APPENDIX B

Laboratory Testing
Tabulated Test Results
Individual Test Results
Soil Chemistry Results

LABORATORY TESTING

A. Samples were reviewed along with field logs to determine which would be analyzed further. Those chosen for laboratory analysis were considered representative of soils that would be exposed and/or used during grading, and those deemed to be within the influence of proposed structures. Test results are presented in graphic and tabular form in this Appendix.

B. In-situ moisture content and unit dry weight for the ring samples were determined in general accordance with ASTM D 2937.

C. The relative strength characteristics of the soils were determined from the results of a direct shear tests on remolded and undisturbed samples. Specimens were placed in contact with water at least 24 hours before testing, and were then sheared under normal loads ranging from 0.5 to 2.0 kips per square foot in general accordance with ASTM D 3080.

D. Settlement characteristics were developed from the results of one dimensional consolidation tests performed in general accordance with ASTM D 2435. The samples were typically loaded to 0.1.25 ksf, flooded with water, and then incrementally loaded to 0.25, 0.50, 1.0, 2.0, 4.0, and 8.0 ksf. The samples were allowed to consolidate under each load increment. Rebound was measured under reverse alternate loading. Compression was measured by dial gauges accurate to 0.0001 inch. Results of the consolidation tests in the form of percent consolidation versus log of pressure curves are presented in this Appendix.

E. Expansion index tests were performed on bulk soil samples in accordance with ASTM D 4829. The samples were surcharged under 144 pounds per square foot at moisture content of near 50% saturation. The samples were then submerged in water for 24 hours and the amount of expansion was recorded with a dial indicator.

F. Maximum density tests were performed to estimate the moisture-density relationship of typical soil materials. The tests were performed in accordance with ASTM 1557.

G. The gradation characteristics of selected samples were made by hydrometer (in accordance with ASTM D 422) and sieve analysis procedures. Selected samples were soaked in water until individual soil particles were separated and then washed on the No. 200 mesh sieve, oven dried, weighed to calculate the percent passing the No. 200 sieve and then mechanically sieved. Additionally, hydrometer analyses were performed to assess the distribution of the minus No. 200 mesh material of selected samples. The hydrometer test was run using sodium hexametaphosphate as a dispersing agent.

H. Concrete and metal corrosion potential of the near surface soil was determined by measuring pH, resistivity, and soluble sulfate and soluble chloride contents. The tests were performed by Capco.

TABULATED TEST RESULTS

REMOLDED SAMPLES

BORING AND DEPTH	B-1 @ 0-5'	B-3 @ 0-5'
USCS	SM	SC/CL
MAXIMUM DENSITY (pcf)	131	122.5
OPTIMUM MOISTURE (%)	8.5	9
COHESION (psf)	0	180
ANGLE OF INTERNAL FRICTION	37	24
EXPANSION INDEX	5	48
GRAIN SIZE DISTRIBUTION (%)		
GRAVEL	7.7	0.4
SAND	63.5	47.5
SILT	17.5	24.1
CLAY	11.3	28.0

GRAIN SIZE DISTRIBUTION (%)

BORING AND DEPTH	1 @ 25'	1 @ 30'	1 @ 40'	1 @ 45'
GRAVEL	0	99.7	0.8	1.1
SAND	44.5	0	45.5	74.9
SILT	34.7	0.3	27.9	1.1
CLAY	20.8	0	25.8	22.9

BORING AND DEPTH	2 @ 22'
GRAVEL	0
SAND	95.6
SILT	3.6
CLAY	0.8

VT-22503-01

Jul 9. 2001

MAXIMUM DENSITY / OPTIMUM MOISTURE

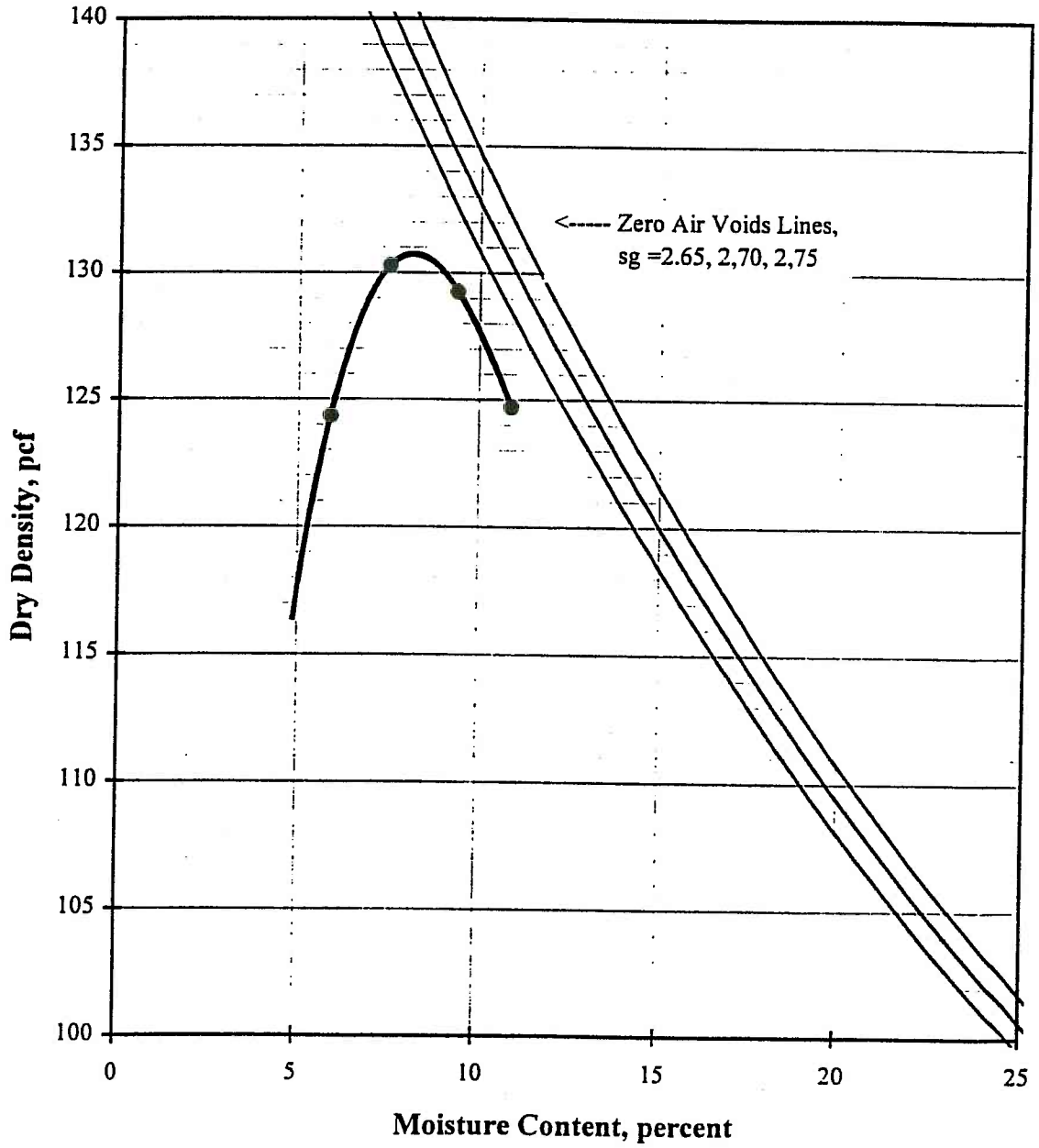
ASTM D 1557-91 (Modified)

Job Name: Santa Barbara Zoological Gardens
Sample ID: B 1 @ 0 - 5
Location:
Description: Silty Sand

Procedure Used: A
Prep. Method: Moist
Rammer Type: Manual

Maximum Density: **131 pcf**
Optimum Moisture: **8.5%**
Corrected for Oversize (ASTM D4718)

Sieve Size	% Retained
3/4"	0.0
3/8"	0.0
#4	11.0



VT-22503-01

Jul 9. 2001

MAXIMUM DENSITY / OPTIMUM MOISTURE

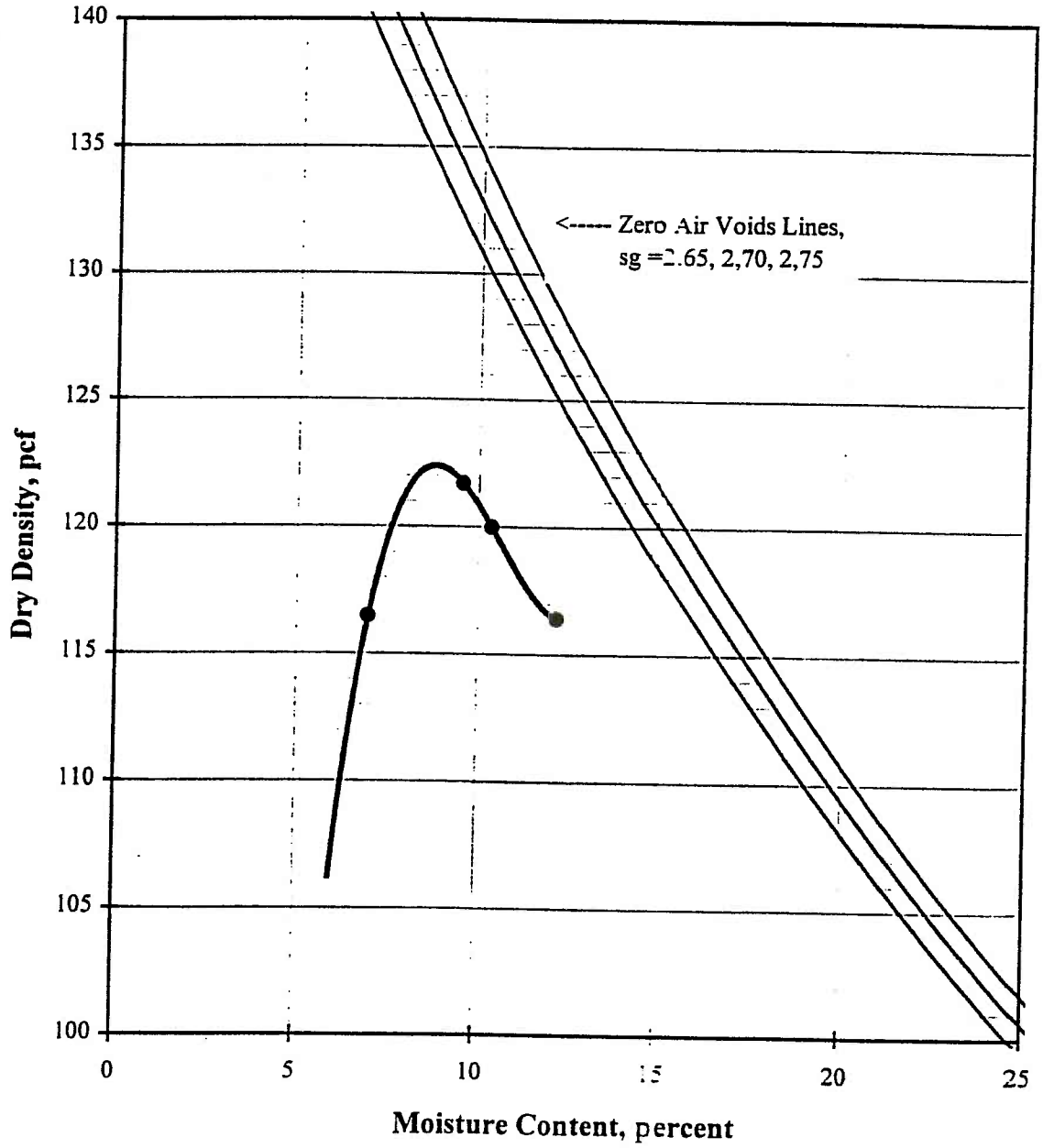
ASTM D 1557-91 (Modified)

Job Name: Santa Barbara Zoological Gardens
Sample ID: B 3 @ 0 - 5
Location:
Description: Silty Clayey Sand

Procedure Used: A
Prep. Method: Moist
Rammer Type: Manual

Maximum Density: **122.5 pcf**
Optimum Moisture: **9%**

Sieve Size	% Retained
3/4"	0.0
3/8"	0.0
#4	0.0



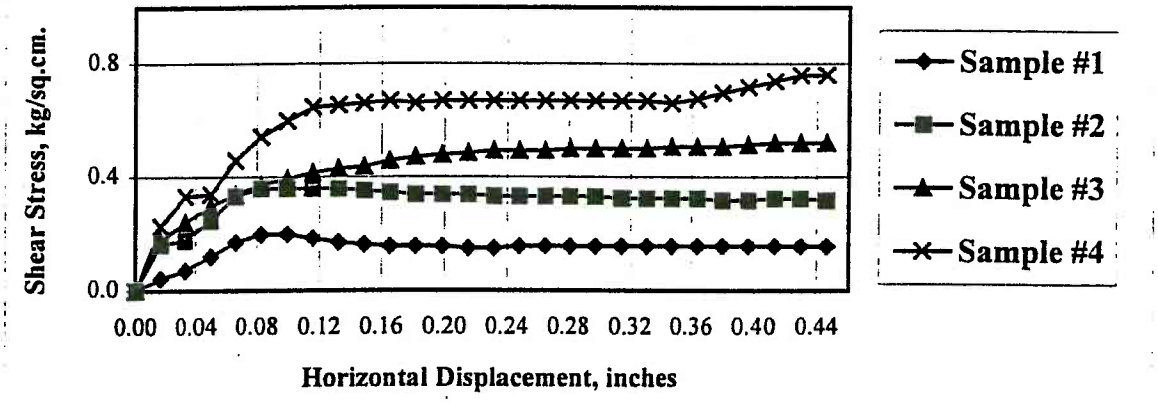
DIRECT SHEAR

080-90 (modified for unconsolidated. undrained conditions)

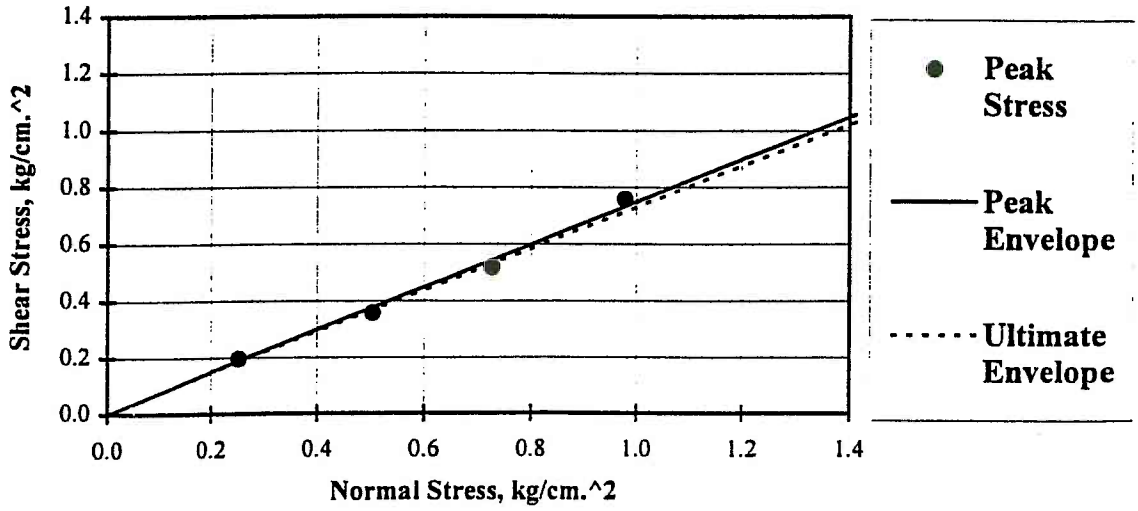
Santa Barbara Zoological Gardens
B 1 @ 0 - 5
Silty Sand
Remolded

Initial Dry Density: 113.9 pcf
Initial Mosture Content: 8.5 %
Peak Friction Angle (Ø): 37°
Cohesion (c): 0.000 kg/cm^2 (0 psf)

Sample No.	1	2	3	4	Average
Initial					
Dry Density, pcf	113.8	113.9	113.9	113.9	113.9
Moisture Content, %	8.5	8.5	8.5	8.5	8.5
Saturation, %	49	49	49	49	49
At Test					
Moisture Content, %	17.0	16.1	16.8	16.5	16.6
Saturation, %	98	93	97	95	96
Normal Stress, kg/cm^2	0.25	0.51	0.73	0.98	
Peak Stress, kg/cm^2	0.20	0.36	0.52	0.76	
Ultimate Stress, kg/cm^2	0.15	0.32	0.52	0.76	



SHEAR vs. NORMAL STRESS DIAGRAM



VT-22503-01

Jul. 9, 2001

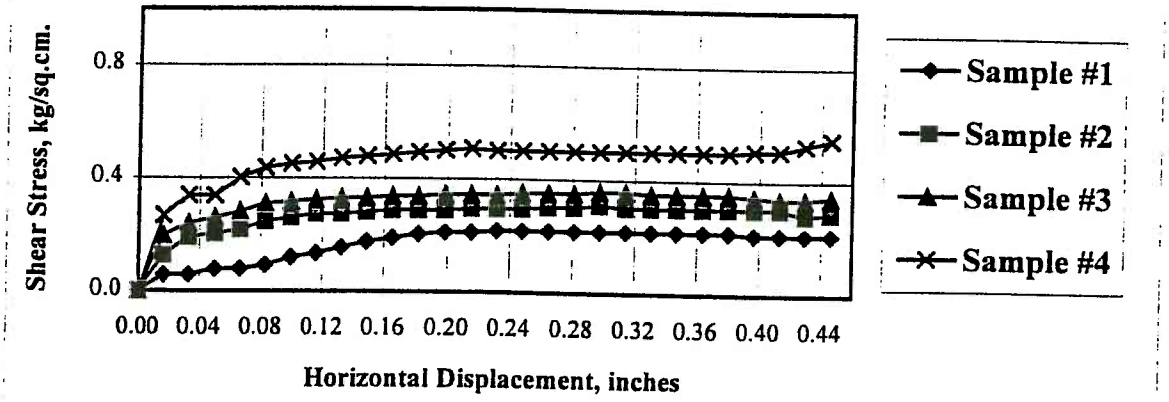
DIRECT SHEAR

080-90 (modified for unconsolidated, undrained conditions)

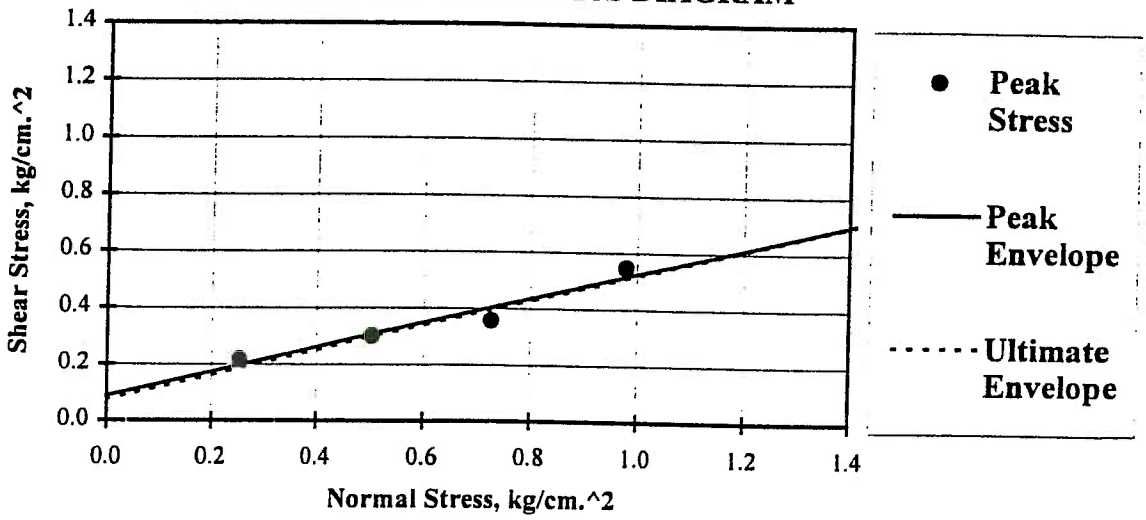
Santa Barbara Zoological Gardens
B 3 @ 0 - 5
Silty Clayey Sand
Remolded

Initial Dry Density: 109.4 pcf
Initial Mosture Content: 9.5 %
Peak Friction Angle (Ø): 24°
Cohesion (c): 0.087 kg/cm^2 (180 psf)

