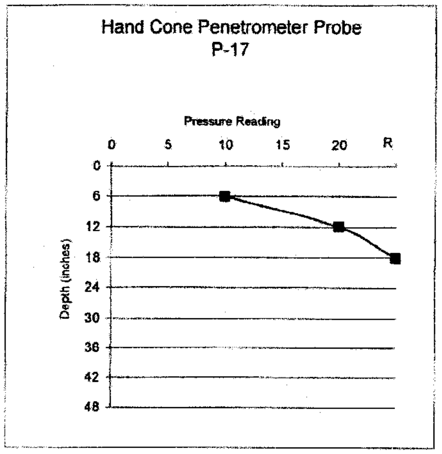


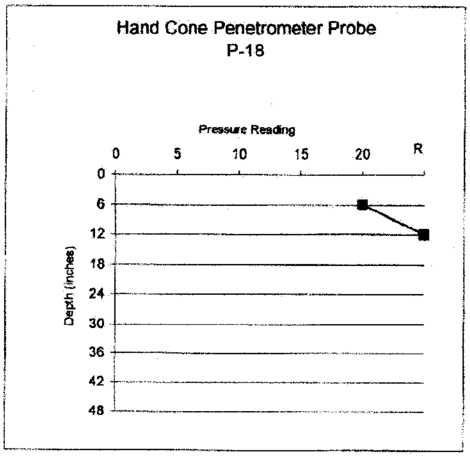
APPENDIX B-5

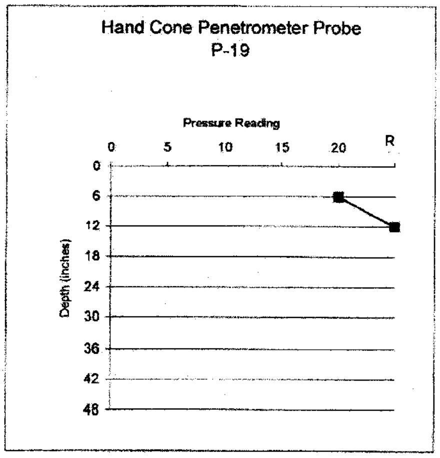
Hand Cone Penetrometer Graphs - Hilpert Residence - 10464 Cranston Street, Spring Hill, Florida

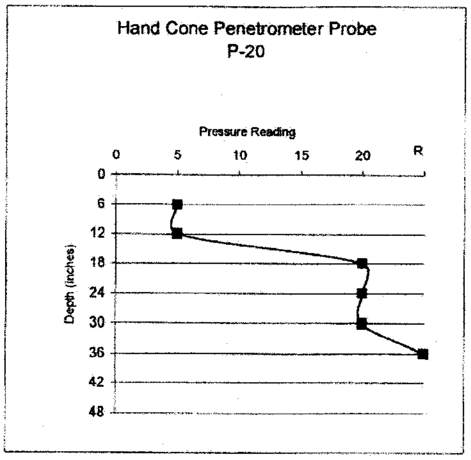






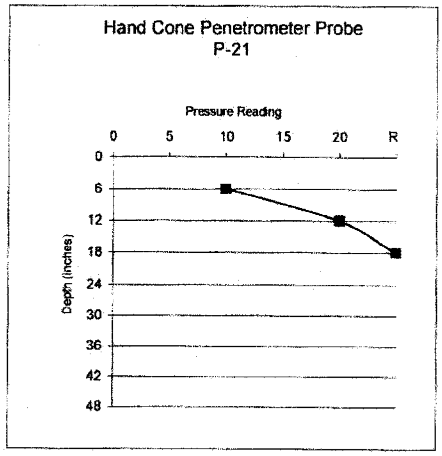


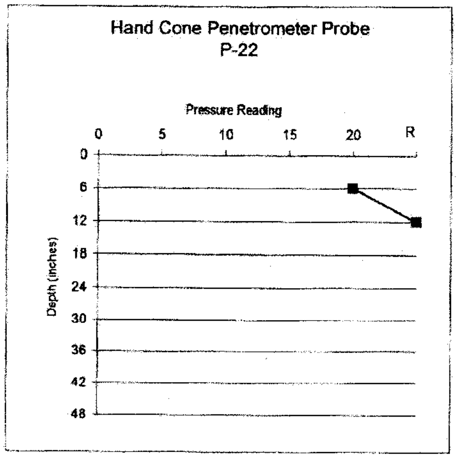


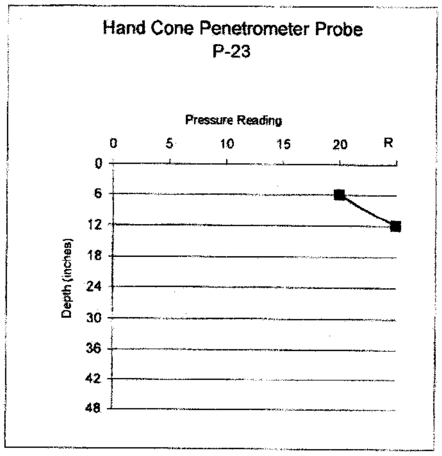


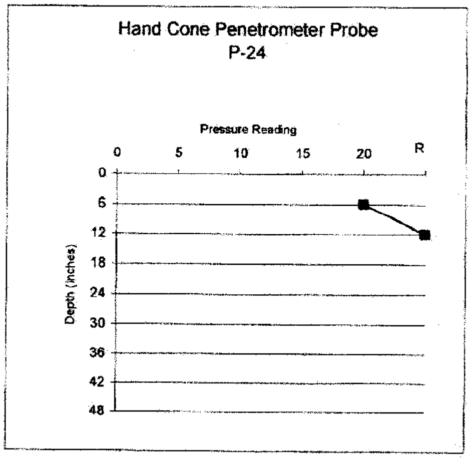
APPENDIX B-5

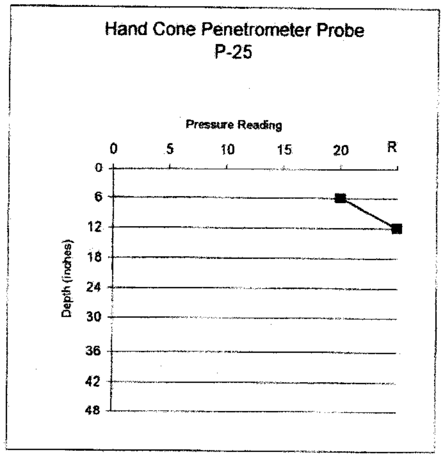
Hand Cone Penetrometer Graphs - Hilpert Residence - 10464 Cranston Street, Spring Hill, Florida

