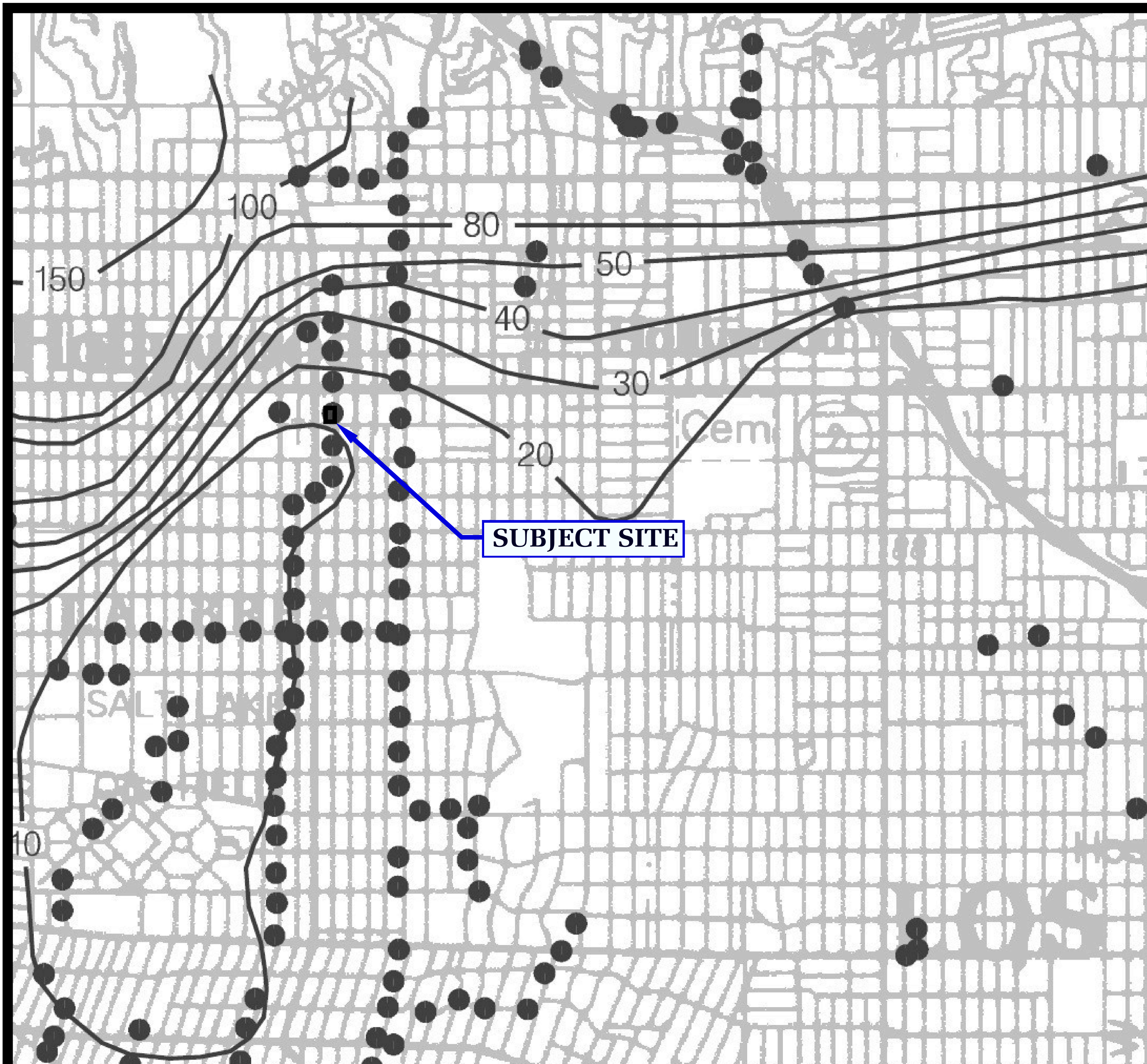
Appendix F2

Geotechnical Investigation



ONE MILE

SCALE

20 Depth to groundwater in feet

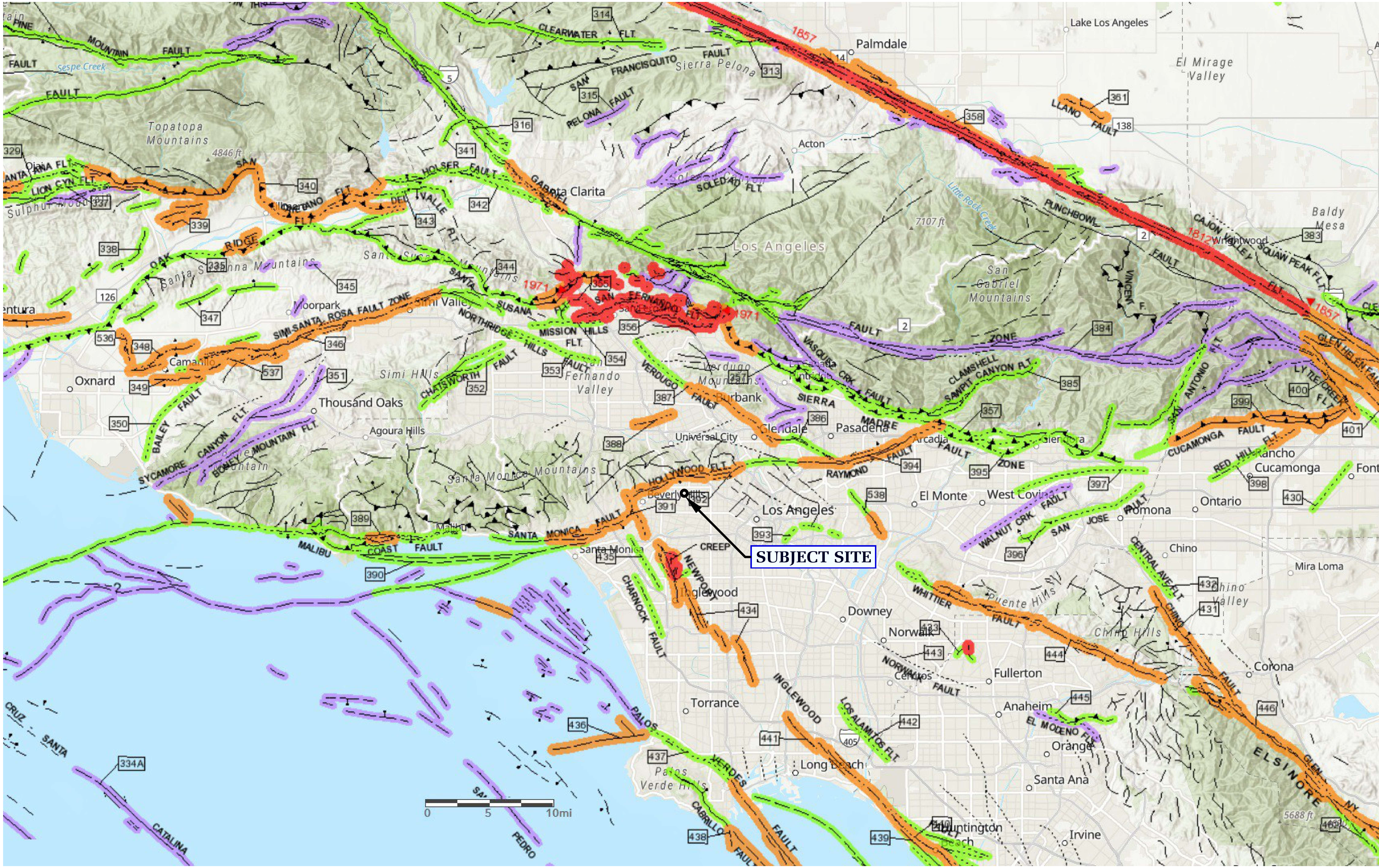
REFERENCE: CDMG, SEISMIC HAZARD ZONE REPORT, 026
HOLLYWOOD 7.5 - MINUTE QUADRANGLE, LOS ANGELES COUNTY, CALIFORNIA (1998, REVISED 2006)

HISTORICALLY HIGHEST GROUNDWATER LEVELS

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1011 N. SYCAMORE AVE., LOS ANGELES

FILE NO. 21849



REGIONAL FAULT LOCATION MAP

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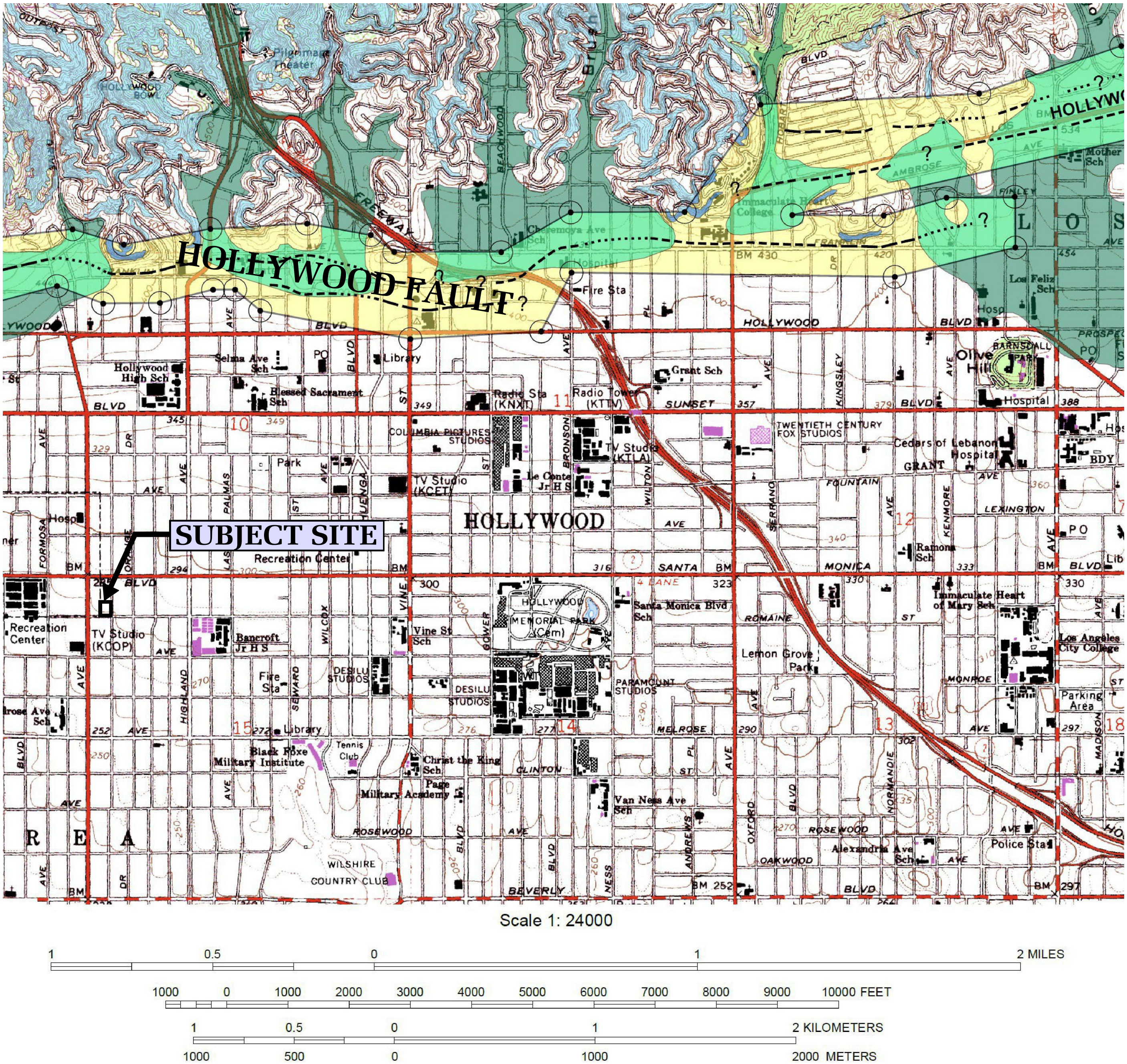
FARING
1011 N. SYCAMORE AVENUE, LOS ANGELES

FILE No. 21849

REFERENCE: California Department of Conservation, 2010 Fault Activity Map



Earthquake Fault Zones

Alquist-Priolo Earthquake Fault Zone

REFERENCE: EARTHQUAKE FAULT ZONES, HOLLYWOOD QUADRANGLE, CALIFORNIA GEOLOGICAL SURVEY, NOVEMBER 2014

EARTHQUAKE FAULT ZONE

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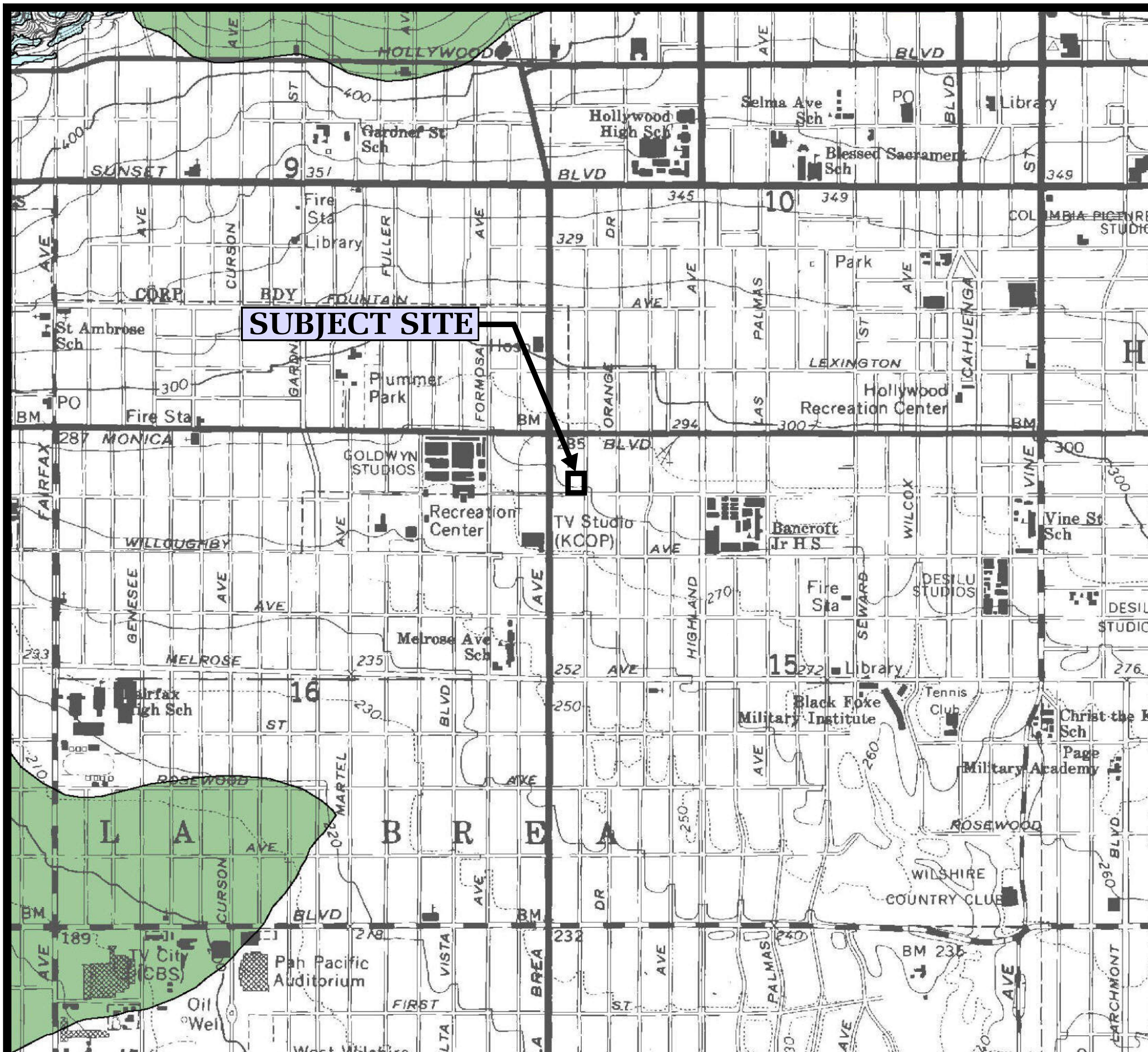
FILE NO. 21849



SCALE 1:24,000

1 — .5 — 0 — 1 MILE

1000 — 0 — 1000 — 2000 — 3000 — 4000 — 5000 — 6000 — 7000 FEET

1 — .5 — 0 — 1 KILOMETER

N

LIQUEFACTION AREA

REFERENCE: SEISMIC HAZARD ZONES, BURBANK QUADRANGLE OFFICIAL MAP (CDMG, 1999)

SEISMIC HAZARD ZONE MAP

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FARING
1011 N. SYCAMORE AVE., LOS ANGELES

FILE NO. 21849

BORING LOG NUMBER 1

Faring **Date: 08/07/19**

File No. 21849 **Method: 8-inch diameter Hollow Stem Auger**

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description Surface Conditions: Concrete Driveway
				0 --		7½-inch Concrete over 5½-inch Base
				-		
				1 --		
				-		FILL: Silty Clay, dark brown, moist, stiff
				2 --		
				-		
				3 --		
				-		
				4 --		
				-		
5	28	19.6	106.2	5 --		
				-	ML	OLDER ALLUVIUM: Sandy to Clayey Silt, dark brown, moist, stiff
				6 --		
				-		
				7 --		
				-		
				8 --		
				-		
				9 --		
				-		
10	17	20.4	SPT	10 --		
				-		
				11 --		
				-		
				12 --		
				-		
				13 --		
				-		
				14 --		
				-		
15	54	21.8	99.0	15 --		
				-		gray to dark gray
				16 --		
				-		
				17 --		
				-		
				18 --		
				-		
				19 --		
				-		
20	35	15.6	SPT	20 --		
				-	SM/SP	Silty Sand to Sand, dark gray to gray, moist to very moist, medium dense, fine to medium grained
				21 --		
				-		
				22 --		
				-		
				23 --		
				-		
				24 --		
				-		
25	38	25.3	96.8	25 --		
				-	SM/ML	Silty Sand to Sandy Silt, dark brown, very moist, medium dense, stiff, fine grained

BORING LOG NUMBER 1

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				26 --		
				-		
				27 --		
				-		
				28 --		
				-		
				29 --		
				-		
30	47	18.5	SPT	30 --		
				-	SP	Sand, dark brown, wet, medium dense, fine to coarse grained, minor gravel
				31 --		
				-		
				32 --		
				-		
				33 --		
				-		
				34 --		
				-		
35	41	17.0	113.5	35 --		
				-	SP/SM	Sand to Silty Sand, dark brown, wet to moist, medium dense, fine grained
				36 --		
				-		
				37 --		
				-		
				38 --		
				-		
				39 --		
				-		
40	22	26.9	SPT	40 --		
				-	CL	Silty Clay, dark brown, moist, stiff
				41 --		
				-		
				42 --		
				-		
				43 --		
				-		
				44 --		
				-		
45	44	24.2	101.3	45 --		
				-	ML	Sandy Silt, dark and gray, moist, stiff
				46 --		
				-		
				47 --		
				-		
				48 --		
				-		
				49 --		
				-		
50	30	21.3	SPT	50 --		
				-	SM/ML	Silty Sand to Sandy Silt, dark brown, very moist, medium dense, stiff, fine grained

BORING LOG NUMBER 1

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				- 51 -- - 52 -- - 53 -- - 54 -- -		
55	76	14.9	121.6	55 -- - 56 -- - 57 -- - 58 -- - 59 -- -	SM/SP	Silty Sand to Sand, dark brown, wet, very dense, fine to medium grained
60	33	22.0	SPT	60 -- - 61 -- - 62 -- - 63 -- - 64 -- -	SP/ML	Sand to Sandy Silt, dark brown, wet, medium dense, stiff, fine grained
65	78	20.6	101.9	65 -- - 66 -- - 67 -- - 68 -- - 69 -- -	SM/SP	Silty Sand to Sand, dark brown, wet, dense, fine to medium grained
70	54	15.8	SPT	70 -- - 71 -- - 72 -- - 73 -- - 74 -- -	SP	Sand, dark brown, wet, dense, fine to medium grained, minor gravel
75	72	27.8	96.9	75 -- -	SM/ML	Silty Sand to Sandy Silt, dark and gray, moist, dense, stiff, fine grained

BORING LOG NUMBER 1

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				76 --		
				-		
				77 --		
				-		
				78 --		
				-		
				79 --		
				-		
80	36	18.9	SPT	80 --		
				-	ML/CL	Clayey Silt to Silty Clay, dark brown, moist, stiff
				81 --		
				-		
				82 --		
				-		
				83 --		
				-		
				84 --		
				-		
85	90	21.1	99.3	85 --		
				-	ML	Sandy Silt, dark brown, moist, very stiff
				86 --		
				-		
				87 --		
				-		
				88 --		
				-		
				89 --		
				-		
90	48	31.1	SPT	90 --		
				-	ML/CL	Clayey Silt to Silty Clay, dark brown, moist, stiff
				91 --		
				-		
				92 --		
				-		
				93 --		
				-		
				94 --		
				-		
95	57	14.8	100.8	95 --		
				-	SP/CL	Sand to Silty Clay, dark brown, wet, dense, stiff, fine grained
				96 --		
				-		
				97 --		
				-		
				98 --		
				-		
				99 --		
				-		
100	38	20.7	SPT	100 --		
				-	SP	Sand, dark and gray, wet, medium dense, fine to medium grained

BORING LOG NUMBER 1

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				101		
				102		
				103		
				104		
105	40 50/5"	7.4	125.3	105		very dense, few gravel
				106		
				107		
				108		
				109		
110	79	13.8	SPT	110		yellow and gray, fine to coarse grained, few gravel
				111		
				112		
				113		
				114		
115	91	27.1	100.0	115		BEDROCK (PUENTE FORMATION): Siltstone, dark gray to gray, moderately hard
				116		
				117		
				118		
				119		
120	61	30.7	SPT	120		
				121		
				122		
				123		
				124		
125	36 50/4"	27.1	101.6	125		

BORING LOG NUMBER 1

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				126 --		
				-		
				127 --		
				-		
				128 --		
				-		
				129 --		
				-		
130	50	30.4	SPT	130 --		
				-		Total Depth 130 feet
				131 --		Water at 20 feet
				-		Fill to 5 feet
				132 --		
				-		
				133 --		NOTE: The stratification lines represent the approximate
				-		boundary between earth types; the transition may be gradual.
				134 --		
				-		Used 8-inch diameter Hollow-Stem Auger
				135 --		140-lb. Automatic Hammer, 30-inch drop
				-		Modified California Sampler used unless otherwise noted
				136 --		
				-		SPT=Standard Penetration Test
				137 --		
				-		
				138 --		
				-		
				139 --		
				-		
				140 --		
				-		
				141 --		
				-		
				142 --		
				-		
				143 --		
				-		
				144 --		
				-		
				145 --		
				-		
				146 --		
				-		
				147 --		
				-		
				148 --		
				-		
				149 --		
				-		
				150 --		
				-		

BORING LOG NUMBER 2

Faring | **Date: 08/01/19**

File No. 21849 | **Method: 8-inch diameter Hollow Stem Auger**

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description Surface Conditions: Concrete Slab
				0 --		8-inch Concrete over 4-inch Base
				-		
				1 --		
				-		FILL: Silty clay, dark brown, moist, stiff
				2 --		
				-		
				3 --		
				-		
				4 --		
				-		
5	5	23.6	SPT	5 --		- - - - - - - - - - -
				-		Silty Sand to Silty Clay, dark brown and gray, moist, medium dense, stiff, fine grained
				6 --		
				-		
				7 --		
				-		
				8 --		
				-	SM	OLDER ALLUVIUM: Silty Sand, dark and yellowish brown, moist, medium dense to dense, fine grained
				9 --		
				-		
10	53 50/5"	16.6	114.5	10 --		
				-		
				11 --		
				-		
				12 --		
				-		
				13 --		
				-		
				14 --		
				-		
15	12	23.9	SPT	15 --		
				-	CL	Sandy Clay, dark brown, moist, stiff
				16 --		
				-		
				17 --		
				-		
				18 --		
				-		
				19 --		
				-		
20	33	17.9	113.7	20 --		
				-	SM/SP	Silty Sand to Sand, dark brown, moist, medium dense, fine grained
				21 --		
				-		
				22 --		
				-		
				23 --		
				-		
				24 --		
				-		
25	36	27.3	SPT	25 --		
				-	ML	Sandy to Clayey Silt, dark brown, moist, stiff

BORING LOG NUMBER 2

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				26 --		
				-		
				27 --		
				-		
				28 --		
				-		
				29 --		
				-		
30	56	24.5	99.8	30 --		
				-	CL	Silty Clay, dark and grayish brown, moist, stiff
				31 --		
				-		
				32 --		
				-		
				33 --		
				-		
				34 --		
				-		
35	22	28.4	SPT	35 --		
				-		yellowish brown
				36 --		
				-		
				37 --		
				-		
				38 --		
				-		
				39 --		
				-		
40	35	14.0	116.3	40 --		
				-		Sandy Clay, yellowish brown, moist, stiff
				41 --		
				-		
				42 --		
				-		
				43 --		
				-		
				44 --		
				-		
45	24	21.6	SPT	45 --		
				-		
				46 --		
				-		
				47 --		
47.5	82	14.7	113.3	-		
				48 --	SP/SW	Sand, dark brown, moist to wet, very dense, fine grained, few gravel
				-		
				49 --		
				-		
50	28	14.6	SPT	50 --		
				-	SM/ML	Silty Sand to Sandy Silt, dark and gray, moist to wet, medium dense, stiff, fine to coarse grained

BORING LOG NUMBER 2

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				51 --		
				-		
				52 --		
52.5	72	20.7	109.1	-		
				53 --	SM	Silty Sand, dark brown, moist, dense, fine grained, few cobbles
				-		
				54 --		
				-		
55	32	15.7	SPT	55 --		
				-	SP/SM	Sand to Silty Sand, dark brown, wet, medium dense, fine to medium grained
				56 --		
				-		
				57 --		
57.5	63	20.3	110.5	-		
				58 --	SM/ML	Silty Sand to Sandy Silt, brown, moist, dense, stiff, fine grained
				-		
				59 --		
				-		
60	30	25.4	SPT	60 --		
				-	SP/SM	Sand to Silty Sand, dark brown, moist, medium dense, fine grained
				61 --		
				-		
				62 --		
62.5	61	20.6	108.1	-		
				63 --	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, dense, stiff, fine grained, few gravel
				-		
				64 --		
				-		
65	44	18.6	SPT	65 --		
				-	SP/SM	Silty Sand to Sand, dark and yellowish brown, wet, dense, fine grained, few gravel
				66 --		
				-		
				67 --		
67.5	48 50/4"	15.5	116.2	-		
				68 --		
				-		
				69 --		
				-		
70	47	20.2	SPT	70 --		
				-	SC/CL	Sandy Clay to Clayey Sand, yellowish brown, wet, dense, stiff, fine to medium grained
				71 --		
				-		
				72 --		
72.5	35 50/5"	25.8	98.3	-		
				73 --		
				-		
				74 --		
				-		
75	35	18.9	SPT	75 --		
				-		dark and yellowish brown, medium dense, stiff

BORING LOG NUMBER 2

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				76 --		
				77 --		
77.5	36 50/5"	27.2	95.4			
				78 --	CL	Sandy to Silty Clay, dark and gray, moist, stiff
				79 --		
80	34	17.8	SPT	80 --		
				81 --		
				82 --		
82.5	40 50/5"	17.7	113.5			
				83 --	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, very dense, very stiff, fine grained
				84 --		
85	31	21.6	SPT	85 --		
					ML/CL	Clayey Silt to Silty Clay, dark and gray, moist, stiff
				86 --		
				87 --		
87.5	90	20.6	108.1			
				88 --		
				89 --		
90	35	34.2	SPT	90 --		
				91 --		
				92 --		
92.5	39	30.6	93.0			
				93 --	CL	Silty Clay, dark and grayish brown, moist, stiff
				94 --		
95	33	16.8	SPT	95 --		
					SP	Sand, dark and gray, wet, medium dense, fine grained
				96 --		
				97 --		
97.5	40 50/4"	18.0	109.3			
				98 --		very dense
				99 --		
100	74	17.9	SPT	100 --		

