FLOOD CONTROL BRIDGE

75th Avenue South of Bell Road
Peoria, Arizona

Prepared for

Royden Engineering Company
3055 W. Indian School Road
Phoenix, Arizona

THOMAS-HARTIG & ASSOCIATES, INC.
SOIL & FOUNDATION ENGINEERS

THOMAS-HARTIG & ASSOCIATES, INC.

SOIL AND FOUNDATION ENGINEERS

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Royden Engineering Company
3055 West Indian School Road
Phoenix, Arizona

2 November 1984

Attention: Andy DiLeo

Project: Flood Control Bridge
75th Avenue South of Bell Road
Peoria, Arizona

Project No. 84-708
Supplement No. 1

In accordane with your request, we have reviewed our original report relative to the following:

1. Estimated pier settlements of 3/4 inch as presented on page 6.

2. Estimated differential settlements.

The review was based upon the following final design information.

Pier and abutment caisson embedment depth--------40 feet
Pier caisson diameter----------7.0 feet
Pier caisson dead load----------860 kips
Abutment caisson diameter----------5.0 feet
Abutment caisson dead load----------520 kips

Based on our review, we present the following discussion.

1. The original estimated settlement presented on page 6 was an estimate based on original preliminary design loads and was not changed during preparation of the final report.

   The estimated long-term settlements were computed

using methods presented in the "Soil Mechanics Design Manual 7.1," pages 220 thru 222, prepared by The Department of the Navy. These long-term settlements are 1.1 and 0.9 inches for piers and abutments, respectively. Immediate settlements, as computed using the methods showen on page 219, are 0.55 and 0.60 inches for piers and abutments, respectively.

2. Differential settlements between pier and abutment are estimated at 1/4 inch with the majority of movement occuring prior to placement of final bridge deck. Based on the uniformly high N values (in place densities) and uniformity of soil across the bridge site alignment, it is our judgement that differential settlements, between adjacent caisson elements within either an abutment or pier, will be 40 percent or less of the long-term settlements reported above, i.e. approximately 3/8 inch or less. This differential settlement, for caisson spacing of 20 feet results in an angel of distortion of 1 in 640.

This supplement will be attached to the original report and shall become a part thereof. Please call us if we may be of further service to you.

Respectfully submitted,
THOMAS-HARTIG & ASSOCIATES, INC.

By: _____ Reviewed by: _____

Glen K. Copeland, P.E. Harry E. Hartig, P.E.

Registered Professional Engineer (Civil) CERTIFICATE NO. 6858 GLEN K. COPELAND Date Signed 11/2/84 ARIZONA, U.S.A.

Registered Professional Engineer CERTIFICATE NO. 7841 HARRY E. HARTIG Date Signed 11/2/84 ARIZONA, U.S.A.

/eap
Copies to: Addressee (5)

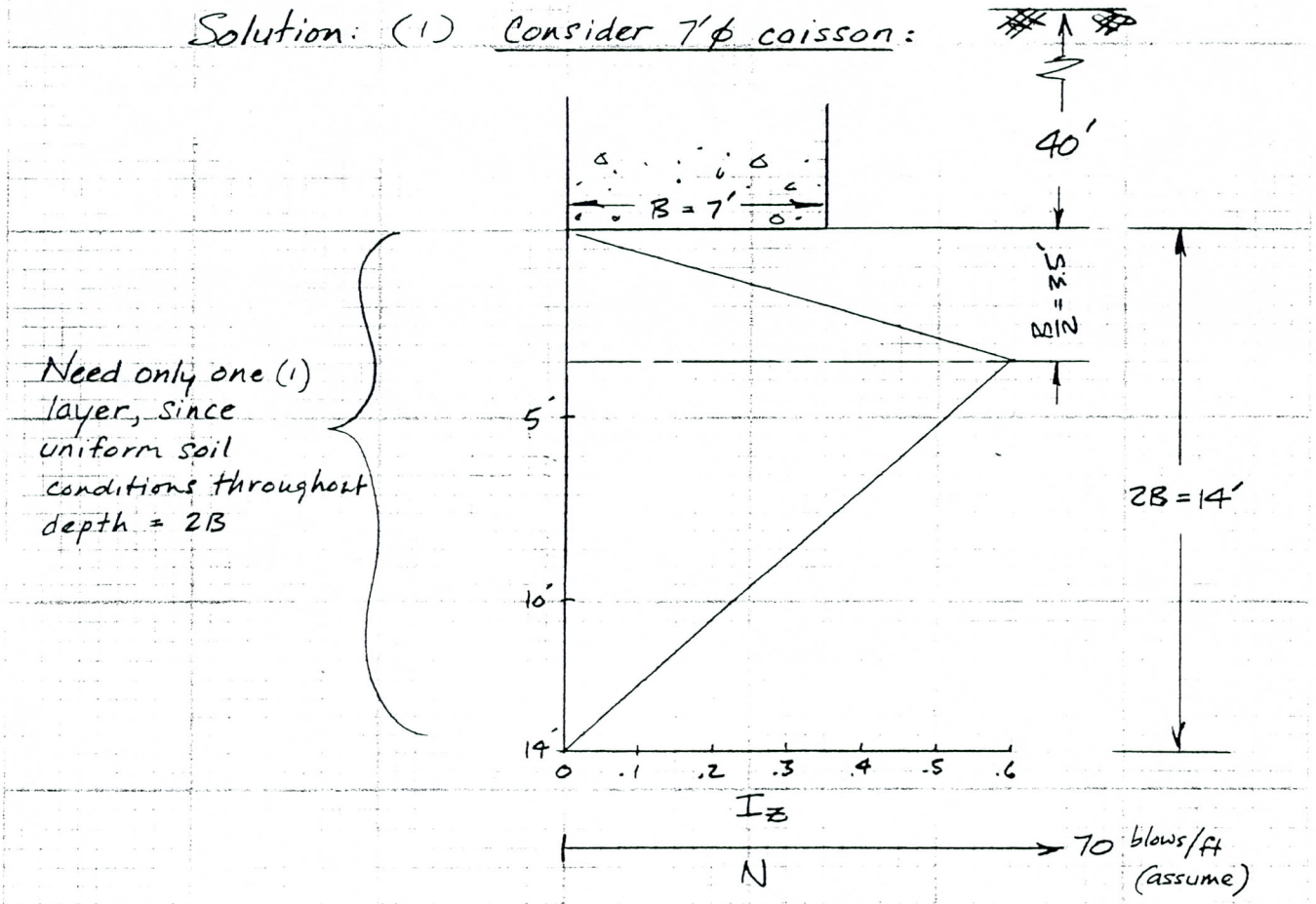
Thomas-Hartig & Assoc, Inc.
2720 S. Hardy Drive
Tempe, Arizona 85282

PROJECT NO. 84-708 COMPUTED BY RAB DATE 10/31/84
SUBJECT Schmertmann's Method for settlement — NAVFAC 1982 7.1-220, 7.1-221 CHECKED BY GRC DATE 10/31/84

Given: 7'ϕ caisson @ 11 tsf, 40' deep
5'ϕ caisson @ 13 tsf, 40' deep
N values >> 50 blows/ft. ∴ Use N = 70 blows/ft
γ_m = 120 pcf; soil is clayey sand & gravel

Find: Settlement using Schmertmann's method for footings over granular soil (NAVFAC DM-7.1 1982)

Solution: (1) Consider 7'ϕ caisson:



Need only one (1) layer, since uniform soil conditions throughout depth = 2B

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PROJECT NO. 84-708 COMPUTED BY RAB DATE 10/31/84
SUBJECT (cont.) CHECKED BY GKC DATE 10/31/84

By inspection, can use just one (1) layer in the analysis, since uniform soil conditions exist throughout depth = 2B

∴ Need only consider one (1) layer, 14' deep

Layer	Δz (in)	N blows/ft	E_s/N	E_s tsf	Z_c (in)	I_z	$\frac{I_z}{E_s}\Delta z$
1	168	70	10	700	84	0.3	0.072

$0.6/2$ (avg strain influence)

$p_o = 40\text{ ft} \times 0.120\text{ kcf} = 4.8\text{ ksf} = 2.4\text{ tsf}$

$\Delta p = 11\text{ tsf}$

Δt @ 40 years,

$C_1 = 1 - 0.5\left(2.4/11\right) = 0.891$

$C_2 = 1 + 0.2\log(10)(40) = 1.520$

$\Delta H_{7'\phi} = (0.891)(1.52)(11)(0.072) = \underline{1.07''}$

For 5'φ caisson:

$\Delta z = 2(5')(12) = 120''$ ∴ $\frac{I_z}{E_s}\Delta z = \frac{.3}{700}(120) = 0.051$

$C_1 = 1 - 0.5\left(2.4/13\right) = 0.908$ C_1 - same

$\therefore \Delta H_{5'\phi} = (0.908)(1.52)(13)(0.051) = \underline{0.92''}$

(Note: These numbers are conservative because side-wall shear resistance has not been included).

