BUSH HIGHWAY BOX CULVERTS

Spookhill Floodway about 3.5 miles north of McDowell Road
Maricopa County, Arizona

Prepared for

Inca Engineers
1702 East Highland, Suite 207
Phoenix, Arizona

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Attention: Mark Wavering

Project: Bush Highway Box Culverts
Spookhill Floodway about 3.5 miles
north of McDowell Road
Maricopa County, Arizona

Project No. 91-0312

This report presents the results of the geotechnical engineering services authorized on the site for the proposed Bush Highway Box Culverts located in the Spookhill Floodway approximately 3.5 miles north of McDowell Road in Maricopa County, Arizona (north of Mesa).

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.

Registered Professional Engineer CERTIFICATE NO. 24038 KENNETH D. WALSH WASHINGTON Date Signed 2/14/91 ARIZONA, U.S.A.

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PART I
REPORT

SCOPE

The proposed improvements to the existing Bush Highway Box Culverts will include the addition of two new barrels. The new box culvert barrels will be 10 feet wide by 7 feet high and 81 feet long, and will be placed at a 45 degree skew to the road. The new barrels will be placed immediately south of the existing barrels or one on either side of the existing barrels. This firm should be contacted for review and possible supplemental recommendations if any design concepts are significantly modified.

SITE DESCRIPTION

The site of the proposed box culvert improvements is located on Bush Highway approximately 3.5 miles north of McDowell Road, north of Mesa in Maricopa County, Arizona. There is currently a 2-barrel 10-foot by 7-foot by 81-foot long box culvert, skewed at 45 degrees to the road, and associated wingwalls and appurtenances. The roadway is in a fill section, with the roadway approximately 13 feet above the invert elevation of the box culvert. The surrounding area is undeveloped desert. Granite is outcropped north of the upstream end of the box culvert.

INVESTIGATION

The field investigation included a site reconnaissance and subsurface exploration. The subsurface exploration consisted of drilling 2 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. Test Borings 1 and 2 were drilled to depths of 27 and 14 feet, respectively. Standard Penetration Test (SPT) sampling and driven ring sampling was performed in all test borings, typically 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.

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".

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 (4)	Classification and correlation of engineering properties
Dry Density and Moisture Content	Undisturbed (2)	In-situ density and moisture determination to correlate engineering properties
Compression	Undisturbed (1)	Settlement analyses
pH, Sulfates, and Chlorides	Representative (2)	Corrosion potential
ASTM D698	Representative Grab Sample (1)	Compaction

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 at the boring locations is presented on the graphical boring logs in Appendix A. The soil profile at the site consists of a medium dense to dense silty or clayey gravelly sand. This material is light brown to brown, and contains occasional to scattered cobbles. The fines exhibit low plasticity. Underlying this material is a weathered, fractured granite which outcrops north of the box culvert and through which the road is cut just north of the box culvert. This material was encountered at 27 feet and 14 feet at Test Borings 1 and 2, respectively.

Test pits excavated by the Soil Conservation Service (SCS) in July 1990, also encountered the granite. These pits encountered rock at shallower depths north of the existing box centerline than south of the centerline, as observed in test drilling

for this project. All test pits were located in or near the channel. Depth to rock at the SCS pits along or north of centerline ranged from 0 to 4 feet, while the depths south of centerline ranged from 7 to 10 feet.

Soil moisture contents at the time of test drilling were generally described as damp. No free groundwater was encountered in test borings during drilling. These moisture and groundwater conditions represent only those conditions encountered at the time of our field drilling operations. Groundwater levels and moisture contents may vary with time, seasonal conditions, and/or water flow in the Salt River and the floodway.

DISCUSSION AND RECOMMENDATIONS

General: 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.