BORING LOG NUMBER 2

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				101 --		
				-		
				102 --		
102.5	45	14.9	121.6	-		- - - - - - - - - -
	50/4"			103 --		fine to medium grained, few gravel
				-		
				104 --		
				-		
105	49	19.3	SPT	105 --		- - - - - - - - - -
				-		dense
				106 --		
				-		
				107 --		
107.5	88	24.8	99.9	-		
				108 --		BEDROCK (PUENTE FORMATION): Siltstone, dark gray, moist, moderately hard
				-		
				109 --		
				-		
110	43	28.4	SPT	110 --		
				-		
				111 --		
				-		
				112 --		
112.5	72	27.8	95.2	-		
				113 --		
				-		
				114 --		
				-		
115	33	26.3	SPT	115 --		
				-		
				116 --		
				-		
				117 --		
117.5	45	23.8	103.8	-		
	50/4"			118 --		
				-		
				119 --		
				-		
120	48	23.9	SPT	120 --		
				-		
				121 --		
				-		
				122 --		
122.5	88	23.8	101.3	-		
				123 --		
				-		
				124 --		
				-		
125	54	27.0	SPT	125 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				126 --		
				-		
				127 --		
127.5	40	24.4	101.2	-		
	50/4"			128 --		Claystone, dark gray, moist, hard
				-		
				129 --		
				-		
130	56	26.0	SPT	130 --		
				-		Siltstone, dark gray, moist, moderately hard
				131 --		
				-		
				132 --		
				-		
				133 --		
				-		
				134 --		
				-		
135	79	23.2	103.3	135 --		
				-		
				136 --		
				-		
				137 --		
				-		
				138 --		
				-		
				139 --		
				-		
140	47	25.9	SPT	140 --		
				-		
				141 --		
				-		
				142 --		
				-		
				143 --		
				-		
				144 --		
				-		
145	46	23.2	102.5	145 --		
	50/4"			-		gray
				146 --		
				-		
				147 --		
				-		
				148 --		
				-		
				149 --		
				-		
150	61	26.7	SPT	150 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				151		
				152		
				153		
				154		
155	100/8"	26.8	98.2	155		
				156		
				157		
				158		
				159		
160	50	25.6	SPT	160		
				161		
				162		
				163		
				164		
165	40 50/3"	24.8	105.4	165		– – – – – – – – – – dark gray
				166		
				167		
				168		
				169		
170	57	24.7	SPT	170		
				171		
				172		
				173		
				174		
175	68	24.8	102.2	175		

BORING LOG NUMBER 2

Faring

File No. 21849

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				- 176 -- - 177 -- - 178 -- - 179 -- -		
180	92	25.9	SPT	180 --		
				- 181 -- - 182 -- - 183 -- - 184 -- - 185 -- - 186 -- - 187 -- - 188 -- - 189 -- - 190 -- - 191 -- - 192 -- - 193 -- - 194 -- - 195 -- - 196 -- - 197 -- - 198 -- - 199 -- - 200 -- -		Total Depth 180 feet Water at 19 feet Fill to 8 feet NOTE: The stratification lines represent the approximate boundary between earth types; the transition may be gradual. Used 8-inch diameter Hollow-Stem Auger 140-lb. Automatic Hammer, 30-inch drop Modified California Sampler used unless otherwise noted SPT=Standard Penetration Test

ASTM D 1557

SAMPLE	B1 @ 1-5'	B2 @ 1-5'
SOIL TYPE:	SM/ML	SM/ML
MAXIMUM DENSITY pcf.	118.6	117.9
OPTIMUM MOISTURE %	13.9	14.1

ASTM D 4829

SAMPLE	B1 @ 1-5'	B2 @ 1-5'
SOIL TYPE:	SM/ML	SM/ML
EXPANSION INDEX UBC STANDARD 18-2	128	82
EXPANSION CHARACTER	HIGH	MODERATE

SULFATE CONTENT

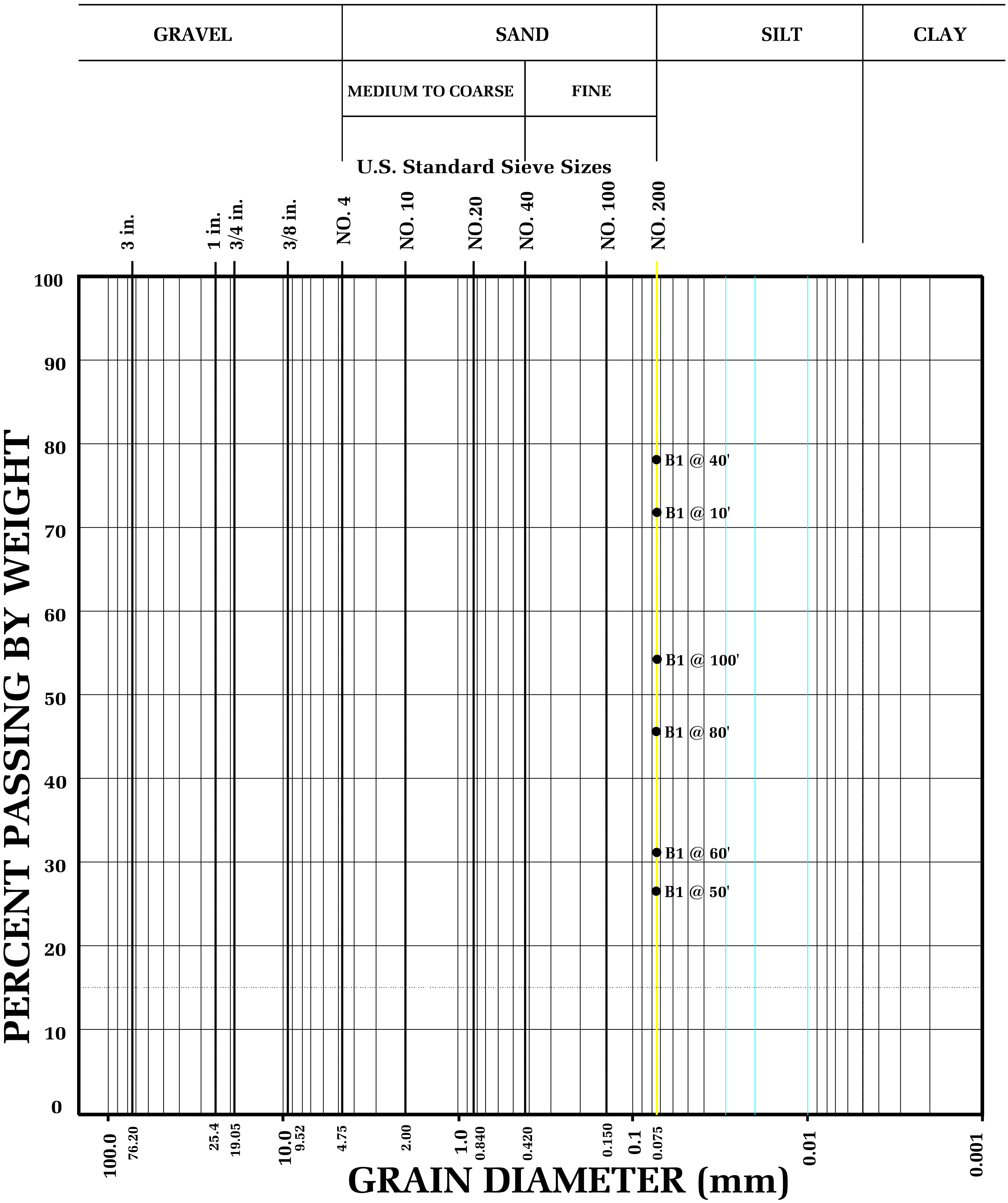
SAMPLE	B1 @ 1-5'	B2 @ 1-5'
SULFATE CONTENT: (percentage by weight)	< 0.10%	< 0.10%

COMPACTION/EXPANSION DATA SHEET

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1011 N. SYCAMORE AVENUE, LOS ANGELES

FILE NO. 21849 | PLATE: D

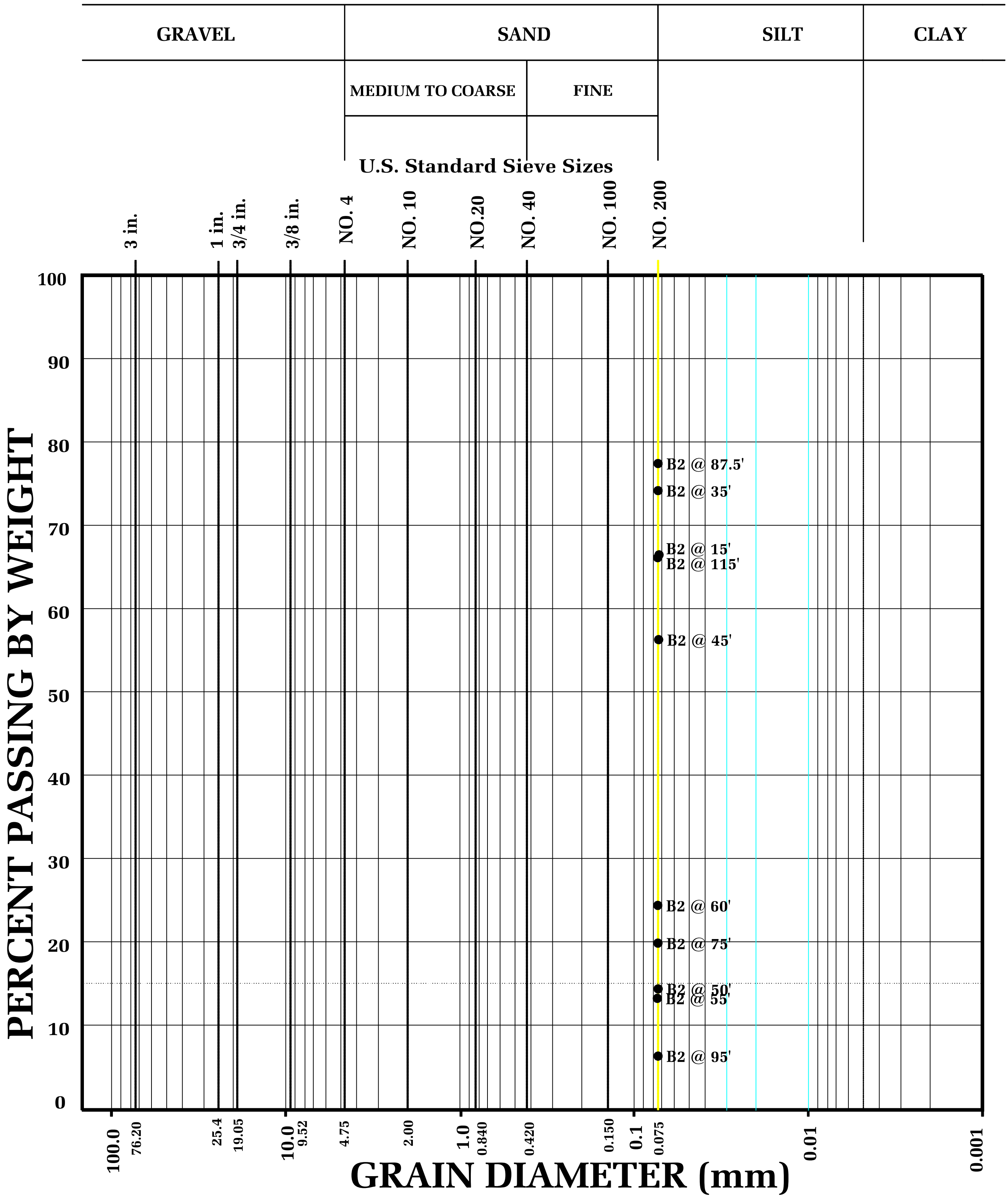


GRAIN SIZE DISTRIBUTION

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1011 N. SYCAMORE AVENUE, LOS ANGELES

FILE NO. 21849 | **PLATE: E-1**



GRAIN SIZE DISTRIBUTION

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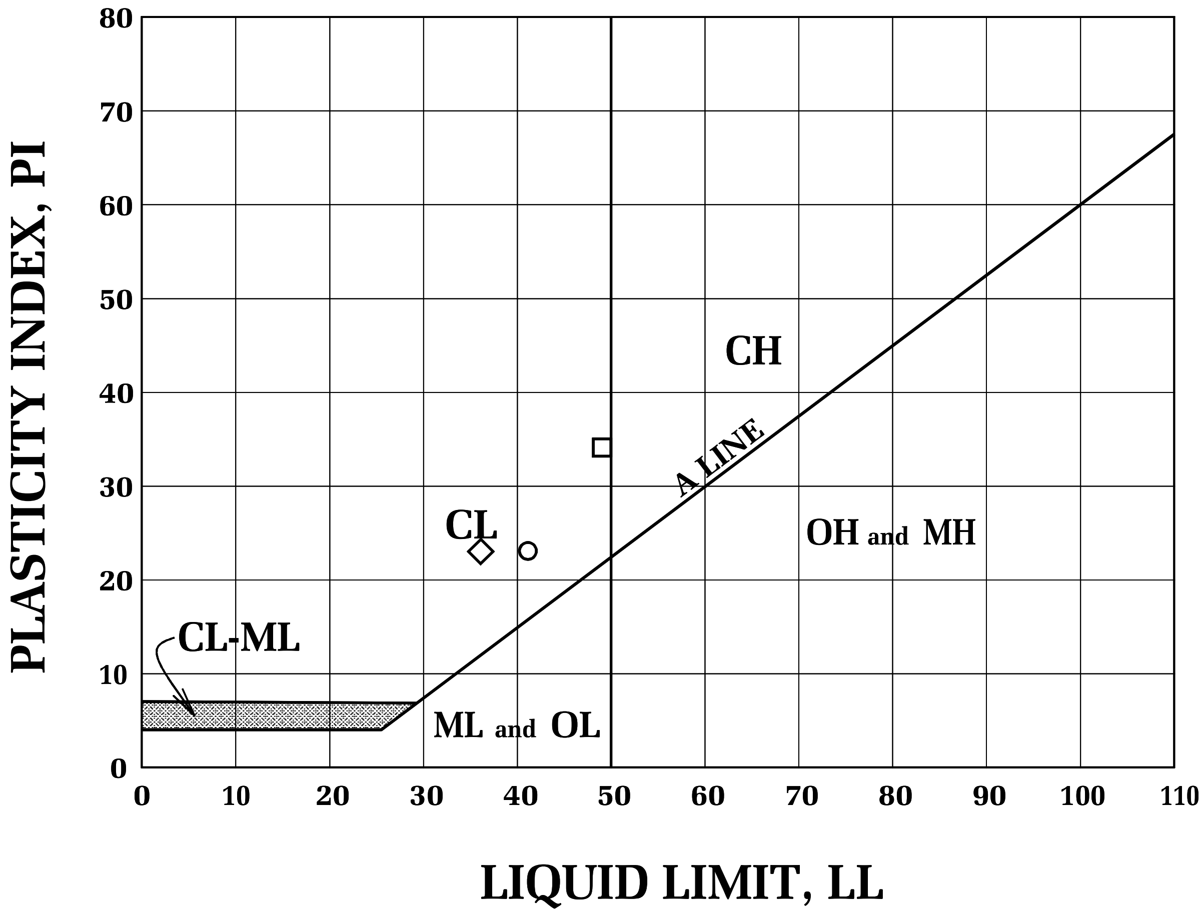
FILE NO. 21849	PLATE: E-2

ASTM D4318



BORING NUMBER	DEPTH (FEET)	TEST SYMBOL	LL	PL	PI	DESCRIPTION
B1	10	○	41	18	23	CL
B1	40	□	49	15	34	CL
B1	80	◇	36	13	23	CL

ATTERBERG LIMITS DETERMINATION

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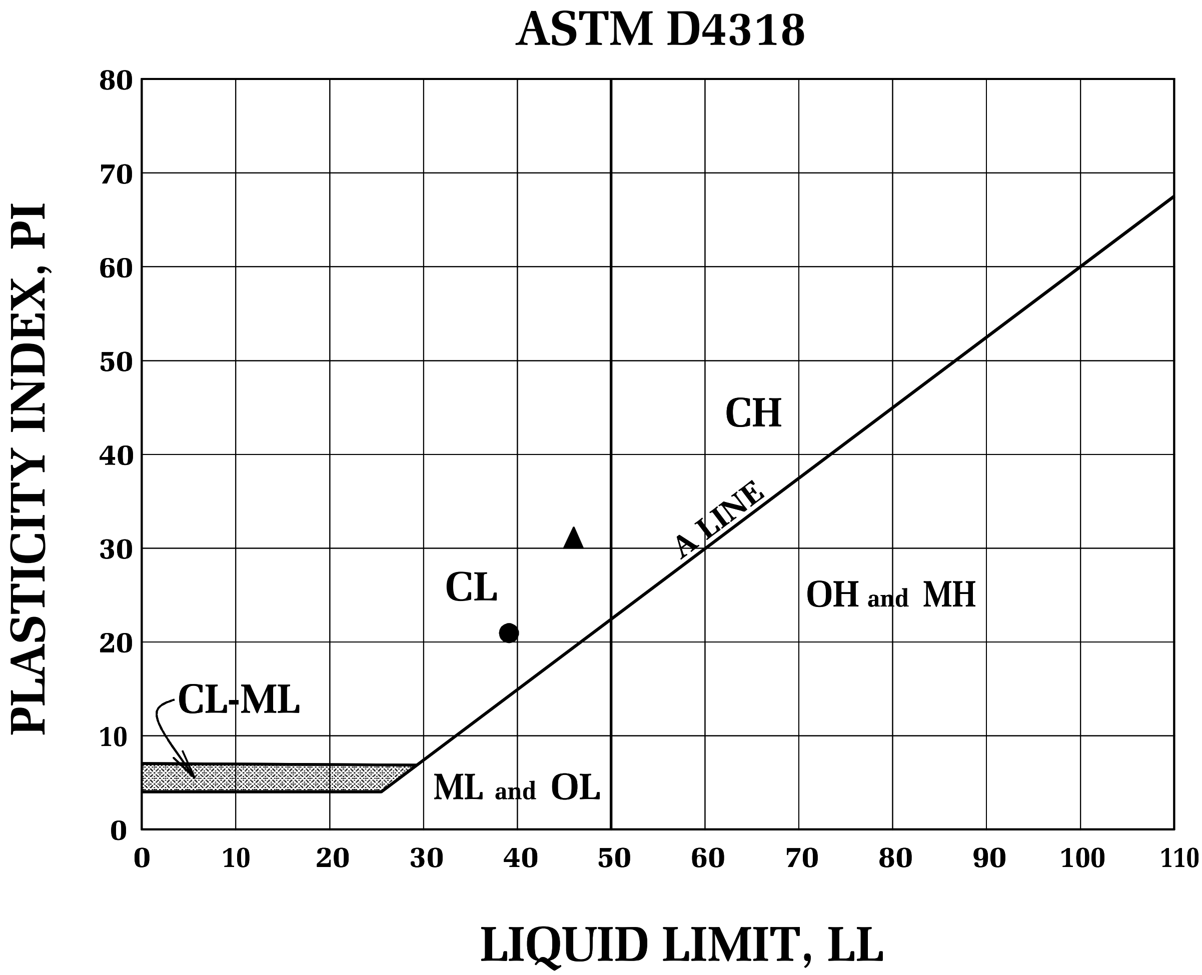
FILE NO. 21849 | PLATE: F-1



BORING NUMBER	DEPTH (FEET)	TEST SYMBOL	LL	PL	PI	DESCRIPTION
B2	15	●	39	18	21	CL
B2	35	▲	46	15	31	CL

ATTERBERG LIMITS DETERMINATION

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FARING
1011 N. SYCAMORE AVENUE, LOS ANGELES

FILE NO. 21849 | PLATE: F-2

Geotechnologies, Inc.

Project: FARING
File No.: 21849
Description: Liquefaction Analysis
Boring No: B1

LIQUEFACTION EVALUATION (Idriss & Boulanger, EERI NO 12)

EARTHQUAKE INFORMATION:

Earthquake Magnitude (M):	6.9
Peak Ground Horizontal Acceleration, PGA (g):	0.99
Calculated Mag.Wtg.Factor:	1.171

GROUNDWATER INFORMATION:

Current Groundwater Level (ft):	18.0
Historically Highest Groundwater Level* (ft):	10.0
Unit Weight of Water (pcf):	62.4

* Based on California Geological Survey Seismic Hazard Evaluation Report

BOREHOLE AND SAMPLER INFORMATION:

Borehole Diameter (inches):	8
SPT Sampler with room for Liner (Y/N):	Y

LIQUEFACTION BOUNDARY:

Plastic Index Cut Off (PI):	18
Minimum Liquefaction FS:	1.3

Depth to Base Layer (feet)	Total Unit Weight (pcf)	Current Water Level (feet)	Historical Water Level (feet)	Field SPT Blowcount N	Depth of SPT Blowcount (feet)	Fines Content #200 Sieve (%)	Plastic Index (PI)	Vetical Stress σ_{vc}, (psf)	Effective Vert. Stress σ_{vc}', (psf)	Fines Corrected $(N_1)_{60-cs}$	Stress Reduction Coeff, r_d	Cyclic Shear Ratio CSR	Mag. Scaling Factor (Sand) MSF	Overburden Corr. Factor K_σ	Cyclic Resist. Ratio $CRR_{M7.5,\sigma vc'=1}$	Cyclic Resistance Ratio (CRR)	Factor of Safety CRR/CSR (F.S.)	Liquefaction Settlment ΔS_i (inches)
1	126.9	Unsaturated	Unsaturated	17	10	71.8	23	126.9	126.9	46.1	1.00	0.646	1.17	1.10	2.000	2.000	Non-Liq.	0.00
2	126.9	Unsaturated	Unsaturated	17	10	71.8	23	253.8	253.8	46.1	1.00	0.644	1.17	1.10	2.000	2.000	Non-Liq.	0.00
3	126.9	Unsaturated	Unsaturated	17	10	71.8	23	380.7	380.7	45.4	1.00	0.642	1.17	1.10	2.000	2.000	Non-Liq.	0.00
4	126.9	Unsaturated	Unsaturated	17	10	71.8	23	507.6	507.6	42.9	0.99	0.640	1.17	1.10	2.000	2.000	Non-Liq.	0.00
5	126.9	Unsaturated	Unsaturated	17	10	71.8	23	634.5	634.5	42.7	0.99	0.638	1.17	1.10	2.000	2.000	Non-Liq.	0.00
6	126.9	Unsaturated	Unsaturated	17	10	71.8	23	761.4	761.4	41.0	0.99	0.636	1.17	1.10	2.000	2.000	Non-Liq.	0.00
7	126.9	Unsaturated	Unsaturated	17	10	71.8	23	888.3	888.3	39.4	0.98	0.633	1.17	1.10	2.000	2.000	Non-Liq.	0.00
8	126.9	Unsaturated	Unsaturated	17	10	71.8	23	1015.2	1015.2	37.7	0.98	0.631	1.17	1.10	2.000	2.000	Non-Liq.	0.00
9	126.9	Unsaturated	Unsaturated	17	10	71.8	23	1142.1	1142.1	38.3	0.98	0.628	1.17	1.10	2.000	2.000	Non-Liq.	0.00
10	126.9	Unsaturated	Unsaturated	17	10	71.8	23	1269.0	1269.0	37.0	0.97	0.626	1.17	1.10	1.740	2.000	Non-Liq.	0.00
11	126.9	Unsaturated	Saturated	17	10	71.8	23	1395.9	1333.5	35.8	0.97	0.652	1.17	1.10	1.307	1.684	Non-Liq.	0.00
12	126.9	Unsaturated	Saturated	17	10	71.8	23	1522.8	1398.0	34.7	0.96	0.676	1.17	1.08	1.036	1.315	Non-Liq.	0.00
13	126.9	Unsaturated	Saturated	17	10	71.8	23	1649.7	1462.5	33.7	0.96	0.696	1.17	1.06	0.854	1.061	Non-Liq.	0.00
14	126.9	Unsaturated	Saturated	17	10	71.8	23	1776.6	1527.0	32.7	0.95	0.715	1.17	1.04	0.727	0.886	Non-Liq.	0.00
15	126.9	Unsaturated	Saturated	17	10	71.8	23	1903.5	1591.5	35.5	0.95	0.731	1.17	1.03	1.243	1.496	Non-Liq.	0.00
16	120.6	Unsaturated	Saturated	17	10	71.8	23	2024.1	1649.7	34.7	0.95	0.747	1.17	1.01	1.047	1.239	Non-Liq.	0.00
17	120.6	Unsaturated	Saturated	17	10	71.8	23	2144.7	1707.9	34.0	0.94	0.760	1.17	1.00	0.901	1.052	Non-Liq.	0.00
18	120.6	Unsaturated	Saturated	17	10	71.8	23	2265.3	1766.1	33.2	0.94	0.772	1.17	0.98	0.791	0.911	Non-Liq.	0.00
19	120.6	Saturated	Saturated	17	10	71.8	23	2385.9	1824.3	32.9	0.93	0.783	1.17	0.98	0.747	0.855	Non-Liq.	0.00
20	120.6	Saturated	Saturated	17	10	71.8	23	2506.5	1882.5	32.6	0.93	0.793	1.17	0.97	0.708	0.806	Non-Liq.	0.00
21	120.6	Saturated	Saturated	35	20	0.0	0	2627.1	1940.7	59.8	0.92	0.802	1.17	0.96	2.000	2.000	2.9	0.00
22	120.6	Saturated	Saturated	35	20	0.0	0	2747.7	1998.9	59.4	0.92	0.810	1.17	0.95	2.000	2.000	2.9	0.00
23	120.6	Saturated	Saturated	35	20	0.0	0	2868.3	2057.1	59.1	0.91	0.817	1.17	0.94	2.000	2.000	2.9	0.00
24	120.6	Saturated	Saturated	35	20	0.0	0	2988.9	2115.3	58.7	0.90	0.823	1.17	0.94	2.000	2.000	2.8	0.00
25	120.6	Saturated	Saturated	35	20	0.0	0	3109.5	2173.5	58.4	0.90	0.828	1.17	0.93	2.000	2.000	2.8	0.00
26	121.3	Saturated	Saturated	47	30	0.0	0	3230.8	2232.4	78.0	0.89	0.833	1.17	0.92	2.000	2.000	2.8	0.00
27	121.3	Saturated	Saturated	47	30	0.0	0	3352.1	2291.3	77.5	0.89	0.837	1.17	0.92	2.000	2.000	2.8	0.00
28	121.3	Saturated	Saturated	47	30	0.0	0	3473.4	2350.2	81.2	0.88	0.840	1.17	0.91	2.000	2.000	2.8	0.00
29	121.3	Saturated	Saturated	47	30	0.0	0	3594.7	2409.1	80.7	0.88	0.843	1.17	0.91	2.000	2.000	2.8	0.00
30	121.3	Saturated	Saturated	47	30	0.0	0	3716.0	2468.0	80.3	0.87	0.845	1.17	0.90	2.000	2.000	2.8	0.00
31	121.3	Saturated	Saturated	47	30	0.0	0	3837.3	2526.9	79.9	0.87	0.847	1.17	0.89	2.000	2.000	2.8	0.00
32	121.3	Saturated	Saturated	47	30	0.0	0	3958.6	2585.8	79.5	0.86	0.848	1.17	0.89	2.000	2.000	2.7	0.00
33	121.3	Saturated	Saturated	47	30	0.0	0	4079.9	2644.7	79.1	0.85	0.849	1.17	0.88	2.000	2.000	2.7	0.00
34	121.3	Saturated	Saturated	47	30	0.0	0	4201.2	2703.6	78.7	0.85	0.849	1.17	0.88	2.000	2.000	2.7	0.00
35	121.3	Saturated	Saturated	47	30	0.0	0	4322.5	2762.5	78.3	0.84	0.849	1.17	0.87	2.000	2.000	2.7	0.00
36	132.8	Saturated	Saturated	47	30	0.0	0	4455.3	2832.9	77.9	0.84	0.848	1.17	0.87	2.000	2.000	2.7	0.00
37	132.8	Saturated	Saturated	47	30	0.0	0	4588.1	2903.3	77.4	0.83	0.846	1.17	0.86	2.000	2.000	2.8	0.00
38	132.8	Saturated	Saturated	47	30	0.0	0	4720.9	2973.7	77.0	0.83	0.844	1.17	0.85	2.000	1.998	2.8	0.00
39	132.8	Saturated	Saturated	47	30	0.0	0	4853.7	3044.1	76.6	0.82	0.842	1.17	0.85	2.000	1.984	2.7	0.00
40	132.8	Saturated	Saturated	47	30	0.0	0	4986.5	3114.5	76.2	0.81	0.839	1.17	0.84	2.000	1.971	2.7	0.00
41	132.8	Saturated	Saturated	22	40	78.2	34	5119.3	3184.9	38.1	0.81	0.836	1.17	0.84	2.000	1.957	Non-Liq.	0.00
42	132.8	Saturated	Saturated	22	40	78.2	34	5252.1	3255.3	37.8	0.80	0.834	1.17	0.83	2.000	1.944	Non-Liq.	0.00
43	132.8	Saturated	Saturated	22	40	78.2	34	5384.9	3325.7	37.5	0.80	0.831	1.17	0.82	2.000	1.931	Non-Liq.	0.00
44	132.8	Saturated	Saturated	22	40	78.2	34	5517.7	3396.1	37.3	0.79	0.827	1.17	0.82	1.867	1.791	Non-Liq.	0.00
45	125.8	Saturated	Saturated	22	40	78.2	34	5643.5	3459.5	37.0	0.79	0.825	1.17	0.81	1.750	1.669	Non-Liq.	0.00
46	125.8	Saturated	Saturated	22	40	78.2	34	5769.3	3522.9	36.7	0.78	0.822	1.17	0.81	1.644	1.565	Non-Liq.	0.00
47	125.8	Saturated	Saturated	22	40	78.2	34	5895.1	3586.3	36.5	0.77	0.819	1.17	0.81	1.549	1.471	Non-Liq.	0.00
48	125.8	Saturated	Saturated	22	40	78.2	34	6020.9	3649.7	36.3	0.77	0.816	1.17	0.81	1.463	1.386	Non-Liq.	0.00
49	125.8	Saturated	Saturated	22	40	78.2	34	6146.7	3713.1	36.0	0.76	0.813	1.17	0.81	1.384	1.309	Non-Liq.	0.00
50	125.8	Saturated	Saturated	22	40	78.2	34	6272.5	3776.5	35.8	0.76	0.809	1.17	0.81	1.312	1.239	Non-Liq.	0.00
51	125.8	Saturated	Saturated	30	50	26.6	0	6398.3	3839.9	51.6	0.75	0.806	1.17	0.79	2.000	1.844	2.7	0.00
52	125.8	Saturated	Saturated	30	50	26.6	0	6524.1	3903.3	51.4	0.75	0.802	1.17	0.78	2.000	1.834	2.7	0.00
53	125.8	Saturated	Saturated	30	50	26.6	0	6649.9	3966.7	51.2	0.74	0.799	1.17	0.78	2.000	1.824	2.7	0.00
54	125.8	Saturated	Saturated	30	50	26.6	0	6775.7	4030.1	51.0	0.73	0.795	1.17	0.77	2.000	1.815	2.7	0.00
55	125.8	Saturated	Saturated	30	50	26.6	0	6901.5	4093.5	50.8	0.73	0.792	1.17	0.77	2.000	1.805	2.7	0.00
56	139.8	Saturated	Saturated	30	50	26.6	0	7041.3	4170.9	50.5	0.72	0.787	1.17	0.77	2.000	1.793	2.7	0.00
57	139.8	Saturated	Saturated	30	50	26.6	0	7181.1	4248.3	50.3	0.72	0.782	1.17	0.76	2.000	1.782	2.7	0.00
58	139.8	Saturated	Saturated	30	50	26.6	0	7320.9	4325.7	50.0	0.71	0.777	1.17	0.76	2.000	1.771	2.7	0.00
59	139.8	Saturated	Saturated	30	50	26.6	0	7460.7	4403.1	49.8	0.71	0.772	1.17	0.75	2.000	1.760	2.7	0.00
60	139.8	Saturated	Saturated	30	50	26.6	0	7600.5	4480.5	49.6	0.70	0.768	1.17	0.75	2.000	1.749	2.7	0.00
61	139.8	Saturated	Saturated	33	60	31.2	0	7740.3	4557.9	54.4	0.70	0.763	1.17	0.74	2.000	1.738	2.7	0.00
62	139.8	Saturated	Saturated	33	60	31.2	0	7880.1	4635.3	54.2	0.69	0.758	1.17	0.74	2.000	1.728	2.7	0.00
63	139.8	Saturated	Saturated	33	60	31.2	0	8019.9	4712.7	54.0	0.69	0.753	1.17	0.73	2.000	1.717	2.7	0.00
64	139.8	Saturated	Saturated	33	60	31.2	0	8159.7	4790.1	53.8	0.68	0.749	1.17	0.73	2.000	1.707	2.7	0.00
65	139.8	Saturated	Saturated	33	60	31.2	0	8299.5	4867.5	53.6	0.68	0.744	1.17	0.72	2.000	1.697	2.7	0.00
66	122.9	Saturated	Saturated	33	60	31.2	0	8422.4	4928.0	53.5	0.67	0.740	1.17	0.72	2.000	1.690	2.7	0.00
67	122.9	Saturated	Saturated	33	60	31.2	0	8545.3	4988.5	53.4	0.67	0.737	1.17	0.72	2.000	1.682	2.7	0.00
68	122.9	Saturated	Saturated	33	60	31.2	0	8668.2	5049.0	53.2	0.66	0.733	1.17	0.71	2.000	1.674	2.7	0.00
69	122.9	Saturated	Saturated	33	60	31.2	0	8791.1	5109.5	53.1	0.66	0.730	1.17	0.71	2.000	1.667	2.7	0.00
70	122.9	Saturated	Saturated	33	60	31.2	0	8914.0	5170.0	53.0	0.65	0.726	1.17	0.71	2.000	1.659	2.7	0.00
71	122.9	Saturated	Saturated	54	70	0.0	0	9036.9	5230.5	77.6	0.65	0.723	1.17	0.71	2.000	1.652	2.7	0.00
72	122.9	Saturated	Saturated	54	70	0.0	0	9159.8	5291.0	77.4	0.65	0.720	1.17	0.70	2.000	1.645	2.7	0.00
73	122.9	Saturated	Saturated	54	70	0.0	0	9282.7	5351.5	77.2	0.64	0.716	1.17	0.70	2.000	1.638	2.7	0.00
74	122.9	Saturated	Saturated	54	70	0.0	0	9405.6	5412.0	76.9	0.64	0.713	1.17	0.70	2.000	1.630	2.7	0.00
75	122.9	Saturated	Saturated	54	70	0.0	0	9528.5	5472.5	76.7	0.63	0.709	1.17	0.69	2.000	1.623	2.7	0.00
76	123.9	Saturated	Saturated	54	70	0.0	0	9652.4	5534.0	76.5	0.63	0.706	1.17	0.69	2.000	1.616	2.7	0.00
77	123.9	Saturated	Saturated	54	70	0.0	0	9776.3	5595.5	76.3	0.63	0.703	1.17	0.69	2.000	1.609	2.7	0.00
78	123.9	Saturated	Saturated	54	70	0.0	0	9900.2	5657.0	76.1	0.62	0.700	1.17	0.68	2.000	1.602	2.7	0.00
79	123.9	Saturated	Saturated	54	70	0.0	0	10024.1	5718.5	75.9	0.62	0.696	1.17	0.68	2.000	1.596	2.7	0.00
80	123.9	Saturated	Saturated	54	70	0.0	0	10148.0	5780.0	75.7	0.61	0.693	1.17	0.68	2.000	1.589	2.7	0.00
81	123.9	Saturated	Saturated	36	80	45.6	0	10271.9	5841.5	56.0	0.61	0.690	1.17	0.68	2.000	1.582	2.7	0.00
82	123.9	Saturated	Saturated	36	80	45.6	0	10395.8	5903.0	55.8	0.61	0.687	1.17	0.67	2.000	1.575	2.7	0.00
83	123.9	Saturated	Saturated	36	80	45.6	0	10519.7	5964.5	55.7	0.60	0.684	1.17	0.67	2.000	1.569	2.7	0.00
84	123.9	Saturated	Saturated	36	80	45.6	0	10643.6	6026.0	55.6	0.60	0.682	1.17	0.67	2.000	1.562	2.7	0.00
85	123.9	Saturated	Saturated	36	80	45.6	0	10767.5	6087.5	55.5	0.60	0.679	1.17	0.66	2.000	1.556	2.7	0.00
86	120.3	Saturated	Saturated	36	80	45.6	0	10887.8	6145.4	55.4	0.59	0.676	1.17	0.66	2.000	1.550	2.7	0.00
87	120.3	Saturated	Saturated	36	80	45.6	0	11008.1	6203.3	55.2	0.59	0.674	1.17	0.66	2.000	1.544	2.7	0.00
88	120.3	Saturated	Saturated	36	80	45.6	0	11128.4	6261.2	55.1	0.59	0.671	1.17	0.66	2.000	1.538	2.7	0.00
89	120.3	Saturated	Saturated	36	80	45.6	0	11248.7	6319.1	55.0	0.58	0.669	1.17	0.65	2.000	1.532	2.7	0.00
90	120.3	Saturated	Saturated	36	80	45.6	0	11369.0	6377.0	54.9	0.58	0.667	1.17	0.65	2.000	1.526	2.7	0.00
91	120.3	Saturated	Saturated	48	90	0.0	0	11609.6	6555.2	65.3	0.58	0.659	1.17	0.64	2.000	1.508	2.7	0.00
92	120.3	Saturated	Saturated	48	90	0.0	0	11729.9	6613.1	65.1	0.58	0.657	1.17	0.64	2.000	1.503	2.7	0.00
93	120.3	Saturated	Saturated	48	90	0.0	0	11850.2	6671.0	65.0	0.57	0.655	1.17	0.64	2.000	1.497	2.7	0.00
94	120.3	Saturated	Saturated	48	90	0.0	0	11970.5	6728.9	64.9	0.57	0.653	1.17	0.64	2.000	1.491	2.7	0.00
95	120.3	Saturated	Saturated	48	90	0.0	0	12090.8	6786.8	64.7	0.57	0.651	1.17	0.63	2.000	1.486	2.7	0.00
96	120.3	Saturated	Saturated	48	90	0.0	0	12211.1	6844.7	64.6	0.57	0.650	1.17	0.63	2.000	1.480	2.7	0.00
97	120.3	Saturated	Saturated	48	90	0.0	0	12331.4	6902.6	64.5	0.56	0.648	1.17	0.63	2.000	1.475	2.7	0.00
98	120.3	Saturated	Saturated	48	90	0.0	0	12451.7	6960.5	64.3	0.56	0.646	1.17	0.63	2.000	1.470	2.6	0.00
99	120.3	Saturated	Saturated	48	90	0.0	0	12572.0	7018.4	64.2	0.56	0.645	1.17	0.63	2.000	1.464	2.6	0.00
100	120.3	Saturated	Saturated	48	90	0.0	0	12692.3	7076.3	64.1	0.56	0.644	1.17	0.62	2.000	1.459	2.6	0.00
101	121.6	Saturated	Saturated	38	100	54.3	0	12813.9	7135.5	56.2	0.56	0.642	1.17	0.62	2.000	1.454	2.6	0.00
102	121.6	Saturated	Saturated	38	100	54.3	0	12935.5	7194.7	56.1	0.55	0.641	1.17	0.62	2.000	1.448	2.6	0.00
103	121.6	Saturated	Saturated	38	100	54.3	0	13057.1	7253.9	56.0	0.55	0.640	1.17	0.62	2.000	1.443	2.6	0.00
104	121.6	Saturated	Saturated	38	100	54.3	0	13178.7	7313.1	55.9	0.55	0.639	1.17	0.61	2.000	1.438	2.6	0.00
105	134.5	Saturated	Saturated	38	100	54.3	0	13313.2	7385.2	55.8	0.55	0.637	1.17	0.61	2.000	1.431	2.6	0.00
106	134.5	Saturated	Saturated	79	110	0.0	0	13447.7	7457.3	104.1	0.55	0.636	1.17	0.61	2.000	1.425	2.6	0.00
107	134.5	Saturated	Saturated	79	110	0.0	0	13582.2	7529.4	103.9	0.55	0.635	1.17	0.61	2.000	1.419	2.6	0.00
108	134.5	Saturated	Saturated	79	110	0.0	0	13716.7	7601.5	103.6	0.55	0.634	1.17	0.60	2.000	1.413	2.6	0.00
109	134.5	Saturated	Saturated	79	110	0.0	0	13851.2	7673.6	103.4	0.54	0.633	1.17	0.60	2.000	1.406	2.6	0.00
110	134.5	Saturated	Saturated	79	110	0.0	0	13985.7	7745.7	103.1	0.54	0.632	1.17	0.60	2.000	1.400	2.6	0.00
111	134.5	Saturated	Saturated	79	110	0.0	0	14120.2	7817.8	102.9	0.54	0.631	1.17	0.60	2.000	1.394	2.6	0.00
112	134.5	Saturated	Saturated	79	110	0.0	0	14254.7	7889.9	102.7	0.54	0.630	1.17	0.59	2.000	1.388	2.6	0.00
113	134.5	Saturated	Saturated	79	110	0.0	0	14389.2	7962.0	102.4	0.54	0.630	1.17	0.59	2.000	1.383	2.6	0.00
114	134.5	Saturated	Saturated	79	110	0.0	0	14523.7	8034.1	102.2	0.54	0.629	1.17	0.59	2.000	1.377	2.5	0.00
115	134.5	Saturated	Saturated	79	110	0.0	0	14658.2	8106.2	102.0	0.54	0.629	1.17	0.59	2.000	1.371	2.5	0.00
116	127.1	Saturated	Saturated	61	120	0.0	0	14785.3	8170.9	78.6	0.54	0.629	1.17	0.58	2.000	1.366	2.5	0.00
117	127.1	Saturated	Saturated	61	120	0.0	0	14912.4	8235.6	78.4	0.54	0.629	1.17	0.58	2.000	1.361	2.5	0.00
118	127.1	Saturated	Saturated	61	120	0.0	0	15039.5	8300.3	78.3	0.54	0.629	1.17	0.58	2.000	1.355	2.5	0.00
119	127.1	Saturated	Saturated	61	120	0.0	0	15166.6	8365.0	78.1	0.54	0.630	1.17	0.58	2.000	1.350	2.5	0.00
120	127.1	Saturated	Saturated	61	120	0.0	0	15293.7	8429.7	78.0	0.54	0.630	1.17	0.57	2.000	1.345	2.5	0.00
121	127.1	Saturated	Saturated	61	120	0.0	0	15420.8	8494.4	77.8	0.54	0.631	1.17	0.57	2.000	1.340	2.5	0.00
122	127.1	Saturated	Saturated	61	120	0.0	0	15547.9	8559.1	77.7	0.54	0.631	1.17	0.57	2.000	1.335	2.5	0.00
123	127.1	Saturated	Saturated	61	120	0.0	0	15675.0	8623.8	77.5	0.54	0.632	1.17	0.57	2.000	1.330	2.5	0.00
124	127.1	Saturated	Saturated	61	120	0.0	0	15802.1	8688.5	77.4	0.54	0.633	1.17	0.57	2.000	1.326	2.4	0.00
125	127.1	Saturated	Saturated	61	120	0.0	0	15929.2	8753.2	77.3	0.54	0.634	1.17	0.56	2.000	1.321	2.4	0.00
126	129.1	Saturated	Saturated	61	120	0.0	0	16058.3	8819.9	77.1	0.54	0.635	1.17	0.56	2.000	1.316	2.4	0.00
127	129.1	Saturated	Saturated	61	120	0.0	0	16187.4	8886.6	77.0	0.54	0.636	1.17	0.56	2.000	1.311	2.4	0.00
128	129.1	Saturated	Saturated	61	120	0.0	0	16316.5	8953.3	76.8	0.54	0.638	1.17	0.56	2.000	1.306	2.4	0.00
129	129.1	Saturated	Saturated	61	120	0.0	0	16445.6	9020.0	76.7	0.54	0.639	1.17	0.56	2.000	1.301	2.4	0.00
130	129.1	Saturated	Saturated	50	130	0.0	0	16574.7	9086.7	62.7	0.55	0.641	1.17	0.55	2.000	1.296	2.4	0.00

Geotechnologies, Inc.

Project: FARING
File No.: 21849
Description: Liquefaction Analysis
Boring No: B2

LIQUEFACTION EVALUATION (Idriss & Boulanger, EERI NO 12)

EARTHQUAKE INFORMATION:	
Earthquake Magnitude (M):	6.9
Peak Ground Horizontal Acceleration, PGA (g):	0.99
Calculated Mag.Wtg.Factor:	1.171
GROUNDWATER INFORMATION:	
Current Groundwater Level (ft):	18.0
Historically Highest Groundwater Level* (ft):	10.0
Unit Weight of Water (pcf):	62.4

* Based on California Geological Survey Seismic Hazard Evaluation Report

BOREHOLE AND SAMPLER INFORMATION:	
Borehole Diameter (inches):	8
SPT Sampler with room for Liner (Y/N):	Y
LIQUEFACTION BOUNDARY:	
Plastic Index Cut Off (PI):	18
Minimum Liquefaction FS:	1.3

