Geotechnical Report Update

Heber 2 Repower Project
Heber, CA

Prepared for:

Ormat Nevada
1010 Power Plant Road
Reno, NV 89521

Prepared by:

Landmark Consultants, Inc.
780 N. 4th Street
El Centro, CA 92243
(760) 370-3000

April 2019

LANDMARK
Geo-Engineers and Geologists

780 N. 4th Street
El Centro, CA 92243
(760) 370-3000
(760) 337-8900 fax

77-948 Wildcat Drive
Palm Desert, CA 92211
(760) 360-0665
(760) 360-0521 fax

April 30, 2019

Mr. Shlomi Huberman
Ormat Nevada
1010 Power Plant Road
Reno, NV 89521

Geotechnical Report Update
Proposed Heber 2 Repower Project
855 Dogwood Road
Heber, California
LCI Report No. LE19075

Dear Mr. Huberman:

Landmark Consultants, Inc. is providing this geotechnical report for the project at the Heber 2 Repower geothermal power plant. This report updates Landmark's 2004 and 2007 Geotechnical Reports for the power plant located at 855 Dogwood Road southwest of Heber, California. The update addresses changes made due to the adoption of the 2016 California Building Code (CBC) and geotechnical engineering standard of practice in Imperial County. The original reports (LCI Report No. LE04354, dated January 10, 2005 and LCI Report No. LE07178, dated May 9, 2007) are provided in Appendix D and Appendix E, respectively.

This update report presents selected elements of our findings and professional opinions only. It does not present all details that may be needed for the proper application of our findings and professional opinions. Our findings, professional opinions, and application options are best related through reading the full Geotechnical Report Update, and with the active participation of the engineer of record who developed them during design and construction of the project.

Seismic Parameters

Seismic Risk: The project site is located in the seismically active Imperial Valley of southern California with numerous mapped faults of the San Andreas Fault System traversing the region. The San Andreas Fault System is comprised of the San Andreas, San Jacinto, and Elsinore Fault Zones in southern California. The Imperial fault represents a transition from the more continuous San Andreas fault to a more nearly echelon pattern characteristic of the faults under the Gulf of California (USGS 1990). We have performed a computer-aided search of known faults or seismic zones that lie within a 36 mile (57 kilometer) radius of the project site as provided in Table 1.

A fault map illustrating known active faults relative to the site is presented on Figure 1, *Regional Fault Map*. A legend for the regional fault map is presented on Figure 2. The criterion for fault classification adopted by the California Geological Survey defines Earthquake Fault Zones along active or potentially active faults. An active fault is one that has ruptured during Holocene time (roughly within the last 11,000 years). A fault that has ruptured during the last 1.8 million years (Quaternary time), but has not been proven by direct evidence to have not moved within Holocene time is considered to be potentially active. A fault that has not moved during both Pleistocene and Holocene time (that is no movement within the last 1.8 million years) is considered to be inactive. Review of the current Alquist-Priolo Earthquake Fault Zone maps (CGS, 2000a) indicates that the nearest mapped Earthquake Fault Zones are the Imperial fault located approximately 9.4 miles southwest of the project site.

<u>Site Acceleration:</u> The project site is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. Ground motions are dependent primarily on the earthquake magnitude and distance to the seismogenic (rupture) zone. Accelerations also are dependent upon attenuation by rock and soil deposits, direction of rupture and type of fault; therefore, ground motions may vary considerably in the same general area.

<u>CBC General Ground Motion Parameters:</u> The 2016 CBC general ground motion parameters are based on the Risk-Targeted Maximum Considered Earthquake (MCE_R). The Structural Engineers Association of California (SEAOC) and Office of Statewide Health Planning and Development (OSHPD) Seismic Design Maps Web Application (SEAOC, 2019) was used to obtain the site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters. **The site soils have been classified as Site Class D (stiff soil profile).**

Design spectral response acceleration parameters are defined as the earthquake ground motions that are two-thirds (2/3) of the corresponding MCE_R ground motions. Design earthquake ground motion parameters are provided in Table 2. **A Risk Category III was determined using Table 1604.5 and the Seismic Design Category is D since S_1 is less than 0.75**.

The Maximum Considered Earthquake Geometric Mean (MCE_G) peak ground acceleration (PGA_M) value was determined from the "U.S. Seismic Design Maps Web Application" (SEAOC, 2019) for liquefaction and seismic settlement analysis in accordance with 2016 CBC Section 1803.5.12 and CGS Note 48 ($PGA_M = F_{PGA}*PGA$). **A PGA_M value of 0.50g is used for liquefaction settlement analysis.**

Subsurface Soil and Groundwater

Subsurface soils encountered during Landmark's 2004 and 2007 geotechnical studies consist of surficial dry very stiff lean silty clays to a depth of 4 to 5 feet. Stiff clays extend from about 6 feet to a depth of 38 to 40 feet. Silty clay to clayey silt was encountered from 40 to 50 feet, the maximum depth of exploration. The subsurface logs (Plates B-1 through B-5 in Appendix B) depict the stratigraphic relationships of the various soil types. Groundwater was not noted in the CPT soundings, but is typically encountered at a depth of about 8 to 10 feet below ground surface at the plant site.

Liquefaction Potential

Liquefaction potential at the project site was evaluated using the 1997 NCEER Liquefaction Workshop methods. The 1997 NCEER methods utilize direct SPT blow counts or CPT cone readings from site exploration and earthquake magnitude/PGA estimates from the seismic hazard analysis. The resistance to liquefaction is plotted on a chart of cyclic shear stress ratio (CSR) versus a corrected blow count $N_{1(60)}$ or Qc_{1N}. A PGA_M value of 0.50g was used in the analysis with a 15-foot groundwater depth and a threshold factor of safety (FS) of 1.3.

The computer program CLiq (Version 2.2.0.32, Geologismiki, 2017) was utilized for liquefaction assessment at the project site. The estimated settlements have been adjusted for transition zones between layers and the post liquefaction volumetric strain has been weighed with depth (Robertson, 2014 and Cetin et al., 2009). Computer printouts of the liquefaction analyses are provided in Appendix C.

Liquefaction is not expected occur at the project site due to the cohesive nature of the subsurface soils. No mitigation is required for liquefaction induced settlements at this project site.

Site Preparation

Structure Subgrade Preparation: The exposed surface soil within foundation areas should be removed to 18 inches below the foundation elevation or existing grade (whichever is lower) extending five feet beyond all foundation lines. Exposed subgrade should be neat cut (flat blade on bucket).

A minimum of 18 inches of Caltrans Class 2 aggregate base shall be placed and compacted in 6 inch maximum lifts to 95% of ASTM D1557 maximum dry density below each foundation or mat slab.

Imported fill soil (if required) should have a Plasticity Index less than 15 and sulfates (SO_4) less than 1,000 ppm or non-expansive, granular soil meeting the USCS classifications of SM, SP-SM, or SW-SM with a maximum rock size of 3 inches and 5 to 35% passing the No. 200 sieve. The geotechnical engineer should approve imported fill soil sources before hauling material to the site. Imported granular fill should be placed in lifts no greater than 8 inches in loose thickness and compacted to at least 95% of ASTM D1557 maximum dry density at optimum moisture ±2%.

Trench Backfill: On-site soil free of debris, vegetation, and other deleterious matter may be suitable for use as utility trench backfill. Backfill soil within paved areas should be placed in layers not more than 6 inches in thickness and mechanically compacted to a minimum of 90% of the ASTM D1557 maximum dry density except for the top 12 inches of the trench which shall be compacted to at least 95%. Native backfill should only be placed and compacted after encapsulating buried pipes with suitable bedding and pipe envelope material. Pipe envelope/bedding should either be clean sand (Sand Equivalent SE>30). Precautions should be taken in the compaction of the backfill to avoid damage to the pipes and structures.

Observation and Density Testing: All site preparation and fill placement should be continuously observed and tested by a representative of a qualified geotechnical engineering firm. Full-time observation services during the excavation and scarification process is necessary to detect undesirable materials or conditions and soft areas that may be encountered in the construction area. The geotechnical firm that provides observation and testing during construction shall assume the responsibility of "*geotechnical engineer of record*" and, as such, shall perform additional tests and investigation as necessary to satisfy themselves as to the site conditions and the geotechnical parameters for site development.

Auxiliary Structures Foundation Preparation: Auxiliary structures such as free standing or retaining walls should have footings extended to a minimum of 24 inches below grade. The existing soil beneath the structure foundation prepared in the manner described for foundations except the preparation needed only to extend 12 inches below and beyond the footing.

Foundations and Settlements

Shallow spread footings and continuous wall footings are suitable to support the structures associated with the plant upgrades. Footings shall be founded on a layer of properly prepared and compacted soil as described in Section 4.1. The foundations may be designed using an allowable soil bearing pressure of 2,000 psf at 18-inch embedment depth when foundations are supported on compacted Caltrans Class 2 aggregate base (extending a minimum of 1.5 feet below footings).

The allowable soil pressure may be increased by 20% for each foot of embedment depth in excess of 18 inches and by one-third for short term loads induced by winds or seismic events. The maximum allowable soil pressure at increased embedment depths shall not exceed 4,000 psf.

Flat Plate Structural Mats: Structural mats may be designed for a modulus of subgrade reaction (Ks) of 100 pci when placed on compacted clay or a subgrade modulus of 250 pci when placed on 2.5 feet of granular fill. Mats shall overlay 2 inches of sand and a 10-mil polyethylene vapor retarder. The structure support pad shall be moisture conditioned and recompacted as specified in Section 4.1 of this report.

Resistance to horizontal loads will be developed by passive earth pressure on the sides of footings and frictional resistance developed along the bases of footings and concrete slabs. Passive resistance to lateral earth pressure may be calculated using an equivalent fluid pressure of 300 pcf to resist lateral loadings. The top one foot of embedment should not be considered in computing passive resistance unless the adjacent area is confined by a slab or pavement. An allowable friction coefficient of 0.35 may also be used at the base of the footings to resist lateral loading. Foundation movement under the estimated loadings are estimated to not exceed ½ inch with differential movement of about two-thirds of total movement for the loading assumptions stated above when the subgrade preparation guidelines given above are followed.

Note: The entire plant area overlays a geothermal fluids reservoir that geothermal fluids extraction and reinjection is causing annual ground surface settlement of 1 to 2 inches per year. The settlement is not uniform.

Drilled Piers: New foundations may be supported on cast-in-place, drilled piers. Design criteria are provided below.

Vertical Capacity**:** Vertical capacity for 24 and 36-inch diameter shafts are presented in Figure 3. Capacities for other shaft sizes can be determined in direct proportion to shaft diameters. Point bearing and skin friction parameters have been used to determine the allowable shaft capacity. The allowable capacities include a factor of safety of 2.5. The allowable vertical compression capacities may be increased by 33 percent to accommodate temporary loads such as from wind or seismic forces. The allowable vertical shaft capacities are based on the supporting capacity of the soil.

Lateral Capacity**:** The allowable lateral capacities for 24 and 36-inch diameter shafts are given in the table shown below. The allowable horizontal deflection has been assumed to be one-half inch (0.50 inch).

Table 3 – Lateral Capacities

Shaft Diameter (in.)	**24**		**36**	
Head Condition	Free	(*) Fixed	Free	(*) Fixed
Allowable Head Deflection (in.)	0.5	0.5	0.5	0.5
Minimum Length (ft.)	10	10	10	10
Lateral Capacity (kips)	15.6	50.8	20.0	65.0
Maximum Moment (foot-kips)	42.2	-293.3	53.7	-362.4
@Depth from Pier Head (ft.)	4.2	0	4.2	0
Minimum Length (ft.)	20	20	20	20
Lateral Capacity (kips)	32.0	70.5	52.0	124.0
Maximum Moment (foot-kips)	142.5	-393.3	266.7	-1025.0
@Depth from Pier Head (ft.)	9.0	0	9.8	0
Minimum Length (ft.)	30	30	30	30
Lateral Capacity (kips)	32.5	73.5	65.8	152.0
Maximum Moment (foot-kips)	145.0	-407.5	413.3	-1141.7
@Depth from Pier Head (ft.)	9.0	0	11.6	0

(*) Fixed head is defined as there is no rotation in the pier head (concrete foundation surrounding the pier heads).

Uplift Capacity: Pier capacity in tension may be assumed to be 50% of the compression capacity.

Settlement: Total settlements (non-seismic) of less than ¼ inch, and differential movement of about two-thirds of total movement for single pier designed according to the preceding recommendations. If pier spacing is at least 2.5 pier diameters center-to-center, no reduction in axial load capacity is considered necessary for group effect.

Note: The entire plant area overlays a geothermal fluids reservoir that geothermal fluids extraction and reinjection is causing annual ground surface settlement of 1 to 2 inches per year. The settlement is not uniform.

Note: Soil strength parameters obtained from field data and laboratory testing were modified based on our engineering judgment and our previous experience in the general site vicinity.

Soil Parameters: Interpretive engineering soil parameters of the subsurface soil for use in the Allpile Computer Program are presented in the table below.

Table 4 – Soil Strength Parameters

Layer Type	Depth (ft)	Unit Weight (pcf)	Friction Angle (deg)	Cohesion (ksf)	Lateral Soil Modulus, k (pci)	e_{50} or Dr	Strength Reduction Factor
SM	0 to 5	115	34°	0	80	45.0	1.0
CL-CH	5 to 12	125	---	1.25	315	0.85	1.0
CL-CH	12 to 40	125	---	1.75	550	0.70	1.0
ML	40 to 50	120	24°	0.50	225	1.00	1.0

***Installation*:** The drilled piers shall be placed in conformance to ACI 336 guidelines. Excavation for piers should be inspected by the geotechnical consultant. A tremie pipe should be used to pour concrete from the bottom up and to ensure less than five feet of free fall. All drilled piers extending below groundwater shall be cased to prevent caving or lateral deformation. Groundwater is expected to be encountered at approximately 8 feet below ground surface.

The structural steel and concrete should be placed immediately after drilling. Prior to placing any structural steel or concrete, loose soil or slough material should be removed from the bottom of the drilled pier excavation.

Slabs-On-Grade

Structural Concrete: Structural concrete slabs are those slabs (foundations) that underlie structures or covered housekeeping slabs (shades). Concrete slabs and flatwork shall be a minimum of 6 inches thick due to equipment loads. Concrete slab and flatwork reinforcement should consist of chaired rebar slab reinforcement (minimum of No. 3 bars at 18-inch centers, both horizontal directions) placed at slab mid-height to resist drying shrinkage cracking. Slab thickness and steel reinforcement are minimums only and should be verified by the structural engineer/designer knowing the actual project loadings.

All steel components of the foundation system should be protected from corrosion by maintaining a 3-inch minimum concrete cover of densely consolidated concrete at footings (by use of a vibrator).

Control joints should be provided in all concrete slabs-on-grade at a maximum spacing (in feet) of 2 to 3 times the slab thickness (in inches) as recommended by American Concrete Institute (ACI) guidelines. All joints should form approximately square patterns to reduce randomly oriented contraction cracks. Contraction joints in the slabs should be tooled at the time of the pour or sawcut (¼ of slab depth) within 6 to 8 hours of concrete placement. Construction (cold) joints in foundations and area flatwork should either be thickened butt-joints with dowels or a thickened keyed-joint designed to resist vertical deflection at the joint.

All joints in flatwork should be sealed to prevent moisture, vermin, or foreign material intrusion. Precautions should be taken to prevent curling of slabs in this arid desert region (refer to ACI guidelines).

Concrete Mixes and Corrosivity

Selected chemical analyses for corrosivity were conducted on bulk samples of the near surface soil from the project site. The native soils were found to have S1 to S2 (moderate to severe) levels of sulfate ion concentration (1,052 to 3,006 ppm). Sulfate ions in high concentrations can attack the cementitious material in concrete, causing weakening of the cement matrix and eventual deterioration by raveling. The following table provides American Concrete Institute (ACI) recommended cement types, water-cement ratio and minimum compressive strengths for concrete in contact with soils:

Table 5. Concrete Mix Design Criteria due to Soluble Sulfate Exposure

Sulfate Exposure Class	Water-soluble Sulfate (SO_4) in soil, ppm	Cement Type	Maximum Water-Cement Ratio by weight	Minimum Strength f'c (psi)
S0	0-1,000	–	–	–
S1	1,000-2,000	II	0.50	4,000
S2	2,000-20,000	V	0.45	4,500
S3	Over 20,000	V (plus Pozzolon)	0.45	4,500

Note: From ACI 318-14 Table 19.3.1.1 and Table 19.3.2.1

A minimum of 6.0 sacks per cubic yard of concrete (4,500 psi) of Type V Portland Cement with a maximum water/cement ratio of 0.45 (by weight) should be used for concrete placed in contact with native soil on this project (sitework including foundations and housekeeping slabs). Admixtures may be required to allow placement of this low water/cement ratio concrete.

The native soil has moderate to very severe level of chloride ion concentration (210 to 3,040 ppm). Chloride ions can cause corrosion of reinforcing steel, anchor bolts and other buried metallic conduits. Resistivity determinations on the soil indicate very severe potential for metal loss because of electrochemical corrosion processes. Mitigation of the corrosion of steel can be achieved by using steel pipes coated with epoxy corrosion inhibitors, asphaltic and epoxy coatings, cathodic protection or by encapsulating the portion of the pipe lying above groundwater with a minimum of 3 inches of densely consolidated concrete. ***No metallic water pipes or conduits should be placed below foundations.***

Foundation designs shall provide a minimum concrete cover of three (3) inches around steel reinforcing or embedded components (anchor bolts, etc.) exposed to native soil. If the 3-inch concrete edge distance cannot be achieved, all embedded steel components (anchor bolts, etc.) shall be epoxy coated for corrosion protection (in accordance with ASTM D3963/A934) or a corrosion inhibitor and a permanent waterproofing membrane shall be placed along the exterior face of the exterior footings.

Additionally, the concrete should be thoroughly vibrated at footings during placement to decrease the permeability of the concrete.

Excavations

All site excavations should conform to CalOSHA requirements for Type C soil. The contractor is solely responsible for the safety of workers entering trenches. Temporary excavations with depths of 4 feet or less may cut nearly vertical for short duration. Sandy soil slopes should be kept moist, but not saturated, to reduce the potential of raveling or sloughing. Excavations below 4 feet will require shoring or slope inclinations in conformance to CAL/OSHA regulations for Type C soil.

Surcharge loads of stockpiled soil or construction materials should be set back from the top of the slope a minimum distance equal to the height of the slope. All permanent slopes should not be steeper than 3:1 to reduce wind and rain erosion. Protected slopes with ground cover may be as steep as 2:1. However, maintenance with motorized equipment may not be possible at this inclination.

Seismic Design

This site is located in the seismically active southern California area and the site structures are subject to strong ground shaking due to potential fault movements along the Imperial and Cerro Prieto faults. Engineered design and earthquake-resistant construction are the common solutions to increase safety and development of seismic areas. Designs should comply with the latest edition of the CBC for Site Class D using the seismic coefficients given in Table 2 of this report.

Closure

We did not encounter soil conditions that would preclude implementation of the proposed project provided the recommendations contained in this report are implemented in the design and construction of this project. We appreciate the opportunity to provide our findings and professional opinions regarding geotechnical conditions at the site. If you have any questions or comments regarding our findings, please call our office at (760) 370-3000.

Respectfully Submitted,
Landmark Consultants, Inc.

JEFFREY O. LYON
No. 31921
EXPIRES 12-31-20

Jeffrey O. Lyon, PE
President

STEVEN K. WILLIAMS
CEG 2261

Steven K. Williams, PG, EG
Senior Engineering Geologist

JULIAN R. AVALOS
No. 73339
EXPIRES 12-31-20

Julian R. Avalos, PE
Senior Engineer

TABLES

Table 1
Summary of Characteristics of Closest Known Active Faults

Fault Name	Approximate Distance (miles)	Approximate Distance (km)	Maximum Moment Magnitude (Mw)	Fault Length (km)	Slip Rate (mm/yr)
Imperial	7.0	11.2	7	62 ± 6	20 ± 5
Superstition Hills	8.4	13.5	6.6	23 ± 2	4 ± 2
Unnamed 2*	8.5	13.6			
Brawley *	8.8	14.1			
Rico *	9.9	15.9			
Unnamed 1*	12.0	19.2			
Borrego (Mexico)*	13.0	20.7			
Yuha*	13.3	21.2			
Superstition Mountain	14.7	23.5	6.6	24 ± 2	5 ± 3
Laguna Salada	14.8	23.6	7	67 ± 7	3.5 ± 1.5
Cerro Prieto *	15.2	24.3			
Pescadores (Mexico)*	17.2	27.5			
Shell Beds	17.3	27.6			
Yuha Well *	17.8	28.5			
Cucapah (Mexico)*	18.4	29.4			
Vista de Anza*	20.4	32.7			
Painted Gorge Wash*	24.0	38.4			
Ocotillo*	25.4	40.6			
Elmore Ranch	28.3	45.3	6.6	29 ± 3	1 ± 0.5
Elsinore - Coyote Mountain	29.1	46.6	6.8	39 ± 4	4 ± 2
San Jacinto - Borrego	33.6	53.8	6.6	29 ± 3	4 ± 2
Algodones *	35.6	57.0			

* Note: Faults not included in CGS database.

Table 2
2016 California Building Code (CBC) and ASCE 7-10 Seismic Parameters

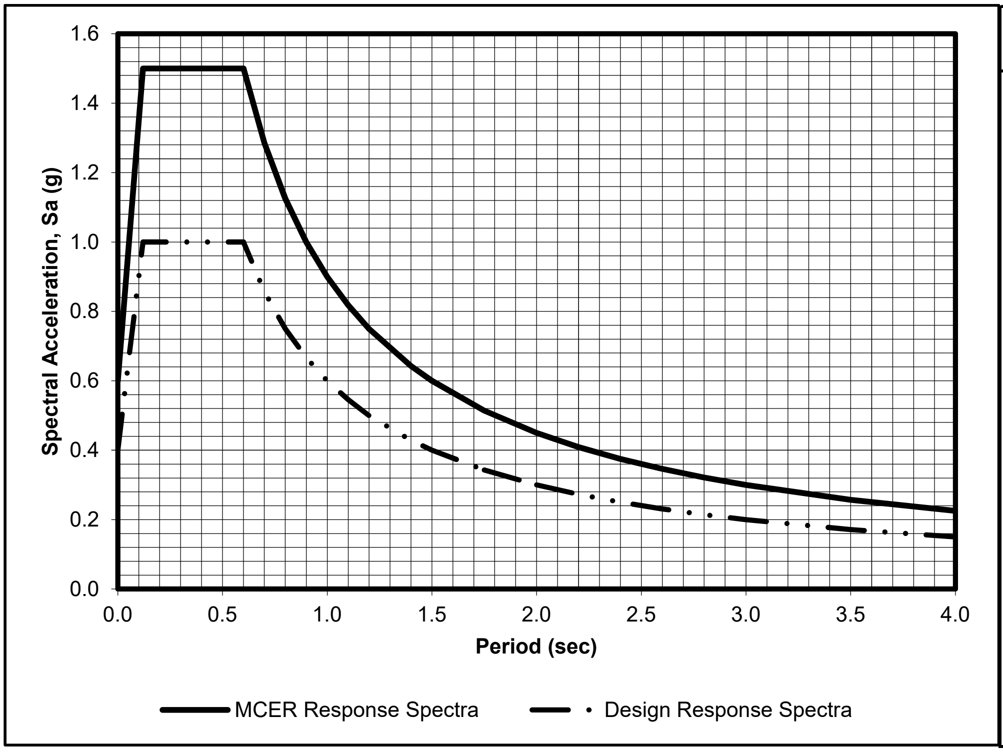
			ASCE 7-10 Reference
Soil Site Class:	**D**		Table 20.3-1
Latitude:	32.7139	N	
Longitude:	-115.5375	W	
Risk Category:	III		
Seismic Design Category:	D		

Maximum Considered Earthquake (MCE) Ground Motion

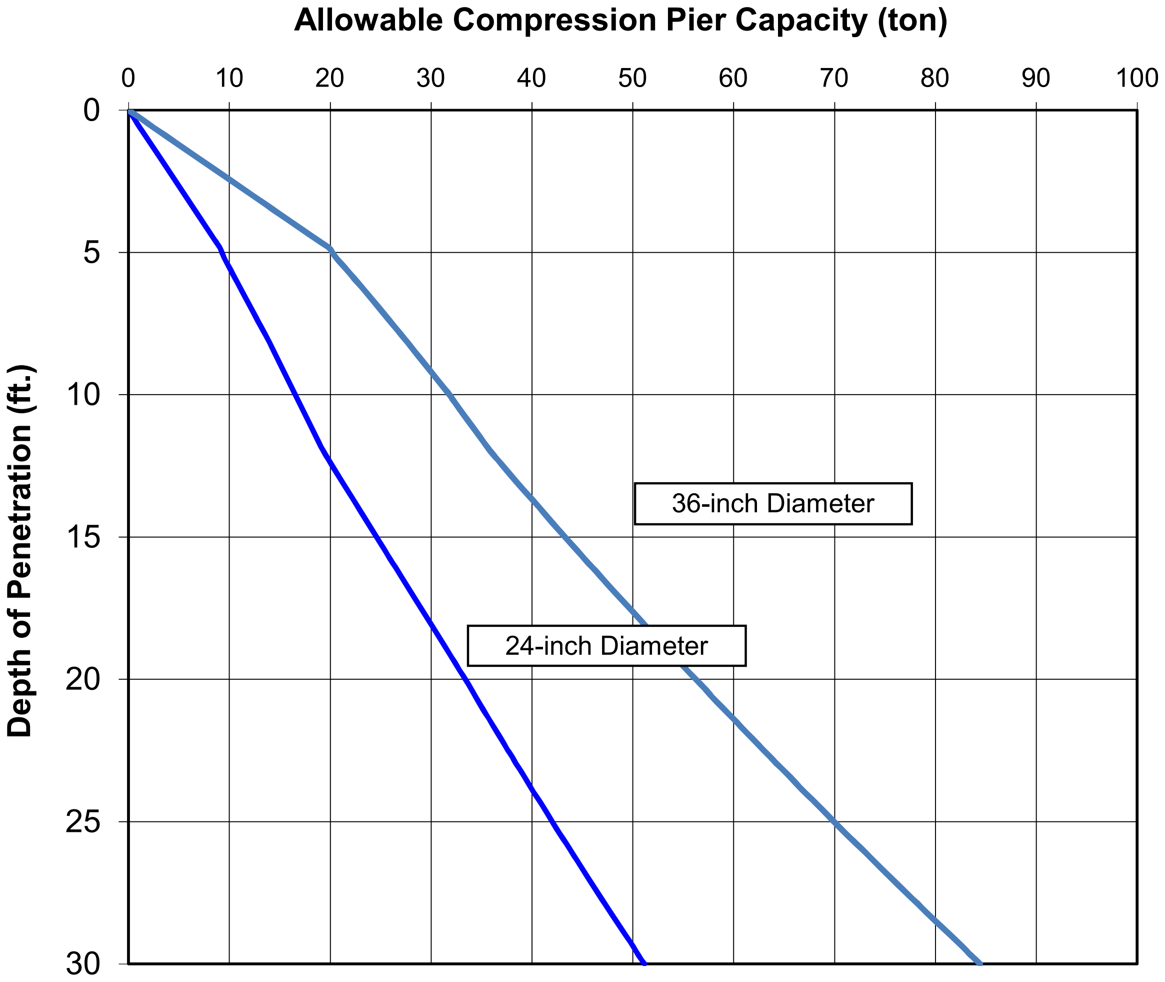
Mapped MCE_R Short Period Spectral Response	$\mathbf{S_s}$	1.500 g	CBC Figure 1613.3.1(1)	
Mapped MCE_R 1 second Spectral Response	$\mathbf{S_1}$	0.600 g	CBC Figure 1613.3.1(2)	
Short Period (0.2 s) Site Coefficient	$\mathbf{F_a}$	1.00	CBC Table 1613.3.3(1)	
Long Period (1.0 s) Site Coefficient	$\mathbf{F_v}$	1.50	CBC Table 1613.3.3(2)	
MCE_R Spectral Response Acceleration Parameter (0.2 s)	$\mathbf{S_{MS}}$	1.500 g	$= F_a * S_s$	CBC Equation 16-37
MCE_R Spectral Response Acceleration Parameter (1.0 s)	$\mathbf{S_{M1}}$	0.900 g	$= F_v * S_1$	CBC Equation 16-38

Design Earthquake Ground Motion

Design Spectral Response Acceleration Parameter (0.2 s)	$\mathbf{S_{DS}}$	1.000 g	$= 2/3*S_{MS}$	CBC Equation 16-39
Design Spectral Response Acceleration Parameter (1.0 s)	$\mathbf{S_{D1}}$	0.600 g	$= 2/3*S_{M1}$	CBC Equation 16-40
Risk Coefficient at Short Periods (less than 0.2 s)	$\mathbf{C_{RS}}$	1.106		ASCE Figure 22-17
Risk Coefficient at Long Periods (greater than 1.0 s)	$\mathbf{C_{R1}}$	1.073		ASCE Figure 22-18
	$\mathbf{T_L}$	8.00 sec		ASCE Figure 22-12
	$\mathbf{T_O}$	0.12 sec	$=0.2*S_{D1}/S_{DS}$	
	$\mathbf{T_S}$	0.60 sec	$=S_{D1}/S_{DS}$	
Peak Ground Acceleration	$\mathbf{PGA_M}$	0.50 g		ASCE Equation 11.8-1



Period T (sec)	Sa (g)	MCE_R Sa (g)
0.00	0.40	0.60
0.12	1.00	1.50
0.60	1.00	1.50
0.70	0.86	1.29
0.80	0.75	1.13
0.90	0.67	1.00
1.00	0.60	0.90
1.10	0.55	0.82
1.20	0.50	0.75
1.20	0.50	0.75
1.40	0.43	0.64
1.50	0.40	0.60
1.75	0.34	0.51
2.00	0.30	0.45
2.20	0.27	0.41
2.40	0.25	0.38
2.60	0.23	0.35
2.80	0.21	0.32
3.00	0.20	0.30
3.50	0.17	0.26
4.00	0.15	0.23



Notes:

1. Compression load capacity are based on skin friction and end-bearing capacity. The structural capacity of the piers should be checked.

2. The indicated capacities are for sustained (dead plus live) vertical compression load, and include a factor of safety of at least 2.5

3. For temporary wind or seismic load, the above values may be increased by one-third.

4. Capacities of other pier sizes are in direct proportion to the pile diameter.

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE19075

Drilled Pier Compression Capacity Chart
Ormat's Heber #2 Plant Expansion
Heber, California

Figure
3

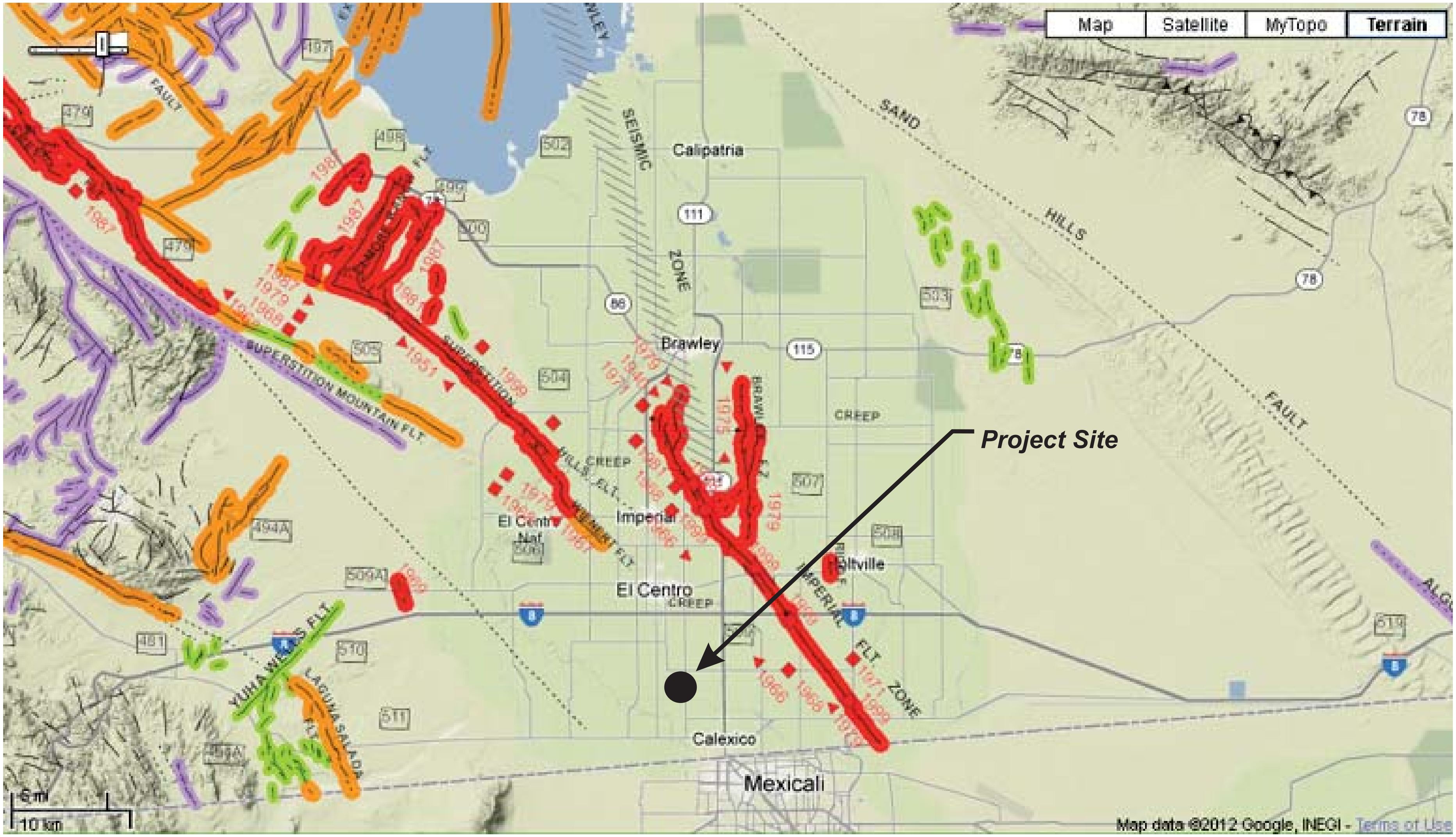
FIGURES

Source: California Geological Survey 2010 Fault Activity Map of California
http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html#

LANDMARK
Geo-Engineers and Geologists
Project No.: LE19075

Regional Fault Map

Figure 1



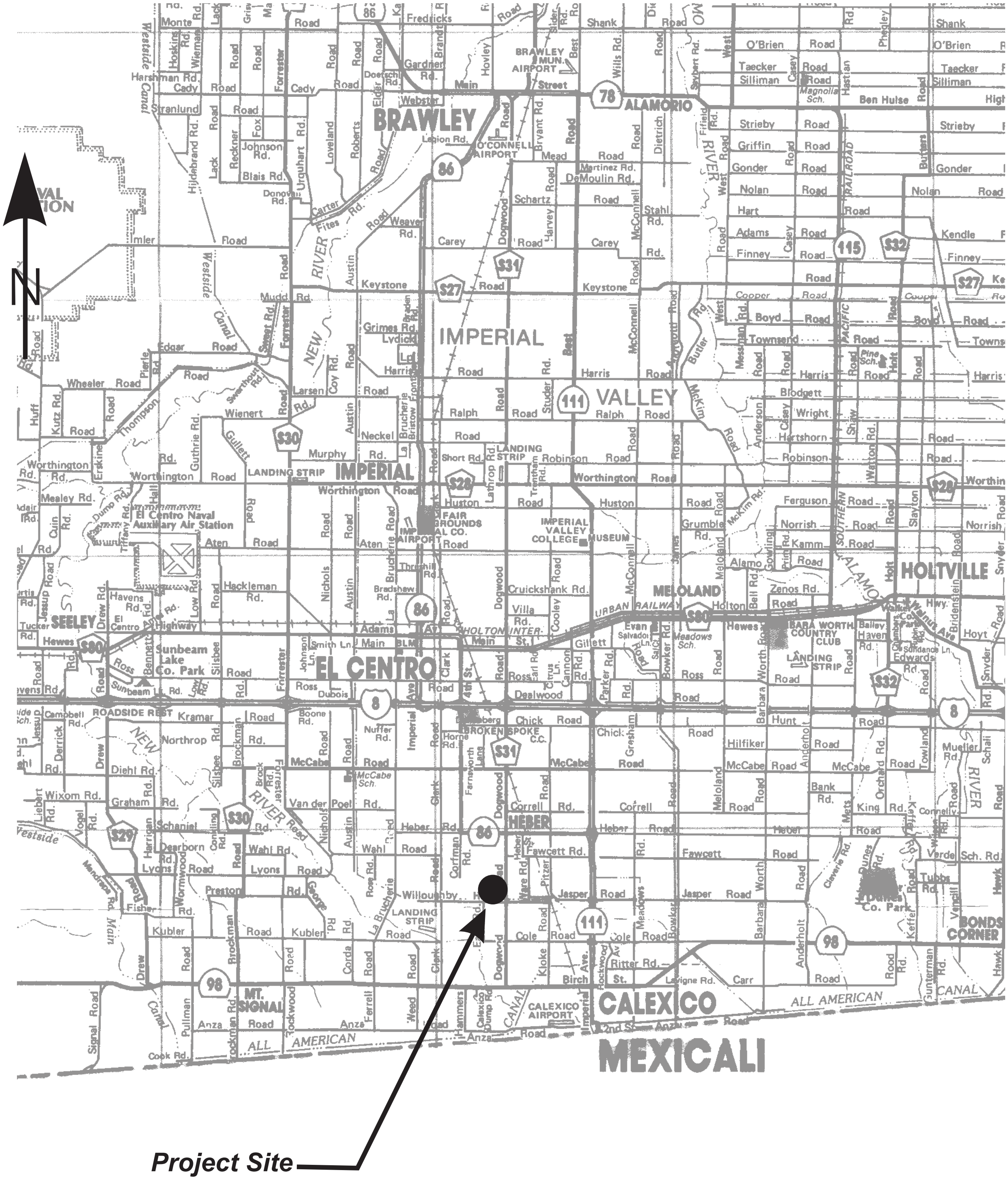
Source: California Geological Survey 2010 Fault Activity Map of California
http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html#

LANDMARK
Geo-Engineers and Geologists
Project No.: LE19075

Map of Local Faults

Figure 2

APPENDIX A

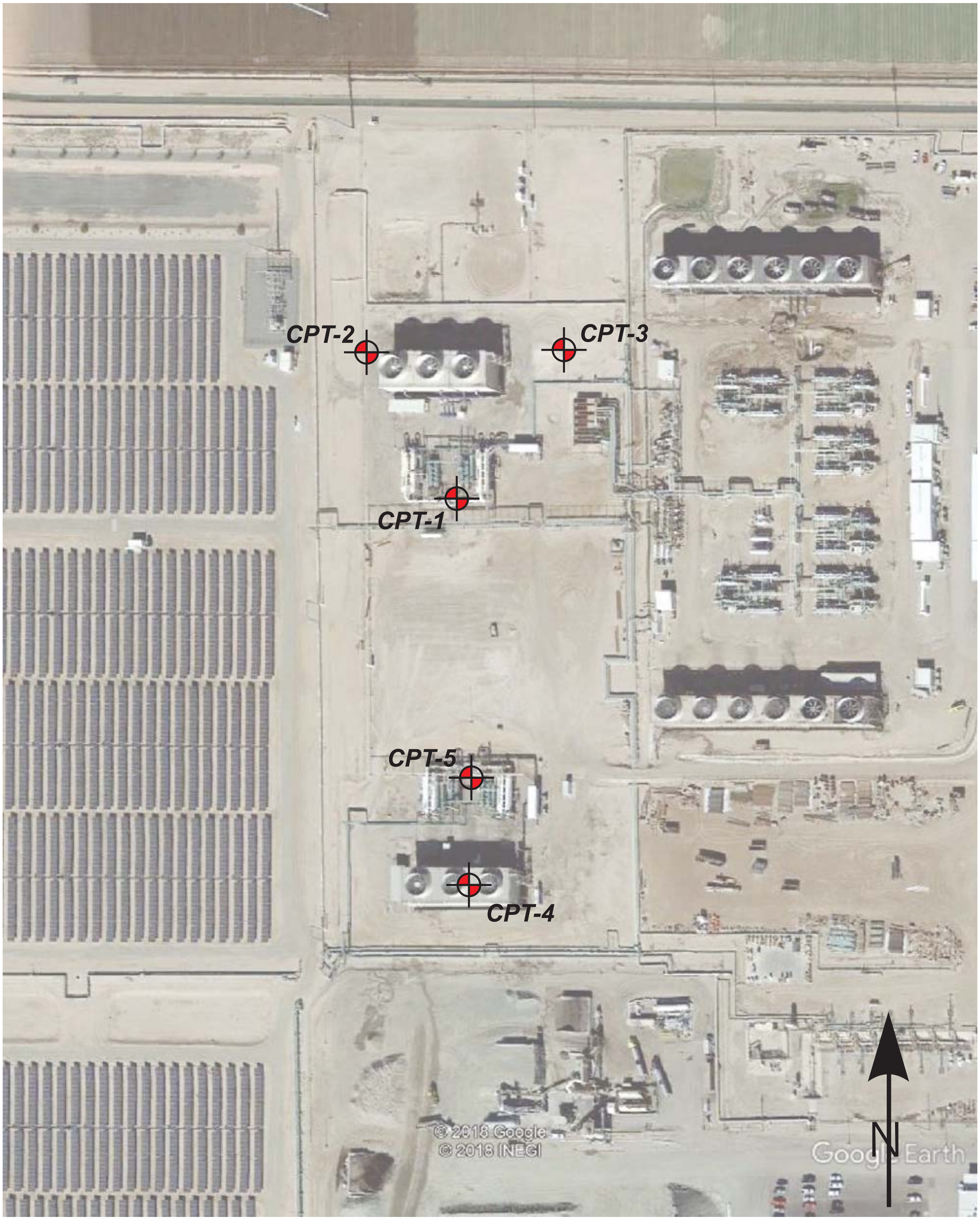


LANDMARK
Geo-Engineers and Geologists

Project No.: LE19075

Vicinity Map

Plate
A-1



LANDMARK
Geo-Engineers and Geologists

Project No.: LE19075

Site and Exploration Map

Plate A-2

APPENDIX B

CLIENT: Ormat Nevada Inc
PROJECT: Heber 2 Repower Project - Heber, CA
LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: Middle Earth Geotesting Truck Mounted Electric
Cone with 23 ton reaction weight
DATE: 12/20/2004

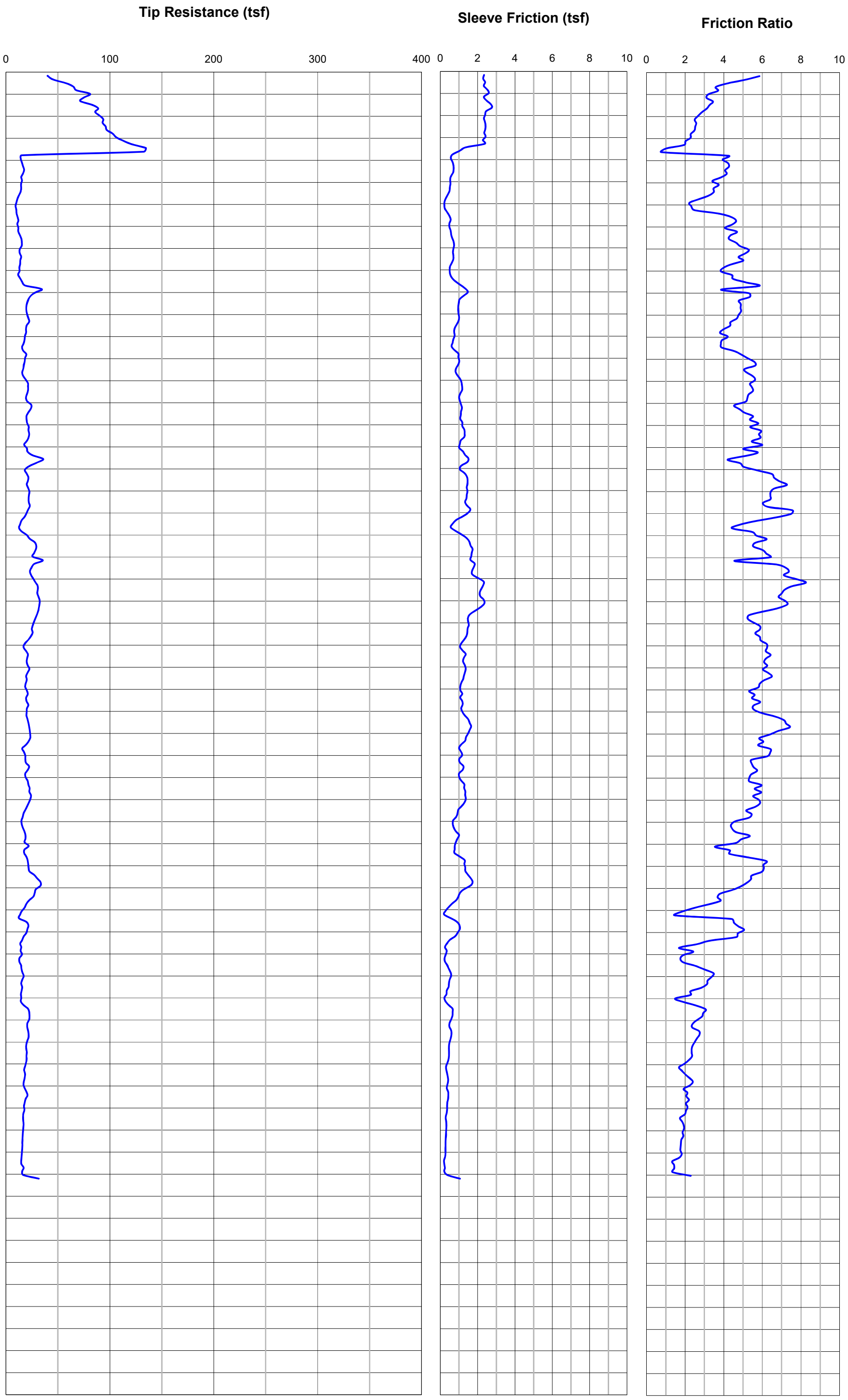
CONE SOUNDING DATA CPT-1

DEPTH

INTERPRETED SOIL PROFILE
From Robertson and Campanella (1989

GROUND ELEVATION +/-

Clayey Silt to Silty Clay	ML/CL	hard
Sandy Silt to Clayey Silt	ML	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Silty Clay to Clay	CL	stiff
Silty Clay to Clay	" "	stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Silty Clay to Clay	CL	stiff
Clayey Silt to Silty Clay	ML/CL	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff
Sandy Silt to Clayey Silt	ML	very loose
Sandy Silt to Clayey Silt	" "	very loose
Clayey Silt to Silty Clay	ML/CL	stiff
Sandy Silt to Clayey Silt	ML	very loose



END OF SOUNDING AT 50 ft.