Foundations: Wing wall and box culverts founded at shallow levels below the finished grade and supported on compacted fill and/or undisturbed native soils were evaluated for support of the proposed improvements. The soil at the site is fairly strong, and the box culvert will be lighter than the soil it replaces. Therefore, we anticipate low settlements of less than 1/2 inch. The following tabulation presents foundation bearing design recommendations for shallow wall or box culvert foundations bearing on undisturbed native soils and/or compacted fills placed and compacted as described in Parts II and III of this report.

Foundation Depth	Allowable Foundation Bearing Pressure
1.5 ft.	2200 psf
2 ft.	2400 psf
3 ft.	2600 psf
4 ft.	2800 psf

Foundation depth refers to the depth of the foundation base below finished grade, which is defined as the lowest adjacent grade within 5 feet of the foundation for wingwalls or final channel grade for box culverts.

Foundation bearing surfaces should be free of debris and water softened materials prior to placing concrete and reinforcing steel. All foundation excavations should be reviewed by the geotechnical engineer prior to placing the foundation material. Any loose or disturbed zones should be removed and replaced with compacted fill or lean concrete.

Recommended foundation bearing pressures should be considered allowable maximums for dead load plus design live loads and may be increased by one-third when considering transient wind or seismic forces. The weight of foundation concrete below grade may be neglected in dead load computations. All wall foundations should have a minimum width of 1.33 feet.

Foundation excavations north of the existing box culverts may encounter the granite rock described under "Soil Conditions". This material will be at least as strong as the soil above it, but the design bearing pressures listed above should be used for all foundation elements. This approach is recommended because the rock surface elevation is variable across the site, and the depths at which it might be encountered in foundation construction cannot be accurately predicted.

Lateral Design Parameters: The following tabulation presents recommendations for lateral stability analyses:

[1]Foundation Toe Pressures----------1.33 x allowable
[2]Lateral Backfill Pressures:
Unrestrained walls ---------- 30 psf/ft.
Restrained walls ---------- 50 psf/ft.
Lateral Passive Pressures:
Continuous walls/footings---------- 250 psf/ft.
Coefficient of Base Friction:
Independent of passive resistance ------0.40
In conjunction with passive resistance--0.30

[1] Increase in allowable foundation bearing pressure (previously tabulated) for foundation toe pressures due to eccentric or lateral loading. The entire footing bearing surface should remain in compression.

[2] Equivalent fluid pressures for vertical walls and horizontal backfill surfaces (maximum 12-foot height). Pressures do not include temporary forces imposed during compaction of the backfill, swelling pressures developed by over-compacted clayey backfill, hydrostatic pressures from inundation of backfill, or surcharge loads. Walls should be suitably braced during backfilling to prevent damage and excessive deflection.

Compaction of the backfill soils against embedded footings or walls designed to provide passive resistance should be accomplished to a minimum 95 percent of the maximum ASTM D698 density to develop this resistance with low strains. We recommend that compaction against culvert or wing walls within 3 feet of the walls be accomplished using manual compaction equipment only.

Pavement: Pavement reconstruction will be required over the box culvert installation. The section described below is based upon the laboratory results presented in Appendix B and the design guidelines presented on Maricopa County Highway Department Standard Detail Number 2015.

Materials	Thickness (inches)
Asphalt Concrete	3
Aggregate Base Course	10

Pavement materials should not be placed when the subgrade is wet. The surface should be sealed after weathering is apparent to minimize water infiltration directly through the pavement section and retard oxidation.

Excavation Conditions: 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.

Excavations into the silty or clayey gravelly sands should be possible with conventional excavating equipment. Excavations into the underlying granite may be more difficult, and may require the use of specialized equipment including blasting. Based upon the results of test drilling conducted by this firm and test pits excavated by the Soil Conservation Service, the granite is more likely to be encountered for some portion of the excavation north of the existing box culverts than south.

Construction Excavations: The following criteria are presented to aid in development of excavation plans.

1. Unbraced temporary slopes in the existing soils should stand at slopes of 1H:1V. Locally, it may be necessary to further flatten slopes if very clean, loose sand lenses of significant thickness are encountered. As an alternative, localized bracing or shoring may be required in areas of caving.