Depth to Base Layer (feet)	Total Unit Weight (pcf)	Current Water Level (feet)	Historical Water Level (feet)	Field SPT Blowcount N	Depth of SPT Blowcount (feet)	Fines Content #200 Sieve (%)	Plastic Index (PI)	Vetical Stress σ_{vc}, (psf)	Effective Vert. Stress σ_{vc}', (psf)	Fines Corrected $(N_1)_{60\text{-}cs}$	Stress Reduction Coeff, r_d	Cyclic Shear Ratio CSR	Mag. Scaling Factor (Sand) MSF	Overburden Corr. Factor K_σ	Cyclic Resist. Ratio $CRR_{M7.5,\sigma vc'=1}$	Cyclic Resistance Ratio (CRR)	Factor of Safety CRR/CSR (F.S.)	Liquefaction Settlment ΔS_i (inches)
1	133.6	Unsaturated	Unsaturated	5	5	0.0	0	133.6	133.6	10.1	1.00	0.646	1.17	1.10	0.119	0.153	Non-Liq.	0.00
2	133.6	Unsaturated	Unsaturated	5	5	0.0	0	267.2	267.2	10.1	1.00	0.644	1.17	1.10	0.119	0.153	Non-Liq.	0.00
3	133.6	Unsaturated	Unsaturated	5	5	0.0	0	400.8	400.8	10.1	1.00	0.642	1.17	1.10	0.119	0.153	Non-Liq.	0.00
4	133.6	Unsaturated	Unsaturated	5	5	0.0	0	534.4	534.4	10.1	0.99	0.640	1.17	1.10	0.119	0.153	Non-Liq.	0.00
5	133.6	Unsaturated	Unsaturated	5	5	0.0	0	668.0	668.0	10.8	0.99	0.638	1.17	1.10	0.123	0.159	Non-Liq.	0.00
6	133.6	Unsaturated	Unsaturated	5	5	0.0	0	801.6	801.6	10.6	0.99	0.636	1.17	1.09	0.122	0.156	Non-Liq.	0.00
7	133.6	Unsaturated	Unsaturated	5	5	0.0	0	935.2	935.2	9.8	0.98	0.633	1.17	1.07	0.117	0.147	Non-Liq.	0.00
8	133.6	Unsaturated	Unsaturated	5	5	0.0	0	1068.8	1068.8	9.2	0.98	0.631	1.17	1.06	0.113	0.140	Non-Liq.	0.00
9	133.6	Unsaturated	Unsaturated	12	15	66.5	21	1202.4	1202.4	27.8	0.98	0.628	1.17	1.10	0.376	0.485	Non-Liq.	0.00
10	133.6	Unsaturated	Unsaturated	12	15	66.5	21	1336.0	1336.0	26.8	0.97	0.626	1.17	1.08	0.338	0.428	Non-Liq.	0.00
11	133.6	Unsaturated	Saturated	12	15	66.5	21	1469.6	1407.2	25.8	0.97	0.651	1.17	1.06	0.310	0.386	Non-Liq.	0.00
12	133.6	Unsaturated	Saturated	12	15	66.5	21	1603.2	1478.4	25.0	0.96	0.673	1.17	1.04	0.289	0.354	Non-Liq.	0.00
13	133.6	Unsaturated	Saturated	12	15	66.5	21	1736.8	1549.6	24.2	0.96	0.692	1.17	1.03	0.272	0.328	Non-Liq.	0.00
14	133.6	Unsaturated	Saturated	12	15	66.5	21	1870.4	1620.8	23.5	0.95	0.709	1.17	1.02	0.258	0.308	Non-Liq.	0.00
15	133.6	Unsaturated	Saturated	12	15	66.5	21	2004.0	1692.0	25.2	0.95	0.724	1.17	1.01	0.294	0.347	Non-Liq.	0.00
16	133.6	Unsaturated	Saturated	12	15	66.5	21	2137.6	1763.2	24.5	0.95	0.738	1.17	1.00	0.279	0.326	Non-Liq.	0.00
17	133.6	Unsaturated	Saturated	12	15	66.5	21	2271.2	1834.4	23.9	0.94	0.750	1.17	0.99	0.267	0.309	Non-Liq.	0.00
18	133.6	Unsaturated	Saturated	12	15	66.5	21	2404.8	1905.6	23.4	0.94	0.760	1.17	0.98	0.256	0.294	Non-Liq.	0.00
19	133.6	Saturated	Saturated	12	15	66.5	21	2538.4	1976.8	23.1	0.93	0.769	1.17	0.98	0.251	0.287	Non-Liq.	0.00
20	133.6	Saturated	Saturated	12	15	66.5	21	2672.0	2048.0	22.8	0.93	0.777	1.17	0.97	0.246	0.281	Non-Liq.	0.00
21	134.0	Saturated	Saturated	12	15	66.5	21	2806.0	2119.6	22.6	0.92	0.784	1.17	0.97	0.242	0.274	Non-Liq.	0.00
22	134.0	Saturated	Saturated	12	15	66.5	21	2940.0	2191.2	22.3	0.92	0.791	1.17	0.96	0.238	0.269	Non-Liq.	0.00
23	134.0	Saturated	Saturated	12	15	66.5	21	3074.0	2262.8	22.1	0.91	0.796	1.17	0.96	0.234	0.264	Non-Liq.	0.00
24	134.0	Saturated	Saturated	12	15	66.5	21	3208.0	2334.4	21.8	0.90	0.800	1.17	0.96	0.231	0.259	Non-Liq.	0.00
25	134.0	Saturated	Saturated	12	15	66.5	21	3342.0	2406.0	21.6	0.90	0.804	1.17	0.95	0.227	0.254	Non-Liq.	0.00
26	134.0	Saturated	Saturated	36	25	0.0	0	3476.0	2477.6	58.4	0.89	0.807	1.17	0.90	2.000	2.000	2.9	0.00
27	134.0	Saturated	Saturated	36	25	0.0	0	3610.0	2549.2	58.0	0.89	0.810	1.17	0.89	2.000	2.000	2.9	0.00
28	134.0	Saturated	Saturated	36	25	0.0	0	3744.0	2620.8	60.7	0.88	0.812	1.17	0.88	2.000	2.000	2.9	0.00
29	134.0	Saturated	Saturated	36	25	0.0	0	3878.0	2692.4	60.3	0.88	0.813	1.17	0.88	2.000	2.000	2.9	0.00
30	134.0	Saturated	Saturated	36	25	0.0	0	4012.0	2764.0	60.0	0.87	0.814	1.17	0.87	2.000	2.000	2.9	0.00
31	124.3	Saturated	Saturated	22	35	74.2	31	4136.3	2825.9	39.8	0.87	0.816	1.17	0.87	2.000	2.000	Non-Liq.	0.00
32	124.3	Saturated	Saturated	22	35	74.2	31	4260.6	2887.8	39.5	0.86	0.817	1.17	0.86	2.000	2.000	Non-Liq.	0.00
33	124.3	Saturated	Saturated	22	35	74.2	31	4384.9	2949.7	39.2	0.85	0.818	1.17	0.85	2.000	2.000	Non-Liq.	0.00
34	124.3	Saturated	Saturated	22	35	74.2	31	4509.2	3011.6	38.9	0.85	0.818	1.17	0.85	2.000	1.991	Non-Liq.	0.00
35	124.3	Saturated	Saturated	22	35	74.2	31	4633.5	3073.5	38.6	0.84	0.818	1.17	0.84	2.000	1.979	Non-Liq.	0.00
36	124.3	Saturated	Saturated	22	35	74.2	31	4757.8	3135.4	38.4	0.84	0.818	1.17	0.84	2.000	1.967	Non-Liq.	0.00
37	124.3	Saturated	Saturated	22	35	74.2	31	4882.1	3197.3	38.1	0.83	0.817	1.17	0.83	2.000	1.955	Non-Liq.	0.00
38	124.3	Saturated	Saturated	22	35	74.2	31	5006.4	3259.2	37.8	0.83	0.817	1.17	0.83	2.000	1.944	Non-Liq.	0.00
39	124.3	Saturated	Saturated	22	35	74.2	31	5130.7	3321.1	37.6	0.82	0.815	1.17	0.82	2.000	1.932	Non-Liq.	0.00
40	124.3	Saturated	Saturated	22	35	74.2	31	5255.0	3383.0	37.3	0.81	0.814	1.17	0.82	1.899	1.824	Non-Liq.	0.00
41	132.6	Saturated	Saturated	22	35	74.2	31	5387.6	3453.2	37.0	0.81	0.812	1.17	0.81	1.767	1.686	Non-Liq.	0.00
42	132.6	Saturated	Saturated	22	35	74.2	31	5520.2	3523.4	36.8	0.80	0.809	1.17	0.81	1.649	1.569	Non-Liq.	0.00
43	132.6	Saturated	Saturated	22	35	74.2	31	5652.8	3593.6	36.5	0.80	0.807	1.17	0.81	1.543	1.465	Non-Liq.	0.00
44	132.6	Saturated	Saturated	22	35	74.2	31	5785.4	3663.8	36.2	0.79	0.804	1.17	0.81	1.449	1.372	Non-Liq.	0.00
45	132.6	Saturated	Saturated	22	35	74.2	31	5918.0	3734.0	36.0	0.79	0.801	1.17	0.81	1.364	1.289	Non-Liq.	0.00
46	132.6	Saturated	Saturated	24	45	56.3	0	6050.6	3804.2	39.8	0.78	0.798	1.17	0.79	2.000	1.850	2.7	0.00
47	132.6	Saturated	Saturated	24	45	56.3	0	6183.2	3874.4	39.5	0.77	0.795	1.17	0.78	2.000	1.839	2.7	0.00
48	130.0	Saturated	Saturated	28	50	14.4	0	6313.2	3942.0	45.4	0.77	0.792	1.17	0.78	2.000	1.828	2.7	0.00
49	130.0	Saturated	Saturated	28	50	14.4	0	6443.2	4009.6	45.2	0.76	0.789	1.17	0.78	2.000	1.818	2.7	0.00
50	130.0	Saturated	Saturated	28	50	14.4	0	6573.2	4077.2	45.0	0.76	0.786	1.17	0.77	2.000	1.807	2.7	0.00
51	130.0	Saturated	Saturated	28	50	14.4	0	6703.2	4144.8	44.7	0.75	0.782	1.17	0.77	2.000	1.797	2.7	0.00
52	130.0	Saturated	Saturated	28	50	14.4	0	6833.2	4212.4	44.4	0.75	0.779	1.17	0.76	2.000	1.787	2.7	0.00
53	131.8	Saturated	Saturated	28	50	14.4	0	6965.0	4281.8	44.1	0.74	0.775	1.17	0.76	2.000	1.777	2.7	0.00
54	131.8	Saturated	Saturated	28	50	14.4	0	7096.8	4351.2	43.8	0.73	0.771	1.17	0.75	2.000	1.767	2.7	0.00
55	131.8	Saturated	Saturated	28	50	14.4	0	7228.6	4420.6	43.6	0.73	0.768	1.17	0.75	2.000	1.757	2.7	0.00
56	131.8	Saturated	Saturated	32	55	13.3	0	7360.4	4490.0	50.3	0.72	0.764	1.17	0.75	2.000	1.748	2.7	0.00
57	131.8	Saturated	Saturated	32	55	13.3	0	7492.2	4559.4	50.1	0.72	0.760	1.17	0.74	2.000	1.738	2.7	0.00
58	132.9	Saturated	Saturated	32	55	13.3	0	7625.1	4629.9	50.0	0.71	0.756	1.17	0.74	2.000	1.729	2.7	0.00
59	132.9	Saturated	Saturated	32	55	13.3	0	7758.0	4700.4	49.8	0.71	0.752	1.17	0.73	2.000	1.719	2.7	0.00
60	132.9	Saturated	Saturated	32	55	13.3	0	7890.9	4770.9	49.6	0.70	0.748	1.17	0.73	2.000	1.710	2.7	0.00
61	132.9	Saturated	Saturated	30	60	24.4	0	8023.8	4841.4	48.3	0.70	0.744	1.17	0.73	2.000	1.701	2.7	0.00
62	132.9	Saturated	Saturated	30	60	24.4	0	8156.7	4911.9	48.1	0.69	0.740	1.17	0.72	2.000	1.692	2.7	0.00
63	130.4	Saturated	Saturated	30	60	24.4	0	8287.1	4979.9	47.9	0.69	0.737	1.17	0.72	2.000	1.683	2.7	0.00
64	130.4	Saturated	Saturated	30	60	24.4	0	8417.5	5047.9	47.7	0.68	0.733	1.17	0.71	2.000	1.674	2.7	0.00
65	130.4	Saturated	Saturated	30	60	24.4	0	8547.9	5115.9	47.5	0.68	0.729	1.17	0.71	2.000	1.666	2.7	0.00
66	130.4	Saturated	Saturated	44	65	0.0	0	8678.3	5183.9	63.4	0.67	0.725	1.17	0.71	2.000	1.658	2.7	0.00
67	130.4	Saturated	Saturated	44	65	0.0	0	8808.7	5251.9	63.2	0.67	0.722	1.17	0.70	2.000	1.649	2.7	0.00
68	134.2	Saturated	Saturated	44	65	0.0	0	8942.9	5323.7	62.9	0.66	0.718	1.17	0.70	2.000	1.641	2.7	0.00
69	134.2	Saturated	Saturated	44	65	0.0	0	9077.1	5395.5	62.7	0.66	0.714	1.17	0.70	2.000	1.632	2.7	0.00
70	134.2	Saturated	Saturated	44	65	0.0	0	9211.3	5467.3	62.5	0.65	0.710	1.17	0.69	2.000	1.624	2.7	0.00
71	134.2	Saturated	Saturated	47	70	0.0	0	9345.5	5539.1	66.6	0.65	0.706	1.17	0.69	2.000	1.616	2.7	0.00
72	134.2	Saturated	Saturated	47	70	0.0	0	9479.7	5610.9	66.4	0.65	0.702	1.17	0.69	2.000	1.608	2.7	0.00
73	123.7	Saturated	Saturated	47	70	0.0	0	9603.4	5672.2	66.2	0.64	0.699	1.17	0.68	2.000	1.601	2.7	0.00
74	123.7	Saturated	Saturated	47	70	0.0	0	9727.1	5733.5	66.0	0.64	0.696	1.17	0.68	2.000	1.594	2.7	0.00
75	123.7	Saturated	Saturated	47	70	0.0	0	9850.8	5794.8	65.9	0.63	0.693	1.17	0.68	2.000	1.587	2.7	0.00
76	123.7	Saturated	Saturated	35	75	19.9	0	9974.5	5856.1	53.4	0.63	0.690	1.17	0.67	2.000	1.580	2.7	0.00
77	123.7	Saturated	Saturated	35	75	19.9	0	10098.2	5917.4	53.3	0.63	0.687	1.17	0.67	2.000	1.574	2.7	0.00
78	121.4	Saturated	Saturated	34	80	0.0	0	10219.6	5976.4	47.3	0.62	0.684	1.17	0.67	2.000	1.567	2.7	0.00
79	121.4	Saturated	Saturated	34	80	0.0	0	10341.0	6035.4	47.2	0.62	0.681	1.17	0.67	2.000	1.561	2.7	0.00
80	121.4	Saturated	Saturated	34	80	0.0	0	10462.4	6094.4	47.1	0.61	0.678	1.17	0.66	2.000	1.555	2.7	0.00
81	121.4	Saturated	Saturated	34	80	0.0	0	10583.8	6153.4	47.0	0.61	0.675	1.17	0.66	2.000	1.549	2.7	0.00
82	121.4	Saturated	Saturated	34	80	0.0	0	10705.2	6212.4	46.9	0.61	0.673	1.17	0.66	2.000	1.543	2.7	0.00
83	133.5	Saturated	Saturated	34	80	0.0	0	10838.7	6283.5	46.7	0.60	0.669	1.17	0.66	2.000	1.535	2.7	0.00
84	133.5	Saturated	Saturated	34	80	0.0	0	10972.2	6354.6	46.6	0.60	0.666	1.17	0.65	2.000	1.528	2.7	0.00
85	133.5	Saturated	Saturated	34	80	0.0	0	11105.7	6425.7	46.5	0.60	0.663	1.17	0.65	2.000	1.521	2.7	0.00
86	133.5	Saturated	Saturated	31	85	77.5	0	11239.2	6496.8	45.9	0.59	0.660	1.17	0.65	2.000	1.514	2.7	0.00
87	133.5	Saturated	Saturated	31	85	77.5	0	11372.7	6567.9	45.7	0.59	0.657	1.17	0.64	2.000	1.507	2.7	0.00
88	130.3	Saturated	Saturated	31	85	77.5	0	11503.0	6635.8	45.4	0.59	0.655	1.17	0.64	2.000	1.500	2.7	0.00
89	130.3	Saturated	Saturated	31	85	77.5	0	11633.3	6703.7	45.2	0.58	0.652	1.17	0.64	2.000	1.494	2.7	0.00
90	130.3	Saturated	Saturated	31	85	77.5	0	11763.6	6771.6	45.0	0.58	0.650	1.17	0.63	2.000	1.487	2.7	0.00
91	130.3	Saturated	Saturated	35	90	0.0	0	12024.2	6969.8	46.9	0.58	0.642	1.17	0.63	2.000	1.469	2.7	0.00
92	130.3	Saturated	Saturated	35	90	0.0	0	12154.5	7037.7	46.8	0.58	0.640	1.17	0.62	2.000	1.462	2.7	0.00
93	121.4	Saturated	Saturated	35	90	0.0	0	12275.9	7096.7	46.7	0.57	0.638	1.17	0.62	2.000	1.457	2.7	0.00
94	121.4	Saturated	Saturated	35	90	0.0	0	12397.3	7155.7	46.6	0.57	0.636	1.17	0.62	2.000	1.452	2.7	0.00
95	121.4	Saturated	Saturated	35	90	0.0	0	12518.7	7214.7	46.5	0.57	0.634	1.17	0.62	2.000	1.446	2.7	0.00
96	121.4	Saturated	Saturated	33	95	6.3	0	12640.1	7273.7	42.7	0.57	0.633	1.17	0.62	2.000	1.441	2.7	0.00
97	121.4	Saturated	Saturated	33	95	6.3	0	12761.5	7332.7	42.6	0.56	0.631	1.17	0.61	2.000	1.436	2.6	0.00
98	128.9	Saturated	Saturated	74	100	0.0	0	12890.4	7399.2	97.7	0.56	0.630	1.17	0.61	2.000	1.430	2.6	0.00
99	128.9	Saturated	Saturated	74	100	0.0	0	13019.3	7465.7	97.5	0.56	0.628	1.17	0.61	2.000	1.424	2.6	0.00
100	128.9	Saturated	Saturated	74	100	0.0	0	13148.2	7532.2	97.3	0.56	0.626	1.17	0.61	2.000	1.419	2.6	0.00
101	128.9	Saturated	Saturated	74	100	0.0	0	13277.1	7598.7	97.1	0.56	0.625	1.17	0.60	2.000	1.413	2.6	0.00
102	128.9	Saturated	Saturated	74	100	0.0	0	13406.0	7665.2	96.9	0.55	0.624	1.17	0.60	2.000	1.407	2.6	0.00
103	139.7	Saturated	Saturated	74	100	0.0	0	13545.7	7742.5	96.6	0.55	0.622	1.17	0.60	2.000	1.401	2.6	0.00
104	139.7	Saturated	Saturated	74	100	0.0	0	13685.4	7819.8	96.4	0.55	0.620	1.17	0.60	2.000	1.394	2.6	0.00
105	139.7	Saturated	Saturated	74	100	0.0	0	13825.1	7897.1	96.1	0.55	0.619	1.17	0.59	2.000	1.388	2.6	0.00
106	139.7	Saturated	Saturated	49	105	0.0	0	13964.8	7974.4	63.5	0.55	0.618	1.17	0.59	2.000	1.382	2.6	0.00
107	139.7	Saturated	Saturated	49	105	0.0	0	14104.5	8051.7	63.4	0.55	0.617	1.17	0.59	2.000	1.375	2.6	0.00
108	124.8	Saturated	Saturated	43	110	0.0	0	14229.3	8114.1	55.5	0.55	0.616	1.17	0.58	2.000	1.370	2.6	0.00
109	124.8	Saturated	Saturated	43	110	0.0	0	14354.1	8176.5	55.4	0.54	0.615	1.17	0.58	2.000	1.365	2.6	0.00
110	124.8	Saturated	Saturated	43	110	0.0	0	14478.9	8238.9	55.3	0.54	0.615	1.17	0.58	2.000	1.360	2.6	0.00
111	124.8	Saturated	Saturated	43	110	0.0	0	14603.7	8301.3	55.2	0.54	0.615	1.17	0.58	2.000	1.355	2.6	0.00
112	124.8	Saturated	Saturated	43	110	0.0	0	14728.5	8363.7	55.1	0.54	0.614	1.17	0.58	2.000	1.350	2.6	0.00
113	121.6	Saturated	Saturated	43	110	0.0	0	14850.1	8422.9	55.0	0.54	0.614	1.17	0.57	2.000	1.346	2.6	0.00
114	121.6	Saturated	Saturated	43	110	0.0	0	14971.7	8482.1	54.9	0.54	0.614	1.17	0.57	2.000	1.341	2.5	0.00
115	121.6	Saturated	Saturated	43	110	0.0	0	15093.3	8541.3	54.8	0.54	0.615	1.17	0.57	2.000	1.337	2.5	0.00
116	121.6	Saturated	Saturated	33	115	66.1	0	15214.9	8600.5	44.8	0.54	0.615	1.17	0.57	2.000	1.332	2.5	0.00
117	121.6	Saturated	Saturated	33	115	66.1	0	15336.5	8659.7	44.6	0.54	0.615	1.17	0.57	2.000	1.328	2.5	0.00
118	128.5	Saturated	Saturated	33	115	66.1	0	15465.0	8725.8	44.5	0.54	0.616	1.17	0.56	2.000	1.323	2.5	0.00
119	128.5	Saturated	Saturated	33	115	66.1	0	15593.5	8791.9	44.3	0.54	0.616	1.17	0.56	2.000	1.318	2.5	0.00
120	128.5	Saturated	Saturated	33	115	66.1	0	15722.0	8858.0	44.2	0.54	0.616	1.17	0.56	2.000	1.313	2.5	0.00
121	128.5	Saturated	Saturated	48	120	0.0	0	15850.5	8924.1	60.5	0.54	0.617	1.17	0.56	2.000	1.308	2.5	0.00
122	128.5	Saturated	Saturated	48	120	0.0	0	15979.0	8990.2	60.4	0.54	0.618	1.17	0.56	2.000	1.303	2.5	0.00
123	125.5	Saturated	Saturated	48	120	0.0	0	16104.5	9053.3	60.3	0.54	0.619	1.17	0.55	2.000	1.299	2.4	0.00
124	125.5	Saturated	Saturated	48	120	0.0	0	16230.0	9116.4	60.2	0.54	0.620	1.17	0.55	2.000	1.294	2.4	0.00
125	125.5	Saturated	Saturated	48	120	0.0	0	16355.5	9179.5	60.1	0.54	0.621	1.17	0.55	2.000	1.290	2.4	0.00
126	125.5	Saturated	Saturated	54	120	0.0	0	16481.0	9242.6	67.5	0.54	0.622	1.17	0.55	2.000	1.285	2.4	0.00
127	125.5	Saturated	Saturated	54	120	0.0	0	16606.5	9305.7	67.4	0.54	0.623	1.17	0.55	2.000	1.281	2.4	0.00
128	125.9	Saturated	Saturated	54	120	0.0	0	16732.4	9369.2	67.2	0.54	0.625	1.17	0.54	2.000	1.276	2.4	0.00
129	125.9	Saturated	Saturated	54	120	0.0	0	16858.3	9432.7	67.1	0.54	0.627	1.17	0.54	2.000	1.272	2.4	0.00
130	125.9	Saturated	Saturated	54	120	0.0	0	16984.2	9496.2	67.0	0.55	0.628	1.17	0.54	2.000	1.267	2.3	0.00
131	125.9	Saturated	Saturated	56	130	0.0	0	17110.1	9559.7	69.4	0.55	0.630	1.17	0.54	2.000	1.263	2.3	0.00
132	125.9	Saturated	Saturated	56	130	0.0	0	17236.0	9623.2	69.3	0.55	0.632	1.17	0.54	2.000	1.259	2.3	0.00
133	125.9	Saturated	Saturated	56	130	0.0	0	17361.9	9686.7	69.2	0.55	0.634	1.17	0.54	2.000	1.254	2.3	0.00
134	125.9	Saturated	Saturated	56	130	0.0	0	17487.8	9750.2	69.0	0.55	0.636	1.17	0.53	2.000	1.250	2.3	0.00
135	125.9	Saturated	Saturated	56	130	0.0	0	17613.7	9813.7	68.9	0.55	0.639	1.17	0.53	2.000	1.246	2.3	0.00
136	127.3	Saturated	Saturated	56	130	0.0	0	17741.0	9878.6	68.8	0.55	0.641	1.17	0.53	2.000	1.241	2.3	0.00
137	127.3	Saturated	Saturated	56	130	0.0	0	17868.3	9943.5	68.7	0.56	0.643	1.17	0.53	2.000	1.237	2.2	0.00
138	127.3	Saturated	Saturated	56	130	0.0	0	17995.6	10008.4	68.6	0.56	0.646	1.17	0.53	2.000	1.233	2.2	0.00
139	127.3	Saturated	Saturated	56	130	0.0	0	18122.9	10073.3	68.5	0.56	0.649	1.17	0.52	2.000	1.229	2.2	0.00
140	127.3	Saturated	Saturated	56	130	0.0	0	18250.2	10138.2	68.4	0.56	0.652	1.17	0.52	2.000	1.224	2.2	0.00
141	127.3	Saturated	Saturated	47	140	0.0	0	18377.5	10203.1	57.3	0.56	0.655	1.17	0.52	2.000	1.220	2.2	0.00
142	127.3	Saturated	Saturated	47	140	0.0	0	18504.8	10268.0	57.2	0.57	0.658	1.17	0.52	2.000	1.216	2.2	0.00
143	127.3	Saturated	Saturated	47	140	0.0	0	18632.1	10332.9	57.1	0.57	0.661	1.17	0.52	2.000	1.212	2.1	0.00
144	127.3	Saturated	Saturated	47	140	0.0	0	18759.4	10397.8	57.0	0.57	0.664	1.17	0.52	2.000	1.208	2.1	0.00
145	127.3	Saturated	Saturated	47	140	0.0	0	18886.7	10462.7	56.9	0.57	0.668	1.17	0.51	2.000	1.204	2.1	0.00
146	126.3	Saturated	Saturated	47	140	0.0	0	19013.0	10526.6	56.8	0.58	0.671	1.17	0.51	2.000	1.200	2.1	0.00
147	126.3	Saturated	Saturated	47	140	0.0	0	19139.3	10590.5	56.8	0.58	0.675	1.17	0.51	2.000	1.196	2.1	0.00
148	126.3	Saturated	Saturated	47	140	0.0	0	19265.6	10654.4	56.7	0.58	0.679	1.17	0.51	2.000	1.192	2.0	0.00
149	126.3	Saturated	Saturated	47	140	0.0	0	19391.9	10718.3	56.6	0.59	0.683	1.17	0.51	2.000	1.188	2.0	0.00
150	126.3	Saturated	Saturated	47	140	0.0	0	19518.2	10782.2	56.5	0.59	0.687	1.17	0.51	2.000	1.184	2.0	0.00
151	126.3	Saturated	Saturated	61	150	0.0	0	19644.5	10846.1	73.2	0.59	0.692	1.17	0.50	2.000	1.180	2.0	0.00
152	126.3	Saturated	Saturated	61	150	0.0	0	19770.8	10910.0	73.1	0.60	0.696	1.17	0.50	2.000	1.176	2.0	0.00
153	126.3	Saturated	Saturated	61	150	0.0	0	19897.1	10973.9	73.0	0.60	0.701	1.17	0.50	2.000	1.172	1.9	0.00
154	126.3	Saturated	Saturated	61	150	0.0	0	20023.4	11037.8	72.9	0.60	0.705	1.17	0.50	2.000	1.168	1.9	0.00
155	126.3	Saturated	Saturated	61	150	0.0	0	20149.7	11101.7	72.8	0.61	0.710	1.17	0.50	2.000	1.164	1.9	0.00
156	124.4	Saturated	Saturated	61	150	0.0	0	20274.1	11163.7	72.7	0.61	0.715	1.17	0.50	2.000	1.161	1.9	0.00
157	124.4	Saturated	Saturated	61	150	0.0	0	20398.5	11225.7	72.6	0.62	0.720	1.17	0.49	2.000	1.157	1.9	0.00
158	124.4	Saturated	Saturated	61	150	0.0	0	20522.9	11287.7	72.5	0.62	0.725	1.17	0.49	2.000	1.153	1.9	0.00
159	124.4	Saturated	Saturated	61	150	0.0	0	20647.3	11349.7	72.4	0.62	0.731	1.17	0.49	2.000	1.150	1.8	0.00
160	124.4	Saturated	Saturated	61	150	0.0	0	20771.7	11411.7	72.3	0.63	0.736	1.17	0.49	2.000	1.146	1.8	0.00
161	124.4	Saturated	Saturated	50	160	0.0	0	20896.1	11473.7	59.2	0.63	0.742	1.17	0.49	2.000	1.143	1.8	0.00
162	124.4	Saturated	Saturated	50	160	0.0	0	21020.5	11535.7	59.1	0.64	0.748	1.17	0.49	2.000	1.139	1.8	0.00
163	124.4	Saturated	Saturated	50	160	0.0	0	21144.9	11597.7	59.0	0.64	0.754	1.17	0.48	2.000	1.135	1.8	0.00
164	124.4	Saturated	Saturated	50	160	0.0	0	21269.3	11659.7	58.9	0.65	0.760	1.17	0.48	2.000	1.132	1.7	0.00
165	124.4	Saturated	Saturated	50	160	0.0	0	21393.7	11721.7	58.9	0.65	0.766	1.17	0.48	2.000	1.128	1.7	0.00
166	131.6	Saturated	Saturated	50	160	0.0	0	21525.3	11790.9	58.8	0.66	0.772	1.17	0.48	2.000	1.124	1.7	0.00
167	131.6	Saturated	Saturated	50	160	0.0	0	21656.9	11860.1	58.7	0.66	0.778	1.17	0.48	2.000	1.121	1.7	0.00
168	131.6	Saturated	Saturated	50	160	0.0	0	21788.5	11929.3	58.6	0.67	0.784	1.17	0.48	2.000	1.117	1.7	0.00
169	131.6	Saturated	Saturated	50	160	0.0	0	21920.1	11998.5	58.5	0.67	0.791	1.17	0.48	2.000	1.113	1.6	0.00
170	131.6	Saturated	Saturated	50	160	0.0	0	22051.7	12067.7	58.4	0.68	0.797	1.17	0.47	2.000	1.109	1.6	0.00
171	131.6	Saturated	Saturated	57	170	0.0	0	22183.3	12136.9	66.5	0.68	0.804	1.17	0.47	2.000	1.105	1.6	0.00
172	131.6	Saturated	Saturated	57	170	0.0	0	22314.9	12206.1	66.4	0.69	0.811	1.17	0.47	2.000	1.101	1.6	0.00
173	131.6	Saturated	Saturated	57	170	0.0	0	22446.5	12275.3	66.3	0.69	0.818	1.17	0.47	2.000	1.098	1.6	0.00
174	131.6	Saturated	Saturated	57	170	0.0	0	22578.1	12344.5	66.2	0.70	0.825	1.17	0.47	2.000	1.094	1.5	0.00
175	131.6	Saturated	Saturated	57	170	0.0	0	22709.7	12413.7	66.1	0.71	0.832	1.17	0.47	2.000	1.090	1.5	0.00
176	137.6	Saturated	Saturated	57	170	0.0	0	22847.3	12488.9	66.0	0.71	0.839	1.17	0.46	2.000	1.086	1.5	0.00
177	137.6	Saturated	Saturated	57	170	0.0	0	22984.9	12564.1	65.9	0.72	0.846	1.17	0.46	2.000	1.082	1.5	0.00
178	137.6	Saturated	Saturated	57	170	0.0	0	23122.5	12639.3	65.8	0.73	0.854	1.17	0.46	2.000	1.078	1.5	0.00
179	137.6	Saturated	Saturated	57	170	0.0	0	23260.1	12714.5	65.7	0.73	0.861	1.17	0.46	2.000	1.074	1.5	0.00
180	137.6	Saturated	Saturated	92	180	0.0	0	23397.7	12789.7	105.9	0.74	0.868	1.17	0.46	2.000	1.070	1.4	0.00

October 22, 2019

Project No. 19041A

Mr. Gregorio Varela
Geotechnologies, Inc.
439 Western Avenue
Glendale, California 91201

**SUBJECT: DOWNHOLE SEISMIC TEST RESULTS
BORING NUMBER 2
1010-1020 NORTH LA BREA AVENUE
WEST HOLLYWOOD, CALIFORNIA**

Dear Mr. Varela,

Per your request and in accordance with the provisions of our proposal, dated June 3, 2019, we performed downhole seismic tests within Boring Number 2 drilled by Geotechnologies on the property located at 1010-1020 North La Brea Avenue in West Hollywood, California. The log of Boring Number 2 provided by Geotechnologies, Inc. is included in Attachment 1 and indicates that the subsurface materials are composed of:

1. Fill primarily consisting of silty clay to silty sand (CL, SM) from the ground surface to approximately 8 feet below ground surface;
2. Older Alluvium consisting of alternating layers of sand, silt, and clay (SP, SM, ML, CL) from approximately 8 to 108 feet; and
3. Puente Formation Bedrock consisting of predominantly siltstone and claystone from approximately 108 to 180 feet (bottom of hole).

Additionally, the groundwater surface was noted at a depth of 19 feet during borehole drilling on August 1, 2019. At the time of the downhole seismic test on September 3, 2019, GeoPentech staff measured the depth to water in the cased boring at approximately 26 ft below the ground surface and the bottom of the casing at 149 ft below ground surface. Downhole seismic tests were performed within the boring to assist Geotechnologies, Inc. with their evaluation of the site. This letter summarizes the results of the downhole seismic tests and the evaluation of V_{s30}.

Seismic Downhole Methods and Procedures

Downhole seismic tests were collected within Boring Number 2 on September 3, 2019. The downhole seismic test method makes direct measurements of in-situ vertically propagating compression (P) and horizontally polarized shear (SH) wave velocities as a function of depth within the geologic material adjacent to a borehole. Measurement procedures followed ASTM D7400-08, "Standard Test Methods for Downhole Seismic Testing". The geophysical data were collected, processed, and interpreted by a GeoPentech senior staff scientist and reviewed by a California-licensed Professional Geophysicist (PGp).

The boring was drilled with an 8-inch diameter bit using hollow stem auger drilling methods, and a 2-inch diameter PVC casing was installed under the direction of Geotechnologies, Inc. as part of their geotechnical investigation program. The annular space between the 8-inch diameter hole and 2-inch diameter casing was backfilled with bentonite-cement grout, which was assumed to be formulated to approximate the density of the surrounding geologic material and pumped in from the base of the borehole to completely fill the annular space.

A seismic source was used to generate a seismic wave (P or SH) at the ground surface. The seismic source was offset 5 feet horizontally from the borehole. The P-wave seismic source consisted of a ground plate that was struck vertically with a sledgehammer. The SH-wave seismic source consisted of an 8-foot long by 6-inch wide by 4-inch high wood beam capped on both ends with a steel plate, which was loaded in place by the front end of a vehicle parked on top of the beam. The ends of this beam were positioned equidistant from the borehole. Initially, one end of the beam was struck horizontally with a sledgehammer to produce an SH-wave (forward hit). Next, the opposite end of the beam was struck horizontally with the sledgehammer to produce an opposite polarity SH-wave (reverse hit). The combination of the two opposite polarity SH-waves were used to determine SH travel times.

A downhole receiver positioned at a selected depth within the borehole was used to record the arrival of the seismic wave (P or SH). A three-component triaxial borehole geophone (one vertical channel and two orthogonal horizontal channels) that could be firmly fixed pneumatically against the PVC casing sidewall was used to collect the downhole seismic measurements. Multiple downhole seismic measurements were performed at successive receiver depths within the borehole. The receiver depth was referenced to ground surface, and measurements were made at 5-foot intervals from 5 feet below ground surface to the bottom of the cased boring (149 ft).

A Geometrics S12 signal enhancing seismograph was used to record the response of the downhole receiver. The seismic source (sledgehammer) contained a trigger that was connected to the seismograph and initiated signal recording, allowing the travel time between seismic source and downhole receiver to be measured. Downhole seismic test records were digitally recorded and stored with a 0.062 ms sample interval.

The recorded digital downhole seismic records were analyzed using the OYO Corporation program PickWin Version 5.1.1.2. The digital waveforms were analyzed to identify arrival times. The first prominent departure of the vertical receiver trace was identified as the P-wave first arrival. The SH-wave forward and reverse hits recorded on the two horizontal receiver channels were superimposed. The SH-wave first arrival was identified at the location of the first prominent relatively low-frequency departure of the forward hit and an 180º polarity change is noted to have occurred on the reverse hit. For analysis, 57 Hz low-cut and 262 Hz high-cut filters were applied to the P waveforms, and 25 Hz low-cut and 69 Hz high-cut filters were applied to the SH waveforms.

After correcting the P and SH-wave travel time for the source offset, the P and SH-wave travel-times were plotted versus depth. P and SH layer and interval velocities were calculated as the slope of lines drawn through the plotted data.

Seismic Downhole Results

The results of the seismic downhole measurements collected within the boring are presented on Figure 1. Figure 1 shows (1) a table of the measured P- and SH-wave travel-times and depths; (2) a plot of the P- and SH-wave travel-times as a function of depth showing the interpreted layer velocities; (3) a table of the calculated P- and SH-wave interval velocities and depth ranges; (4) a table of the interpreted P- and SH-wave layer velocities and depth ranges; and (5) a plot of the layer and interval velocity models as a function of depth.

Table 1 below summarizes the interpreted P and SH layer velocities and depths shown on Figure 1 for the various geologic units within the boring, as logged by Geotechnologies, Inc. It is noted that the groundwater level was measured at a depth of 19 feet during drilling on August 1, 2019 and at 26 feet during the downhole seismic measurements on September 3, 2019. The measured P-wave velocities agree with the observed depths to water, suggesting the material adjacent to the borehole is saturated below a depth of approximately 25 feet with water first encountered below a depth of about 15 feet.

Based on the results shown on Figure 1, the V_{s30} was calculated based on the procedures outlined in the National Earthquake Hazards Reduction Program (NEHRP) and UBC. The V_{s30} was calculated from the following equation from these references:

$$v_s = \frac{\sum_{i=1}^{n} di}{\sum_{i=1}^{n} \frac{d_i}{v_{si}}}$$

where:

i = distinct different soil and/or rock layer between 1 and n
v_{si} = shear wave velocity in feet per second of layer i
d_i = thickness of any layer within the 100-foot interval
$\sum_{i=1}^{n} d_i$ = 100 feet

Based on this procedure, the V_{s30} for Boring Number 2 was calculated between various depth ranges. The results are summarized on Table 2.