LETTER OF TRANSMITTAL

ROYDEN ENGINEERING CO.
3055 W. Indian School Rd.
PHOENIX, ARIZONA 85017

Phone 279-3541

TO FLOOD CONTROL DIST.
OF MARICOPA COUNTY

DATE	JOB NO. 1040
ATTENTION NICK KARAN	
RE: 75TH AVE BRIDGE OVER A.C.D.C.	

WE ARE SENDING YOU ☒ Attached ☐ Under separate cover via _____ the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications
☐ Copy of letter ☐ Change order ☐ _____

COPIES	DATE	NO.	DESCRIPTION

THESE ARE TRANSMITTED as checked below:

☐ For approval ☐ Approved as submitted ☐ Resubmit_____copies for approval
☐ For your use ☐ Approved as noted ☐ Submit_____copies for distribution
☒ As requested ☐ Returned for corrections ☐ Return_____corrected prints
☐ For review and comment ☐ _____
☐ FOR BIDS DUE _____ 19_____ ☐ PRINTS RETURNED AFTER LOAN TO US

REMARKS

SOILS & FOUNDATION REPORT
CALCULATIONS

COPY TO _____

SIGNED: Andy DiLeo

If enclosures are not as noted, kindly notify us at once.

Thomas-Hartig & Assoc, Inc.
2720 S. Hardy Drive
Tempe, Arizona 85282

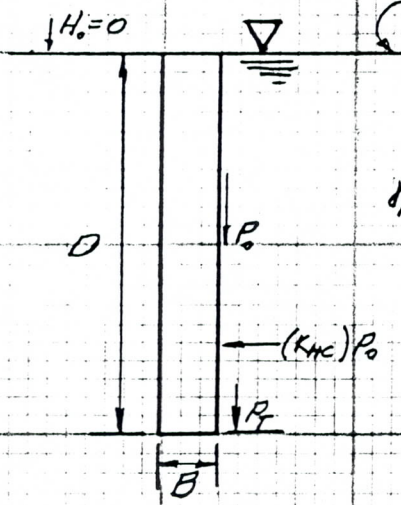
PROJECT NO. 84-708 COMPUTED BY GKC DATE 7/23/84
SUBJECT Pier Capacity CHECKED BY HH DATE 7-23-84

1. Analysis based on NAVFAC MANUAL, Pg. 7.2-193, Figure 1.

where: Allowable Pier Capacity = q_{ult}

$$q_{ult} = P_T N_q A_T + \sum_{H=H_0}^{H=H_0+D} (K_{HC} \times P_0)(\tan\delta)(S)$$

But Flood Control District wants either end bearing or friction analysis but not both.



Use end bearing only

$\therefore q_{ult} = P_T N_q A_T$

where: $P_T = \gamma_{mtrl} D$

N_q = Bearing Capacity Factor

A_T = Area of base of caisson.

A review of Standard Penetration Tests (SPT) for this project shows that N values throughout the depth of probable foundation bearing in > 50 blows per foot.

Based on "Foundation Design" by Wayne C. Teng, pg. 12

For $N \geq 50$, $\gamma_{moist} \geq 130$ pcf & $\phi = 41°$
$\gamma_{sat} \geq 75$ pcf.

$\therefore$ For basis of calculations use:

$\phi = 36°$ and $\gamma_{sat} = 75$ pcf since the granular soils could become saturated

Thomas-Hartig & Assoc, Inc.
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Tempe, Arizona 85282

PROJECT NO. 84-708 COMPUTED BY GKC DATE 7/23/84
SUBJECT Pier Capacity CHECKED BY HH DATE 7-23-84

2. Per Navfac, the ultimate pier capacity in end bearing does not increase significantly below a depth of approximately 20 times the pier diameter (i.e. $D = 20B$).

∴ For the minimum diameter $B = 3'0'' \Rightarrow D = 20 \times 3 = 60$ feet.
∴ No end bearing reduction appears likely since we will be less than 60 embedment.

Bearing Capacity Factor $N_q = 30$ (for $\phi = 36°$).

$A_T = \pi B^2/4$

$P_T = D\gamma_{sub.} = 0.075D$ (ksf)

B	A_T	$N_q A_T$	Depth = D	P_T
3	7.07	212.1	10	0.75
4	12.57	377.1	20	1.50
5	19.63	588.9	30	2.25
6	28.27	848.1	40	3.00
7	38.48	1154.5	50	3.75
			60	4.50

Thomas-Hartig & Assoc, Inc.
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Tempe, Arizona 85282

PROJECT NO. 84-708 COMPUTED BY GRC DATE 7/23/84
SUBJECT Pier Capacity CHECKED BY HH DATE 7-23-84

3. Compute allowable pier capacities.
Use Factor of Safety = 3.0

Diam.	Depth	P_T	$N_q A_T$	q_{ult} (kips)	$q_{allowable}$ (kips)
3	10	0.75	212.1	159	53
	20	1.50		318	106
	30	2.25		477	159
	40	3.00		636	212
	50	3.75		795	265
	60	4.50	212.1	954	318
4	10	0.75	377.1	283	94
	20	1.50		566	188
	30	2.25		848	283
	40	3.00		1131	377
	50	3.75		1414	471
	60	4.50	377.1	1697	566
5	10	0.75	588.9	442	147
	20	1.50		883	294
	30	2.25		1325	442
	40	3.00		1767	589
	50	3.75		2208	736
	60	4.50	588.9	2650	883
6	10	0.75	848.1	636	212
	20	1.50		1272	424
	30	2.25		1908	636
	40	3.00		2544	848
	50	3.75		3180	1060
	60	4.50	848.1	3816	1272
7	10	0.75	1154.5	866	288
	20	1.50		1732	577
	30	2.25		2598	866
	40	3.00		3464	1155
	50	3.75		4330	1443
	60	4.50	1154.5	5195	1732

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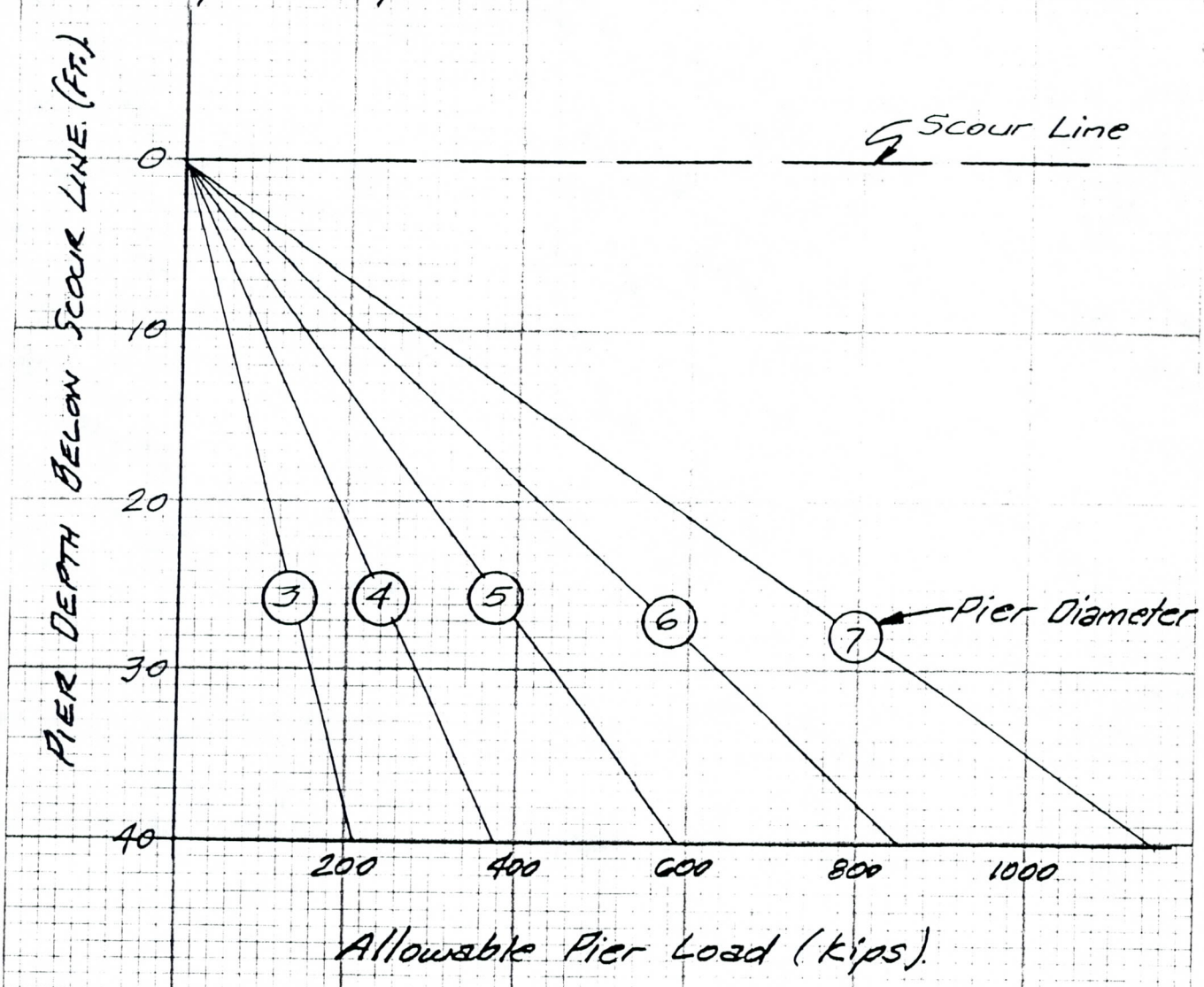
PROJECT NO. 84-708 COMPUTED BY GKC DATE 7/23/84
SUBJECT Pier Capacity CHECKED BY HH DATE 7-23-84

4. Plot pier capacities



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PROJECT NO. 84-708 COMPUTED BY GKC DATE 7/23/84
SUBJECT Pier Settlement. CHECKED BY HH DATE 7-23-84

Compute settlements based on analysis developed in "Soil Mechanics in Engineering Practice" by Terzaghi & Peck, pp 488 & 489.