2. Surface areas behind the crest of excavations should be graded so that surface waters do not pond within 15 feet of the crest, nor drain into the excavation from roadway drainage.

3. Heavy material stockpiles should not be placed within 10 feet of the crest of slopes. Similarly, heavy construction equipment should not pass over or be parked within 10 feet of the crest.

4. The crest of slopes should be monitored daily for evidence of movement or potential problems.

5. Excavations into the underlying granite may have vertical walls.

The design of any bracing systems should be reviewed by the geotechnical engineer. Also, observations should be made by the geotechnical engineer during

excavating to evaluate site conditions and determine if modifications are necessary in excavation procedures. If unbraced slopes are utilized, some surface raveling, erosion, and spalling should be expected unless measures are taken to stabilize exposed cut surfaces.

Structural Backfills: Backfill behind subsurface walls designed to support utilities, pavement, or other facilities should be compacted to density criteria presented in Parts II and III of this report. Backfills should consist of granular soils which exhibit low expansive potentials. On-site soils may be used in structural backfills. If backfills are not compacted as recommended, subsidence may result in areas adjoining backfilled subsurface walls. Even properly compacted deep backfills may tend to settle differentially relative to subsurface walls and should not be used for support of adjoining facilities or utilities prone to damage from differential settlements.

Saturation of backfill and development of hydrostatic pressures is possible in below-grade areas due to breakage of utility lines embedded in loose backfills, from infiltration of surface water through loose backfills, or from leakage from the proposed box culverts. Backfill compaction should be accomplished by mechanical methods, with water settling or jetting not permitted.

PART II
MATERIALS

FILL MATERIALS

All fill materials should be soils free of vegetation, debris, organic contaminants, and fragments larger then *6 inches in size. The existing site surface soils may be used for fill when compacted as described under Site Grading.

Imported soil used for fills below box culverts or backfills in depressions deeper than 4 feet should be granular soils 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 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 tank backfills where the fill thickness is greater than 4 feet.

BASE COURSE

Base course materials for use beneath pavements should be well graded sand and gravel materials meeting the Maricopa Association of Governments' Specifications for Aggregate Base Materials (Section 702).

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 provided for the grading and excavation required for installation of the box culverts. All phases of earthwork should be performed under observation and testing directed by the geotechnical engineer.

1. Excavate as necessary for placement of the new box culverts. The base of the excavation should be flat and should extend at least 3 feet beyond the culvert walls. Sides should be braced or sloped in accordance with previous recommendations under Construction Excavations.

2. The base should be cleaned of all organic contaminants, debris, wingwall foundation remnants and any loose or disturbed soils encountered. The cleaned surface should be observed for evidences of debris laden soils, disturbance, concealed wingwall remnants, or loose zones requiring additional removal. The surface should then be scarified, moisture conditioned, and compacted to a minimum 8 inch thickness.

3. At new wingwall locations, existing site soils should be removed to at least 2 feet beyond the footing edge. The exposed areas should be reviewed by the geotechnical engineer and deepened, if required. The surface should then be moisture conditioned and compacted.

4. In surface slab and pavement areas, scarify, moisture condition and compact exposed surface soils to a minimum 8-inch depth before placement of base course materials.

5. If rock is encountered in foundation areas, the rock surface should be excavated flat and cleaned of loose or broken rock, until the exposed surface consists entirely of unbroken competent material. Any resulting depressions in the rock surface should be repaired with lean concrete.

6. Place backfill as required to elevate site areas to required grade or replace disturbed or removed soil. Fill material should be placed and compacted in horizontal lifts compatible with the compaction equipment being used.

7. Compaction of exposed site soil, backfill, fill, and base course materials should be accomplished to the following density criteria.