TABLE 1
SUMMARY OF SH-WAVE AND P-WAVE VELOCITY LAYERS WITHIN BORING NUMBER 2

<table>
<tr><th>PREDOMINANT LITHOLOGY</th><th>Depth Range (ft)</th><th>SH-WAVE Velocity (ft/sec)</th><th>P-WAVE Velocity (ft/sec)</th></tr>
<tr><td>Stiff, silty CLAY (CL)
[Fill]</td><td>0 to 5</td><td>863</td><td rowspan="2">1,901</td></tr>
<tr><td>Medium dense to dense, silty SAND (SM)
[Older Alluvium]</td><td>5 to 15</td><td rowspan="4">1,166</td></tr>
<tr><td>Stiff, sandy CLAY (CL), Boring log indicates water at 19 ft
[Older Alluvium]</td><td>15 to 20</td><td>3,548</td></tr>
<tr><td>Medium dense, silty SAND to SAND (SM/SP)
[Older Alluvium]</td><td>20 to 25</td><td>4,478</td></tr>
<tr><td>Stiff, SILT and CLAY (ML/CL)
[Older Alluvium]</td><td>25 to 35</td><td rowspan="3">5,333</td></tr>
<tr><td>Stiff, Silty CLAY (CL), SAND (SP/SW) seam from 47.5 to 50 ft
[Older Alluvium]</td><td>35 to 50</td><td>934</td></tr>
<tr><td>Alternating layers of Stiff, Sandy SILT (ML) and
Medium dense to dense SAND (SM, SC)
[Older Alluvium]</td><td>50 to 75</td><td>1,256</td></tr>
<tr><td>Stiff Clay(CL), Stiff to very stiff SILT (ML),
and Medium dense to very dense SAND (SC, SM)
[Older Alluvium]</td><td>75 to 95</td><td>1,010</td><td rowspan="2">6,184</td></tr>
<tr><td>Very dense, SAND (SP) 95 to 108 ft;
[Older Alluvium]
Moderately Hard, Siltstone 108 to 115 ft
(Puente Formation Bedrock)</td><td>95 to 115</td><td rowspan="3">1,459</td></tr>
<tr><td>Moderately Hard Siltstone and Hard Claystone
(Puente Formation Bedrock)</td><td>115 to 140</td><td>5,588</td></tr>
<tr><td>Moderately Hard, Siltstone
(Puente Formation Bedrock)</td><td>140 to 149</td><td>5,085</td></tr>
</table>

TABLE 2
CALCULATED V_{s30} WITHIN BORING NUMBER 2

DEPTH RANGE (ft, below ground surface)	V_{s30} (ft/sec)	NEHRP Site Class
0 to 100	1,102	D
10 to 110	1,143	D
20 to 120	1,166	D
30 to 130	1,190	D
40 to 140	1,231	C
49 to 149	1,286	C

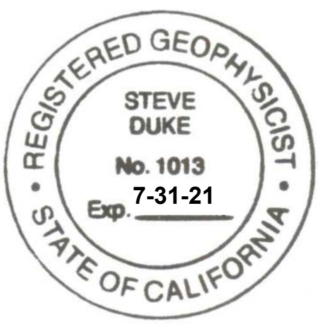
Limitations

The above information is based on limited observations and geophysical measurements made as described above. GeoPentech does not guarantee the performance of the project, only that the information provided meets the standard of care of the profession at this time under the same scope limitations imposed by the project. In this regard, our scope of work included making the P- and SH-wave velocity measurements in one borehole under the direction of Geotechnologies, Inc. personnel. We relied upon the assumption that the annular space between the PVC casing and the borehole wall was properly filled with bentonite-cement grout so that PVC casing and the borehole wall were in continuous contact and that the grout was formulated to approximate the density of the surrounding geologic material.

We trust the contents of this letter will meet your current needs. If you have questions or require additional information, please call.

Very Truly Yours,

GeoPentech



Steven K. Duke
Geophysicist
GP 1013

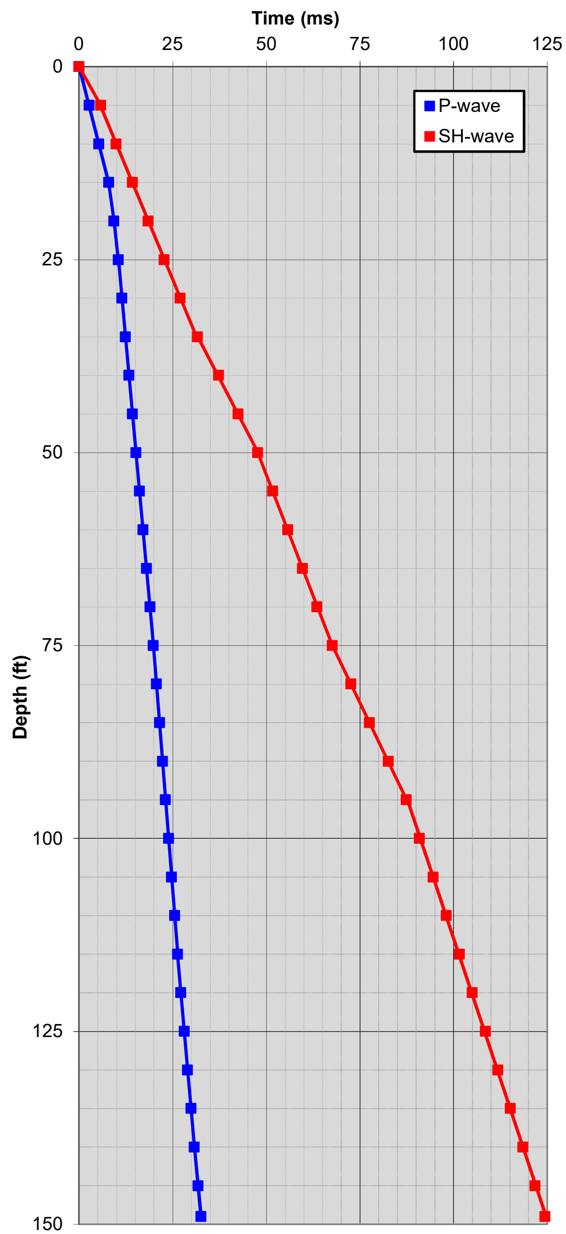
Ryan D. Hort, Ph.D.
Senior Staff Scientist

SEISMIC WAVE TRAVEL TIMES

Depth (ft)	P-time (ms)	P-layer	SH-wave (ms)	SH layer
0	0	1	0	1
5	3.82	1	8.19	12
10	5.85	1	11.06	2
15	8.35	12	14.98	2
20	9.62	23	18.99	2
25	10.65	34	23.17	2
30	11.60	4	27.34	2
35	12.53	4	31.90	23
40	13.45	4	37.54	3
45	14.37	4	42.75	3
50	15.28	4	47.91	34
55	16.19	4	51.90	4
60	17.10	4	55.88	4
65	18.10	4	59.86	4
70	18.99	4	63.67	4
75	19.88	45	67.80	45
80	20.72	5	72.72	5
85	21.53	5	77.64	5
90	22.33	5	82.70	5
95	23.13	5	87.51	56
100	23.94	5	90.95	6
105	24.74	5	94.67	6
110	25.54	5	98.15	6
115	26.35	56	101.62	6
120	27.20	6	105.09	6
125	28.10	6	108.56	6
130	29.00	6	111.89	6
135	29.91	6	115.21	6
140	30.81	67	118.53	6
145	31.77	7	121.85	6
149	32.58	7	124.43	6

Source Offset (ft)
5

TRAVEL TIME PLOT



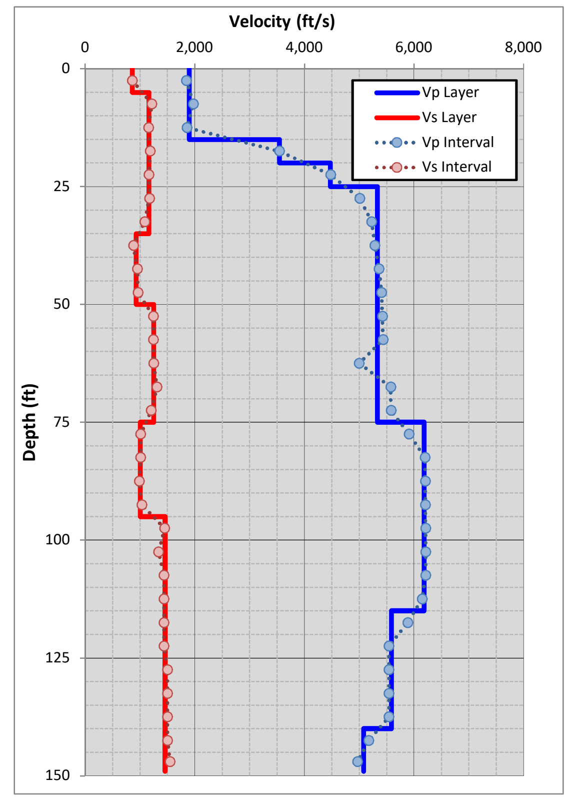
INTERVAL VELOCITES

Depth Range	P-Velocity (ft/s)	SH-Velocity (ft/s)
0 to 5	1,849	863
5 to 10	1,975	1,220
10 to 15	1,861	1,157
15 to 20	3,548	1,189
20 to 25	4,478	1,164
25 to 30	5,012	1,175
30 to 35	5,230	1,086
35 to 40	5,285	881
40 to 45	5,363	954
45 to 50	5,408	964
50 to 55	5,424	1,247
55 to 60	5,435	1,249
60 to 65	5,002	1,250
65 to 70	5,575	1,310
70 to 75	5,581	1,207
75 to 80	5,912	1,014
80 to 85	6,203	1,014
85 to 90	6,206	988
90 to 95	6,209	1,038
95 to 100	6,211	1,450
100 to 105	6,213	1,341
105 to 110	6,215	1,438
110 to 115	6,148	1,438
115 to 120	5,884	1,438
120 to 125	5,542	1,438
125 to 130	5,542	1,501
130 to 135	5,543	1,504
135 to 140	5,543	1,505
140 to 145	5,175	1,505
145 to 149	4,970	1,548

LAYER VELOCITES

Layer	P-Depth (ft)	P-Velocity (ft/s)	SH-Depth (ft)	SH-Velocity (ft/s)
1	0 to 15	1,901	0 to 5	863
2	15 to 20	3,548	5 to 35	1,166
3	20 to 25	4,478	35 to 50	934
4	25 to 75	5,333	50 to 75	1,256
5	75 to 115	6,184	75 to 95	1,010
6	115 to 140	5,588	95 to 149	1,459
7	140 to 149	5,085		
8				
9				
10				

VELOCITY MODEL



V_{S30} CALCULATION

Vs30 (ft/s)	Depth (ft)
1,102	0 to 100
1,286	49 to 149

GeoPentech

SEISMIC DOWNHOLE TEST RESULTS
1010 - 1020 LA BREA AVENUE

PROJECT: 1010-1020 LA BREA AVE

PROJECT #: 19041A | DATE: OCT 2019 | FIGURE: A-1

ATTACHMENT 1

BORING LOG NUMBER 2
GEOTECHNOLOGIES, INC.

BORING LOG NUMBER 2

Faring | **Date: 08/01/19**

File No. 21848 | **Method: 8-inch diameter Hollow Stem Auger**

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description Surface Conditions: Concrete Slab
				0 --		8-inch Concrete over 4-inch Base
				-		
				1 --		
				-		FILL: Silty clay, dark brown, moist, stiff
				2 --		
				-		
				3 --		
				-		
				4 --		
				-		
5	5	23.6	SPT	5 --		
				-		Silty Sand to Silty Clay, dark brown and gray, moist, medium dense, stiff, fine grained
				6 --		
				-		
				7 --		
				-		
				8 --		
				-	SM	OLDER ALLUVIUM: Silty Sand, dark and yellowish brown, moist, medium dense to dense, fine grained
				9 --		
				-		
10	53 50/5"	16.6	114.5	10 --		
				-		
				11 --		
				-		
				12 --		
				-		
				13 --		
				-		
				14 --		
				-		
15	12	23.9	SPT	15 --		
				-	CL	Sandy Clay, dark brown, moist, stiff
				16 --		
				-		
				17 --		
				-		
				18 --		
				-		
				19 --		
				-		
20	33	17.9	113.7	20 --		
				-	SM/SP	Silty Sand to Sand, dark brown, moist, medium dense, fine grained
				21 --		
				-		
				22 --		
				-		
				23 --		
				-		
				24 --		
				-		
25	36	27.3	SPT	25 --		
				-	ML	Sandy to Clayey Silt, dark brown, moist, stiff

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				26		
				27		
				28		
				29		
30	56	24.5	99.8	30		
				31	CL	Silty Clay, dark and grayish brown, moist, stiff
				32		
				33		
				34		
35	22	28.4	SPT	35		yellowish brown
				36		
				37		
				38		
				39		
40	35	14.0	116.3	40		Sandy Clay, yellowish brown, moist, stiff
				41		
				42		
				43		
				44		
45	24	21.6	SPT	45		
				46		
				47		
47.5	82	14.7	113.3			
				48	SP/SW	Sand, dark brown, moist to wet, very dense, fine grained, few gravel
				49		
50	28	14.6	SPT	50		
					SM/ML	Silty Sand to Sandy Silt, dark and gray, moist to wet, medium dense, stiff, fine to coarse grained

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				- 51 -- - 52 --		
52.5	72	20.7	109.1	- 53 -- - 54 -- -	SM	Silty Sand, dark brown, moist, dense, fine grained, few cobbles
55	32	15.7	SPT	55 -- - 56 -- - 57 --	SP/SM	Sand to Silty Sand, dark brown, wet, medium dense, fine to medium grained
57.5	63	20.3	110.5	- 58 -- - 59 -- -	SM/ML	Silty Sand to Sandy Silt, brown, moist, dense, stiff, fine grained
60	30	25.4	SPT	60 -- - 61 -- - 62 --	SP/SM	Sand to Silty Sand, dark brown, moist, medium dense, fine grained
62.5	61	20.6	108.1	- 63 -- - 64 -- -	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, dense, stiff, fine grained, few gravel
65	44	18.6	SPT	65 -- - 66 -- - 67 --	SP/SM	Silty Sand to Sand, dark and yellowish brown, wet, dense, fine grained, few gravel
67.5	48 50/4"	15.5	116.2	- 68 -- - 69 -- -		
70	47	20.2	SPT	70 -- - 71 -- - 72 --	SC/CL	Sandy Clay to Clayey Sand, yellowish brown, wet, dense, stiff, fine to medium grained
72.5	35 50/5"	25.8	98.3	- 73 -- - 74 -- -		
75	35	18.9	SPT	75 -- -		dark and yellowish brown, medium dense, stiff

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				76 --		
				-		
				77 --		
77.5	36	27.2	95.4	-		
	50/5"			78 --	CL	Sandy to Silty Clay, dark and gray, moist, stiff
				-		
				79 --		
				-		
80	34	17.8	SPT	80 --		
				-		
				81 --		
				-		
				82 --		
82.5	40	17.7	113.5	-		
	50/5"			83 --	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, very dense, very stiff, fine grained
				-		
				84 --		
				-		
85	31	21.6	SPT	85 --		
				-	ML/CL	Clayey Silt to Silty Clay, dark and gray, moist, stiff
				86 --		
				-		
				87 --		
87.5	90	20.6	108.1	-		
				88 --		
				-		
				89 --		
				-		
90	35	34.2	SPT	90 --		
				-		
				91 --		
				-		
				92 --		
92.5	39	30.6	93.0	-		
				93 --	CL	Silty Clay, dark and grayish brown, moist, stiff
				-		
				94 --		
				-		
95	33	16.8	SPT	95 --		
				-	SP	Sand, dark and gray, wet, medium dense, fine grained
				96 --		
				-		
				97 --		
97.5	40	18.0	109.3	-		
	50/4"			98 --		very dense
				-		
				99 --		
				-		
100	74	17.9	SPT	100 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				101		
				102		
102.5	45 50/4"	14.9	121.6	103		fine to medium grained, few gravel
				104		
105	49	19.3	SPT	105		dense
				106		
				107		
107.5	88	24.8	99.9	108		BEDROCK (PUENTE FORMATION): Siltstone, dark gray, moist, moderately hard
				109		
110	43	28.4	SPT	110		
				111		
				112		
112.5	72	27.8	95.2	113		
				114		
115	33	26.3	SPT	115		
				116		
				117		
117.5	45 50/4"	23.8	103.8	118		
				119		
120	48	23.9	SPT	120		
				121		
				122		
122.5	88	23.8	101.3	123		
				124		
125	54	27.0	SPT	125		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				126		
				127		
127.5	40 50/4"	24.4	101.2			
				128		Claystone, dark gray, moist, hard
				129		
130	56	26.0	SPT	130		
						Siltstone, dark gray, moist, moderately hard
				131		
				132		
				133		
				134		
135	79	23.2	103.3	135		
				136		
				137		
				138		
				139		
140	47	25.9	SPT	140		
				141		
				142		
				143		
				144		
145	46 50/4"	23.2	102.5	145		
						gray
				146		
				147		
				148		
				149		
150	61	26.7	SPT	150		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				151 --		
				-		
				152 --		
				-		
				153 --		
				-		
				154 --		
				-		
155	100/8"	26.8	98.2	155 --		
				-		
				156 --		
				-		
				157 --		
				-		
				158 --		
				-		
				159 --		
				-		
160	50	25.6	SPT	160 --		
				-		
				161 --		
				-		
				162 --		
				-		
				163 --		
				-		
				164 --		
				-		
165	40	24.8	105.4	165 --	- - -	- - - - - - - - -
	50/3"			-		dark gray
				166 --		
				-		
				167 --		
				-		
				168 --		
				-		
				169 --		
				-		
170	57	24.7	SPT	170 --		
				-		
				171 --		
				-		
				172 --		
				-		
				173 --		
				-		
				174 --		
				-		
175	68	24.8	102.2	175 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				176 --		
				-		
				177 --		
				-		
				178 --		
				-		
				179 --		
				-		
180	92	25.9	SPT	180 --		
				-		Total Depth 180 feet
				181 --		Water at 19 feet
				-		Fill to 8 feet
				182 --		
				-		
				183 --		NOTE: The stratification lines represent the approximate
				-		boundary between earth types; the transition may be gradual.
				184 --		
				-		Used 8-inch diameter Hollow-Stem Auger
				185 --		140-lb. Automatic Hammer, 30-inch drop
				-		Modified California Sampler used unless otherwise noted
				186 --		
				-		SPT=Standard Penetration Test
				187 --		
				-		
				188 --		
				-		
				189 --		
				-		
				190 --		
				-		
				191 --		
				-		
				192 --		
				-		
				193 --		
				-		
				194 --		
				-		
				195 --		
				-		
				196 --		
				-		
				197 --		
				-		
				198 --		
				-		
				199 --		
				-		
				200 --		
				-		

Soil Corrosivity Evaluation Report for Faring

October 9, 2019

Prepared for:

Gregorio Varela
Geotechnologies, Inc
439 Western Ave.
Glendale, CA, 91201
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Project X Job #: S191003A
Client Job or PO #: 21848 & 21849

Contents

1 Executive Summary

A corrosion evaluation of the soils at Faring was performed to provide corrosion control recommendations for general construction materials. The site is located at 1010-1020 North La Brea Avenue, West Hollywood, CA and 1011 North Sycamore Avenue, Los Angeles, CA. (34.089367, -118.343410). Seven (7) samples were tested to a depth of 75.0 ft. Site ground water and topography information was provided via Geotechnologies, Inc. and determined to be 19 feet below finished grade.

Every material has its weakness. Aluminums, galvanized/zinc coatings, and coppers do not survive well in very alkaline or very acidic pH environments. Copper and brasses do not survive well in high nitrate or ammonia environments. Steels and irons do not survive well in low soil resistivity and high chloride environments. High chloride environments can even overcome and attack steel encased in normally protective concrete. Concrete does not survive well in high sulfate environments. And nothing survives well in high sulfide and low redox potential environments with corrosive bacteria. This is why Project X tests for these 8 factors to determine a soil's corrosivity towards various construction materials. **Depending solely on soil resistivity or Caltrans corrosion guidelines, which over-simplify descriptions as corrosive or non-corrosive, will not detect these other factors because it is possible to have bad levels of corrosive ions and still have greater than 1,100 ohm-cm soil resistivity. We have observed this fact on thousands of soil samples tested in our laboratory.**

It should not be forgotten that import soil also be tested for all factors to avoid making your site more corrosive than it was to begin with.

The recommendations outlined herein are not a substitute for any design documents previously prepared for the purpose of construction and apply only to the depth of samples collected.

Soil samples were tested for minimum resistivity, pH, chlorides, sulfates, ammonia, nitrates, sulfides and redox.

As-Received soil resistivities ranged between 804 ohm-cm and 2,814 ohm-cm. This data would be similar to a Wenner 4 pin test in the field and used in the design of a cathodic protection or grounding bed system. This resistivity can change seasonally depending on the weather and moisture in the ground. This reading alone can be misleading because condensation or minor water leaks will occur underground along pipe surfaces creating a saturated soil environment in the trench along infrastructure surfaces which is why minimum or saturated soil resistivity measurements are more important than as-received resistivities.

Saturated soil resistivities ranged between 804 ohm-cm to 2,077 ohm-cm. The worst of these values is considered to be severely corrosive to general metals.

PH levels ranged between 7.8 to 8.2 pH. PH levels were determined to be at levels not detrimental to copper or aluminum alloys. The pH of these samples can allow corrosion of steel and iron in moist environments.

Chlorides ranged between 8 mg/kg to 23 mg/kg. Chloride levels in these samples are low and may cause insignificant corrosion of metals.

Sulfates ranged between 21 mg/kg to 56 mg/kg. Sulfate levels in these samples are negligible for corrosion of metals and cement. Any type of cement can be used that does not contain encased metal.

Ammonia ranged between 0.0 mg/kg to 0.3 mg/kg. Nitrates ranged between 0.0 mg/kg to 1.1 mg/kg. Concentrations of these elements were not high enough to cause accelerated corrosion of copper and copper alloys such as brass.

Sulfides presence was determined to be trace. REDOX ranged between + 215 mV to + 243 mV. Though sulfides were detected, the probability of corrosive bacteria was determined to be low due to very positive REDOX levels determined in these samples.

2 Corrosion Control Recommendations

The following recommendations are based upon the results of soil testing.

2.1 Cement

The highest reading for sulfates was 56 mg/kg or 0.0056 percent by weight.

Per ACI 318-14, Table 19.3.1.1, sulfate levels in these samples categorized as S0 and are negligible for corrosion of metals and cement. Per ACI 318-14 Table 19.3.2.1 any type of cement not containing steel or other metal can be used.

2.2 Steel Reinforced Cement/ Cement Mortar Lined & Coated (CML&C)

Chlorides in soil can overcome the corrosion inhibiting property of cement for steel, as it can also break through passivated surfaces of aluminum and stainless steels.[1,2] The highest concentration of chlorides was 23 mg/kg.

Chloride levels in these samples are not significantly corrosive to metals not in tension. Standard cement cover may be used in these soils.

1) Use hardware coated with epoxy or equivalent where 3 inches of cement cover cannot be achieved, or
2) Since chlorides in these soil samples were not high enough to require DCI or special cement additives, additives such as DCI can be used in the slabs if 3 inches of cement cover cannot be achieved on steel items where epoxy coated hardware is not desired or possible.

As the cost of cement, epoxy coated hardware, cement additives, and waterproofing systems seem to vary throughout the year and between contractors, we provide OPTIONS so that the most cost effect decision can be made.

2.3 Stainless Steel Pipe/Conduit/Fittings

Stainless steels derive their corrosion resistance from their chromium content and oxide layer which needs oxygen to regenerate if damaged. Thus stainless steel is not good for deep soil applications where oxygen levels are extremely low. Stainless steels should not be installed deeper than a plant root zone. Stainless steels typically have the same nobility as copper on the

[1] Design Manual 303: Cement Cylinder Pipe. Ameron. p.65
[2] *Chapter 19, Table 1904.2.2(1), 2012 International Building Code*

galvanic series and can be connected to copper. If stainless steel must be used, it must be backfilled with soil having greater than 10,000 ohm-cm resistivity and excellent drainage. 304 Stainless steel will also corrode if in contact with carbon materials such as activated carbon. Stainless steel welds should be pickled.

The soil at this site has low probability for anaerobic corrosive bacteria and low chloride levels. Per Nickel Institute guidelines, 316 Stainless steels can be used in these soils.

2.4 Steel Post Tensioning Systems

The proper sealing of stressing holes is of utmost importance in PT Systems. Cut off excess strand 1/2" to 3/4" back in the hole. Coat or paint exposed anchorage, grippers, and stub of strands with "Rust-o-leum" or equal. After tendons have been coated, the cement contractor shall dry pack blockouts within ten (10) days. A non-shrink, non-metallic, non-porous moisture-insensitive grout (Master EMACO S 488 or equivalent), or epoxy grout shall be used for this purpose. If an encapsulated post-tension system is used, regular non-shrink grout can be used.

Due to the low chloride concentrations measured on samples obtained from this site, post-tensioned slabs should be protected in accordance with soil considered normal (non-corrosive).[3,4]

2.5 Steel Piles

Steel piles are most susceptible to corrosion in disturbed soil where oxygen is available. Further, a dissimilar environment corrosion cell would exist between the steel embedded in cement, such as pile caps and the steel in the soil. In the cell, the steel in the soil is the anode (corroding metal), and the steel in cement is the cathode (protected metal). This cell can be minimized by coating the part of the steel piles that will be embedded in cement to prevent contact with cement and reinforcing steel.

Piles driven into soils without disturbing soils will avoid oxygen introduction and low corrosion rates unless there is a probability for corrosive anaerobic bacteria. Galvanized steel's zinc coating can provide significant protection for driven piles. In corrosive soils in which normal zinc coatings are not enough, the life of piles can be extended by increasing zinc coating thickness, using sacrificial metal, or providing a combination of epoxy coatings and cathodic protection. Corrosion has been observed to be extremely localized even at and below underground water tables. Pit depths of this magnitude do not have an appreciable effect on the strength or useful life of piling structures because the reduction in pile cross section is not significant.[5] Pitting is of more importance to pipes transporting liquids or gases which should not be leaked into the ground.

The following recommendations are recommended to achieve desired life. We defer to structural engineers to use our estimated corrosion rates and to choose from the corrosion control options listed below.

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[3] *Post-Tensioning Manual, sixth edition. Post-Tensioning Institute (PTI), Phoenix, AZ, 2006.*
[4] *Specification for Unbonded Single Strand Tendons. Post-tensioning Institute (PTI), Phoenix, AZ, 2000.*

[5] Melvin Romanoff, Corrosion of Steel Pilings in Soils, National Bureau of Standards Monograph 58, pg 20.

1) Sacrificial metal by use of thicker piles per non-disturbed soil corrosion rates, or
2) Galvanized steel piles per non-disturbed soil corrosion rates, or
3) Combination of galvanized and sacrificial metal per non-disturbed soil corrosion rates, or
4) For no loss of metal, coat entire pile with abrasion resistant epoxy coating such as 3M Scotchkote 323, or PowercreteDD, or equivalent, or
5) Use high yield steel which will corrode at the same rate as mild steel but have greater yield strength and thus be able to suffer more material loss than mild steel.

2.5.1 Expected Corrosion Rate of Steel and Zinc in disturbed soil

In general, the corrosion rate of metals in soil depends on the electrical resistivity, the elemental composition, and the oxygen content of the soil. Soils can vary greatly from one acre to the next, especially at earthquake faults. The better a soil is for farming; the easier it will be for corrosion to take place. Expansive soils will also be considered disturbed simply because of their nature from dry to wet seasons.

In Melvin Romanoff's NBS Circular 579, the corrosion rates of carbon steels and various metals was studied over long term periods. Various metals were placed in various soil types to gather corrosion rate data of all metals in all soil types. Samples were collected and material loss measured over the course of 20 years in some sites. The following corrosion rates were estimated by comparing the worst results of soils tested with similar soils in Romanoff's studies and Highway Research Board's publications.[6] The corrosion rate of zinc in disturbed soils is determined per Romanoff studies and King Nomograph.[7]

Expected Corrosion Rate for Steel = 2.28 mils/year for one sided attack

Expected Corrosion Rate for Zinc = 0.84 mils/year for one sided attack.