Sample No.	1	2	3	4	Average
Initial					
Dry Density, pcf	109.4	109.4	109.4	109.4	109.4
Moisture Content, %	9.5	9.5	9.5	9.5	9.5
Saturation, %	49	49	49	49	49
At Test					
Moisture Content, %	19.4	18.4	19.1	19.1	19.0
Saturation, %	99	94	98	98	97
Normal Stress, kg/cm^2	0.25	0.51	0.73	0.98	
Peak Stress, kg/cm^2	0.22	0.30	0.36	0.55	
Ultimate Stress, kg/cm^2	0.21	0.29	0.34	0.55	



SHEAR vs. NORMAL STRESS DIAGRAM

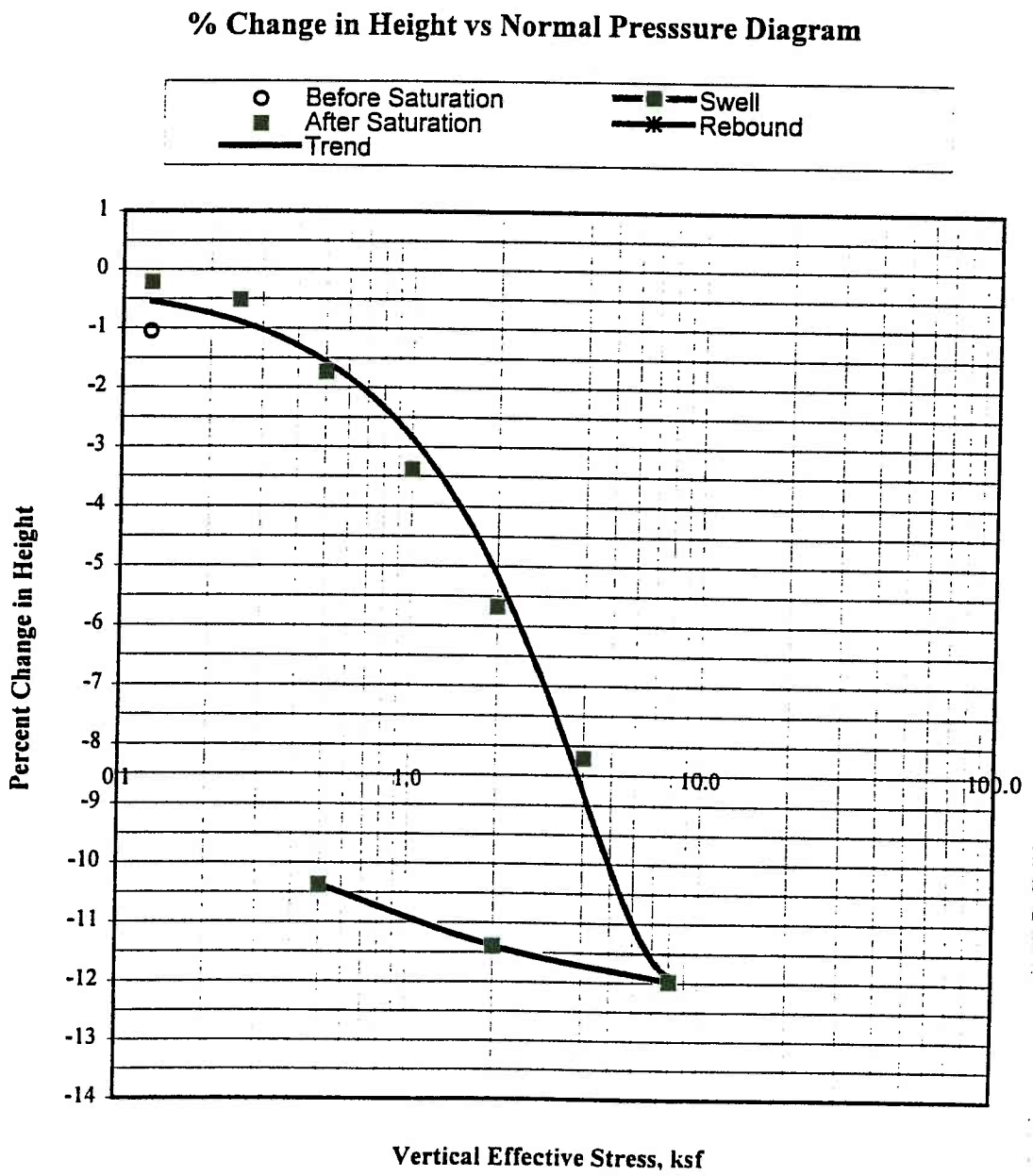


CONSOLIDATION TEST

ASTM D 2435-90

Santa Barbara Zoological Gardens
1 @ 10
Silty Clay
Ring Sample

Initial Dry Density: 112.3 pcf
Initial Moisture, %: 17.7%
Specific Gravity: 2.67 (assumed
Initial Void Ratio: 0.484

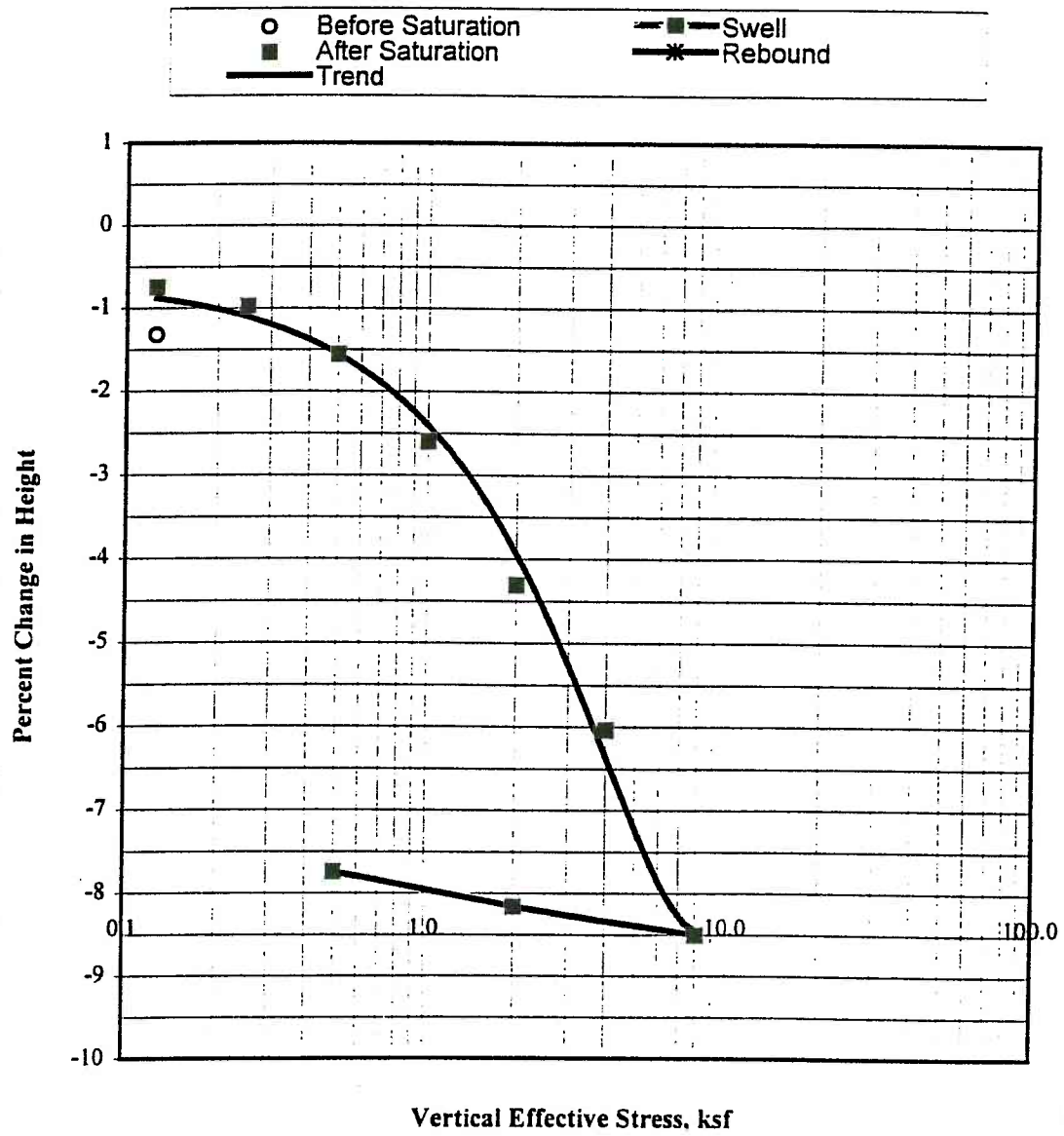


CONSOLIDATION TEST

ASTM D 2435-90

Santa Barbara Zoological Gardens
5 @ 2
Silty Sand
Ring Sample

Initial Dry Density: 109.0 pcf
Initial Moisture, %: 11.9%
Specific Gravity: 2.67 (assumed
Initial Void Ratio: 0.529

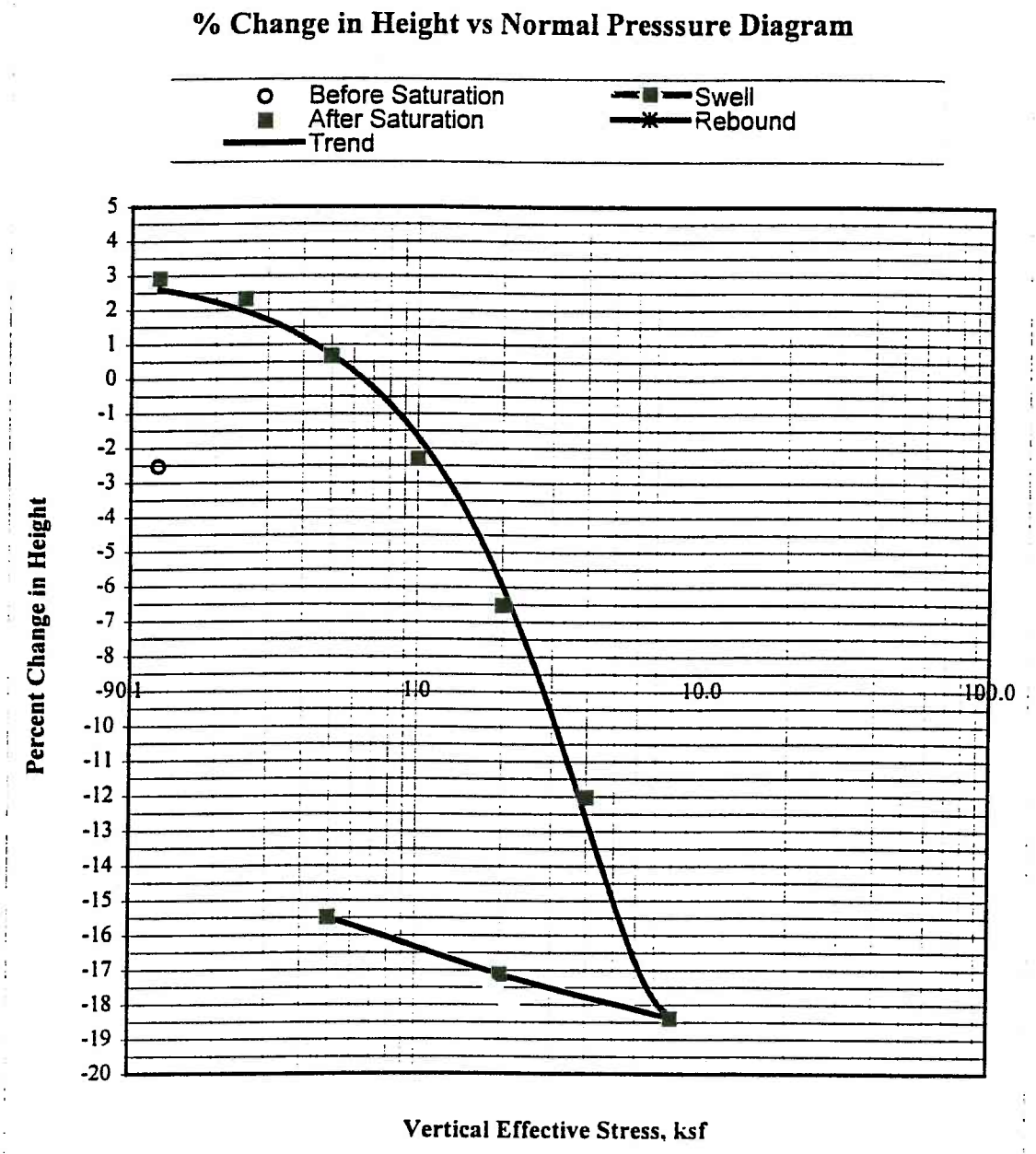


CONSOLIDATION TEST

ASTM D 2435-90

Santa Barbara Zoological Gardens
2 @ 10
Silty Clay
Ring Sample

Initial Dry Density: 114.2 pcf
Initial Moisture, %: 15.2%
Specific Gravity: 2.67 (assumed
Initial Void Ratio: 0.459



Capco Analytical Services INC. (CAS)
1536 Eastman Avenue, Suite B
Ventura CA 93003
(805) 644-1095

Client: Earth Systems
Sample ID: B1 @ 0-5
Date Received: 06/27/01
Date Sampled: N/A

Sample Matrix: Soil
CAS LAB NO: 01128901

WET CHEMISTRY ANALYSIS SUMMARY

COMPOUND	RESULT	UNITS	DF	PQL	METHOD	ANALYZED
*Chloride	22	mg/Kg	1	10	300.0M	06/27/01
pH	8.2	S.U.	1	---	9045	06/27/01
*Resistivity	1880	ohms-cm	1	3	CA test 424	06/27/01
*Sulfate	610	mg/Kg	5	50	300.0M	06/27/01

*Sample was analyzed on a 1:10 soil/water extract. Results were reported based on the original soil sample weight.
PQL: Practical Quantitation Limit
BQL: Below Practical Quantitation Limit

Principal Analyst

CAPCO Analytical Services, Inc.

Capco Analytical Services INC. (CAS)
1536 Eastman Avenue, Suite B
Ventura CA 93003
(805) 644-1095

Client: Earth Systems
Sample ID: B3 @ 0-5
Date Received: 06/27/01
Date Sampled: N/A

Sample Matrix: Soil
CAS LAB NO: 01128902

WET CHEMISTRY ANALYSIS SUMMARY

COMPOUND	RESULT	UNITS	DF	PQL	METHOD	ANALYZED
*Chloride	29	mg/Kg	1	10	300.0M	06/27/01
pH	7.4	S.U.	1	---	9045	06/27/01
*Resistivity	4610	ohms-cm	1	3	CA test 424	06/27/01
*Sulfate	79	mg/Kg	1	10	300.0M	06/27/01

*Sample was analyzed on a 1:10 soil/water extract. Results were reported based on the original soil sample weight.
PQL: Practical Quantitation Limit
BQL: Below Practical Quantitation Limit

Principal Analyst

CAPCO Analytical Services, Inc.

APPENDIX C

Liquefaction Analyses

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA

Developed 2001 by Shelton L. Stringer, GE. Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-1 Plot: 1

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

Magnitude: 7 7.5
PGA, g: 0.70 0.59
MSF: 1.19 130
GWT, feet: 13.0

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara &Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.39
Avg SF of Liquefiable Layers: 0.57