Project No.
LE19075

LANDMARK
Geo-Engineers and Geologists

PLATE
B-1

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 12/20/2004

CONE SOUNDING: CPT-1
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth (m)	Base Depth (ft)	Avg Tip Qc, tsf	Avg Friction Ratio, %	Soil Classification	USCS	Density or Consistency	Est. Density (pcf)	SPT N(60)	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	**Nk:** Phi (deg.)	**17** Su (tsf)	OCR
0.15	0.5	47.46	5.04	Silty Clay to Clay	CL	hard	125	27		60			2.79	>10
0.30	1.0	71.19	3.50	Sandy Silt to Clayey Silt	ML	very dense	115	20	134.6	45	107	43		
0.45	1.5	76.38	3.27	Sandy Silt to Clayey Silt	ML	very dense	115	22	144.4	40	102	42		
0.60	2.0	88.21	2.88	Sandy Silt to Clayey Silt	ML	very dense	115	25	166.8	35	101	42		
0.75	2.5	94.19	2.53	Silty Sand to Sandy Silt	SM/ML	very dense	115	21	178.0	30	100	42		
0.93	3.0	101.94	2.35	Silty Sand to Sandy Silt	SM/ML	very dense	115	23	192.7	30	99	42		
1.08	3.5	123.24	1.66	Sand to Silty Sand	SP/SM	very dense	115	22	233.0	20	102	42		
1.23	4.0	53.93	2.99	Sandy Silt to Clayey Silt	ML	dense	115	15	101.9	45	76	39		
1.38	4.5	16.43	4.19	Clay	CL/CH	stiff	125	13		85			0.95	>10
1.53	5.0	15.53	3.80	Silty Clay to Clay	CL	stiff	125	9		85			0.90	>10
1.68	5.5	13.99	3.48	Silty Clay to Clay	CL	stiff	125	8		85			0.80	>10
1.83	6.0	10.16	2.42	Clayey Silt to Silty Clay	ML/CL	stiff	120	4		85			0.58	>10
1.98	6.5	10.41	3.55	Silty Clay to Clay	CL	stiff	125	6		95			0.59	>10
2.13	7.0	11.62	4.38	Clay	CL/CH	stiff	125	9		100			0.66	>10
2.28	7.5	13.29	4.44	Clay	CL/CH	stiff	125	11		95			0.76	>10
2.45	8.0	14.55	4.93	Clay	CL/CH	stiff	125	12		95			0.83	>10
2.60	8.5	13.90	4.96	Clay	CL/CH	stiff	125	11		95			0.79	>10
2.75	9.0	13.23	4.08	Clay	CL/CH	stiff	125	11		95			0.75	>10
2.90	9.5	13.66	4.68	Clay	CL/CH	stiff	125	11		100			0.77	>10
3.05	10.0	26.88	5.00	Clay	CL/CH	very stiff	125	22		80			1.55	>10
3.20	10.5	21.69	5.01	Clay	CL/CH	very stiff	125	17		85			1.24	>10
3.35	11.0	19.84	4.85	Clay	CL/CH	very stiff	125	16		90			1.13	>10
3.50	11.5	21.31	4.45	Silty Clay to Clay	CL	very stiff	125	12		85			1.22	>10
3.65	12.0	18.97	4.00	Silty Clay to Clay	CL	very stiff	125	11		85			1.08	>10
3.80	12.5	16.82	3.88	Silty Clay to Clay	CL	stiff	125	10		90			0.95	>10
3.95	13.0	18.18	4.91	Clay	CL/CH	very stiff	125	15		95			1.03	>10
4.13	13.5	17.33	5.43	Clay	CL/CH	stiff	125	14		100			0.98	>10
4.28	14.0	17.04	5.46	Clay	CL/CH	stiff	125	14		100			0.96	>10
4.43	14.5	21.21	5.45	Clay	CL/CH	very stiff	125	17		100			1.21	>10
4.58	15.0	19.96	5.21	Clay	CL/CH	very stiff	125	16		100			1.13	>10
4.73	15.5	23.41	4.80	Clay	CL/CH	very stiff	125	19		90			1.34	>10
4.88	16.0	20.50	5.51	Clay	CL/CH	very stiff	125	16		100			1.16	>10
5.03	16.5	21.94	5.88	Clay	CL/CH	very stiff	125	18		100			1.25	>10
5.18	17.0	19.22	5.48	Clay	CL/CH	very stiff	125	15		100			1.09	>10
5.33	17.5	27.57	5.03	Clay	CL/CH	very stiff	125	22		90			1.58	>10
5.48	18.0	23.29	5.22	Clay	CL/CH	very stiff	125	19		100			1.32	>10
5.65	18.5	20.85	6.67	Clay	CL/CH	very stiff	125	17		100			1.18	>10
5.80	19.0	21.33	6.77	Clay	CL/CH	very stiff	125	17		100			1.21	>10
5.95	19.5	21.97	6.29	Clay	CL/CH	very stiff	125	18		100			1.24	>10
6.10	20.0	21.34	7.09	Clay	CL/CH	very stiff	125	17		100			1.21	>10
6.25	20.5	15.48	5.72	Clay	CL/CH	stiff	125	12		100			0.86	6.21
6.40	21.0	15.87	5.20	Clay	CL/CH	stiff	125	13		100			0.88	6.32
6.55	21.5	26.53	5.79	Clay	CL/CH	very stiff	125	21		100			1.51	>10
6.70	22.0	27.19	6.21	Clay	CL/CH	very stiff	125	22		100			1.55	>10
6.85	22.5	29.12	6.18	Clay	CL/CH	very stiff	125	23		100			1.66	>10
7.00	23.0	24.40	7.41	Clay	CL/CH	very stiff	125	20		100			1.38	>10
7.18	23.5	29.74	7.65	Clay	CL/CH	very stiff	125	24		100			1.69	>10
7.33	24.0	31.24	7.01	Clay	CL/CH	very stiff	125	25		100			1.78	>10
7.48	24.5	31.71	6.74	Clay	CL/CH	very stiff	125	25		100			1.81	>10
7.63	25.0	28.38	5.36	Clay	CL/CH	very stiff	125	23		100			1.61	>10
7.78	25.5	25.50	5.79	Clay	CL/CH	very stiff	125	20		100			1.44	>10
7.93	26.0	21.23	6.01	Clay	CL/CH	very stiff	125	17		100			1.19	7.85
8.08	26.5	19.41	6.26	Clay	CL/CH	very stiff	125	16		100			1.08	6.54
8.23	27.0	21.10	6.12	Clay	CL/CH	very stiff	125	17		100			1.18	7.27
8.38	27.5	20.13	6.30	Clay	CL/CH	very stiff	125	16		100			1.12	6.54
8.53	28.0	19.23	5.66	Clay	CL/CH	very stiff	125	15		100			1.07	6.00
8.68	28.5	20.08	5.65	Clay	CL/CH	very stiff	125	16		100			1.12	6.32
8.85	29.0	20.55	5.67	Clay	CL/CH	very stiff	125	16		100			1.14	6.32
9.00	29.5	20.76	7.00	Clay	CL/CH	very stiff	125	17		100			1.15	6.32
9.15	30.0	22.80	6.88	Clay	CL/CH	very stiff	125	18		100			1.27	7.27
9.30	30.5	21.60	5.89	Clay	CL/CH	very stiff	125	17		100			1.20	6.43
9.45	31.0	17.19	6.36	Clay	CL/CH	stiff	125	14		100			0.94	4.37
9.60	31.5	20.05	5.47	Clay	CL/CH	very stiff	125	16		100			1.11	5.53
9.75	32.0	19.47	5.50	Clay	CL/CH	very stiff	125	16		100			1.07	5.10
9.90	32.5	21.74	5.63	Clay	CL/CH	very stiff	125	17		100			1.21	6.00
10.05	33.0	23.37	5.76	Clay	CL/CH	very stiff	125	19		100			1.30	6.65
10.20	33.5	20.39	5.56	Clay	CL/CH	very stiff	125	16		100			1.13	5.21
10.38	34.0	15.97	5.12	Clay	CL/CH	stiff	125	13		100			0.86	3.50
10.53	34.5	16.45	4.48	Clay	CL/CH	stiff	125	13		100			0.89	3.58
10.68	35.0	18.50	4.96	Clay	CL/CH	very stiff	125	15		100			1.01	4.18
10.83	35.5	19.11	4.05	Silty Clay to Clay	CL	very stiff	125	11		100			1.05	5.53
10.98	36.0	20.64	5.86	Clay	CL/CH	very stiff	125	17		100			1.13	4.78
11.13	36.5	25.44	5.72	Clay	CL/CH	very stiff	125	20		100			1.42	6.65
11.28	37.0	31.72	4.84	Silty Clay to Clay	CL	very stiff	125	18		100			1.79	>10
11.43	37.5	25.49	3.77	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.42	>10
11.58	38.0	17.68	2.48	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.96	6.10
11.73	38.5	15.25	3.47	Silty Clay to Clay	CL	stiff	125	9		100			0.81	3.50

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 12/20/2004

CONE SOUNDING: CPT-1
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base	Base	Avg	Avg				Est.			Est.	Rel.	**Nk:**	**17**	
Depth	Depth	Tip	Friction	Soil		Density or	Density	SPT	Norm.	%	Dens.	Phi	Su	
(m)	(ft)	Qc, tsf	Ratio, %	Classification	USCS	Consistency	(pcf)	N(60)	Qc1n	Fines	Dr (%)	(deg.)	(tsf)	OCR
11.88	39.0	20.64	4.84	Clay	CL/CH	very stiff	125	17		100			1.13	4.28
12.05	39.5	15.50	3.51	Silty Clay to Clay	CL	stiff	125	9		100			0.83	3.50
12.20	40.0	14.77	2.00	Clayey Silt to Silty Clay	ML/CL	stiff	120	6		100			0.78	4.18
12.35	40.5	13.50	2.07	Clayey Silt to Silty Clay	ML/CL	stiff	120	5		100			0.71	3.58
12.50	41.0	15.96	3.29	Silty Clay to Clay	CL	stiff	125	9		100			0.85	3.50
12.65	41.5	15.32	3.05	Clayey Silt to Silty Clay	ML/CL	stiff	120	6		100			0.81	4.28
12.80	42.0	14.74	2.01	Clayey Silt to Silty Clay	ML/CL	stiff	120	6		100			0.78	3.91
12.95	42.5	17.48	2.54	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.94	5.10
13.10	43.0	22.47	2.80	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.23	7.70
13.25	43.5	20.78	2.49	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.13	6.65
13.40	44.0	21.29	2.62	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.16	6.76
13.58	44.5	19.71	2.35	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.07	5.88
13.73	45.0	19.60	2.17	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.06	5.76
13.88	45.5	18.05	1.84	Sandy Silt to Clayey Silt	ML	very loose	115	5	13.8	100	14	30		
14.03	46.0	17.42	2.29	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.93	4.57
14.18	46.5	19.49	2.03	Sandy Silt to Clayey Silt	ML	very loose	115	6	14.7	100	16	30		
14.33	47.0	17.99	2.10	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.96	4.68
14.48	47.5	16.62	1.85	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.88	4.09
14.63	48.0	16.66	1.91	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.88	4.00
14.78	48.5	15.96	1.83	Clayey Silt to Silty Clay	ML/CL	stiff	120	6		100			0.84	3.74
14.93	49.0	15.56	1.78	Clayey Silt to Silty Clay	ML/CL	stiff	120	6		100			0.81	3.58
15.10	49.5	14.89	1.48	Sandy Silt to Clayey Silt	ML	very loose	115	4	11.0	100	7	29		
15.25	50.0	16.44	1.69	Sandy Silt to Clayey Silt	ML	very loose	115	5	12.1	100	10	29		

CLIENT: Ormat Nevada Inc
PROJECT: Heber 2 Repower Project - Heber, CA

LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: Middle Earth Geotesting Truck Mounted Electric Cone with 23 ton reaction weight

DATE: 12/20/2004

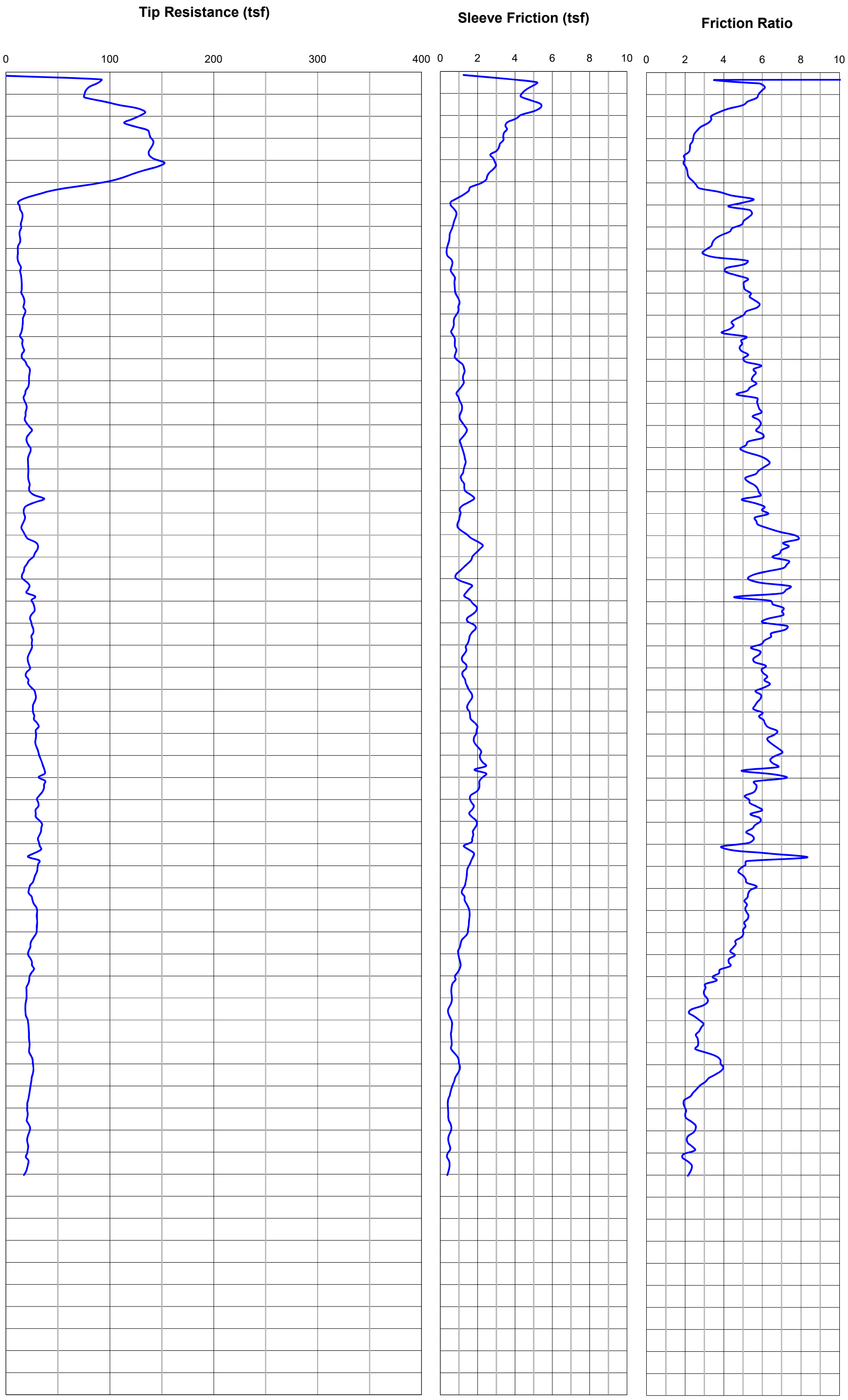
CONE SOUNDING DATA CPT-2

DEPTH

INTERPRETED SOIL PROFILE
From Robertson and Campanella (1989

GROUND ELEVATION +/-

Overconsolidated Soil	??	very dense
Overconsolidated Soil	" "	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Silty Sand to Sandy Silt	" "	very dense
Clayey Silt to Silty Clay	ML/CL	hard
Clay	CL/CH	stiff
Silty Clay to Clay	CL	stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Silty Clay to Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Sandy Silt to Clayey Silt	ML	very loose
Clayey Silt to Silty Clay	ML/CL	very stiff
Sandy Silt to Clayey Silt	ML	very loose
Sandy Silt to Clayey Silt	" "	very loose



END OF SOUNDING AT 50 ft.

Project No.

LE19075

LANDMARK
Geo-Engineers and Geologists

PLATE

B-2

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 12/20/2004

CONE SOUNDING: CPT-2
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth (m)	Base Depth (ft)	Avg Tip Qc, tsf	Avg Friction Ratio, %	Soil Classification	USCS	Density or Consistency	Est. Density (pcf)	SPT N(60)	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	**Nk:** Phi (deg.)	**17** Su (tsf)	OCR
0.15	0.5	60.03	169.32	Overconsolidated Soil	??	very dense	120	60	113.5	100	119	45		
0.30	1.0	77.82	5.97	Overconsolidated Soil	??	very dense	120	78	147.1	55	110	43		
0.45	1.5	91.98	5.31	Overconsolidated Soil	??	very dense	120	92	173.9	50	107	43		
0.60	2.0	129.94	3.78	Sandy Silt to Clayey Silt	ML	very dense	115	37	245.6	35	113	44		
0.75	2.5	119.62	3.11	Sandy Silt to Clayey Silt	ML	very dense	115	34	226.1	30	107	43		
0.93	3.0	137.68	2.51	Silty Sand to Sandy Silt	SM/ML	very dense	115	31	260.3	25	108	43		
1.08	3.5	140.87	2.30	Silty Sand to Sandy Silt	SM/ML	very dense	115	31	266.3	25	106	43		
1.23	4.0	139.35	2.04	Silty Sand to Sandy Silt	SM/ML	very dense	115	31	263.4	20	104	43		
1.38	4.5	144.85	2.01	Silty Sand to Sandy Silt	SM/ML	very dense	115	32	273.8	20	103	42		
1.53	5.0	113.08	2.24	Silty Sand to Sandy Silt	SM/ML	very dense	115	25	208.9	25	94	41		
1.68	5.5	52.70	3.38	Clayey Silt to Silty Clay	ML/CL	hard	120	21		50			3.08	>10
1.83	6.0	13.87	4.91	Clay	CL/CH	stiff	125	11		95			0.80	>10
1.98	6.5	15.08	5.36	Clay	CL/CH	stiff	125	12		95			0.87	>10
2.13	7.0	14.77	4.81	Clay	CL/CH	stiff	125	12		95			0.85	>10
2.28	7.5	13.38	3.90	Clay	CL/CH	stiff	125	11		90			0.76	>10
2.45	8.0	12.25	3.27	Silty Clay to Clay	CL	stiff	125	7		90			0.69	>10
2.60	8.5	11.34	3.86	Clay	CL/CH	stiff	125	9		95			0.64	>10
2.75	9.0	13.62	4.43	Clay	CL/CH	stiff	125	11		95			0.77	>10
2.90	9.5	14.76	4.97	Clay	CL/CH	stiff	125	12		95			0.84	>10
3.05	10.0	15.04	5.19	Clay	CL/CH	stiff	125	12		100			0.85	>10
3.20	10.5	17.24	5.61	Clay	CL/CH	stiff	125	14		100			0.98	>10
3.35	11.0	17.82	5.31	Clay	CL/CH	very stiff	125	14		95			1.02	>10
3.50	11.5	16.22	4.53	Clay	CL/CH	stiff	125	13		95			0.92	>10
3.65	12.0	14.59	4.45	Clay	CL/CH	stiff	125	12		100			0.82	>10
3.80	12.5	15.95	4.89	Clay	CL/CH	stiff	125	13		100			0.90	>10
3.95	13.0	16.10	5.07	Clay	CL/CH	stiff	125	13		100			0.91	>10
4.13	13.5	20.52	5.55	Clay	CL/CH	very stiff	125	16		95			1.17	>10
4.28	14.0	22.48	5.55	Clay	CL/CH	very stiff	125	18		95			1.28	>10
4.43	14.5	20.89	5.42	Clay	CL/CH	very stiff	125	17		100			1.19	>10
4.58	15.0	17.79	5.37	Clay	CL/CH	very stiff	125	14		100			1.01	>10
4.73	15.5	19.47	5.86	Clay	CL/CH	very stiff	125	16		100			1.10	>10
4.88	16.0	19.76	5.77	Clay	CL/CH	very stiff	125	16		100			1.12	>10
5.03	16.5	22.53	5.91	Clay	CL/CH	very stiff	125	18		100			1.28	>10
5.18	17.0	21.67	5.09	Clay	CL/CH	very stiff	125	17		100			1.23	>10
5.33	17.5	22.15	5.77	Clay	CL/CH	very stiff	125	18		100			1.26	>10
5.48	18.0	21.43	6.10	Clay	CL/CH	very stiff	125	17		100			1.21	>10
5.65	18.5	21.56	5.34	Clay	CL/CH	very stiff	125	17		100			1.22	>10
5.80	19.0	22.73	5.72	Clay	CL/CH	very stiff	125	18		100			1.29	>10
5.95	19.5	30.63	5.48	Clay	CL/CH	very stiff	125	25		90			1.75	>10
6.10	20.0	17.95	6.14	Clay	CL/CH	very stiff	125	14		100			1.01	8.41
6.25	20.5	17.30	5.70	Clay	CL/CH	stiff	125	14		100			0.97	7.56
6.40	21.0	16.60	6.99	Clay	CL/CH	stiff	125	13		100			0.93	6.76
6.55	21.5	26.75	7.44	Clay	CL/CH	very stiff	125	21		100			1.52	>10
6.70	22.0	28.17	6.81	Clay	CL/CH	very stiff	125	23		100			1.60	>10
6.85	22.5	20.17	7.24	Clay	CL/CH	very stiff	125	16		100			1.13	8.85
7.00	23.0	16.15	5.62	Clay	CL/CH	stiff	125	13		100			0.90	5.88
7.18	23.5	21.37	6.84	Clay	CL/CH	very stiff	125	17		100			1.20	9.19
7.33	24.0	24.23	5.98	Clay	CL/CH	very stiff	125	19		100			1.37	>10
7.48	24.5	27.09	6.88	Clay	CL/CH	very stiff	125	22		100			1.54	>10
7.63	25.0	23.97	6.46	Clay	CL/CH	very stiff	125	19		100			1.35	>10
7.78	25.5	25.90	6.98	Clay	CL/CH	very stiff	125	21		100			1.46	>10
7.93	26.0	24.80	6.17	Clay	CL/CH	very stiff	125	20		100			1.40	>10
8.08	26.5	22.94	5.66	Clay	CL/CH	very stiff	125	18		100			1.29	8.85
8.23	27.0	22.28	5.92	Clay	CL/CH	very stiff	125	18		100			1.25	8.14
8.38	27.5	20.15	6.14	Clay	CL/CH	very stiff	125	16		100			1.12	6.65
8.53	28.0	24.13	6.05	Clay	CL/CH	very stiff	125	19		100			1.36	9.00
8.68	28.5	28.28	5.86	Clay	CL/CH	very stiff	125	23		100			1.60	>10
8.85	29.0	26.02	5.73	Clay	CL/CH	very stiff	125	21		100			1.46	>10
9.00	29.5	28.06	6.01	Clay	CL/CH	very stiff	125	22		100			1.58	>10
9.15	30.0	29.72	6.57	Clay	CL/CH	very stiff	125	24		100			1.68	>10
9.30	30.5	28.55	6.41	Clay	CL/CH	very stiff	125	23		100			1.61	>10
9.45	31.0	31.07	6.84	Clay	CL/CH	very stiff	125	25		100			1.76	>10
9.60	31.5	34.71	6.59	Clay	CL/CH	very stiff	125	28		100			1.97	>10
9.75	32.0	35.27	6.25	Clay	CL/CH	hard	125	28		100			2.00	>10
9.90	32.5	37.01	5.65	Clay	CL/CH	hard	125	30		100			2.10	>10
10.05	33.0	32.37	5.31	Clay	CL/CH	very stiff	125	26		100			1.83	>10
10.20	33.5	30.28	5.70	Clay	CL/CH	very stiff	125	24		100			1.71	>10
10.38	34.0	29.97	5.71	Clay	CL/CH	very stiff	125	24		100			1.69	>10
10.53	34.5	34.16	5.42	Clay	CL/CH	very stiff	125	27		100			1.93	>10
10.68	35.0	31.53	5.44	Clay	CL/CH	very stiff	125	25		100			1.78	>10
10.83	35.5	31.18	4.96	Clay	CL/CH	very stiff	125	25		100			1.76	>10
10.98	36.0	28.08	6.21	Clay	CL/CH	very stiff	125	22		100			1.57	8.14
11.13	36.5	28.95	4.94	Clay	CL/CH	very stiff	125	23		100			1.62	8.41
11.28	37.0	23.74	5.43	Clay	CL/CH	very stiff	125	19		100			1.32	5.88
11.43	37.5	24.03	5.19	Clay	CL/CH	very stiff	125	19		100			1.33	5.88
11.58	38.0	28.73	5.16	Clay	CL/CH	very stiff	125	23		100			1.61	7.70
11.73	38.5	29.89	5.19	Clay	CL/CH	very stiff	125	24		100			1.68	8.14

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 12/20/2004

CONE SOUNDING: CPT-2
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base	Base	Avg	Avg				Est.			Est.	Rel.	**Nk:**	**17**	
Depth	Depth	Tip	Friction	Soil		Density or	Density	SPT	Norm.	%	Dens.	Phi	Su	
(m)	(ft)	Qc, tsf	Ratio, %	Classification	USCS	Consistency	(pcf)	N(60)	Qc1n	Fines	Dr (%)	(deg.)	(tsf)	OCR
11.88	39.0	29.55	5.05	Clay	CL/CH	very stiff	125	24		100			1.65	7.85
12.05	39.5	25.32	4.72	Clay	CL/CH	very stiff	125	20		100			1.40	5.88
12.20	40.0	22.19	4.46	Clay	CL/CH	very stiff	125	18		100			1.22	4.68
12.35	40.5	24.43	4.30	Silty Clay to Clay	CL	very stiff	125	14		100			1.35	7.00
12.50	41.0	24.85	3.66	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.37	>10
12.65	41.5	21.29	3.25	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.16	7.41
12.80	42.0	19.81	3.04	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.08	6.43
12.95	42.5	18.87	2.79	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.02	5.88
13.10	43.0	19.60	2.48	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.06	6.10
13.25	43.5	21.70	2.84	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.18	7.13
13.40	44.0	22.24	2.62	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.22	7.27
13.58	44.5	22.52	2.78	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.23	7.41
13.73	45.0	25.15	3.77	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.38	8.85
13.88	45.5	26.20	3.80	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.45	9.59
14.03	46.0	24.44	3.02	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.34	8.14
14.18	46.5	22.65	2.43	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.24	7.00
14.33	47.0	20.81	1.98	Sandy Silt to Clayey Silt	ML	very loose	115	6	15.7	100	18	30		
14.48	47.5	20.51	2.12	Sandy Silt to Clayey Silt	ML	very loose	115	6	15.4	100	17	30		
14.63	48.0	22.61	2.50	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.23	6.65
14.78	48.5	20.83	2.13	Sandy Silt to Clayey Silt	ML	very loose	115	6	15.5	100	17	30		
14.93	49.0	20.93	2.27	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.13	5.76
15.10	49.5	20.67	2.11	Sandy Silt to Clayey Silt	ML	very loose	115	6	15.3	100	17	30		
15.25	50.0	19.06	2.25	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.02	4.78

CLIENT: Ormat Nevada Inc
PROJECT: Heber 2 Repower Project - Heber, CA
LOCATION: See Site and Boring Location Plan

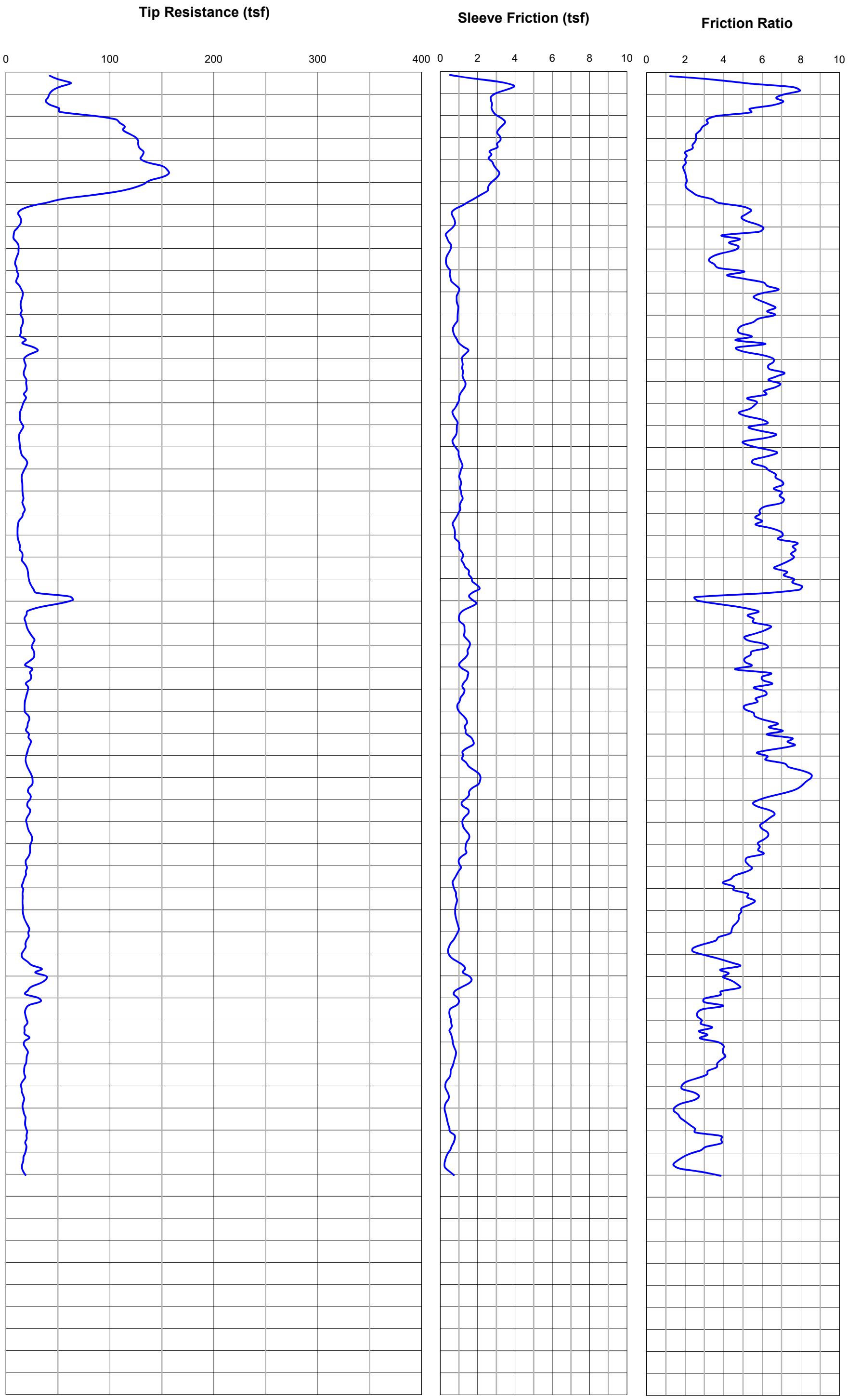
CONE PENETROMETER: Middle Earth Geotesting Truck Mounted Electric
Cone with 23 ton reaction weight
DATE: 12/20/2004

CONE SOUNDING DATA CPT-3

INTERPRETED SOIL PROFILE
From Robertson and Campanella (1989

GROUND ELEVATION +/-

Clay	CL/CH	hard
Clay	" "	hard
Sandy Silt to Clayey Silt	ML	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Sandy Silt to Clayey Silt	ML	dense
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	hard
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Silty Clay to Clay	CL	very stiff
Silty Clay to Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clayey Silt to Silty Clay	ML/CL	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff



END OF SOUNDING AT 50 ft.

