APPENDIX B1
GDC LABORATORY TESTING

APPENDIX B1
LABORATORY TESTING

B1.1 General

The laboratory testing program performed for this investigation by GDC included determination of Moisture Content, Dry Unit Weight, Atterberg Limits, Consolidation, Pocket Penetrometer, Laboratory Vane Shear, Direct Shear, Expansion Index, Corrosivity, Compaction, and Grain Size/Percent Passing No. 200 Sieve. Descriptions of these tests are given below.

B1.2 Moisture Content and Dry Unit Weight

The natural moisture content and dry unit weight of California ring samples were determined in general accordance with ASTM D 2216 and ASTM D2937. Results of these tests are presented on the boring logs in Appendix A1.

B1.3 Atterberg Limits

Soil plasticity was evaluated by measuring the Atterberg limits. This test includes Liquid Limit (LL) and Plastic Limit (PL) tests to determine the Plasticity Index (PI) in accordance with ASTM D4318. Results of these tests are illustrated in the plasticity charts shown in Figures B1-1a to B1-1p and are presented on the boring logs in Appendix A1.

B1.4 Grain Size Distribution and Percent Passing No. 200 Sieve:

Representative samples were dried, weighed, soaked in water until individual soil particles were separated, and then washed on the No. 200 sieve. The percentage of fines (soil passing No. 200 sieve) was determined for selected samples in accordance with ASTM D 1140. For selected samples the washed fraction retained on the No. 200 sieve was then screened on a No. 4 sieve, and the fraction retained on No. 4 was weighed to determine the percentage of gravel. For selected samples, the washed material retained on No. 200 sieve was shaken through a standard stack of sieves in accordance with ASTM D 422 to determine the grain size distribution. The results of grain size distribution tests are plotted in Figures B1-4a through B1-4b of this appendix. The relative proportion (or percentage) by dry weight of fines (passing No. 200 sieve) are listed on the boring records in Appendix A1.

B1.5 Consolidation

The consolidation characteristics of the foundation soils were determined by performing one-dimensional consolidation in general accordance with ASTM D2435, using a floating ring consolidometer and dead weight system. Results of these tests are presented in Figures B1-2a to B1-2t.

B1.6 Direct Shear Test

To determine the shear strength parameters of the on-site soils, direct shear tests were performed on selected undisturbed drive samples in accordance with ASTM D 3080. After the initial weight and volume measurements were made, the sample was placed in a calibrated shear machine and a selected normal load was applied. The samples were submerged, allowed to consolidate, and then were sheared to failure. Shear stress and sample deformation were monitored throughout the test. The process was repeated under two additional normal loads. The test results are graphically presented in Figures B1-3a and B1-3t.

B1.7 Pocket Penetrometer

Undrained shear strengths (S_u) of cohesive samples were measured using a pocket penetrometer. The measured S_u values (in ksf) are presented in the boring logs of Appendix A1.

B.7 Miniature Vane Shear

Shear strength of selected cohesive samples was estimated in the laboratory in general accordance with ASTM D 4648 using a Geonor™ Inspection Vane Tester H-60 Miniature Vane Shear device with a 16 x 32 mm vane having an area ratio of 14%, respectively. The test consists of inserting the miniature shear vane into the soil sample, rotating the vane at a constant rate until the cylindrical surface surrounding the vane fails in shear, measuring the maximum torque exerted on the vane during testing, and calculating the unit shearing resistance on the cylindrical surface. Undrained shear strengths measured in the test are presented in the boring logs of Appendix A1.

B1.8 Soil Expansion Index

A silty sand sample of near surface soil in boring B-RW049 was collected from the site and tested to determine the expansion index. Testing was performed according to ASTM D4829. The results of these tests are presented in Table B1-1.

B1.9 Soil Corrosivity

Corrosivity testing included performing soil pH and resistivity (Caltrans Test Method 643), water-soluble chlorides (ASTM D512), and water soluble sulfates (ASTM D516). The test results are summarized in Table B1-2.

B1.10 Compaction

Compaction testing was performed on 10 representative bulk sample of the fill soils encountered in Area A. Testing was performed according to ASTM D1557-91. The results of the compaction test is summarized in Table B1-3.

B1.12 List Tables and Figures

The following table and figures are attached and complete this appendix:

Table B1-1	Soil Expansion
Table B1-2	Soil Corrosivity
Table B1-3	Compaction
Figures B1-1a to B1-1p	Atterberg Limits Plots
Figures B1-2a to B1-2t	Consolidation Plots
Figures B1-3a to B1-3t	Direct Shear Plots
Figures B1-4a to B1-4b	Sieve Analysis Plots

Table B1-1. Soil Expansion

Boring	Sample Depth, feet	Expansion Index
B-RW049	0 to 1	0 (very low)

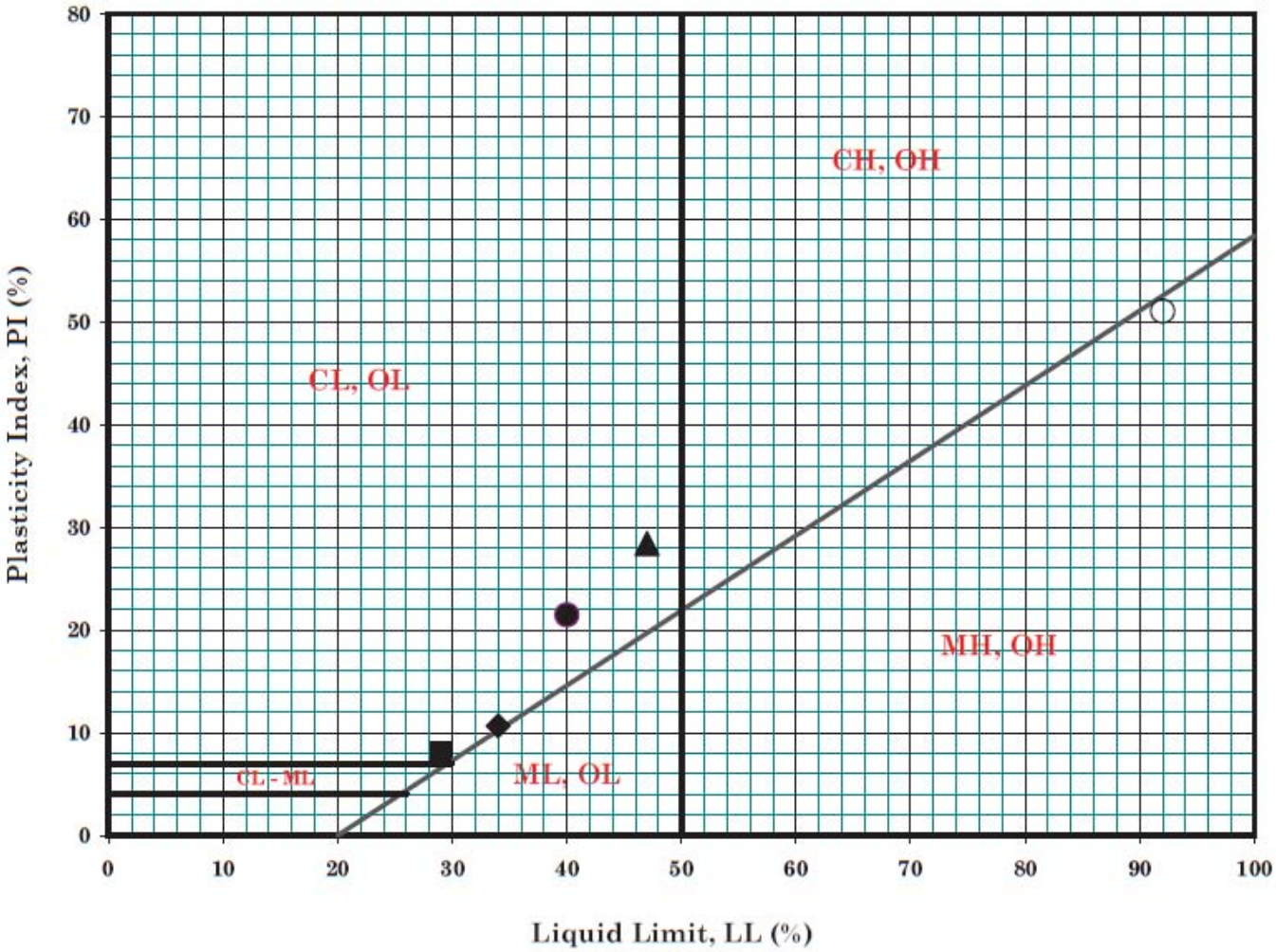
Table B1-2. Soil Corrosivity

Boring	Sample Depth, feet	pH	Chlorides ppm	Sulfates (% by weight)	Minimum Resistivity ohm-cm
B-RW049	0 to 1	7.61	55	0.04	1441

Table B1-3. Compaction

Boring	Sample Depth, feet	Maximum Dry Density, (pcf)	Optimum Moisture Content, (%)
A-HSA016	0-1	107.5	15
A-HSA016	8	121	12.5
A-HSA016	17	116	13
A-HSA017	0-1	105	15.5
A-HSA017	6.5	119.5	13
A-HSA017	15	119	13
A-HSA018	0-1	110	15
A-HSA018	18	116	15
A-HSA066	0-1	112.5	15
A-HSA067	0-1	109.5	16.5

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	A-RW003	SH5B	20.0	21.5	6.1	6.6		40	19	21	Dark Greenish Gray Silty Clay (CL)
▲	A-RW003	S8	35.0	36.5	10.7	11.1		47	19	28	Very Dark Greenish Gray Silty Clay (CL)
◆	A-RW003	R13A	55.0	56.5	16.8	17.2		34	23	11	Very Dark Greenish Gray Silty Clay (CL)
■	A-RW003	R15	65.0	66.5	19.8	20.3		29	21	8	Very Dark Greenish Gray Silty Clay (CL)
○	A-RW005	S6	30.0	31.5	9.2	9.6		92	41	51	Dark Olive Brown Clay or Silt w/ Shells and Organic Matters (OH)
△											
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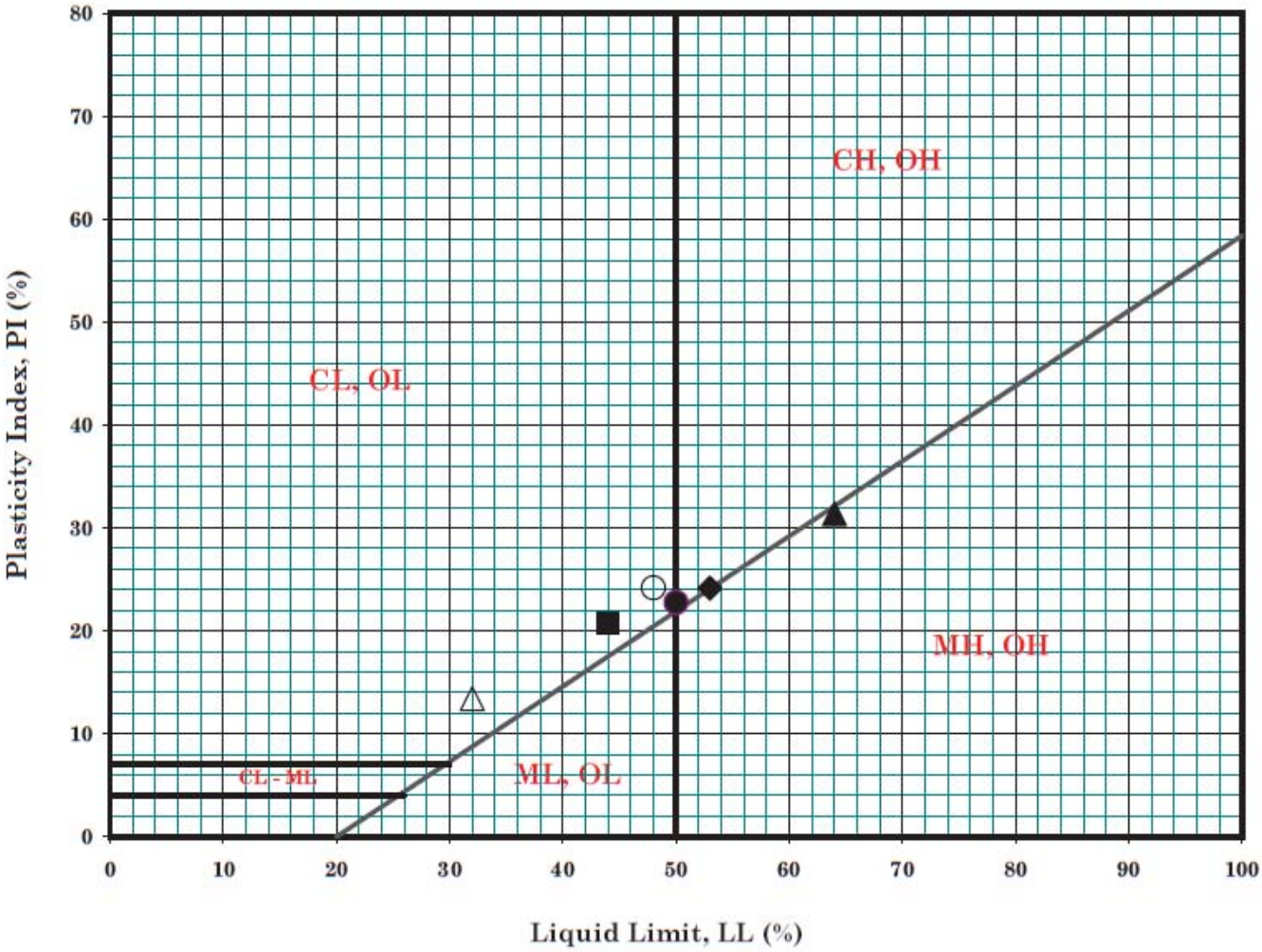
ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1a

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	A-RW006	S5	20.0	21.5	6.1	6.6		50	27	23	Dark Grayish Brown Silty Clay (CL)
▲	A-RW006	SH8B	35.0	36.5	10.7	11.1		64	33	31	Dark Olive Gray Clayey Silt (MH)
◆	A-RW006	S9	40.0	41.5	12.2	12.7		53	29	24	Dark Olive Gray Clay / Silt with Shells (CH)
■	A-RW006	S11	50.0	51.5	15.3	15.7		44	23	21	Very Dark Greenish Gray Silty Clay (CL)
○	A-RW006	S13	60.0	61.5	18.3	18.8		48	24	24	Very Dark Greenish Gray Silty Clay (CL)
△	A-RW006	S15	70.0	71.5	21.4	21.8		32	19	13	Very Dark Greenish Gray Sandy Silty Clay (CL)
◇											
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ATTERBERG LIMITS
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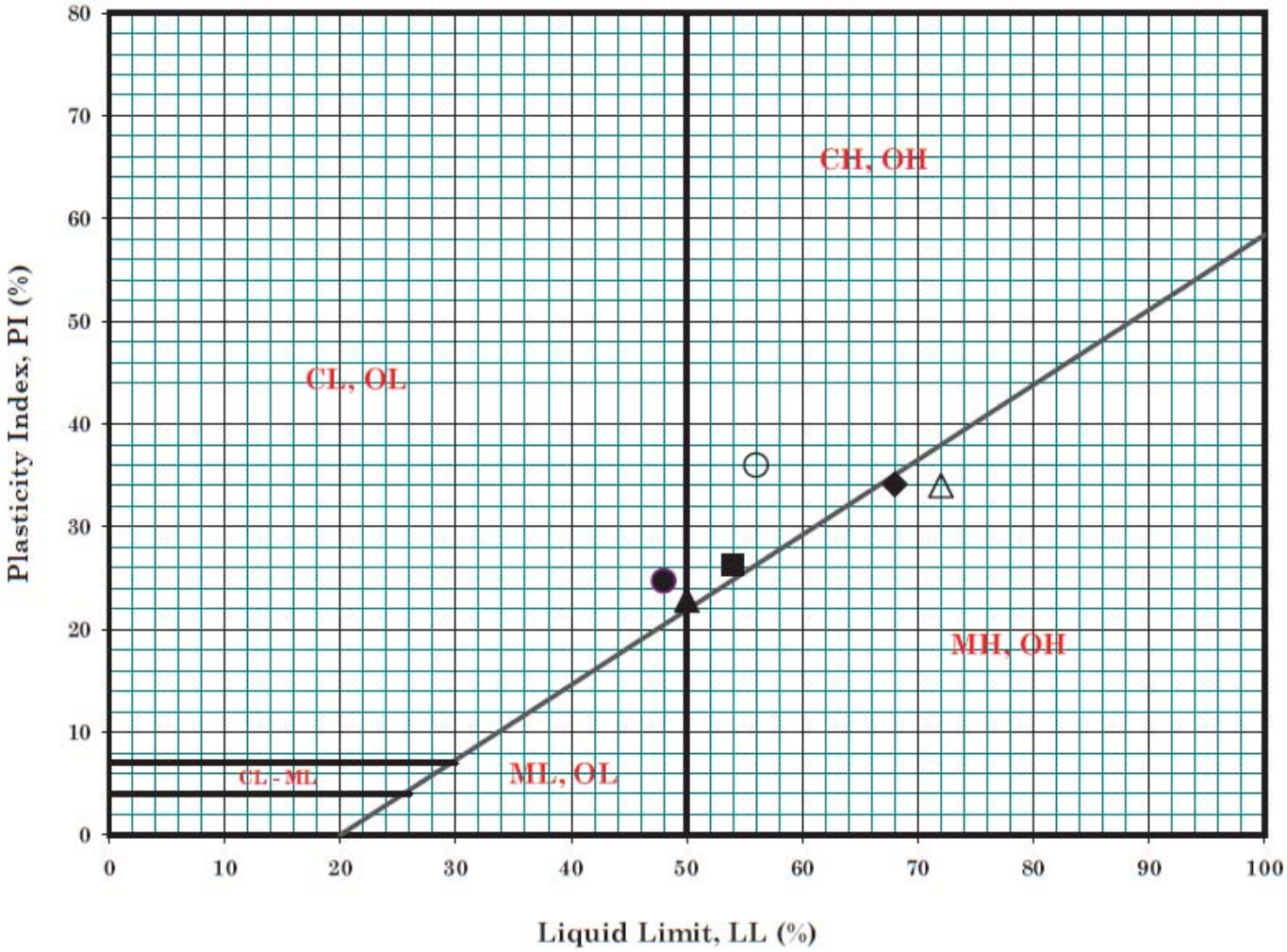
Figure No. : B1-1b

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	A-RW008	R2	10.0	11.5	3.1	3.5		48	23	25	Dark Greenish Gray Silty Clay with Sand (CL)
▲	A-RW008	R5	25.0	26.5	7.6	8.1		50	27	23	Dark Greenish Gray Lean / Fat Clay with Traces of Shells (CL / CH)
◆	A-RW008	R6A	30.0	31.5	9.2	9.6		68	34	34	Dark Greenish Gray Clayey Silt with Traces of Shells (MH)
■	A-RW008	R10	45.0	46.5	13.7	14.2		54	28	26	Very Dark Greenish Gray Fat Clay (CH)
○	A-RW009	S6	25.0	26.5	7.6	8.1		56	20	36	Dark Greenish Gray Fat Clay (CH)
△	A-RW009	R11A	50.0	51.5	15.3	15.7		72	38	34	Very Dark Greenish Gray to Black Clay w/ Organic Matter (OH)
◇											
□											

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ATTERBERG LIMITS
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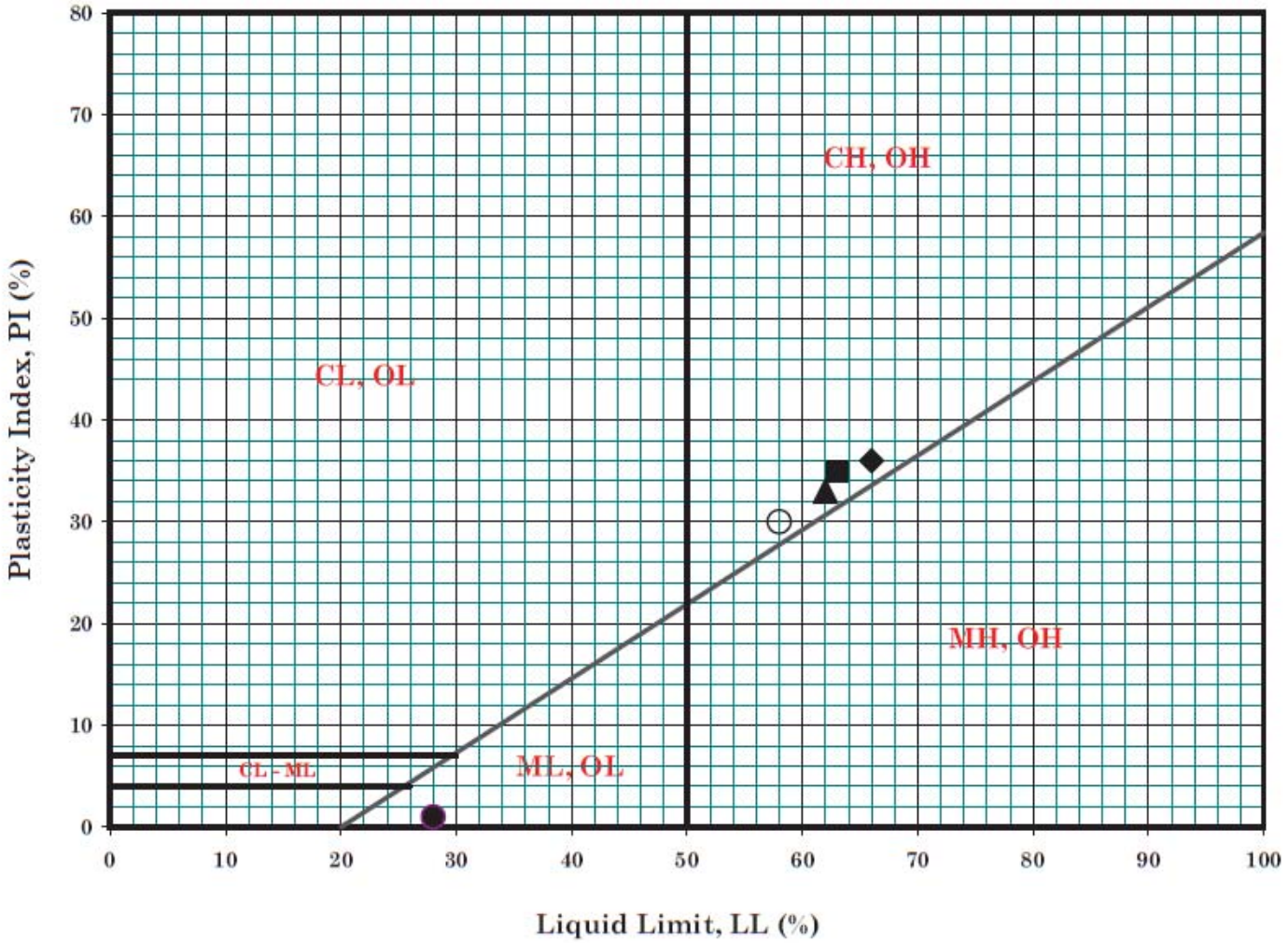
Figure No. : B1-1c

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	A-RW011	R2	5.0	6.5	1.5	2.0		28	27	1	Dark Greenish Gray Sandy Silt (ML)
▲	A-RW011	R4	15.0	16.5	4.6	5.0		62	29	33	Light Olive Brown Fat Clay (CH)
◆	A-RW011	S5	20.0	21.5	6.1	6.6		66	30	36	Dark Greenish Gray Fat Clay (CH)
■	A-RW011	R6A	25.0	26.5	7.6	8.1		63	28	35	Dark Greenish Gray Fat Clay with Traces of Shells (CH)
○	A-RW011	S10	45.0	46.5	13.7	14.2		58	28	30	Very Dark Gray Fat Clay (CH)
△											
◇											
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ATTERBERG LIMITS
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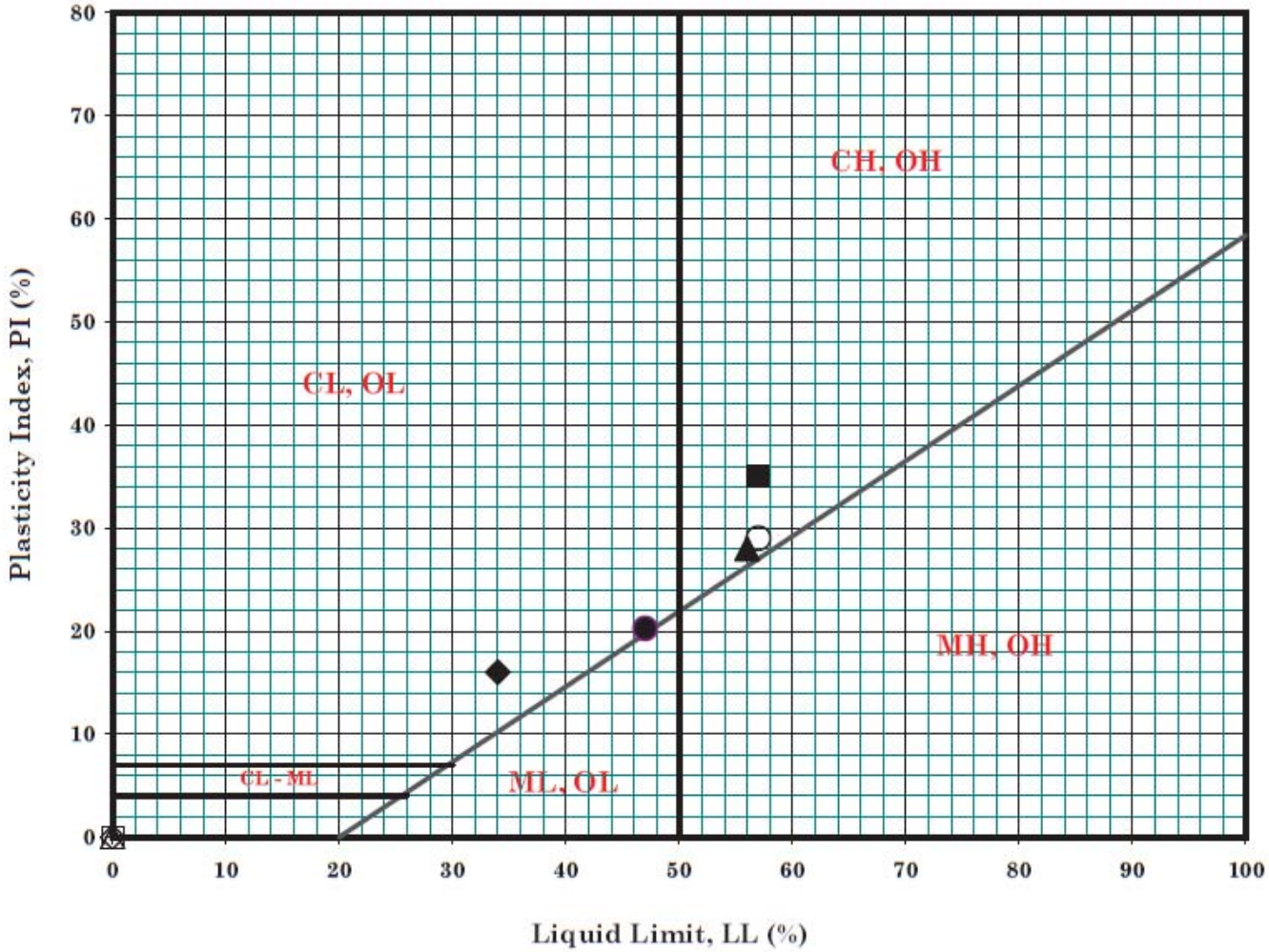
Figure No. : B1-1d

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	A-RW013	R4	15.0	16.5	4.6	5.0		47	27	20	Olive Brown Silty Clay (CL)
▲	A-RW013	S5	20.0	21.5	6.1	6.6		56	28	28	Dark Greenish Gray Fat Clay (CH)
◆	A-RW013	R7	30.0	31.5	9.2	9.6		34	18	16	Very Dark Greenish Gray Sandy Clay w/ Traces of Gravel (CL)
■	A-RW015	R3	10.0	11.5	3.1	3.5		57	22	35	Very Dark Greenish Gray Fat Clay (CH)
○	A-RW015	S11	45.0	46.5	13.7	14.2		57	28	29	Dark Greenish Gray Fat Clay (CH)
△											
◇											
□											

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ATTERBERG LIMITS
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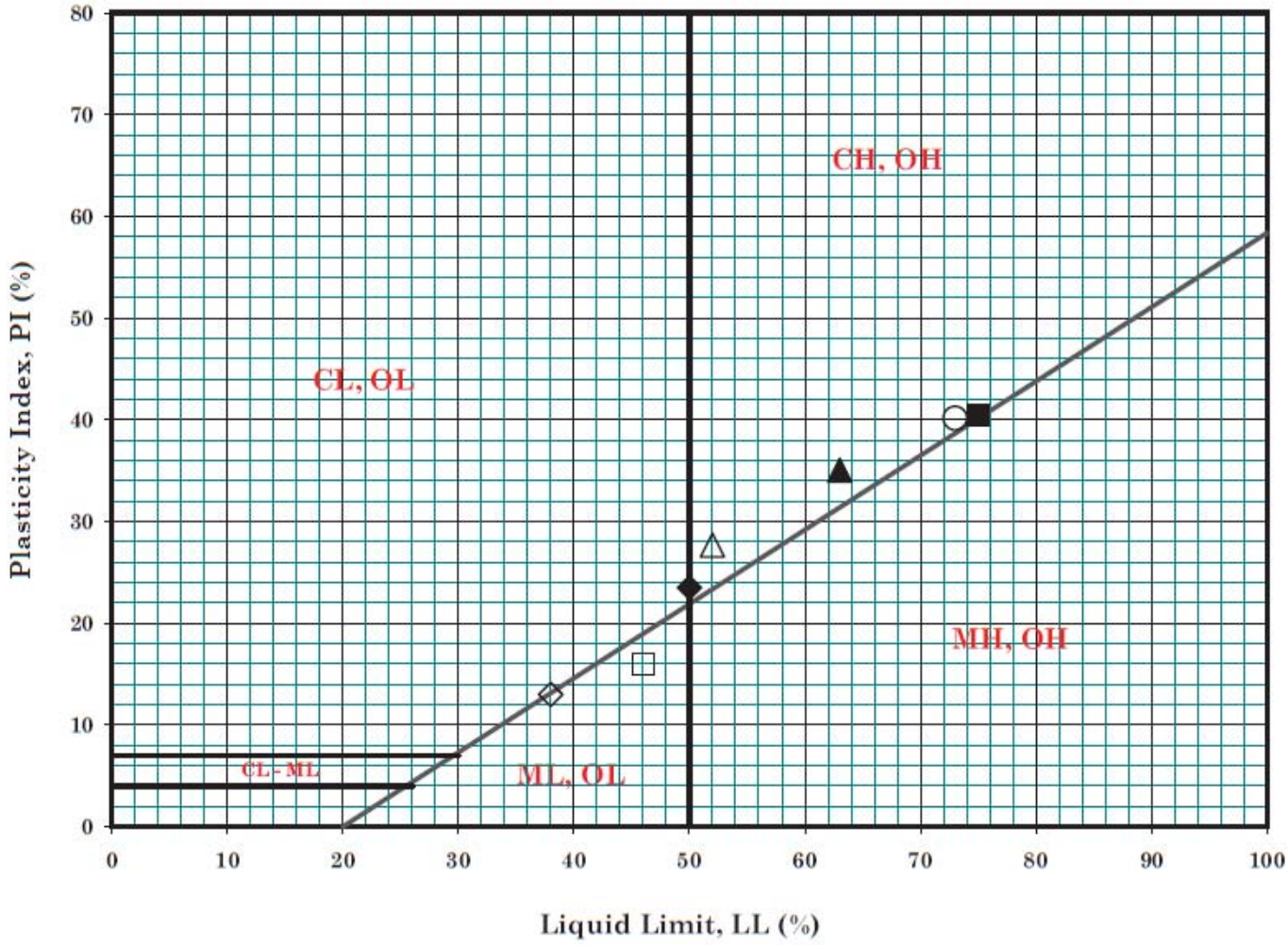
Figure No. : B1-1e

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●											
▲	A-RW020	R4A	15.0	16.5	4.6	5.0		63	28	35	Olive Brown Fat Clay (CH)
◆	A-RW020	S5	20.0	21.5	6.1	6.6		50	26	24	Dark Greenish Gray Silty Clay / Clayey Silt w/ Shells (CL/CH)
■	A-RW020	R6	25.0	26.5	7.6	8.1		75	35	40	Dark Greenish Gray Clay / Silt (CH / MH)
○	A-RW020	R8A	35.0	36.5	10.7	11.1		73	33	40	Dark Greenish Gray Silty Clay to Fat Clay (CH)
△	A-RW020	R11	50.0	51.5	15.3	15.7		52	24	28	Very Dark Greenish Gray Clay with Organic Matter (CH / OH)
◇	A-RW023	S3	10.0	11.5	3.1	3.5		38	25	13	Very Dark Greenish Gray Sandy Silty Clay/Sandy Clayey Silt (CL/ML)
□	A-RW023	S5	20.0	21.5	6.1	6.6		46	30	16	Dark Greenish Gray Sandy Clayey Silt (ML)

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ATTERBERG LIMITS
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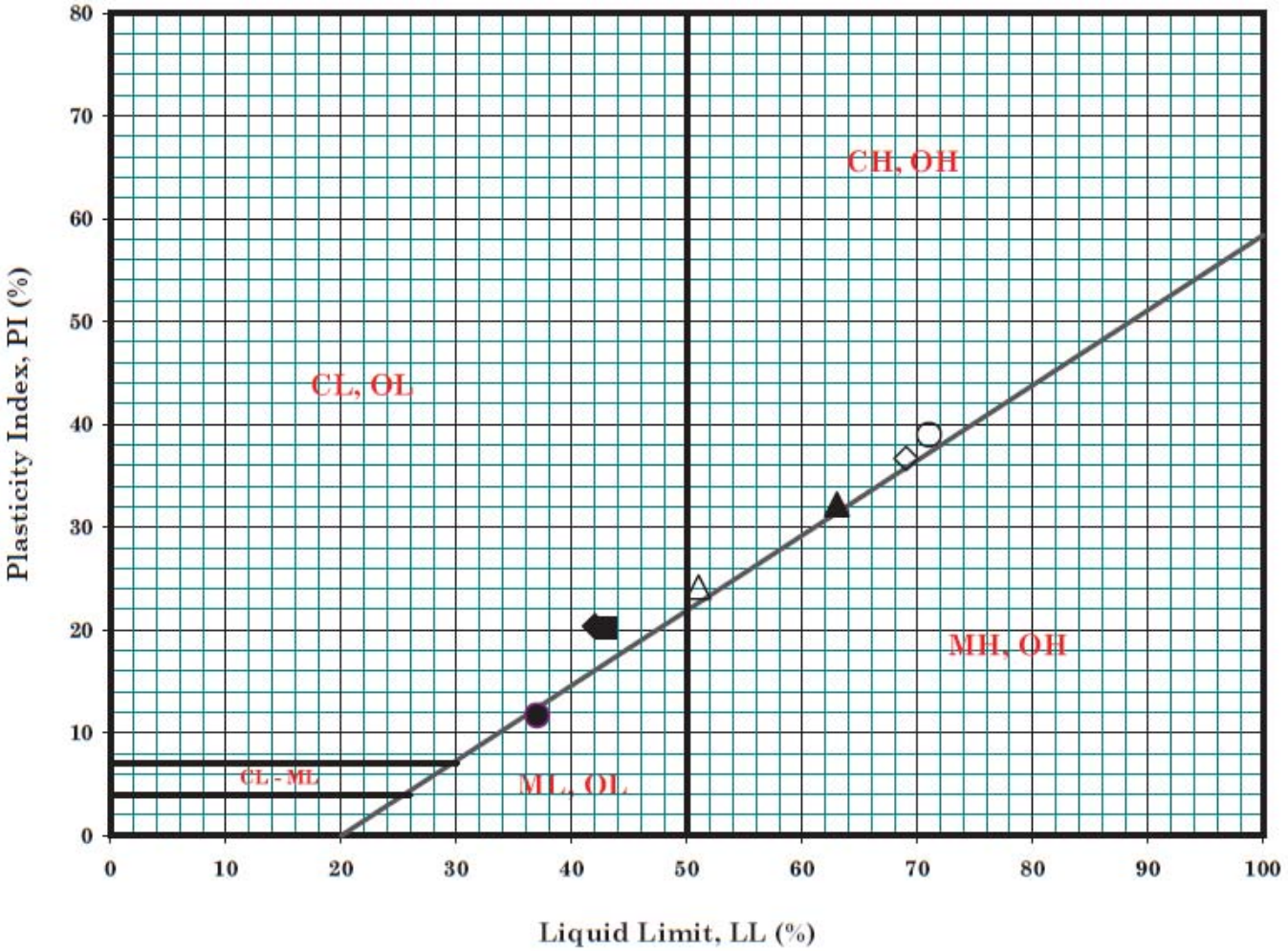
Figure No. : B1-1f

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	A-HSA016	B9	17.0	18.5	5.2	5.6		37	25	12	Dark Olive Gray Sandy Silt / Sandy Clay (CL-ML)
▲	A-HSA018	S6	12.5	14.0	3.8	4.3		63	31	32	Light Greenish Gray Clayey Silt / Clay (MH-CH)
◆	A-HSA064	S5	12.5	14.0	3.8	4.3		42	22	20	Olive Gray Sandy Clay with Shells (CL)
■	A-HSA064	S7	17.5	19.0	5.3	5.8		43	23	20	Dark Grayish Brown Silty Clay with Shells (CL)
○	A-HSA066	R8	17.5	19.0	5.3	5.8		71	32	39	Olive Brown Fat Clay (CH)
△	A-HSA066	S9	20.0	21.5	6.1	6.6		51	27	24	Dark Greenish Gray Fat Clay w/ Traces of Shells (CH)
◇	A-HSA067	R5	12.5	14.0	3.8	4.3		69	32	37	Olive Brown Fat Clay (CH)
□											

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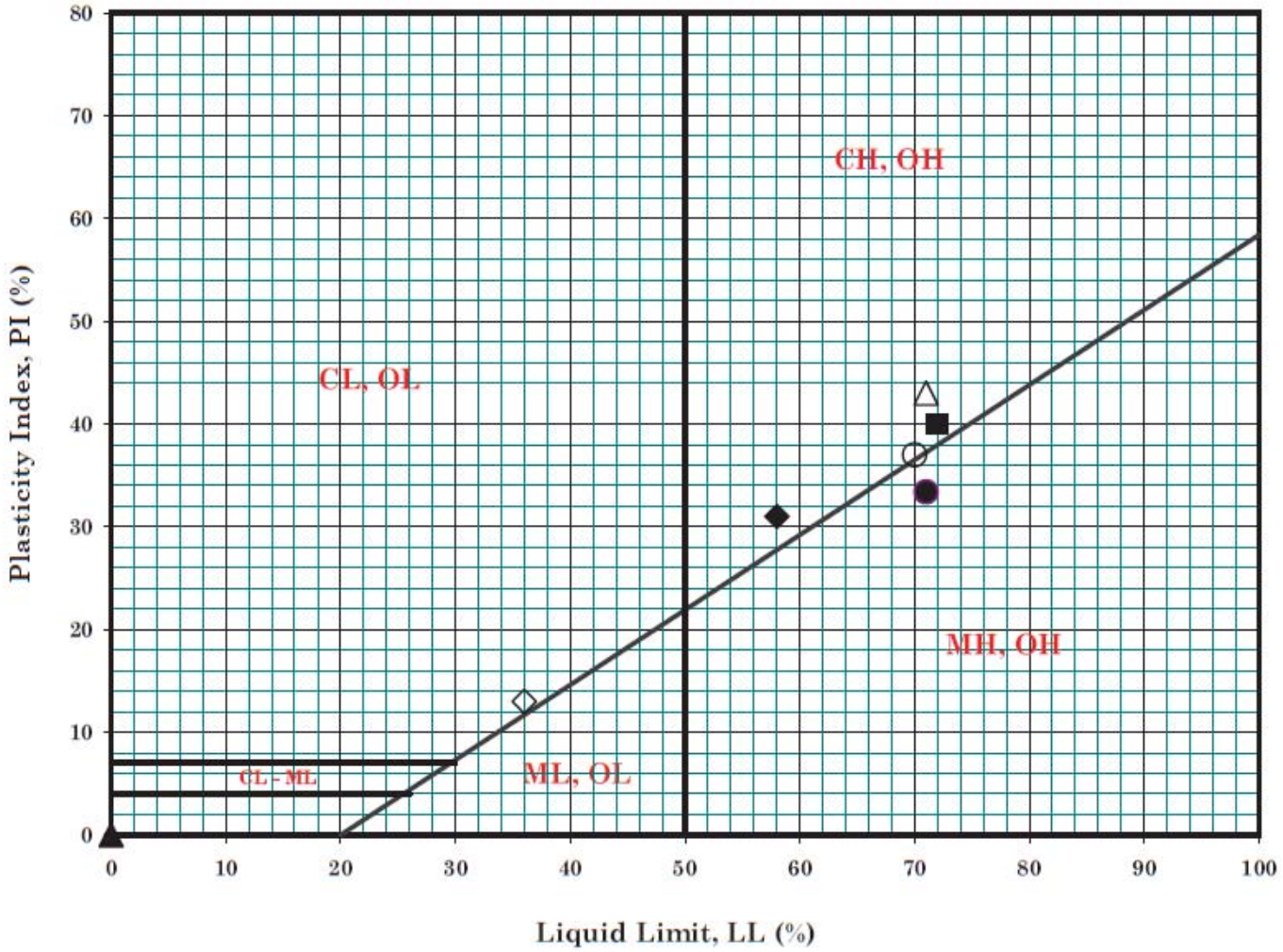
Date : 11/19/12

ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1g

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	B-RW027	S3	15.0	16.5	4.6	5.0		71	38	33	Very Dark Greenish Gray Clayey Silt with Traces of Shells (MH)
▲	B-RW027	R4A	20.0	21.5	6.1	6.6		0	0	0	Dark Geenish Gray Silty Fine Sand with traces of Shells (NP)
◆	B-RW027	S6	25.0	26.5	7.6	8.1		58	27	31	Dark Greenish Gray Fat Clay (CH)
■	B-RW030	S2	5.0	6.5	1.5	2.0		72	32	40	Olive Brown Fat Clay (CH)
○	B-RW030	R3	10.0	11.5	3.1	3.5		70	33	37	Olive Brown Fat Clay with Shells (CH)
△	B-RW032	R3A	10.0	11.5	3.1	3.5		71	28	43	Light Olive Brown Fat Clay (CH)
◇	B-RW032	S10	45.0	46.5	13.7	14.2		36	23	13	Very Dark Greenish Gray Sandy Silty Clay (CL)
□											

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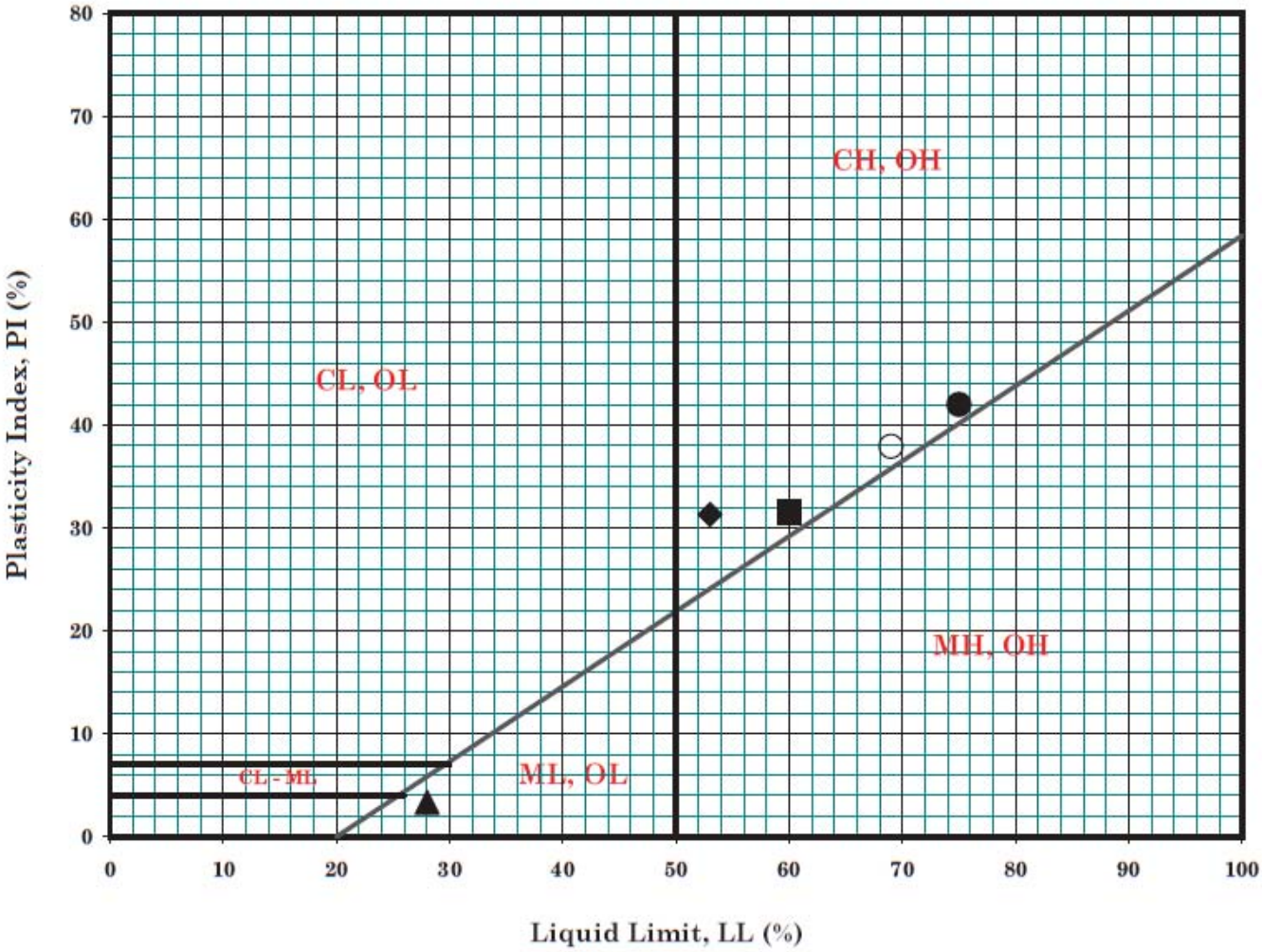
Project No. : LA962A

Date : 11/02/12

ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1h

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	B-RW033	R3A	15.0	16.5	4.6	5.0		75	33	42	Dark Greenish Gray Fat Clay (CH)
▲	B-RW033	S9	40.0	41.5	12.2	12.7		28	25	3	Very Dark Greenish Gray Sandy Silt with Shells (ML)
◆	B-RW033	R10A	45.0	46.5	13.7	14.2		53	22	31	Very Dark Greenish Gray Fat Clay (CH)
■	B-RW036	R2A	10.0	11.5	3.1	3.5		60	28	32	Dark Greenish Gray Fat Clay (CH)
○	B-RW036	S3	15.0	16.5	4.6	5.0		69	31	38	Dark Olive Gray Fat Clay (CH)
△											
◇											
□											

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Ballona Creek Wetlands Restoration

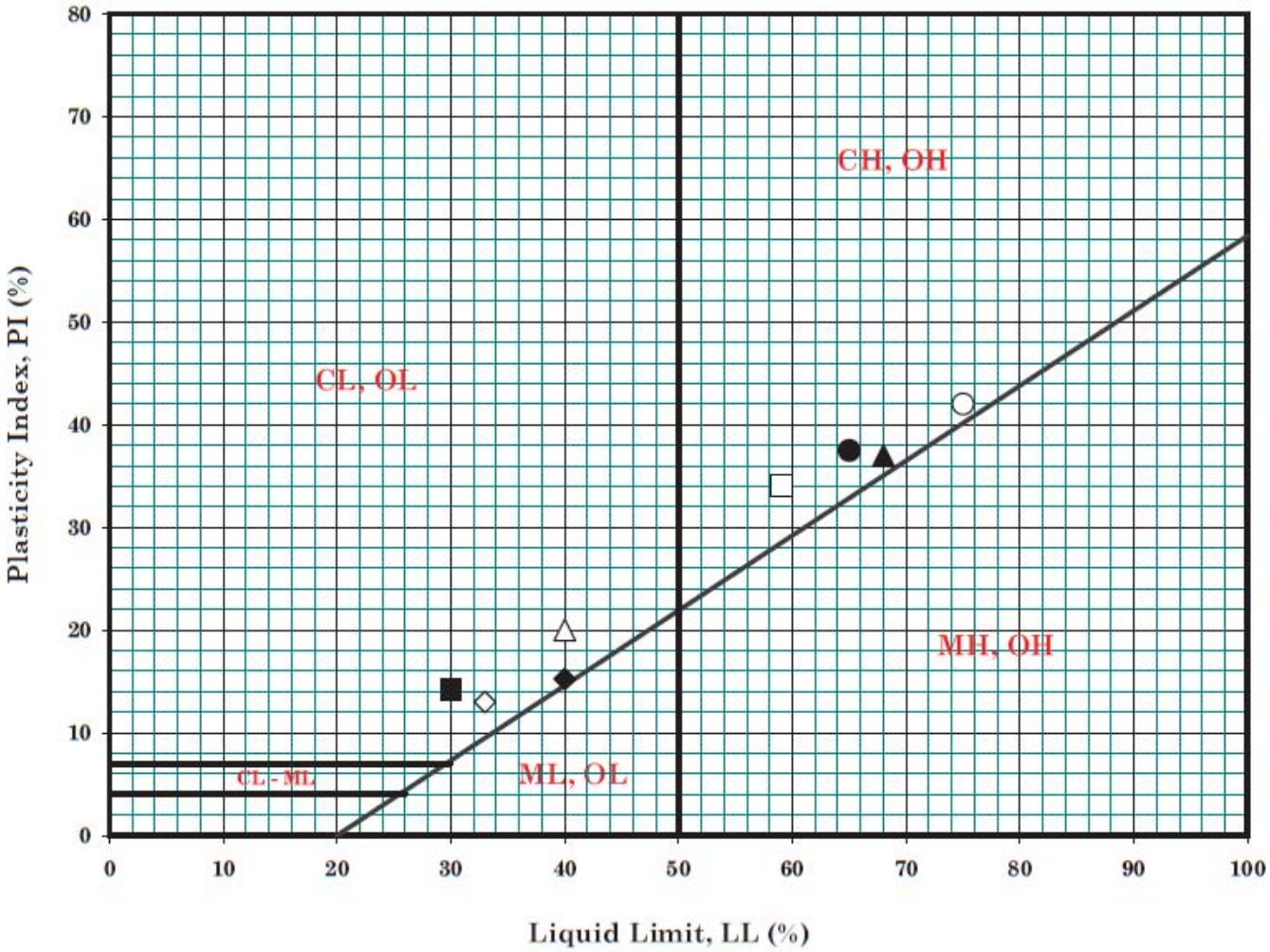
Project No. : LA962A

Date : 01/28/13

ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1i

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC	LL	PL	PI	Description
							(%)				
●	B-RW039	S1	5.0	6.5	1.5	2.0		65	28	37	Dark Yellowish Brown Fat Clay
▲	B-RW039	SH2B	10.0	11.5	3.1	3.5		68	31	37	Olive Gray Fat Clay with Shells (CH)
◆	B-RW039	S7	35.0	36.5	10.7	11.1		40	25	15	Very Dark Greenish Gray Silty Clay / Clayey Silt with Shells
■	B-RW039	R8A	40.0	41.5	12.2	12.7		30	16	14	Very Dark Greenish Gray Sandy Clay
○	B-RW041	R6A	25.0	26.5	7.6	8.1		75	33	42	Dark Greenish Gray Fat Clay (CH)
△	B-RW041	S7	30.0	31.5	9.2	9.6		40	20	20	Very Dark Greenish Gray Silty Clay (CL)
◇	B-RW041	R9	40.0	41.5	12.2	12.7		33	20	13	Very Dark Greenish Gray Silty Clay (CL)
□	B-RW041	S12	55.0	56.5	16.8	17.2		59	25	34	Dark Gray Fat Clay (CH)

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Project No. : LA962A

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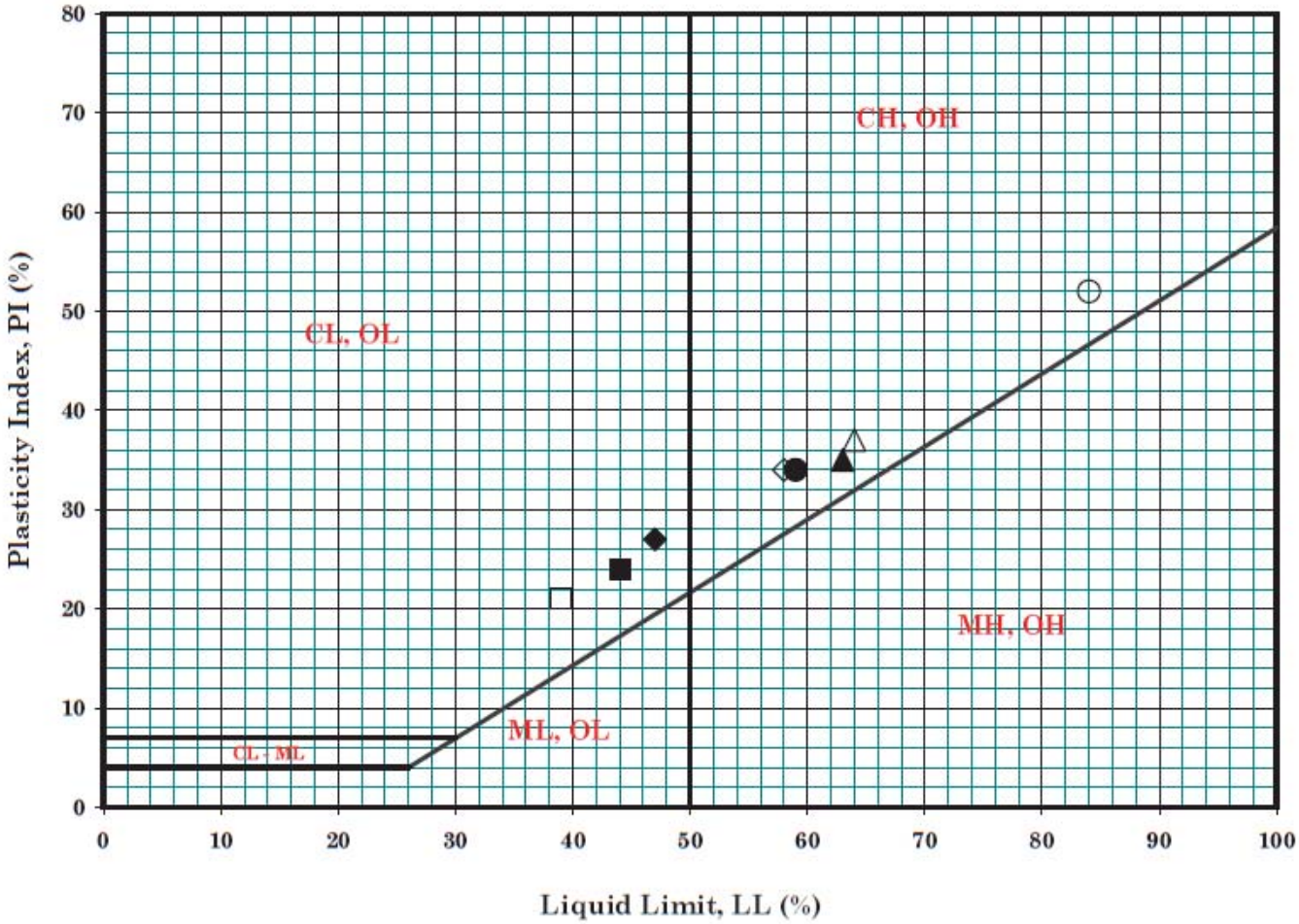
ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1j

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	LI	Description
●	B-RW043	R3A	10.0	11.5	3.1	3.5		59	25	34		Dark Greenish Gray Fat Clay (CH)
▲	B-RW043	S6	25.0	26.5	7.6	8.1		63	28	35		Very Dark Greenish Gray Fat Clay (CH)
◆	B-RW043	SH7B	30.0	31.5	9.2	9.6		47	20	27		Very Dark Greenish Gray Lean Clay (CL)
■	B-RW043	R11	50.0	51.5	15.3	15.7		44	20	24		Very Dark Greenish Gray Lean Clay (CL)
○	B-RW044	R1A	5.0	6.5	1.5	2.0		84	32	52		Dark Greenish Gray Fat Clay (CH)
△	B-RW044	SH3B	15.0	16.5	4.6	5.0		64	27	37		Dark Greenish Gray Fat Clay (CH)
◇	B-RW044	R5A	25.0	26.5	7.6	8.1		58	24	34		Very Dark Gray Fat Clay (CH)
□	B-RW044	R11	55.0	56.5	16.8	17.2		39	18	21		Dark Gray Silty Lean Clay (CL)

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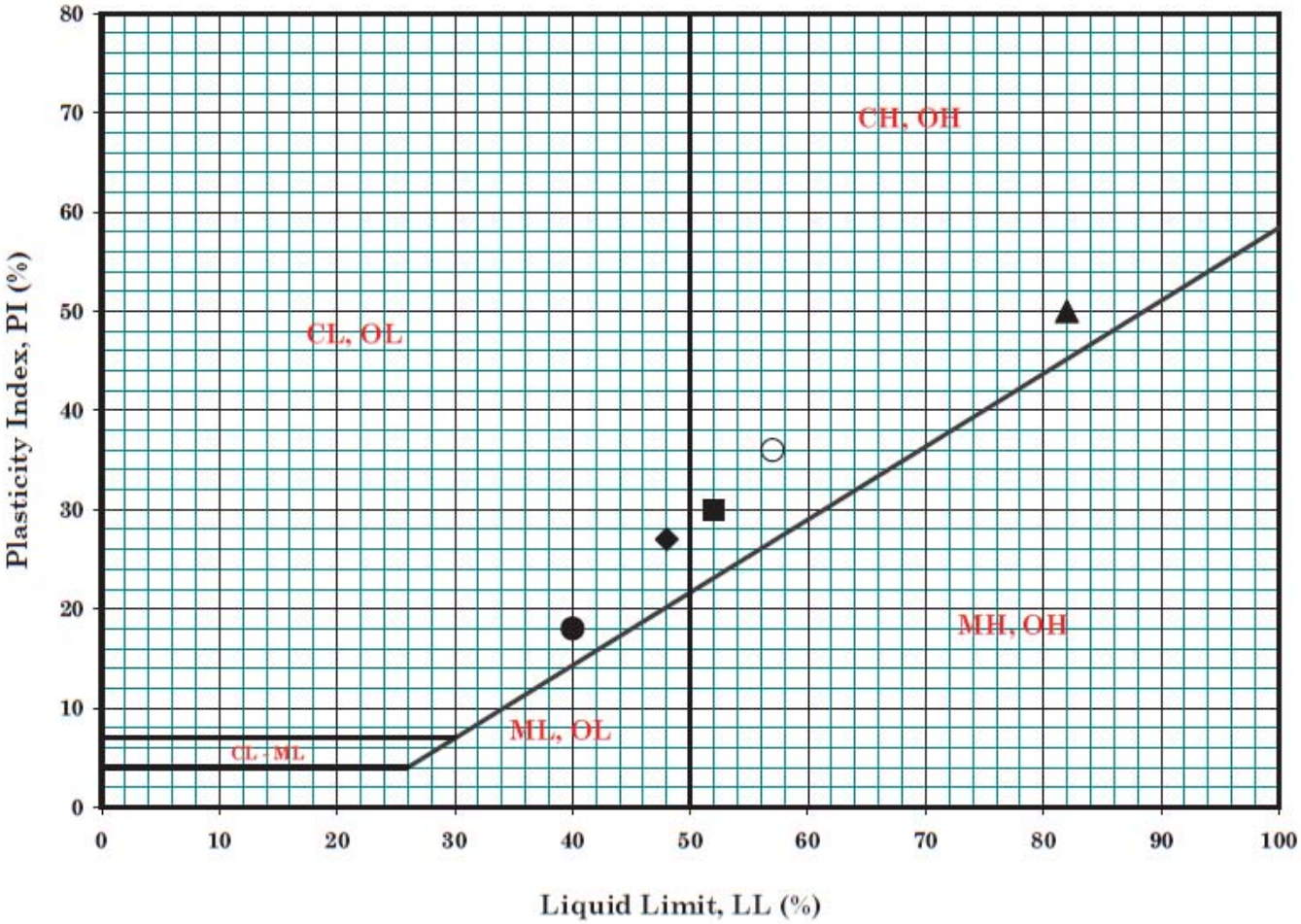
Project No. : LA962A

Date : 10/12/12

ATTERBERG LIMITS
(ASTM D-4318 / CT-204 / T-89)

Figure No. : B1-1k

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	LI	Description
●	B-RW047	SH3A	10.0	11.5	3.1	3.5		40	22	18		Light Gray Silty Lean Clay(CL)
▲	B-RW047	SH5A	20.0	16.5	6.1	5.0		82	32	50		Dark Greenish Gray Fat Clay (CH)
◆	B-RW047	S6	25.0	26.5	7.6	8.1		48	21	27		Dark Gray Silty Lean Clay (CL)
■	B-RW047	R11	50.0	51.5	15.3	15.7		52	22	30		Very Dark Gray Fat Clay (CH)
○	B-RW047	S10	45.0	46.5	13.7	14.2		57	21	36		Very Dark Gray Fat Clay (CH)
△												
◇												
□												

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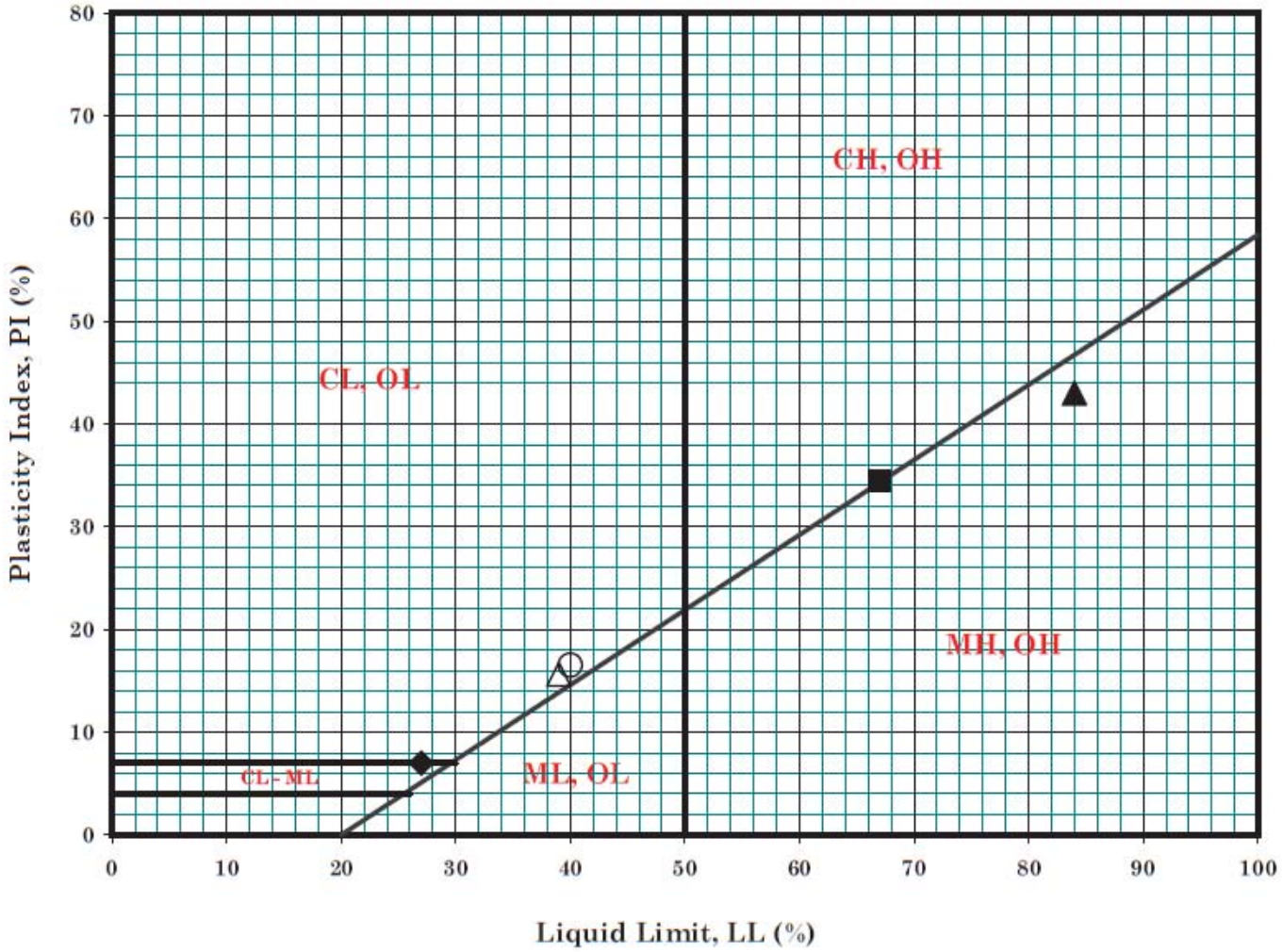
Project No. : LA962A

Date : 10/11/12

ATTERBERG LIMITS
(ASTM D-4318 / CT-204 / T-89)

Figure No. : B1-11

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●											
▲	B-RW049	R4A	15.0	16.5	4.6	5.0		84	41	43	Black to Light Olive Brown Silt or Clay with Organic Matter (OH)
◆	B-RW049	S5	20.0	21.5	6.1	6.6		27	20	7	Light Brown Clayey Silt (ML-CL)
■	B-RW049	R6A	25.0	26.5	7.6	8.1		67	33	34	Dark Geenish Gray Silt / Clay with Traces of Shells (CH/MH)
○	B-RW049	R8A	35.0	36.5	10.7	11.1		40	23	17	Very Dark Greenish Gray Silty Clay (CL)
△	B-RW049	R13	60.0	61.5	18.3	18.8		39	23	16	Very Dark Greenish Gray Sandy Silty Clay (CL)
◇											
□											

Remark :

GROUP DELTA CONSULTANTS

Ballona Creek Wetlands Restoration

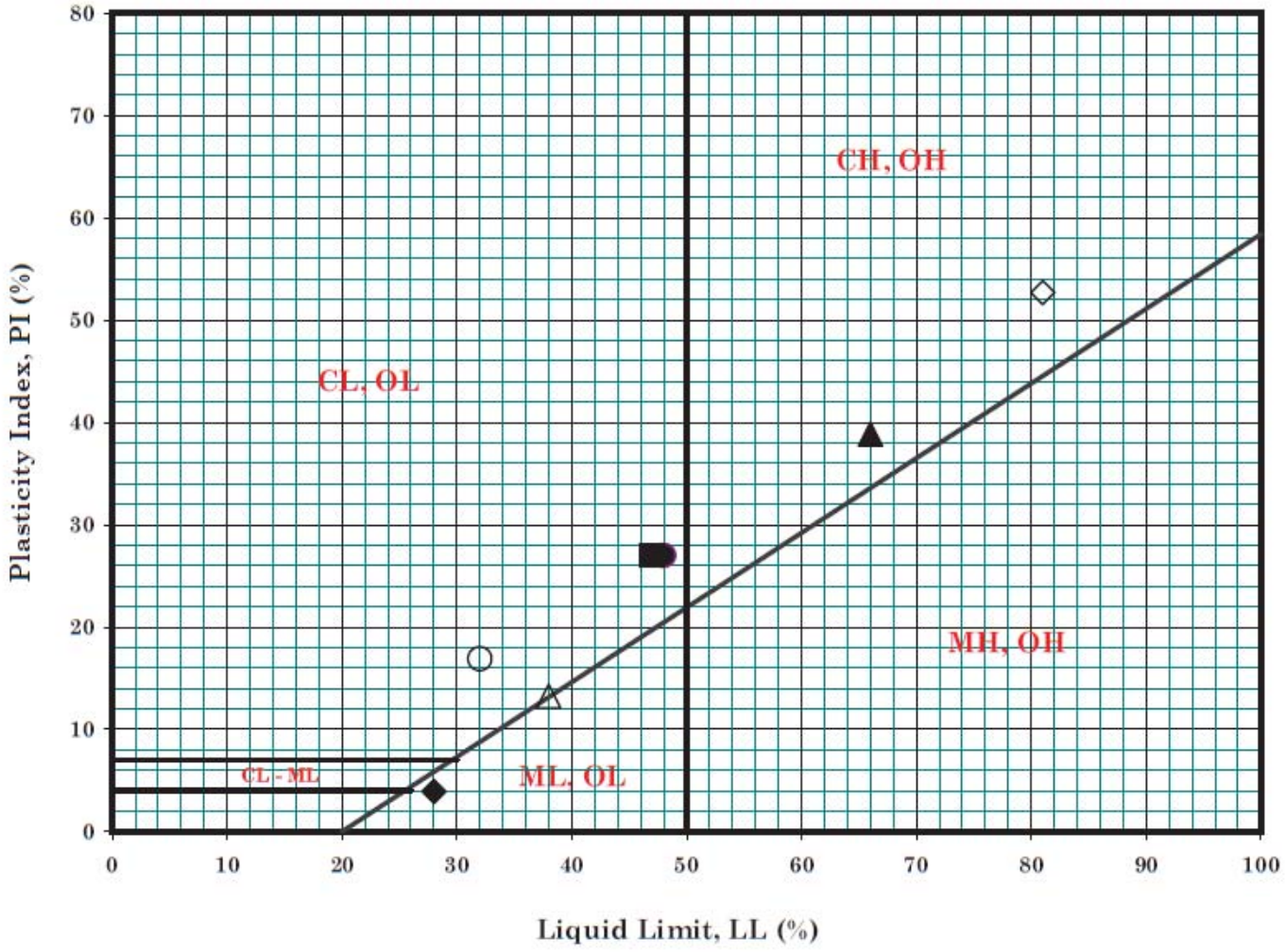
Project No. : LA962A

Date : 11/02/12

ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1m

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	B-RW053	S1	5.0	6.5	1.5	2.0		48	21	27	Dark Gray Silty Lean Clay with Shells (CL)
▲	B-RW053	R2A	10.0	11.5	3.1	3.5		66	27	39	Dark to Light Olive Brown Clay with traces of Shells (CH)
◆	B-RW053	SH4B	20.0	21.5	6.1	6.6		28	24	4	Dark Greenish Gray Clayey Sandy Silt with Traces of Shells (ML)
■	B-RW053	S9	45.0	46.5	13.7	14.2		47	20	27	Dark Gray Silty Lean Clay with Shells (CL)
○	B-RW053	R10A	50.0	51.5	15.3	15.7		32	15	17	Dark Greenish Gray Sandy Clay (CL)
△	B-RW053	R12A	60.0	61.5	18.3	18.8		38	25	13	Very Dark Greenish Gray Silty Clay / Clayey Silt (CL/ML)
◇	B-RW053	R14A	70.0	71.5	21.4	21.8		81	28	53	Very Dark Greenish Gray Fat Clay (CH)
□											

Remark :

GROUP DELTA CONSULTANTS

Ballona Creek Wetlands Restoration

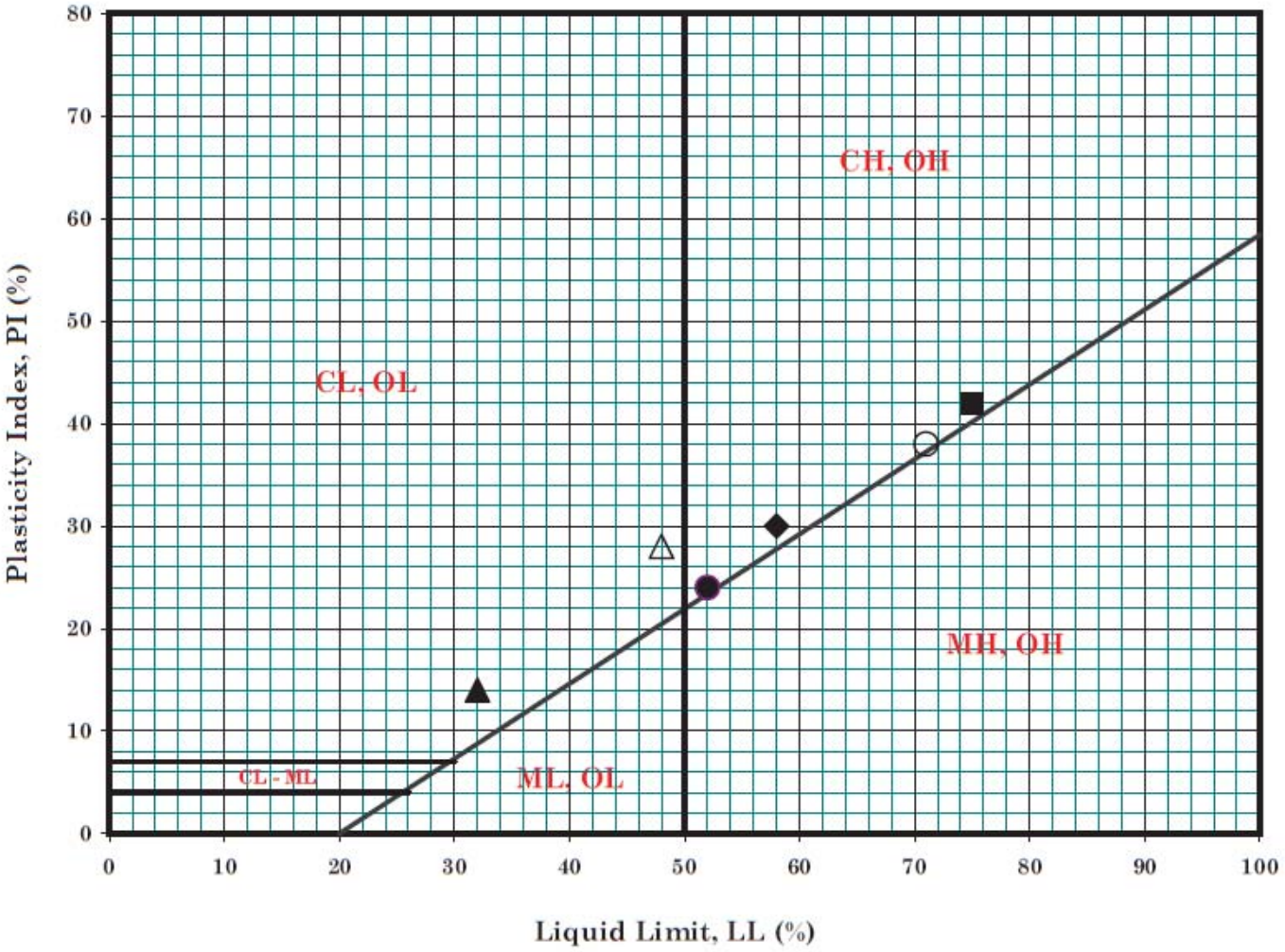
Project No. : LA962A

Date : 11/02/12

ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1n

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	B-RW055	R2A	10.0	11.5	3.1	3.5		52	28	24	Yellowish Brown Clay with Shells (CH)
▲	B-RW055	R10	45.0	46.5	13.7	14.2		32	18	14	Very Dark Greenish Gray Sandy Clay with Traces of Gravel (CL)
◆	B-RW058	S2	10.0	11.5	3.1	3.5		58	28	30	Brown Fat Clay (CH)
■	B-RW058	R3A	15.0	16.5	4.6	5.0		75	33	42	Olive Clay with Organic Matter (CH or OH)
○	B-RW058	R5A	25.0	26.5	7.6	8.1		71	33	38	Dark Olive Brown Fat Clay with Traces of Shells (CH)
△	B-RW058	S12	60.0	61.5	18.3	18.8		48	20	28	Dark Gray Silty Lean Clay with Shells (CL)
◇											
□											

Remark :

GROUP DELTA CONSULTANTS

Ballona Creek Wetlands Restoration

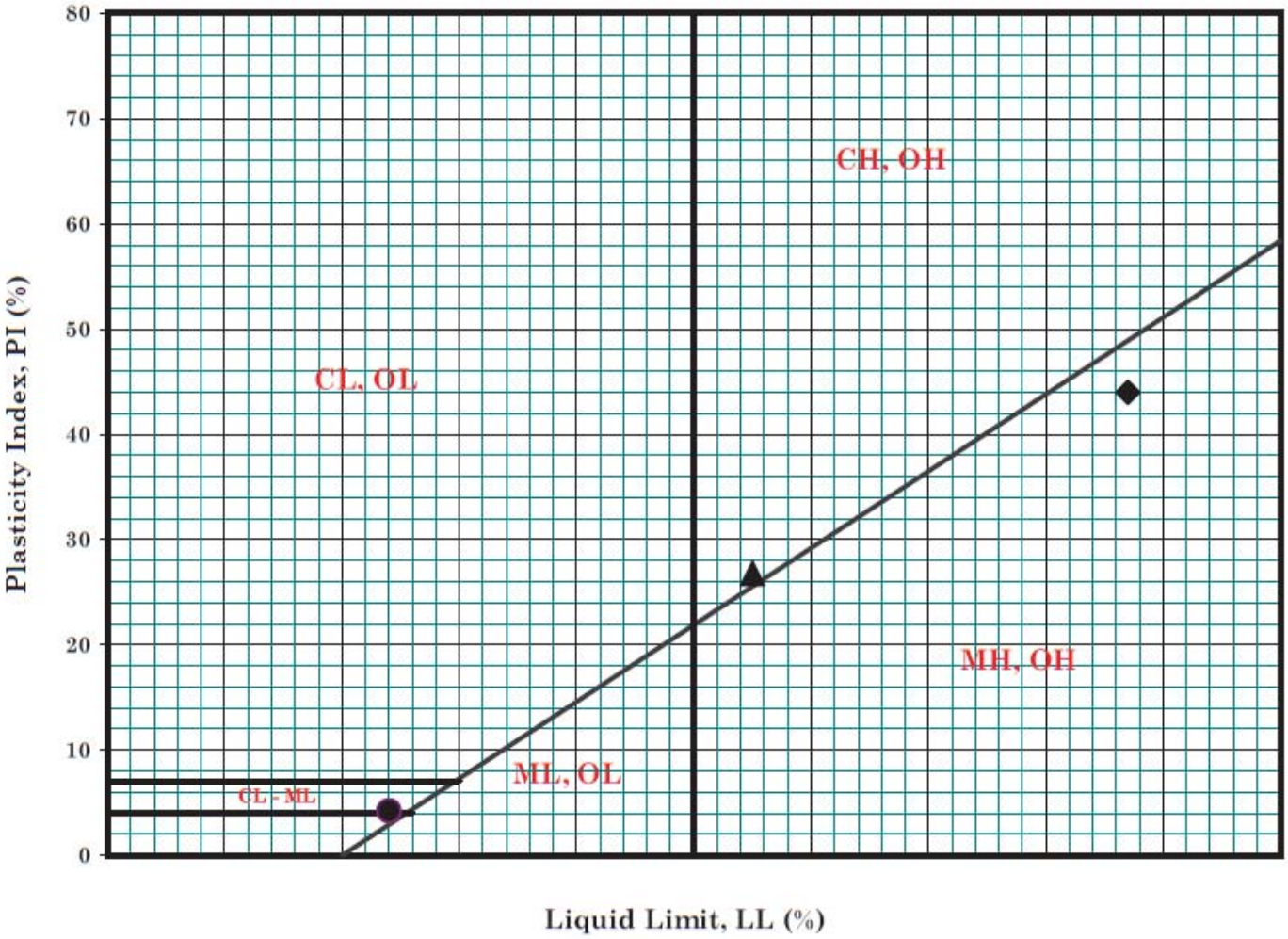
Project No. : LA962A

Date : 11/02/12

ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1o

PLASTICITY CHART



Symbol	Boring No.	Sample No.	Depth (ft)		Depth (m)		MC (%)	LL (%)	PL (%)	PI (%)	Description
●	C-HSA061	R7	17.5	19.0	5.3	5.8		24	20	4	Dark Olive Brown Sandy Clay-Sandy Silt with Fine Gravel (CL-ML)
▲	C-HSA061	R11	30.0	31.5	9.2	9.6		55	28	27	Olive Brown Silty Clay to Fat Clay (CH)
◆	B-HSA051	S6	12.5	14.0	3.8	4.3		87	43	44	Dark Olive Gray Clayey Silt (MH)
■											
○											
△											
◇											
□											

Remark :

GROUP DELTA CONSULTANTS

Ballona Creek Wetlands Restoration

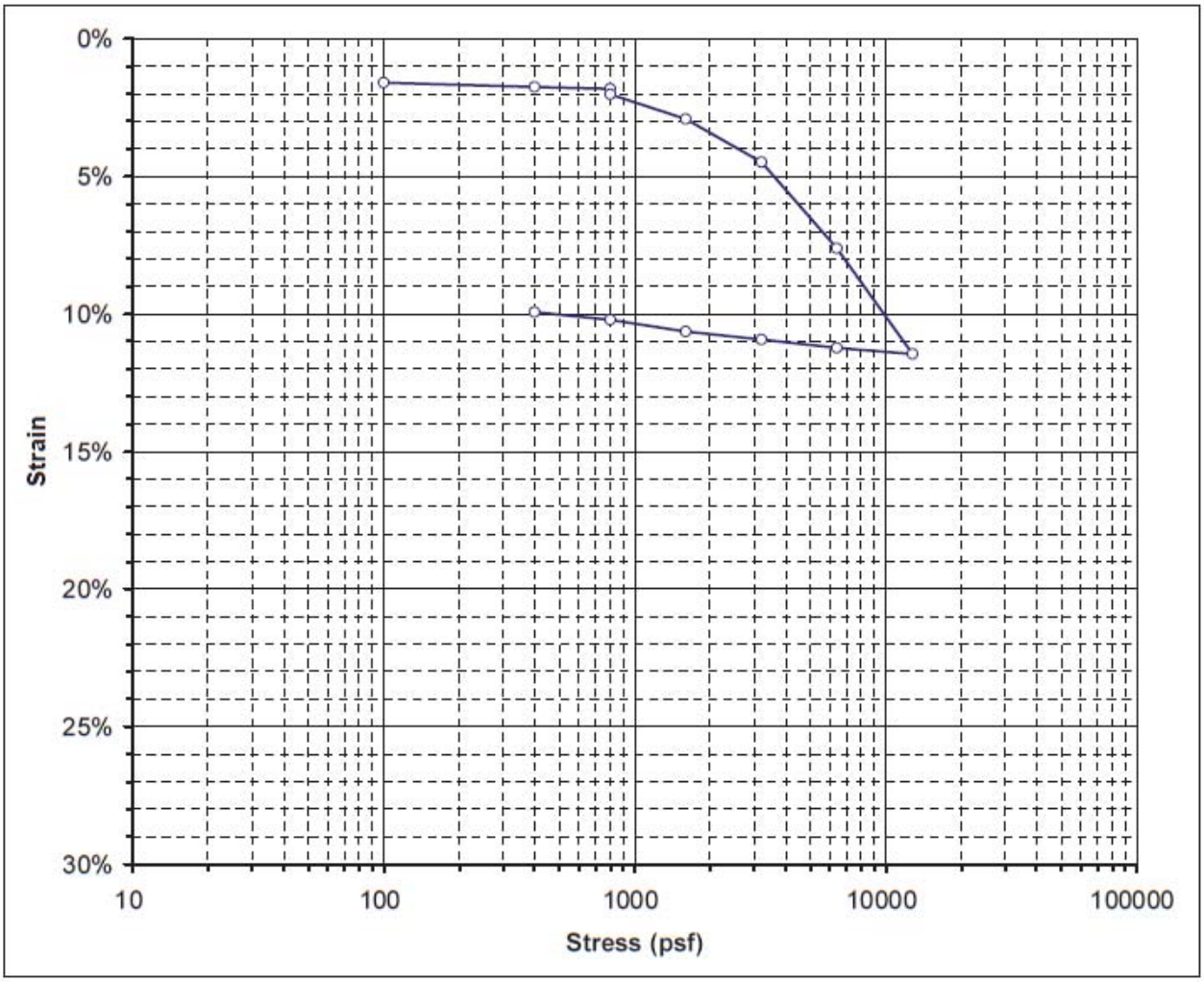
Project No. : LA962A

Date : 11/19/12

ATTERBERG LIMITS
(ASTM D-4318-84)

Figure No. : B1-1p

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW003	Sample Depth	30 ft
Sample No.	R7A	USCS	0

BEFORE TEST

Initial Moisture Content:	35.6%	
Initial Dry Unit Wt:	85.8	pcf
Initial Total Unit Wt.:	116.3	pcf
Initial Void Ratio:	1.0301	
Initial Degree of Saturation:	96.3%	

AFTER TEST

Final Moisture Content:	30.2%	
Final Dry Unit Wt:	94.4	pcf
Final Total Unit Wt.:	112.8	pcf
Final Void Ratio:	0.8450	
Final Degree of Saturation:	99.6%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.60%	0.9976
400	1.75%	0.9945
800	1.82%	0.9931
800	2.02%	0.9890
1600	2.92%	0.9709
3200	4.49%	0.9390
6400	7.63%	0.8753
12800	11.45%	0.7976
6400	11.23%	0.8021
3200	10.93%	0.8082
1600	10.64%	0.8141
800	10.22%	0.8226
400	9.94%	0.8283

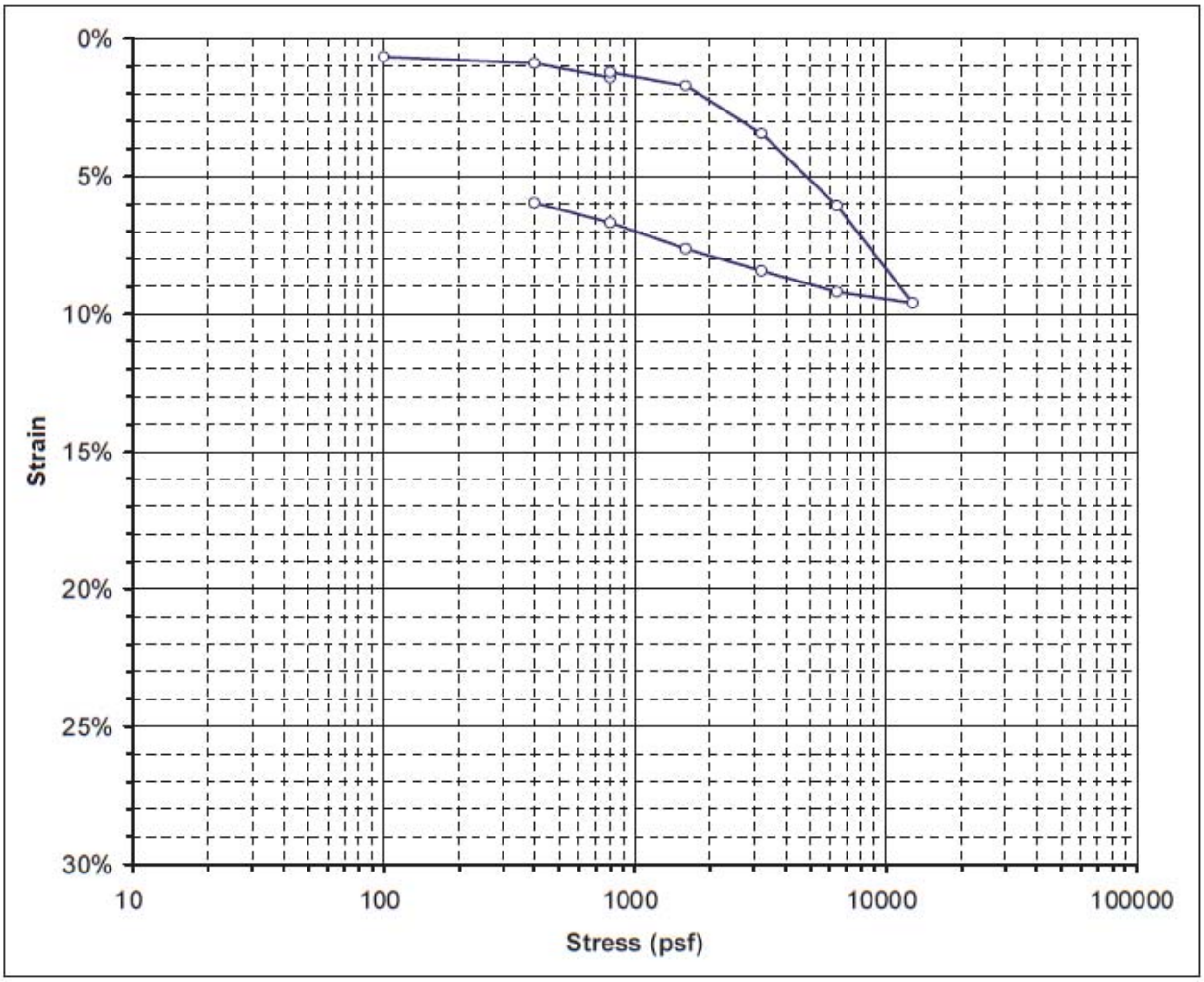
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2a

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-3-12\Consol A-RW003R7A@30'_1.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW005	Sample Depth	5 ft
Sample No.	R1	USCS	0

BEFORE TEST

Initial Moisture Content:	37.4%	
Initial Dry Unit Wt:	82.0	pcf
Initial Total Unit Wt.:	112.7	pcf
Initial Void Ratio:	1.1234	
Initial Degree of Saturation:	92.9%	

AFTER TEST

Final Moisture Content:	36.4%	
Final Dry Unit Wt:	86.5	pcf
Final Total Unit Wt.:	110.1	pcf
Final Void Ratio:	1.0129	
Final Degree of Saturation:	100.2%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.66%	1.1093
400	0.90%	1.1043
800	1.41%	1.0935
800	1.21%	1.0976
1600	1.71%	1.0870
3200	3.45%	1.0501
6400	6.06%	0.9947
12800	9.60%	0.9195
6400	9.19%	0.9281
3200	8.44%	0.9442
1600	7.63%	0.9613
800	6.69%	0.9812
400	5.96%	0.9968

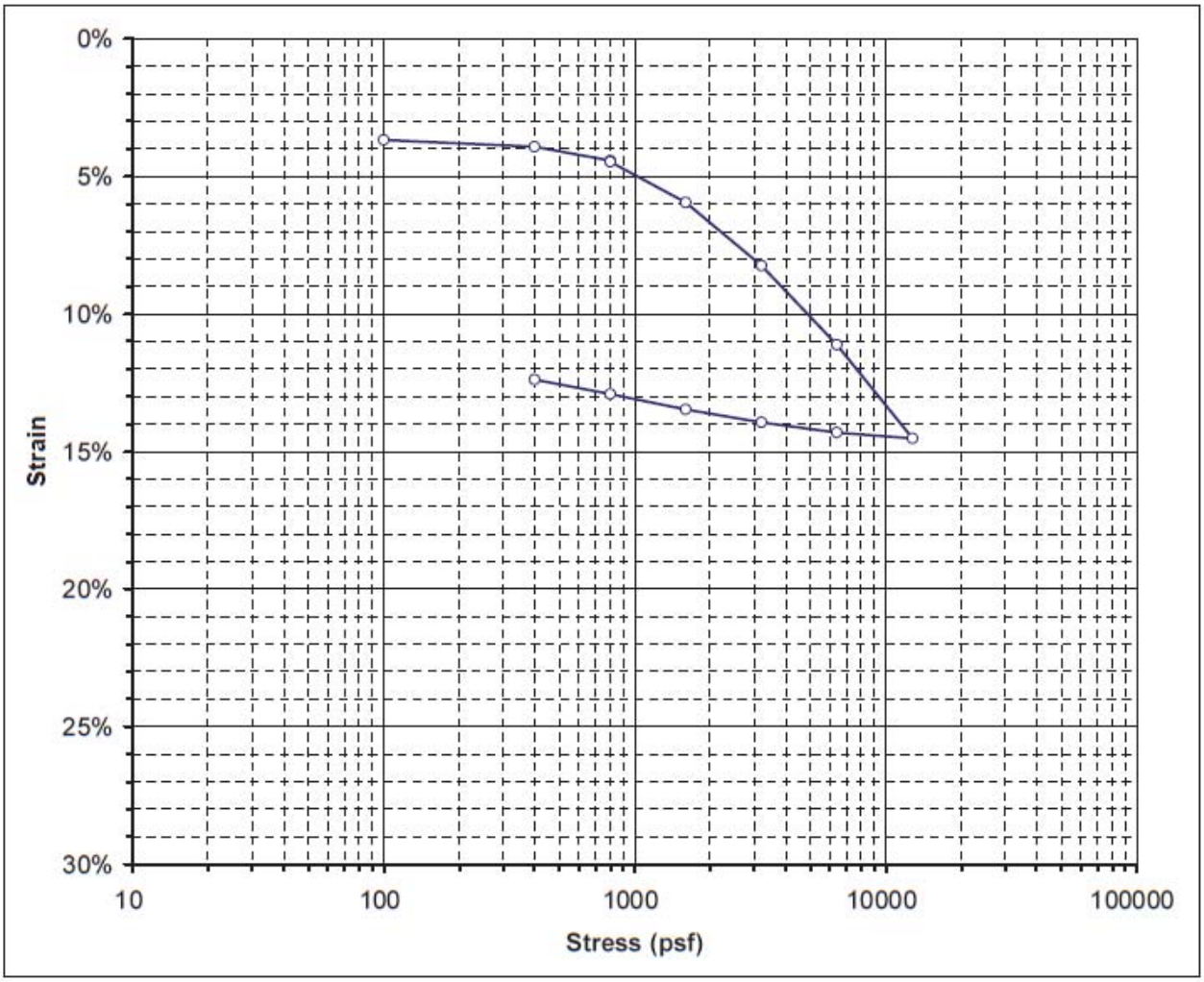
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2b

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-30-12\A-RW005 R1@5'_3.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW005	Sample Depth	15 ft
Sample No.	R3	USCS	0

BEFORE TEST

Initial Moisture Content:	43.7%	
Initial Dry Unit Wt:	77.9	pcf
Initial Total Unit Wt.:	111.9	pcf
Initial Void Ratio:	1.2358	
Initial Degree of Saturation:	98.7%	

AFTER TEST

Final Moisture Content:	35.5%	
Final Dry Unit Wt:	87.5	pcf
Final Total Unit Wt.:	115.5	pcf
Final Void Ratio:	0.9895	
Final Degree of Saturation:	100.0%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	3.68%	1.1536
400	3.93%	1.1480
800	4.43%	1.1367
800	4.47%	1.1358
1600	5.95%	1.1028
3200	8.25%	1.0513
6400	11.13%	0.9871
12800	14.52%	0.9111
6400	14.31%	0.9158
3200	13.94%	0.9242
1600	13.48%	0.9345
800	12.91%	0.9471
400	12.39%	0.9588

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2c

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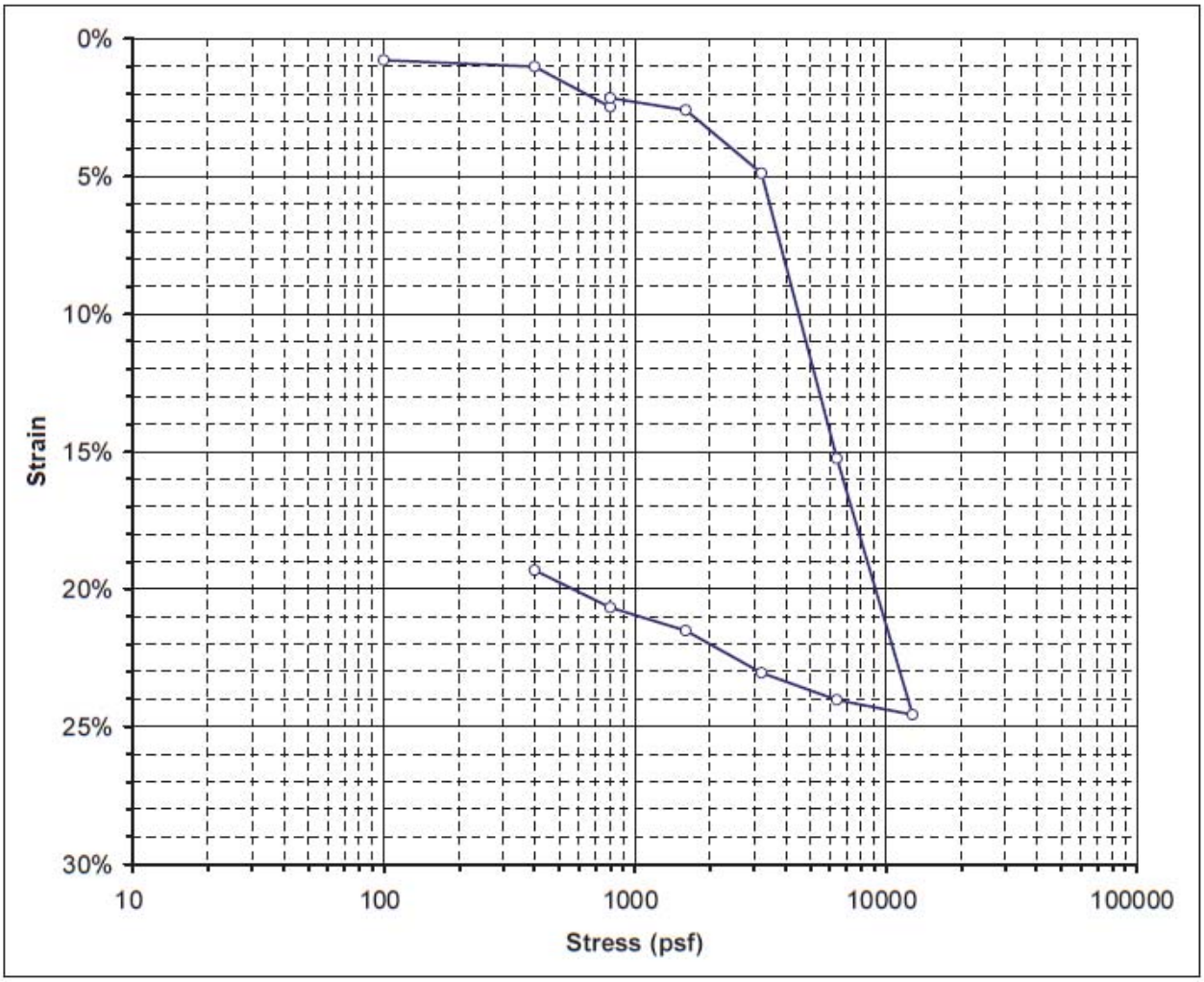
CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW006	Sample Depth	35 ft
Sample No.	R8A	USCS	MH

BEFORE TEST

Initial Moisture Content:	75.0%	
Initial Dry Unit Wt:	56.1	pcf
Initial Total Unit Wt.:	98.2	pcf
Initial Void Ratio:	2.1032	
Initial Degree of Saturation:	99.5%	

AFTER TEST

Final Moisture Content:	59.2%	
Final Dry Unit Wt:	68.1	pcf
Final Total Unit Wt.:	124.1	pcf
Final Void Ratio:	1.5571	
Final Degree of Saturation:	106.1%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=	64	PL=	33	PI=	31

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.78%	2.0790
400	1.02%	2.0716
800	2.48%	2.0263
800	2.16%	2.0362
1600	2.60%	2.0225
3200	4.89%	1.9515
6400	15.25%	1.6300
12800	24.56%	1.3411
6400	24.03%	1.3575
3200	23.04%	1.3882
1600	21.51%	1.4357
800	20.67%	1.4618
400	19.31%	1.5040

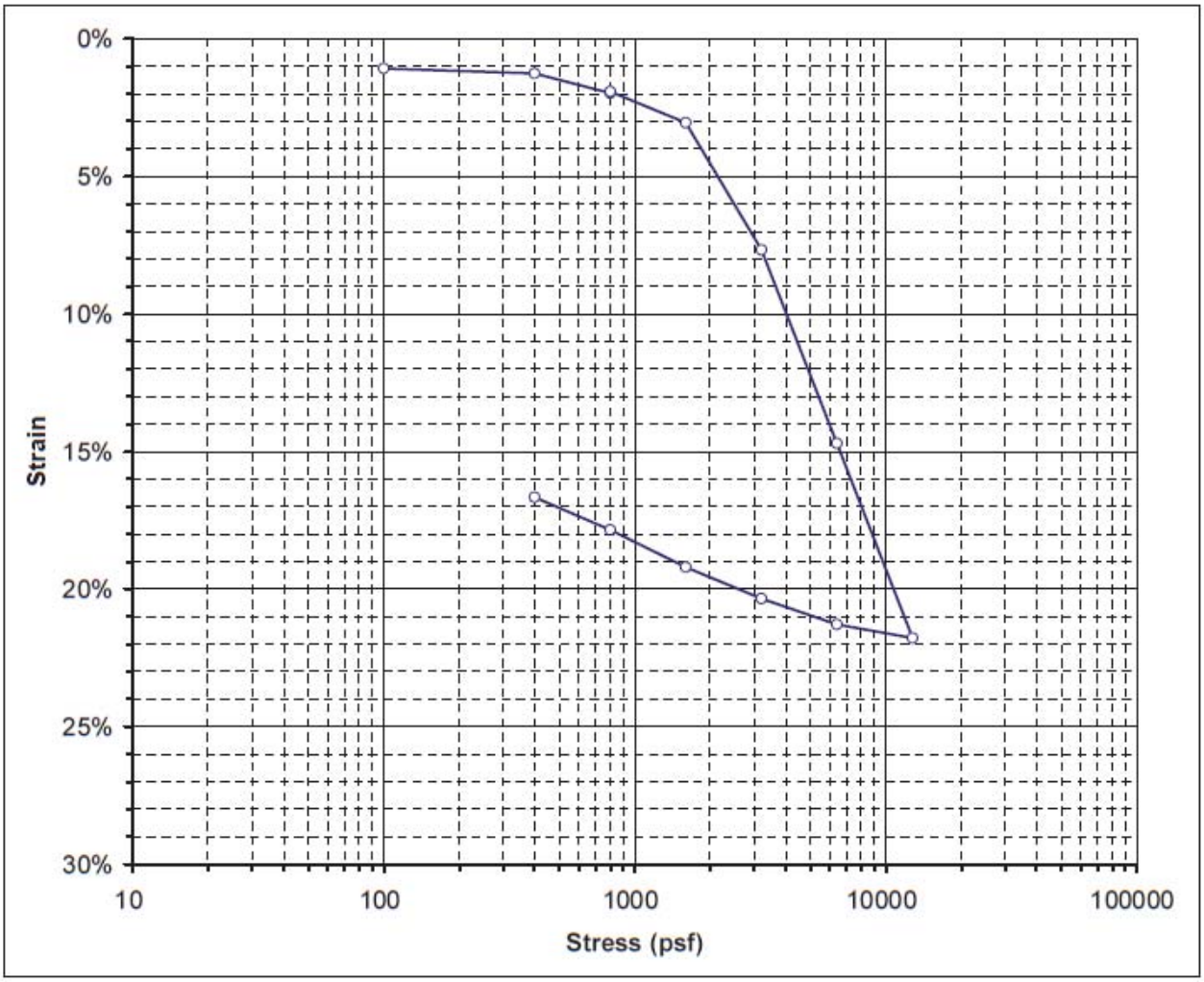
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2d

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 9-21-12\Consol A-RW006R8A@35'_1.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW008	Sample Depth	30 ft
Sample No.	R6A	USCS	0

BEFORE TEST

Initial Moisture Content:	62.1%	
Initial Dry Unit Wt:	63.1	pcf
Initial Total Unit Wt.:	102.2	pcf
Initial Void Ratio:	1.7601	
Initial Degree of Saturation:	98.4%	

AFTER TEST

Final Moisture Content:	49.2%	
Final Dry Unit Wt:	74.4	pcf
Final Total Unit Wt.:	120.7	pcf
Final Void Ratio:	1.3389	
Final Degree of Saturation:	102.5%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.09%	1.7301
400	1.26%	1.7254
800	1.98%	1.7055
800	1.92%	1.7071
1600	3.06%	1.6757
3200	7.68%	1.5482
6400	14.70%	1.3544
12800	21.78%	1.1590
6400	21.28%	1.1728
3200	20.34%	1.1987
1600	19.20%	1.2302
800	17.85%	1.2675
400	16.66%	1.3003

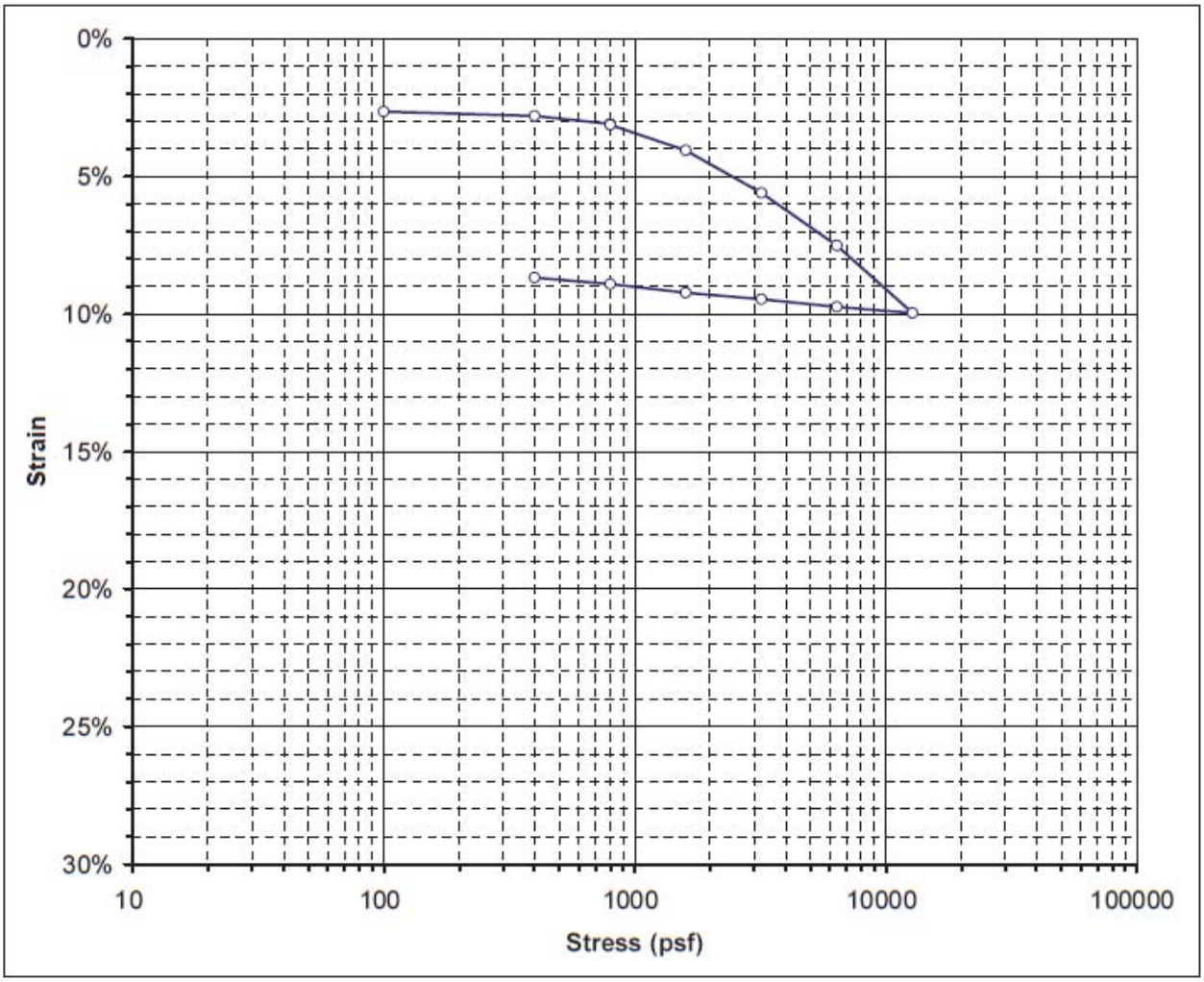
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2e

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-17-12\Consol A-RW008R6A@30'_1.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW011	Sample Depth	5
Sample No.	R2	USCS	0

BEFORE TEST

Initial Moisture Content:	35.2%	
Initial Dry Unit Wt:	86.8	pcf
Initial Total Unit Wt.:	117.3	pcf
Initial Void Ratio:	1.0058	
Initial Degree of Saturation:	97.6%	

AFTER TEST

Final Moisture Content:	29.0%	
Final Dry Unit Wt:	94.1	pcf
Final Total Unit Wt.:	114.3	pcf
Final Void Ratio:	0.8507	
Final Degree of Saturation:	95.0%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	2.65%	0.9526
400	2.80%	0.9495
800	3.10%	0.9435
800	3.13%	0.9429
1600	4.06%	0.9243
3200	5.61%	0.8933
6400	7.52%	0.8550
12800	9.97%	0.8058
6400	9.74%	0.8104
3200	9.46%	0.8159
1600	9.24%	0.8205
800	8.92%	0.8269
400	8.68%	0.8317

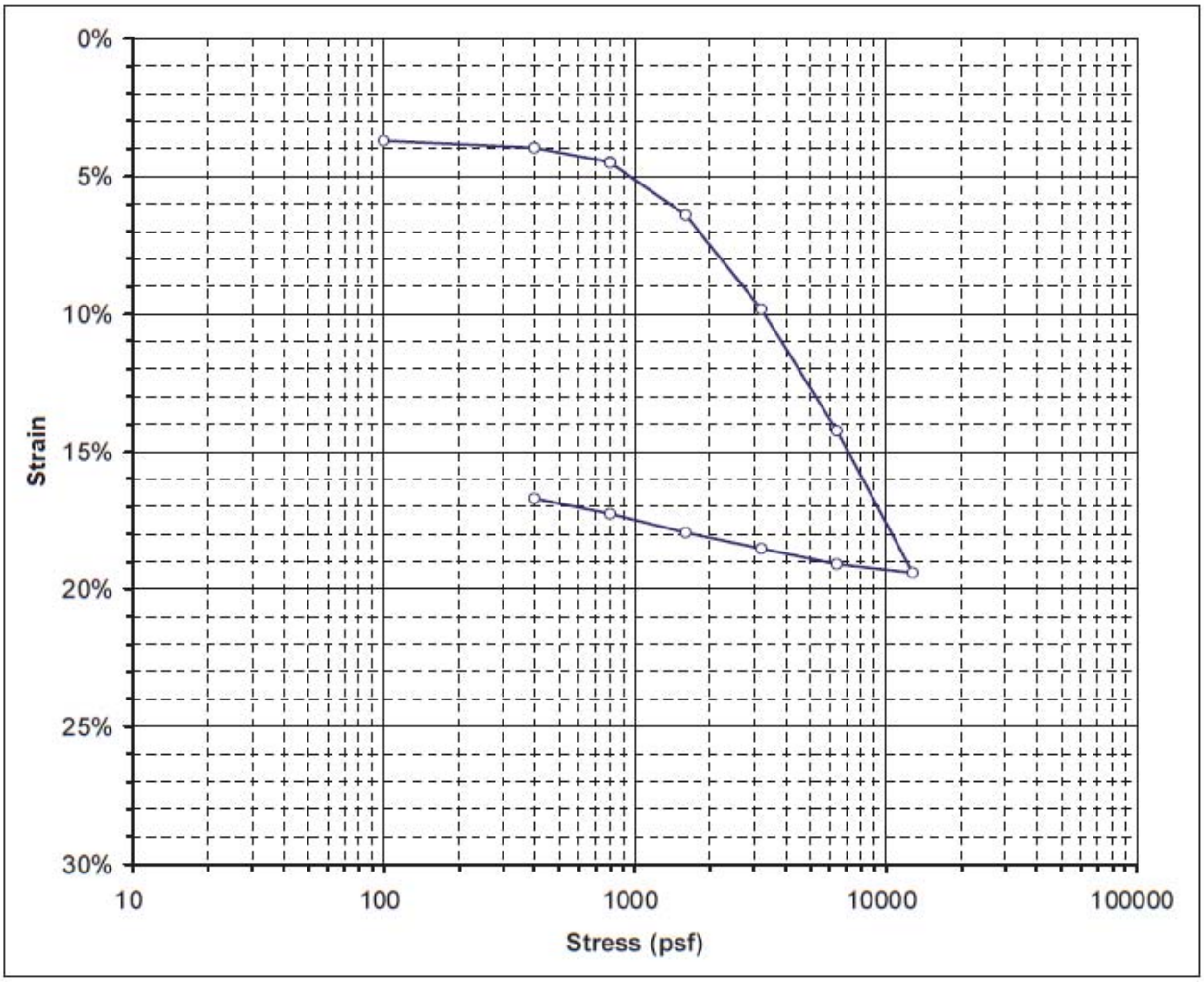
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2f

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-17-'21\Consol A-RW011R2@5'_2.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW013	Sample Depth	15
Sample No.	R4	USCS	0

BEFORE TEST

Initial Moisture Content:	50.9%	
Initial Dry Unit Wt:	73.3	pcf
Initial Total Unit Wt.:	110.6	pcf
Initial Void Ratio:	1.3750	
Initial Degree of Saturation:	103.3%	

AFTER TEST

Final Moisture Content:	38.6%	
Final Dry Unit Wt:	86.7	pcf
Final Total Unit Wt.:	123.5	pcf
Final Void Ratio:	1.0076	
Final Degree of Saturation:	106.9%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	3.71%	1.2868
400	3.97%	1.2807
800	4.49%	1.2684
800	4.51%	1.2679
1600	6.41%	1.2228
3200	9.84%	1.1414
6400	14.24%	1.0367
12800	19.41%	0.9141
6400	19.09%	0.9216
3200	18.53%	0.9349
1600	17.95%	0.9487
800	17.27%	0.9650
400	16.70%	0.9783

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2g

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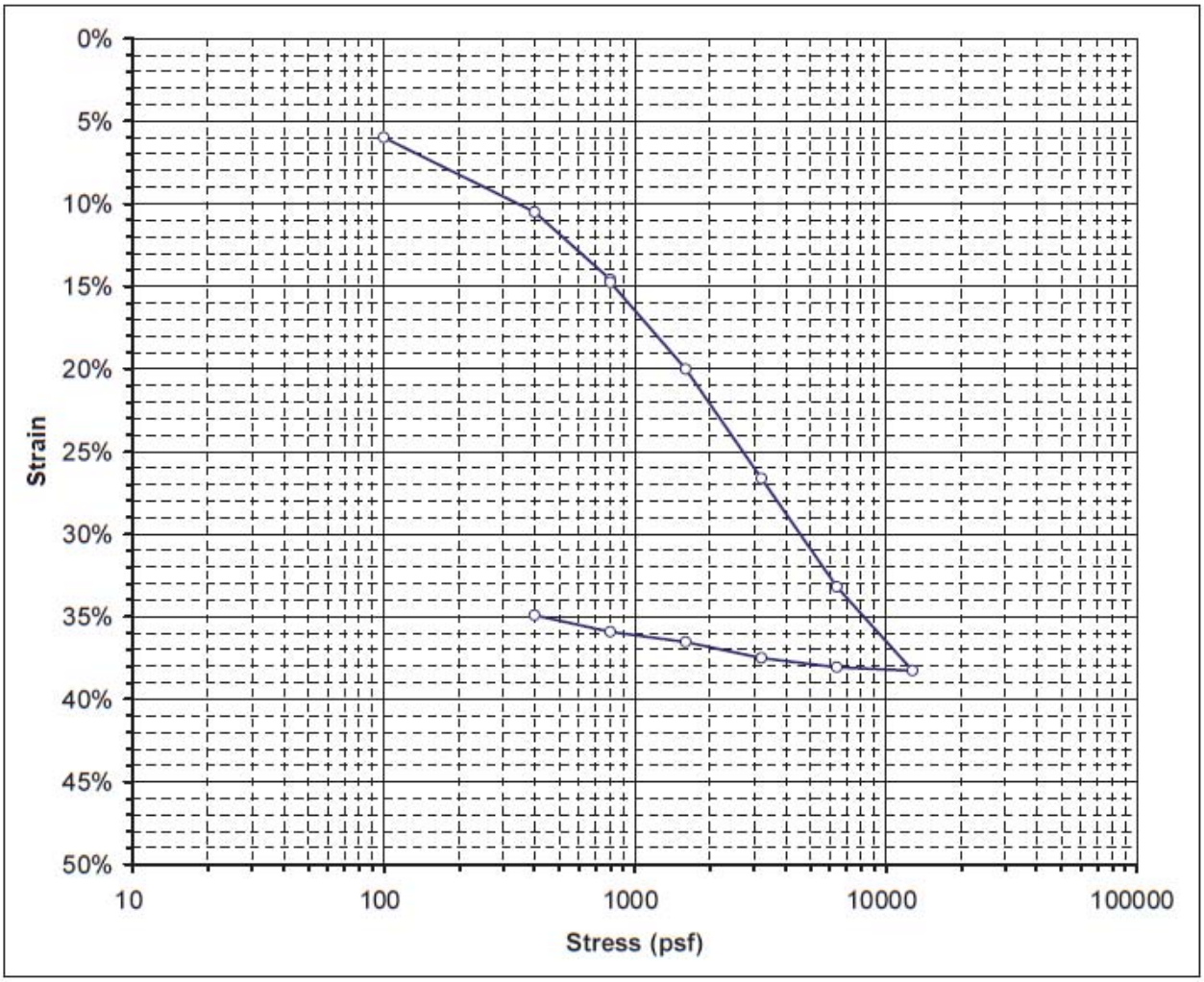
CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW030	Sample Depth	10
Sample No.	R3	USCS	0

BEFORE TEST

Initial Moisture Content:	107.6%	
Initial Dry Unit Wt:	43.5	pcf
Initial Total Unit Wt.:	90.3	pcf
Initial Void Ratio:	3.0033	
Initial Degree of Saturation:	100.0%	

AFTER TEST

Final Moisture Content:	61.0%	
Final Dry Unit Wt:	64.6	pcf
Final Total Unit Wt.:	152.6	pcf
Final Void Ratio:	1.6946	
Final Degree of Saturation:	100.5%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	5.99%	2.7633
400	10.49%	2.5833
800	14.58%	2.4197
800	14.75%	2.4128
1600	20.01%	2.2022
3200	26.63%	1.9373
6400	33.19%	1.6745
12800	38.26%	1.4715
6400	38.06%	1.4795
3200	37.51%	1.5016
1600	36.53%	1.5410
800	35.92%	1.5652
400	34.92%	1.6053

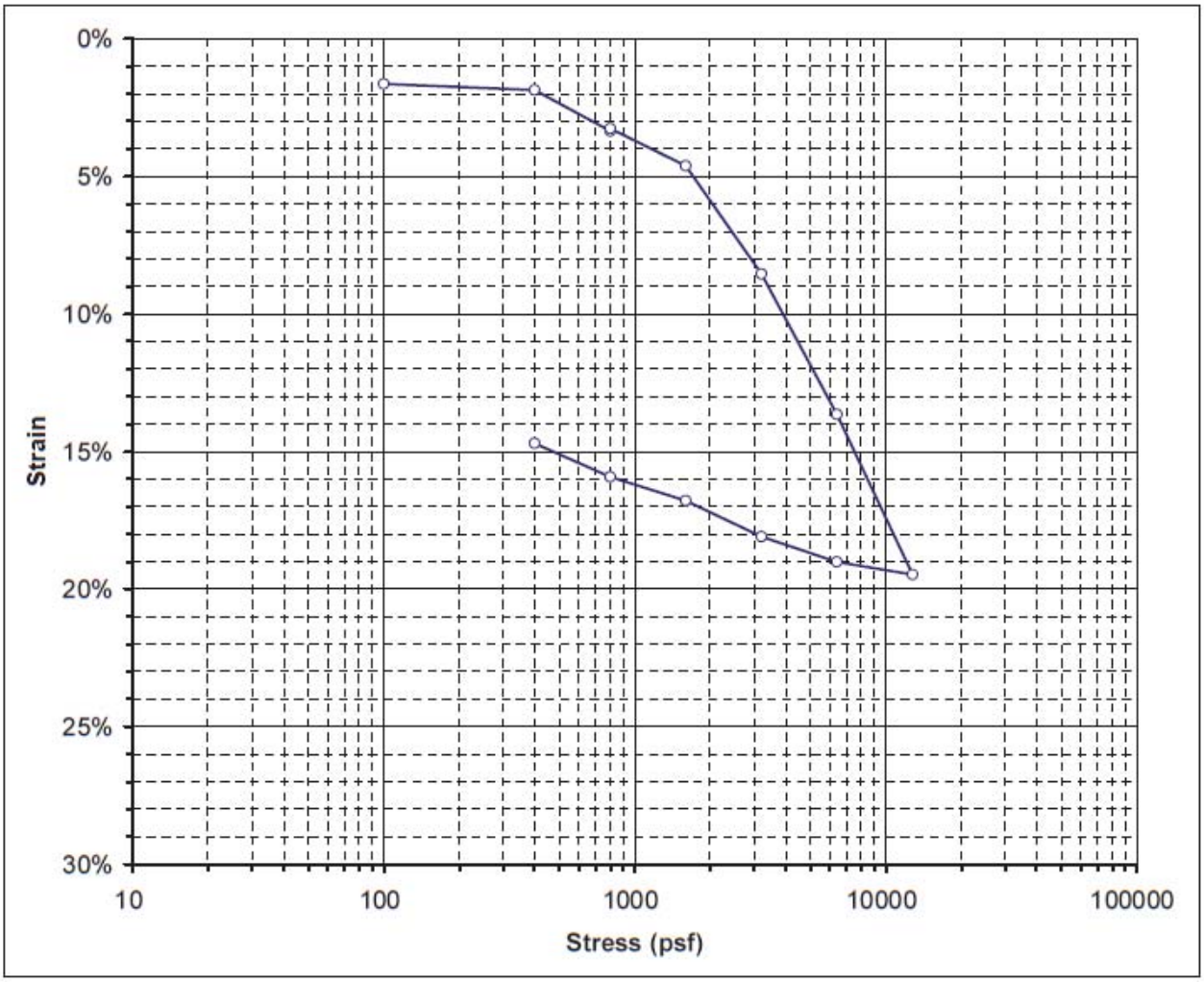
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2h

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 11-8-12\B-RW030 R3@ 10'_1.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW032	Sample Depth	10
Sample No.	R3A	USCS	CH

BEFORE TEST

Initial Moisture Content:	53.5%	
Initial Dry Unit Wt:	69.4	pcf
Initial Total Unit Wt.:	106.6	pcf
Initial Void Ratio:	1.5080	
Initial Degree of Saturation:	99.1%	

AFTER TEST

Final Moisture Content:	44.0%	
Final Dry Unit Wt:	79.8	pcf
Final Total Unit Wt.:	118.1	pcf
Final Void Ratio:	1.1817	
Final Degree of Saturation:	103.9%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=	71	PL=	28	PI=	43

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.65%	1.4667
400	1.87%	1.4612
800	3.35%	1.4239
800	3.26%	1.4262
1600	4.62%	1.3922
3200	8.55%	1.2935
6400	13.65%	1.1656
12800	19.47%	1.0198
6400	19.01%	1.0314
3200	18.09%	1.0543
1600	16.79%	1.0870
800	15.92%	1.1087
400	14.71%	1.1391

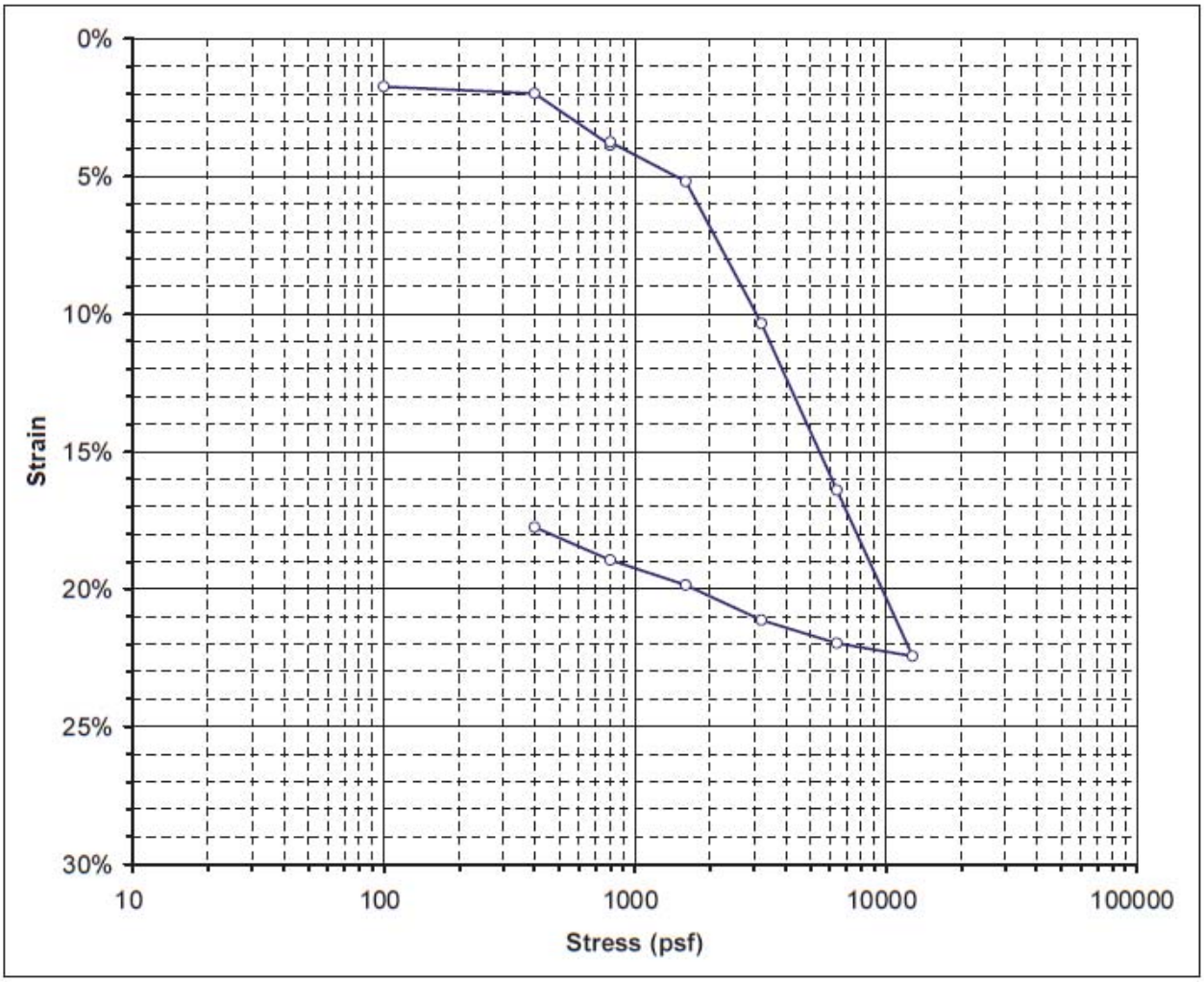
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2i

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 9-21-12\Consol B-RW032R3A@ 10'_2.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW036	Sample Depth	10
Sample No.	R2A	USCS	CH

BEFORE TEST

Initial Moisture Content:	51.2%	
Initial Dry Unit Wt:	71.3	pcf
Initial Total Unit Wt.:	107.7	pcf
Initial Void Ratio:	1.4431	
Initial Degree of Saturation:	98.9%	

AFTER TEST

Final Moisture Content:	39.0%	
Final Dry Unit Wt:	84.8	pcf
Final Total Unit Wt.:	122.3	pcf
Final Void Ratio:	1.0521	
Final Degree of Saturation:	103.3%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=	60	PL=	28	PI=	32

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.75%	1.4004
400	1.99%	1.3945
800	3.88%	1.3484
800	3.76%	1.3513
1600	5.19%	1.3163
3200	10.35%	1.1902
6400	16.41%	1.0423
12800	22.44%	0.8949
6400	21.97%	0.9064
3200	21.12%	0.9270
1600	19.85%	0.9581
800	18.95%	0.9802
400	17.75%	1.0094

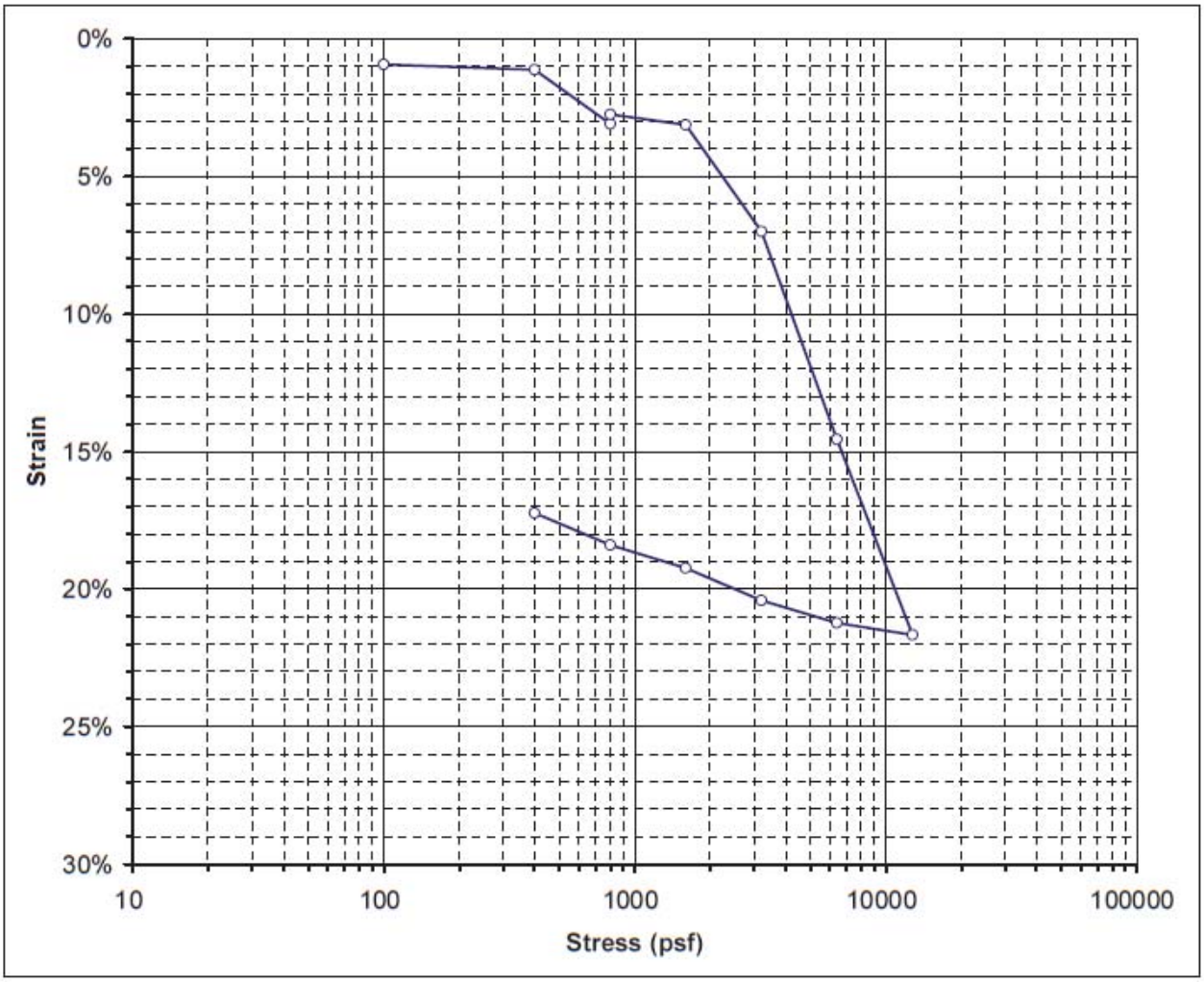
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2j

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 9-21-12\Consol B-RW036R2A@ 10'_3.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW036	Sample Depth	30
Sample No.	R6A	USCS	MH

BEFORE TEST

Initial Moisture Content:	58.8%	
Initial Dry Unit Wt:	64.8	pcf
Initial Total Unit Wt.:	102.9	pcf
Initial Void Ratio:	1.6871	
Initial Degree of Saturation:	97.3%	

AFTER TEST

Final Moisture Content:	46.7%	
Final Dry Unit Wt:	76.3	pcf
Final Total Unit Wt.:	121.1	pcf
Final Void Ratio:	1.2809	
Final Degree of Saturation:	101.6%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.93%	1.6619
400	1.13%	1.6568
800	3.10%	1.6039
800	2.75%	1.6131
1600	3.14%	1.6028
3200	7.01%	1.4988
6400	14.56%	1.2958
12800	21.67%	1.1048
6400	21.23%	1.1167
3200	20.41%	1.1386
1600	19.24%	1.1702
800	18.39%	1.1929
400	17.24%	1.2239

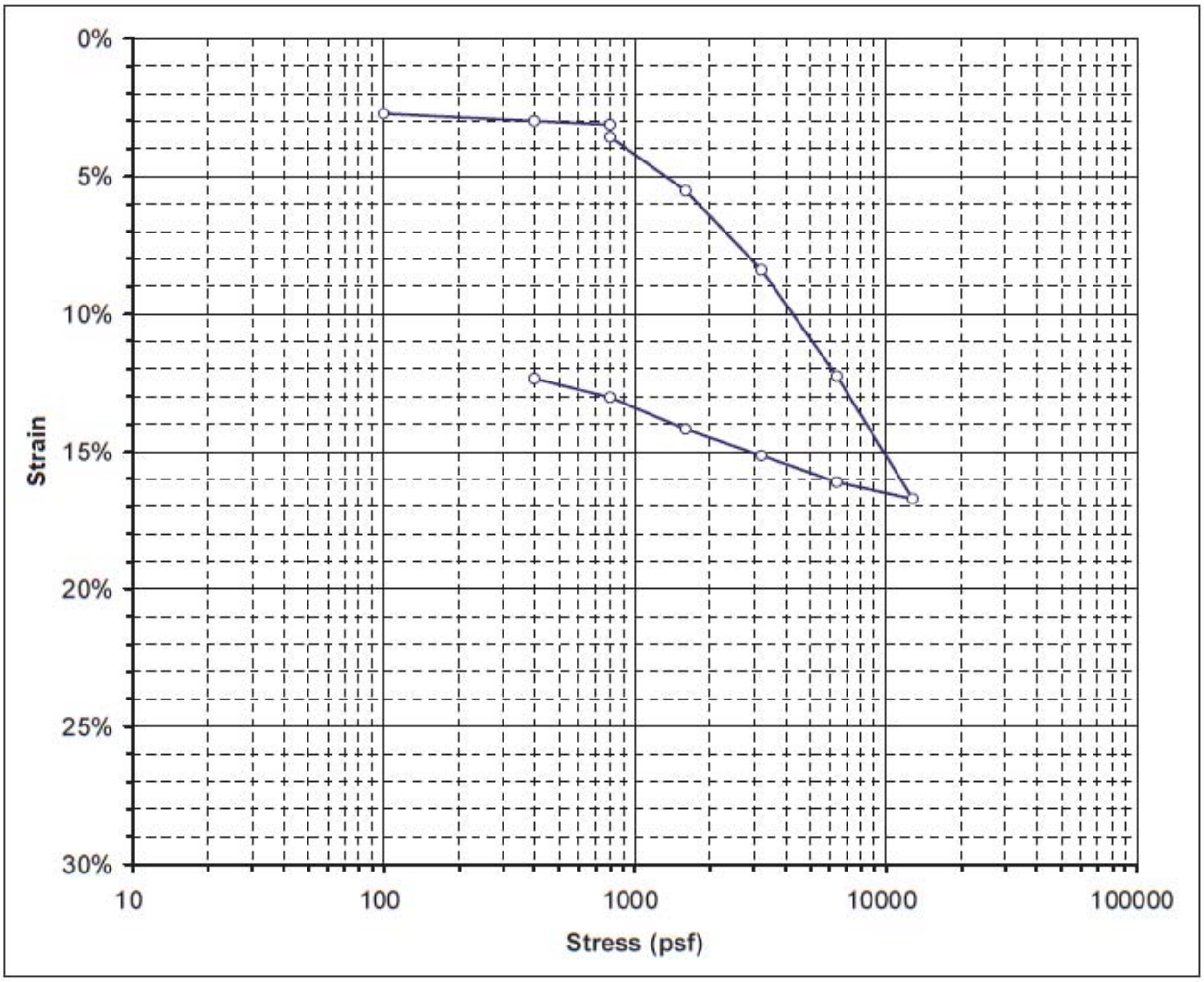
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2k

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 9-21-12\Consol B-RW036R6A@30'_4.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW041	Sample Depth	5 ft
Sample No.	R2A	USCS	0

BEFORE TEST

Initial Moisture Content:	47.4%	
Initial Dry Unit Wt:	75.0	pcf
Initial Total Unit Wt.:	110.6	pcf
Initial Void Ratio:	1.3207	
Initial Degree of Saturation:	100.2%	

AFTER TEST

Final Moisture Content:	39.5%	
Final Dry Unit Wt:	84.4	pcf
Final Total Unit Wt.:	115.2	pcf
Final Void Ratio:	1.0622	
Final Degree of Saturation:	103.7%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	2.73%	1.2573
400	3.00%	1.2510
800	3.13%	1.2480
800	3.58%	1.2376
1600	5.53%	1.1925
3200	8.41%	1.1256
6400	12.26%	1.0361
12800	16.72%	0.9328
6400	16.12%	0.9467
3200	15.16%	0.9690
1600	14.18%	0.9915
800	13.03%	1.0183
400	12.35%	1.0341

PROJECT NUMBER: LA-962A

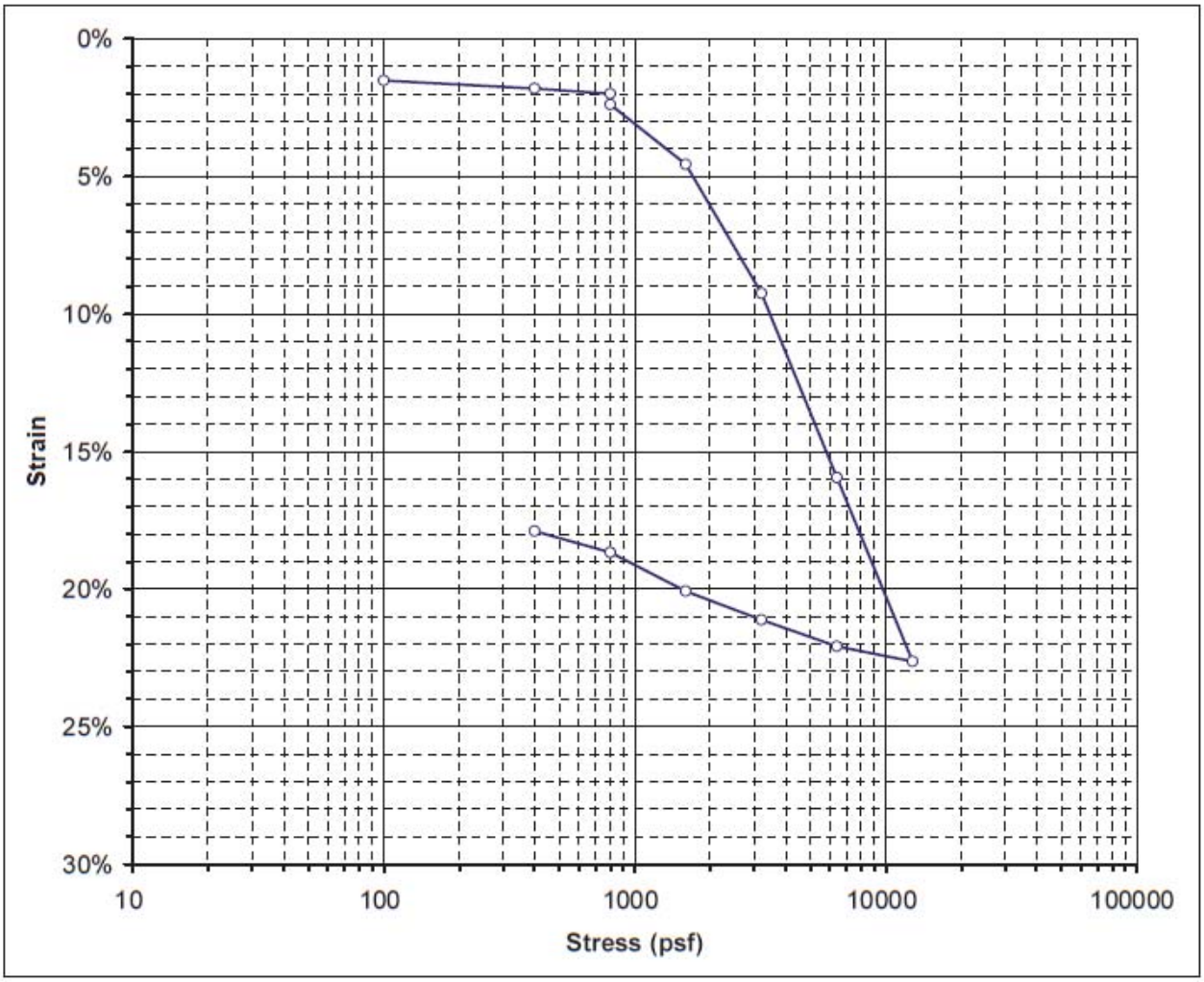
PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2I

GROUP DELTA CONSULTANTS

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-3-12\Consol B-RW041R2A@5'_2.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW041	Sample Depth	25 ft
Sample No.	R6A	USCS	0

BEFORE TEST

Initial Moisture Content:	58.0%	
Initial Dry Unit Wt:	65.2	pcf
Initial Total Unit Wt.:	103.0	pcf
Initial Void Ratio:	1.6717	
Initial Degree of Saturation:	96.8%	

AFTER TEST

Final Moisture Content:	45.4%	
Final Dry Unit Wt:	78.3	pcf
Final Total Unit Wt.:	122.9	pcf
Final Void Ratio:	1.2229	
Final Degree of Saturation:	103.5%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=	64	PL=	33	PI=	31

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.52%	1.6311
400	1.81%	1.6234
800	2.00%	1.6183
800	2.40%	1.6076
1600	4.57%	1.5496
3200	9.25%	1.4246
6400	15.94%	1.2459
12800	22.63%	1.0671
6400	22.08%	1.0818
3200	21.11%	1.1077
1600	20.08%	1.1353
800	18.67%	1.1729
400	17.89%	1.1938

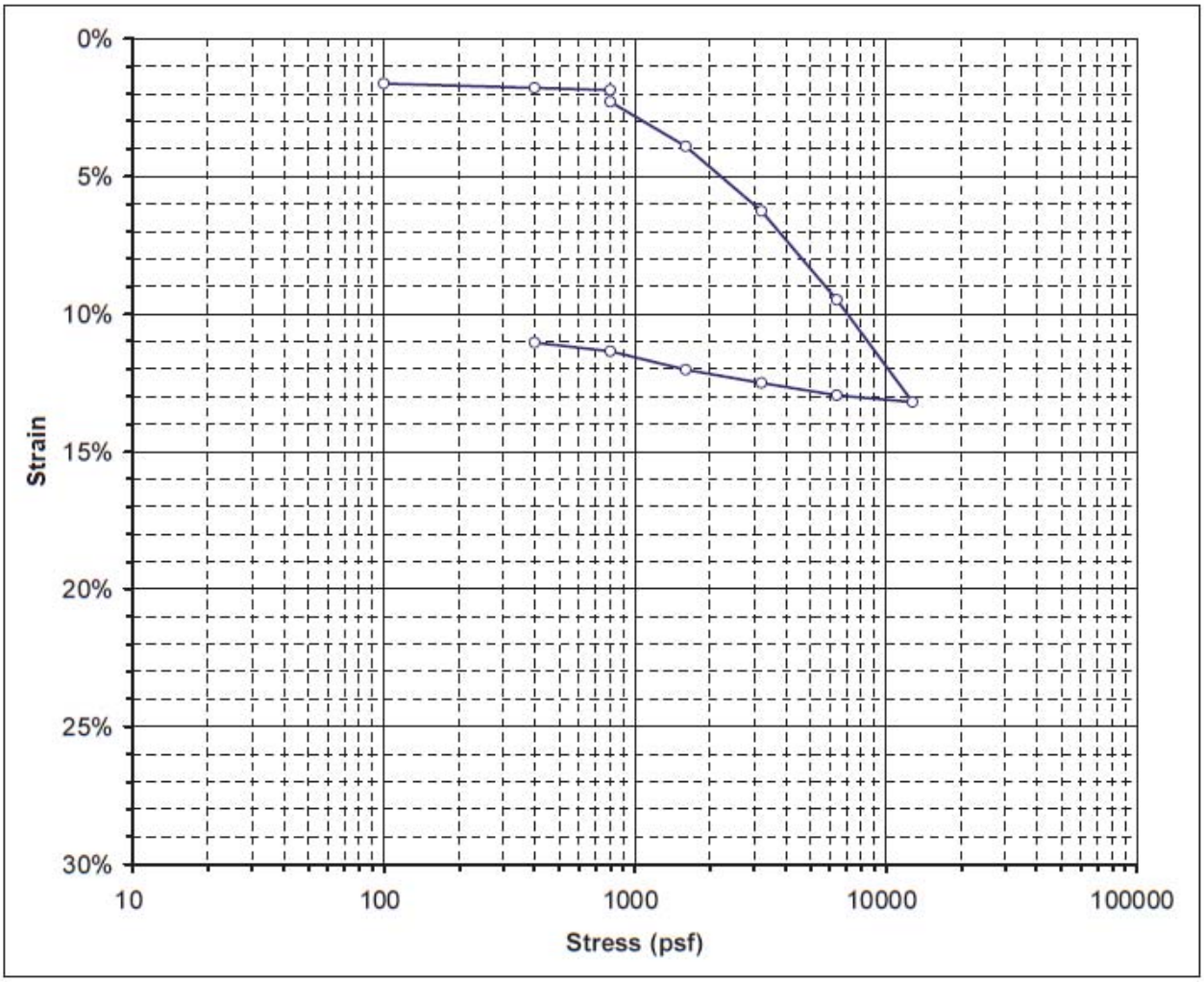
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2m

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-3-12\Consol B-RW041R6A@25'_3.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW044	Sample Depth	55 ft
Sample No.	R11	USCS	0

BEFORE TEST

Initial Moisture Content:	33.3%	
Initial Dry Unit Wt:	88.0	pcf
Initial Total Unit Wt.:	117.3	pcf
Initial Void Ratio:	0.9775	
Initial Degree of Saturation:	95.0%	

AFTER TEST

Final Moisture Content:	27.8%	
Final Dry Unit Wt:	98.4	pcf
Final Total Unit Wt.:	114.5	pcf
Final Void Ratio:	0.7692	
Final Degree of Saturation:	100.9%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.63%	0.9452
400	1.79%	0.9420
800	1.86%	0.9406
800	2.29%	0.9321
1600	3.92%	0.9000
3200	6.26%	0.8536
6400	9.49%	0.7898
12800	13.21%	0.7163
6400	12.96%	0.7213
3200	12.51%	0.7302
1600	12.02%	0.7397
800	11.36%	0.7528
400	11.04%	0.7591

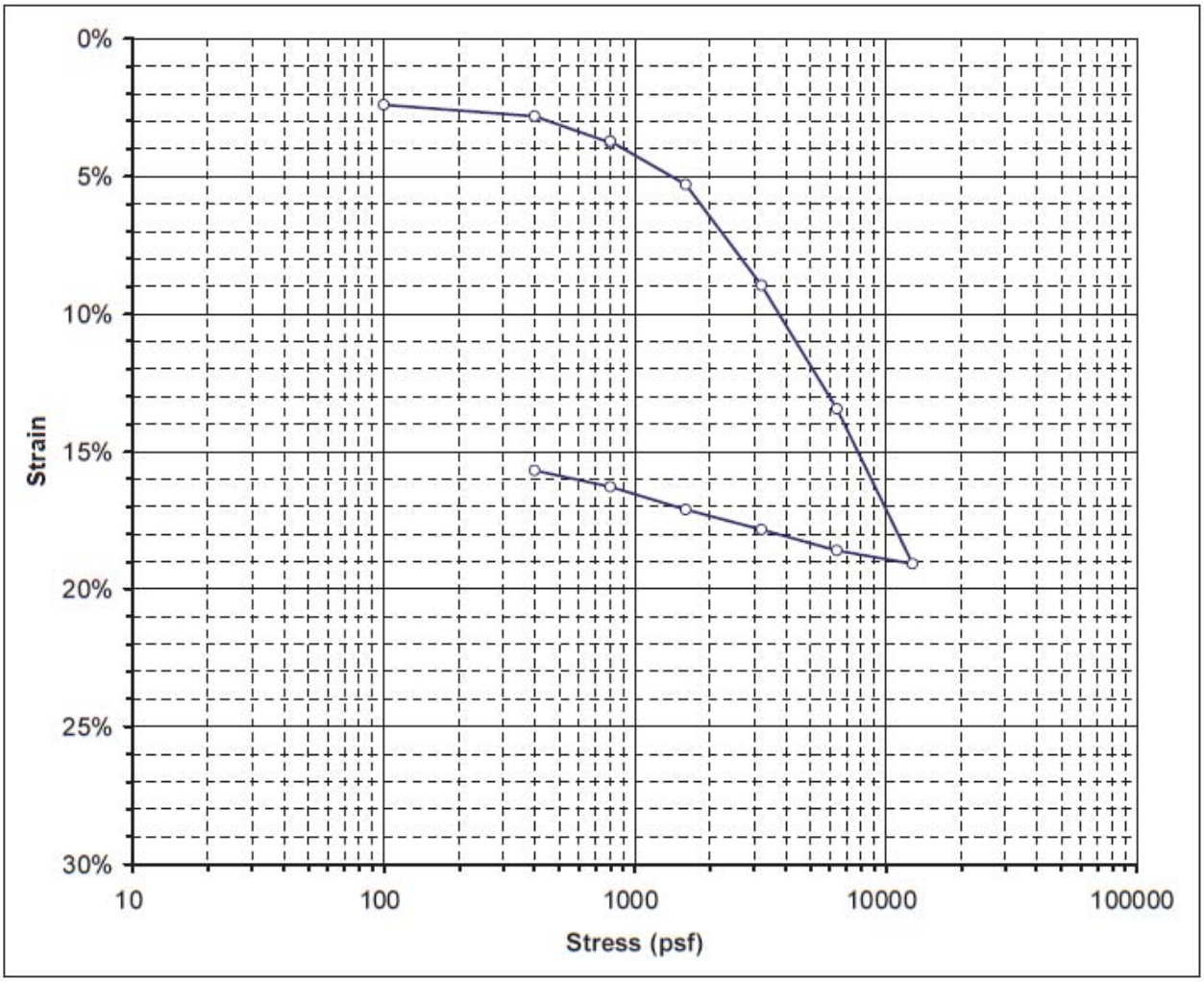
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2n

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-3-12\Consol B-RW044R11@57_4.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW049	Sample Depth	15
Sample No.	R4A	USCS	0

BEFORE TEST

Initial Moisture Content:	72.7%	
Initial Dry Unit Wt:	56.2	pcf
Initial Total Unit Wt.:	97.1	pcf
Initial Void Ratio:	2.0975	
Initial Degree of Saturation:	96.7%	

AFTER TEST

Final Moisture Content:	59.5%	
Final Dry Unit Wt:	65.9	pcf
Final Total Unit Wt.:	120.1	pcf
Final Void Ratio:	1.6422	
Final Degree of Saturation:	101.0%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	2.40%	2.0230
400	2.82%	2.0103
800	3.78%	1.9805
800	3.73%	1.9820
1600	5.30%	1.9333
3200	8.96%	1.8200
6400	13.45%	1.6810
12800	19.08%	1.5065
6400	18.60%	1.5214
3200	17.84%	1.5450
1600	17.10%	1.5677
800	16.28%	1.5931
400	15.69%	1.6114

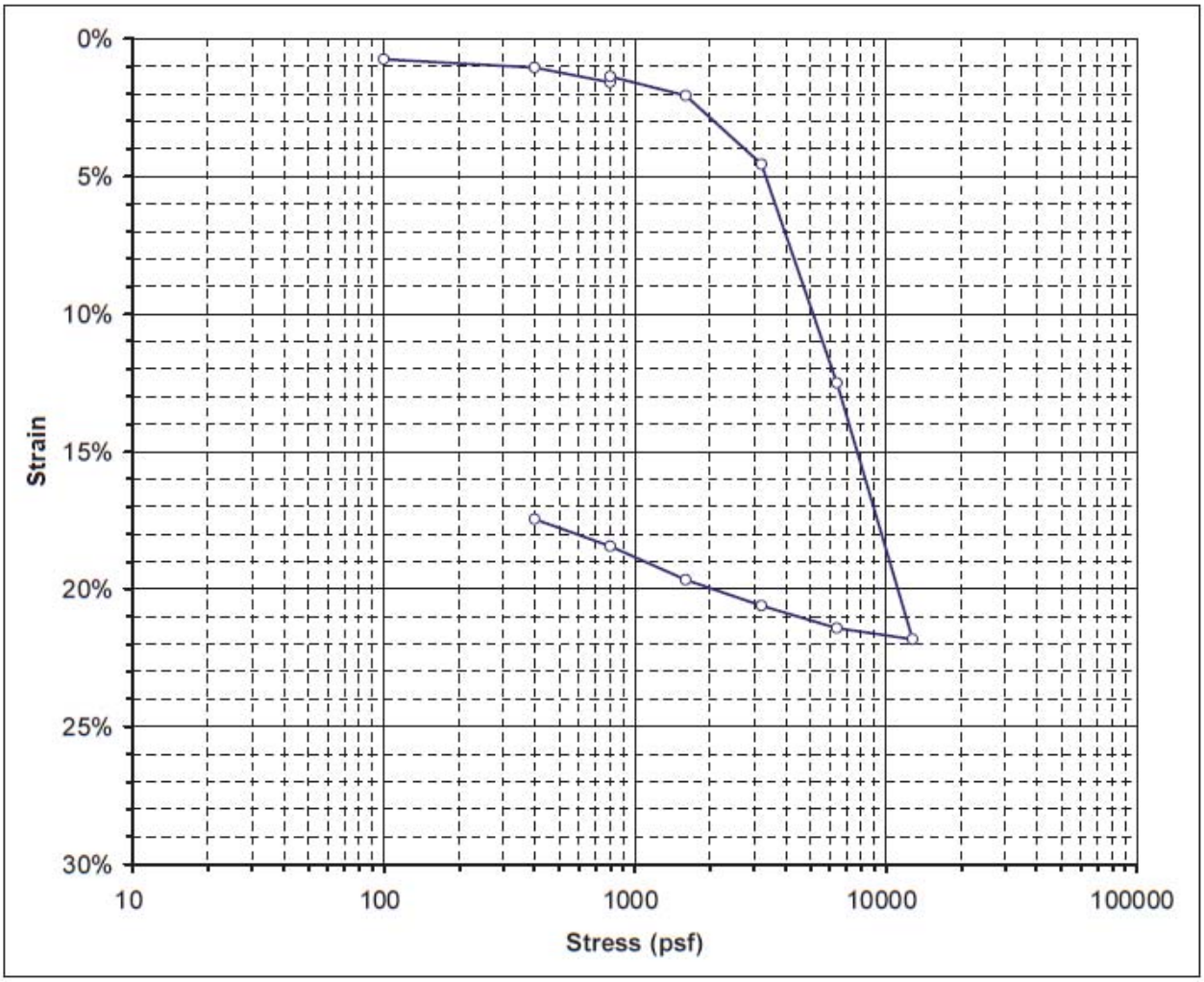
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2o

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-17-12\Consol A-RW049R4A@15'_4.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW049	Sample Depth	25 ft
Sample No.	R6A	USCS	0

BEFORE TEST

Initial Moisture Content:	64.3%	
Initial Dry Unit Wt:	60.4	pcf
Initial Total Unit Wt.:	99.2	pcf
Initial Void Ratio:	1.8822	
Initial Degree of Saturation:	95.2%	

AFTER TEST

Final Moisture Content:	50.8%	
Final Dry Unit Wt:	72.4	pcf
Final Total Unit Wt.:	122.8	pcf
Final Void Ratio:	1.4048	
Final Degree of Saturation:	100.8%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.75%	1.8605
400	1.05%	1.8518
800	1.59%	1.8362
800	1.37%	1.8426
1600	2.07%	1.8224
3200	4.57%	1.7505
6400	12.51%	1.5217
12800	21.82%	1.2532
6400	21.42%	1.2647
3200	20.60%	1.2884
1600	19.66%	1.3155
800	18.44%	1.3508
400	17.45%	1.3791

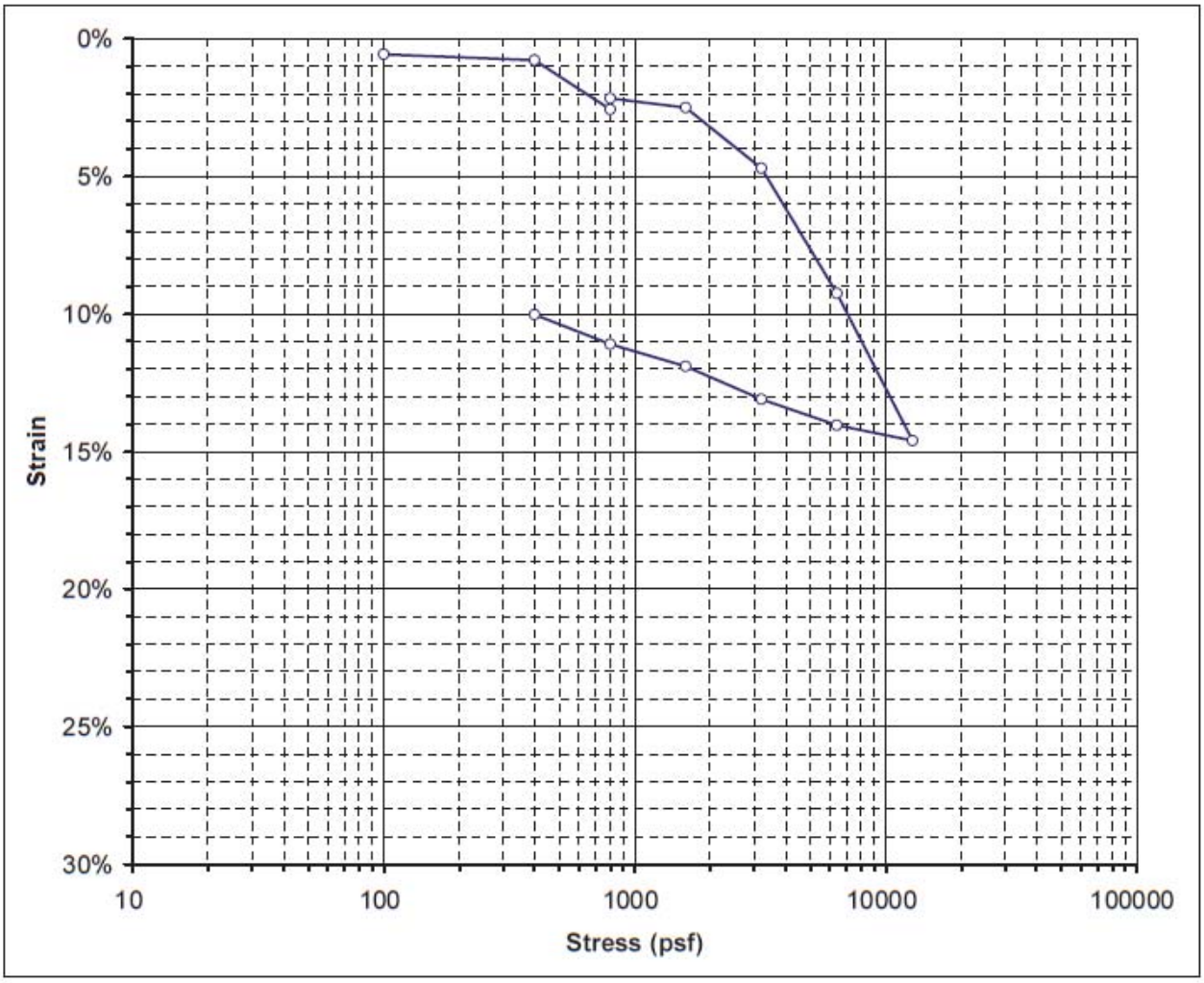
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2p

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-30-12\A-RW049 R6A@25'_1.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-HSA051	Sample Depth	5 ft
Sample No.	R3	USCS	0

BEFORE TEST

Initial Moisture Content:	45.1%	
Initial Dry Unit Wt:	75.7	pcf
Initial Total Unit Wt.:	109.9	pcf
Initial Void Ratio:	1.2998	
Initial Degree of Saturation:	96.9%	

AFTER TEST

Final Moisture Content:	40.9%	
Final Dry Unit Wt:	82.5	pcf
Final Total Unit Wt.:	111.6	pcf
Final Void Ratio:	1.1111	
Final Degree of Saturation:	102.6%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.57%	1.2867
400	0.78%	1.2819
800	2.58%	1.2406
800	2.17%	1.2498
1600	2.51%	1.2422
3200	4.71%	1.1915
6400	9.26%	1.0869
12800	14.60%	0.9641
6400	14.05%	0.9768
3200	13.11%	0.9984
1600	11.90%	1.0261
800	11.10%	1.0445
400	10.03%	1.0692

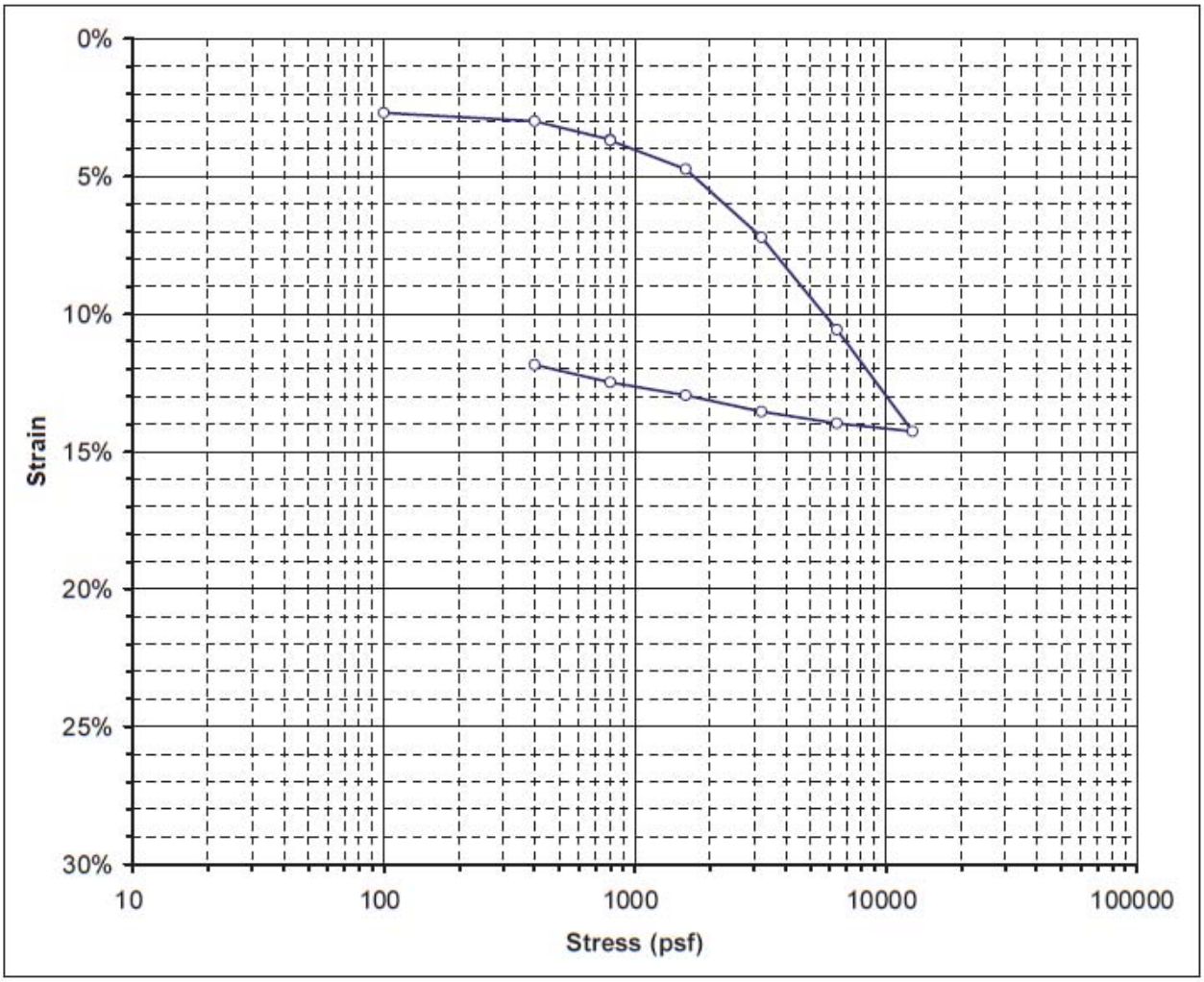
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2q

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 11-9-12\B-HSA051 R3@5_2.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-HSA051	Sample Depth	10 ft
Sample No.	R5	USCS	0

BEFORE TEST

Initial Moisture Content:	43.6%	
Initial Dry Unit Wt:	77.5	pcf
Initial Total Unit Wt.:	111.3	pcf
Initial Void Ratio:	1.2466	
Initial Degree of Saturation:	97.5%	

AFTER TEST

Final Moisture Content:	36.8%	
Final Dry Unit Wt:	86.3	pcf
Final Total Unit Wt.:	114.5	pcf
Final Void Ratio:	1.0165	
Final Degree of Saturation:	100.9%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	2.69%	1.1861
400	2.99%	1.1793
800	3.67%	1.1642
800	3.70%	1.1635
1600	4.74%	1.1401
3200	7.22%	1.0845
6400	10.57%	1.0091
12800	14.27%	0.9260
6400	13.98%	0.9326
3200	13.55%	0.9423
1600	12.95%	0.9556
800	12.48%	0.9662
400	11.85%	0.9804

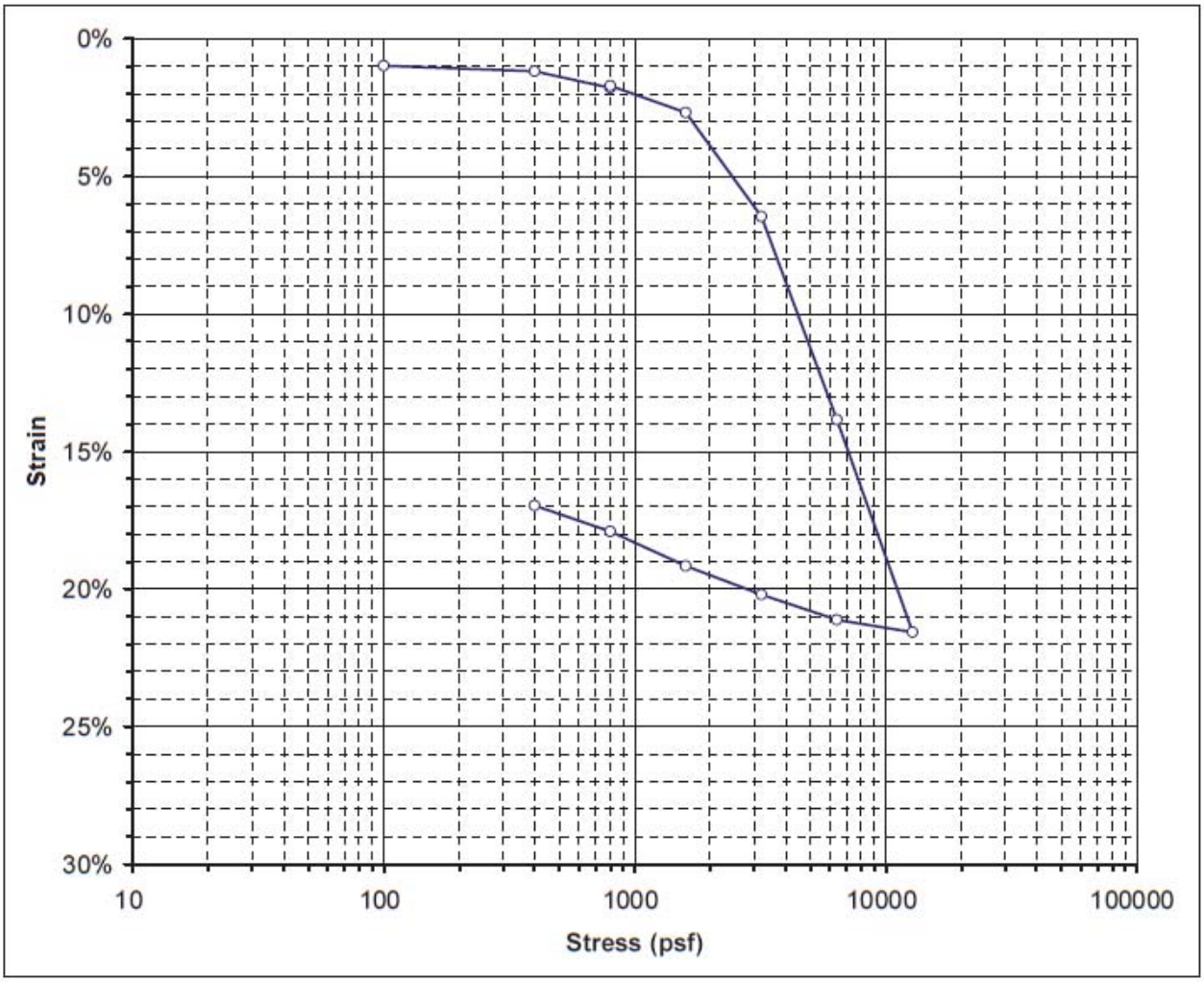
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2r

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 11-9-12\B-HSA051 R5@10'_3.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW053	Sample Depth	10 ft
Sample No.	R2A	USCS	0

BEFORE TEST

Initial Moisture Content:	59.5%	
Initial Dry Unit Wt:	63.9	pcf
Initial Total Unit Wt.:	101.8	pcf
Initial Void Ratio:	1.7261	
Initial Degree of Saturation:	96.1%	

AFTER TEST

Final Moisture Content:	47.6%	
Final Dry Unit Wt:	76.2	pcf
Final Total Unit Wt.:	122.1	pcf
Final Void Ratio:	1.2845	
Final Degree of Saturation:	103.4%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.98%	1.6993
400	1.19%	1.6937
800	1.79%	1.6773
800	1.71%	1.6795
1600	2.69%	1.6528
3200	6.47%	1.5498
6400	13.84%	1.3488
12800	21.56%	1.1384
6400	21.12%	1.1504
3200	20.20%	1.1755
1600	19.16%	1.2038
800	17.90%	1.2382
400	16.96%	1.2638

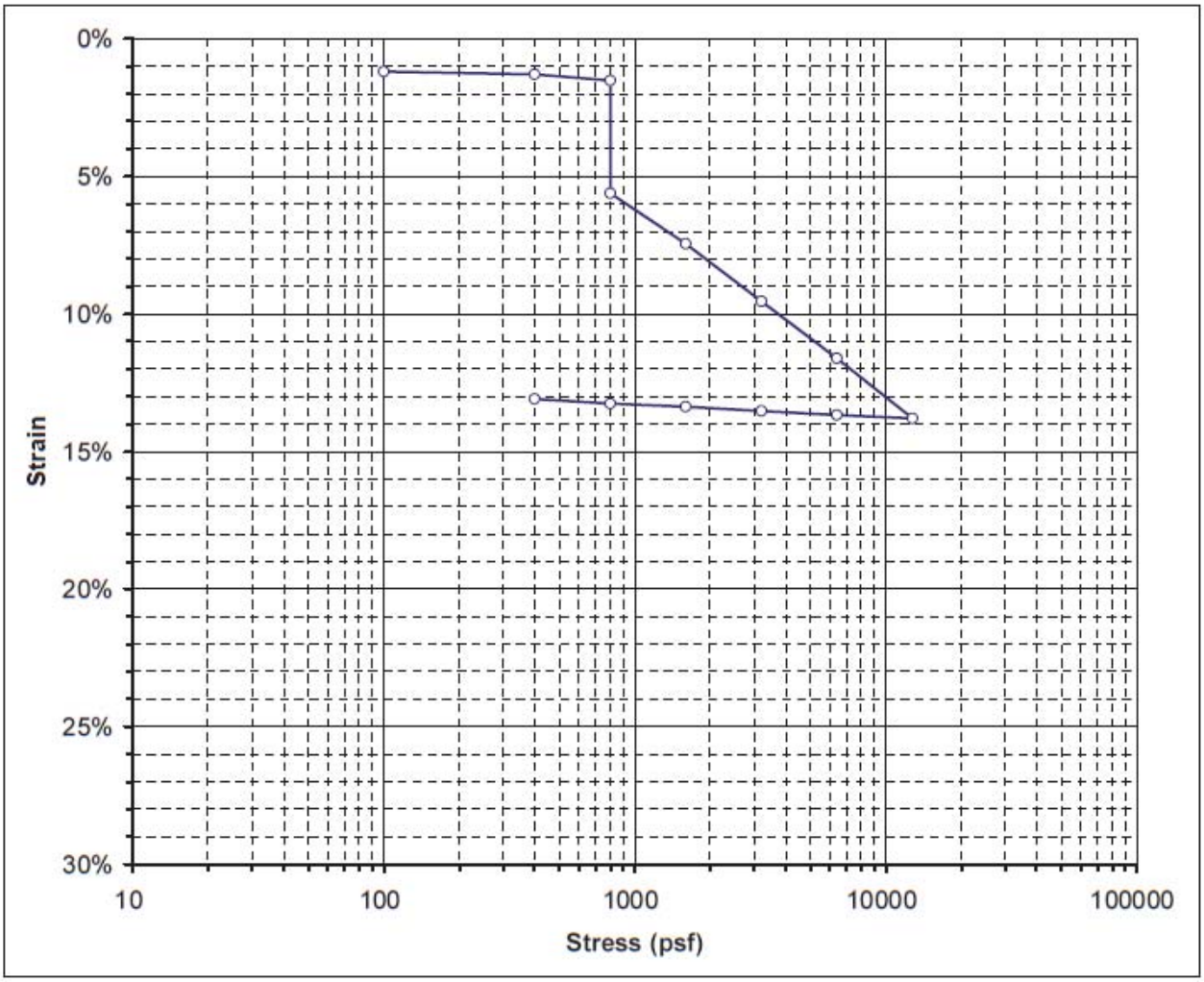
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2s

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 10-30-12\A-RW053 R2A@10' 2.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	C-HSA061	Sample Depth	7.5 ft
Sample No.	R3	USCS	0

BEFORE TEST

Initial Moisture Content:	7.2%	
Initial Dry Unit Wt:	88.6	pcf
Initial Total Unit Wt.:	94.9	pcf
Initial Void Ratio:	0.9655	
Initial Degree of Saturation:	20.8%	

AFTER TEST

Final Moisture Content:	20.7%	
Final Dry Unit Wt:	101.4	pcf
Final Total Unit Wt.:	117.1	pcf
Final Void Ratio:	0.7167	
Final Degree of Saturation:	80.7%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

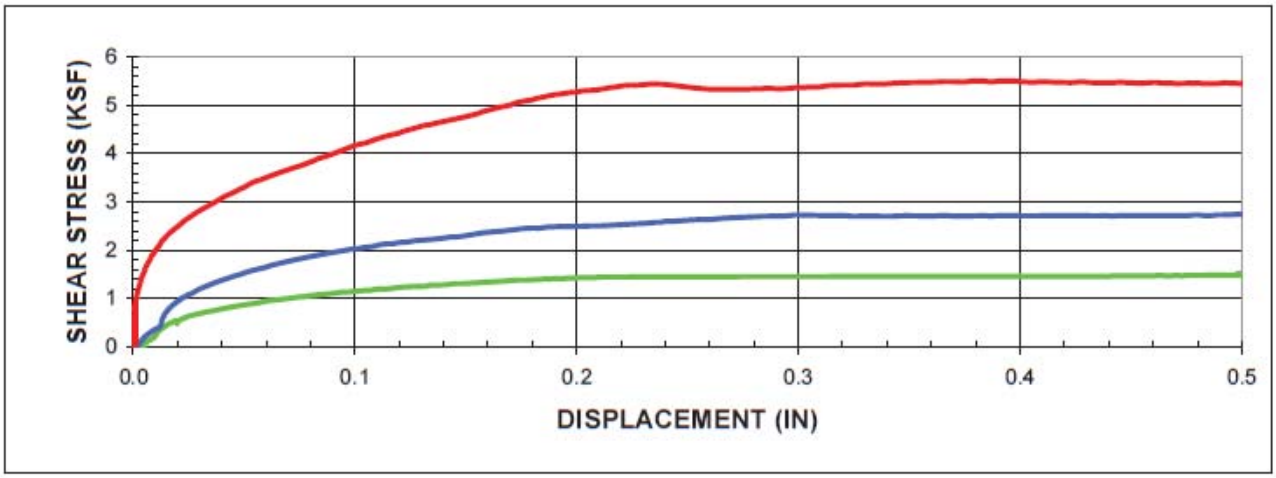
PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.20%	0.9419
400	1.30%	0.9400
800	1.52%	0.9356
800	5.62%	0.8551
1600	7.45%	0.8191
3200	9.55%	0.7778
6400	11.61%	0.7373
12800	13.80%	0.6943
6400	13.67%	0.6968
3200	13.53%	0.6996
1600	13.37%	0.7027
800	13.26%	0.7049
400	13.09%	0.7082

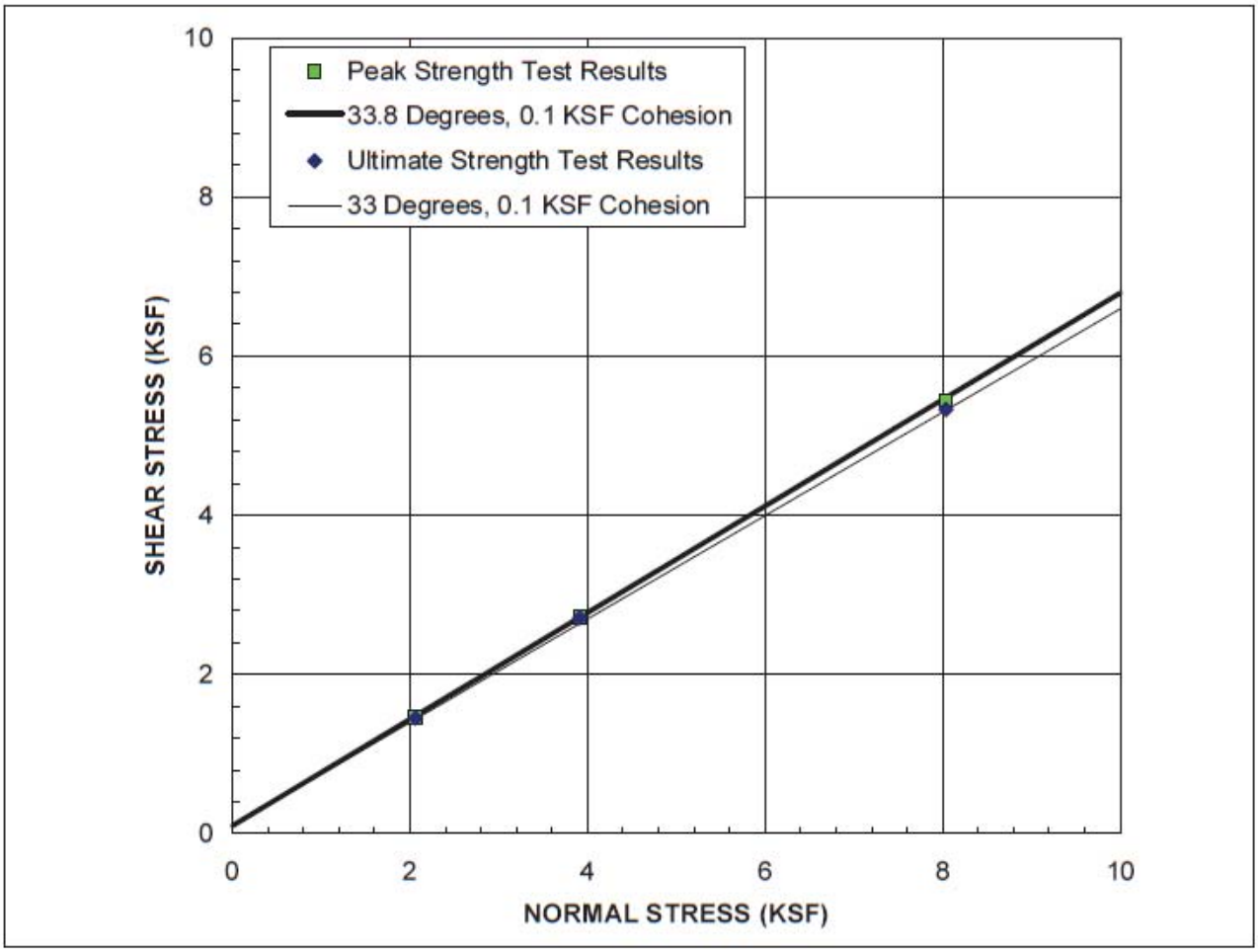
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B1-2t

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptual geotech\Lab\Consol LA962A 11-9-12\C-HSA061 R3@7.5_4.xls





SAMPLE: A-RW002 R6@40'

Description: Very Dark Greenish Gray Sandy Silty Clay with Traces of Shells

STRAIN RATE: 0.0025 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	33.8 °	33.0 °
c'	0.10 KSF	0.10 KSF

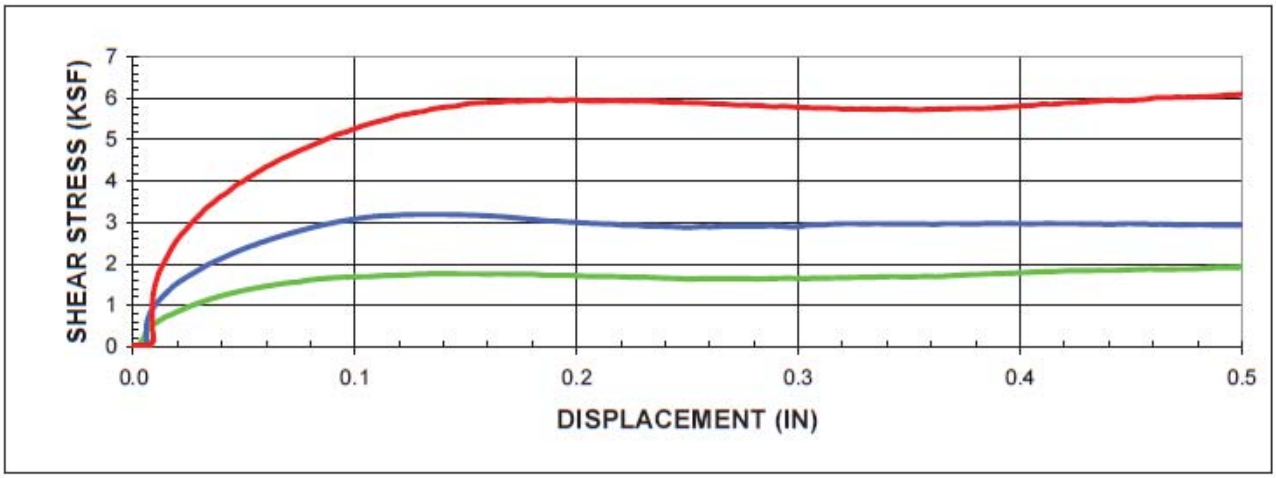
	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	36.1 %

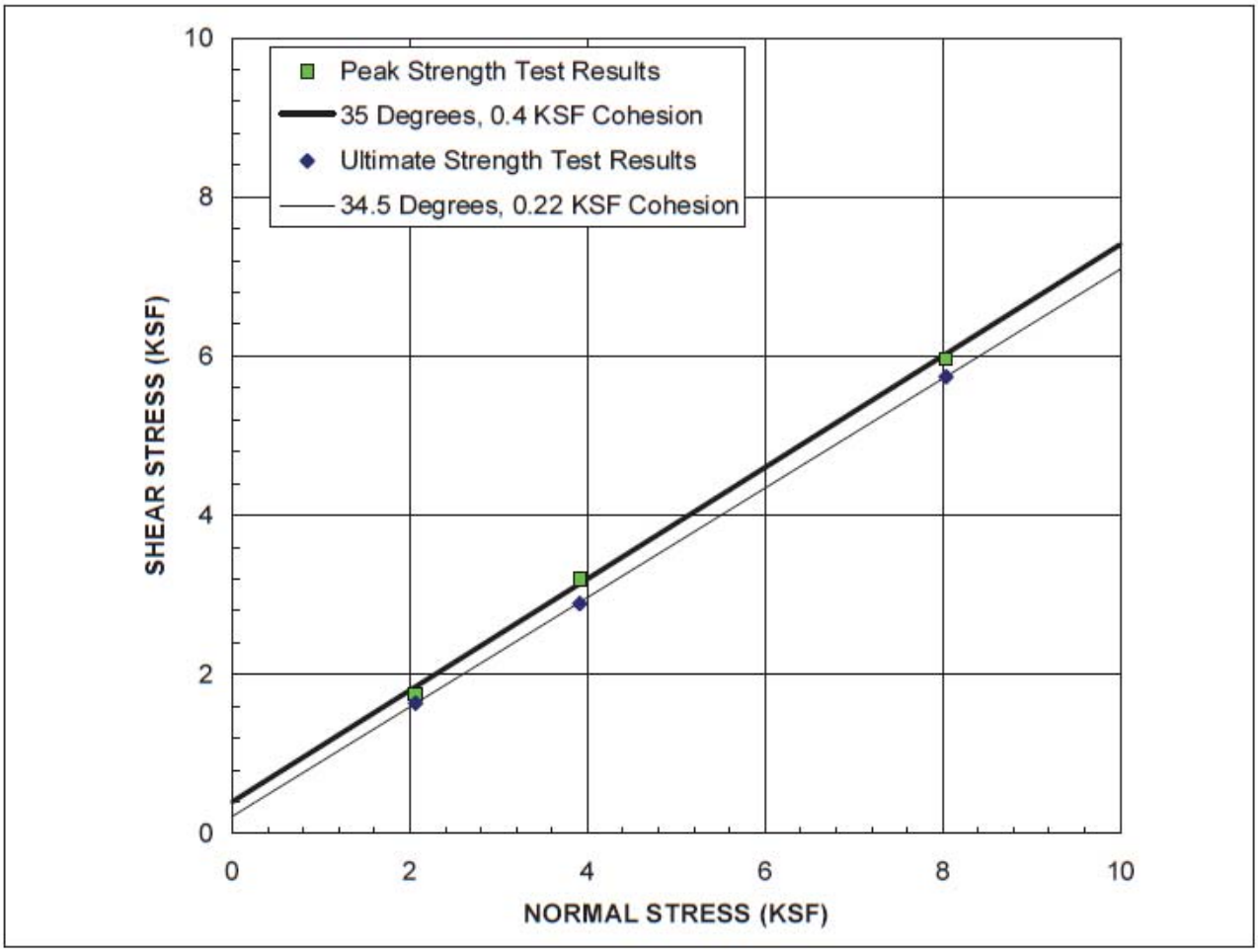
GROUP DELTA
370 Amapola Ave., Suite 212, Torrance, CA 90501
32 Mauchly, Suite B, Irvine, CA 92618
4201 Santa Ana St., Suite F, Ontario, CA 91761
9245 Activity Road, Suite 103, San Diego, CA 92126

DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3a





SAMPLE: A-RW003 R3A@10'

Description:	Very Dark Greenish Gray Clayey Sand with Traces of Shells

STRAIN RATE: 0.0050 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	35 °	34.5 °
c'	0.40 KSF	0.22 KSF

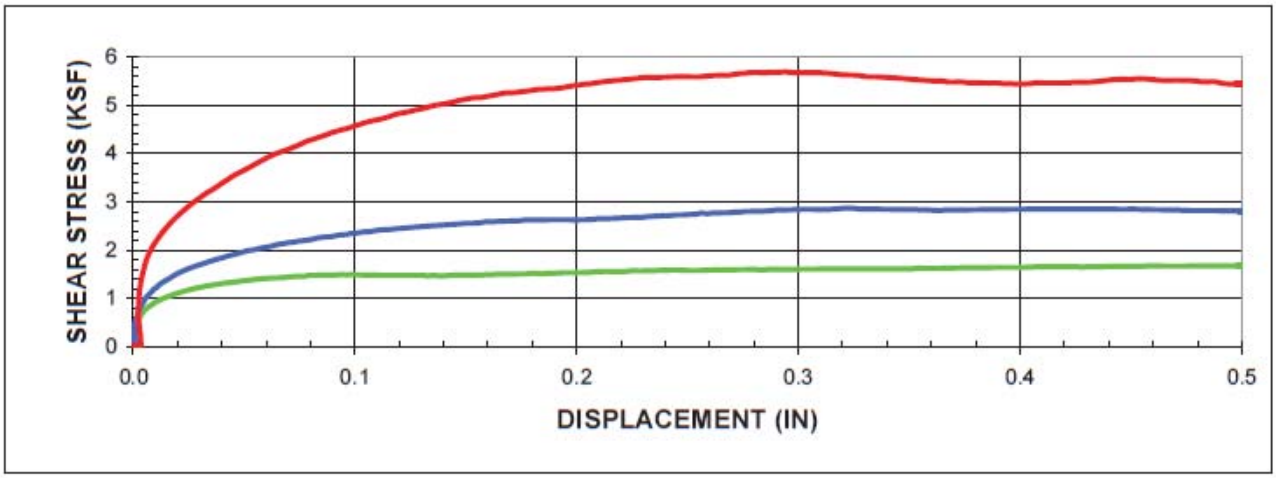
	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	22.0 %

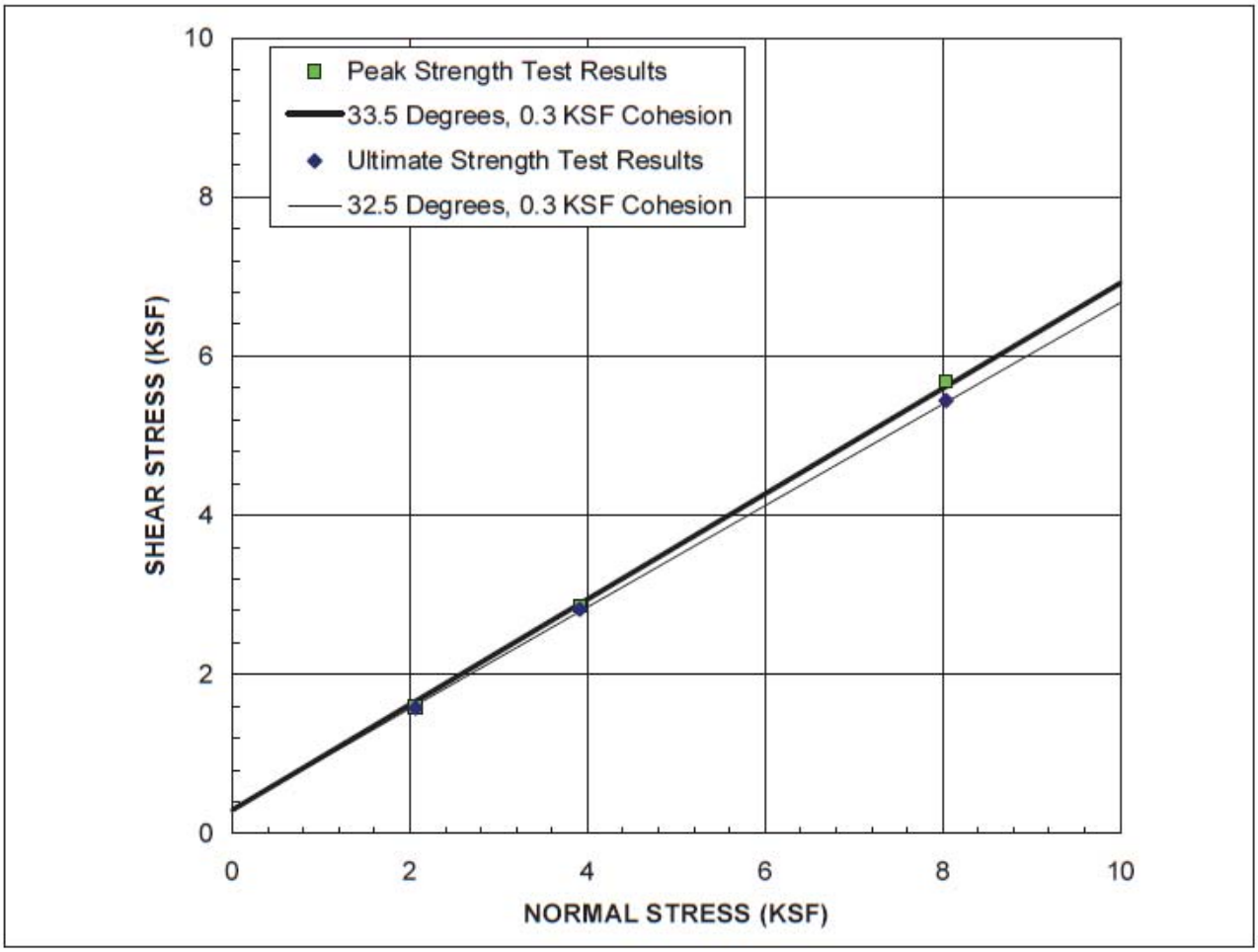
GROUP DELTA CONSULTANTS
370 Amapola Ave., Suite 212, Torrance, CA 90501
32 Mauchly, Suite B, Irvine, CA 92618
4201 Santa Ana St., Suite F, Ontario, CA 91761
9245 Activity Road, Suite 103, San Diego, CA 92126

DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3b





SAMPLE: A-RW003 R7A@30'

Description: Very Dark Greenish Gray Sandy Clay with Shells

STRAIN RATE: 0.0030 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	33.5 °	32.5 °
c'	0.30 KSF	0.30 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	29.3 %

GROUP DELTA CONSULTANTS
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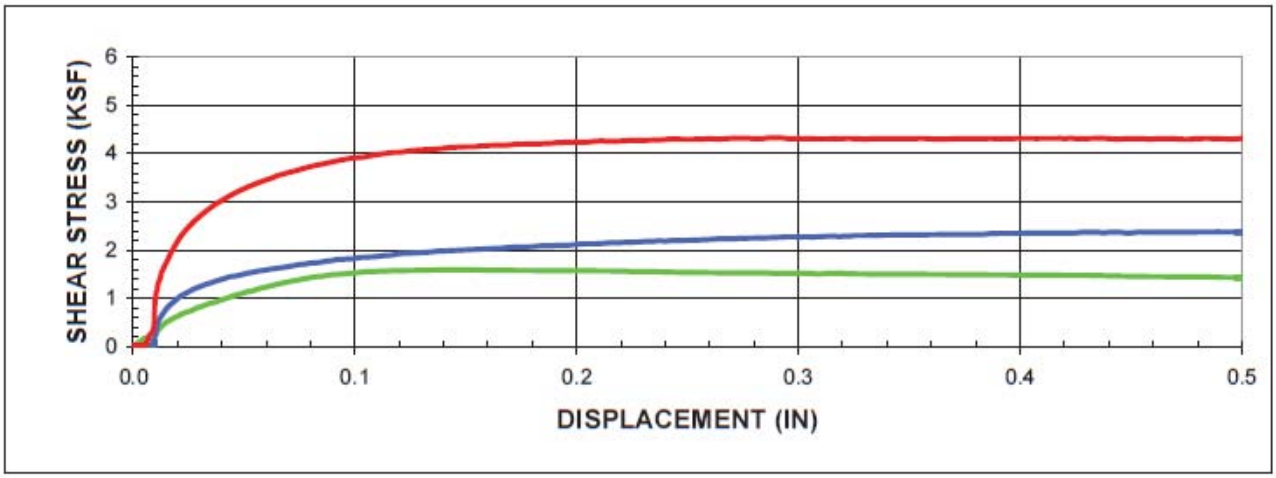
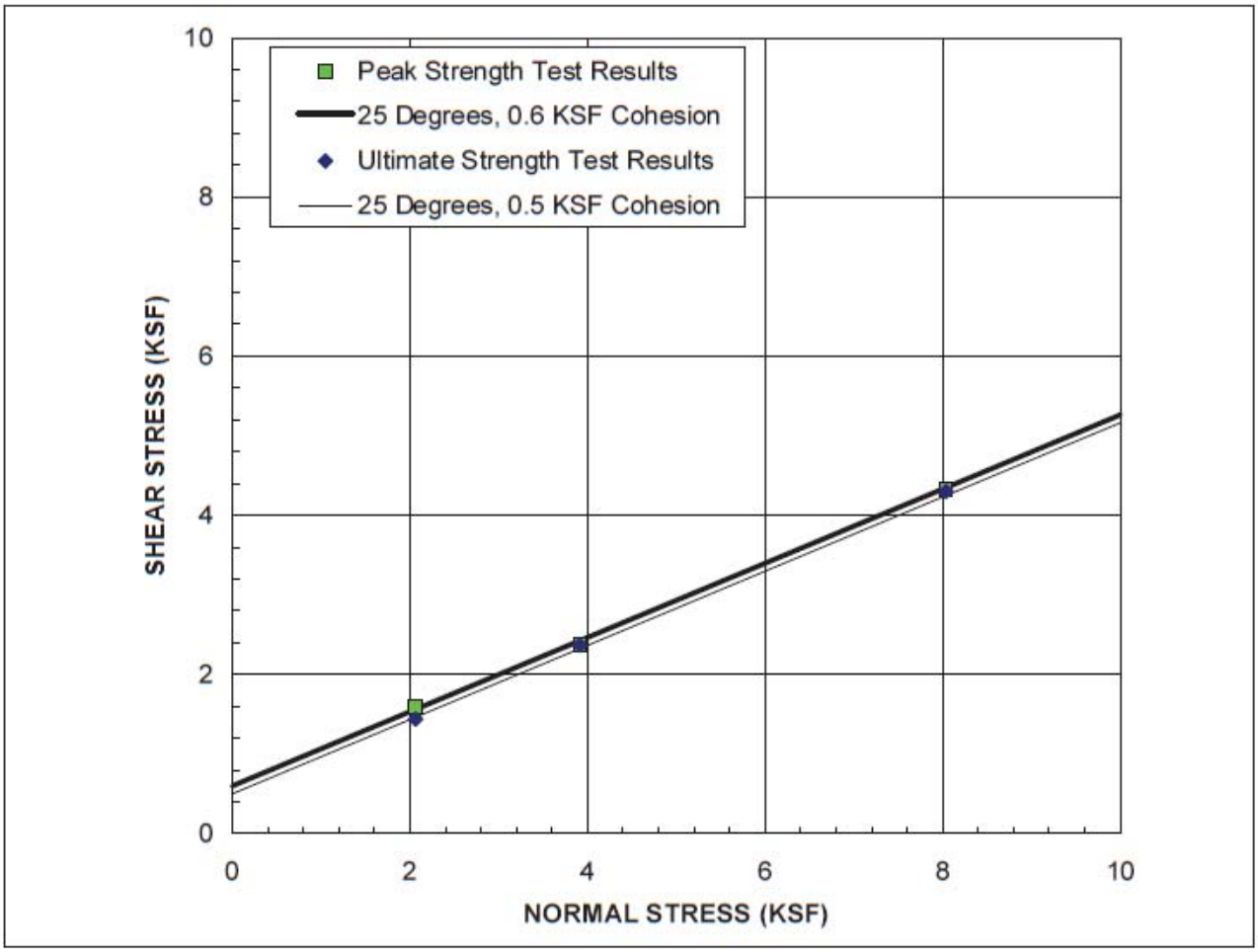
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3c





SAMPLE: A-RW005 R1@5'

Description: Olive Brown Clay with Shells

STRAIN RATE: 0.0025 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	25.0 °	25.0 °
c'	0.60 KSF	0.50 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	28.3 %

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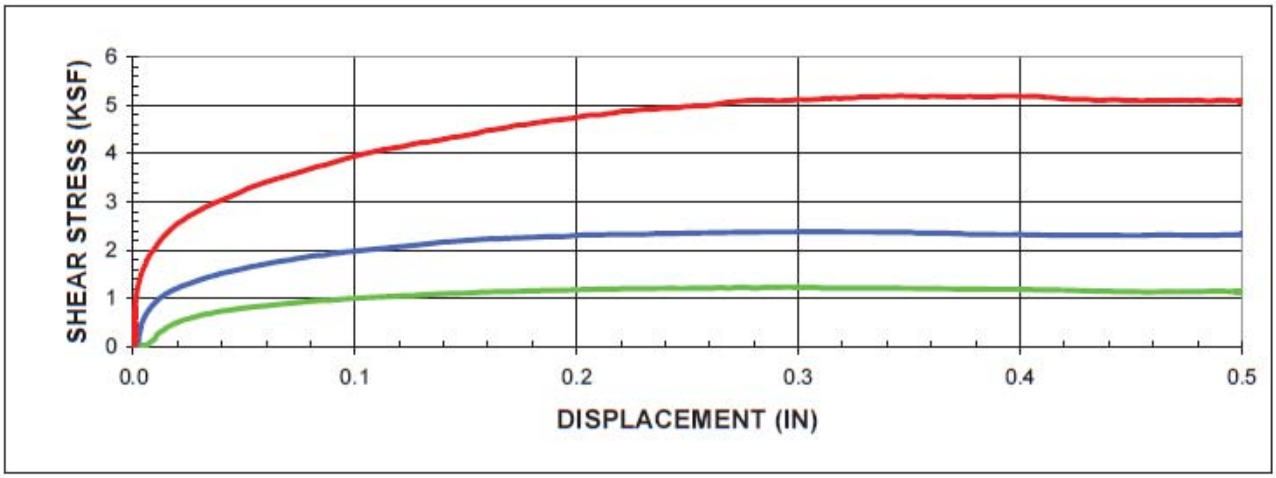
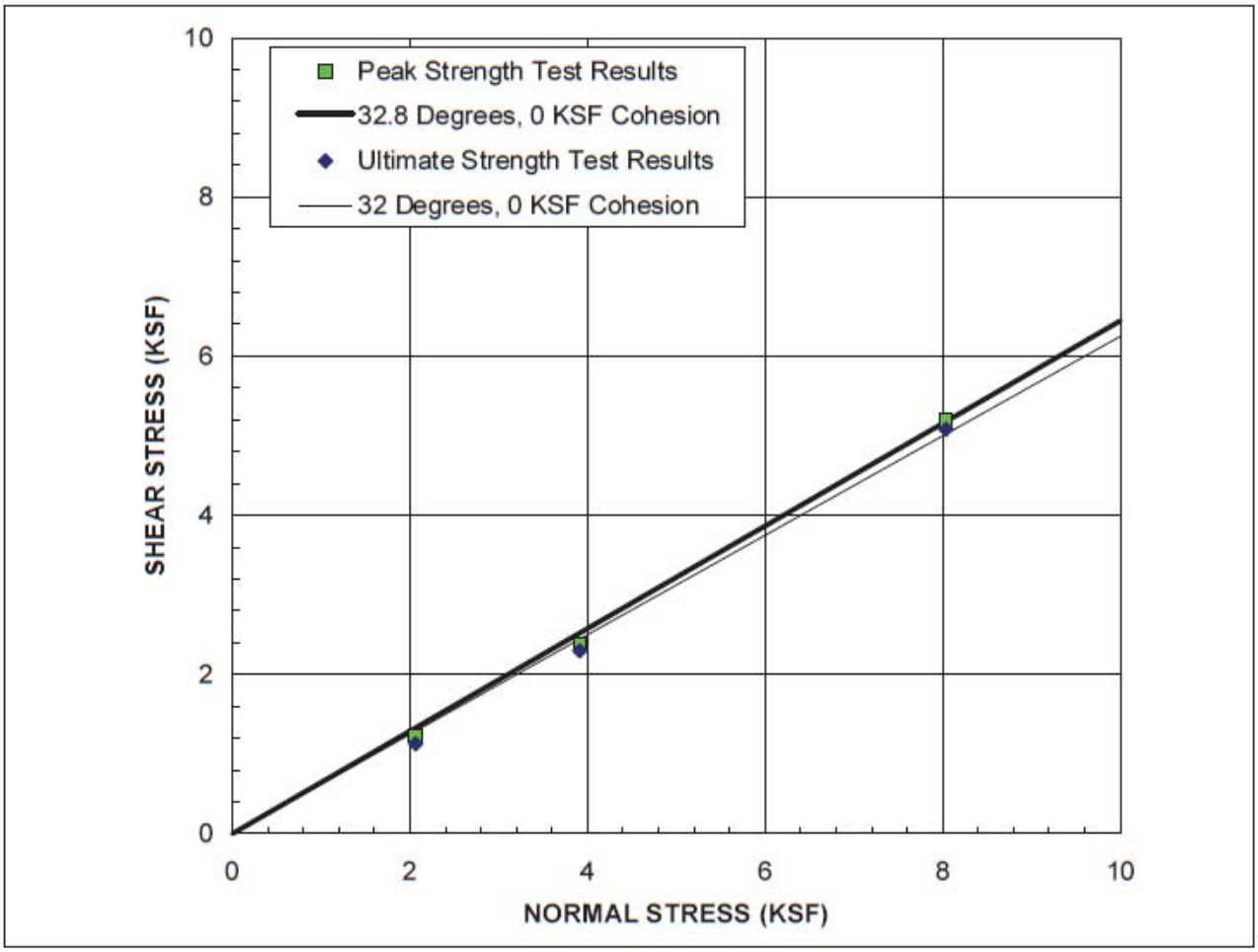
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3d





SAMPLE: A-RW005 R7@35'

Description: Very Dark Greenish Gray Sandy Silty Clay with Traces of Shells

STRAIN RATE: 0.0025 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	32.8 °	32 °
c'	0.00 KSF	0.00 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	43.8 %

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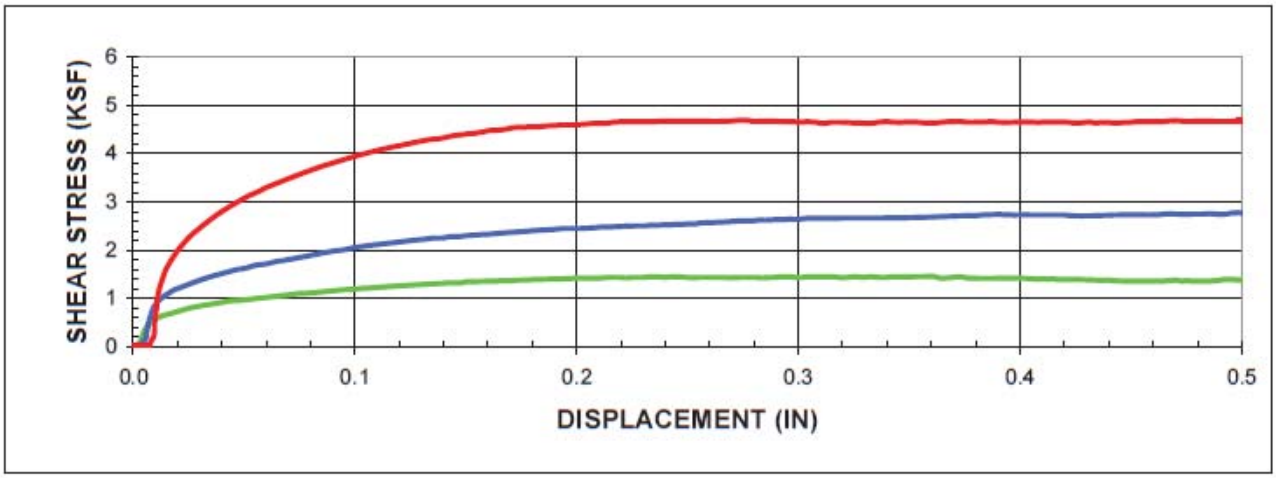
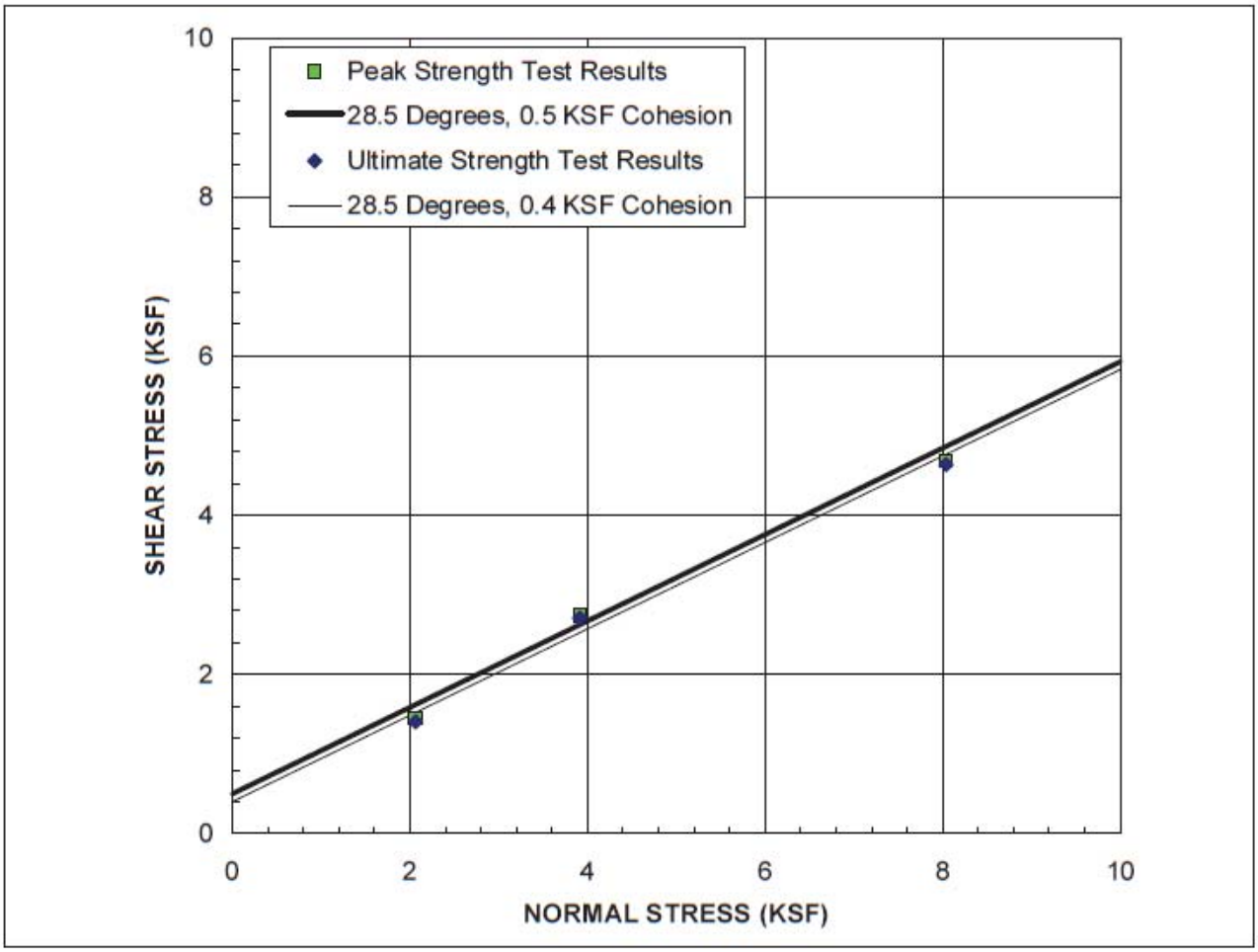
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3e





SAMPLE: A-RW006 R2@5'

Description:	Dark Brown Sandy Silt with Clay and Traces of Gravel with Asphalt

STRAIN RATE: 0.0030 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	28.5 °	28.5 °
c'	0.50 KSF	0.40 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	17.5 %

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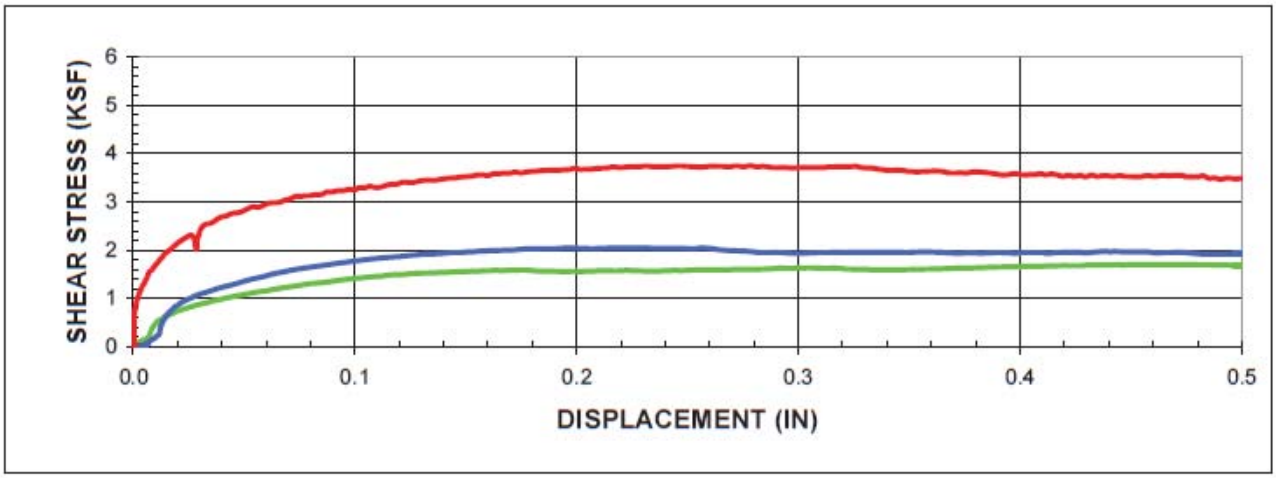
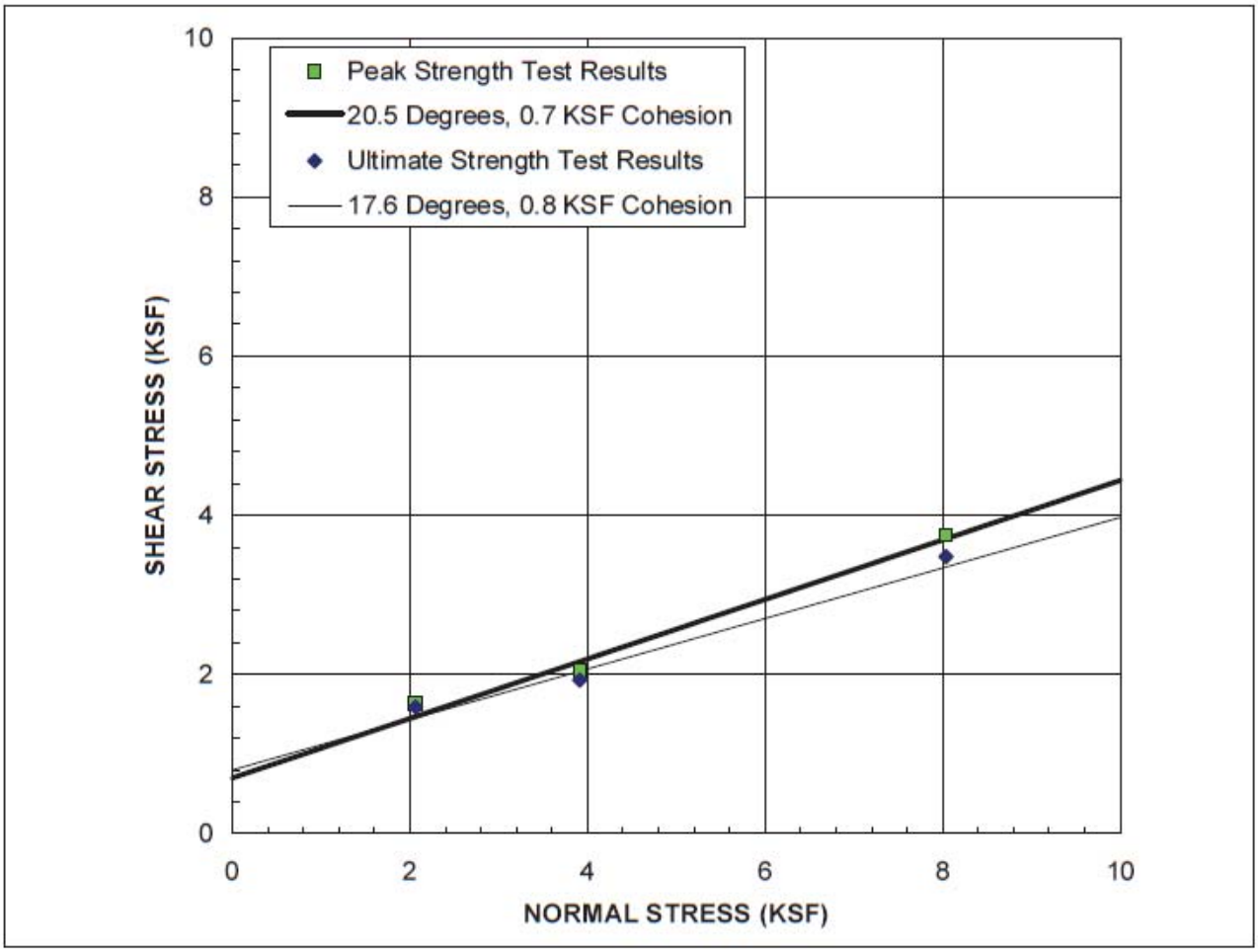
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3f





SAMPLE: A-RW008 R2@10'

Description: Olive Silty Clay with Sand

STRAIN RATE: 0.0025 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	20.5 °	17.6 °
c'	0.70 KSF	0.80 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	37.7 %

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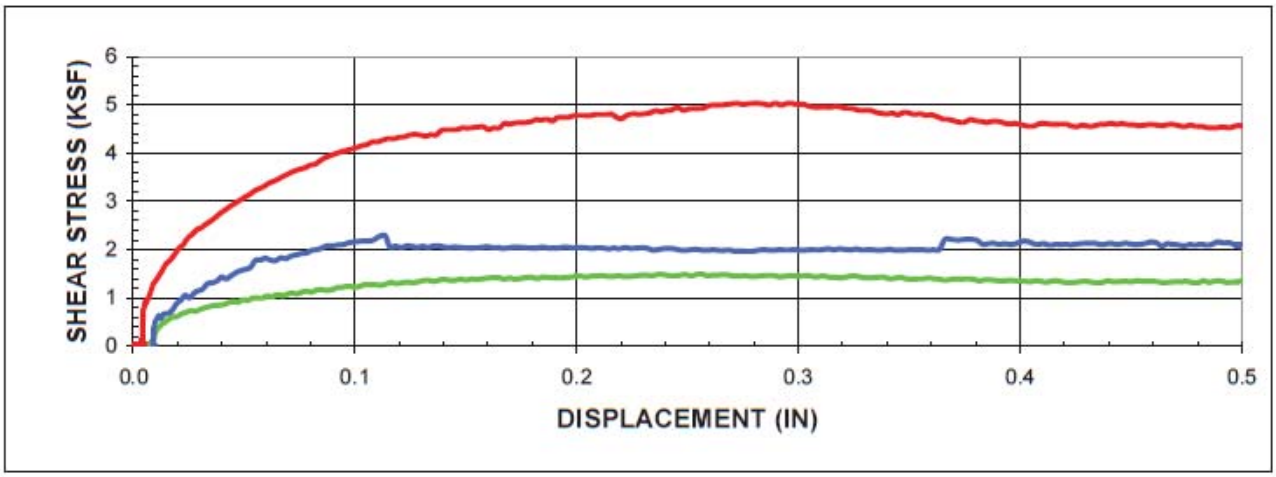
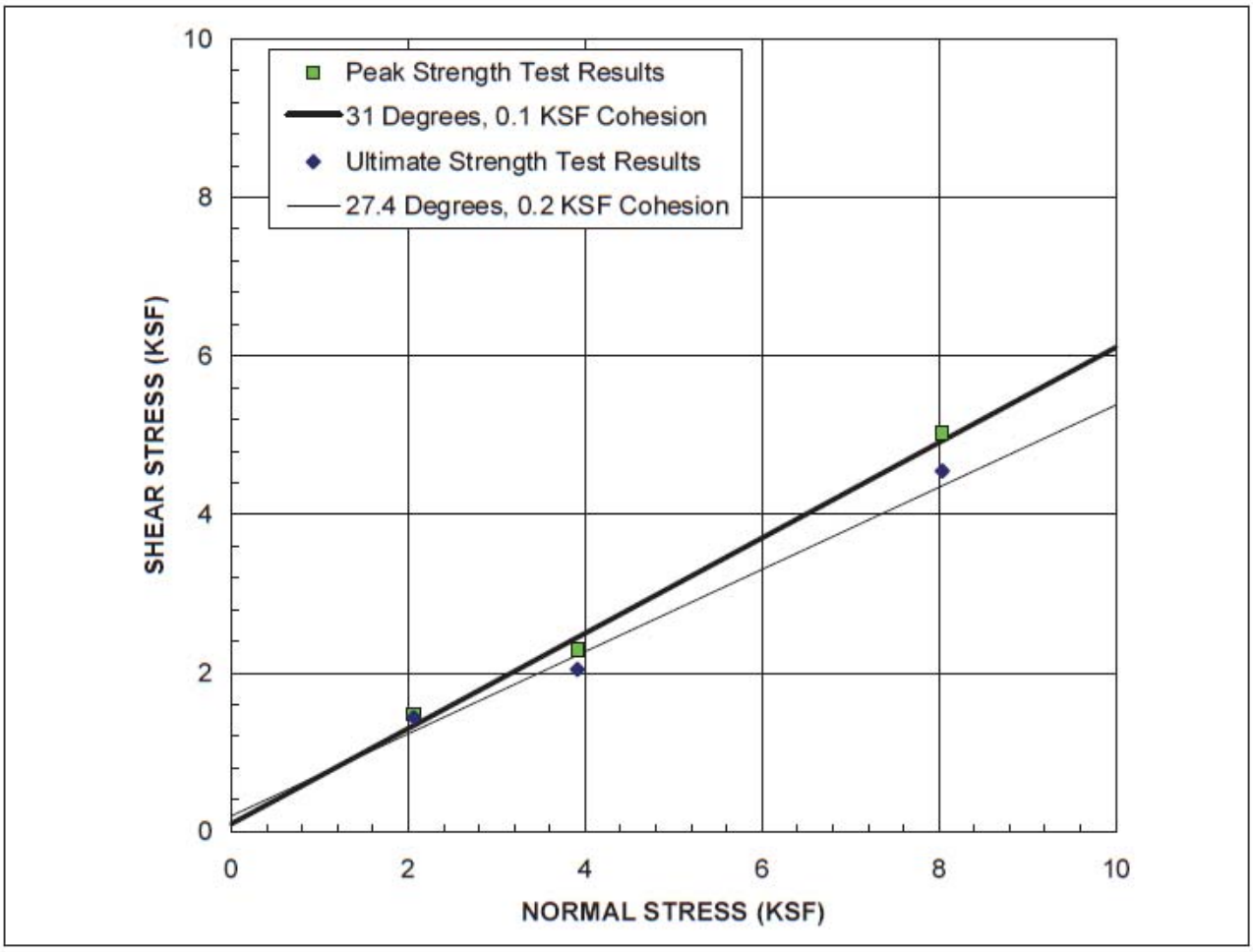
DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3g





SAMPLE: A-RW015 R5@20'

Description: Very Dark greenish Gray Silty Sand with Traces of Shells

	PEAK	ULTIMATE
ϕ'	31 °	27.4 °
c'	0.10 KSF	0.20 KSF

STRAIN RATE: 0.0050 IN/MIN

(Sample was consolidated and drained)

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	34.8 %

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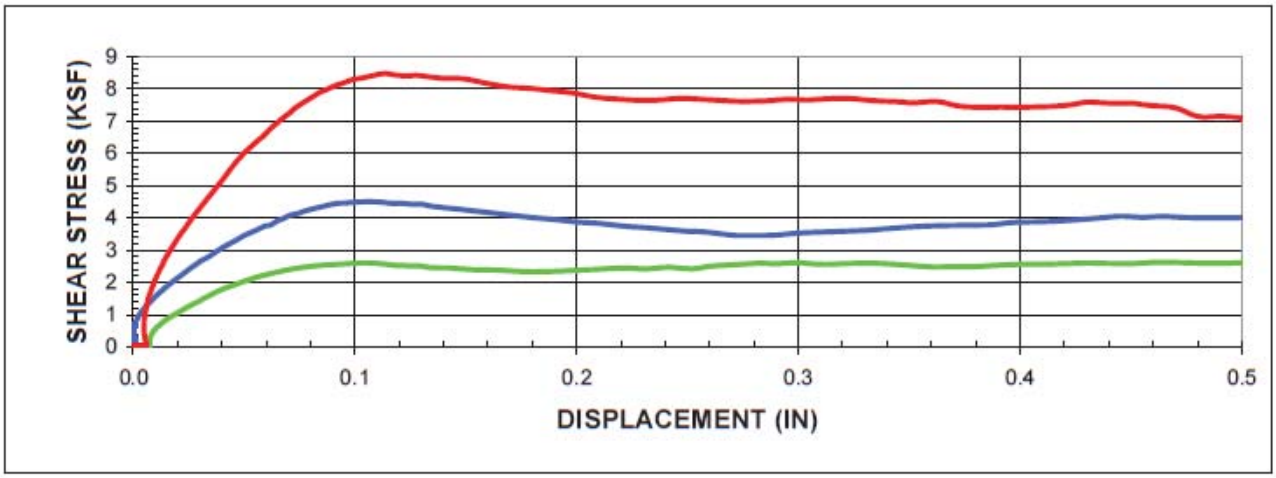
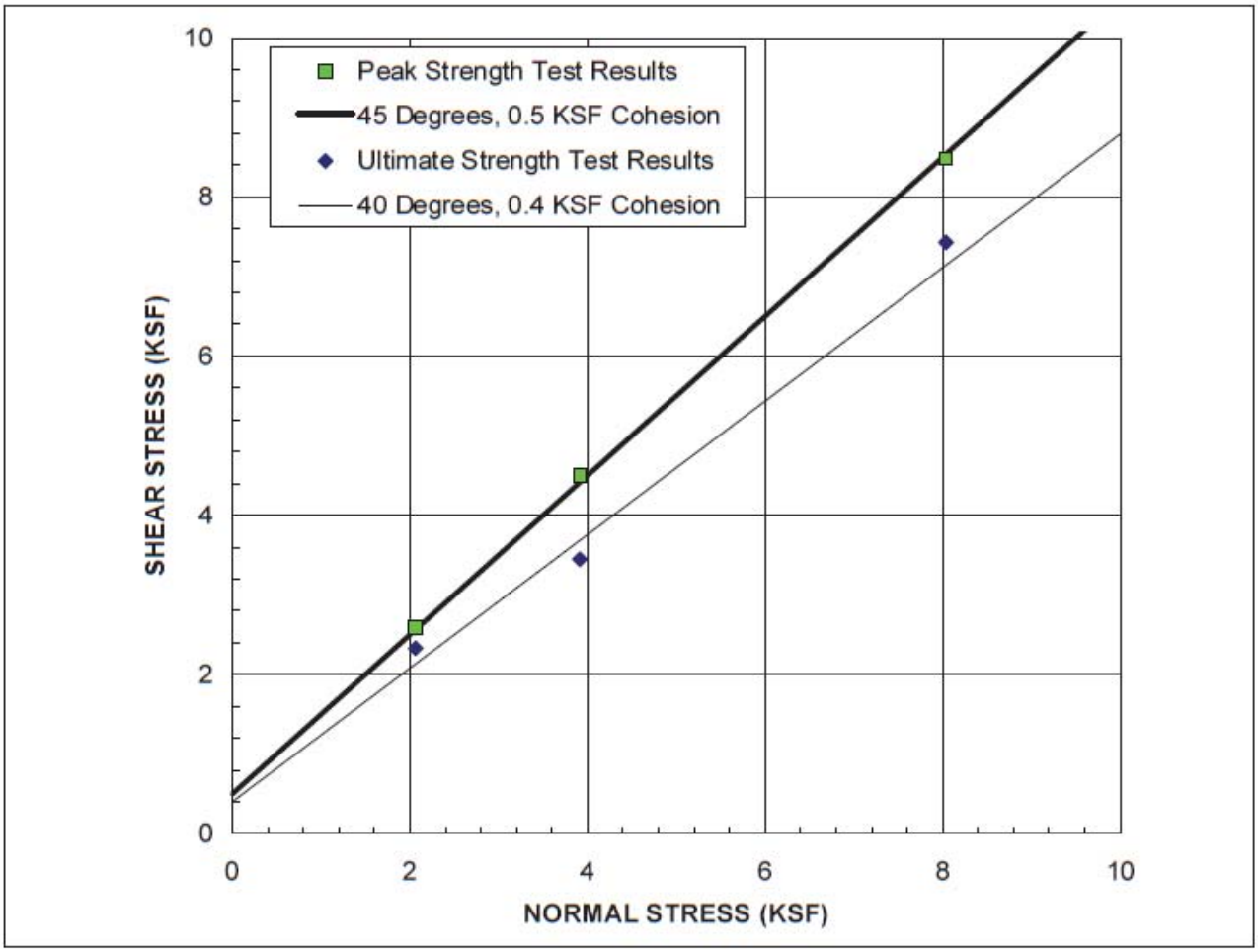
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3h





SAMPLE: A-RW015 R8@32.5

Description: Very Dark Greenish Gray Coarse Sand

STRAIN RATE: 0.0250 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	45 °	40 °
c'	0.50 KSF	0.40 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	19.1 %

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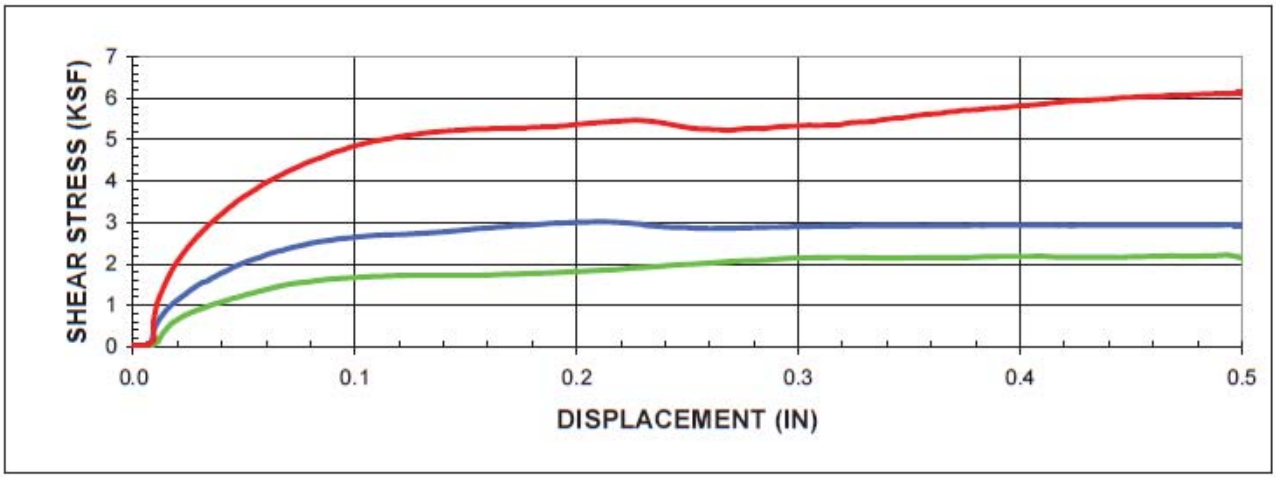
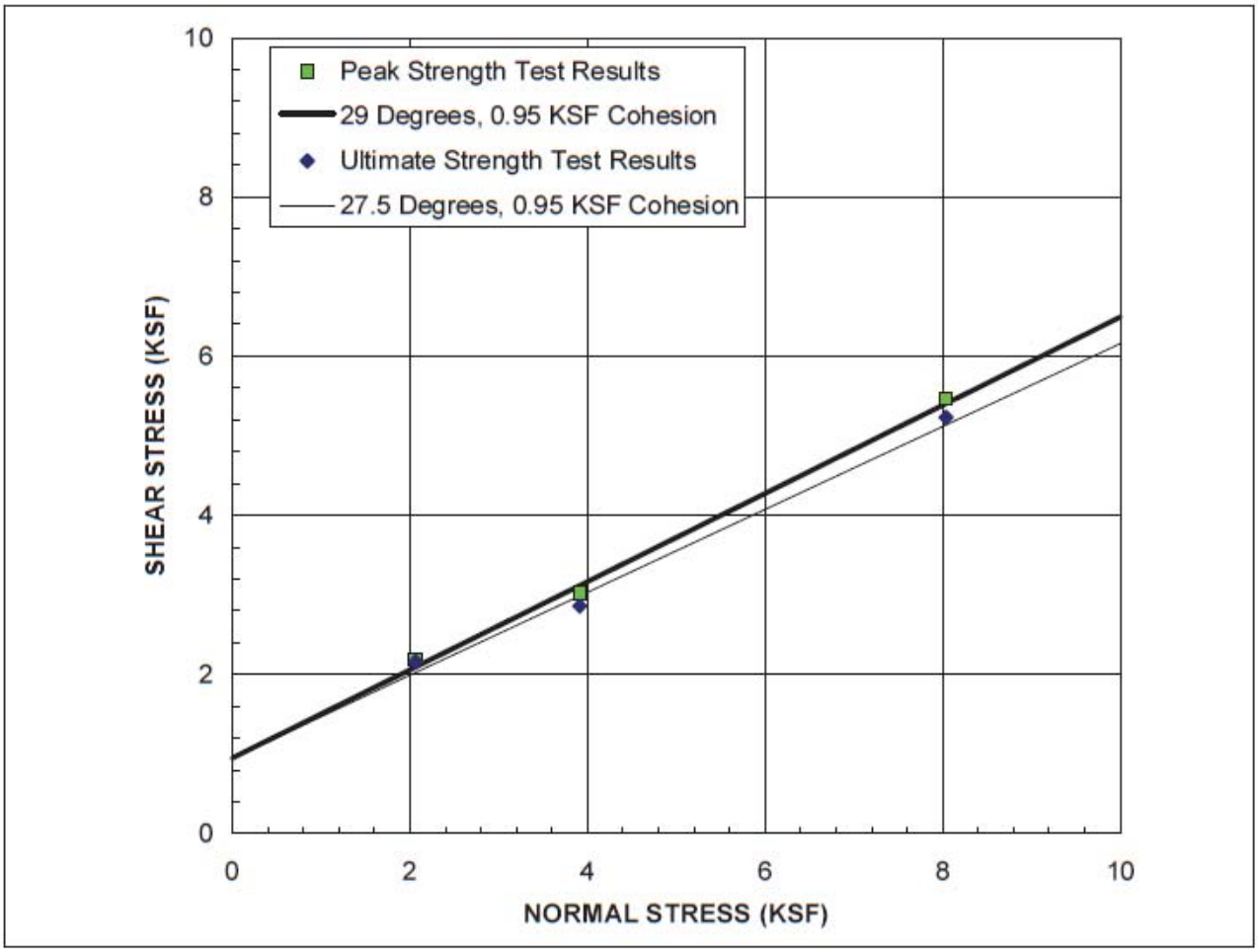
DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3i





SAMPLE: B-RW027 R1@5'

Description: Yellowish Brown Clayey Fine Sand

STRAIN RATE: 0.0050 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	29.0 °	27.5 °
c'	0.95 KSF	0.95 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	25.3 %

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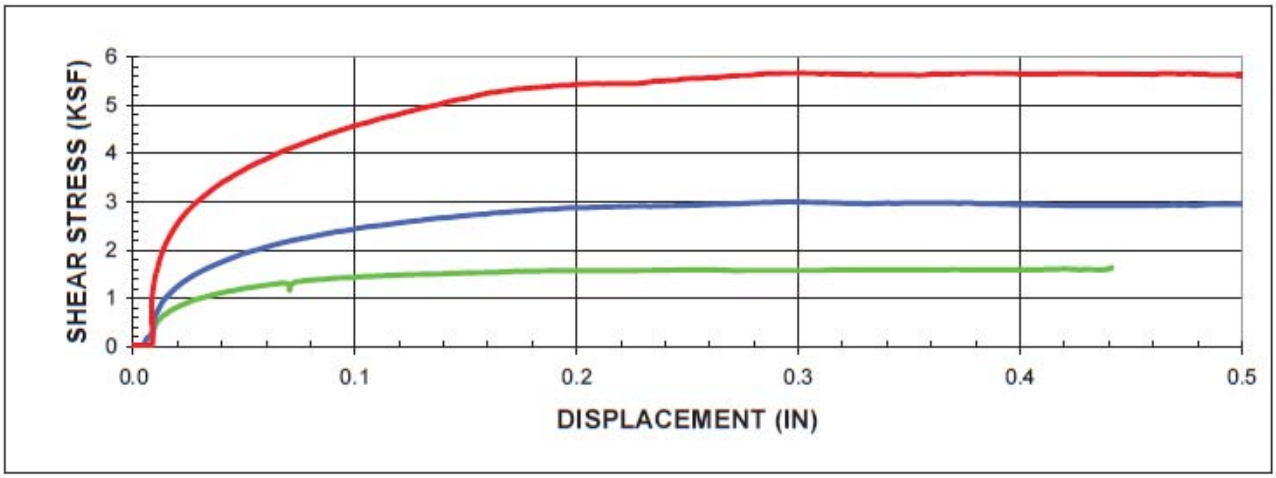
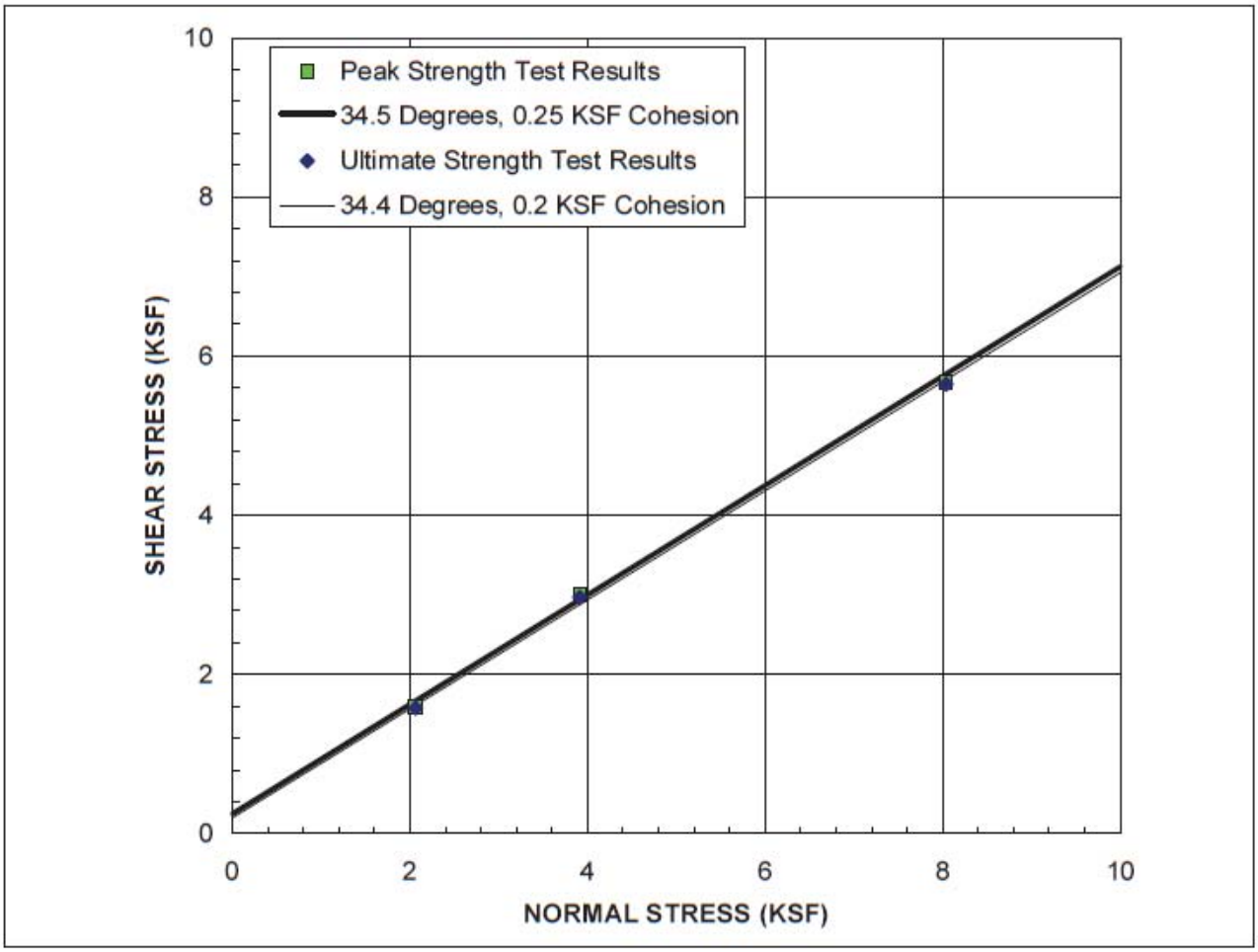
DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3j





SAMPLE: B-RW027 R4A@20'

Description:	Dark Greenish Gray Silty Sand with Traces of Shells

	PEAK	ULTIMATE
ϕ'	34.5 °	34.4 °
c'	0.25 KSF	0.20 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	33.3 %

STRAIN RATE: 0.0050 IN/MIN

(Sample was consolidated and drained)

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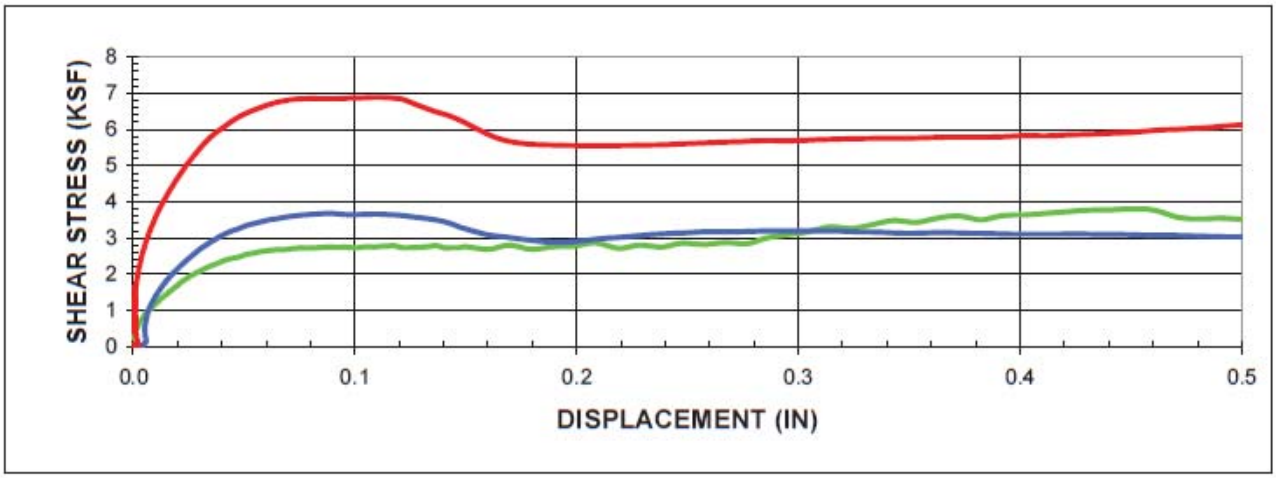
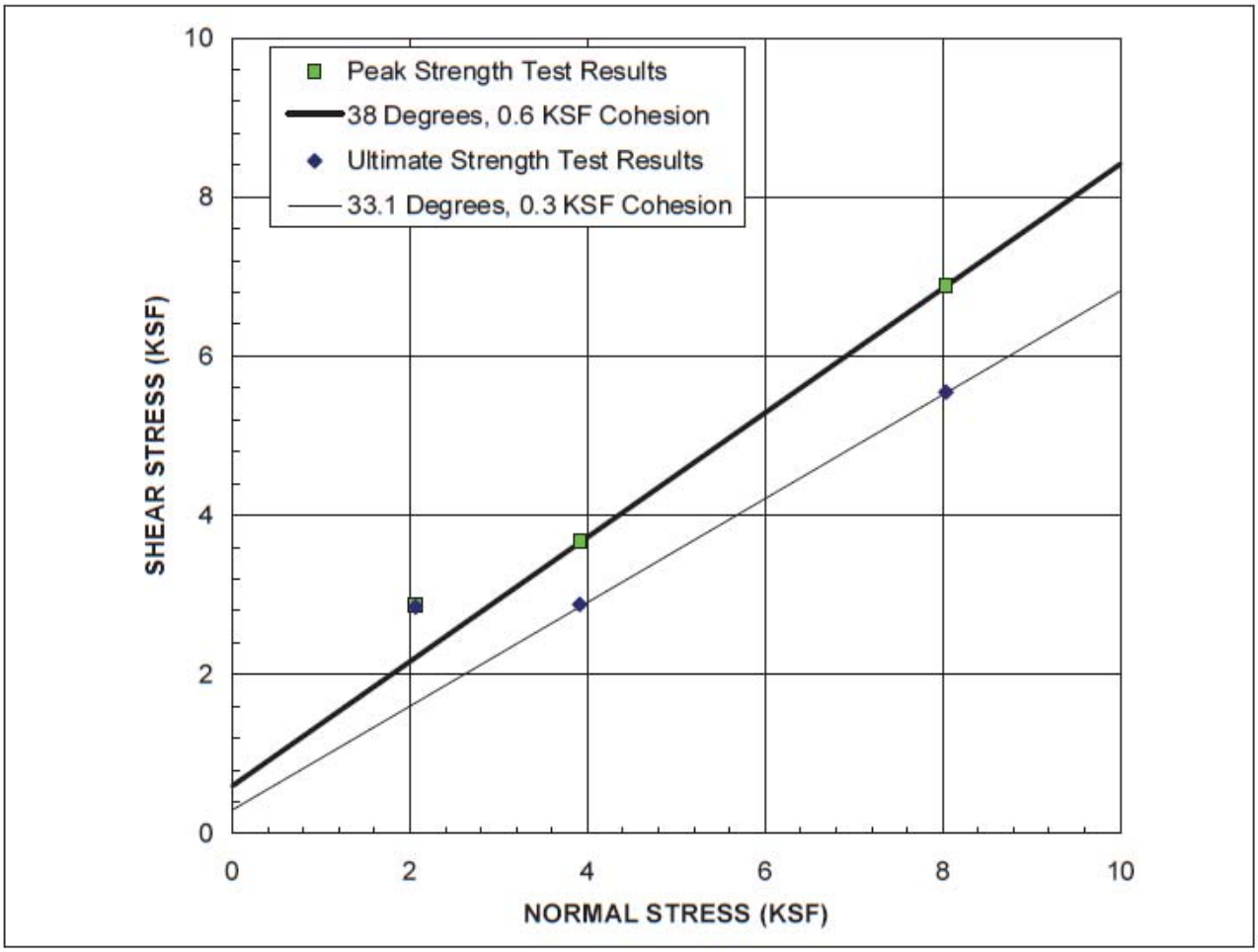
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3k





SAMPLE: B-RW030 R7@30'

Description:	Very Dark Greenish Gray Fine Sand with Silt and Traces of Shells

	PEAK	ULTIMATE
ϕ'	38.0 °	33.1 °
c'	0.60 KSF	0.30 KSF

STRAIN RATE: 0.0250 IN/MIN

(Sample was consolidated and drained)

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	26.3 %

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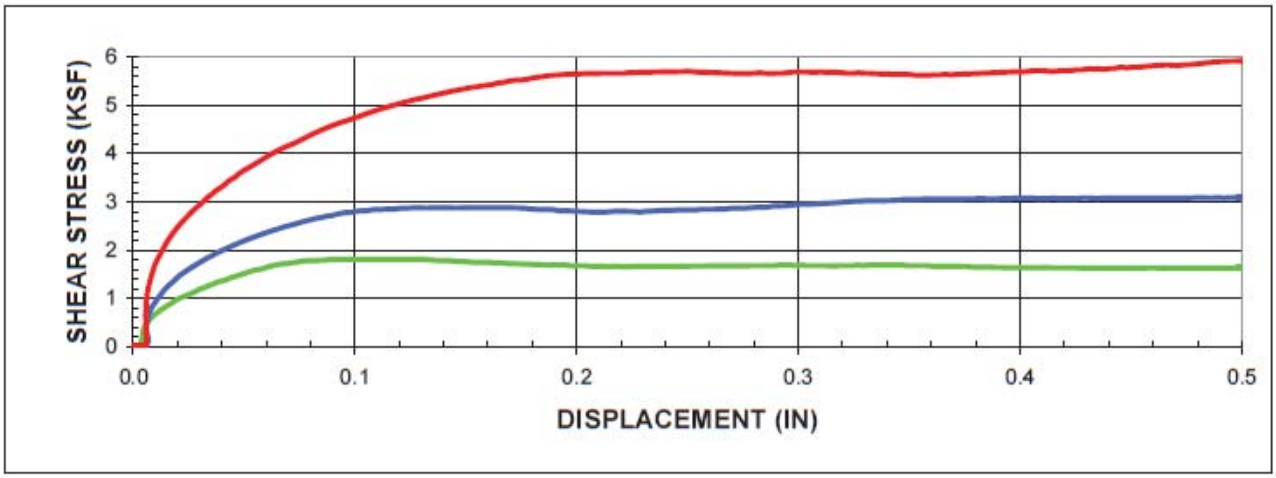
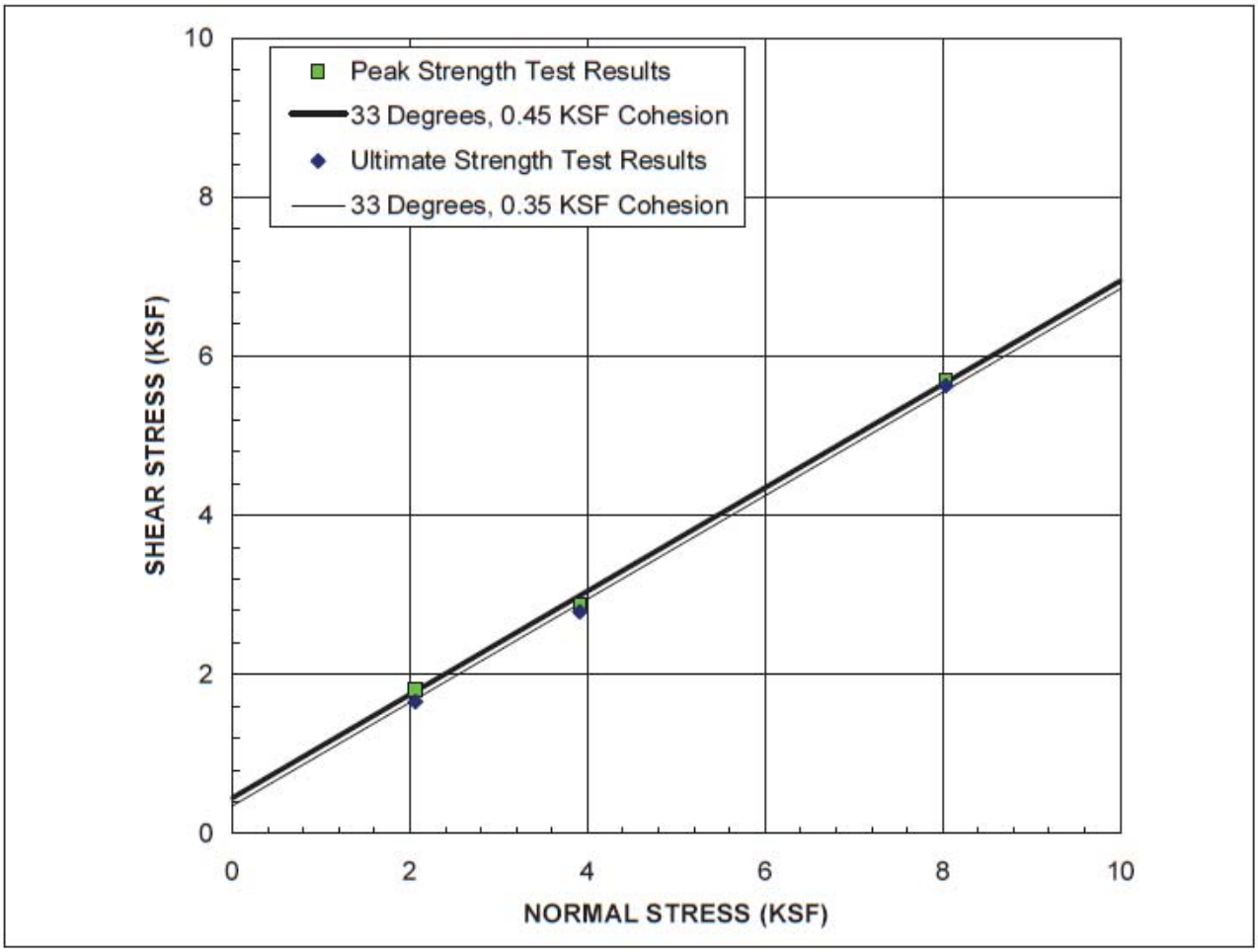
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3I





SAMPLE: B-RW032 R7A@30'

Description: Very Dark Greenish Gray Silty Sand with Shells

STRAIN RATE: 0.0050 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	33 °	33 °
c'	0.45 KSF	0.35 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	30.0 %

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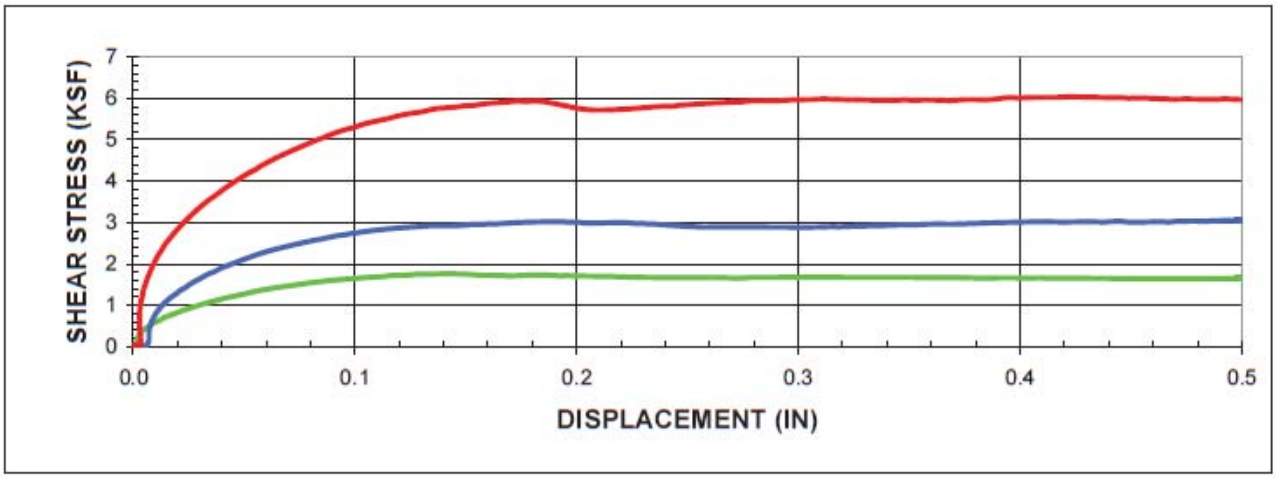
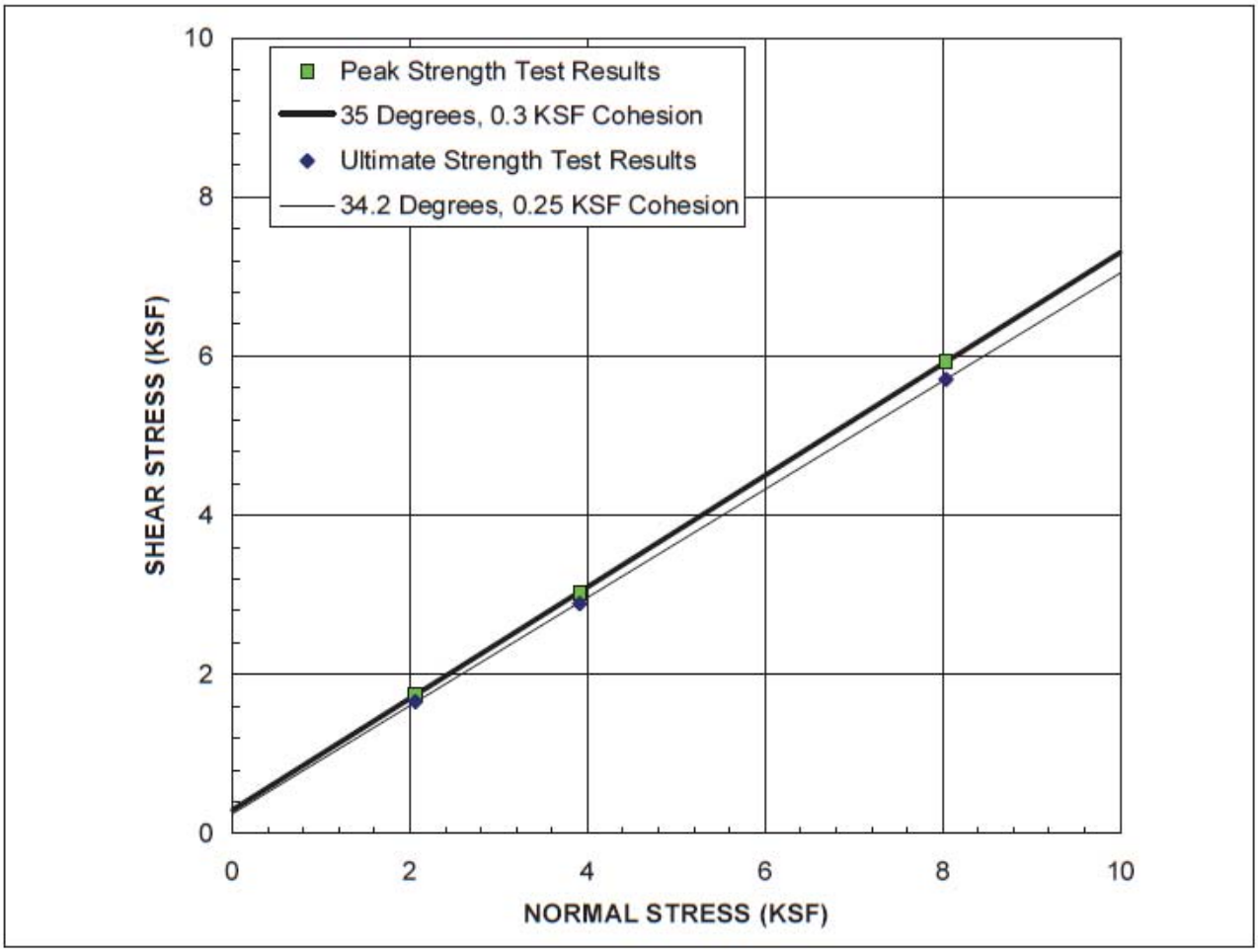
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3m





SAMPLE: B-RW032 R9@40'

Description: Very Dark Greenish Gray Silty Sand

STRAIN RATE: 0.0050 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	35 °	34.2 °
c'	0.30 KSF	0.25 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	31.0 %

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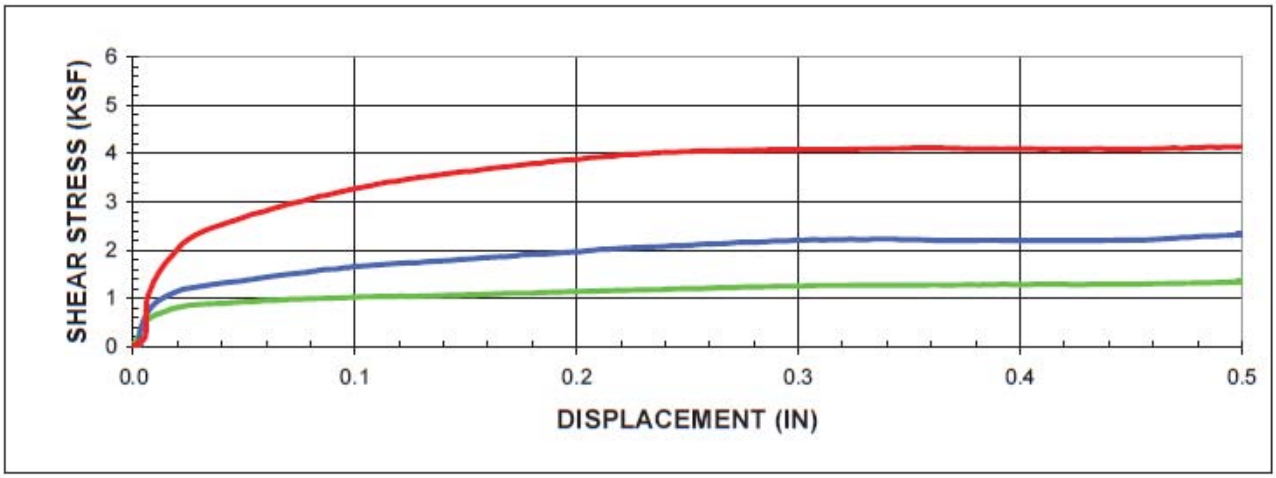
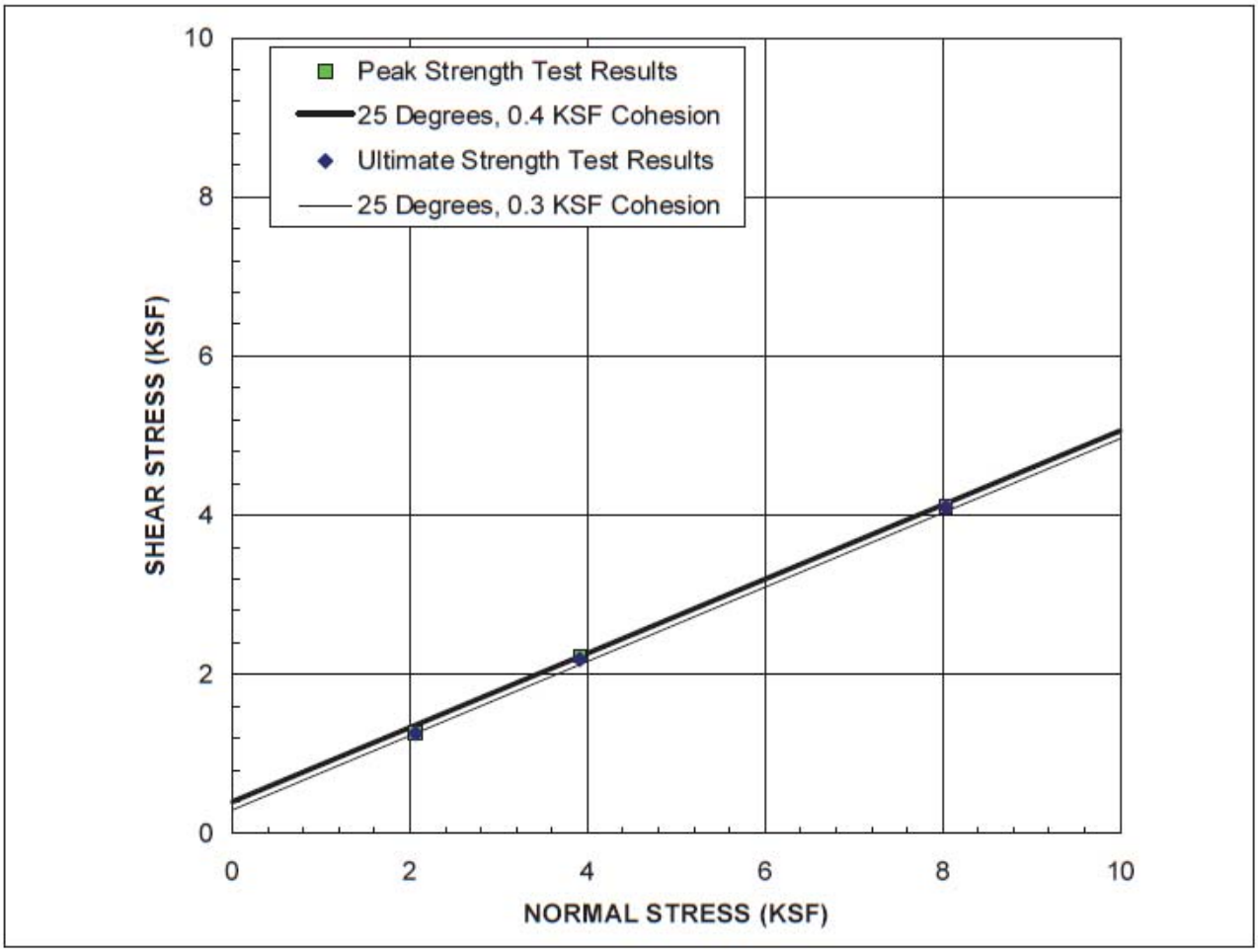
DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3n