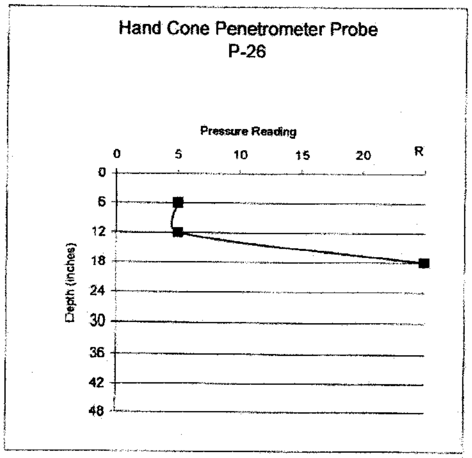






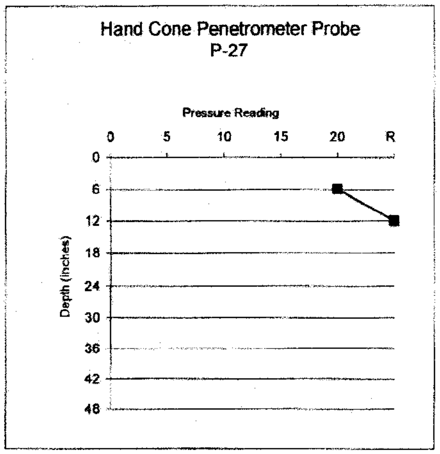


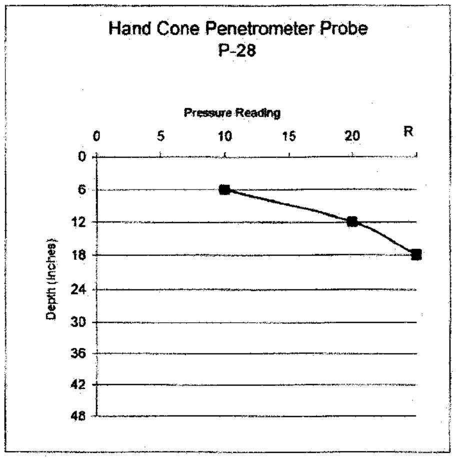


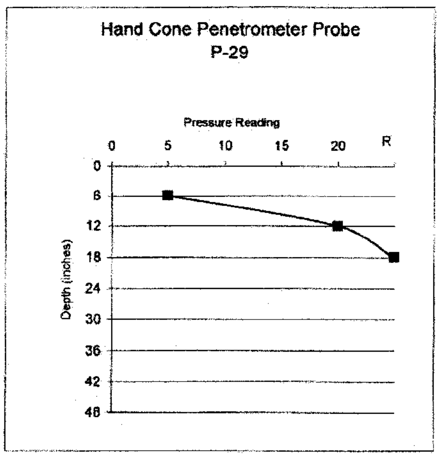


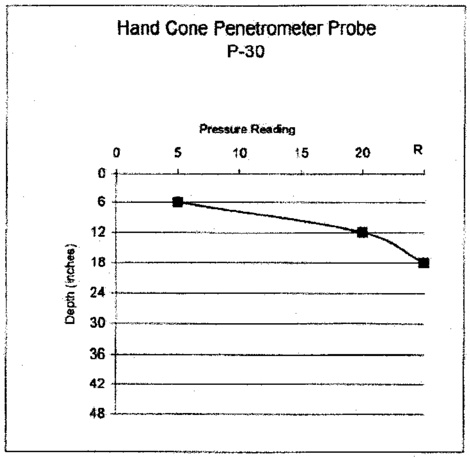
APPENDIX B-5

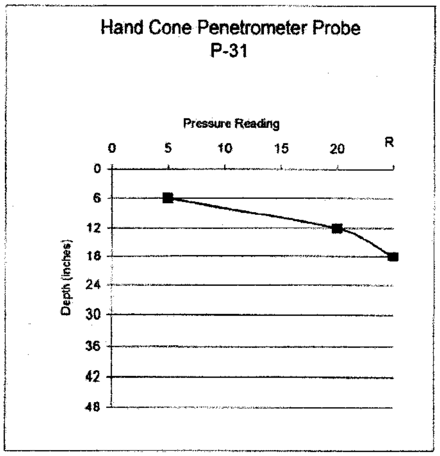
Hand Cone Penetrometer Graphs - Hilpert Residence - 10464 Cranston Street, Spring Hill, Florida











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Tampa, Florida 33619
(813) 740-8506

BORING LOG

PROJECT NO.:	0830.1000350.0000
APPENDIX:	B-6
PAGE:	1

PROJECT: Hilpert Residence
10464 Cranston Street
Spring Hill, Florida

ENGINEER: Mark Hardy, P.E.

CLIENT: Citizens Property Insurance

LOCATION: SEE BORING LOCATION PLAN

REMARKS:

BORING DESIGNATION: **HA-1** SHEET: **1 of 1**

SECTION: 7 TOWNSHIP: 23S RANGE: 18E

STATION:

DATE STARTED: 10/2/10

WATER TABLE (ft): >10.0

DATE FINISHED: 10/2/10

DATE OF READING: 10/2/2010

DRILLED BY: JH

EST. W.S.W.T. (ft):

TYPE OF SAMPLING: HAND AUGER

DEPTH (ft)	SAMPLE	BLOWS PER 6" INCREMENT	N (bpf)	SPT-N vs DEPTH (bpf) 0 25 50	GWT	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	PL	PI	ORG (%)
0							Gray sand (SP)						
							Brown sand (SP)						
							Light brown sand (SP)						
5													
10							Boring terminated at 10 ft.						

ALT UES BORING LOG HILPERT HA LOGS.GPJ UES_NEW.GDT 10/22/10

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BORING LOG

PROJECT NO.:	0830.1000350.0000
APPENDIX:	B-6
PAGE:	2

PROJECT: Hilpert Residence
10464 Cranston Street
Spring Hill, Florida

ENGINEER: Mark Hardy, P.E.

CLIENT: Citizens Property Insurance

LOCATION: SEE BORING LOCATION PLAN

REMARKS:

BORING DESIGNATION: **HA-2** SHEET: **1 of 1**

SECTION: 7 TOWNSHIP: 23S RANGE: 18E

STATION:

WATER TABLE (ft): >10.0

DATE OF READING: 10/2/2010

EST. W.S.W.T. (ft):

DATE STARTED: 10/2/10

DATE FINISHED: 10/2/10

DRILLED BY: JH

TYPE OF SAMPLING: HAND AUGER

DEPTH (ft)	SAMPLE	BLOWS PER 6" INCREMENT	N (bpf)	SPT-N vs DEPTH (bpf) 0 25 50	GWT	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	PL	PI	ORG (%)
0							Brown sand (SP)						
							Brown sand (SP)						
							Light brown sand (SP)						
5													
10							Boring terminated at 10 ft.						

ALT UES BORING LOG HILPERT HA LOGS.GPJ UES_NEW.GDT 10/22/10

UNIVERSAL ENGINEERING SCIENCES 9802 Palm River Road Tampa, Florida 33619 (813) 740-8506	BORING LOG	PROJECT NO.: 0830.1000350.0000 APPENDIX: B-6 PAGE: 3

PROJECT: Hilpert Residence, 10464 Cranston Street, Spring Hill, Florida

ENGINEER: Mark Hardy, P.E.

CLIENT: Citizens Property Insurance

LOCATION: SEE BORING LOCATION PLAN

REMARKS:

BORING DESIGNATION: **HA-3** SHEET: **1 of 1**

SECTION: 7 TOWNSHIP: 23S RANGE: 18E

STATION:

WATER TABLE (ft): >10.0

DATE OF READING: 10/2/2010

EST. W.S.W.T. (ft):

DATE STARTED: 10/2/10

DATE FINISHED: 10/2/10

DRILLED BY: JH

TYPE OF SAMPLING: HAND AUGER

DEPTH (ft)	SAMPLE	BLOWS PER 6" INCREMENT	N (bpf)	SPT-N vs DEPTH (bpf) 0 25 50	GWT	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	PL	PI	ORG (%)
0							Gray sand (SP)						
							Brown sand (SP)						
							Light brown sand (SP)						
5													
10							Boring terminated at 10 ft.						

ALT UES BORING LOG HILPERT HA LOGS.GPJ UES_NEW.GDT 10/22/10

UNIVERSAL ENGINEERING SCIENCES 9802 Palm River Road Tampa, Florida 33619 (813) 740-8506	# BORING LOG	PROJECT NO.: 0830.1000350.0000 APPENDIX: B-7 PAGE: 1

PROJECT: Hilpert Residence
10464 Cranston Street
Spring Hill, Florida

ENGINEER: Mark Hardy, P.E.

CLIENT: Citizens Property Insurance

LOCATION: SEE BORING LOCATION PLAN

REMARKS: Set casing at 30 feet.