Project No.
LE19075

LANDMARK
Geo-Engineers and Geologists

PLATE
B-3

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 12/20/2004

CONE SOUNDING: CPT-3
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth (m)	Base Depth (ft)	Avg Tip Qc, tsf	Avg Friction Ratio, %	Soil Classification	USCS	Density or Consistency	Est. Density (pcf)	SPT N(60)	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	**Nk:** Phi (deg.)	**17** Su (tsf)	OCR
0.15	0.5	51.76	3.36	Clayey Silt to Silty Clay	ML/CL	hard	120	21		50			3.04	>10
0.30	1.0	46.42	7.56	Clay	CL/CH	hard	125	37		75			2.73	>10
0.45	1.5	40.35	6.79	Clay	CL/CH	hard	125	32		75			2.37	>10
0.60	2.0	61.72	4.80	Silty Clay to Clay	CL	hard	125	35		55			3.62	>10
0.75	2.5	109.67	3.07	Sandy Silt to Clayey Silt	ML	very dense	115	31	207.3	35	104	43		
0.93	3.0	118.60	2.64	Silty Sand to Sandy Silt	SM/ML	very dense	115	26	224.2	30	103	42		
1.08	3.5	127.70	2.43	Silty Sand to Sandy Silt	SM/ML	very dense	115	28	241.4	25	103	42		
1.23	4.0	131.15	2.02	Silty Sand to Sandy Silt	SM/ML	very dense	115	29	247.9	25	102	42		
1.38	4.5	147.55	1.96	Silty Sand to Sandy Silt	SM/ML	very dense	115	33	278.9	20	103	42		
1.53	5.0	148.38	2.05	Silty Sand to Sandy Silt	SM/ML	very dense	115	33	271.7	20	102	42		
1.68	5.5	111.44	2.28	Silty Sand to Sandy Silt	SM/ML	very dense	115	25	194.4	25	92	41		
1.83	6.0	40.17	4.02	Clayey Silt to Silty Clay	ML/CL	hard	120	16		60			2.34	>10
1.98	6.5	13.36	5.18	Clay	CL/CH	stiff	125	11		100			0.76	>10
2.13	7.0	13.22	5.65	Clay	CL/CH	stiff	125	11		100			0.75	>10
2.28	7.5	7.68	4.85	Clay	CL/CH	firm	125	6		100			0.43	6.10
2.45	8.0	11.50	4.55	Clay	CL/CH	stiff	125	9		100			0.65	>10
2.60	8.5	10.61	3.49	Silty Clay to Clay	CL	stiff	125	6		95			0.60	>10
2.75	9.0	9.81	4.10	Clay	CL/CH	stiff	125	8		100			0.55	7.27
2.90	9.5	10.85	5.09	Clay	CL/CH	stiff	125	9		100			0.61	8.27
3.05	10.0	14.61	6.36	Clay	CL/CH	stiff	125	12		100			0.83	>10
3.20	10.5	14.97	5.91	Clay	CL/CH	stiff	125	12		100			0.85	>10
3.35	11.0	14.49	6.53	Clay	CL/CH	stiff	125	12		100			0.82	>10
3.50	11.5	15.94	5.42	Clay	CL/CH	stiff	125	13		100			0.90	>10
3.65	12.0	14.15	5.01	Clay	CL/CH	stiff	125	11		100			0.80	>10
3.80	12.5	20.31	5.15	Clay	CL/CH	very stiff	125	16		95			1.16	>10
3.95	13.0	23.81	5.79	Clay	CL/CH	very stiff	125	19		95			1.36	>10
4.13	13.5	18.35	6.42	Clay	CL/CH	very stiff	125	15		100			1.04	>10
4.28	14.0	18.13	6.73	Clay	CL/CH	very stiff	125	15		100			1.03	>10
4.43	14.5	19.70	6.56	Clay	CL/CH	very stiff	125	16		100			1.12	>10
4.58	15.0	18.07	5.71	Clay	CL/CH	very stiff	125	14		100			1.02	>10
4.73	15.5	14.86	5.24	Clay	CL/CH	stiff	125	12		100			0.83	8.27
4.88	16.0	14.60	5.69	Clay	CL/CH	stiff	125	12		100			0.82	7.70
5.03	16.5	13.49	6.25	Clay	CL/CH	stiff	125	11		100			0.75	6.43
5.18	17.0	13.31	5.44	Clay	CL/CH	stiff	125	11		100			0.74	6.10
5.33	17.5	16.20	6.21	Clay	CL/CH	stiff	125	13		100			0.91	8.27
5.48	18.0	19.16	5.98	Clay	CL/CH	very stiff	125	15		100			1.08	>10
5.65	18.5	15.49	6.80	Clay	CL/CH	stiff	125	12		100			0.86	7.13
5.80	19.0	15.81	6.89	Clay	CL/CH	stiff	125	13		100			0.88	7.13
5.95	19.5	16.32	7.00	Clay	CL/CH	stiff	125	13		100			0.91	7.27
6.10	20.0	17.26	5.95	Clay	CL/CH	stiff	125	14		100			0.97	7.85
6.25	20.5	13.28	5.76	Clay	CL/CH	stiff	125	11		100			0.73	4.89
6.40	21.0	11.14	6.84	Clay	CL/CH	stiff	125	9		100			0.60	3.58
6.55	21.5	12.48	7.40	Clay	CL/CH	stiff	125	10		100			0.68	4.18
6.70	22.0	14.92	7.62	Clay	CL/CH	stiff	125	12		100			0.82	5.42
6.85	22.5	17.77	6.98	Clay	CL/CH	stiff	125	14		100			0.99	7.00
7.00	23.0	21.45	7.34	Clay	CL/CH	very stiff	125	17		100			1.21	9.59
7.18	23.5	24.58	7.84	Clay	CL/CH	very stiff	125	20		100			1.39	>10
7.33	24.0	51.65	3.68	Clayey Silt to Silty Clay	ML/CL	hard	120	21		70			2.98	>10
7.48	24.5	34.37	4.91	Clay	CL/CH	very stiff	125	27		90			1.96	>10
7.63	25.0	18.84	5.44	Clay	CL/CH	very stiff	125	15		100			1.05	6.76
7.78	25.5	21.09	6.11	Clay	CL/CH	very stiff	125	17		100			1.18	8.00
7.93	26.0	26.12	5.49	Clay	CL/CH	very stiff	125	21		100			1.48	>10
8.08	26.5	26.28	5.55	Clay	CL/CH	very stiff	125	21		100			1.48	>10
8.23	27.0	21.92	5.06	Clay	CL/CH	very stiff	125	18		100			1.23	7.85
8.38	27.5	23.63	6.15	Clay	CL/CH	very stiff	125	19		100			1.33	8.85
8.53	28.0	20.49	6.07	Clay	CL/CH	very stiff	125	16		100			1.14	6.65
8.68	28.5	19.11	5.87	Clay	CL/CH	very stiff	125	15		100			1.06	5.88
8.85	29.0	18.15	5.24	Clay	CL/CH	very stiff	125	15		100			1.00	5.21
9.00	29.5	21.72	6.18	Clay	CL/CH	very stiff	125	17		100			1.21	6.88
9.15	30.0	20.63	6.55	Clay	CL/CH	very stiff	125	17		100			1.15	6.21
9.30	30.5	22.90	7.51	Clay	CL/CH	very stiff	125	18		100			1.28	7.13
9.45	31.0	20.57	6.23	Clay	CL/CH	very stiff	125	16		100			1.14	5.88
9.60	31.5	19.55	6.90	Clay	CL/CH	very stiff	125	16		100			1.08	5.31
9.75	32.0	23.76	8.37	Clay	CL/CH	very stiff	125	19		100			1.33	7.13
9.90	32.5	24.30	8.05	Clay	CL/CH	very stiff	125	19		100			1.36	7.27
10.05	33.0	22.78	6.54	Clay	CL/CH	very stiff	125	18		100			1.27	6.32
10.20	33.5	21.56	5.91	Clay	CL/CH	very stiff	125	17		100			1.19	5.76
10.38	34.0	20.82	6.40	Clay	CL/CH	very stiff	125	17		100			1.15	5.31
10.53	34.5	21.17	6.04	Clay	CL/CH	very stiff	125	17		100			1.17	5.31
10.68	35.0	24.71	6.05	Clay	CL/CH	very stiff	125	20		100			1.38	6.65
10.83	35.5	23.14	5.91	Clay	CL/CH	very stiff	125	19		100			1.28	5.88
10.98	36.0	19.96	5.21	Clay	CL/CH	very stiff	125	16		100			1.10	4.57
11.13	36.5	19.03	4.88	Clay	CL/CH	very stiff	125	15		100			1.04	4.18
11.28	37.0	16.19	4.33	Clay	CL/CH	stiff	125	13		100			0.87	3.28
11.43	37.5	16.02	5.36	Clay	CL/CH	stiff	125	13		100			0.86	3.14
11.58	38.0	16.15	5.06	Clay	CL/CH	stiff	125	13		100			0.87	3.14
11.73	38.5	17.81	4.75	Clay	CL/CH	stiff	125	14		100			0.96	3.50

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 12/20/2004

CONE SOUNDING: CPT-3
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

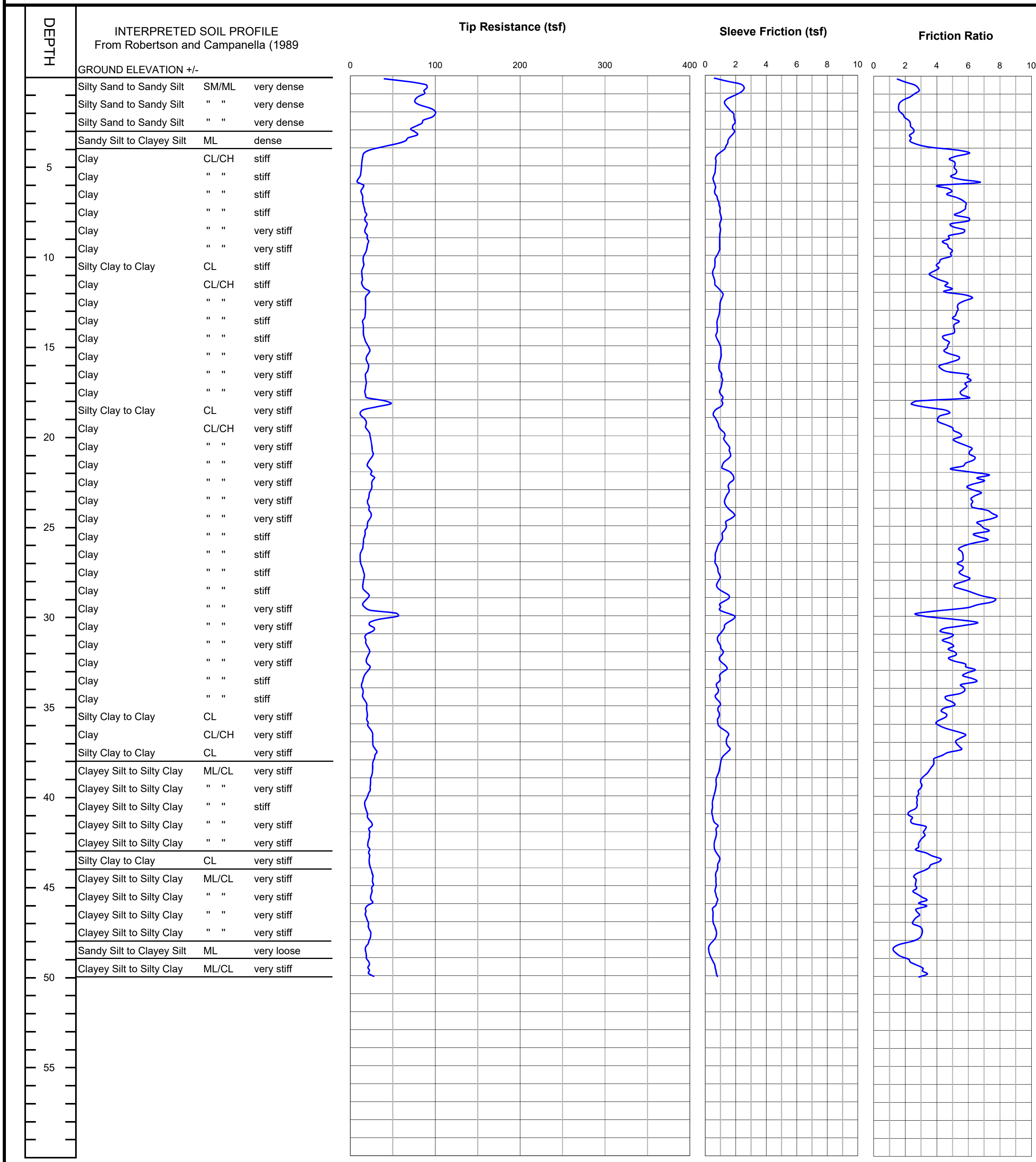
Base Depth (m)	Base Depth (ft)	Avg Tip Qc, tsf	Avg Friction Ratio, %	Soil Classification	USCS	Density or Consistency	Est. Density (pcf)	SPT N(60)	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	**Nk:** Phi (deg.)	**17** Su (tsf)	OCR
11.88	39.0	21.66	4.41	Silty Clay to Clay	CL	very stiff	125	12		100			1.19	6.00
12.05	39.5	20.18	3.42	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.10	7.13
12.20	40.0	17.00	2.62	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.91	5.31
12.35	40.5	20.64	4.32	Silty Clay to Clay	CL	very stiff	125	12		100			1.13	5.31
12.50	41.0	33.91	4.01	Clayey Silt to Silty Clay	ML/CL	very stiff	120	14		100			1.91	>10
12.65	41.5	31.64	4.64	Silty Clay to Clay	CL	very stiff	125	18		100			1.77	>10
12.80	42.0	23.58	3.56	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.30	8.70
12.95	42.5	24.97	3.28	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.38	9.79
13.10	43.0	19.07	2.71	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.03	5.88
13.25	43.5	18.86	2.98	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.02	5.65
13.40	44.0	19.54	3.20	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.06	5.88
13.58	44.5	19.29	3.97	Silty Clay to Clay	CL	very stiff	125	11		100			1.04	4.18
13.73	45.0	19.79	3.86	Silty Clay to Clay	CL	very stiff	125	11		100			1.07	4.28
13.88	45.5	17.66	3.31	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.94	4.78
14.03	46.0	16.42	2.18	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.87	4.18
14.18	46.5	15.61	2.35	Clayey Silt to Silty Clay	ML/CL	stiff	120	6		100			0.82	3.74
14.33	47.0	16.68	1.80	Sandy Silt to Clayey Silt	ML	very loose	115	5	12.5	100	11	30		
14.48	47.5	18.25	1.80	Sandy Silt to Clayey Silt	ML	very loose	115	5	13.7	100	14	30		
14.63	48.0	19.39	2.43	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.04	5.21
14.78	48.5	19.39	3.87	Silty Clay to Clay	CL	very stiff	125	11		100			1.04	3.83
14.93	49.0	19.13	2.69	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.02	4.89
15.10	49.5	16.46	1.59	Sandy Silt to Clayey Silt	ML	very loose	115	5	12.1	100	10	29		
15.25	50.0	16.91	2.83	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.89	3.91

CLIENT: Ormat Nevada Inc
PROJECT: Heber 2 Repower Project - Heber, CA

CONE PENETROMETER: Middle Earth Geotesting Truck Mounted Electric
Cone with 23 ton reaction weight

LOCATION: See Site and Boring Location Plan
DATE: 5/2/2007

CONE SOUNDING DATA CPT-4



INTERPRETED SOIL PROFILE
From Robertson and Campanella (1989

GROUND ELEVATION +/-

Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Silty Sand to Sandy Silt	" "	very dense
Sandy Silt to Clayey Silt	ML	dense
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	stiff
Clay	CL/CH	stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clay	CL/CH	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Silty Clay to Clay	CL	very stiff
Clay	CL/CH	very stiff
Silty Clay to Clay	CL	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Sandy Silt to Clayey Silt	ML	very loose
Clayey Silt to Silty Clay	ML/CL	very stiff

END OF SOUNDING AT 50 ft.

Project No.
LE19075

LANDMARK
Geo-Engineers and Geologists

PLATE
B-4

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 5/2/2007

CONE SOUNDING: CPT-4
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth (m)	Base Depth (ft)	Avg Tip Qc, tsf	Avg Friction Ratio, %	Soil Classification	USCS	Density or Consistency	Est. Density (pcf)	SPT N(60)	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	**Nk:** Phi (deg.)	**17** Su (tsf)	OCR
0.15	0.5	66.25	2.04	Silty Sand to Sandy Silt	SM/ML	very dense	115	15	125.2	35	122	45		
0.30	1.0	88.18	2.75	Sandy Silt to Clayey Silt	ML	very dense	115	25	166.7	35	114	44		
0.45	1.5	77.73	1.95	Silty Sand to Sandy Silt	SM/ML	very dense	115	17	146.9	30	103	42		
0.60	2.0	92.53	1.60	Silty Sand to Sandy Silt	SM/ML	very dense	115	21	174.9	25	103	42		
0.75	2.5	93.95	2.02	Silty Sand to Sandy Silt	SM/ML	very dense	115	21	177.6	25	100	42		
0.93	3.0	77.68	2.40	Silty Sand to Sandy Silt	SM/ML	very dense	115	17	146.8	35	91	41		
1.08	3.5	74.47	2.39	Sandy Silt to Clayey Silt	ML	dense	115	21	140.8	35	88	40		
1.23	4.0	52.73	2.83	Sandy Silt to Clayey Silt	ML	dense	115	15	99.7	45	75	39		
1.38	4.5	18.49	5.55	Clay	CL/CH	very stiff	125	15		90			1.07	>10
1.53	5.0	13.75	5.02	Clay	CL/CH	stiff	125	11		100			0.79	>10
1.68	5.5	12.39	5.11	Clay	CL/CH	stiff	125	10		100			0.71	>10
1.83	6.0	10.98	5.45	Clay	CL/CH	stiff	125	9		100			0.63	>10
1.98	6.5	13.51	4.77	Clay	CL/CH	stiff	125	11		95			0.77	>10
2.13	7.0	14.72	5.56	Clay	CL/CH	stiff	125	12		100			0.84	>10
2.28	7.5	16.58	5.71	Clay	CL/CH	stiff	125	13		95			0.95	>10
2.45	8.0	17.99	5.72	Clay	CL/CH	very stiff	125	14		95			1.03	>10
2.60	8.5	18.67	5.21	Clay	CL/CH	very stiff	125	15		90			1.07	>10
2.75	9.0	19.02	5.07	Clay	CL/CH	very stiff	125	15		90			1.09	>10
2.90	9.5	20.58	4.59	Clay	CL/CH	very stiff	125	16		85			1.18	>10
3.05	10.0	17.46	4.91	Clay	CL/CH	stiff	125	14		90			1.00	>10
3.20	10.5	15.45	4.14	Clay	CL/CH	stiff	125	12		90			0.88	>10
3.35	11.0	13.93	3.83	Silty Clay to Clay	CL	stiff	125	8		95			0.79	>10
3.50	11.5	13.83	4.23	Clay	CL/CH	stiff	125	11		100			0.78	>10
3.65	12.0	18.01	4.65	Clay	CL/CH	very stiff	125	14		95			1.02	>10
3.80	12.5	18.70	5.93	Clay	CL/CH	very stiff	125	15		100			1.06	>10
3.95	13.0	18.01	5.35	Clay	CL/CH	very stiff	125	14		100			1.02	>10
4.13	13.5	17.39	5.15	Clay	CL/CH	stiff	125	14		100			0.99	>10
4.28	14.0	14.93	5.20	Clay	CL/CH	stiff	125	12		100			0.84	9.59
4.43	14.5	15.49	4.86	Clay	CL/CH	stiff	125	12		100			0.87	>10
4.58	15.0	18.22	4.65	Clay	CL/CH	very stiff	125	15		100			1.03	>10
4.73	15.5	22.11	4.64	Clay	CL/CH	very stiff	125	18		90			1.26	>10
4.88	16.0	19.85	4.92	Clay	CL/CH	very stiff	125	16		100			1.13	>10
5.03	16.5	19.77	4.96	Clay	CL/CH	very stiff	125	16		100			1.12	>10
5.18	17.0	18.38	5.96	Clay	CL/CH	very stiff	125	15		100			1.04	>10
5.33	17.5	17.64	5.69	Clay	CL/CH	stiff	125	14		100			0.99	9.79
5.48	18.0	25.50	4.80	Clay	CL/CH	very stiff	125	20		90			1.45	>10
5.65	18.5	32.47	3.36	Clayey Silt to Silty Clay	ML/CL	very stiff	120	13		75			1.86	>10
5.80	19.0	13.48	4.36	Clay	CL/CH	stiff	125	11		100			0.75	5.53
5.95	19.5	18.41	4.55	Clay	CL/CH	very stiff	125	15		100			1.03	9.00
6.10	20.0	22.07	5.36	Clay	CL/CH	very stiff	125	18		100			1.25	>10
6.25	20.5	24.57	5.40	Clay	CL/CH	very stiff	125	20		100			1.40	>10
6.40	21.0	26.18	6.13	Clay	CL/CH	very stiff	125	21		100			1.49	>10
6.55	21.5	23.24	6.19	Clay	CL/CH	very stiff	125	19		100			1.31	>10
6.70	22.0	22.66	5.55	Clay	CL/CH	very stiff	125	18		100			1.28	>10
6.85	22.5	26.25	6.97	Clay	CL/CH	very stiff	125	21		100			1.49	>10
7.00	23.0	25.11	6.17	Clay	CL/CH	very stiff	125	20		100			1.42	>10
7.18	23.5	22.18	6.48	Clay	CL/CH	very stiff	125	18		100			1.25	>10
7.33	24.0	21.09	6.24	Clay	CL/CH	very stiff	125	17		100			1.18	8.70
7.48	24.5	23.54	7.51	Clay	CL/CH	very stiff	125	19		100			1.33	>10
7.63	25.0	21.31	6.90	Clay	CL/CH	very stiff	125	17		100			1.19	8.41
7.78	25.5	18.21	6.87	Clay	CL/CH	very stiff	125	15		100			1.01	6.21
7.93	26.0	15.91	6.78	Clay	CL/CH	stiff	125	13		100			0.88	4.89
8.08	26.5	13.54	5.59	Clay	CL/CH	stiff	125	11		100			0.74	3.66
8.23	27.0	11.78	5.53	Clay	CL/CH	stiff	125	9		100			0.63	3.00
8.38	27.5	14.49	5.56	Clay	CL/CH	stiff	125	12		100			0.79	3.91
8.53	28.0	16.02	5.84	Clay	CL/CH	stiff	125	13		100			0.88	4.47
8.68	28.5	15.04	5.37	Clay	CL/CH	stiff	125	12		100			0.82	3.91
8.85	29.0	20.59	6.98	Clay	CL/CH	very stiff	125	16		100			1.15	6.43
9.00	29.5	16.05	6.66	Clay	CL/CH	stiff	125	13		100			0.88	4.18
9.15	30.0	44.48	3.37	Clayey Silt to Silty Clay	ML/CL	hard	120	18		75			2.55	>10
9.30	30.5	27.03	5.86	Clay	CL/CH	very stiff	125	22		100			1.52	9.79
9.45	31.0	24.88	4.56	Clay	CL/CH	very stiff	125	20		100			1.39	8.14
9.60	31.5	17.85	4.68	Clay	CL/CH	stiff	125	14		100			0.98	4.57
9.75	32.0	21.43	4.98	Clay	CL/CH	very stiff	125	17		100			1.19	6.00
9.90	32.5	19.94	5.01	Clay	CL/CH	very stiff	125	16		100			1.10	5.21
10.05	33.0	21.67	6.03	Clay	CL/CH	very stiff	125	17		100			1.20	5.88
10.20	33.5	17.09	5.96	Clay	CL/CH	stiff	125	14		100			0.93	3.91
10.38	34.0	13.75	5.92	Clay	CL/CH	stiff	125	11		100			0.73	2.91
10.53	34.5	14.75	5.27	Clay	CL/CH	stiff	125	12		100			0.79	3.14
10.68	35.0	17.80	4.91	Clay	CL/CH	stiff	125	14		100			0.97	3.91
10.83	35.5	19.50	4.45	Clay	CL/CH	very stiff	125	16		100			1.07	4.47
10.98	36.0	20.06	4.23	Silty Clay to Clay	CL	very stiff	125	11		100			1.10	6.00
11.13	36.5	23.73	5.01	Clay	CL/CH	very stiff	125	19		100			1.32	6.00
11.28	37.0	26.37	5.33	Clay	CL/CH	very stiff	125	21		100			1.47	6.88
11.43	37.5	29.22	5.23	Clay	CL/CH	very stiff	125	23		100			1.64	8.14
11.58	38.0	28.26	4.00	Silty Clay to Clay	CL	very stiff	125	16		100			1.58	>10
11.73	38.5	26.29	3.66	Clayey Silt to Silty Clay	ML/CL	very stiff	120	11		100			1.46	>10

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 5/2/2007

CONE SOUNDING: CPT-4
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth (m)	Base Depth (ft)	Avg Tip Qc, tsf	Avg Friction Ratio, %	Soil Classification	USCS	Density or Consistency	Est. Density (pcf)	SPT N(60)	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	**Nk:** Phi (deg.)	**17** Su (tsf)	OCR
11.88	39.0	24.98	3.19	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.39	>10
12.05	39.5	23.62	3.00	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.30	>10
12.20	40.0	21.78	2.80	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.20	8.27
12.35	40.5	17.57	2.75	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.95	5.53
12.50	41.0	19.10	2.36	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.04	6.32
12.65	41.5	22.54	2.42	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.24	8.27
12.80	42.0	23.41	3.23	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.29	8.70
12.95	42.5	22.05	3.08	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.21	7.70
13.10	43.0	21.46	2.78	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.17	7.13
13.25	43.5	22.21	3.76	Silty Clay to Clay	CL	very stiff	125	13		100			1.21	5.42
13.40	44.0	22.69	3.76	Silty Clay to Clay	CL	very stiff	125	13		100			1.24	5.53
13.58	44.5	25.69	2.81	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.42	9.59
13.73	45.0	26.50	2.66	Clayey Silt to Silty Clay	ML/CL	very stiff	120	11		100			1.46	>10
13.88	45.5	25.22	2.66	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.39	8.85
14.03	46.0	24.83	3.10	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.36	8.41
14.18	46.5	18.88	2.93	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.01	5.21
14.33	47.0	19.43	2.64	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.05	5.31
14.48	47.5	22.40	3.03	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.22	6.65
14.63	48.0	23.12	2.75	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.26	7.00
14.78	48.5	18.94	1.38	Sandy Silt to Clayey Silt	ML	very loose	115	5	14.1	100	15	30		
14.93	49.0	18.77	1.78	Sandy Silt to Clayey Silt	ML	very loose	115	5	13.9	100	14	30		
15.10	49.5	21.59	2.73	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.17	6.00
15.25	50.0	23.82	3.12	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.30	6.88

CLIENT: Ormat Nevada Inc
PROJECT: Heber 2 Repower Project - Heber, CA

LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: Middle Earth Geotesting Truck Mounted Electric
Cone with 23 ton reaction weight

DATE: 5/2/2007

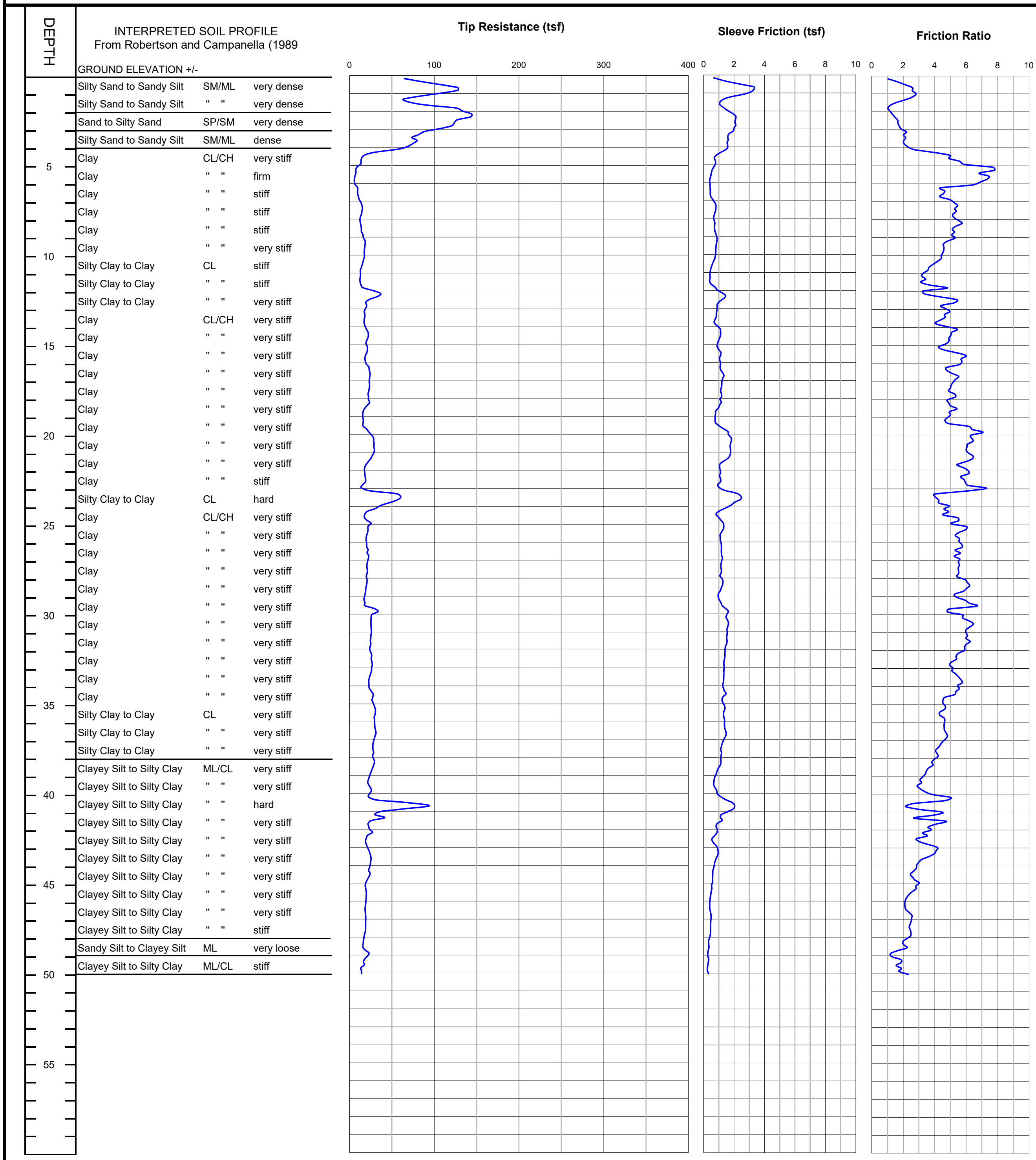
CONE SOUNDING DATA CPT-5

DEPTH

INTERPRETED SOIL PROFILE
From Robertson and Campanella (1989

GROUND ELEVATION +/-

Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Sand to Silty Sand	SP/SM	very dense
Silty Sand to Sandy Silt	SM/ML	dense
Clay	CL/CH	very stiff
Clay	" "	firm
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	stiff
Silty Clay to Clay	" "	stiff
Silty Clay to Clay	" "	very stiff
Clay	CL/CH	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Silty Clay to Clay	CL	hard
Clay	CL/CH	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Silty Clay to Clay	" "	very stiff
Silty Clay to Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	hard
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff
Sandy Silt to Clayey Silt	ML	very loose
Clayey Silt to Silty Clay	ML/CL	stiff



END OF SOUNDING AT 50 ft.

Project No.

LE19075

LANDMARK
Geo-Engineers and Geologists

PLATE

B-5

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 5/2/2007

CONE SOUNDING: CPT-5
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth (m)	Base Depth (ft)	Avg Tip Qc, tsf	Avg Friction Ratio, %	Soil Classification	USCS	Density or Consistency	Est. Density (pcf)	SPT N(60)	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	**Nk:** Phi (deg.)	**17** Su (tsf)	OCR
0.15	0.5	85.14	1.61	Silty Sand to Sandy Silt	SM/ML	very dense	115	19	161.0	25	130	46		
0.30	1.0	120.36	2.66	Silty Sand to Sandy Silt	SM/ML	very dense	115	27	227.5	30	124	45		
0.45	1.5	72.28	2.13	Silty Sand to Sandy Silt	SM/ML	very dense	115	16	136.6	30	101	42		
0.60	2.0	116.67	1.12	Sand to Silty Sand	SP/SM	very dense	115	21	220.6	15	110	43		
0.75	2.5	138.05	1.48	Sand to Silty Sand	SP/SM	very dense	115	25	261.0	15	111	44		
0.93	3.0	117.13	1.76	Silty Sand to Sandy Silt	SM/ML	very dense	115	26	221.4	20	104	42		
1.08	3.5	81.23	2.12	Silty Sand to Sandy Silt	SM/ML	very dense	115	18	153.5	30	90	41		
1.23	4.0	74.63	2.12	Silty Sand to Sandy Silt	SM/ML	dense	115	17	141.1	30	86	40		
1.38	4.5	34.90	3.90	Clayey Silt to Silty Clay	ML/CL	hard	120	14		60			2.04	>10
1.53	5.0	13.76	5.45	Clay	CL/CH	stiff	125	11		100			0.79	>10
1.68	5.5	7.57	7.44	Clay	CL/CH	firm	125	6		100			0.43	>10
1.83	6.0	5.99	6.88	Clay	CL/CH	firm	125	5		100			0.33	6.10
1.98	6.5	9.47	4.51	Clay	CL/CH	stiff	125	8		100			0.54	>10
2.13	7.0	11.69	4.84	Clay	CL/CH	stiff	125	9		100			0.66	>10
2.28	7.5	14.81	5.37	Clay	CL/CH	stiff	125	12		95			0.85	>10
2.45	8.0	13.05	5.28	Clay	CL/CH	stiff	125	10		100			0.74	>10
2.60	8.5	13.41	5.40	Clay	CL/CH	stiff	125	11		100			0.76	>10
2.75	9.0	15.40	5.21	Clay	CL/CH	stiff	125	12		95			0.88	>10
2.90	9.5	18.24	4.66	Clay	CL/CH	very stiff	125	15		85			1.04	>10
3.05	10.0	17.49	4.50	Clay	CL/CH	stiff	125	14		90			1.00	>10
3.20	10.5	16.07	4.15	Clay	CL/CH	stiff	125	13		90			0.91	>10
3.35	11.0	13.34	3.48	Silty Clay to Clay	CL	stiff	125	8		95			0.75	>10
3.50	11.5	12.52	3.24	Silty Clay to Clay	CL	stiff	125	7		95			0.70	>10
3.65	12.0	18.93	3.91	Silty Clay to Clay	CL	very stiff	125	11		85			1.08	>10
3.80	12.5	31.15	4.38	Silty Clay to Clay	CL	very stiff	125	18		75			1.80	>10
3.95	13.0	19.46	4.78	Clay	CL/CH	very stiff	125	16		95			1.11	>10
4.13	13.5	17.74	4.74	Clay	CL/CH	very stiff	125	14		100			1.01	>10
4.28	14.0	17.58	4.34	Clay	CL/CH	stiff	125	14		95			1.00	>10
4.43	14.5	21.21	5.18	Clay	CL/CH	very stiff	125	17		95			1.21	>10
4.58	15.0	20.43	4.83	Clay	CL/CH	very stiff	125	16		95			1.16	>10
4.73	15.5	20.79	4.75	Clay	CL/CH	very stiff	125	17		95			1.18	>10
4.88	16.0	18.89	5.75	Clay	CL/CH	very stiff	125	15		100			1.07	>10
5.03	16.5	23.41	4.88	Clay	CL/CH	very stiff	125	19		95			1.33	>10
5.18	17.0	23.59	5.34	Clay	CL/CH	very stiff	125	19		95			1.34	>10
5.33	17.5	23.27	4.98	Clay	CL/CH	very stiff	125	19		95			1.32	>10
5.48	18.0	22.19	5.13	Clay	CL/CH	very stiff	125	18		100			1.26	>10
5.65	18.5	20.81	5.10	Clay	CL/CH	very stiff	125	17		100			1.18	>10
5.80	19.0	15.78	4.92	Clay	CL/CH	stiff	125	13		100			0.88	7.13
5.95	19.5	16.06	5.23	Clay	CL/CH	stiff	125	13		100			0.90	7.00
6.10	20.0	22.81	6.58	Clay	CL/CH	very stiff	125	18		100			1.29	>10
6.25	20.5	28.53	6.30	Clay	CL/CH	very stiff	125	23		100			1.63	>10
6.40	21.0	28.99	6.06	Clay	CL/CH	very stiff	125	23		100			1.65	>10
6.55	21.5	24.82	6.26	Clay	CL/CH	very stiff	125	20		100			1.41	>10
6.70	22.0	18.48	5.79	Clay	CL/CH	very stiff	125	15		100			1.03	7.70
6.85	22.5	18.41	5.89	Clay	CL/CH	very stiff	125	15		100			1.03	7.41
7.00	23.0	15.96	6.46	Clay	CL/CH	stiff	125	13		100			0.88	5.76
7.18	23.5	46.63	4.62	Silty Clay to Clay	CL	hard	125	27		75			2.69	>10
7.33	24.0	47.09	4.48	Silty Clay to Clay	CL	hard	125	27		75			2.71	>10
7.48	24.5	23.27	4.67	Clay	CL/CH	very stiff	125	19		100			1.31	>10
7.63	25.0	21.09	5.34	Clay	CL/CH	very stiff	125	17		100			1.18	8.27
7.78	25.5	21.71	5.85	Clay	CL/CH	very stiff	125	17		100			1.22	8.41
7.93	26.0	19.90	5.47	Clay	CL/CH	very stiff	125	16		100			1.11	7.00
8.08	26.5	20.78	5.59	Clay	CL/CH	very stiff	125	17		100			1.16	7.41
8.23	27.0	21.98	5.44	Clay	CL/CH	very stiff	125	18		100			1.23	8.00
8.38	27.5	20.73	5.53	Clay	CL/CH	very stiff	125	17		100			1.16	6.88
8.53	28.0	20.36	5.62	Clay	CL/CH	very stiff	125	16		100			1.13	6.54
8.68	28.5	19.99	6.11	Clay	CL/CH	very stiff	125	16		100			1.11	6.21
8.85	29.0	18.33	5.49	Clay	CL/CH	very stiff	125	15		100			1.01	5.31
9.00	29.5	17.78	6.27	Clay	CL/CH	stiff	125	14		100			0.98	4.89
9.15	30.0	29.76	5.16	Clay	CL/CH	very stiff	125	24		100			1.68	>10
9.30	30.5	25.36	6.14	Clay	CL/CH	very stiff	125	20		100			1.42	8.56
9.45	31.0	25.65	6.08	Clay	CL/CH	very stiff	125	21		100			1.44	8.56
9.60	31.5	24.99	6.11	Clay	CL/CH	very stiff	125	20		100			1.40	8.00
9.75	32.0	24.42	5.93	Clay	CL/CH	very stiff	125	20		100			1.37	7.41
9.90	32.5	25.69	5.42	Clay	CL/CH	very stiff	125	21		100			1.44	8.00
10.05	33.0	26.43	5.06	Clay	CL/CH	very stiff	125	21		100			1.48	8.27
10.20	33.5	24.95	5.31	Clay	CL/CH	very stiff	125	20		100			1.39	7.27
10.38	34.0	22.88	5.62	Clay	CL/CH	very stiff	125	18		100			1.27	6.21
10.53	34.5	25.51	5.40	Clay	CL/CH	very stiff	125	20		100			1.42	7.27
10.68	35.0	27.31	4.56	Silty Clay to Clay	CL	very stiff	125	16		100			1.53	>10
10.83	35.5	30.04	4.55	Silty Clay to Clay	CL	very stiff	125	17		100			1.69	>10
10.98	36.0	29.52	4.52	Silty Clay to Clay	CL	very stiff	125	17		100			1.66	>10
11.13	36.5	30.25	4.64	Silty Clay to Clay	CL	very stiff	125	17		100			1.70	>10
11.28	37.0	29.39	4.68	Silty Clay to Clay	CL	very stiff	125	17		100			1.65	>10
11.43	37.5	27.60	4.22	Silty Clay to Clay	CL	very stiff	125	16		100			1.54	>10
11.58	38.0	27.92	4.11	Silty Clay to Clay	CL	very stiff	125	16		100			1.56	>10
11.73	38.5	28.57	3.77	Clayey Silt to Silty Clay	ML/CL	very stiff	120	11		100			1.60	>10

LANDMARK CONSULTANTS, INC.
CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

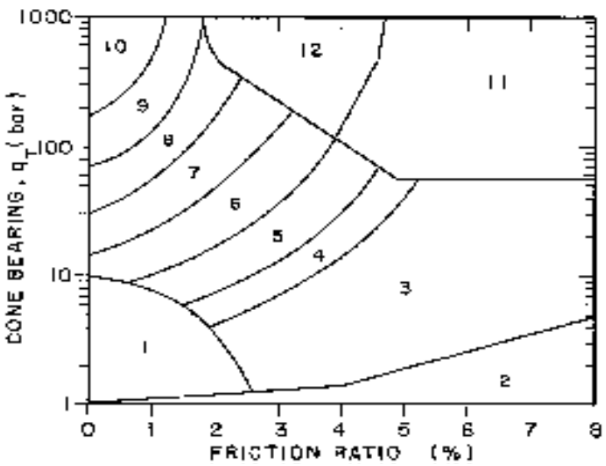
Project: Heber 2 Repower Project - Heber, CA **Project No:** LE19075 **Date:** 5/2/2007

CONE SOUNDING: CPT-5
Est. GWT (ft): 8
Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth (m)	Base Depth (ft)	Avg Tip Qc, tsf	Avg Friction Ratio, %	Soil Classification	USCS	Density or Consistency	Est. Density (pcf)	SPT N(60)	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	**Nk:** Phi (deg.)	**17** Su (tsf)	OCR
11.88	39.0	24.62	3.37	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.36	>10
12.05	39.5	22.28	3.04	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.23	8.70
12.20	40.0	24.64	3.45	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.36	>10
12.35	40.5	41.78	4.14	Clayey Silt to Silty Clay	ML/CL	hard	120	17		95			2.37	>10
12.50	41.0	64.96	3.22	Sandy Silt to Clayey Silt	ML	medium dense	115	19	51.8	70	53	35		
12.65	41.5	32.37	3.75	Clayey Silt to Silty Clay	ML/CL	very stiff	120	13		100			1.82	>10
12.80	42.0	22.75	3.82	Silty Clay to Clay	CL	very stiff	125	13		100			1.25	6.00
12.95	42.5	22.78	3.20	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.25	8.14
13.10	43.0	19.79	3.62	Silty Clay to Clay	CL	very stiff	125	11		100			1.07	4.57
13.25	43.5	23.86	3.91	Silty Clay to Clay	CL	very stiff	125	14		100			1.31	6.10
13.40	44.0	24.93	3.00	Clayey Silt to Silty Clay	ML/CL	very stiff	120	10		100			1.37	9.19
13.58	44.5	23.46	2.65	Clayey Silt to Silty Clay	ML/CL	very stiff	120	9		100			1.29	8.00
13.73	45.0	21.13	2.78	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.15	6.54
13.88	45.5	19.10	2.73	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.03	5.42
14.03	46.0	19.63	2.23	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.06	5.65
14.18	46.5	18.74	2.12	Clayey Silt to Silty Clay	ML/CL	very stiff	120	7		100			1.01	5.10
14.33	47.0	18.93	2.49	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.02	5.10
14.48	47.5	18.85	2.42	Clayey Silt to Silty Clay	ML/CL	very stiff	120	8		100			1.01	5.00
14.63	48.0	17.53	2.38	Clayey Silt to Silty Clay	ML/CL	stiff	120	7		100			0.93	4.37
14.78	48.5	16.01	2.08	Clayey Silt to Silty Clay	ML/CL	stiff	120	6		100			0.84	3.74
14.93	49.0	20.91	1.36	Sandy Silt to Clayey Silt	ML	very loose	115	6	15.5	100	17	30		
15.10	49.5	17.29	1.76	Sandy Silt to Clayey Silt	ML	very loose	115	5	12.8	100	12	30		
15.25	50.0	13.85	1.98	Clayey Silt to Silty Clay	ML/CL	stiff	120	6		100			0.71	3.00

Simplified Soil Classification Chart

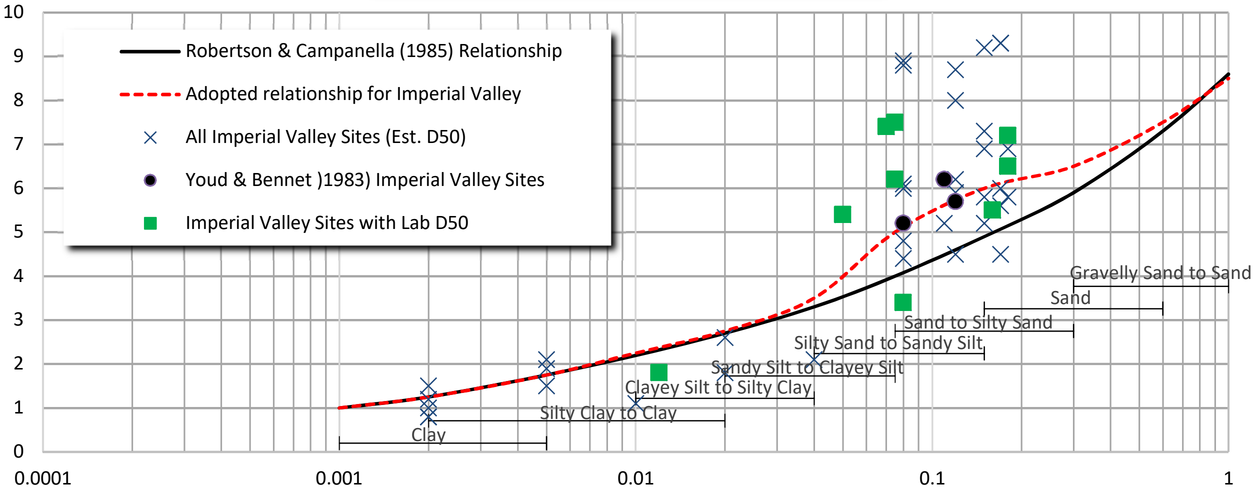
After Robertson & Campanella (1989)



Geotechnical Parameters from CPT Data:

Equivalent SPT N(60) blow count = Qc/(Qc/N Ratio)
N1(60) = Cn*N(60) Normalized SPT blow count
Cn = 1/(p'o)^0.5 < 1.6 max. from Liao & Whitman (1986)
p'o = effective overburden pressure (tsf) using unit densities
given below and estimated groundwater table.
Dr = Relative density (%) from Jamiolkowski et. al. (1986) relationship
= -98 +68*log(Qc/p'o^0.5) where Qc, p'o in tonne/sqm
Note: 1 tonne/sqm = 0.1024 tsf, 1 bar =1.0443 tsf
Phi = Friction Angle estimated from either:
1. Roberton & Campanella (1983) chart:
Phi = 5.3 + 24*(log(Qc/p'o))+3(log(Qc/p'o))^2
2. Peck, Hansen & Thornburn (1974) N-Phi Correlation
3. Schmertman (1978) chart [Phi = 28+0.14*Dr for fine uniform sands]
Su = undrained shear strength (tsf)
= (Qc-p'o)/Nk where Nk varies from 10 to 22, 17 for OC clays
OCR = Overconsolidation Ratio estimated from Schmertman (1978)
chart using Su/p'o ratio and estimated normal consolidated Su/p'o

