REPORT FOR
GEOTECHNICAL ENGINEERING SERVICES
CACTUS ROAD STORM DRAIN
67TH AVENUE TO THE
AGUA FRIA (OUTER LOOP) FREEWAY
GLENDALE AND PEORIA, ARIZONA

Registered Professional Engineer
CERTIFICATE NO.
WALSH
Date Signed 6-27-91
ARIZONA, U.S.A.

THOMAS-HARTIG & ASSOCIATES, INC.

GEOTECHNICAL, MATERIALS TESTING, AND ENVIRONMENTAL CONSULTANTS

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REPORT FOR GEOTECHNICAL ENGINEERING SERVICES CACTUS ROAD STORM DRAIN 67TH AVENUE TO THE AGUA FRIA (OUTER LOOP) FREEWAY GLENDALE AND PEORIA, ARIZONA

Submitted To:

Stanley-Franzoy-Corey Engineering Company
7776 Pointe Parkway West, Suite 290
Phoenix, Arizona

Project No. 91-0715

27 June 1991

THOMAS-HARTIG & ASSOCIATES, INC.

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27 June 1991

Attention: Mark E. Courtney, Vice President

Subject: Report for Geotechnical Engineering Services
Cactus Road Storm Drain
67th Avenue to the Agua Fria (Outer Loop) Freeway
Glendale and Peoria, Arizona

Project No. 91-0715

This report presents the results of the geotechnical engineering services authorized for the proposed Cactus Road Storm Drain located at 67th Avenue to the Agua Fria (Outer Loop) Freeway in Glendale and Peoria, Arizona.

The purpose of these services is to determine the soil conditions at the locations indicated which thereby provide a basis for the design discussions and recommendations presented herein. This firm should be notified for evaluation if conditions other than described herein are encountered during construction.

The services performed provide an evaluation at selected locations of the soils throughout the zone of significant foundation influence. Our field services have not included exploration for underlying geologic conditions or evaluation of potential geologic hazards such as seismic activity, faulting, and ground subsidence/cracking potential due to groundwater withdrawal, or the presence of contamination.

The recommendations presented in this report are based upon the project information received and described in "Scope" Part I. This firm should be contacted for review if the design conditions are changed substantially.

If requested, we will be available to review project plans and specifications relative to compliance to the intent of this report.

Respectfully submitted,

THOMAS-HARTIG & ASSOCIATES, INC.

By: _____ Reviewed by: _____

Kenneth D. Walsh, P.E. Kenneth L. Ricker, P.E.

/dkl-s
Copies to: Addressee (5)

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Registered Professional Engineer
CERTIFICATE NO. 23823
KENNETH WALSH
Date Signed 6-27-91
ARIZONA, U.S.A.

PROJECT NO. 91-0715

PART I
REPORT

SCOPE

The proposed drainage improvements along Cactus Road will consist of new 10-year storm drain main from 67th Avenue to the Agua Fria (Outer Loop) Freeway. Existing drains will be connected to the proposed main, which will outfall into the Outer Loop Freeway drainage channel. This report contains a description of our field operations and laboratory results and design recommendations concerning construction practices, excavations and slope stability, bearing capacity and lateral earth pressures, bedding and backfilling materials, and replacement pavement thicknesses for streets impacted by this project. We understand the new storm drain is to be placed approximately 15 to 20 feet below ground, and will be on the order of 84 to 120 inch diameter.

SITE DESCRIPTION

The proposed improvements will extend from 67th Avenue to the Agua Fria (Outer Loop) Freeway along Cactus Road in Peoria, Arizona. Cactus Road is paved from 67th Avenue to 91st Avenue, and has a varying width depending on fronting development. Where residential or commercial development has occurred on land adjacent to Cactus Road, the roadway has an improved half-street which carries two traffic lanes, usually with a center turn lane, and has improved curbs, gutters, and sidewalks. Elsewhere, the roadway is typically one lane each direction with wide soft shoulders. West of 91st Avenue, Cactus Road is not paved.

INVESTIGATION

The field investigation included a site reconnaissance, subsurface exploration, and field resistivity testing. The subsurface exploration consisted of drilling 35 test borings at the locations shown on the site plan in Appendix A. The test borings were drilled with a CME 55 drill rig using 7-inch diameter hollow stem augers. The test borings were drilled to depths of 11 to 26 feet below the pavement section, with refusal encountered at some locations. Standard Penetration Test (SPT) sampling and driven ring sampling was performed in all borings, alternating at 5- foot intervals, to obtain an indication of the relative density and/or consistency of the formation being penetrated and to obtain samples for laboratory testing. Bulk samples were obtained from the cuttings.

During the field investigation, the soils encountered were visually classified by our field engineer. The results of the test drilling conducted for this project are presented on the boring logs in Appendix A, "Field Results."

The soil resistivity was measured in the field using a 4-terminal "Megger Earth Tester" resistivity meter. The resistivity tests were conducted using two different electrode spacings to indicate the variation of soil resistance with depth. The resistivity values ranged from about 1150 to 11600 ohm-cm. The results of the field resistivity testing conducted for this project are presented in Appendix A, "Field Results".

LABORATORY INVESTIGATION

Laboratory testing was conducted on representative soil samples obtained during the test drilling. The testing was conducted to obtain the data necessary to develop design recommendations for this project. The following tests were conducted:

Test	Sample(s)	Purpose
Sieve Analysis & Atterberg Limits	Representative (70)	Classification and correlation of engineering properties
Dry density and Moisture Content	Undisturbed (57) Disturbed (2)*	In-situ density and moisture determination to correlate engineering properties
Direct Shear	Undisturbed (5)	Bearing capacity and slope stability analysis
Compression	Undisturbed (1)	Settlement analyses
Soluble Salts, Sulfates and Chlorides	Representative (11)	Corrosion potential
ASTM D698	Representative (5)	Compaction characteristics

*Disturbed samples tested for moisture content only.

The results of the moisture and density testing are presented on the graphical boring logs in Appendix A. The results of the remainder of the testing are presented in Appendix B.

SOIL CONDITIONS

The soil profile encountered at the test boring locations was somewhat variable, and detailed descriptions are presented on the graphical boring logs in Appendix A. The profile generally consisted of a sandy clay to clayey sand deposit overlying a sandy gravel deposit. The upper sandy clay deposit varied from 0 to 17 feet thick along the alignment, and was generally uncemented to lightly cemented near the surface. Cementation generally increased to moderate intensity with depths below 3 to 4 feet, with some lenses or zones of heavy cementation or cemented nodules. The sandy gravel deposit consisted of stratified gravels with fine to coarse sand and occasional to scattered cobbles and boulders interbedded with sandier zones or zones with clayey fines. Moderately to heavily cemented clayey soils of low to medium plasticity were found under these soils in some locations. Soil moisture contents at the time of test drilling were generally described as slightly damp to moist, and no free groundwater was encountered during drilling. This groundwater condition represents only that encountered at the time of our field drilling operations. Groundwater levels may vary with time, seasonal conditions, and/or water flow in the New River or the Agua Fria (Outer Loop) Freeway drainage channel, but are not expected to rise to the depths of storm drain construction.

DISCUSSION AND RECOMMENDATIONS

General: The proposed storm drain may consist of precast concrete pipe, cast-in-place concrete pipe, and coated or uncoated metal pipes. Granular deposits were encountered at and above invert elevations in a majority of the test borings. These granular deposits contain gravel and some cobbles and boulders and clean sand layers. Because of the coarse granular materials and potential for caving in this formation, a shaped excavation for cast-in-place pipe may be difficult to impossible to construct. The other types of storm drain being considered appear to be appropriate for this project.

Geotechnical engineering recommendations are presented in the following sections. These recommendations are based upon the results of the field and

laboratory testing which are presented in Appendices A and B of this report. Alternative recommendations may be possible and will be considered upon request.

Expansion Potential: Existing surface soils are sandy clays and clayey sands, predominantly of medium plasticity. At existing moisture conditions, the undisturbed soils will demonstrate moderately low potentials for expansion. However, compaction of these soils could create high expansive pressures, especially if these soils are compacted to relatively high densities at moisture contents below optimum. Expansive potentials of backfills constructed with these soils are estimated on the order of 1/4 to 1/2-inch per foot of compacted fill. Additionally, significant swelling pressures could develop against storm drain walls adjacent to compacted backfills composed of surface soils. For this reason, imported granular soils exhibiting low expansive potentials or granular site soils are recommended for any backfills along the sides of the storm drain pipe and within 2 feet of pavement sections.

Storm Drain Support: The proposed storm drain will be placed from 15 to 20 feet below ground. The soil along the alignment is fairly strong, and the drain will be lighter than the soil it replaces. Estimated contact pressures are less than existing overburden pressures. Therefore, we anticipate low settlements of less than 1/4 inch due to construction related disturbance, with an allowable bearing capacity of 5000 psf afforded miscellaneous structures, manholes, etc.

Lateral Design Parameters: We recommend that storm drain structures be designed to resist lateral earth pressures of 60 psf/ft for current groundwater conditions. Should the storm drain be encompassed by rising groundwater or the trench flooded during backfilled, the pressure below the groundwater table could increase to 95 psf/ft.

These pressures are equivalent fluid pressures for vertical walls and horizontal backfill surfaces. Pressures do not include temporary forces imposed during compaction of the backfill, swelling pressures developed by over-compacted clayey backfill, or surcharge loads. Walls should be suitably braced during backfilling to prevent damage and excessive deflection.

Excavation Conditions and Slope Stability: The test drilling and field sampling at the site were performed for design purposes. It is not possible to accurately correlate auger drilling results with the ease or difficulty of digging for various types and sizes of excavation equipment. We present the following general comments regarding excavatability for the designers' information with the understanding that they are approximations based only on test boring data. More accurate information regarding excavatability should be evaluated by contractors or other interested parties from test excavations using the intended equipment.

The near surface soils are non-cemented to lightly cemented sandy clay and clayey sand deposits which can probably be removed with conventional excavating equipment. However, variable carbonate cementation (caliche) was encountered in some locations, typically below about 3 to 4 feet, and excavations into these deeper soils could be more difficult. The granular deposits underlying the surface clays are typical river deposited materials, with clean granular and clayey zones and zones with cobbles and boulders. Slope stability problems ranging from slope raveling to caving may occur in random clean sandy zones or as soils dry out.

The deep sandy clay deposit encountered in some locations beneath the gravels was generally moderately cemented. However, areas with heavy cementation were encountered, and excavation into this deposit could be difficult, especially in heavily cemented areas.

All excavations should be braced or sloped to provide personnel safety and satisfy local safety code regulations. We recommend maximum temporary cut slopes or 1/4:1 (horizontal:vertical) in the sandy clay/clayey sand, and 1:1 (horizontal:vertical) in the granular soils. Flattened slopes may be required where clean sand deposits or backfill zones are encountered, where excavation spoil are placed adjacent to slopes, where traffic is adjacent to slopes, and if the excavation becomes inundated. Excavation bracing may be desirable to limit the width of the top of the excavation. The geotechnical engineer should be contacted for review of excavation bracing systems proposed by the contractor.

Storm Drain Backfills: Backfill adjacent to and over the storm drain will support utilities and pavement sections. In order to limit settlement of the backfill material, the backfill should be compacted to density criteria presented in Parts II and III of this report. If backfills are not compacted as recommended, subsidence may result in the pavement section and in utilities supported in the backfill. Even properly compacted deep backfills may tend to settle differentially relative to the storm drain and may result in some surface movement and pavement cracking.

Saturation of backfill and development of hydrostatic pressures is possible during construction as the result of the breakage of utility lines or from infiltration of storm water runoff. Backfill compaction should be accomplished by mechanical methods. Water jetting or flooding of loose, dumped backfills must be prohibited.

Corrosion: Corrosion is most likely to occur in fills and natural soils with high moisture contents. Field resistivity tests were performed to evaluate possible zones of higher corrosion potential. Relatively low resistivities (high conductivities) were encountered only near Test Borings 17 and 19. In addition, laboratory tests were performed on selected samples to determine pH, soluble salts, soluble sulfates, and soluble chlorides. The results are presented in Appendix B. Based on the field and laboratory test values, the corrosion potential to concrete is low. Concrete in contact with soils should use Type II cement. Therefore, a moderate potential for corrosion of buried unprotected metal conduits is indicated in areas where soil moisture contents are high. We recommend that these test results be reviewed by a person or firm experienced in corrosion protection.

Pavement Replacement: Pavement reconstruction will be required on Cactus Road and some cross-streets due to excavation for storm drain placement. Based on conversations with City of Peoria Engineering Staff, we recommend replacement in kind with existing pavement. Measured pavement sections are tabulated as follows:

		Thickness in Inches	
Test Boring	Station	Asphalt Concrete	Aggregate Base
1	179+21	3.25	12.0
2	172+00	3.0	13.0
3	169+00	3.0	13.5

Test Boring	Station	Thickness in Inches	
		Asphalt Concrete	Aggregate Base
4	164+00	4.5	12.0
5	159+00	5.5	11.0
6	153+00	3.5	12.0
7	149+00	4.0	13.0
8	144+00	3.5	12.0
9	139+00	3.5	11.0
10	134+00	4.0	8.0
11	129+00	5.5	12.0
12	124+00	6.0	13.0
13	119+00	4.5	11.0
14	114+00	2.0	11.0
15	109+00	4.0	11.0
16	104+00	4.0	13.0
17	99+00	4.5	12.5
18	94+00	5.0	11.0
19	89+00	4.5	17.5
20	84+00	4.5	13.0
21	79+00	5.0	12.0
22	75+00	4.0	13.0
23	69+00	3.0	10.0
24	64+00	3.5	21.5
25	59+00	4.5	15.0
26	54+00	4.5	15.0
27	49+00	4.5	15.0
28	44+00	*	*
29	39+00	9.0	11.0
30	34+00	4.0	8.0
31	29+00	3.5	8.5
32	24+00	4.0	10.0
33	19+00	**	**
34	14+00	**	**
35	10+00	**	**

* Pavement section not measured.
** Cactus Road is not paved west of 91st Avenue.

The average thicknesses encountered were 4.25 inches of asphaltic concrete and 12.5 inches of aggregate base.

PART II
MATERIALS

FILL MATERIALS

All fill materials should be soils free of vegetation, debris, organic contaminants, and fragments larger than *6 inches in size. The existing site surface soils become moderately expansive when compacted. Therefore, these soils should not be used for backfill against the sides of the storm drain or within two feet of pavement sections, but may be used as backfill above the top of the storm drain. All backfills against the side of the storm drain should be of imported soils with low expansive potentials or granular site soils.

Backfill materials against storm drain sides should be imported granular soils or conforming to the following specification requirements:

Maximum particle size	6 inches*
Maximum percent expansion	1.5**
Maximum percent passing No. 200 sieve	25***
Maximum plasticity index	5***

* Maximum size may be reduced at engineer's direction to satisfy trenching and landscaping requirements, etc.

** Performed on sample remolded to 95 percent of the maximum ASTM D698 density and 2 percent below optimum moisture under a 100 psf surcharge pressure.

*** Required for deep fills or backfills where the fill thickness is greater than 4 feet.

The recommended sequence of backfill materials consists of:

1. Bedding.
2. Imported or granular site soils with low expansive potentials to 1 foot above the top of the pipe.
3. Native soils to within 2 feet of pavement subsurface.
4. Imported or granular site soils with low expansive potentials to pavement subsurface level.

Bedding material and pipe shaping materials should conform to Maricopa Association of Government Standard Specifications for Trench Excavation, Backfilling, and Compaction (Section 601).

PAVEMENT

Pavement materials should be in accordance with the requirements of the Maricopa Association of Governments Standard Specifications for Asphalt Concrete (Section 710, Type C-3/4).

PART III
EXECUTION

SITE GRADING

The following recommendations are presented for grading and excavation along the storm drain alignment. All phases of earthwork should be performed under observation and testing directed by the geotechnical engineer.

1. Excavate to the proposed base of excavation for placement of the storm drain. The sides should be braced or sloped in accordance with recommendations under "Excavation Conditions and Slope Stability".

2. The base of the excavation should be cleaned of all organic contaminants, debris, utilities or subsurface facility remnants and any loose or disturbed soils encountered. The cleaned surface should be observed for evidences of debris laden soils, disturbance, concealed facility remnants, or loose zones requiring additional removal.

3. Place the storm drain bedding in the excavation.

4. Backfill against the sides of the storm drain with granular site soils or imported fill materials as previously described under "Fill Materials". We recommend that only manual or light weight mechanical compaction equipment be used within 5 feet of the storm drain sides. Backfill should be placed and compacted in horizontal lifts of thicknesses compatible with the compaction equipment used.