BORING DESIGNATION: **B-1** SHEET: **1 of 1**
SECTION: 7 TOWNSHIP: 23S RANGE: 18E

STATION:

WATER TABLE (ft): >10.0

DATE OF READING: 10/1/2010

EST. W.S.W.T. (ft):

DATE STARTED: 10/1/10

DATE FINISHED: 10/1/10

DRILLED BY: JH

TYPE OF SAMPLING: SPT

DEPTH (ft)	SAMPLE	BLOWS PER 6" INCREMENT	N (bpf)	SPT-N vs DEPTH (bpf) 0 25 50	GWT	SYMBOL	DESCRIPTION	-200 (%)	MC (%)	ATTERBERG LIMITS LL	PL	PI	ORG (%)
0							Gray sand (SP)						
							Brown sand (SP)						
							Very loose to loose, light brown sand (SP)						
5	X	2-2-1	3										
	X	2-2-2	4										
	X	3-2-2	4										
10	X	4-4-4	8										
15	X	7-8-11	19				Medium dense, light brown sand w/ clay (SP-SC)						
20	X	9-9-10	19										
25	X	11-14-14	28				Medium dense, light brown sand (SP)						
30	X	8-8-10	18				Medium dense, light brown sand w/ clay (SP-SC)						
35	X	10-10-10	20										
40	X	5-4-5	9										
45	X	4-6-8	14				...Loss of circulation @ 48.5 ft bls.						
50	X	10-11-10	21				Limestone						
55		50/3"	50/3"	>>									
60	X	15-10-37	47				Boring terminated at 61.5 ft.						

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PROJECT: Hilpert Residence, 10464 Cranston Street, Spring Hill, Florida

ENGINEER: Mark Hardy, P.E.

CLIENT: Citizens Property Insurance

LOCATION: SEE BORING LOCATION PLAN

REMARKS: Set casing at 30 feet.

BORING DESIGNATION: **B-2** SHEET: **1 of 1**

SECTION: 7 TOWNSHIP: 23S RANGE: 18E

STATION:

DATE STARTED: 10/1/10

WATER TABLE (ft): >10.0

DATE FINISHED: 10/1/10

DATE OF READING: 10/1/2010

DRILLED BY: JH

EST. W.S.W.T. (ft):

TYPE OF SAMPLING: SPT

DEPTH (ft)	BLOWS PER 6" INCREMENT	N (bpf)	DESCRIPTION	-200 (%)	MC (%)	LL	PL	PI	ORG (%)
0			Dark gray sand (SP)						
			Brown sand (SP)						
			Loose, light brown sand (SP)						
5	2-3-2	5							
	2-3-3	6							
	4-5-4	9							
10	4-3-3	6							
15	11-11-15	26	Medium dense, light brown sand w/ clay (SP-SC)						
20	10-12-15	27	Medium dense, light brown sand (SP)						
25	9-10-12	22							
30	9-9-9	18	Medium dense to loose, light brown sand w/ clay (SP-SC)						
35	7-4-4	8							
40	5-5-3	8	...Loss of circulation @ 40 ft bls.						
45	9-6-23	29	Limestone						
50	50/5"	50/5"							
55	50/1"	50/1"	Boring terminated at 55.1 ft.						

ALT UES BORING LOG HILPERT SPT LOGS.GPJ UES_NEW.GDT 10/22/10

UNIVERSAL ENGINEERING SCIENCES 9802 Palm River Road Tampa, Florida 33619 (813) 740-8506	BORING LOG	PROJECT NO.: 0830.1000350.0000 APPENDIX: B-7 PAGE: 3

PROJECT: Hilpert Residence
10464 Cranston Street
Spring Hill, Florida

ENGINEER: Mark Hardy, P.E.

CLIENT: Citizens Property Insurance

LOCATION: SEE BORING LOCATION PLAN

REMARKS:

BORING DESIGNATION: **B-3** SHEET: **1 of 1**
SECTION: 7 TOWNSHIP: 23S RANGE: 18E

STATION:

WATER TABLE (ft): >10.0

DATE OF READING: 10/2/2010

EST. W.S.W.T. (ft):

DATE STARTED: 10/2/10

DATE FINISHED: 10/2/10

DRILLED BY: JH

TYPE OF SAMPLING: SPT

DEPTH (ft)	BLOWS PER 6" INCREMENT	N (bpf)	DESCRIPTION	-200 (%)	MC (%)	LL	PL	PI	ORG (%)
0			Brown sand (SP)						
5	2-2-3	5	Loose, light brown sand (SP)						
	3-3-3	6							
	4-4-5	9	Loose, light brown sand w/ clay (SP-SC)						
10	4-4-5	9							
15	6-8-11	19	Medium dense, light brown sand (SP)						
20	8-9-11	20							
25	6-7-6	13							
30	5-6-5	11							
35	4-4-4	8	Loose, light brown sand w/ clay (SP-SC) ...Loss of circulation @ 37 ft bls.						
40	2-2-3	5	Loose, light brown sand (SP)						
45			...weight of rod event from 45 to 54 ft bls; light brown sand w/ clay (SP-SC)						
50									
	wor/9'	wor/9'							
55	6-7-24	31	Limestone						
60	50/2"	50/2"							
65	50/1"	50/1"	Boring terminated at 65.1 ft.						

SPT-N vs DEPTH (bpf): 0 25 50

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BORING LOG

PROJECT NO.:	0830.1000350.0000
APPENDIX:	B-7
PAGE:	4

PROJECT: Hilpert Residence, 10464 Cranston Street, Spring Hill, Florida
ENGINEER: Mark Hardy, P.E.
CLIENT: Citizens Property Insurance
LOCATION: SEE BORING LOCATION PLAN
REMARKS: Set casing at 30 feet.

BORING DESIGNATION: **B-4** SHEET: **1 of 1**
SECTION: 7 TOWNSHIP: 23S RANGE: 18E
STATION:
WATER TABLE (ft): >10.0
DATE OF READING: 10/1/2010
EST. W.S.W.T. (ft):
DATE STARTED: 10/1/10
DATE FINISHED: 10/2/10
DRILLED BY: JH
TYPE OF SAMPLING: SPT

DEPTH (ft)	BLOWS PER 6" INCREMENT	N (bpf)	DESCRIPTION	-200 (%)	MC (%)	LL	PL	PI	ORG (%)
0			Gray sand (SP)						
			Brown sand (SP)						
			gray sand (SP)						
4.5			...weight of hammer event from 4.5 to 8.5 ft bls; light brown sand (SP)						
8.5	woh/4'	woh/4'	Loose, light brown sand w/ clay (SP-SC)						
10	4-3-4	7							
16	5-7-6	13							
20	8-9-10	19	Medium dense, light brown sand (SP)						
26	8-9-8	17							
30	6-10-8	18	Medium dense, light brown sand w/ clay (SP-SC)						
35	4-4-5	9	Loose, light brown clayey sand w/ limestone (SC)						
39			...Loss of circulation @ 39 ft bls						
40			...weight of rod event from 40 to 46 ft bls; light brown clayey sand (SC)						
46	wor/6'	wor/6'	Limestone						
47	2-2-2	4							
50	50/2"	50/2"							
55	50/1"	50/1"							
60	50/1"	50/1"	Boring terminated at 60.1 ft.						

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SOIL CLASSIFICATION CHART

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE-GRAINED SOILS (major portions retained on No. 200 sieve): includes (1) clean gravel and sands and (2) silty or clayey gravels and sands. Condition is rated according to relative density as determined by laboratory tests or standard penetration resistance tests.

Descriptive Terms	Relative Density	SPT Blow Count
Very loose	0 to 15 %	< 4
Loose	15 to 35 %	4 to 10
Medium dense	35 to 65 %	10 to 30
Dense	65 to 85 %	30 to 50
Very dense	85 to 100 %	> 50

FINE-GRAINED SOILS (major portions passing on No. 200 sieve): includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings, SPT blow count, or unconfined compression tests.

Descriptive Terms	Unconfined Compressive Strength kPa	SPT Blow Count
Very soft	< 25	< 2
Soft	25 to 50	2 to 4
Medium stiff	50 to 100	4 to 8
Stiff	100 to 200	8 to 15
Very stiff	200 to 400	15 to 30
Hard	> 400	> 30

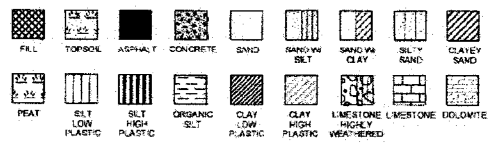
GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.