SAMPLE: B-RW036 R6A@30'

Description:	Very Dark Greenish Gray Sandy Silty Clay with Traces of Shells

	PEAK	ULTIMATE
ϕ'	25 °	25 °
c'	0.40 KSF	0.30 KSF

STRAIN RATE: 0.0030 IN/MIN

(Sample was consolidated and drained)

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	48.1 %

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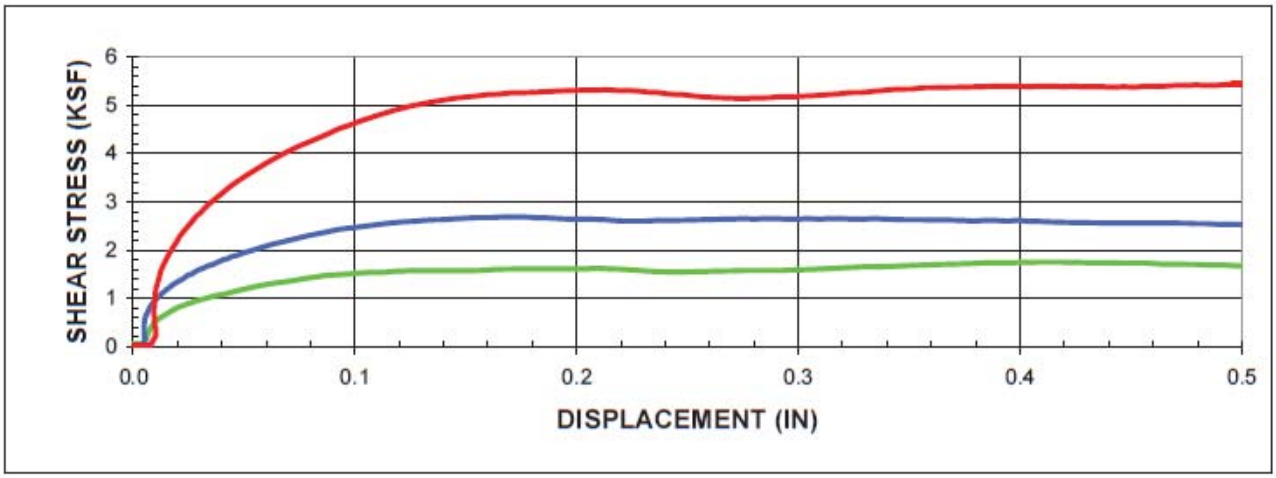
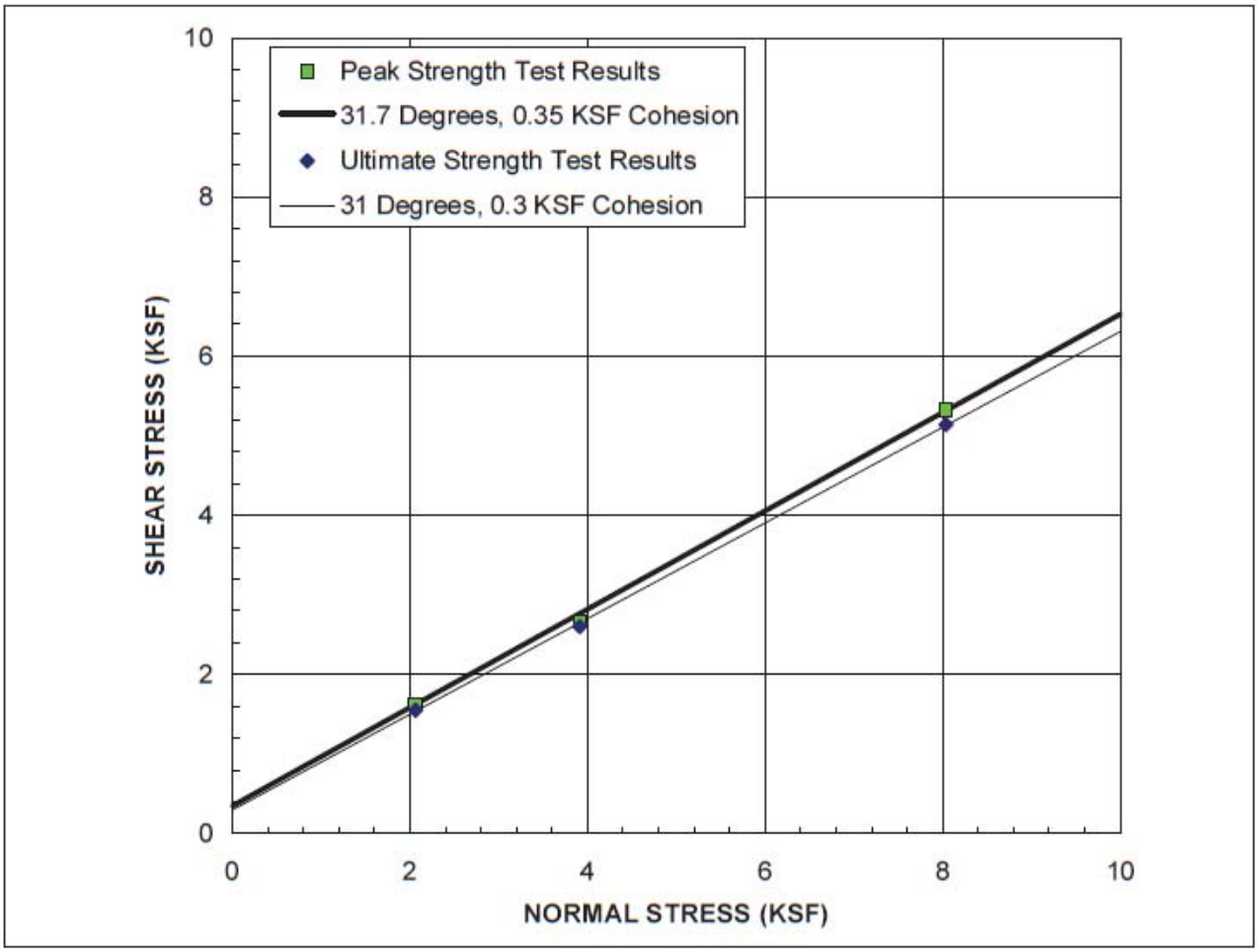
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3o





SAMPLE: B-RW041 R2A@5'

Description: Yellowish Brown Clayey Silty Sand

STRAIN RATE: 0.0050 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	31.7 °	31 °
c'	0.35 KSF	0.30 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	36.1 %

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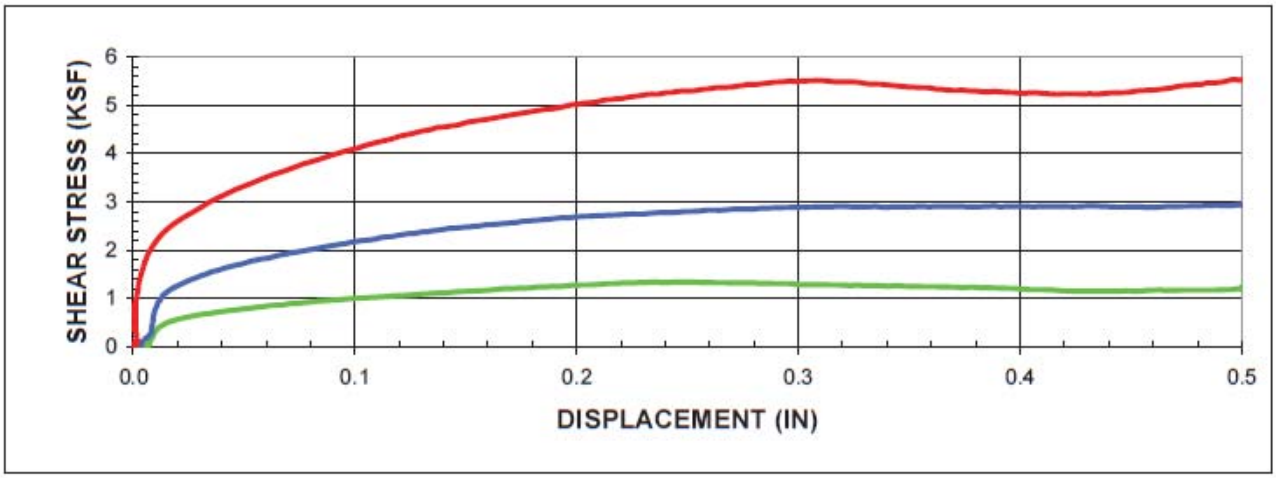
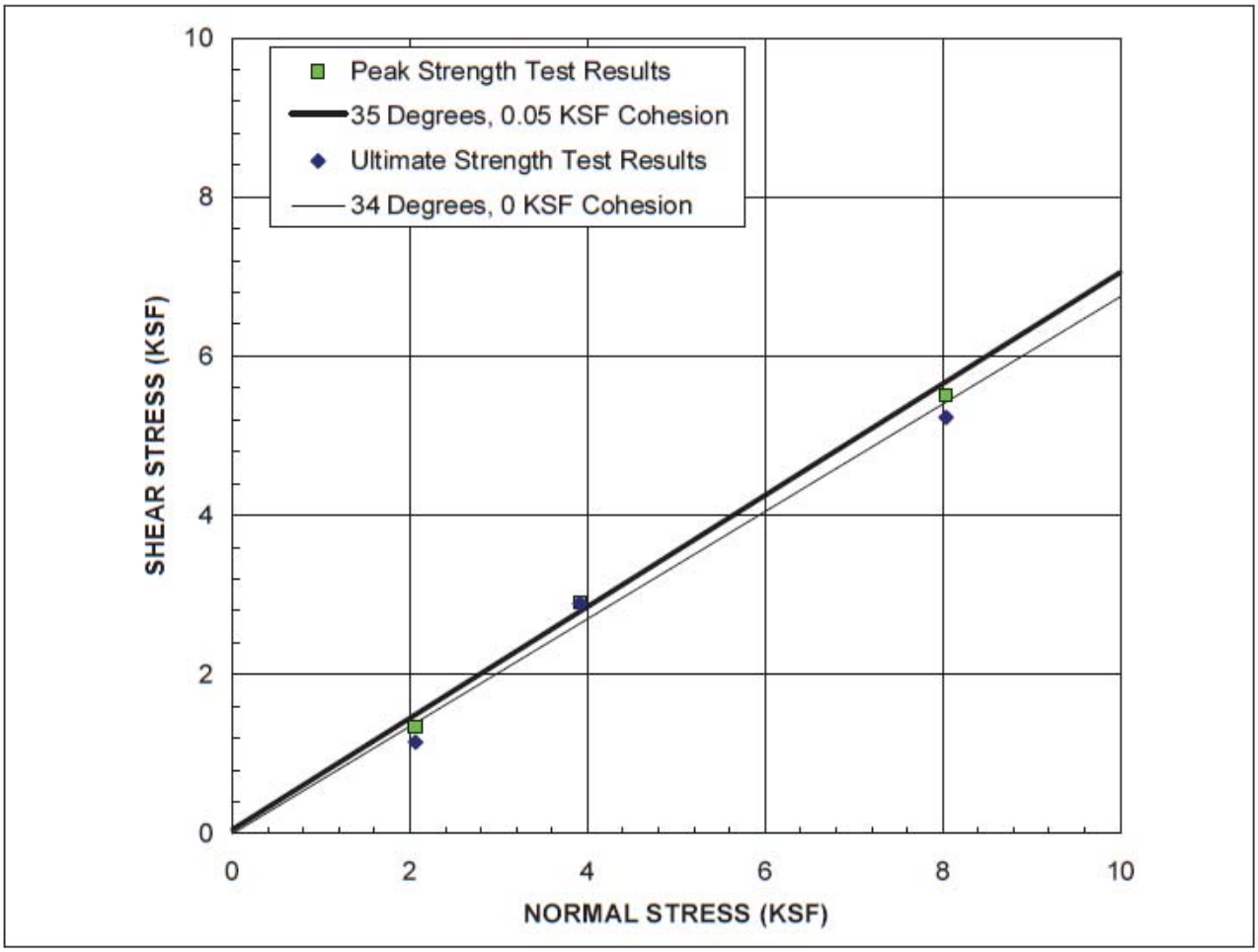
DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3p





SAMPLE: B-RW041 R4A@15'

Description:	Dark Greenish Gray Clayey Silt / Silty Clay with Sand

STRAIN RATE: 0.0025 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	35 °	34 °
c'	0.05 KSF	0.00 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	43.8 %

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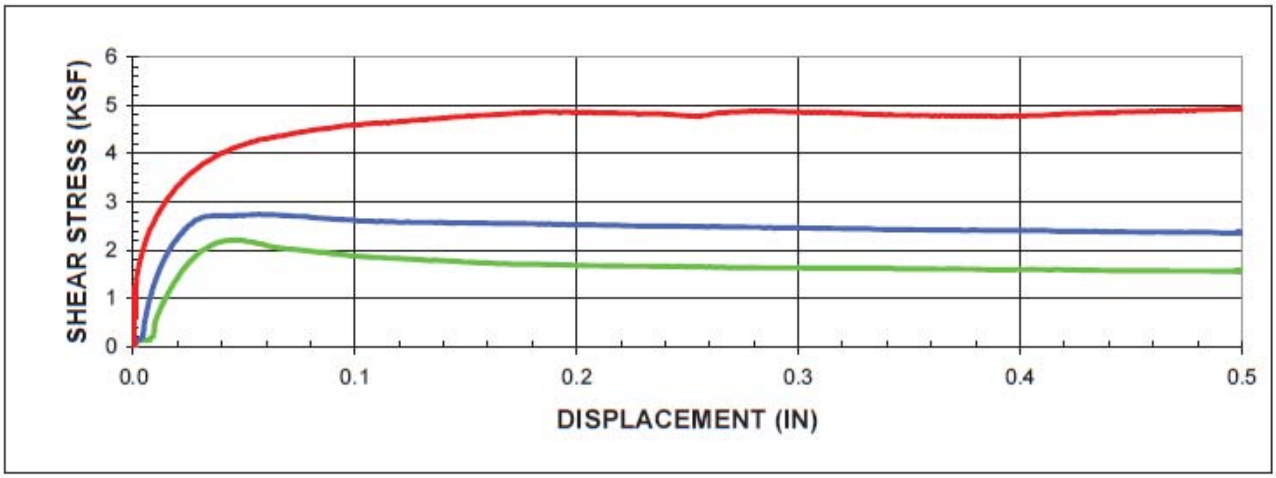
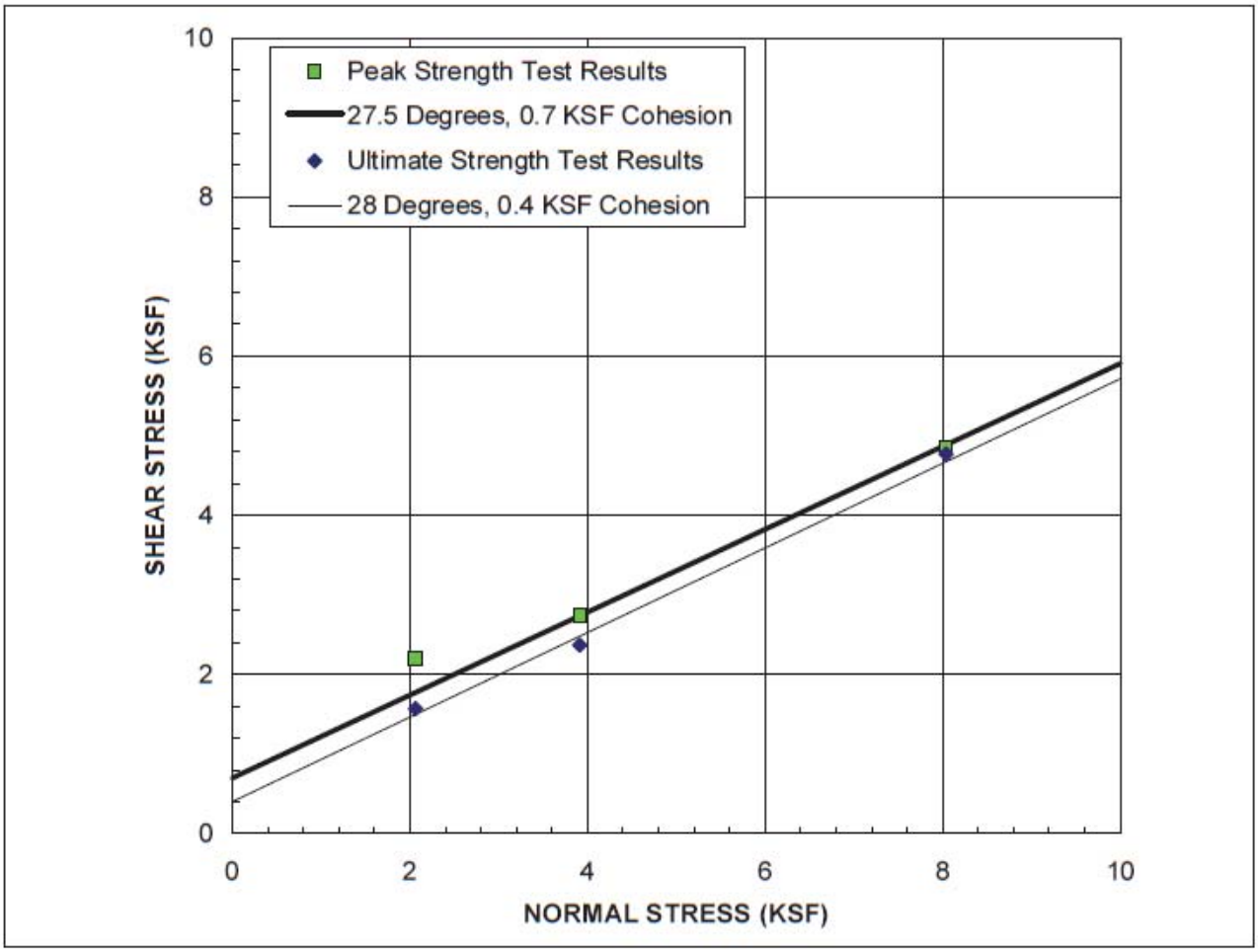
DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3q





SAMPLE: B-RW044 R7A@35'

Description: Very Dark Greenish Gray Clay

STRAIN RATE: 0.0025 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	27.5 °	28.0 °
c'	0.70 KSF	0.40 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	23.3 %

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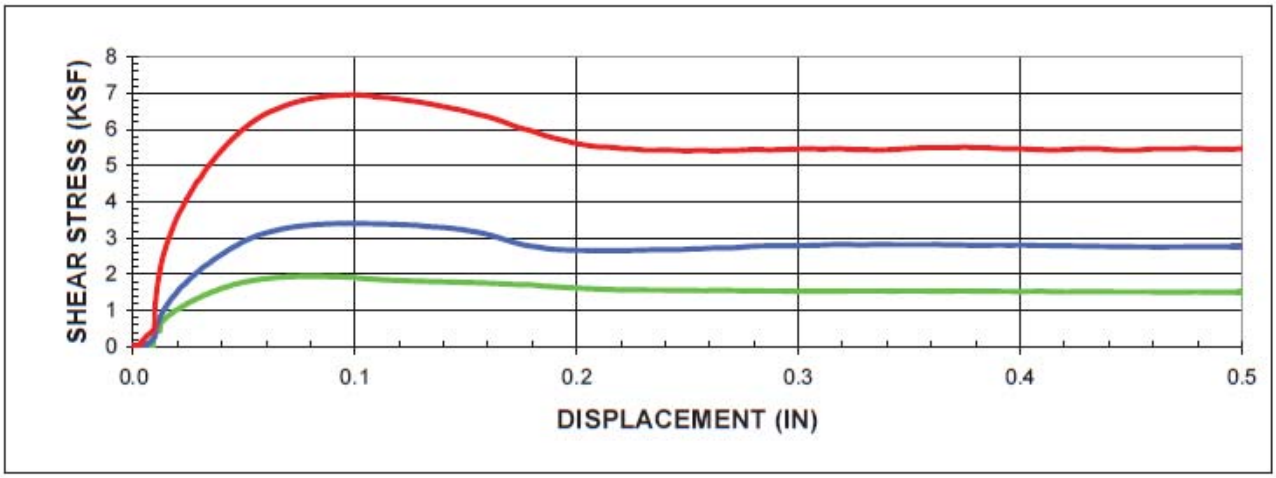
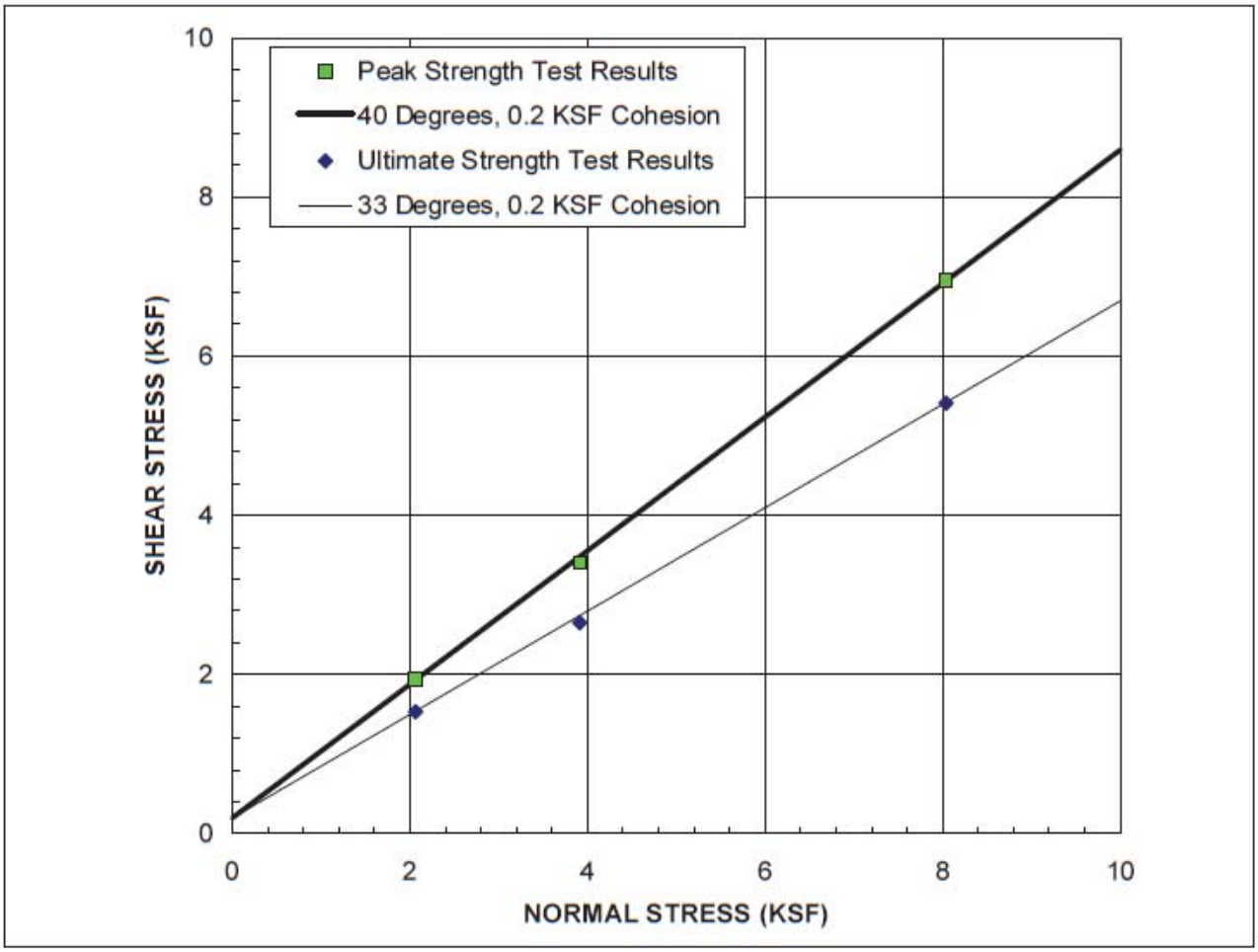
DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3r





SAMPLE: B-RW049 R9@40'

Description: Dark Greenish Gray Sand

STRAIN RATE: 0.0250 IN/MIN

(Sample was consolidated and drained)

	PEAK	ULTIMATE
ϕ'	40 °	33 °
c'	0.20 KSF	0.20 KSF

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	23.0 %

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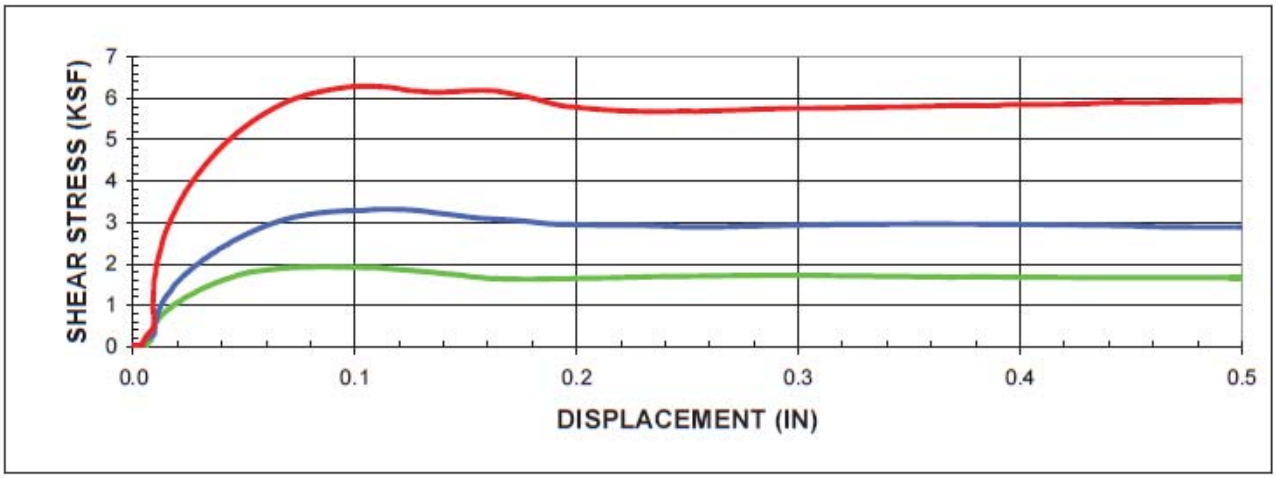
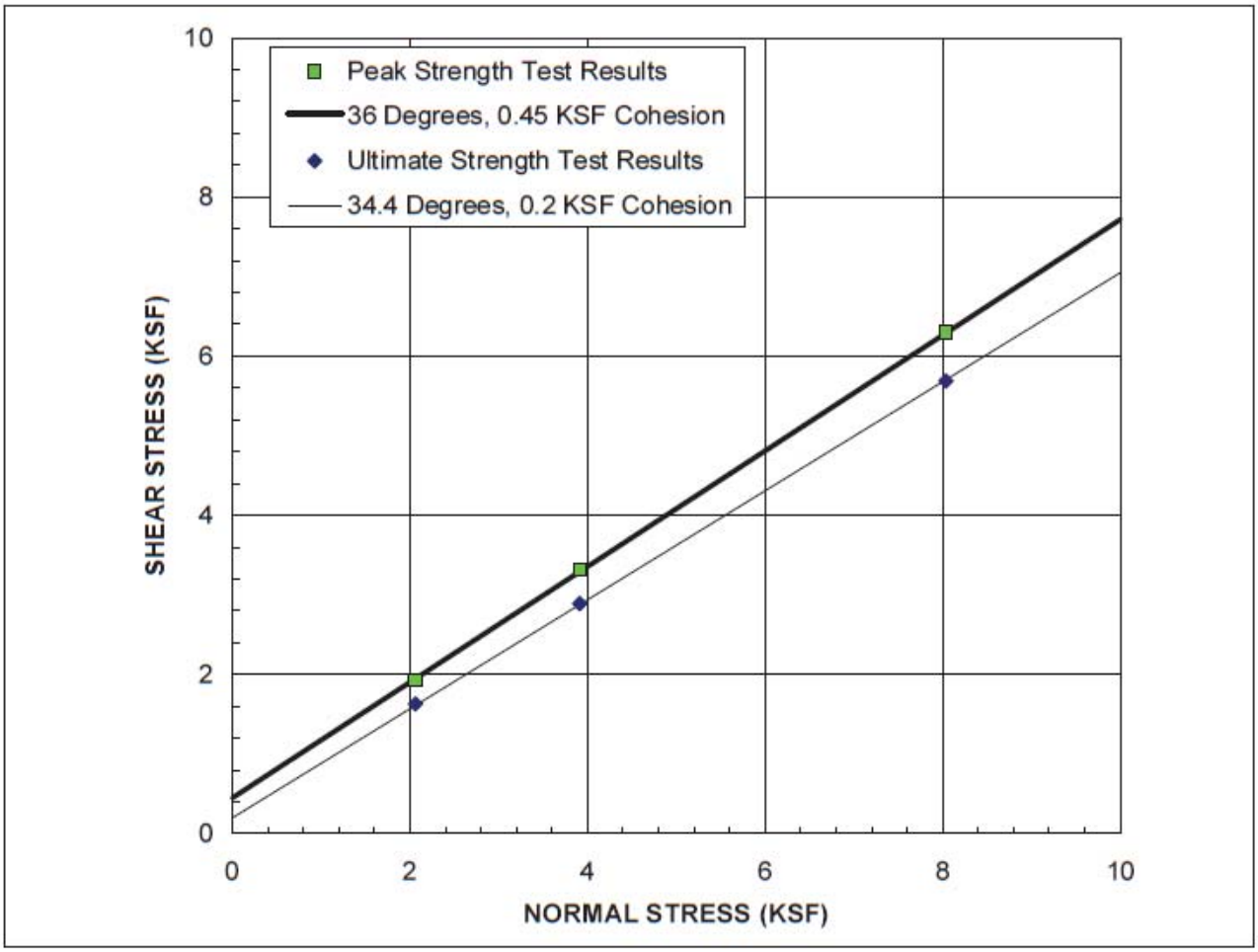
DIRECT SHEAR TEST RESULTS

Project No.: LA962A

FIGURE B1-3s





SAMPLE: B-RW053 R6A@30'

Description: Very Dark Greenish Gray Silty Sand

	PEAK	ULTIMATE
ϕ'	36 °	34.4 °
c'	0.45 KSF	0.20 KSF

STRAIN RATE: 0.0050 IN/MIN

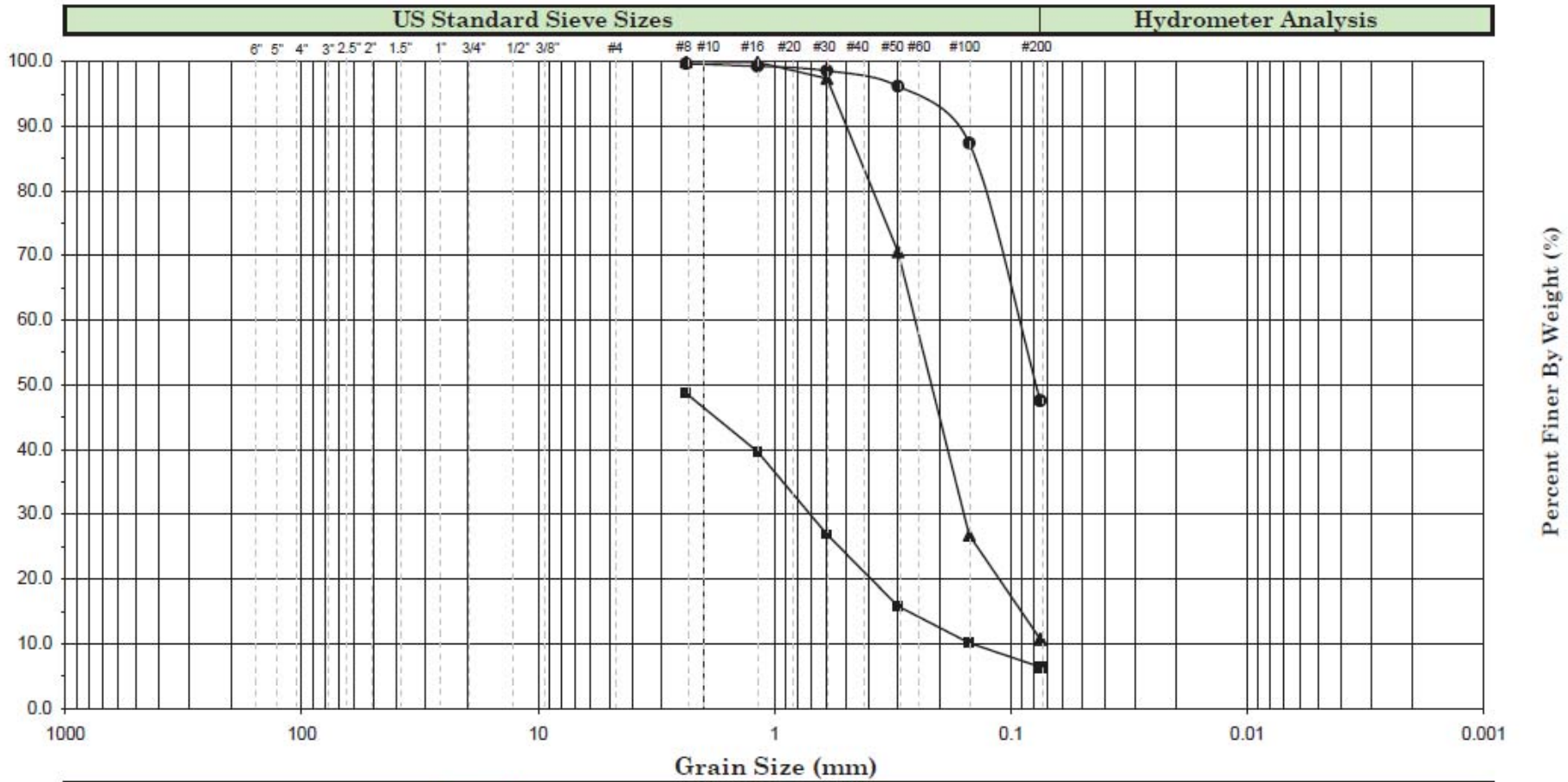
(Sample was consolidated and drained)

	IN-SITU	AS-TESTED
γ_d	PCF	0.0 PCF
w_c	%	29.4 %

GROUP DELTA CONSULTANTS
370 Amapola Ave., Suite 212, Torrance, CA 90501
32 Mauchly, Suite B, Irvine, CA 92618
4201 Santa Ana St., Suite F, Ontario, CA 91761
9245 Activity Road, Suite 103, San Diego, CA 92126

DIRECT SHEAR TEST RESULTS

Project No.: LA962A
FIGURE B1-3t



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	A-HSA066	R4	7.5	9.0	2.3	2.7	Dark Grayish Brown	Clayey Sand with Shells	SC
▲	C-HSA061	R1	2.5	4.0	0.8	1.2	Yellowish Brown	Poorly graded Sand with Silt	SP-SM
■	B-RW041	R13	60.0	61.5	18.3	18.8	Dark Greenish Gray	Poorly graded Sand with Silt and Gravel	SP-SM
◆									
○									
△									
Remark									

GROUP DELTA CONSULTANTS

Ballona Creek Wetlands Restoration

Project No. : LA962A

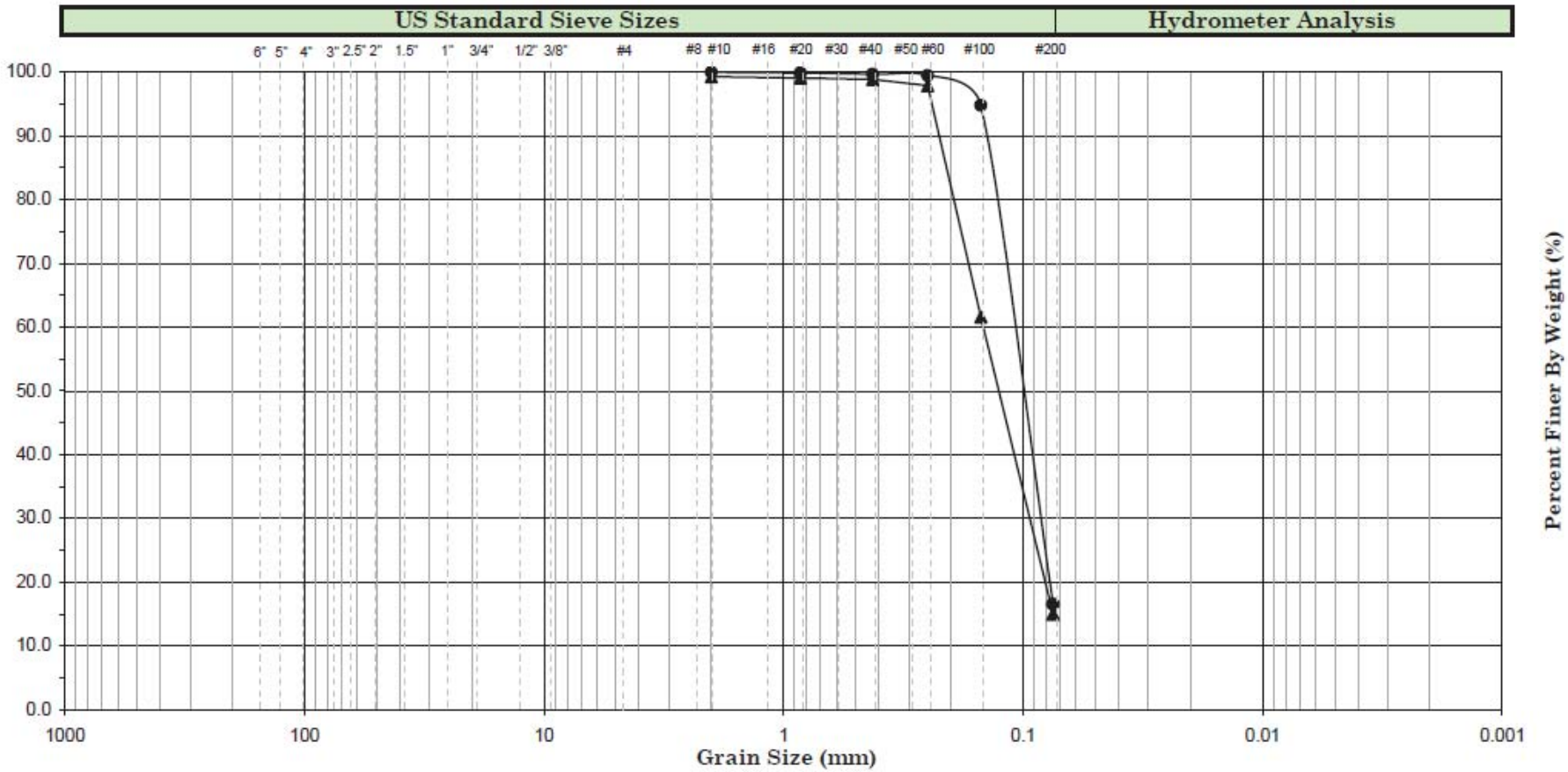
Date : 01/28/13

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. : B1-4a

1



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	B-RW041	S5	20.0	21.5	6.1	6.6	Very Dark Greenish Gray	Sand with Silt	SM
▲	B-RW053	S7	35.0	36.5	10.7	11.1	Dark Greenish Gray	Sand with Silt	SM
■									
◆									
○									
△									
Remark									

GROUP DELTA CONSULTANTS

Ballona Creek Wetlands Restoration

Project No. : LA962A

Date : 01/28/13

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. : B1-4b

2

APPENDIX B2
LABORATORY TESTING BY OTHERS

APPENDIX B
PREVIOUS LABORATORY TESTING

B2.1 General

Laboratory testing has been conducted as part of the previous geotechnical and environmental investigations at Ballona Creek Wetlands site. A short summary of the geotechnical laboratory testing programs adopted in previous investigations by Law Crandall, Inc. Diaz.Yourman & Associates and Weston Solutions, Inc. are presented below.

B2.2 Law Crandall, Inc. Laboratory Testing

Area A:

Field moisture content and dry density tests were performed on undisturbed samples. Atterberg limit tests were also performed on selected samples. Liquid limit tests were repeated on some oven-dried samples to assess the organic content. Direct shear tests were performed on selected undisturbed samples to determine the strength of the soils. The direct shear tests were performed at field and increased moisture content and at various different surcharge pressures on in-situ samples and some remolded samples. Confined consolidation tests were performed on 23 undisturbed samples to determine the compressibility of the soils. The samples were tested at field moisture content. Particle size analyses were performed using mechanical sieve analysis and hydrometer analysis testing methods on six samples. Compaction tests in accordance with the ASTM Designation D1557-70 were also performed on samples from two borings. Permeability tests were performed on ten undisturbed samples to determine the coefficient of permeability of the soils, under confining pressures of 200 and 1,000 psf. Soil corrosivity tests were also performed on eleven samples.

Area B

Field moisture content and dry density tests were performed on undisturbed samples. Atterberg limit tests were also performed on 4 samples. Direct shear tests were performed on selected undisturbed samples to determine the strength of the soils. The tests were performed at field and increased moisture content and at various different surcharge pressures. Tests were also performed on some remolded samples. Confined consolidation tests were performed on 10 undisturbed samples and 2 remolded samples to determine the compressibility of the soils. Most samples were tested at field moisture content, while three of the samples were tested at increased moisture content. Compaction tests in accordance with the ASTM Designation D1557-78 were performed on samples from two borings. Expansion Index tests were performed on two samples in accordance with Uniform Building Code No. 29-2 method. Permeability tests were performed on eight undisturbed samples to determine the coefficient of permeability of the soils, under

confining pressure of 200 psf. Particle size analyses were performed on representative samples to aid in classification of the soils.

Area C

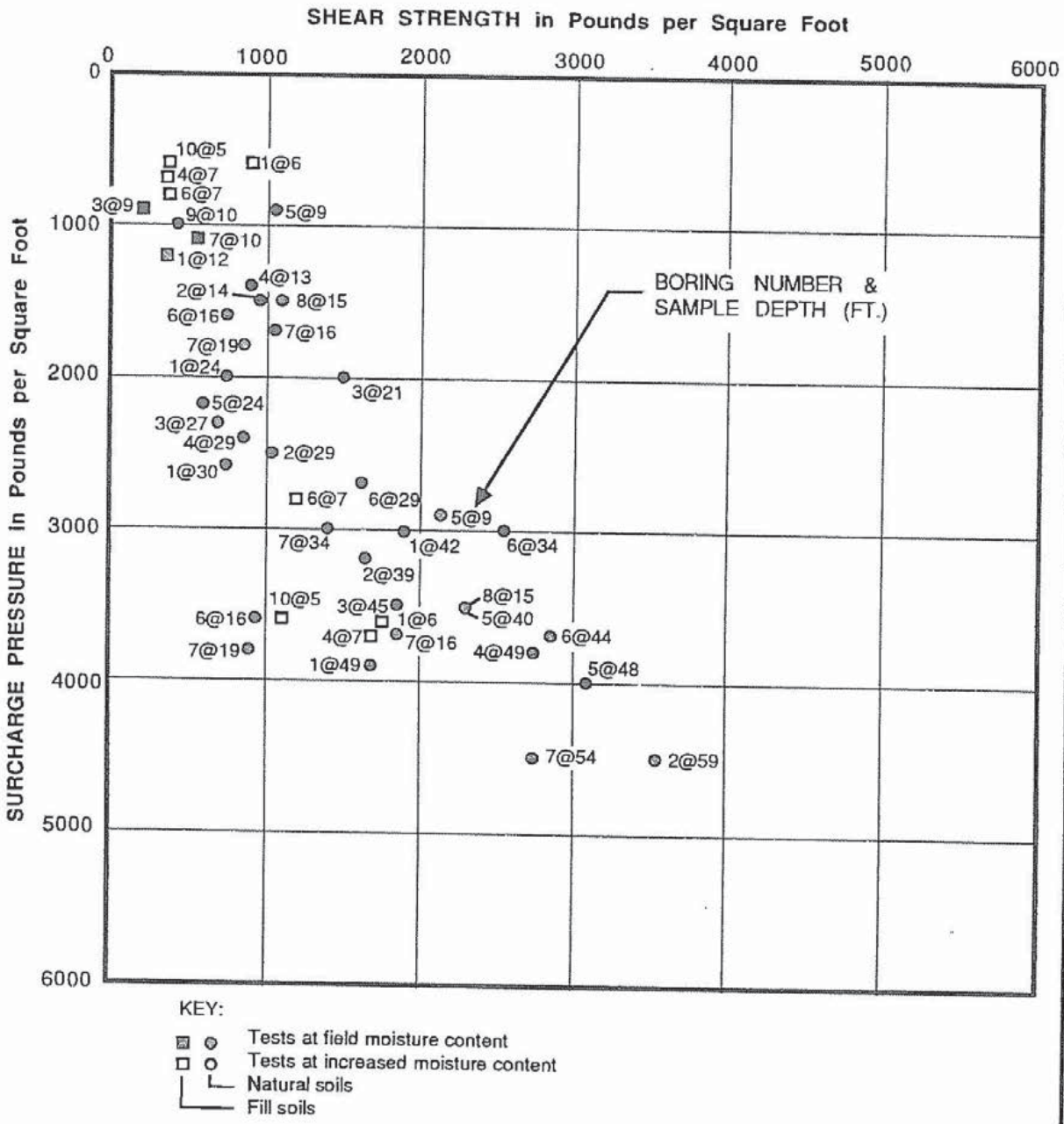
Field moisture content and dry density tests were performed on undisturbed samples. Atterberg limit tests were also performed on three samples. Direct shear tests were performed on selected undisturbed samples to determine the strength of the soils. The tests were performed at field and near saturation moisture content, and at field overburden and increased surcharge pressures. Direct shear tests were also performed on some remolded samples. Confined consolidation tests were performed on 5 undisturbed samples to determine the compressibility of the soils. Four samples were tested at field moisture content, while one of the samples was tested at increased moisture content. Particle size analyses were performed using mechanical sieve analysis on two samples. Also, Expansion Index test was performed on one sample in accordance with Uniform Building Code No. 29-2 method.

B2.3 Diaz.Yourman & Associates Laboratory Testing

Laboratory testing by Diaz.Yourman & Associates was limited to Areas B and C, and included field moisture content test and particle size analysis testing (including full sieve, percent passing #200 sieves, and hydrometer testing) on most samples, as well as Atterberg limits tests on selected samples. Furthermore, compaction tests were performed on three selected samples.

B2.4 Weston Solutions, Inc. Laboratory Testing

In addition to environmental testing, geotechnical sampling and testing was included as part of Weston's testing program in Area A. Geotechnical tests including in-situ moisture content, grain-size distribution tests (including mechanical sieve analyses and hydrometer testing), and Atterberg limits tests were performed on selected geotechnical samples.



JOB AE-88473 DATE 1/31/89 DR lp O.E. JC CHKD.

DIRECT SHEAR TEST DATA

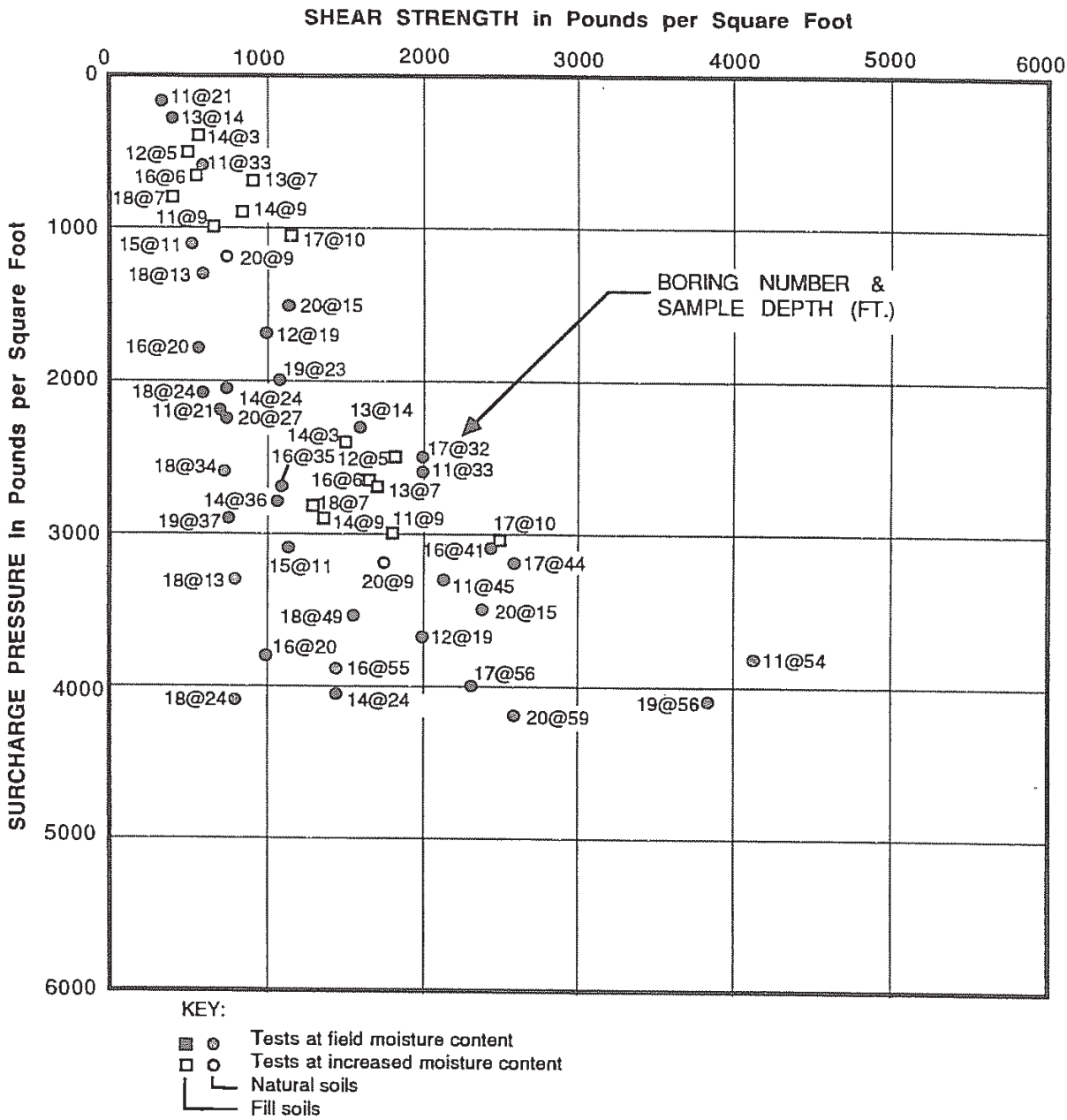
LeROY CRANDALL AND ASSOCIATES

PLATE A-3.1

Law Crandall Area A

PLATE B2-1

JOB AE-88473 DATE 1/31/89 DR lp O.E. JC CHKD.



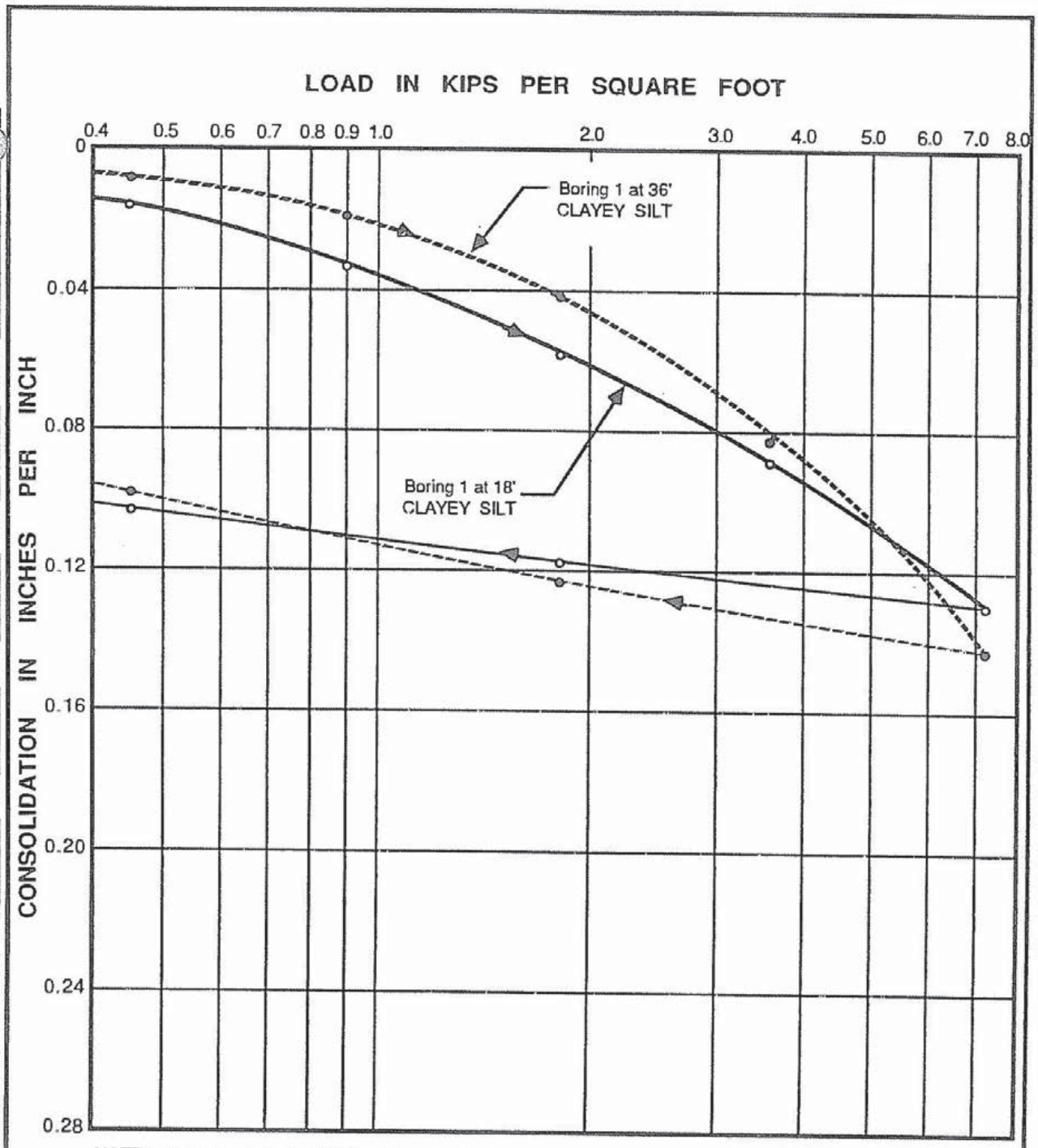
DIRECT SHEAR TEST DATA

LeROY CRANDALL AND ASSOCIATES

Law Crandall Area A

PLATE A - 3.2

PLATE B2-2



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

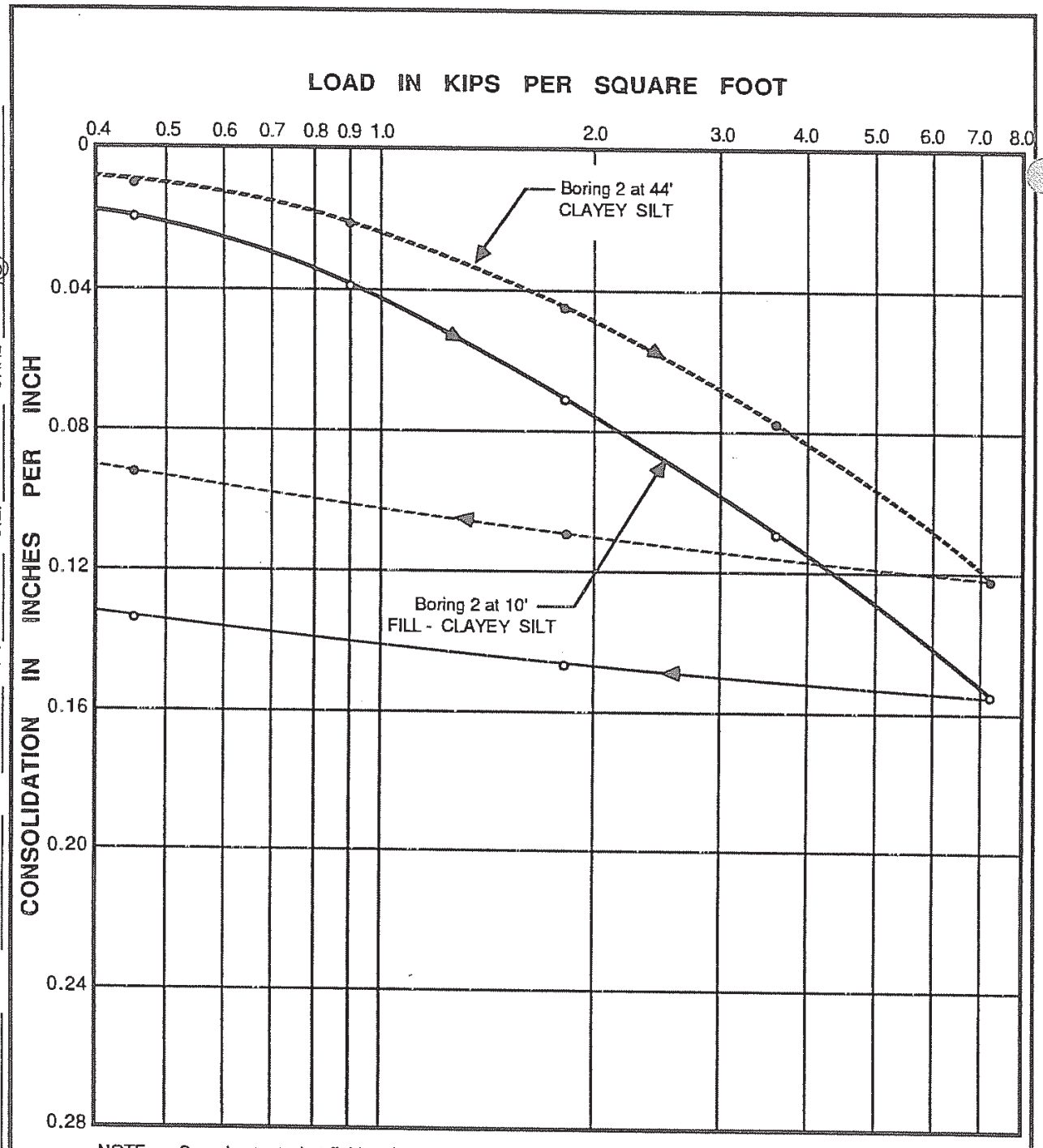
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

Law Crandall Area A

PLATE A-4.1

PLATE B2-3



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

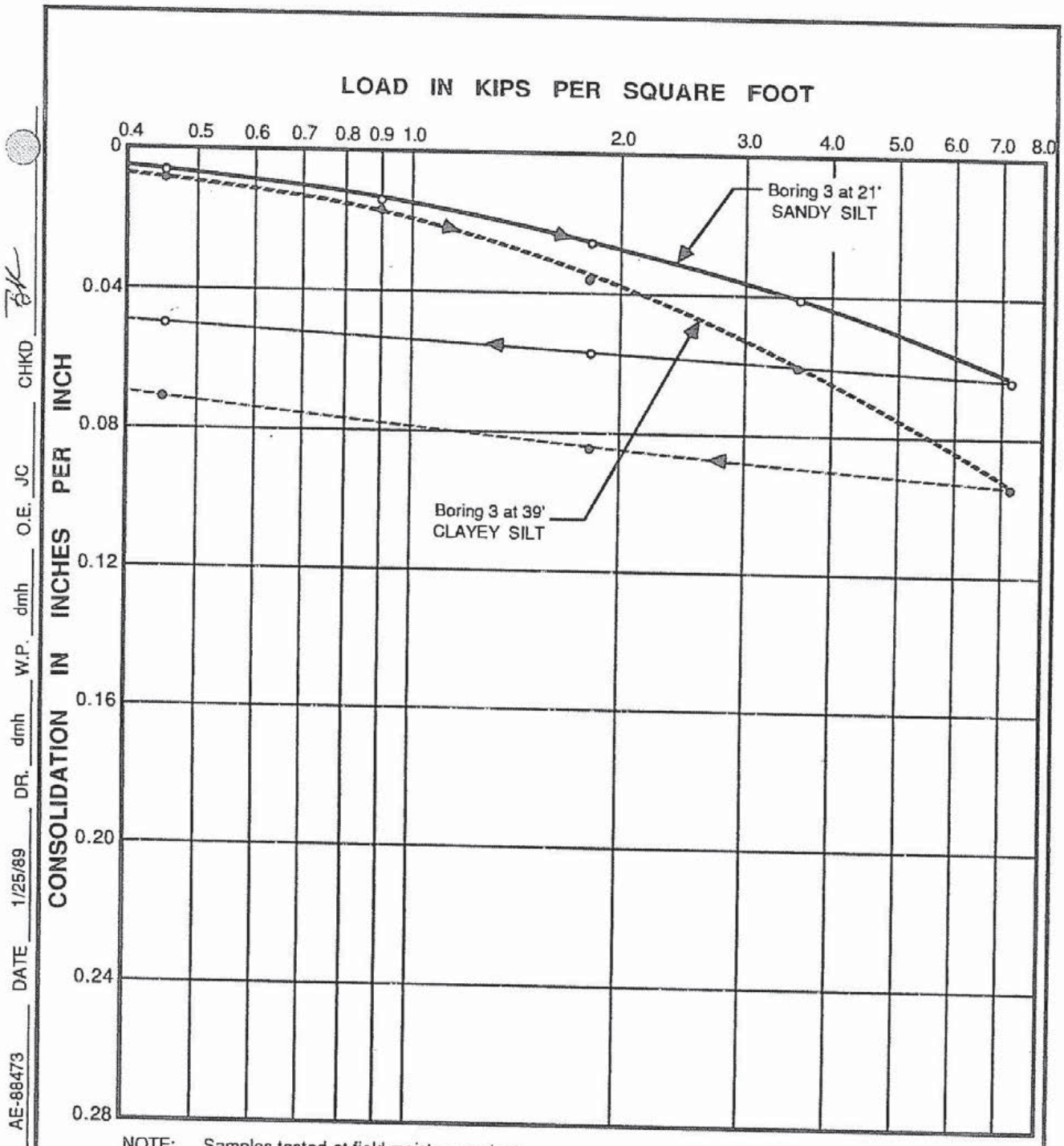
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A - 4.2

Law Crandall Area A

PLATE B2-4



NOTE: Samples tested at field moisture content.

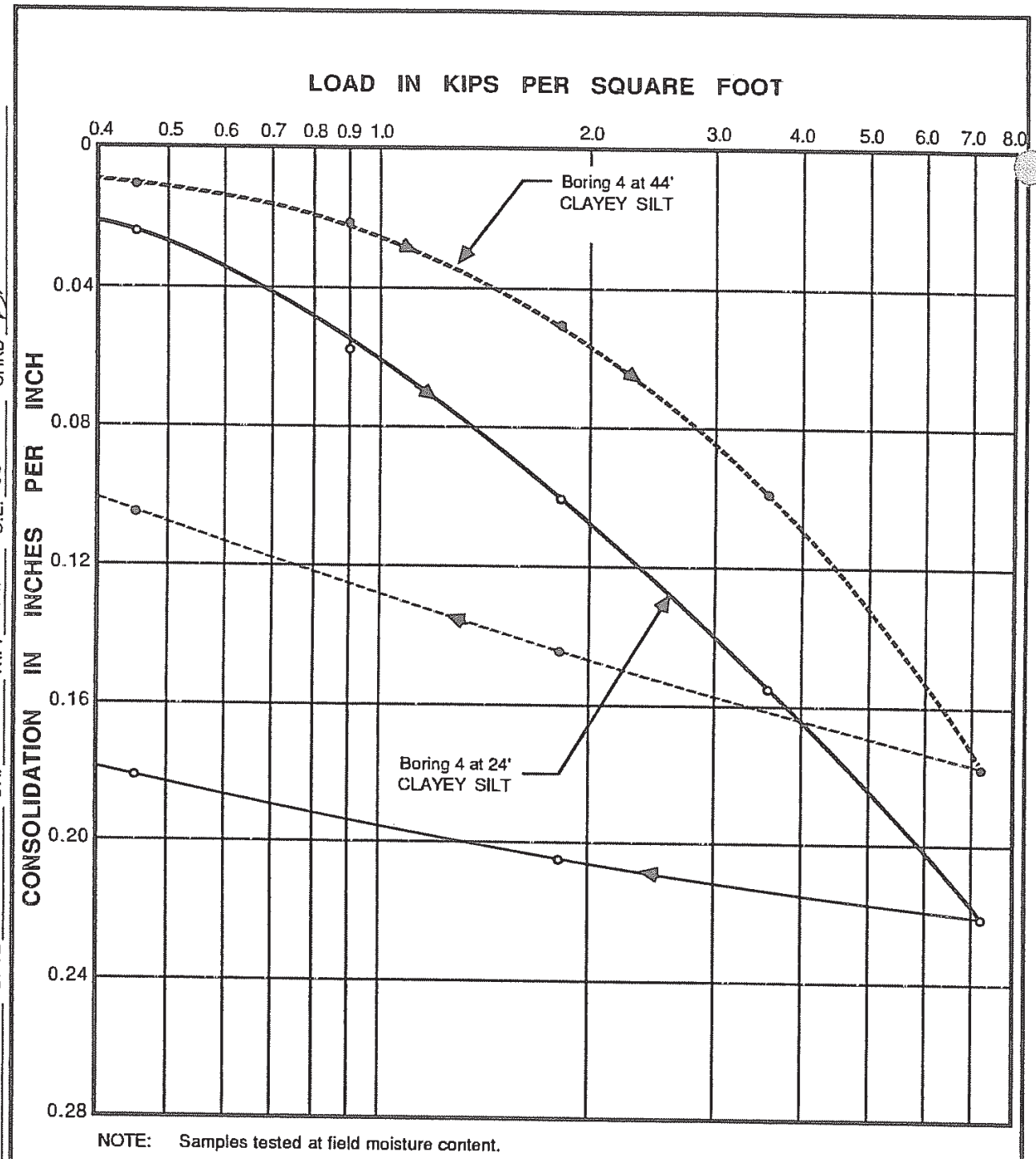
JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

Law Crandall Area A

PLATE A - 4.3
PLATE B2-5



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD BK

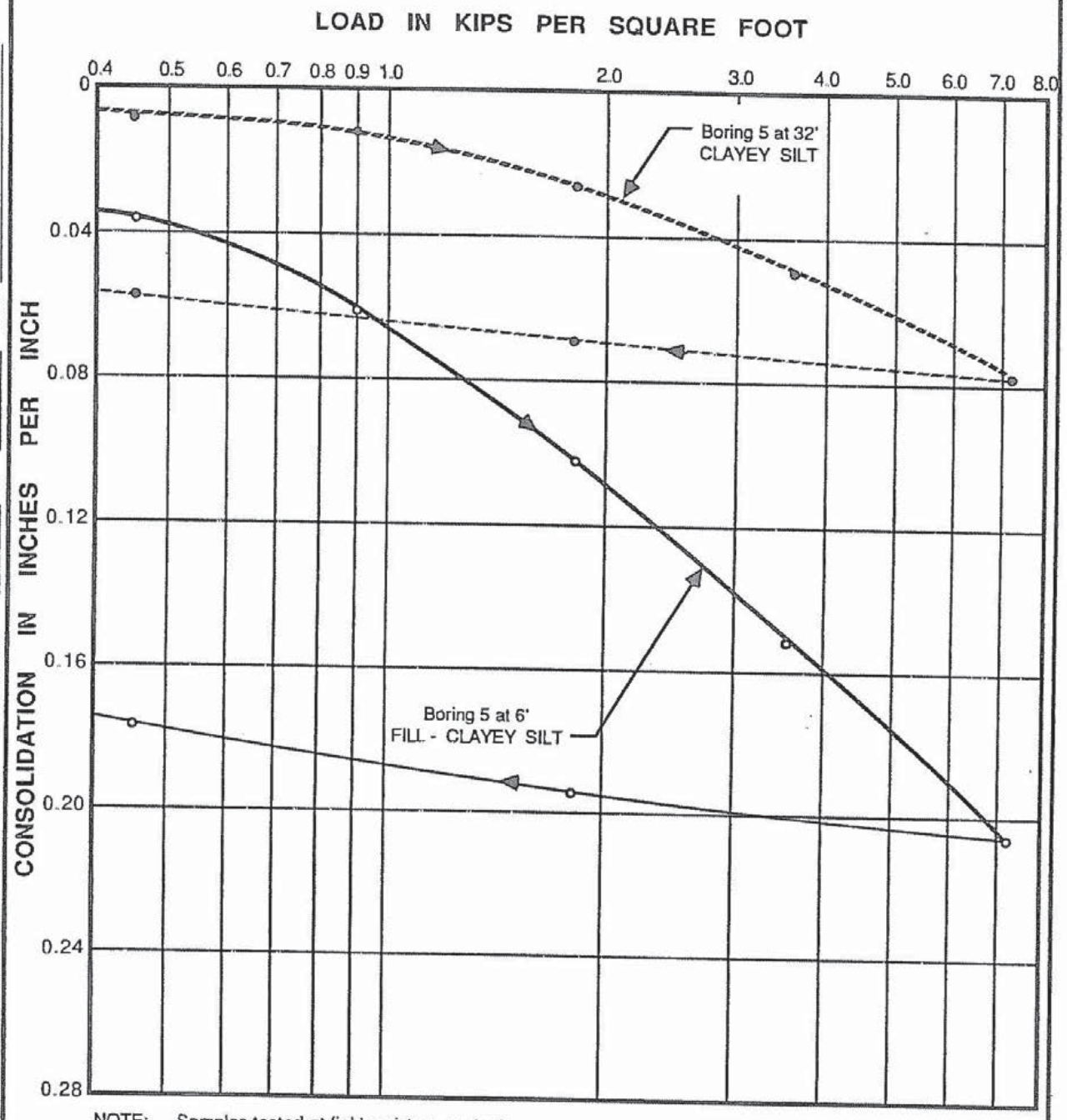
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A - 4.4

Law Crandall Area A

PLATE B2-6



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

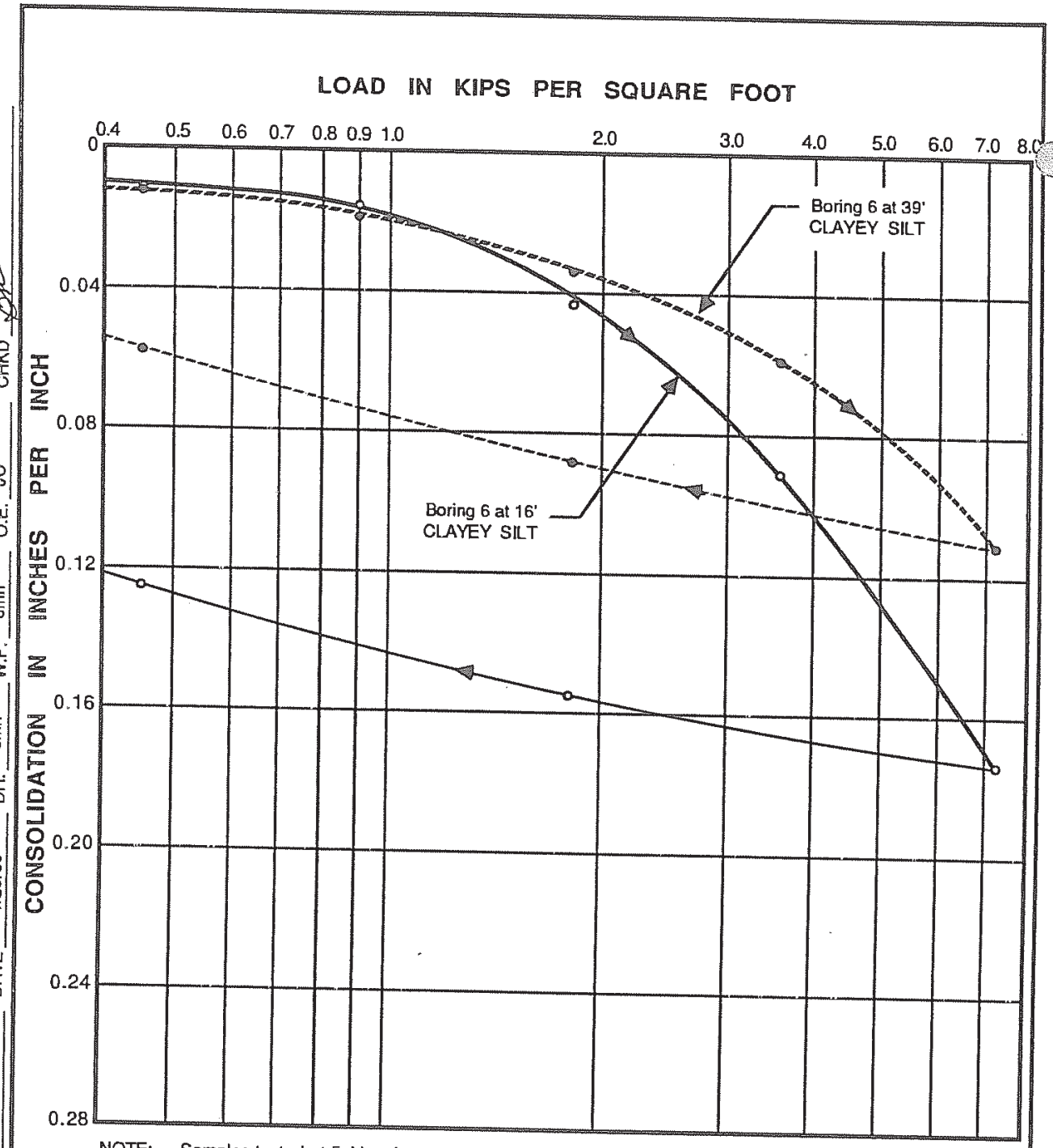
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

Law Crandall Area A

PLATE A - 4.5

PLATE B2-7



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

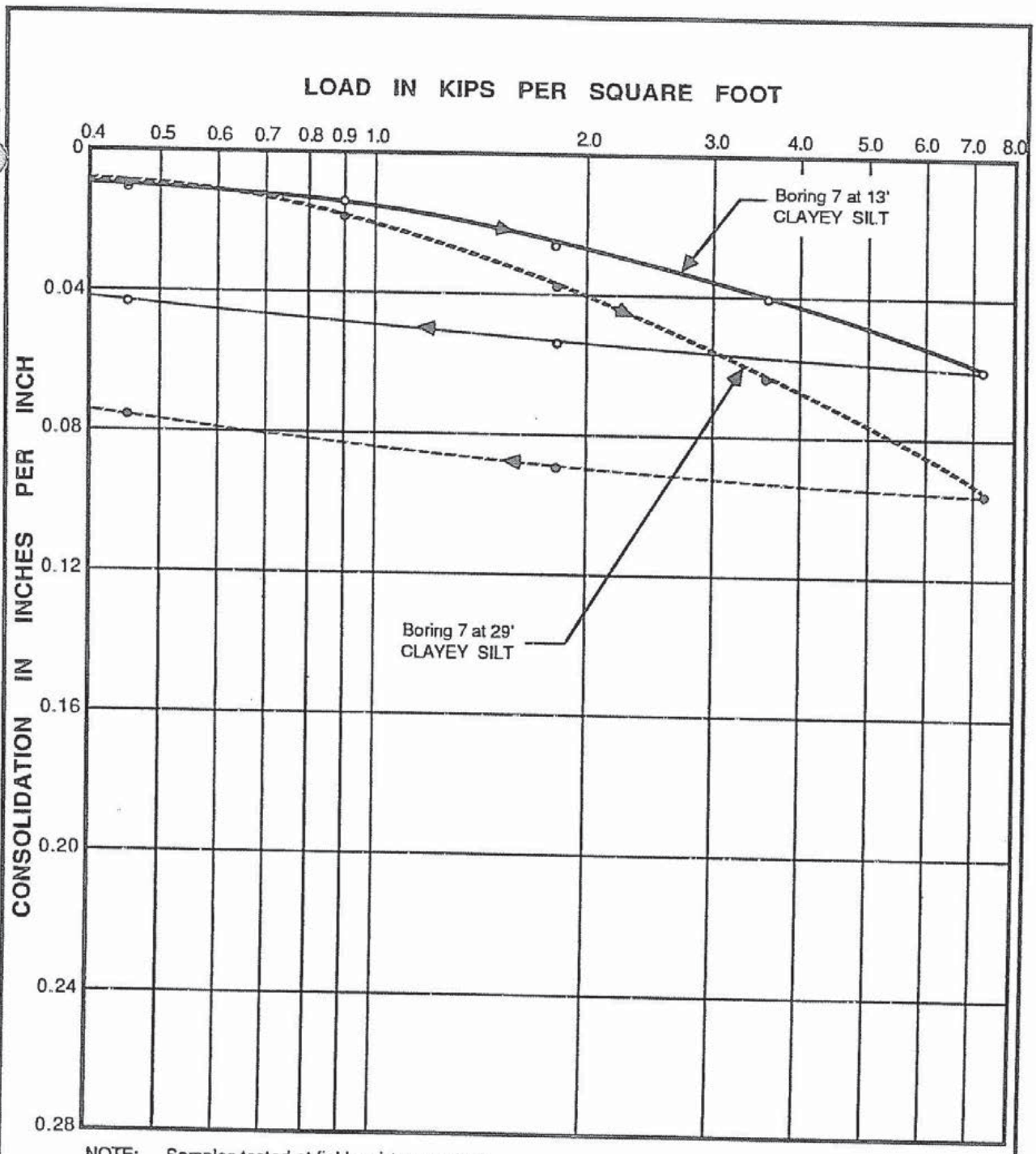
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

Law Crandall Area A

PLATE A-4.6

PLATE B2-8



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

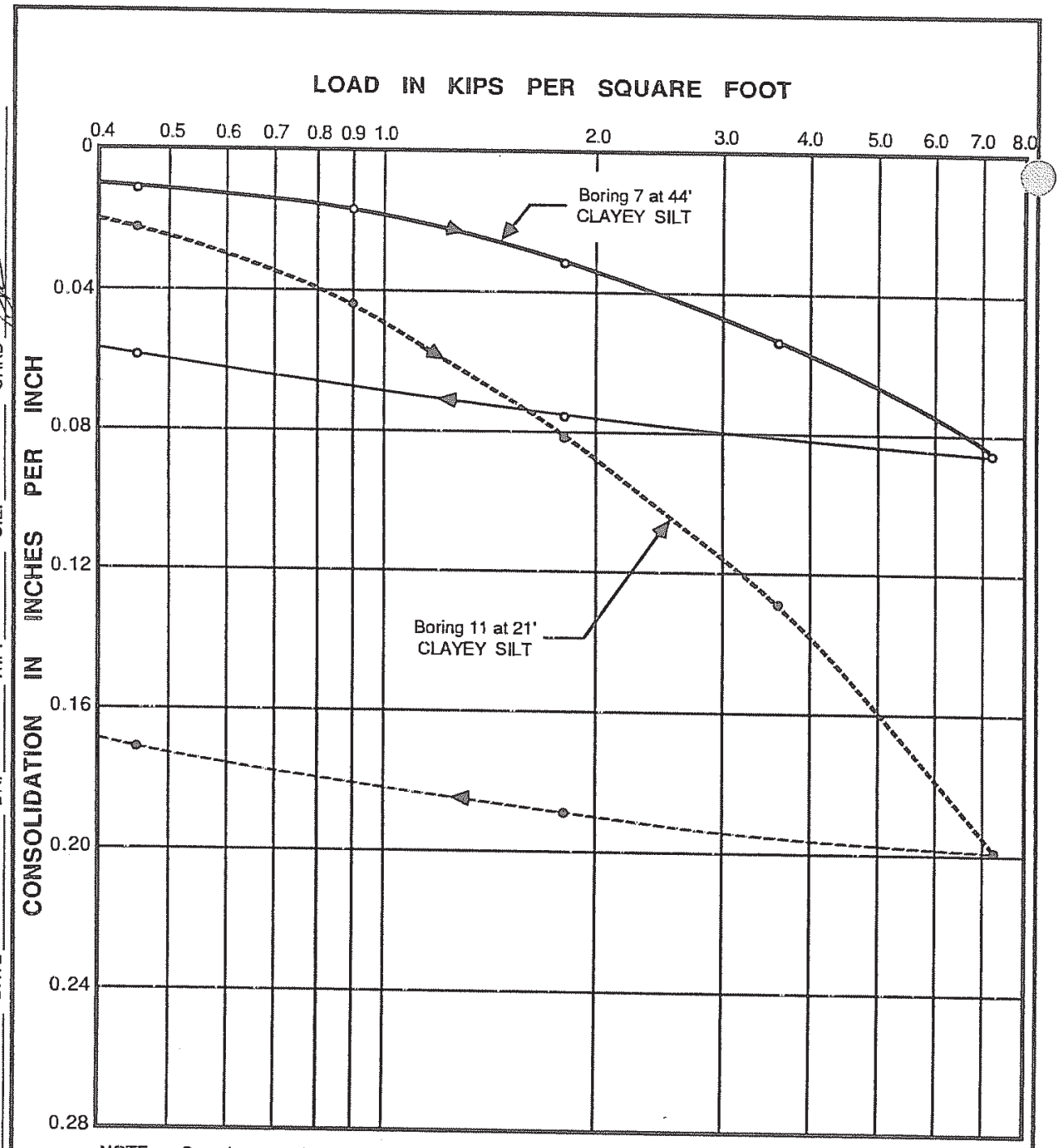
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A-4.7

Law Crandall Area A

PLATE B2-9



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

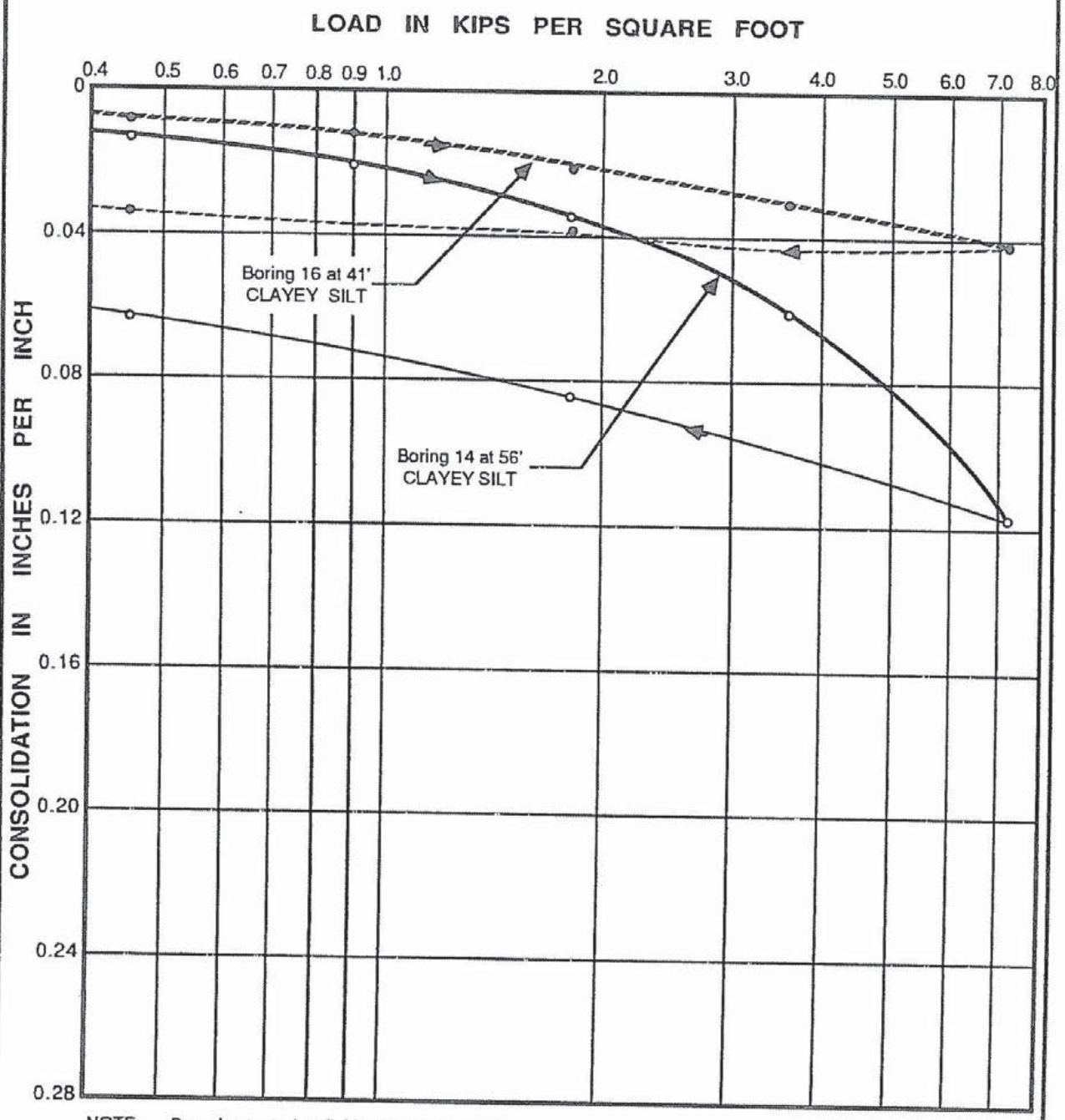
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A - 4.8

Law Crandall Area A

PLATE B2-10



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

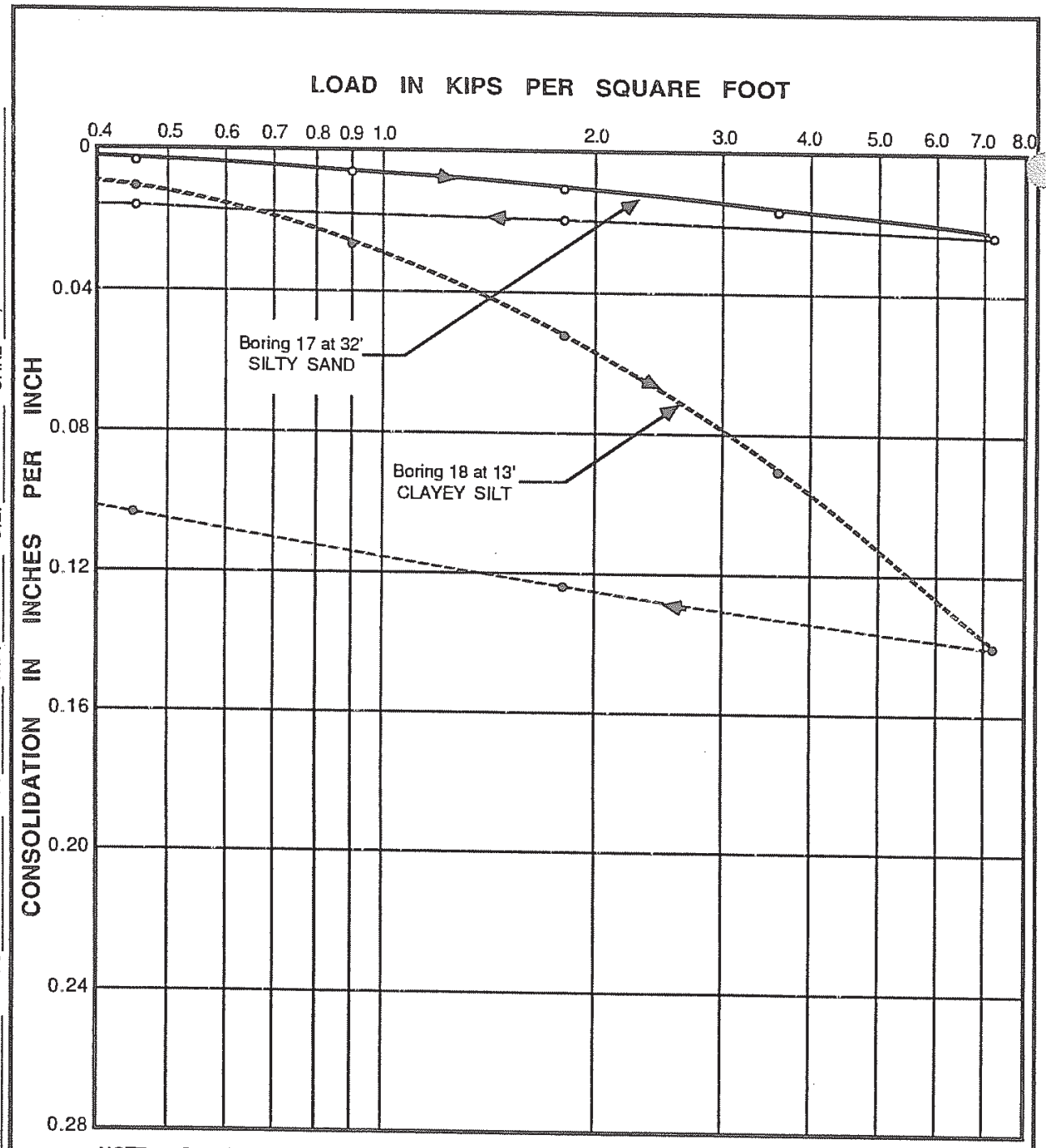
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A-4.9

Law Crandall Area A

PLATE B2-11



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

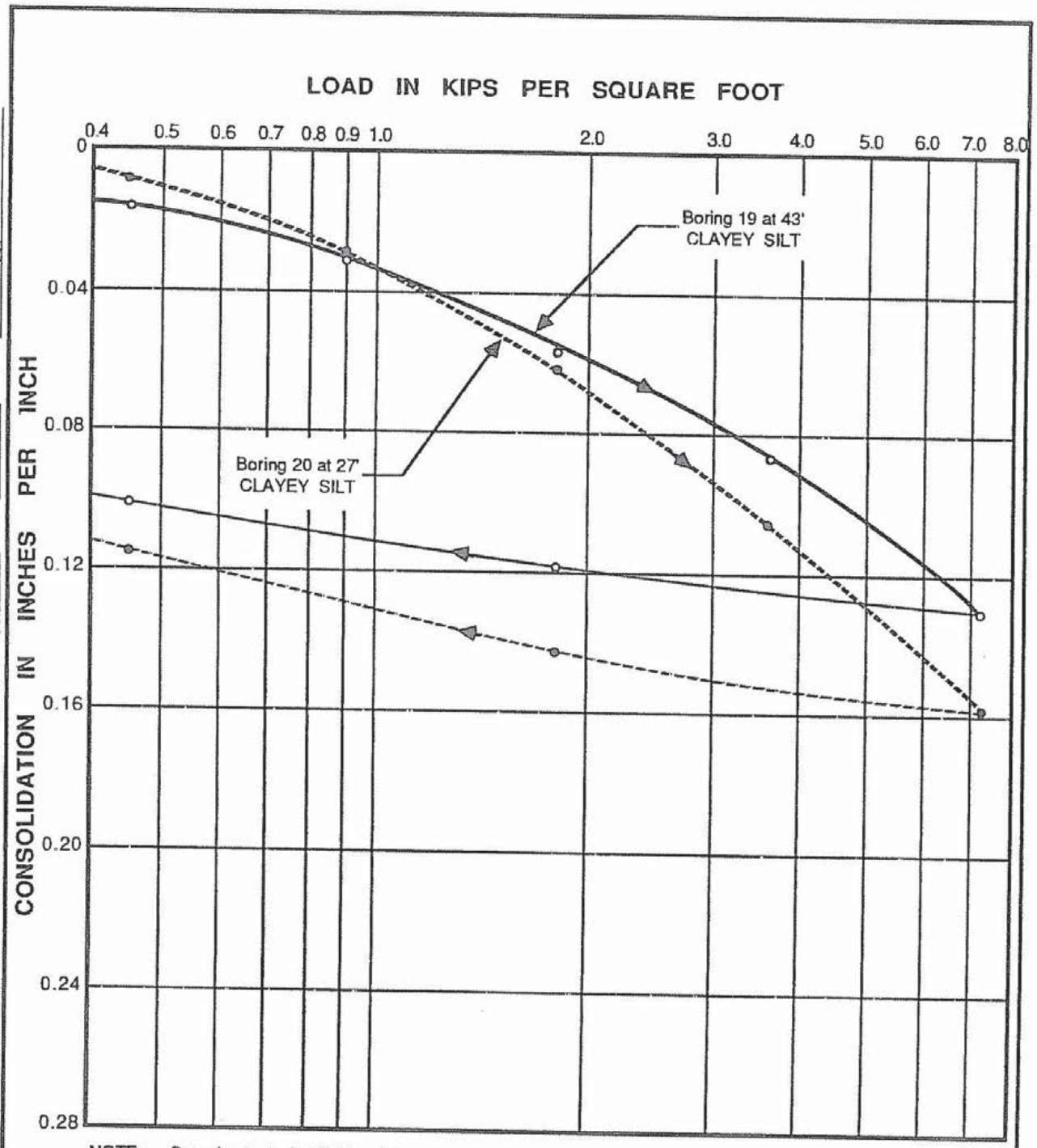
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A - 4.10

Law Crandall Area A

PLATE B2-12



NOTE: Samples tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

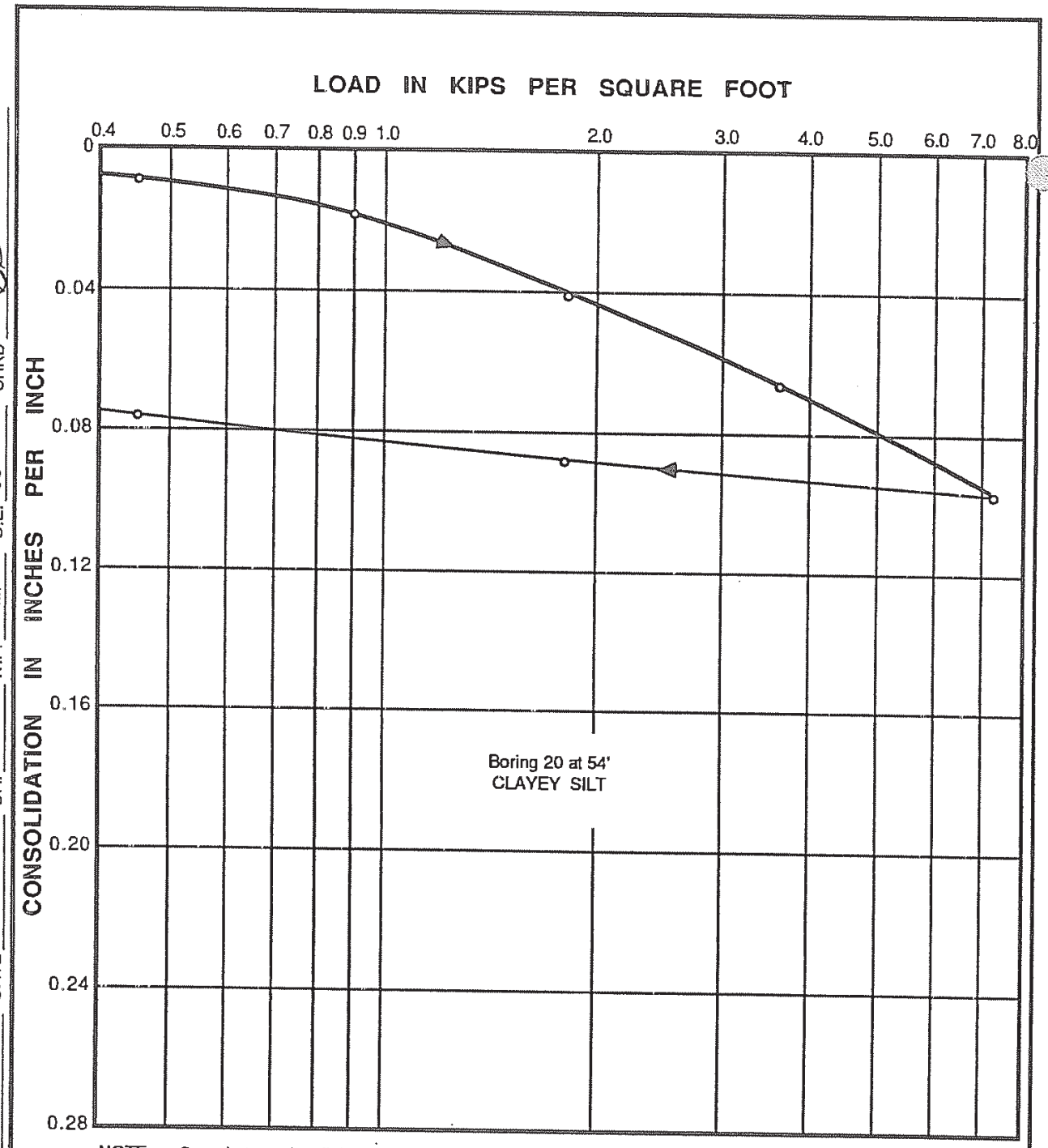
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A - 4. 11

Law Crandall Area A

PLATE B2-13



NOTE: Sample tested at field moisture content.

JOB AE-88473 DATE 1/25/89 DR. dmh W.P. dmh O.E. JC CHKD

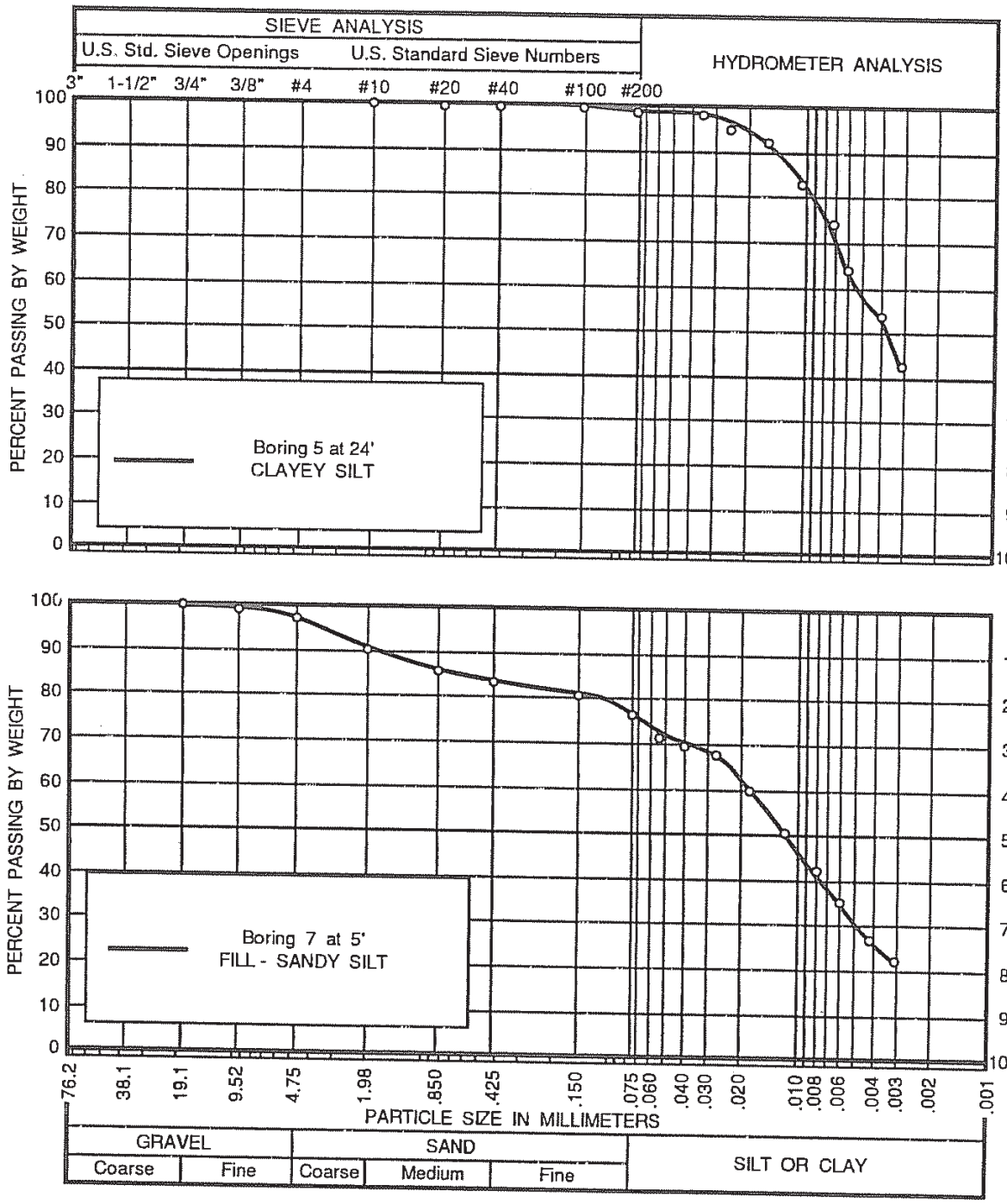
CONSOLIDATION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A - 4.12

Law Crandall Area A

PLATE B2-14



JOB AE-88473 DATE 3/23/89 BY dmh O.E. BK CHKD.

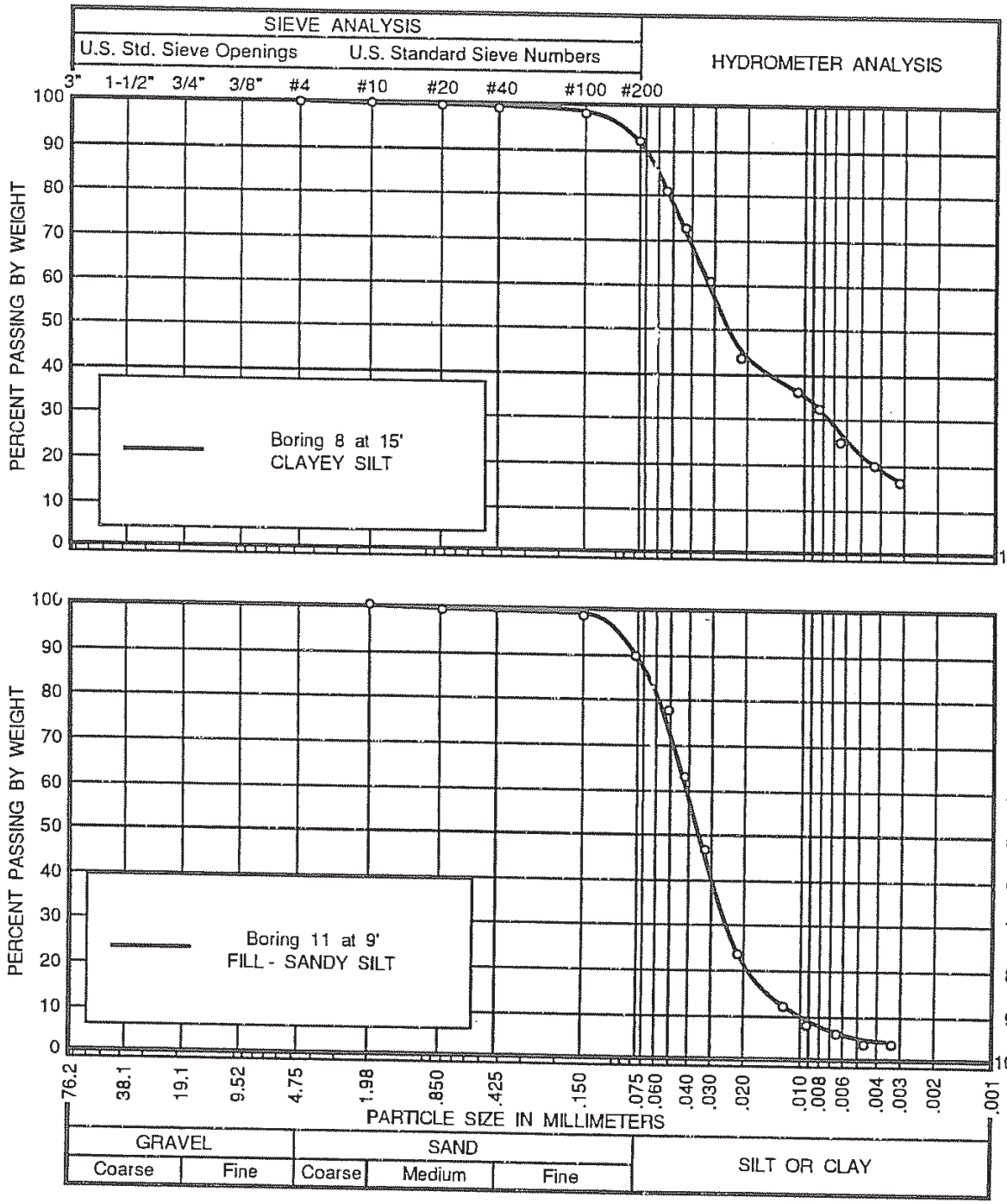
PARTICLE SIZE DISTRIBUTION

LeROY CRANDALL AND ASSOCIATES

Law Crandall Area A

PLATE A-5.1

PLATE B2-15



JOB AE-88473 DATE 3/23/89 BY dmh O.E. BK CHKD.

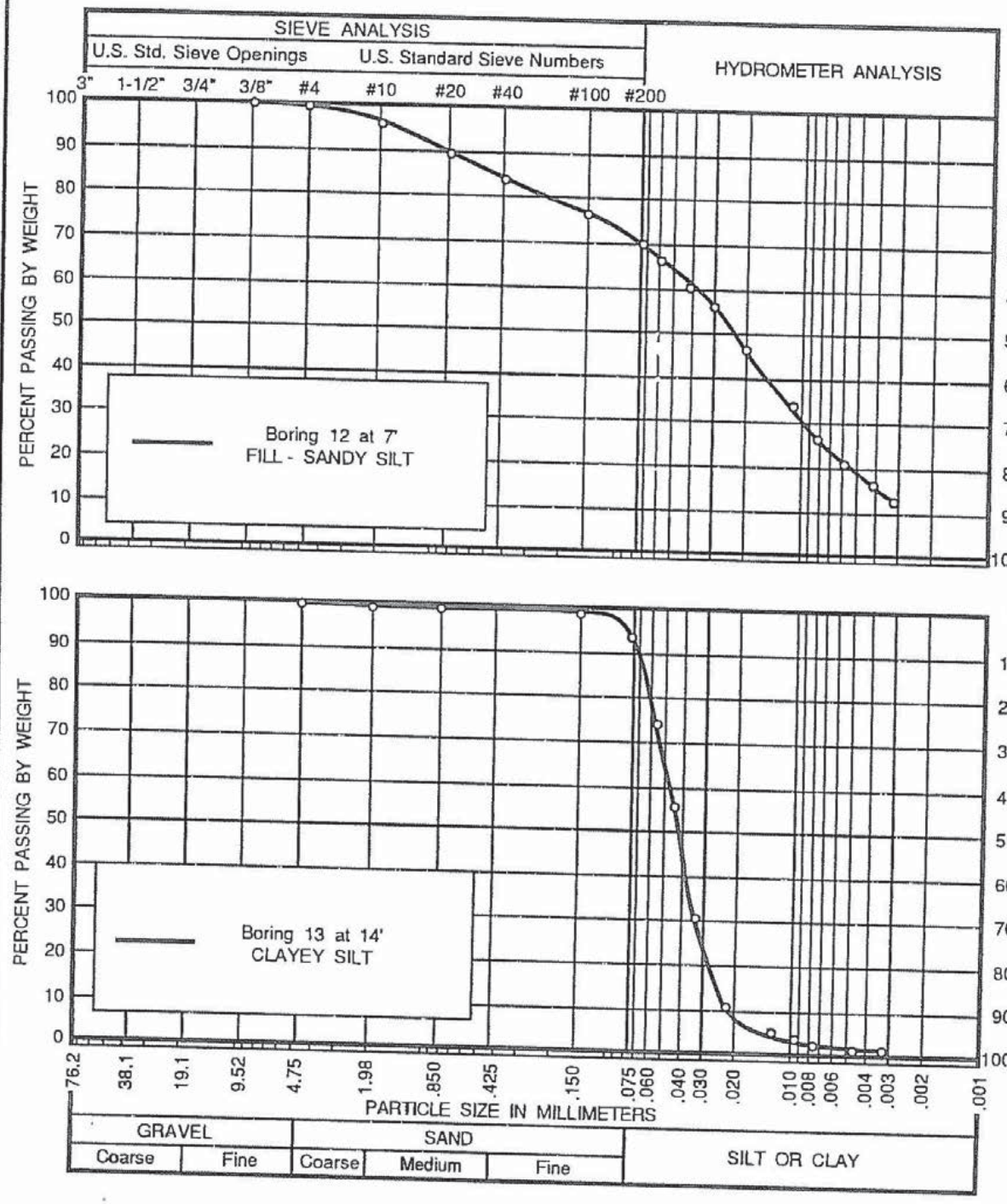
PARTICLE SIZE DISTRIBUTION

LeROY CRANDALL AND ASSOCIATES

PLATE A-5.2

Law Crandall Area A

PLATE B2-16



JOB AE-88473 DATE 3/23/89 BY dmh O.E. BK CHKD

PARTICLE SIZE DISTRIBUTION

LeROY CRANDALL AND ASSOCIATES

Law Crandall Area A

PLATE A-5.3

PLATE B2-17

JOB AE-88473 DATE 1/26/89 W.P. dmh O.E. JC CHKD

BORING NUMBER AND SAMPLE DEPTH :	8 at 0' to 4'	9 at 4' to 8'
SOIL TYPE :	FILL - SANDY SILT	FILL - CLAYEY SILT
MAXIMUM DRY DENSITY : (lbs./cu. ft.)	116	110
OPTIMUM MOISTURE CONTENT : (% of dry wt.)	14	19

TEST METHOD : ASTM Designation D1557 - 70

COMPACTION TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A - 6

Law Crandall Area A

PLATE B2-18

JOB AE-88473 DATE 1/26/89 W.P. dmh O.E. JC CHKD

BORING NUMBER AND SAMPLE DEPTH	SOIL TYPE	SURCHARGE PRESSURE (psf)	COEFFICIENT OF PERMEABILITY Ft./Yr.	Cm./Sec.
1 at 24'	CLAYEY SILT	900	0.1	1×10^{-7}
2 at 14'	SANDY SILT	200	11.1	1×10^{-5}
4 at 19'	SILTY SAND	500	3.6	3×10^{-6}
5 at 16'	SILTY SAND	400	1.9	2×10^{-6}
6 at 29'	SANDY SILT	1000	0.1	1×10^{-7}
11 at 33'	SANDY SILT	1000	7.5	7×10^{-6}
12 at 14'	CLAYEY SILT	200	0.1	1×10^{-7}
14 at 20'	CLAYEY SILT	600	0.1	1×10^{-7}
16 at 28'	SANDY SILT	1000	0.1	9×10^{-8}
19 at 23'	CLAYEY SILT	900	0.3	3×10^{-7}

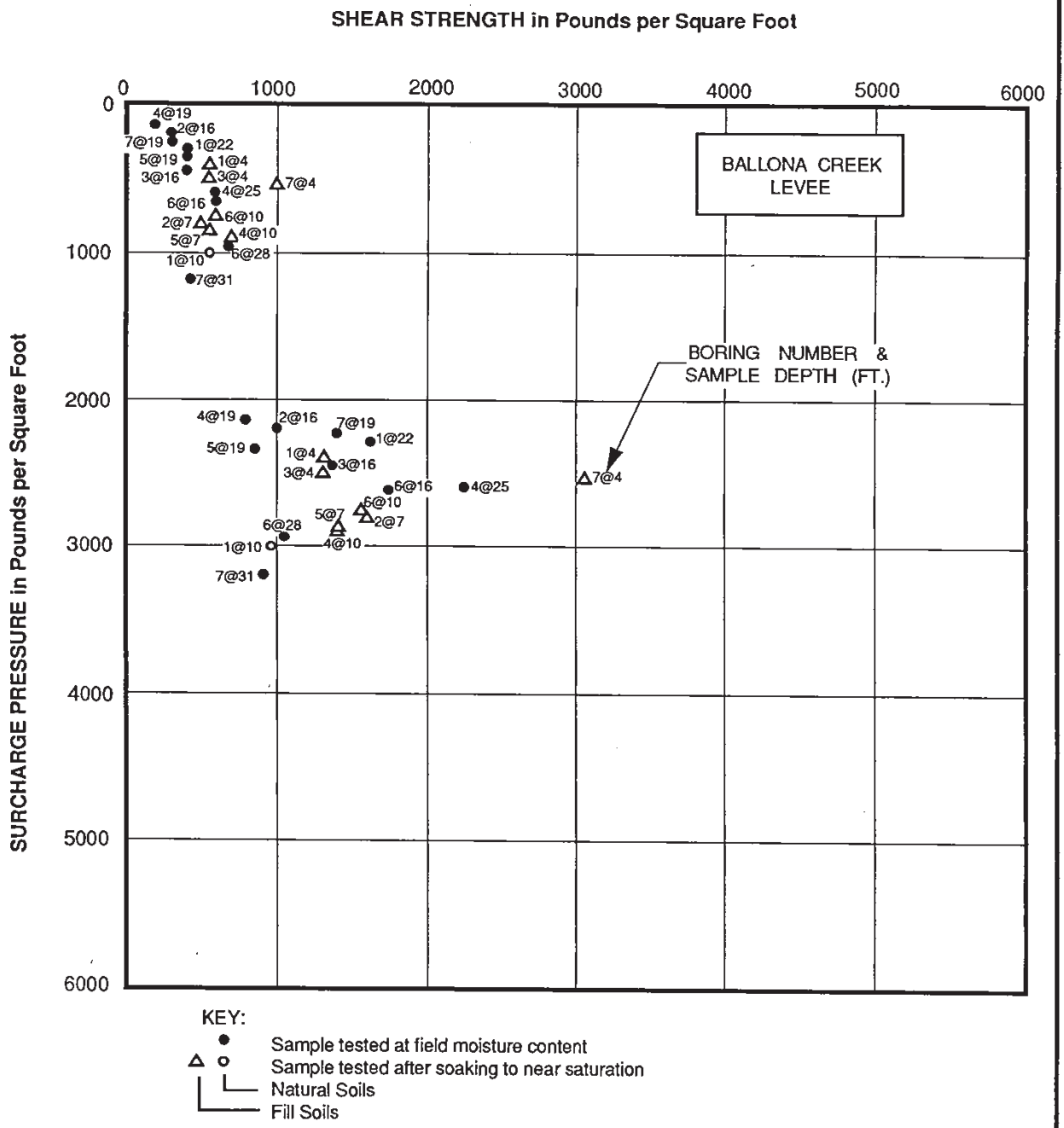
PERMEABILITY TEST DATA

LeROY CRANDALL AND ASSOCIATES

PLATE A-7

Law Crandall Area A

PLATE B2-19



JOB L91028.AEO DATE 4/1/91 DR ph O.E. JLR CHKD.

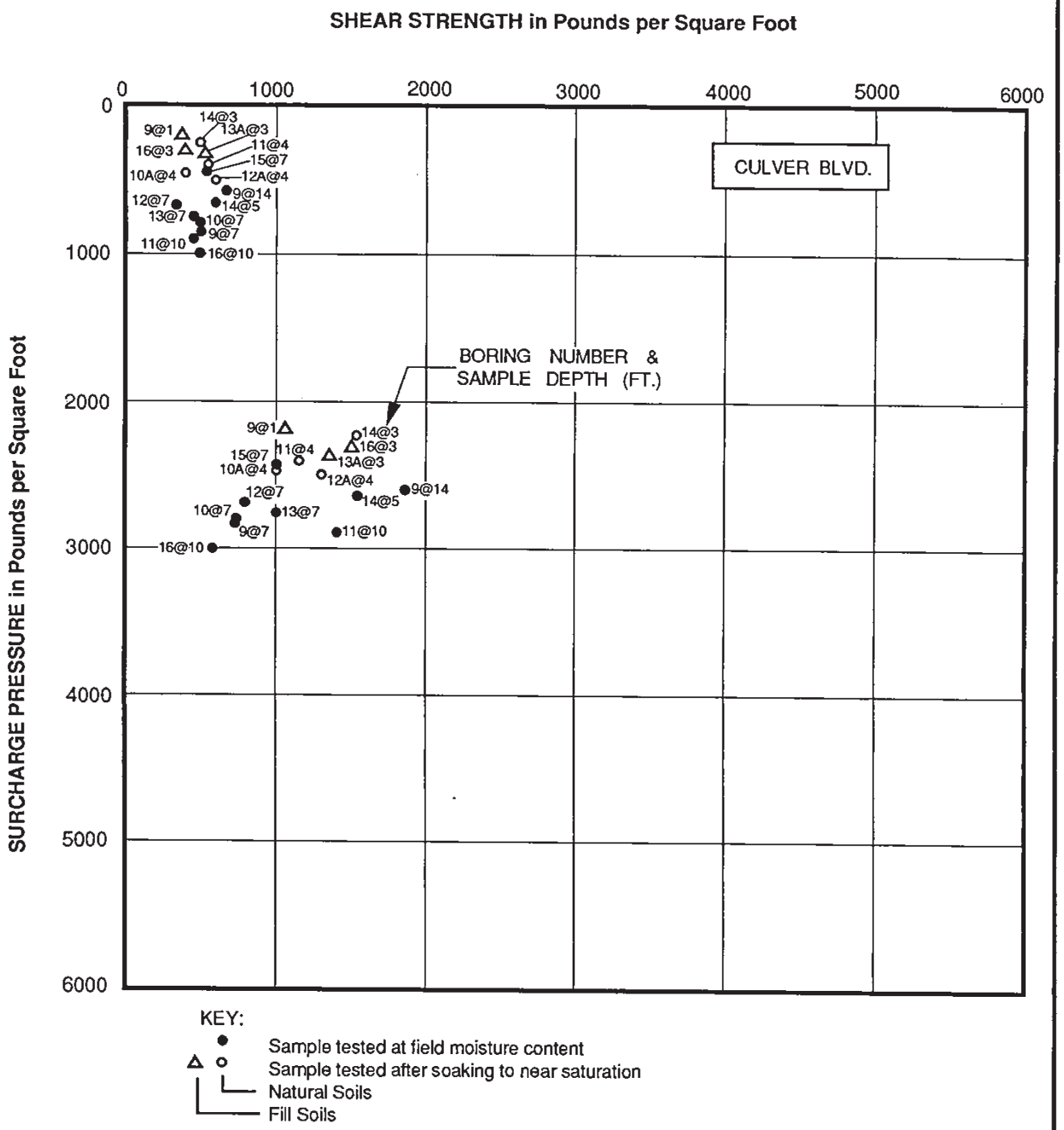
DIRECT SHEAR TEST DATA

LAW/CRANDALL, INC.

PLATE A-3.1

Law Crandall Area B

PLATE B2-20



JOB L91028.AEO DATE 4/1/91 DR ph O.E. JLR CHKD.

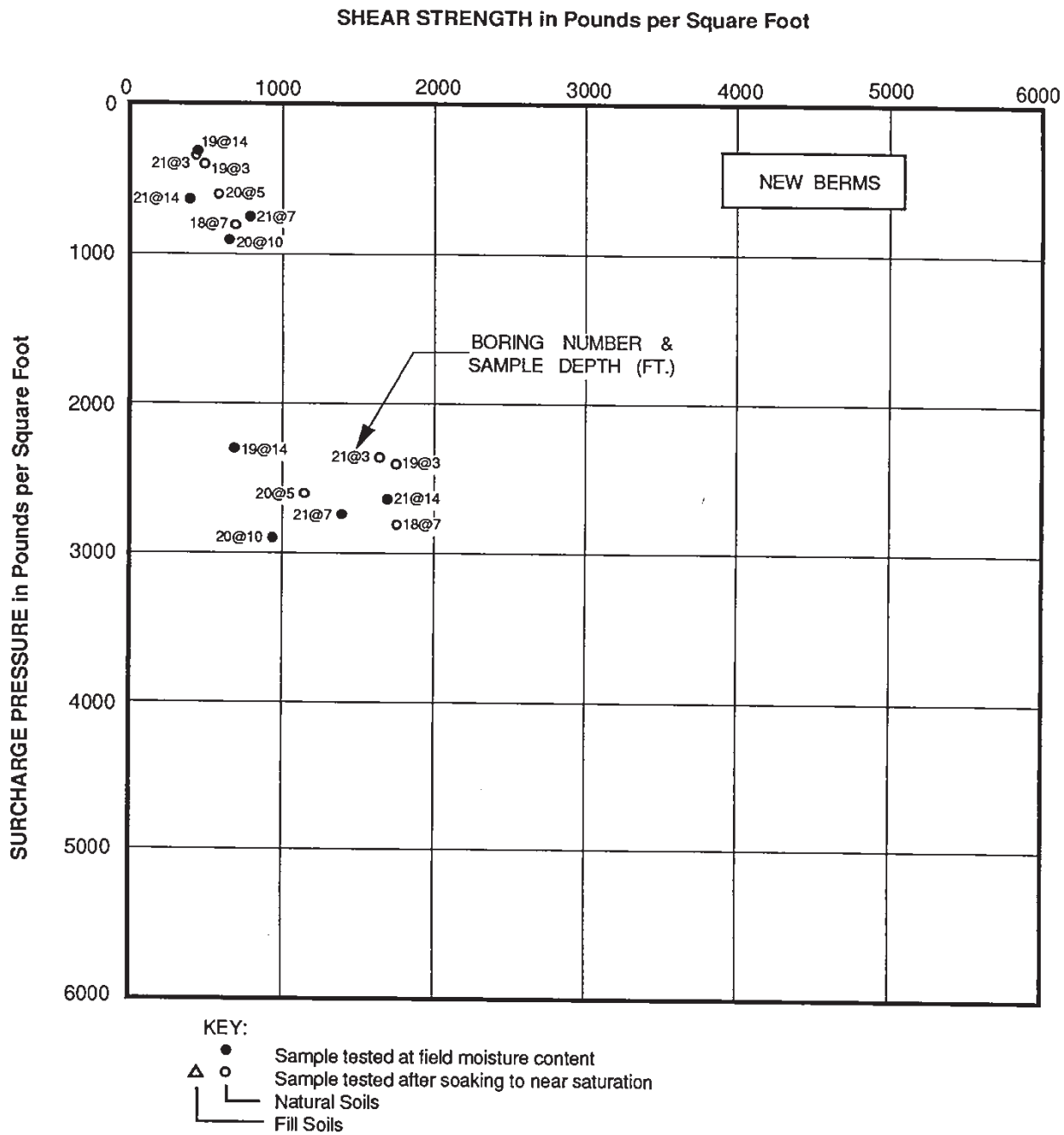
DIRECT SHEAR TEST DATA

LAW/CRANDALL, INC.

PLATE A-3.2

Law Crandall Area B

PLATE B2-21



JOB L91028.AEO DATE 4/1/91 DR ph O.E. FH CHKD.

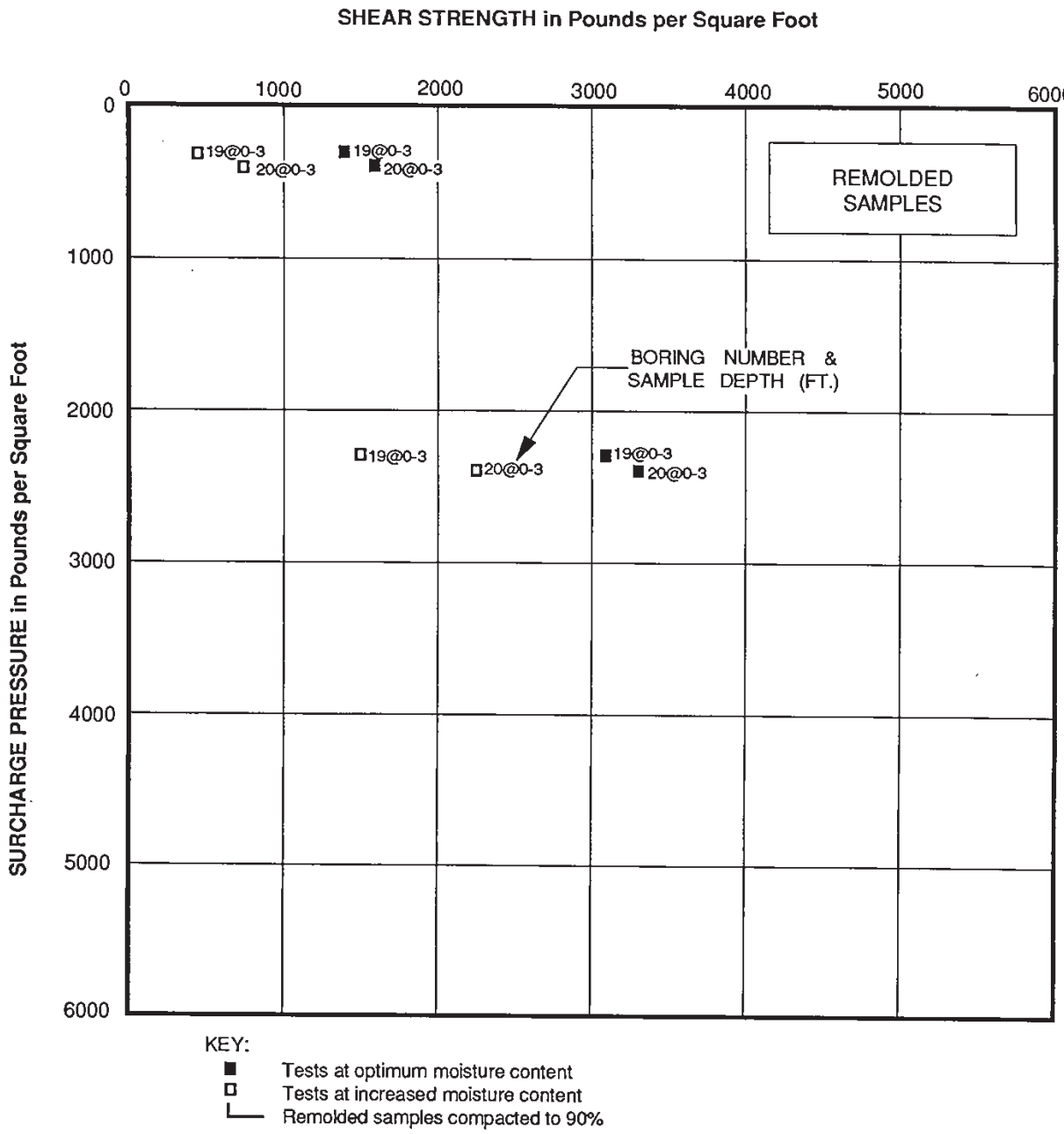
DIRECT SHEAR TEST DATA

LAW/CRANDALL, INC.

PLATE A-3.3

Law Crandall Area B

PLATE B2-22



JOB L91028.AEO DATE 4/1/91 DR ph O.E. FH CHKD.

DIRECT SHEAR TEST DATA

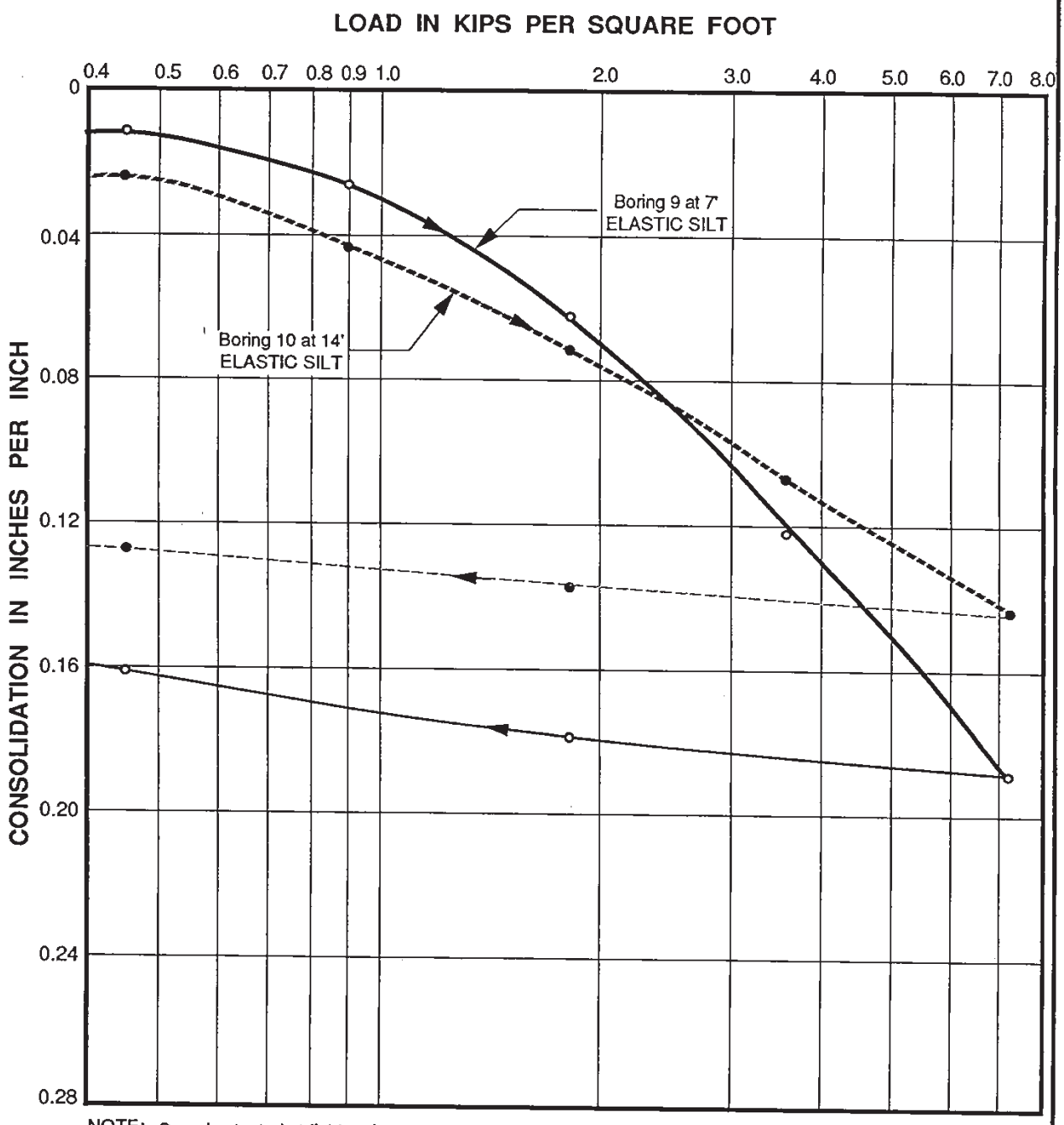
LAW/CRANDALL, INC.

PLATE A-3.4

Law Crandall Area B

PLATE B2-23

JOB L91028.AEO DATE 3/29/91 DR. ph W.P. ph O.E. JLR/BK CHKD



NOTE: Samples tested at field moisture content.

CONSOLIDATION TEST DATA

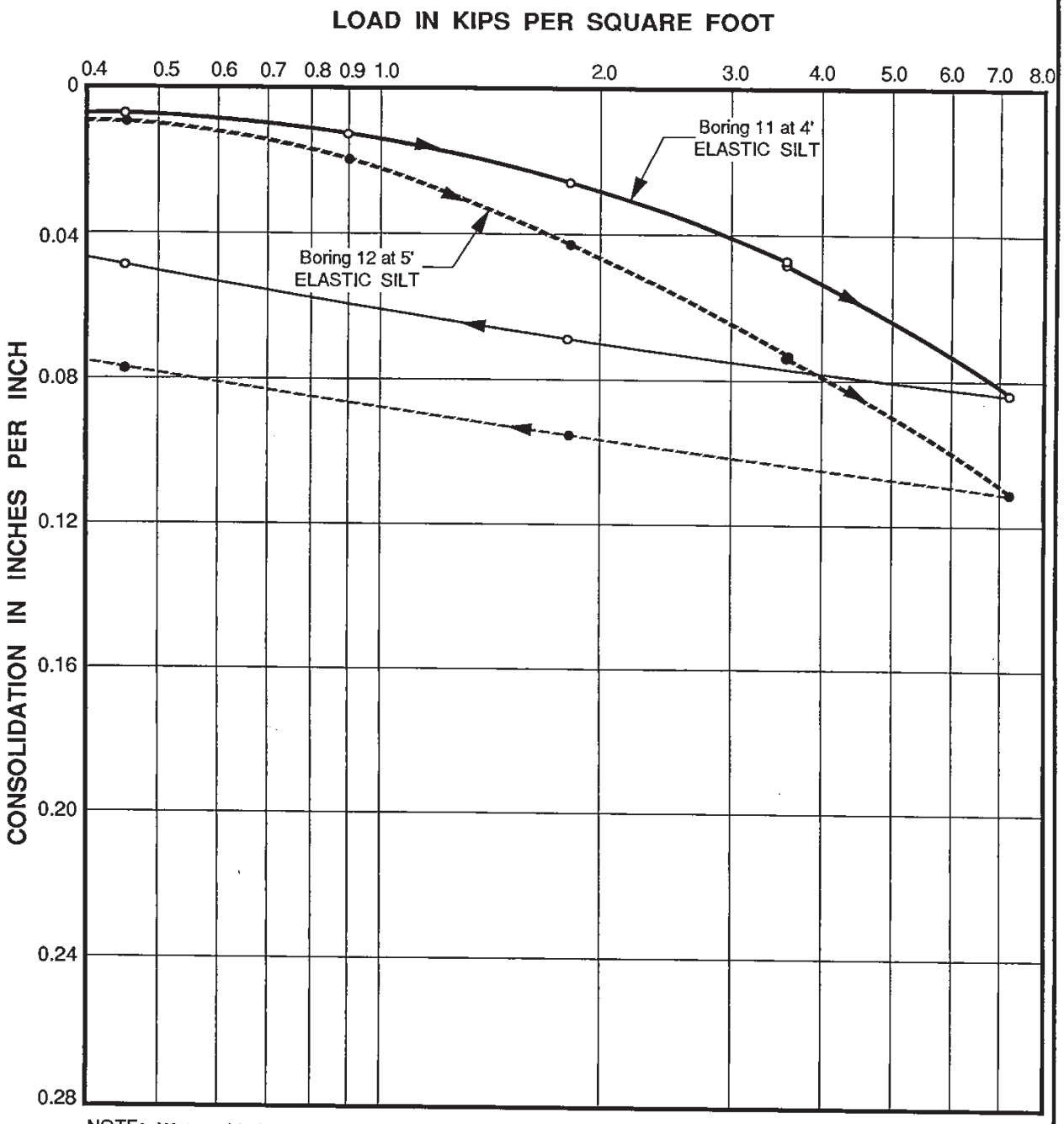
LAW/CRANDALL, INC.

Law Crandall Area B

PLATE A-4.1

PLATE B2-24

JOB L91028.AEO DATE 3/29/91 DR. ph W.P. ph O.E. JLR/BK CHKD



NOTE: Water added to samples after consolidation under a load of 3.6 kips per square foot.

CONSOLIDATION TEST DATA

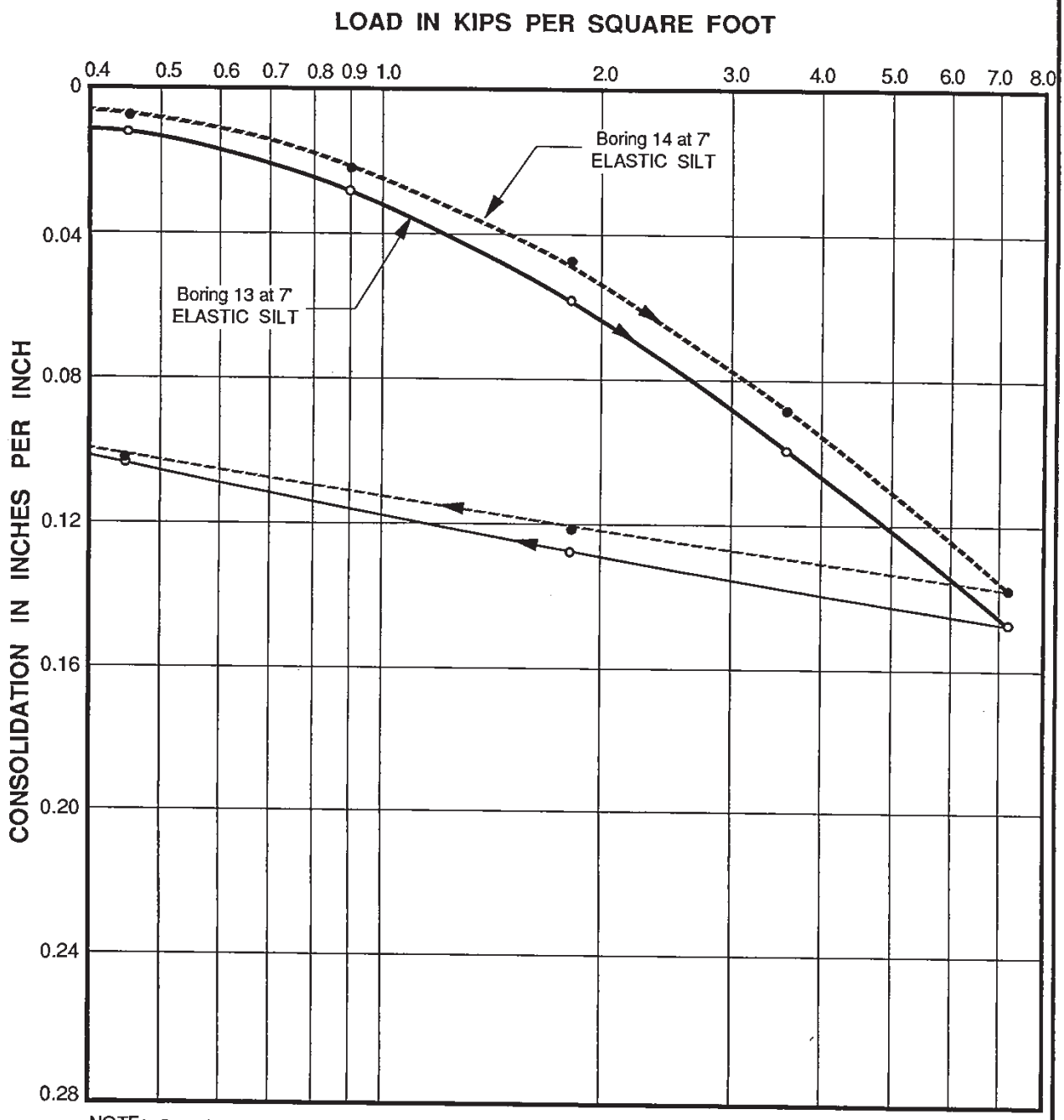
LAW/CRANDALL, INC.

PLATE A - 4.2

Law Crandall Area B

PLATE B2-25

JOB L91028.AEO DATE 3/29/91 DR. ph W.P. ph O.E. JLR/BK CHKD



NOTE: Samples tested at field moisture content.

CONSOLIDATION TEST DATA

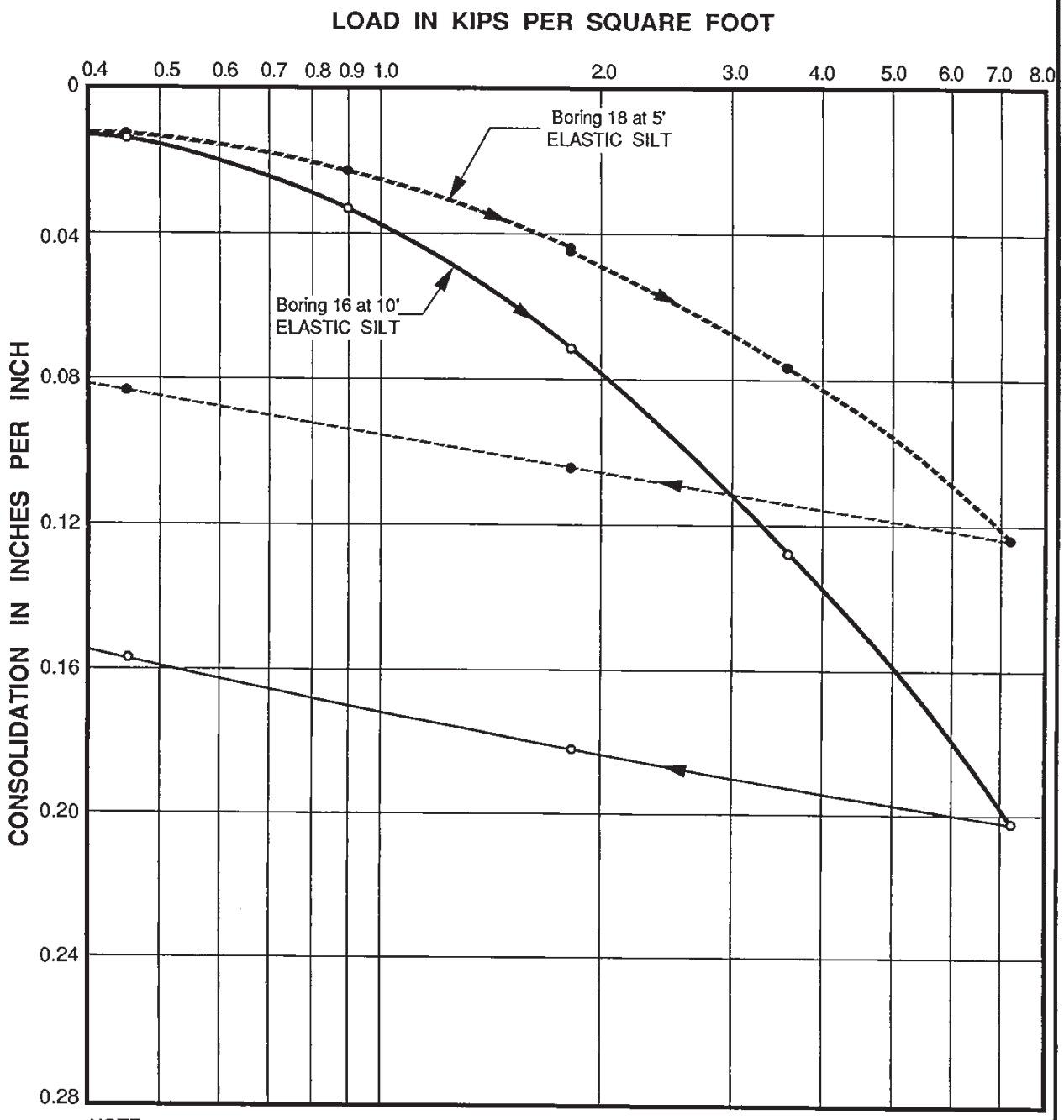
LAW/CRANDALL, INC.

PLATE A-4.3

Law Crandall Area B

PLATE B2-26

JOB L91028.AEO DATE 3/29/91 DR. ph W.P. ph O.E. JLR/BK CHKD



NOTE: Water added to sample from Boring 18 after consolidation under a load of 1.8 kips per square foot. The other sample tested at field moisture content.

CONSOLIDATION TEST DATA

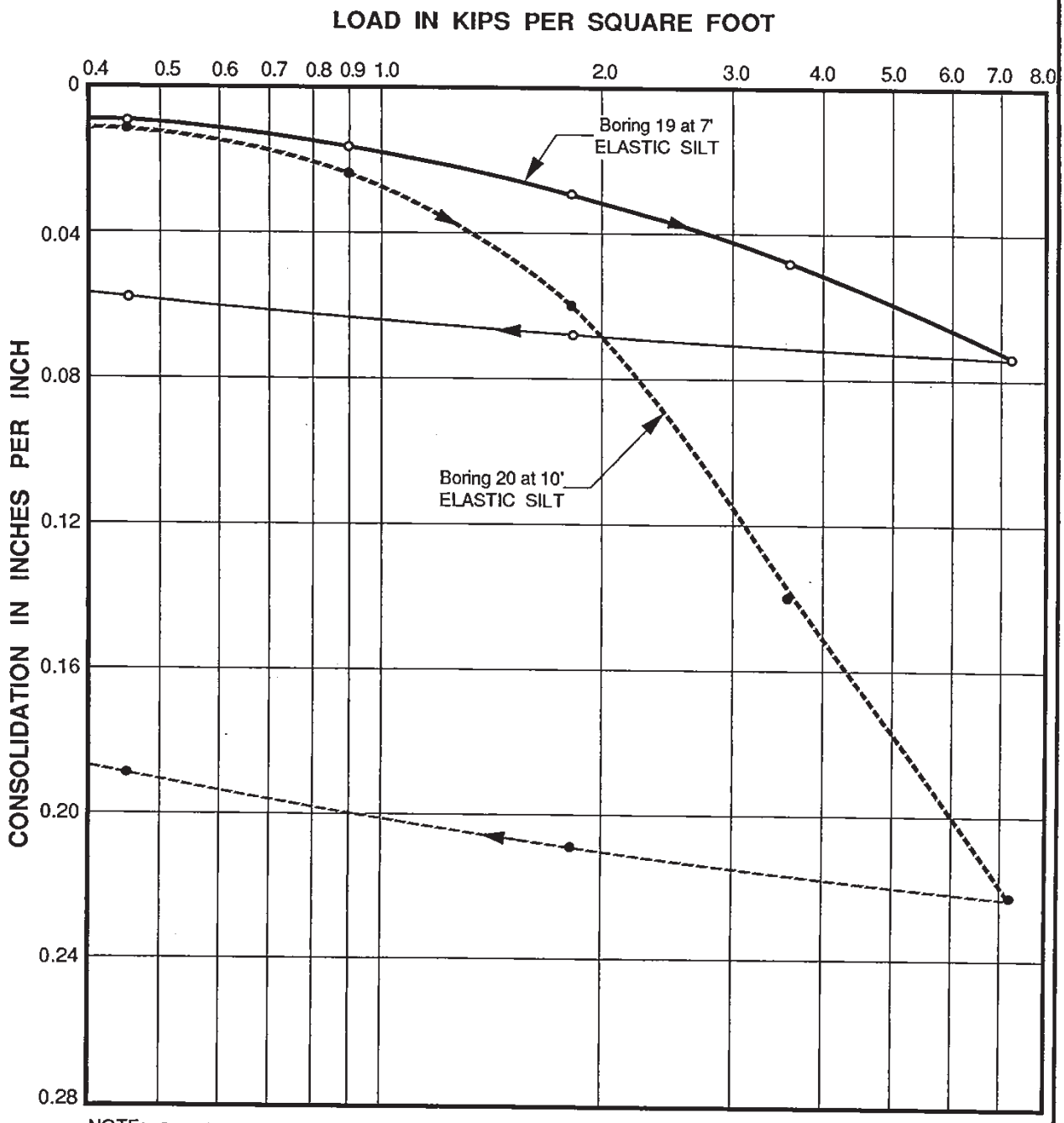
LAW/CRANDALL, INC.

Law Crandall Area B

PLATE A-4.4

PLATE B2-27

JOB L91028.AEO DATE 3/29/91 DR. ph W.P. ph O.E. JLR/BK CHKD



NOTE: Samples tested at field moisture content.

CONSOLIDATION TEST DATA

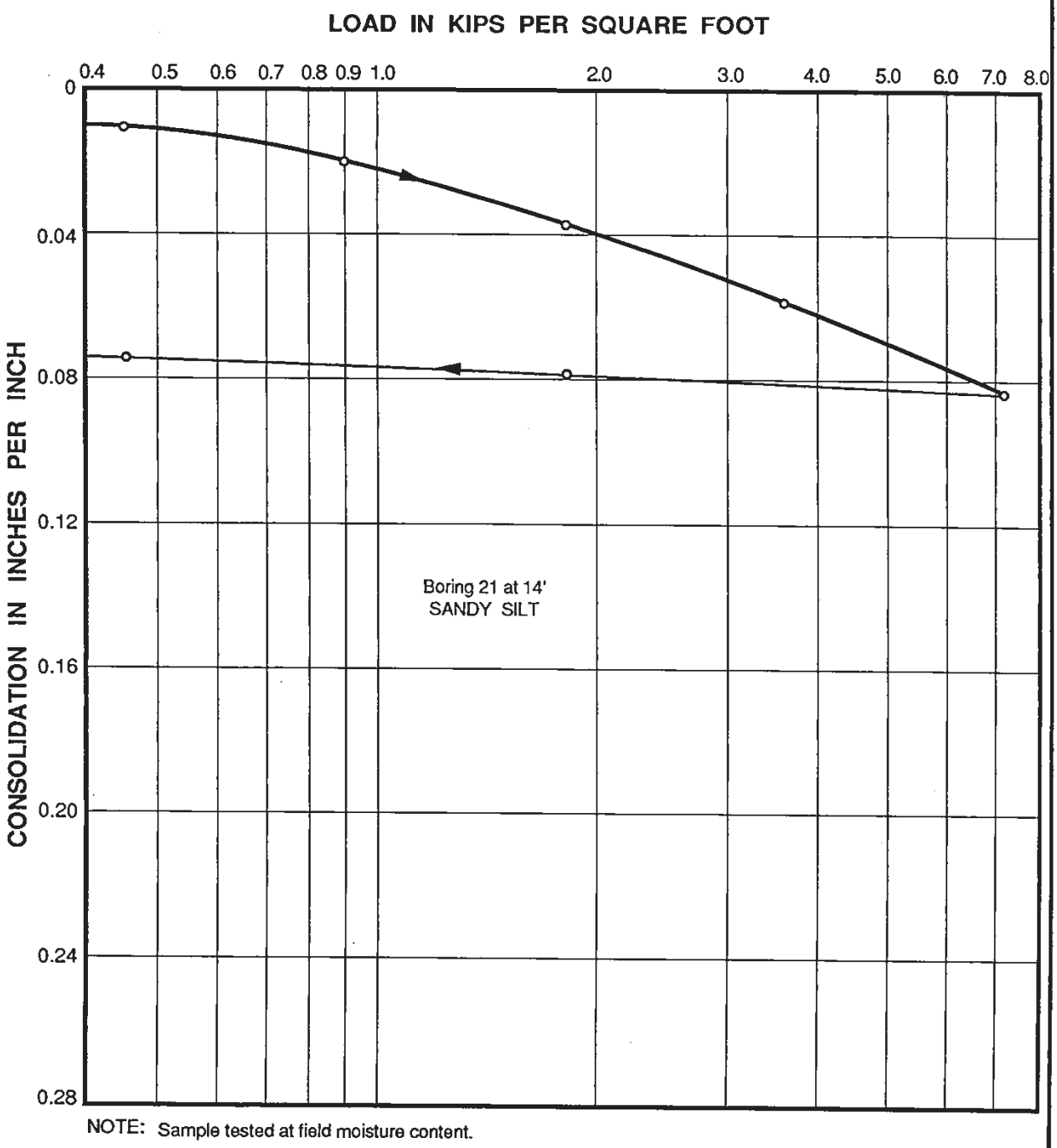
LAW/CRANDALL, INC.

Law Crandall Area B

PLATE A-4.5

PLATE B2-28

JOB L91028.AEO DATE 3/29/91 DR. ph W.P. ph O.E. JLR/BK CHKD



NOTE: Sample tested at field moisture content.

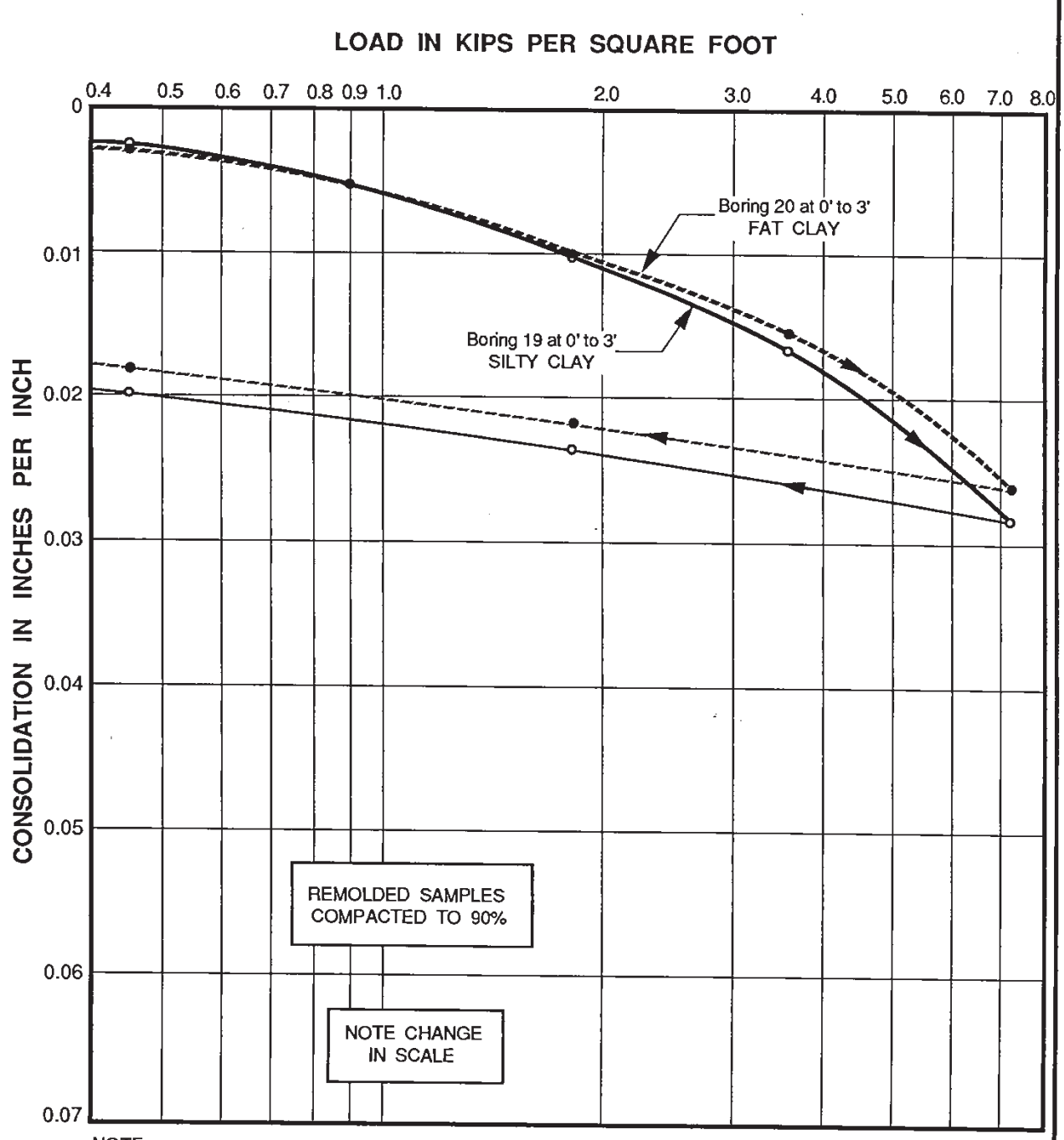
CONSOLIDATION TEST DATA

LAW/CRANDALL, INC.

Law Crandall Area B

PLATE A - 4.6

PLATE B2-29



NOTE: Samples tested at optimum moisture content.

JOB L91028.AEO DATE 3/29/91 DR. ph W.P. ph O.E. JLR/BK CHKD

CONSOLIDATION TEST DATA

LAW/CRANDALL, INC.

PLATE A-4.7

Law Crandall Area B

PLATE B2-30

JOB L91028.AEO DATE 4/1/91 W.P. ph O.E. FH CHKD

BORING NUMBER AND SAMPLE DEPTH :	19 at 0' to 3'	20 at 0' to 3'
SOIL TYPE :	SILTY CLAY	FAT CLAY
MAXIMUM DRY DENSITY : (lbs./cu. ft.)	114	109
OPTIMUM MOISTURE CONTENT : (% of dry)	14	18

TEST METHOD: ASTM Designation D1557 - 78

COMPACTION TEST DATA

LAW/CRANDALL, INC.

PLATE A-5

Law Crandall Area B

PLATE B2-31

JOB L91028.AEO DATE 4/1/91 W.P. ph O.E. FH CHKD

BORING NUMBER AND SAMPLE DEPTH:	19 at 0' to 3'	20 at 0' to 3'
SOIL TYPE:	SILTY CLAY	FAT CLAY
CONFINING PRESSURE: (lbs./sq. ft.)	144	144
INITIAL MOISTURE CONTENT: (% of dry wt.)	13.0	13.0
FINAL MOISTURE CONTENT: (% of dry wt.)	33.8	38.1
DRY DENSITY: (lbs./cu. ft.)	98	99
EXPANSION INDEX:	87	155

TEST METHOD: Uniform Building Code Standard No. 29-2, Expansion Index Test

EXPANSION INDEX TEST DATA

LAW/CRANDALL, INC.

PLATE A-6

Law Crandall Area B

PLATE B2-32

JOB L91028.AEO DATE 4/1/91 W.P. ph O.E. JLR CHKD

BORING NUMBER AND SAMPLE DEPTH (ft.)	SOIL TYPE	COEFFICIENT OF PERMEABILITY (cm / sec)
9 at 7'	ELASTIC SILT	3.6×10^{-7}
10 at 5'	ELASTIC SILT	1.7×10^{-7}
11 at 10'	ELASTIC SILT	1.9×10^{-7}
12 at 5'	ELASTIC SILT	5.1×10^{-7}
16 at 10'	ELASTIC SILT	9.7×10^{-8}
18 at 7'	ELASTIC SILT	8.7×10^{-7}
20 at 10'	ELASTIC SILT	9.7×10^{-8}
24 at 14'	SILTY SAND	1.4×10^{-6}

PERMEABILITY TEST DATA

LAW/CRANDALL, INC.

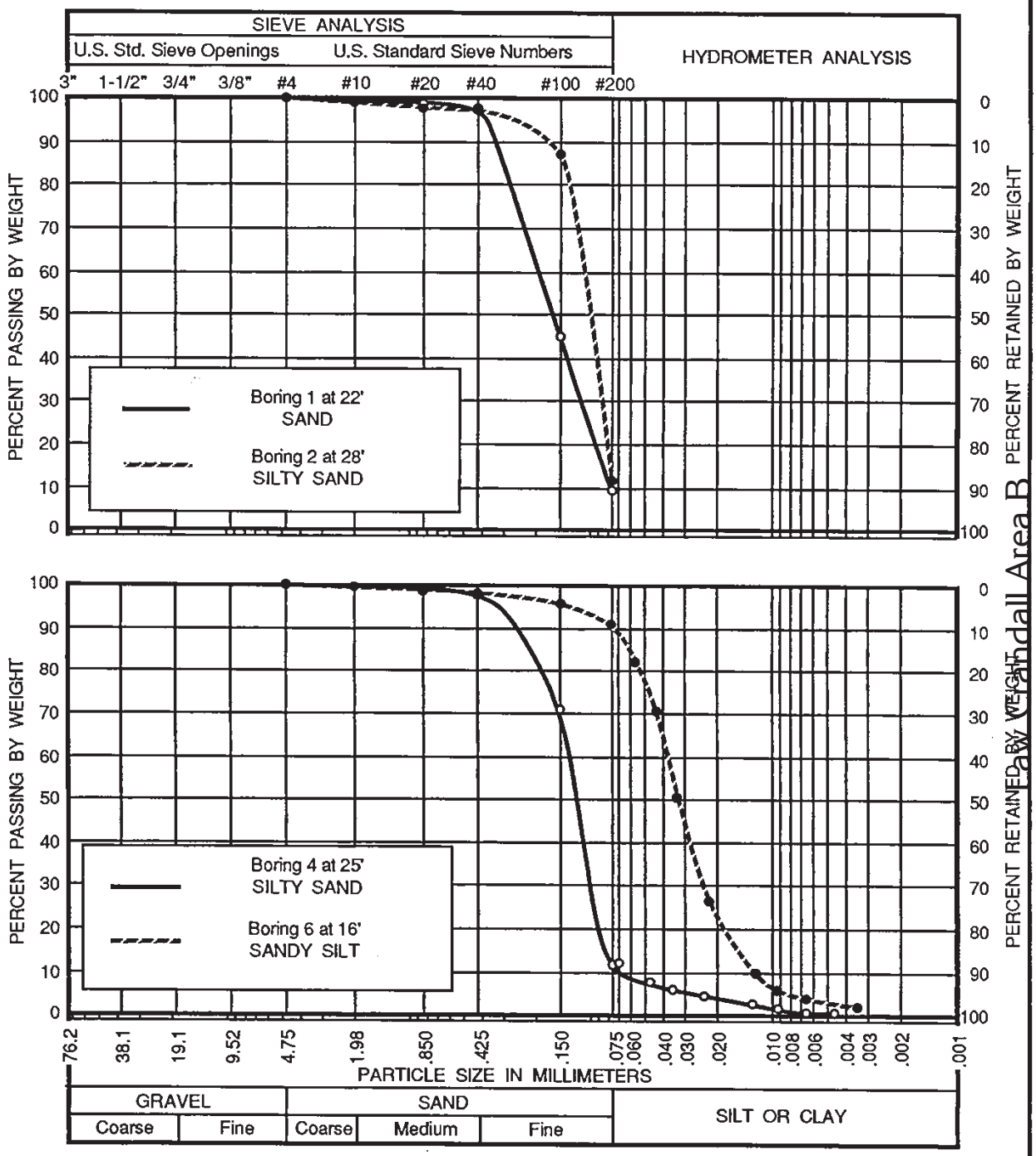
PLATE A-7

Law Crandall Area B

PLATE B2-33

PLATE B2-34

JOB L91028.AEO DATE 4/1/91 DR ph O.E. FH CHKD.

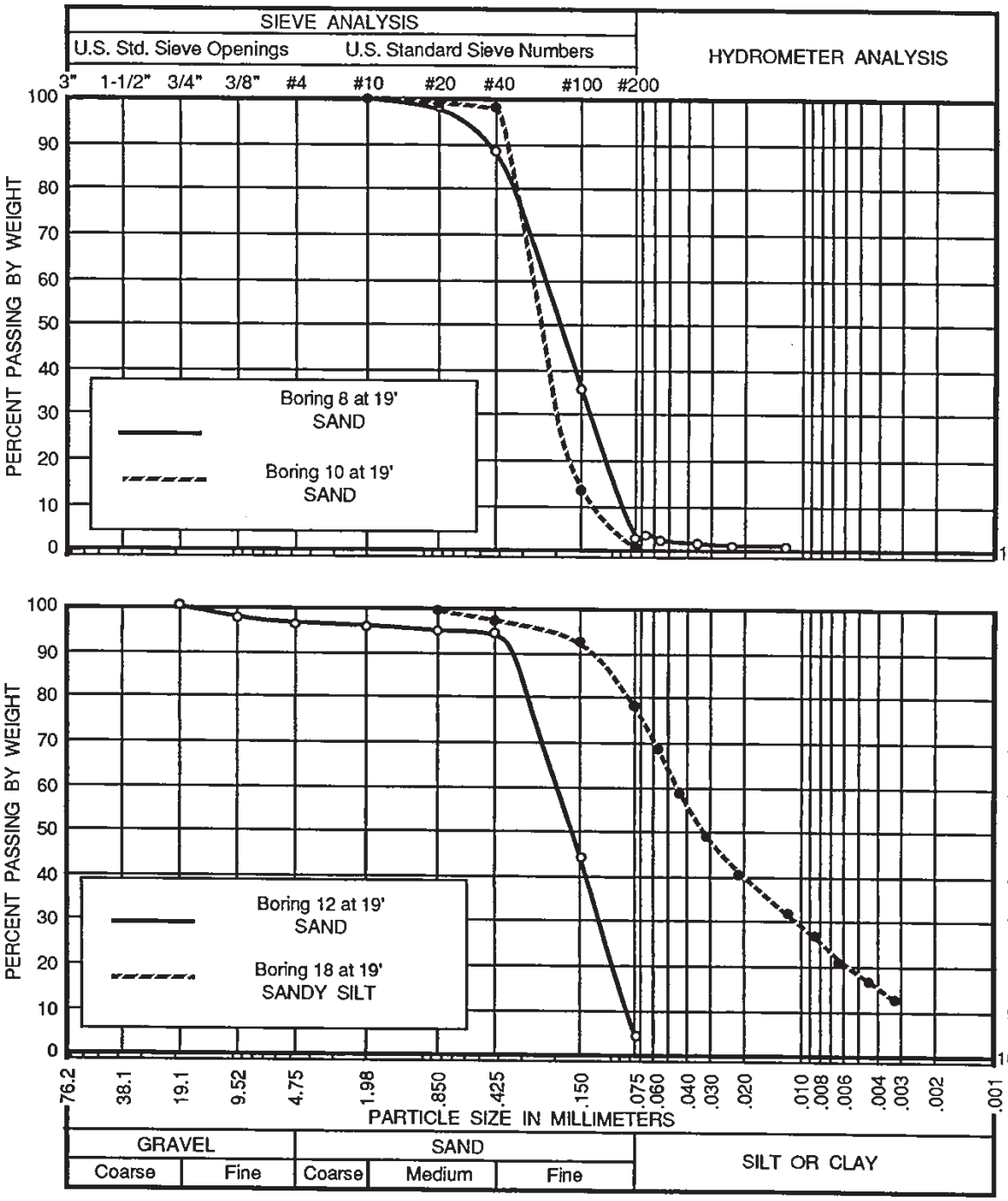


Law Crandall Area B

PARTICLE SIZE DISTRIBUTION

LAW/CRANDALL, INC.

PLATE A-8.1



JOB L91028.AEO DATE 4/1/91 DR ph O.E. BK CHKD.

PARTICLE SIZE DISTRIBUTION

LAW/CRANDALL, INC.

PLATE A-8.2

Law Crandall Area B

PLATE B2-35

Table C2 - GEOTECHNICAL LABORATORY TEST SUMMARY

BORING NUMBER	DEPTH (feet)	SOIL TYPE	INSITU MOISTURE CONTENT (percent)	PERCENTAGE PASSING SIEVE NO. 200	LIQUID LIMIT	PLASTICITY INDEX
B-1	3	ML	39	98	41	7
	6	ML	32	52	--	--
	9	MH	43	98	55	22
	12	MH	60	93	--	--
	15	MH	91	93	--	--
B-2	3	CH	39	97	50	31
	6	ML	37	53	--	--
	9	CL	40	98	--	--
	10	CL	38	51	--	--
	12	CH	83	95	--	--
	15	MH	107	96	64	17
B-3	0	ML	19	66	--	--
	6	CL	45	99	46	21
	9	CL	37	91	--	--
	12	MH	42	98	--	--
	15	CH	62	90	73	45
	18	CH	87	96	--	--
B-4	0	ML	20	94	--	--
	3	CL	34	91	--	--
	6	ML	34	98	NP	NP
	9	ML	36	66	--	--
	12	ML	42	99	40	2
	15	ML	100	93	--	--
B-5	0	CL	23	83	--	--
	6	CL	34	82	--	--
	9	MH	49	98	62	29
	12	CH	59	90	--	--
	15	CH	95	95	62	38
B-6	0	CH	54	98	--	--
	2.5	MH	46	99	70	35
	4.5	CH	43	92	--	--
B-7	3	CH	58	98	--	--
	6	ML	26	95	33	7
	9	MH	40	96	59	25
	12	CH	60	92	--	--
	15	SC	34	39	--	--
B-8	0	CH	41	99	67	45
	3	CH	36	80	--	--
	6	CH	71	97	--	--
	9	CH	58	98	53	24
	12	SC	40	36	--	--
	15	SC	26	16	--	--
B-9	1	CH	43	99	64	37
	3	CH	52	99	58	29
	6	MH	58	97	--	--
	9	MH	81	97	--	--
	12	SC	37	35	--	--
	15	SC	25	14	--	--
B-10	0	ML	29	76	--	--
	3	CH	54	93	--	--
	6	ML	31	94	NP	NP
	9	CL	59	100	--	--
	12	ML	48	100	46	15
	15	CL	48	52	--	--
	18	SM	29	12	--	--

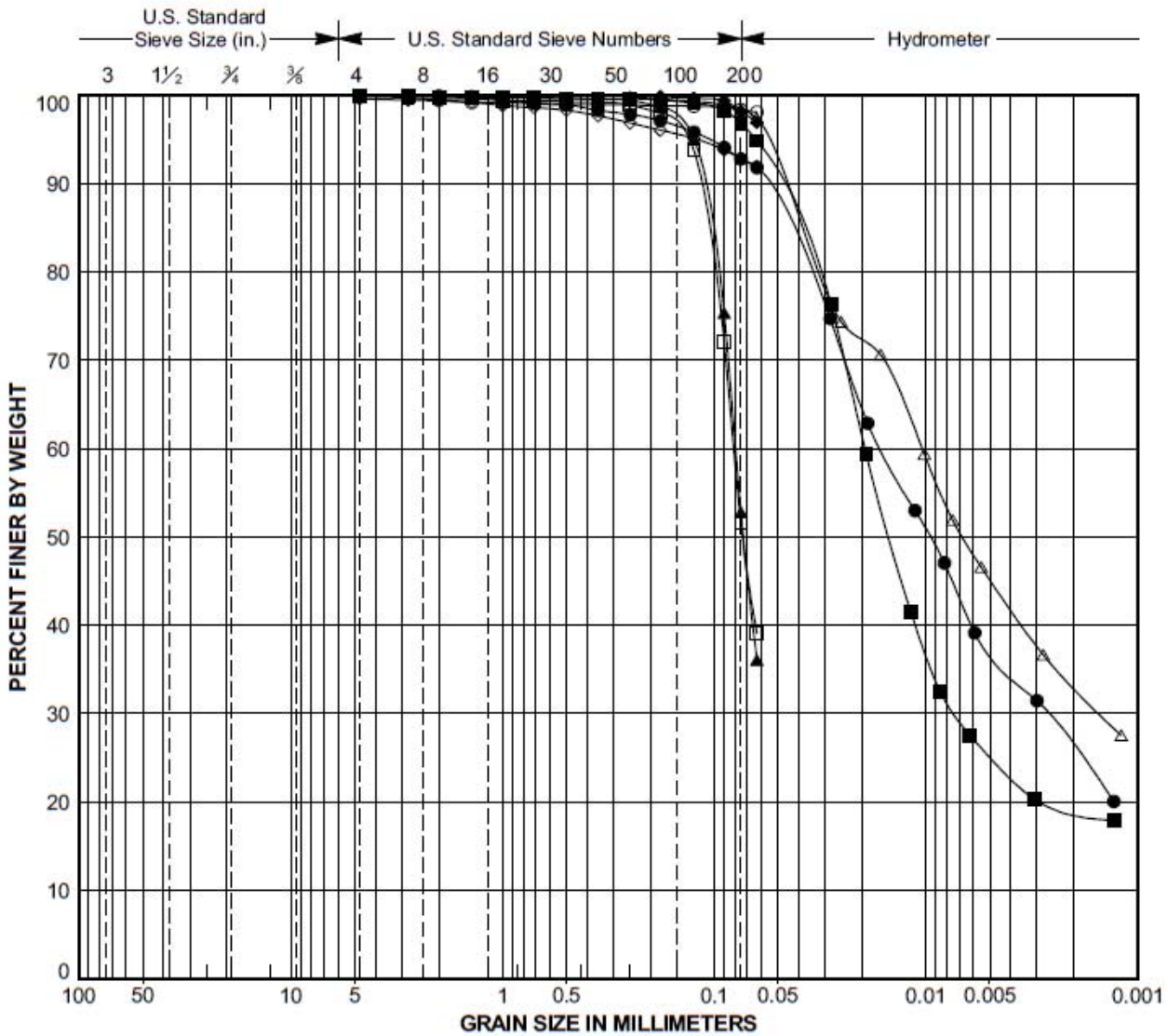
Table C2 - GEOTECHNICAL LABORATORY TEST SUMMARY

BORING NUMBER	DEPTH (feet)	SOIL TYPE	INSITU MOISTURE CONTENT (percent)	PERCENTAGE PASSING SIEVE NO. 200	LIQUID LIMIT	PLASTICITY INDEX
B-11	0	CL	37	90	--	--
	3	MH	72	96	80	40
	6	MH	58	91	--	--
	9	MH	60	97	61	28
	12	MH	71	90	--	--
	15	SC	54	45	--	--
B-12	0	CL	49	98	--	--
	3	MH	45	97	--	--
	6	MH	69	96	--	--
	9	MH	84	95	52	13
	12	MH	59	90	--	--
	15	CH	56	56	--	--
B-13	0	SC	17	21	--	--
	3	CH	65	97	--	--
	6	CH	56	96	60	29
	9	CH	93	95	--	--
	12	CH	65	99	--	--
	15	SC	43	47	--	--
C-1	0	SC	15	37	--	--
	6	CL	34	96	40	20
	7	CL	34	90	--	--
	9	CL	22	59	--	--
	12	CH	46	92	25	47
	15	CH	27	83	--	--
	18	CL	33	95	--	--
	21	SC	13	28	--	--
	24	SP-SC	12	7	--	--
	30	CH	34	99	--	--
C-2	0	SC	12	42	--	--
	6	CH	45	98	57	36
	9	CH	48	96	--	--
	12	SC	18	23	--	--
	15	CL	20	52	--	--
	18	CL	19	52	--	--
	24	SP-SC	19	7	--	--
	27	SP-SC	14	7	--	--
C-4	0	SP	4	5	--	--
	3	SP	8	11	--	--
	4	SP	18	60	--	--
	6	SC	23	44	--	--
	9	CH	20	57	--	--
	12	MH	38	95	54	23
	15	CH	23	60	--	--
	18	CH	22	68	--	--
	21	ML	23	61	--	--
	24	ML	24	79	NP	NP
C-5	0	CL	21	65	--	--
	3	SM	16	25	--	--
	6	SC	25	38	--	--
	12	CL	19	57	--	--
	15	SM	15	21	--	--
	24	ML	43	99	47	19

Table C2 - GEOTECHNICAL LABORATORY TEST SUMMARY

BORING NUMBER	DEPTH (feet)	SOIL TYPE	INSITU MOISTURE CONTENT (percent)	PERCENTAGE PASSING SIEVE NO. 200	LIQUID LIMIT	PLASTICITY INDEX
C-6	0	SP	4	3	--	--
	3	SP-SM	4	5	--	--
	6	SP	2	2	--	--
	9	CL	30	91	--	--
	12	CH	43	98	57	36
	15	CH	39	100	--	--
	18	CL	29	70	42	23
	21	CL	22	62	--	--
	24	CH	22	55	--	--
	27	SC	23	21	--	--
C-7	0	SM	7	15	--	--
	3	SM	8	15	--	--
	6	CH	30	75	--	--
	9	ML	31	92	49	12
	12	CH	42	88	--	--
	18	ML	51	71	--	--
	21	CH	27	74	51	33

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-01	3.0	SILT (ML)	39	41	7	98
□	B-01	6.0	SANDY SILT (ML)	32			52
△	B-01	9.0	ELASTIC SILT (MH)	43	55	22	98
◇	B-01	12.0	ELASTIC SILT (MH)	60			93
●	B-01	15.0	ELASTIC SILT (MH)	91			93
■	B-02	3.0	FAT CLAY (CH)	39	50	31	97
▲	B-02	6.0	SANDY SILT (ML)	37			53
◆	B-02	9.0	LEAN CLAY (CL)	40			98

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

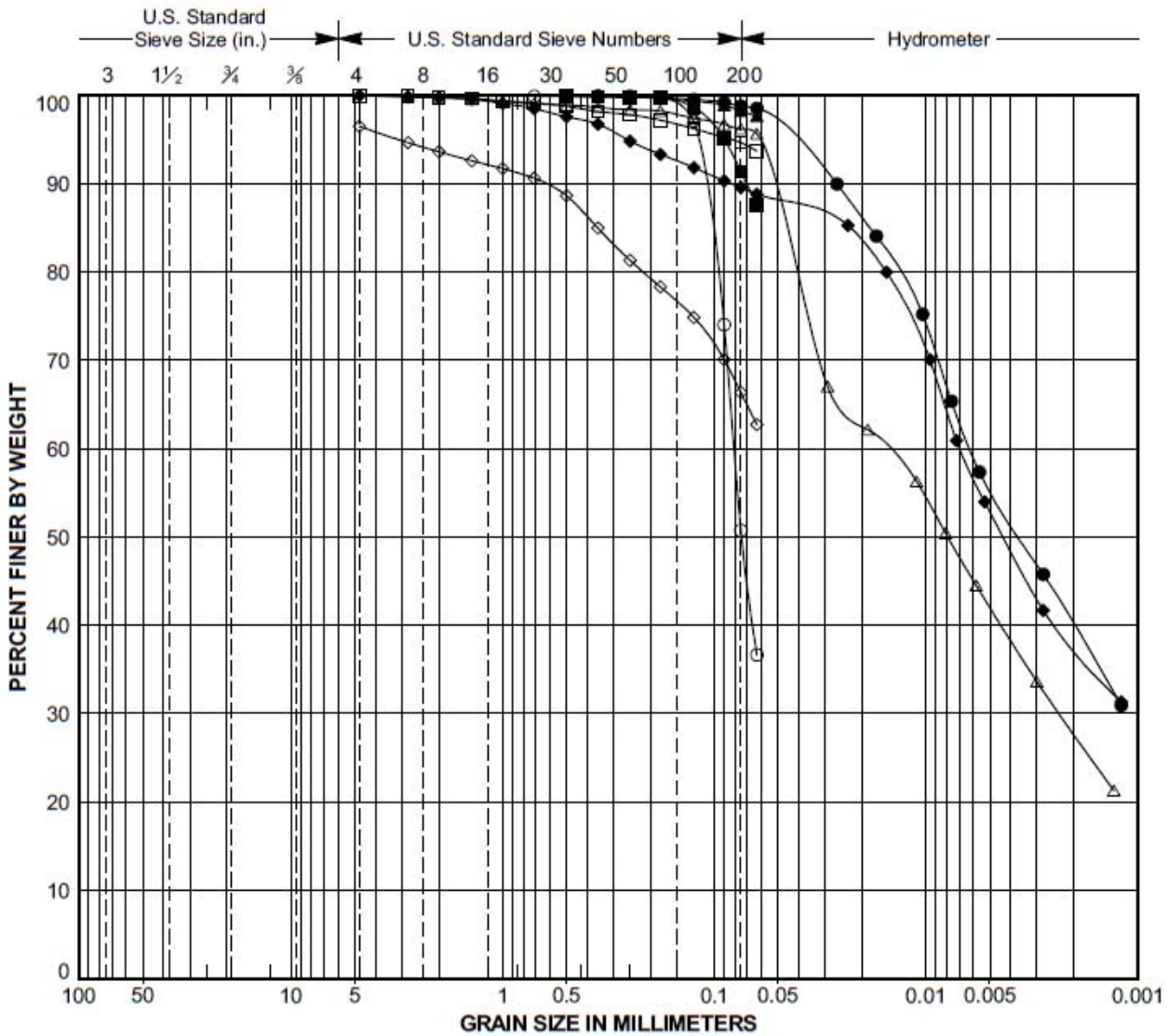
Diaz Yourman Areas B and C

PLATE

C1

PLATE B2-39

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-02	10.0	SANDY LEAN CLAY (CL)	38			51
□	B-02	12.0	FAT CLAY (CH)	83			95
△	B-02	15.0	ELASTIC SILT (MH)	107	64	17	96
◇	B-03	0.0	SANDY SILT (ML)	19			66
●	B-03	6.0	LEAN CLAY (CL)	45	46	21	99
■	B-03	9.0	LEAN CLAY (CL)	37			91
▲	B-03	12.0	ELASTIC SILT (MH)	42			98
◆	B-03	15.0	FAT CLAY (CH)	62	73	45	90

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

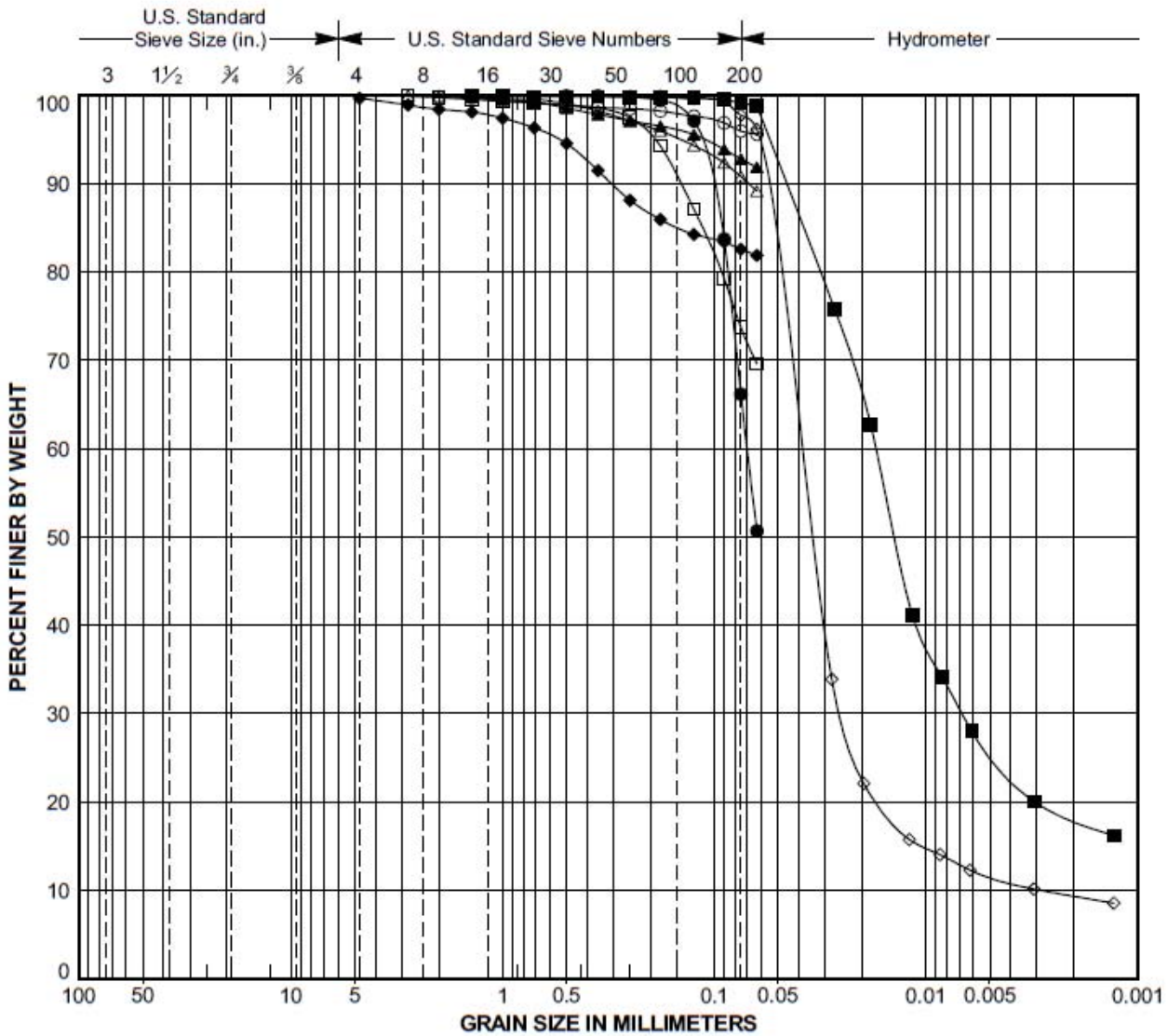
Diaz Yourman Areas B and C

PLATE

C2

PLATE B2-40

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-03	18.0	FAT CLAY (CH)	87			96
□	B-04	0.0	SILT WITH SAND (ML)	20			74
△	B-04	3.0	LEAN CLAY (CL)	34			91
◇	B-04	6.0	SILT (ML)	34	NP	NP	98
●	B-04	9.0	SANDY SILT (ML)	36			66
■	B-04	12.0	SILT (ML)	42	40	7	99
▲	B-04	15.0	SILT (ML)	100			93
◆	B-05	0.0	LEAN CLAY WITH SAND (CL)	23			83

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

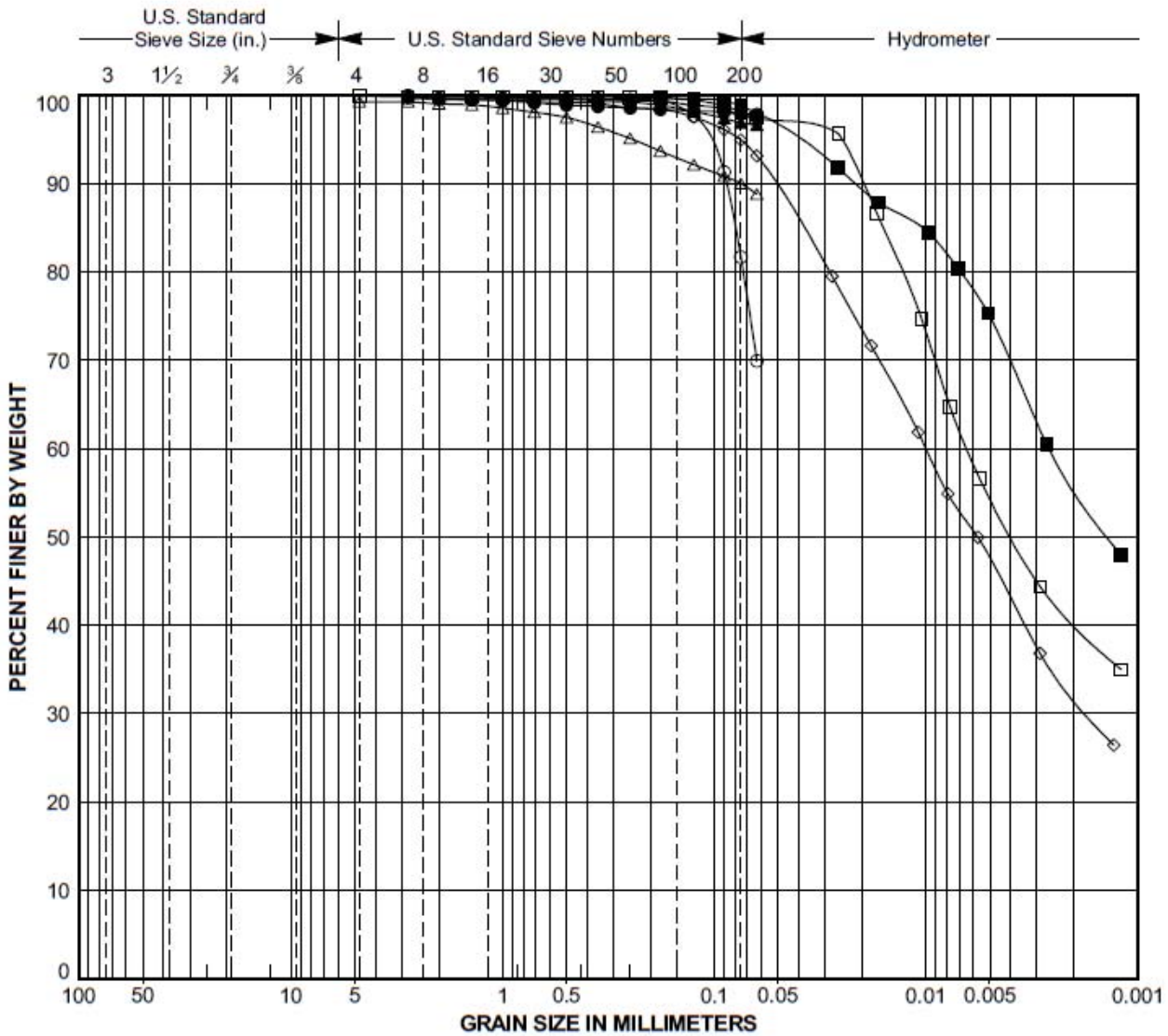
Diaz Yourman Areas B and C

PLATE

C3

PLATE B2-41

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-05	6.0	LEAN CLAY WITH SAND (CL)	34			82
□	B-05	9.0	ELASTIC SILT (MH)	49	62	29	98
△	B-05	12.0	FAT CLAY (CH)	59			90
◇	B-05	15.0	FAT CLAY (CH)	95	67	38	95
●	B-06	0.0	FAT CLAY (CH)	54			98
■	B-06	2.5	ELASTIC SILT (MH)	46	70	35	99
▲	B-06	4.5	FAT CLAY (CH)	43			97
◆	B-07	3.0	FAT CLAY (CH)	58			98

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

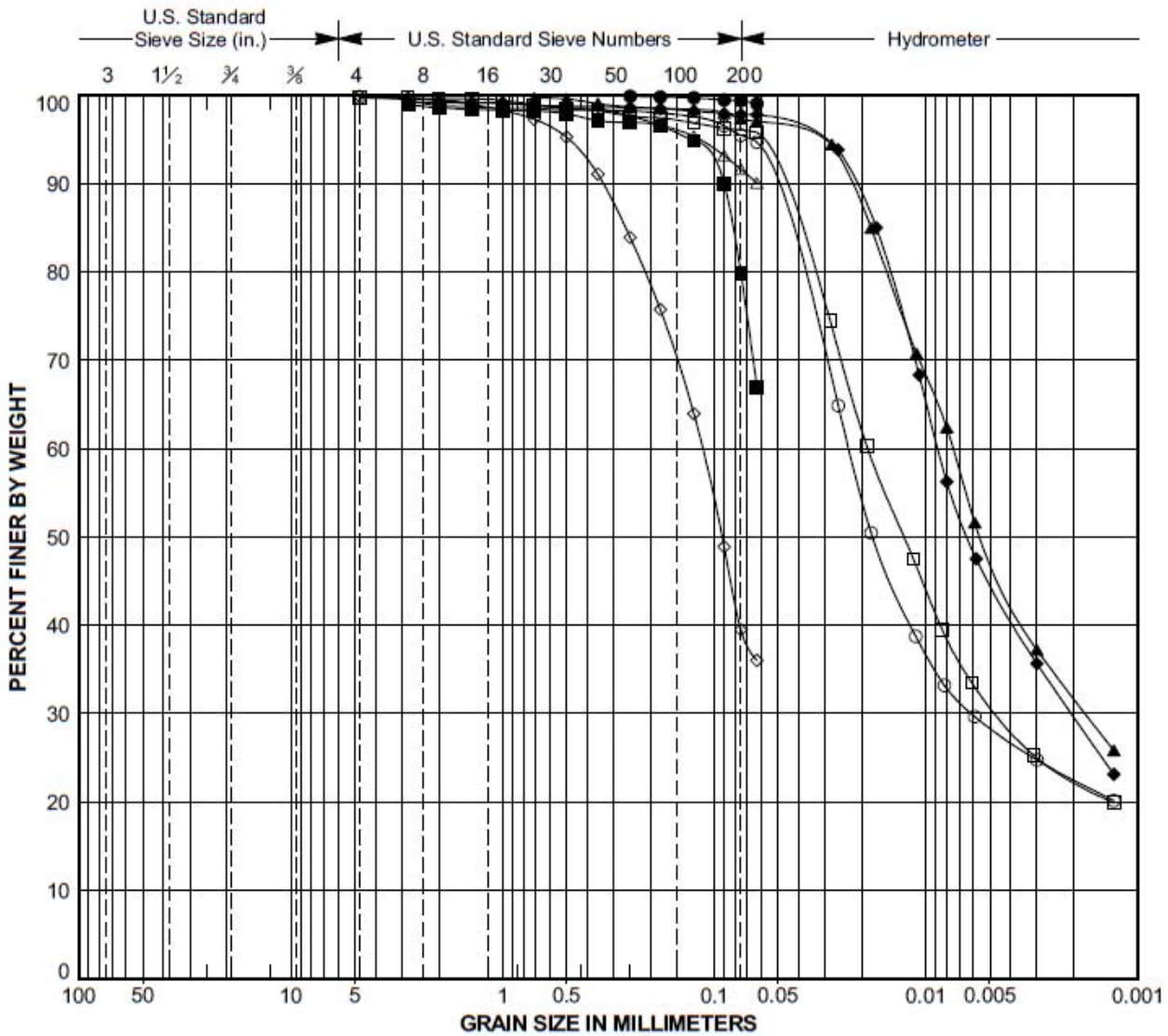
Diaz Yourman Areas B and C

PLATE

C4

PLATE B2-42

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-07	6.0	SILT (ML)	26	33	7	95
□	B-07	9.0	ELASTIC SILT (MH)	40	59	25	96
△	B-07	12.0	FAT CLAY (CH)	60			92
◇	B-07	15.0	CLAYEY SAND (SC)	34			39
●	B-08	0.0	FAT CLAY (CH)	41	67	45	99
■	B-08	3.0	FAT CLAY WITH SAND (CH)	36			80
▲	B-08	6.0	FAT CLAY (CH)	71			97
◆	B-08	9.0	FAT CLAY (CH)	58	53	24	98

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

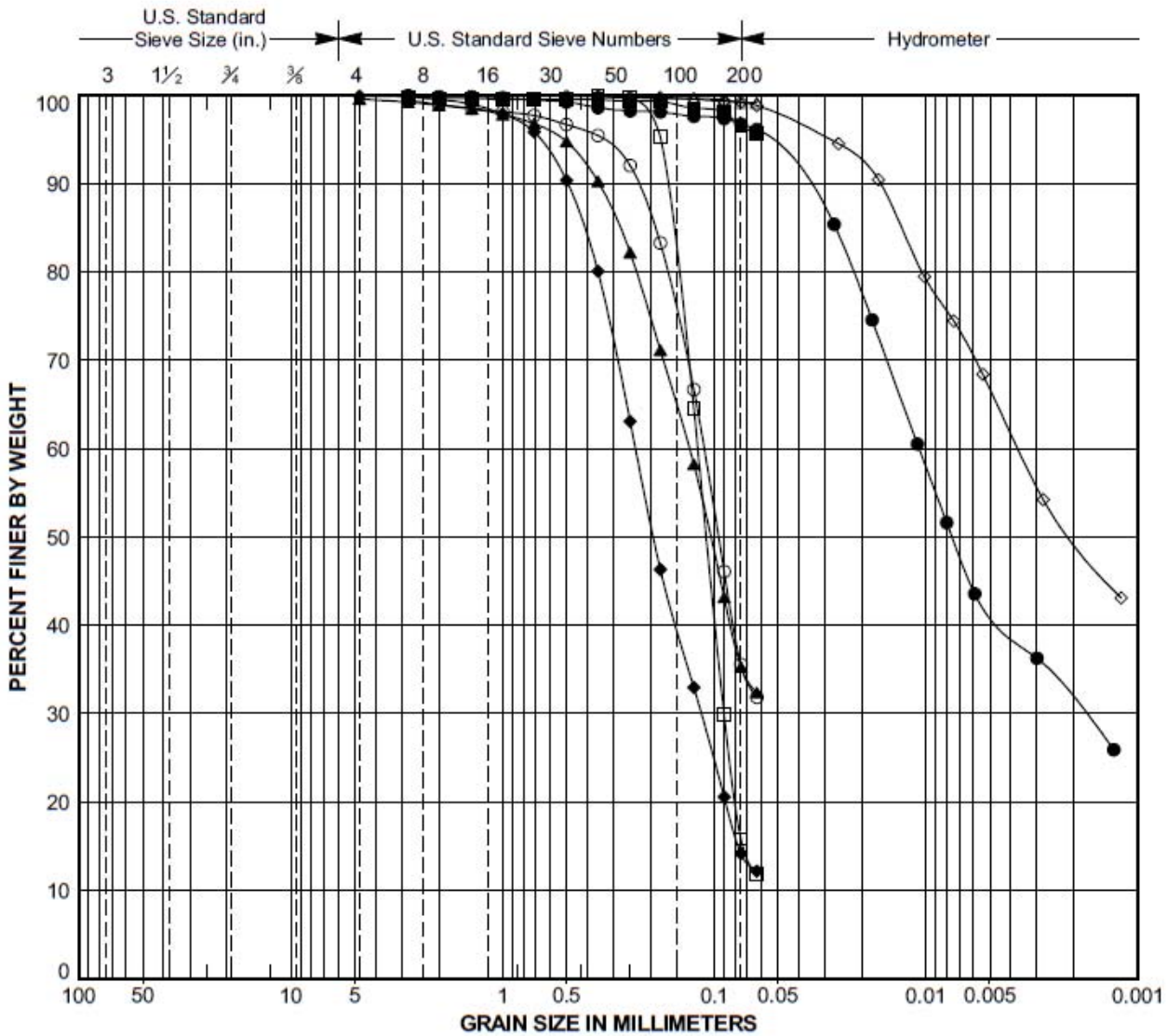
Diaz Yourman Areas B and C

PLATE

C5

PLATE B2-43

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-08	12.0	CLAYEY SAND (SC)	40			36
□	B-08	15.0	CLAYEY SAND (SC)	26			16
△	B-09	1.0	FAT CLAY (CH)	43	64	37	99
◇	B-09	3.0	FAT CLAY (CH)	52	58	29	99
●	B-09	6.0	ELASTIC SILT (MH)	58			97
■	B-09	9.0	ELASTIC SILT (MH)	81			97
▲	B-09	12.0	CLAYEY SAND (SC)	37			35
◆	B-09	15.0	CLAYEY SAND (SC)	25			14

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

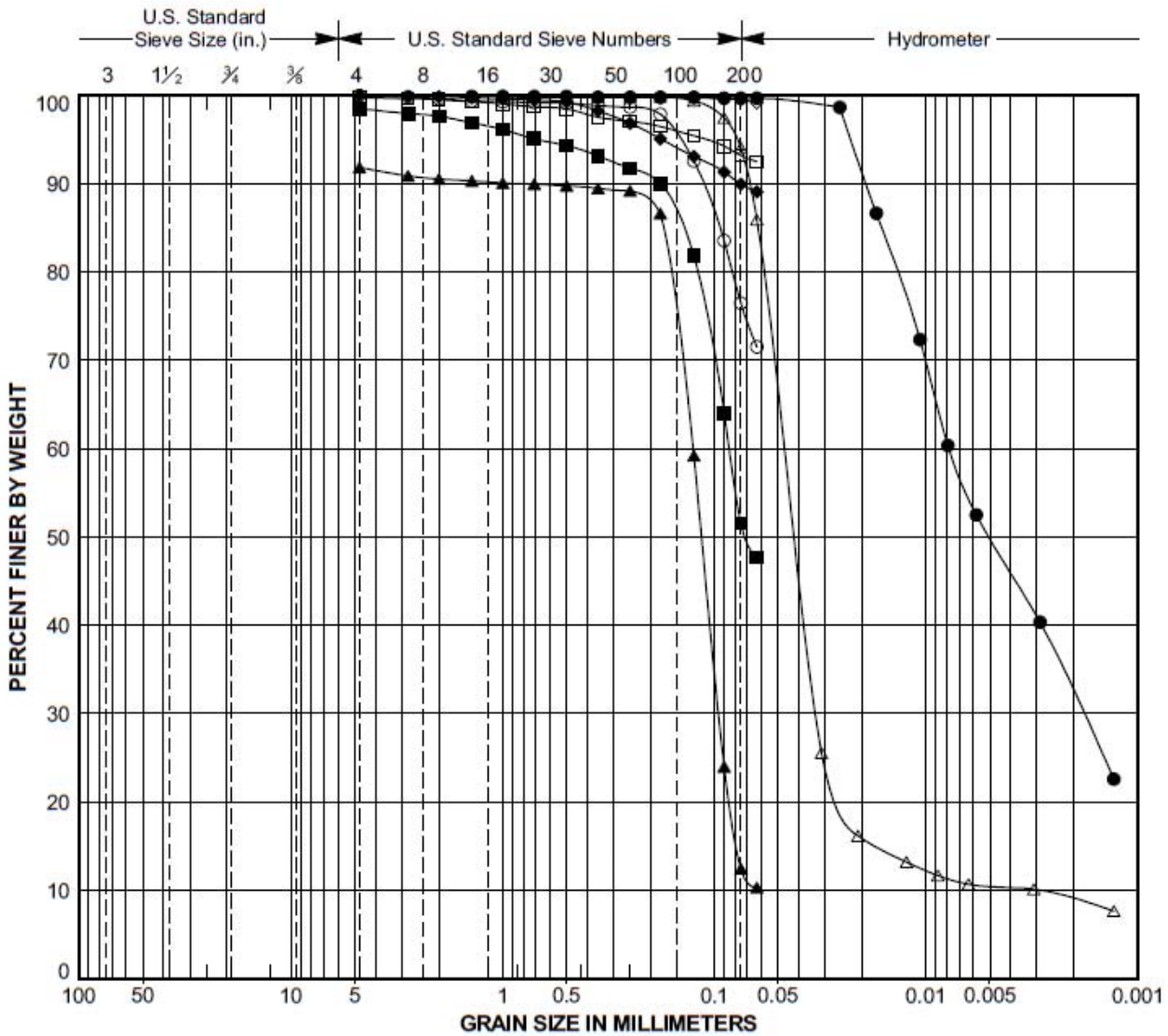
Diaz Yourman Areas B and C

PLATE

C6

PLATE B2-44

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-10	0.0	SILT WITH SAND (ML)	29			76
□	B-10	3.0	FAT CLAY (CH)	54			93
△	B-10	6.0	SILT (ML)	31	NP	NP	94
◇	B-10	9.0	LEAN CLAY (CL)	59			100
●	B-10	12.0	SILT (ML)	48	46	15	100
■	B-10	15.0	SANDY LEAN CLAY (CL)	48			52
▲	B-10	18.0	POORLY GRADED SAND WITH SILT (SP-SM)	29			12
◆	B-11	0.0	LEAN CLAY (CL)	37			90

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

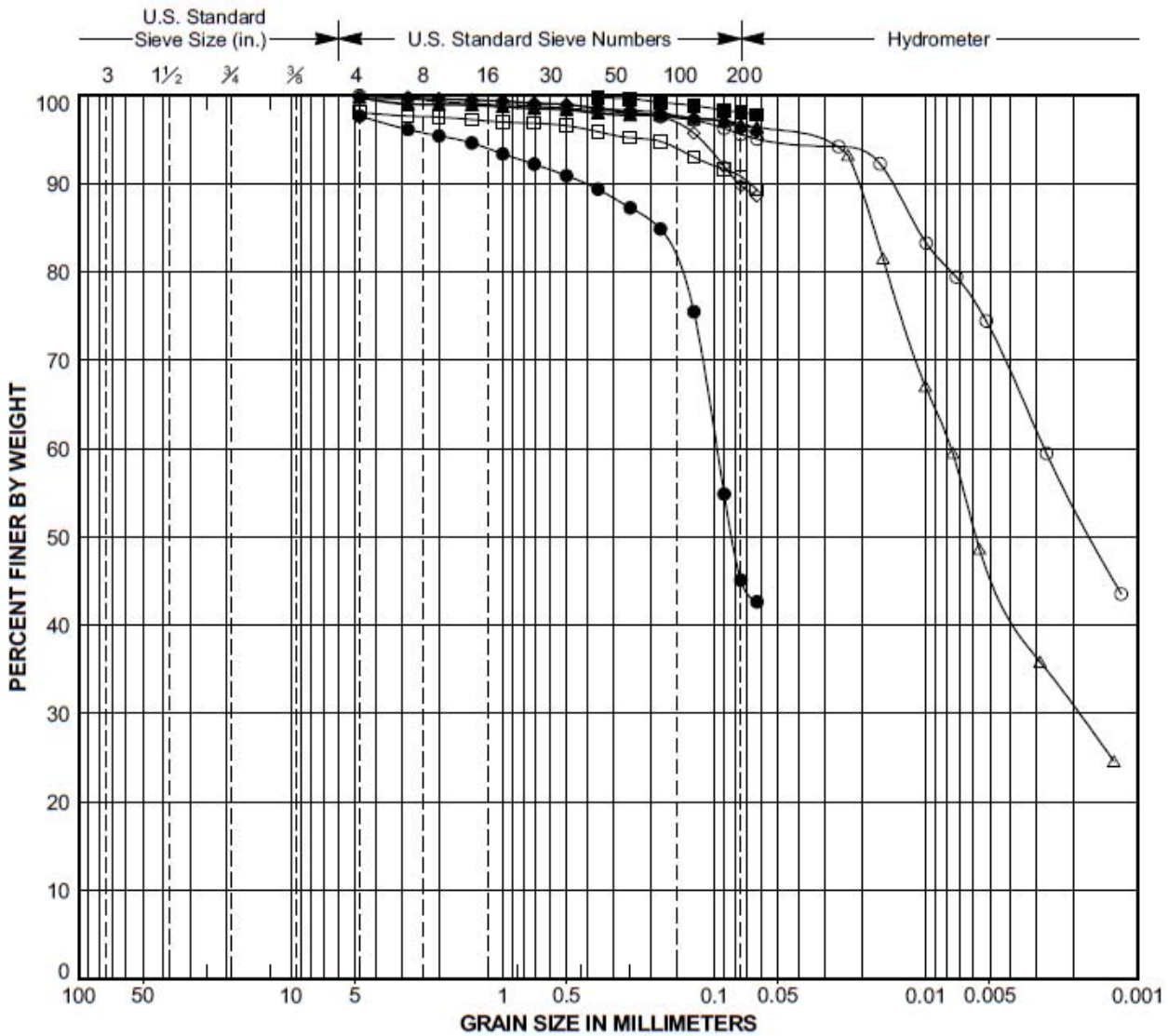
Diaz Yourman Areas B and C

PLATE

C7

PLATE B2-45

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-11	3.0	ELASTIC SILT (MH)	72	80	40	96
□	B-11	6.0	ELASTIC SILT (MH)	58			91
△	B-11	9.0	ELASTIC SILT (MH)	60	61	28	97
◇	B-11	12.0	ELASTIC SILT (MH)	71			90
●	B-11	15.0	CLAYEY SAND (SC)	54			45
■	B-12	0.0	LEAN CLAY (CL)	49			98
▲	B-12	3.0	ELASTIC SILT (MH)	45			97
◆	B-12	6.0	ELASTIC SILT (MH)	69			96

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

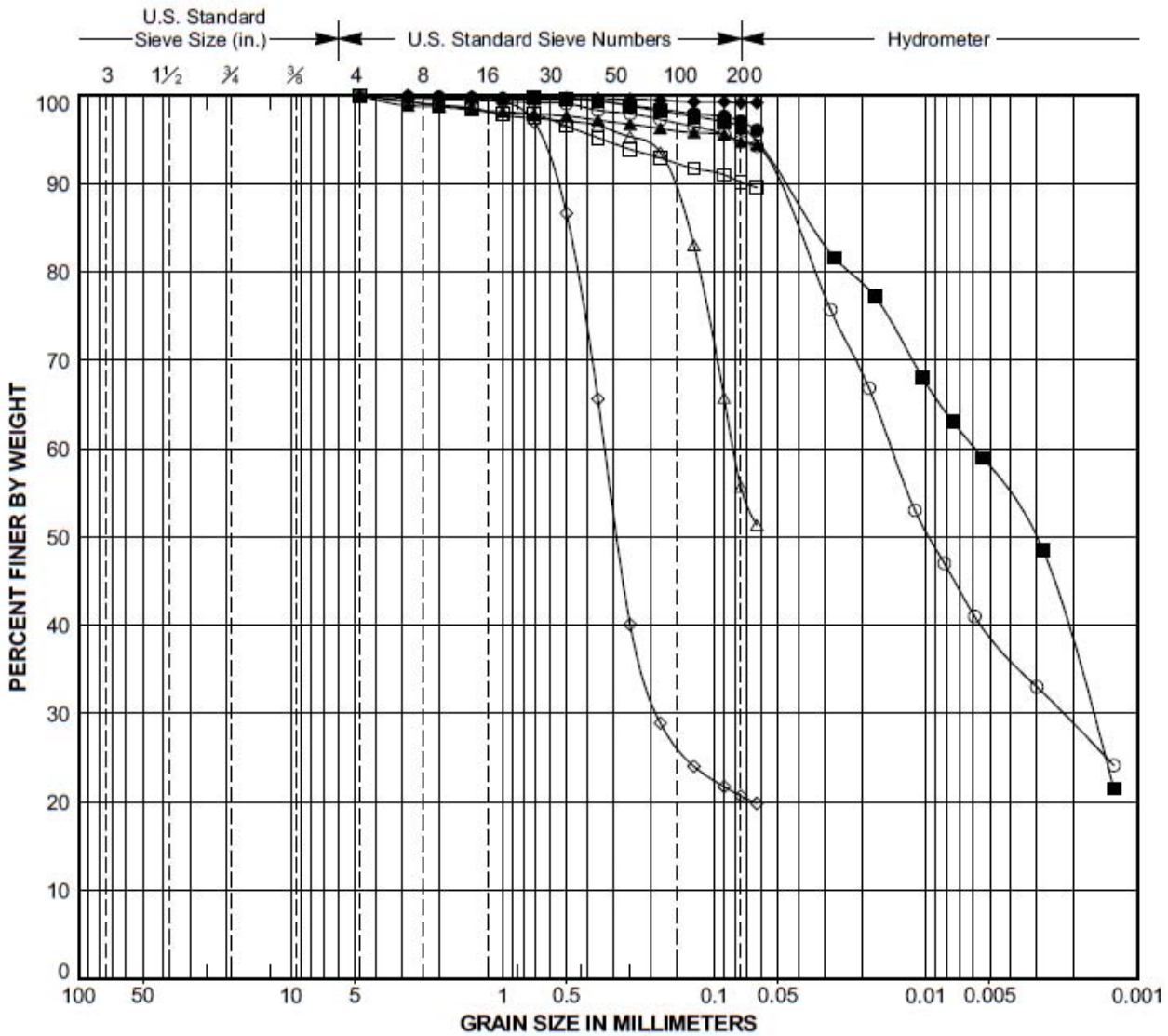
Diaz Yourman Areas B and C

PLATE

C8

PLATE B2-46

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-12	9.0	ELASTIC SILT (MH)	84	52	13	95
□	B-12	12.0	ELASTIC SILT (MH)	59			90
△	B-12	15.0	SANDY FAT CLAY (CH)	56			56
◇	B-13	0.0	CLAYEY SAND (SC)	17			21
●	B-13	3.0	FAT CLAY (CH)	65			97
■	B-13	6.0	FAT CLAY (CH)	56	60	29	96
▲	B-13	9.0	FAT CLAY (CH)	93			95
◆	B-13	12.0	FAT CLAY (CH)	65			99

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

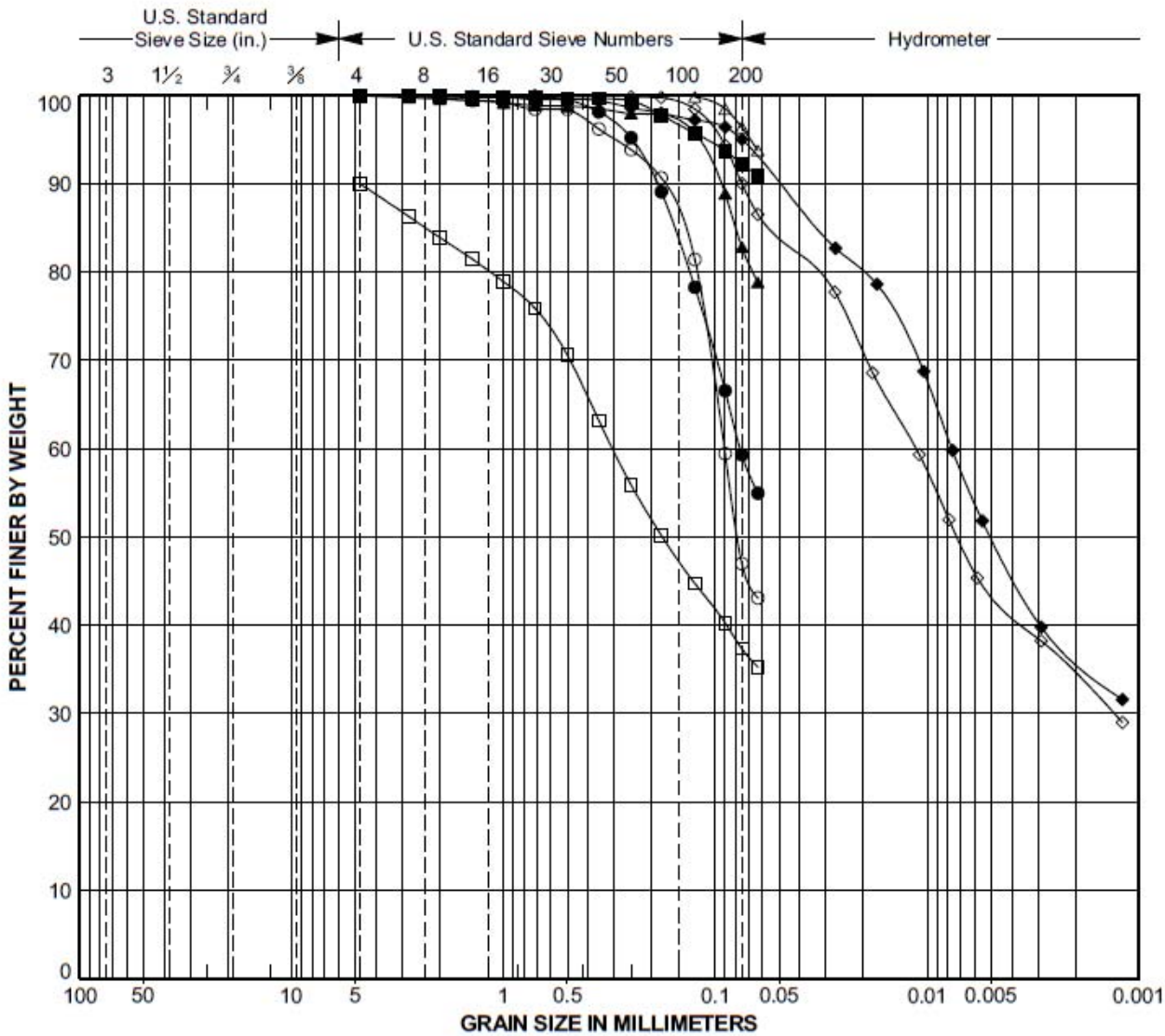
Diaz Yourman Areas B and C

PLATE

C9

PLATE B2-47

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-13	15.0	CLAYEY SAND (SC)	43			47
□	C-01	0.0	CLAYEY SAND (SC)	15			37
△	C-01	6.0	LEAN CLAY (CL)	34	40	20	96
◇	C-01	7.0	LEAN CLAY (CL)	34			90
●	C-01	9.0	SANDY LEAN CLAY (CL)	22			59
■	C-01	12.0	FAT CLAY (CH)	46	75	47	92
▲	C-01	15.0	FAT CLAY WITH SAND (CH)	27			83
◆	C-01	18.0	LEAN CLAY (CL)	33			95

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

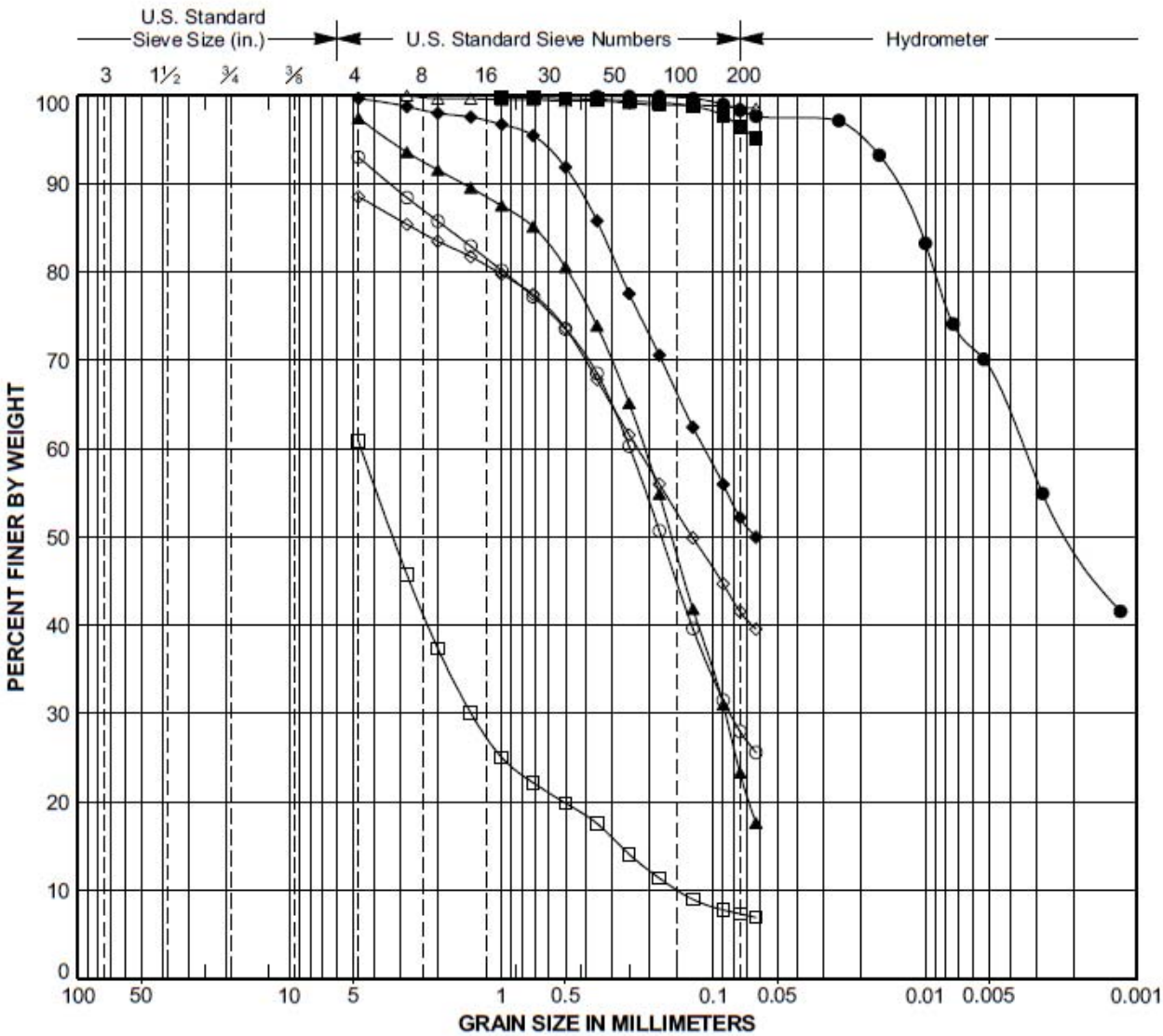
Diaz Yourman Areas B and C

PLATE

C10

PLATE B2-48

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-01	21.0	CLAYEY SAND (SC)	13			28
□	C-01	24.0	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC)	12			7
△	C-01	30.0	FAT CLAY (CH)	34			99
◇	C-02	0.0	CLAYEY SAND (SC)	12			42
●	C-02	6.0	FAT CLAY (CH)	45	57	36	98
■	C-02	9.0	FAT CLAY (CH)	48			96
▲	C-02	12.0	CLAYEY SAND (SC)	18			23
◆	C-02	15.0	SANDY LEAN CLAY (CL)	20			52

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

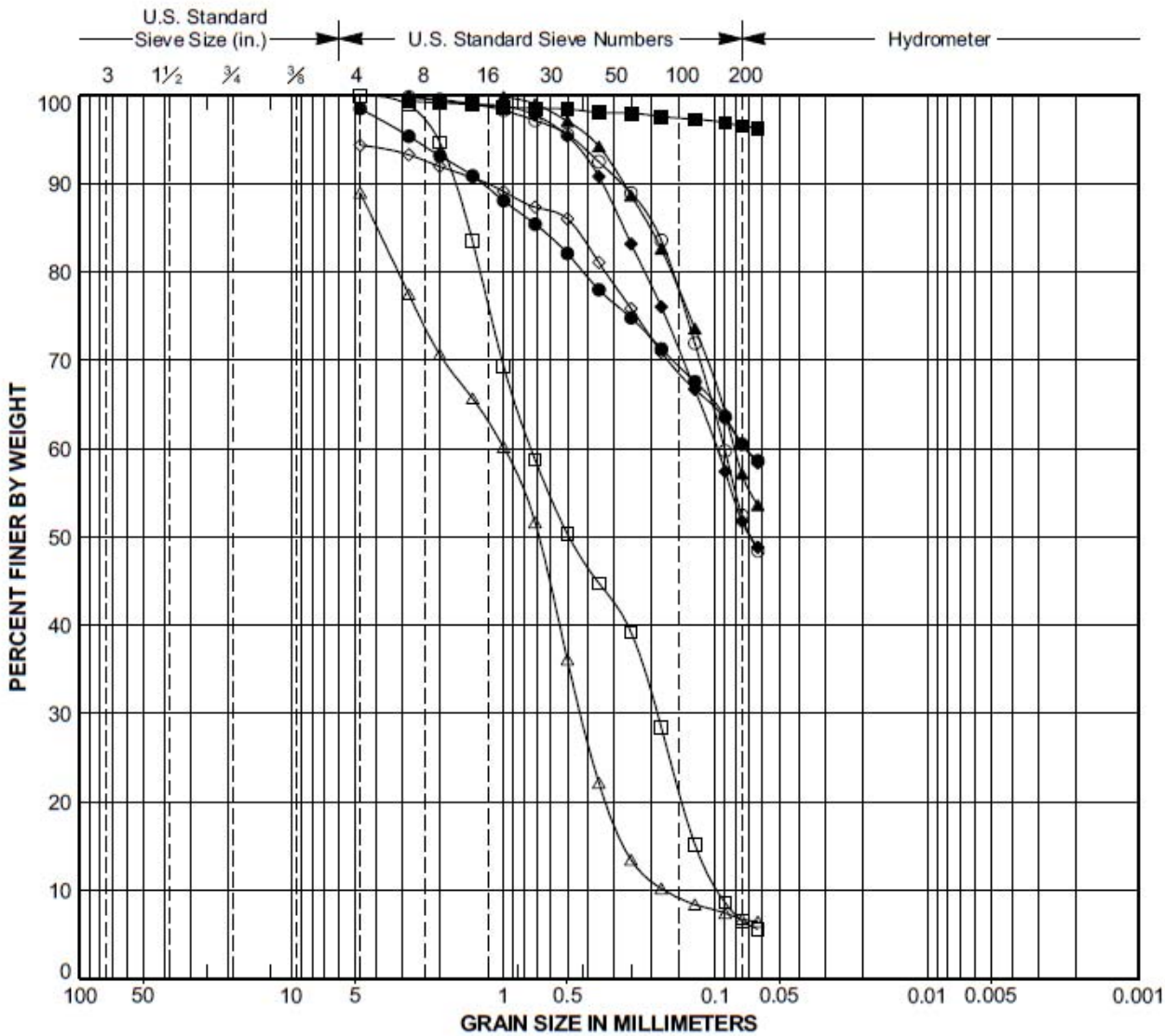
Diaz Yourman Areas B and C

PLATE

C11

PLATE B2-49

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-02	18.0	SANDY LEAN CLAY (CL)	19			52
□	C-02	24.0	POORLY GRADED SAND WITH CLAY (SP-SC)	19			7
△	C-02	27.0	POORLY GRADED SAND WITH CLAY (SP-SC)	14			7
◇	C-03	0.0	SANDY LEAN CLAY (CL)	17			61
●	C-03	3.0	SANDY LEAN CLAY (CL)	16			61
■	C-03	6.0	FAT CLAY (CH)	46			97
▲	C-03	9.0	SANDY LEAN CLAY (CL)	23			57
◆	C-03	12.0	SANDY LEAN CLAY (CL)	23			52

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

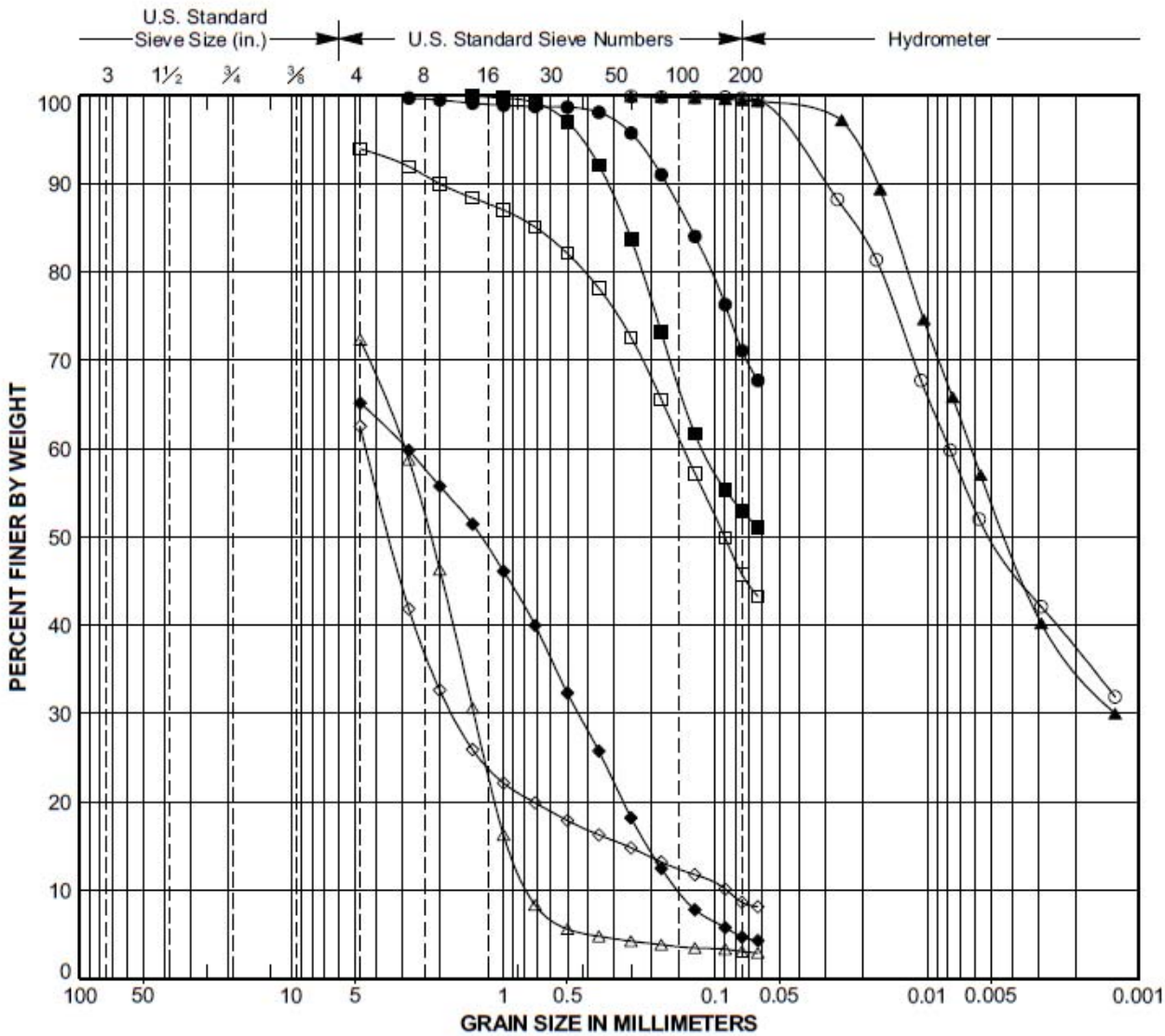
Diaz Yourman Areas B and C

PLATE

C12

PLATE B2-50

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-03	15.0	FAT CLAY (CH)	51	53	26	100
□	C-03	18.0	CLAYEY SAND (SC)	14			46
△	C-03	21.0	POORLY GRADED SAND WITH GRAVEL (SP)	15			3
◇	C-03	24.0	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC)	13			9
●	C-03	27.0	LEAN CLAY WITH SAND (CL)	27			71
■	C-03	30.0	SANDY LEAN CLAY (CL)	23			53
▲	C-03	33.0	SILT (ML)	38	NP	NP	99
◆	C-04	0.0	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC)	4			5

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

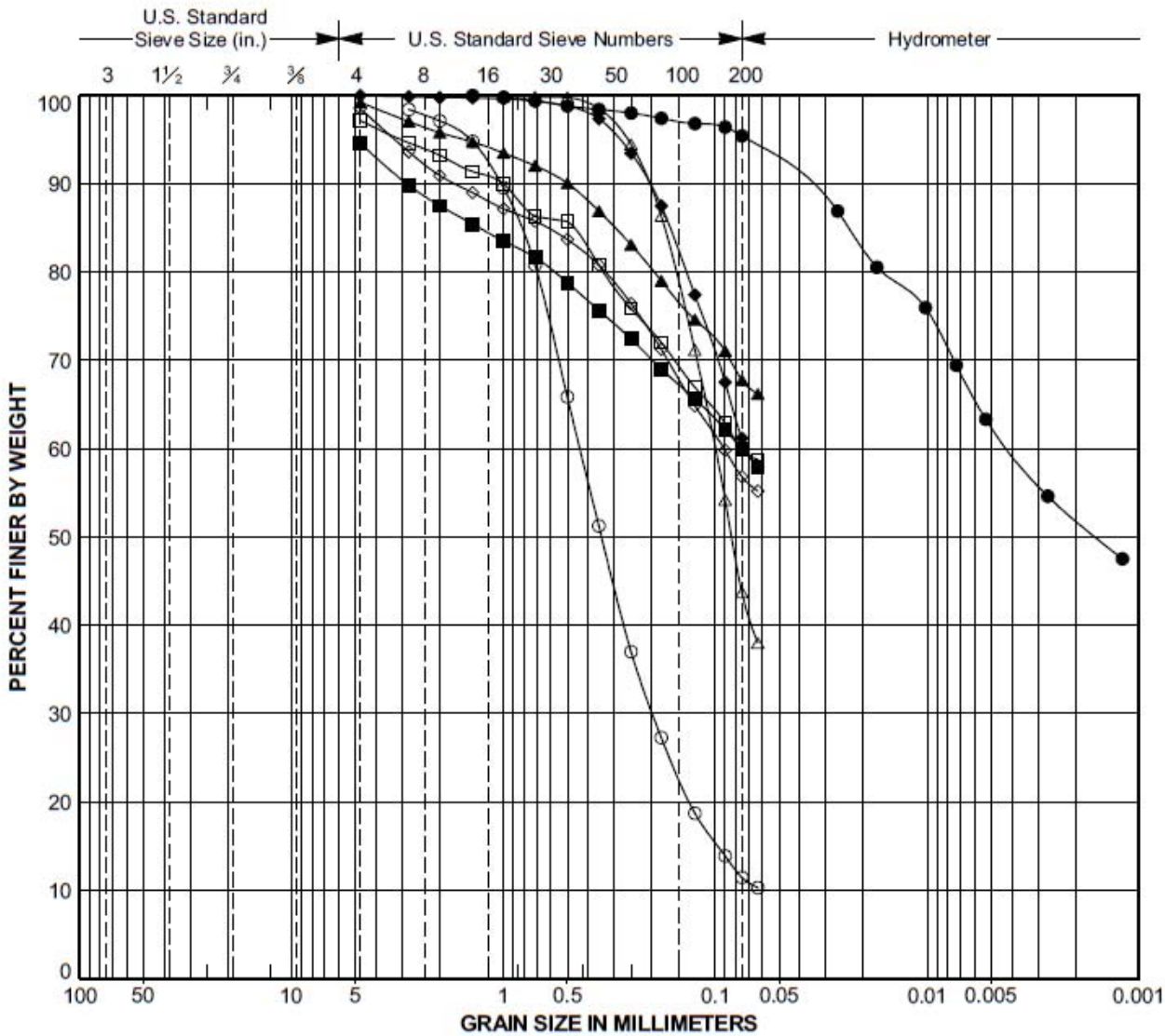
Diaz Yourman Areas B and C

PLATE

C13

PLATE B2-51

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-04	3.0	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC)	8			11
□	C-04	4.0	SANDY LEAN CLAY (CL)	18			60
△	C-04	6.0	CLAYEY SAND (SC)	23			44
◇	C-04	9.0	SANDY FAT CLAY (CH)	20			57
●	C-04	12.0	ELASTIC SILT (MH)	38	54	23	95
■	C-04	15.0	SANDY FAT CLAY (CH)	23			60
▲	C-04	18.0	SANDY FAT CLAY (CH)	22			68
◆	C-04	21.0	SANDY SILT (ML)	23			61

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

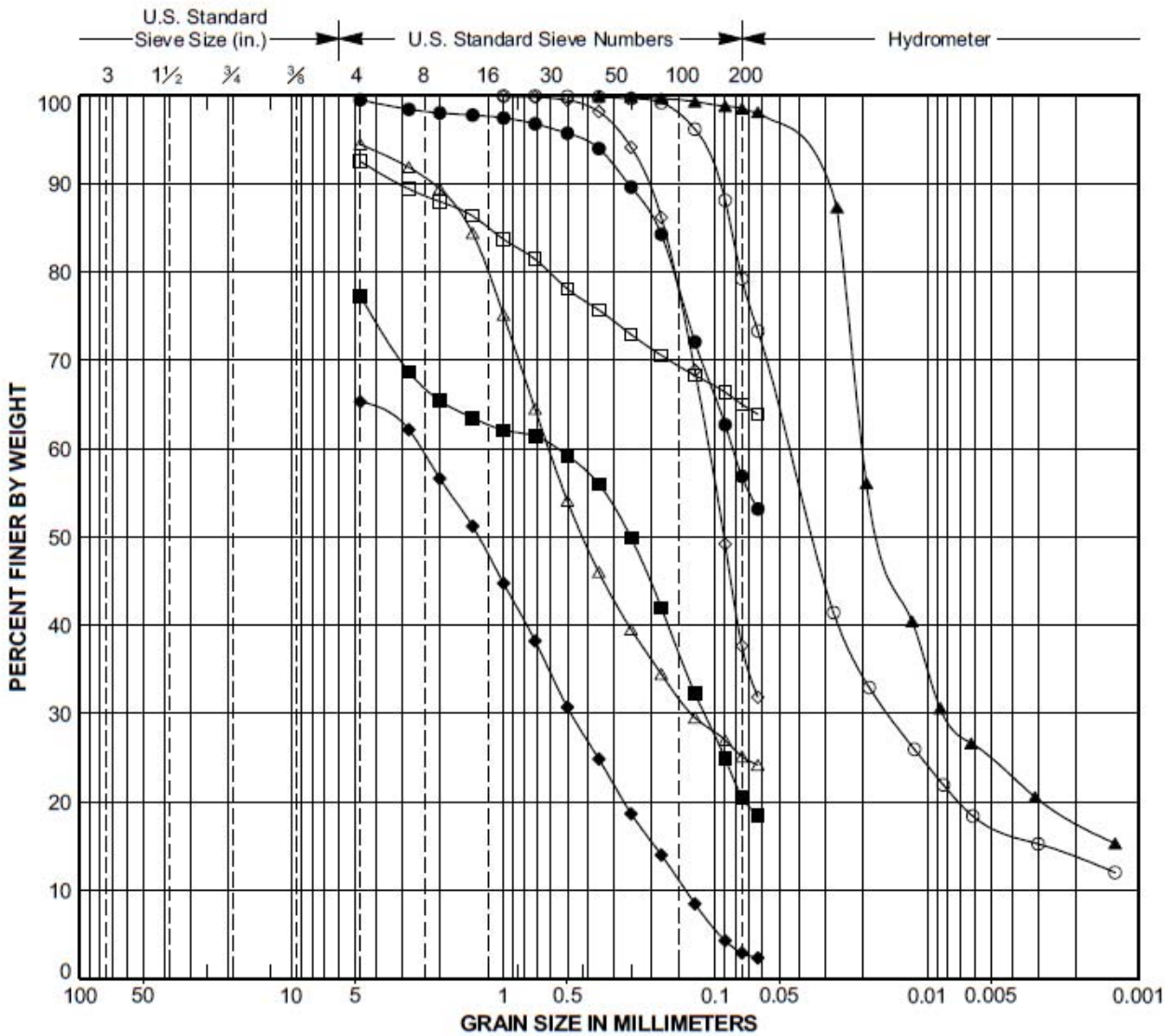
Diaz Yourman Areas B and C

PLATE

C14

PLATE B2-52

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-04	24.0	SILT WITH SAND (ML)	24	NP	NP	79
□	C-05	0.0	SANDY LEAN CLAY (CL)	21			65
△	C-05	3.0	SILTY SAND (SM)	16			25
◇	C-05	6.0	CLAYEY SAND (SC)	25			38
●	C-05	12.0	SANDY LEAN CLAY (CL)	19			57
■	C-05	15.0	SILTY SAND WITH GRAVEL (SM)	15			21
▲	C-05	24.0	SILT (ML)	43	47	19	99
◆	C-06	0.0	POORLY GRADED SAND WITH GRAVEL (SP)	4			3

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

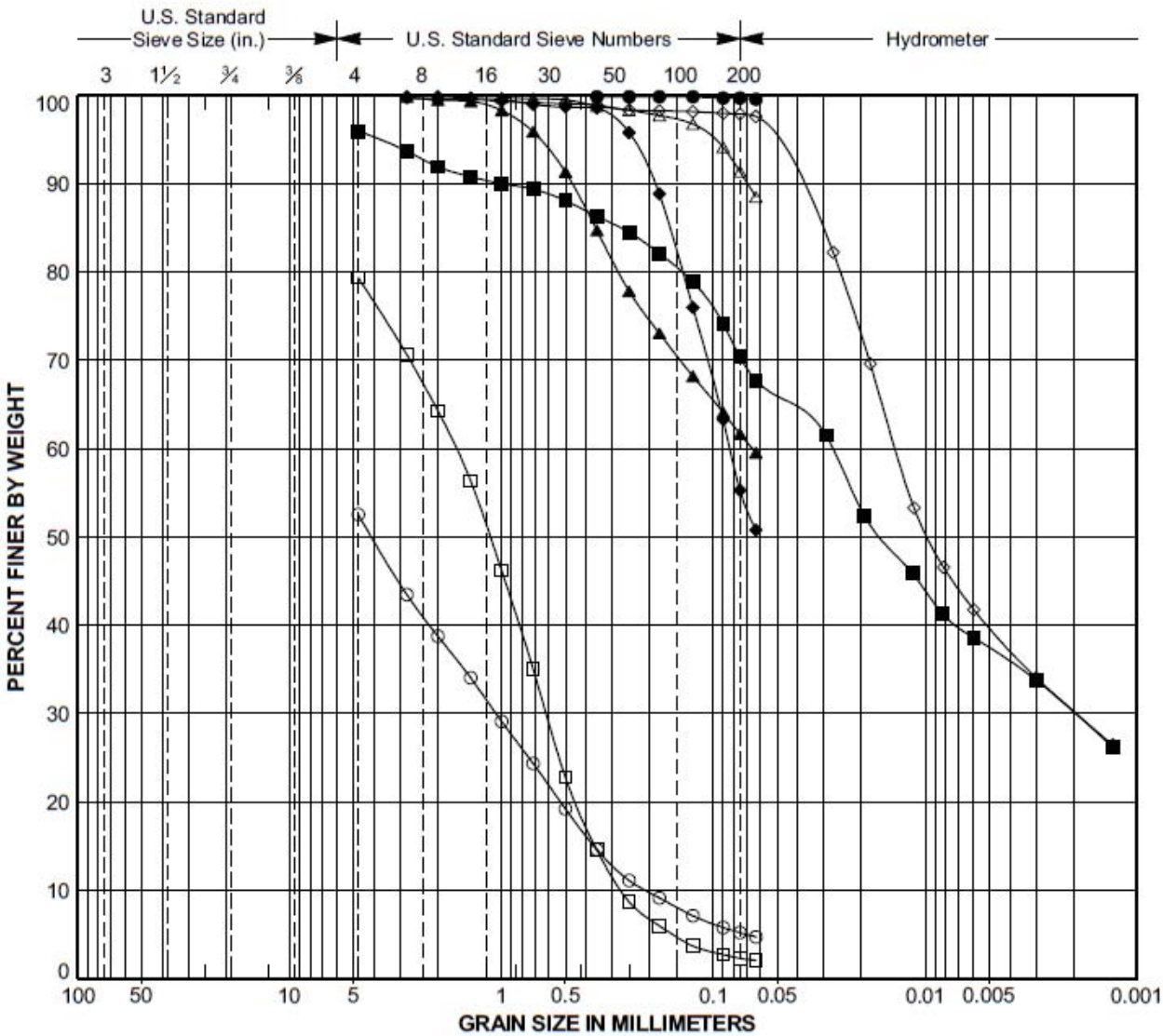
Diaz Yourman Areas B and C

PLATE

C15

PLATE B2-53

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-06	3.0	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)	4			5
□	C-06	6.0	POORLY GRADED SAND WITH GRAVEL (SP)	2			2
△	C-06	9.0	LEAN CLAY (CL)	30			91
◇	C-06	12.0	FAT CLAY (CH)	43	57	36	98
●	C-06	15.0	FAT CLAY (CH)	39			100
■	C-06	18.0	SANDY LEAN CLAY (CL)	29	42	23	70
▲	C-06	21.0	SANDY LEAN CLAY (CL)	22			62
◆	C-06	24.0	SANDY FAT CLAY (CH)	22			55

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

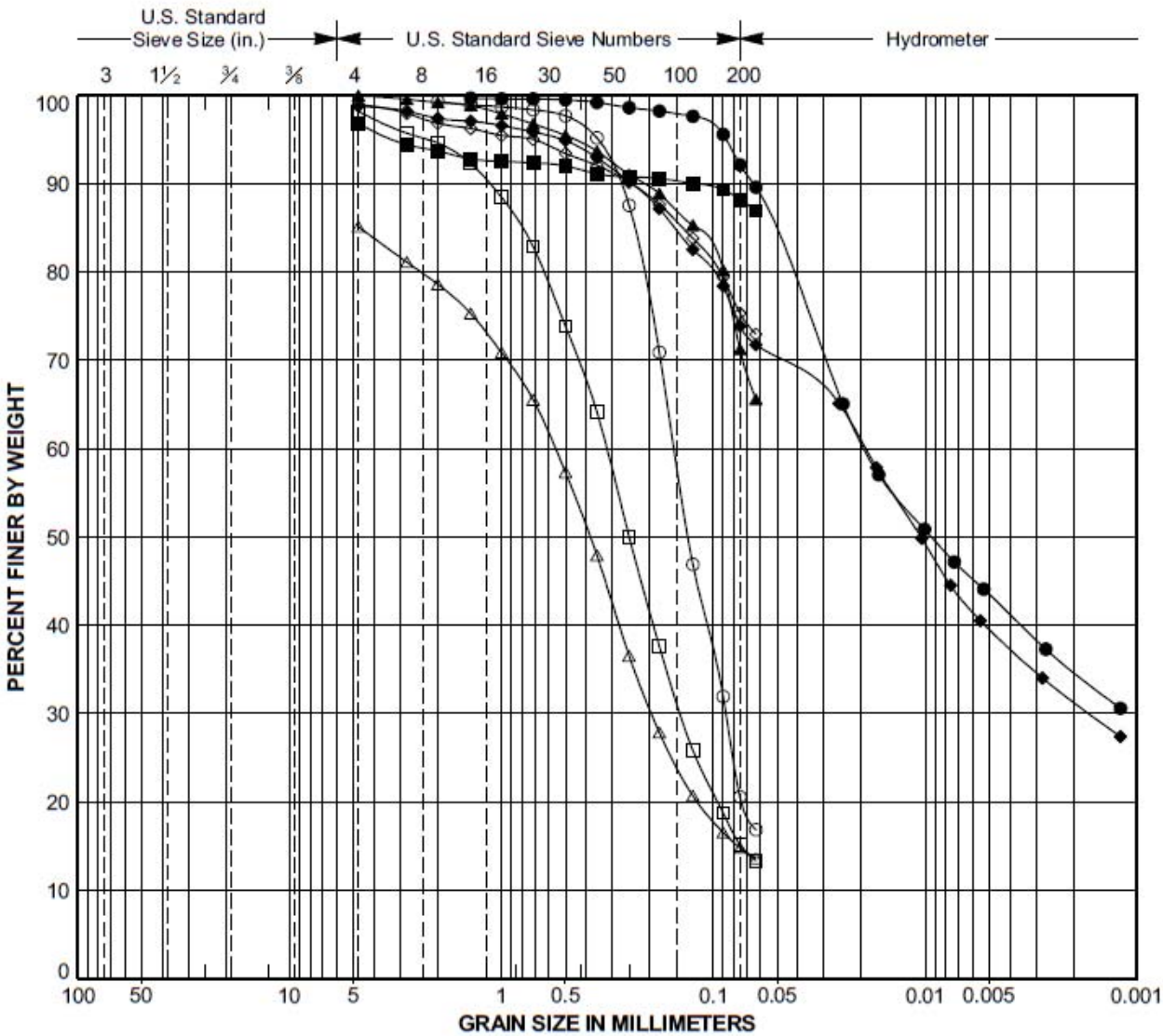
Diaz Yourman Areas B and C

PLATE

C16

PLATE B2-54

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-06	27.0	CLAYEY SAND (SC)	23			21
□	C-07	0.0	SILTY SAND (SM)	7			15
△	C-07	3.0	SILTY SAND WITH GRAVEL (SM)	8			15
◇	C-07	6.0	FAT CLAY WITH SAND (CH)	30			75
●	C-07	9.0	SILT (ML)	31	49	12	92
■	C-07	12.0	FAT CLAY (CH)	42			88
▲	C-07	18.0	SILT WITH SAND (ML)	51			71
◆	C-07	21.0	FAT CLAY WITH SAND (CH)	27	51	33	74

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

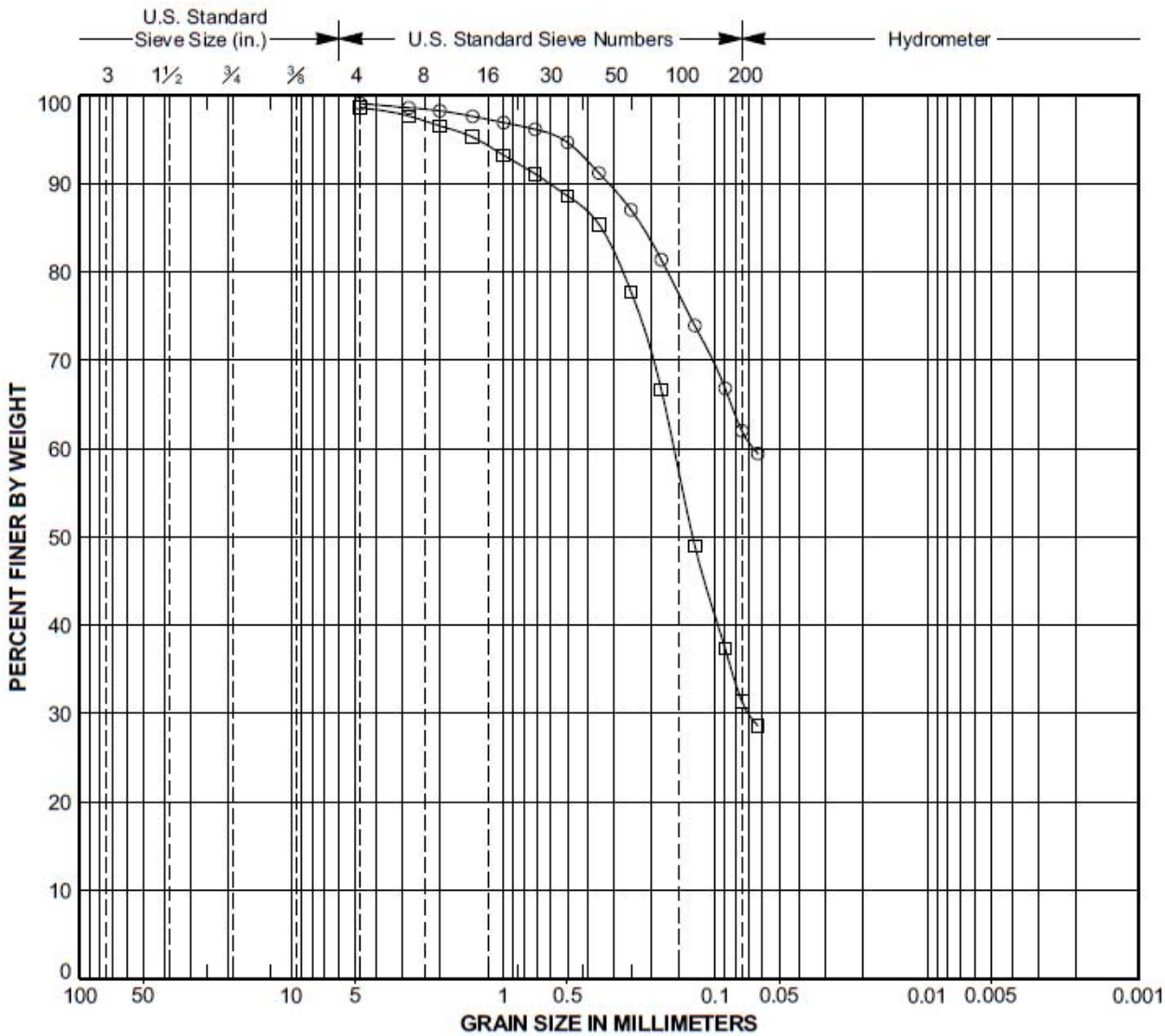
Diaz Yourman Areas B and C

PLATE

C17

PLATE B2-55

Template: DY_SIEVE_WIN



COBBLES	Coarse	Fine	Coarse	Medium	Fine	SILT or CLAY
	GRAVEL		SAND			

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-07	24.0	SANDY FAT CLAY (CH)	23			62
□	C-07	27.0	CLAYEY SAND (SC)	20			31

PARTICLE SIZE ANALYSIS

USACE Ballona Creek Watershed

Project No. 2006-023.05

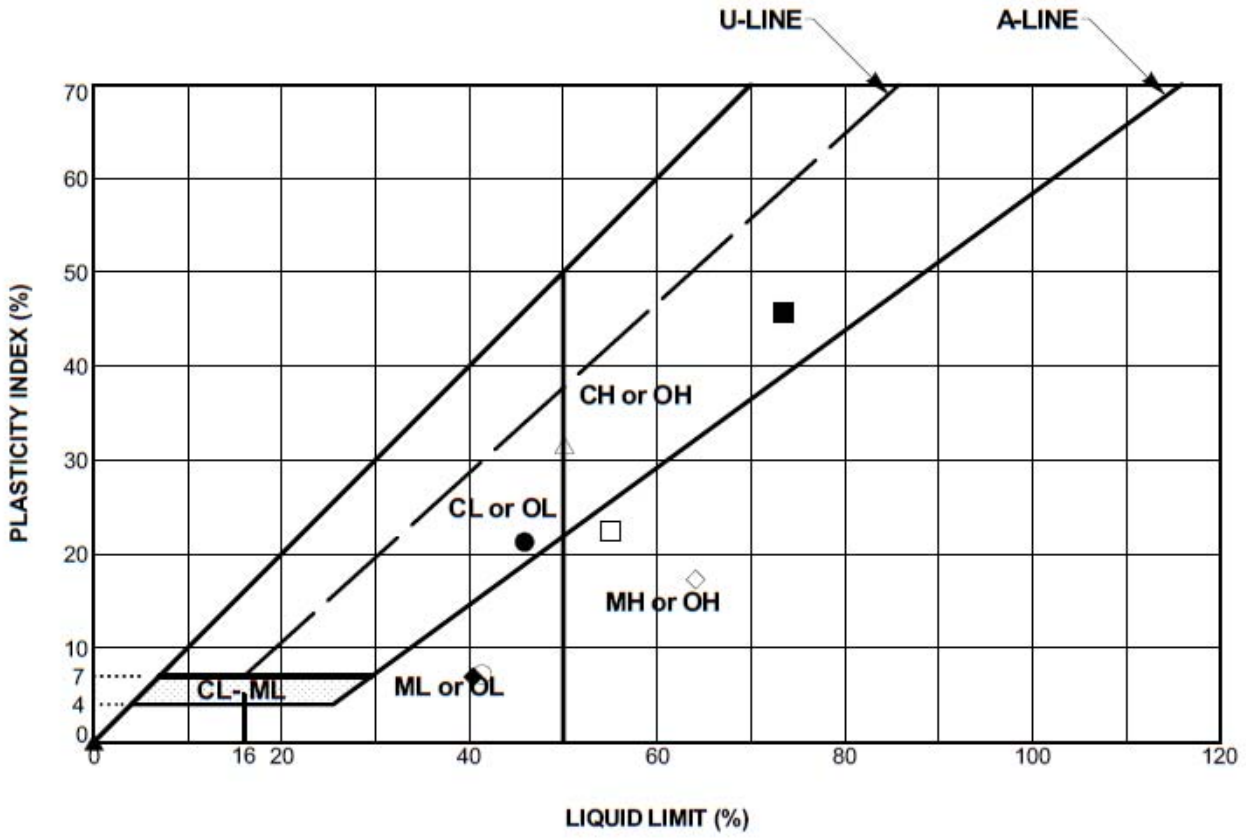
Diaz Yourman Areas B and C

PLATE

C18

PLATE B2-56

Template: DY_ATTERBERG_CHART_WIN



Laboratory Testing by: Diaz Yourman & Associates

Test Method: ASTM D4318-05

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-01	3.0	SILT (ML)	39	41	34	7	98
□	B-01	9.0	ELASTIC SILT (MH)	43	55	33	22	98
△	B-02	3.0	FAT CLAY (CH)	39	50	19	31	97
◇	B-02	15.0	ELASTIC SILT (MH)	107	64	47	17	96
●	B-03	6.0	LEAN CLAY (CL)	45	46	25	21	99
■	B-03	15.0	FAT CLAY (CH)	62	73	28	45	90
▲	B-04	6.0	SILT (ML)	34	NP	NP	NP	98
◆	B-04	12.0	SILT (ML)	42	40	33	7	99

PLASTICITY CHART

USACE Ballona Creek Watershed

Project No. 2006-023.05

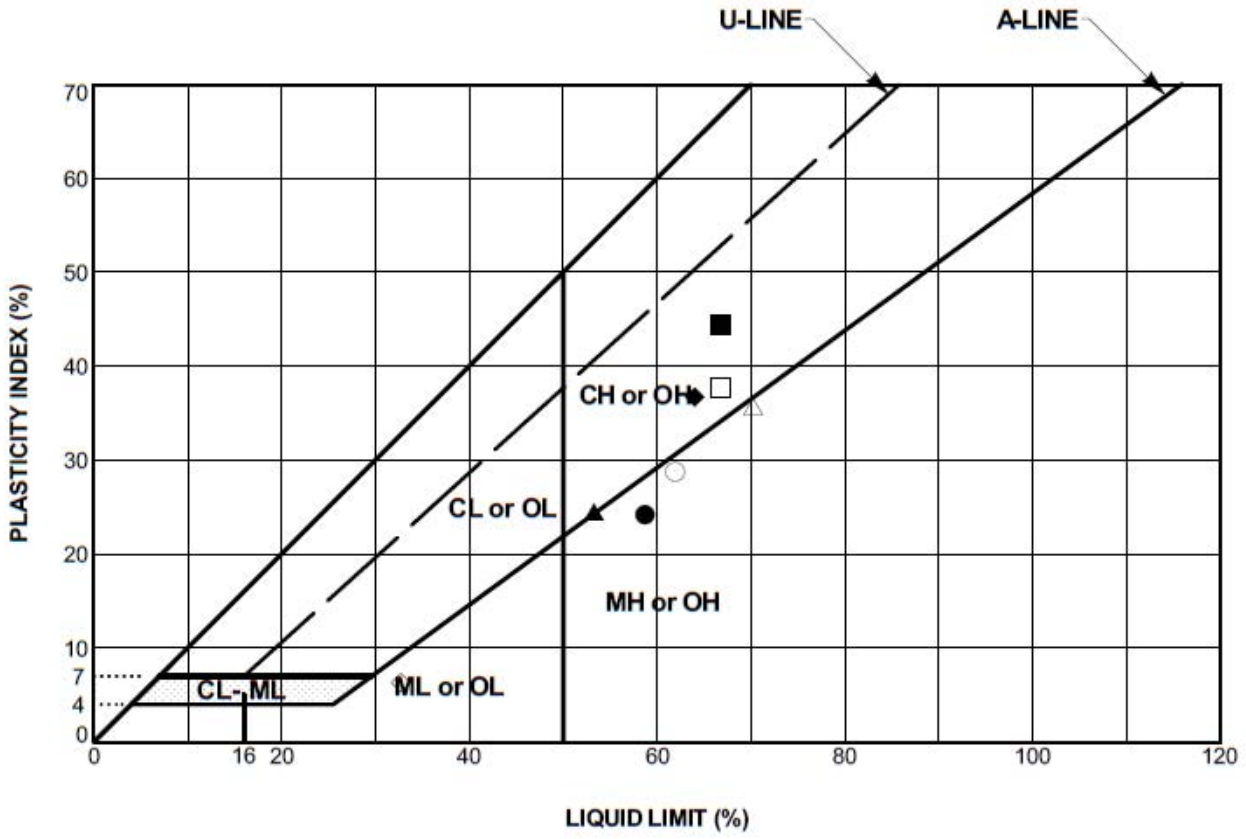
Diaz Yourman Areas B and C

PLATE

C19

PLATE B2-57

Template: DY_ATTERBERG_CHART_WIN



Laboratory Testing by: Diaz Yourman & Associates

Test Method: ASTM D4318-05

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-05	9.0	ELASTIC SILT (MH)	49	62	33	29	98
□	B-05	15.0	FAT CLAY (CH)	95	67	29	38	95
△	B-06	2.5	ELASTIC SILT (MH)	46	70	35	35	99
◇	B-07	6.0	SILT (ML)	26	33	26	7	95
●	B-07	9.0	ELASTIC SILT (MH)	40	59	34	25	96
■	B-08	0.0	FAT CLAY (CH)	41	67	22	45	99
▲	B-08	9.0	FAT CLAY (CH)	58	53	29	24	98
◆	B-09	1.0	FAT CLAY (CH)	43	64	27	37	99

PLASTICITY CHART

USACE Ballona Creek Watershed

Project No. 2006-023.05

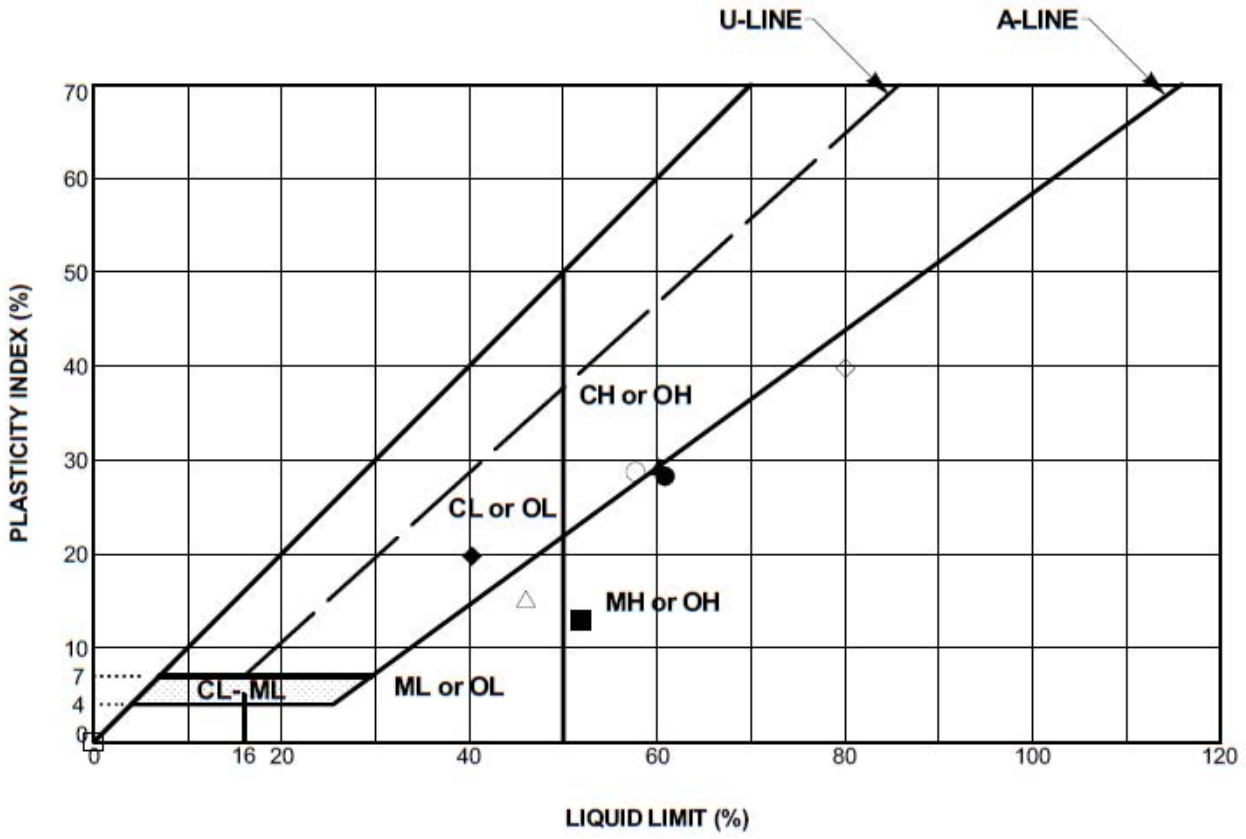
Diaz Yourman Areas B and C

PLATE

C20

PLATE B2-58

Template: DY_ATTERBERG_CHART_WIN



Laboratory Testing by: Diaz Yourman & Associates

Test Method: ASTM D4318-05

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	B-09	3.0	FAT CLAY (CH)	52	58	29	29	99
□	B-10	6.0	SILT (ML)	31	NP	NP	NP	94
△	B-10	12.0	SILT (ML)	48	46	31	15	100
◇	B-11	3.0	ELASTIC SILT (MH)	72	80	40	40	96
●	B-11	9.0	ELASTIC SILT (MH)	60	61	33	28	97
■	B-12	9.0	ELASTIC SILT (MH)	84	52	39	13	95
▲	B-13	6.0	FAT CLAY (CH)	56	60	31	29	96
◆	C-01	6.0	LEAN CLAY (CL)	34	40	21	20	96

PLASTICITY CHART

USACE Ballona Creek Watershed

Project No. 2006-023.05

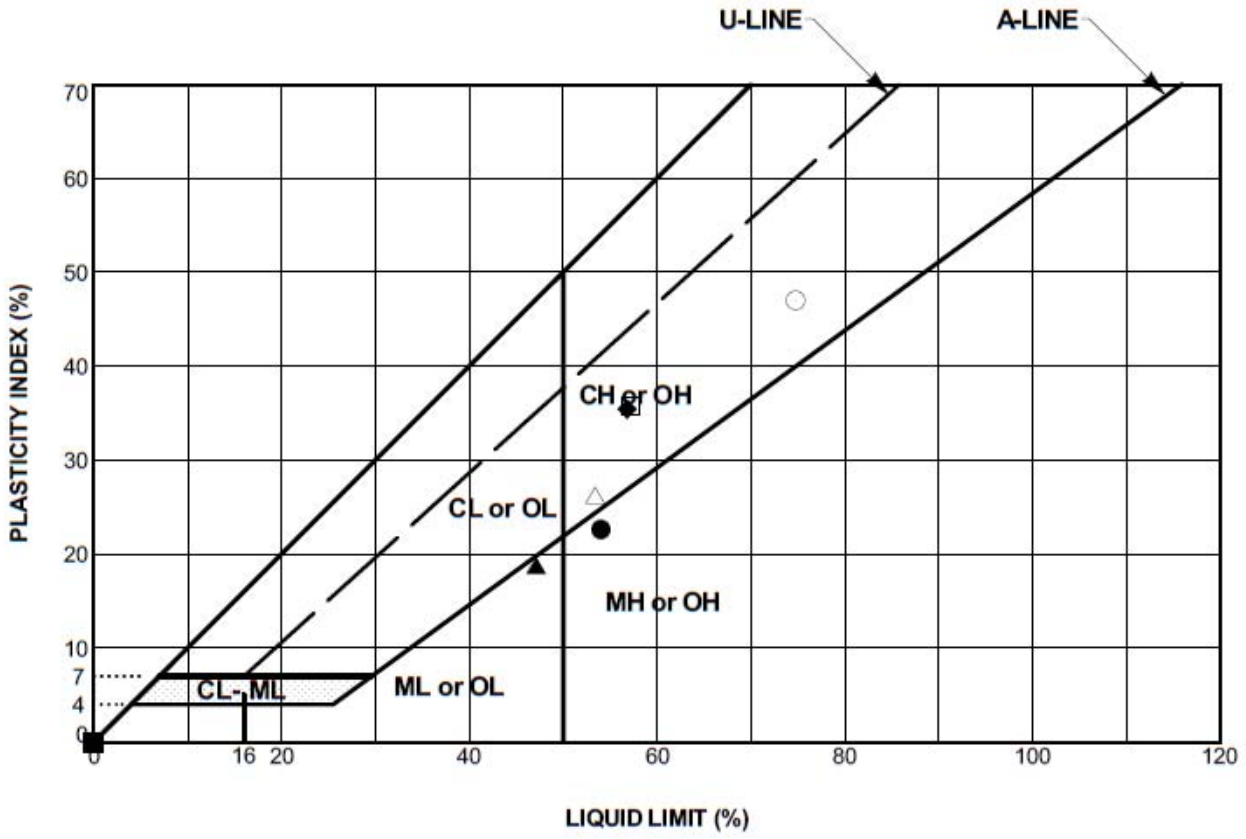
Diaz Yourman Areas B and C

PLATE

C21

PLATE B2-59

Template: DY_ATTERBERG_CHART_WIN



Laboratory Testing by: Diaz Yourman & Associates

Test Method: ASTM D4318-05

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-01	12.0	FAT CLAY (CH)	46	75	28	47	92
□	C-02	6.0	FAT CLAY (CH)	45	57	21	36	98
△	C-03	15.0	FAT CLAY (CH)	51	53	27	26	100
◇	C-03	33.0	SILT (ML)	38	NP	NP	NP	99
●	C-04	12.0	ELASTIC SILT (MH)	38	54	31	23	95
■	C-04	24.0	SILT WITH SAND (ML)	24	NP	NP	NP	79
▲	C-05	24.0	SILT (ML)	43	47	28	19	99
◆	C-06	12.0	FAT CLAY (CH)	43	57	21	36	98

PLASTICITY CHART

USACE Ballona Creek Watershed

Project No. 2006-023.05

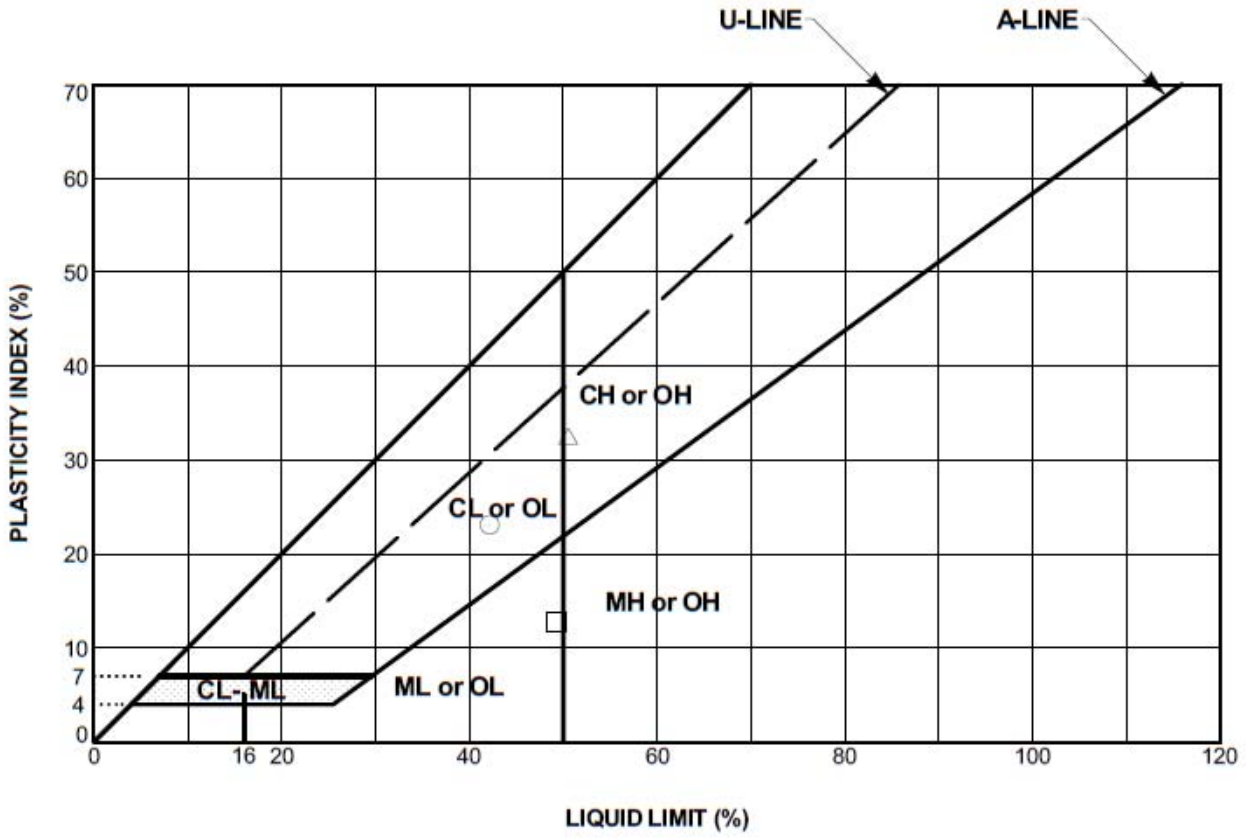
Diaz Yourman Areas B and C

PLATE

C22

PLATE B2-60

Template: DY_ATTERBERG_CHART_WIN



Laboratory Testing by: Diaz Yourman & Associates

Test Method: ASTM D4318-05

Symbol	Source	Depth (feet)	Classification	Natural M. C. (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% Passing #200 Sieve
○	C-06	18.0	SANDY LEAN CLAY (CL)	29	42	19	23	70
□	C-07	9.0	SILT (ML)	31	49	37	12	92
△	C-07	21.0	FAT CLAY WITH SAND (CH)	27	51	18	33	74

PLASTICITY CHART

USACE Ballona Creek Watershed

Project No. 2006-023.05

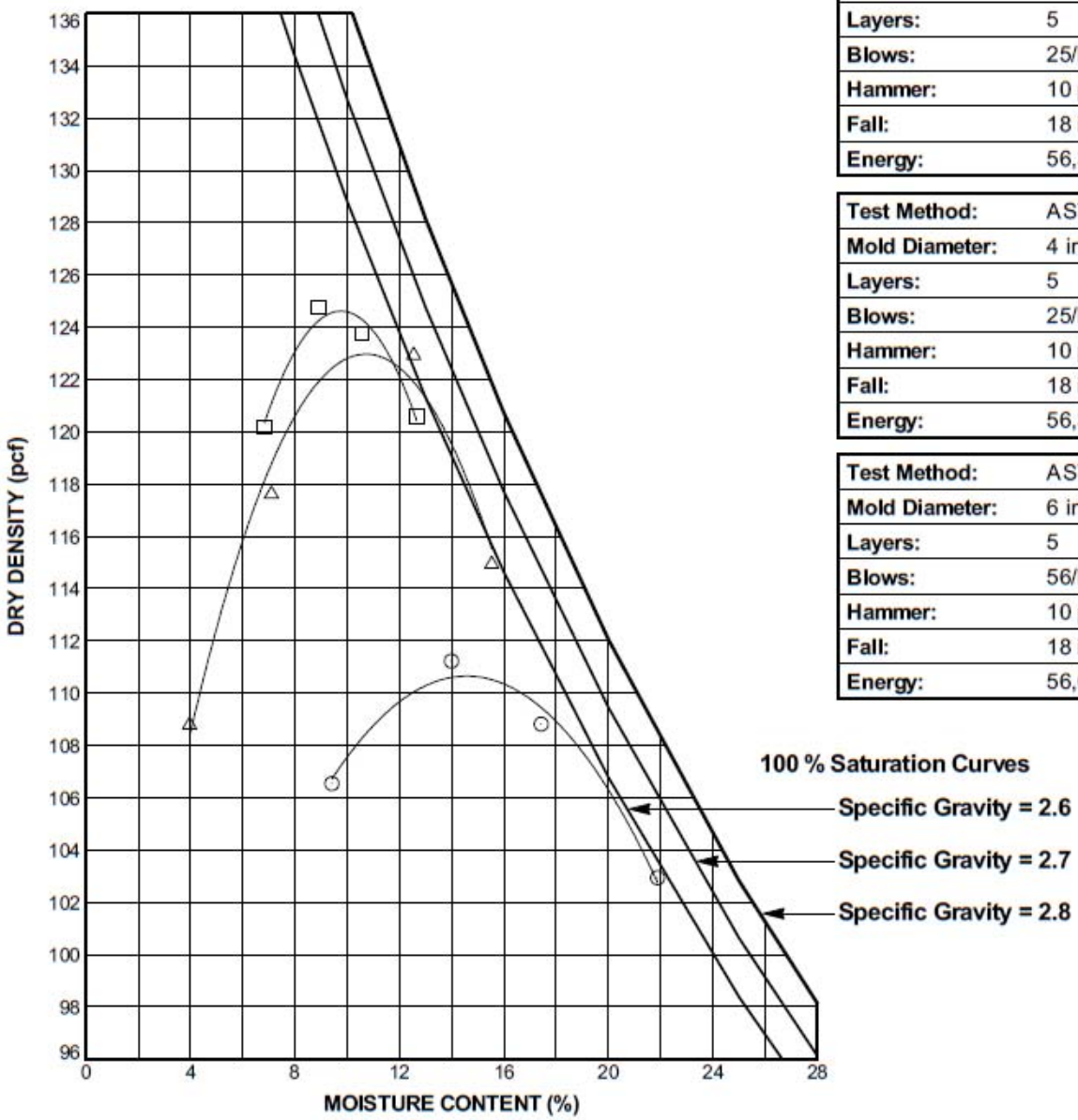
Diaz Yourman Areas B and C

PLATE

C23

PLATE B2-61

Template: DY_COMPACT_4_PLOTS_WIN REV FEB07



Test Method:	ASTM D1557-91(A)
Mold Diameter:	4 inches
Layers:	5
Blows:	25/layer
Hammer:	10 pounds
Fall:	18 inches
Energy:	56,300 ft-lbs/cu ft

Test Method:	ASTM D1557-91(B)
Mold Diameter:	4 inches
Layers:	5
Blows:	25/layer
Hammer:	10 pounds
Fall:	18 inches
Energy:	56,300 ft-lbs/cu ft

Test Method:	ASTM D1557-91(C)
Mold Diameter:	6 inches
Layers:	5
Blows:	56/layer
Hammer:	10 pounds
Fall:	18 inches
Energy:	56,000 ft-lbs/cu ft

Laboratory Testing by: Diaz Yourman & Associates

Symbol	Source	Depth (feet)	Classification	Optimum Moisture Content (%)	Max. Dry Density (pcf)	Liquid Limit (%)	Plasticity Index (%)	%<#200 Sieve	ASTM Test Method
○	B-02	0.0	LEAN CLAY WITH SAND (CL)	16	112				1557A
□	B-13	0.0	CLAYEY SAND (SC)	10	126			21	1557A
△	C-01	0.0	CLAYEY SAND (SC)	10.5	124.5			37	1557A

COMPACTION TEST DATA

USACE Ballona Creek Watershed

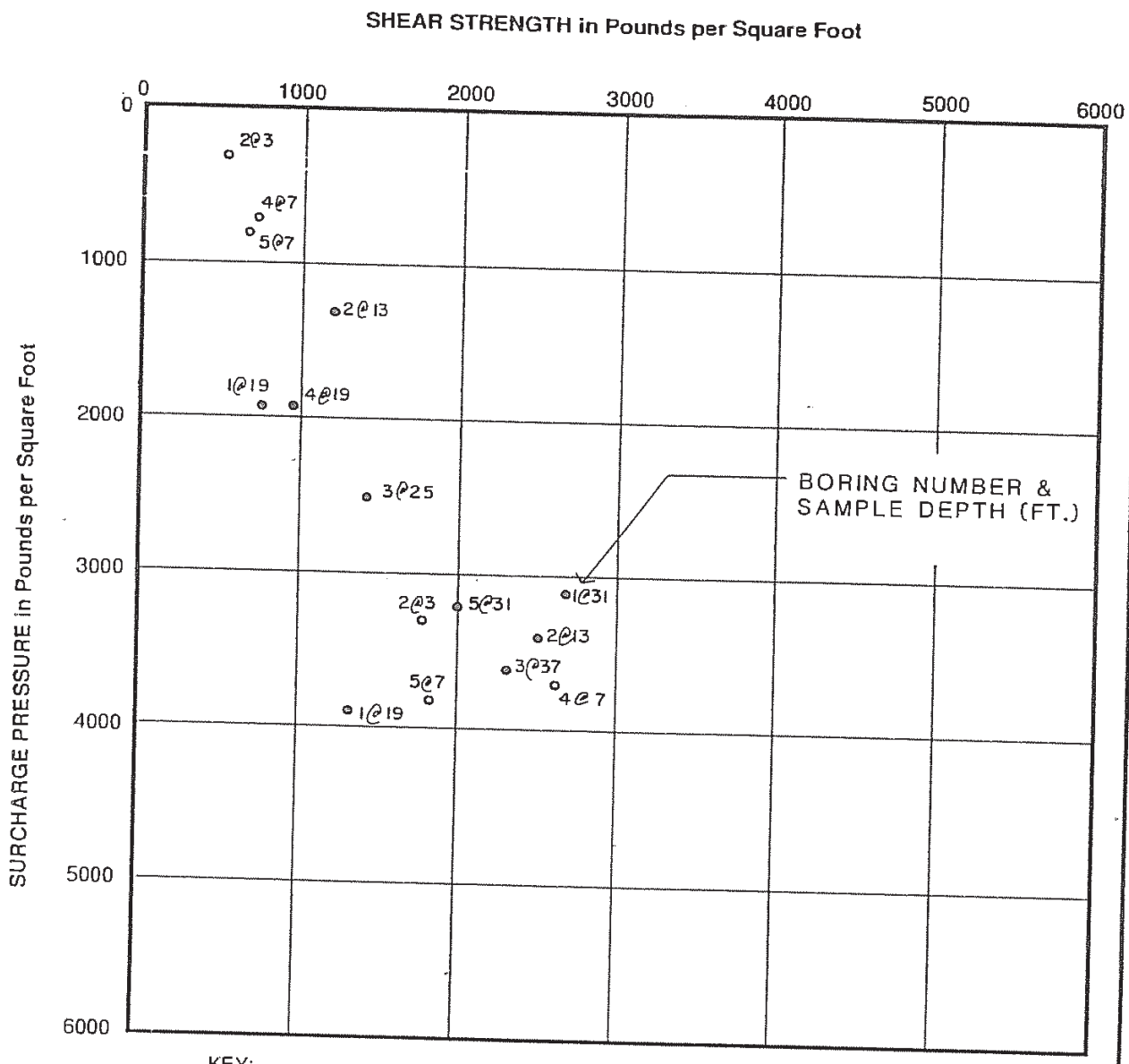
Project No. 2006-023.05

Diaz Yourman Areas B and C

PLATE

C24

PLATE B2-62

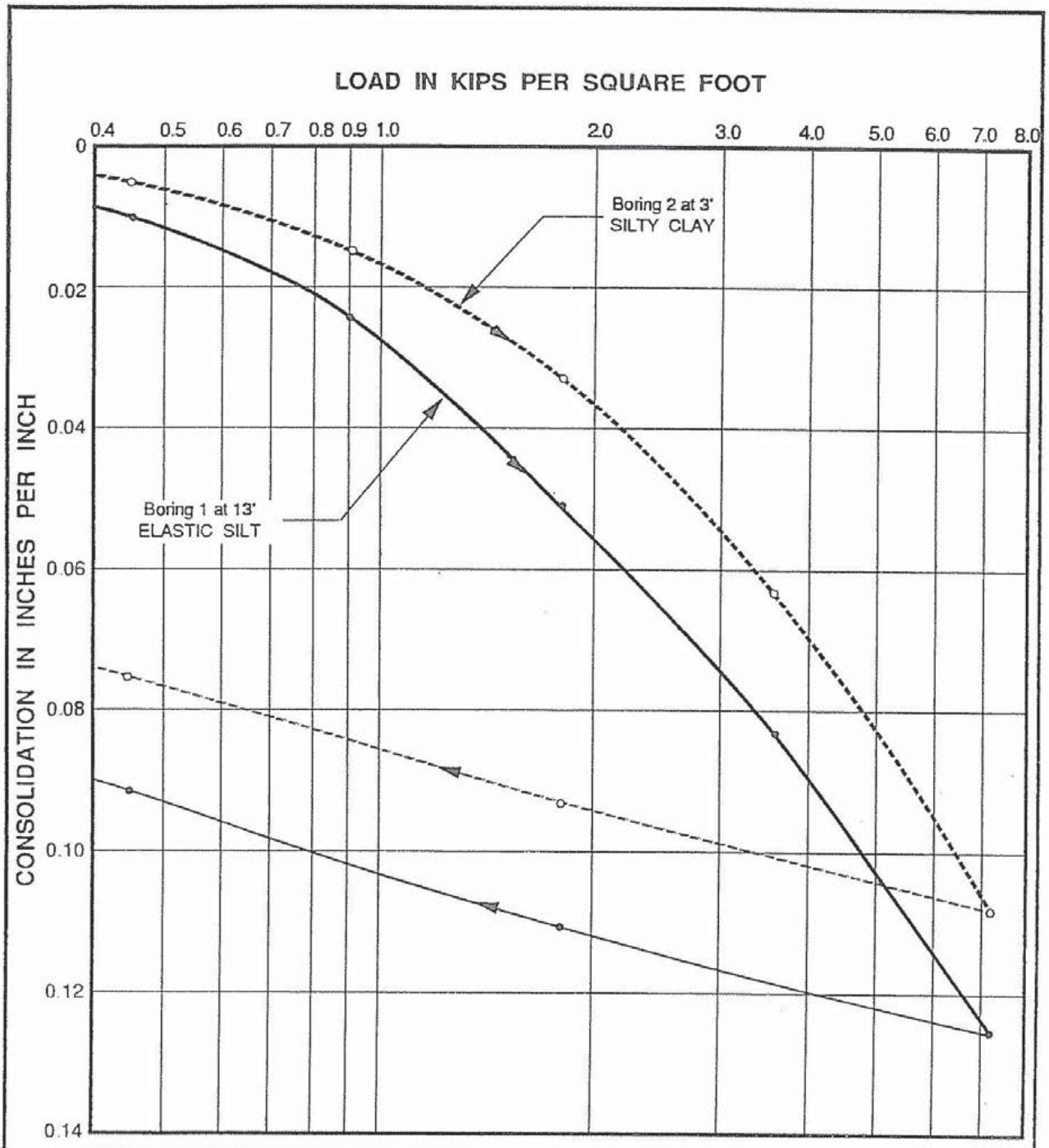


DIRECT SHEAR TEST DATA

Law Crandall Area C LAW/CRANDALL, INC.