5. All backfill should be placed and compacted in horizontal lifts of thickness compatible with the compaction equipment used. Native site clayey soils may be used more than 1 foot above the top of the storm drain and more than 2 feet below the pavement subsurface.

6. Compaction of backfill materials should be accomplished to the density requirements in the Maricopa Association of Governments Standard Specifications for Trench Excavations, Backfilling and Compaction (Section 601). Aggregate base course below asphaltic concrete should be compacted to at least 100% of the ASTM D698 Maximum dry density.

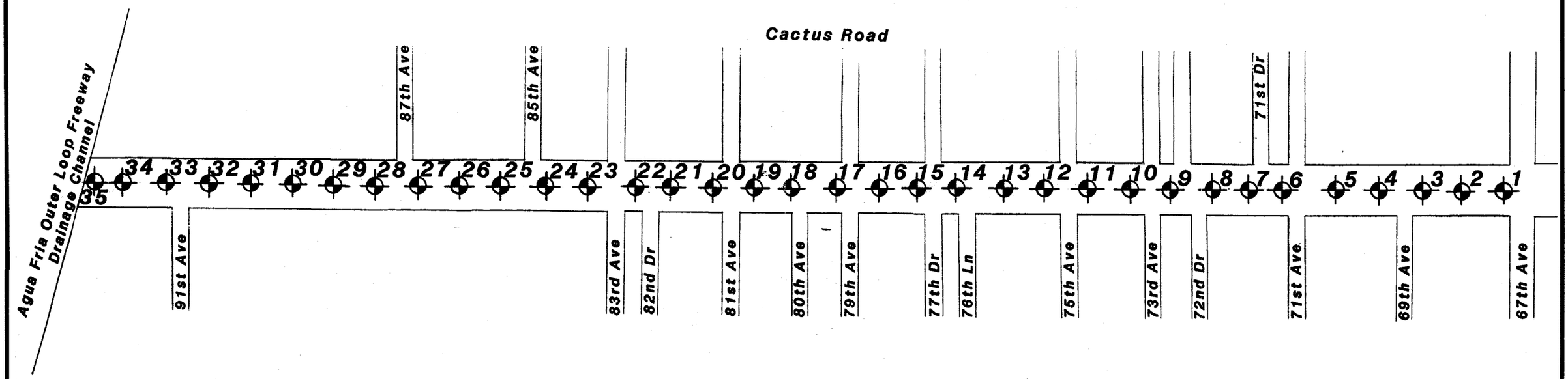
Compaction of clayey site soil should be performed with soils uniformly mixed at a moisture content between optimum ±2 percent. Compaction of imported fill soils with low expansive potentials or granular site soils should be accomplished within the range of optimum moisture content ±3 percent. Compaction of exposed soil and fill material within the upper 2 feet of backfill below asphaltic pavement should be accomplished at a moisture content 2 percent below optimum, or lower.

Natural undisturbed soils or compacted soils subsequently disturbed or removed by construction operations should be replaced with materials compacted as specified above.

PAVING

Placement requirements for paving should be in accordance with the Maricopa Association of Governments' Specifications for Asphalt Concrete Pavement (Section 321). Observation and testing should be performed as necessary to verify conformance with these recommended specifications, especially compaction requirements for asphaltic concrete surfacing.

APPENDIX A
FIELD RESULTS



LEGEND:

Test Boring Location

Elevations from plan and profile provided by Stanley-Franzoy-Corey Engineering Company.

N

SITE PLAN

Project No. 91-0715

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LEGEND

SOIL CLASSIFICATION

COARSE-GRAINED SOIL

More than 50% larger than 200 sieve size

SYMBOL	LETTER	DESCRIPTION	MAJOR DIVISIONS
	GW	WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES. LESS THAN 5% - #200 FINES	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size
	GP	POORLY-GRADED GRAVELS OR GRAVEL-SAND MIXTURES. LESS THAN 5% - #200 FINES	
	GM	SILTY GRAVELS. GRAVEL-SAND-SILT MIXTURES. MORE THAN 12% - #200 FINES	
	GC	CLAYEY GRAVELS. GRAVEL-SAND-CLAY MIXTURES. MORE THAN 12% - #200 FINES	
	SW	WELL-GRADED SANDS OR GRAVELLY SANDS. LESS THAN 5% - #200 FINES	SANDS More than half of coarse fraction is smaller than No. 4 sieve size
	SP	POORLY-GRADED SANDS OR GRAVELLY SANDS. LESS THAN 5% - #200 FINES	
	SM	SILTY SANDS. SAND-SILT MIXTURES MORE THAN 12% - #200 FINES	
	SC	CLAYEY SANDS. SAND-CLAY MIXTURES MORE THAN 12% - #200 FINES	

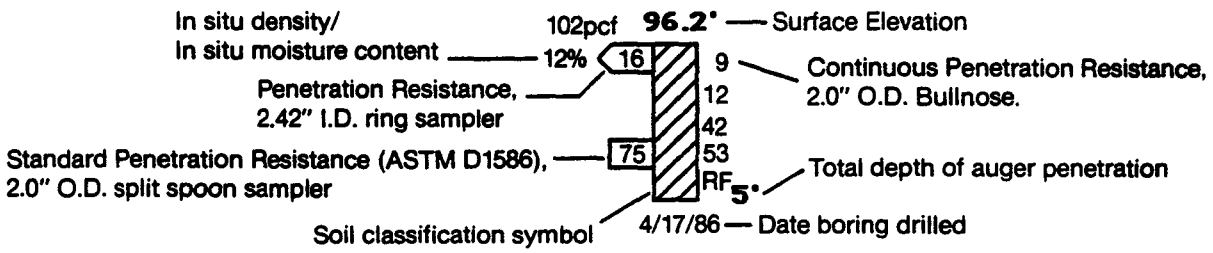
FINE-GRAINED SOIL

More than 50% smaller than 200 sieve size

SYMBOL	LETTER	DESCRIPTION	MAJOR DIVISIONS
	ML	INORGANIC SILTS. ROCK FLOUR. AND FINE SANDY OR CLAYEY SILTS OF LOW TO MEDIUM PLASTICITY	SILTS AND CLAYS Liquid limit less than 50
	CL	INORGANIC CLAYS. GRAVELLY CLAYS. SANDY CLAYS. SILTY CLAYS. AND LEAN CLAYS OF LOW TO MEDIUM PLASTICITY	
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAY MIXTURES OF LOW TO MEDIUM PLASTICITY	
	MH	INORGANIC SILTS. MICACEOUS OR DIATOMACEOUS. AND FINE SANDY OR CLAYEY SILTS OF HIGH PLASTICITY	SILTS AND CLAYS Liquid limit greater than 50
	CH	INORGANIC CLAYS. FAT CLAYS. AND SILTY CLAYS OF HIGH PLASTICITY	
	OH	ORGANIC CLAYS AND ORGANIC SILTS OF MEDIUM TO HIGH PLASTICITY	
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	

LEGEND FOR GRAPHICAL BORING LOGS:

Log denotes visual approximation unless accompanied by mechanical analysis and Atterberg limits.



PENETRATION RESISTANCE: Blows per foot using 140 lb. hammer with 30" free-fall unless otherwise noted.

GRAIN SIZES							
U.S. STANDARD SERIES SIEVE	200	40	10	4	CLEAR SQUARE SIEVE OPENINGS 3/4"	3"	12"
SILTS & CLAYS DISTINGUISHED ON BASIS OF PLASTICITY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

MOISTURE CONDITION (INCREASING MOISTURE →)

DRY — SLIGHTLY DAMP — DAMP (Plastic Limit) — MOIST — VERY MOIST — WET (SATURATED) (Liquid Limit)

CONSISTENCY CORRELATION		RELATIVE DENSITY CORRELATION	
CLAYS & SILTS	BLOWS/FOOT*	SANDS & GRAVELS	BLOWS/FOOT*
VERY SOFT	0-2	VERY LOOSE	0-4
SOFT	2-4	LOOSE	4-10
FIRM	4-8	MEDIUM DENSE	10-30
STIFF	8-16	DENSE	30-50
VERY STIFF	16-32	VERY DENSE	OVER 50
HARD	OVER 32		

*Number of blows of 140 lb. hammer falling 30" to drive a 2" O.D. (1-3/8" I.D.) split-spoon sampler (ASTM D1586).

Project No. 91-0715

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LEGEND OF SOIL TYPES

ASPHALT CEMENT OVER AGGREGATE BASE See individual logs for thicknesses.

SANDY CLAY (SC/CL); brown; firm to stiff; generally medium plasticity; some fine to coarse sand; generally light to moderate calcareous cementation with intensity increasing with depth; stratified; occasional lenses or zones of clayey sand (SC); damp to moist.

CLAYEY SAND (SC); light brown to brown; medium dense to dense; generally low to medium plasticity; fine to coarse subangular to subrounded sand with traces to some fine gravel; generally uncemented to light calcareous cementation; stratified; lenses or zones of sandy clay (CL) or clayey gravel (GC, GP/GL); damp.

CEMENTED SANDY CLAY (CL, CL/ML); light brown to whitish brown; stiff to hard; low plasticity; some fine to coarse sand; generally moderate calcareous cementation; traces of fine gravel; occasional sandy zones (SC, SC-CL); damp.

SANDY GRAVEL (GP, GM, GP/GM); light brown; medium dense to dense; fine to coarse subangular to subrounded sand; subangular to subrounded gravels with occasional to scattered cobbles and boulders; stratified with lenses or zones with clayey fines (GC, GC/GP); sandy zones (SP, SM); damp.

SILTY SAND (SP, SP/SM, SM); light brown to brown; medium dense; fine to coarse subangular to subrounded sand and traces to some fine to coarse gravel; stratified, with lenses or zones of gravels (GP, GP/GM, GM); uncemented to variable light to moderate cementation with some heavily cemented nodules or clumps; damp.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

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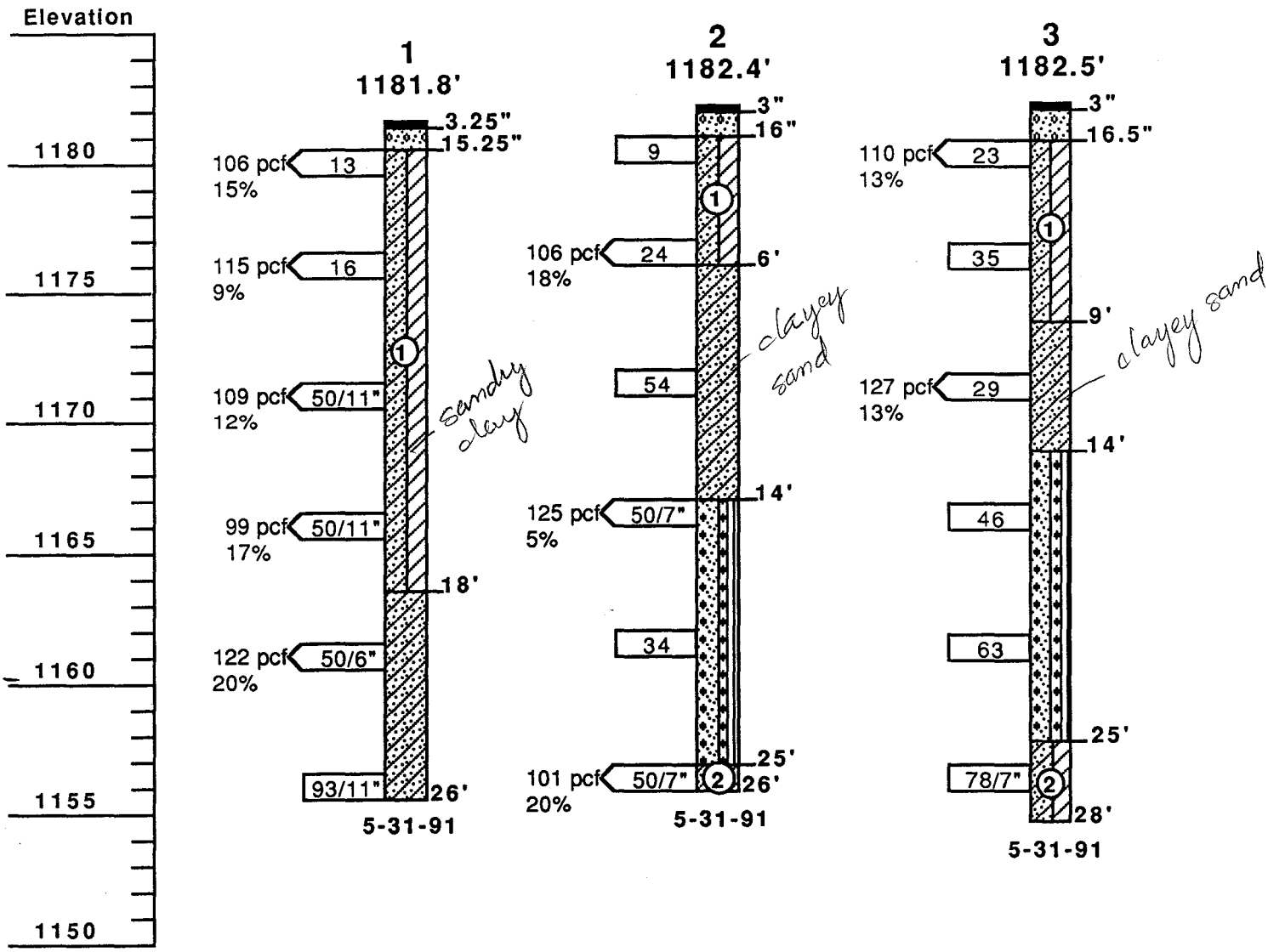
GRAPHICAL BORING LOGS



No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

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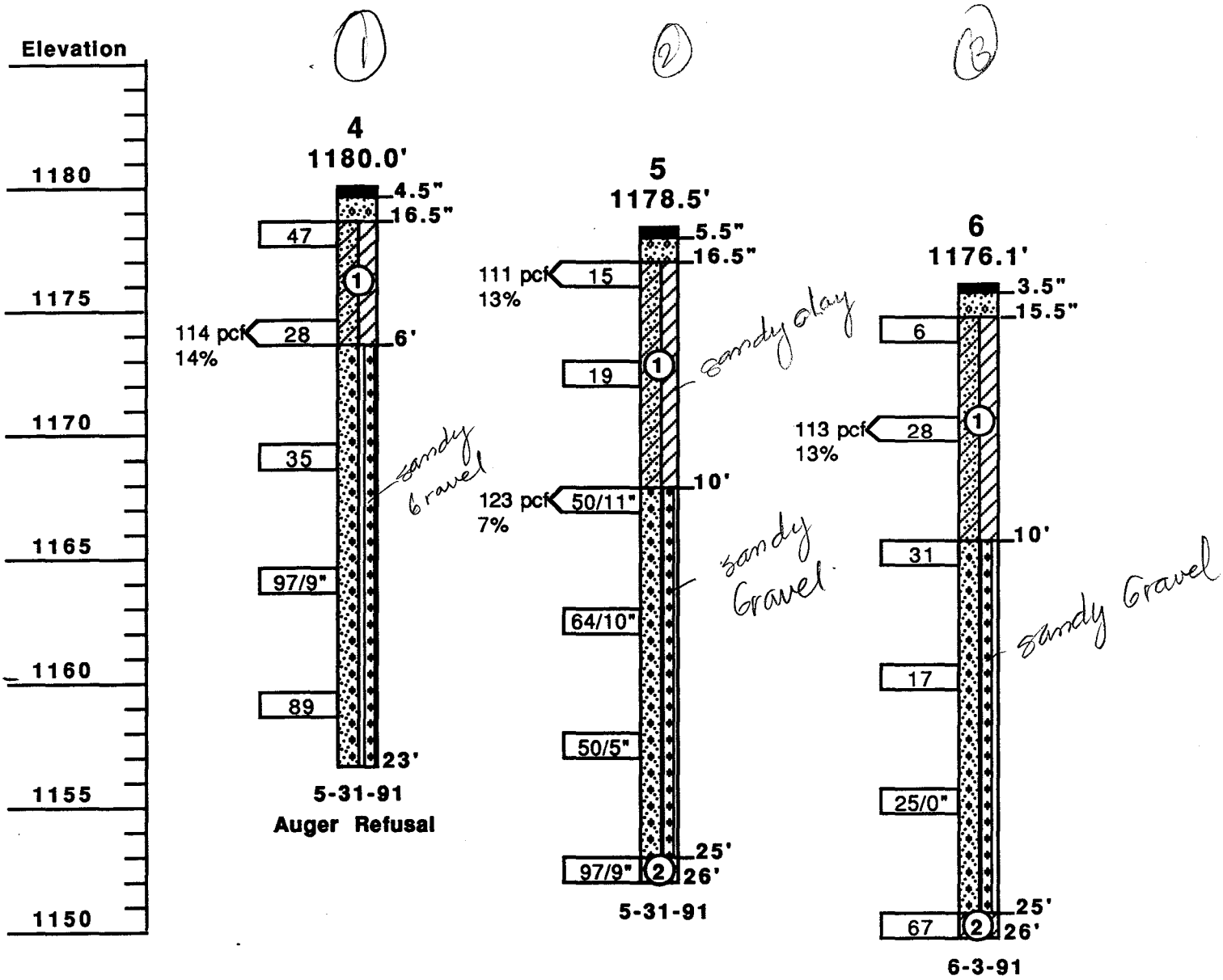