2. Surface elevations are based on topographic maps and estimated locations.

3. Descriptions on these boring logs apply only at the specific boring locations and at the time the borings were made. They are not guaranteed to be representative of subsurface conditions at other locations or times.

SOIL SYMBOLS

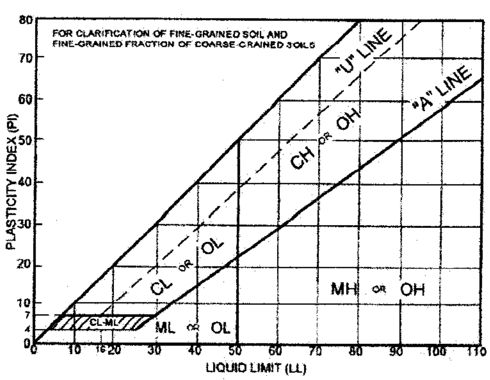


OTHER SYMBOLS

▼ Measured Water Table Level

▽ Estimated Seasonal High Water Table

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria	
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP; More than 12 percent...... GM, GC, SM, SC; 5 to 12 percent...... Borderline cases requiring dual symbols*	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW
		Gravel with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4 — Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			SP	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4 — Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 60)		ML	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart	
			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 60)		MH	Inorganic silts, micaceous or disto-maceous fine sandy or silty soils, organic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
Highly Organic Soils			Pt	Peat and other highly organic soils		



Plasticity Chart

Material		Particle Size: Sieve sizes	Particle Size: mm
Silt or clay		< #200	< 0.074
Sand	Fine	#200 to #40	0.074 to 0.42
	Medium	#40 to #10	0.42 to 2.00
	Coarse	#10 to #4	2.00 to 4.76
Gravel	Fine	#4 to 3/4 in.	4.76 to 19.1
	Coarse	3/4 in. to 3 in.	19.1 to 76.2
Cobble		3 in. to 12 in.	76.2 to 304.8
Boulders		12 in. to 36 in.	304.8 to 914.4

* When the percent passing a No. 200 sieve is between 5% and 12%, a dual symbol is used to denote the soil. For example; SP-SC, poorly-graded sand with clay content between 5% and 12%.

APPENDIX C

C-1: Description of Evaluation Methods
C-2: Categorization of Damage
C-3: Key Terms and Definitions

C-1
DESCRIPTION OF EVALUATION METHODS

Universal Engineering Sciences (UES) employs a number of qualitative and quantitative methodologies in the course of a forensic site evaluation. Brief descriptions of the procedures used are presented below. Since each site evaluation is unique unto itself, we may not conduct every listed method for every site.

FIELD METHODS

Floor Slab Relative Elevation Survey

UES performs a floor slab relative elevation survey (FSRES) using either a gas-filled manometer or a water filled manometer. Elevation readings are obtained on an approximate five foot grid except where furniture and fixed improvements such as cabinets are located. Accuracy of readings is 0.01 feet. The field data consisting of a scaled floor plan with three dimensional data points are introduced into contouring software which interpolates elevations between measured locations and produces an elevation contour map. Significant variation in floor coverings is noted in the field and accounted for in the process.

The contouring of the discrete points is not intended to produce exact replication of floor slab surface elevations. However, it is useful in evaluating larger abrupt elevation changes, trends and patterns of elevation, and quantification of differential elevation.

A FSRES is not performed by a licensed land surveyor and is not tied to a permanent bench mark of known elevation. The end product reports elevations relative to each other.

Ground Penetrating Radar (GPR)

Ground Penetrating Radar (GPR) is a geophysical exploration tool used to provide a graphic cross-sectional view of subsurface conditions. This cross-sectional view is created from the reflections of repetitive electromagnetic (EM) waves which are generated by an antenna in contact with the ground surface as the antenna is pulled in linear traverses across the ground surface. The reflections occur at the subsurface contacts between materials with differing electrical properties. GPR is commonly used to identify such targets as underground utilities, underground storage tanks, buried debris, or geological features. This recorded information can be used to assist in setting locations for geotechnical borings.

The GPR surveys are directed by Meagen Gonzalez, Professional Geologist. Universal Engineering Sciences utilizes a Mala GPR system. GPR surveys are performed in general accordance with ASTM D 6432, *Using the Ground Penetrating Radar Method for Subsurface Investigation*. A GPR survey is conducted along survey lines (transects) which are measured paths along which the GPR antenna is moved. Known reference points (i.e., building corners, driveways, etc.) are placed on a master map, which includes traces of the GPR transects overlying the survey geometry. This survey map allows for correlation between the GPR data and the position of the GPR antenna on the ground.

The features observed on the GPR data that are most commonly associated with sinkhole activity are:

- A down-warping of GPR reflector sets that are associated with suspected lithological contacts, towards a common center. Such features typically have a bowl or funnel shaped configuration and are often associated with deflection of overlying sediment horizons caused by the migration of sediments into voids in the underlying limestone.

- Localized significant increases in the depth of penetration and/or amplitude of the GPR signal response. The increase in GPR signal penetration depth or amplitude is often associated with a localized increase in sand content at depth.

- An apparent discontinuity in GPR reflector sets that are associated with suspected lithological contacts. The apparent discontinuities and/or disruption of the GPR reflector sets may be associated with the downward migration of sediments.

The greater the severity of the above features or a combination of these features, the greater the likelihood that the identified feature is related to past or present sinkhole activity.

Depth estimates to the top of the lithological contacts or targets of interest are derived by dividing the time of travel of the GPR signal from the ground surface to the top of the feature by the velocity of the GPR signal. The velocity of the GPR signal is usually obtained for a given geographic area and earth material from published sources. In general, the accuracy of the GPR-derived depth estimates ranges from ±10 to 20 percent of the total depth.

Although the GPR is very useful in locating significant lithologic soil changes, strata thickness, and inferred subsurface anomalies, the GPR cannot identify the nature of earth materials nor their condition (i.e., loose vs. dense sand, soft vs. stiff clay). The GPR data is best used in conjunction with other geotechnical and physical tests to constrain the interpretation of the virtual cross-section profiles.

Test Pits

Test pits are hand excavated with a shovel to expose a small portion of the foundations. Measurements are obtained of the physical dimensions of the foundation, i.e., thickness, and width and any offset of the stem-wall. Also, the type of foundation is noted along with the depth of embedment (depth from adjacent ground surface to the bottom of the foundation). Current Florida Building Code requires that a foundation have a minimum depth of embedment of 12 inches from lowest adjacent grade. The purpose of the embedment is to create uniform confinement so that bearing stresses do not cause lateral migration of soil from beneath the foundation and to minimize surface erosion and undermining of foundation support soils.

Hand Auger Borings

C-1
DESCRIPTION OF EVALUATION METHODS

Hand auger borings are performed in general accordance with ASTM D 1452. The device is a simple rod with a handle at one end and an approximately six inch long bucket at the opposite end. The procedure consists of advancement of the bucket into the soil in approximate six inch intervals by manual rotation and pressure. The device is removed from the auger hole each interval and soils visually described. Representative soil samples are collected from the cuttings and sealed in appropriate containers for transport back to the laboratory.

Hand Cone Penetrometer (HCP) Probes

The hand cone penetrometer method is a widely accepted in-situ testing procedure. The device used for the test is a thin shaft tipped with a conical point having a projected area of 2.0 square centimeters. The shaft is slightly smaller in diameter than the diameter of the cone base. The other end of the rod is equipped with a handle above a "proving ring" fitted with a dial indicator which measures the amount of linear compression of the ring when force is applied. The dial gauge indicator is accurate to .001 inch.

The test consists of manually pushing the rod in approximate 6 inch intervals under a relatively uniform rate of advancement into the soil and measuring the resistance of the soil to the penetration. The dial indicator reading is recorded for this purpose. The value of the ring compression is correlated to an applied load over the given cone tip area in tons/square foot (tsf). This value has been empirically correlated to typical soil strength properties.

The HCP probe resistance values are generally recorded as an average resistance over the 6 inch increment. Often times the probe is conducted while performing hand augers. If a soil is sufficiently loose, the rod can be manually pushed through the soil without advancing the penetration hole by use of a hand auger.