Material	Percent Compaction (ASTM D698)
Subgrade Soil:	
Below box culverts	95 min.
Below base of footings	95 min.
Below pavement	95 min.
Excavation Backfill:	
More than 5 feet below roadway grade	100 min.
Less than 5 feet below roadway grade	95 min.
Base Course below asphalt paving	100 min.

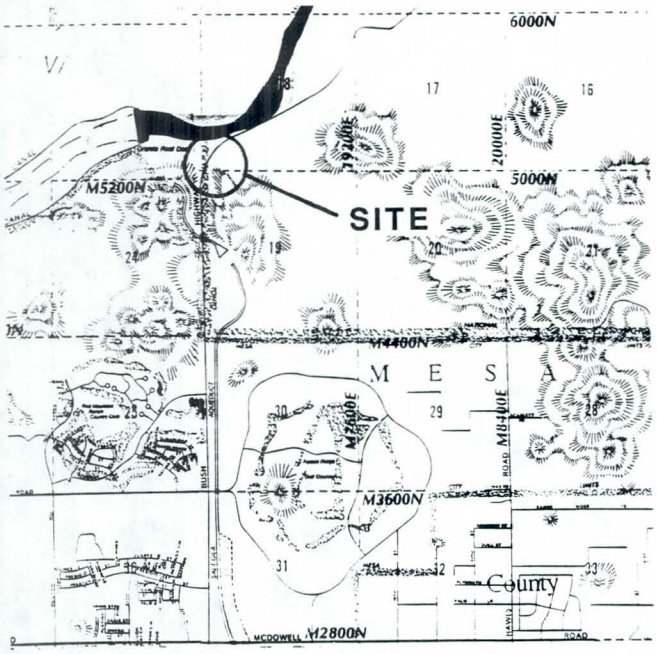
Compaction of on site or imported soil below box culverts or footings should be accomplished at a moisture content between optimum ±3 percent. Compaction of exposed soil and fill material below asphalt pavement should be accomplished at a moisture content 2 percent below optimum or lower.

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

PAVEMENT

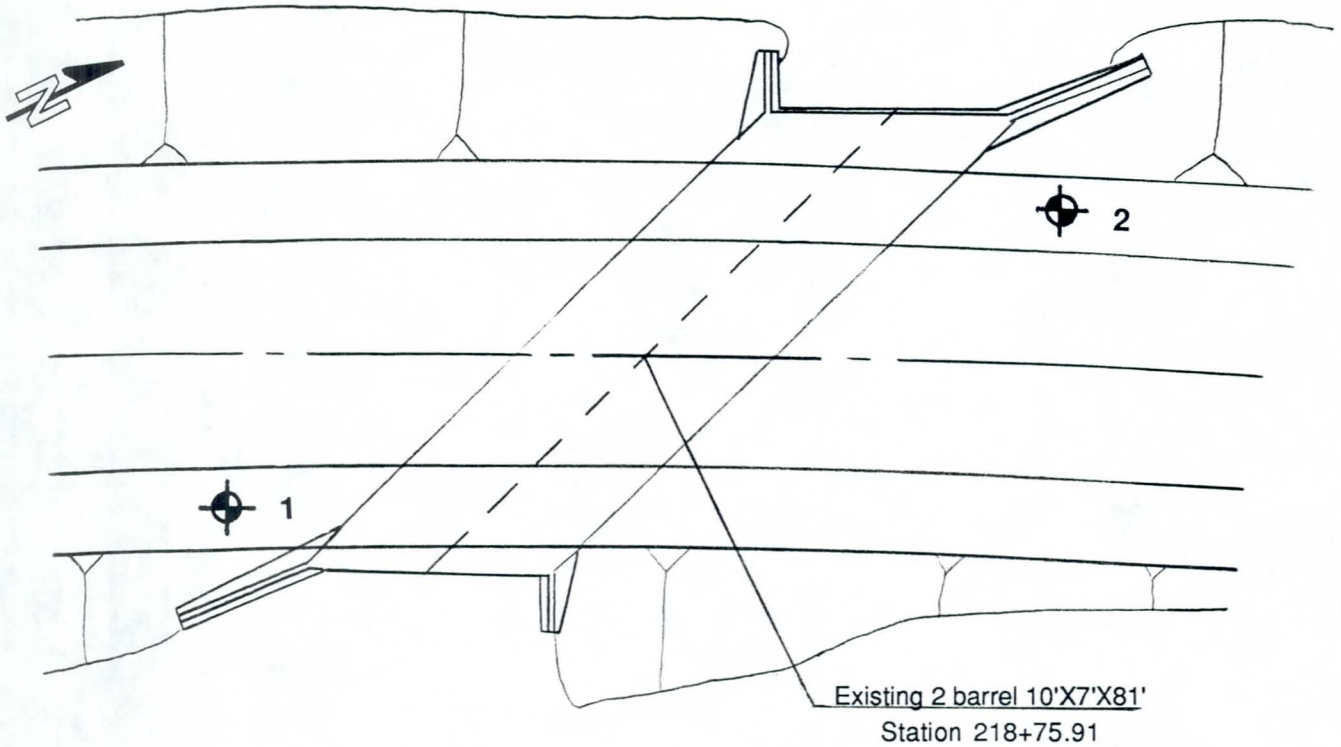
Placement requirements for paving materials should be in accordance with the requirements of the Maricopa Association of Governments' Standard Specifications for Asphalt Concrete (Section 321) with appropriate City of Phoenix supplements. Observation and testing should be performed as necessary to verify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