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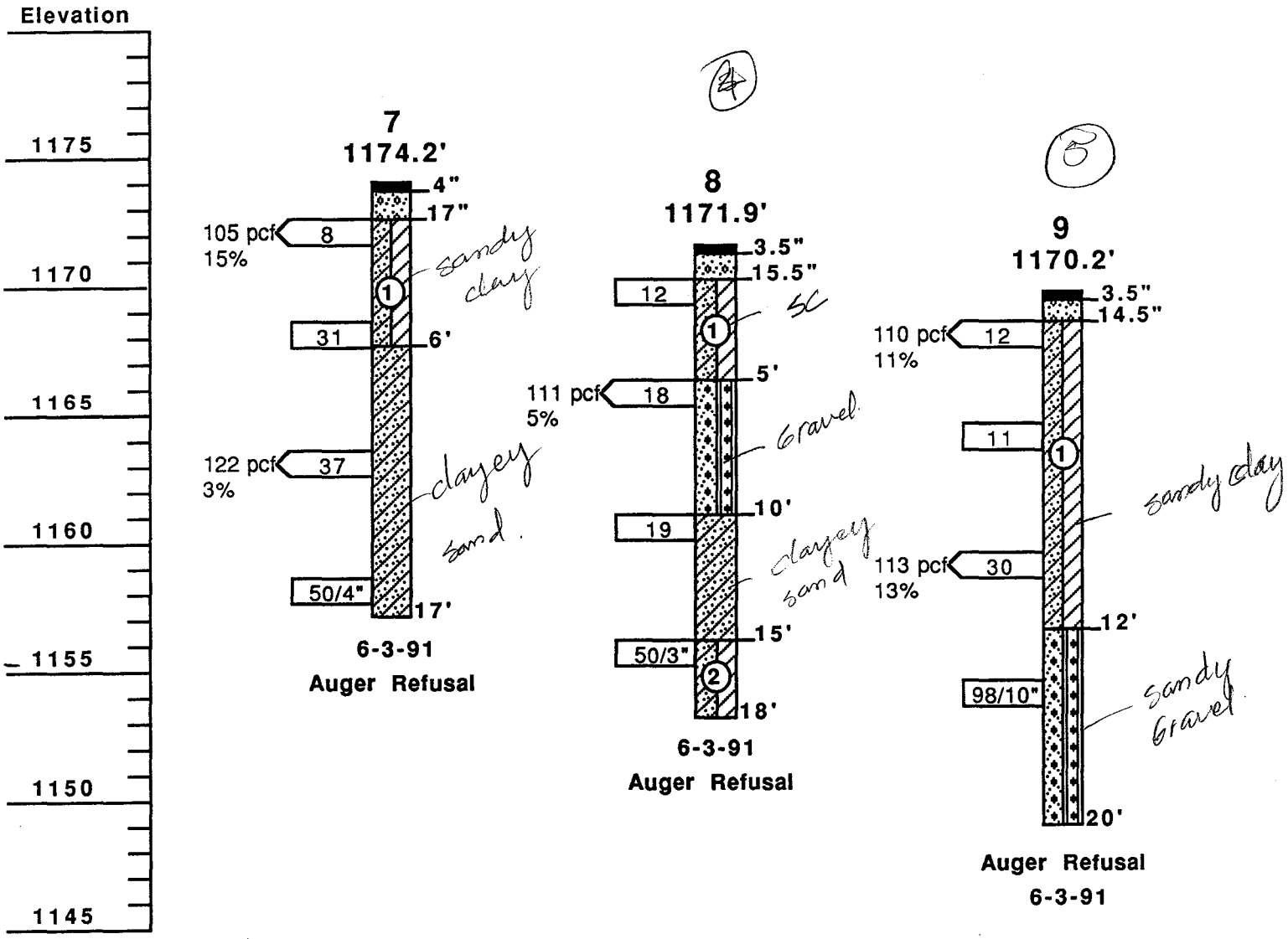


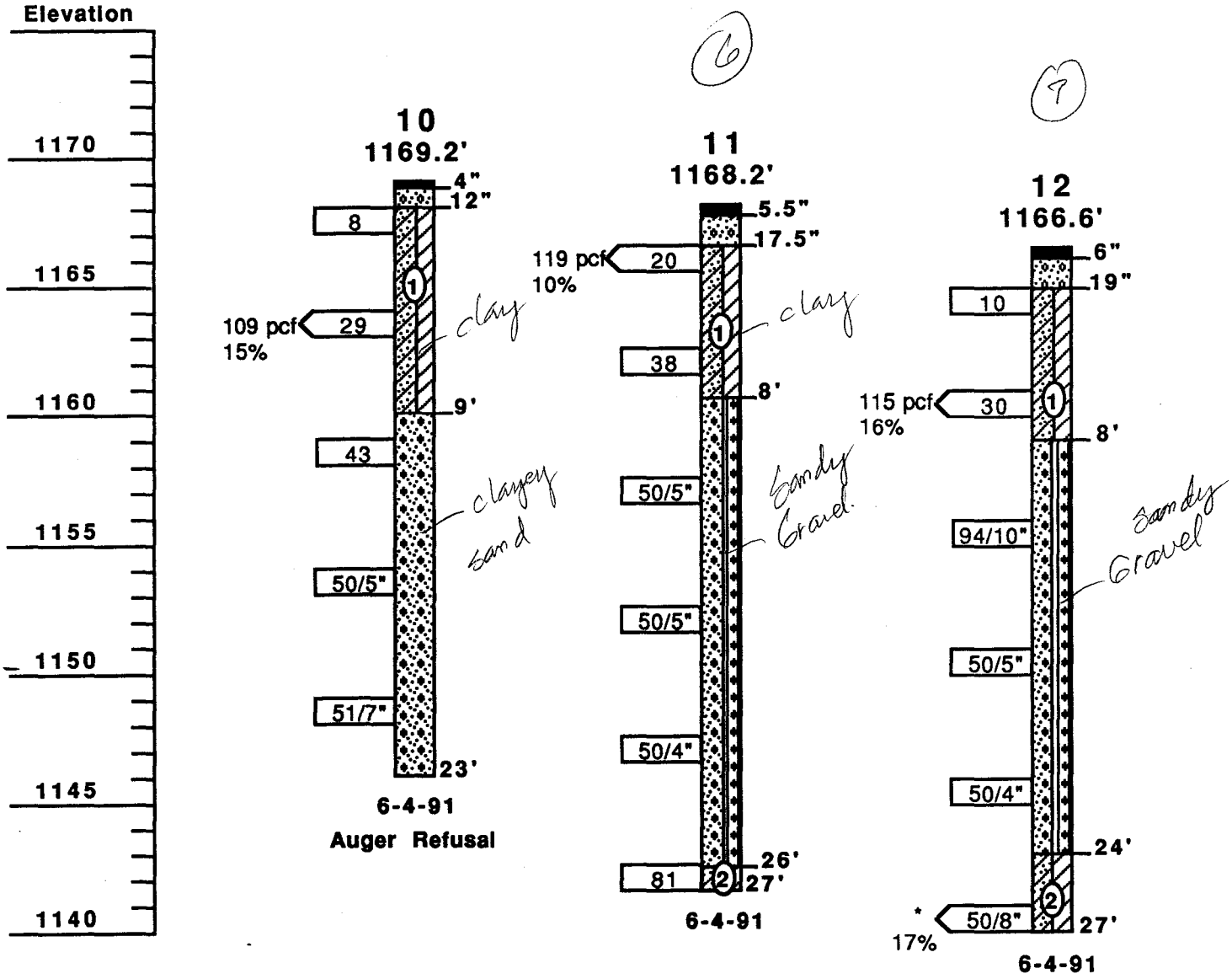
No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

Project No. 91-0715
Thomas-Hartig & Associates

GRAPHICAL BORING LOGS



*Sample too disturbed to determine density.

No free groundwater was encountered in any of the borings during drilling.

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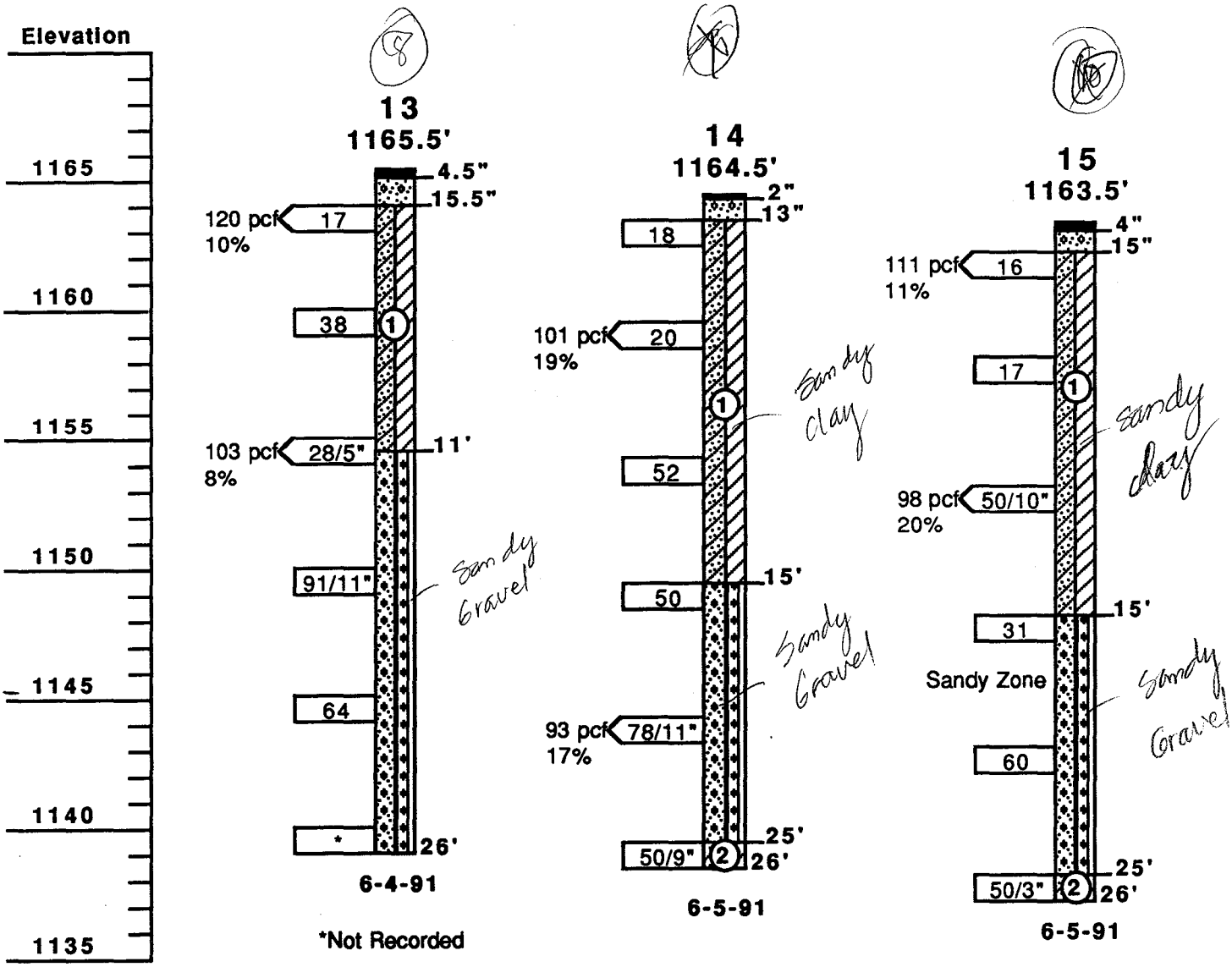
Thomas-Hartig & Associates

GRAPHICAL BORING LOGS



No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

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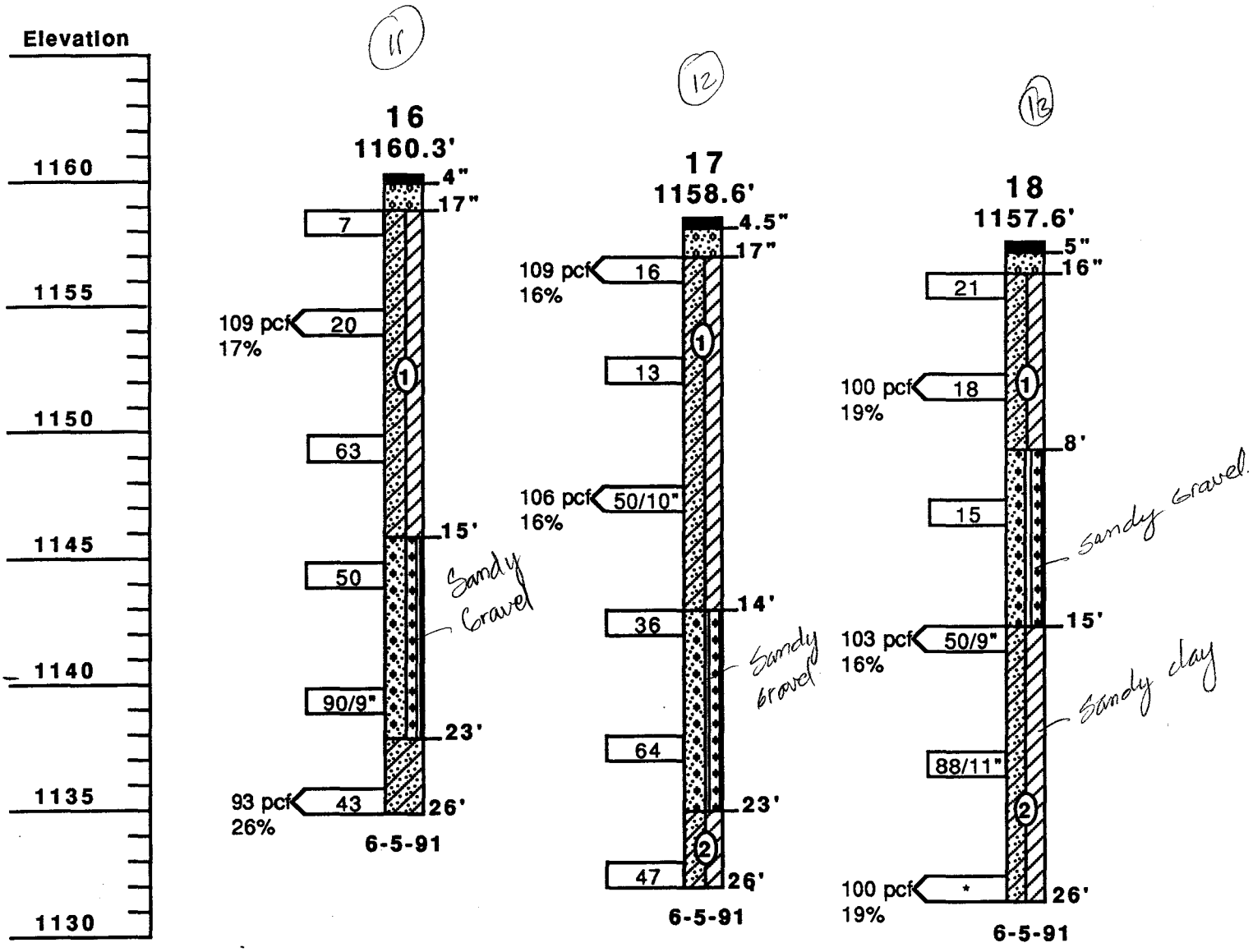
Thomas-Hartig & Associates

GRAPHICAL BORING LOGS



*Not recorded.