A general correlation of proving ring compression vs. cone bearing capacity for cohesive soils (clays) and cohesionless soils (sands) are presented in the following table. We note that the q_{cone} bearing capacity is not the same as the soil bearing capacity.

Dial Reading (0.001 inches)	q_{cone} - Cone Bearing Capacity (tsf)	Cohesive Soil Consistency	Cohesionless Soil Relative Density
<5	<15	medium stiff	very loose
5-15	15-40	stiff	loose
15-40	40-120	very stiff to hard	medium dense

Standard Penetration Test (SPT)

UES performs the Standard Penetration Test (SPT) borings in general accordance with the procedures of ASTM D 1586 except with continuous samples collected in the upper 10 feet. This is typically done to detect slight variations in the soil profile at shallow depths. The basic procedure for the SPT is as follows: A standard split-barrel sampler is driven into the soil by a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler 12 inches, after seating 6-inches, is designated the penetration resistance, or N-value; an index to soi l strength and consistency.

The sampling device is split "spoon" cylinder with a 2 inch outer diameter and 1.5 inches inner diameter. After the a split spoon is driven into the soil (at depth), it is removed from the ground and the cylinder is then split in half to expose, visually examine, and collect representative soil sample(s).

The borehole is advanced by rotary wash methods. This involves the use of a drill rod with hollow center tipped with a drill bit of larger diameter (usually 2 to 4 inches in diameter) than the rod. The rod is turned and drilling fluid (water/bentonite clay slurry) pumped under pressure through the drill rod and bit. The fluid returns cutting up and out of the borehole. The drilling fluid is used to maintain the borehole open since it has a density greater than water and exerts a light force against the sidewalls of the borehole.

LABORATORY METHODS

In general, soil profiles depicted in the boring logs presented in **Appendix B** are generated from information recorded during drilling operations as well as review of the recovered soil samples in the laboratory. Soils are classified according to their engineering properties, in general accordance with ASTM D 2488.

In addition, laboratory soil tests are often performed to aid in the classification of recovered soil samples. The following tests may be performed during the evaluation:

Soil Test	ASTM Guideline	Brief Description
Natural Moisture Content	ASTM D 2216	The natural moisture content of a soil is the ratio of weight of water within the voids of the soil to the oven dry weight of the soil expressed in percent.
Percent Finer than #200 Sieve	ASTM D 1140	The Percent Finer than #200 Sieve test measures the silt+clay percentage of the soil sample and is primarily used to aid in the classification of sandy soils.
Grain Size Analysis	ASTM D 422	On occasion it is helpful to evaluate the overall compositional characteristics of a soil and the #200 sieve analysis is supplemented with a full grain size distribution.
Organic Content	ASTM D 2974	This test is used to evaluate the percentage of organic matter within the soil.
Plasticity Index of Soils	ASTM D 4318	The Plasticity Index is derived by measuring the Liquid Limit (LL) and Plastic Limit (PL) of a soil and is used to aid in classification of silts and clays. These values can be used to estimate the potential for the soil to shrink or swell at varying moisture contents.

C-2
CATEGORIZATION OF DAMAGE

Florida Statute 627.706 does not define "structural damage" and the statute requires the professional to render an opinion on whether the cause of the actual physical and structural damage is/is not related to sinkhole activity. Accordingly, in order to meet the spirit and intent of the statute, UES has adopted a categorization of damage of the structure as generally proposed by Burland, et. al [1,2] This categorization is presented in tabular form below.

Damage	Category	Description of Typical Damage	Crack Width (mm) [in]
< COSMETIC >	Negligible	Superficial hairline cracks in stucco covering masonry, may paint or leave alone	< 0.1 [.004]
	Very Slight	Fine cracks which can be easily treated during normal maintenance, possible isolated slight non-structural fracture in building, cracks in external brickwork or masonry visible on close inspection	1 [.04]
< FUNCTIONAL >	Slight	Non-structural related cracks which can be easily patched and painted, several slight see-through non-structural fractures may appear exposing the building interior, cracks which are externally visible, doors and windows may stick, may have compromised weather tightness	<5 [.2]
	Moderate	Significant cracks that require some manicuring and patching by a professional, recurrent cracks that can be masked by flexible coatings, small amount of block/brick replacement, doors and windows stick, utility pipes may fracture, weather tightness is compromised	5 -15 [.2-.6]
<<< STRUCTURAL >	Severe	Large cracks requiring extensive repair involving removal and replacement of wall sections, distorted windows and door frames, noticeably sloping floors, leaning or bulging walls, some loss of bearing in beams and foundations, disrupted utility pipes	15-25 [.6-1]
	Very Severe	Major structural repairs involving partial or complete reconstruction, loss of bearing of beams and foundations, leaning walls which require shoring, windows broken and frames distorted, danger of structural instability	>25 [1]

The categorization is not meant to be all inclusive as there are numerous variants to any such categorization. UES believes the above is a reasonable, practical approach supported by readily observable conditions.

References

1. JB Burland and CP Wroth: "Settlement of Buildings and Associated Damage," Building Research Establishment Current Paper, 1975, Building Research Establishment, Watford.

2. JB Burland, BB Broms, and VFB Demello: "Behavior of Foundations and Structures: State of the Art Report," Proc. of the 9th Int. Conf. On Soil Mechanics and Foundation Engineering, 1977, Tokyo, 495-546.

KEY TERMS AND DEFINITIONS

Activity – Commonly used as an indicator of the expansive potential of a clayey soil. The activity of a soil is estimated by dividing the plasticity index by the clay fraction of the soil.

Aquifer – Geologic unit that is saturated with and transmits ground water.

Atterberg limits – Tests performed on cohesive (clayey) soils to determine the range of moisture contents over which the soil changes from one physical condition to another. These limits are used as parameters to classify and estimate behavior of the clayey soils. See Liquid Limit, Plastic Limit, Plasticity Index.

Bearing capacity – A measure of allowable bearing (load) placed on a given soil profile before a pre-determined failure (yield) criteria is met.

Blow count – The number of times a 140-lb hammer must fall 30 inches to drive a split spoon sampler 6 inches. See Standard Penetration Test (Description of Evaluation Methods, **Appendix C**).

Calcareous/Carbonate – Refers to earth materials composed of calcium carbonate ($CaCO_3$).

Chert – Rock type composed of amorphous quartz (SiO_2). The material is highly insoluble and usually found in the upper zones of the limestone bedrock. It is vary hard and difficult to drill.

Cohesive – Soils which exhibit plastic behavior when moist which is generally comprised of clay minerals.

Concrete shrinkage – The volumetric change (shrinkage) of concrete due to the evaporation of water from the hardened concrete. Tensile stresses are generated and cracks are common.

Confining unit – A geologic unit, primarily composed of clay minerals, which retards the flow of ground water.

Consolidation – The loss of volume of a cohesive soil mass due to loading (pressure) where water is "squeezed" out over time. Often misused interchangeably with settlement or deformation in sandy soils.

Cover collapse sinkhole – Steep-sided depression in the ground surface formed by the erosion of overburden soils into subterranean voids in underlying geologic units (clay and limestone). Collapse generally refers to a sudden or catastrophic collapse of the ground surface and is generally driven by gravity or a combination of gravity and groundwater flow.

Cover subsidence sinkhole - Sinkhole formed by small scale erosion of overburden soils into smaller voids in underlying geologic units. The process is considered slower than a cover collapse event and is more dominated by moving ground water. The process results in loss confinement in sands, a reduction in soil strength, and a bowl-shaped depression in the ground surface. The process may also lack a surface expression initially.

Epikarst – The zone of weathering found at the upper surface of the limestone bedrock. The weathering of the limestone surface results in an irregular surface and limestone pinnacles and boulders are common within the zone.

Erosion – The transportation of earth materials, usually accomplished by water, wind, or gravity.

Expansive soil – A clay rich soil deposit that undergoes volume (shrink/swell) change with moisture content fluctuations. Composed primarily of Montmorillonite and Illite clay.