Note: 1 mil = 0.001 inch

In undisturbed soils, a corrosion rate of 1 mil/year for steel is expected with little change in the corrosion rate of zinc due to it's low nobility in the galvanic series.

Per CTM 643: Years to perforation of corrugated galvanized steel culverts

- 22.8 Years to Perforation for a 18 gage metal culvert
- 29.7 Years to Perforation for a 16 gage metal culvert
- 36.5 Years to Perforation for a 14 gage metal culvert
- 50.2 Years to Perforation for a 12 gage metal culvert
- 63.9 Years to Perforation for a 10 gage metal culvert
- 77.6 Years to Perforation for a 8 gage metal culvert

2.5.2 Expected Corrosion Rate of Steel and Zinc in Undisturbed soil

Expected Corrosion Rate for Steel = 1 mils/year for one sided attack

Expected Corrosion Rate for Zinc = 0.84 mils/year for one sided attack.

[6] Field test for Estimating Service Life of Corrugated Metal Culverts, J.L. Beaton, Proc. Highway Research Board, Vol 41, P. 255, 1962
[7] King, R.A. 1977, Corrosion Nomograph, TRRC Supplementary Report, British Corrosion Journal

Note: 1 mil = 0.001 inch

2.6 Steel Storage tanks

Underground fuel tanks must be constructed and protected in accordance with California Underground Storage Tank Regulations, CCR, Title 23, Division 3, Chapter 16. Metals should be protected with cathodic protection or isolated from backfill material with an epoxy coating.

2.7 Steel Pipelines

Though a site may not be corrosive in nature at the time of construction, **installation of corrosion test stations and electrical continuity joint bonding should be performed during construction** so that future corrosion inspections can be performed. If steel pipes with gasket joints or other possibly non-conductive type joints are installed, their joints should be bonded across by welding or pin brazing a #8 AWG copper strand bond cable. Electrical continuity is necessary for corrosion inspections and for cathodic protection.

Corrosion test stations should be installed every 1,000 feet of pipeline.

Test stations shall have two #8 HMWPE copper strand wire test leads welded or pin brazed to the underground pipe, brought up into the test station hand hole and marked CTS. Wires should be brought into test station hand hole at finished grade with 12 inches of wire coiled within test station.

At isolation joints and pipe casings, 4 wire test stations shall be installed using #8 HMWPE copper strand wire test leads. Use different color wires to distinguish which wires are bonded to one side of isolation joint or to casing. Wires should be brought into test station hand hole at finished grade with 12 inches of wire coiled within test station.

Prevent dissimilar metal corrosion cells per NACE SP0286:

1) Electrically isolate dissimilar metal connections
2) Electrically isolate dissimilar coatings (Epoxy vs CML&C) segments connections
3) Electrically isolate river crossing segments
4) Electrically isolate freeway crossing segments
5) Electrically isolate old existing pipelines from new pipelines
6) Electrically isolate aboveground and underground pipe segments with flange isolation joint kits. **These are especially important for fire risers.**

The corrosivity at this site is corrosive to steel. Any piping that must be jack bored should use abrasion resistant epoxy coating such as 3M Scotchkote 323, or PowercreteDD, or equivalent. The corrosion control options for this site are as follows:

1) Wax tape, or
2) Coal tar enamel, or
3) Fusion bonded epoxy
4) And install cathodic protection system per NACE SP0169.

Or instead of CP and Dielectric coating

5) Apply 3 inch coating of Type II cement or high pH slurry that will maintain pH higher than 12. Cement is both a corrosion inhibitor and a coating for ferrous metals. Cement naturally holds a pH of 12 or higher for many years if not exposed to high levels of carbon dioxide.

It is critical for the life of the pipe that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.8 Steel Fittings

The corrosivity at this site is very corrosive to steel. The corrosion control options for this site are as follows:

1) Apply impermeable dielectric coating such as minimum 8 mil thick polyethylene, or
2) Tape coating system, or
3) Wax tape, or
4) Coal tar enamel, or
5) Fusion bonded epoxy, or
6) And install cathodic protection system per NACE SP0169.

Or instead of CP and Dielectric coating

7) Apply 3 inch coating of Type II cement or high pH slurry that will maintain pH higher than 12. Cement is both a corrosion inhibitor and a coating for ferrous metals. Cement naturally holds a pH of 12 or higher for many years if not exposed to high levels of carbon dioxide.

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.9 Ductile Iron (DI) Fittings

AWWA C105 developed a 10 point system to classify sites as aggressive or non-aggressive to ductile iron materials. The 10-point system does not, and was never intended to, quantify the corrosivity of a soil. It is a tool used to distinguish nonaggressive from aggressive soils relative to iron pipe. Soils <10 points are considered nonaggressive to iron pipe, whereas soils ≥ 10

points are considered aggressive. A 15 and a 20 point soil are both considered aggressive to iron pipe, however, because of the nature of the soil parameters measured, the 20 point soil may not necessarily be more aggressive than the 15 point soil. The criterion is based upon soil resistivities, soil drainage, pH, sulfide presence, and reduction-oxidation (REDOX) potential. The soil samples tested for this site resulted in a score of 12 out of 25.5. A score greater or equal to 10 points classifies soils as aggressive to iron materials.

The corrosivity at this site is very corrosive to iron. The corrosion control options for this site are as follows:

1) Apply impermeable dielectric coating such as minimum 8 mil thick polyethylene, or
2) Wax tape, or
3) Coal tar enamel, or
4) Fusion bonded epoxy, or
5) And install cathodic protection system per NACE SP0169.

   Or instead of CP and Dielectric coating

6) Apply 3 inch coating of Type II cement or high pH slurry that will maintain pH higher than 12. Cement is both a corrosion inhibitor and a coating for ferrous metals. Cement naturally holds a pH of 12 or higher for many years if not exposed to high levels of carbon dioxide.

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.10 Ductile Iron Pipe

AWWA C105 developed a 10 point system to classify sites as aggressive or non-aggressive to ductile iron materials. The 10-point system does not, and was never intended to, quantify the corrosivity of a soil. It is a tool used to distinguish nonaggressive from aggressive soils relative to iron pipe. Soils <10 points are considered nonaggressive to iron pipe, whereas soils ≥10 points are considered aggressive. A 15 and a 20 point soil are both considered aggressive to iron pipe, however, because of the nature of the soil parameters measured, the 20 point soil may not necessarily be more aggressive than the 15 point soil. The criterion is based upon soil resistivities, soil drainage, pH, sulfide presence, and reduction-oxidation (REDOX) potential. The soil samples tested for this site resulted in a score of 12 out of 25.5. A score greater or equal to 10 points classifies soils as aggressive to iron materials.

Though a site may not be corrosive in nature at the time of construction, **installation of corrosion test stations and electrical continuity joint bonding should be performed during construction** so that future corrosion inspections can be performed. If steel pipes with gasket joints or other possibly non-conductive type joints are installed, their joints should be bonded across by welding or pin brazing a #8 AWG copper strand bond cable. Electrical continuity is necessary for corrosion inspections and for cathodic protection.

Pea gravel is used by plumbers to lay pipes and establish slopes. If the gravel has more than 200 ppm chlorides or is not tested, a 25 mil plastic should be placed between the gravel and pipe to avoid corrosion.

Corrosion test stations should be installed every 1,000 feet of pipeline.

Test stations shall have two #8 HMWPE copper strand wire test leads welded or pin brazed to the underground pipe, brought up into the test station hand hole and marked CTS. Wires should be brought into test station hand hole at finished grade with 12 inches of wire coiled within test station.

At isolation joints and pipe casings, 4 wire test stations shall be installed using #8 HMWPE copper strand wire test leads. Use different color wires to distinguish which wires are bonded to one side of isolation joint or to casing. Wires should be brought into test station hand hole at finished grade with 12 inches of wire coiled within test station.

Prevent dissimilar metal corrosion cells per NACE SP0286:

1) Electrically isolate dissimilar metal connections
2) Electrically isolate dissimilar coatings (Epoxy vs CML&C) segments connections
3) Electrically isolate river crossing segments
4) Electrically isolate freeway crossing segments
5) Electrically isolate old existing pipelines from new pipelines
6) Electrically isolate aboveground and underground pipe segments with flange isolation joint kits**. These are especially important for fire risers.**

The corrosivity at this site is corrosive to iron. The corrosion control options for this site are as follows:

1) Apply impermeable dielectric coating such as minimum 8 mil thick polyethylene, or
2) Tape coating system, or
3) Wax tape, or
4) Coal tar enamel, or
5) Fusion bonded epoxy, or
6) And install cathodic protection system per NACE SP0169.

   Or instead of CP and Dielectric coating

7) Apply 3 inch coating of Type II cement or high pH slurry that will maintain pH higher than 12. Cement is both a corrosion inhibitor and a coating for ferrous metals. Cement naturally holds a pH of 12 or higher for many years if not exposed to high levels of carbon dioxide.

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.11 Copper Materials

Copper is an amphoteric material which is susceptible to corrosion at very high and very low pH. It is one of the most noble metals used in construction thus typically making it a cathode when connected to dissimilar metals. Copper's nobility can change with temperature, similar to the phenomenon in zinc. When zinc is at room temperature, it is less noble than steel and can provide cathodic protection to steel. But when zinc is at a temperature above 140F such as in a water heater, it becomes nobler than the steel and the steel becomes the sacrificial anode. This is why zinc is not used in steel water heaters or boilers. Copper when cold has one native potential, but when heated develops a more electronegative electro-potential. Thus hot and cold copper pipes should be electrically isolated from each other to avoid creation of a thermo-galvanic corrosion cell.

2.11.1 Copper Pipes

The lowest pH for this area was measured to be 7.8. Copper is greatly affected by pH, ammonia and nitrate concentrations[8]. The highest nitrate concentration was 1.1 mg/kg and the highest ammonia concentration was 0.3 mg/kg at this site.

These soils were determined to be corrosive to copper and copper alloys such as brass.

Aboveground, underground, cold water and hot water pipes should be electrically isolated from each other by use of dielectric unions and plastic in-wall pipe supports. The following are corrosion control options for underground copper water pipes.

1) Run copper pipes within PVC pipes to prevent soil contact, or
2) Cover piping with a 20 mil epoxy coating free of scratches and defects, or
3) Cover copper pipes with minimum 10 mil polyethylene sleeve over a suitable primer and apply cathodic protection per NACE SP0169

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.11.2 Brass Fittings

Brass fittings should be electrically isolated from dissimilar metals by use of dielectric unions or isolation joint kits.

[8] Corrosion Data Handbook, Table 6, Corrosion Resistance of copper alloys to various environments, 1995

These soils were determined to be corrosive to copper and copper alloys such as brass.

The following are corrosion control options for underground brass.

1) Prevent soil contact by use of impermeable coating system such as wax tape, or
2) Prevent soil contact by use of a 20 mil epoxy coating free of scratches and defects, or
3) Cover brass with minimum 10 mil polyethylene sleeve over a suitable primer and apply cathodic protection per NACE SP0169

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.11.3 Bare Copper Grounding Wire

It is assumed that corrosion will occur at all sides of the bare wire, thus the corrosion rate is calculated as a two sided attack determining the time it takes for the corrosion from two sides to meet at the center of the wire. The estimated life of bare copper wire for this site is the following:[9]

Size (AWG)	**Diameter (mils)**	**Est. Time to penetration (Yrs)**
14	64.1	160.3
13	72	180.0
12	80.8	202.0
11	90.7	226.8
10	101.9	254.8
9	114.4	286.0
8	128.5	321.3
7	144.3	360.8
6	162	405.0
5	181.9	454.8
4	204.3	510.8
3	229.4	573.5
2	257.6	644.0
1	289.3	723.3

If the bare copper wire is being used as a grounding wire connected to less noble metals such as galvanized steel or carbon steel, the less noble metals will provide additional cathodic protection to the copper reducing the corrosion rate of the copper.

It is recommended that a corrosion inhibiting and water-repelling coating such as Corrosion X Part No. 90102 by Corrosion Technologies (no affiliation to Project X) be applied to

[9] Soil-Corrosion studies 1946 and 1948: Copper Alloys, Lead, and Zinc, Melvin Romanoff, National Bureau of Standards, Research Paper RP2077, 1950

aboveground and belowground copper-to-dissimilar metal connections to reduce risk of dissimilar corrosion.

2.12 Aluminum Pipe/Conduit/Fittings

Aluminum is an amphoteric material prone to pitting corrosion in environments that are very acidic or very alkaline or high in chlorides.

Conditions at this site are safe for aluminum.

Aluminum derives its corrosion resistance from its oxide layer which needs oxygen to regenerate if damaged, similar to stainless steels. Thus aluminum is not good for deep soil applications. Since aluminum corrodes at very alkaline environments, it cannot be encased or placed against cement or mortar such as brick wall mortar up against an aluminum window frame.

Aluminum is also very low on the galvanic series scale making it most likely to become a sacrificial anode when in contact with dissimilar metals in moist environments. Avoid electrical continuity with dissimilar metals by use of insulators, dielectric unions, or isolation joints. Pooling of water at post bottoms or surfaces should be avoided by integrating good drainage.

2.13 Carbon Fiber or Graphite Materials

Carbon fiber or other graphite materials are extremely noble on the galvanic series and should always be electrically isolated from dissimilar metals. They can conduct electricity and will create corrosion cells if placed in contact within a moist environment with any metal.

2.14 Plastic and Vitrified Clay Pipe

No special precautions are required for plastic and vitrified clay piping from a corrosion viewpoint.

Protect all metallic fittings and pipe restraining joints with wax tape per AWWA C217, cement if previously recommended, or epoxy.

3 CLOSURE

In addition to soils chemistry and resistivity, another contributing influence to the corrosion of buried metallic structures is stray electrical currents. These electrical currents flowing through the earth originate from buried electrical systems, grounding of electrical systems in residences, commercial buildings, and from high voltage overhead power grids. Therefore, it is imperative that the application of protective wraps and/or coatings and electrical isolation joints be properly applied and inspected.

It is the responsibility of the builder and/or contractor to closely monitor the installation of such materials requiring protection in order to assure that the protective wraps or coatings are not damaged.

The recommendations outlined herein are in conformance with current accepted standards of practice that meet or exceed the provisions of the Uniform Building Code (UBC), the

International Building Code (IBC), California Building Code (CBC), the American Cement Institute (ACI), Nickel Institute, National Association of Corrosion Engineers (NACE International), Post-Tensioning Institute Guide Specifications and State of California Department of Transportation, Standard Specifications, American Water Works Association (AWWA) and the Ductile Iron Pipe Research Association (DIPRA).

Our services have been performed with the usual thoroughness and competence of the engineering profession. No other warranty or representation, either expressed or implied, is included or intended.

Please call if you have any questions.

Prepared by,

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Respectfully Submitted,

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Professional Engineer
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4 SOIL ANALYSIS LAB RESULTS

Client: Geotechnologies, Inc
Job Name: Faring
Client Job Number: 21848 & 21849
Project X Job Number: S191003A
October 9, 2019

	Method	ASTM D4327		ASTM D4327		ASTM G187		ASTM G51	ASTM G200	SM 4500-S2-D	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327
Bore# / Description	**Depth**	**Sulfates** SO_4^{2-}		**Chlorides** Cl^-		**Resistivity** As Rec'd	Minimum	**pH**	**Redox**	**Sulfide** S^{2-}	**Nitrate** NO_3^-	**Ammonium** NH_4^+	**Lithium** Li^+	**Sodium** Na^+	**Potassium** K^+	**Magnesium** Mg^{2+}	**Calcium** Ca^{2+}	**Flouride** F_2^-	**Phosphate** PO_4^{3-}
	(ft)	(mg/kg)	(wt%)	(mg/kg)	(wt%)	(Ohm-cm)	(Ohm-cm)		(mV)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
B2	5.0	30.0	0.0030	12.1	0.0012	1,474	1,340	8.2	243.0	1.9	0.1	0.3	ND	100.4	0.2	25.6	40.7	3.5	4.3
B2	15.0	21.2	0.0021	7.9	0.0008	1,541	1,474	7.9	215.0	1.1	0.0	0.2	0.0	44.0	0.1	7.1	17.6	2.8	2.0
B2	25.0	55.6	0.0056	22.6	0.0023	804	804	8.1	222.0	4.1	0.1	0.2	0.0	49.5	0.3	29.6	76.1	3.7	2.3
B2	40.0	50.4	0.0050	11.9	0.0012	1,943	1,742	7.9	228.0	0.9	1.1	0.0	ND	43.0	0.1	9.0	23.3	3.7	2.0
B2	52.5	41.7	0.0042	8.2	0.0008	2,010	1,809	7.9	226.0	0.7	0.7	0.1	ND	34.8	0.3	7.9	21.4	3.6	2.1
B2	65.0	46.1	0.0046	22.6	0.0023	2,814	2,077	7.8	233.0	0.3	0.3	0.2	0.0	42.1	0.3	5.9	15.2	3.2	0.6
B2	75.0	37.4	0.0037	19.0	0.0019	1,072	1,005	7.9	224.0	0.8	0.3	0.0	0.0	30.3	0.2	8.2	21.4	3.2	1.4

Unk = Unknown
NT = Not Tested
ND = 0 = Not Detected
mg/kg = milligrams per kilogram (parts per million) of dry soil weight
Chemical Analysis performed on 1:3 Soil-To-Water extract
Anions and Cations tested via Ion Chromatograph except Sulfide.

Figure 1 Soil Sample Locations, 1010-1020 North La Brea Avenue, West Hollywood, CA and 1011 North Sycamore Avenue, Los Angeles, CA. (34.0893, -118.3434)

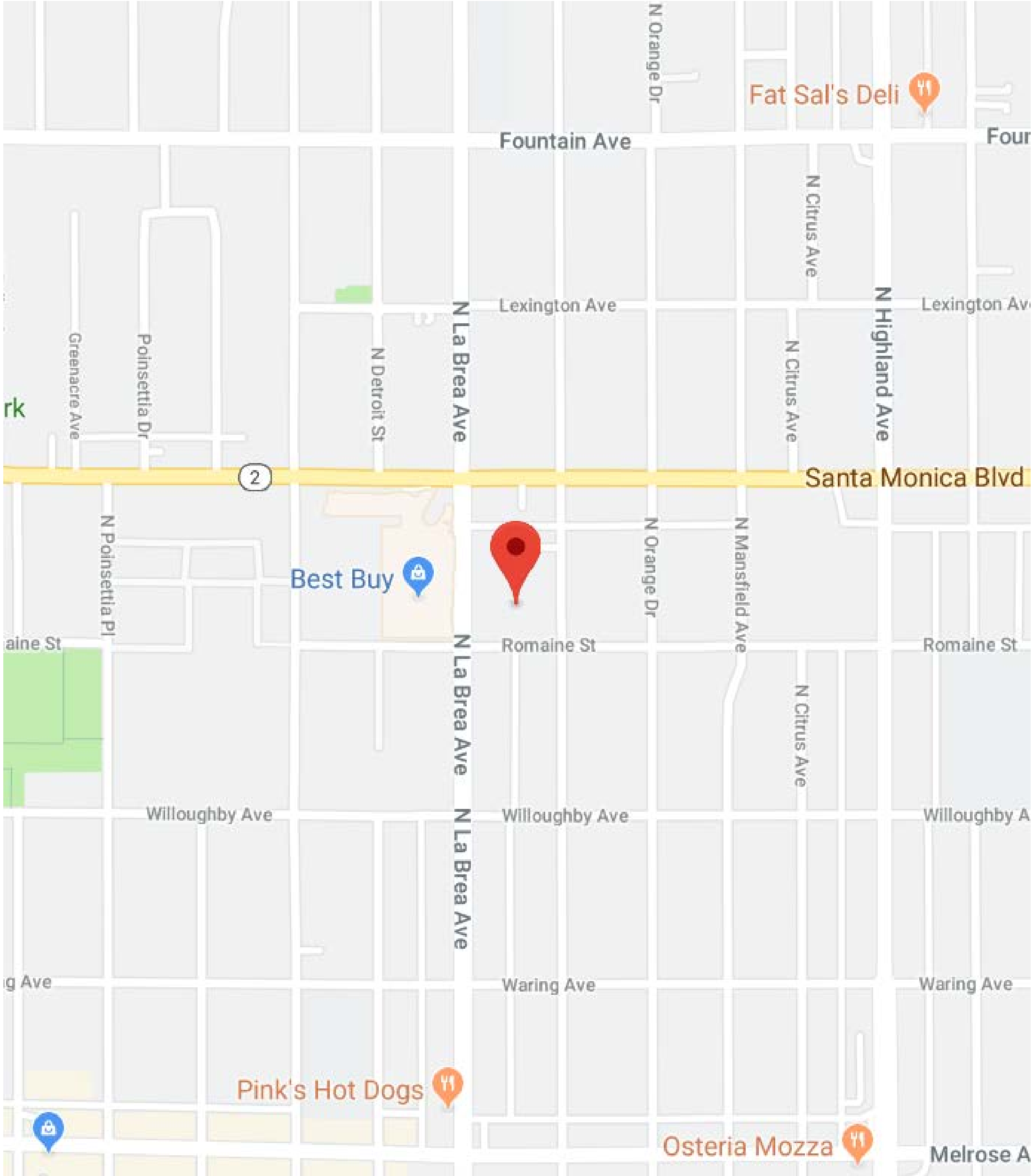


Figure 2 Vicinity Map, 1010-1020 North La Brea Avenue, West Hollywood, CA and 1011 North Sycamore Avenue, Los Angeles, CA. (34.0893, -118.3434)

5 Corrosion Basics

In general, the corrosion rate of metals in soil depends on the electrical resistivity, the elemental composition, and the oxygen content of the soil. Soils can vary greatly from one acre to the next, especially at earthquake faults. The better a soil is for farming; the easier it will be for corrosion to take place. Oxygen content in soil can be increased during construction. These soils are considered disturbed soils. When construction equipment at a site is simply driving piles into soil without digging into the soil, the activity can still disturb soil down to 3 feet. Expansive soils will also be considered disturbed simply because of their nature from dry to wet seasons.

5.1 Pourbaix Diagram – In regards to a material's environment

All metals are unique and have a weakness. Some metals do not like acidic (low pH) environments. Some metals do not like alkaline (high pH) environments. Some metals don't like either high or low pH environments such as aluminum. These are called amphoteric materials. Some metals become passivated and do not corrode at high pH environments such as steel. These characteristics are documented in Marcel Pourbaix's book "Atlas of electrochemical equilibria in aqueous solutions"

In the mid 1900's, Marcel Pourbaix developed the Pourbaix diagram which describes a metal's reaction to an environment dependant on pH and voltage conditions. It describes when a metal remains passive (non-corroding) and in which conditions metals become soluble (corrode). Steels are passive in pH over 12 such as the condition when it is encased in cement. If the cement were to carbonate and its pH reduce to below 12, the cement would no longer be able to act as a corrosion inhibitor and the steel will begin to corrode when moist.

Some metals such as aluminum are amphoteric, meaning that they react with acids and bases. They can corrode in low pH and in high pH conditions. Aluminum alloys are generally passive within a pH of 4 and 8.5 but will corrode outside of those ranges. This is why aluminum cannot be embedded in cement and why brick mortar should not be laid against an aluminum window frame without a protective barrier between them.

5.2 Galvanic Series – In regards to dissimilar metal connections

All metals have a natural electrical potential. This electrical potential is measured using a high impedance voltmeter connected to the metal being tested and with the common lead connected to a copper copper-sulfate reference electrode (CSE) in water or soil. There are many types of reference electrodes. In laboratory measurements, a Standard Hydrogen Electrode (SHE) is commonly used. When different metal alloys are tested they can be ranked into an order from most noble (less corrosion), to least noble (more active corrosion). When a more noble metal is connected to a less noble metal, the less noble metal will become an anode and sacrifice itself through corrosion providing corrosion protection to the more noble metal. This hierarchy is known as the galvanic series named after Luigi Galvani whose experiments with electricity and muscles led Alessandro Volta to discover the reactions between dissimilar metals leading to the early battery. The greater the voltage difference between two metals, the faster the corrosion rate will be.

Table 1- Dissimilar Metal Corrosion Risk

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Lead	Mild Steel	Tin	Copper	Stainless Steel
Zinc	None	Low	Medium	High	High	High	High	High	High
Galvanized Steel	Low	None	Medium	Medium	Medium	High	High	High	High
Aluminum	Medium	Medium	None	Medium	Medium	Medium	Medium	High	High
Cast Iron	High	Medium	Medium	None	Low	Low	Low	Medium	Medium
Lead	High	Medium	Medium	Low	None	Low	Low	Medium	Medium
Mild Steel	High	High	Medium	Low	Low	None	Low	Medium	Medium
Tin	High	High	Medium	Low	Low	Low	None	Medium	Medium
Copper	High	High	High	Medium	Medium	Medium	Medium	None	Low
Stainless Steel	High	High	High	Medium	Medium	Medium	Medium	Low	None

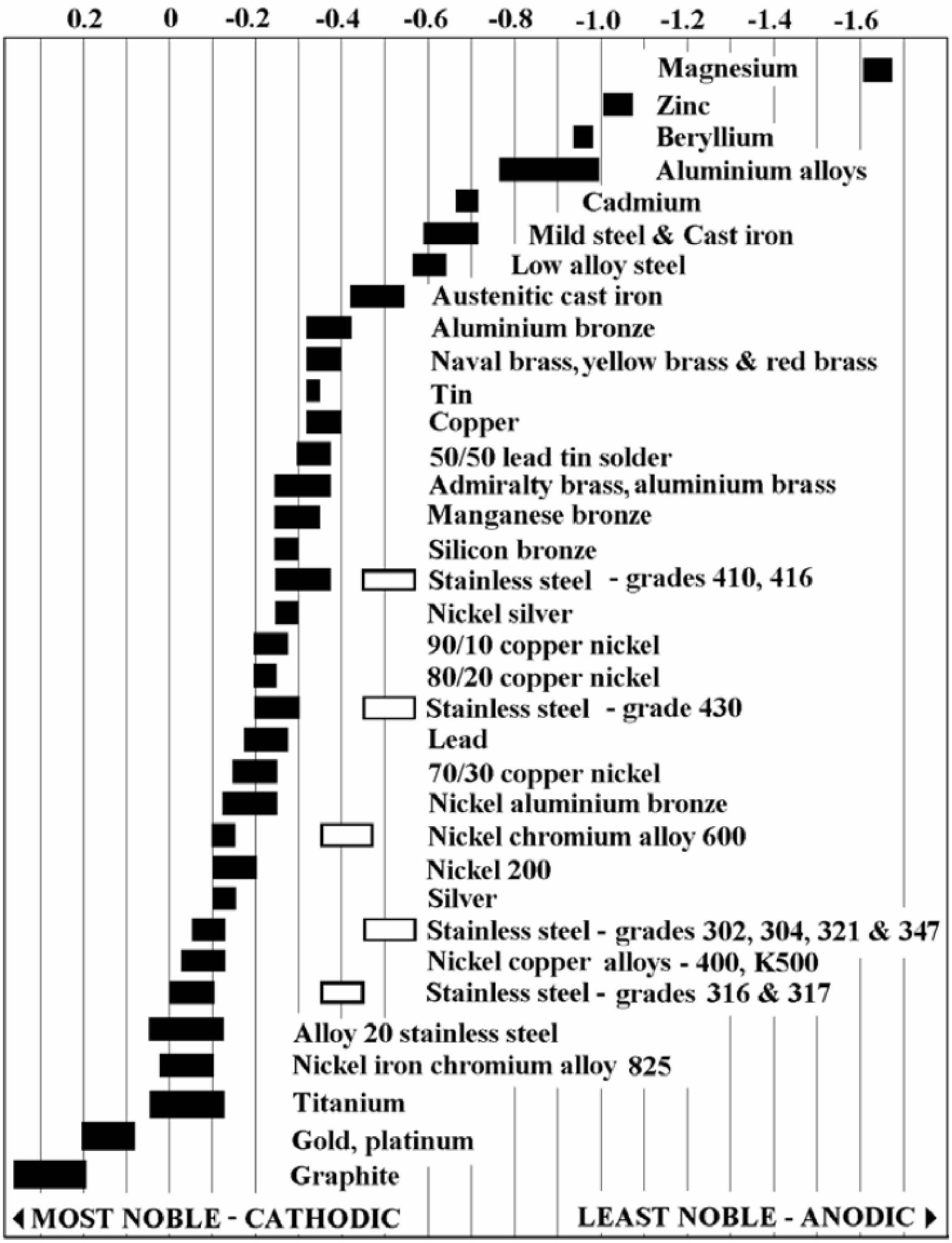
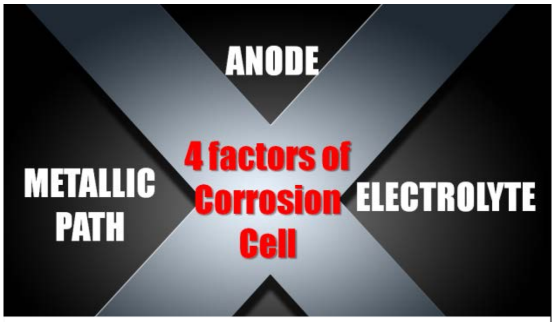
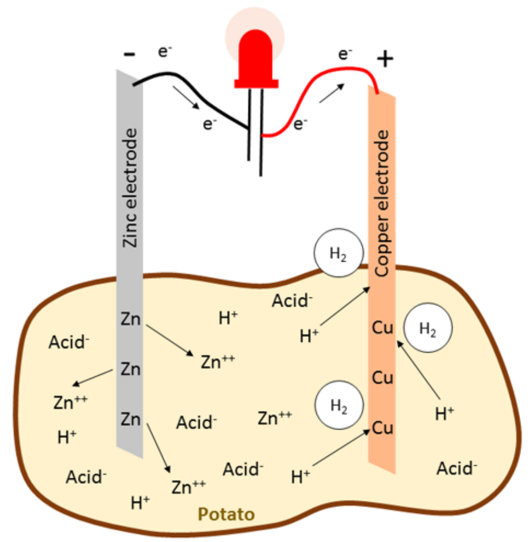


Figure 3 - Galvanic series of metals relative to CSE half cell.