Total Liquefied Thickness (feet): 7.2

Total Induced Subsidence (inches): 2.0

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Overide	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H m1	K_H	Clean Sand Qc1n	Kσ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	Volumetric Strain (%)
0.16	1.32	0.15	11.14	128	0.010	1.000	11.23	1.00	1.70	2.10	3.88			100					1.00		0.381	Non-Liq.	0.00
0.33	2.32	0.77	33.28	128	0.021	1.000	33.58	1.00	1.70	3.69	4.00			100					1.00		0.381	Non-Liq.	0.00
0.49	152.58	1.77	1.16	128	0.031	1.000	1.16	0.51	1.70	245.60	1.68		100	15	1.02	0.95	1.01	253.9	1.00	Infin.	0.381	Non-Liq.	0.00
0.66	129.85	2.02	1.55	128	0.042	1.000	1.55	0.55	1.70	208.58	1.82		100	20	1.12	0.95	1.01	236.6	1.00	Infin.	0.381	Non-Liq.	0.00
0.82	89.72	1.98	2.21	128	0.052	1.000	2.21	0.62	1.70	144.08	2.04		92	35	1.36	0.95	1.01	197.8	1.00	Infin.	0.381	Non-Liq.	0.00
0.98	71.38	1.62	2.27	128	0.063	1.000	2.27	0.64	1.70	114.59	2.12		82	35	1.48	0.95	1.01	171.8	1.00	Infin.	0.381	Non-Liq.	0.00
1.15	50.27	1.40	2.79	128	0.073	0.999	2.79	0.69	1.70	80.66	2.28		68	50	1.90	0.95	1.01	154.8	1.00	0.425	0.381	Non-Liq.	0.00
1.31	105.71	1.58	1.49	128	0.084	0.999	1.50	0.57	1.70	169.72	1.87		99	25	1.16	0.95	1.01	198.7	1.00	Infin.	0.381	Non-Liq.	0.00
1.48	172.17	1.81	1.05	128	0.094	0.999	1.05	0.50	1.70	276.49	1.61		100	10	1.00	0.95	1.01	279.4	1.00	Infin.	0.381	Non-Liq.	0.00
1.64	179.67	1.59	0.88	128	0.105	0.998	0.88	0.50	1.70	288.53	1.54		100	10	1.00	0.95	1.01	291.5	1.00	Infin.	0.381	Non-Liq.	0.00
1.80	143.64	1.50	1.05	128	0.115	0.998	1.05	0.51	1.70	230.62	1.66		100	15	1.01	0.95	1.01	235.8	1.00	Infin.	0.381	Non-Liq.	0.00
1.97	118.56	1.10	0.93	128	0.126	0.998	0.93	0.51	1.70	190.78	1.68		100	15	1.02	0.95	1.01	197.5	1.00	Infin.	0.381	Non-Liq.	0.00
2.13	97.79	0.63	0.64	128	0.136	0.997	0.64	0.50	1.70	156.91	1.64		96	15	1.00	0.95	1.01	158.6	1.00	0.451	0.380	Non-Liq.	0.00
2.30	67.09	0.53	0.79	128	0.147	0.997	0.79	0.55	1.70	107.56	1.82		80	20	1.12	0.95	1.01	122.0	1.00	0.249	0.380	Non-Liq.	0.00
2.46	48.78	0.36	0.74	128	0.157	0.996	0.74	0.58	1.70	78.13	1.92		67	25	1.21	0.95	1.01	95.2	1.00	0.160	0.380	Non-Liq.	0.00
2.62	32.04	0.33	1.02	128	0.168	0.996	1.02	0.65	1.70	51.21	2.15		49	40	1.55	0.95	1.01	80.1	1.00	0.128	0.380	Non-Liq.	0.00
2.79	21.88	0.29	1.35	128	0.178	0.996	1.36	0.71	1.70	34.87	2.35		33	55	2.14	0.95	1.01	75.3	1.00	0.120	0.380	Non-Liq.	0.00
2.95	15.68	0.23	1.49	128	0.189	0.995	1.51	0.76	1.70	24.89	2.50		19	65	2.77	0.95	1.01	69.8	1.00	0.112	0.380	Non-Liq.	0.00
3.12	30.21	0.24	0.80	128	0.199	0.995	0.80	0.64	1.70	48.22	2.11		47	35	1.48	0.95	1.01	71.9	1.00	0.115	0.380	Non-Liq.	0.00
3.28	31.10	0.35	1.14	128	0.210	0.994	1.14	0.66	1.70	49.63	2.19		48	40	1.64	0.95	1.01	82.0	1.00	0.131	0.379	Non-Liq.	0.00
3.44	15.19	0.20	1.29	128	0.220	0.994	1.31	0.75	1.70	24.05	2.48		18	65	2.67	0.95	1.01	65.0	1.00	0.106	0.379	Non-Liq.	0.00
3.61	7.44	0.09	1.23	128	0.231	0.994	1.27	0.83	1.70	11.58	2.75			90					1.00		0.379	Non-Liq.	0.00
3.77	6.39	0.06	1.00	128	0.241	0.993	1.04	0.84	1.70	9.88	2.77			95					1.00		0.379	Non-Liq.	0.00
3.94	5.99	0.02	0.34	128	0.252	0.993	0.36	0.79	1.70	9.22	2.62			80	1.00				1.00		0.379	Non-Liq.	0.00
4.10	5.93	0.10	1.74	128	0.262	0.993	1.82	0.88	1.70	9.11	2.91			100					1.00		0.379	Non-Liq.	0.00
4.27	10.11	0.05	0.48	128	0.273	0.992	0.49	.74	1.70	15.81	2.45		0	60	1.00	0.10	1.64	26.0	1.00	0.072	0.378	Non-Liq.	0.00
4.43	6.76	0.03	0.43	128	0.283	0.992	0.45	79	1.70	10.41	2.60			75	1.00				1.00		0.378	Non-Liq.	0.00
4.59	5.76	0.02	0.35	128	0.294	0.991	0.37	0.80	1.70	8.78	2.65			80	1.00				1.00		0.378	Non-Liq.	0.00
4.76	4.65	0.03	0.58	128	0.304	0.991	0.62	0.85	1.70	6.98	2.81			100					1.00		0.378	Non-Liq.	0.00
4.92	4.44	0.02	0.53	128	0.315	0.991	0.57	0.85	1.70	6.63	2.82			100					1.00		0.378	Non-Liq.	0.00
5.09	5.35	0.03	0.59	128	0.325	0.990	0.62	0.84	1.70	8.07	2.76			95					1.00		0.378	Non-Liq.	0.00
5.25	7.71	0.03	0.44	128	0.336	0.990	0.46	0.77	1.70	11.85	2.55		-12	70	1.00	0.25	1.46	17.3	1.00	0.064	0.378	Non-Liq.	0.00
5.41	10.41	0.11	1.05	128	0.346	0.989	1.09	0.78	1.70	16.17	2.59		1	75	3.24	0.30	1.41	73.8	1.00	0.117	0.377	Non-Liq.	0.00
5.58	12.62	0.40	3.15	128	0.357	0.989	3.25	0.84	1.70	19.70	2.78			95					1.00		0.377	Non-Liq.	0.00
5.74	15.57	0.61	3.91	128	0.367	0.989	4.01	0.84	1.70	24.43	2.77			95					1.00		0.377	Non-Liq.	0.00
5.91	17.87	0.62	3.48	128	0.378	0.988	3.55	0.81	1.70	28.11	2.69			85					1.00		0.377	Non-Liq.	0.00
6.07	20.65	0.68	3.29	128	0.388	0.988	3.36	0.79	1.70	32.56	2.62			80					1.00		0.377	Non-Liq.	0.00
6.23	23.24	0.87	3.73	128	0.399	0.988	3.79	0.79	1.70	36.70	2.62			80					1.00		0.377	Non-Liq.	0.00
6.40	26.24	0.98	3.72	128	0.409	0.987	3.78	0.78	1.70	41.50	2.58		40	75	3.21	0.60	1.15	153.6	1.00	0.417	0.377	Non-Liq.	0.00
6.56	25.41	0.92	3.63	128	0.420	0.987	3.69	0.78	1.70	40.15	2.58		39	75	3.23	0.65	1.12	145.6	1.00	0.367	0.376	Non-Liq.	0.00
6.73	23.56	0.88	3.73	128	0.430	0.986	3.80	0.79	1.70	37.16	2.62			80					1.00		0.376	Non-Liq.	0.00
6.89	21.88	0.80	3.64	128	0.441	0.986	3.72	0.80	1.70	34.45	2.63			80					1.00		0.376	Non-Liq.	0.00
7.05	18.82	0.77	4.12	128	0.451	0.986	4.22	0.82	1.70	29.51	2.72			90					1.00		0.376	Non-Liq.	0.00
7.22	17.06	0.79	4.63	128	0.462	0.985	4.76	0.84	1.70	26.67	2.79			95					1.00		0.376	Non-Liq.	0.00
7.38	19.80	0.80	4.02	128	0.472	0.985	4.12	0.82	1.70	31.06	2.70			85					1.00		0.376	Non-Liq.	0.00
7.55	25.54	1.04	4.08	128	0.483	0.985	4.16	0.79	1.70	40.26	2.62			80					1.00		0.376	Non-Liq.	0.00
7.71	33.01	1.33	4.04	128	0.493	0.984	4.10	0.77	1.70	52.25	2.54		50	70	2.96	1.00	1.00	155.0	1.00	0.426	0.375	Non-Liq.	0.00
7.87	50.67	2.56	5.05	128	0.504	0.984	5.10	0.75	1.70	80.61	2.48		68	65	2.68	1.05	1.00	215.9	1.00	Infin.	0.375	Non-Liq.	0.00
8.04	80.77	3.72	4.61	128	0.514	0.984	4.64	0.71	1.67	126.31	2.33		87	55	2.05	1.10	1.00	259.0	1.00	Infin.	0.375	Non-Liq.	0.00
8.20	87.29	4.14	4.74	128	0.525	0.983	4.77	0.71	1.64	134.46	2.32		89	50	2.03	1.15	1.00	273.1	1.00	Infin.	0.375	Non-Liq.	0.00
8.37	93.52	3.61	3.86	128	0.535	0.983	3.89	0.68	1.59	139.73	2.24		91	45	1.78	1.20	1.00	248.4	1.00	Infin.	0.375	Non-Liq.	0.00
8.53	88.61	2.72	3.07	128	0.546	0.982	3.09	0.66	1.55	129.08	2.18		87	40	1.63	1.25	1.00	210.1	1.00	Infin.	0.375	Non-Liq.	0.00
8.69	69.34	2.53	3.65	128	0.556	0.982	3.68	0.70	1.57	101.97	2.31		78	50	1.97	1.25	1.00	201.3	1.00	Infin.	0.375	Non-Liq.	0.00
8.86	62.46	2.45	3.92	128	0.567	0.982	3.95	0.72	1.56	91.47	2.36		73	55	2.16	1.25	1.00	197.8	1.00	Infin.	0.375	Non-Liq.	0.00
9.02	57.70	2.76	4.78	128	0.577	0.981	4.83	0.74	1.57	84.67	2.45		70	65	2.53	1.25	1.00	214.1	1.00	Infin.	0.374	Non-Liq.	0.00
9.19	56.38	2.64	4.69	128	0.588	0.981	4.74	0.74	1.55	81.65	2.45		68	65	2.55	1.25	1.00	207.8	1.00	Infin.	0.374	Non-Liq.	0.00
9.35	57.55	2.61	4.54	128	0.598	0.981	4.58	0.74	1.52	82.08	2.44		69	60	2.49	1.25	1.00	204.3	1.00	Infin.	0.374	Non-Liq.	0.00
9.51	56.40	2.64	4.67	128	0.609	0.980	4.73	0.75	1.51	79.62	2.46		67	65	2.57	1.25	1.00	204.9	1.00	Infin.	0.374	Non-Liq.	0.00
9.68	55.32	2.60	4.71	128	0.619	0.980	4.76	0.75	1.49	77.21	2.47		66	65	2.63	1.25	1.00	202.7	1.00	Infin.	0.374	Non-Liq.	0.00
9.84	52.64	2.13	4.05	128	0.630	0.980	4.10	0.74	1.47	72.16	2.44		63	60	2.48	1.25	1.00	179.3	1.00	Infin.	0.374	Non-Liq.	0.00
10.01	47.67	1.48	3.10	131	0.641	0.979	3.14	0.73	1.44	63.96	2.39		58	60	2.28	1.25	1.00	145.6	1.00	0.367	0.374	Non-Liq.	0.00
10.17	41.77	1.12	2.67	131	0.651	0.979	2.71	0.73	1.42	55.25	2.39		52	60	2.28	1.25	1.00	125.9	1.00	0.265	0.373	Non-Liq.	0.00
10.33	38.90	0.93	2.38	131	0.662	0.979	2.43	0.72	1.40	50.73	2.39		49	55	2.25	1.25	1.00	114.3	1.00	0.219	0.373	Non-Liq.	0.00
10.50	34.29	0.88	2.56	131	0.673	0.978	2.61	0.74	1.40	44.47	2.45		43	35	2.52	1.25	1.00	112.3	1.00	0.212	0.373	Non-Liq.	0.00
10.66	31.36	0.72	2.31	131	0.684	0.978	2.36	0.74	1.38	40.13	2.45		39	65	2.55	1.25	1.00	102.1	1.00	0.179	0.373	Non-Liq.	0.00
10.83	32.42	0.63	1.93	131	0.694	0.978	1.97	0.73	1.36	40.74	2.40		40	60	2.31	1.25	1.00	94.0	1.00	0.157	0.373	Non-Liq.	0.00
10.99	32.95	0.58	1.76	131	0.705	0.977	1.80	0.72	1.34	40.81	2.37		40	55	2.20	1.25	1.00	90.0	1.00	0.148	0.373	Non-Liq.	0.00
11.15	29.49	0.75	2.56	131	0.716	0.977	2.62	0.76	1.35	36.63	2.51		35	70	2.84	1.25	1.00	104.0	1.00	0.184	0.373	Non-Liq.	0.00
11.32	28.04	0.76	2.71	131	0.727	0.977	2.78	0.77	1.34	34.51	2.55		33	70	3.03	1.25	1.00	104.7	1.00	0.187	0.373	Non-Liq.	0.00
11.48	27.36	0.76	2.77	131	0.737	0.976	2.85	0.78	1.32	33.33	2.57		31	75	3.14	1.25	1.00	104.6	1.00	0.186	0.372	Non-Liq.	0.00
11.65	25.75	0.66	2.55	131	0.748	0.976	2.62	0.78	1.31	30.95	2.57		28	75	3.15	1.25	1.00	97.4	1.00	0.166	0.372	Non-Liq.	0.00
11.81	23.77	0.61	2.55	131	0.759	0.975	2.63	0.79	1.30	28.26	2.60			75					1.00		0.372	Non-Liq.	0.00
11.98	22.84	0.62	2.73	131	0.770	0.975	2.83	0.80	1.29	26.90	2.64			80					1.00		0.372	Non-Liq.	0.00
12.14	23.94	0.64	2.67	131	0.780	0.975	2.76	0.79	1.27	27.87	2.62			80					1.00		0.372	Non-Liq.	0.00
12.30	24.07	0.67	2.79	131	0.791	0.974	2.88	0.80	1.26	27.75	2.63			80					1.00		0.372	Non-Liq.	0.00

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA

Developed 2001 by Shelton L. Stringer, GE. Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-1 Plot: 1

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

Magnitude:	7	7.5
PGA, g:	0.70	0.59
MSF:	1.19	130
GWT, feet:	13.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara &Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.39
Avg SF of Liquefiable Layers: 0.57

Total Liquefied Thickness (feet): 7.2

Total Induced Subsidence (inches): 2.0

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Overide	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	Kσ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	Volumetric Strain (%)
12.47	18.72	0.66	3.51	131	0.802	0.974	3.67	0.84	1.26	21.40	2.79			95					1.00		0.372	Non-Liq.	0.00
12.63	16.32	0.56	3.41	131	0.813	0.974	3.58	0.86	1.25	18.38	2.83			100					1.00		0.371	Non-Liq.	0.00
12.80	14.72	0.49	3.31	131	0.823	0.973	3.50	0.87	1.24	16.33	2.86			100					1.00		0.371	Non-Liq.	0.00
12.96	13.04	0.39	2.96	131	0.834	0.973	3.16	0.87	1.23	14.20	2.89			100					1.00		0.371	Non-Liq.	0.00
13.12	11.81	0.52	4.42	131	0.844	0.973	4.76	0.92	1.23	12.76	3.03			100					1.00		0.372	Non-Liq.	0.00
13.29	12.41	0.44	3.52	131	0.849	0.972	3.78	0.89	1.22	13.30	2.96			100					1.00		0.374	Non-Liq.	0.00
13.45	40.66	0.53	1.30	131	0.855	0.972	1.33	0.69	1.16	43.58	2.27		42	50	1.86	0.40	1.31	105.9	1.00	0.191	0.376	0.51	1.37
13.62	58.66	0.65	1.12	131	0.860	0.972	1.13	0.64	1.14	62.35	2.10		57	35	1.46	0.40	1.31	119.4	1.00	0.238	0.378	0.63	1.19
13.78	71.51	0.86	1.20	131	0.866	0.971	1.21	0.63	1.13	75.67	2.06		65	35	1.38	0.40	1.31	136.9	1.00	0.319	0.380	0.84	0.99
13.94	68.13	0.65	0.95	131	0.872	0.971	0.97	0.61	1.13	71.58	2.02		63	30	1.32	0.40	1.31	123.7	1.00	0.256	0.382	0.67	1.14
14.11	42.89	0.55	1.29	131	0.877	0.971	1.32	0.69	1.14	45.15	2.26		44	45	1.82	0.40	1.31	107.4	1.00	0.195	0.384	0.51	1.36
14.27	24.94	0.58	2.32	131	0.883	0.970	2.41	0.79	1.15	26.23	2.60			75					1.00		0.386	Non-Liq.	0.00
14.44	24.16	0.58	2.40	131	0.889	0.970	2.49	0.80	1.15	25.27	2.62			80					1.00		0.388	Non-Liq.	0.00
14.60	17.99	0.42	2.36	131	0.894	0.970	2.49	0.83	1.15	18.57	2.73			90					1.00		0.389	Non-Liq.	0.00
14.76	14.62	0.31	2.10	131	0.900	0.969	2.24	0.84	1.15	14.86	2.78			95					1.00		0.391	Non-Liq.	0.00
14.93	13.32	0.22	1.67	131	0.905	0.969	1.79	0.84	1.14	13.37	2.77			95					1.00		0.393	Non-Liq.	0.00
15.09	12.02	0.50	4.16	131	0.911	0.969	4.50	0.92	1.15	12.05	3.04			100					1.00		0.395	Non-Liq.	0.00
15.26	17.06	0.56	3.28	131	0.917	0.968	3.47	0.86	1.13	17.26	2.84			100					1.00		0.397	Non-Liq.	0.00
15.42	23.79	0.44	1.86	131	0.922	0.968	1.94	0.78	1.11	24.06	2.58		18	75	3.18	0.40	1.31	100.2	1.00	0.174	0.398	0.44	1.47
15.58	32.76	0.41	1.26	131	0.928	0.967	1.30	0.72	1.10	33.05	2.36		31	55	2.17	0.40	1.31	93.7	1.00	0.157	0.400	0.39	1.57
15.75	31.36	0.58	1.85	131	0.934	0.967	1.91	0.75	1.10	31.59	2.48		29	65	2.65	0.45	1.26	106.0	1.00	0.191	0.402	0.47	1.39
15.91	33.01	0.75	2.26	131	0.939	0.967	2.32	0.76	1.10	33.19	2.51		31	70	2.83	0.50	1.22	115.1	1.00	0.222	0.403	0.55	1.26
16.08	54.30	1.12	2.06	131	0.945	0.966	2.10	0.70	1.08	54.61	2.32		52	50	2.01	0.50	1.22	134.4	1.00	0.306	0.405	0.76	1.03
16.24	55.45	1.16	2.10	131	0.950	0.966	2.13	0.70	1.08	55.55	2.32		52	50	2.01	0.50	1.22	136.7	1.00	0.317	0.407	0.78	1.01
16.40	40.88	1.02	2.49	131	0.956	0.966	2.55	0.75	1.08	40.71	2.47		40	65	2.63	0.50	1.22	130.9	1.00	0.288	0.408	0.71	1.08
16.57	29.96	0.65	2.17	131	0.962	0.965	2.25	77	1.08	29.50	2.54		26	70	3.00	0.50	1.22	108.3	1.00	0.198	0.410	0.48	1.36
16.73	19.74	0.30	1.54	131	0.967	0.965	1.62	9	1.07	19.05	2.61			80					1.00		0.411	Non-Liq.	0.00
16.90	14.34	0.25	1.72	131	0.973	0.965	1.84	0.84	1.07	13.55	2.77			95					1.00		0.413	Non-Liq.	0.00
17.06	13.79	0.32	2.30	131	0.979	0.964	2.47	0.87	1.07	12.95	2.86			100					1.00		0.414	Non-Liq.	0.00
17.22	14.98	0.65	4.32	131	0.984	0.964	4.63	0.90	1.07	14.12	2.99			100					1.00		0.416	Non-Liq.	0.00
17.39	26.81	1.38	5.16	131	0.990	0.963	5.36	0.86	1.06	25.84	2.83			100					1.00		0.417	Non-Liq.	0.00
17.55	68.79	1.66	2.42	131	0.995	0.963	2.45	0.70	1.04	66.86	2.30		60	50	1.95	0.50	1.22	159.9	1.00	0.460	0.419	1.10	0.40
17.72	101.76	1.70	1.67	131	1.001	0.963	1.69	0.63	1.04	98.60	2.07		76	35	1.40	0.50	1.22	168.7	1.02	Infin.	0.420	Non-Liq.	0.00
17.88	121.82	1.43	1.17	131	1.007	0.962	1.18	0.58	1.03	117.53	1.91		84	25	1.19	0.50	1.22	171.7	1.02	Infin.	0.422	Non-Liq.	0.00
18.04	131.34	2.14	1.63	131	1.012	0.962	1.64	0.60	1.03	126.50	1.98		87	30	1.28	0.50	1.22	197.9	1.02	Infin.	0.423	Non-Liq.	0.00
18.21	125.45	2.66	2.12	131	1.018	0.962	2.14	0.63	1.02	120.52	2.08		85	35	1.42	0.50	1.22	209.8	1.02	Infin.	0.424	Non-Liq.	0.00
18.37	131.46	2.72	2.07	131	1.024	0.961	2.09	0.63	1.02	125.87	2.06		86	35	1.39	0.50	1.22	213.9	1.01	Infin.	0.426	Non-Liq.	0.00
18.54	131.89	1.41	1.07	131	1.029	0.961	1.08	0.57	1.02	125.63	1.86		86	25	1.15	0.50	1.22	177.0	1.01	Infin.	0.427	Non-Liq.	0.00
18.70	92.16	0.77	0.84	131	1.035	0.960	0.85	0.58	1.01	87.25	1.91		71	25	1.20	0.50	1.22	128.3	1.01	0.276	0.428	0.65	1.12
18.86	46.02	0.42	0.92	131	1.040	0.960	0.94	0.67	1.01	42.99	2.19		42	40	1.64	0.50	1.22	86.5	1.00	0.140	0.430	0.33	1.70
19.03	22.43	0.33	1.47	131	1.046	0.960	1.54	0.78	1.01	20.39	2.58		11	75	3.20	0.50	1.22	79.8	1.00	0.127	0.431	0.30	1.81
19.19	15.42	0.26	1.69	131	1.052	0.959	1.82	0.84	1.01	13.65	2.76			95					1.00		0.432	Non-Liq.	0.00
19.36	15.78	0.34	2.18	131	1.057	0.959	2.33	0.85	1.00	13.92	2.82			100					1.00		0.433	Non-Liq.	0.00
19.52	17.34	0.53	3.03	131	1.063	0.958	3.23	0.87	1.00	15.32	2.87			100					1.00		0.435	Non-Liq.	0.00
19.69	17.63	0.64	3.66	131	1.069	0.958	3.89	0.88	0.99	15.52	2.91			100					1.00		0.436	Non-Liq.	0.00
19.85	16.34	0.62	3.79	131	1.074	0.957	4.05	0.89	0.99	14.23	2.95			100					1.00		0.437	Non-Liq.	0.00
20.01	15.25	0.57	3.71	131	1.080	0.957	3.99	0.90	0.98	13.15	2.97			100					1.00		0.438	Non-Liq.	0.00
20.18	12.79	0.46	3.60	131	1.085	0.957	3.93	0.92	0.98	10.81	3.04			100					0.99		0.439	Non-Liq.	0.00
20.34	10.41	0.32	3.06	131	1.091	0.956	3.41	0.93	0.97	8.56	3.08			100					0.99		0.440	Non-Liq.	0.00
20.51	8.92	0.18	2.07	131	1.097	0.956	2.36	0.93	0.97	7.15	3.06			100					0.99		0.442	Non-Liq.	0.00
20.67	9.71	0.18	1.85	131	1.102	0.955	2.12	0.92	0.96	6.92	3.05			100					0.99		0.443	Non-Liq.	0.00
20.83	9.88	0.12	1.20	131	1.108	0.955	1.36	0.88	0.96	7.96	2.90			100					0.99		0.444	Non-Liq.	0.00
21.00	10.71	0.13	1.19	131	1.114	0.954	1.33	0.87	0.96	8.68	2.87			100					0.99		0.445	Non-Liq.	0.00
21.16	11.88	0.19	1.61	131	1.119	0.954	1.78	0.87	0.95	9.68	2.89			100					0.99		0.446	Non-Liq.	0.00
21.33	13.53	0.28	2.07	131	1.125	0.954	2.26	0.88	0.95	11.11	2.89			100					0.99		0.447	Non-Liq.	0.00
21.49	15.34	0.43	2.77	131	1.130	0.953	2.99	0.88	0.94	12.67	2.91			100					0.99		0.448	Non-Liq.	0.00
21.65	20.52	0.71	3.45	131	1.136	0.953	3.65	0.87	0.94	17.23	2.86			100					0.99		0.449	Non-Liq.	0.00
21.82	26.90	0.96	3.56	131	1.142	0.952	3.71	0.84	0.94	22.84	2.77			95					0.98		0.450	Non-Liq.	0.00
21.98	30.21	1.17	3.87	131	1.147	0.952	4.02	0.83	0.93	25.67	2.75			90					0.98		0.451	Non-Liq.	0.00
22.15	32.08	1.31	4.09	131	1.153	0.951	4.25	0.83	0.93	27.21	2.75			90					0.98		0.452	Non-Liq.	0.00
22.31	33.35	1.38	4.14	131	1.159	0.951	4.29	0.83	0.93	28.22	2.74			90					0.98		0.453	Non-Liq.	0.00
22.47	32.59	1.36	4.17	131	1.164	0.950	4.33	0.83	0.92	27.43	2.75			90					0.98		0.454	Non-Liq.	0.00
22.64	30.27	1.28	4.22	131	1.170	0.950	4.39	0.84	0.92	25.27	2.78			95					0.98		0.455	Non-Liq.	0.00
22.80	29.89	1.08	3.63	131	1.175	0.949	3.78	0.83	0.92	24.87	2.74			90					0.98		0.456	Non-Liq.	0.00
22.97	29.28	1.17	3.99	131	1.181	0.949	4.16	0.84	0.91	24.21	2.78			95					0.98		0.456	Non-Liq.	0.00
23.13	30.34	1.11	3.64	131	1.187	0.948	3.79	0.83	0.91	25.05	2.74			90					0.98		0.457	Non-Liq.	0.00
23.29	44.89	1.33	2.96	131	1.192	0.948	3.04	0.77	0.91	37.66	2.55		36	70	3.02	0.35	1.36	154.0	0.98	0.420	0.458	0.89	0.64
23.46	54.11	1.71	3.16	131	1.198	0.947	3.23	0.76	0.91	45.51	2.50		44	65	2.79	0.35	1.36	172.4	0.98	Infin.	0.459	Non-Liq.	0.00
23.62	63.56	2.30	3.63	131	1.204	0.947	3.70	0.76	0.91	53.46	2.50		51	65	2.75	0.35	1.36	199.2	0.96	Infin.	0.460	Non-Liq.	0.00
23.79	67.45	2.14	3.17	131	1.209	0.946	3.23	0.74	0.91	56.72	2.44		53	60	2.47	0.35	1.36	189.7	0.96	Infin.	0.461	Non-Liq.	0.00
23.95	52.71	1.19	2.27	131	1.215	0.946	2.32	0.73	0.90	43.98	2.42		43	60	2.39	0.40	1.31	137.6	0.97	0.322	0.461	0.68	1.03
24.11	40.94	1.10	2.67	131	1.221	0.945	2.76	0.77	0.90	33.61	2.56		32	70	3.07	0.45	1.26	130.4	0.97	0.286	0.462	0.60	1.10
24.28	35.98	1.12	2.88	131	1.226	0.945	2.97	0.79	0.89	31.77	2.60		29	75	3.30	0.50	1.22	128.4	0.97	0.277	0.463	0.58	1.13
24.44	38.52	1.28	3.31	131	1.232	0.944	3.42	0.80	0.89	31.20	2.64			80					0.97		0.464	Non-Liq.	0.00
24.61	37.69	1.36	3.60	131	1.237	0.943	3.73	0.81	0.88	30.35	2.68			85					0.97		0.464	Non-Liq.	0.00