APPENDIX A
FIELD RESULTS



Vicinity Plan

- LOCATION OF SCS PITS ? & DEPTH TO BEDROCK



Test Boring Location
Elevations from Brass Cap on cattleguard north of box culverts, Elevation = 1344.62

Site Plan

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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	

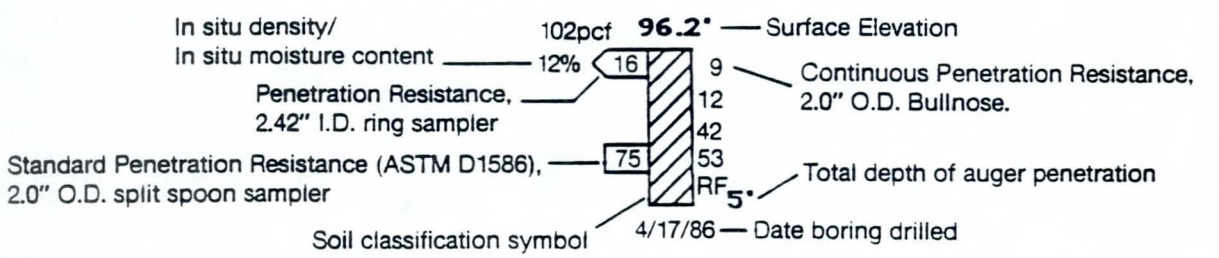
FINE-GRAINED SOIL

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.

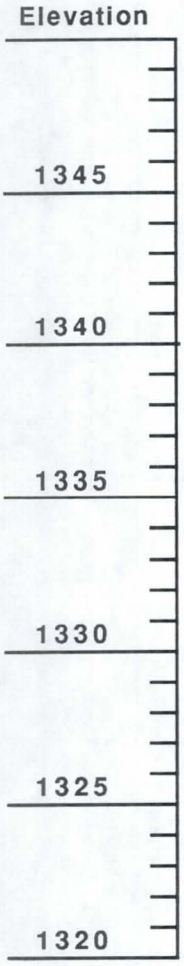
GRAIN SIZES								
U.S. STANDARD SERIES SIEVE				CLEAR SQUARE SIEVE OPENINGS				
200	40	10	4	3/4"		3"	12"	
SILTS & CLAYS DISTINGUISHED ON BASIS OF PLASTICITY	SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE			