PLATE B2-63

PLATE A-3



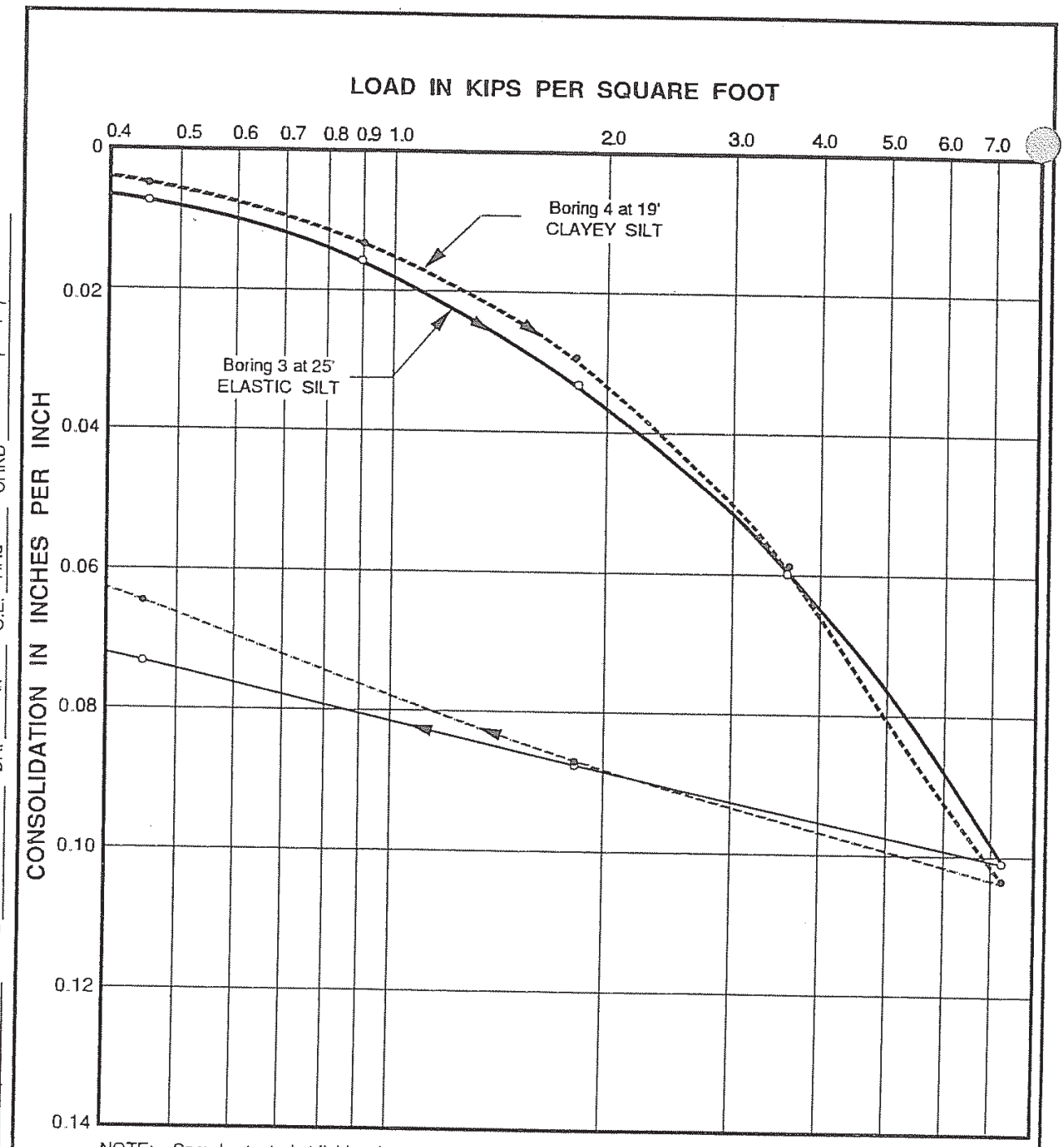
NOTE: Samples tested at field moisture content.

JOB L91177.AEB DATE 7/12/91 DR. lk O.E. HRL CHKD FH

CONSOLIDATION TEST DATA

Law Crandall Area C LAW/CRANDALL, INC.

PLATE B2-64 FIGURE 4.1



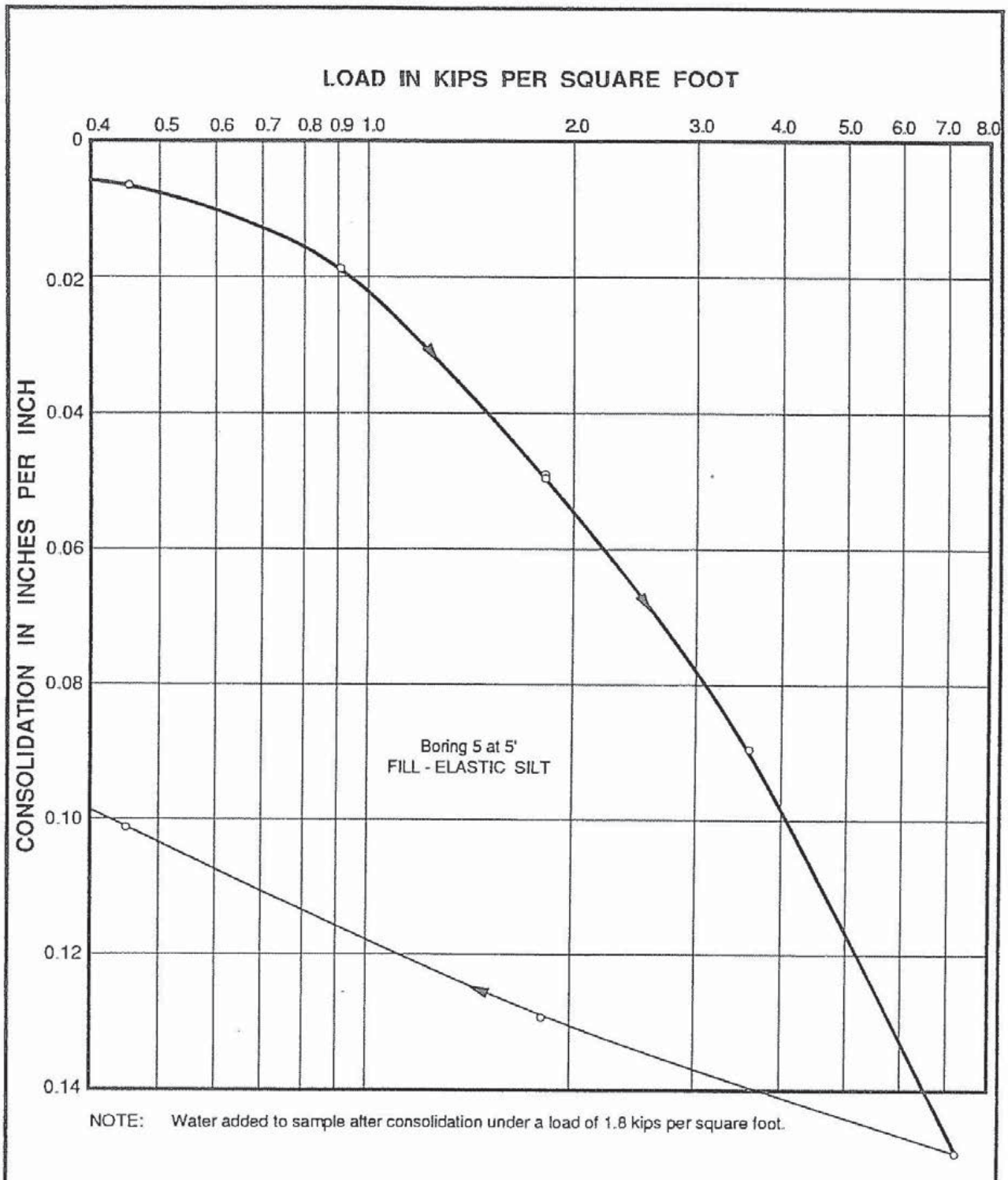
NOTE: Samples tested at field moisture content.

JOB L91177.AEB DATE 7/12/91 DR. lk O.E. HRL CHKD FH

CONSOLIDATION TEST DATA

Law Crandall Area C LAW/CRANDALL, INC.

PLATE B2-65-4.2



NOTE: Water added to sample after consolidation under a load of 1.8 kips per square foot.

JOB L91177.AEB DATE 7/18/91 F.T. TC DR. lk O.E. HRL CHKD

CONSOLIDATION TEST DATA

LAW/CRANDALL, INC.

PLATE B2-66.3

Law Crandall Area C

JOB L91177.AEB DATE 7/12/91 DR. lk O.E. HRL CHKD FH

BORING NUMBER AND SAMPLE DEPTH:	2 at 1' and 2 at 3' (Combined Sample)
SOIL TYPE:	SILTY CLAY
CONFINING PRESSURE: (lbs./sq. ft.)	144
INITIAL MOISTURE CONTENT: (% of dry wt.)	13.3
FINAL MOISTURE CONTENT: (% of dry wt.)	34.7
DRY DENSITY: (lbs./cu. ft.)	98
EXPANSION INDEX:	95

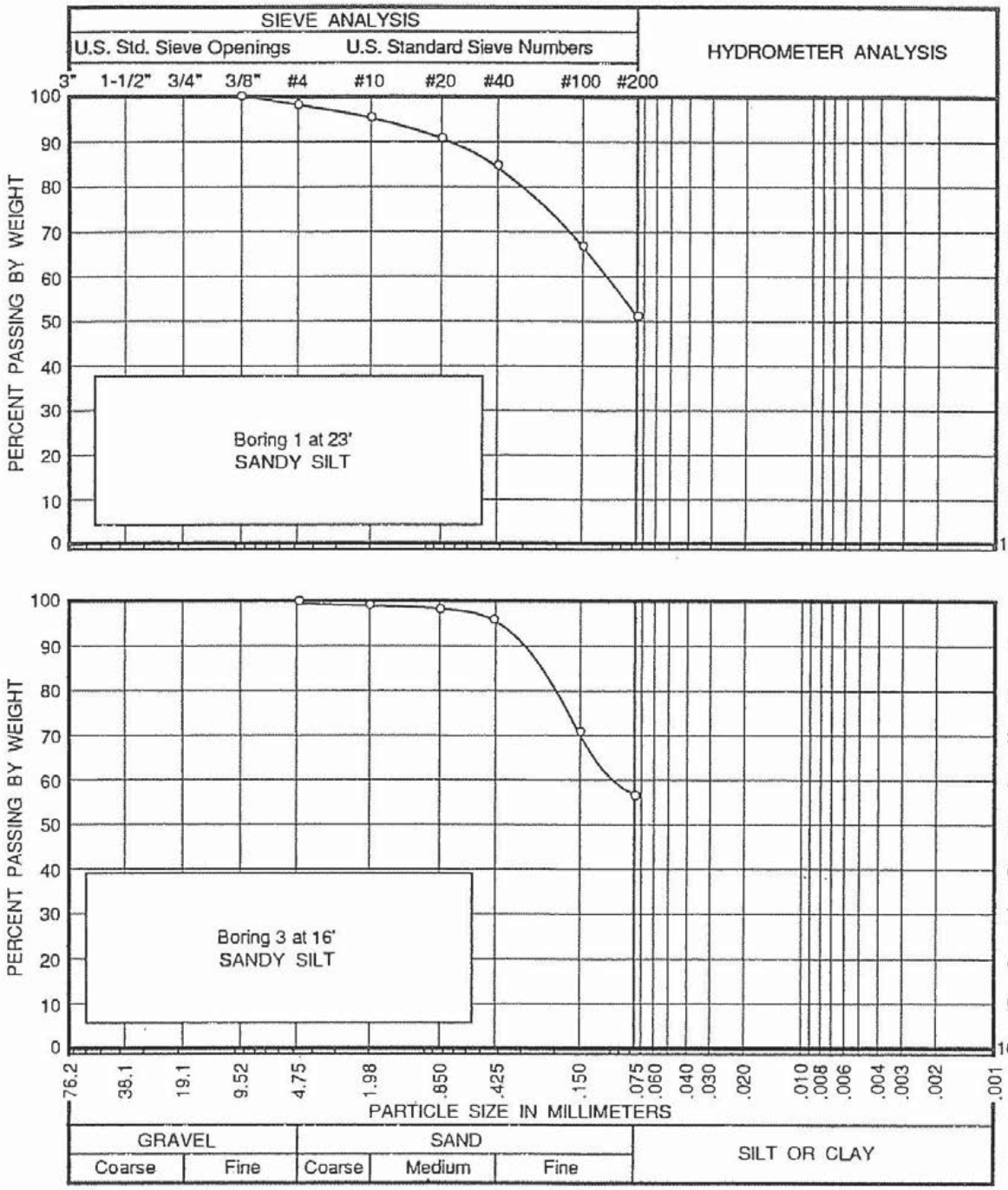
TEST METHOD: Uniform Building Code Standard No. 29-2, Expansion Index Test

EXPANSION INDEX TEST DATA

Law Crandall Area LAW/CRANDALL, INC.

PLATE B2-67

PLATE A-5



JOB L91177.AEB DATE 7/12/91 DR. lk O.E. HRL CHKD

PARTICLE SIZE DISTRIBUTION

Law Crandall Area C LAW/CRANDALL, INC.

PLATE B2-6A

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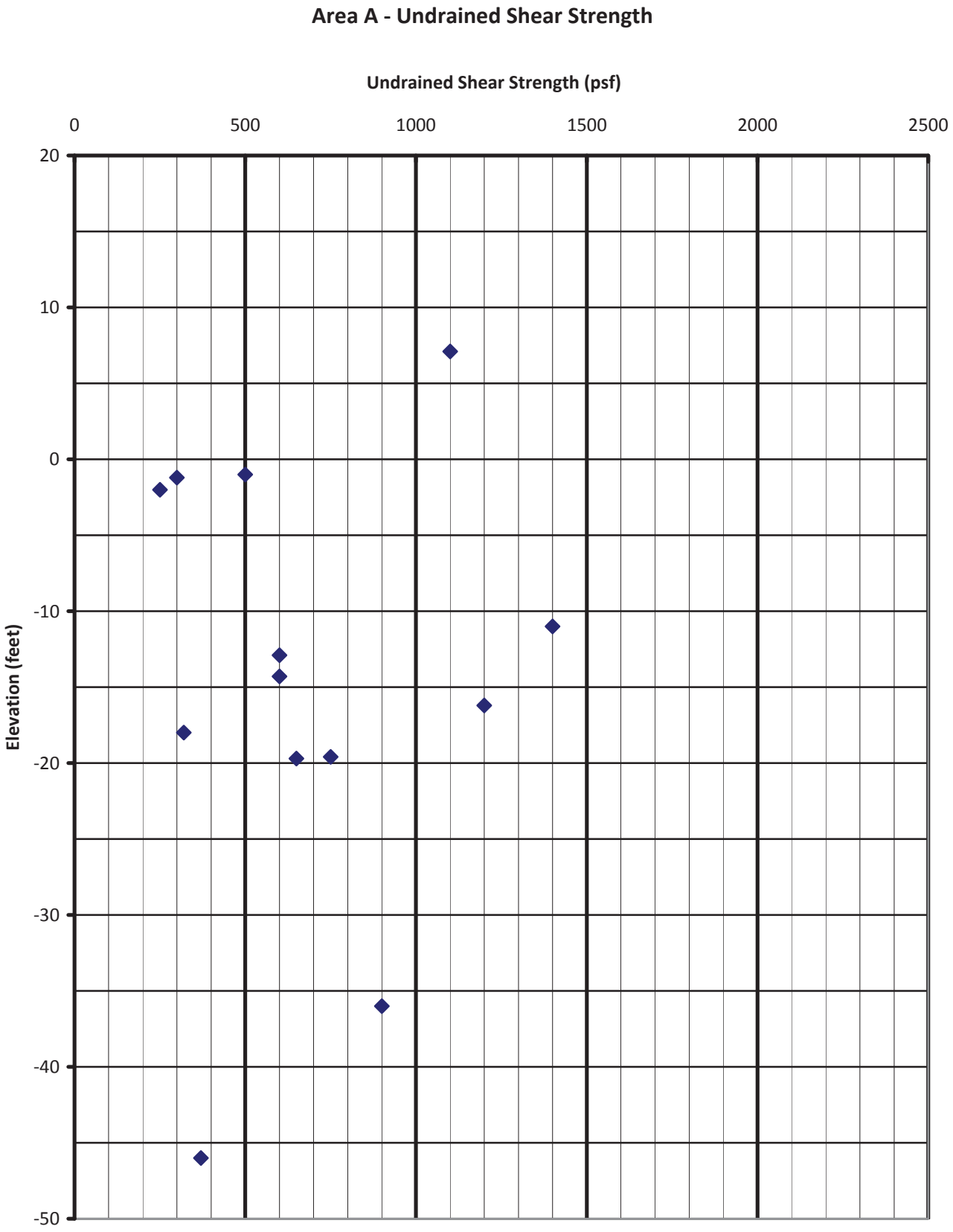
APPENDIX B3
LABORATORY TESTING INTERPRETATIONS OF GDC INVESTIGATION

APPENDIX B3
LABORATORY TESTING INTERPRETATIONS

B3.1 General

The following interpretation plots were generated based on the results of our laboratory data in Areas A, B, and C:

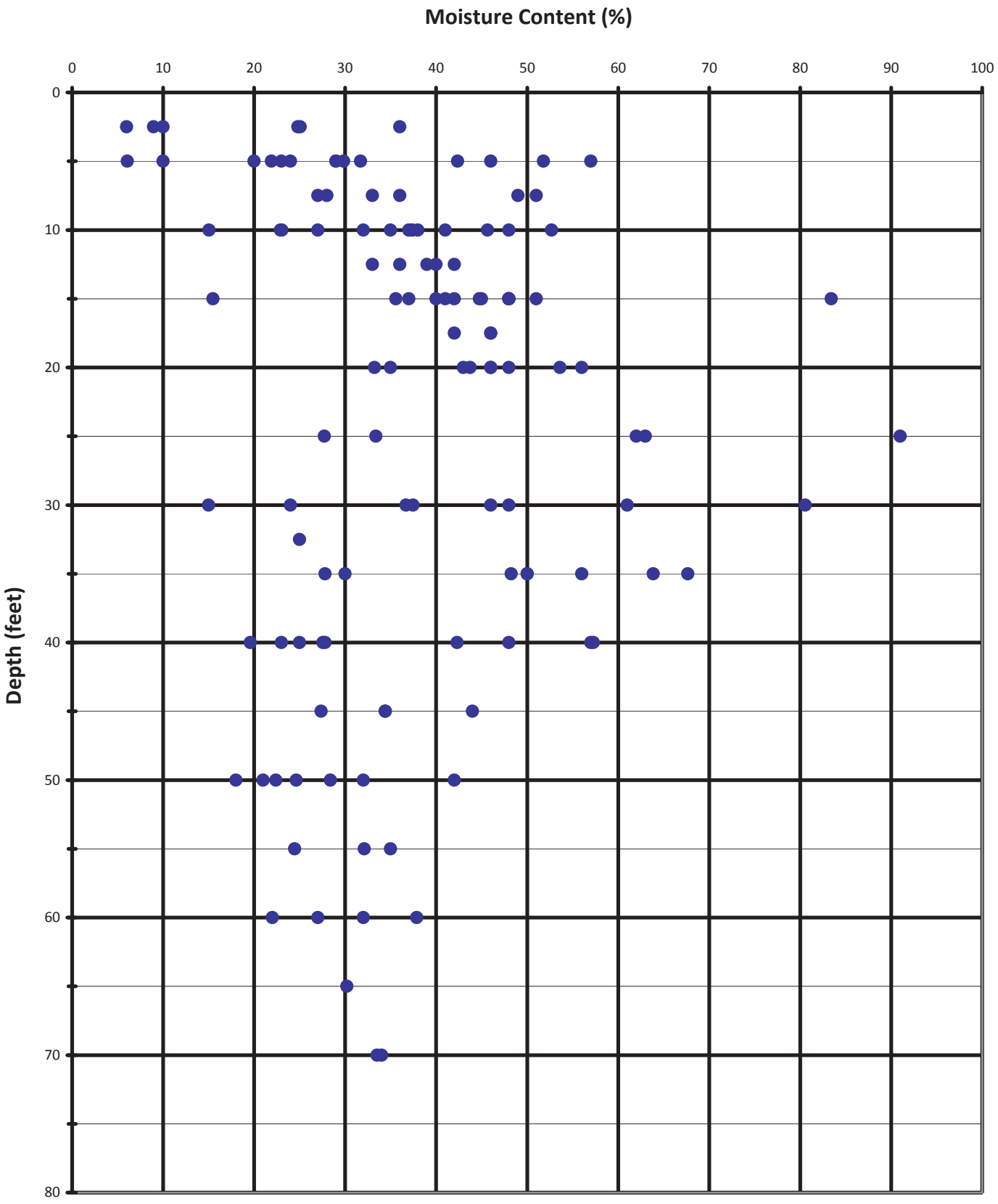
Plate B3-1	Area A – Undrained Shear Strength
Plate B3-2	Variation of Moisture Content with Depth – Area A
Plate B3-3	Variation of Dry Density with Depth – Area A
Plate B3-4	Variation of Liquid Limit with Depth – Area A
Plate B3-5	Variation of Plastic Limit with Depth – Area A
Plate B3-6	Variation of Fines Content with Depth – Area A
Plate B3-7	Plot of Moisture Content vs. Dry Density – Area A
Plate B3-8	Variation of Moisture Content with Elevation – Area A Fill Soils
Plate B3-9	Variation of Dry Density with Elevation – Area A Fill Soils
Plate B3-10	Variation of Liquid Limit with Elevation – Area A Fill Soils
Plate B3-11	Variation of Plastic Limit with Elevation – Area A Fill Soils
Plate B3-12	Variation of Fines Content with Elevation – Area A Fill Soils
Plate B3-13	Plot of Moisture Content vs. Dry Density – Area A Fill Soils
Plate B3-14	Area B – Undrained Shear Strength
Plate B3-15	Variation of Moisture Content with Depth – Area B
Plate B3-16	Variation of Dry Density with Depth – Area B
Plate B3-17	Variation of Liquid Limit with Depth – Area B
Plate B3-18	Variation of Plastic Limit with Depth – Area B
Plate B3-19	Variation of Fines Content with Depth – Area B
Plate B3-20	Plot of Moisture Content vs. Dry Density – Area B
Plate B3-21	Variation of Moisture Content with Depth – Area C
Plate B3-22	Variation of Dry Density with Depth – Area C
Plate B3-23	Variation of Liquid Limit with Depth – Area C
Plate B3-24	Variation of Plastic Limit with Depth – Area C
Plate B3-25	Variation of Fines Content with Depth – Area C
Plate B3-26	Plot of Moisture Content vs. Dry Density – Area C



Laboratory Vane Shear - Area A

PLATE B3-1

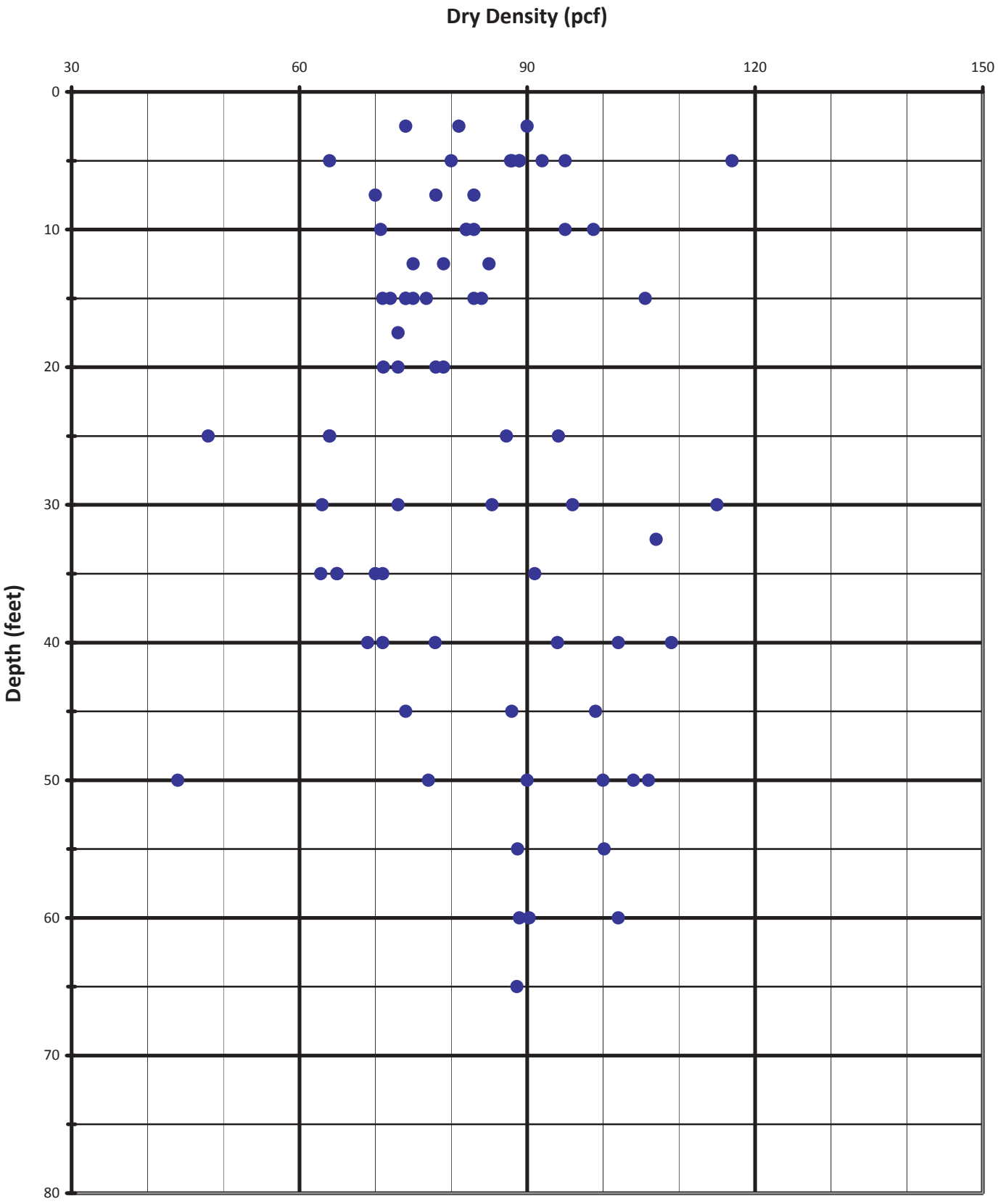
Variation of Moisture Content with Depth



Area A

PLATE B3-2

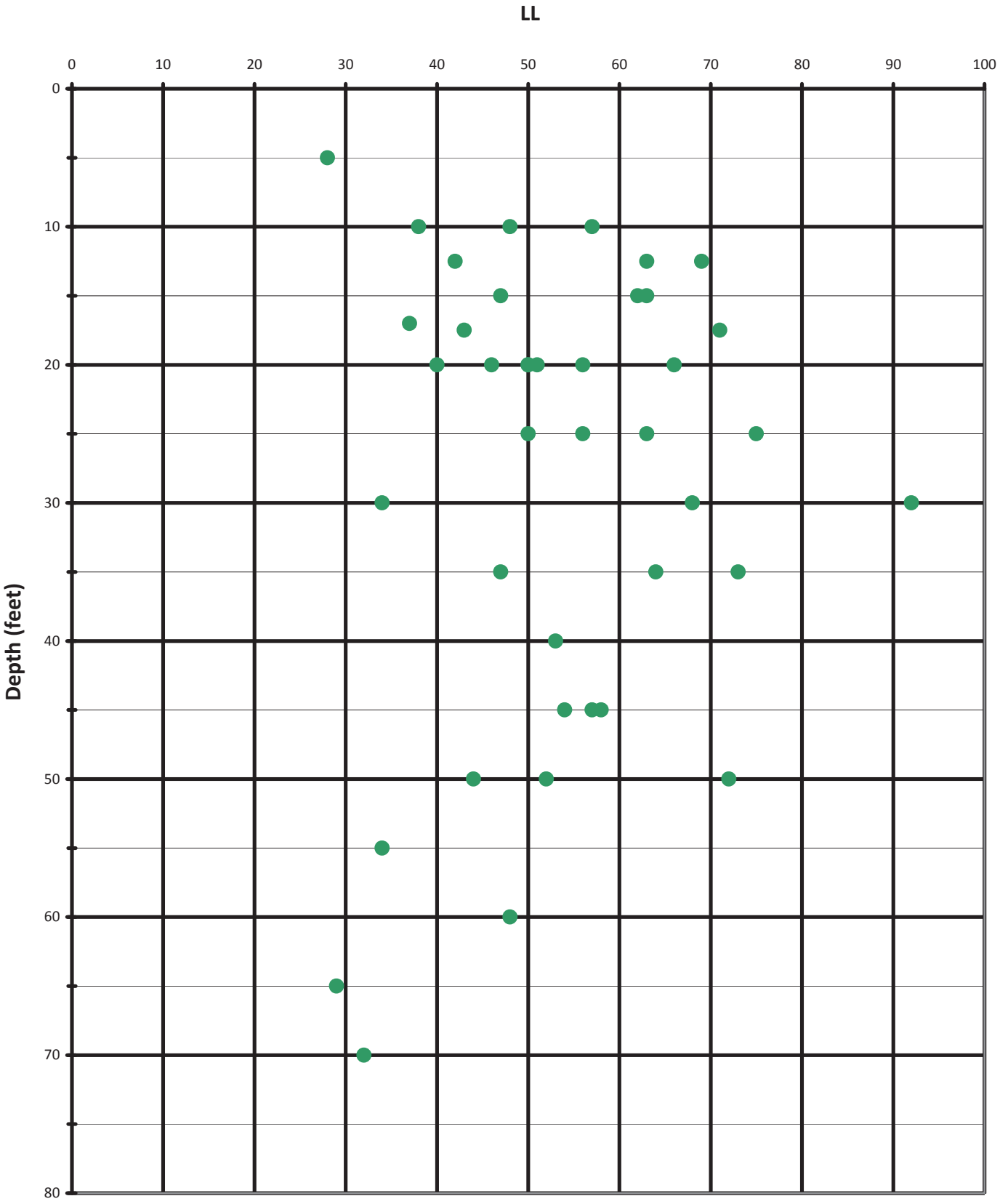
Variation of Dry Density with Depth



Area A

PLATE B3-3

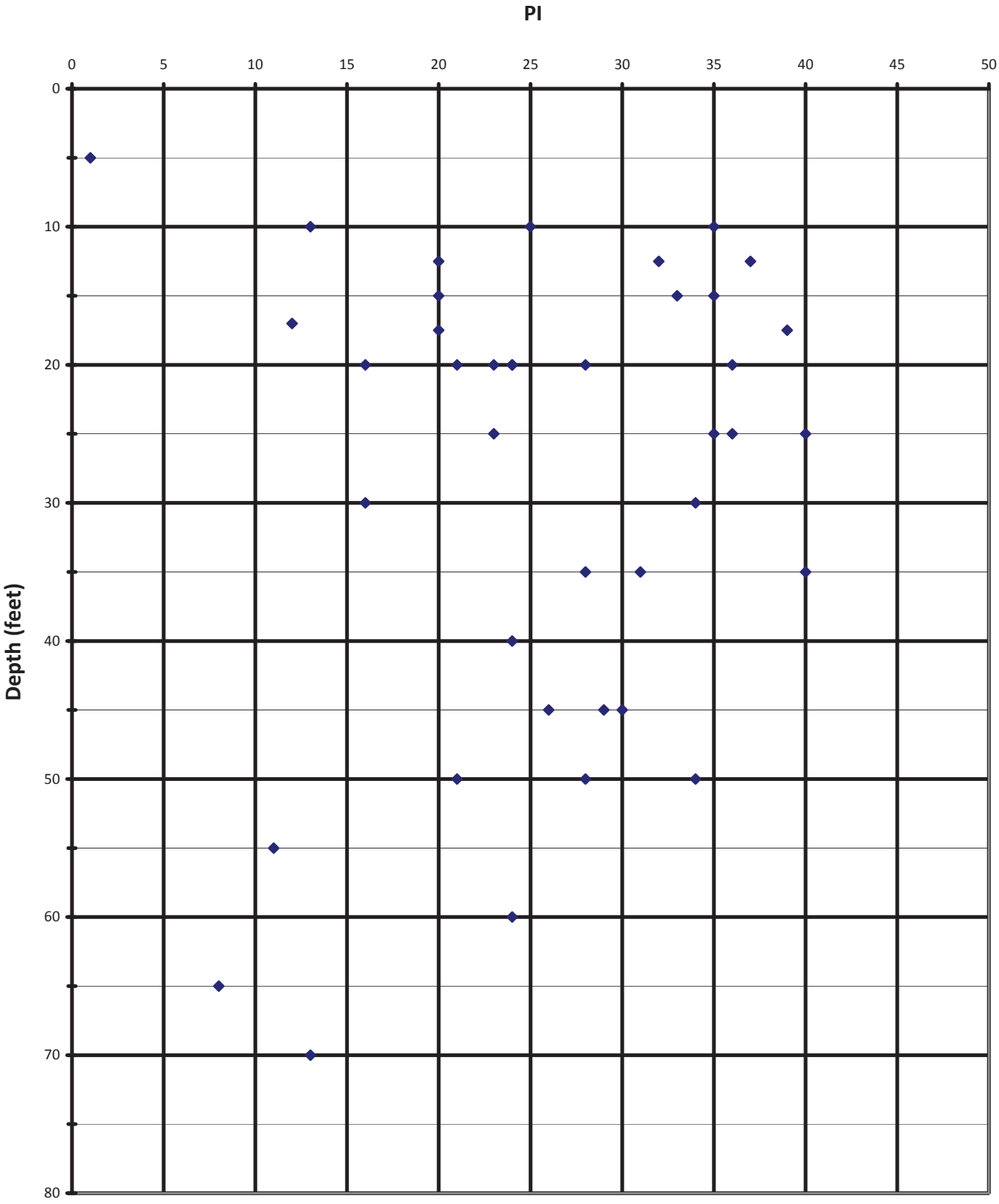
Variation of Liquid Limit with Depth



Area A

PLATE B3-4

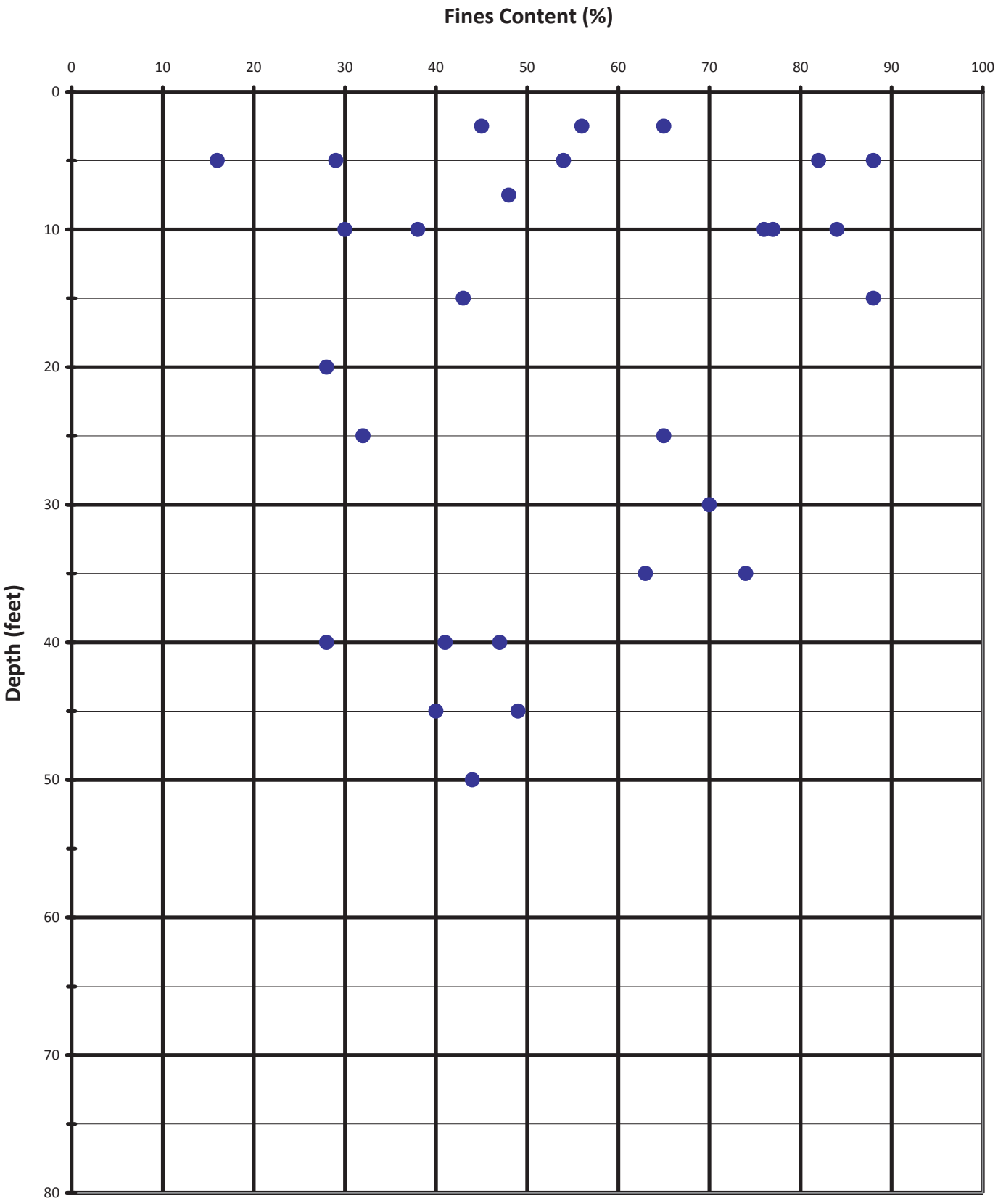
Variation of Plasticity Index with Depth



Area A

PLATE B3-5

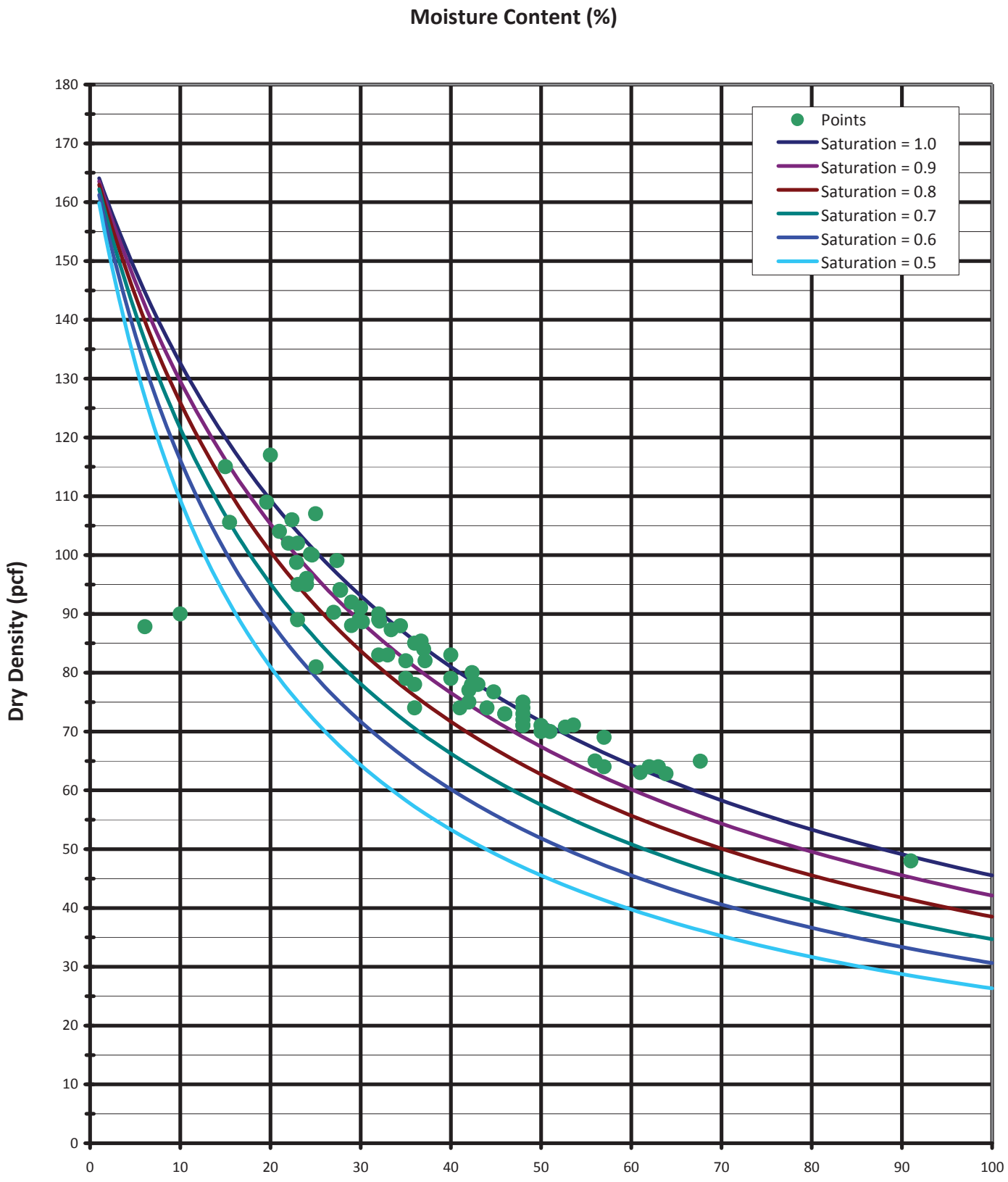
Variation of Fines Content with Depth



Area A

PLATE B3-6

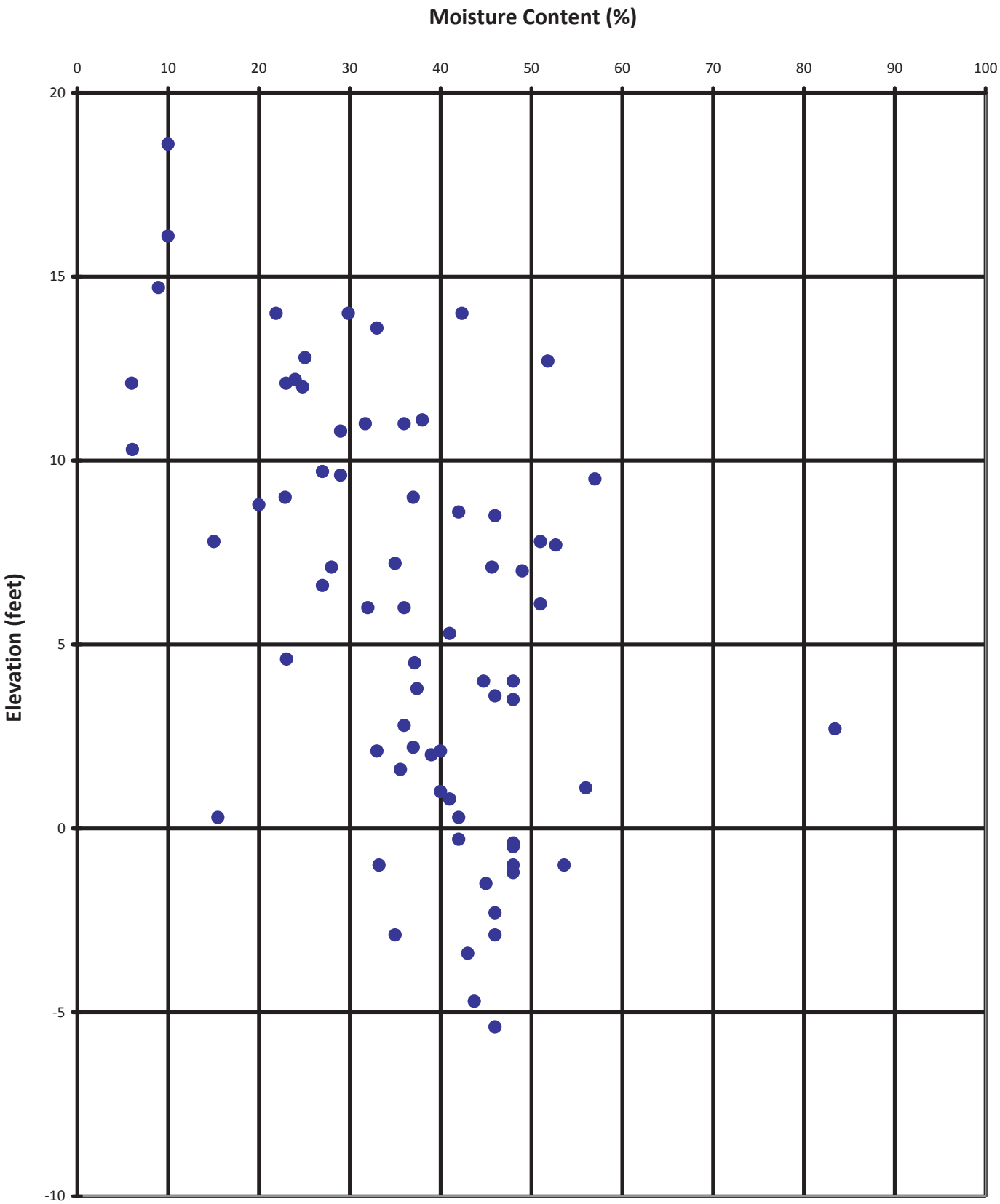
Moisture Content vs Dry Density



Area A

PLATE B3-7

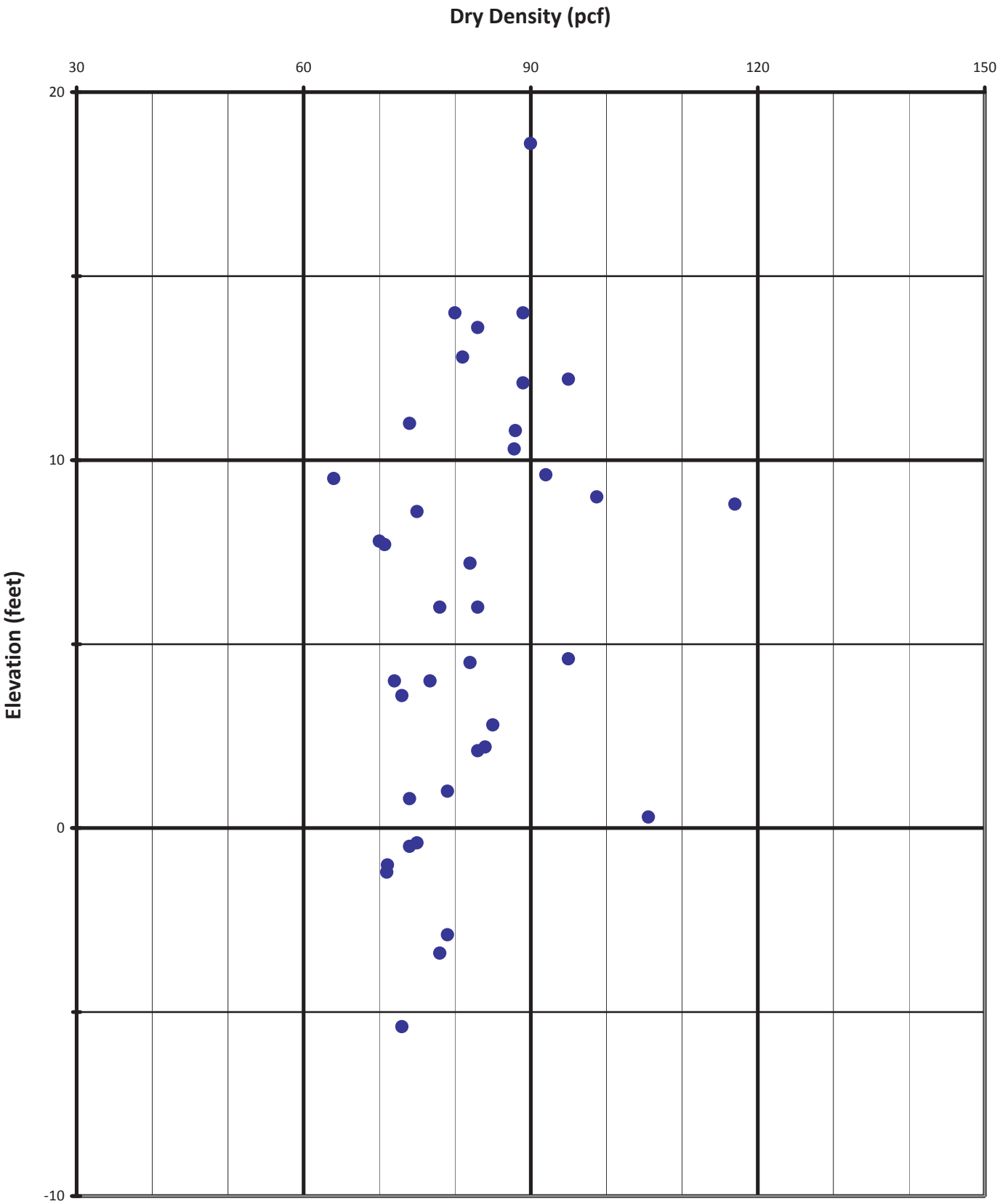
Variation of Moisture Content with Elevation



Fill Soils - Area A

PLATE B3-8

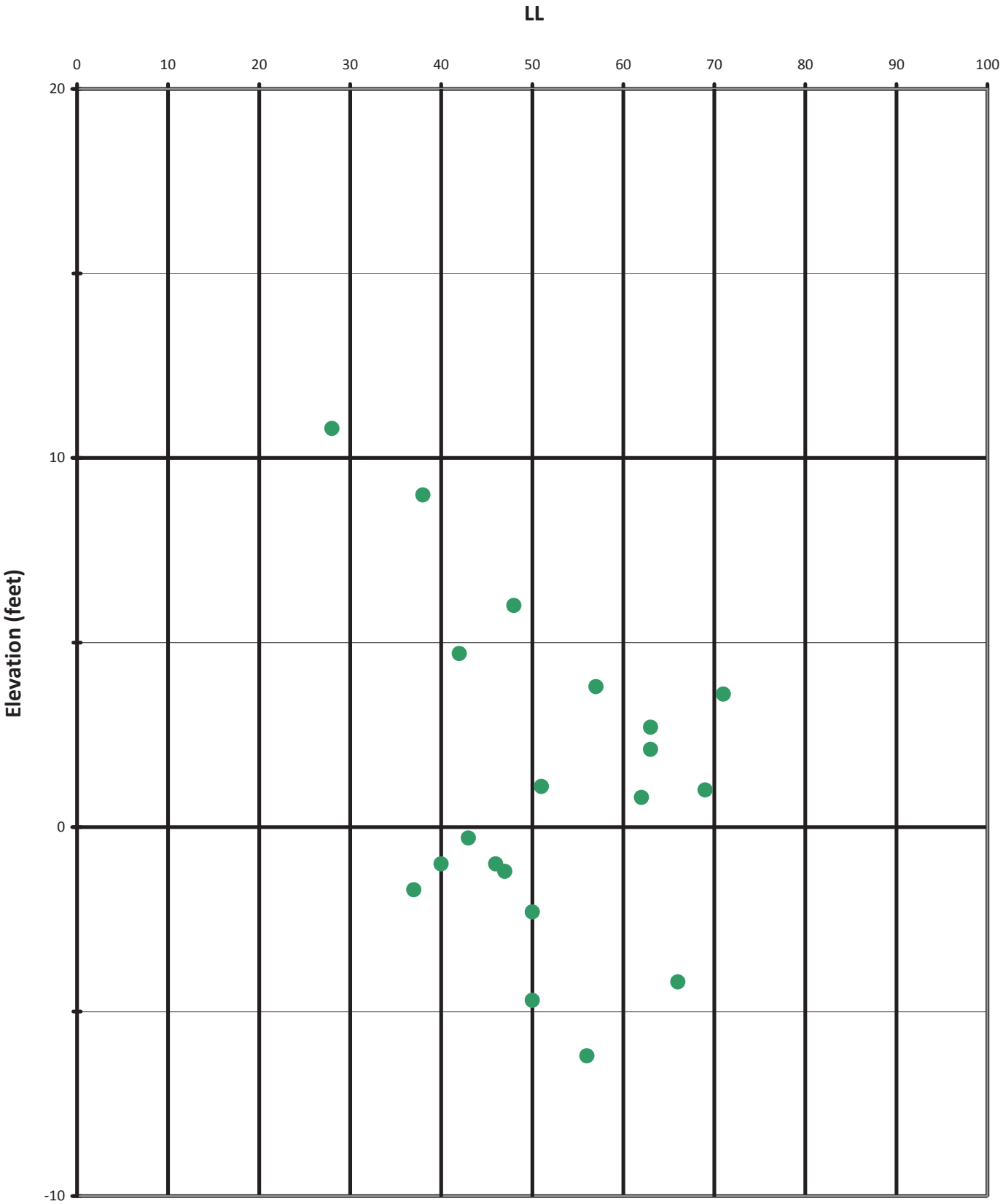
Variation of Dry Density with Elevation



Fill Soils - Area A

PLATE B3-9

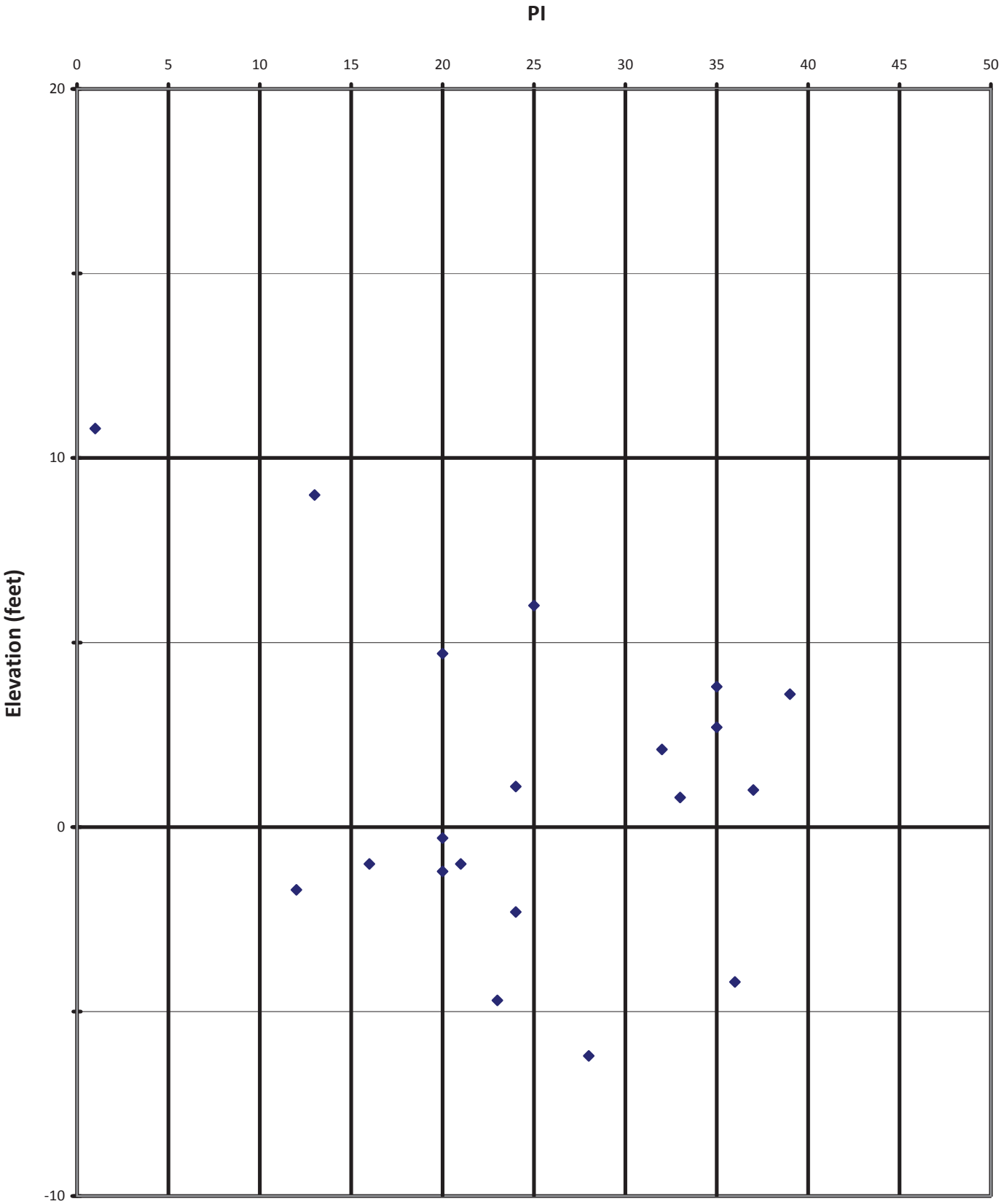
Variation of Liquid Limit with Elevation



Fill Soils - Area A

PLATE B3-10

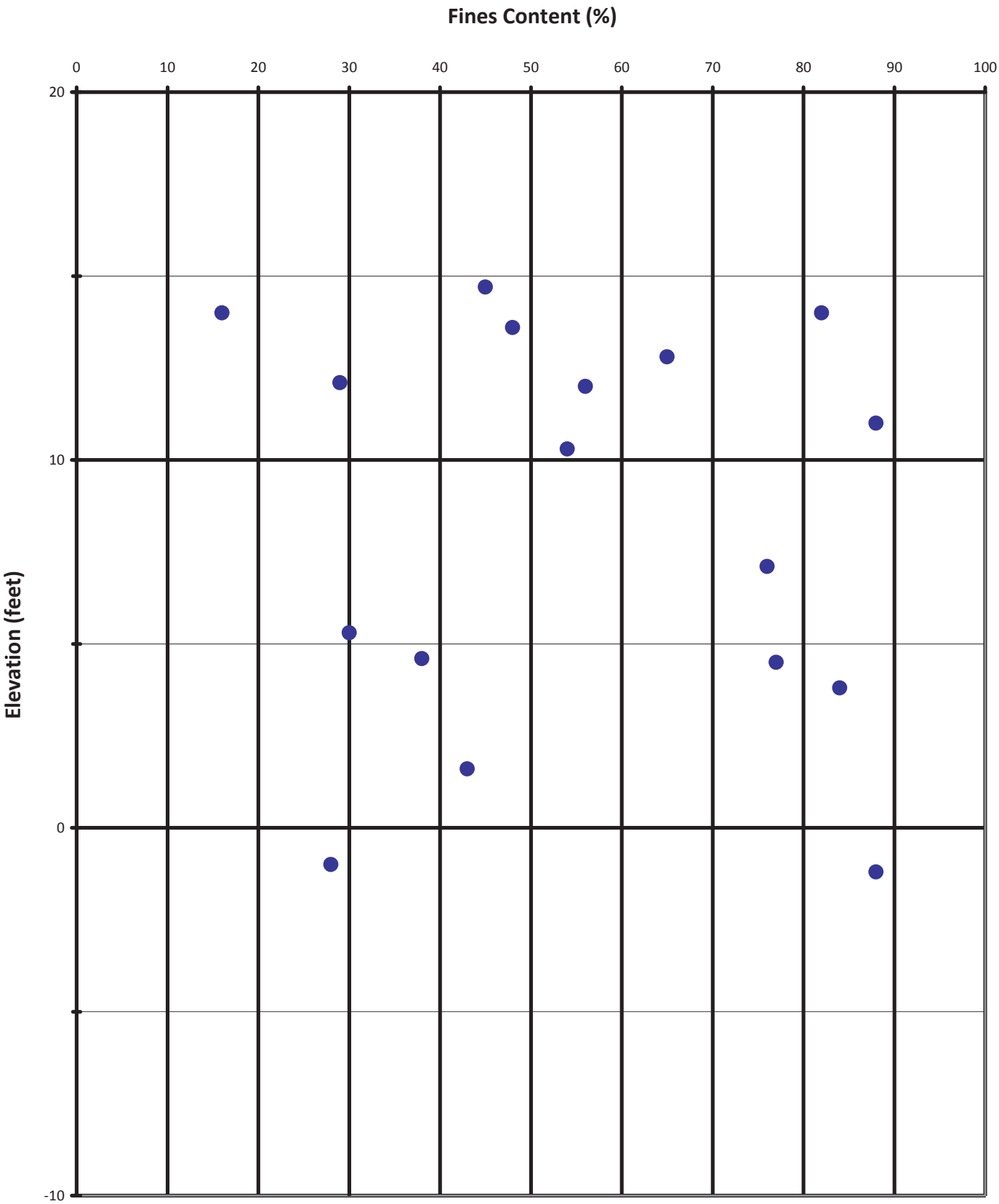
Variation of Plasticity Index with Elevation



Fill Soils - Area A

PLATE B3-11

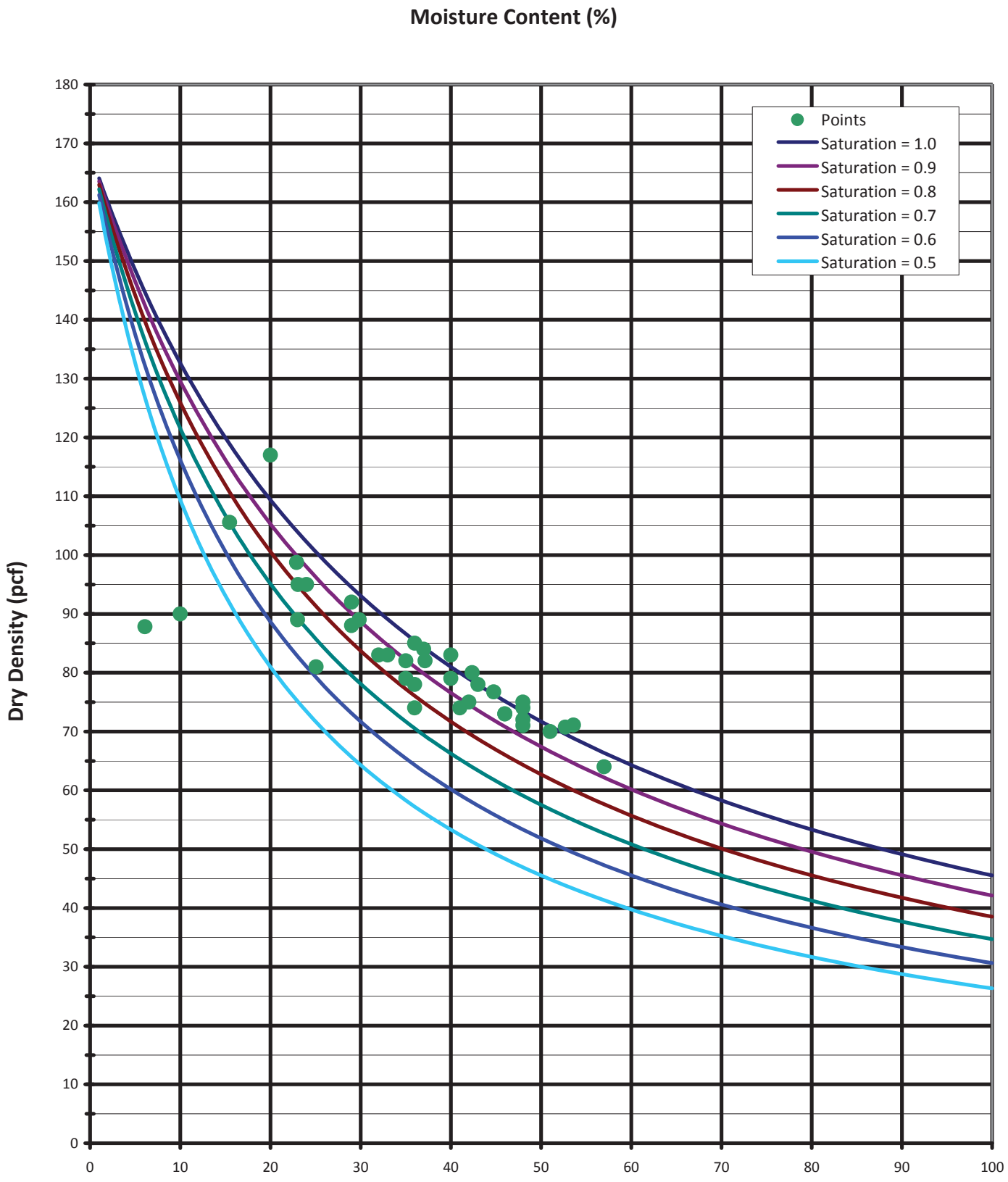
Variation of Fines Content with Elevation



Fill Soils - Area A

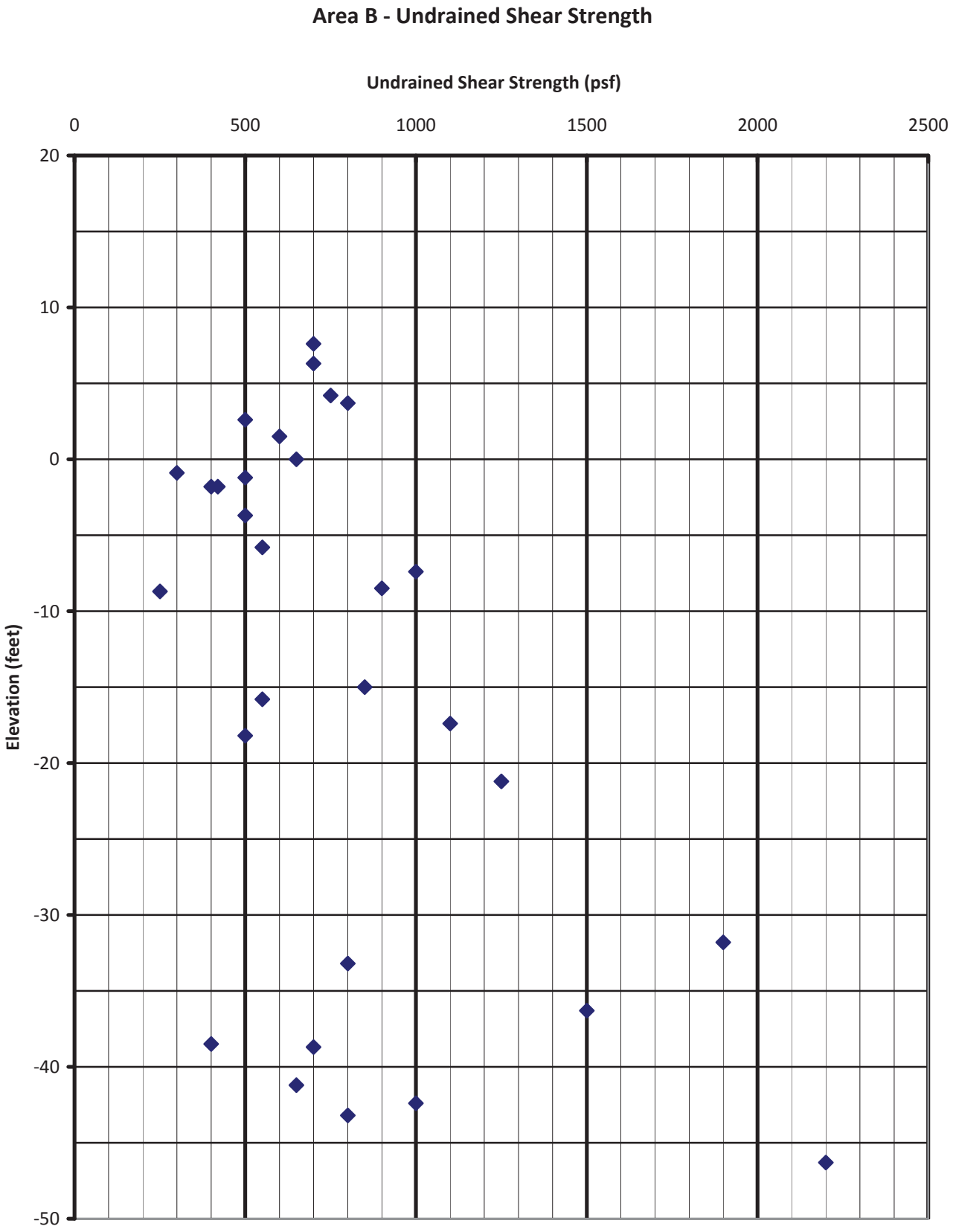
PLATE B3-12

Moisture Content vs Dry Density



Fill Soils - Area A

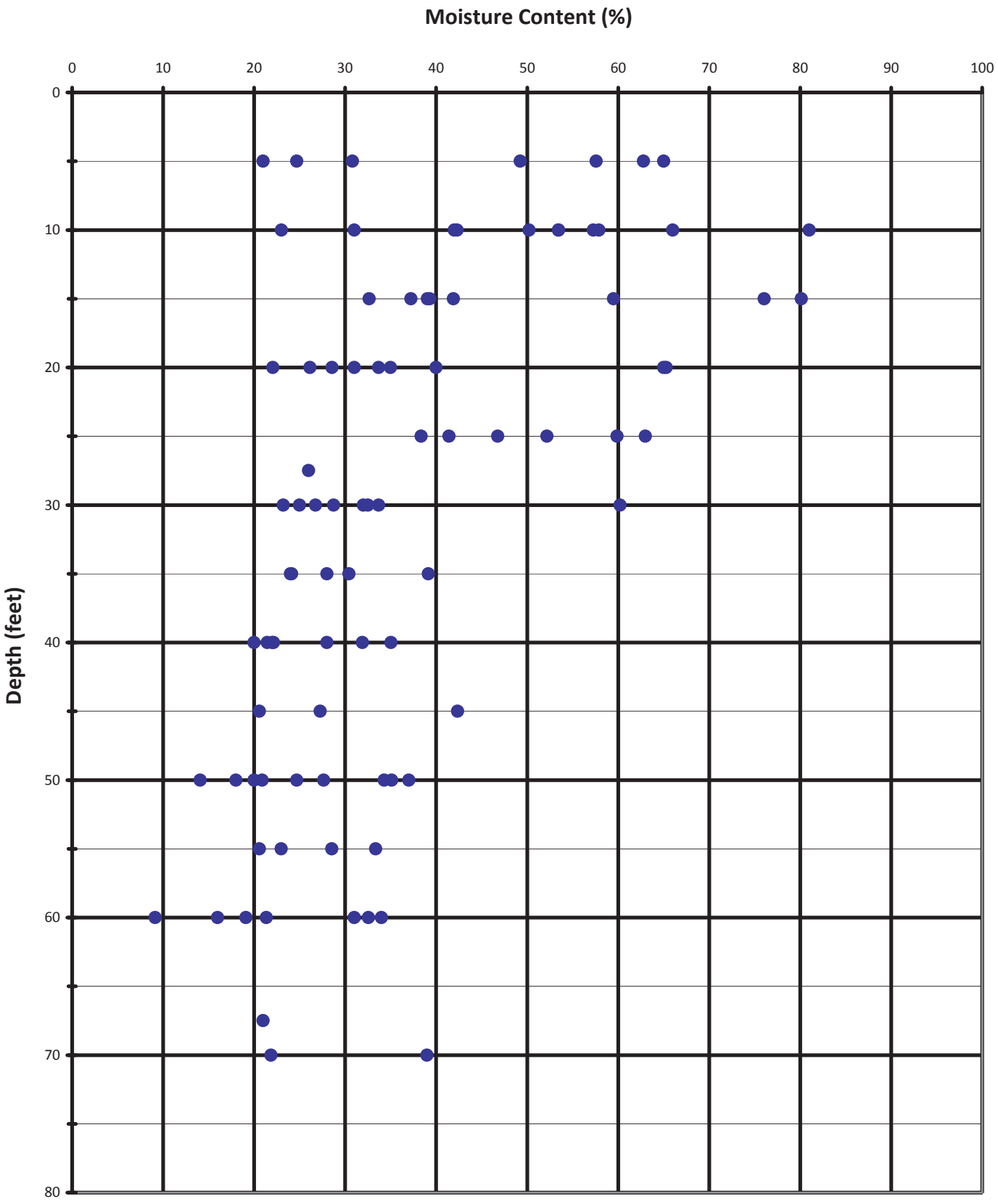
PLATE B3-13



Laboratory Vane Shear - Area B

PLATE B3-14

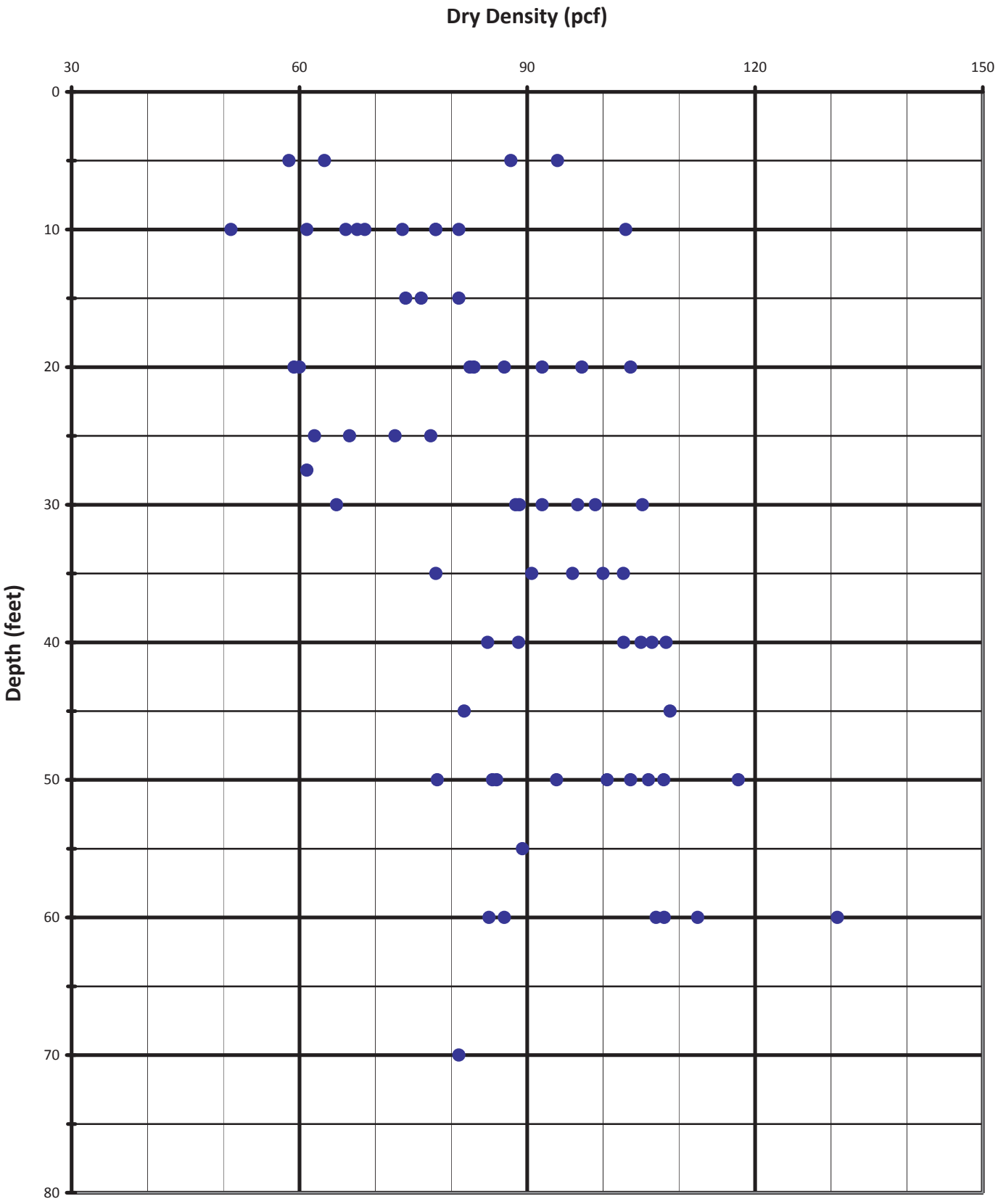
Variation of Moisture Content with Depth



Area B

PLATE B3-15

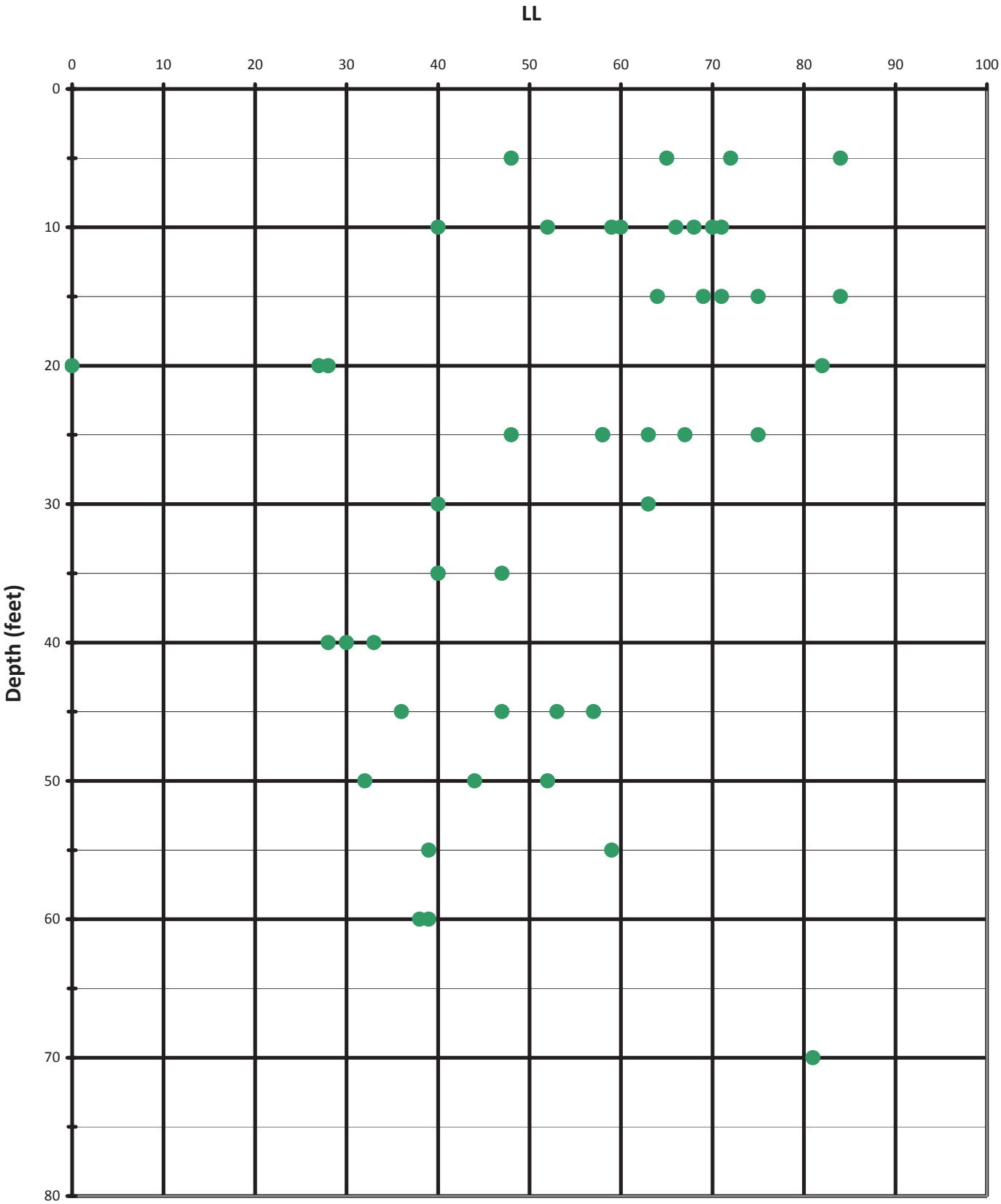
Variation of Dry Density with Depth



Area B

PLATE B3-16

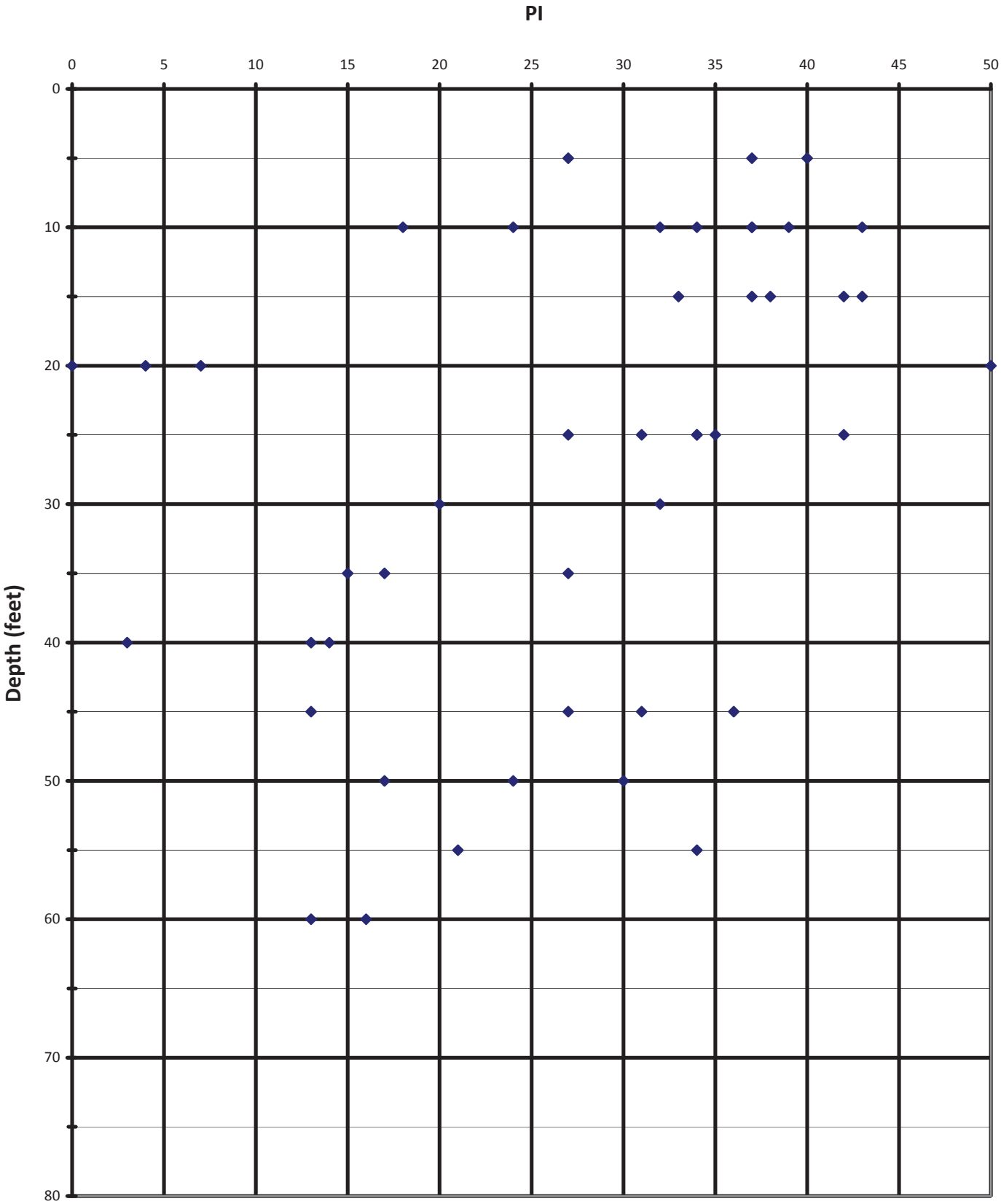
Variation of Liquid Limit with Depth



Area B

PLATE B3-17

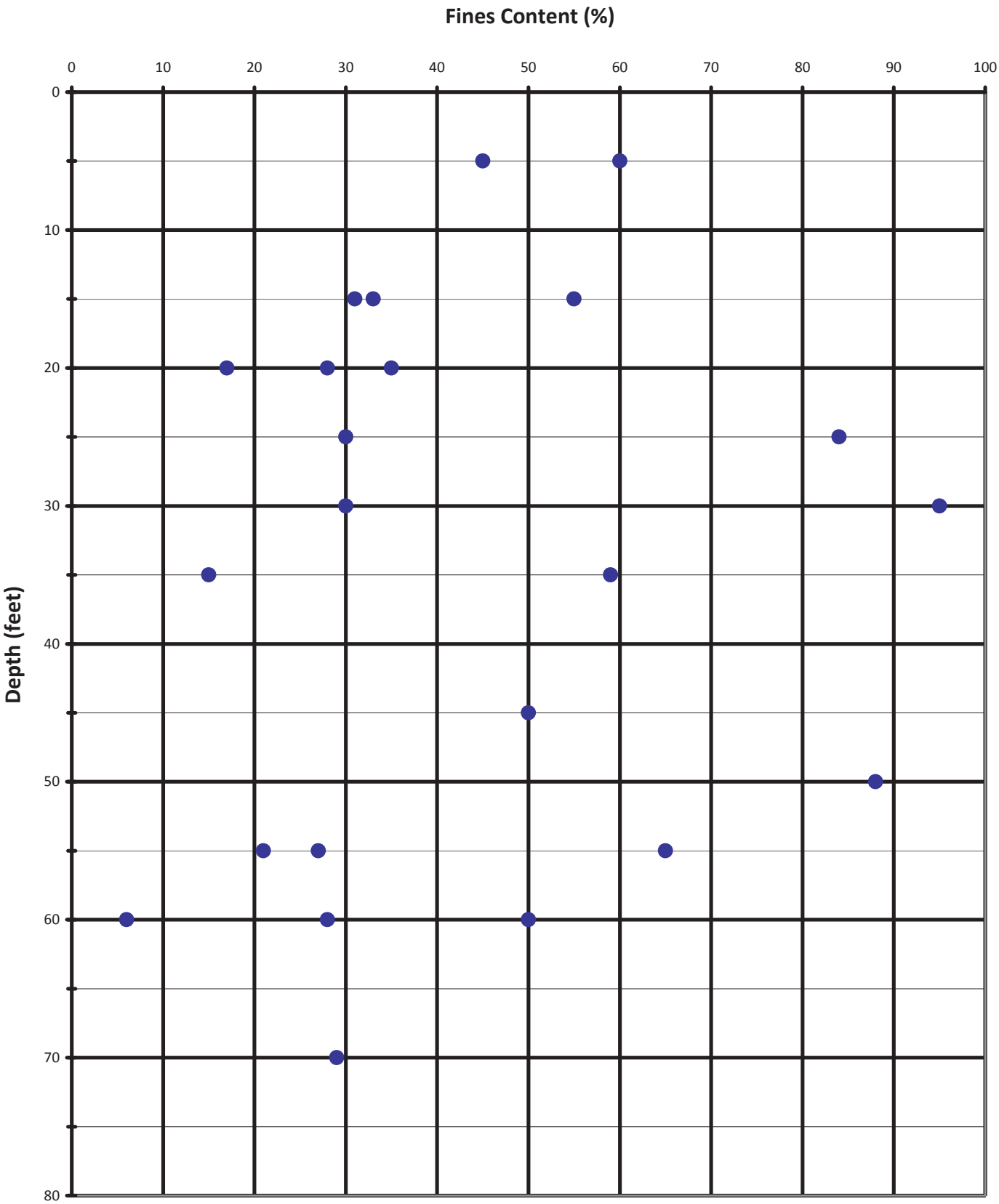
Variation of Plasticity Index with Depth



Area B

PLATE B3-18

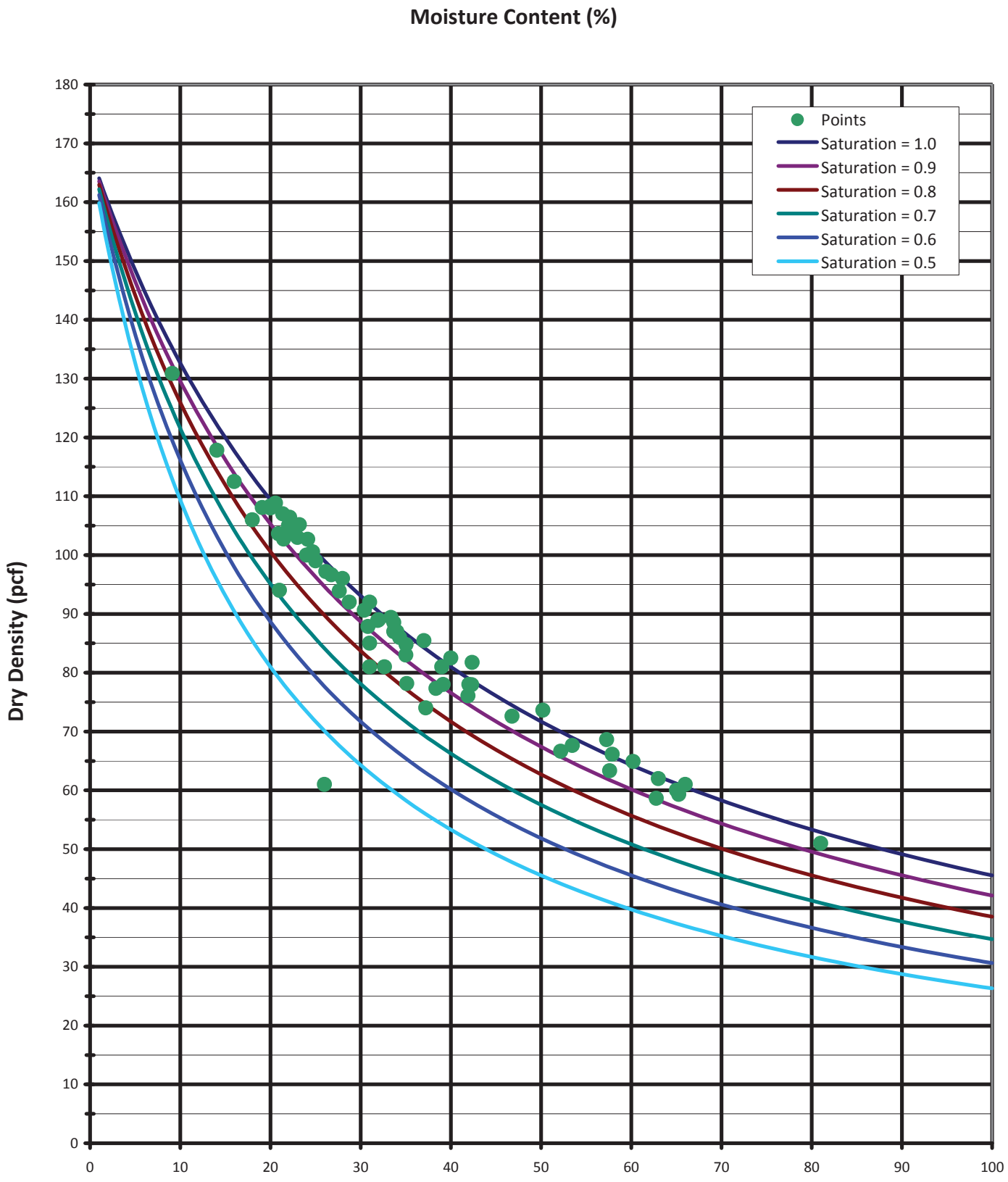
Variation of Fines Content with Depth



Area B

PLATE B3-19

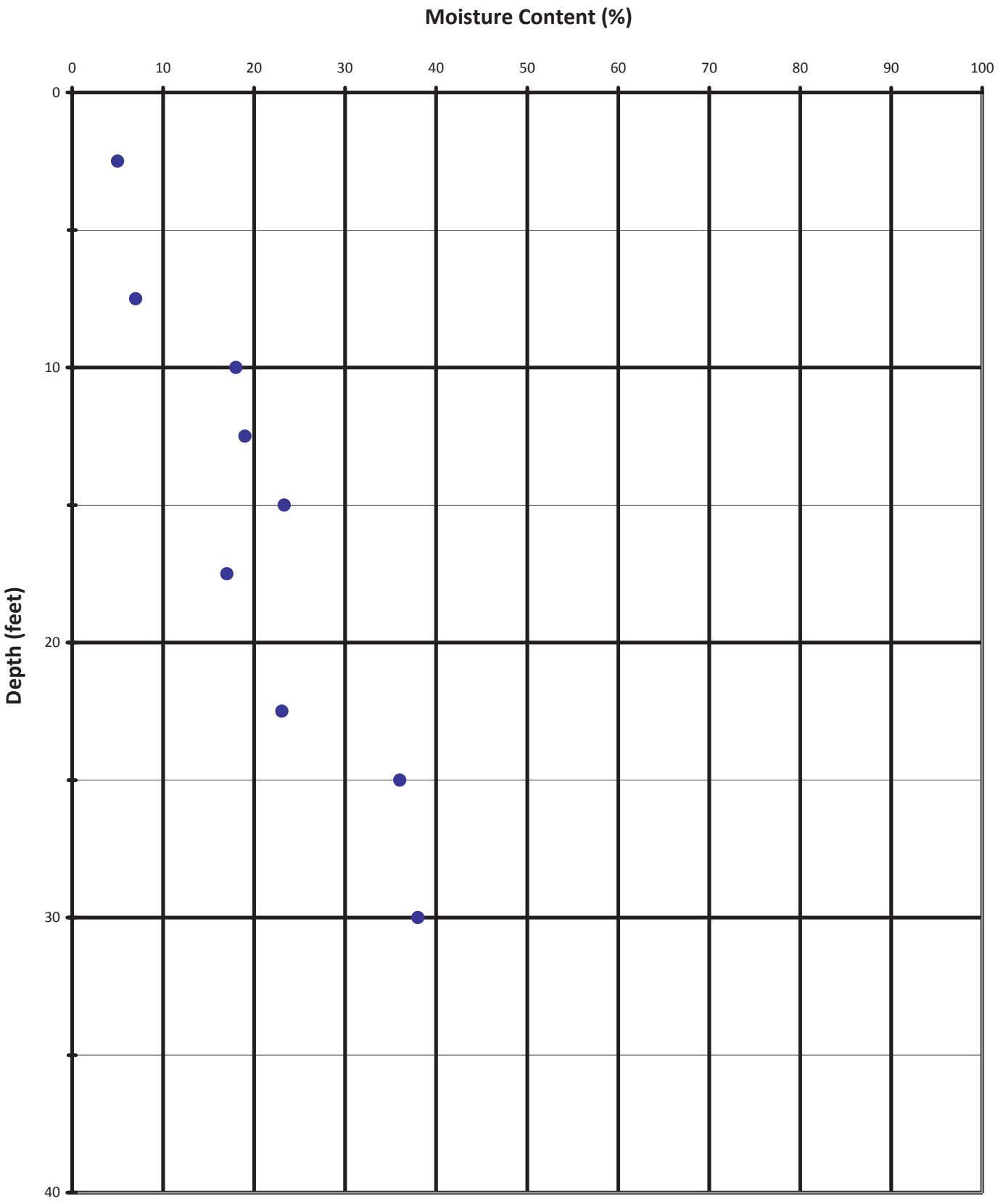
Moisture Content vs Dry Density



Area B

PLATE B3-20

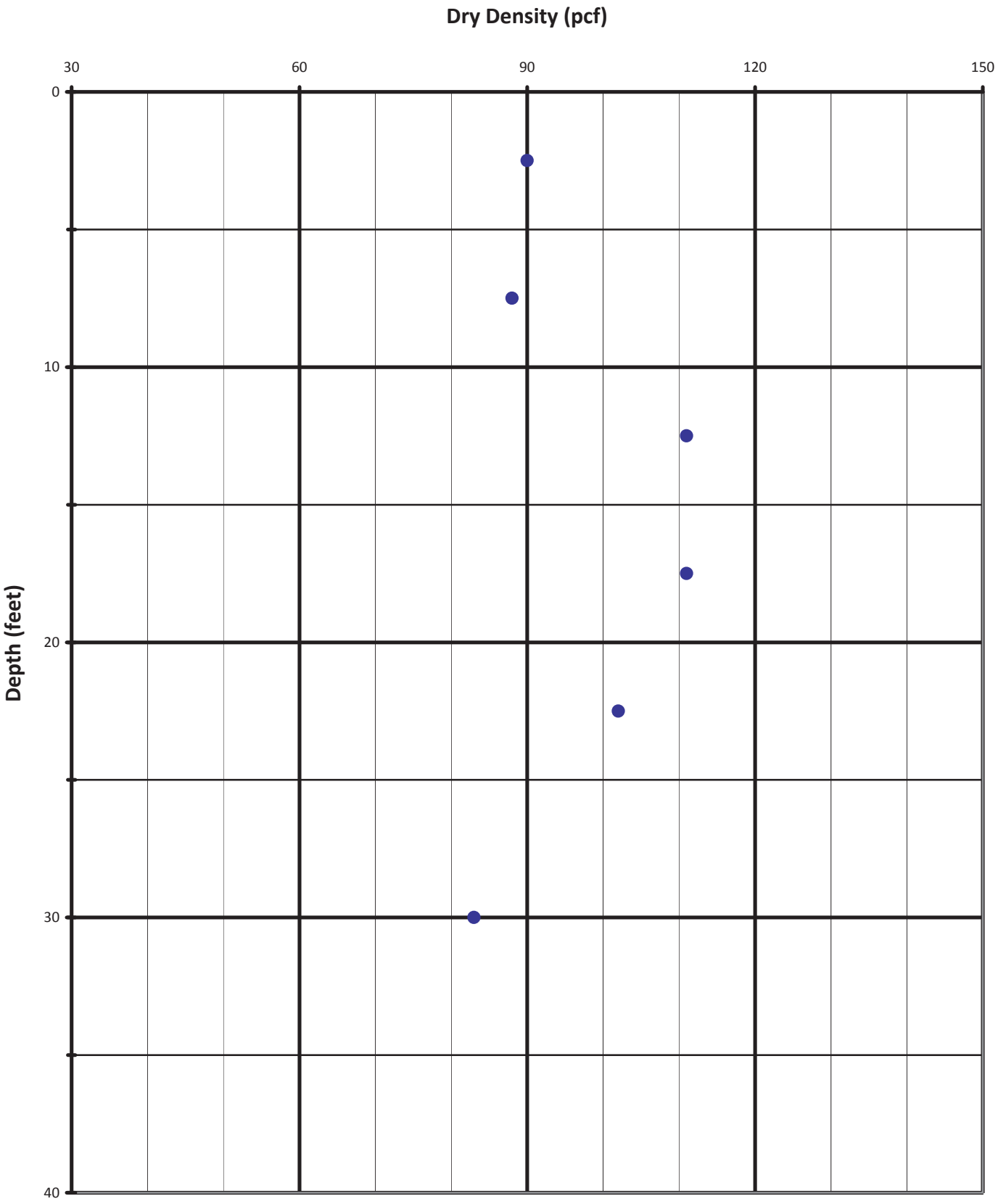
Variation of Moisture Content with Depth



Area C

PLATE B3-21

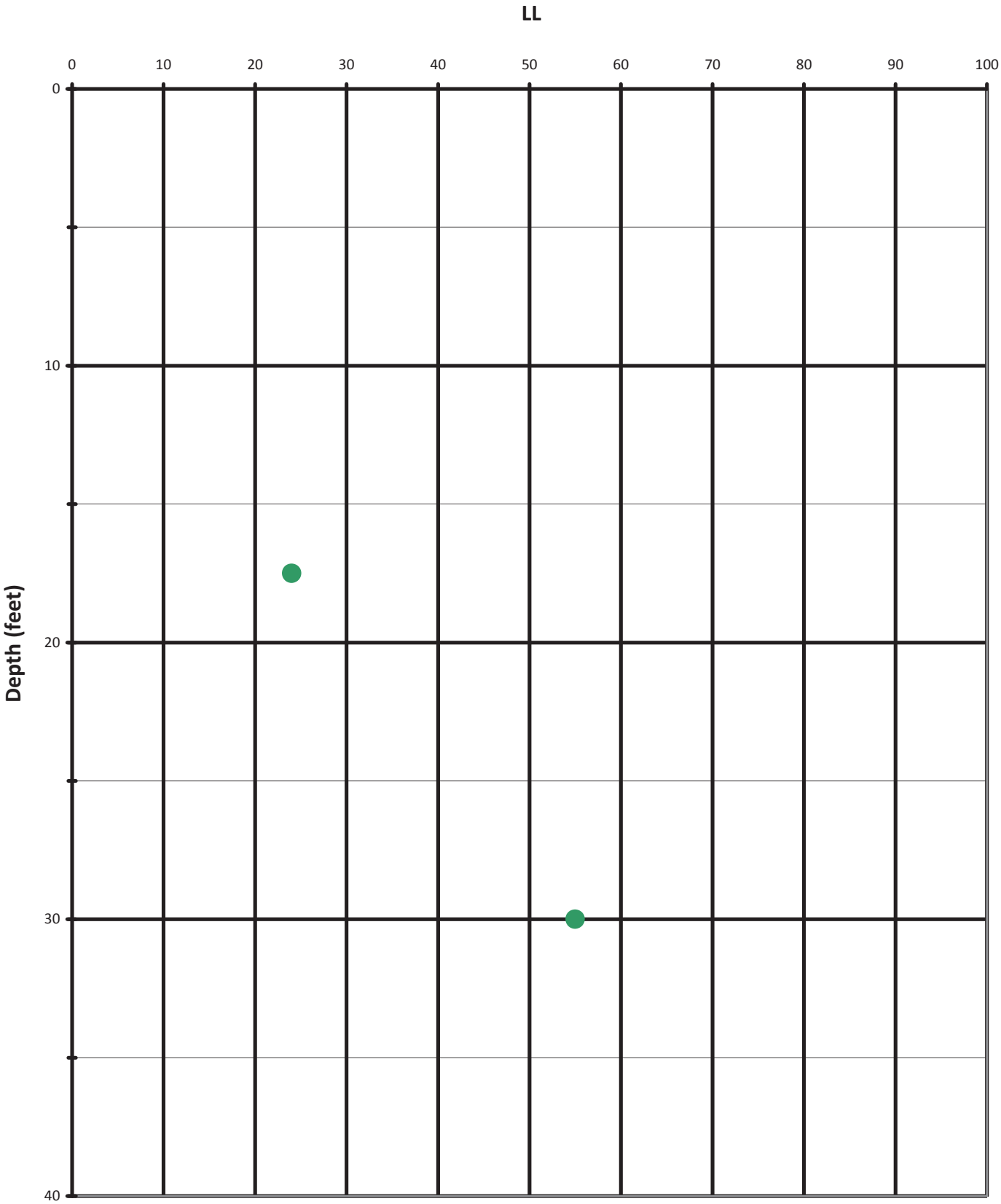
Variation of Dry Density with Depth



Area C

PLATE B3-22

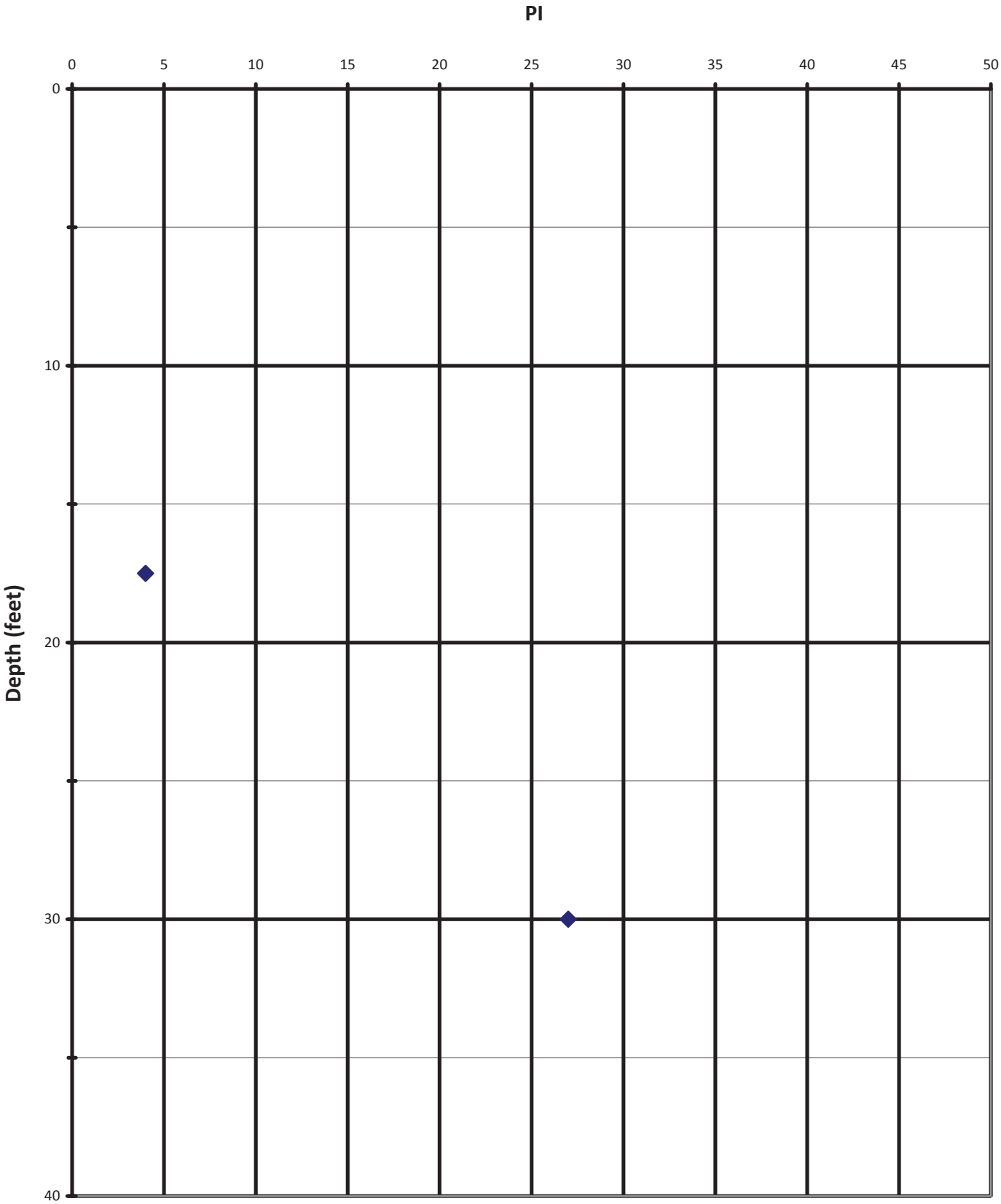
Variation of Liquid Limit with Depth



Area C

PLATE B3-23

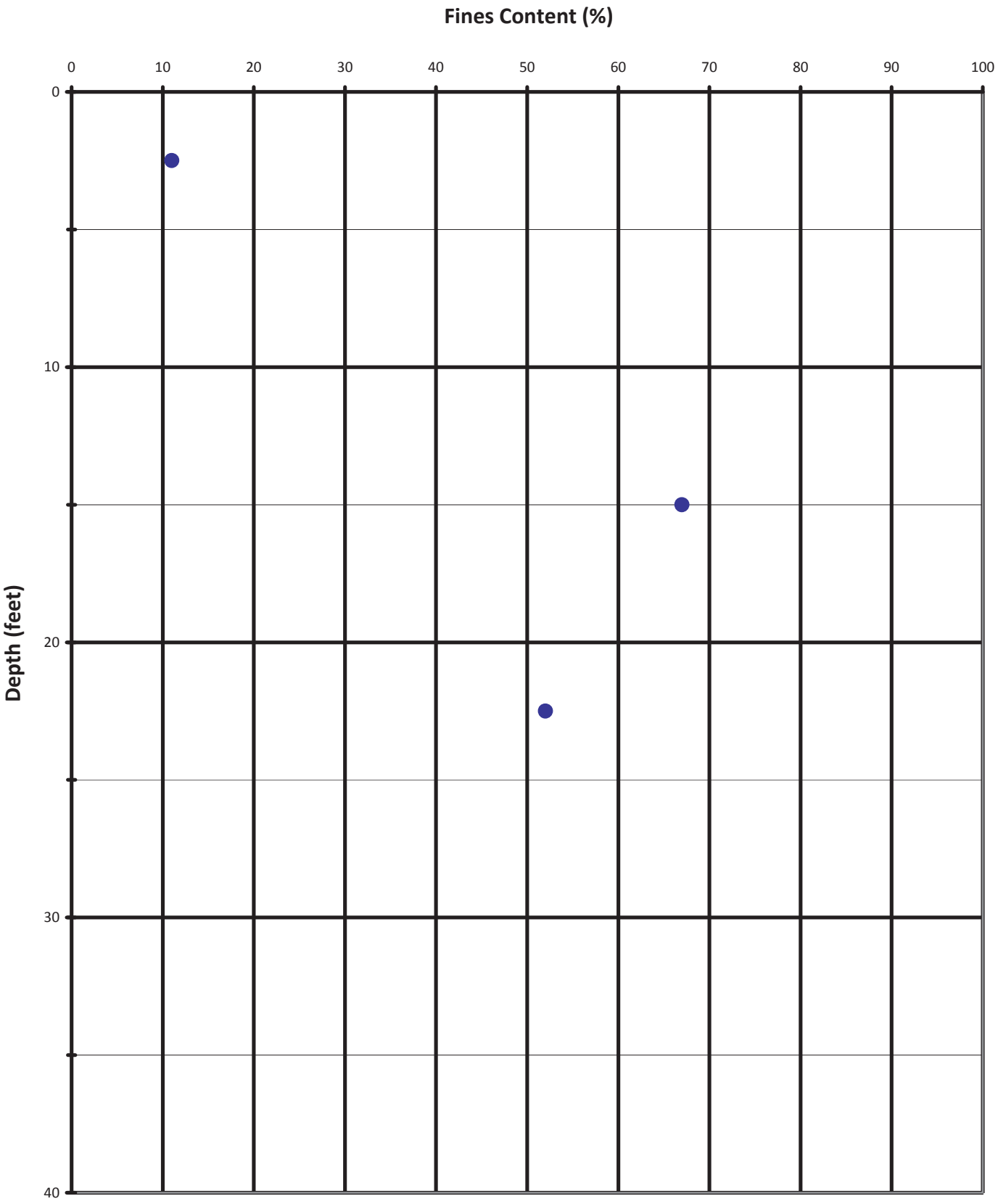
Variation of Plasticity Index with Depth



Area C

PLATE B3-24

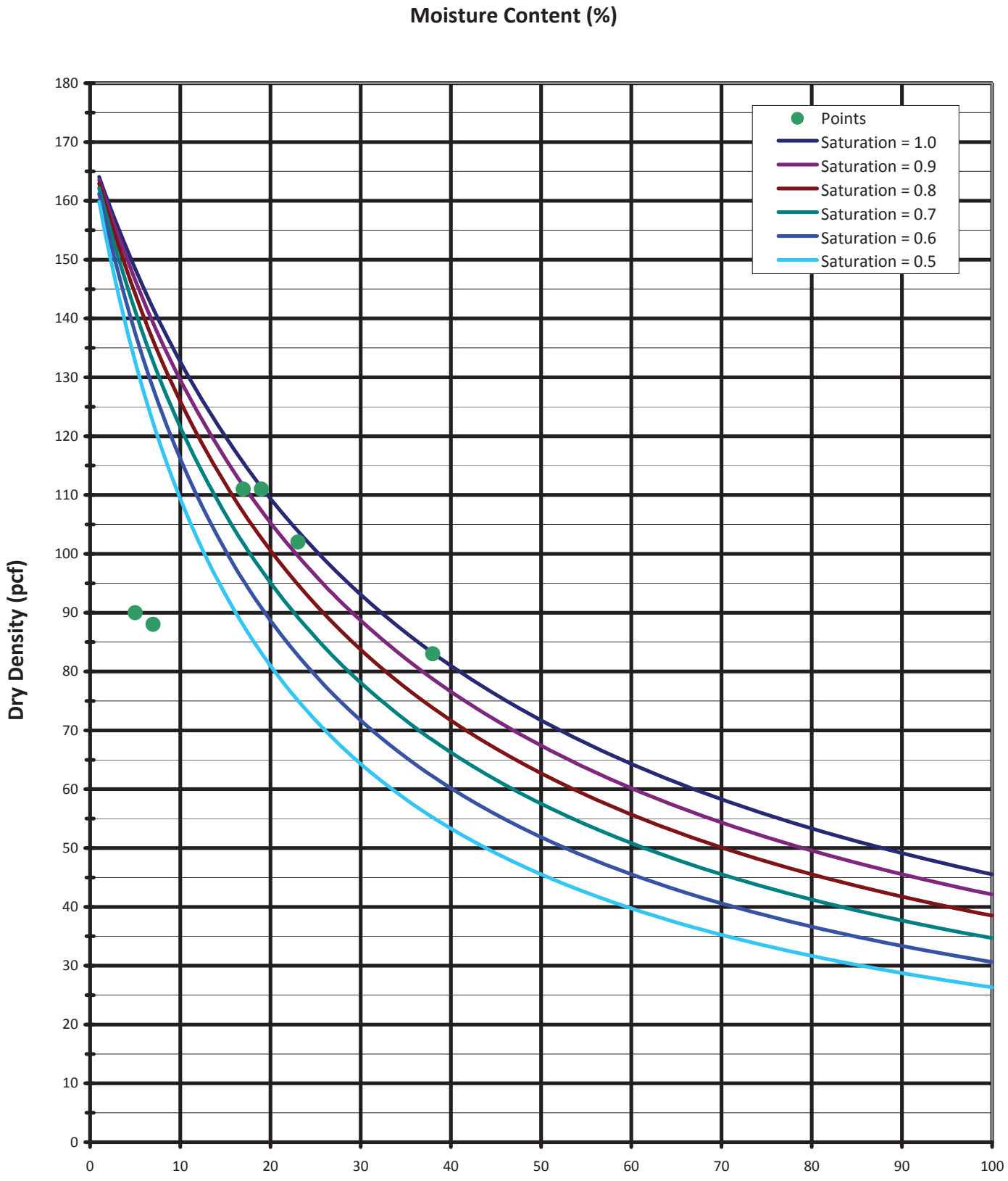
Variation of Fines Content with Depth



Area C

PLATE B3-25

Moisture Content vs Dry Density



Area C

PLATE B3-26

APPENDIX B4
LABORATORY TESTING INTERPRETATIONS OF INVESTIGATIONS BY OTHERS

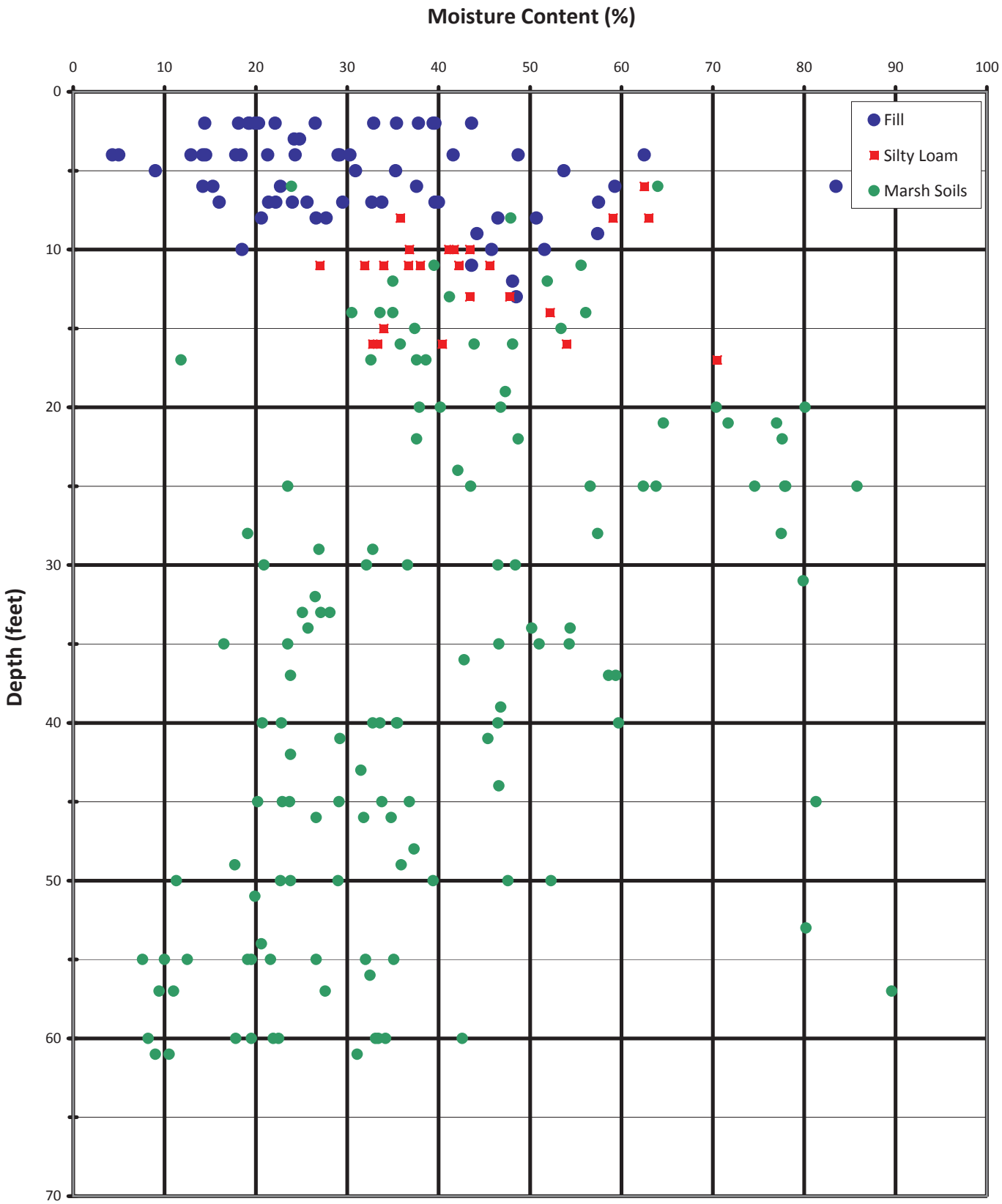
APPENDIX B4
LABORATORY TESTING INTERPRETATIONS

B4.1 General

The following interpretation plots were generated based on the results of laboratory testing data by other investigators, in Areas A, B, and C:

Plate B4-1	Variation of Moisture Content with Depth – Area A
Plate B4-2	Variation of Dry Density with Depth – Area A
Plate B4-3	Variation of Liquid Limit with Depth – Area A
Plate B4-4	Variation of Plastic Limit with Depth – Area A
Plate B4-5	Variation of Fines Content with Depth – Area A
Plate B4-6	Plot of Moisture Content vs. Dry Density – Area A
Plate B4-7	Variation of Moisture Content with Depth – Area B
Plate B4-8	Variation of Dry Density with Depth – Area B
Plate B4-9	Variation of Liquid Limit with Depth – Area B
Plate B4-10	Variation of Plastic Limit with Depth – Area B
Plate B4-11	Variation of Fines Content with Depth – Area B
Plate B4-12	Plot of Moisture Content vs. Dry Density – Area B
Plate B4-13	Variation of Moisture Content with Depth – Area C
Plate B4-14	Variation of Dry Density with Depth – Area C
Plate B4-15	Variation of Liquid Limit with Depth – Area C
Plate B4-16	Variation of Plastic Limit with Depth – Area C
Plate B4-17	Variation of Fines Content with Depth – Area C
Plate B4-18	Plot of Moisture Content vs. Dry Density – Area C

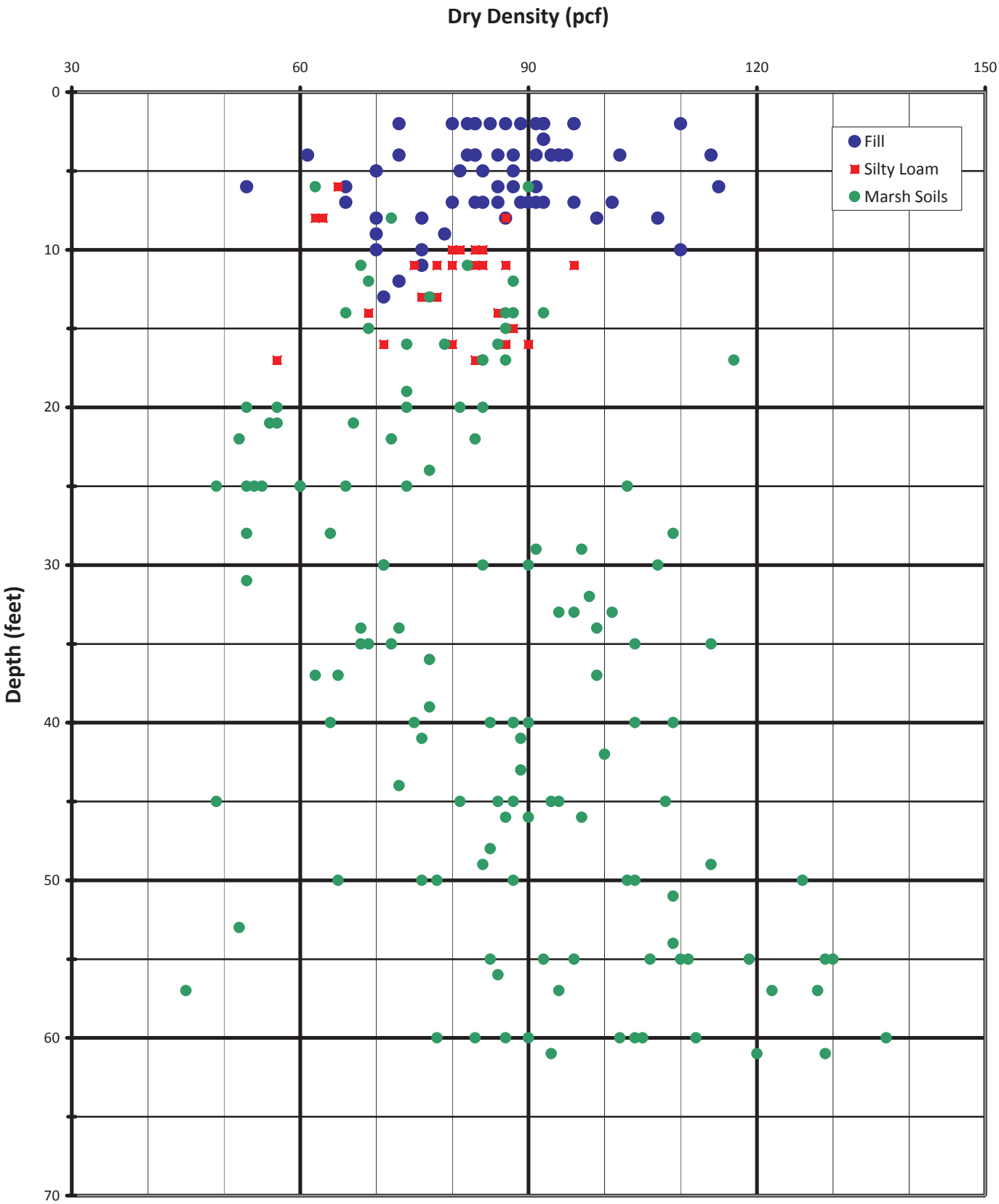
Variation of Moisture Content with Depth



Area A

PLATE B4-1

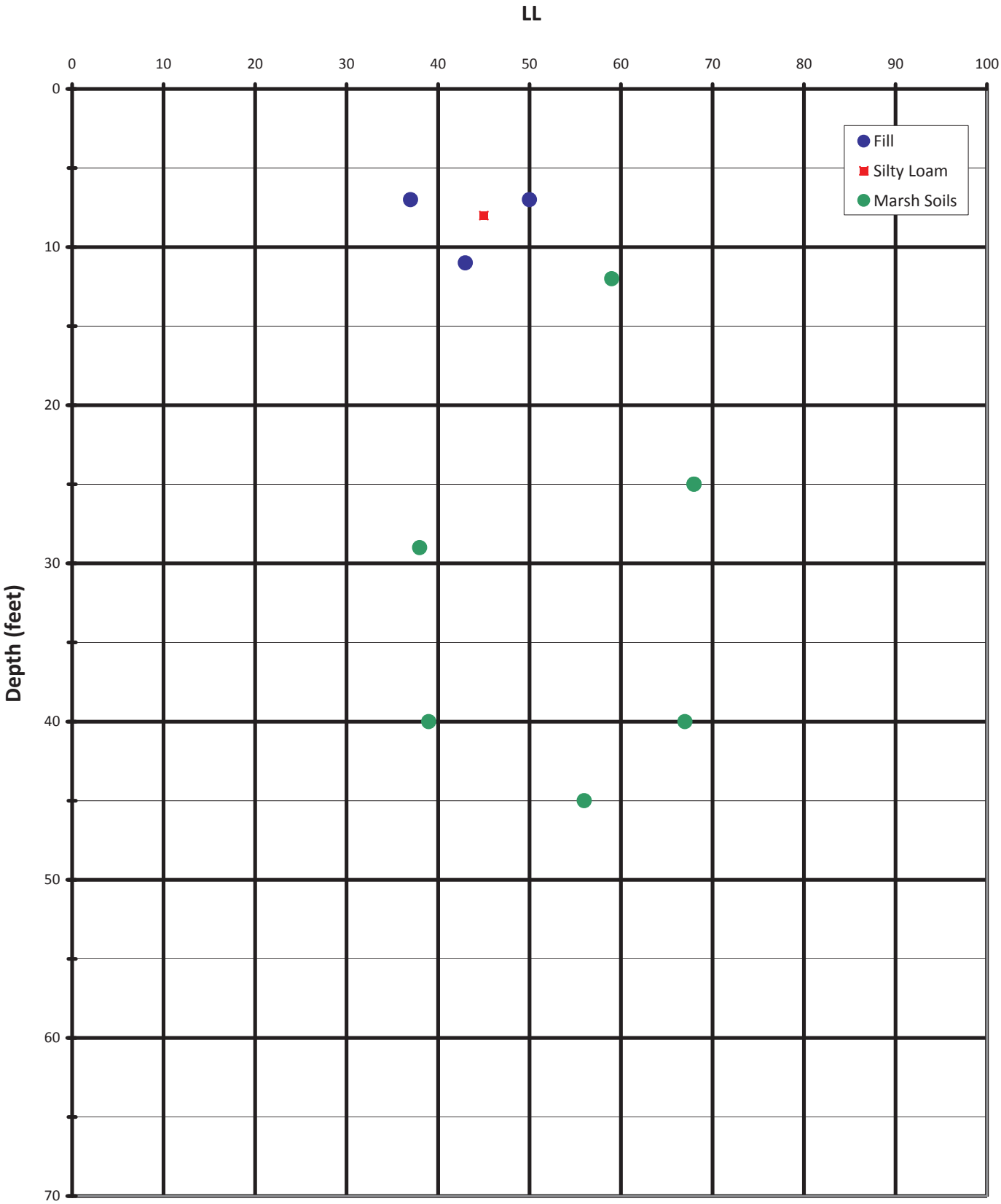
Variation of Dry Density with Depth



Area A

PLATE B4-2

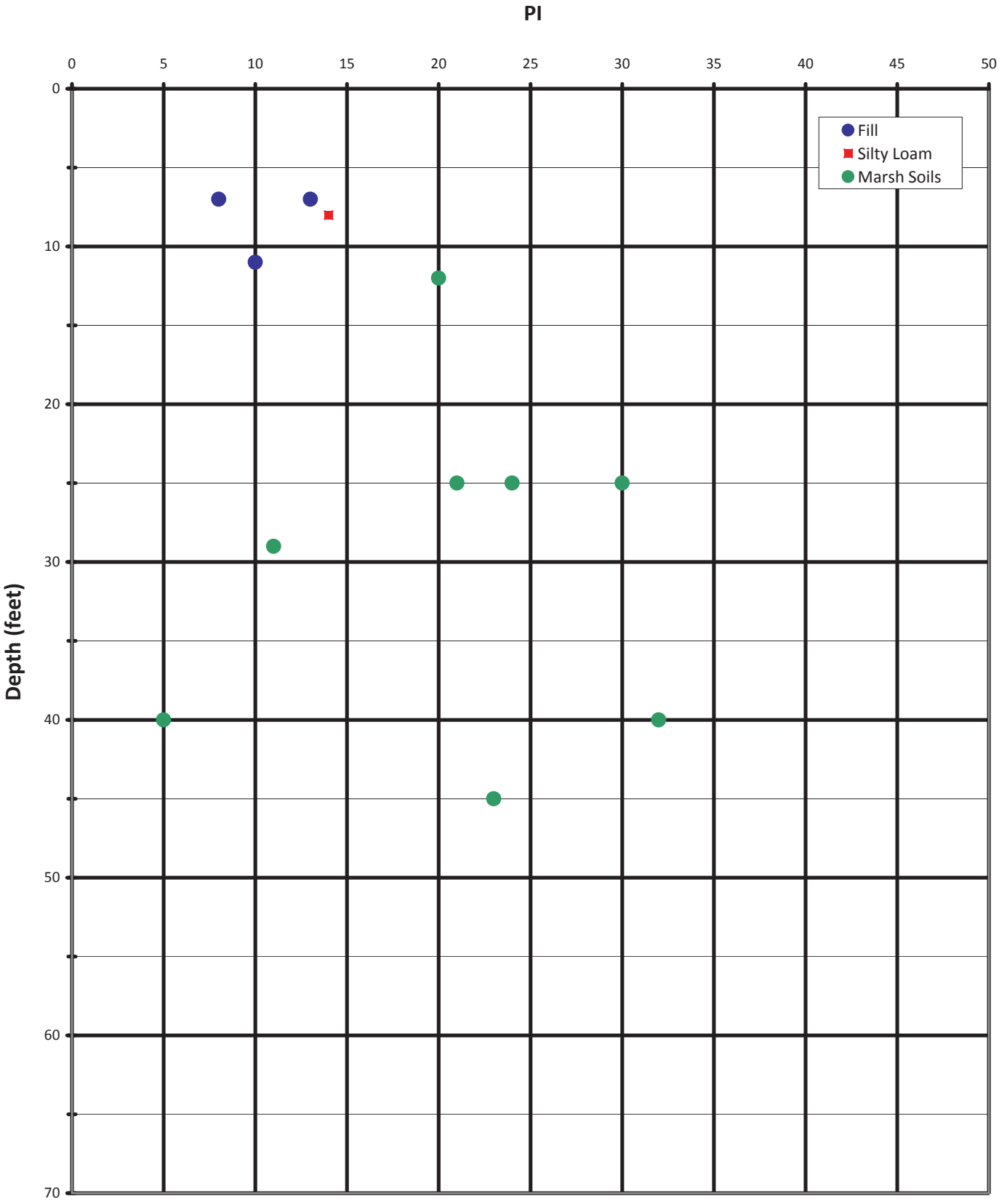
Variation of Liquid Limit with Depth



Area A

PLATE B4-3

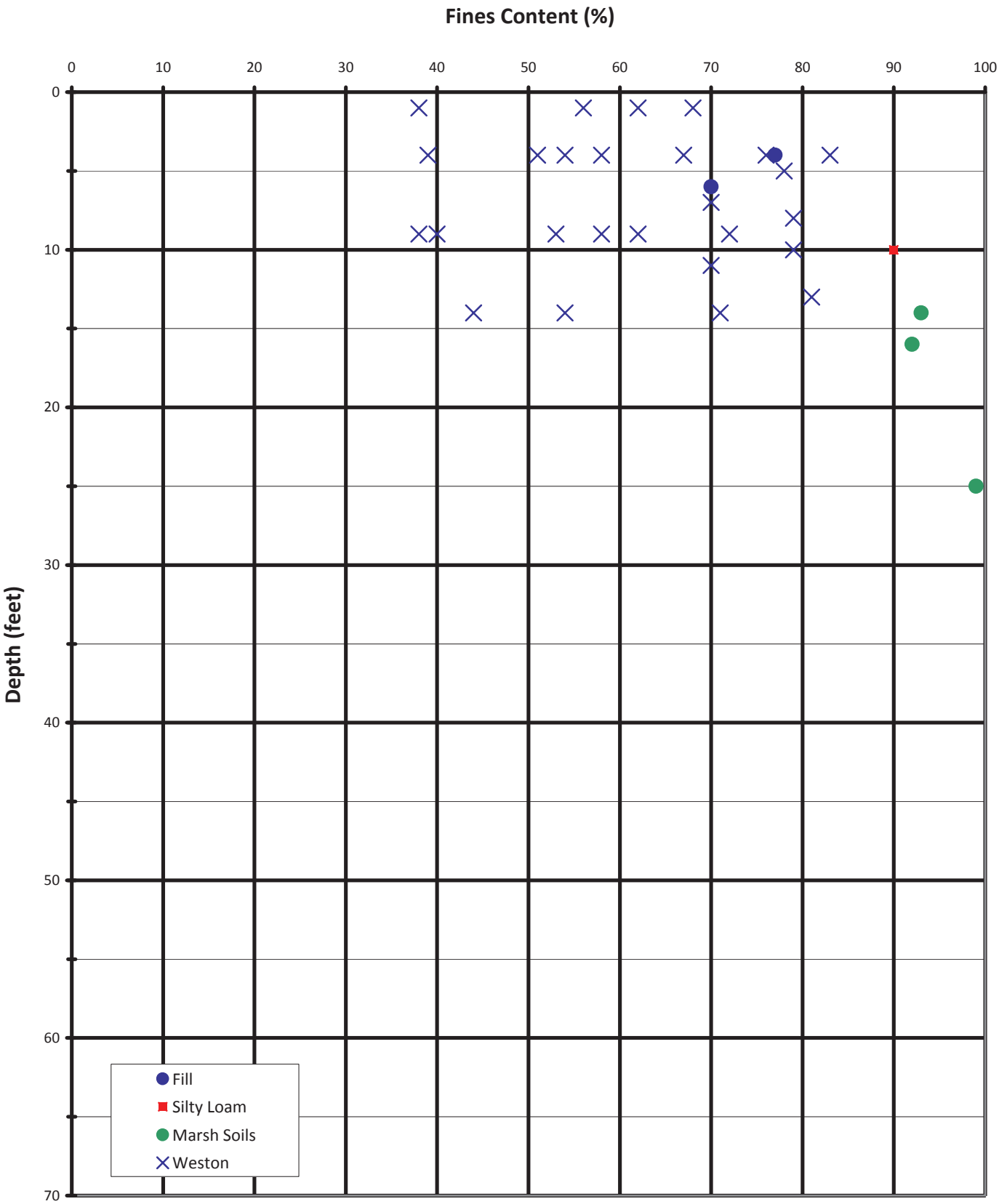
Variation of Plasticity Index with Depth



Area A

PLATE B4-4

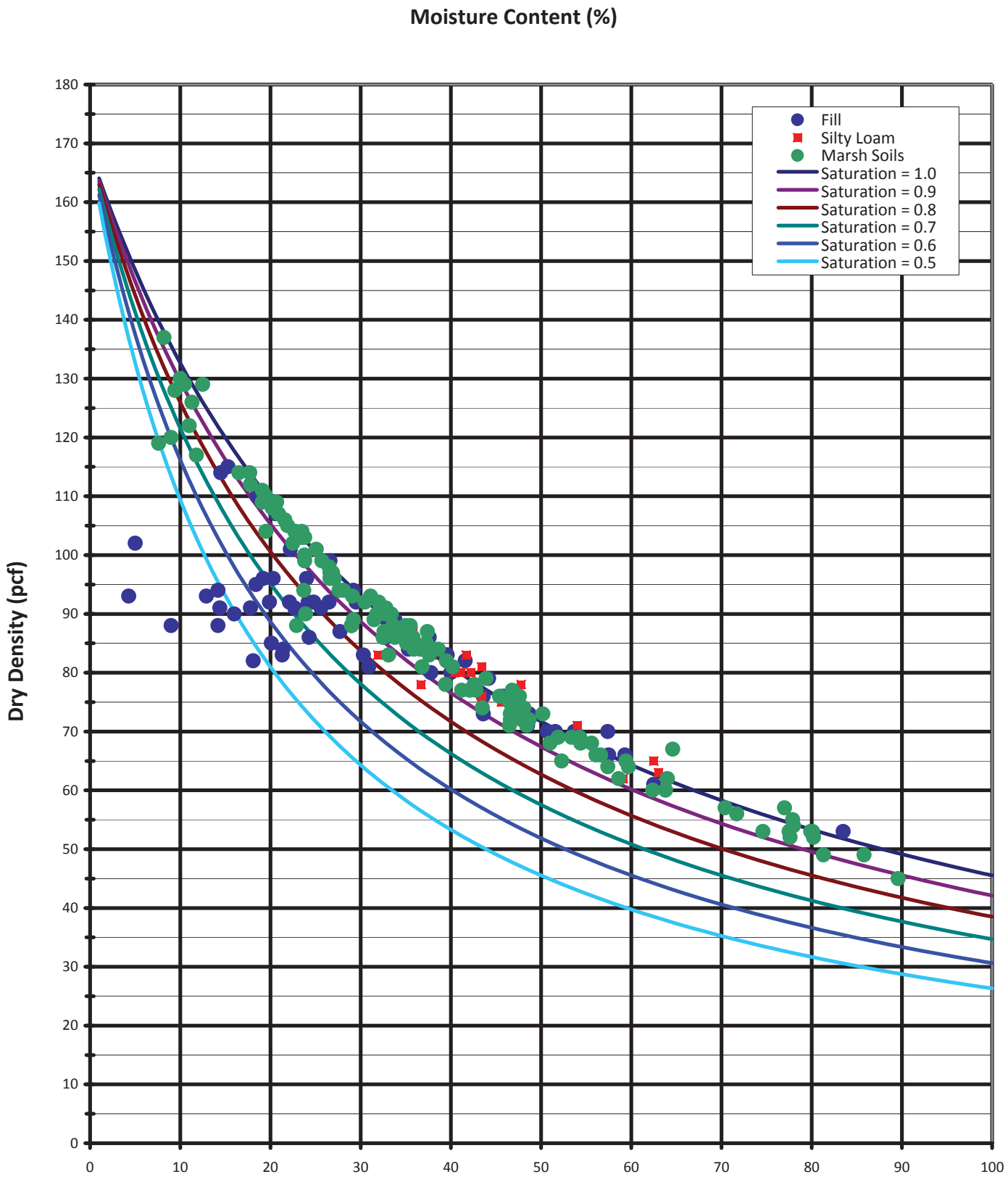
Variation of Fines Content with Depth



Area A

PLATE B4-5

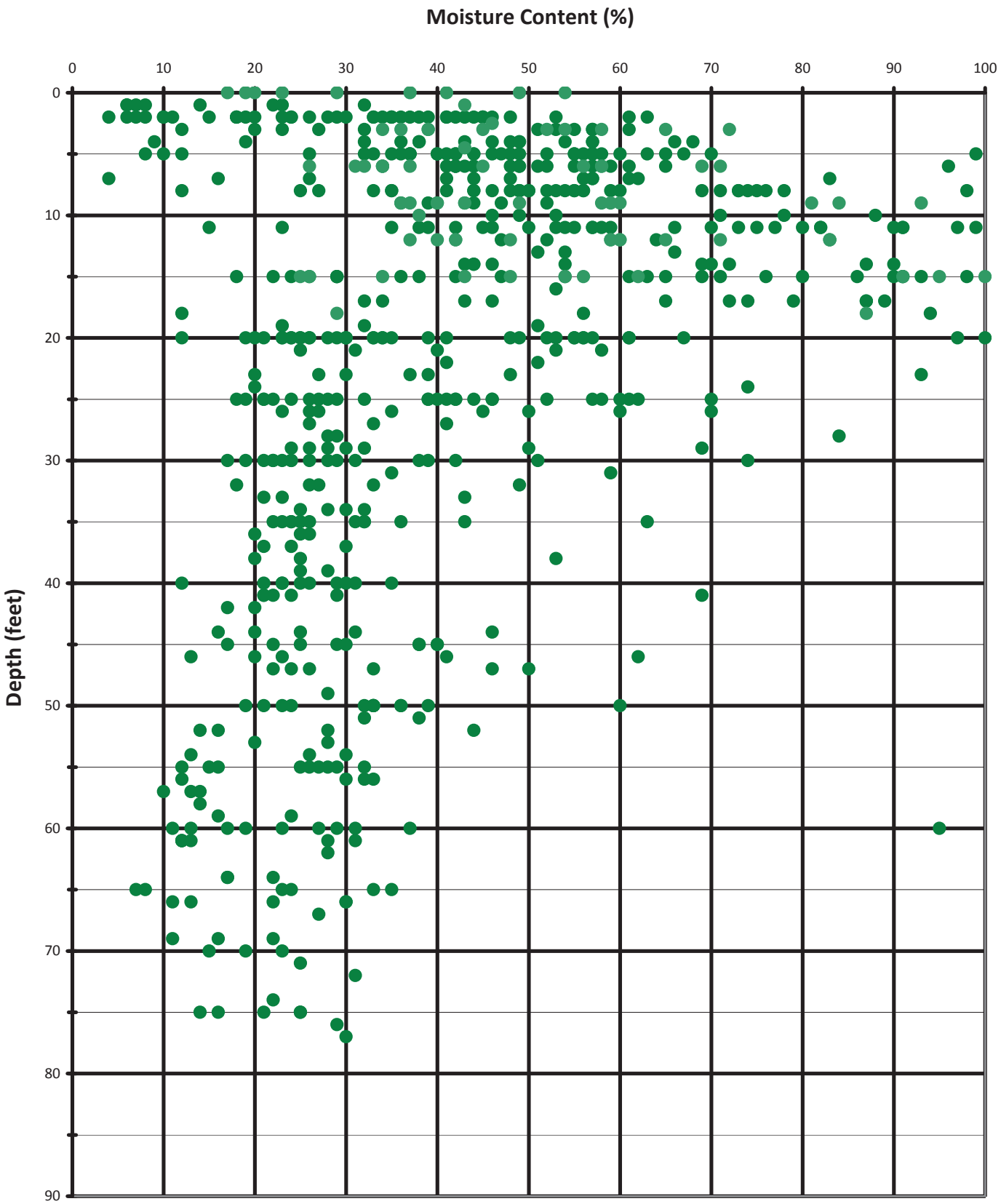
Moisture Content vs Dry Density



Area A

PLATE B4-6

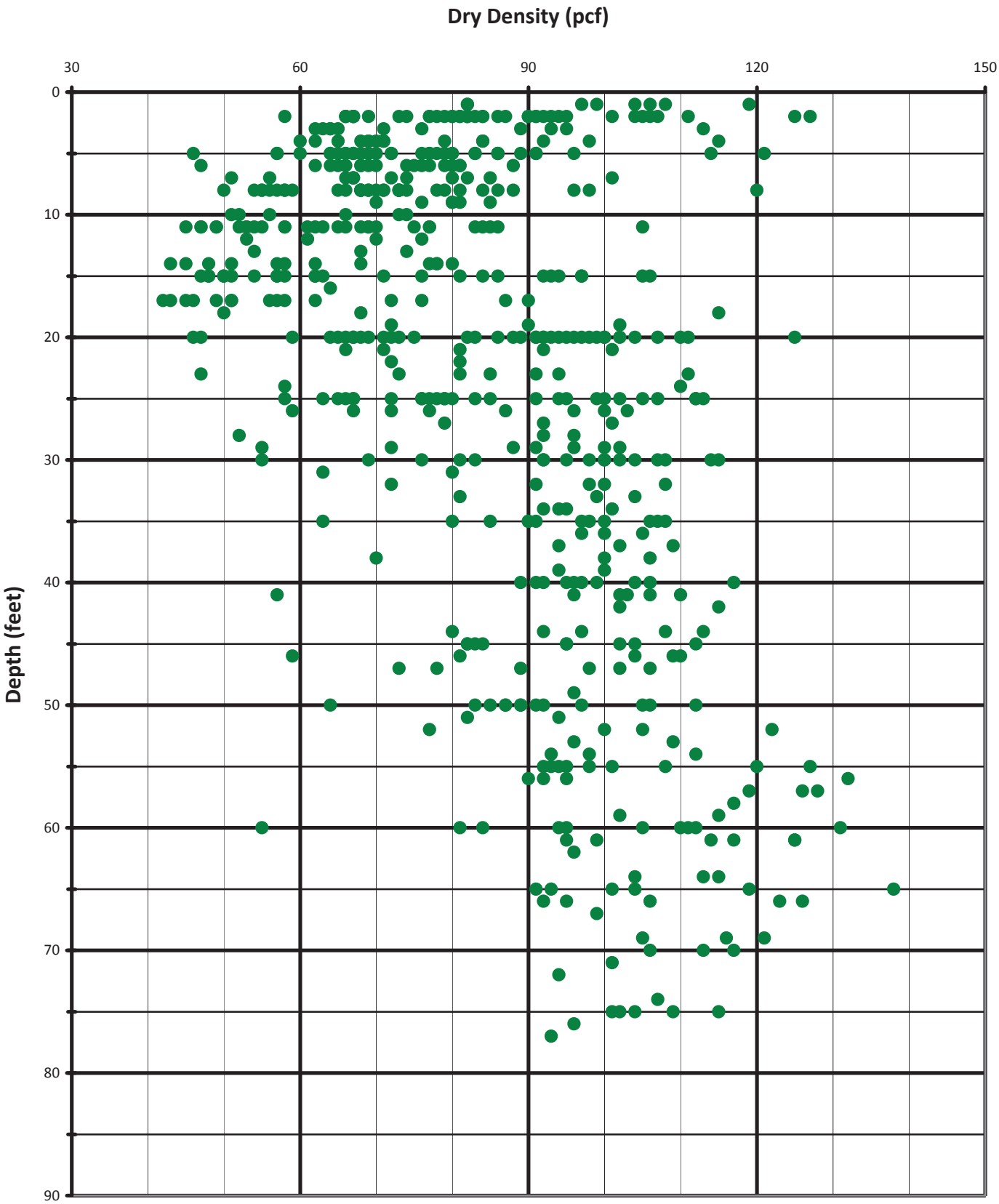
Variation of Moisture Content with Depth



Area B

PLATE B4-7

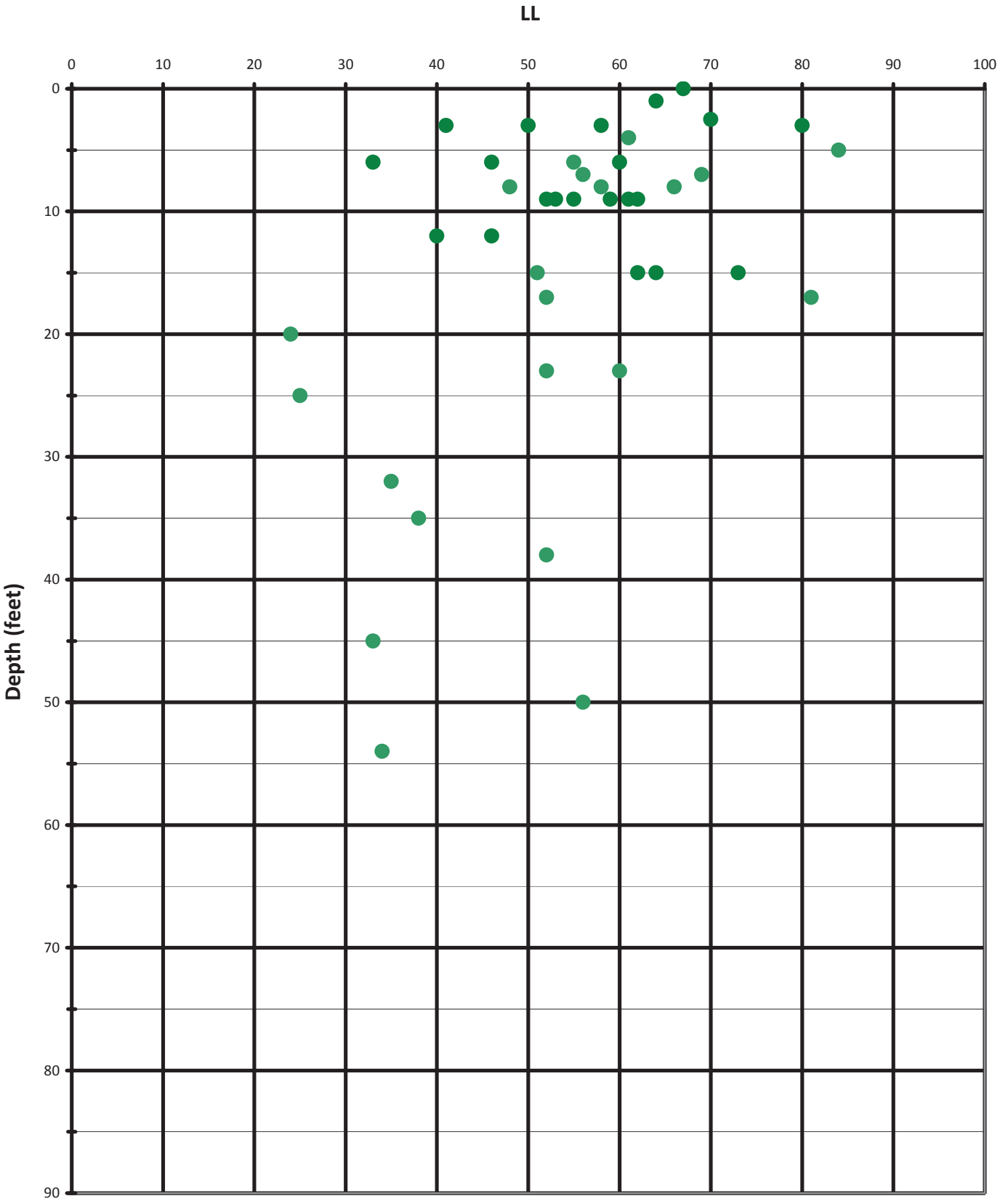
Variation of Dry Density with Depth



Area B

PLATE B4-8

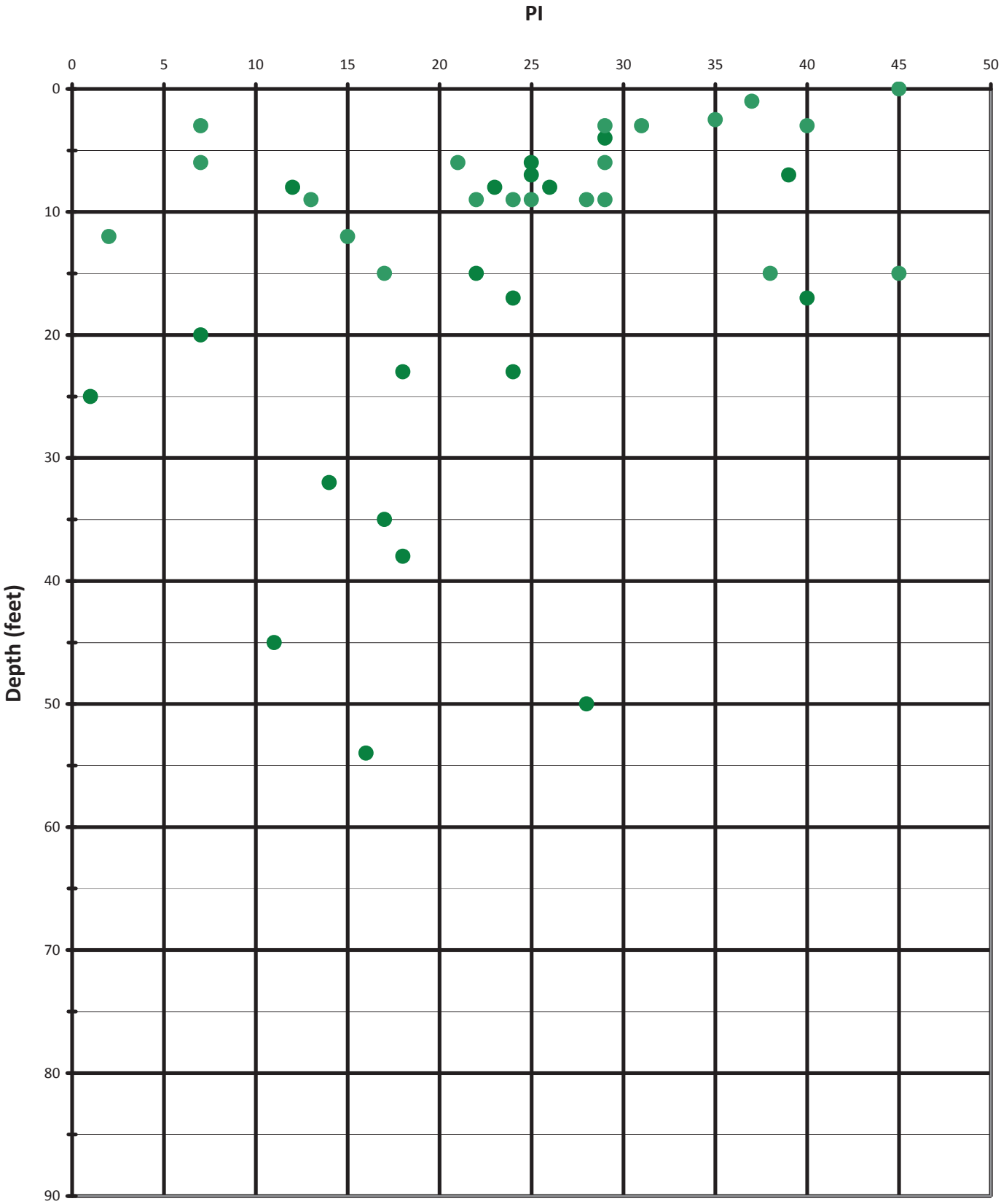
Variation of Liquid Limit with Depth



Area B

PLATE B4-9

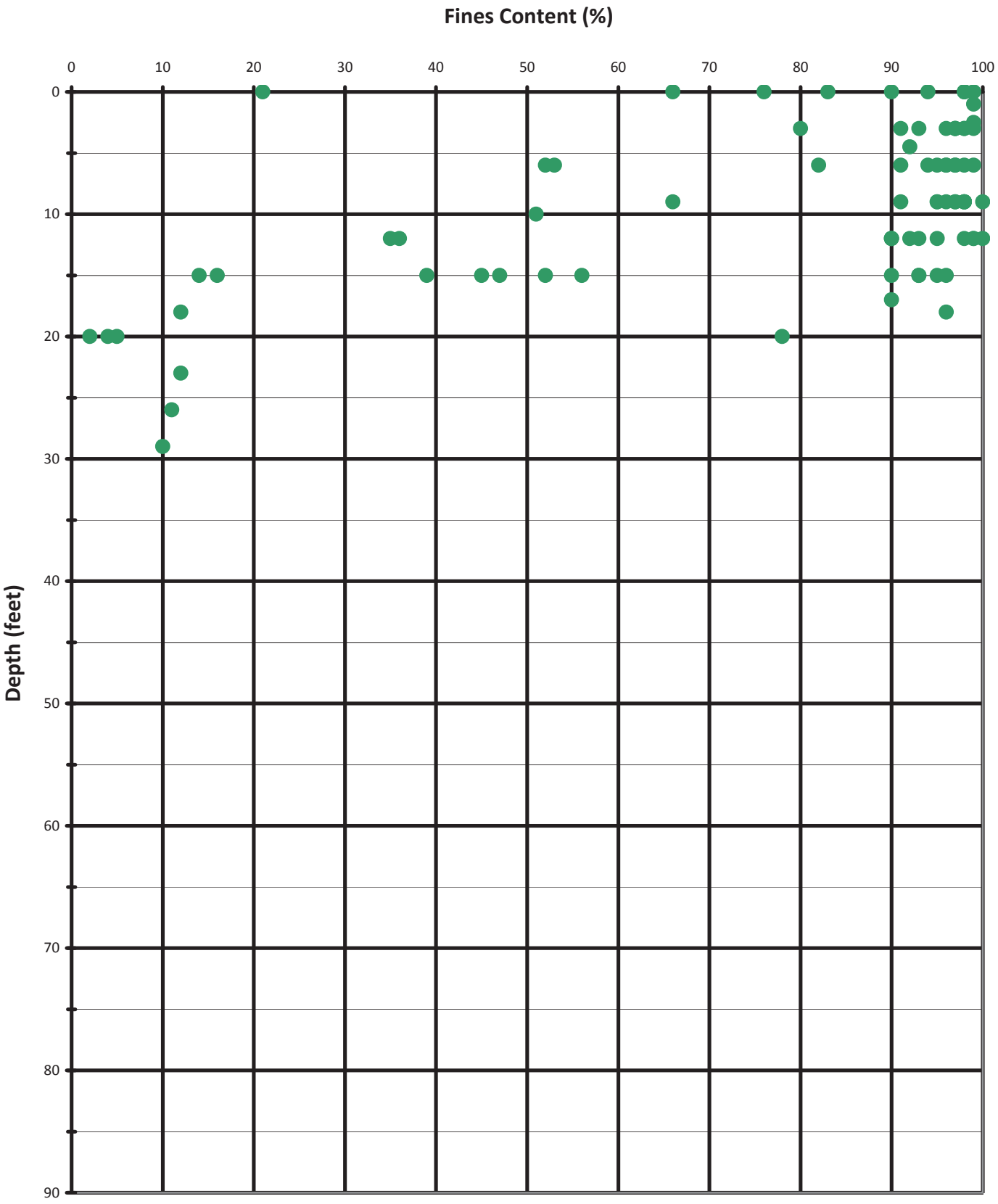
Variation of Plasticity Index with Depth



Area B

PLATE B4-10

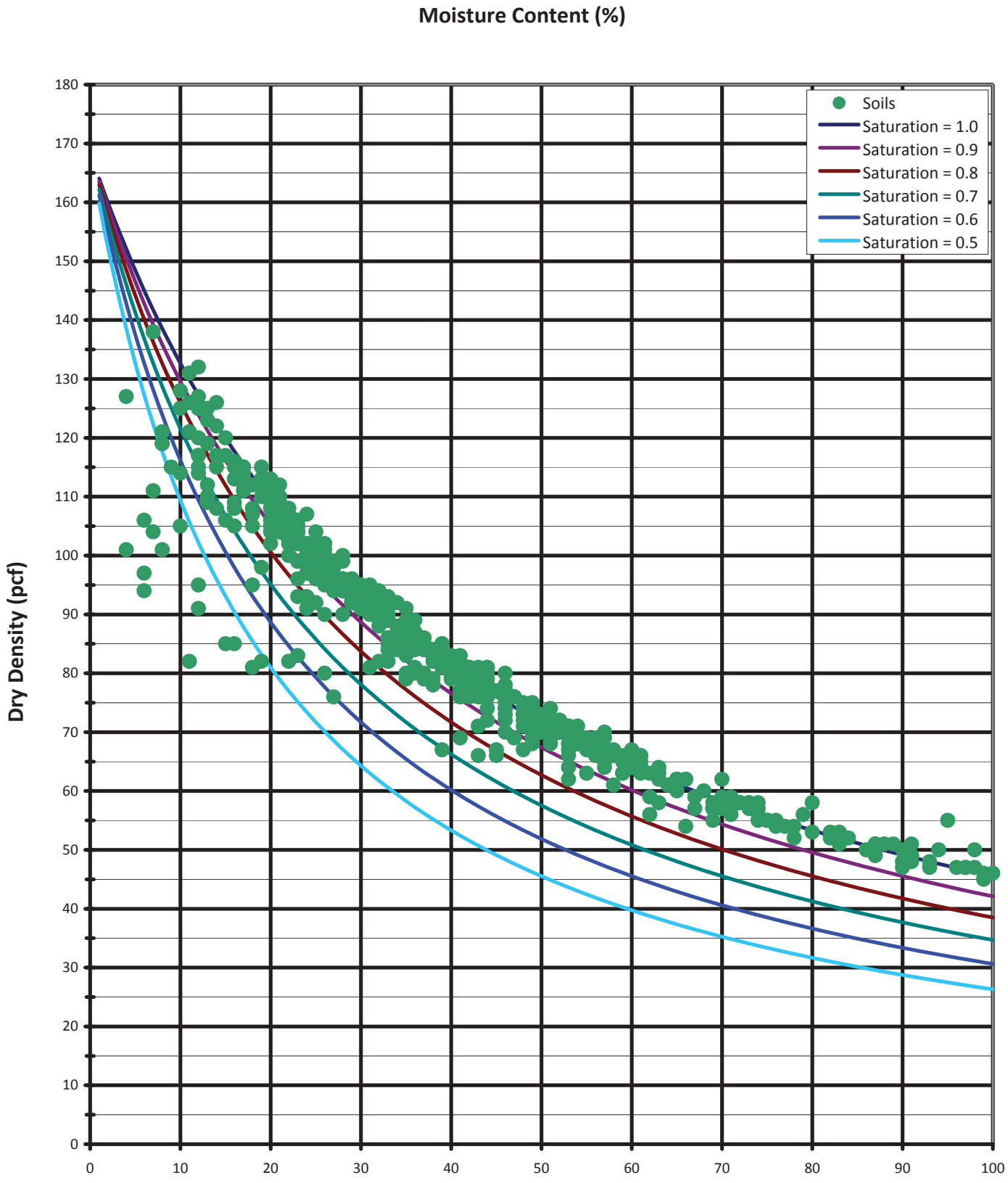
Variation of Fines Content with Depth



Area B

PLATE B4-11

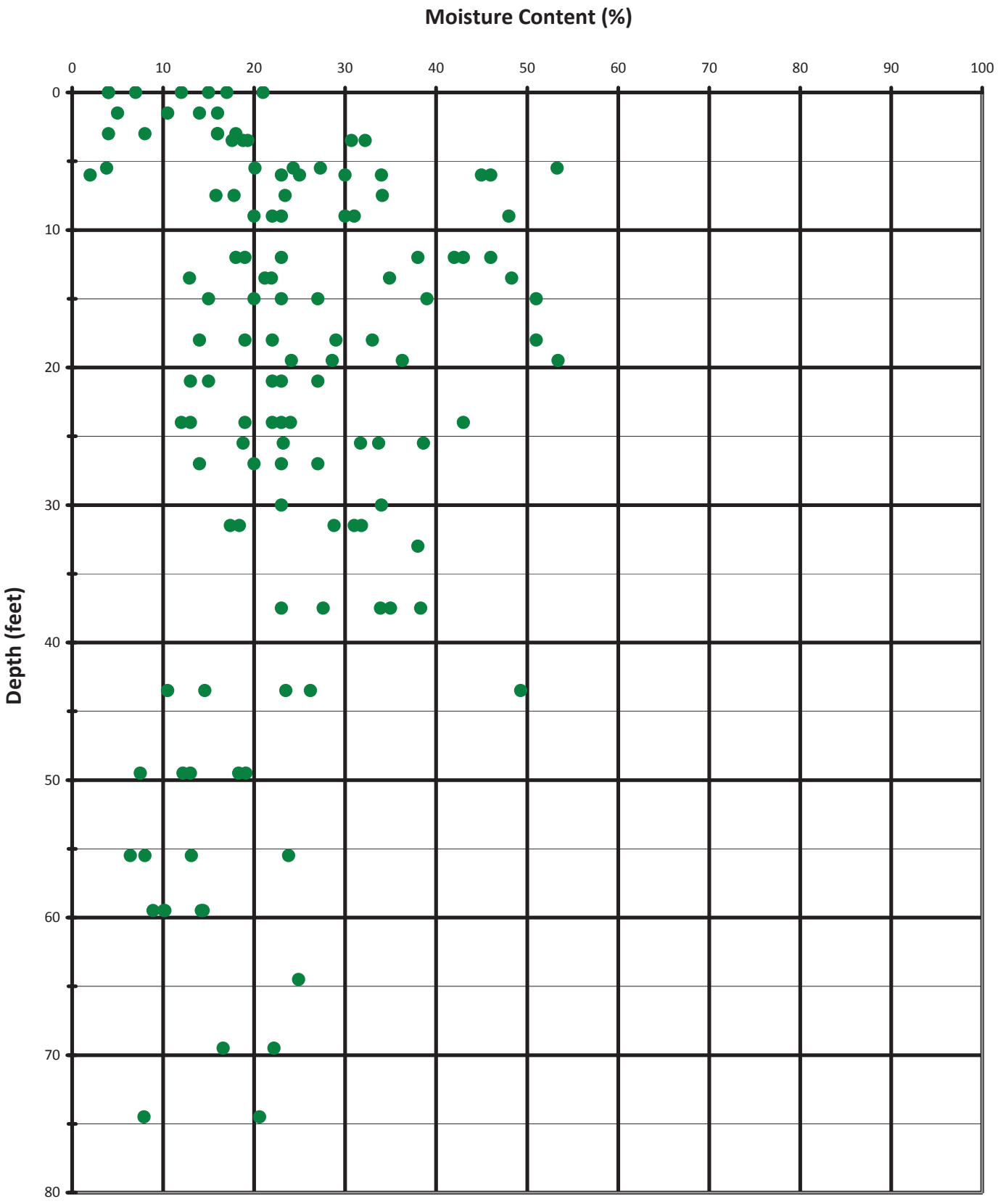
Moisture Content vs Dry Density



Area B

PLATE B4-12

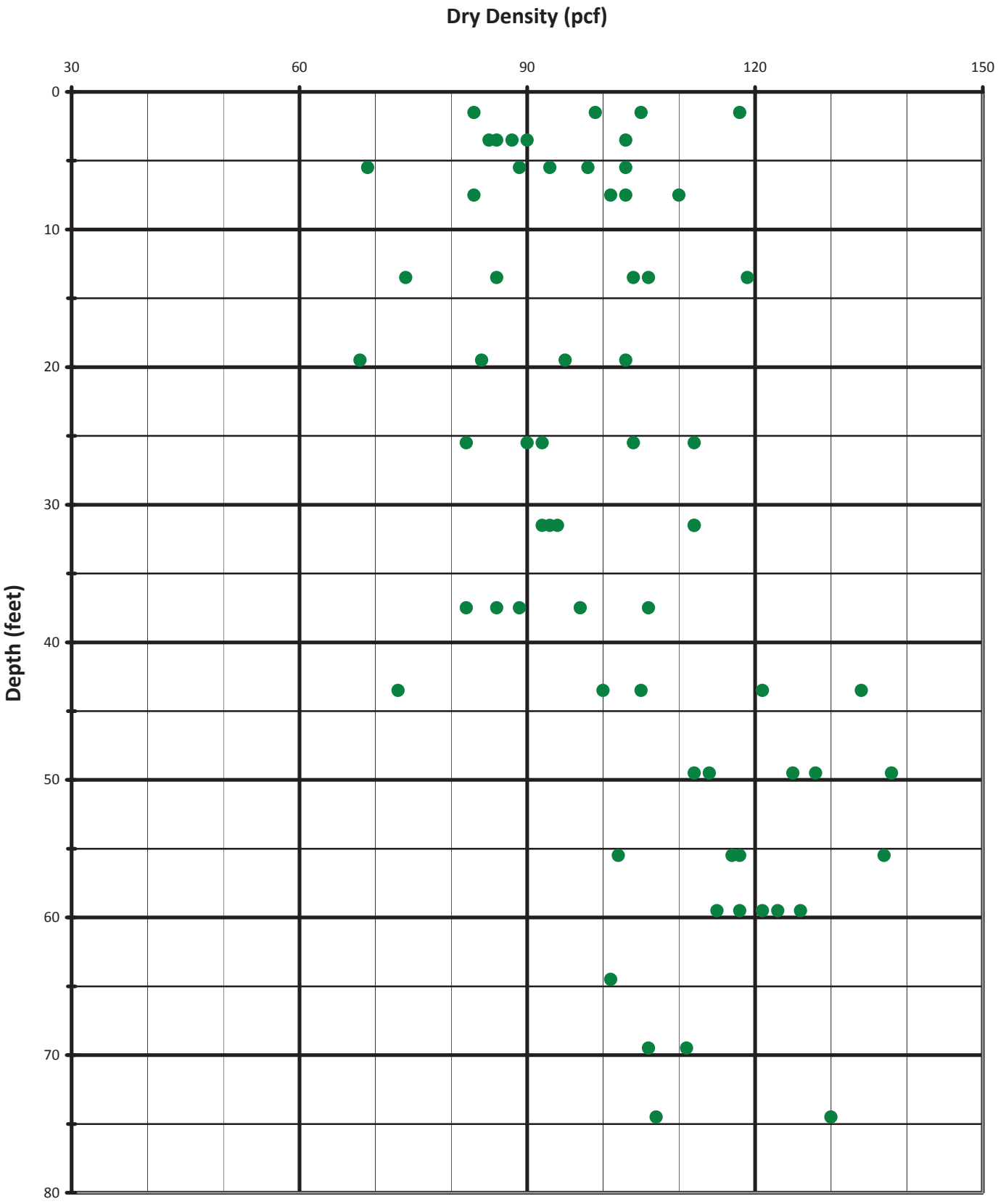
Variation of Moisture Content with Depth



AREA C

PLATE B4-13

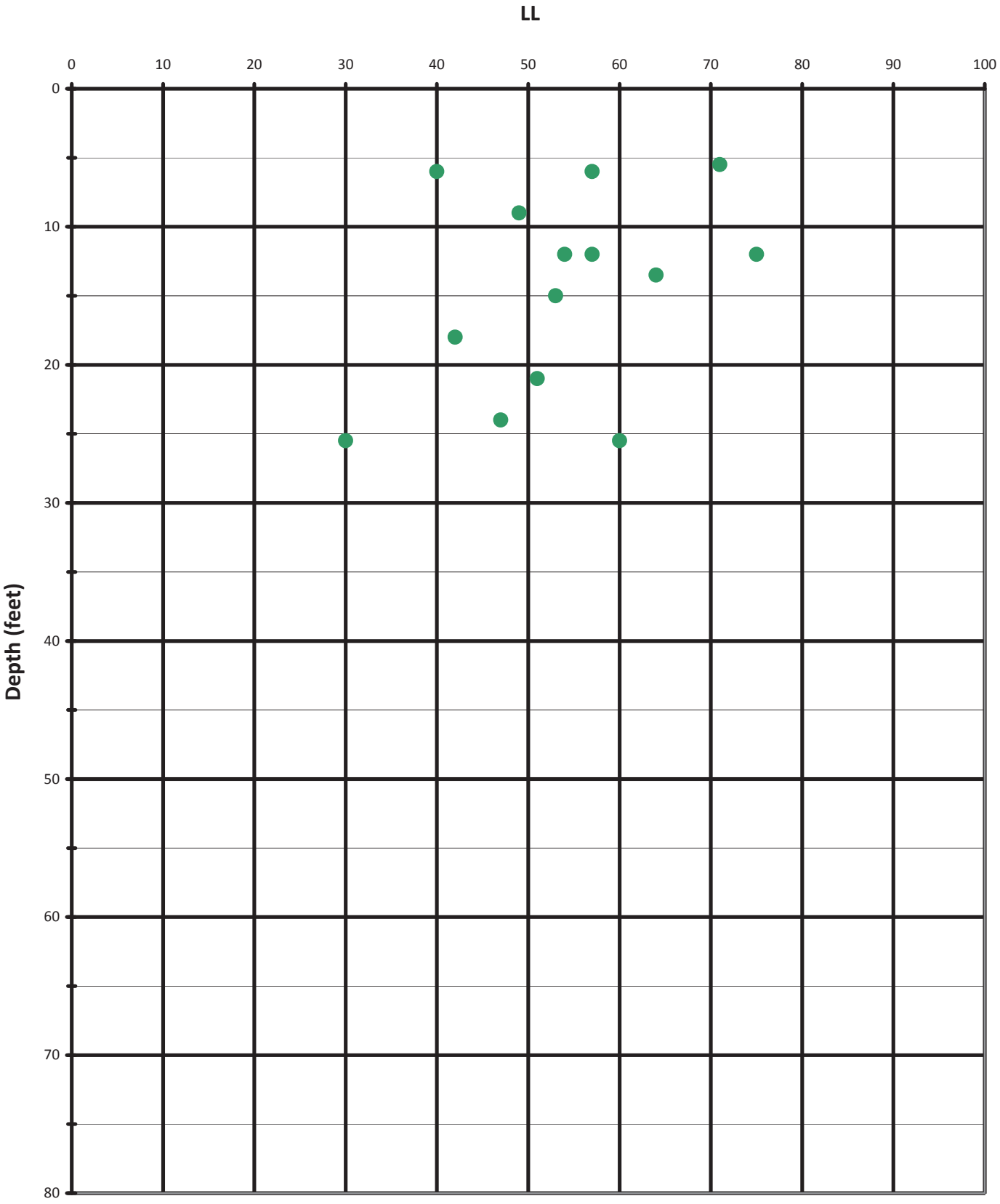
Variation of Dry Density with Depth



AREA C

PLATE B4-14

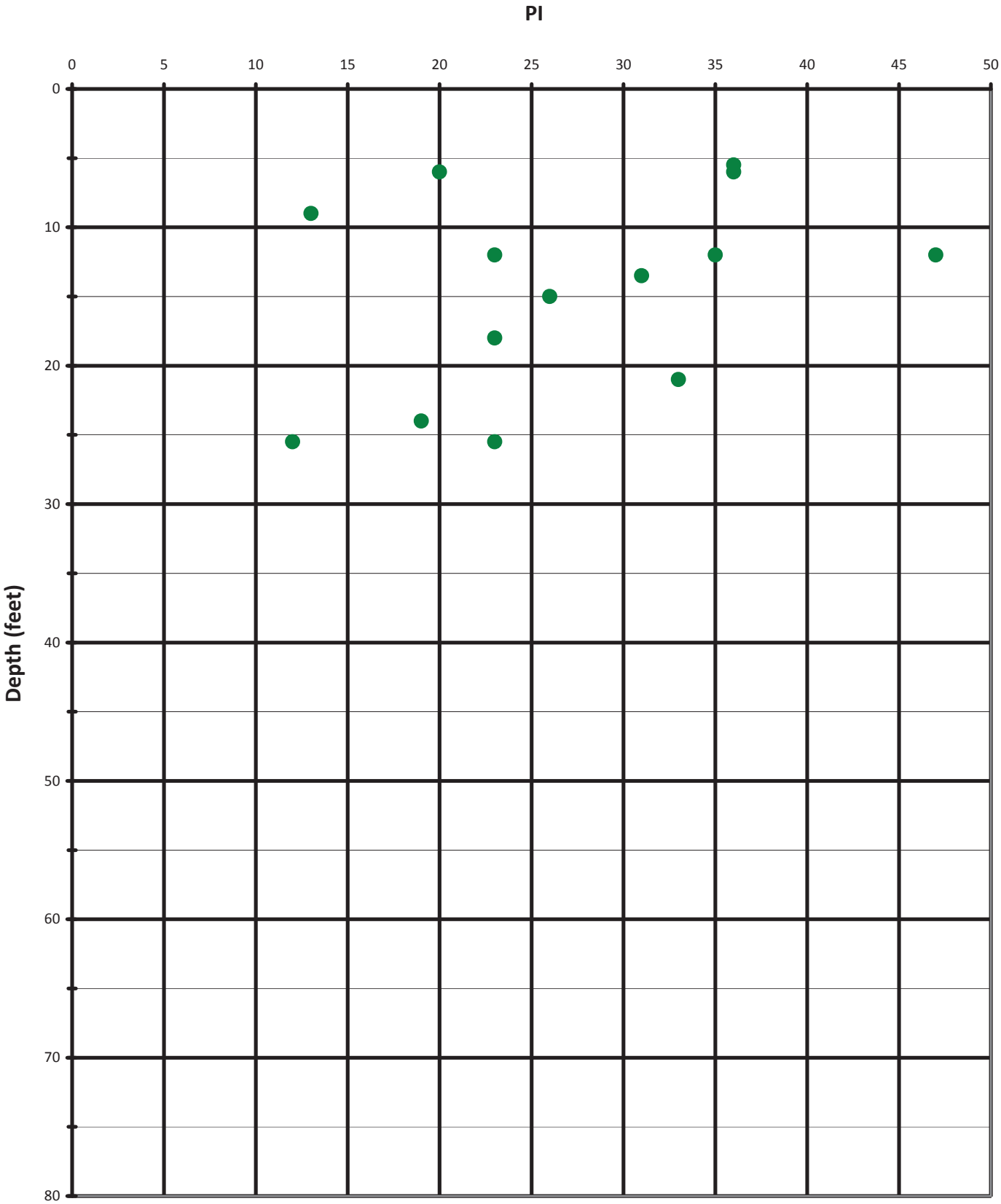
Variation of Liquid Limit with Depth



AREA C

PLATE B4-15

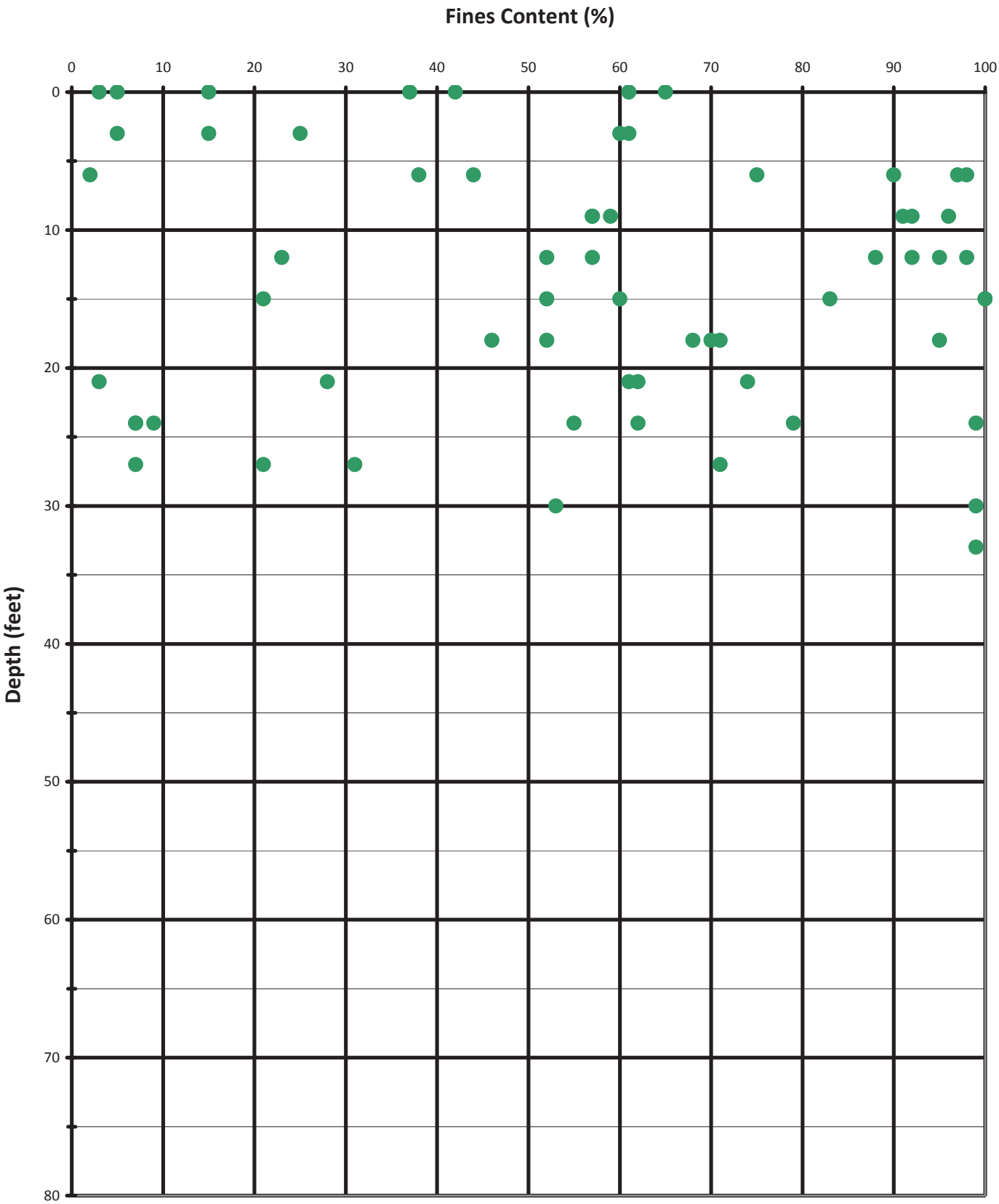
Variation of Plasticity Index with Depth



AREA C

PLATE B4-16

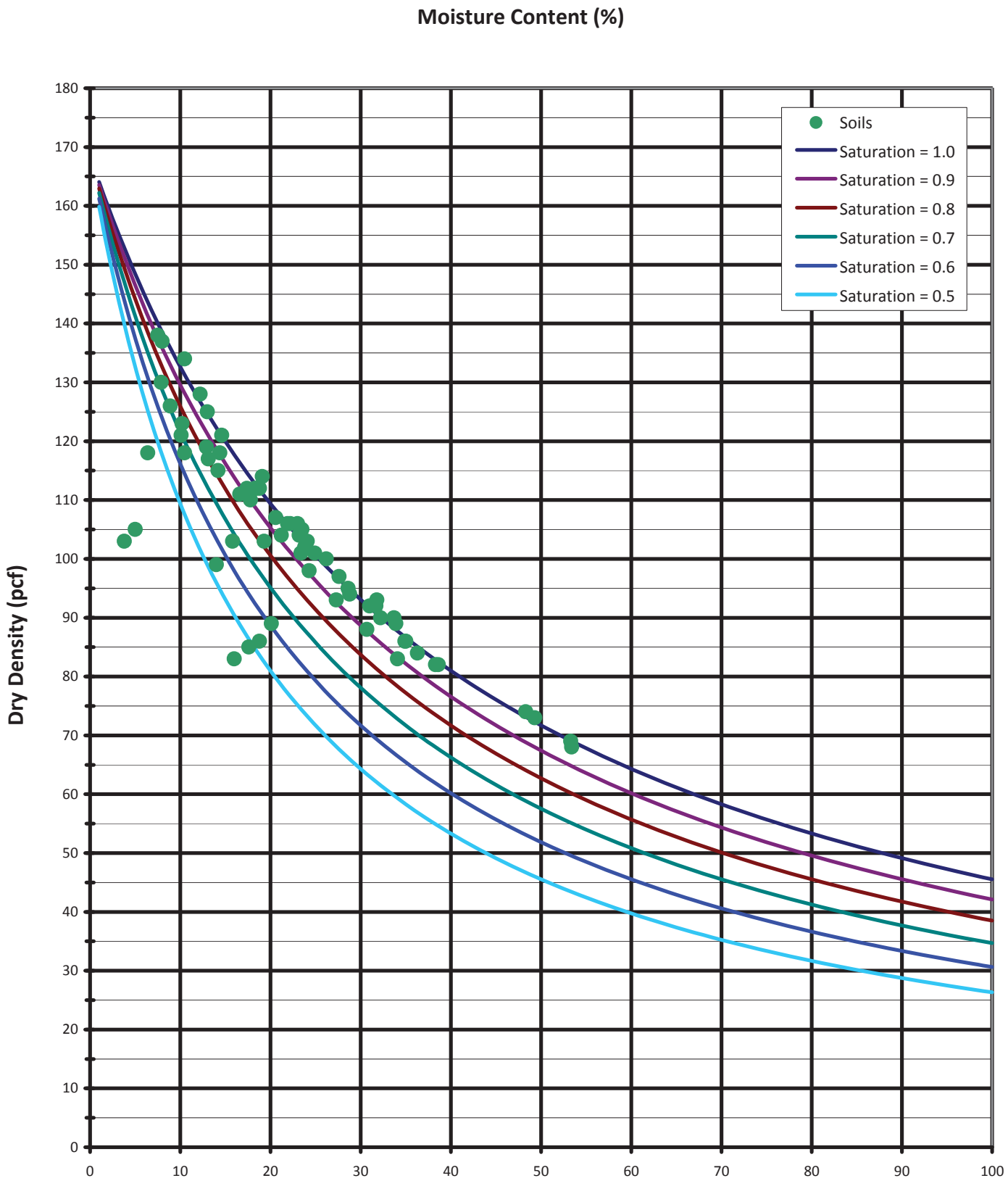
Variation of Fines Content with Depth



AREA C

PLATE B4-17

Moisture Content vs Dry Density



AREA C

PLATE B4-18

APPENDIX C
GEOLOGIC MAP / AERIAL PHOTOS

APPENDIX C
GEOLOGIC MAP/AERIAL PHOTOS

C.1 Contents

This appendix includes a geologic map, aerial photos of Ballona Wetlands selected from the UCLA Library Spence Collection of Aerial Photos (from years 1924 to 1938), and Topographic Maps from USGS prior and after the construction of the existing levees.

A list of the plates presented in this appendix follows:

Plate C-1	Geologic Map
Plate C-2 through C-9	UCLA Library Spence Aerial Photos (circa 1924-1938)
Plate C-10 and C-11	USGS Topographic Maps (1924 and 1942)

DATE: 6/28/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	GEOLOGIC MAP	PROJECT NUMBER: LA962A
REVISION:	APPROVED BY: P. Kashighandi		Ballona Wetlands Restoration Los Angeles, CA	SCALE: 1" = 750'
REVISION:				PLATE NUMBER: C-1

Playa Del Rey - View of Bluffs to the South of Ballona Creek -

UCLA Library - Spence Photos - 1924

Marina Del Rey - Ballona Lagoons - Northward View -

UCLA Library - Spence Photos - 1928

PLATE C-4

Marina Del Rey - Westward View - Showing Oil Wells, Ballona Lagoon, Culver Boulevard, and Pacific Electric Railroad - 1933

UCLA Library - Spence Photos - 1933

PLATE C-5

Marina Del Rey- Eastward View - Showing Ballona Lagoon, Oil Wells, Culver Boulevard passing through in a southwestly

UCLA Library - Spence Photos - 1933

Ballona Creek Levees - 1937 - Eastward View

PLATE C-6

UCLA Library - Spence Photos - 1937

Ballona Creek Levees - 1937 - Eastward View

PLATE C-7

UCLA Library - Spence Photos - 1937

Marina Del Rey - Eastward view showing Pacific Electric Railroad, Lincoln Boulevard, Realignment of Culver Boulevard, and Ballona Creek

UCLA Library - Spence Photos - 1937

PLATE C-9

Marina Del Rey - Eastward view showing Completed Ballona Creek Levee

UCLA Library - Spence Photos - 1938

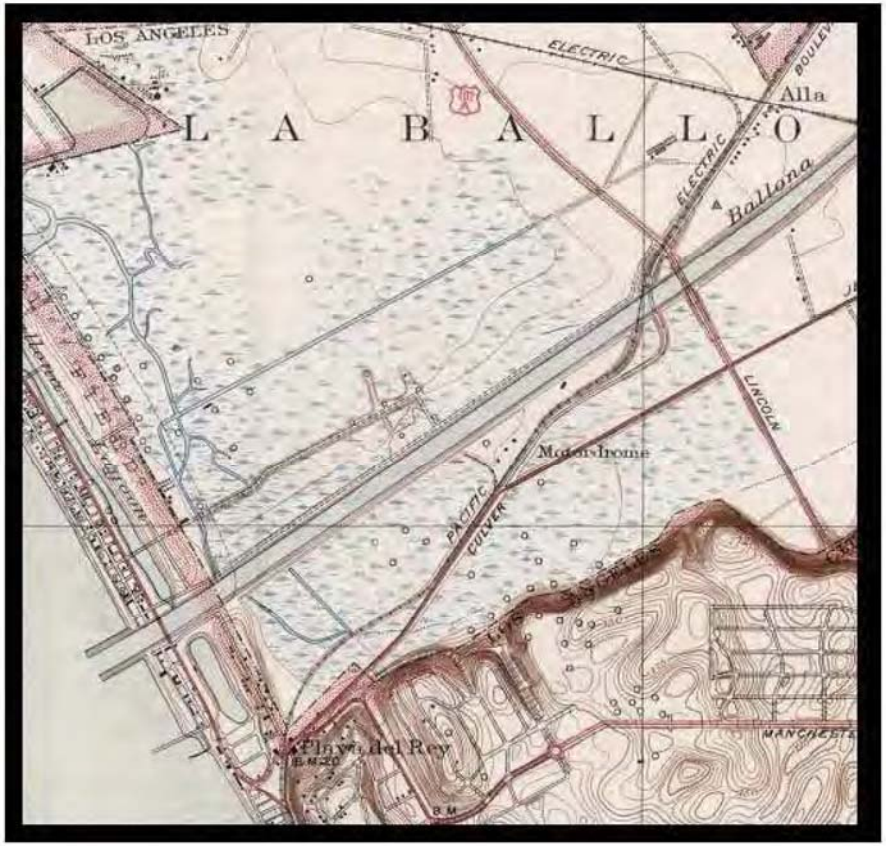
1924 USGS

Historic Topo:	**Venice**
Edition Date:	1924
Scale 1:	24000
County:	Los Angeles .
Longitude:	33°50', 33°55', 34°00'
Latitude:	118°20', 118°25', 118°30'
Township:	T2S SBM, T3S SBM.
Range:	R14W SBM, R15W SBM.
Bodies of Water:	Ballona Lagoon, Santa Monica Bay.
Place Names:	Alla, Culver Garden, Cypress Grove, Del Ray,
Schools:	Playa Del Rey School, Venice High School.
RR/Utilities:	Pacific Electric.
Roadways/Trails:	Coast Boulevard, Collingwood Street, El Segu
Land Grants:	La Ballona, Sausal Redondo.
File name:	HT_834.jpg

USGS TOPO MAPS - 1924

PLATE C-10

1942 USGS



Historic Topo:	**Venice**
Edition Date:	1934, 1942
Scale 1:	24000
County:	Los Angeles .
Longitude:	33°50', 33°55', 34°00'
Latitude:	118°20', 118°25', 118°30'
Township:	T2S SBM, T3S SBM.
Range:	R14W SBM, R15W SBM.
Bodies of Water:	Ballona Lagoon, Santa Monica Bay.
Place Names:	Alla, Culver City, Culver Garden, Cypress Grove, Del Ray,
Schools:	Playa Del Rey School, Venice High School.
RR/Utilities:	Pacific Electric.
Roadways/Trails:	Coast Boulevard, Collingwood Street, El Segundo Avenue, Boulevard.
Land Grants:	La Ballona, Sausal Redondo.
File name:	HT_835.jpg

USGS TOPO MAPS - 1942

PLATE C-11

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APPENDIX D
SEISMIC HAZARD MAPS AND SEISMIC DESIGN CRITERIA

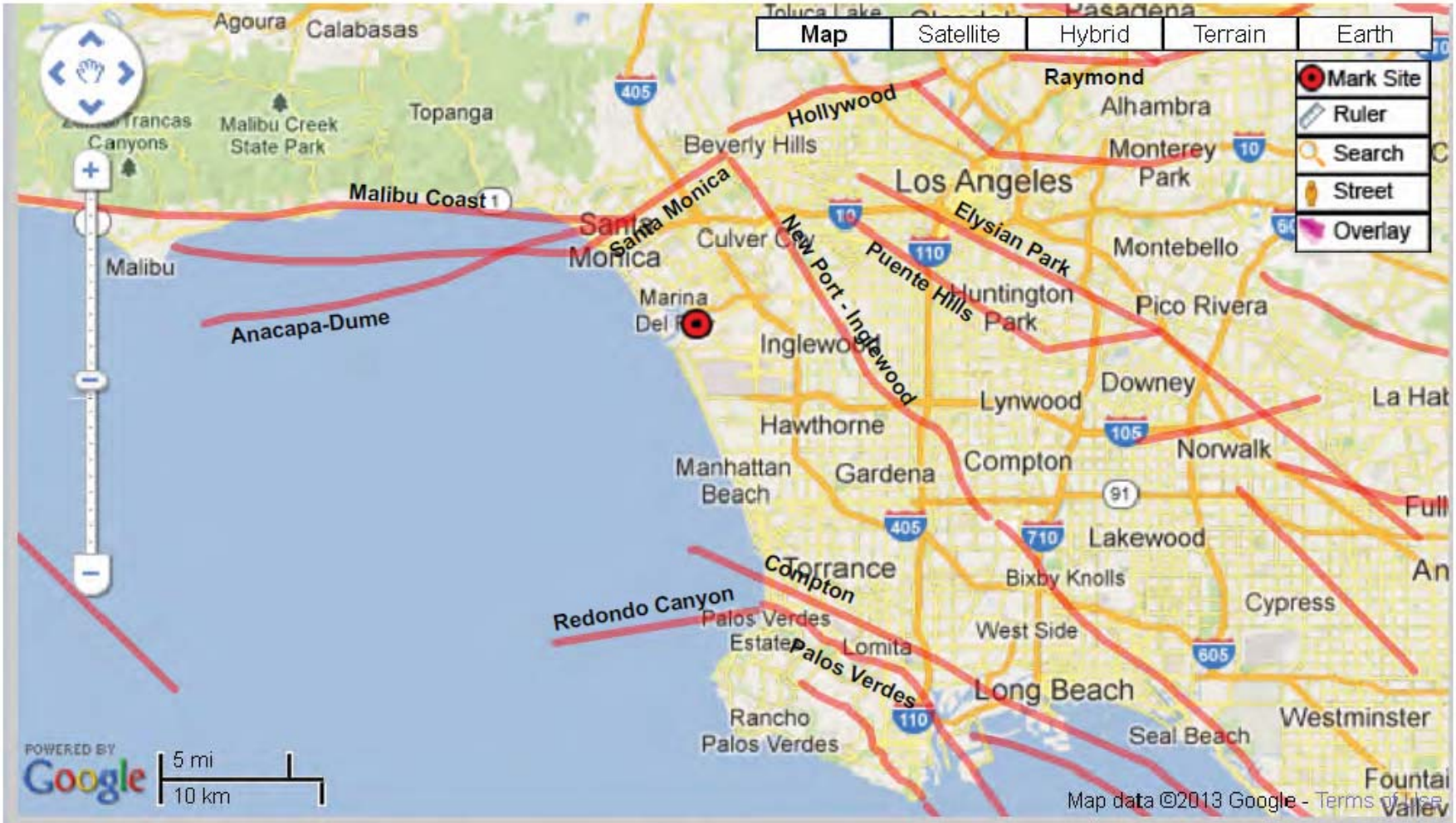
APPENDIX D
SEISMIC HAZARD MAPS / SEISMIC DESIGN CRITERIA

D.1 Contents

This appendix includes the seismic hazard maps and seismic design criteria adopted for the Ballona Wetlands Restoration Project.

A list of the plates presented in this appendix follows:

Plate D-1	CALTRANS Fault Map
Plate D-2	Mapped Location of Charnock Fault
Plate D-3	Estimation of Epicenter and Local Magnitude at or in the Vicinity of the Site (Past 10 years)
Plate D-4 through D-13	USGS Deaggregation Results at Ballona Wetlands for Return Period of 224 years (Vs = 202 m/s)
Plate D-14 through D-17	Shear Wave Velocity Profiles (Area A, B, West B, and C)
Plate D-18	CGS Historically Highest Ground Water Contour Map
Plate D-19	CGS Liquefaction Hazard Zone Map
Plate D-20	CGS Landslide Hazard Zone Map
Plate D-21	Navigate LA – Fault Rupture Study Zones and Landslide



GROUP DELTA CONSULTANTS

Caltrans Fault Map

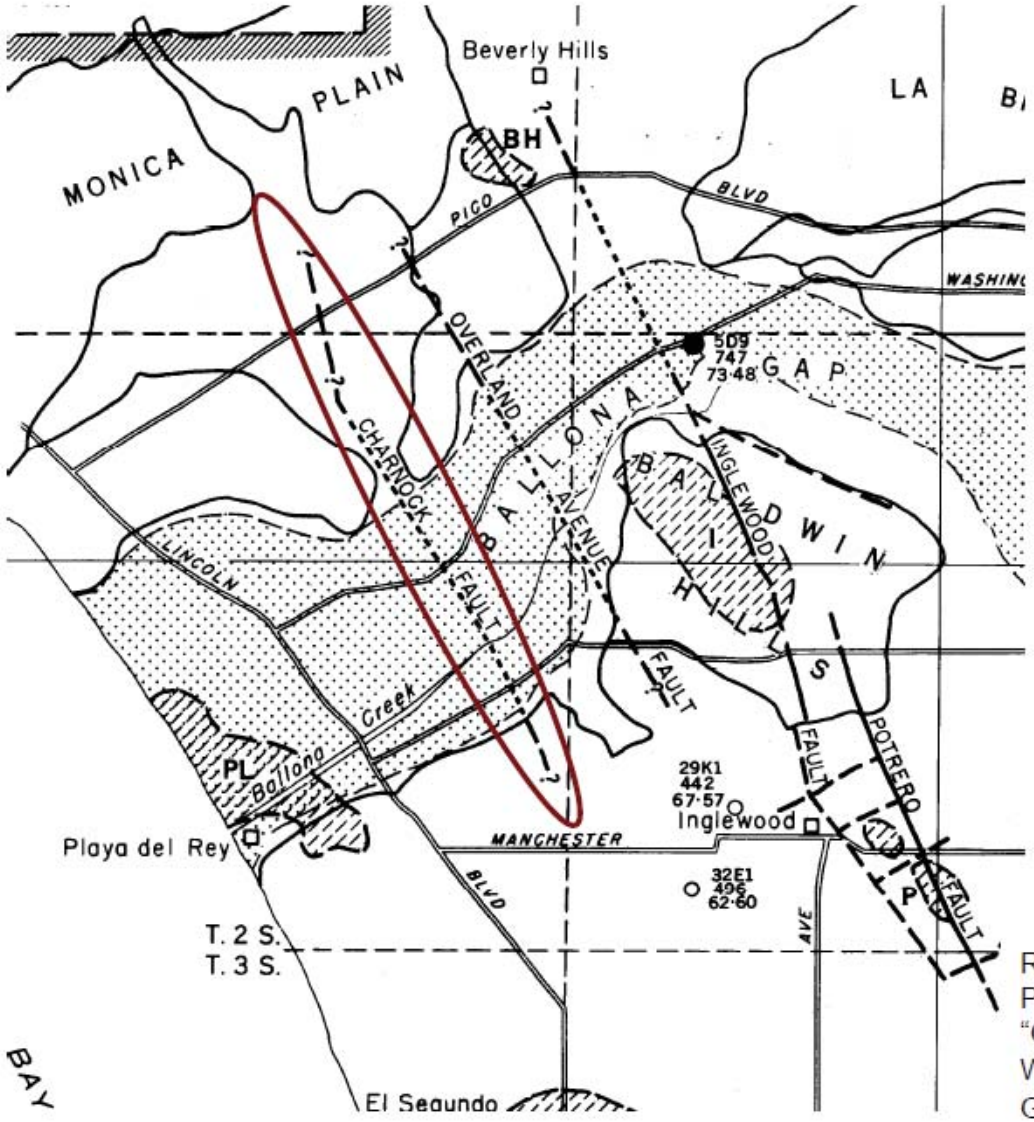
Project Number LA-962A

Date: 2/19/2013

Group Delta Consultants. INC.
370 Amapola Ave.
Torrance, Ca 90501

Ballona Creek Wetlands Restoration Project
Marina Del Rey, CA

PLATE D-1



EXPLANATION

Area underlain by Gaspur water-bearing zone or "50-foot gravel"

Fault, long dashes where approximately located, short dashes where concealed

Approximate location of ground-water barrier not related to known faults

Reference:
Poland et al., 1959
"Geology, Hydrology, and Chemical Character of Ground Waters in the Torrance – Santa Monica Area, California Geologic Survey Water - Supply Paper 146"

GROUP DELTA CONSULTANTS

Map showing Charnock Fault

Project Number LA-962A

Date: 3/11//2013

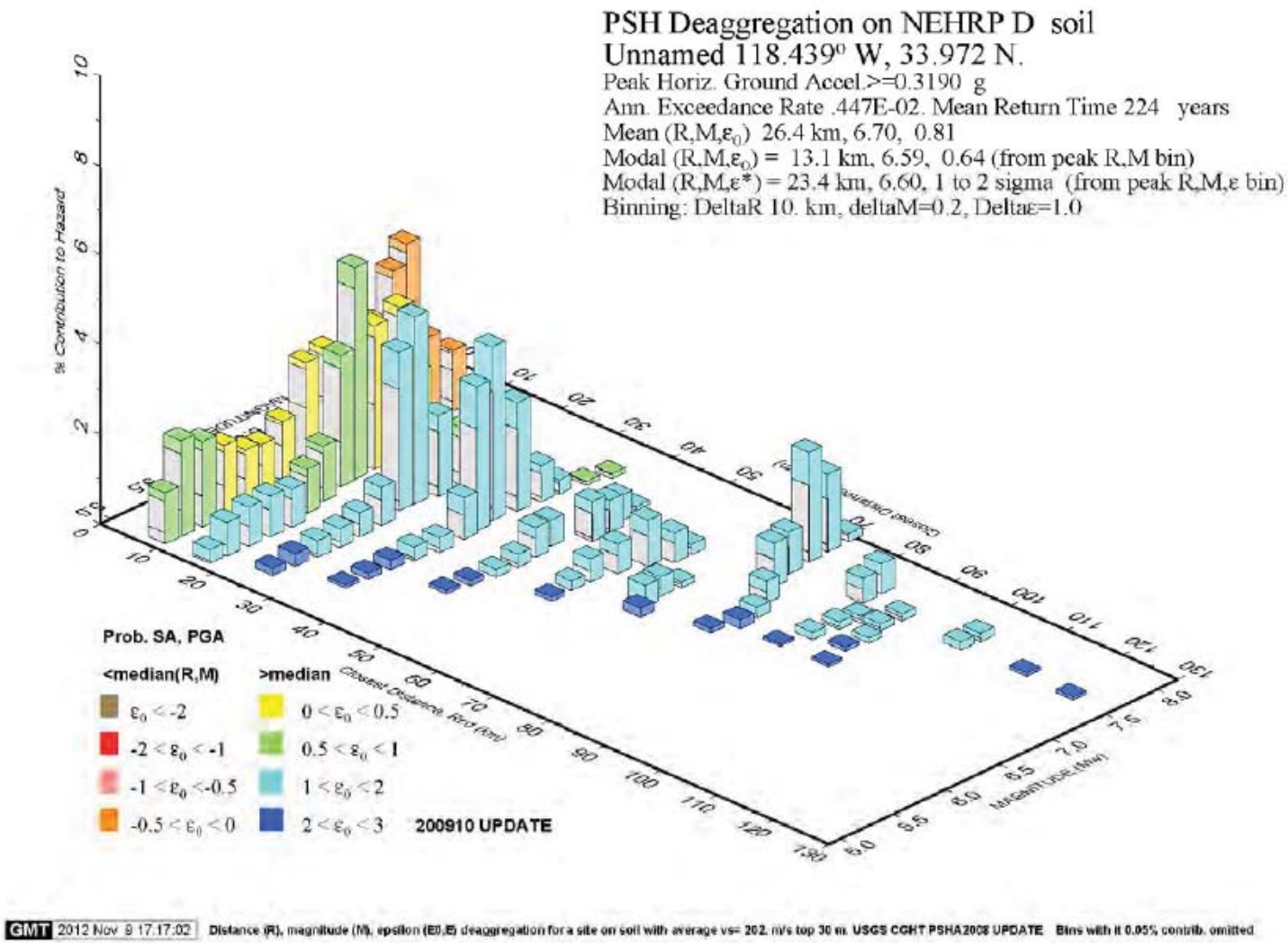
Group Delta Consultants. INC.
370 Amapola Ave.
Torrance, Ca 90501

Ballona Creek Wetlands Restoration Project
Marina Del Rey, CA

PLATE D-2

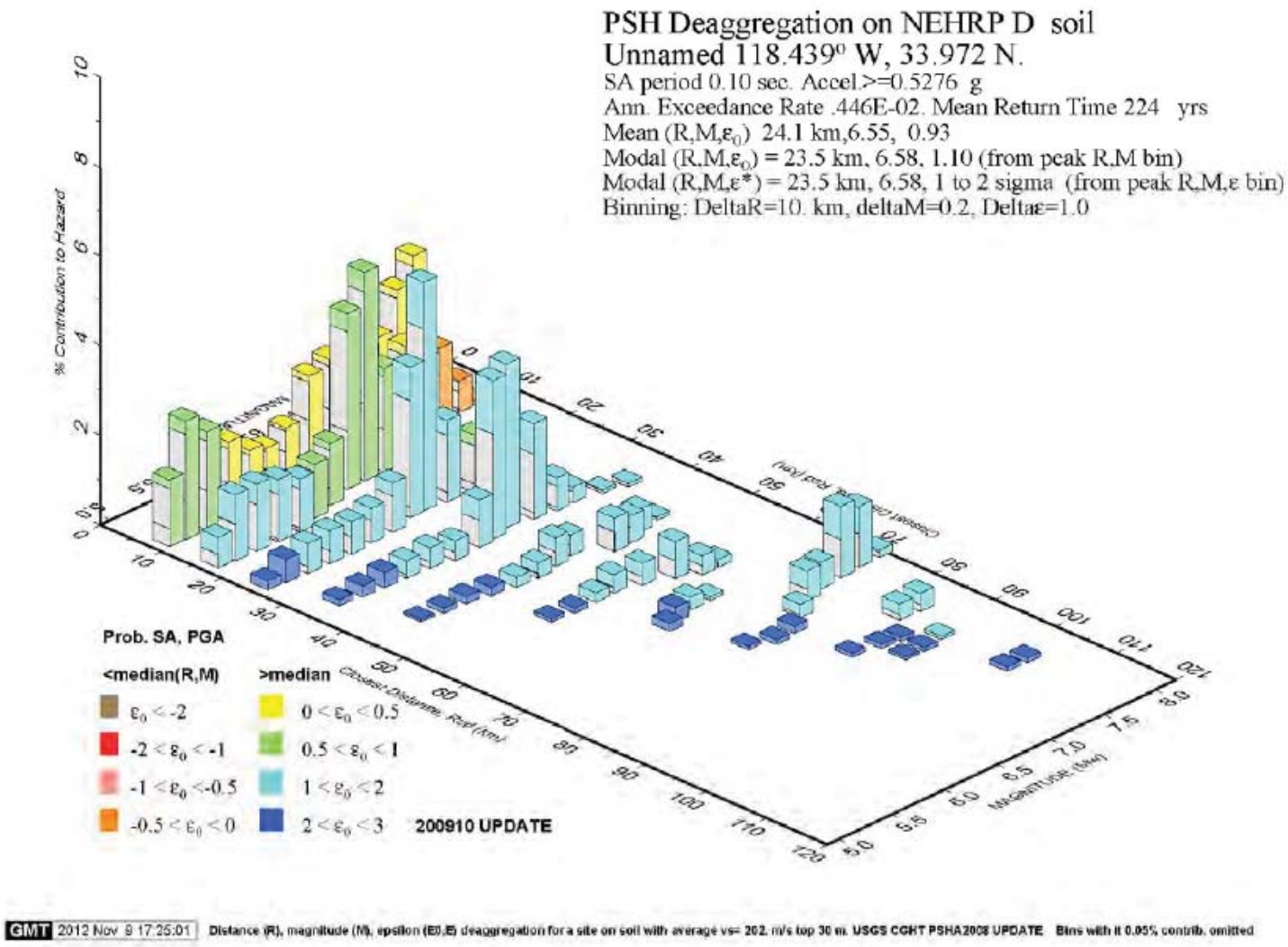
Estimation of Epicenter and Local Magnitude at or in the Vicinity of the Site
(Past 10 years)

PLATE D-3



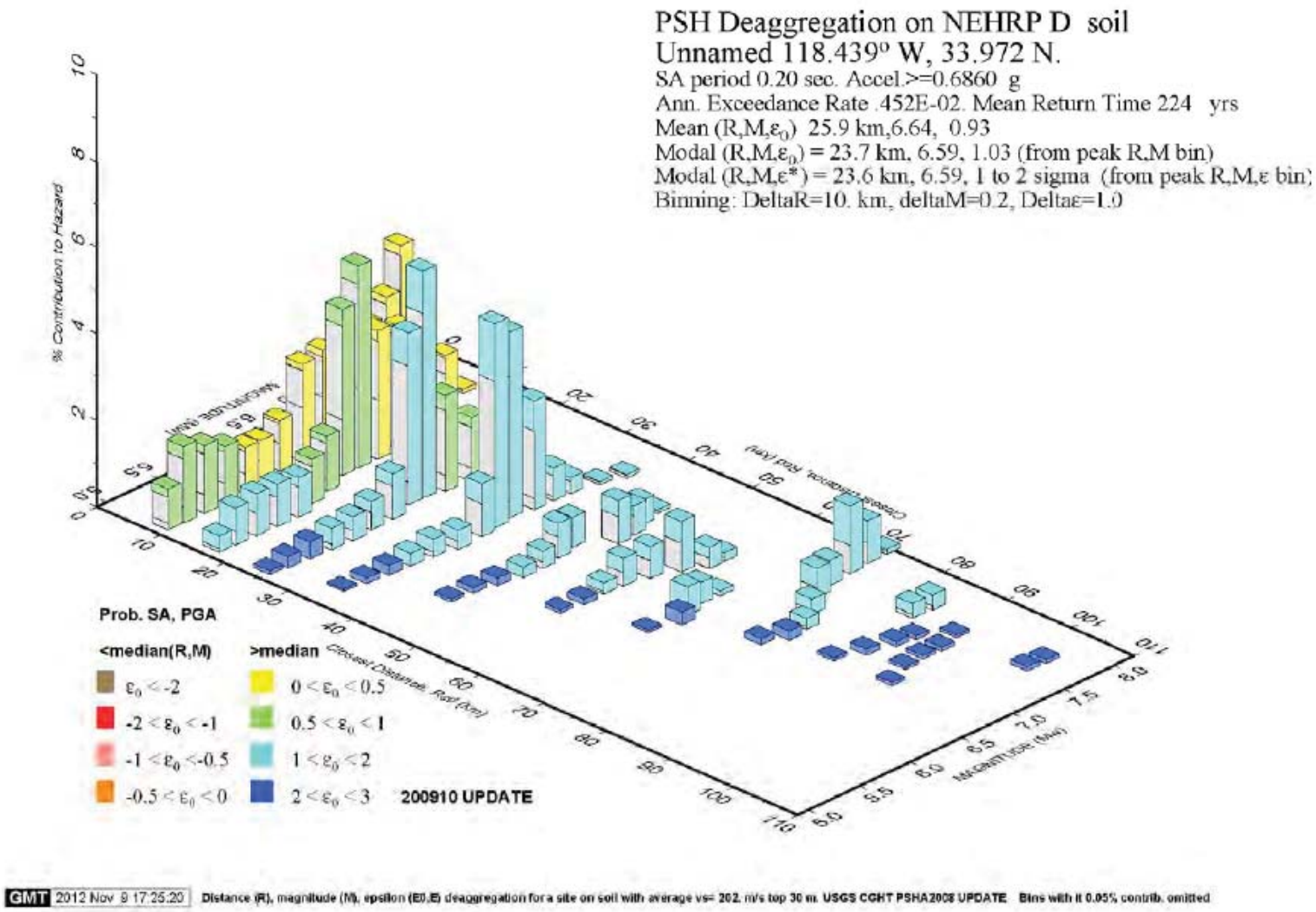
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At PGA

PLATE D-4



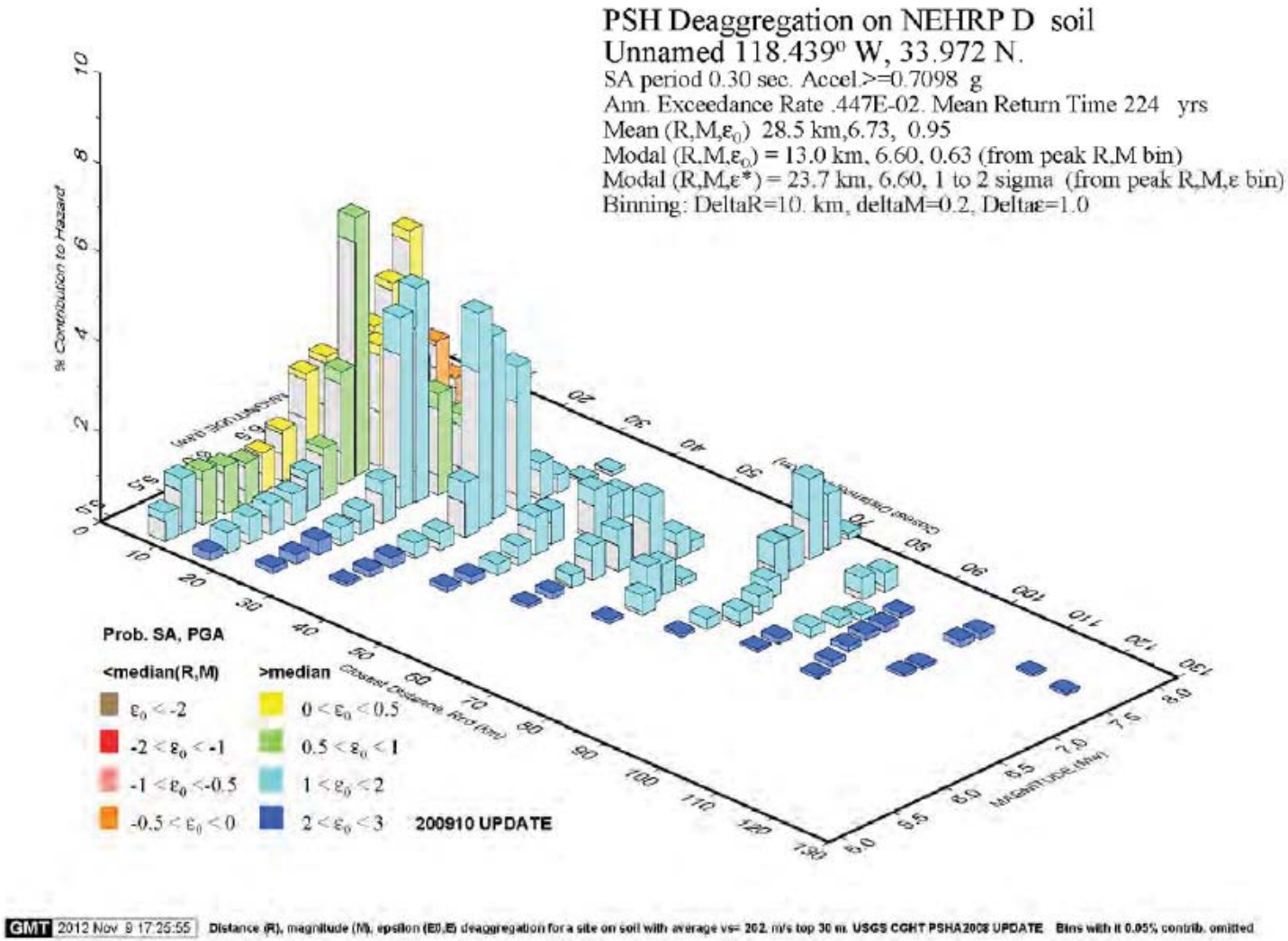
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=0.1 second

PLATE D-5



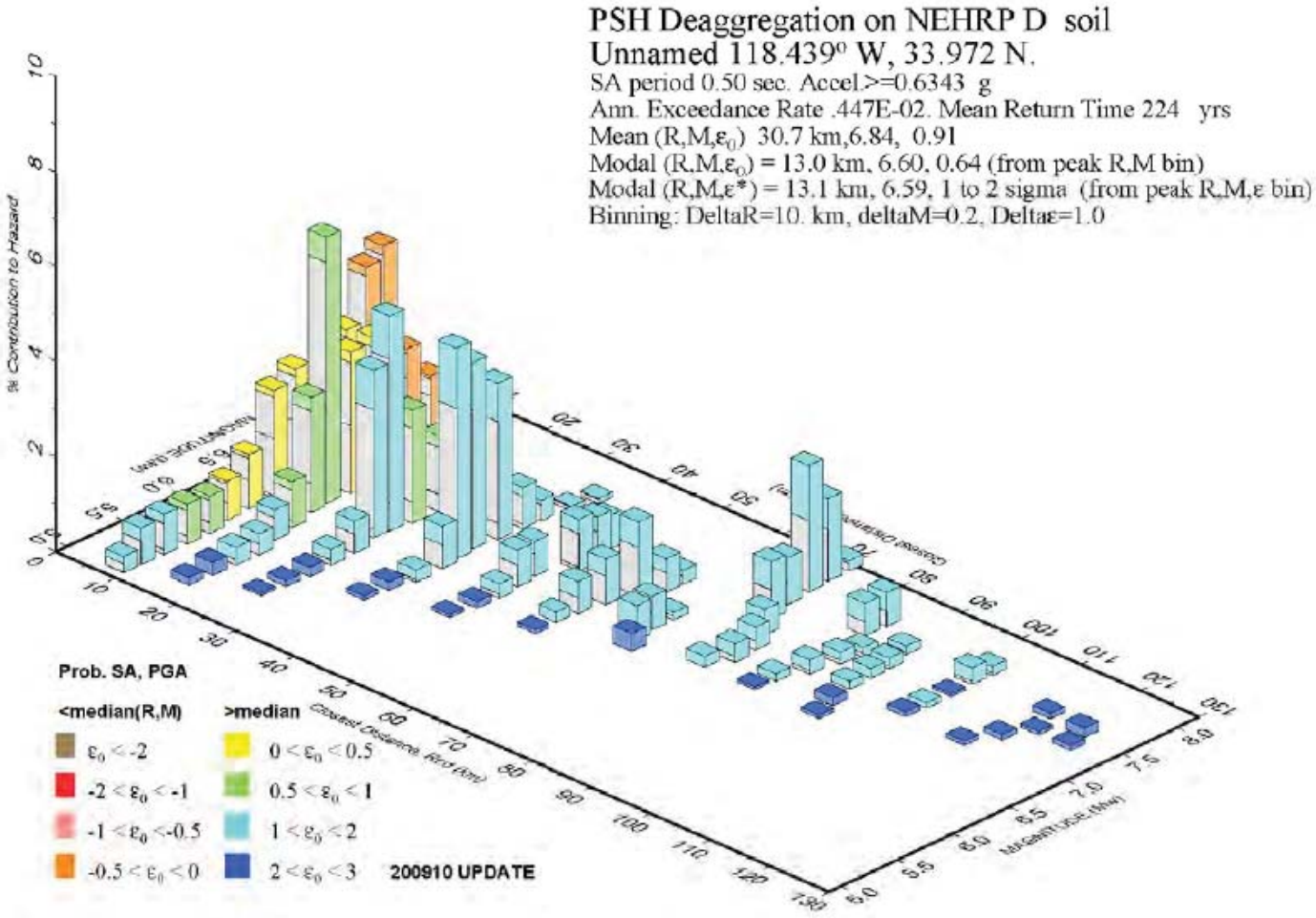
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=0.2 second

PLATE D-6



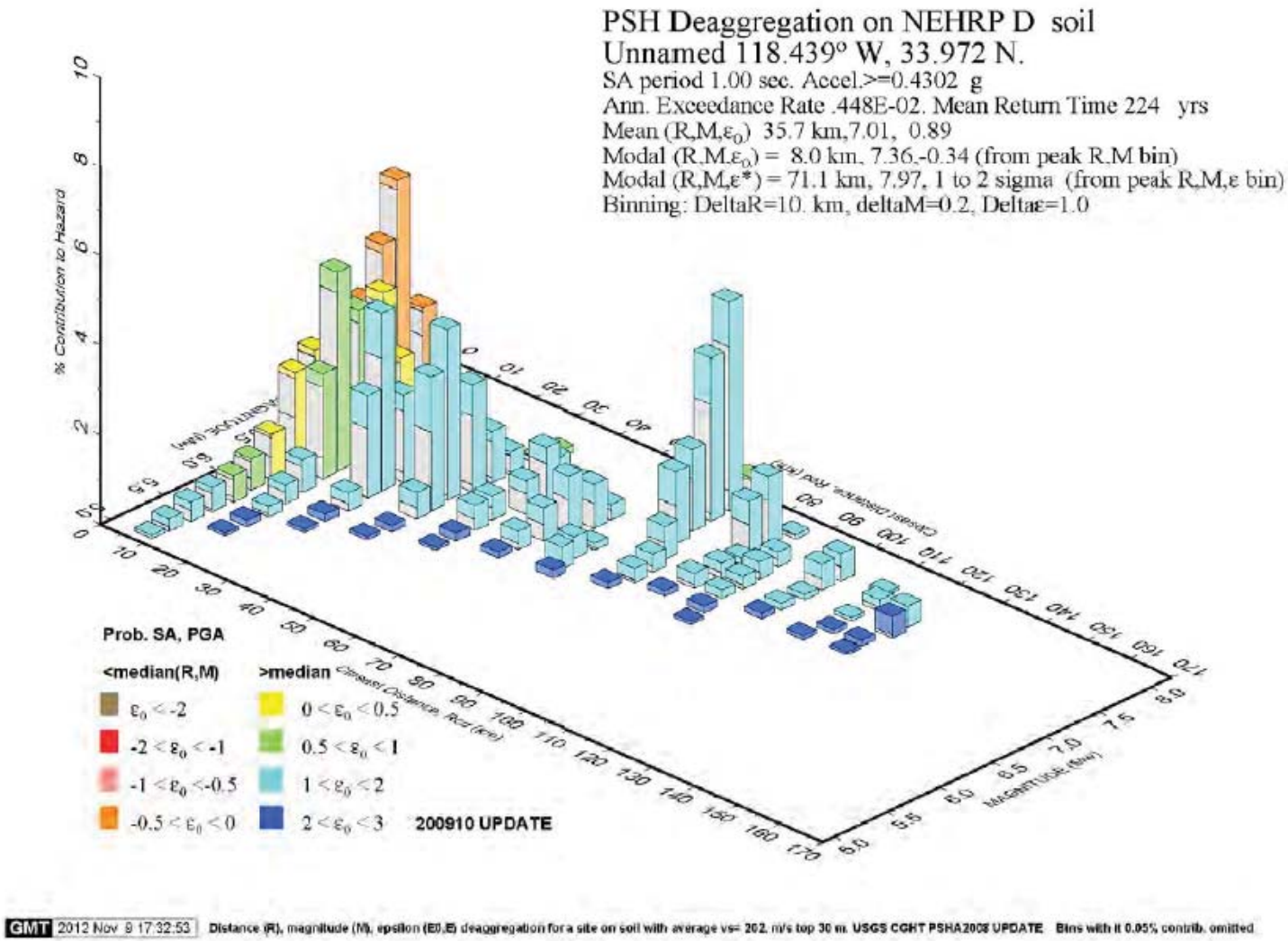
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=0.3 second

PLATE D-7



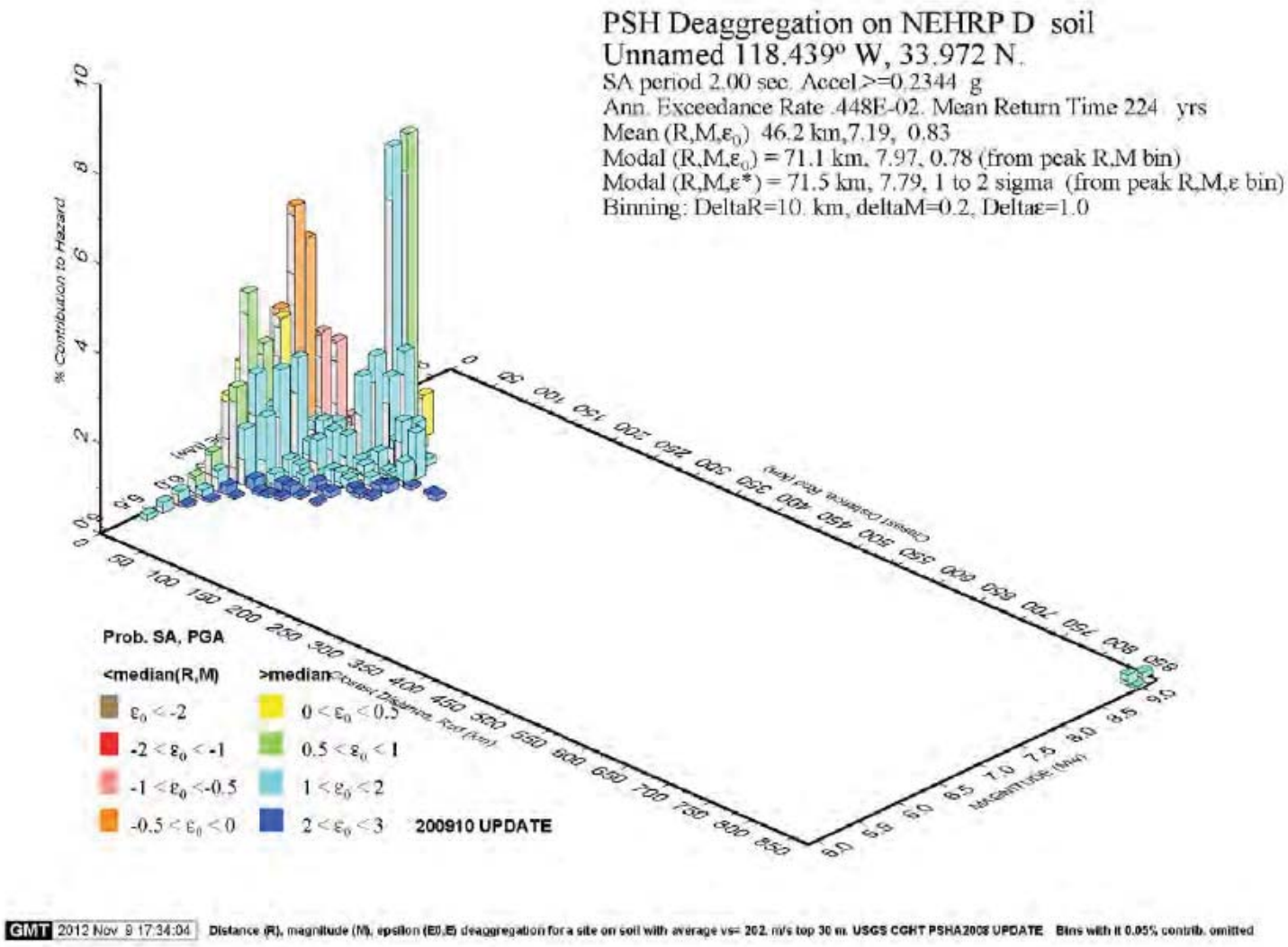
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=0.5 second

PLATE D-8



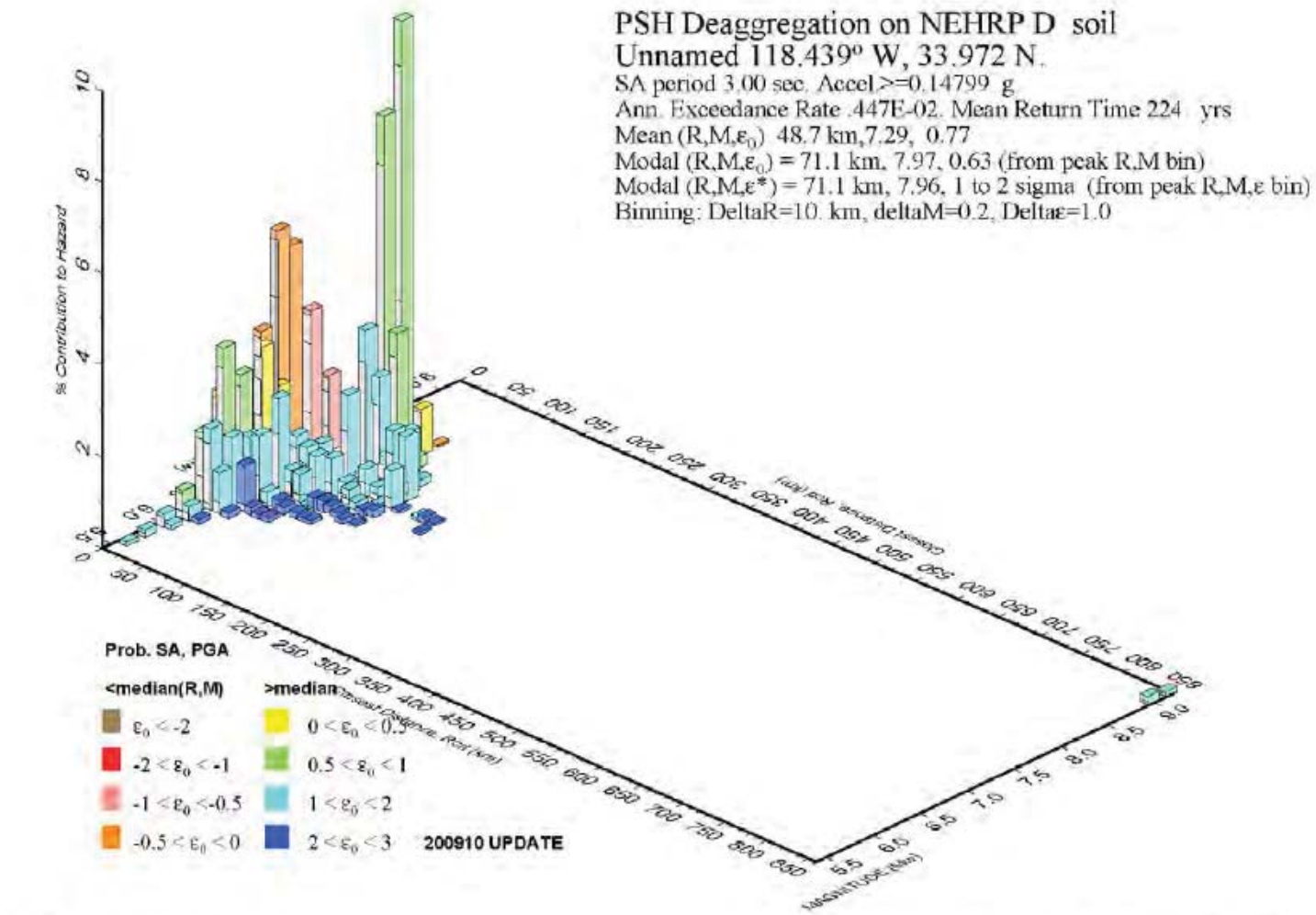
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=1.0 second

PLATE D-9



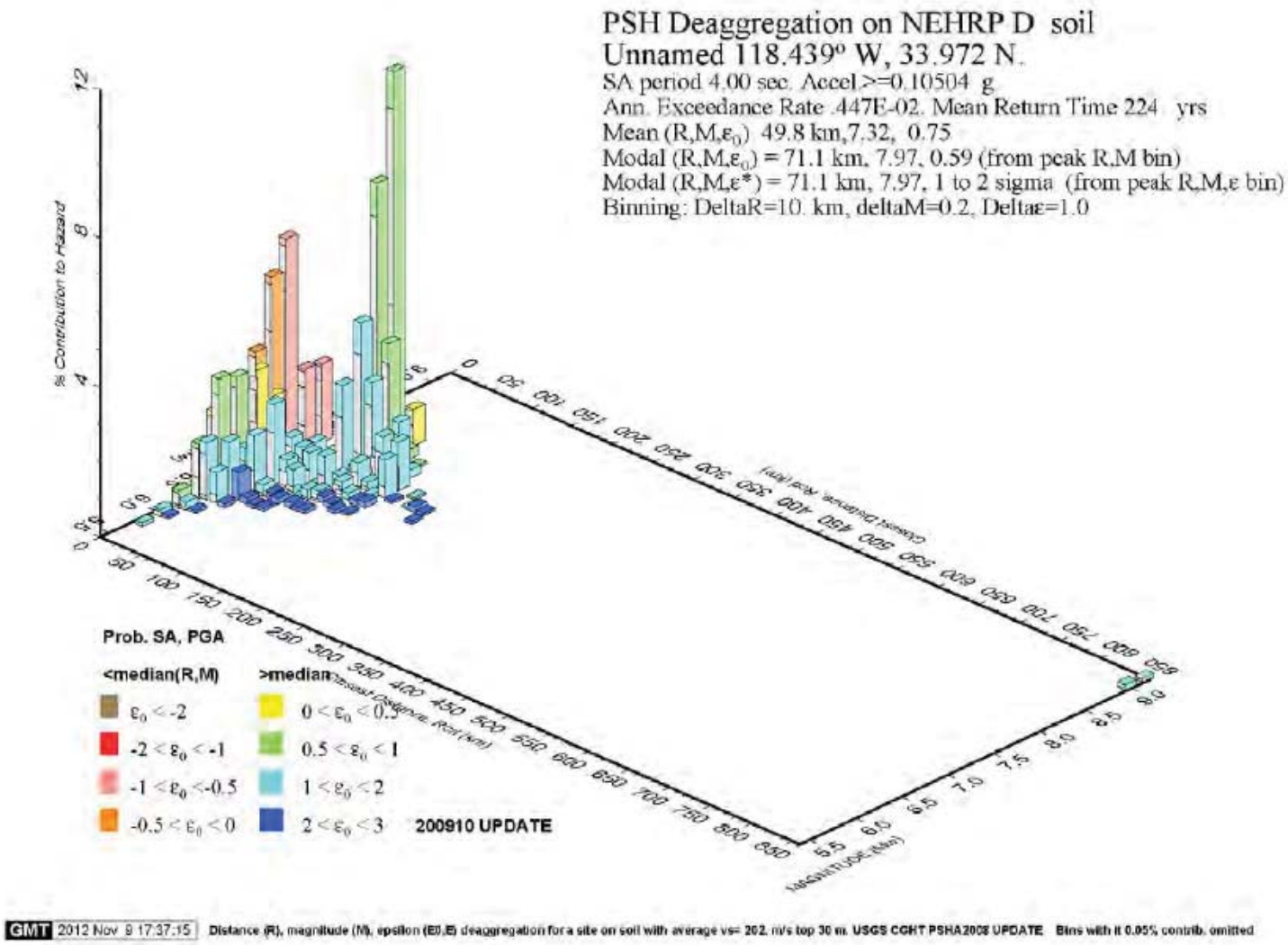
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=2.0 second

PLATE D-10



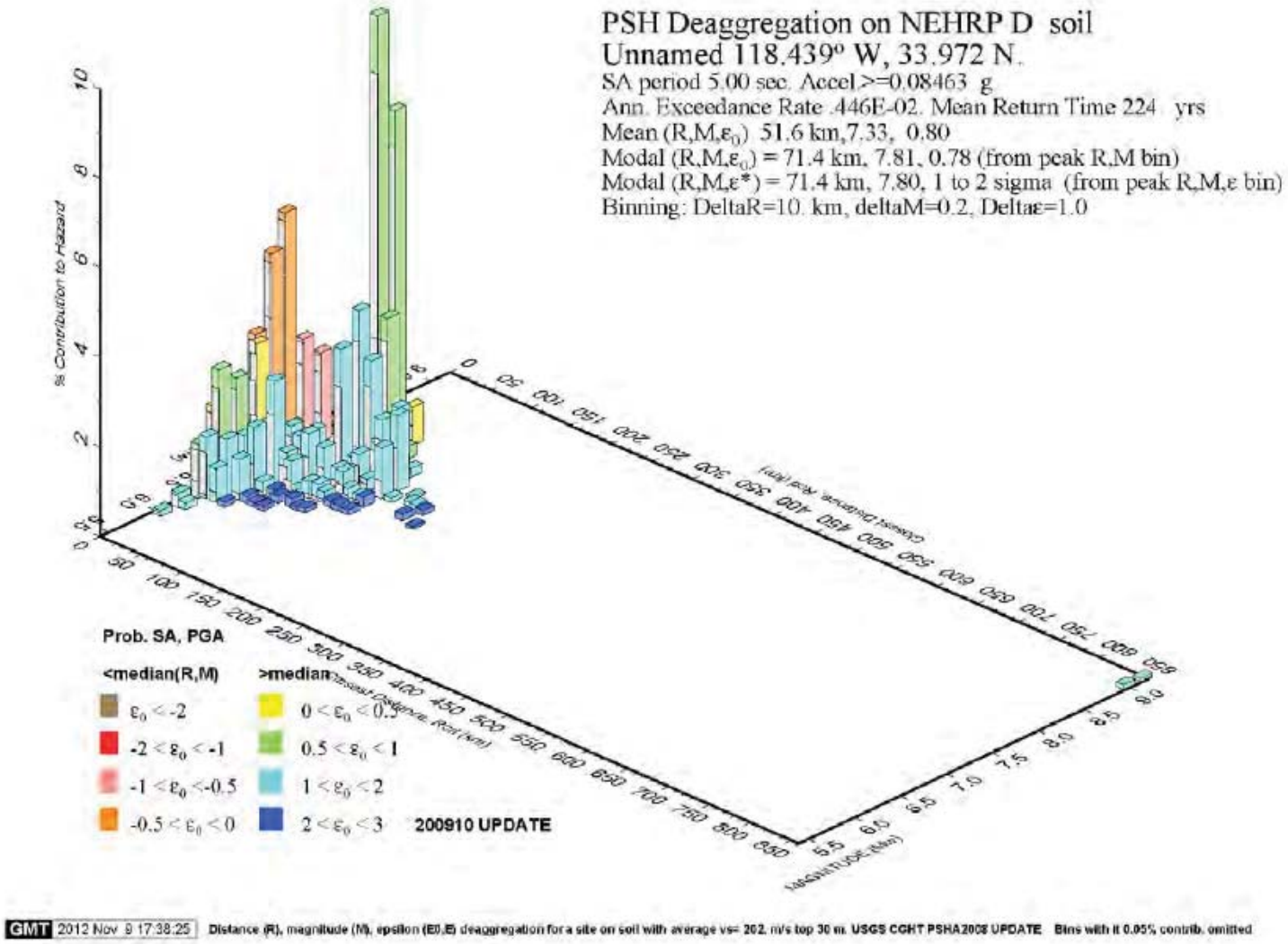
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=3.0 second

PLATE D-11



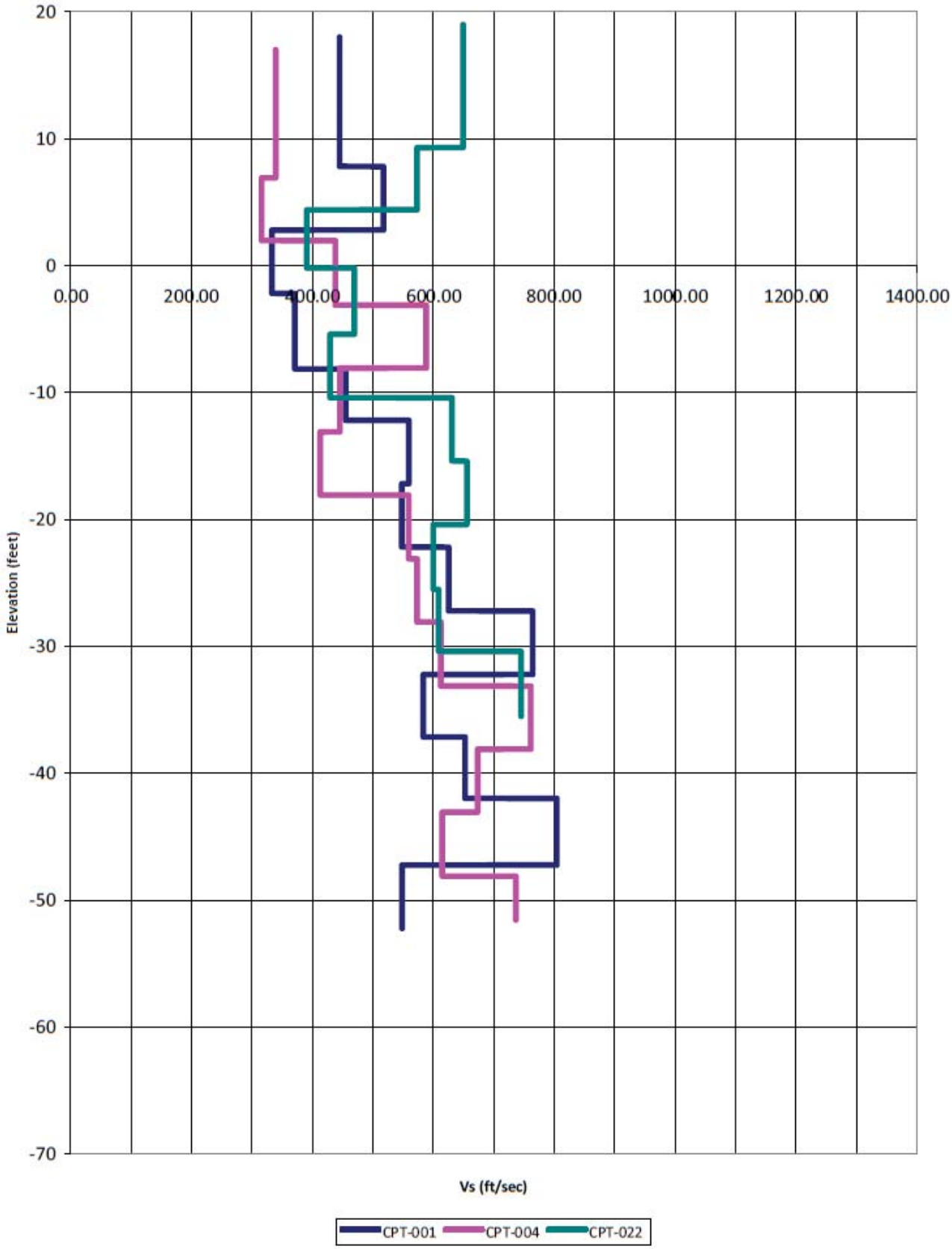
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=4.0 second

PLATE D-12



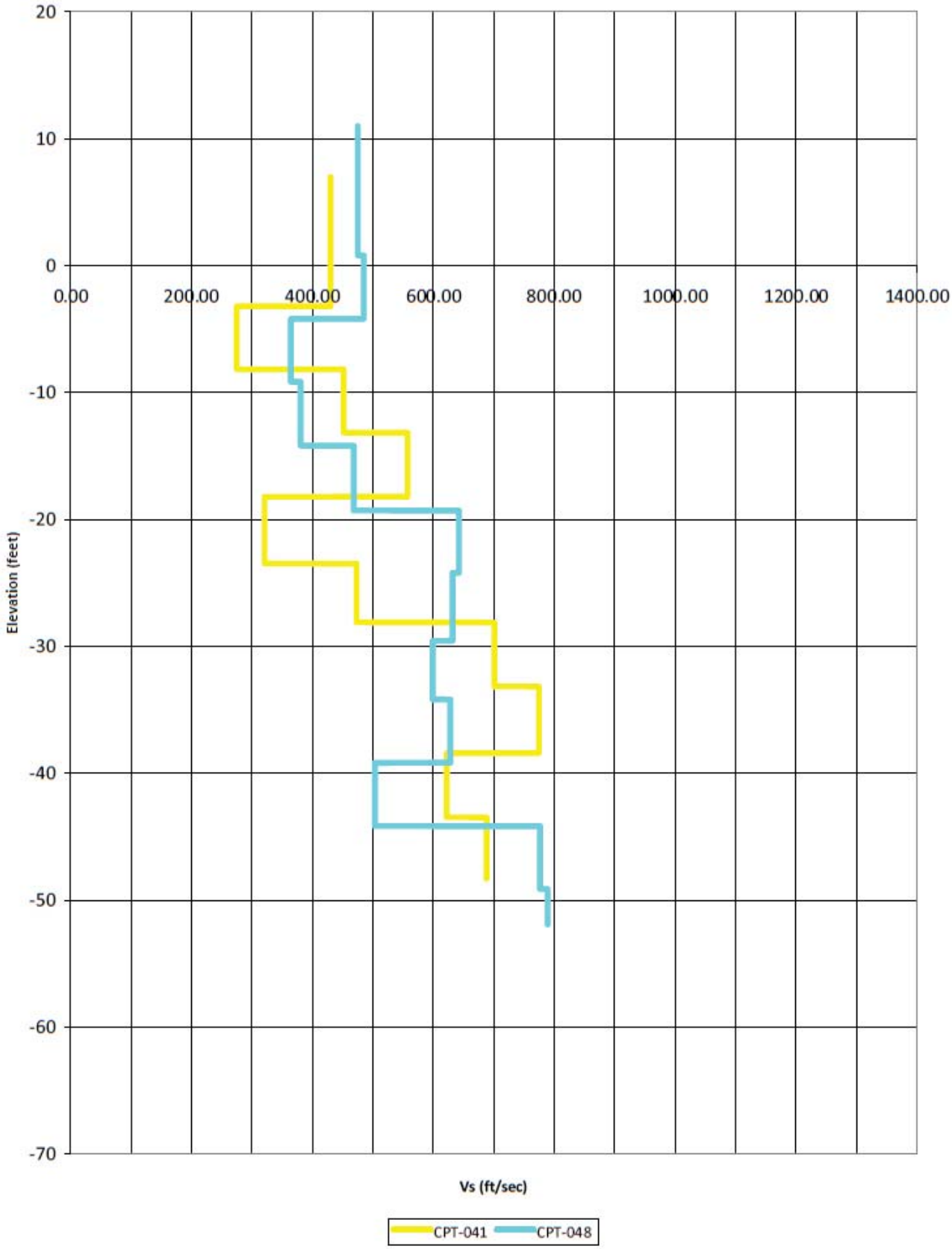
USGS Deaggregation at Ballona Wetlands for a Return Period of 224 years (Vs30 = 202 m/s)
At T=5.0 second

PLATE D-13



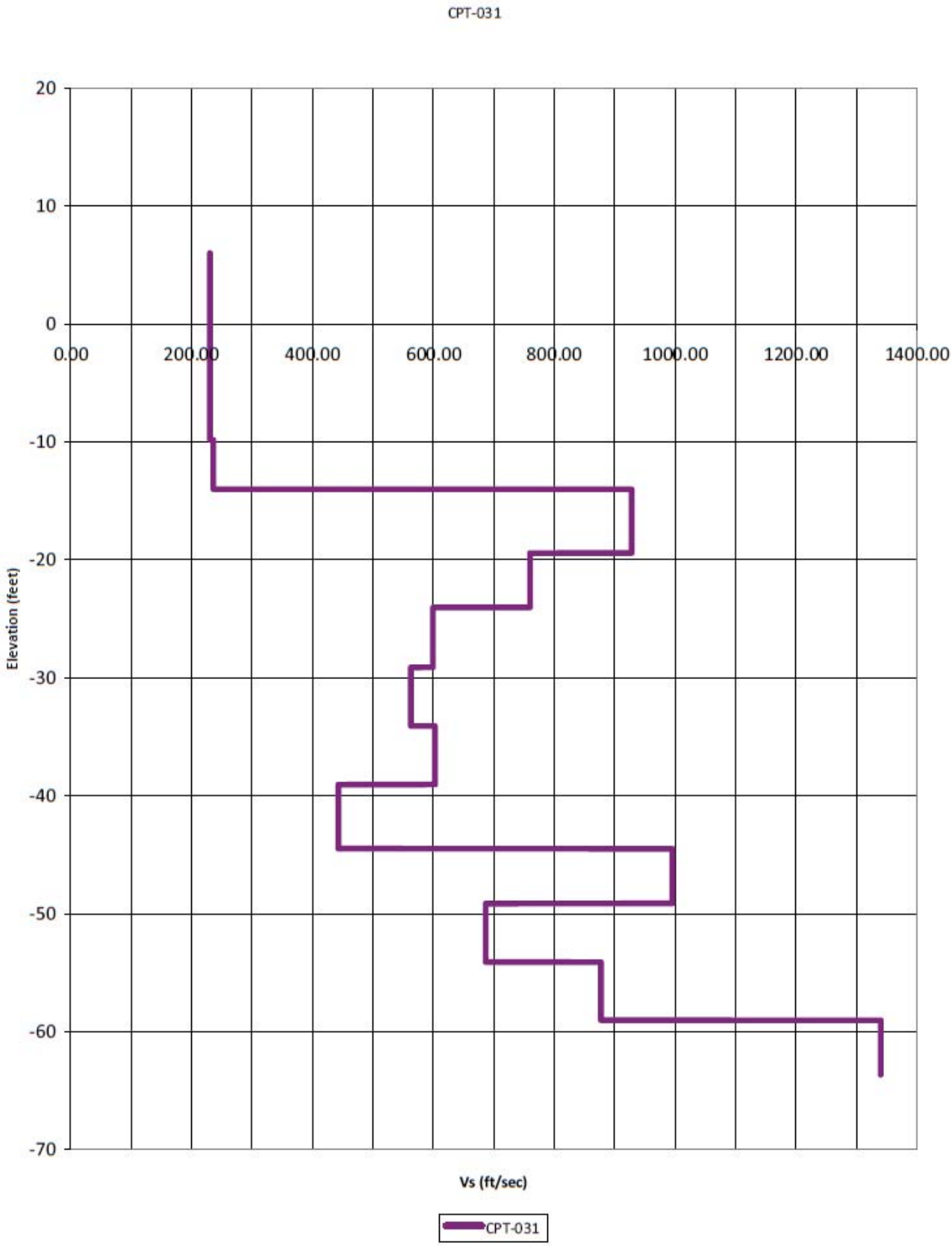
Shear Wave Velocity Profile
Area A

PLATE D-14



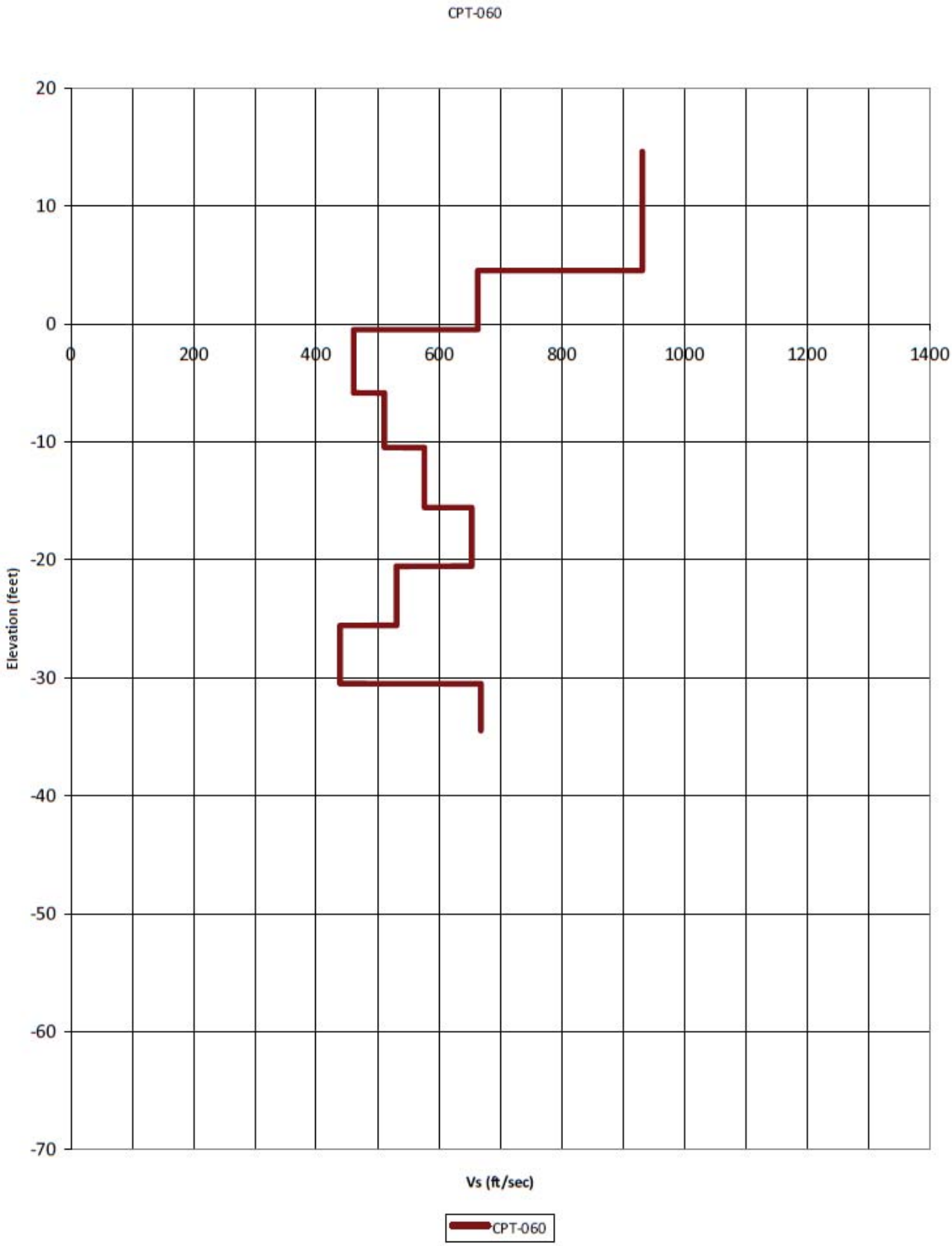
Shear Wave Velocity Profile
Area B

PLATE D-15



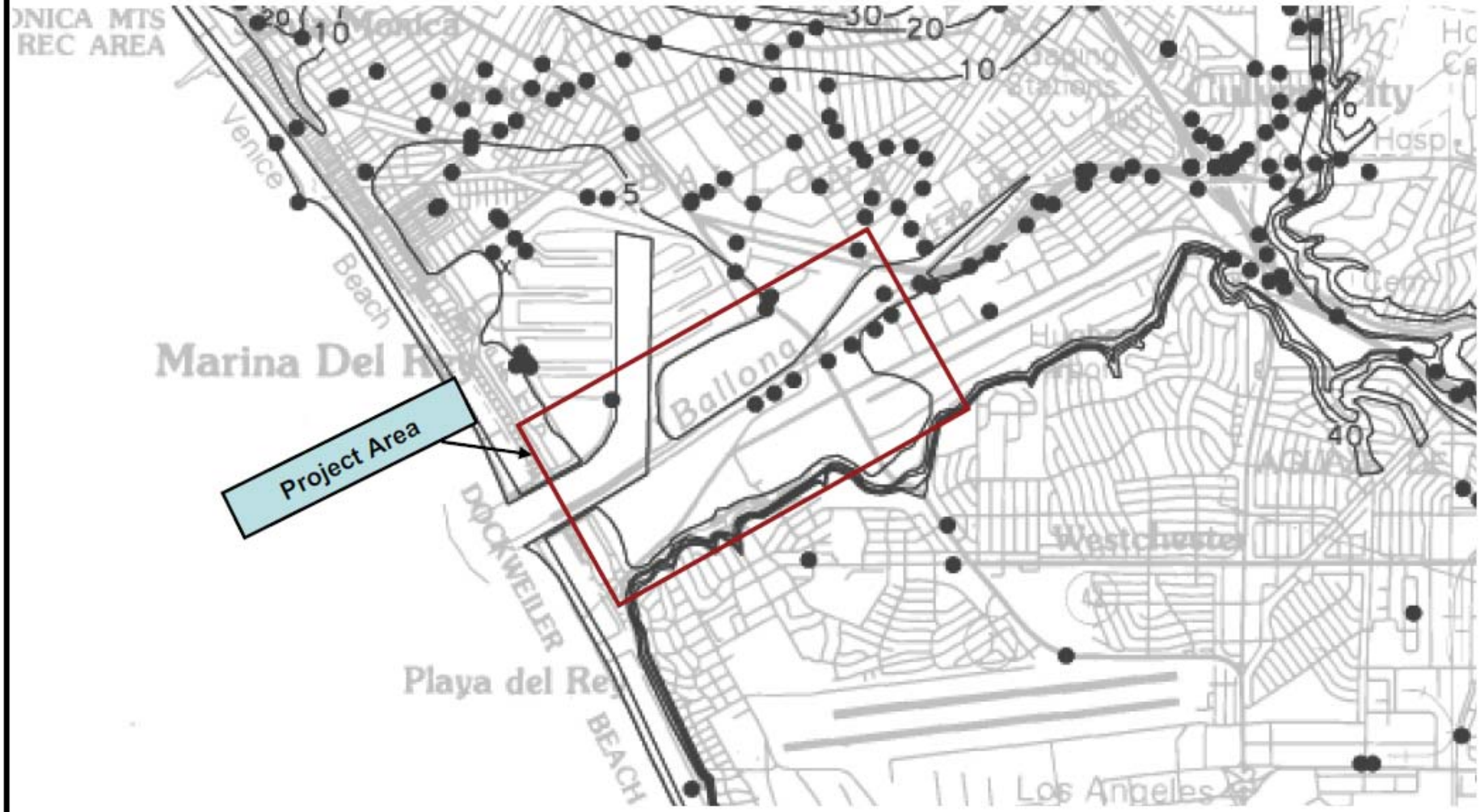
Shear Wave Velocity Profile
West Area B

PLATE D-16

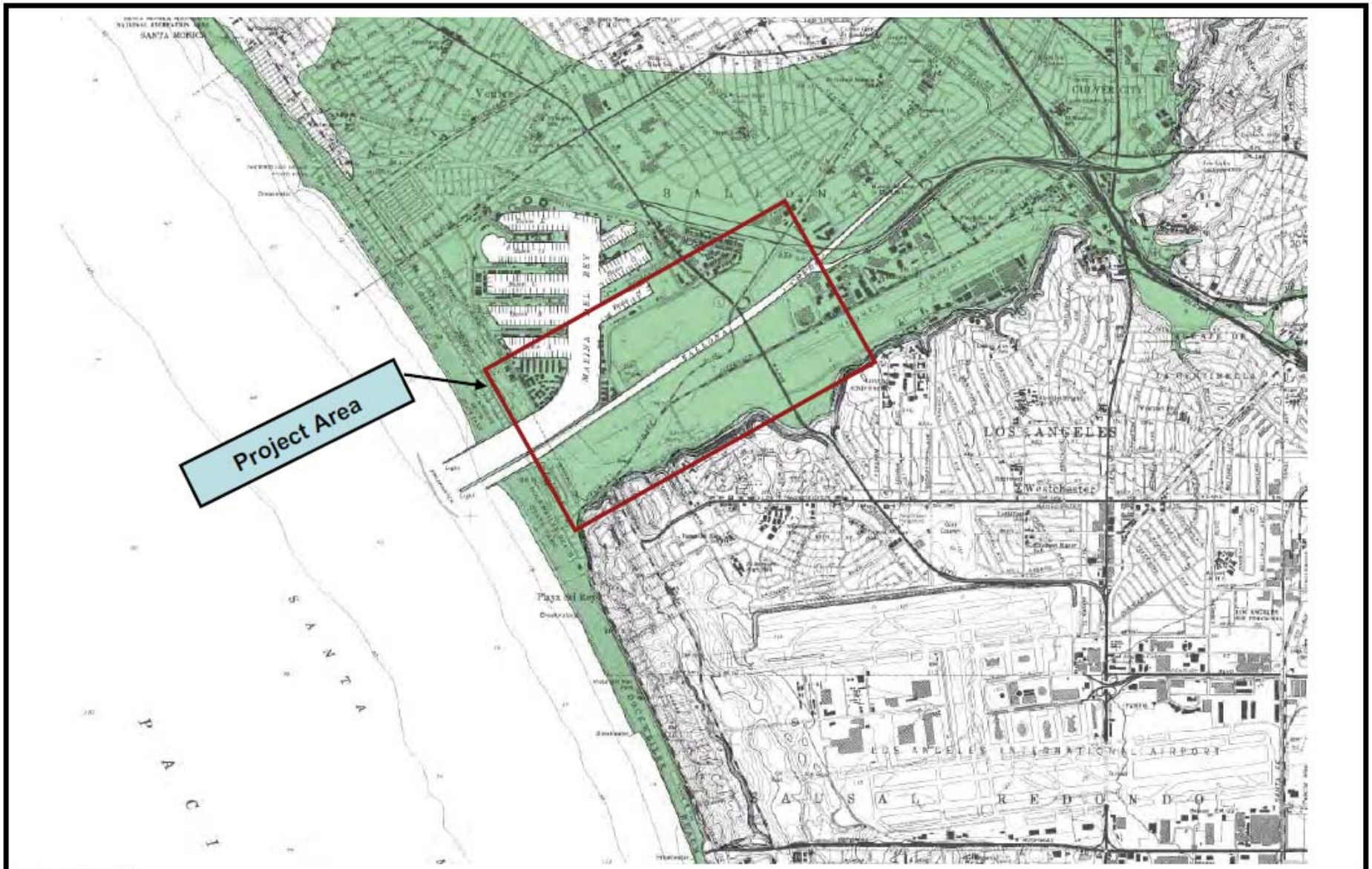


Shear Wave Velocity Profile
Area C

PLATE D-17



GROUP DELTA CONSULTANTS	**CGS Historically Highest Ground Water Contour Map**	Project Number LA-962A Date: 11/9/2012
Group Delta Consultants. INC. 370 Amapola Ave. Torrance, Ca 90501	Ballona Creek Wetlands Restoration Project Marina Del Rey, CA	PLATE D-18



GROUP DELTA CONSULTANTS

CGS Liquefaction Hazard Zone Map

Project Number LA-962A

Date: 11/9/2012

Group Delta Consultants. INC.
370 Amapola Ave.
Torrance, Ca 90501

Ballona Creek Wetlands Restoration Project
Marina Del Rey, CA

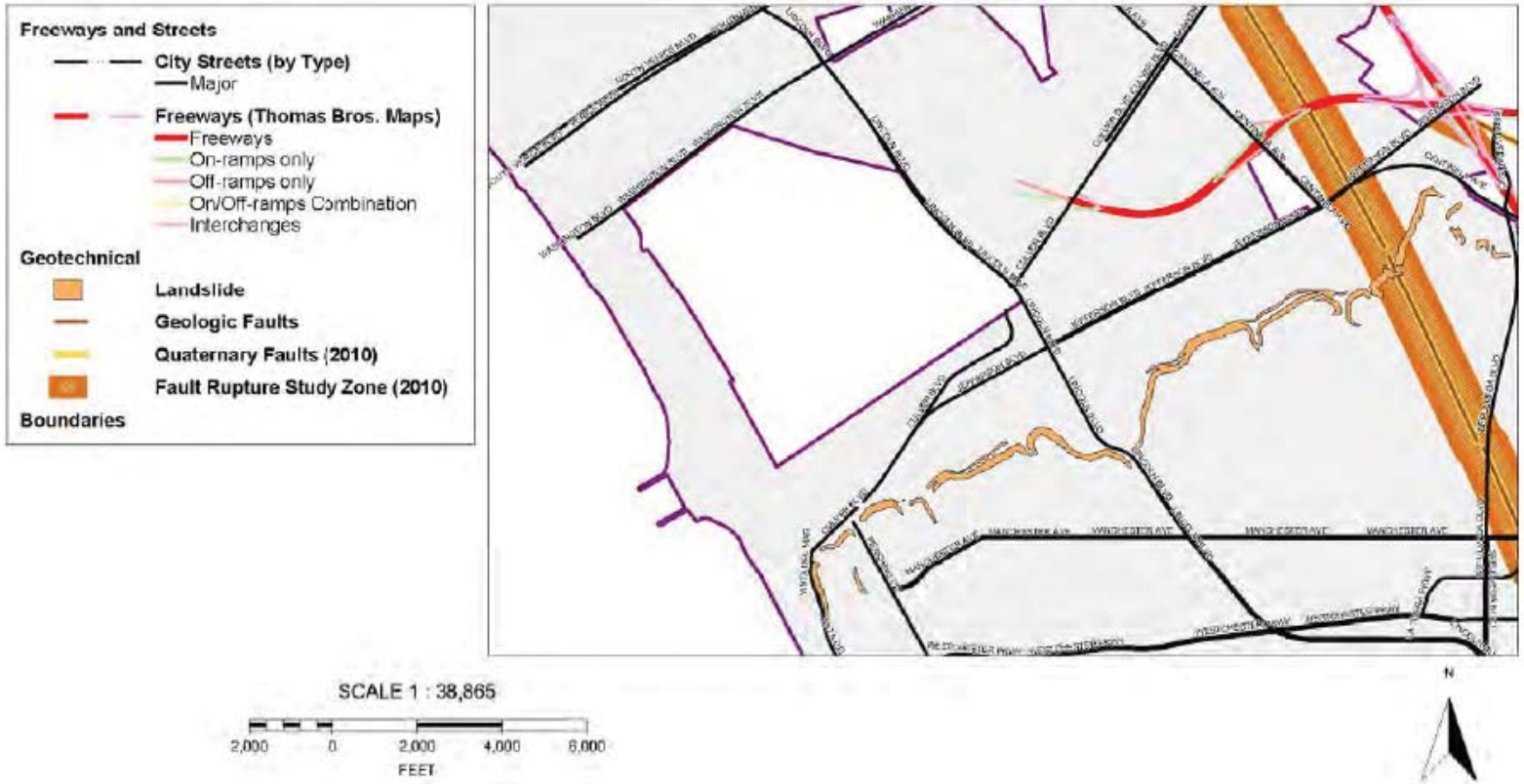
PLATE D-19

Plate 2.1 Landslide inventory, Shear Test Sample Locations, Venice Quadrangle.

shear test sample location landslide

GROUP DELTA CONSULTANTS	**CGS Landslide Hazard Zone Map**	Project Number LA-962A Date: 11/9/2012
Group Delta Consultants. INC. 370 Amapola Ave. Torrance, Ca 90501	Ballona Creek Wetlands Restoration Project Marina Del Rey, CA	PLATE D-20

NavigateLA



GROUP DELTA CONSULTANTS	**Navigate LA – Faults Rupture Study Zones and Landslides**	Project Number LA-962A Date: 11/9/2012
	Group Delta Consultants. INC. 370 Amapola Ave. Torrance, Ca 90501	Ballona Creek Wetlands Restoration Project Marina Del Rey, CA	PLATE D-21

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APPENDIX E
LIQUEFACTION SETTLMENT AND LATERAL SPREADING

APPENDIX E
LIQUEFACTION SETTLEMENT AND LATERAL SPREADING

E.1 Contents

This appendix includes the results estimates of post liquefaction settlements within the site and lateral spreading displacements of the new levees.