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA

Developed 2001 by Shelton L. Stringer, GE, Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-1 Plot: 1

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

Total Liquefied Thickness (feet): 7.2

Total Induced Subsidence (inches): 2.0

EARTHQUAKE INFORMATION:

Magnitude:	7	7.5
PGA, g:	0.70	0.59
MSF:	1.19	130
GWT, feet:	13.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara &Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.39
Avg SF of Liquefiable Layers: 0.57

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Overide	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	Kσ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	*Volumetric Strain (%)*
24.77	35.61	1.20	3.37	131	1.243	0.943	3.49	0.81	0.88	28.50	2.68			85					0.97		0.465	Non-Liq.	0.00
24.93	33.99	1.04	3.05	131	1.249	0.942	3.17	0.81	0.87	27.07	2.67			85					0.97		0.466	Non-Liq.	0.00
25.10	30.25	0.99	3.28	131	1.254	0.942	3.42	0.83	0.87	23.81	2.73			90					0.97		0.467	Non-Liq.	0.00
25.26	28.77	1.02	3.56	131	1.260	0.941	3.72	0.84	0.86	22.45	2.77			95					0.97		0.467	Non-Liq.	0.00
25.43	31.74	1.33	4.20	131	1.266	0.941	4.38	0.84	0.86	24.76	2.79			95					0.96		0.468	Non-Liq.	0.00
25.59	36.88	1.52	4.11	131	1.271	0.940	4.26	0.83	0.86	28.92	2.73			90					0.96		0.469	Non-Liq.	0.00
25.75	42.85	1.81	4.21	131	1.277	0.939	4.34	0.81	0.86	33.72	2.69			85					0.96		0.469	Non-Liq.	0.00
25.92	63.86	2.33	3.65	131	1.282	0.939	3.73	0.76	0.86	51.09	2.51		49	70	2.83	0.55	1.19	171.6	0.96	Infin.	0.470	Non-Liq.	0.00
26.08	76.44	2.59	3.38	131	1.288	0.938	3.44	0.74	0.86	61.44	2.43		57	60	2.45	0.55	1.19	178.3	0.94	Infin.	0.471	Non-Liq.	0.00
26.25	91.25	2.52	2.76	131	1.294	0.938	2.80	0.70	0.87	73.84	2.31		64	50	1.99	0.55	1.19	174.2	0.94	Infin.	0.471	Non-Liq.	0.00
26.41	96.30	2.39	2.48	131	1.299	0.937	2.52	0.69	0.87	77.98	2.26		67	50	1.83	0.55	1.19	169.5	0.94	Infin.	0.472	Non-Liq.	0.00
26.57	103.31	2.37	2.30	131	1.305	0.936	2.32	0.67	0.87	83.72	2.22		69	45	1.71	0.55	1.19	169.5	0.94	Infin.	0.472	Non-Liq.	0.00
26.74	124.05	1.45	1.16	131	1.311	0.936	1.18	0.59	0.88	102.19	1.95		78	30	1.24	0.55	1.19	150.2	0.92	0.395	0.473	0.77	0.74
26.90	134.39	0.95	0.71	131	1.316	0.935	0.71	0.54	0.89	111.73	1.78		81	20	1.09	0.55	1.19	145.0	0.92	0.363	0.474	0.70	0.88
27.07	117.51	1.13	0.96	131	1.322	0.934	0.98	0.58	0.88	96.46	1.92		75	25	1.20	0.55	1.19	137.8	0.91	0.323	0.474	0.62	1.02
27.23	86.02	1.13	1.31	131	1.327	0.934	1.33	0.64	0.86	69.21	2.11		62	35	1.48	0.60	1.15	117.8	0.93	0.232	0.475	0.46	1.25
27.40	53.28	0.67	1.27	131	1.333	0.933	1.30	0.69	0.85	41.85	2.28		41	50	1.88	0.65	1.12	88.4	0.95	0.144	0.475	0.29	1.67
27.56	31.61	0.62	1.95	131	1.339	0.932	2.03	0.79	0.83	23.78	2.59		17	75	3.28	0.70	1.10	85.4	0.95	0.138	0.476	0.28	1.72
27.72	30.17	0.95	3.15	131	1.344	0.932	3.29	0.83	0.82	22.33	2.74			90					0.95		0.476	Non-Liq.	0.00
27.89	41.32	1.14	2.75	131	1.350	0.931	2.85	0.78	0.83	31.20	2.59		28	75	3.26	0.80	1.05	107.1	0.95	0.194	0.477	0.39	1.39
28.05	37.99	1.49	3.93	131	1.356	0.930	4.08	0.83	0.81	28.22	2.73			90					0.95		0.477	Non-Liq.	0.00
28.22	55.28	1.92	3.48	131	1.361	0.929	3.57	0.78	0.82	41.91	2.56		41	75	3.09	0.90	1.02	132.3	0.95	0.295	0.478	0.59	1.08
28.38	50.65	1.97	3.88	131	1.367	0.929	3.99	0.80	0.82	38.00	2.62			80					0.95		0.478	Non-Liq.	0.00
28.54	88.40	1.76	1.99	131	1.372	0.928	2.03	0.68	0.84	68.95	2.23		61	45	1.75	1.00	1.00	121.4	0.92	0.247	0.478	0.48	1.21
28.71	119.10	1.86	1.56	131	1.378	0.927	1.58	0.63	0.85	94.30	2.06		74	35	1.39	1.05	1.00	130.9	0.90	0.288	0.479	0.54	1.10
28.87	145.61	1.55	1.07	131	1.384	0.926	1.08	.57	0.86	116.92	1.88		83	25	1.17	1.10	1.00	136.9	0.90	0.318	0.479	0.60	1.03
29.04	161.67	2.54	1.57	131	1.389	0.926	1.58	60	0.85	128.72	1.97		87	30	1.26	1.15	1.00	162.0	0.90	Infin.	0.480	Non-Liq.	0.00
29.20	171.42	2.38	1.39	131	1.395	0.925	1.40	0.58	0.85	136.87	1.91		90	25	1.20	1.20	1.00	163.8	0.90	Infin.	0.480	Non-Liq.	0.00
29.36	208.03	3.58	1.72	131	1.401	0.924	1.73	0.58	0.85	165.77	1.92		98	25	1.21	1.25	1.00	200.6	0.89	Infin.	0.480	Non-Liq.	0.00
29.53	258.59	3.53	1.38	131	1.406	0.923	1.38	0.54	0.86	206.64	1.79		100	20	1.10	1.30	1.00	226.5	0.89	Infin.	0.481	Non-Liq.	0.00
29.69	220.58	4.60	2.09	131	1.412	0.923	2.10	0.60	0.84	174.25	1.97		100	30	1.27	1.35	1.00	220.5	0.89	Infin.	0.481	Non-Liq.	0.00
29.86	278.86	5.50	1.97	131	1.417	0.922	1.98	0.57	0.85	221.68	1.89		100	25	1.18	1.40	1.00	261.1	0.89	Infin.	0.481	Non-Liq.	0.00
30.02	229.51	6.20	2.70	131	1.423	0.921	2.72	0.62	0.83	179.17	2.05		100	35	1.38	1.45	1.00	246.7	0.89	Infin.	0.482	Non-Liq.	0.00
30.18	213.06	6.71	3.15	131	1.429	0.920	3.17	0.65	0.82	164.71	2.13		98	40	1.51	1.50	1.00	248.7	0.89	Infin.	0.482	Non-Liq.	0.00
30.35	240.47	6.53	2.72	131	1.434	0.919	2.73	0.62	0.83	187.01	2.04		100	35	1.36	1.55	1.00	254.8	0.89	Infin.	0.482	Non-Liq.	0.00
30.51	273.80	4.99	1.82	131	1.440	0.918	1.83	0.57	0.84	216.06	1.87		100	25	1.16	1.60	1.00	250.6	0.88	Infin.	0.483	Non-Liq.	0.00
30.68	268.98	3.19	1.18	131	1.446	0.918	1.19	0.53	0.85	214.62	1.72		100	15	1.05	1.65	1.00	226.3	0.88	Infin.	0.483	Non-Liq.	0.00
30.84	249.31	3.58	1.43	131	1.451	0.917	1.44	0.55	0.84	196.79	1.81		100	20	1.12	1.70	1.00	219.6	0.88	Infin.	0.483	Non-Liq.	0.00
31.00	225.51	4.08	1.81	131	1.457	0.916	1.82	0.58	0.83	175.66	1.92		100	25	1.21	1.75	1.00	212.5	0.88	Infin.	0.483	Non-Liq.	0.00
31.17	224.92	4.27	1.90	131	1.462	0.915	1.91	0.59	0.83	174.48	1.94		100	25	1.23	1.80	1.00	214.4	0.88	Infin.	0.484	Non-Liq.	0.00
31.33	236.41	4.22	1.78	131	1.468	0.914	1.80	0.58	0.83	183.68	1.90		100	25	1.19	1.85	1.00	219.2	0.88	Infin.	0.484	Non-Liq.	0.00
31.50	251.73	5.73	2.28	131	1.474	0.913	2.29	0.60	0.82	193.88	1.97		100	30	1.27	1.90	1.00	245.6	0.88	Infin.	0.484	Non-Liq.	0.00
31.66	312.77	7.83	2.50	131	1.479	0.912	2.51	0.59	0.82	241.14	1.95		100	30	1.24	1.95	1.00	299.4	0.87	Infin.	0.484	Non-Liq.	0.00
31.82	370.25	4.33	1.17	131	1.485	0.911	1.18	0.50	0.84	294.20	1.63		100	15	1.00	2.00	1.00	294.2	0.87	Infin.	0.484	Non-Liq.	0.00
31.99	401.51	4.63	1.15	131	1.491	0.910	1.16	0.50	0.84	318.54	1.61		100	10	1.00	2.05	1.00	318.5	0.87	Infin.	0.485	Non-Liq.	0.00
32.15	389.42	4.93	1.26	131	1.496	0.909	1.27	0.50	0.84	308.07	1.65		100	15	1.00	2.10	1.00	308.6	0.87	Infin.	0.485	Non-Liq.	0.00
32.32	354.41	5.11	1.44	131	1.502	0.908	1.45	0.52	0.83	277.61	1.72		100	15	1.05	2.15	1.00	291.9	0.87	Infin.	0.485	Non-Liq.	0.00
32.48	329.72	5.21	1.58	131	1.507	0.907	1.59	0.54	0.83	256.24	1.77		100	20	1.09	2.20	1.00	278.7	0.87	Infin.	0.485	Non-Liq.	0.00
32.64	353.73	5.60	1.58	131	1.513	0.906	1.59	0.53	0.83	274.93	1.76		100	20	1.08	2.25	1.00	295.7	0.87	Infin.	0.485	Non-Liq.	0.00
32.81	367.94	6.40	1.74	131	1.519	0.905	1.75	0.54	0.82	284.71	1.78		100	20	1.09	2.30	1.00	311.0	0.87	Infin.	0.485	Non-Liq.	0.00
32.97	369.57	6.99	1.89	131	1.524	0.904	1.90	0.55	0.82	284.45	1.81		100	20	1.11	2.35	1.00	316.9	0.86	Infin.	0.485	Non-Liq.	0.00
33.14	384.49	8.25	2.15	131	1.530	0.903	2.15	0.56	0.81	294.15	1.85		100	20	1.14	2.40	1.00	336.4	0.86	Infin.	0.486	Non-Liq.	0.00
33.30	366.90	9.28	2.53	131	1.536	0.902	2.54	0.58	0.80	277.75	1.92		100	25	1.21	2.45	1.00	336.1	0.86	Infin.	0.486	Non-Liq.	0.00
33.46	384.85	9.36	2.43	131	1.541	0.901	2.44	0.58	0.80	291.63	1.90		100	25	1.19	2.50	1.00	345.6	0.86	Infin.	0.486	Non-Liq.	0.00
33.63	389.54	9.42	2.42	131	1.547	0.900	2.43	0.58	0.80	294.72	1.89		100	25	1.18	2.55	1.00	348.0	0.86	Infin.	0.486	Non-Liq.	0.00
33.79	402.70	8.75	1.68	131	1.552	0.899	1.68	0.53	0.82	309.19	1.75		100	20	1.07	2.60	1.00	330.6	0.86	Infin.	0.486	Non-Liq.	0.00
33.96	419.05	7.22	1.72	131	1.558	0.898	1.73	0.53	0.81	321.13	1.75		100	20	1.07	2.65	1.00	343.6	0.86	Infin.	0.486	Non-Liq.	0.00
34.12	428.53	7.17	1.67	131	1.564	0.897	1.68	0.53	0.81	328.41	1.73		100	15	1.06	2.70	1.00	347.8	0.86	Infin.	0.486	Non-Liq.	0.00
34.28	428.81	6.93	1.62	131	1.569	0.896	1.62	0.52	0.81	328.49	1.72		100	15	1.05	2.75	1.00	345.1	0.85	Infin.	0.486	Non-Liq.	0.00
34.45	427.87	7.76	1.81	131	1.575	0.895	1.82	0.54	0.81	325.43	1.76		100	20	1.08	2.80	1.00	351.6	0.85	Infin.	0.486	Non-Liq.	0.00
34.61	430.02	8.79	2.04	131	1.581	0.894	2.05	0.55	0.80	324.71	1.81		100	20	1.11	2.85	1.00	361.0	0.85	Infin.	0.486	Non-Liq.	0.00
34.78	435.26	8.95	2.06	131	1.586	0.893	2.06	0.55	0.80	328.04	1.81		100	20	1.11	2.85	1.00	364.7	0.85	Infin.	0.486	Non-Liq.	0.00
34.94	442.40	9.60	2.17	131	1.592	0.892	2.18	0.56	0.80	332.08	1.82		100	20	1.12	2.85	1.00	373.5	0.85	Infin.	0.486	Non-Liq.	0.00
35.10	434.41	7.43	1.71	131	1.597	0.890	1.72	0.53	0.80	328.87	1.74		100	15	1.06	2.85	1.00	349.9	0.85	Infin.	0.486	Non-Liq.	0.00
35.27	411.49	8.36	2.03	131	1.603	0.889	2.04	0.55	0.79	307.85	1.82		100	20	1.12	2.85	1.00	344.6	0.85	Infin.	0.486	Non-Liq.	0.00
35.43	413.64	9.74	2.36	131	1.609	0.888	2.36	0.57	0.79	306.72	1.87		100	25	1.16	2.85	1.00	357.1	0.85	Infin.	0.486	Non-Liq.	0.00
35.60	407.69	10.01	2.46	131	1.614	0.887	2.47	0.58	0.78	300.92	1.89		100	25	1.18	2.85	1.00	355.7	0.84	Infin.	0.486	Non-Liq.	0.00
35.76	395.98	9.82	2.48	131	1.620	0.886	2.49	0.58	0.78	291.24	1.90		100	25	1.19	2.85	1.00	347.2	0.84	Infin.	0.485	Non-Liq.	0.00
35.93	394.69	8.81	2.23	131	1.626	0.885	2.24	0.57	0.78	291.14	1.87		100	25	1.16	2.85	1.00	337.1	0.84	Infin.	0.485	Non-Liq.	0.00
36.09	389.76	9.03	2.32	131	1.631	0.883	2.33	0.57	0.78	286.28	1.88		100	25	1.17	2.85	1.00	335.8	0.84	Infin.	0.485	Non-Liq.	0.00
36.25	404.39	9.17	2.27	131	1.637	0.882	2.28	0.57	0.78	297.12	1.87		100	25	1.16	2.85	1.00	344.2	0.84	Infin.	0.485	Non-Liq.	0.00
36.42	396.47	8.28	2.09	131	1.643	0.881	2.10	0.56	0.78	291.70	1.84		100	20	1.14	2.85	1.00	331.7	0.84	Infin.	0.485	Non-Liq.	0.00
36.58	384.68	7.28	1.89	131	1.648	0.880	1.89	0.55	0.78	283.57	1.81		100	20	1.11	2.85	1.00	316.0	0.84	Infin.	0.485	Non-Liq.	0.00
36.75	331.48	7.49	2.26	131	1.654	0.878	2.27	0.58	0.77	240.29	1.92		100	25	1.20	2.85	1.00	289.4	0.84	Infin.	0.485	Non-Liq.	0.00
36.91	231.70	6.18	2.67	131	1.659	0.877	2.68	0.63	0.75	163.76	2.07		97	35	1.41	2.85	1.00	230.4	0.84	Infin.	0.485	Non-Liq.	0.00

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA

Developed 2001 by Shelton L. Stringer, GE, Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-1 Plot: 1

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

	Magnitude:	7	7.5
	PGA, g:	0.70	0.59
	MSF:	1.19	130
	GWT, feet:	13.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara & Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.39
Avg SF of Liquefiable Layers: 0.57