Variation of Qc/N Ratio with Grain Size



Note: Assumed Properties and Adopted Qc/N Ratio based on correlations from Imperial Valley, California soils

Table of Soil Types and Assumed Properties

Zone	Soil Classification	UCS	Density (pcf)	R&C Qc/N	Adopted Qc/N	Est. PI	Fines (%)	D50 (mm)
1	Sensitive fine grained	ML	120	2	2	NP-15	65-100	0.02
2	Organic Material	OL/OH	120	1	1	--	--	--
3	Clay	CL/CH	125	1	1.25	25-40+	90-100	0.002
4	Silty Clay to Clay	CL	125	1.5	2	15-40	90-100	0.01
5	Clayey Silt to Silty Clay	ML/CL	120	2	2.75	25-May	90-100	0.02
6	Sandy Silt to Clayey Silt	ML	115	2.5	3.5	NP-10	65-100	0.04
7	Silty Sand to Sandy Silt	SM/ML	115	3	5	NP	35-75	0.075
8	Sand to Silty Sand	SP/SM	115	4	6	NP	May-35	0.15
9	Sand	SP	110	5	6.5	NP	0-5	0.3
10	Gravelly Sand to Sand	SW	115	6	7.5	NP	0-5	0.6
11	Overconsolidated Soil	--	120	1	1	NP	90-100	0.01
12	Sand to Clayey Sand	SP/SC	115	2	2	NP-5	--	---

Su (tsf)	Consistency
0-0.13	very soft
0.13-.25	soft
0.25-0.5	firm
0.5-1.0	stiff
1.0-2.0	very stiff
>2.0	hard

Dr (%)	Relative Density
0-15	very loose
15-35	loose
35-65	medium dense
65-85	dense
>85	very dense

LANDMARK
Geo-Engineers and Geologists

Project No: LE19075

Key to CPT Interpretation of Logs

Plate
B-6

APPENDIX C

LANDMARK
Geo-Engineers and Geologists

Landmark Consultants, Inc.
780 N. 4th Street
El Centro, CA 92243

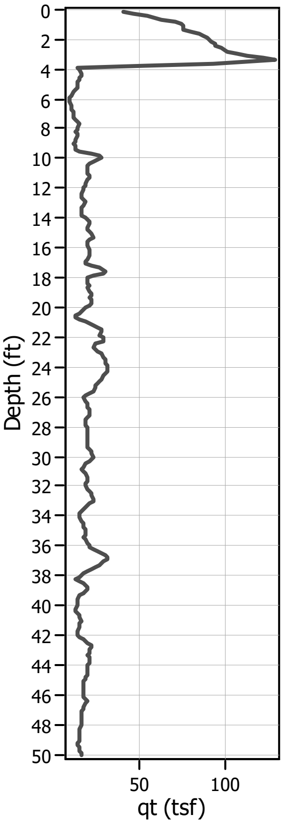
LIQUEFACTION ANALYSIS REPORT

Project title : Heber 2 Repower Project **Location : Heber, CA**

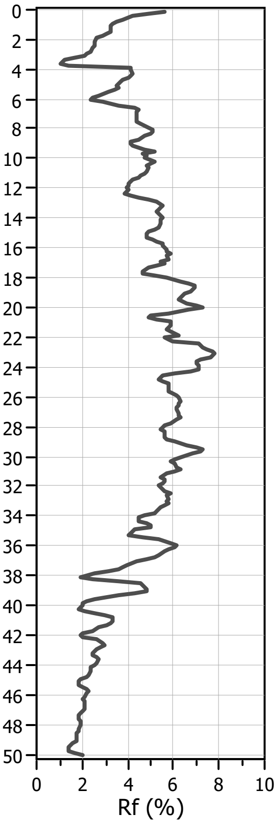
CPT file : CPT-1

Input parameters and analysis data

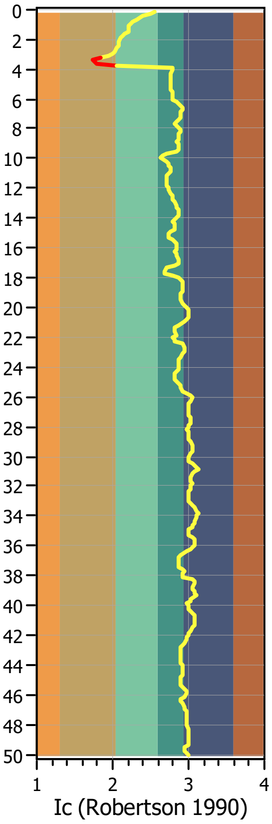
Analysis method:	NCEER (1998)	G.W.T. (in-situ):	8.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	8.00 ft	Fill height:	N/A		
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude M_w:	7.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	N/A
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based



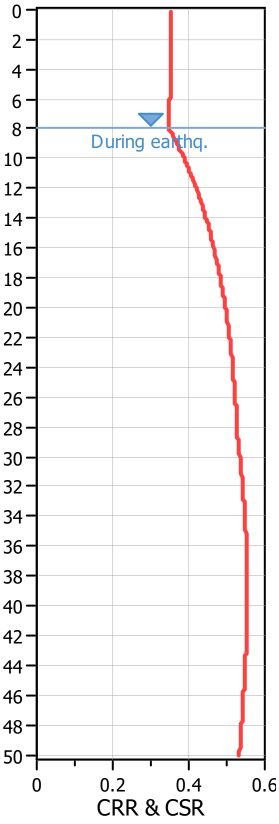
Cone resistance



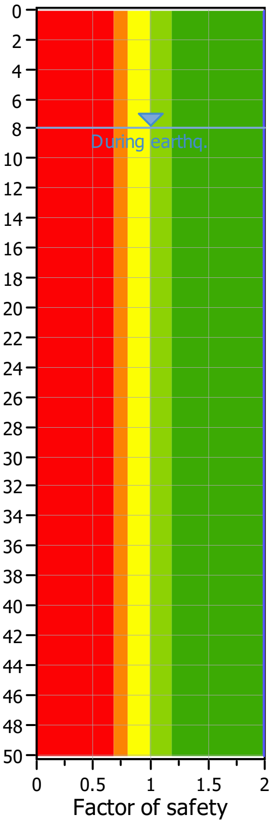
Friction Ratio



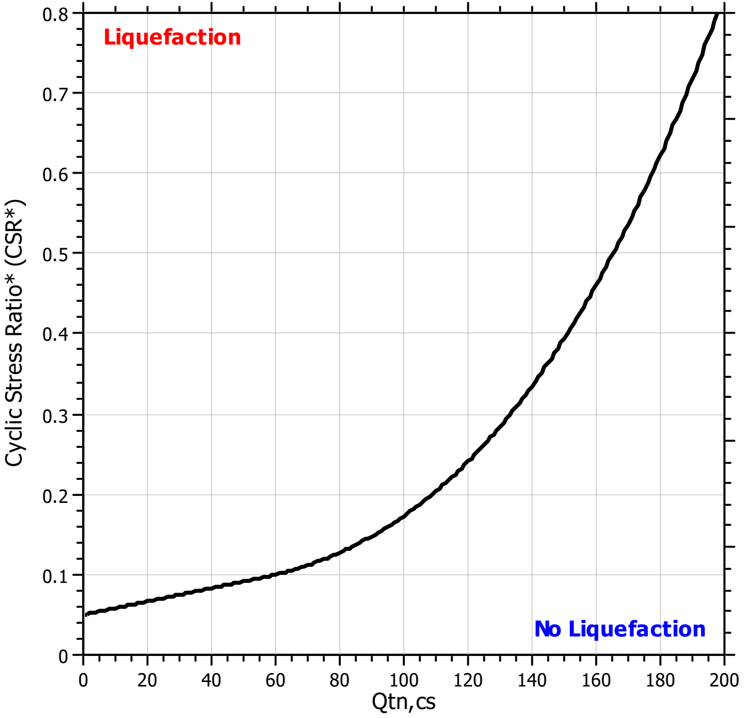
SBTn Plot



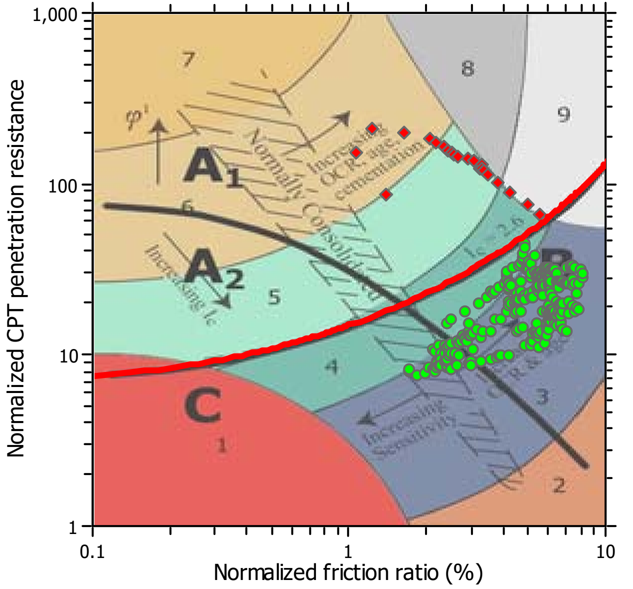
CRR plot



FS Plot



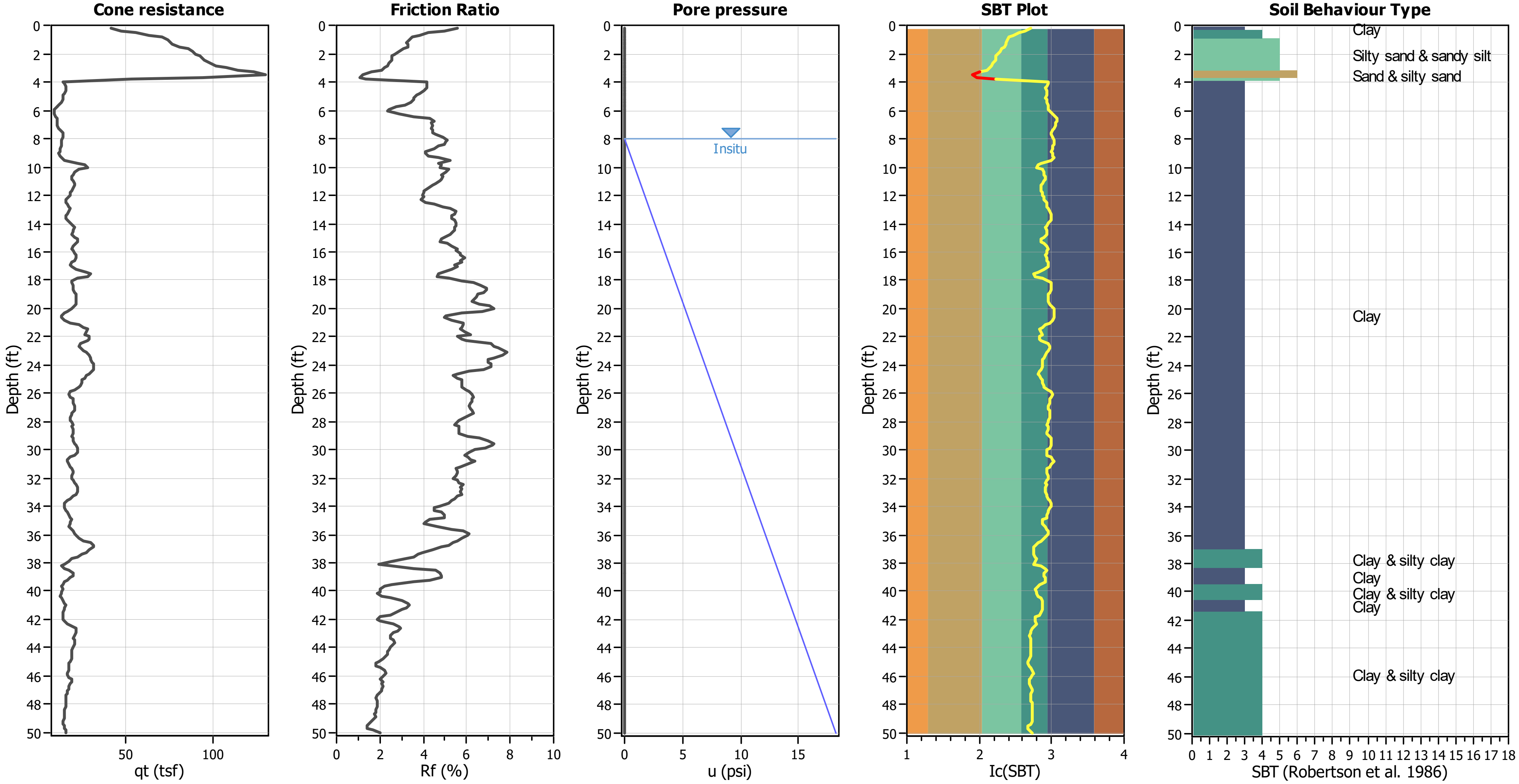
M_w=$7^{1/2}$, sigma'=1 atm base curve



Summary of liquefaction potential

Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



Input parameters and analysis data

Analysis method: NCEER (1998)
Fines correction method: NCEER (1998)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.00
Peak ground acceleration: 0.50
Depth to water table (insitu): 8.00 ft

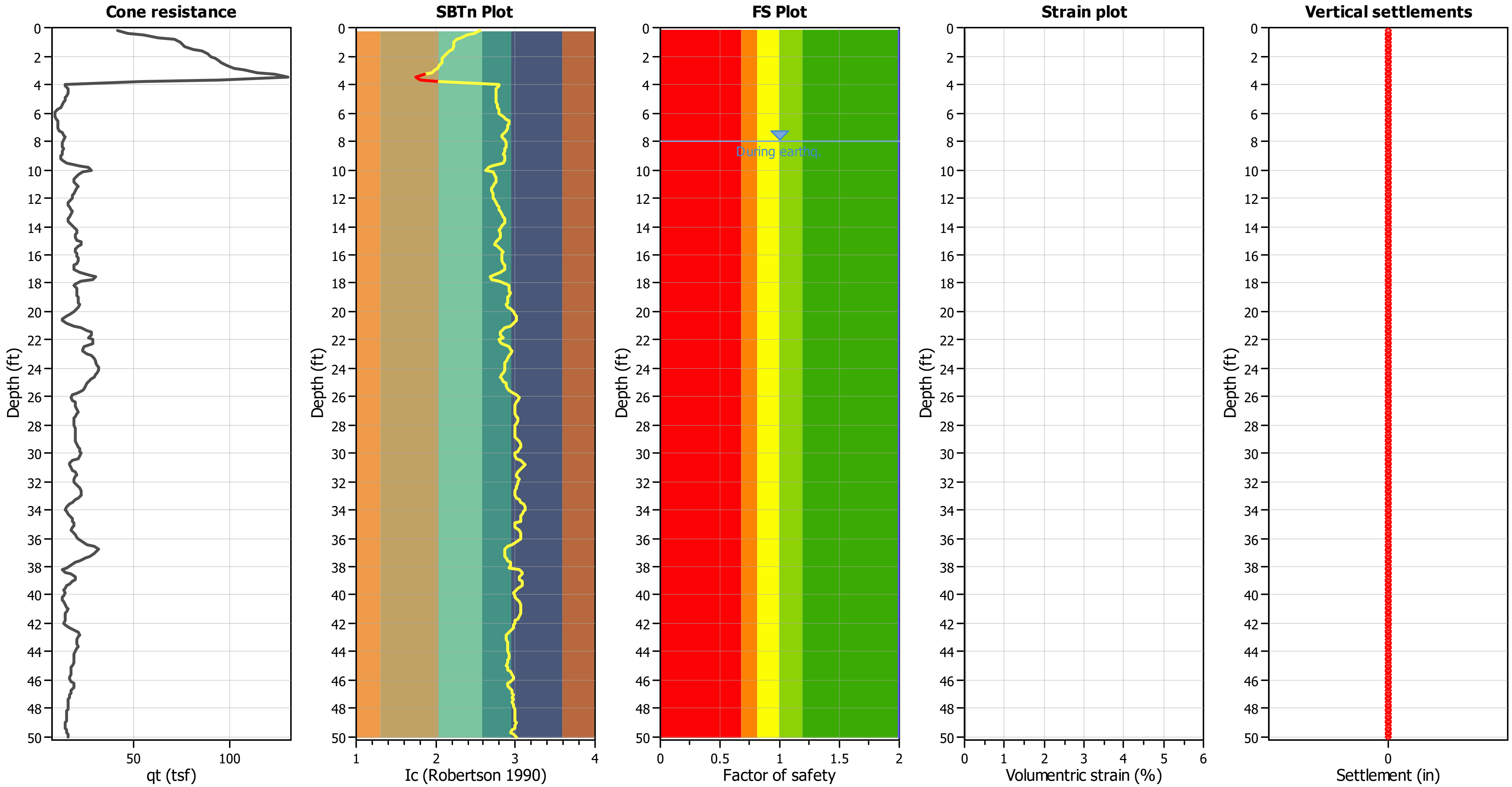
Depth to water table (erthq.): 8.00 ft
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sands only
Limit depth applied: No
Limit depth: N/A

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
8.04	119.97	2.00	0.00	0.86	0.00	8.20	118.98	2.00	0.00	0.86	0.00
8.37	118.57	2.00	0.00	0.86	0.00	8.53	116.33	2.00	0.00	0.86	0.00
8.69	111.11	2.00	0.00	0.85	0.00	8.86	105.42	2.00	0.00	0.85	0.00
9.02	103.12	2.00	0.00	0.85	0.00	9.19	106.12	2.00	0.00	0.84	0.00
9.35	114.80	2.00	0.00	0.84	0.00	9.51	129.15	2.00	0.00	0.84	0.00
9.68	142.81	2.00	0.00	0.84	0.00	9.84	155.83	2.00	0.00	0.83	0.00
10.01	158.63	2.00	0.00	0.83	0.00	10.17	154.96	2.00	0.00	0.83	0.00
10.33	145.30	2.00	0.00	0.82	0.00	10.50	138.73	2.00	0.00	0.82	0.00
10.66	137.47	2.00	0.00	0.82	0.00	10.83	136.96	2.00	0.00	0.82	0.00
10.99	137.99	2.00	0.00	0.81	0.00	11.15	137.59	2.00	0.00	0.81	0.00
11.32	134.89	2.00	0.00	0.81	0.00	11.48	129.13	2.00	0.00	0.81	0.00
11.65	123.50	2.00	0.00	0.80	0.00	11.81	121.19	2.00	0.00	0.80	0.00
11.98	119.62	2.00	0.00	0.80	0.00	12.14	117.79	2.00	0.00	0.79	0.00
12.30	113.63	2.00	0.00	0.79	0.00	12.47	115.50	2.00	0.00	0.79	0.00
12.63	123.82	2.00	0.00	0.79	0.00	12.80	132.97	2.00	0.00	0.78	0.00
12.96	139.15	2.00	0.00	0.78	0.00	13.12	139.59	2.00	0.00	0.78	0.00
13.29	136.63	2.00	0.00	0.77	0.00	13.45	131.74	2.00	0.00	0.77	0.00
13.62	130.26	2.00	0.00	0.77	0.00	13.78	134.95	2.00	0.00	0.77	0.00
13.94	140.91	2.00	0.00	0.76	0.00	14.11	145.02	2.00	0.00	0.76	0.00
14.27	146.42	2.00	0.00	0.76	0.00	14.44	144.79	2.00	0.00	0.76	0.00
14.60	141.29	2.00	0.00	0.75	0.00	14.76	138.10	2.00	0.00	0.75	0.00
14.93	137.24	2.00	0.00	0.75	0.00	15.09	138.96	2.00	0.00	0.74	0.00
15.26	139.60	2.00	0.00	0.74	0.00	15.42	140.43	2.00	0.00	0.74	0.00
15.58	139.21	2.00	0.00	0.74	0.00	15.75	140.96	2.00	0.00	0.73	0.00
15.91	141.85	2.00	0.00	0.73	0.00	16.08	145.91	2.00	0.00	0.73	0.00
16.24	147.66	2.00	0.00	0.72	0.00	16.40	149.68	2.00	0.00	0.72	0.00
16.57	145.56	2.00	0.00	0.72	0.00	16.73	140.89	2.00	0.00	0.72	0.00
16.90	134.62	2.00	0.00	0.71	0.00	17.06	136.61	2.00	0.00	0.71	0.00
17.22	140.20	2.00	0.00	0.71	0.00	17.39	146.14	2.00	0.00	0.71	0.00
17.55	148.16	2.00	0.00	0.70	0.00	17.72	144.49	2.00	0.00	0.70	0.00
17.88	139.25	2.00	0.00	0.70	0.00	18.04	138.26	2.00	0.00	0.69	0.00
18.21	144.57	2.00	0.00	0.69	0.00	18.37	151.78	2.00	0.00	0.69	0.00
18.54	154.52	2.00	0.00	0.69	0.00	18.70	153.95	2.00	0.00	0.68	0.00
18.86	153.12	2.00	0.00	0.68	0.00	19.03	151.55	2.00	0.00	0.68	0.00
19.19	150.73	2.00	0.00	0.67	0.00	19.36	148.04	2.00	0.00	0.67	0.00
19.52	147.69	2.00	0.00	0.67	0.00	19.69	151.40	2.00	0.00	0.67	0.00
19.85	154.31	2.00	0.00	0.66	0.00	20.01	150.07	2.00	0.00	0.66	0.00
20.18	135.86	2.00	0.00	0.66	0.00	20.34	119.17	2.00	0.00	0.66	0.00
20.51	104.85	2.00	0.00	0.65	0.00	20.67	104.13	2.00	0.00	0.65	0.00
20.83	114.48	2.00	0.00	0.65	0.00	21.00	131.00	2.00	0.00	0.64	0.00
21.16	142.62	2.00	0.00	0.64	0.00	21.33	149.15	2.00	0.00	0.64	0.00
21.49	153.07	2.00	0.00	0.64	0.00	21.65	154.99	2.00	0.00	0.63	0.00
21.82	156.00	2.00	0.00	0.63	0.00	21.98	152.30	2.00	0.00	0.63	0.00
22.15	154.57	2.00	0.00	0.62	0.00	22.31	156.68	2.00	0.00	0.62	0.00
22.47	159.95	2.00	0.00	0.62	0.00	22.64	157.92	2.00	0.00	0.62	0.00
22.80	160.98	2.00	0.00	0.61	0.00	22.97	169.52	2.00	0.00	0.61	0.00
23.13	176.91	2.00	0.00	0.61	0.00	23.29	178.34	2.00	0.00	0.61	0.00
23.46	174.45	2.00	0.00	0.60	0.00	23.62	171.54	2.00	0.00	0.60	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
23.79	172.69	2.00	0.00	0.60	0.00	23.95	175.54	2.00	0.00	0.59	0.00
24.11	175.55	2.00	0.00	0.59	0.00	24.28	168.97	2.00	0.00	0.59	0.00
24.44	157.41	2.00	0.00	0.59	0.00	24.61	146.69	2.00	0.00	0.58	0.00
24.77	140.58	2.00	0.00	0.58	0.00	24.93	139.79	2.00	0.00	0.58	0.00
25.10	139.62	2.00	0.00	0.57	0.00	25.26	138.81	2.00	0.00	0.57	0.00
25.43	136.75	2.00	0.00	0.57	0.00	25.59	133.88	2.00	0.00	0.57	0.00
25.75	129.01	2.00	0.00	0.56	0.00	25.92	123.09	2.00	0.00	0.56	0.00
26.08	121.15	2.00	0.00	0.56	0.00	26.25	124.71	2.00	0.00	0.56	0.00
26.41	127.90	2.00	0.00	0.55	0.00	26.57	128.10	2.00	0.00	0.55	0.00
26.74	126.91	2.00	0.00	0.55	0.00	26.90	128.06	2.00	0.00	0.54	0.00
27.07	129.48	2.00	0.00	0.54	0.00	27.23	128.59	2.00	0.00	0.54	0.00
27.40	126.11	2.00	0.00	0.54	0.00	27.56	122.56	2.00	0.00	0.53	0.00
27.72	119.14	2.00	0.00	0.53	0.00	27.89	116.40	2.00	0.00	0.53	0.00
28.05	117.08	2.00	0.00	0.52	0.00	28.22	116.67	2.00	0.00	0.52	0.00
28.38	118.11	2.00	0.00	0.52	0.00	28.54	118.18	2.00	0.00	0.52	0.00
28.71	118.83	2.00	0.00	0.51	0.00	28.87	118.78	2.00	0.00	0.51	0.00
29.04	120.47	2.00	0.00	0.51	0.00	29.20	126.00	2.00	0.00	0.51	0.00
29.36	131.40	2.00	0.00	0.50	0.00	29.53	135.95	2.00	0.00	0.50	0.00
29.69	136.80	2.00	0.00	0.50	0.00	29.86	135.40	2.00	0.00	0.49	0.00
30.02	131.15	2.00	0.00	0.49	0.00	30.18	127.34	2.00	0.00	0.49	0.00
30.35	121.69	2.00	0.00	0.49	0.00	30.51	115.70	2.00	0.00	0.48	0.00
30.68	111.80	2.00	0.00	0.48	0.00	30.84	112.22	2.00	0.00	0.48	0.00
31.00	112.33	2.00	0.00	0.47	0.00	31.17	111.25	2.00	0.00	0.47	0.00
31.33	112.16	2.00	0.00	0.47	0.00	31.50	114.87	2.00	0.00	0.47	0.00
31.66	114.02	2.00	0.00	0.46	0.00	31.82	110.25	2.00	0.00	0.46	0.00
31.99	108.73	2.00	0.00	0.46	0.00	32.15	112.92	2.00	0.00	0.46	0.00
32.32	116.75	2.00	0.00	0.45	0.00	32.48	119.82	2.00	0.00	0.45	0.00
32.64	120.23	2.00	0.00	0.45	0.00	32.81	121.28	2.00	0.00	0.44	0.00
32.97	120.46	2.00	0.00	0.44	0.00	33.14	117.67	2.00	0.00	0.44	0.00
33.30	111.47	2.00	0.00	0.44	0.00	33.46	105.37	2.00	0.00	0.43	0.00
33.63	100.20	2.00	0.00	0.43	0.00	33.79	95.08	2.00	0.00	0.43	0.00
33.96	90.37	2.00	0.00	0.42	0.00	34.12	87.91	2.00	0.00	0.42	0.00
34.28	90.52	2.00	0.00	0.42	0.00	34.45	96.32	2.00	0.00	0.42	0.00
34.61	99.51	2.00	0.00	0.41	0.00	34.78	99.39	2.00	0.00	0.41	0.00
34.94	95.45	2.00	0.00	0.41	0.00	35.10	92.69	2.00	0.00	0.41	0.00
35.27	91.26	2.00	0.00	0.40	0.00	35.43	95.67	2.00	0.00	0.40	0.00
35.60	104.11	2.00	0.00	0.40	0.00	35.76	111.84	2.00	0.00	0.39	0.00
35.93	115.82	2.00	0.00	0.39	0.00	36.09	116.17	2.00	0.00	0.39	0.00
36.25	118.60	2.00	0.00	0.39	0.00	36.42	122.19	2.00	0.00	0.38	0.00
36.58	126.65	2.00	0.00	0.38	0.00	36.75	127.95	2.00	0.00	0.38	0.00
36.91	123.10	2.00	0.00	0.37	0.00	37.07	114.03	2.00	0.00	0.37	0.00
37.24	104.72	2.00	0.00	0.37	0.00	37.40	98.46	2.00	0.00	0.37	0.00
37.57	91.59	2.00	0.00	0.36	0.00	37.73	82.25	2.00	0.00	0.36	0.00
37.89	70.62	2.00	0.00	0.36	0.00	38.06	60.48	2.00	0.00	0.35	0.00
38.22	63.21	2.00	0.00	0.35	0.00	38.39	76.34	2.00	0.00	0.35	0.00
38.55	91.11	2.00	0.00	0.35	0.00	38.71	98.86	2.00	0.00	0.34	0.00
38.88	99.34	2.00	0.00	0.34	0.00	39.04	95.61	2.00	0.00	0.34	0.00
39.21	86.80	2.00	0.00	0.34	0.00	39.37	76.19	2.00	0.00	0.33	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
39.53	64.64	2.00	0.00	0.33	0.00	39.70	60.43	2.00	0.00	0.33	0.00
39.86	58.79	2.00	0.00	0.32	0.00	40.03	58.19	2.00	0.00	0.32	0.00
40.19	55.59	2.00	0.00	0.32	0.00	40.35	57.57	2.00	0.00	0.32	0.00
40.52	62.98	2.00	0.00	0.31	0.00	40.68	69.67	2.00	0.00	0.31	0.00
40.85	73.76	2.00	0.00	0.31	0.00	41.01	74.59	2.00	0.00	0.30	0.00
41.17	72.68	2.00	0.00	0.30	0.00	41.34	69.91	2.00	0.00	0.30	0.00
41.50	66.62	2.00	0.00	0.30	0.00	41.67	63.67	2.00	0.00	0.29	0.00
41.83	58.22	2.00	0.00	0.29	0.00	41.99	56.51	2.00	0.00	0.29	0.00
42.16	59.31	2.00	0.00	0.29	0.00	42.32	68.96	2.00	0.00	0.28	0.00
42.49	76.21	2.00	0.00	0.28	0.00	42.65	79.83	2.00	0.00	0.28	0.00
42.81	78.47	2.00	0.00	0.27	0.00	42.98	75.37	2.00	0.00	0.27	0.00
43.14	72.19	2.00	0.00	0.27	0.00	43.31	72.07	2.00	0.00	0.27	0.00
43.47	73.96	2.00	0.00	0.26	0.00	43.64	75.40	2.00	0.00	0.26	0.00
43.80	74.08	2.00	0.00	0.26	0.00	43.96	71.55	2.00	0.00	0.25	0.00
44.13	69.30	2.00	0.00	0.25	0.00	44.29	68.40	2.00	0.00	0.25	0.00
44.46	68.25	2.00	0.00	0.25	0.00	44.62	67.81	2.00	0.00	0.24	0.00
44.78	65.86	2.00	0.00	0.24	0.00	44.95	62.49	2.00	0.00	0.24	0.00
45.11	59.84	2.00	0.00	0.24	0.00	45.28	59.58	2.00	0.00	0.23	0.00
45.44	61.66	2.00	0.00	0.23	0.00	45.60	63.62	2.00	0.00	0.23	0.00
45.77	63.78	2.00	0.00	0.22	0.00	45.93	62.47	2.00	0.00	0.22	0.00
46.10	62.45	2.00	0.00	0.22	0.00	46.26	63.43	2.00	0.00	0.22	0.00
46.42	64.80	2.00	0.00	0.21	0.00	46.59	63.69	2.00	0.00	0.21	0.00
46.75	62.33	2.00	0.00	0.21	0.00	46.92	61.14	2.00	0.00	0.20	0.00
47.08	60.30	2.00	0.00	0.20	0.00	47.24	58.40	2.00	0.00	0.20	0.00
47.41	57.02	2.00	0.00	0.20	0.00	47.57	56.85	2.00	0.00	0.19	0.00
47.74	57.68	2.00	0.00	0.19	0.00	47.90	57.58	2.00	0.00	0.19	0.00
48.06	57.06	2.00	0.00	0.19	0.00	48.23	56.18	2.00	0.00	0.18	0.00
48.39	55.57	2.00	0.00	0.18	0.00	48.56	54.87	2.00	0.00	0.18	0.00
48.72	54.42	2.00	0.00	0.17	0.00	48.88	54.29	2.00	0.00	0.17	0.00
49.05	53.61	2.00	0.00	0.17	0.00	49.21	51.61	2.00	0.00	0.17	0.00
49.38	49.82	2.00	0.00	0.16	0.00	49.54	49.51	2.00	0.00	0.16	0.00
49.70	49.89	2.00	0.00	0.16	0.00	49.87	54.16	2.00	0.00	0.15	0.00
50.03	57.29	2.00	0.00	0.15	0.00						

Total estimated settlement: 0.00

Abbreviations

$Q_{tn,cs}$:	Equivalent clean sand normalized cone resistance
FS:	Factor of safety against liquefaction
e_v (%):	Post-liquefaction volumentric strain
DF:	e_v depth weighting factor
Settlement:	Calculated settlement

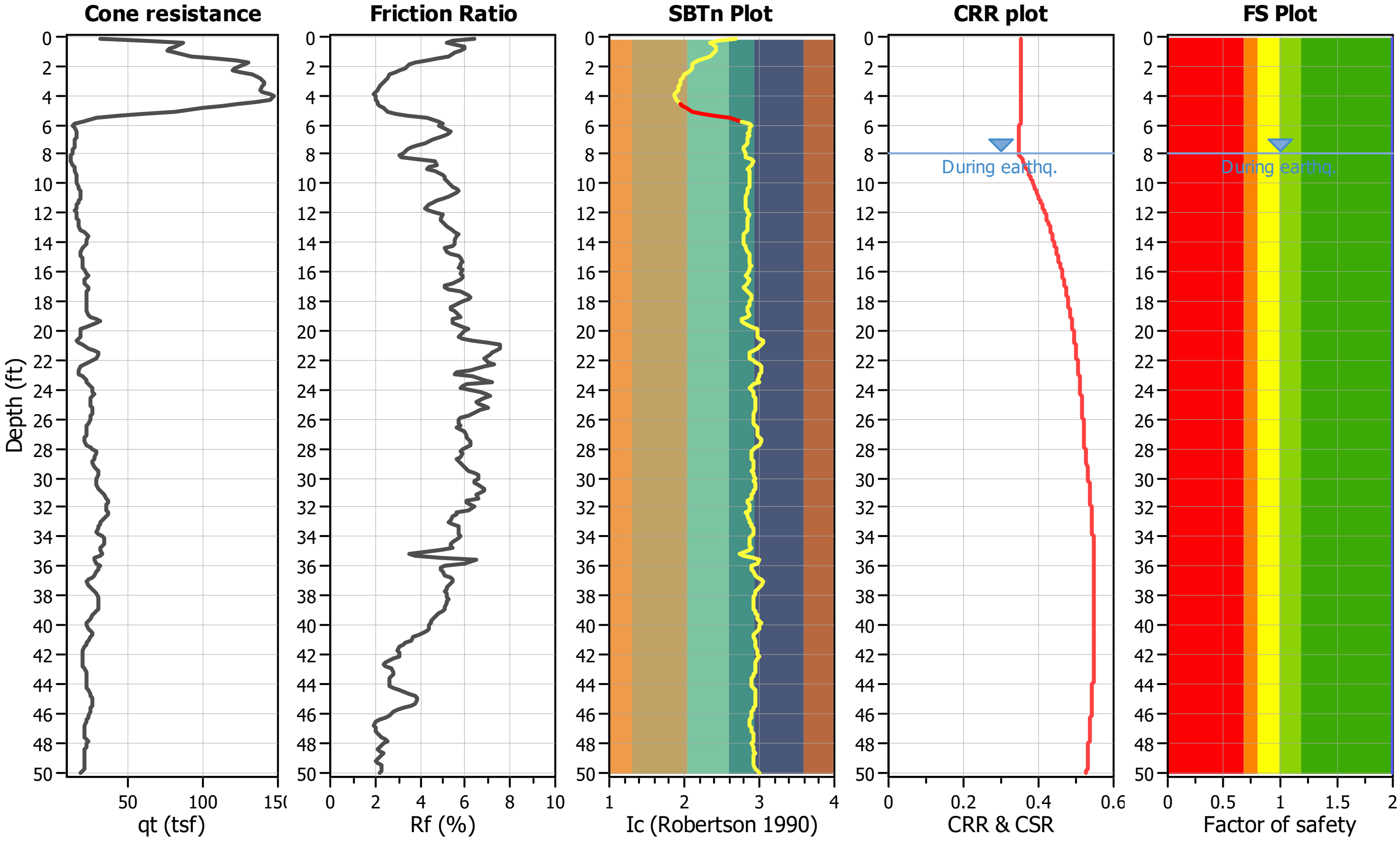
LIQUEFACTION ANALYSIS REPORT

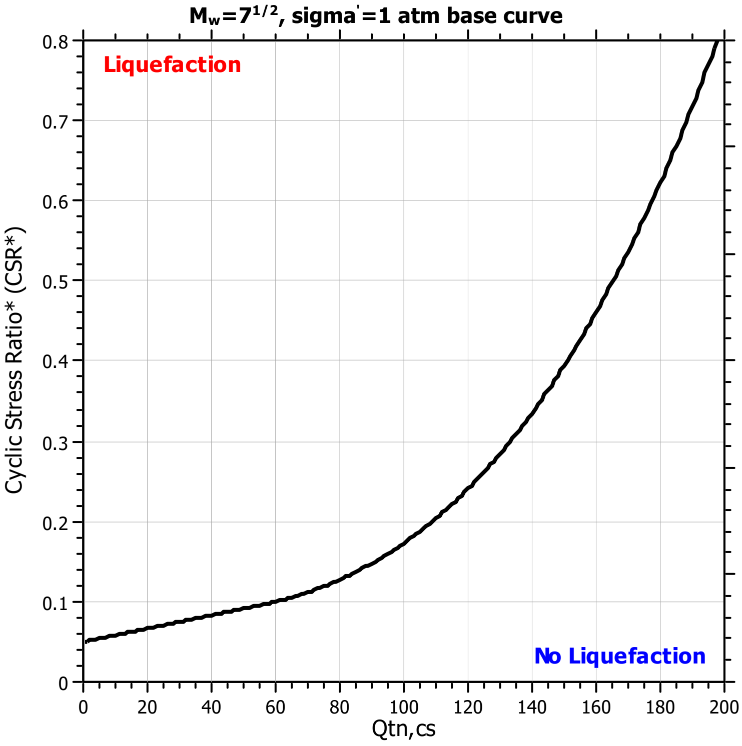
Project title : Heber 2 Repower Project **Location : Heber, CA**

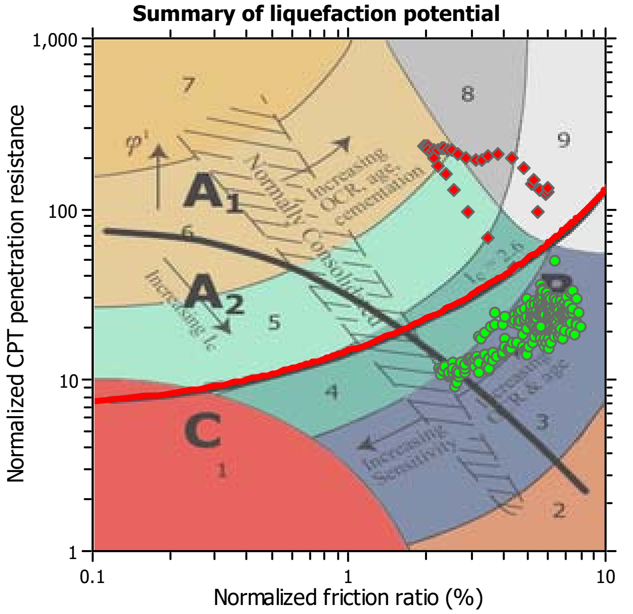
CPT file : CPT-2

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	8.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	8.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	7.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