Post liquefaction settlements were performed using the Youd et al. (2001) method for estimation of post liquefaction settlements using the results of the CPTs within the area. The analyses assume design earthquake parameters for a 224 year return period, and a design groundwater at El. +10 feet NAVD.

Lateral spreading displacements were estimated using Youd et al. (2002) method based on distances of about 300 and 1000 feet from the meander channel, as would be applicable for the new levees.

A list of the plates presented in this appendix follows:

Plate E-1 through E-29 Post-liquefaction Settlements based on CPTs
Plate E-30 and E-32 Range of Lateral Spreading Displacements for New Levees

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT001

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	17.80 ft
GWT Elev. During Test	0.30 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_\alpha$ —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 17.50 ft below ground surface
GWT Depth For Design, Zwd = 7.80 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 13.00 feet

Earthquake-Induced Settlements:

- Liquefaction-Induced Settlement = 1.15 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <— Dry or Unsaturated Sands

Total: 1.15 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	188.17	1.56	0.83	sand	16.8	1.66	62	60	60	60	0.95	1.00	1,798.77	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	105.9	0.007	0.000	0.00	1.15
1.50	26.63	0.92	3.47	clayey silt to silty clay	15.8	1.00	13	180	180	180	2.33	2.04	181.14	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.15
2.50	14.13	0.41	2.86	clayey silt to silty clay	14.8	1.00	7	300	300	300	2.54	3.00	109.37	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.15
3.50	14.38	0.42	2.90	clayey silt to silty clay	13.8	1.00	7	420	420	420	2.60	3.31	104.00	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.15
4.50	14.98	0.45	2.99	clayey silt to silty clay	12.8	1.00	7	540	540	540	2.53	2.91	116.59	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.15
5.50	12.13	0.32	2.64	clayey silt to silty clay	11.8	1.00	6	660	660	660	2.61	N/A	N/A	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.15
6.50	11.68	0.24	2.05	clayey silt to silty clay	10.8	1.00	6	780	780	780	2.61	N/A	N/A	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.15
7.50	9.53	0.24	2.49	silty clay to clay	9.8	1.00	6	900	900	900	2.77	N/A	N/A	0.983	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.15
8.50	16.22	0.24	1.45	sandy silt to clayey silt	8.8	1.00	6	1,020	976	1,020	2.52	2.90	67.23	0.980	1.000	0.213	0.108	0.678	YES	2.8	11.9	428	15.9	N/A	0.181	0.02	1.13
9.50	16.05	0.16	1.02	sandy silt to clayey silt	7.8	1.00	6	1,140	1,034	1,140	2.46	2.57	57.29	0.978	1.000	0.224	0.097	0.580	YES	2.8	11.3	389	15.2	N/A	0.457	0.05	1.07
10.50	11.43	0.23	2.03	clayey silt to silty clay	6.8	1.00	6	1,260	1,092	1,260	2.70	N/A	N/A	0.976	N/A	0.234	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
11.50	7.85	0.21	2.72	silty clay to clay	5.8	1.00	5	1,380	1,149	1,380	2.93	N/A	N/A	0.973	N/A	0.243	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
12.50	8.32	0.16	1.93	clayey silt to silty clay	4.8	1.00	4	1,500	1,207	1,500	2.84	N/A	N/A	0.971	N/A	0.251	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
13.50	8.00	0.18	2.22	silty clay to clay	3.8	1.00	5	1,620	1,264	1,620	2.91	N/A	N/A	0.969	N/A	0.258	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
14.50	20.03	0.56	2.79	clayey silt to silty clay	2.8	1.66	17	1,740	1,322	1,740	2.36	2.17	88.36	0.966	1.000	0.265	0.144	0.727	YES	2.8	20.6	1,200	N/A	N/A	0.000	0.00	1.07
15.50	7.27	0.25	3.49	clay	1.8	1.00	7	1,860	1,380	1,860	3.08	N/A	N/A	0.964	N/A	0.270	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
16.50	6.73	0.19	2.86	clay	0.8	1.00	7	1,980	1,437	1,980	3.08	N/A	N/A	0.962	N/A	0.276	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
17.50	5.28	0.13	2.54	clay	-0.2	1.00	5	2,100	1,495	2,100	3.16	N/A	N/A	0.959	N/A	0.280	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
18.50	4.67	0.08	1.75	sensitive fine grained	-1.2	1.00	2	2,220	1,552	2,158	3.14	N/A	N/A	0.957	N/A	0.285	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
19.50	5.08	0.03	0.50	sensitive fine grained	-2.2	1.00	3	2,340	1,610	2,215	2.88	5.52	33.03	0.955	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
20.50	10.00	0.07	0.66	sandy silt to clayey silt	-3.2	1.00	4	2,460	1,668	2,273	2.65	3.64	41.68	0.952	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
21.50	5.32	0.04	0.78	sensitive fine grained	-4.2	1.00	3	2,580	1,725	2,330	2.97	N/A	N/A	0.950	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
22.50	5.40	0.04	0.80	sensitive fine grained	-5.2	1.00	3	2,700	1,783	2,388	2.97	N/A	N/A	0.948	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
23.50	5.22	0.02	0.38	sensitive fine grained	-6.2	1.00	3	2,820	1,840	2,446	2.88	5.54	30.74	0.945	N/A	0.301	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
24.50	7.50	0.06	0.75	sensitive fine grained	-7.2	1.00	4	2,940	1,898	2,503	2.84	5.15	40.17	0.943	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
25.50	6.18	0.04	0.69	sensitive fine grained	-8.2	1.00	3	3,060	1,956	2,561	2.92	5.92	37.26	0.941	N/A	0.306	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
26.50	7.02	0.10	1.39	clayey silt to silty clay	-9.2	1.00	4	3,180	2,013	2,618	3.01	N/A	N/A	0.938	N/A	0.308	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
27.50	11.82	0.10	0.84	sandy silt to clayey silt	-10.2	1.00	5	3,300	2,071	2,676	2.70	3.97	45.75	0.936	N/A	0.310	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
28.50	23.13	0.11	0.47	silty sand to sandy silt	-11.2	1.00	8	3,420	2,128	2,734	2.31	2.00	44.77	0.934	0.988	0.312	0.087	0.369	YES	2.8	9.4	280	12.9	N/A	2.145	0.26	0.82
29.50	44.48	0.48	1.07	silty sand to sandy silt	-12.2	1.00	15	3,540	2,186	2,791	2.23	1.76	74.69	0.931	0.977	0.314	0.119	0.493	YES	2.8	15.4	712	20.1	N/A	1.114	0.13	0.68
30.50	89.57	1.30	1.45	silty sand to sandy silt	-13.2	1.00	30	3,660	2,244	2,849	2.08	1.41	119.58	0.926	0.958	0.314	0.239	0.972	YES	2.8	27.8	1,200	35.0	N/A	0.033	0.00	0.68
31.50	130.97	2.44	1.86	silty sand to sandy silt	-14.2	1.66	72	3,780	2,301	2,906	1.73	1.06	213.46	0.918	0.945	0.314	N/A	N/A	NO	N/A	N/A	N/A	77.0	N/A	0.000	0.00	0.68
32.50	19.67	0.63	3.21	clayey silt to silty clay	-15.2	1.66	16	3,900	2,359	2,964	2.53	2.93	84.19	0.909	0.956	0.313	0.135	0.552	YES	2.8	16.2	791	N/A	N/A	0.000	0.00	0.68
33.50	8.57	0.13	1.53	clayey silt to silty clay	-16.2	1.00	4	4,020	2,416	3,022	3.01	N/A	N/A	0.901	N/A	0.312	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
34.50	8.80	0.12	1.36	clayey silt to silty clay	-17.2	1.00	4	4,140	2,474	3,079	2.98	N/A	N/A	0.893	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
35.50	8.67	0.15	1.67	clayey silt to silty clay	-18.2	1.00	4	4,260	2,532	3,137	3.05	N/A	N/A	0.885	N/A	0.310	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
36.50	8.65	0.14	1.57	clayey silt to silty clay	-19.2	1.00	4	4,380	2,589	3,194	3.04	N/A	N/A	0.877	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
37.50	10.43	0.20	1.83	clayey silt to silty clay	-20.2	1.00	5	4,500	2,647	3,252	3.00	N/A	N/A	0.869	N/A	0.307	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
38.50	38.50	0.48	1.24	silty sand to sandy silt	-21.2	1.00	13	4,620	2,704	3,310	2.37	2.18	72.34	0.861	0.931	0.306	0.115	0.468	YES	2.8	12.8	493	17.0	N/A	1.529	0.18	0.49
39.50	191.38	3.04	1.59	sand to silty sand	-22.2	1.00	48	4,740	2,762	3,367	1.90	1.19	193.95	0.852	0.879	0.304	N/A	N/A	NO	N/A	N/A	N/A	41.1	N/A	0.000	0.00	0.49
40.50	199.73	4.30	2.15	silty sand to sandy silt	-23.2	1.00	67	4,860	2,820	3,425	1.99	1.29	217.34	0.844	0.872	0.303	N/A	N/A	NO	N/A	N/A	N/A	66.1	N/A	0.000	0.00	0.49
41.50	101.99	2.26	2.21	silty sand to sandy silt	-24.2	1.66	56	4,980	2,877	3,482	1.89	1.18	166.16	0.836	0.865	0.301	N/A	N/A	NO	N/A	N/A	N/A	56.2	N/A	0.000	0.00	0.49
42.50	27.32	0.36	1.33	sandy silt to clayey silt	-25.2	1.00	11	5,100	2,935	3,540	2.57	3.12	63.93	0.828	0.921	0.299	0.104	0.428	YES	2.8	11.0	371	14.9	N/A	1.840	0.22	0.27
43.50	18.42	0.37	1.98	sandy silt to clayey silt	-26.2	1.00	7	5,220	2,992	3,598	2.82	N/A	N/A	0.820	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
44.50	14.42	0.34	2.34	clayey silt to silty clay	-27.2	1.00	7	5,340	3,050	3,655	2.97	N/A	N/A	0.812	N/A	0.296	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
45.50	14.82	0.58	3.87	silty clay to clay	-28.2	1.00	10	5,460	3,107	3,713	3.09	N/A	N/A	0.804	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
46.50	13.62	0.41	2.96	clayey silt to silty clay	-29.2	1.00	7	5,580	3,165	3,770	3.07	N/A	N/A	0.795	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
47.50	22.00	1.06	4.77	clay	-30.2	1.00	22	5,700	3,223	3,828	3.01	N/A	N/A	0.787	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
48.50	16.22	0.84	5.11	clay	-31.2	1.00	16	5,820	3,280	3,886	3.15	N/A	N/A	0.779	N/A	0.288	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
49.50	22.52	0.76	3.35	clayey silt to silty clay	-32.2	1.00	11	5,940	3,338	3,943	2.91	N/A	N/A	0.771	N/A	0.285	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
50.50	41.47	1.96	4.69	silty clay to clay	-33.2	1.00	28	6,060	3,395	4,001	2.79	N/A	N/A	0.763	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
51.50	49.78	1.18	2.35	sandy silt to clayey silt	-34.2	1.66	33	6,180	3,453	4,058	2.18	1.61	100.86	0.755	0.821	0.281	0.175	0.684	YES	2.8	25.9	1,200	32.8	N/A	0.041	0.00	0.27
52.50	21.00	0.58	2.73	clayey silt to silty clay	-35.2	1.00	11	6,300	3,511	4,116	2.90	N/A	N/A	0.747	N/A	0.279	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
53.50	29.18	1.03	3.51	clayey silt to silty clay	-36.2	1.00	15	6,420	3,568	4,174	2.85	N/A	N/A	0.739	N/A	0.276	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
54.50	19.02	0.68	3.53	silty clay to clay	-37.2	1.00	13	6,540	3,626	4,231	3.02	N/A	N/A	0.730	N/A	0.274	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
55.50	13.17	0.35	2.65	clayey silt to silty clay	-38.2	1.00	7	6,660	3,683	4,289	3.11	N/A	N/A	0.722	N/A	0.272	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
56.50	14.05	0.36	2.52	clayey silt to silty clay	-39.2	1.00	7	6,780	3,741	4,346	3.07	N/A	N/A	0.714	N/A	0.269	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
57.50	15.17	0.34	2.20	clayey silt to silty clay	-40.2	1.00	8	6,900	3,799	4,404	3.01	N/A	N/A	0.706	N/A	0.267	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
58.50	52.13	0.95	1.82	silty sand to sandy silt	-41.2	1.00	17	7,020	3,856	4,462	2.48	2.67	85.15	0.698	0.845	0.264	0.137	0.587	YES	2.8	14.4	629	19.0	N/A	0.289	0.03	0.23
59.50	92.83	0.93	1.00	sand to silty sand	-42.2	1.00	23	7,140	3,914	4,519	2.06	1.39	92.21	0.690	0.820	0.262	0.153	0.640	YES	1.3	16.8	850	18.7	N/A	0.308	0.04	0.20
60.50	72.43	0.70	0.96	sand to silty sand	-43.2	1.00	18	7,260	3,971	4,577	2.14	1.54	79.08	0.682	0.837	0.259	0.126	0.543	YES	1.3	13.3	534	15.0	N/A	1.643	0.20	0.00

max= 1,200
min= 280
avg= 698

PLATE E-1

CPT001
Output Sheet

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT004

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	17.00 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_w	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	17.00 ft below ground surface
GWT Depth For Design, Zwd =	7.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	21.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	1.14 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	1.14 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	47.68	1.31	2.74	sandy silt to clayey silt	16.0	1.66	32	60	60	60	1.65	1.00	457.98	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	69.4	N/A	N/A	N/A	1.14
1.50	23.57	0.89	3.79	silty clay to clay	15.0	1.66	26	180	180	180	2.08	1.42	185.19	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
2.50	6.97	0.29	4.12	clay	14.0	1.00	7	300	300	300	2.73	N/A	N/A	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
3.50	11.33	0.53	4.72	clay	13.0	1.66	19	420	420	420	2.50	2.78	113.99	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
4.50	4.33	0.22	5.12	clay	12.0	1.00	4	540	540	540	3.10	N/A	N/A	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
5.50	6.90	0.24	3.46	clay	11.0	1.00	7	660	660	660	2.88	N/A	N/A	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
6.50	7.58	0.26	3.36	clay	10.0	1.00	8	780	780	780	2.89	N/A	N/A	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
7.50	8.62	0.34	3.88	clay	9.0	1.00	9	900	869	900	2.91	N/A	N/A	0.983	N/A	0.212	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
8.50	6.52	0.23	3.44	clay	8.0	1.00	7	1,020	926	1,020	3.00	N/A	N/A	0.980	N/A	0.224	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
9.50	12.68	0.14	1.07	sandy silt to clayey silt	7.0	1.00	5	1,140	984	1,140	2.55	3.05	55.17	0.978	1.000	0.236	0.096	0.541	YES	2.8	9.5	286	13.1	N/A	2.037	0.24	0.90
10.50	30.49	0.28	0.91	silty sand to sandy silt	6.0	1.66	17	1,260	1,042	1,260	1.89	1.18	82.51	0.976	1.000	0.245	0.132	0.719	YES	2.8	24.0	1,200	30.4	N/A	0.048	0.01	0.89
11.50	8.35	0.13	1.58	clayey silt to silty clay	5.0	1.66	7	1,380	1,099	1,380	2.52	2.85	53.17	0.973	1.000	0.254	0.094	0.493	YES	2.8	11.1	378	N/A	N/A	0.000	0.00	0.89
12.50	4.17	0.06	1.44	sensitive fine grained	4.0	1.00	2	1,500	1,157	1,500	3.05	N/A	N/A	0.971	N/A	0.262	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.89
13.50	9.82	0.27	2.73	silty clay to clay	3.0	1.00	7	1,620	1,214	1,620	2.87	N/A	N/A	0.969	N/A	0.269	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.89
14.50	8.78	0.31	3.53	clay	2.0	1.00	9	1,740	1,272	1,740	2.99	N/A	N/A	0.966	N/A	0.275	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.89
15.50	16.15	0.37	2.31	clayey silt to silty clay	1.0	1.66	13	1,860	1,330	1,860	2.39	2.28	74.81	0.964	1.000	0.280	0.119	0.566	YES	2.8	16.7	839	N/A	N/A	0.000	0.00	0.89
16.50	8.07	0.22	2.77	silty clay to clay	0.0	1.00	5	1,980	1,387	1,980	2.99	N/A	N/A	0.962	N/A	0.285	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.89
17.50	7.65	0.19	2.48	silty clay to clay	-1.0	1.00	5	2,100	1,445	2,069	2.99	N/A	N/A	0.959	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.89
18.50	30.60	0.35	1.15	silty sand to sandy silt	-2.0	1.00	10	2,220	1,502	2,126	2.32	2.01	70.98	0.957	1.000	0.294	0.113	0.514	YES	2.8	12.7	487	16.9	N/A	1.496	0.18	0.71
19.50	36.17	0.34	0.95	silty sand to sandy silt	-3.0	1.00	12	2,340	1,560	2,184	2.22	1.71	70.01	0.955	1.000	0.298	0.112	0.501	YES	2.8	14.3	621	18.8	N/A	1.198	0.14	0.57
20.50	69.24	1.21	1.75	silty sand to sandy silt	-4.0	1.00	23	2,460	1,618	2,242	2.16	1.58	121.38	0.952	1.000	0.301	0.246	1.091	YES	2.8	24.6	1,200	31.2	N/A	0.055	0.01	0.56
21.50	68.00	1.06	1.56	silty sand to sandy silt	-5.0	1.00	23	2,580	1,675	2,299	2.14	1.53	113.79	0.950	1.000	0.304	0.217	0.952	YES	2.8	23.9	1,200	30.4	N/A	0.061	0.01	0.56
22.50	60.93	1.00	1.64	silty sand to sandy silt	-6.0	1.00	20	2,700	1,733	2,357	2.20	1.66	108.51	0.948	1.000	0.307	0.199	0.864	YES	2.8	21.5	1,200	27.5	N/A	0.080	0.01	0.55
23.50	88.15	1.53	1.73	silty sand to sandy silt	-7.0	1.00	29	2,820	1,790	2,414	2.10	1.45	135.18	0.945	1.000	0.310	0.310	1.335	NO	N/A	N/A	N/A	37.1	N/A	0.019	0.00	0.54
24.50	52.98	0.85	1.61	silty sand to sandy silt	-8.0	1.66	29	2,940	1,848	2,472	1.94	1.23	111.97	0.943	1.000	0.312	0.211	0.900	YES	2.8	29.1	1,200	36.6	N/A	0.022	0.00	0.54
25.50	21.53	0.37	1.73	sandy silt to clayey silt	-9.0	1.66	14	3,060	1,906	2,530	2.29	1.90	69.48	0.941	1.000	0.314	0.111	0.472	YES	2.8	15.5	725	20.2	N/A	1.095	0.13	0.41
26.50	6.75	0.17	2.42	silty clay to clay	-10.0	1.00	5	3,180	1,963	2,587	3.15	N/A	N/A	0.938	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
27.50	6.00	0.10	1.59	sensitive fine grained	-11.0	1.00	3	3,300	2,021	2,645	3.12	N/A	N/A	0.936	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
28.50	7.28	0.18	2.44	silty clay to clay	-12.0	1.00	5	3,420	2,078	2,702	3.14	N/A	N/A	0.934	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
29.50	7.20	0.18	2.42	silty clay to clay	-13.0	1.00	5	3,540	2,136	2,760	3.15	N/A	N/A	0.931	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
30.50	6.15	0.15	2.42	silty clay to clay	-14.0	1.00	4	3,660	2,194	2,818	3.24	N/A	N/A	0.926	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
31.50	6.23	0.12	1.89	silty clay to clay	-15.0	1.00	4	3,780	2,251	2,875	3.18	N/A	N/A	0.918	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
32.50	6.70	0.09	1.29	sensitive fine grained	-16.0	1.00	3	3,900	2,309	2,933	3.08	N/A	N/A	0.909	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
33.50	6.95	0.15	2.05	silty clay to clay	-17.0	1.00	5	4,020	2,366	2,990	3.17	N/A	N/A	0.901	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
34.50	6.75	0.15	2.04	silty clay to clay	-18.0	1.00	5	4,140	2,424	3,048	3.20	N/A	N/A	0.893	N/A	0.317	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
35.50	6.78	0.13	1.83	silty clay to clay	-19.0	1.00	5	4,260	2,482	3,106	3.19	N/A	N/A	0.885	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
36.50	7.58	0.18	2.16	silty clay to clay	-20.0	1.00	5	4,380	2,539	3,163	3.18	N/A	N/A	0.877	N/A	0.315	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
37.50	23.82	0.77	3.19	clayey silt to silty clay	-21.0	1.00	12	4,500	2,597	3,221	2.81	N/A	N/A	0.869	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
38.50	52.55	0.94	1.78	silty sand to sandy silt	-22.0	1.00	18	4,620	2,654	3,278	2.34	2.10	95.85	0.861	0.924	0.312	0.162	0.641	YES	2.8	16.5	821	21.4	N/A	0.405	0.05	0.36
39.50	113.20	1.99	1.76	silty sand to sandy silt	-23.0	1.00	38	4,740	2,712	3,336	2.09	1.44	139.83	0.852	0.885	0.310	0.334	1.274	YES	2.8	32.0	1,200	40.1	N/A	0.000	0.00	0.36
40.50	107.65	2.25	2.09	silty sand to sandy silt	-24.0	1.66	59	4,860	2,770	3,394	1.85	1.15	173.58	0.844	0.878	0.308	N/A	N/A	NO	N/A	N/A	N/A	59.7	N/A	0.000	0.00	0.36
41.50	35.81	0.76	2.12	sandy silt to clayey silt	-25.0	1.66	24	4,980	2,827	3,451	2.23	1.73	86.33	0.836	0.896	0.306	0.140	0.545	YES	2.8	20.9	1,200	26.7	N/A	0.085	0.01	0.35
42.50	10.73	0.36	3.36	silty clay to clay	-26.0	1.00	7	5,100	2,885	3,509	3.17	N/A	N/A	0.828	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.35
43.50	11.28	0.31	2.74	silty clay to clay	-27.0	1.00	8	5,220	2,942	3,566	3.10	N/A	N/A	0.820	N/A	0.303	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.35
44.50	9.95	0.30	3.01	silty clay to clay	-28.0	1.00	7	5,340	3,000	3,624	3.19	N/A	N/A	0.812	N/A	0.301	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.35
45.50	9.13	0.26	2.81	silty clay to clay	-29.0	1.00	6	5,460	3,058	3,682	3.22	N/A	N/A	0.804	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.35
46.50	11.53	0.39	3.28	silty clay to clay	-30.0	1.00	8	5,580	3,115	3,739	3.16	N/A	N/A	0.795	N/A	0.296	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.35
47.50	13.92	0.58	4.11	clay	-31.0	1.00	14	5,700	3,173	3,797	3.15	N/A	N/A	0.787	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.35
48.50	12.18	0.49	3.93	clay	-32.0	1.00	12	5,820	3,230	3,854	3.20	N/A	N/A	0.779	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.35
49.50	14.30	0.49	3.36	silty clay to clay	-33.0	1.00	10	5,940	3,288	3,912	3.09	N/A	N/A	0.771	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.35
50.50	41.67	0.92	2.20	sandy silt to clayey silt	-34.0	1.00	17	6,060	3,346	3,970	2.57	3.17	89.70	0.763	0.876	0.287	0.147	0.598	YES	2.8	14.6	647	19.2	N/A	1.029	0.12	0.23
51.50	63.07	1.52	2.40	sandy silt to clayey silt	-35.0	1.00	25	6,180	3,403	4,027	2.41	2.36	114.32	0.755	0.845	0.285	0.219	0.866	YES	2.8	20.6	1,200	26.3	N/A	0.080	0.01	0.22
52.50	82.49	1.60	1.94	silty sand to sandy silt	-36.0	1.00	27	6,300	3,461	4,085	2.26	1.84	115.25	0.747	0.835	0.283	0.222	0.876	YES	2.8	22.0	1,200	28.1	N/A	0.069	0.01	0.21
53.50	57.45	1.35	2.34	sandy silt to clayey silt	-37.0	1.66	38	6,420	3,518	4,142	2.13	1.51	108.12	0.739	0.804	0.280	0.198	0.756	YES	2.8	29.2	1,200	36.7	N/A	0.019	0.00	0.21
54.50	17.78	0.62	3.43	silty clay to clay	-38.0	1.00	12	6,540	3,576	4,200	3.04	N/A	N/A	0.730	N/A	0.278	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
55.50	24.25	0.60	2.42	sandy silt to clayey silt	-39.0	1.00	10	6,660	3,634	4,258	2.83	N/A	N/A	0.722	N/A	0.275	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
56.50	24.97	0.58	2.30	sandy silt to clayey silt	-40.0	1.00	10	6,780	3,691	4,315	2.81	N/A	N/A	0.714	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
57.50	75.28	0.93	1.24	sand to silty sand	-41.0	1.00	19	6,900	3,749	4,373	2.18	1.63	89.52	0.706	0.845	0.270	0.147	0.612	YES	1.3	14.1	597	15.8	N/A	1.532	0.18	0.02
58.50	102.48	1.58	1.54	silty sand to sandy silt	-42.0	1.00	34	7,020	3,806	4,430	2.14	1.53	113.99	0.698	0.794	0.268	0.218	0.861	YES	2.8	25.8	1,200	32.5	N/A	0.041	0.00	0.02
59.50	157.78	1.25	0.79	sand	-43.0	1.00	32	7,140	3,864	4,488	1.81	1.11	126.41	0.690	0.797	0.265	0.268	1.075	YES	0.0	21.1	1,200	21.1	N/A	0.119	0.01	0.00
60.50	175.23	2.32	1.32	sand to silty sand	-44.0	1.00	44	7,260	3,922	4,546	1.93	1.21	151.90	0.682	0.764	0.262	0.406	1.577	NO	N/A	N/A	N/A	33.0	N/A	0.038	0.00	0.00

max= 1,200
min= 286
avg= 943

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT007

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	15.30 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_w	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ CSR = 0.65 A_{max} (σ_v/σ_v') r_d

+++ FS = ($CRR_{7.5}$/CSR) MSF K_σ $K_{\alpha \to >>}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	15.30 ft below ground surface
GWT Depth For Design, Zwd =	5.30 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	13.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	1.06 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	1.06 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{t1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	16.44	0.03	0.19	silty sand to sandy silt	14.3	1.00	5	60	60	60	1.57	1.00	94.92	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	16.2	0.012	0.026	0.00	1.06
1.50	19.10	0.11	0.60	sandy silt to clayey silt	13.3	1.00	8	180	180	180	1.94	1.23	78.40	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	20.6	N/A	N/A	N/A	1.06
2.50	12.52	0.28	2.26	clayey silt to silty clay	12.3	1.00	6	300	300	300	2.52	2.85	92.24	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.06
3.50	11.08	0.28	2.55	clayey silt to silty clay	11.3	1.00	6	420	420	420	2.52	2.87	102.38	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.06
4.50	9.28	0.27	2.96	silty clay to clay	10.3	1.00	6	540	540	540	2.69	N/A	N/A	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.06
5.50	33.18	0.72	2.18	sandy silt to clayey silt	9.3	1.00	13	660	648	660	2.31	1.99	116.03	0.987	1.000	0.209	0.225	1.436	NO	N/A	N/A	N/A	32.1	N/A	0.034	0.00	1.06
6.50	76.04	0.47	0.62	sand to silty sand	8.3	1.00	19	780	705	780	1.70	1.04	132.89	0.985	1.000	0.227	0.298	1.756	NO	N/A	N/A	N/A	34.4	N/A	0.026	0.00	1.05
7.50	50.91	0.33	0.64	sand to silty sand	7.3	1.00	13	900	763	900	1.87	1.16	95.44	0.983	1.000	0.241	0.161	0.890	YES	1.3	20.3	1,200	22.4	N/A	0.086	0.01	1.04
8.50	29.77	0.19	0.64	silty sand to sandy silt	6.3	1.66	16	1,020	820	1,020	1.78	1.00	76.97	0.980	1.000	0.254	0.122	0.644	YES	2.8	25.8	1,200	32.6	N/A	0.038	0.00	1.04
9.50	9.00	0.07	0.74	clayey silt to silty clay	5.3	1.66	7	1,140	878	1,140	2.29	1.00	22.49	0.978	1.000	0.264	0.069	0.347	YES	2.8	12.7	485	N/A	N/A	0.000	0.00	1.04
10.50	2.65	0.03	1.06	sensitive fine grained	4.3	1.00	1	1,260	936	1,260	3.11	N/A	N/A	0.976	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
11.50	2.58	0.03	0.98	sensitive fine grained	3.3	1.00	1	1,380	993	1,380	3.13	N/A	N/A	0.973	N/A	0.281	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
12.50	2.45	0.02	0.86	sensitive fine grained	2.3	1.00	1	1,500	1,051	1,500	3.16	N/A	N/A	0.971	N/A	0.288	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
13.50	2.50	0.02	0.80	sensitive fine grained	1.3	1.00	1	1,620	1,108	1,620	3.16	N/A	N/A	0.969	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
14.50	2.73	0.03	0.98	sensitive fine grained	0.3	1.00	1	1,740	1,166	1,740	3.18	N/A	N/A	0.966	N/A	0.300	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
15.50	4.39	0.10	2.16	clay	-0.7	1.00	4	1,860	1,224	1,848	3.14	N/A	N/A	0.964	N/A	0.305	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
16.50	5.58	0.12	2.08	silty clay to clay	-1.7	1.00	4	1,980	1,281	1,905	3.05	N/A	N/A	0.962	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
17.50	6.02	0.11	1.77	silty clay to clay	-2.7	1.00	4	2,100	1,339	1,963	2.99	N/A	N/A	0.959	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
18.50	6.98	0.15	2.17	silty clay to clay	-3.7	1.00	5	2,220	1,396	2,020	2.99	N/A	N/A	0.957	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
19.50	30.45	0.28	0.93	silty sand to sandy silt	-4.7	1.00	10	2,340	1,454	2,078	2.26	1.84	65.63	0.955	1.000	0.320	0.106	0.444	YES	2.8	12.8	492	16.9	N/A	1.576	0.19	0.85
20.50	20.71	0.11	0.52	silty sand to sandy silt	-5.7	1.66	11	2,460	1,512	2,136	2.01	1.00	39.44	0.952	1.000	0.322	0.083	0.343	YES	2.8	13.9	580	18.3	N/A	1.406	0.17	0.68
21.50	8.18	0.08	0.96	clayey silt to silty clay	-6.7	1.00	4	2,580	1,569	2,193	2.79	N/A	N/A	0.950	N/A	0.325	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
22.50	4.65	0.05	1.17	sensitive fine grained	-7.7	1.00	2	2,700	1,627	2,251	3.09	N/A	N/A	0.948	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
23.50	5.25	0.11	2.18	silty clay to clay	-8.7	1.00	3	2,820	1,684	2,308	3.18	N/A	N/A	0.945	N/A	0.329	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
24.50	5.40	0.07	1.35	sensitive fine grained	-9.7	1.00	3	2,940	1,742	2,366	3.08	N/A	N/A	0.943	N/A	0.331	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
25.50	5.46	0.07	1.28	sensitive fine grained	-10.7	1.00	3	3,060	1,800	2,424	3.07	N/A	N/A	0.941	N/A	0.333	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
26.50	5.81	0.07	1.19	sensitive fine grained	-11.7	1.00	3	3,180	1,857	2,481	3.04	N/A	N/A	0.938	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
27.50	6.76	0.11	1.67	silty clay to clay	-12.7	1.00	5	3,300	1,915	2,539	3.06	N/A	N/A	0.936	N/A	0.335	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
28.50	6.52	0.13	1.97	silty clay to clay	-13.7	1.00	4	3,420	1,972	2,596	3.12	N/A	N/A	0.934	N/A	0.337	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
29.50	5.42	0.07	1.34	sensitive fine grained	-14.7	1.00	3	3,540	2,030	2,654	3.13	N/A	N/A	0.931	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
30.50	6.22	0.12	1.91	silty clay to clay	-15.7	1.00	4	3,660	2,088	2,712	3.16	N/A	N/A	0.926	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
31.50	6.14	0.09	1.45	sensitive fine grained	-16.7	1.00	3	3,780	2,145	2,769	3.11	N/A	N/A	0.918	N/A	0.336	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
32.50	6.06	0.06	1.02	sensitive fine grained	-17.7	1.00	3	3,900	2,203	2,827	3.06	N/A	N/A	0.909	N/A	0.335	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
33.50	6.77	0.11	1.55	clayey silt to silty clay	-18.7	1.00	3	4,020	2,260	2,884	3.10	N/A	N/A	0.901	N/A	0.333	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
34.50	7.52	0.15	1.93	silty clay to clay	-19.7	1.00	5	4,140	2,318	2,942	3.11	N/A	N/A	0.893	N/A	0.332	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
35.50	7.49	0.13	1.67	clayey silt to silty clay	-20.7	1.00	4	4,260	2,376	3,000	3.09	N/A	N/A	0.885	N/A	0.330	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
36.50	8.44	0.12	1.40	clayey silt to silty clay	-21.7	1.00	4	4,380	2,433	3,057	3.01	N/A	N/A	0.877	N/A	0.328	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
37.50	11.92	0.22	1.82	clayey silt to silty clay	-22.7	1.00	6	4,500	2,491	3,115	2.92	N/A	N/A	0.869	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
38.50	8.47	0.21	2.43	silty clay to clay	-23.7	1.00	6	4,620	2,548	3,172	3.15	N/A	N/A	0.861	N/A	0.325	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
39.50	11.67	0.26	2.18	clayey silt to silty clay	-24.7	1.00	6	4,740	2,606	3,230	2.99	N/A	N/A	0.852	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
40.50	15.56	0.47	3.01	clayey silt to silty clay	-25.7	1.00	8	4,860	2,664	3,288	2.96	N/A	N/A	0.844	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
41.50	18.32	0.48	2.62	clayey silt to silty clay	-26.7	1.00	9	4,980	2,721	3,345	2.87	N/A	N/A	0.836	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
42.50	11.54	0.34	2.96	silty clay to clay	-27.7	1.00	8	5,100	2,779	3,403	3.09	N/A	N/A	0.828	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
43.50	12.07	0.29	2.37	clayey silt to silty clay	-28.7	1.00	6	5,220	2,836	3,460	3.03	N/A	N/A	0.820	N/A	0.314	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
44.50	9.54	0.26	2.71	silty clay to clay	-29.7	1.00	6	5,340	2,894	3,518	3.17	N/A	N/A	0.812	N/A	0.312	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
45.50	29.99	0.36	1.21	silty sand to sandy silt	-30.7	1.00	10	5,460	2,951	3,575	2.51	2.82	63.10	0.804	0.923	0.309	0.103	0.412	YES	2.8	10.3	327	14.0	N/A	1.982	0.24	0.44
46.50	23.30	0.36	1.53	sandy silt to clayey silt	-31.7	1.66	15	5,580	3,009	3,633	2.32	2.01	63.22	0.795	0.902	0.307	0.103	0.406	YES	2.8	14.2	613	18.7	N/A	1.268	0.15	0.29
47.50	10.97	0.28	2.52	clayey silt to silty clay	-32.7	1.00	5	5,700	3,067	3,691	3.11	N/A	N/A	0.787	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
48.50	9.54	0.25	2.65	silty clay to clay	-33.7	1.00	6	5,820	3,124	3,748	3.19	N/A	N/A	0.779	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
49.50	10.15	0.23	2.22	clayey silt to silty clay	-34.7	1.00	5	5,940	3,182	3,806	3.13	N/A	N/A	0.771	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
50.50	11.77	0.34	2.88	silty clay to clay	-35.7	1.00	8	6,060	3,239	3,863	3.13	N/A	N/A	0.763	N/A	0.297	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
51.50	11.06	0.27	2.45	clayey silt to silty clay	-36.7	1.00	6	6,180	3,297	3,921	3.13	N/A	N/A	0.755	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
52.50	15.43	0.94	6.10	clay	-37.7	1.00	15	6,300	3,355	3,979	3.23	N/A	N/A	0.747	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
53.50	22.38	0.45	2.01	sandy silt to clayey silt	-38.7	1.00	9	6,420	3,412	4,036	2.79	N/A	N/A	0.739	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
54.50	64.20	1.09	1.71	silty sand to sandy silt	-39.7	1.00	21	6,540	3,470	4,094	2.31	1.99	97.02	0.730	0.852	0.286	0.165	0.655	YES	2.8	17.8	950	22.9	N/A	0.101	0.01	0.28
55.50	137.03	1.24	0.91	sand	-40.7	1.00	27	6,660	3,527	4,151	1.88	1.17	120.69	0.722	0.831	0.284	0.243	0.951	YES	0.0	19.0	1,083	19.0	N/A	1.011	0.12	0.16
56.50	176.53	1.32	0.75	sand	-41.7	1.66	58	6,780	3,585	4,209	1.43	1.00	218.31	0.714	0.792	0.281	N/A	N/A	NO	N/A	N/A	N/A	40.3	N/A	0.000	0.00	0.16
57.50	49.22	0.61	1.23	silty sand to sandy silt	-42.7	1.00	16	6,900	3,643	4,267	2.33	2.06	75.16	0.706	0.860	0.278	0.119	0.493	YES	2.8	14.0	595	18.5	N/A	1.041	0.12	0.03
58.50	112.23	0.91	0.81	sand to silty sand	-43.7	1.00	28	7,020	3,700	4,324	1.93	1.22	100.36	0.698	0.817	0.275	0.174	0.689	YES	1.3	20.4	1,200	22.5	N/A	0.098	0.01	0.02
59.50	87.65	1.27	1.45	silty sand to sandy silt	-44.7	1.00	29	7,140	3,758	4,382	2.17	1.60	102.62	0.690	0.810	0.273	0.180	0.716	YES	2.8	22.5	1,200	28.7	N/A	0.063	0.01	0.01
60.50	65.28	0.75	1.15	silty sand to sandy silt	-45.7	1.00	22	7,260	3,815	4,439	2.22	1.72	81.12	0.682	0.831	0.270	0.130	0.533	YES	2.8	17.4	914	22.5	N/A	0.096	0.01	0.00

max= 1,200
min= 327
avg= 834

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT010

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	16.00 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

\+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ CSR = 0.65 A_{max} (σ_v/σ_v') r_d

+++ FS = $(CRR_{7.5}/CSR)$ MSF K_σ K_{α} —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 16.00 ft below ground surface
GWT Depth For Design, Zwd = 6.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 13.00 feet
Earthquake-Induced Settlements:
- Liquefaction-Induced Settlement = 1.32 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <— Dry or Unsaturated Sands

Total: 1.32 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	42.96	0.29	0.68	silty sand to sandy silt	15.0	1.00	14	60	60	60	1.51	1.00	248.00	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	34.2	0.009	0.008	0.00	1.32
1.50	31.23	0.10	0.32	silty sand to sandy silt	14.0	1.00	10	180	180	180	1.62	1.00	104.11	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	26.2	0.018	0.022	0.00	1.32
2.50	21.15	0.16	0.75	sandy silt to clayey silt	13.0	1.00	8	300	300	300	2.05	1.37	75.04	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	22.3	N/A	N/A	N/A	1.32
3.50	38.51	0.47	1.23	silty sand to sandy silt	12.0	1.66	21	420	420	420	1.72	1.05	146.04	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	48.4	0.022	0.000	0.00	1.32
4.50	17.39	0.49	2.80	clayey silt to silty clay	11.0	1.00	9	540	540	540	2.57	3.13	104.68	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.32
5.50	39.93	0.37	0.92	silty sand to sandy silt	10.0	1.66	22	660	660	660	1.71	1.04	120.12	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	50.0	0.027	0.000	0.00	1.32
6.50	15.32	0.40	2.60	clayey silt to silty clay	9.0	1.00	8	780	749	780	2.56	3.11	99.47	0.985	1.000	0.213	0.172	1.073	YES	2.8	15.1	686	N/A	N/A	0.000	0.00	1.32
7.50	25.22	0.25	1.00	silty sand to sandy silt	8.0	1.66	14	900	806	900	1.93	1.22	80.40	0.983	1.000	0.228	0.128	0.751	YES	2.8	23.5	1,200	29.9	N/A	0.047	0.01	1.32
8.50	5.77	0.12	2.13	silty clay to clay	7.0	1.00	4	1,020	864	1,020	2.91	N/A	N/A	0.980	N/A	0.241	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.32
9.50	3.40	0.05	1.34	sensitive fine grained	6.0	1.00	2	1,140	922	1,140	3.04	N/A	N/A	0.978	N/A	0.252	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.32
10.50	6.97	0.27	3.81	clay	5.0	1.00	7	1,260	979	1,260	3.02	N/A	N/A	0.976	N/A	0.261	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.32
11.50	8.93	0.24	2.71	silty clay to clay	4.0	1.00	6	1,380	1,037	1,380	2.86	N/A	N/A	0.973	N/A	0.269	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.32
12.50	32.10	0.23	0.70	silty sand to sandy silt	3.0	1.66	18	1,500	1,094	1,500	1.83	1.00	71.85	0.971	1.000	0.277	0.114	0.552	YES	2.8	23.3	1,200	29.5	N/A	0.059	0.01	1.31
13.50	15.59	0.18	1.15	sandy silt to clayey silt	2.0	1.00	6	1,620	1,152	1,620	2.52	2.87	59.03	0.969	1.000	0.283	0.099	0.467	YES	2.8	9.7	297	13.3	N/A	2.083	0.25	1.06
14.50	19.87	0.25	1.24	sandy silt to clayey silt	1.0	1.66	13	1,740	1,210	1,740	2.15	1.55	65.57	0.966	1.000	0.289	0.106	0.490	YES	2.8	16.9	864	21.9	N/A	0.160	0.02	1.04
15.50	9.47	0.15	1.62	clayey silt to silty clay	0.0	1.00	5	1,860	1,267	1,860	2.77	N/A	N/A	0.964	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
16.50	4.99	0.10	2.00	silty clay to clay	-1.0	1.00	3	1,980	1,325	1,949	3.09	N/A	N/A	0.962	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
17.50	24.30	0.16	0.67	silty sand to sandy silt	-2.0	1.00	8	2,100	1,382	2,006	2.27	1.86	54.25	0.959	1.000	0.303	0.095	0.418	YES	2.8	10.9	363	14.7	N/A	1.869	0.22	0.82
18.50	19.55	0.17	0.87	sandy silt to clayey silt	-3.0	1.00	8	2,220	1,440	2,064	2.42	2.39	54.97	0.957	1.000	0.307	0.095	0.415	YES	2.8	10.5	340	14.2	N/A	1.942	0.23	0.58
19.50	17.39	0.13	0.76	sandy silt to clayey silt	-4.0	1.00	7	2,340	1,498	2,122	2.44	2.50	50.27	0.955	1.000	0.310	0.092	0.395	YES	2.8	9.6	288	13.1	N/A	2.115	0.25	0.33
20.50	25.65	0.15	0.57	silty sand to sandy silt	-5.0	1.66	14	2,460	1,555	2,179	1.95	1.00	48.15	0.952	1.000	0.313	0.090	0.384	YES	2.8	16.4	809	21.3	N/A	0.456	0.05	0.27
21.50	5.06	0.08	1.65	sensitive fine grained	-6.0	1.00	3	2,580	1,613	2,237	3.12	N/A	N/A	0.950	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
22.50	5.09	0.08	1.50	sensitive fine grained	-7.0	1.00	3	2,700	1,670	2,294	3.11	N/A	N/A	0.948	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
23.50	5.91	0.10	1.73	silty clay to clay	-8.0	1.00	4	2,820	1,728	2,352	3.08	N/A	N/A	0.945	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
24.50	5.47	0.07	1.29	sensitive fine grained	-9.0	1.00	3	2,940	1,786	2,410	3.07	N/A	N/A	0.943	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
25.50	6.18	0.10	1.67	silty clay to clay	-10.0	1.00	4	3,060	1,843	2,467	3.08	N/A	N/A	0.941	N/A	0.325	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
26.50	5.54	0.09	1.54	sensitive fine grained	-11.0	1.00	3	3,180	1,901	2,525	3.12	N/A	N/A	0.938	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
27.50	5.63	0.11	1.91	silty clay to clay	-12.0	1.00	4	3,300	1,958	2,582	3.17	N/A	N/A	0.936	N/A	0.328	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
28.50	5.80	0.09	1.48	sensitive fine grained	-13.0	1.00	3	3,420	2,016	2,640	3.12	N/A	N/A	0.934	N/A	0.329	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
29.50	6.12	0.07	1.08	sensitive fine grained	-14.0	1.00	3	3,540	2,074	2,698	3.04	N/A	N/A	0.931	N/A	0.331	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
30.50	8.23	0.23	2.74	silty clay to clay	-15.0	1.00	5	3,660	2,131	2,755	3.12	N/A	N/A	0.926	N/A	0.331	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
31.50	9.70	0.29	3.03	silty clay to clay	-16.0	1.00	6	3,780	2,189	2,813	3.09	N/A	N/A	0.918	N/A	0.330	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
32.50	29.05	0.64	2.21	sandy silt to clayey silt	-17.0	1.66	19	3,900	2,246	2,870	2.27	1.85	84.04	0.909	0.966	0.328	0.135	0.530	YES	2.8	18.9	1,066	24.3	N/A	0.159	0.02	0.26
33.50	9.35	0.24	2.61	silty clay to clay	-18.0	1.00	6	4,020	2,304	2,928	3.08	N/A	N/A	0.901	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.26
34.50	10.28	0.35	3.41	silty clay to clay	-19.0	1.00	7	4,140	2,362	2,986	3.12	N/A	N/A	0.893	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.26
35.50	10.39	0.34	3.27	silty clay to clay	-20.0	1.00	7	4,260	2,419	3,043	3.11	N/A	N/A	0.885	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.26
36.50	9.21	0.29	3.14	silty clay to clay	-21.0	1.00	6	4,380	2,477	3,101	3.16	N/A	N/A	0.877	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.26
37.50	26.36	0.86	3.27	clayey silt to silty clay	-22.0	1.66	22	4,500	2,534	3,158	2.43	2.44	94.59	0.869	0.929	0.321	0.159	0.613	YES	2.8	20.2	1,200	N/A	N/A	0.000	0.00	0.26
38.50	8.63	0.34	3.91	clay	-23.0	1.00	9	4,620	2,592	3,216	3.26	N/A	N/A	0.861	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.26
39.50	9.98	0.40	4.00	clay	-24.0	1.00	10	4,740	2,650	3,274	3.21	N/A	N/A	0.852	N/A	0.317	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.26
40.50	11.57	0.42	3.59	silty clay to clay	-25.0	1.00	8	4,860	2,707	3,331	3.13	N/A	N/A	0.844	N/A	0.315	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.26
41.50	14.74	0.30	2.03	clayey silt to silty clay	-26.0	1.00	7	4,980	2,765	3,389	2.89	N/A	N/A	0.836	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.26
42.50	18.09	0.36	1.97	sandy silt to clayey silt	-27.0	1.66	12	5,100	2,822	3,446	2.49	2.73	63.18	0.828	0.925	0.311	0.103	0.410	YES	2.8	11.9	431	16.0	N/A	1.695	0.20	0.05
43.50	8.72	0.29	3.31	clay	-28.0	1.00	9	5,220	2,880	3,504	3.26	N/A	N/A	0.820	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
44.50	8.45	0.32	3.77	clay	-29.0	1.00	8	5,340	2,938	3,562	3.31	N/A	N/A	0.812	N/A	0.307	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
45.50	7.98	0.21	2.59	silty clay to clay	-30.0	1.00	5	5,460	2,995	3,619	3.25	N/A	N/A	0.804	N/A	0.305	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
46.50	8.93	0.21	2.31	silty clay to clay	-31.0	1.00	6	5,580	3,053	3,677	3.18	N/A	N/A	0.795	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
47.50	10.48	0.34	3.23	silty clay to clay	-32.0	1.00	7	5,700	3,110	3,734	3.20	N/A	N/A	0.787	N/A	0.300	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
48.50	10.73	0.50	4.63	clay	-33.0	1.00	11	5,820	3,168	3,792	3.29	N/A	N/A	0.779	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
49.50	9.21	0.31	3.41	clay	-34.0	1.00	9	5,940	3,226	3,850	3.28	N/A	N/A	0.771	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
50.50	94.10	0.80	0.85	sand to silty sand	-35.0	1.00	24	6,060	3,283	3,907	1.98	1.28	93.81	0.763	0.859	0.293	0.157	0.613	YES	1.3	18.2	993	20.1	N/A	0.427	0.05	0.00

max= 1,200
min= 288
avg= 749

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT012

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	13.80 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	13.80 ft below ground surface
GWT Depth For Design, Zwd =	3.80 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	11.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	1.47 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	1.47 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	24.82	0.14	0.55	silty sand to sandy silt	12.8	1.00	8	60	60	60	1.63	1.00	143.28	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	21.9	0.011	0.016	0.00	1.47
1.50	17.96	0.31	1.75	sandy silt to clayey silt	11.8	1.00	7	180	180	180	2.24	1.77	105.76	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	19.7	N/A	N/A	N/A	1.47
2.50	17.84	0.43	2.43	clayey silt to silty clay	10.8	1.00	9	300	300	300	2.42	2.39	110.19	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
3.50	12.61	0.47	3.71	silty clay to clay	9.8	1.00	8	420	420	420	2.59	3.25	131.98	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
4.50	11.08	0.41	3.69	clay	8.8	1.00	11	540	496	540	2.67	N/A	N/A	0.990	N/A	0.224	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
5.50	10.27	0.44	4.33	clay	7.8	1.00	10	660	554	660	2.77	N/A	N/A	0.987	N/A	0.245	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
6.50	13.97	0.46	3.32	silty clay to clay	6.8	1.00	9	780	612	780	2.61	N/A	N/A	0.985	N/A	0.261	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
7.50	9.15	0.46	5.02	clay	5.8	1.00	9	900	669	900	2.90	N/A	N/A	0.983	N/A	0.275	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
8.50	19.39	0.33	1.69	sandy silt to clayey silt	4.8	1.00	8	1,020	727	1,020	2.45	2.51	80.63	0.980	1.000	0.286	0.129	0.600	YES	2.8	13.7	563	18.0	N/A	1.227	0.15	1.33
9.50	13.18	0.17	1.32	sandy silt to clayey silt	3.8	1.66	9	1,140	784	1,140	2.24	1.76	61.33	0.978	1.000	0.296	0.101	0.458	YES	2.8	14.4	623	18.9	N/A	1.177	0.14	1.19
10.50	4.06	0.15	3.68	clay	2.8	1.00	4	1,260	842	1,260	3.18	N/A	N/A	0.976	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.19
11.50	7.84	0.21	2.69	silty clay to clay	1.8	1.00	5	1,380	900	1,380	2.87	N/A	N/A	0.973	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.19
12.50	26.73	0.38	1.44	sandy silt to clayey silt	0.8	1.66	18	1,500	957	1,500	2.03	1.34	85.96	0.971	1.000	0.316	0.139	0.586	YES	2.8	23.2	1,200	29.5	N/A	0.069	0.01	1.18
13.50	6.36	0.14	2.14	silty clay to clay	-0.2	1.00	4	1,620	1,015	1,620	2.93	N/A	N/A	0.969	N/A	0.322	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.18
14.50	4.23	0.08	1.88	silty clay to clay	-1.2	1.00	3	1,740	1,072	1,696	3.08	N/A	N/A	0.966	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.18
15.50	6.58	0.06	0.97	sensitive fine grained	-2.2	1.00	3	1,860	1,130	1,754	2.78	N/A	N/A	0.964	N/A	0.330	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.18
16.50	11.25	0.10	0.90	sandy silt to clayey silt	-3.2	1.66	7	1,980	1,188	1,812	2.30	1.96	47.45	0.962	1.000	0.333	0.090	0.358	YES	2.8	10.6	347	14.4	N/A	1.931	0.23	0.95
17.50	4.83	0.03	0.65	sensitive fine grained	-4.2	1.00	2	2,100	1,245	1,869	2.87	5.37	37.00	0.959	N/A	0.336	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
18.50	5.79	0.07	1.16	sensitive fine grained	-5.2	1.00	3	2,220	1,303	1,927	2.91	N/A	N/A	0.957	N/A	0.339	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
19.50	7.67	0.13	1.73	clayey silt to silty clay	-6.2	1.00	4	2,340	1,360	1,984	2.90	N/A	N/A	0.955	N/A	0.342	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
20.50	8.52	0.14	1.66	clayey silt to silty clay	-7.2	1.00	4	2,460	1,418	2,042	2.86	N/A	N/A	0.952	N/A	0.344	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
21.50	9.05	0.14	1.57	clayey silt to silty clay	-8.2	1.00	5	2,580	1,476	2,100	2.83	N/A	N/A	0.950	N/A	0.345	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
22.50	7.40	0.13	1.79	silty clay to clay	-9.2	1.00	5	2,700	1,533	2,157	2.96	N/A	N/A	0.948	N/A	0.347	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
23.50	8.48	0.13	1.51	clayey silt to silty clay	-10.2	1.00	4	2,820	1,591	2,215	2.88	N/A	N/A	0.945	N/A	0.349	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
24.50	9.64	0.31	3.17	silty clay to clay	-11.2	1.00	6	2,940	1,648	2,272	3.01	N/A	N/A	0.943	N/A	0.350	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
25.50	9.70	0.31	3.18	silty clay to clay	-12.2	1.00	6	3,060	1,706	2,330	3.02	N/A	N/A	0.941	N/A	0.351	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
26.50	7.97	0.26	3.22	clay	-13.2	1.00	8	3,180	1,764	2,388	3.12	N/A	N/A	0.938	N/A	0.352	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
27.50	7.46	0.22	2.92	clay	-14.2	1.00	7	3,300	1,821	2,445	3.13	N/A	N/A	0.936	N/A	0.353	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
28.50	8.94	0.18	2.04	clayey silt to silty clay	-15.2	1.00	4	3,420	1,879	2,503	2.98	N/A	N/A	0.934	N/A	0.353	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.95
29.50	46.97	1.41	3.00	sandy silt to clayey silt	-16.2	1.00	19	3,540	1,936	2,560	2.48	2.66	127.14	0.931	1.000	0.354	0.271	1.022	YES	2.8	19.4	1,123	24.9	N/A	0.195	0.02	0.92
30.50	26.33	0.55	2.09	sandy silt to clayey silt	-17.2	1.00	11	3,660	1,994	2,618	2.58	3.22	84.89	0.926	1.000	0.353	0.137	0.517	YES	2.8	12.0	437	16.0	N/A	1.748	0.21	0.71
31.50	16.33	0.49	2.98	clayey silt to silty clay	-18.2	1.00	8	3,780	2,052	2,676	2.86	N/A	N/A	0.918	N/A	0.352	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.71
32.50	24.22	0.42	1.74	sandy silt to clayey silt	-19.2	1.00	10	3,900	2,109	2,733	2.58	3.21	74.80	0.909	0.989	0.350	0.119	0.448	YES	2.8	11.1	375	14.9	N/A	1.873	0.22	0.49
33.50	20.00	0.52	2.59	clayey silt to silty clay	-20.2	1.00	10	4,020	2,167	2,791	2.76	N/A	N/A	0.901	N/A	0.348	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.49
34.50	21.24	0.36	1.70	sandy silt to clayey silt	-21.2	1.00	8	4,140	2,224	2,848	2.64	N/A	N/A	0.893	N/A	0.346	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.49
35.50	13.79	0.12	0.87	sandy silt to clayey silt	-22.2	1.00	6	4,260	2,282	2,906	2.67	N/A	N/A	0.885	N/A	0.344	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.49
36.50	23.17	0.32	1.36	sandy silt to clayey silt	-23.2	1.00	9	4,380	2,340	2,964	2.57	3.14	64.71	0.877	0.968	0.341	0.105	0.398	YES	2.8	10.4	335	14.1	N/A	1.965	0.24	0.25
37.50	36.54	0.53	1.45	silty sand to sandy silt	-24.2	1.00	12	4,500	2,397	3,021	2.40	2.32	77.53	0.869	0.958	0.339	0.123	0.465	YES	2.8	12.7	488	16.9	N/A	1.629	0.20	0.06
38.50	29.82	0.47	1.58	sandy silt to clayey silt	-25.2	1.66	20	4,620	2,455	3,079	2.19	1.65	73.37	0.861	0.941	0.337	0.117	0.435	YES	2.8	18.7	1,051	24.1	N/A	0.189	0.02	0.03
39.50	13.32	0.30	2.23	clayey silt to silty clay	-26.2	1.00	7	4,740	2,512	3,136	2.93	N/A	N/A	0.852	N/A	0.335	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
40.50	12.01	0.19	1.56	clayey silt to silty clay	-27.2	1.00	6	4,860	2,570	3,194	2.90	N/A	N/A	0.844	N/A	0.332	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
41.50	9.60	0.27	2.82	silty clay to clay	-28.2	1.00	6	4,980	2,627	3,251	3.14	N/A	N/A	0.836	N/A	0.330	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
42.50	10.70	0.32	3.00	silty clay to clay	-29.2	1.00	7	5,100	2,685	3,309	3.12	N/A	N/A	0.828	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
43.50	12.89	0.70	5.46	clay	-30.2	1.00	13	5,220	2,743	3,367	3.21	N/A	N/A	0.820	N/A	0.325	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
44.50	11.44	0.37	3.20	silty clay to clay	-31.2	1.00	8	5,340	2,800	3,424	3.12	N/A	N/A	0.812	N/A	0.322	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
45.50	29.29	0.92	3.13	clayey silt to silty clay	-32.2	1.00	15	5,460	2,858	3,482	2.75	N/A	N/A	0.804	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
46.50	104.71	1.47	1.41	sand to silty sand	-33.2	1.00	26	5,580	2,915	3,539	2.06	1.39	120.53	0.795	0.882	0.317	0.243	0.903	YES	1.3	21.0	1,200	23.1	N/A	0.181	0.02	0.01
47.50	188.21	1.16	0.61	sand	-34.2	1.00	38	5,700	2,973	3,597	1.63	1.00	154.37	0.787	0.854	0.314	0.422	1.532	NO	N/A	N/A	N/A	28.1	N/A	0.078	0.01	0.00

max=	1,200
min=	335
avg=	704

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT014

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	16.00 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	16.00 ft below ground surface
GWT Depth For Design, Zwd =	6.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	14.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.83 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	0.83 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	8.66	0.05	0.54	sensitive fine grained	15.0	1.00	4	60	60	60	2.01	1.31	65.54	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
1.50	54.88	0.17	0.32	sand to silty sand	14.0	1.66	23	180	180	180	1.11	1.00	302.88	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	43.0	0.015	0.000	0.00	0.83
2.50	25.56	0.33	1.27	sandy silt to clayey silt	13.0	1.00	10	300	300	300	2.12	1.49	98.29	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	25.9	N/A	N/A	N/A	0.83
3.50	24.49	0.93	3.81	silty clay to clay	12.0	1.00	16	420	420	420	2.51	2.81	150.22	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
4.50	33.69	1.31	3.90	clayey silt to silty clay	11.0	1.00	17	540	540	540	2.46	2.56	166.27	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
5.50	27.89	1.37	4.89	clay	10.0	1.00	28	660	660	660	2.54	2.96	189.59	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
6.50	23.82	0.87	3.67	silty clay to clay	9.0	1.00	16	780	749	780	2.60	3.31	128.68	0.985	1.000	0.213	0.278	1.739	NO	N/A	N/A	N/A	N/A	N/A	0.000	0.00	0.83
7.50	20.13	0.84	4.16	silty clay to clay	8.0	1.00	13	900	806	900	2.63	N/A	N/A	0.983	N/A	0.228	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
8.50	17.54	0.53	3.01	clayey silt to silty clay	7.0	1.00	9	1,020	864	1,020	2.60	3.31	108.80	0.980	1.000	0.241	0.200	1.107	YES	2.8	15.1	687	N/A	N/A	0.000	0.00	0.83
9.50	12.87	0.53	4.14	clay	6.0	1.00	13	1,140	922	1,140	2.81	N/A	N/A	0.978	N/A	0.252	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
10.50	8.69	0.37	4.30	clay	5.0	1.00	9	1,260	979	1,260	2.97	N/A	N/A	0.976	N/A	0.261	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
11.50	11.48	0.48	4.21	clay	4.0	1.00	11	1,380	1,037	1,380	2.89	N/A	N/A	0.973	N/A	0.269	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
12.50	22.82	0.42	1.85	sandy silt to clayey silt	3.0	1.66	15	1,500	1,094	1,500	2.18	1.61	82.20	0.971	1.000	0.277	0.132	0.635	YES	2.8	20.3	1,200	25.9	N/A	0.079	0.01	0.82
13.50	8.02	0.33	4.05	clay	2.0	1.00	8	1,620	1,152	1,620	3.03	N/A	N/A	0.969	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.82
14.50	40.27	0.54	1.34	silty sand to sandy silt	1.0	1.00	13	1,740	1,210	1,740	2.22	1.71	88.72	0.966	1.000	0.289	0.145	0.669	YES	2.8	17.2	893	22.3	N/A	0.143	0.02	0.80
15.50	78.51	0.64	0.81	sand to silty sand	0.0	1.00	20	1,860	1,267	1,860	1.86	1.16	113.95	0.964	1.000	0.294	0.218	0.987	YES	1.3	21.7	1,200	23.8	N/A	0.098	0.01	0.79
16.50	72.42	0.74	1.02	sand to silty sand	-1.0	1.00	18	1,980	1,325	1,949	1.96	1.25	111.32	0.962	1.000	0.299	0.208	0.930	YES	1.3	19.7	1,152	21.7	N/A	0.199	0.02	0.77
17.50	47.27	0.58	1.23	silty sand to sandy silt	-2.0	1.66	26	2,100	1,382	2,006	1.85	1.15	108.18	0.959	1.000	0.303	0.198	0.871	YES	2.8	28.8	1,200	36.3	N/A	0.024	0.00	0.76
18.50	9.68	0.33	3.36	clay	-3.0	1.00	10	2,220	1,440	2,064	2.98	N/A	N/A	0.957	N/A	0.307	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
19.50	10.83	0.27	2.52	silty clay to clay	-4.0	1.00	7	2,340	1,498	2,122	2.88	N/A	N/A	0.955	N/A	0.310	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
20.50	7.38	0.15	1.97	silty clay to clay	-5.0	1.00	5	2,460	1,555	2,179	2.98	N/A	N/A	0.952	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
21.50	6.06	0.04	0.71	sensitive fine grained	-6.0	1.00	3	2,580	1,613	2,237	2.87	5.40	38.47	0.950	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
22.50	5.75	0.04	0.75	sensitive fine grained	-7.0	1.00	3	2,700	1,670	2,294	2.92	5.85	38.46	0.948	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
23.50	5.36	0.03	0.54	sensitive fine grained	-8.0	1.00	3	2,820	1,728	2,352	2.90	5.74	34.31	0.945	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
24.50	7.27	0.12	1.62	clayey silt to silty clay	-9.0	1.00	4	2,940	1,786	2,410	2.99	N/A	N/A	0.943	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
25.50	9.19	0.22	2.38	silty clay to clay	-10.0	1.00	6	3,060	1,843	2,467	2.99	N/A	N/A	0.941	N/A	0.325	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
26.50	8.39	0.18	2.19	silty clay to clay	-11.0	1.00	6	3,180	1,901	2,525	3.02	N/A	N/A	0.938	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.76
27.50	48.12	0.68	1.42	silty sand to sandy silt	-12.0	1.00	16	3,300	1,958	2,582	2.26	1.82	88.61	0.936	1.000	0.328	0.145	0.589	YES	2.8	16.9	865	21.9	N/A	0.535	0.06	0.70
28.50	117.01	0.59	0.50	sand	-13.0	1.00	23	3,420	2,016	2,640	1.68	1.03	119.52	0.934	0.997	0.329	0.239	0.965	YES	0.0	20.4	1,200	20.4	N/A	1.164	0.14	0.56
29.50	60.52	0.76	1.26	silty sand to sandy silt	-14.0	1.00	20	3,540	2,074	2,698	2.16	1.57	93.15	0.931	0.989	0.331	0.155	0.619	YES	2.8	20.2	1,200	25.8	N/A	0.099	0.01	0.55
30.50	35.17	0.47	1.32	silty sand to sandy silt	-15.0	1.00	12	3,660	2,131	2,755	2.37	2.19	74.73	0.926	0.985	0.331	0.119	0.472	YES	2.8	12.8	494	17.0	N/A	1.601	0.19	0.36
31.50	119.31	0.58	0.49	sand	-16.0	1.00	24	3,780	2,189	2,813	1.68	1.00	114.05	0.918	0.970	0.330	0.218	0.856	YES	0.0	20.1	1,198	20.1	N/A	1.196	0.14	0.21
32.50	102.38	0.48	0.47	sand	-17.0	1.66	34	3,900	2,246	2,870	1.43	1.00	159.95	0.909	0.955	0.328	0.461	1.787	NO	N/A	N/A	N/A	28.3	N/A	0.081	0.01	0.20
33.50	45.71	0.42	0.92	silty sand to sandy silt	-18.0	1.00	15	4,020	2,304	2,928	2.20	1.67	70.92	0.901	0.963	0.327	0.113	0.445	YES	2.8	15.4	716	20.1	N/A	1.184	0.14	0.06
34.50	32.02	0.42	1.30	silty sand to sandy silt	-19.0	1.66	18	4,140	2,362	2,986	2.11	1.47	71.95	0.893	0.954	0.326	0.115	0.448	YES	2.8	17.3	900	22.4	N/A	0.386	0.05	0.01
35.50	11.89	0.22	1.81	clayey silt to silty clay	-20.0	1.00	6	4,260	2,419	3,043	2.91	N/A	N/A	0.885	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
36.50	8.71	0.15	1.73	clayey silt to silty clay	-21.0	1.00	4	4,380	2,477	3,101	3.04	N/A	N/A	0.877	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
37.50	11.78	0.24	1.99	clayey silt to silty clay	-22.0	1.00	6	4,500	2,534	3,158	2.95	N/A	N/A	0.869	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
38.50	12.34	0.34	2.72	clayey silt to silty clay	-23.0	1.00	6	4,620	2,592	3,216	3.02	N/A	N/A	0.861	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
39.50	10.46	0.24	2.34	clayey silt to silty clay	-24.0	1.00	5	4,740	2,650	3,274	3.06	N/A	N/A	0.852	N/A	0.317	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
40.50	14.14	0.49	3.43	silty clay to clay	-25.0	1.00	9	4,860	2,707	3,331	3.04	N/A	N/A	0.844	N/A	0.315	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
41.50	14.94	0.44	2.94	clayey silt to silty clay	-26.0	1.00	7	4,980	2,765	3,389	2.98	N/A	N/A	0.836	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
42.50	9.06	0.35	3.82	clay	-27.0	1.00	9	5,100	2,822	3,446	3.27	N/A	N/A	0.828	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
43.50	8.45	0.20	2.39	silty clay to clay	-28.0	1.00	6	5,220	2,880	3,504	3.19	N/A	N/A	0.820	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
44.50	11.55	0.33	2.88	silty clay to clay	-29.0	1.00	8	5,340	2,938	3,562	3.10	N/A	N/A	0.812	N/A	0.307	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
45.50	9.83	0.44	4.44	clay	-30.0	1.00	10	5,460	2,995	3,619	3.29	N/A	N/A	0.804	N/A	0.305	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
46.50	10.60	0.29	2.74	silty clay to clay	-31.0	1.00	7	5,580	3,053	3,677	3.14	N/A	N/A	0.795	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
47.50	14.48	0.35	2.42	clayey silt to silty clay	-32.0	1.00	7	5,700	3,110	3,734	2.98	N/A	N/A	0.787	N/A	0.300	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
48.50	18.05	0.52	2.89	clayey silt to silty clay	-33.0	1.00	9	5,820	3,168	3,792	2.95	N/A	N/A	0.779	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
49.50	28.10	1.25	4.44	silty clay to clay	-34.0	1.00	19	5,940	3,226	3,850	2.90	N/A	N/A	0.771	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
50.50	62.12	1.40	2.26	sandy silt to clayey silt	-35.0	1.00	25	6,060	3,283	3,907	2.39	2.29	110.80	0.763	0.855	0.293	0.206	0.804	YES	2.8	20.6	1,200	26.3	N/A	0.083	0.01	0.00
51.50	243.30	1.16	0.48	sand	-36.0	1.00	49	6,180	3,341	3,965	1.50	1.00	188.25	0.755	0.814	0.290	N/A	N/A	NO	N/A	N/A	N/A	34.6	N/A	0.033	0.00	0.00

max=	1,200
min=	494
avg=	1,007

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT019

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	16.80 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\ A_{max}\ (\sigma_v/\sigma_v')\ r_d$

+++ $FS = (CRR_{7.5}/CSR)\ MSF\ K_\sigma\ K_{\alpha}$ —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 16.80 ft below ground surface
GWT Depth For Design, Zwd = 6.80 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 19.00 feet

Earthquake-Induced Settlements:

- Liquefaction-Induced Settlement = 2.05 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <— Dry or Unsaturated Sands

Total: 2.05 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	72.08	1.46	2.02	silty sand to sandy silt	15.8	1.00	24	60	60	60	1.75	1.07	445.07	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	54.0	0.008	0.000	0.00	2.05
1.50	46.26	0.74	1.61	silty sand to sandy silt	14.8	1.00	15	180	180	180	1.92	1.21	186.06	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	36.5	0.016	0.013	0.00	2.05
2.50	59.46	1.10	1.84	silty sand to sandy silt	13.8	1.66	33	300	300	300	1.66	1.01	256.05	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	72.0	0.016	0.000	0.00	2.05
3.50	27.69	0.97	3.50	clayey silt to silty clay	12.8	1.00	14	420	420	420	2.44	2.50	151.34	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.05
4.50	29.09	1.28	4.38	silty clay to clay	11.8	1.66	32	540	540	540	2.23	1.74	161.20	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.05
5.50	11.79	0.47	4.01	clay	10.8	1.00	12	660	660	660	2.74	N/A	N/A	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.05
6.50	9.40	0.31	3.27	silty clay to clay	9.8	1.00	6	780	780	780	2.80	N/A	N/A	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.05
7.50	8.02	0.27	3.40	clay	8.8	1.00	8	900	856	900	2.90	N/A	N/A	0.983	N/A	0.215	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.05
8.50	7.67	0.21	2.72	silty clay to clay	7.8	1.00	5	1,020	914	1,020	2.87	N/A	N/A	0.980	N/A	0.228	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.05
9.50	9.02	0.21	2.36	silty clay to clay	6.8	1.00	6	1,140	972	1,140	2.80	N/A	N/A	0.978	N/A	0.239	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.05
10.50	27.06	0.18	0.65	silty sand to sandy silt	5.8	1.00	9	1,260	1,029	1,260	2.16	1.58	59.44	0.976	1.000	0.248	0.100	0.535	YES	2.8	14.2	606	18.6	N/A	0.185	0.02	2.03
11.50	15.45	0.15	0.94	sandy silt to clayey silt	4.8	1.66	10	1,380	1,087	1,380	2.17	1.59	55.14	0.973	1.000	0.257	0.096	0.496	YES	2.8	15.1	691	19.8	N/A	0.157	0.02	2.01
12.50	7.60	0.15	1.95	silty clay to clay	3.8	1.00	5	1,500	1,144	1,500	2.87	N/A	N/A	0.971	N/A	0.265	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.01
13.50	19.01	0.27	1.43	sandy silt to clayey silt	2.8	1.00	8	1,620	1,202	1,620	2.50	2.79	68.35	0.969	1.000	0.272	0.110	0.539	YES	2.8	11.2	386	15.1	N/A	1.703	0.20	1.81
14.50	32.47	0.30	0.92	silty sand to sandy silt	1.8	1.66	18	1,740	1,260	1,740	1.91	1.19	80.91	0.966	1.000	0.278	0.129	0.621	YES	2.8	22.0	1,200	28.1	N/A	0.068	0.01	1.80
15.50	11.42	0.23	2.00	clayey silt to silty clay	0.8	1.00	6	1,860	1,317	1,860	2.76	N/A	N/A	0.964	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.80
16.50	5.94	0.15	2.60	clay	-0.2	1.00	6	1,980	1,375	1,980	3.09	N/A	N/A	0.962	N/A	0.288	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.80
17.50	11.84	0.17	1.46	clayey silt to silty clay	-1.2	1.00	6	2,100	1,432	2,056	2.70	N/A	N/A	0.959	N/A	0.293	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.80
18.50	16.42	0.19	1.13	sandy silt to clayey silt	-2.2	1.66	11	2,220	1,490	2,114	2.24	1.78	56.09	0.957	1.000	0.297	0.096	0.434	YES	2.8	13.4	540	17.7	N/A	1.377	0.17	1.63
19.50	7.77	0.18	2.34	silty clay to clay	-3.2	1.00	5	2,340	1,548	2,172	3.00	N/A	N/A	0.955	N/A	0.300	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
20.50	6.77	0.20	2.98	clay	-4.2	1.00	7	2,460	1,605	2,229	3.12	N/A	N/A	0.952	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
21.50	6.12	0.10	1.61	sensitive fine grained	-5.2	1.00	3	2,580	1,663	2,287	3.04	N/A	N/A	0.950	N/A	0.307	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
22.50	5.93	0.08	1.33	sensitive fine grained	-6.2	1.00	3	2,700	1,720	2,344	3.02	N/A	N/A	0.948	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
23.50	6.73	0.16	2.39	silty clay to clay	-7.2	1.00	4	2,820	1,778	2,402	3.11	N/A	N/A	0.945	N/A	0.312	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
24.50	6.28	0.13	2.14	silty clay to clay	-8.2	1.00	4	2,940	1,836	2,460	3.12	N/A	N/A	0.943	N/A	0.314	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
25.50	5.93	0.10	1.70	silty clay to clay	-9.2	1.00	4	3,060	1,893	2,517	3.11	N/A	N/A	0.941	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
26.50	5.87	0.08	1.43	sensitive fine grained	-10.2	1.00	3	3,180	1,951	2,575	3.09	N/A	N/A	0.938	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
27.50	6.84	0.13	1.89	silty clay to clay	-11.2	1.00	5	3,300	2,008	2,632	3.09	N/A	N/A	0.936	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
28.50	5.98	0.06	0.99	sensitive fine grained	-12.2	1.00	3	3,420	2,066	2,690	3.03	N/A	N/A	0.934	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
29.50	5.92	0.04	0.63	sensitive fine grained	-13.2	1.00	3	3,540	2,124	2,748	2.96	6.29	35.62	0.931	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
30.50	7.24	0.07	0.96	sensitive fine grained	-14.2	1.00	4	3,660	2,181	2,805	2.95	N/A	N/A	0.926	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.63
31.50	20.33	0.22	1.07	sandy silt to clayey silt	-15.2	1.66	13	3,780	2,239	2,863	2.23	1.75	55.65	0.918	0.972	0.322	0.096	0.386	YES	2.8	14.1	597	18.5	N/A	1.374	0.16	1.47
32.50	9.03	0.07	0.75	clayey silt to silty clay	-16.2	1.00	5	3,900	2,296	2,920	2.83	5.00	40.71	0.909	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
33.50	7.75	0.14	1.74	clayey silt to silty clay	-17.2	1.00	4	4,020	2,354	2,978	3.08	N/A	N/A	0.901	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
34.50	7.44	0.13	1.69	clayey silt to silty clay	-18.2	1.00	4	4,140	2,412	3,036	3.10	N/A	N/A	0.893	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
35.50	7.56	0.12	1.62	clayey silt to silty clay	-19.2	1.00	4	4,260	2,469	3,093	3.09	N/A	N/A	0.885	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
36.50	8.33	0.20	2.38	silty clay to clay	-20.2	1.00	6	4,380	2,527	3,151	3.14	N/A	N/A	0.877	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
37.50	8.60	0.15	1.77	clayey silt to silty clay	-21.2	1.00	4	4,500	2,584	3,208	3.07	N/A	N/A	0.869	N/A	0.315	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
38.50	13.25	0.19	1.45	clayey silt to silty clay	-22.2	1.00	7	4,620	2,642	3,266	2.84	N/A	N/A	0.861	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
39.50	14.70	0.23	1.59	sandy silt to clayey silt	-23.2	1.00	6	4,740	2,700	3,324	2.83	N/A	N/A	0.852	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
40.50	12.33	0.35	2.82	silty clay to clay	-24.2	1.00	8	4,860	2,757	3,381	3.05	N/A	N/A	0.844	N/A	0.310	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
41.50	18.48	0.51	2.75	clayey silt to silty clay	-25.2	1.00	9	4,980	2,815	3,439	2.89	N/A	N/A	0.836	N/A	0.308	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
42.50	20.83	0.56	2.69	clayey silt to silty clay	-26.2	1.00	10	5,100	2,872	3,496	2.84	N/A	N/A	0.828	N/A	0.306	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
43.50	25.53	0.64	2.50	sandy silt to clayey silt	-27.2	1.00	10	5,220	2,930	3,554	2.75	N/A	N/A	0.820	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.47
44.50	60.51	0.43	0.71	sand to silty sand	-28.2	1.00	15	5,340	2,987	3,611	2.08	1.43	70.70	0.812	0.904	0.302	0.113	0.451	YES	1.3	12.6	479	14.3	N/A	1.931	0.23	1.24
45.50	41.48	0.61	1.47	silty sand to sandy silt	-29.2	1.00	14	5,460	3,045	3,669	2.41	2.34	78.51	0.804	0.904	0.300	0.125	0.503	YES	2.8	13.0	511	17.3	N/A	1.462	0.18	1.06
46.50	31.19	0.89	2.84	sandy silt to clayey silt	-30.2	1.00	12	5,580	3,103	3,727	2.73	N/A	N/A	0.795	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.06
47.50	59.82	0.65	1.09	silty sand to sandy silt	-31.2	1.00	20	5,700	3,160	3,784	2.20	1.67	79.44	0.787	0.878	0.295	0.127	0.502	YES	2.8	17.3	903	22.4	N/A	0.158	0.02	1.04
48.50	134.91	0.53	0.39	sand	-32.2	1.00	27	5,820	3,218	3,842	1.66	1.00	106.36	0.779	0.854	0.293	0.192	0.746	YES	0.0	19.5	1,130	19.5	N/A	1.052	0.13	0.92
49.50	81.41	0.40	0.50	sand to silty sand	-33.2	1.66	34	5,940	3,275	3,899	1.61	1.00	105.33	0.771	0.834	0.291	0.189	0.722	YES	1.3	25.5	1,200	27.8	N/A	0.073	0.01	0.91
50.50	13.11	0.19	1.46	clayey silt to silty clay	-34.2	1.00	7	6,060	3,333	3,957	2.93	N/A	N/A	0.763	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.91
51.50	11.33	0.19	1.63	clayey silt to silty clay	-35.2	1.00	6	6,180	3,391	4,015	3.03	N/A	N/A	0.755	N/A	0.286	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.91
52.50	24.60	0.28	1.12	sandy silt to clayey silt	-36.2	1.00	10	6,300	3,448	4,072	2.62	N/A	N/A	0.747	N/A	0.284	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.91
53.50	53.97	0.49	0.91	silty sand to sandy silt	-37.2	1.00	18	6,420	3,506	4,130	2.22	1.71	69.56	0.739	0.862	0.281	0.111	0.455	YES	2.8	15.3	709	20.0	N/A	0.302	0.04	0.87
54.50	73.59	0.59	0.80	sand to silty sand	-38.2	1.00	18	6,540	3,563	4,187	2.07	1.40	77.45	0.730	0.857	0.279	0.123	0.505	YES	1.3	14.0	596	15.8	N/A	1.595	0.19	0.68
55.50	58.87	0.54	0.92	sand to silty sand	-39.2	1.00	15	6,660	3,621	4,245	2.19	1.65	72.15	0.722	0.868	0.276	0.115	0.482	YES	1.3	11.4	398	13.1	N/A	2.118	0.25	0.43
56.50	69.53	0.72	1.04	sand to silty sand	-40.2	1.00	17	6,780	3,679	4,303	2.16	1.58	80.99	0.714	0.854	0.274	0.129	0.539	YES	1.3	13.2	525	14.9	N/A	1.763	0.21	0.21
57.50	76.31	0.88	1.15	sand to silty sand	-41.2	1.00	19	6,900	3,736	4,360	2.16	1.57	87.78	0.706	0.845	0.271	0.143	0.594	YES	1.3	14.3	614	16.0	N/A	1.493	0.18	0.04
58.50	107.92	0.94	0.87	sand to silty sand	-42.2	1.00	27	7,020	3,794	4,418	1.97	1.26	98.59	0.698	0.815	0.269	0.169	0.685	YES	1.3	19.5	1,132	21.5	N/A	0.108	0.01	0.02
59.50	113.67	0.97	0.85	sand to silty sand	-43.2	1.00	28	7,140	3,851	4,475	1.94	1.23	100.98	0.690	0.807	0.266	0.176	0.712	YES	1.3	20.3	1,200	22.4	N/A	0.095	0.01	0.01
60.50	112.56	1.15	1.02	sand to silty sand	-44.2	1.00	28	7,260	3,909	4,533	2.00	1.30	104.38	0.682	0.805	0.263	0.186	0.758	YES	1.3	20.0	1,188	22.1	N/A	0.096	0.01	0.00

max= 1,200
min= 386
avg= 769

PLATE E-7

CPT019liq
Output Sheet

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT021

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	16.60 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\ A_{max}\ (\sigma_v/\sigma_v')\ r_d$

+++ $FS = (CRR_{7.5}/CSR)\ MSF\ K_\sigma\ K_\alpha$ —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 16.60 ft below ground surface
GWT Depth For Design, Zwd = 6.60 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 13.00 feet

Earthquake-Induced Settlements:

- Liquefaction-Induced Settlement = 0.77 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.01 inches <— Dry or Unsaturated Sands

Total: 0.78 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	19.24	0.33	1.73	silty sand to sandy silt	15.6	1.00	6	60	60	60	2.04	1.35	150.44	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	18.1	0.012	0.022	0.00	0.78
1.50	21.70	0.46	2.12	silty sand to sandy silt	14.6	1.00	7	180	180	180	2.23	1.75	126.76	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	19.8	0.020	0.033	0.00	0.78
2.50	40.57	1.15	2.85	silty sand to sandy silt	13.6	1.00	14	300	300	300	2.22	1.71	178.74	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	32.6	0.021	0.020	0.00	0.78
3.50	23.66	1.01	4.27	clayey silt to silty clay	12.6	1.00	12	420	420	420	2.55	3.06	157.86	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
4.50	21.27	0.56	2.62	silty clay to clay	11.6	1.00	14	540	540	540	2.48	2.67	109.49	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
5.50	33.40	0.83	2.49	clay	10.6	1.00	33	660	660	660	2.35	2.13	123.90	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
6.50	29.44	0.79	2.67	silty clay to clay	9.6	1.66	32	780	780	780	2.13	1.51	118.04	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
7.50	8.68	0.25	2.92	clay	8.6	1.00	9	900	844	900	2.82	N/A	N/A	0.983	N/A	0.218	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
8.50	7.92	0.19	2.38	silty clay to clay	7.6	1.00	5	1,020	901	1,020	2.83	N/A	N/A	0.980	N/A	0.231	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
9.50	5.73	0.13	2.27	silty clay to clay	6.6	1.00	4	1,140	959	1,140	2.96	N/A	N/A	0.978	N/A	0.242	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
10.50	6.88	0.14	2.02	silty sand to sandy silt	5.6	1.00	2	1,260	1,017	1,260	2.88	N/A	N/A	0.976	N/A	0.251	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
11.50	20.27	0.38	1.87	sandy silt to clayey silt	4.6	1.00	8	1,380	1,074	1,380	2.53	2.91	80.40	0.973	1.000	0.260	0.128	0.659	YES	2.8	12.6	477	16.7	N/A	1.201	0.14	0.63
12.50	38.98	0.29	0.75	silty clay to clay	3.6	1.66	43	1,500	1,132	1,500	1.77	1.00	85.79	0.971	1.000	0.268	0.139	0.692	YES	5.0	54.7	1,200	N/A	N/A	0.000	0.00	0.63
13.50	13.47	0.21	1.55	sandy silt to clayey silt	2.6	1.66	9	1,620	1,189	1,620	2.34	2.10	60.67	0.969	1.000	0.274	0.101	0.490	YES	2.8	12.7	488	16.9	N/A	1.330	0.16	0.47
14.50	5.08	0.20	3.87	silty sand to sandy silt	1.6	1.00	2	1,740	1,247	1,740	3.22	N/A	N/A	0.966	N/A	0.280	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
15.50	35.36	0.23	0.64	clayey silt to silty clay	0.6	1.00	18	1,860	1,305	1,860	2.10	1.46	63.96	0.964	1.000	0.286	0.104	0.487	YES	2.8	21.1	1,200	N/A	N/A	0.000	0.00	0.47
16.50	20.67	0.21	1.00	clay	-0.4	1.66	34	1,980	1,362	1,980	2.11	1.48	61.23	0.962	1.000	0.291	0.101	0.465	YES	5.0	39.4	1,200	N/A	N/A	0.000	0.00	0.47
17.50	4.82	0.12	2.46	clayey silt to silty clay	-1.4	1.00	2	2,100	1,420	2,044	3.18	N/A	N/A	0.959	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
18.50	5.94	0.17	2.83	sandy silt to clayey silt	-2.4	1.00	2	2,220	1,477	2,101	3.14	N/A	N/A	0.957	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
19.50	5.76	0.16	2.77	silty clay to clay	-3.4	1.00	4	2,340	1,535	2,159	3.16	N/A	N/A	0.955	N/A	0.303	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
20.50	4.24	0.05	1.14	clay	-4.4	1.00	4	2,460	1,593	2,217	3.12	N/A	N/A	0.952	N/A	0.306	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
21.50	5.44	0.09	1.65	sensitive fine grained	-5.4	1.00	3	2,580	1,650	2,274	3.09	N/A	N/A	0.950	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
22.50	5.38	0.11	2.08	sensitive fine grained	-6.4	1.00	3	2,700	1,708	2,332	3.16	N/A	N/A	0.948	N/A	0.312	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
23.50	5.35	0.08	1.44	silty clay to clay	-7.4	1.00	4	2,820	1,765	2,389	3.10	N/A	N/A	0.945	N/A	0.314	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
24.50	6.26	0.11	1.75	silty clay to clay	-8.4	1.00	4	2,940	1,823	2,447	3.08	N/A	N/A	0.943	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
25.50	6.26	0.12	1.94	silty clay to clay	-9.4	1.00	4	3,060	1,881	2,505	3.11	N/A	N/A	0.941	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
26.50	5.36	0.11	2.00	sensitive fine grained	-10.4	1.00	3	3,180	1,938	2,562	3.20	N/A	N/A	0.938	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
27.50	6.30	0.14	2.29	silty clay to clay	-11.4	1.00	4	3,300	1,996	2,620	3.17	N/A	N/A	0.936	N/A	0.322	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
28.50	5.95	0.10	1.74	sensitive fine grained	-12.4	1.00	3	3,420	2,053	2,677	3.15	N/A	N/A	0.934	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
29.50	6.04	0.07	1.07	sensitive fine grained	-13.4	1.00	3	3,540	2,111	2,735	3.05	N/A	N/A	0.931	N/A	0.325	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
30.50	6.88	0.11	1.64	sensitive fine grained	-14.4	1.00	3	3,660	2,169	2,793	3.09	N/A	N/A	0.926	N/A	0.325	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
31.50	7.49	0.17	2.31	sandy silt to clayey silt	-15.4	1.00	3	3,780	2,226	2,850	3.14	N/A	N/A	0.918	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
32.50	7.47	0.15	2.00	clayey silt to silty clay	-16.4	1.00	4	3,900	2,284	2,908	3.11	N/A	N/A	0.909	N/A	0.323	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
33.50	7.85	0.16	2.07	clayey silt to silty clay	-17.4	1.00	4	4,020	2,341	2,965	3.11	N/A	N/A	0.901	N/A	0.322	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
34.50	9.94	0.23	2.30	clayey silt to silty clay	-18.4	1.00	5	4,140	2,399	3,023	3.04	N/A	N/A	0.893	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
35.50	15.70	0.42	2.70	clayey silt to silty clay	-19.4	1.00	8	4,260	2,457	3,081	2.90	N/A	N/A	0.885	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
36.50	14.24	0.41	2.89	silty clay to clay	-20.4	1.00	9	4,380	2,514	3,138	2.96	N/A	N/A	0.877	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
37.50	64.25	0.49	0.77	clayey silt to silty clay	-21.4	1.66	53	4,500	2,572	3,196	1.74	1.00	93.81	0.869	0.904	0.316	0.157	0.598	YES	2.8	44.9	1,200	N/A	N/A	0.000	0.00	0.47
38.50	27.60	0.69	2.51	clayey silt to silty clay	-22.4	1.00	14	4,620	2,629	3,253	2.69	N/A	N/A	0.861	N/A	0.315	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
39.50	49.60	0.88	1.78	sandy silt to clayey silt	-23.4	1.00	20	4,740	2,687	3,311	2.37	2.18	93.41	0.852	0.917	0.313	0.156	0.609	YES	2.8	18.2	999	23.5	N/A	0.153	0.02	0.45
40.50	124.15	1.04	0.84	silty clay to clay	-24.4	1.00	83	4,860	2,745	3,369	1.85	1.14	121.13	0.844	0.881	0.311	0.245	0.927	YES	5.0	68.8	1,200	N/A	N/A	0.000	0.00	0.45
41.50	126.75	0.76	0.60	clayey silt to silty clay	-25.4	1.66	105	4,980	2,802	3,426	1.45	1.00	177.30	0.836	0.874	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	0.000	0.00	0.45
42.50	59.31	0.87	1.46	clayey silt to silty clay	-26.4	1.00	30	5,100	2,860	3,484	2.26	1.83	90.91	0.828	0.881	0.307	0.150	0.573	YES	2.8	25.3	1,200	N/A	N/A	0.000	0.00	0.45
43.50	79.24	0.68	0.86	sandy silt to clayey silt	-27.4	1.66	52	5,220	2,917	3,541	1.72	1.05	113.95	0.820	0.860	0.305	0.218	0.818	YES	2.8	42.2	1,200	52.3	N/A	0.000	0.00	0.45
44.50	22.85	0.60	2.64	sand to silty sand	-28.4	1.00	6	5,340	2,975	3,599	2.81	N/A	N/A	0.812	N/A	0.303	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
45.50	18.29	0.39	2.16	silty sand to sandy silt	-29.4	1.00	6	5,460	3,033	3,657	2.85	N/A	N/A	0.804	N/A	0.301	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
46.50	20.29	0.31	1.53	sandy silt to clayey silt	-30.4	1.00	8	5,580	3,090	3,714	2.73	N/A	N/A	0.795	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
47.50	13.24	0.23	1.76	silty sand to sandy silt	-31.4	1.00	4	5,700	3,148	3,772	2.95	N/A	N/A	0.787	N/A	0.297	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
48.50	16.58	0.38	2.28	sand	-32.4	1.00	3	5,820	3,205	3,829	2.92	N/A	N/A	0.779	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
49.50	82.23	0.84	1.03	sand to silty sand	-33.4	1.00	21	5,940	3,263	3,887	2.08	1.42	91.11	0.771	0.869	0.292	0.150	0.597	YES	1.3	16.1	782	18.0	N/A	1.297	0.16	0.30
50.50	56.96	0.98	1.71	clayey silt to silty clay	-34.4	1.66	47	6,060	3,321	3,945	2.03	1.35	98.61	0.763	0.816	0.290	0.169	0.636	YES	2.8	36.4	1,200	N/A	N/A	0.000	0.00	0.30
51.50	26.41	0.73	2.76	clayey silt to silty clay	-35.4	1.00	13	6,180	3,378	4,002	2.80	N/A	N/A	0.755	N/A	0.287	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
52.50	13.33	0.25	1.90	sandy silt to clayey silt	-36.4	1.00	5	6,300	3,436	4,060	3.00	N/A	N/A	0.747	N/A	0.285	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
53.50	12.72	0.23	1.78	silty sand to sandy silt	-37.4	1.00	4	6,420	3,493	4,117	3.01	N/A	N/A	0.739	N/A	0.282	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
54.50	16.32	0.46	2.83	sand to silty sand	-38.4	1.00	4	6,540	3,551	4,175	3.02	N/A	N/A	0.730	N/A	0.280	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
55.50	18.97	0.41	2.15	sand to silty sand	-39.4	1.00	5	6,660	3,609	4,233	2.89	N/A	N/A	0.722	N/A	0.277	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
56.50	18.83	0.44	2.36	sand to silty sand	-40.4	1.00	5	6,780	3,666	4,290	2.92	N/A	N/A	0.714	N/A	0.275	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
57.50	21.42	0.58	2.70	sand to silty sand	-41.4	1.00	5	6,900	3,724	4,348	2.91	N/A	N/A	0.706	N/A	0.272	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
58.50	47.00	0.90	1.92	sand to silty sand	-42.4	1.00	12	7,020	3,781	4,405	2.53	2.90	84.67	0.698	0.874	0.269	0.136	0.591	YES	1.3	9.2	273	10.8	N/A	2.472	0.30	0.00
59.50	296.19	0.61	0.21	sand to silty sand	-43.4	1.00	74	7,140	3,839	4,463	1.26	1.00	213.78	0.690	0.770	0.267	N/A	N/A	NO	N/A	N/A	N/A	54.5	N/A	0.000	0.00	0.00

max= 1,200
min= 273
avg= 971

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT022

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	19.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_w	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

\+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ CSR = 0.65 A_{max} (σ_v/σ_v') r_d

+++ FS = ($CRR_{7.5}$/CSR) MSF K_σ $K_{\alpha\ -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	16.00 ft below ground surface
GWT Depth For Design, Zwd =	9.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	12.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.47 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	0.47 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	130.52	0.99	0.76	sand	18.0	1.00	26	60	60	60	1.25	1.00	753.54	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	44.4	0.009	0.000	0.00	0.47
1.50	90.65	0.80	0.89	sand to silty sand	17.0	1.00	23	180	180	180	1.53	1.00	302.15	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	42.9	0.015	0.000	0.00	0.47
2.50	91.71	1.03	1.12	sand to silty sand	16.0	1.66	38	300	300	300	1.37	1.00	392.08	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	70.1	0.017	0.000	0.00	0.47
3.50	12.80	0.67	5.24	clay	15.0	1.00	13	420	420	420	2.69	N/A	N/A	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
4.50	9.58	0.36	3.75	clay	14.0	1.00	10	540	540	540	2.74	N/A	N/A	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
5.50	8.50	0.29	3.38	clay	13.0	1.00	8	660	660	660	2.81	N/A	N/A	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
6.50	8.45	0.27	3.19	clay	12.0	1.00	8	780	780	780	2.84	N/A	N/A	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
7.50	10.08	0.24	2.42	silty clay to clay	11.0	1.00	7	900	900	900	2.74	N/A	N/A	0.983	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
8.50	10.11	0.18	1.76	clayey silt to silty clay	10.0	1.00	5	1,020	1,020	1,020	2.69	N/A	N/A	0.980	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
9.50	16.23	0.28	1.75	sandy silt to clayey silt	9.0	1.00	6	1,140	1,109	1,140	2.59	3.29	71.74	0.978	1.000	0.209	0.114	0.730	YES	2.8	11.4	395	15.3	N/A	0.196	0.02	0.45
10.50	12.21	0.36	2.91	silty clay to clay	8.0	1.00	8	1,260	1,166	1,260	2.79	N/A	N/A	0.976	N/A	0.219	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
11.50	33.41	0.24	0.73	silty sand to sandy silt	7.0	1.00	11	1,380	1,224	1,380	2.14	1.53	65.30	0.973	1.000	0.228	0.106	0.619	YES	2.8	16.2	794	21.1	N/A	0.088	0.01	0.43
12.50	28.77	0.36	1.24	silty sand to sandy silt	6.0	1.66	16	1,500	1,282	1,500	2.02	1.33	79.07	0.971	1.000	0.236	0.126	0.711	YES	2.8	21.1	1,200	27.0	N/A	0.062	0.01	0.43
13.50	7.55	0.18	2.32	silty clay to clay	5.0	1.00	5	1,620	1,339	1,620	2.95	N/A	N/A	0.969	N/A	0.244	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
14.50	14.19	0.25	1.74	clayey silt to silty clay	4.0	1.00	7	1,740	1,397	1,740	2.66	N/A	N/A	0.966	N/A	0.250	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
15.50	39.50	0.39	1.00	silty sand to sandy silt	3.0	1.00	13	1,860	1,454	1,860	2.18	1.63	75.34	0.964	1.000	0.256	0.120	0.623	YES	2.8	16.5	818	21.4	N/A	0.097	0.01	0.42
16.50	23.64	0.48	2.01	sandy silt to clayey silt	2.0	1.66	16	1,980	1,512	1,949	2.24	1.78	80.11	0.962	1.000	0.262	0.128	0.651	YES	2.8	18.7	1,045	24.0	N/A	0.085	0.01	0.41
17.50	7.78	0.18	2.31	silty clay to clay	1.0	1.00	5	2,100	1,570	2,006	2.99	N/A	N/A	0.959	N/A	0.267	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
18.50	5.99	0.11	1.76	silty clay to clay	0.0	1.00	4	2,220	1,627	2,064	3.05	N/A	N/A	0.957	N/A	0.272	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
19.50	5.98	0.08	1.25	sensitive fine grained	-1.0	1.00	3	2,340	1,685	2,122	2.99	N/A	N/A	0.955	N/A	0.276	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
20.50	6.11	0.09	1.48	sensitive fine grained	-2.0	1.00	3	2,460	1,742	2,179	3.03	N/A	N/A	0.952	N/A	0.280	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
21.50	5.84	0.09	1.46	sensitive fine grained	-3.0	1.00	3	2,580	1,800	2,237	3.06	N/A	N/A	0.950	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
22.50	6.31	0.10	1.51	sensitive fine grained	-4.0	1.00	3	2,700	1,858	2,294	3.04	N/A	N/A	0.948	N/A	0.286	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
23.50	6.59	0.10	1.51	clayey silt to silty clay	-5.0	1.00	3	2,820	1,915	2,352	3.04	N/A	N/A	0.945	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
24.50	7.78	0.15	1.94	silty clay to clay	-6.0	1.00	5	2,940	1,973	2,410	3.03	N/A	N/A	0.943	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
25.50	7.10	0.14	1.97	silty clay to clay	-7.0	1.00	5	3,060	2,030	2,467	3.08	N/A	N/A	0.941	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
26.50	7.82	0.18	2.32	silty clay to clay	-8.0	1.00	5	3,180	2,088	2,525	3.09	N/A	N/A	0.938	N/A	0.297	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
27.50	7.17	0.08	1.06	sensitive fine grained	-9.0	1.00	4	3,300	2,146	2,582	2.97	N/A	N/A	0.936	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
28.50	8.54	0.10	1.16	clayey silt to silty clay	-10.0	1.00	4	3,420	2,203	2,640	2.92	N/A	N/A	0.934	N/A	0.301	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
29.50	10.54	0.14	1.29	clayey silt to silty clay	-11.0	1.00	5	3,540	2,261	2,698	2.86	N/A	N/A	0.931	N/A	0.303	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
30.50	10.28	0.18	1.74	clayey silt to silty clay	-12.0	1.00	5	3,660	2,318	2,755	2.94	N/A	N/A	0.926	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
31.50	12.20	0.24	1.97	clayey silt to silty clay	-13.0	1.00	6	3,780	2,376	2,813	2.91	N/A	N/A	0.918	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
32.50	13.60	0.23	1.71	clayey silt to silty clay	-14.0	1.00	7	3,900	2,434	2,870	2.84	N/A	N/A	0.909	N/A	0.303	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
33.50	10.92	0.27	2.48	clayey silt to silty clay	-15.0	1.00	5	4,020	2,491	2,928	3.03	N/A	N/A	0.901	N/A	0.303	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
34.50	11.62	0.25	2.12	clayey silt to silty clay	-16.0	1.00	6	4,140	2,549	2,986	2.97	N/A	N/A	0.893	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
35.50	11.93	0.39	3.27	silty clay to clay	-17.0	1.00	8	4,260	2,606	3,043	3.08	N/A	N/A	0.885	N/A	0.301	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
36.50	11.58	0.39	3.37	silty clay to clay	-18.0	1.00	8	4,380	2,664	3,101	3.10	N/A	N/A	0.877	N/A	0.300	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
37.50	14.23	0.39	2.75	clayey silt to silty clay	-19.0	1.00	7	4,500	2,722	3,158	2.98	N/A	N/A	0.869	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
38.50	15.05	0.36	2.37	clayey silt to silty clay	-20.0	1.00	8	4,620	2,779	3,216	2.92	N/A	N/A	0.861	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
39.50	18.38	0.45	2.44	clayey silt to silty clay	-21.0	1.00	9	4,740	2,837	3,274	2.86	N/A	N/A	0.852	N/A	0.296	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
40.50	25.33	0.60	2.35	sandy silt to clayey silt	-22.0	1.00	10	4,860	2,894	3,331	2.73	N/A	N/A	0.844	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
41.50	126.77	0.74	0.59	sand	-23.0	1.00	25	4,980	2,952	3,389	1.76	1.08	112.61	0.836	0.879	0.293	0.213	0.851	YES	0.0	19.5	1,131	19.5	N/A	1.053	0.13	0.28
42.50	104.24	1.04	1.00	sand to silty sand	-24.0	1.66	43	5,100	3,010	3,446	1.66	1.01	142.24	0.828	0.849	0.292	0.348	1.350	NO	N/A	N/A	N/A	36.9	N/A	0.018	0.00	0.28
43.50	43.49	0.83	1.90	sandy silt to clayey silt	-25.0	1.00	17	5,220	3,067	3,504	2.46	2.56	89.76	0.820	0.890	0.290	0.147	0.603	YES	2.8	15.9	769	20.8	N/A	0.273	0.03	0.24
44.50	130.99	0.52	0.40	sand	-26.0	1.00	26	5,340	3,125	3,562	1.67	1.00	104.80	0.812	0.862	0.289	0.187	0.746	YES	0.0	19.6	1,147	19.6	N/A	0.464	0.06	0.19
45.50	106.03	0.75	0.70	sand to silty sand	-27.0	1.66	44	5,460	3,182	3,619	1.58	1.00	139.18	0.804	0.830	0.287	0.331	1.278	YES	1.3	34.0	1,200	36.7	N/A	0.019	0.00	0.19
46.50	30.92	0.91	2.95	clayey silt to silty clay	-28.0	1.00	15	5,580	3,240	3,677	2.75	N/A	N/A	0.795	N/A	0.285	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
47.50	19.36	0.36	1.87	sandy silt to clayey silt	-29.0	1.00	8	5,700	3,298	3,734	2.82	N/A	N/A	0.787	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
48.50	14.03	0.27	1.95	clayey silt to silty clay	-30.0	1.00	7	5,820	3,355	3,792	2.97	N/A	N/A	0.779	N/A	0.281	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
49.50	15.34	0.37	2.38	clayey silt to silty clay	-31.0	1.00	8	5,940	3,413	3,850	2.98	N/A	N/A	0.771	N/A	0.279	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
50.50	16.81	0.37	2.22	clayey silt to silty clay	-32.0	1.00	8	6,060	3,470	3,907	2.93	N/A	N/A	0.763	N/A	0.277	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
51.50	13.66	0.29	2.11	clayey silt to silty clay	-33.0	1.00	7	6,180	3,528	3,965	3.01	N/A	N/A	0.755	N/A	0.275	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
52.50	13.41	0.38	2.87	clayey silt to silty clay	-34.0	1.00	7	6,300	3,586	4,022	3.10	N/A	N/A	0.747	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
53.50	14.86	0.45	3.03	clayey silt to silty clay	-35.0	1.00	7	6,420	3,643	4,080	3.08	N/A	N/A	0.739	N/A	0.271	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
54.50	14.85	0.43	2.88	clayey silt to silty clay	-36.0	1.00	7	6,540	3,701	4,138	3.07	N/A	N/A	0.730	N/A	0.268	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
55.50	15.76	0.47	2.97	clayey silt to silty clay	-37.0	1.00	8	6,660	3,758	4,195	3.06	N/A	N/A	0.722	N/A	0.266	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
56.50	32.02	0.65	2.02	sandy silt to clayey silt	-38.0	1.00	13	6,780	3,816	4,253	2.69	N/A	N/A	0.714	N/A	0.264	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
57.50	44.03	0.62	1.42	silty sand to sandy silt	-39.0	1.00	15	6,900	3,874	4,310	2.48	2.67	71.51	0.706	0.855	0.262	0.114	0.497	YES	2.8	12.8	495	17.0	N/A	1.145	0.14	0.05
58.50	50.96	0.75	1.47	silty sand to sandy silt	-40.0	1.00	17	7,020	3,931	4,368	2.38	2.23	80.95	0.698	0.842	0.259	0.129	0.561	YES	2.8	14.3	617	18.8	N/A	0.260	0.03	0.02
59.50	148.80	1.58	1.06	sand	-41.0	1.00	30	7,140	3,989	4,426	1.92	1.21	126.98	0.690	0.793	0.257	0.270	1.115	YES	0.0	20.0	1,186	20.0	N/A	0.144	0.02	0.00

max=	1,200
min=	395
avg=	900

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT024

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	16.90 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	16.90 ft below ground surface
GWT Depth For Design, Zwd =	6.90 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	19.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	1.31 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	1.31 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	9.40	0.12	1.24	clayey silt to silty clay	15.9	1.00	5	60	60	60	2.18	1.61	87.66	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.31
1.50	13.07	0.23	1.75	clayey silt to silty clay	14.9	1.00	7	180	180	180	2.35	2.10	91.69	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.31
2.50	37.77	0.55	1.44	silty sand to sandy silt	13.9	1.00	13	300	300	300	2.02	1.33	130.08	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	30.7	0.022	0.022	0.00	1.31
3.50	40.61	1.03	2.53	sandy silt to clayey silt	12.9	1.66	27	420	420	420	1.92	1.21	176.85	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	59.9	N/A	N/A	N/A	1.31
4.50	17.49	0.42	2.39	clayey silt to silty clay	11.9	1.00	9	540	540	540	2.52	2.88	96.80	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.31
5.50	12.81	0.21	1.66	clayey silt to silty clay	10.9	1.00	6	660	660	660	2.57	3.15	70.34	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.31
6.50	11.99	0.21	1.76	clayey silt to silty clay	9.9	1.00	6	780	780	780	2.56	3.07	74.59	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.31
7.50	7.14	0.26	3.63	clay	8.9	1.00	7	900	863	900	2.96	N/A	N/A	0.983	N/A	0.213	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.31
8.50	26.29	0.35	1.33	sandy silt to clayey silt	7.9	1.00	11	1,020	920	1,020	2.32	2.00	77.56	0.980	1.000	0.226	0.123	0.729	YES	2.8	17.5	927	22.7	N/A	0.080	0.01	1.30
9.50	31.94	0.28	0.86	silty sand to sandy silt	6.9	1.00	11	1,140	978	1,140	2.15	1.56	71.08	0.978	1.000	0.237	0.113	0.638	YES	2.8	16.9	863	21.9	N/A	0.087	0.01	1.29
10.50	22.23	0.21	0.95	sandy silt to clayey silt	5.9	1.66	15	1,260	1,035	1,260	2.02	1.33	67.83	0.976	1.000	0.247	0.109	0.589	YES	2.8	21.3	1,200	27.3	N/A	0.064	0.01	1.28
11.50	3.60	0.06	1.75	sensitive fine grained	4.9	1.00	2	1,380	1,093	1,380	3.13	N/A	N/A	0.973	N/A	0.256	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.28
12.50	15.83	0.13	0.82	sandy silt to clayey silt	3.9	1.00	6	1,500	1,151	1,500	2.44	2.48	51.79	0.971	1.000	0.263	0.093	0.471	YES	2.8	10.1	318	13.8	N/A	2.004	0.24	1.04
13.50	26.87	0.14	0.51	silty sand to sandy silt	2.9	1.66	15	1,620	1,208	1,620	1.86	1.00	57.24	0.969	1.000	0.270	0.097	0.481	YES	2.8	19.3	1,110	24.8	N/A	0.084	0.01	1.03
14.50	12.60	0.10	0.75	sandy silt to clayey silt	1.9	1.66	8	1,740	1,266	1,740	2.24	1.00	26.21	0.966	1.000	0.276	0.072	0.347	YES	2.8	11.7	418	15.7	N/A	1.599	0.19	0.84
15.50	3.93	0.05	1.37	sensitive fine grained	0.9	1.00	2	1,860	1,323	1,860	3.11	N/A	N/A	0.964	N/A	0.282	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
16.50	4.02	0.05	1.15	sensitive fine grained	-0.1	1.00	2	1,980	1,381	1,980	3.08	N/A	N/A	0.962	N/A	0.287	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
17.50	3.54	0.02	0.57	sensitive fine grained	-1.1	1.00	2	2,100	1,439	2,063	3.03	7.08	32.12	0.959	N/A	0.291	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
18.50	4.81	0.05	1.08	sensitive fine grained	-2.1	1.00	2	2,220	1,496	2,120	3.02	N/A	N/A	0.957	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
19.50	5.35	0.07	1.25	sensitive fine grained	-3.1	1.00	3	2,340	1,554	2,178	3.02	N/A	N/A	0.955	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
20.50	5.06	0.06	1.25	sensitive fine grained	-4.1	1.00	3	2,460	1,611	2,235	3.05	N/A	N/A	0.952	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
21.50	4.73	0.04	0.78	sensitive fine grained	-5.1	1.00	2	2,580	1,669	2,293	3.01	N/A	N/A	0.950	N/A	0.305	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
22.50	5.42	0.07	1.24	sensitive fine grained	-6.1	1.00	3	2,700	1,727	2,351	3.05	N/A	N/A	0.948	N/A	0.308	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
23.50	19.76	0.14	0.73	sandy silt to clayey silt	-7.1	1.66	13	2,820	1,784	2,408	2.12	1.00	34.65	0.945	1.000	0.311	0.079	0.339	YES	2.8	14.7	655	19.3	N/A	1.205	0.14	0.69
24.50	8.64	0.08	0.94	clayey silt to silty clay	-8.1	1.00	4	2,940	1,842	2,466	2.81	N/A	N/A	0.943	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.69
25.50	8.14	0.20	2.45	silty clay to clay	-9.1	1.00	5	3,060	1,899	2,523	3.06	N/A	N/A	0.941	N/A	0.315	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.69
26.50	9.84	0.18	1.80	clayey silt to silty clay	-10.1	1.00	5	3,180	1,957	2,581	2.92	N/A	N/A	0.938	N/A	0.317	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.69
27.50	13.05	0.28	2.16	clayey silt to silty clay	-11.1	1.00	7	3,300	2,015	2,639	2.86	N/A	N/A	0.936	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.69
28.50	15.61	0.56	3.60	silty clay to clay	-12.1	1.00	10	3,420	2,072	2,696	2.93	N/A	N/A	0.934	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.69
29.50	55.69	0.87	1.56	silty sand to sandy silt	-13.1	1.00	19	3,540	2,130	2,754	2.25	1.79	96.87	0.931	0.981	0.322	0.165	0.669	YES	2.8	18.6	1,041	24.0	N/A	0.155	0.02	0.67
30.50	82.40	1.19	1.44	silty sand to sandy silt	-14.1	1.00	27	3,660	2,187	2,811	2.10	1.45	114.36	0.926	0.968	0.322	0.219	0.878	YES	2.8	26.0	1,200	32.8	N/A	0.049	0.01	0.67
31.50	66.36	0.51	0.77	sand to silty sand	-15.1	1.66	27	3,780	2,245	2,869	1.71	1.00	103.70	0.918	0.959	0.321	0.184	0.732	YES	1.3	24.3	1,200	26.5	N/A	0.091	0.01	0.66
32.50	13.41	0.31	2.32	clayey silt to silty clay	-16.1	1.00	7	3,900	2,303	2,927	2.90	N/A	N/A	0.909	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.66
33.50	7.83	0.21	2.72	silty clay to clay	-17.1	1.00	5	4,020	2,360	2,984	3.18	N/A	N/A	0.901	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.66
34.50	7.16	0.26	3.58	clay	-18.1	1.00	7	4,140	2,418	3,042	3.29	N/A	N/A	0.893	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.66
35.50	7.81	0.22	2.87	silty clay to clay	-19.1	1.00	5	4,260	2,475	3,099	3.21	N/A	N/A	0.885	N/A	0.317	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.66
36.50	11.21	0.40	3.60	clay	-20.1	1.00	11	4,380	2,533	3,157	3.12	N/A	N/A	0.877	N/A	0.315	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.66
37.50	36.15	0.67	1.86	sandy silt to clayey silt	-21.1	1.00	14	4,500	2,591	3,215	2.51	2.80	83.47	0.869	0.937	0.314	0.134	0.534	YES	2.8	14.2	609	18.7	N/A	1.311	0.16	0.50
38.50	98.01	0.84	0.86	sand to silty sand	-22.1	1.66	41	4,620	2,648	3,272	1.62	1.00	141.03	0.861	0.894	0.312	0.341	1.302	NO	N/A	N/A	N/A	35.7	N/A	0.028	0.00	0.50
39.50	32.75	1.04	3.18	clayey silt to silty clay	-23.1	1.00	16	4,740	2,706	3,330	2.70	N/A	N/A	0.852	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
40.50	50.06	1.04	2.07	sandy silt to clayey silt	-24.1	1.00	20	4,860	2,763	3,387	2.41	2.36	100.41	0.844	0.909	0.309	0.174	0.684	YES	2.8	18.2	995	23.5	N/A	0.144	0.02	0.48
41.50	32.86	0.91	2.77	sandy silt to clayey silt	-25.1	1.66	22	4,980	2,821	3,445	2.33	2.04	93.43	0.836	0.900	0.307	0.156	0.610	YES	2.8	19.4	1,121	24.9	N/A	0.096	0.01	0.47
42.50	15.83	0.58	3.64	silty clay to clay	-26.1	1.00	11	5,100	2,879	3,503	3.03	N/A	N/A	0.828	N/A	0.305	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
43.50	26.61	0.34	1.29	sandy silt to clayey silt	-27.1	1.00	11	5,220	2,936	3,560	2.57	3.14	62.69	0.820	0.922	0.303	0.103	0.418	YES	2.8	10.8	356	14.6	N/A	1.889	0.23	0.24
44.50	43.53	0.53	1.21	silty sand to sandy silt	-28.1	1.66	24	5,340	2,994	3,618	2.03	1.33	78.62	0.812	0.880	0.301	0.125	0.488	YES	2.8	20.7	1,200	26.4	N/A	0.085	0.01	0.23
45.50	17.73	0.43	2.44	clayey silt to silty clay	-29.1	1.00	9	5,460	3,051	3,675	2.90	N/A	N/A	0.804	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
46.50	15.94	0.37	2.31	clayey silt to silty clay	-30.1	1.00	8	5,580	3,109	3,733	2.93	N/A	N/A	0.795	N/A	0.297	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
47.50	14.89	0.24	1.58	sandy silt to clayey silt	-31.1	1.00	6	5,700	3,167	3,791	2.88	N/A	N/A	0.787	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
48.50	11.42	0.28	2.45	clayey silt to silty clay	-32.1	1.00	6	5,820	3,224	3,848	3.10	N/A	N/A	0.779	N/A	0.293	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
49.50	12.76	0.32	2.51	clayey silt to silty clay	-33.1	1.00	6	5,940	3,282	3,906	3.06	N/A	N/A	0.771	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
50.50	17.59	0.55	3.10	clayey silt to silty clay	-34.1	1.00	9	6,060	3,339	3,963	2.99	N/A	N/A	0.763	N/A	0.288	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
51.50	13.42	0.44	3.30	silty clay to clay	-35.1	1.00	9	6,180	3,397	4,021	3.12	N/A	N/A	0.755	N/A	0.286	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
52.50	10.88	0.29	2.66	silty clay to clay	-36.1	1.00	7	6,300	3,455	4,079	3.17	N/A	N/A	0.747	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
53.50	12.96	0.29	2.23	clayey silt to silty clay	-37.1	1.00	6	6,420	3,512	4,136	3.05	N/A	N/A	0.739	N/A	0.281	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
54.50	41.91	0.48	1.14	silty sand to sandy silt	-38.1	1.66	23	6,540	3,570	4,194	2.06	1.38	71.93	0.730	0.841	0.278	0.115	0.462	YES	2.8	18.8	1,056	24.2	N/A	0.090	0.01	0.22
55.50	15.76	0.47	2.97	clayey silt to silty clay	-39.1	1.00	8	6,660	3,627	4,251	3.05	N/A	N/A	0.722	N/A	0.276	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.22
56.50	32.02	0.65	2.02	sandy silt to clayey silt	-40.1	1.00	13	6,780	3,685	4,309	2.68	N/A	N/A	0.714	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.22
57.50	44.03	0.62	1.42	silty sand to sandy silt	-41.1	1.00	15	6,900	3,743	4,367	2.47	2.62	72.16	0.706	0.862	0.271	0.115	0.489	YES	2.8	12.7	490	16.9	N/A	1.283	0.15	0.07
58.50	50.96	0.75	1.47	silty sand to sandy silt	-42.1	1.00	17	7,020	3,800	4,424	2.37	2.20	81.49	0.698	0.850	0.268	0.130	0.551	YES	2.8	14.2	611	18.7	N/A	0.375	0.04	0.02
59.50	148.80	1.58	1.06	sand	-43.1	1.00	30	7,140	3,858	4,482	1.91	1.20	128.54	0.690	0.803	0.265	0.278	1.120	YES	0.0	19.9	1,173	19.9	N/A	0.184	0.02	0.00

max=	1,200
min=	318
avg=	871

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT025

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	20.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	17.00 ft below ground surface
GWT Depth For Design, Zwd =	10.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	8.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.29 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	0.29 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	87.79	1.11	1.27	sand to silty sand	19.0	1.66	36	60	60	60	1.23	1.00	839.18	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	67.2	0.008	0.000	0.00	0.29
1.50	21.28	0.46	2.14	sandy silt to clayey silt	18.0	1.00	9	180	180	180	2.24	1.78	126.25	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	22.4	N/A	N/A	N/A	0.29
2.50	20.04	0.57	2.83	clayey silt to silty clay	17.0	1.00	10	300	300	300	2.43	2.43	125.49	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
3.50	10.43	0.40	3.86	clay	16.0	1.00	10	420	420	420	2.66	N/A	N/A	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
4.50	16.19	0.55	3.38	silty clay to clay	15.0	1.00	11	540	540	540	2.54	2.98	128.61	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
5.50	31.94	1.13	3.53	clayey silt to silty clay	14.0	1.00	16	660	660	660	2.47	2.64	146.69	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
6.50	20.76	0.67	3.25	clayey silt to silty clay	13.0	1.00	10	780	780	780	2.54	2.96	124.54	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
7.50	20.52	0.65	3.15	clayey silt to silty clay	12.0	1.00	10	900	900	900	2.57	3.12	116.69	0.983	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
8.50	16.60	0.52	3.15	clayey silt to silty clay	11.0	1.00	8	1,020	1,020	1,020	2.67	N/A	N/A	0.980	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
9.50	16.04	0.47	2.90	clayey silt to silty clay	10.0	1.00	8	1,140	1,140	1,140	2.69	N/A	N/A	0.978	N/A	0.203	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
10.50	10.63	0.35	3.29	silty clay to clay	9.0	1.00	7	1,260	1,229	1,260	2.89	N/A	N/A	0.976	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
11.50	9.58	0.31	3.20	silty clay to clay	8.0	1.00	6	1,380	1,286	1,380	2.93	N/A	N/A	0.973	N/A	0.217	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
12.50	7.46	0.21	2.80	silty clay to clay	7.0	1.00	5	1,500	1,344	1,500	3.00	N/A	N/A	0.971	N/A	0.225	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
13.50	7.07	0.19	2.74	silty clay to clay	6.0	1.00	5	1,620	1,402	1,620	3.03	N/A	N/A	0.969	N/A	0.233	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
14.50	5.95	0.16	2.68	clay	5.0	1.00	6	1,740	1,459	1,740	3.11	N/A	N/A	0.966	N/A	0.240	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
15.50	6.02	0.16	2.70	clay	4.0	1.00	6	1,860	1,517	1,860	3.12	N/A	N/A	0.964	N/A	0.246	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
16.50	5.53	0.15	2.78	clay	3.0	1.00	6	1,980	1,574	1,980	3.18	N/A	N/A	0.962	N/A	0.252	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
17.50	5.79	0.14	2.37	silty clay to clay	2.0	1.00	4	2,100	1,632	2,069	3.13	N/A	N/A	0.959	N/A	0.257	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
18.50	5.55	0.10	1.80	silty clay to clay	1.0	1.00	4	2,220	1,690	2,126	3.10	N/A	N/A	0.957	N/A	0.262	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
19.50	6.05	0.14	2.23	silty clay to clay	0.0	1.00	4	2,340	1,747	2,184	3.12	N/A	N/A	0.955	N/A	0.266	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
20.50	5.90	0.15	2.50	silty clay to clay	-1.0	1.00	4	2,460	1,805	2,242	3.17	N/A	N/A	0.952	N/A	0.270	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
21.50	5.84	0.13	2.18	silty clay to clay	-2.0	1.00	4	2,580	1,862	2,299	3.16	N/A	N/A	0.950	N/A	0.274	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
22.50	5.76	0.12	2.03	silty clay to clay	-3.0	1.00	4	2,700	1,920	2,357	3.16	N/A	N/A	0.948	N/A	0.277	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
23.50	4.99	0.06	1.20	sensitive fine grained	-4.0	1.00	2	2,820	1,978	2,414	3.12	N/A	N/A	0.945	N/A	0.280	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
24.50	4.95	0.05	0.98	sensitive fine grained	-5.0	1.00	2	2,940	2,035	2,472	3.10	N/A	N/A	0.943	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
25.50	5.38	0.06	1.07	sensitive fine grained	-6.0	1.00	3	3,060	2,093	2,530	3.09	N/A	N/A	0.941	N/A	0.286	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
26.50	5.81	0.10	1.64	sensitive fine grained	-7.0	1.00	3	3,180	2,150	2,587	3.15	N/A	N/A	0.938	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
27.50	6.16	0.07	1.11	sensitive fine grained	-8.0	1.00	3	3,300	2,208	2,645	3.05	N/A	N/A	0.936	N/A	0.291	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
28.50	6.97	0.10	1.49	clayey silt to silty clay	-9.0	1.00	3	3,420	2,266	2,702	3.07	N/A	N/A	0.934	N/A	0.293	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
29.50	7.95	0.18	2.20	silty clay to clay	-10.0	1.00	5	3,540	2,323	2,760	3.11	N/A	N/A	0.931	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
30.50	24.38	0.19	0.79	silty sand to sandy silt	-11.0	1.66	13	3,660	2,381	2,818	2.11	1.48	54.68	0.926	0.957	0.296	0.095	0.411	YES	2.8	14.1	603	18.6	N/A	1.225	0.15	0.14
31.50	8.82	0.17	1.97	clayey silt to silty clay	-12.0	1.00	4	3,780	2,438	2,875	3.05	N/A	N/A	0.918	N/A	0.296	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
32.50	9.69	0.21	2.18	clayey silt to silty clay	-13.0	1.00	5	3,900	2,496	2,933	3.05	N/A	N/A	0.909	N/A	0.296	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
33.50	12.14	0.26	2.16	clayey silt to silty clay	-14.0	1.00	6	4,020	2,554	2,990	2.96	N/A	N/A	0.901	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
34.50	6.88	0.08	1.16	sensitive fine grained	-15.0	1.00	3	4,140	2,611	3,048	3.08	N/A	N/A	0.893	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
35.50	10.95	0.30	2.78	silty clay to clay	-16.0	1.00	7	4,260	2,669	3,106	3.08	N/A	N/A	0.885	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
36.50	19.50	0.66	3.40	clayey silt to silty clay	-17.0	1.00	10	4,380	2,726	3,163	2.91	N/A	N/A	0.877	N/A	0.293	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
37.50	12.50	0.45	3.56	silty clay to clay	-18.0	1.00	8	4,500	2,784	3,221	3.10	N/A	N/A	0.869	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
38.50	8.11	0.27	3.38	clay	-19.0	1.00	8	4,620	2,842	3,278	3.28	N/A	N/A	0.861	N/A	0.291	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
39.50	9.98	0.36	3.65	clay	-20.0	1.00	10	4,740	2,899	3,336	3.21	N/A	N/A	0.852	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
40.50	11.22	0.39	3.50	silty clay to clay	-21.0	1.00	7	4,860	2,957	3,394	3.16	N/A	N/A	0.844	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
41.50	32.05	0.83	2.60	sandy silt to clayey silt	-22.0	1.00	13	4,980	3,014	3,451	2.68	N/A	N/A	0.836	N/A	0.287	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.14
42.50	68.66	1.14	1.66	silty sand to sandy silt	-23.0	1.00	23	5,100	3,072	3,509	2.26	1.82	100.91	0.828	0.875	0.286	0.176	0.717	YES	2.8	20.1	1,194	25.7	N/A	0.084	0.01	0.13
43.50	100.05	1.65	1.65	silty sand to sandy silt	-24.0	1.66	55	5,220	3,130	3,566	1.82	1.12	148.75	0.820	0.836	0.284	0.386	1.514	NO	N/A	N/A	N/A	54.6	N/A	0.000	0.00	0.13
44.50	46.94	1.06	2.25	sandy silt to clayey silt	-25.0	1.00	19	5,340	3,187	3,624	2.52	2.88	95.31	0.812	0.878	0.283	0.161	0.664	YES	2.8	16.7	848	21.7	N/A	0.148	0.02	0.11
45.50	106.30	0.88	0.82	sand to silty sand	-26.0	1.00	27	5,460	3,245	3,682	1.93	1.22	101.45	0.804	0.852	0.281	0.177	0.715	YES	1.3	20.9	1,200	23.0	N/A	0.098	0.01	0.10
46.50	129.32	0.58	0.45	sand	-27.0	1.00	26	5,580	3,302	3,739	1.71	1.00	100.64	0.795	0.849	0.280	0.175	0.708	YES	0.0	18.9	1,072	18.9	N/A	0.477	0.06	0.05
47.50	154.94	0.66	0.43	sand	-28.0	1.00	31	5,700	3,360	3,797	1.64	1.00	119.54	0.787	0.832	0.278	0.239	0.954	YES	0.0	22.5	1,200	22.5	N/A	0.099	0.01	0.03
48.50	130.19	0.80	0.62	sand	-29.0	1.66	43	5,820	3,418	3,854	1.48	1.00	164.91	0.779	0.807	0.276	N/A	N/A	NO	N/A	N/A	N/A	31.1	N/A	0.050	0.01	0.03
49.50	56.42	1.05	1.87	silty sand to sandy silt	-30.0	1.00	19	5,940	3,475	3,912	2.38	2.24	95.93	0.771	0.859	0.274	0.162	0.678	YES	2.8	16.2	798	21.1	N/A	0.149	0.02	0.01
50.50	35.13	0.69	1.95	sandy silt to clayey silt	-31.0	1.66	23	6,060	3,533	3,970	2.25	1.81	79.01	0.763	0.841	0.272	0.126	0.519	YES	2.8	19.3	1,114	24.8	N/A	0.084	0.01	0.00
51.50	13.43	0.29	2.13	clayey silt to silty clay	-32.0	1.00	7	6,180	3,590	4,027	3.03	N/A	N/A	0.755	N/A	0.270	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
52.50	15.00	0.33	2.18	clayey silt to silty clay	-33.0	1.00	7	6,300	3,648	4,085	2.99	N/A	N/A	0.747	N/A	0.268	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
53.50	17.74	0.51	2.90	clayey silt to silty clay	-34.0	1.00	9	6,420	3,706	4,142	3.00	N/A	N/A	0.739	N/A	0.266	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
54.50	17.17	0.61	3.55	silty clay to clay	-35.0	1.00	11	6,540	3,763	4,200	3.07	N/A	N/A	0.730	N/A	0.264	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
55.50	14.53	0.40	2.78	clayey silt to silty clay	-36.0	1.00	7	6,660	3,821	4,258	3.08	N/A	N/A	0.722	N/A	0.262	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
56.50	13.79	0.30	2.20	clayey silt to silty clay	-37.0	1.00	7	6,780	3,878	4,315	3.05	N/A	N/A	0.714	N/A	0.260	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
57.50	13.66	0.33	2.43	clayey silt to silty clay	-38.0	1.00	7	6,900	3,936	4,373	3.09	N/A	N/A	0.706	N/A	0.257	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
58.50	15.13	0.39	2.58	clayey silt to silty clay	-39.0	1.00	8	7,020	3,994	4,430	3.06	N/A	N/A	0.698	N/A	0.255	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
59.50	16.65	0.37	2.24	clayey silt to silty clay	-40.0	1.00	8	7,140	4,051	4,488	2.99	N/A	N/A	0.690	N/A	0.253	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
60.50	17.85	0.38	2.11	clayey silt to silty clay	-41.0	1.00	9	7,260	4,109	4,546	2.95	N/A	N/A	0.682	N/A	0.250	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max= 1,200
min= 603
avg= 1,004

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT026

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	13.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_w	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ CSR = 0.65 A_{max} (σ_v/σ_v') r_d

+++ FS = ($CRR_{7.5}$/CSR) MSF K_σ $K_{\alpha \rightarrow >>}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	10.00 ft below ground surface
GWT Depth For Design, Zwd =	3.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	16.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	2.31 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	2.31 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	239.18	2.65	1.11	sand	12.0	1.66	79	60	60	60	1.05	1.00	2,286.45	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	134.6	0.006	0.000	0.00	2.31
1.50	103.30	2.11	2.04	silty sand to sandy silt	11.0	1.00	34	180	180	180	1.79	1.10	378.98	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	75.2	0.013	0.000	0.00	2.31
2.50	60.72	1.59	2.62	sandy silt to clayey silt	10.0	1.66	40	300	300	300	1.77	1.08	281.51	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	87.0	N/A	N/A	N/A	2.31
3.50	29.23	0.73	2.49	sandy silt to clayey silt	9.0	1.00	12	420	389	420	2.31	1.98	131.54	0.992	1.000	0.223	0.292	1.746	NO	N/A	N/A	N/A	28.9	N/A	0.051	0.01	2.31
4.50	17.20	0.38	2.21	clayey silt to silty clay	8.0	1.00	9	540	446	540	2.47	2.63	95.82	0.990	1.000	0.249	0.162	0.867	YES	2.8	17.4	916	N/A	N/A	0.000	0.00	2.31
5.50	13.28	0.18	1.37	sandy silt to clayey silt	7.0	1.00	5	660	504	660	2.46	2.58	68.39	0.987	1.000	0.269	0.110	0.545	YES	2.8	11.8	425	15.8	N/A	1.521	0.18	2.12
6.50	25.92	0.67	2.57	sandy silt to clayey silt	6.0	1.00	10	780	562	780	2.42	2.39	116.75	0.985	1.000	0.285	0.228	1.069	YES	2.8	19.4	1,123	24.9	N/A	0.088	0.01	2.11
7.50	84.57	1.25	1.48	silty sand to sandy silt	5.0	1.00	28	900	619	900	1.90	1.19	180.28	0.983	1.000	0.297	N/A	N/A	NO	N/A	N/A	N/A	55.4	N/A	0.000	0.00	2.11
8.50	77.98	0.86	1.11	sand to silty sand	4.0	1.00	19	1,020	677	1,020	1.85	1.14	153.07	0.980	1.000	0.307	0.414	1.796	NO	N/A	N/A	N/A	31.1	N/A	0.057	0.01	2.11
9.50	126.50	1.18	0.93	sand to silty sand	3.0	1.66	52	1,140	734	1,140	1.34	1.00	345.65	0.978	1.000	0.316	N/A	N/A	NO	N/A	N/A	N/A	75.2	N/A	0.000	0.00	2.11
10.50	62.21	0.74	1.18	silty sand to sandy silt	2.0	1.66	34	1,260	792	1,229	1.65	1.01	164.74	0.976	1.000	0.323	N/A	N/A	NO	N/A	N/A	N/A	57.6	N/A	0.000	0.00	2.11
11.50	7.37	0.23	3.05	clay	1.0	1.00	7	1,380	850	1,286	2.91	N/A	N/A	0.973	N/A	0.329	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
12.50	4.68	0.15	3.17	clay	0.0	1.00	5	1,500	907	1,344	3.11	N/A	N/A	0.971	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
13.50	5.90	0.24	4.01	clay	-1.0	1.00	6	1,620	965	1,402	3.10	N/A	N/A	0.969	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
14.50	4.55	0.12	2.60	clay	-2.0	1.00	5	1,740	1,022	1,459	3.12	N/A	N/A	0.966	N/A	0.342	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
15.50	4.33	0.11	2.46	clay	-3.0	1.00	4	1,860	1,080	1,517	3.14	N/A	N/A	0.964	N/A	0.345	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
16.50	4.42	0.05	1.06	sensitive fine grained	-4.0	1.00	2	1,980	1,138	1,574	2.97	N/A	N/A	0.962	N/A	0.348	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
17.50	3.35	0.03	0.84	sensitive fine grained	-5.0	1.00	2	2,100	1,195	1,632	3.07	N/A	N/A	0.959	N/A	0.351	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
18.50	5.58	0.04	0.66	sensitive fine grained	-6.0	1.00	3	2,220	1,253	1,690	2.81	4.88	38.70	0.957	N/A	0.353	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
19.50	5.27	0.04	0.76	sensitive fine grained	-7.0	1.00	3	2,340	1,310	1,747	2.88	5.48	39.63	0.955	N/A	0.355	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.11
20.50	11.44	0.05	0.46	sandy silt to clayey silt	-8.0	1.00	5	2,460	1,368	1,805	2.51	2.82	38.99	0.952	1.000	0.356	0.082	0.309	YES	2.8	7.6	204	10.8	N/A	2.474	0.30	1.81
21.50	13.58	0.06	0.43	sandy silt to clayey silt	-9.0	1.66	9	2,580	1,426	1,862	2.15	1.00	26.64	0.950	1.000	0.358	0.072	0.269	YES	2.8	12.1	445	16.2	N/A	1.737	0.21	1.60
22.50	5.17	0.02	0.32	sensitive fine grained	-10.0	1.00	3	2,700	1,483	1,920	2.80	4.76	30.81	0.948	N/A	0.359	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.60
23.50	4.68	0.02	0.35	sensitive fine grained	-11.0	1.00	2	2,820	1,541	1,978	2.87	5.42	30.88	0.945	N/A	0.360	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.60
24.50	11.62	0.06	0.54	sandy silt to clayey silt	-12.0	1.00	5	2,940	1,598	2,035	2.54	2.99	41.12	0.943	1.000	0.361	0.084	0.312	YES	2.8	7.4	196	10.5	N/A	2.513	0.30	1.30
25.50	51.43	0.24	0.46	sand to silty sand	-13.0	1.00	13	3,060	1,656	2,093	1.94	1.00	56.52	0.941	1.000	0.361	0.097	0.357	YES	1.3	13.9	584	15.7	N/A	1.798	0.22	1.08
26.50	154.23	1.71	1.11	sand	-14.0	1.00	31	3,180	1,714	2,150	1.78	1.09	181.94	0.938	1.000	0.362	N/A	N/A	NO	N/A	N/A	N/A	29.7	N/A	0.080	0.01	1.07
27.50	191.15	2.32	1.21	sand	-15.0	1.00	38	3,300	1,771	2,208	1.75	1.07	217.52	0.936	1.000	0.363	N/A	N/A	NO	N/A	N/A	N/A	36.4	N/A	0.028	0.00	1.07
28.50	99.75	1.52	1.52	silty sand to sandy silt	-16.0	1.66	55	3,420	1,829	2,266	1.71	1.05	180.69	0.934	1.000	0.363	N/A	N/A	NO	N/A	N/A	N/A	67.1	N/A	0.000	0.00	1.07
29.50	40.55	0.53	1.31	silty sand to sandy silt	-17.0	1.00	14	3,540	1,886	2,323	2.29	1.93	80.43	0.931	1.000	0.363	0.128	0.471	YES	2.8	15.3	712	20.0	N/A	1.319	0.16	0.91
30.50	30.12	0.29	0.96	silty sand to sandy silt	-18.0	1.00	10	3,660	1,944	2,381	2.34	2.07	63.18	0.926	1.000	0.363	0.103	0.381	YES	2.8	12.0	436	16.0	N/A	1.758	0.21	0.70
31.50	81.61	1.09	1.34	sand to silty sand	-19.0	1.00	20	3,780	2,002	2,438	2.07	1.40	113.87	0.918	1.000	0.360	0.217	0.804	YES	1.3	19.8	1,166	21.9	N/A	1.108	0.13	0.57
32.50	94.55	1.20	1.27	sand to silty sand	-20.0	1.00	24	3,900	2,059	2,496	2.01	1.31	121.93	0.909	0.990	0.358	0.249	0.917	YES	1.3	22.5	1,200	24.7	N/A	0.277	0.03	0.53
33.50	62.58	0.48	0.77	sand to silty sand	-21.0	1.00	16	4,020	2,117	2,554	2.02	1.33	81.10	0.901	0.984	0.356	0.130	0.478	YES	1.3	15.2	697	17.0	N/A	1.642	0.20	0.34
34.50	155.35	1.46	0.94	sand	-22.0	1.00	31	4,140	2,174	2,611	1.77	1.08	161.24	0.893	0.968	0.354	N/A	N/A	NO	N/A	N/A	N/A	27.2	N/A	0.097	0.01	0.33
35.50	278.95	4.48	1.61	sand to silty sand	-23.0	1.00	70	4,260	2,232	2,669	1.77	1.09	286.95	0.885	0.957	0.351	N/A	N/A	NO	N/A	N/A	N/A	65.8	N/A	0.000	0.00	0.33
36.50	282.60	4.64	1.64	sand to silty sand	-24.0	1.00	71	4,380	2,290	2,726	1.78	1.09	288.48	0.877	0.947	0.349	N/A	N/A	NO	N/A	N/A	N/A	65.9	N/A	0.000	0.00	0.33
37.50	161.95	2.66	1.64	sand to silty sand	-25.0	1.00	40	4,500	2,347	2,784	1.94	1.23	183.36	0.869	0.938	0.346	N/A	N/A	NO	N/A	N/A	N/A	38.5	N/A	0.011	0.00	0.32
38.50	118.52	1.40	1.18	sand to silty sand	-26.0	1.00	30	4,620	2,405	2,842	1.94	1.23	132.63	0.861	0.933	0.344	0.297	1.075	YES	1.3	26.2	1,200	28.6	N/A	0.084	0.01	0.31
39.50	141.72	1.79	1.26	sand to silty sand	-27.0	1.00	35	4,740	2,462	2,899	1.90	1.19	152.27	0.852	0.920	0.341	0.408	1.469	NO	N/A	N/A	N/A	33.3	N/A	0.048	0.01	0.31
40.50	155.78	1.91	1.23	sand to silty sand	-28.0	1.00	39	4,860	2,520	2,957	1.87	1.16	161.06	0.844	0.912	0.339	N/A	N/A	NO	N/A	N/A	N/A	36.1	N/A	0.028	0.00	0.31
41.50	168.59	2.30	1.36	sand to silty sand	-29.0	1.00	42	4,980	2,578	3,014	1.88	1.17	173.92	0.836	0.904	0.336	N/A	N/A	NO	N/A	N/A	N/A	38.5	N/A	0.011	0.00	0.30
42.50	207.23	2.77	1.34	sand to silty sand	-30.0	1.00	52	5,100	2,635	3,072	1.82	1.12	201.88	0.828	0.896	0.333	N/A	N/A	NO	N/A	N/A	N/A	46.3	N/A	0.000	0.00	0.30
43.50	234.58	3.47	1.48	sand to silty sand	-31.0	1.00	59	5,220	2,693	3,130	1.82	1.12	226.24	0.820	0.888	0.331	N/A	N/A	NO	N/A	N/A	N/A	51.6	N/A	0.000	0.00	0.30
44.50	267.75	4.60	1.72	sand to silty sand	-32.0	1.00	67	5,340	2,750	3,187	1.83	1.13	258.65	0.812	0.880	0.328	N/A	N/A	NO	N/A	N/A	N/A	58.1	N/A	0.000	0.00	0.30
45.50	188.20	2.99	1.59	sand to silty sand	-33.0	1.00	47	5,460	2,808	3,245	1.91	1.20	190.29	0.804	0.873	0.325	N/A	N/A	NO	N/A	N/A	N/A	41.2	N/A	0.000	0.00	0.30
46.50	197.58	2.56	1.30	sand to silty sand	-34.0	1.66	82	5,580	2,866	3,302	1.52	1.00	273.31	0.795	0.866	0.322	N/A	N/A	NO	N/A	N/A	N/A	69.2	N/A	0.000	0.00	0.30
47.50	78.23	1.37	1.76	silty sand to sandy silt	-35.0	1.66	43	5,700	2,923	3,360	1.91	1.20	128.39	0.787	0.859	0.319	0.277	0.994	YES	2.8	36.1	1,200	45.0	N/A	0.000	0.00	0.30
48.50	19.92	0.32	1.61	sandy silt to clayey silt	-36.0	1.00	8	5,820	2,981	3,418	2.74	N/A	N/A	0.779	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
49.50	13.70	0.18	1.35	sandy silt to clayey silt	-37.0	1.00	5	5,940	3,038	3,475	2.86	N/A	N/A	0.771	N/A	0.314	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
50.50	12.85	0.16	1.27	sandy silt to clayey silt	-38.0	1.00	5	6,060	3,096	3,533	2.89	N/A	N/A	0.763	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
51.50	41.63	0.41	0.97	silty sand to sandy silt	-39.0	1.00	14	6,180	3,154	3,590	2.31	1.99	65.82	0.755	0.896	0.308	0.107	0.414	YES	2.8	13.2	523	17.4	N/A	1.467	0.18	0.13
52.50	50.60	0.71	1.40	silty sand to sandy silt	-40.0	1.00	17	6,300	3,211	3,648	2.33	2.06	82.08	0.747	0.882	0.305	0.131	0.508	YES	2.8	15.3	707	20.0	N/A	1.066	0.13	0.00

max= 1,200
min= 196
avg= 733

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT031

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	6.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	6.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	3.00 ft below ground surface
GWT Depth For Design, Zwd =	0.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	20.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	1.99 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	1.99 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) σ_v' (psf)	Effective Vert. Stress (Test) σ_v' (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	8.10	0.09	1.15	clayey silt to silty clay	5.0	1.00	4	60	29	60	2.08	1.42	96.05	0.999	1.000	0.433	0.162	0.501	YES	2.8	9.7	295	N/A	N/A	0.000	0.00	1.99
1.50	33.45	0.19	0.58	silty sand to sandy silt	4.0	1.00	11	180	86	180	1.60	1.00	160.94	0.997	1.000	0.432	N/A	N/A	NO	N/A	N/A	N/A	27.7	N/A	0.383	0.05	1.94
2.50	24.75	0.31	1.25	sandy silt to clayey silt	3.0	1.66	16	300	144	300	1.69	1.03	157.55	0.994	1.000	0.431	0.444	1.374	NO	N/A	N/A	N/A	38.4	N/A	0.015	0.00	1.94
3.50	3.77	0.15	3.85	clay	2.0	1.00	4	420	202	389	2.83	N/A	N/A	0.992	N/A	0.430	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
4.50	5.05	0.23	4.33	clay	1.0	1.00	5	540	259	446	2.83	N/A	N/A	0.990	N/A	0.429	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
5.50	2.62	0.15	5.75	clay	0.0	1.00	3	660	317	504	3.19	N/A	N/A	0.987	N/A	0.428	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
6.50	2.27	0.11	4.58	clay	-1.0	1.00	2	780	374	562	3.24	N/A	N/A	0.985	N/A	0.427	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
7.50	2.55	0.14	5.35	clay	-2.0	1.00	3	900	432	619	3.28	N/A	N/A	0.983	N/A	0.426	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
8.50	2.82	0.15	5.09	clay	-3.0	1.00	3	1,020	490	677	3.27	N/A	N/A	0.980	N/A	0.425	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
9.50	2.97	0.13	4.18	clay	-4.0	1.00	3	1,140	547	734	3.23	N/A	N/A	0.978	N/A	0.424	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
10.50	2.40	0.08	3.20	clay	-5.0	1.00	2	1,260	605	792	3.29	N/A	N/A	0.976	N/A	0.423	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
11.50	2.68	0.09	3.24	clay	-6.0	1.00	3	1,380	662	850	3.28	N/A	N/A	0.973	N/A	0.422	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
12.50	2.35	0.08	3.20	clay	-7.0	1.00	2	1,500	720	907	3.37	N/A	N/A	0.971	N/A	0.421	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
13.50	1.83	0.07	3.53	clay	-8.0	1.00	2	1,620	778	965	3.56	N/A	N/A	0.969	N/A	0.420	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
14.50	2.37	0.10	3.67	clay	-9.0	1.00	2	1,740	835	1,022	3.47	N/A	N/A	0.966	N/A	0.419	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
15.50	1.80	0.06	2.70	clay	-10.0	1.00	2	1,860	893	1,080	3.59	N/A	N/A	0.964	N/A	0.418	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
16.50	1.85	0.05	2.23	sensitive fine grained	-11.0	1.00	1	1,980	950	1,138	3.55	N/A	N/A	0.962	N/A	0.417	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
17.50	2.60	0.07	2.39	clay	-12.0	1.00	3	2,100	1,008	1,195	3.40	N/A	N/A	0.959	N/A	0.416	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.94
18.50	11.12	0.09	0.82	sandy silt to clayey silt	-13.0	1.00	4	2,220	1,066	1,253	2.58	3.19	48.61	0.957	1.000	0.415	0.090	0.291	YES	2.8	8.4	235	11.7	N/A	2.326	0.28	1.66
19.50	67.00	0.25	0.37	sand to silty sand	-14.0	1.00	17	2,340	1,123	1,310	1.72	1.00	89.40	0.955	1.000	0.414	0.146	0.472	YES	1.3	22.0	1,200	24.2	N/A	1.076	0.13	1.53
20.50	149.81	0.95	0.64	sand	-15.0	1.00	30	2,460	1,181	1,368	1.56	1.00	194.98	0.952	1.000	0.413	N/A	N/A	NO	N/A	N/A	N/A	36.2	N/A	0.035	0.00	1.53
21.50	152.55	1.15	0.75	sand	-16.0	1.00	31	2,580	1,238	1,426	1.61	1.00	193.86	0.950	1.000	0.412	N/A	N/A	NO	N/A	N/A	N/A	36.1	N/A	0.036	0.00	1.52
22.50	219.10	1.34	0.61	sand	-17.0	1.00	44	2,700	1,296	1,483	1.45	1.00	272.18	0.948	1.000	0.411	N/A	N/A	NO	N/A	N/A	N/A	50.9	N/A	0.000	0.00	1.52
23.50	234.98	1.63	0.69	sand	-18.0	1.00	47	2,820	1,354	1,541	1.47	1.00	285.63	0.945	1.000	0.410	N/A	N/A	NO	N/A	N/A	N/A	53.5	N/A	0.000	0.00	1.52
24.50	222.10	1.30	0.58	sand	-19.0	1.00	44	2,940	1,411	1,598	1.44	1.00	264.40	0.943	1.000	0.409	N/A	N/A	NO	N/A	N/A	N/A	49.7	N/A	0.000	0.00	1.52
25.50	150.53	1.30	0.86	sand	-20.0	1.66	50	3,060	1,469	1,656	1.38	1.00	290.84	0.941	1.000	0.408	N/A	N/A	NO	N/A	N/A	N/A	54.8	N/A	0.000	0.00	1.52
26.50	46.82	0.28	0.59	sand to silty sand	-21.0	1.00	12	3,180	1,526	1,714	2.01	1.31	70.35	0.938	1.000	0.407	0.112	0.369	YES	1.3	14.0	590	15.8	N/A	1.827	0.22	1.30
27.50	35.45	0.19	0.52	silty sand to sandy silt	-22.0	1.66	20	3,300	1,584	1,771	1.81	1.00	65.95	0.936	1.000	0.406	0.107	0.351	YES	2.8	23.6	1,200	29.9	N/A	0.092	0.01	1.29
28.50	8.43	0.07	0.80	clayey silt to silty clay	-23.0	1.00	4	3,420	1,642	1,829	2.77	N/A	N/A	0.934	N/A	0.405	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.29
29.50	78.17	0.41	0.53	sand to silty sand	-24.0	1.00	20	3,540	1,699	1,886	1.81	1.12	94.58	0.931	1.000	0.404	0.159	0.525	YES	1.3	21.5	1,200	23.6	N/A	1.104	0.13	1.16
30.50	113.10	0.81	0.71	sand to silty sand	-25.0	1.00	28	3,660	1,757	1,944	1.76	1.08	130.03	0.926	1.000	0.401	0.284	0.946	YES	1.3	30.0	1,200	32.6	N/A	0.067	0.01	1.15
31.50	85.01	0.54	0.64	sand to silty sand	-26.0	1.00	21	3,780	1,814	2,002	1.84	1.14	101.31	0.918	1.000	0.398	0.177	0.593	YES	1.3	22.6	1,200	24.8	N/A	0.870	0.10	1.05
32.50	99.32	0.40	0.40	sand	-27.0	1.00	20	3,900	1,872	2,059	1.68	1.00	102.66	0.909	1.000	0.394	0.181	0.611	YES	0.0	19.6	1,141	19.6	N/A	1.453	0.17	0.87
33.50	103.27	0.64	0.62	sand to silty sand	-28.0	1.00	26	4,020	1,930	2,117	1.77	1.09	114.33	0.901	1.000	0.391	0.219	0.748	YES	1.3	26.4	1,200	28.8	N/A	0.097	0.01	0.86
34.50	118.85	0.66	0.55	sand	-29.0	1.00	24	4,140	1,987	2,174	1.70	1.04	123.59	0.893	1.000	0.387	0.256	0.881	YES	0.0	22.8	1,200	22.8	N/A	1.119	0.13	0.73
35.50	104.30	0.62	0.59	sand to silty sand	-30.0	1.00	26	4,260	2,045	2,232	1.77	1.08	111.76	0.885	0.992	0.384	0.210	0.724	YES	1.3	26.0	1,200	28.4	N/A	0.098	0.01	0.72
36.50	91.42	0.65	0.71	sand to silty sand	-31.0	1.00	23	4,380	2,102	2,290	1.87	1.16	103.28	0.877	0.983	0.380	0.182	0.630	YES	1.3	22.7	1,200	24.9	N/A	0.433	0.05	0.66
37.50	92.20	0.67	0.73	sand to silty sand	-32.0	1.00	23	4,500	2,160	2,347	1.87	1.16	103.33	0.869	0.974	0.376	0.183	0.630	YES	1.3	22.6	1,200	24.8	N/A	0.417	0.05	0.61
38.50	120.58	0.52	0.43	sand	-33.0	1.00	24	4,620	2,218	2,405	1.66	1.00	114.51	0.861	0.964	0.373	0.220	0.758	YES	0.0	22.0	1,200	22.0	N/A	1.143	0.14	0.48
39.50	150.62	0.72	0.48	sand	-34.0	1.00	30	4,740	2,275	2,462	1.60	1.00	141.21	0.852	0.951	0.369	0.342	1.174	YES	0.0	27.1	1,200	27.1	N/A	0.118	0.01	0.46
40.50	118.30	0.82	0.70	sand	-35.0	1.66	39	4,860	2,333	2,520	1.48	1.00	181.40	0.844	0.940	0.366	N/A	N/A	NO	N/A	N/A	N/A	34.9	N/A	0.040	0.00	0.46
41.50	22.51	0.20	0.86	sandy silt to clayey silt	-36.0	1.00	9	4,980	2,390	2,578	2.47	2.64	54.27	0.836	0.963	0.362	0.095	0.336	YES	2.8	10.7	354	14.5	N/A	1.926	0.23	0.23
42.50	19.22	0.26	1.30	sandy silt to clayey silt	-37.0	1.00	8	5,100	2,448	2,635	2.65	N/A	N/A	0.828	N/A	0.359	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
43.50	11.22	0.13	1.14	clayey silt to silty clay	-38.0	1.00	6	5,220	2,506	2,693	2.86	N/A	N/A	0.820	N/A	0.355	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
44.50	8.38	0.09	0.96	clayey silt to silty clay	-39.0	1.66	7	5,340	2,563	2,750	2.65	3.66	42.17	0.812	N/A	0.352	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
45.50	3.83	0.09	1.77	sensitive fine grained	-40.0	1.00	2	5,460	2,621	2,808	3.65	N/A	N/A	0.804	N/A	0.348	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
46.50	5.60	0.19	2.85	clay	-41.0	1.00	6	5,580	2,678	2,866	3.48	N/A	N/A	0.795	N/A	0.345	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
47.50	10.32	0.24	2.14	clayey silt to silty clay	-42.0	1.00	5	5,700	2,736	2,923	3.08	N/A	N/A	0.787	N/A	0.341	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
48.50	9.12	0.10	1.05	clayey silt to silty clay	-43.0	1.00	5	5,820	2,794	2,981	2.99	N/A	N/A	0.779	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
49.50	12.77	0.05	0.39	sandy silt to clayey silt	-44.0	1.00	5	5,940	2,851	3,038	2.66	3.69	36.10	0.771	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
50.50	7.33	0.06	0.71	sensitive fine grained	-45.0	1.00	4	6,060	2,909	3,096	3.05	N/A	N/A	0.763	N/A	0.331	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
51.50	22.72	0.40	1.71	sandy silt to clayey silt	-46.0	1.00	9	6,180	2,966	3,154	2.72	N/A	N/A	0.755	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
52.50	24.56	0.44	1.79	sandy silt to clayey silt	-47.0	1.00	10	6,300	3,024	3,211	2.70	N/A	N/A	0.747	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
53.50	44.10	1.02	2.31	sandy silt to clayey silt	-48.0	1.00	18	6,420	3,082	3,269	2.55	3.01	96.02	0.739	0.887	0.320	0.162	0.600	YES	2.8	16.6	833	21.6	N/A	0.482	0.06	0.17
54.50	50.70	0.56	1.09	silty sand to sandy silt	-49.0	1.00	17	6,540	3,139	3,326	2.26	1.84	74.51	0.730	0.885	0.316	0.118	0.442	YES	2.8	15.9	765	20.7	N/A	1.039	0.12	0.04
55.50	201.12	0.98	0.49	sand	-50.0	1.00	40	6,660	3,197	3,384	1.56	1.00	159.08	0.722	0.829	0.313	0.454	1.606	NO	N/A	N/A	N/A	30.9	N/A	0.059	0.01	0.04
56.50	268.27	0.95	0.35	gravelly sand to sand	-51.0	1.00	45	6,780	3,254	3,442	1.38	1.00	210.31	0.714	0.823	0.309	N/A	N/A	NO	N/A	N/A	N/A	34.1	N/A	0.038	0.00	0.03
57.50	280.95	0.81	0.29	gravelly sand to sand	-52.0	1.66	78	6,900	3,312	3,499	1.02	1.00	361.49	0.706	0.817	0.306	N/A	N/A	NO	N/A	N/A	N/A	58.6	N/A	0.000	0.00	0.03
58.50	99.32	1.06	1.07	sand to silty sand	-53.0	1.00	25	7,020	3,370	3,557	2.03	1.34	102.37	0.698	0.845	0.302	0.180	0.670	YES	1.3	20.0	1,181	22.0	N/A	0.195	0.02	0.01
59.50	132.62	1.55	1.17	sand to silty sand	-54.0	1.00	33	7,140	3,427	3,614	1.96	1.25	126.44	0.690	0.818	0.299	0.268	0.979	YES	1.3	26.0	1,200	28.3	N/A	0.072	0.01	0.00

max=	1,200
min=	235
avg=	1,000

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT035

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	7.40 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	7.40 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ CSR = 0.65 A_{max} (σ_v/σ_v') r_d

+++ FS = ($CRR_{7.5}$/CSR) MSF K_σ $K_{\alpha\ -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	4.40 ft below ground surface
GWT Depth For Design, Zwd =	0.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	25.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	2.07 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	2.07 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	175.98	2.02	1.15	sand	6.4	1.00	35	60	29	60	1.31	1.00	1,466.53	0.999	1.000	0.433	N/A	N/A	NO	N/A	N/A	N/A	59.8	N/A	0.000	0.00	2.07
1.50	156.73	2.05	1.31	sand to silty sand	5.4	1.00	39	180	86	180	1.46	1.00	754.08	0.997	1.000	0.432	N/A	N/A	NO	N/A	N/A	N/A	72.3	N/A	0.000	0.00	2.07
2.50	130.05	1.59	1.22	sand to silty sand	4.4	1.66	54	300	144	300	1.23	1.00	802.48	0.994	1.000	0.431	N/A	N/A	NO	N/A	N/A	N/A	98.4	N/A	0.000	0.00	2.07
3.50	63.90	0.59	0.92	sand to silty sand	3.4	1.00	16	420	202	420	1.66	1.01	203.54	0.992	1.000	0.430	N/A	N/A	NO	N/A	N/A	N/A	31.0	N/A	0.089	0.01	2.06
4.50	42.17	0.36	0.86	silty sand to sandy silt	2.4	1.00	14	540	259	534	1.82	1.12	131.09	0.990	1.000	0.429	0.290	0.501	YES	2.8	26.7	1,200	33.7	N/A	0.062	0.01	2.05
5.50	27.98	0.37	1.31	sandy silt to clayey silt	1.4	1.66	19	660	317	591	1.80	1.10	128.59	0.987	1.000	0.428	0.278	0.866	YES	2.8	34.3	1,200	42.8	N/A	0.000	0.00	2.05
6.50	7.87	0.09	1.10	clayey silt to silty clay	0.4	1.00	4	780	374	649	2.56	3.07	55.90	0.985	1.000	0.427	0.096	0.301	YES	2.8	9.5	285	N/A	N/A	0.000	0.00	2.05
7.50	9.67	0.22	2.24	clayey silt to silty clay	-0.6	1.66	8	900	432	707	2.37	2.18	75.05	0.983	1.000	0.426	0.119	0.374	YES	2.8	16.3	800	N/A	N/A	0.000	0.00	2.05
8.50	4.75	0.13	2.70	clay	-1.6	1.00	5	1,020	490	764	2.89	N/A	N/A	0.980	N/A	0.425	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.05
9.50	19.92	0.17	0.85	sandy silt to clayey silt	-2.6	1.00	8	1,140	547	822	2.22	1.71	65.03	0.978	1.000	0.424	0.106	0.332	YES	2.8	15.2	701	19.9	N/A	1.473	0.18	1.87
10.50	20.70	0.38	1.82	sandy silt to clayey silt	-3.6	1.66	14	1,260	605	879	2.10	1.46	90.89	0.976	1.000	0.423	0.150	0.473	YES	2.8	23.5	1,200	29.8	N/A	0.098	0.01	1.86
11.50	4.58	0.03	0.73	sensitive fine grained	-4.6	1.00	2	1,380	662	937	2.70	4.03	42.31	0.973	N/A	0.422	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.86
12.50	3.82	0.01	0.22	sensitive fine grained	-5.6	1.00	2	1,500	720	995	2.63	3.54	29.06	0.971	N/A	0.421	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.86
13.50	3.60	0.01	0.19	sensitive fine grained	-6.6	1.00	2	1,620	778	1,052	2.68	3.84	28.10	0.969	N/A	0.420	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.86
14.50	3.73	0.01	0.13	sensitive fine grained	-7.6	1.00	2	1,740	835	1,110	2.65	3.67	26.40	0.966	N/A	0.419	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.86
15.50	4.10	0.00	0.08	sensitive fine grained	-8.6	1.00	2	1,860	893	1,167	2.60	3.34	25.06	0.964	N/A	0.418	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.86
16.50	4.27	0.00	0.04	sensitive fine grained	-9.6	1.00	2	1,980	950	1,225	2.60	3.31	24.69	0.962	1.000	0.417	0.071	0.226	YES	5.0	7.7	208	N/A	N/A	0.000	0.00	1.86
17.50	4.30	0.00	0.04	sensitive fine grained	-10.6	1.00	2	2,100	1,008	1,283	2.61	3.41	24.51	0.959	N/A	0.416	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.86
18.50	4.18	0.00	0.04	sensitive fine grained	-11.6	1.00	2	2,220	1,066	1,340	2.64	3.60	24.18	0.957	N/A	0.415	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.86
19.50	8.08	0.03	0.31	sensitive fine grained	-12.6	1.00	4	2,340	1,123	1,398	2.56	3.08	33.24	0.955	1.000	0.414	0.078	0.251	YES	5.0	9.8	303	N/A	N/A	0.000	0.00	1.86
20.50	36.33	0.20	0.55	silty sand to sandy silt	-13.6	1.00	12	2,460	1,181	1,455	2.04	1.36	64.42	0.952	1.000	0.413	0.105	0.339	YES	2.8	17.0	873	22.0	N/A	1.266	0.15	1.71
21.50	103.53	1.13	1.09	sand to silty sand	-14.6	1.00	26	2,580	1,238	1,513	1.85	1.14	150.62	0.950	1.000	0.412	0.398	1.289	YES	1.3	31.1	1,200	33.7	N/A	0.059	0.01	1.70
22.50	132.07	1.76	1.33	sand to silty sand	-15.6	1.00	33	2,700	1,296	1,571	1.84	1.14	186.82	0.948	1.000	0.411	N/A	N/A	NO	N/A	N/A	N/A	41.5	N/A	0.000	0.00	1.70
23.50	96.18	1.46	1.52	silty sand to sandy silt	-16.6	1.00	32	2,820	1,354	1,628	1.99	1.28	150.11	0.945	1.000	0.410	0.395	1.285	YES	2.8	38.3	1,200	47.6	N/A	0.000	0.00	1.70
24.50	78.52	0.90	1.14	sand to silty sand	-17.6	1.66	33	2,940	1,411	1,686	1.66	1.01	156.81	0.943	1.000	0.409	0.439	1.432	NO	N/A	N/A	N/A	39.6	N/A	0.004	0.00	1.70
25.50	17.18	0.30	1.76	sandy silt to clayey silt	-18.6	1.00	7	3,060	1,469	1,743	2.61	N/A	N/A	0.941	N/A	0.408	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.70
26.50	14.98	0.08	0.51	sandy silt to clayey silt	-19.6	1.00	6	3,180	1,526	1,801	2.44	2.49	42.66	0.938	1.000	0.407	0.086	0.281	YES	2.8	9.1	267	12.6	N/A	2.196	0.26	1.44
27.50	15.32	0.08	0.49	sandy silt to clayey silt	-20.6	1.00	6	3,300	1,584	1,859	2.43	2.45	42.09	0.936	1.000	0.406	0.085	0.280	YES	2.8	9.2	268	12.6	N/A	2.189	0.26	1.17
28.50	29.73	0.18	0.59	silty sand to sandy silt	-21.6	1.66	16	3,420	1,642	1,916	1.90	1.00	54.34	0.934	1.000	0.405	0.095	0.313	YES	2.8	19.6	1,140	25.1	N/A	0.837	0.10	1.07
29.50	11.05	0.07	0.58	sandy silt to clayey silt	-22.6	1.00	4	3,540	1,699	1,974	2.60	3.34	41.67	0.931	N/A	0.404	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
30.50	7.62	0.02	0.22	sensitive fine grained	-23.6	1.00	4	3,660	1,757	2,031	2.64	3.56	29.91	0.926	N/A	0.401	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
31.50	8.81	0.10	1.07	clayey silt to silty clay	-24.6	1.00	4	3,780	1,814	2,089	2.84	N/A	N/A	0.918	N/A	0.398	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
32.50	12.92	0.18	1.37	clayey silt to silty clay	-25.6	1.00	6	3,900	1,872	2,147	2.74	N/A	N/A	0.909	N/A	0.394	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.07
33.50	50.90	0.45	0.87	silty sand to sandy silt	-26.6	1.00	17	4,020	1,930	2,204	2.11	1.48	76.80	0.901	1.000	0.391	0.122	0.417	YES	2.8	19.0	1,076	24.4	N/A	0.889	0.11	0.97
34.50	71.78	0.89	1.23	sand to silty sand	-27.6	1.66	30	4,140	1,987	2,262	1.78	1.09	129.84	0.893	1.000	0.387	0.284	0.978	YES	1.3	29.3	1,200	31.8	N/A	0.070	0.01	0.96
35.50	34.73	0.30	0.85	silty sand to sandy silt	-28.6	1.66	19	4,260	2,045	2,319	1.96	1.25	71.18	0.885	0.993	0.384	0.114	0.392	YES	2.8	20.6	1,200	26.4	N/A	0.173	0.02	0.94
36.50	8.75	0.06	0.68	clayey silt to silty clay	-29.6	1.00	4	4,380	2,102	2,377	2.81	4.83	40.69	0.877	N/A	0.380	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.94
37.50	12.42	0.06	0.45	sandy silt to clayey silt	-30.6	1.00	5	4,500	2,160	2,435	2.59	3.26	38.22	0.869	0.985	0.376	0.082	0.286	YES	2.8	7.3	193	10.4	N/A	2.533	0.30	0.63
38.50	12.70	0.08	0.65	sandy silt to clayey silt	-31.6	1.00	5	4,620	2,218	2,492	2.65	3.64	42.81	0.861	N/A	0.373	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
39.50	10.12	0.04	0.34	sandy silt to clayey silt	-32.6	1.00	4	4,740	2,275	2,550	2.66	3.68	33.82	0.852	N/A	0.369	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
40.50	8.57	0.06	0.69	clayey silt to silty clay	-33.6	1.00	4	4,860	2,333	2,607	2.86	5.28	40.33	0.844	N/A	0.366	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
41.50	16.27	0.23	1.42	sandy silt to clayey silt	-34.6	1.00	7	4,980	2,390	2,665	2.73	N/A	N/A	0.836	N/A	0.362	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
42.50	19.60	0.48	2.41	clayey silt to silty clay	-35.6	1.00	10	5,100	2,448	2,723	2.79	N/A	N/A	0.828	N/A	0.359	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
43.50	22.08	0.76	3.40	clayey silt to silty clay	-36.6	1.00	11	5,220	2,506	2,780	2.85	N/A	N/A	0.820	N/A	0.355	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
44.50	17.78	0.55	3.06	clayey silt to silty clay	-37.6	1.00	9	5,340	2,563	2,838	2.91	N/A	N/A	0.812	N/A	0.352	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
45.50	17.18	0.47	2.70	clayey silt to silty clay	-38.6	1.00	9	5,460	2,621	2,895	2.90	N/A	N/A	0.804	N/A	0.348	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
46.50	19.00	0.57	2.98	clayey silt to silty clay	-39.6	1.00	10	5,580	2,678	2,953	2.89	N/A	N/A	0.795	N/A	0.345	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
47.50	83.72	1.00	1.19	sand to silty sand	-40.6	1.00	21	5,700	2,736	3,011	2.08	1.42	101.68	0.787	0.908	0.341	0.178	0.631	YES	1.3	18.4	1,017	20.4	N/A	1.212	0.15	0.49
48.50	113.13	1.30	1.15	sand to silty sand	-41.6	1.66	47	5,820	2,794	3,068	1.66	1.01	159.97	0.779	0.875	0.338	0.461	1.593	NO	N/A	N/A	N/A	42.1	N/A	0.000	0.00	0.49
49.50	55.47	1.22	2.20	sandy silt to clayey silt	-42.6	1.00	22	5,940	2,851	3,126	2.40	2.32	107.69	0.771	0.894	0.334	0.196	0.700	YES	2.8	20.5	1,200	26.3	N/A	0.097	0.01	0.48
50.50	77.98	0.74	0.95	sand to silty sand	-43.6	1.00	19	6,060	2,909	3,183	2.06	1.38	89.40	0.763	0.895	0.331	0.146	0.529	YES	1.3	16.8	852	18.7	N/A	1.383	0.17	0.31
51.50	84.08	1.16	1.38	sand to silty sand	-44.6	1.00	21	6,180	2,966	3,241	2.13	1.52	104.90	0.755	0.887	0.327	0.187	0.678	YES	1.3	17.8	960	19.8	N/A	1.224	0.15	0.16
52.50	54.76	0.97	1.77	silty sand to sandy silt	-45.6	1.66	30	6,300	3,024	3,299	2.04	1.36	100.00	0.747	0.860	0.324	0.173	0.614	YES	2.8	26.3	1,200	33.2	N/A	0.046	0.01	0.16
53.50	24.82	0.69	2.77	clayey silt to silty clay	-46.6	1.00	12	6,420	3,082	3,356	2.81	N/A	N/A	0.739	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.16
54.50	17.07	0.37	2.15	clayey silt to silty clay	-47.6	1.00	9	6,540	3,139	3,414	2.90	N/A	N/A	0.730	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.16
55.50	13.13	0.23	1.77	clayey silt to silty clay	-48.6	1.00	7	6,660	3,197	3,471	2.97	N/A	N/A	0.722	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.16
56.50	35.10	0.78	2.23	sandy silt to clayey silt	-49.6	1.00	14	6,780	3,254	3,529	2.63	N/A	N/A	0.714	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.16
57.50	77.77	1.35	1.73	silty sand to sandy silt	-50.6	1.00	26	6,900	3,312	3,587	2.24	1.78	107.65	0.706	0.847	0.306	0.196	0.724	YES	2.8	22.2	1,200	28.2	N/A	0.075	0.01	0.15
58.50	42.52	1.05	2.48	sandy silt to clayey silt	-51.6	1.00	17	7,020	3,370	3,644	2.60	N/A	N/A	0.698	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.15
59.50	46.10	0.86	1.87	silty sand to sandy silt	-52.6	1.00	15	7,140	3,427	3,702	2.50	2.77	85.38	0.690	0.873	0.299	0.138	0.537	YES	2.8	14.1	600	18.6	N/A	1.251	0.15	0.00
60.50	37.88	0.90	2.38	sandy silt to clayey silt	-53.6	1.00	15	7,260	3,485	3,759	2.64	N/A	N/A	0.682	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max= 1,200
min= 193
avg= 862

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT037

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	5.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	5.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	2.00 ft below ground surface
GWT Depth For Design, Zwd =	0.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	14.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.93 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	0.93 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{t1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	127.88	0.67	0.52	sand	4.0	1.00	26	60	29	60	1.04	1.00	1,065.69	0.999	1.000	0.433	N/A	N/A	NO	N/A	N/A	N/A	43.5	N/A	0.000	0.00	0.93
1.50	101.18	0.97	0.96	sand to silty sand	3.0	1.66	42	180	86	180	1.13	1.00	806.04	0.997	1.000	0.432	N/A	N/A	NO	N/A	N/A	N/A	77.1	N/A	0.000	0.00	0.93
2.50	29.52	0.40	1.34	sandy silt to clayey silt	2.0	1.66	20	300	144	269	1.66	1.01	183.52	0.994	1.000	0.431	N/A	N/A	NO	N/A	N/A	N/A	44.9	N/A	0.000	0.00	0.93
3.50	7.55	0.29	3.78	clay	1.0	1.00	8	420	202	326	2.59	3.24	136.80	0.992	1.000	0.430	0.318	0.987	YES	5.0	17.8	959	N/A	N/A	0.000	0.00	0.93
4.50	4.42	0.17	3.84	clay	0.0	1.00	4	540	259	384	2.84	N/A	N/A	0.990	N/A	0.429	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
5.50	4.53	0.16	3.54	clay	-1.0	1.00	5	660	317	442	2.85	N/A	N/A	0.987	N/A	0.428	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
6.50	3.88	0.16	4.11	clay	-2.0	1.00	4	780	374	499	2.99	N/A	N/A	0.985	N/A	0.427	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
7.50	7.13	0.16	2.19	silty clay to clay	-3.0	1.66	8	900	432	557	2.47	2.62	66.59	0.983	1.000	0.426	0.107	0.337	YES	5.0	18.4	1,016	N/A	N/A	0.000	0.00	0.93
8.50	3.38	0.06	1.75	sensitive fine grained	-4.0	1.00	2	1,020	490	614	2.91	N/A	N/A	0.980	N/A	0.425	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
9.50	3.07	0.05	1.48	sensitive fine grained	-5.0	1.00	2	1,140	547	672	2.96	N/A	N/A	0.978	N/A	0.424	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
10.50	2.96	0.03	1.17	sensitive fine grained	-6.0	1.00	1	1,260	605	730	2.95	N/A	N/A	0.976	N/A	0.423	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
11.50	2.93	0.05	1.60	sensitive fine grained	-7.0	1.00	1	1,380	662	787	3.06	N/A	N/A	0.973	N/A	0.422	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
12.50	3.28	0.04	1.22	sensitive fine grained	-8.0	1.00	2	1,500	720	845	2.98	N/A	N/A	0.971	N/A	0.421	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
13.50	3.25	0.03	0.97	sensitive fine grained	-9.0	1.00	2	1,620	778	902	2.97	N/A	N/A	0.969	N/A	0.420	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
14.50	4.15	0.03	0.64	sensitive fine grained	-10.0	1.00	2	1,740	835	960	2.81	4.85	38.73	0.966	N/A	0.419	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
15.50	3.40	0.01	0.24	sensitive fine grained	-11.0	1.00	2	1,860	893	1,018	2.77	4.57	28.42	0.964	N/A	0.418	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
16.50	3.97	0.02	0.54	sensitive fine grained	-12.0	1.00	2	1,980	950	1,075	2.85	5.19	35.94	0.962	N/A	0.417	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
17.50	24.82	0.19	0.75	silty sand to sandy silt	-13.0	1.00	8	2,100	1,008	1,133	2.23	1.73	60.60	0.959	1.000	0.416	0.101	0.323	YES	2.8	13.8	574	18.2	N/A	1.614	0.19	0.74
18.50	81.40	0.58	0.71	sand to silty sand	-14.0	1.00	20	2,220	1,066	1,190	1.79	1.10	122.31	0.957	1.000	0.415	0.250	0.805	YES	1.3	27.7	1,200	30.1	N/A	0.093	0.01	0.72
19.50	144.83	1.97	1.36	sand to silty sand	-15.0	1.00	36	2,340	1,123	1,248	1.80	1.11	214.05	0.955	1.000	0.414	N/A	N/A	NO	N/A	N/A	N/A	50.5	N/A	0.000	0.00	0.72
20.50	140.19	2.14	1.52	sand to silty sand	-16.0	1.00	35	2,460	1,181	1,306	1.85	1.15	209.65	0.952	1.000	0.413	N/A	N/A	NO	N/A	N/A	N/A	48.0	N/A	0.000	0.00	0.72
21.50	96.40	1.29	1.33	sand to silty sand	-17.0	1.00	24	2,580	1,238	1,363	1.93	1.22	149.36	0.950	1.000	0.412	0.391	1.268	YES	1.3	30.5	1,200	33.1	N/A	0.064	0.01	0.72
22.50	93.60	1.27	1.35	sand to silty sand	-18.0	1.66	39	2,700	1,296	1,421	1.64	1.00	192.01	0.948	1.000	0.411	N/A	N/A	NO	N/A	N/A	N/A	50.7	N/A	0.000	0.00	0.72
23.50	24.65	0.42	1.71	sandy silt to clayey silt	-19.0	1.66	16	2,820	1,354	1,478	2.17	1.60	79.31	0.945	1.000	0.410	0.126	0.412	YES	2.8	21.8	1,200	27.8	N/A	0.157	0.02	0.70
24.50	6.30	0.06	0.90	sensitive fine grained	-20.0	1.00	3	2,940	1,411	1,536	2.86	N/A	N/A	0.943	N/A	0.409	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
25.50	6.15	0.08	1.34	sensitive fine grained	-21.0	1.00	3	3,060	1,469	1,594	2.97	N/A	N/A	0.941	N/A	0.408	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
26.50	6.15	0.12	1.93	silty clay to clay	-22.0	1.00	4	3,180	1,526	1,651	3.07	N/A	N/A	0.938	N/A	0.407	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
27.50	6.13	0.07	1.07	sensitive fine grained	-23.0	1.00	3	3,300	1,584	1,709	2.96	N/A	N/A	0.936	N/A	0.406	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
28.50	6.17	0.10	1.64	silty clay to clay	-24.0	1.00	4	3,420	1,642	1,766	3.06	N/A	N/A	0.934	N/A	0.405	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
29.50	8.80	0.16	1.74	clayey silt to silty clay	-25.0	1.00	4	3,540	1,699	1,824	2.93	N/A	N/A	0.931	N/A	0.404	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
30.50	7.00	0.04	0.61	sensitive fine grained	-26.0	1.00	4	3,660	1,757	1,882	2.82	4.98	38.45	0.926	N/A	0.401	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
31.50	13.54	0.20	1.45	sandy silt to clayey silt	-27.0	1.00	5	3,780	1,814	1,939	2.73	N/A	N/A	0.918	N/A	0.398	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
32.50	12.32	0.14	1.10	sandy silt to clayey silt	-28.0	1.00	5	3,900	1,872	1,997	2.71	N/A	N/A	0.909	N/A	0.394	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
33.50	7.60	0.06	0.78	sensitive fine grained	-29.0	1.00	4	4,020	1,930	2,054	2.86	N/A	N/A	0.901	N/A	0.391	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70
34.50	19.80	0.24	1.18	sandy silt to clayey silt	-30.0	1.00	8	4,140	1,987	2,112	2.55	3.05	60.67	0.893	1.000	0.387	0.101	0.347	YES	2.8	10.5	340	14.2	N/A	1.961	0.24	0.46
35.50	23.72	0.09	0.37	silty sand to sandy silt	-31.0	1.66	13	4,260	2,045	2,170	1.97	1.00	38.84	0.885	0.994	0.384	0.082	0.285	YES	2.8	15.4	714	20.1	N/A	1.376	0.17	0.30
36.50	8.00	0.03	0.41	sensitive fine grained	-32.0	1.00	4	4,380	2,102	2,227	2.76	4.46	34.37	0.877	N/A	0.380	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
37.50	7.53	0.05	0.69	sensitive fine grained	-33.0	1.00	4	4,500	2,160	2,285	2.89	N/A	N/A	0.869	N/A	0.376	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
38.50	7.87	0.11	1.34	clayey silt to silty clay	-34.0	1.00	4	4,620	2,218	2,342	3.01	N/A	N/A	0.861	N/A	0.373	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
39.50	13.92	0.29	2.07	clayey silt to silty clay	-35.0	1.00	7	4,740	2,275	2,400	2.87	N/A	N/A	0.852	N/A	0.369	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
40.50	16.48	0.45	2.67	clayey silt to silty clay	-36.0	1.00	8	4,860	2,333	2,458	2.88	N/A	N/A	0.844	N/A	0.366	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
41.50	15.77	0.47	2.96	clayey silt to silty clay	-37.0	1.00	8	4,980	2,390	2,515	2.93	N/A	N/A	0.836	N/A	0.362	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
42.50	19.25	0.82	4.23	clay	-38.0	1.00	19	5,100	2,448	2,573	2.95	N/A	N/A	0.828	N/A	0.359	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
43.50	11.72	0.31	2.60	clayey silt to silty clay	-39.0	1.00	6	5,220	2,506	2,630	3.03	N/A	N/A	0.820	N/A	0.355	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.30
44.50	39.25	0.80	2.03	sandy silt to clayey silt	-40.0	1.00	16	5,340	2,563	2,688	2.48	2.68	92.81	0.812	0.934	0.352	0.154	0.547	YES	2.8	16.3	808	21.3	N/A	1.146	0.14	0.16
45.50	74.43	1.06	1.42	silty sand to sandy silt	-41.0	1.00	25	5,460	2,621	2,746	2.16	1.58	102.73	0.804	0.911	0.348	0.181	0.631	YES	2.8	24.0	1,200	30.4	N/A	0.071	0.01	0.15
46.50	60.63	1.06	1.75	silty sand to sandy silt	-42.0	1.00	20	5,580	2,678	2,803	2.30	1.93	101.31	0.795	0.913	0.345	0.177	0.625	YES	2.8	19.9	1,172	25.5	N/A	0.143	0.02	0.13
47.50	50.70	0.99	1.95	silty sand to sandy silt	-43.0	1.00	17	5,700	2,736	2,861	2.39	2.28	98.82	0.787	0.915	0.341	0.170	0.608	YES	2.8	16.9	866	22.0	N/A	1.021	0.12	0.01
48.50	33.65	0.76	2.25	sandy silt to clayey silt	-44.0	1.00	13	5,820	2,794	2,918	2.61	N/A	N/A	0.779	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
49.50	27.10	0.71	2.62	sandy silt to clayey silt	-45.0	1.00	11	5,940	2,851	2,976	2.74	N/A	N/A	0.771	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
50.50	16.50	0.38	2.27	clayey silt to silty clay	-46.0	1.00	8	6,060	2,909	3,034	2.90	N/A	N/A	0.763	N/A	0.331	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
51.50	22.13	0.48	2.15	sandy silt to clayey silt	-47.0	1.00	9	6,180	2,966	3,091	2.78	N/A	N/A	0.755	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
52.50	18.19	0.44	2.40	clayey silt to silty clay	-48.0	1.00	9	6,300	3,024	3,149	2.89	N/A	N/A	0.747	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
53.50	29.92	0.64	2.13	sandy silt to clayey silt	-49.0	1.00	12	6,420	3,082	3,206	2.67	N/A	N/A	0.739	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
54.50	78.33	1.26	1.60	silty sand to sandy silt	-50.0	1.00	26	6,540	3,139	3,264	2.21	1.69	105.91	0.730	0.858	0.316	0.190	0.689	YES	2.8	23.2	1,200	29.5	N/A	0.069	0.01	0.00
55.50	49.98	1.19	2.37	sandy silt to clayey silt	-51.0	1.66	33	6,660	3,197	3,322	2.16	1.58	103.47	0.722	0.837	0.313	0.183	0.653	YES	2.8	28.5	1,200	35.8	N/A	0.027	0.00	0.00
56.50	13.42	0.36	2.63	clayey silt to silty clay	-52.0	1.00	7	6,780	3,254	3,379	3.06	N/A	N/A	0.714	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
57.50	17.62	0.14	0.77	sandy silt to clayey silt	-53.0	1.00	7	6,900	3,312	3,437	2.68	3.82	46.10	0.706	N/A	0.306	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
58.50	10.80	0.10	0.91	sandy silt to clayey silt	-54.0	1.00	4	7,020	3,370	3,494	2.94	N/A	N/A	0.698	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
59.50	9.42	0.19	1.93	clayey silt to silty clay	-55.0	1.00	5	7,140	3,427	3,552	3.18	N/A	N/A	0.690	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
60.50	10.62	0.28	2.56	silty clay to clay	-56.0	1.00	7	7,260	3,485	3,610	3.19	N/A	N/A	0.682	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max= 1,200
min= 340
avg= 975

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT038

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	8.40 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	8.40 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

\+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\ A_{max}\ (\sigma_v/\sigma_v')\ r_d$

+++ $FS = (CRR_{7.5}/CSR)\ MSF\ K_\sigma\ K_{\alpha}$ —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 5.40 ft below ground surface
GWT Depth For Design, Zwd = 0.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 27.00 feet
Earthquake-Induced Settlements:
- Liquefaction-Induced Settlement = 1.98 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <— Dry or Unsaturated Sands

Total: 1.98 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	243.24	2.91	1.19	sand	7.4	1.66	81	60	29	60	1.08	1.00	3,356.15	0.999	1.000	0.433	N/A	N/A	NO	N/A	N/A	N/A	136.9	N/A	0.000	0.00	1.98
1.50	85.37	2.17	2.54	sandy silt to clayey silt	6.4	1.00	34	180	86	180	1.84	1.13	466.18	0.997	1.000	0.432	N/A	N/A	NO	N/A	N/A	N/A	74.7	N/A	0.000	0.00	1.98
2.50	47.72	0.58	1.22	silty sand to sandy silt	5.4	1.66	26	300	144	300	1.48	1.00	294.48	0.994	1.000	0.431	N/A	N/A	NO	N/A	N/A	N/A	58.7	N/A	0.000	0.00	1.98
3.50	12.23	0.38	3.11	silty clay to clay	4.4	1.00	8	420	202	420	2.55	3.04	117.14	0.992	1.000	0.430	0.229	0.712	YES	5.0	18.9	1,066	N/A	N/A	0.000	0.00	1.98
4.50	6.79	0.22	3.24	clay	3.4	1.00	7	540	259	540	2.64	N/A	N/A	0.990	N/A	0.429	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.98
5.50	4.83	0.07	1.42	sensitive fine grained	2.4	1.00	2	660	317	654	2.60	3.30	63.46	0.987	1.000	0.428	0.104	0.324	YES	5.0	9.1	266	N/A	N/A	0.000	0.00	1.98
6.50	6.05	0.15	2.45	silty clay to clay	1.4	1.00	4	780	374	711	2.70	N/A	N/A	0.985	N/A	0.427	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.98
7.50	15.80	0.28	1.76	clayey silt to silty clay	0.4	1.66	13	900	432	769	2.13	1.51	84.90	0.983	1.000	0.426	0.137	0.429	YES	2.8	23.9	1,200	N/A	N/A	0.000	0.00	1.98
8.50	7.06	0.16	2.27	silty clay to clay	-0.6	1.00	5	1,020	490	827	2.69	N/A	N/A	0.980	N/A	0.425	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.98
9.50	5.06	0.06	1.19	sensitive fine grained	-1.6	1.00	3	1,140	547	884	2.70	N/A	N/A	0.978	N/A	0.424	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.98
10.50	4.40	0.01	0.23	sensitive fine grained	-2.6	1.00	2	1,260	605	942	2.52	2.88	31.02	0.976	1.000	0.423	0.076	0.239	YES	5.0	8.2	226	N/A	N/A	0.000	0.00	1.98
11.50	10.17	0.03	0.33	sandy silt to clayey silt	-3.6	1.00	4	1,380	662	999	2.35	1.00	17.66	0.973	1.000	0.422	0.065	0.205	YES	2.8	8.6	241	11.9	N/A	2.301	0.28	1.71
12.50	6.63	0.05	0.80	sensitive fine grained	-4.6	1.00	3	1,500	720	1,057	2.60	3.30	47.17	0.971	1.000	0.421	0.089	0.283	YES	5.0	9.6	288	N/A	N/A	0.000	0.00	1.71
13.50	3.99	0.02	0.38	sensitive fine grained	-5.6	1.00	2	1,620	778	1,115	2.71	4.10	33.14	0.969	N/A	0.420	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.71
14.50	3.94	0.01	0.30	sensitive fine grained	-6.6	1.00	2	1,740	835	1,172	2.71	4.10	31.11	0.966	N/A	0.419	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.71
15.50	5.82	0.02	0.26	sensitive fine grained	-7.6	1.00	3	1,860	893	1,230	2.54	2.99	31.90	0.964	1.000	0.418	0.077	0.245	YES	5.0	8.7	248	N/A	N/A	0.000	0.00	1.71
16.50	4.76	0.00	0.00	sensitive fine grained	-8.6	1.00	2	1,980	950	1,287	2.89	5.59	46.42	0.962	N/A	0.417	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.71
17.50	17.18	0.10	0.58	sandy silt to clayey silt	-9.6	1.00	7	2,100	1,008	1,345	2.32	2.01	48.66	0.959	1.000	0.416	0.091	0.291	YES	2.8	11.2	381	15.1	N/A	1.893	0.23	1.48
18.50	85.95	0.45	0.53	sand to silty sand	-10.6	1.00	21	2,220	1,066	1,403	1.69	1.03	121.34	0.957	1.000	0.415	0.246	0.792	YES	1.3	27.0	1,200	29.4	N/A	0.100	0.01	1.47
19.50	149.32	1.24	0.83	sand	-11.6	1.00	30	2,340	1,123	1,460	1.63	1.00	199.25	0.955	1.000	0.414	N/A	N/A	NO	N/A	N/A	N/A	35.0	N/A	0.047	0.01	1.46
20.50	171.04	1.57	0.92	sand	-12.6	1.00	34	2,460	1,181	1,518	1.63	1.00	222.60	0.952	1.000	0.413	N/A	N/A	NO	N/A	N/A	N/A	39.3	N/A	0.007	0.00	1.46
21.50	161.96	1.82	1.12	sand	-13.6	1.00	32	2,580	1,238	1,575	1.72	1.05	216.37	0.950	1.000	0.412	N/A	N/A	NO	N/A	N/A	N/A	36.5	N/A	0.033	0.00	1.46
22.50	135.51	1.28	0.95	sand	-14.6	1.66	45	2,700	1,296	1,633	1.42	1.00	278.72	0.948	1.000	0.411	N/A	N/A	NO	N/A	N/A	N/A	49.7	N/A	0.000	0.00	1.46
23.50	59.26	0.70	1.18	silty sand to sandy silt	-15.6	1.00	20	2,820	1,354	1,691	2.07	1.41	101.32	0.945	1.000	0.410	0.177	0.576	YES	2.8	24.3	1,200	30.8	N/A	0.085	0.01	1.45
24.50	32.63	0.26	0.81	silty sand to sandy silt	-16.6	1.66	18	2,940	1,411	1,748	1.90	1.19	76.41	0.943	1.000	0.409	0.121	0.397	YES	2.8	22.1	1,200	28.1	N/A	0.142	0.02	1.43
25.50	8.30	0.09	1.02	clayey silt to silty clay	-17.6	1.00	4	3,060	1,469	1,806	2.78	N/A	N/A	0.941	N/A	0.408	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.43
26.50	17.70	0.13	0.73	sandy silt to clayey silt	-18.6	1.00	7	3,180	1,526	1,863	2.44	2.48	50.24	0.938	1.000	0.407	0.092	0.301	YES	2.8	10.1	319	13.8	N/A	2.007	0.24	1.19
27.50	13.65	0.11	0.77	sandy silt to clayey silt	-19.6	1.00	5	3,300	1,584	1,921	2.54	2.98	48.46	0.936	1.000	0.406	0.090	0.297	YES	2.8	8.4	233	11.7	N/A	2.335	0.28	0.91
28.50	57.52	0.35	0.61	sand to silty sand	-20.6	1.00	14	3,420	1,642	1,979	1.95	1.24	78.85	0.934	1.000	0.405	0.126	0.414	YES	1.3	15.8	754	17.7	N/A	1.651	0.20	0.71
29.50	85.55	0.84	0.98	sand to silty sand	-21.6	1.00	21	3,540	1,699	2,036	1.94	1.22	113.61	0.931	1.000	0.404	0.216	0.716	YES	1.3	22.5	1,200	24.7	N/A	0.999	0.12	0.59
30.50	178.65	2.17	1.22	sand to silty sand	-22.6	1.00	45	3,660	1,757	2,094	1.77	1.08	206.80	0.926	1.000	0.401	N/A	N/A	NO	N/A	N/A	N/A	48.2	N/A	0.000	0.00	0.59
31.50	202.66	3.12	1.54	sand to silty sand	-23.6	1.00	51	3,780	1,814	2,151	1.82	1.12	237.91	0.918	1.000	0.398	N/A	N/A	NO	N/A	N/A	N/A	53.7	N/A	0.000	0.00	0.59
32.50	117.07	1.38	1.18	sand to silty sand	-24.6	1.00	29	3,900	1,872	2,209	1.90	1.19	143.96	0.909	1.000	0.394	0.357	1.210	YES	1.3	29.2	1,200	31.7	N/A	0.073	0.01	0.58
33.50	112.39	1.30	1.16	sand to silty sand	-25.6	1.00	28	4,020	1,930	2,267	1.91	1.20	137.50	0.901	1.000	0.391	0.322	1.099	YES	1.3	27.7	1,200	30.2	N/A	0.085	0.01	0.57
34.50	108.40	1.33	1.23	sand to silty sand	-26.6	1.00	27	4,140	1,987	2,324	1.95	1.24	134.51	0.893	1.000	0.387	0.306	1.056	YES	1.3	26.5	1,200	28.8	N/A	0.095	0.01	0.56
35.50	142.66	2.15	1.51	sand to silty sand	-27.6	1.00	36	4,260	2,045	2,382	1.93	1.22	171.56	0.885	0.991	0.384	N/A	N/A	NO	N/A	N/A	N/A	36.8	N/A	0.027	0.00	0.56
36.50	80.56	1.77	2.20	silty sand to sandy silt	-28.6	1.66	44	4,380	2,102	2,439	1.91	1.20	156.33	0.877	0.980	0.380	0.435	1.498	NO	N/A	N/A	N/A	53.3	N/A	0.000	0.00	0.56
37.50	13.04	0.22	1.69	clayey silt to silty clay	-29.6	1.00	7	4,500	2,160	2,497	2.83	N/A	N/A	0.869	N/A	0.376	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56
38.50	10.27	0.07	0.71	sandy silt to clayey silt	-30.6	1.00	4	4,620	2,218	2,555	2.76	4.44	42.21	0.861	N/A	0.373	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56
39.50	11.22	0.08	0.68	sandy silt to clayey silt	-31.6	1.00	4	4,740	2,275	2,612	2.72	4.15	42.32	0.852	N/A	0.369	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56
40.50	14.00	0.12	0.87	sandy silt to clayey silt	-32.6	1.00	6	4,860	2,333	2,670	2.68	N/A	N/A	0.844	N/A	0.366	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56
41.50	18.11	0.37	2.04	clayey silt to silty clay	-33.6	1.00	9	4,980	2,390	2,727	2.77	N/A	N/A	0.836	N/A	0.362	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56
42.50	21.15	0.65	3.07	clayey silt to silty clay	-34.6	1.00	11	5,100	2,448	2,785	2.83	N/A	N/A	0.828	N/A	0.359	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56
43.50	20.32	0.70	3.42	clayey silt to silty clay	-35.6	1.00	10	5,220	2,506	2,843	2.88	N/A	N/A	0.820	N/A	0.355	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56
44.50	16.44	0.48	2.93	clayey silt to silty clay	-36.6	1.00	8	5,340	2,563	2,900	2.93	N/A	N/A	0.812	N/A	0.352	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56
45.50	71.95	1.03	1.43	silty sand to sandy silt	-37.6	1.00	24	5,460	2,621	2,958	2.17	1.61	101.04	0.804	0.914	0.348	0.176	0.616	YES	2.8	22.5	1,200	28.7	N/A	0.084	0.01	0.55
46.50	98.17	1.21	1.23	sand to silty sand	-38.6	1.00	25	5,580	2,678	3,015	2.03	1.34	114.03	0.795	0.907	0.345	0.218	0.765	YES	1.3	21.3	1,200	23.4	N/A	0.380	0.05	0.50
47.50	129.55	1.24	0.96	sand to silty sand	-39.6	1.00	32	5,700	2,736	3,073	1.87	1.16	128.65	0.787	0.887	0.341	0.278	0.964	YES	1.3	27.5	1,200	29.9	N/A	0.073	0.01	0.49
48.50	191.91	1.00	0.52	sand	-40.6	1.00	38	5,820	2,794	3,131	1.57	1.00	162.38	0.779	0.875	0.338	N/A	N/A	NO	N/A	N/A	N/A	30.7	N/A	0.067	0.01	0.48
49.50	173.66	0.73	0.42	sand	-41.6	1.00	35	5,940	2,851	3,188	1.56	1.00	145.44	0.771	0.870	0.334	0.366	1.272	YES	0.0	27.5	1,200	27.5	N/A	0.088	0.01	0.47
50.50	139.30	0.47	0.34	sand	-42.6	1.00	28	6,060	2,909	3,246	1.60	1.00	115.51	0.763	0.877	0.331	0.223	0.790	YES	0.0	21.9	1,200	21.9	N/A	0.803	0.10	0.38
51.50	182.96	0.61	0.33	sand	-43.6	1.00	37	6,180	2,966	3,303	1.49	1.00	150.23	0.755	0.854	0.327	0.395	1.377	NO	N/A	N/A	N/A	28.5	N/A	0.079	0.01	0.37
52.50	116.86	0.85	0.72	sand	-44.6	1.00	23	6,300	3,024	3,361	1.85	1.14	108.73	0.747	0.877	0.324	0.200	0.721	YES	0.0	18.0	979	18.0	N/A	1.443	0.17	0.19
53.50	98.09	0.49	0.50	sand to silty sand	-45.6	1.66	41	6,420	3,082	3,419	1.53	1.00	130.84	0.739	0.841	0.320	0.288	1.011	YES	1.3	32.4	1,200	35.0	N/A	0.033	0.00	0.19
54.50	18.29	0.34	1.87	sandy silt to clayey silt	-46.6	1.00	7	6,540	3,139	3,476	2.83	N/A	N/A	0.730	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
55.50	14.23	0.21	1.45	sandy silt to clayey silt	-47.6	1.00	6	6,660	3,197	3,534	2.89	N/A	N/A	0.722	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
56.50	27.90	0.80	2.85	clayey silt to silty clay	-48.6	1.00	14	6,780	3,254	3,591	2.79	N/A	N/A	0.714	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19
57.50	96.74	1.12	1.15	sand to silty sand	-49.6	1.00	24	6,900	3,312	3,649	2.06	1.38	103.74	0.706	0.852	0.306	0.184	0.683	YES	1.3	19.2	1,106	21.3	N/A	0.367	0.04	0.15
58.50	128.98	0.83	0.64	sand	-50.6	1.00	26	7,020	3,370	3,707	1.80	1.11	110.14	0.698	0.843	0.302	0.204	0.760	YES	0.0	18.9	1,075	18.9	N/A	1.210	0.15	0.00

max= 1,200
min= 226
avg= 888

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT040

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	6.90 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	6.90 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

\+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\ A_{max}\ (\sigma_v/\sigma_v')\ r_d$

+++ $FS = (CRR_{7.5}/CSR)\ MSF\ K_\sigma\ K_{\alpha \to\to}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 3.90 ft below ground surface
GWT Depth For Design, Zwd = 0.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 9.00 feet

Earthquake-Induced Settlements:

- Liquefaction-Induced Settlement = 0.47 inches <--- Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <--- Dry or Unsaturated Sands

Total: 0.47 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +											
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR
0.50	13.50	0.25	1.82	clayey silt to silty clay	5.9	1.00	7	60	29	60	2.05	1.37	154.26	0.999	1.000	0.433
1.50	11.40	0.48	4.17	clay	4.9	1.00	11	180	86	180	2.53	2.92	159.98	0.997	1.000	0.432
2.50	6.73	0.38	5.57	clay	3.9	1.00	7	300	144	300	2.66	N/A	N/A	0.994	N/A	0.431
3.50	6.17	0.32	5.19	clay	2.9	1.00	6	420	202	420	2.75	N/A	N/A	0.992	N/A	0.430
4.50	4.60	0.23	5.02	clay	1.9	1.00	5	540	259	503	2.89	N/A	N/A	0.990	N/A	0.429
5.50	4.37	0.22	4.92	clay	0.9	1.00	4	660	317	560	2.96	N/A	N/A	0.987	N/A	0.428
6.50	21.60	0.33	1.51	sandy silt to clayey silt	-0.1	1.66	14	780	374	618	1.95	1.24	102.68	0.985	1.000	0.427
7.50	8.52	0.23	2.75	silty clay to clay	-1.1	1.66	9	900	432	675	2.46	2.58	78.22	0.983	1.000	0.426
8.50	3.87	0.07	1.86	sensitive fine grained	-2.1	1.00	2	1,020	490	733	2.87	N/A	N/A	0.980	N/A	0.425
9.50	3.55	0.03	0.97	sensitive fine grained	-3.1	1.00	2	1,140	547	791	2.80	N/A	N/A	0.978	N/A	0.424
10.50	3.16	0.02	0.65	sensitive fine grained	-4.1	1.00	2	1,260	605	848	2.81	4.90	37.91	0.976	N/A	0.423
11.50	4.03	0.03	0.72	sensitive fine grained	-5.1	1.00	2	1,380	662	906	2.75	4.40	40.63	0.973	N/A	0.422
12.50	3.40	0.01	0.30	sensitive fine grained	-6.1	1.00	2	1,500	720	963	2.72	4.18	30.58	0.971	N/A	0.421
13.50	2.80	0.01	0.31	sensitive fine grained	-7.1	1.00	1	1,620	778	1,021	2.84	5.11	29.07	0.969	N/A	0.420
14.50	4.75	0.02	0.47	sensitive fine grained	-8.1	1.00	2	1,740	835	1,079	2.69	3.93	35.95	0.966	N/A	0.419
15.50	3.25	0.01	0.31	sensitive fine grained	-9.1	1.00	2	1,860	893	1,136	2.83	5.02	29.90	0.964	N/A	0.418
16.50	16.12	0.08	0.50	sandy silt to clayey silt	-10.1	1.00	6	1,980	950	1,194	2.30	1.96	45.80	0.962	1.000	0.417
17.50	85.13	1.03	1.22	sand to silty sand	-11.1	1.00	21	2,100	1,008	1,251	1.91	1.20	143.76	0.959	1.000	0.416
18.50	121.43	2.12	1.74	silty sand to sandy silt	-12.1	1.00	40	2,220	1,066	1,309	1.93	1.21	201.87	0.957	1.000	0.415
19.50	112.13	1.99	1.77	silty sand to sandy silt	-13.1	1.00	37	2,340	1,123	1,367	1.96	1.25	187.37	0.955	1.000	0.414
20.50	109.01	1.96	1.80	silty sand to sandy silt	-14.1	1.00	36	2,460	1,181	1,424	1.98	1.28	181.25	0.952	1.000	0.413
21.50	100.82	2.15	2.14	silty sand to sandy silt	-15.1	1.66	56	2,580	1,238	1,482	1.76	1.08	228.30	0.950	1.000	0.412
22.50	21.07	0.37	1.75	sandy silt to clayey silt	-16.1	1.66	14	2,700	1,296	1,539	2.22	1.73	74.86	0.948	1.000	0.411
23.50	8.37	0.08	0.99	clayey silt to silty clay	-17.1	1.00	4	2,820	1,354	1,597	2.74	N/A	N/A	0.945	N/A	0.410
24.50	6.07	0.06	0.97	sensitive fine grained	-18.1	1.00	3	2,940	1,411	1,655	2.89	N/A	N/A	0.943	N/A	0.409
25.50	5.40	0.06	1.15	sensitive fine grained	-19.1	1.00	3	3,060	1,469	1,712	3.00	N/A	N/A	0.941	N/A	0.408
26.50	5.50	0.04	0.70	sensitive fine grained	-20.1	1.00	3	3,180	1,526	1,770	2.90	5.74	38.68	0.938	N/A	0.407
27.50	5.63	0.07	1.24	sensitive fine grained	-21.1	1.00	3	3,300	1,584	1,827	3.02	N/A	N/A	0.936	N/A	0.406
28.50	7.37	0.12	1.57	clayey silt to silty clay	-22.1	1.00	4	3,420	1,642	1,885	2.96	N/A	N/A	0.934	N/A	0.405
29.50	6.33	0.03	0.42	sensitive fine grained	-23.1	1.00	3	3,540	1,699	1,943	2.80	4.76	34.07	0.931	N/A	0.404
30.50	9.95	0.10	1.02	clayey silt to silty clay	-24.1	1.00	5	3,660	1,757	2,000	2.76	N/A	N/A	0.926	N/A	0.401
31.50	6.61	0.01	0.19	sensitive fine grained	-25.1	1.00	3	3,780	1,814	2,058	2.70	3.99	28.41	0.918	N/A	0.398
32.50	9.27	0.08	0.83	clayey silt to silty clay	-26.1	1.00	5	3,900	1,872	2,115	2.78	N/A	N/A	0.909	N/A	0.394
33.50	10.87	0.16	1.46	clayey silt to silty clay	-27.1	1.00	5	4,020	1,930	2,173	2.83	N/A	N/A	0.901	N/A	0.391
34.50	13.12	0.27	2.05	clayey silt to silty clay	-28.1	1.00	7	4,140	1,987	2,231	2.85	N/A	N/A	0.893	N/A	0.387
35.50	18.42	0.48	2.61	clayey silt to silty clay	-29.1	1.00	9	4,260	2,045	2,288	2.78	N/A	N/A	0.885	N/A	0.384
36.50	15.97	0.32	1.98	clayey silt to silty clay	-30.1	1.00	8	4,380	2,102	2,346	2.78	N/A	N/A	0.877	N/A	0.380
37.50	20.98	0.86	4.08	silty clay to clay	-31.1	1.00	14	4,500	2,160	2,403	2.87	N/A	N/A	0.869	N/A	0.376
38.50	55.10	1.24	2.25	sandy silt to clayey silt	-32.1	1.00	22	4,620	2,218	2,461	2.37	2.18	114.10	0.861	0.966	0.373
39.50	99.28	1.30	1.31	sand to silty sand	-33.1	1.66	41	4,740	2,275	2,519	1.71	1.04	160.58	0.852	0.950	0.369
40.50	43.88	1.30	2.96	sandy silt to clayey silt	-34.1	1.66	29	4,860	2,333	2,576	2.22	1.70	114.69	0.844	0.943	0.366
41.50	21.27	0.66	3.08	clayey silt to silty clay	-35.1	1.00	11	4,980	2,390	2,634	2.82	N/A	N/A	0.836	N/A	0.362
42.50	53.62	0.96	1.79	silty sand to sandy silt	-36.1	1.00	18	5,100	2,448	2,691	2.33	2.04	98.97	0.828	0.942	0.359
43.50	31.38	0.89	2.83	sandy silt to clayey silt	-37.1	1.00	13	5,220	2,506	2,749	2.67	N/A	N/A	0.820	N/A	0.355
44.50	17.47	0.46	2.63	clayey silt to silty clay	-38.1	1.00	9	5,340	2,563	2,807	2.87	N/A	N/A	0.812	N/A	0.352
45.50	15.10	0.30	2.01	clayey silt to silty clay	-39.1	1.00	8	5,460	2,621	2,864	2.87	N/A	N/A	0.804	N/A	0.348
46.50	11.02	0.15	1.32	clayey silt to silty clay	-40.1	1.00	6	5,580	2,678	2,922	2.92	N/A	N/A	0.795	N/A	0.345
47.50	11.67	0.15	1.25	clayey silt to silty clay	-41.1	1.00	6	5,700	2,736	2,979	2.89	N/A	N/A	0.787	N/A	0.341
48.50	10.27	0.13	1.22	clayey silt to silty clay	-42.1	1.00	5	5,820	2,794	3,037	2.95	N/A	N/A	0.779	N/A	0.338
49.50	9.60	0.12	1.21	clayey silt to silty clay	-43.1	1.00	5	5,940	2,851	3,095	2.99	N/A	N/A	0.771	N/A	0.334
50.50	8.55	0.05	0.60	sensitive fine grained	-44.1	1.00	4	6,060	2,909	3,152	2.92	5.85	37.79	0.763	N/A	0.331
51.50	9.15	0.02	0.22	sensitive fine grained	-45.1	1.00	5	6,180	2,966	3,210	2.74	4.28	29.17	0.755	N/A	0.327
52.50	9.14	0.15	1.67	clayey silt to silty clay	-46.1	1.00	5	6,300	3,024	3,267	3.10	N/A	N/A	0.747	N/A	0.324
53.50	14.10	0.42	2.98	clayey silt to silty clay	-47.1	1.00	7	6,420	3,082	3,325	3.05	N/A	N/A	0.739	N/A	0.320
54.50	16.10	0.51	3.16	clayey silt to silty clay	-48.1	1.00	8	6,540	3,139	3,383	3.02	N/A	N/A	0.730	N/A	0.316
55.50	15.82	0.46	2.93	clayey silt to silty clay	-49.1	1.00	8	6,660	3,197	3,440	3.01	N/A	N/A	0.722	N/A	0.313
56.50	11.37	0.26	2.28	clayey silt to silty clay	-50.1	1.00	6	6,780	3,254	3,498	3.10	N/A	N/A	0.714	N/A	0.309
57.50	20.52	0.49	2.38	clayey silt to silty clay	-51.1	1.00	10	6,900	3,312	3,555	2.87	N/A	N/A	0.706	N/A	0.306
58.50	164.50	1.53	0.93	sand	-52.1	1.00	33	7,020	3,370	3,613	1.82	1.12	141.96	0.698	0.824	0.302
59.50	375.80	2.01	0.54	gravelly sand to sand	-53.1	1.00	63	7,140	3,427	3,671	1.39	1.00	287.08	0.690	0.806	0.299

Soil Depth During Test (ft)	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	RESIDUAL STRENGTH * SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	GROUND SETTLEMENT ** Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	0.421	1.299	YES	2.8	14.3	615	N/A	N/A	0.000	0.00	0.47
1.50	0.461	1.424	NO	N/A	N/A	N/A	N/A	N/A	0.000	0.00	0.47
2.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
3.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
4.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
5.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.47
6.50	0.181	0.565	YES	2.8	27.1	1,200	34.2	N/A	0.057	0.01	0.46
7.50	0.125	0.390	YES	5.0	21.0	1,200	N/A	N/A	0.000	0.00	0.46
8.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.46
9.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.46
10.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.46
11.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.46
12.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.46
13.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.46
14.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.46
15.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.46
16.50	0.088	0.282	YES	2.8	11.1	379	15.0	N/A	1.897	0.23	0.23
17.50	0.356	1.144	YES	1.3	28.2	1,200	30.7	N/A	0.088	0.01	0.22
18.50	N/A	N/A	NO	N/A	N/A	N/A	65.0	N/A	0.000	0.00	0.22
19.50	N/A	N/A	NO	N/A	N/A	N/A	59.3	N/A	0.000	0.00	0.22
20.50	N/A	N/A	NO	N/A	N/A	N/A	56.7	N/A	0.000	0.00	0.22
21.50	N/A	N/A	NO	N/A	N/A	N/A	82.6	N/A	0.000	0.00	0.22
22.50	0.119	0.387	YES	2.8	18.7	1,049	24.1	N/A	1.077	0.13	0.09
23.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
24.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
25.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
26.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
27.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
28.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
29.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
30.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
31.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
32.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
33.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
34.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
35.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
36.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
37.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
38.50	0.218	0.754	YES	2.8	22.7	1,200	28.8	N/A	0.090	0.01	0.08
39.50	N/A	N/A	NO	N/A	N/A	N/A	40.9	N/A	0.000	0.00	0.08
40.50	0.220	0.758	YES	2.8	28.4	1,200	35.7	N/A	0.034	0.00	0.08
41.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.08
42.50	0.170	0.596	YES	2.8	18.2	997	23.5	N/A	0.562	0.07	0.01
43.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
44.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
45.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
46.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
47.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
48.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
49.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
50.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
51.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
52.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
53.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
54.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
55.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
56.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
57.50	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
58.50	0.346	1.258	YES	0.0	24.5	1,200	24.5	N/A	0.097	0.01	0.00
59.50	N/A	N/A	NO	N/A	N/A	N/A	46.2	N/A	0.000	0.00	0.00

max= 1,200
min= 379
avg= 1,024

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT045

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	9.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	9.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

\+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\ A_{max}\ (\sigma_v/\sigma_v')\ r_d$

+++ $FS = (CRR_{7.5}/CSR)\ MSF\ K_\sigma\ K_\alpha$ —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 6.00 ft below ground surface
GWT Depth For Design, Zwd = 0.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 16.00 feet
Earthquake-Induced Settlements:
- Liquefaction-Induced Settlement = 0.88 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <— Dry or Unsaturated Sands

Total: 0.88 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	17.12	0.29	1.68	sandy silt to clayey silt	8.0	1.00	7	60	29	60	1.95	1.24	177.56	0.999	1.000	0.433	N/A	N/A	NO	N/A	N/A	N/A	19.0	N/A	1.565	0.19	0.88
1.50	9.62	0.39	4.06	clay	7.0	1.00	10	180	86	180	2.57	3.16	146.11	0.997	1.000	0.432	0.370	1.144	YES	5.0	21.3	1,200	N/A	N/A	0.000	0.00	0.88
2.50	5.98	0.35	5.87	clay	6.0	1.00	6	300	144	300	2.71	N/A	N/A	0.994	N/A	0.431	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.88
3.50	5.32	0.35	6.51	clay	5.0	1.66	9	420	202	420	2.55	3.02	148.47	0.992	1.000	0.430	0.384	1.193	YES	5.0	20.0	1,182	N/A	N/A	0.000	0.00	0.88
4.50	2.40	0.11	4.65	clay	4.0	1.00	2	540	259	540	3.10	N/A	N/A	0.990	N/A	0.429	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.88
5.50	2.15	0.06	2.87	clay	3.0	1.00	2	660	317	660	3.08	N/A	N/A	0.987	N/A	0.428	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.88
6.50	2.32	0.07	2.89	clay	2.0	1.00	2	780	374	749	3.10	N/A	N/A	0.985	N/A	0.427	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.88
7.50	1.72	0.07	3.86	clay	1.0	1.00	2	900	432	806	3.35	N/A	N/A	0.983	N/A	0.426	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.88
8.50	24.22	0.13	0.53	silty sand to sandy silt	0.0	1.00	8	1,020	490	864	2.02	1.33	64.88	0.980	1.000	0.425	0.105	0.331	YES	2.8	15.1	687	19.7	N/A	1.490	0.18	0.70
9.50	19.60	0.20	1.01	sandy silt to clayey silt	-1.0	1.66	13	1,140	547	922	1.96	1.25	77.59	0.978	1.000	0.424	0.123	0.389	YES	2.8	21.9	1,200	27.9	N/A	0.226	0.03	0.67
10.50	1.71	0.08	4.70	organic material	-2.0	1.00	2	1,260	605	979	3.53	N/A	N/A	0.976	N/A	0.423	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
11.50	1.92	0.05	2.54	clay	-3.0	1.00	2	1,380	662	1,037	3.36	N/A	N/A	0.973	N/A	0.422	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
12.50	2.70	0.09	3.31	clay	-4.0	1.00	3	1,500	720	1,094	3.29	N/A	N/A	0.971	N/A	0.421	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
13.50	2.67	0.07	2.45	clay	-5.0	1.00	3	1,620	778	1,152	3.26	N/A	N/A	0.969	N/A	0.420	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
14.50	1.73	0.03	1.98	sensitive fine grained	-6.0	1.00	1	1,740	835	1,210	3.45	N/A	N/A	0.966	N/A	0.419	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
15.50	1.62	0.04	2.80	clay	-7.0	1.00	2	1,860	893	1,267	3.61	N/A	N/A	0.964	N/A	0.418	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
16.50	1.37	0.03	1.92	sensitive fine grained	-8.0	1.00	1	1,980	950	1,325	3.71	N/A	N/A	0.962	N/A	0.417	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
17.50	2.33	0.05	2.25	sensitive fine grained	-9.0	1.00	1	2,100	1,008	1,382	3.41	N/A	N/A	0.959	N/A	0.416	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
18.50	3.18	0.03	0.90	sensitive fine grained	-10.0	1.00	2	2,220	1,066	1,440	3.07	N/A	N/A	0.957	N/A	0.415	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
19.50	3.48	0.06	1.74	sensitive fine grained	-11.0	1.00	2	2,340	1,123	1,498	3.19	N/A	N/A	0.955	N/A	0.414	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.67
20.50	29.69	0.18	0.59	silty sand to sandy silt	-12.0	1.00	10	2,460	1,181	1,555	2.14	1.53	58.98	0.952	1.000	0.413	0.099	0.320	YES	2.8	14.0	594	18.5	N/A	1.586	0.19	0.48
21.50	49.63	0.36	0.73	silty sand to sandy silt	-13.0	1.66	27	2,580	1,238	1,613	1.69	1.00	104.44	0.950	1.000	0.412	0.186	0.603	YES	2.8	33.3	1,200	41.6	N/A	0.000	0.00	0.48
22.50	9.72	0.19	1.93	clayey silt to silty clay	-14.0	1.00	5	2,700	1,296	1,670	2.82	N/A	N/A	0.948	N/A	0.411	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
23.50	5.53	0.14	2.58	clay	-15.0	1.00	6	2,820	1,354	1,728	3.14	N/A	N/A	0.945	N/A	0.410	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
24.50	6.88	0.13	1.85	silty clay to clay	-16.0	1.00	5	2,940	1,411	1,786	2.98	N/A	N/A	0.943	N/A	0.409	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
25.50	6.08	0.16	2.60	clay	-17.0	1.00	6	3,060	1,469	1,843	3.13	N/A	N/A	0.941	N/A	0.408	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
26.50	3.87	0.08	1.98	clay	-18.0	1.00	4	3,180	1,526	1,901	3.30	N/A	N/A	0.938	N/A	0.407	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
27.50	4.93	0.12	2.37	clay	-19.0	1.00	5	3,300	1,584	1,958	3.23	N/A	N/A	0.936	N/A	0.406	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
28.50	4.60	0.08	1.83	silty clay to clay	-20.0	1.00	3	3,420	1,642	2,016	3.22	N/A	N/A	0.934	N/A	0.405	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
29.50	9.32	0.11	1.15	clayey silt to silty clay	-21.0	1.00	5	3,540	1,699	2,074	2.81	N/A	N/A	0.931	N/A	0.404	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
30.50	24.22	0.65	2.70	clayey silt to silty clay	-22.0	1.00	12	3,660	1,757	2,131	2.65	N/A	N/A	0.926	N/A	0.401	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
31.50	22.70	0.75	3.33	clayey silt to silty clay	-23.0	1.00	11	3,780	1,814	2,189	2.74	N/A	N/A	0.918	N/A	0.398	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
32.50	23.72	0.93	3.91	silty clay to clay	-24.0	1.00	16	3,900	1,872	2,246	2.78	N/A	N/A	0.909	N/A	0.394	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
33.50	25.67	0.75	2.92	clayey silt to silty clay	-25.0	1.00	13	4,020	1,930	2,304	2.68	N/A	N/A	0.901	N/A	0.391	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
34.50	38.37	1.30	3.38	clayey silt to silty clay	-26.0	1.00	19	4,140	1,987	2,362	2.59	3.25	125.24	0.893	1.000	0.387	0.263	0.906	YES	2.8	20.5	1,200	N/A	N/A	0.000	0.00	0.48
35.50	41.48	1.08	2.61	sandy silt to clayey silt	-27.0	1.66	27	4,260	2,045	2,419	2.18	1.61	109.25	0.885	0.992	0.384	0.201	0.694	YES	2.8	27.8	1,200	35.0	N/A	0.042	0.01	0.48
36.50	15.73	0.23	1.46	sandy silt to clayey silt	-28.0	1.00	6	4,380	2,102	2,477	2.71	N/A	N/A	0.877	N/A	0.380	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
37.50	17.05	0.31	1.79	sandy silt to clayey silt	-29.0	1.00	7	4,500	2,160	2,534	2.73	N/A	N/A	0.869	N/A	0.376	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.48
38.50	34.87	0.38	1.08	silty sand to sandy silt	-30.0	1.00	12	4,620	2,218	2,592	2.33	2.06	68.37	0.861	0.976	0.373	0.110	0.383	YES	2.8	13.0	511	17.3	N/A	1.642	0.20	0.28
39.50	21.35	0.41	1.90	sandy silt to clayey silt	-31.0	1.00	9	4,740	2,275	2,650	2.68	N/A	N/A	0.852	N/A	0.369	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.28
40.50	41.35	0.68	1.64	silty sand to sandy silt	-32.0	1.00	14	4,860	2,333	2,707	2.39	2.26	86.39	0.844	0.961	0.366	0.140	0.491	YES	2.8	14.6	648	19.2	N/A	1.416	0.17	0.11
41.50	37.34	0.56	1.50	silty sand to sandy silt	-33.0	1.66	21	4,980	2,390	2,765	2.09	1.44	81.36	0.836	0.946	0.362	0.130	0.453	YES	2.8	20.3	1,200	26.0	N/A	0.160	0.02	0.09
42.50	8.05	0.09	1.08	clayey silt to silty clay	-34.0	1.00	4	5,100	2,448	2,822	2.99	N/A	N/A	0.828	N/A	0.359	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
43.50	11.92	0.26	2.15	clayey silt to silty clay	-35.0	1.00	6	5,220	2,506	2,880	2.97	N/A	N/A	0.820	N/A	0.355	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
44.50	32.78	0.85	2.58	sandy silt to clayey silt	-36.0	1.00	13	5,340	2,563	2,938	2.63	N/A	N/A	0.812	N/A	0.352	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
45.50	35.50	0.55	1.54	silty sand to sandy silt	-37.0	1.66	20	5,460	2,621	2,995	2.14	1.52	78.15	0.804	0.922	0.348	0.124	0.439	YES	2.8	18.8	1,061	24.2	N/A	0.260	0.03	0.06
46.50	11.98	0.22	1.88	clayey silt to silty clay	-38.0	1.00	6	5,580	2,678	3,053	2.96	N/A	N/A	0.795	N/A	0.345	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.06
47.50	99.50	1.20	1.21	sand to silty sand	-39.0	1.66	41	5,700	2,736	3,110	1.71	1.05	147.47	0.787	0.882	0.341	0.378	1.305	NO	N/A	N/A	N/A	37.1	N/A	0.021	0.00	0.06
48.50	16.35	0.49	2.99	clayey silt to silty clay	-40.0	1.66	14	5,820	2,794	3,168	2.63	N/A	N/A	0.779	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.06
49.50	7.15	0.14	1.91	silty clay to clay	-41.0	1.00	5	5,940	2,851	3,226	3.23	N/A	N/A	0.771	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.06
50.50	6.52	0.15	2.28	silty clay to clay	-42.0	1.00	4	6,060	2,909	3,283	3.33	N/A	N/A	0.763	N/A	0.331	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.06
51.50	6.98	0.23	3.34	clay	-43.0	1.00	7	6,180	2,966	3,341	3.40	N/A	N/A	0.755	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.06
52.50	8.57	0.22	2.64	silty clay to clay	-44.0	1.00	6	6,300	3,024	3,398	3.24	N/A	N/A	0.747	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.06
53.50	12.23	0.22	1.81	clayey silt to silty clay	-45.0	1.00	6	6,420	3,082	3,456	2.99	N/A	N/A	0.739	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.06
54.50	19.78	0.62	3.15	clayey silt to silty clay	-46.0	1.00	10	6,540	3,139	3,514	2.93	N/A	N/A	0.730	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.06
55.50	73.55	1.03	1.40	silty sand to sandy silt	-47.0	1.00	25	6,660	3,197	3,571	2.20	1.66	96.53	0.722	0.860	0.313	0.164	0.600	YES	2.8	21.1	1,200	27.0	N/A	0.085	0.01	0.05
56.50	68.25	1.02	1.49	silty sand to sandy silt	-48.0	1.00	23	6,780	3,254	3,629	2.24	1.78	95.35	0.714	0.861	0.309	0.161	0.596	YES	2.8	19.7	1,153	25.3	N/A	0.095	0.01	0.03
57.50	69.22	1.10	1.59	silty sand to sandy silt	-49.0	1.00	23	6,900	3,312	3,686	2.26	1.83	98.21	0.706	0.856	0.306	0.168	0.627	YES	2.8	19.8	1,164	25.4	N/A	0.093	0.01	0.02
58.50	106.67	1.64	1.54	sand to silty sand	-50.0	1.00	27	7,020	3,370	3,744	2.11	1.47	120.64	0.698	0.841	0.302	0.243	0.903	YES	1.3	20.8	1,200	22.9	N/A	0.152	0.02	0.00
59.50	235.33	2.01	0.86	sand	-51.0	1.00	47	7,140	3,427	3,802	1.68	1.02	184.04	0.690	0.806	0.299	N/A	N/A	NO	N/A	N/A	N/A	34.1	N/A	0.036	0.00	0.00

max= 1,200
min= 511
avg= 1,038

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT048

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	11.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_w	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	8.00 ft below ground surface
GWT Depth For Design, Zwd =	1.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	11.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.45 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	0.45 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	79.50	2.35	2.95	sandy silt to clayey silt	10.0	1.00	32	60	60	60	1.87	1.17	534.77	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	69.9	N/A	N/A	N/A	0.45
1.50	119.95	5.11	4.26	very stiff fine grained (*)	9.0	1.00	120	180	149	180	2.03	1.34	587.21	0.997	1.000	0.251	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	0.000	0.00	0.45
2.50	168.40	5.89	3.50	sandy silt to clayey silt	8.0	1.00	67	300	206	300	1.92	1.21	631.72	0.994	1.000	0.301	N/A	N/A	NO	N/A	N/A	N/A	142.4	N/A	0.000	0.00	0.45
3.50	89.02	5.53	6.22	very stiff fine grained (*)	7.0	1.00	89	420	264	420	2.29	1.90	466.44	0.992	1.000	0.328	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	0.000	0.00	0.45
4.50	122.97	2.78	2.26	silty sand to sandy silt	6.0	1.00	41	540	322	540	1.86	1.15	352.83	0.990	1.000	0.346	N/A	N/A	NO	N/A	N/A	N/A	88.6	N/A	0.000	0.00	0.45
5.50	161.12	2.46	1.53	sand to silty sand	5.0	1.66	67	660	379	660	1.37	1.00	612.65	0.987	1.000	0.357	N/A	N/A	NO	N/A	N/A	N/A	121.3	N/A	0.000	0.00	0.45
6.50	33.18	1.49	4.50	silty clay to clay	4.0	1.00	22	780	437	780	2.48	2.67	189.31	0.985	1.000	0.366	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	0.000	0.00	0.45
7.50	18.23	0.94	5.16	clay	3.0	1.00	18	900	494	900	2.62	N/A	N/A	0.983	N/A	0.372	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
8.50	12.40	0.66	5.38	clay	2.0	1.00	12	1,020	552	989	2.77	N/A	N/A	0.980	N/A	0.377	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
9.50	30.37	1.02	3.34	clayey silt to silty clay	1.0	1.66	25	1,140	610	1,046	2.15	1.55	141.44	0.978	1.000	0.380	0.343	1.204	YES	2.8	37.6	1,200	N/A	N/A	0.000	0.00	0.45
10.50	12.01	0.45	3.77	clay	0.0	1.00	12	1,260	667	1,104	2.73	N/A	N/A	0.976	N/A	0.383	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.45
11.50	17.03	0.44	2.61	clayey silt to silty clay	-1.0	1.00	9	1,380	725	1,162	2.52	2.89	105.48	0.973	1.000	0.385	0.189	0.655	YES	2.8	14.0	590	N/A	N/A	0.000	0.00	0.45
12.50	33.40	0.59	1.78	sandy silt to clayey silt	-2.0	1.00	13	1,500	782	1,219	2.29	1.90	101.65	0.971	1.000	0.387	0.178	0.612	YES	2.8	19.9	1,176	25.5	N/A	0.283	0.03	0.42
13.50	27.28	0.53	1.94	sandy silt to clayey silt	-3.0	1.66	18	1,620	840	1,277	2.08	1.42	98.85	0.969	1.000	0.389	0.170	0.583	YES	2.8	25.4	1,200	32.1	N/A	0.068	0.01	0.41
14.50	10.33	0.31	3.00	silty clay to clay	-4.0	1.00	7	1,740	898	1,334	2.80	N/A	N/A	0.966	N/A	0.390	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
15.50	5.85	0.20	3.41	clay	-5.0	1.00	6	1,860	955	1,392	3.06	N/A	N/A	0.964	N/A	0.390	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
16.50	5.52	0.15	2.74	clay	-6.0	1.00	6	1,980	1,013	1,450	3.05	N/A	N/A	0.962	N/A	0.391	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
17.50	6.00	0.15	2.56	clay	-7.0	1.00	6	2,100	1,070	1,507	3.02	N/A	N/A	0.959	N/A	0.391	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
18.50	6.38	0.15	2.35	silty clay to clay	-8.0	1.00	4	2,220	1,128	1,565	2.99	N/A	N/A	0.957	N/A	0.392	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
19.50	6.27	0.15	2.35	silty clay to clay	-9.0	1.00	4	2,340	1,186	1,622	3.01	N/A	N/A	0.955	N/A	0.392	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
20.50	6.51	0.13	2.04	silty clay to clay	-10.0	1.00	4	2,460	1,243	1,680	2.98	N/A	N/A	0.952	N/A	0.392	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
21.50	6.97	0.17	2.45	silty clay to clay	-11.0	1.00	5	2,580	1,301	1,738	3.01	N/A	N/A	0.950	N/A	0.392	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
22.50	6.40	0.16	2.56	silty clay to clay	-12.0	1.00	4	2,700	1,358	1,795	3.07	N/A	N/A	0.948	N/A	0.392	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
23.50	7.90	0.24	3.08	clay	-13.0	1.00	8	2,820	1,416	1,853	3.04	N/A	N/A	0.945	N/A	0.392	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
24.50	7.33	0.16	2.17	silty clay to clay	-14.0	1.00	5	2,940	1,474	1,910	3.00	N/A	N/A	0.943	N/A	0.391	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
25.50	7.77	0.12	1.55	clayey silt to silty clay	-15.0	1.00	4	3,060	1,531	1,968	2.91	N/A	N/A	0.941	N/A	0.391	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
26.50	8.82	0.25	2.80	silty clay to clay	-16.0	1.00	6	3,180	1,589	2,026	3.01	N/A	N/A	0.938	N/A	0.391	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
27.50	9.87	0.24	2.47	silty clay to clay	-17.0	1.00	7	3,300	1,646	2,083	2.94	N/A	N/A	0.936	N/A	0.390	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
28.50	11.75	0.24	2.06	clayey silt to silty clay	-18.0	1.00	6	3,420	1,704	2,141	2.84	N/A	N/A	0.934	N/A	0.390	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
29.50	11.68	0.20	1.70	clayey silt to silty clay	-19.0	1.00	6	3,540	1,762	2,198	2.81	N/A	N/A	0.931	N/A	0.389	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
30.50	13.83	0.24	1.73	clayey silt to silty clay	-20.0	1.00	7	3,660	1,819	2,256	2.75	N/A	N/A	0.926	N/A	0.387	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
31.50	14.24	0.38	2.71	clayey silt to silty clay	-21.0	1.00	7	3,780	1,877	2,314	2.86	N/A	N/A	0.918	N/A	0.384	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
32.50	21.87	1.08	4.96	clay	-22.0	1.00	22	3,900	1,934	2,371	2.88	N/A	N/A	0.909	N/A	0.381	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
33.50	25.48	0.69	2.72	clayey silt to silty clay	-23.0	1.00	13	4,020	1,992	2,429	2.67	N/A	N/A	0.901	N/A	0.378	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
34.50	43.57	1.48	3.39	clayey silt to silty clay	-24.0	1.00	22	4,140	2,050	2,486	2.55	3.05	130.56	0.893	0.992	0.375	0.287	1.012	YES	2.8	22.3	1,200	N/A	N/A	0.000	0.00	0.41
35.50	23.07	1.23	5.33	clay	-25.0	1.00	23	4,260	2,107	2,544	2.91	N/A	N/A	0.885	N/A	0.372	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
36.50	28.33	0.77	2.71	sandy silt to clayey silt	-26.0	1.00	11	4,380	2,165	2,602	2.65	N/A	N/A	0.877	N/A	0.369	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
37.50	28.93	0.87	3.01	clayey silt to silty clay	-27.0	1.00	14	4,500	2,222	2,659	2.68	N/A	N/A	0.869	N/A	0.366	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
38.50	59.73	0.99	1.65	silty sand to sandy silt	-28.0	1.66	33	4,620	2,280	2,717	1.94	1.23	114.03	0.861	0.949	0.363	0.218	0.761	YES	2.8	31.1	1,200	38.9	N/A	0.008	0.00	0.41
39.50	22.60	0.58	2.57	clayey silt to silty clay	-29.0	1.00	11	4,740	2,338	2,774	2.74	N/A	N/A	0.852	N/A	0.360	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.41
40.50	36.63	0.94	2.55	sandy silt to clayey silt	-30.0	1.00	15	4,860	2,395	2,832	2.57	3.15	100.75	0.844	0.954	0.356	0.175	0.625	YES	2.8	15.1	690	19.8	N/A	1.330	0.16	0.25
41.50	22.23	0.73	3.27	clayey silt to silty clay	-31.0	1.00	11	4,980	2,453	2,890	2.83	N/A	N/A	0.836	N/A	0.353	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
42.50	13.85	0.36	2.62	clayey silt to silty clay	-32.0	1.00	7	5,100	2,510	2,947	2.96	N/A	N/A	0.828	N/A	0.350	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
43.50	11.67	0.23	1.97	clayey silt to silty clay	-33.0	1.00	6	5,220	2,568	3,005	2.97	N/A	N/A	0.820	N/A	0.347	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
44.50	11.38	0.32	2.77	silty clay to clay	-34.0	1.00	8	5,340	2,626	3,062	3.07	N/A	N/A	0.812	N/A	0.343	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
45.50	9.10	0.14	1.54	clayey silt to silty clay	-35.0	1.00	5	5,460	2,683	3,120	3.04	N/A	N/A	0.804	N/A	0.340	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
46.50	10.28	0.16	1.51	clayey silt to silty clay	-36.0	1.00	5	5,580	2,741	3,178	2.99	N/A	N/A	0.795	N/A	0.337	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
47.50	12.00	0.28	2.33	clayey silt to silty clay	-37.0	1.00	6	5,700	2,798	3,235	3.03	N/A	N/A	0.787	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
48.50	13.30	0.21	1.60	clayey silt to silty clay	-38.0	1.00	7	5,820	2,856	3,293	2.90	N/A	N/A	0.779	N/A	0.330	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
49.50	9.65	0.13	1.30	clayey silt to silty clay	-39.0	1.00	5	5,940	2,914	3,350	3.00	N/A	N/A	0.771	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
50.50	11.77	0.21	1.79	clayey silt to silty clay	-40.0	1.00	6	6,060	2,971	3,408	2.99	N/A	N/A	0.763	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
51.50	11.45	0.20	1.70	clayey silt to silty clay	-41.0	1.00	6	6,180	3,029	3,466	3.00	N/A	N/A	0.755	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
52.50	12.07	0.19	1.53	clayey silt to silty clay	-42.0	1.00	6	6,300	3,086	3,523	2.96	N/A	N/A	0.747	N/A	0.317	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
53.50	11.70	0.19	1.63	clayey silt to silty clay	-43.0	1.00	6	6,420	3,144	3,581	3.00	N/A	N/A	0.739	N/A	0.314	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
54.50	12.58	0.19	1.51	clayey silt to silty clay	-44.0	1.00	6	6,540	3,202	3,638	2.95	N/A	N/A	0.730	N/A	0.310	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
55.50	18.40	0.33	1.81	sandy silt to clayey silt	-45.0	1.00	7	6,660	3,259	3,696	2.83	N/A	N/A	0.722	N/A	0.307	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
56.50	44.15	0.87	1.97	sandy silt to clayey silt	-46.0	1.00	18	6,780	3,317	3,754	2.52	2.88	87.15	0.714	0.873	0.304	0.142	0.543	YES	2.8	15.7	744	20.5	N/A	0.498	0.06	0.19
57.50	103.22	1.44	1.39	sand to silty sand	-47.0	1.66	43	6,900	3,374	3,811	1.78	1.09	143.44	0.706	0.811	0.300	0.354	1.278	YES	1.3	32.3	1,200	34.9	N/A	0.031	0.00	0.19
58.50	48.20	0.85	1.75	silty sand to sandy silt	-48.0	1.00	16	7,020	3,432	3,869	2.42	2.41	88.57	0.698	0.871	0.297	0.145	0.566	YES	2.8	14.4	622	18.9	N/A	1.189	0.14	0.05
59.50	54.03	1.09	2.01	silty sand to sandy silt	-49.0	1.00	18	7,140	3,490	3,926	2.42	2.41	98.47	0.690	0.861	0.294	0.169	0.661	YES	2.8	15.7	741	20.4	N/A	0.381	0.05	0.00
60.50	37.43	1.17	3.11	clayey silt to silty clay	-50.0	1.00	19	7,260	3,547	3,984	2.73	N/A	N/A	0.682	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max=	1,200
min=	590
avg=	960

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT050

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	20.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\,-->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	17.00 ft below ground surface
GWT Depth For Design, Zwd =	10.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	14.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.84 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.02 inches	<--- Dry or Unsaturated Sands
Total:	0.86 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	104.53	0.23	0.22	sand	19.0	1.00	21	60	60	60	0.89	1.00	603.52	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	35.5	0.009	0.008	0.00	0.86
1.50	57.47	0.13	0.22	sand to silty sand	18.0	1.00	14	180	180	180	1.31	1.00	191.56	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	28.1	0.017	0.019	0.00	0.86
2.50	42.85	0.26	0.61	silty sand to sandy silt	17.0	1.00	14	300	300	300	1.75	1.07	118.28	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	34.1	0.021	0.018	0.00	0.86
3.50	36.18	0.13	0.37	silty sand to sandy silt	16.0	1.00	12	420	420	420	1.76	1.00	78.96	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	29.6	0.026	0.027	0.00	0.85
4.50	23.82	0.10	0.41	silty sand to sandy silt	15.0	1.00	8	540	540	540	1.99	1.00	45.84	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	21.2	0.033	0.051	0.01	0.85
5.50	19.15	0.16	0.83	sandy silt to clayey silt	14.0	1.00	8	660	660	660	2.26	1.82	60.74	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	20.6	N/A	N/A	N/A	0.85
6.50	25.97	0.27	1.05	silty sand to sandy silt	13.0	1.00	9	780	780	780	2.23	1.75	72.79	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	21.6	0.039	0.059	0.01	0.84
7.50	30.67	0.48	1.58	sandy silt to clayey silt	12.0	1.00	12	900	900	900	2.30	1.96	89.50	0.983	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	26.9	N/A	N/A	N/A	0.84
8.50	124.85	0.89	0.72	sand	11.0	1.66	41	1,020	1,020	1,020	1.32	1.00	289.46	0.980	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	57.9	0.032	0.000	0.00	0.84
9.50	29.12	0.76	2.60	sandy silt to clayey silt	10.0	1.00	12	1,140	1,140	1,140	2.50	2.77	106.76	0.978	N/A	0.203	N/A	N/A	NO	N/A	N/A	N/A	23.5	N/A	N/A	N/A	0.84
10.50	15.40	0.37	2.43	clayey silt to silty clay	9.0	1.00	8	1,260	1,229	1,260	2.67	N/A	N/A	0.976	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
11.50	11.35	0.32	2.82	silty clay to clay	8.0	1.00	8	1,380	1,286	1,380	2.84	N/A	N/A	0.973	N/A	0.217	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
12.50	10.83	0.32	2.97	silty clay to clay	7.0	1.00	7	1,500	1,344	1,500	2.88	N/A	N/A	0.971	N/A	0.225	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
13.50	9.40	0.30	3.19	silty clay to clay	6.0	1.00	6	1,620	1,402	1,620	2.96	N/A	N/A	0.969	N/A	0.233	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
14.50	7.12	0.20	2.82	silty clay to clay	5.0	1.00	5	1,740	1,459	1,740	3.05	N/A	N/A	0.966	N/A	0.240	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
15.50	9.43	0.30	3.15	silty clay to clay	4.0	1.00	6	1,860	1,517	1,860	2.98	N/A	N/A	0.964	N/A	0.246	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
16.50	9.40	0.26	2.74	silty clay to clay	3.0	1.00	6	1,980	1,574	1,980	2.96	N/A	N/A	0.962	N/A	0.252	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.84
17.50	24.28	0.28	1.14	sandy silt to clayey silt	2.0	1.66	16	2,100	1,632	2,069	2.11	1.48	65.77	0.959	1.000	0.257	0.106	0.553	YES	2.8	18.6	1,040	24.0	N/A	0.084	0.01	0.83
18.50	8.22	0.22	2.73	silty clay to clay	1.0	1.00	5	2,220	1,690	2,126	3.03	N/A	N/A	0.957	N/A	0.262	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
19.50	6.90	0.21	3.06	clay	0.0	1.00	7	2,340	1,747	2,184	3.14	N/A	N/A	0.955	N/A	0.266	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.83
20.50	36.31	0.43	1.18	silty sand to sandy silt	-1.0	1.00	12	2,460	1,805	2,242	2.29	1.93	73.81	0.952	1.000	0.270	0.117	0.580	YES	2.8	14.2	612	18.7	N/A	0.393	0.05	0.78
21.50	27.67	0.40	1.46	sandy silt to clayey silt	-2.0	1.00	11	2,580	1,862	2,299	2.45	2.55	73.00	0.950	1.000	0.274	0.116	0.566	YES	2.8	13.1	520	17.4	N/A	1.214	0.15	0.64
22.50	25.75	0.34	1.32	sandy silt to clayey silt	-3.0	1.66	17	2,700	1,920	2,357	2.15	1.56	67.90	0.948	1.000	0.277	0.109	0.525	YES	2.8	18.5	1,029	23.9	N/A	0.091	0.01	0.63
23.50	6.98	0.15	2.23	silty clay to clay	-4.0	1.00	5	2,820	1,978	2,414	3.10	N/A	N/A	0.945	N/A	0.280	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
24.50	6.27	0.06	1.01	sensitive fine grained	-5.0	1.00	3	2,940	2,035	2,472	2.99	N/A	N/A	0.943	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
25.50	7.67	0.11	1.44	clayey silt to silty clay	-6.0	1.00	4	3,060	2,093	2,530	2.98	N/A	N/A	0.941	N/A	0.286	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
26.50	8.15	0.11	1.42	clayey silt to silty clay	-7.0	1.00	4	3,180	2,150	2,587	2.96	N/A	N/A	0.938	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
27.50	7.30	0.09	1.21	sensitive fine grained	-8.0	1.00	4	3,300	2,208	2,645	2.99	N/A	N/A	0.936	N/A	0.291	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
28.50	6.95	0.07	0.95	sensitive fine grained	-9.0	1.00	3	3,420	2,266	2,702	2.97	N/A	N/A	0.934	N/A	0.293	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
29.50	7.42	0.08	1.09	sensitive fine grained	-10.0	1.00	4	3,540	2,323	2,760	2.98	N/A	N/A	0.931	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
30.50	7.92	0.11	1.43	clayey silt to silty clay	-11.0	1.00	4	3,660	2,381	2,818	3.02	N/A	N/A	0.926	N/A	0.296	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.63
31.50	17.09	0.13	0.77	sandy silt to clayey silt	-12.0	1.66	11	3,780	2,438	2,875	2.25	1.00	25.62	0.918	0.955	0.296	0.071	0.307	YES	2.8	12.2	453	16.3	N/A	1.596	0.19	0.44
32.50	7.88	0.09	1.08	clayey silt to silty clay	-13.0	1.00	4	3,900	2,496	2,933	2.98	N/A	N/A	0.909	N/A	0.296	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.44
33.50	10.13	0.18	1.78	clayey silt to silty clay	-14.0	1.00	5	4,020	2,554	2,990	2.99	N/A	N/A	0.901	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.44
34.50	14.62	0.20	1.35	sandy silt to clayey silt	-15.0	1.00	6	4,140	2,611	3,048	2.78	N/A	N/A	0.893	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.44
35.50	14.37	0.37	2.59	clayey silt to silty clay	-16.0	1.00	7	4,260	2,669	3,106	2.95	N/A	N/A	0.885	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.44
36.50	14.97	0.46	3.09	clayey silt to silty clay	-17.0	1.00	7	4,380	2,726	3,163	2.98	N/A	N/A	0.877	N/A	0.293	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.44
37.50	47.78	0.57	1.20	silty sand to sandy silt	-18.0	1.66	26	4,500	2,784	3,221	1.97	1.27	84.92	0.869	0.893	0.292	0.137	0.559	YES	2.8	23.6	1,200	29.9	N/A	0.061	0.01	0.43
38.50	12.20	0.37	3.08	silty clay to clay	-19.0	1.00	8	4,620	2,842	3,278	3.08	N/A	N/A	0.861	N/A	0.291	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
39.50	10.58	0.29	2.78	silty clay to clay	-20.0	1.00	7	4,740	2,899	3,336	3.12	N/A	N/A	0.852	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
40.50	10.32	0.23	2.24	clayey silt to silty clay	-21.0	1.00	5	4,860	2,957	3,394	3.08	N/A	N/A	0.844	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
41.50	37.01	0.68	1.83	sandy silt to clayey silt	-22.0	1.00	15	4,980	3,014	3,451	2.54	2.95	80.37	0.836	0.902	0.287	0.128	0.537	YES	2.8	14.1	598	18.5	N/A	1.150	0.14	0.29
42.50	32.33	0.99	3.06	clayey silt to silty clay	-23.0	1.00	16	5,100	3,072	3,509	2.73	N/A	N/A	0.828	N/A	0.286	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.29
43.50	57.98	1.02	1.77	silty sand to sandy silt	-24.0	1.00	19	5,220	3,130	3,566	2.34	2.08	96.18	0.820	0.880	0.284	0.163	0.672	YES	2.8	17.3	901	22.4	N/A	0.123	0.01	0.28
44.50	67.35	1.30	1.93	silty sand to sandy silt	-25.0	1.00	22	5,340	3,187	3,624	2.31	1.99	106.33	0.812	0.867	0.283	0.192	0.784	YES	2.8	19.5	1,131	25.0	N/A	0.087	0.01	0.26
45.50	140.32	1.92	1.37	sand to silty sand	-26.0	1.00	35	5,460	3,245	3,682	1.97	1.27	139.73	0.804	0.831	0.281	0.334	1.316	NO	N/A	N/A	N/A	29.6	0.060	0.01	0.26
46.50	104.55	0.60	0.57	sand	-27.0	1.66	35	5,580	3,302	3,739	1.54	1.00	134.72	0.795	0.828	0.280	0.307	1.214	YES	0.0	25.3	1,200	25.3	N/A	0.084	0.01	0.25
47.50	48.68	0.51	1.05	silty sand to sandy silt	-28.0	1.00	16	5,700	3,360	3,797	2.28	1.88	70.67	0.787	0.875	0.278	0.113	0.474	YES	2.8	14.6	642	19.1	N/A	0.417	0.05	0.20
48.50	36.22	0.61	1.70	sandy silt to clayey silt	-29.0	1.00	14	5,820	3,418	3,854	2.56	3.09	74.92	0.779	0.878	0.276	0.119	0.506	YES	2.8	13.2	529	17.5	N/A	1.214	0.15	0.05
49.50	49.93	0.75	1.50	silty sand to sandy silt	-30.0	1.00	17	5,940	3,475	3,912	2.37	2.18	82.47	0.771	0.867	0.274	0.132	0.558	YES	2.8	14.7	653	19.3	N/A	0.347	0.04	0.01
50.50	37.35	0.65	1.75	sandy silt to clayey silt	-31.0	1.66	25	6,060	3,533	3,970	2.20	1.67	77.76	0.763	0.836	0.272	0.124	0.507	YES	2.8	20.4	1,200	26.1	N/A	0.077	0.01	0.00
51.50	17.12	0.46	2.68	clayey silt to silty clay	-32.0	1.00	9	6,180	3,590	4,027	2.98	N/A	N/A	0.755	N/A	0.270	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
52.50	14.99	0.31	2.11	clayey silt to silty clay	-33.0	1.00	7	6,300	3,648	4,085	2.98	N/A	N/A	0.747	N/A	0.268	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
53.50	15.17	0.26	1.71	clayey silt to silty clay	-34.0	1.00	8	6,420	3,706	4,142	2.93	N/A	N/A	0.739	N/A	0.266	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
54.50	14.72	0.34	2.34	clayey silt to silty clay	-35.0	1.00	7	6,540	3,763	4,200	3.03	N/A	N/A	0.730	N/A	0.264	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
55.50	15.32	0.36	2.37	clayey silt to silty clay	-36.0	1.00	8	6,660	3,821	4,258	3.02	N/A	N/A	0.722	N/A	0.262	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
56.50	16.47	0.43	2.61	clayey silt to silty clay	-37.0	1.00	8	6,780	3,878	4,315	3.02	N/A	N/A	0.714	N/A	0.260	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
57.50	20.08	0.33	1.67	sandy silt to clayey silt	-38.0	1.00	8	6,900	3,936	4,373	2.83	N/A	N/A	0.706	N/A	0.257	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
58.50	15.08	0.40	2.68	clayey silt to silty clay	-39.0	1.00	8	7,020	3,994	4,430	3.07	N/A	N/A	0.698	N/A	0.255	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
59.50	13.00	0.26	2.02	clayey silt to silty clay	-40.0	1.00	7	7,140	4,051	4,488	3.07	N/A	N/A	0.690	N/A	0.253	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
60.50	18.82	0.34	1.83	sandy silt to clayey silt	-41.0	1.00	8	7,260	4,109	4,546	2.90	N/A	N/A	0.682	N/A	0.250	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max=	1,200
min=	453
avg=	836