Fill – Soils (generally sands) used to backfill excavations and to elevate site grades during construction.

Footing – The potion of the foundation that transfers the structural load to underlying soils.

Hand Cone Penetrometer (HCP) – See Description of Evaluation Methods, Appendix C.

Incipient – Early in development, beginning to take place. Generally used to describe the initial stages of cover subsidence sinkhole activity that may not have resulted as a surface expression.

Indurated – Cemented or compacted sediments.

Kaolinite – Clay sized mineral with a low expansion potential.

Karst – A term describing landforms that have been modified by the dissolution of carbonate rock (limestone or dolomite). Also colloquially refers to the process resulting in the development of karst landscape.

Lintel – A horizontal structural member (beam) that spans an opening (window, door, etc.). Loads are transferred to the sides of the opening.

Liquid Limit (LL) – The moisture content at which a cohesive soil (clay) ceases to behave plastically and flows (as a viscous fluid).

KEY TERMS AND DEFINITIONS

Loss of drilling fluid circulation (LOC) – Loss of drilling fluid circulation occurs when drilling fluid is lost to voids or openings in underlying geologic units. In addition, drilling fluid may be lost due to drilling conditions (clogging of drill bit, etc.)

Masonry – Stone, brick, concrete, or similar building materials bonded together with mortar to form a wall.

Moisture content – The measure of the amount of water in a bulk soil mass. Calculated by dividing the weight of water by the weight of sample dry weight and is expressed as a percentage.

Montmorillonite – A clay sized mineral with a high expansion potential.

N-Value – The sum of the blows required to drive a split spoon sampler 12 inches of soil. See Standard Penetration Test (Description of Evaluation Methods, **Appendix C**).

Overburden soils – The sediments located directly over the bedrock. Generally composed of sand and clay in Florida.

Peat – An organic-rich soil or sediment with greater than 50 percent by dry weight organic component.

Plastic Limit (PL) - The moisture content at which a cohesive soil (clay) ceases to be brittle and becomes plastic (able to be molded).

Plasticity Index (PI) – The range of moisture over which a cohesive soil behaves plastically. The PI is calculated as the liquid limit minus the plastic limit and is expressed as a whole number.

Potentiometric surface – A theoretical elevation that represents the level to which ground water would rise in a well.

Raveling – An erosional process where groundwater transports soil particles by seepage forces (drag) downward into fractures and openings in underlying geologic units.

Settlement – Deformation of soil in the (downward) vertical direction. Settlements observed in soils may be the result of several conditions, including loading, drag forces from moving water, and erosion.

Sinkhole – A landform created by subsidence of soil, sediment, or rock into voids or fractures in underlying strata. These voids are generally a result of weathering (dissolution) of carbonate bedrock. The influx of ground water may continue the weathering of the bedrock (primarily limestone), continuing the process.

Soil Series – A classification derived by the USDA originally used for agricultural purposes. In general, the upper 6 or 7 feet of soils are described in the soil series.

Solution sinkhole – Small diameter opening in the limestone bedrock. The small opening may be in-filled with sediment from above or (if the limestone is sufficiently shallow) may produce a small "hole" in the ground surface. The latter is often referred to as a "chimney sinkhole."

Standard Penetration Test (SPT) – See discussion in the Description of Evaluation Methods, **Appendix C**.

Surficial aquifer – The ground water contained in the upper sequences of sands or other overburden sediments In general, the upper surface is free to move with changes in ground water volume change (due to increases/decreases in rainfall, evaporation).

Surficial sands – Generally refers to the upper sequences of sand found below the ground surface.

Thickened edge monolithic slab – A single concrete slab with a thickened edge which serves as a foundation for load bearing walls.

Water table – The upper surface of the surficial aquifer.

Weathering – The physical or chemical change of an earth material.

Weight of hammer (WOH) – An event where the drilling hammer, rod, and bit are allowed to rest on the bottom of the borehole and advance under their own weight.

Weight of rod (WOR) – An event where the drilling rod and bit (before the placement of the hammer on the anvil) is allowed to rest on the bottom of the borehole and advance under their own weight.

APPENDIX D

D-1: Grouting Program Recommendations
D-2: Preliminary Grout Injection Point Location Plan
D-3: Preliminary Polyurethane Injection Point Location Plan

APPENDIX D-1
REMEDIATION PROGRAM RECOMMENDATIONS
HILPERT RESIDENCE
10464 CRANSTON STREET
SPRING HILL, FLORIDA 34608

1.1 SCOPE OF WORK

1.1.1 The work covered by this section consists of providing project control, supervision, all labor and equipment, and performing all operations in connection with improvement of the deep soils underlying the existing residential units and foundations by injection of low slump grout. Grouting shall begin at each primary grouting location at depths as directed by the Geotechnical Engineer.

1.1.2 **In general, the goal of the proposed grouting program shall be to compact, fill, and improve loose soils and/or fill void space <u>at and above</u> the soil/limestone interface.** The grout shall be a sand-cement mixture with appropriate additives and a 2-day compressive strength on the order of 150 pounds per square inch (psi).

1.1.3 The placement of low slump grout within the soil shall act to compress and densify the surrounding soil. Additionally, the grouting may plug openings that may exist in the top of the limestone layer. Grout with a maximum slump of 6 inches shall be used for the low slump grouting operations.

1.1.4 The grouting program includes the placement of grout injection pipes at the locations discussed in this report, or elsewhere as specifically approved by the Geotechnical Engineer. **Soil improvements shall primarily consist of injection of a low slump compaction grout under pressure at the injection points beginning just below the limestone/overburden interface.**

1.1.5 This recommendation is issued as an appendix to the Universal Engineering Sciences geotechnical exploration, Universal Project No. 0830.1000350.0000. All findings and recommendations provided by the report and appended data are included by reference in this recommendation. All bidders are requested to submit the bid in a format and based on quantities presented in 3.1.1.

1.2 EQUIPMENT

1.2.1 Only approved pumping equipment shall be used in the preparation or handling of compaction grout. All equipment shall be maintained in good working condition at all times.

1.2.2 Compaction grout pumps shall have an on-line pressure gauge with range of 50-500 psi.

1.2.3 The contractor shall provide vertical survey control in the vicinity of each injection point to determine when surface heave has occurred.

1.2.4 The contractor's equipment used for installation of the grout casing shall have the capability of installing injection pipes on angles, so as to extend grout piping beneath the building.

2.1 INJECTION POINT SPACING AND PLACEMENT

2.1.1 The method of installation of the grout injection pipes (GIP) shall be determined by the contractor, with the knowledge that the contractor assumes the risk of any subsidence damage that is deemed to result from the method used. The Primary GIPs should be advanced through the surface and underlying soils to an expected depth of approximately 50 TO 55 feet below existing grade at the locations indicated on the proposed Grout Injection Point Location Plan (**Appendix D-2**). Variation in depth shall be at the direction of the Geotechnical Engineer. **GIPs shall not be installed deeper than 55 feet unless under the direction of the Geotechnical Engineer.**

Grout injection points (casing) installed deeper than the above prescribed depth without the direction of the Geotechnical Engineer shall be re-drilled in an adjacent location under the direct supervision of the Geotechnical Engineer.

2.1.2 Dependent upon the installation depth and grout take for the initially planned injection points, additional secondary GIPs may be installed.

2.1.3 All changes in injection pipe spacing, grout delivery pressure, and allowable quantities of grout at a given depth and location shall be as directed by the Geotechnical Engineer.

2.1.4 The diameter of injection pipes shall be adequate to permit injection of compaction grout. The use of augers for the delivery of grout in lieu of injection pipes is unacceptable.

2.1.5 For all types of injection points, accurate installation records shall be kept by the contractor, including location and depth of injection points, method of installation, and other pertinent data such as difficulties encountered during drilling or pipe driving. Universal should monitor the installation of the GIPs to ensure that the goals of the grouting operations are met.

2.1.6 The Geotechnical Engineer should be notified immediately so that adequate protection measures can be implemented in order to protect integrity of the structure should a soil subsidence occur.