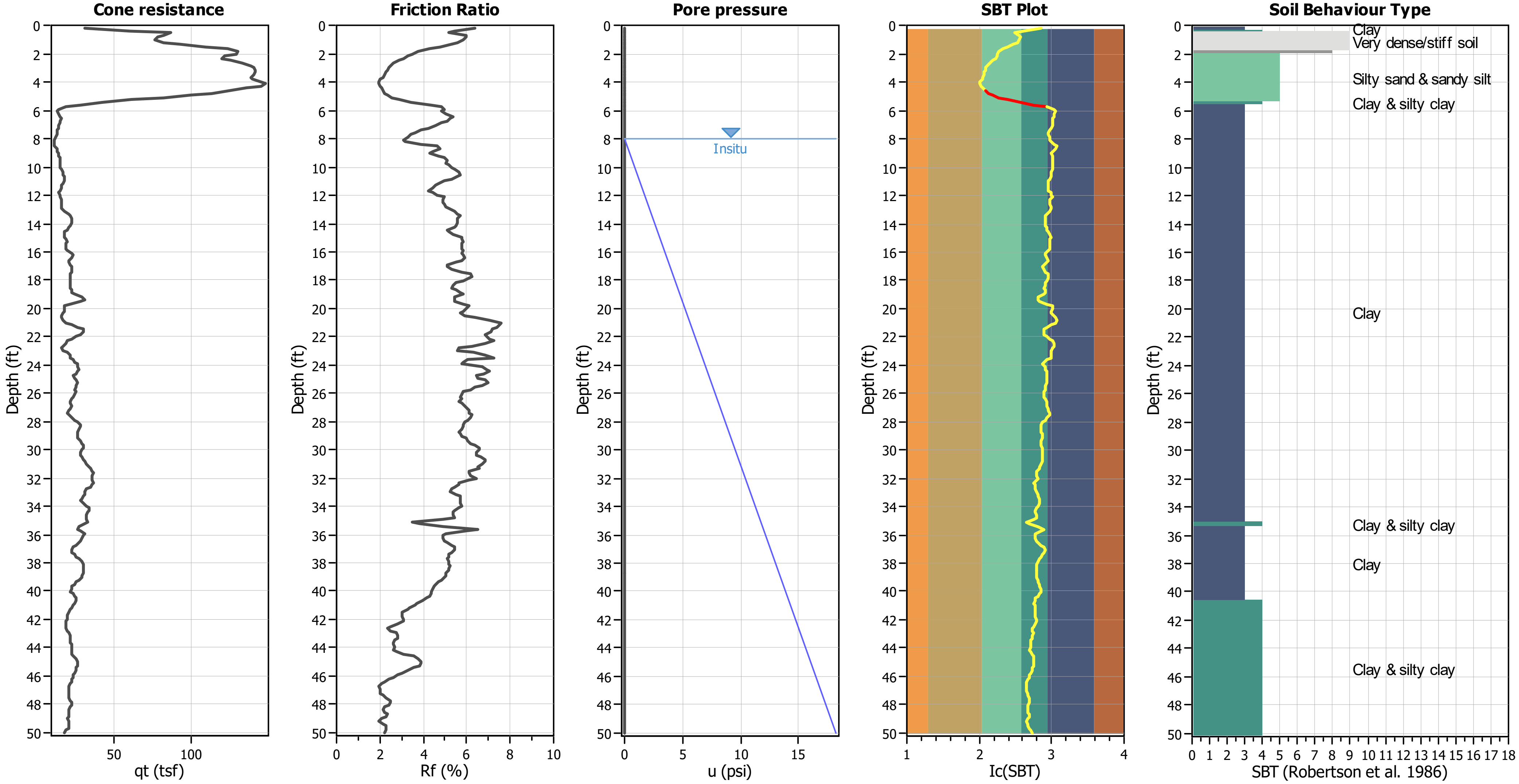






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



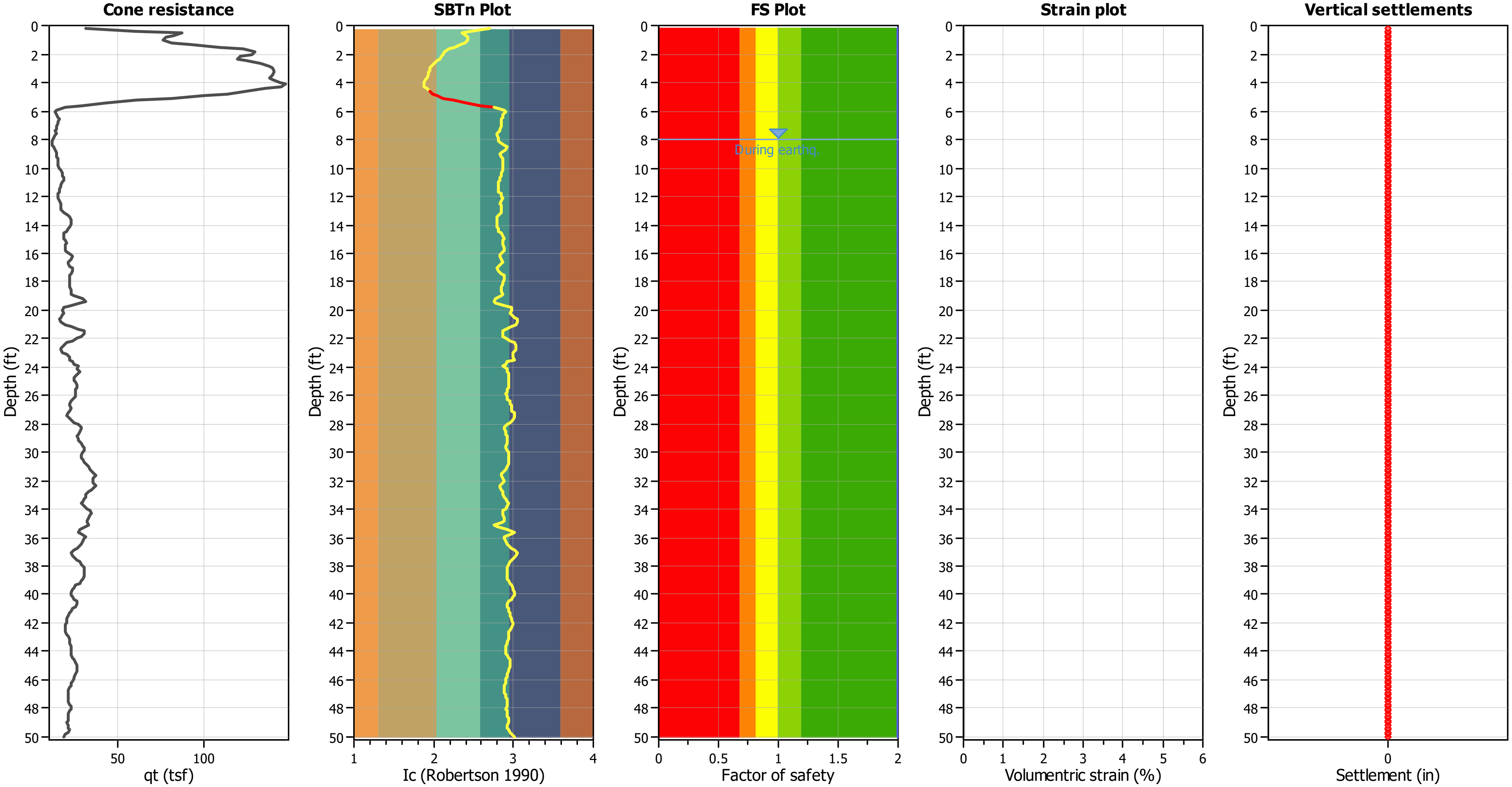
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	8.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.00	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	8.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
8.04	87.36	2.00	0.00	0.86	0.00	8.20	87.19	2.00	0.00	0.86	0.00
8.37	96.18	2.00	0.00	0.86	0.00	8.53	106.38	2.00	0.00	0.86	0.00
8.69	112.48	2.00	0.00	0.85	0.00	8.86	110.89	2.00	0.00	0.85	0.00
9.02	111.02	2.00	0.00	0.85	0.00	9.19	116.47	2.00	0.00	0.84	0.00
9.35	122.07	2.00	0.00	0.84	0.00	9.51	124.70	2.00	0.00	0.84	0.00
9.68	124.57	2.00	0.00	0.84	0.00	9.84	125.67	2.00	0.00	0.83	0.00
10.01	128.65	2.00	0.00	0.83	0.00	10.17	133.81	2.00	0.00	0.83	0.00
10.33	139.27	2.00	0.00	0.82	0.00	10.50	141.24	2.00	0.00	0.82	0.00
10.66	140.53	2.00	0.00	0.82	0.00	10.83	137.12	2.00	0.00	0.82	0.00
10.99	132.08	2.00	0.00	0.81	0.00	11.15	125.69	2.00	0.00	0.81	0.00
11.32	121.22	2.00	0.00	0.81	0.00	11.48	118.55	2.00	0.00	0.81	0.00
11.65	114.78	2.00	0.00	0.80	0.00	11.81	114.47	2.00	0.00	0.80	0.00
11.98	117.86	2.00	0.00	0.80	0.00	12.14	123.32	2.00	0.00	0.79	0.00
12.30	124.95	2.00	0.00	0.79	0.00	12.47	126.35	2.00	0.00	0.79	0.00
12.63	127.12	2.00	0.00	0.79	0.00	12.80	126.75	2.00	0.00	0.78	0.00
12.96	128.67	2.00	0.00	0.78	0.00	13.12	137.01	2.00	0.00	0.78	0.00
13.29	146.43	2.00	0.00	0.77	0.00	13.45	152.65	2.00	0.00	0.77	0.00
13.62	152.23	2.00	0.00	0.77	0.00	13.78	150.77	2.00	0.00	0.77	0.00
13.94	149.69	2.00	0.00	0.76	0.00	14.11	147.77	2.00	0.00	0.76	0.00
14.27	143.23	2.00	0.00	0.76	0.00	14.44	134.40	2.00	0.00	0.76	0.00
14.60	130.85	2.00	0.00	0.75	0.00	14.76	131.78	2.00	0.00	0.75	0.00
14.93	137.68	2.00	0.00	0.75	0.00	15.09	141.06	2.00	0.00	0.74	0.00
15.26	142.59	2.00	0.00	0.74	0.00	15.42	140.26	2.00	0.00	0.74	0.00
15.58	137.71	2.00	0.00	0.74	0.00	15.75	138.11	2.00	0.00	0.73	0.00
15.91	142.76	2.00	0.00	0.73	0.00	16.08	148.65	2.00	0.00	0.73	0.00
16.24	151.42	2.00	0.00	0.72	0.00	16.40	149.65	2.00	0.00	0.72	0.00
16.57	142.62	2.00	0.00	0.72	0.00	16.73	137.02	2.00	0.00	0.72	0.00
16.90	134.47	2.00	0.00	0.71	0.00	17.06	136.99	2.00	0.00	0.71	0.00
17.22	140.40	2.00	0.00	0.71	0.00	17.39	144.16	2.00	0.00	0.71	0.00
17.55	147.16	2.00	0.00	0.70	0.00	17.72	147.34	2.00	0.00	0.70	0.00
17.88	145.63	2.00	0.00	0.70	0.00	18.04	142.20	2.00	0.00	0.69	0.00
18.21	137.49	2.00	0.00	0.69	0.00	18.37	134.79	2.00	0.00	0.69	0.00
18.54	135.52	2.00	0.00	0.69	0.00	18.70	138.83	2.00	0.00	0.68	0.00
18.86	142.10	2.00	0.00	0.68	0.00	19.03	147.42	2.00	0.00	0.68	0.00
19.19	153.72	2.00	0.00	0.67	0.00	19.36	155.93	2.00	0.00	0.67	0.00
19.52	149.47	2.00	0.00	0.67	0.00	19.69	138.34	2.00	0.00	0.67	0.00
19.85	130.61	2.00	0.00	0.66	0.00	20.01	127.39	2.00	0.00	0.66	0.00
20.18	126.45	2.00	0.00	0.66	0.00	20.34	122.79	2.00	0.00	0.66	0.00
20.51	120.62	2.00	0.00	0.65	0.00	20.67	123.16	2.00	0.00	0.65	0.00
20.83	132.56	2.00	0.00	0.65	0.00	21.00	144.81	2.00	0.00	0.64	0.00
21.16	158.42	2.00	0.00	0.64	0.00	21.33	169.86	2.00	0.00	0.64	0.00
21.49	175.02	2.00	0.00	0.64	0.00	21.65	173.22	2.00	0.00	0.63	0.00
21.82	164.99	2.00	0.00	0.63	0.00	21.98	158.59	2.00	0.00	0.63	0.00
22.15	151.83	2.00	0.00	0.62	0.00	22.31	144.28	2.00	0.00	0.62	0.00
22.47	133.91	2.00	0.00	0.62	0.00	22.64	122.50	2.00	0.00	0.62	0.00
22.80	113.97	2.00	0.00	0.61	0.00	22.97	115.77	2.00	0.00	0.61	0.00
23.13	130.82	2.00	0.00	0.61	0.00	23.29	142.43	2.00	0.00	0.61	0.00
23.46	145.56	2.00	0.00	0.60	0.00	23.62	138.07	2.00	0.00	0.60	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
23.79	137.78	2.00	0.00	0.60	0.00	23.95	142.26	2.00	0.00	0.59	0.00
24.11	152.61	2.00	0.00	0.59	0.00	24.28	157.26	2.00	0.00	0.59	0.00
24.44	157.24	2.00	0.00	0.59	0.00	24.61	149.93	2.00	0.00	0.58	0.00
24.77	142.55	2.00	0.00	0.58	0.00	24.93	143.51	2.00	0.00	0.58	0.00
25.10	149.66	2.00	0.00	0.57	0.00	25.26	152.78	2.00	0.00	0.57	0.00
25.43	148.83	2.00	0.00	0.57	0.00	25.59	143.18	2.00	0.00	0.57	0.00
25.75	139.46	2.00	0.00	0.56	0.00	25.92	135.62	2.00	0.00	0.56	0.00
26.08	133.19	2.00	0.00	0.56	0.00	26.25	130.04	2.00	0.00	0.56	0.00
26.41	126.80	2.00	0.00	0.55	0.00	26.57	123.29	2.00	0.00	0.55	0.00
26.74	124.77	2.00	0.00	0.55	0.00	26.90	128.04	2.00	0.00	0.54	0.00
27.07	127.87	2.00	0.00	0.54	0.00	27.23	124.65	2.00	0.00	0.54	0.00
27.40	123.42	2.00	0.00	0.54	0.00	27.56	125.82	2.00	0.00	0.53	0.00
27.72	129.41	2.00	0.00	0.53	0.00	27.89	132.22	2.00	0.00	0.53	0.00
28.05	136.18	2.00	0.00	0.52	0.00	28.22	139.19	2.00	0.00	0.52	0.00
28.38	139.58	2.00	0.00	0.52	0.00	28.54	136.40	2.00	0.00	0.52	0.00
28.71	132.41	2.00	0.00	0.51	0.00	28.87	131.90	2.00	0.00	0.51	0.00
29.04	133.41	2.00	0.00	0.51	0.00	29.20	135.88	2.00	0.00	0.51	0.00
29.36	139.24	2.00	0.00	0.50	0.00	29.53	144.11	2.00	0.00	0.50	0.00
29.69	147.91	2.00	0.00	0.50	0.00	29.86	148.75	2.00	0.00	0.49	0.00
30.02	146.27	2.00	0.00	0.49	0.00	30.18	143.95	2.00	0.00	0.49	0.00
30.35	143.23	2.00	0.00	0.49	0.00	30.51	146.19	2.00	0.00	0.48	0.00
30.68	150.88	2.00	0.00	0.48	0.00	30.84	153.31	2.00	0.00	0.48	0.00
31.00	153.80	2.00	0.00	0.47	0.00	31.17	154.28	2.00	0.00	0.47	0.00
31.33	157.57	2.00	0.00	0.47	0.00	31.50	153.01	2.00	0.00	0.47	0.00
31.66	154.59	2.00	0.00	0.46	0.00	31.82	152.70	2.00	0.00	0.46	0.00
31.99	155.75	2.00	0.00	0.46	0.00	32.15	151.09	2.00	0.00	0.46	0.00
32.32	147.83	2.00	0.00	0.45	0.00	32.48	145.76	2.00	0.00	0.45	0.00
32.64	140.14	2.00	0.00	0.45	0.00	32.81	133.97	2.00	0.00	0.44	0.00
32.97	130.32	2.00	0.00	0.44	0.00	33.14	132.24	2.00	0.00	0.44	0.00
33.30	133.70	2.00	0.00	0.44	0.00	33.46	131.98	2.00	0.00	0.43	0.00
33.63	130.38	2.00	0.00	0.43	0.00	33.79	132.66	2.00	0.00	0.43	0.00
33.96	137.36	2.00	0.00	0.42	0.00	34.12	139.02	2.00	0.00	0.42	0.00
34.28	136.49	2.00	0.00	0.42	0.00	34.45	134.01	2.00	0.00	0.42	0.00
34.61	131.99	2.00	0.00	0.41	0.00	34.78	130.99	2.00	0.00	0.41	0.00
34.94	124.05	2.00	0.00	0.41	0.00	35.10	106.18	2.00	0.00	0.41	0.00
35.27	108.32	2.00	0.00	0.40	0.00	35.43	116.24	2.00	0.00	0.40	0.00
35.60	131.29	2.00	0.00	0.40	0.00	35.76	128.43	2.00	0.00	0.39	0.00
35.93	124.20	2.00	0.00	0.39	0.00	36.09	120.99	2.00	0.00	0.39	0.00
36.25	118.67	2.00	0.00	0.39	0.00	36.42	117.46	2.00	0.00	0.38	0.00
36.58	116.41	2.00	0.00	0.38	0.00	36.75	114.96	2.00	0.00	0.38	0.00
36.91	112.18	2.00	0.00	0.37	0.00	37.07	109.16	2.00	0.00	0.37	0.00
37.24	108.67	2.00	0.00	0.37	0.00	37.40	109.91	2.00	0.00	0.37	0.00
37.57	113.02	2.00	0.00	0.36	0.00	37.73	115.42	2.00	0.00	0.36	0.00
37.89	118.48	2.00	0.00	0.36	0.00	38.06	120.42	2.00	0.00	0.35	0.00
38.22	120.97	2.00	0.00	0.35	0.00	38.39	120.42	2.00	0.00	0.35	0.00
38.55	119.67	2.00	0.00	0.35	0.00	38.71	118.51	2.00	0.00	0.34	0.00
38.88	117.61	2.00	0.00	0.34	0.00	39.04	115.20	2.00	0.00	0.34	0.00
39.21	110.80	2.00	0.00	0.34	0.00	39.37	105.70	2.00	0.00	0.33	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
39.53	101.48	2.00	0.00	0.33	0.00	39.70	98.49	2.00	0.00	0.33	0.00
39.86	96.59	2.00	0.00	0.32	0.00	40.03	95.67	2.00	0.00	0.32	0.00
40.19	97.13	2.00	0.00	0.32	0.00	40.35	98.64	2.00	0.00	0.32	0.00
40.52	98.88	2.00	0.00	0.31	0.00	40.68	96.83	2.00	0.00	0.31	0.00
40.85	92.14	2.00	0.00	0.31	0.00	41.01	88.77	2.00	0.00	0.30	0.00
41.17	84.35	2.00	0.00	0.30	0.00	41.34	81.40	2.00	0.00	0.30	0.00
41.50	77.39	2.00	0.00	0.30	0.00	41.67	76.16	2.00	0.00	0.29	0.00
41.83	76.40	2.00	0.00	0.29	0.00	41.99	76.66	2.00	0.00	0.29	0.00
42.16	75.61	2.00	0.00	0.29	0.00	42.32	71.98	2.00	0.00	0.28	0.00
42.49	68.05	2.00	0.00	0.28	0.00	42.65	66.80	2.00	0.00	0.28	0.00
42.81	69.47	2.00	0.00	0.27	0.00	42.98	73.47	2.00	0.00	0.27	0.00
43.14	75.84	2.00	0.00	0.27	0.00	43.31	76.24	2.00	0.00	0.27	0.00
43.47	75.02	2.00	0.00	0.26	0.00	43.64	74.38	2.00	0.00	0.26	0.00
43.80	74.31	2.00	0.00	0.26	0.00	43.96	74.98	2.00	0.00	0.25	0.00
44.13	74.60	2.00	0.00	0.25	0.00	44.29	76.20	2.00	0.00	0.25	0.00
44.46	80.54	2.00	0.00	0.25	0.00	44.62	86.78	2.00	0.00	0.24	0.00
44.78	90.93	2.00	0.00	0.24	0.00	44.95	93.24	2.00	0.00	0.24	0.00
45.11	93.73	2.00	0.00	0.24	0.00	45.28	92.65	2.00	0.00	0.23	0.00
45.44	89.03	2.00	0.00	0.23	0.00	45.60	84.92	2.00	0.00	0.23	0.00
45.77	80.93	2.00	0.00	0.22	0.00	45.93	77.69	2.00	0.00	0.22	0.00
46.10	74.24	2.00	0.00	0.22	0.00	46.26	71.34	2.00	0.00	0.22	0.00
46.42	68.07	2.00	0.00	0.21	0.00	46.59	65.10	2.00	0.00	0.21	0.00
46.75	63.06	2.00	0.00	0.21	0.00	46.92	62.80	2.00	0.00	0.20	0.00
47.08	63.25	2.00	0.00	0.20	0.00	47.24	63.50	2.00	0.00	0.20	0.00
47.41	64.30	2.00	0.00	0.20	0.00	47.57	66.85	2.00	0.00	0.19	0.00
47.74	69.90	2.00	0.00	0.19	0.00	47.90	71.36	2.00	0.00	0.19	0.00
48.06	69.62	2.00	0.00	0.19	0.00	48.23	66.49	2.00	0.00	0.18	0.00
48.39	64.48	2.00	0.00	0.18	0.00	48.56	65.33	2.00	0.00	0.18	0.00
48.72	67.11	2.00	0.00	0.17	0.00	48.88	66.06	2.00	0.00	0.17	0.00
49.05	63.01	2.00	0.00	0.17	0.00	49.21	61.74	2.00	0.00	0.17	0.00
49.38	63.70	2.00	0.00	0.16	0.00	49.54	65.97	2.00	0.00	0.16	0.00
49.70	65.40	2.00	0.00	0.16	0.00	49.87	62.98	2.00	0.00	0.15	0.00
50.03	60.76	2.00	0.00	0.15	0.00						

Total estimated settlement: 0.00

Abbreviations

$Q_{tn,cs}$:	Equivalent clean sand normalized cone resistance
FS:	Factor of safety against liquefaction
e_v (%):	Post-liquefaction volumentric strain
DF:	e_v depth weighting factor
Settlement:	Calculated settlement

Landmark Consultants, Inc.
780 N. 4th Street
El Centro, CA 92243

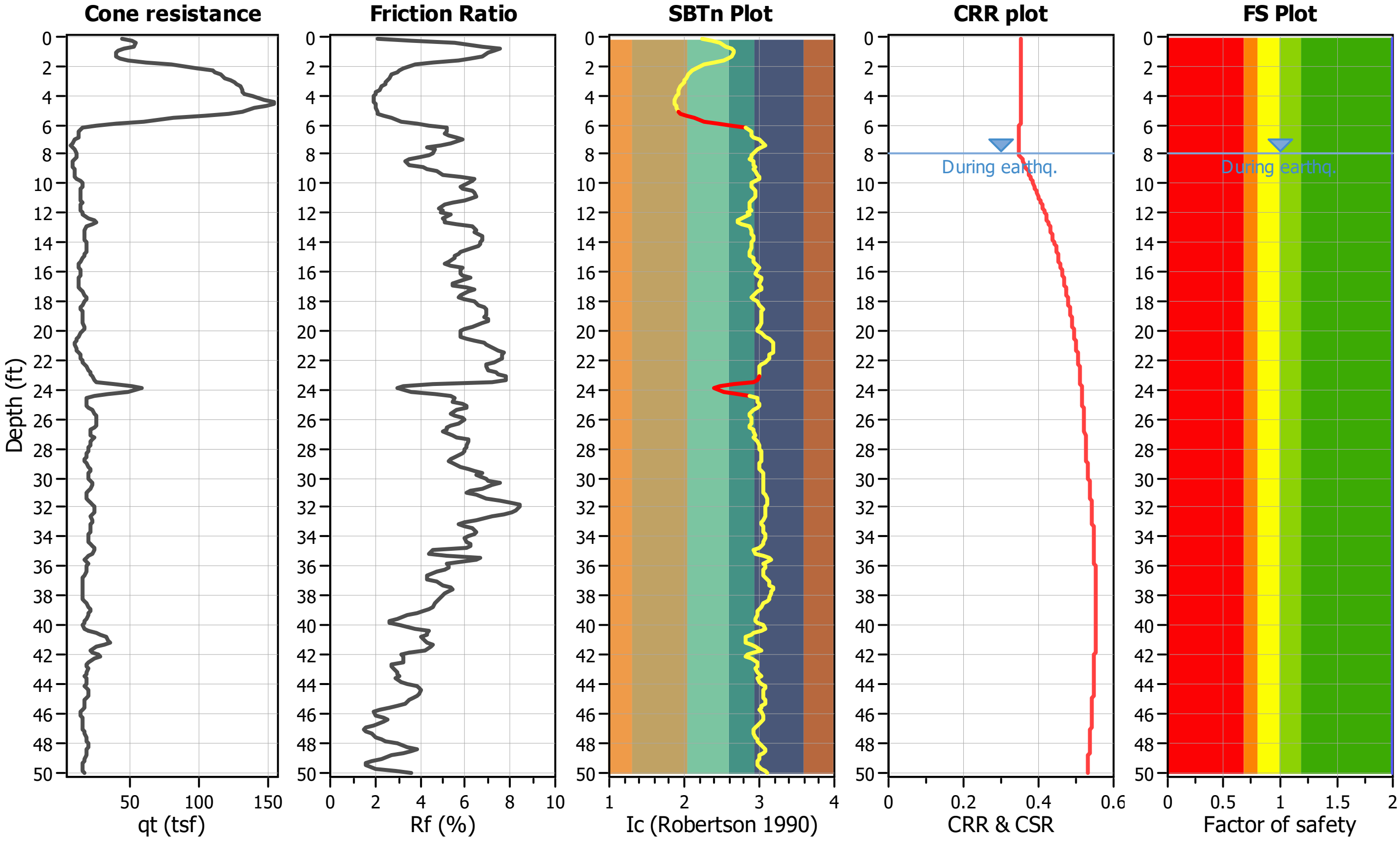
LIQUEFACTION ANALYSIS REPORT

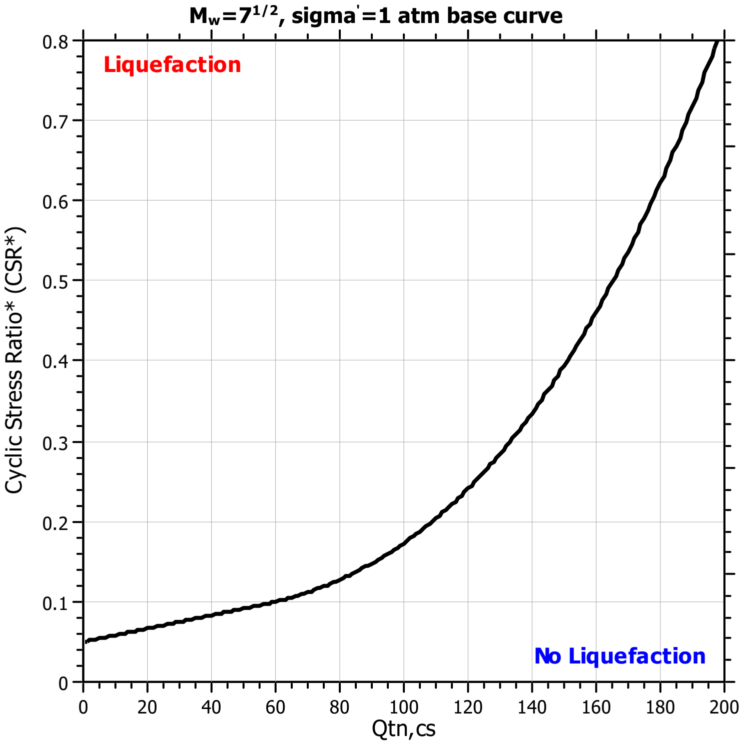
Project title : Heber 2 Repower Project **Location : Heber, CA**

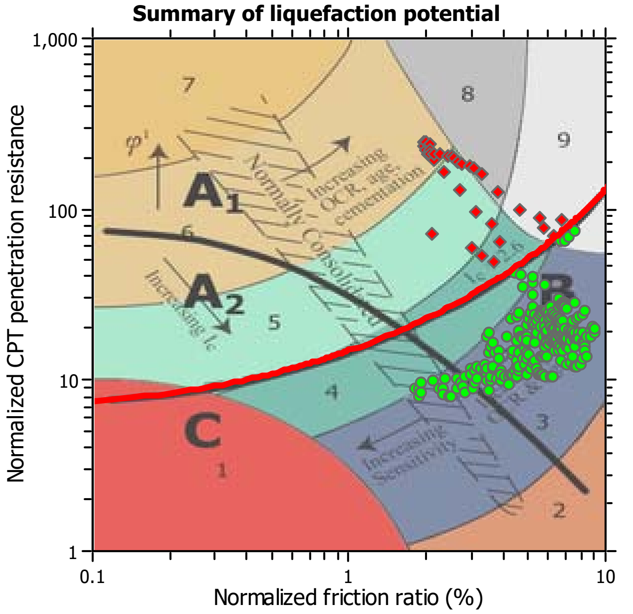
CPT file : CPT-3

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	8.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	8.00 ft	Fill height:	N/A		
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude M_w:	7.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	N/A
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based

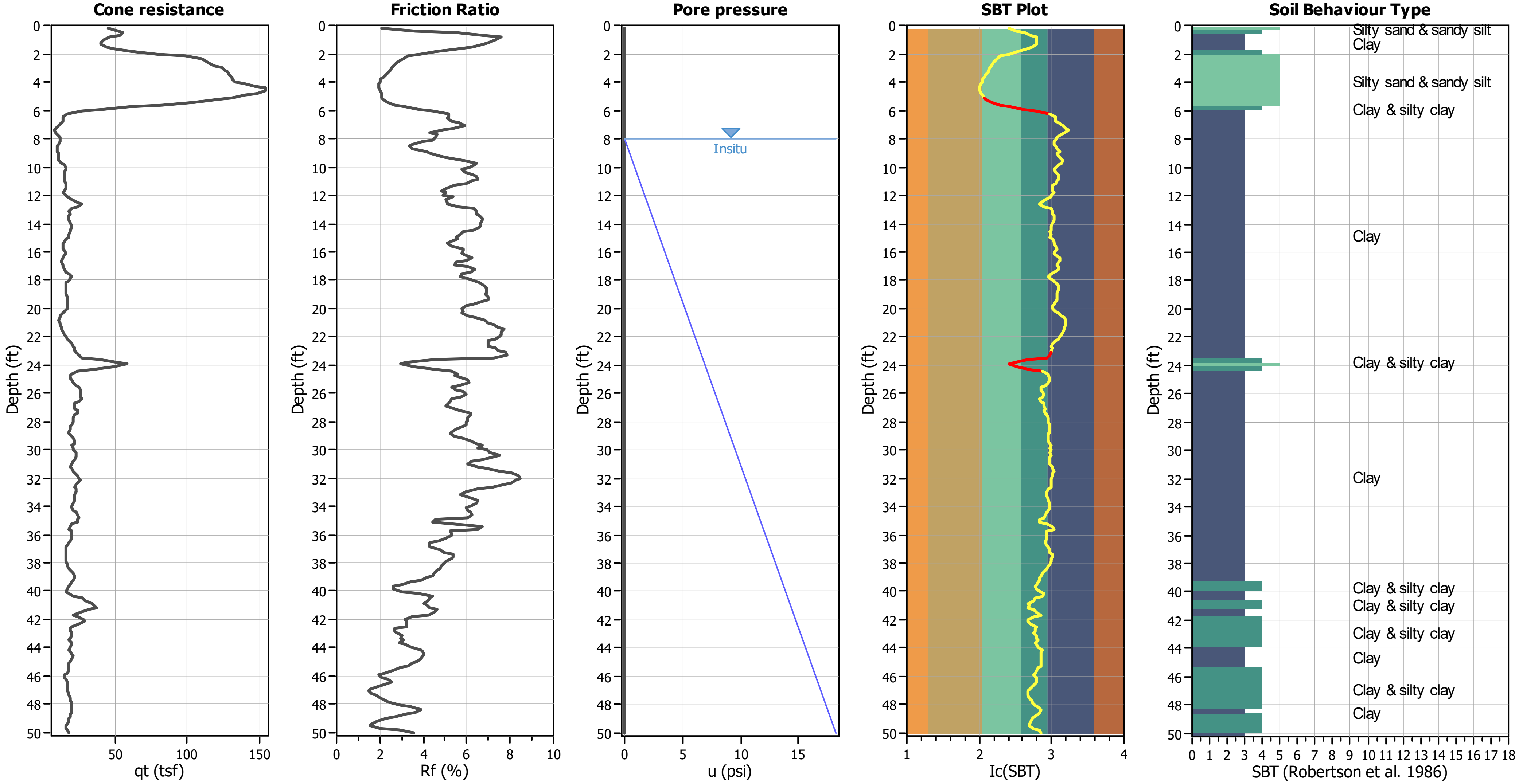






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



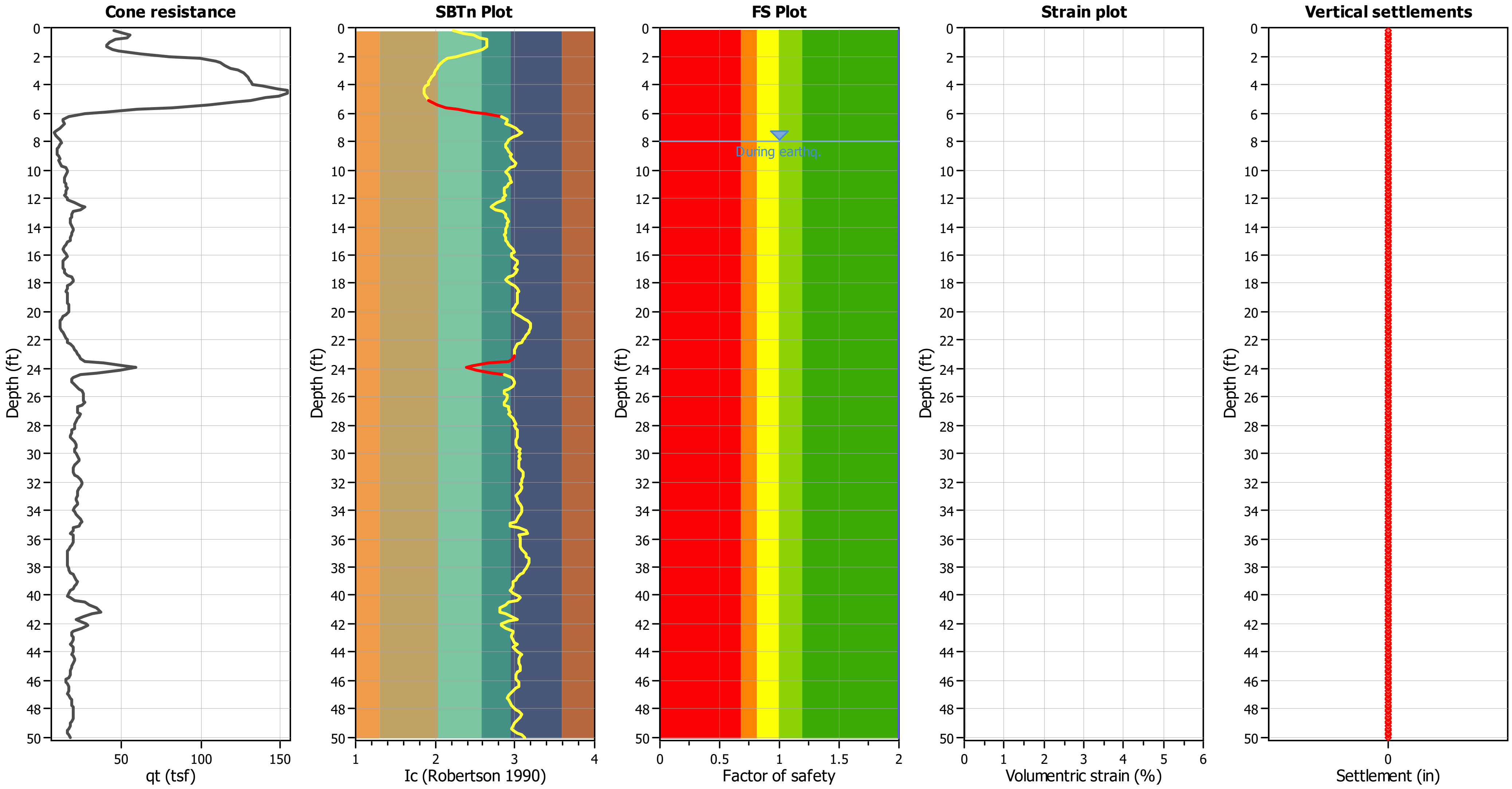
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	8.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.00	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	8.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥	1. Sensitive fine grained	🟩	4. Clayey silt to silty	🟧	7. Gravely sand to sand
🟫	2. Organic material	🟩	5. Silty sand to sandy silt	◼	8. Very stiff sand to
🟦	3. Clay to silty clay	🟫	6. Clean sand to silty sand	⬜	9. Very stiff fine grained