Total Liquefied Thickness (feet)
7.2

Total Induced Subsidence (inches)
2.0

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Override	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	Kσ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	Volumetric Strain (%)
37.07	134.29	3.59	2.67	131	1.665	0.876	2.70	0.68	0.74	92.15	2.24		73	45	1.76	2.85	1.00	161.9	0.83	Infin.	0.484	Non-Liq.	0.00
37.24	73.58	1.64	2.08	131	1.671	0.875	2.13	0.71	0.72	52.59	2.34		50	55	2.07	2.85	1.00	108.7	0.87	0.200	0.484	0.36	1.37
37.40	56.83	1.32	2.32	131	1.676	0.873	2.39	0.75	0.71	36.85	2.49		35	65	2.70	2.85	1.00	99.4	0.91	0.171	0.484	0.32	1.50
37.57	52.22	1.19	2.28	131	1.682	0.872	2.35	0.76	0.70	33.56	2.51		32	70	2.83	2.85	1.00	95.0	0.91	0.160	0.484	0.30	1.56
37.73	48.06	1.28	2.67	131	1.688	0.871	2.77	0.79	0.69	30.38	2.59		27	75	3.27	2.85	1.00	99.4	0.91	0.171	0.484	0.32	1.50
37.89	44.38	1.32	2.97	131	1.693	0.869	3.08	0.80	0.69	27.65	2.65			80					0.91		0.483	Non-Liq.	0.00
38.06	45.61	1.17	2.56	131	1.699	0.868	2.66	0.79	0.69	28.58	2.60			75					0.91		0.483	Non-Liq.	0.00
38.22	40.90	0.95	2.31	131	1.704	0.867	2.42	0.79	0.69	25.39	2.61			80					0.91		0.483	Non-Liq.	0.00
38.39	41.94	0.92	2.19	131	1.710	0.865	2.28	0.79	0.69	26.08	2.59		21	75	3.27	0.20	1.52	129.4	0.91	0.282	0.483	0.53	1.12
38.55	40.03	1.12	2.80	131	1.716	0.864	2.92	0.81	0.68	24.46	2.68			85					0.91		0.482	Non-Liq.	0.00
38.71	42.21	1.23	2.90	131	1.721	0.863	3.03	0.81	0.67	25.81	2.67			85					0.91		0.482	Non-Liq.	0.00
38.88	41.92	1.27	3.04	131	1.727	0.861	3.17	0.81	0.67	25.49	2.69			85					0.91		0.482	Non-Liq.	0.00
39.04	42.28	1.42	3.35	131	1.733	0.860	3.49	0.82	0.67	25.55	2.71			90					0.91		0.481	Non-Liq.	0.00
39.21	44.59	1.46	3.27	131	1.738	0.859	3.40	0.81	0.67	27.04	2.69			85					0.91		0.481	Non-Liq.	0.00
39.37	43.96	1.47	3.34	131	1.744	0.857	3.48	0.82	0.66	26.51	2.70			85					0.90		0.481	Non-Liq.	0.00
39.53	44.00	1.39	3.17	131	1.749	0.856	3.30	0.81	0.66	26.53	2.69			85					0.90		0.480	Non-Liq.	0.00
39.70	51.41	1.58	3.07	131	1.755	0.854	3.18	0.79	0.67	31.41	2.62			80					0.90		0.480	Non-Liq.	0.00
39.86	76.55	2.43	3.17	131	1.761	0.853	3.25	0.75	0.68	48.13	2.49		46	65	2.71	0.20	1.52	198.2	0.90	Infin.	0.480	Non-Liq.	0.00
40.03	92.46	3.53	3.82	131	1.766	0.852	3.89	0.75	0.68	58.25	2.49		54	65	2.70	0.20	1.52	239.0	0.86	Infin.	0.479	Non-Liq.	0.00
40.19	169.72	5.48	3.23	131	1.772	0.850	3.26	0.68	0.70	111.76	2.24		81	45	1.78	0.20	1.52	301.3	0.81	Infin.	0.479	Non-Liq.	0.00
40.35	124.41	5.38	4.33	131	1.778	0.849	4.39	0.74	0.68	78.98	2.44		67	60	2.47	0.20	1.52	296.5	0.86	Infin.	0.479	Non-Liq.	0.00
40.52	68.85	3.27	4.74	131	1.783	0.847	4.87	0.81	0.66	41.63	2.66			80					0.90		0.478	Non-Liq.	0.00
40.68	52.13	1.73	3.31	131	1.789	0.846	3.43	0.80	0.66	31.25	2.64			80					0.90		0.478	Non-Liq.	0.00
40.85	46.82	1.44	3.08	131	1.794	0.844	3.21	0.81	0.65	27.79	2.66			80					0.90		0.478	Non-Liq.	0.00
41.01	42.85	1.41	3.29	131	1.800	0.843	3.44	0.82	0.65	25.06	2.72			90					0.90		0.477	Non-Liq.	0.00
41.17	43.15	1.57	3.65	131	1.806	0.841	3.81	0.83	0.64	25.06	2.74			90					0.90		0.477	Non-Liq.	0.00
41.34	48.71	2.08	4.27	131	1.811	0.840	4.44	0.83	0.64	28.33	2.75			90					0.90		0.476	Non-Liq.	0.00
41.50	73.51	2.22	3.02	131	1.817	0.838	3.10	0.76	0.66	45.01	2.50		44	65	2.75	0.15	1.58	195.2	0.90	Infin.	0.476	Non-Liq.	0.00
41.67	60.89	2.19	3.59	131	1.823	0.837	3.70	0.79	0.65	36.27	2.62			80					0.90		0.475	Non-Liq.	0.00
41.83	55.13	1.98	3.60	131	1.828	0.835	3.72	0.80	0.64	32.45	2.65			80					0.90		0.475	Non-Liq.	0.00
41.99	49.95	2.05	4.10	131	1.834	0.834	4.25	0.83	0.63	28.85	2.73			90					0.90		0.474	Non-Liq.	0.00
42.16	46.36	1.99	4.28	131	1.839	0.832	4.46	0.84	0.63	26.45	2.77			95					0.90		0.474	Non-Liq.	0.00
42.32	42.96	1.62	3.77	131	1.845	0.831	3.94	0.84	0.63	24.40	2.76			95					0.89		0.473	Non-Liq.	0.00
42.49	38.71	1.29	3.34	131	1.851	0.829	3.51	0.84	0.63	21.80	2.77			95					0.89		0.473	Non-Liq.	0.00
42.65	34.16	1.20	3.50	131	1.856	0.827	3.70	0.86	0.62	18.85	2.83			100					0.89		0.473	Non-Liq.	0.00
42.81	34.65	1.06	3.07	131	1.862	0.826	3.24	0.84	0.62	19.23	2.79			95					0.89		0.472	Non-Liq.	0.00
42.98	33.95	0.96	2.83	131	1.868	0.824	2.99	0.84	0.62	18.81	2.77			95					0.89		0.471	Non-Liq.	0.00
43.14	31.78	0.89	2.80	131	1.873	0.823	2.97	0.85	0.62	17.42	2.80			95					0.89		0.471	Non-Liq.	0.00
43.31	31.19	0.87	2.80	131	1.879	0.821	2.98	0.85	0.61	17.00	2.81			100					0.89		0.470	Non-Liq.	0.00
43.47	35.69	1.16	3.24	131	1.884	0.820	3.42	0.85	0.61	19.60	2.80			95					0.89		0.470	Non-Liq.	0.00
43.64	50.01	1.58	3.16	131	1.890	0.818	3.28	0.81	0.63	28.49	2.66			80					0.89		0.469	Non-Liq.	0.00
43.80	50.58	1.53	3.02	131	1.896	0.816	3.14	0.80	0.63	28.84	2.64			80					0.89		0.469	Non-Liq.	0.00
43.96	55.05	0.94	1.71	131	1.901	0.815	1.77	0.74	0.65	32.51	2.45		30	60	2.51	0.15	1.58	129.1	0.89	0.280	0.468	0.53	1.12
44.13	44.25	0.73	1.64	131	1.907	0.813	1.71	0.77	0.64	25.50	2.52		20	70	2.89	0.15	1.58	116.6	0.89	0.227	0.468	0.43	1.27
44.29	43.28	0.88	2.02	131	1.913	0.811	2.12	0.79	0.63	24.56	2.59		19	75	3.27	0.15	1.58	127.0	0.89	0.270	0.467	0.51	1.14
44.46	43.15	1.13	2.61	131	1.918	0.810	2.73	0.81	0.62	24.10	2.67			85					0.89		0.467	Non-Liq.	0.00
44.62	47.29	1.32	2.80	131	1.924	0.808	2.92	0.80	0.62	26.52	2.65			80					0.89		0.466	Non-Liq.	0.00
44.78	48.25	1.30	2.69	131	1.929	0.807	2.80	0.80	0.62	27.11	2.63			80					0.89		0.465	Non-Liq.	0.00
44.95	45.04	1.04	2.30	131	1.935	0.805	2.41	0.79	0.62	25.25	2.62			80					0.89		0.465	Non-Liq.	0.00
45.11	36.65	0.86	2.34	131	1.941	0.803	2.47	0.82	0.61	19.96	2.70			85					0.89		0.464	Non-Liq.	0.00
45.28	28.21	0.79	2.80	131	1.946	0.802	3.01	0.87	0.59	14.63	2.86			100					0.89		0.464	Non-Liq.	0.00
45.44	28.74	0.79	2.74	131	1.952	0.800	2.94	0.86	0.59	14.92	2.85			100					0.88		0.463	Non-Liq.	0.00
45.60	28.79	0.83	2.90	131	1.958	0.798	3.11	0.87	0.59	14.87	2.87			100					0.88		0.462	Non-Liq.	0.00
45.77	29.30	0.90	3.07	131	1.963	0.797	3.30	0.87	0.58	15.08	2.88			100					0.88		0.462	Non-Liq.	0.00
45.93	29.66	0.96	3.23	131	1.969	0.795	3.46	0.87	0.58	15.21	2.89			100					0.88		0.461	Non-Liq.	0.00
46.10	30.08	1.24	4.12	131	1.974	0.793	4.41	0.89	0.57	15.21	2.95			100					0.88		0.461	Non-Liq.	0.00
46.26	29.74	1.72	5.79	131	1.980	0.792	6.21	0.93	0.56	14.69	3.06			100					0.88		0.460	Non-Liq.	0.00
46.42	93.54	2.93	3.13	131	1.986	0.790	3.20	0.74	0.63	54.23	2.45		51	60	2.51	0.20	1.52	207.1	0.83	Infin.	0.459	Non-Liq.	0.00
46.59	83.45	4.49	5.38	131	1.991	0.788	5.51	0.81	0.60	46.20	2.67			85					0.88		0.459	Non-Liq.	0.00
46.75	78.54	4.27	5.44	131	1.997	0.787	5.58	0.82	0.60	43.11	2.69			85					0.88		0.458	Non-Liq.	0.00
46.92	94.31	4.26	4.51	131	2.003	0.785	4.61	0.78	0.61	53.09	2.57		51	75	3.14	0.25	1.46	243.3	0.83	Infin.	0.457	Non-Liq.	0.00
47.08	113.09	7.34	6.49	131	2.008	0.783	6.61	0.80	0.60	62.91	2.64			80					0.88		0.457	Non-Liq.	0.00
47.24	167.43	9.94	5.34	131	2.014	0.782	5.40	0.74	0.62	96.87	2.45		76	65	2.54	0.25	1.46	359.4	0.77	Infin.	0.456	Non-Liq.	0.00
47.41	161.46	11.15	6.91	131	2.019	0.780	6.99	0.78	0.61	91.29	2.56		73	70	3.08	0.25	1.46	410.5	0.77	Infin.	0.455	Non-Liq.	0.00
47.57	139.03	6.50	4.67	131	2.025	0.778	4.74	0.75	0.62	79.77	2.46		67	65	2.58	0.25	1.46	300.3	0.82	Infin.	0.455	Non-Liq.	0.00
47.74	43.13	3.09	7.17	131	2.031	0.777	7.52	0.91	0.55	21.52	2.99			100					0.88		0.454	Non-Liq.	0.00
47.90	36.84	2.48	6.73	131	2.036	0.775	7.12	0.92	0.55	18.04	3.03			100					0.88		0.453	Non-Liq.	0.00
48.06	33.25	2.15	6.48	131	2.042	0.773	6.90	0.93	0.54	16.04	3.06			100					0.88		0.453	Non-Liq.	0.00
48.23	98.66	4.30	4.36	131	2.048	0.772	4.45	0.77	0.60	54.85	2.55		52	70	3.02	0.25	1.46	241.7	0.82	Infin.	0.452	Non-Liq.	0.00
48.39	200.61	6.37	3.17	131	2.053	0.770	3.21	0.67	0.64	120.12	2.22		84	45	1.71	0.25	1.46	299.7	0.77	Infin.	0.451	Non-Liq.	0.00
48.56	171.85	7.90	4.60	131	2.059	0.768	4.65	0.73	0.62	98.93	2.40		76	60	2.29	0.25	1.46	331.6	0.77	Infin.	0.451	Non-Liq.	0.00
48.72	127.98	6.42	5.02	131	2.065	0.767	5.10	0.76	0.60	71.48	2.52		63	70	2.85	0.25	1.46	297.2	0.82	Infin.	0.450	Non-Liq.	0.00
48.88	69.68	3.60	5.17	131	2.070	0.765	5.33	0.83	0.57	36.73	2.72			90					0.87		0.449	Non-Liq.	0.00
49.05	50.29	2.00	3.97	131	2.076	0.763	4.14	0.84	0.57	25.96	2.76			95					0.87		0.449	Non-Liq.	0.00
49.21	56.43	1.84	3.27	131	2.081	0.762	3.39	0.80	0.58	29.81	2.65			80					0.87		0.448	Non-Liq.	0.00

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA

Developed 2001 by Shelton L. Stringer, GE, Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-1 **Plot:** 1

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

Magnitude:	7	7.5
PGA, g:	0.70	0.59
MSF:	1.19	1.30
GWT, feet:	13.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara & Yoshimine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.39
Avg SF of Liquefiable Layers: 0.57

Total Liquefied Thickness (feet) 7.2

Total Induced Subsidence (inches) 2.0

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Overide	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	K_σ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	*Volumetric Strain (%)*
49.38	81.71	1.90	2.32	131	2.087	0.760	2.39	0.73	0.61	45.76	2.41		44	60	2.37	0.25	1.46	158.5	0.87	0.450	0.447	0.88	0.52
49.54	74.27	2.04	2.75	131	2.093	0.758	2.83	0.76	0.60	40.66	2.50		39	65	2.78	0.25	1.46	165.0	0.87	Infin.	0.446	Non-Liq.	0.00
49.70	65.29	1.86	2.85	131	2.098	0.757	2.95	0.78	0.59	35.10	2.56		33	75	3.10	0.25	1.46	158.8	0.87	0.452	0.446	0.88	0.50
49.87	66.79	1.45	2.18	131	2.104	0.755	2.25	0.75	0.60	36.52	2.47		35	65	2.63	0.25	1.46	140.3	0.87	0.337	0.445	0.66	0.99
50.03	58.10	1.58	2.72	131	2.110	0.753	2.82	0.79	0.58	30.77	2.59		28	75	3.28	0.25	1.46	147.4	0.87	0.378	0.444	0.74	0.80

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA
Developed 2001 by Shelton L. Stringer, GE, Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-2 Plot: 2

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

Magnitude:	7	7.5
PGA, g:	0.70	0.59
MSF:	1.19	130
GWT, feet:	15.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara &Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.00
Avg SF of Liquefiable Layers: #DIV/0!