2.2 GROUT INJECTION PROCEDURES

2.2.1 The grouting shall proceed in alternating locations so that a minimum 6 hours curing time elapses prior to drilling and grouting adjacent holes.

2.2.2 The injection of grout shall begin at the bottom depth of the injection pipe and proceed upward in 3 to 5-foot intervals to within 15 feet of existing grade. No grout other than that required to fill the casing hole should be injected above the 15 feet depth.

2.2.3 A maximum grout line pressure of 150 psi over the static pressure is recommended.

2.2.4 The grouting procedure shall continue with the grout pipe withdrawn in a controlled manner and with sufficient pressure on the grout to assure that the drilled hole is filled with grout to prevent a breaching of any clay layer present. The Geotechnical Engineer may stop the withdrawal at pre-selected depth intervals for the grouting of extremely loose to near-void conditions.

2.2.5 In general, injection at each interval shall continue, except as specifically otherwise approved, until one of the following occurs:

A. A maximum grout pressure of 150 psi increase over the static line pressure, in which case the grout pipe should be withdrawn 2 to 5 feet and the grouting should continue at that depth.

B. At maximum grout pressures at the ground surface of 350 psi or as directed by the Geotechnical Engineer, the grouting pipe should be withdrawn 3 to 5 feet and the grouting of the particular grout injection point should continue.

C. If 5 cubic yards of grout per 5-foot interval is injected and the maximum grout pressures at the ground surface is 100 psi or higher, the grouting pipe should be withdrawn 5 feet and the grouting of the particular grout injection point should continue.

If 5 cubic yards of grout per 5-foot interval is injected and the maximum grout pressures at the ground surface is 100 psi or lower, the grouting pipe should be withdrawn 5 feet, the grouting pipe should be flushed and the grouting of the particular grout injection point should continue a minimum of 6 hours later.

D. Surface heave of more than 1/16 inch per interval.

E. Any observable heave of the structure.

The above criteria may be altered by the Geotechnical Engineer during grouting dependent upon field conditions.

2.2.6 **No more than 10 cubic yards per day or 25 cubic yards total of grout shall be injected into any GIP without the direction of the Geotechnical Engineer.**

2.2.7 Ready mix tickets shall be saved and made part of the permanent project records.

2.3 CONTRACTOR'S SUPERVISION AND QUALITY CONTROL

2.3.1 A level control system shall be installed and operated by the contractor for use during grouting. The monitoring shall be carried out so as to detect any movement within 25 feet of the grouting operations whenever grouting is occurring.

2.3.2 Any grout injection performed by the contractor without representation of the geotechnical engineer present shall not be compensated and processes shall be repeated.

Grout injection performed by the contractor beyond the above referenced criteria (Sections 2.2.5 and 2.2.6) without the direction of the Geotechnical Engineer shall not be compensated.

2.3.3 Contractor drilling reports shall be required and shall contain at least the following information: Name of driller, type of drill, method being used, date started, date completed, location of hole, type and depth of materials encountered. Contractor grouting reports shall be required and shall contain at least the following information: Name of grout technician, constituents and proportions of grout, log of quantity injected per lineal foot of hole, date, rate of pumping, and pressure at the hole.

2.4 TESTING AND QUALITY

2.4.1 The testing and on-site observation of the operations shall be done at the owner's expense, by the Geotechnical Engineer. His activities shall include, but are not limited to, observing the drilling operations, observing the grouting activities, and monitoring grout volumes and depths.

2.4.2 In rare cases the Geotechnical Engineer reserves the option to perform Standard Penetration Test truth borings in improved areas during the grouting operations or after completion to evaluate the success of the grouting operation.

3.1 MEASUREMENT AND PAYMENT

3.1.1 The approved grouting contractor shall submit a bid based on the following quantities.

Item No.	Description	Estimated Quantity	Unit	Unit Price	Total
1	Mobilization / Demobilization	1	lump sum		
2	Grout injection point piping	2100	lineal feet		
3	Cubic yards of compaction grout	400 – 420	cu.yds.		
4	Polyurethane Material	2000	cu.yds.		

3.1.2 Payment will be made solely at the bid prices, based on actual quantities performed. Additional payment for remobilization shall be made only where contractor was authorized by the Geotechnical Engineer to demobilize from the site and not as a result of variations in the scope or quantity of the grouting program or time of performance.

APPENDIX D-1
REMEDIATION PROGRAM RECOMMENDATIONS
HILPERT RESIDENCE
10464 CRANSTON STREET
SPRING HILL, FLORIDA 34608

1.0 DESCRIPTION

The work specified in this section consists of soil densification using high density polyurethane material. The Contractor shall furnish all labor, materials, and equipment necessary to complete the work. All installation procedures and equipment shall be in accordance with manufacturer's recommendations.

2.0 MATERIALS

2.1 The high density polyurethane material used for void filling and soil densifcation shall be a water blown formulation exhibiting the following physical characteristics and properties:

Property	**Value**	
Material Density - lbs/ft^3	3.0	Minimum
Tensile Strength – psi	100	Minimum
Elongation, %	51	Maximum
Compressive Strength – psi	50	Minimum

2.2 The following ASTM Test Methods are applicable for testing:

Compressive Strength	D1621
Flexural Strength	D790
Shear Strength	C273
Density	D1622
Dimensional Stability	D2126
Coefficient of Expansion	D696
Solvent Resistance	D543
Fungus Resistance	G21
Water Absorption	D2842

The polyurethane material shall reach 90% of full compressive strength within 15 minutes of injection.

2.3 The Contractor shall furnish, from the manufacturer to the Engineer, a certified test report for the material furnished and described in this specification indicating the material meets all specification requirements.

3.0 EQUIPMENT

The Contractor shall furnish the following equipment, as a minimum, and any additional equipment necessary to provide an acceptable job:

A. A method of providing *½ inch* diameter holes through the soils or foundation
B. A truck-mounted pumping unit capable of injecting the high density polyurethane formulation into the soils
C. A leveling unit to monitor lift

APPENDIX D-1
REMEDIATION PROGRAM RECOMMENDATIONS
HILPERT RESIDENCE
10464 CRANSTON STREET
SPRING HILL, FLORIDA 34608

4.0 CONSTRUCTION METHODS

4.1 Preparation: A leveling unit shall be set in place and properly adjusted prior to beginning of injection. A series of 1/2-inch diameter holes shall be drilled and copper placed into the soils at locations and spacing as determined by the engineer.