Bearing Depth	Pier Diam.	Load (Kips)	Effective Bearing Press.	* $\delta_{1\text{-}1}$	S_{ave} **	$S_{red.}$
30'	3	159	18.7 ksf	0.45"	1.00"	0.50
	4	283	18.8 ksf		1.15"	0.57
	5	442	18.8 ksf		1.25"	0.63
	6	636	18.7 ksf		1.32"	0.66
	7	866	18.8 ksf	0.45"	1.38"	0.70
40'	3	212	30.0 ksf	1.00"	2.25"	1.13
	4	377	30.0 ksf		2.56"	1.28
	5	589	30.0 ksf		2.78"	1.39
	6	848	30.0 ksf		2.94"	1.47
	7	1155	30.0 ksf	1.00"	3.06"	1.53

* Note:

** Note: These settlements are based on bearing surface at the ground surface. For deep footings, the settlements should be reduced by 50%.

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SOIL AND FOUNDATION ENGINEERS

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James R. Morrow, Lab Director

Royden Engineering Company
3055 W. Indian School Road
Phoenix, Arizona

8 October 1984

Attention: Andy DiLeo

Project: Flood Control Bridge
75th Avenue South of Bell Road
Peoria, Arizona

Project No. 84-708

This report presents the results of the soil engineering services authorized on the site for the proposed flood control bridge. 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 surface and subsoils throughout the zone of significant foundation influence. Our services have not included determination of the underlying geologic conditions or evaluation of potential geologic hazards such as seismic activity, faulting, and ground subsidence/cracking potential due to ground water withdrawal.

The recommendations included are presented 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.

Complimentary to this report, we will be pleased to review project plans and specifications relative to compliance to the intent of this report.

Respectfully submitted,

THOMAS-HARTIG & ASSOCIATES, INC.

Registered Professional Engineer (Civil) CERTIFICATE NO. 6858 GLEN K. COPELAND Date Signed 10-8-84 ARIZONA, U.S.A.

By: _____
Glen K. Copeland, P.E.

Reviewed by: _____
Harry E. Hartig, P.E.

Registered Professional Engineer (Civil) CERTIFICATE NO. 7641 HARRY E. HARTIG Date Signed 10-8-84 ARIZONA, U.S.A.

/cms

Copies to: Addressee (5)

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REPORT

SCOPE

The 75th Avenue bridge is to span a diversion channel to be excavated as shown on the accompanying site plan. It is understood that design concepts for the bridge structure and diversion channel are as follows:

Bridge Length	467 feet
Width of Bridge	82'10"
Number of Spans	4 at 116'9"
Skew of Bridge	~~30°~~ 20°30'
Deck Elevation	Elev. 1214 feet
Channel Elevation	Elev. 1186.40 feet
Channel Bottom Width	220 feet
Channel Side Slopes	6.0 horizontal to 1.0 vertical
Channel Lining	Earth
Abutment Reactions	Dead Load = 2078 kips
	Live Load = 235 kips
Pier Reactions	Dead Load = 3443 kips
	Live Load = 424 kips
Channel Flow Rate	29,000 cfs
Channel Flow Depth	18 feet
Channel Flow Velocity	5 feet per second

INVESTIGATION

Five (5) test borings were drilled at abutment and pier locations as shown on the accompanying site plan. The borings were drilled with a rotary auger (Mobile) drill rig using 7 inch diameter, continuous hollow stem flight augers. Field penetration tests were made at 5 foot vertical intervals in the granular subsoils for a guide to their relative in-situ density. Penetration resistance was measured by driving a 2.0 inch diameter standard split spoon sampler with a 40 inch free fall drop hammer weighing 140 pounds (ASTM: D1586) with the hollow stem filled with water. Additionally, a single, large diameter test boring (No.3A) was advanced near test hole No. 3 to evaluate caisson drilling conditions, soil caving potential, and material characteristics. The results and discussion relative to this boring are attached at Appendix A. Boring logs presenting the results of the test drilling are presented in "Part II, Field Results". Additionally, a graphical depiction of test boring data is included in "Part II".

Representative soil samples obtained during the field investigation were subjected to the following laboratory analyses:

Test	Sample(s)	Purpose
*Moisture Content	Driven Spoon Sampler (55)	In-situ moisture determination

*Reported on boring logs and graphical presentation.

The results of the testing are presented in "Part III, Laboratory Results".

SITE CONDITIONS

The proposed bridge alignment will coincide with the existing 75th Avenue alignment. The test borings were drilled on the roadway shoulders at the proposed abutment and pier locations.

As disclosed by the test borings, the subsoil stratification is relatively uniform. The surface soils to depths of 8 to 15 feet are predominantly clays interbedded with lenses or layers of clayey to silty sands and gravels. The underlying soils are dense, roughly mixed sands and gravels with variable silt and clay content. Specific soil data is presented on the boring logs, with the following tabulation presenting a generalization of the depths and thicknesses of the predominant strata.

Boring No.	Sandy Clay	Clayey Sand Clayey Gravel	Mixed Sands and Gravels Silty Interval	Mixed Sands and Gravels Silty to Clean Interval
1	0 - 8 ft.	---------	8 - 24 ft.	24 - 80.5 ft.
2	0 - 13 ft.	38 - 58 ft.	-------	13 - 38 ft. & 58 - 88 ft.
3	0 - 2 ft.& 6 - 9.5 ft.	2 - 6 ft.	33 - 55 ft.	9.5 - 33 ft.& 55 - 60.5 ft.
4	0 - 15 ft.	--------	34 - 45 ft.	15 - 34 ft.& 45 - 100.5 ft.
5	2 - 5.5 ft.& 7 - 13 ft.	0 - 2 ft.& 5.5 - 7 ft.	43 - 51 ft.	13 - 43 ft.& 51 - 80.5 ft.

The subsoils throughout the depth of test drilling were generally described as damp, and no free groundwater was encountered in the test borings.

FOUNDATION BEARING

A relatively deep footing system was initially proposed for support of the proposed structure. The results of this investigation indicate that circular drilled cast-in-place concrete piers would be the most suitable deep footing system. As per your request (and the approval of Mr. Nick Karan with the Flood Control District of Maricopa County) relatively shallow footing systems were also analyzed for support. The following tabulations and graphs present allowable design capacities for both footing systems. Calculations for other sizes will be provided upon request.

Also, in small diameter borings it is not possible to totally predict caving or sloughing which could occur during footing excavations. Therefore, a large diameter test boring was advanced to evaluate this potential and the results are included in Appendix A.

Footing embedment depths are referenced below the predicted scour depth as computed using the formula developed by FHWA in the book "Highways in River Environment". The Flood Control District requires that the pier diameter used in the equation be either pier width plus 4 feet or 3 times pier width. Using a pier width of 5 feet (an effective pier width of 15 feet, i.e. 3 x 5), the predicted scour depth is 21 feet or to elevation 1165.4 feet. Actual scour depths will be dependent upon footing size (pier width) established by final design and the final predicted scour elevation should be adjusted accordingly.

OPTION 1: SPREAD FOUNDATIONS

The following tabulation presents the relationship between footing depth and allowable soil bearing pressure for selected footing widths.