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT052

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	12.00 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

\+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\ A_{max}\ (\sigma_v/\sigma_v')\ r_d$

+++ $FS = (CRR_{7.5}/CSR)\ MSF\ K_\sigma\ K_{\alpha}$ —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	9.00 ft below ground surface
GWT Depth For Design, Zwd =	2.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	26.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	2.92 inches	<— Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<— Dry or Unsaturated Sands
Total:	2.92 inches	

INPUT SOIL PROFILE (CPT DATA)

Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)
0.50	99.30	0.99	0.99	sand to silty sand
1.50	37.35	0.99	2.66	sandy silt to clayey silt
2.50	13.08	0.50	3.85	clay
3.50	7.10	0.32	4.49	clay
4.50	6.42	0.24	3.69	clay
5.50	9.08	0.28	3.02	silty clay to clay
6.50	6.02	0.22	3.60	clay
7.50	5.30	0.18	3.42	clay
8.50	5.78	0.19	3.26	clay
9.50	6.15	0.17	2.76	clay
10.50	5.63	0.16	2.91	clay
11.50	5.33	0.26	4.80	clay
12.50	4.80	0.21	4.39	clay
13.50	5.38	0.18	3.30	clay
14.50	13.98	0.23	1.61	clayey silt to silty clay
15.50	3.95	0.08	1.98	clay
16.50	3.78	0.06	1.44	sensitive fine grained
17.50	4.40	0.07	1.61	sensitive fine grained
18.50	10.05	0.07	0.71	sandy silt to clayey silt
19.50	12.68	0.07	0.52	sandy silt to clayey silt
20.50	17.41	0.08	0.47	sandy silt to clayey silt
21.50	6.22	0.07	1.12	sensitive fine grained
22.50	5.13	0.04	0.74	sensitive fine grained
23.50	6.55	0.08	1.16	sensitive fine grained
24.50	78.00	0.73	0.94	sand to silty sand
25.50	127.10	1.87	1.47	sand to silty sand
26.50	66.67	1.30	1.94	silty sand to sandy silt
27.50	55.60	0.60	1.08	silty sand to sandy silt
28.50	51.23	0.80	1.56	silty sand to sandy silt
29.50	23.58	0.22	0.94	sandy silt to clayey silt
30.50	50.57	0.30	0.58	sand to silty sand
31.50	26.97	0.22	0.82	silty sand to sandy silt
32.50	15.73	0.13	0.81	sandy silt to clayey silt
33.50	66.23	0.65	0.98	sand to silty sand
34.50	91.12	0.87	0.95	sand to silty sand
35.50	109.57	1.06	0.96	sand to silty sand
36.50	211.85	2.87	1.36	sand to silty sand
37.50	253.80	3.97	1.56	sand to silty sand
38.50	268.83	4.21	1.57	sand to silty sand
39.50	271.32	4.40	1.62	sand to silty sand
40.50	140.67	2.48	1.76	silty sand to sandy silt
41.50	56.64	0.79	1.40	silty sand to sandy silt
42.50	10.05	0.23	2.23	clayey silt to silty clay
43.50	44.48	0.48	1.07	silty sand to sandy silt
44.50	57.98	0.58	1.00	silty sand to sandy silt
45.50	30.63	0.43	1.41	sandy silt to clayey silt
46.50	34.40	0.29	0.83	silty sand to sandy silt
47.50	11.43	0.22	1.85	clayey silt to silty clay
48.50	10.08	0.15	1.48	clayey silt to silty clay
49.50	26.98	0.33	1.23	sandy silt to clayey silt
50.50	22.52	0.48	2.11	sandy silt to clayey silt
51.50	23.28	0.45	1.93	sandy silt to clayey silt
52.50	20.74	0.64	3.02	clayey silt to silty clay
53.50	17.70	0.57	3.16	clayey silt to silty clay
54.50	27.90	0.71	2.52	sandy silt to clayey silt
55.50	48.17	1.06	2.19	sandy silt to clayey silt
56.50	66.10	0.99	1.50	silty sand to sandy silt
57.50	46.38	1.09	2.34	sandy silt to clayey silt
58.50	43.50	0.87	2.00	sandy silt to clayey silt
59.50	36.70	0.96	2.61	sandy silt to clayey silt
60.50	16.43	0.60	3.67	silty clay to clay

SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +

Soil Depth During Test (ft)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?
0.50	11.0	1.66	41	60	60	60	1.11	1.00	949.25	0.999	N/A	0.208	N/A	N/A	NO
1.50	10.0	1.66	25	180	180	180	1.84	1.13	233.71	0.997	N/A	0.207	N/A	N/A	NO
2.50	9.0	1.00	13	300	269	300	2.48	2.68	158.13	0.994	1.000	0.231	0.448	2.589	NO
3.50	8.0	1.00	7	420	326	420	2.77	N/A	N/A	0.992	N/A	0.265	N/A	N/A	NO
4.50	7.0	1.00	6	540	384	540	2.79	N/A	N/A	0.990	N/A	0.289	N/A	N/A	NO
5.50	6.0	1.00	6	660	442	660	2.65	N/A	N/A	0.987	N/A	0.307	N/A	N/A	NO
6.50	5.0	1.00	6	780	499	780	2.88	N/A	N/A	0.985	N/A	0.320	N/A	N/A	NO
7.50	4.0	1.00	5	900	557	900	2.94	N/A	N/A	0.983	N/A	0.330	N/A	N/A	NO
8.50	3.0	1.00	6	1,020	614	1,020	2.92	N/A	N/A	0.980	N/A	0.338	N/A	N/A	NO
9.50	2.0	1.00	6	1,140	672	1,109	2.88	N/A	N/A	0.978	N/A	0.345	N/A	N/A	NO
10.50	1.0	1.00	6	1,260	730	1,166	2.95	N/A	N/A	0.976	N/A	0.350	N/A	N/A	NO
11.50	0.0	1.00	5	1,380	787	1,224	3.13	N/A	N/A	0.973	N/A	0.355	N/A	N/A	NO
12.50	-1.0	1.00	5	1,500	845	1,282	3.17	N/A	N/A	0.971	N/A	0.359	N/A	N/A	NO
13.50	-2.0	1.00	5	1,620	902	1,339	3.07	N/A	N/A	0.969	N/A	0.362	N/A	N/A	NO
14.50	-3.0	1.66	12	1,740	960	1,397	2.30	1.95	65.02	0.966	1.000	0.364	0.106	0.387	YES
15.50	-4.0	1.00	4	1,860	1,018	1,454	3.12	N/A	N/A	0.964	N/A	0.366	N/A	N/A	NO
16.50	-5.0	1.00	2	1,980	1,075	1,512	3.09	N/A	N/A	0.962	N/A	0.368	N/A	N/A	NO
17.50	-6.0	1.00	2	2,100	1,133	1,570	3.06	N/A	N/A	0.959	N/A	0.370	N/A	N/A	NO
18.50	-7.0	1.00	4	2,220	1,190	1,627	2.56	3.09	45.82	0.957	1.000	0.371	0.088	0.317	YES
19.50	-8.0	1.00	5	2,340	1,248	1,685	2.47	2.62	42.03	0.955	1.000	0.372	0.085	0.305	YES
20.50	-9.0	1.66	12	2,460	1,306	1,742	2.04	1.00	35.69	0.952	1.000	0.373	0.080	0.285	YES
21.50	-10.0	1.00	3	2,580	1,363	1,800	2.90	N/A	N/A	0.950	N/A	0.374	N/A	N/A	NO
22.50	-11.0	1.00	3	2,700	1,421	1,858	2.92	N/A	N/A	0.948	N/A	0.375	N/A	N/A	NO
23.50	-12.0	1.00	3	2,820	1,478	1,915	2.91	N/A	N/A	0.945	N/A	0.375	N/A	N/A	NO
24.50	-13.0	1.00	20	2,940	1,536	1,973	1.94	1.23	109.15	0.943	1.000	0.375	0.201	0.714	YES
25.50	-14.0	1.00	32	3,060	1,594	2,030	1.92	1.20	171.45	0.941	1.000	0.376	N/A	N/A	NO
26.50	-15.0	1.00	22	3,180	1,651	2,088	2.21	1.69	124.08	0.938	1.000	0.376	0.258	0.915	YES
27.50	-16.0	1.00	19	3,300	1,709	2,146	2.11	1.48	88.87	0.936	1.000	0.376	0.145	0.516	YES
28.50	-17.0	1.66	28	3,420	1,766	2,203	1.94	1.22	110.46	0.934	1.000	0.376	0.205	0.729	YES
29.50	-18.0	1.00	9	3,540	1,824	2,261	2.41	2.37	58.54	0.931	1.000	0.376	0.099	0.350	YES
30.50	-19.0	1.00	13	3,660	1,882	2,318	2.02	1.33	69.11	0.926	1.000	0.375	0.111	0.394	YES
31.50	-20.0	1.00	9	3,780	1,939	2,376	2.34	2.09	57.33	0.918	1.000	0.372	0.098	0.350	YES
32.50	-21.0	1.00	6	3,900	1,997	2,434	2.56	3.12	49.08	0.909	1.000	0.369	0.091	0.328	YES
33.50	-22.0	1.00	17	4,020	2,054	2,491	2.06	1.38	90.39	0.901	0.992	0.367	0.149	0.537	YES
34.50	-23.0	1.00	23	4,140	2,112	2,549	1.94	1.23	109.25	0.893	0.982	0.364	0.201	0.724	YES
35.50	-24.0	1.00	27	4,260	2,170	2,606	1.89	1.18	123.98	0.885	0.971	0.361	0.257	0.922	YES
36.50	-25.0	1.00	53	4,380	2,227	2,664	1.79	1.10	220.68	0.877	0.958	0.359	N/A	N/A	NO
37.50	-26.0	1.00	63	4,500	2,285	2,722	1.79	1.10	261.27	0.869	0.948	0.356	N/A	N/A	NO
38.50	-27.0	1.00	67	4,620	2,342	2,779	1.78	1.09	271.31	0.861	0.939	0.353	N/A	N/A	NO
39.50	-28.0	1.00	68	4,740	2,400	2,837	1.79	1.10	272.83	0.852	0.930	0.350	N/A	N/A	NO
40.50	-29.0	1.66	78	4,860	2,458	2,894	1.70	1.04	217.80	0.844	0.921	0.347	N/A	N/A	NO
41.50	-30.0	1.66	31	4,980	2,515	2,952	1.93	1.22	102.23	0.836	0.917	0.344	0.179	0.637	YES
42.50	-31.0	1.00	5	5,100	2,573	3,010	3.07	N/A	N/A	0.828	N/A	0.341	N/A	N/A	NO
43.50	-32.0	1.00	15	5,220	2,630	3,067	2.27	1.87	72.40	0.820	0.931	0.338	0.115	0.423	YES
44.50	-33.0	1.00	19	5,340	2,688	3,125	2.16	1.58	78.89	0.812	0.917	0.335	0.126	0.458	YES
45.50	-34.0	1.00	12	5,460	2,746	3,182	2.52	2.87	69.25	0.804	0.929	0.332	0.111	0.413	YES
46.50	-35.0	1.66	19	5,580	2,803	3,240	2.02	1.33	63.96	0.795	0.907	0.329	0.104	0.383	YES
47.50	-36.0	1.00	6	5,700	2,861	3,298	3.00	N/A	N/A	0.787	N/A	0.326	N/A	N/A	NO
48.50	-37.0	1.00	5	5,820	2,918	3,355	3.02	N/A	N/A	0.779	N/A	0.323	N/A	N/A	NO
49.50	-38.0	1.00	11	5,940	2,976	3,413	2.56	3.09	61.97	0.771	0.918	0.320	0.102	0.391	YES
50.50	-39.0	1.00	9	6,060	3,034	3,470	2.77	N/A	N/A	0.763	N/A	0.317	N/A	N/A	NO
51.50	-40.0	1.00	9	6,180	3,091	3,528	2.74	N/A	N/A	0.755	N/A	0.314	N/A	N/A	NO
52.50	-41.0	1.00	10	6,300	3,149	3,586	2.91	N/A	N/A	0.747	N/A	0.311	N/A	N/A	NO
53.50	-42.0	1.00	9	6,420	3,206	3,643	2.99	N/A	N/A	0.739	N/A	0.308	N/A	N/A	NO
54.50	-43.0	1.00	11	6,540	3,264	3,701	2.76	N/A	N/A	0.730	N/A	0.304	N/A	N/A	NO
55.50	-44.0	1.00	19	6,660	3,322	3,758	2.52	2.87	94.47	0.722	0.867	0.301	0.158	0.608	YES
56.50	-45.0	1.00	22	6,780	3,379	3,816	2.26	1.84	93.45	0.714	0.855	0.298	0.156	0.597	YES
57.50	-46.0	1.00	19	6,900	3,437	3,874	2.56	3.09	95.59	0.706	0.862	0.295	0.161	0.629	YES
58.50	-47.0	1.00	17	7,020	3,494	3,931	2.54	3.01	86.03	0.698	0.863	0.292	0.139	0.550	YES
59.50	-48.0	1.66	24	7,140	3,552	3,989	2.32	2.00	91.16	0.690	0.836	0.288	0.150	0.582	YES
60.50	-49.0	1.00	11	7,260	3,610	4,046	3.09	N/A	N/A	0.682	N/A	0.285	N/A	N/A	NO

RESIDUAL STRENGTH * and **GROUND SETTLEMENT ****

Soil Depth During Test (ft)	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	N/A	N/A	N/A	75.7	0.007	0.000	0.00	2.92
1.50	N/A	N/A	N/A	55.5	N/A	N/A	N/A	2.92
2.50	N/A	N/A	N/A	N/A	N/A	0.000	0.00	2.92
3.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
4.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
5.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
6.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
7.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
8.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
9.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
10.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
11.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
12.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
13.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
14.50	2.8	16.7	838	N/A	N/A	0.000	0.00	2.92
15.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
16.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
17.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.92
18.50	2.8	7.3	191	10.3	N/A	2.541	0.30	2.61
19.50	2.8	8.3	231	11.6	N/A	2.343	0.28	2.33
20.50	2.8	15.2	694	19.8	N/A	1.372	0.16	2.17
21.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.17
22.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.17
23.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.17
24.50	1.3	21.0	1,200	23.1	N/A	1.041	0.12	2.04
25.50	N/A	N/A	N/A	35.6	N/A	0.036	0.00	2.04
26.50	2.8	24.5	1,200	31.1	N/A	0.073	0.01	2.03
27.50	2.8	20.7	1,200	26.5	N/A	0.161	0.02	2.01
28.50	2.8	29.7	1,200	37.3	N/A	0.022	0.00	2.01
29.50	2.8	11.7	414	15.6	N/A	1.814	0.22	1.79
30.50	1.3	13.1	516	14.8	N/A	1.900	0.23	1.56
31.50	2.8	11.0	373	14.9	N/A	1.889	0.23	1.33
32.50	2.8	8.5	239	11.8	N/A	2.310	0.28	1.06
33.50	1.3	16.2	791	18.0	N/A	1.545	0.19	0.87
34.50	1.3	21.5	1,200	23.6	N/A	0.621	0.07	0.80
35.50	1.3	25.3	1,200	27.6	N/A	0.096	0.01	0.79
36.50	N/A	N/A	N/A	50.6	N/A	0.000	0.00	0.79
37.50	N/A	N/A	N/A	59.5	N/A	0.000	0.00	0.79
38.50	N/A	N/A	N/A	62.3	N/A	0.000	0.00	0.79
39.50	N/A	N/A	N/A	62.2	N/A	0.000	0.00	0.79
40.50	N/A	N/A	N/A	82.5	N/A	0.000	0.00	0.79
41.50	2.8	28.5	1,200	35.9	N/A	0.030	0.00	0.78
42.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.78
43.50	2.8	14.8	659	19.4	N/A	1.325	0.16	0.62
44.50	2.8	18.3	1,003	23.6	N/A	0.251	0.03	0.59
45.50	2.8	12.5	473	16.7	N/A	1.647	0.20	0.40
46.50	2.8	17.7	946	22.9	N/A	0.318	0.04	0.36
47.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.36
48.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.36
49.50	2.8	11.1	374	14.9	N/A	1.855	0.22	0.13
50.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.13
51.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.13
52.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.13
53.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.13
54.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.13
55.50	2.8	16.9	858	21.9	N/A	0.198	0.02	0.11
56.50	2.8	18.8	1,054	24.1	N/A	0.098	0.01	0.10
57.50	2.8	16.1	787	21.0	N/A	0.287	0.03	0.06
58.50	2.8	15.2	699	19.9	N/A	0.456	0.05	0.01
59.50	2.8	20.0	1,187	25.7	N/A	0.085	0.01	0.00
60.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max= 1,200
min= 191
avg= 797

PLATE E-21

CPT052
Output Sheet

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT054

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	15.30 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)
++ $CSR = 0.65\ A_{max}\ (\sigma_v/\sigma_v')\ r_d$
+++ $FS = (CRR_{7.5}/CSR)\ MSF\ K_\sigma\ K_\alpha$ —>> where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33
* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)
** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).
Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 12.30 ft below ground surface
GWT Depth For Design, Zwd = 5.30 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 24.00 feet
Earthquake-Induced Settlements:
- Liquefaction-Induced Settlement = 2.25 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <— Dry or Unsaturated Sands

Total: 2.25 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	68.05	0.64	0.95	sand to silty sand	14.3	1.00	17	60	60	60	1.48	1.00	392.89	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	32.8	0.010	0.009	0.00	2.25
1.50	74.52	1.04	1.40	silty sand to sandy silt	13.3	1.00	25	180	180	180	1.74	1.06	264.26	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	55.7	0.014	0.000	0.00	2.25
2.50	70.53	0.73	1.04	sand to silty sand	12.3	1.00	18	300	300	300	1.73	1.06	192.71	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	33.9	0.021	0.019	0.00	2.25
3.50	50.92	0.94	1.84	silty sand to sandy silt	11.3	1.66	28	420	420	420	1.75	1.07	196.89	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	62.3	0.020	0.000	0.00	2.25
4.50	17.27	0.59	3.40	silty clay to clay	10.3	1.00	12	540	540	540	2.52	2.88	132.69	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
5.50	12.13	0.36	2.97	silty clay to clay	9.3	1.00	8	660	648	660	2.64	N/A	N/A	0.987	N/A	0.209	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
6.50	6.58	0.20	2.96	clay	8.3	1.00	7	780	705	780	2.88	N/A	N/A	0.985	N/A	0.227	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
7.50	6.63	0.21	3.18	clay	7.3	1.00	7	900	763	900	2.92	N/A	N/A	0.983	N/A	0.241	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
8.50	5.25	0.12	2.32	silty clay to clay	6.3	1.00	4	1,020	820	1,020	2.95	N/A	N/A	0.980	N/A	0.254	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
9.50	5.53	0.14	2.50	clay	5.3	1.00	6	1,140	878	1,140	2.97	N/A	N/A	0.978	N/A	0.264	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
10.50	5.89	0.14	2.43	silty clay to clay	4.3	1.00	4	1,260	936	1,260	2.96	N/A	N/A	0.976	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
11.50	5.50	0.12	2.24	silty clay to clay	3.3	1.00	4	1,380	993	1,380	2.98	N/A	N/A	0.973	N/A	0.281	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
12.50	5.93	0.14	2.27	silty clay to clay	2.3	1.00	4	1,500	1,051	1,488	2.98	N/A	N/A	0.971	N/A	0.288	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
13.50	7.47	0.20	2.63	silty clay to clay	1.3	1.00	5	1,620	1,108	1,545	2.94	N/A	N/A	0.969	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
14.50	6.20	0.19	3.04	clay	0.3	1.00	6	1,740	1,166	1,603	3.06	N/A	N/A	0.966	N/A	0.300	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25
15.50	14.57	0.20	1.34	sandy silt to clayey silt	-0.7	1.00	6	1,860	1,224	1,660	2.55	3.03	63.82	0.964	1.000	0.305	0.104	0.456	YES	2.8	9.2	270	12.7	N/A	2.182	0.26	1.99
16.50	14.28	0.16	1.13	sandy silt to clayey silt	-1.7	1.66	9	1,980	1,281	1,718	2.27	1.85	54.60	0.962	1.000	0.309	0.095	0.411	YES	2.8	13.0	511	17.2	N/A	1.499	0.18	1.81
17.50	4.67	0.08	1.73	sensitive fine grained	-2.7	1.00	2	2,100	1,339	1,776	3.09	N/A	N/A	0.959	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.81
18.50	5.12	0.06	1.24	sensitive fine grained	-3.7	1.00	3	2,220	1,396	1,833	3.00	N/A	N/A	0.957	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.81
19.50	6.02	0.06	0.98	sensitive fine grained	-4.7	1.00	3	2,340	1,454	1,891	2.89	N/A	N/A	0.955	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.81
20.50	5.41	0.04	0.75	sensitive fine grained	-5.7	1.00	3	2,460	1,512	1,948	2.90	5.75	38.38	0.952	N/A	0.322	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.81
21.50	5.78	0.04	0.70	sensitive fine grained	-6.7	1.00	3	2,580	1,569	2,006	2.88	5.48	38.01	0.950	N/A	0.325	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.81
22.50	5.82	0.02	0.38	sensitive fine grained	-7.7	1.00	3	2,700	1,627	2,064	2.79	4.71	32.00	0.948	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.81
23.50	5.98	0.03	0.42	sensitive fine grained	-8.7	1.00	3	2,820	1,684	2,121	2.81	4.83	32.89	0.945	N/A	0.329	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.81
24.50	6.35	0.01	0.16	sensitive fine grained	-9.7	1.00	3	2,940	1,742	2,179	2.68	3.82	26.92	0.943	N/A	0.331	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.81
25.50	27.37	0.13	0.48	silty sand to sandy silt	-10.7	1.00	9	3,060	1,800	2,236	2.21	1.70	49.09	0.941	1.000	0.333	0.091	0.365	YES	2.8	11.4	397	15.4	N/A	1.811	0.22	1.59
26.50	73.22	0.65	0.89	sand to silty sand	-11.7	1.00	18	3,180	1,857	2,294	1.98	1.27	96.76	0.938	1.000	0.334	0.164	0.656	YES	1.3	18.4	1,020	20.4	N/A	1.182	0.14	1.45
27.50	107.97	1.06	0.98	sand to silty sand	-12.7	1.00	27	3,300	1,915	2,352	1.88	1.17	128.90	0.936	1.000	0.335	0.279	1.110	YES	1.3	26.2	1,200	28.6	N/A	0.081	0.01	1.44
28.50	218.17	2.48	1.14	sand	-13.7	1.00	44	3,420	1,972	2,409	1.71	1.04	228.89	0.934	1.000	0.337	N/A	N/A	NO	N/A	N/A	N/A	39.8	N/A	0.002	0.00	1.44
29.50	233.58	2.94	1.26	sand	-14.7	1.00	47	3,540	2,030	2,467	1.72	1.05	244.26	0.931	0.994	0.338	N/A	N/A	NO	N/A	N/A	N/A	42.1	N/A	0.000	0.00	1.44
30.50	202.17	2.90	1.43	sand to silty sand	-15.7	1.66	84	3,660	2,088	2,524	1.50	1.00	327.64	0.926	0.983	0.338	N/A	N/A	NO	N/A	N/A	N/A	80.6	N/A	0.000	0.00	1.44
31.50	91.94	1.81	1.97	silty sand to sandy silt	-16.7	1.66	51	3,780	2,145	2,582	1.84	1.14	167.25	0.918	0.972	0.336	N/A	N/A	NO	N/A	N/A	N/A	58.6	N/A	0.000	0.00	1.44
32.50	9.68	0.21	2.13	clayey silt to silty clay	-17.7	1.00	5	3,900	2,203	2,640	3.01	N/A	N/A	0.909	N/A	0.335	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.44
33.50	10.93	0.14	1.25	clayey silt to silty clay	-18.7	1.00	5	4,020	2,260	2,697	2.84	N/A	N/A	0.901	N/A	0.333	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.44
34.50	9.03	0.15	1.64	clayey silt to silty clay	-19.7	1.00	5	4,140	2,318	2,755	2.99	N/A	N/A	0.893	N/A	0.332	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.44
35.50	8.82	0.12	1.34	clayey silt to silty clay	-20.7	1.00	4	4,260	2,376	2,812	2.97	N/A	N/A	0.885	N/A	0.330	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.44
36.50	26.65	0.32	1.20	sandy silt to clayey silt	-21.7	1.00	11	4,380	2,433	2,870	2.50	2.75	63.25	0.877	0.957	0.328	0.104	0.403	YES	2.8	11.7	415	15.7	N/A	1.764	0.21	1.23
37.50	73.80	0.64	0.87	sand to silty sand	-22.7	1.00	18	4,500	2,491	2,928	2.02	1.33	88.17	0.869	0.938	0.326	0.144	0.551	YES	1.3	16.6	831	18.5	N/A	1.394	0.17	1.06
38.50	104.85	1.00	0.96	sand to silty sand	-23.7	1.00	26	4,620	2,548	2,985	1.93	1.22	113.06	0.861	0.919	0.325	0.214	0.810	YES	1.3	22.8	1,200	25.0	N/A	0.116	0.01	1.05
39.50	61.57	1.06	1.72	silty sand to sandy silt	-24.7	1.00	21	4,740	2,606	3,043	2.28	1.88	101.37	0.852	0.922	0.323	0.177	0.675	YES	2.8	19.4	1,127	25.0	N/A	0.111	0.01	1.03
40.50	73.67	0.69	0.94	sand to silty sand	-25.7	1.00	18	4,860	2,664	3,100	2.06	1.38	88.22	0.844	0.921	0.320	0.144	0.551	YES	1.3	16.1	786	18.0	N/A	1.435	0.17	0.86
41.50	90.73	0.89	0.98	sand to silty sand	-26.7	1.66	38	4,980	2,721	3,158	1.69	1.03	132.53	0.836	0.884	0.318	0.296	1.099	YES	1.3	31.2	1,200	33.8	N/A	0.041	0.00	0.85
42.50	20.33	0.52	2.52	clayey silt to silty clay	-27.7	1.00	10	5,100	2,779	3,215	2.82	N/A	N/A	0.828	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.85
43.50	15.63	0.32	2.01	clayey silt to silty clay	-28.7	1.00	8	5,220	2,836	3,273	2.88	N/A	N/A	0.820	N/A	0.314	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.85
44.50	24.57	0.22	0.89	silty sand to sandy silt	-29.7	1.00	8	5,340	2,894	3,331	2.51	2.84	52.96	0.812	0.929	0.312	0.094	0.373	YES	2.8	9.1	268	12.6	N/A	2.191	0.26	0.59
45.50	17.48	0.19	1.06	sandy silt to clayey silt	-30.7	1.00	7	5,460	2,951	3,388	2.70	N/A	N/A	0.804	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.59
46.50	28.32	0.70	2.45	sandy silt to clayey silt	-31.7	1.00	11	5,580	3,009	3,446	2.72	N/A	N/A	0.795	N/A	0.307	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.59
47.50	69.18	1.01	1.45	silty sand to sandy silt	-32.7	1.00	23	5,700	3,067	3,503	2.22	1.72	96.05	0.787	0.875	0.304	0.162	0.623	YES	2.8	20.2	1,200	25.9	N/A	0.089	0.01	0.58
48.50	127.83	0.72	0.56	sand	-33.7	1.00	26	5,820	3,124	3,561	1.76	1.08	110.23	0.779	0.864	0.302	0.205	0.781	YES	0.0	19.2	1,097	19.2	N/A	1.174	0.14	0.44
49.50	178.62	0.64	0.36	sand	-34.7	1.00	36	5,940	3,182	3,619	1.53	1.00	141.61	0.771	0.836	0.299	0.344	1.282	YES	0.0	26.6	1,200	26.6	N/A	0.083	0.01	0.43
50.50	167.72	0.54	0.32	sand	-35.7	1.00	34	6,060	3,239	3,676	1.54	1.00	131.78	0.763	0.835	0.297	0.293	1.100	YES	0.0	24.7	1,200	24.7	N/A	0.094	0.01	0.42
51.50	140.88	0.55	0.39	sand	-36.7	1.00	28	6,180	3,297	3,734	1.65	1.00	109.73	0.755	0.843	0.294	0.203	0.776	YES	0.0	20.6	1,200	20.6	N/A	0.353	0.04	0.38
52.50	117.41	0.37	0.32	sand	-37.7	1.00	23	6,300	3,355	3,791	1.68	1.00	90.66	0.747	0.852	0.292	0.149	0.582	YES	0.0	17.1	879	17.1	N/A	1.449	0.17	0.20
53.50	124.77	0.52	0.41	sand	-38.7	1.00	25	6,420	3,412	3,849	1.71	1.00	95.52	0.739	0.844	0.289	0.161	0.627	YES	0.0	18.0	974	18.0	N/A	1.264	0.15	0.05
54.50	114.97	1.01	0.88	sand to silty sand	-39.7	1.00	29	6,540	3,470	3,907	1.93	1.22	106.23	0.730	0.829	0.286	0.191	0.740	YES	1.3	21.9	1,200	24.1	N/A	0.094	0.01	0.04
55.50	162.95	1.33	0.82	sand	-40.7	1.00	33	6,660	3,527	3,964	1.79	1.10	135.07	0.722	0.815	0.284	0.309	1.185	YES	0.0	23.1	1,200	23.1	N/A	0.098	0.01	0.03
56.50	184.97	0.80	0.43	sand	-41.7	1.00	37	6,780	3,585	4,022	1.59	1.00	138.15	0.714	0.800	0.281	0.325	1.235	YES	0.0	26.1	1,200	26.1	N/A	0.080	0.01	0.02
57.50	169.50	1.23	0.72	sand	-42.7	1.66	56	6,900	3,643	4,079	1.44	1.00	207.95	0.706	0.787	0.278	N/A	N/A	NO	N/A	N/A	N/A	39.3	N/A	0.004	0.00	0.02
58.50	79.53	1.41	1.77	silty sand to sandy silt	-43.7	1.00	27	7,020	3,700	4,137	2.26	1.83	106.93	0.698	0.820	0.275	0.194	0.770	YES	2.8	21.2	1,200	27.1	N/A	0.072	0.01	0.01
59.50	49.45	0.95	1.93	silty sand to sandy silt	-44.7	1.66	27	7,140	3,758	4,195	2.14	1.53	91.28	0.690	0.814	0.273	0.151	0.601	YES	2.8	21.6	1,200	27.6	N/A	0.069	0.01	0.00
60.50	12.78	0.29	2.29	clayey silt to silty clay	-45.7	1.00	6	7,260	3,815	4,252	3.10	N/A	N/A	0.682	N/A	0.270	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max= 1,200
min= 268
avg= 957

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT056

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	15.40 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_w	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

\+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	12.40 ft below ground surface
GWT Depth For Design, Zwd =	5.40 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	14.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	1.20 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.01 inches	<--- Dry or Unsaturated Sands
Total:	1.21 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	32.82	0.11	0.33	silty sand to sandy silt	14.4	1.00	11	60	60	60	1.40	1.00	189.47	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	27.3	0.010	0.012	0.00	1.21
1.50	23.25	0.27	1.15	sandy silt to clayey silt	13.4	1.00	9	180	180	180	2.04	1.35	104.63	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	24.0	N/A	N/A	N/A	1.21
2.50	25.53	0.23	0.89	silty sand to sandy silt	12.4	1.00	9	300	300	300	2.02	1.33	87.89	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	22.4	0.024	0.035	0.00	1.20
3.50	18.52	0.22	1.18	sandy silt to clayey silt	11.4	1.00	7	420	420	420	2.27	1.86	74.98	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	20.1	N/A	N/A	N/A	1.20
4.50	34.65	1.06	3.05	clayey silt to silty clay	10.4	1.00	17	540	540	540	2.37	2.20	146.78	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
5.50	23.42	0.79	3.37	clayey silt to silty clay	9.4	1.66	19	660	654	660	2.24	1.78	120.64	0.987	1.000	0.207	0.243	1.566	NO	N/A	N/A	N/A	N/A	N/A	0.000	0.00	1.20
6.50	11.70	0.22	1.91	clayey silt to silty clay	8.4	1.00	6	780	711	780	2.56	3.10	78.67	0.985	1.000	0.225	0.125	0.744	YES	2.8	12.2	448	N/A	N/A	0.000	0.00	1.20
7.50	8.12	0.10	1.23	clayey silt to silty clay	7.4	1.00	4	900	769	900	2.62	N/A	N/A	0.983	N/A	0.239	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
8.50	6.65	0.08	1.13	sensitive fine grained	6.4	1.00	3	1,020	827	1,020	2.70	N/A	N/A	0.980	N/A	0.252	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
9.50	7.02	0.18	2.61	silty clay to clay	5.4	1.00	5	1,140	884	1,140	2.89	N/A	N/A	0.978	N/A	0.262	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
10.50	5.40	0.12	2.26	silty clay to clay	4.4	1.00	4	1,260	942	1,260	2.97	N/A	N/A	0.976	N/A	0.271	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
11.50	5.78	0.03	0.49	sensitive fine grained	3.4	1.00	3	1,380	999	1,380	2.66	3.72	36.22	0.973	N/A	0.280	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
12.50	5.75	0.02	0.41	sensitive fine grained	2.4	1.00	3	1,500	1,057	1,494	2.65	3.67	34.06	0.971	N/A	0.287	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
13.50	9.27	0.19	2.03	clayey silt to silty clay	1.4	1.00	5	1,620	1,115	1,551	2.79	N/A	N/A	0.969	N/A	0.293	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
14.50	11.95	0.24	1.98	clayey silt to silty clay	0.4	1.00	6	1,740	1,172	1,609	2.71	N/A	N/A	0.966	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
15.50	7.88	0.11	1.34	clayey silt to silty clay	-0.6	1.00	4	1,860	1,230	1,667	2.79	N/A	N/A	0.964	N/A	0.303	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.20
16.50	14.50	0.16	1.09	sandy silt to clayey silt	-1.6	1.00	6	1,980	1,287	1,724	2.52	2.87	57.87	0.962	1.000	0.308	0.098	0.425	YES	2.8	9.0	263	12.5	N/A	2.209	0.27	0.94
17.50	30.38	0.29	0.95	silty sand to sandy silt	-2.6	1.66	17	2,100	1,345	1,782	1.95	1.24	76.08	0.959	1.000	0.312	0.121	0.518	YES	2.8	20.6	1,200	26.3	N/A	0.089	0.01	0.93
18.50	9.13	0.09	0.94	clayey silt to silty clay	-3.6	1.00	5	2,220	1,403	1,839	2.70	N/A	N/A	0.957	N/A	0.315	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
19.50	6.02	0.06	0.97	sensitive fine grained	-4.6	1.00	3	2,340	1,460	1,897	2.90	N/A	N/A	0.955	N/A	0.318	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
20.50	6.13	0.03	0.44	sensitive fine grained	-5.6	1.00	3	2,460	1,518	1,955	2.77	4.50	33.89	0.952	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
21.50	5.73	0.01	0.17	sensitive fine grained	-6.6	1.00	3	2,580	1,575	2,012	2.70	3.96	27.17	0.950	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
22.50	5.90	0.01	0.17	sensitive fine grained	-7.6	1.00	3	2,700	1,633	2,070	2.69	3.94	27.07	0.948	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
23.50	5.80	0.01	0.17	sensitive fine grained	-8.6	1.00	3	2,820	1,691	2,127	2.71	4.10	26.97	0.945	N/A	0.328	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
24.50	7.20	0.01	0.12	sensitive fine grained	-9.6	1.00	4	2,940	1,748	2,185	2.59	3.29	26.24	0.943	1.000	0.330	0.072	0.291	YES	5.0	8.4	236	N/A	N/A	0.000	0.00	0.93
25.50	6.22	0.01	0.16	sensitive fine grained	-10.6	1.00	3	3,060	1,806	2,243	2.70	3.99	26.80	0.941	N/A	0.332	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
26.50	8.27	0.01	0.10	sensitive fine grained	-11.6	1.00	4	3,180	1,863	2,300	2.55	3.02	26.31	0.938	1.000	0.333	0.072	0.288	YES	5.0	8.9	254	N/A	N/A	0.000	0.00	0.93
27.50	37.08	0.09	0.24	sand to silty sand	-12.6	1.00	9	3,300	1,921	2,358	1.99	1.00	37.84	0.936	1.000	0.334	0.082	0.325	YES	1.3	9.9	305	11.4	N/A	2.371	0.28	0.64
28.50	123.80	1.29	1.04	sand to silty sand	-13.6	1.00	31	3,420	1,979	2,415	1.85	1.15	142.99	0.934	1.000	0.336	0.352	1.399	NO	N/A	N/A	N/A	32.0	N/A	0.057	0.01	0.64
29.50	175.17	2.50	1.43	sand to silty sand	-14.6	1.00	44	3,540	2,036	2,473	1.85	1.14	198.55	0.931	0.993	0.337	N/A	N/A	NO	N/A	N/A	N/A	43.8	N/A	0.000	0.00	0.64
30.50	188.88	3.11	1.65	sand to silty sand	-15.6	1.00	47	3,660	2,094	2,531	1.88	1.17	215.68	0.926	0.982	0.337	N/A	N/A	NO	N/A	N/A	N/A	46.5	N/A	0.000	0.00	0.64
31.50	178.76	2.65	1.48	sand to silty sand	-16.6	1.66	74	3,780	2,151	2,588	1.55	1.00	285.37	0.918	0.971	0.335	N/A	N/A	NO	N/A	N/A	N/A	70.7	N/A	0.000	0.00	0.64
32.50	83.45	1.58	1.90	silty sand to sandy silt	-17.6	1.66	46	3,900	2,209	2,646	1.86	1.16	152.17	0.909	0.961	0.334	0.408	1.565	NO	N/A	N/A	N/A	53.1	N/A	0.000	0.00	0.64
33.50	10.73	0.20	1.82	clayey silt to silty clay	-18.6	1.00	5	4,020	2,267	2,703	2.94	N/A	N/A	0.901	N/A	0.333	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.64
34.50	8.05	0.06	0.73	sensitive fine grained	-19.6	1.00	4	4,140	2,324	2,761	2.88	N/A	N/A	0.893	N/A	0.331	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.64
35.50	8.37	0.07	0.76	clayey silt to silty clay	-20.6	1.00	4	4,260	2,382	2,819	2.88	N/A	N/A	0.885	N/A	0.329	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.64
36.50	8.18	0.09	1.03	clayey silt to silty clay	-21.6	1.00	4	4,380	2,439	2,876	2.96	N/A	N/A	0.877	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.64
37.50	7.80	0.06	0.79	sensitive fine grained	-22.6	1.00	4	4,500	2,497	2,934	2.94	N/A	N/A	0.869	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.64
38.50	13.40	0.25	1.83	clayey silt to silty clay	-23.6	1.00	7	4,620	2,555	2,991	2.89	N/A	N/A	0.861	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.64
39.50	58.43	0.50	0.86	sand to silty sand	-24.6	1.00	15	4,740	2,612	3,049	2.12	1.48	75.91	0.852	0.933	0.322	0.121	0.467	YES	1.3	13.2	523	14.9	N/A	1.859	0.22	0.41
40.50	145.95	1.63	1.11	sand to silty sand	-25.6	1.00	36	4,860	2,670	3,107	1.87	1.16	146.73	0.844	0.891	0.320	0.374	1.390	NO	N/A	N/A	N/A	33.2	N/A	0.046	0.01	0.41
41.50	128.70	1.17	0.91	sand to silty sand	-26.6	1.66	53	4,980	2,727	3,164	1.55	1.00	182.48	0.836	0.883	0.318	N/A	N/A	NO	N/A	N/A	N/A	46.9	N/A	0.000	0.00	0.41
42.50	57.77	0.86	1.49	silty sand to sandy silt	-27.6	1.66	32	5,100	2,785	3,222	1.96	1.25	101.44	0.828	0.883	0.315	0.177	0.661	YES	2.8	27.9	1,200	35.1	N/A	0.032	0.00	0.40
43.50	10.65	0.09	0.82	sandy silt to clayey silt	-28.6	1.00	4	5,220	2,843	3,279	2.85	N/A	N/A	0.820	N/A	0.313	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
44.50	9.50	0.06	0.59	sandy silt to clayey silt	-29.6	1.00	4	5,340	2,900	3,337	2.85	5.24	37.68	0.812	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
45.50	9.58	0.04	0.41	sandy silt to clayey silt	-30.6	1.00	4	5,460	2,958	3,395	2.80	4.75	33.93	0.804	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
46.50	9.27	0.06	0.62	sandy silt to clayey silt	-31.6	1.00	4	5,580	3,015	3,452	2.89	5.56	37.86	0.795	N/A	0.306	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
47.50	8.80	0.07	0.72	clayey silt to silty clay	-32.6	1.00	4	5,700	3,073	3,510	2.95	N/A	N/A	0.787	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
48.50	11.25	0.14	1.21	clayey silt to silty clay	-33.6	1.00	6	5,820	3,131	3,567	2.94	N/A	N/A	0.779	N/A	0.301	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
49.50	10.58	0.12	1.11	clayey silt to silty clay	-34.6	1.00	5	5,940	3,188	3,625	2.96	N/A	N/A	0.771	N/A	0.299	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
50.50	8.93	0.09	0.93	clayey silt to silty clay	-35.6	1.00	4	6,060	3,246	3,683	3.02	N/A	N/A	0.763	N/A	0.296	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
51.50	9.38	0.13	1.34	clayey silt to silty clay	-36.6	1.00	5	6,180	3,303	3,740	3.08	N/A	N/A	0.755	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
52.50	9.87	0.18	1.78	clayey silt to silty clay	-37.6	1.00	5	6,300	3,361	3,798	3.12	N/A	N/A	0.747	N/A	0.291	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
53.50	17.12	0.35	1.99	clayey silt to silty clay	-38.6	1.00	9	6,420	3,419	3,855	2.91	N/A	N/A	0.739	N/A	0.288	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40
54.50	41.43	0.64	1.53	silty sand to sandy silt	-39.6	1.00	14	6,540	3,476	3,913	2.49	2.73	74.80	0.730	0.878	0.286	0.119	0.487	YES	2.8	12.7	485	16.8	N/A	1.443	0.17	0.23
55.50	34.18	0.59	1.72	sandy silt to clayey silt	-40.6	1.00	14	6,660	3,534	3,971	2.60	N/A	N/A	0.722	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
56.50	45.73	0.59	1.29	silty sand to sandy silt	-41.6	1.00	15	6,780	3,591	4,028	2.37	2.19	74.86	0.714	0.866	0.280	0.119	0.490	YES	2.8	13.5	554	17.9	N/A	1.191	0.14	0.09
57.50	49.22	0.61	1.23	silty sand to sandy silt	-42.6	1.00	16	6,900	3,649	4,086	2.33	2.06	75.14	0.706	0.858	0.278	0.119	0.493	YES	2.8	14.3	616	18.8	N/A	0.477	0.06	0.03
58.50	112.23	0.91	0.81	sand to silty sand	-43.6	1.00	28	7,020	3,707	4,143	1.93	1.22	100.30	0.698	0.815	0.275	0.174	0.688	YES	1.3	20.8	1,200	22.9	N/A	0.096	0.01	0.02
59.50	87.65	1.27	1.45	silty sand to sandy silt	-44.6	1.00	29	7,140	3,764	4,201	2.17	1.61	102.57	0.690	0.808	0.272	0.180	0.715	YES	2.8	23.0	1,200	29.2	N/A	0.060	0.01	0.01
60.50	65.28	0.75	1.15	silty sand to sandy silt	-45.6	1.00	22	7,260	3,822	4,259	2.22	1.72	81.09	0.682	0.829	0.269	0.130	0.532	YES	2.8	17.7	946	22.9	N/A	0.094	0.01	0.00

max= 1,200
min= 236
avg= 674

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT057

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	14.60 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\ A_{max}\ (\sigma_v/\sigma_v')\ r_d$

+++ $FS = (CRR_{7.5}/CSR)\ MSF\ K_\sigma\ K_\alpha$ —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 11.60 ft below ground surface
GWT Depth For Design, Zwd = 4.60 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 24.00 feet

Earthquake-Induced Settlements:

- Liquefaction-Induced Settlement = 2.80 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <— Dry or Unsaturated Sands

Total: 2.80 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	64.60	0.82	1.26	silty sand to sandy silt	13.6	1.00	22	60	60	60	1.60	1.00	372.97	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	48.9	0.008	0.000	0.00	2.80
1.50	44.37	0.60	1.35	silty sand to sandy silt	12.6	1.00	15	180	180	180	1.87	1.17	172.41	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	35.2	0.016	0.014	0.00	2.80
2.50	62.97	0.73	1.16	silty sand to sandy silt	11.6	1.00	21	300	300	300	1.80	1.11	179.71	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	47.8	0.019	0.000	0.00	2.80
3.50	41.70	0.83	2.00	sandy silt to clayey silt	10.6	1.00	17	420	420	420	2.15	1.54	140.37	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	39.0	N/A	N/A	N/A	2.80
4.50	45.55	1.24	2.72	sandy silt to clayey silt	9.6	1.00	18	540	540	540	2.25	1.81	158.58	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	42.2	N/A	N/A	N/A	2.80
5.50	22.92	0.63	2.76	clayey silt to silty clay	8.6	1.00	11	660	604	660	2.49	2.72	113.47	0.987	1.000	0.224	0.216	1.283	YES	2.8	22.3	1,200	N/A	N/A	0.000	0.00	2.80
6.50	13.93	0.18	1.28	sandy silt to clayey silt	7.6	1.00	6	780	661	780	2.48	2.66	64.48	0.985	1.000	0.242	0.105	0.580	YES	2.8	11.7	417	15.7	N/A	1.209	0.15	2.65
7.50	13.87	0.11	0.79	sandy silt to clayey silt	6.6	1.00	6	900	719	900	2.39	2.28	52.70	0.983	1.000	0.256	0.094	0.488	YES	2.8	11.1	374	14.9	N/A	1.649	0.20	2.46
8.50	16.27	0.24	1.50	sandy silt to clayey silt	5.6	1.00	7	1,020	777	1,020	2.49	2.72	70.93	0.980	1.000	0.268	0.113	0.564	YES	2.8	11.9	430	15.9	N/A	1.488	0.18	2.28
9.50	11.02	0.27	2.41	clayey silt to silty clay	4.6	1.00	6	1,140	834	1,140	2.69	N/A	N/A	0.978	N/A	0.278	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.28
10.50	10.70	0.25	2.34	clayey silt to silty clay	3.6	1.00	5	1,260	892	1,260	2.71	N/A	N/A	0.976	N/A	0.287	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.28
11.50	12.87	0.19	1.47	clayey silt to silty clay	2.6	1.00	6	1,380	949	1,380	2.54	3.00	67.46	0.973	1.000	0.294	0.109	0.492	YES	2.8	10.5	342	N/A	N/A	0.000	0.00	2.28
12.50	31.27	0.23	0.75	silty sand to sandy silt	1.6	1.66	17	1,500	1,007	1,444	1.83	1.00	72.96	0.971	1.000	0.301	0.116	0.515	YES	2.8	23.1	1,200	29.4	N/A	0.066	0.01	2.27
13.50	15.30	0.27	1.76	clayey silt to silty clay	0.6	1.00	8	1,620	1,065	1,501	2.56	3.08	75.70	0.969	1.000	0.307	0.120	0.524	YES	2.8	11.6	411	N/A	N/A	0.000	0.00	2.27
14.50	18.33	0.24	1.31	sandy silt to clayey silt	-0.4	1.00	7	1,740	1,122	1,559	2.49	2.69	65.95	0.966	1.000	0.312	0.107	0.457	YES	2.8	11.1	377	15.0	N/A	1.838	0.22	2.05
15.50	21.15	0.44	2.10	sandy silt to clayey silt	-1.4	1.66	14	1,860	1,180	1,617	2.25	1.80	81.89	0.964	1.000	0.316	0.131	0.553	YES	2.8	18.4	1,015	23.7	N/A	0.153	0.02	2.03
16.50	6.48	0.16	2.46	silty clay to clay	-2.4	1.00	4	1,980	1,237	1,674	3.01	N/A	N/A	0.962	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.03
17.50	6.52	0.14	2.14	silty clay to clay	-3.4	1.00	4	2,100	1,295	1,732	2.99	N/A	N/A	0.959	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.03
18.50	18.17	0.14	0.79	sandy silt to clayey silt	-4.4	1.66	12	2,220	1,353	1,789	2.11	1.00	36.58	0.957	1.000	0.327	0.080	0.329	YES	2.8	15.5	728	20.3	N/A	1.162	0.14	1.89
19.50	8.62	0.13	1.48	clayey silt to silty clay	-5.4	1.00	4	2,340	1,410	1,847	2.82	N/A	N/A	0.955	N/A	0.329	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.89
20.50	6.94	0.14	2.06	silty clay to clay	-6.4	1.00	5	2,460	1,468	1,905	3.00	N/A	N/A	0.952	N/A	0.332	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.89
21.50	6.25	0.04	0.67	sensitive fine grained	-7.4	1.00	3	2,580	1,525	1,962	2.83	5.04	38.58	0.950	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.89
22.50	6.15	0.03	0.44	sensitive fine grained	-8.4	1.00	3	2,700	1,583	2,020	2.78	4.61	33.82	0.948	N/A	0.336	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.89
23.50	7.32	0.07	0.99	sensitive fine grained	-9.4	1.00	4	2,820	1,641	2,077	2.86	N/A	N/A	0.945	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.89
24.50	6.67	0.02	0.35	sensitive fine grained	-10.4	1.00	3	2,940	1,698	2,135	2.73	4.25	32.01	0.943	N/A	0.340	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.89
25.50	7.68	0.04	0.50	sensitive fine grained	-11.4	1.00	4	3,060	1,756	2,193	2.74	4.26	36.11	0.941	N/A	0.341	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.89
26.50	7.38	0.01	0.16	sensitive fine grained	-12.4	1.00	4	3,180	1,813	2,250	2.63	3.48	27.69	0.938	N/A	0.342	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.89
27.50	10.43	0.04	0.40	sandy silt to clayey silt	-13.4	1.00	4	3,300	1,871	2,308	2.59	3.27	35.89	0.936	1.000	0.343	0.080	0.311	YES	2.8	6.7	173	9.7	N/A	2.647	0.32	1.57
28.50	19.40	0.09	0.44	silty sand to sandy silt	-14.4	1.00	6	3,420	1,929	2,365	2.35	1.00	19.76	0.934	1.000	0.344	0.066	0.258	YES	2.8	8.7	249	12.1	N/A	2.265	0.27	1.30
29.50	58.08	0.22	0.38	sand to silty sand	-15.4	1.66	24	3,540	1,986	2,423	1.60	1.00	96.50	0.931	1.000	0.345	0.164	0.632	YES	1.3	23.2	1,200	25.4	N/A	0.148	0.02	1.28
30.50	19.48	0.14	0.72	sandy silt to clayey silt	-16.4	1.00	8	3,660	2,044	2,481	2.46	2.55	49.17	0.926	0.996	0.345	0.091	0.350	YES	2.8	9.8	301	13.4	N/A	2.070	0.25	1.03
31.50	48.89	0.38	0.77	silty sand to sandy silt	-17.4	1.00	16	3,780	2,101	2,538	2.12	1.48	70.72	0.918	0.986	0.343	0.113	0.433	YES	2.8	17.3	900	22.4	N/A	0.875	0.10	0.93
32.50	116.87	1.60	1.37	sand to silty sand	-18.4	1.66	48	3,900	2,159	2,596	1.66	1.01	187.65	0.909	0.970	0.342	N/A	N/A	NO	N/A	N/A	N/A	47.0	N/A	0.000	0.00	0.93
33.50	53.45	1.06	1.99	silty sand to sandy silt	-19.4	1.66	29	4,020	2,217	2,653	2.03	1.33	112.22	0.901	0.962	0.340	0.211	0.798	YES	2.8	28.4	1,200	35.7	N/A	0.031	0.00	0.93
34.50	8.52	0.11	1.33	clayey silt to silty clay	-20.4	1.00	4	4,140	2,274	2,711	2.97	N/A	N/A	0.893	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
35.50	8.92	0.10	1.06	clayey silt to silty clay	-21.4	1.00	4	4,260	2,332	2,769	2.91	N/A	N/A	0.885	N/A	0.336	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
36.50	9.33	0.14	1.49	clayey silt to silty clay	-22.4	1.00	5	4,380	2,389	2,826	2.97	N/A	N/A	0.877	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
37.50	8.55	0.10	1.18	clayey silt to silty clay	-23.4	1.00	4	4,500	2,447	2,884	2.97	N/A	N/A	0.869	N/A	0.332	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
38.50	8.90	0.14	1.52	clayey silt to silty clay	-24.4	1.00	4	4,620	2,505	2,941	3.02	N/A	N/A	0.861	N/A	0.330	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
39.50	9.65	0.13	1.29	clayey silt to silty clay	-25.4	1.00	5	4,740	2,562	2,999	2.95	N/A	N/A	0.852	N/A	0.328	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
40.50	12.03	0.17	1.37	clayey silt to silty clay	-26.4	1.00	6	4,860	2,620	3,057	2.88	N/A	N/A	0.844	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
41.50	15.33	0.20	1.28	sandy silt to clayey silt	-27.4	1.00	6	4,980	2,677	3,114	2.76	N/A	N/A	0.836	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
42.50	14.73	0.24	1.62	clayey silt to silty clay	-28.4	1.00	7	5,100	2,735	3,172	2.84	N/A	N/A	0.828	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
43.50	21.02	0.44	2.09	sandy silt to clayey silt	-29.4	1.00	8	5,220	2,793	3,229	2.77	N/A	N/A	0.820	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
44.50	20.45	0.46	2.21	sandy silt to clayey silt	-30.4	1.00	8	5,340	2,850	3,287	2.80	N/A	N/A	0.812	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
45.50	20.95	0.57	2.70	clayey silt to silty clay	-31.4	1.00	10	5,460	2,908	3,345	2.85	N/A	N/A	0.804	N/A	0.314	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
46.50	27.90	1.14	4.04	silty clay to clay	-32.4	1.00	19	5,580	2,965	3,402	2.86	N/A	N/A	0.795	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
47.50	38.10	1.90	4.95	clay	-33.4	1.00	38	5,700	3,023	3,460	2.81	N/A	N/A	0.787	N/A	0.309	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.93
48.50	41.47	0.94	2.25	sandy silt to clayey silt	-34.4	1.00	17	5,820	3,081	3,517	2.56	3.08	92.48	0.779	0.892	0.306	0.154	0.597	YES	2.8	15.3	708	20.0	N/A	1.073	0.13	0.80
49.50	31.82	0.95	2.96	clayey silt to silty clay	-35.4	1.00	16	5,940	3,138	3,575	2.74	N/A	N/A	0.771	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.80
50.50	39.75	0.93	2.32	sandy silt to clayey silt	-36.4	1.00	16	6,060	3,196	3,633	2.59	3.28	91.81	0.763	0.886	0.301	0.152	0.597	YES	2.8	14.6	644	19.2	N/A	1.168	0.14	0.66
51.50	50.58	1.09	2.15	sandy silt to clayey silt	-37.4	1.00	20	6,180	3,253	3,690	2.45	2.53	100.34	0.755	0.869	0.298	0.174	0.676	YES	2.8	17.7	944	22.9	N/A	0.143	0.02	0.64
52.50	71.21	0.85	1.19	sand to silty sand	-38.4	1.00	18	6,300	3,311	3,748	2.17	1.60	88.54	0.747	0.873	0.295	0.145	0.570	YES	1.3	14.3	621	16.1	N/A	1.626	0.20	0.44
53.50	62.25	1.50	2.41	sandy silt to clayey silt	-39.4	1.00	25	6,420	3,369	3,805	2.42	2.38	114.28	0.739	0.847	0.293	0.219	0.845	YES	2.8	20.9	1,200	26.7	N/A	0.081	0.01	0.43
54.50	176.72	2.76	1.56	sand to silty sand	-40.4	1.66	73	6,540	3,426	3,863	1.64	1.00	222.94	0.730	0.806	0.290	N/A	N/A	NO	N/A	N/A	N/A	57.7	N/A	0.000	0.00	0.43
55.50	68.08	1.61	2.37	sandy silt to clayey silt	-41.4	1.66	45	6,660	3,484	3,921	2.07	1.41	120.18	0.722	0.801	0.287	0.241	0.898	YES	2.8	35.0	1,200	43.6	N/A	0.000	0.00	0.43
56.50	16.08	0.45	2.75	clayey silt to silty clay	-42.4	1.00	8	6,780	3,541	3,978	3.02	N/A	N/A	0.714	N/A	0.284	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
57.50	18.58	0.40	2.14	clayey silt to silty clay	-43.4	1.00	9	6,900	3,599	4,036	2.90	N/A	N/A	0.706	N/A	0.282	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
58.50	26.37	0.43	1.60	sandy silt to clayey silt	-44.4	1.00	11	7,020	3,657	4,093	2.69	N/A	N/A	0.698	N/A	0.279	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
59.50	39.08	0.63	1.60	silty sand to sandy silt	-45.4	1.00	13	7,140	3,714	4,151	2.55	3.01	73.91	0.690	0.870	0.276	0.118	0.495	YES	2.8	11.8	425	15.9	N/A	1.570	0.19	0.25
60.50	30.82	0.36	1.16	silty sand to sandy silt	-46.4	1.00	10	7,260	3,772	4,209	2.57	3.12	59.77	0.682	0.881	0.273	0.100	0.430	YES	2.8	9.9	305	13.5	N/A	2.054	0.25	0.00

max= 1,200
min= 173
avg= 690

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT059

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	18.70 ft
GWT Elev. During Test	3.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_w	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\,-->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	15.70 ft below ground surface
GWT Depth For Design, Zwd =	8.70 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	14.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	1.53 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.01 inches	<--- Dry or Unsaturated Sands
Total:	1.54 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	VoL Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	60.80	0.32	0.52	sand to silty sand	17.7	1.00	15	60	60	60	1.31	1.00	351.03	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	29.6	0.010	0.010	0.00	1.54
1.50	58.72	0.39	0.66	sand to silty sand	16.7	1.00	15	180	180	180	1.57	1.00	195.72	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	28.7	0.017	0.019	0.00	1.54
2.50	37.82	0.24	0.62	silty sand to sandy silt	15.7	1.00	13	300	300	300	1.79	1.10	107.70	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	30.7	0.022	0.022	0.00	1.54
3.50	33.95	0.18	0.52	silty sand to sandy silt	14.7	1.00	11	420	420	420	1.85	1.15	85.04	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	28.1	0.027	0.029	0.00	1.53
4.50	37.25	0.71	1.89	sandy silt to clayey silt	13.7	1.00	15	540	540	540	2.20	1.68	120.19	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	35.4	N/A	N/A	N/A	1.53
5.50	26.37	0.63	2.38	sandy silt to clayey silt	12.7	1.00	11	660	660	660	2.42	2.38	109.19	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	26.5	N/A	N/A	N/A	1.53
6.50	17.62	0.19	1.07	sandy silt to clayey silt	11.7	1.00	7	780	780	780	2.38	2.23	62.91	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	18.5	N/A	N/A	N/A	1.53
7.50	15.18	0.22	1.45	sandy silt to clayey silt	10.7	1.00	6	900	900	900	2.53	2.94	66.61	0.983	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	15.9	N/A	N/A	N/A	1.53
8.50	13.40	0.17	1.27	sandy silt to clayey silt	9.7	1.00	5	1,020	1,020	1,020	2.57	3.17	59.42	0.980	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	14.0	N/A	N/A	N/A	1.53
9.50	18.52	0.09	0.50	sandy silt to clayey silt	8.7	1.00	7	1,140	1,090	1,140	2.27	1.86	46.68	0.978	1.000	0.213	0.089	0.558	YES	2.8	12.6	481	16.8	N/A	0.126	0.02	1.52
10.50	14.87	0.14	0.95	sandy silt to clayey silt	7.7	1.00	6	1,260	1,148	1,260	2.49	2.74	53.70	0.976	1.000	0.223	0.094	0.565	YES	2.8	10.3	328	14.0	N/A	1.457	0.17	1.34
11.50	15.62	0.17	1.09	sandy silt to clayey silt	6.7	1.00	6	1,380	1,205	1,380	2.51	2.84	57.19	0.973	1.000	0.232	0.097	0.561	YES	2.8	10.3	329	14.0	N/A	1.646	0.20	1.15
12.50	28.37	0.37	1.31	sandy silt to clayey silt	5.7	1.66	19	1,500	1,263	1,500	2.04	1.35	79.93	0.971	1.000	0.240	0.127	0.709	YES	2.8	24.5	1,200	31.0	N/A	0.044	0.01	1.14
13.50	8.37	0.12	1.45	clayey silt to silty clay	4.7	1.00	4	1,620	1,320	1,620	2.80	N/A	N/A	0.969	N/A	0.247	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.14
14.50	19.70	0.39	2.00	sandy silt to clayey silt	3.7	1.00	8	1,740	1,378	1,740	2.57	3.13	81.46	0.966	1.000	0.254	0.130	0.685	YES	2.8	11.2	386	15.1	N/A	1.569	0.19	0.95
15.50	22.53	0.37	1.63	sandy silt to clayey silt	2.7	1.66	15	1,860	1,436	1,860	2.20	1.66	73.08	0.964	1.000	0.260	0.116	0.597	YES	2.8	18.3	1,004	23.6	N/A	0.087	0.01	0.94
16.50	8.07	0.18	2.29	silty clay to clay	1.7	1.00	5	1,980	1,493	1,930	2.96	N/A	N/A	0.962	N/A	0.265	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.94
17.50	5.80	0.13	2.22	silty clay to clay	0.7	1.00	4	2,100	1,551	1,988	3.10	N/A	N/A	0.959	N/A	0.270	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.94
18.50	6.63	0.12	1.89	silty clay to clay	-0.3	1.00	4	2,220	1,608	2,045	3.02	N/A	N/A	0.957	N/A	0.275	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.94
19.50	15.90	0.16	1.03	sandy silt to clayey silt	-1.3	1.00	6	2,340	1,666	2,103	2.55	3.01	54.84	0.955	1.000	0.279	0.095	0.456	YES	2.8	9.0	261	12.4	N/A	2.217	0.27	0.68
20.50	9.73	0.13	1.32	clayey silt to silty clay	-2.3	1.00	5	2,460	1,724	2,160	2.80	N/A	N/A	0.952	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
21.50	8.10	0.23	2.89	silty clay to clay	-3.3	1.00	5	2,580	1,781	2,218	3.07	N/A	N/A	0.950	N/A	0.286	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
22.50	6.15	0.07	1.13	sensitive fine grained	-4.3	1.00	3	2,700	1,839	2,276	2.99	N/A	N/A	0.948	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
23.50	5.75	0.03	0.48	sensitive fine grained	-5.3	1.00	3	2,820	1,896	2,333	2.88	5.48	32.80	0.945	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
24.50	7.72	0.08	1.01	sensitive fine grained	-6.3	1.00	4	2,940	1,954	2,391	2.89	N/A	N/A	0.943	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
25.50	7.48	0.07	0.88	sensitive fine grained	-7.3	1.00	4	3,060	2,012	2,448	2.89	N/A	N/A	0.941	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
26.50	7.57	0.06	0.80	sensitive fine grained	-8.3	1.00	4	3,180	2,069	2,506	2.87	N/A	N/A	0.938	N/A	0.300	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
27.50	6.80	0.02	0.27	sensitive fine grained	-9.3	1.00	3	3,300	2,127	2,564	2.77	4.49	29.19	0.936	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
28.50	7.47	0.06	0.81	sensitive fine grained	-10.3	1.00	4	3,420	2,184	2,621	2.90	N/A	N/A	0.934	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
29.50	6.42	0.01	0.21	sensitive fine grained	-11.3	1.00	3	3,540	2,242	2,679	2.78	4.63	27.24	0.931	N/A	0.306	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
30.50	6.30	0.03	0.51	sensitive fine grained	-12.3	1.00	3	3,660	2,300	2,736	2.92	5.91	33.52	0.926	N/A	0.306	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
31.50	6.13	0.02	0.26	sensitive fine grained	-13.3	1.00	3	3,780	2,357	2,794	2.85	5.22	28.30	0.918	N/A	0.306	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
32.50	7.08	0.01	0.17	sensitive fine grained	-14.3	1.00	4	3,900	2,415	2,852	2.75	4.34	26.66	0.909	N/A	0.305	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
33.50	7.90	0.07	0.87	sensitive fine grained	-15.3	1.00	4	4,020	2,472	2,909	2.94	N/A	N/A	0.901	N/A	0.305	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
34.50	11.10	0.10	0.92	sandy silt to clayey silt	-16.3	1.00	4	4,140	2,530	2,967	2.81	N/A	N/A	0.893	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
35.50	8.95	0.12	1.39	clayey silt to silty clay	-17.3	1.00	4	4,260	2,588	3,024	2.99	N/A	N/A	0.885	N/A	0.303	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
36.50	8.03	0.07	0.90	sensitive fine grained	-18.3	1.00	4	4,380	2,645	3,082	2.96	N/A	N/A	0.877	N/A	0.302	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
37.50	8.92	0.11	1.25	clayey silt to silty clay	-19.3	1.00	4	4,500	2,703	3,140	2.99	N/A	N/A	0.869	N/A	0.301	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
38.50	9.40	0.06	0.66	sandy silt to clayey silt	-20.3	1.00	4	4,620	2,760	3,197	2.85	5.22	38.53	0.861	N/A	0.300	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
39.50	16.47	0.21	1.26	sandy silt to clayey silt	-21.3	1.00	7	4,740	2,818	3,255	2.74	N/A	N/A	0.852	N/A	0.298	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
40.50	15.17	0.24	1.58	sandy silt to clayey silt	-22.3	1.00	6	4,860	2,876	3,312	2.83	N/A	N/A	0.844	N/A	0.297	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
41.50	17.71	0.39	2.19	clayey silt to silty clay	-23.3	1.00	9	4,980	2,933	3,370	2.86	N/A	N/A	0.836	N/A	0.295	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
42.50	21.82	0.61	2.76	clayey silt to silty clay	-24.3	1.00	11	5,100	2,991	3,428	2.84	N/A	N/A	0.828	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
43.50	26.73	1.00	3.71	clayey silt to silty clay	-25.3	1.00	13	5,220	3,048	3,485	2.85	N/A	N/A	0.820	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
44.50	20.58	0.59	2.86	clayey silt to silty clay	-26.3	1.00	10	5,340	3,106	3,543	2.88	N/A	N/A	0.812	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
45.50	18.78	0.20	1.03	sandy silt to clayey silt	-27.3	1.00	8	5,460	3,164	3,600	2.68	N/A	N/A	0.804	N/A	0.288	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
46.50	20.37	0.61	2.97	clayey silt to silty clay	-28.3	1.00	10	5,580	3,221	3,658	2.91	N/A	N/A	0.795	N/A	0.287	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.68
47.50	62.70	0.39	0.62	sand to silty sand	-29.3	1.00	16	5,700	3,279	3,716	2.06	1.38	67.67	0.787	0.882	0.285	0.109	0.450	YES	1.3	12.8	498	14.6	N/A	1.868	0.22	0.45
48.50	34.98	0.64	1.84	sandy silt to clayey silt	-30.3	1.00	14	5,820	3,336	3,773	2.59	3.25	77.52	0.779	0.885	0.283	0.123	0.515	YES	2.8	13.0	509	17.2	N/A	1.346	0.16	0.29
49.50	110.05	0.85	0.78	sand to silty sand	-31.3	1.00	28	5,940	3,394	3,831	1.91	1.20	101.04	0.771	0.838	0.281	0.176	0.701	YES	1.3	21.2	1,200	23.3	N/A	0.096	0.01	0.28
50.50	209.07	0.63	0.30	sand	-32.3	1.00	42	6,060	3,452	3,888	1.45	1.00	159.14	0.763	0.804	0.279	0.455	1.751	NO	N/A	N/A	N/A	30.0	N/A	0.057	0.01	0.27
51.50	159.57	0.35	0.22	sand	-33.3	1.00	32	6,180	3,509	3,946	1.50	1.00	120.46	0.755	0.818	0.276	0.243	0.957	YES	0.0	22.7	1,200	22.7	N/A	0.097	0.01	0.26
52.50	152.01	0.45	0.30	sand	-34.3	1.00	30	6,300	3,567	4,004	1.58	1.00	113.83	0.747	0.818	0.274	0.217	0.864	YES	0.0	21.5	1,200	21.5	N/A	0.131	0.02	0.25
53.50	155.73	0.68	0.44	sand	-35.3	1.66	52	6,420	3,624	4,061	1.35	1.00	191.54	0.739	0.788	0.272	N/A	N/A	NO	N/A	N/A	N/A	36.2	N/A	0.021	0.00	0.24
54.50	62.98	0.66	1.05	sand to silty sand	-36.3	1.00	16	6,540	3,682	4,119	2.20	1.67	77.71	0.730	0.859	0.270	0.124	0.525	YES	1.3	12.3	458	14.0	N/A	1.965	0.24	0.01
55.50	94.80	0.92	0.97	sand to silty sand	-37.3	1.66	39	6,660	3,740	4,176	1.73	1.06	121.23	0.722	0.783	0.268	0.246	0.960	YES	1.3	28.5	1,200	31.0	N/A	0.049	0.01	0.00
56.50	24.02	0.30	1.26	sandy silt to clayey silt	-38.3	1.00	10	6,780	3,797	4,234	2.68	N/A	N/A	0.714	N/A	0.265	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
57.50	19.02	0.22	1.16	sandy silt to clayey silt	-39.3	1.00	8	6,900	3,855	4,292	2.77	N/A	N/A	0.706	N/A	0.263	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
58.50	28.63	0.38	1.33	sandy silt to clayey silt	-40.3	1.00	11	7,020	3,912	4,349	2.63	N/A	N/A	0.698	N/A	0.260	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
59.50	26.22	0.33	1.27	sandy silt to clayey silt	-41.3	1.00	10	7,140	3,970	4,407	2.66	N/A	N/A	0.690	N/A	0.258	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
60.50	19.10	0.44	2.28	clayey silt to silty clay	-42.3	1.00	10	7,260	4,028	4,464	2.94	N/A	N/A	0.682	N/A	0.256	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max=	1,200
min=	261
avg=	732

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT060

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	14.60 ft
GWT Elev. During Test	-2.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

\+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ CSR = 0.65 A_{max} (σ_v/σ_v') r_d

+++ FS = $(CRR_{7.5}/CSR)$ MSF K_σ K_α —>> where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw = 16.60 ft below ground surface
GWT Depth For Design, Zwd = 4.60 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils = 12.00 feet

Earthquake-Induced Settlements:

- Liquefaction-Induced Settlement = 0.52 inches <— Saturated Sands
- Seismic Compaction Settlement = 0.00 inches <— Dry or Unsaturated Sands

Total: 0.52 inches

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	19.68	0.09	0.44	silty sand to sandy silt	13.6	1.00	7	60	60	60	1.66	1.00	113.64	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	18.4	0.012	0.022	0.00	0.52
1.50	39.48	0.28	0.70	silty sand to sandy silt	12.6	1.00	13	180	180	180	1.72	1.05	138.48	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	31.8	0.017	0.016	0.00	0.52
2.50	84.72	0.42	0.50	sand to silty sand	11.6	1.00	21	300	300	300	1.46	1.00	218.74	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	40.2	0.020	0.000	0.00	0.52
3.50	95.70	0.53	0.55	sand to silty sand	10.6	1.00	24	420	420	420	1.50	1.00	208.83	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	45.1	0.023	0.000	0.00	0.52
4.50	108.37	0.84	0.77	sand to silty sand	9.6	1.00	27	540	540	540	1.60	1.00	208.55	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	50.8	0.025	0.000	0.00	0.52
5.50	59.78	0.54	0.90	sand to silty sand	8.6	1.00	15	660	604	660	1.85	1.15	124.94	0.987	1.000	0.224	0.261	1.554	NO	N/A	N/A	N/A	29.1	N/A	0.050	0.01	0.51
6.50	63.75	0.50	0.78	sand to silty sand	7.6	1.00	16	780	661	780	1.81	1.11	123.43	0.985	1.000	0.242	0.255	1.408	NO	N/A	N/A	N/A	29.2	N/A	0.053	0.01	0.51
7.50	55.93	0.65	1.16	silty sand to sandy silt	6.6	1.66	31	900	719	900	1.67	1.02	156.81	0.983	1.000	0.256	0.439	2.288	NO	N/A	N/A	N/A	60.2	N/A	0.000	0.00	0.51
8.50	6.58	0.26	3.88	clay	5.6	1.00	7	1,020	777	1,020	2.98	N/A	N/A	0.980	N/A	0.268	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.51
9.50	6.73	0.14	2.03	silty clay to clay	4.6	1.00	4	1,140	834	1,140	2.83	N/A	N/A	0.978	N/A	0.278	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.51
10.50	19.70	0.59	2.99	clayey silt to silty clay	3.6	1.00	10	1,260	892	1,260	2.57	3.13	112.87	0.976	1.000	0.287	0.214	0.995	YES	2.8	15.2	699	N/A	N/A	0.000	0.00	0.51
11.50	11.53	0.27	2.34	clayey silt to silty clay	2.6	1.00	6	1,380	949	1,380	2.70	N/A	N/A	0.973	N/A	0.294	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.51
12.50	6.02	0.25	4.20	clay	1.6	1.00	6	1,500	1,007	1,500	3.11	N/A	N/A	0.971	N/A	0.301	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.51
13.50	14.68	0.28	1.93	clayey silt to silty clay	0.6	1.00	7	1,620	1,065	1,620	2.60	3.30	77.84	0.969	1.000	0.307	0.124	0.539	YES	2.8	11.0	367	N/A	N/A	0.000	0.00	0.51
14.50	30.67	0.30	0.96	silty sand to sandy silt	-0.4	1.66	17	1,740	1,122	1,740	1.92	1.20	81.60	0.966	1.000	0.312	0.131	0.559	YES	2.8	20.9	1,200	26.8	N/A	0.086	0.01	0.50
15.50	10.13	0.24	2.34	clayey silt to silty clay	-1.4	1.00	5	1,860	1,180	1,860	2.81	N/A	N/A	0.964	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
16.50	6.68	0.09	1.27	sensitive fine grained	-2.4	1.00	3	1,980	1,237	1,980	2.85	N/A	N/A	0.962	N/A	0.320	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
17.50	4.78	0.02	0.42	sensitive fine grained	-3.4	1.00	2	2,100	1,295	2,044	2.81	4.90	32.48	0.959	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
18.50	4.55	0.02	0.44	sensitive fine grained	-4.4	1.00	2	2,220	1,353	2,101	2.86	5.31	32.41	0.957	N/A	0.327	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
19.50	5.38	0.02	0.33	sensitive fine grained	-5.4	1.00	3	2,340	1,410	2,159	2.76	4.45	31.14	0.955	N/A	0.329	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
20.50	7.77	0.15	1.89	clayey silt to silty clay	-6.4	1.00	4	2,460	1,468	2,217	2.94	N/A	N/A	0.952	N/A	0.332	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
21.50	9.65	0.11	1.05	clayey silt to silty clay	-7.4	1.00	5	2,580	1,525	2,274	2.74	N/A	N/A	0.950	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
22.50	12.27	0.23	1.80	clayey silt to silty clay	-8.4	1.00	6	2,700	1,583	2,332	2.77	N/A	N/A	0.948	N/A	0.336	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.50
23.50	113.27	0.60	0.53	sand	-9.4	1.00	23	2,820	1,641	2,389	1.67	1.02	127.27	0.945	1.000	0.338	0.272	1.073	YES	0.0	20.7	1,200	20.7	N/A	1.157	0.14	0.36
24.50	99.23	0.63	0.64	sand to silty sand	-10.4	1.00	25	2,940	1,698	2,447	1.77	1.08	116.81	0.943	1.000	0.340	0.228	0.897	YES	1.3	23.8	1,200	26.0	N/A	0.106	0.01	0.34
25.50	68.52	1.31	1.92	silty sand to sandy silt	-11.4	1.00	23	3,060	1,756	2,505	2.21	1.68	122.83	0.941	1.000	0.341	0.252	0.988	YES	2.8	23.2	1,200	29.5	N/A	0.076	0.01	0.33
26.50	41.15	0.75	1.83	sandy silt to clayey silt	-12.4	1.66	27	3,180	1,813	2,562	2.06	1.38	98.86	0.938	1.000	0.342	0.170	0.662	YES	2.8	26.9	1,200	33.9	N/A	0.044	0.01	0.33
27.50	11.00	0.31	2.85	silty clay to clay	-13.4	1.00	7	3,300	1,871	2,620	2.97	N/A	N/A	0.936	N/A	0.343	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.33
28.50	51.33	0.72	1.40	silty sand to sandy silt	-14.4	1.00	17	3,420	1,929	2,677	2.23	1.74	91.02	0.934	1.000	0.344	0.150	0.582	YES	2.8	17.6	933	22.7	N/A	0.589	0.07	0.26
29.50	61.30	0.41	0.66	sand to silty sand	-15.4	1.66	25	3,540	1,986	2,735	1.68	1.00	101.85	0.931	1.000	0.345	0.178	0.689	YES	1.3	23.0	1,200	25.2	N/A	0.156	0.02	0.24
30.50	13.80	0.36	2.59	clayey silt to silty clay	-16.4	1.00	7	3,660	2,044	2,793	2.89	N/A	N/A	0.926	N/A	0.345	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.24
31.50	50.23	0.51	1.02	silty sand to sandy silt	-17.4	1.66	28	3,780	2,101	2,850	1.86	1.16	93.76	0.918	0.982	0.343	0.157	0.598	YES	2.8	26.0	1,200	32.9	N/A	0.052	0.01	0.23
32.50	14.47	0.32	2.20	clayey silt to silty clay	-18.4	1.00	7	3,900	2,159	2,908	2.84	N/A	N/A	0.909	N/A	0.342	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23
33.50	61.22	0.32	0.52	sand to silty sand	-19.4	1.66	25	4,020	2,217	2,965	1.66	1.00	96.28	0.901	0.965	0.340	0.163	0.618	YES	1.3	22.1	1,200	24.3	N/A	0.187	0.02	0.21
34.50	16.90	0.27	1.61	sandy silt to clayey silt	-20.4	1.00	7	4,140	2,274	3,023	2.72	N/A	N/A	0.893	N/A	0.338	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
35.50	10.35	0.19	1.89	clayey silt to silty clay	-21.4	1.00	5	4,260	2,332	3,081	2.97	N/A	N/A	0.885	N/A	0.336	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
36.50	10.93	0.28	2.59	silty clay to clay	-22.4	1.00	7	4,380	2,389	3,138	3.03	N/A	N/A	0.877	N/A	0.334	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
37.50	14.53	0.42	2.88	clayey silt to silty clay	-23.4	1.00	7	4,500	2,447	3,196	2.95	N/A	N/A	0.869	N/A	0.332	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
38.50	11.98	0.42	3.54	silty clay to clay	-24.4	1.00	8	4,620	2,505	3,253	3.09	N/A	N/A	0.861	N/A	0.330	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
39.50	9.60	0.33	3.40	clay	-25.4	1.00	10	4,740	2,562	3,311	3.18	N/A	N/A	0.852	N/A	0.328	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
40.50	16.77	0.64	3.82	silty clay to clay	-26.4	1.00	11	4,860	2,620	3,369	2.99	N/A	N/A	0.844	N/A	0.326	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
41.50	13.70	0.35	2.53	clayey silt to silty clay	-27.4	1.00	7	4,980	2,677	3,426	2.97	N/A	N/A	0.836	N/A	0.324	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
42.50	10.45	0.26	2.46	clayey silt to silty clay	-28.4	1.00	5	5,100	2,735	3,484	3.09	N/A	N/A	0.828	N/A	0.321	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
43.50	10.80	0.26	2.36	clayey silt to silty clay	-29.4	1.00	5	5,220	2,793	3,541	3.07	N/A	N/A	0.820	N/A	0.319	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
44.50	14.23	0.34	2.30	clayey silt to silty clay	-30.4	1.00	7	5,340	2,850	3,599	2.96	N/A	N/A	0.812	N/A	0.316	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
45.50	10.73	0.31	2.73	silty clay to clay	-31.4	1.00	7	5,460	2,908	3,657	3.14	N/A	N/A	0.804	N/A	0.314	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
46.50	9.87	0.22	2.10	clayey silt to silty clay	-32.4	1.00	5	5,580	2,965	3,714	3.12	N/A	N/A	0.795	N/A	0.311	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.21
47.50	31.07	0.48	1.50	sandy silt to clayey silt	-33.4	1.00	12	5,700	3,023	3,772	2.56	3.11	70.89	0.787	0.911	0.309	0.113	0.445	YES	2.8	11.8	426	15.9	N/A	1.703	0.20	0.01
48.50	283.85	1.57	0.55	gravelly sand to sand	-34.4	1.00	47	5,820	3,081	3,829	1.47	1.00	228.71	0.779	0.841	0.306	N/A	N/A	NO	N/A	N/A	N/A	34.2	N/A	0.037	0.00	0.00
49.50	578.80	0.00	0.00	gravelly sand to sand	-35.4	1.00	96	5,940	3,138	3,887	2.68	3.85	1,590.87	0.771	N/A	0.304	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max= 1,200
min= 367
avg= 1,002

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT062

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	23.00 ft
GWT Elev. During Test	-2.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\,-->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	25.00 ft below ground surface
GWT Depth For Design, Zwd =	13.00 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	11.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.77 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.02 inches	<--- Dry or Unsaturated Sands
Total:	0.79 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	205.77	1.04	0.51	sand	22.0	1.00	41	60	60	60	1.01	1.00	1,188.00	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	70.0	0.007	0.000	0.00	0.79
1.50	162.27	1.86	1.15	sand to silty sand	21.0	1.00	41	180	180	180	1.48	1.00	540.89	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	74.8	0.013	0.000	0.00	0.79
2.50	189.85	2.20	1.16	sand	20.0	1.00	38	300	300	300	1.50	1.00	490.19	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	64.5	0.017	0.000	0.00	0.79
3.50	213.83	1.53	0.72	sand	19.0	1.00	43	420	420	420	1.34	1.00	466.62	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	72.7	0.019	0.000	0.00	0.79
4.50	219.92	0.89	0.40	sand	18.0	1.00	44	540	540	540	1.18	1.00	423.23	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	74.8	0.022	0.000	0.00	0.79
5.50	172.27	1.00	0.58	sand	17.0	1.00	34	660	660	660	1.40	1.00	299.88	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	58.6	0.026	0.000	0.00	0.79
6.50	98.57	0.99	1.00	sand to silty sand	16.0	1.00	25	780	780	780	1.76	1.08	170.68	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	43.9	0.031	0.000	0.00	0.79
7.50	60.80	0.56	0.92	sand to silty sand	15.0	1.00	15	900	900	900	1.92	1.21	109.67	0.983	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	26.2	0.039	0.047	0.01	0.78
8.50	55.45	0.39	0.70	sand to silty sand	14.0	1.00	14	1,020	1,020	1,020	1.91	1.20	92.87	0.980	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	22.8	0.043	0.062	0.01	0.77
9.50	35.88	0.58	1.61	silty sand to sandy silt	13.0	1.66	20	1,140	1,140	1,140	1.99	1.28	100.93	0.978	N/A	0.203	N/A	N/A	NO	N/A	N/A	N/A	36.5	0.039	0.032	0.00	0.77
10.50	7.77	0.12	1.52	clayey silt to silty clay	12.0	1.00	4	1,260	1,260	1,260	2.82	N/A	N/A	0.976	N/A	0.203	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
11.50	6.40	0.03	0.39	sensitive fine grained	11.0	1.00	3	1,380	1,380	1,380	2.68	3.89	32.86	0.973	N/A	0.202	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
12.50	8.98	0.05	0.56	sandy silt to clayey silt	10.0	1.66	6	1,500	1,500	1,500	2.36	2.17	37.27	0.971	N/A	0.202	N/A	N/A	NO	N/A	N/A	N/A	13.2	N/A	N/A	N/A	0.77
13.50	3.95	0.02	0.51	sensitive fine grained	9.0	1.00	2	1,620	1,589	1,620	2.98	6.52	30.62	0.969	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
14.50	3.87	0.02	0.43	sensitive fine grained	8.0	1.00	2	1,740	1,646	1,740	2.98	6.55	29.32	0.966	N/A	0.212	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
15.50	3.65	0.01	0.27	sensitive fine grained	7.0	1.00	2	1,860	1,704	1,860	2.96	6.33	26.04	0.964	N/A	0.219	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
16.50	4.45	0.02	0.41	sensitive fine grained	6.0	1.00	2	1,980	1,762	1,980	2.93	6.04	29.54	0.962	N/A	0.225	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
17.50	15.98	0.32	2.03	clayey silt to silty clay	5.0	1.00	8	2,100	1,819	2,100	2.72	N/A	N/A	0.959	N/A	0.230	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
18.50	9.67	0.23	2.38	silty clay to clay	4.0	1.00	6	2,220	1,877	2,220	2.97	N/A	N/A	0.957	N/A	0.235	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
19.50	10.45	0.26	2.48	silty clay to clay	3.0	1.00	7	2,340	1,934	2,340	2.95	N/A	N/A	0.955	N/A	0.240	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
20.50	7.46	0.14	1.88	silty clay to silty clay	2.0	1.00	5	2,460	1,992	2,460	3.03	N/A	N/A	0.952	N/A	0.245	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
21.50	5.72	0.06	1.03	sensitive fine grained	1.0	1.00	3	2,580	2,050	2,580	3.03	N/A	N/A	0.950	N/A	0.249	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
22.50	8.90	0.14	1.54	clayey silt to silty clay	0.0	1.00	4	2,700	2,107	2,700	2.94	N/A	N/A	0.948	N/A	0.253	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
23.50	10.45	0.06	0.59	sandy silt to clayey silt	-1.0	1.00	4	2,820	2,165	2,820	2.69	3.94	38.82	0.945	N/A	0.256	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
24.50	16.15	0.27	1.68	sandy silt to clayey silt	-2.0	1.00	6	2,940	2,222	2,940	2.73	N/A	N/A	0.943	N/A	0.259	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.77
25.50	28.30	0.43	1.53	sandy silt to clayey silt	-3.0	1.00	11	3,060	2,280	3,029	2.51	2.81	72.03	0.941	0.971	0.263	0.115	0.566	YES	2.8	12.0	436	16.0	N/A	1.410	0.17	0.60
26.50	20.83	0.68	3.26	clayey silt to silty clay	-4.0	1.00	10	3,180	2,338	3,086	2.82	N/A	N/A	0.938	N/A	0.265	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.60
27.50	78.68	1.08	1.37	silty sand to sandy silt	-5.0	1.00	26	3,300	2,395	3,144	2.11	1.48	106.34	0.936	0.940	0.268	0.192	0.897	YES	2.8	23.7	1,200	30.1	N/A	0.054	0.01	0.60
28.50	188.78	0.56	0.29	sand	-6.0	1.00	38	3,420	2,453	3,202	1.42	1.00	170.47	0.934	0.922	0.271	N/A	N/A	NO	N/A	N/A	N/A	29.8	N/A	0.056	0.01	0.59
29.50	212.07	1.30	0.61	sand	-7.0	1.00	42	3,540	2,510	3,259	1.56	1.00	189.29	0.931	0.913	0.273	N/A	N/A	NO	N/A	N/A	N/A	33.2	N/A	0.038	0.00	0.58
30.50	250.87	0.79	0.32	gravelly sand to sand	-8.0	1.00	42	3,660	2,568	3,317	1.34	1.00	221.39	0.926	0.905	0.274	N/A	N/A	NO	N/A	N/A	N/A	32.5	N/A	0.042	0.01	0.58
31.50	191.36	0.75	0.39	sand	-9.0	1.00	38	3,780	2,626	3,374	1.49	1.00	167.01	0.918	0.897	0.275	N/A	N/A	NO	N/A	N/A	N/A	29.5	N/A	0.059	0.01	0.57
32.50	158.78	0.55	0.34	sand	-10.0	1.66	53	3,900	2,683	3,432	1.24	1.00	226.98	0.909	0.889	0.275	N/A	N/A	NO	N/A	N/A	N/A	40.1	N/A	0.000	0.00	0.57
33.50	52.02	0.53	1.02	silty sand to sandy silt	-11.0	1.00	17	4,020	2,741	3,490	2.21	1.68	74.74	0.901	0.918	0.275	0.119	0.529	YES	2.8	15.9	767	20.8	N/A	0.172	0.02	0.55
34.50	56.05	0.32	0.58	sand to silty sand	-12.0	1.00	14	4,140	2,798	3,547	2.05	1.38	65.17	0.893	0.922	0.275	0.106	0.473	YES	1.3	11.9	426	13.5	N/A	2.050	0.25	0.31
35.50	42.77	0.48	1.12	silty sand to sandy silt	-13.0	1.00	14	4,260	2,856	3,605	2.31	1.98	70.76	0.885	0.917	0.275	0.113	0.503	YES	2.8	13.4	544	17.7	N/A	1.148	0.14	0.17
36.50	45.28	0.62	1.37	silty sand to sandy silt	-14.0	1.00	15	4,380	2,914	3,662	2.34	2.10	78.67	0.877	0.910	0.274	0.125	0.555	YES	2.8	14.0	588	18.4	N/A	1.000	0.12	0.05
37.50	48.08	1.10	2.28	sandy silt to clayey silt	-15.0	1.66	32	4,500	2,971	3,720	2.15	1.55	101.29	0.869	0.866	0.274	0.177	0.746	YES	2.8	26.2	1,200	33.0	N/A	0.039	0.00	0.04
38.50	15.25	0.37	2.46	clayey silt to silty clay	-16.0	1.00	8	4,620	3,029	3,778	2.95	N/A	N/A	0.861	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04
39.50	14.87	0.37	2.48	clayey silt to silty clay	-17.0	1.00	7	4,740	3,086	3,835	2.96	N/A	N/A	0.852	N/A	0.272	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04
40.50	14.20	0.41	2.88	clayey silt to silty clay	-18.0	1.00	7	4,860	3,144	3,893	3.03	N/A	N/A	0.844	N/A	0.271	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04
41.50	11.71	0.34	2.92	silty clay to clay	-19.0	1.00	8	4,980	3,202	3,950	3.12	N/A	N/A	0.836	N/A	0.271	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04
42.50	14.27	0.40	2.82	clayey silt to silty clay	-20.0	1.00	7	5,100	3,259	4,008	3.03	N/A	N/A	0.828	N/A	0.270	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04
43.50	15.57	0.54	3.51	silty clay to clay	-21.0	1.00	10	5,220	3,317	4,066	3.06	N/A	N/A	0.820	N/A	0.268	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.04
44.50	42.62	0.73	1.71	silty sand to sandy silt	-22.0	1.66	24	5,340	3,374	4,123	2.14	1.53	83.03	0.812	0.853	0.267	0.133	0.568	YES	2.8	19.2	1,100	24.7	N/A	0.083	0.01	0.03
45.50	15.93	0.40	2.52	clayey silt to silty clay	-23.0	1.00	8	5,460	3,432	4,181	2.98	N/A	N/A	0.804	N/A	0.266	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
46.50	30.27	0.58	1.93	sandy silt to clayey silt	-24.0	1.00	12	5,580	3,490	4,238	2.66	N/A	N/A	0.795	N/A	0.265	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
47.50	113.07	1.47	1.30	sand to silty sand	-25.0	1.00	28	5,700	3,547	4,296	2.05	1.36	115.87	0.787	0.828	0.263	0.225	0.943	YES	1.3	20.6	1,200	22.7	N/A	0.092	0.01	0.02
48.50	180.27	0.98	0.54	sand	-26.0	1.66	60	5,820	3,605	4,354	1.34	1.00	222.32	0.779	0.790	0.262	N/A	N/A	NO	N/A	N/A	N/A	40.5	N/A	0.000	0.00	0.02
49.50	51.97	1.20	2.31	sandy silt to clayey silt	-27.0	1.00	21	5,940	3,662	4,411	2.53	2.92	96.32	0.771	0.844	0.260	0.163	0.706	YES	2.8	16.8	853	21.8	N/A	0.096	0.01	0.01
50.50	36.23	0.96	2.66	sandy silt to clayey silt	-28.0	1.00	14	6,060	3,720	4,469	2.70	N/A	N/A	0.763	N/A	0.259	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
51.50	19.75	0.56	2.86	clayey silt to silty clay	-29.0	1.00	10	6,180	3,778	4,526	2.95	N/A	N/A	0.755	N/A	0.257	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
52.50	16.60	0.35	2.11	clayey silt to silty clay	-30.0	1.00	8	6,300	3,835	4,584	2.95	N/A	N/A	0.747	N/A	0.255	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
53.50	15.45	0.31	2.01	clayey silt to silty clay	-31.0	1.00	8	6,420	3,893	4,642	2.98	N/A	N/A	0.739	N/A	0.253	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
54.50	16.48	0.24	1.47	sandy silt to clayey silt	-32.0	1.00	7	6,540	3,950	4,699	2.88	N/A	N/A	0.730	N/A	0.252	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01
55.50	73.55	1.18	1.61	silty sand to sandy silt	-33.0	1.00	25	6,660	4,008	4,757	2.27	1.87	96.99	0.722	0.812	0.250	0.165	0.716	YES	2.8	18.7	1,049	24.1	N/A	0.081	0.01	0.00
56.50	359.00	2.36	0.66	gravelly sand to sand	-34.0	1.00	60	6,780	4,066	4,814	1.49	1.00	251.80	0.714	0.753	0.248	N/A	N/A	NO	N/A	N/A	N/A	38.6	N/A	0.007	0.00	0.00
57.50	471.80	3.13	0.66	gravelly sand to sand	-35.0	1.00	79	6,900	4,123	4,872	1.41	1.00	328.59	0.706	0.749	0.246	N/A	N/A	NO	N/A	N/A	N/A	50.4	N/A	0.000	0.00	0.00

max=	1,200
min=	426
avg=	851

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	B-CPT063

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	23.20 ft
GWT Elev. During Test	-2.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_w	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ $CSR = 0.65\, A_{max}\, (\sigma_v/\sigma_v')\, r_d$

+++ $FS = (CRR_{7.5}/CSR)\, MSF\, K_\sigma\, K_{\alpha\, -->}$ where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	25.20 ft below ground surface
GWT Depth For Design, Zwd =	13.20 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	12.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.37 inches	<--- Saturated Sands
- Seismic Compaction Settlement =	0.00 inches	<--- Dry or Unsaturated Sands
Total:	0.37 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance q_{t-avg} (tsf)	Average Sleeve Friction f_{s-avg} (tsf)	Average Friction Ratio R_{f-avg} (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	56.22	0.63	1.12	silty sand to sandy silt	22.2	1.00	19	60	60	60	1.59	1.00	324.57	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	43.2	0.009	0.000	0.00	0.37
1.50	78.40	1.41	1.80	silty sand to sandy silt	21.2	1.00	26	180	180	180	1.81	1.12	291.72	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	58.3	0.014	0.000	0.00	0.37
2.50	47.15	1.11	2.34	sandy silt to clayey silt	20.2	1.00	19	300	300	300	2.11	1.47	179.18	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	43.5	N/A	N/A	N/A	0.37
3.50	59.10	1.31	2.21	sandy silt to clayey silt	19.2	1.00	24	420	420	420	2.07	1.41	181.67	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	53.2	N/A	N/A	N/A	0.37
4.50	90.68	2.68	2.96	sandy silt to clayey silt	18.2	1.00	36	540	540	540	2.09	1.44	251.10	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	79.0	N/A	N/A	N/A	0.37
5.50	50.78	0.71	1.39	silty sand to sandy silt	17.2	1.00	17	660	660	660	2.05	1.37	120.74	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	39.5	0.029	0.022	0.00	0.37
6.50	94.05	1.15	1.22	sand to silty sand	16.2	1.66	39	780	780	780	1.53	1.00	249.36	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	67.8	0.027	0.000	0.00	0.37
7.50	9.90	0.37	3.72	clay	15.2	1.00	10	900	900	900	2.86	N/A	N/A	0.983	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
8.50	7.13	0.10	1.36	clayey silt to silty clay	14.2	1.00	4	1,020	1,020	1,020	2.77	N/A	N/A	0.980	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
9.50	6.95	0.06	0.82	sensitive fine grained	13.2	1.00	3	1,140	1,140	1,140	2.71	4.08	43.18	0.978	N/A	0.203	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
10.50	5.81	0.05	0.90	sensitive fine grained	12.2	1.00	3	1,260	1,260	1,260	2.84	N/A	N/A	0.976	N/A	0.203	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
11.50	4.42	0.02	0.44	sensitive fine grained	11.2	1.00	2	1,380	1,380	1,380	2.87	5.37	31.34	0.973	N/A	0.202	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
12.50	4.47	0.02	0.37	sensitive fine grained	10.2	1.00	2	1,500	1,500	1,500	2.86	5.36	29.72	0.971	N/A	0.202	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
13.50	4.90	0.03	0.54	sensitive fine grained	9.2	1.00	2	1,620	1,601	1,620	2.90	5.70	33.00	0.969	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
14.50	4.85	0.02	0.41	sensitive fine grained	8.2	1.00	2	1,740	1,659	1,740	2.87	5.46	30.45	0.966	N/A	0.211	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
15.50	4.98	0.02	0.39	sensitive fine grained	7.2	1.00	2	1,860	1,716	1,860	2.87	5.43	30.33	0.964	N/A	0.217	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
16.50	5.38	0.01	0.24	sensitive fine grained	6.2	1.00	3	1,980	1,774	1,980	2.79	4.67	27.53	0.962	N/A	0.223	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
17.50	75.22	1.76	2.34	sandy silt to clayey silt	5.2	1.00	30	2,100	1,832	2,100	2.24	1.78	139.55	0.959	1.000	0.229	0.333	1.941	NO	N/A	N/A	N/A	40.2	N/A	0.000	0.00	0.37
18.50	52.78	1.78	3.37	clayey silt to silty clay	4.2	1.66	44	2,220	1,889	2,220	2.16	1.57	140.90	0.957	1.000	0.234	0.340	1.941	NO	N/A	N/A	N/A	N/A	N/A	0.000	0.00	0.37
19.50	23.03	0.59	2.57	clayey silt to silty clay	3.2	1.00	12	2,340	1,947	2,340	2.67	N/A	N/A	0.955	N/A	0.239	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
20.50	20.53	0.51	2.50	clayey silt to silty clay	2.2	1.00	10	2,460	2,004	2,460	2.71	N/A	N/A	0.952	N/A	0.243	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
21.50	27.05	0.95	3.51	clayey silt to silty clay	1.2	1.00	14	2,580	2,062	2,580	2.72	N/A	N/A	0.950	N/A	0.247	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.37
22.50	51.63	1.02	1.98	silty sand to sandy silt	0.2	1.00	17	2,700	2,120	2,700	2.34	2.07	103.93	0.948	0.983	0.251	0.184	0.964	YES	2.8	17.6	936	22.8	N/A	0.088	0.01	0.36
23.50	149.02	0.98	0.66	sand	-0.8	1.00	30	2,820	2,177	2,820	1.68	1.02	146.17	0.945	0.969	0.255	0.370	1.880	NO	N/A	N/A	N/A	25.1	N/A	0.077	0.01	0.35
24.50	141.30	0.58	0.41	sand	-1.8	1.00	28	2,940	2,235	2,940	1.58	1.00	133.67	0.943	0.961	0.258	0.302	1.501	NO	N/A	N/A	N/A	23.3	N/A	0.087	0.01	0.34
25.50	152.65	0.57	0.38	sand	-2.8	1.00	31	3,060	2,292	3,041	1.54	1.00	142.58	0.941	0.950	0.261	0.350	1.697	NO	N/A	N/A	N/A	24.8	N/A	0.081	0.01	0.33
26.50	169.92	0.73	0.43	sand	-3.8	1.00	34	3,180	2,350	3,099	1.53	1.00	156.75	0.938	0.939	0.264	0.438	2.079	NO	N/A	N/A	N/A	27.3	N/A	0.068	0.01	0.32
27.50	184.73	0.63	0.34	sand	-4.8	1.00	37	3,300	2,408	3,156	1.45	1.00	168.37	0.936	0.928	0.267	N/A	N/A	NO	N/A	N/A	N/A	29.4	N/A	0.057	0.01	0.32
28.50	149.45	0.45	0.30	sand	-5.8	1.00	30	3,420	2,465	3,214	1.51	1.00	134.61	0.934	0.927	0.269	0.307	1.408	NO	N/A	N/A	N/A	23.6	N/A	0.090	0.01	0.31
29.50	171.27	1.18	0.69	sand	-6.8	1.00	34	3,540	2,523	3,272	1.67	1.02	155.02	0.931	0.914	0.272	0.426	1.913	NO	N/A	N/A	N/A	26.8	N/A	0.073	0.01	0.30
30.50	121.12	0.43	0.36	sand	-7.8	1.00	24	3,660	2,580	3,329	1.64	1.00	106.63	0.926	0.921	0.273	0.193	0.867	YES	0.0	18.8	1,057	18.8	N/A	0.421	0.05	0.25
31.50	75.84	0.56	0.73	sand to silty sand	-8.8	1.00	19	3,780	2,638	3,387	1.98	1.28	84.27	0.918	0.924	0.273	0.136	0.611	YES	1.3	15.9	765	17.8	N/A	1.126	0.14	0.11
32.50	52.93	0.61	1.15	silty sand to sandy silt	-9.8	1.00	18	3,900	2,696	3,444	2.23	1.74	79.17	0.909	0.921	0.274	0.126	0.567	YES	2.8	16.2	798	21.1	N/A	0.147	0.02	0.09
33.50	48.85	0.64	1.31	silty sand to sandy silt	-10.8	1.66	27	4,020	2,753	3,502	1.98	1.28	88.23	0.901	0.897	0.274	0.144	0.629	YES	2.8	23.2	1,200	29.4	N/A	0.059	0.01	0.09
34.50	12.33	0.26	2.12	clayey silt to silty clay	-11.8	1.00	6	4,140	2,811	3,560	2.97	N/A	N/A	0.893	N/A	0.274	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
35.50	12.28	0.33	2.70	clayey silt to silty clay	-12.8	1.00	6	4,260	2,868	3,617	3.04	N/A	N/A	0.885	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
36.50	14.52	0.49	3.38	silty clay to clay	-13.8	1.00	10	4,380	2,926	3,675	3.04	N/A	N/A	0.877	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
37.50	14.38	0.35	2.44	clayey silt to silty clay	-14.8	1.00	7	4,500	2,984	3,732	2.96	N/A	N/A	0.869	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
38.50	14.13	0.34	2.45	clayey silt to silty clay	-15.8	1.00	7	4,620	3,041	3,790	2.98	N/A	N/A	0.861	N/A	0.272	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
39.50	19.23	0.43	2.27	clayey silt to silty clay	-16.8	1.00	10	4,740	3,099	3,848	2.84	N/A	N/A	0.852	N/A	0.271	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.09
40.50	50.43	0.87	1.73	silty sand to sandy silt	-17.8	1.00	17	4,860	3,156	3,905	2.38	2.24	89.86	0.844	0.888	0.270	0.147	0.646	YES	2.8	14.8	665	19.4	N/A	0.279	0.03	0.05
41.50	196.71	1.68	0.85	sand	-18.8	1.66	65	4,980	3,214	3,963	1.41	1.00	256.93	0.836	0.827	0.269	N/A	N/A	NO	N/A	N/A	N/A	46.3	N/A	0.000	0.00	0.05
42.50	80.42	1.54	1.92	silty sand to sandy silt	-19.8	1.66	44	5,100	3,272	4,020	1.94	1.23	128.32	0.828	0.821	0.268	0.276	1.129	YES	2.8	34.1	1,200	42.6	N/A	0.000	0.00	0.05
43.50	23.93	0.58	2.43	sandy silt to clayey silt	-20.8	1.00	10	5,220	3,329	4,078	2.80	N/A	N/A	0.820	N/A	0.267	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
44.50	170.13	1.48	0.87	sand	-21.8	1.00	34	5,340	3,387	4,136	1.79	1.10	143.49	0.812	0.825	0.266	0.355	1.467	NO	N/A	N/A	N/A	23.7	N/A	0.088	0.01	0.04
45.50	174.05	1.26	0.73	sand	-22.8	1.66	58	5,460	3,444	4,193	1.42	1.00	219.60	0.804	0.805	0.265	N/A	N/A	NO	N/A	N/A	N/A	39.8	N/A	0.001	0.00	0.04
46.50	74.67	1.33	1.79	silty sand to sandy silt	-23.8	1.00	25	5,580	3,502	4,251	2.27	1.87	105.30	0.795	0.841	0.264	0.189	0.802	YES	2.8	19.9	1,172	25.5	N/A	0.078	0.01	0.03
47.50	57.80	0.95	1.64	silty sand to sandy silt	-24.8	1.00	19	5,700	3,560	4,308	2.34	2.09	90.53	0.787	0.855	0.262	0.149	0.648	YES	2.8	15.9	767	20.8	N/A	0.125	0.01	0.02
48.50	58.50	1.94	3.31	sandy silt to clayey silt	-25.8	1.66	39	5,820	3,617	4,366	2.23	1.73	124.71	0.779	0.796	0.261	0.260	1.061	YES	2.8	29.0	1,200	36.5	N/A	0.019	0.00	0.02
49.50	28.33	0.67	2.39	sandy silt to clayey silt	-26.8	1.00	11	5,940	3,675	4,424	2.76	N/A	N/A	0.771	N/A	0.259	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
50.50	21.35	0.49	2.30	sandy silt to clayey silt	-27.8	1.00	9	6,060	3,732	4,481	2.86	N/A	N/A	0.763	N/A	0.258	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
51.50	20.38	0.40	1.97	sandy silt to clayey silt	-28.8	1.00	8	6,180	3,790	4,539	2.85	N/A	N/A	0.755	N/A	0.256	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
52.50	20.34	0.38	1.89	sandy silt to clayey silt	-29.8	1.00	8	6,300	3,848	4,596	2.84	N/A	N/A	0.747	N/A	0.254	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
53.50	97.75	1.93	1.98	silty sand to sandy silt	-30.8	1.00	33	6,420	3,905	4,654	2.23	1.75	122.40	0.739	0.793	0.253	0.251	1.050	YES	2.8	24.2	1,200	30.6	N/A	0.048	0.01	0.01
54.50	352.53	1.37	0.39	gravelly sand to sand	-31.8	1.66	97	6,540	3,963	4,712	1.04	1.00	414.67	0.730	0.761	0.251	N/A	N/A	NO	N/A	N/A	N/A	63.4	N/A	0.000	0.00	0.01
55.50	73.55	1.18	1.61	silty sand to sandy silt	-32.8	1.00	25	6,660	4,020	4,769	2.27	1.87	96.92	0.722	0.812	0.249	0.165	0.717	YES	2.8	18.7	1,046	24.1	N/A	0.081	0.01	0.00
56.50	359.00	2.36	0.66	gravelly sand to sand	-33.8	1.00	60	6,780	4,078	4,827	1.49	1.00	251.41	0.714	0.752	0.247	N/A	N/A	NO	N/A	N/A	N/A	38.5	N/A	0.007	0.00	0.00
57.50	471.80	3.13	0.66	gravelly sand to sand	-34.8	1.00	79	6,900	4,136	4,884	1.41	1.00	328.10	0.706	0.748	0.245	N/A	N/A	NO	N/A	N/A	N/A	50.3	N/A	0.000	0.00	0.00

max=	1,200
min=	665
avg=	1,000

EVALUATION OF LIQUEFACTION POTENTIAL AND EARTHQUAKE-INDUCED SETTLEMENTS USING CPT DATA (METHOD 2)

(Engineer: Curt Scheyhing)

PROJECT INFORMATION	
Project Name	Ballona Wetlands Restoration
Project No.	LA-962A
Location	Los Angeles
Exploration No.	A-CPT065

GENERAL INPUT DATA	
Ground Surf. Elev. During Test	20.50 ft
GWT Elev. During Test	0.00 ft
GWT Elev. For Design	10.00 ft
Total Soil Unit Weight, γ_t	120.00 pcf
Earthquake Magnitude, M_{eq}	6.70
Peak Ground Acceleration, A_{max}	0.32 g
Required Factor of Safety	1.30

REFERENCES

+ Liquefaction Resistance of Soils: Summary Report From the 1996 NCEER and 1998 NCEER/NSF Workshops (Edited by: T.L. Youd and I.M. Idriss, 2001)

++ CSR = 0.65 A_{max} (σ_v/σ_v') r_d

+++ FS = ($CRR_{7.5}$/CSR) MSF K_σ K_α —» where $CRR_{7.5}$ is evaluated from direct CPT data, K_α =1.0 and MSF = 1.33

* Residual strength values of liquefied soils are evaluated from converted SPT blow counts using the median curve by Seed & Harder (1990)

** Ground settlements are evaluated from converted SPT blow counts using the method developed by Tokimatsu and Seed (1987).

Note: This analysis assumes level ground condition and depth of liquefiable soils does not change.

GWT Depth During Test, Zw =	20.50 ft below ground surface
GWT Depth For Design, Zwd =	10.50 ft below ground surface

***** SUMMARY OF RESULTS *****

Total Thickness of Liquefiable Soils =	14.00 feet	
Earthquake-Induced Settlements:		
- Liquefaction-Induced Settlement =	0.90 inches	<— Saturated Sands
- Seismic Compaction Settlement =	0.01 inches	<— Dry or Unsaturated Sands
Total:	0.91 inches	

INPUT SOIL PROFILE (CPT DATA)					SOIL LIQUEFACTION POTENTIAL ANALYSIS (1996 NCEER & 1998 NCEER/NSF WORKSHOPS) +															RESIDUAL STRENGTH *			GROUND SETTLEMENT **				
Soil Depth During Test (ft)	Average Cone Tip Resistance $q_{t\text{-}avg}$ (tsf)	Average Sleeve Friction $f_{s\text{-}avg}$ (tsf)	Average Friction Ratio $R_{f\text{-}avg}$ (%)	Soil Behavior Type (Robertson et al., 1983)	Bottom of Layer Elevation (ft)	Thin Layer Correction Factor (Lunne, et al., 1997)	Equiv. SPT Blow Count N_{60}(blows/ft)	Total Vert. Stress σ_v (psf)	Effective Vert. Stress (Design) $\sigma_{v'}$ (psf)	Effective Vert. Stress (Test) $\sigma_{v'}$ (psf)	Soil Behavior Type Index I_c	Fines Correction Factor K_c	Corrected Tip Resistance q_{c1Ncs}	Shear Stress Reduction Coeff. r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio ++ CSR	Cyclic Res. Ratio $CRR_{7.5}$	Factor of Safety Against Liqefaction +++ FS	Liquefy ?	SPT Blow Count Correction $N_{corr.}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Residual Shear Strength S_r (psf)	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Cyclic Shear Strain γ_c (%)	Vol. Strain ε_v (%)	Layer Settlement S_i (in.)	Cumulative Settlement Profile (in.)
0.50	26.90	0.57	2.12	sandy silt to clayey silt	19.5	1.00	11	60	60	60	2.01	1.31	203.42	0.999	N/A	0.208	N/A	N/A	NO	N/A	N/A	N/A	27.0	N/A	N/A	N/A	0.91
1.50	55.69	0.49	0.89	sand to silty sand	18.5	1.00	14	180	180	180	1.68	1.02	189.55	0.997	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	27.3	0.018	0.020	0.00	0.91
2.50	36.25	0.22	0.61	silty sand to sandy silt	17.5	1.00	12	300	300	300	1.80	1.11	103.89	0.994	N/A	0.207	N/A	N/A	NO	N/A	N/A	N/A	29.7	0.022	0.023	0.00	0.90
3.50	65.50	1.15	1.75	silty sand to sandy silt	16.5	1.00	22	420	420	420	1.97	1.26	180.16	0.992	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	49.5	0.022	0.000	0.00	0.90
4.50	84.23	2.30	2.73	sandy silt to clayey silt	15.5	1.66	56	540	540	540	1.78	1.09	292.39	0.990	N/A	0.206	N/A	N/A	NO	N/A	N/A	N/A	118.8	N/A	N/A	N/A	0.90
5.50	33.06	1.10	3.32	clayey silt to silty clay	14.5	1.00	17	660	660	660	2.44	2.50	143.77	0.987	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
6.50	17.83	0.61	3.41	silty clay to clay	13.5	1.00	12	780	780	780	2.60	N/A	N/A	0.985	N/A	0.205	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
7.50	22.29	0.69	3.11	clayey silt to silty clay	12.5	1.00	11	900	900	900	2.60	3.33	110.54	0.983	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
8.50	16.36	0.59	3.63	silty clay to clay	11.5	1.00	11	1,020	1,020	1,020	2.71	N/A	N/A	0.980	N/A	0.204	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
9.50	17.40	0.57	3.25	clayey silt to silty clay	10.5	1.00	9	1,140	1,140	1,140	2.69	N/A	N/A	0.978	N/A	0.203	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
10.50	19.30	0.56	2.90	clayey silt to silty clay	9.5	1.00	10	1,260	1,260	1,260	2.65	N/A	N/A	0.976	N/A	0.203	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
11.50	15.28	0.46	3.00	clayey silt to silty clay	8.5	1.00	8	1,380	1,318	1,380	2.75	N/A	N/A	0.973	N/A	0.212	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
12.50	10.95	0.13	1.22	clayey silt to silty clay	7.5	1.00	5	1,500	1,375	1,500	2.67	N/A	N/A	0.971	N/A	0.220	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
13.50	6.66	0.11	1.63	silty clay to clay	6.5	1.00	4	1,620	1,433	1,620	2.94	N/A	N/A	0.969	N/A	0.228	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90
14.50	15.78	0.22	1.37	sandy silt to clayey silt	5.5	1.00	6	1,740	1,490	1,740	2.58	3.19	62.77	0.966	1.000	0.235	0.103	0.586	YES	2.8	9.6	289	13.1	N/A	2.023	0.24	0.66
15.50	30.86	0.41	1.33	silty sand to sandy silt	4.5	1.00	10	1,860	1,548	1,860	2.35	2.14	74.92	0.964	1.000	0.241	0.119	0.660	YES	2.8	13.5	548	17.8	N/A	0.200	0.02	0.64
16.50	17.25	0.20	1.13	sandy silt to clayey silt	3.5	1.66	11	1,980	1,606	1,980	2.24	1.77	56.31	0.962	1.000	0.247	0.097	0.523	YES	2.8	14.3	616	18.8	N/A	0.170	0.02	0.62
17.50	5.76	0.18	3.04	clay	2.5	1.00	6	2,100	1,663	2,100	3.20	N/A	N/A	0.959	N/A	0.252	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.62
18.50	36.88	0.37	0.99	silty sand to sandy silt	1.5	1.00	12	2,220	1,721	2,220	2.24	1.77	70.25	0.957	1.000	0.257	0.112	0.583	YES	2.8	14.5	632	19.0	N/A	0.198	0.02	0.59
19.50	40.47	0.34	0.85	silty sand to sandy silt	0.5	1.00	13	2,340	1,778	2,340	2.17	1.60	68.77	0.955	1.000	0.261	0.110	0.563	YES	2.8	15.3	705	20.0	N/A	0.163	0.02	0.57
20.50	43.19	0.36	0.84	silty sand to sandy silt	-0.5	1.66	24	2,460	1,836	2,460	1.85	1.14	85.45	0.952	1.000	0.265	0.138	0.694	YES	2.8	24.3	1,200	30.8	N/A	0.050	0.01	0.57
21.50	17.62	0.25	1.40	sandy silt to clayey silt	-1.5	1.66	12	2,580	1,894	2,518	2.31	1.98	59.38	0.950	1.000	0.269	0.099	0.493	YES	2.8	13.2	526	17.5	N/A	1.130	0.14	0.43
22.50	6.42	0.09	1.39	sensitive fine grained	-2.5	1.00	3	2,700	1,951	2,575	3.03	N/A	N/A	0.948	N/A	0.273	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
23.50	6.11	0.10	1.56	sensitive fine grained	-3.5	1.00	3	2,820	2,009	2,633	3.09	N/A	N/A	0.945	N/A	0.276	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
24.50	6.13	0.07	1.20	sensitive fine grained	-4.5	1.00	3	2,940	2,066	2,690	3.04	N/A	N/A	0.943	N/A	0.279	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
25.50	5.71	0.09	1.48	sensitive fine grained	-5.5	1.00	3	3,060	2,124	2,748	3.13	N/A	N/A	0.941	N/A	0.282	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
26.50	5.57	0.08	1.34	sensitive fine grained	-6.5	1.00	3	3,180	2,182	2,806	3.13	N/A	N/A	0.938	N/A	0.284	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
27.50	5.80	0.08	1.29	sensitive fine grained	-7.5	1.00	3	3,300	2,239	2,863	3.12	N/A	N/A	0.936	N/A	0.287	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
28.50	7.64	0.16	2.11	silty clay to clay	-8.5	1.00	5	3,420	2,297	2,921	3.11	N/A	N/A	0.934	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.43
29.50	19.05	0.18	0.93	sandy silt to clayey silt	-9.5	1.66	13	3,540	2,354	2,978	2.24	1.77	51.42	0.931	0.961	0.291	0.093	0.408	YES	2.8	13.1	521	17.4	N/A	1.385	0.17	0.27
30.50	6.72	0.17	2.52	silty clay to clay	-10.5	1.00	4	3,660	2,412	3,036	3.23	N/A	N/A	0.926	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
31.50	13.37	0.30	2.22	clayey silt to silty clay	-11.5	1.00	7	3,780	2,470	3,094	2.91	N/A	N/A	0.918	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
32.50	12.38	0.32	2.62	clayey silt to silty clay	-12.5	1.00	6	3,900	2,527	3,151	2.99	N/A	N/A	0.909	N/A	0.292	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.27
33.50	32.07	0.45	1.40	silty sand to sandy silt	-13.5	1.00	11	4,020	2,585	3,209	2.48	2.65	70.18	0.901	0.946	0.292	0.112	0.485	YES	2.8	11.2	385	15.1	N/A	1.780	0.21	0.05
34.50	28.96	1.06	3.65	clayey silt to silty clay	-14.5	1.00	14	4,140	2,642	3,266	2.77	N/A	N/A	0.893	N/A	0.291	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
35.50	36.69	0.95	2.59	sandy silt to clayey silt	-15.5	1.00	15	4,260	2,700	3,324	2.60	N/A	N/A	0.885	N/A	0.290	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
36.50	20.27	0.58	2.87	clayey silt to silty clay	-16.5	1.66	17	4,380	2,758	3,382	2.53	2.94	77.48	0.877	0.917	0.290	0.123	0.521	YES	2.8	15.7	746	N/A	N/A	0.000	0.00	0.05
37.50	7.82	0.21	2.69	silty clay to clay	-17.5	1.00	5	4,500	2,815	3,439	3.23	N/A	N/A	0.869	N/A	0.289	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
38.50	9.09	0.32	3.56	clay	-18.5	1.00	9	4,620	2,873	3,497	3.24	N/A	N/A	0.861	N/A	0.288	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
39.50	10.33	0.32	3.10	silty clay to clay	-19.5	1.00	7	4,740	2,930	3,554	3.16	N/A	N/A	0.852	N/A	0.287	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
40.50	18.55	0.58	3.13	clayey silt to silty clay	-20.5	1.00	9	4,860	2,988	3,612	2.93	N/A	N/A	0.844	N/A	0.286	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
41.50	33.35	0.74	2.23	sandy silt to clayey silt	-21.5	1.00	13	4,980	3,046	3,670	2.63	N/A	N/A	0.836	N/A	0.284	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
42.50	33.73	0.82	2.43	sandy silt to clayey silt	-22.5	1.00	13	5,100	3,103	3,727	2.65	N/A	N/A	0.828	N/A	0.283	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.05
43.50	105.27	1.54	1.46	sand to silty sand	-23.5	1.00	26	5,220	3,161	3,785	2.08	1.43	119.44	0.820	0.861	0.282	0.238	0.972	YES	1.3	20.5	1,200	22.5	N/A	0.104	0.01	0.04
44.50	184.64	1.29	0.70	sand	-24.5	1.66	61	5,340	3,218	3,842	1.38	1.00	240.99	0.812	0.827	0.280	N/A	N/A	NO	N/A	N/A	N/A	44.1	N/A	0.000	0.00	0.04
45.50	76.78	0.80	1.04	sand to silty sand	-25.5	1.66	32	5,460	3,276	3,900	1.80	1.10	109.68	0.804	0.838	0.279	0.203	0.814	YES	1.3	24.1	1,200	26.4	N/A	0.078	0.01	0.03
46.50	19.24	0.65	3.39	clayey silt to silty clay	-26.5	1.00	10	5,580	3,334	3,958	2.97	N/A	N/A	0.795	N/A	0.277	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
47.50	39.81	1.45	3.63	clayey silt to silty clay	-27.5	1.00	20	5,700	3,391	4,015	2.73	N/A	N/A	0.787	N/A	0.275	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.03
48.50	47.75	1.18	2.48	sandy silt to clayey silt	-28.5	1.66	32	5,820	3,449	4,073	2.20	1.67	100.66	0.779	0.825	0.274	0.175	0.704	YES	2.8	25.0	1,200	31.6	N/A	0.047	0.01	0.02
49.50	18.15	0.52	2.85	clayey silt to silty clay	-29.5	1.00	9	5,940	3,506	4,130	2.97	N/A	N/A	0.771	N/A	0.272	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
50.50	16.72	0.35	2.07	clayey silt to silty clay	-30.5	1.00	8	6,060	3,564	4,188	2.93	N/A	N/A	0.763	N/A	0.270	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
51.50	16.28	0.30	1.83	clayey silt to silty clay	-31.5	1.00	8	6,180	3,622	4,246	2.91	N/A	N/A	0.755	N/A	0.268	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
52.50	16.18	0.43	2.65	clayey silt to silty clay	-32.5	1.00	8	6,300	3,679	4,303	3.01	N/A	N/A	0.747	N/A	0.266	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
53.50	19.80	0.57	2.89	clayey silt to silty clay	-33.5	1.00	10	6,420	3,737	4,361	2.96	N/A	N/A	0.739	N/A	0.264	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.02
54.50	44.30	1.01	2.28	sandy silt to clayey silt	-34.5	1.00	18	6,540	3,794	4,418	2.59	3.29	90.11	0.730	0.847	0.262	0.148	0.639	YES	2.8	14.7	655	19.3	N/A	0.204	0.02	0.00
55.50	30.03	0.98	3.25	clayey silt to silty clay	-35.5	1.00	15	6,660	3,852	4,476	2.84	N/A	N/A	0.722	N/A	0.260	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
56.50	21.87	0.76	3.46	clayey silt to silty clay	-36.5	1.00	11	6,780	3,910	4,534	2.98	N/A	N/A	0.714	N/A	0.258	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
57.50	15.90	0.41	2.57	clayey silt to silty clay	-37.5	1.00	8	6,900	3,967	4,591	3.04	N/A	N/A	0.706	N/A	0.255	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
58.50	14.87	0.32	2.16	clayey silt to silty clay	-38.5	1.00	7	7,020	4,025	4,649	3.03	N/A	N/A	0.698	N/A	0.253	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
59.50	16.99	0.35	2.08	clayey silt to silty clay	-39.5	1.00	8	7,140	4,082	4,706	2.97	N/A	N/A	0.690	N/A	0.251	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00
60.50	30.12	0.61	2.02	sandy silt to clayey silt	-40.5	1.00	12	7,260	4,140	4,764	2.73	N/A	N/A	0.682	N/A	0.249	N/A	N/A	NO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00

max=	1,200
min=	289
avg=	744

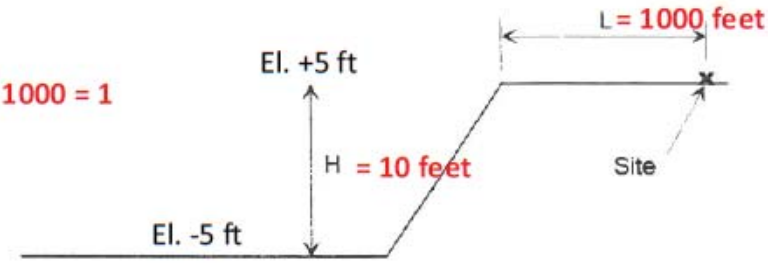
Youd et al. (2002) Procedure for Estimating Lateral Spread Displacements

Free-Face Conditions:

$$\log(D_H) = -16.713 + 1.532M - 1.406\log R^* - 0.012R + 0.592\log W$$
$$+ 0.540\log(T_{15}) + 3.413\log(100 - F_{15}) - 0.795\log(D50_{15} + 0.1mm)$$

D_H	=	lateral ground displacement, m
M	=	magnitude (generally M_w). Range is 6-8.
R^*	=	$Ro + r_{jb}$; $Ro = 10^{(0.89M - 5.64)}$
		r_{jb} = closest horizontal distance to surface projection of seismic source (≥ 0.5 km)
W	=	$100 \cdot H/L$, see figure: Range is W = 1 to 20%

W = 100 x 10 / 1000 = 1



			Addition of Terms	
Input Parameters			-16.71	
Magnitude	M:	6.7	10.26	
Distance	R	13	-0.16	
$Ro = 10^{(0.89M - 5.64)}$	Ro:	2	0.00	
$R^* = R + R_o$	R*:	15	-1.66	
Freeface Ratio (%)	W:	1	0.00	
Cumulative Thickness (m)	T15:	6.1	0.42	
Average Fine Contents	F15:	35	6.19	
Mean Grain Size (mm)	D50:	0.1	0.56	
	log (DH):		-1.10	
	DH:		0.08	meter
			0.26	feet
			3	inches

Youd et al. (2002) Procedure for Estimating Lateral Spread Displacements

Free-Face Conditions:

$$\log(D_H) = -16.713 + 1.532M - 1.406\log R^* - 0.012R + 0.592\log W$$
$$+ 0.540\log(T_{15}) + 3.413\log(100 - F_{15}) - 0.795\log(D50_{15} + 0.1mm)$$

D_H = lateral ground displacement, m

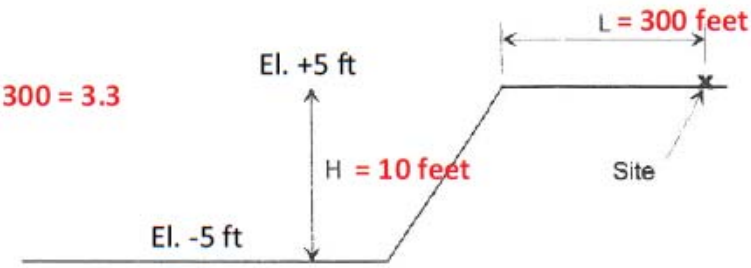
M = magnitude (generally M_w). Range is 6-8.

R^* = $Ro + r_{jb}$; $Ro = 10^{(0.89M - 5.64)}$

r_{jb} = closest horizontal distance to surface projection of seismic source (≥ 0.5 km)

W = $100 \cdot H/L$, see figure: Range is W = 1 to 20%

W = 100 x 10 / 300 = 3.3



			Addition of Terms	
Input Parameters			-16.71	
Magnitude	M:	6.7	10.26	
Distance	R	13	-0.16	
$Ro = 10^{(0.89M - 5.64)}$	Ro:	2	0.00	
$R^* = R + R_o$	R*:	15	-1.66	
Freeface Ratio (%)	W:	3.3	0.31	
Cumulative Thickness (m)	T15:	6.1	0.42	
Average Fine Contents	F15:	35	6.19	
Mean Grain Size (mm)	D50:	0.1	0.56	
	log (DH):		-0.79	
	DH:		0.16	meter
			0.53	feet
			6	inches

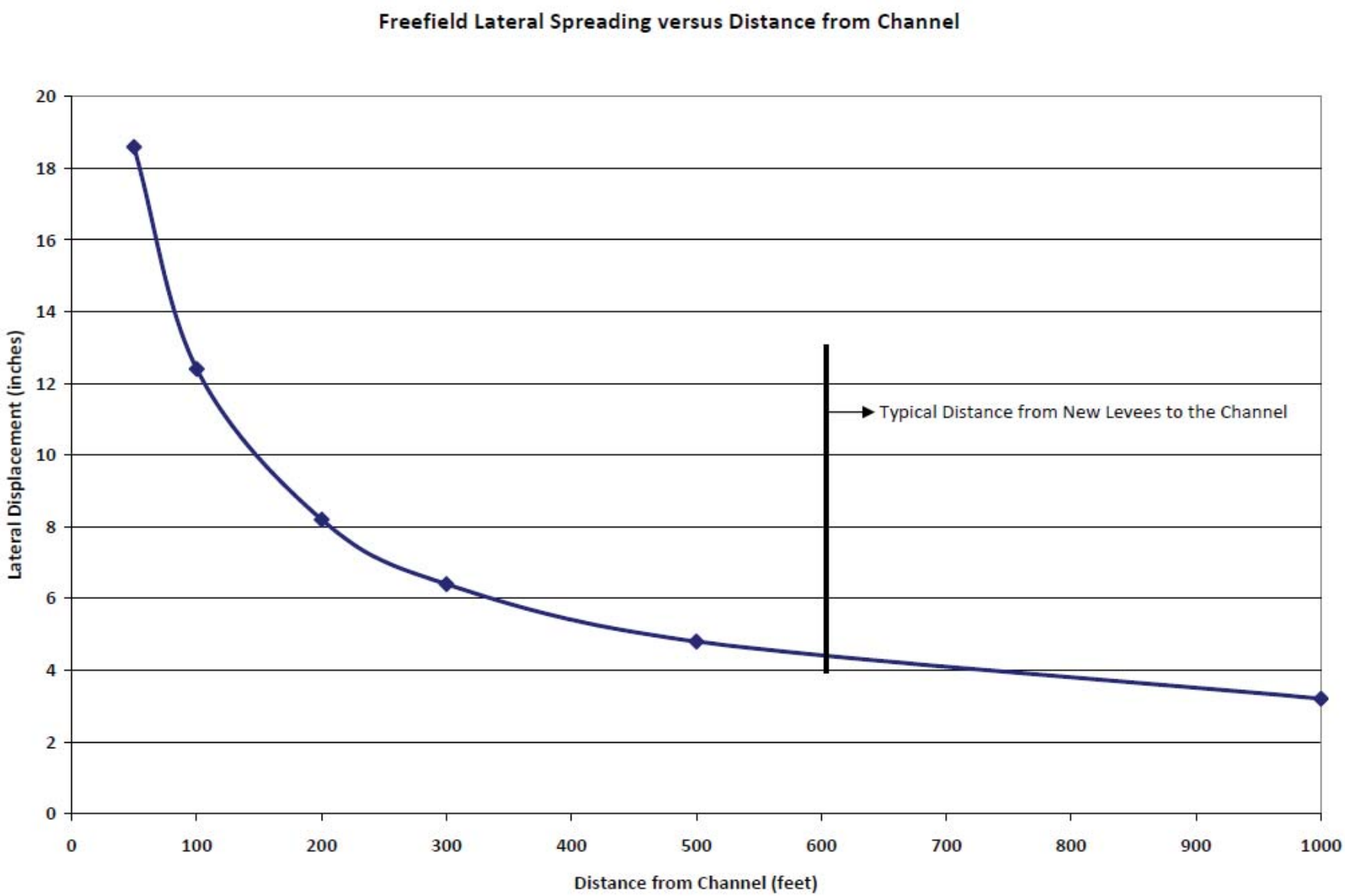

Freefield Lateral Spreading versus Distance from Channel
Lateral Displacement (inches)
20
18
16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600
700
800
900
1000
Distance from Channel (feet)
Typical Distance from New Levees to the Channel

PLATE E-32

APPENDIX F
SEEPAGE

APPENDIX F
SEEPAGE

F.1 Contents

This appendix includes the results calculations of permeability using our field permeability data, as well as the results of the seepage analyses. using the RocScience Program, Slide v.5.

Seepage analyses included estimation of hydraulic gradients for two conservative conditions as follows:

- Steady State Condition at Existing North Area A Levee after Excavation of the New Meander Channel and Prior to Breach
- Steady State Condition at West Area B Existing Levee During a High Water Event

The seepage analyses also show the results of the transient seepage analysis during a week of typical tidal changes, as well as the transient seepage analysis following a 10-day high water flood condition.

A list of the plates presented in this appendix follows:

Plate F-1 and F-2	Permeability Calculations
Plate F-3	Hydraulic Gradient – Steady State Condition at Existing North Area A Levee after Excavation and Prior to Breach
Plate F-4	Hydraulic Gradient – Steady State Condition at West Area B Levee
Plate F-5	Transient Water Level for Tidal Changes over a period of a week
Plate F-6	Typical Tidal Changes in Water Level in Santa Monica Bay Over One Week – Used in Seepage Analyses
Plate F-7 thru F-16	Discharge Flow Analysis for Tidal Changes over a Week
Plate F-17	Transient Water Level for a 10-day Flood Condition
Plate F-17 thru F-29	Discharge Flow Analysis During and After a 10-day Flood

Field Permeability Test Data

Boring A-HSA066

5 foot deep hole
(8 inch diameter hole)

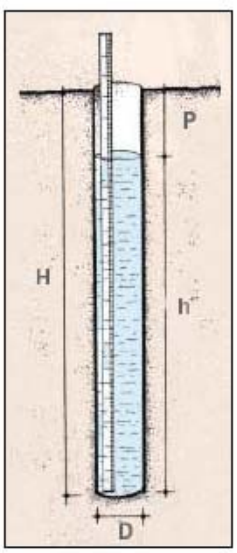
Average Permeability: K ~= 1.5 x 10^-3 cm/s

Time (min)	Reading (inches)	Drop in Water (inches)	Height of Water (inches)	Rate of Descent (in/min)	K (in/min)	K (cm/s)
0	0	-14				
0.5	14	0	46	0.00	0.00000	0.00000
1	14	0	46	1.00	0.04396	0.00186
2	15	1	45	1.00	0.04495	0.00190
3	16	2	44	0.00	0.00000	0.00000
4	16	2	44	1.00	0.04598	0.00195
5	17	3	43	0.80	0.03810	0.00161
7.5	19	5	41	1.20	0.06079	0.00257
10	22	8	38	0.60	0.03290	0.00139
15	25	11	35			

10 foot deep hole
(8 inch diameter hole)

Average Permeability: K ~= 3.2 x 10^-4 cm/s

Time (min)	Reading (inches)	Drop in Water (inches)	Height of Water (inches)	Rate of Descent (in/min)	K (in/min)	K (cm/s)
0	0	-7				
0.5	7	0	113	2.00	0.03556	0.00151
1	8	1	112	2.00	0.03604	0.00153
2	10	3	110	1.00	0.01826	0.00077
3	11	4	109	1.00	0.01843	0.00078
4	12	5	108	1.00	0.01860	0.00079
5	13	6	107	0.40	0.00751	0.00032
7.5	14	7	106	0.40	0.00758	0.00032
10	15	8	105	0.40	0.00769	0.00033
15	17	10	103			



$$K = (D \div 2) \times \ln (h_1 \div h_2) / 2 (t_2 - t_1)$$

Source: ftp://ftp.fao.org/fi/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm

Field Permeability Test Data

Boring A-HSA064

5 foot deep hole
(8 inch diameter hole)

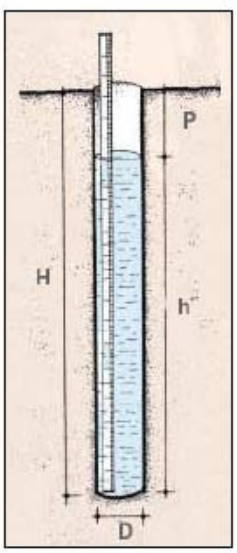
Average Permeability: K ~= 7.5 x 10^-4 cm/s

Time (min)	Reading (inches)	Drop in Water (inches)	Height of Water (inches)	Rate of Descent (in/min)	K (in/min)	K (cm/s)
0	0					
0.5	6	0	54	2.00	0.07477	0.00317
1	7	1	53	1.00	0.03810	0.00161
2	8	2	52	1.00	0.03884	0.00164
3	9	3	51	1.00	0.03961	0.00168
4	10	4	50	1.00	0.04041	0.00171
5	11	5	49	0.40	0.01650	0.00070
7.5	12	6	48	0.80	0.03405	0.00144
10	14	8	46	0.40	0.01778	0.00075
15	16	10	44			

10 foot deep hole
(8 inch diameter hole)

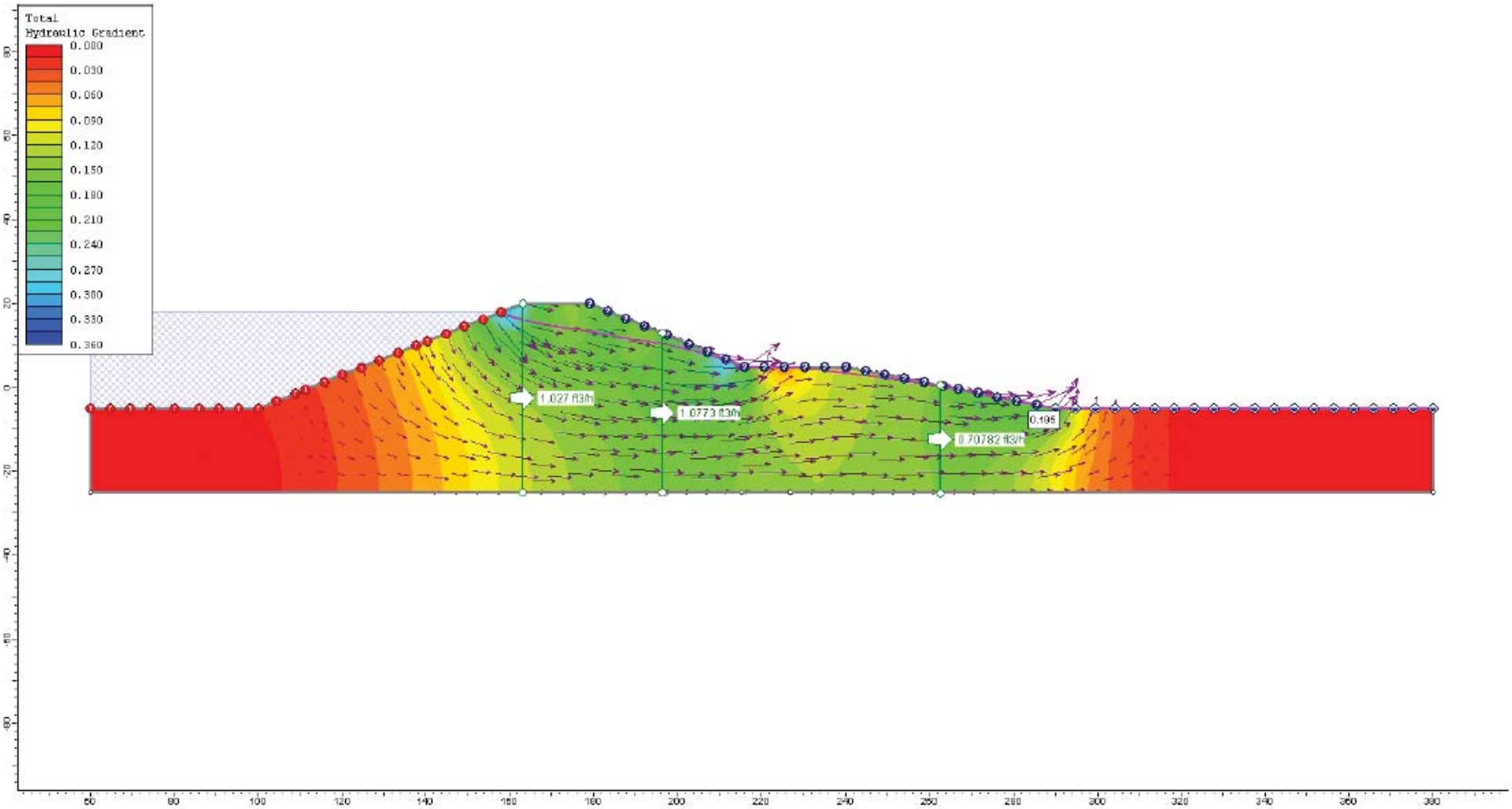
Average Permeability: K ~= 7.5 x 10^-4 cm/s

Time (min)	Reading (inches)	Drop in Water (inches)	Height of Water (inches)	Rate of Descent (in/min)	K (in/min)	K (cm/s)
0	0					
0.5	6	0	114	136.00	3.63023	0.15368
1	74	68	46	0.00	0.00000	0.00000
2	74	68	46	0.00	0.00000	0.00000
3	74	68	46	0.00	0.00000	0.00000
4	74	68	46	0.00	0.00000	0.00000
5	74	68	46	0.00	0.00000	0.00000
7.5	74	68	46	0.00	0.00000	0.00000
10	74	68	46	0.40	0.01778	0.00075
15	76	70	44			



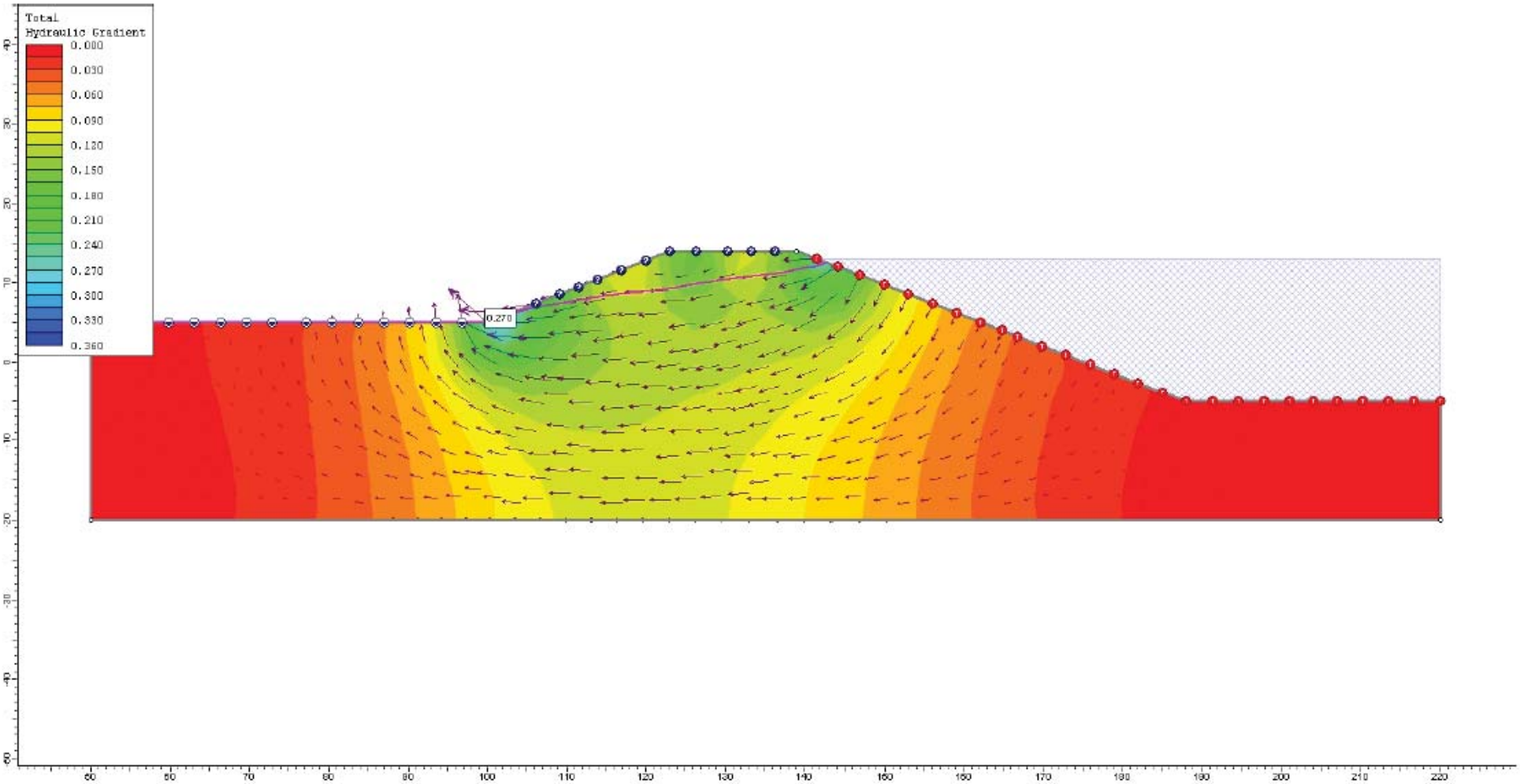
$$K = (D \div 2) \times \ln (h_1 \div h_2) / 2 (t_2 - t_1)$$

Source: ftp://ftp.fao.org/fi/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm



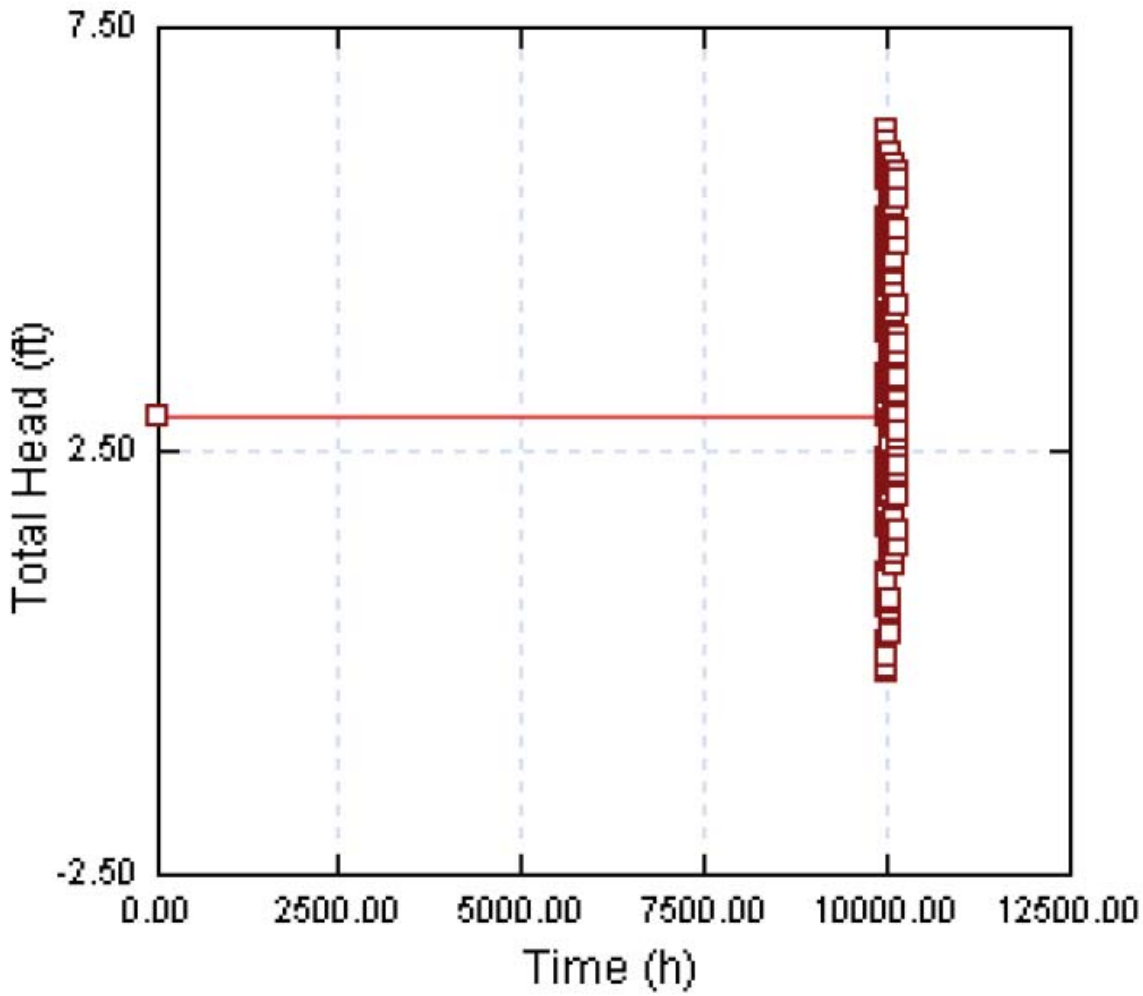
Hydraulic Gradient – Steady State Condition at Existing North Area A Levee after Excavation and Prior to Breach (i=0.195; FS > 5)

PLATE F-3



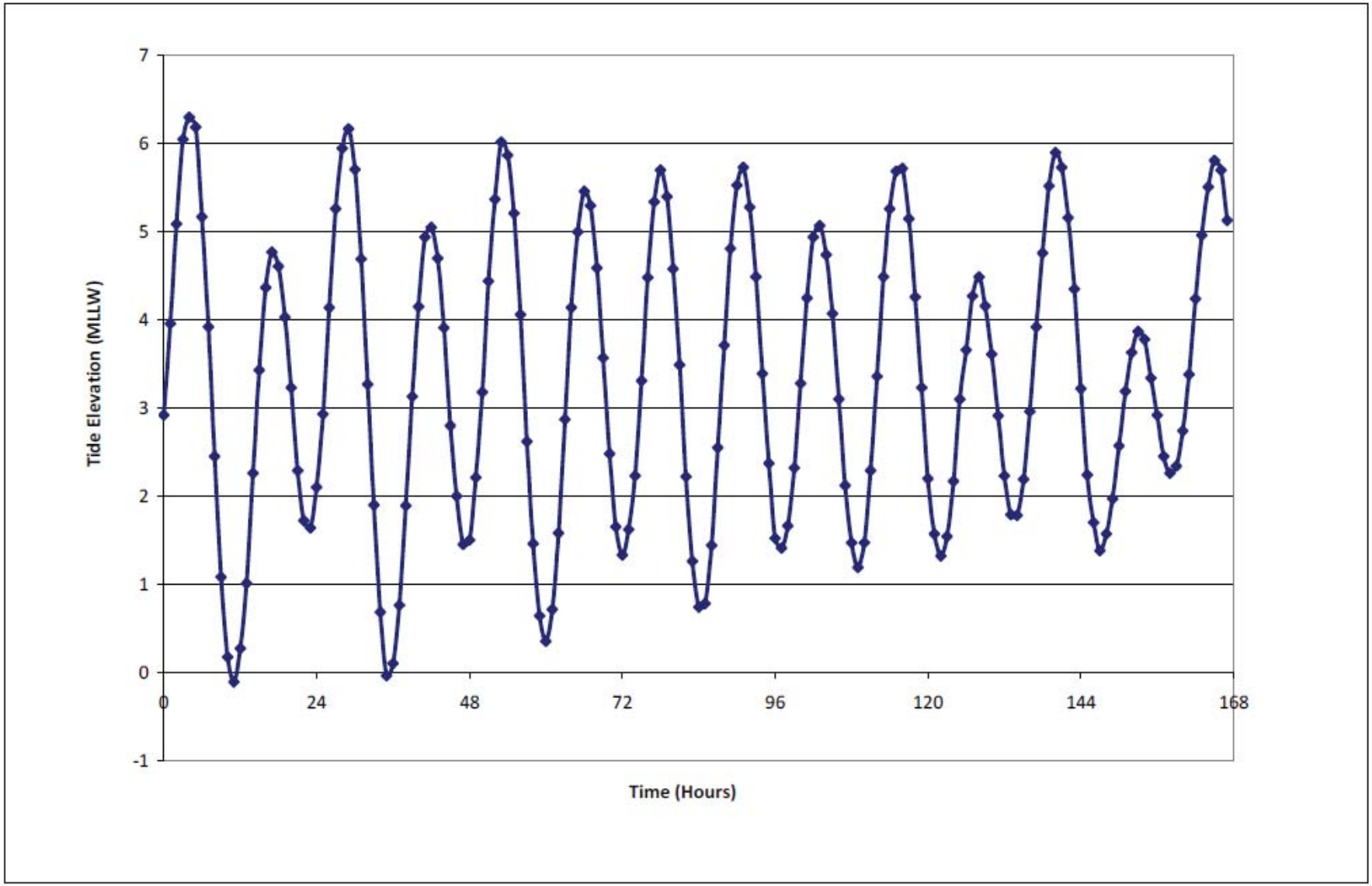
Hydraulic Gradient – Steady State Condition at West Area B Levee (i=0.27; FS > 3.7)

PLATE F-4



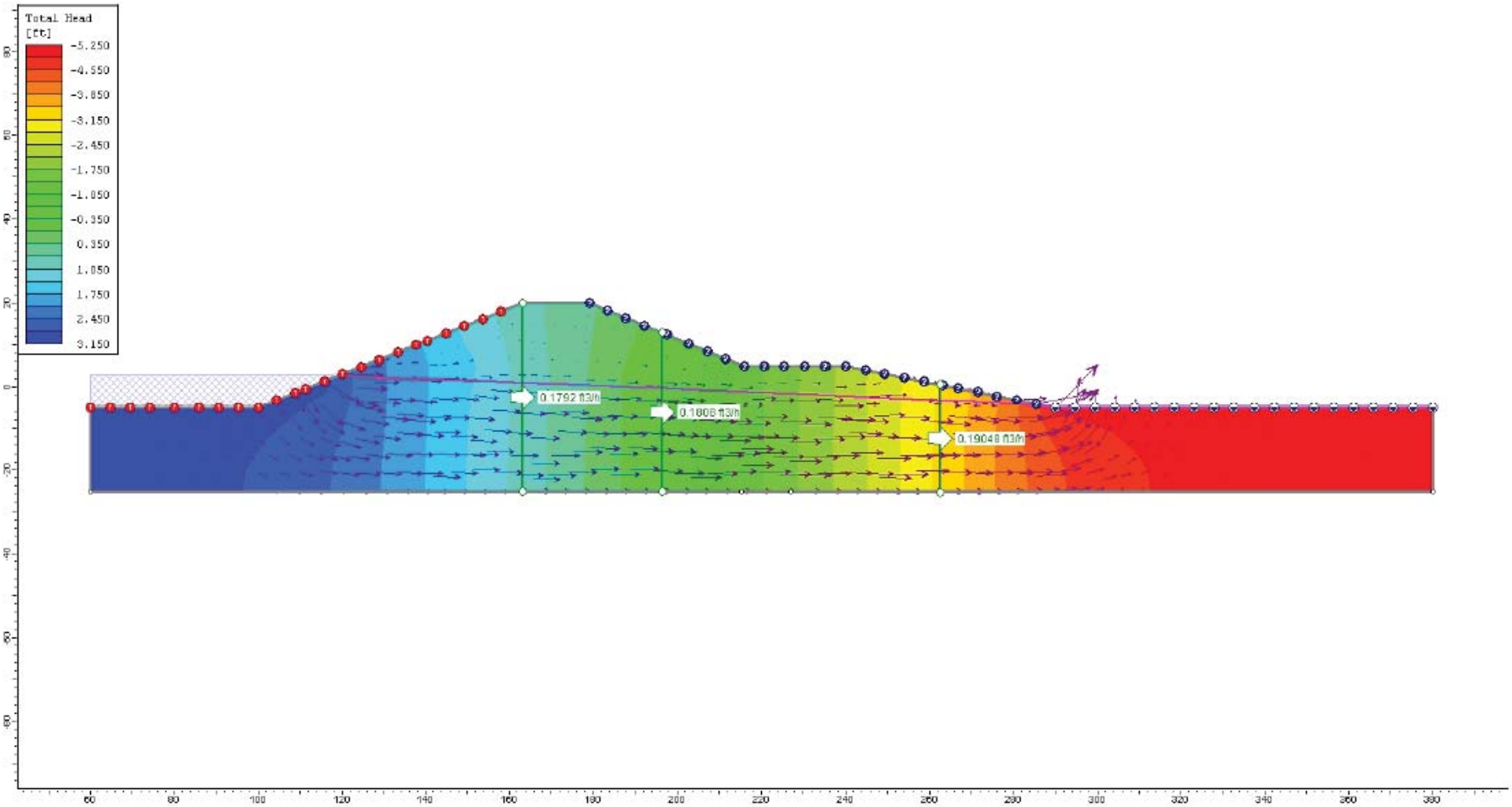
Transient Water Level for Tidal Changed over a Period of One Week

PLATE F-5



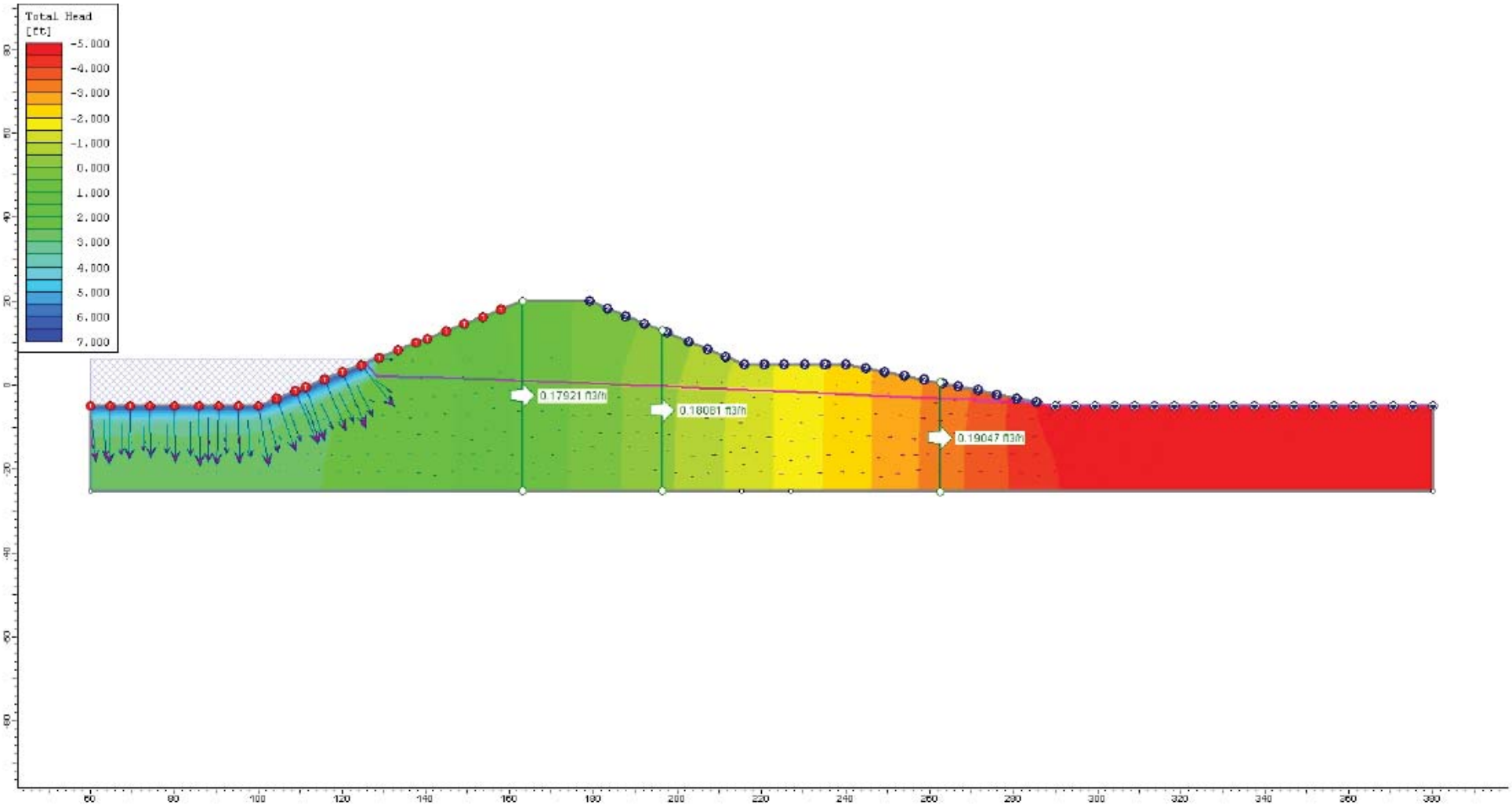
Typical Tidal Changes in Water Level in Santa Monica Bay Over One Week - Used in Seepage Analysis

PLATE F-6



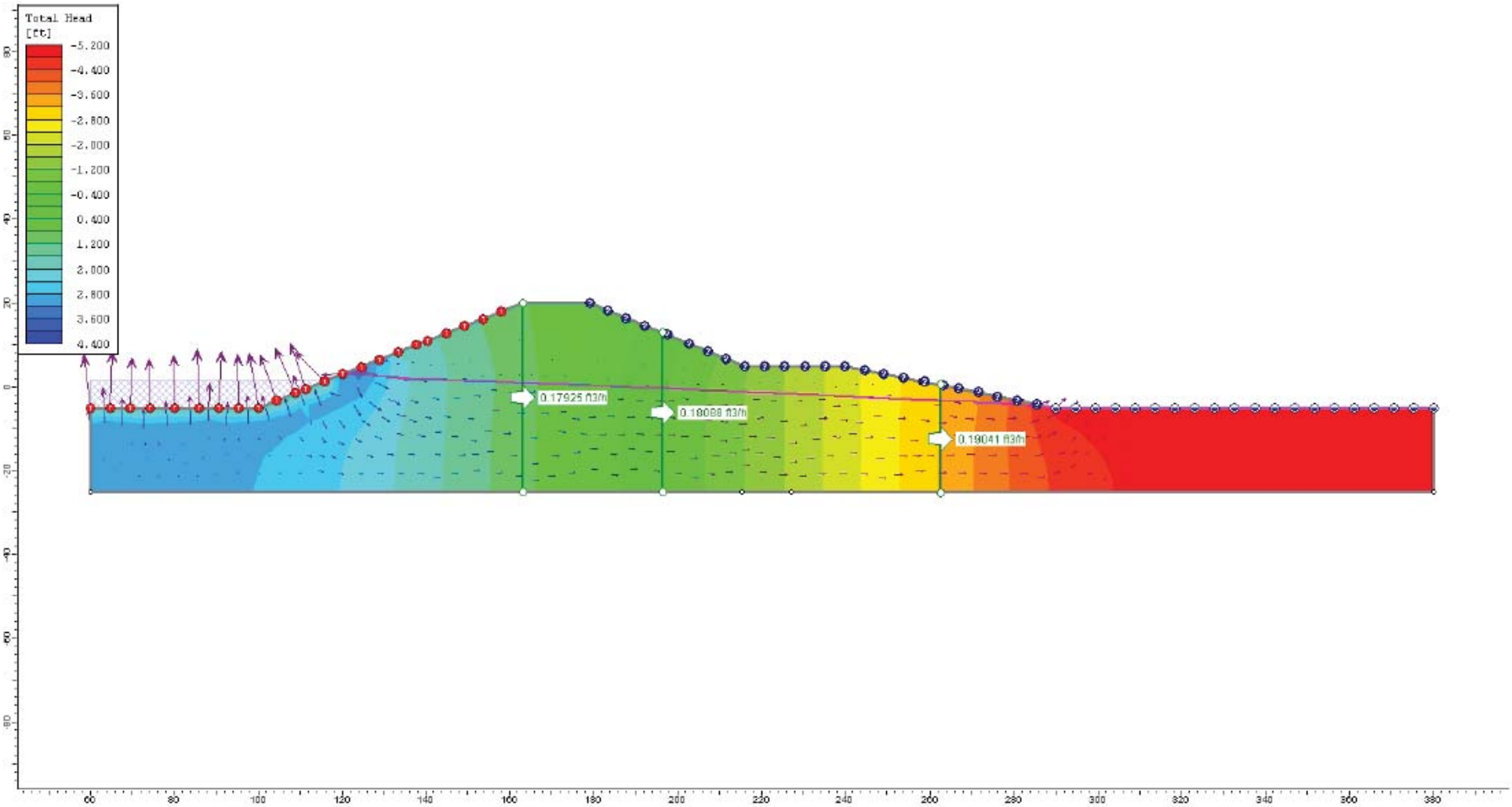
Stage 1 – Steady State at Average Tide Hide Prior to Tidal Fluctuations in the Analysis

PLATE F-7



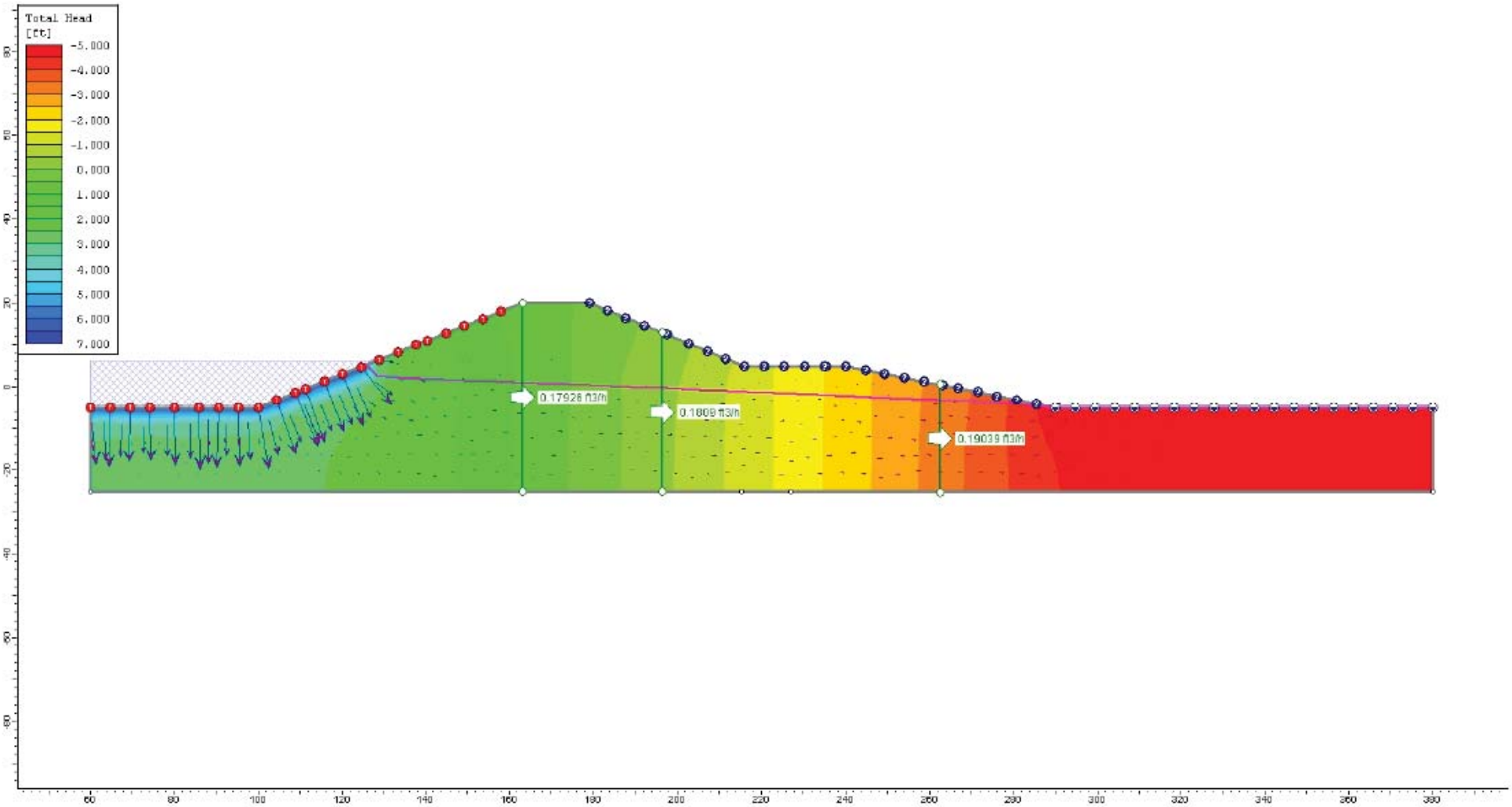
Stage 2 – First Peak – 4th Hour

PLATE F-8



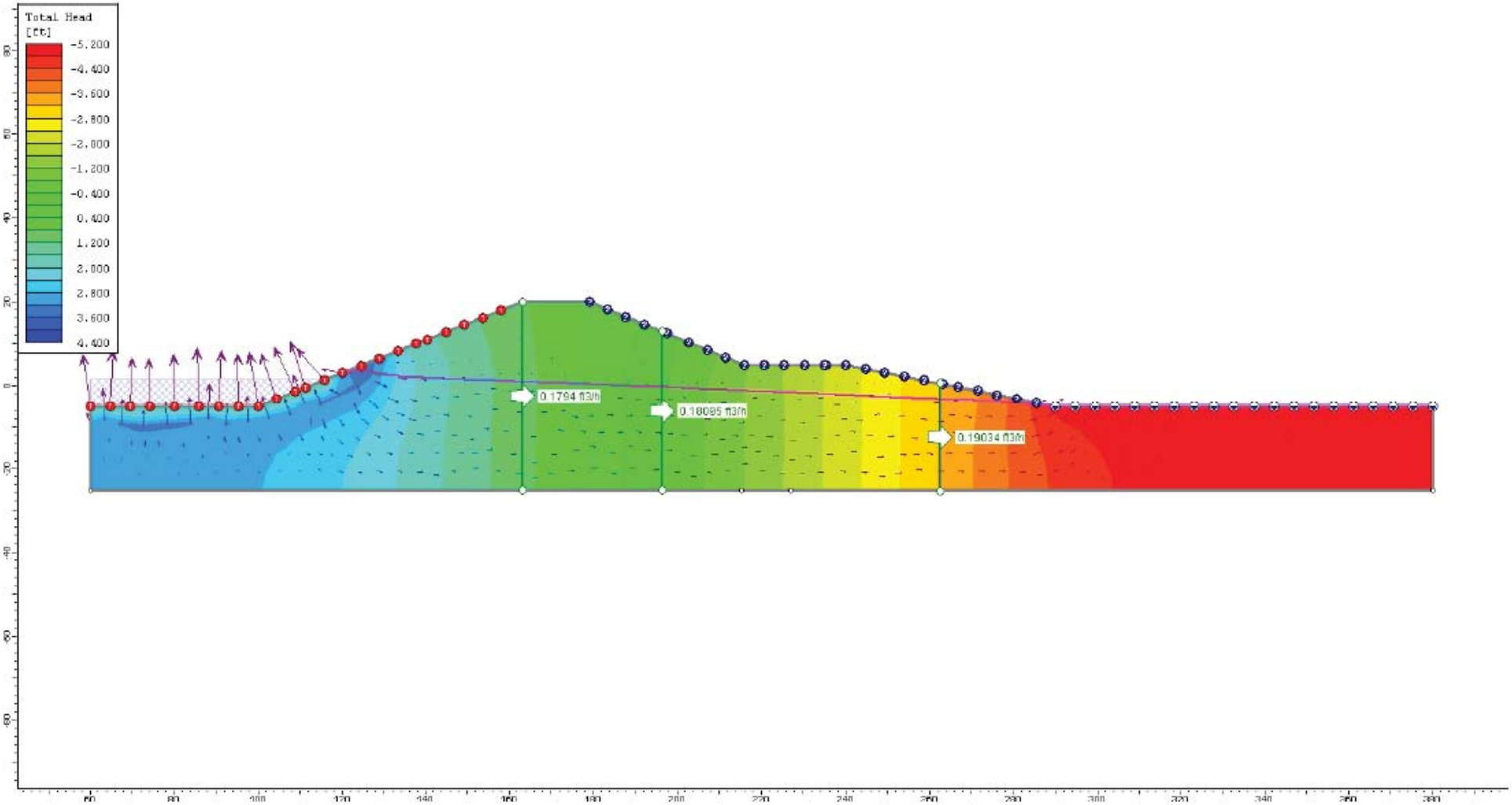
Stage 4 – Second Valley – 23th Hour

PLATE F-9



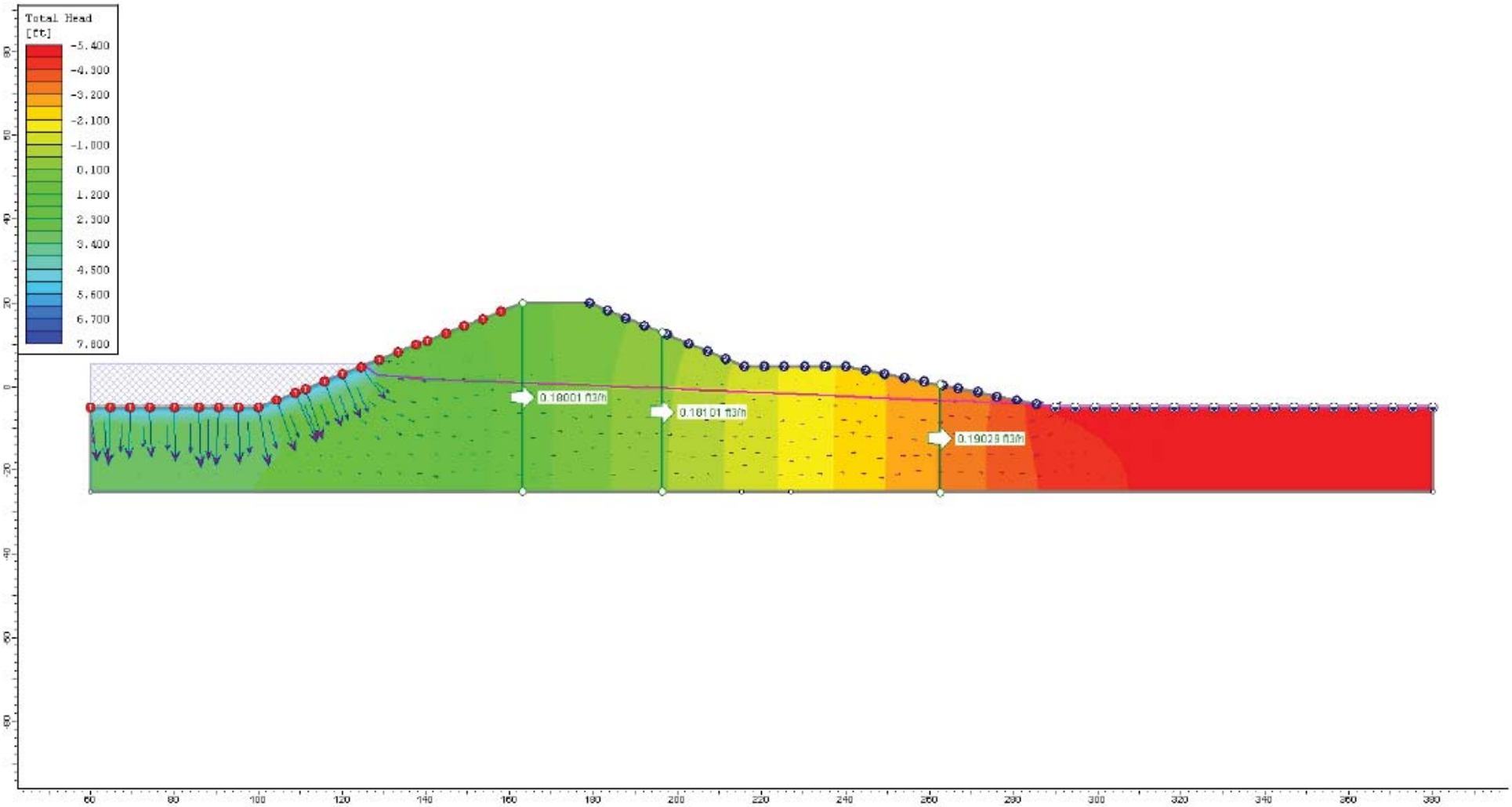
Stage 5 – Third Peak – 29th Hour

PLATE F-10



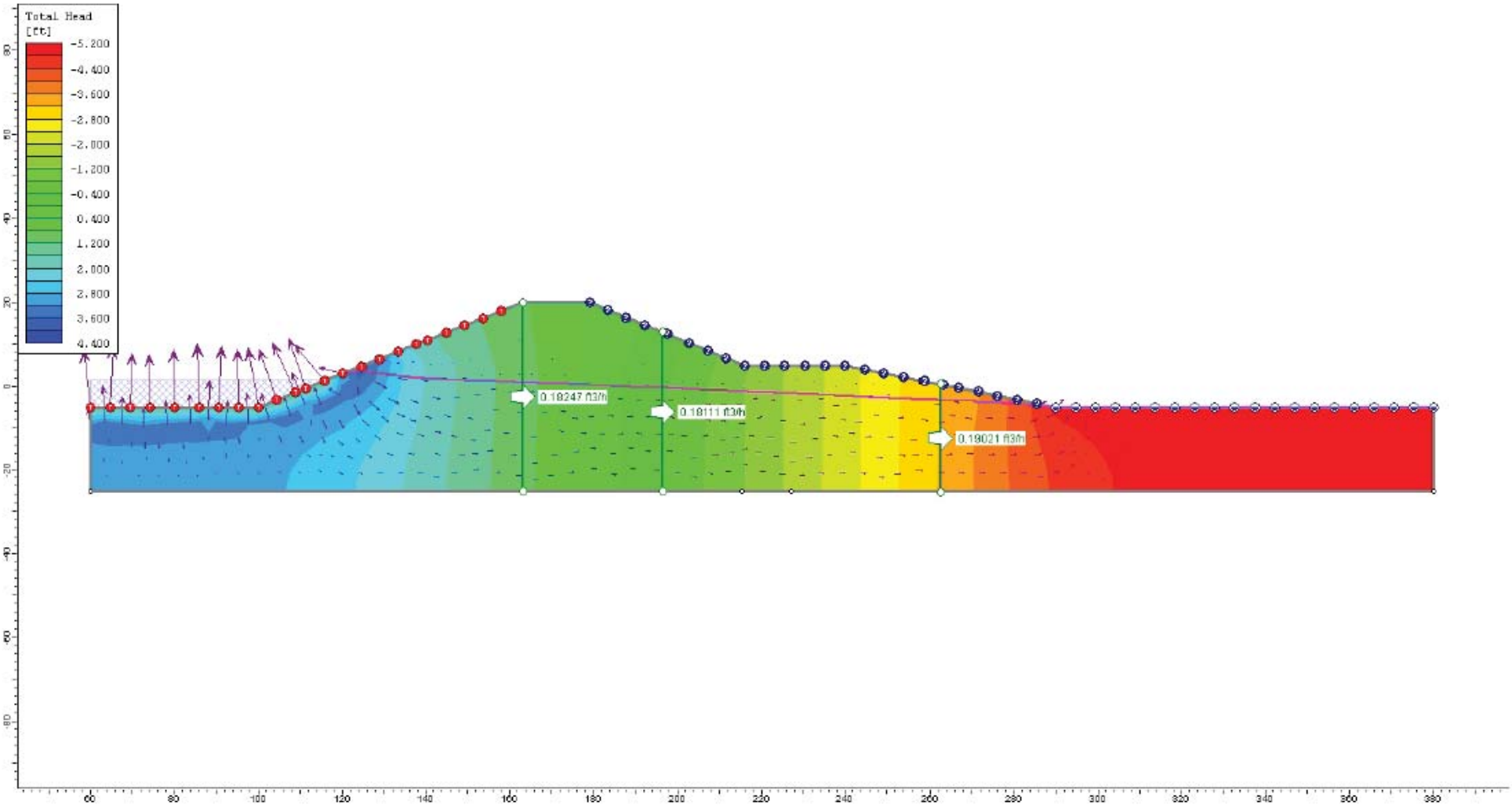
Stage 9 – Fourth Valley – 47th Hour

PLATE F-11



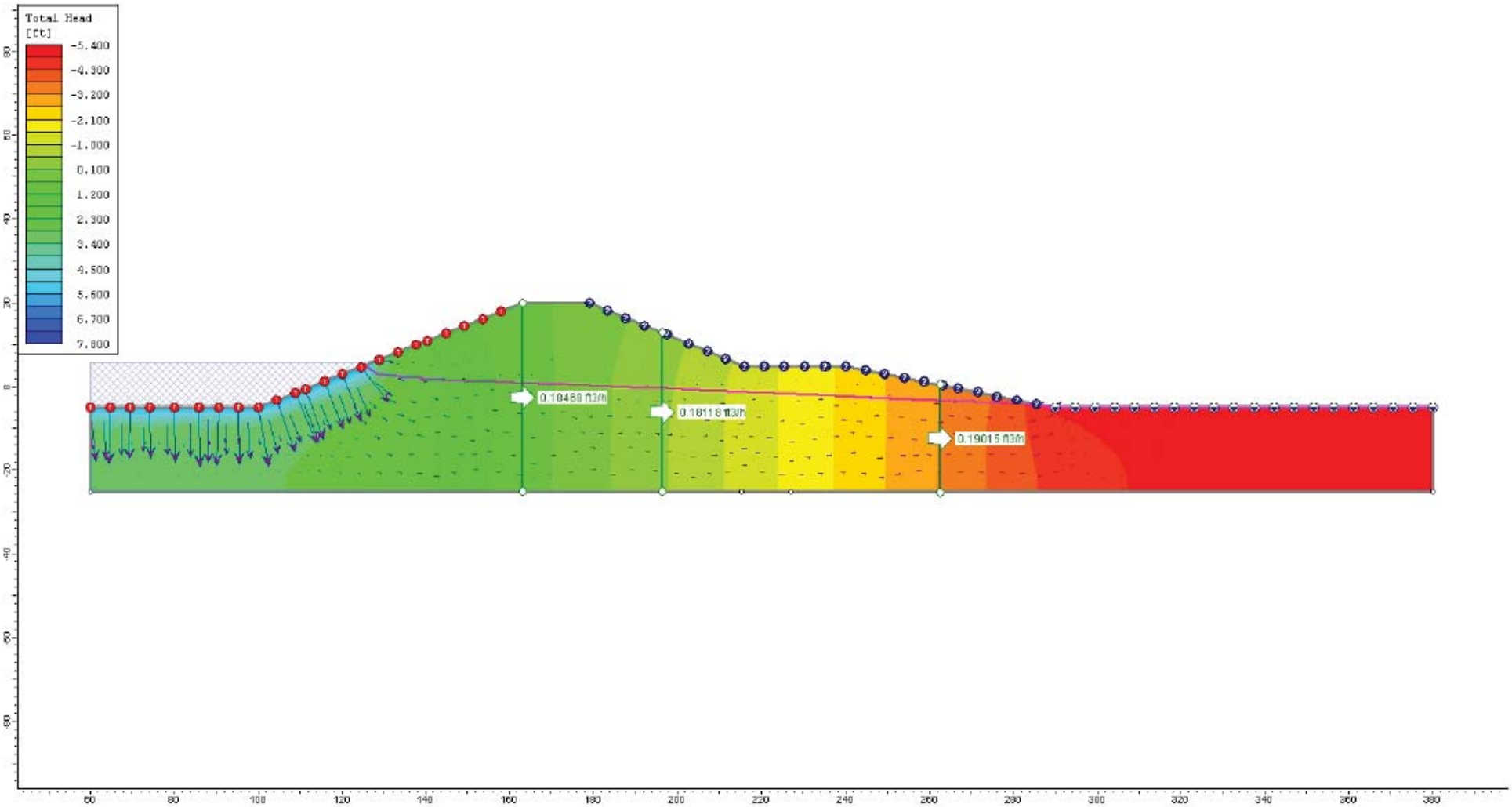
Stage 12 – Sixth Peak – 66th Hour

PLATE F-12



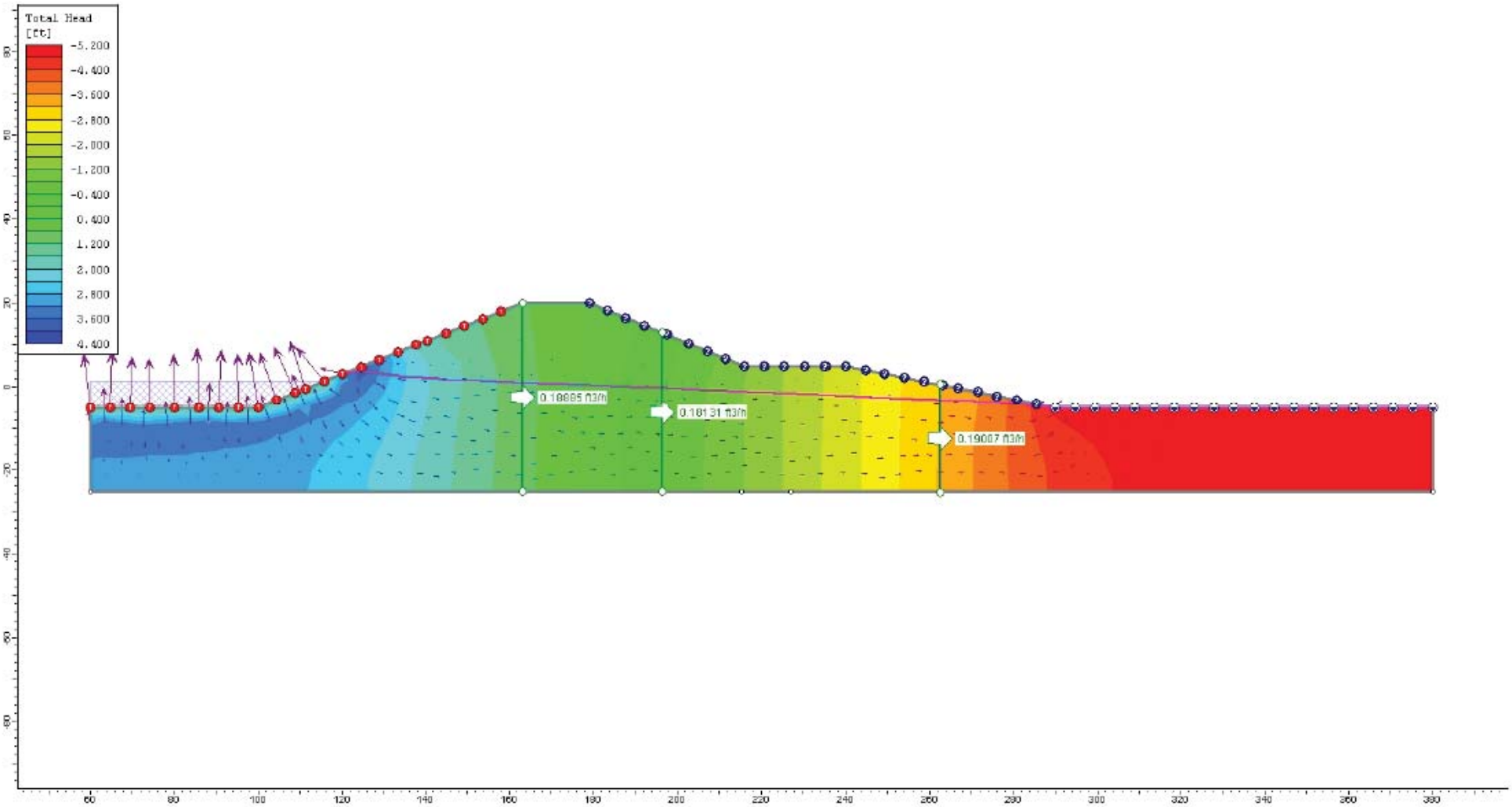
Stage 17 – Sixth Peak – 97th Hour

PLATE F-13



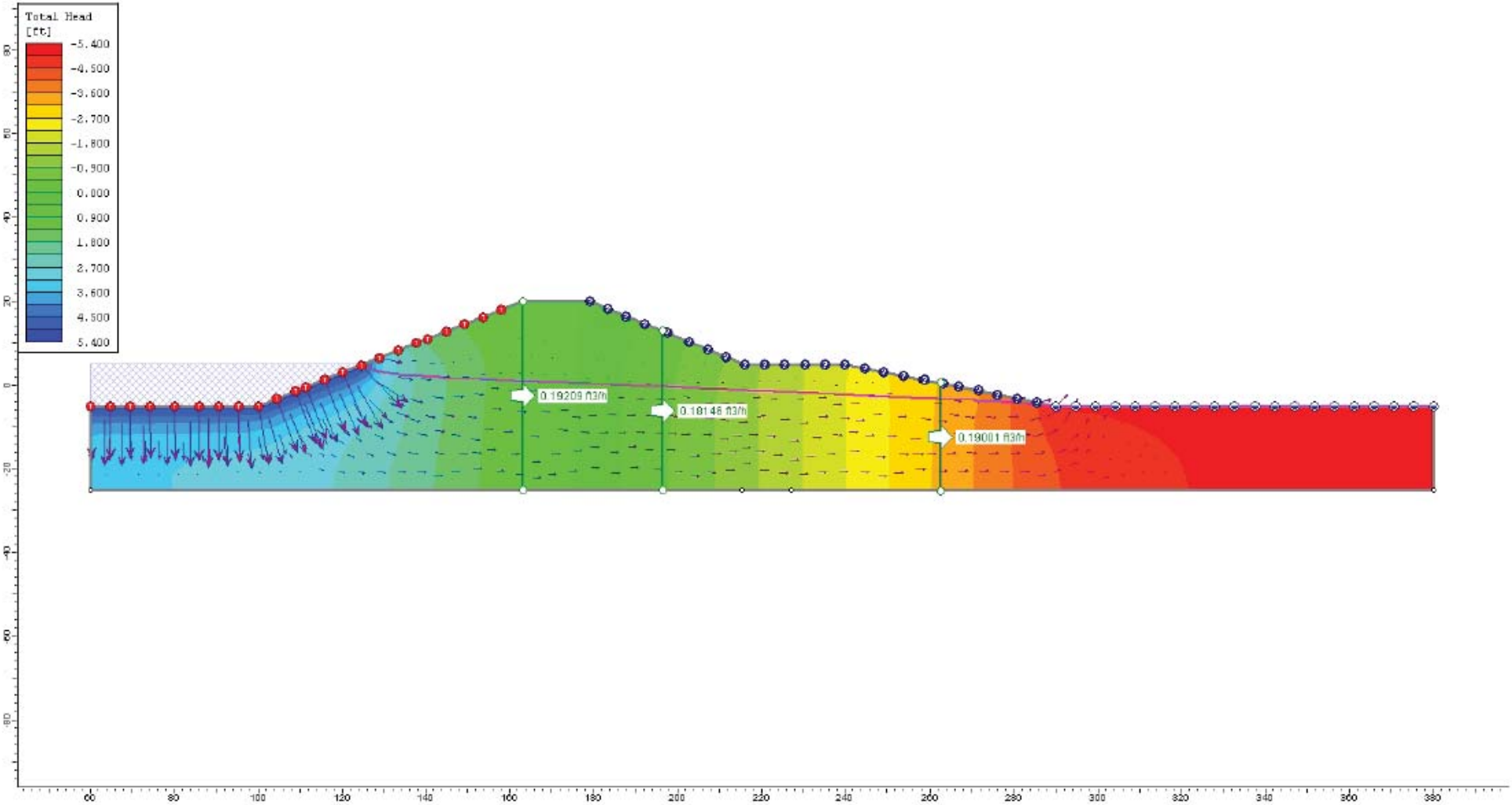
Stage 20 – Tenth Peak – 116th Hour

PLATE F-14



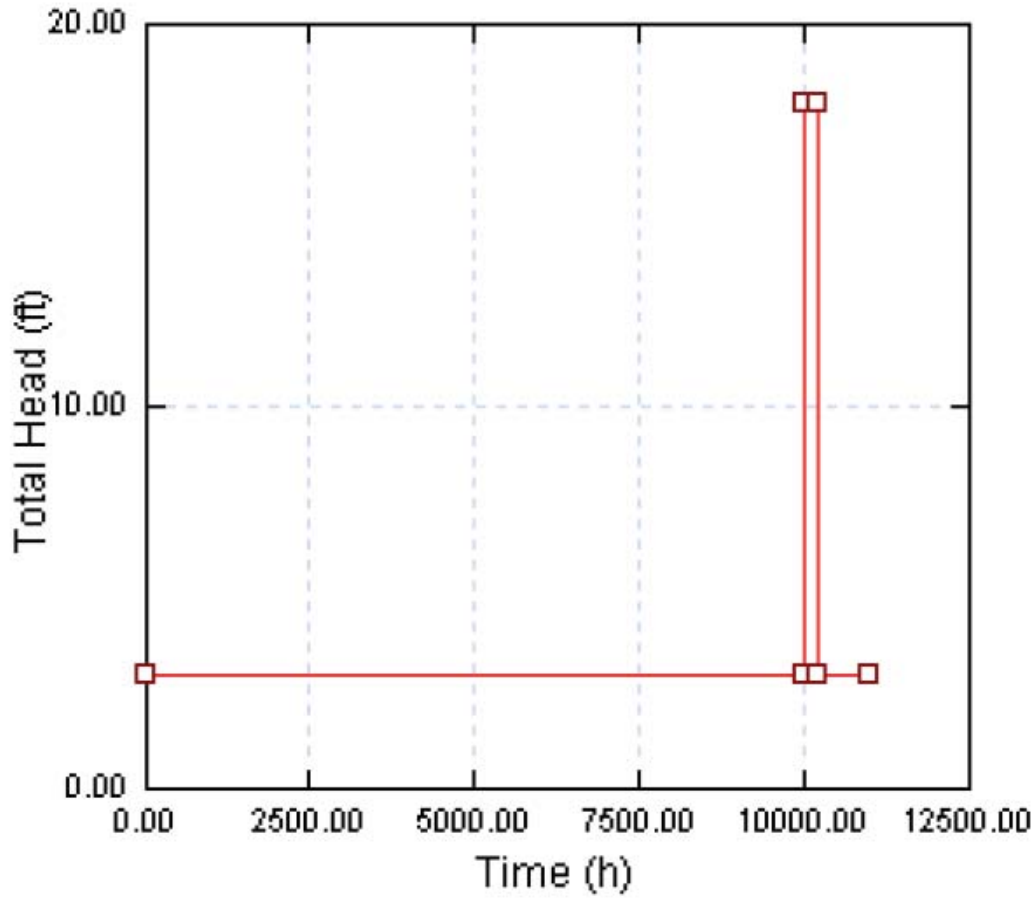
Stage 25 – Twelfth Valley – 147th Hour

PLATE F-15



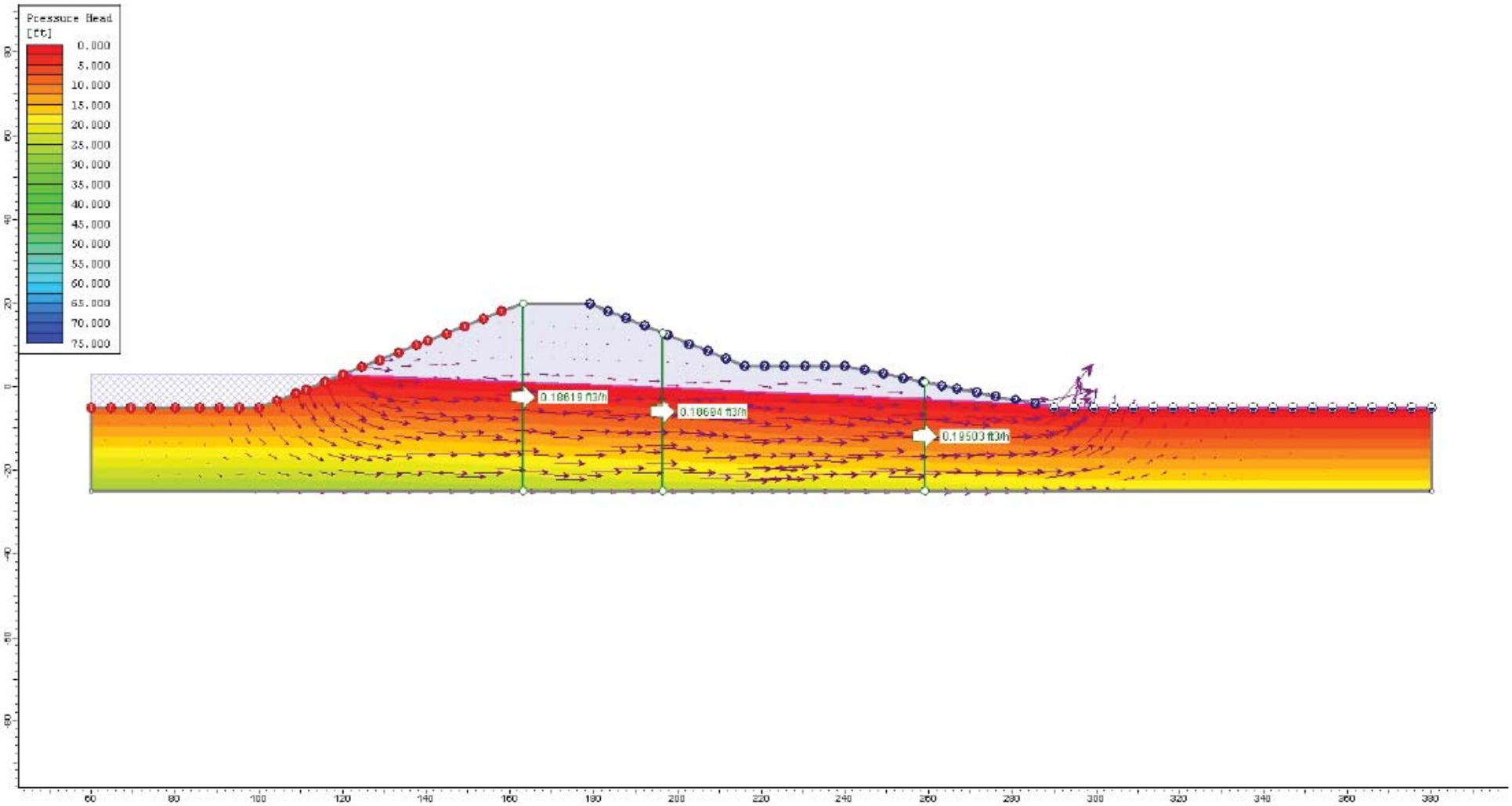
Stage 29 – Fourtheenth Valley – 170th Hour

PLATE F-16



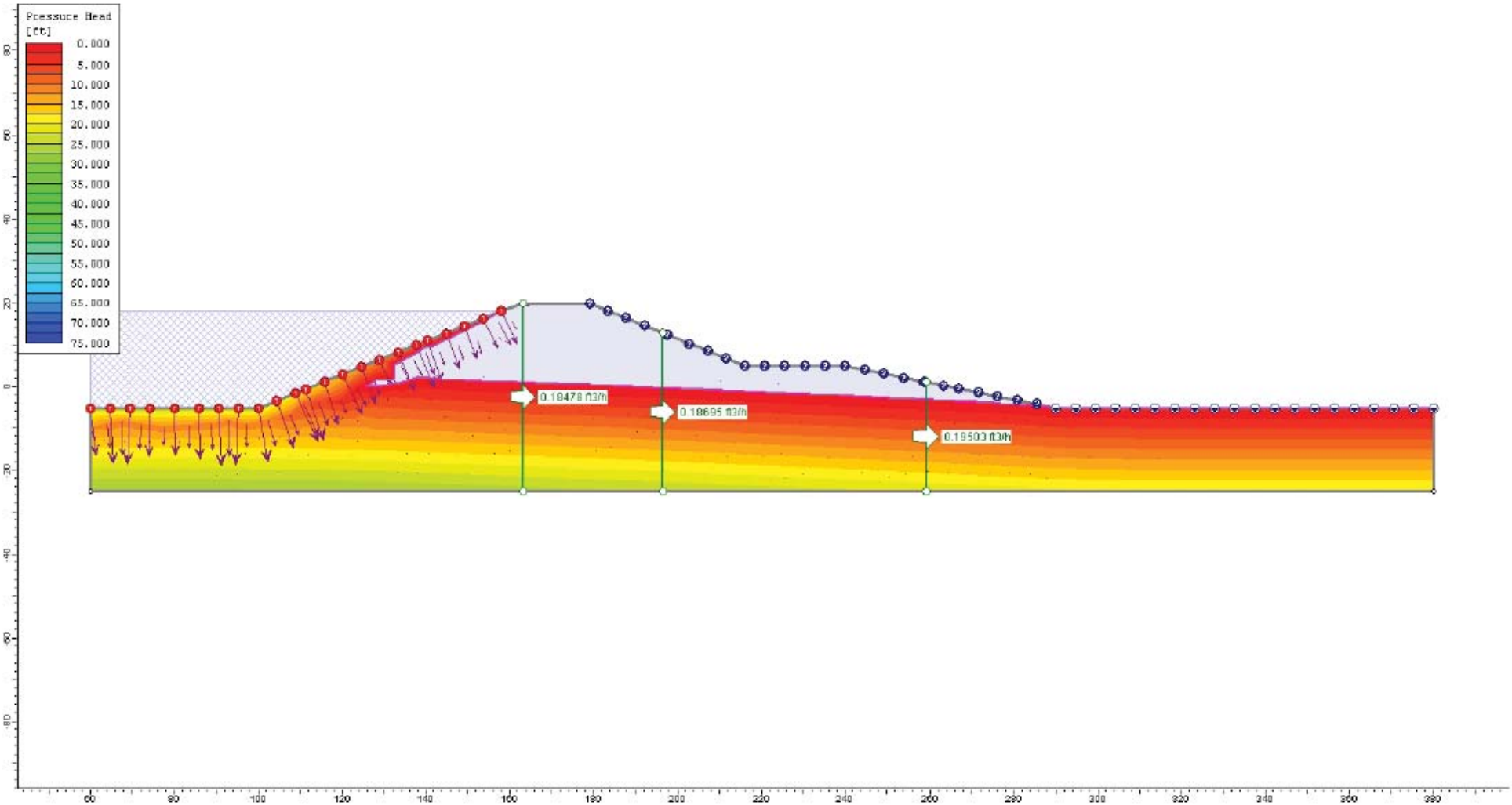
Transient Water Level for a 10 day Flood Condition:
1) Steady State is reached with Water Level at El. +3 feet
2) 10-Day Flood with Water Level at El. +18 feet
3) Water Level droped to El. +3 feet

PLATE F-17



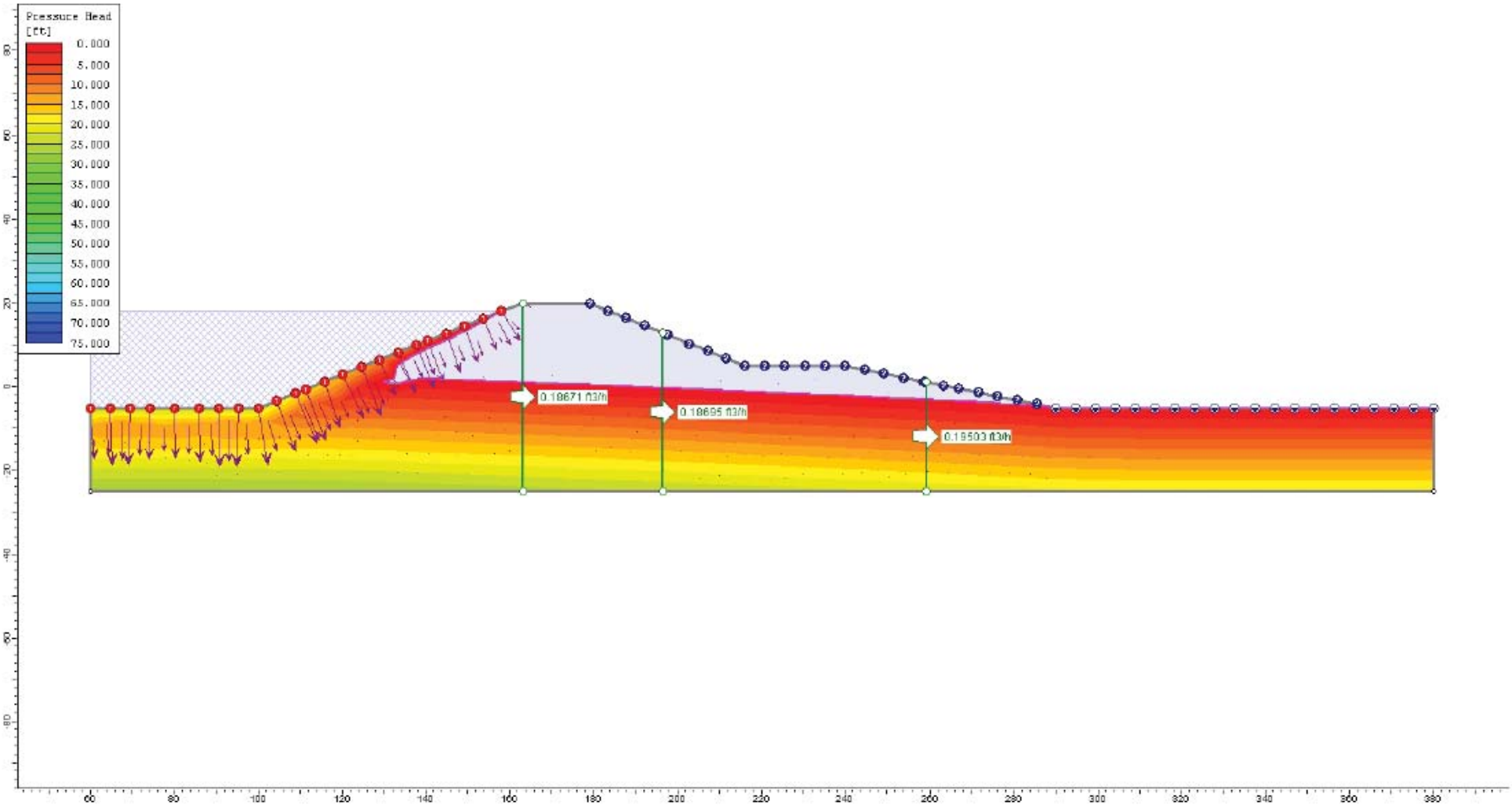
Stage 1 – Steady State Water Levels Prior to Flood

PLATE F-18



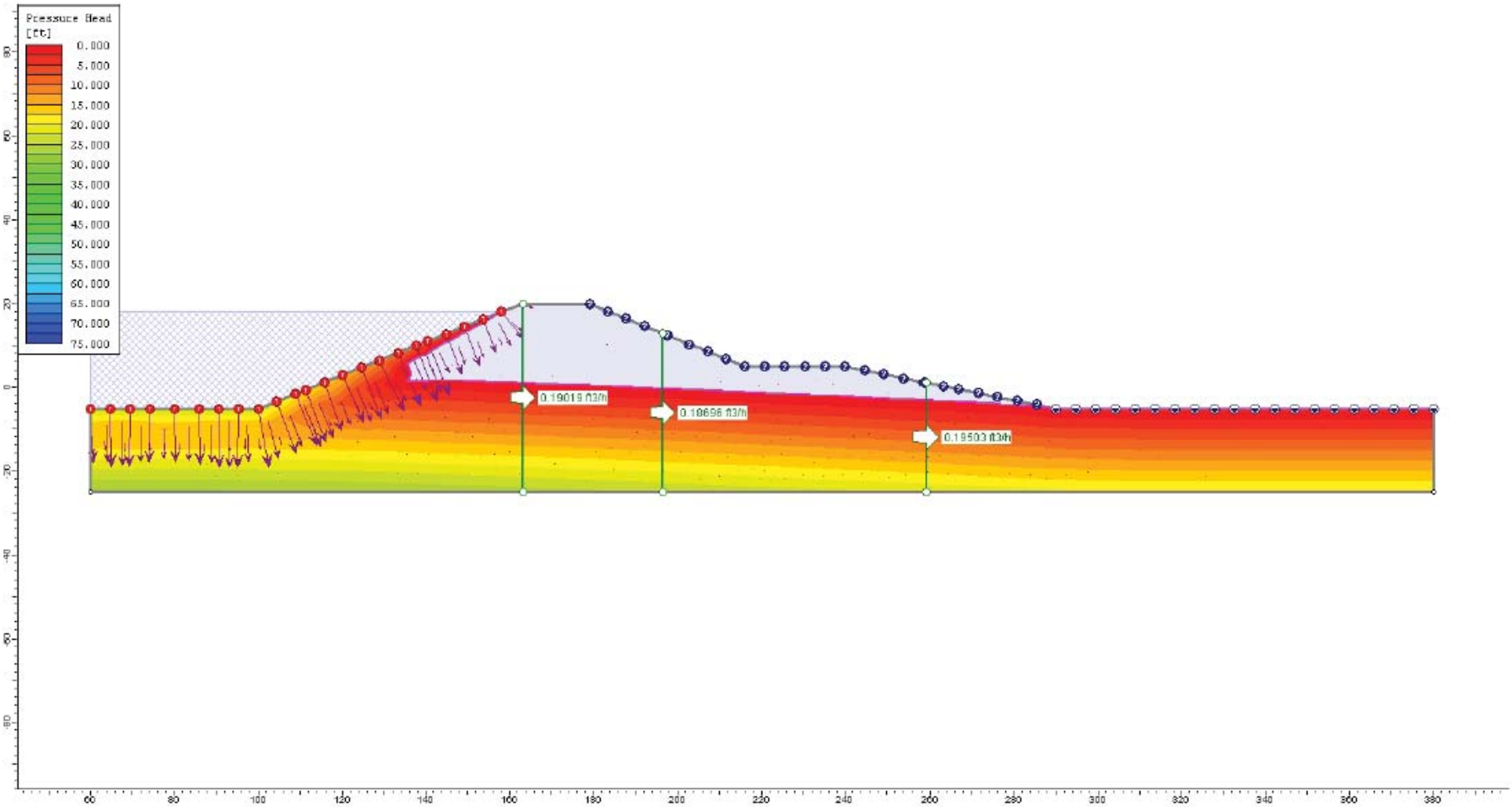
Stage 2 – One hour after the start of the Flood

PLATE F-19



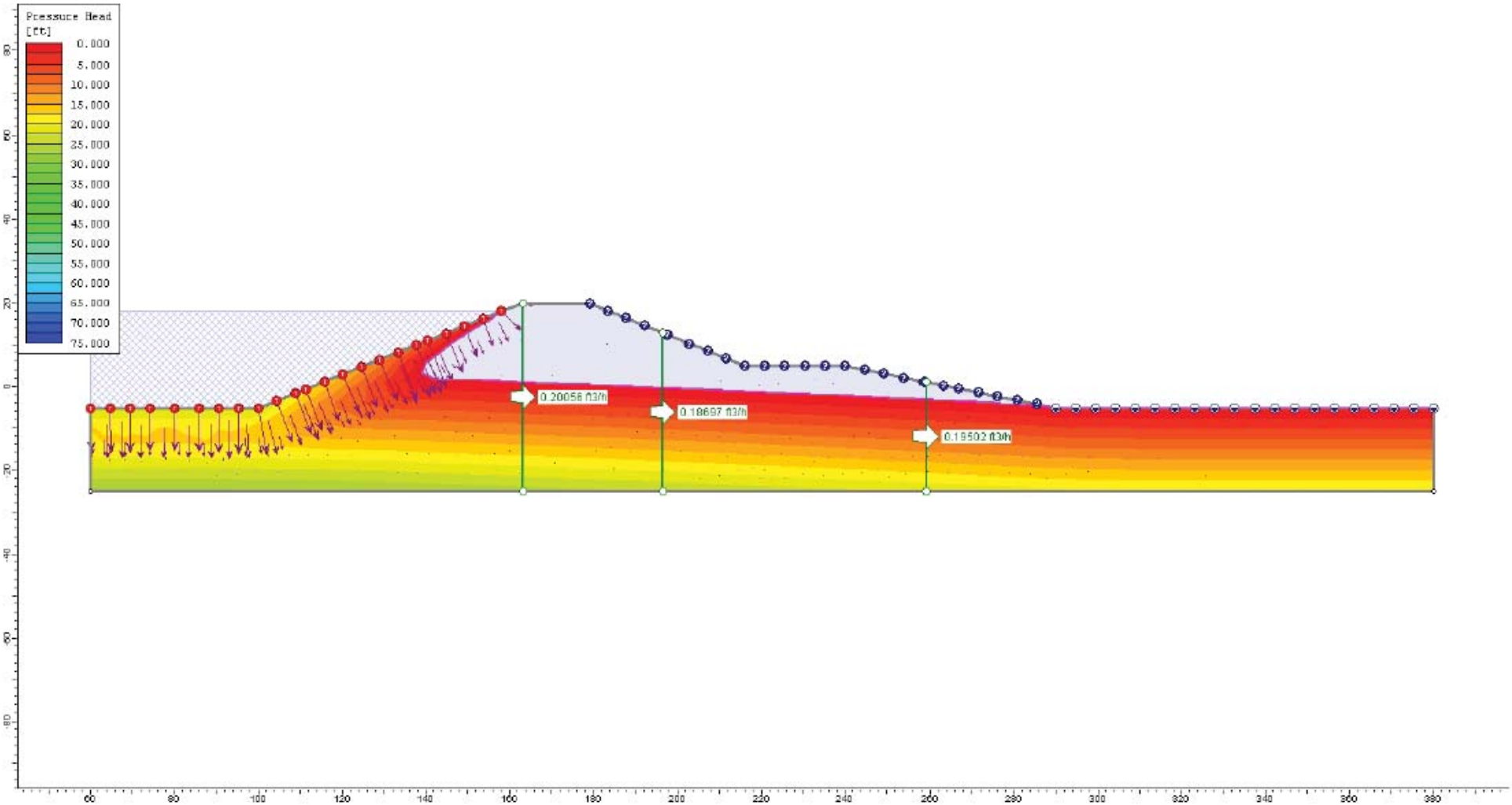
Stage 3 – Two hours after the start of the Flood

PLATE F-20



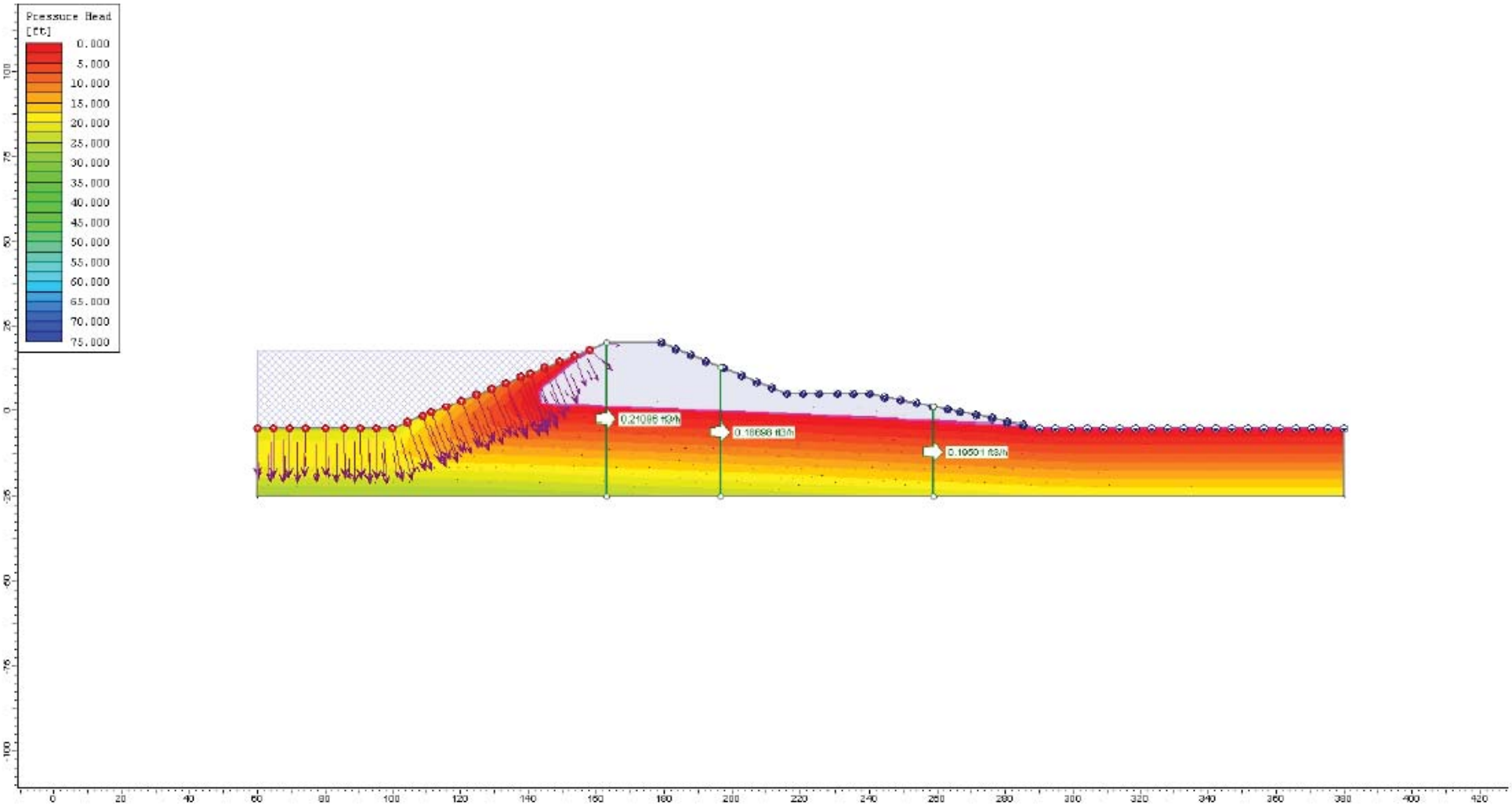
Stage 4 – Four hours after the start of the Flood

PLATE F-21



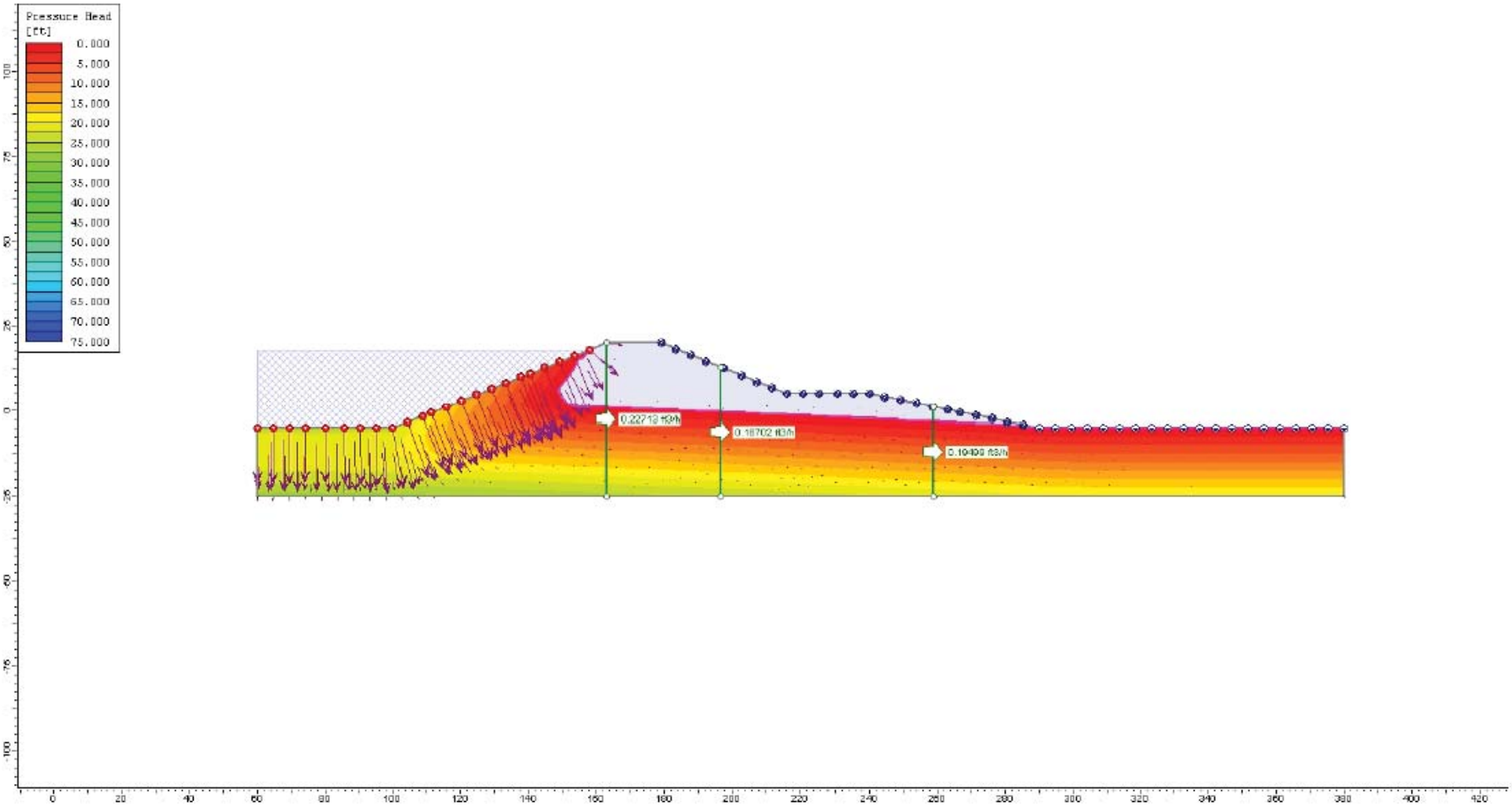
Stage 5 – Eight hours after the start of the Flood

PLATE F-22



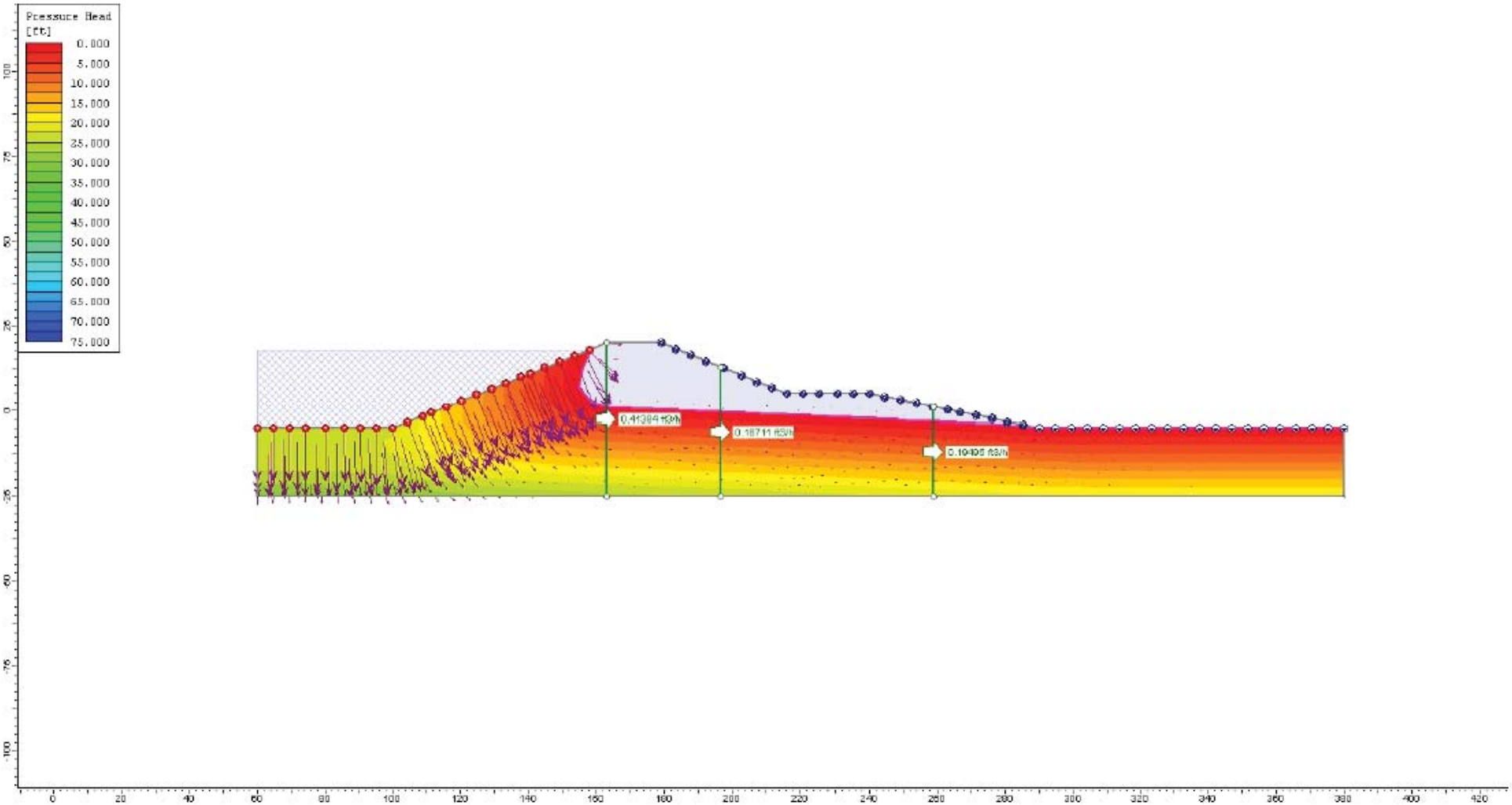
Stage 6 – 12 hours after the start of the Flood

PLATE F-23



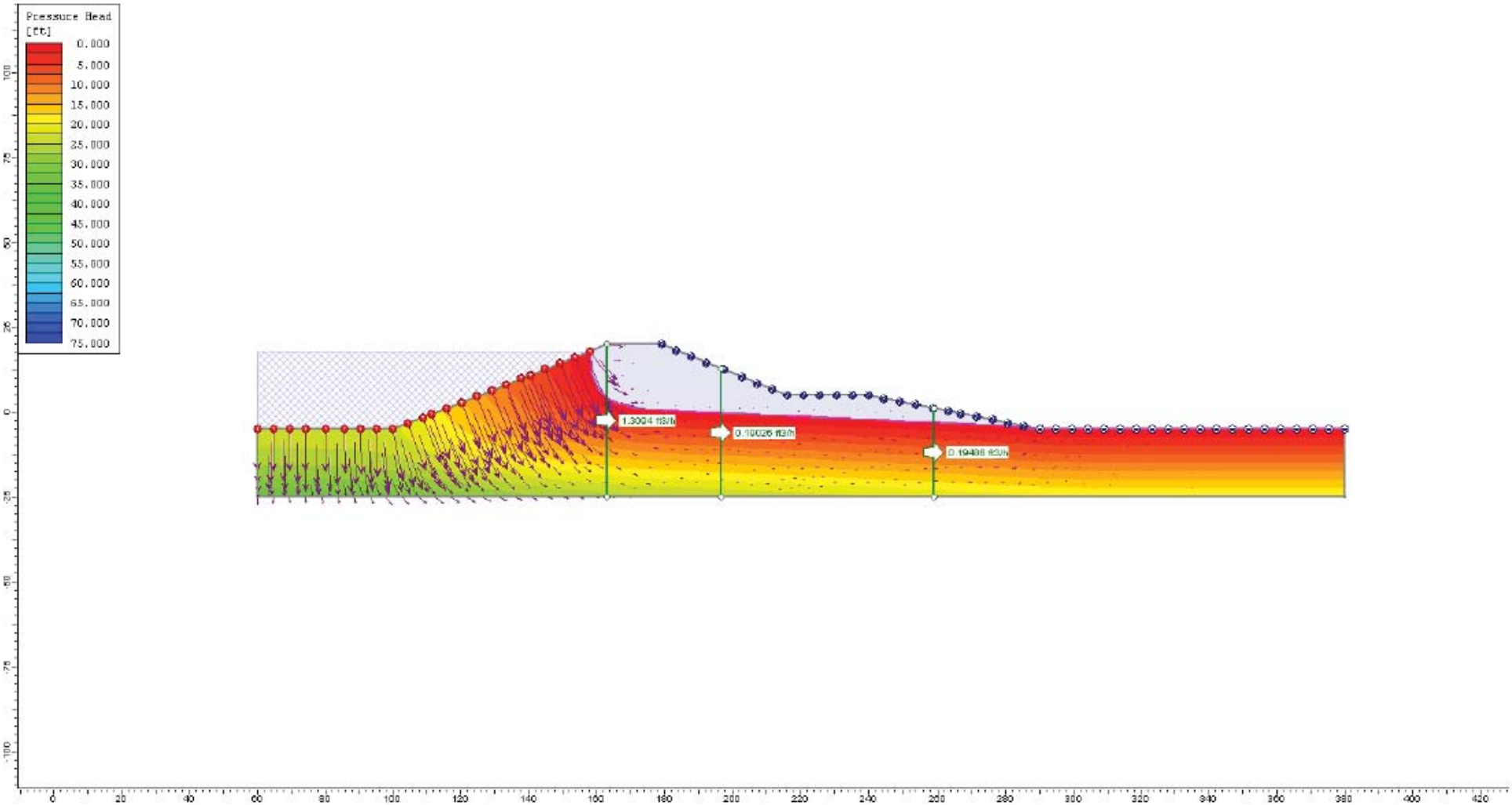
Stage 7 – 24 hours after the start of the Flood

PLATE F-24



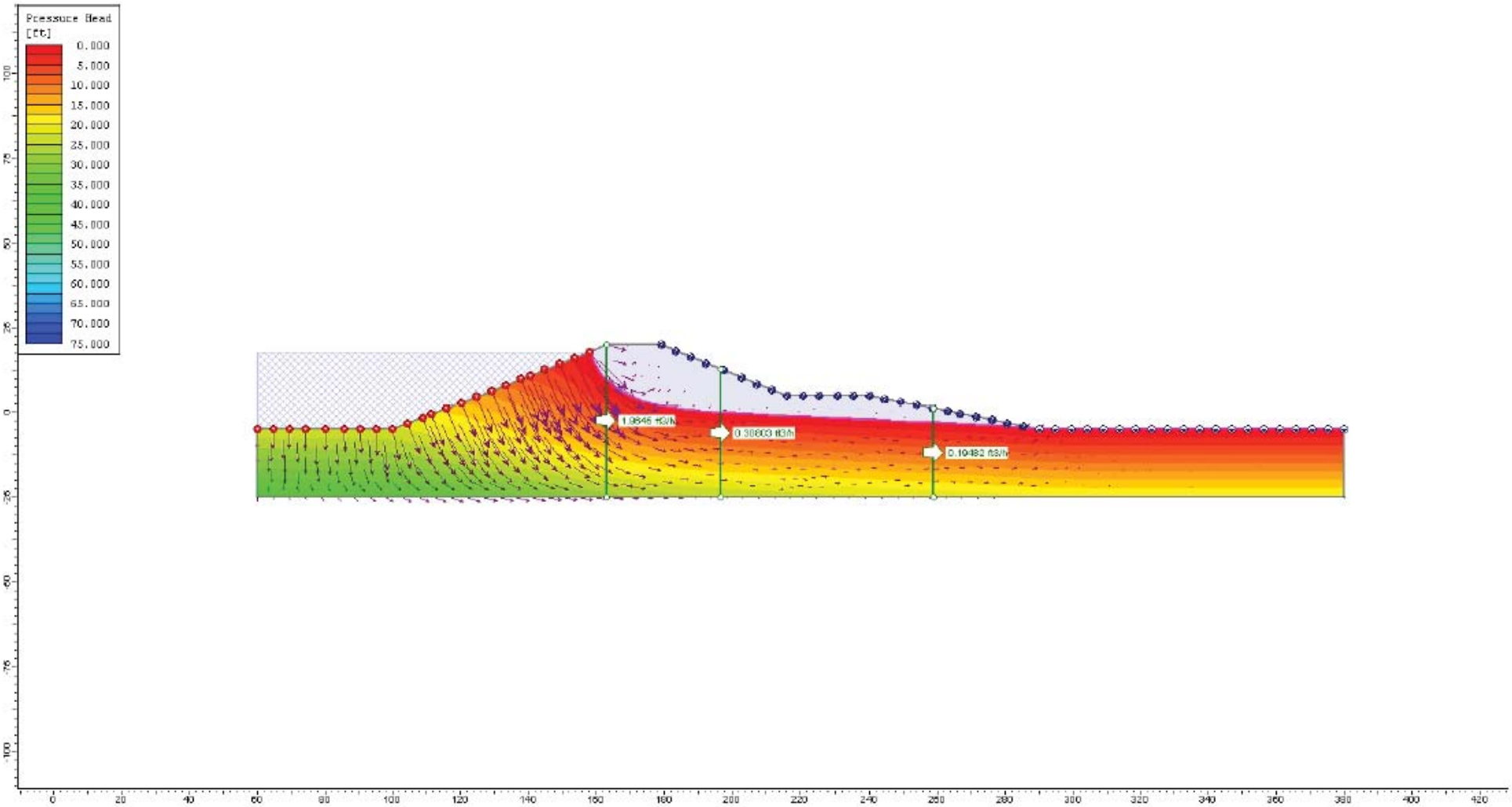
Stage 8 – 48 hours after the start of the Flood

PLATE F-25



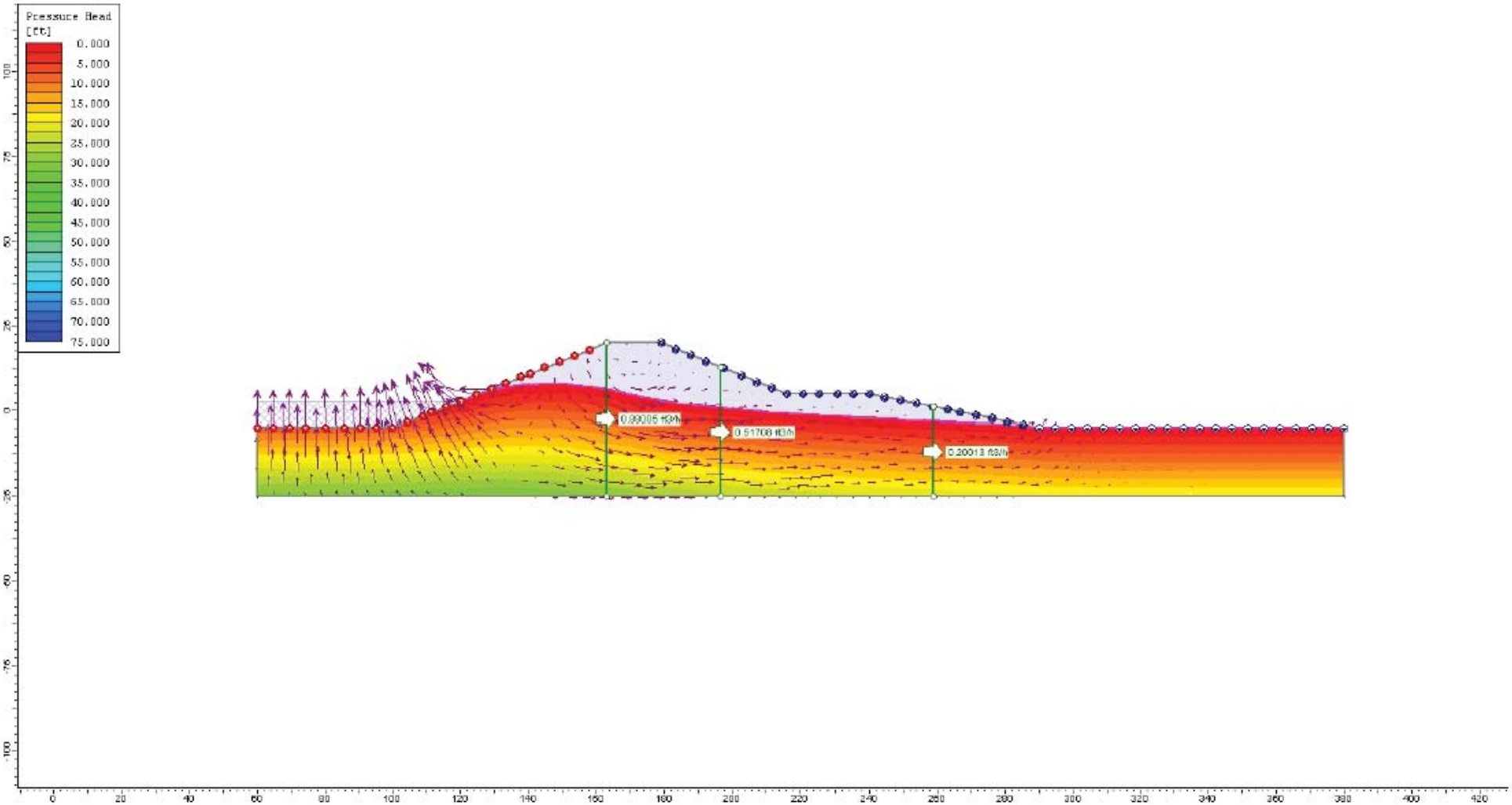
Stage 9 – 4 days after the start of the Flood

PLATE F-26



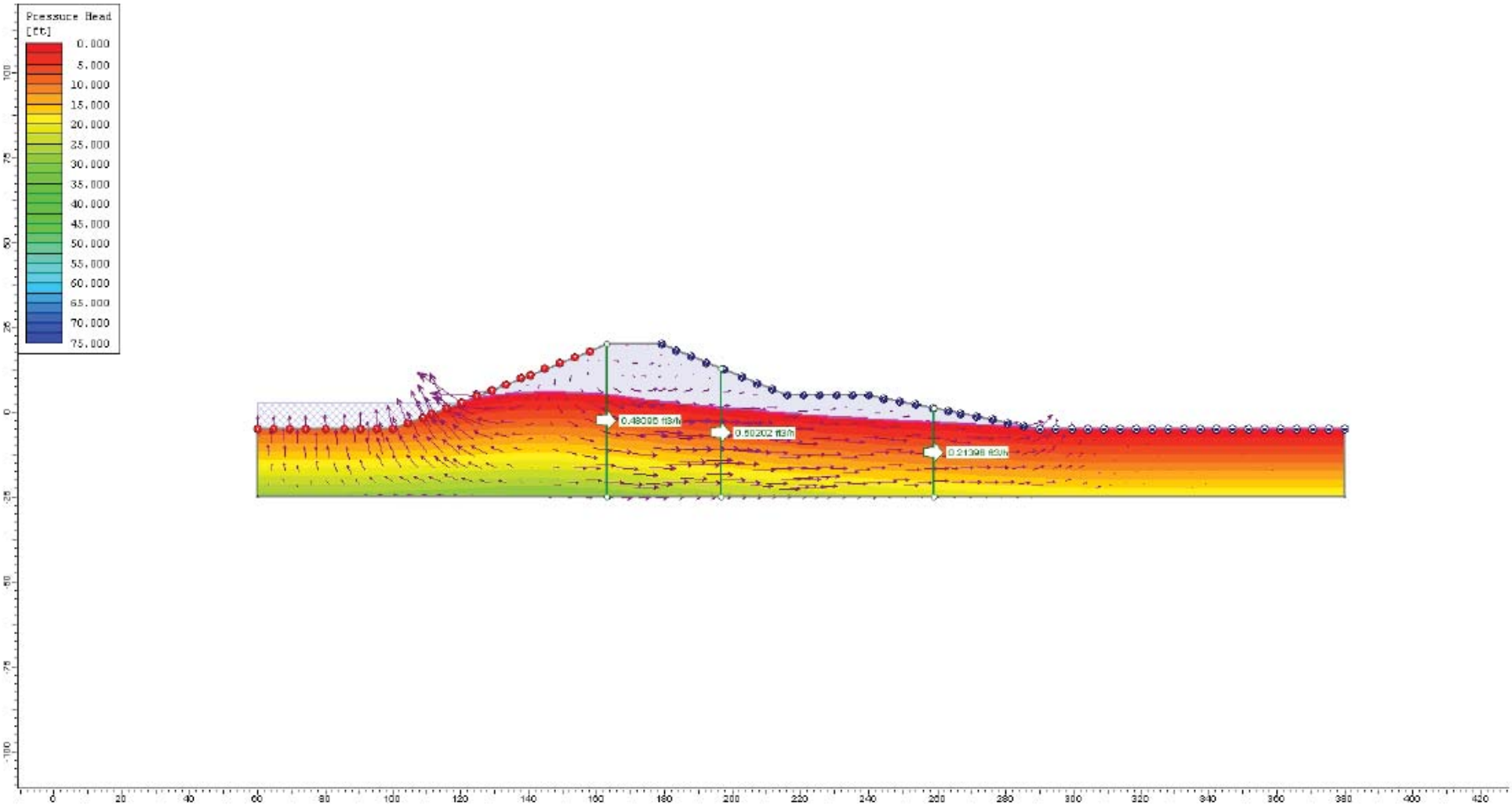
Stage 10 – 10 days after the start of the Flood (End of Flood)

PLATE F-27



Stage 11 – 10 days after the 10-day Flood

PLATE F-28



Stage 12 – 20 days after the 10-day Flood

PLATE F-29

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APPENDIX G
SLOPE STABILITY

APPENDIX G
SLOPE STABILITY

G.1 Summary of Contents

This appendix includes the following:

- Generalized soil profiles adopted for slope stability analyses of the levees.
- Soil strength parameters criteria, and adopted values for slope stability analyses.
- Strength gain calculations under the West Area B levees using SHANSEP method
- Summary of static analyses for end of construction (short term low water), short term high water, long term high water (steady state) for selected sections, seismic post liquefaction analysis, and analyses for determination of yield acceleration and seismic displacements using Bray and Rathje (1998) method, and potential mitigation measures for reducing seismic displacements for two sections of the existing levees.
- Comparison of FLAC SLOPE results with RocScience Slide v.5 Results
- Analysis results showing the effect of water level fluctuation of seismic deformations of existing levees

G.2 Generalized Soil Profile Tables

Generalized soils profiles shown in Tables G-1 thru G-12 were adopted based on the estimates of soil strength parameters using our boring and CPT and laboratory testing results for the conservative boring/CPT layering within each area.

G.3 Soil Strength Parameters

Soil strength parameter selection criteria are shown graphically in Plates G-7 through G-15. The undrained shear strengths within Areas A and B were selected based on vane shear test results corrected for plasticity index (using Bjerrum, 1972 chart), as well as CPT tip resistances in each area.

Plates G-10 and G-11 show the results of direct shear tests performed on Fill soils in Areas A and B, and also include the conservatively adopted shear strength parameters for Fills soils in all areas. The soil strength for the embankments (levees) was selected to have just slightly higher cohesion than the soil strength parameters for Fill soils, since the soils used for embankments will be primary comprised of Fill soils, but will be well compacted to 90% relative compaction; hence the higher cohesion.

Plates G-12 through G-15 show the profiles of CPTs within different areas, with potentially liquefiable layers/depths highlighted in green, on the CPTs. The adopted extents (depths) of potentially liquefiable layers are also shown within different areas. The post liquefaction residual shear strength values were determined based on

average $(N1)_{60cs}$ of representative liquefiable layers using Seed and Harder (1990) graph, as shown on the Plates.

G.4 Soil Strength Gain (SHANSEP)

The shallow clayey soils underlying portions of West Area B are naturally very soft with undrained shear strengths on the order of 300 psf, under current conditions. However, after placement of the fill these soils will consolidate and gain strength. The strength gain for clayey soils can be determined using the SHANSEP method, as presented in plates G-16 through G-22.

The SHANSEP strength gain analysis for these clayey soils assumed that the soils at a depth of 15 feet and beyond are normally consolidated, and the overconsolidation ratio (OCR) decreases linearly from 2 to 1 from a depth of 5 to 15 feet. The upper 5 feet of the profile were assumed to be Fill soils of different nature and strength parameters.

Assuming normally consolidated clayey soils with a strength of about 300 psf exist at a depth of 15 feet, the shear strength ratio, $(Su/\sigma v')_{NC}$ for normally consolidated was found to be 0.27. After calculating the increase in vertical effective stresses at different locations along the levee cross section as a result of construction of the levee, the final vertical effective stresses were calculated (Plate G-16). The increased shear strength for normally consolidated soils were then determined by multiplying the shear strength ratio, $(Su/\sigma v')_{NC}$ by the final vertical effective stresses, at each location along the levee section (Plate G-17).

A simplified strength layering was then used in levee slope stability analyses for West Area B levees, based on the results of the SHANSEP method.

G.5 Slope Stability Analyses

Static and seismic levee slope stability analyses were performed for different loading conditions at 12 distinct cross sections of both new and portions of the existing levees that remain as part of the project. Additionally, the static stability of portions of the existing north levee that will be breached after/during construction of the new meander channels was analyzed. The analyses were performed in FLAC/Slope V.7. The output plot and the input geometry and layering of each of the analyses are included in this appendix, as shown in Plates G-23 through G-144.

For the portions of the existing levees that will tie in to the new levees and remain as part of the project, the seismic displacements were found to be higher than generally acceptable. Analyses showing possible mitigation measures using ground improvement by Deep Soil Mixing (DSM) are also shown for two of the sections (Sections D-D' and E-E'). Rapid drawdown is not a likely condition, and a viable mode of failure for the Ballona Wetlands levees, and was not included in the levee stability analyses.

G.6 Examples of Comparison of FLAC SLOPE FOS with RocScience Slide

The FOS results from FLAC SLOPE were compared with the results of the RocScience Slide v.5 Slope Stability Program, for a number of Sections and Load Cases. As can be seen from the results shown on Plates G-145 thru G-147, the estimated FOS values from Slide v.5 are agreement with the estimated FOS values from FLAC Slope with variations on the order of 3%, or less. This validates the results of our slope stability analyses.

G.7 Analysis Results Showing the Effect of Water Level Fluctuation of Seismic Deformations of Existing Levees

The effect of changes in water level in the channel on the seismic displacements predicted for the existing levees was investigated for the existing levee located immediately downstream of Lincoln Boulevard (Section E-E') for the following four water levels:

- Case 1 – The water in the channel and in the area outside the channel coincide with the ground surface elevation of +7 feet. This is the design groundwater condition adopted for the previously presented seismic stability analyses of existing levees (Results presented in Plates G-69 and G-70).
- Case 2 – The water in the channel and in the area outside the channel is at Elevation +3 feet. This condition approximately corresponds to the average tidal condition (Plates G-148 and G-149).
- Case 3 – A water level in the channel at Elevation +0 feet (corresponding to low tide) and a groundwater level outside the channel at Elevation +7 feet (Plates G-150 and G-151).
- Case 4 – A water level in the channel of +0 feet and a groundwater level outside the channel at Elevation +3 feet (Plates G-152 and G-153).

The yield accelerations change slightly depending on the variation in water levels; however, estimated seismic displacement for each case is unacceptable. Therefore, mitigations are recommended as described in the text.

A list of the plates presented in this appendix follows:

Plate G-1 and G-6	Soil Profile Tables for Slope Stability
Plate G-7 and G-9	Undrained Shear Strength of Fine Grained Soils
Plate G-10 and G-11	Soil Strength Parameters for Fill Soils
Plate G-12 thru G-15	Liquefied Layers and Residual Strength Values for Difference Areas
Plate G-16 thru G-22	Strength Gain under West Area B Levees using SHANSEP Method
Plates G-23 thru G-33	Static and Seismic/Deformation Analyses – Section A-A'
Plates G-34 thru G-43	Static and Seismic/Deformation Analyses – Section B-B'
Plates G-44 thru G-51	Static and Seismic/Deformation Analyses – Section C-C'
Plates G-52 thru G-62	Static and Seismic/Deformation Analyses and Potential Mitigation Measures – Section D-D'
Plates G-63 thru G-73	Static and Seismic/Deformation Analyses and Potential Mitigation Measures – Section E-E'
Plates G-74 thru G-82	Static and Seismic/Deformation Analyses – Section F-F'
Plates G-83 thru G-93	Static and Seismic/Deformation Analyses - Section G-G'
Plates G-94 thru G-102	Static and Seismic/Deformation Analyses - Section H-H'
Plates G-103 thru G-113	Static and Seismic/Deformation Analyses – Section I-I'
Plates G-114 thru G-122	Static and Seismic/Deformation Analyses – Section J-J'
Plates G-123 thru G-131	Static and Seismic/Deformation Analyses – Section K-K'
Plates G-132 thru G-140	Static and Seismic/Deformation Analyses – Section L-L'
Plates G-141 thru G-144	Static Analyses of Existing North Levee during Meander Channel Excavation
Plates G-145 thru G-147	Comparison of FLAC Slope FOS values with RocScience Slide for a few sections and load cases
Plates G-148 thru G-153	Effect of Water Level Fluctuations on Seismic Deformation of Existing Levees (Section E-E')

Table G-1: East Area A Static Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)
		From	To		
Embankment	115	20	10	28	300
Fill	115	10	0	28	250
Soft Clay	115	0	-20	0	500 [1]
Stiff Clay	115	-20	-35	0	1200
Dense Sand	120	-35	-55	35	0

Notes: 1) For drained condition, $\phi = 27$, c = 200 psf

Table G-2: East Area A Seismic Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)	Post-Liquefaction Strength (psf)
		From	To			
Embankment	115	20	10	28	300	N/A
Liquefied Fill	115	10	0	N/A	N/A	300
Soft Clay	115	0	-15	0	500 [1]	N/A
Liq Sand	115	-15	-30	N/A	N/A	400
Stiff Clay	115	-30	-35	0	1200	N/A
Dense Sand	120	-35	-55	35	0	N/A

Notes: 1) For drained condition, $\phi = 27$, c = 200 psf

Table G-3: West Area A Static Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)
		From	To		
Embankment	115	20	10	28	300
Fill	115	10	0	28	250
Soft Clay	115	0	-25	0	500 [1]
Stiff Clay	115	-25	-52	0	1000
Dense Sand	120	-52	-55	35	0

Notes: 1) For drained condition, $\phi = 27$, c = 200 psf

Table G-4: West Area A Seismic Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)	Post-Liquefaction Strength (psf)
		From	To			
Embankment	115	20	10	28	300	N/A
Liquefied Fill	115	10	0	N/A	N/A	300
Soft Clay	115	0	-20	0	500 [1]	N/A
Liq Sand	115	-20	-25	N/A	N/A	400
Stiff Clay	115	-25	-33	0	1000	N/A
Liq Sand 2	115	-33	-45	N/A	N/A	500
Stiff Clay	115	-45	-52	0	1000	N/A
Dense Sand	120	-35	-55	35	0	N/A

Notes: 1) For drained condition, $\phi = 27$, c = 200 psf

Table G-5: East Ballona Creek Static Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)
		From	To		
Embankment	115	20	7	28	300
Soft Clay	115	7	-10	0	500 [1]
Stiff Clay	115	-10	-25	0	1000 [1]
Med. Sand	115	-25	-35	33	0
Stiff Clay	115	-35	-45	0	1000 [1]
Dense Sand	120	-45	-55	35	0

Notes: 1) For drained condition, $\phi = 34$, c = 0 psf

Table G-6: East Ballona Creek Seismic Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)	Post-Liquefaction Strength (psf)
		From	To			
Embankment	115	20	7	28	300	N/A
Liquefied Sand	115	7	-3	N/A	N/A	300
Soft Clay	115	-3	-10	0	500 [1]	N/A
Stiff Clay	115	-10	-20	0	1000 [1]	N/A
Liq Sand 2	115	-20	-35	N/A	N/A	550
Stiff Clay	115	-35	-45	0	1000 [1]	N/A
Dense Sand	120	-45	-55	35	0	N/A

Notes: 1) For drained condition, $\phi = 34$, c = 0 psf

Table G-7: East Area B Static Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)
		From	To		
Embankment	115	20	9	28	300
Fill	115	9	2	28	250
Soft Clay	115	2	-10	0	500 [1]
Med. Sand	115	-10	-15	33	0
Med. Stiff Clay	115	-15	-48	0	600 [1]
Dense Sand	120	-48	-55	35	0

Notes: 1) For drained condition, $\phi = 34$, c = 0 psf

Table G-8: East Area B Seismic Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)	Post-Liquefaction Strength (psf)
		From	To			
Embankment	115	20	9	28	300	N/A
Liquefied Fill	115	9	2	N/A	N/A	300
Soft Clay	115	2	-10	0	500 [1]	N/A
Liq Sand	115	-10	-13	N/A	N/A	300
Med Stiff Clay	115	-13	-20	0	600 [1]	N/A
Liq Sand	115	-20	-42	N/A	N/A	300
Med Stiff Clay	115	-42	-48	0	600 [1]	N/A
Dense Sand	120	-48	-55	35	0	N/A

Notes: 1) For drained condition, $\phi = 34$, c = 0 psf

Table G-9: West Area B Static Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)
		From	To		
Embankment	115	20	7	28	300
Fill	115	7	2	28	250
Soft Clay	115	2	-12	0	300 [1,2]
Med. Sand	115	-12	-34	33	0
Stiff Clay	115	-34	-43	0	1000 [1]
Med. Sand	115	-43	-48	33	0
Dense Sand	120	-48	-55	35	0

Notes: 1) For drained condition, $\phi = 34$, c = 0 psf

2) Undrained shear strength underneath the levee is higher due levee surcharge

Table G-10: West Area B Seismic Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)	Post-Liquefaction Strength (psf)
		From	To			
Embankment	115	20	7	28	300	N/A
Liquefied Fill	115	7	2	N/A	N/A	300
Soft Clay	115	2	-12	0	300 [1,2]	N/A
Liq Sand	115	-12	-34	N/A	N/A	300
Stiff Clay	115	-34	-43	0	1000 [1]	N/A
Liq Sand 2	115	-43	-48	N/A	N/A	500
Dense Sand	120	-48	-55	35	0	N/A

Notes: 1) For drained condition, $\phi = 34$, c = 0 psf

2) Undrained shear strength underneath the levee is higher due levee surcharge

Table G-11: Area C Static Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)
		From	To		
Fill	115	20	5	28	250
Soft Clay	115	5	-3	0	500 [1]
Med. Sand	115	-3	-13	33	0
Stiff Clay	115	-13	-33	0	1200
Dense Sand	120	-33	-55	35	0

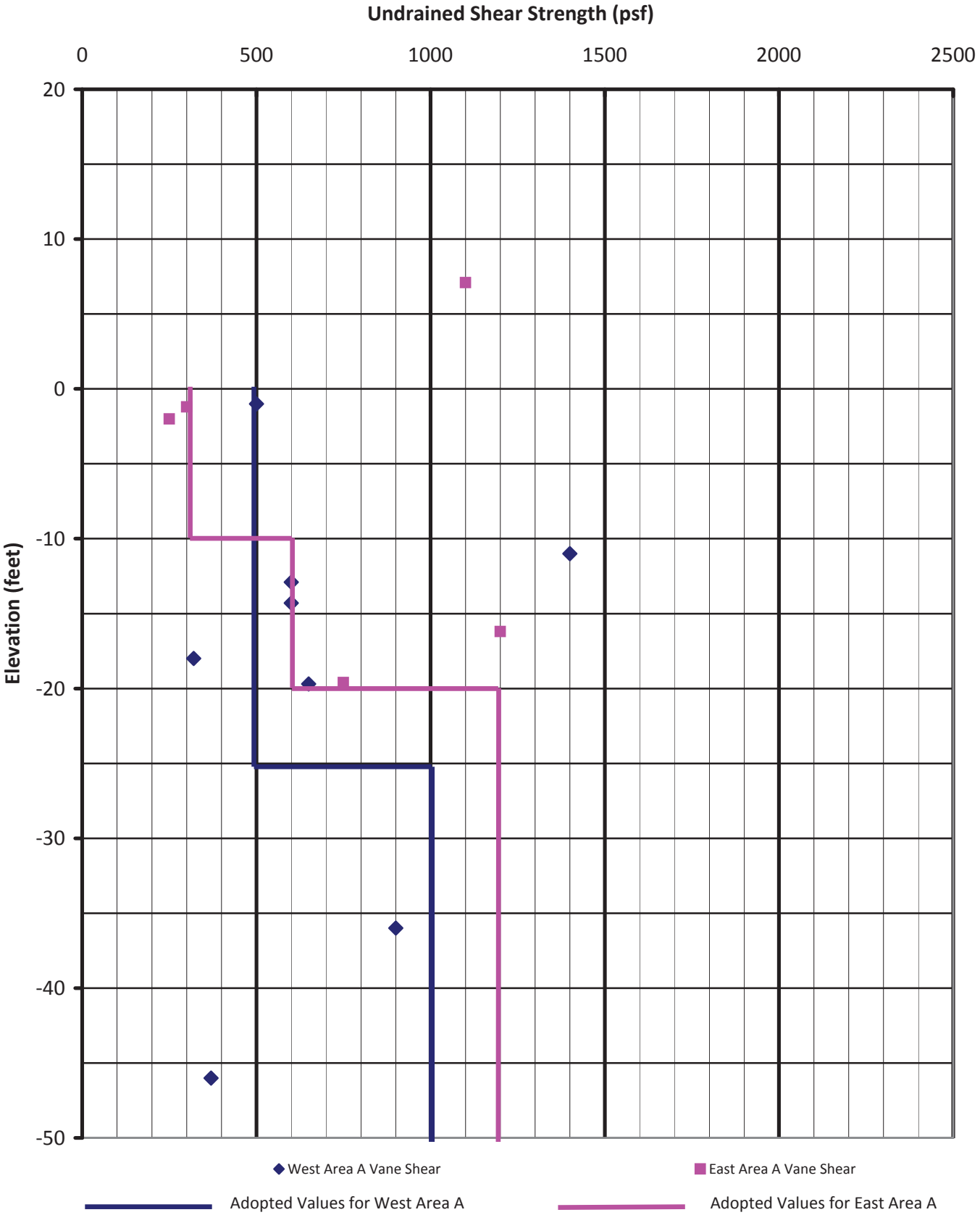
Notes: 1) For drained condition, $\phi = 27$, c = 200 psf

Table G-12: Area C Seismic Profile

Layer	Total Unit Weight (pcf)	Elevation (feet)		Friction Angle (Degrees)	Cohesion (psf)	Post-Liquefaction Strength (psf)
		From	To			
Fill	115	20	5	28	250	N/A
Soft Clay	115	5	-3	0	500 [1]	N/A
Med. Sand	115	-3	-8	33	0	N/A
Liq Sand	115	-8	-13	N/A	N/A	400
Stiff Clay	115	-13	-20	0	1200	N/A
Liq Sand 2	115	-20	-27	N/A	N/A	500
Stiff Clay	115	-27	-33	0	1200	N/A
Dense Sand	120	-33	-55	35	0	N/A

Notes: 1) For drained condition, $\phi = 27$, c = 200 psf

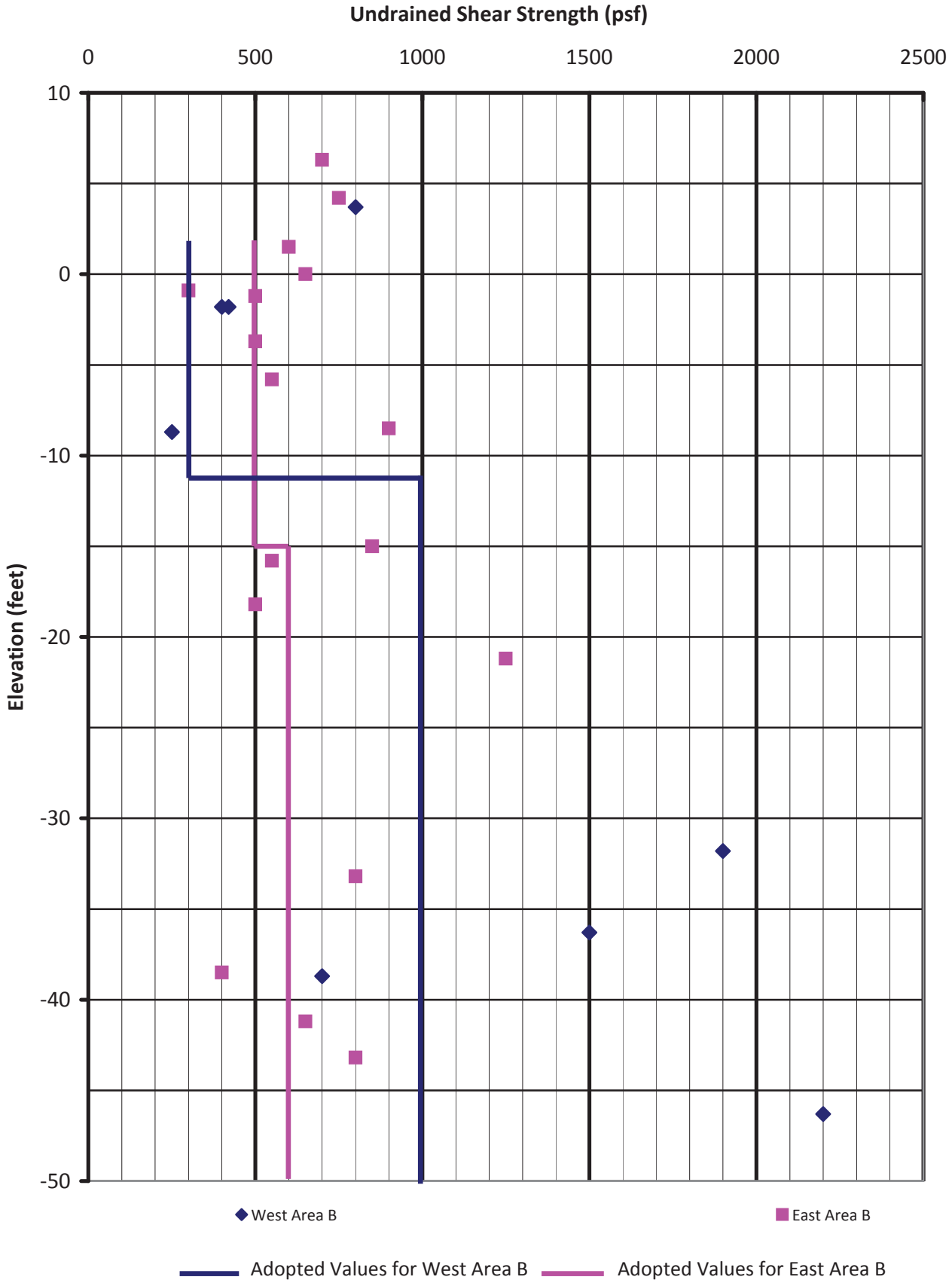
Area A - Undrained Shear Strength



Note: 1) The points shown on the graph are Vane Shear Strength Values adjusted based on Plasticity Index using Bjerrum (1972) Curve.
2) The adopted values consider the results of Lab Vane Shear, as well as estimates of undrained shear strength from CPT data.