5.3 Corrosion Cell

In order for corrosion to occur, four factors must be present. (1) The anode (2) the cathode (3) the electrolyte and (4) the metallic or conductive path joining the anode and the cathode. If any one of these is removed, corrosion activity will stop. This is how a simple battery produces electricity. An example of a non-metallic yet conductive material is graphite. Graphite is similar in nobility to gold. Do not connect graphite to anything in moist environments.





The anode is where the corrosion occurs, and the cathode is the corrosion free material. Sometimes the anode and cathode are different materials connected by a wire or union. Sometimes the anode and cathode are on the same pipe with one area of the pipe in a low oxygen zone while the other part of the pipe is in a high oxygen zone. A good example of this is a post in the ocean that is repeatedly splashed. Deep underwater, corrosion is minimal, but at the splash zone, the corrosion rate is greatest.

Low oxygen zones and crevices can also harbor corrosive bacteria which in moist environments will lead to corrosion. This is why pipes are laid on backfill instead of directly on native cut soil in a trench. Filling a trench slightly with backfill before installing pipe then finishing the backfill creates a uniform environment around the entire surface of the pipe.

The electrolyte is generally water, seawater, or moist soil which allows for the transfer of ions and electrical current. Pure water itself is not very conductive. It is when salts and minerals dissolve into pure water that it becomes a good conductor of electricity and chemical reactions. Metal ores are turned into metal alloys which we use in construction. They naturally want to return to their natural metal ore state but it requires energy to return to it. The corrosion cell, creates the energy needed to return a metal to its natural ore state.

The metallic or conductive path can be a wire or coupling. Examples are steel threaded into a copper joint, or an electrician grounding equipment to steel pipes inadvertently connecting electrical grid copper grounding systems to steel or iron underground pipes.

The ratio of surface area between the anode and the cathode is very important. If the anode is very large, and the cathode is very small, then the corrosion rate will be very small and the anode may live a long life. An example of this is when short copper laterals were connected to a large and long steel pipeline. The steel had plenty of surface area to spread the copper's attack, thus corrosion was not noticeable. But if the copper was the large pipe and the steel the short laterals, the steel would corrode at an amazing rate.

5.4 Design Considerations to Avoid Corrosion

The following recommendations are based upon typical observations and conclusions made by forensic engineers in construction defect lawsuits and NACE International (Corrosion Society) recommendations.

5.4.1 Testing Soil Factors (Resistivity, pH, REDOX, SO, CL, NO3, NH3)

As previously mentioned, different factors can cause corrosion. The most useful and common test for categorizing a soil's corrosivity has been the measure of soil resistivity which is typically measured in units of (ohm-cm) by corrosion engineers and geologists. Soil resistivity is the ability of soil to conduct or resist electrical currents and ion transfer. The lower the soil resistivity, the more conductive and corrosive it is. The following are "generally" accepted categories but keep in mind, the question is not "Is my soil corrosive?", the question should be, "What is my soil corrosive to?" and to answer that question, soil resistivity and chemistry must be tested. Though **soil resistivity is a good corrosivity indicator for steel materials, high chlorides or other corrosive elements do not always lower soil resistivity, thus if you don't test for chlorides and other water soluble salts, you can get an unpleasant surprise.** The largest contributing factor to a soil's electrical resistivity is its clay, mineral, metal, or sand make-up.

Table 2 - Corrosion Basics- An Introduction, NACE, 1984, pg 191

(Ohm-cm)	Corrosivity Description
0-500	Very Corrosive
500-1,000	Corrosive
1,000-2,000	Moderately Corrosive
2,000-10,000	Mildly Corrosive
Above 10,000	Progressively less corrosive

Testing a soil's pH provides information to reference the Pourbaix diagram of specific metals. Some elements such as ammonia and nitrates can create localized alkaline conditions which will greatly affect amphoteric materials such as aluminum and copper alloys.

Excess sulfates can break-down the structural integrity of cement and high concentrations of chlorides can overcome cement's corrosion inhibiting effect on encased ferrous metals and break down protective passivated surface layers on stainless steels and aluminum.

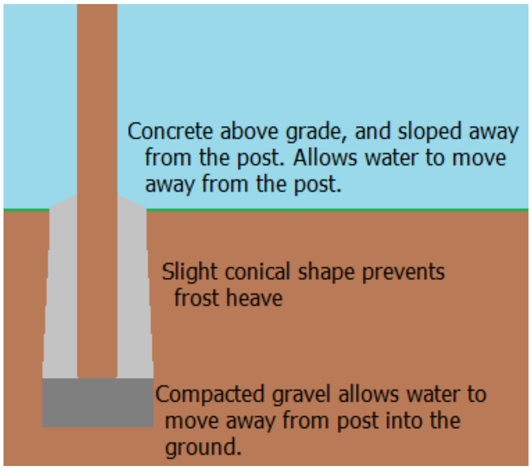
Corrosive bacteria are everywhere but can multiply significantly in anaerobic conditions with plentiful sulfates. The bacteria themselves do not eat the metal but their by-products can form corrosive sulfuric acids. The probability of corrosive bacteria is tested by measuring a soil's oxidation-reduction (REDOX) electro-potential and by testing for the presence of sulfides.

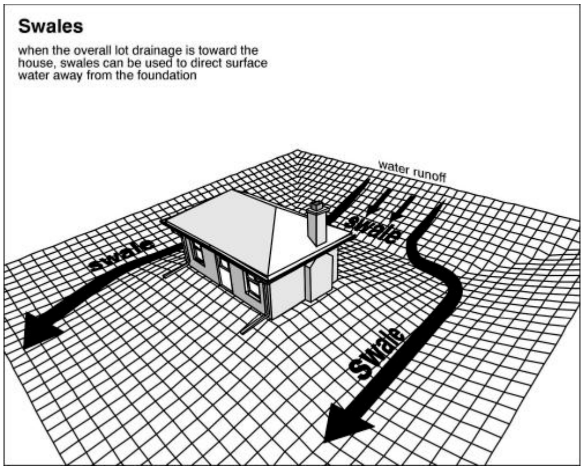
Only by testing a soil's chemistry for minimum resistivity, pH, chlorides, sulfates, sulfides, ammonia, nitrate, and redox potential can one have the information to evaluate the corrosion risk to construction materials such as steel, stainless steel, galvanized steel, iron, copper, brass, aluminum, and concrete.

5.4.2 Proper Drainage

It cannot be emphasized enough that pooled stagnant water on metals will eventually lead to corrosion. This stands for internal corrosion and external corrosion situations. In soils, providing good drainage will lower soil moisture content reducing corrosion rates. Attention to properly sealing polyethylene wraps around valves and piping will avoid water intrusion which would allow water to pool against metals. Above ground structures should not have cupped or flat surfaces that will pond water after rain or irrigation events.

Buildings typically are built on pads and have swales when constructed to drain water away from buildings directing it towards an acceptable exit point such as a driveway where it continues draining to a local storm drain. Many homeowners, landscapers and flatwork contractors appear to not be aware of this and destroy swales during remodeling. The majority of garage floor and finished grade elevations are governed by drainage during design. [10,11]



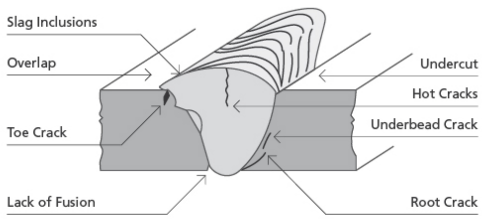


5.4.3 Avoiding Crevices

Crevices are excellent locations for oxygen differential induced corrosion cells to begin. Crevices can also harbor corrosive bacteria even in the most chemically treated waters. Crevices will also gather salts. If water's total alkalinity is low, its ability to maintain a stable pH can also become more difficult within a crevice allowing the pH to drop to acidic levels continuing a pitting process. Welds in extremely corrosive environments should be complete and well filleted without sharp edges to avoid crevices. Sharp edges should be avoided to allow uniform coating of protective epoxy. Detection of crevices in welds should be treated immediately. If pressures and loads are low, sanding and rewelding or epoxy patching can be suitable repairs. Damaged coatings can usually be repaired with Direct to Metal paints. **Scratches and crevice corrosion are like infections, they should not be left to fester or the infection will spread making things worse.**

[10] https://www.fencedaddy.com/blogs/tips-and-tricks/132606467-how-to-repair-a-broken-fence-post

[11] http://southdownstudio.co.uk/problme-drainage-maison.html



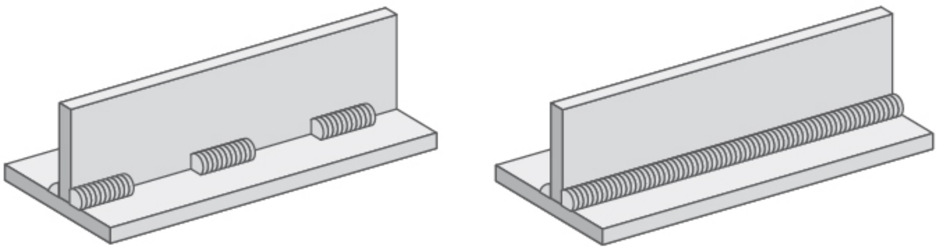


Figure 4 Defects which form weld crevices[12]

5.4.4 Coatings and Cathodic Protection

When faced with a corrosive environment, the best defense against corrosion is removing the electrolyte from the corrosion cell by applying coatings to separate the metal from the soil. During construction and installation, there is always some scratch or damage made to a coating. NACE training recommends that coatings be used as a first line of defense and that sacrificial or impressed current cathodic protection is used as a 2nd line of defense to protect the scratched areas. Use of a good coating dramatically reduces the amount of anodes a CP system would need. If CP is not installed as a 2nd line of defense in an extremely corrosive environment, the small scratched zones will suffer accelerated corrosion. CP details such as anode installation instructions must be designed by corrosion engineers or vessel manufacturers on a per project basis because it depends on electrolyte resistivity, surface area of infrastructure to be protected, and system geometry.

There are two types of cathodic protection systems, a Galvanic Anode Cathodic Protection (GACP) system and an Impressed Current Cathodic Protection (ICCP) system. A Galvanic Anode Cathodic Protection (GACP) system is simpler to install and maintain than an Impressed Current Cathodic Protection (ICCP) system. To protect the metals, they must all be electrically continuous to each other. In a GACP system, sacrificial zinc or magnesium anodes are then buried at locations per the CP design and connected by wire to a structure at various points in system. At the connection points, a wire connecting to the structure and the wire from the anode are joined in a Cathodic Protection Test Station hand hole which looks similar in size and shape to an irrigation valve pull box. By coating the underground structures, one can reduce the number of anodes needed to provide cathodic protection by 80% in many instances.

An ICCP system requires a power source, a rectifier, significantly more trenching, and more expensive type anodes. These systems are typically specified when bare metal is requiring protection

[12] http://www.daroproducts.co.uk/makes-good-weld/

in severely corrosive environments in which galvanic anodes do not provide enough power to polarize infrastructure to -850 mV structure-to-soil potential or be able to create a 100 mV potential shift as required by NACE SP169 to control corrosion. In severely corrosive environments, a GACP system simply may not last a required lifetime due to the high rate of consumption of the sacrificial anodes. ICCP system rectifiers must be inspected and adjusted quarterly or at a minimum bi-annually per NACE recommendations. Different anode installations may be possible but for large sites, anodes are placed evenly throughout the site and all anode wires must be trenched to the rectifier. For a large site, it may be beneficial to use two or more rectifiers to reduce wire lengths or trenching.

To simplify, a GACP system can be installed and practically forgotten with minor trenching because the anodes can be installed very close to the structures. An ICCP system must be inspected annually and anode wires run back to the rectifier which itself connects to the pile system. If any type of trenching or development is expected to occur at the site during the life of the site, it is a good idea to inspect the anode connections once a year to make sure wires are not cut and that the infrastructure is still being provided adequate protection. A common situation that occurs with ICCP systems is that a contractor accidently cuts the wires during construction then reconnects them incorrectly, turning the once cathode, into a sacrificing anode.

Design of a cathodic protection system protecting against soil side corrosion requires that Wenner Four Pin ground resistance measurements per ASTM G57 be performed by corrosion engineers at various locations of the site to determine the best depths and locations for anode installations. Ideally, a sample pile is installed and experiments determining current requirement are conducted. Using this data, the decision is made whether a GACP system is feasible or if an ICCP must be used.

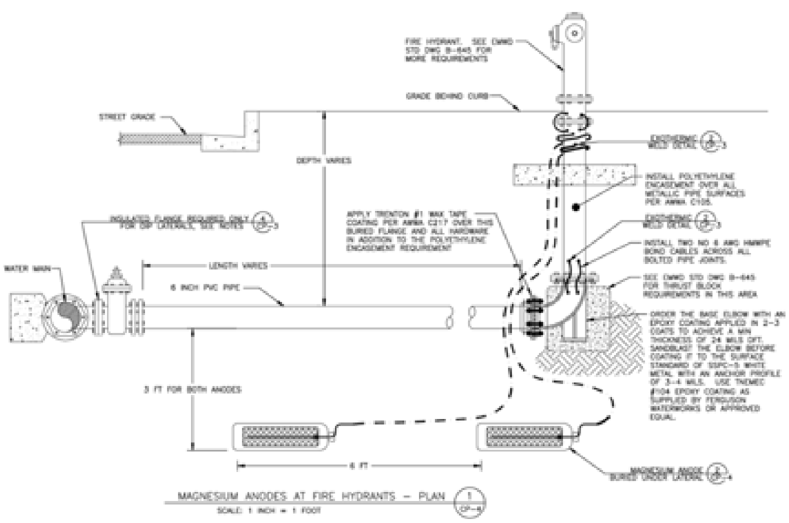


Figure 5 Sample anode design for fire hydrant underground piping

Vessels such as water tanks will have protective interior coatings and anodes to protect the interior surfaces. Anodes can also be buried on site and connected to system skid supports to protect the metal in contact with soil. A good example of a vessel cathodic protection system exists in all home water heaters which contain sacrificial aluminum or magnesium anodes. In environments that exceed 140F, zinc anodes cannot be used with carbon steel because they become the aggressor (Cathodic) to the steel instead of sacrificial (anodic). Anodes in vessels containing extremely brackish water with chloride levels over 2,000 ppm should inspect or change out their anodes every 6 months.

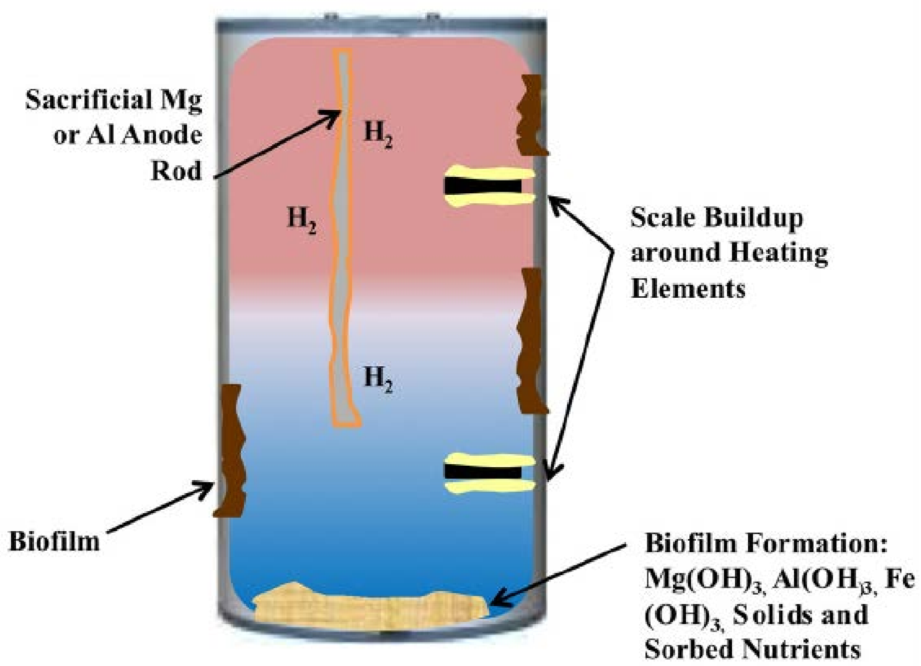


Figure 6 Cross section of boiler with anode

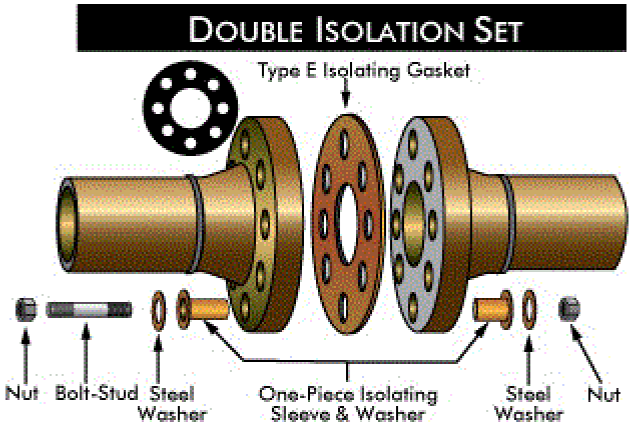
Cathodic protection can only protect a few diameters within a pipeline thus it is not recommended for small diameter pipelines and tubing internal corrosion protection. Anodes are like a lamp shining light in a room. They can only protect along their line of sight.

5.4.5 Good Electrical Continuity

In order for cathodic protection to protect a long pipeline or system of pipes from external soil side corrosion, they must all be electrically continuous to each other so that the electric current from the anode can travel along the pipes, then return through the earth to the anode. Electrical continuity is achieved by welding or pin brazing #8 AWG copper strand bond cable to the end of pipe sticks which have rubber gaskets at bell and spigots. If steel pipes are joined by full weld, bonding wires are not needed.

Electrical continuity between dissimilar metals is not desirable. Isolation joints or di-electric unions should be installed between dissimilar metals, such as steel pipes connecting to a brass valve. Bonding wires should then be welded onto the steel pipes by-passing the brass valve so that the cathodic protection system's current can continue to travel along the steel piping but isolate the brass valve from the steel pipeline. Another option would be to provide a separate cathodic protection system for steel pipes on both sides of the brass valve.

Typically, water heater inlets and outlets, gas meters and water meters have dielectric unions installed in them to separate utility property from homeowner property. This also protects them in the case that a home owner somehow electrically connects water pipes or gas pipes to a neighborhood electrical grounding system which can potentially have less noble steel in soil now connected to much more noble copper in soil which will then create a corrosion cell. This is exactly how a lemon powered clock works when a galvanized zinc nail and a steel nail are inserted into a lemon then connected to a clock. The clock is powered by the corrosion cell created.



5.4.6 *Bad Electrical Continuity*

Bad electrical continuity is when two different materials or systems are made electrically continuous (aka shorted) when they were not designed to be electrically continuous. Examples of this would be when gas lines are shorted to water lines or to electrical grounding beds. Very often, fire risers are shorted to electrical grounding systems, and water pipes at business parks. Since fire risers usually have a very short ductile iron pipe in the ground which connects to PVC pipe systems, they tend to experience leaks after 7 to 10 years of being attacked by underground copper systems.

It is absolutely imperative that any copper water piping or other metal conduits penetrating cement slab or footings, not come in contact with the reinforcing steel or post-tensioning tendons to avoid creation of galvanic corrosion cells.

5.4.7 *Corrosion Test Stations*

Corrosion test stations should be installed every 1,000 feet along pipelines in order to measure corrosion activity in the future. For a simple pipeline, two #8 AWG copper strand bond cable welded or pin brazed onto the pipeline are run up to finished grade and left in a hand hole. Corrosion test stations are used to measure pipe-to-soil electro potential relative to a copper copper-sulfate reference electrode to determine if the pipe is experiencing significant corrosion activity. By measuring test stations along a pipeline, hot spots can be determined, if any. The wires also allow for electrical continuity testing, condition assessment, and a multitude of other types of tests.

At isolation joints and pipe casings, two wires should be welded to either side of the isolation joint for a total of 4 wires to be brought up to the hand hole. This allows for future tests of the isolation joint, casing separation confirmation, and pipe-to-soil potential readings during corrosion surveys.

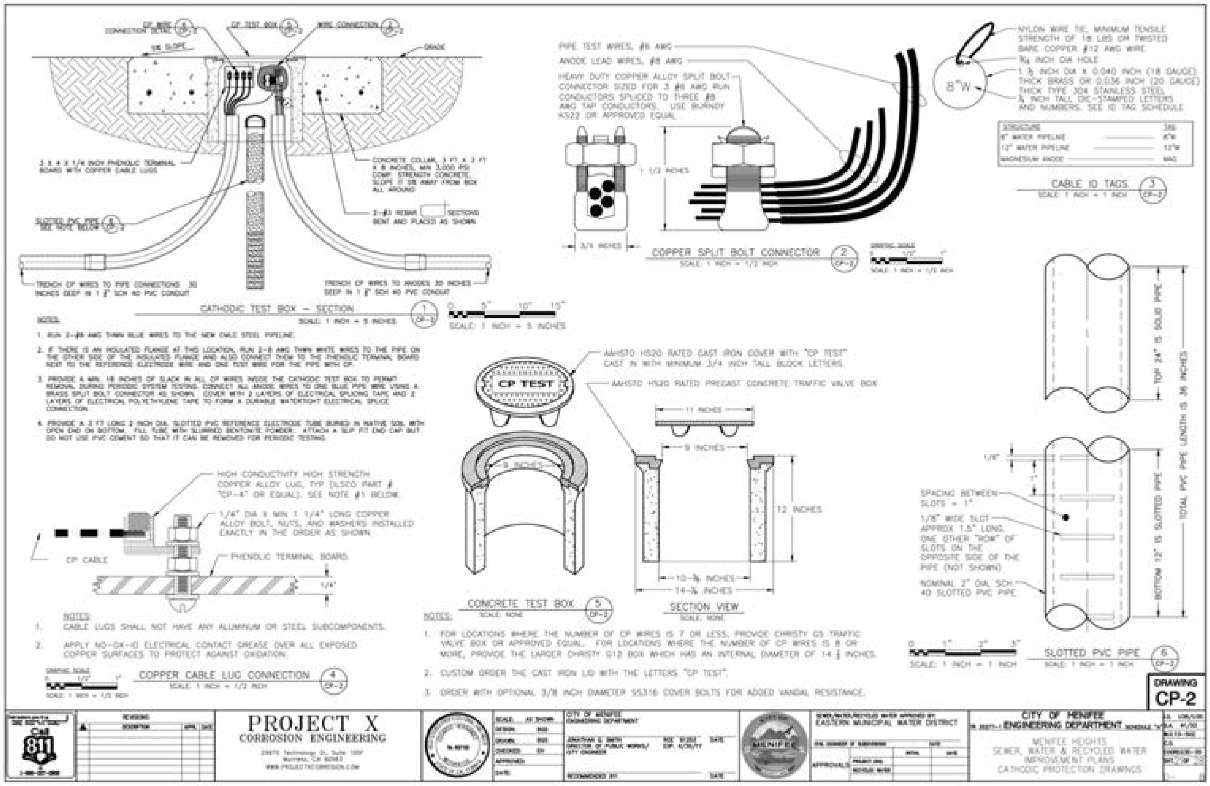


Figure 7 Sample of corrosion test station specification drawing

5.4.8 Excess Flux in Plumbing

Investigations of internal corrosion of domestic water plumbing systems almost always finds excess flux to be the cause of internal pitting of copper pipes. Some people believe that there is no such thing as too much flux. Flux runs have been observed to travel up to 20 feet with pitting occurring along the flux run. Flushing a soldered plumbing system with hot water for 15 minutes can remove significant amounts of excess flux left in the pipes. If a plumbing system is expected to be stagnant for some time, it should be drained to avoid stagnant water conditions that can lead to pitting and dezincification of yellow brasses.

5.4.9 Landscapers and Irrigation Sprinkler Systems

A significant amount of corrosion of fences is due to landscaper tools scratching fence coatings and irrigation sprinklers spraying these damaged fences. Recycled water typically has a higher salt content than potable drinking water, meaning that it is more corrosive than regular tap water. The same risk from damage and water spray exists for above ground pipe valves and backflow preventers. Fiber glass covers, cages, and cement footings have worked well to keep tools at an arm's length.

5.4.10 Roof Drainage splash zones

Unbelievably, even the location where your roof drain splashes down can matter. We have seen drainage from a home's roof valley fall directly down onto a gas meter causing it's piping to corrode at an accelerated rate reaching 50% wall thickness within 4 years. It is the same effect as a splash zone in the ocean or in a pool which has a lot of oxygen and agitation that can remove material as it corrodes.

5.4.11 Stray Current Sources

Stray currents which cause material loss when jumping off of metals may originate from direct-current distribution lines, substations, or street railway systems, etc., and flow into a pipe system or other steel structure. Alternating currents may occasionally cause corrosion. The corrosion resulting from stray currents (external sources) is similar to that from galvanic cells (which generate their own current) but different remedial measures may be indicated. In the electrolyte and at the metal-electrolyte interfaces, chemical and electrical reactions occur and are the same as those in the galvanic cell; specifically, the corroding metal is again considered to be the anode from which current leaves to flow to the cathode. Soil and water characteristics affect the corrosion rate in the same manner as with galvanic-type corrosion.

However, stray current strengths may be much higher than those produced by galvanic cells and, as a consequence, corrosion may be much more rapid. Another difference between galvanic-type currents and stray currents is that the latter are more likely to operate over long distances since the anode and cathode are more likely to be remotely separated from one another. Seeking the path of least resistance, the stray current from a foreign installation may travel along a pipeline causing severe corrosion where it leaves the line. Knowing when stray currents are present becomes highly important when remedial measures are undertaken since a simple sacrificial anode system is likely to be ineffectual in preventing corrosion under such circumstances.[13] Stray currents can be avoided by installing proper electrical shielding, installation of isolation joints, or installation of sacrificial jump off anodes at crossings near protected structures such as metal gas pipelines or electrical feeders.