Total Liquefied Thickness (feet): 0.0
Total Induced Subsidence (inches): 0.1

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Override	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	Kσ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	Volumetric Strain (%)
0.16	0.17	0.01	5.88	128	0.010	1.000	6.27	1.00	1.70	0.26	4.53			100					1.00		0.381	Non-Liq.	0.00
0.33	0.57	0.12	21.05	128	0.021	1.000	21.86	1.00	1.70	0.88	4.36			100					1.00		0.381	Non-Liq.	0.00
0.49	2.17	0.38	17.51	128	0.031	1.000	17.77	1.00	1.70	3.44	3.83			100					1.00		0.381	Non-Liq.	0.00
0.66	4.50	0.76	16.89	128	0.042	1.000	17.05	1.00	1.70	7.16	3.58			100					1.00		0.381	Non-Liq.	0.00
0.82	37.65	1.04	2.76	128	0.052	1.000	2.77	0.72	1.70	60.41	2.37		56	55	2.19	0.25	1.46	193.5	1.00	Infin.	0.381	Non-Liq.	0.00
0.98	32.65	1.02	3.12	128	0.063	1.000	3.13	0.74	1.70	52.36	2.45		50	65	2.53	0.30	1.41	186.7	1.00	Infin.	0.381	Non-Liq.	0.00
1.15	25.68	0.91	3.54	128	0.073	0.999	3.55	0.78	1.70	41.14	2.56		40	75	3.12	0.35	1.36	174.0	1.00	Infin.	0.381	Non-Liq.	0.00
1.31	20.76	0.83	4.00	128	0.084	0.999	4.01	0.81	1.70	33.22	2.67			85					1.00		0.381	Non-Liq.	0.00
1.48	20.40	0.77	3.77	128	0.094	0.999	3.79	0.81	1.70	32.63	2.66			80					1.00		0.381	Non-Liq.	0.00
1.64	18.55	0.73	3.94	128	0.105	0.998	3.96	0.82	1.70	29.64	2.70			85					1.00		0.381	Non-Liq.	0.00
1.80	18.70	0.69	3.69	128	0.115	0.998	3.71	0.81	1.70	29.86	2.68			85					1.00		0.381	Non-Liq.	0.00
1.97	19.84	0.88	4.44	128	0.126	0.998	4.46	0.82	1.70	31.68	2.72			90					1.00		0.381	Non-Liq.	0.00
2.13	21.39	0.95	4.44	128	0.136	0.997	4.47	0.82	1.70	34.15	2.69			85					1.00		0.380	Non-Liq.	0.00
2.30	22.16	1.02	4.60	128	0.147	0.997	4.63	0.82	1.70	35.37	2.69			85					1.00		0.380	Non-Liq.	0.00
2.46	21.90	1.04	4.75	128	0.157	0.996	4.78	0.82	1.70	34.94	2.71			85					1.00		0.380	Non-Liq.	0.00
2.62	21.80	1.15	5.28	128	0.168	0.996	5.32	0.83	1.70	34.76	2.74			90					1.00		0.380	Non-Liq.	0.00
2.79	22.05	1.23	5.58	128	0.178	0.996	5.62	0.83	1.70	35.14	2.75			90					1.00		0.380	Non-Liq.	0.00
2.95	23.43	1.25	5.34	128	0.189	0.995	5.38	0.82	1.70	37.34	2.72			90					1.00		0.380	Non-Liq.	0.00
3.12	26.17	1.23	4.70	128	0.199	0.995	4.74	0.80	1.70	41.73	2.65			80					1.00		0.380	Non-Liq.	0.00
3.28	29.68	1.11	3.74	128	0.210	0.994	3.77	0.77	1.70	47.35	2.54		46	70	2.97	0.50	1.22	172.3	1.00	Infin.	0.379	Non-Liq.	0.00
3.44	30.57	1.01	3.30	128	0.220	0.994	3.33	0.76	1.70	48.77	2.49		47	65	2.73	0.55	1.19	157.9	1.00	0.446	0.379	Non-Liq.	0.00
3.61	30.85	1.09	3.53	128	0.231	0.994	3.56	0.76	1.70	49.20	2.51		47	70	2.82	0.60	1.15	159.9	1.00	0.460	0.379	Non-Liq.	0.00
3.77	31.70	1.07	3.38	128	0.241	0.993	3.40	0.75	1.70	50.55	2.49		49	65	2.71	0.65	1.12	153.5	1.00	0.416	0.379	Non-Liq.	0.00
3.94	34.88	1.11	3.18	128	0.252	0.993	3.21	0.74	1.70	55.64	2.44		53	60	2.48	0.70	1.10	151.3	1.00	0.402	0.379	Non-Liq.	0.00
4.10	42.70	1.23	2.88	128	0.262	0.993	2.90	0.71	1.70	68.19	2.35		61	55	2.11	0.75	1.07	154.0	1.00	0.420	0.379	Non-Liq.	0.00
4.27	31.97	1.27	3.97	128	0.273	0.992	4.01	0.77	1.70	50.93	2.54		49	70	2.96	0.80	1.05	158.3	1.00	0.449	0.378	Non-Liq.	0.00
4.43	27.92	1.26	4.51	128	0.283	0.992	4.56	0.79	1.70	44.41	2.62			80					1.00		0.378	Non-Liq.	0.00
4.59	28.15	1.26	4.48	128	0.294	0.991	4.52	0.79	1.70	44.76	2.61			80					1.00		0.378	Non-Liq.	0.00
4.76	26.96	1.40	5.19	128	0.304	0.991	5.25	0.81	1.70	42.83	2.67			85					1.00		0.378	Non-Liq.	0.00
4.92	39.64	1.32	3.33	128	0.315	0.991	3.36	0.73	1.70	63.19	2.42		58	60	2.38	0.80	1.05	157.9	1.00	0.446	0.378	Non-Liq.	0.00
5.09	64.41	1.40	2.17	128	0.325	0.990	2.18	0.65	1.70	102.97	2.13		78	40	1.52	0.80	1.05	164.5	1.00	Infin.	0.378	Non-Liq.	0.00
5.25	82.58	1.43	1.73	128	0.336	0.990	1.74	0.60	1.70	132.15	1.99		88	30	1.28	0.80	1.05	178.4	1.00	Infin.	0.378	Non-Liq.	0.00
5.41	87.27	1.20	1.38	128	0.346	0.989	1.38	0.58	1.70	139.67	1.90		91	25	1.19	0.80	1.05	174.3	1.00	Infin.	0.377	Non-Liq.	0.00
5.58	85.36	1.27	1.49	128	0.357	0.989	1.49	0.59	1.70	136.58	1.93		90	25	1.22	0.80	1.05	174.9	1.00	Infin.	0.377	Non-Liq.	0.00
5.74	82.09	1.44	1.75	128	0.367	0.989	1.76	0.61	1.70	131.31	1.99		88	30	1.29	0.80	1.05	178.4	1.00	Infin.	0.377	Non-Liq.	0.00
5.91	87.25	1.71	1.96	128	0.378	0.988	1.97	0.61	1.70	139.59	2.01		91	30	1.32	0.80	1.05	193.1	1.00	Infin.	0.377	Non-Liq.	0.00
6.07	98.79	1.88	1.90	128	0.388	0.988	1.91	0.60	1.70	158.11	1.97		96	30	1.26	0.80	1.05	209.3	1.00	Infin.	0.377	Non-Liq.	0.00
6.23	119.46	2.01	1.68	128	0.399	0.988	1.69	0.57	1.70	191.31	1.87		100	25	1.16	0.80	1.05	234.1	1.00	Infin.	0.377	Non-Liq.	0.00
6.40	124.58	2.03	1.63	128	0.409	0.987	1.63	0.56	1.70	199.52	1.85		100	20	1.15	0.80	1.05	240.2	1.00	Infin.	0.377	Non-Liq.	0.00
6.56	123.33	1.97	1.60	128	0.420	0.987	1.60	0.56	1.68	195.42	1.85		100	20	1.14	0.80	1.05	235.1	1.00	Infin.	0.376	Non-Liq.	0.00
6.73	111.83	1.87	1.67	128	0.430	0.986	1.68	0.58	1.68	176.73	1.89		100	25	1.18	0.80	1.05	219.6	1.00	Infin.	0.376	Non-Liq.	0.00
6.89	88.74	1.95	2.20	128	0.441	0.986	2.21	0.62	1.70	141.88	2.05		91	35	1.36	0.80	1.05	203.4	1.00	Infin.	0.376	Non-Liq.	0.00
7.05	58.62	2.05	3.62	128	0.451	0.986	3.65	0.71	1.70	90.25	2.34		73	55	2.08	0.80	1.05	197.3	1.00	Infin.	0.376	Non-Liq.	0.00
7.22	43.38	2.12	4.89	128	0.462	0.985	4.94	0.76	1.70	68.96	2.51		61	70	2.84	0.80	1.05	206.1	1.00	Infin.	0.376	Non-Liq.	0.00
7.38	37.39	1.97	5.27	128	0.472	0.985	5.34	0.78	1.70	59.32	2.58		55	75	3.22	0.80	1.05	200.9	1.00	Infin.	0.376	Non-Liq.	0.00
7.55	35.27	1.86	5.27	128	0.483	0.985	5.35	0.79	1.70	55.90	2.60			75					1.00		0.376	Non-Liq.	0.00
7.71	33.69	1.81	5.37	128	0.493	0.984	5.45	0.79	1.70	53.34	2.62			80					1.00		0.375	Non-Liq.	0.00
7.87	36.24	1.88	5.19	128	0.504	0.984	5.26	0.78	1.70	57.42	2.59		54	75	3.25	0.55	1.19	221.5	1.00	Infin.	0.375	Non-Liq.	0.00
8.04	36.71	1.82	4.96	128	0.514	0.984	5.03	0.78	1.70	58.16	2.57		54	75	3.14	0.55	1.19	216.9	1.00	Infin.	0.375	Non-Liq.	0.00
8.20	35.59	1.72	4.83	128	0.525	0.983	4.91	0.78	1.70	56.34	2.57		53	75	3.15	0.55	1.19	210.5	1.00	Infin.	0.375	Non-Liq.	0.00
8.37	37.16	1.87	5.03	128	0.535	0.983	5.11	0.78	1.70	58.85	2.57		55	75	3.15	0.55	1.19	220.1	1.00	Infin.	0.375	Non-Liq.	0.00
8.53	41.07	2.07	5.04	128	0.546	0.982	5.11	0.77	1.67	63.85	2.55		58	70	3.02	0.55	1.19	228.8	1.00	Infin.	0.375	Non-Liq.	0.00
8.69	42.13	1.99	4.72	128	0.556	0.982	4.79	0.77	1.64	64.26	2.52		58	70	2.89	0.60	1.15	214.4	1.00	Infin.	0.375	Non-Liq.	0.00
8.86	42.02	1.85	4.40	128	0.567	0.982	4.46	0.76	1.61	62.96	2.51		58	70	2.81	0.65	1.12	198.3	1.00	Infin.	0.375	Non-Liq.	0.00
9.02	43.45	1.92	4.42	128	0.577	0.981	4.48	0.76	1.58	64.16	2.50		58	65	2.78	0.70	1.10	195.6	1.00	Infin.	0.374	Non-Liq.	0.00
9.19	42.11	1.98	4.70	128	0.588	0.981	4.77	0.77	1.57	61.64	2.54		57	70	2.95	0.75	1.07	195.0	1.00	Infin.	0.374	Non-Liq.	0.00
9.35	40.15	1.90	4.73	128	0.598	0.981	4.80	0.77	1.55	58.12	2.55		54	70	3.06	0.80	1.05	186.9	1.00	Infin.	0.374	Non-Liq.	0.00
9.51	37.20	1.78	4.78	128	0.609	0.980	4.86	0.78	1.54	53.31	2.58		51	75	3.23	0.85	1.03	178.0	1.00	Infin.	0.374	Non-Liq.	0.00
9.68	36.14	1.76	4.87	128	0.619	0.980	4.95	0.79	1.53	51.20	2.60			75					1.00		0.374	Non-Liq.	0.00
9.84	36.97	1.85	5.00	128	0.630	0.980	5.09	0.79	1.51	51.74	2.61			75					1.00		0.374	Non-Liq.	0.00
10.01	41.36	1.99	4.81	128	0.640	0.979	4.89	0.78	1.48	56.87	2.57		53	75	3.13	1.00	1.00	178.5	1.00	Infin.	0.374	Non-Liq.	0.00
10.17	47.18	1.99	4.22	128	0.651	0.979	4.28	0.76	1.44	63.47	2.49		58	65	2.73	1.05	1.00	173.0	1.00	Infin.	0.373	Non-Liq.	0.00
10.33	41.94	1.81	4.32	128	0.661	0.979	4.38	0.77	1.43	55.99	2.54		53	70	2.96	1.10	1.00	165.6	1.00	Infin.	0.373	Non-Liq.	0.00
10.50	39.88	1.74	4.36	128	0.672	0.978	4.44	0.78	1.42	52.69	2.56		50	70	3.08	1.15	1.00	162.2	1.00	Infin.	0.373	Non-Liq.	0.00
10.66	39.41	1.72	4.36	128	0.682	0.978	4.44	0.78	1.41	51.48	2.57		49	75	3.12	1.20	1.00	160.6	1.00	Infin.	0.373	Non-Liq.	0.00
10.83	38.45	1.75	4.55	128	0.693	0.978	4.63	0.78	1.39	49.74	2.59		48	75	3.26	1.25	1.00	162.1	1.00	Infin.	0.373	Non-Liq.	0.00
10.99	38.30	1.70	4.44	128	0.703	0.977	4.52	0.78	1.38	48.93	2.59		47	75	3.24	1.30	1.00	158.6	1.00	0.451	0.373	Non-Liq.	0.00
11.15	41.09	1.72	4.19	128	0.714	0.977	4.26	0.77	1.36	51.73	2.55		49	70	3.04	1.35	1.00	157.1	1.00	0.440	0.373	Non-Liq.	0.00
11.32	41.41	1.77	4.27	128	0.724	0.977	4.35	0.78	1.34	51.58	2.56		49	70	3.08	1.40	1.00	158.8	1.00	0.452	0.373	Non-Liq.	0.00
11.48	41.09	1.80	4.38	128	0.735	0.976	4.46	0.78	1.33	50.67	2.57		49	75	3.15	1.45	1.00	159.8	1.00	0.460	0.372	Non-Liq.	0.00
11.65	42.87	1.99	4.64	128	0.745	0.976	4.72	0.78	1.31	52.36	2.58		50	75	3.20	1.45	1.00	167.8	1.00	Infin.	0.372	Non-Liq.	0.00
11.81	47.21	2.31	4.89	128	0.756	0.975	4.97	0.78	1.30	57.06	2.57		54	75	3.15	1.45	1.00	179.9	1.00	Infin.	0.372	Non-Liq.	0.00
11.98	50.33	2.34	4.65	128	0.766	0.975	4.72	0.77	1.28	60.04	2.54		56	70	2.98	1.45	1.00	178.7	1.00	Infin.	0.372	Non-Liq.	0.00
12.14	53.56	2.46	4.59	131	0.777	0.975	4.66	0.76	1.27	63.15	2.52		58	70	2.88	1.45	1.00	181.6	1.00	Infin.	0.372	Non-Liq.	0.00
12.30	61.48	2.53	4.12	131	0.788	0.974	4.17	0.74	1.24	71.40	2.45		63	65	2.52	1.45	1.00	180.2	1.00	Infin.	0.372	Non-Liq.	0.00

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA
Developed 2001 by Shelton L. Stringer, GE, Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-2 Plot: 2

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

Magnitude:	7	7.5
PGA, g:	0.70	0.59
MSF:	1.19	130
GWT feet:	15.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara &Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.00
Avg SF of Liquefiable Layers: #DIV/0!

Total Liquefied Thickness (feet): 0.0
Total Induced Subsidence (inches): 0.1

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Overide	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	Kσ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	Volumetric Strain (%)
12.47	71.68	2.64	3.68	131	0.799	0.974	3.72	0.72	1.22	82.03	2.37		69	55	2.20	1.45	1.00	180.8	1.00	Infin.	0.372	Non-Liq.	0.00
12.63	77.50	3.05	3.92	131	0.809	0.974	3.96	0.72	1.21	88.24	2.37		72	55	2.20	1.45	1.00	194.4	1.00	Infin.	0.371	Non-Liq.	0.00
12.80	73.39	3.27	4.17	131	0.820	0.973	4.22	0.73	1.20	88.21	2.39		72	60	2.28	1.45	1.00	201.6	1.00	Infin.	0.371	Non-Liq.	0.00
12.96	73.51	3.41	4.64	131	0.831	0.973	4.69	0.74	1.20	82.20	2.45		69	60	2.52	1.45	1.00	207.3	1.00	Infin.	0.371	Non-Liq.	0.00
13.12	78.67	3.39	4.31	131	0.842	0.973	4.36	0.73	1.18	86.94	2.41		71	60	2.35	1.45	1.00	204.0	1.00	Infin.	0.371	Non-Liq.	0.00
13.29	74.21	3.22	4.34	131	0.852	0.972	4.39	0.74	1.17	81.31	2.43		68	60	2.44	1.45	1.00	198.1	1.00	Infin.	0.371	Non-Liq.	0.00
13.45	65.67	3.09	4.71	131	0.863	0.972	4.77	0.76	1.17	71.45	2.49		63	65	2.73	1.45	1.00	195.3	1.00	Infin.	0.371	Non-Liq.	0.00
13.62	61.40	3.10	5.05	131	0.874	0.972	5.12	0.77	1.16	66.28	2.54		60	70	2.97	1.45	1.00	196.7	1.00	Infin.	0.371	Non-Liq.	0.00
13.78	61.95	3.07	4.96	131	0.885	0.971	5.03	0.77	1.15	66.22	2.53		60	70	2.94	1.45	1.00	194.4	1.00	Infin.	0.371	Non-Liq.	0.00
13.94	64.48	3.30	5.12	131	0.895	0.971	5.19	0.77	1.14	68.32	2.53		61	70	2.94	1.45	1.00	201.2	1.00	Infin.	0.370	Non-Liq.	0.00
14.11	69.68	3.54	5.08	131	0.906	0.971	5.15	0.76	1.13	73.15	2.51		64	70	2.83	1.45	1.00	207.0	1.00	Infin.	0.370	Non-Liq.	0.00
14.27	72.87	3.45	4.73	131	0.917	0.970	4.79	0.75	1.11	75.74	2.48		65	65	2.66	1.45	1.00	201.6	1.00	Infin.	0.370	Non-Liq.	0.00
14.44	62.88	3.20	5.09	131	0.928	0.970	5.17	0.77	1.11	64.82	2.55		59	70	3.02	1.45	1.00	195.6	1.00	Infin.	0.370	Non-Liq.	0.00
14.60	56.89	2.86	5.03	131	0.938	0.970	5.11	0.78	1.10	58.08	2.57		54	75	3.18	1.45	1.00	184.5	1.00	Infin.	0.370	Non-Liq.	0.00
14.76	53.73	2.48	4.89	131	0.949	0.969	4.98	0.79	1.09	51.26	2.60			75					1.00		0.370	Non-Liq.	0.00
14.93	52.03	2.28	4.38	131	0.960	0.969	4.46	0.78	1.08	52.07	2.56		50	75	3.11	0.10	1.64	266.2	1.00	Infin.	0.370	Non-Liq.	0.00
15.09	48.35	2.15	4.45	131	0.970	0.969	4.54	0.79	1.07	47.94	2.59		46	75	3.28	0.10	1.64	258.9	1.00	Infin.	0.370	Non-Liq.	0.00
15.26	42.94	2.20	5.12	131	0.976	0.968	5.24	0.81	1.07	42.35	2.68			85					1.00		0.371	Non-Liq.	0.00
15.42	39.75	2.39	6.01	131	0.982	0.968	6.16	0.83	1.06	39.01	2.75			90					1.00		0.373	Non-Liq.	0.00
15.58	45.06	2.50	5.55	131	0.987	0.967	5.67	0.81	1.06	44.08	2.69			85					1.00		0.375	Non-Liq.	0.00
15.75	43.04	2.31	5.37	131	0.993	0.967	5.49	0.82	1.05	41.86	2.69			85					1.00		0.377	Non-Liq.	0.00
15.91	41.68	2.16	5.18	131	0.998	0.967	5.31	0.82	1.05	40.32	2.69			85					1.00		0.378	Non-Liq.	0.00
16.08	42.15	2.20	5.22	131	1.004	0.966	5.35	0.82	1.04	40.59	2.69			85					1.01		0.380	Non-Liq.	0.00
16.24	38.84	2.19	5.64	131	1.010	0.966	5.79	0.83	1.04	37.18	2.75			90					1.01		0.382	Non-Liq.	0.00
16.40	33.29	2.09	6.28	131	1.015	0.966	6.48	0.86	1.04	31.60	2.83			100					1.01		0.383	Non-Liq.	0.00
16.57	32.84	1.72	5.24	131	1.021	0.965	5.41	0.84	1.03	30.99	2.78			95					1.01		0.385	Non-Liq.	0.00
16.73	30.74	1.40	4.55	131	1.027	0.965	4.71	0.84	1.03	28.80	2.76			95					1.01		0.387	Non-Liq.	0.00
16.90	30.00	1.44	4.80	131	1.032	0.965	4.97	0.84	1.02	27.96	2.79			95					1.00		0.388	Non-Liq.	0.00
17.06	31.87	1.71	5.37	131	1.038	0.964	5.55	0.85	1.02	29.62	2.80			100					1.00		0.390	Non-Liq.	0.00
17.22	30.36	1.95	6.42	131	1.043	0.964	6.65	0.87	1.01	28.05	2.87			100					1.00		0.391	Non-Liq.	0.00
17.39	37.43	2.17	5.80	131	1.049	0.963	5.96	0.84	1.01	34.63	2.78			95					1.00		0.393	Non-Liq.	0.00
17.55	36.77	1.81	4.92	131	1.055	0.963	5.07	0.83	1.00	33.85	2.73			90					1.00		0.394	Non-Liq.	0.00
17.72	27.53	1.52	5.52	131	1.060	0.963	5.74	0.87	1.00	24.97	2.87			100					1.00		0.396	Non-Liq.	0.00
17.88	27.55	1.53	5.55	131	1.066	0.962	5.78	0.87	0.99	24.87	2.87			100					1.00		0.397	Non-Liq.	0.00
18.04	30.89	1.77	5.73	131	1.072	0.962	5.94	0.86	0.99	27.88	2.84			100					1.00		0.399	Non-Liq.	0.00
18.21	32.87	1.88	5.72	131	1.077	0.962	5.91	0.85	0.98	29.59	2.82			100					1.00		0.400	Non-Liq.	0.00
18.37	34.63	1.84	5.31	131	1.083	0.961	5.48	0.84	0.98	31.10	2.78			95					1.00		0.401	Non-Liq.	0.00
18.54	37.24	1.74	4.67	131	1.088	0.961	4.81	0.82	0.98	33.38	2.72			90					0.99		0.403	Non-Liq.	0.00
18.70	39.77	2.02	5.08	131	1.094	0.960	5.22	0.83	0.97	35.56	2.73			90					0.99		0.404	Non-Liq.	0.00
18.86	48.37	2.40	4.96	131	1.100	0.960	5.08	0.81	0.97	43.31	2.66			80					0.99		0.405	Non-Liq.	0.00
19.03	65.86	3.03	4.60	131	1.105	0.960	4.68	0.77	0.97	59.18	2.54		55	70	2.98	1.00	1.00	177.2	0.99	Infin.	0.407	Non-Liq.	0.00
19.19	83.56	3.92	4.69	131	1.111	0.959	4.75	0.75	0.96	75.12	2.48		65	65	2.66	1.05	1.00	199.8	0.99	Infin.	0.408	Non-Liq.	0.00
19.36	97.17	4.41	4.54	131	1.117	0.959	4.59	0.74	0.96	87.26	2.42		71	60	2.42	1.10	1.00	210.9	0.98	Infin.	0.409	Non-Liq.	0.00
19.52	136.03	5.57	4.09	131	1.122	0.958	4.13	0.70	0.96	122.38	2.30		85	50	1.94	1.15	1.00	237.7	0.98	Infin.	0.411	Non-Liq.	0.00
19.69	160.27	5.62	3.51	131	1.128	0.958	3.53	0.67	0.96	144.13	2.20		92	45	1.67	1.20	1.00	240.6	0.97	Infin.	0.412	Non-Liq.	0.00
19.85	207.84	5.53	2.66	131	1.133	0.957	2.68	0.62	0.96	187.22	2.04		100	35	1.35	1.25	1.00	252.9	0.97	Infin.	0.413	Non-Liq.	0.00
20.01	235.69	5.43	2.30	131	1.139	0.957	2.32	0.59	0.96	212.18	1.95		100	30	1.24	1.30	1.00	264.0	0.97	Infin.	0.414	Non-Liq.	0.00
20.18	247.54	5.75	2.32	131	1.145	0.957	2.33	0.59	0.95	222.29	1.95		100	25	1.23	1.35	1.00	274.4	0.97	Infin.	0.416	Non-Liq.	0.00
20.34	256.30	5.91	2.31	131	1.150	0.956	2.32	0.59	0.95	229.58	1.93		100	25	1.22	1.40	1.00	280.8	0.97	Infin.	0.417	Non-Liq.	0.00
20.51	263.46	5.78	2.19	131	1.156	0.956	2.20	0.58	0.95	235.49	1.91		100	25	1.20	1.45	1.00	282.3	0.97	Infin.	0.418	Non-Liq.	0.00
20.67	263.82	5.56	2.11	131	1.162	0.955	2.12	0.58	0.95	235.24	1.90		100	25	1.19	1.50	1.00	278.8	0.96	Infin.	0.419	Non-Liq.	0.00
20.83	263.78	5.86	2.22	131	1.167	0.955	2.23	0.58	0.94	234.41	1.92		100	25	1.20	1.55	1.00	282.3	0.96	Infin.	0.420	Non-Liq.	0.00
21.00	256.40	6.41	2.50	131	1.173	0.954	2.51	0.60	0.94	226.83	1.97		100	30	1.26	1.60	1.00	285.4	0.96	Infin.	0.421	Non-Liq.	0.00
21.16	255.62	6.76	2.64	131	1.178	0.954	2.66	0.60	0.94	225.32	1.99		100	30	1.28	1.65	1.00	289.5	0.96	Infin.	0.423	Non-Liq.	0.00
21.33	263.07	7.45	2.78	131	1.184	0.954	2.79	0.61	0.93	235.61	2.00		100	30	1.29	1.70	1.00	304.8	0.96	Infin.	0.424	Non-Liq.	0.00
21.49	279.48	7.49	2.68	131	1.190	0.953	2.69	0.60	0.93	245.17	1.97		100	30	1.27	1.75	1.00	310.2	0.95	Infin.	0.425	Non-Liq.	0.00
21.65	297.43	7.11	2.39	131	1.195	0.953	2.40	0.58	0.93	260.77	1.92		100	25	1.20	1.80	1.00	314.1	0.95	Infin.	0.426	Non-Liq.	0.00
21.82	302.29	5.66	1.87	131	1.201	0.952	1.88	0.56	0.93	265.25	1.82		100	20	1.12	1.85	1.00	298.3	0.95	Infin.	0.427	Non-Liq.	0.00
21.98	295.69	5.93	2.01	131	1.207	0.952	2.01	0.56	0.93	258.44	1.86		100	25	1.15	1.90	1.00	297.0	0.95	Infin.	0.428	Non-Liq.	0.00
22.15	287.02	6.44	2.24	131	1.212	0.951	2.25	0.58	0.92	249.67	1.90		100	25	1.19	1.95	1.00	297.7	0.95	Infin.	0.429	Non-Liq.	0.00
22.31	297.26	6.99	2.35	131	1.218	0.951	2.36	0.58	0.92	257.82	1.91		100	25	1.20	2.00	1.00	309.7	0.95	Infin.	0.430	Non-Liq.	0.00
22.47	313.40	7.37	2.35	131	1.223	0.950	2.36	0.58	0.92	271.29	1.90		100	25	1.19	2.05	1.00	322.7	0.94	Infin.	0.431	Non-Liq.	0.00
22.64	326.15	7.24	2.22	131	1.229	0.950	2.23	0.57	0.92	282.00	1.87		100	25	1.16	2.10	1.00	327.7	0.94	Infin.	0.432	Non-Liq.	0.00
22.80	321.60	7.53	2.34	131	1.235	0.949	2.35	0.58	0.91	277.02	1.89		100	25	1.18	2.15	1.00	327.8	0.94	Infin.	0.433	Non-Liq.	0.00
22.97	319.52	7.70	2.41	131	1.240	0.949	2.42	0.58	0.91	274.33	1.91		100	25	1.20	2.20	1.00	327.9	0.94	Infin.	0.434	Non-Liq.	0.00
23.13	328.00	8.09	2.47	131	1.246	0.948	2.48	0.58	0.91	280.85	1.91		100	25	1.20	2.25	1.00	336.5	0.94	Infin.	0.435	Non-Liq.	0.00
23.29	333.86	8.08	2.42	131	1.252	0.948	2.43	0.58	0.91	285.29	1.90		100	25	1.19	2.30	1.00	339.0	0.93	Infin.	0.436	Non-Liq.	0.00
23.46	344.65	8.02	2.33	131	1.257	0.947	2.34	0.57	0.91	294.10	1.88		100	25	1.17	2.35	1.00	343.7	0.93	Infin.	0.436	Non-Liq.	0.00
23.62	350.35	7.83	2.23	131	1.263	0.947	2.24	0.57	0.90	298.51	1.86		100	25	1.15	2.40	1.00	344.2	0.93	Infin.	0.437	Non-Liq.	0.00
23.79	350.20	7.49	2.14	131	1.268	0.946	2.15	0.56	0.90	297.88	1.84		100	20	1.14	2.45	1.00	339.6	0.93	Infin.	0.438	Non-Liq.	0.00
23.95	341.38	6.74	1.97	131	1.274	0.946	1.98	0.55	0.90	289.99	1.82		100	20	1.12	2.50	1.00	325.5	0.93	Infin.	0.439	Non-Liq.	0.00
24.11	318.48	6.23	1.97	131	1.280	0.945	1.98	0.56	0.90	267.82	1.84		100	20	1.14	2.55	1.00	304.4	0.93	Infin.	0.440	Non-Liq.	0.00
24.28	295.41	6.21	2.10	131	1.285	0.945	2.11	0.57	0.89	248.69	1.88		100	25	1.17	2.60	1.00	291.4	0.93	Infin.	0.441	Non-Liq.	0.00
24.44	286.55	6.89	2.40	131	1.291	0.944	2.42	0.59	0.89	239.77	1.94		100	25	1.23	2.65	1.00	294.3	0.92	Infin.	0.442	Non-Liq.	0.00
24.61	287.38	7.60	2.64	131	1.297	0.943	2.66	0.60	0.89	239.34	1.97		100	30	1.27	2.70	1.00	303.2	0.92	Infin.	0.442	Non-Liq.	0.00