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
8.04	105.22	2.00	0.00	0.86	0.00	8.20	98.09	2.00	0.00	0.86	0.00
8.37	89.48	2.00	0.00	0.86	0.00	8.53	84.06	2.00	0.00	0.86	0.00
8.69	85.12	2.00	0.00	0.85	0.00	8.86	93.40	2.00	0.00	0.85	0.00
9.02	99.67	2.00	0.00	0.85	0.00	9.19	104.91	2.00	0.00	0.84	0.00
9.35	106.95	2.00	0.00	0.84	0.00	9.51	115.87	2.00	0.00	0.84	0.00
9.68	128.34	2.00	0.00	0.84	0.00	9.84	137.59	2.00	0.00	0.83	0.00
10.01	139.16	2.00	0.00	0.83	0.00	10.17	135.75	2.00	0.00	0.83	0.00
10.33	134.00	2.00	0.00	0.82	0.00	10.50	136.19	2.00	0.00	0.82	0.00
10.66	138.03	2.00	0.00	0.82	0.00	10.83	138.95	2.00	0.00	0.82	0.00
10.99	137.77	2.00	0.00	0.81	0.00	11.15	136.64	2.00	0.00	0.81	0.00
11.32	132.10	2.00	0.00	0.81	0.00	11.48	125.76	2.00	0.00	0.81	0.00
11.65	120.13	2.00	0.00	0.80	0.00	11.81	120.19	2.00	0.00	0.80	0.00
11.98	125.19	2.00	0.00	0.80	0.00	12.14	132.55	2.00	0.00	0.79	0.00
12.30	140.53	2.00	0.00	0.79	0.00	12.47	151.43	2.00	0.00	0.79	0.00
12.63	157.43	2.00	0.00	0.79	0.00	12.80	158.94	2.00	0.00	0.78	0.00
12.96	155.22	2.00	0.00	0.78	0.00	13.12	152.28	2.00	0.00	0.78	0.00
13.29	151.52	2.00	0.00	0.77	0.00	13.45	152.54	2.00	0.00	0.77	0.00
13.62	152.19	2.00	0.00	0.77	0.00	13.78	153.09	2.00	0.00	0.77	0.00
13.94	154.64	2.00	0.00	0.76	0.00	14.11	156.69	2.00	0.00	0.76	0.00
14.27	155.45	2.00	0.00	0.76	0.00	14.44	149.53	2.00	0.00	0.76	0.00
14.60	141.82	2.00	0.00	0.75	0.00	14.76	137.16	2.00	0.00	0.75	0.00
14.93	132.83	2.00	0.00	0.75	0.00	15.09	128.46	2.00	0.00	0.74	0.00
15.26	120.02	2.00	0.00	0.74	0.00	15.42	114.98	2.00	0.00	0.74	0.00
15.58	115.12	2.00	0.00	0.74	0.00	15.75	121.64	2.00	0.00	0.73	0.00
15.91	125.61	2.00	0.00	0.73	0.00	16.08	126.76	2.00	0.00	0.73	0.00
16.24	125.34	2.00	0.00	0.72	0.00	16.40	122.47	2.00	0.00	0.72	0.00
16.57	116.72	2.00	0.00	0.72	0.00	16.73	112.12	2.00	0.00	0.72	0.00
16.90	113.22	2.00	0.00	0.71	0.00	17.06	120.49	2.00	0.00	0.71	0.00
17.22	126.45	2.00	0.00	0.71	0.00	17.39	130.53	2.00	0.00	0.71	0.00
17.55	132.64	2.00	0.00	0.70	0.00	17.72	135.99	2.00	0.00	0.70	0.00
17.88	137.42	2.00	0.00	0.70	0.00	18.04	136.58	2.00	0.00	0.69	0.00
18.21	132.83	2.00	0.00	0.69	0.00	18.37	131.91	2.00	0.00	0.69	0.00
18.54	132.44	2.00	0.00	0.69	0.00	18.70	132.83	2.00	0.00	0.68	0.00
18.86	132.94	2.00	0.00	0.68	0.00	19.03	132.94	2.00	0.00	0.68	0.00
19.19	135.47	2.00	0.00	0.67	0.00	19.36	134.98	2.00	0.00	0.67	0.00
19.52	132.82	2.00	0.00	0.67	0.00	19.69	129.87	2.00	0.00	0.67	0.00
19.85	126.97	2.00	0.00	0.66	0.00	20.01	123.39	2.00	0.00	0.66	0.00
20.18	116.87	2.00	0.00	0.66	0.00	20.34	109.55	2.00	0.00	0.66	0.00
20.51	105.52	2.00	0.00	0.65	0.00	20.67	105.35	2.00	0.00	0.65	0.00
20.83	107.65	2.00	0.00	0.65	0.00	21.00	108.62	2.00	0.00	0.64	0.00
21.16	112.61	2.00	0.00	0.64	0.00	21.33	117.42	2.00	0.00	0.64	0.00
21.49	121.92	2.00	0.00	0.64	0.00	21.65	125.67	2.00	0.00	0.63	0.00
21.82	129.09	2.00	0.00	0.63	0.00	21.98	130.92	2.00	0.00	0.63	0.00
22.15	132.02	2.00	0.00	0.62	0.00	22.31	133.84	2.00	0.00	0.62	0.00
22.47	140.34	2.00	0.00	0.62	0.00	22.64	144.51	2.00	0.00	0.62	0.00
22.80	149.71	2.00	0.00	0.61	0.00	22.97	152.21	2.00	0.00	0.61	0.00
23.13	158.62	2.00	0.00	0.61	0.00	23.29	164.29	2.00	0.00	0.61	0.00
23.46	163.34	2.00	0.00	0.60	0.00	23.62	149.57	2.00	0.00	0.60	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
23.79	137.21	2.00	0.00	0.60	0.00	23.95	138.01	2.00	0.00	0.59	0.00
24.11	142.14	2.00	0.00	0.59	0.00	24.28	141.20	2.00	0.00	0.59	0.00
24.44	130.89	2.00	0.00	0.59	0.00	24.61	121.03	2.00	0.00	0.58	0.00
24.77	117.62	2.00	0.00	0.58	0.00	24.93	121.38	2.00	0.00	0.58	0.00
25.10	126.27	2.00	0.00	0.57	0.00	25.26	130.22	2.00	0.00	0.57	0.00
25.43	129.59	2.00	0.00	0.57	0.00	25.59	131.09	2.00	0.00	0.57	0.00
25.75	135.18	2.00	0.00	0.56	0.00	25.92	139.49	2.00	0.00	0.56	0.00
26.08	139.40	2.00	0.00	0.56	0.00	26.25	137.13	2.00	0.00	0.56	0.00
26.41	133.24	2.00	0.00	0.55	0.00	26.57	128.22	2.00	0.00	0.55	0.00
26.74	120.94	2.00	0.00	0.55	0.00	26.90	117.65	2.00	0.00	0.54	0.00
27.07	123.39	2.00	0.00	0.54	0.00	27.23	130.15	2.00	0.00	0.54	0.00
27.40	134.00	2.00	0.00	0.54	0.00	27.56	130.29	2.00	0.00	0.53	0.00
27.72	125.72	2.00	0.00	0.53	0.00	27.89	123.53	2.00	0.00	0.53	0.00
28.05	123.09	2.00	0.00	0.52	0.00	28.22	121.41	2.00	0.00	0.52	0.00
28.38	117.09	2.00	0.00	0.52	0.00	28.54	111.50	2.00	0.00	0.52	0.00
28.71	108.31	2.00	0.00	0.51	0.00	28.87	107.69	2.00	0.00	0.51	0.00
29.04	112.56	2.00	0.00	0.51	0.00	29.20	119.74	2.00	0.00	0.51	0.00
29.36	125.93	2.00	0.00	0.50	0.00	29.53	127.06	2.00	0.00	0.50	0.00
29.69	126.51	2.00	0.00	0.50	0.00	29.86	125.39	2.00	0.00	0.49	0.00
30.02	129.92	2.00	0.00	0.49	0.00	30.18	135.27	2.00	0.00	0.49	0.00
30.35	140.32	2.00	0.00	0.49	0.00	30.51	137.30	2.00	0.00	0.48	0.00
30.68	129.14	2.00	0.00	0.48	0.00	30.84	120.95	2.00	0.00	0.48	0.00
31.00	116.56	2.00	0.00	0.47	0.00	31.17	119.19	2.00	0.00	0.47	0.00
31.33	123.11	2.00	0.00	0.47	0.00	31.50	131.51	2.00	0.00	0.47	0.00
31.66	140.19	2.00	0.00	0.46	0.00	31.82	148.00	2.00	0.00	0.46	0.00
31.99	151.97	2.00	0.00	0.46	0.00	32.15	151.52	2.00	0.00	0.46	0.00
32.32	145.89	2.00	0.00	0.45	0.00	32.48	138.22	2.00	0.00	0.45	0.00
32.64	131.44	2.00	0.00	0.45	0.00	32.81	126.66	2.00	0.00	0.44	0.00
32.97	120.92	2.00	0.00	0.44	0.00	33.14	115.82	2.00	0.00	0.44	0.00
33.30	117.32	2.00	0.00	0.44	0.00	33.46	122.10	2.00	0.00	0.43	0.00
33.63	123.45	2.00	0.00	0.43	0.00	33.79	118.97	2.00	0.00	0.43	0.00
33.96	114.29	2.00	0.00	0.42	0.00	34.12	113.26	2.00	0.00	0.42	0.00
34.28	116.07	2.00	0.00	0.42	0.00	34.45	120.77	2.00	0.00	0.42	0.00
34.61	124.37	2.00	0.00	0.41	0.00	34.78	124.30	2.00	0.00	0.41	0.00
34.94	107.22	2.00	0.00	0.41	0.00	35.10	104.14	2.00	0.00	0.41	0.00
35.27	103.90	2.00	0.00	0.40	0.00	35.43	114.48	2.00	0.00	0.40	0.00
35.60	108.91	2.00	0.00	0.40	0.00	35.76	103.69	2.00	0.00	0.39	0.00
35.93	103.19	2.00	0.00	0.39	0.00	36.09	102.94	2.00	0.00	0.39	0.00
36.25	100.79	2.00	0.00	0.39	0.00	36.42	95.16	2.00	0.00	0.38	0.00
36.58	89.61	2.00	0.00	0.38	0.00	36.75	86.08	2.00	0.00	0.38	0.00
36.91	85.66	2.00	0.00	0.37	0.00	37.07	88.52	2.00	0.00	0.37	0.00
37.24	90.83	2.00	0.00	0.37	0.00	37.40	92.89	2.00	0.00	0.37	0.00
37.57	92.98	2.00	0.00	0.36	0.00	37.73	92.32	2.00	0.00	0.36	0.00
37.89	90.55	2.00	0.00	0.36	0.00	38.06	89.64	2.00	0.00	0.35	0.00
38.22	90.25	2.00	0.00	0.35	0.00	38.39	91.89	2.00	0.00	0.35	0.00
38.55	94.23	2.00	0.00	0.35	0.00	38.71	96.50	2.00	0.00	0.34	0.00
38.88	96.89	2.00	0.00	0.34	0.00	39.04	94.80	2.00	0.00	0.34	0.00
39.21	90.16	2.00	0.00	0.34	0.00	39.37	83.66	2.00	0.00	0.33	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
39.53	76.97	2.00	0.00	0.33	0.00	39.70	70.89	2.00	0.00	0.33	0.00
39.86	68.91	2.00	0.00	0.32	0.00	40.03	71.76	2.00	0.00	0.32	0.00
40.19	81.13	2.00	0.00	0.32	0.00	40.35	93.57	2.00	0.00	0.32	0.00
40.52	103.75	2.00	0.00	0.31	0.00	40.68	107.44	2.00	0.00	0.31	0.00
40.85	110.91	2.00	0.00	0.31	0.00	41.01	115.14	2.00	0.00	0.30	0.00
41.17	118.91	2.00	0.00	0.30	0.00	41.34	114.80	2.00	0.00	0.30	0.00
41.50	103.67	2.00	0.00	0.30	0.00	41.67	91.95	2.00	0.00	0.29	0.00
41.83	88.04	2.00	0.00	0.29	0.00	41.99	90.47	2.00	0.00	0.29	0.00
42.16	92.83	2.00	0.00	0.29	0.00	42.32	87.29	2.00	0.00	0.28	0.00
42.49	78.72	2.00	0.00	0.28	0.00	42.65	71.54	2.00	0.00	0.28	0.00
42.81	71.84	2.00	0.00	0.27	0.00	42.98	73.65	2.00	0.00	0.27	0.00
43.14	75.58	2.00	0.00	0.27	0.00	43.31	74.00	2.00	0.00	0.27	0.00
43.47	73.64	2.00	0.00	0.26	0.00	43.64	73.86	2.00	0.00	0.26	0.00
43.80	76.92	2.00	0.00	0.26	0.00	43.96	78.92	2.00	0.00	0.25	0.00
44.13	81.06	2.00	0.00	0.25	0.00	44.29	83.91	2.00	0.00	0.25	0.00
44.46	85.95	2.00	0.00	0.25	0.00	44.62	85.68	2.00	0.00	0.24	0.00
44.78	83.55	2.00	0.00	0.24	0.00	44.95	80.58	2.00	0.00	0.24	0.00
45.11	77.10	2.00	0.00	0.24	0.00	45.28	74.16	2.00	0.00	0.23	0.00
45.44	71.31	2.00	0.00	0.23	0.00	45.60	66.96	2.00	0.00	0.23	0.00
45.77	60.99	2.00	0.00	0.22	0.00	45.93	55.97	2.00	0.00	0.22	0.00
46.10	56.91	2.00	0.00	0.22	0.00	46.26	61.03	2.00	0.00	0.22	0.00
46.42	64.41	2.00	0.00	0.21	0.00	46.59	62.81	2.00	0.00	0.21	0.00
46.75	58.05	2.00	0.00	0.21	0.00	46.92	53.06	2.00	0.00	0.20	0.00
47.08	52.59	2.00	0.00	0.20	0.00	47.24	54.97	2.00	0.00	0.20	0.00
47.41	58.19	2.00	0.00	0.20	0.00	47.57	61.05	2.00	0.00	0.19	0.00
47.74	64.16	2.00	0.00	0.19	0.00	47.90	66.86	2.00	0.00	0.19	0.00
48.06	73.10	2.00	0.00	0.19	0.00	48.23	77.76	2.00	0.00	0.18	0.00
48.39	80.72	2.00	0.00	0.18	0.00	48.56	78.24	2.00	0.00	0.18	0.00
48.72	74.42	2.00	0.00	0.17	0.00	48.88	68.90	2.00	0.00	0.17	0.00
49.05	63.15	2.00	0.00	0.17	0.00	49.21	57.14	2.00	0.00	0.17	0.00
49.38	52.74	2.00	0.00	0.16	0.00	49.54	51.53	2.00	0.00	0.16	0.00
49.70	56.86	2.00	0.00	0.16	0.00	49.87	66.86	2.00	0.00	0.15	0.00
50.03	74.65	2.00	0.00	0.15	0.00						

Total estimated settlement: 0.00

Abbreviations

$Q_{tn,cs}$:	Equivalent clean sand normalized cone resistance
FS:	Factor of safety against liquefaction
e_v (%):	Post-liquefaction volumentric strain
DF:	e_v depth weighting factor
Settlement:	Calculated settlement

LANDMARK
Geo-Engineers and Geologists

Landmark Consultants, Inc.
780 N. 4th Street
El Centro, CA 92243

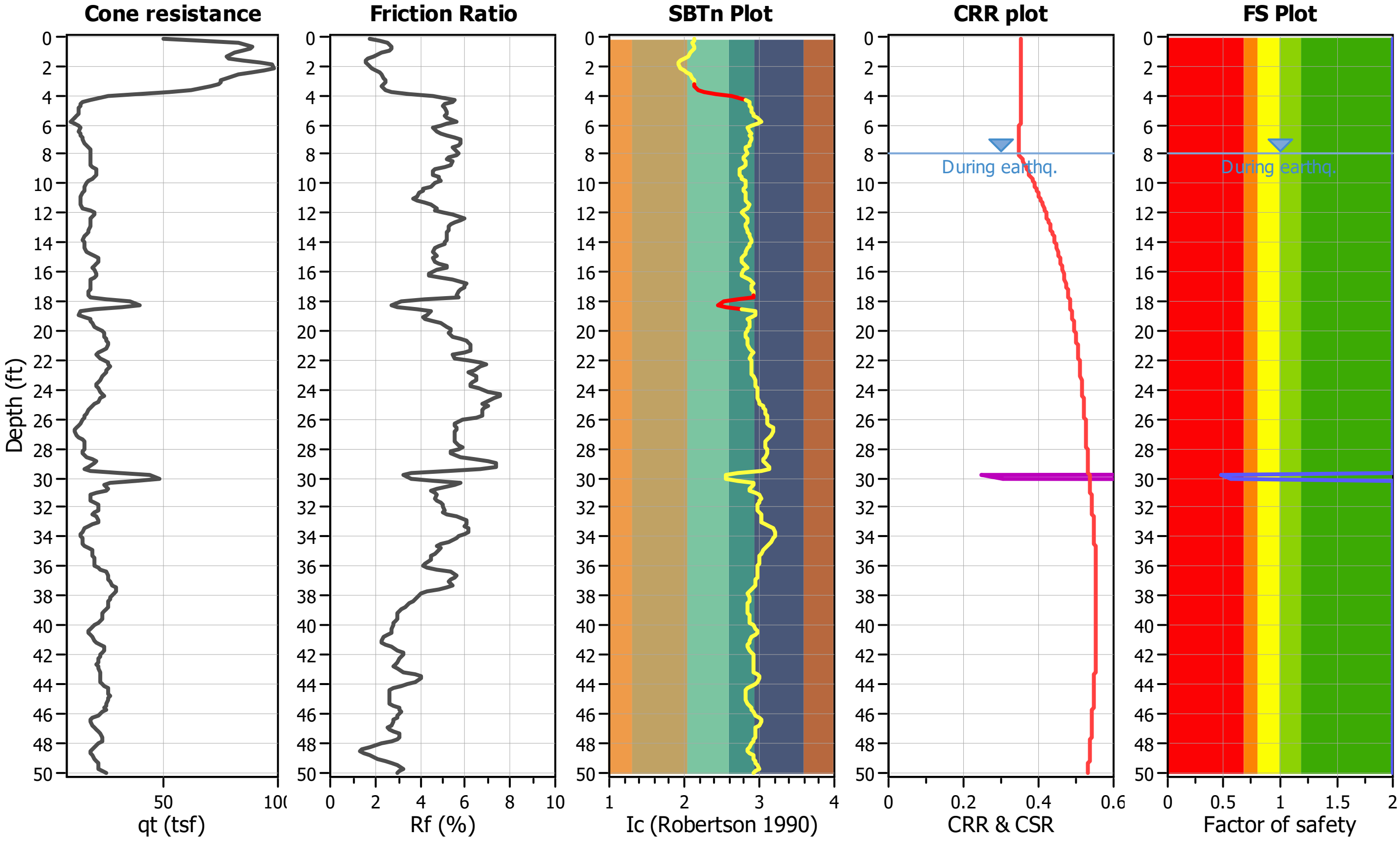
LIQUEFACTION ANALYSIS REPORT

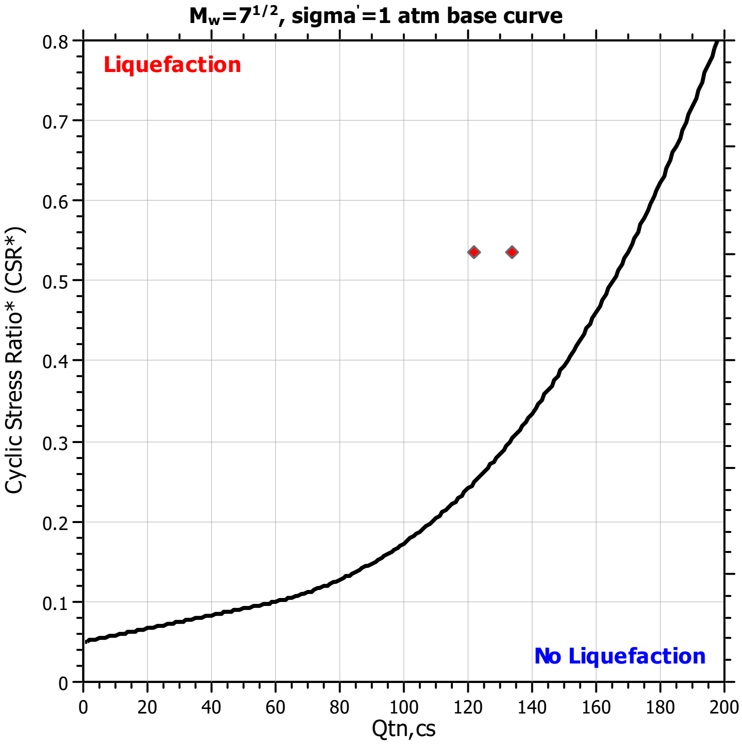
Project title : Heber 2 Repower Project **Location : Heber, CA**

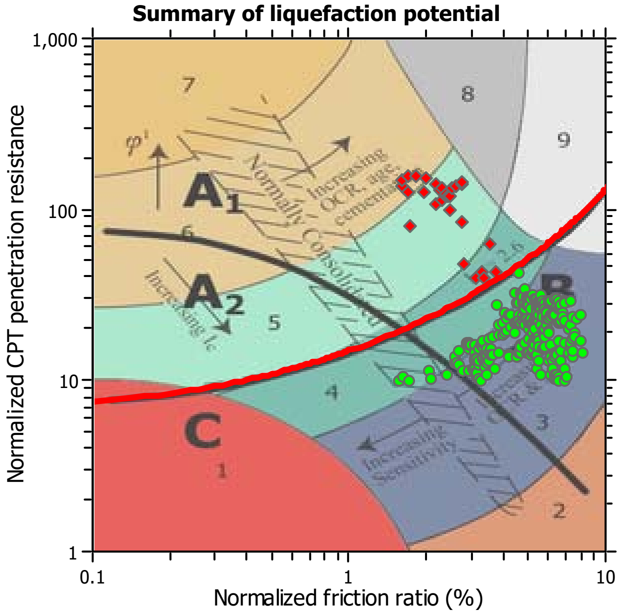
CPT file : CPT-4

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	8.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	8.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	7.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

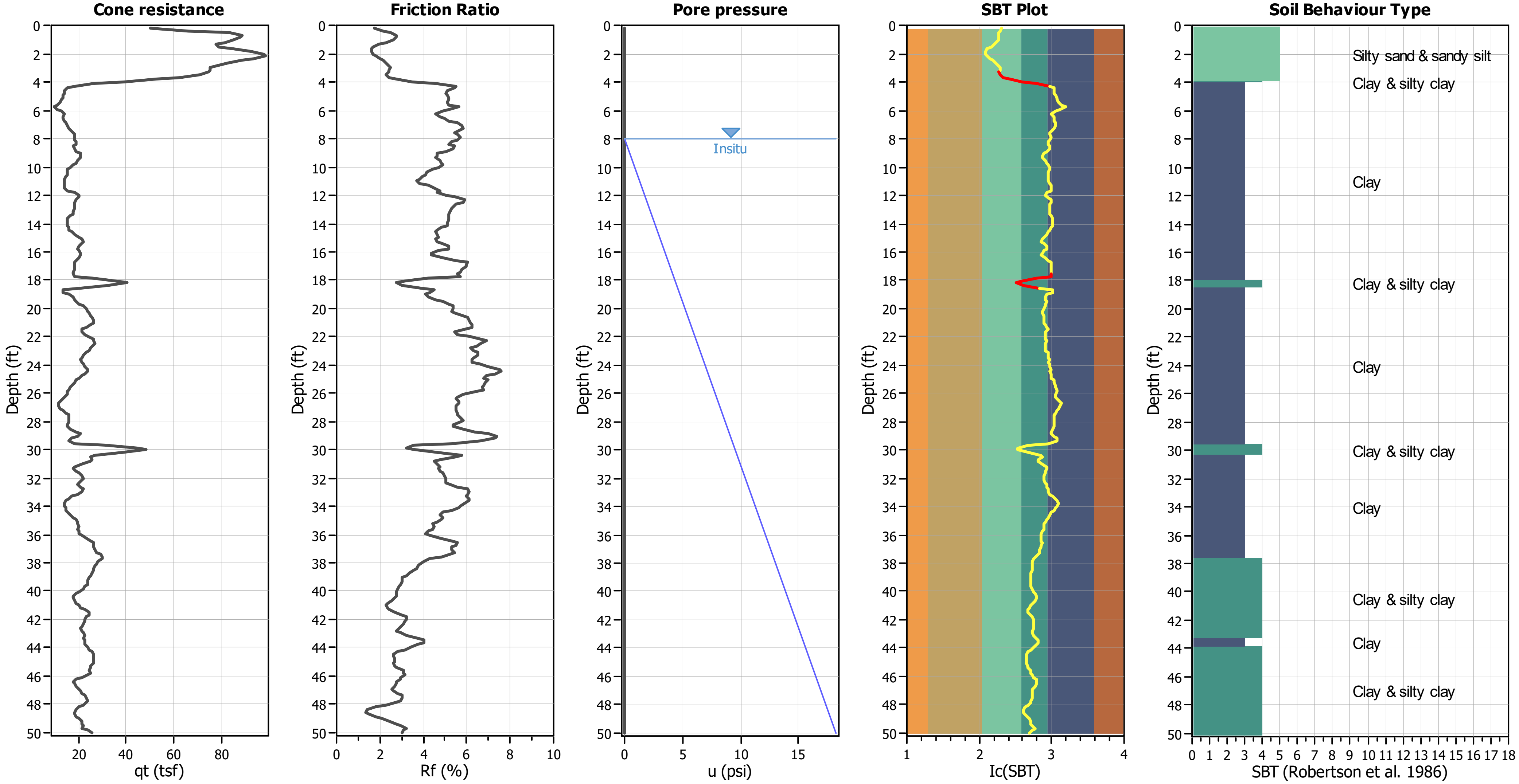






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



Input parameters and analysis data

Analysis method: NCEER (1998)
Fines correction method: NCEER (1998)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.00
Peak ground acceleration: 0.50
Depth to water table (insitu): 8.00 ft

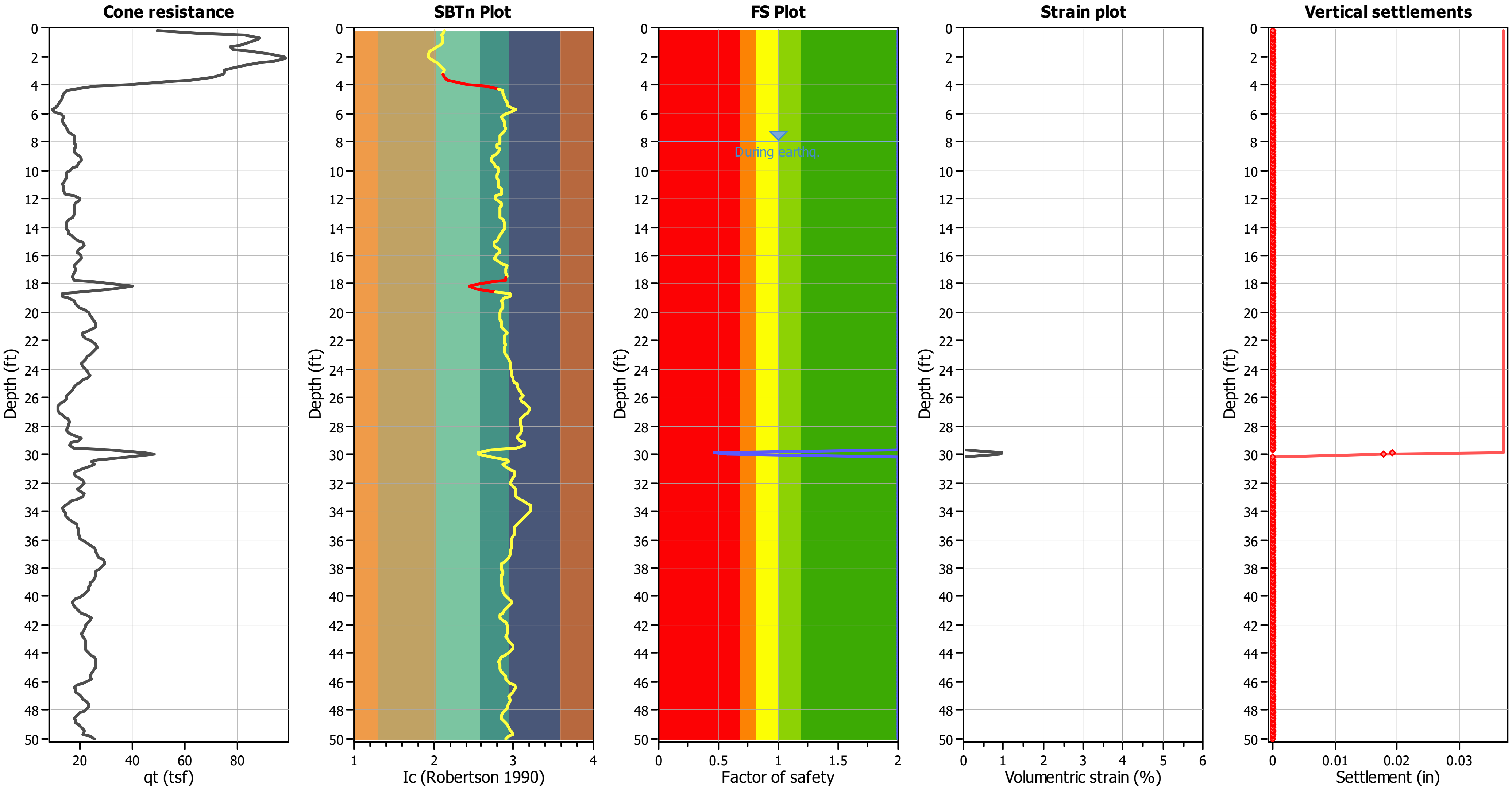
Depth to water table (erthq.): 8.00 ft
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: Yes
K_σ applied: Yes
Clay like behavior applied: Sands only
Limit depth applied: No
Limit depth: N/A

SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
8.04	142.33	2.00	0.00	0.86	0.00	8.20	139.48	2.00	0.00	0.86	0.00
8.37	138.37	2.00	0.00	0.86	0.00	8.53	139.38	2.00	0.00	0.86	0.00
8.69	139.25	2.00	0.00	0.85	0.00	8.86	137.40	2.00	0.00	0.85	0.00
9.02	135.29	2.00	0.00	0.85	0.00	9.19	135.08	2.00	0.00	0.84	0.00
9.35	134.94	2.00	0.00	0.84	0.00	9.51	135.74	2.00	0.00	0.84	0.00
9.68	134.20	2.00	0.00	0.84	0.00	9.84	130.53	2.00	0.00	0.83	0.00
10.01	123.17	2.00	0.00	0.83	0.00	10.17	117.24	2.00	0.00	0.83	0.00
10.33	113.17	2.00	0.00	0.82	0.00	10.50	112.17	2.00	0.00	0.82	0.00
10.66	108.77	2.00	0.00	0.82	0.00	10.83	104.41	2.00	0.00	0.82	0.00
10.99	101.82	2.00	0.00	0.81	0.00	11.15	104.52	2.00	0.00	0.81	0.00
11.32	109.26	2.00	0.00	0.81	0.00	11.48	112.95	2.00	0.00	0.81	0.00
11.65	119.67	2.00	0.00	0.80	0.00	11.81	128.35	2.00	0.00	0.80	0.00
11.98	140.47	2.00	0.00	0.80	0.00	12.14	147.20	2.00	0.00	0.79	0.00
12.30	148.82	2.00	0.00	0.79	0.00	12.47	144.70	2.00	0.00	0.79	0.00
12.63	140.44	2.00	0.00	0.79	0.00	12.80	138.49	2.00	0.00	0.78	0.00
12.96	137.16	2.00	0.00	0.78	0.00	13.12	135.57	2.00	0.00	0.78	0.00
13.29	132.50	2.00	0.00	0.77	0.00	13.45	129.05	2.00	0.00	0.77	0.00
13.62	125.64	2.00	0.00	0.77	0.00	13.78	124.00	2.00	0.00	0.77	0.00
13.94	123.55	2.00	0.00	0.76	0.00	14.11	123.41	2.00	0.00	0.76	0.00
14.27	120.42	2.00	0.00	0.76	0.00	14.44	118.59	2.00	0.00	0.76	0.00
14.60	119.72	2.00	0.00	0.75	0.00	14.76	124.75	2.00	0.00	0.75	0.00
14.93	129.68	2.00	0.00	0.75	0.00	15.09	132.02	2.00	0.00	0.74	0.00
15.26	133.55	2.00	0.00	0.74	0.00	15.42	134.74	2.00	0.00	0.74	0.00
15.58	134.99	2.00	0.00	0.74	0.00	15.75	133.14	2.00	0.00	0.73	0.00
15.91	128.53	2.00	0.00	0.73	0.00	16.08	125.13	2.00	0.00	0.73	0.00
16.24	124.40	2.00	0.00	0.72	0.00	16.40	129.52	2.00	0.00	0.72	0.00
16.57	133.92	2.00	0.00	0.72	0.00	16.73	138.54	2.00	0.00	0.72	0.00
16.90	138.35	2.00	0.00	0.71	0.00	17.06	138.11	2.00	0.00	0.71	0.00
17.22	135.17	2.00	0.00	0.71	0.00	17.39	131.59	2.00	0.00	0.71	0.00
17.55	129.88	2.00	0.00	0.70	0.00	17.72	132.65	2.00	0.00	0.70	0.00
17.88	129.80	2.00	0.00	0.70	0.00	18.04	125.42	2.00	0.00	0.69	0.00
18.21	120.72	2.00	0.00	0.69	0.00	18.37	117.18	2.00	0.00	0.69	0.00
18.54	111.78	2.00	0.00	0.69	0.00	18.70	102.14	2.00	0.00	0.68	0.00
18.86	99.81	2.00	0.00	0.68	0.00	19.03	103.57	2.00	0.00	0.68	0.00
19.19	110.46	2.00	0.00	0.67	0.00	19.36	115.60	2.00	0.00	0.67	0.00
19.52	121.21	2.00	0.00	0.67	0.00	19.69	128.63	2.00	0.00	0.67	0.00
19.85	135.46	2.00	0.00	0.66	0.00	20.01	137.97	2.00	0.00	0.66	0.00
20.18	138.68	2.00	0.00	0.66	0.00	20.34	141.42	2.00	0.00	0.66	0.00
20.51	148.20	2.00	0.00	0.65	0.00	20.67	152.28	2.00	0.00	0.65	0.00
20.83	154.70	2.00	0.00	0.65	0.00	21.00	155.14	2.00	0.00	0.64	0.00
21.16	153.33	2.00	0.00	0.64	0.00	21.33	146.51	2.00	0.00	0.64	0.00
21.49	137.48	2.00	0.00	0.64	0.00	21.65	130.46	2.00	0.00	0.63	0.00
21.82	135.64	2.00	0.00	0.63	0.00	21.98	146.28	2.00	0.00	0.63	0.00
22.15	157.92	2.00	0.00	0.62	0.00	22.31	162.22	2.00	0.00	0.62	0.00
22.47	158.98	2.00	0.00	0.62	0.00	22.64	153.08	2.00	0.00	0.62	0.00
22.80	147.97	2.00	0.00	0.61	0.00	22.97	147.24	2.00	0.00	0.61	0.00
23.13	146.00	2.00	0.00	0.61	0.00	23.29	142.46	2.00	0.00	0.61	0.00
23.46	137.35	2.00	0.00	0.60	0.00	23.62	134.72	2.00	0.00	0.60	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
23.79	135.51	2.00	0.00	0.60	0.00	23.95	140.30	2.00	0.00	0.59	0.00
24.11	148.28	2.00	0.00	0.59	0.00	24.28	155.88	2.00	0.00	0.59	0.00
24.44	157.27	2.00	0.00	0.59	0.00	24.61	150.21	2.00	0.00	0.58	0.00
24.77	141.21	2.00	0.00	0.58	0.00	24.93	135.75	2.00	0.00	0.58	0.00
25.10	133.99	2.00	0.00	0.57	0.00	25.26	129.44	2.00	0.00	0.57	0.00
25.43	124.86	2.00	0.00	0.57	0.00	25.59	121.99	2.00	0.00	0.57	0.00
25.75	119.46	2.00	0.00	0.56	0.00	25.92	114.39	2.00	0.00	0.56	0.00
26.08	108.01	2.00	0.00	0.56	0.00	26.25	102.56	2.00	0.00	0.56	0.00
26.41	98.09	2.00	0.00	0.55	0.00	26.57	94.88	2.00	0.00	0.55	0.00
26.74	93.00	2.00	0.00	0.55	0.00	26.90	92.55	2.00	0.00	0.54	0.00
27.07	94.48	2.00	0.00	0.54	0.00	27.23	98.16	2.00	0.00	0.54	0.00
27.40	102.11	2.00	0.00	0.54	0.00	27.56	105.58	2.00	0.00	0.53	0.00
27.72	108.32	2.00	0.00	0.53	0.00	27.89	108.90	2.00	0.00	0.53	0.00
28.05	105.70	2.00	0.00	0.52	0.00	28.22	101.01	2.00	0.00	0.52	0.00
28.38	101.21	2.00	0.00	0.52	0.00	28.54	109.35	2.00	0.00	0.52	0.00
28.71	122.45	2.00	0.00	0.51	0.00	28.87	132.20	2.00	0.00	0.51	0.00
29.04	132.26	2.00	0.00	0.51	0.00	29.20	122.61	2.00	0.00	0.51	0.00
29.36	113.45	2.00	0.00	0.50	0.00	29.53	108.45	2.00	0.00	0.50	0.00
29.69	112.51	2.00	0.00	0.50	0.00	29.86	122.10	0.47	0.98	0.49	0.02
30.02	134.00	0.57	0.90	0.49	0.02	30.18	139.79	2.00	0.00	0.49	0.00
30.35	134.38	2.00	0.00	0.49	0.00	30.51	125.58	2.00	0.00	0.48	0.00
30.68	118.58	2.00	0.00	0.48	0.00	30.84	113.67	2.00	0.00	0.48	0.00
31.00	107.11	2.00	0.00	0.47	0.00	31.17	101.29	2.00	0.00	0.47	0.00
31.33	99.19	2.00	0.00	0.47	0.00	31.50	101.98	2.00	0.00	0.47	0.00
31.66	105.65	2.00	0.00	0.46	0.00	31.82	110.41	2.00	0.00	0.46	0.00
31.99	112.05	2.00	0.00	0.46	0.00	32.15	110.51	2.00	0.00	0.46	0.00
32.32	106.64	2.00	0.00	0.45	0.00	32.48	106.90	2.00	0.00	0.45	0.00
32.64	113.40	2.00	0.00	0.45	0.00	32.81	120.33	2.00	0.00	0.44	0.00
32.97	120.02	2.00	0.00	0.44	0.00	33.14	113.57	2.00	0.00	0.44	0.00
33.30	105.91	2.00	0.00	0.44	0.00	33.46	102.21	2.00	0.00	0.43	0.00
33.63	98.16	2.00	0.00	0.43	0.00	33.79	94.29	2.00	0.00	0.43	0.00
33.96	92.81	2.00	0.00	0.42	0.00	34.12	94.31	2.00	0.00	0.42	0.00
34.28	92.55	2.00	0.00	0.42	0.00	34.45	90.14	2.00	0.00	0.42	0.00
34.61	91.88	2.00	0.00	0.41	0.00	34.78	97.81	2.00	0.00	0.41	0.00
34.94	99.81	2.00	0.00	0.41	0.00	35.10	98.30	2.00	0.00	0.41	0.00
35.27	96.86	2.00	0.00	0.40	0.00	35.43	97.74	2.00	0.00	0.40	0.00
35.60	97.15	2.00	0.00	0.40	0.00	35.76	95.38	2.00	0.00	0.39	0.00
35.93	94.33	2.00	0.00	0.39	0.00	36.09	98.44	2.00	0.00	0.39	0.00
36.25	106.57	2.00	0.00	0.39	0.00	36.42	116.11	2.00	0.00	0.38	0.00
36.58	121.17	2.00	0.00	0.38	0.00	36.75	121.27	2.00	0.00	0.38	0.00
36.91	118.99	2.00	0.00	0.37	0.00	37.07	118.97	2.00	0.00	0.37	0.00
37.24	121.97	2.00	0.00	0.37	0.00	37.40	122.80	2.00	0.00	0.37	0.00
37.57	119.74	2.00	0.00	0.36	0.00	37.73	112.21	2.00	0.00	0.36	0.00
37.89	105.81	2.00	0.00	0.36	0.00	38.06	101.75	2.00	0.00	0.35	0.00
38.22	99.67	2.00	0.00	0.35	0.00	38.39	97.89	2.00	0.00	0.35	0.00
38.55	95.90	2.00	0.00	0.35	0.00	38.71	93.10	2.00	0.00	0.34	0.00
38.88	89.59	2.00	0.00	0.34	0.00	39.04	86.60	2.00	0.00	0.34	0.00
39.21	85.25	2.00	0.00	0.34	0.00	39.37	84.76	2.00	0.00	0.33	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
39.53	83.85	2.00	0.00	0.33	0.00	39.70	81.80	2.00	0.00	0.33	0.00
39.86	79.22	2.00	0.00	0.32	0.00	40.03	76.47	2.00	0.00	0.32	0.00
40.19	73.46	2.00	0.00	0.32	0.00	40.35	71.67	2.00	0.00	0.32	0.00
40.52	70.72	2.00	0.00	0.31	0.00	40.68	69.95	2.00	0.00	0.31	0.00
40.85	69.28	2.00	0.00	0.31	0.00	41.01	69.53	2.00	0.00	0.30	0.00
41.17	71.27	2.00	0.00	0.30	0.00	41.34	74.52	2.00	0.00	0.30	0.00
41.50	80.79	2.00	0.00	0.30	0.00	41.67	83.97	2.00	0.00	0.29	0.00
41.83	85.73	2.00	0.00	0.29	0.00	41.99	83.77	2.00	0.00	0.29	0.00
42.16	83.35	2.00	0.00	0.29	0.00	42.32	81.51	2.00	0.00	0.28	0.00
42.49	78.90	2.00	0.00	0.28	0.00	42.65	77.04	2.00	0.00	0.28	0.00
42.81	76.77	2.00	0.00	0.27	0.00	42.98	78.97	2.00	0.00	0.27	0.00
43.14	83.16	2.00	0.00	0.27	0.00	43.31	88.56	2.00	0.00	0.27	0.00
43.47	91.55	2.00	0.00	0.26	0.00	43.64	91.06	2.00	0.00	0.26	0.00
43.80	88.91	2.00	0.00	0.26	0.00	43.96	86.77	2.00	0.00	0.25	0.00
44.13	84.65	2.00	0.00	0.25	0.00	44.29	82.07	2.00	0.00	0.25	0.00
44.46	80.48	2.00	0.00	0.25	0.00	44.62	80.38	2.00	0.00	0.24	0.00
44.78	80.96	2.00	0.00	0.24	0.00	44.95	80.56	2.00	0.00	0.24	0.00
45.11	79.49	2.00	0.00	0.24	0.00	45.28	79.02	2.00	0.00	0.23	0.00
45.44	79.84	2.00	0.00	0.23	0.00	45.60	82.76	2.00	0.00	0.23	0.00
45.77	83.63	2.00	0.00	0.22	0.00	45.93	82.78	2.00	0.00	0.22	0.00
46.10	77.11	2.00	0.00	0.22	0.00	46.26	72.76	2.00	0.00	0.22	0.00
46.42	69.37	2.00	0.00	0.21	0.00	46.59	69.74	2.00	0.00	0.21	0.00
46.75	69.62	2.00	0.00	0.21	0.00	46.92	69.91	2.00	0.00	0.20	0.00
47.08	72.01	2.00	0.00	0.20	0.00	47.24	75.02	2.00	0.00	0.20	0.00
47.41	78.40	2.00	0.00	0.20	0.00	47.57	79.97	2.00	0.00	0.19	0.00
47.74	79.74	2.00	0.00	0.19	0.00	47.90	76.12	2.00	0.00	0.19	0.00
48.06	69.32	2.00	0.00	0.19	0.00	48.23	60.53	2.00	0.00	0.18	0.00
48.39	53.50	2.00	0.00	0.18	0.00	48.56	51.55	2.00	0.00	0.18	0.00
48.72	53.74	2.00	0.00	0.17	0.00	48.88	58.38	2.00	0.00	0.17	0.00
49.05	63.34	2.00	0.00	0.17	0.00	49.21	68.92	2.00	0.00	0.17	0.00
49.38	72.80	2.00	0.00	0.16	0.00	49.54	76.03	2.00	0.00	0.16	0.00
49.70	77.80	2.00	0.00	0.16	0.00	49.87	79.94	2.00	0.00	0.15	0.00
50.03	81.33	2.00	0.00	0.15	0.00						

Total estimated settlement: 0.04

Abbreviations

$Q_{tn,cs}$:	Equivalent clean sand normalized cone resistance
FS:	Factor of safety against liquefaction
e_v (%):	Post-liquefaction volumentric strain
DF:	e_v depth weighting factor
Settlement:	Calculated settlement

LANDMARK
Geo-Engineers and Geologists

Landmark Consultants, Inc.
780 N. 4th Street
El Centro, CA 92243

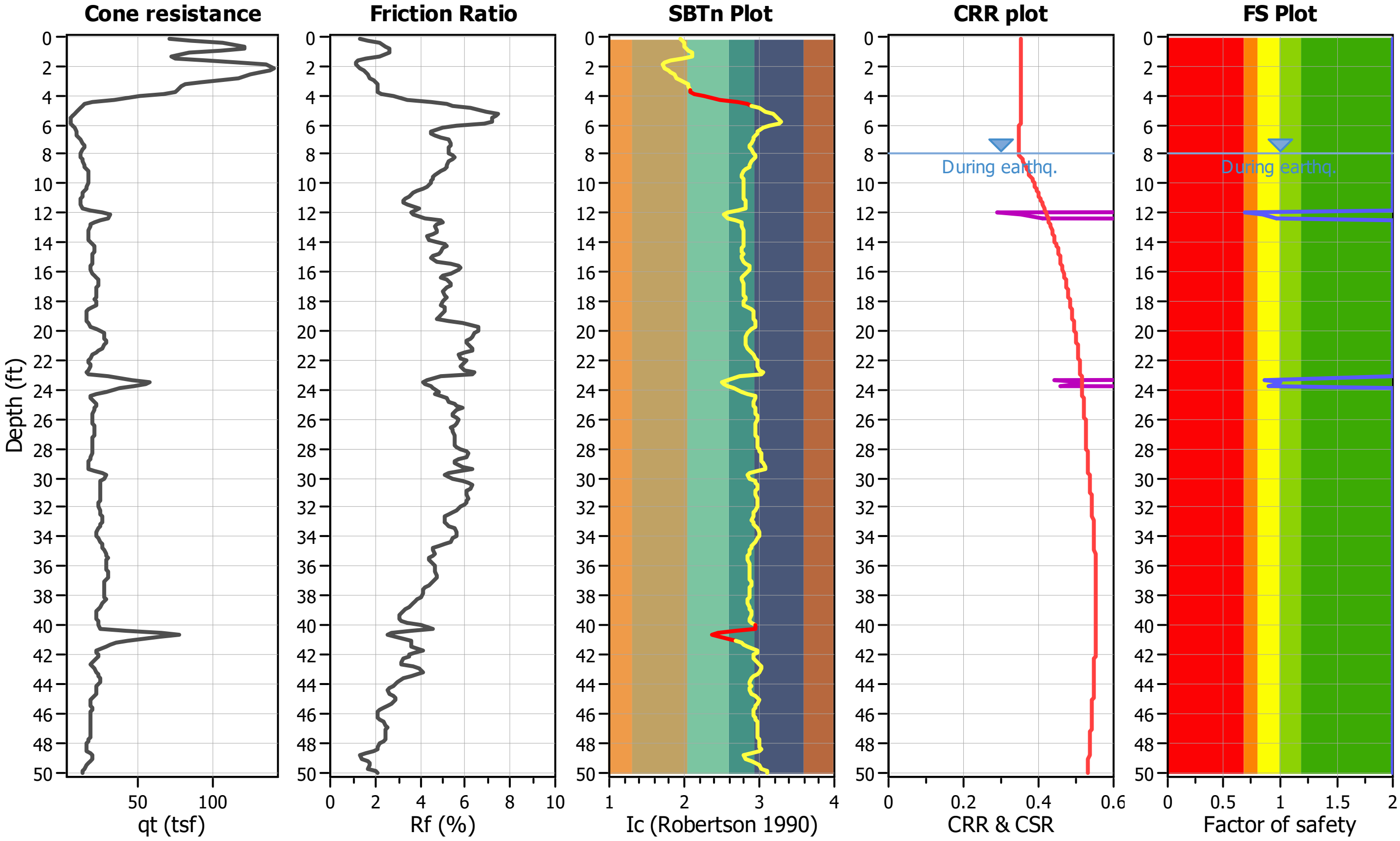
LIQUEFACTION ANALYSIS REPORT

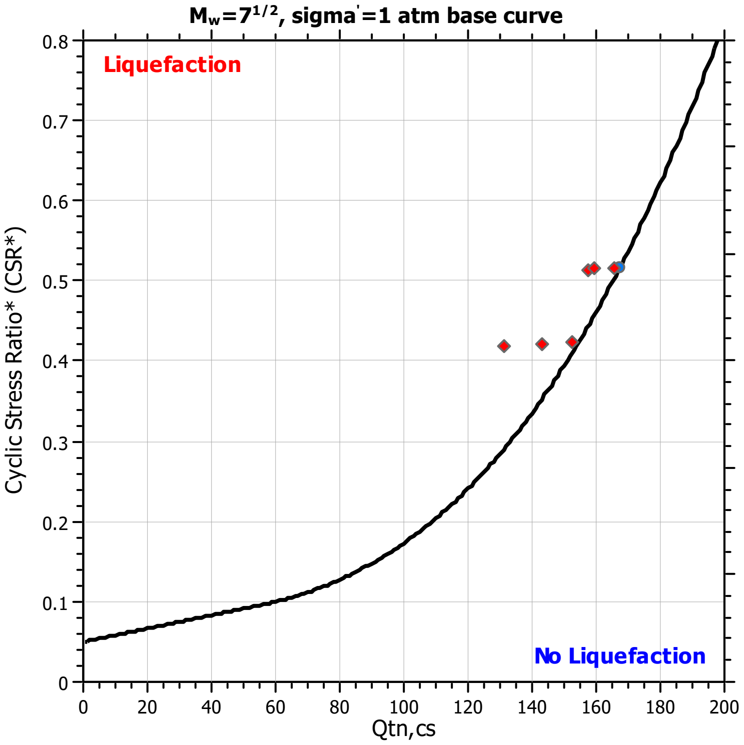
Project title : Heber 2 Repower Project **Location : Heber, CA**