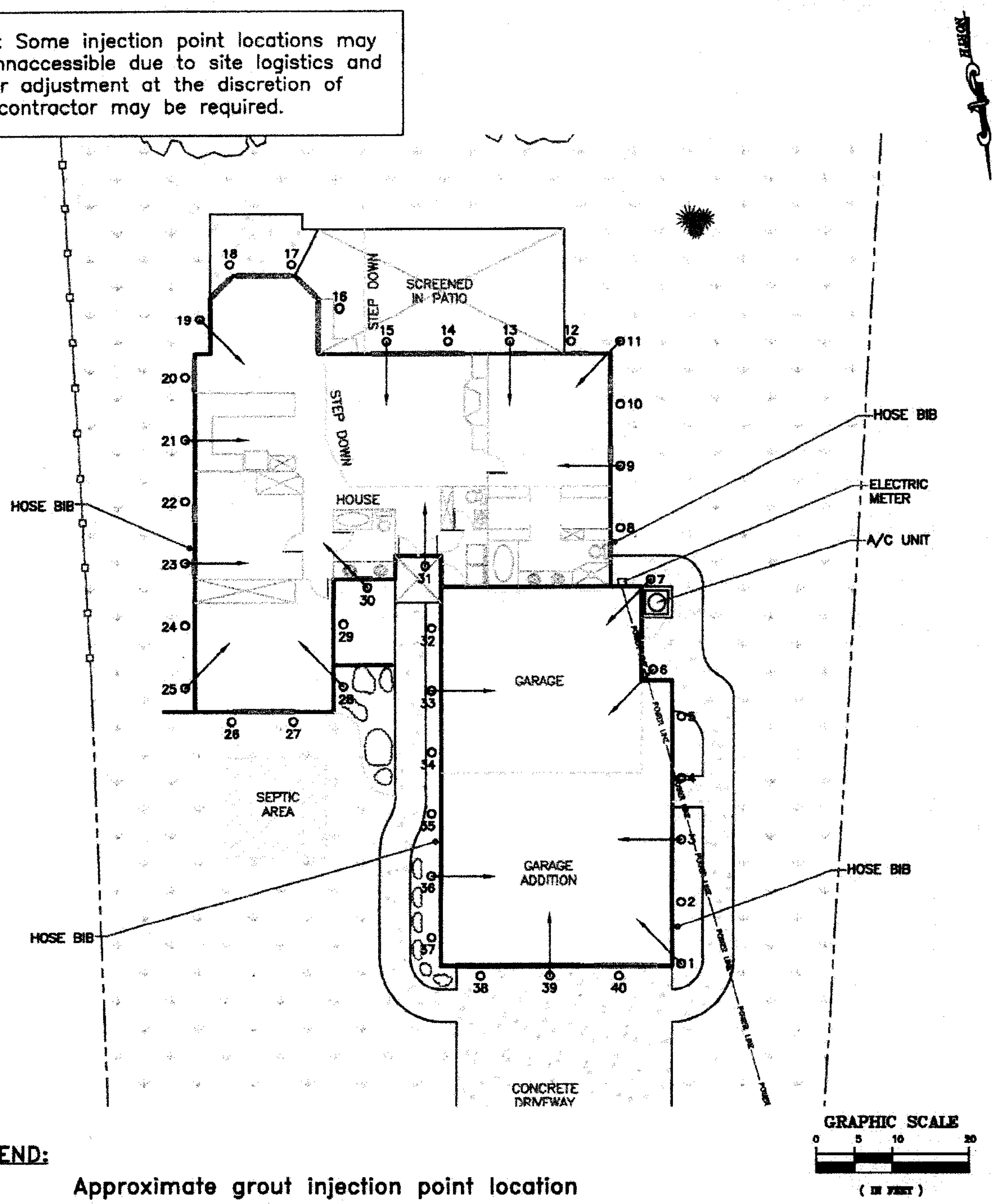
Prior to receiving approval to proceed with the stabilizing operation, the Contractor shall satisfactorily demonstrate to the Engineer the ability to stabilize for that particular application using high density polyurethane.

4.2 Injection: The high density polyurethane foam shall be injected through a 1/2 inch copper tubing (depths varying from 2 to 5 feet below the bottom of the foundation footing) so to fill any possible voids and densify the soils at multiple depths. The polyurethane shall be allowed to expand, harden, and exert the necessary lifting forces. The amount of rise, or lift, shall be controlled, using the pumping unit, by regulating the rate of injection of the material.

5.0 METHOD OF MEASUREMENT

The quantity to be paid for under this section shall be the weight, in pounds, of material authorized, used, and accepted to perform the necessary shallow soil compaction and structure lift (if applicable). Measurement shall be by a certified metering device attached to the pumping equipment.

Note: Some injection point locations may be innaccessible due to site logistics and minor adjustment at the discretion of the contractor may be required.



LEGEND:

O 1 Approximate grout injection point location

O——→ Approximate angled grout injection point location

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HILPERT RESIDENCE
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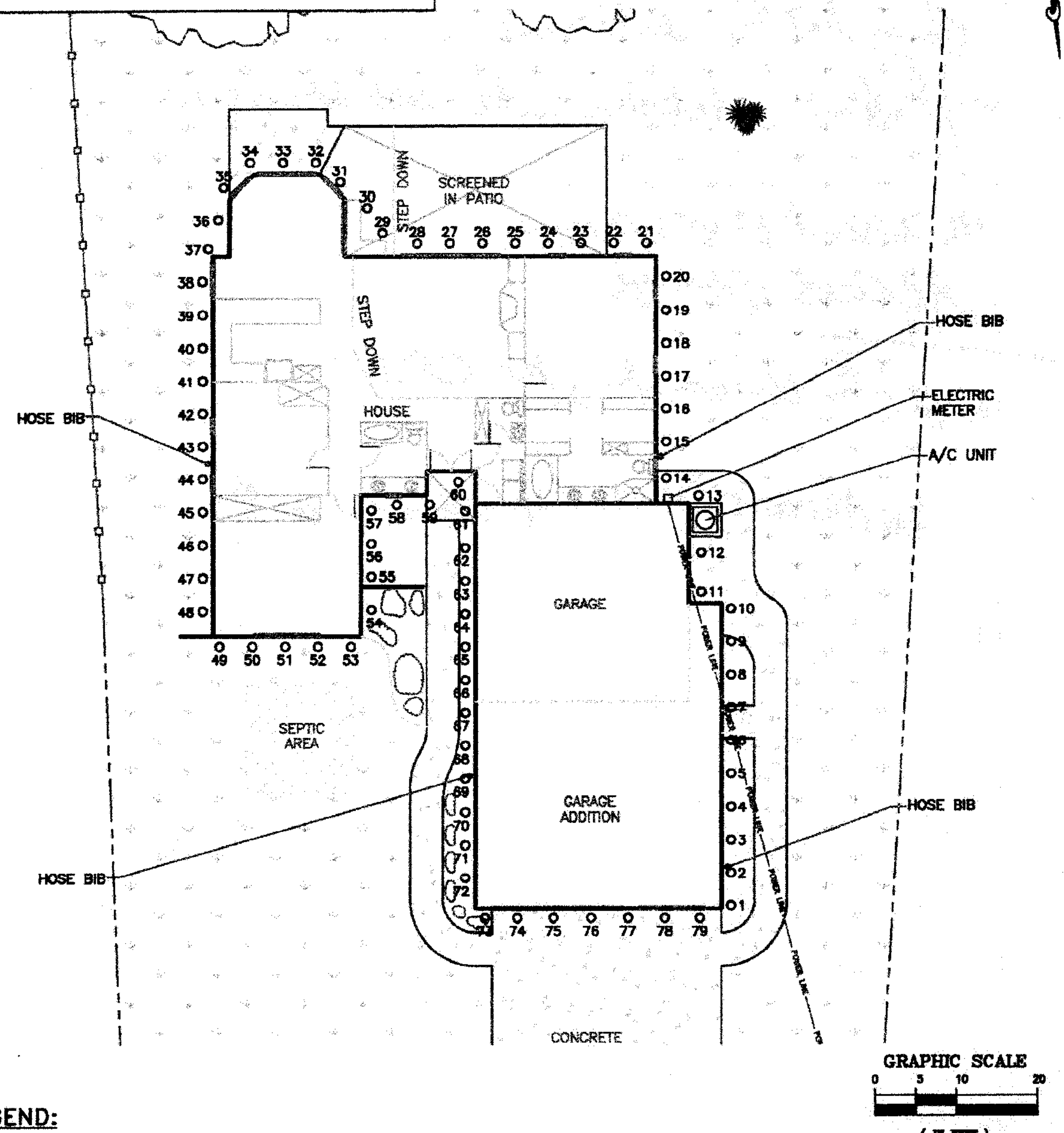
SPRING HILL, HERNANDO COUNTY, FLORIDA

PRELIMINARY GROUT INJECTION POINT LOCATION PLAN

DRAWN BY: SB	DATE: OCT 12, 2010	REVIEWED BY: MH	DATE: OCT 12, 2010
SCALE: 1" = 20'	PROJECT NO: 0830.1000350.0000		APPENDIX: D–2

Note: Some injection point locations may be innaccessible due to site logistics and minor adjustment at the discretion of the contractor may be required.



LEGEND:

O 1 Approximate poly-grout injection point location

UNIVERSAL ENGINEERING SCIENCES

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PRELIMINARY POLYURETHANE INJECTION POINT LOCATION PLAN

DRAWN BY: SB	DATE: OCT 12, 2010	REVIEWED BY: MH	DATE: OCT 12, 2010
SCALE: 1" = 20'	PROJECT NO: 0830.1000350.0000		APPENDIX: D-3