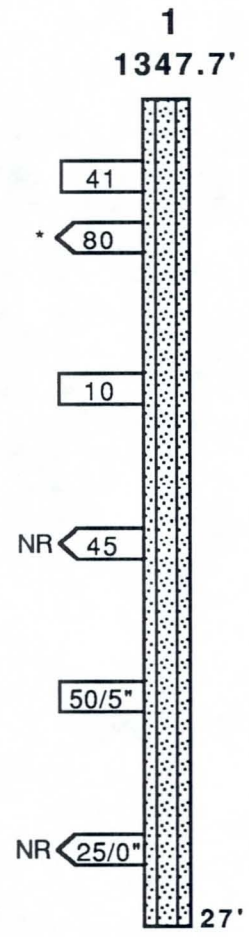
MOISTURE CONDITION (INCREASING MOISTURE →)					
DRY	SLIGHTLY DAMP	DAMP (Plastic Limit)	MOIST	VERY MOIST	WET (SATURATED) (Liquid Limit)

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		

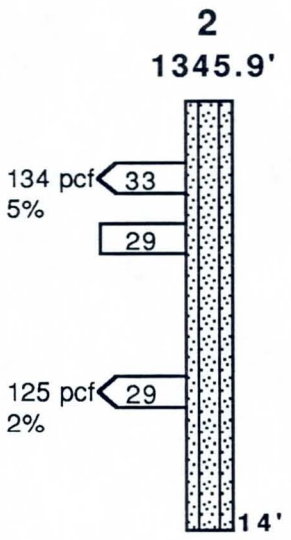
*Number of blows of 140 lb. hammer falling 30" to drive a 2" O.D. (1-3/8" I.D.) split-spoon sampler (ASTM D1586).

GRAPHICAL BORING LOGS





1-24-91
Refual to auger penetration on rock.



1-24-91
Refual to auger penetration on rock.

*Sample too disturbed to determine density

LEGEND OF SOIL TYPES

SILTY OR CLAYEY GRAVELLY SAND (SP-SC, SP-(SM-SC), SP-SM, SM-SC); light brown to brown; fine to coarse subangular to subrounded sand; subangular to angular primarily granitic gravel particles; scattered to occasional cobbles; low plasticity fines; medium dense to dense; damp.

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

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

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

APPENDIX B
LABORATORY RESULTS

REPORT ON GRADATION AND PLASTICITY INDEX

SAMPLE:

Date: 2-5-91

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' - 6'	28	8	11	15	19	24	31	42	59	92	94	99	100	SP-SC
1; 13' - 20'	23	5	8	11	15	20	27	41	67	98	100			SP-(SM-SC)
2; 0' - 7'	23	5	15	21	27	34	43	55	72	97	98	100		SM-SC
2; 7' - 14'	29	10	8	11	13	16	22	39	67	99	99	100		SP-SC