Footing Depth*	Footing Width	Allowable Soil Bearing Capacity**	Estimated Settlements**
6.0 ft.(min)	5.0 ft.(min)	12 ksf	0.6" - 0.8"
	7.0 ft.	14 ksf	0.8" - 1.0"
	10.0 ft.	17 ksf	1.2" - 1.3"
8.0 ft.	5.0 ft.	13 ksf	0.6" - 0.8"
	7.0 ft.	15 ksf	0.8" - 1.0"
	10.0 ft.	18 ksf	1.2" - 1.3"
10.0 ft.	5.0 ft.	14 ksf	0.8" - 0.9"
	7.0 ft.	16 ksf	1.1" - 1.3"
	10.0 ft.	20 ksf	1.6" - 1.8"

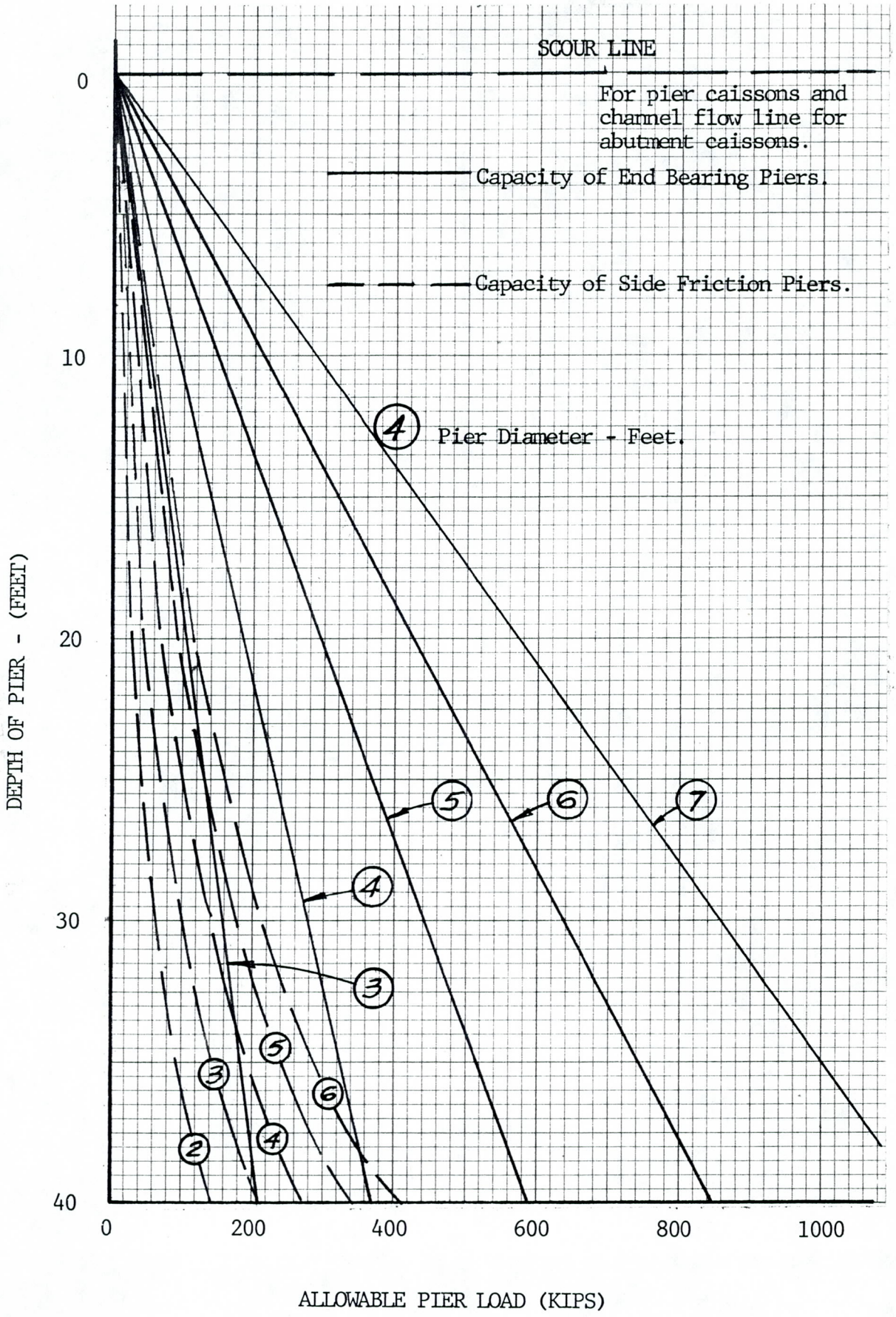
*Depth to base of footing below predicted scour depth level.

**Allowable bearing capacity and estimated settlements based on total submergence of footing/bearing soil system and bouyant unit weight of soils. The estimated settlements would reduce by approximately 50% if the bearing soils are not saturated. The allowable bearing capacity is developed using a safety factor of three (3).

The recommended bearing capacities, as tabulated above, are considered as allowable maximums for dead plus design live loads, and may be increased by one-third when considering total loads including wind or seismic forces. Five (5.0) feet is recommended as the minimum width of square or strip pier footings.

OPTION 2: CIRCULAR DRILLED CAST-IN-PLACE PIERS

The following graphical chart presents allowable pier loads for either side friction piers or end-bearing piers. It is our understanding that the Flood Control District does not wish to use a combined pier capacity; therefore, the design should use either end-bearing or side friction pier loads but not a combination.


SCOUR LINE
For pier caissons and channel flow line for abutment caissons.
Capacity of End Bearing Piers.
Capacity of Side Friction Piers.
4 Pier Diameter - Feet.
0
10
20
30
40
DEPTH OF PIER - (FEET)
0
200
400
600
800
1000
ALLOWABLE PIER LOAD (KIPS)

The allowable pier loads as presented are for dead plus design live loads except that a one-third increase is allowable for wind or seismic forces. No reduction in pier capacity for group action should be required where pier spacings exceed 3.0 diameters. Estimated pier settlements should not exceed 3/4 inch.

Although no free groundwater was encountered at the time of test drilling, the analyses are based upon the assumption that saturation of the subsoils may develop during periods of heavy flow. Also, it was assumed that the pier excavating would be performed without the addition of water or slurry, although some sloughing and caving may be experienced when excavations penetrate the cleaner granular subsoils. A heavy-duty drilling rig capable of developing high torque and down pressure will probably be required.

Lateral Earth Pressures/Parameters: The following tabulation presents recommendations for lateral stability analyses:

Foundation Toe Pressures	1.33 x max. allowable
Equivalent "Active" Soil Pressure (Yielding Structure)	30 psf/ft.
Equivalent "At-Rest" Soil Pressure (Rigid Structure)	50 psf/ft.
Equivalent "Passive" Soil Pressure (Shallow Spread Footing Systems)	500 psf/ft.
Horizontal Modulus of Subgrade Reaction (Circular Drilled Piers)	50 pci*

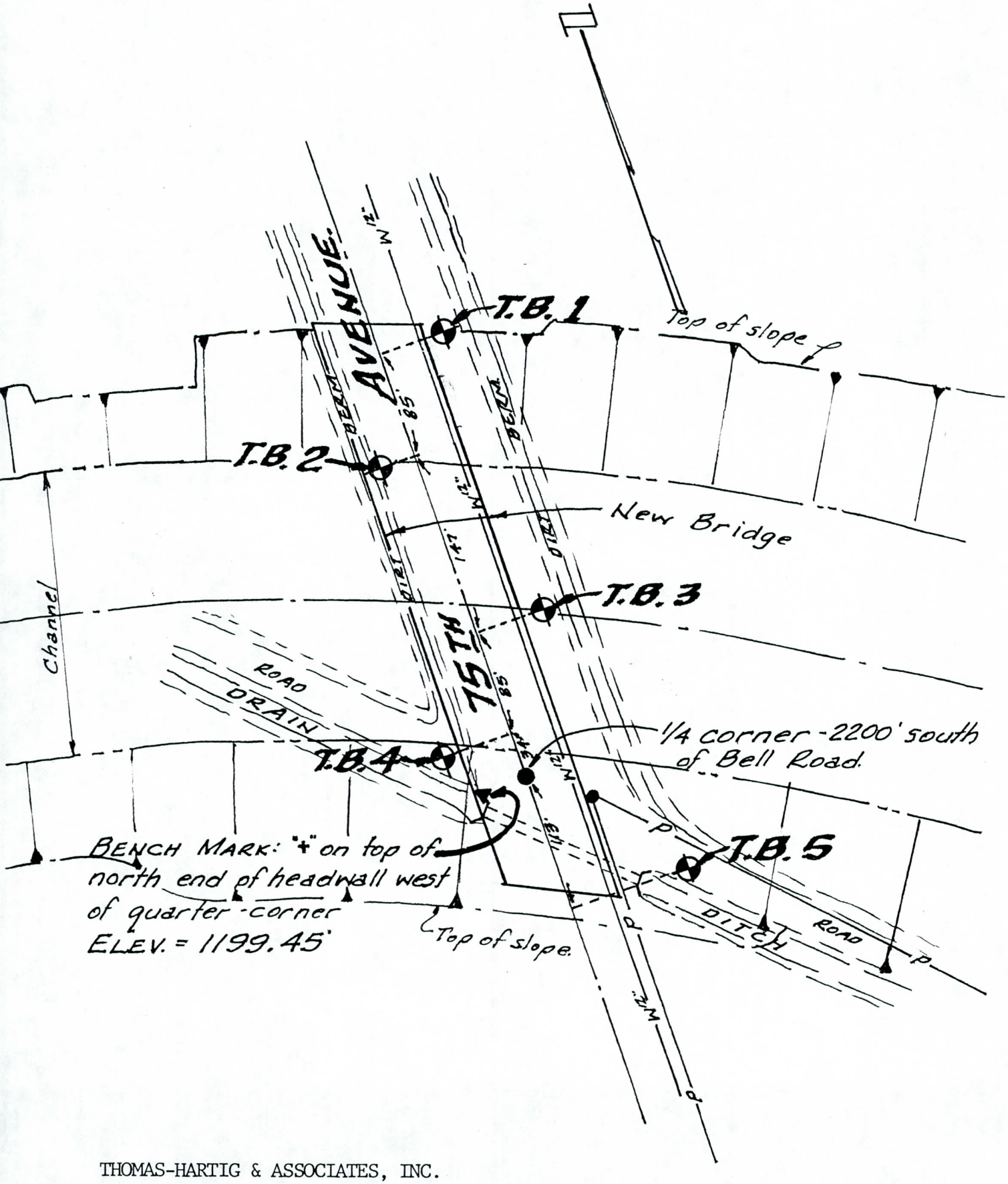
*Assumes the stiffness of a dense granular soil increases linearly with depth beginning with zero (0) at the level of potential scour and increasing according to the above value per foot of depth. No reduction for group action where pile spacings exceed 3.0 diameters.