No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

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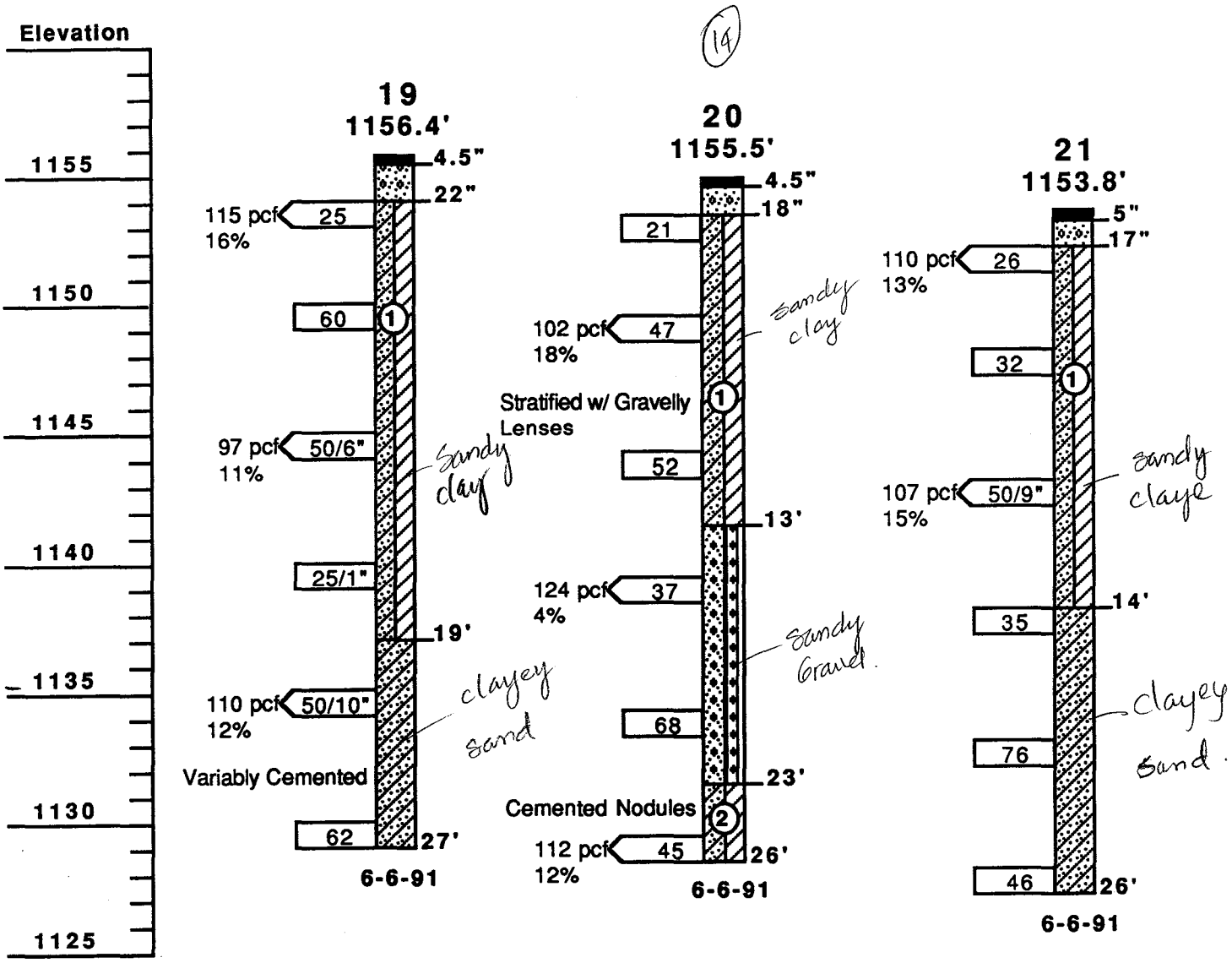
GRAPHICAL BORING LOGS



No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

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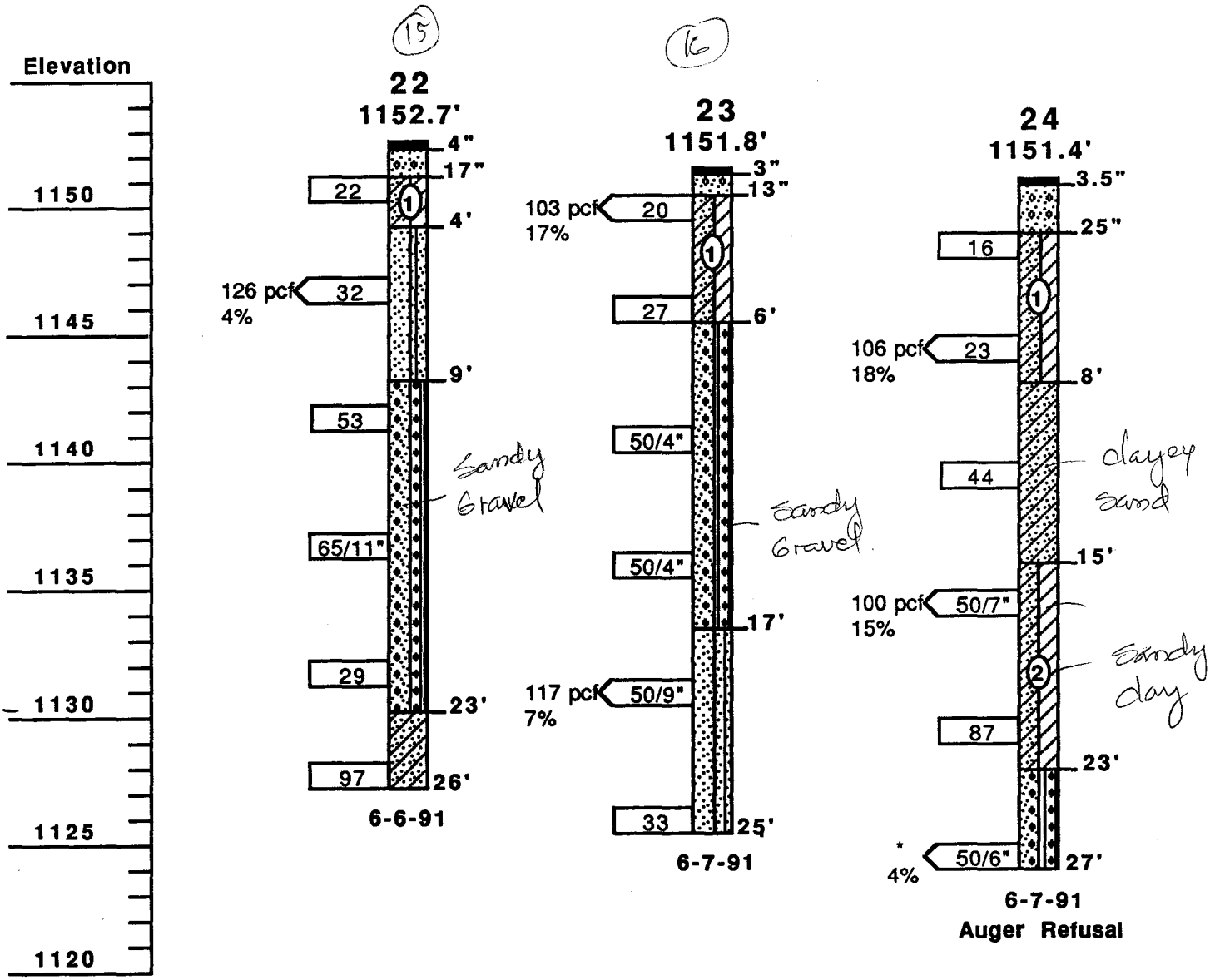
GRAPHICAL BORING LOGS



* Sample too disturbed to determine density.

No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

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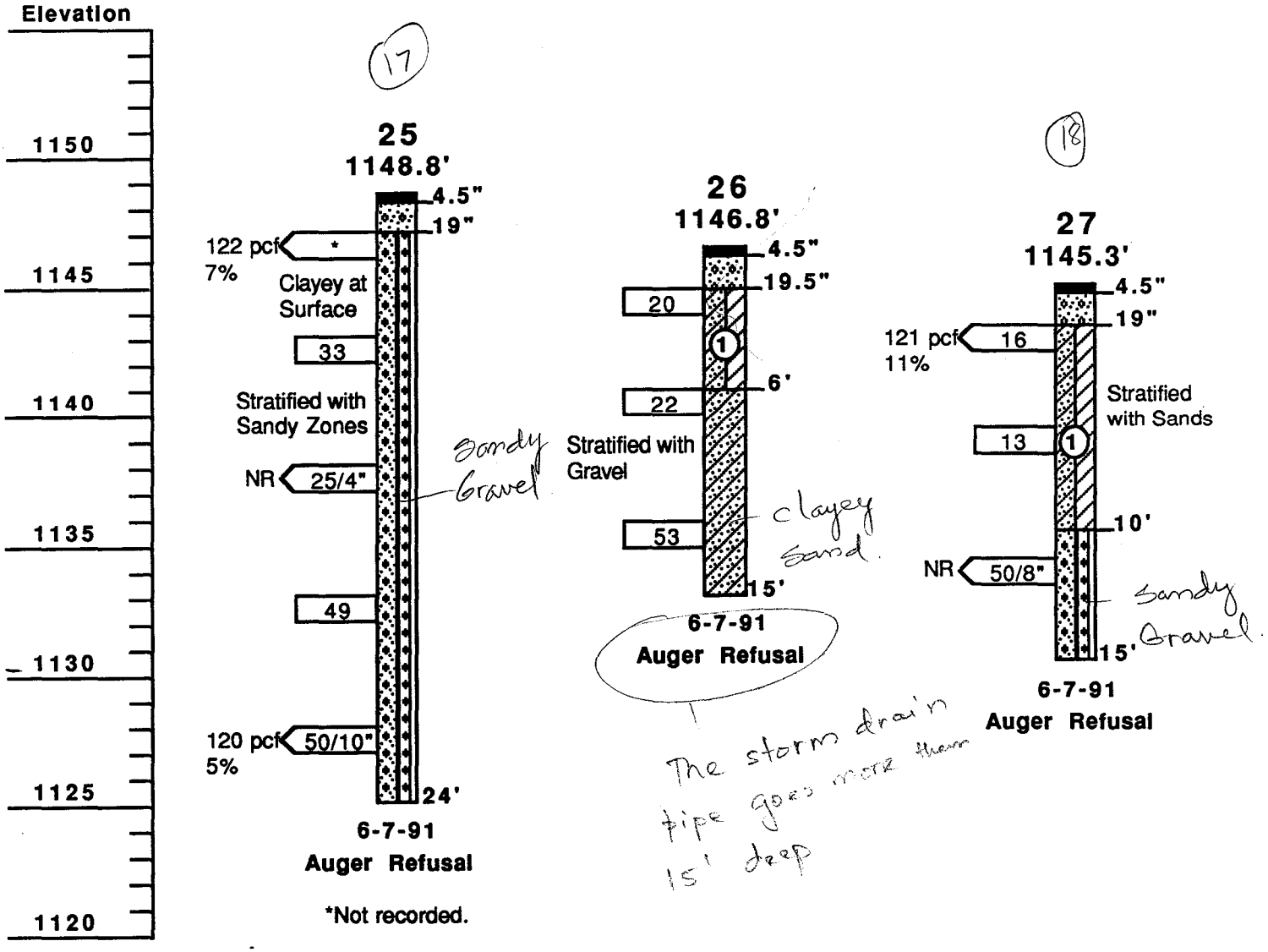
Thomas-Hartig & Associates

GRAPHICAL BORING LOGS



NR = No Recovery

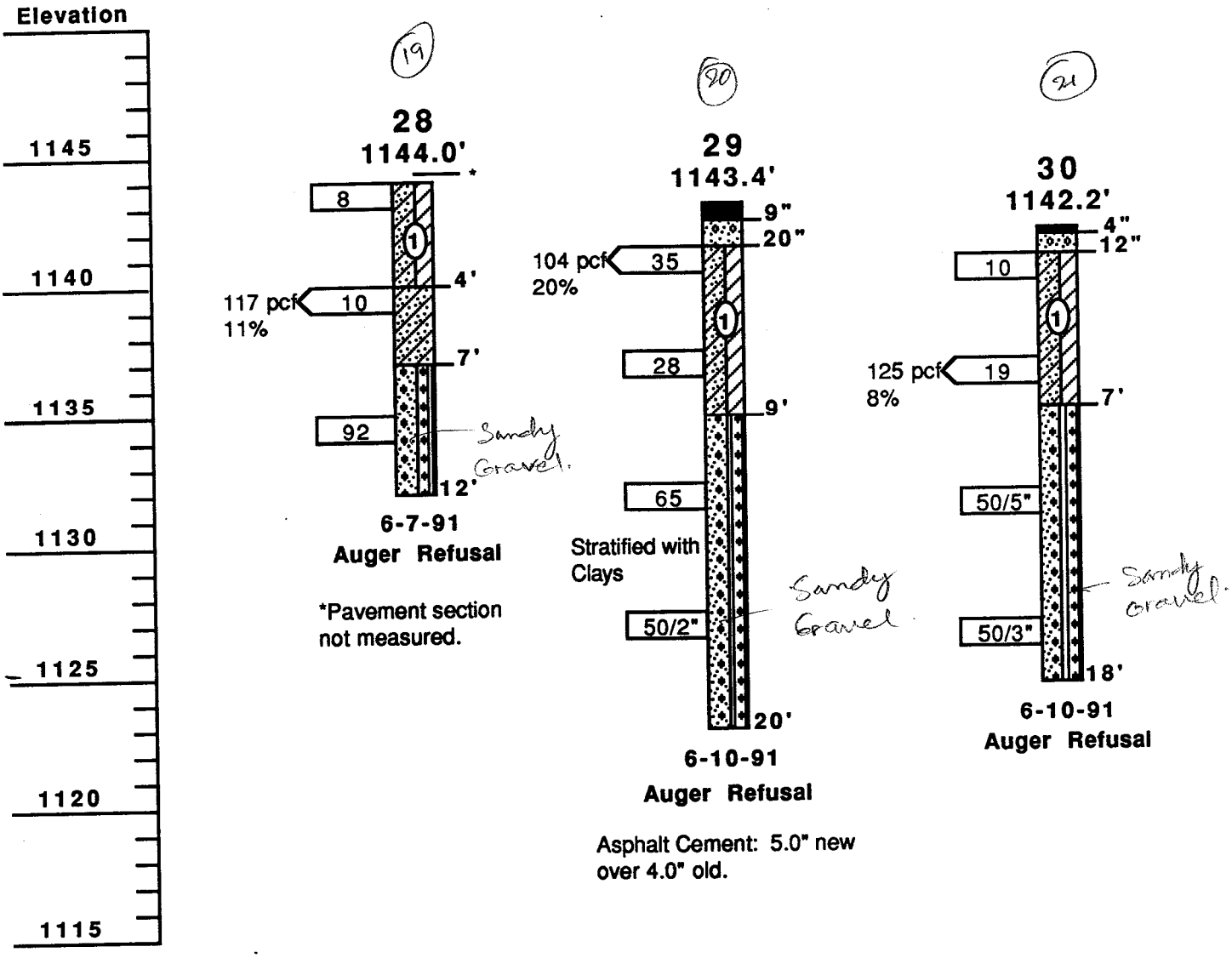
No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