*Unified Soil Classification

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REPORT ON LABORATORY TESTS

SAMPLE: Date 2-4-91

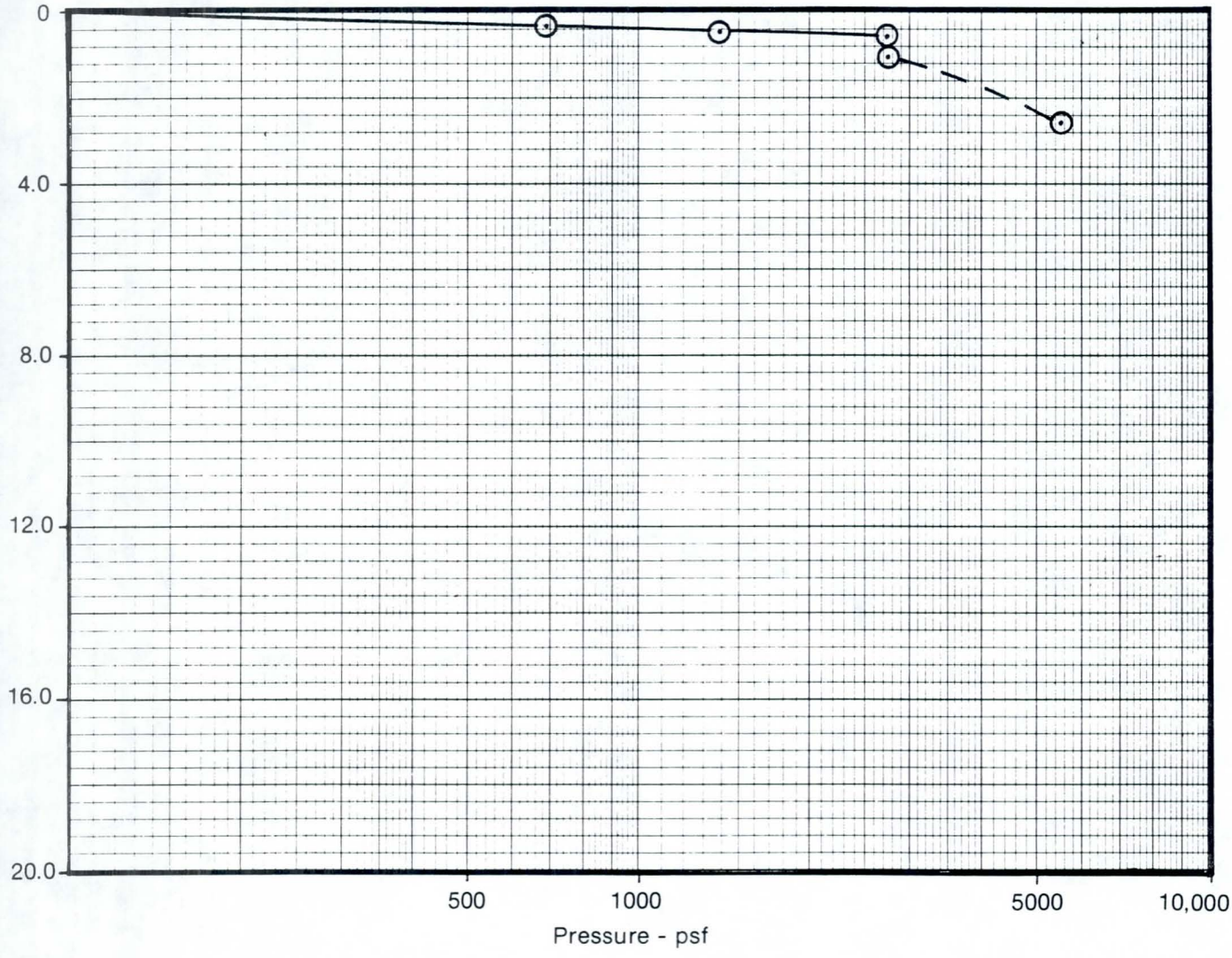
Source Test Boring 2; 9' - 10'

Type Driven Ring Sample; 125 pcf dry density; 2% field moisture

Material Clayey Gravelly Sand (SP-SC)

Sampled By TH/Thompson

TESTED: Compression; test sample saturated at 2770 psf



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REPORT ON pH, CHLORIDES & SULFATES

SAMPLE:

Date: 2-8-91

Source: Noted Below
Type: Bulk Samples
Material: Subsurface Soil
Sampled By: TH/Thompson

TESTED: pH, Chlorides & Sulfates.