STRUCTURAL BACKFILLING

Backfill required against abutment walls and other retaining structures should be granular soils meeting the Arizona Highway Department Specifications for Select Backfill Materials. The backfill soils should be free of any silty or clayey fines so that the backfill will be free draining and not susceptible to increased loadings due to hydrostatic forces. Backfill around spread footing systems should consist of excavated materials from footing areas.

Compction should be accomplished to a minimum 95 percent of the AASHTO: T-180 maximum density. Retaining structures should be braced to resist equipment loadings during compaction of the backfill.

FIELD RESULTS



THOMAS-HARTIG & ASSOCIATES, INC.

Project No: 84-708

LEGEND

SOIL CLASSIFICATION ASTM: D2487

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 AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	SILTS AND CLAYS Liquid limit less than 50
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAYS OF LOW PLASTICITY	
	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS, ELASTIC SILTS	SILTS AND CLAYS Liquid limit greater than 50
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	

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

GRAIN SIZES

U.S. STANDARD SERIES SIEVE: 200 | 50 | 16 | 4

CLEAR SQUARE SIEVE OPENINGS: ¾" | 3" | 6"

SILTS & CLAYS DISTINGUISHED ON BASIS OF PLASTICITY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

MOISTURE CONDITION (INCREASING MOISTURE ⟶)

DRY | SLIGHTLY DAMP | DAMP | MOIST | VERY MOIST | WET (SATURATED)

(PL) (LL)

DEFINITIONS

Penetration Resistance — Blows per foot using 'A' rod and 140 lb. hammer with 30 inch free fall unless otherwise noted.

N Standard Penetration Resistance (ASTM:D1586), 2.0 inch O.D. split barrel sampler.

C Continuous Penetration Resistance, 2.0 inch O.D. Bull Nose.

R Penetration Resistance, 2.42 inch I.D. Ring Sampler

Sample Type

R - Ring T - Shelby Tube S - Standard Split Barrel B - Block
G - Grab C - Cutting V - Vertical Face Cut

CONSISTENCY			RELATIVE DENSITY	
CLAYS & SILTS	BLOWS/FOOT*	STRENGTH‡	SANDS & GRAVELS	BLOWS/FOOT*
VERY SOFT	0-2	0-¼	VERY LOOSE	0-4
SOFT	2-4	¼-½	LOOSE	4-10
FIRM	4-8	½-1	MEDIUM DENSE	10-30
STIFF	8-16	1-2	DENSE	30-50
VERY STIFF	16-32	2-4	VERY DENSE	OVER 50
HARD	OVER 32	OVER 4		

* Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1-⅜ inch I.D.) split spoon (ASTM D-1588).

‡ Unconfined compressive strength in tons/sq. ft. Read from a pocket penetrometer.

Project No. 84-708

SOIL BORING LOG

NO* 1 ELEV: 1202.1 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/9/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
1					below	Sandy Clay; light brown,	CL		X	X	X								X	X			X	X			X			
2					p.1.	slightly vesicular, some																								
3						fine to medium sands.																								
4																														
5		10	S	----	7.2																									
6																														
7																														
8																														
9					damp	Silty Gravelly Sand; gray-	SM-		X		X	X			X	X		X									X			
10		33	S	----	5.9	brown, interbedded sand with	GM																							
1						gravels and mixed with vari-																								
2						able amounts of silt and																								
3						clay of low plasticity; occa-																								
4						sional thin layers of sandy																								
5		81	S	----	8.5	clay (CL).																								
6																														
7																														
8																														
9																														
20		50/4"	S	----	10.3																									
1																														
2																														
3																														
4																														
5		43	S	----	8.6	Sands & Gravels; brown,	SP-		X		X	X			X	X		X									X			
6					damp	rougly stratified deposit	SM																							
7						with occasional interbedded	to																							
8						silty or clayey zones. Some	GP-																							
9						cobbles below the depth indi-	GM																							
30		50/4"	S	----	12.5	cated below.																								
1																														
2						Slow drilling with cobbles																								
3						below 30 feet.																								
4																														
5		50/3"	S	----	14.9																									
6																														
7																														
8																														
9																														
40		50/4"	S	----	12.5																									

* Drilled at location 55.5 feet east of monument line.

CONTINUED

**All samples driven with full standing column of water in hollow stem auger.

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 1 ELEV: 1202.1 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/9/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
41					damp	Sands & Gravels; brown,	SP-	X				X	X				X	X	X								X			
2						roughly stratified deposit	SM																								
3						with occasional interbedded	to																								
4						silty or clayey zones. Some	GP-																								
5		50/3"	S	----	248	cobbles below 30 feet.	GM																								
6																														
7																														
8																														
9																														
50		50/4"	S	----	8.9																										
1																														
2																														
3																														
4																														
5		50/1"	S	NR																										
6																														
7																														
8																														
9																														
60		50/4"	S	NR																										
1																														
2																														
3																														
4																														
5		50/5"	S	NR																										
6																														
7																														
8																														
9																														
70		50/4"	S	----	11.0																										
1																														
2																														
3																														
4																														
5		50/3"	S	----	16.1																										
6																														
7																														
8																														
9																														
80		50/1"	S	NR																										

Drilled at location 55.5 feet east of monument line.

* All samples driven with full standing column of water in hollow stem auger.

N - No Sample Recovery.

CONTINUED

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO:* 1 ELEV: 1202.1 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/9/84

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
81					damp	Sands & Gravels; brown, roughly stratified deposit with occasional interbedded silty or clayey zones.	SP-SM to GP-GM	X				X	X			X		XX									X			
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
90																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
100																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
110																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
120																														

Drilled at location 55.5 feet east of monument line.

Stopped drilling at 80.5 feet

Ground water encountered: none

* All samples driven with full standing column of water in hollow stem auger.

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 2 ELEV: 1202.0 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/12/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
1					below	Sandy Clay; light brown,	CL		X	X		X							X	X			X	X			X			
2					p.1.	slightly vesicular, some fine																									
3						to medium sands.																									
4																														
5		6	S	----	10.7																									
6																														
7																														
8																														
9																														
10		12	S	----	4.5																									
1																														
2																														
3																														
4					damp	Sands & Gravels; brown,	SP-		X			X	X			X	X														
5		50/2"	S	----	3.0	roughly stratified deposit	SM																								
6						with occasional interbedded	to																								
7						silty or clayey zones. Some	GP-																								
8						cobbles below the depth indi-	GM																								
9						cated below.																									
20		52	S	----	5.4																									
1																														
2																														
3						Hard drilling below 22 feet,																									
4						heavy gravels and occasional																									
5		50/1"	S	NR		cobbles.																									
6																														
7																														
8																														
9																														
30		50/5"	S	----	10.2																									
1																														
2																														
3																														
4																														
5		50/4"	S	----	9.1																									
6																														
7																														
8					damp	Silty Gravelly Sand; gray-	SM-		X			X	X		X	X		X										X			
9						brown, (CONTINUED)	GM																								
40		97/9"	S	NR																										

* Drilled at location 27 feet west of monument line.

CONTINUED

**All samples driven with full standing column of water in hollow stem auger.

NR - No Sample Recovery.

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 2 ELEV: 1202.0 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/12/84

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
41					damp	Silty Gravelly Sand; gray-	SM-		X			X	X			X	X		X									X			
2						brown, interbedded sand with	GM																									
3						gravels and mixed with vari-																											
4						able amounts of silt and clay																											
5		50/1"	S	NR		of low plasticity; occasional																										
6						thin layers of sandy clay																											
7						(CL).																										
8																															
9																															
50		50/9"	S	----	14.7																											
1																															
2																															
3																															
4																															
5		50/3"	S	NR																											
6																															
7																															
8					damp	Sands & Gravels; brown,	SP-		X			X	X				X	X	X									X			
9						roughly stratified deposit	SM																									
60		59	S	----	6.6	with occasional interbedded	to																									
1						silty or clayey zones. Some	GP-																									
2						cobbles below 57 feet.	GM																									
3																															
4																															
5		82	S	----	8.1																											
6																															
7																															
8																															
9																															
70		92/11"	S	----	7.3																											
1																															
2																															
3																															
4																															
5		50/3"	S	----	19.6																											
6																															
7																															
8																															
9																															
80		50/1"	S	NR																											

Drilled at location 27 feet west of monument line.

* All samples driven with full standing column of water in hollow stem auger.

NR - No Sample Recovery.