Project No. 91-0715
Thomas-Hartig & Associates

GRAPHICAL BORING LOGS



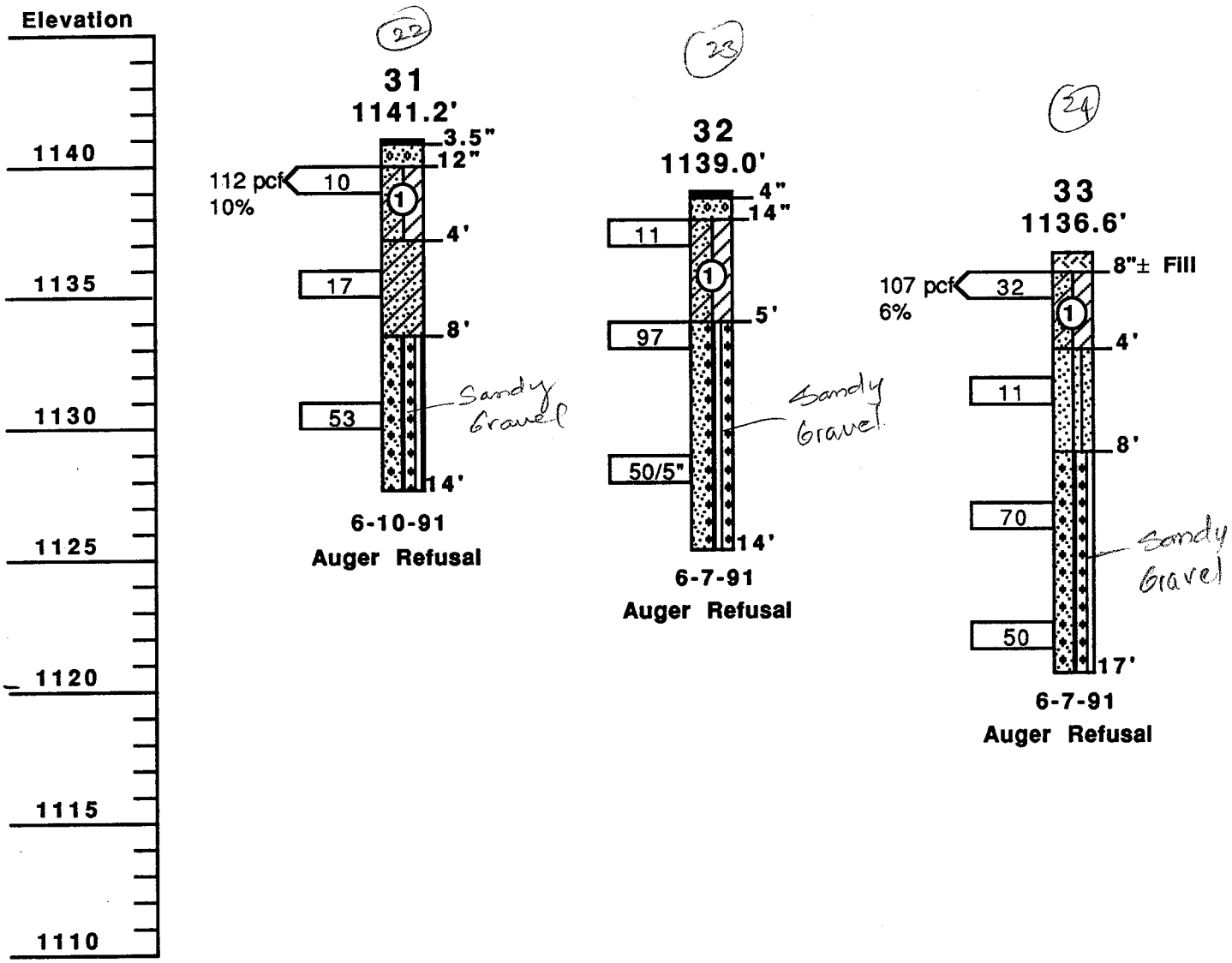
No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

Project No. 91-0715
Thomas-Hartig & Associates

GRAPHICAL BORING LOGS



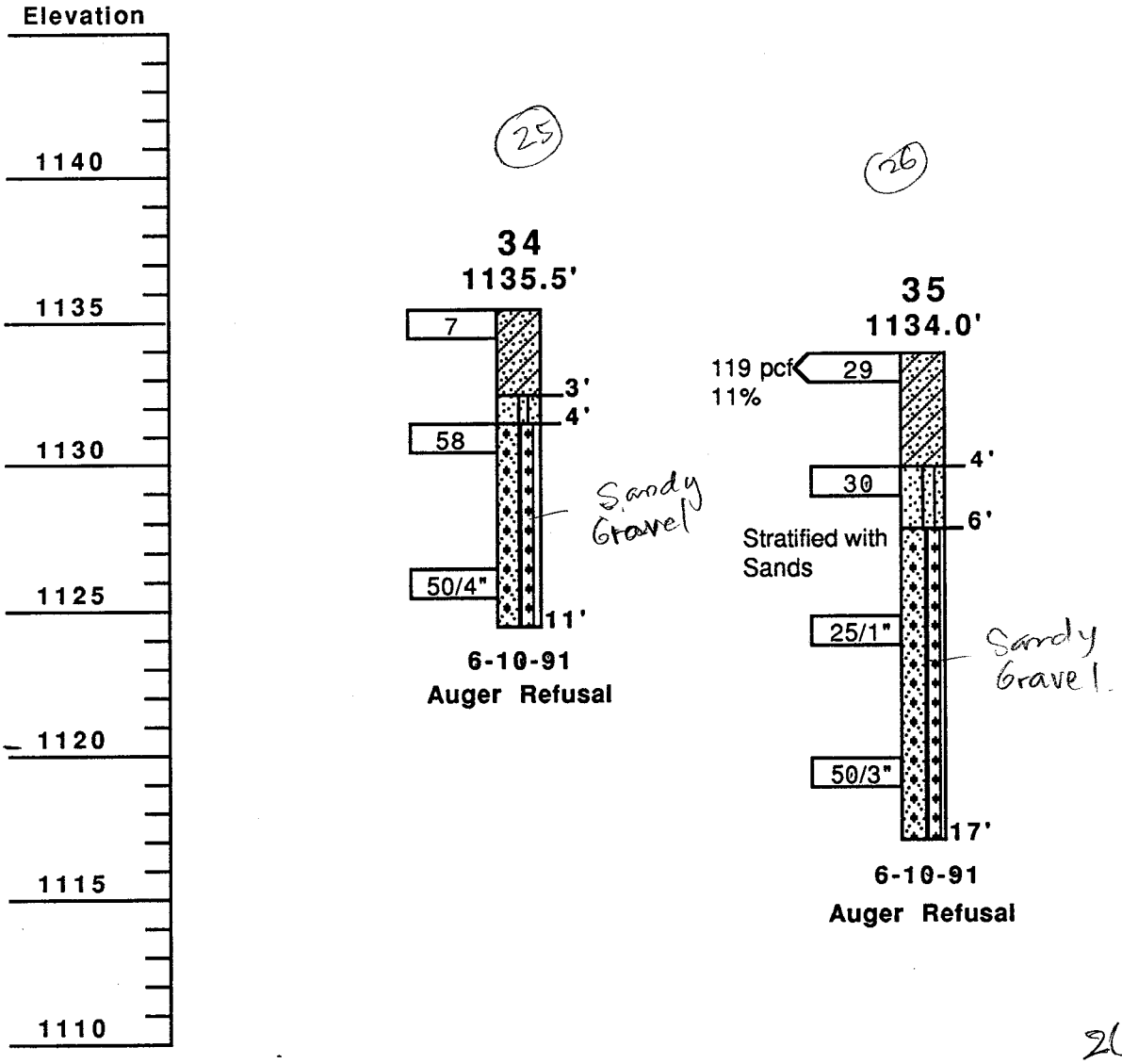
No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

Project No. 91-0715
Thomas-Hartig & Associates

GRAPHICAL BORING LOGS



26 out of 35 Boring logs have Sandy Gravel soil between 10' & 20' layer which is not good for cast-in-place pipe. Soil may cave in at trench excavation. Raj

No free groundwater was encountered in any of the borings during drilling.

All borings drilled with 7" diameter hollow stem auger unless otherwise noted.

NOTE: The data presented on the boring logs represents subsurface conditions only at the specific locations and at the time designated. This data may not represent conditions at other locations and/or times. Contacts between soil strata are approximate and changes between soil types may be gradual rather than abrupt. This boring data was compiled primarily for design purposes and should not be construed as part of the plans governing construction or defining construction techniques. Bidders are fully responsible for interpretations or conclusions they draw from the boring log.

Project No. 91-0715
Thomas-Hartig & Associates

REPORT ON FIELD RESISTIVITY TESTS

DESCRIPTION: Date: 6/20/91 thru 6/25/91

Location: Noted Below
Material: Subsurface Soil
Performed By: TH/Thompson & TH/Walsh

TESTED: Field electrical resistivity using the 4-probe method.

RESULTS:

Test Boring	Resistivity (ohm-cm) 0 - 15 ft.	0 - 25 ft.
1	2010	2350
2	3790	4450
3	3620	5030
4	3160	4210
5	2470	2730
6	3300	3210
7	2610	3110
8	3300	3350
9	2930	3210
10	2700	4790
11	2180	3210
12	3450	3730
13	2210	2680
14	2180	2490
15	2840	3930
16	2360	3260
17	1840	2630
18	4280	4640
19	1520	1150
20	3390	6700
21	4650	5080
22	6060	6510
23	7100	5890
24	3420	3880
25	4020	4210
26	3450	3690
27	2410	2060
28	5030	5460
29	5230	6510
30	3880	3730
31	5370	5170
32	2610	2729
33	4740	6510
34	9480	11600
35	8070	9100

Project No. 91-0715

Thomas-Hartig & Associates, Inc.

APPENDIX B
LABORATORY RESULTS

REPORT ON GRADATION AND PLASTICITY INDEX

SAMPLE: Date: 6-18-91

Source: Noted Below

Type: Bulk Samples

Material: Subsurface Soil

Sampled By: TH/Thompson

TESTED: Sieve Analysis and Plasticity Index

RESULTS

			Sieve Size - Accumulative % Passing											*
Sample	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class.
1; 0' - 3'	36	19	64	75	84	89	94	97	99	100				CL
1; 10' - 17'	57	27	62	72	79	84	89	92	95	100				CH
2; 0' - 3'	41	21	61	69	74	79	85	91	96	100				CL
2; 15' - 24'	31	13	13	16	20	28	43	60	76	94	94	100		SC
3; 0' - 3'	47	27	73	80	85	90	95	98	100					CL
3; 7' - 12'	39	18	21	25	29	36	45	58	70	99	100			SC
4; 0' - 3'	46	26	63	72	78	85	92	96	99	100				CL
4; 16' - 22'	36	19	6	7	8	9	12	19	35	79	88	100		GW-GC
5; 0' - 3'	39	21	67	78	86	90	95	98	100					CL
5; 14' - 19'	34	17	12	15	17	20	25	31	39	82	88	100		GC
6; 0' - 3'	26	10	41	50	58	69	82	91	98	100				SC
6; 10' - 14'	37	18	17	20	23	27	33	40	52	81	87	100		GC
7; 0' - 3'	41	23	67	76	83	87	92	96	98	100				CL
7; 10' - 15'	38	18	7	8	10	11	14	20	31	77	86	100		GP-GC
8; 0' - 3'	37	19	64	71	76	81	88	92	96	100				CL
8; 4' - 9'	33	17	17	19	22	27	37	47	60	93	99	100		SC

*Unified Soil Classification

Project No. 91-0715

Thomas-Hartig & Associates, Inc.

REPORT ON GRADATION AND PLASTICITY INDEX

SAMPLE: Date: 6-18-91

Source: Noted Below

Type: Bulk Samples

Material: Subsurface Soil

Sampled By: TH/Thompson

TESTED: Sieve Analysis and Plasticity Index

RESULTS

			Sieve Size - Accumulative % Passing											*
Sample	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class.
9; 0' - 3'	31	14	64	77	84	89	93	97	99	100				CL
9; 11' - 18'	39	20	25	28	31	35	43	53	63	92	100			GC
10; 0' - 3'	38	20	51	59	66	71	80	91	96	100				SC-CL
10; 8' - 12'	42	23	18	21	23	26	29	35	46	81	90	100		GC
11; 0' - 3'	29	12	53	64	71	78	86	92	96	98	100			SC-CL
11; 12' - 18'	35	16	7	8	10	12	14	25	34	67	81	100		GW-GC
12; 0' - 3'	40	22	71	79	85	89	94	97	99	100				CL
12; 6' - 12'	36	17	19	22	26	30	37	47	59	93	99	100		GC
13; 0' - 3'	32	15	58	68	75	77	86	91	95	100				CL
13; 14' - 19'	40	22	21	24	26	31	41	53	65	92	98	100		GC
14; 0' - 3'	43	24	68	77	83	89	95	98	99	100				CL
14; 14' - 19'	47	26	28	30	33	37	41	50	62	92	98	100		GC
15; 0' - 3'	52	30	64	71	76	81	87	93	96	100				CH
15; 19' - 24'	43	23	10	12	13	15	18	22	33	73	86	100		GP-GC
16; 0' - 3'	42	21	65	73	79	85	90	95	97	100				CL
16; 14' - 22'	42	22	14	16	19	22	27	34	44	73	82	95	100	GC

*Unified Soil Classification

Project No. 91-0715

Thomas-Hartig & Associates, Inc.

REPORT ON GRADATION AND PLASTICITY INDEX

SAMPLE: Date: 6-18-91

Source: Noted Below

Type: Bulk Samples

Material: Subsurface Soil

Sampled By: TH/Thompson

TESTED: Sieve Analysis and Plasticity Index

RESULTS

			Sieve Size - Accumulative % Passing											*
Sample	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class.
17; 0' - 3'	37	18	65	74	82	89	95	99	100					CL
17; 13' - 18'	36	16	28	33	39	46	56	64	73	93	98	100		SC
18; 0' - 3'	25	7	60	68	75	83	91	96	98	100				CL
18; 7' - 12'	24	6	34	46	63	75	84	90	95	98	100			SC-SM
19; 0' - 3'	40	21	68	76	83	89	94	97	99	100				CL
19; 18' - 24'	45	23	42	49	54	59	67	77	87	100				SC
20; 0' - 3'	52	26	60	67	72	76	81	87	91	97	100			CH
20; 12' - 18'	40	19	26	30	34	38	45	53	64	88	92	100		SC
21; 0' - 3'	40	21	66	74	82	87	92	96	98	100				CL
21; 19' - 20'**	32	12	25	30	37	49	59	67	76	91	95	100		SC
22; 0' - 3'	30	14	46	53	60	67	74	80	87	100				SC/CL
22; 14' - 15'**	30	8	25	30	37	49	62	76	89	100				SC
23; 0' - 3'	45	25	67	73	78	83	87	92	96	100				CL
23; 19' - 20'+		NP	10	14	24	46	66	78	91	100				SW
24; 0' - 3'	42	24	64	70	76	84	91	95	97	100				CL
24; 6' - 13'	38	18	23	26	31	38	47	58	68	93	96	100		SC

** SPT Sample

+ Ring Sample

*Unified Soil Classification

NP = Non-Pastic

Project No. 91-0715

Thomas-Hartig & Associates, Inc.

REPORT ON GRADATION AND PLASTICITY INDEX

SAMPLE: Date: 6-18-91

Source: Noted Below

Type: Bulk Samples

Material: Subsurface Soil

Sampled By: TH/Thompson

TESTED: Sieve Analysis and Plasticity Index

RESULTS

			Sieve Size - Accumulative % Passing											*
Sample	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class.
25; 0' - 3'	40	17	24	27	31	35	42	51	62	96	99	100		SC/GC
25; 14' - 15' **	26	6	13	16	21	29	44	56	67	89	100			SC-SM
26; 0' - 3'	52	30	61	67	71	76	81	87	92	98	100			CH
26; 9' - 10' **	47	24	46	51	57	64	71	77	82	91	91	100		SC/CL
27; 0' - 3'	37	20	57	64	71	79	89	96	98	100				CL
27; 8' - 13'	39	20	21	23	26	30	38	48	58	89	98	100		GC
28; 0' - 3'	33	17	51	59	67	76	85	90	93	100				SC/CL
28; 7' - 12'	29	13	15	18	22	27	33	38	43	69	76	100		SC
29; 0' - 3'	37	17	71	77	82	88	94	98	99	100				CL
29; 9' - 10' **	24	7	14	17	22	30	44	58	69	100				SC-SM
30; 0' - 3'	32	16	55	64	71	81	92	97	98	100				CL
30; 12' - 17'	33	17	8	9	11	13	19	30	43	88	94	100		GP-GC
31; 0' - 3'	39	20	64	72	78	86	93	97	99	100				CL
31; 9' - 10' **	31	13	13	16	20	29	44	59	72	96	100			SC
32; 0' - 3'	37	19	61	68	74	83	93	97	98	100				CL
32; 4' - 13'	35	18	19	21	24	28	35	44	55	89	95	100		GC

** SPT Sample

+ Ring Sample

*Unified Soil Classification

NP = Non-Plastic

Project No. 91-0715

Thomas-Hartig & Associates, Inc.