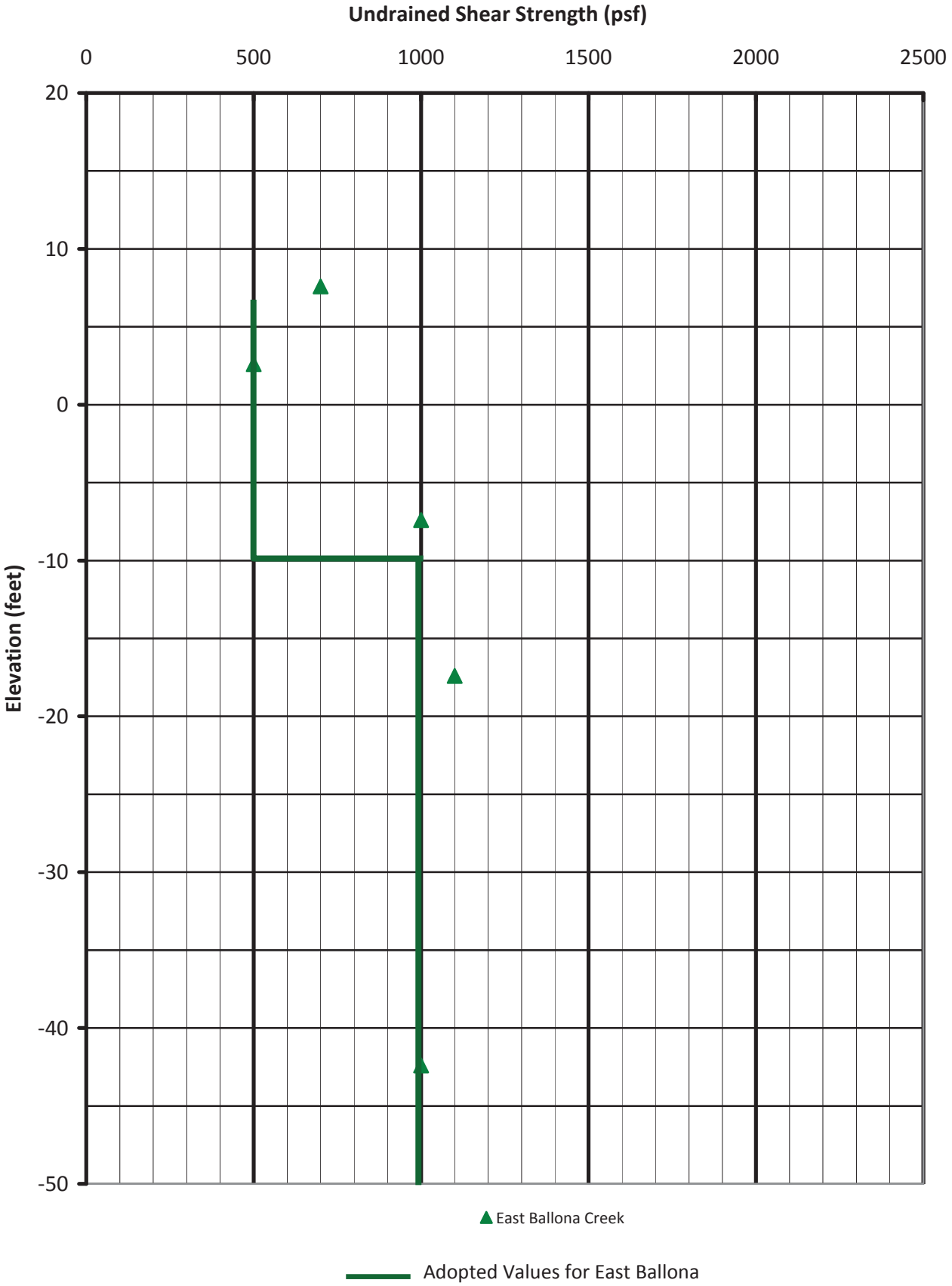
PLATE G-7

Area B - Undrained Shear Strength



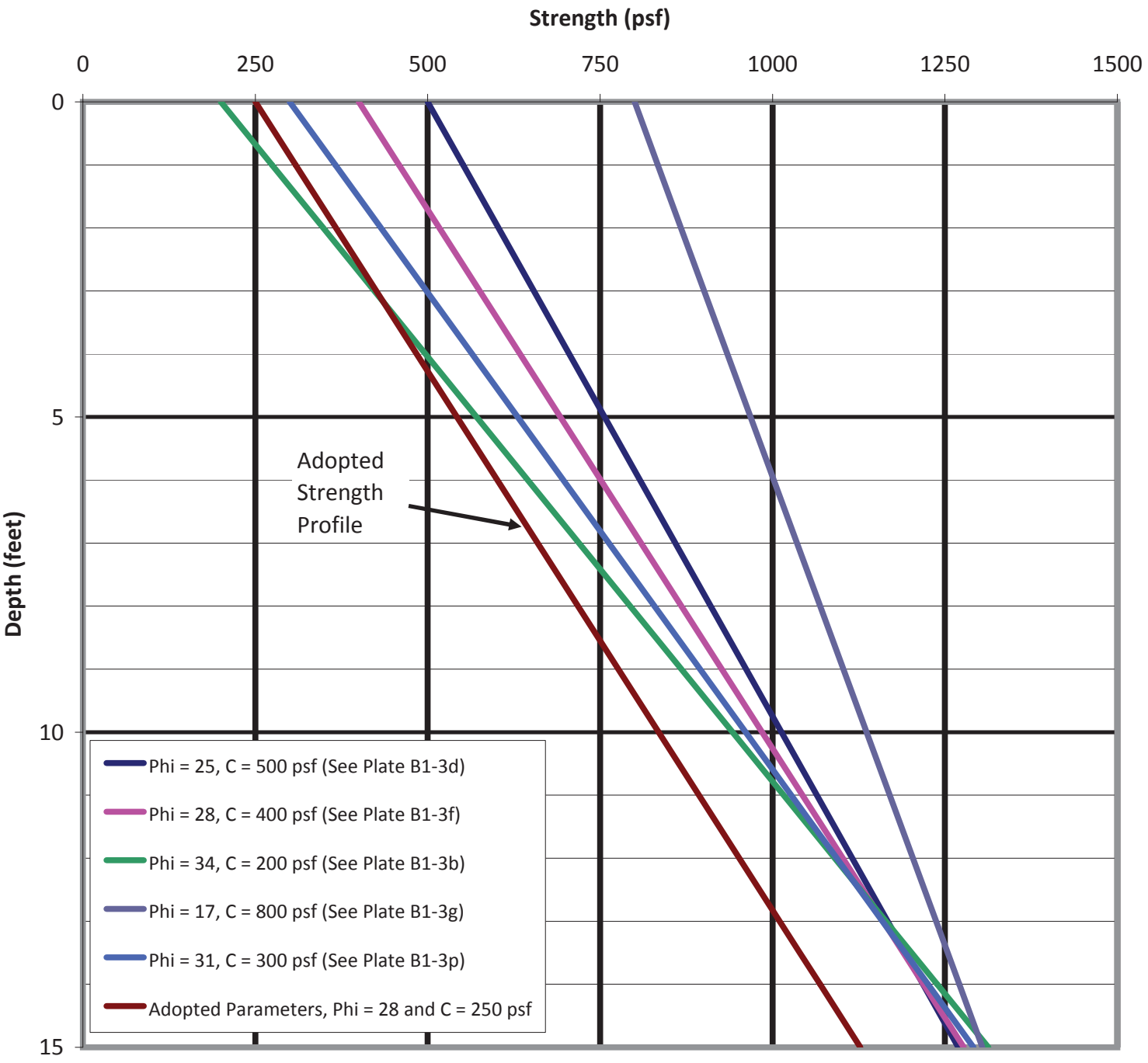
Note: 1) The points shown on the graph are Vane Shear Strength Values adjusted based on Plasticity Index using Bjerrum (1972) Curve.
2) The adopted values consider the results of Lab Vane Shear, as well as estimates of undrained shear strength from CPT data.

East Ballona Creek - Undrained Shear Strength



Note: 1) The points shown on the graph are Vane Shear Strength Values adjusted based on Plasticity Index using Bjerrum (1972) Curve.
2) The adopted values consider the results of Lab Vane Shear, as well as estimates of undrained shear strength from CPT data.

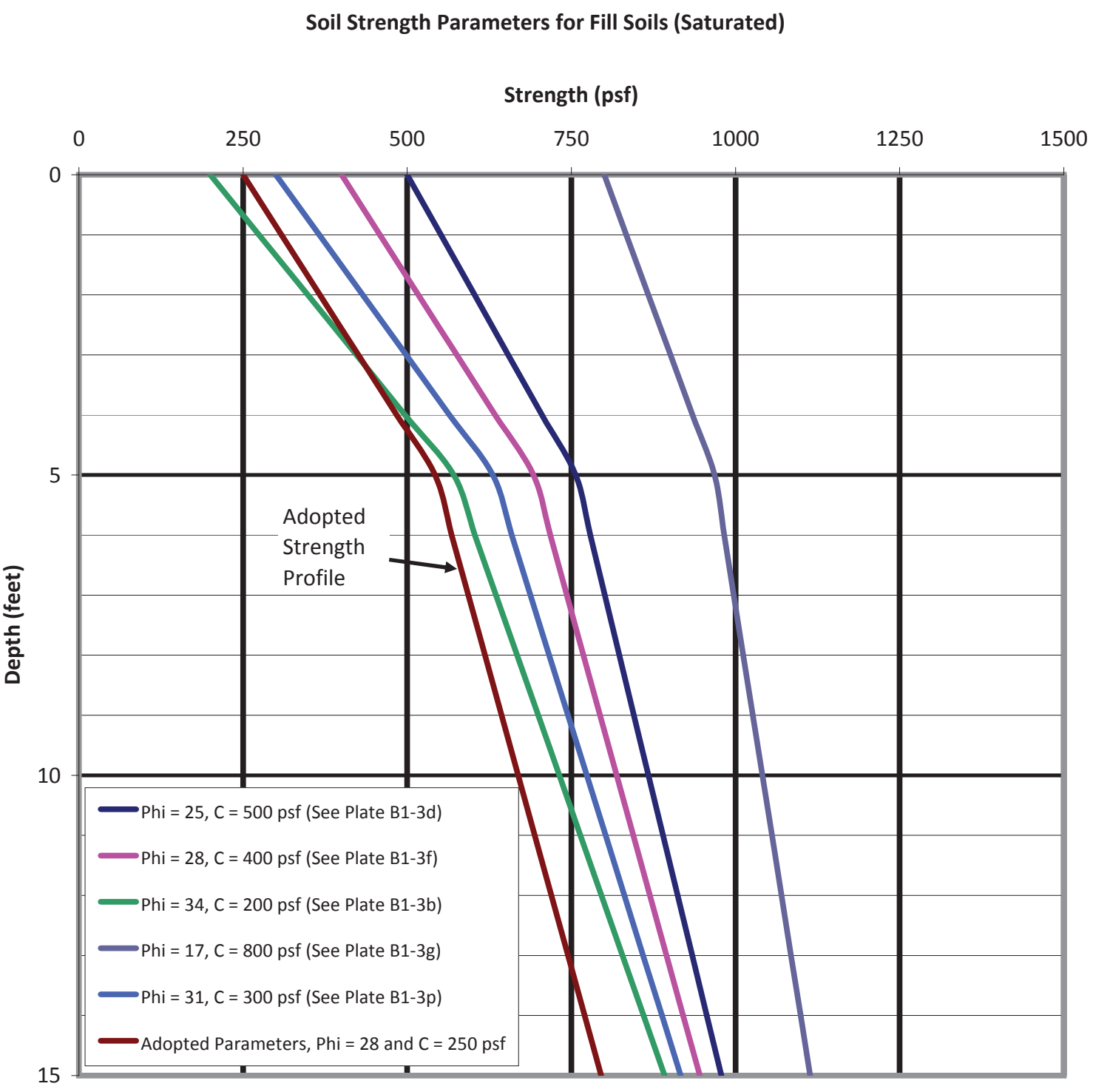
Soil Strength Parameters for Fill Soils (Unsaturated)



Note: 1) The lines shown are strength profiles versus depth using Parameters found from Direct Shear Tests on Near Surface Fill Soils.

2) The adopted profile is generally conservative, based on a Phi = 28 degrees, and C = 250 psf.

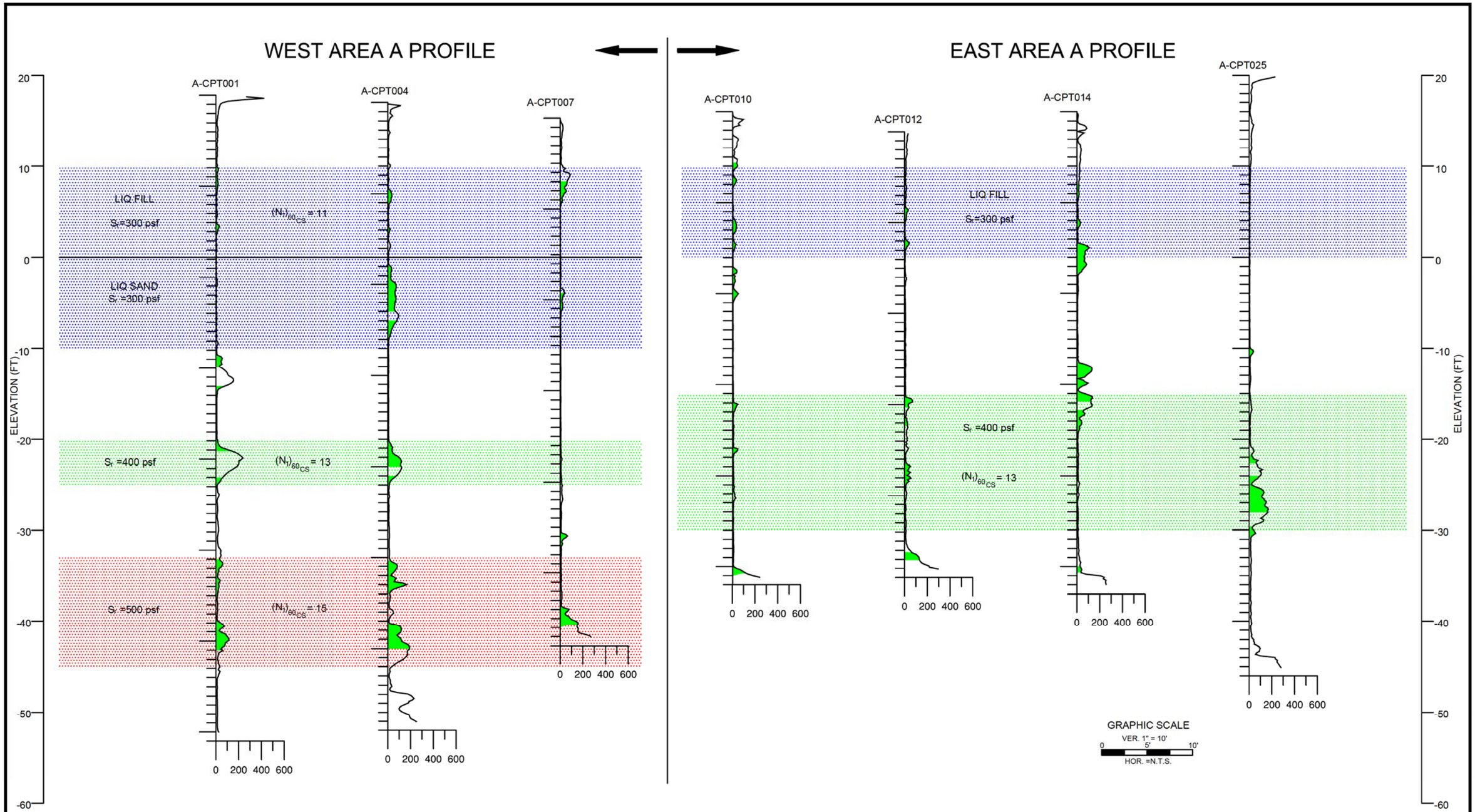
3) The adopted soil parameters for Embankment Soils are Phi = 28 degrees, and C = 300 psf, assuming proper compaction.



Note: 1) The lines shown are strength profiles versus depth using Parameters found from Direct Shear Tests on Near Surface Fill Soils, and assuming a groundwater depth of 5 feet.

2) The adopted profile is generally conservative, based on a Phi = 28 degrees, and C = 250 psf.

3) The adopted soil parameters for Embankment Soils are Phi = 28 degrees, and C = 300 psf, assuming proper compaction.



LEGEND

NOTE

(1) SOME CPT'S ARE SHOWN PROJECTED.

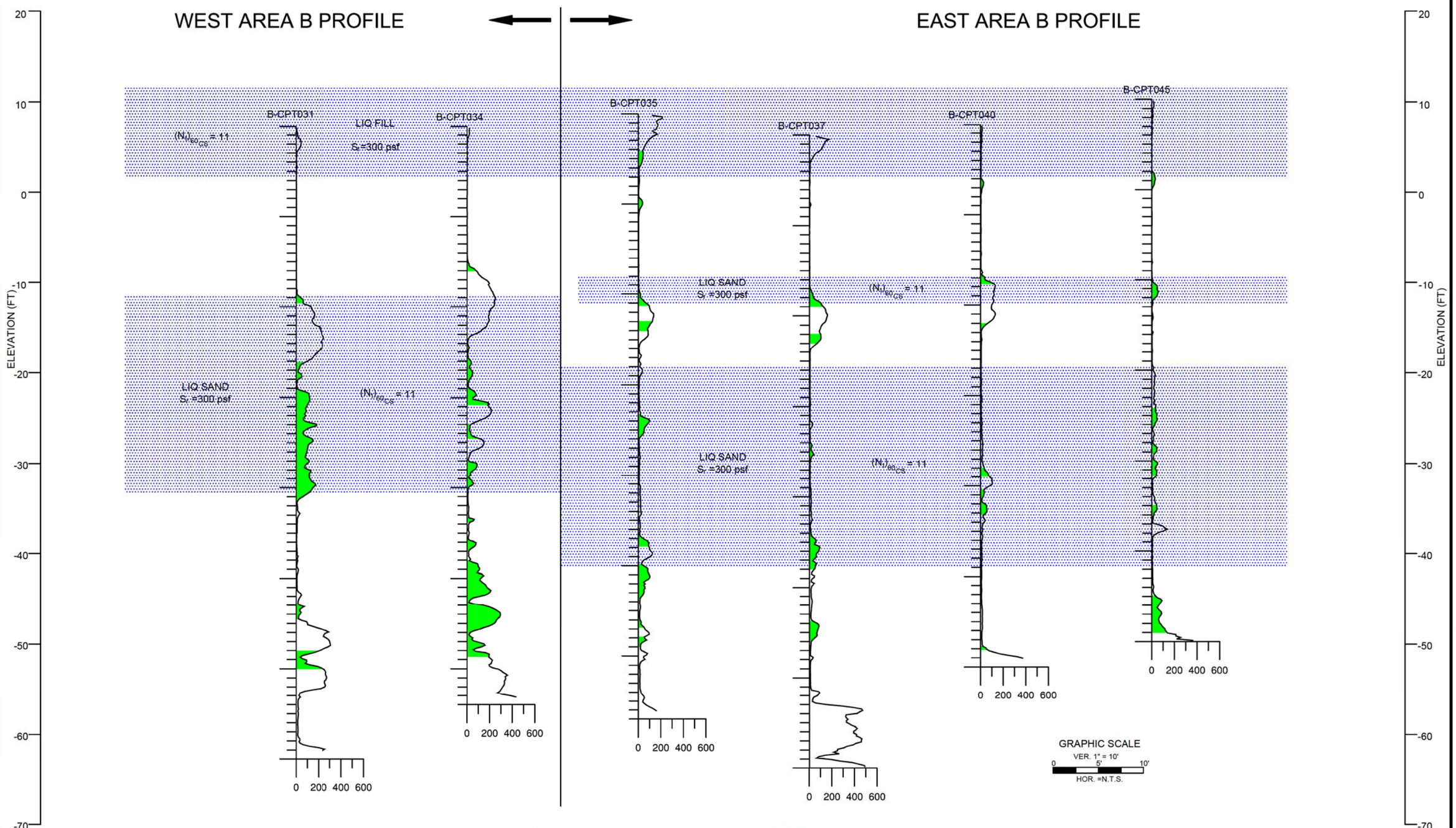
(2) THE CROSS SECTION IS BASED ON GEOLOGIC INTERPRETATION OF CONDITIONS ENCOUNTERED AT EXPLORATION LOCATIONS. ACTUAL CONDITIONS MAY VARY BETWEEN EXPLORATIONS.

DATE: 2/28/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	LIQUEFIED LAYERS ALONG AREA A PERIMETER LEVEE
REVISION: 3/5/2013	APPROVED BY: P. Kashighandi		BALLONA WETLANDS RESTORATION PROJECT LOS ANGELES, CA
REVISION:			

PROJECT NUMBER: L962A

SCALE: AS SHOWN

PLATE NUMBER: G-12



LEGEND

NOTE

(1) SOME CPT'S ARE SHOWN PROJECTED.

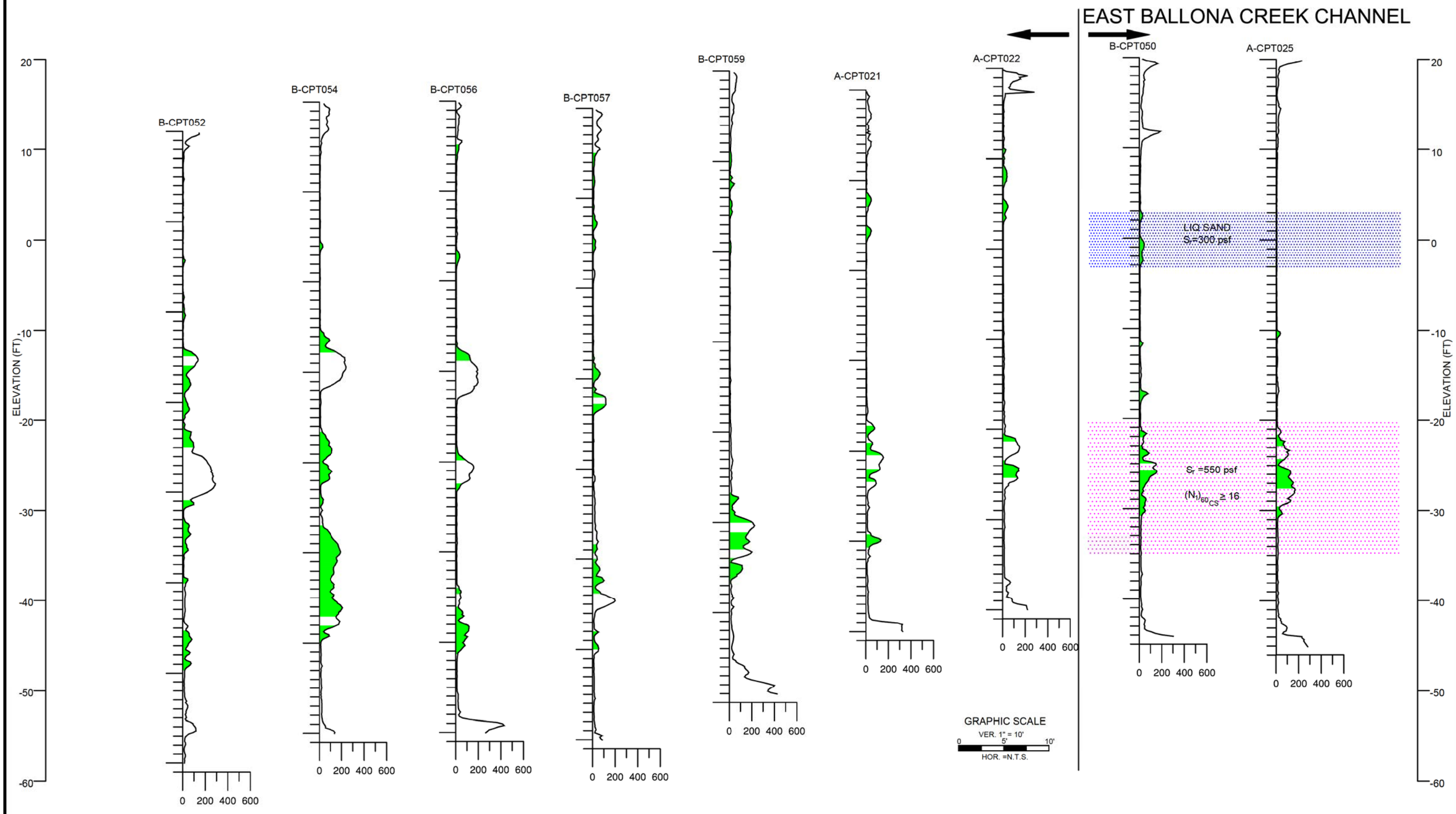
(2) THE CROSS SECTION IS BASED ON GEOLOGIC INTERPRETATION OF CONDITIONS ENCOUNTERED AT EXPLORATION LOCATIONS. ACTUAL CONDITIONS MAY VARY BETWEEN EXPLORATIONS.

DATE: 2/28/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	LIQUEFIED LAYERS ALONG AREA B PERIMETER LEVEE
REVISION: 3/5/2013	APPROVED BY: P. Kashighandi		BALLONA WETLANDS RESTORATION PROJECT LOS ANGELES, CA
REVISION:			

PROJECT NUMBER: L962A

SCALE: AS SHOWN

PLATE NUMBER: G-13



LEGEND

NOTE

(1) SOME CPT'S ARE SHOWN PROJECTED.

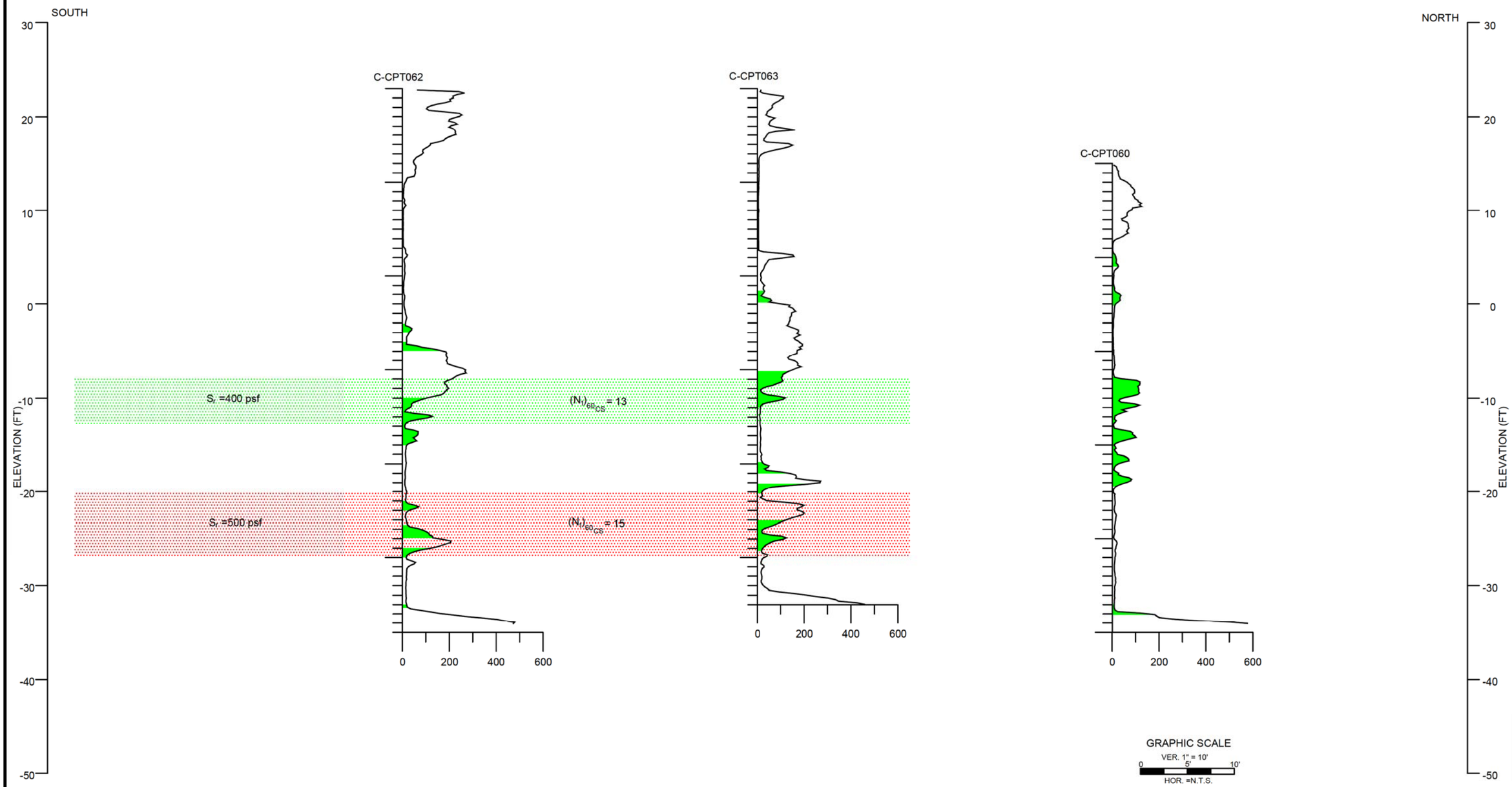
(2) THE CROSS SECTION IS BASED ON GEOLOGIC INTERPRETATION OF CONDITIONS ENCOUNTERED AT EXPLORATION LOCATIONS. ACTUAL CONDITIONS MAY VARY BETWEEN EXPLORATIONS.

DATE: 2/28/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	LIQUEFIED LAYERS ALONG BALLONA CREEK LEVEE
REVISION: 3/5/2013	APPROVED BY: P. Kashighandi		BALLONA WETLANDS RESTORATION PROJECT LOS ANGELES, CA
REVISION:			

PROJECT NUMBER: L962A

SCALE: AS SHOWN

PLATE NUMBER: G-14



LEGEND

NOTE

(1) SOME CPT'S ARE SHOWN PROJECTED.

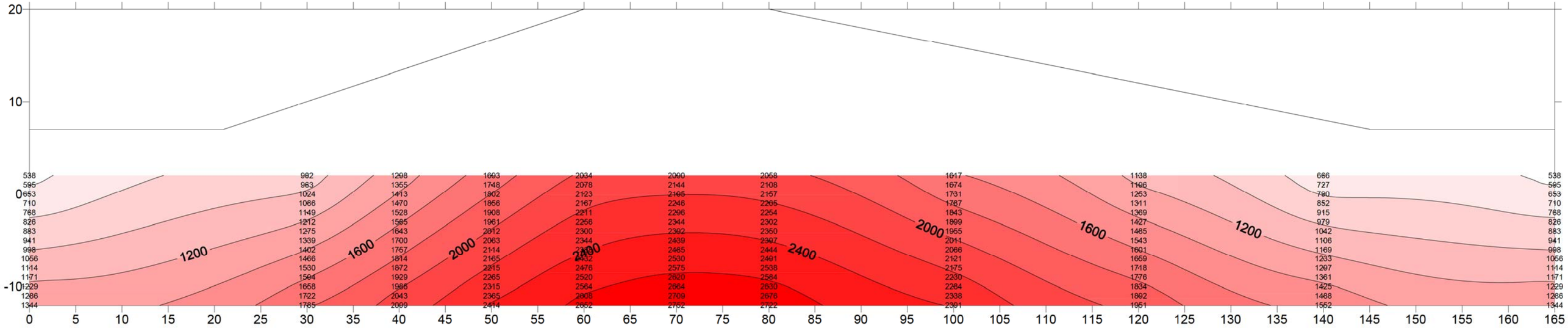
(2) THE CROSS SECTION IS BASED ON GEOLOGIC INTERPRETATION OF CONDITIONS ENCOUNTERED AT EXPLORATION LOCATIONS. ACTUAL CONDITIONS MAY VARY BETWEEN EXPLORATIONS.

DATE: 2/28/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	LIQUEFIED LAYERS WITHIN AREA C
REVISION: 3/5/2013	APPROVED BY: P. Kashighandi		BALLONA WETLANDS RESTORATION PROJECT LOS ANGELES, CA
REVISION:			

PROJECT NUMBER: L962A

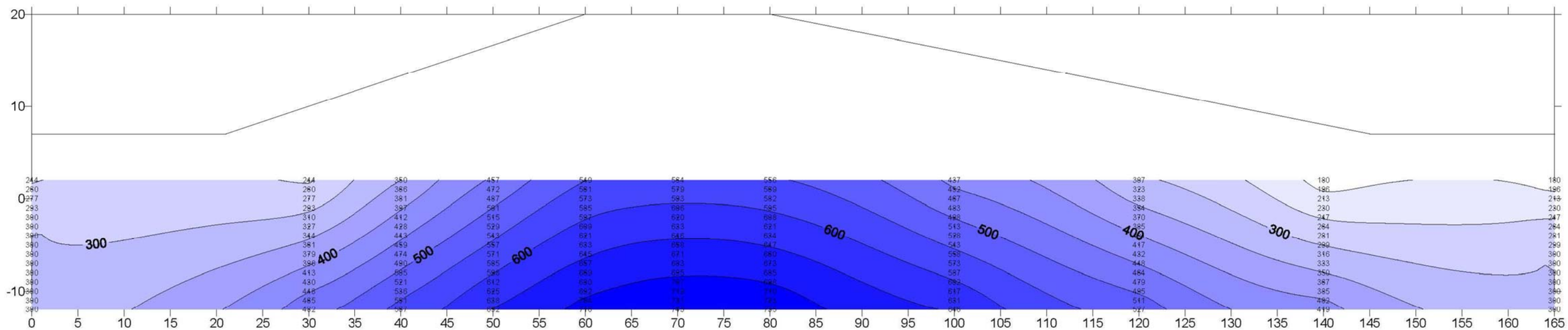
SCALE: AS SHOWN

FIGURE NUMBER: G-15



Stresses under West Area B Levees

PLATE G-16



SHANSEP assuming Normal Consolidation at 15', with $S_u = 300$ psf

$$\sigma_v' = 4 \times 120 + 11 \times (120 - 62.4) = 1114 \text{ psf}$$

$$\left(\frac{S_u}{\sigma_v'}\right)_{NC} = \left(\frac{300}{1114}\right) = \underline{0.27}$$

Typical Range

$$\left(\frac{S_u}{\sigma_v'}\right) \simeq 0.11 + 0.0037\,(\overset{40}{PI}) = 0.26$$

$$\left(\frac{S_u}{\sigma_v'}\right) \simeq 0.45\left(\frac{LL}{100}\right) = 0.45\,(0.7) = 0.32$$

Undrained Shear Strength Gain Due to Surcharging Under West Area B Levees using SHANSEP

PLATE G-17

Center of Embankment

Elev.	Depth	$\sigma v'_{init.}$	OCR	σ p	$\Delta\sigma$	$\sigma v'_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	1,553	2,090	564
1	6	595	1.9	1131	1,548	2,144	579
0	7	653	1.8	1175	1,543	2,195	593
-1	8	710	1.7	1208	1,536	2,246	606
-2	9	768	1.6	1229	1,528	2,296	620
-3	10	826	1.5	1238	1,518	2,344	633
-4	11	883	1.4	1236	1,508	2,392	646
-5	12	941	1.3	1223	1,498	2,439	658
-6	13	998	1.2	1198	1,486	2,485	671
-7	14	1056	1.1	1162	1,474	2,530	683
-8	15	1114	1.0	1114	1,462	2,575	695
-9	16	1171	1.0	1171	1,449	2,620	707
-10	17	1229	1.0	1229	1,436	2,664	719
-11	18	1286	1.0	1286	1,422	2,709	731
-12	19	1344	1.0	1344	1,408	2,752	743

Dry Side Edge of Crest

Elev.	Depth	$\sigma v'_{init.}$	OCR	σ p	$\Delta\sigma$	$\sigma v'_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	1,496	2,034	549
1	6	595	1.9	1131	1,483	2,078	561
0	7	653	1.8	1175	1,470	2,123	573
-1	8	710	1.7	1208	1,457	2,167	585
-2	9	768	1.6	1229	1,443	2,211	597
-3	10	826	1.5	1238	1,430	2,256	609
-4	11	883	1.4	1236	1,417	2,300	621
-5	12	941	1.3	1223	1,403	2,344	633
-6	13	998	1.2	1198	1,390	2,388	645
-7	14	1056	1.1	1162	1,376	2,432	657
-8	15	1114	1.0	1114	1,363	2,476	669
-9	16	1171	1.0	1171	1,349	2,520	680
-10	17	1229	1.0	1229	1,335	2,564	692
-11	18	1286	1.0	1286	1,322	2,608	704
-12	19	1344	1.0	1344	1,308	2,652	716

Undrained Shear Strength Gain Due to Surcharging Under West Area B Levees using SHANSEP

Water Side Edge of Crest

Elev.	Depth	$\sigma v'_{init.}$	OCR	σp	$\Delta\sigma$	$\sigma v'_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	1,521	2,058	556
1	6	595	1.9	1131	1,512	2,108	569
0	7	653	1.8	1175	1,504	2,157	582
-1	8	710	1.7	1208	1,495	2,205	595
-2	9	768	1.6	1229	1,486	2,254	608
-3	10	826	1.5	1238	1,476	2,302	621
-4	11	883	1.4	1236	1,466	2,350	634
-5	12	941	1.3	1223	1,456	2,397	647
-6	13	998	1.2	1198	1,446	2,444	660
-7	14	1056	1.1	1162	1,435	2,491	673
-8	15	1114	1.0	1114	1,424	2,538	685
-9	16	1171	1.0	1171	1,413	2,584	698
-10	17	1229	1.0	1229	1,402	2,630	710
-11	18	1286	1.0	1286	1,390	2,676	723
-12	19	1344	1.0	1344	1,378	2,722	735

10 foot Dry Side of Crest

Elev.	Depth	$\sigma v'_{init.}$	OCR	σp	$\Delta\sigma$	$\sigma v'_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	1,156	1,693	457
1	6	595	1.9	1131	1,153	1,748	472
0	7	653	1.8	1175	1,149	1,802	487
-1	8	710	1.7	1208	1,145	1,856	501
-2	9	768	1.6	1229	1,140	1,908	515
-3	10	826	1.5	1238	1,135	1,961	529
-4	11	883	1.4	1236	1,129	2,012	543
-5	12	941	1.3	1223	1,123	2,063	557
-6	13	998	1.2	1198	1,116	2,114	571
-7	14	1056	1.1	1162	1,109	2,165	585
-8	15	1114	1.0	1114	1,101	2,215	598
-9	16	1171	1.0	1171	1,094	2,265	612
-10	17	1229	1.0	1229	1,086	2,315	625
-11	18	1286	1.0	1286	1,078	2,365	638
-12	19	1344	1.0	1344	1,070	2,414	652

Undrained Shear Strength Gain Due to Surcharging Under West Area B Levees using SHANSEP

20 foot Dry Side of Crest

Elev.	Depth	$\sigma v'_{init.}$	OCR	σp	$\Delta\sigma$	$\sigma v'_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	760	1,298	350
1	6	595	1.9	1131	760	1,355	366
0	7	653	1.8	1175	760	1,413	381
-1	8	710	1.7	1208	760	1,470	397
-2	9	768	1.6	1229	760	1,528	412
-3	10	826	1.5	1238	760	1,585	428
-4	11	883	1.4	1236	759	1,643	443
-5	12	941	1.3	1223	759	1,700	459
-6	13	998	1.2	1198	759	1,757	474
-7	14	1056	1.1	1162	758	1,814	490
-8	15	1114	1.0	1114	758	1,872	505
-9	16	1171	1.0	1171	757	1,929	521
-10	17	1229	1.0	1229	757	1,986	536
-11	18	1286	1.0	1286	756	2,043	551
-12	19	1344	1.0	1344	755	2,099	567

30 foot Dry Side of Crest

Elev.	Depth	$\sigma v'_{init.}$	OCR	σp	$\Delta\sigma$	$\sigma v'_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	365	902	**244**
1	6	595	1.9	1131	368	963	**260**
0	7	653	1.8	1175	372	1,024	**277**
-1	8	710	1.7	1208	376	1,086	**293**
-2	9	768	1.6	1229	381	1,149	**310**
-3	10	826	1.5	1238	386	1,212	**327**
-4	11	883	1.4	1236	392	1,275	344
-5	12	941	1.3	1223	398	1,339	361
-6	13	998	1.2	1198	404	1,402	379
-7	14	1056	1.1	1162	410	1,466	396
-8	15	1114	1.0	1114	416	1,530	413
-9	16	1171	1.0	1171	423	1,594	430
-10	17	1229	1.0	1229	429	1,658	448
-11	18	1286	1.0	1286	435	1,722	465
-12	19	1344	1.0	1344	441	1,785	482

Note: Bold Su values imply that soils are still overconsolidated.
Strength gain is more than what's shown for overconsolidated depths

Undrained Shear Strength Gain Due to Surcharging Under West Area B Levees using SHANSEP

20 foot Water Side of Crest

Elev.	Depth	σv' $_{init.}$	OCR	σ p	Δσ	σv' $_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	1,079	1,617	437
1	6	595	1.9	1131	1,079	1,674	452
0	7	653	1.8	1175	1,078	1,731	467
-1	8	710	1.7	1208	1,077	1,787	483
-2	9	768	1.6	1229	1,075	1,843	498
-3	10	826	1.5	1238	1,074	1,899	513
-4	11	883	1.4	1236	1,072	1,955	528
-5	12	941	1.3	1223	1,070	2,011	543
-6	13	998	1.2	1198	1,067	2,066	558
-7	14	1056	1.1	1162	1,065	2,121	573
-8	15	1114	1.0	1114	1,062	2,175	587
-9	16	1171	1.0	1171	1,058	2,230	602
-10	17	1229	1.0	1229	1,055	2,284	617
-11	18	1286	1.0	1286	1,051	2,338	631
-12	19	1344	1.0	1344	1,047	2,391	646

40 foot Water Side of Crest

Elev.	Depth	σv' $_{init.}$	OCR	σ p	Δσ	σv' $_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	600	1,138	307
1	6	595	1.9	1131	600	1,196	323
0	7	653	1.8	1175	601	1,253	338
-1	8	710	1.7	1208	601	1,311	354
-2	9	768	1.6	1229	601	1,369	370
-3	10	826	1.5	1238	601	1,427	385
-4	11	883	1.4	1236	602	1,485	401
-5	12	941	1.3	1223	602	1,543	417
-6	13	998	1.2	1198	603	1,601	432
-7	14	1056	1.1	1162	603	1,659	448
-8	15	1114	1.0	1114	604	1,718	464
-9	16	1171	1.0	1171	605	1,776	479
-10	17	1229	1.0	1229	605	1,834	495
-11	18	1286	1.0	1286	606	1,892	511
-12	19	1344	1.0	1344	607	1,951	527

Undrained Shear Strength Gain Due to Surcharging Under West Area B Levees using SHANSEP

60 foot Water Side of Crest

Elev.	Depth	$\sigma v'_{init.}$	OCR	σp	$\Delta\sigma$	$\sigma v'_{final}$	Su (psf)
7	0	0					Fil
6	1	120					Fil
5	2	240					Fil
4	3	360					Fil
3	4	480					Fil
2	5	538	2.0	1075	128	666	**180**
1	6	595	1.9	1131	132	727	**196**
0	7	653	1.8	1175	137	790	**213**
-1	8	710	1.7	1208	142	852	**230**
-2	9	768	1.6	1229	147	915	**247**
-3	10	826	1.5	1238	153	979	**264**
-4	11	883	1.4	1236	159	1,042	**281**
-5	12	941	1.3	1223	165	1,106	**299**
-6	13	998	1.2	1198	171	1,169	**316**
-7	14	1056	1.1	1162	177	1,233	333
-8	15	1114	1.0	1114	183	1,297	350
-9	16	1171	1.0	1171	190	1,361	367
-10	17	1229	1.0	1229	196	1,425	385
-11	18	1286	1.0	1286	202	1,488	402
-12	19	1344	1.0	1344	208	1,552	419

Note: Bold Su values imply that soils are still overconsolidated.
Strength gain is more than what's shown for overconsolidated depths

Undrained Shear Strength Gain Due to Surcharging Under West Area B Levees using SHANSEP

JOB TITLE : Section A-A' - End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 11:07

Factor of Safety 3.39

Shear Strain Rate Contours

- 5.00E-08
- 1.00E-07
- 1.50E-07
- 2.00E-07
- 2.50E-07
- 3.00E-07
- 3.50E-07
- 4.00E-07
- 4.50E-07

Contour interval= 5.00E-08
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

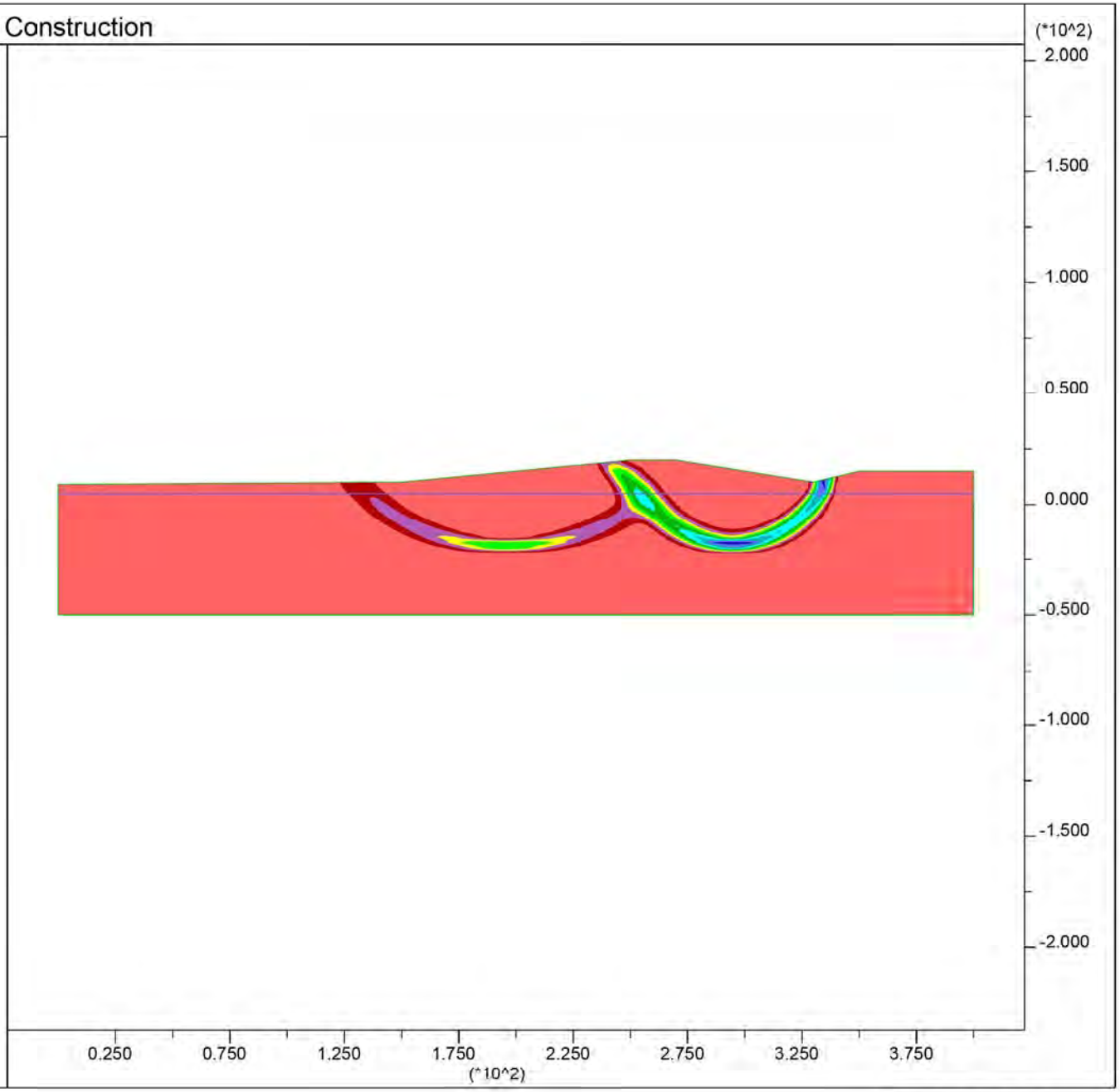


PLATE G-23

JOB TITLE : Section A-A' - End of Construction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 11:04

Factor of Safety 3.39

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

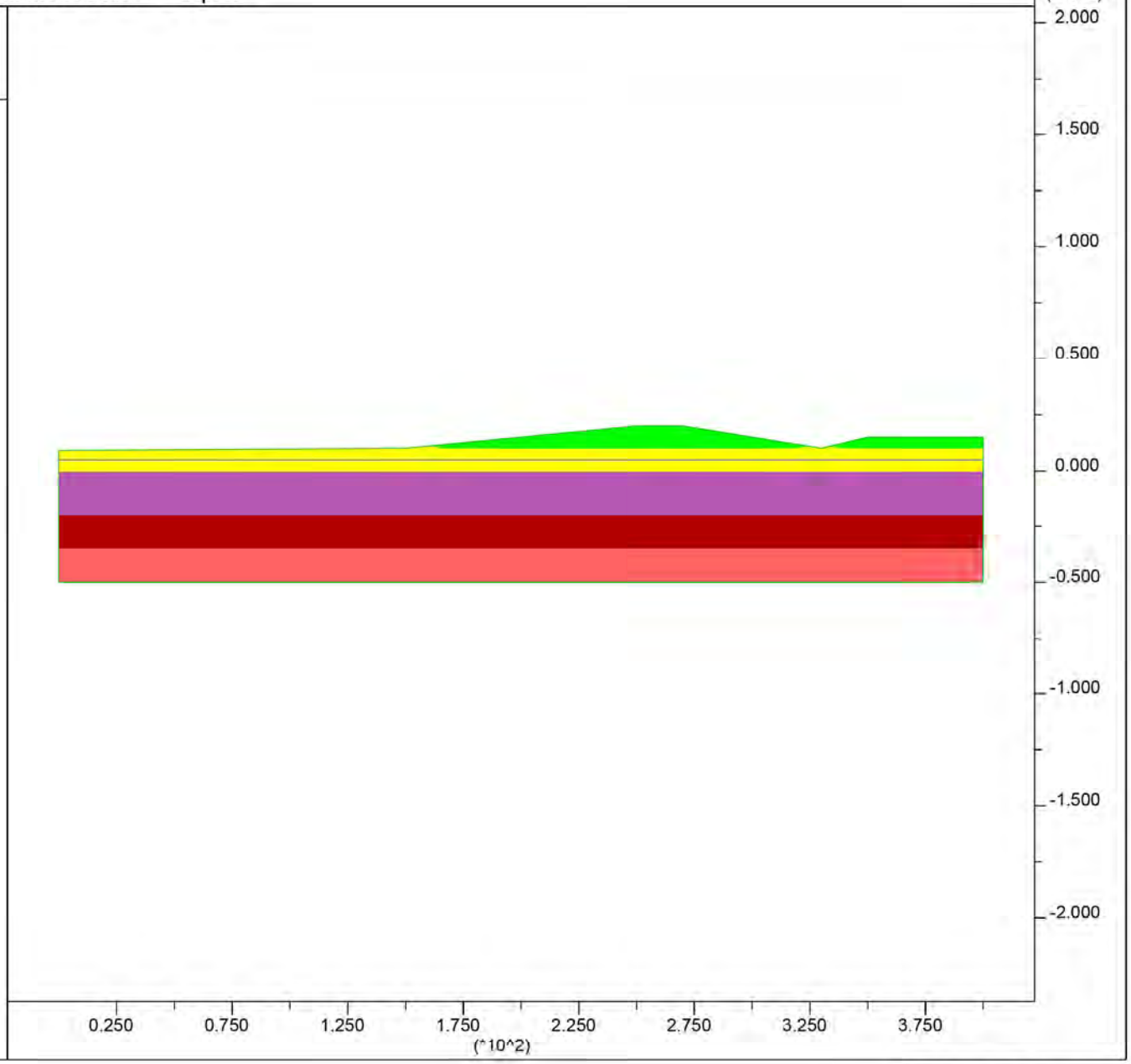


PLATE G-24

JOB TITLE : Section A-A' - High Water Short Term

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 11:09

Factor of Safety 3.35

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06
- 1.75E-06
- 2.00E-06
- 2.25E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.247E+03

Group Delta Consultants
Ballona Wetlands

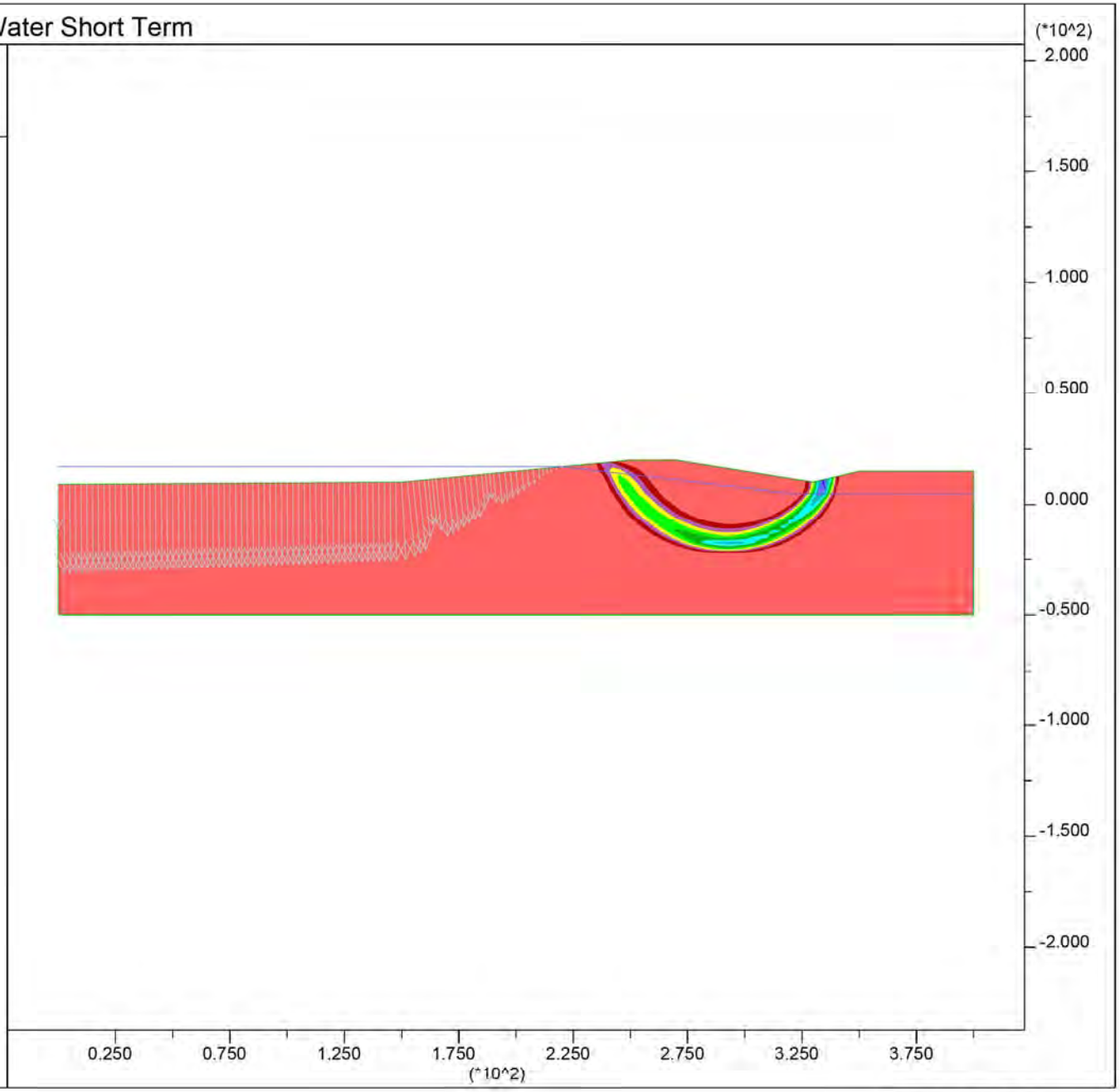


PLATE G-25

JOB TITLE : Section A-A' - High Water Short Term - Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 11:04

Factor of Safety 3.35

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.247E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

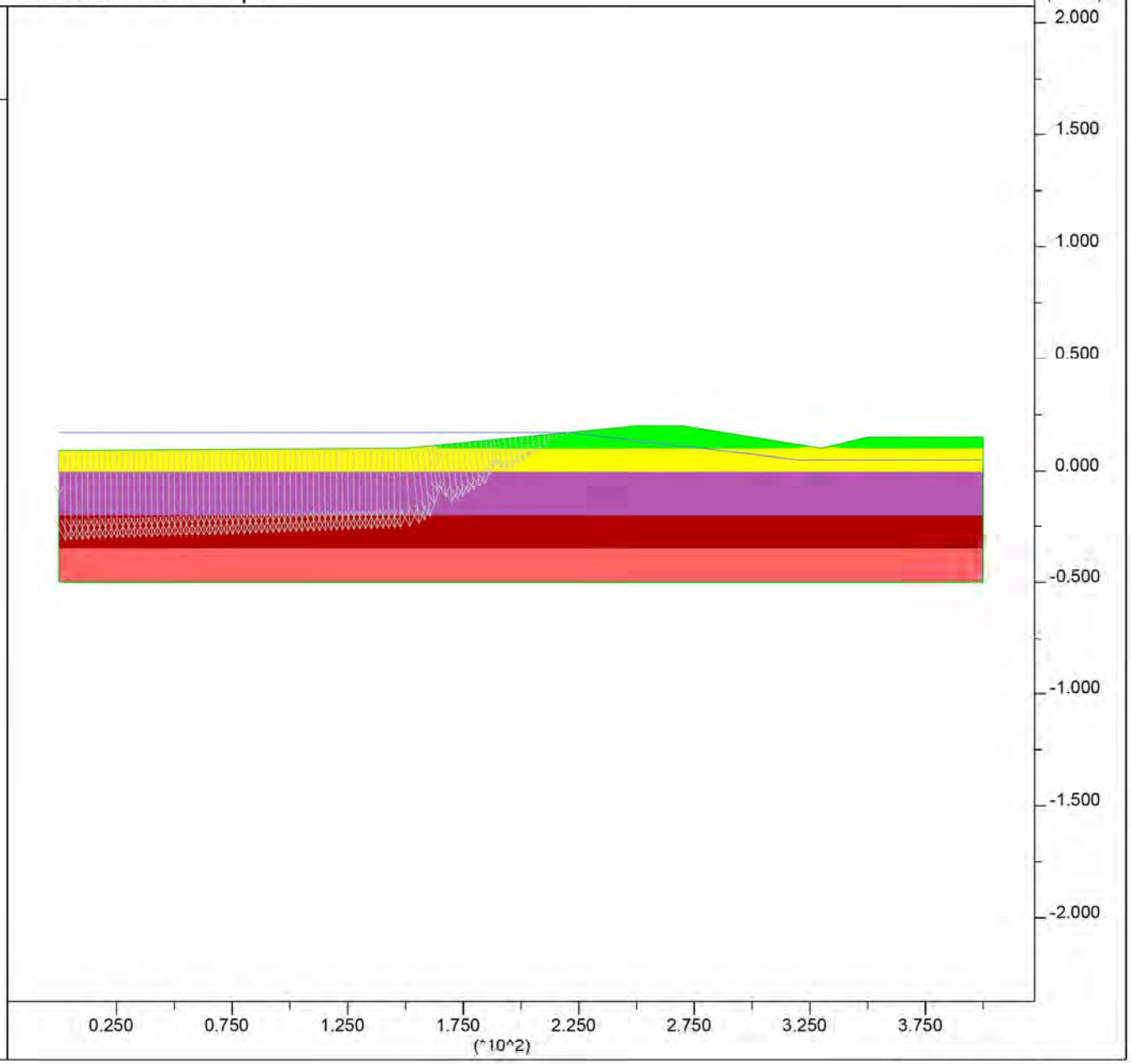


PLATE G-26

JOB TITLE : Section A-A' - High Water Long Term (Steady State)

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:14

Factor of Safety 5.21

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Net Applied Forces

max vector = 9.947E+02

0 2E 3

Group Delta Consultants
Ballona Wetlands

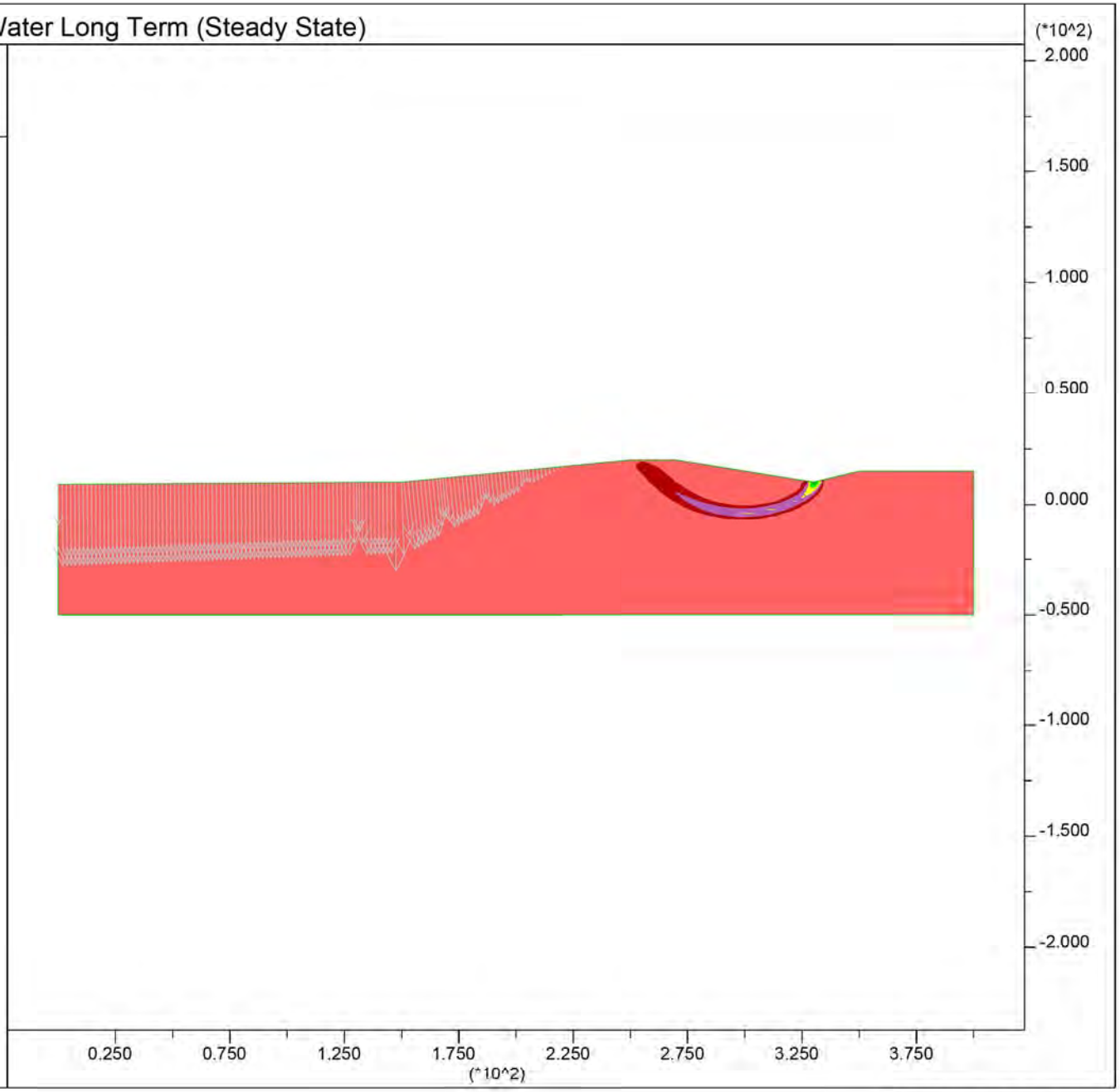


PLATE G-27

JOB TITLE : Section A-A' - High Water Long Term (Steady State) - Input

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:22

Factor of Safety 5.21

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Net Applied Forces

max vector = 9.947E+02

0 2E 3

Group Delta Consultants
Ballona Wetlands

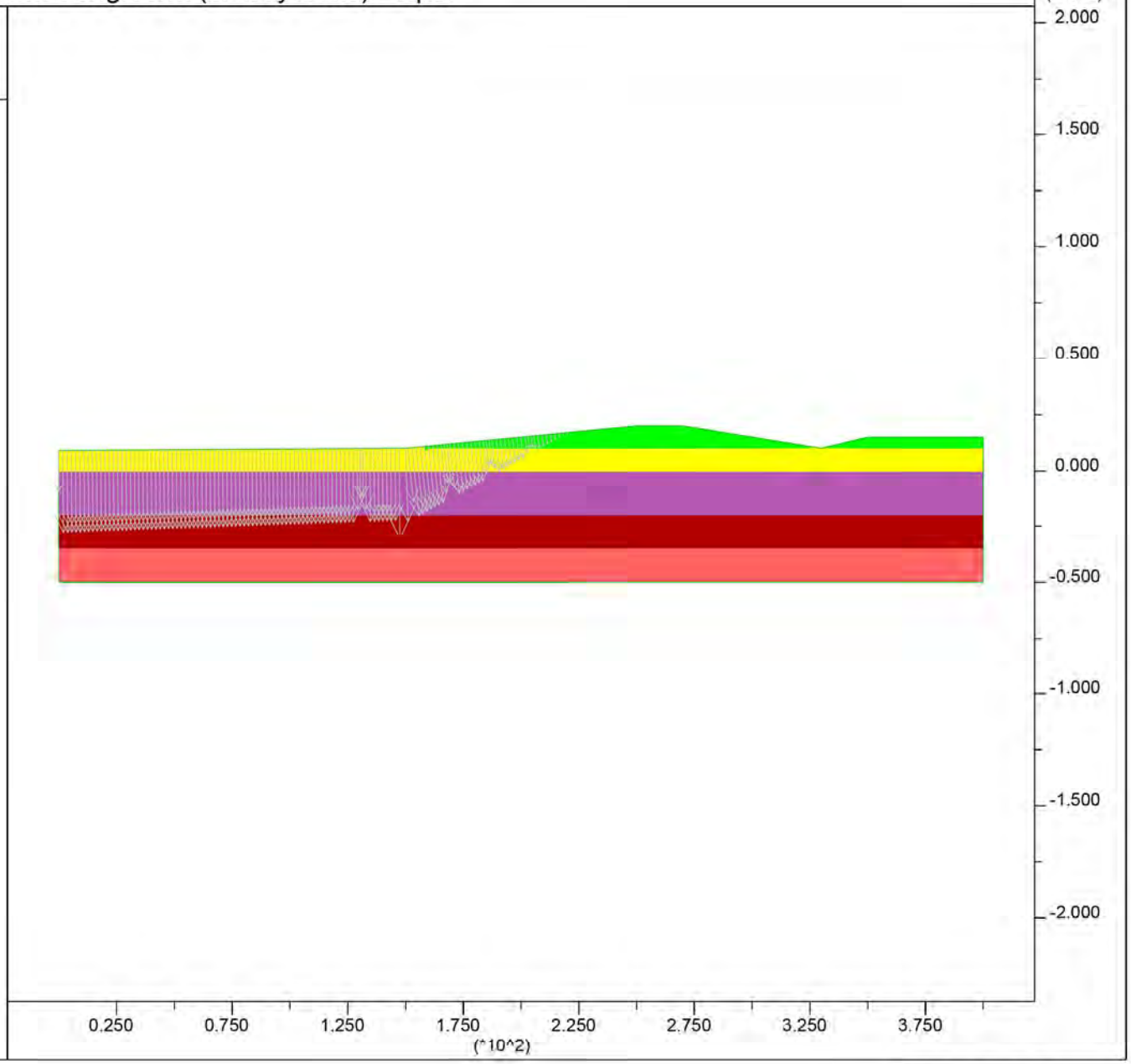


PLATE G-28

JOB TITLE : Section A-A' - Post Liquefaction

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 13:49

Factor of Safety 2.38

Shear Strain Rate Contours

- 2.00E-07
- 4.00E-07
- 6.00E-07
- 8.00E-07
- 1.00E-06
- 1.20E-06

Contour interval= 2.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.536E+02

0 5E 2

Group Delta Consultants
Ballona Wetlands

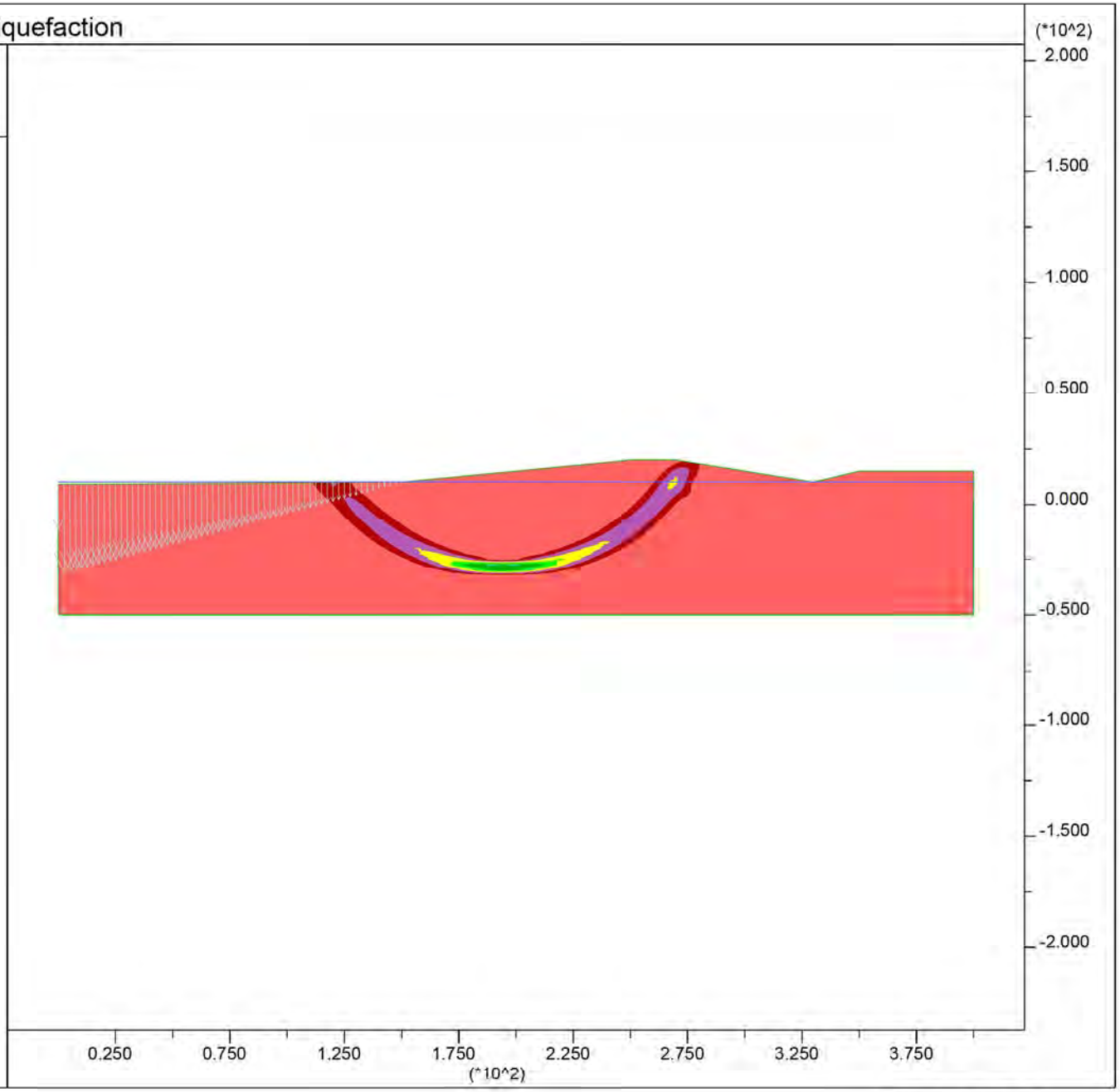


PLATE G-29

JOB TITLE : Section A-A' - Post Liquefaction Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 13:50

Factor of Safety 2.38

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand'
- 'User:Soft Clay'
- 'User:Liq Fill'
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.536E+02

0 5E 2

Group Delta Consultants
Ballona Wetlands

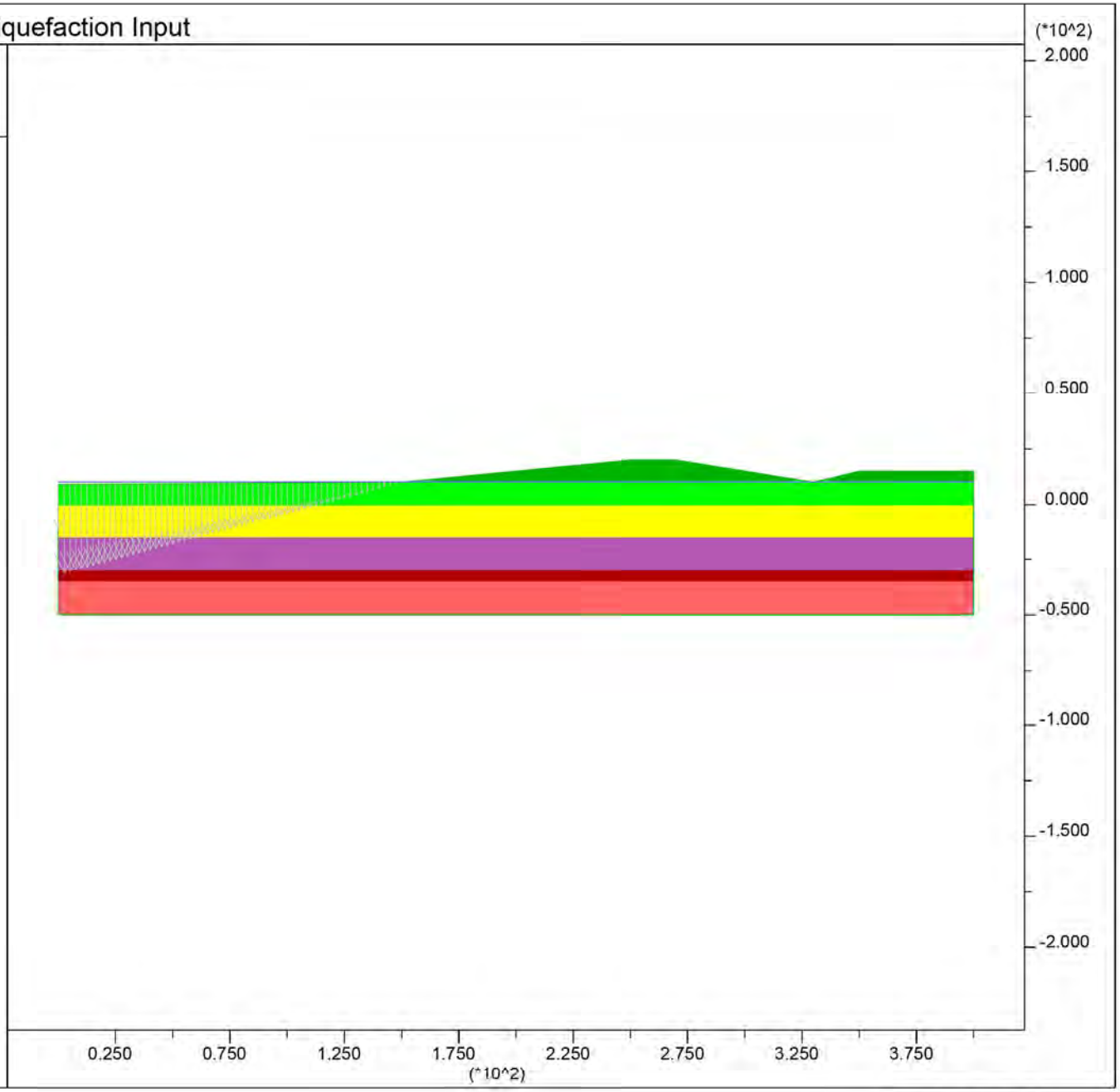


PLATE G-30

JOB TITLE : Section A-A' - Ky=0.09

FLAC/SLOPE (Version 7.00)

LEGEND

26-Mar-13 14:07

Factor of Safety 1.03

Shear Strain Rate Contours

- 1.00E-06
- 2.00E-06
- 3.00E-06
- 4.00E-06
- 5.00E-06

Contour interval= 1.00E-06
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Group Delta Consultants
Ballona Wetlands

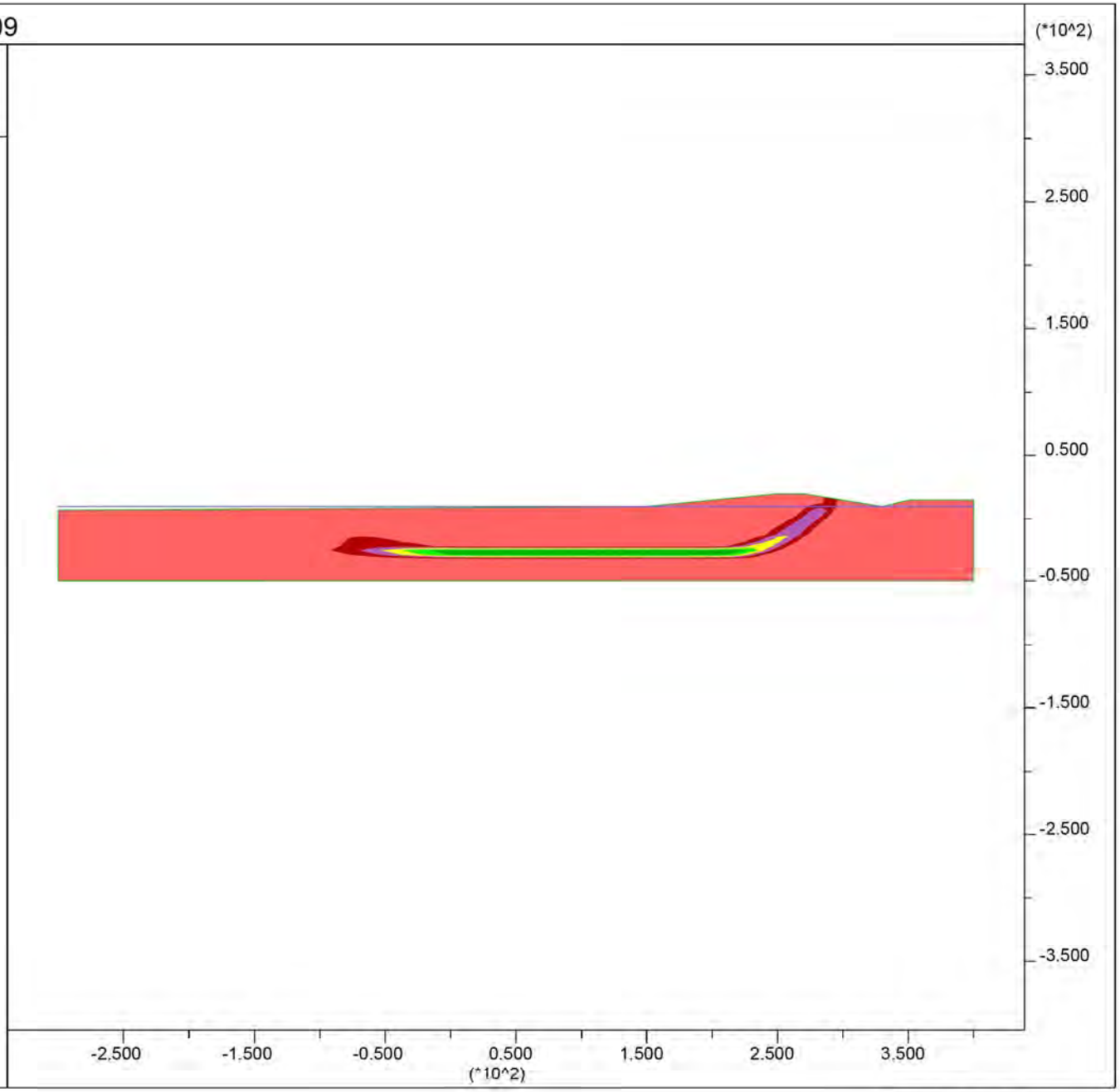


PLATE G-31

JOB TITLE : Section A-A' - Ky=0.09 Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Mar-13 14:07

Factor of Safety 1.03

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand'
- 'User:Soft Clay'
- 'User:Liq Fill'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Group Delta Consultants
Ballona Wetlands

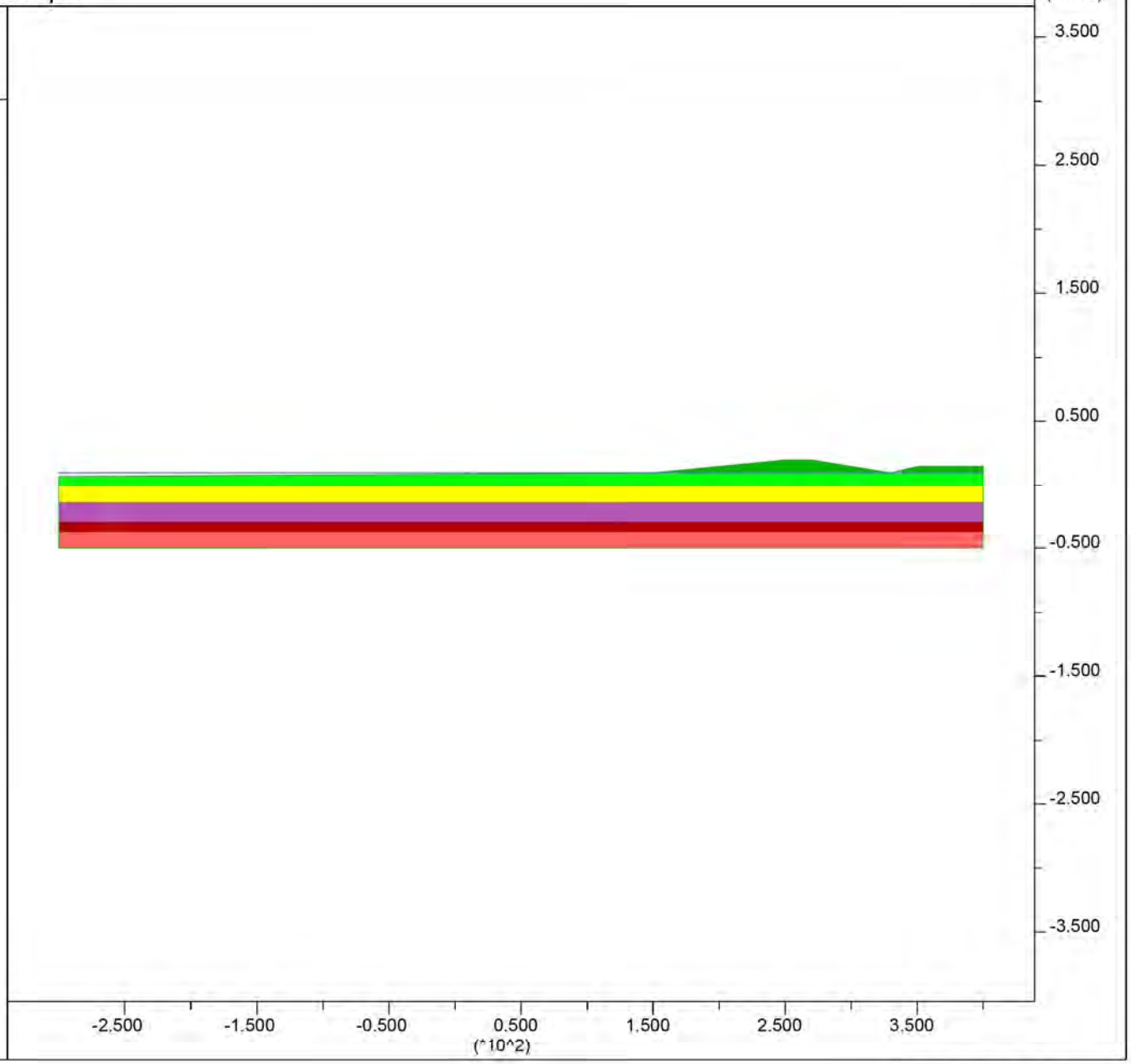


PLATE G-32

Newmark Displacements using Bray and Rathje (1998):

Section A-A'

Site Input

PGA,rock =	0.25	g		
M =	6.6			
r =	13	km		
ky =	0.09		32.185	2.89665

Sliding Mass Input

Vs =	150	m/s	assumed
Thickness, H =	13.7	m	
	45	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.37	sec				
NRF =	1.15					
Ts/Tm =	0.75					
kmax/(PGA,rock*NRF)	0.67					
kmax =	0.19					
ky / kmax =	0.47					
Displacement, u =	4	cm	0.1	feet	1.4	inches

PLATE G-33

JOB TITLE : Section B-B' - End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 14:08

Factor of Safety 3.51

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06
- 4.00E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

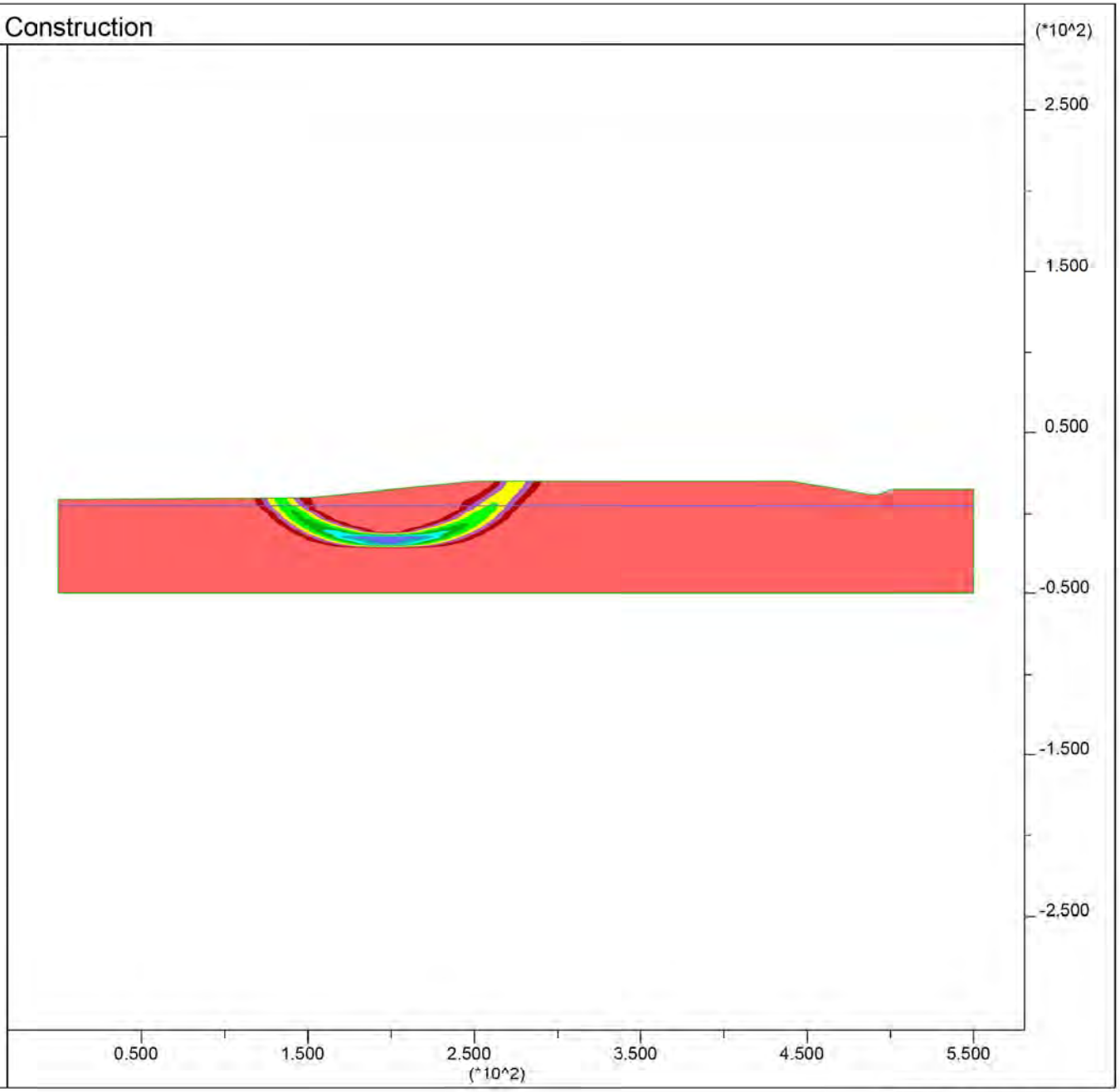


PLATE G-34

JOB TITLE : Section B-B' - End of Construction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 14:08

Factor of Safety 3.51

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

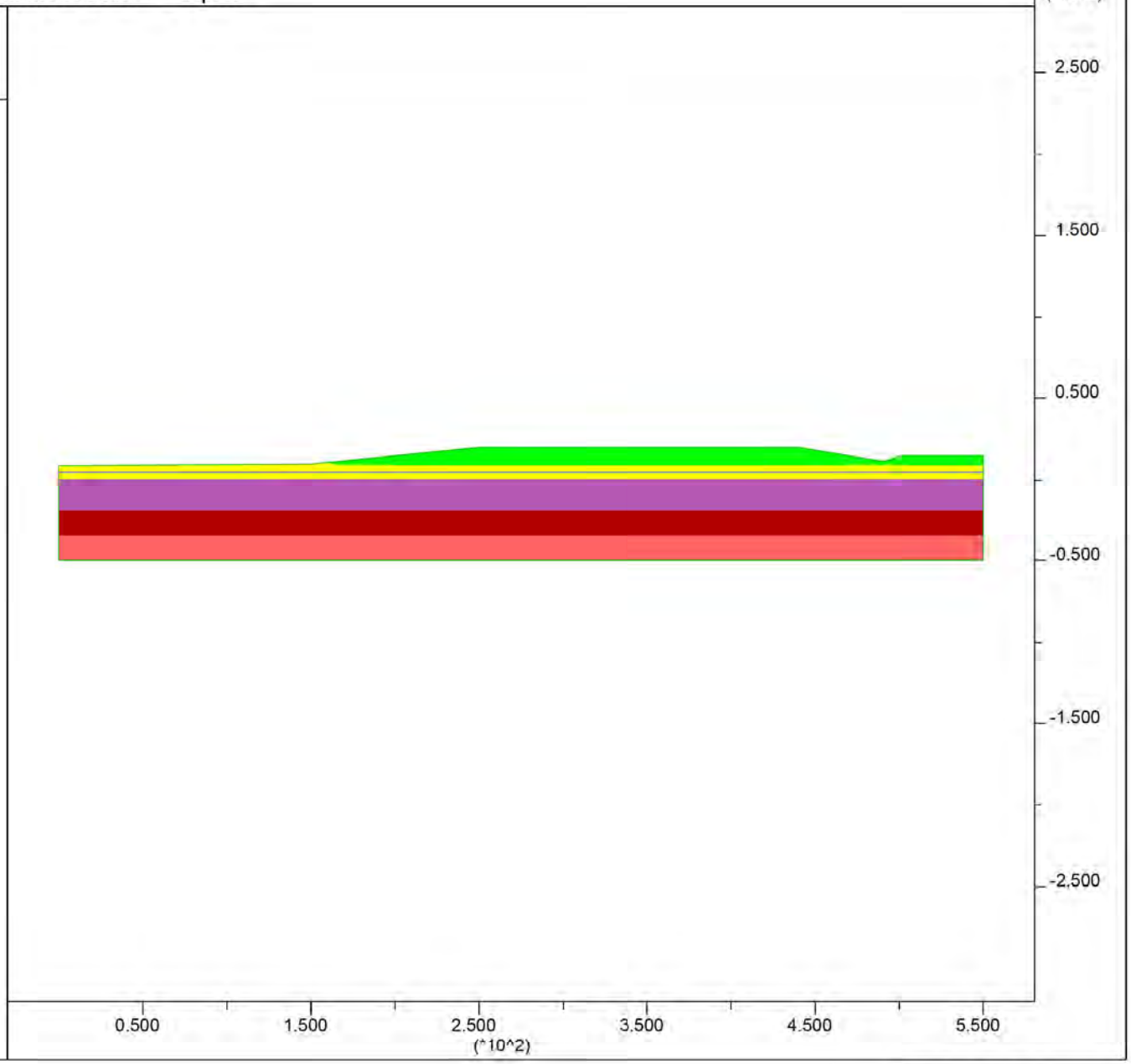


PLATE G-35

JOB TITLE : Section B-B' - High Water Short Term

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 14:24

Factor of Safety 4.32

Shear Strain Rate Contours

- 2.50E-06
- 5.00E-06
- 7.50E-06
- 1.00E-05
- 1.25E-05
- 1.50E-05
- 1.75E-05
- 2.00E-05
- 2.25E-05

Contour interval= 2.50E-06
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.713E+03

Group Delta Consultants
Ballona Wetlands

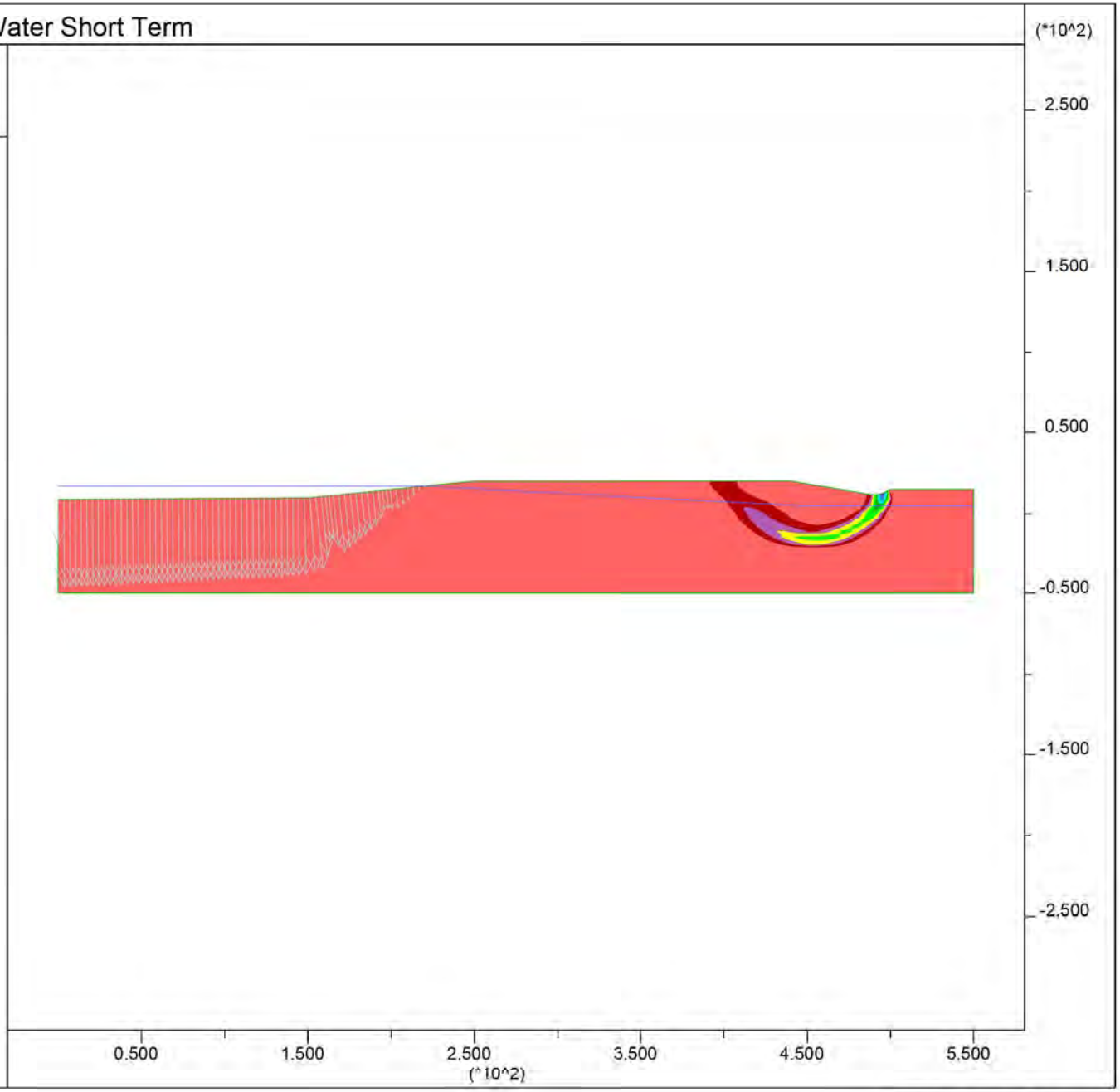


PLATE G-36

JOB TITLE : Section B-B' - High Water Short Term - Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 14:25

Factor of Safety 4.32

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.713E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

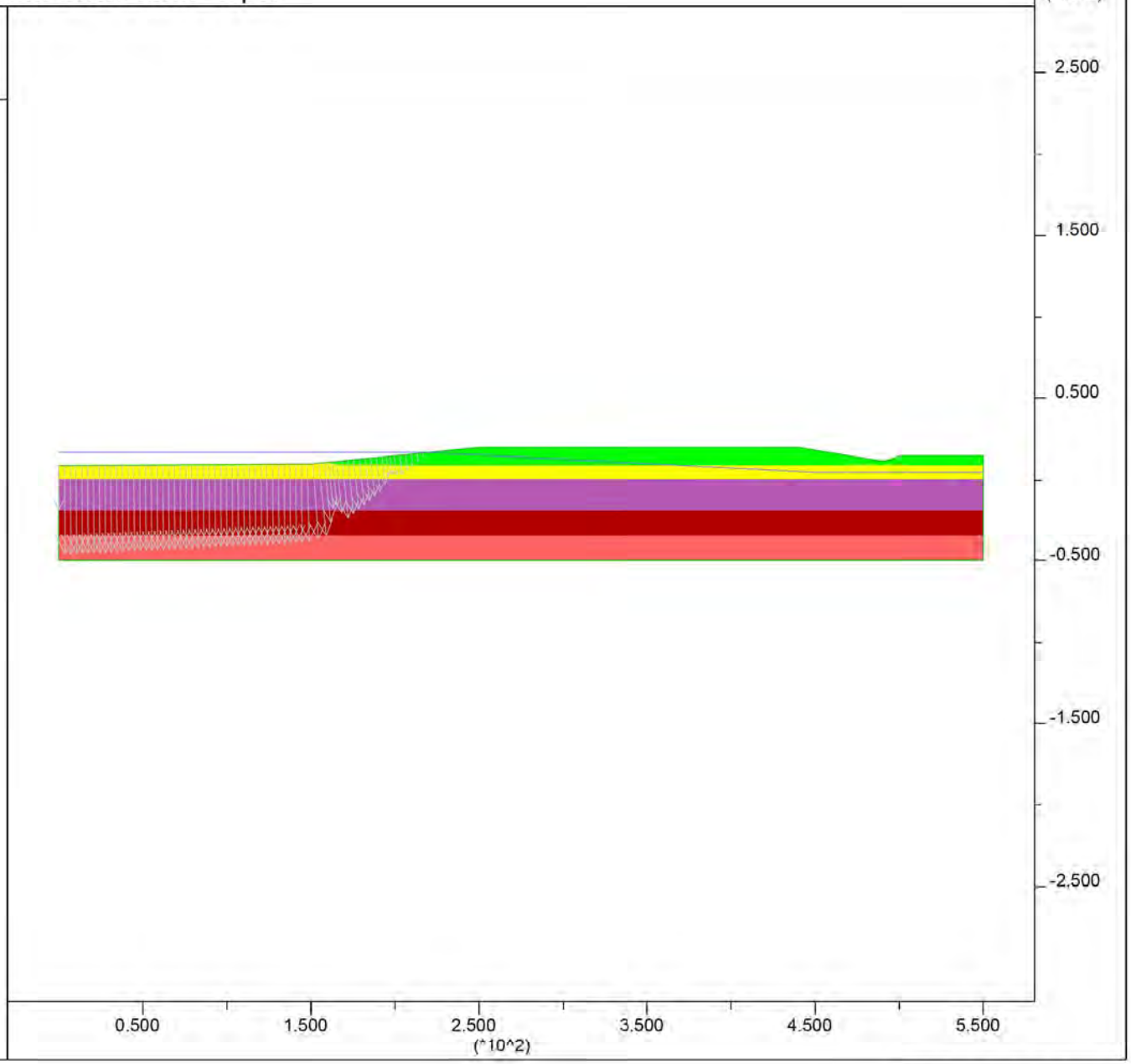


PLATE G-37

JOB TITLE : Section B-B' - Post Liquefaction

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 14:36

Factor of Safety 2.38

Shear Strain Rate Contours

1.00E-06
2.00E-06
3.00E-06
4.00E-06
5.00E-06

Contour interval= 1.00E-06
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.098E+02

0 5E 2

Group Delta Consultants
Ballona Wetlands

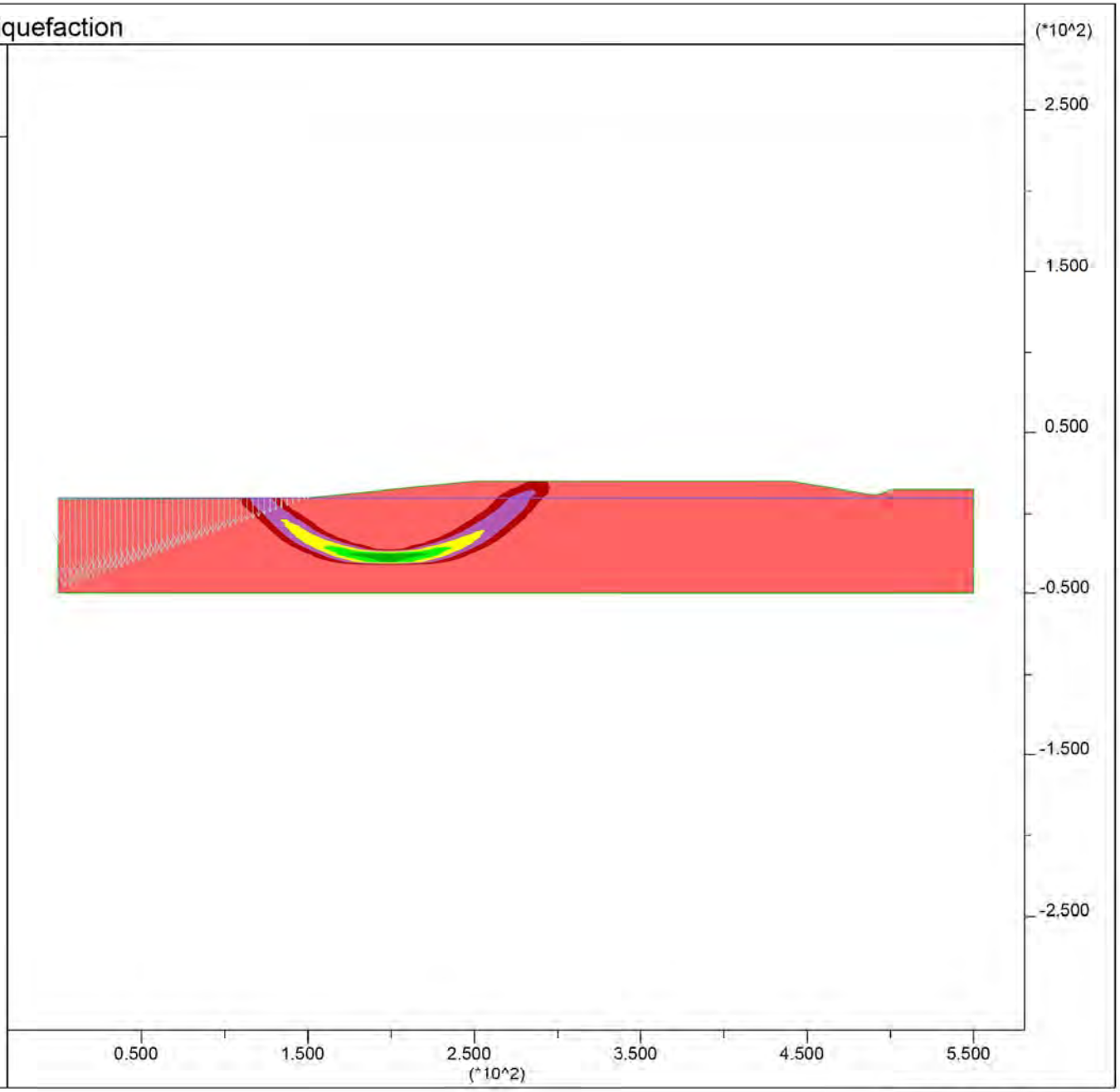


PLATE G-38

JOB TITLE : Section B-B' - Post Liquefaction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 14:37

Factor of Safety 2.38

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand'
- 'User:Soft Clay'
- 'User:Liq Fill'
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.098E+02

0 5E 2

Group Delta Consultants
Ballona Wetlands

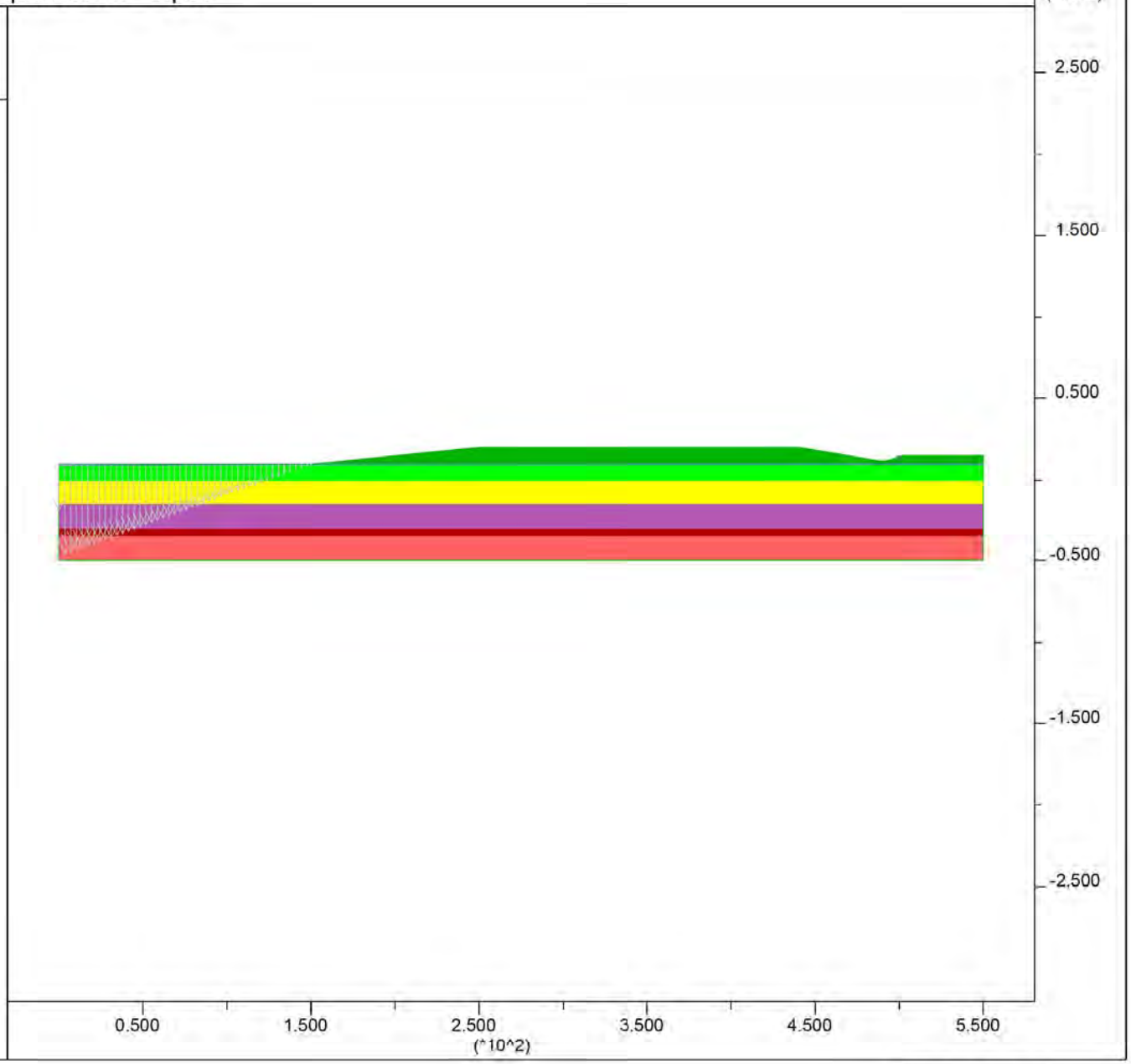


PLATE G-39

JOB TITLE : Section B-B' - Ky=0.08

FLAC/SLOPE (Version 7.00)

LEGEND

26-Mar-13 14:11

Factor of Safety 1.01

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06
- 1.75E-06
- 2.00E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

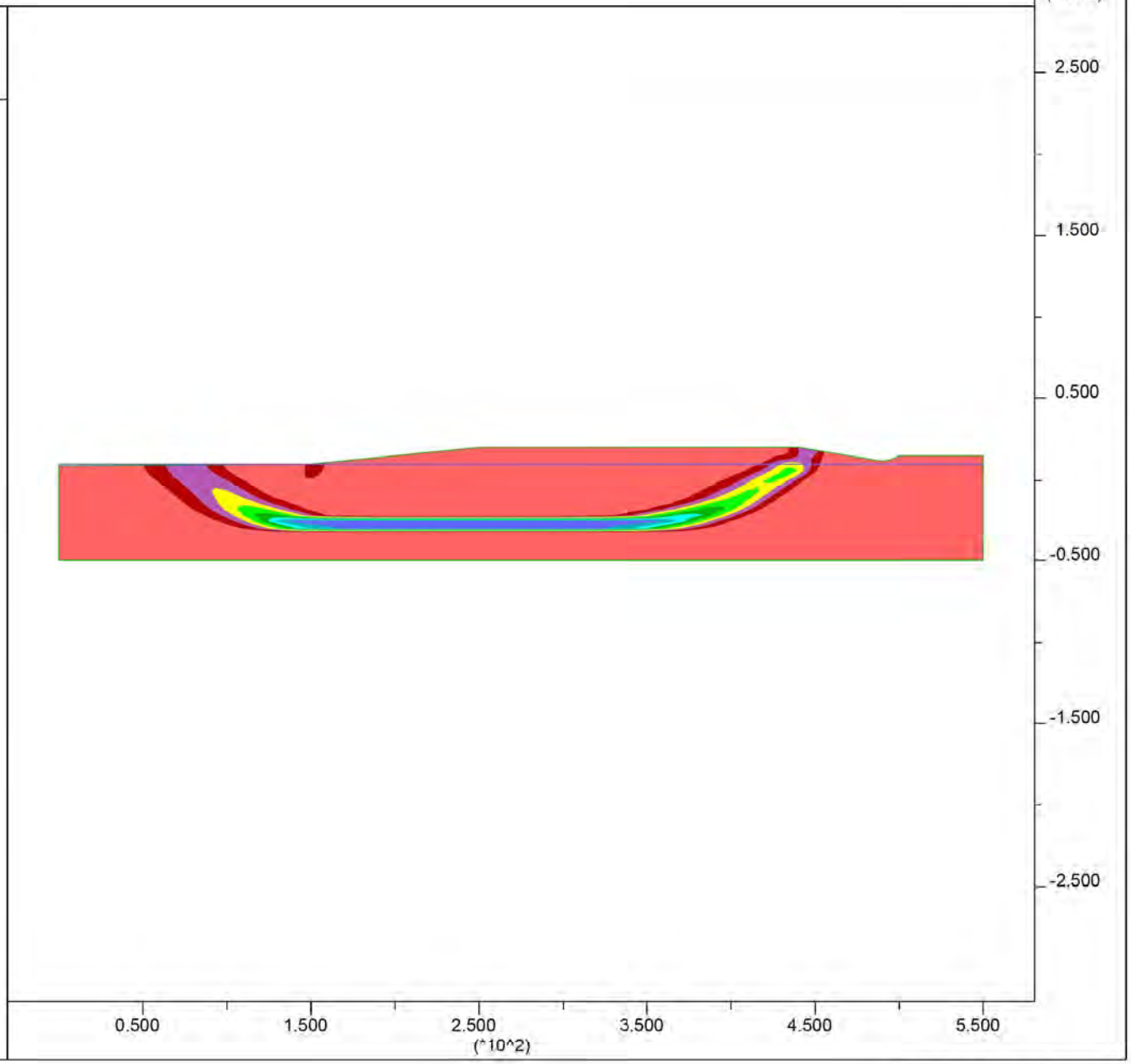


PLATE G-40

JOB TITLE : Section B-B' - Ky=0.08 Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Mar-13 14:12

Factor of Safety 1.01

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand'
- 'User:Soft Clay'
- 'User:Liq Fill'
- User:Embankment

Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

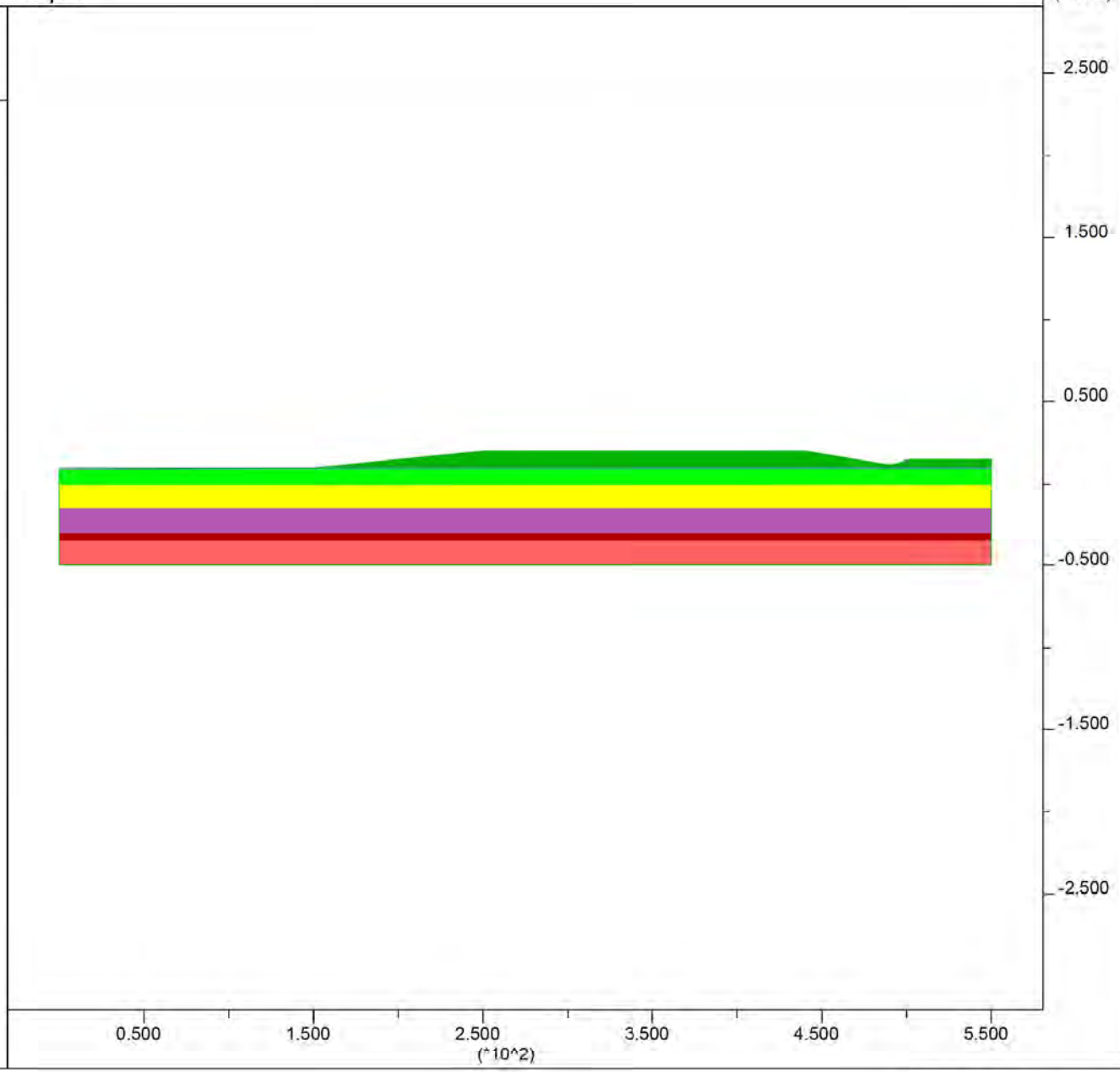


PLATE G-41

Newmark Displacements using Bray and Rathje (1998):

Section B-B'

Site Input

PGA,rock =	0.25	g		
M =	6.6			
r =	13	km		
ky =	0.08		32.185	2.5748

Sliding Mass Input

Vs =	150	m/s	assumed
Thickness, H =	15.3	m	
	50	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.41	sec				
NRF =	1.15					
Ts/Tm =	0.83					
kmax/(PGA,rock*NRF)	0.62					
kmax =	0.18					
ky / kmax =	0.45					
Displacement, u =	4	cm	0.1	feet	1.5	inches

PLATE G-42

JOB TITLE : Section C-C' -End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 16:16

Factor of Safety 3.45

Shear Strain Rate Contours

- 2.00E-07
- 4.00E-07
- 6.00E-07
- 8.00E-07
- 1.00E-06
- 1.20E-06

Contour interval= 2.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

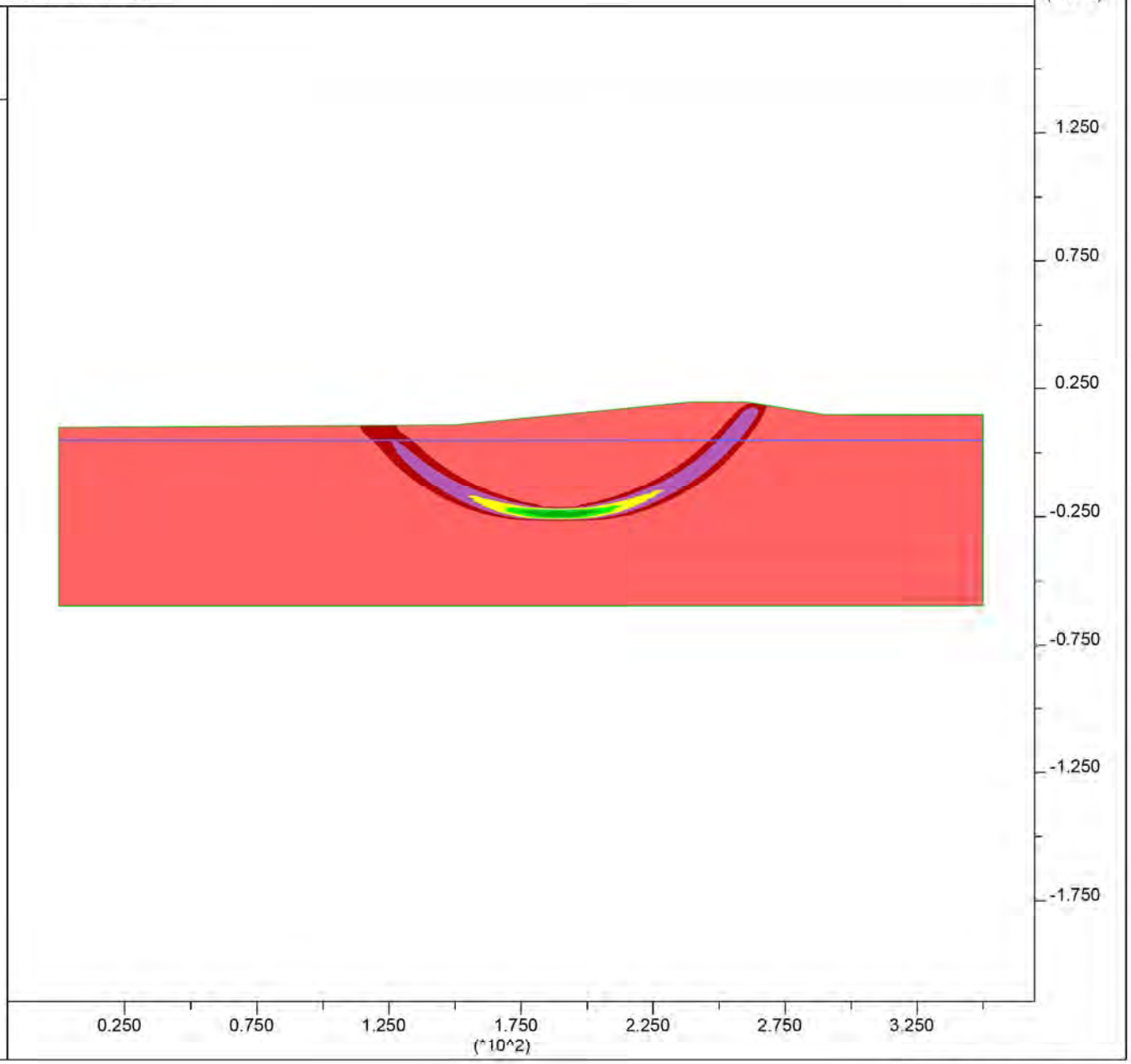


PLATE G-43

JOB TITLE : Section C-C' -End of Construction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 16:17

Factor of Safety 3.45

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

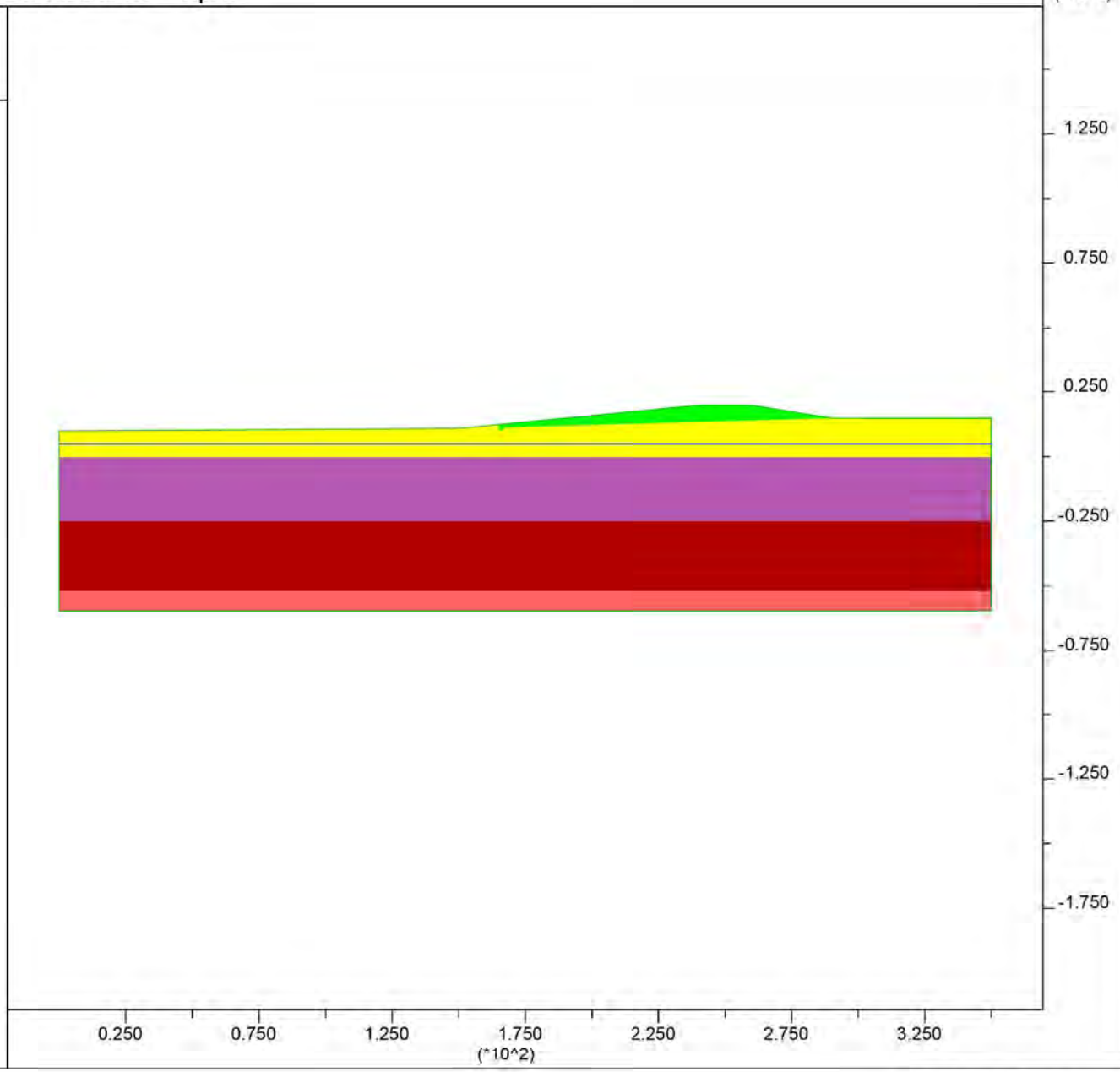


PLATE G-44

JOB TITLE : Section C-C' - High Water Short Term

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 17:38

Factor of Safety 5.28

Shear Strain Rate Contours

- 2.50E-08
- 5.00E-08
- 7.50E-08
- 1.00E-07
- 1.25E-07
- 1.50E-07
- 1.75E-07
- 2.00E-07

Contour interval= 2.50E-08
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 8.486E+02

Group Delta Consultants
Ballona Wetlands

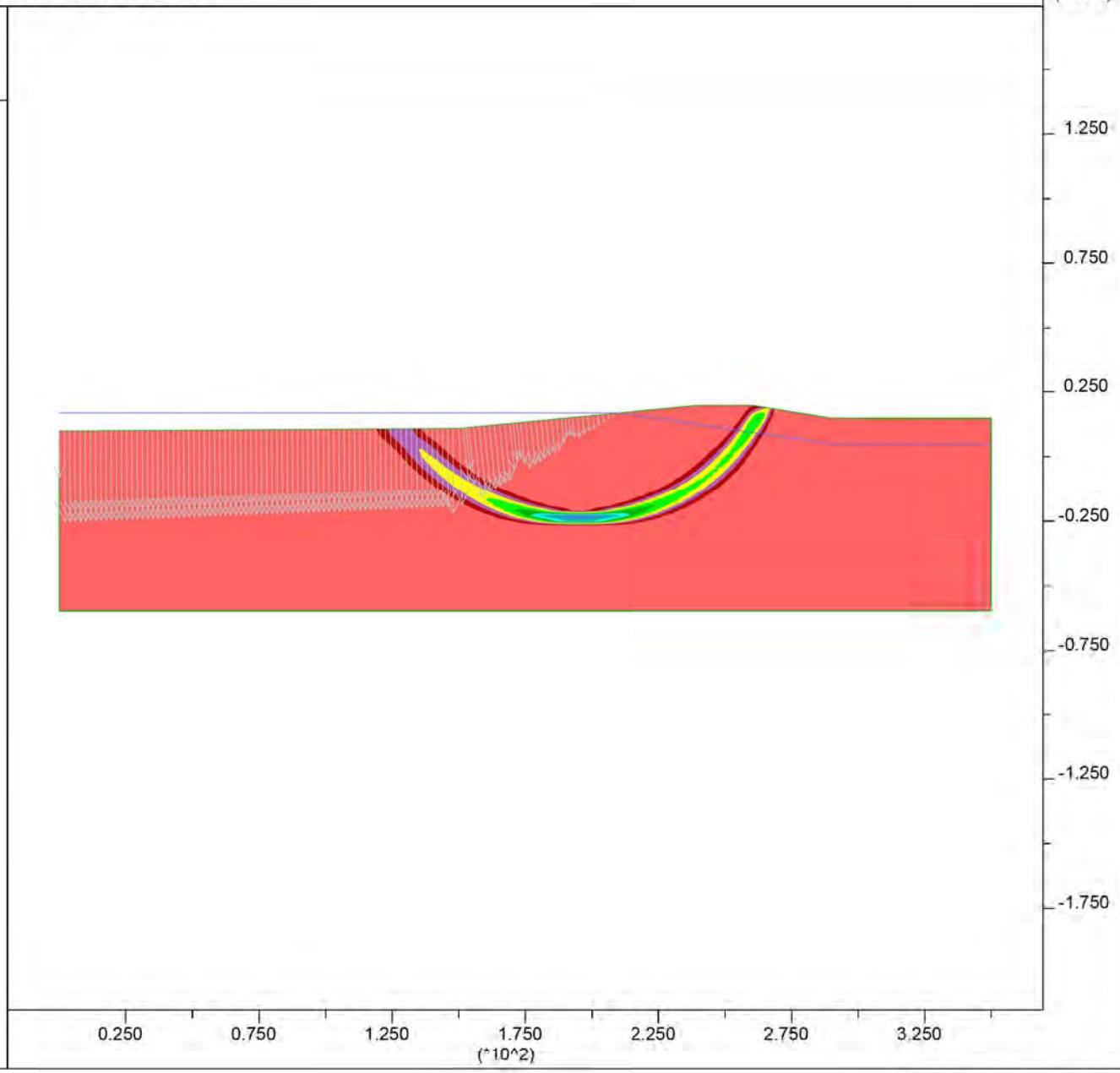


PLATE G-45

JOB TITLE : Section C-C' - High Water Short Term - Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 17:38

Factor of Safety 5.28

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 8.486E+02

0 2E 3

Group Delta Consultants
Ballona Wetlands

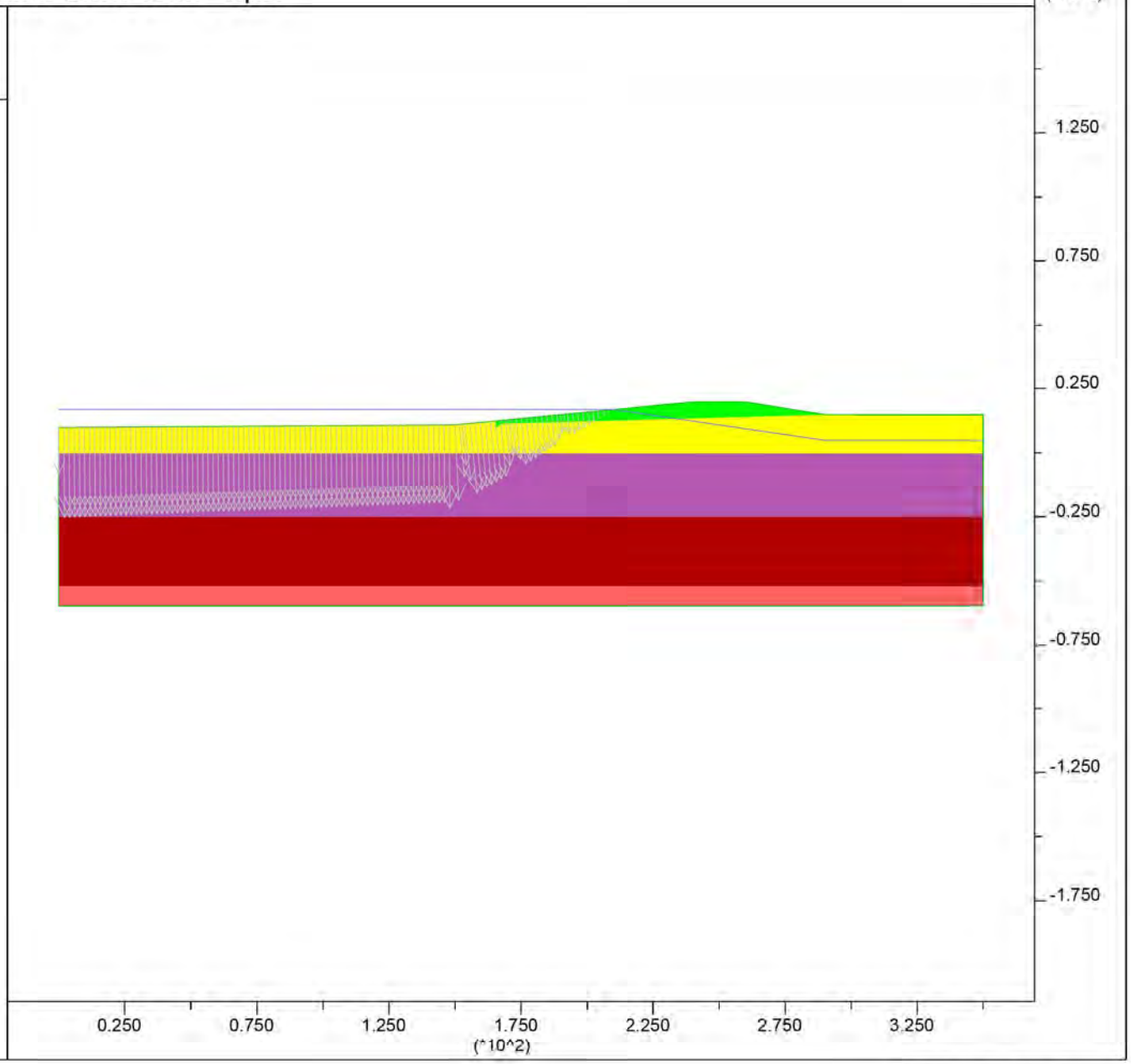


PLATE G-46

JOB TITLE : Section C-C' - Post Liquefaction

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 18:09

Factor of Safety 2.42

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

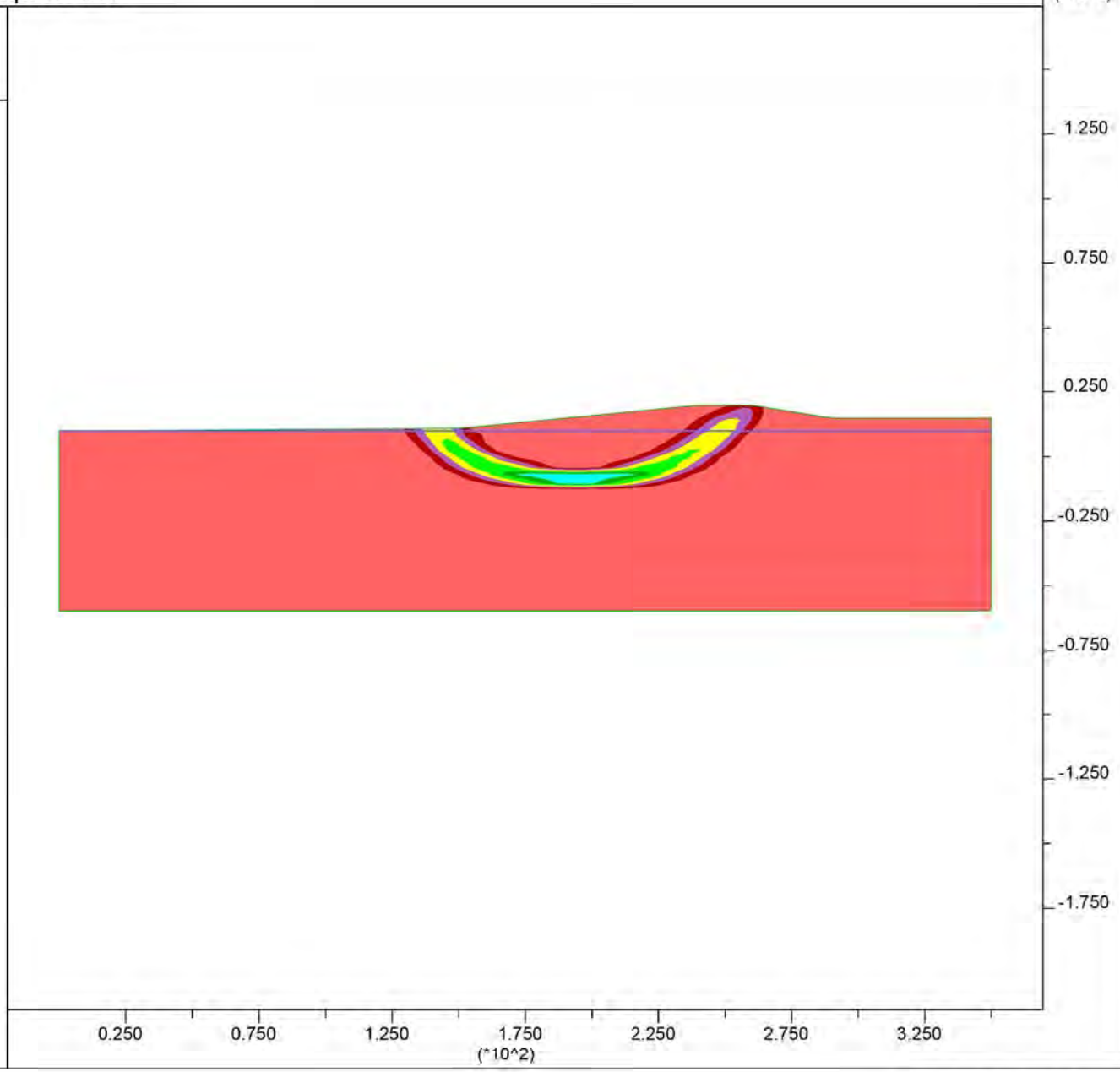


PLATE G-47

JOB TITLE : Section C-C' - Post Liquefaction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 18:09

Factor of Safety 2.42

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand Deep'
- 'User:Liq Sand 2'
- 'User:Soft Clay'
- 'User:Liq Sand Shallow'
- 'User:Liq Fill'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

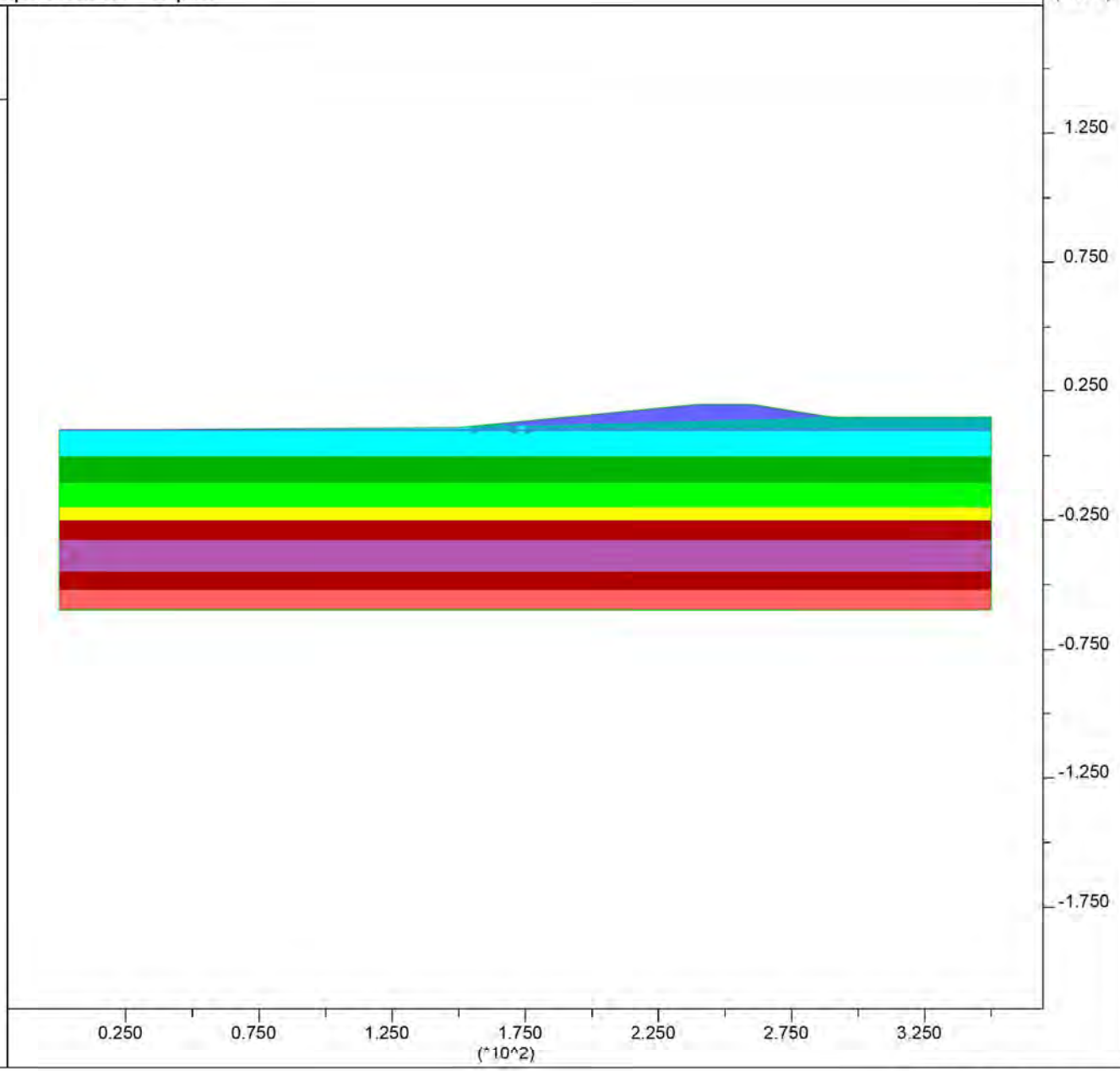


PLATE G-48

JOB TITLE : Section C-C' - Ky=0.1

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 19:11

Factor of Safety 0.99

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06
- 1.75E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

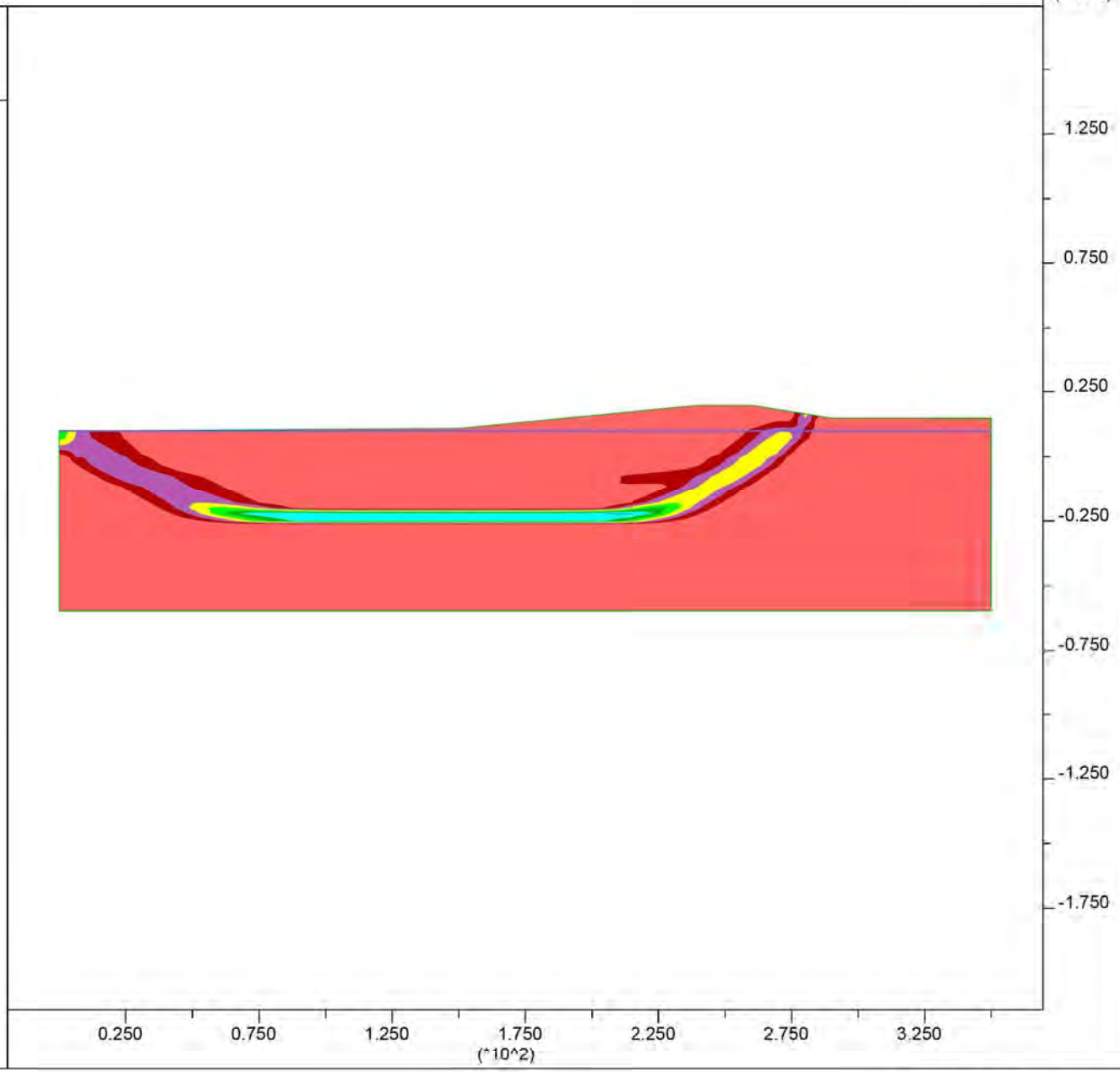


PLATE G-49

JOB TITLE : Section C-C' - Ky=0.1 nput

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 19:14

Factor of Safety 0.99

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand Deep'
- 'User:Liq Sand 2'
- 'User:Soft Clay'
- 'User:Liq Sand Shallow'
- 'User:Liq Fill'
- User:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

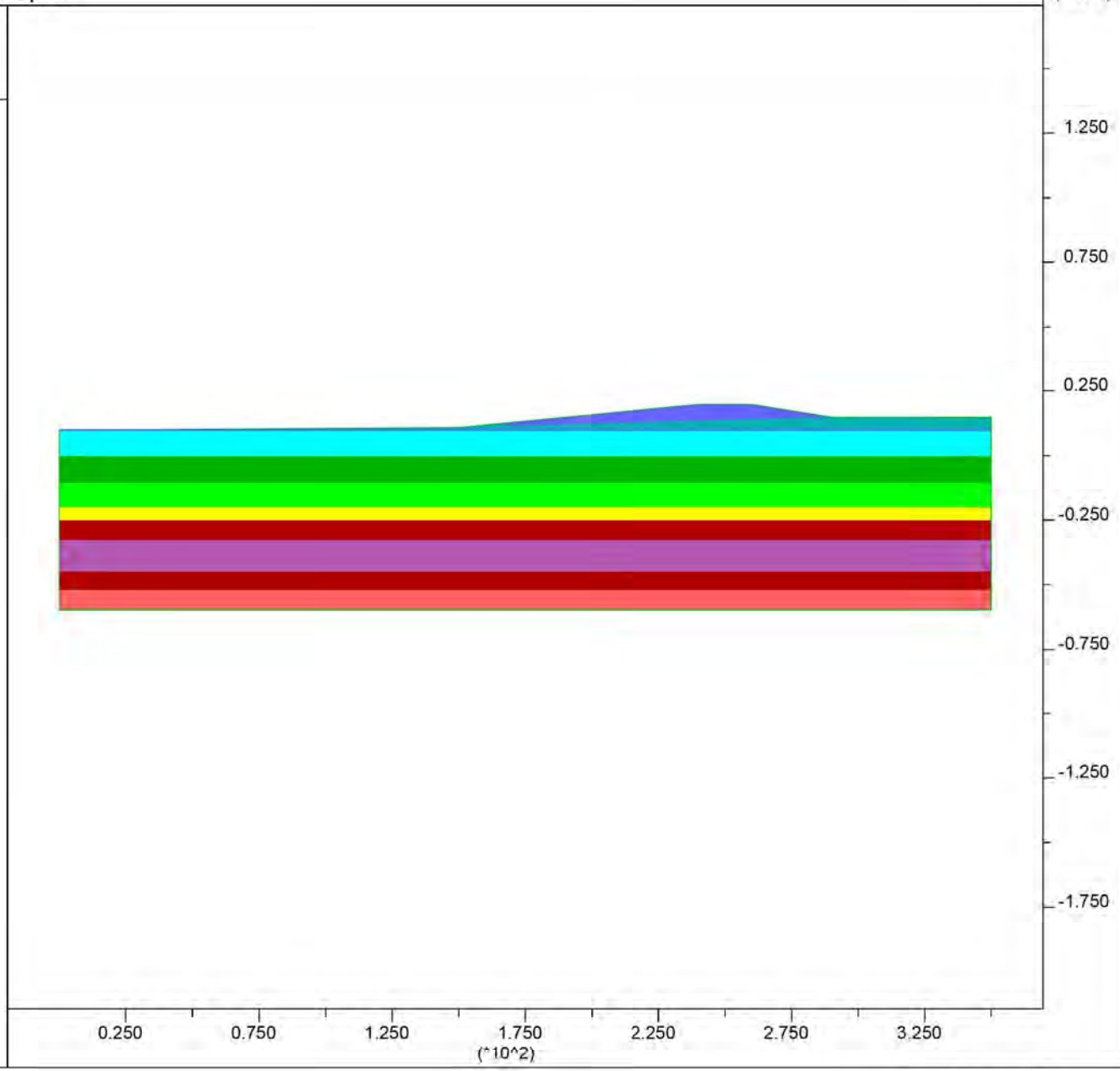


PLATE G-50

Newmark Displacements using Bray and Rathje (1998):

Section C-C'

Site Input

PGA,rock =	0.25	g	
M =	6.6		
r =	13	km	
ky =	0.1		
Sliding Mass Input			
Vs =	150	m/s	assumed
Thickness, H =	12.2	m	
	40	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.33	sec				
NRF =	1.15					
Ts/Tm =	0.67					
kmax/(PGA,rock*NRF)	0.74					
kmax =	0.21					
ky / kmax =	0.47					
Displacement, u =	4	cm	0.1	feet	1.5	inches

PLATE G-51

JOB TITLE : Section D-D' - End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 9:18

Factor of Safety 1.49

Shear Strain Rate Contours

1.00E-06
2.00E-06
3.00E-06
4.00E-06
5.00E-06
6.00E-06
7.00E-06
8.00E-06

Contour interval= 1.00E-06
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.366E+03

Group Delta Consultants
Ballona Wetlands

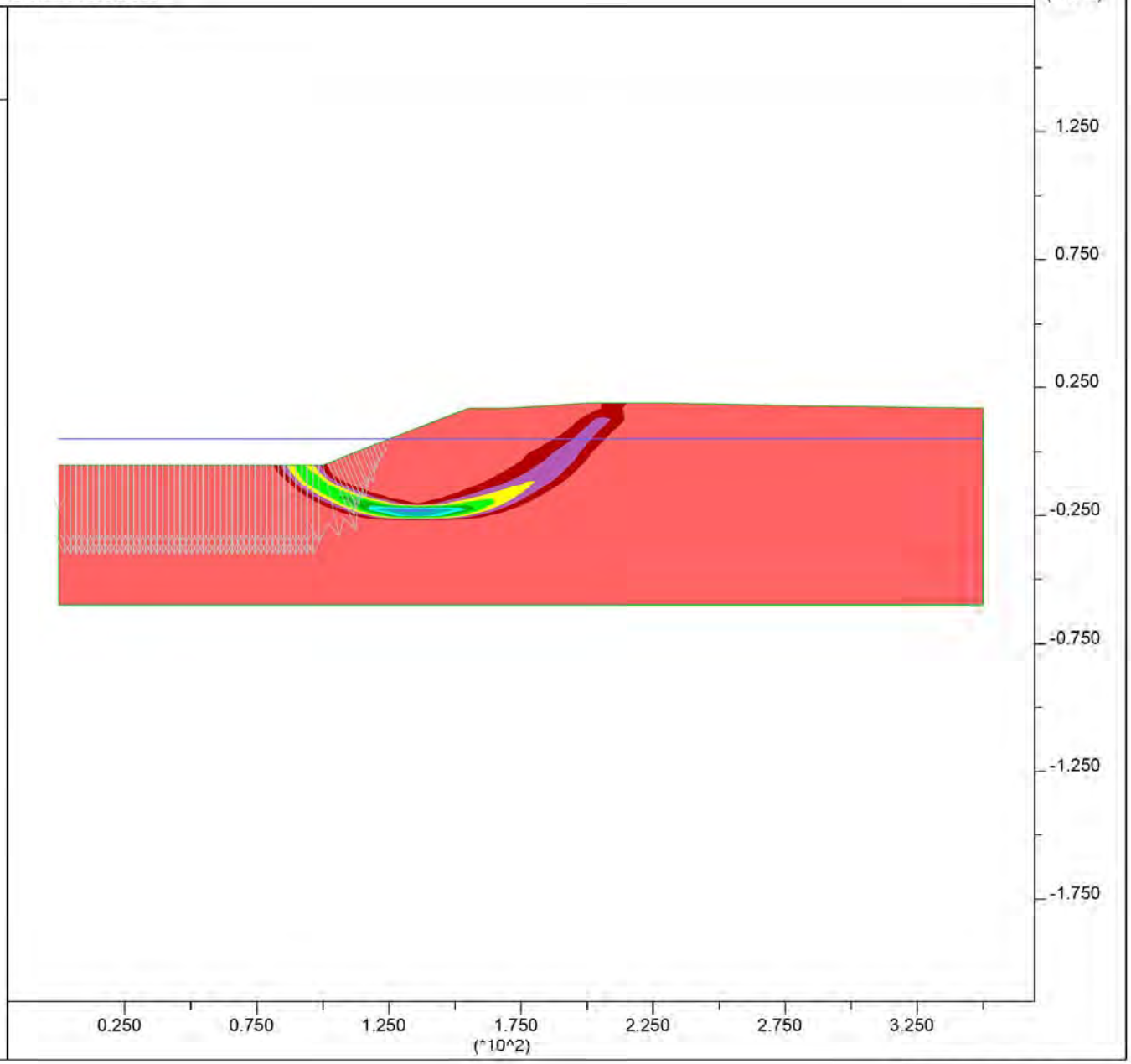


PLATE G-52

JOB TITLE : Section D-D' - End of Construction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 9:18

Factor of Safety 1.49

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.366E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

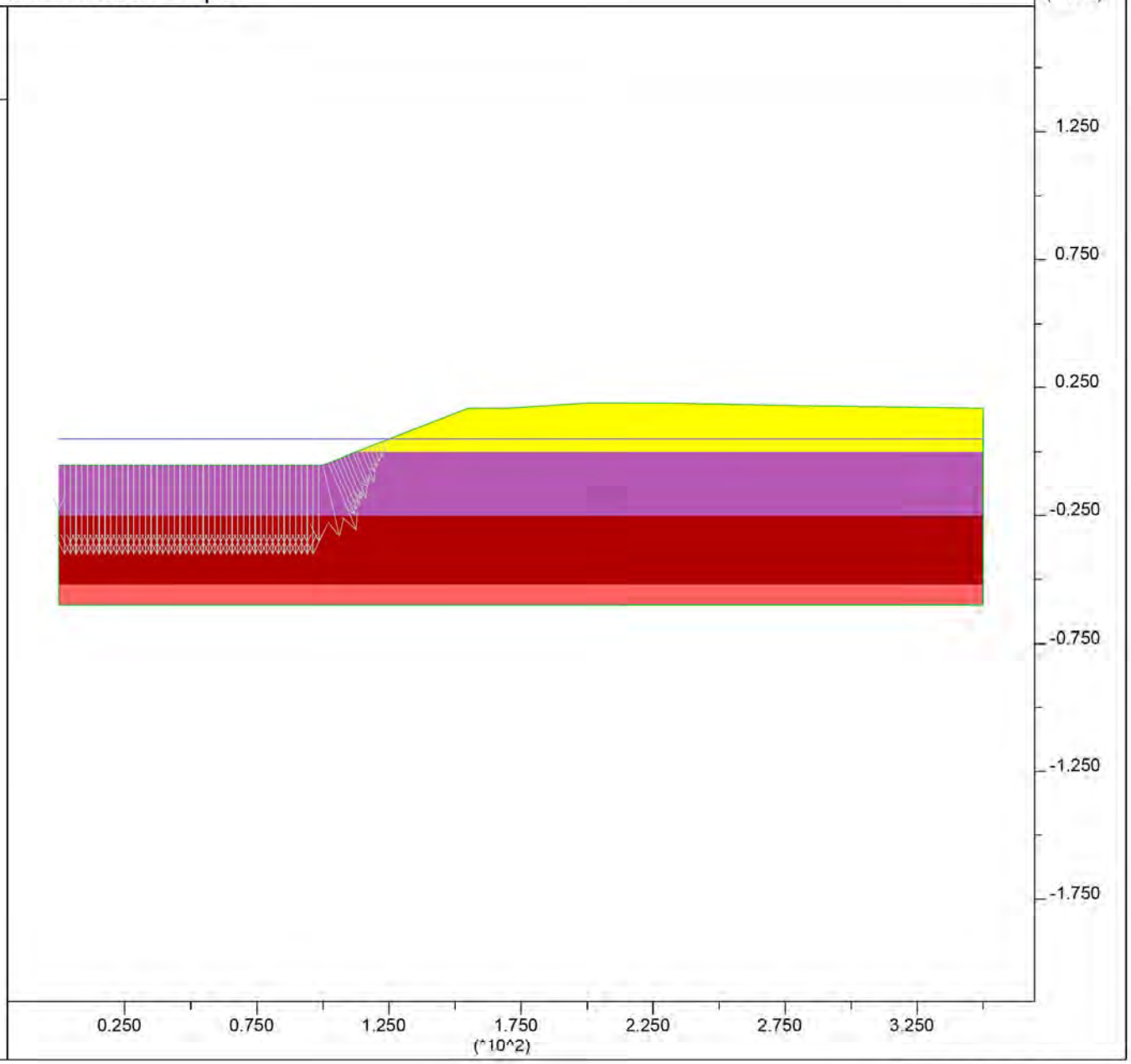


PLATE G-53

JOB TITLE : Section D-D' - High Water Short Term

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 9:19

Factor of Safety 2.28

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06
- 4.00E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.733E+03

Group Delta Consultants
Ballona Wetlands

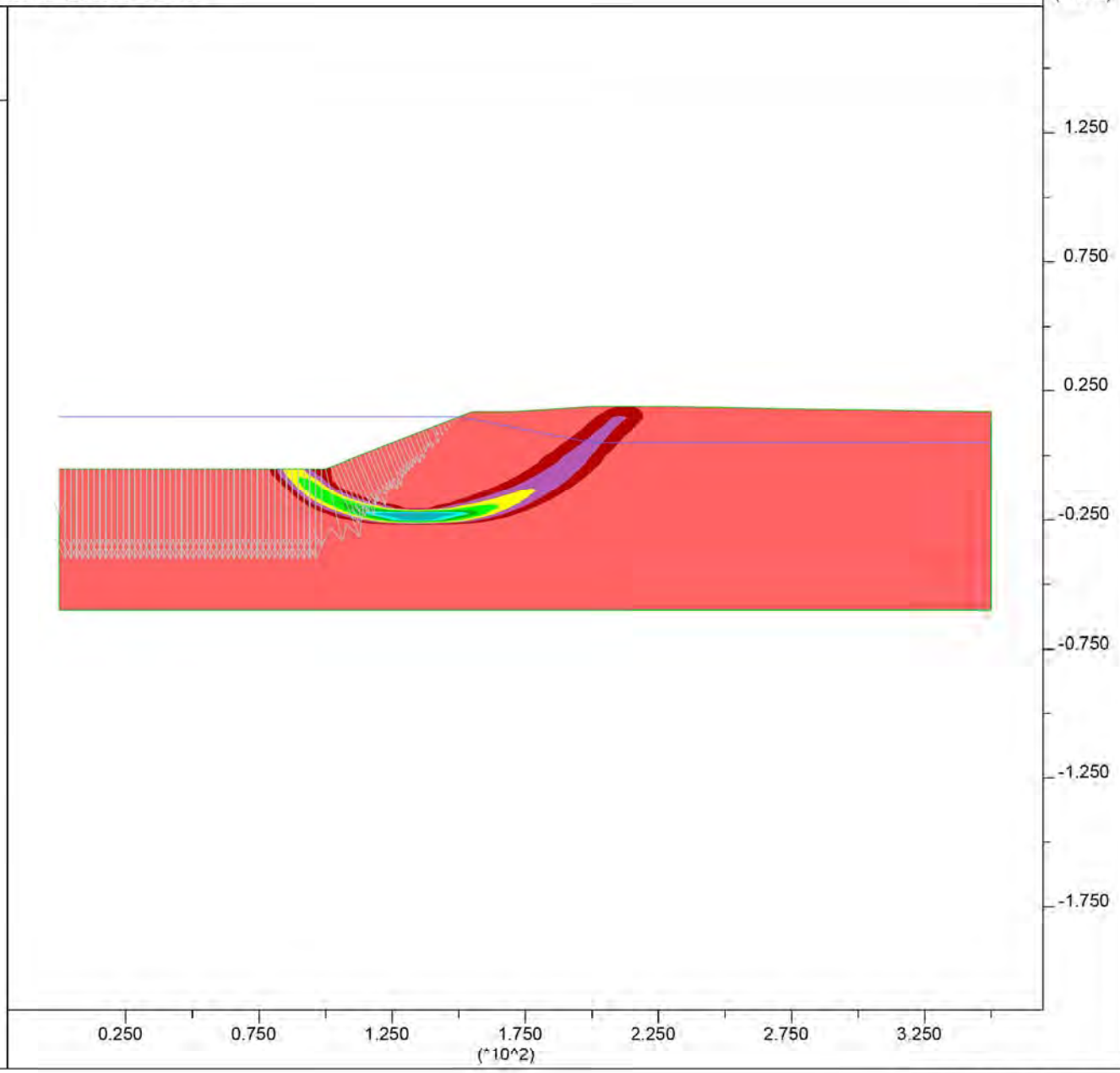


PLATE G-54

JOB TITLE : Section D-D' - High Water Short Term - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 9:20

Factor of Safety 2.28

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- User:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.733E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

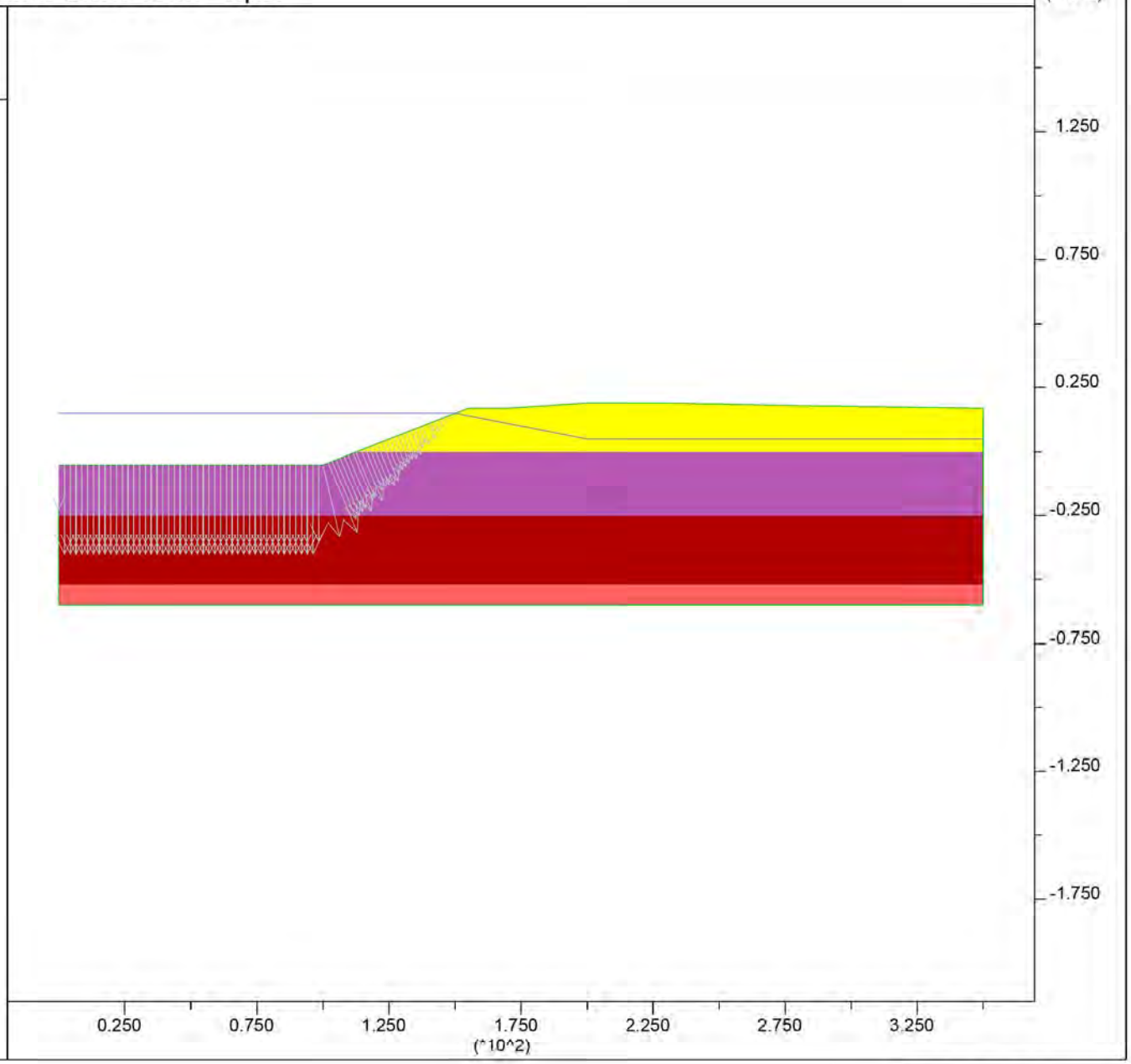


PLATE G-55

JOB TITLE : Section D-D' - Post Liquefaction

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 9:21

Factor of Safety 1.29

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06
- 1.75E-06
- 2.00E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.050E+03

Group Delta Consultants
Ballona Wetlands

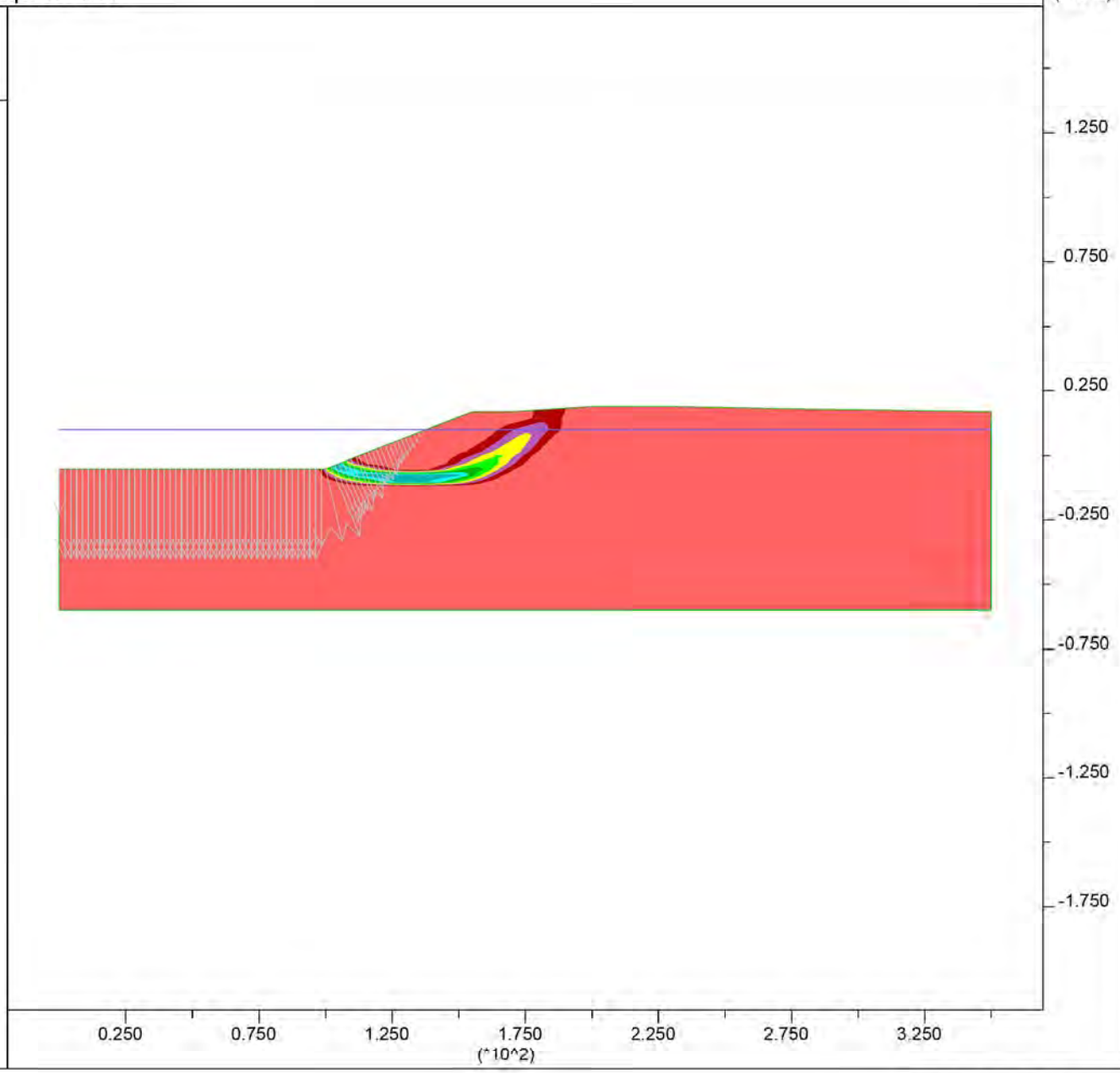


PLATE G-56

JOB TITLE : Section D-D' - Post Liquefaction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 9:22

Factor of Safety 1.29

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand Deep'
- 'User:Liq Sand 2'
- 'User:Soft Clay'
- 'User:Liq Sand Shallow'
- User:LiqFill
- User:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.050E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

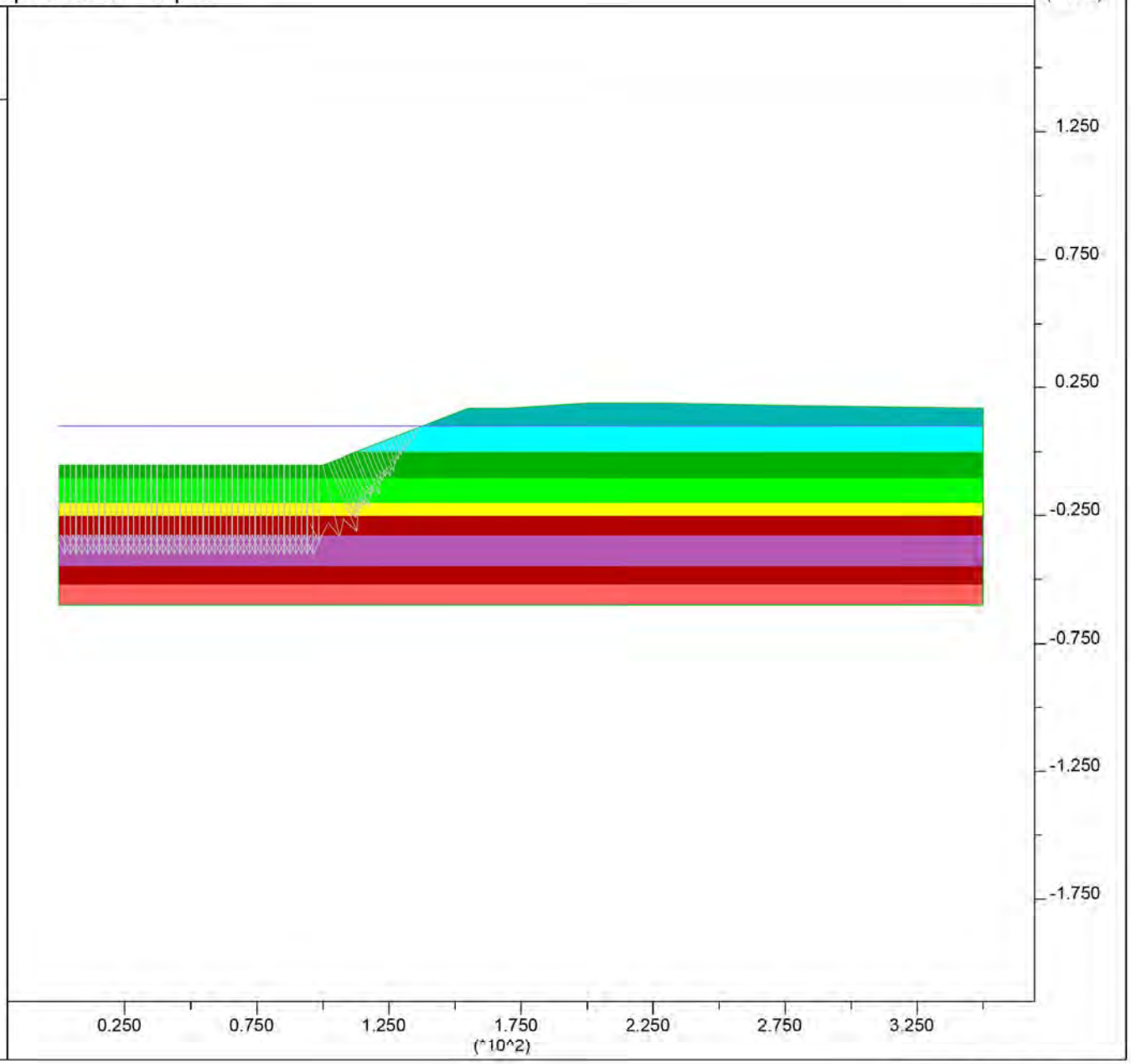


PLATE G-57

JOB TITLE : Section D-D' - Ky=0.05

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 9:25

Factor of Safety 1.00

Shear Strain Rate Contours

1.00E-07
2.00E-07
3.00E-07
4.00E-07
5.00E-07
6.00E-07
7.00E-07
8.00E-07

Contour interval= 1.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.052E+03

Group Delta Consultants
Ballona Wetlands

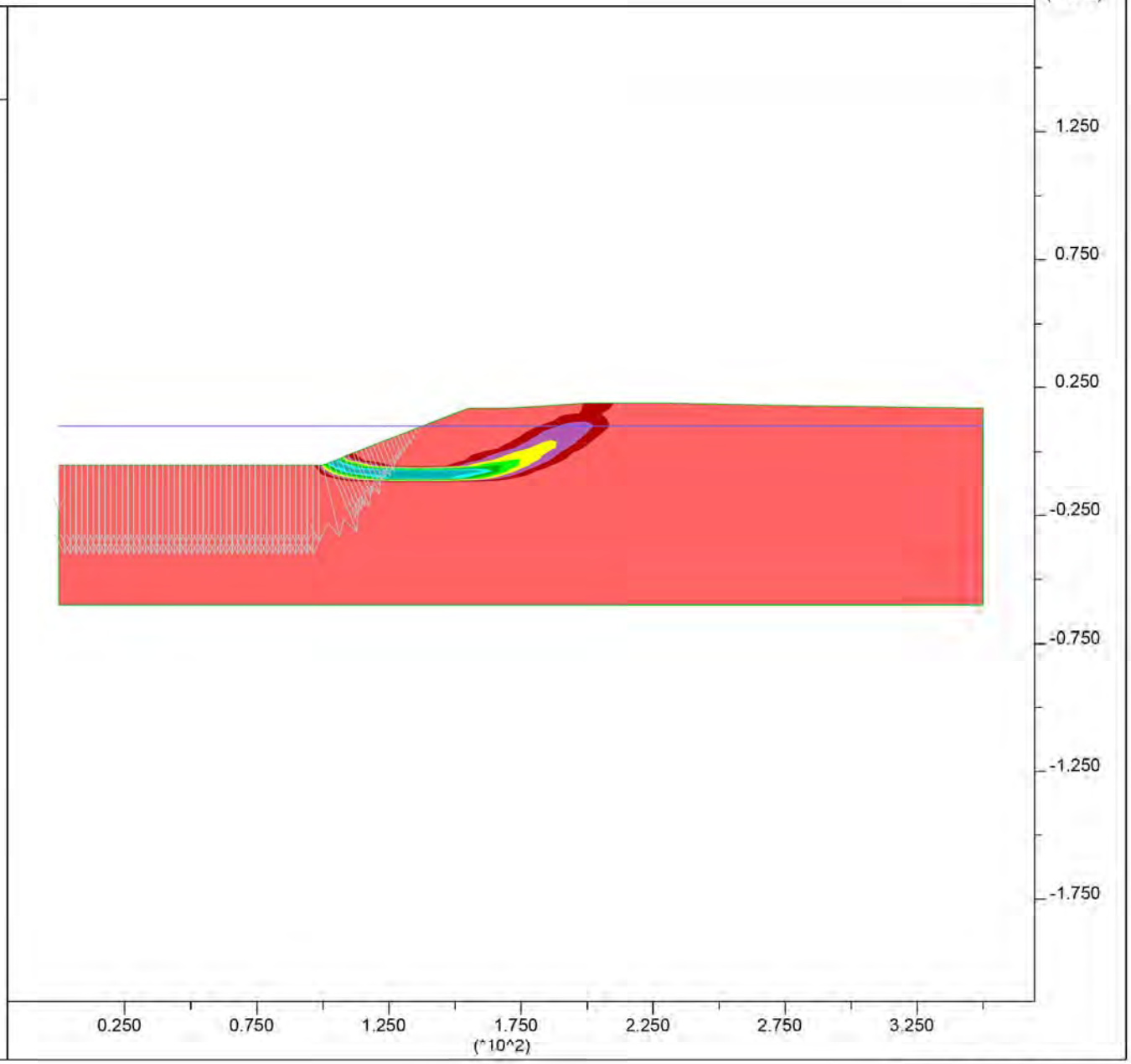


PLATE G-58

JOB TITLE : Section D-D' - Ky=0.05 - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 9:24

Factor of Safety 1.00

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand Deep'
- 'User:Liq Sand 2'
- 'User:Soft Clay'
- 'User:Liq Sand Shallow'
- User:LiqFill
- User:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.052E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

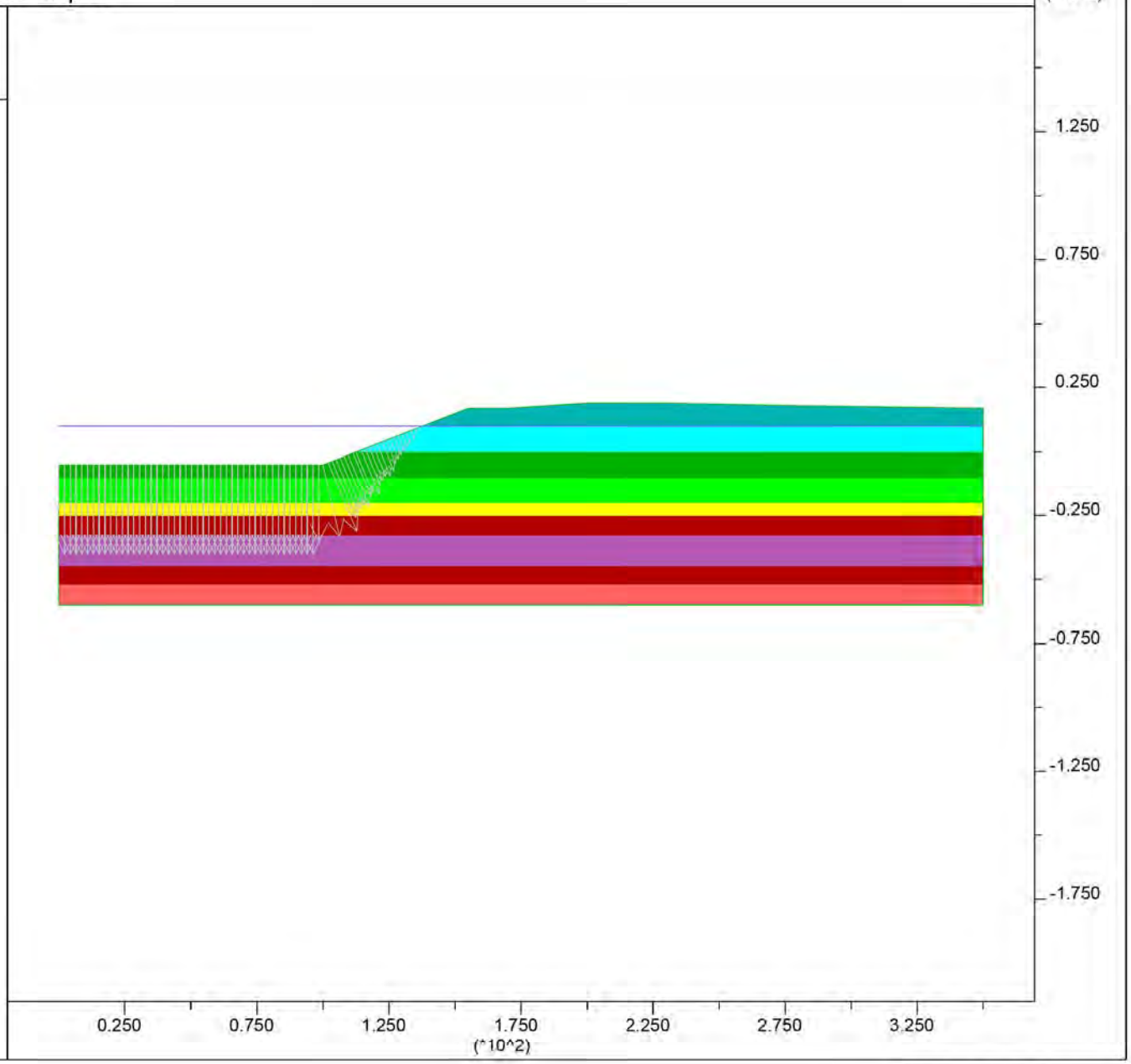


PLATE G-59

Newmark Displacements using Bray and Rathje (1998):

Section D-D'

Site Input

PGA,rock =	0.25	g		
M =	6.6			
r =	13	km		
ky =	0.05		32.185	1.60925

Sliding Mass Input

Vs =	137	m/s	assumed
Thickness, H =	8.2	m	
	27	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.24	sec				
NRF =	1.15					
Ts/Tm =	0.49					
kmax/(PGA,rock*NRF)	0.93					
kmax =	0.27					
ky / kmax =	0.19					
Displacement, u =	47	cm	1.5	feet	18.4	inches

PLATE G-60

JOB TITLE : Section D-D' - Ground Improvement with DSM (ky=0.07)

FLAC (Version 7.00)

LEGEND

5-Mar-13 17:21
step 33918
-1.944E+01 <x< 3.694E+02
-2.149E+02 <y< 1.739E+02

Factor of Safety 0.98

Max. shear strain-rate
0.00E+00
5.00E-07
1.00E-06
1.50E-06
2.00E-06
2.50E-06
3.00E-06
3.50E-06
4.00E-06
4.50E-06

Contour interval= 5.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Group Delta Consultants
Ballona Wetlands

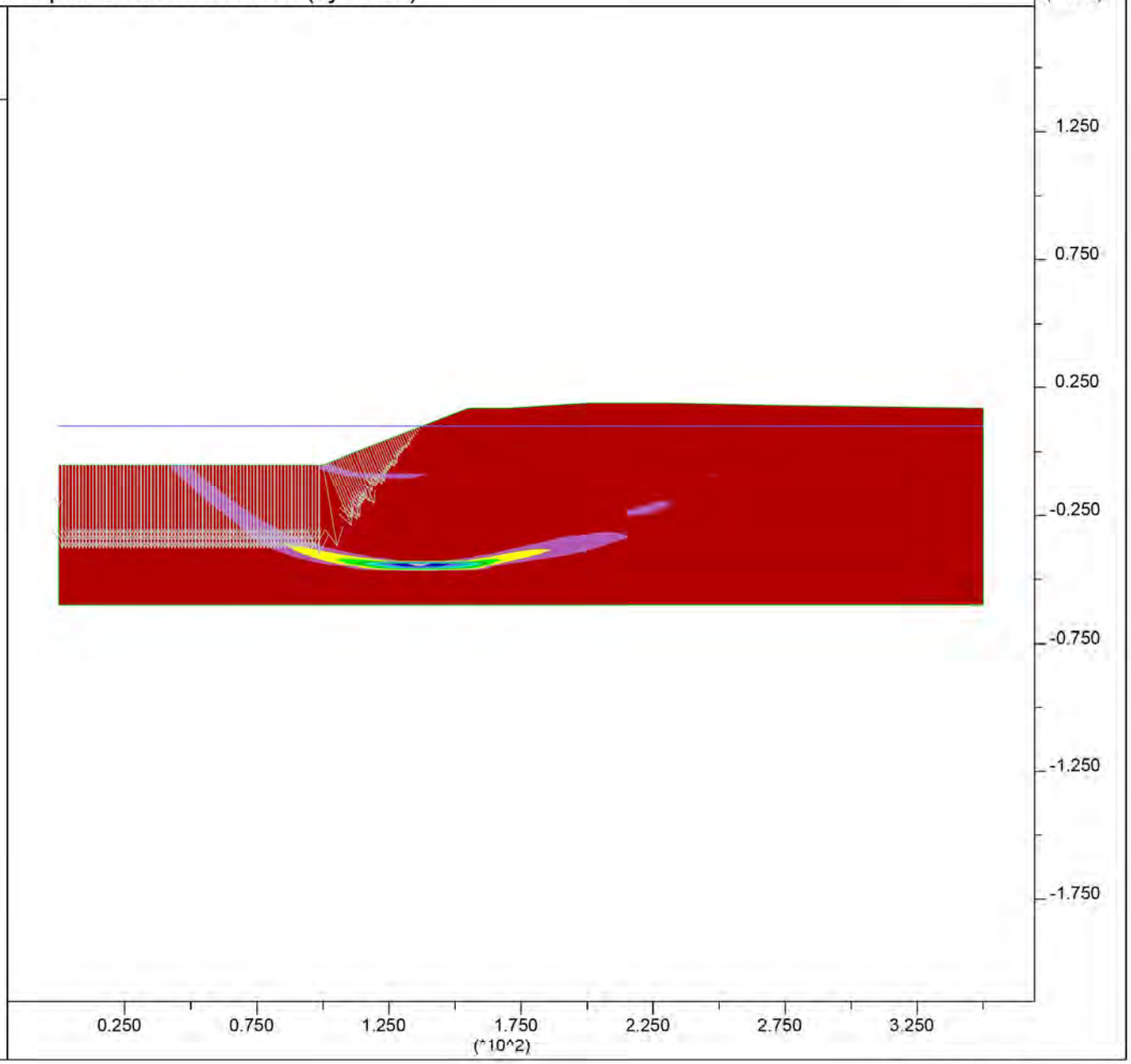


PLATE G-61

JOB TITLE : Section D-D' - Ground Improvement with DSM (ky=0.07) - Input

FLAC (Version 7.00)

LEGEND

5-Mar-13 17:20
step 0
-1.944E+01 <x< 3.694E+02
-2.149E+02 <y< 1.739E+02

User-defined Groups
- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand Deep'
- 'User:Liq Sand 2'
- 'User:Soft Clay'
- 'User:Liq Sand Shallow'
- User:LiqFill
- User:Fill
- User:DSM

Net Applied Forces

max vector = 1.301E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

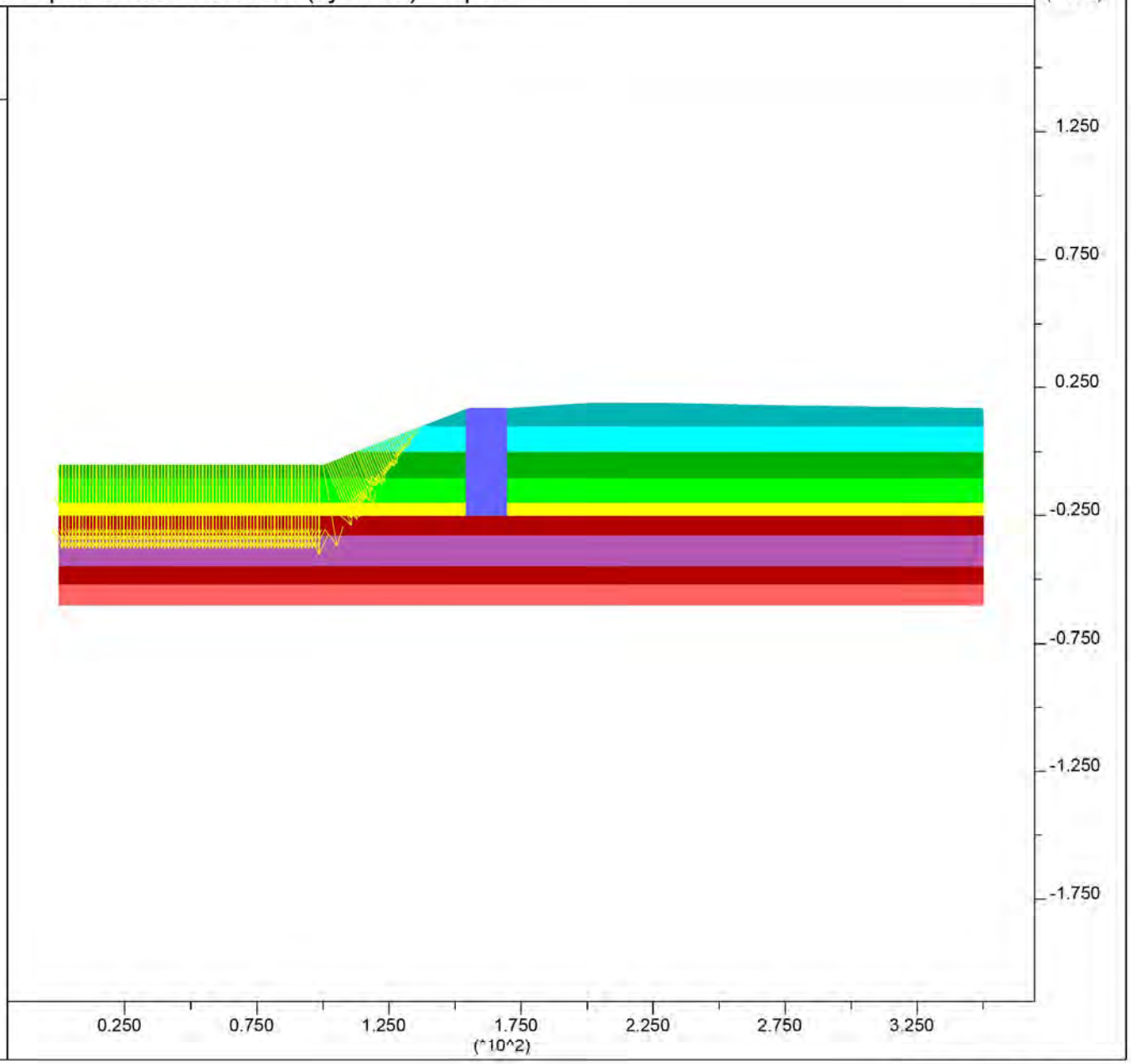


PLATE G-62

JOB TITLE : Section E-E' - End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:38

Factor of Safety 1.57

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 1.718E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

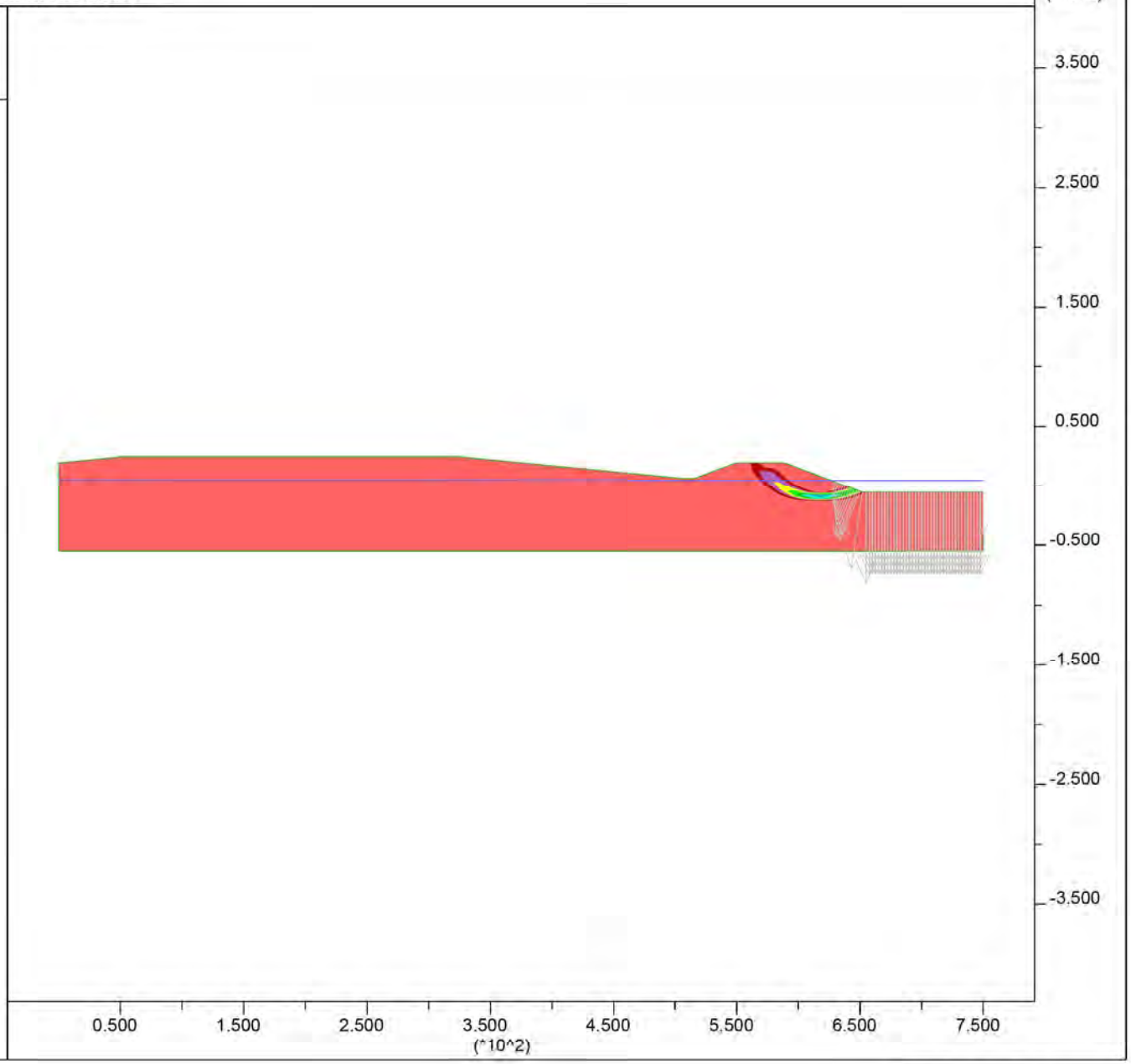


PLATE G-63

JOB TITLE : Section E-E' - End of Construction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:39

Factor of Safety 1.57

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- Fill:Fill
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 1.718E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

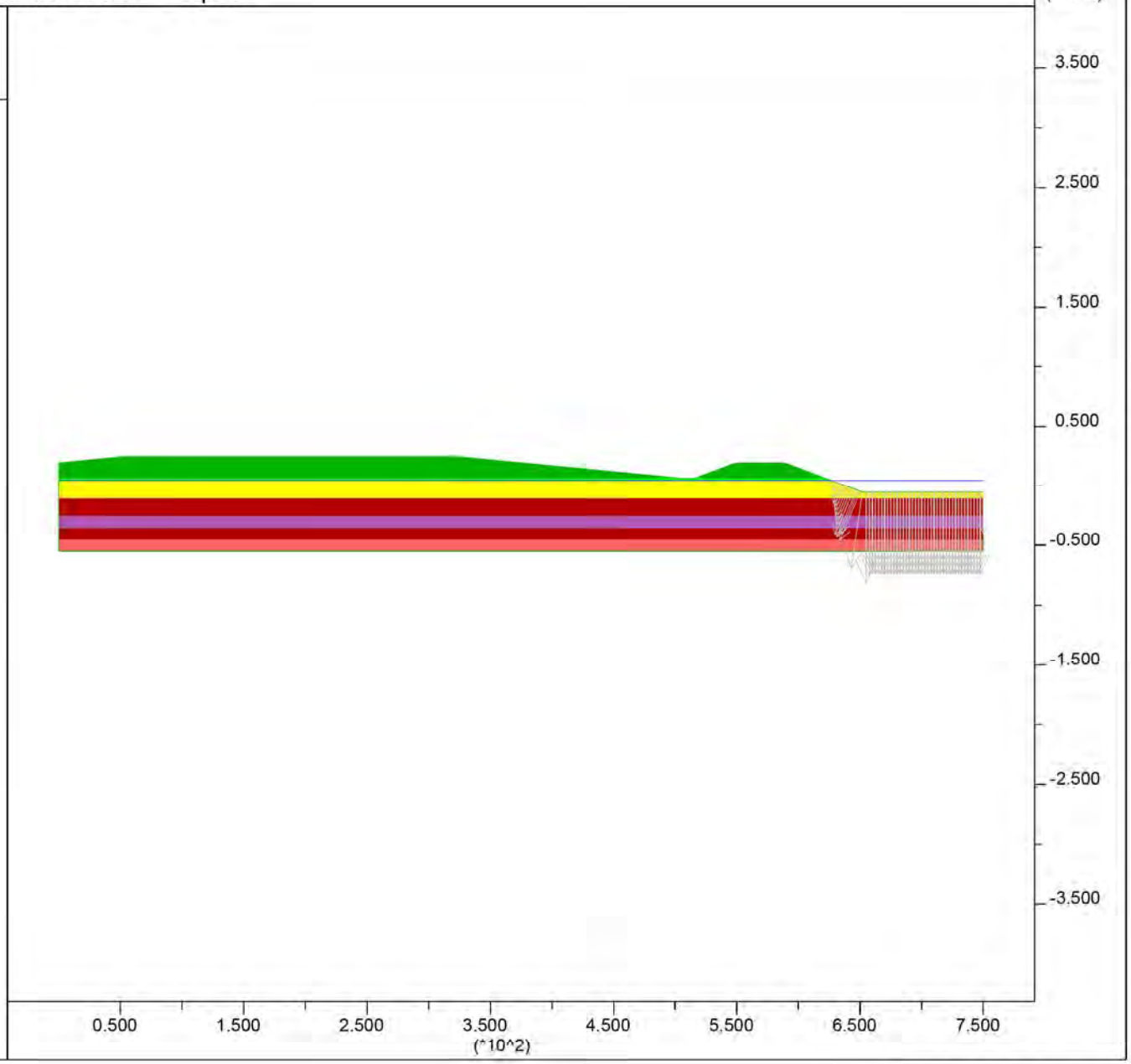


PLATE G-64

JOB TITLE : Section E-E' - High Water Short Term

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:37

Factor of Safety 2.07

Shear Strain Rate Contours

1.00E-06
2.00E-06
3.00E-06
4.00E-06
5.00E-06
6.00E-06
7.00E-06

Contour interval= 1.00E-06
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 3.779E+03

0 1E 4

Group Delta Consultants
Ballona Wetlands

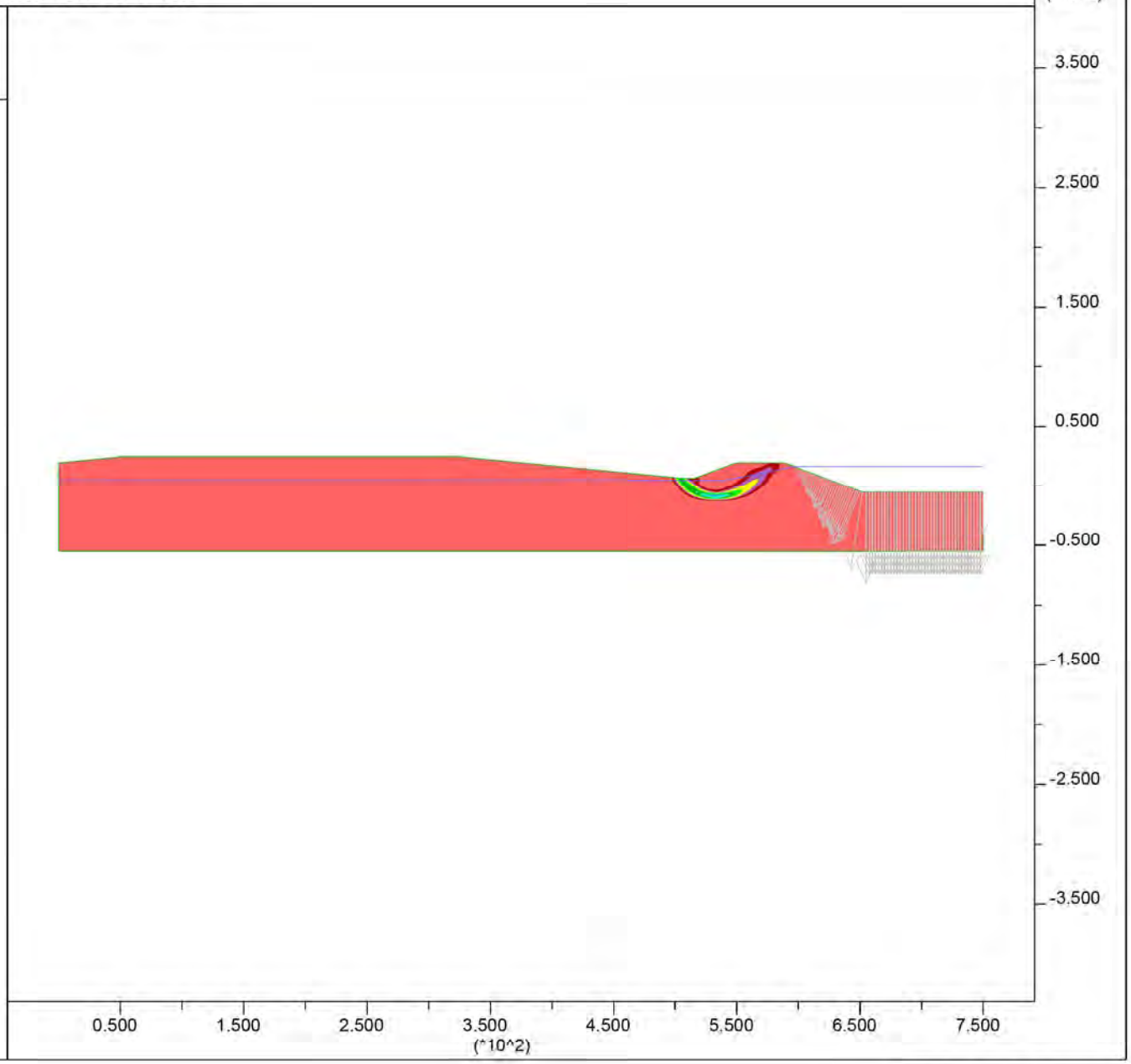


PLATE G-65

JOB TITLE : Section E-E' - High Water Short Term - Input

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:37

Factor of Safety 2.07

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- Fill:Fill
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 3.779E+03

0 1E 4

Group Delta Consultants
Ballona Wetlands

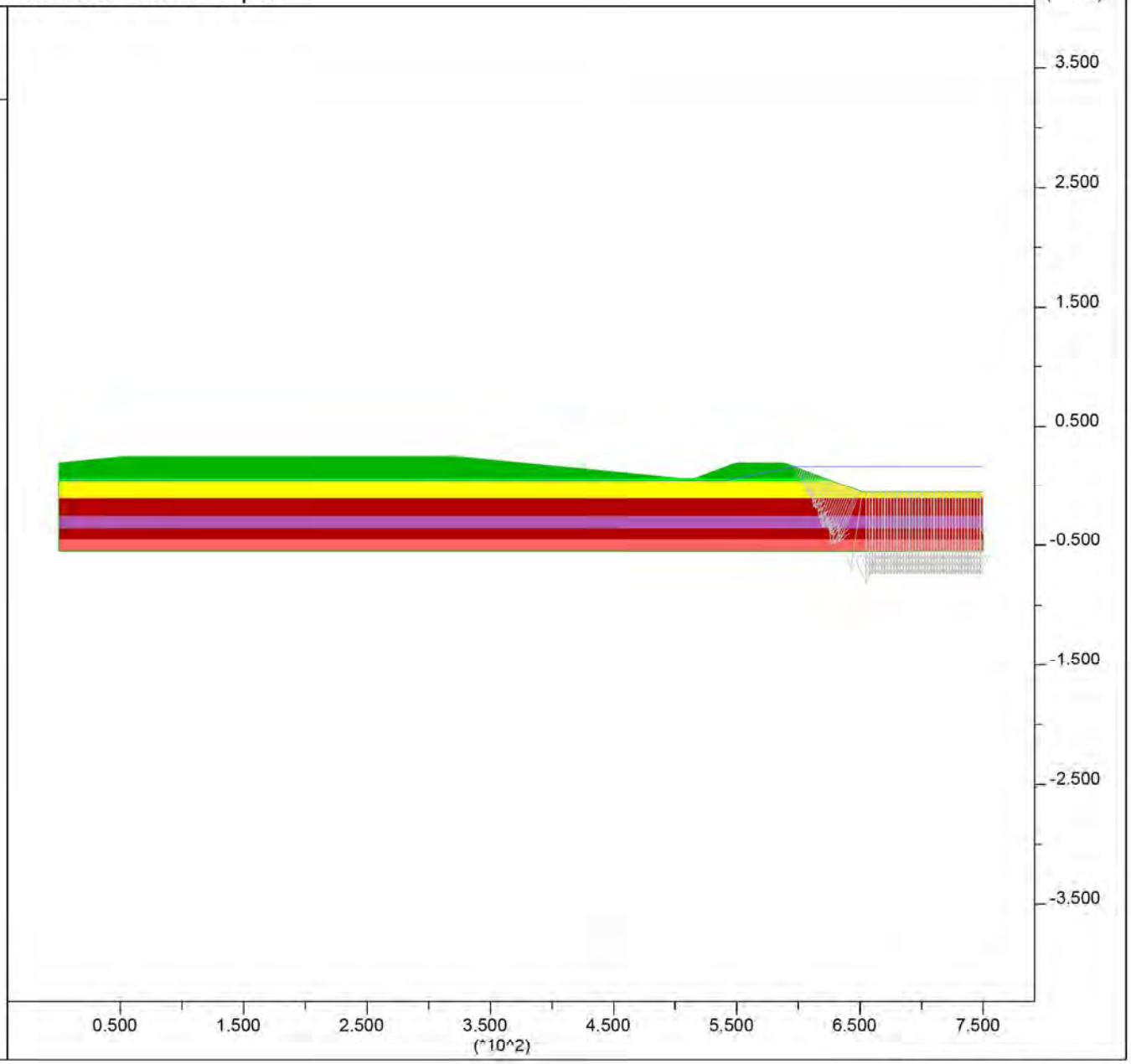


PLATE G-66

JOB TITLE : Section E-E' - Post Liquefaction

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:40

Factor of Safety 1.33

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06
- 1.75E-06
- 2.00E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 2.061E+03

Group Delta Consultants
Ballona Wetlands

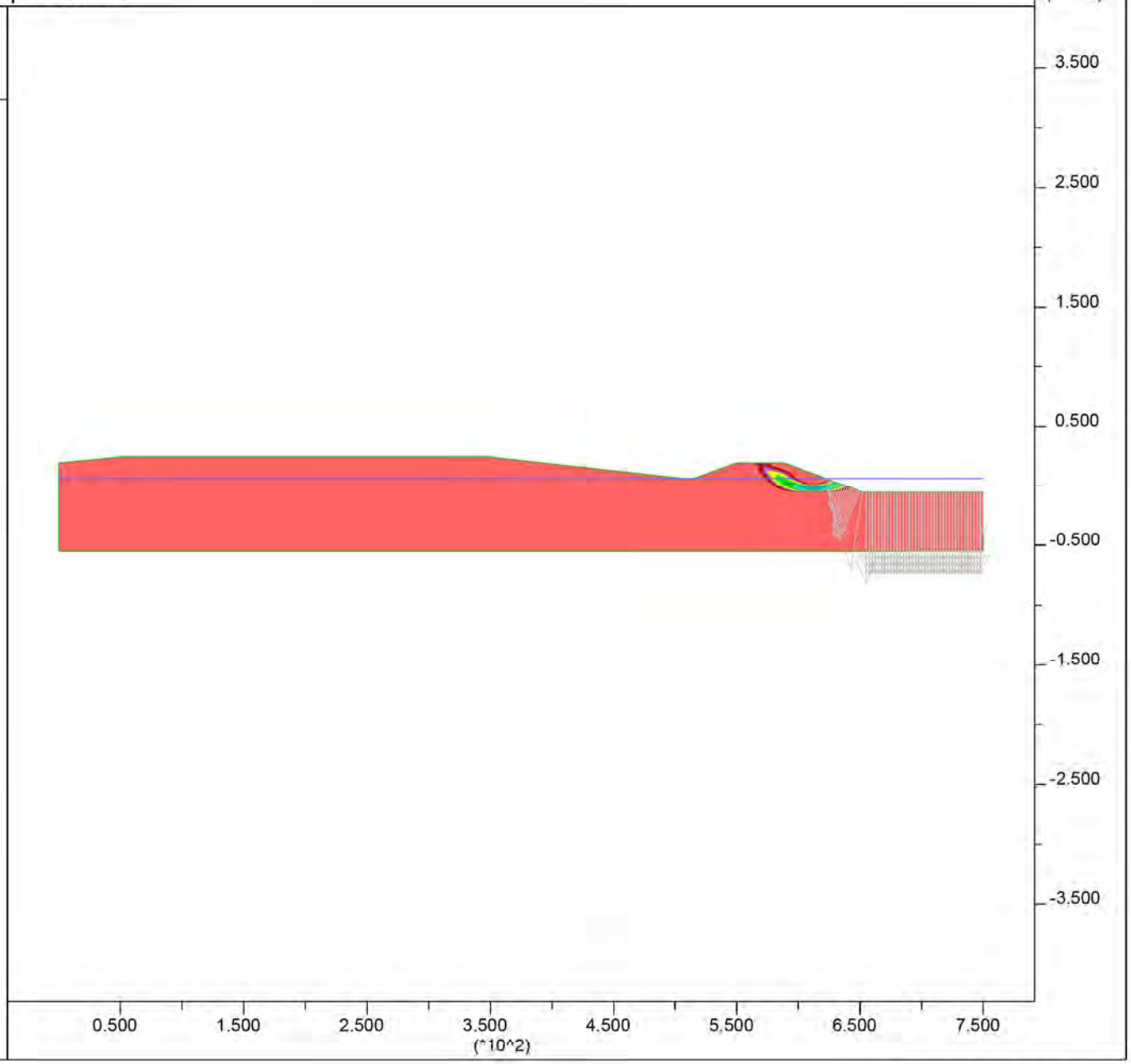


PLATE G-67

JOB TITLE : Section E-E' - Post Liquefaction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:40

Factor of Safety 1.33

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'Fill:Liq Sand 2'
- 'User:Soft Clay'
- 'Fill:Liq Fill'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 2.061E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

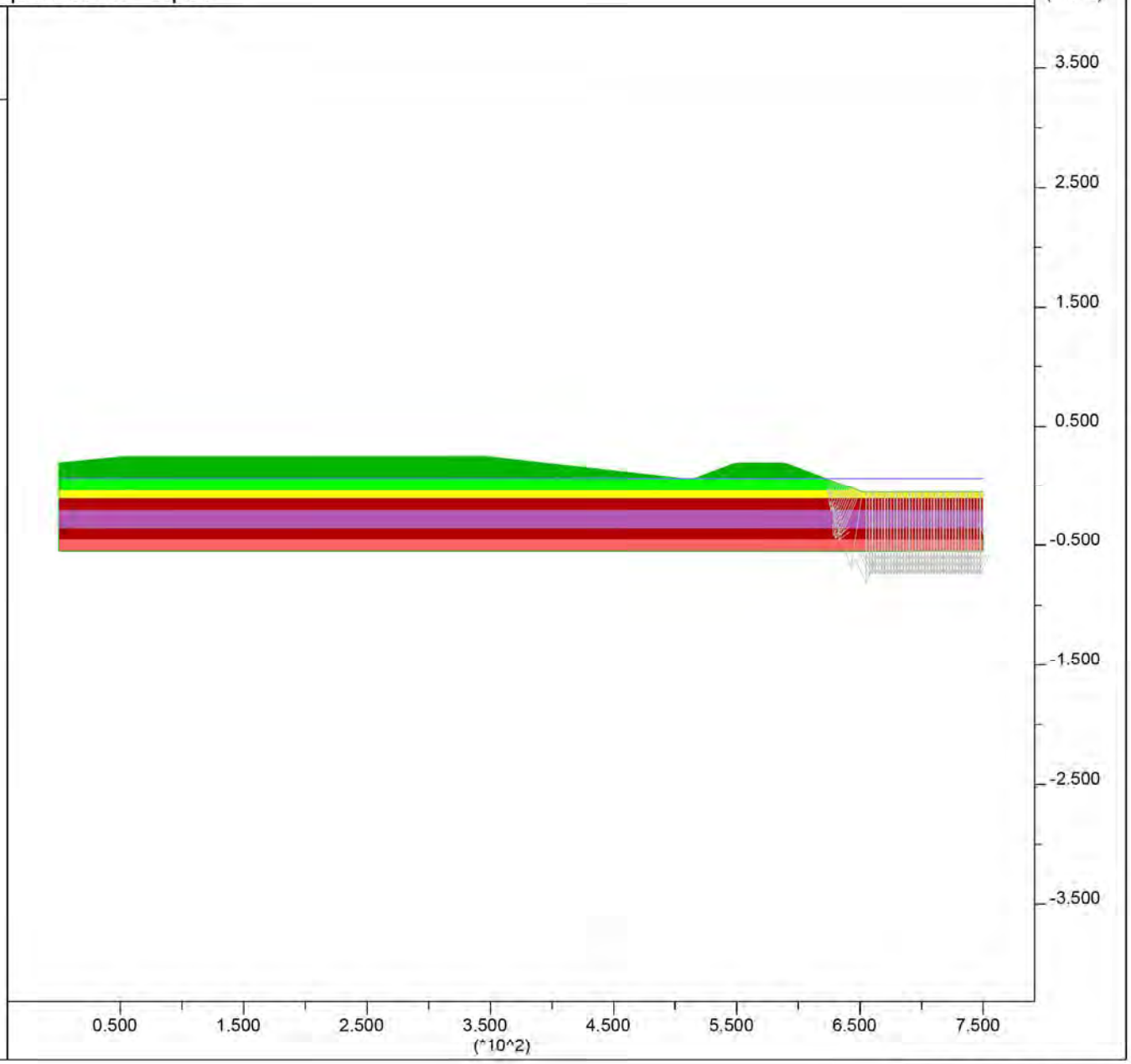


PLATE G-68

JOB TITLE : Section E-E' - Ky=0.08

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:42

Factor of Safety 0.98

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06
- 4.00E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 2.068E+03

Group Delta Consultants
Ballona Wetlands

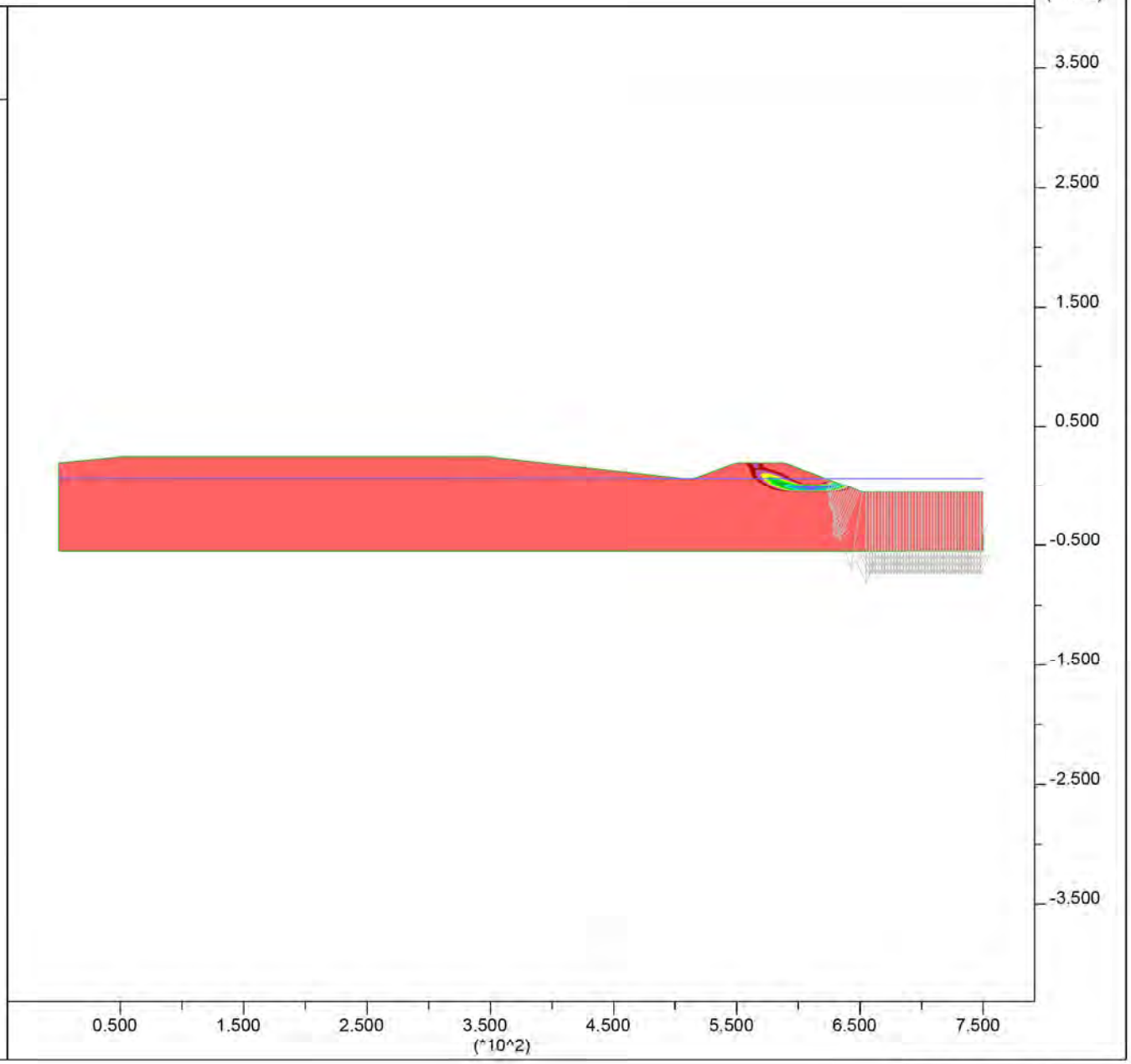


PLATE G-69

JOB TITLE : Section E-E' - Ky=0.08 - Input

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:43

Factor of Safety 0.98

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'Fill:Liq Sand 2'
- 'User:Soft Clay'
- 'Fill:Liq Fill'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 2.068E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

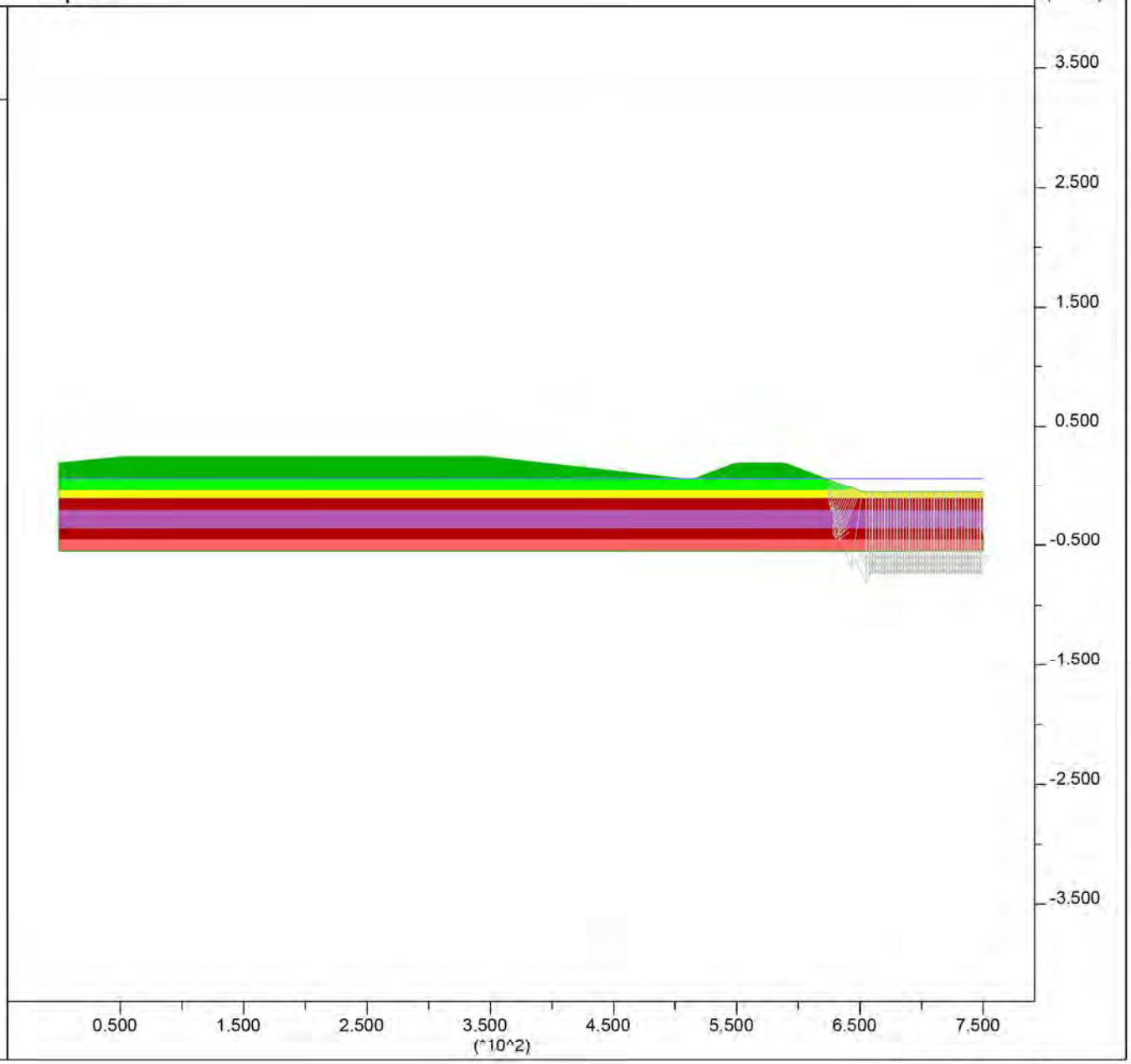


PLATE G-70

Newmark Displacements using Bray and Rathje (1998):

Section E-E'

Site Input						
PGA,rock =	0.25	g				
M =	6.6					
r =	13	km				
ky =	0.08			32.185	2.5748	
Sliding Mass Input						
Vs =	137	m/s	assumed			
Thickness, H =	6.1	m				
	20	ft				
Output						
Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.18	sec				
NRF =	1.15					
Ts/Tm =	0.36					
kmax/(PGA,rock*NRF)	1.18					
kmax =	0.34					
ky / kmax =	0.24					
Displacement, u =	40	cm		1.3	feet	15.6	inches

PLATE G-71

JOB TITLE : Section E-E' - Ground Improvement with DSM (ky=0.08)

FLAC (Version 7.00)

LEGEND

5-Mar-13 17:17
step 13290
-4.167E+01 <x< 7.917E+02
-4.317E+02 <y< 4.017E+02

Factor of Safety 1.00

Max. shear strain-rate
0.00E+00
5.00E-07
1.00E-06
1.50E-06
2.00E-06
2.50E-06

Contour interval= 5.00E-07
Extrap. by averaging
Boundary plot
0 2E 2

Water Table

Net Applied Forces

max vector = 2.061E+03

Group Delta Consultants
Ballona Wetlands

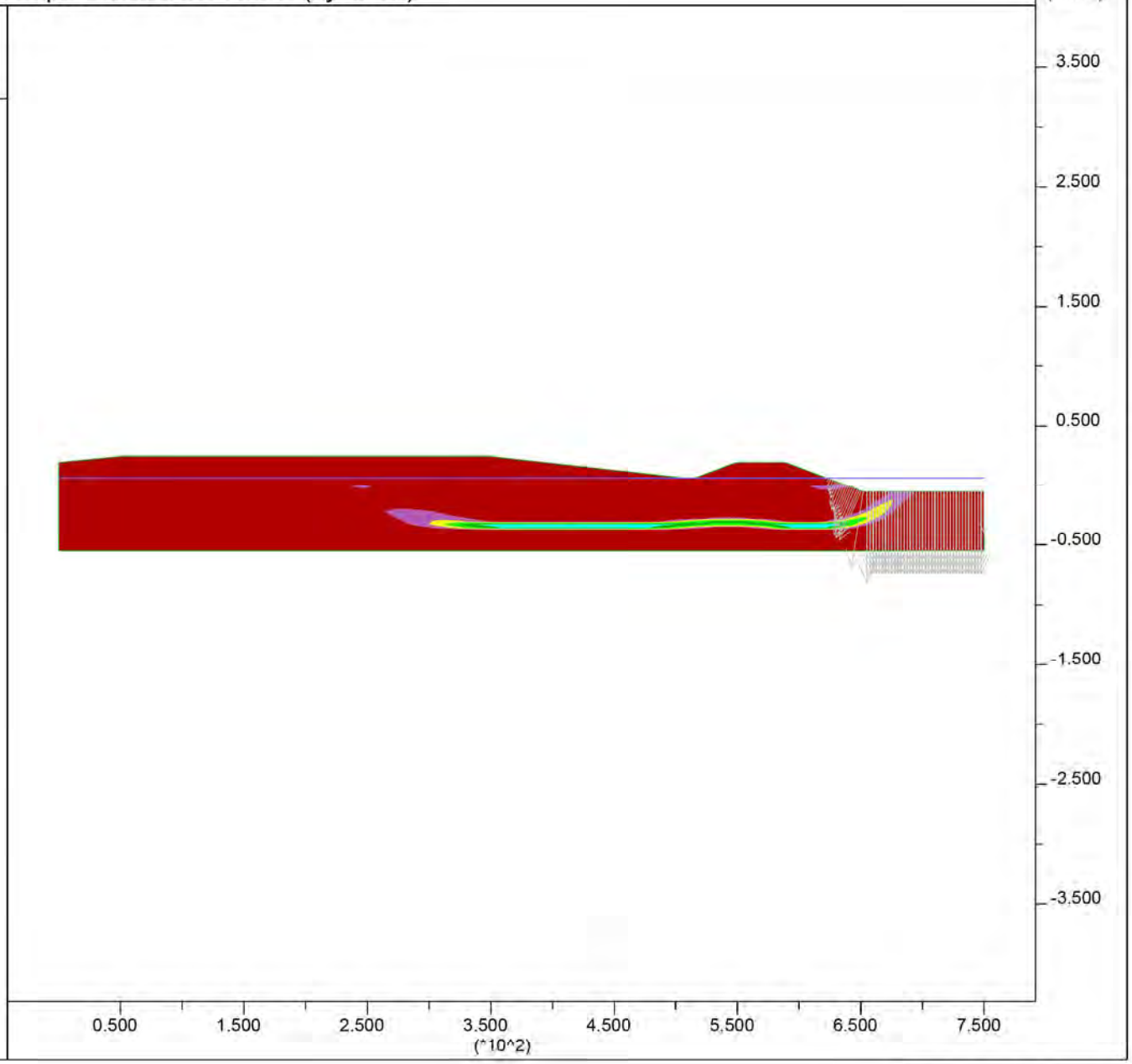


PLATE G-72

JOB TITLE : Section E-E' - Ground Improvement with DSM (ky=0.08) - Input

FLAC (Version 7.00)

LEGEND

5-Mar-13 17:16
step 13290
-4.167E+01 <x< 7.917E+02
-4.317E+02 <y< 4.017E+02

User-defined Groups
- User:Sand
- 'User:Stiff Clay'
- 'Fill:Liq Sand 2'
- 'User:Soft Clay'
- 'Fill:Liq Fill'
- User:Embankment
- User:DSM

Net Applied Forces

max vector = 2.061E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

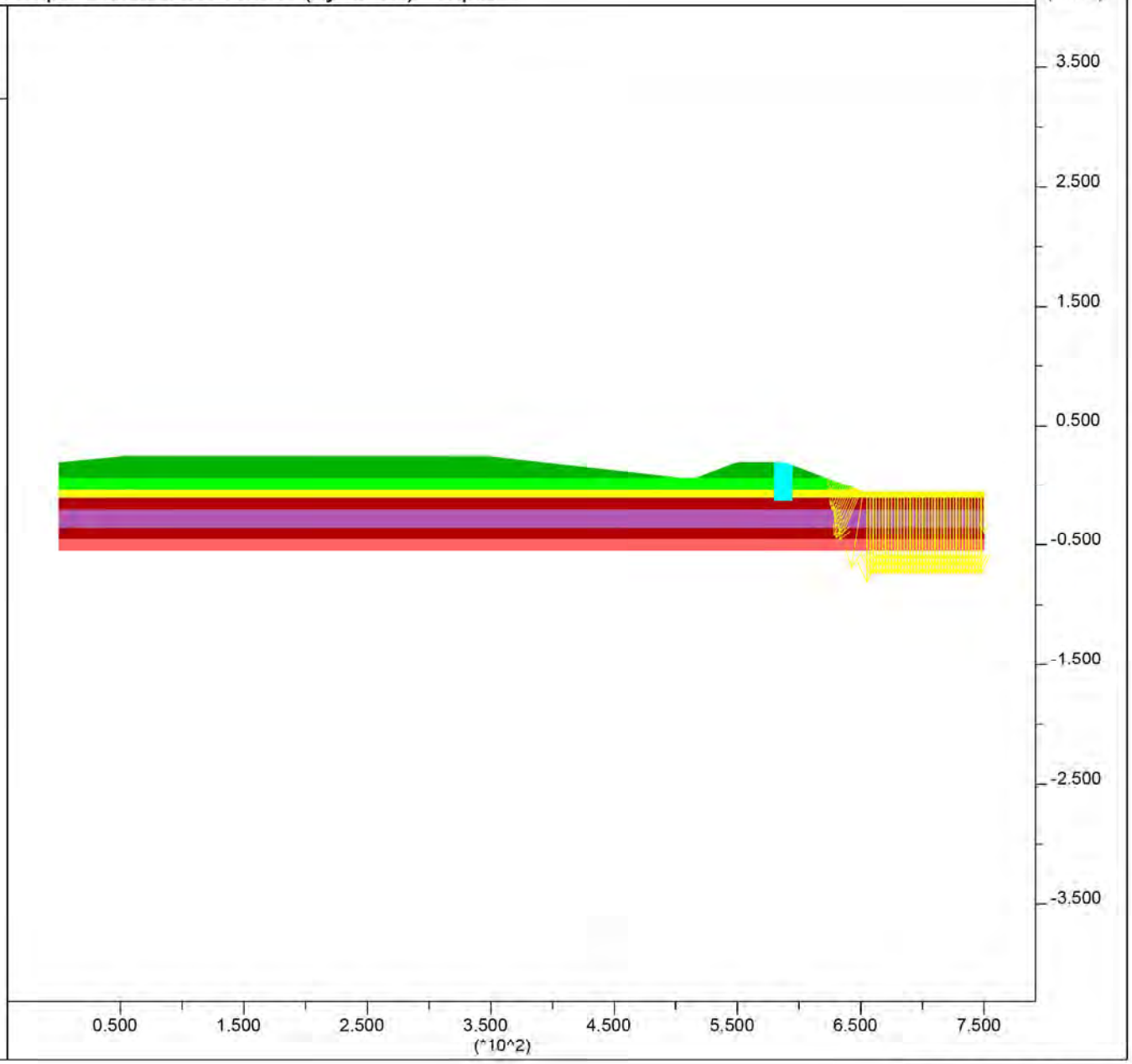


PLATE G-73

JOB TITLE : Section F-F' - End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 20:06

Factor of Safety 2.19

Shear Strain Rate Contours

1.00E-06
2.00E-06
3.00E-06
4.00E-06
5.00E-06

Contour interval= 1.00E-06
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 3.123E+03

0 1E 4

Group Delta Consultants
Torrance, CA

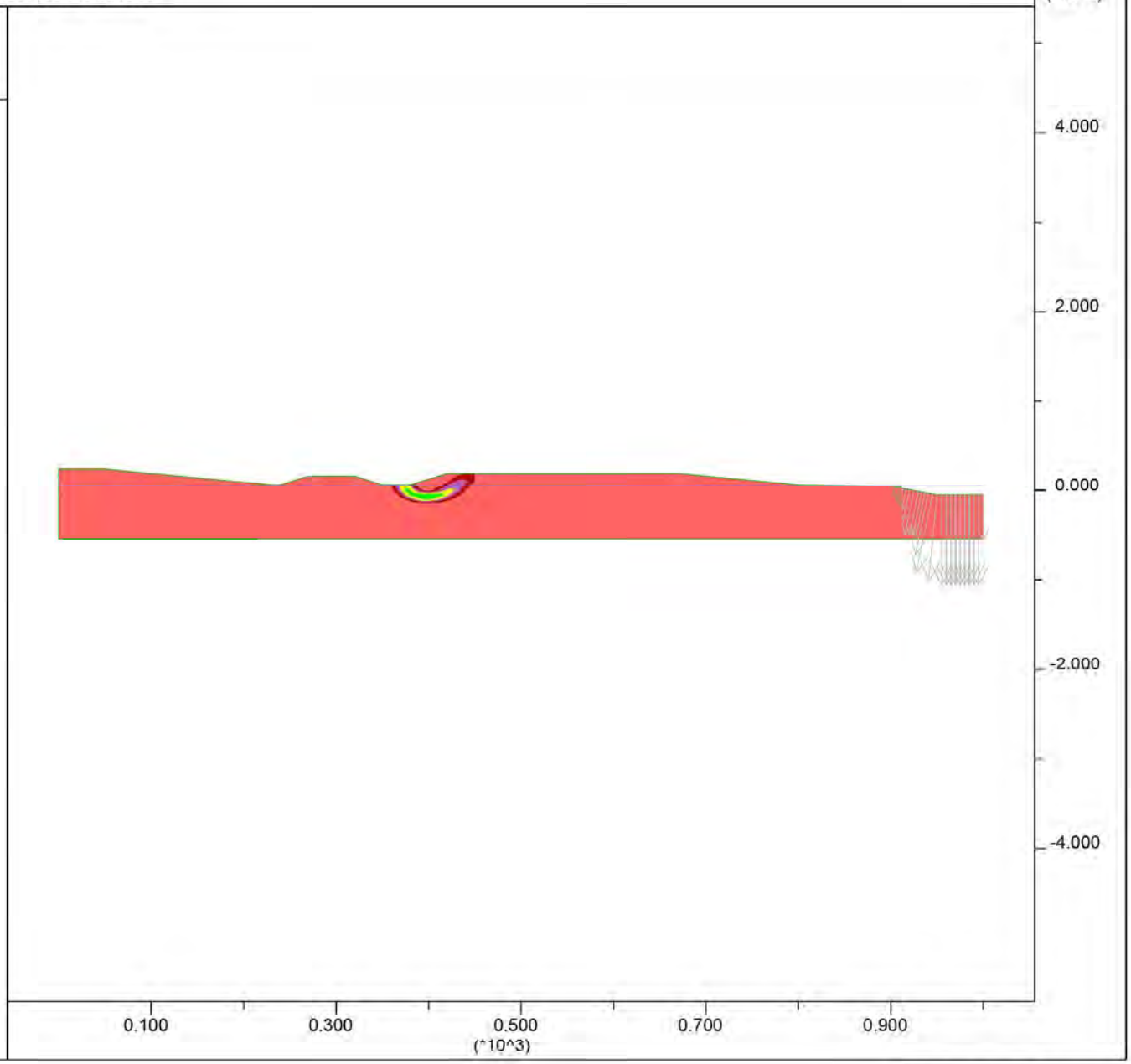


PLATE G-74

JOB TITLE : Section F-F' - End of Construction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 20:05

Factor of Safety 2.19

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- User:Embankment
- Fill:Fill

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 3.123E+03

0 1E 4

Group Delta Consultants
Torrance, CA

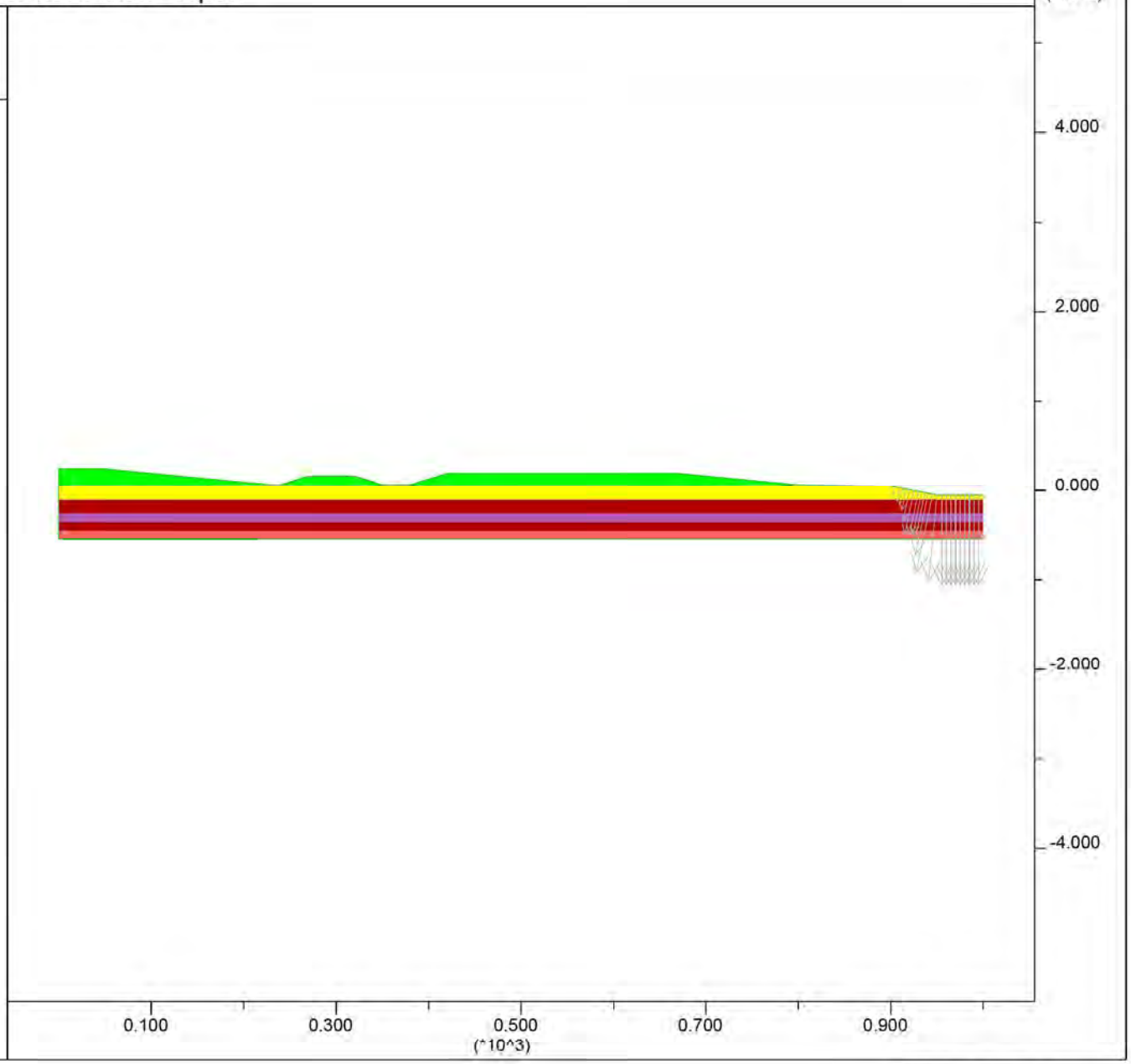


PLATE G-75

JOB TITLE : Section F-F' - High Water Short Term

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 19:52

Factor of Safety 2.19

Shear Strain Rate Contours

- 2.00E-06
- 4.00E-06
- 6.00E-06
- 8.00E-06
- 1.00E-05

Contour interval= 2.00E-06
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 6.322E+03

0 2E 4

Group Delta Consultants
Torrance, CA

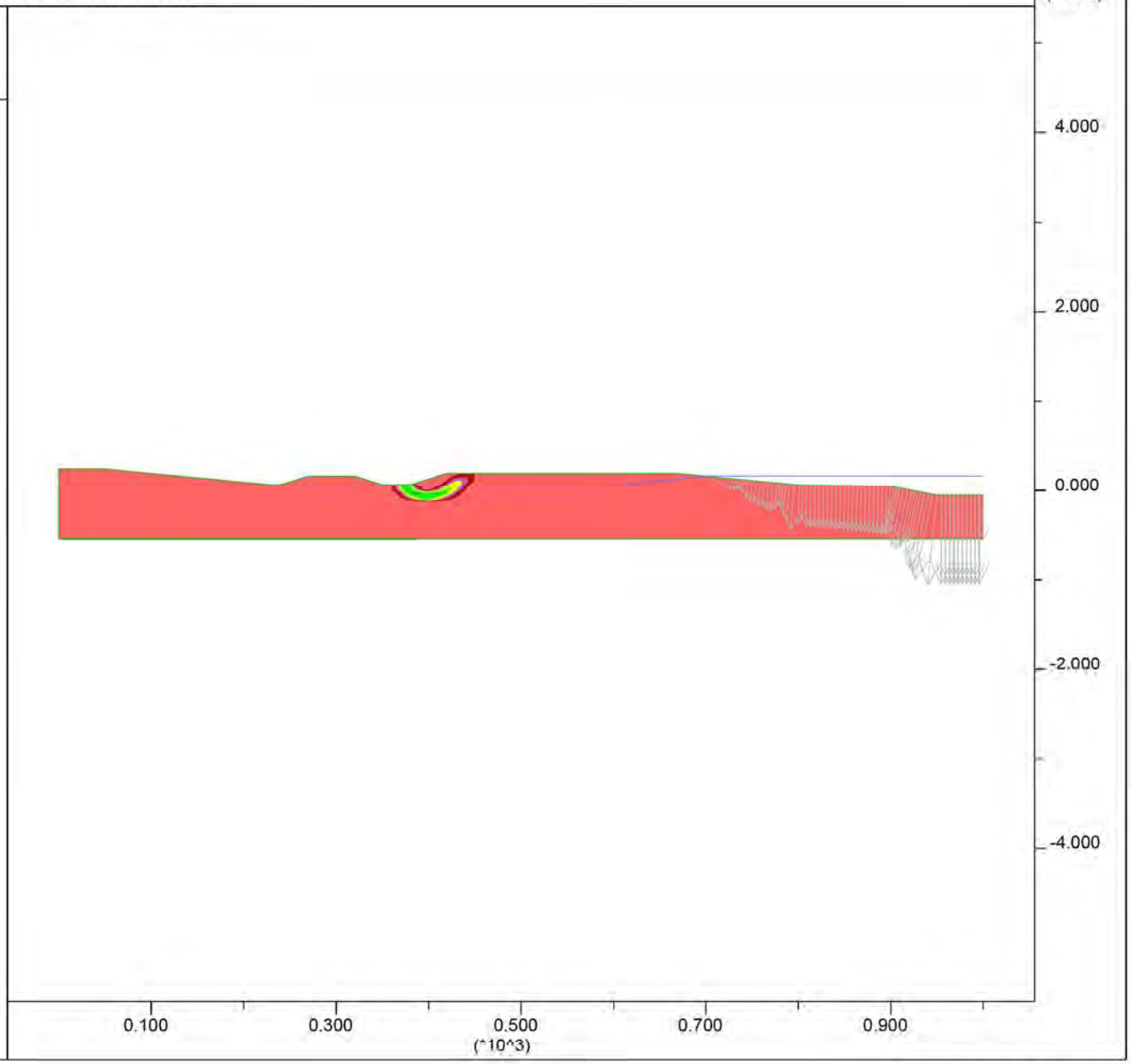


PLATE G-76

JOB TITLE : Section F-F' - High Water Short Term - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 19:52

Factor of Safety 2.19

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- User:Embankment
- Fill:Fill

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 6.322E+03

0 2E 4

Group Delta Consultants
Torrance, CA

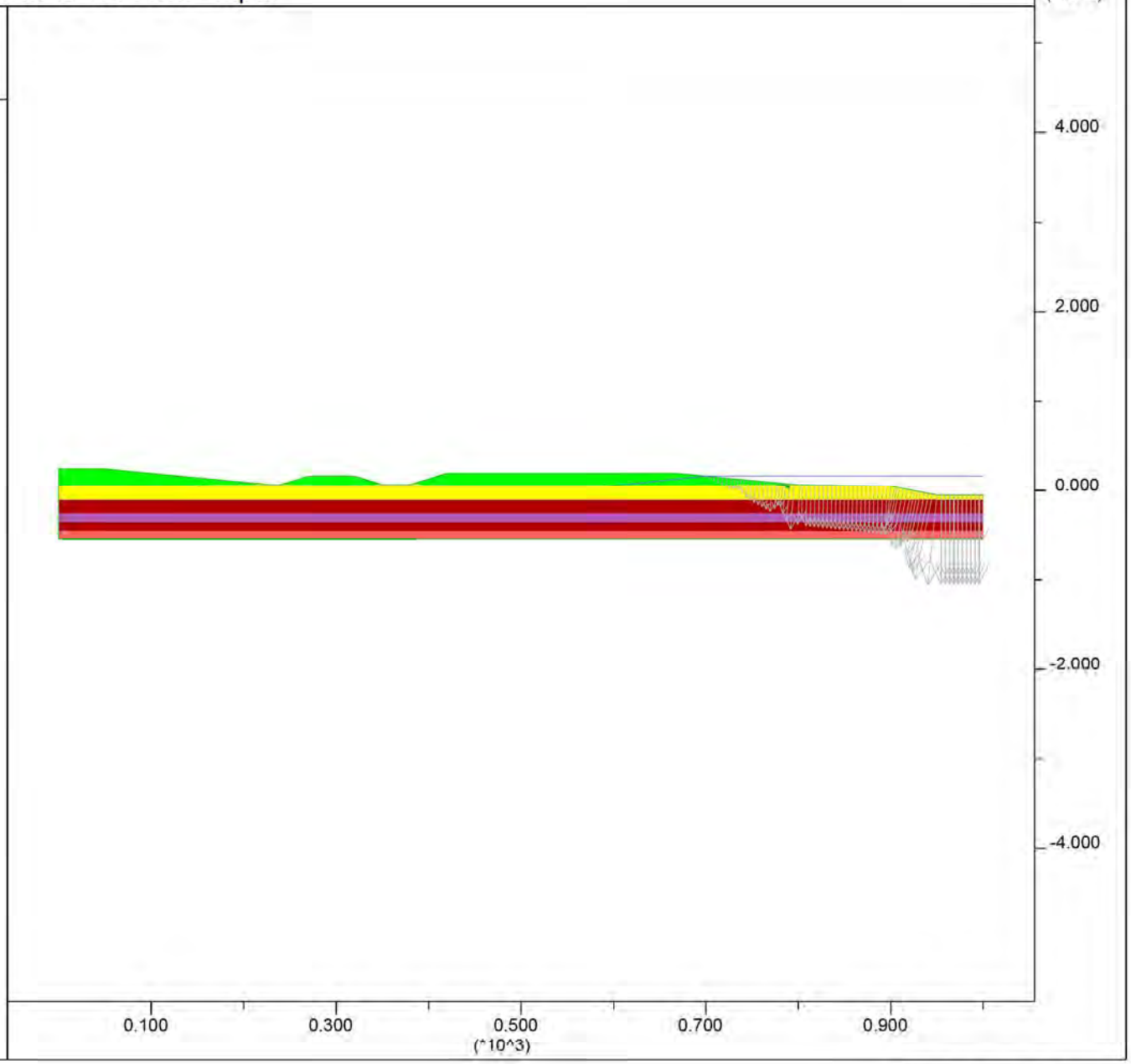


PLATE G-77

JOB TITLE : Section F-F' - Post Liquefaction

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:45

Factor of Safety 1.59

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06
- 4.00E-06
- 4.50E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 2.342E+03

Group Delta Consultants
Ballona Wetlands

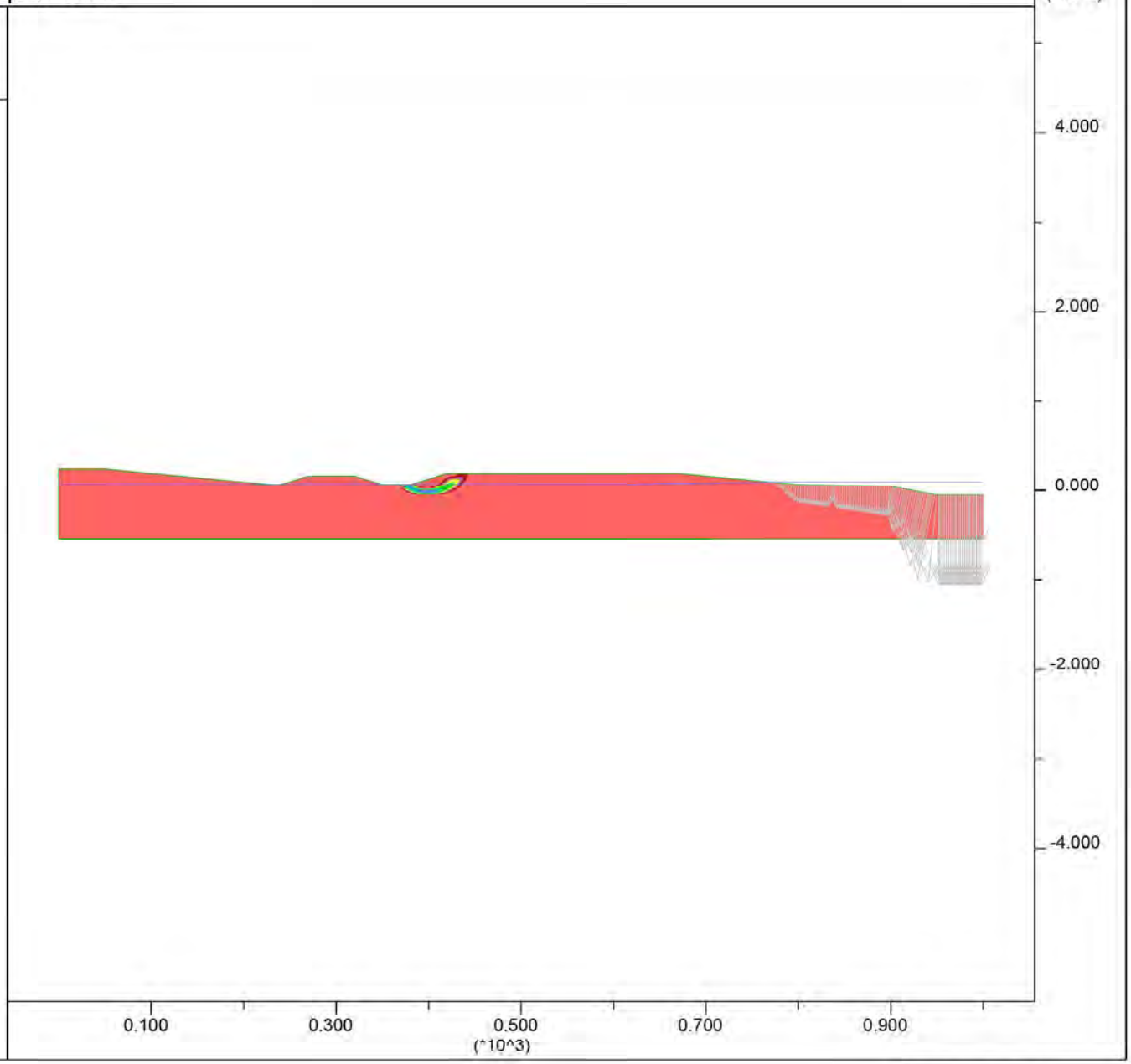


PLATE G-78

JOB TITLE : Section F-F' - Post Liquefaction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:46

Factor of Safety 1.59

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand Deep'
- 'User:Soft Clay'
- 'User:Liq Sand'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 2.342E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

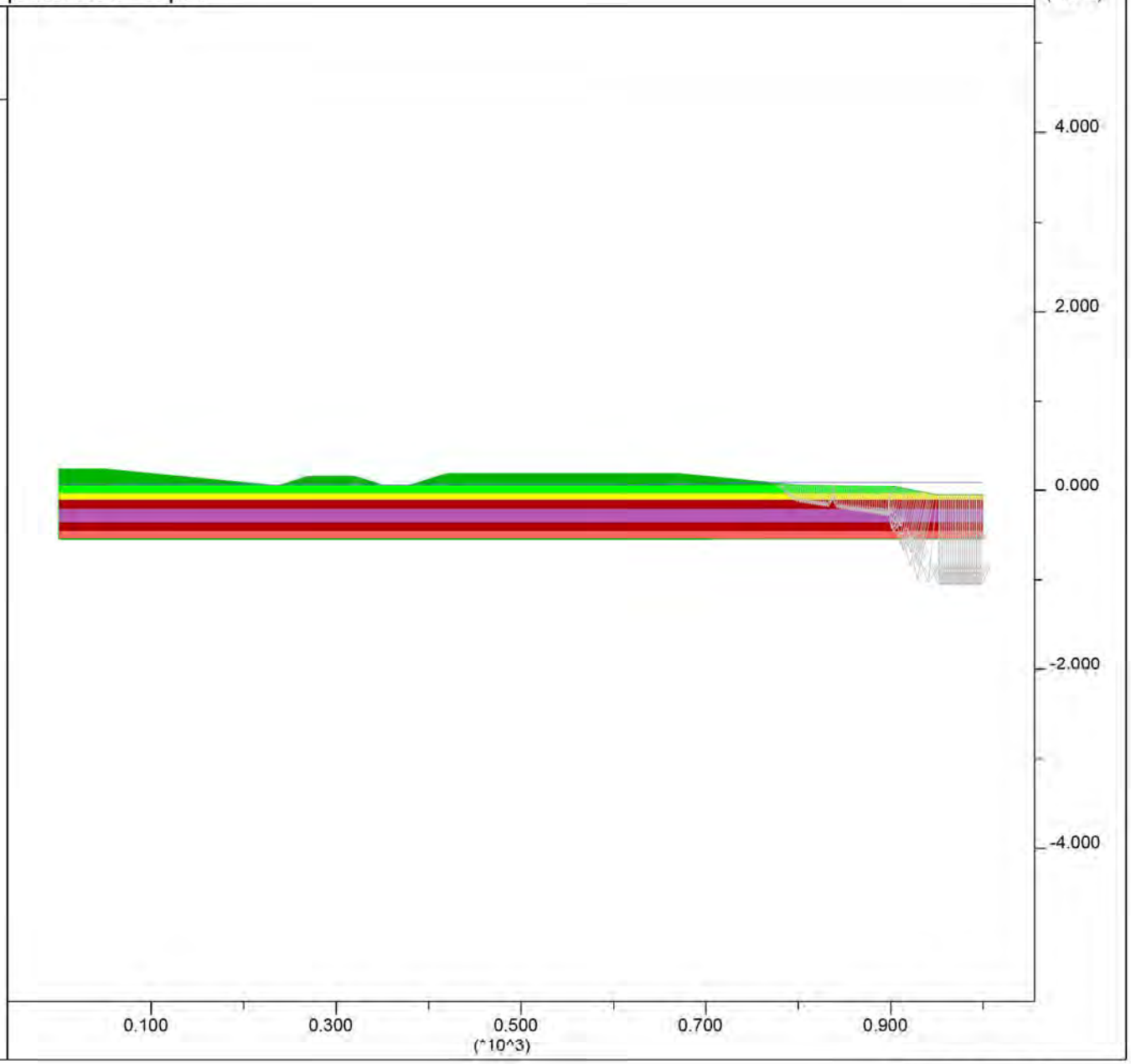


PLATE G-79

JOB TITLE : Section F-F' - Ky=0.10

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:48

Factor of Safety 0.96

Shear Strain Rate Contours

1.00E-06
2.00E-06
3.00E-06
4.00E-06
5.00E-06
6.00E-06

Contour interval= 1.00E-06
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 2.354E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

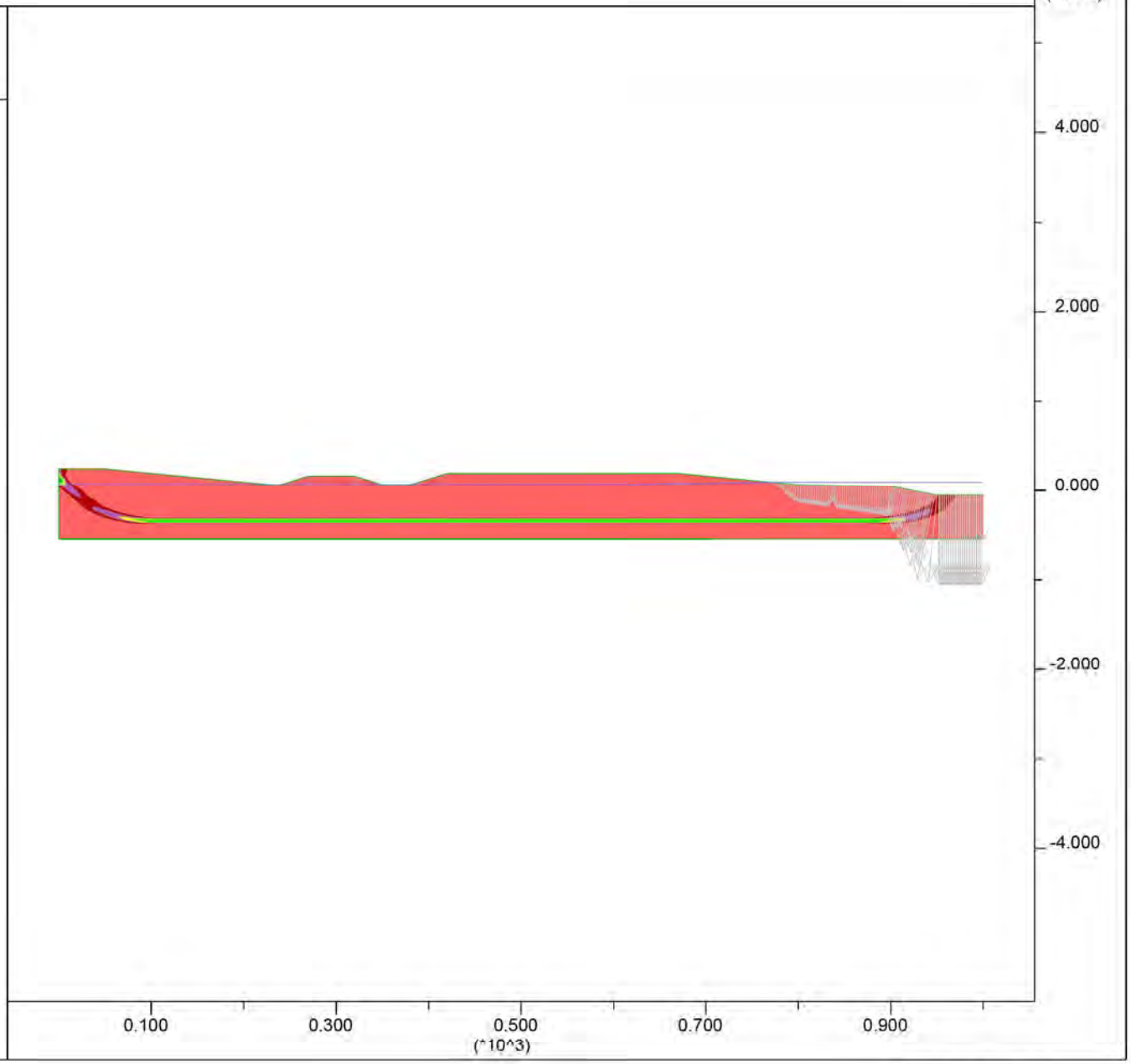


PLATE G-80

JOB TITLE : Section F-F' - Ky=0.10 - Input

FLAC/SLOPE (Version 7.00)