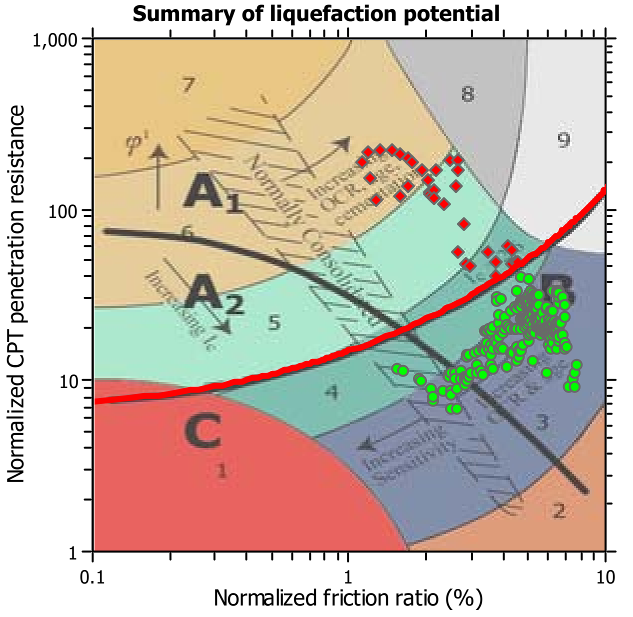
CPT file : CPT-5

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	8.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	8.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	7.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.50	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

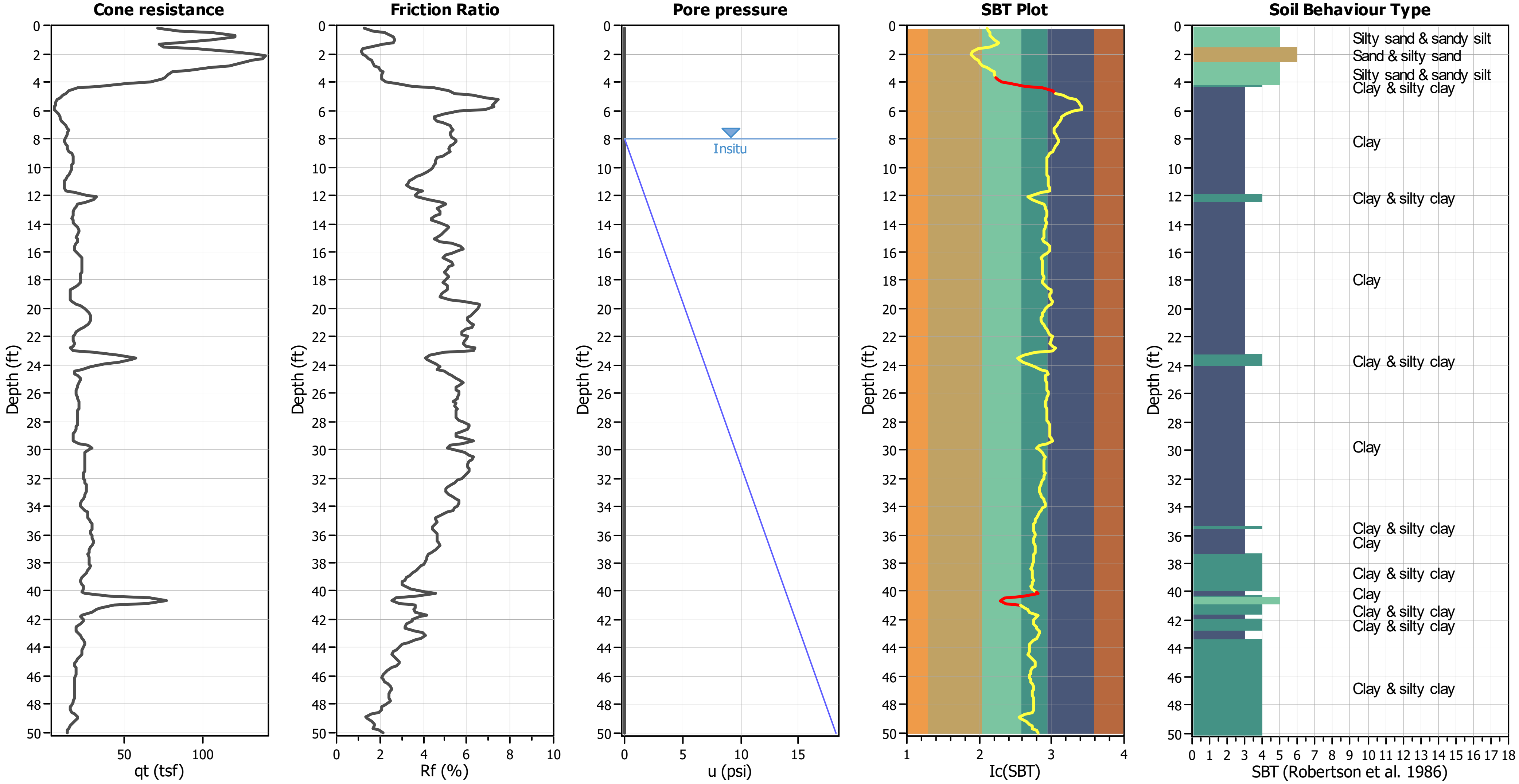






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



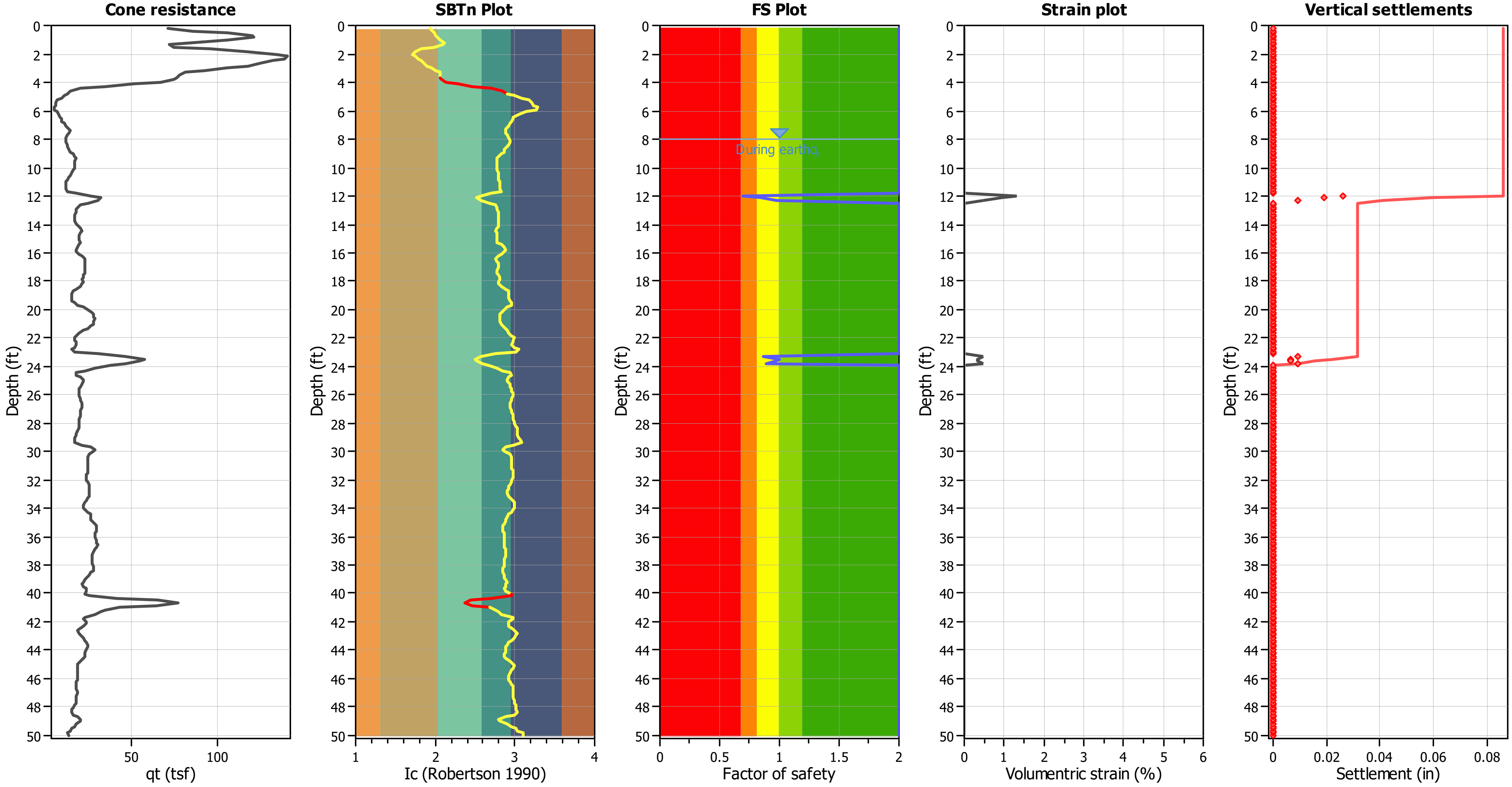
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	8.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.00	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.50	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	8.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥	1. Sensitive fine grained	🟩	4. Clayey silt to silty	🟧	7. Gravely sand to sand
🟫	2. Organic material	🟩	5. Silty sand to sandy silt	⬛	8. Very stiff sand to
🟦	3. Clay to silty clay	🟨	6. Clean sand to silty sand	⬜	9. Very stiff fine grained

Estimation of post-earthquake settlements



Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

:: Post-earthquake settlement due to soil liquefaction ::

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
8.04	119.22	2.00	0.00	0.86	0.00	8.20	120.85	2.00	0.00	0.86	0.00
8.37	121.77	2.00	0.00	0.86	0.00	8.53	121.74	2.00	0.00	0.86	0.00
8.69	123.66	2.00	0.00	0.85	0.00	8.86	127.30	2.00	0.00	0.85	0.00
9.02	130.40	2.00	0.00	0.85	0.00	9.19	130.61	2.00	0.00	0.84	0.00
9.35	129.25	2.00	0.00	0.84	0.00	9.51	127.22	2.00	0.00	0.84	0.00
9.68	125.93	2.00	0.00	0.84	0.00	9.84	124.71	2.00	0.00	0.83	0.00
10.01	123.50	2.00	0.00	0.83	0.00	10.17	120.59	2.00	0.00	0.83	0.00
10.33	115.49	2.00	0.00	0.82	0.00	10.50	108.81	2.00	0.00	0.82	0.00
10.66	102.72	2.00	0.00	0.82	0.00	10.83	97.88	2.00	0.00	0.82	0.00
10.99	94.40	2.00	0.00	0.81	0.00	11.15	93.33	2.00	0.00	0.81	0.00
11.32	92.09	2.00	0.00	0.81	0.00	11.48	95.09	2.00	0.00	0.81	0.00
11.65	105.48	2.00	0.00	0.80	0.00	11.81	117.60	2.00	0.00	0.80	0.00
11.98	131.26	0.69	1.33	0.80	0.03	12.14	143.05	0.84	0.96	0.79	0.02
12.30	152.70	0.97	0.47	0.79	0.01	12.47	152.80	2.00	0.00	0.79	0.00
12.63	143.18	2.00	0.00	0.79	0.00	12.80	134.31	2.00	0.00	0.78	0.00
12.96	130.65	2.00	0.00	0.78	0.00	13.12	129.65	2.00	0.00	0.78	0.00
13.29	127.91	2.00	0.00	0.77	0.00	13.45	124.35	2.00	0.00	0.77	0.00
13.62	120.29	2.00	0.00	0.77	0.00	13.78	120.60	2.00	0.00	0.77	0.00
13.94	128.55	2.00	0.00	0.76	0.00	14.11	137.42	2.00	0.00	0.76	0.00
14.27	142.24	2.00	0.00	0.76	0.00	14.44	141.06	2.00	0.00	0.76	0.00
14.60	138.35	2.00	0.00	0.75	0.00	14.76	133.75	2.00	0.00	0.75	0.00
14.93	129.06	2.00	0.00	0.75	0.00	15.09	127.77	2.00	0.00	0.74	0.00
15.26	132.22	2.00	0.00	0.74	0.00	15.42	138.42	2.00	0.00	0.74	0.00
15.58	140.75	2.00	0.00	0.74	0.00	15.75	139.78	2.00	0.00	0.73	0.00
15.91	138.74	2.00	0.00	0.73	0.00	16.08	138.05	2.00	0.00	0.73	0.00
16.24	137.36	2.00	0.00	0.72	0.00	16.40	138.60	2.00	0.00	0.72	0.00
16.57	143.48	2.00	0.00	0.72	0.00	16.73	146.06	2.00	0.00	0.72	0.00
16.90	145.22	2.00	0.00	0.71	0.00	17.06	141.94	2.00	0.00	0.71	0.00
17.22	139.81	2.00	0.00	0.71	0.00	17.39	137.72	2.00	0.00	0.71	0.00
17.55	137.02	2.00	0.00	0.70	0.00	17.72	137.39	2.00	0.00	0.70	0.00
17.88	136.19	2.00	0.00	0.70	0.00	18.04	135.45	2.00	0.00	0.69	0.00
18.21	132.44	2.00	0.00	0.69	0.00	18.37	130.93	2.00	0.00	0.69	0.00
18.54	124.17	2.00	0.00	0.69	0.00	18.70	118.78	2.00	0.00	0.68	0.00
18.86	113.72	2.00	0.00	0.68	0.00	19.03	112.47	2.00	0.00	0.68	0.00
19.19	112.04	2.00	0.00	0.67	0.00	19.36	117.35	2.00	0.00	0.67	0.00
19.52	128.21	2.00	0.00	0.67	0.00	19.69	143.57	2.00	0.00	0.67	0.00
19.85	153.43	2.00	0.00	0.66	0.00	20.01	160.71	2.00	0.00	0.66	0.00
20.18	163.07	2.00	0.00	0.66	0.00	20.34	164.44	2.00	0.00	0.66	0.00
20.51	162.92	2.00	0.00	0.65	0.00	20.67	161.17	2.00	0.00	0.65	0.00
20.83	160.88	2.00	0.00	0.65	0.00	21.00	160.69	2.00	0.00	0.64	0.00
21.16	158.54	2.00	0.00	0.64	0.00	21.33	151.78	2.00	0.00	0.64	0.00
21.49	140.81	2.00	0.00	0.64	0.00	21.65	130.93	2.00	0.00	0.63	0.00
21.82	126.27	2.00	0.00	0.63	0.00	21.98	126.66	2.00	0.00	0.63	0.00
22.15	126.16	2.00	0.00	0.62	0.00	22.31	126.33	2.00	0.00	0.62	0.00
22.47	126.09	2.00	0.00	0.62	0.00	22.64	123.91	2.00	0.00	0.62	0.00
22.80	121.99	2.00	0.00	0.61	0.00	22.97	126.99	2.00	0.00	0.61	0.00
23.13	143.39	2.00	0.00	0.61	0.00	23.29	157.57	0.86	0.48	0.61	0.01
23.46	167.32	1.00	0.33	0.60	0.01	23.62	165.76	0.98	0.33	0.60	0.01

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
23.79	159.66	0.89	0.47	0.60	0.01	23.95	148.21	2.00	0.00	0.59	0.00
24.11	135.94	2.00	0.00	0.59	0.00	24.28	120.89	2.00	0.00	0.59	0.00
24.44	113.50	2.00	0.00	0.59	0.00	24.61	115.23	2.00	0.00	0.58	0.00
24.77	123.04	2.00	0.00	0.58	0.00	24.93	128.87	2.00	0.00	0.58	0.00
25.10	131.54	2.00	0.00	0.57	0.00	25.26	130.14	2.00	0.00	0.57	0.00
25.43	125.79	2.00	0.00	0.57	0.00	25.59	121.98	2.00	0.00	0.57	0.00
25.75	120.15	2.00	0.00	0.56	0.00	25.92	121.20	2.00	0.00	0.56	0.00
26.08	122.21	2.00	0.00	0.56	0.00	26.25	122.93	2.00	0.00	0.56	0.00
26.41	122.83	2.00	0.00	0.55	0.00	26.57	122.65	2.00	0.00	0.55	0.00
26.74	123.77	2.00	0.00	0.55	0.00	26.90	123.52	2.00	0.00	0.54	0.00
27.07	122.85	2.00	0.00	0.54	0.00	27.23	120.78	2.00	0.00	0.54	0.00
27.40	120.44	2.00	0.00	0.54	0.00	27.56	120.16	2.00	0.00	0.53	0.00
27.72	118.94	2.00	0.00	0.53	0.00	27.89	119.67	2.00	0.00	0.53	0.00
28.05	121.33	2.00	0.00	0.52	0.00	28.22	123.92	2.00	0.00	0.52	0.00
28.38	122.71	2.00	0.00	0.52	0.00	28.54	119.82	2.00	0.00	0.52	0.00
28.71	115.02	2.00	0.00	0.51	0.00	28.87	111.29	2.00	0.00	0.51	0.00
29.04	109.61	2.00	0.00	0.51	0.00	29.20	112.15	2.00	0.00	0.51	0.00
29.36	116.02	2.00	0.00	0.50	0.00	29.53	122.43	2.00	0.00	0.50	0.00
29.69	128.66	2.00	0.00	0.50	0.00	29.86	132.51	2.00	0.00	0.49	0.00
30.02	133.32	2.00	0.00	0.49	0.00	30.18	133.01	2.00	0.00	0.49	0.00
30.35	134.24	2.00	0.00	0.49	0.00	30.51	135.73	2.00	0.00	0.48	0.00
30.68	134.98	2.00	0.00	0.48	0.00	30.84	133.52	2.00	0.00	0.48	0.00
31.00	132.42	2.00	0.00	0.47	0.00	31.17	131.76	2.00	0.00	0.47	0.00
31.33	131.41	2.00	0.00	0.47	0.00	31.50	130.79	2.00	0.00	0.47	0.00
31.66	129.46	2.00	0.00	0.46	0.00	31.82	127.40	2.00	0.00	0.46	0.00
31.99	125.47	2.00	0.00	0.46	0.00	32.15	124.76	2.00	0.00	0.46	0.00
32.32	123.94	2.00	0.00	0.45	0.00	32.48	122.71	2.00	0.00	0.45	0.00
32.64	121.40	2.00	0.00	0.45	0.00	32.81	120.70	2.00	0.00	0.44	0.00
32.97	120.37	2.00	0.00	0.44	0.00	33.14	120.33	2.00	0.00	0.44	0.00
33.30	119.72	2.00	0.00	0.44	0.00	33.46	119.43	2.00	0.00	0.43	0.00
33.63	118.76	2.00	0.00	0.43	0.00	33.79	117.66	2.00	0.00	0.43	0.00
33.96	117.16	2.00	0.00	0.42	0.00	34.12	117.75	2.00	0.00	0.42	0.00
34.28	120.54	2.00	0.00	0.42	0.00	34.45	119.94	2.00	0.00	0.42	0.00
34.61	117.36	2.00	0.00	0.41	0.00	34.78	114.03	2.00	0.00	0.41	0.00
34.94	115.06	2.00	0.00	0.41	0.00	35.10	117.56	2.00	0.00	0.41	0.00
35.27	118.09	2.00	0.00	0.40	0.00	35.43	116.84	2.00	0.00	0.40	0.00
35.60	115.80	2.00	0.00	0.40	0.00	35.76	116.35	2.00	0.00	0.39	0.00
35.93	117.12	2.00	0.00	0.39	0.00	36.09	117.39	2.00	0.00	0.39	0.00
36.25	117.58	2.00	0.00	0.39	0.00	36.42	118.84	2.00	0.00	0.38	0.00
36.58	119.93	2.00	0.00	0.38	0.00	36.75	119.47	2.00	0.00	0.38	0.00
36.91	116.76	2.00	0.00	0.37	0.00	37.07	113.06	2.00	0.00	0.37	0.00
37.24	109.88	2.00	0.00	0.37	0.00	37.40	107.43	2.00	0.00	0.37	0.00
37.57	106.75	2.00	0.00	0.36	0.00	37.73	106.32	2.00	0.00	0.36	0.00
37.89	106.17	2.00	0.00	0.36	0.00	38.06	105.28	2.00	0.00	0.35	0.00
38.22	104.58	2.00	0.00	0.35	0.00	38.39	102.50	2.00	0.00	0.35	0.00
38.55	98.98	2.00	0.00	0.35	0.00	38.71	94.70	2.00	0.00	0.34	0.00
38.88	90.90	2.00	0.00	0.34	0.00	39.04	87.39	2.00	0.00	0.34	0.00
39.21	84.59	2.00	0.00	0.34	0.00	39.37	82.78	2.00	0.00	0.33	0.00

:: Post-earthquake settlement due to soil liquefaction :: (continued)

Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)	Depth (ft)	$Q_{tn,cs}$	FS	e_v (%)	DF	Settlement (in)
39.53	84.00	2.00	0.00	0.33	0.00	39.70	87.03	2.00	0.00	0.33	0.00
39.86	90.97	2.00	0.00	0.32	0.00	40.03	96.73	2.00	0.00	0.32	0.00
40.19	105.29	2.00	0.00	0.32	0.00	40.35	115.76	2.00	0.00	0.32	0.00
40.52	121.29	2.00	0.00	0.31	0.00	40.68	125.41	2.00	0.00	0.31	0.00
40.85	123.12	2.00	0.00	0.31	0.00	41.01	117.19	2.00	0.00	0.30	0.00
41.17	107.63	2.00	0.00	0.30	0.00	41.34	102.80	2.00	0.00	0.30	0.00
41.50	99.33	2.00	0.00	0.30	0.00	41.67	95.42	2.00	0.00	0.29	0.00
41.83	90.50	2.00	0.00	0.29	0.00	41.99	89.98	2.00	0.00	0.29	0.00
42.16	88.92	2.00	0.00	0.29	0.00	42.32	83.52	2.00	0.00	0.28	0.00
42.49	78.18	2.00	0.00	0.28	0.00	42.65	77.51	2.00	0.00	0.28	0.00
42.81	82.85	2.00	0.00	0.27	0.00	42.98	88.58	2.00	0.00	0.27	0.00
43.14	92.04	2.00	0.00	0.27	0.00	43.31	92.24	2.00	0.00	0.27	0.00
43.47	90.25	2.00	0.00	0.26	0.00	43.64	86.84	2.00	0.00	0.26	0.00
43.80	83.41	2.00	0.00	0.26	0.00	43.96	80.95	2.00	0.00	0.25	0.00
44.13	78.49	2.00	0.00	0.25	0.00	44.29	76.67	2.00	0.00	0.25	0.00
44.46	75.23	2.00	0.00	0.25	0.00	44.62	74.90	2.00	0.00	0.24	0.00
44.78	74.57	2.00	0.00	0.24	0.00	44.95	73.31	2.00	0.00	0.24	0.00
45.11	72.32	2.00	0.00	0.24	0.00	45.28	70.79	2.00	0.00	0.23	0.00
45.44	69.68	2.00	0.00	0.23	0.00	45.60	67.68	2.00	0.00	0.23	0.00
45.77	65.78	2.00	0.00	0.22	0.00	45.93	64.39	2.00	0.00	0.22	0.00
46.10	63.45	2.00	0.00	0.22	0.00	46.26	63.10	2.00	0.00	0.22	0.00
46.42	63.80	2.00	0.00	0.21	0.00	46.59	65.52	2.00	0.00	0.21	0.00
46.75	67.21	2.00	0.00	0.21	0.00	46.92	67.86	2.00	0.00	0.20	0.00
47.08	67.38	2.00	0.00	0.20	0.00	47.24	66.55	2.00	0.00	0.20	0.00
47.41	66.19	2.00	0.00	0.20	0.00	47.57	66.07	2.00	0.00	0.19	0.00
47.74	65.63	2.00	0.00	0.19	0.00	47.90	63.67	2.00	0.00	0.19	0.00
48.06	60.77	2.00	0.00	0.19	0.00	48.23	58.45	2.00	0.00	0.18	0.00
48.39	57.99	2.00	0.00	0.18	0.00	48.56	57.54	2.00	0.00	0.18	0.00
48.72	56.34	2.00	0.00	0.17	0.00	48.88	54.30	2.00	0.00	0.17	0.00
49.05	55.00	2.00	0.00	0.17	0.00	49.21	55.85	2.00	0.00	0.17	0.00
49.38	55.75	2.00	0.00	0.16	0.00	49.54	53.84	2.00	0.00	0.16	0.00
49.70	52.12	2.00	0.00	0.16	0.00	49.87	53.14	2.00	0.00	0.15	0.00
50.03	54.80	2.00	0.00	0.15	0.00						

Total estimated settlement: 0.09

Abbreviations

$Q_{tn,cs}$:	Equivalent clean sand normalized cone resistance
FS:	Factor of safety against liquefaction
e_v (%):	Post-liquefaction volumentric strain
DF:	e_v depth weighting factor
Settlement:	Calculated settlement

APPENDIX D

Geotechnical Report

New Turbine Generator and Cooling Tower
Heber 2 Geothermal Plant
Heber, CA

Prepared for:

ORMAT
947 Dogwood Road
Heber, CA 92249

Prepared by:

Landmark Consultants, Inc.
780 N. 4th Street
El Centro, CA 92243
(760) 370-3000

January 2005

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

780 N. 4th Street
El Centro, CA 92243
(760) 370-3000
(760) 337-8900 fax

77-948 Wildcat Drive
Palm Desert, CA 92211
(760) 360-0665
(760) 360-0521 fax

January 10, 2005

Mr. Mike Collins
ORMAT
947 Dogwood Road
Heber, CA 92249

Geotechnical Investigation
New Turbine Generator and Cooling Tower
Heber 2 Geothermal Plant
Dogwood Road
Heber, California
LCI Report No. LE04354 (2)

Dear Mr. Collins:

This geotechnical report is provided for design and construction of the new turbine generator and cooling tower additions to the Ormat Heber 2 geothermal power plant located on Dogwood Road southwest of Heber, California. Our geotechnical investigation was conducted in response to your request for our services. The enclosed report describes our soil engineering investigation and presents our professional opinions regarding geotechnical conditions at the site to be considered in the design and construction of the project.

This executive summary presents ***selected*** elements of our findings and recommendations only. It ***does not*** present crucial details needed for the proper application of our findings and recommendations. Our findings, recommendations, and application options are related ***only through reading the full report***, and are best evaluated with the active participation of the engineer of record who developed them.

The findings of this study indicate that the site is predominantly underlain by clays of moderate expansion.

The soil are highly corrosive to metals and contain sufficient sulfates and chlorides to require special concrete mixes (4,500 psi with a 0.45 maximum water cement ratio) and protection of embedded steel building components when concrete is placed in contact with native soil. If the native soils are replaced with imported granular soils with low sulfate and chloride content, no special concrete mixes are required.

Evaluation of liquefaction potential at the site indicates that it is unlikely that the subsurface soil will liquefy under seismically induced groundshaking due to the nature of the soil (clays soils predominate). No mitigation is required for liquefaction effects at this site.

Foundation settlements are indicated on figures 2 thru 5. Differential settlement is estimated to be about of two-thirds of total settlement.

We did not encounter soil conditions that would preclude development of the site for its intended use provided the recommendations contained in this report are implemented in the design and construction of this project.

We appreciate the opportunity to provide our findings and professional opinions regarding geotechnical conditions at the site. If you have any questions or comments regarding our findings, please call our office at (760) 370-3000.

Respectfully Submitted,
Landmark Consultants, Inc.

Steven K. Williams, CEG
Senior Engineering Geologist

REGISTERED GEOLOGIST
STEVEN K. WILLIAMS
CERTIFIED ENGINEERING GEOLOGIST
CEG 2261
STATE OF CALIFORNIA

Julian R. Avalos
Staff Engineer

Jeffrey O. Lyon, PE
President

REGISTERED PROFESSIONAL ENGINEER
JEFFREY O. LYON
No. 31921
EXPIRES 12-31-~~04~~ 06
CIVIL
STATE OF CALIFORNIA

Distribution:
Client (4)

TABLE OF CONTENTS

Section 1
INTRODUCTION

1.1 Project Description

This report presents the findings of our geotechnical investigation for the proposed additions to the Ormat Heber 2 geothermal power plant located on Dogwood Road southwest of Heber, California (See Vicinity Map, Plate A-1). The proposed development will consist of the addition of one (1) turbine/generator set and one (1) cooling tower. A site plan for the proposed power plant improvements was not made available to us at the time that this report was prepared.

Small structures may be are planned for electrical control panels, consisting of masonry or panelized concrete construction. Expected footing loads are estimated at 1 to 2 kips per lineal foot for the small structures. Expected plant components, cooling tower and turbine/generator columns loads range from 5 to 400 kips. If structural loads exceed those stated above, we should be notified so we may evaluate their impact on foundation settlement and bearing capacity. Site development will include foundation support pad preparation and underground utility installation.

1.2 Purpose and Scope of Work

The purpose of this geotechnical study was to investigate the upper 50 feet of subsurface soil at selected locations within the site for physical/engineering properties. From the subsequent field and laboratory data, professional opinions were developed and are provided in this report regarding geotechnical conditions at this site and the effect on design and construction. The scope of our services consisted of the following:

- Field exploration and in-situ testing of the site soils at selected locations and depths.
- Laboratory testing for physical properties of selected samples.
- A review of the available literature and publications pertaining to local geology, faulting, and seismicity.
- Engineering analysis and evaluation of the data collected.
- Preparation of this report presenting our findings, professional opinions, and recommendations for the geotechnical aspects of project design and construction.

This report addresses the following geotechnical issues:

- Subsurface soil and groundwater conditions
- Site geology, regional faulting and seismicity, near source factors, and site seismic accelerations
- Liquefaction potential and its mitigation
- Expansive soil and methods of mitigation
- Aggressive soil conditions to metals and concrete

Professional opinions with regard to the above issues are presented for the following:

- Site grading and earthwork
- Foundation subgrade preparation
- Allowable soil bearing pressures and expected settlements
- Concrete slabs-on-grade
- Mitigation of the potential effects of salt concentrations in native soil to concrete mixes and steel reinforcement
- Seismic design parameters

Our scope of work for this report did not include an evaluation of the site for the presence of environmentally hazardous materials or conditions.

1.3 Authorization

Mr. Mike Collins, Project Manager of Ormat for Power Generation Construction provided authorization by written agreement to proceed with our work on December 14, 2004. We conducted our work according to our written proposal dated December 13, 2004.

Section 2
METHODS OF INVESTIGATION

2.1 Field Exploration

Subsurface exploration was performed on December 20, 2004 using Holguin, Fahan, & Associates, Inc. of Cypress, California to advance three (3) electric cone penetrometer (CPT) soundings to an approximate depth of 50 feet below existing ground surface. The soundings were made at the locations shown on the Site and Exploration Plan (Plate A-2). The approximate sounding locations were established in the field and plotted on the site map by sighting to discernable site features.

CPT soundings provide a continuous profile of the soil stratigraphy with readings every 2.5cm (1 inch) in depth. Direct sampling for visual and physical confirmation of soil properties has been used by our firm to establish direct correlations with CPT exploration in this geographical region.

The CPT exploration was conducted by hydraulically advancing an instrumented Hogentogler 10cm^2 conical probe into the ground at a rate of 2cm per second using a 23-ton truck as a reaction mass. An electronic data acquisition system recorded a nearly continuous log of the resistance of the soil against the cone tip (Qc) and soil friction against the cone sleeve (Fs) as the probe was advanced. Empirical relationships (Robertson and Campanella, 1989) were then applied to the data to give a continuous profile of the soil stratigraphy. Interpretation of CPT data provides correlations for SPT blow count, phi (ϕ) angle (soil friction angle), undrained shear strength (S_u) of clays and over-consolidation ratio (OCR). These correlations may then be used to evaluate vertical and lateral soil bearing capacities and consolidation characteristics of the subsurface soil.

Interpretive logs of the CPT soundings were produced and presented in final form after review of field and laboratory data and are presented on Plates B-1 through B-3 in Appendix B. A key to the interpretation of CPT soundings is presented on Plate B-4. The stratification lines shown on the subsurface logs represent the approximate boundaries between the various strata. However, the transition from one stratum to another may be gradual over some range of depth.

2.2 Laboratory Testing

Laboratory tests were conducted on selected bulk soil samples obtained from hand auger borings made adjacent to the CPT locations to aid in classification and evaluation of selected engineering properties of the near surface soils. The tests were conducted in general conformance to the procedures of the American Society for Testing and Materials (ASTM) or other standardized methods as referenced below. The laboratory testing program consisted of the following tests:

- Plasticity Index (ASTM D4318) – used for soil classification and expansive soil design criteria.
- Chemical Analyses (soluble sulfates & chlorides, pH, and resistivity) (Caltrans Methods) – used for concrete mix evaluations and corrosion protection requirements.

The laboratory test results are presented on the subsurface logs (Appendix B) and on Plates C-1, C-2 and C-3 in Appendix C.

Engineering parameters of soil strength, compressibility and relative density utilized for developing design criteria provided within this report were either extrapolated from correlations with the subsurface CPT data or from data obtained from the field and laboratory testing program.

Section 3
DISCUSSION

3.1 Site Conditions

The plant additions are located in the northwest corner of the Heber 2 geothermal plant on the west side of the existing turbine generators and cooling tower. The area is relatively vacant and approximately has the same elevation as the existing plant facilities. An overhead pipe rack is located to the south side of the proposed location.

Adjacent properties outside of the fenced operations yard consist of agricultural land to the north and west. The site is bounded on the east by Dogwood Road and headquarters facilities of a general engineering construction company lie to the south side. Dogwood Road is slated to be a 6-lane north-south arterial from Calexico to Brawley in Imperial County. Adjacent properties are flat-lying and are approximately at the same elevation with this site.

The project site lies at an elevation of approximately 15 feet below mean sea level (MSL) (El. 985 local datum) in the Imperial Valley region of the California low desert. The surrounding properties lie on terrain which is flat (planar), part of a large agricultural valley, which was previously an ancient lake bed covered with fresh water to an elevation of 43± feet above MSL. Annual rainfall in this arid region is less than 4 inches per year with four months of average summertime temperatures above 100 °F. Winter temperatures are mild, seldom reaching freezing.

3.2 Geologic Setting

The project site is located in the Imperial Valley portion of the Salton Trough physiographic province. The Salton Trough is a geologic structural depression resulting from large scale regional faulting. The trough is bounded on the northeast by the San Andreas Fault and Chocolate Mountains and the southwest by the Peninsular Range and faults of the San Jacinto Fault Zone. The Salton Trough represents the northward extension of the Gulf of California, containing both marine and non-marine sediments since the Miocene Epoch. Tectonic activity that formed the trough continues at a high rate as evidenced by deformed young sedimentary deposits and high levels of seismicity. Figure 1 shows the location of the site in relation to regional faults and physiographic features.

The Imperial Valley is directly underlain by lacustrine deposits, which consist of interbedded lenticular and tabular silt, sand, and clay. The Late Pleistocene to Holocene lake deposits are probably less than 100 feet thick and derived from periodic flooding of the Colorado River which intermittently formed a fresh water lake (Lake Cahuilla). Older deposits consist of Miocene to Pleistocene non-marine and marine sediments deposited during intrusions of the Gulf of California. Basement rock consisting of Mesozoic granite and Paleozoic metamorphic rocks are estimated to exist at depths between 15,000 - 20,000 feet.

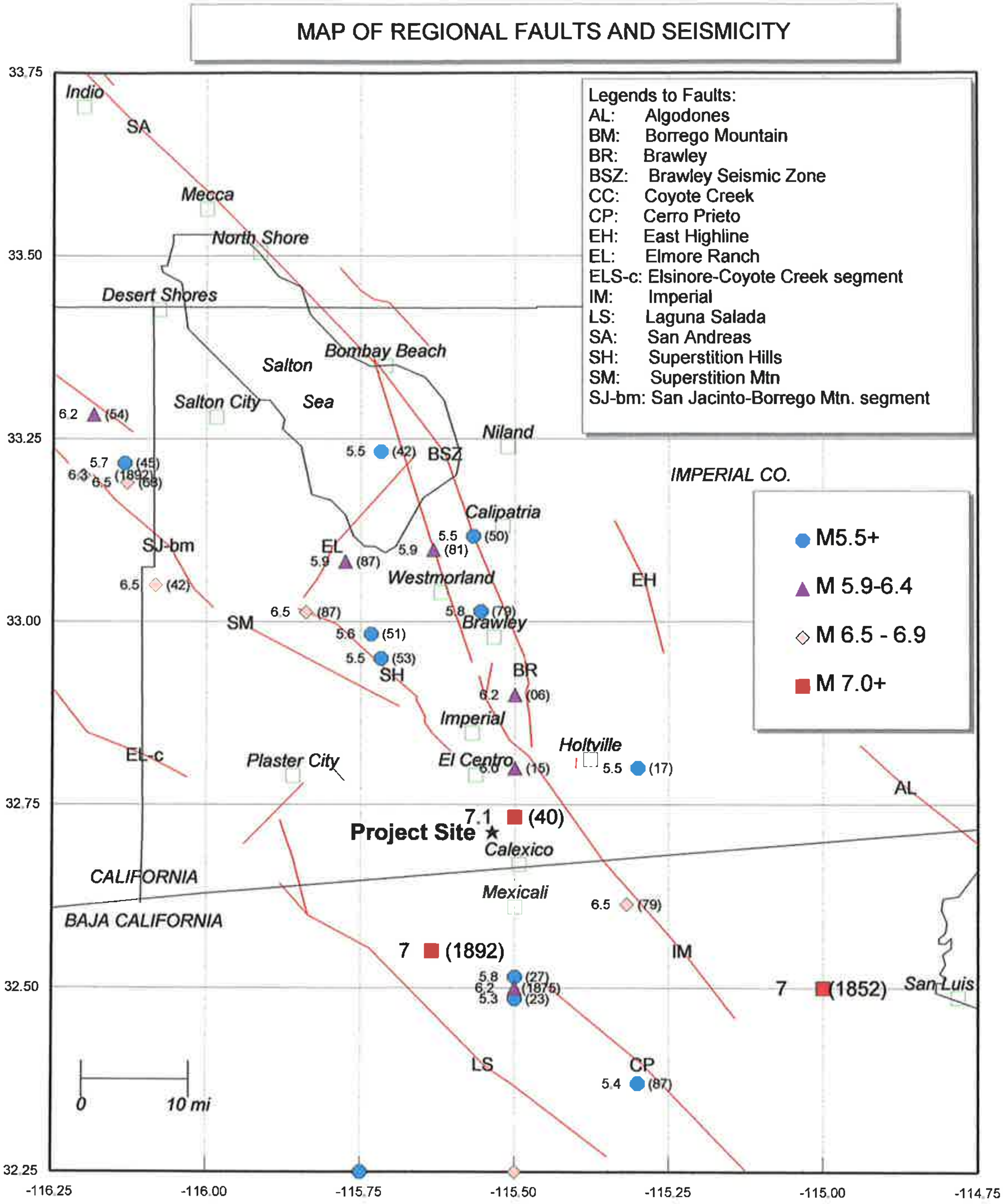
3.3 Seismicity and Faulting

Faulting and Seismic Sources: We have performed a computer-aided search of known faults or seismic zones that lie within a 62 mile (100 kilometers) radius of the project site as shown on Figure 1 and Table 1. The search identifies known faults within this distance and computes deterministic ground accelerations at the site based on the maximum credible earthquake expected on each of the faults and the distance from the fault to the site. The Maximum Magnitude Earthquake (Mmax) listed was taken from published geologic information available for each fault (CDMG OFR 96-08 and Jennings, 1994).

Seismic Risk: The project site is located in the seismically active Imperial Valley of southern California and is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. The proposed site structures should be designed in accordance with the California Building Code (CBC) for near source factors derived from a "Design Basis Earthquake" (DBE). The DBE is defined as the motion having a 10 percent probability of being exceeded in 50 years. The DBE generally corresponds to the Mmax magnitude discussed here.

Seismic Hazards.