REPORT ON GRADATION AND PLASTICITY INDEX

SAMPLE: Date: 6-18-91

Source: Noted Below

Type: Bulk Samples

Material: Subsurface Soil

Sampled By: TH/Thompson

TESTED: Sieve Analysis and Plasticity Index

RESULTS

			Sieve Size - Accumulative % Passing											*
Sample	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class.
33; 0' - 3'	22	4	50	64	78	88	94	96	97	100				CL-ML
33; 9' - 16'	21	4	10	13	16	20	26	32	39	80	90	100		GM-GP
34; 0' - 3'	24	6	38	47	55	68	82	88	92	97	100			SC-SM
34; 4' - 11'		NP	14	18	26	43	59	71	80	84	99	100		SM
35; 0' - 3'	33	16	48	55	62	69	77	83	87	95	95	100		SC/CL
35; 10' - 17'	21	5	7	9	12	18	27	33	38	70	85	100		GC-GM

*Unified Soil Classification

NP = Non-Plastic

Project No. 91-0715

Thomas-Hartig & Associates, Inc.

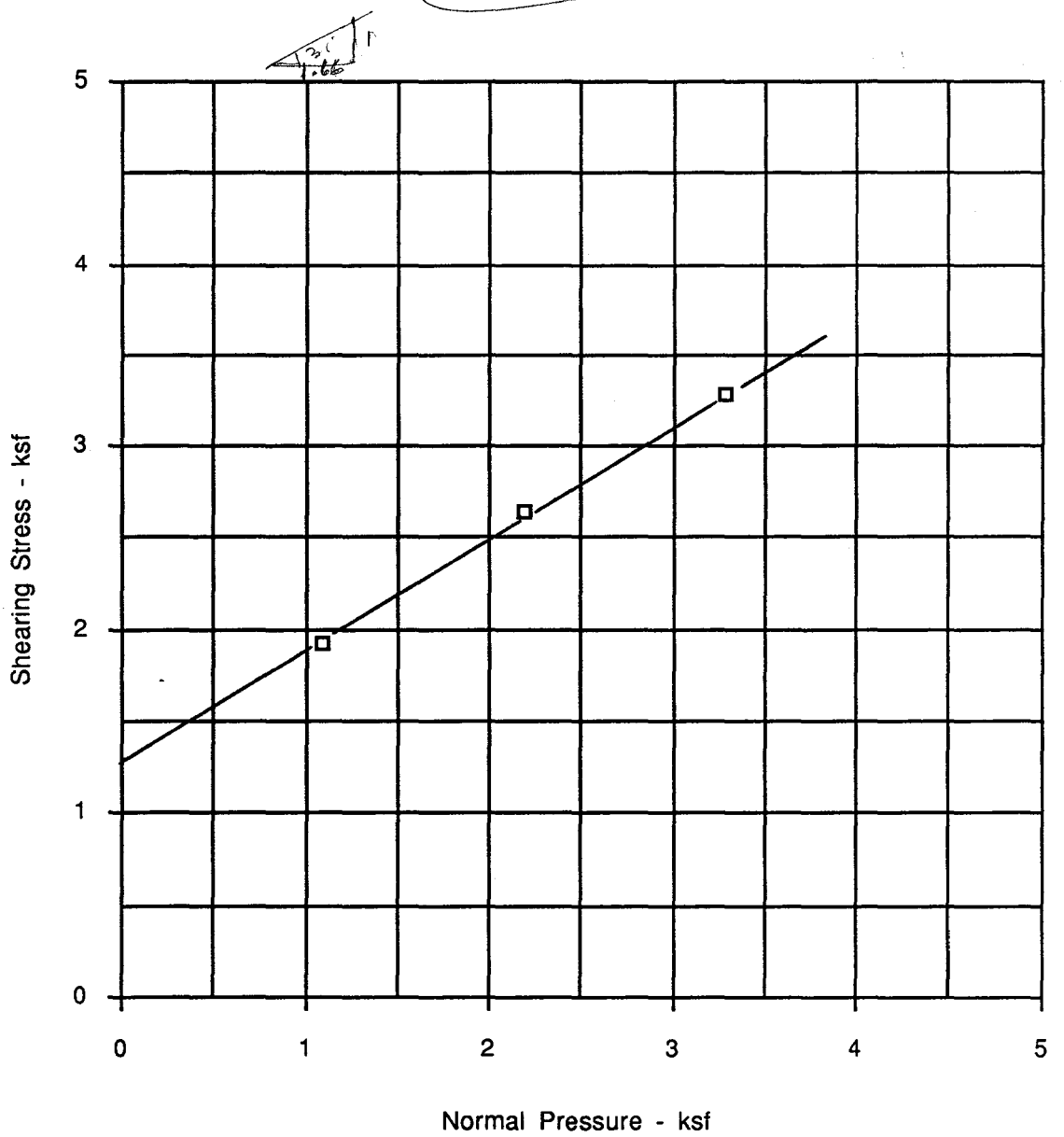
REPORT ON DIRECT SHEAR TESTS

SAMPLE: Date: 6-4-91

Source: Test Boring 1; 4' - 5'
Type: Driven Ring Sample; 115 pcf Dry Density; 9% Field Moisture
Material: Sandy Clay (CL)
Sampled by: TH/Thompson

TESTED: Direct Shear with sample at in-situ moisture content.

RESULTS: Friction Angle (ϕ) = 31 degrees, Cohesion (c) = 1.3 ksf



Project No. 91-0715

Thomas-Hartig & Associates, Inc.

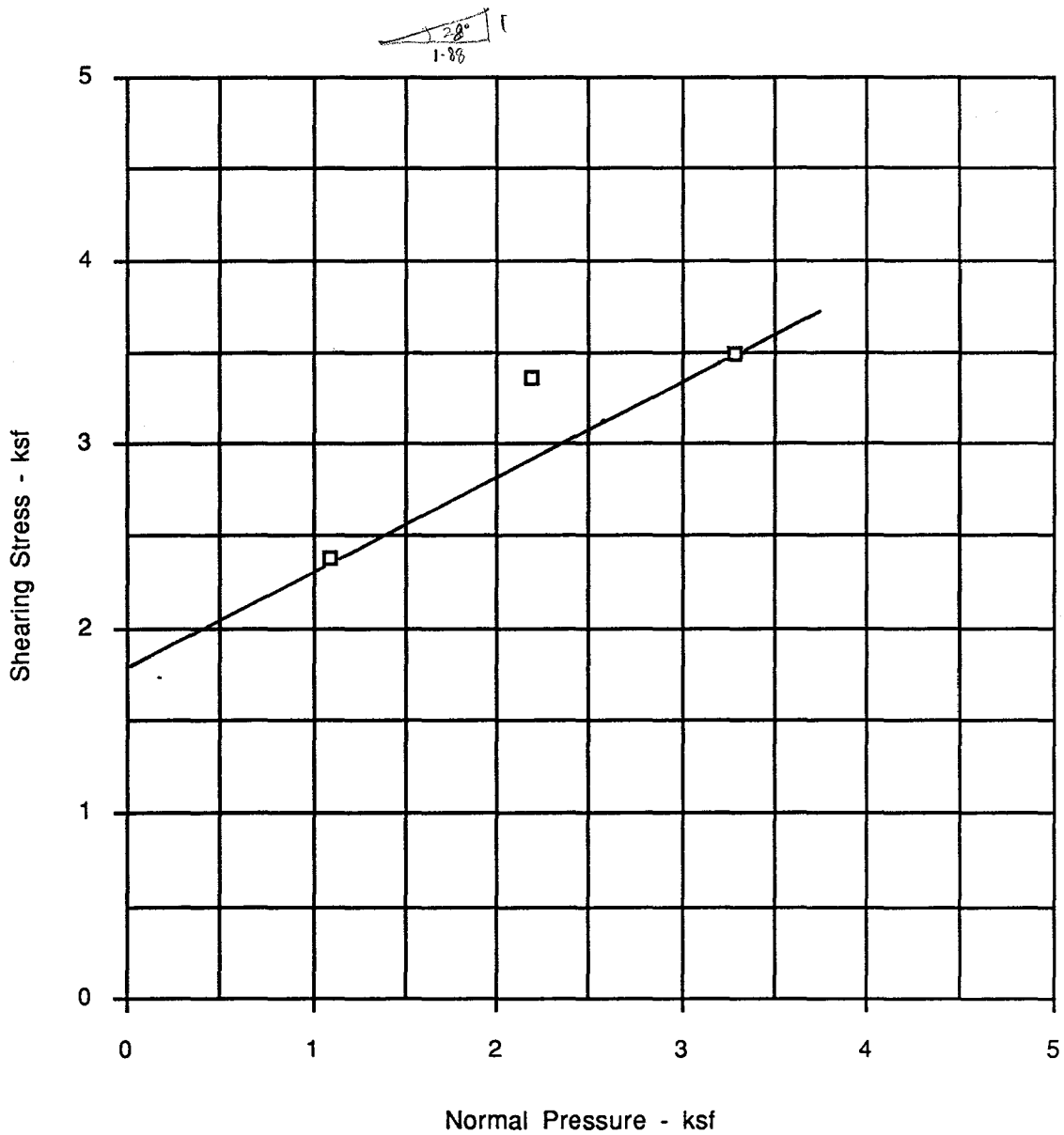
REPORT ON DIRECT SHEAR TESTS

SAMPLE: Date: 6-6-91

Source: Test Boring 9; 9' - 10'
Type: Driven Ring Sample; 113 pcf Dry Density; 13% Field Moisture
Material: Sandy Clay (CL)
Sampled by: TH/Thompson

TESTED: Direct Shear with sample at in-situ moisture content.

RESULTS: Friction Angle (ϕ) = 28 degrees, Cohesion (c) = 1.8 ksf



Project No. 91-0715

Thomas-Hartig & Associates, Inc.

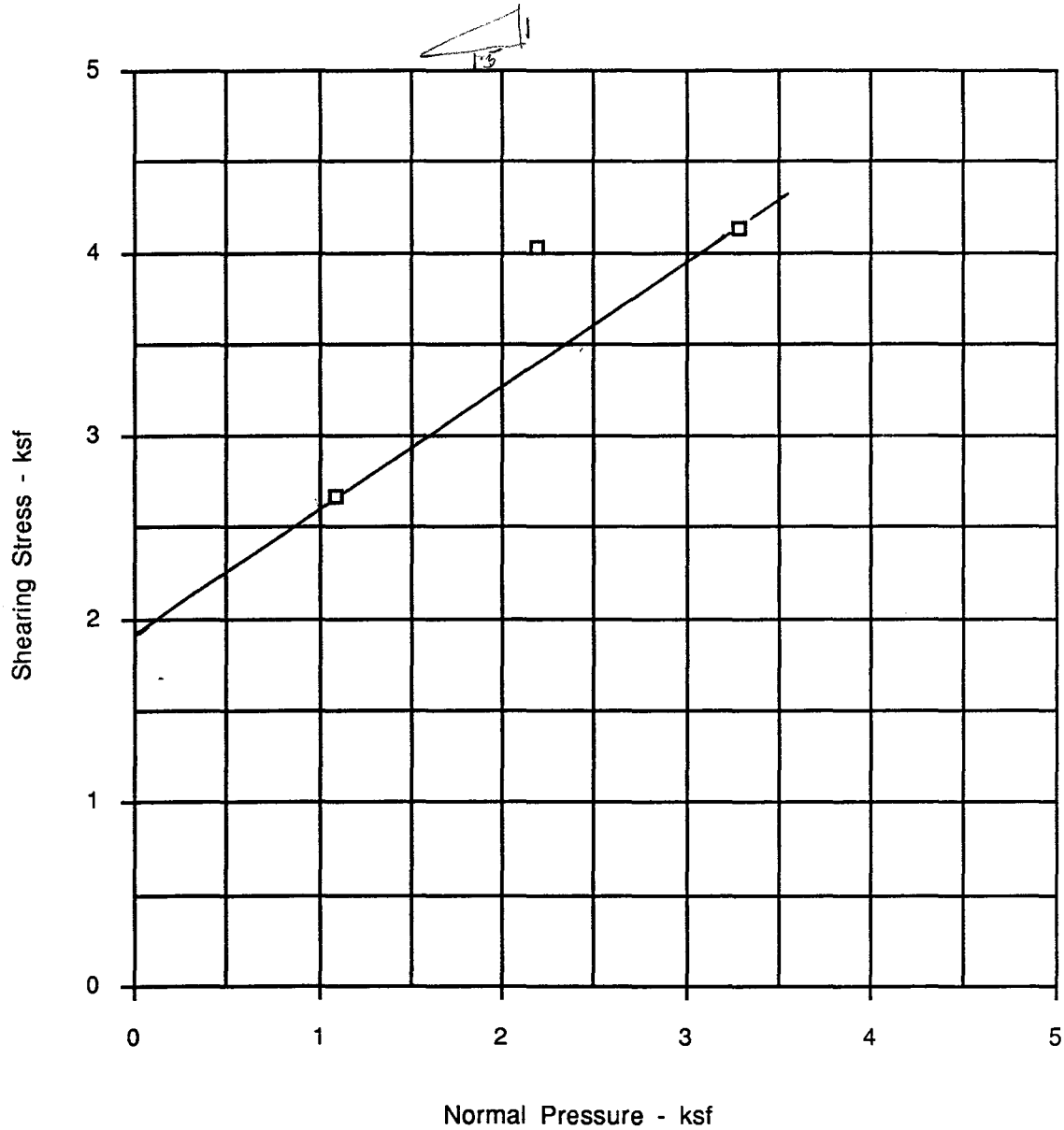
REPORT ON DIRECT SHEAR TESTS

SAMPLE: Date: 6-7-91

Source: Test Boring 18; 14' - 15'
Type: Driven Ring Sample; 103 pcf Dry Density; 16% Field Moisture
Material: Sandy Silty Clay (CL-ML)
Sampled by: TH/Thompson

TESTED: Direct Shear with sample at in-situ moisture content.

RESULTS: Friction Angle (ϕ) = 33 degrees, Cohesion (c) = 1.9 ksf



Project No. 91-0715

Thomas-Hartig & Associates, Inc.

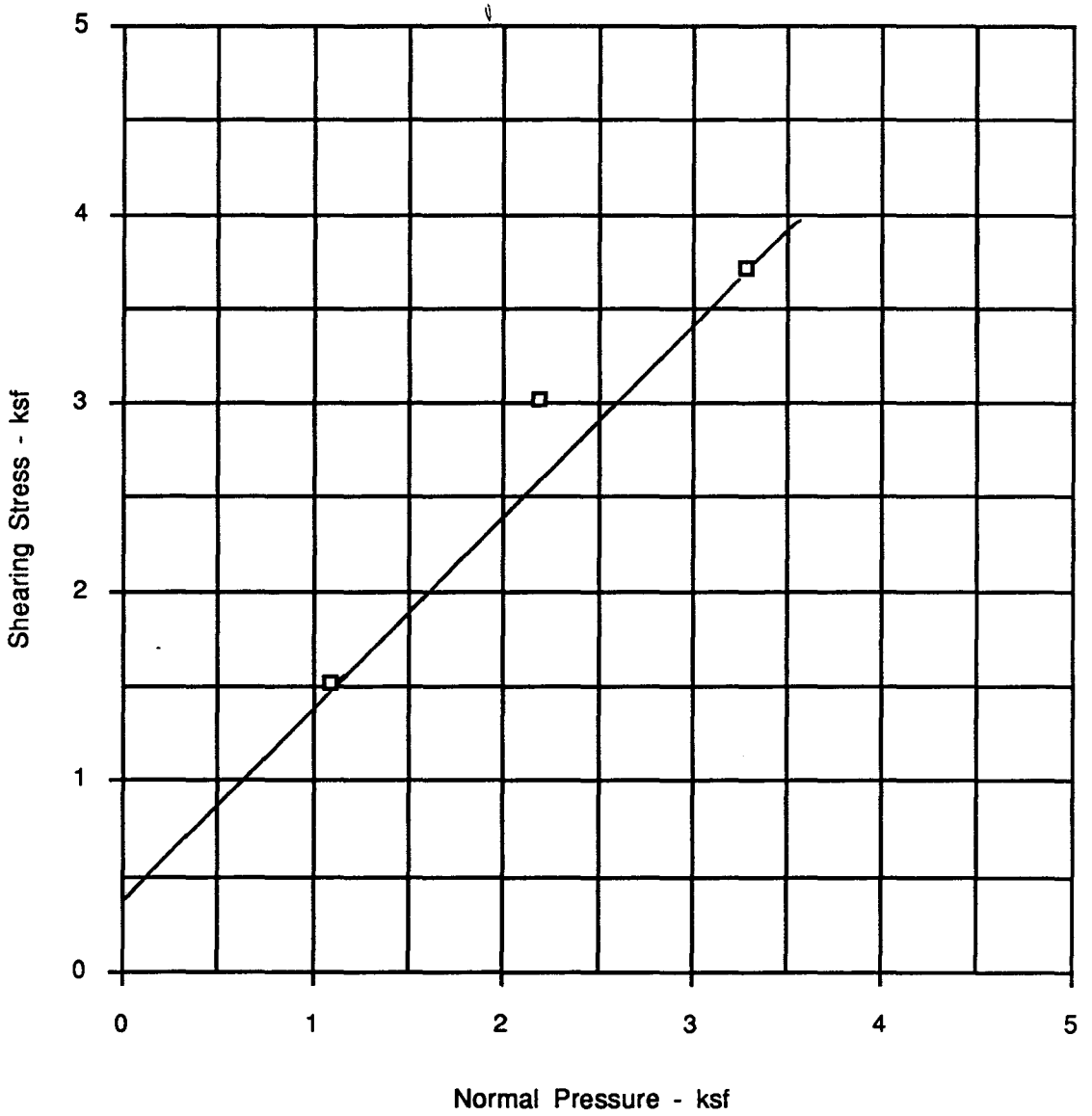
REPORT ON DIRECT SHEAR TESTS

SAMPLE: Date: 6-18-91

Source: Test Boring 20; 14' - 15'
Type: Driven Ring Sample; 124 pcf Dry Density; 4% Field Moisture
Material: Gravelly, Silty Sand (SM)
Sampled by: TH/Thompson

TESTED: Direct Shear with sample at in-situ moisture content.