CONTINUED

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 2 ELEV: 1202.0 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/12/84

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SURANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
81					damp	Sands & Gravels; brown,	SP-		X			X		X			XX	X	X								X			
2						roughly stratified deposit	SM																								
3						with occasional interbedded	to																								
4						silty or clayey zones.	GP-																								
5		50/1"	S	NR			GM																								
6																														
7																														
8																														
9		50/2"	S	----	6.5																										
90																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8						Auger refusal at 88 feet on																										
9						gravels and cobbles; auger																										
100						is bouncing and grinding																										
1						with no advancement.																										
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
110																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
120																														

Drilled at location 27 feet west of monument line.

* All samples driven with full standing column of water in hollow stem auger.

N - No Sample Recovery.

Auger Refusal at 88 feet

Ground water encountered: none

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 3 ELEV: 1202.2 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/11/84

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SURANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
1					below p.l.	Sandy Clay; light brown, slightly vesicular, some fine to medium sands.	CL		X	X		X							X	X			X	X			X			
2																														
3					damp		SC-GC		X	X		X	X		X				X	X							X			
4						Clayey Sand & Gravel; brown, fine to coarse sands and gravels and few cobbles.																									
5		57	S	----	7.9																									
6																														
7					below p.l.	Sandy Clay; light brown, slightly vesicular, some fine to medium sands.	CL		X	X		X							X	X			X	X			X			
8																														
9																														
10		50/5"	S	----	25.4																									
1					damp	Sands & Gravels; brown, roughly stratified deposit with occasional interbedded silty or clayey zones. Some cobbles below the depth indicated below.	SP-SM to GP-GM		X			X	X			X	X			X	X							X			
2																														
3																														
4																														
5		50/4"	S	----	13.8																									
6																														
7																														
8																														
9																														
20		50/0"	S	NR		Cobbles below 19 feet.																								
1																														
2																														
3																														
4																														
5		50/2"	S	NR																										
6																														
7																														
8																														
9																														
30		50/2"	S	NR																										
1																														
2																														
3																														
4					damp	Silty Gravelly Sand; gray-brown, interbedded sand with gravels and mixed with variable amounts of silt and clay of low plasticity; occasional thin layers of sandy clay (CL).	SM-GM		X			X	X		X	X		X									X			
5		50/5"	S	----	10.5																									
6																														
7																														
8																														
9																														
40		50/3"	S	----	8.4																									

*Drilled at location 58 feet east of monument line.

**All samples driven with full standing column of water in hollow stem auger.

NR - No Sample Recovery.

CONTINUED

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 3 ELEV: 1202.2 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/11/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT. C	N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION WELL	MED	POOR	GRAIN SHAPE ANGULAR	SUBANGULAR	ROUNDED	SUBROUNDED	RELATIVE DENSITY LOW	MED	HIGH	PLASTICITY NONE	LOW	MEDIUM	HIGH	CONSISTENCY SOFT	FIRM	STIFF	VERY STIFF	HARD	CEMENTATION NONE	WEAK	MEDIUM	STRONG
41					damp	Silty Gravelly Sand; gray-	SM-	X			X		X	X	X	X		X									X			
2						brown, interbedded sand with	GM																								
3						gravels and mixed with vari-																									
4						able amounts of silt and																									
5		50/5"	S	----	12.9	clay of low plasticity; occa-																									
6						sion thin layers of sandy																									
7						clay (CL).																									
8																														
9																														
50		50/5"	S	----	6.3																									
1																														
2																														
3																														
4																														
5		50/4"	S	----	10.7																									
6					damp	Sands & Gravels; brown,	SP-	X			X		X	X			X	X	X								X			
7						roughly stratified deposit	SM																								
8						with occasional interbedded	to																								
9						silty or clayey zones. Very	GP-																								
60		50/0"	S	NR		difficult drilling below 58	GM																								
1						feet in cobbles.																									
2																														
3																														
4																														
5																														
6																														
7																														
8						Auger refusal at 60.5 feet																									
9						on cobbles.																									
70																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
80																														

*Drilled at location 58 feet east of monument line.

*All samples driven with full standing column of water in hollow stem auger.

R - No Sample Recovery.

Auger Refusal at 60.5 feet

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO* 4 ELEV: 1204.1 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/9/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
1					below	Sandy Clay; light brown,	CL		X	X		X								X	X			X	X			X			
2					p.l.	slightly vesicular, some fine																									
3						to medium sands.																									
4																														
5		32	S	----	12.0																									
6																														
7						Gravel and cobble lens at																									
8						7 feet.																									
9																														
10		53	S	----	21.3																									
1																														
2																														
3																														
4																														
5		75	S	----	28.1																									
6					damp	Sands & Gravels; brown,	SP-	X			X		X			X		X	X									X			
7						roughly stratified deposit	SM																									
8						with occasional interbedded	to																									
9						silty or clayey zones. Some	GP-																									
20		50/2"	S	----	7.0	cobbles below 18 feet.	GM																									
1																														
2																														
3																														
4																														
5		50/3"	S	----	7.4																									
6																														
7																														
8																														
9																														
30		50/5"	S	----	9.0																									
1																														
2																														
3																														
4																														
5		50/5"	S	----	14.4																									
6																														
7																														
8																														
9																														
40		90/7"	S	----	23.3	Silty Gravelly Sand: (CONTD)																									

* Drilled at location 53 feet west of monument line.

CONTINUED

**All samples driven with full standing column of water in hollow stem auger.

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 4 ELEV: 1204.1 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/9/84

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
41					damp	Silty Gravelly Sand; gray-	SM-		X			X		X		X	X		X								X			
2						brown, interbedded sand with	GM																								
3						gravels and mixed with vari-																										
4						able amounts of silt and clay																										
5		57	S	----	8.2	of low plasticity; occasional																									
6					damp	thin layers of sandy clay	SP-		X			X		X			X	X	X									X			
7						(CL).	SM																								
8						Sands & Gravels; brown,	to																								
9						roughly stratified deposit	GP-																								
50		50/5"	S	----	11.2	with occasional interbedded	GM																								
1						silty or clayey zones. Some																										
2						cobbles.																									
3																														
4																														
5		50/6"	S	----	16.1																										
6																														
7																														
8																														
9																														
60		50/4"	S	----	6.0																										
1																														
2																														
3																														
4																														
5		50/4"	S	----	9.3																										
6																														
7																														
8																														
9																														
70		50/5"	S	----	15.9																										
1																														
2																														
3																														
4																														
5		50/3"	S	NR																										
6																														
7																														
8																														
9																														
80		50/3"	S	----	9.4																										

Drilled at location 53 feet west of monument line.

CONTINUED

* All samples driven with full standing column of water in hollow stem auger.

NR - No Sample Recovery.

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 4 ELEV: 1204.1 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/9/84

DEPTH FT	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
81					damp	Sands & Gravels; brown,	SP-		X			X	X				X	X	X									X		
2						roughly stratified deposit	SM																								
3						with occasional interbedded	to																								
4						silty or clayey zones. Some	GP-																								
5		50/9"	S	----	235	cobbles.	GM																								
6																														
7																														
8																														
9																														
90		80/5"	S	----	172																									
1																														
2																														
3																														
4																														
5		50/4"	S	----	281																									
6																														
7																														
8																														
9																														
100		50/2"	S	NR																										
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
110																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
120																														

Drilled at location 53 feet west of monument line.

*All samples driven with full standing column of water in hollow stem auger.

R - No Sample Recovery.

Stopped drilling at 100.5 feet

Ground water encountered: none

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 5 ELEV: 1203.5 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/10/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT. C	PENETRATION RESISTANCE BLOWS/FT. N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
1					damp	Clayey Sand & Gravel; brown,	SC-		X	X		X	X			X			X	X							X			
2						fine to coarse sands and gra-	GC																								
3					below	vels and few cobbles.	CL		X	X		X							X	X			X	X			X			
4					p.1.	Sandy Clay; light brown,																									
5		71	S	----	115	slightly vesicular, some fine																									
6					damp	to medium sands.	SC-		X	X		X	X			X			X	X							X			
7						Clayey Sand & Gravel; brown,	GC																								
8					below	fine to coarse sands and gra-	CL		X	X		X							X	X			X	X			X			
9					p.1	vels and few cobbles.																									
10		50/5"	S	----	245	Sandy Clay; light brown,																									
1						slightly vesicular, some fine																									
2						to medium sands.																									
3																													
4					damp	Sands & Gravels; brown,	SP-	X			X	X					X	X	X								X			
5		82/10"	S	----	226	roughly stratified deposit	SM																								
6						with occasional interbedded	to																								
7						silty or clayey zones. Some	GP-																								
8						cobbles below the depth indi-	GM																								
9						cated below.																									
20		50/4"	S	----	3.9																										
1																														
2																														
3						Hard drilling in cobbles																									
4						below 22 feet.																									
5		50/8"	S	NR																										
6																														
7																														
8																														
9																														
30		50/2"	S	NR																										
1																														
2																														
3																														
4																														
5		80/8"	S	----	183																										
6																														
7																														
8																														
9																														
40		50/0"	S	NR																										

Drilled in location 98 feet east of monument line to avoid existing drainage ditch and power lines.

**All samples driven with full standing column of water in hollow stem auger.

NR - No Sample Recovery.