LEGEND

4-Mar-13 17:48

Factor of Safety 0.96

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand Deep'
- 'User:Soft Clay'
- 'User:Liq Sand'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 2.354E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

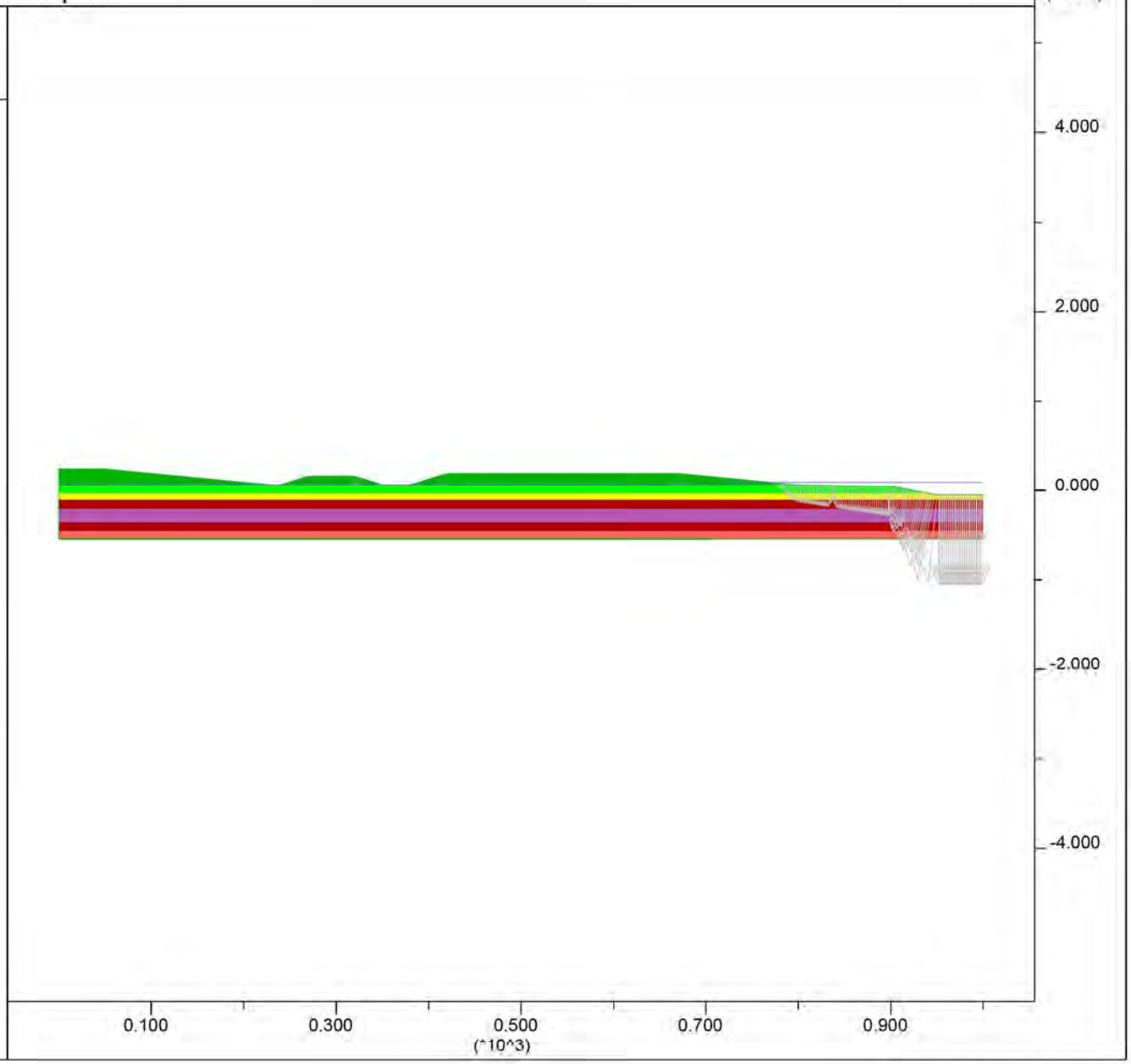


PLATE G-81

Newmark Displacements using Bray and Rathje (1998):

Section F-F'

Site Input

PGA,rock =	0.25	g		
M =	6.6			
r =	13	km		
ky =	0.1		32.185	3.2185
Sliding Mass Input				
Vs =	200	m/s	assumed	
Thickness, H =	16.8	m		
	55	ft		

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.34	sec				
NRF =	1.15					
Ts/Tm =	0.69					
kmax/(PGA,rock*NRF)	0.72					
kmax =	0.21					
ky / kmax =	0.49					
Displacement, u =	3	cm	0.1	feet	1.3	inches

PLATE G-82

JOB TITLE : Section G-G' - End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

21-Feb-13 14:43

Factor of Safety 2.55

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06
- 1.75E-06
- 2.00E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

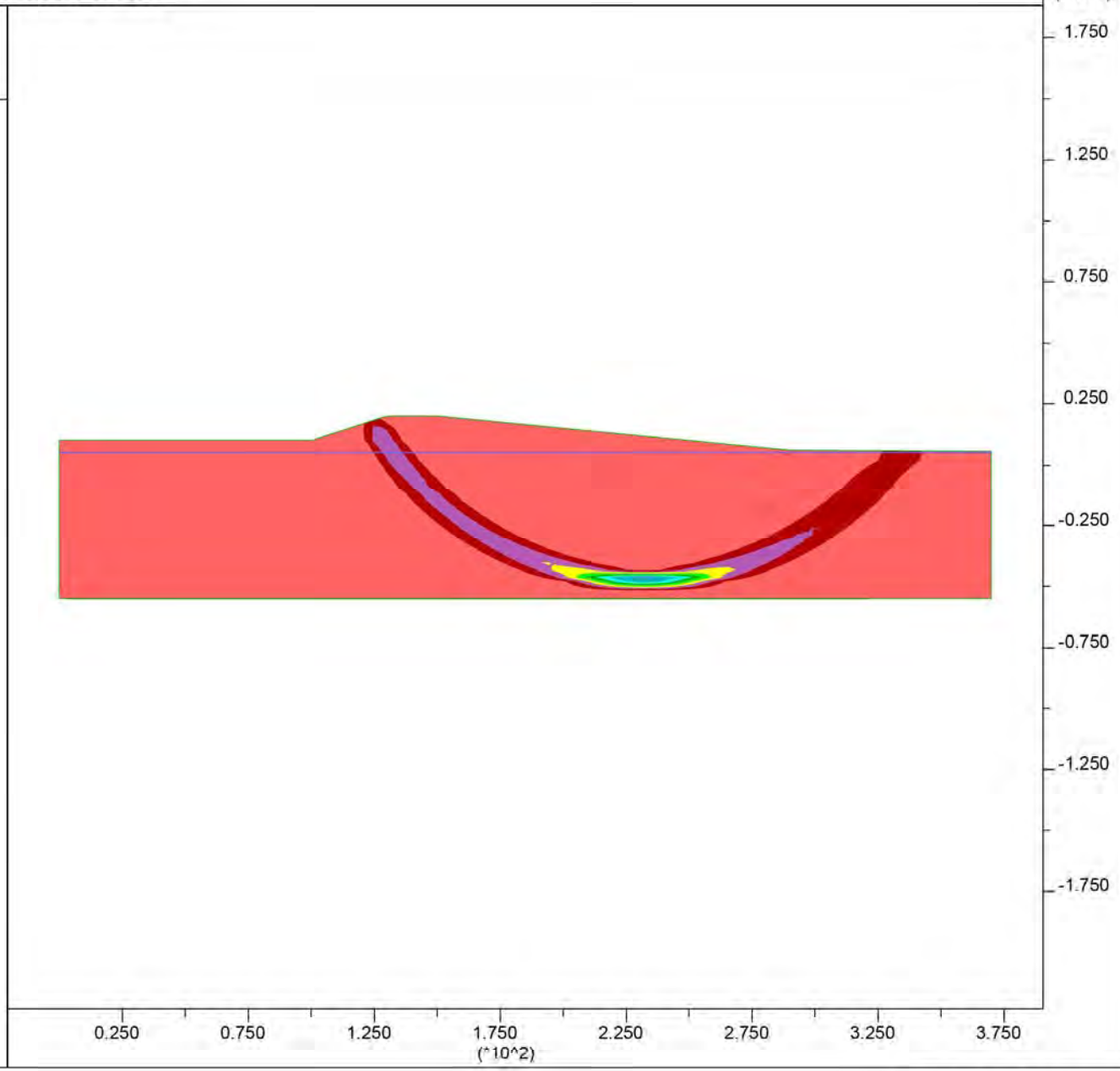


PLATE G-83

JOB TITLE : Section G-G' - End of Construction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

21-Feb-13 14:45

Factor of Safety 2.55

User-defined Groups

- User:Sand
- 'User:Med Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- Fill:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

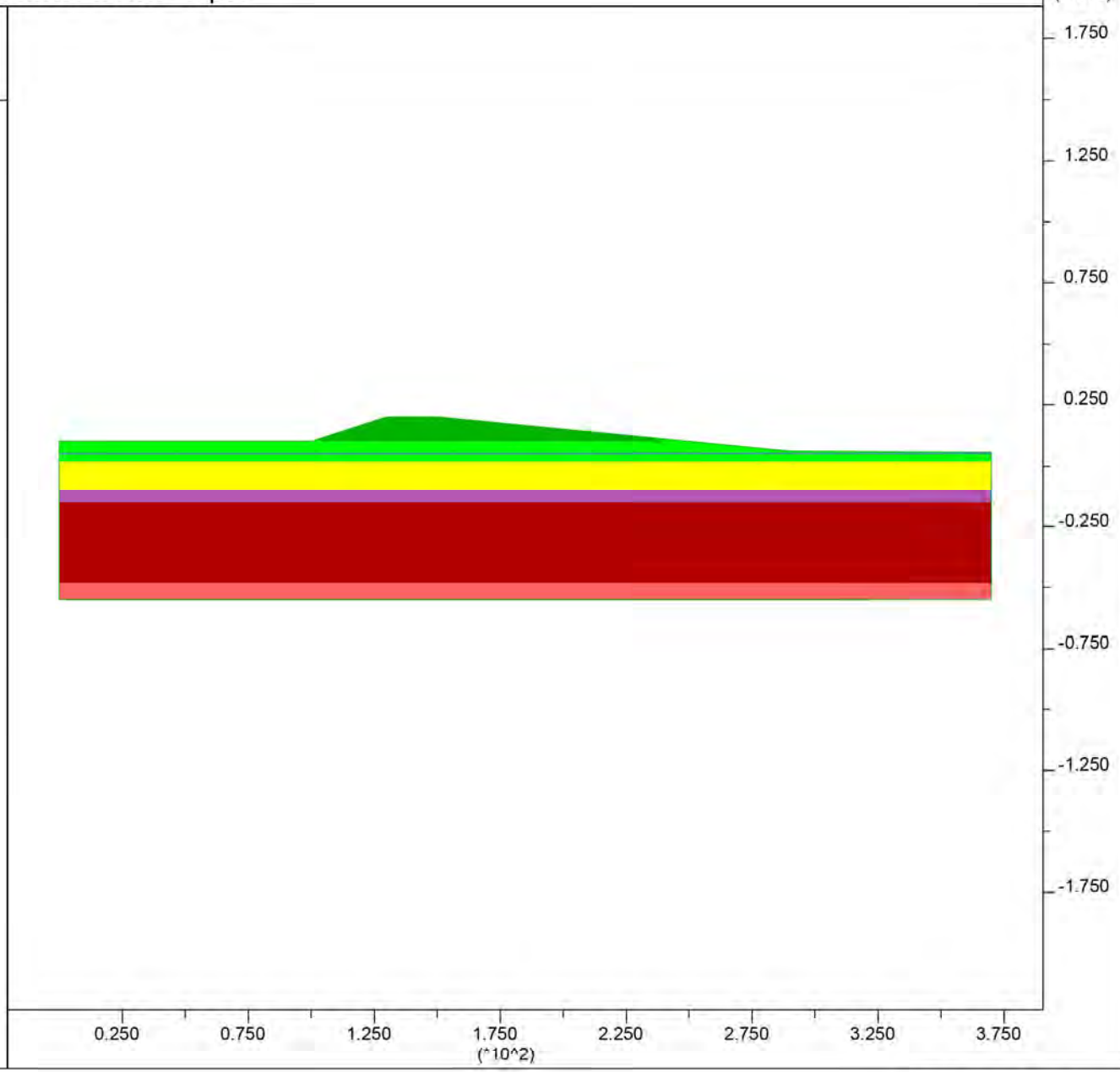


PLATE G-84

JOB TITLE : Section G-G' - High Water Short Term

FLAC/SLOPE (Version 7.00)

LEGEND

21-Feb-13 14:42

Factor of Safety 2.73

Shear Strain Rate Contours

- 2.00E-07
- 4.00E-07
- 6.00E-07
- 8.00E-07
- 1.00E-06
- 1.20E-06

Contour interval= 2.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.041E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

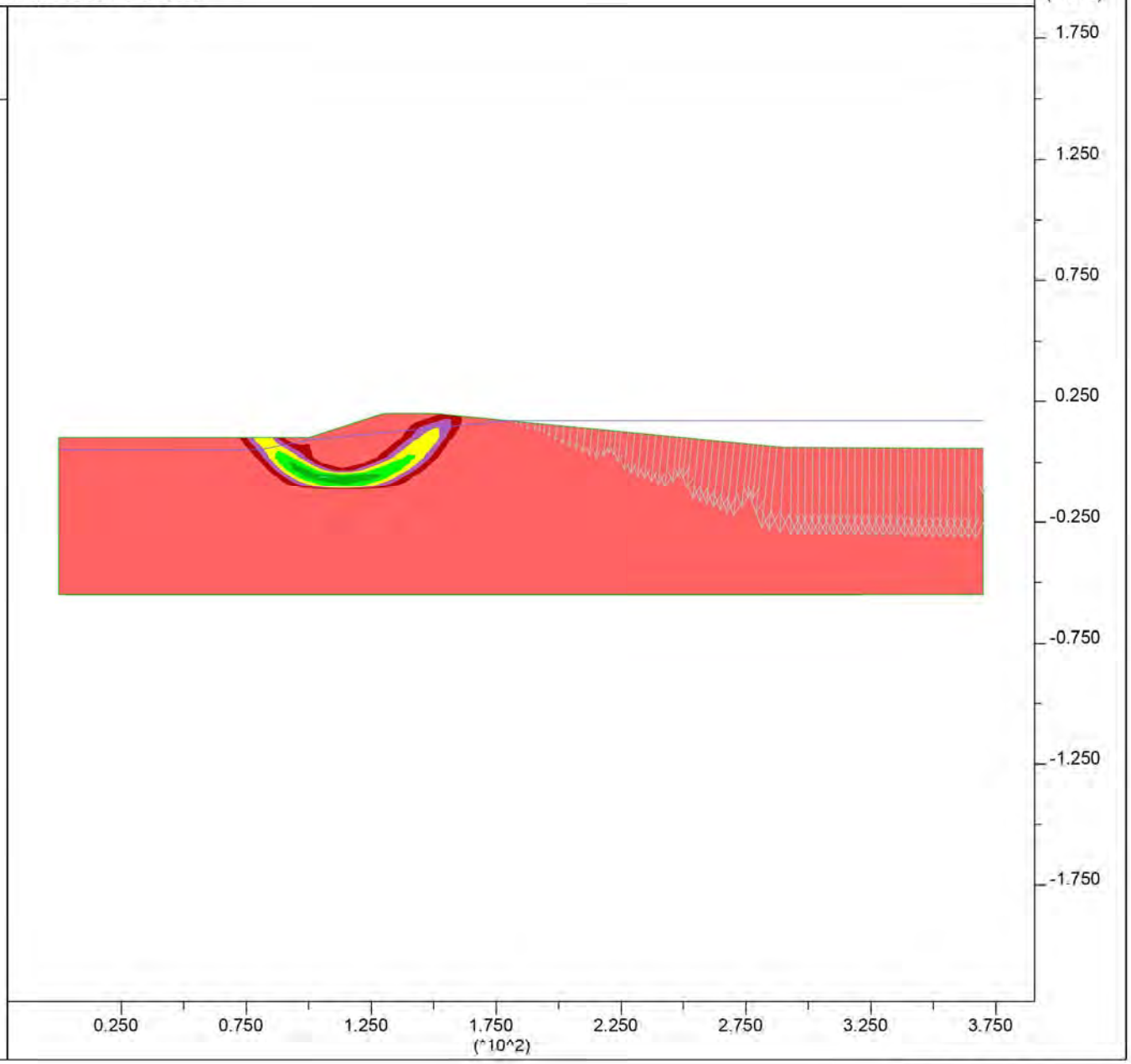


PLATE G-85

JOB TITLE : Section G-G' - High Water Short Term - Input

FLAC/SLOPE (Version 7.00)

LEGEND

21-Feb-13 14:40

Factor of Safety 2.73

User-defined Groups

- User:Sand
- 'User:Med Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- Fill:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.041E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

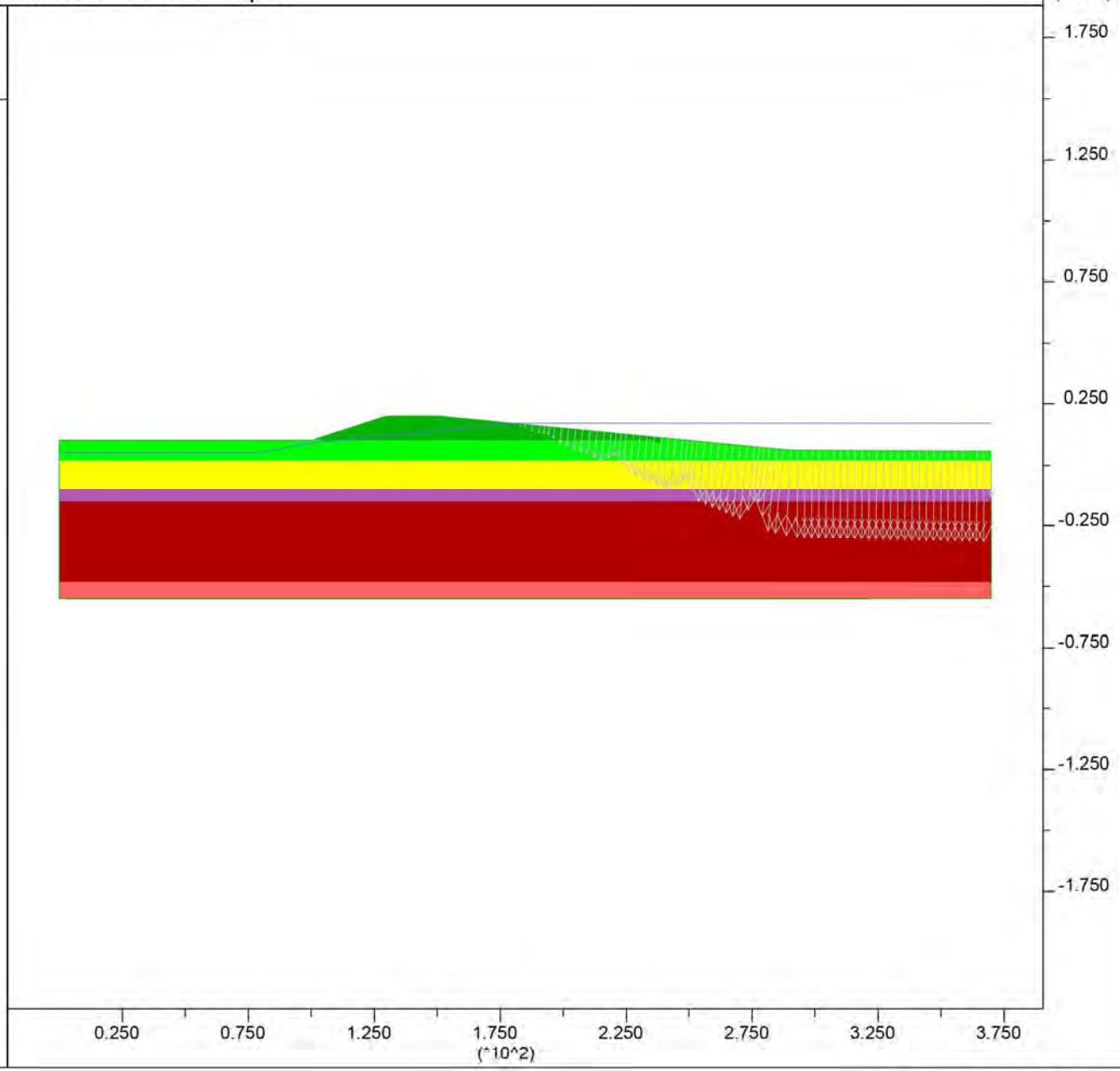


PLATE G-86

JOB TITLE : Section G-G' - High Water Long Term (Steady State)

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:24

Factor of Safety 3.42

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.326E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

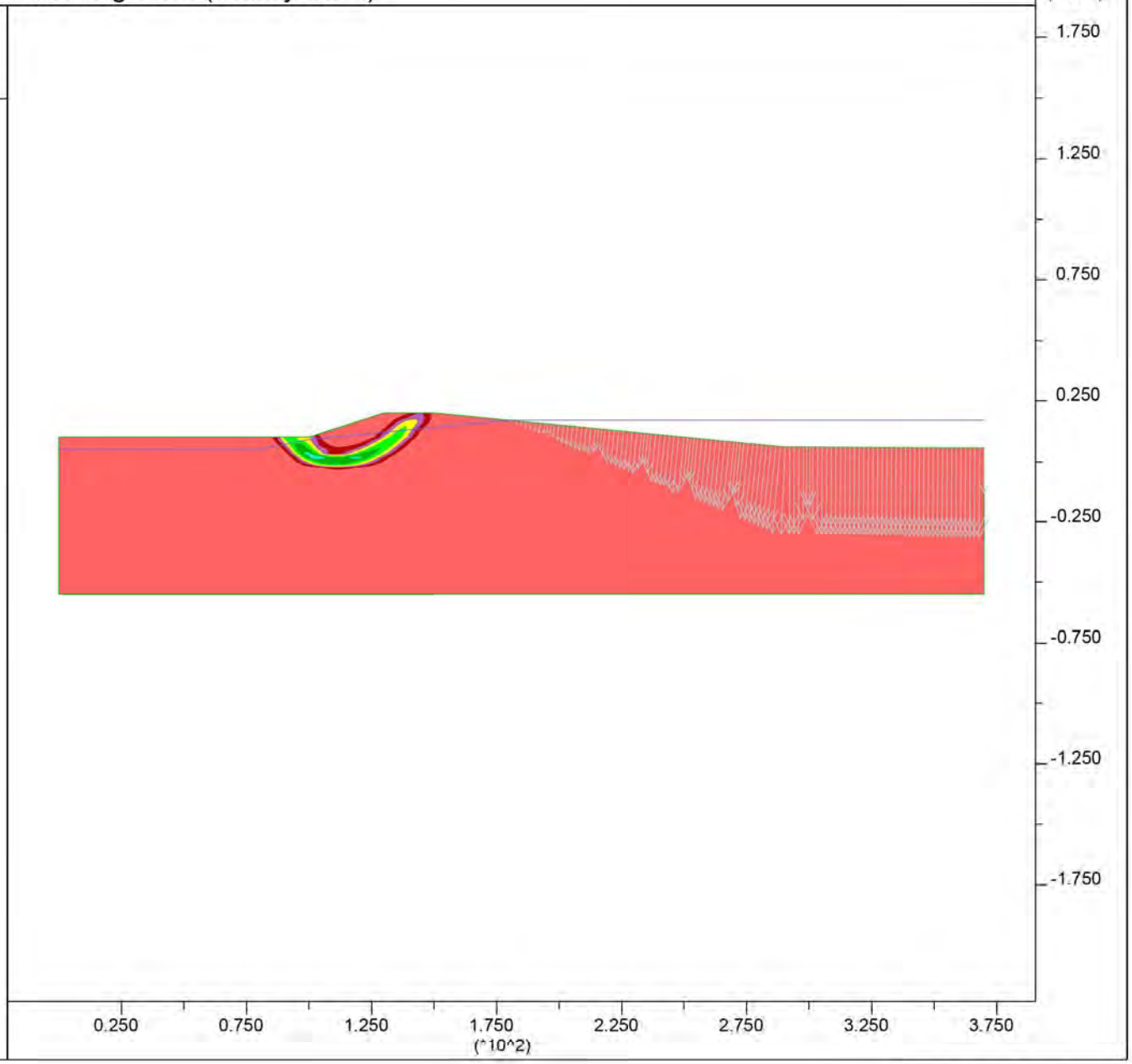


PLATE G-87

JOB TITLE : Section G-G' - High Water Long Term (Steady State) - Input

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:24

Factor of Safety 3.42

User-defined Groups

- User:Sand
- 'User:Med Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- Fill:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.326E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

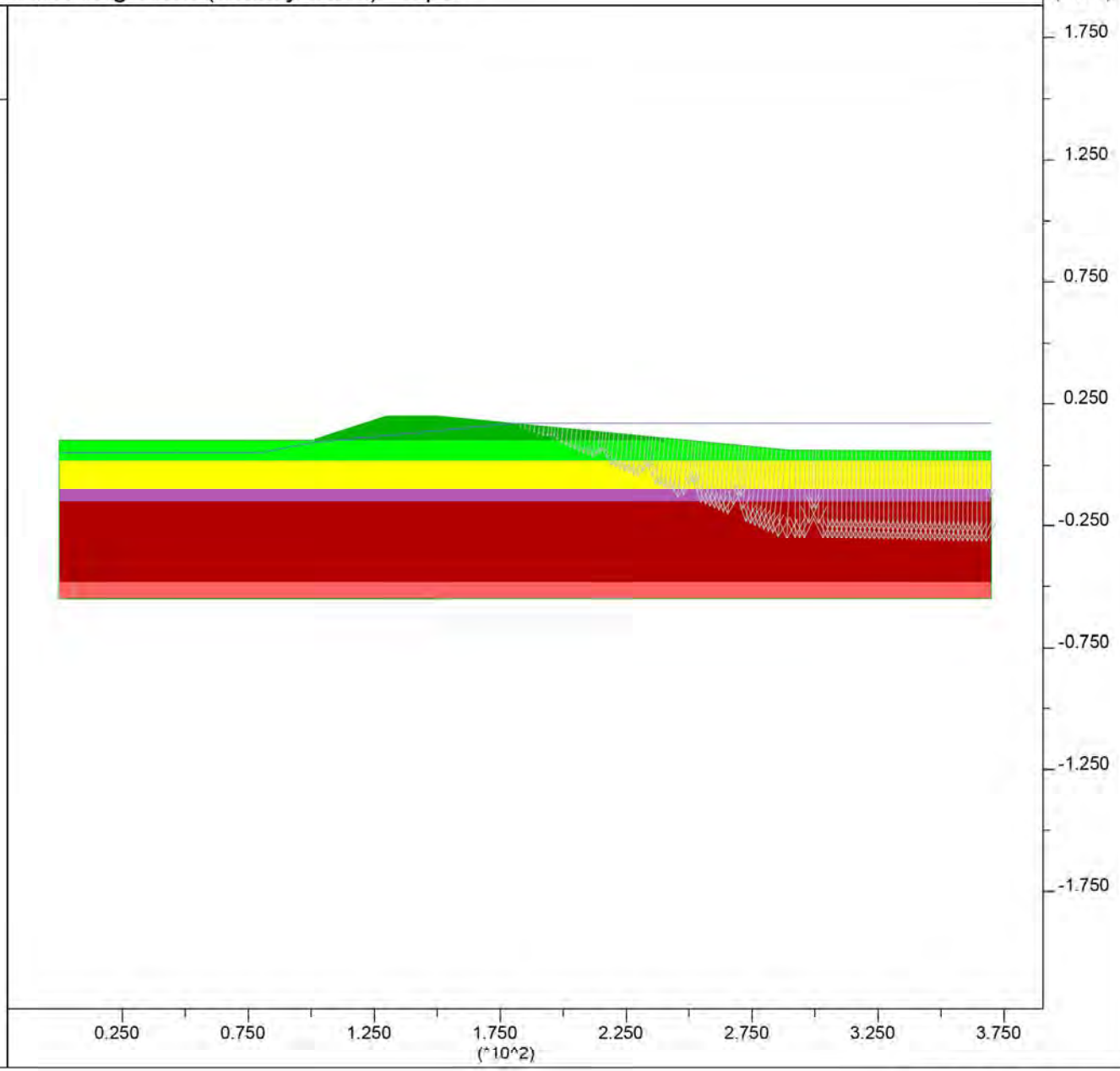


PLATE G-88

JOB TITLE : Section G-G' - Post Liquefaction

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 19:01

Factor of Safety 1.79

Shear Strain Rate Contours

- 5.00E-08
- 1.00E-07
- 1.50E-07
- 2.00E-07
- 2.50E-07
- 3.00E-07

Contour interval= 5.00E-08
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 6.479E+02

0 2E 3

Group Delta Consultants
Torrance, CA

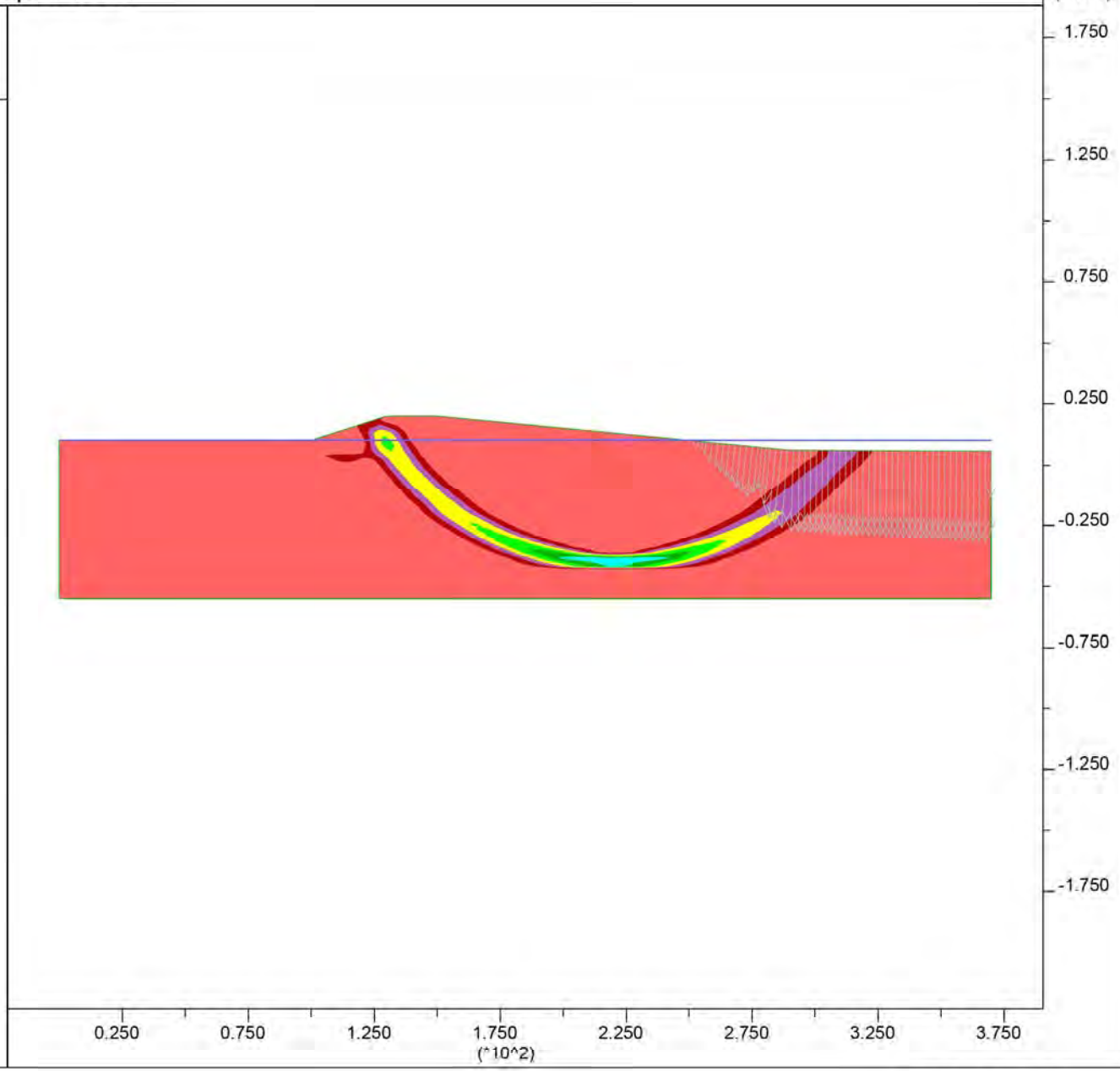


PLATE G-89

JOB TITLE : Section G-G' - Post Liquefaction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 19:01

Factor of Safety 1.79

User-defined Groups

- User:Sand
- 'User:Med Clay'
- 'User:Liq Sand'
- 'User:Soft Clay'
- 'Liq Fill:Liq Fill'
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 6.479E+02

0 2E 3

Group Delta Consultants
Torrance, CA

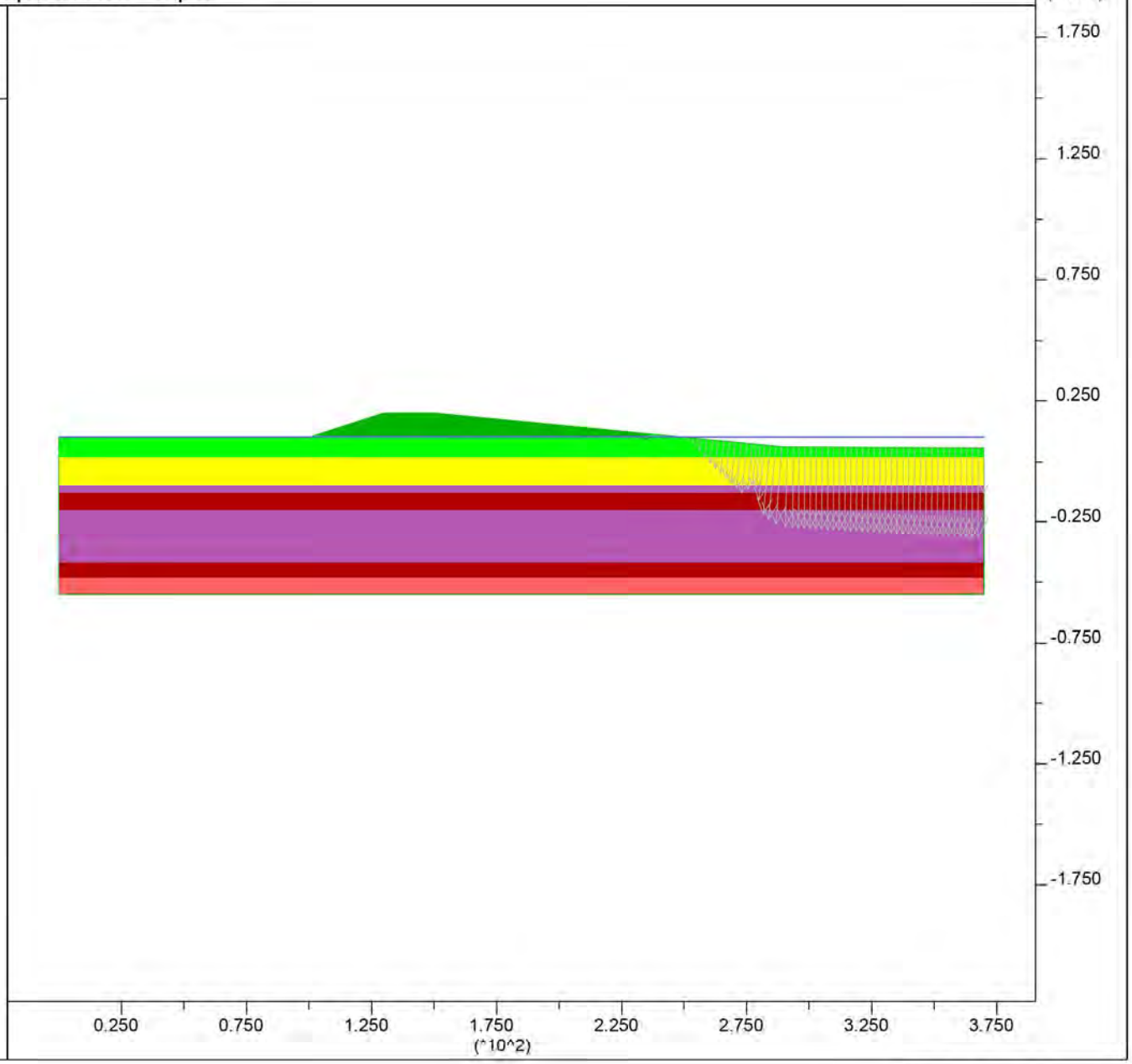


PLATE G-90

JOB TITLE : Section G-G' - Ky=0.05

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 19:26

Factor of Safety 0.98

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 3.377E+03

0 1E 4

Group Delta Consultants
Torrance, CA

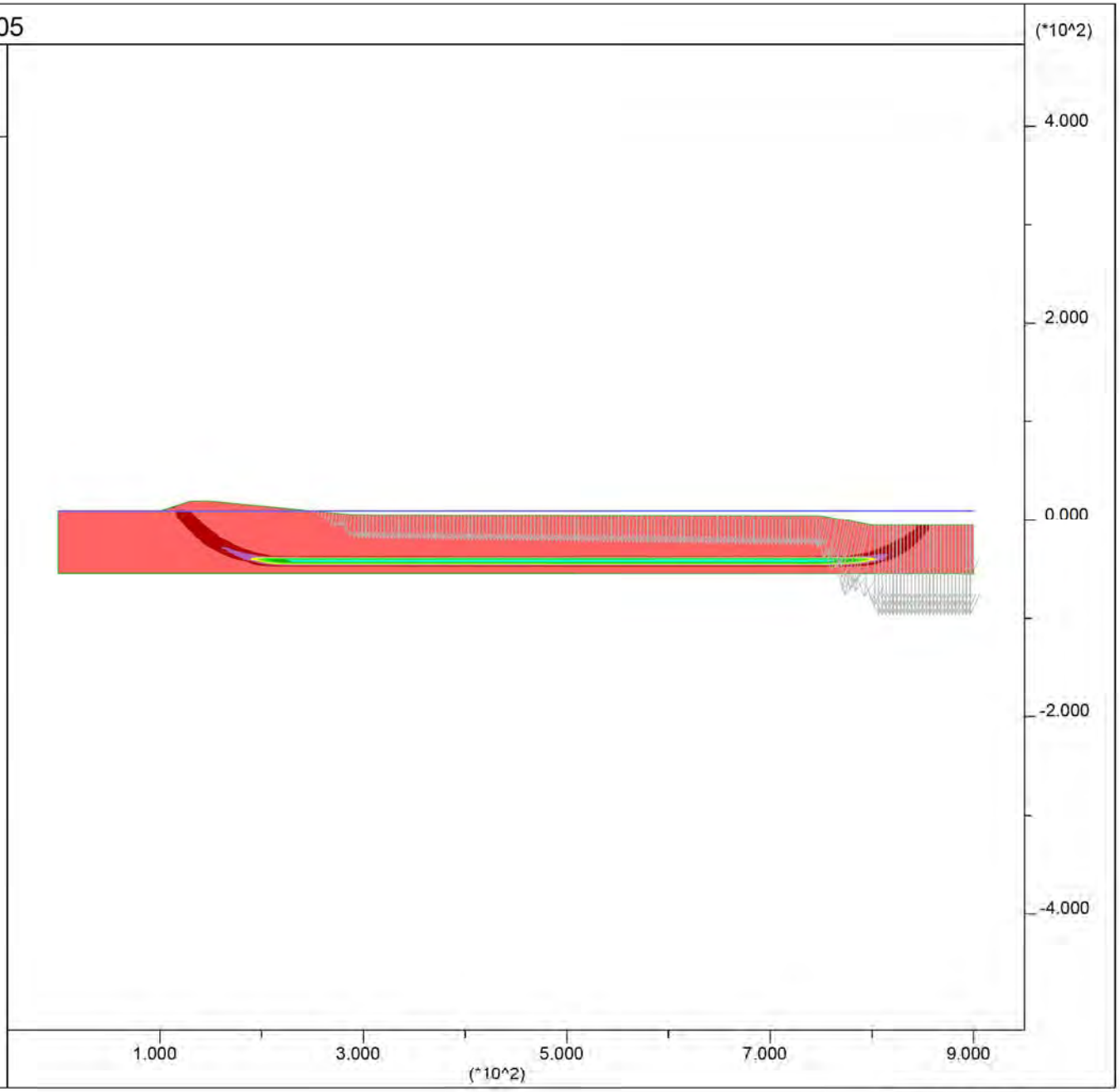


PLATE G-91

JOB TITLE : Section G-G' - Ky=0.05 - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 19:25

Factor of Safety 0.98

User-defined Groups

- User:Sand
- 'User:Med Clay'
- 'User:Liq Sand'
- 'User:Soft Clay'
- 'Liq Fill:Liq Fill'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 3.377E+03

0 1E 4

Group Delta Consultants
Torrance, CA

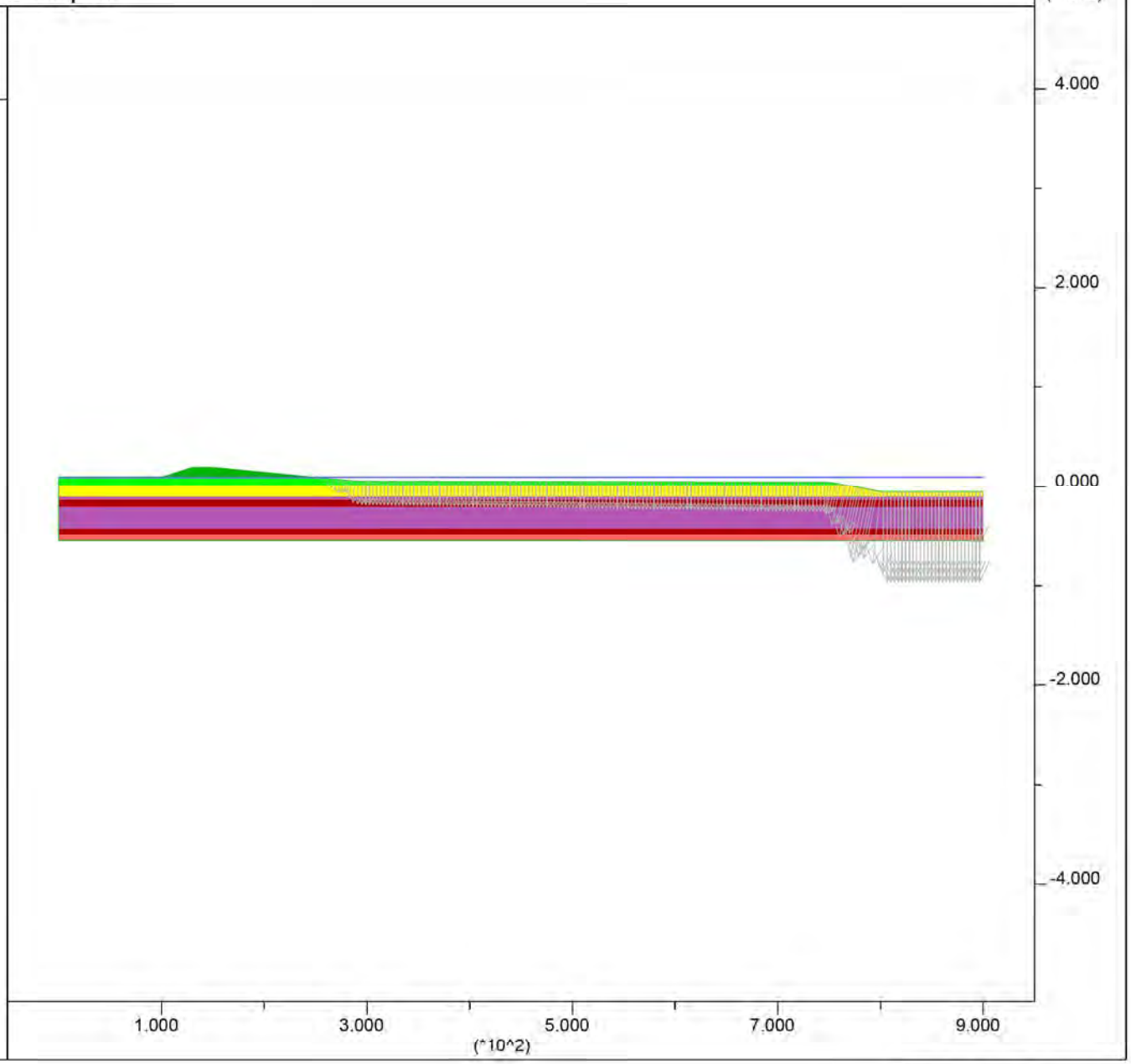


PLATE G-92

Newmark Displacements using Bray and Rathje (1998):

Section G-G'

Site Input

PGA,rock =	0.25	g		
M =	6.6			
r =	13	km		
ky =	0.05		32.185	1.60925

Sliding Mass Input

Vs =	150	m/s	assumed
Thickness, H =	18.3	m	
	60	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.49	sec				
NRF =	1.15					
Ts/Tm =	1.00					
kmax/(PGA,rock*NRF)	0.54					
kmax =	0.15					
ky / kmax =	0.33					
Displacement, u =	9	cm	0.3	feet	3.5	inches

PLATE G-93

JOB TITLE : Section H-H' - End of Construction - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 13:52
step 18280
-2.778E+01 <x< 5.278E+02
-2.953E+02 <y< 2.603E+02

Factor of Safety 1.94

Max. shear strain-rate
0.00E+00
5.00E-07
1.00E-06
1.50E-06
2.00E-06
2.50E-06
3.00E-06
3.50E-06

Contour interval= 5.00E-07
Extrap. by averaging
Boundary plot
0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

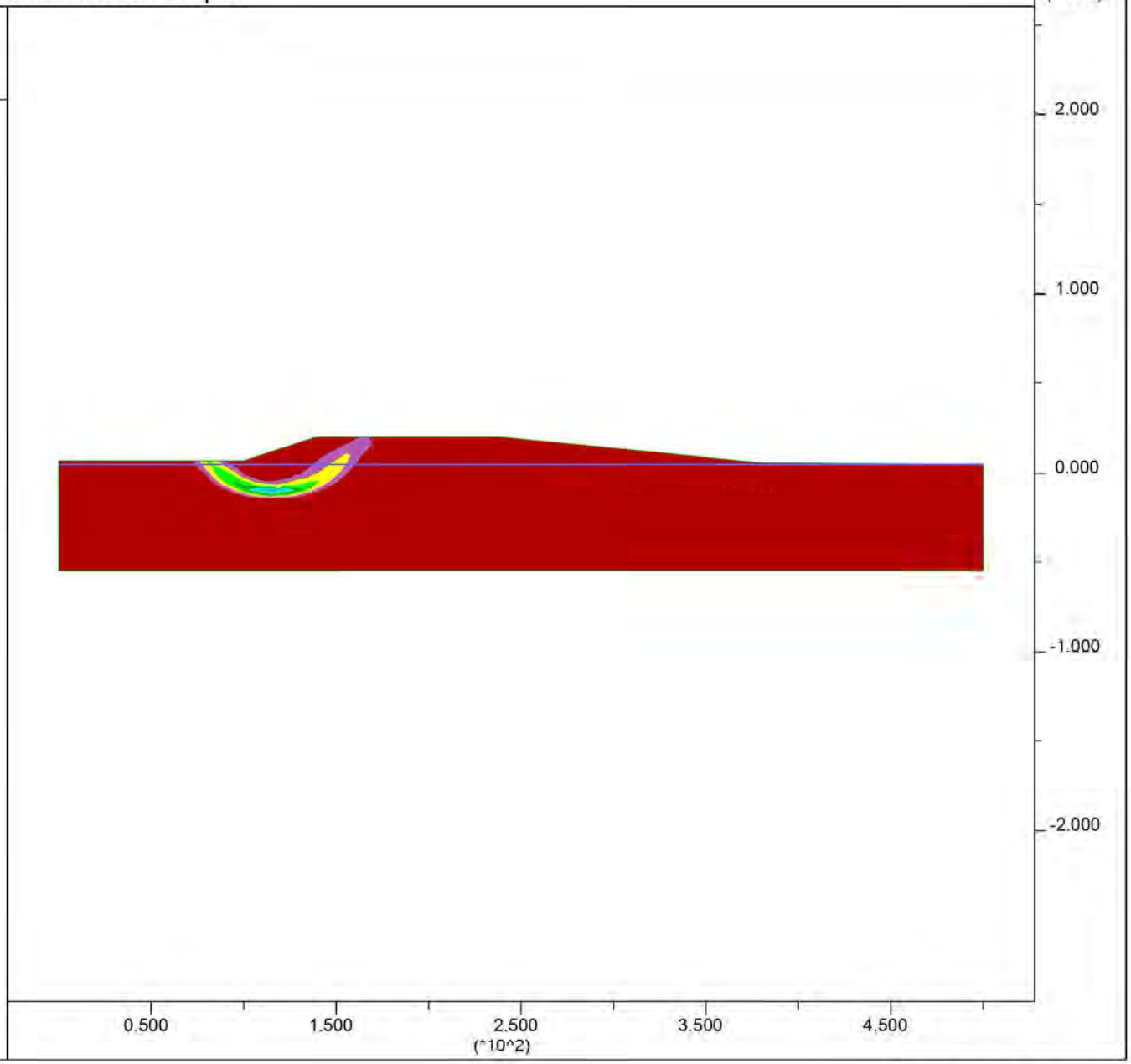


PLATE G-94

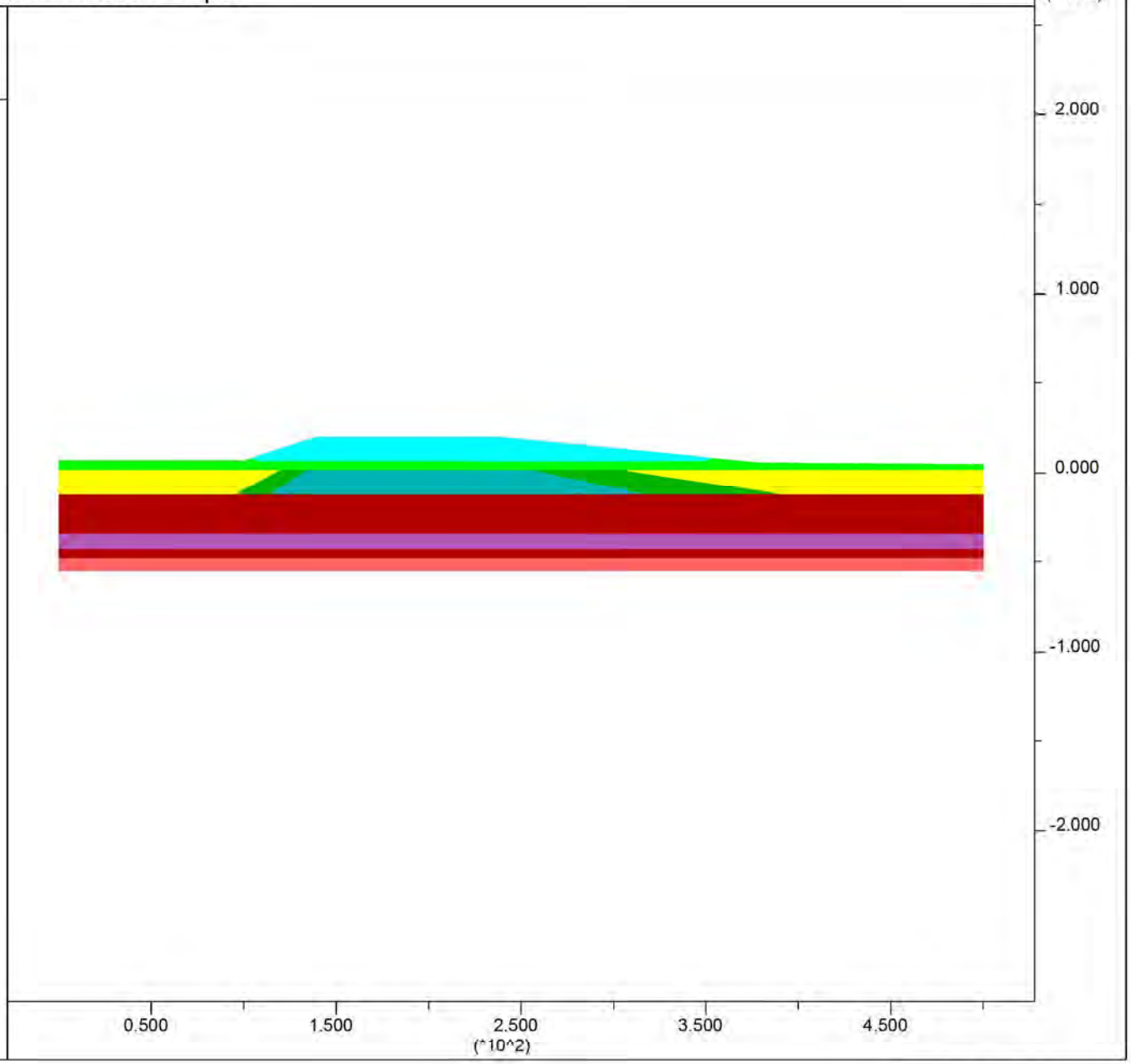
JOB TITLE : Section H-H' - End of Construction - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 13:49
step 0
-2.778E+01 <x< 5.278E+02
-2.953E+02 <y< 2.603E+02

User-defined Groups
- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:V Soft Clay'
- Fill:Fill
- 'User:Clay 400'
- User:Embankment
- 'User:Soft Clay'



Group Delta Consultants
Ballona Wetlands

PLATE G-95

JOB TITLE : Section H-H' - High Water Short Term

FLAC (Version 7.00)

LEGEND

27-Feb-13 19:06
step 20150
-2.778E+01 <x< 5.278E+02
-2.953E+02 <y< 2.603E+02

Factor of Safety 1.87

Max. shear strain-rate
0.00E+00
2.50E-06
5.00E-06
7.50E-06
1.00E-05
1.25E-05

Contour interval= 2.50E-06
Extrap. by averaging
Boundary plot
0 1E 2

Water Table

Net Applied Forces

max vector = 1.892E+03

Group Delta Consultants
Ballona Wetlands

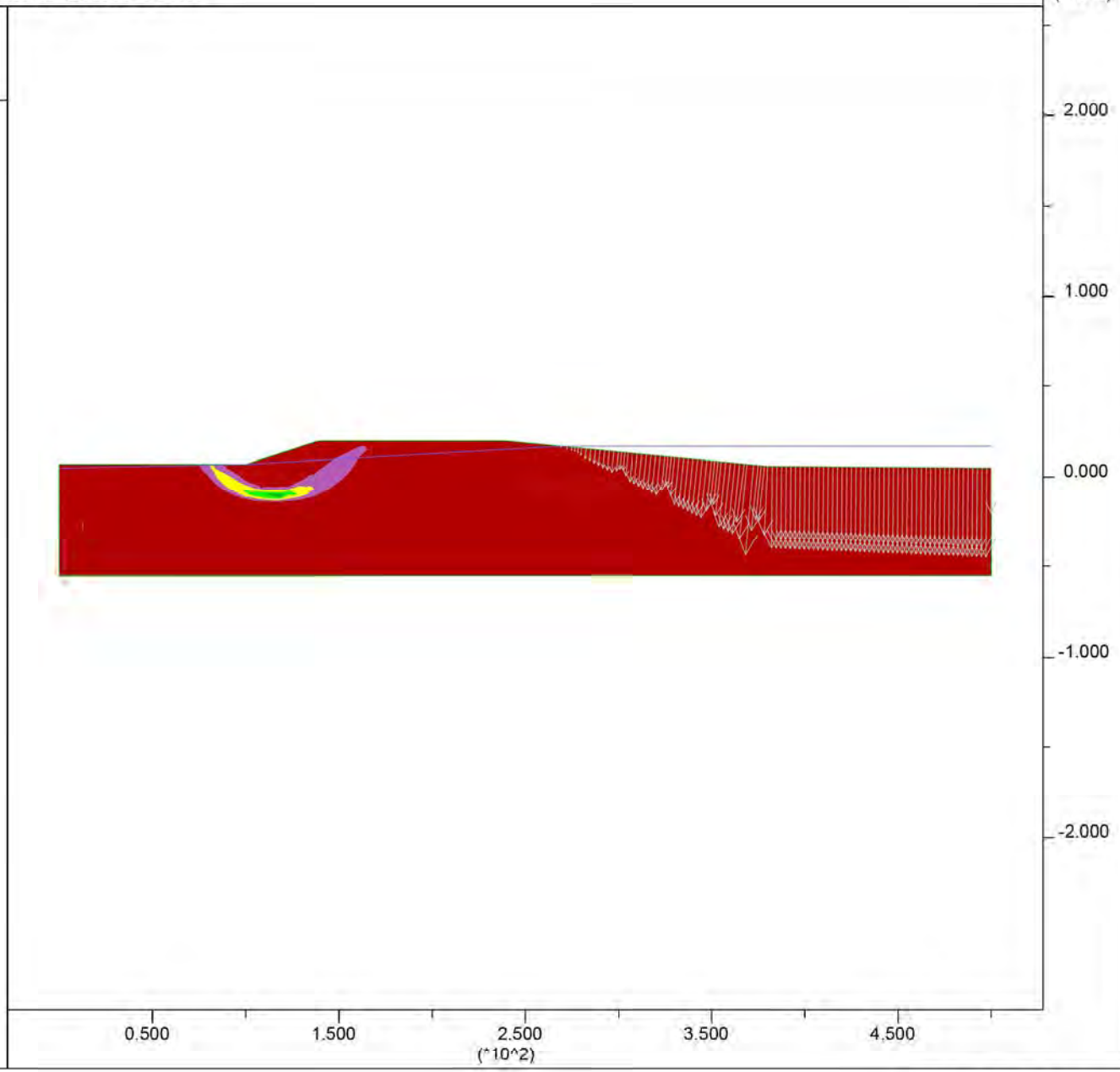


PLATE G-96

JOB TITLE : Section H-H' - High Water Short Term - Input

FLAC (Version 7.00)

LEGEND

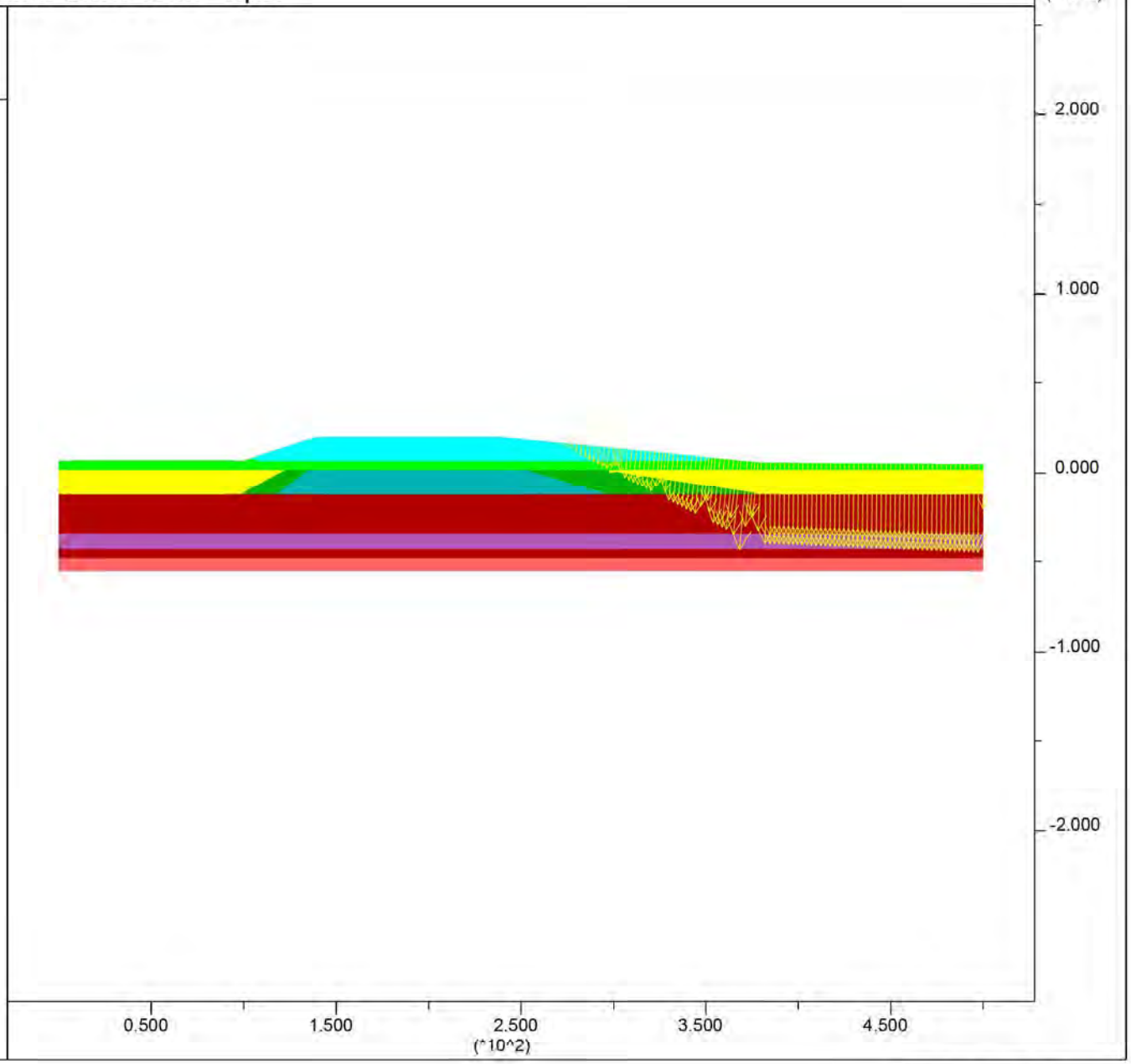
27-Feb-13 19:09
step 20150
-2.778E+01 <x< 5.278E+02
-2.953E+02 <y< 2.603E+02

User-defined Groups
- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:V Soft Clay'
- Fill:Fill
- 'User:Clay 400'
- User:Embankment
- 'User:Soft Clay'

Net Applied Forces

max vector = 1.892E+03

0 5E 3



Group Delta Consultants
Ballona Wetlands

PLATE G-97

JOB TITLE : Section H-H' - Post Liquefaction

FLAC (Version 7.00)

LEGEND

26-Mar-13 14:19
step 28268
-2.778E+01 <x< 5.278E+02
-2.953E+02 <y< 2.603E+02

Factor of Safety 1.24

Max. shear strain-rate
0.00E+00
1.00E-06
2.00E-06
3.00E-06
4.00E-06
5.00E-06
6.00E-06
7.00E-06

Contour interval= 1.00E-06
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

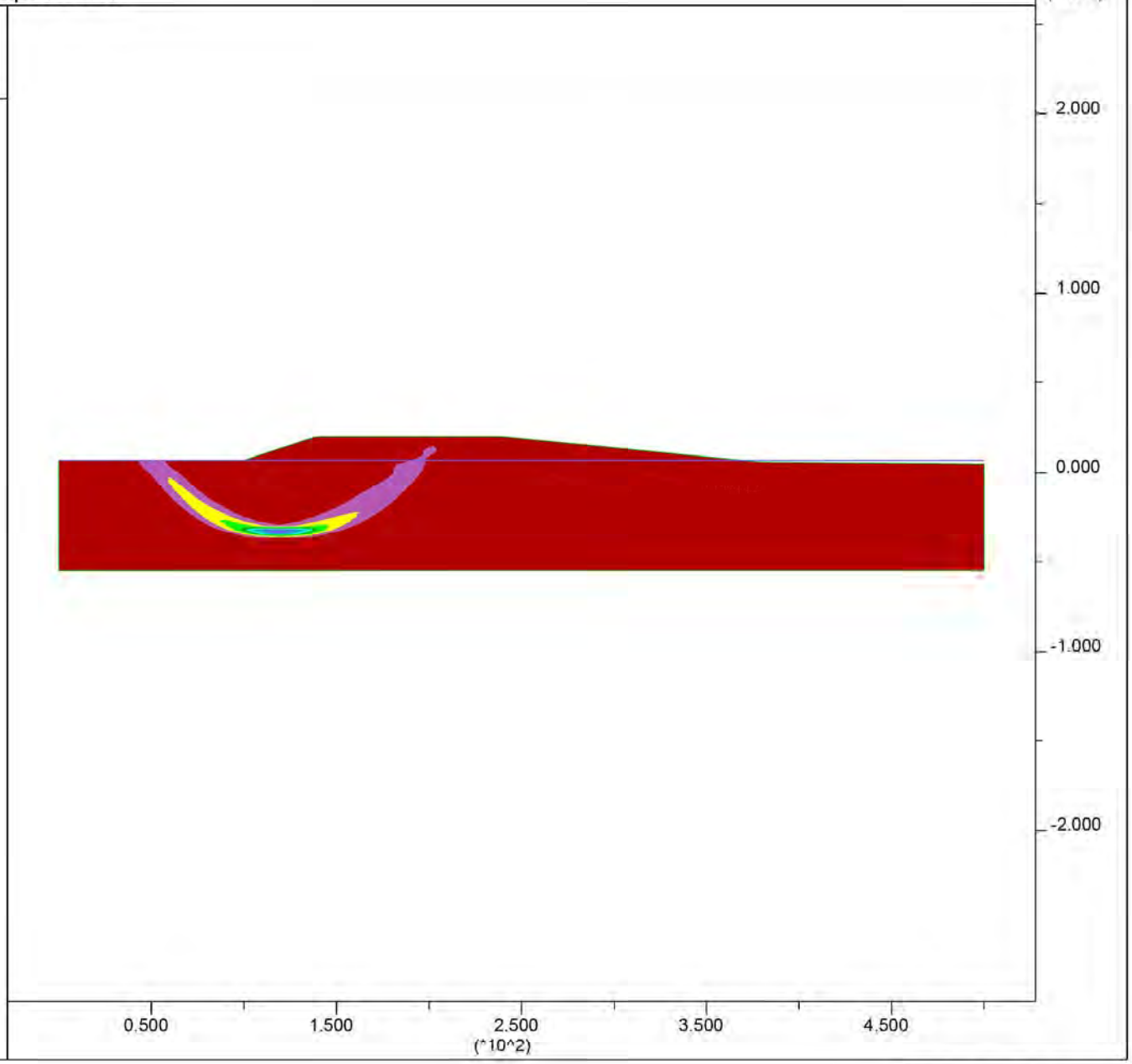


PLATE G-98

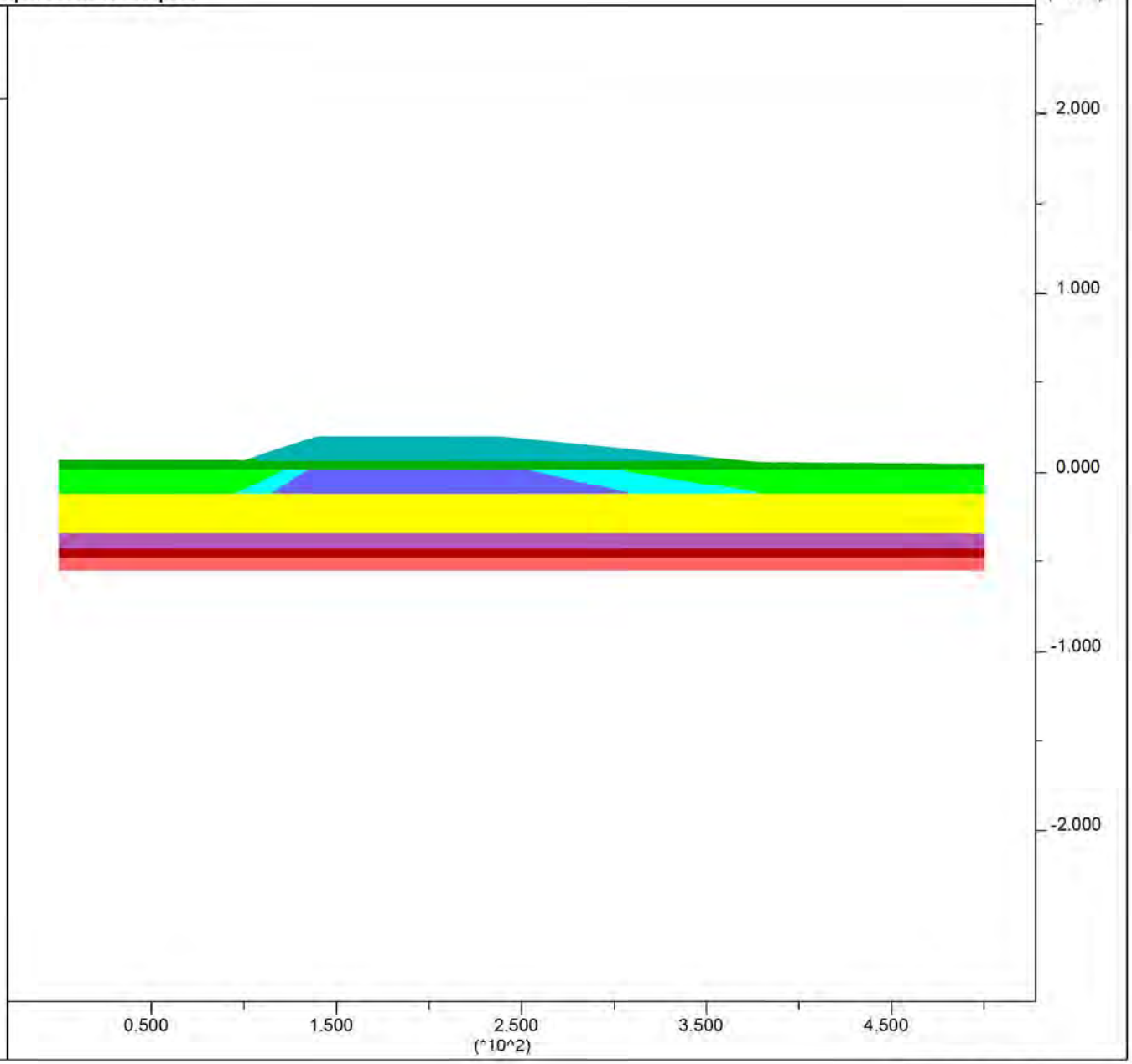
JOB TITLE : Section H-H' - Post Liquefaction Input

FLAC (Version 7.00)

LEGEND

26-Mar-13 14:21
step 28268
-2.778E+01 <x< 5.278E+02
-2.953E+02 <y< 2.603E+02

User-defined Groups
- User:Sand
- 'User:Liq Sand Deep'
- 'S:Stiff Clay'
- 'User:Liq Sand'
- 'User:V Soft Clay'
- 'User:Liq Fill'
- User:Clay400
- User:Embankment
- 'User:Soft Clay'



Group Delta Consultants
Ballona Wetlands

PLATE G-99

JOB TITLE : Section H-H' - Ky=0.04

FLAC (Version 7.00)

LEGEND

26-Mar-13 14:24
step 24768
-2.778E+01 <x< 5.278E+02
-2.953E+02 <y< 2.603E+02

Factor of Safety 0.99

Max. shear strain-rate
0.00E+00
2.50E-08
5.00E-08
7.50E-08
1.00E-07
1.25E-07
1.50E-07
1.75E-07
2.00E-07

Contour interval= 2.50E-08
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

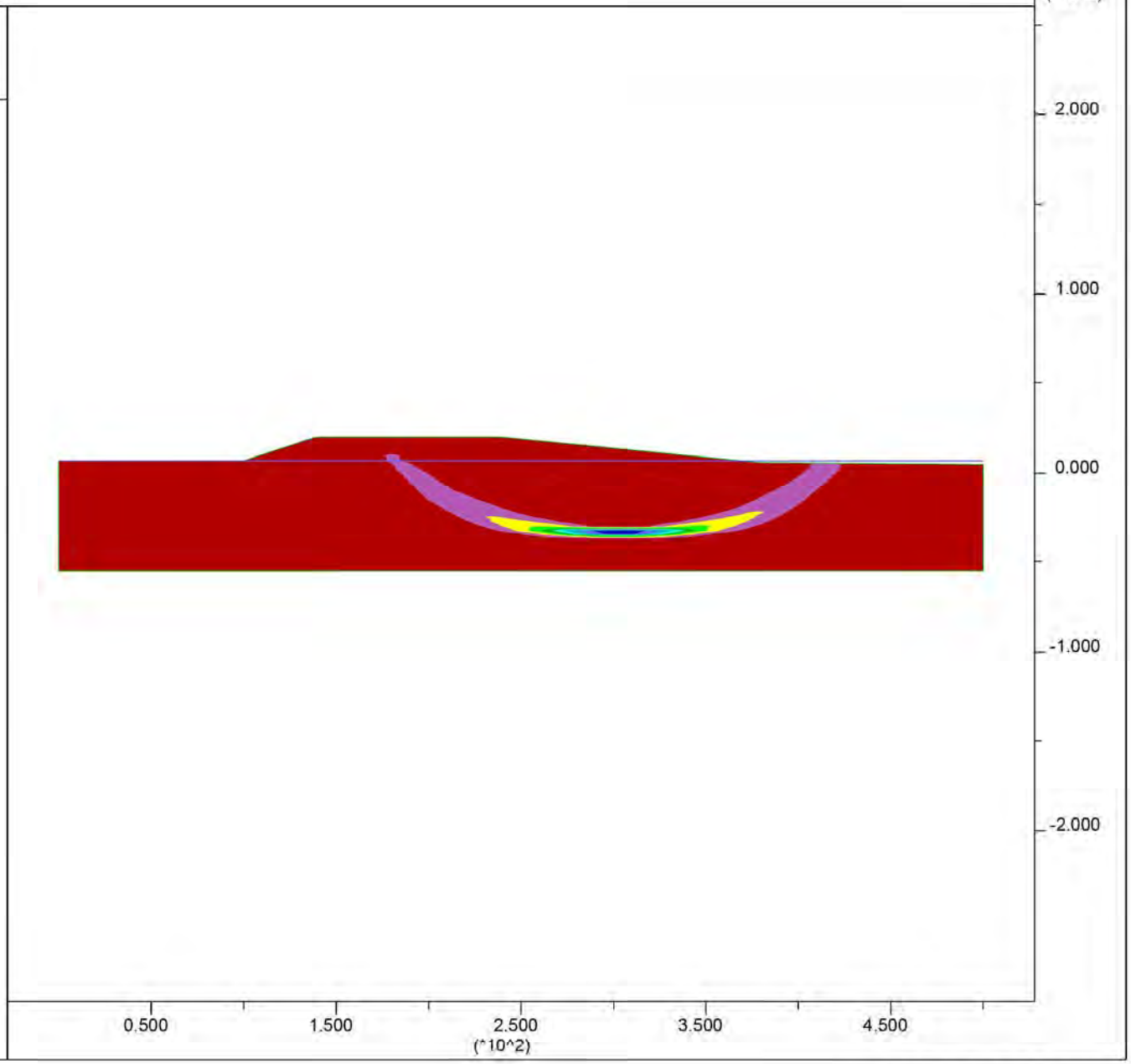


PLATE G-100

JOB TITLE : Section H-H' - Ky=0.04 - Input

FLAC (Version 7.00)

LEGEND

26-Mar-13 14:22
step 24768
-2.778E+01 <x< 5.278E+02
-2.953E+02 <y< 2.603E+02

User-defined Groups
- User:Sand
- 'User:Liq Sand Deep'
- 'S:Stiff Clay'
- 'User:Liq Sand'
- 'User:V Soft Clay'
- 'User:Liq Fill'
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Group Delta Consultants
Ballona Wetlands

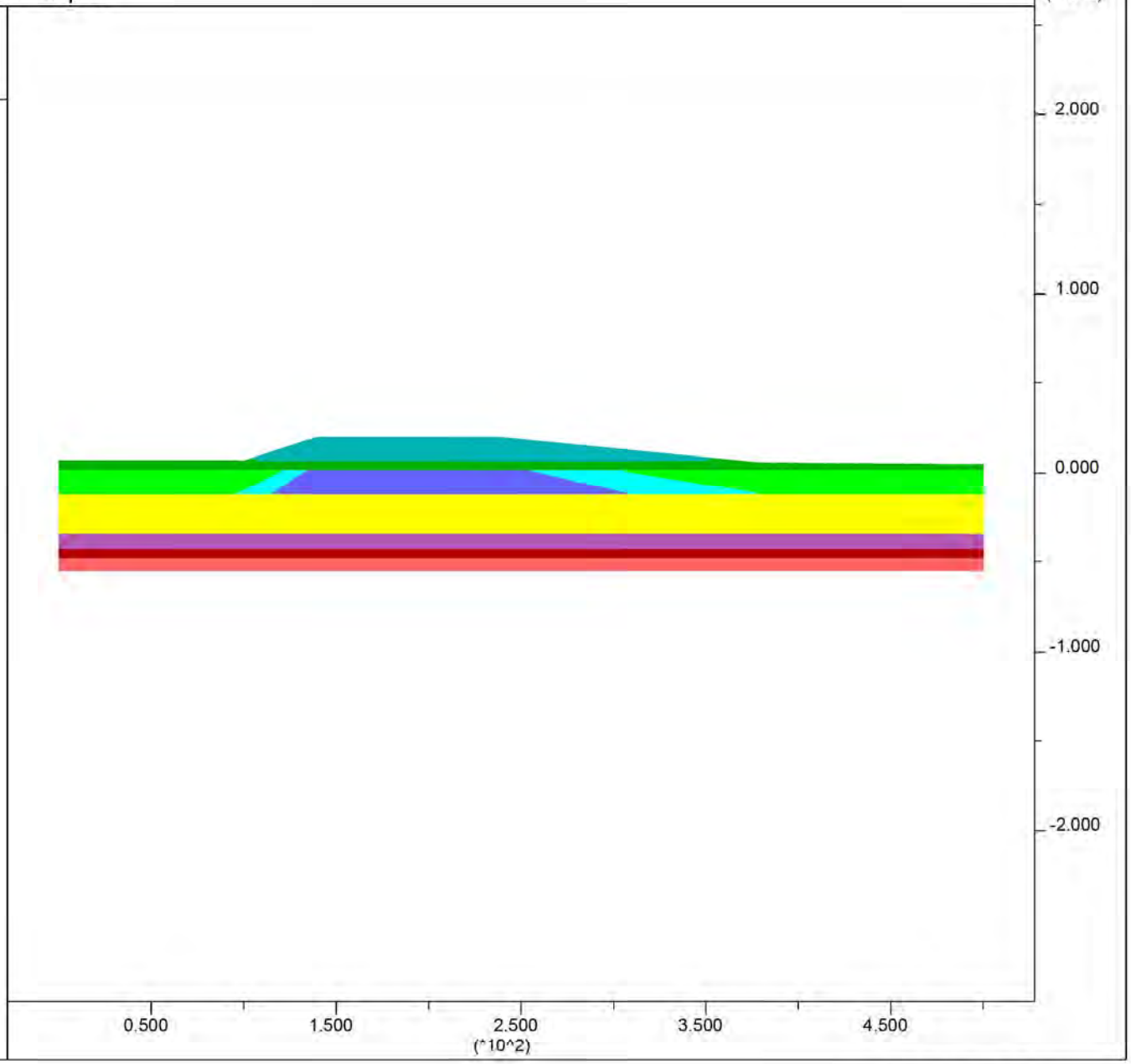


PLATE G-101

Newmark Displacements using Bray and Rathje (1998):

Section H-H'

Site Input

PGA,rock =	0.25	g		
M =	6.6			
r =	13	km		
ky =	0.04		32.185	1.2874

Sliding Mass Input

Vs =	110	m/s	assumed
Thickness, H =	16.8	m	
	55	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.61	sec				
NRF =	1.15					
Ts/Tm =	1.25					
kmax/(PGA,rock*NRF)	0.45					
kmax =	0.13					
ky / kmax =	0.31					
Displacement, u =	8	cm	0.3	feet	3.3	inches

PLATE G-102

JOB TITLE : Section I-I' - End of Construction

FLAC (Version 7.00)

LEGEND

27-Feb-13 14:56
step 10281
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

Factor of Safety 1.68

Max. shear strain-rate
0.00E+00
5.00E-07
1.00E-06
1.50E-06
2.00E-06
2.50E-06
3.00E-06
3.50E-06

Contour interval= 5.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

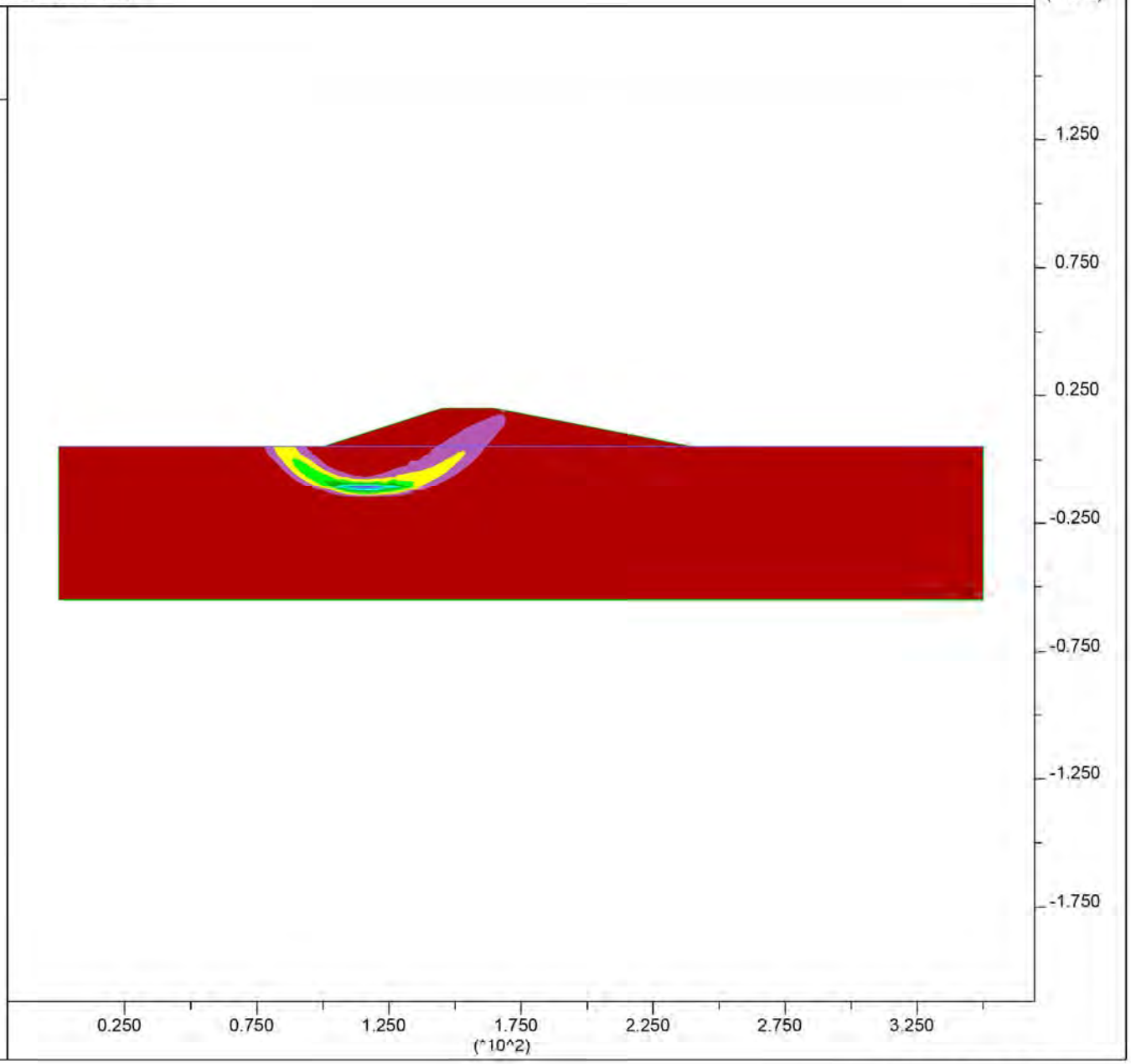


PLATE G-103

JOB TITLE : Section I-I' - End of Construction - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 14:57
step 10281
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

User-defined Groups
- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:V Soft Clay'
- Fill:Fill
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Group Delta Consultants
Ballona Wetlands

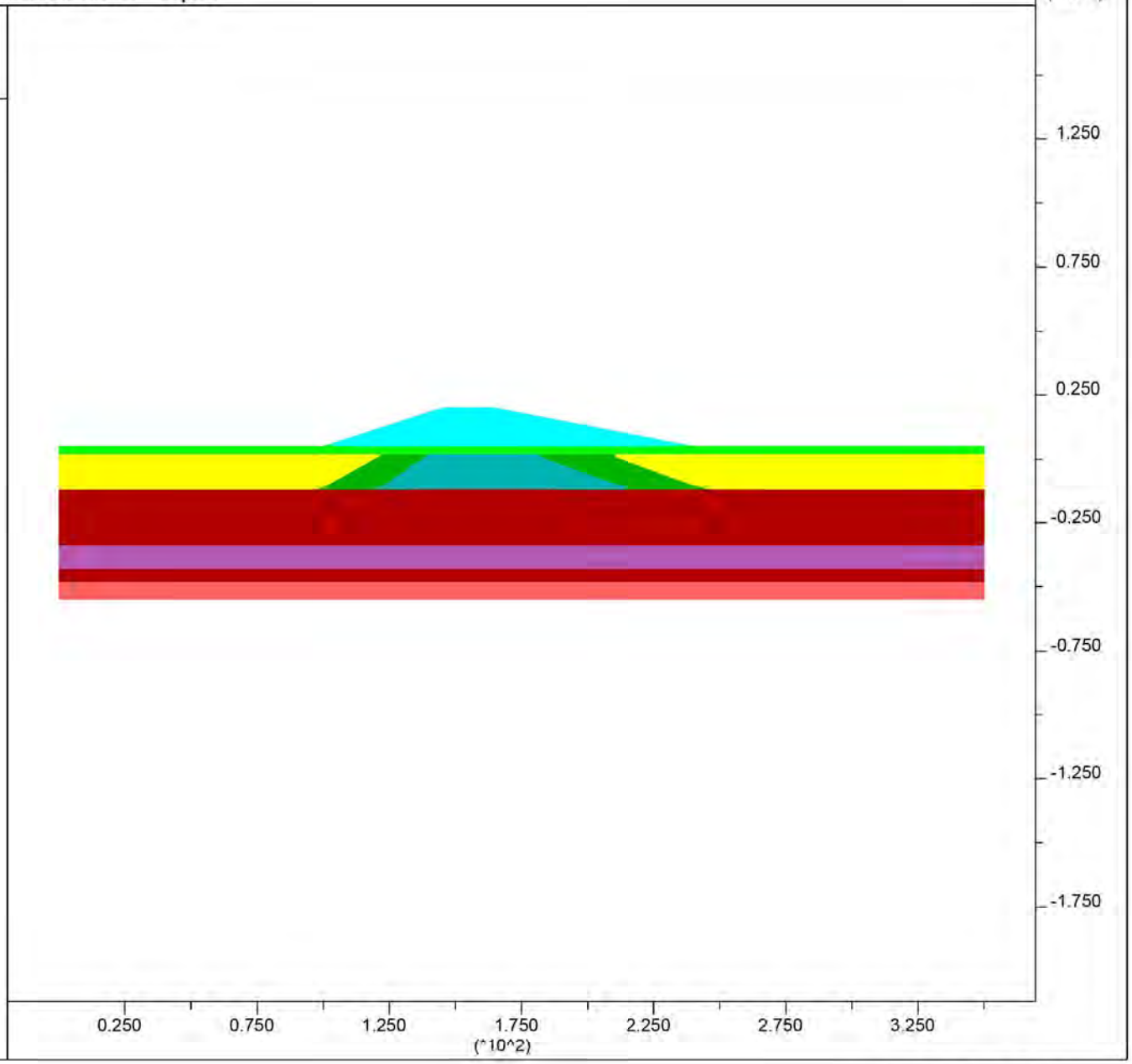


PLATE G-104

JOB TITLE : Section I-I' - High Water Short Term

FLAC (Version 7.00)

LEGEND

27-Feb-13 14:37
step 21996
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

Factor of Safety 1.61

Max. shear strain-rate
0.00E+00
5.00E-07
1.00E-06
1.50E-06
2.00E-06
2.50E-06

Contour interval= 5.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.874E+03

Group Delta Consultants
Ballona Wetlands

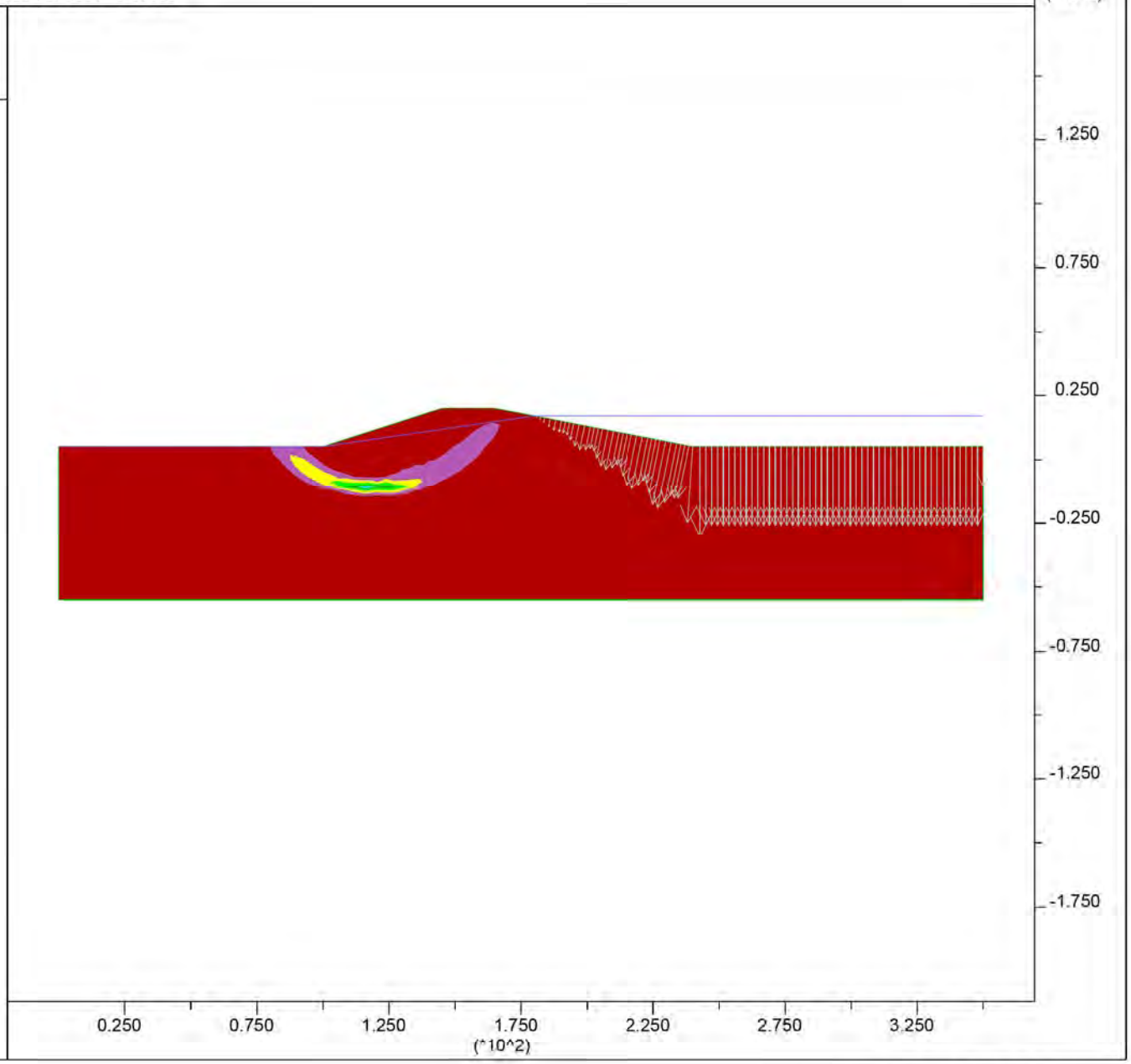


PLATE G-105

JOB TITLE : Section I-I' - High Water Short Term - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 14:38
step 21996
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

User-defined Groups
- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:V Soft Clay'
- Fill:Fill
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Grid plot

0 1E 2

Net Applied Forces

max vector = 1.874E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

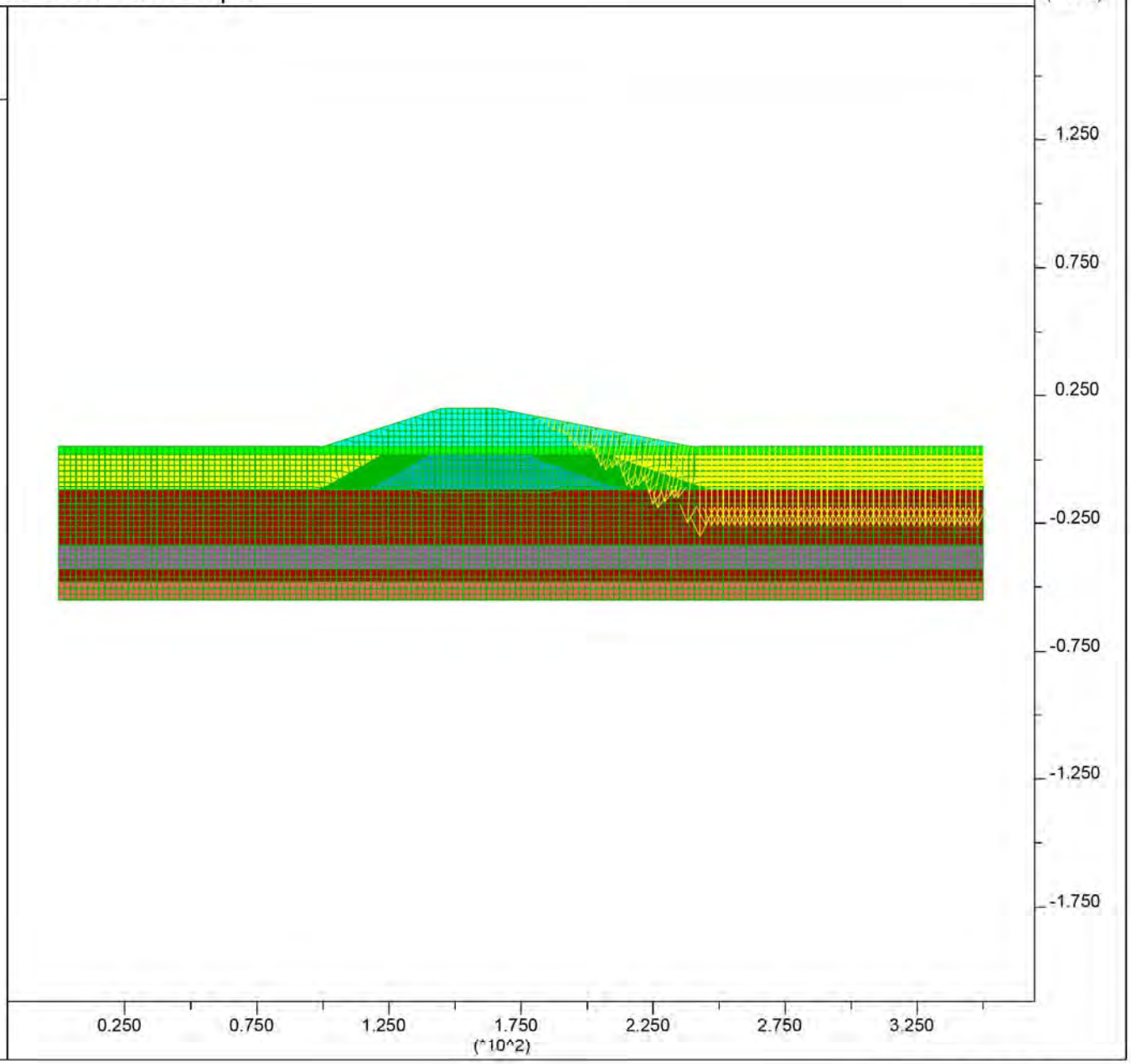


PLATE G-106

JOB TITLE : Section I-I' - High Water Long Term (Steady State)

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:26

Factor of Safety 2.29

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06
- 1.75E-06
- 2.00E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.327E+03

Group Delta Consultants
Ballona Wetlands

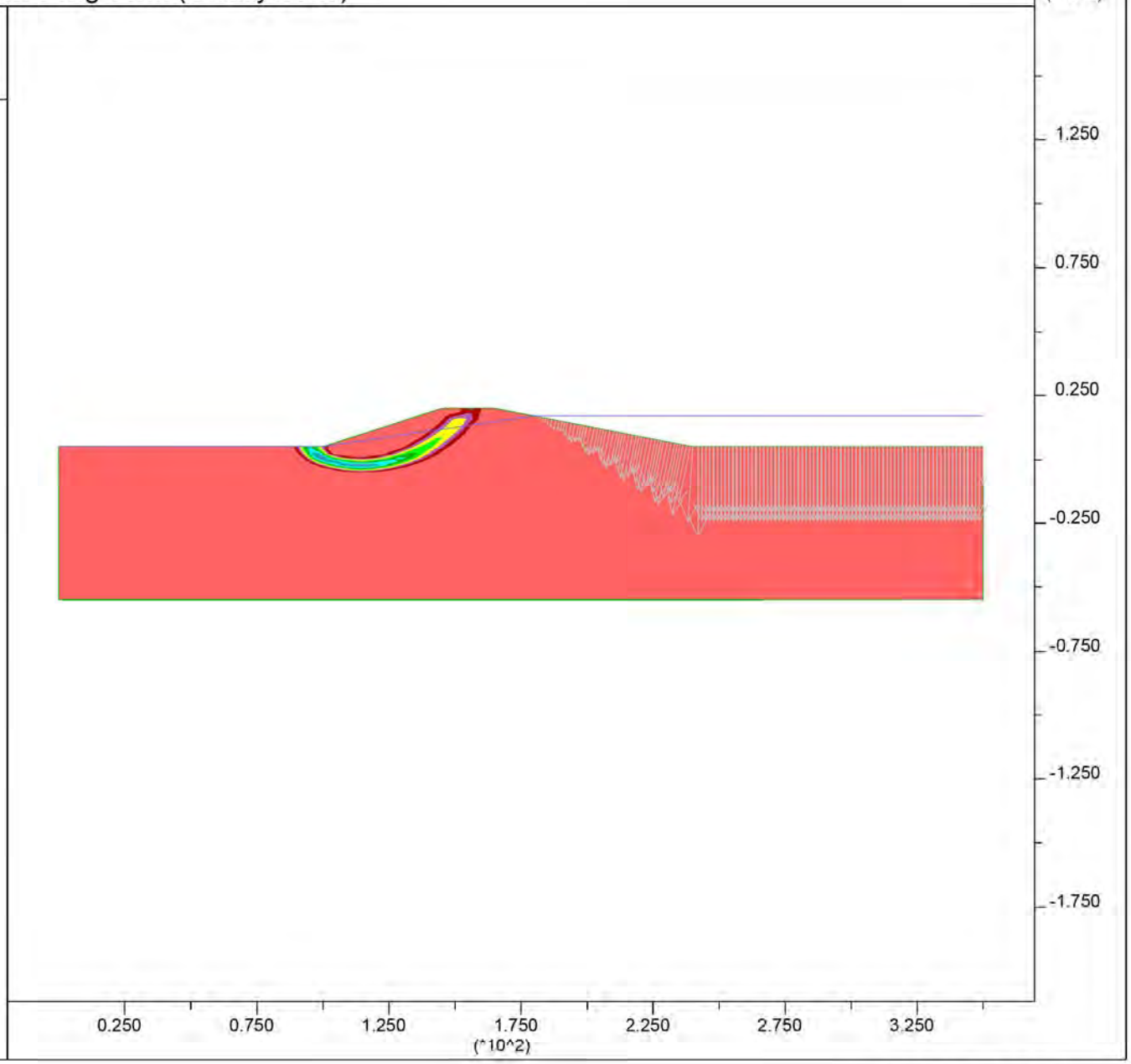


PLATE G-107

JOB TITLE : Section I-I' - High Water Long Term (Steady State) - Input

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:27

Factor of Safety 2.29

User-defined Groups

- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:Soft Clay'
- Fill:Fill
- User:Embankment

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.327E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

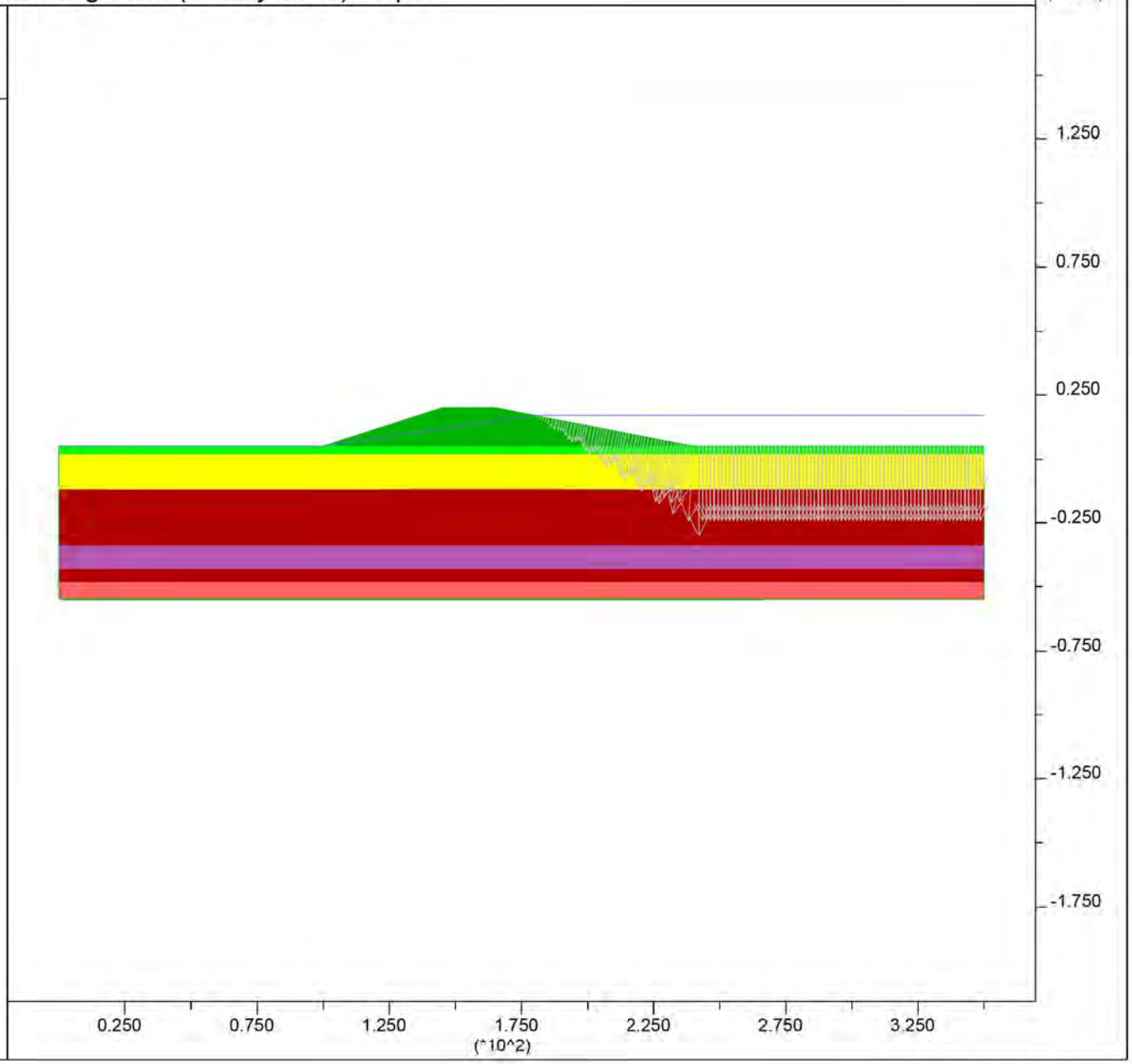


PLATE G-108

JOB TITLE : Section I-I' - Post Liquefaction

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:15
step 9213
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

Factor of Safety 1.17

Max. shear strain-rate
0.00E+00
2.00E-07
4.00E-07
6.00E-07
8.00E-07
1.00E-06

Contour interval= 2.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

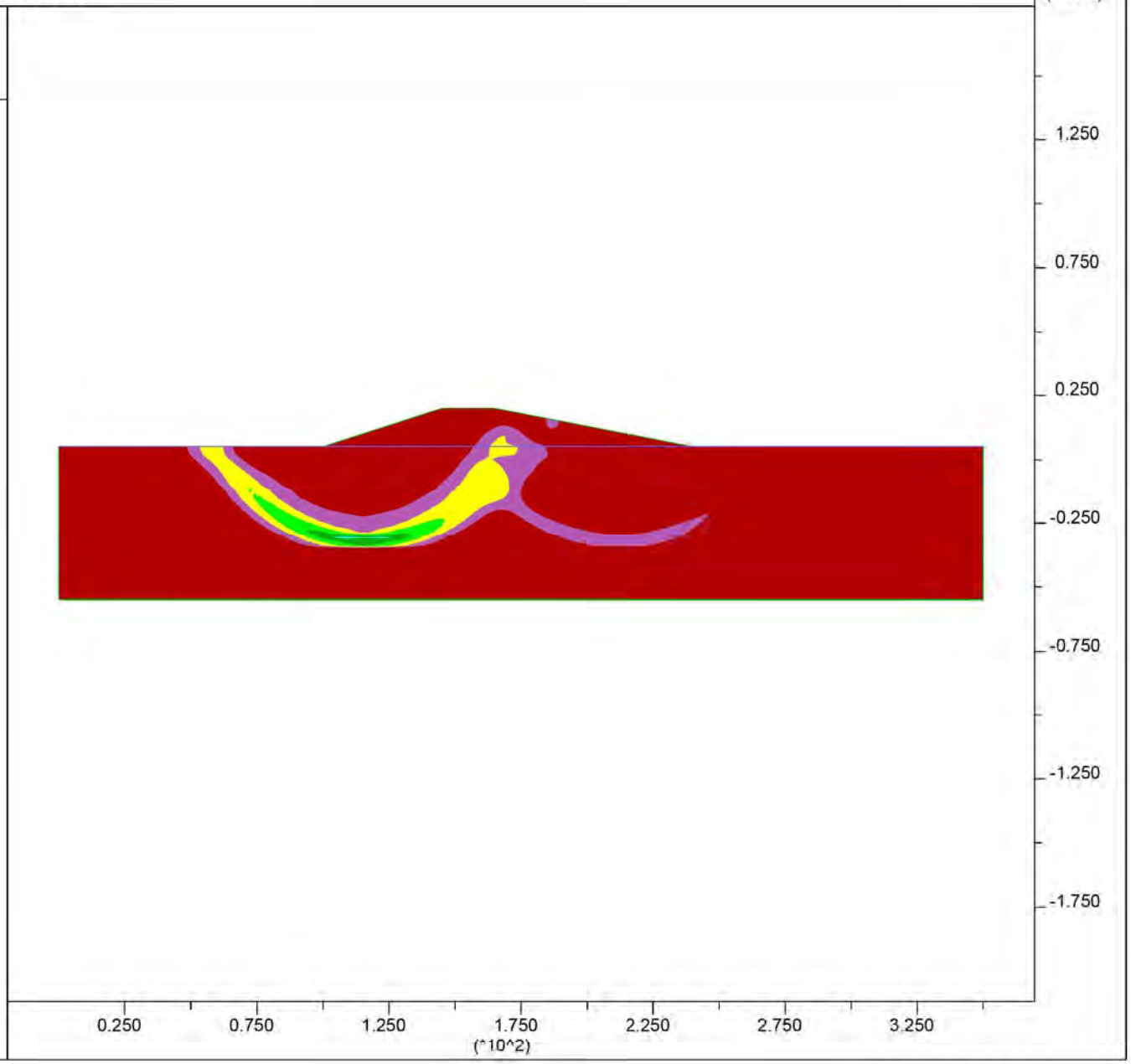


PLATE G-109

JOB TITLE : Section I-I' - Post Liquefaction - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:17
step 0
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

User-defined Groups
- User:Sand
- User:LiqSandDeep
- 'S:Stiff Clay'
- User:LiqSand
- 'User:V Soft Clay'
- Fill:LiqFill
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Group Delta Consultants
Ballona Wetlands

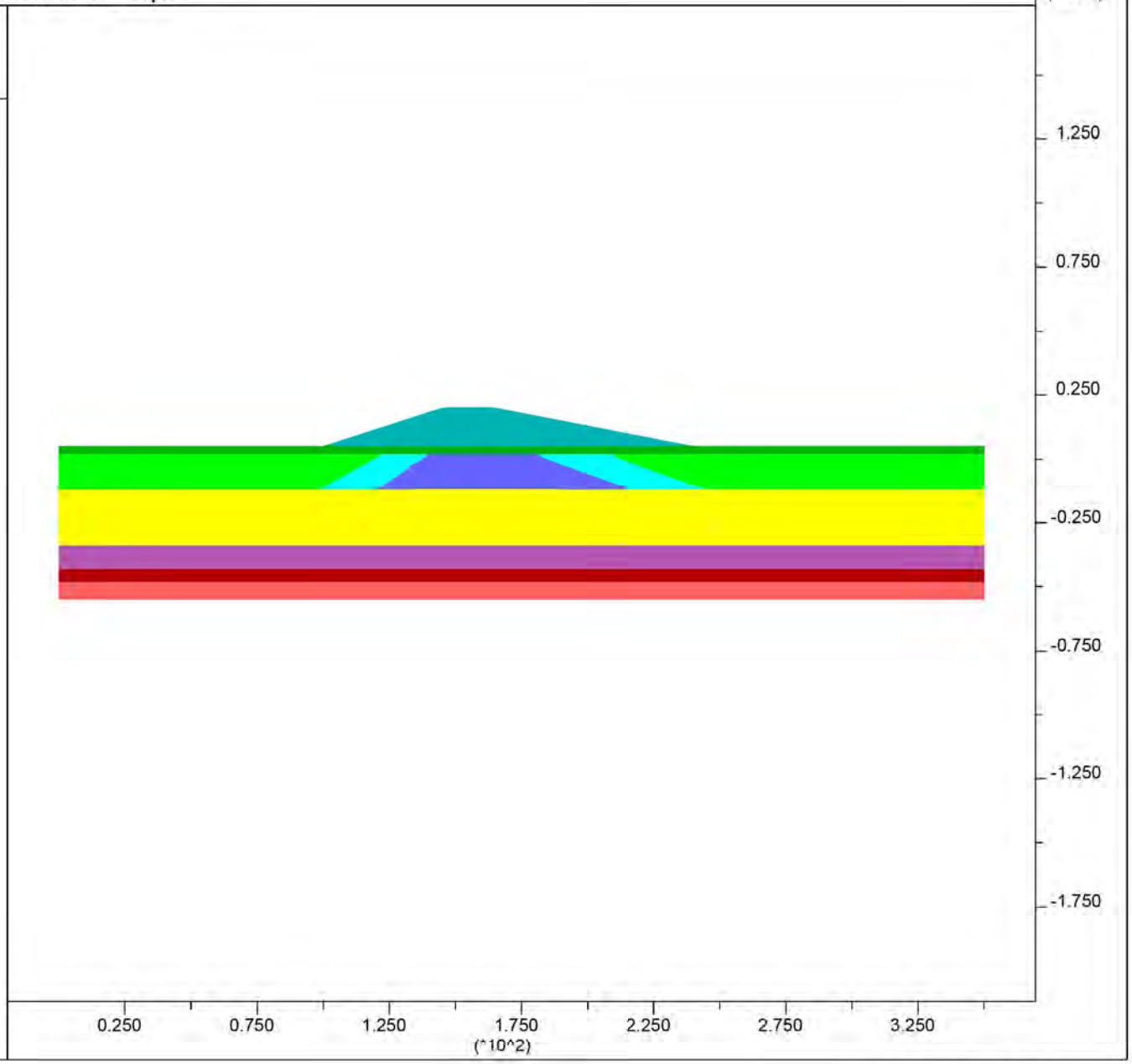


PLATE G-110

JOB TITLE : Section I-I' - Ky=0.04

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:23
step 30986
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

Factor of Safety 1.00

Max. shear strain-rate
0.00E+00
1.00E-07
2.00E-07
3.00E-07
4.00E-07
5.00E-07
6.00E-07
7.00E-07
8.00E-07
9.00E-07

Contour interval= 1.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Group Delta Consultants
Ballona Wetlands

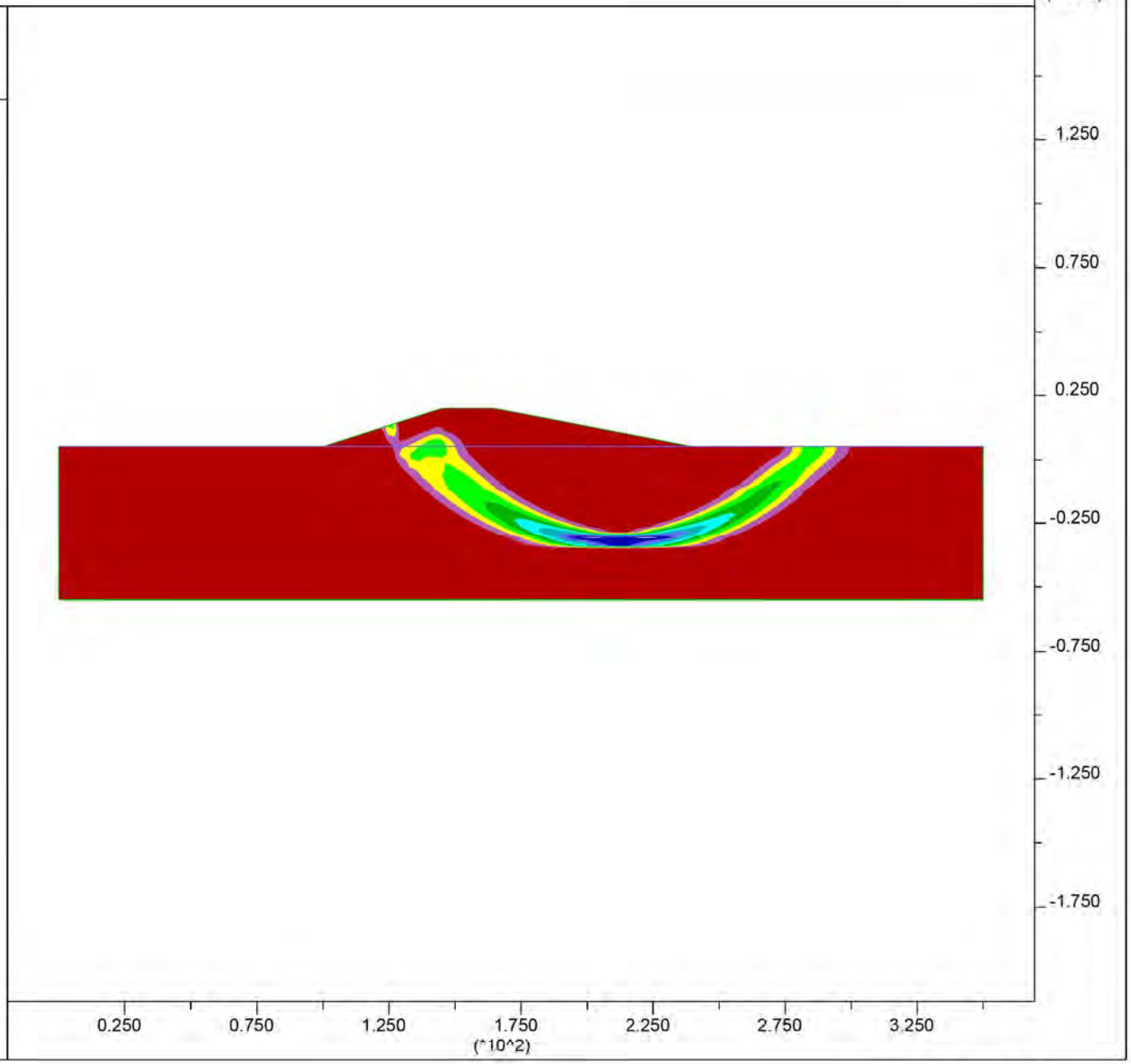


PLATE G-111

JOB TITLE : Section I-I' - Ky=0.04 - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:25
step 0
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

User-defined Groups
- User:Sand
- User:LiqSandDeep
- 'S:Stiff Clay'
- User:LiqSand
- 'User:V Soft Clay'
- Fill:LiqFill
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Group Delta Consultants
Ballona Wetlands

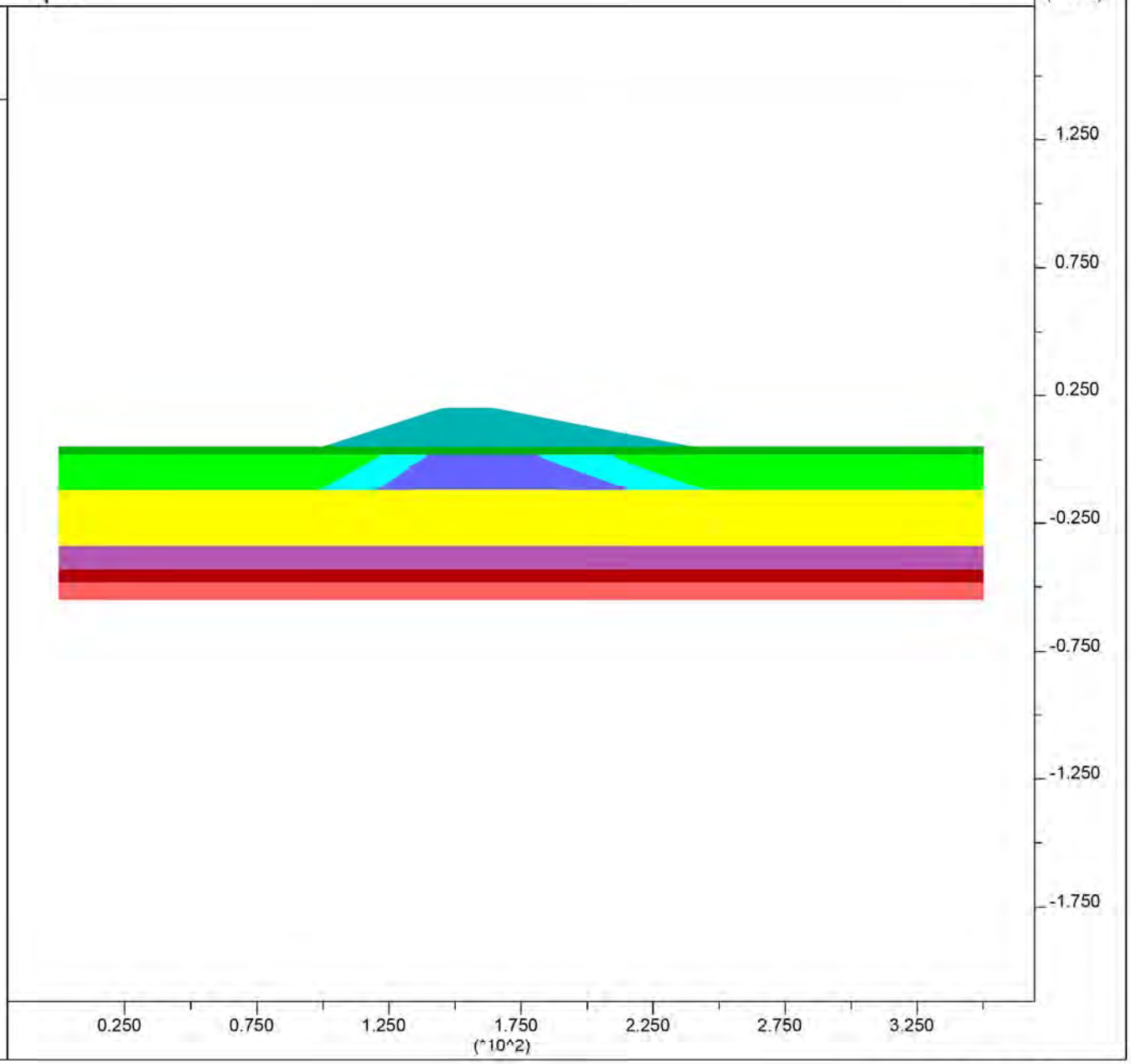


PLATE G-112

Newmark Displacements using Bray and Rathje (1998):

Section I-I'

Site Input

PGA,rock =	0.25	g	
M =	6.6		
r =	13	km	
ky =	0.04		
Sliding Mass Input			
Vs =	110	m/s	assumed
Thickness, H =	15.3	m	
	50	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.55	sec				
NRF =	1.15					
Ts/Tm =	1.14					
kmax/(PGA,rock*NRF)	0.48					
kmax =	0.14					
ky / kmax =	0.29					
Displacement, u =	11	cm	0.4	feet	4.3	inches

PLATE G-113

JOB TITLE : Section J-J' - End of Construction

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:27
step 16426
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

Factor of Safety 2.09

Max. shear strain-rate
0.00E+00
5.00E-07
1.00E-06
1.50E-06
2.00E-06
2.50E-06
3.00E-06
3.50E-06
4.00E-06

Contour interval= 5.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

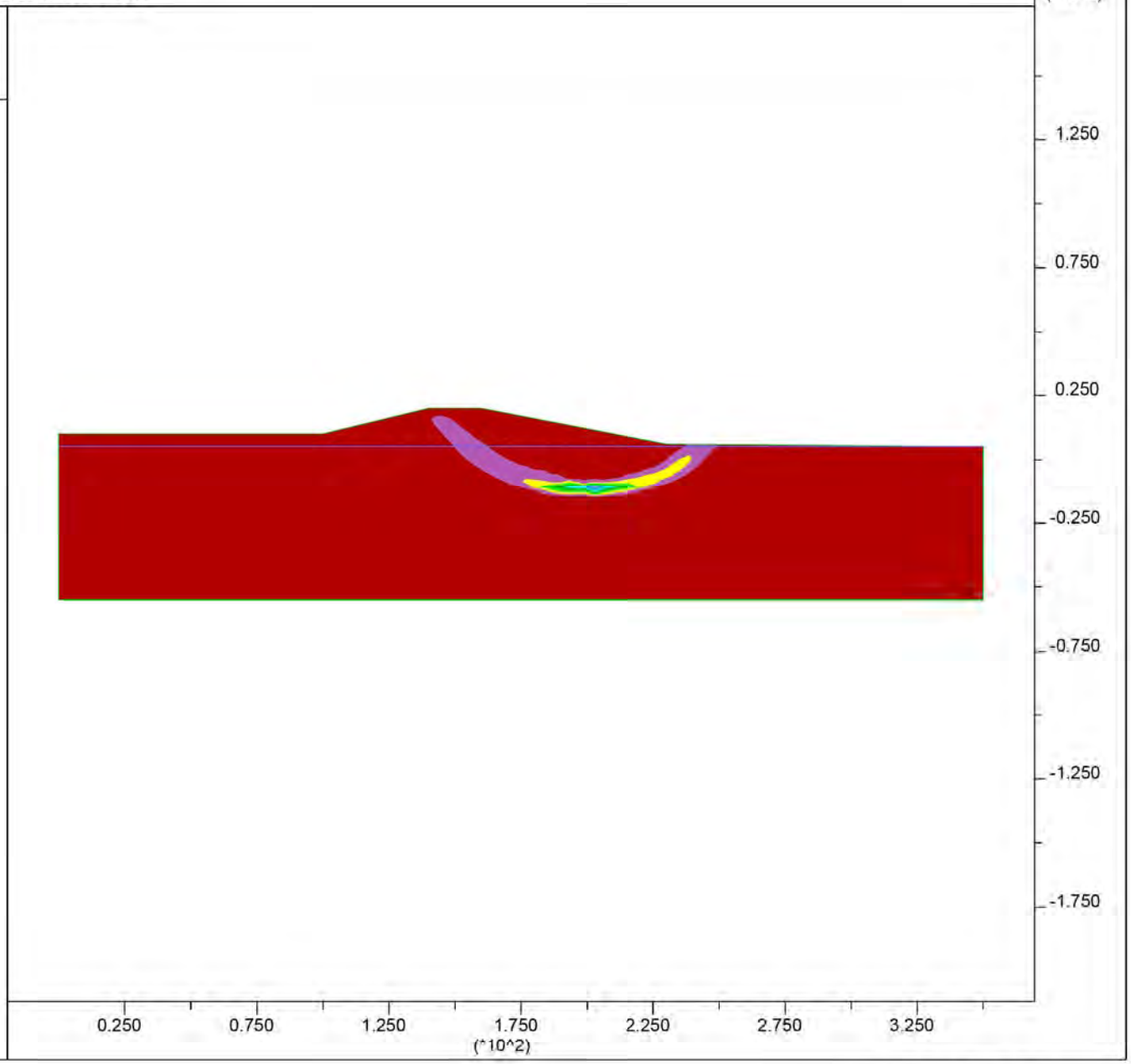


PLATE G-114

JOB TITLE : Section J-J' - End of Construction - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:30
step 0
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

User-defined Groups
- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:V Soft Clay'
- Fill:Fill
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Group Delta Consultants
Ballona Wetlands

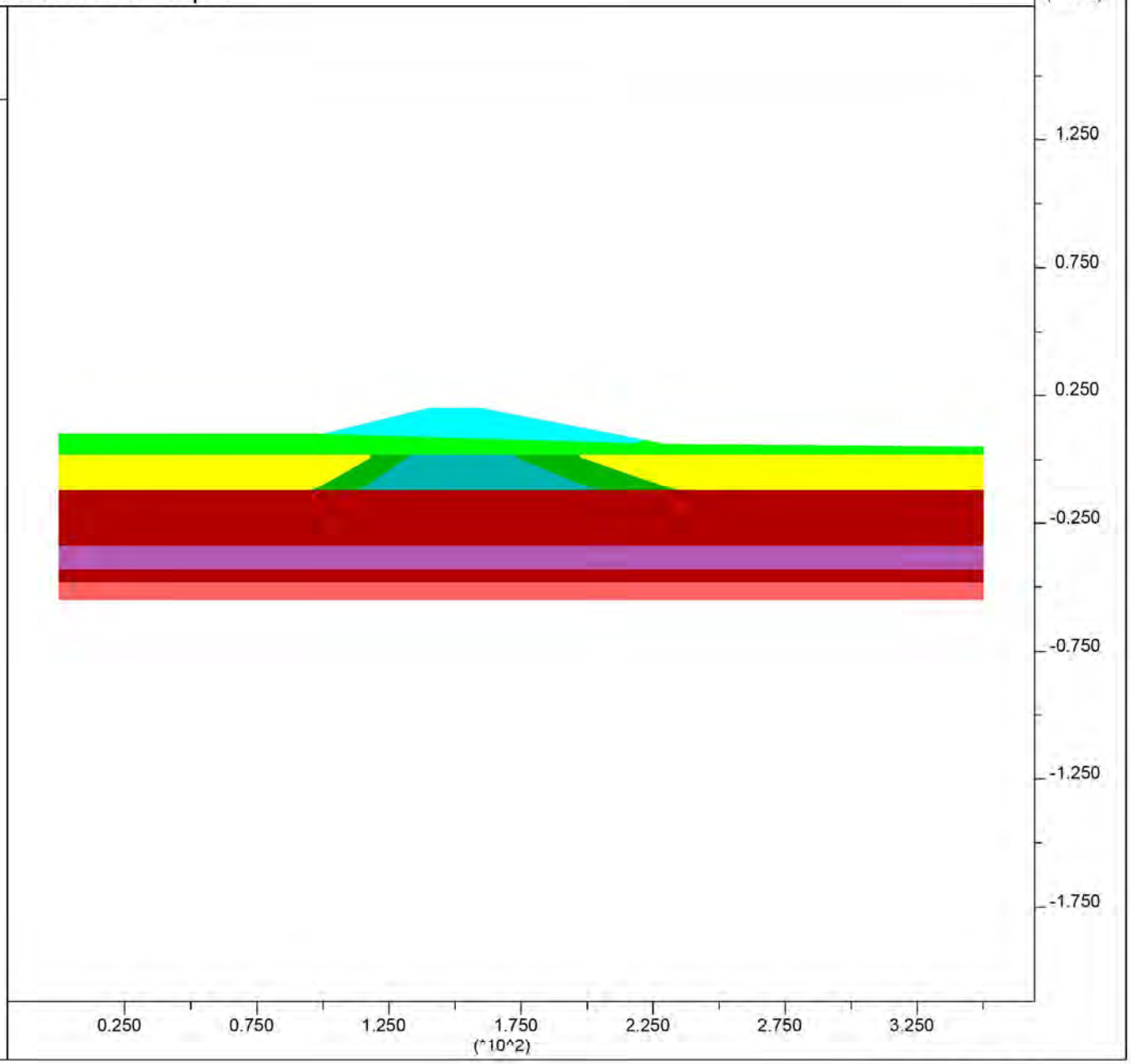


PLATE G-115

JOB TITLE : Section J-J' - High Water Short Term

FLAC (Version 7.00)

LEGEND

27-Feb-13 16:12
step 8130
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

Factor of Safety 2.48

Max. shear strain-rate
- 0.00E+00
- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06

Contour interval= 5.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.636E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

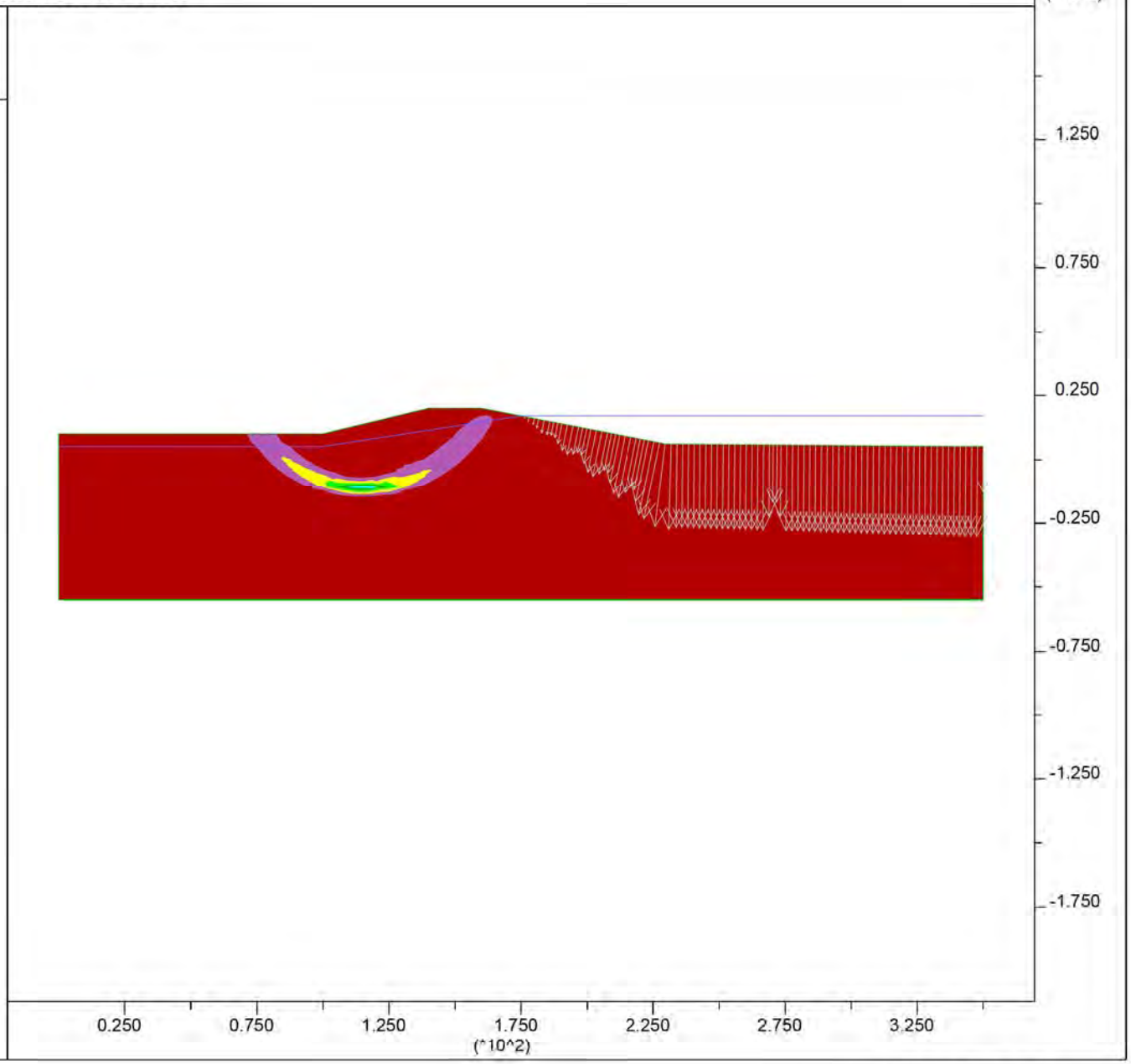


PLATE G-116

JOB TITLE : Section J-J' - High Water Short Term - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:37
step 1860
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

User-defined Groups
- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:V Soft Clay'
- Fill:Fill
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Net Applied Forces

max vector = 1.636E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

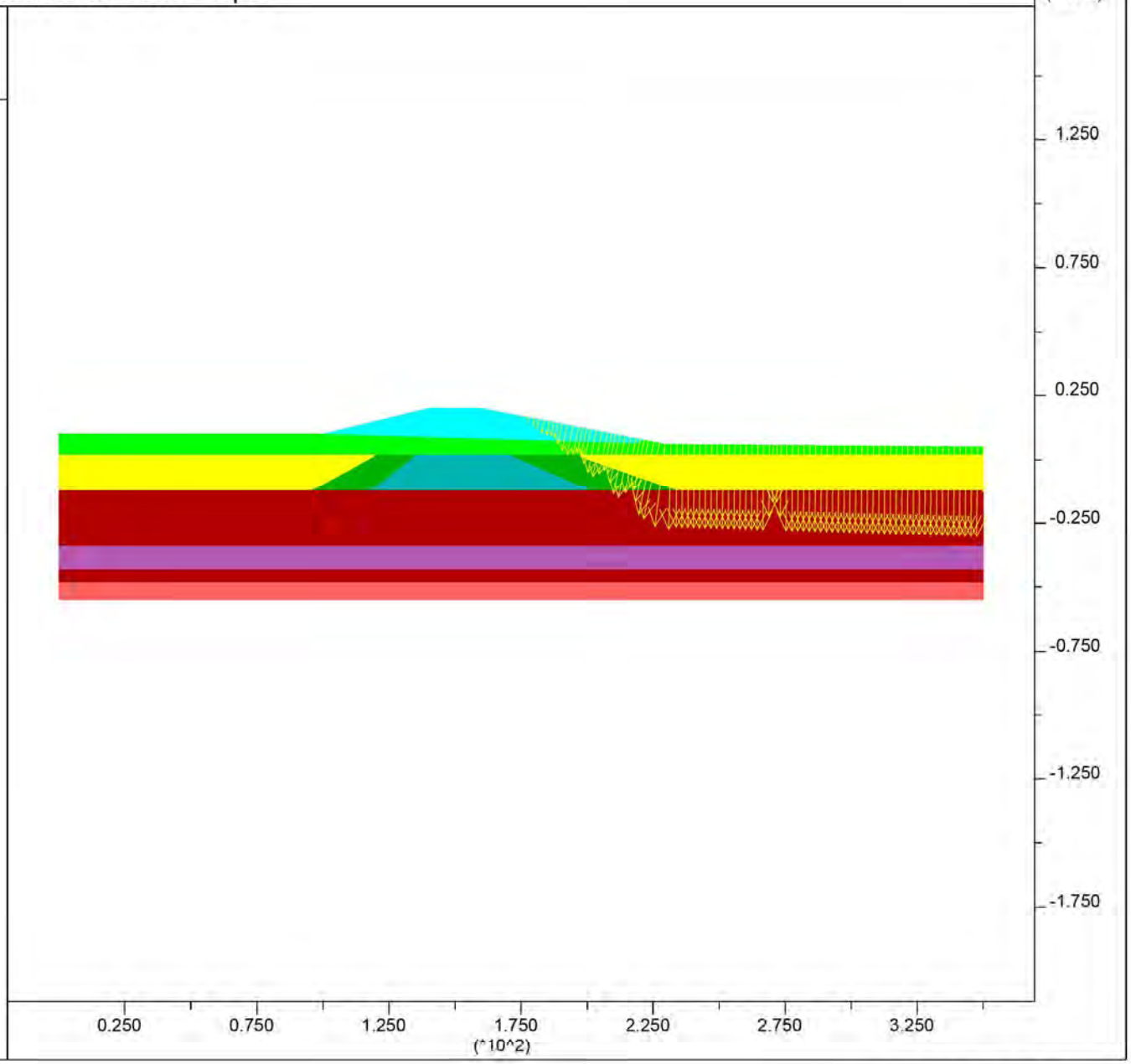


PLATE G-117

JOB TITLE : Section J-J' - Post Liquefaction

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:33
step 19390
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

Factor of Safety 1.47

Max. shear strain-rate
0.00E+00
2.00E-07
4.00E-07
6.00E-07
8.00E-07
1.00E-06

Contour interval= 2.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 6.801E+02

Group Delta Consultants
Ballona Wetlands

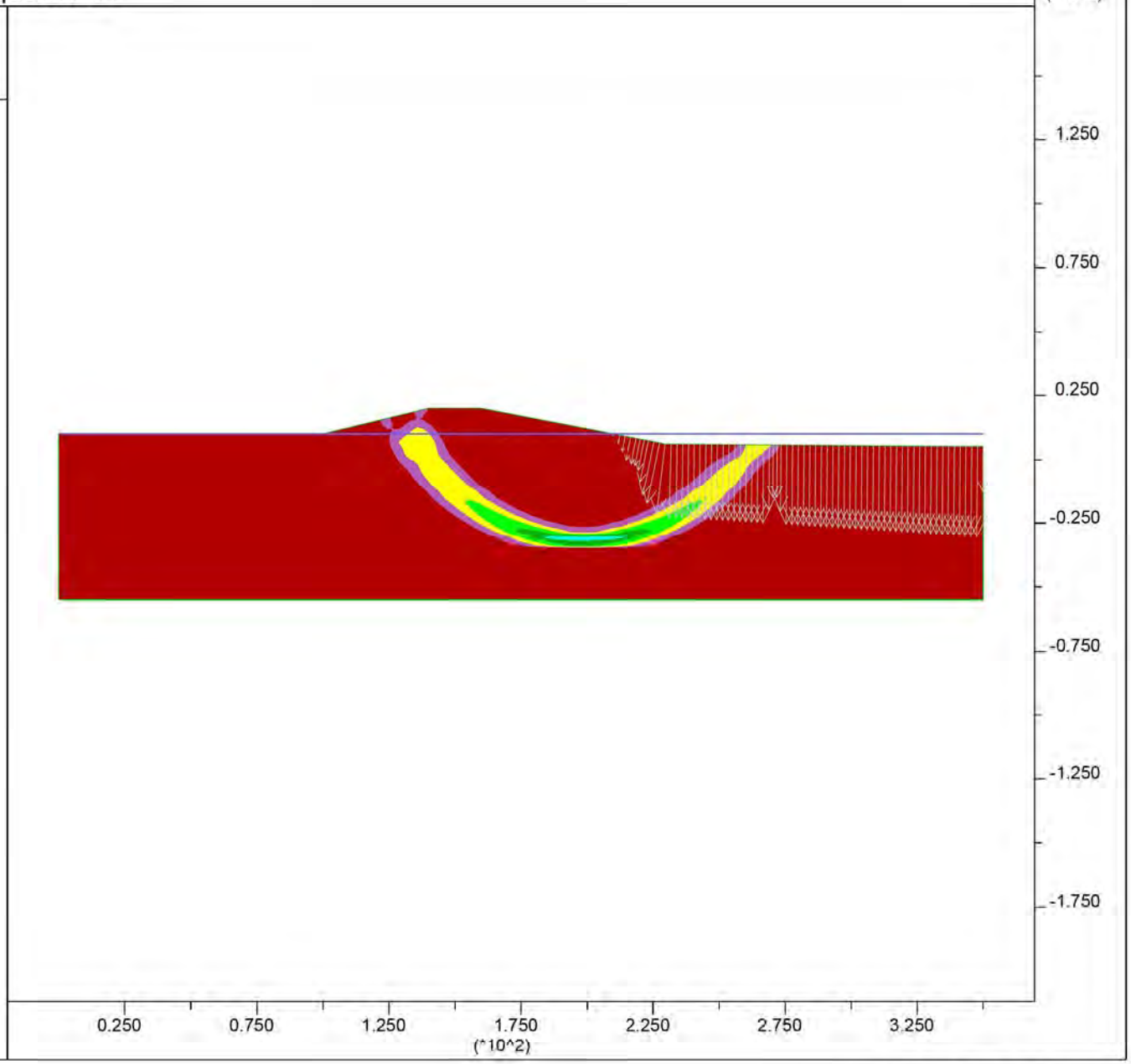


PLATE G-118

JOB TITLE : Section J-J' - Post Liquefaction - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:34
step 2710
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

User-defined Groups
- User:Sand
- User:LiqSandDeep
- 'S:Stiff Clay'
- User:LiqSand
- 'User:V Soft Clay'
- Fill:LiqFill
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Net Applied Forces

max vector = 6.801E+02

0 2E 3

Group Delta Consultants
Ballona Wetlands

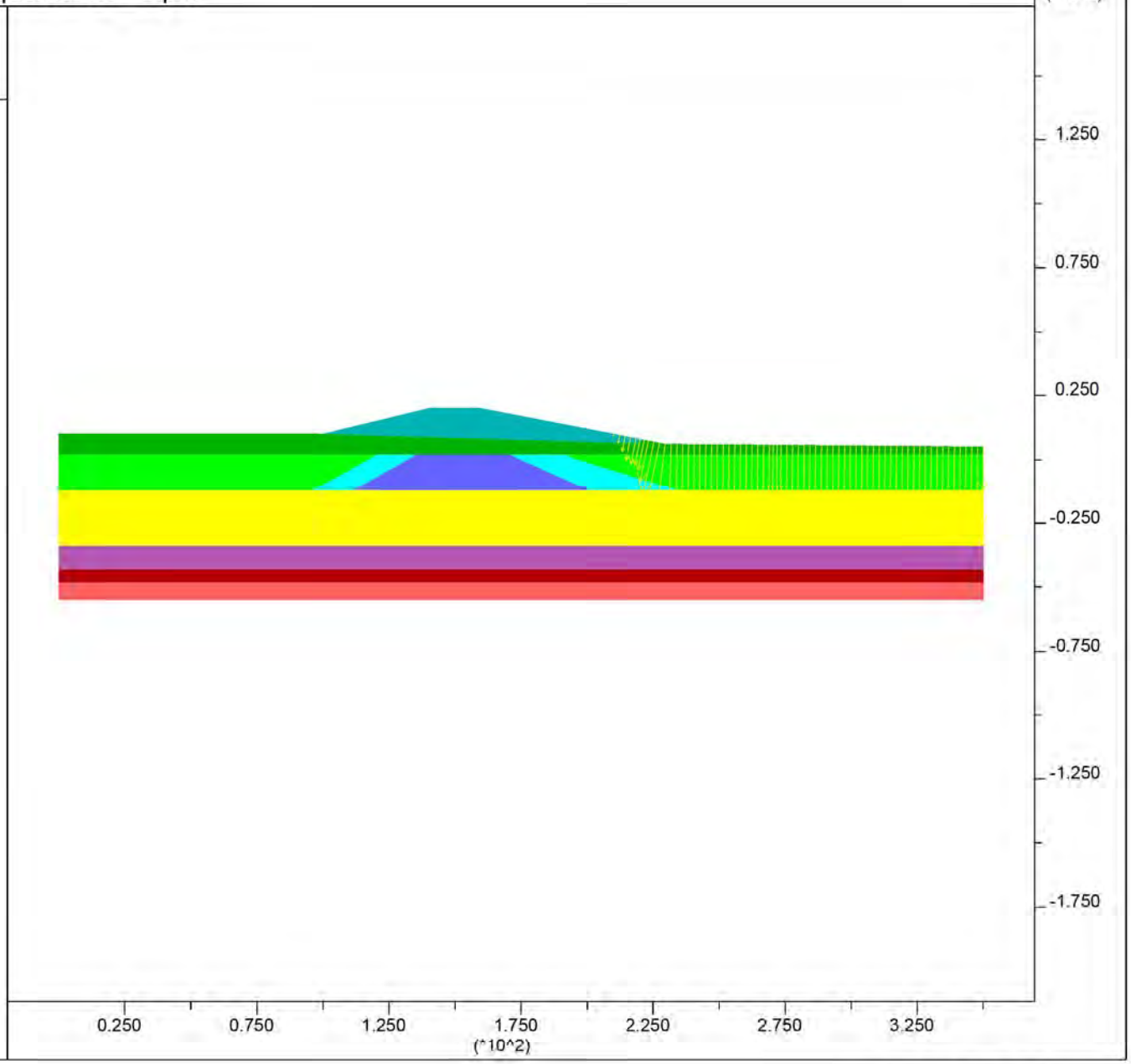


PLATE G-119

JOB TITLE : Section J-J' - Ky=0.05

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:35
step 27420
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

Factor of Safety 1.01

Max. shear strain-rate
0.00E+00
1.00E-07
2.00E-07
3.00E-07
4.00E-07
5.00E-07
6.00E-07
7.00E-07
8.00E-07

Contour interval= 1.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

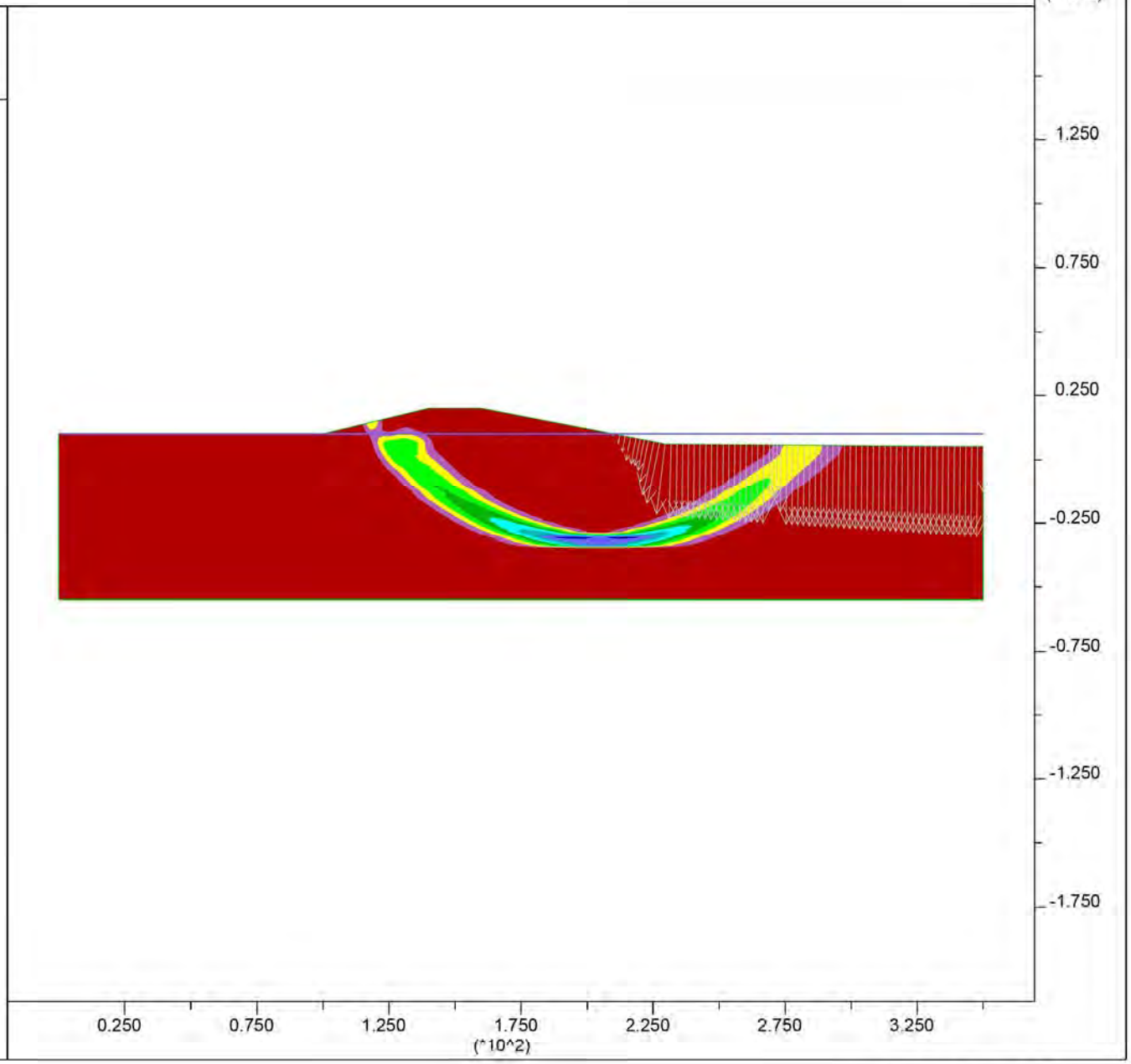


PLATE G-120

JOB TITLE : Section J-J' - Ky=0.05 - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 15:36
step 27420
-1.944E+01 <x< 3.694E+02
-2.119E+02 <y< 1.769E+02

User-defined Groups
- User:Sand
- User:LiqSandDeep
- 'S:Stiff Clay'
- User:LiqSand
- 'User:V Soft Clay'
- Fill:LiqFill
- User:Clay400
- User:Embankment
- 'User:Soft Clay'

Net Applied Forces

max vector = 6.801E+02

0 2E 3

Group Delta Consultants
Ballona Wetlands

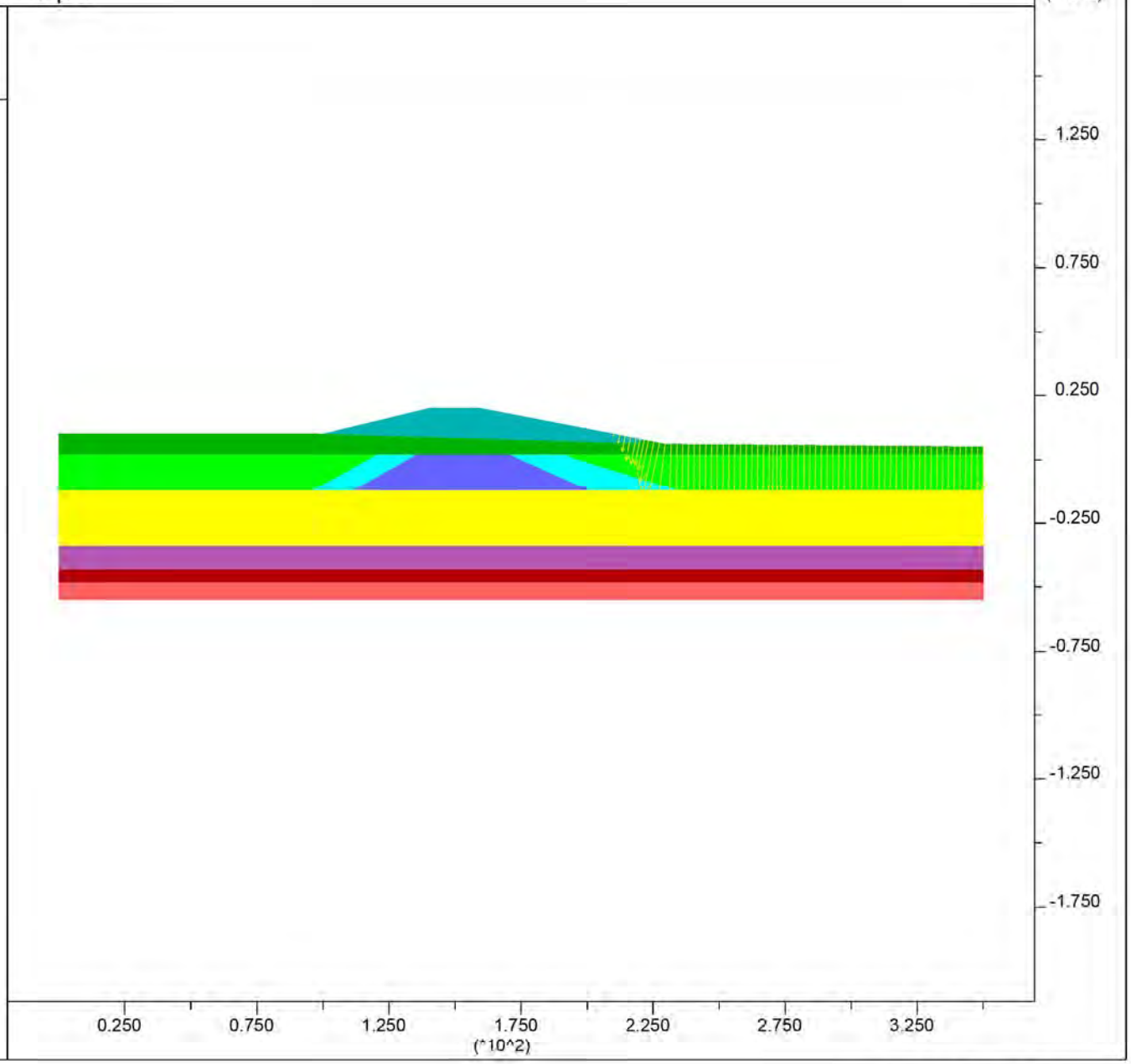


PLATE G-121

Newmark Displacements using Bray and Rathje (1998):

Section J-J'

Site Input

PGA,rock =	0.25	g	
M =	6.6		
r =	13	km	
ky =	0.05		
Sliding Mass Input			
Vs =	110	m/s	assumed
Thickness, H =	15.3	m	
	50	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.55	sec				
NRF =	1.15					
Ts/Tm =	1.14					
kmax/(PGA,rock*NRF)	0.48					
kmax =	0.14					
ky / kmax =	0.36					
Displacement, u =	6	cm	0.2	feet	2.4	inches

PLATE G-122

JOB TITLE : Section K-K' - End of Construction

FLAC (Version 7.00)

LEGEND

27-Feb-13 16:15
step 33610
-1.667E+01 <x< 3.167E+02
-1.872E+02 <y< 1.462E+02

Factor of Safety 1.58

Max. shear strain-rate
- 0.00E+00
- 2.00E-08
- 4.00E-08
- 6.00E-08
- 8.00E-08
- 1.00E-07

Contour interval= 2.00E-08
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.327E+03

Group Delta Consultants
Ballona Wetlands

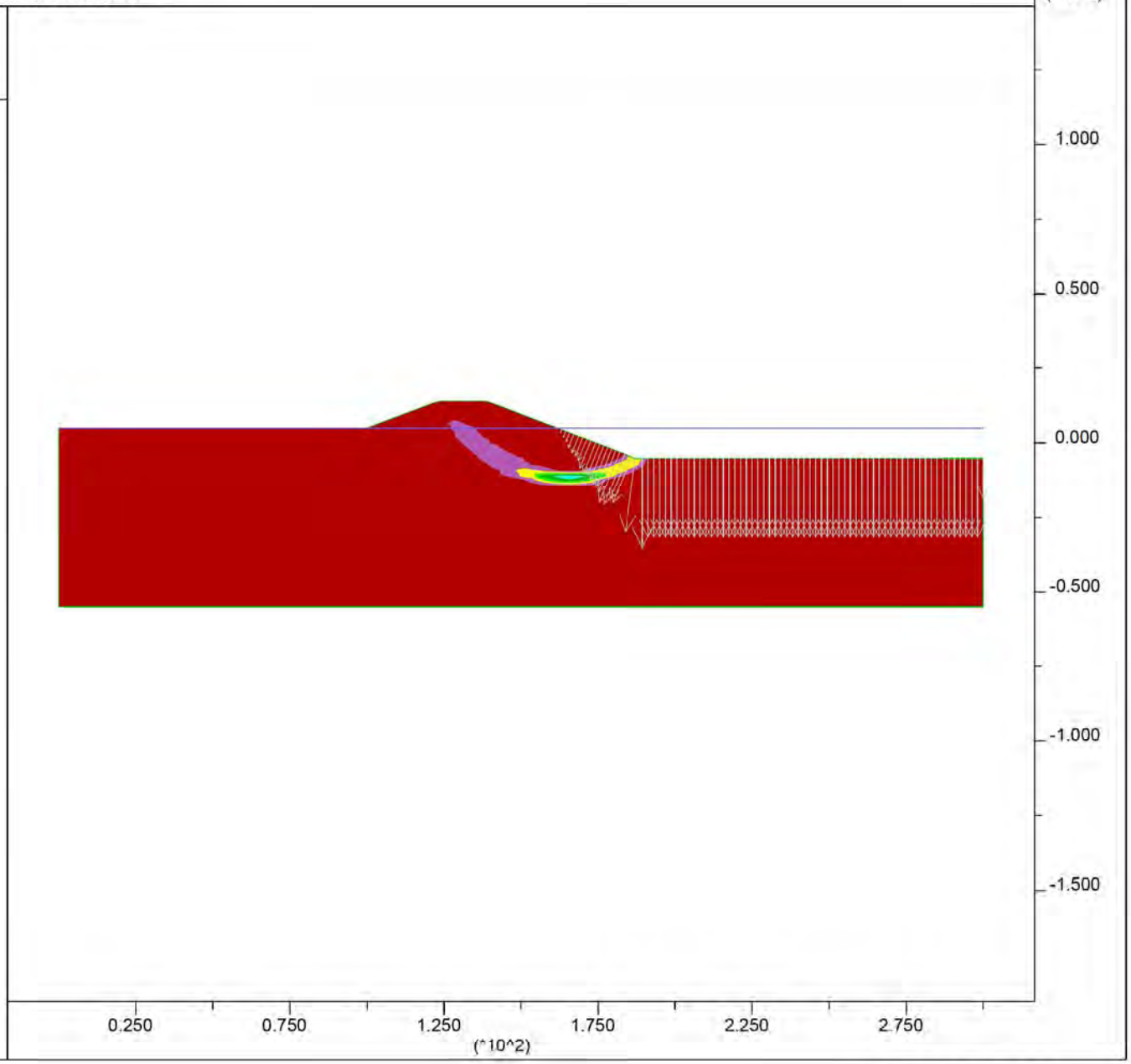


PLATE G-123

JOB TITLE : Section K-K' - End of Construction - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 16:17
step 670
-1.667E+01 <x< 3.167E+02
-1.872E+02 <y< 1.462E+02

User-defined Groups
- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:V Soft Clay'
- Fill:Fill
- User:Embankment
- 'User:Clay 400'
- 'User:Soft Clay'

Net Applied Forces

max vector = 1.327E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

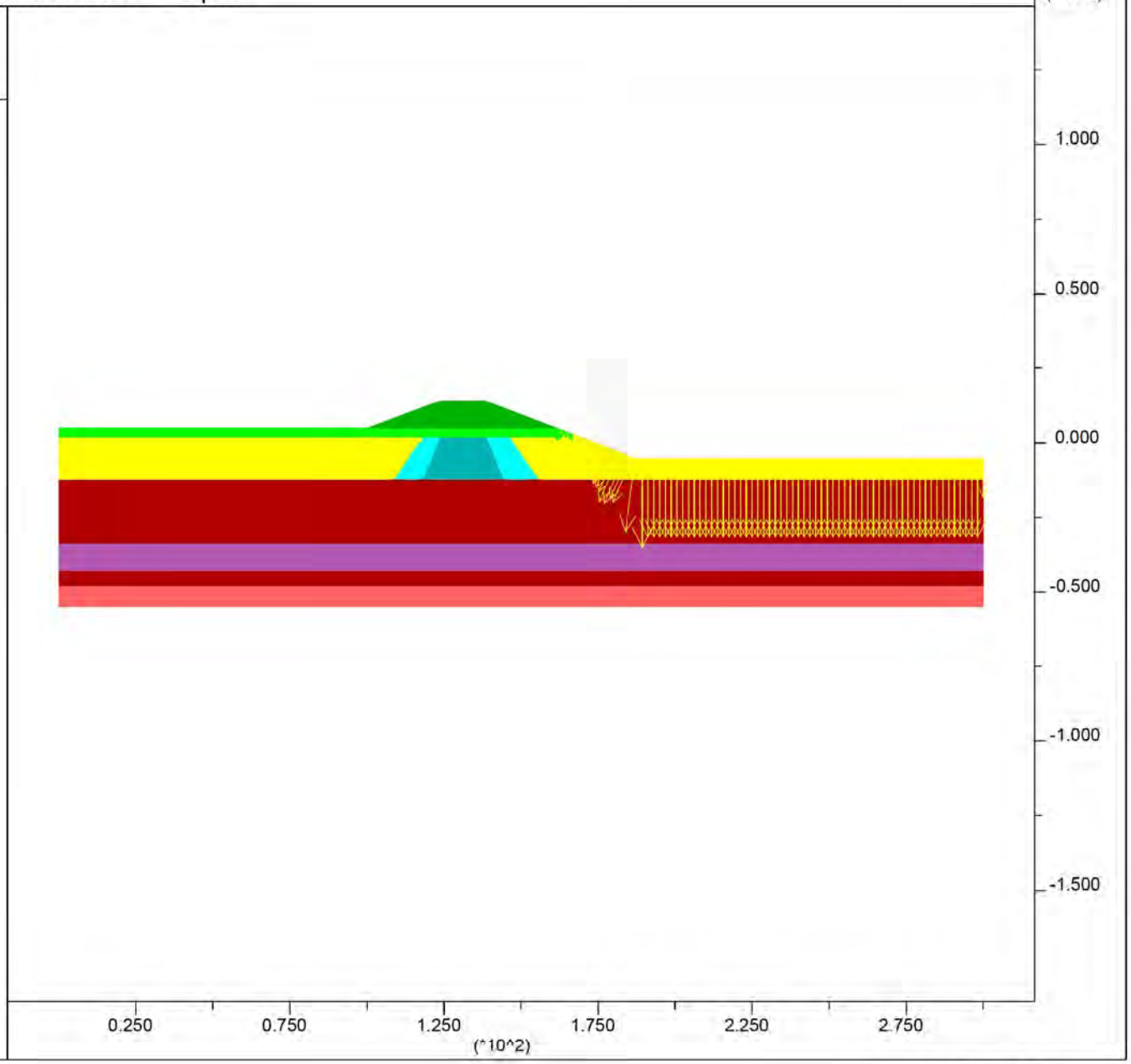


PLATE G-124

JOB TITLE : Section K-K' - High Water Short Term

FLAC (Version 7.00)

LEGEND

27-Feb-13 17:26
step 41778
-1.667E+01 <x< 3.167E+02
-1.872E+02 <y< 1.462E+02

Factor of Safety 2.13

Max. shear strain-rate
- 0.00E+00
- 1.00E-07
- 2.00E-07
- 3.00E-07
- 4.00E-07
- 5.00E-07
- 6.00E-07

Contour interval= 1.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.389E+03

Group Delta Consultants
Ballona Wetlands

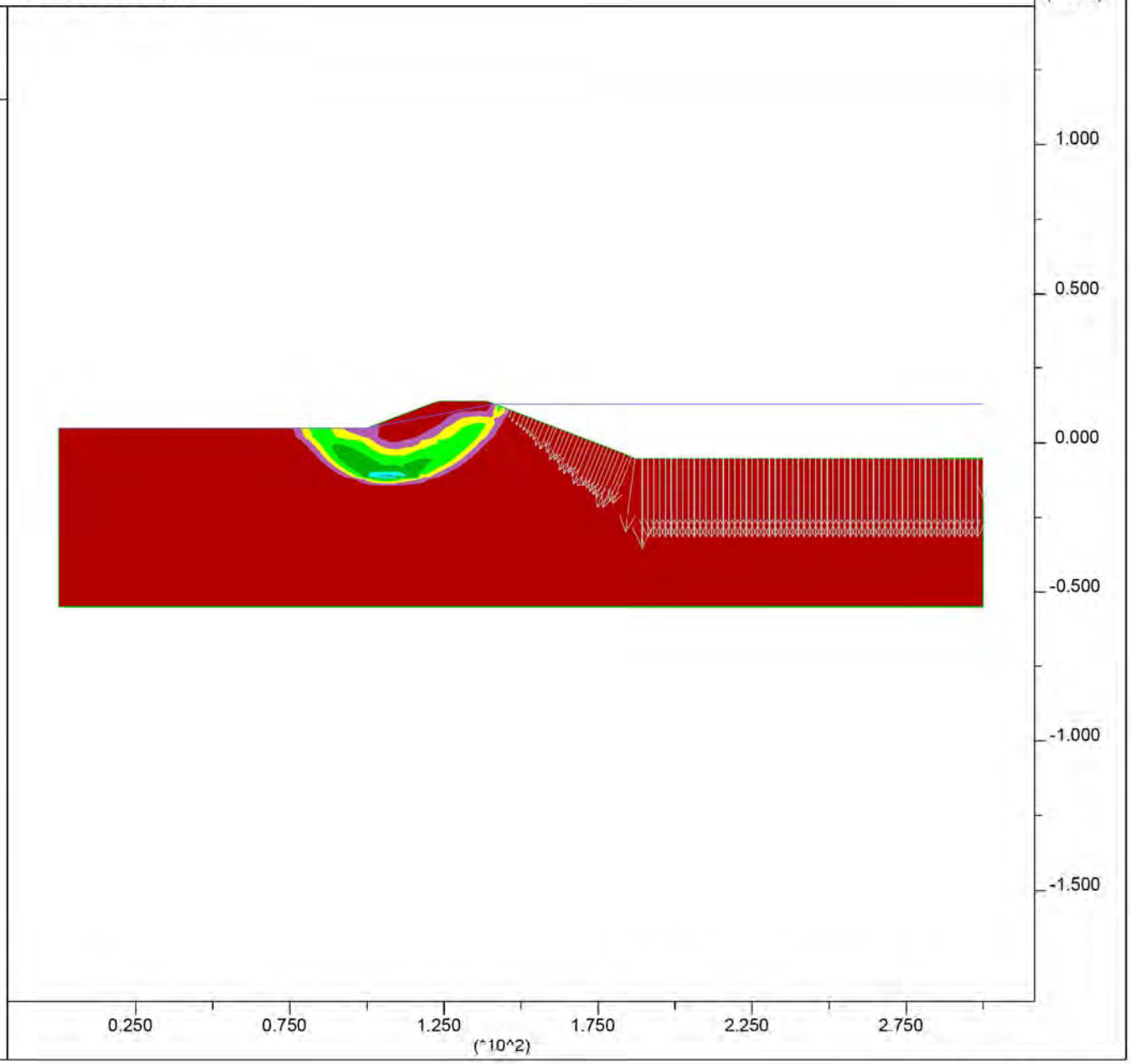


PLATE G-125

JOB TITLE : Section K-K' - High Water Short Term - Input

FLAC (Version 7.00)

LEGEND

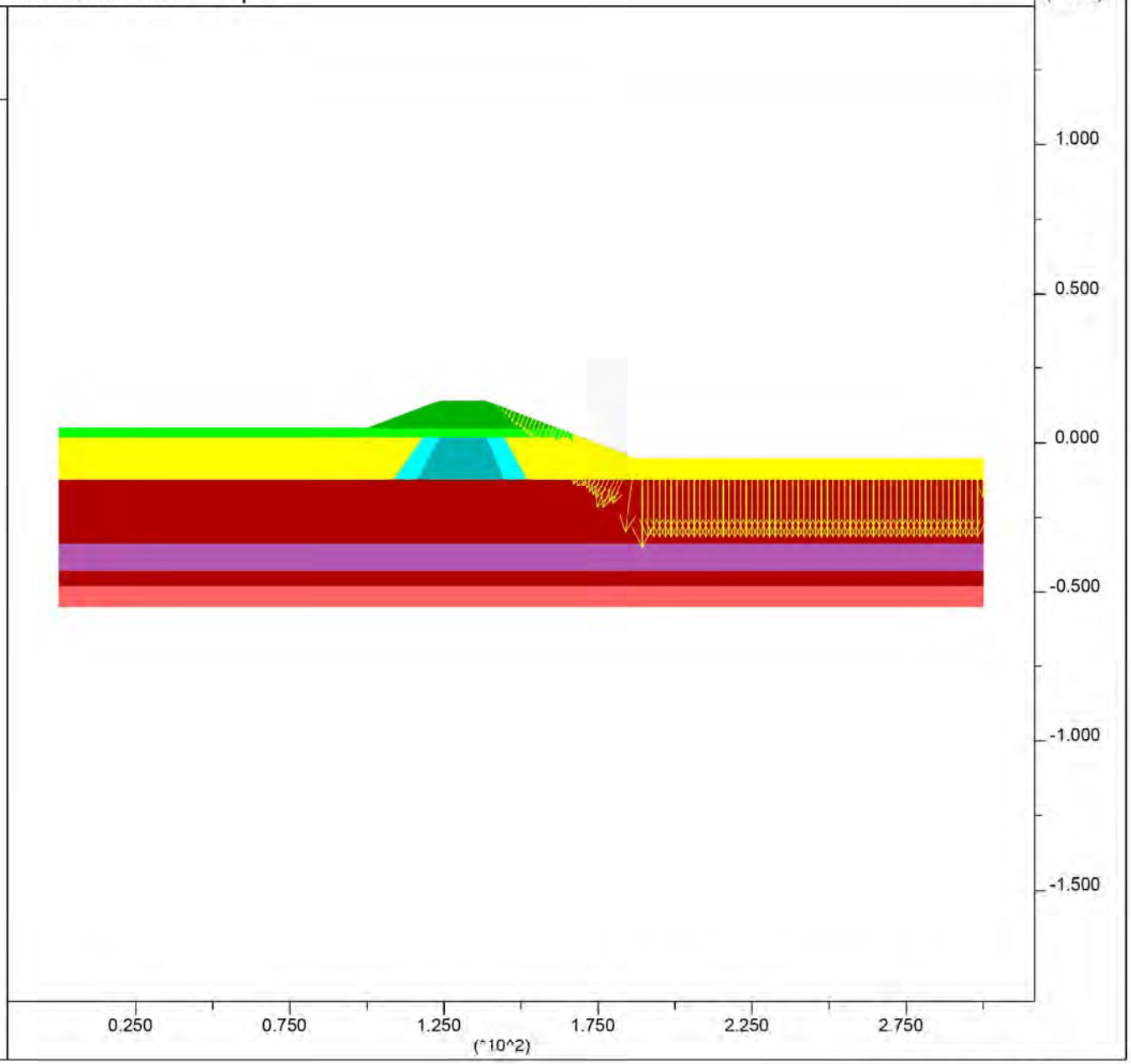
27-Feb-13 16:24
step 0
-1.667E+01 <x< 3.167E+02
-1.872E+02 <y< 1.462E+02

User-defined Groups
- User:Sand
- 'User:Med Sand'
- 'S:Stiff Clay'
- 'User:V Soft Clay'
- Fill:Fill
- User:Embankment
- User:Clay400
- 'User:Soft Clay'

Net Applied Forces

max vector = 2.389E+03

0 5E 3



Group Delta Consultants
Ballona Wetlands

PLATE G-126

JOB TITLE : Section K-K' - Post Liquefaction

FLAC (Version 7.00)

LEGEND

27-Feb-13 16:18
step 24366
-1.667E+01 <x< 3.167E+02
-1.872E+02 <y< 1.462E+02

Factor of Safety 1.26

Max. shear strain-rate
0.00E+00
1.00E-07
2.00E-07
3.00E-07
4.00E-07
5.00E-07
6.00E-07

Contour interval= 1.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.327E+03

Group Delta Consultants
Ballona Wetlands

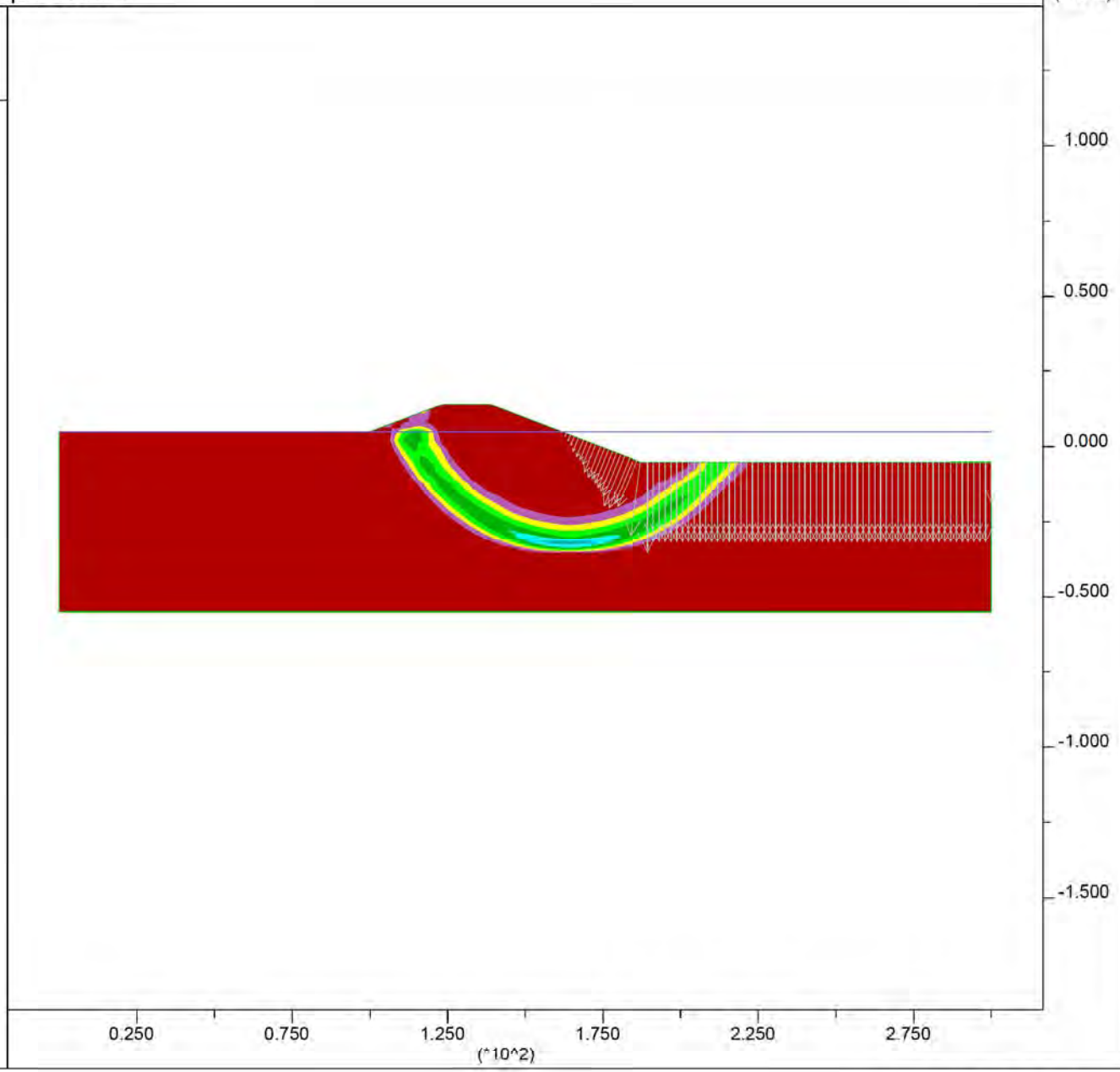


PLATE G-127

JOB TITLE : Section K-K' - Post Liquefaction - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 16:19
step 550
-1.667E+01 <x< 3.167E+02
-1.872E+02 <y< 1.462E+02

User-defined Groups
- User:Sand
- User:SandLiqDeep
- 'S:Stiff Clay'
- Fill:SandLiq
- 'User:V Soft Clay'
- Fill:FillLiq
- User:Embankment
- User:Clay400
- 'User:Soft Clay'

Net Applied Forces

max vector = 1.327E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

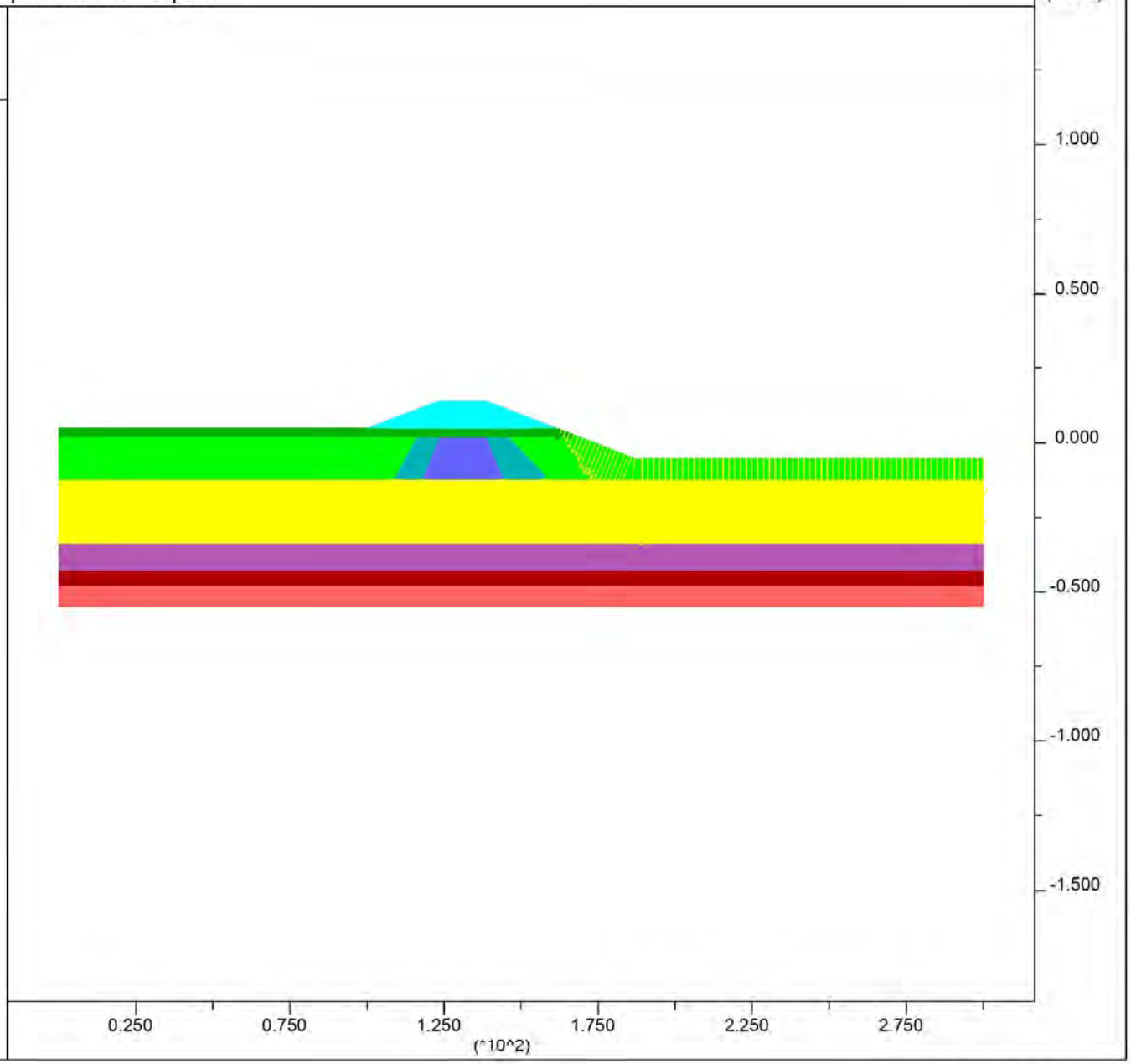


PLATE G-128

JOB TITLE : Section K-K' - Ky=0.04

FLAC (Version 7.00)

LEGEND

27-Feb-13 16:21
step 34246
-1.667E+01 <x< 3.167E+02
-1.872E+02 <y< 1.462E+02

Factor of Safety 1.01

Max. shear strain-rate
- 0.00E+00
- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06

Contour interval= 5.00E-07
Extrap. by averaging
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.327E+03

Group Delta Consultants
Ballona Wetlands

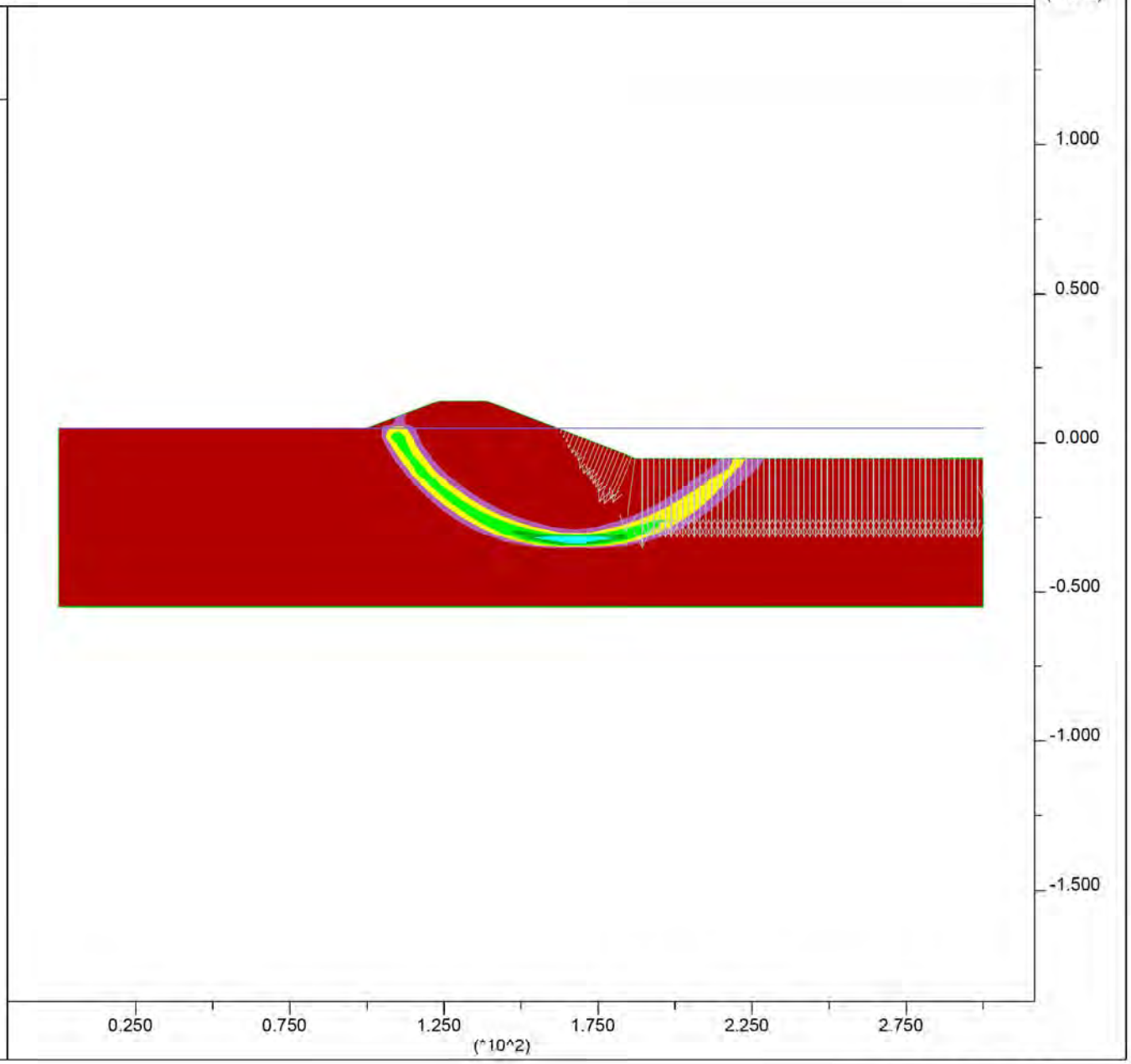


PLATE G-129

JOB TITLE : Section K-K' - Ky=0.04 - Input

FLAC (Version 7.00)

LEGEND

27-Feb-13 16:20
step 550
-1.667E+01 <x< 3.167E+02
-1.872E+02 <y< 1.462E+02

User-defined Groups
- User:Sand
- User:SandLiqDeep
- 'S:Stiff Clay'
- Fill:SandLiq
- 'User:V Soft Clay'
- Fill:FillLiq
- User:Embankment
- User:Clay400
- 'User:Soft Clay'

Net Applied Forces

max vector = 1.327E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

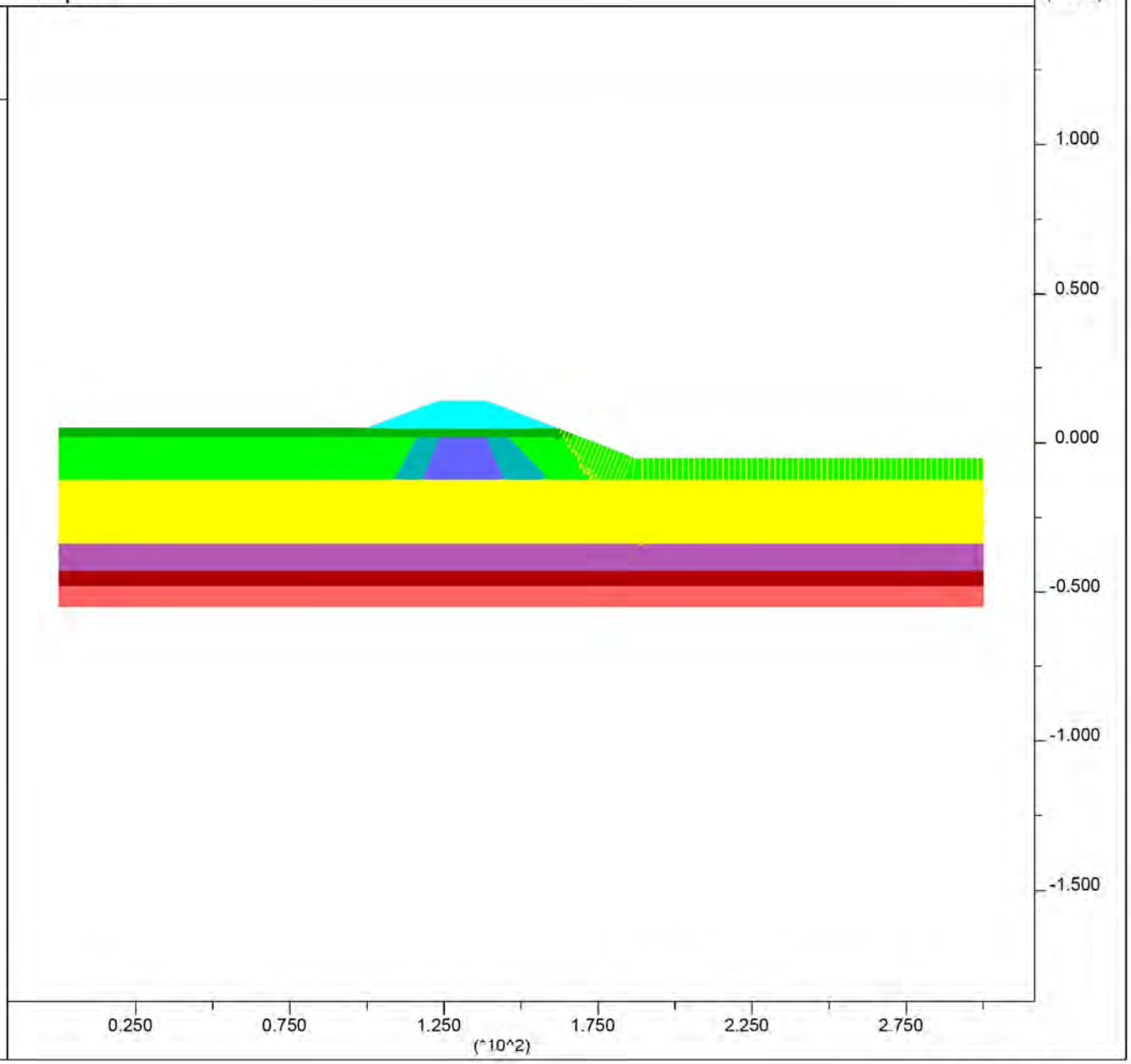


PLATE G-130

Newmark Displacements using Bray and Rathje (1998):

Section K-K'

Site Input

PGA,rock =	0.25	g		
M =	6.6			
r =	13	km		
ky =	0.04		32.185	1.2874

Sliding Mass Input

Vs =	100	m/s	assumed
Thickness, H =	12.2	m	
	40	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.49	sec				
NRF =	1.15					
Ts/Tm =	1.00					
kmax/(PGA,rock*NRF)	0.54					
kmax =	0.15					
ky / kmax =	0.26					
Displacement, u =	15	cm	0.5	feet	5.9	inches

PLATE G-131

JOB TITLE : Section L-L' - End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 14:43

Factor of Safety 1.60

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.366E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

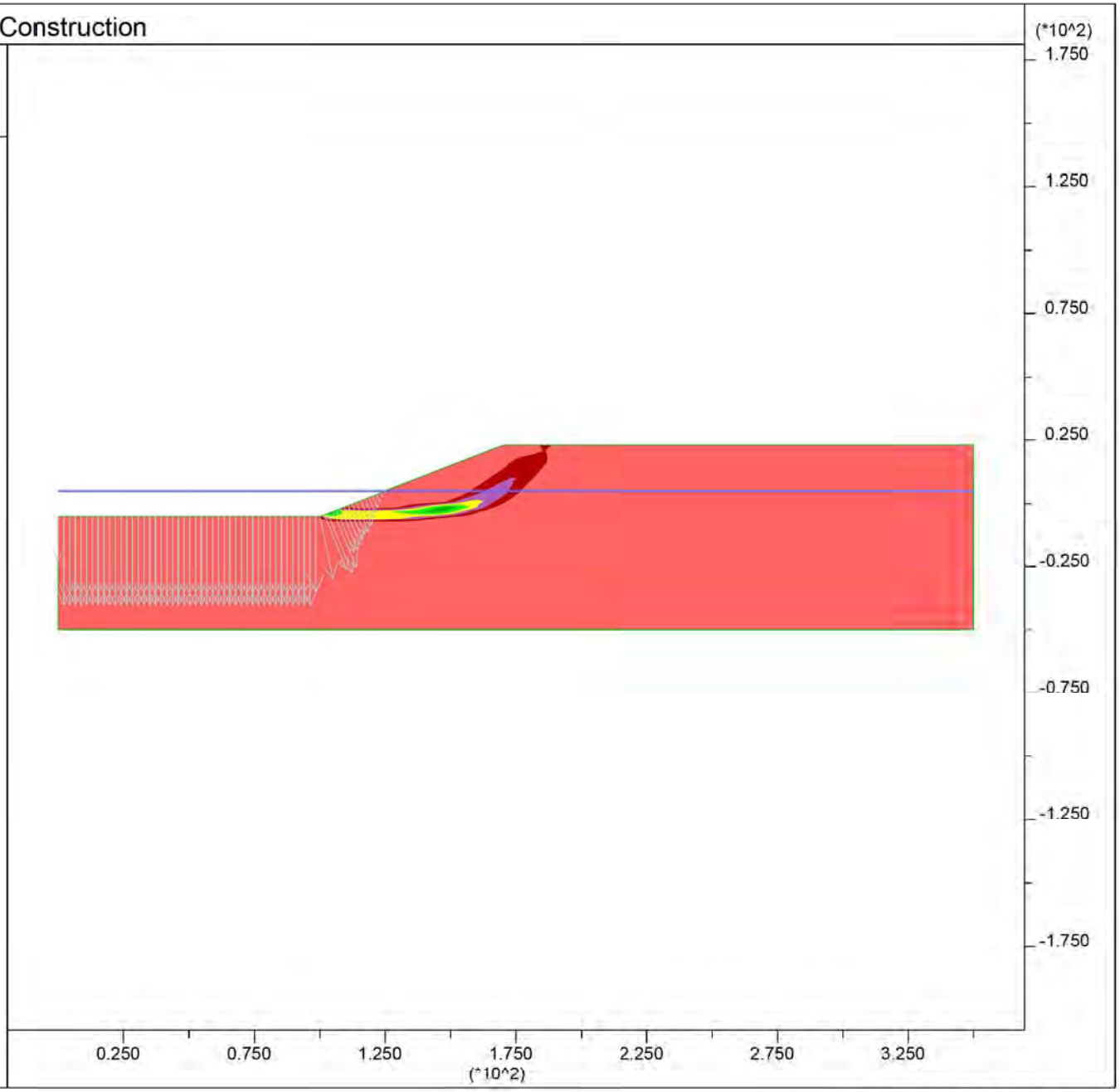


PLATE G-132

JOB TITLE : Section L-L' - End of Construction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 14:46

Factor of Safety 1.60

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- User:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.366E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

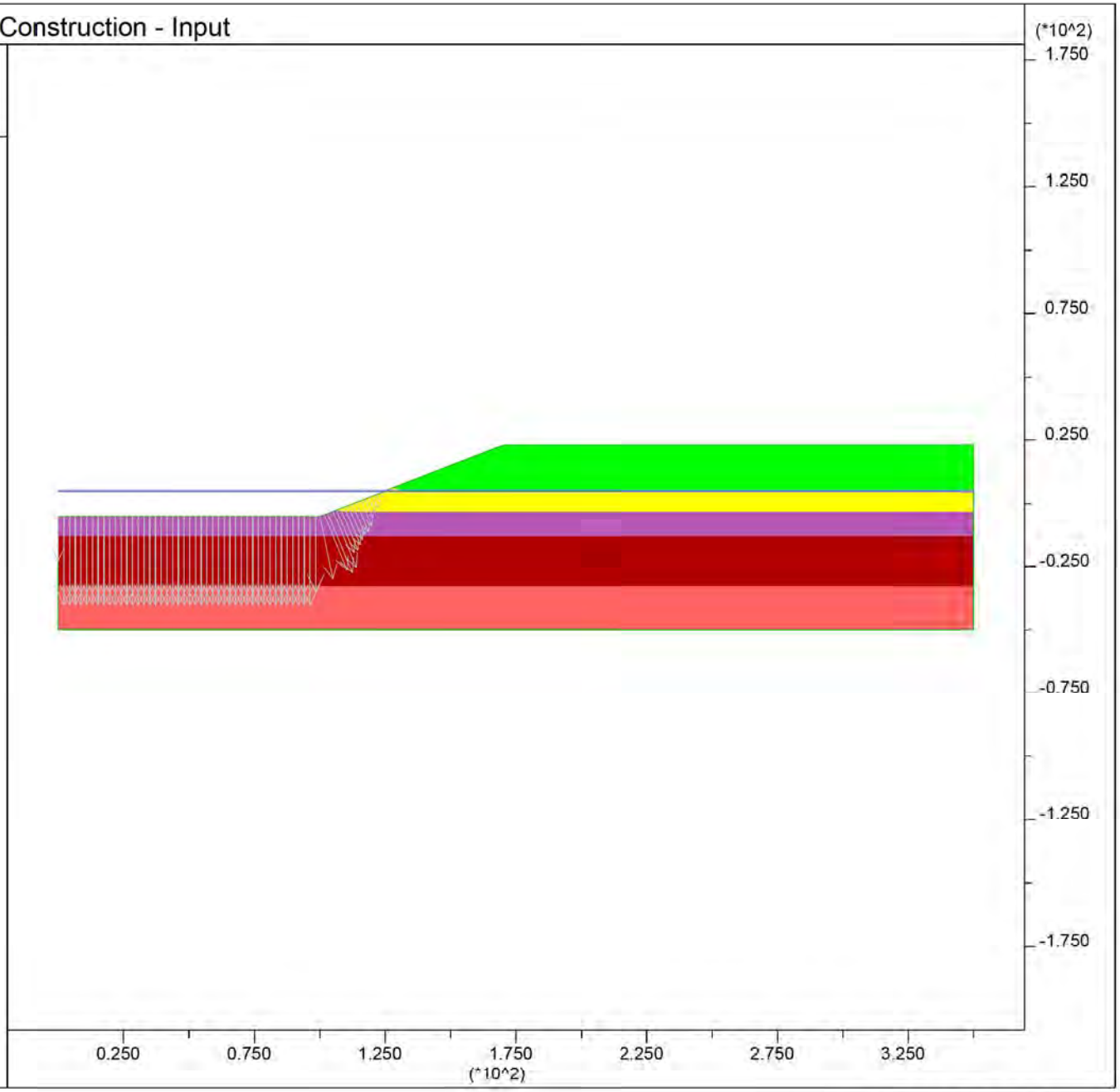


PLATE G-133

JOB TITLE : Section L-L' - High Water Short Term

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 14:49

Factor of Safety 2.26

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 3.006E+03

0 1E 4

Group Delta Consultants
Ballona Wetlands

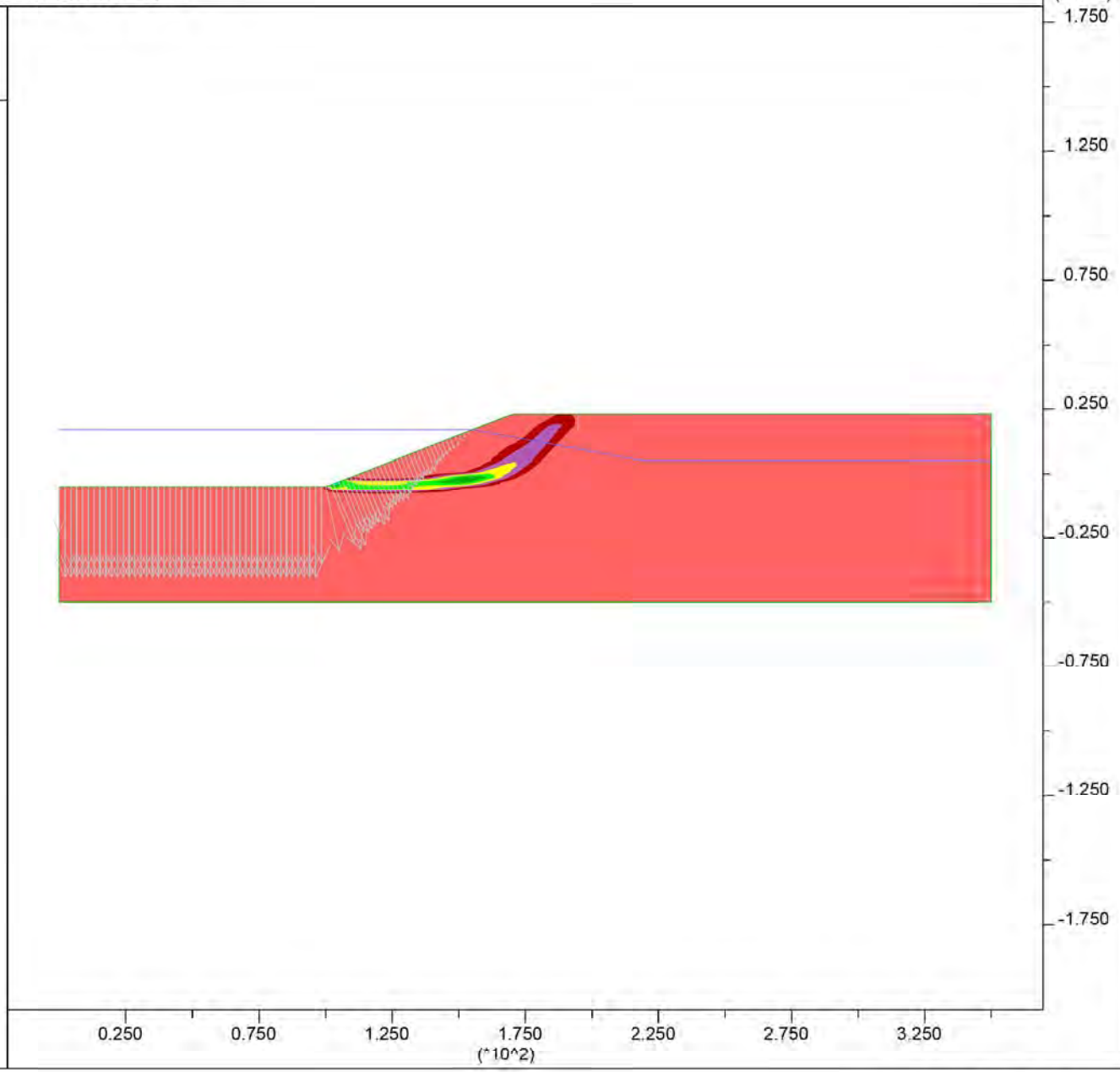


PLATE G-134

JOB TITLE : Section L-L' - High Water Short Term - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 14:48

Factor of Safety 2.26

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Med Sand'
- 'User:Soft Clay'
- User:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 3.006E+03

0 1E 4

Group Delta Consultants
Ballona Wetlands

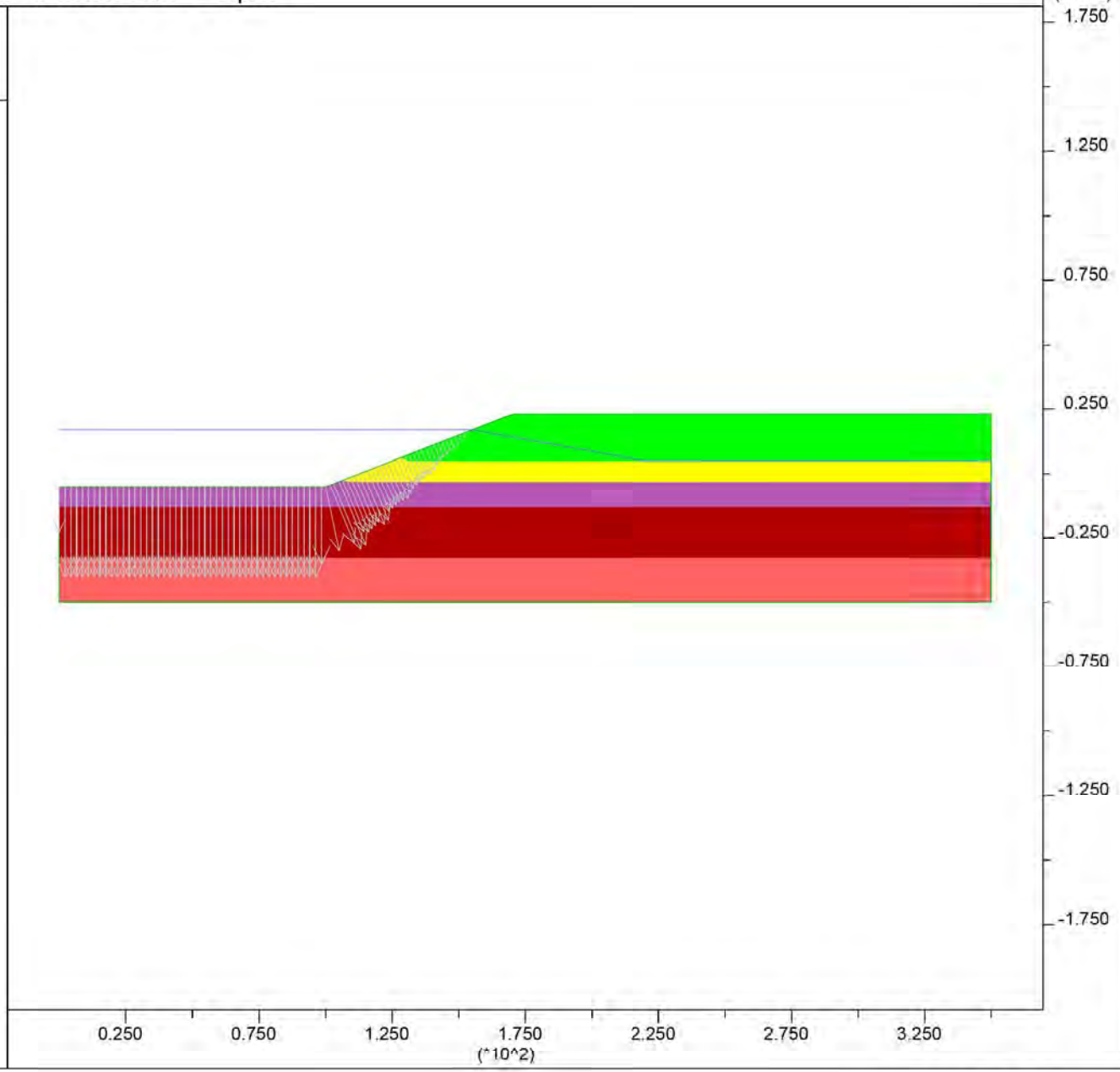


PLATE G-135

JOB TITLE : Section L-L' - Post Liquefaction

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 15:01

Factor of Safety 1.40

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.050E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

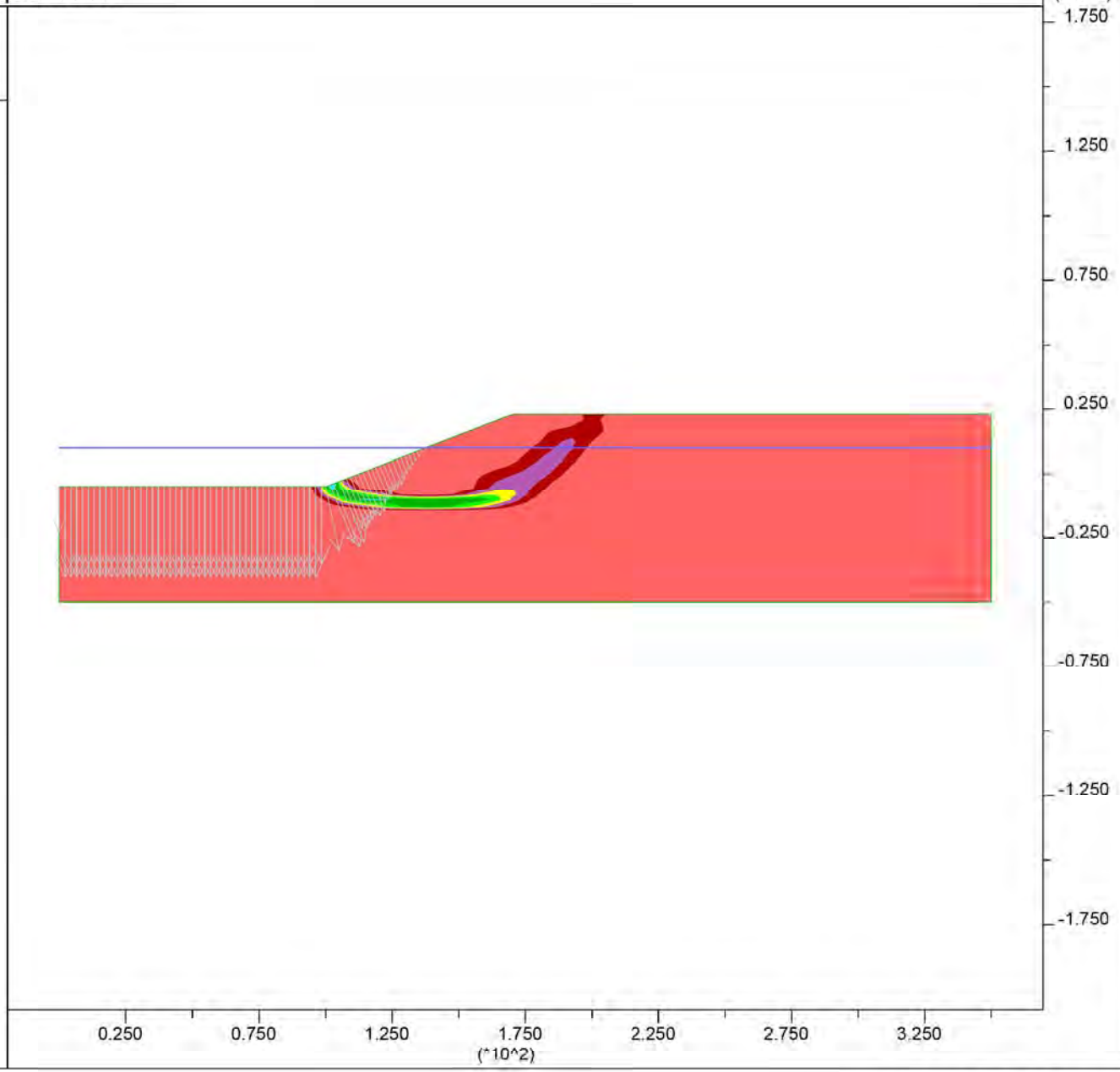


PLATE G-136

JOB TITLE : Section L-L' - Post Liquefaction - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 15:03

Factor of Safety 1.40

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand 2'
- 'User:Liq Sand'
- 'User:Med Sand'
- 'User:Soft Clay'
- User:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.050E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

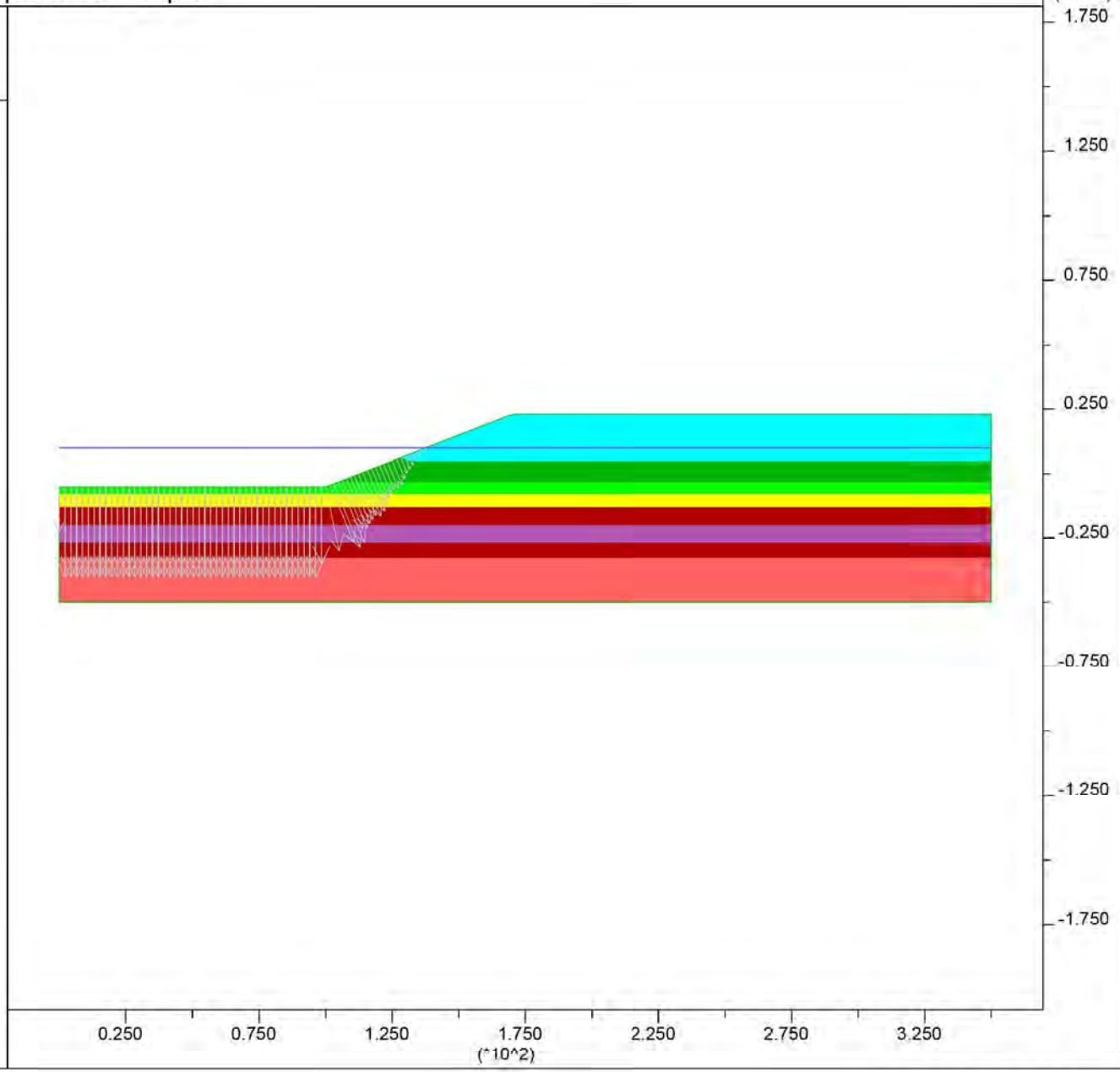


PLATE G-137

JOB TITLE : Section L-L' - Ky=0.08

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 14:53

Factor of Safety 0.99

Shear Strain Rate Contours

- 1.00E-07
- 2.00E-07
- 3.00E-07
- 4.00E-07
- 5.00E-07
- 6.00E-07
- 7.00E-07

Contour interval= 1.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Net Applied Forces

max vector = 2.056E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

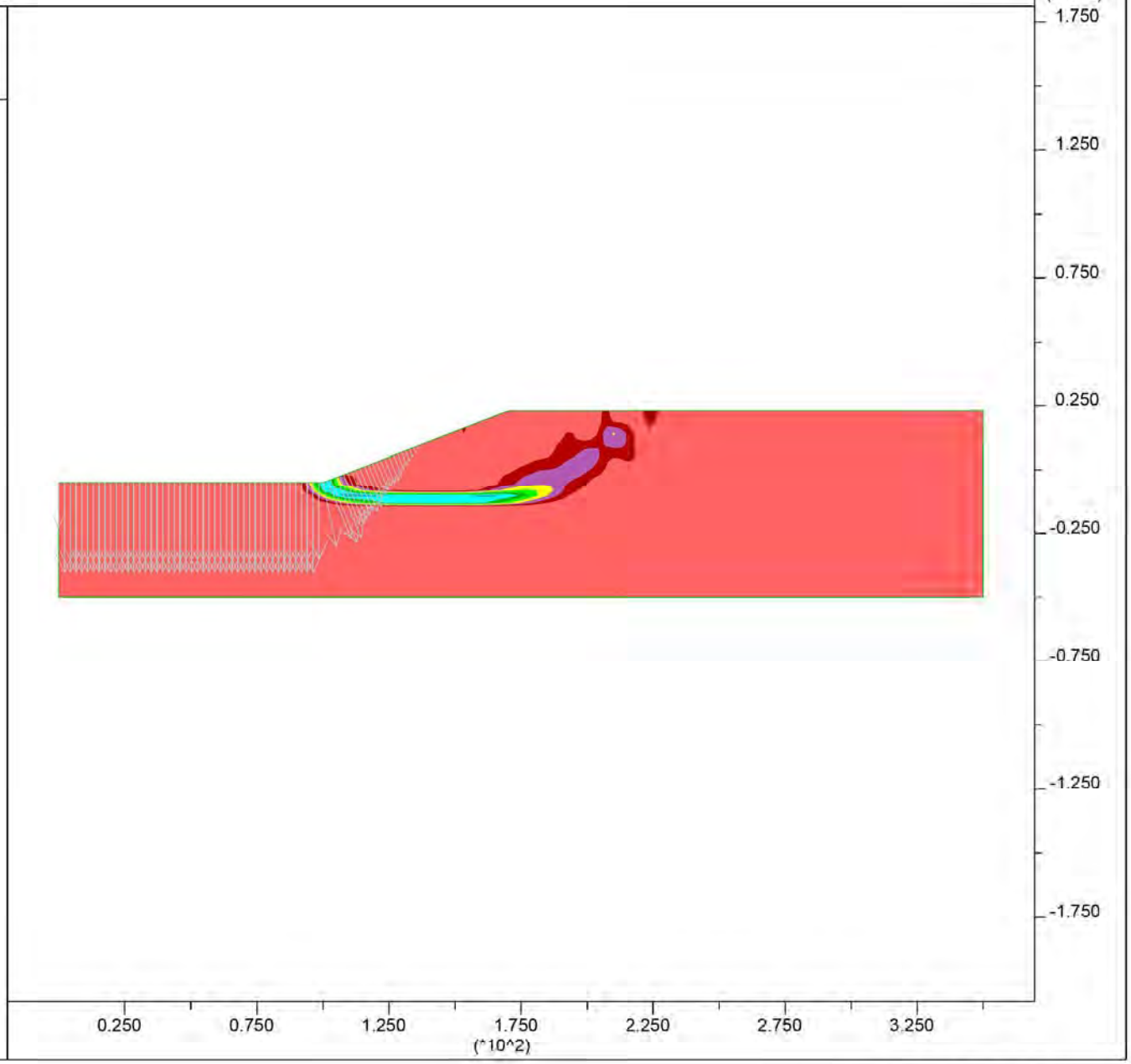


PLATE G-138

JOB TITLE : Section L-L' - Ky=0.08 - Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Feb-13 15:05

Factor of Safety 0.99

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Liq Sand 2'
- 'User:Liq Sand'
- 'User:Med Sand'
- 'User:Soft Clay'
- User:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 2.056E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

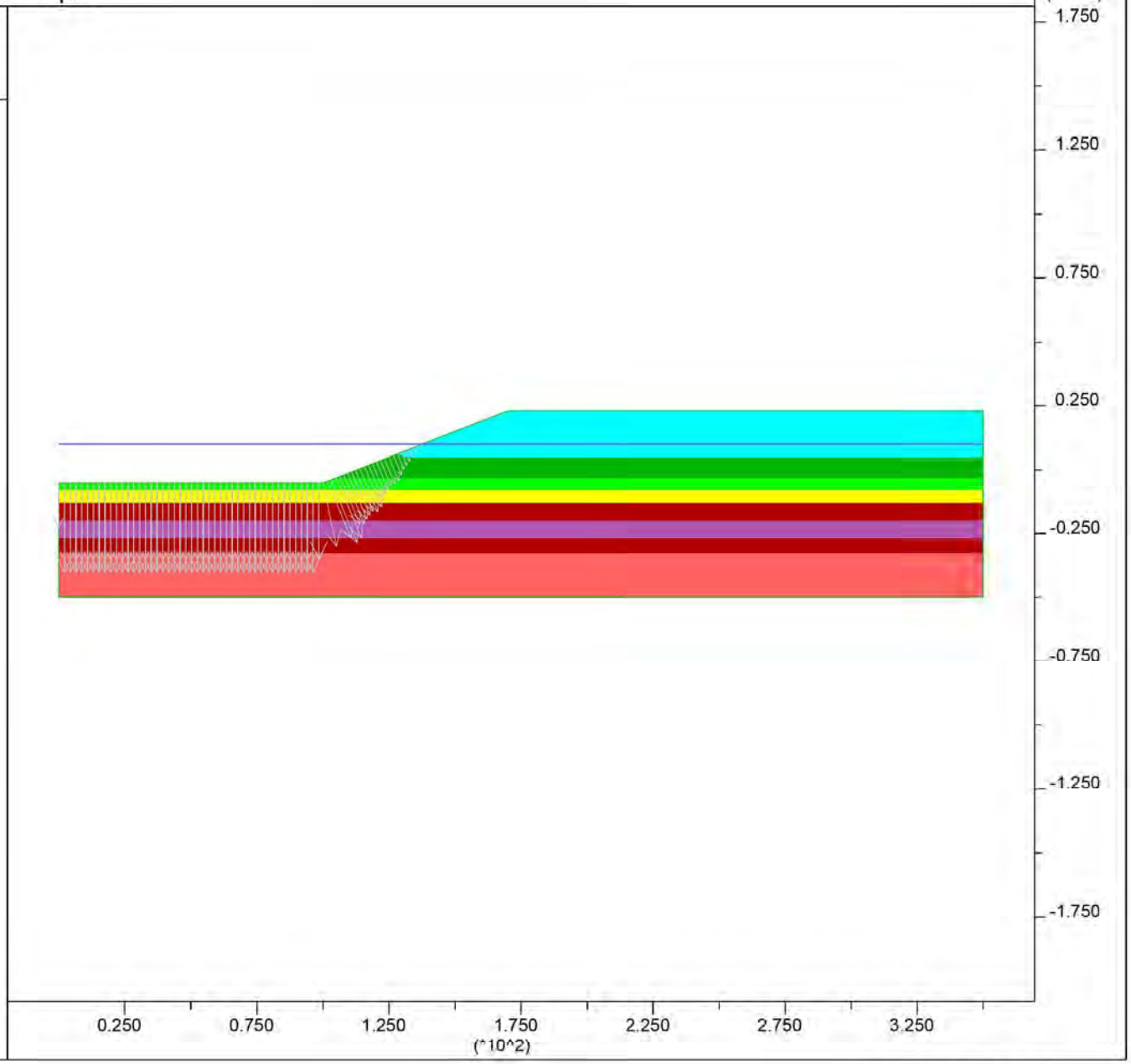


PLATE G-139

Newmark Displacements using Bray and Rathje (1998):

Section L-L'

Site Input

PGA,rock =	0.25	g	
M =	6.6		
r =	13	km	
ky =	0.08		
Sliding Mass Input			
Vs =	200	m/s	assumed
Thickness, H =	10.1	m	
	33	ft	

Output

Tm =	0.49	sec				
D5-95 =	10.5	sec				
Ts =	0.20	sec				
NRF =	1.15					
Ts/Tm =	0.41					
kmax/(PGA,rock*NRF)	1.07					
kmax =	0.31					
ky / kmax =	0.26					
Displacement, u =	30	cm	1.0	feet	11.7	inches

PLATE G-140

JOB TITLE : Existing North Levee during Meander Channel Excavation - 60 foot berm

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:09

Factor of Safety 1.46

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06
- 1.50E-06
- 1.75E-06
- 2.00E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.666E+03

0 9E 3

Group Delta Consultants
Ballona Wetlands

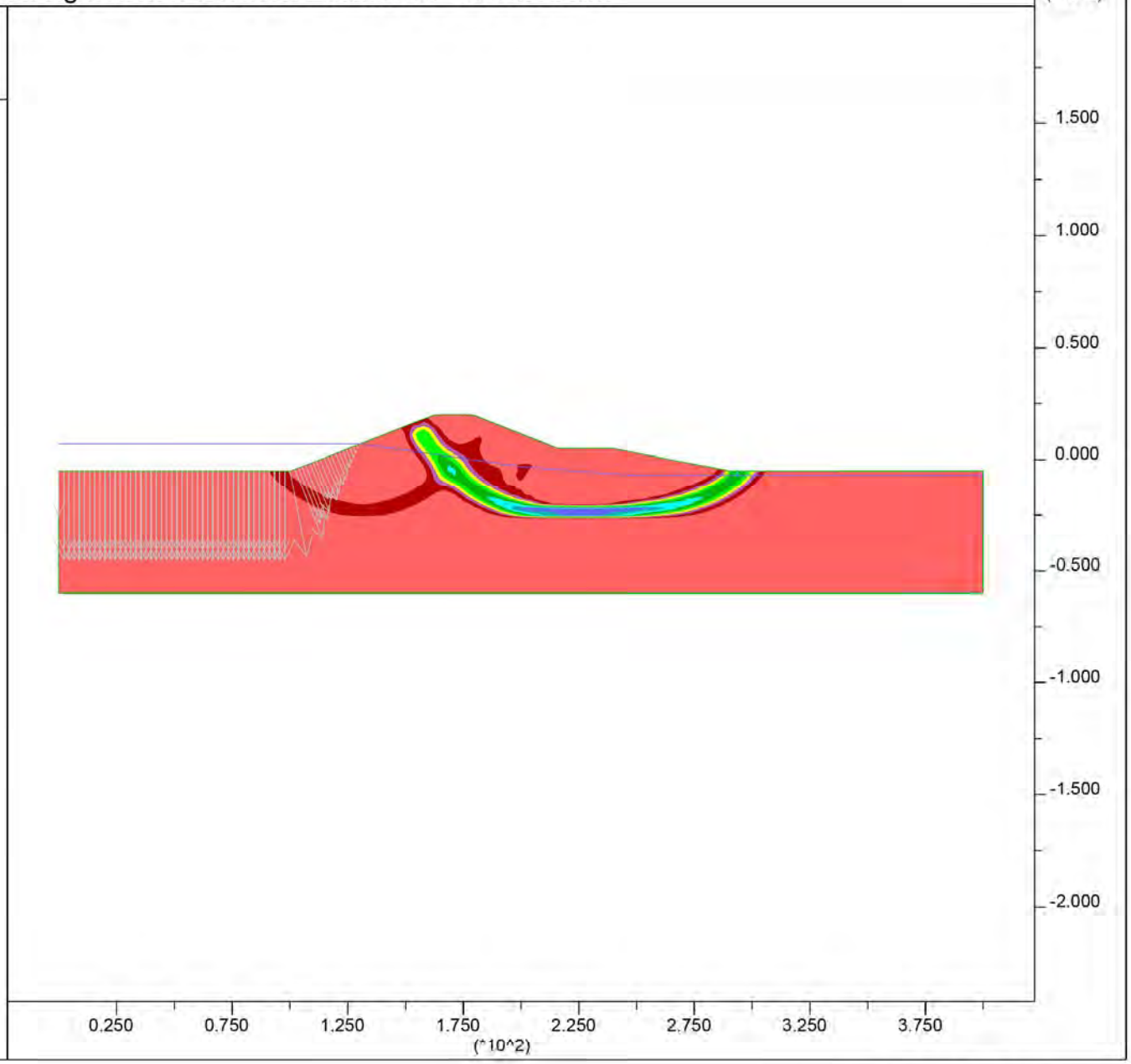


PLATE G-141

JOB TITLE : Existing North Levee during Meander Channel Excavation - 60 foot berm - Inp

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:10

Factor of Safety 1.46

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- Fill:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.666E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

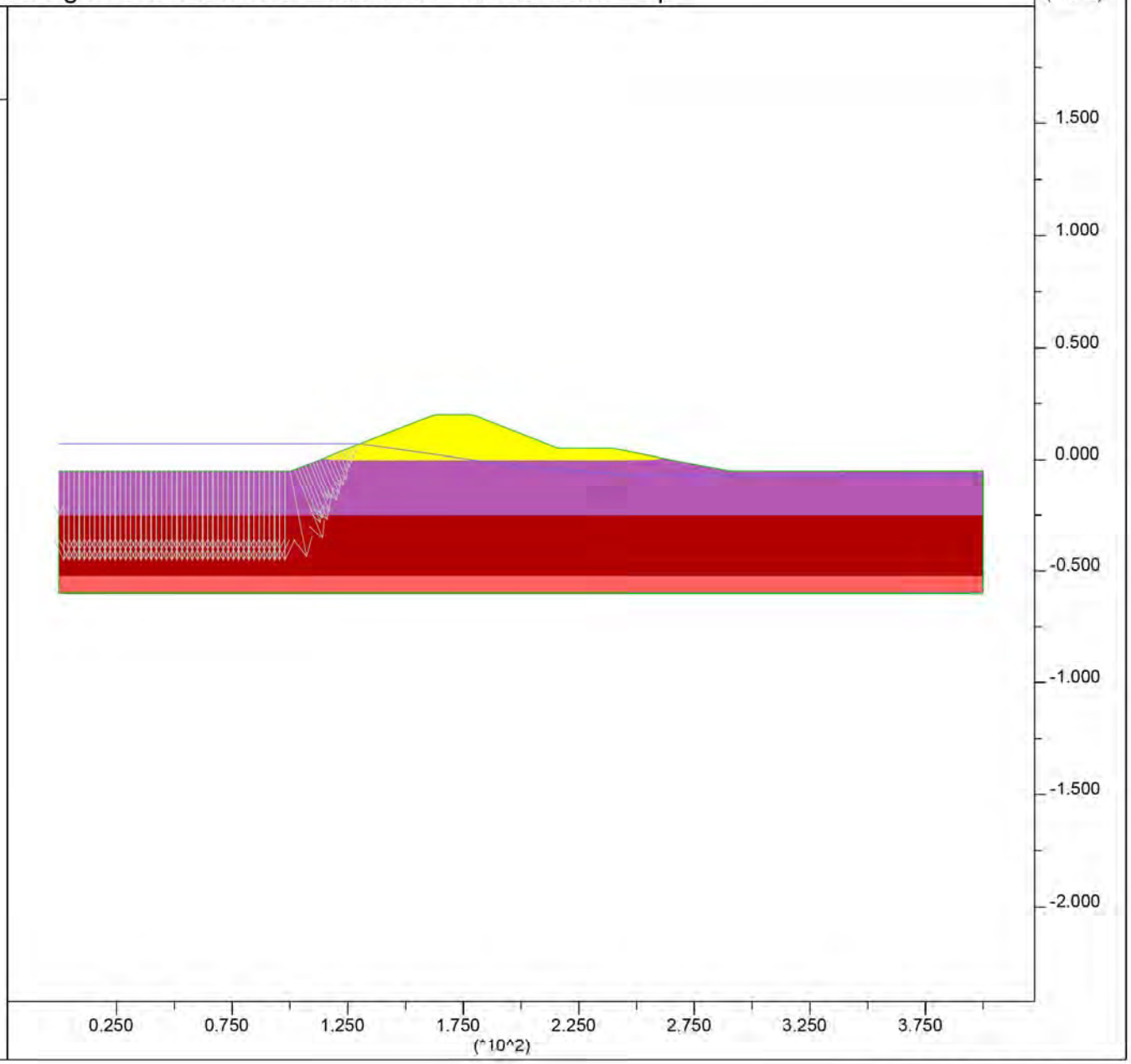


PLATE G-142

JOB TITLE : Existing North Levee during Meander Channel Excavation - 70 foot berm

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:09

Factor of Safety 1.51

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.874E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

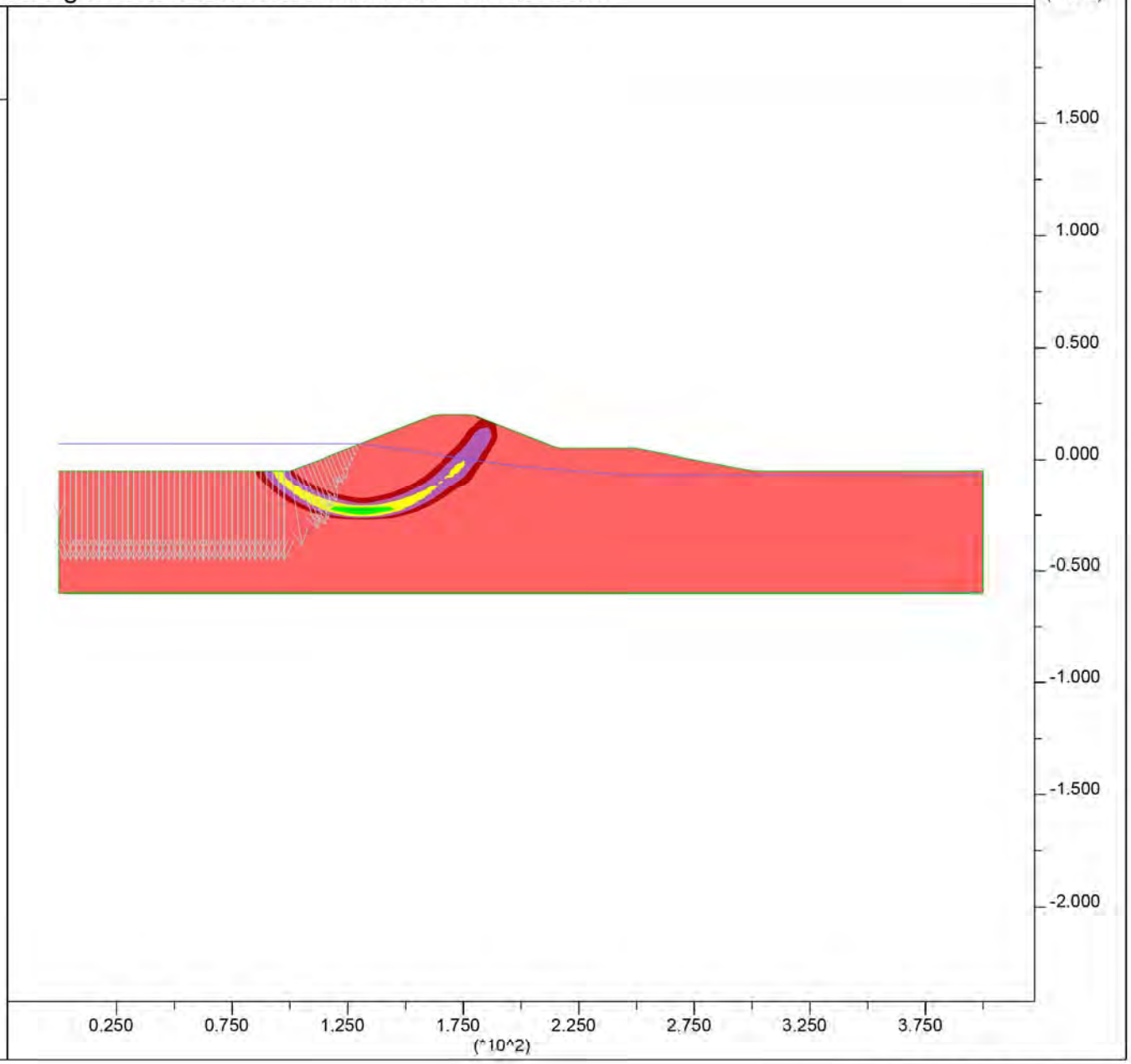


PLATE G-143

JOB TITLE : Existing North Levee during Meander Channel Excavation - 70 foot berm - Inp

FLAC/SLOPE (Version 7.00)

LEGEND

5-Mar-13 14:08

Factor of Safety 1.51

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'User:Soft Clay'
- Fill:Fill

Boundary plot

0 1E 2

Water Table

Net Applied Forces

max vector = 1.874E+03

0 5E 3

Group Delta Consultants
Ballona Wetlands

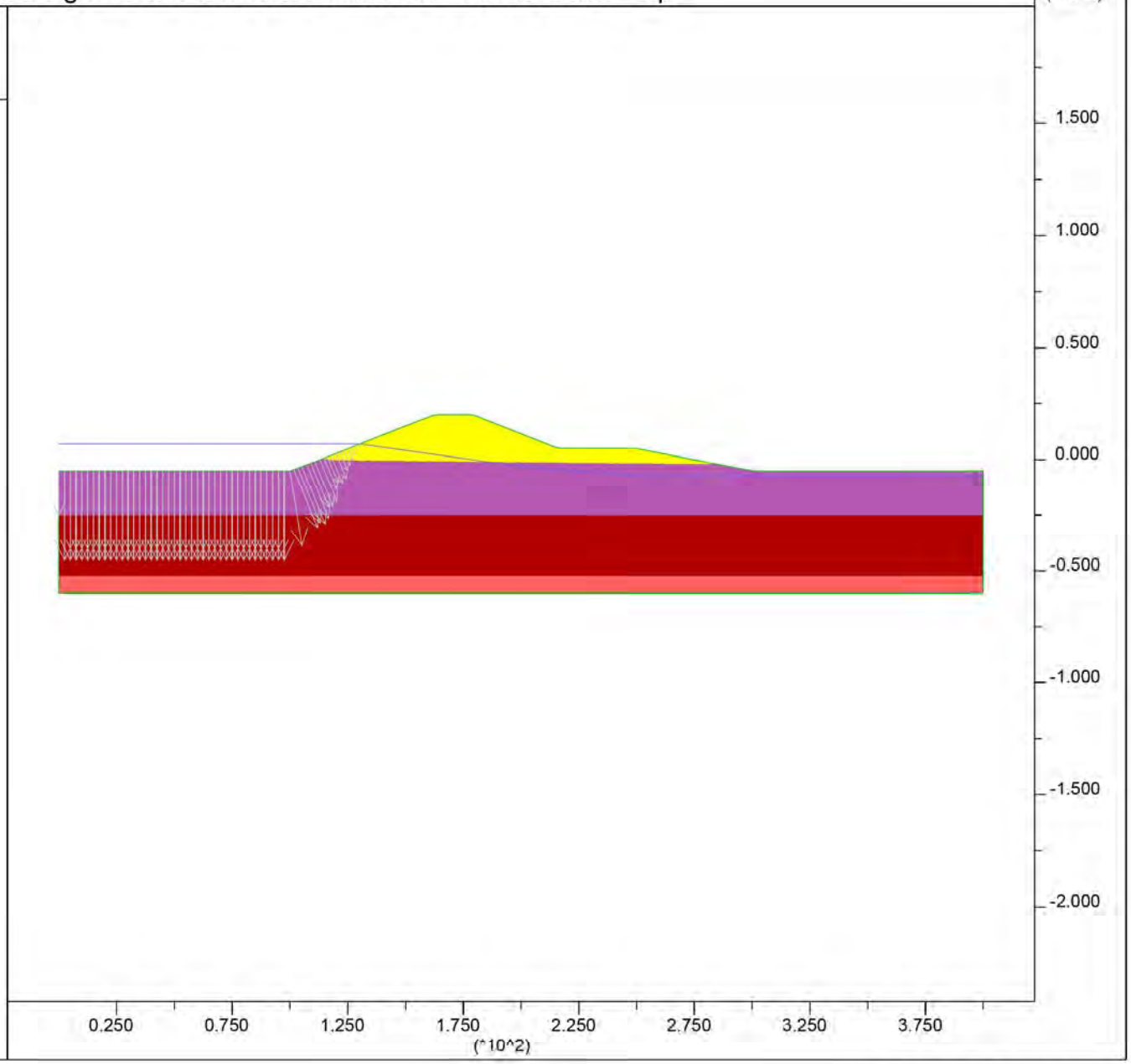
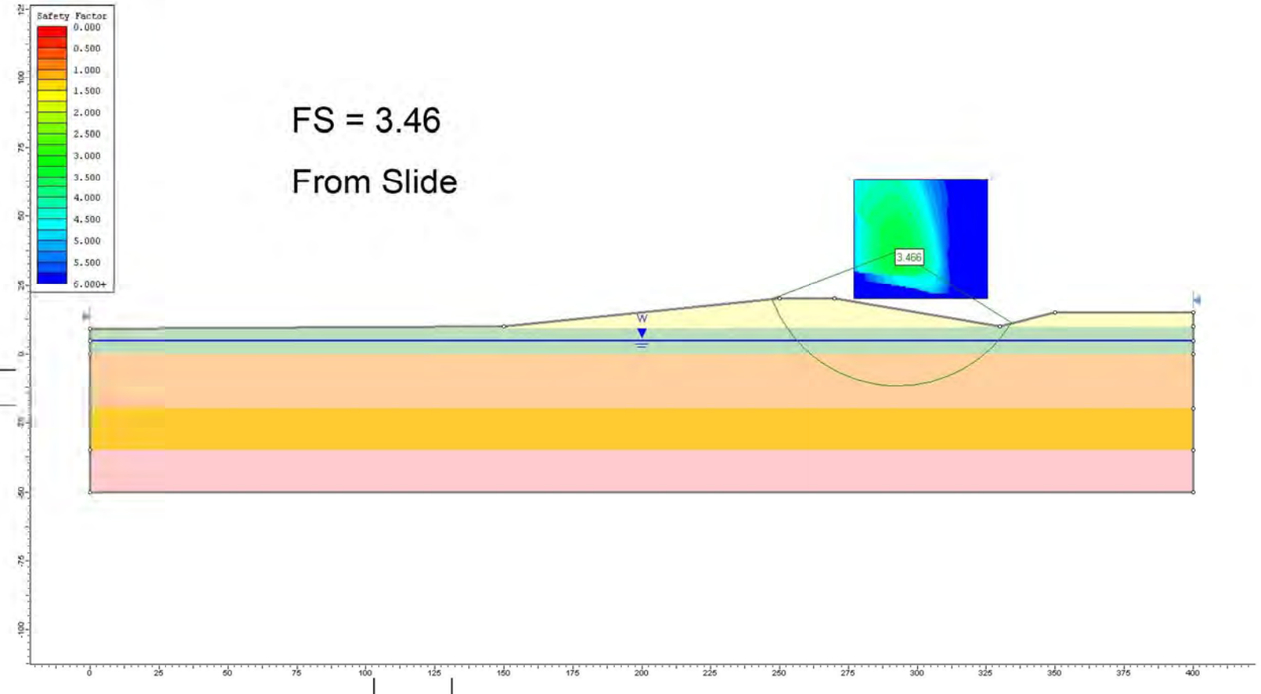


PLATE G-144

Section A-A' – End of Construction



FS = 3.46

From Slide

JOB TITLE : Section A-A' - End of Construction

FLAC/SLOPE (Version 7.00)

LEGEND

26-Feb-13 11:07

Factor of Safety 3.39

Shear Strain Rate Contours

- 5.00E-08
- 1.00E-07
- 1.50E-07
- 2.00E-07
- 2.50E-07
- 3.00E-07
- 3.50E-07
- 4.00E-07
- 4.50E-07

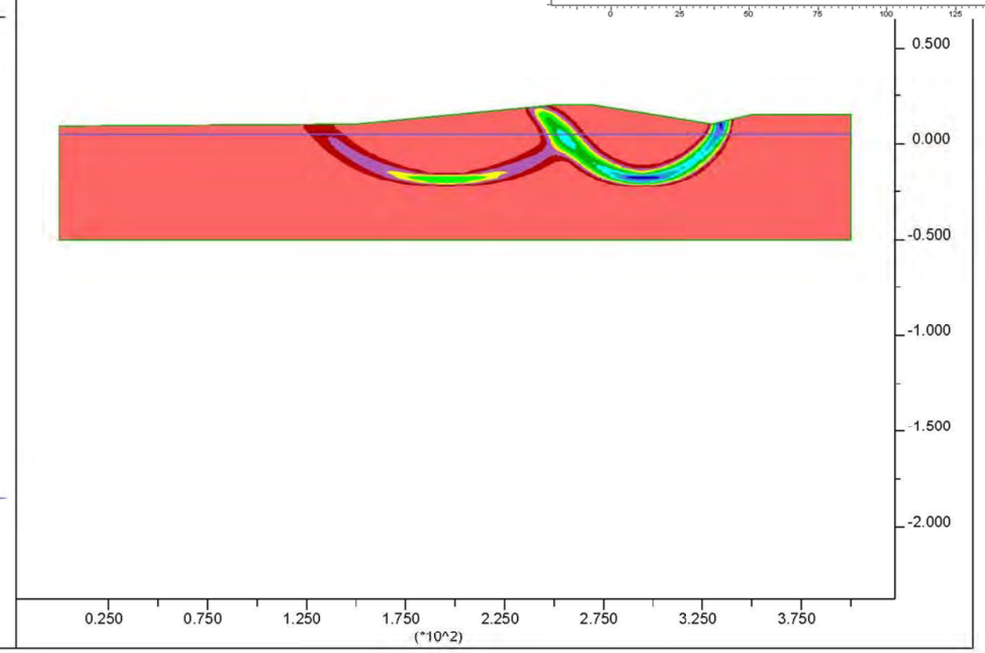
Contour interval= 5.00E-08
(zero contour omitted)
Boundary plot

0 1E 2

Water Table

Group Delta Consultants
Ballona Wetlands

FS = 3.39
From FLAC SLOPE

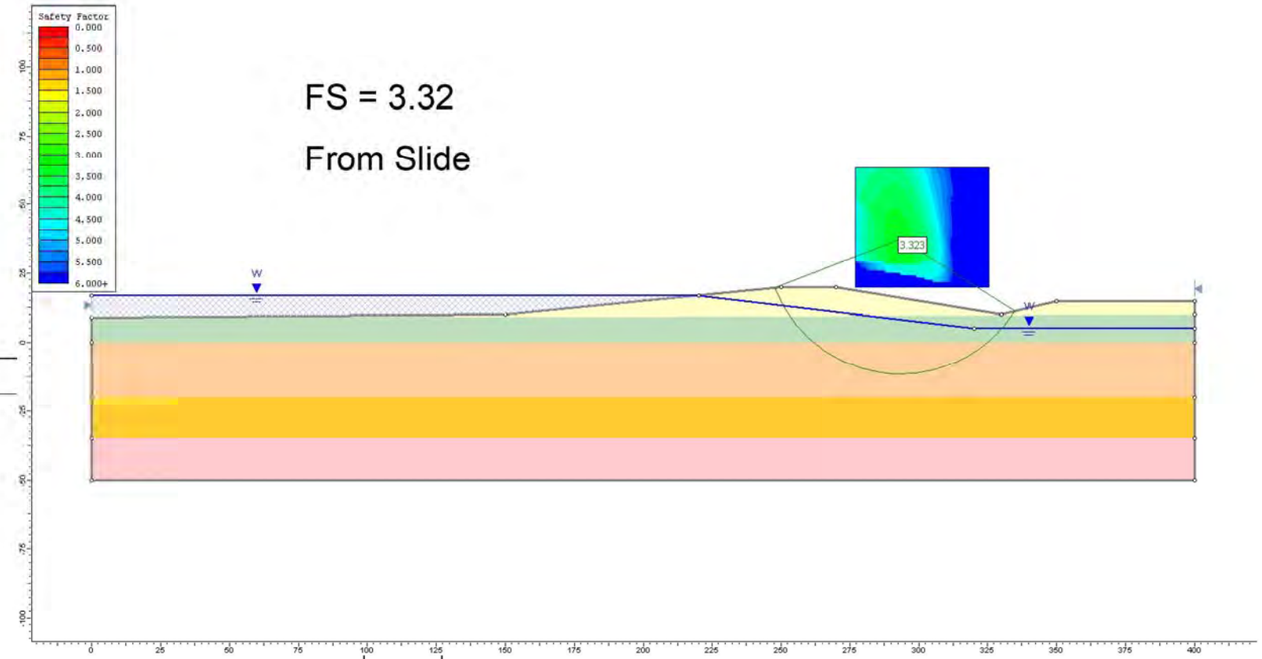


Percent Difference = 2.2%

Comparison of FLAC SLOPE and RocScience Slide Results

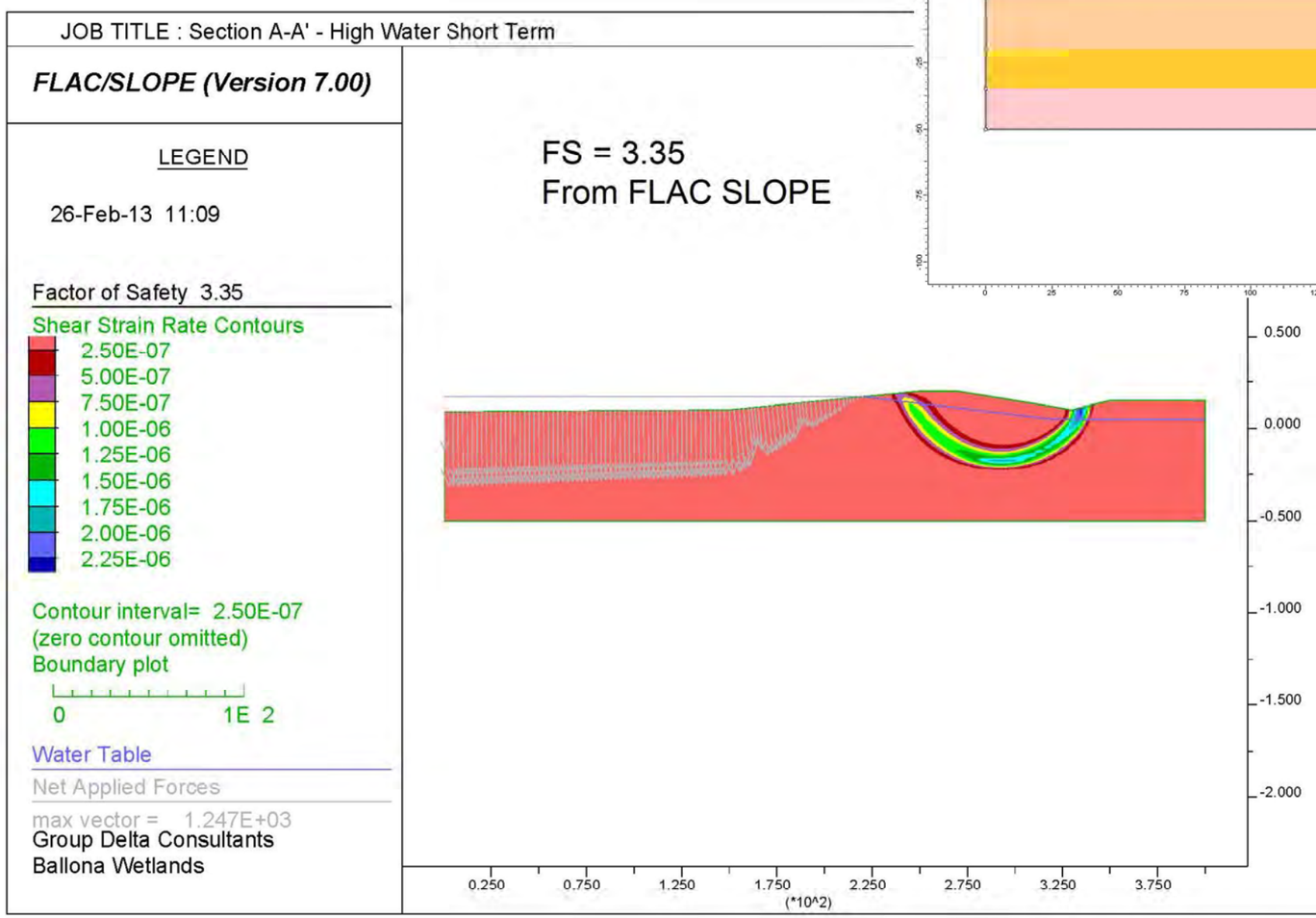
PLATE G-145

Section A-A' – High Water Short Term



FS = 3.32

From Slide



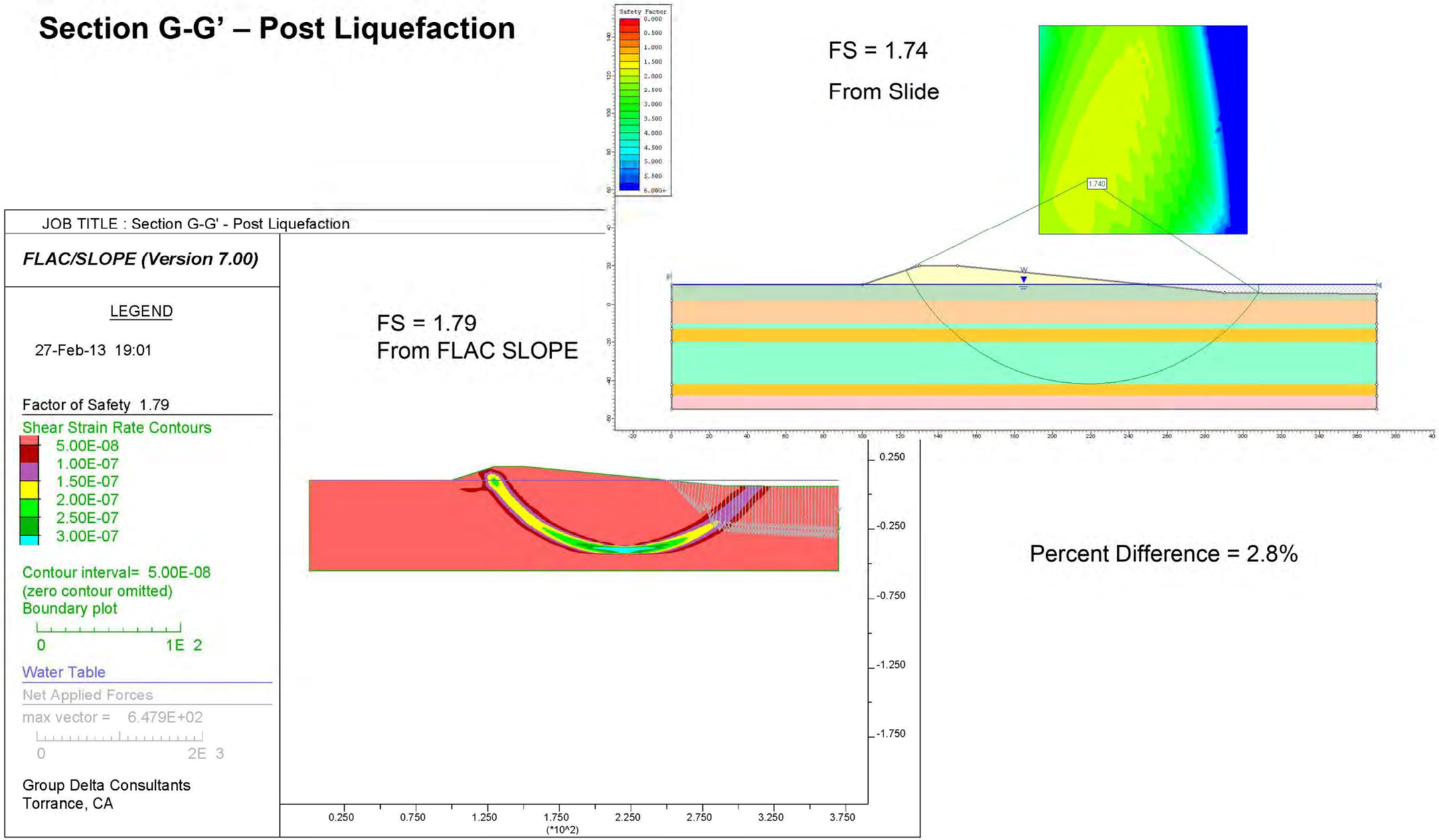
FS = 3.35
From FLAC SLOPE

Percent Difference = 0.9%

Comparison of FLAC SLOPE and RocScience Slide Results

PLATE G-146

Section G-G' – Post Liquefaction



Percent Difference = 2.8%

Comparison of FLAC SLOPE and RocScience Slide Results

PLATE G-147

JOB TITLE : Section E ky =0.06 - Groundwater at El +7, Channel Water at Low Tide El. 0

FLAC/SLOPE (Version 7.00)

LEGEND

27-Mar-13 15:13

Factor of Safety 0.97

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06
- 4.00E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 8.604E+02

Group Delta Consultants
Ballona Wetlands

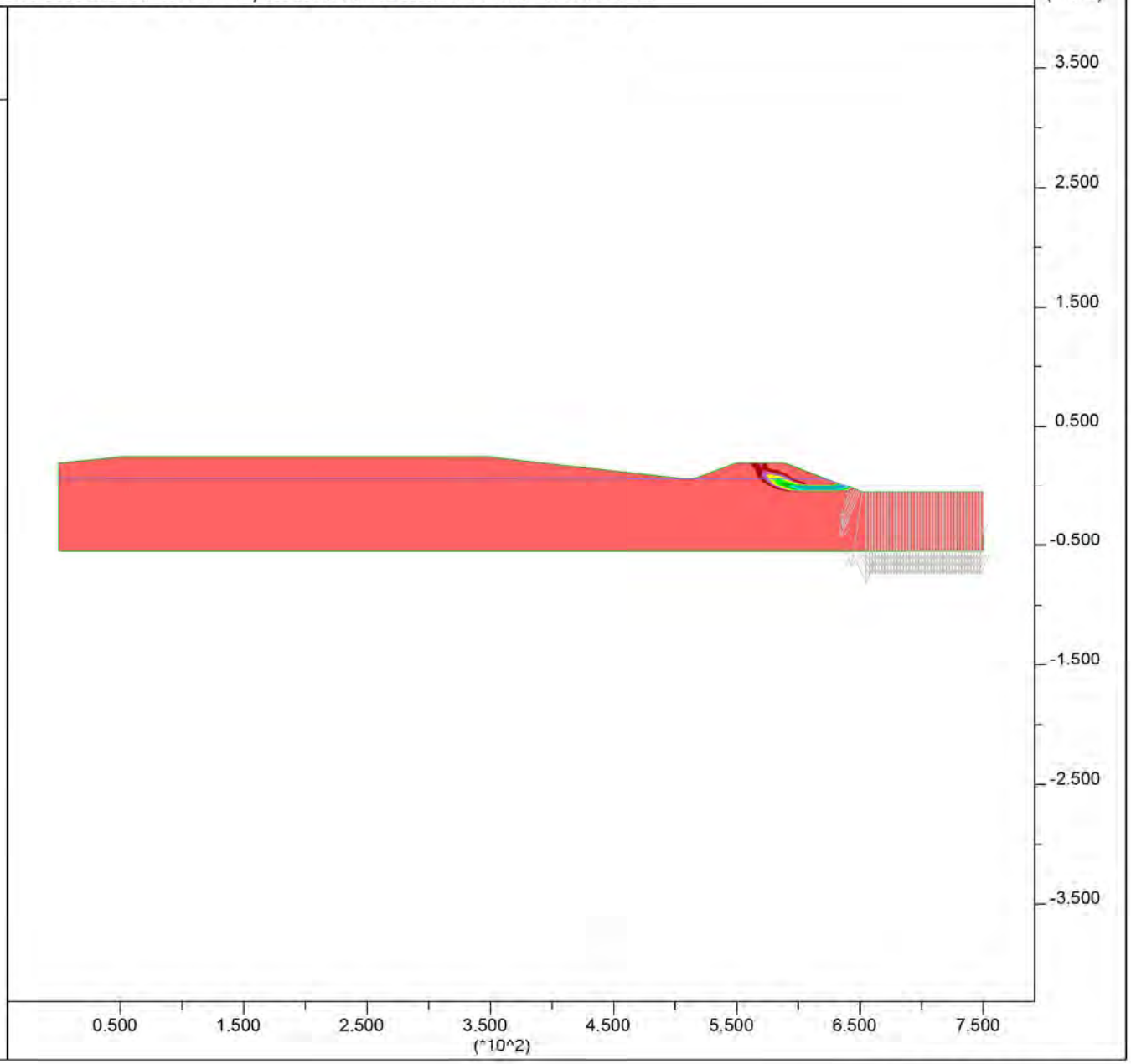


PLATE G-148

JOB TITLE : Section E ky =0.06 - GW at El +7, Channel Water at Low Tide El. 0 _ Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Mar-13 15:13

Factor of Safety 0.97

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'Fill:Liq Sand 2'
- 'User:Soft Clay'
- 'Fill:Liq Fill'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 8.604E+02

0 2E 3

Group Delta Consultants
Ballona Wetlands

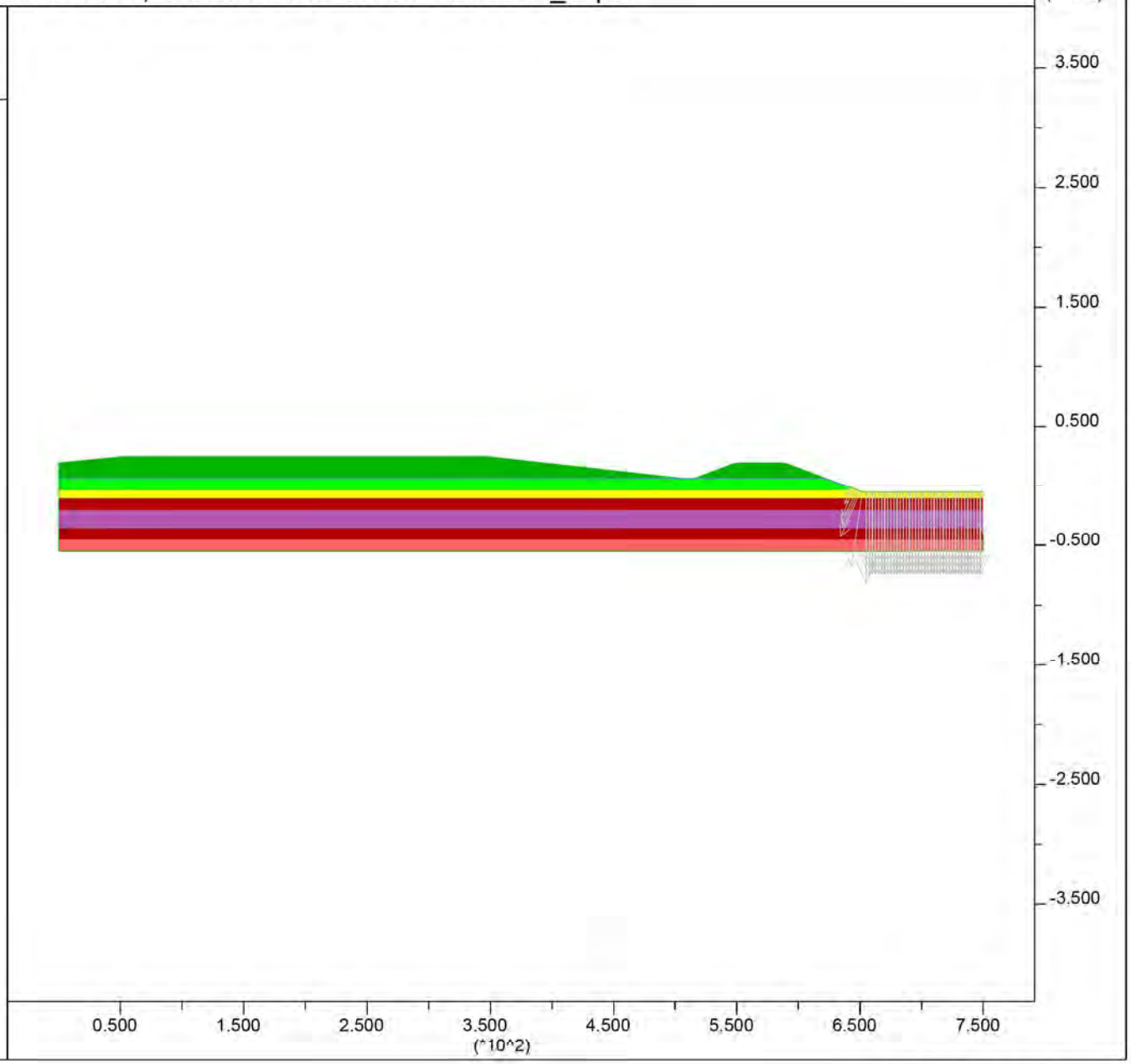


PLATE G-149

JOB TITLE : Section E ky =0.08 - Groundwater at El +3, Channel Water at Avg tide El +3

FLAC/SLOPE (Version 7.00)

LEGEND

27-Mar-13 15:19

Factor of Safety 0.99

Shear Strain Rate Contours

- 5.00E-07
- 1.00E-06
- 1.50E-06
- 2.00E-06
- 2.50E-06
- 3.00E-06
- 3.50E-06
- 4.00E-06

Contour interval= 5.00E-07
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 1.379E+03

Group Delta Consultants
Ballona Wetlands

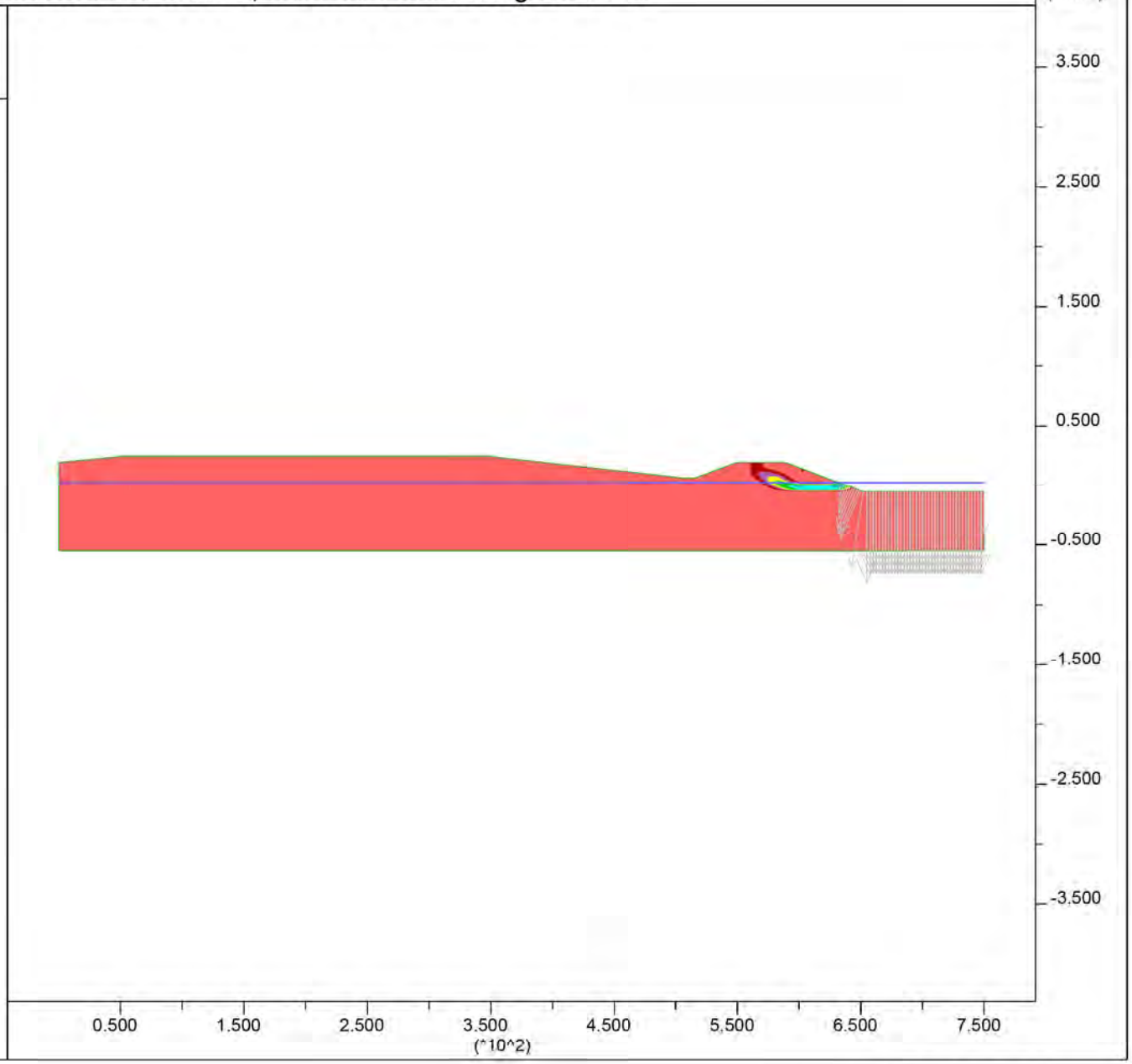


PLATE G-150

JOB TITLE : Section E ky =0.08 - GW at El +3, Channel Water at Avg tide El +3 _ Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Mar-13 15:17

Factor of Safety 0.99

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'Fill:Liq Sand 2'
- 'User:Soft Clay'
- 'Fill:Liq Fill'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 1.379E+03

0 2E 3

Group Delta Consultants
Ballona Wetlands

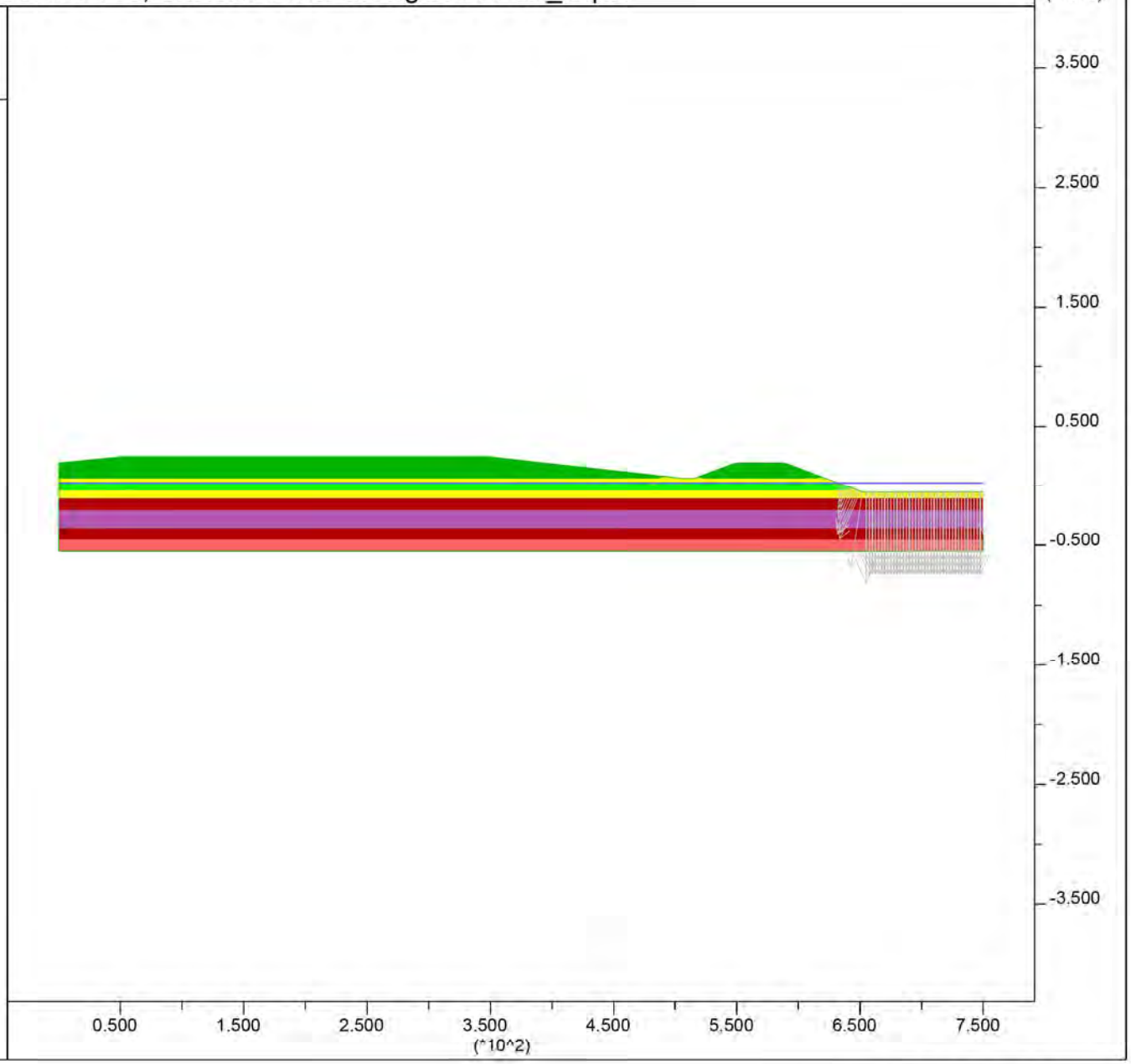


PLATE G-151

JOB TITLE : Section E ky =0.07 - Groundwater at El +3, Channel Water at Low Tide El. 0

FLAC/SLOPE (Version 7.00)

LEGEND

27-Mar-13 15:14

Factor of Safety 1.01

Shear Strain Rate Contours

- 2.50E-07
- 5.00E-07
- 7.50E-07
- 1.00E-06
- 1.25E-06

Contour interval= 2.50E-07
(zero contour omitted)
Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 8.610E+02

0 2E 3

Group Delta Consultants
Ballona Wetlands

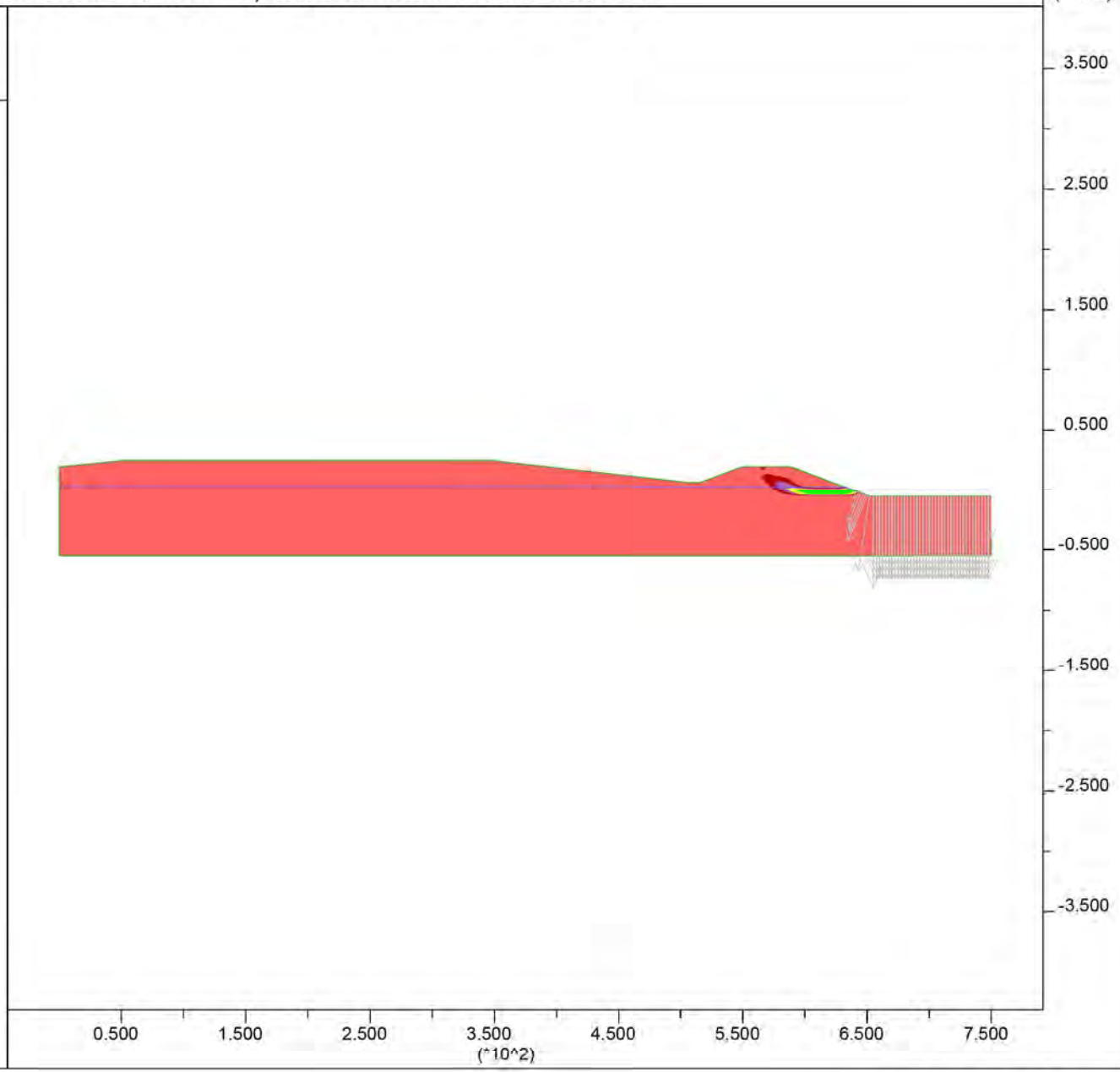


PLATE G-152

JOB TITLE : Section E ky =0.07 - GW at El +3, Channel Water at Low Tide El. 0 _ Input

FLAC/SLOPE (Version 7.00)

LEGEND

27-Mar-13 15:15

Factor of Safety 1.01

User-defined Groups

- User:Sand
- 'User:Stiff Clay'
- 'Fill:Liq Sand 2'
- 'User:Soft Clay'
- 'Fill:Liq Fill'
- User:Embankment

Boundary plot

0 2E 2

Water Table

Net Applied Forces

max vector = 8.610E+02

0 2E 3

Group Delta Consultants
Ballona Wetlands

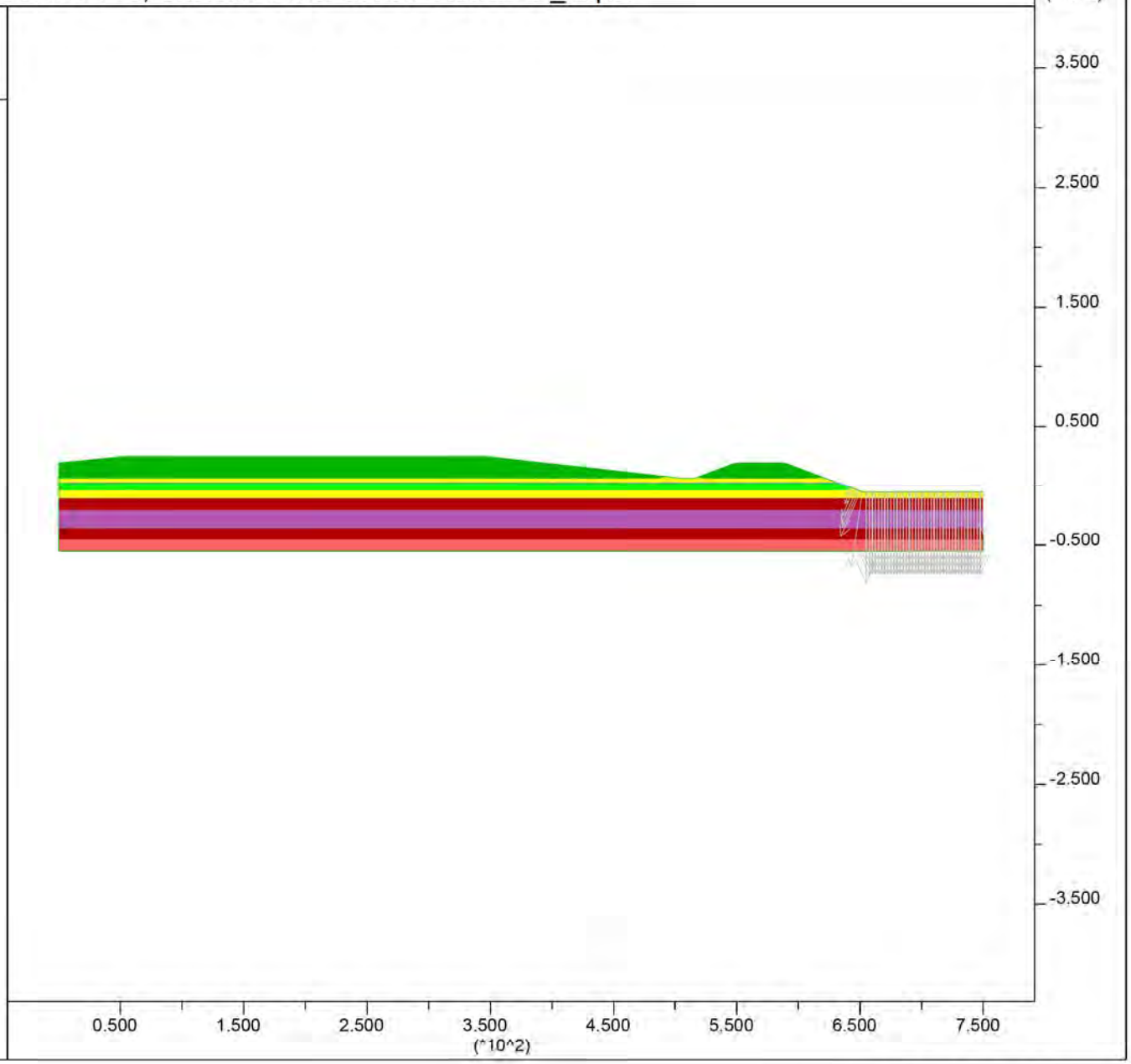


PLATE G-153

APPENDIX H
SETTLEMENT

APPENDIX H
SETTLEMENT

H.1 Summary of Contents

This appendix includes the following:

- Cc / (1+e_o) data in Areas A, B, and C, and OCR data within Areas A and B
- Settlements at different locations along different sections of levees
- Settlement bowl beyond dry side toe of levees/embankments
- Examples showing stresses below different portions of levees
- Settlements along different locations below Section I-I' of West Area B levees
- Spreadsheets showing maximum settlement for different Sections of levees
- Consolidation Curves showing P_P and OCR Determination
- Examples of Settlement Monitoring Results at the Adjacent Playa Vista

H.2 Determination of Cc / (1+e_o) and OCR for Settlement Analysis

Plots included in Plates H-1 to H-5 show the values determined from consolidation data for Cc / (1+e_o) in Areas A, B, and C, and OCR in Areas A, and B plotted versus depth. Cc / (1+e_o) is particularly important for settlement analyses at this site, since the clayey soils deeper than about 10 feet are essentially normally consolidated. For this reason, the Cc / (1+e_o) values are companioned with values inferred from correlations with soil moisture content developed from our experience at Playa Vista, as well as a well-known correlation based on the Terzaghi and Peck (1967) relationship. Adopted values for Cc / (1+e_o) and OCR at different depths are also shown for different areas. The adopted OCR values for Area A were also used for Area C. Consolidation test results showing P_P and OCR determination are included in Plates H-26 to H-45.