RESULTS: Friction Angle (ϕ) = 45 degrees, Cohesion (c) = 0.4 ksf



Project No. 91-0715

Thomas-Hartig & Associates, Inc.

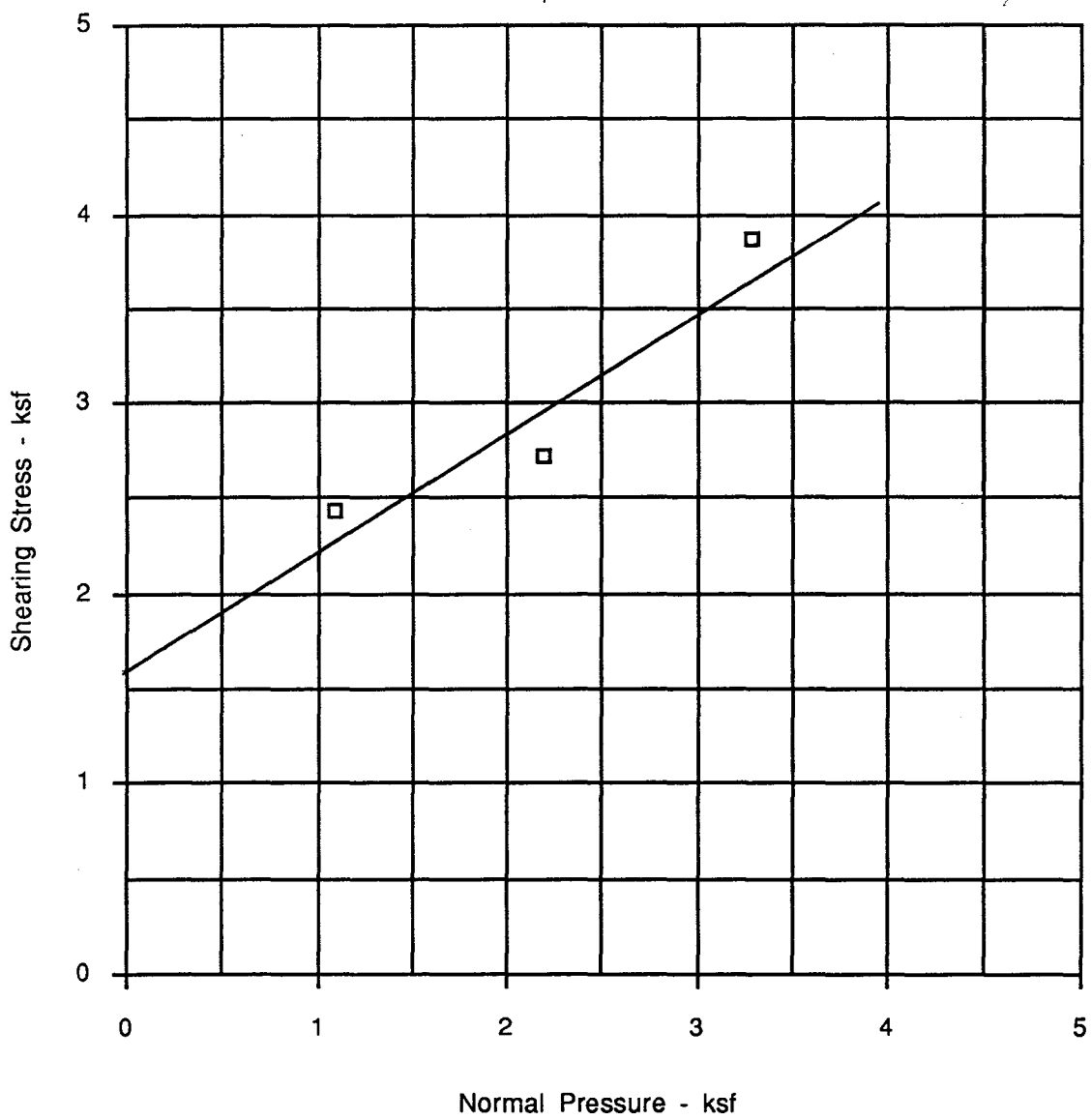
REPORT ON DIRECT SHEAR TESTS

SAMPLE: Date: 6-18-91

Source: Test Boring 30; 4' - 5'
Type: Driven Ring Sample; 125 pcf Dry Density; 8% Field Moisture
Material: Sandy Clay (CL)
Sampled by: TH/Thompson

TESTED: Direct Shear with sample at in-situ moisture content.

RESULTS: Friction Angle (ϕ) = 32 degrees, Cohesion (c) = 1.6 ksf



Project No. 91-0715

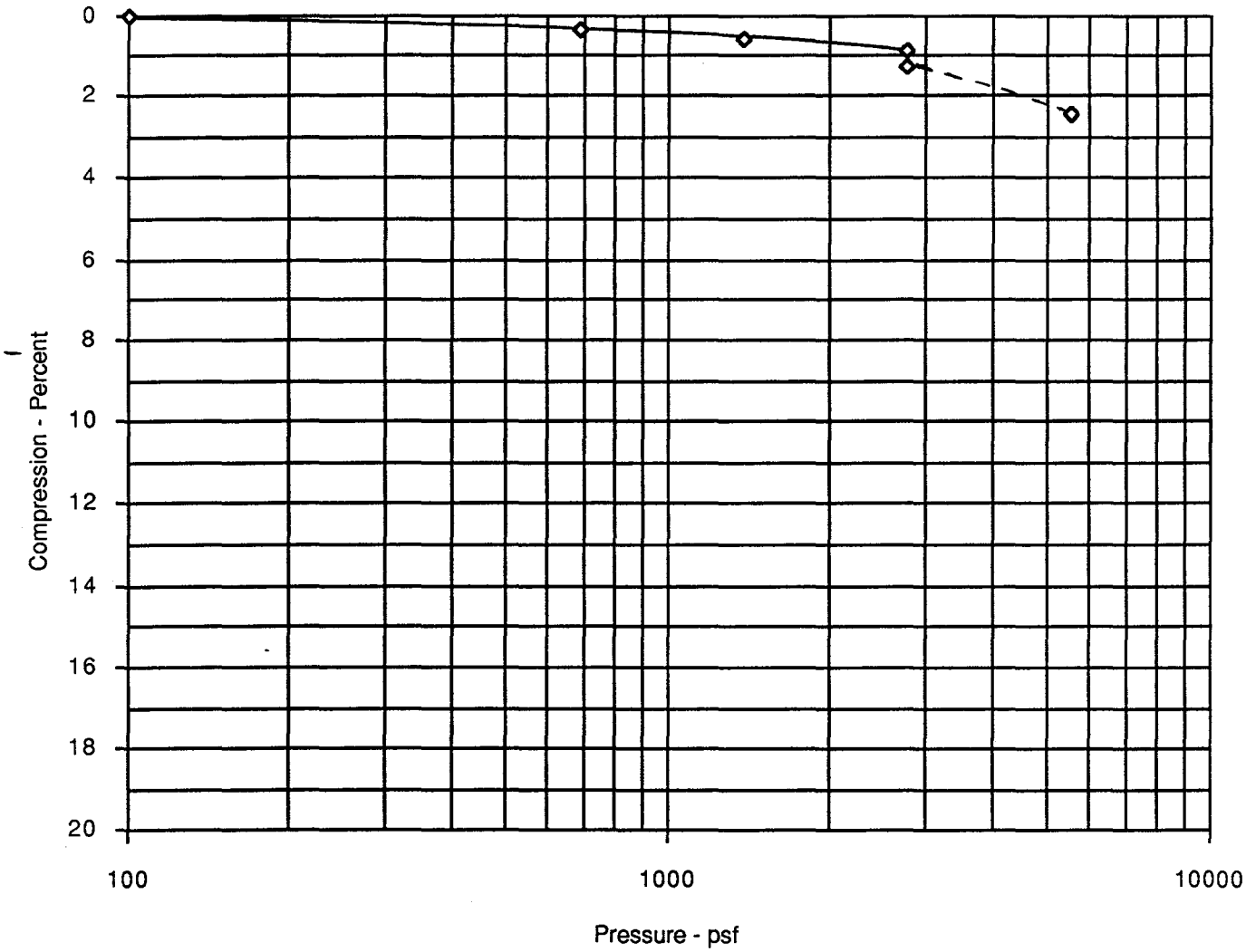
Thomas-Hartig & Associates, Inc.

REPORT ON COMPRESSION TESTS

SAMPLE: Date: 6-5-91

Source: Test Boring 3; 9' - 10'
Type: Driven Ring Sample; 127 pcf Dry Density; 13% Field Moisture
Material: Clayey Sand (SC)
Sampled by: TH/Thompson

TESTED: Compression; test sample soaked at 2770 psf



Project No. 91-0715

Thomas-Hartig & Associates, Inc.

REPORT ON pH, SOLUBLE SALTS, SULFATES & CHLORIDES

SAMPLE: Date: 6-18-91

Source: Noted Below
Type: Bulk Samples
Material: Subsurface Soil
Sampled By: THThompson

TESTED: pH, Soluble Salts, Sulfates and Chlorides.

TEST RESULTS

Sample	pH	Soluble Salts (%)	Sulfates Percent	Chlorides Percent
2; 0' - 3'	7.8	0.077	0.012	0.012
4; 16' - 22'	8.2	0.056	0.006	0.007
8; 4' - 9'	7.7	0.049	0.006	0.008
9; 11' - 18'	7.7	0.056	0.006	0.009
11; 12' - 18'	7.6	0.042	0.006	0.009
15; 0' - 3'	7.7	0.077	0.012	0.007
19; 18' - 24'	8.2	0.130	0.033	0.013
24; 6' - 13'	8.2	0.098	0.006	0.021
27; 8' - 13'	8.2	0.084	0.009	0.009
30; 12' - 17'	8.2	0.056	0.012	0.007
35; 10' - 17'	8.2	0.056	0.012	0.008

Project No. 91-0715

Thomas-Hartig & Associates, Inc.

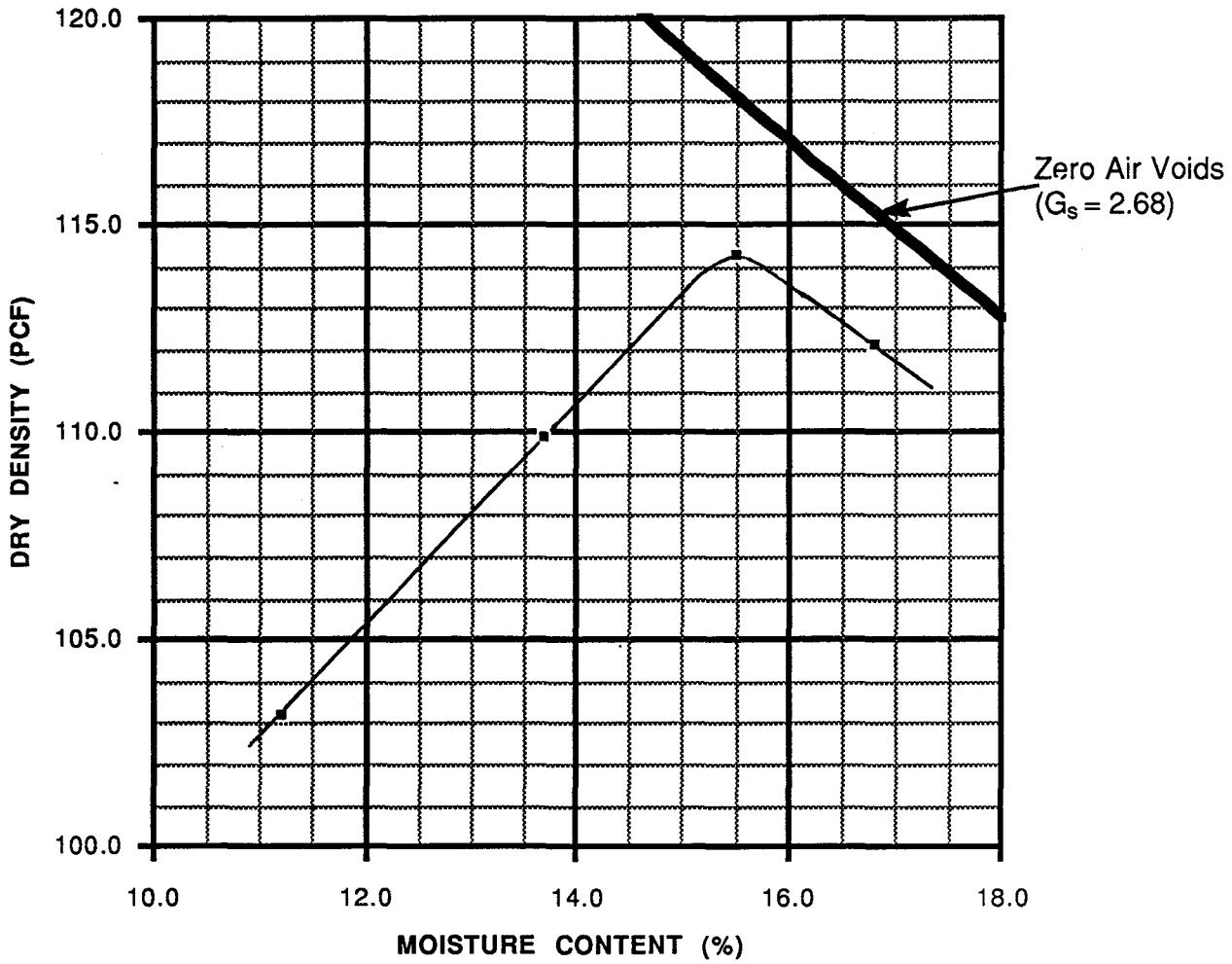
REPORT ON MOISTURE-DENSITY RELATIONSHIP TESTS

SAMPLE: Date: 6-5-91

Source: Test Boring 2; 0' - 3'
Type: Bulk Sample
Material: Sandy Clay (CL)
Sampled By: TH/Thompson

TESTED: Moisture-Density Relationship Curve; ASTM D698, Method A

RESULTS:
Maximum Dry Density (pcf)= 114.5 pcf
Optimum Moisture Content (%)= 15.7%



Project No.: 91-0715

Thomas-Hartig & Associates, Inc.