CONTINUED

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 5 ELEV: 1203.5 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/10/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT C	PENETRATION RESISTANCE BLOWS/FT N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
41					damp	Sands & Gravels; brown,	SP-	X				X	X	X			X	XX									X			
2						roughly stratified deposit	SM																								
3						with occasional interbedded	to																								
4					damp	silty or clayey zones. Some	GP-	X				X	X	X		XX			X								X			
5		83	S	----	3.4	cobbles below 22 feet.	SM-																								
6						Silty Gravelly Sand; gray-	GM																								
7						brown, interbedded sand with																									
8						gravels and mixed with vari-																									
9						able amounts of silt and																									
50		70/9"	S	----	1.7	clay of low plasticity; occa-																									
1						sional thin layers of sandy																									
2					damp	clay (CL)	SP-	X				X	X			X		XX								X				
3						Sands & Gravels; brown,	SM																								
4						roughly stratified deposit	to																								
5		50/5"	S	----	8.9	with occasional interbedded																									
6						silty or clayey zones. Some																									
7						cobbles.																									
8																															
9																															
60		50/4"	S	----	11.4																										
1																															
2																															
3																															
4																															
5		50/3"	S	----	12.2																										
6																															
7																															
8																															
9																															
70		50/3"	S	----	10.0																										
1																															
2																															
3																															
4																															
5		50/1"	S	----	15.1																										
6																															
7																															
8																															
9																															
80		50/2"	S	NR																											

*Drilled at location 98 feet east of monument line to avoid existing drainage ditch and power lines.

*All samples driven with full standing column of water in hollow stem auger.

NR - No Sample Recovery.

CONTINUED

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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SOIL BORING LOG

NO.* 5 ELEV: 1203.5 ft. SIZE OF HOLE 7 in. FIELD ENGR: M.F. DATE: 7/10/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT. C	N**	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION WELL	MED.	POOR	GRAIN SHAPE ANGULAR	SUBANGULAR	ROUNDED	SUBROUNDED	RELATIVE DENSITY LOW	MED	HIGH	PLASTICITY NONE	LOW	MEDIUM	HIGH	CONSISTENCY SOFT	FIRM	STIFF	VERY STIFF	HARD	CEMENTATION NONE	WEAK	MEDIUM	STRONG
81					damp	Sands & Gravels; brown,	SP-		X			X		X			X	X	X								X			
2						roughly stratified deposit	SM																							
3						with occasional interbedded	to																							
4						silty or clayey zones. Some	GP-																							
5						cobbles.	GM																							
6																														
7																														
8																														
9																														
90																														
1																														
2																														
3																														
4																														
5																														
6																														
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8																														
9																														
100																														
1																														
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8																														
9																														
110																														
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
9																														
120																														

*Drilled at location 98 feet east of monument line to avoid existing drainage ditch and power lines.

**All samples driven with full standing column of water in hollow stem auger.

Stopped drilling at 80.5 feet

Ground water encountered: none

Project No. 84-708

THOMAS-HARTIG & ASSOCIATES, INC.

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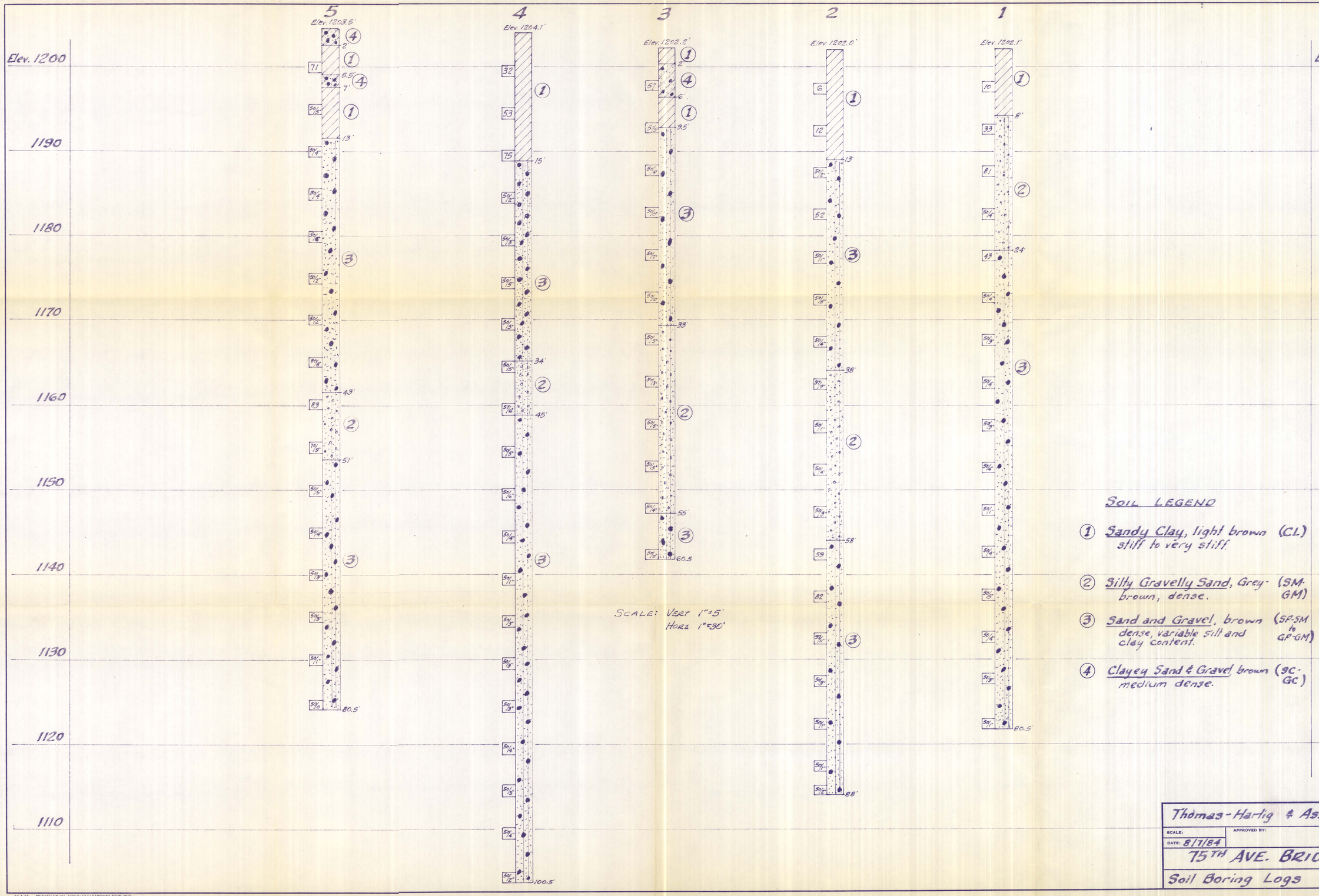
GRAPHICAL SOIL PROFILE



Thomas-Hartig & Associates		
SCALE:	APPROVED BY:	DRAWN BY GKC
DATE: 8/7/84		REVISED
75TH AVE. BRIDGE		
Soil Boring Logs		DRAWING NUMBER 84-708

APPENDIX A

THOMAS-HARTIG & ASSOCIATES, INC.
SOIL AND FOUNDATION ENGINEERS

Tom W. Thomas, P.E.
Harry E. Hartig, P.E.

2720 South Hardy Drive
Tempe, Arizona 85282
(602) 968-8778

John P. Boyd, P.E.
Charles H. Atkinson, P.E.
Glen K. Copeland, P.E.
James R. Morrow, Lab Director

Royden Engineering Company
3055 W. Indian School Road
Phoenix, Arizona

3 October 1984

Attention: Andy DiLeo, P.E.

Project: Large Diameter Test Boring
75th Ave. Bridge South of Bell Rd.

Project No: 84-1054
(RE: 84-708)

In accordance with your authorization, we have drilled a large diameter test hole at the referenced project. This additional testing was requested to supplement our small diameter borings and to provide the following:

1. Better indication of material size/gradation;
2. Difficulty or ease of drilling caisson footings;
3. Caving potential or hole stabilization problems;
4. Concrete overruns.

Natural Materials:

As disclosed by the large diameter boring and illustrated on the attached boring log, the stratification of the soils is similar to those encountered and observed at the small diameter test borings. However, a better indication of general character and size was developed using the large diameter auger. The soils are roughly stratified, subangular to subrounded sands and gravels which contain variable amounts of silt and clay. Additionally, some cobbles and boulders occur randomly within the strata. Maximum observed size was approximately 10 inches.

A very thin, clean water bearing sand was encountered at a depth of 33 feet. Water seepage into the boring was described as slight.

Four (4) sieve analysis and plasticity index tests were conducted on bulk samples and the results of testing are attached.

Drilling Difficulty:

The test boring was drilled with a Texoma Taurus drill rig using a 36 inch diameter flight auger. This specific drill rig can apply a torsional force of 83,000 ft./lbs. and a crowd pressure of 51,000 lbs. maximum. The excavation of the test hole to an 80 foot depth was accomplished without difficulty and was accomplished in approximately 3 hours.