H.3 Settlements at Different Locations along Sections of Levee

Settlements were determined for different levees sections by estimating the increase in vertical stresses under the embankment at different locations along sections of the levee. Examples of calculation of stresses at different locations below the embankment are included in Plates H-8 and H-9. The stresses were then used to estimate settlement at different locations under the embankments. Estimated settlements at different locations under embankment for section I-I' are exemplified in Plates H-10 through H-18. Maximum estimated settlements are shown for the sections that were analyzed on H-19 through H-25. A summary of settlements at different locations along different sections of the levees that were analyzed is presented on Plate H-6.

H.4 Settlement away from Protected Side Toe of Levees or Embankments

To minimize the settlement impact to utility lines and adjacent structures, the levees/embankments should be offset a minimum distance from roads, utilities, and other essential facilities. Therefore, estimations of settlements were made for

different sections along the levees/embankments at distances of 0, 10, 30, and 50 feet away from the protected side toe, for the sections that were analyzed. The settlement bowl away from the protected side toe is presented graphically on Plate H-7. Impact of settlements to utilities perpendicular to the levee alignment are minimal where the slope of change in settlement over length becomes less than 1/480. This slope is also shown on Plate H-7.

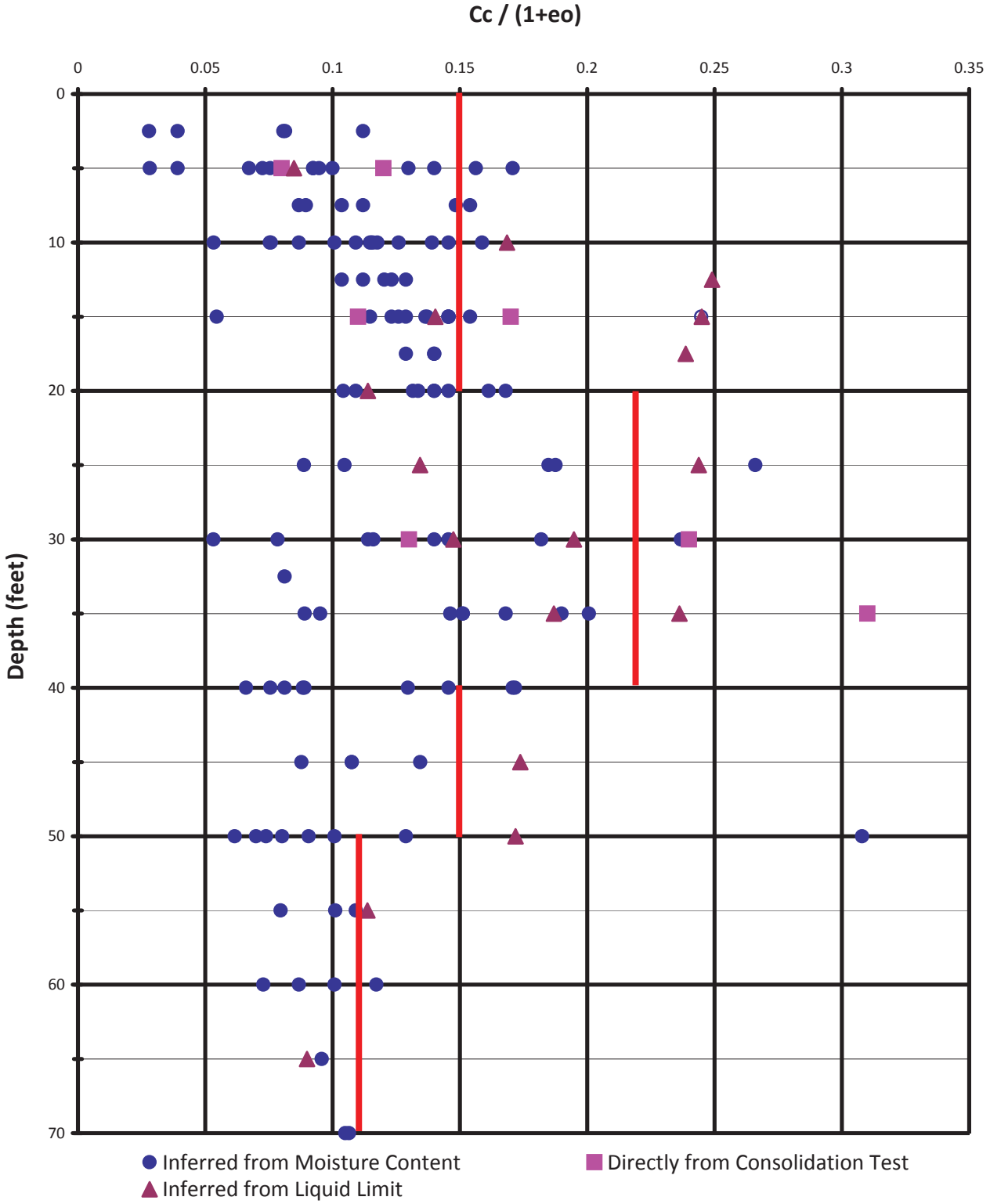
H.5 Rate of Settlement at the Adjacent Playa Vista Development

Examples of settlement monitoring results from our experience at the adjacent Playa Vista Development are included in this appendix. The normalized results (Plate H-47) suggest that 90% consolidation at Lots 1-6 of Area D2 within Playa Vista (located just south of Jefferson Blvd. and about 3,000 feet east of Lincoln Blvd.) occurred within about 100 to 150 days after placement of the full surcharge. Similar time rates of settlements are anticipated at the Ballona Wetlands Restoration Project.

A list of the plates presented in this appendix follows:

Plate H-1 and H-5	$Cc / (1+e_o)$ and OCR Plots showing Consolidation Data, Correlations, and Adopted Values
Plate H-6	Settlements at Different Locations along Different Sections of Levees and Embankments
Plate H-7	Settlement away from Protected Side Toe of Levees or Embankments
Plate H-8 and H-9	Examples of Stresses under the Embankments
Plate H-10 thru H-18	Settlement Spreadsheet Showing Settlement along Different Locations along Section I-I'
Plates H-19 thru H-25	Maximum Levee/Embankment Settlements
Plates H-26 thru H-45	Consolidation Results showing P_P and OCR Estimations
Plates H-46 and H-47	Example of Settlement Monitoring Results at Playa Vista

Variation of Cc / (1+e_o) with Depth in Area A



Note: 1) Correlation based on Moisture Content is derived from experience at Playa Vista and Similar Soils:

$Cc / (1+eo) = Mc \times 0.0028 + 0.0112$

2) Correlation based on Liquid Limit is based on Terzaghi and Peck (1967):

$Cc / (1+eo) = 0.009 \times (LL - 10) / (1+eo)$

PLATE H-1

Variation of OCR with Depth in Area A

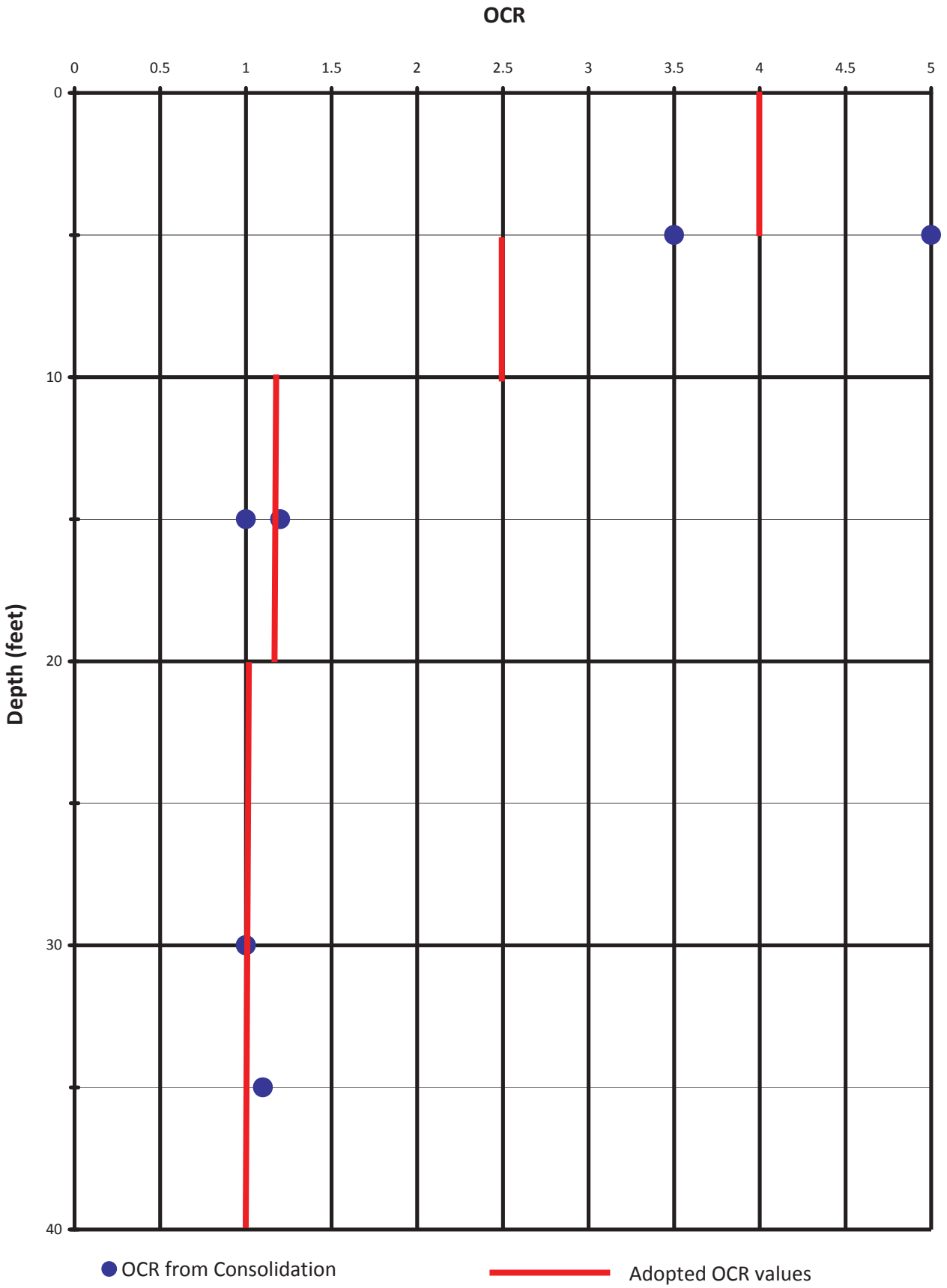
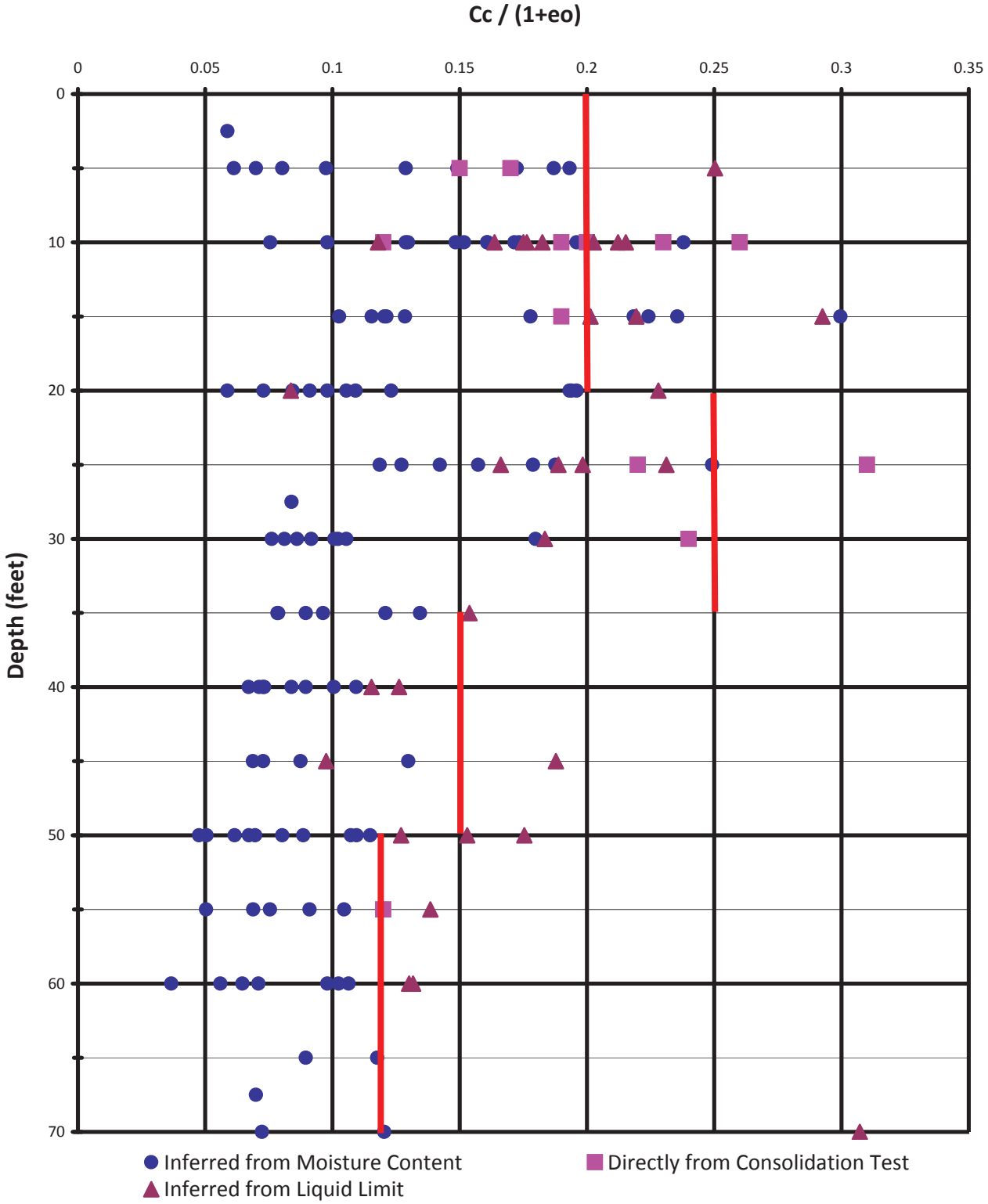


PLATE H-2

Variation of Cc / (1+e_o) with Depth in Area B



Note: 1) Correlation based on Moisture Content is derived from experience at Playa Vista and Similar Soils:

Cc / (1+eo) = Mc x 0.0028 + 0.0112

2) Correlation based on Liquid Limit is based on Terzaghi and Peck (1967):

Cc / (1+eo) = 0.009 x (LL - 10) / (1+eo)

Variation of OCR with Depth in Area B

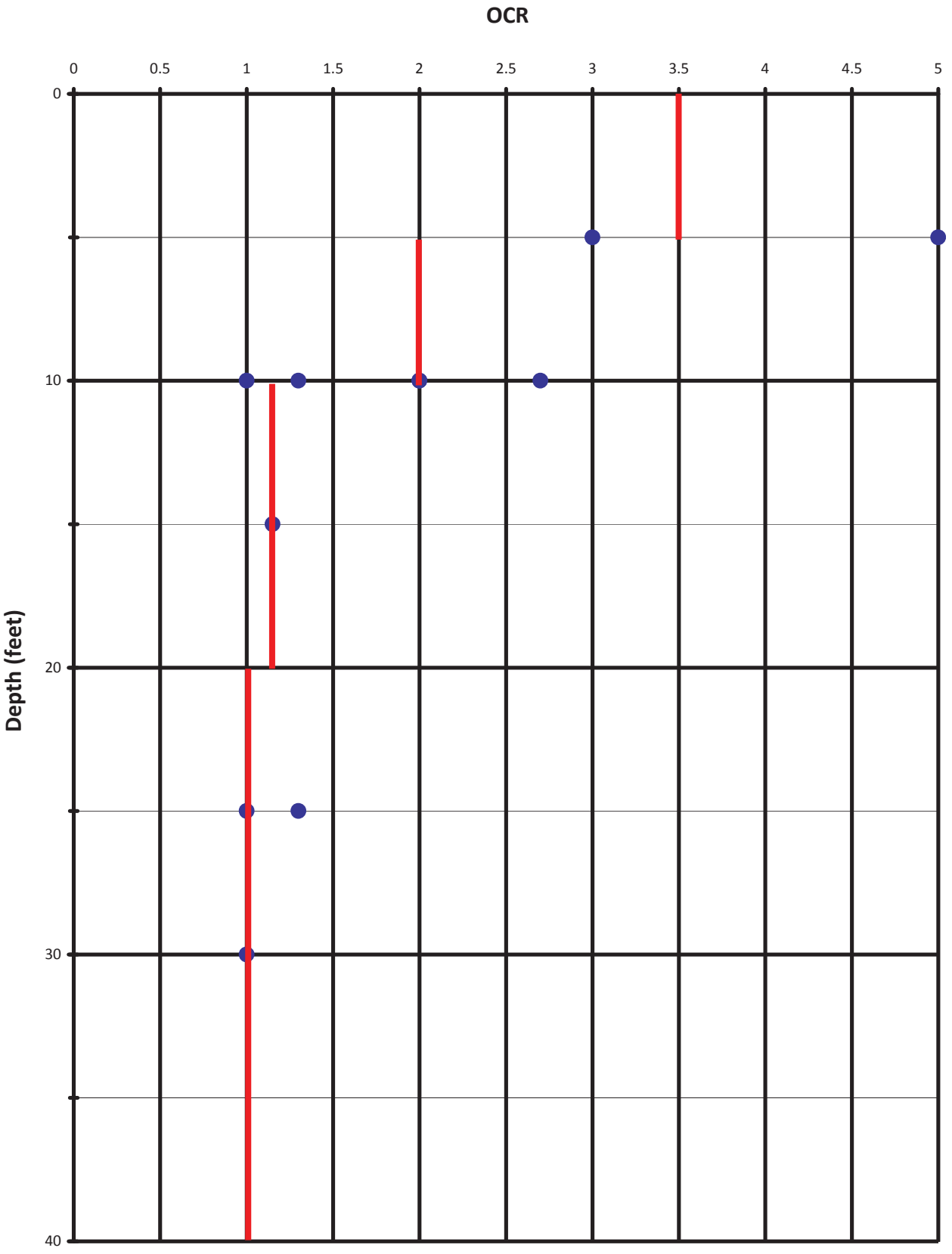
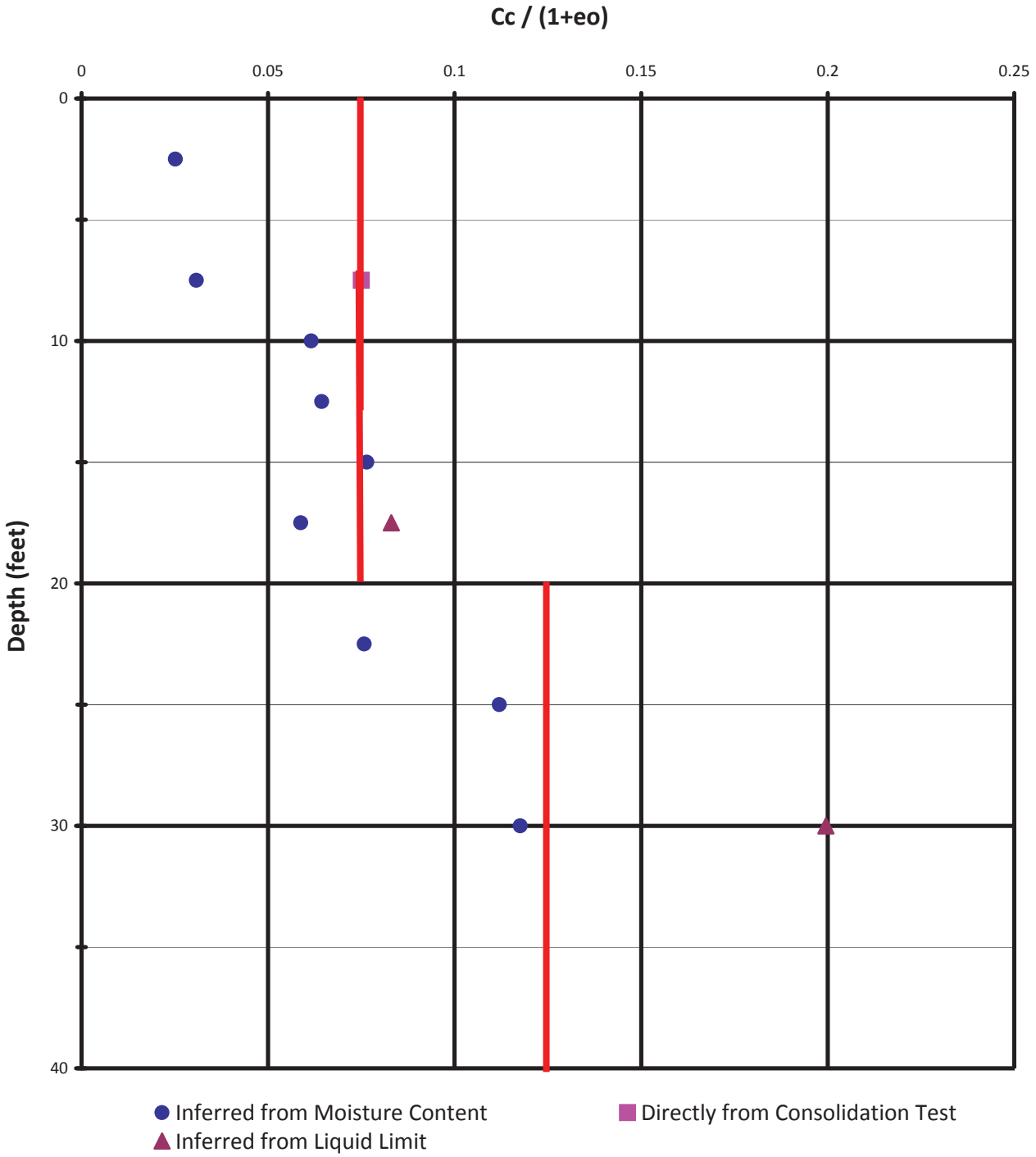


PLATE H-4

Variation of Cc / (1+e_o) with Depth in Area C



Note: 1) Correlation based on Moisture Content is derived from experience at Playa Vista and Similar Soils:

Cc / (1+eo) = Mc x 0.0028 + 0.0112

2) Correlation based on Liquid Limit is based on Terzaghi and Peck (1967):

Cc / (1+eo) = 0.009 x (LL - 10) / (1+eo)

PLATE H-5

Area	Section	Approximate Embankment Height (feet)	Settlement (inches)									Max Settlement per foot of Fill (inches)
			Wet Side Toe	1/3 Height of Wet Side Slope	2/3 Height of Wet Side Slope	Wet Side Edge of Crest	Center	Dry Side Edge of Crest	2/3 Height of Dry Side Slope	1/3 Height of Dry Side Slope	Dry Side Toe	
Area A	Section A-A'	10	2.1	7.8	14.3	19	19.1	18.4	13.9	8.2	3.1	1.9
Area B	Section B-B'	10	2.1	7.9	14.6	19.9	21.4	19	14.2	8.3	3.2	2.1
	Section C-C'	5	1	4.2	7.5	9.9	9.9	9.5	7.4	4.6	2.4	2.0
	Section F-F'	14	2.2	11.7	23.1	32	33.4	29	22	13	5.8	2.4
	Section H-H'	14	2.2	11.7	23.1	31.9	32.9	28.9	22	13	5.8	2.4
	Section I-I'	15	2.1	12.3	24.5	32.5	32.1	30.4	23.3	13.6	5.8	2.2
	Surcharge Area B	25	2.2	20.9	38.5	50.7	51.8	50.7	38.5	20.9	2.2	2.1
Area C	Surcharge Area C	30	1.5	13.8	24	30.8	31.6	30.8	24	13.8	1.5	1.1

PLATE H-6

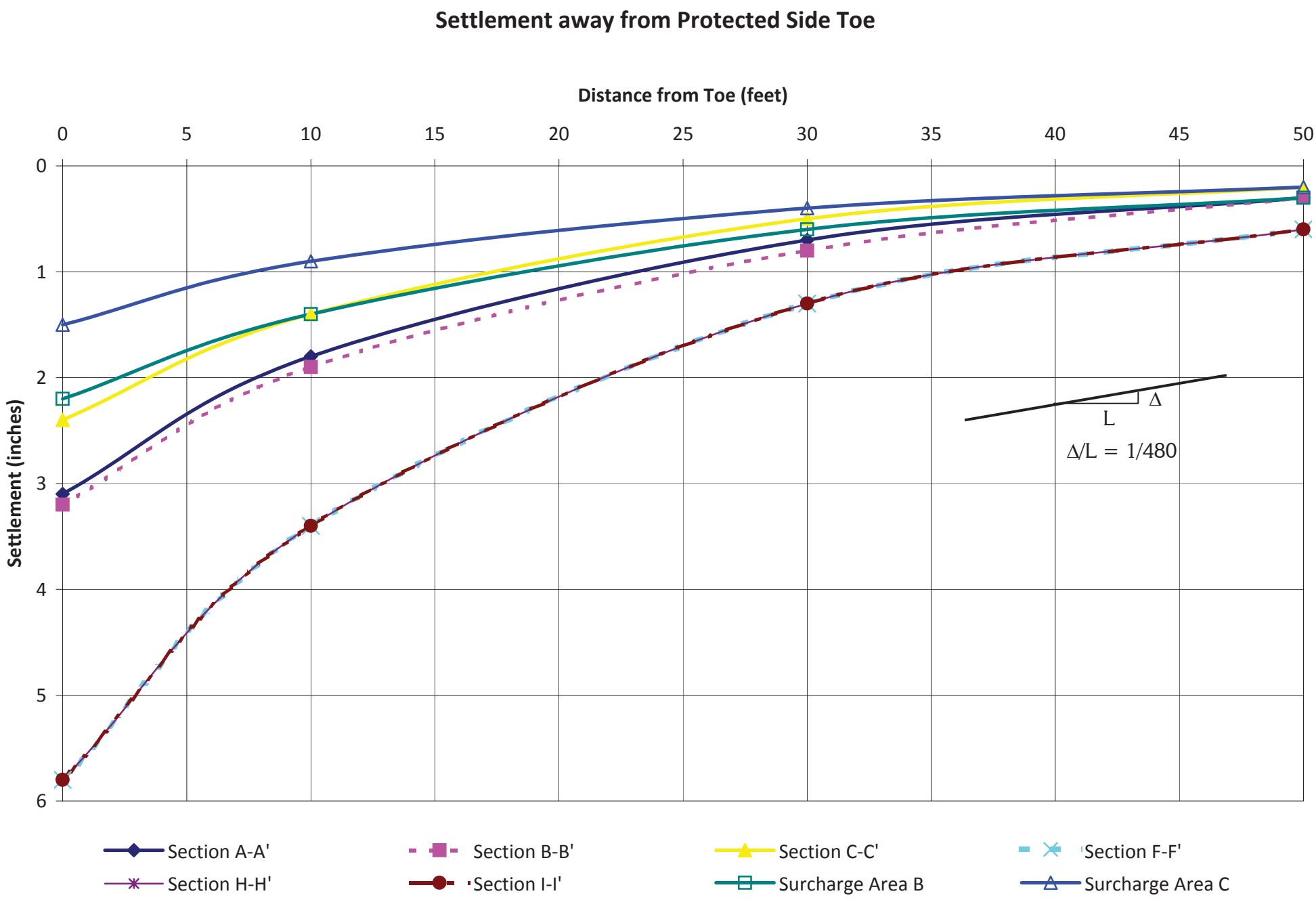

Settlement away from Protected Side Toe
Distance from Toe (feet)
0
5
10
15
20
25
30
35
40
45
50
Settlement (inches)
0
1
2
3
4
5
6
Δ
L
Δ/L = 1/480
Section A-A'
Section B-B'
Section C-C'
Section F-F'
Section H-H'
Section I-I'
Surcharge Area B
Surcharge Area C

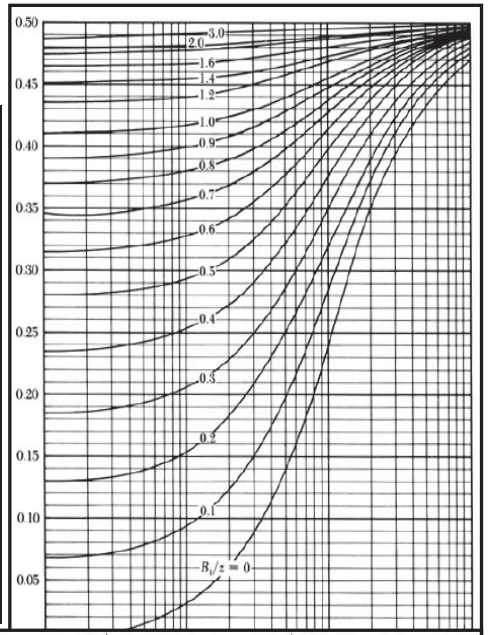
PLATE H-7

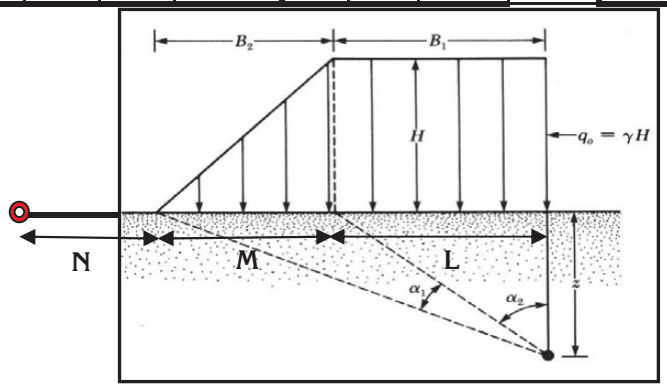
Osterberg, 1957 Chart Stresses Under An Embankemnt

Location: Center of Levee Section I-I'

H:	**Surcharge Height:**	15	feet
q_o:	**Surcharge**	1,800	psf
L:	**Levee Crest Width:**	20	feet
M:	**Dry Side Slope HorizontalDist:**	45	feet
N:	**Distance to Levee Toe:**	NA	feet
O:	**Creek Side Horizontal Slope Dist:**	150	feet

LARGE TRAPEZOID				ADDITIVE TRAPEZOID				SUBTRACTIVE TRAPEZOID					
B1= 10 feet				B1= 10 feet				B1= 0 feet					
B2= 150 feet				B2= 45 feet				B2= 0 feet					
Z	α_2	α_1	σ	Z	α_2	α_1	σ	Z	α_2	α_1	σ	$\Delta\sigma$	% Surcharge
2.5	1.33	0.23	899.81	2.5	1.33	0.20	899	2.5	0.00	0.00	0	1799	99.94
7.5	0.93	0.60	895.95	7.5	0.93	0.51	887	7.5	0.00	0.00	0	1783	99.05
12.5	0.67	0.82	886.58	12.5	0.67	0.67	858	12.5	0.00	0.00	0	1744	96.90
17.5	0.52	0.94	873.59	17.5	0.52	0.74	818	17.5	0.00	0.00	0	1692	93.98
22.5	0.42	1.01	858.64	22.5	0.42	0.76	775	22.5	0.00	0.00	0	1633	90.75
27.5	0.35	1.05	842.65	27.5	0.35	0.76	731	27.5	0.00	0.00	0	1574	87.42
32.5	0.30	1.07	826.12	32.5	0.30	0.74	688	32.5	0.00	0.00	0	1514	84.13
37.5	0.26	1.08	809.35	37.5	0.26	0.71	648	37.5	0.00	0.00	0	1457	80.95
42.5	0.23	1.08	792.50	42.5	0.23	0.68	610	42.5	0.00	0.00	0	1402	77.91
47.5	0.21	1.07	775.70	47.5	0.21	0.65	575	47.5	0.00	0.00	0	1350	75.02
52.5	0.19	1.07	759.04	52.5	0.19	0.62	542	52.5	0.00	0.00	0	1301	72.30
57.5	0.17	1.05	742.57	57.5	0.17	0.59	513	57.5	0.00	0.00	0	1255	69.73
70	0.14	1.02	702.53	70	0.14	0.52	448	70	0.00	0.00	0	1151	63.93





Schematics from Das

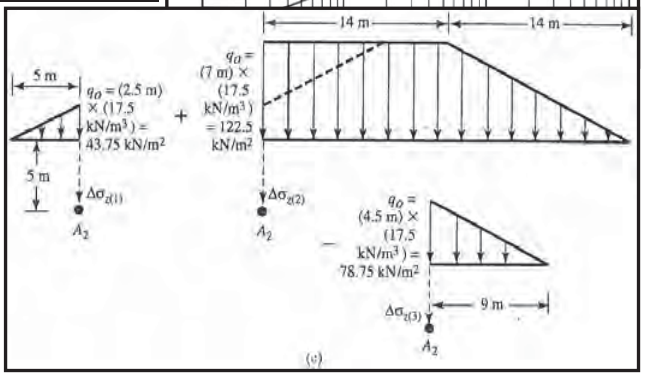


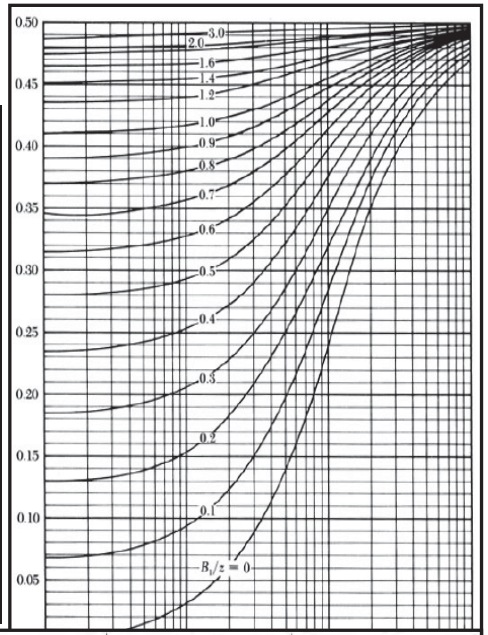
PLATE H-8

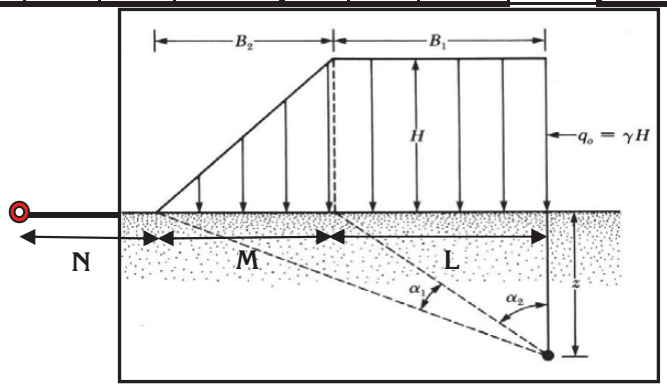
Osterberg, 1957 Chart Stresses Under An Embankemnt

Location: 1/3 of Height - Dry Side Section I-I'

H:	**Surcharge Height:**	15	feet
q_o:	**Surcharge**	1,800	psf
L:	**Levee Crest Width:**	20	feet
M:	**Dry Side Slope HorizontalDist:**	45	feet
N:	**Distance to Levee Toe:**	NA	feet
O:	**Creek Side Horizontal Slope Dist:**	150	feet

LARGE TRAPEZOID				ADDITIVE TRAPEZOID				SUBTRACTIVE TRAPEZOID					
B1= 50 feet				B1= 0 feet				B1= 0 feet					
B2= 150 feet				B2= 15 feet				B2= 30 feet					
Z	α_2	α_1	σ	Z	α_2	α_1	σ	Z	α_2	α_1	σ	$\Delta\sigma$	% Surcharge
2.5	1.52	0.04	899.99	2.5	0.00	1.41	268	2.5	0.00	1.49	568	600	33.34
7.5	1.42	0.11	899.80	7.5	0.00	1.11	211	7.5	0.00	1.33	506	605	33.60
12.5	1.33	0.18	899.10	12.5	0.00	0.88	167	12.5	0.00	1.18	449	617	34.29
17.5	1.23	0.25	897.62	17.5	0.00	0.71	135	17.5	0.00	1.04	398	635	35.26
22.5	1.15	0.31	895.18	22.5	0.00	0.59	112	22.5	0.00	0.93	354	653	36.29
27.5	1.07	0.37	891.65	27.5	0.00	0.50	95	27.5	0.00	0.83	317	670	37.25
32.5	0.99	0.42	887.01	32.5	0.00	0.43	83	32.5	0.00	0.75	285	685	38.05
37.5	0.93	0.46	881.30	37.5	0.00	0.38	73	37.5	0.00	0.67	258	696	38.68
42.5	0.87	0.50	874.59	42.5	0.00	0.34	65	42.5	0.00	0.61	235	705	39.14
47.5	0.81	0.53	866.97	47.5	0.00	0.31	58	47.5	0.00	0.56	215	710	39.46
52.5	0.76	0.55	858.55	52.5	0.00	0.28	53	52.5	0.00	0.52	198	713	39.63
57.5	0.72	0.58	849.44	57.5	0.00	0.26	49	57.5	0.00	0.48	184	714	39.69
70	0.62	0.61	824.34	70	0.00	0.21	40	70	0.00	0.40	155	710	39.44





Schematics from Das

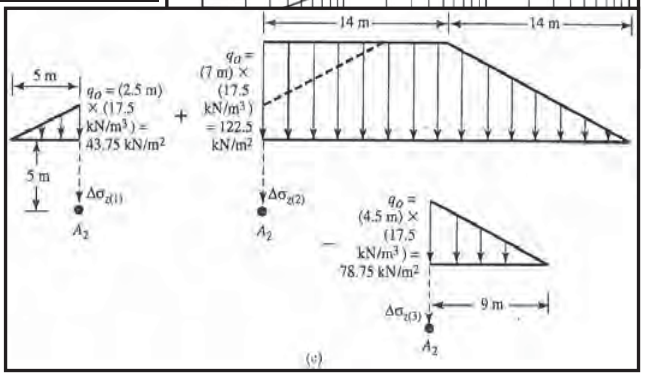


PLATE H-9

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Wet Side Toe

Loaded Area	**Load, Q**	1,680	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **2.14** inches 0.15 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	10	C		0.025	0.2	1	0.000348	0.02	0.01
Clay	5	10	7.5	5	57.6	744	2	1,488	29	C		0.025	0.2	1	0.000411	0.02	0.02
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	48	C		0.025	0.2	1	0.000489	0.03	0.03
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	66	C		0.025	0.2	1	0.000532	0.03	0.03
Clay	20	25	22.5	5	57.6	1,608	1	1,608	85	C		0.025	0.25	3	0.005575	0.33	0.33
Clay	25	30	27.5	5	57.6	1,896	1	1,896	103	C		0.025	0.25	3	0.005732	0.34	0.34
Clay	30	35	32.5	5	57.6	2,184	1	2,184	120	C		0.025	0.25	3	0.005828	0.35	0.35
Clay	35	40	37.5	5	57.6	2,472	1	2,472	138	C		0.025	0.15	3	0.003529	0.21	0.21
Clay	40	45	42.5	5	57.6	2,760	1	2,760	154	C		0.025	0.15	3	0.003542	0.21	0.21
Clay	45	50	47.5	5	57.6	3,048	1	3,048	170	C		0.025	0.15	3	0.003541	0.21	0.21
Clay	50	55	52.5	5	57.6	3,336	1	3,336	186	C		0.025	0.12	3	0.002822	0.17	0.17
Clay	55	60	57.5	5	57.6	3,624	1	3,624	200	C		0.025	0.12	3	0.002804	0.17	0.17
Sand	60	80	70	20	57.6	4,344	1	4,344	234	E	1200	0.025	0.1	N/A	0.000195	0.05	0.05

TOTAL= **2.14** inches

PLATE H-10

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: 1/3 of Height - Wet Side - Slope I-I' of Area B

Loaded Area	**Load, Q**	1,800	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **12.26** inches 0.82 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	599	C		0.025	0.2	1	0.011915	0.71	0.50
Clay	5	10	7.5	5	57.6	744	2	1,488	597	C		0.025	0.2	1	0.006396	0.38	0.27
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	595	C		0.025	0.2	2	0.025711	1.54	1.54
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	595	C		0.025	0.2	2	0.018445	1.11	1.11
Clay	20	25	22.5	5	57.6	1,608	1	1,608	594	C		0.025	0.25	3	0.034155	2.05	2.05
Clay	25	30	27.5	5	57.6	1,896	1	1,896	595	C		0.025	0.25	3	0.029633	1.78	1.78
Clay	30	35	32.5	5	57.6	2,184	1	2,184	596	C		0.025	0.25	3	0.026202	1.57	1.57
Clay	35	40	37.5	5	57.6	2,472	1	2,472	598	C		0.025	0.15	3	0.014106	0.85	0.85
Clay	40	45	42.5	5	57.6	2,760	1	2,760	599	C		0.025	0.15	3	0.012803	0.77	0.77
Clay	45	50	47.5	5	57.6	3,048	1	3,048	601	C		0.025	0.15	3	0.011728	0.70	0.70
Clay	50	55	52.5	5	57.6	3,336	1	3,336	603	C		0.025	0.12	3	0.008658	0.52	0.52
Clay	55	60	57.5	5	57.6	3,624	1	3,624	604	C		0.025	0.12	3	0.008039	0.48	0.48
Sand	60	80	70	20	57.6	4,344	1	4,344	606	E	1200	0.025	0.1	N/A	0.000505	0.12	0.12

TOTAL= **12.26** inches

PLATE H-11

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: 2/3 of Height - Wet Side - Slope I-I' of Area B

Loaded Area	**Load, Q**	1,800	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **24.49** inches 1.63 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	1200	C		0.025	0.2	2	0.044581	2.67	1.87
Clay	5	10	7.5	5	57.6	744	2	1,488	1200	C		0.025	0.2	2	0.030727	1.84	1.29
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1198	C		0.025	0.2	2	0.053078	3.18	3.18
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1195	C		0.025	0.2	2	0.042148	2.53	2.53
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1191	C		0.025	0.25	3	0.06016	3.61	3.61
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1183	C		0.025	0.25	3	0.052659	3.16	3.16
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1174	C		0.025	0.25	3	0.046713	2.80	2.80
Clay	35	40	37.5	5	57.6	2,472	1	2,472	1163	C		0.025	0.15	3	0.025112	1.51	1.51
Clay	40	45	42.5	5	57.6	2,760	1	2,760	1149	C		0.025	0.15	3	0.022674	1.36	1.36
Clay	45	50	47.5	5	57.6	3,048	1	3,048	1134	C		0.025	0.15	3	0.020598	1.24	1.24
Clay	50	55	52.5	5	57.6	3,336	1	3,336	1116	C		0.025	0.12	3	0.015045	0.90	0.90
Clay	55	60	57.5	5	57.6	3,624	1	3,624	1098	C		0.025	0.12	3	0.013792	0.83	0.83
Sand	60	80	70	20	57.6	4,344	1	4,344	1048	E	1200	0.025	0.1	N/A	0.000873	0.21	0.21

TOTAL= **24.49** inches

PLATE H-12

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Wet Side Edge of Crest - Slope I-I' of Area B

Loaded Area	**Load, Q**	1,800	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **32.45** inches 2.16 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	1790	C		0.025	0.2	2	0.073396	4.40	3.08
Clay	5	10	7.5	5	57.6	744	2	1,488	1768	C		0.025	0.2	2	0.052995	3.18	2.23
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1737	C		0.025	0.2	2	0.071882	4.31	4.31
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1699	C		0.025	0.2	2	0.057996	3.48	3.48
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1654	C		0.025	0.25	3	0.076794	4.61	4.61
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1605	C		0.025	0.25	3	0.06658	3.99	3.99
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1554	C		0.025	0.25	3	0.058333	3.50	3.50
Clay	35	40	37.5	5	57.6	2,472	1	2,472	1502	C		0.025	0.15	3	0.030923	1.86	1.86
Clay	40	45	42.5	5	57.6	2,760	1	2,760	1451	C		0.025	0.15	3	0.027514	1.65	1.65
Clay	45	50	47.5	5	57.6	3,048	1	3,048	1401	C		0.025	0.15	3	0.02463	1.48	1.48
Clay	50	55	52.5	5	57.6	3,336	1	3,336	1352	C		0.025	0.12	3	0.017733	1.06	1.06
Clay	55	60	57.5	5	57.6	3,624	1	3,624	1306	C		0.025	0.12	3	0.016035	0.96	0.96
Sand	60	80	70	20	57.6	4,344	1	4,344	1198	E	1200	0.025	0.1	N/A	0.000999	0.24	0.24

TOTAL= **32.45** inches

PLATE H-13

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Center of Levee - Slope I-I' of Area B

Loaded Area	**Load, Q**	1,800	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **32.11** inches 2.14 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	1799	C		0.025	0.2	2	0.073763	4.43	3.10
Clay	5	10	7.5	5	57.6	744	2	1,488	1783	C		0.025	0.2	2	0.053522	3.21	2.25
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1744	C		0.025	0.2	2	0.072095	4.33	4.33
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1692	C		0.025	0.2	2	0.057792	3.47	3.47
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1633	C		0.025	0.25	3	0.076113	4.57	4.57
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1574	C		0.025	0.25	3	0.065608	3.94	3.94
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1514	C		0.025	0.25	3	0.057189	3.43	3.43
Clay	35	40	37.5	5	57.6	2,472	1	2,472	1457	C		0.025	0.15	3	0.030186	1.81	1.81
Clay	40	45	42.5	5	57.6	2,760	1	2,760	1402	C		0.025	0.15	3	0.026764	1.61	1.61
Clay	45	50	47.5	5	57.6	3,048	1	3,048	1350	C		0.025	0.15	3	0.023892	1.43	1.43
Clay	50	55	52.5	5	57.6	3,336	1	3,336	1301	C		0.025	0.12	3	0.017165	1.03	1.03
Clay	55	60	57.5	5	57.6	3,624	1	3,624	1255	C		0.025	0.12	3	0.015498	0.93	0.93
Sand	60	80	70	20	57.6	4,344	1	4,344	1151	E	1200	0.025	0.1	N/A	0.000959	0.23	0.23

TOTAL= **32.11** inches

PLATE H-14

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Dry Side Edge of Crest - Slope I-I' of Area B

Loaded Area	**Load, Q**	1,800	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **30.40** inches 2.03 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	1768	C		0.025	0.2	2	0.072471	4.35	3.04
Clay	5	10	7.5	5	57.6	744	2	1,488	1704	C		0.025	0.2	2	0.05077	3.05	2.13
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1640	C		0.025	0.2	2	0.068766	4.13	4.13
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1576	C		0.025	0.2	2	0.054381	3.26	3.26
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1513	C		0.025	0.25	3	0.072015	4.32	4.32
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1454	C		0.025	0.25	3	0.061786	3.71	3.71
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1397	C		0.025	0.25	3	0.053682	3.22	3.22
Clay	35	40	37.5	5	57.6	2,472	1	2,472	1344	C		0.025	0.15	3	0.028276	1.70	1.70
Clay	40	45	42.5	5	57.6	2,760	1	2,760	1294	C		0.025	0.15	3	0.025041	1.50	1.50
Clay	45	50	47.5	5	57.6	3,048	1	3,048	1247	C		0.025	0.15	3	0.022344	1.34	1.34
Clay	50	55	52.5	5	57.6	3,336	1	3,336	1204	C		0.025	0.12	3	0.016056	0.96	0.96
Clay	55	60	57.5	5	57.6	3,624	1	3,624	1163	C		0.025	0.12	3	0.014506	0.87	0.87
Sand	60	80	70	20	57.6	4,344	1	4,344	1072	E	1200	0.025	0.1	N/A	0.000894	0.21	0.21

TOTAL= **30.40** inches

PLATE H-15

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: 2/3 of Height - Dry Side - Slope I-I' of Area B

Loaded Area	**Load, Q**	1,800	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **23.29** inches 1.55 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	1200	C		0.025	0.2	2	0.044569	2.67	1.87
Clay	5	10	7.5	5	57.6	744	2	1,488	1195	C		0.025	0.2	2	0.030501	1.83	1.28
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1180	C		0.025	0.2	2	0.052367	3.14	3.14
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1158	C		0.025	0.2	2	0.040859	2.45	2.45
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1133	C		0.025	0.25	3	0.057896	3.47	3.47
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1106	C		0.025	0.25	3	0.049892	2.99	2.99
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1079	C		0.025	0.25	3	0.043601	2.62	2.62
Clay	35	40	37.5	5	57.6	2,472	1	2,472	1053	C		0.025	0.15	3	0.023123	1.39	1.39
Clay	40	45	42.5	5	57.6	2,760	1	2,760	1028	C		0.025	0.15	3	0.02063	1.24	1.24
Clay	45	50	47.5	5	57.6	3,048	1	3,048	1004	C		0.025	0.15	3	0.018552	1.11	1.11
Clay	50	55	52.5	5	57.6	3,336	1	3,336	981	C		0.025	0.12	3	0.013436	0.81	0.81
Clay	55	60	57.5	5	57.6	3,624	1	3,624	959	C		0.025	0.12	3	0.012234	0.73	0.73
Sand	60	80	70	20	57.6	4,344	1	4,344	907	E	1200	0.025	0.1	N/A	0.000756	0.18	0.18

TOTAL= **23.29** inches

PLATE H-16

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: 1/3 of Height - Dry Side - Slope I-I' of Area B

Loaded Area	**Load, Q**	1,800	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **13.56** inches 0.90 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	600	C		0.025	0.2	1	0.011931	0.72	0.50
Clay	5	10	7.5	5	57.6	744	2	1,488	605	C		0.025	0.2	1	0.00646	0.39	0.27
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	617	C		0.025	0.2	2	0.026863	1.61	1.61
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	635	C		0.025	0.2	2	0.020243	1.21	1.21
Clay	20	25	22.5	5	57.6	1,608	1	1,608	653	C		0.025	0.25	3	0.037017	2.22	2.22
Clay	25	30	27.5	5	57.6	1,896	1	1,896	670	C		0.025	0.25	3	0.032872	1.97	1.97
Clay	30	35	32.5	5	57.6	2,184	1	2,184	685	C		0.025	0.25	3	0.029615	1.78	1.78
Clay	35	40	37.5	5	57.6	2,472	1	2,472	696	C		0.025	0.15	3	0.016166	0.97	0.97
Clay	40	45	42.5	5	57.6	2,760	1	2,760	705	C		0.025	0.15	3	0.014812	0.89	0.89
Clay	45	50	47.5	5	57.6	3,048	1	3,048	710	C		0.025	0.15	3	0.013645	0.82	0.82
Clay	50	55	52.5	5	57.6	3,336	1	3,336	713	C		0.025	0.12	3	0.0101	0.61	0.61
Clay	55	60	57.5	5	57.6	3,624	1	3,624	714	C		0.025	0.12	3	0.009378	0.56	0.56
Sand	60	80	70	20	57.6	4,344	1	4,344	710	E	1200	0.025	0.1	N/A	0.000592	0.14	0.14

TOTAL= **13.56** inches

PLATE H-17

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Dry Side Toe - Slope I-I' of Area B

Loaded Area	**Load, Q**	1,800	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **5.78** inches 0.39 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	32	C		0.025	0.2	1	0.001101	0.07	0.05
Clay	5	10	7.5	5	57.6	744	2	1,488	95	C		0.025	0.2	1	0.001299	0.08	0.05
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	155	C		0.025	0.2	1	0.001517	0.09	0.09
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	211	C		0.025	0.2	1	0.001611	0.10	0.10
Clay	20	25	22.5	5	57.6	1,608	1	1,608	263	C		0.025	0.25	3	0.016434	0.99	0.99
Clay	25	30	27.5	5	57.6	1,896	1	1,896	309	C		0.025	0.25	3	0.016403	0.98	0.98
Clay	30	35	32.5	5	57.6	2,184	1	2,184	350	C		0.025	0.25	3	0.016151	0.97	0.97
Clay	35	40	37.5	5	57.6	2,472	1	2,472	386	C		0.025	0.15	3	0.009456	0.57	0.57
Clay	40	45	42.5	5	57.6	2,760	1	2,760	417	C		0.025	0.15	3	0.009169	0.55	0.55
Clay	45	50	47.5	5	57.6	3,048	1	3,048	444	C		0.025	0.15	3	0.008852	0.53	0.53
Clay	50	55	52.5	5	57.6	3,336	1	3,336	466	C		0.025	0.12	3	0.006814	0.41	0.41
Clay	55	60	57.5	5	57.6	3,624	1	3,624	485	C		0.025	0.12	3	0.006543	0.39	0.39
Sand	60	80	70	20	57.6	4,344	1	4,344	518	E	1200	0.025	0.1	N/A	0.000432	0.10	0.10

TOTAL= **5.78** inches

PLATE H-18

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Center of Levee - Slope A-A' of Area A

Loaded Area	**Load, Q**	1,200	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **19.12** inches 1.91 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	4	1,200	1199	C		0.025	0.15	2	0.029558	1.77	1.24
Clay	5	10	7.5	5	57.6	744	2.5	1,860	1189	C		0.025	0.15	2	0.012467	0.75	0.52
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1165	C		0.025	0.15	2	0.039323	2.36	2.36
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1132	C		0.025	0.15	2	0.030435	1.83	1.83
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1094	C		0.025	0.22	3	0.049588	2.98	2.98
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1055	C		0.025	0.22	3	0.042259	2.54	2.54
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1015	C		0.025	0.22	3	0.036473	2.19	2.19
Clay	35	40	37.5	5	57.6	2,472	1	2,472	976	C		0.025	0.22	3	0.0318	1.91	1.91
Clay	40	45	42.5	5	57.6	2,760	1	2,760	938	C		0.025	0.15	3	0.019065	1.14	1.14
Clay	45	50	47.5	5	57.6	3,048	1	3,048	902	C		0.025	0.15	3	0.016886	1.01	1.01
Clay	50	55	52.5	5	57.6	3,336	1	3,336	867	C		0.025	0.11	3	0.011036	0.66	0.66
Clay	55	60	57.5	5	57.6	3,624	1	3,624	834	C		0.025	0.11	3	0.009891	0.59	0.59
sand	60	80	70	20	57.6	4,344	1	4,344	757	E	1200	0.025	0.11	N/A	0.000631	0.15	0.15

TOTAL= **19.12** inches

PLATE H-19

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Center of Levee - Slope B-B' of Area A

Loaded Area	**Load, Q**	1,200	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **21.43** inches 2.14 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	4	1,200	1200	C		0.025	0.15	2	0.029571	1.77	1.24
Clay	5	10	7.5	5	57.6	744	2.5	1,860	1200	C		0.025	0.15	2	0.012818	0.77	0.54
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1199	C		0.025	0.15	2	0.040338	2.42	2.42
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1199	C		0.025	0.15	2	0.032191	1.93	1.93
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1197	C		0.025	0.22	3	0.053168	3.19	3.19
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1195	C		0.025	0.22	3	0.046697	2.80	2.80
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1192	C		0.025	0.22	3	0.041612	2.50	2.50
Clay	35	40	37.5	5	57.6	2,472	1	2,472	1188	C		0.025	0.22	3	0.037496	2.25	2.25
Clay	40	45	42.5	5	57.6	2,760	1	2,760	1183	C		0.025	0.15	3	0.02324	1.39	1.39
Clay	45	50	47.5	5	57.6	3,048	1	3,048	1177	C		0.025	0.15	3	0.021275	1.28	1.28
Clay	50	55	52.5	5	57.6	3,336	1	3,336	1170	C		0.025	0.11	3	0.014366	0.86	0.86
Clay	55	60	57.5	5	57.6	3,624	1	3,624	1163	C		0.025	0.11	3	0.013292	0.80	0.80
Sand	60	80	70	20	57.6	4,344	1	4,344	1139	E	1200	0.025	0.11	N/A	0.000949	0.23	0.23

TOTAL= **21.43** inches

PLATE H-20

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Center of Levee - Slope C-C' of Area A

Loaded Area	**Load, Q**	600	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **9.93** inches 1.99 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	4	1,200	600	C		0.025	0.15	1	0.011924	0.72	0.50
Clay	5	10	7.5	5	57.6	744	2.5	1,860	595	C		0.025	0.15	1	0.006377	0.38	0.27
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	582	C		0.025	0.15	2	0.019255	1.16	1.16
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	566	C		0.025	0.15	2	0.013341	0.80	0.80
Clay	20	25	22.5	5	57.6	1,608	1	1,608	547	C		0.025	0.22	3	0.027976	1.68	1.68
Clay	25	30	27.5	5	57.6	1,896	1	1,896	527	C		0.025	0.22	3	0.023447	1.41	1.41
Clay	30	35	32.5	5	57.6	2,184	1	2,184	508	C		0.025	0.22	3	0.019966	1.20	1.20
Clay	35	40	37.5	5	57.6	2,472	1	2,472	488	C		0.025	0.22	3	0.017217	1.03	1.03
Clay	40	45	42.5	5	57.6	2,760	1	2,760	469	C		0.025	0.15	3	0.010228	0.61	0.61
Clay	45	50	47.5	5	57.6	3,048	1	3,048	451	C		0.025	0.15	3	0.008988	0.54	0.54
Clay	50	55	52.5	5	57.6	3,336	1	3,336	433	C		0.025	0.11	3	0.005836	0.35	0.35
Clay	55	60	57.5	5	57.6	3,624	1	3,624	417	C		0.025	0.11	3	0.005201	0.31	0.31
Sand	60	80	70	20	57.6	4,344	1	4,344	379	E	1200	0.025	0.11	N/A	0.000316	0.08	0.08

TOTAL= **9.93** inches

PLATE H-21

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Center of Levee - Slope F-F'

Loaded	**Load, Q**	1,680	**psf**		(C)
Area	**Depth, D**	0	**ft**	**must be at a layer boundary**	(D)

TOTAL= **33.44** inches 2.39 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	1679	C		0.025	0.2	2	0.068659	4.12	2.88
Clay	5	10	7.5	5	57.6	744	2	1,488	1680	C		0.025	0.2	2	0.049899	2.99	2.10
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1679	C		0.025	0.2	2	0.070048	4.20	4.20
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1679	C		0.025	0.2	2	0.057421	3.45	3.45
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1678	C		0.025	0.25	3	0.077591	4.66	4.66
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1676	C		0.025	0.25	3	0.068777	4.13	4.13
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1674	C		0.025	0.25	3	0.061778	3.71	3.71
Clay	35	40	37.5	5	57.6	2,472	1	2,472	1671	C		0.025	0.15	3	0.03364	2.02	2.02
Clay	40	45	42.5	5	57.6	2,760	1	2,760	1667	C		0.025	0.15	3	0.030783	1.85	1.85
Clay	45	50	47.5	5	57.6	3,048	1	3,048	1663	C		0.025	0.15	3	0.028359	1.70	1.70
Clay	50	55	52.5	5	57.6	3,336	1	3,336	1657	C		0.025	0.12	3	0.021017	1.26	1.26
Clay	55	60	57.5	5	57.6	3,624	1	3,624	1651	C		0.025	0.12	3	0.01956	1.17	1.17
Sand	60	80	70	20	57.6	4,344	1	4,344	1631	E	1200	0.025	0.1	N/A	0.001359	0.33	0.33

TOTAL= **33.44** inches

PLATE H-22

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Center of Levee - Slope H-H' of Area B

Loaded Area	**Load, Q**	1,680	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **32.91** inches 2.35 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	1680	C		0.025	0.2	2	0.068675	4.12	2.88
Clay	5	10	7.5	5	57.6	744	2	1,488	1679	C		0.025	0.2	2	0.049881	2.99	2.10
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	1677	C		0.025	0.2	2	0.069962	4.20	4.20
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	1672	C		0.025	0.2	2	0.057213	3.43	3.43
Clay	20	25	22.5	5	57.6	1,608	1	1,608	1663	C		0.025	0.25	3	0.077112	4.63	4.63
Clay	25	30	27.5	5	57.6	1,896	1	1,896	1652	C		0.025	0.25	3	0.068023	4.08	4.08
Clay	30	35	32.5	5	57.6	2,184	1	2,184	1636	C		0.025	0.25	3	0.06071	3.64	3.64
Clay	35	40	37.5	5	57.6	2,472	1	2,472	1618	C		0.025	0.15	3	0.032797	1.97	1.97
Clay	40	45	42.5	5	57.6	2,760	1	2,760	1596	C		0.025	0.15	3	0.029733	1.78	1.78
Clay	45	50	47.5	5	57.6	3,048	1	3,048	1573	C		0.025	0.15	3	0.027104	1.63	1.63
Clay	50	55	52.5	5	57.6	3,336	1	3,336	1547	C		0.025	0.12	3	0.019856	1.19	1.19
Clay	55	60	57.5	5	57.6	3,624	1	3,624	1520	C		0.025	0.12	3	0.018254	1.10	1.10
Sand	60	80	70	20	57.6	4,344	1	4,344	1449	E	1200	0.025	0.1	N/A	0.001207	0.29	0.29

TOTAL= **32.91** inches

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Center of Surchage Area B

Loaded Area	**Load, Q**	3,000	**psf**		**(C)**
	Depth, D	0	**ft**	**must be at a layer boundary**	**(D)**

TOTAL= **51.83** inches 2.07 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	3.5	1,050	2999	C		0.025	0.2	2	0.113051	6.78	4.75
Clay	5	10	7.5	5	57.6	744	2	1,488	3000	C		0.025	0.2	2	0.087667	5.26	3.68
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	3000	C		0.025	0.2	2	0.104505	6.27	6.27
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	2999	C		0.025	0.2	2	0.089113	5.35	5.35
Clay	20	25	22.5	5	57.6	1,608	1	1,608	2999	C		0.025	0.25	3	0.114279	6.86	6.86
Clay	25	30	27.5	5	57.6	1,896	1	1,896	2998	C		0.025	0.25	3	0.102956	6.18	6.18
Clay	30	35	32.5	5	57.6	2,184	1	2,184	2997	C		0.025	0.25	3	0.093784	5.63	5.63
Clay	35	40	37.5	5	57.6	2,472	1	2,472	2995	C		0.025	0.15	3	0.051706	3.10	3.10
Clay	40	45	42.5	5	57.6	2,760	1	2,760	2993	C		0.025	0.15	3	0.047846	2.87	2.87
Clay	45	50	47.5	5	57.6	3,048	1	3,048	2990	C		0.025	0.15	3	0.044534	2.67	2.67
Clay	50	55	52.5	5	57.6	3,336	1	3,336	2987	C		0.025	0.12	3	0.033323	2.00	2.00
Clay	55	60	57.5	5	57.6	3,624	1	3,624	2983	C		0.025	0.12	3	0.031299	1.88	1.88
Sand	60	80	70	20	57.6	4,344	1	4,344	2971	E	1200	0.025	0.1	N/A	0.002476	0.59	0.59

TOTAL= **51.83** inches

PLATE H-24

PROJECT NAME: Ballona Wetlands Restoration Project **PROJECT NUMBER:** LA-962A

PROBLEM DESCRIPTION: Center of Levee - Area C Surcharge

Loaded Area	**Load, Q**	3,600	**psf**		(C)
	Depth, D	0	**ft**	**must be at a layer boundary**	(D)

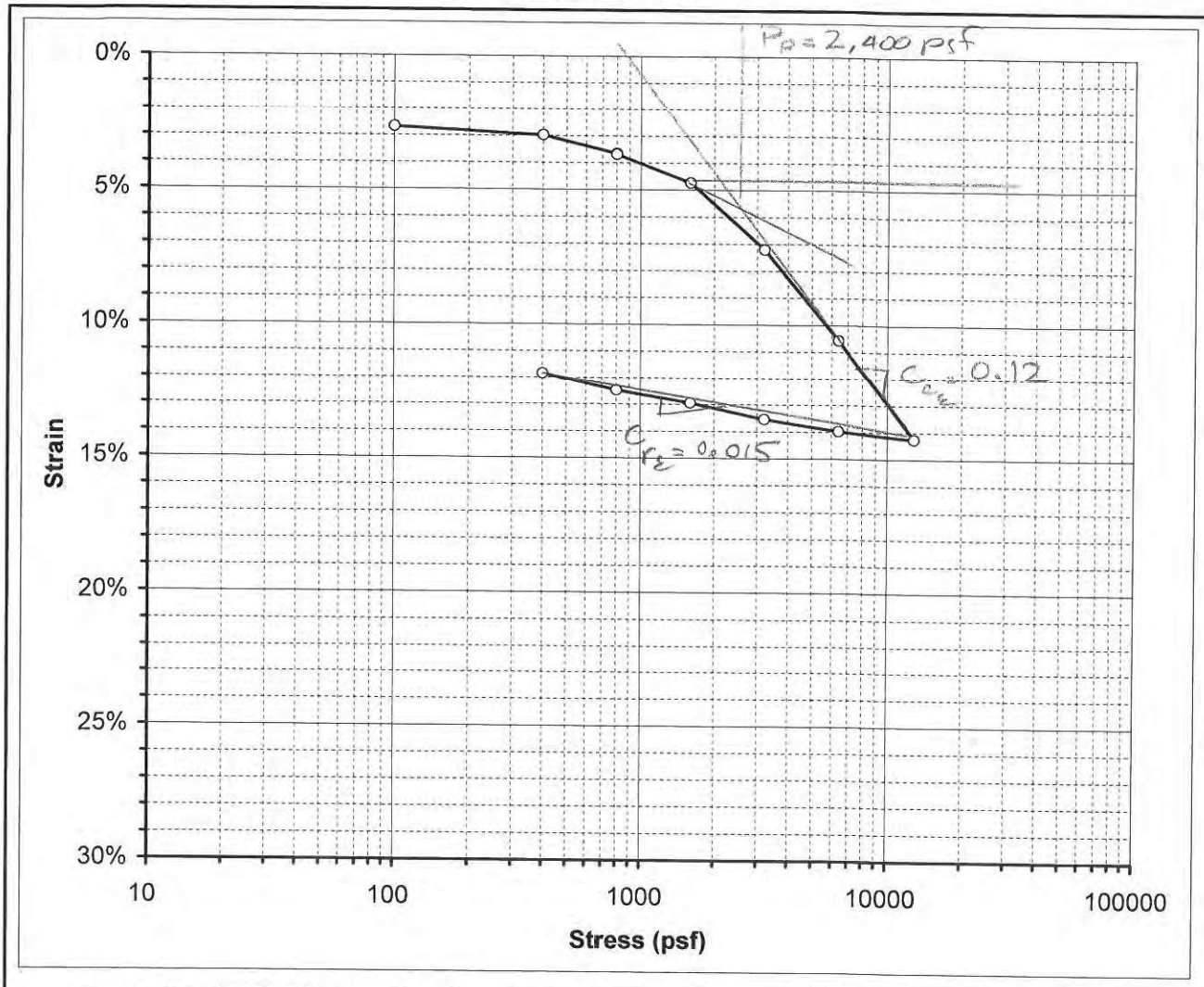
TOTAL= **31.63** inches 1.05 inch per foot

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Soil Layer	**Depth (feet) top**	**bottom**	**center**	**Layer Height (feet)**	**γ (pcf)**	**σ'v (psf)**	**OCR**	**σ'p (psf)**	**Stress Distribution Δσ (psf)**	**Compress. Type E or C**	**E (ksf)**	**Cr 1+e0**	**Cc 1+e0**	**OCR Case**	**Strain ε (in/in)**	**Layer Settle (in)**	**Adjusted Layer Settle (in)**
Clay	0	5	2.5	5	120	300	4	1,200	3599	C		0.025	0.075	2	0.053437	3.21	2.24
Clay	5	10	7.5	5	57.6	744	2.5	1,860	3600	C		0.025	0.075	2	0.037575	2.25	1.58
Clay	10	15	12.5	5	57.6	1,032	1.2	1,238	3600	C		0.025	0.075	2	0.044945	2.70	2.70
Clay	15	20	17.5	5	57.6	1,320	1.2	1,584	3599	C		0.025	0.075	2	0.03889	2.33	2.33
Clay	20	25	22.5	5	57.6	1,608	1	1,608	3599	C		0.025	0.125	3	0.063784	3.83	3.83
Clay	25	30	27.5	5	57.6	1,896	1	1,896	3598	C		0.025	0.125	3	0.057752	3.47	3.47
Clay	30	35	32.5	5	57.6	2,184	1	2,184	3596	C		0.025	0.125	3	0.052835	3.17	3.17
Clay	35	40	37.5	5	57.6	2,472	1	2,472	3594	C		0.025	0.125	3	0.048732	2.92	2.92
Clay	40	45	42.5	5	57.6	2,760	1	2,760	3591	C		0.025	0.11	3	0.039816	2.39	2.39
Clay	45	50	47.5	5	57.6	3,048	1	3,048	3588	C		0.025	0.11	3	0.03717	2.23	2.23
Clay	50	55	52.5	5	57.6	3,336	1	3,336	3584	C		0.025	0.11	3	0.034859	2.09	2.09
Clay	55	60	57.5	5	57.6	3,624	1	3,624	3580	C		0.025	0.11	3	0.032821	1.97	1.97
sand	60	80	70	20	57.6	4,344	1	4,344	3565	E	1200	0.025	0.11	N/A	0.002971	0.71	0.71

TOTAL= **31.63** inches

PLATE H-25

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-HSA051	Sample Depth	10 ft
Sample No.	R5	USCS	0

BEFORE TEST

Initial Moisture Content:	43.6%	
Initial Dry Unit Wt:	77.5	pcf
Initial Total Unit Wt.:	111.3	pcf
Initial Void Ratio:	1.2466	
Initial Degree of Saturation:	97.5%	

AFTER TEST

Final Moisture Content:	36.8%	
Final Dry Unit Wt:	86.3	pcf
Final Total Unit Wt.:	114.5	pcf
Final Void Ratio:	1.0165	
Final Degree of Saturation:	100.9%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	2.69%	1.1861
400	2.99%	1.1793
800	3.67%	1.1642
800	3.70%	1.1635
1600	4.74%	1.1401
3200	7.22%	1.0845
6400	10.57%	1.0091
12800	14.27%	0.9260
6400	13.98%	0.9326
3200	13.55%	0.9423
1600	12.95%	0.9556
800	12.48%	0.9662
400	11.85%	0.9804

$\sigma_v' = 5 \times 120 + 5 \times 57.6 = 888$

$OCR = \frac{2400}{888} = 2.7$

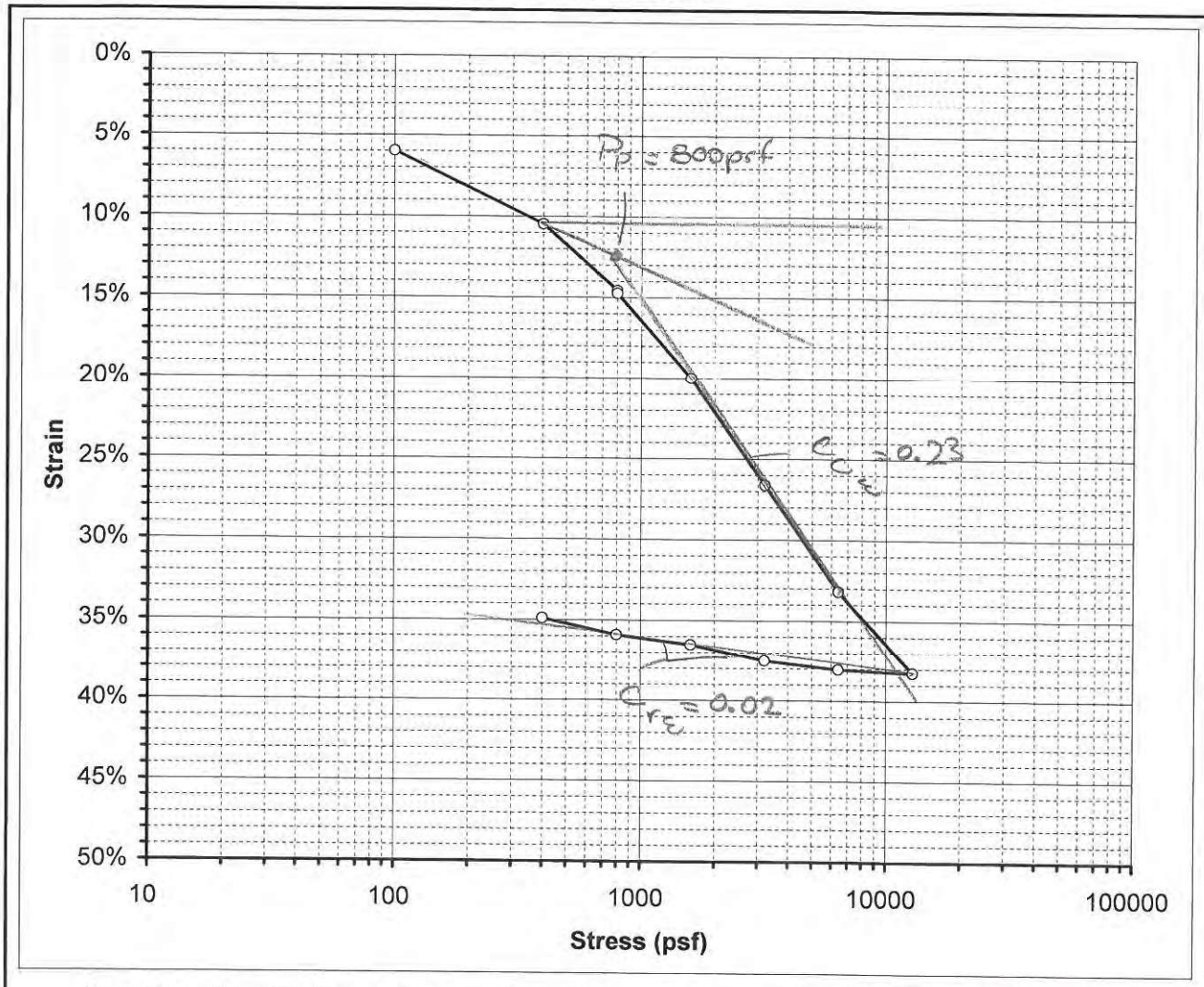
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 11-9-12\B-HSA051 R5@10'_3.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW030	Sample Depth	10
Sample No.	R3	USCS	0

BEFORE TEST

Initial Moisture Content:	107.6%	
Initial Dry Unit Wt:	43.5	pcf
Initial Total Unit Wt.:	90.3	pcf
Initial Void Ratio:	3.0033	
Initial Degree of Saturation:	100.0%	

AFTER TEST

Final Moisture Content:	61.0%	
Final Dry Unit Wt:	64.6	pcf
Final Total Unit Wt.:	152.6	pcf
Final Void Ratio:	1.6946	
Final Degree of Saturation:	100.5%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' = 5 \times 120 + 5 \times 57.6 = 888$ psf

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	5.99%	2.7633
400	10.49%	2.5833
800	14.58%	2.4197
800	14.75%	2.4128
1600	20.01%	2.2022
3200	26.63%	1.9373
6400	33.19%	1.6745
12800	38.26%	1.4715
6400	38.06%	1.4795
3200	37.51%	1.5016
1600	36.53%	1.5410
800	35.92%	1.5652
400	34.92%	1.6053

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

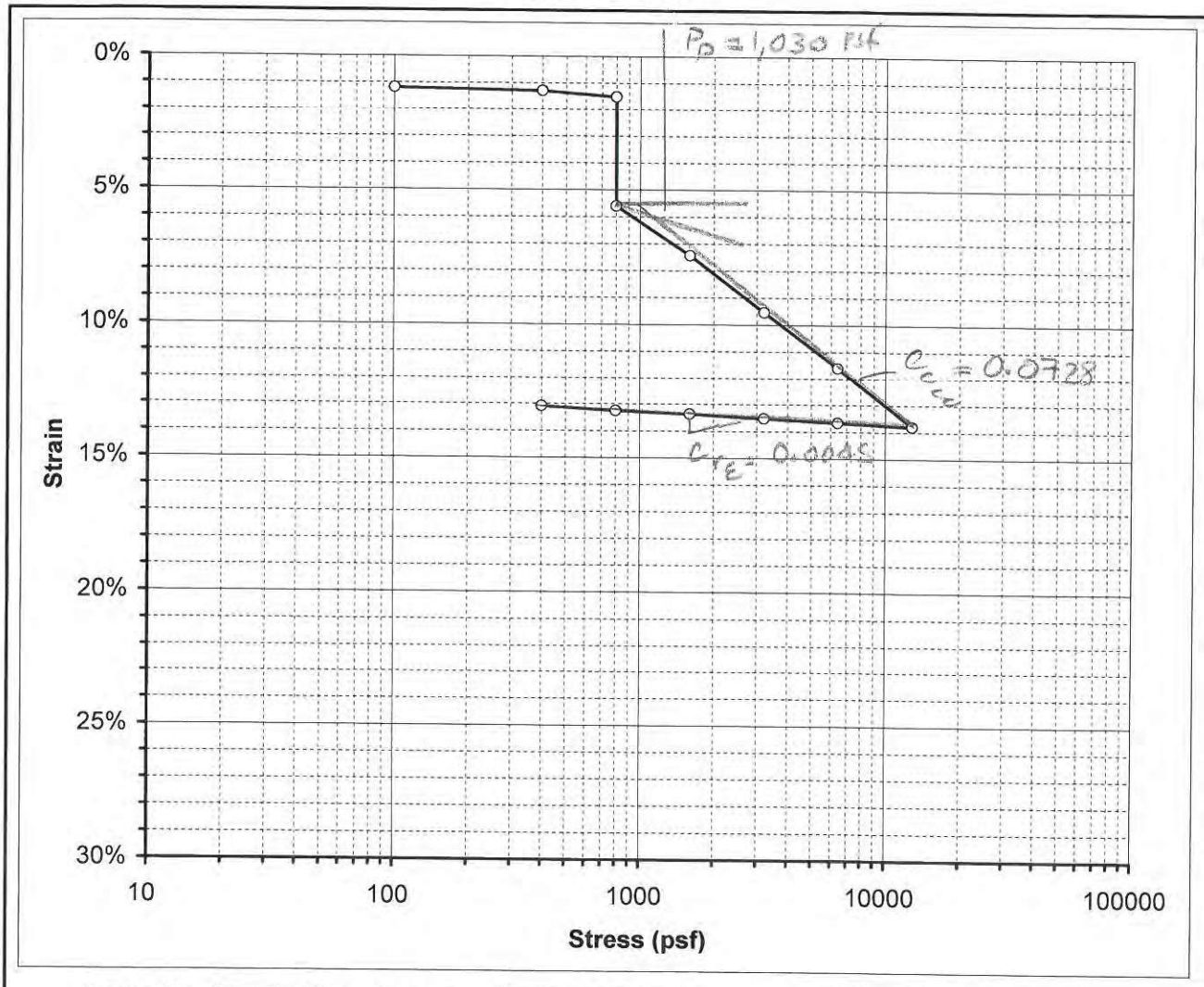
$OCR = \frac{800}{888} \sim 1.0$

FIGURE NO. B-3

GROUP DELTA CONSULTANTS

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 11-9-12\B-RW030 R3@10'_1.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	C-HSA061	Sample Depth	7.5 ft
Sample No.	R3	USCS	0

BEFORE TEST

Initial Moisture Content:	7.2%	
Initial Dry Unit Wt:	88.6	pcf
Initial Total Unit Wt.:	94.9	pcf
Initial Void Ratio:	0.9655	
Initial Degree of Saturation:	20.8%	

AFTER TEST

Final Moisture Content:	20.7%	
Final Dry Unit Wt:	101.4	pcf
Final Total Unit Wt.:	117.1	pcf
Final Void Ratio:	0.7167	
Final Degree of Saturation:	80.7%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.20%	0.9419
400	1.30%	0.9400
800	1.52%	0.9356
800	5.62%	0.8551
1600	7.45%	0.8191
3200	9.55%	0.7778
6400	11.61%	0.7373
12800	13.80%	0.6943
6400	13.67%	0.6968
3200	13.53%	0.6996
1600	13.37%	0.7027
800	13.26%	0.7049
400	13.09%	0.7082

$\sigma_v' = 120 \times 7.5 = 900$ psf $OCR = \frac{1,030}{900} = 1.15$

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

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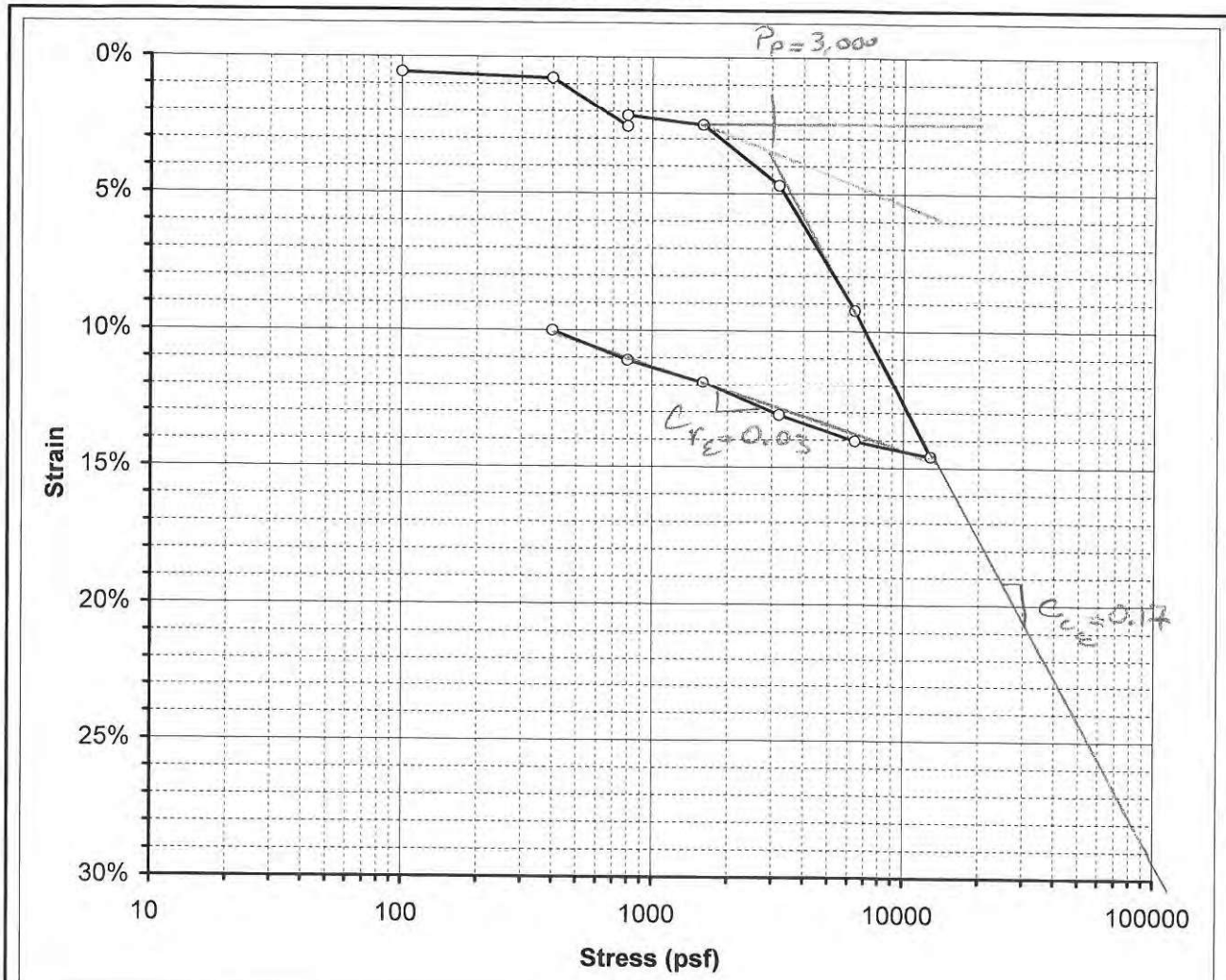
CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-HSA051	Sample Depth	5 ft
Sample No.	R3	USCS	0

BEFORE TEST

Initial Moisture Content:	45.1%	
Initial Dry Unit Wt:	75.7	pcf
Initial Total Unit Wt.:	109.9	pcf
Initial Void Ratio:	1.2998	
Initial Degree of Saturation:	96.9%	

AFTER TEST

Final Moisture Content:	40.9%	
Final Dry Unit Wt:	82.5	pcf
Final Total Unit Wt.:	111.6	pcf
Final Void Ratio:	1.1111	
Final Degree of Saturation:	102.6%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.57%	1.2867
400	0.78%	1.2819
800	2.58%	1.2406
800	2.17%	1.2498
1600	2.51%	1.2422
3200	4.71%	1.1915
6400	9.26%	1.0869
12800	14.60%	0.9641
6400	14.05%	0.9768
3200	13.11%	0.9984
1600	11.90%	1.0261
800	11.10%	1.0445
400	10.03%	1.0692

$\sigma_v' = 5 \times 120 = 600$ psf $OCR = \frac{3000}{600} \approx 5.0$

PROJECT NUMBER: LA-962A

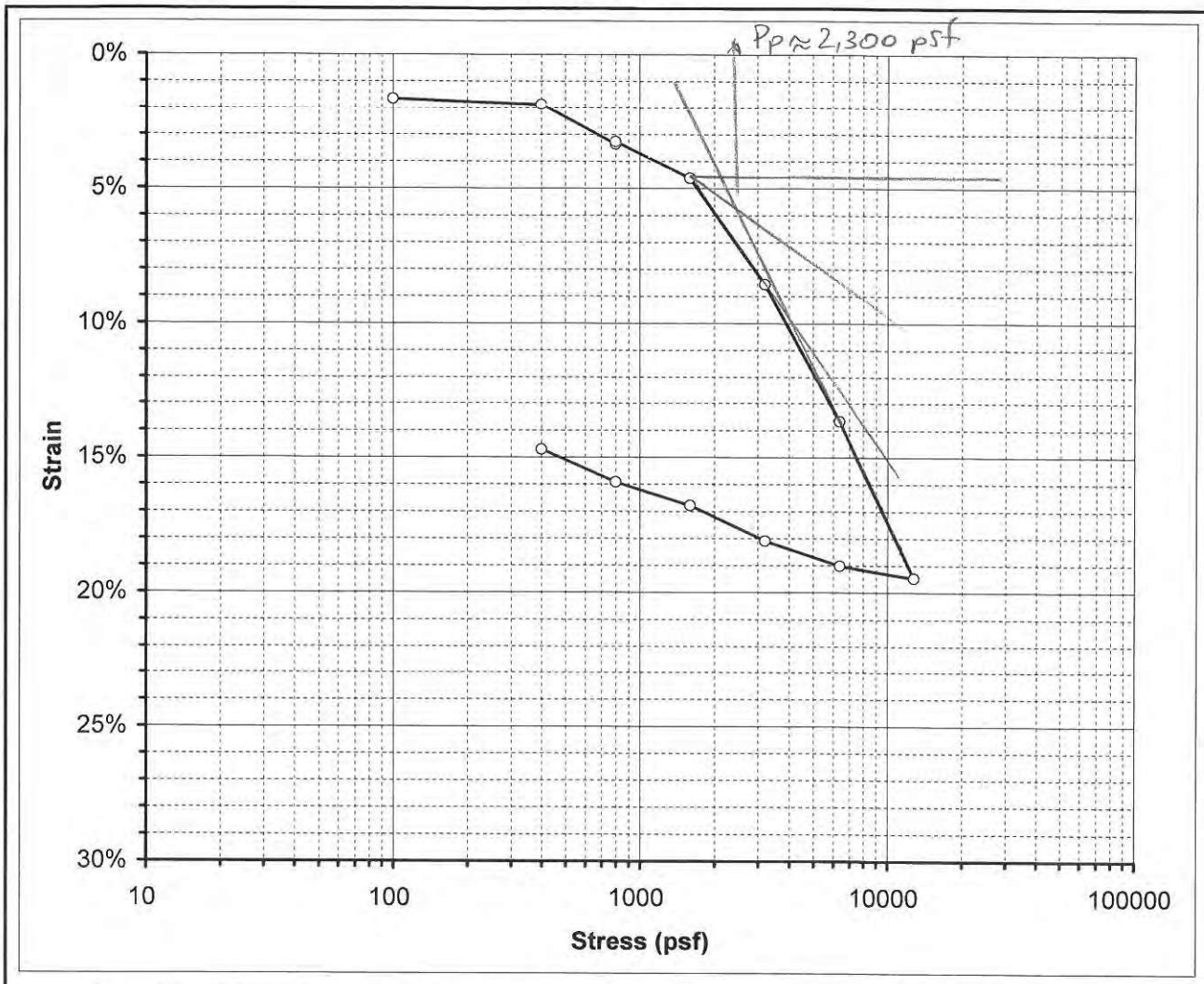
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA CONSULTANTS

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 11-9-12\B-HSA051 R3@5'_2.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW032	Sample Depth	10
Sample No.	R3A	USCS	CH

BEFORE TEST

Initial Moisture Content:	53.5%	
Initial Dry Unit Wt:	69.4	pcf
Initial Total Unit Wt.:	106.6	pcf
Initial Void Ratio:	1.5080	
Initial Degree of Saturation:	99.1%	

AFTER TEST

Final Moisture Content:	44.0%	
Final Dry Unit Wt:	79.8	pcf
Final Total Unit Wt.:	118.1	pcf
Final Void Ratio:	1.1817	
Final Degree of Saturation:	103.9%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=	71	PL=	28	PI=	43

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.65%	1.4667
400	1.87%	1.4612
800	3.35%	1.4239
800	3.26%	1.4262
1600	4.62%	1.3922
3200	8.55%	1.2935
6400	13.65%	1.1656
12800	19.47%	1.0198
6400	19.01%	1.0314
3200	18.09%	1.0543
1600	16.79%	1.0870
800	15.92%	1.1087
400	14.71%	1.1391

$\sigma_v' \approx 1{,}200$ psf OCR ~ 2.0

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

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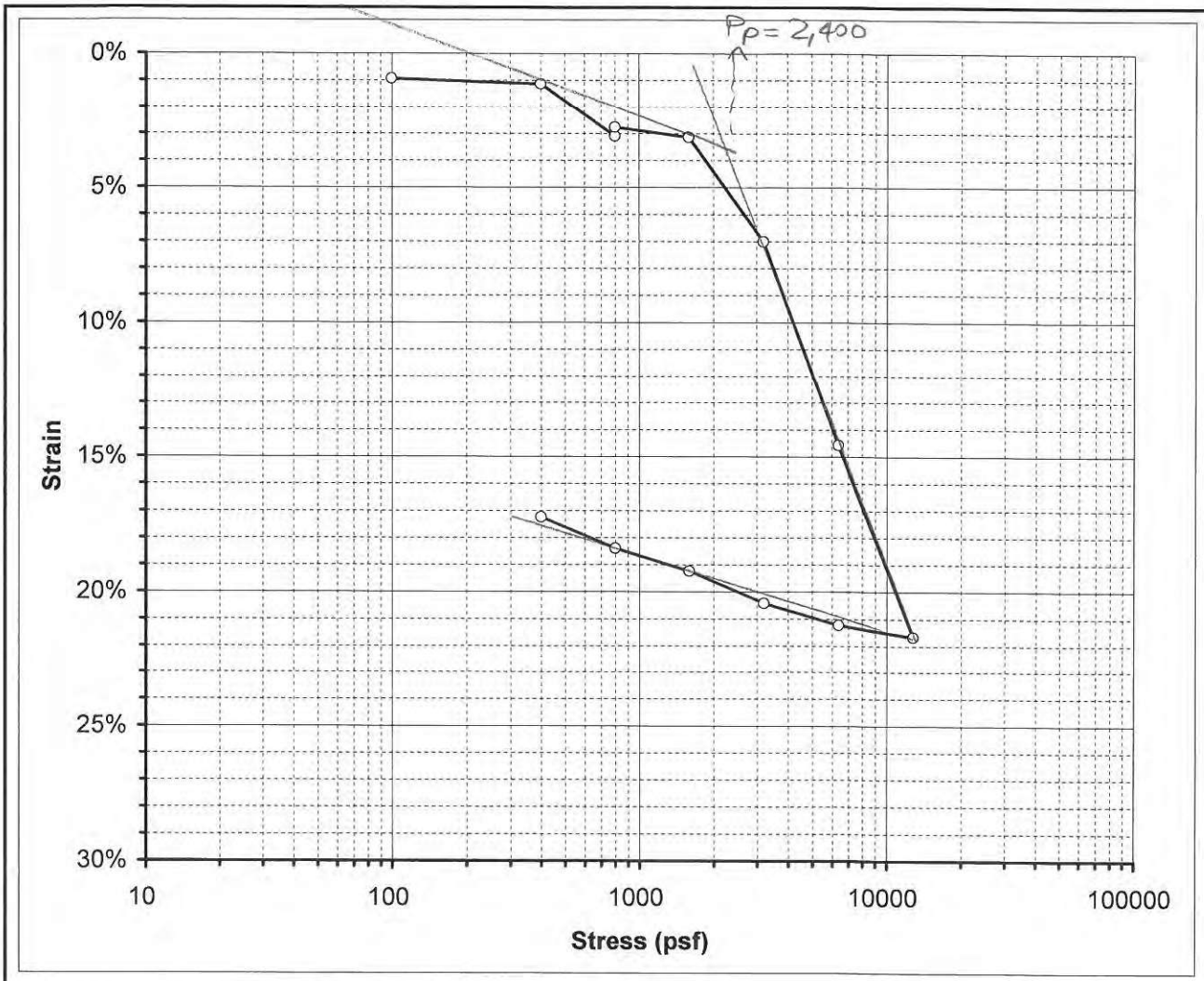
CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW036	Sample Depth	30
Sample No.	R6A	USCS	MH

BEFORE TEST

Initial Moisture Content:	58.8%	
Initial Dry Unit Wt:	64.8	pcf
Initial Total Unit Wt.:	102.9	pcf
Initial Void Ratio:	1.6871	
Initial Degree of Saturation:	97.3%	

AFTER TEST

Final Moisture Content:	46.7%	
Final Dry Unit Wt:	76.3	pcf
Final Total Unit Wt.:	121.1	pcf
Final Void Ratio:	1.2809	
Final Degree of Saturation:	101.6%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' \approx 2{,}400$ OCR ~ 1

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.93%	1.6619
400	1.13%	1.6568
800	3.10%	1.6039
800	2.75%	1.6131
1600	3.14%	1.6028
3200	7.01%	1.4988
6400	14.56%	1.2958
12800	21.67%	1.1048
6400	21.23%	1.1167
3200	20.41%	1.1386
1600	19.24%	1.1702
800	18.39%	1.1929
400	17.24%	1.2239

PROJECT NUMBER: LA-962A

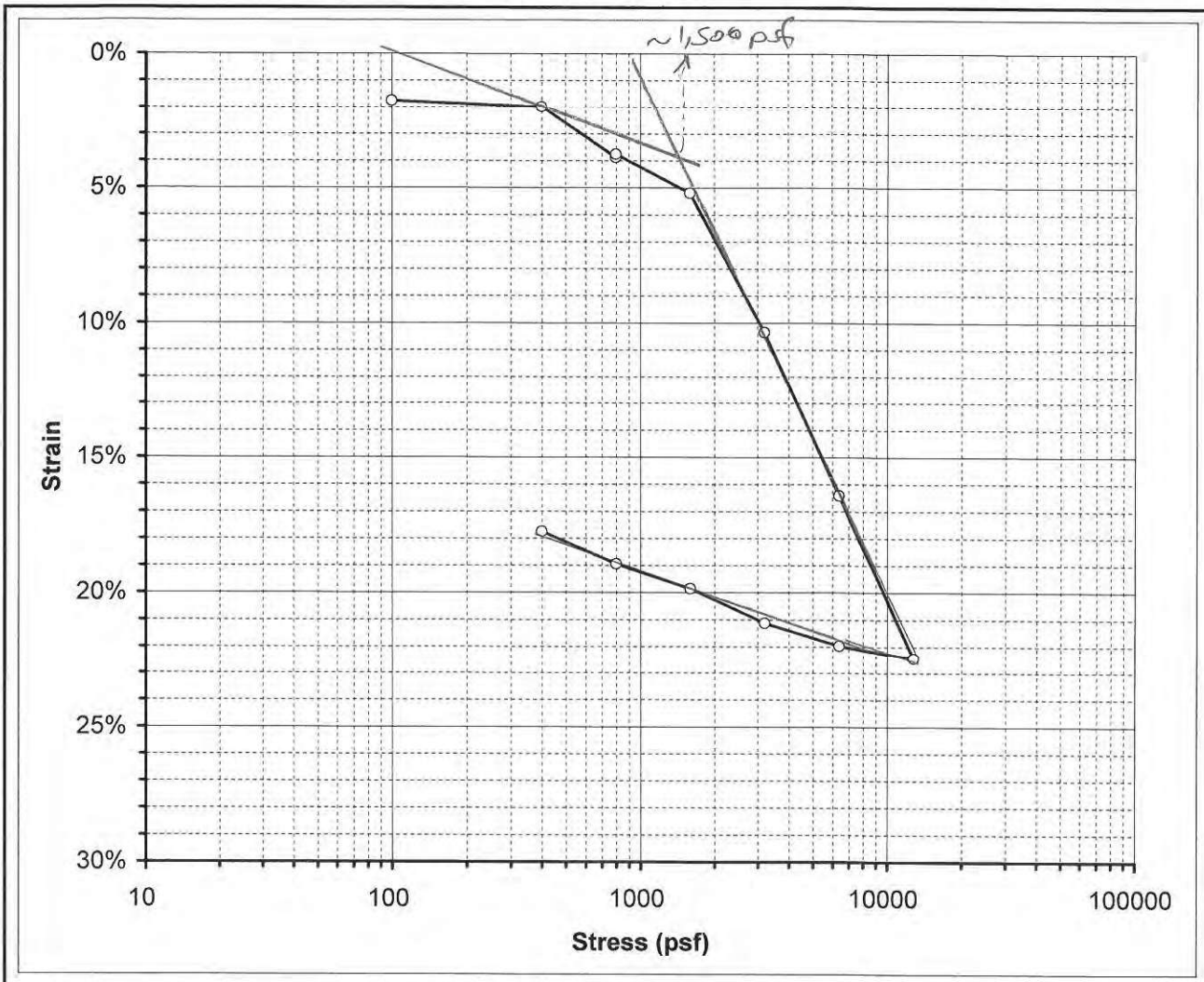
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA CONSULTANTS

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 9-21-12\Consol B-RW036R6A@30'_4.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW036	Sample Depth	10
Sample No.	R2A	USCS	CH

BEFORE TEST

Initial Moisture Content:	51.2%	
Initial Dry Unit Wt:	71.3	pcf
Initial Total Unit Wt.:	107.7	pcf
Initial Void Ratio:	1.4431	
Initial Degree of Saturation:	98.9%	

AFTER TEST

Final Moisture Content:	39.0%	
Final Dry Unit Wt:	84.8	pcf
Final Total Unit Wt.:	122.3	pcf
Final Void Ratio:	1.0521	
Final Degree of Saturation:	103.3%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=	60	PL=	28	PI=	32

$\sigma_v' \approx 1150$ psf OCR ~ 1.3

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.75%	1.4004
400	1.99%	1.3945
800	3.88%	1.3484
800	3.76%	1.3513
1600	5.19%	1.3163
3200	10.35%	1.1902
6400	16.41%	1.0423
12800	22.44%	0.8949
6400	21.97%	0.9064
3200	21.12%	0.9270
1600	19.85%	0.9581
800	18.95%	0.9802
400	17.75%	1.0094

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

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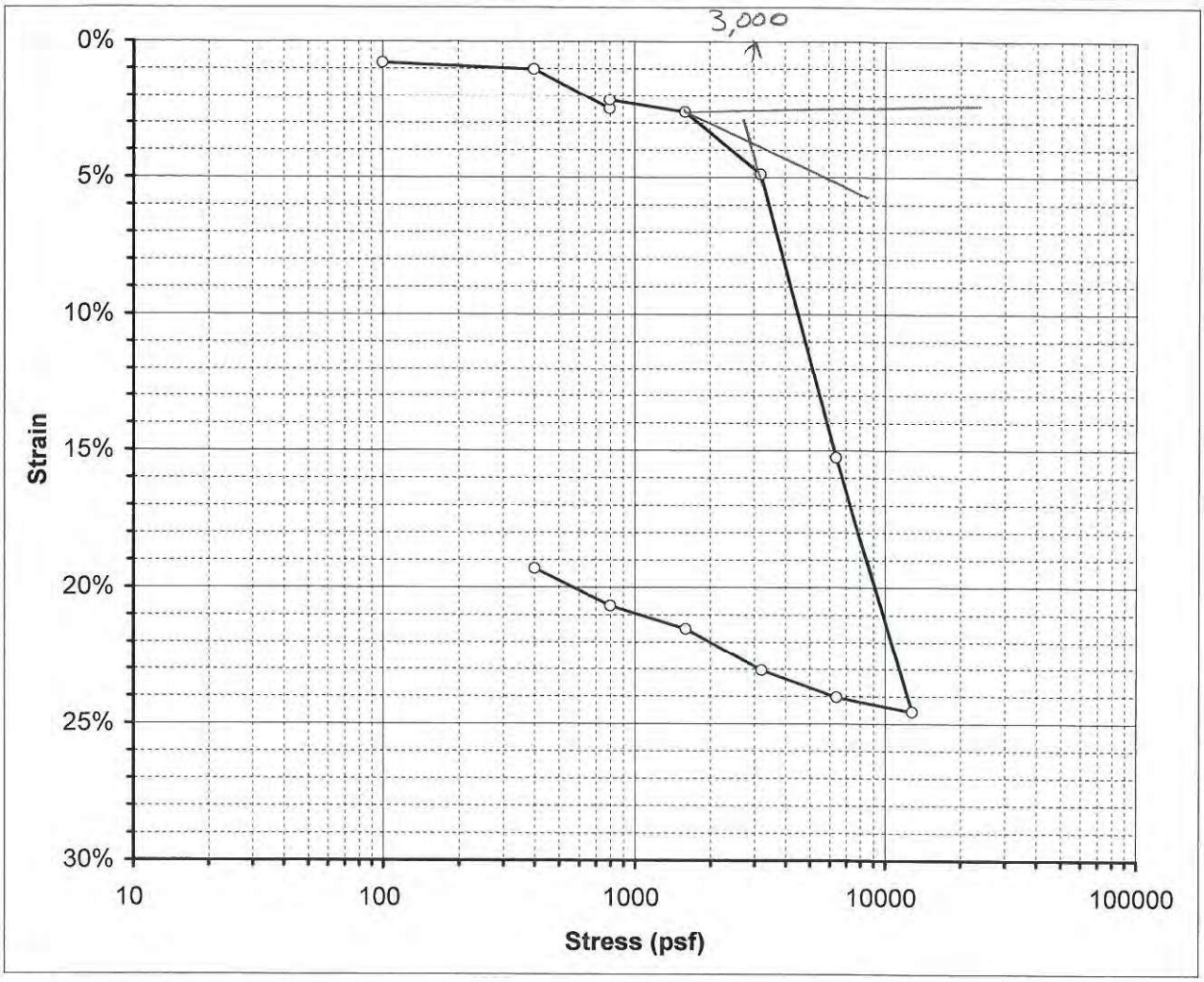
CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW006	Sample Depth	35 ft
Sample No.	R8A	USCS	MH

BEFORE TEST

Initial Moisture Content:	75.0%	
Initial Dry Unit Wt:	56.1	pcf
Initial Total Unit Wt.:	98.2	pcf
Initial Void Ratio:	2.1032	
Initial Degree of Saturation:	99.5%	

AFTER TEST

Final Moisture Content:	59.2%	
Final Dry Unit Wt:	68.1	pcf
Final Total Unit Wt.:	124.1	pcf
Final Void Ratio:	1.5571	
Final Degree of Saturation:	106.1%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=	64	PL=	33	PI=	31

$\sigma_v' \approx 2650$ OCR ~ 1.1

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.78%	2.0790
400	1.02%	2.0716
800	2.48%	2.0263
800	2.16%	2.0362
1600	2.60%	2.0225
3200	4.89%	1.9515
6400	15.25%	1.6300
12800	24.56%	1.3411
6400	24.03%	1.3575
3200	23.04%	1.3882
1600	21.51%	1.4357
800	20.67%	1.4618
400	19.31%	1.5040

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

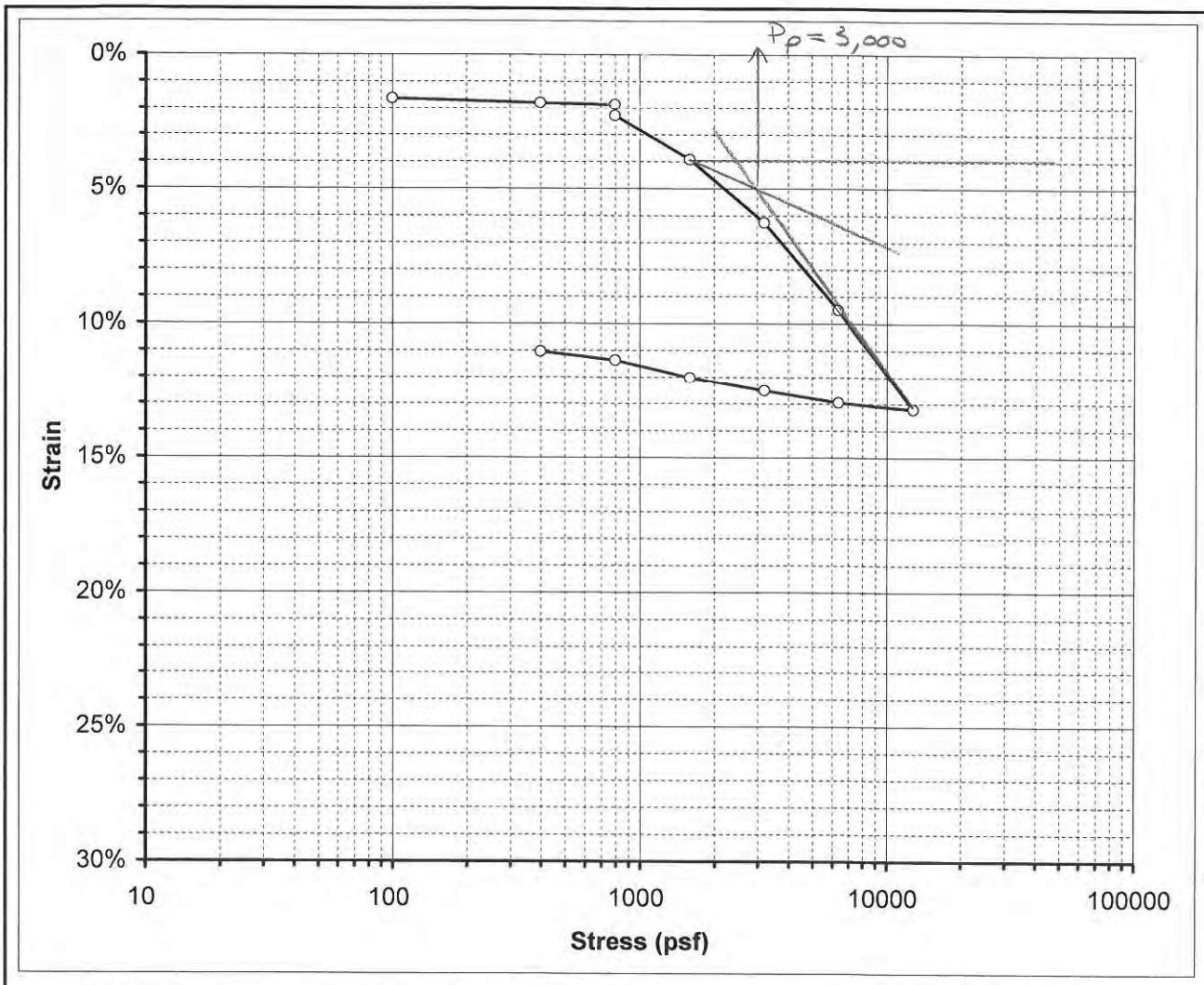
FIGURE NO. B-3

GROUP DELTA

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 9-21-12\Consol A-RW006R8A@35'_1.xls

PLATE H-33

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW044	Sample Depth	55 ft
Sample No.	R11	USCS	0

BEFORE TEST

Initial Moisture Content:	33.3%	
Initial Dry Unit Wt:	88.0	pcf
Initial Total Unit Wt.:	117.3	pcf
Initial Void Ratio:	0.9775	
Initial Degree of Saturation:	95.0%	

AFTER TEST

Final Moisture Content:	27.8%	
Final Dry Unit Wt:	98.4	pcf
Final Total Unit Wt.:	114.5	pcf
Final Void Ratio:	0.7692	
Final Degree of Saturation:	100.9%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' \approx 3{,}500$ psf OCR = 1

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.63%	0.9452
400	1.79%	0.9420
800	1.86%	0.9406
800	2.29%	0.9321
1600	3.92%	0.9000
3200	6.26%	0.8536
6400	9.49%	0.7898
12800	13.21%	0.7163
6400	12.96%	0.7213
3200	12.51%	0.7302
1600	12.02%	0.7397
800	11.36%	0.7528
400	11.04%	0.7591

PROJECT NUMBER: LA-962A

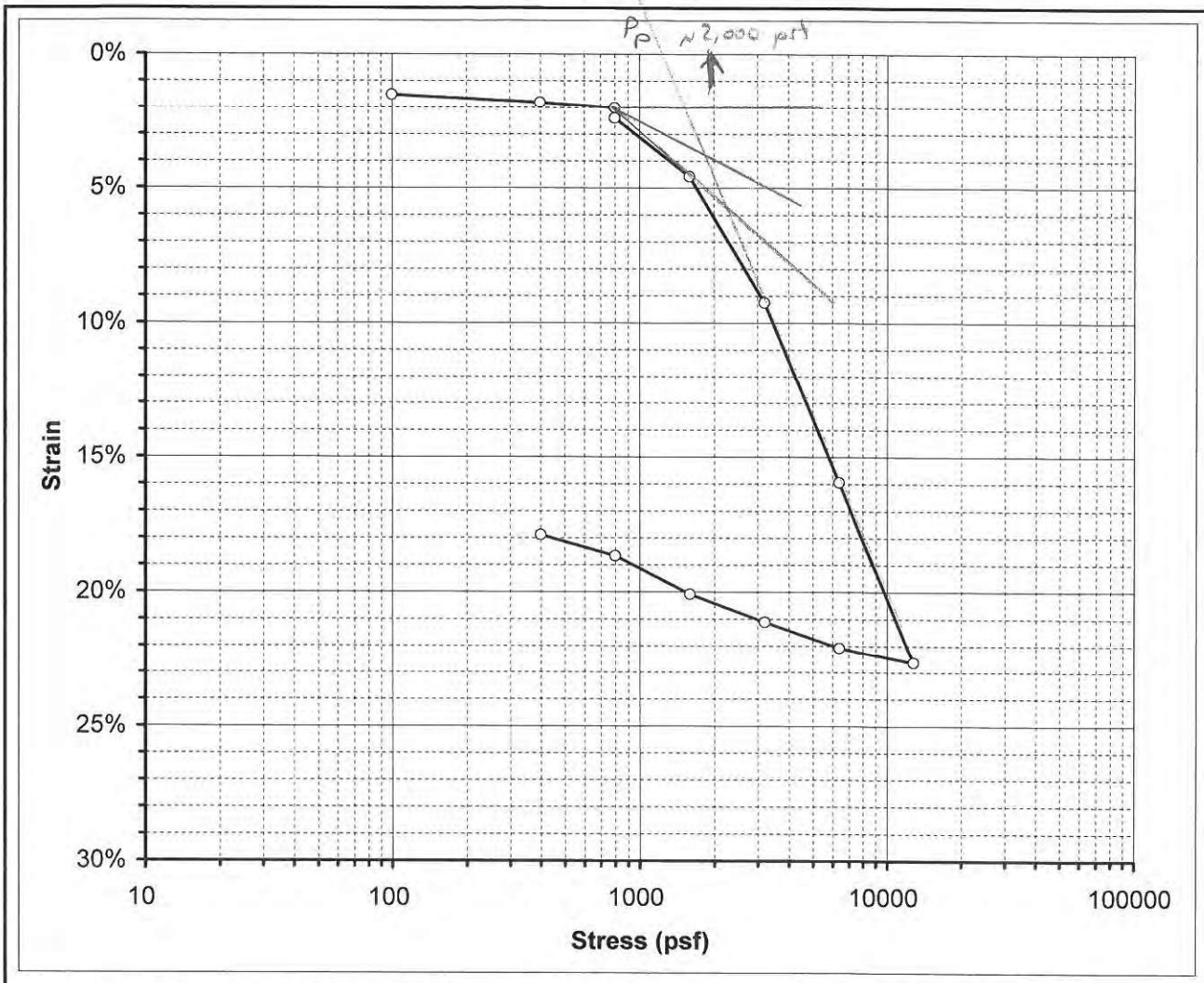
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-3-12\Consol B-RW044R11@55'_4.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW041	Sample Depth	25 ft
Sample No.	R6A	USCS	0

BEFORE TEST

Initial Moisture Content:	58.0%	
Initial Dry Unit Wt:	65.2	pcf
Initial Total Unit Wt.:	103.0	pcf
Initial Void Ratio:	1.6717	
Initial Degree of Saturation:	96.8%	

AFTER TEST

Final Moisture Content:	45.4%	
Final Dry Unit Wt:	78.3	pcf
Final Total Unit Wt.:	122.9	pcf
Final Void Ratio:	1.2229	
Final Degree of Saturation:	103.5%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=	64	PL=	33	PI=	31

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.52%	1.6311
400	1.81%	1.6234
800	2.00%	1.6183
800	2.40%	1.6076
1600	4.57%	1.5496
3200	9.25%	1.4246
6400	15.94%	1.2459
12800	22.63%	1.0671
6400	22.08%	1.0818
3200	21.11%	1.1077
1600	20.08%	1.1353
800	18.67%	1.1729
400	17.89%	1.1938

$\sigma_v' \approx 2{,}100$ psf OCR = 1

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

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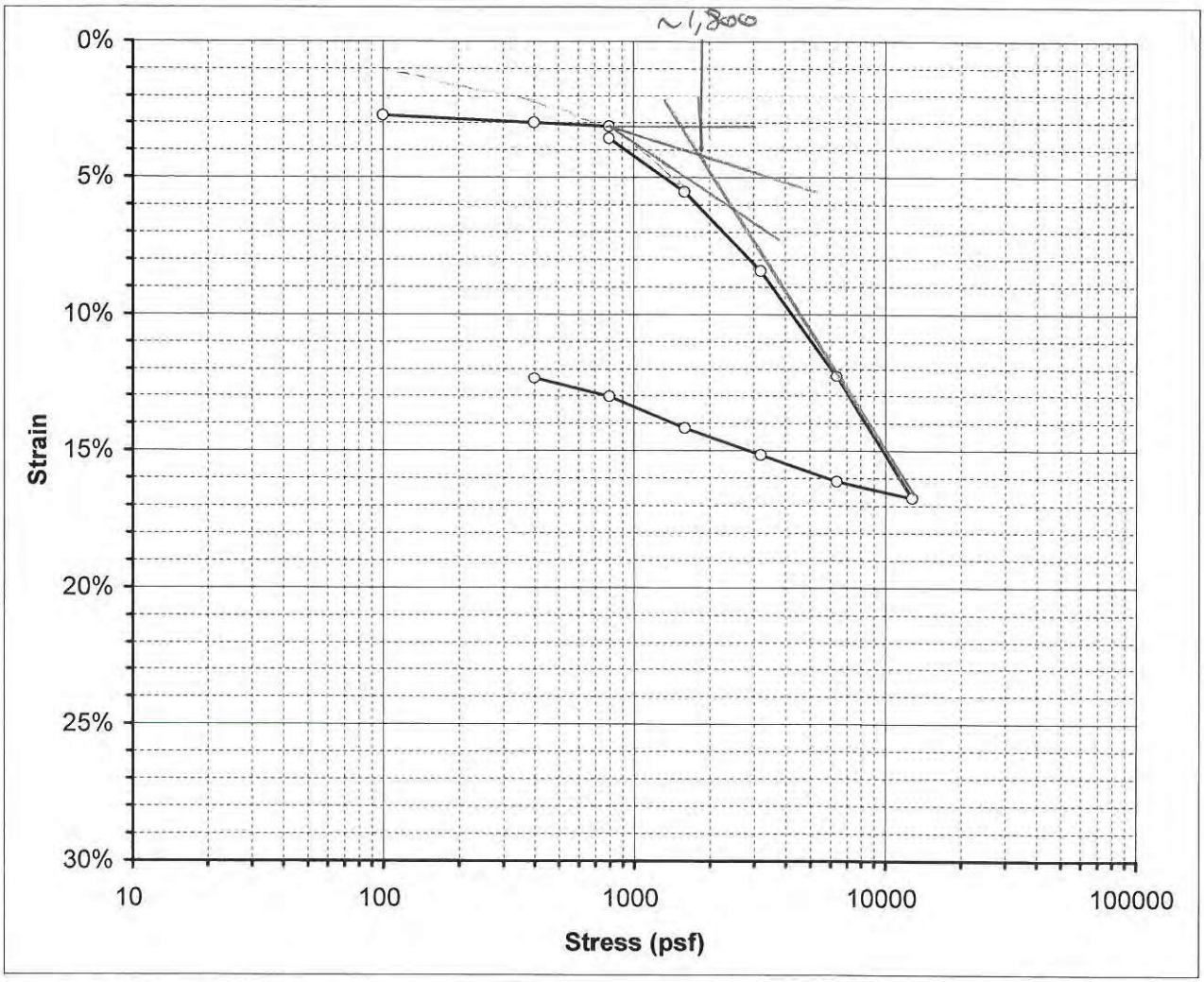
CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	B-RW041	Sample Depth	5 ft
Sample No.	R2A	USCS	0

BEFORE TEST

Initial Moisture Content:	47.4%	
Initial Dry Unit Wt:	75.0	pcf
Initial Total Unit Wt.:	110.6	pcf
Initial Void Ratio:	1.3207	
Initial Degree of Saturation:	100.2%	

AFTER TEST

Final Moisture Content:	39.5%	
Final Dry Unit Wt:	84.4	pcf
Final Total Unit Wt.:	115.2	pcf
Final Void Ratio:	1.0622	
Final Degree of Saturation:	103.7%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' \approx 600$ psf OCR ~ 3

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	2.73%	1.2573
400	3.00%	1.2510
800	3.13%	1.2480
800	3.58%	1.2376
1600	5.53%	1.1925
3200	8.41%	1.1256
6400	12.26%	1.0361
12800	16.72%	0.9328
6400	16.12%	0.9467
3200	15.16%	0.9690
1600	14.18%	0.9915
800	13.03%	1.0183
400	12.35%	1.0341

PROJECT NUMBER: LA-962A

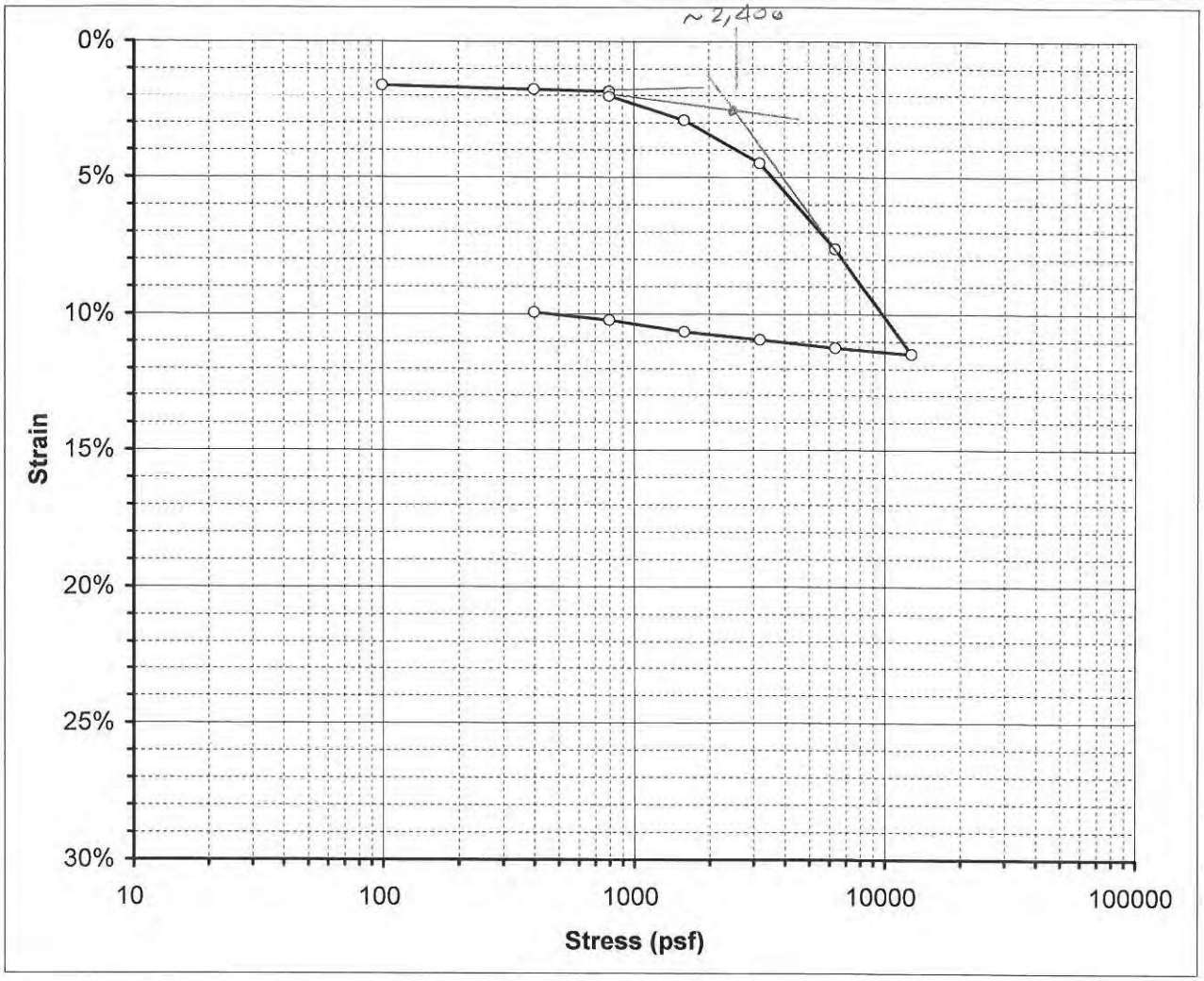
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-3-12\Consol B-RW041R2A@5'_2.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW003	Sample Depth	30 ft
Sample No.	R7A	USCS	0

BEFORE TEST

Initial Moisture Content:	35.6%	
Initial Dry Unit Wt:	85.8	pcf
Initial Total Unit Wt.:	116.3	pcf
Initial Void Ratio:	1.0301	
Initial Degree of Saturation:	96.3%	

AFTER TEST

Final Moisture Content:	30.2%	
Final Dry Unit Wt:	94.4	pcf
Final Total Unit Wt.:	112.8	pcf
Final Void Ratio:	0.8450	
Final Degree of Saturation:	99.6%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' \approx 2400$ OCR ~ 1

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.60%	0.9976
400	1.75%	0.9945
800	1.82%	0.9931
800	2.02%	0.9890
1600	2.92%	0.9709
3200	4.49%	0.9390
6400	7.63%	0.8753
12800	11.45%	0.7976
6400	11.23%	0.8021
3200	10.93%	0.8082
1600	10.64%	0.8141
800	10.22%	0.8226
400	9.94%	0.8283

PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

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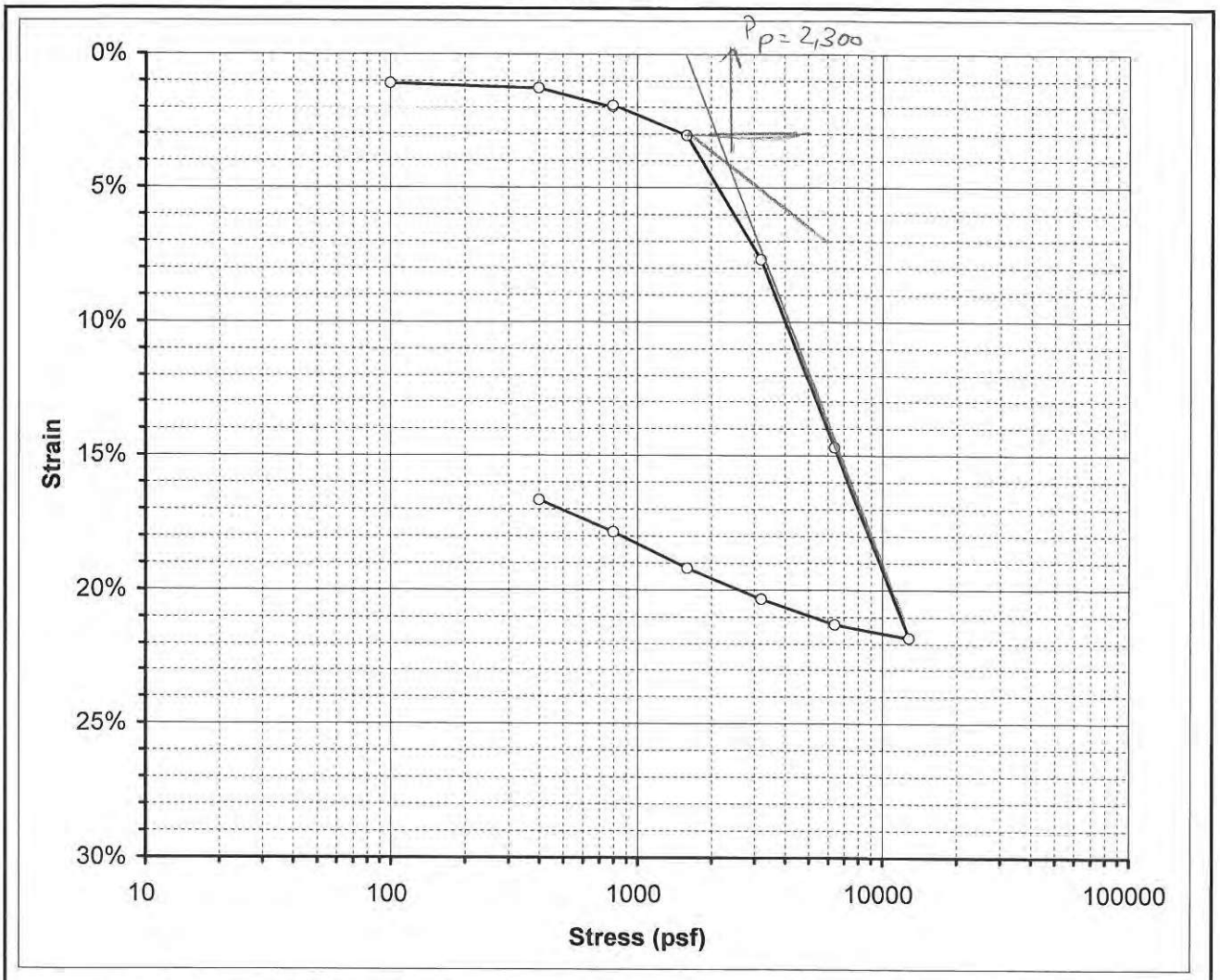
CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW008	Sample Depth	30 ft
Sample No.	R6A	USCS	0

BEFORE TEST

Initial Moisture Content:	62.1%	
Initial Dry Unit Wt:	63.1	pcf
Initial Total Unit Wt.:	102.2	pcf
Initial Void Ratio:	1.7601	
Initial Degree of Saturation:	98.4%	

AFTER TEST

Final Moisture Content:	49.2%	
Final Dry Unit Wt:	74.4	pcf
Final Total Unit Wt.:	120.7	pcf
Final Void Ratio:	1.3389	
Final Degree of Saturation:	102.5%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' \sim 2350$ psf OCR ~ 1.0

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	1.09%	1.7301
400	1.26%	1.7254
800	1.98%	1.7055
800	1.92%	1.7071
1600	3.06%	1.6757
3200	7.68%	1.5482
6400	14.70%	1.3544
12800	21.78%	1.1590
6400	21.28%	1.1728
3200	20.34%	1.1987
1600	19.20%	1.2302
800	17.85%	1.2675
400	16.66%	1.3003

PROJECT NUMBER: LA-962A

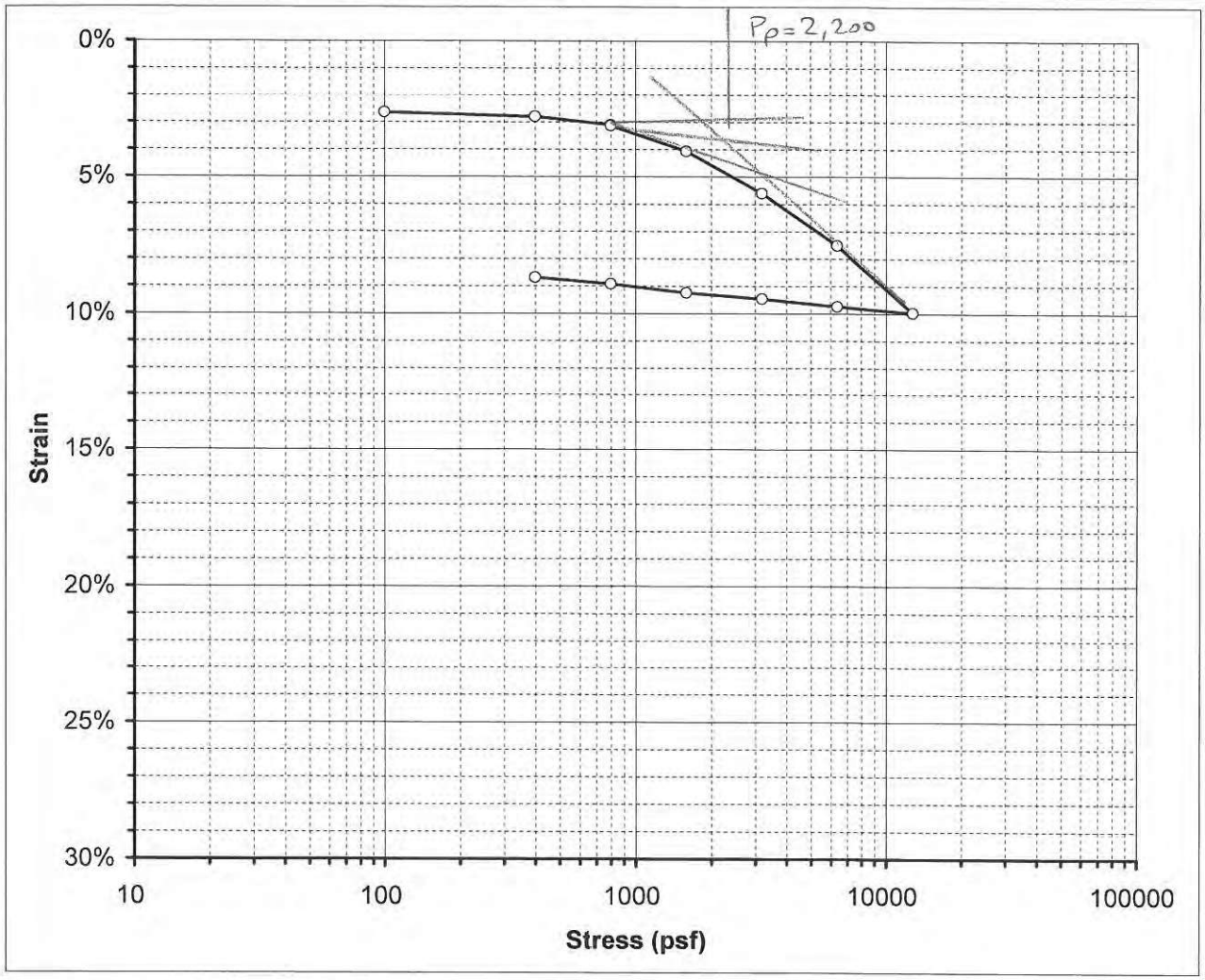
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-17-12\Consol A-RW008R6A@30'_1.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW011	Sample Depth	5
Sample No.	R2	USCS	0

BEFORE TEST

Initial Moisture Content:	35.2%	
Initial Dry Unit Wt:	86.8	pcf
Initial Total Unit Wt.:	117.3	pcf
Initial Void Ratio:	1.0058	
Initial Degree of Saturation:	97.6%	

AFTER TEST

Final Moisture Content:	29.0%	
Final Dry Unit Wt:	94.1	pcf
Final Total Unit Wt.:	114.3	pcf
Final Void Ratio:	0.8507	
Final Degree of Saturation:	95.0%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' \sim 600$ psf OCR ~ 3.5

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	2.65%	0.9526
400	2.80%	0.9495
800	3.10%	0.9435
800	3.13%	0.9429
1600	4.06%	0.9243
3200	5.61%	0.8933
6400	7.52%	0.8550
12800	9.97%	0.8058
6400	9.74%	0.8104
3200	9.46%	0.8159
1600	9.24%	0.8205
800	8.92%	0.8269
400	8.68%	0.8317

PROJECT NUMBER: LA-962A

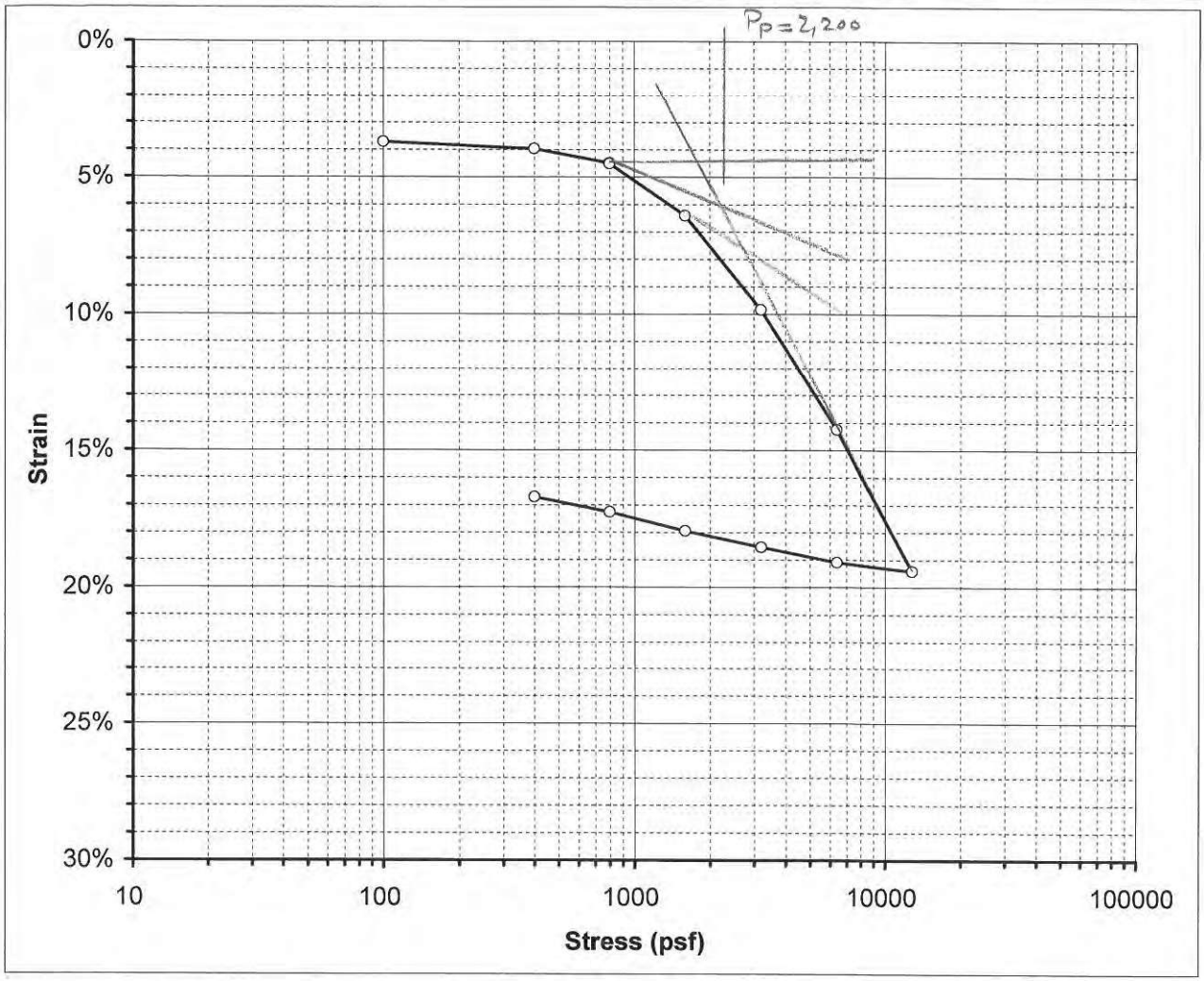
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-17-12\Consol A-RW011R2@5'_2.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW013	Sample Depth	15
Sample No.	R4	USCS	0

BEFORE TEST

Initial Moisture Content:	50.9%	
Initial Dry Unit Wt:	73.3	pcf
Initial Total Unit Wt.:	110.6	pcf
Initial Void Ratio:	1.3750	
Initial Degree of Saturation:	103.3%	

AFTER TEST

Final Moisture Content:	38.6%	
Final Dry Unit Wt:	86.7	pcf
Final Total Unit Wt.:	123.5	pcf
Final Void Ratio:	1.0076	
Final Degree of Saturation:	106.9%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	3.71%	1.2868
400	3.97%	1.2807
800	4.49%	1.2684
800	4.51%	1.2679
1600	6.41%	1.2228
3200	9.84%	1.1414
6400	14.24%	1.0367
12800	19.41%	0.9141
6400	19.09%	0.9216
3200	18.53%	0.9349
1600	17.95%	0.9487
800	17.27%	0.9650
400	16.70%	0.9783

$\sigma_v' \sim 1800$ psf OCR ~ 1.2

PROJECT NUMBER: LA-962A

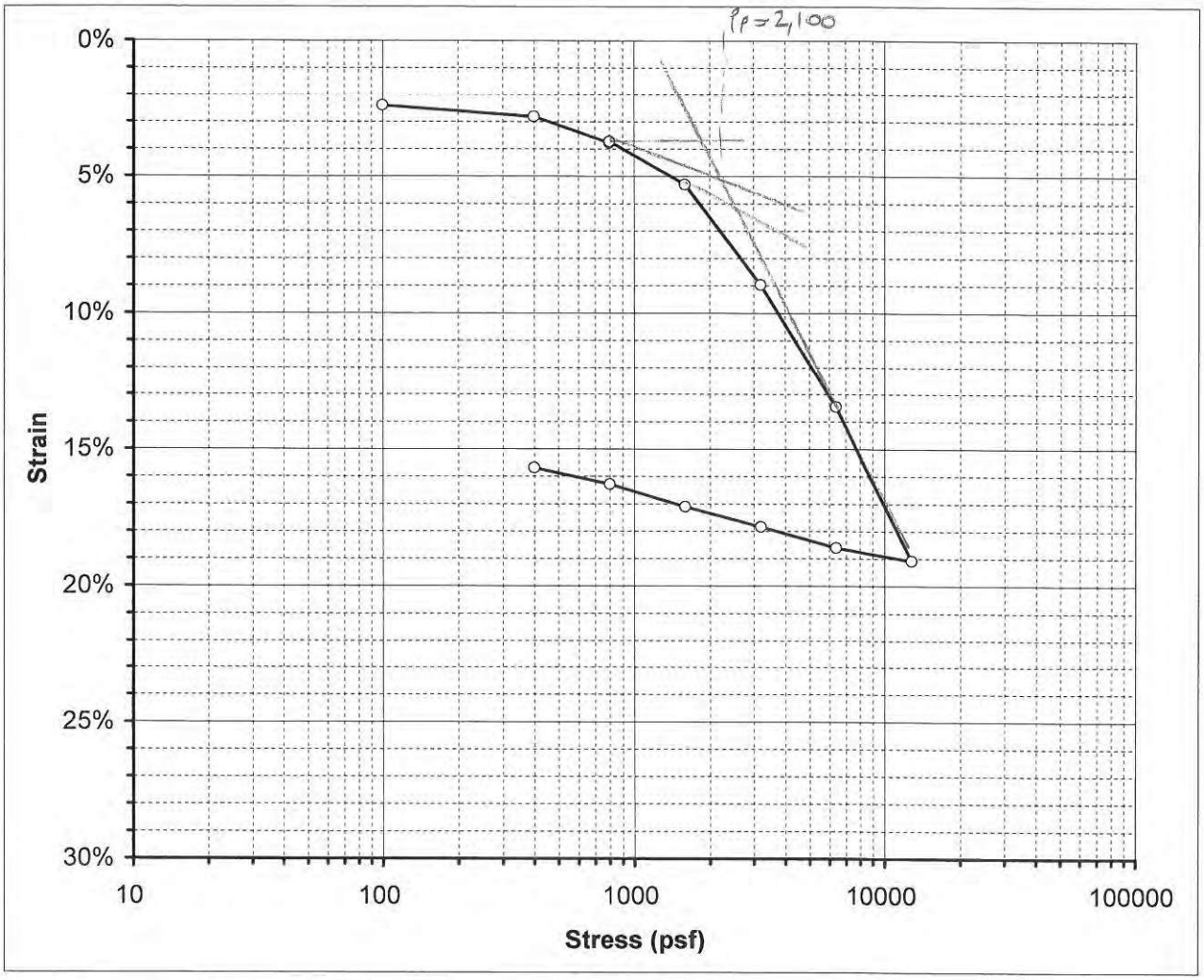
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA CONSULTANTS

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-17-12\Consol A-RW013R4@15'_3.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW049	Sample Depth	15
Sample No.	R4A	USCS	0

BEFORE TEST

Initial Moisture Content:	72.7%	
Initial Dry Unit Wt:	56.2	pcf
Initial Total Unit Wt.:	97.1	pcf
Initial Void Ratio:	2.0975	
Initial Degree of Saturation:	96.7%	

AFTER TEST

Final Moisture Content:	59.5%	
Final Dry Unit Wt:	65.9	pcf
Final Total Unit Wt.:	120.1	pcf
Final Void Ratio:	1.6422	
Final Degree of Saturation:	101.0%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' = 1800$ psf OCR ~ 1.15

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	2.40%	2.0230
400	2.82%	2.0103
800	3.78%	1.9805
800	3.73%	1.9820
1600	5.30%	1.9333
3200	8.96%	1.8200
6400	13.45%	1.6810
12800	19.08%	1.5065
6400	18.60%	1.5214
3200	17.84%	1.5450
1600	17.10%	1.5677
800	16.28%	1.5931
400	15.69%	1.6114

PROJECT NUMBER: LA-962A

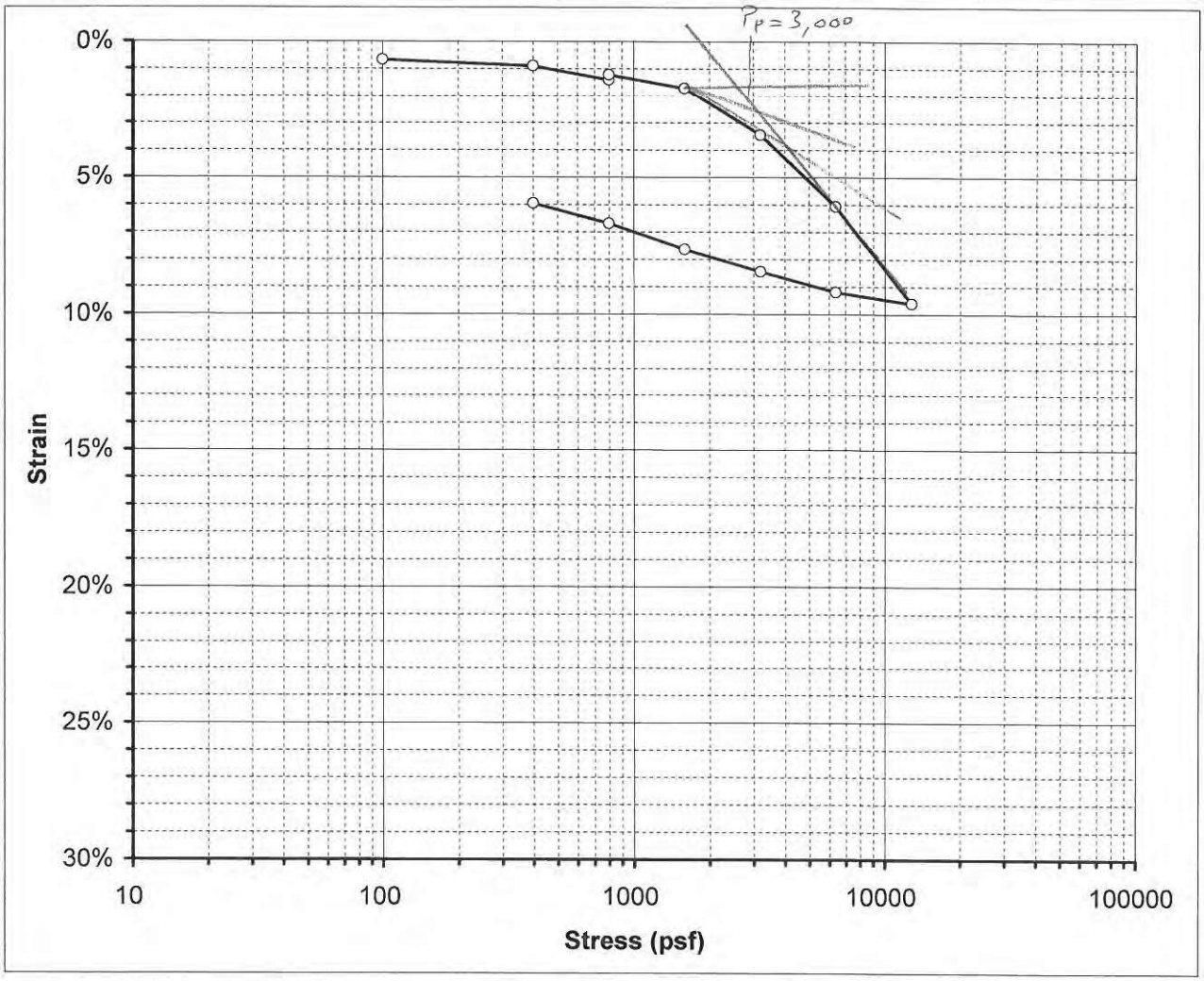
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-17-12\Consol A-RW049R4A@15'_4.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW005	Sample Depth	5 ft
Sample No.	R1	USCS	0

BEFORE TEST

Initial Moisture Content:	37.4%	
Initial Dry Unit Wt:	82.0	pcf
Initial Total Unit Wt.:	112.7	pcf
Initial Void Ratio:	1.1234	
Initial Degree of Saturation:	92.9%	

AFTER TEST

Final Moisture Content:	36.4%	
Final Dry Unit Wt:	86.5	pcf
Final Total Unit Wt.:	110.1	pcf
Final Void Ratio:	1.0129	
Final Degree of Saturation:	100.2%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.66%	1.1093
400	0.90%	1.1043
800	1.41%	1.0935
800	1.21%	1.0976
1600	1.71%	1.0870
3200	3.45%	1.0501
6400	6.06%	0.9947
12800	9.60%	0.9195
6400	9.19%	0.9281
3200	8.44%	0.9442
1600	7.63%	0.9613
800	6.69%	0.9812
400	5.96%	0.9968

$\sigma_v' \sim 600$ psf OCR ~ 5.0

PROJECT NUMBER: LA-962A

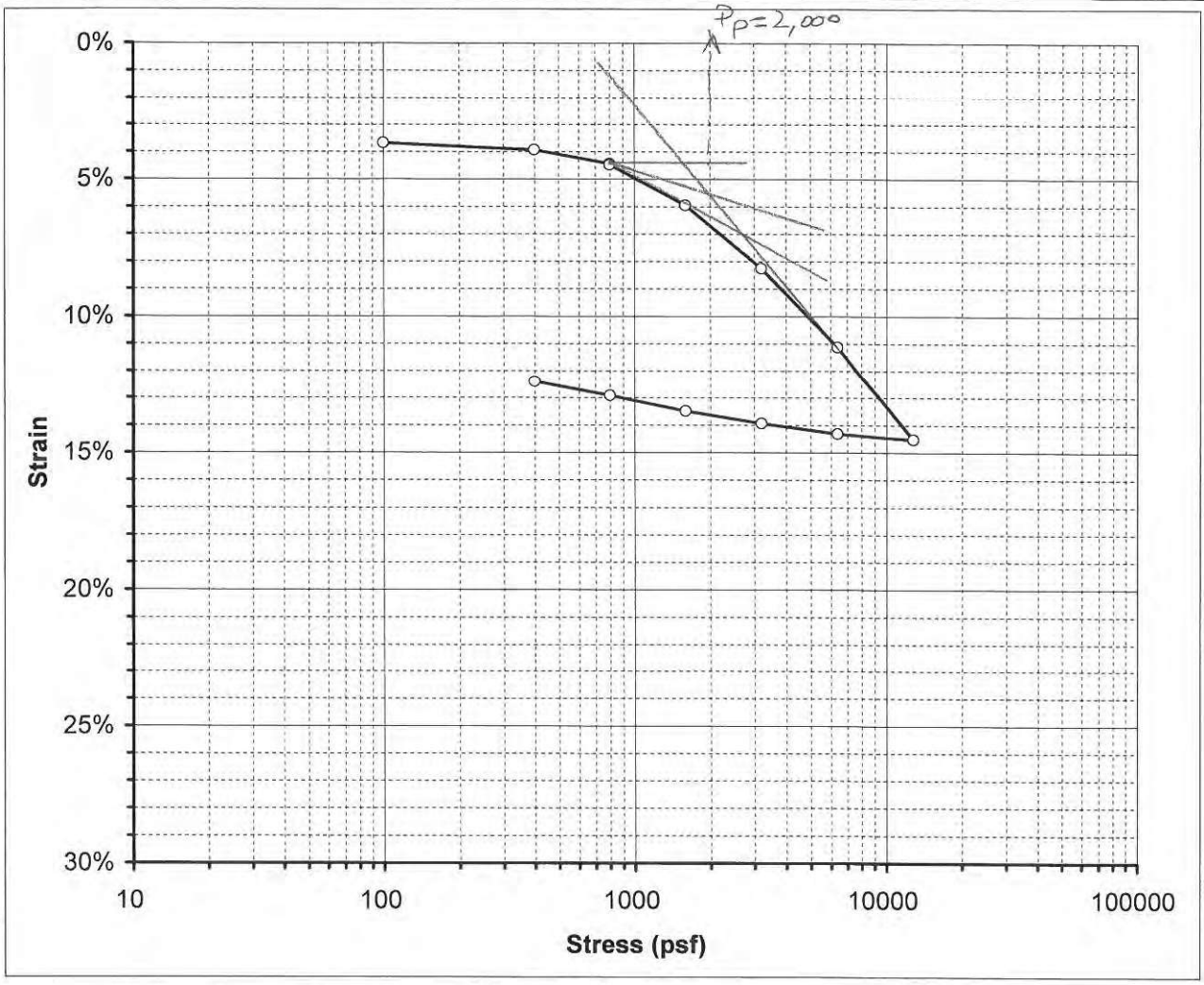
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-30-12\A-RW005 R1@5'_3.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW005	Sample Depth	15 ft
Sample No.	R3	USCS	0

BEFORE TEST

Initial Moisture Content:	43.7%	
Initial Dry Unit Wt:	77.9	pcf
Initial Total Unit Wt.:	111.9	pcf
Initial Void Ratio:	1.2358	
Initial Degree of Saturation:	98.7%	

AFTER TEST

Final Moisture Content:	35.5%	
Final Dry Unit Wt:	87.5	pcf
Final Total Unit Wt.:	115.5	pcf
Final Void Ratio:	0.9895	
Final Degree of Saturation:	100.0%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' \approx 1{,}800$ OCR ~ 1.1

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	3.68%	1.1536
400	3.93%	1.1480
800	4.43%	1.1367
800	4.47%	1.1358
1600	5.95%	1.1028
3200	8.25%	1.0513
6400	11.13%	0.9871
12800	14.52%	0.9111
6400	14.31%	0.9158
3200	13.94%	0.9242
1600	13.48%	0.9345
800	12.91%	0.9471
400	12.39%	0.9588

PROJECT NUMBER: LA-962A

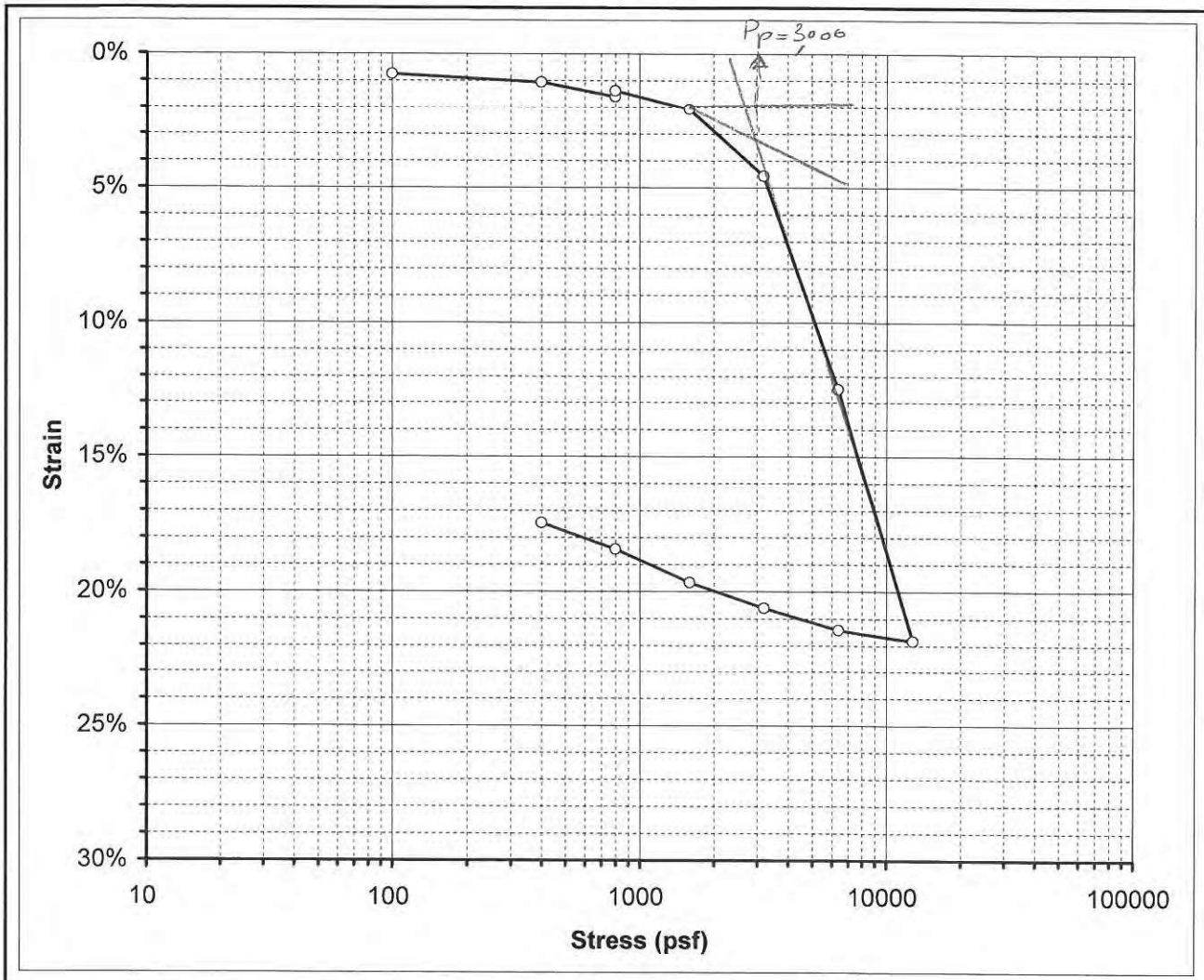
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA CONSULTANTS

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-30-12\A-RW005 R3@15'_4.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW049	Sample Depth	25 ft
Sample No.	R6A	USCS	0

BEFORE TEST

Initial Moisture Content:	64.3%	
Initial Dry Unit Wt:	60.4	pcf
Initial Total Unit Wt.:	99.2	pcf
Initial Void Ratio:	1.8822	
Initial Degree of Saturation:	95.2%	

AFTER TEST

Final Moisture Content:	50.8%	
Final Dry Unit Wt:	72.4	pcf
Final Total Unit Wt.:	122.8	pcf
Final Void Ratio:	1.4048	
Final Degree of Saturation:	100.8%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

$\sigma_v' = 2,200$ psf OCR ~ 1.3

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.75%	1.8605
400	1.05%	1.8518
800	1.59%	1.8362
800	1.37%	1.8426
1600	2.07%	1.8224
3200	4.57%	1.7505
6400	12.51%	1.5217
12800	21.82%	1.2532
6400	21.42%	1.2647
3200	20.60%	1.2884
1600	19.66%	1.3155
800	18.44%	1.3508
400	17.45%	1.3791

PROJECT NUMBER: LA-962A

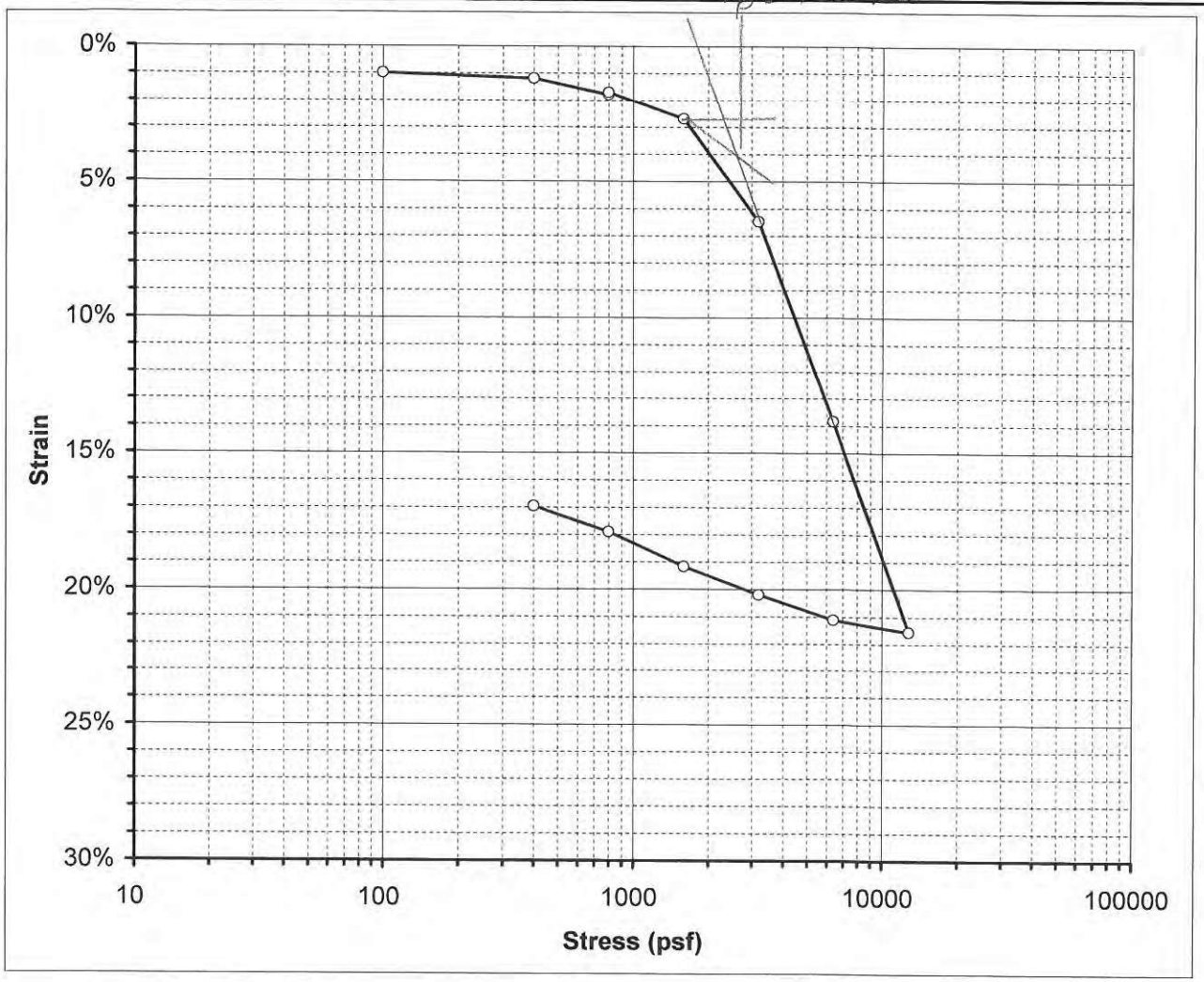
PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

GROUP DELTA

N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-30-12\A-RW049 R6A@25'_1.xls

CONSOLIDATION TEST RESULTS
ASTM D-2435



Boring No.	A-RW053	Sample Depth	10 ft
Sample No.	R2A	USCS	0

BEFORE TEST

Initial Moisture Content:	59.5%	
Initial Dry Unit Wt:	63.9	pcf
Initial Total Unit Wt.:	101.8	pcf
Initial Void Ratio:	1.7261	
Initial Degree of Saturation:	96.1%	

AFTER TEST

Final Moisture Content:	47.6%	
Final Dry Unit Wt:	76.2	pcf
Final Total Unit Wt.:	122.1	pcf
Final Void Ratio:	1.2845	
Final Degree of Saturation:	103.4%	

Water Added at: 800 psf

ATTERBERG LIMITS					
LL=		PL=		PI=	

PRESSURE (psf)	SAMPLE STRAIN	VOID RATIO
100	0.98%	1.6993
400	1.19%	1.6937
800	1.79%	1.6773
800	1.71%	1.6795
1600	2.69%	1.6528
3200	6.47%	1.5498
6400	13.84%	1.3488
12800	21.56%	1.1384
6400	21.12%	1.1504
3200	20.20%	1.1755
1600	19.16%	1.2038
800	17.90%	1.2382
400	16.96%	1.2638

$\sigma_v' \approx 1{,}200$ OCR ~ 2.0

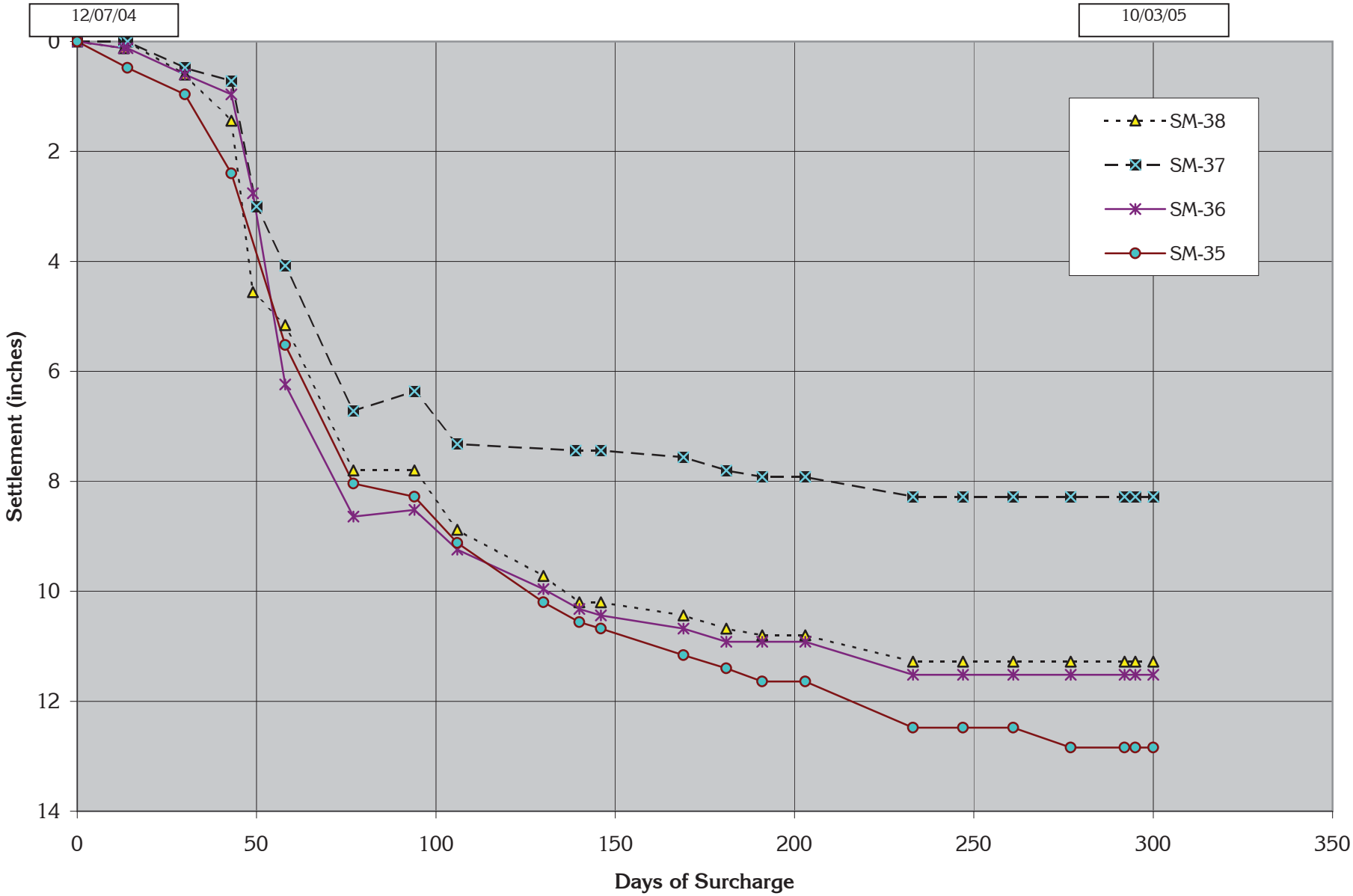
PROJECT NUMBER: LA-962A

PROJECT NAME: Ballona Wetlands

FIGURE NO. B-3

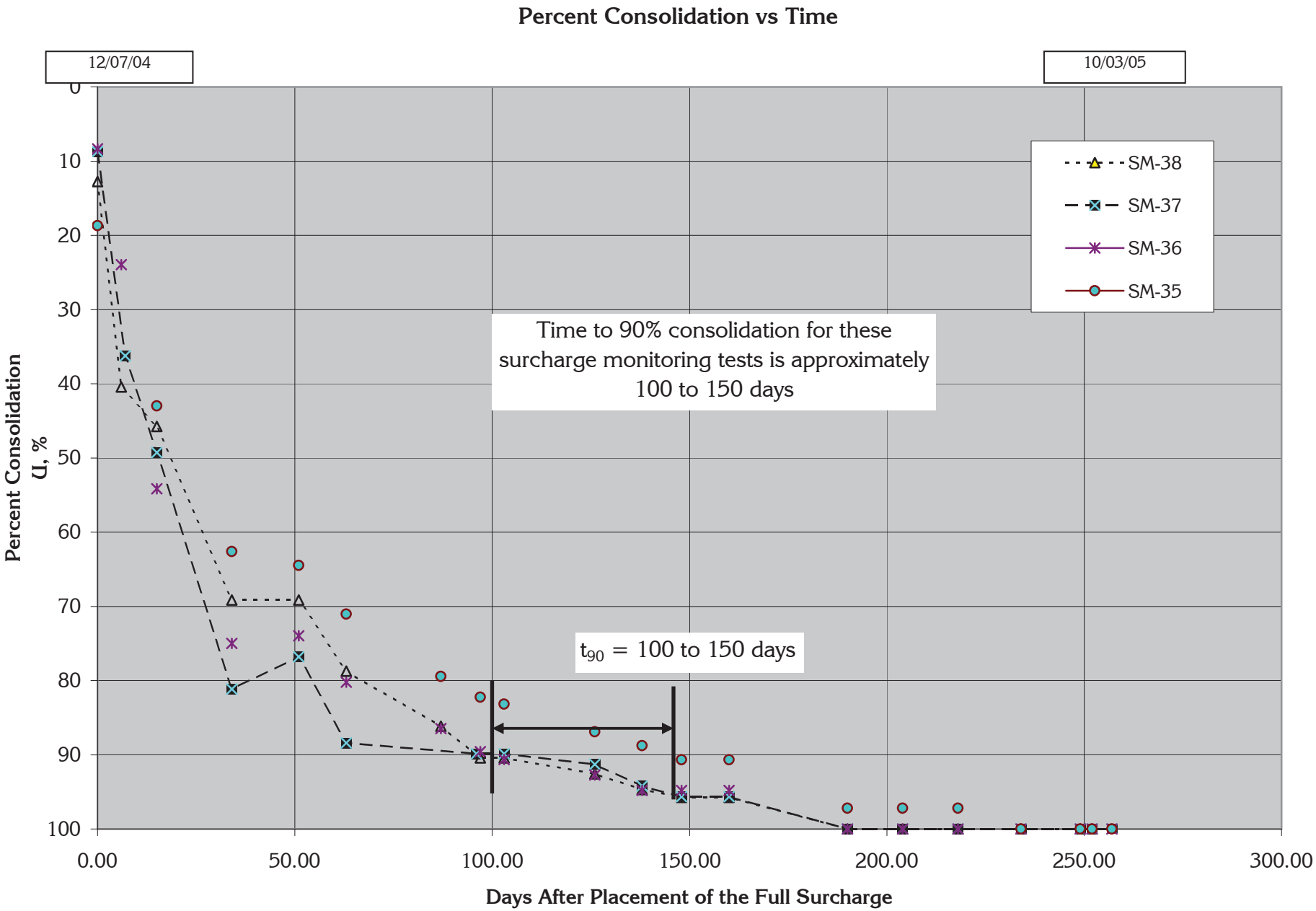
N:\Projects\900-999\L-962 Jones and Stokes - Ballona Wetland Conceptal geotech\Lab\Consol LA962A 10-30-12\A-RW053 R2A@10'_2.xls

Playa Vista Area D2 Surcharge Settlement Lots 1-6



Group Delta Consultants, Inc.

PLATE H-46



Group Delta Consultants, Inc.

PLATE H-47

APPENDIX I
EXTENTS OF REMOVAL AND RECOMPACTION UNDER LEVEES

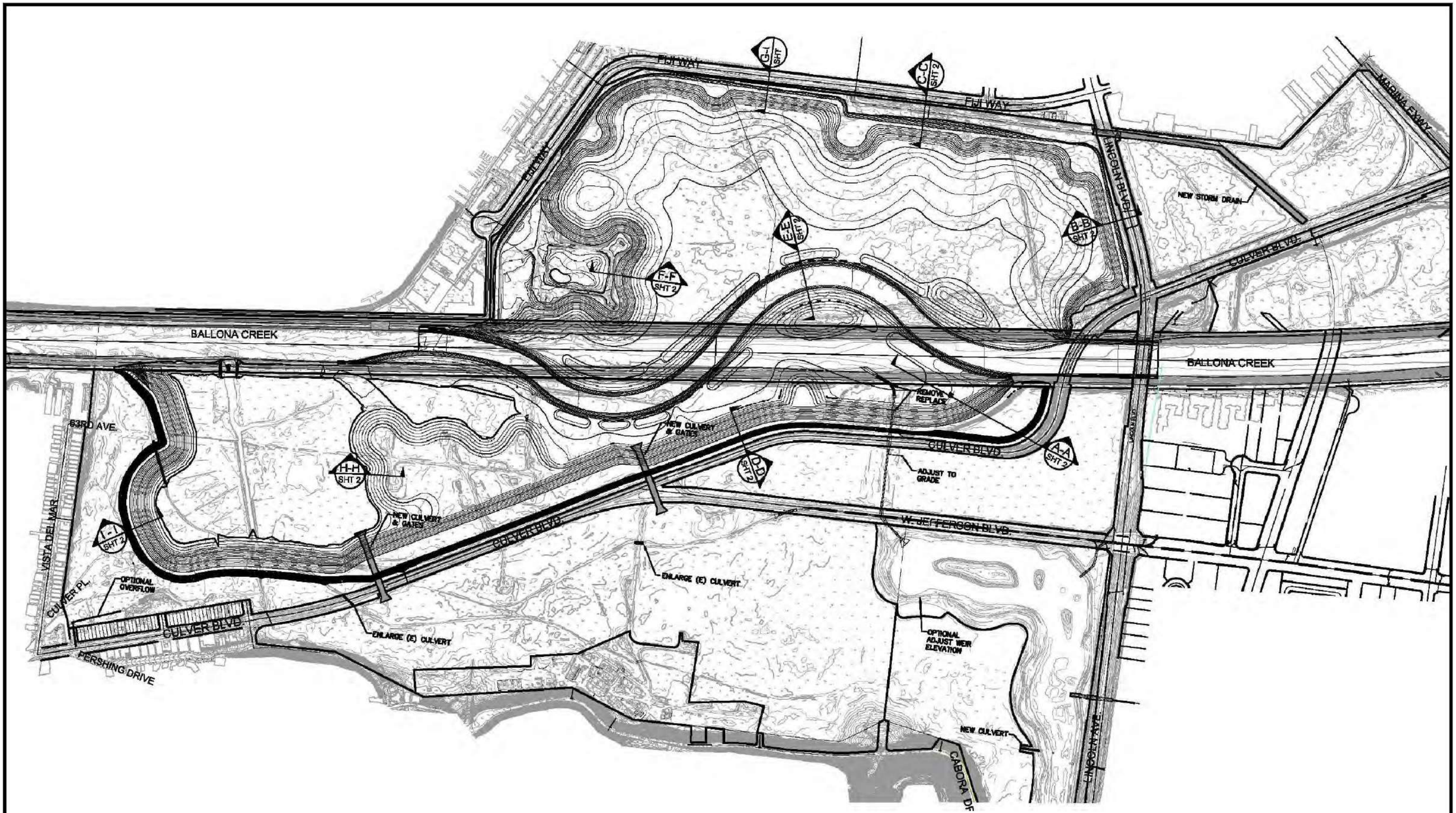
APPENDIX I
EXTENTS OF REMOVAL AND RECOMPACTION UNDER LEVEES

I.1 Contents

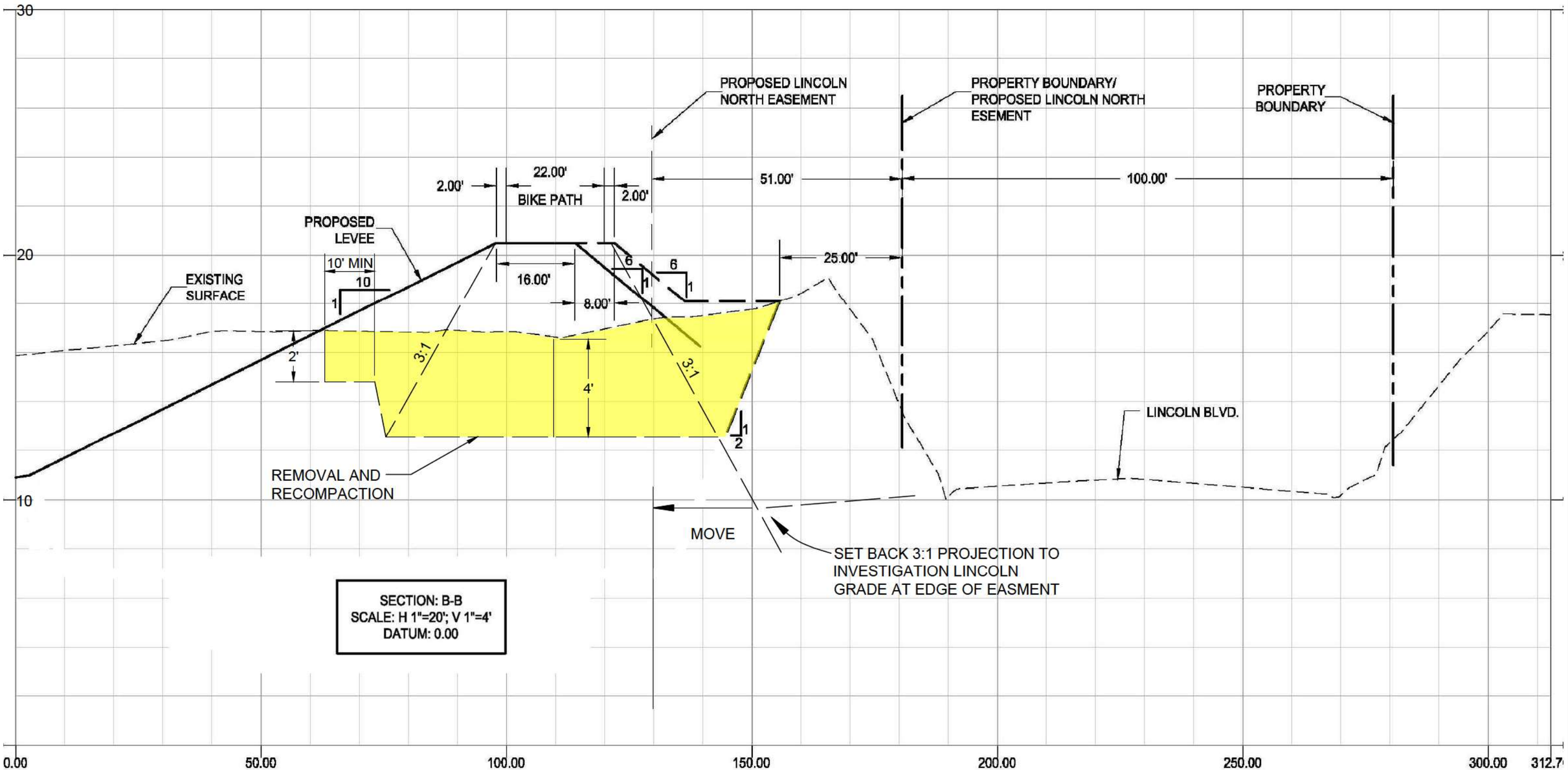
Prior to placement of compacted fill for the new levees, the subgrade soils along the levee alignments should be excavated and recompacted. Under the levee "core" the removals should extend to a minimum depth of 4 feet below the existing grade, while beyond the core, the removals should extend to a minimum depth of 1 feet. The actual limits for removals should be determined by the project geotechnical engineer during construction. The extents of removal and recompaction are shown graphically in this appendix for a number of cross sections.

A list of the plates presented in this appendix follows:

Plate I-1 Ballona Creek Levee Cross Sections Exhibit for Removals
Plate I-2 Extents of Removal and Recompaction (Section B-B)
Plate I-3 Extents of Removal and Recompaction (Sections C-C and D-D)
Plate I-4 Extents of Removal and Recompaction (Sections H-H, I-I and G-G)

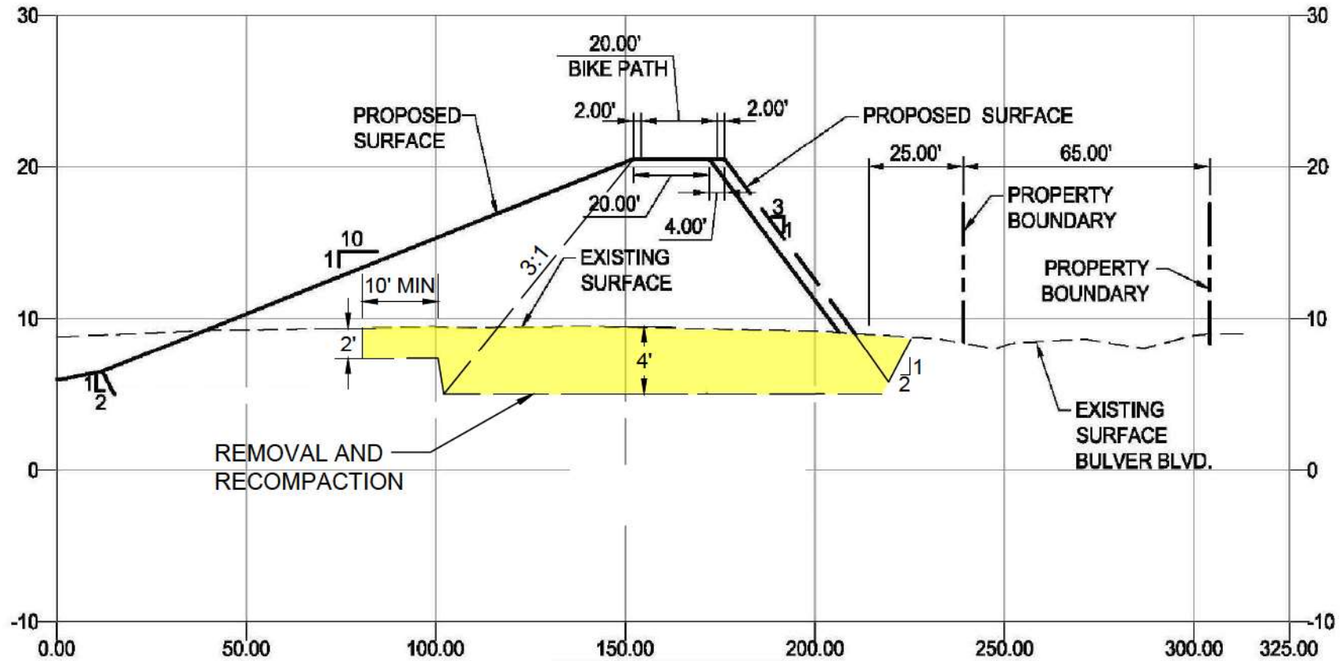


DATE: 3/14/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	BALLONA CREEK LEVEE CROSS SECTIONS EXHIBIT FOR REMOVALS	PROJECT NUMBER: L962A
REVISION: --	APPROVED BY: P. Kashighandi				SCALE: NO SCALE
REVISION: --	E-949			BALLONA WETLANDS RESTORATION PROJECT LOS ANGELES, CA	PLATE NUMBER: I-1

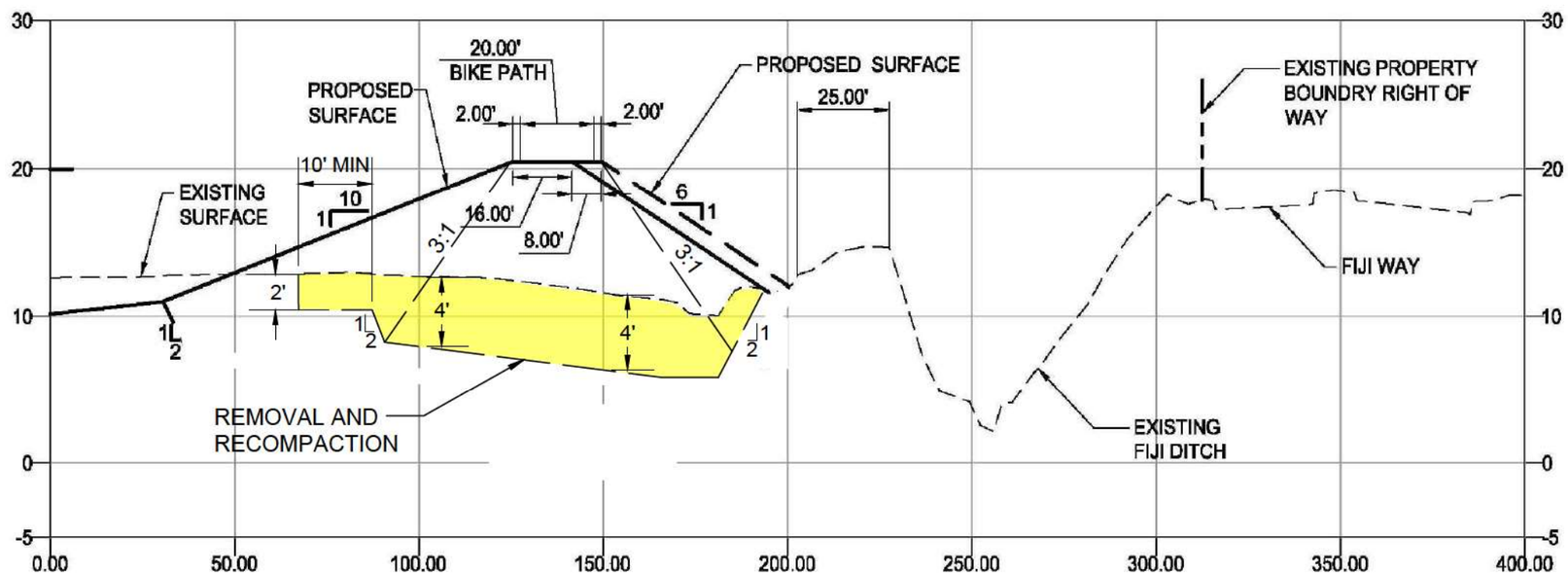


DATE: 6/28/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	EXTENTS OF REMOVAL AND RECOMPACTION (SECTION B-B)
REVISION: --	APPROVED BY: P. Kashighandi			BALLONA WETLANDS RESTORATION PROJECT LOS ANGELES, CA
REVISION: --	E-950			

PROJECT NUMBER: L962A
SCALE: NO SCALE
PLATE NUMBER: I-2



SECTION D-D
SCALE: H 1"=40'; V 1"=10'



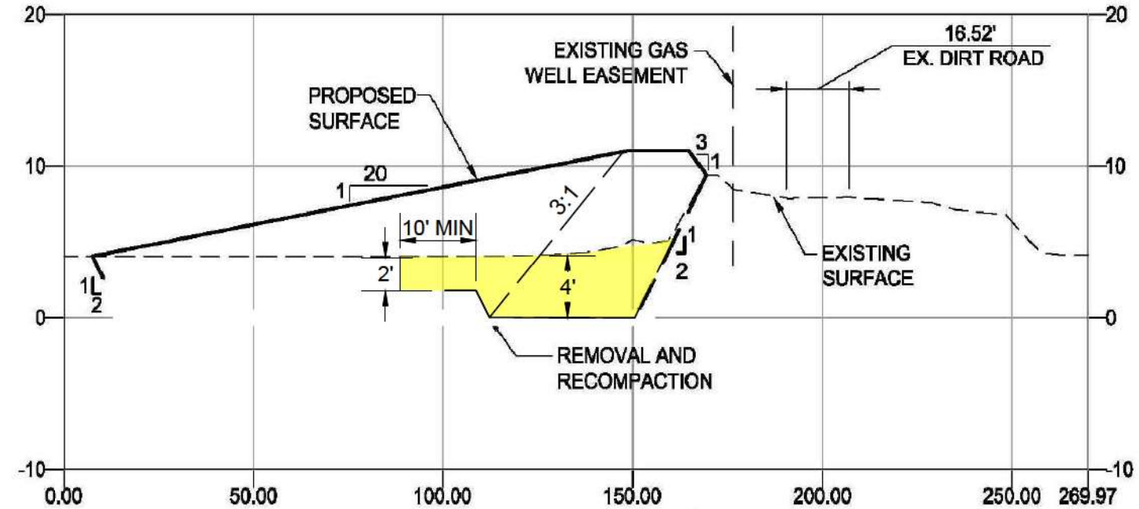
SECTION C-C
SCALE: H 1"=40'; V 1"=10'

DATE: 6/28/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	EXTENTS OF REMOVAL AND RECOMPACTION (SECTIONS C-C & D-D)	PROJECT NUMBER: L962A
REVISION: --	APPROVED BY: P. Kashighandi			BALLONA WETLANDS RESTORATION PROJECT LOS ANGELES, CA	SCALE: NO SCALE
REVISION: --	E-951				PLATE NUMBER: I-3

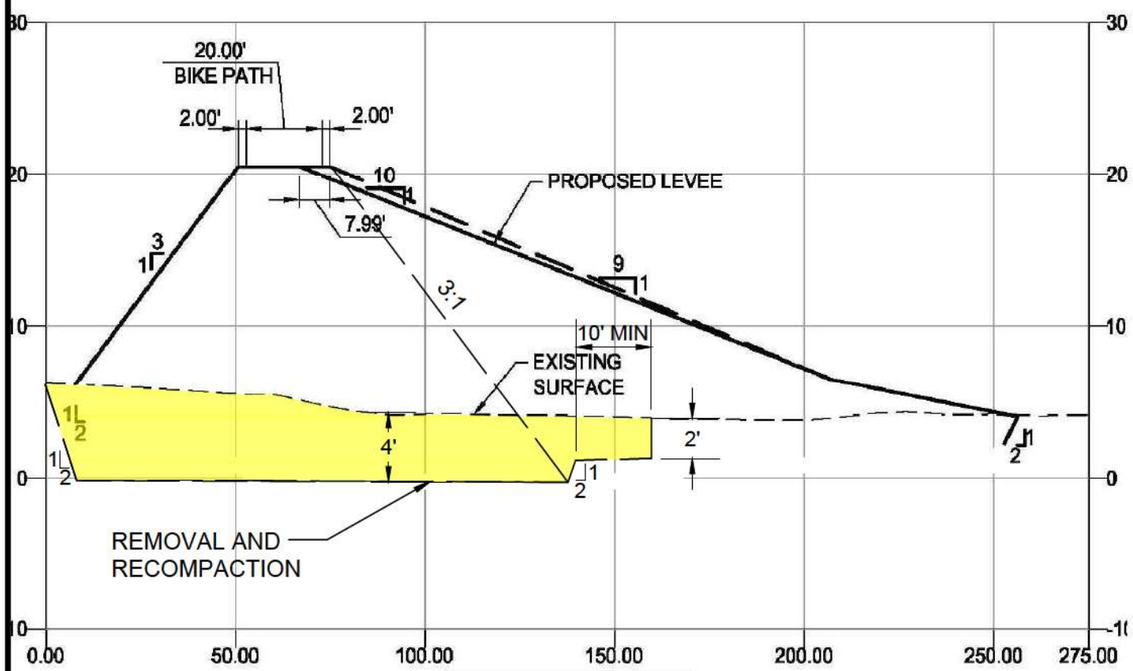
WEST AREA B

ANTICIPATE DEEPER REMOVALS:

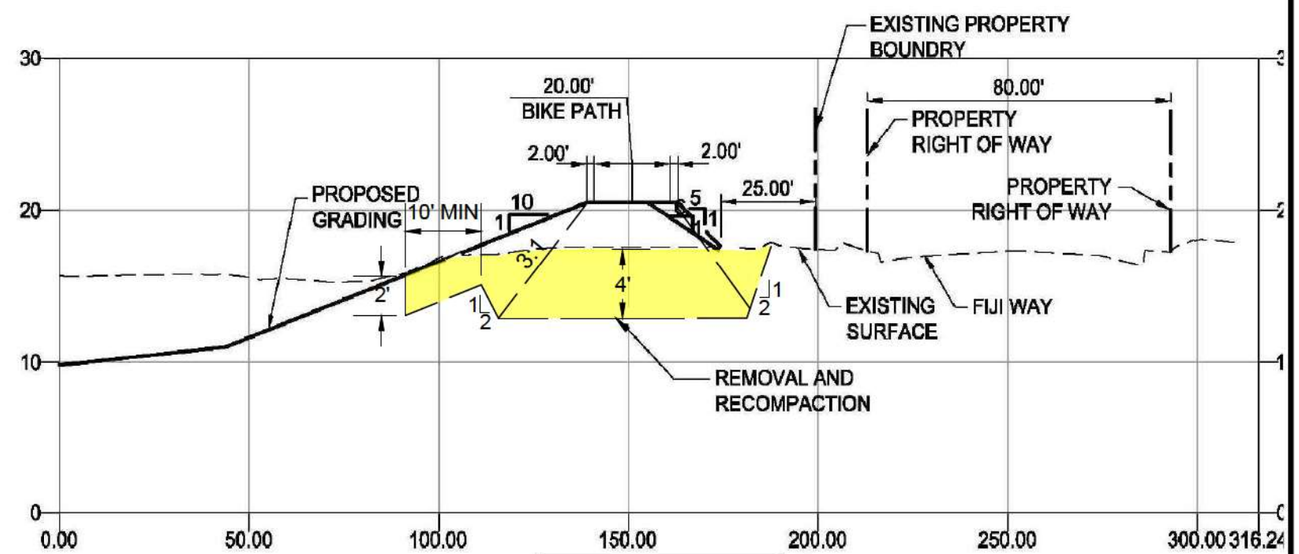
- DE-MUCK AND REMOVE SAND IN CHANNELS AND BACKFILL.
- ENSURE ELIMINATION OF ANY SAND LAGERS UNDER THE LEVEE TO PRTECT AGAINST SEEPAGE.



SECTION H-H
SCALE: H 1"=40'; V 1"=10'



SECTION I-I-
SCALE: H 1"=40'; V 1"=10'



SECTION G-G
SCALE: H 1"=40'; V 1"=10'

DATE: 6/27/2013	DRAWN BY: K. Madamba	GROUP DELTA CONSULTANTS	GROUP DELTA CONSULTANTS, INC 370 Amapola Ave. Suite 212 Torrance, CA. 90501	EXTENTS OF REMOVAL AND RECOMPACTION (SECTIONS H-H, I-I, G-G)
REVISION: --	APPROVED BY: P. Kashighandi			BALLONA WETLANDS RESTORATION PROJECT LOS ANGELES, CA
REVISION: --	E-952			

PROJECT NUMBER: L962A
SCALE: NO SCALE
PLATE NUMBER: I-4

APPENDIX J
AXIAL AND LATERAL CAPACITY OF PILES FOR THE PEDESTRIAN BRIDGE

APPENDIX J
AXIAL AND LATERAL CAPACITY OF PILES FOR THE PEDESTRIAN BRIDGE

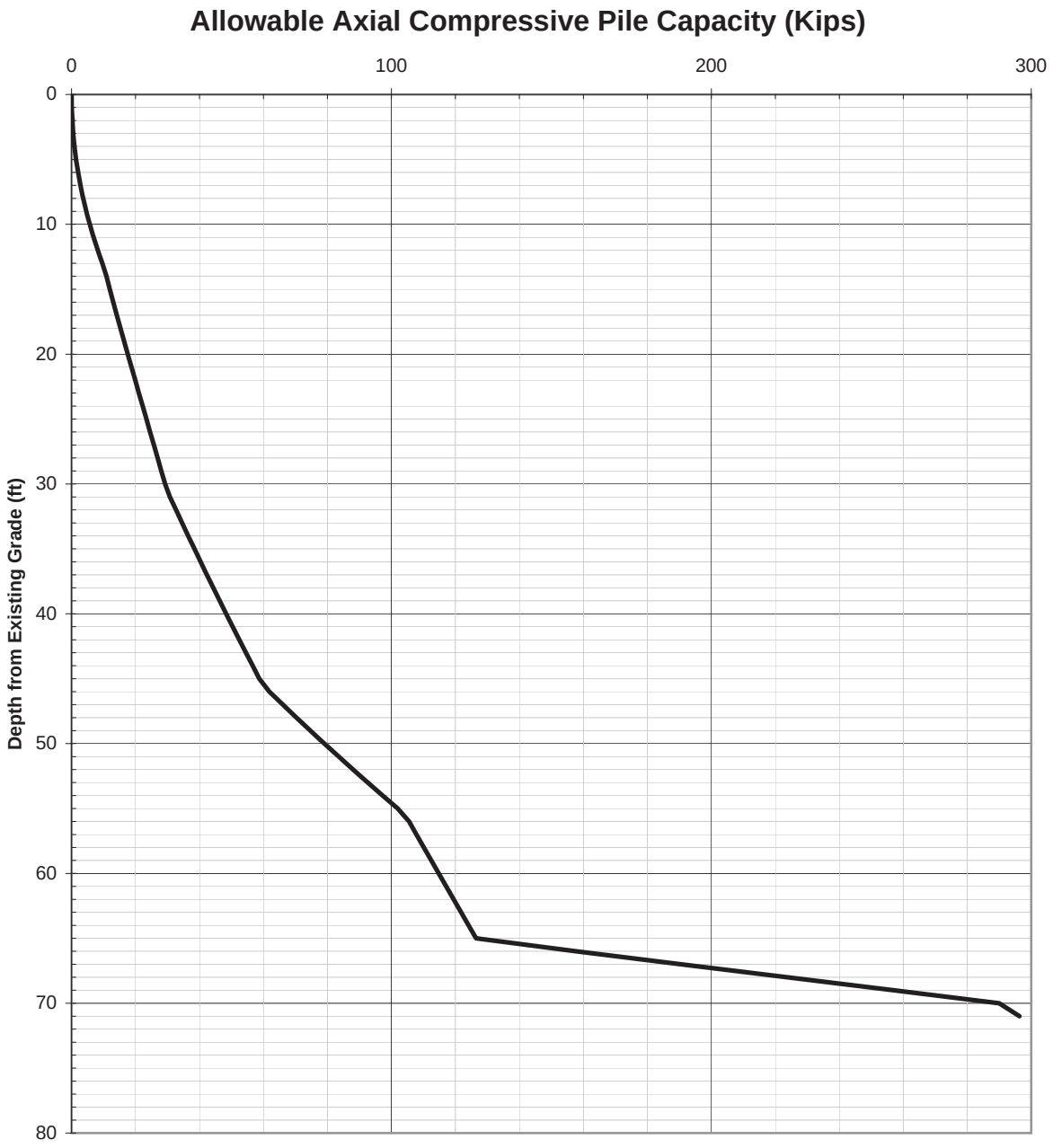
J.1 Contents

A pedestrian bridge is planned to be constructed to the west of the Culver Blvd. as part of the public access plan for the project. Due to large bridge loads, and presence of soft, and liquefiable soils, the bridge should be supported on piles. Pile axial capacity graphs are presented in this appendix for 14-inch square driven piles and 14-inch round Auger Cast Displacement (ACD) Piles. It should be noted that only recommended values presented in the body of the report should be used for the design of the pedestrian bridge. The axial capacity graphs included herein, are solely presented for reference.

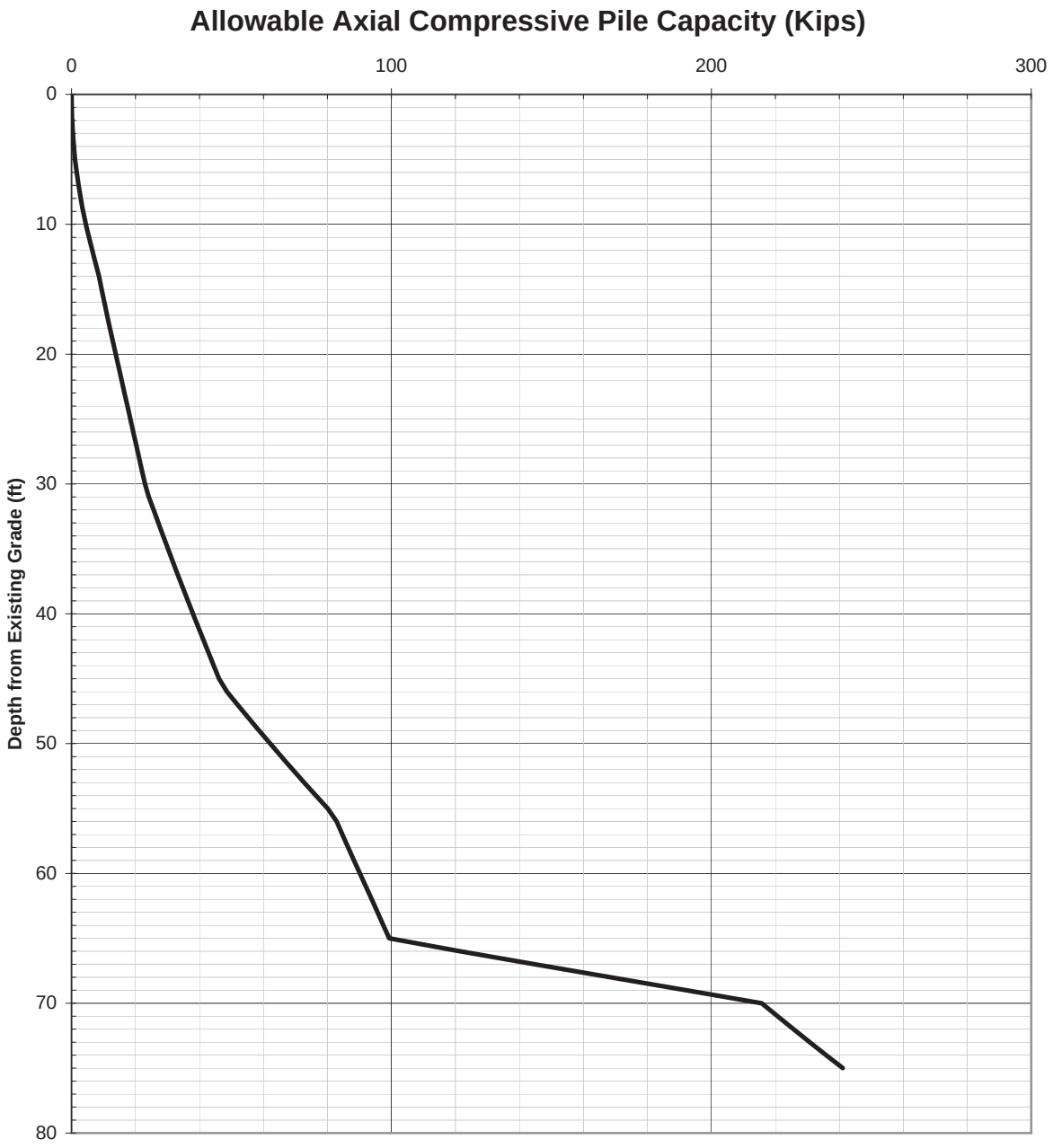
Graphs showing deflections, bending moments, and shear force for the piles under lateral loading are presented for driven and ACD piles for both fixed head and free head conditions.

A list of the plates presented in this appendix follows:

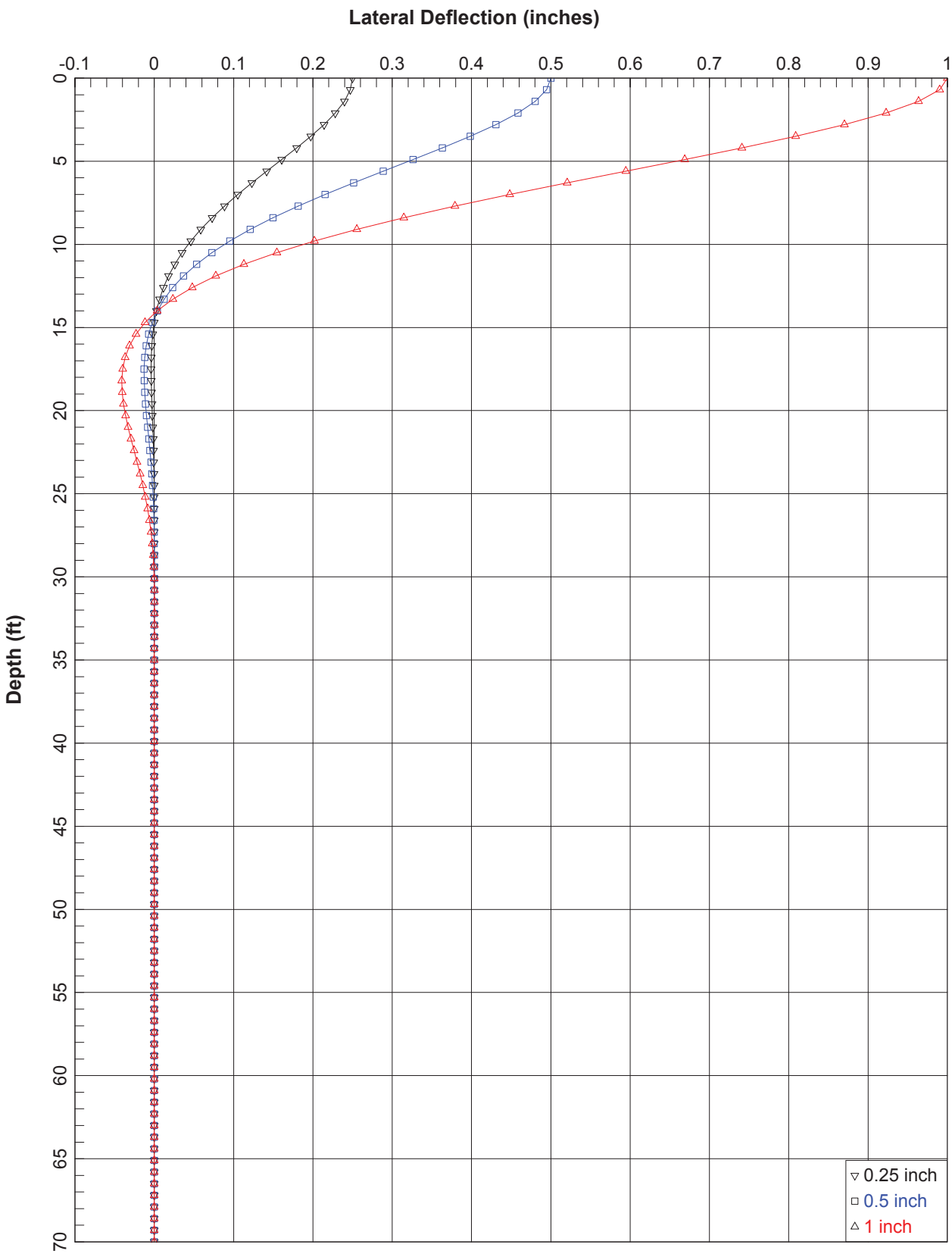
Plate J-1	Axial Capacity of 14-inch Square Driven Piles
Plate J-2	Axial Capacity of 14-inch Round ACD Piles
Plate J-3 thru J-5	Lateral Deflection/Bending Moment/Shear Force graphs for Driven Piles (Fixed Head)
Plate J-6 thru J-8	Lateral Deflection/Bending Moment/Shear Force graphs for ACD Piles (Free Head)
Plate J-9 thru J-11	Lateral Deflection/Bending Moment/Shear Force graphs for Driven Piles (Fixed Head)
Plate J-12 thru J-14	Lateral Deflection/Bending Moment/Shear Force graphs for ACD Piles (Free Head)



GROUP DELTA CONSULTANTS	Project	L962A - Ballona Creek Wetlands Restoration Project
	Pile Type	14-inch Square Driven Pile
	PLATE:	**J-1**

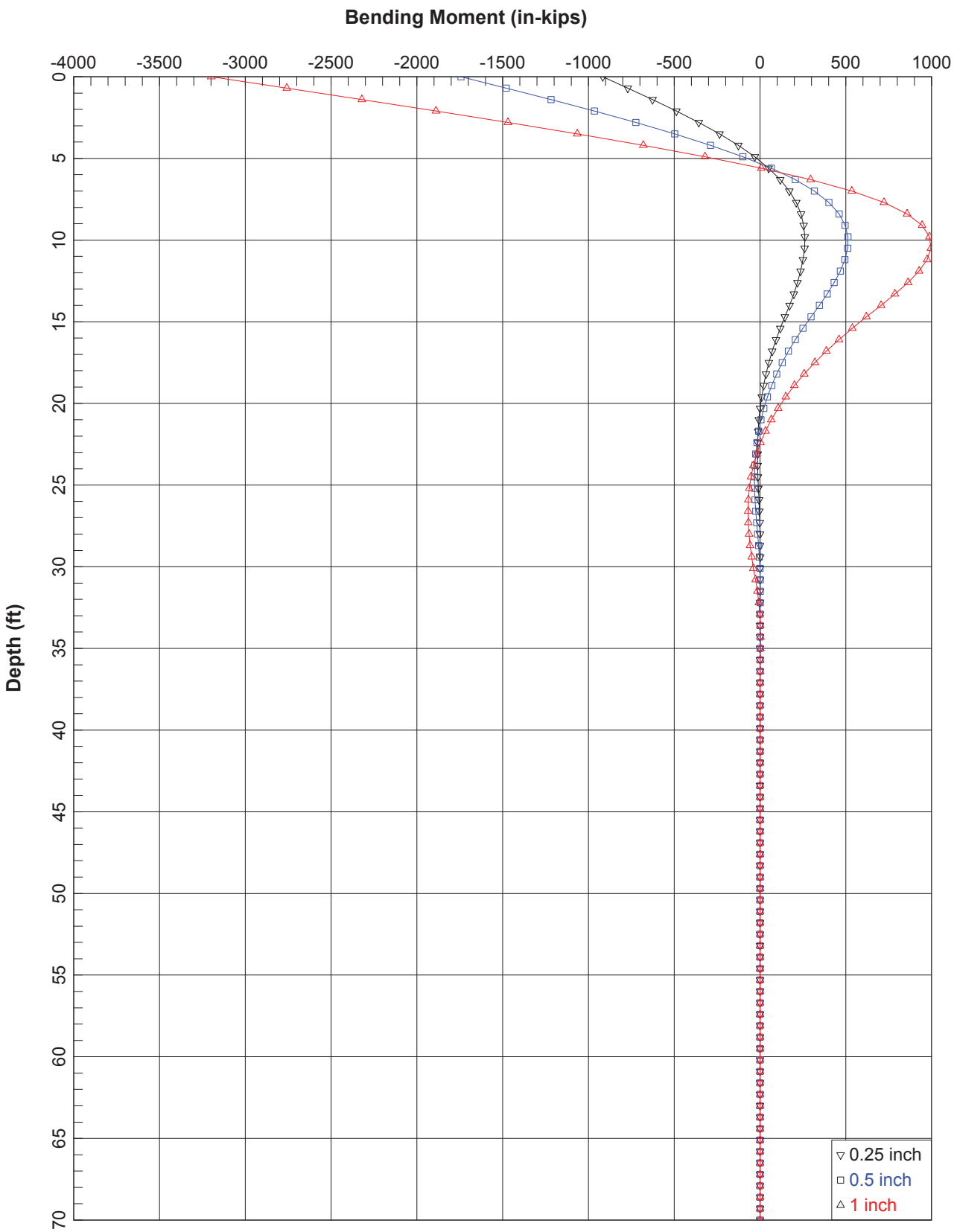


GROUP DELTA CONSULTANTS	Project	L962A - Ballona Creek Wetlands Restoration Project
	Pile Type	14-Diameter Auger Cast Displacement Piles
	PLATE:	**J-2**



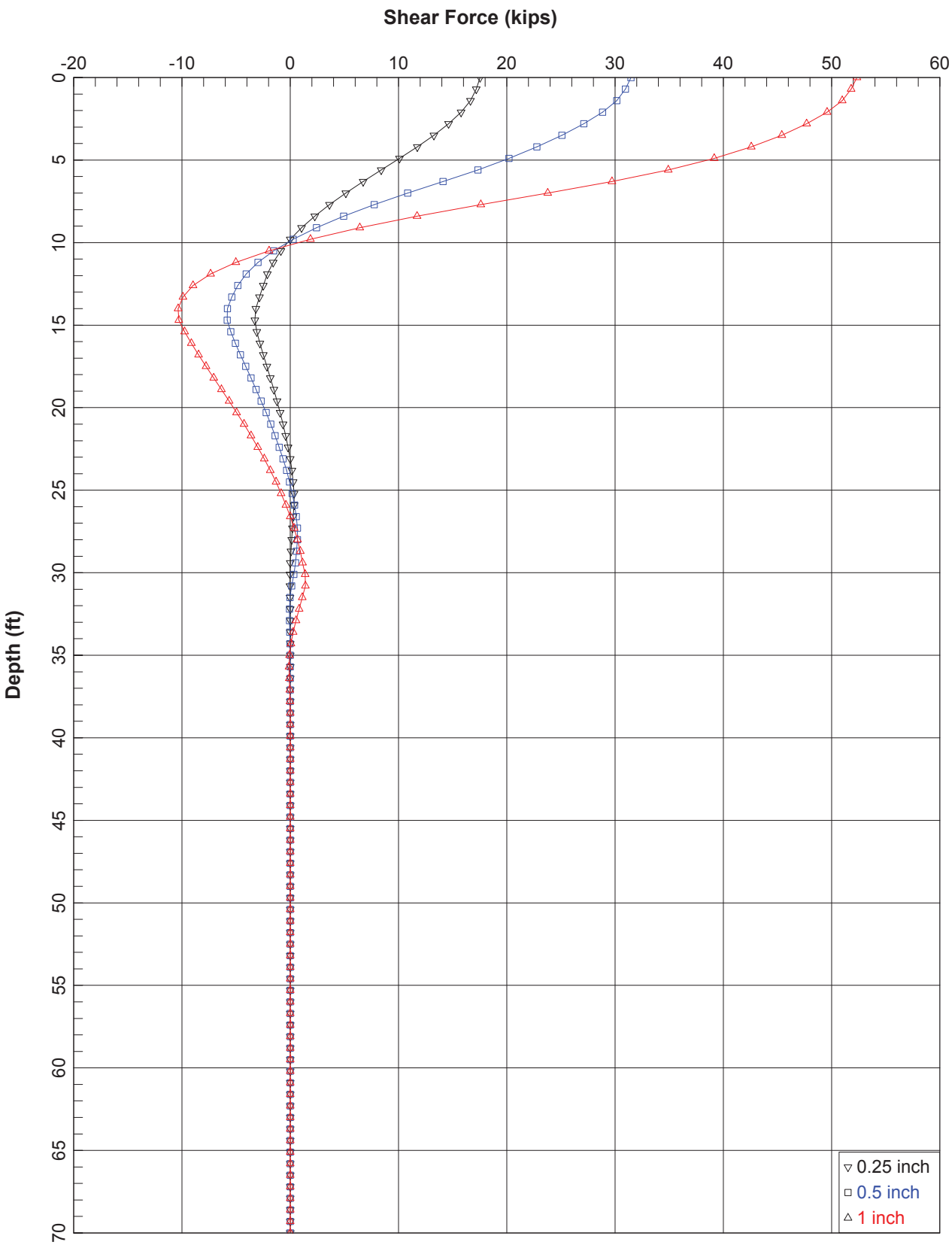
14-inch Square Driven Pile - Fixed Head

PLATE J-3



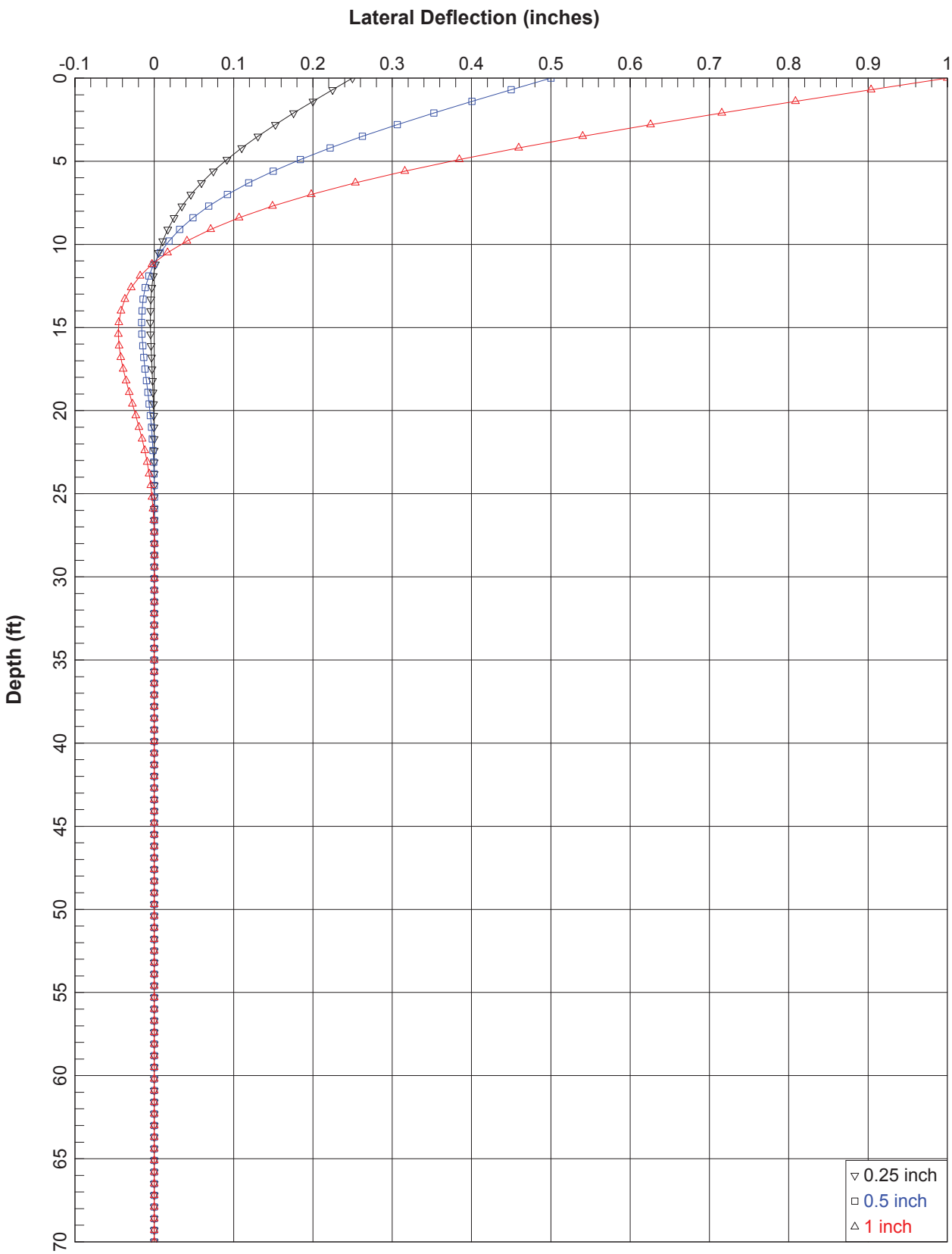
14-inch Square Driven Pile - Fixed Head

PLATE J-4



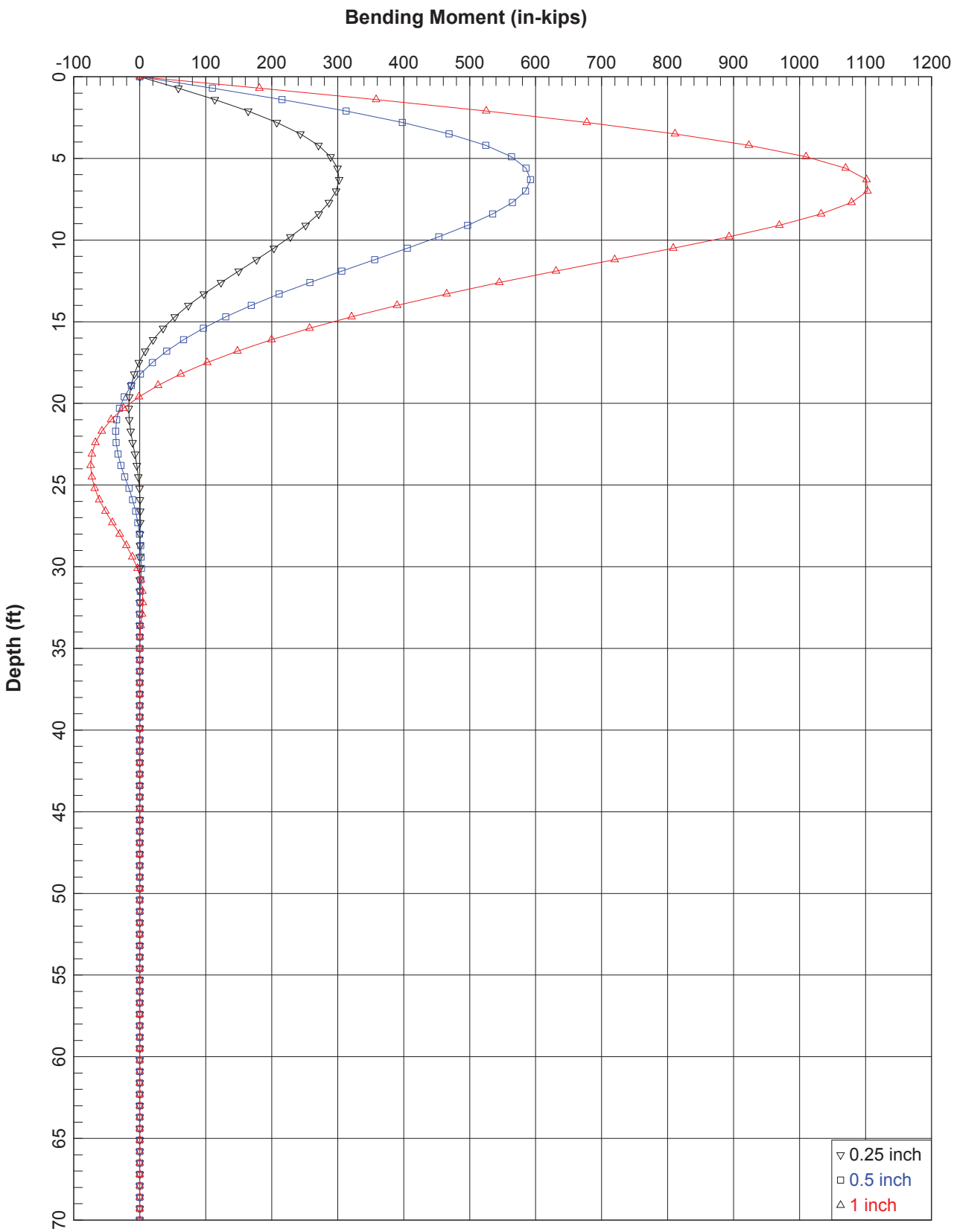
14-inch Square Driven Pile - Fixed Head

PLATE J-5



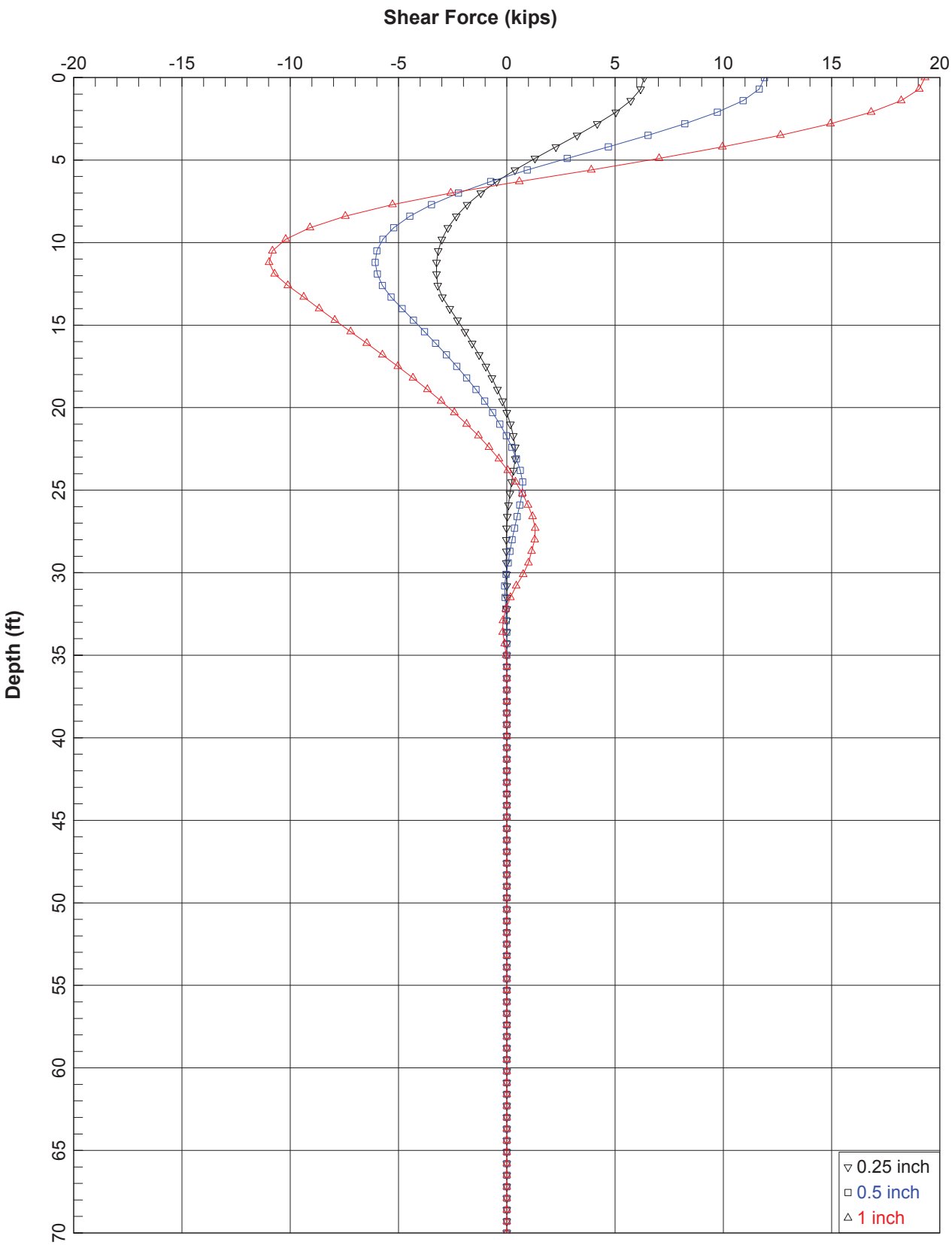
14-inch Square Driven Pile - Free Head

PLATE J-6

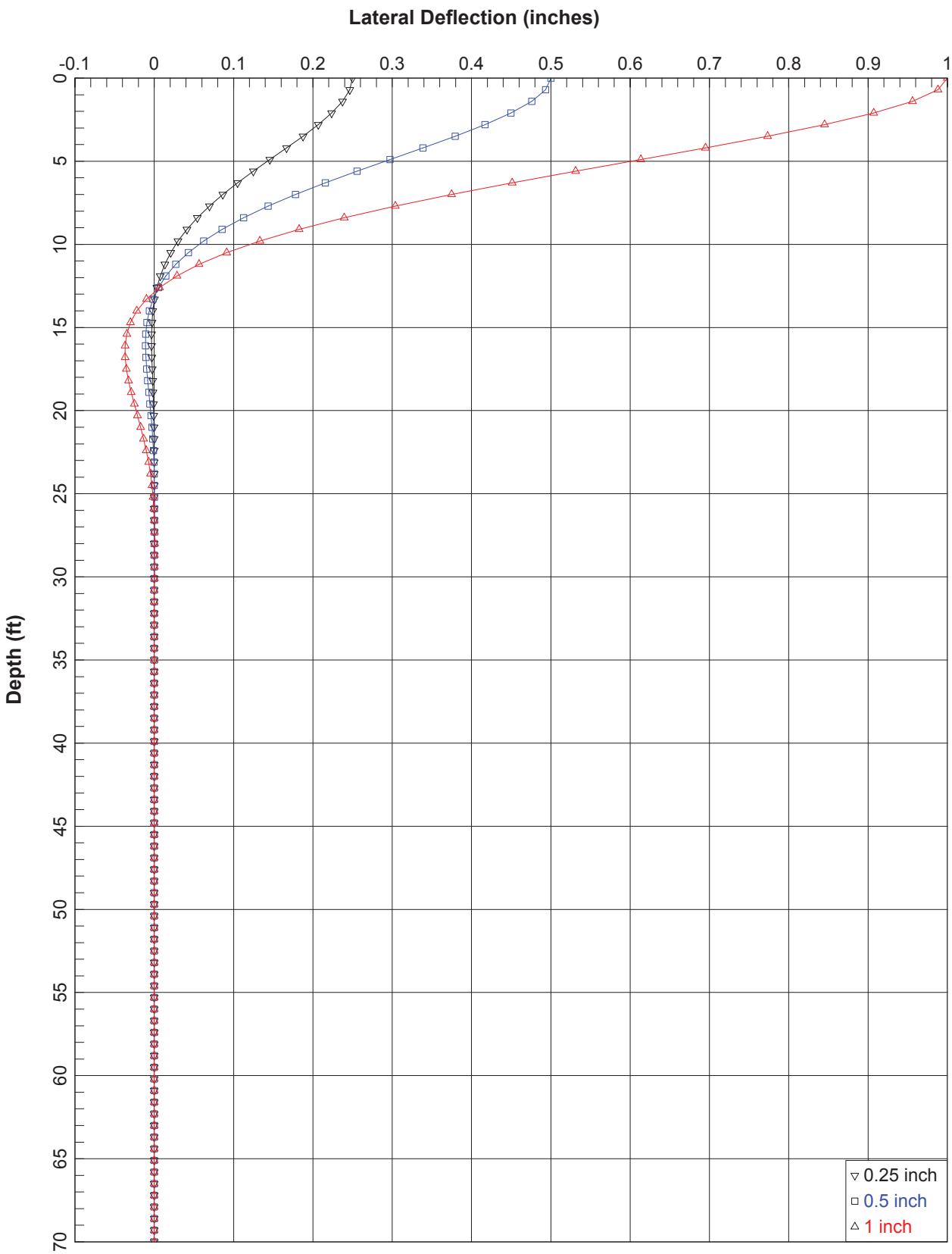


14-inch Square Driven Pile - Free Head

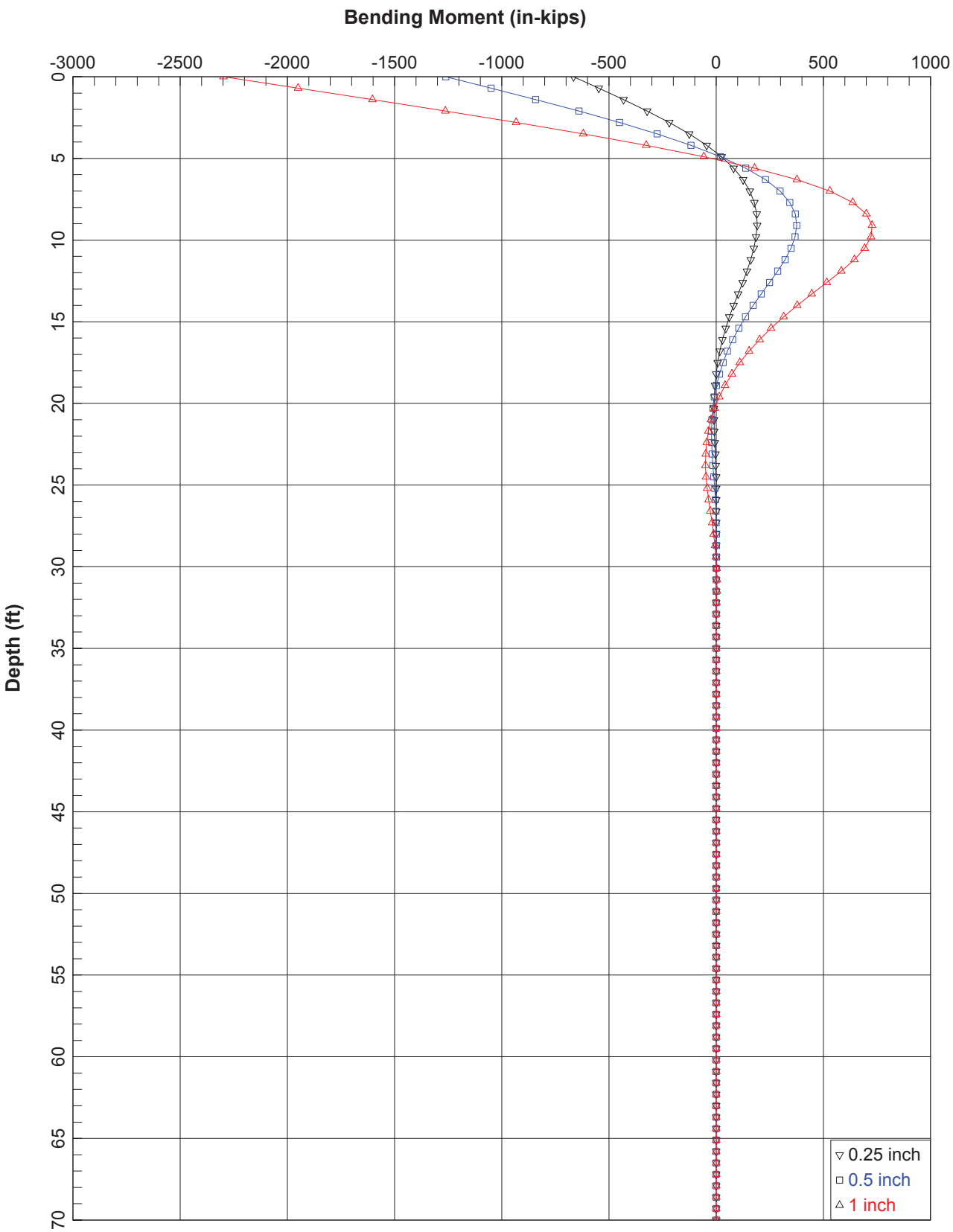
PLATE J-7



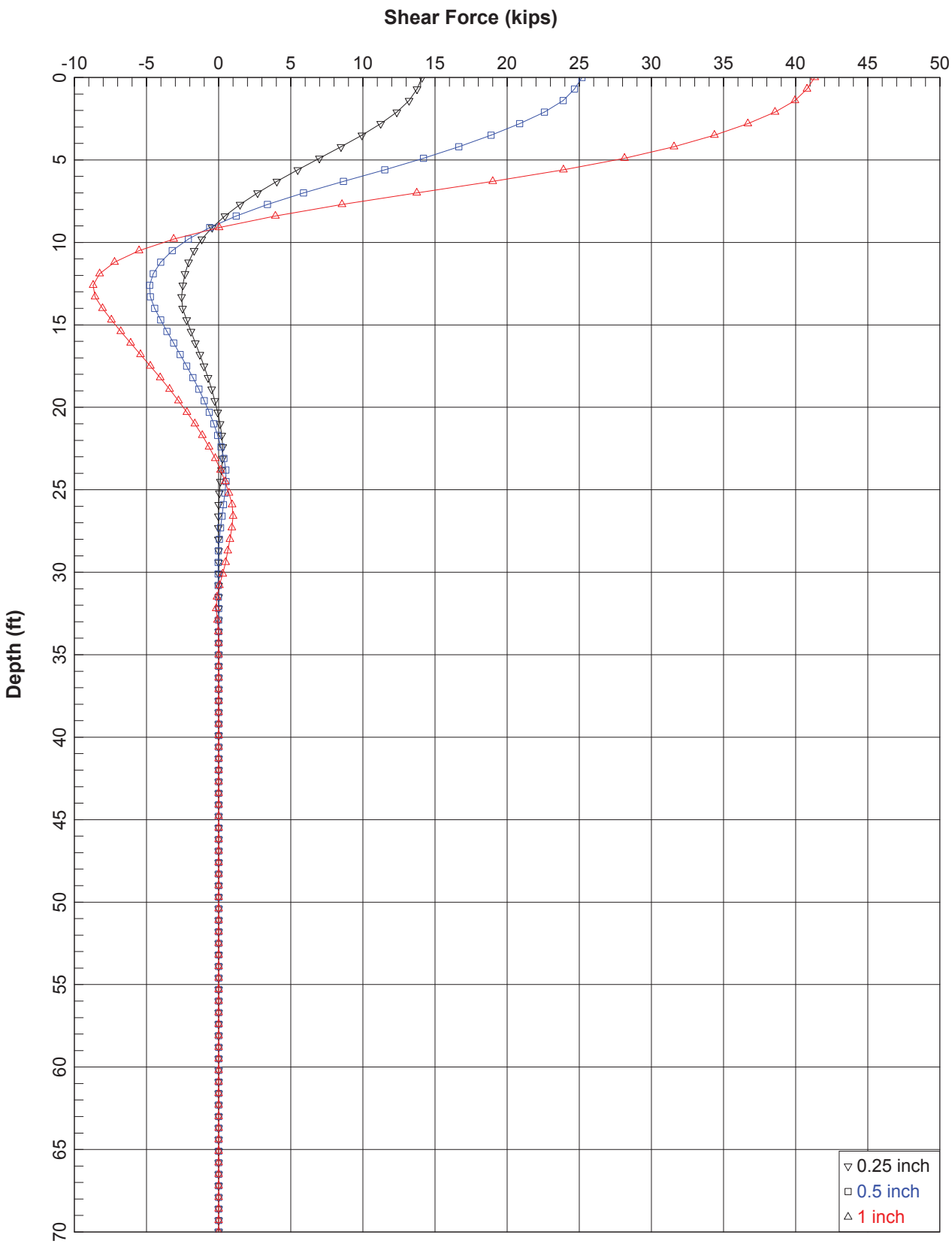
14-inch Square Driven Pile - Free Head



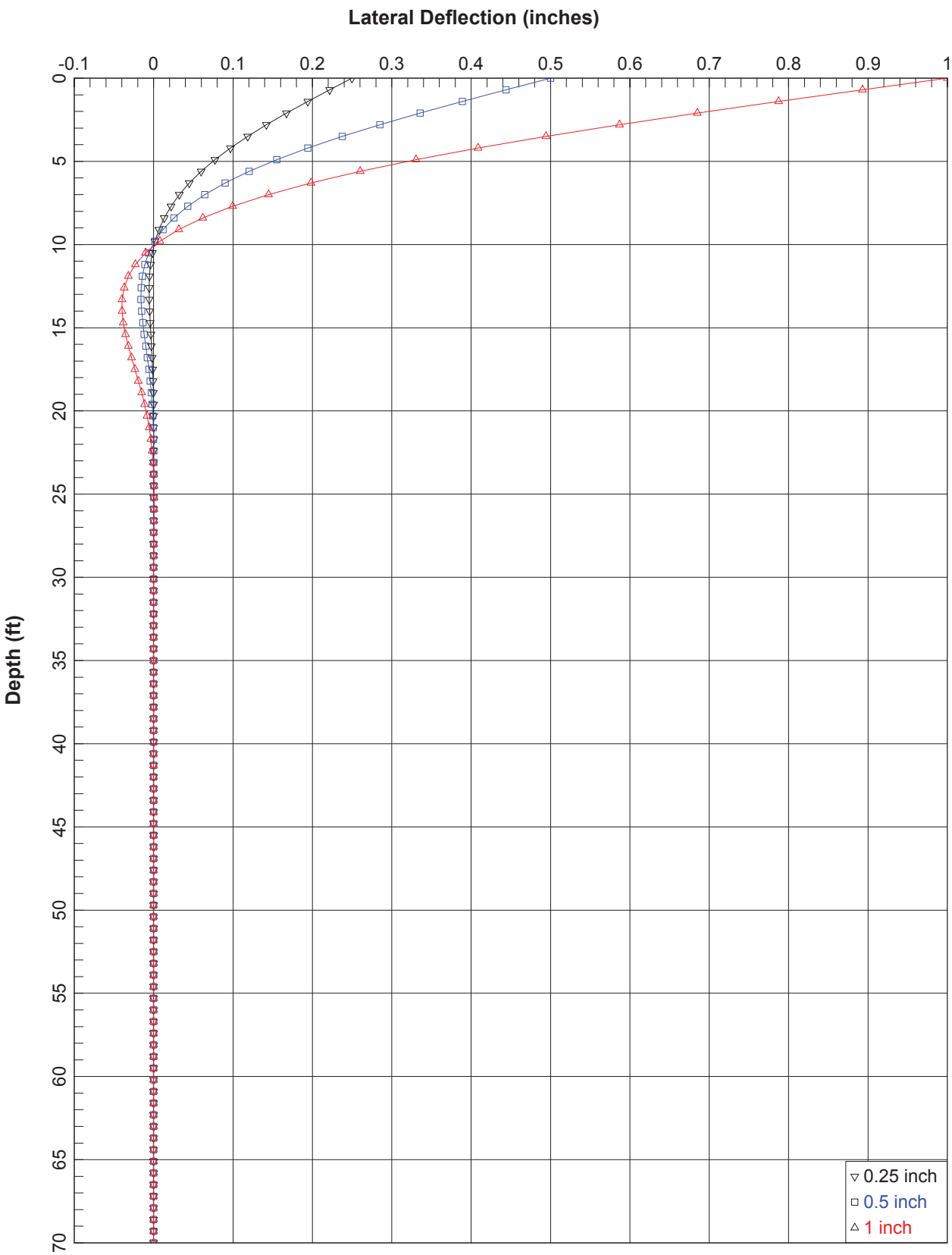
14-inch Round Auger Cast Pile - Fixed Head



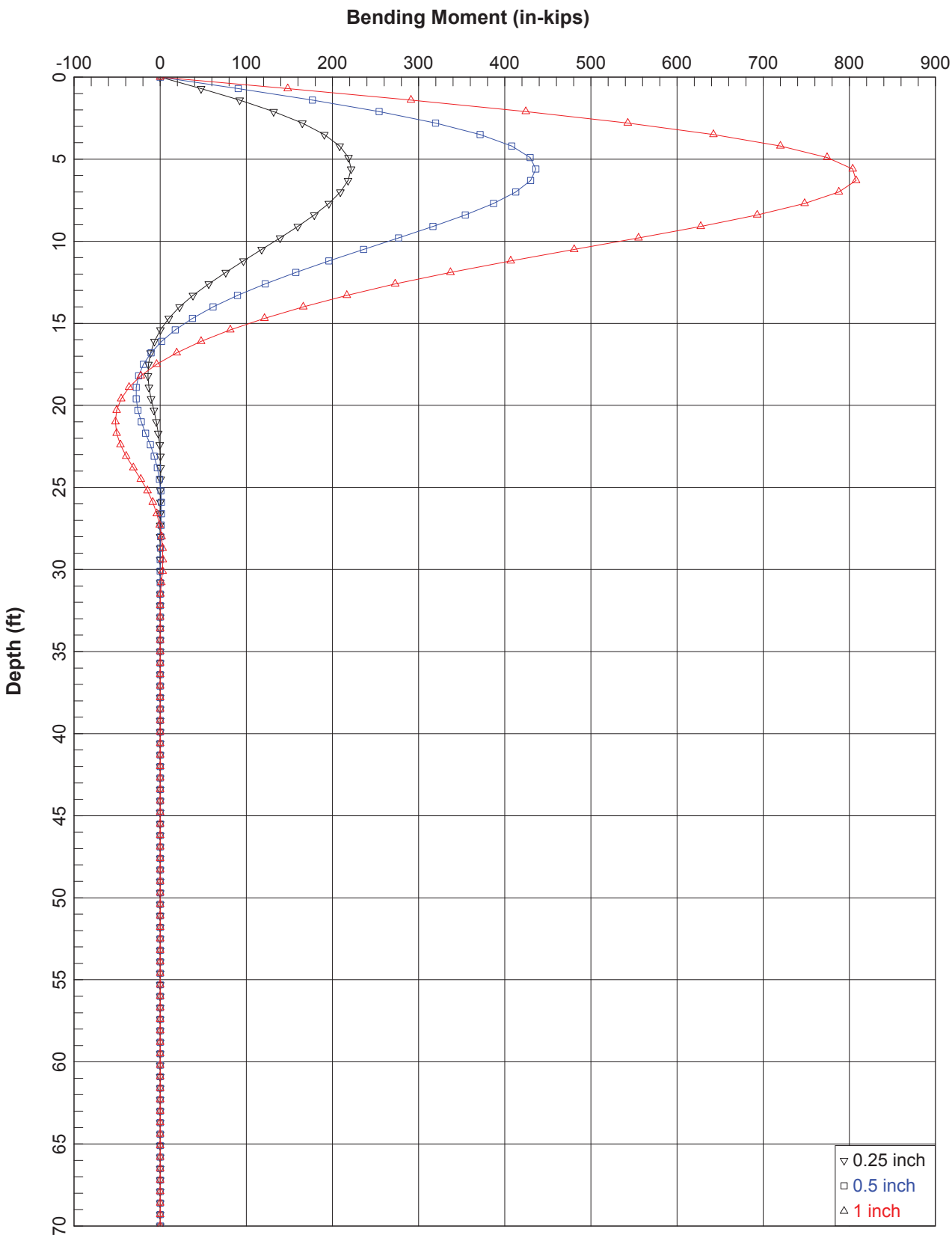
14-inch Round Auger Cast Pile - Fixed Head



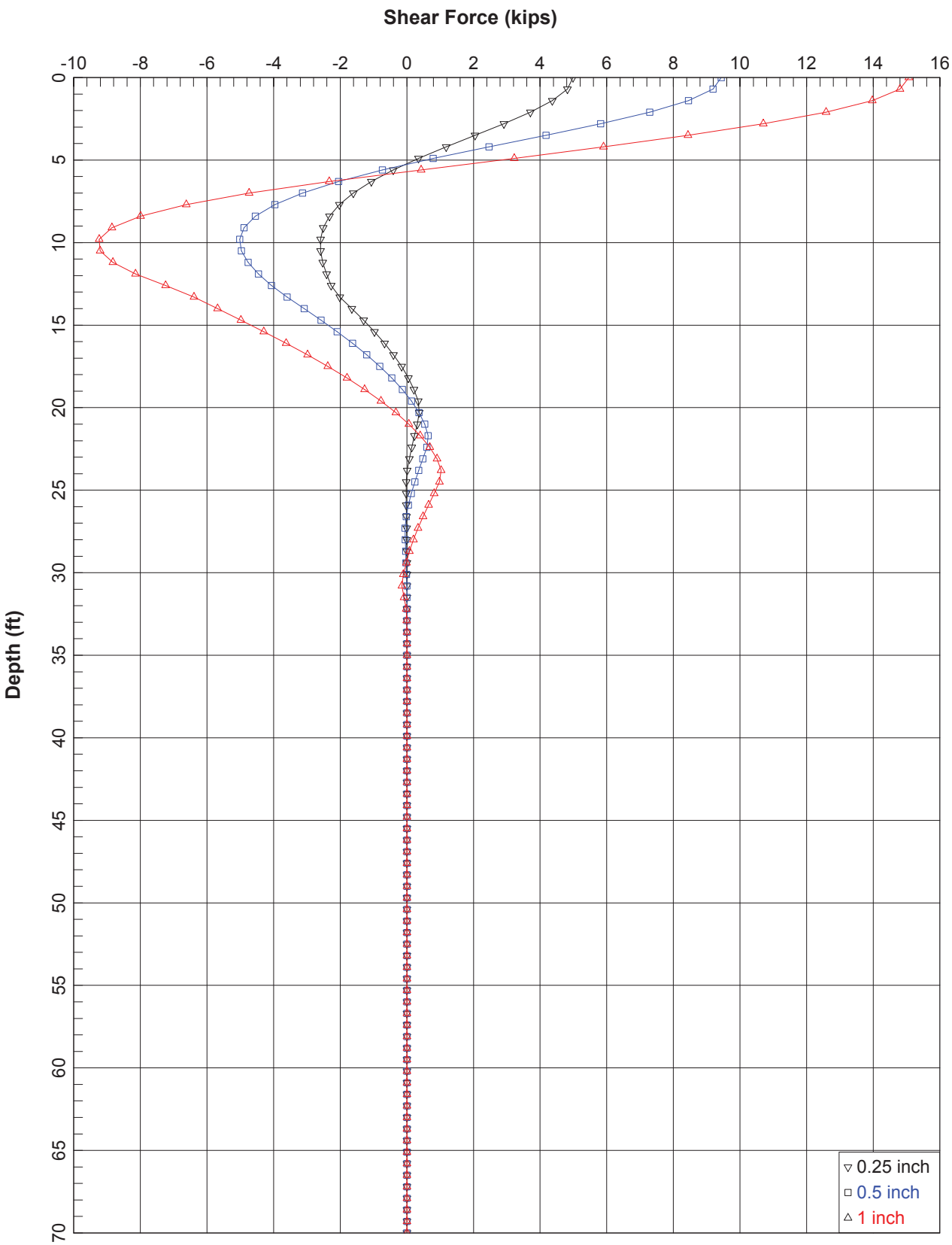
14-inch Round Auger Cast Pile - Fixed Head



14-inch Round Auger Cast Pile - Free Head



14-inch Round Auger Cast Pile - Free Head



14-inch Round Auger Cast Pile - Free Head