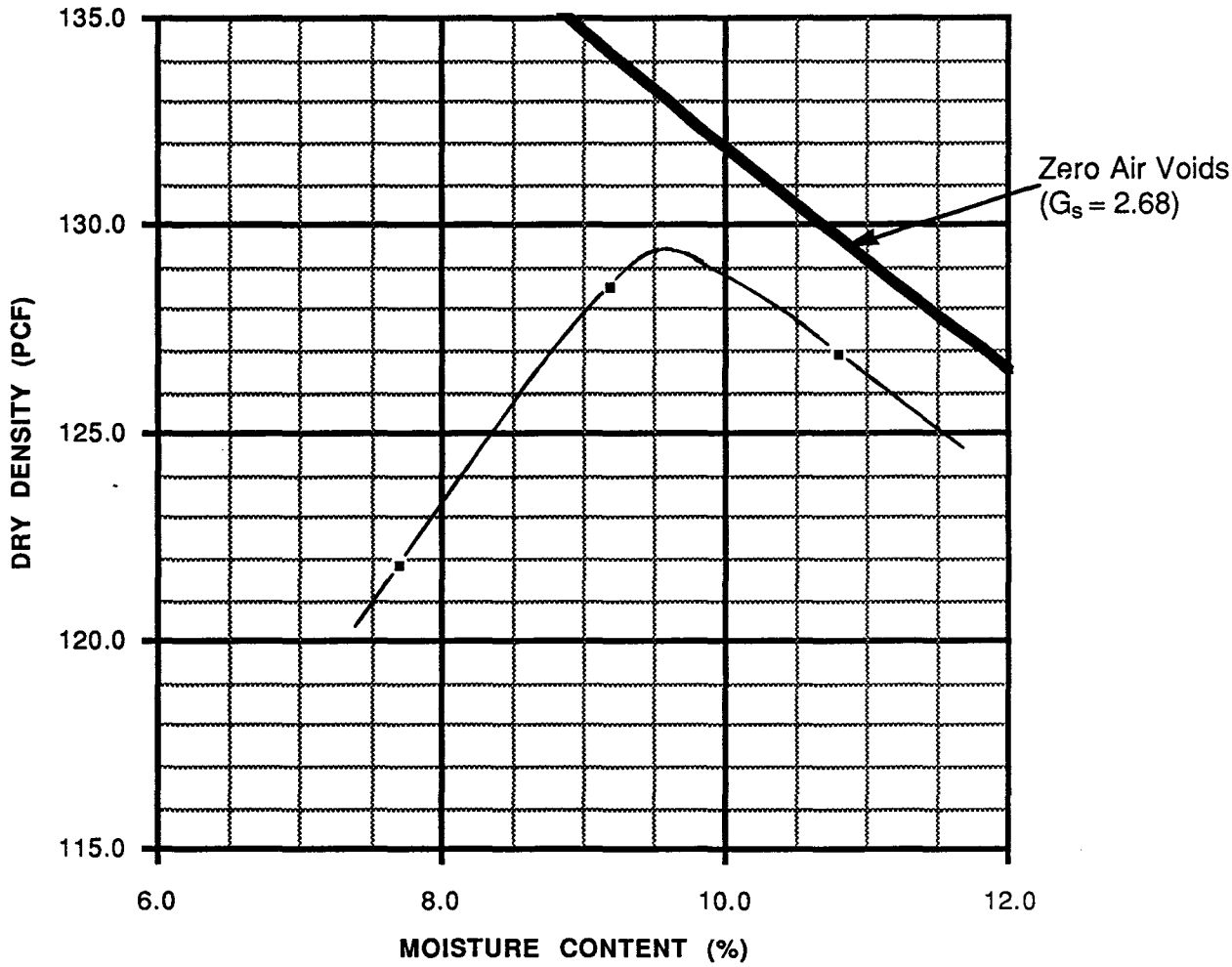
REPORT ON MOISTURE-DENSITY RELATIONSHIP TESTS

SAMPLE: Date: 6-7-91

Source: Test Boring 11; 6' - 24'
Type: Bulk Sample
Material: Clayey Gravel (GC)
Sampled By: TH/Thompson

TESTED: Moisture-Density Relationship Curve; ASTM D698, Method A

RESULTS:
Maximum Dry Density (pcf)= 129.5 pcf
Optimum Moisture Content (%)= 9.6%



Project No.: 91-0715

Thomas-Hartig & Associates, Inc.

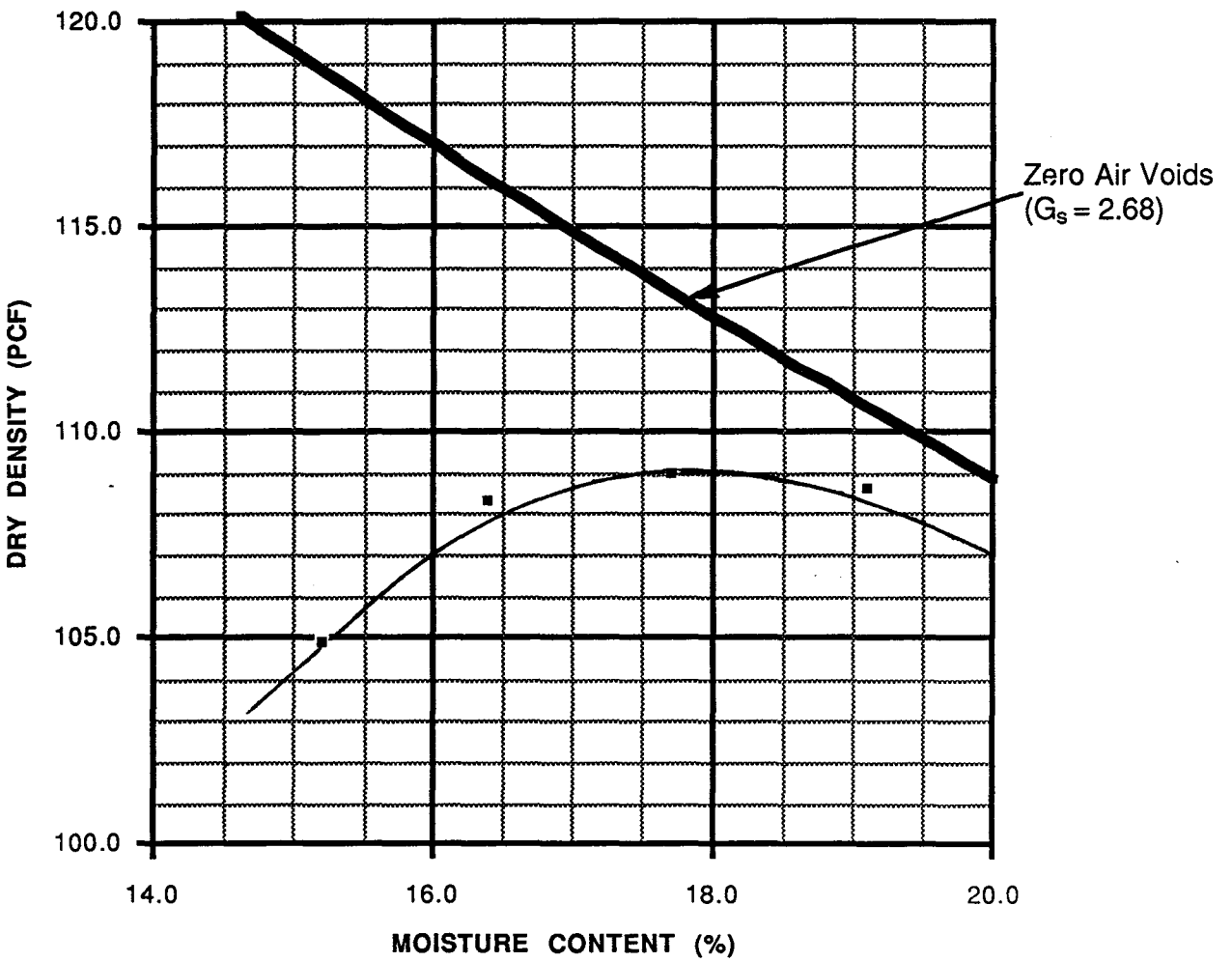
REPORT ON MOISTURE-DENSITY RELATIONSHIP TESTS

SAMPLE: Date: 6-10-91

Source: Test Boring 16; 3' - 14'
Type: Bulk Sample
Material: Sandy Clay (CL)
Sampled By: TH/Thompson

TESTED: Moisture-Density Relationship Curve; ASTM D698, Method A

RESULTS:
Maximum Dry Density (pcf)= 109.0 pcf
Optimum Moisture Content (%)= 17.7%



Project No.: 91-0715

Thomas-Hartig & Associates, Inc.

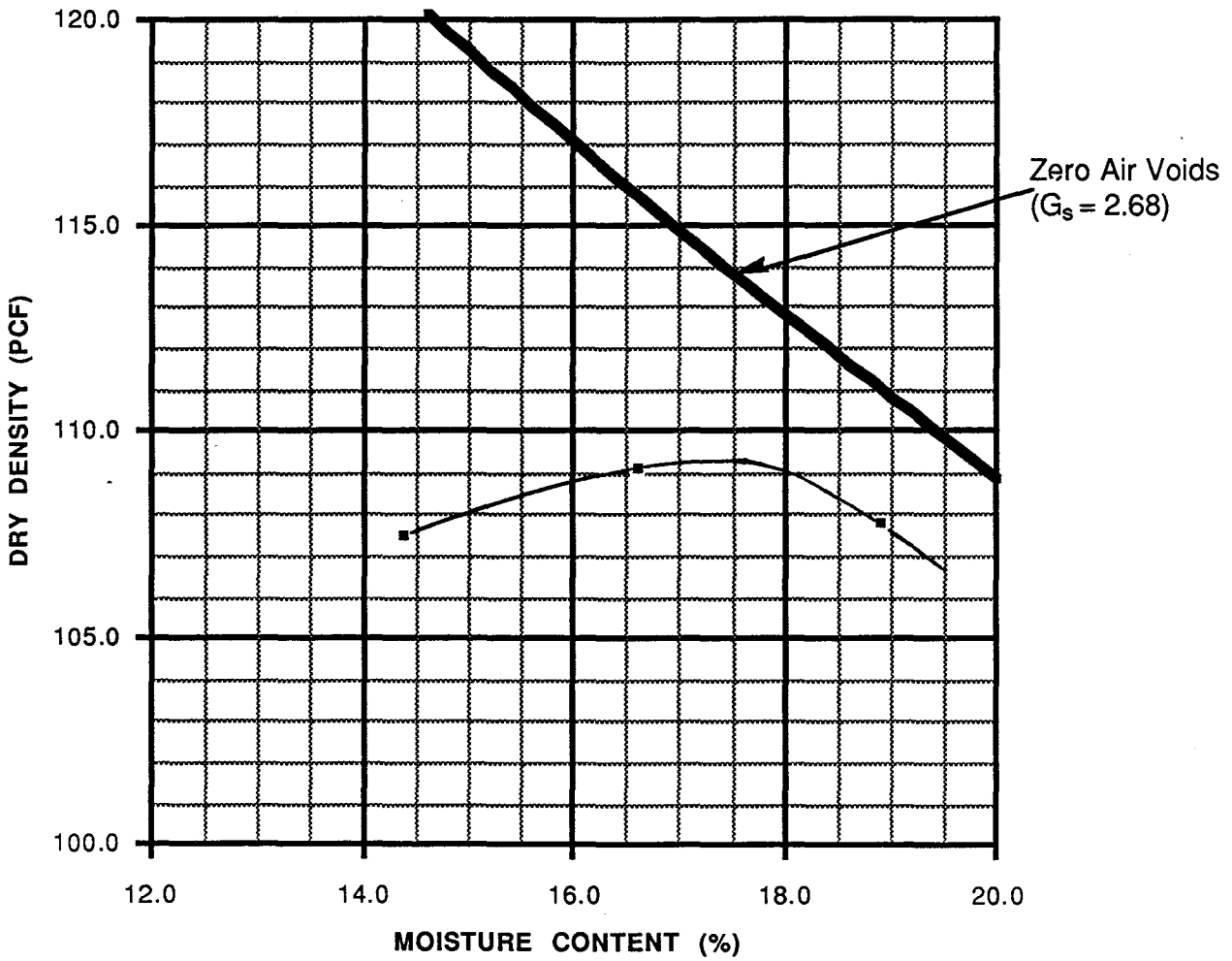
REPORT ON MOISTURE-DENSITY RELATIONSHIP TESTS

SAMPLE: Date: 6-13-91

Source: Test Boring 21; 0' - 3'
Type: Bulk Sample
Material: Sandy Clay)CL)
Sampled By: TH/Thompson

TESTED: Moisture-Density Relationship Curve; ASTM D698, Method A

RESULTS:
Maximum Dry Density (pcf)= 109.3 pcf
Optimum Moisture Content (%)= 17.5%



Project No.: 91-0715

Thomas-Hartig & Associates, Inc.

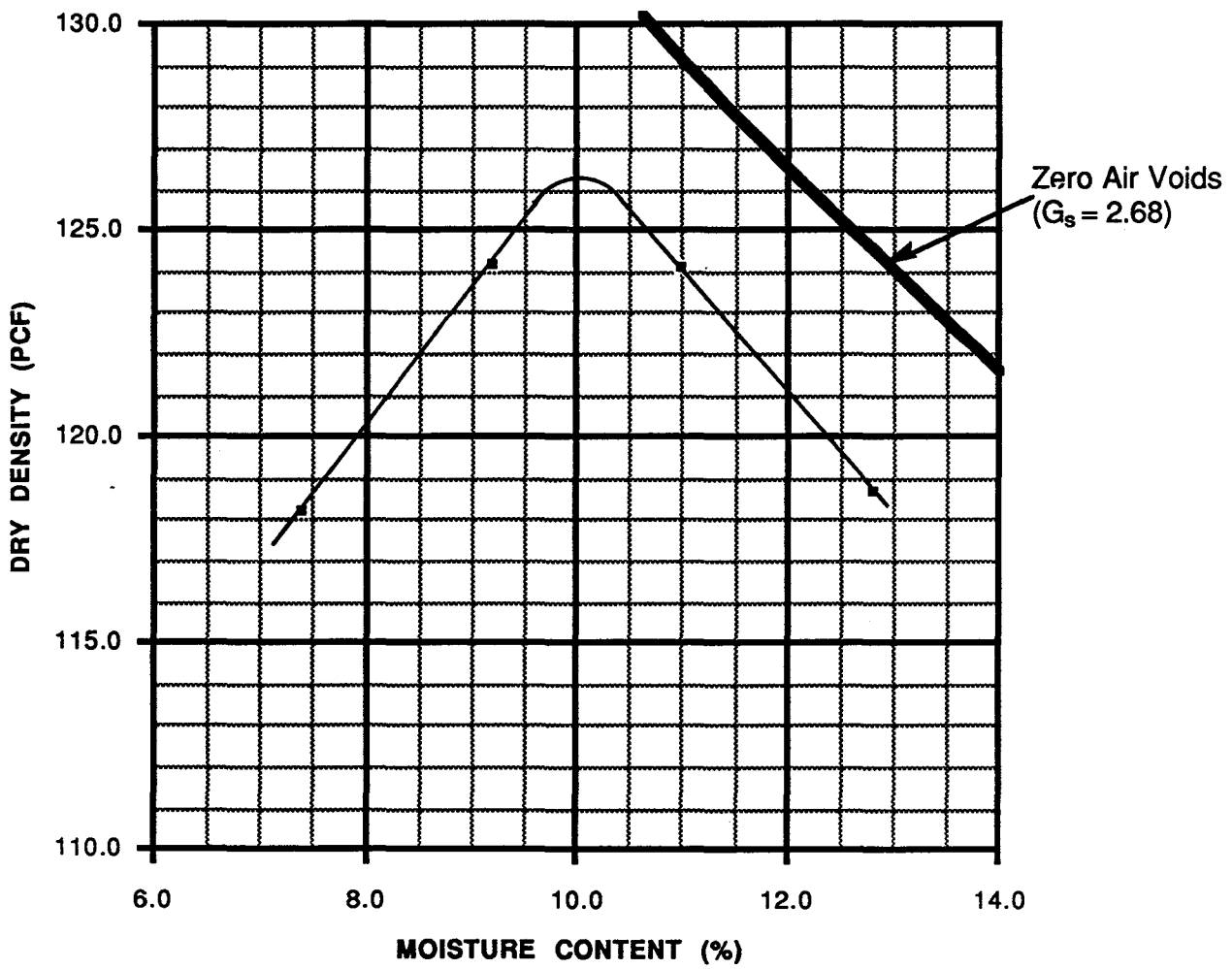
REPORT ON MOISTURE-DENSITY RELATIONSHIP TESTS

SAMPLE: Date: 6-17-91

Source: Test Boring 32; 4' - 13'
Type: Bulk Sample
Material: Clayey Gravel (GC)
Sampled By: TH/Thompson

TESTED: Moisture-Density Relationship Curve; ASTM D698, Method A

RESULTS:
Maximum Dry Density (pcf)= 126.3 pcf
Optimum Moisture Content (%)= 10.0%



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