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA

Developed 2001 by Shelton L. Stringer, GE. Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-2 Plot: 2

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

Magnitude:	7	7.5
PGA, g:	0.70	0.59
MSF:	1.19	130
GWT, feet:	15.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara &Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.00
Avg SF of Liquefiable Layers: #DIV/0!

Total Liquefied Thickness (feet): 0.0

Total Induced Subsidence (inches): 0.1

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Overide	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	Kσ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	Volumetric Strain (%)
24.77	319.54	7.83	2.45	131	1.302	0.943	2.46	0.58	0.89	266.44	1.92		100	25	1.21	2.75	1.00	321.9	0.92	Infin.	0.443	Non-Liq.	0.00
24.93	349.33	6.03	1.73	131	1.308	0.942	1.73	0.54	0.89	293.42	1.77		100	20	1.09	2.80	1.00	318.5	0.92	Infin.	0.444	Non-Liq.	0.00
25.10	362.82	6.37	1.76	131	1.313	0.942	1.76	0.54	0.89	304.14	1.77		100	20	1.08	2.85	1.00	329.5	0.92	Infin.	0.445	Non-Liq.	0.00
25.26	370.23	6.84	1.85	131	1.319	0.941	1.85	0.54	0.89	309.36	1.78		100	20	1.09	2.90	1.00	338.3	0.92	Infin.	0.445	Non-Liq.	0.00
25.43	385.98	6.64	1.72	131	1.325	0.941	1.73	0.53	0.89	322.60	1.75		100	20	1.07	2.95	1.00	344.7	0.91	Infin.	0.446	Non-Liq.	0.00
25.59	401.80	6.40	1.59	131	1.330	0.940	1.60	0.52	0.89	335.98	1.71		100	15	1.04	3.00	1.00	350.5	0.91	Infin.	0.447	Non-Liq.	0.00
25.75	399.89	6.55	1.64	131	1.336	0.939	1.64	0.52	0.88	333.36	1.72		100	15	1.05	3.05	1.00	350.5	0.91	Infin.	0.448	Non-Liq.	0.00
25.92	381.22	6.89	1.81	131	1.342	0.939	1.81	0.54	0.88	315.94	1.77		100	20	1.08	3.10	1.00	342.6	0.91	Infin.	0.448	Non-Liq.	0.00
26.08	358.44	7.31	2.04	131	1.347	0.938	2.05	0.56	0.87	295.03	1.83		100	20	1.13	3.15	1.00	332.9	0.91	Infin.	0.449	Non-Liq.	0.00
26.25	334.29	8.07	2.41	131	1.353	0.938	2.42	0.58	0.87	272.82	1.91		100	25	1.20	3.20	1.00	326.7	0.91	Infin.	0.450	Non-Liq.	0.00
26.41	317.14	8.46	2.67	131	1.358	0.937	2.68	0.60	0.86	257.17	1.96		100	30	1.25	3.25	1.00	321.5	0.90	Infin.	0.450	Non-Liq.	0.00
26.57	316.72	8.41	2.66	131	1.364	0.936	2.67	0.60	0.86	256.20	1.96		100	30	1.25	3.30	1.00	320.1	0.90	Infin.	0.451	Non-Liq.	0.00
26.74	329.19	8.49	2.58	131	1.370	0.936	2.59	0.59	0.86	266.08	1.94		100	25	1.23	3.35	1.00	326.7	0.90	Infin.	0.452	Non-Liq.	0.00
26.90	346.35	8.04	2.32	131	1.375	0.935	2.33	0.57	0.86	280.45	1.89		100	25	1.18	3.40	1.00	330.3	0.90	Infin.	0.452	Non-Liq.	0.00
27.07	356.57	7.81	2.19	131	1.381	0.934	2.20	0.57	0.86	288.73	1.86		100	25	1.15	3.45	1.00	333.0	0.90	Infin.	0.453	Non-Liq.	0.00
27.23	353.05	7.62	2.16	131	1.387	0.934	2.17	0.57	0.86	285.26	1.86		100	25	1.15	3.50	1.00	328.4	0.90	Infin.	0.454	Non-Liq.	0.00
27.40	336.82	8.13	2.41	131	1.392	0.933	2.42	0.58	0.85	270.27	1.91		100	25	1.20	3.55	1.00	324.2	0.90	Infin.	0.454	Non-Liq.	0.00
27.56	322.84	8.64	2.68	131	1.398	0.932	2.69	0.60	0.85	257.33	1.96		100	30	1.25	3.60	1.00	322.1	0.89	Infin.	0.455	Non-Liq.	0.00
27.72	332.55	9.16	2.75	131	1.403	0.932	2.77	0.60	0.84	264.37	1.96		100	30	1.26	3.65	1.00	332.2	0.89	Infin.	0.455	Non-Liq.	0.00
27.89	342.62	9.40	2.74	131	1.409	0.931	2.75	0.59	0.84	271.95	1.96		100	30	1.25	3.70	1.00	339.2	0.89	Infin.	0.456	Non-Liq.	0.00
28.05	359.31	9.08	2.53	131	1.415	0.930	2.54	0.58	0.84	285.60	1.91		100	25	1.20	3.75	1.00	343.7	0.89	Infin.	0.456	Non-Liq.	0.00
28.22	377.88	8.99	2.38	131	1.420	0.929	2.39	0.57	0.84	300.63	1.88		100	25	1.17	3.80	1.00	352.1	0.89	Infin.	0.457	Non-Liq.	0.00
28.38	380.09	7.88	2.07	131	1.426	0.929	2.08	0.56	0.85	303.12	1.83		100	20	1.13	3.85	1.00	341.9	0.89	Infin.	0.457	Non-Liq.	0.00
28.54	367.26	8.14	2.22	131	1.432	0.928	2.23	0.57	0.84	291.31	1.86		100	25	1.16	3.90	1.00	336.5	0.89	Infin.	0.458	Non-Liq.	0.00
28.71	363.18	7.82	2.15	131	1.437	0.927	2.16	0.56	0.84	287.62	1.85		100	25	1.15	3.95	1.00	330.5	0.88	Infin.	0.458	Non-Liq.	0.00
28.87	370.68	8.07	2.18	131	1.443	0.926	2.19	0.56	0.84	292.94	1.85		100	25	1.15	4.00	1.00	336.5	0.88	Infin.	0.459	Non-Liq.	0.00
29.04	371.34	8.87	2.39	131	1.449	0.926	2.40	0.57	0.83	291.86	1.89		100	25	1.18	4.05	1.00	344.1	0.88	Infin.	0.459	Non-Liq.	0.00
29.20	361.80	9.33	2.58	131	1.454	0.925	2.59	0.59	0.83	282.73	1.92		100	25	1.21	4.10	1.00	343.0	0.88	Infin.	0.460	Non-Liq.	0.00
29.36	353.79	9.09	2.57	131	1.460	0.924	2.58	0.59	0.83	275.70	1.93		100	25	1.22	4.15	1.00	335.7	0.88	Infin.	0.460	Non-Liq.	0.00
29.53	344.36	8.92	2.59	131	1.465	0.923	2.60	0.59	0.83	267.44	1.94		100	25	1.23	4.20	1.00	328.5	0.88	Infin.	0.461	Non-Liq.	0.00
29.69	342.70	9.32	2.72	131	1.471	0.923	2.73	0.60	0.82	265.02	1.96		100	30	1.25	4.25	1.00	331.4	0.88	Infin.	0.461	Non-Liq.	0.00
29.86	350.18	9.04	2.58	131	1.477	0.922	2.59	0.59	0.82	270.87	1.94		100	25	1.22	4.30	1.00	331.5	0.88	Infin.	0.461	Non-Liq.	0.00
30.02	340.94	8.43	2.47	131	1.482	0.921	2.48	0.59	0.82	263.34	1.93		100	25	1.21	4.35	1.00	319.8	0.87	Infin.	0.462	Non-Liq.	0.00
30.18	328.21	8.02	2.44	131	1.488	0.920	2.45	0.59	0.82	252.75	1.93		100	25	1.22	4.40	1.00	308.4	0.87	Infin.	0.462	Non-Liq.	0.00
30.35	313.89	7.90	2.52	131	1.494	0.919	2.53	0.59	0.81	240.57	1.95		100	30	1.24	4.45	1.00	299.4	0.87	Infin.	0.462	Non-Liq.	0.00
30.51	323.30	8.36	2.59	131	1.499	0.918	2.60	0.60	0.81	247.17	1.96		100	30	1.25	4.50	1.00	308.5	0.87	Infin.	0.463	Non-Liq.	0.00
30.68	334.20	8.00	2.39	131	1.505	0.918	2.40	0.58	0.81	255.95	1.92		100	25	1.21	4.55	1.00	309.6	0.87	Infin.	0.463	Non-Liq.	0.00
30.84	310.73	7.04	2.27	131	1.510	0.917	2.28	0.58	0.81	237.41	1.92		100	25	1.21	4.60	1.00	286.8	0.87	Infin.	0.463	Non-Liq.	0.00
31.00	314.13	7.42	2.36	131	1.516	0.916	2.37	0.59	0.81	239.16	1.93		100	25	1.22	4.65	1.00	292.1	0.87	Infin.	0.464	Non-Liq.	0.00
31.17	320.86	8.30	2.59	131	1.522	0.915	2.60	0.60	0.81	243.00	1.96		100	30	1.25	4.70	1.00	304.5	0.86	Infin.	0.464	Non-Liq.	0.00
31.33	341.28	8.72	2.56	131	1.527	0.914	2.57	0.59	0.81	258.52	1.94		100	25	1.23	4.75	1.00	318.4	0.86	Infin.	0.464	Non-Liq.	0.00
31.50	356.02	9.30	2.61	131	1.533	0.913	2.62	0.59	0.80	269.19	1.94		100	25	1.23	4.80	1.00	331.1	0.86	Infin.	0.465	Non-Liq.	0.00
31.66	365.67	9.68	2.65	131	1.539	0.912	2.66	0.59	0.80	275.94	1.94		100	25	1.23	4.85	1.00	339.2	0.86	Infin.	0.465	Non-Liq.	0.00
31.82	366.41	9.96	2.72	131	1.544	0.911	2.73	0.59	0.80	275.59	1.95		100	30	1.24	4.90	1.00	341.7	0.86	Infin.	0.465	Non-Liq.	0.00
31.99	356.89	9.88	2.77	131	1.550	0.910	2.78	0.60	0.80	267.40	1.96		100	30	1.26	4.95	1.00	335.7	0.86	Infin.	0.465	Non-Liq.	0.00
32.15	353.79	10.20	2.88	131	1.555	0.909	2.90	0.60	0.79	263.94	1.98		100	30	1.28	5.00	1.00	337.0	0.86	Infin.	0.466	Non-Liq.	0.00
32.32	352.49	10.11	2.87	131	1.561	0.908	2.88	0.60	0.79	262.40	1.98		100	30	1.28	5.05	1.00	334.9	0.86	Infin.	0.466	Non-Liq.	0.00
32.48	352.32	9.60	2.72	131	1.567	0.907	2.74	0.60	0.79	262.28	1.96		100	30	1.25	5.10	1.00	328.9	0.85	Infin.	0.466	Non-Liq.	0.00
32.64	344.42	9.24	2.68	131	1.572	0.906	2.70	0.60	0.79	255.82	1.96		100	30	1.25	5.15	1.00	320.9	0.85	Infin.	0.466	Non-Liq.	0.00
32.81	325.68	8.69	2.67	131	1.578	0.905	2.68	0.60	0.79	240.96	1.98		100	30	1.27	5.20	1.00	305.7	0.85	Infin.	0.466	Non-Liq.	0.00
32.97	326.24	8.40	2.57	131	1.584	0.904	2.59	0.60	0.79	241.24	1.96		100	30	1.25	5.25	1.00	302.3	0.85	Infin.	0.467	Non-Liq.	0.00
33.14	352.39	9.13	2.59	131	1.589	0.903	2.60	0.59	0.79	260.63	1.95		100	25	1.24	5.30	1.00	321.9	0.85	Infin.	0.467	Non-Liq.	0.00
33.30	360.40	9.52	2.64	131	1.595	0.902	2.65	0.59	0.78	265.95	1.95		100	25	1.24	5.35	1.00	329.1	0.85	Infin.	0.467	Non-Liq.	0.00
33.46	363.88	9.51	2.61	131	1.600	0.901	2.63	0.59	0.78	268.16	1.94		100	25	1.23	5.40	1.00	330.2	0.85	Infin.	0.467	Non-Liq.	0.00
33.63	373.06	9.97	2.67	131	1.606	0.900	2.68	0.59	0.78	274.28	1.95		100	25	1.23	5.45	1.00	338.6	0.85	Infin.	0.467	Non-Liq.	0.00
33.79	373.27	10.23	2.74	131	1.612	0.899	2.75	0.59	0.78	273.52	1.95		100	30	1.25	5.50	1.00	340.6	0.85	Infin.	0.467	Non-Liq.	0.00
33.96	374.35	9.69	2.59	131	1.617	0.898	2.60	0.59	0.78	274.50	1.93		100	25	1.22	5.55	1.00	335.4	0.84	Infin.	0.467	Non-Liq.	0.00
34.12	385.32	9.40	2.44	131	1.623	0.897	2.45	0.58	0.78	283.05	1.90		100	25	1.19	5.60	1.00	337.6	0.84	Infin.	0.467	Non-Liq.	0.00
34.28	380.60	9.55	2.51	131	1.629	0.896	2.52	0.58	0.78	278.50	1.92		100	25	1.21	5.65	1.00	336.0	0.84	Infin.	0.468	Non-Liq.	0.00
34.45	369.45	9.54	2.58	131	1.634	0.895	2.59	0.59	0.77	269.10	1.94		100	25	1.23	5.70	1.00	329.8	0.84	Infin.	0.468	Non-Liq.	0.00
34.61	365.07	9.18	2.51	131	1.640	0.894	2.53	0.59	0.77	265.59	1.93		100	25	1.22	5.75	1.00	323.7	0.84	Infin.	0.468	Non-Liq.	0.00
34.78	346.42	8.77	2.53	131	1.645	0.893	2.54	0.59	0.77	250.91	1.95		100	25	1.24	5.80	1.00	310.1	0.84	Infin.	0.468	Non-Liq.	0.00
34.94	338.49	7.32	2.16	131	1.651	0.892	2.17	0.58	0.77	246.35	1.89		100	25	1.18	5.85	1.00	291.5	0.84	Infin.	0.468	Non-Liq.	0.00
35.10	316.34	6.78	2.14	131	1.657	0.890	2.15	0.58	0.77	229.24	1.91		100	25	1.20	5.90	1.00	274.5	0.84	Infin.	0.468	Non-Liq.	0.00
35.27	260.95	5.93	2.27	131	1.662	0.889	2.29	0.60	0.76	186.64	1.98		100	30	1.28	5.95	1.00	238.6	0.83	Infin.	0.468	Non-Liq.	0.00
35.43	220.95	6.51	2.95	131	1.668	0.888	2.97	0.64	0.75	154.54	2.12		95	40	1.50	6.00	1.00	231.4	0.83	Infin.	0.468	Non-Liq.	0.00
35.60	233.23	6.89	2.95	131	1.674	0.887	2.98	0.64	0.75	163.13	2.11		97	35	1.47	6.05	1.00	240.1	0.83	Infin.	0.468	Non-Liq.	0.00
35.76	280.43	7.47	2.66	131	1.679	0.886	2.68	0.61	0.75	198.33	2.02		100	30	1.33	6.10	1.00	263.9	0.83	Infin.	0.468	Non-Liq.	0.00
35.93	283.79	7.36	2.59	131	1.685	0.885	2.61	0.61	0.75	200.65	2.01		100	30	1.31	6.15	1.00	263.6	0.83	Infin.	0.468	Non-Liq.	0.00
36.09	297.53	7.50	2.52	131	1.690	0.883	2.54	0.60	0.75	210.65	1.99		100	30	1.28	6.20	1.00	270.6	0.83	Infin.	0.468	Non-Liq.	0.00
36.25	318.86	7.84	2.46	131	1.696	0.882	2.47	0.60	0.75	226.24	1.96		100	30	1.25	6.25	1.00	283.3	0.83	Infin.	0.468	Non-Liq.	0.00
36.42	333.12	8.70	2.61	131	1.702	0.881	2.63	0.60	0.75	235.55	1.97		100	30	1.27	6.30	1.00	298.2	0.83	Infin.	0.468	Non-Liq.	0.00
36.58	362.35	9.68	2.67	131	1.707	0.880	2.68	0.60	0.75	256.25	1.96		100	30	1.25	6.35	1.00	320.8	0.83	Infin.	0.467	Non-Liq.	0.00
36.75	376.16	10.54	2.80	131	1.713	0.878	2.81	0.60	0.75	265.18	1.97		100	30	1.26	6.40	1.00	334.9	0.82	Infin.	0.467	Non-Liq.	0.00
36.91	371.25	10.66	2.87	131	1.719	0.877	2.88	0.60	0.75	260.69	1.98		100	30	1.28	6.45	1.00	333.4	0.82	Infin.	0.467	Non-Liq.	0.00

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA
Developed 2001 by Shelton L. Stringer, GE. Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-2 Plot: 2

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

	Magnitude:	7	7.5
	PGA, g:	0.70	0.59
	MSF:	1.19	130
	GWT, feet:	15.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara &Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.00
Avg SF of Liquefiable Layers: #DIV/0!