TEST RESULTS

Sample	pH	Chlorides Percent	Sulfates Percent
1; 0' - 6'	8.2	0.0040	0.030
1; 13' - 20'	8.2	0.0050	0.036

REPORT ON LABORATORY TESTS

SAMPLE: Date 2-2-91

Source Test boring 2; 0' - 7'

Type Bulk Sample

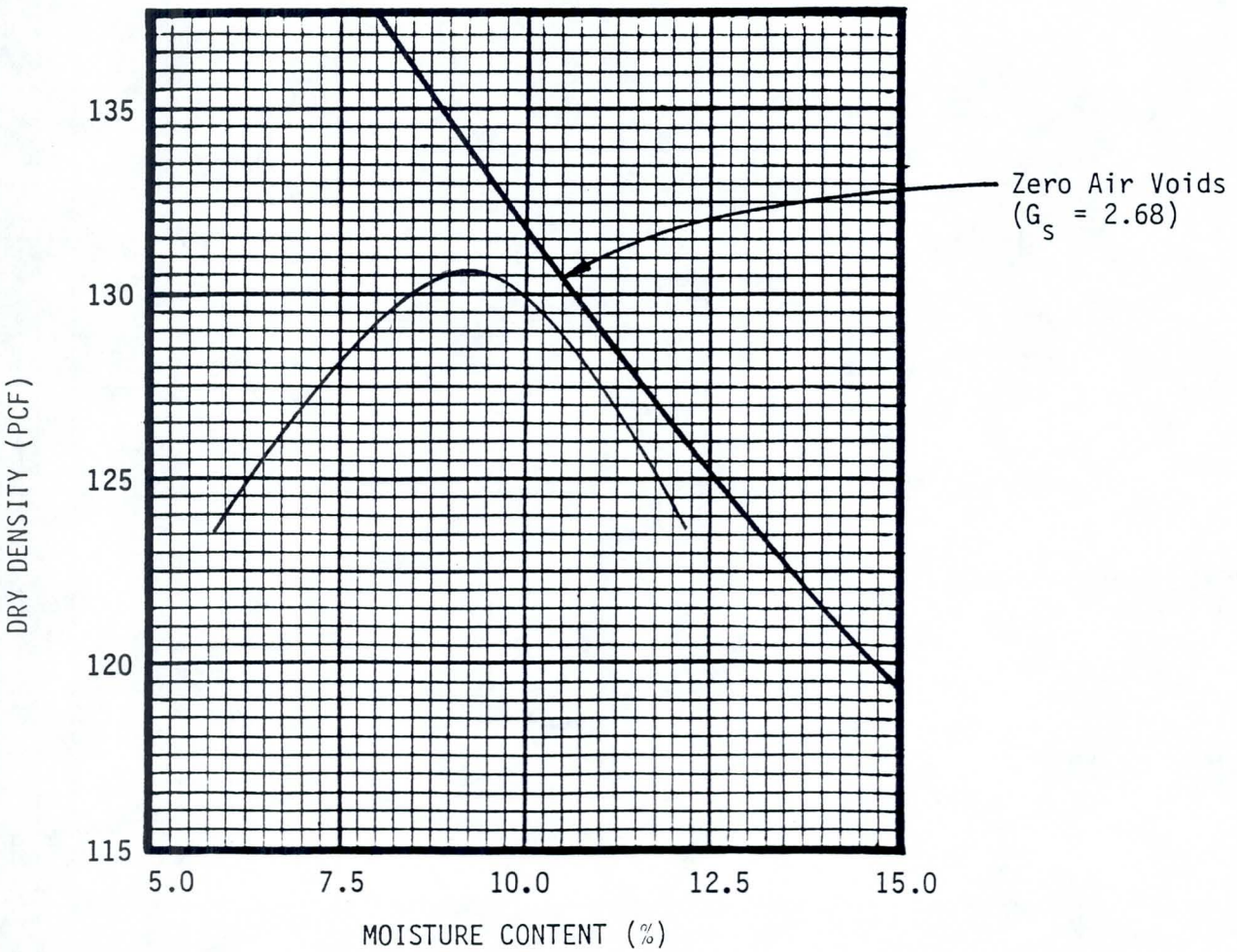
Material Surface Soil

Sampled By TH/Thompson

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

RESULTS:

Max. Dry Density (pcf) 130.5 Optimum Moisture Content (%) 9.2



Project No. 91-0312

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