APPENDIX E

Liquefaction Calculations

CSR, SPT, CPT CALCULATIONS FROM
'SOIL LIQUEFACTION AND ITS EVALUATION
BASED ON SPT AND CPT'
BY ROBERTSON AND FEAR.

CSR : CYCLIC STRESS RATIO

$$CSR = 0.1(M-1)\left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{vo}}{\sigma_{vo}'}\right)(1-0.00457z) \quad , (z \text{ in ft})$$

$M = 7.0$
σ_{vo} = TOTAL VERTICAL OVERBURDEN STRESS
σ_{vo}' = EFFECTIVE VERTICAL OVERBURDEN STRESS

SPT : $(N_1)_{60}$

$(N_1)_{60} = N\, C_N\, C_E\, C_B\, C_R\, C_S$, (SEE SPREAD SHEETS FOR C_B, C_R, C_S)

$$C_N = \left(\frac{P_a}{\sigma_{vo}'}\right)^{0.5} = \left(\frac{2116}{\sigma_{vo}'}\right)^{0.5}$$

$$C_E = \frac{67\%}{60\%} = 1.1$$, (DRILLER TESTED AT 67% ON PREVIOUS JOB)

CPT : q_{c1N}

$$q_{c1N} = \left(\frac{q_c}{P_a}\right) C_Q \quad , (P_a \text{ in tsf})$$

$$C_Q = \left(\frac{P_a}{\sigma_{vo}'}\right)^{0.5} = \left(\frac{2116}{\sigma_{vo}'}\right)^{0.5} \quad , (P_a \text{ in psf})$$

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LIQUEFACTION CALCULATIONS FROM SPT DATA

CPT Number	B10	B11	B15	B18
Station				
Location (offset from ES)				
Depth to Water Table (ft)	6.8	5.6	10.0	5.3
Future Depth to Water Table (ft)	6.8	5.6	10.0	5.3
Soil Density (pcf)	125	125	125	125
C (correction for sampling techn	0.94	0.94	0.94	0.94
M (earthquake magnitude)	7.0	7.0	7.0	7.0
a (max. horz. ground acceleratio	0.60	0.60	0.60	0.60
Depth of Layer (ft)	**5.0**	**5.0**	**5.0**	**5.0**
Soil Type	silty sand	silty sand	silty sand	silty sand
FC (fine content, %)	NA	NA	NA	NA
CSR	**0.298**	**0.332**	**0.235**	**0.342**
N (blow counts)	14	16	17	16
Cn (correction for overburden st	1.84	1.84	1.84	1.84
(N1)60	**24**	**28**	**29**	**28**
Depth of Layer (ft)	**10.0**	**10.0**	**10.0**	**10.0**
Soil Type	silty sand	silty sand	clay	silty sand
FC (fine content, %)	NA	NA	NA	NA
CSR	**0.409**	**0.440**	**0.344**	**0.449**
N (blow counts)	16	16	7	7
Cn (correction for overburden st	1.42	1.47	1.30	1.49
(N1)60	**21**	**22**	**9**	**10**
Depth of Layer (ft)	**15.0**	**15.0**	**15.0**	**15.0**
Soil Type	silty sand	clay	clay	clay & sand
FC (fine content, %)	NA	NA	NA	NA
CSR	**0.461**	**0.488**	**0.402**	**0.495**
N (blow counts)	35		12	10
Cn (correction for overburden st	1.25	1.28	1.16	1.29
(N1)60	**41**	**#VALUE!**	**13**	**12**
Depth of Layer (ft)	**20.0**	**20.0**	**20.0**	**20.0**
Soil Type	sand	silty sand	silty sand	Clay
FC (fine content, %)	NA	NA	NA	NA
CSR	**0.488**	**0.511**	**0.436**	**0.517**
N (blow counts)	18	22	33	13
Cn (correction for overburden st	1.12	1.15	1.06	1.16
(N1)60	**19**	**24**	**33**	**14**
Depth of Layer (ft)	**25.0**	**25.0**	**25.0**	**25.0**
Soil Type	sandy silt	sand	clay	clay
FC (fine content, %)	NA	NA	NA	NA
CSR	**0.501**	**0.521**	**0.455**	**0.526**
N (blow counts)	8	23	14	16
Cn (correction for overburden st	1.03	1.05	0.98	1.06
(N1)60	**8**	**23**	**13**	**16**
Depth of Layer (ft)	**30.0**	**30.0**	**30.0**	**30.0**
Soil Type	clay	silty sand	sand	clay
FC (fine content, %)	NA	NA	NA	NA
CSR	**0.506**	**0.523**	**0.466**	**0.527**
N (blow counts)	8	24	33	20
Cn (correction for overburden st	0.96	0.97	0.92	0.98
(N1)60	**7**	**22**	**28**	**18**

C = Ce x Cb x Cr x Cs = 1.1 x 1.0 x 0.85 x 1.0

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LIQUEFACTION CALCULATIONS FROM CPT DATA

CPT Number	CPT 9	CPT 10	CPT 11	CPT 12	CPT 14	CPT 15	CPT 16	CPT 18	CPT 19
Station									
Location (lane)									
Depth to Water Table (ft)	6.0	6.8	5.6	6.0	6.0	10.0	6.0	5.3	6.0
Future Depth to Water Table (ft)	6.0	6.8	5.6	6.0	6.0	10.0	6.0	5.3	6.0
Soil Density (pcf)	125	125	125	125	125	125	125	125	125
M (earthquake magnitude)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
a (max. horz. ground acceleratio	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Depth of Layer (ft)	**10.5**	**13.5**	**8.5**	**17.5**	**21.0**	**6.5**	**22.5**	**7.0**	**15.0**
Soil Type	silty sand	sand	silty sand	sand	sand	silty sand	sand	silty sand	sand
FC (fine content, %)	NA	NA	NA	NA	NA	NA	NA	NA	NA
CSR	**0.436**	**0.449**	**0.417**	**0.493**	**0.506**	**0.275**	**0.510**	**0.397**	**0.479**
q (tip resistance, tsf)	71	144	81	180	205	104	216	81	229
Cq (correction factor)	1.43	1.29	1.55	1.20	1.12	1.61	1.09	1.66	1.27
qc1n	**96**	**176**	**119**	**204**	**217**	**159**	**222**	**127**	**275**
Depth of Layer (ft)		**20.5**	**20.0**		**29.0**	**22.0**			**25.0**
Soil Type		sand	sand		sand	sand			sand
FC (fine content, %)		NA	NA		NA	NA			NA
CSR		**0.490**	**0.511**		**0.517**	**0.445**			**0.514**
q (tip resistance, tsf)		152	260		158	156			186
Cq (correction factor)		1.11	1.15		0.98	1.03			1.04
qc1n		**160**	**282**		**147**	**152**			**184**
Depth of Layer (ft)			**28.0**						
Soil Type			nd - silty snd						
FC (fine content, %)			NA						
CSR			**0.523**						
q (tip resistance, tsf)			133						
Cq (correction factor)			1.00						
qc1n			**126**						
Depth of Layer (ft)									
Soil Type									
FC (fine content, %)									
CSR									
q (tip resistance, tsf)									
Cq (correction factor)									
qc1n									