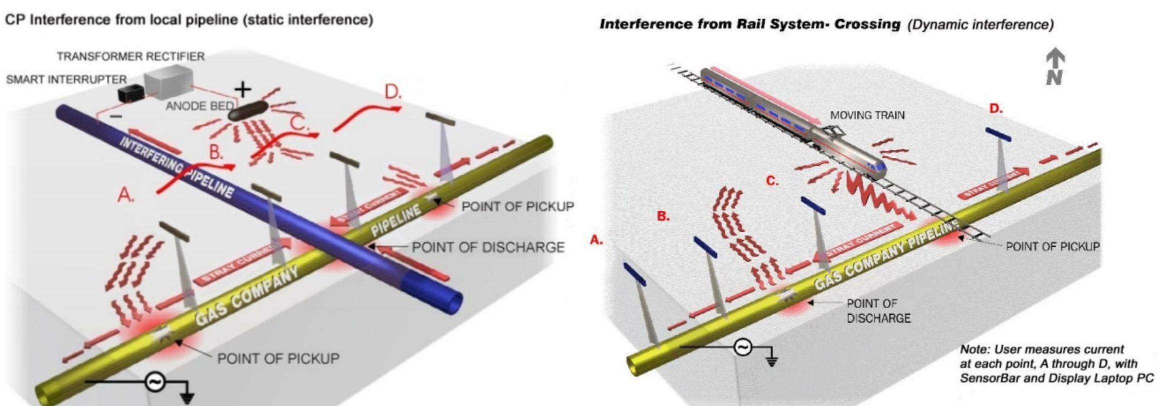


Figure 8 Examples of Stray Current[14]

[13] http://corrosion-doctors.org/StrayCurrent/Introduction.htm

[14] http://www.eastcomassoc.com/

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October 24, 2019
File Number 21848

Faring
659 North Robertson Boulevard
West Hollywood, California 90069

Attention: Sarah Oliveira

Subject: Preliminary Geotechnical Engineering Investigation
Proposed Mixed-Use High-Rise Development
1010, 1014 and 1020 North La Brea Avenue, West Hollywood, California

Dear Ms. Oliveira:

This letter transmits the Preliminary Geotechnical Engineering Investigation for the subject site prepared by Geotechnologies, Inc. This report provides preliminary geotechnical recommendations for the development of the site, including earthwork, seismic design, retaining walls, excavations, shoring and foundation design. Engineering for the proposed project should not begin until approval of the geotechnical investigation is granted by the local building official. Significant changes in the geotechnical recommendations may result due to the building department review process.

This report is preliminary in nature because the proposed project plan remains under development and is not well defined at this time. Due to its preliminary nature, this report is not intended for submission to the building official for building permit purposes. Once the proposed development plan achieves refinement, this firm should re-evaluate the recommendations presented herein, to ensure they are suitable for the proposed development. A final geotechnical engineering investigation, suitable for submission to the building official for building permit purposes, will be prepared at that time.

The validity of the recommendations presented herein is dependent upon review of the geotechnical aspects of the project during construction by this firm. The subsurface conditions described herein have been projected from limited subsurface exploration and laboratory testing. The exploration and testing presented in this report should in no way be construed to reflect any variations which may occur between the exploration locations or which may result from changes in subsurface conditions.

Should you have any questions please contact this office.

Respectfully submitted,
GEOTECHNOLOGIES, INC.

REGISTERED PROFESSIONAL ENGINEER
GREGORIO VARELA
No. 81201
Exp. 9/30/21
CIVIL
STATE OF CALIFORNIA

GREGORIO VARELA
R.C.E. 81201

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TABLE OF CONTENTS

SECTION **PAGE**

TABLE OF CONTENTS

SECTION **PAGE**

TABLE OF CONTENTS

SECTION	**PAGE**

PRELIMINARY GEOTECHNICAL ENGINEERING INVESTIGATION
PROPOSED MIXED-USE HIGH-RISE DEVELOPMENT
1010, 1014 AND 1020 NORTH LA BREA AVENUE
WEST HOLLYWOOD, CALIFORNIA

INTRODUCTION

This report presents the results of the preliminary geotechnical engineering investigation performed on the subject site. The purpose of this investigation was to identify the distribution and engineering properties of the geologic materials underlying the site, and to provide geotechnical recommendations for the design of the proposed development.

This report is preliminary in nature because the proposed project plan remains under development and is not well defined at this time. Due to its preliminary nature, this report is not intended for submission to the building official for building permit purposes. Once the proposed development plan achieves refinement, this firm should re-evaluate the recommendations presented herein, to ensure they are suitable for the proposed development. A final geotechnical engineering investigation, suitable for submission to the building official for building permit purposes, will be prepared at that time.

This investigation included two exploratory excavations, collection of representative samples, laboratory testing, engineering analysis, review of published geologic data, review of available geotechnical engineering information and the preparation of this report. The exploratory excavation locations are shown on the enclosed Plot Plan. The results of the exploration and the laboratory testing are presented in the Appendix of this report.

PROPOSED DEVELOPMENT

Preliminary information concerning the proposed development was furnished by the client. In addition, the preliminary drawings prepared by Gensler, dated September 19, 2019, were reviewed for the preparation of this report. The proposed project consists of the construction of a mixed-use development. It should be noted that the site of the proposed development is located within two different jurisdictions. The western portion of the site is located within the City of West Hollywood, while the eastern portion is located within the City of Los Angeles. At this time it is unknown which jurisdiction would be on charge of reviewing the project. For the purpose of preparing this preliminary investigation, it has been assumed that the portion of the structure proposed within the City of West Hollywood will fall within its jurisdiction. This investigation is specific to the portion of the development located within the City of West Hollywood. A separate investigation is currently being prepared for the portion of the structure located within the City of Los Angeles jurisdiction.

It is anticipated that the structure proposed within the City of West Hollywood may be up to 48 stories in height. The structure will be built over a 3-level subterranean parking garage. Based on review of the enclosed Cross Section A-A', it is anticipated that the finished floor elevation of the lowest subterranean level may extend to a depth of 33 feet below the existing grade. Excavations up to a depth of 43 feet would be anticipated for construction of the proposed subterranean garage, including a potential mat foundation. The proposed location, alignment and depth of the structure is shown in the enclosed Plot Plan and Cross Sections A-A'.

Any changes in the design of the project or location of any structure, as outlined in this report, should be reviewed by this office. The recommendations contained in this report should not be considered valid until reviewed and modified or reaffirmed, in writing, subsequent to such review.

SITE CONDITIONS

The site is located at 1010, 1014 and 1020 North La Brea Avenue, in the City of West Hollywood, California. The site is rectangular in shape, and approximately 1 acre in area. The site is bounded by commercial and office developments to the north and east, Romaine Street to the south, and La Brea Avenue to the west. The site is shown relative to nearby topographic features in the enclosed Vicinity Map.

The site grade is relatively level, with no pronounced highs or lows. The site is currently developed with a commercial building and a concrete plant. Vegetation at the site is non-existent. Drainage across the site appears to be by sheetflow to the City streets.

GEOTECHNICAL EXPLORATION

FIELD EXPLORATION

The site was explored on August 1, 2, 5, 6 and 7, 2019, by drilling two borings. The borings were drilled with the aid of a truck-mounted drilling machine using 8-inch diameter hollowstem augers. Boring B1 was drilled to a depth of 130 feet, while Boring B2 was drilled to a depth of 180 feet below the existing grade. The exploration locations are shown on the Plot Plan and the geologic materials encountered are logged on Plates A-1 and A-2.

The location of exploratory excavations was determined from hardscape features shown in the enclosed Plot Plan. The location of the exploratory excavations should be considered accurate only to the degree implied by the method used.

Geologic Materials

Fill:

Fill materials were encountered in the exploratory borings to a depth 5 and 8 feet below the existing grades, respectively. The existing fill materials consist of a mixture of clay, silt and sand, which is dark brown and gray in color, moist, stiff or medium dense, and fine grained.

Older Alluvium:

Older alluvial soils were observed to underlain the fill in the exploratory borings. The older alluvial soils consist of interlayered mixtures of silty and sandy clays, Sandy and clayey silts, silty and clayey sands, and sands, which are yellowish to dark brown to gray in color, moist to wet, medium dense to very dense, or stiff to very stiff, and fine to coarse grained with occasional gravel and cobbles.

Bedrock (Puente Formation):

Bedrock was encountered in the borings underlying the older alluvial soils. The bedrock was observed at a depth of 105 and 107½ feet below the existing grade, respectively. The bedrock underlying the site is comprised of upper Miocene-age Puente Formation, consisting of thin bedded siltstone and claystone. The bedrock is gray to dark gray in color, moist, and moderately hard to hard.

More detailed descriptions of the earth materials encountered may be obtained from individual logs of the subsurface excavations.

Groundwater

Groundwater was encountered during drilling of Boring 1 and Boring 2, at depths of 18½ and 19 feet below the existing grade, respectively. According to groundwater data provided in the Seismic Hazard Zone Report of the Hollywood 7½-Minute Quadrangle, the historically-highest groundwater level for the site was on the order of 10 feet below the ground surface (CDMG, 1998, Revised 2006). A copy of the historic high water map is appended.

Fluctuations in the level of groundwater may occur due to variations in rainfall, temperature, and other factors not evident at the time of the measurements reported herein. Fluctuations also may occur across the site. High groundwater levels can result in changed conditions.

Caving

Caving could not be directly observed during exploration due to the continuously cased design of the hollow stem auger Based on the experience of this firm, large diameter excavations, excavations that encounter granular, cohesionless soils and excavations below the groundwater table will likely experience caving.

SEISMIC EVALUATION

REGIONAL GEOLOGIC SETTING

The subject site is located in the Los Angeles Basin which is considered the northern portion of the Peninsular Ranges Geomorphic Province. The Peninsular Ranges are characterized by northwest-trending blocks of mountain ridges and sediment-floored valleys. The dominant geologic structural features are northwest trending fault zones that either die out to the northwest or terminate at east-trending reverse faults that form the southern margin of the Transverse Ranges.

The Los Angeles Basin is bounded by the east and southeast by the Santa Ana Mountains and San Joaquin Hills, to the northwest by the Santa Monica Mountains. Over 22 million years ago the Los Angeles basin was a deep marine basin formed by tectonic forces between the North American and Pacific plates. Since that time, over 5 miles of marine and non-marine sedimentary rock as well as intrusive and extrusive igneous rocks have filled the basin. During the last 2 million years, defined by the Pleistocene and Holocene epochs, the Los Angeles basin and surrounding mountain ranges have been uplifted to form the present day landscape. Erosion of the surrounding mountains has resulted in deposition of unconsolidated sediments in low-lying areas by rivers such as the Los Angeles River. Areas that have experienced subtle uplift have been eroded with gullies.

The site is underlain by deep, unconsolidated older alluvial sediments deposited by river and stream action.

REGIONAL FAULTING

Based on criteria established by the California Division of Mines and Geology (CDMG) now called California Geologic Survey (CGS), Faults may be categorized as Holocene-active, Pre-Holocene faults, and Age-undetermined faults. Holocene-active faults are those which show evidence of surface displacement within the last 11,700 years. Pre-Holocene faults are those that have not moved in the past 11,700 years. Age-undetermined faults are faults where the recency of fault movement has not been determined.

Buried thrust faults are faults without a surface expression but are a significant source of seismic activity. They are typically broadly defined based on the analysis of seismic wave recordings of hundreds of small and large earthquakes in the southern California area. Due to the buried nature of these thrust faults, their existence is usually not known until they produce an earthquake. The risk for surface rupture potential of these buried thrust faults is inferred to be low (Leighton, 1990). However, the seismic risk of these buried structures in terms of recurrence and maximum potential magnitude is not well established. Therefore, the potential for surface rupture on these surface-verging splays at magnitudes higher than 6.0 cannot be precluded.

The enclosed Regional Fault Location Map shows faults located in the region. This map is based on the 2010 Fault Activity Map, prepared by the California Department of Conservation. Some of the Holocene-active and Blind Thrusts faults located closest to the site are addressed in the following sections.

Holocene-Active Faults

Hollywood Fault

The Hollywood fault is part of the Transverse Ranges Southern Boundary fault system. The Hollywood fault is located approximately 1 mile north of the site. This fault trends east-west along the base of the Santa Monica Mountains from the West Beverly Hills Lineament in the West Hollywood–Beverly Hills area to the Los Feliz area of Los Angeles. The Hollywood fault is the eastern segment of the reverse oblique Santa Monica–Hollywood fault. Based on geomorphic evidence, stratigraphic correlation between exploratory borings, and fault trenching studies, this fault is classified as active.

Until recently, the approximately 9.3-mile long Hollywood fault was considered to be expressed as a series of linear ground-surface geomorphic expressions and south-facing ridges along the south margin of the eastern Santa Monica Mountains and the Hollywood Hills. Multiple recent fault rupture hazard investigations have shown that the Hollywood fault is located south of the ridges and bedrock outcroppings along portions of Sunset Boulevard. The Hollywood fault has not produced any damaging earthquakes during the historical period and has had relatively minor micro-seismic activity. It is estimated that the Hollywood fault is capable of producing a maximum 6.7 magnitude earthquake. In 2014, the California Geological Survey established an Earthquake Fault Zone for the Hollywood Fault. A copy of this map may be found in the Appendix.

Santa Monica Fault

In 2018, the California Geological Survey established an Earthquake Fault Zone for the Santa Monica Fault. The nearest segment of the active portion of the Santa Monica fault is located approximately 4¼-miles to the west of the site. The Santa Monica fault is a part of the Transverse Ranges Southern Boundary fault system, extending east from the coastline in Pacific Palisades through Santa Monica and West Los Angeles and merges with the Hollywood fault at the West Beverly Hills Lineament in Beverly Hills where its strike is northeast. It is believed that at least six surface ruptures have occurred in the past 50 thousand years. In addition, a well-documented surface rupture occurred between 10 and 17 thousand years ago, although a more recent earthquake probably occurred 1 to 3 thousand years ago. This leads to an average earthquake recurrence interval of 7 to 8 thousand years.[a] It is thought that the Santa Monica fault system may produce earthquakes with a maximum magnitude of 7.4.

Newport-Inglewood Fault System

The Newport-Inglewood fault system is located 4 miles to the southwest of the site. The Newport-Inglewood fault zone is a broad zone of discontinuous north to northwestern echelon faults and northwest to west trending folds. The fault zone extends southeastward from West Los Angeles, across the Los Angeles Basin, to Newport Beach and possibly offshore beyond San Diego (Barrows, 1974; Weber, 1982; Ziony, 1985).

The onshore segment of the Newport-Inglewood fault zone extends for about 37 miles from the Santa Ana River to the Santa Monica Mountains. Here it is overridden by, or merges with, the east-west trending Santa Monica zone of reverse faults.

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[a] *Southern California Earthquake Center, a National Science Foundation and U.S. Geological Survey Center. Active Faults in the Los Angeles Metropolitan Region, www.scec.org/research/special/SCEC001activefaultsLA.pdf; accessed May 24, 2012.*

The surface expression of the Newport-Inglewood fault zone is made up of a strikingly linear alignment of domal hills and mesas that rise on the order of 400 feet above the surrounding plains. From the northern end to its southernmost onshore expression, the Newport-Inglewood fault zone is made up of: Cheviot Hills, Baldwin Hills, Rosecrans Hills, Dominguez Hills, Signal Hill-Reservoir Hill, Alamitos Heights, Landing Hill, Bolsa Chica Mesa, Huntington Beach Mesa, and Newport Mesa. Several single and multiple fault strands, arranged in a roughly left stepping en echelon arrangement, make up the fault zone and account for the uplifted mesas.

The most significant earthquake associated with the Newport-Inglewood fault system was the Long Beach earthquake of 1933 with a magnitude of 6.3 on the Richter scale. It is believed that the Newport-Inglewood fault zone is capable of producing a 7.5 magnitude earthquake.

Raymond Fault

The Raymond fault is located approximately 7 miles to the northeast of the site. The Raymond fault is an effective groundwater barrier which divides the San Gabriel Valley into groundwater sub-basins. Much of the geomorphic evidence for the Raymond fault has been obliterated by urbanization of the San Gabriel Valley. However, a discontinuous escarpment can be traced from Monrovia to the Arroyo Seco in South Pasadena. The very bold, “knife edge” escarpment in Monrovia parallel to Scenic Drive is believed to be a fault scarp of the Raymond fault. Trenching of the Raymond fault is reported to have revealed Holocene movement (Weaver and Dolan, 1997).

The recurrence interval for the Raymond fault is probably slightly less than 3,000 years, with the most recent documented event occurring approximately 1,600 years ago (Crook, et al, 1978). However, historical accounts of an earthquake that occurred in July 1855 as reported by Toppozada and others, 1981, places the epicenter of a Richter Magnitude 6 earthquake within the Raymond fault. It is believed that the Raymond fault is capable of producing a 6.8 magnitude earthquake. The Raymond Fault is considered active by the California Geological Survey.

Verdugo Fault

The Verdugo Fault is located approximately 7½ miles to the north of the site. The Verdugo Fault runs along the southwest edge of the Verdugo Mountains. The fault displays a reverse motion. According to Weber, et. al., (1980) 2 to 3 meter high scarps were identified in alluvial fan deposits in the Burbank and Glendale areas. Further to the northeast, in Sun Valley, a fault was reportedly identified at a depth of 40 feet in a sand and gravel pit. Although considered active by the County of Los Angeles, Department of Public Works (Leighton, 1990), and the United States Geological Survey, the fault is not designated with an Earthquake Fault Zone by the California Geological Survey. It is estimated that the Verdugo Fault is capable of producing a maximum 6.9 magnitude earthquake.

Malibu Coast Fault

The Malibu Coast fault is part of the Transverse Ranges Southern Boundary fault system, a west-trending system of reverse, oblique-slip, and strike-slip faults that extends for more than approximately 124 miles along the southern edge of the Transverse Ranges and includes the Hollywood, Raymond, Anacapa–Dume, Malibu Coast, Santa Cruz Island, and Santa Rosa Island faults.

The Malibu Coast fault zone runs in an east-west orientation onshore subparallel to and along the shoreline for a linear distance of about 17 miles through the Malibu City limits, but also extends offshore to the east and west for a total length of approximately 37.5 miles. The onshore Malibu Coast fault zone involves a broad, wide zone of faulting and shearing as much as 1 mile in width. While the Malibu Coast Fault Zone has not been officially designated as an active fault zone by the State of California and no Special Studies Zones have been delineated along any part of the fault zone under the Alquist-Priolo Act of 1972, evidence for Holocene activity (movement in the last 11,000 years) has been established in several locations along individual fault splays within the fault zone. Due to such evidence, several fault splays within the onshore portion of the fault zone are identified as active.[b]

Large historic earthquakes along the Malibu Coast fault include the 1979, 5.2 magnitude earthquake and the 1989, 5.0 magnitude earthquake.[c] The Malibu Coast fault zone is approximately 11¼-miles northwest of the site and is believed to be capable of producing a maximum 7.0 magnitude earthquake.

Sierra Madre Fault System

The Sierra Madre fault alone forms the southern tectonic boundary of the San Gabriel Mountains in the northern San Fernando Valley. It consists of a system of faults approximately 75 miles in length. The individual segments of the Sierra Madre fault system range up to 16 miles in length and display a reverse sense of displacement and dip to the north. The most recently active portions of the zone include the Mission Hills, Sylmar and Lakeview segments, which produced an earthquake in 1971 of magnitude 6.4. Tectonic rupture along the Lakeview Segment during the San Fernando Earthquake of 1971 produced displacements of approximately 2½ to 4 feet upward and southwestward.

It is believed that the Sierra Madre fault zone is capable of producing an earthquake of magnitude 7.3. The closest trace of the fault is located approximately 12 miles northeast of the site.

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[b] *City of Malibu Planning Department, Malibu General Plan, Chapter 5.0, Safety and Health Element, http://qcode.us/codes/malibu-general-plan/; accessed October 25, 2012.*
[c] *California Institute of Technology, Southern California Data Center. Chronological Earthquake Index, www.data.scec.org/significant/malibu1979.html; accessed October 25, 2012.*

Palos Verdes Fault

Studies indicate that there are several active on-shore extensions of the strike-slip Palos Verdes fault, which is located approximately 14½-miles southwest of the site. Geophysical data also indicate the off-shore extensions of the fault are active, offsetting Holocene age deposits. No historic large magnitude earthquakes are associated with this fault. However, the fault is considered active by the California Geological Survey. It is estimated that the Palos Verdes fault is capable of producing a maximum 7.7 magnitude earthquake.

San Gabriel Fault System

The San Gabriel fault system is located approximately 16 miles northeast of the site. The San Gabriel fault system comprises a series of subparallel, steeply north-dipping faults trending approximately north 40 degrees west with a right-lateral sense of displacement. There is also a small component of vertical dip-slip separation. The fault system exhibits a strong topographic expression and extends approximately 90 miles from San Antonio Canyon on the southeast to Frazier Mountain on the northwest. The estimated right lateral displacement on the fault varies from 34 miles (Crowell, 1982) to 40 miles (Ehlig, 1986), to 10 miles (Weber, 1982). Most scholars accept the larger displacement values and place the majority of activity between the Late Miocene and Late Pliocene Epochs of the Tertiary Era (65 to 1.8 million years before present).

Portions of the San Gabriel fault system are considered active by California Geological Survey. Recent seismic exploration in the Valencia area (Cotton and others, 1983; Cotton, 1985) has established Holocene offset. Radiocarbon data acquired by Cotton (1985) indicate that faulting in the Valencia area occurred between 3,500 and 1,500 years before present.

It is hypothesized by Ehlig (1986) and Stitt (1986) that the Holocene offset on the San Gabriel fault system is due to sympathetic (passive) movement as a result of north-south compression of the upper Santa Susana thrust sheet. Seismic evidence indicates that the San Gabriel fault system is truncated at depth by the younger, north-dipping Santa Susana-Sierra Madre faults (Oakeshott, 1975; Namson and Davis, 1988).

Whittier-Elsinore Fault System

The Whittier fault is located approximately 18 miles to the southeast of the site. The Whittier fault together with the Chino fault comprises the northernmost extension of the northwest trending Elsinore fault system. The mapped surface of the Whittier fault extends in a west-northwest direction for a distance of 20 miles from the Santa Ana River to the terminus of the Puente Hills. The Whittier fault is essentially a strike-slip, northeast dipping fault zone which also exhibits evidence of reverse movement along with en echelon[d] fault segments, en echelon folds and anatomizing (braided) fault segments. Right lateral offsets of stream drainages of up to 8800 feet (Durham and Yerkes, 1964) and vertical separation of the basement complex of 6,000 to 12,000 feet (Yerkes, 1972), have been documented. It is believed that the Whittier fault is capable of producing a 7.8 magnitude earthquake.

The Whittier Narrows earthquakes of October 1, 1987, and October 4, 1987, occurred in the area between the westernmost terminus of the mapped trace of the Whittier fault and the frontal fault system. The main 5.9 magnitude shock of October 1, 1987 was not caused by slip on the Whittier fault. The quake ruptured a gently dipping thrust fault with an east-west strike (Haukson, Jones, Davis and others, 1988). In contrast, the earthquake of October 4, 1987, is assumed to have occurred on the Whittier fault as focal mechanisms show mostly strike-slip movement with a small reverse component on a steeply dipping northwest striking plane (Haukson, Jones, Davis and others, 1988).

[d] *En echelon refers to closely-spaced, parallel or subparallel, overlapping or step-like minor structural features*

Santa Susana Fault

The Santa Susana fault extends approximately 17 miles west-northwest from the northwest edge of the San Fernando Valley into Ventura County and is at the surface high on the south flank of the Santa Susana Mountains. The fault ends near the point where it overrides the south-side-up South strand of the Oak Ridge fault. The Santa Susana fault strikes northeast at the Fernando lateral ramp and turns east at the northern margin of the Sylmar Basin to become the Sierra Madre fault. This fault is exposed near the base of the San Gabriel Mountains for approximately 46 miles from the San Fernando Pass at the Fernando lateral ramp east to its intersection with the San Antonio Canyon fault in the eastern San Gabriel Mountains, east of which the range front is formed by the Cucamonga fault. The Santa Susana fault has not experienced any recent major ruptures except for a slight rupture during the 6.5 magnitude 1971 Sylmar earthquake.[e] The Santa Susana Fault is considered to be active by the County of Los Angeles. It is believed that the Santa Susana fault has the potential to produce a 6.9 magnitude earthquake. The closest trace of the fault is located approximately 18 miles north of the site.

San Andreas Fault System

The San Andreas Fault system forms a major plate tectonic boundary along the western portion of North America. The system is predominantly a series of northwest trending faults characterized by a predominant right lateral sense of movement. At its closest point the San Andreas Fault system is located approximately 34 miles to the northeast of the site.

The San Andreas and associated faults have had a long history of inferred and historic earthquakes. Cumulative displacement along the system exceeds 150 miles in the past 25 million years (Jahns, 1973). Large historic earthquakes have occurred at Fort Tejon in 1857, at Point Reyes in 1906, and at Loma Prieta in 1989. Based on single-event rupture length, the maximum

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[e] *California Institute of Technology, Southern California Data Center. Chronological Earthquake Index, www.data.scec.org/significant/santasusana.html; accessed May 24, 2012.*

Richter magnitude earthquake is expected to be approximately 8.25 (Allen, 1968). The recurrence interval for large earthquakes on the southern portion of the fault system is on the order of 100 to 200 years.

<u>Blind Thrusts Faults</u>

Blind or buried thrust faults are faults without a surface expression but are a significant source of seismic activity. By definition, these faults have no surface trace, therefore the potential for ground surface rupture is considered remote. They are typically broadly defined based on the analysis of seismic wave recordings of hundreds of small and large earthquakes in the Southern California area. Due to the buried nature of these thrust faults, their existence is sometimes not known until they produce an earthquake. Two blind thrust faults in the Los Angeles metropolitan area are the Puente Hills blind thrust and the Elysian Park blind thrust. Another blind thrust fault of note is the Northridge fault located in the northwestern portion of the San Fernando Valley.

The Elysian Park anticline is thought to overlie the Elysian Park blind thrust. This fault has been estimated to cause an earthquake every 500 to 1,300 years in the magnitude range 6.2 to 6.7. The Elysian Park anticline is approximately 3 miles to the southeast of the site.

The Puente Hills blind thrust fault extends eastward from Downtown Los Angeles to the City of Brea in northern Orange County. The Puente Hills blind thrust fault includes three north-dipping segments, named from east to west as the Coyote Hills segment, the Santa Fe Springs segment, and the Los Angeles segment. These segments are overlain by folds expressed at the surface as the Coyote Hills, Santa Fe Springs Anticline, and the Montebello Hills.

The Los Angeles segment of the Puente Hills blind thrust is located approximately 4 miles to the southeast of the site.

The Santa Fe Springs segment of the Puente Hills blind thrust fault is believed to be the cause of the October 1, 1987, Whittier Narrows Earthquake. Based on deformation of late Quaternary age sediments above this fault system and the occurrence of the Whittier Narrows earthquake, the Puente Hills blind thrust fault is considered an active fault capable of generating future earthquakes beneath the Los Angeles Basin. A maximum moment magnitude of 7.0 is estimated by researchers for the Puente Hills blind thrust fault.

The Mw 6.7 Northridge earthquake was caused by the sudden rupture of a previously unknown, blind thrust fault. This fault has since been named the Northridge Thrust, however it is also known in some of the literature as the Pico Thrust. It has been assigned a maximum magnitude of 6.9 and a 1,500 to 1,800 year recurrence interval. The Northridge thrust is located 15¼-miles to the northwest of the site.

SEISMIC HAZARDS AND DESIGN CONSIDERATIONS

The primary geologic hazard at the site is moderate to strong ground motion (acceleration) caused by an earthquake on any of the local or regional faults. The potential for other earthquake-induced hazards was also evaluated including surface rupture, liquefaction, dynamic settlement, inundation and landsliding.

Surface Rupture

In 1972, the Alquist-Priolo Special Studies Zones Act (now known as the Alquist-Priolo Earthquake Fault Zoning Act) was passed into law. As revised in 2018, The Act defines "Holocene-active" Faults utilizing the same aging criteria as that used by California Geological Survey (CGS). However, established state policy has been to zone only those faults which have direct evidence of movement within the last 11,700 years. It is this recency of fault movement that the CGS considers as a characteristic for faults that have a relatively high potential for ground rupture in the future.