Caving Potential:

The stability of the natural soils appears to be adequate for development of uncased drilled caissons as the foundation system. Only minor caving was encountered during the test drilling, and occurred at the interbedded, relatively thin cleaner soil lenses and within the strata which generally have a lower fines content (noted on the boring logs as SP-SM to GP-GM).

The largest caving was located below a depth of 61 feet and increased the hole diameter approximately 1 to 2 feet. If thick clean sand and gravel zones are encountered or if the soils are allowed to dry, additional caving may occur.

Concrete Overruns:

As stated above, caving was minor and although concrete overruns will exceed theoretical volumes, the overrun should be relatively small.

Please do not hesitate to call when we may be of further service to you.

Respectfully submitted,

THOMAS-HARTIG & ASSOCIATES, INC.

Registered Professional Engineer (Civil) CERTIFICATE NO. 6858 GLEN K. COPELAND Date Signed 10-3 ARIZONA, U.S.A.

By: _____
Glen K. Copeland, P.E.

Registered Professional Engineer (Civil) CERTIFICATE NO. 7641 HARRY E. HARTIG Date Signed 10-3 ARIZONA, U.S.A.

Reviewed by: _____
Harry E. Hartig, P.E.

/cms

Copies to: Addressee (5)

LEGEND

SOIL CLASSIFICATION ASTM: D2487

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 AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	SILTS AND CLAYS Liquid limit less than 50
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
	OL	ORGANIC SILTS AND ORGANIC SILT-CLAYS OF LOW PLASTICITY	
	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS, ELASTIC SILTS	SILTS AND CLAYS Liquid limit greater than 50
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	
	PT	PEAT AND OTHER HIGHLY ORGANIC SOILS	

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

GRAIN SIZES

	U.S. STANDARD SERIES SIEVE				CLEAR SQUARE SIEVE OPENINGS			
	200	50	16	4	¾"	3"	6"	
SILTS & CLAYS DISTINGUISHED ON BASIS OF PLASTICITY	SAND				GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE		FINE	COARSE		

MOISTURE CONDITION (INCREASING MOISTURE ⟶)

DRY — SLIGHTLY DAMP — DAMP — MOIST — VERY MOIST — WET (SATURATED)

(PL) (LL)

DEFINITIONS

Penetration Resistance — Blows per foot using 'A' rod and 140 lb. hammer with 30 inch free fall unless otherwise noted.

N Standard Penetration Resistance (ASTM:D1586), 2.0 inch O.D. split barrel sampler.

C Continuous Penetration Resistance, 2.0 inch O.D. Bull Nose.

R Penetration Resistance, 2.42 inch I.D. Ring Sampler

Sample Type

R - Ring T - Shelby Tube S - Standard Split Barrel B - Block
G - Grab C - Cutting V - Vertical Face Cut

CONSISTENCY			RELATIVE DENSITY	
CLAYS & SILTS	BLOWS/FOOT*	STRENGTH‡	SANDS & GRAVELS	BLOWS/FOOT*
VERY SOFT	0-2	0-¼	VERY LOOSE	0-4
SOFT	2-4	¼-½	LOOSE	4-10
FIRM	4-8	½-1	MEDIUM DENSE	10-30
STIFF	8-16	1-2	DENSE	30-50
VERY STIFF	16-32	2-4	VERY DENSE	OVER 50
HARD	OVER 32	OVER 4		

* Number of blows of 140 pound hammer falling 30 inches to drive a 2 inch O.D. (1-⅜ inch I.D.) split spoon (ASTM D-1588).

‡ Unconfined compressive strength in tons/sq. ft. Read from a pocket penetrometer.

Project No. 84-1054

SOIL BORING LOG

NO. 3A ELEV: SIZE OF HOLE 36 in. FIELD ENGR: M.F. DATE: 9/24/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT. C	PENETRATION RESISTANCE BLOWS/FT. N	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION	SOIL CLASSIFICATION	GRADATION WELL	GRADATION MED	GRADATION POOR	GRAIN SHAPE ANGULAR	GRAIN SHAPE SUBANGULAR	GRAIN SHAPE ROUNDED	GRAIN SHAPE SUBROUNDED	RELATIVE DENSITY LOW	RELATIVE DENSITY MED	RELATIVE DENSITY HIGH	PLASTICITY NONE	PLASTICITY LOW	PLASTICITY MEDIUM	PLASTICITY HIGH	CONSISTENCY SOFT	CONSISTENCY FIRM	CONSISTENCY STIFF	CONSISTENCY VERY STIFF	CONSISTENCY HARD	CEMENTATION NONE	CEMENTATION WEAK	CEMENTATION MEDIUM	CEMENTATION STRONG
1					below	Sandy Clay-Clayey Sand; light	CL-		X	X		X				X			X	X			X	X			X			
2					p.l.	brown, slightly vesicular,	SC																								
3						fine to medium sands.																									
4																														
5					damp	Clayey Sand & Gravel; brown,	SC-		X	X		X		X		X			X	X								X			
6						fine to coarse sands and gra-	GC																								
7					below	vels and few cobbles to 5".	CL-		X	X		X				X			X	X			X	X			X			
8					p.l.	Sandy Clay-Clayey Sand; light	SC																								
9						brown, slightly vesicular,																									
10						fine to medium sands.																									
1					damp	Sands & Gravels; brown,	SP-	X				X		X		X			X	X								X			
2						roughly stratified deposit	SM																								
3						with occasional interbedded	to																								
4						silty zones, clayey zones,	GP-																								
5						and cleaner sand and gravel	GM																								
6						zones. Some cobbles below																									
7						19 feet. Maximum size appro-																									
8						ximately 10".																									
9																														
20																														
1						Increased clay fines content	SP-																								
2						in interval of 20 to 24 feet.	SC																								
3							to																							
4							GP-																							
5					damp	Slight caving at cleaner	GC																								
6					to	zones within this deposit.																									
7					very																									
8					damp																									
9																														
30																														
1					moist																									
2						Small water bearing lens at																									
3						33 feet.																									
4					damp	Silty Gravelly Sand; gray-	SM-		X			X		X		X			X									X			
5						brown, interbedded sand with	GM																								
6						gravels and cobbles mixed																									
7						with variable amounts of silt																									
8						and clay of low plasticity;																									
9						occasional thin layers of																									
40						sandy clay (CL).																									

CONTINUED

Project No. 84-1054

THOMAS-HARTIG & ASSOCIATES, INC.

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. 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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NO. 3A ELEV: SIZE OF HOLE 36 in. FIELD ENGR: M.F. DATE: 9/24/84

DEPTH FT.	PENETRATION RESISTANCE BLOWS/FT. C	PENETRATION RESISTANCE BLOWS/FT. N	SAMPLE TYPE	DRY DENSITY PCF	MOISTURE CONTENT	DESCRIPTION (CONTINUED)	SOIL CLASSIFICATION	GRADATION: WELL	GRADATION: MED	GRADATION: POOR	GRAIN SHAPE: ANGULAR	GRAIN SHAPE: SUBANGULAR	GRAIN SHAPE: ROUNDED	GRAIN SHAPE: SUBROUNDED	RELATIVE DENSITY: LOW	RELATIVE DENSITY: MED	RELATIVE DENSITY: HIGH	PLASTICITY: NONE	PLASTICITY: LOW	PLASTICITY: MEDIUM	PLASTICITY: HIGH	CONSISTENCY: SOFT	CONSISTENCY: FIRM	CONSISTENCY: STIFF	CONSISTENCY: VERY STIFF	CONSISTENCY: HARD	CEMENTATION: NONE	CEMENTATION: WEAK	CEMENTATION: MEDIUM	CEMENTATION: STRONG
41					damp	Silty Gravelly Sand; gray-brown, interbedded sand with gravels and cobbles mixed with variable amounts of silt and clay of low plasticity; occasional thin layers of sandy clay (CL). Cobbles increasing below 55 feet with maximum size 8".	SM-GM		X		X		X			X	X		X										X			
50						No caving within this deposit.																									
60																														
70					damp	Sands & Gravels; brown, roughly stratified deposit with occasional interbedded silty zones, clayey zones, and cleaner sand and gravel zones, variable amounts of cobbles and boulders, maximum size 14".	SP-SM to GP-GM		X		X		X			X		X	X										X			
80						Slight caving within this deposit.																									

Stopped test drilling at: 80 feet

Ground water encountered: none

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REPORT ON LABORATORY TESTS

SAMPLE: Date 10/3/84

Source Noted below

Type Bulk Samples

Material Subsoil

Sampled By TH/Frede

TESTED: Sieve analysis and plasticity index

RESULTS:

Sample	LL	PI	Sieve Size - Accum. % Passing 200	100	50	30	16	8	4	3/4"	1"	2"	6"	* Class
3A; 20 - 30'	34	9	9	11	14	23	32	39	46	64	71	81	100	GP-GC
3A; 50 - 60'	28	4	4	5	6	12	19	24	28	41	45	53	63	GP-GM
3A; 61 - 72'		NP	6	10	37	53	64	69	73	85	88	94	100	SP-SM
3A; 72 - 80'		NP	6	8	10	22	32	38	43	63	71	81	100	GP-GM

* Unified Soil Classification

NP = Non-Plastic

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