Total Liquefied Thickness (feet): 0.0
Total Induced Subsidence (inches): 0.1

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. σo (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Override	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	K_σ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	*Volumetric Strain (%)*
37.07	367.71	10.91	2.97	131	1.724	0.876	2.98	0.61	0.74	257.10	2.00		100	30	1.30	6.50	1.00	333.8	0.82	Infin.	0.467	Non-Liq.	0.00
37.24	368.92	11.28	3.06	131	1.730	0.875	3.07	0.61	0.74	257.02	2.01		100	30	1.31	6.55	1.00	337.4	0.82	Infin.	0.467	Non-Liq.	0.00
37.40	393.99	11.48	2.91	131	1.735	0.873	2.93	0.60	0.74	275.39	1.98		100	30	1.27	6.60	1.00	349.7	0.82	Infin.	0.467	Non-Liq.	0.00
37.57	400.46	12.00	3.00	131	1.741	0.872	3.01	0.60	0.74	279.07	1.98		100	30	1.28	6.65	1.00	356.9	0.82	Infin.	0.467	Non-Liq.	0.00
37.73	392.37	11.95	3.05	131	1.747	0.871	3.06	0.61	0.74	272.40	1.99		100	30	1.29	6.70	1.00	352.3	0.82	Infin.	0.467	Non-Liq.	0.00
37.89	380.64	10.63	2.79	131	1.752	0.869	2.81	0.60	0.74	264.72	1.97		100	30	1.26	6.75	1.00	334.1	0.82	Infin.	0.466	Non-Liq.	0.00
38.06	374.21	9.59	2.56	131	1.758	0.868	2.57	0.59	0.74	260.84	1.94		100	25	1.23	6.80	1.00	321.0	0.82	Infin.	0.466	Non-Liq.	0.00
38.22	381.92	9.78	2.56	131	1.764	0.867	2.57	0.59	0.74	265.93	1.94		100	25	1.23	6.85	1.00	325.9	0.82	Infin.	0.466	Non-Liq.	0.00
38.39	374.89	9.67	2.58	131	1.769	0.865	2.59	0.59	0.74	260.20	1.94		100	25	1.23	6.90	1.00	321.0	0.81	Infin.	0.466	Non-Liq.	0.00
38.55	372.32	9.76	2.62	131	1.775	0.864	2.63	0.59	0.74	257.59	1.95		100	30	1.24	6.95	1.00	320.2	0.81	Infin.	0.466	Non-Liq.	0.00
38.71	361.61	9.61	2.66	131	1.780	0.863	2.67	0.60	0.73	249.17	1.97		100	30	1.26	7.00	1.00	313.4	0.81	Infin.	0.465	Non-Liq.	0.00
38.88	357.36	9.32	2.61	131	1.786	0.861	2.62	0.60	0.73	245.90	1.96		100	30	1.25	7.05	1.00	308.2	0.81	Infin.	0.465	Non-Liq.	0.00
39.04	360.55	9.69	2.69	131	1.792	0.860	2.70	0.60	0.73	247.26	1.97		100	30	1.26	7.10	1.00	312.7	0.81	Infin.	0.465	Non-Liq.	0.00
39.21	370.98	10.01	2.70	131	1.797	0.859	2.71	0.60	0.73	254.18	1.97		100	30	1.26	7.15	1.00	319.9	0.81	Infin.	0.465	Non-Liq.	0.00
39.37	378.05	10.15	2.68	131	1.803	0.857	2.70	0.60	0.73	258.81	1.96		100	30	1.25	7.20	1.00	323.9	0.81	Infin.	0.464	Non-Liq.	0.00
39.53	384.53	10.39	2.70	131	1.809	0.856	2.71	0.60	0.73	262.83	1.96		100	30	1.25	7.25	1.00	328.6	0.81	Infin.	0.464	Non-Liq.	0.00
39.70	395.30	10.60	2.68	131	1.814	0.854	2.69	0.59	0.73	270.12	1.95		100	30	1.24	7.30	1.00	334.9	0.81	Infin.	0.464	Non-Liq.	0.00
39.86	409.60	10.81	2.64	131	1.820	0.853	2.65	0.59	0.73	280.07	1.94		100	25	1.22	7.35	1.00	342.9	0.80	Infin.	0.464	Non-Liq.	0.00
40.03	414.66	11.16	2.69	131	1.825	0.852	2.70	0.59	0.72	282.79	1.94		100	25	1.23	7.40	1.00	347.7	0.80	Infin.	0.463	Non-Liq.	0.00
40.19	402.74	11.12	2.76	131	1.831	0.850	2.77	0.60	0.72	273.35	1.96		100	30	1.25	7.45	1.00	341.3	0.80	Infin.	0.463	Non-Liq.	0.00
40.35	387.85	10.98	2.83	131	1.837	0.849	2.84	0.60	0.72	261.88	1.98		100	30	1.27	7.50	1.00	332.9	0.80	Infin.	0.463	Non-Liq.	0.00
40.52	380.92	10.91	2.86	131	1.842	0.847	2.88	0.60	0.72	256.31	1.99		100	30	1.28	7.55	1.00	328.7	0.80	Infin.	0.462	Non-Liq.	0.00
40.68	374.76	10.48	2.80	131	1.848	0.846	2.81	0.60	0.71	251.87	1.98		100	30	1.28	7.60	1.00	321.6	0.80	Infin.	0.462	Non-Liq.	0.00
40.85	371.08	10.13	2.73	131	1.854	0.844	2.74	0.60	0.71	249.19	1.98		100	30	1.27	7.65	1.00	316.3	0.80	Infin.	0.462	Non-Liq.	0.00
41.01	366.26	9.36	2.56	131	1.859	0.843	2.57	0.59	0.72	246.37	1.95		100	30	1.24	7.70	1.00	306.6	0.80	Infin.	0.461	Non-Liq.	0.00
41.17	364.48	8.75	2.40	131	1.865	0.841	2.41	0.59	0.72	245.63	1.93		100	25	1.22	7.75	1.00	299.9	0.80	Infin.	0.461	Non-Liq.	0.00
41.34	361.31	8.24	2.28	131	1.871	0.840	2.29	0.58	0.72	243.73	1.92		100	25	1.20	7.80	1.00	293.5	0.80	Infin.	0.461	Non-Liq.	0.00
41.50	358.80	8.57	2.39	131	1.876	0.838	2.40	0.59	0.71	240.79	1.94		100	25	1.22	7.85	1.00	294.8	0.80	Infin.	0.460	Non-Liq.	0.00
41.67	337.28	8.36	2.48	131	1.882	0.837	2.49	0.60	0.71	224.69	1.97		100	30	1.26	7.90	1.00	282.6	0.79	Infin.	0.460	Non-Liq.	0.00
41.83	334.90	8.53	2.55	131	1.887	0.835	2.56	0.60	0.71	222.21	1.98		100	30	1.27	7.95	1.00	282.8	0.79	Infin.	0.459	Non-Liq.	0.00
41.99	333.05	8.62	2.59	131	1.893	0.834	2.60	0.60	0.70	220.27	1.99		100	30	1.28	8.00	1.00	282.5	0.79	Infin.	0.459	Non-Liq.	0.00
42.16	341.74	8.63	2.53	131	1.899	0.832	2.54	0.60	0.70	226.26	1.97		100	30	1.26	8.05	1.00	285.9	0.79	Infin.	0.459	Non-Liq.	0.00
42.32	350.09	8.94	2.55	131	1.904	0.831	2.57	0.60	0.70	231.47	1.97		100	30	1.26	8.10	1.00	292.0	0.79	Infin.	0.458	Non-Liq.	0.00
42.49	363.71	9.11	2.50	131	1.910	0.829	2.52	0.59	0.70	240.80	1.95		100	30	1.24	8.15	1.00	299.2	0.79	Infin.	0.458	Non-Liq.	0.00
42.65	376.99	9.46	2.51	131	1.916	0.827	2.52	0.59	0.70	249.56	1.94		100	25	1.23	8.20	1.00	307.9	0.79	Infin.	0.457	Non-Liq.	0.00
42.81	372.12	9.68	2.60	131	1.921	0.826	2.61	0.60	0.70	245.12	1.96		100	30	1.25	8.25	1.00	307.2	0.79	Infin.	0.457	Non-Liq.	0.00
42.98	374.72	9.57	2.55	131	1.927	0.824	2.57	0.59	0.70	246.78	1.95		100	30	1.24	8.30	1.00	307.0	0.79	Infin.	0.456	Non-Liq.	0.00
43.14	375.71	9.39	2.50	131	1.932	0.823	2.51	0.59	0.70	247.38	1.95		100	25	1.23	8.35	1.00	305.4	0.79	Infin.	0.456	Non-Liq.	0.00
43.31	365.79	9.13	2.50	131	1.938	0.821	2.51	0.59	0.70	240.10	1.95		100	30	1.24	8.40	1.00	298.2	0.78	Infin.	0.456	Non-Liq.	0.00
43.47	353.96	8.85	2.50	131	1.944	0.820	2.51	0.60	0.70	231.48	1.96		100	30	1.25	8.45	1.00	290.0	0.78	Infin.	0.455	Non-Liq.	0.00
43.64	343.40	8.84	2.57	131	1.949	0.818	2.59	0.60	0.69	223.36	1.98		100	30	1.28	8.50	1.00	285.0	0.78	Infin.	0.455	Non-Liq.	0.00
43.80	349.97	8.68	2.48	131	1.955	0.816	2.49	0.60	0.69	228.03	1.96		100	30	1.25	8.55	1.00	285.9	0.78	Infin.	0.454	Non-Liq.	0.00
43.96	360.99	8.77	2.43	131	1.961	0.815	2.44	0.59	0.69	235.51	1.95		100	25	1.24	8.60	1.00	291.2	0.78	Infin.	0.454	Non-Liq.	0.00
44.13	367.49	8.76	2.38	131	1.966	0.813	2.40	0.59	0.69	239.87	1.94		100	25	1.22	8.65	1.00	293.7	0.78	Infin.	0.453	Non-Liq.	0.00
44.29	356.70	9.05	2.54	131	1.972	0.811	2.55	0.60	0.69	231.03	1.97		100	30	1.26	8.70	1.00	291.0	0.78	Infin.	0.453	Non-Liq.	0.00
44.46	340.64	9.04	2.65	131	1.977	0.810	2.67	0.61	0.68	218.98	2.00		100	30	1.30	8.75	1.00	283.7	0.78	Infin.	0.452	Non-Liq.	0.00
44.62	344.53	9.11	2.64	131	1.983	0.808	2.66	0.61	0.68	221.27	1.99		100	30	1.29	8.80	1.00	285.6	0.78	Infin.	0.452	Non-Liq.	0.00
44.78	343.63	9.04	2.63	131	1.989	0.807	2.65	0.61	0.68	220.34	1.99		100	30	1.29	8.85	1.00	284.2	0.78	Infin.	0.451	Non-Liq.	0.00
44.95	333.08	8.88	2.67	131	1.994	0.805	2.68	0.61	0.68	212.62	2.01		100	30	1.31	8.90	1.00	278.0	0.78	Infin.	0.451	Non-Liq.	0.00
45.11	322.79	8.64	2.68	131	2.000	0.803	2.69	0.61	0.68	205.25	2.02		100	30	1.32	8.95	1.00	271.2	0.78	Infin.	0.450	Non-Liq.	0.00
45.28	319.63	9.21	2.89	131	2.006	0.802	2.91	0.62	0.67	200.97	2.05		100	35	1.37	9.00	1.00	275.1	0.77	Infin.	0.449	Non-Liq.	0.00
45.44	322.16	9.90	3.07	131	2.011	0.800	3.09	0.63	0.67	202.05	2.07		100	35	1.40	9.05	1.00	283.2	0.77	Infin.	0.449	Non-Liq.	0.00
45.60	326.53	9.88	3.03	131	2.017	0.798	3.04	0.63	0.67	204.80	2.06		100	35	1.39	9.10	1.00	284.1	0.77	Infin.	0.448	Non-Liq.	0.00
45.77	322.69	9.57	2.97	131	2.022	0.797	2.98	0.62	0.67	202.18	2.06		100	35	1.38	9.15	1.00	279.2	0.77	Infin.	0.448	Non-Liq.	0.00
45.93	312.57	8.41	2.69	131	2.028	0.795	2.71	0.62	0.67	196.50	2.03		100	30	1.34	9.20	1.00	263.2	0.77	Infin.	0.447	Non-Liq.	0.00
46.10	307.14	7.89	2.57	131	2.034	0.793	2.59	0.61	0.67	193.19	2.02		100	30	1.32	9.25	1.00	255.5	0.77	Infin.	0.447	Non-Liq.	0.00
46.26	304.25	8.06	2.65	131	2.039	0.792	2.67	0.62	0.67	190.49	2.03		100	30	1.34	9.30	1.00	255.8	0.77	Infin.	0.446	Non-Liq.	0.00
46.42	307.18	7.72	2.51	131	2.045	0.790	2.53	0.61	0.67	192.83	2.01		100	30	1.31	9.35	1.00	253.1	0.77	Infin.	0.446	Non-Liq.	0.00
46.59	314.91	8.75	2.78	131	2.051	0.788	2.80	0.62	0.66	196.16	2.04		100	35	1.36	9.40	1.00	266.1	0.77	Infin.	0.445	Non-Liq.	0.00
46.75	310.47	9.54	3.07	131	2.056	0.787	3.09	0.63	0.66	191.44	2.08		100	35	1.42	9.45	1.00	272.6	0.77	Infin.	0.444	Non-Liq.	0.00
46.92	312.02	8.99	2.88	131	2.062	0.785	2.90	0.63	0.66	193.03	2.06		100	35	1.38	9.45	1.00	266.9	0.77	Infin.	0.444	Non-Liq.	0.00
47.08	311.90	9.31	2.98	131	2.067	0.783	3.00	0.63	0.66	192.09	2.07		100	35	1.41	9.45	1.00	269.9	0.76	Infin.	0.443	Non-Liq.	0.00
47.24	319.56	9.37	2.93	131	2.073	0.782	2.95	0.63	0.66	197.00	2.06		100	35	1.38	9.45	1.00	272.8	0.76	Infin.	0.443	Non-Liq.	0.00
47.41	319.97	9.23	2.88	131	2.079	0.780	2.90	0.62	0.66	197.16	2.05		100	35	1.38	9.45	1.00	271.1	0.76	Infin.	0.442	Non-Liq.	0.00
47.57	314.10	9.30	2.96	131	2.084	0.778	2.98	0.63	0.65	192.59	2.07		100	35	1.40	9.45	1.00	269.5	0.76	Infin.	0.441	Non-Liq.	0.00
47.74	310.41	9.12	2.94	131	2.090	0.777	2.96	0.63	0.65	189.96	2.07		100	35	1.40	9.45	1.00	266.0	0.76	Infin.	0.441	Non-Liq.	0.00
47.90	308.37	8.76	2.84	131	2.096	0.775	2.86	0.63	0.65	188.78	2.06		100	35	1.38	9.45	1.00	261.2	0.76	Infin.	0.440	Non-Liq.	0.00
48.06	308.18	8.52	2.76	131	2.101	0.773	2.78	0.62	0.65	188.72	2.05		100	35	1.37	9.45	1.00	258.4	0.76	Infin.	0.439	Non-Liq.	0.00
48.23	303.72	7.67	2.53	131	2.107	0.772	2.54	0.61	0.66	186.77	2.02		100	30	1.33	9.45	1.00	247.7	0.76	Infin.	0.439	Non-Liq.	0.00
48.39	311.64	8.26	2.65	131	2.112	0.770	2.67	0.62	0.65	190.91	2.03		100	30	1.34	9.45	1.00	256.3	0.76	Infin.	0.438	Non-Liq.	0.00
48.56	314.06	8.96	2.85	131	2.118	0.768	2.87	0.63	0.65	191.06	2.06		100	35	1.38	9.45	1.00	263.9	0.76	Infin.	0.438	Non-Liq.	0.00
48.72	319.88	9.21	2.88	131	2.124	0.767	2.90	0.62	0.65	194.34	2.06		100	35	1.38	9.45	1.00	268.1	0.76	Infin.	0.437	Non-Liq.	0.00
48.88	322.90	9.40	2.91	131	2.129	0.765	2.93	0.63	0.65	195.77	2.06		100	35	1.38	9.45	1.00	270.8	0.76	Infin.	0.436	Non-Liq.	0.00
49.05	325.83	9.46	2.90	131	2.135	0.763	2.92	0.62	0.65	197.36	2.05		100	35	1.38	9.45	1.00	272.0	0.76	Infin.	0.436	Non-Liq.	0.00
49.21	332.35	9.18	2.76	131	2.141	0.762	2.78	0.62	0.65	202.00	2.03		100	30	1.34	9.45	1.00	271.3	0.75	Infin.	0.435	Non-Liq.	0.00

CPT-LIQUEFY.XLS - A SPREADSHEET FOR EMPIRICAL ESTIMATION OF LIQUEFACTION POTENTIAL USING CPT DATA

Developed 2001 by Shelton L. Stringer, GE, Earth Systems Southwest

Project: Santa Barbara Zoo
Job No: VT-22503-01
Date: 7/11/01
Sounding: CPT-2 Plot: 2

Methods: Liquefaction Analysis using 1996 & 1998 NCEER workshop methods (Youd & Idriss)
Post-liquefaction Settlement Analysis from Tokimatsu & Seed (1987)
Dry Sand Settlement by Pradel, ASCE Journal of G&GE, Vol 124, No. 4

Induced CSR (M=7.5): = 0.65*PGA*(po/p'o)*rd/MSF
Clean Sand Qc1n = C_Q*K_C*K_H*Qc

EARTHQUAKE INFORMATION:

Magnitude:	7	7.5
PGA, g:	0.70	0.59
MSF:	1.19	130
GWT, feet:	15.0	

Unit Weight of unsaturated soils: 128 pcf
Unit Weight of saturated soils: 131 pcf
Limiting Ic for liquefiable soils: 2.60

Use Tokimatsu & Seed (0) or Ishihara & Yoshmine (1): 0
Required SF: 1.25
Min SF of Liquefiable Layers: 0.00
Avg SF of Liquefiable Layers: #DIV/0!

Total Liquefied Thickness (feet) 0.0

Total Induced Subsidence (inches) 0.1

Layer Depth (feet)	Tip Qc (tsf)	Friction Fs (tsf)	Friction Ratio %	Total Unit Wt. (pcf)	Eff.Stress at Midpt. p'o (tsf)	rd	F	n	C_Q	Corrected Qc1n	Ic	Overide	Rel. Dens. Dr (%)	Est. Fines (%)	K_C	H (m)	K_H	Clean Sand Qc1n	K_σ	$CRR_{7.5}$	Induced M=7.5 CSR	Liquefac. Safety Factor	*Volumetric Strain (%)*
49.38	335.20	9.52	2.84	131	2.146	0.760	2.86	0.62	0.64	203.04	2.04		100	35	1.36	9.45	1.00	275.2	0.75	Infin.	0.434	Non-Liq.	0.00
49.54	352.39	9.41	2.67	131	2.152	0.758	2.69	0.61	0.65	214.81	2.00		100	30	1.30	9.45	1.00	280.3	0.75	Infin.	0.434	Non-Liq.	0.00
49.70	357.19	9.42	2.64	131	2.157	0.757	2.65	0.61	0.65	217.77	2.00		100	30	1.29	9.45	1.00	281.9	0.75	Infin.	0.433	Non-Liq.	0.00
49.87	361.74	8.83	2.44	131	2.163	0.755	2.46	0.60	0.65	221.73	1.96		100	30	1.26	9.45	1.00	278.4	0.75	Infin.	0.432	Non-Liq.	0.00
50.03	0.00	0.00	#DIV/0!	131	3.259																		