- **Groundshaking.** The primary seismic hazard at the project site is the potential for strong groundshaking during earthquakes along the Imperial, Brawley, and Superstition Hills Faults. A further discussion of groundshaking follows in Section 3.4.
- **Surface Rupture.** The project site does not lie within a State of California, Alquist-Priolo Earthquake Fault Zone. Surface fault rupture is considered to be unlikely at the project site because of the well-delineated fault lines through the Imperial Valley as shown on USGS and CGS maps. However, because of the high tectonic activity and deep alluvium of the region, we cannot preclude the potential for surface rupture on undiscovered or new faults that may underlie the site.



Copyright 1997 by Shelton L, Stringer, GE

Faults and Seismic Zones from Jennings (1994), Earthquakes modified from Ellsworth (1990) catalog.

Figure 1. Map of Regional Faults and Seismicity

Table 1
FAULT PARAMETERS & DETERMINISTIC ESTIMATES OF PEAK GROUND ACCELERATION (PGA)

Fault Name or Seismic Zone	Distance (mi) & Direction from Site	Fault Type		Fault Length (km)	Maximum Magnitude Mmax (Mw)	Avg Slip Rate (mm/yr)	Avg Return Period (yrs)	Date of Last Rupture (year)	Largest Historic Event >5.5M	(year)	Est. Site PGA (g)
Reference Notes: (1)		(2)	(3)	(2)	(4)	(3)	(3)	(3)	(5)		(6)
Imperial Valley Faults											
Imperial	7.0 NE	A	B	62	**7.0**	20	79	1979	7.0	1940	**0.33**
Brawley	8.8 NNE	B	B	14	**7.0**	20	---	1979	5.8	1979	**0.28**
Cerro Prieto	15 SSE	A	B	116	**7.2**	34	50	1980	7.1	1934	**0.21**
Brawley Seismic Zone	16 N	B	B	42	**6.4**	25	24		5.9	1981	**0.13**
East Highline Canal	23 NE	C	C	22	**6.3**	1	774				**0.09**
San Jacinto Fault System											
- Superstition Hills	8.5 NNW	B	A	22	**6.6**	4	250	1987	6.5	1987	**0.23**
- Superstition Mtn.	15 NW	B	A	23	**6.6**	5	500	1440 +/-			**0.16**
- Elmore Ranch	28 NW	B	A	29	**6.6**	1	225	1987	5.9	1987	**0.10**
- Borrego Mtn	34 NW	B	A	29	**6.6**	4	175		6.5	1942	**0.08**
- Anza Segment	51 NW	A	A	90	**7.2**	12	250	1918	6.8	1918	**0.08**
- Coyote Creek	53 NW	B	A	40	**6.8**	4	175	1968	6.5	1968	**0.07**
- Whole Zone	15 NW	A	A	245	**7.5**	---	---				**0.25**
Elsinore Fault System											
- Laguna Salada	16 SW	B	B	67	**7.0**	3.5	336		7.0	1891	**0.18**
- Coyote Segment	29 W	B	A	38	**6.8**	4	625				**0.11**
- Julian Segment	55 WNW	A	A	75	**7.1**	5	340				**0.08**
- Earthquake Valley	57 WNW	B	A	20	**6.5**	2	351				**0.05**
- Whole Zone	29 W	A	A	250	**7.5**	---	---				**0.15**
San Andreas Fault System											
- Coachella Valley	45 NNW	A	A	95	**7.4**	25	220	1690+/-	6.5	1948	**0.10**
- Whole S. Calif. Zone	45 NNW	A	A	458	**7.9**	---	---	1857	7.8	1857	**0.13**
Algodones	36 E	C	C	74	**7.0**	0.1	20,000				**0.10**

Notes:

1. Jennings (1994) and CDMG (1996)
2. CDMG (1996), where Type A faults -- slip rate >5 mm/yr and well constrained paleoseismic data
   Type B faults -- all other faults.
3. WGCEP (1995)
4. CDMG (1996) based on Wells & Coppersmith (1994)
5. Ellsworth Catalog in USGS PP 1515 (1990) and USBR (1976), Mw = moment magnitude,
6. The deterministic estimates of the Site PGA are based on the attenuation relationship of:
   Boore, Joyner, Fumal (1997)

▸ **Liquefaction.** Liquefaction is unlikely to be a potential hazard at the site due to the lack of saturated granular soil (clay soils predominate).

Other Secondary Hazards.

▸ **Landsliding.** The hazard of landsliding is unlikely due to the regional planar topography. No ancient landslides are shown on geologic maps of the region and no indications of landslides were observed during our site investigation.

▸ **Volcanic hazards.** The site is not located in proximity to any known volcanically active area and the risk of volcanic hazards is considered very low.

▸ **Tsunamis, sieches, and flooding.** The site does not lie near any large bodies of water, so the threat of tsunami, sieches, or other seismically-induced flooding is unlikely.

▸ **Expansive soil.** In general, much of the near surface soils in the Imperial Valley consist of silty clays and clays which are moderate to highly expansive. The expansive soil conditions are discussed in more detail in Section 3.5.

3.4 Site Acceleration and UBC Seismic Coefficients

Deterministic horizontal peak ground accelerations (PGA) from maximum probable earthquakes on regional faults have been estimated and are included in Table 1. Ground motions are dependent primarily on the earthquake magnitude and distance to the seismogenic (rupture) zone. Accelerations also are dependent upon attenuation by rock and soil deposits, direction of rupture and type of fault; therefore, ground motions may vary considerably in the same general area.

We have used the computer program FRISKSP (Blake, 2000) to provide a probabilistic estimate of the site PGA using the attenuation relationship of Boore, Joyner, and Fumal (1997) Soil (250). The PGA estimate for the project site having a 10% probability of being exceeded in 50 years (return period of 475 years) is **0.60g**.

CBC Seismic Coefficients: The CBC seismic coefficients are roughly based on an earthquake ground motion that has a 10% probability of being exceeded in 50 years. The following table lists seismic and site coefficients (near source factors) determined by Chapter 16 of the 2001 CBC. ***This site lies within 11.3 km of a Type A fault overlying S_D (stiff) soil.***

CBC Seismic Coefficients for Chapter 16 Seismic Provisions

CBC Code Edition	Soil Profile Type	Seismic Source Type	Distance to Critical Source	Near Source Factors		Seismic Coefficients	
				Na	Nv	Ca	Cv
2001	S_D (stiff soil)	A	< 11.3 km	1.00	1.15	0.44	0.74
Ref. Table	16-J	16-U	---	16-S	16-T	16-Q	16-R

3.5 Subsurface Soil

Subsurface soils encountered during the field exploration conducted on December 20, 2004 indicates that 1.0 to 1.5 feet of stiff clay are at ground surface. Dense to very dense silty sands lie below the clays and extend to a depth of 4 to 5 feet. Stiff to very stiff clays extend a depth of 50 feet, the maximum depth of exploration. The subsurface logs (Plates B-1 through B-3) depict the stratigraphic relationships of the various soil types.

The native surface clays exhibit moderate swell potential (Expansion Index, EI = 51 - 90) when correlated to Plasticity index tests (ASTM D4318) performed on the native clays. The clay is expansive when wetted and can shrink with moisture loss (drying). Development of building foundations, concrete flatwork, and asphaltic concrete pavements should include provisions for mitigating potential swelling forces and reduction in soil strength, which can occur from saturation of the soil. Causes for soil saturation include landscape irrigation, broken utility lines, or capillary rise in moisture upon sealing the ground surface to evaporation. Moisture losses can occur with lack of landscape watering, close proximity of structures to downslopes and root system moisture extraction from deep rooted shrubs and trees placed near the foundations. Typical measures used for industrial projects to remediate expansive soil include:

- replacement of silt/clay with non-expansive granular fill,
- moisture conditioning subgrade soils to a minimum of 5% above optimum moisture (ASTM D1557) for the full range in depth of surface soils.
- design of foundations that are resistant to shrink/swell forces of silt/clay soil.

3.6 Groundwater

Groundwater was not noted on the CPT sounding at the time of exploration, but is typically encountered at approximately 10 to 15 feet below ground surface in the vicinity of the site. There is uncertainty in the accuracy of short-term water level measurements, particularly in fine-grained soil. Groundwater levels may fluctuate with precipitation, irrigation of adjacent properties, drainage, and site grading. The referenced groundwater level should not be interpreted to represent an accurate or permanent condition.

3.7 Liquefaction

Liquefaction occurs when granular soil below the water table is subjected to vibratory motions, such as produced by earthquakes. With strong ground shaking, an increase in pore water pressure develops as the soil tends to reduce in volume. If the increase in pore water pressure is sufficient to reduce the vertical effective stress (suspending the soil particles in water), the soil strength decreases and the soil behaves as a liquid (similar to quicksand). Liquefaction can produce excessive settlement, ground rupture, lateral spreading, or failure of shallow bearing foundations.

Four conditions are generally required for liquefaction to occur:

(1) the soil must be saturated (relatively shallow groundwater);
(2) the soil must be loosely packed (low to medium relative density);
(3) the soil must be relatively cohesionless (not clayey); and
(4) groundshaking of sufficient intensity must occur to function as a trigger mechanism.

All of these conditions exist to some degree at this site.

Methods of Analysis: Liquefaction potential at the project site was evaluated using the 1997 NCEER Liquefaction Workshop methods that are based on the Seed, et. al. 1985 and Robertson and Campanella (1985) methods. The 1997 NCEER methods utilize direct SPT blow counts or CPT cone readings from site exploration and earthquake magnitude/PGA estimates from the seismic hazard analysis. The resistance to liquefaction is plotted on a chart of cyclic shear stress ratio (CSR) versus a corrected blow count $N_{1(60)}$ or Qc_{IN}. A ground acceleration of 0.60g was used in the analysis with a 12 foot groundwater depth.

Liquefaction induced settlements have been estimated using the 1987 Tokimatsu and Seed method. Fines content of liquefiable sands and silt increase the liquefaction resistance in that more cycles of ground motions are required to fully develop pore pressures. The SPT blow counts were adjusted to an equivalent clean sand blow count, $N_{1(60)}$ prior to calculating settlements using Robertson and Wride (1997) adjustments. A computed factor of safety less than 1.0 indicates a liquefiable condition.

Liquefaction Effects: Based on empirical relationships, liquefaction is not expected to occur at the project site.

Section 4
RECOMMENDATIONS

4.1 Site Preparation

Clearing and Grubbing: All surface improvements, debris or vegetation including grass and weeds on the site at the time of construction should be removed from the construction area. Organic strippings should be hauled from the site and not used as fill. Any trash, construction debris, concrete slabs, old pavement, landfill, and buried obstructions such as old foundations and utility lines exposed during rough grading should be traced to the limits of the foreign material by the grading contractor and removed under our supervision. Any excavations resulting from site clearing should be dish-shaped to the lowest depth of disturbance and backfilled under observation by the geotechnical engineer's representative with compacted fill as described below.

Structure Subgrade Preparation: The exposed surface soil within the foundation areas should be removed to 12 inches below the foundation elevation or existing grade (whichever is lower). Exposed subgrade should be scarified to a depth of 8 inches, uniformly moisture conditioned to 3 to 8% above optimum moisture content (clays) or 0 to 4% above optimum (silts), and recompacted to at least 90% of the maximum density determined in accordance with ASTM D1557 methods.

The native soil is suitable for use as engineered fill provided it is free from concentrations of organic matter or other deleterious material. The fill soil should be uniformly moisture conditioned by discing and watering to the limits specified above, placed in maximum 8-inch lifts (loose), and compacted to the limits specified above.

Imported fill soil (if required) should have a Plasticity Index less than 15 and sulfates (SO_4) less than 1,000 ppm or non-expansive, granular soil meeting the USCS classifications of SM, SP-SM, or SW-SM with a maximum rock size of 3 inches and 5 to 35% passing the No. 200 sieve. The geotechnical engineer should approve imported fill soil sources before hauling material to the site. Imported granular fill should be placed in lifts no greater than 8 inches in loose thickness and compacted to at least 90% of ASTM D1557 maximum dry density at optimum moisture ±2%.

In areas other than the structures pad which are to receive area concrete slabs, the ground surface should be presaturated to a minimum depth of 18 inches and then scarified to 6 inches, moisture conditioned to a minimum of 5% over optimum, and recompacted to 83-87% of ASTM D1 557 maximum density just prior to concrete placement.

Trench Backfill: On-site soil free of debris, vegetation, and other deleterious matter may be suitable for use as utility trench backfill, but may be difficult to uniformly maintain at specified moistures and compact to the specified densities. Granular material is often more cost effective for backfill of utility trenches.

Backfill soil within roadways or traffic areas should be placed in layers not more that 6 inches in thickness and mechanically compacted to a minimum of 87% of the ASTM D1557 maximum dry density except for the top 12 inches of the trench which shall be compacted to at least 90%. Native backfill should only be placed and compacted after encapsulating buried pipes with suitable bedding and pipe envelope material. Pipe envelope/bedding should either be clean sand (Sand Equivalent SE>30) or crushed rock when encountering groundwater. A geotextile filter fabric (Mirafi 140N or equivalent) should be used to encapsulate the crushed rock when placed below groundwater to reduce the potential for in-washing of fines into the gravel void space. Precautions should be taken in the compaction of the backfill to avoid damage to the pipes and structures.

Observation and Density Testing: All site preparation and fill placement should be continuously observed and tested by a representative of a qualified geotechnical engineering firm. Full-time observation services during the excavation and scarification process is necessary to detect undesirable materials or conditions and soft areas that may be encountered in the construction area. The geotechnical firm that provides observation and testing during construction shall assume the responsibility of "*geotechnical engineer of record*" and, as such, shall perform additional tests and investigation as necessary to satisfy themselves as to the site conditions and the recommendations for site development.

Auxiliary Structures Foundation Preparation: Auxiliary structures such as free standing or retaining walls should have the existing soil beneath the structure foundation prepared in the manner recommended for the building pad except the preparation needed only to extend 12 inches below and beyond the footing.

4.2 Foundations and Settlements

Shallow spread footings and continuous wall footings are suitable to support the structures associated with the turbine generator and cooling tower. Footings shall be founded on a layer of properly prepared and compacted soil as described in Section 4.1. The foundations may be designed using an allowable soil bearing pressure of 1,500 psf for compacted native clay soil and 2,000 psf when foundations are supported on imported sands (extending a minimum of 1.0 feet below footings). The allowable soil pressure may be increased by 20% for each foot of embedment depth in excess of 18 inches and by one-third for short term loads induced by winds or seismic events. The maximum allowable soil pressure at increased embedment depths shall not exceed 3,000 psf (clays). Settlements associated with variable loadings and structure/footing sizes are shown on figures 2 thru 5. As an alternative to shallow spread foundations, flat plate structural mats or grade-beam reinforced foundations may be used to mitigate expansive soil heave.

Flat Plate Structural Mats: Structural mats may be designed for a modulus of subgrade reaction (Ks) of 100 pci when placed on compacted clay or a subgrade modulus of 250 pci when placed on 2.5 feet of granular fill. Mats shall overlay 2 inches of sand and a 10-mil polyethylene vapor retarder. The structure support pad shall be moisture conditioned and recompacted as specified in Section 4.1 of this report.

All exterior and interior foundations should be embedded a minimum of 18 inches below the structure support pad or lowest adjacent final grade, whichever is deeper. Continuous wall footings should have a minimum width of 12 inches. Spread footings should have a minimum width of 24 inches. Recommended concrete reinforcement and sizing for all footings should be provided by the structural engineer.

Resistance to horizontal loads will be developed by passive earth pressure on the sides of footings or grade beams and frictional resistance developed along the bases of footings or grade beams and concrete slabs. Passive resistance to lateral earth pressure may be calculated using an equivalent fluid pressure of 250 pcf (300 pcf for sands) to resist lateral loadings. The top one foot of embedment should not be considered in computing passive resistance unless the adjacent area is confined by a slab or pavement. An allowable friction coefficient of 0.25 (0.35 for sands) may also be used at the base of the footings or grade beams to resist lateral loading.

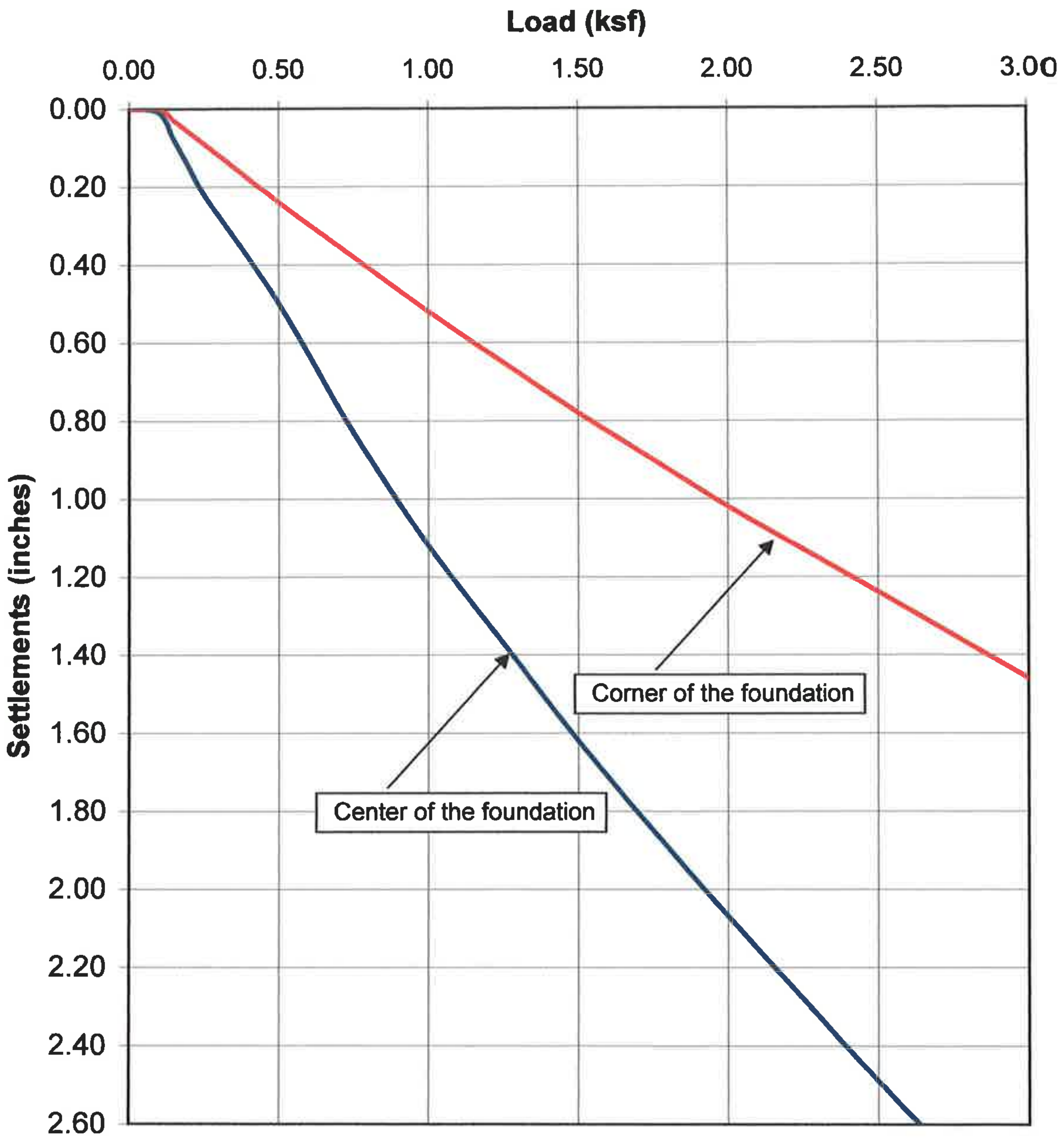
Total foundation movements under estimated loadings are shown on the load/settlement curves (Figures 2 thru 5). Differential movement is estimated to be about two-thirds of total movement

4.3 Slabs-On-Grade

Thin concrete slabs and flatwork (6 inches or less in thickness) placed over native clay soil should be designed in accordance with Chapter 18, Division III of the 2001 CBC (using an Effective Plasticity Index of 17) and shall be a minimum of 5 inches thick due to expansive soil conditions. Concrete floor slabs shall be monolithically placed with the foundations unless placed on 2.5 feet of granular fill or lime treated soil.

The concrete slabs should be underlain by a minimum of 4 inches of clean sand (Sand Equivalent SE>30) or aggregate base or may be placed directly on a 2.5-foot thick granular fill pad (if used) that has been moistened to approximately optimum moisture just before the concrete placement. A 10-mil visqueen vapor retarder, properly lapped and sealed with a 2-inch sand cover and extended a minimum of 12 inches into the footing, should be placed as a capillary break to prevent moisture migration into the slab section. Concrete slabs may be placed directly over a 15-mil vapor retarder if desired (Stego-Wrap or equivalent).

Concrete slab and flatwork reinforcement should consist of chaired rebar slab reinforcement (minimum of No. 4 bars at 18-inch centers, both horizontal directions) placed at slab mid-height to resist potential swell forces and cracking. Slab thickness and steel reinforcement are minimums only and should be verified by the structural engineer/designer knowing the actual project loadings. All steel components of the foundation system should be protected from corrosion by maintaining a 4-inch minimum concrete cover of densely consolidated concrete at footings (by use of a vibrator). The construction joint between the foundation and any mowstrips/sidewalks placed adjacent to foundations should be sealed with a polyurethane based non-hardening sealant to prevent moisture migration between the joint. Epoxy coated embedded steel components or permanent waterproofing membranes placed at the exterior footing sidewall may also be used to mitigate the corrosion potential of concrete placed in contact with native soil.



Notes:

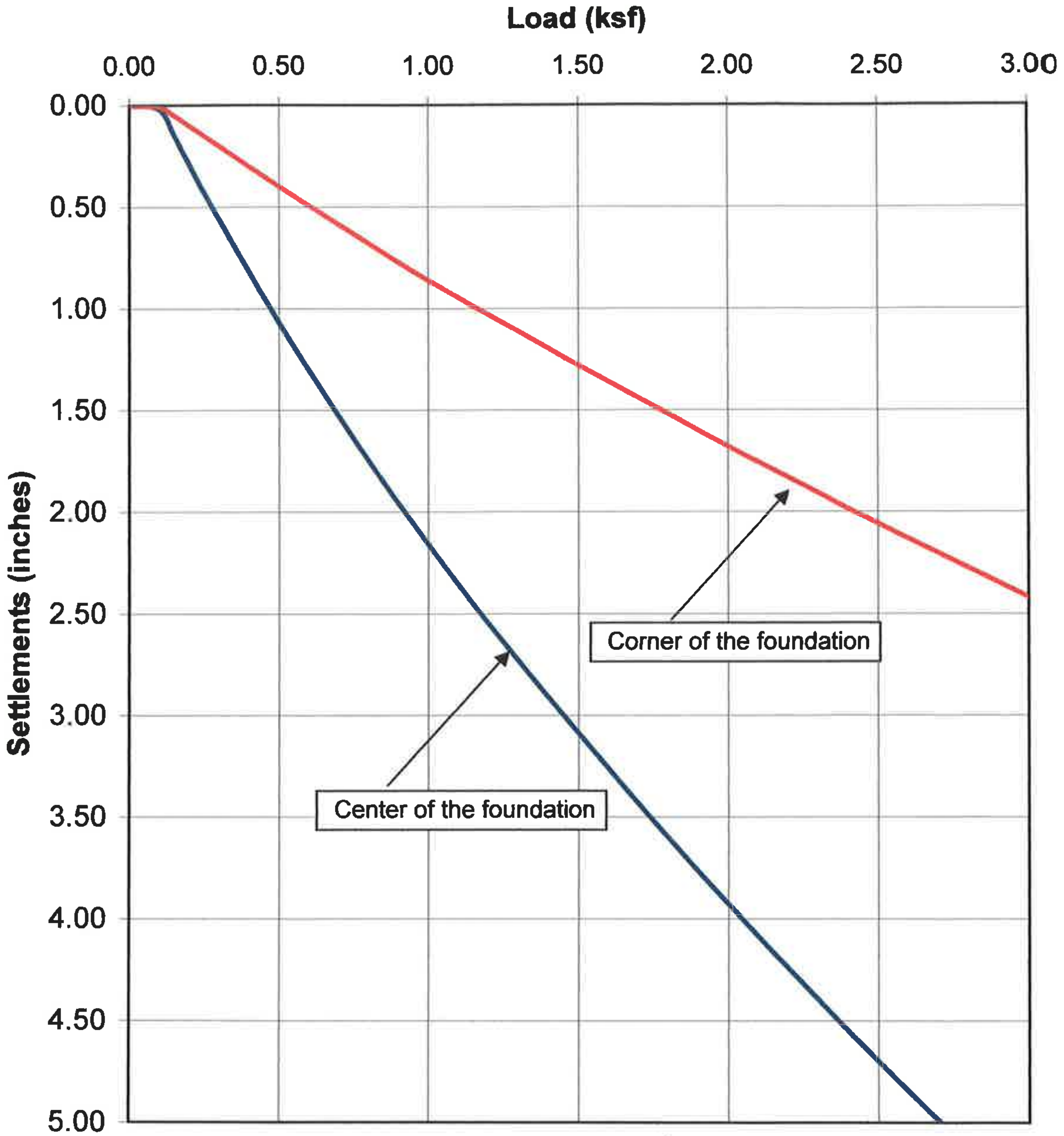
1. A 15' x 15' foundation was used for settlement analysis

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE04354

Total Settlements for a Turbine Generator Foundation at Heber 2 Geothermal Plant

Figure 2



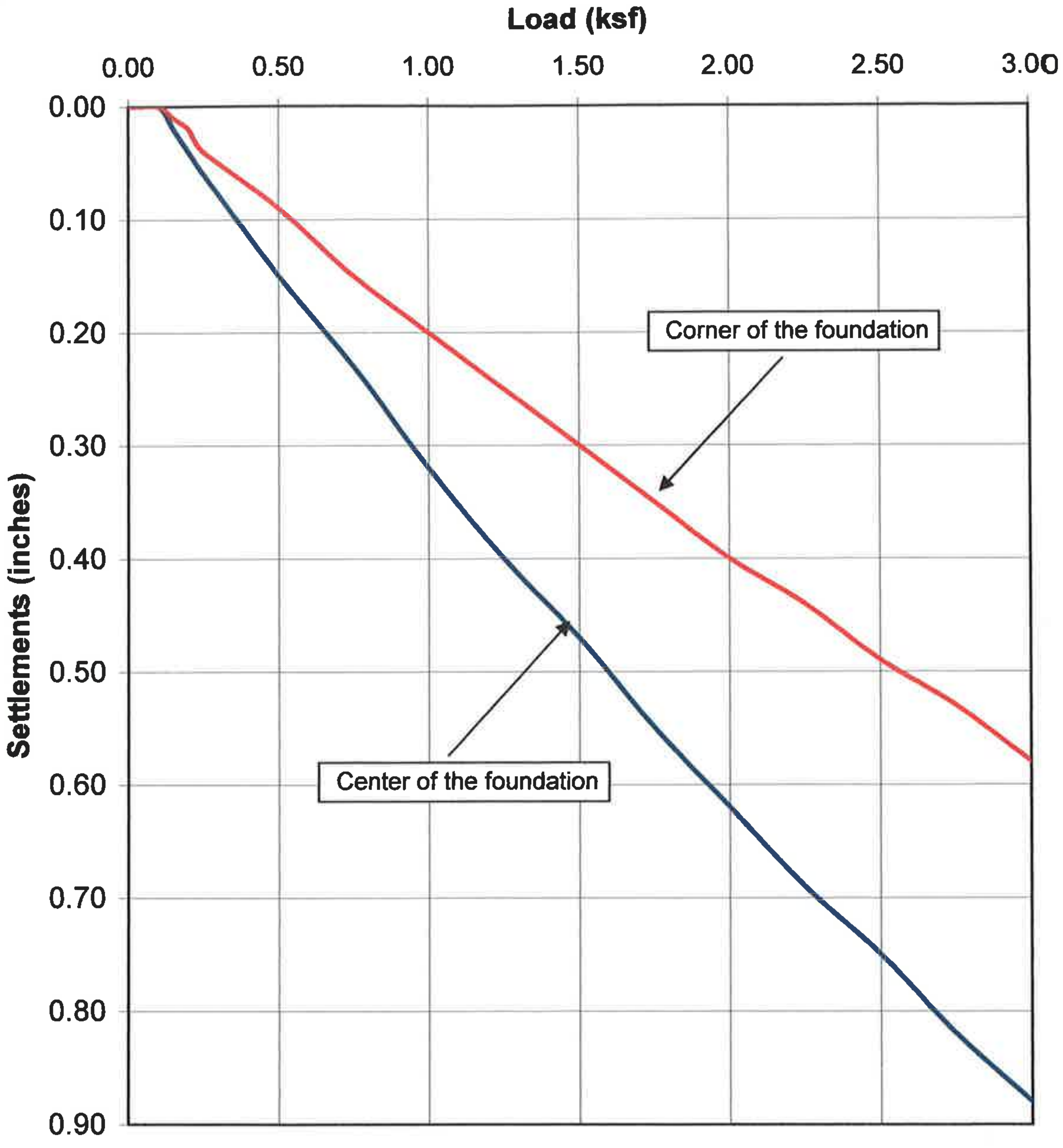
Notes:

1. A 30' x 60' foundation was used for settlement analysis

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company
Project No.: LE04354

Total Settlements for a Turbine Generator Foundation at Heber 2 Geothermal Plant

Figure 3



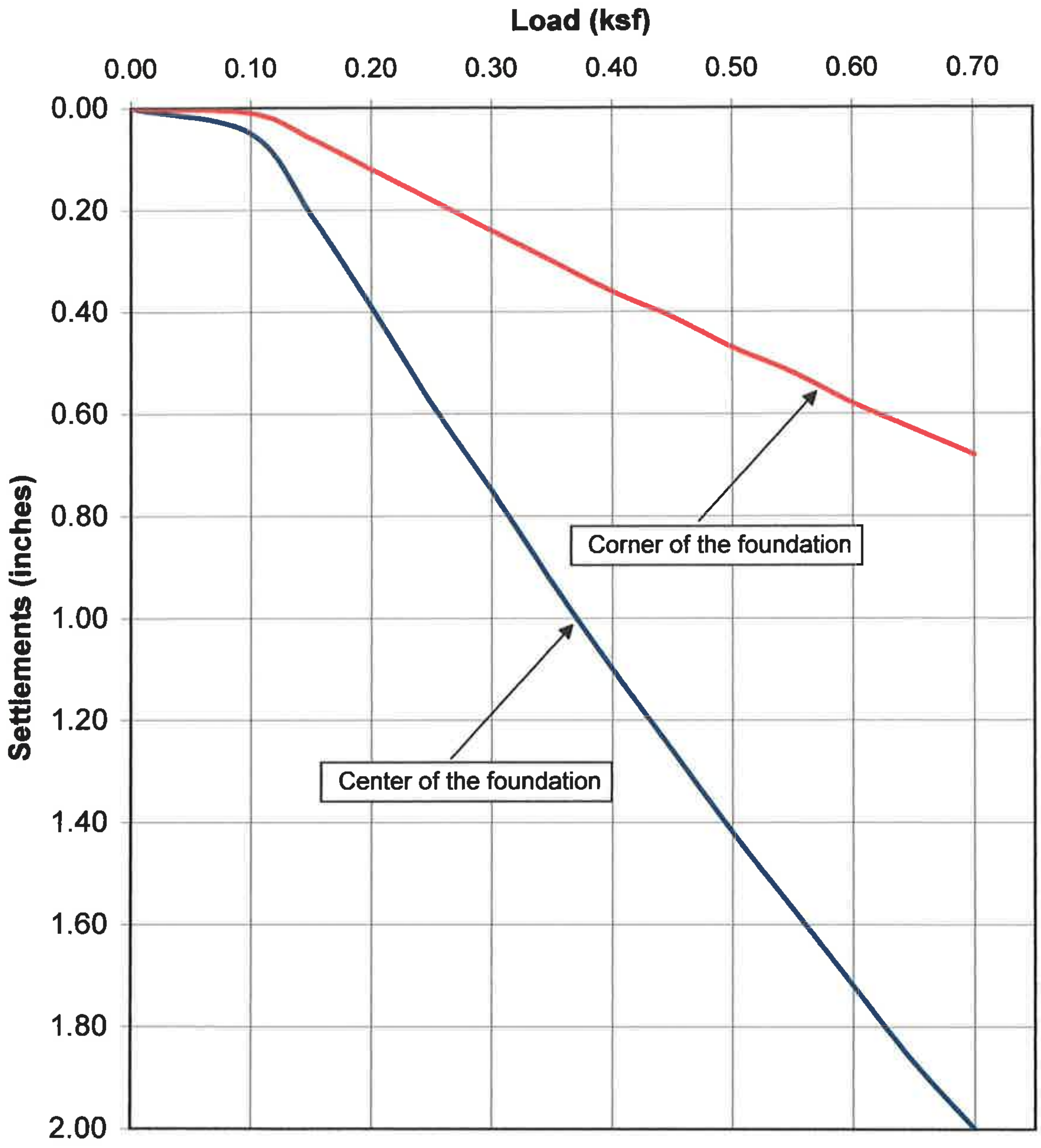
Notes:

1. A 5' x 5' foundation was used for settlement analysis

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company
Project No.: LE04354

Total Settlements for a Cooling Tower Foundation at Heber 2 Geothermal Plant

Figure 4



Notes:

1. A 60' x 180' foundation was used for settlement analysis

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company
Project No.: LE04354

Total Settlements for a Cooling Tower Foundation at Heber 2 Geothermal Plant

Figure 5

Control joints should be provided in all concrete slabs-on-grade at a maximum spacing (in feet) of 2 to 3 times the slab thickness (in inches) as recommended by American Concrete Institute (ACI) guidelines. All joints should form approximately square patterns to reduce randomly oriented contraction cracks. Contraction joints in the slabs should be tooled at the time of the pour or sawcut (¼ of slab depth) within 6 to 8 hours of concrete placement. Construction (cold) joints in foundations and area flatwork should either be thickened butt-joints with dowels or a thickened keyed-joint designed to resist vertical deflection at the joint. All joints in flatwork should be sealed to prevent moisture, vermin, or foreign material intrusion. Precautions should be taken to prevent curling of slabs in this arid desert region (refer to ACI guidelines).

All independent flatwork (sidewalks, housekeeping slabs) should be placed on a minimum of 2 inches of concrete sand or aggregate base, dowelled to the perimeter foundations where adjacent to the structures and sloped 1% or more away from the structure. A minimum of 18 inches of moisture conditioned (3% minimum above optimum) and 8 inches of compacted subgrade (83 to 87%) and a 10-mil (minimum) polyethylene separation sheet should underlie the flatwork. All flatwork should be jointed in square patterns and at irregularities in shape at a maximum spacing of 10 feet or the least width of the sidewalk.

4.4 Concrete Mixes and Corrosivity

Selected chemical analyses for corrosivity were conducted on bulk samples of the near surface soil from the project site (Plates C-2 and C-3). The native soils were found to have moderate to severe levels of sulfate ion concentration (1,052 to 3,006 ppm). Sulfate ions in high concentrations can attack the cementitious material in concrete, causing weakening of the cement matrix and eventual deterioration by raveling. The California Building Code recommends that increased quantities of Type II Portland Cement be used at a low water/cement ratio when concrete is subjected to moderate sulfate concentrations. Type V Portland Cement and/or Type II/V cement with 25% flyash replacement is recommended when the concrete is subjected to soil with severe sulfate concentration.

A minimum of 6.25 sacks per cubic yard of concrete (4,500 psi) of Type V Portland Cement with a maximum water/cement ratio of 0.45 (by weight) should be used for concrete placed in contact with native soil on this project. Admixtures may be required to allow placement of this low water/cement ratio concrete.

There are no special requirements for concrete mixes when foundations are placed on 2.5 feet of low sulfate content granular fill.

The native soil has moderate to very severe level of chloride ion concentration (210 to 3,040 ppm). Chloride ions can cause corrosion of reinforcing steel, anchor bolts and other buried metallic conduits. Resistivity determinations on the soil indicate very severe potential for metal loss because of electrochemical corrosion processes. Mitigation of the corrosion of steel can be achieved by using steel pipes coated with epoxy corrosion inhibitors, asphaltic and epoxy coatings, cathodic protection or by encapsulating the portion of the pipe lying above groundwater with a minimum of 4 inches of densely consolidated concrete. ***No metallic pipes or conduits should be placed below foundations.***

Foundation designs shall provide a minimum concrete cover of four (4 inches around steel reinforcing or embedded components (anchor bolts, hold-downs, etc.) exposed to native soil or landscape water (to 18 inches above grade). If the 4-inch concrete edge distance cannot be achieved, all embedded steel components (anchor bolts, hold-downs, etc.) shall be epoxy dipped for corrosion protection or a corrosion inhibitor and a permanent waterproofing membrane shall be placed along the exterior face of the exterior footings. Additionally, the concrete should be thoroughly vibrated at footings during placement to decrease the permeability of the concrete.

4.5 Excavations

All site excavations should conform to CalOSHA requirements for Type B soil. The contractor is solely responsible for the safety of workers entering trenches. Temporary excavations with depths of 4 feet or less may be cut nearly vertical for short duration. Excavations deeper than 4 feet will require shoring or slope inclinations in conformance to CAL/OSHA regulations for Type B soil. Surcharge loads of stockpiled soil or construction materials should be set back from the top of the slope a minimum distance equal to the height of the slope. All permanent slopes should not be steeper than 3:1 to reduce wind and rain erosion. Protected slopes with ground cover may be as steep as 2:1. However, maintenance with motorized equipment may not be possible at this inclination.

4.6 Seismic Design

This site is located in the seismically active southern California area and the site structures are subject to strong ground shaking due to potential fault movements along the Brawley, Superstition Hills, and Imperial Faults. Engineered design and earthquake-resistant construction are the common solutions to increase safety and development of seismic areas. Designs should comply with the latest edition of the CBC for Seismic Zone 4 using the seismic coefficients given in Section 3.4 of this report. ***This site lies within 11.3 km of a Type A fault overlying S_D (stiff) soil.***

Section 5
LIMITATIONS AND ADDITIONAL SERVICES

5.1 Limitations

The recommendations and conclusions within this report are based on current information regarding the proposed additions to the Ormat Heber 2 geothermal power plant located on Dogwood Road southwest of Heber, California. The conclusions and recommendations of this report are invalid if:

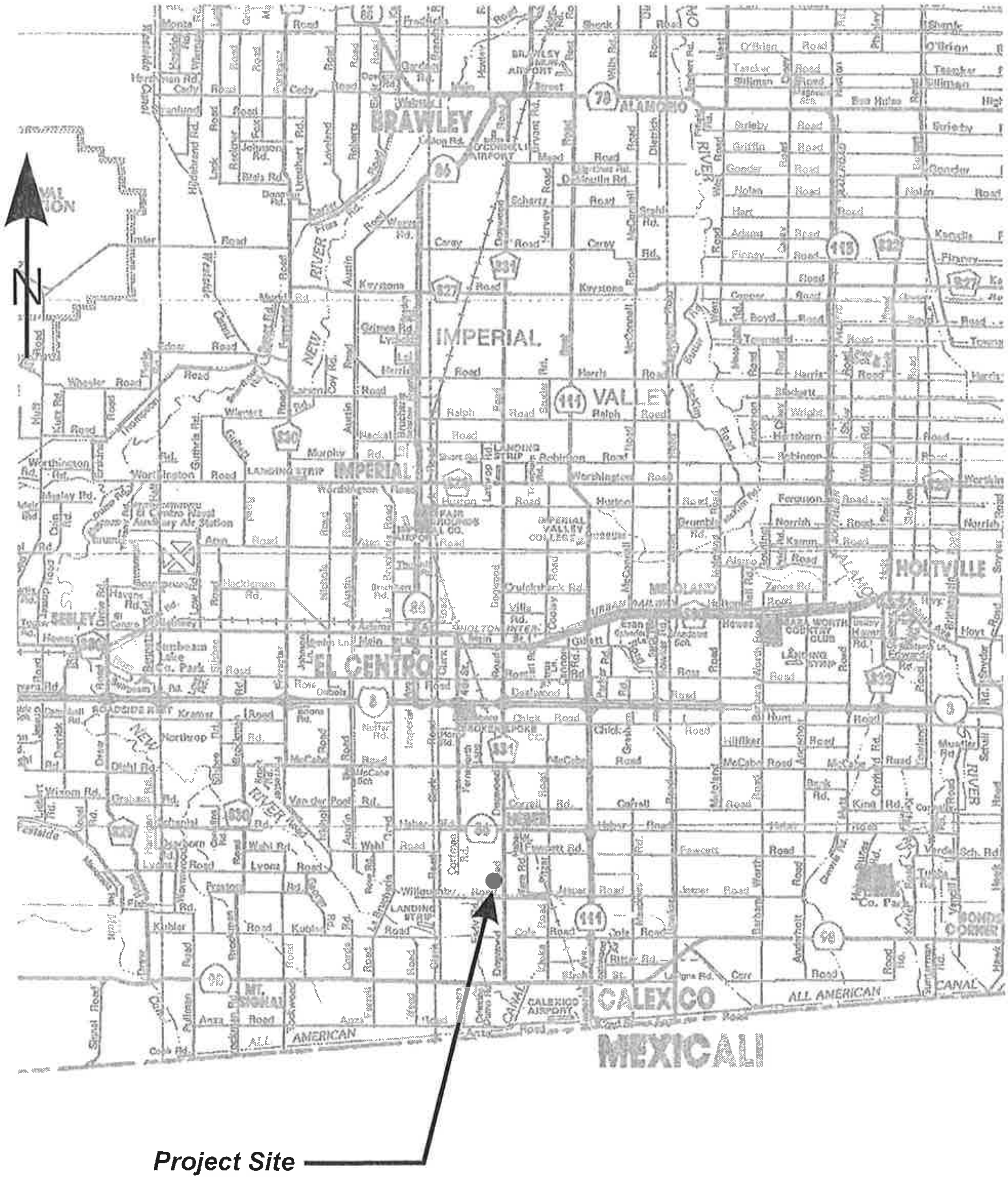
- Structural loads change from those stated or the structures are relocated.
- The Additional Services section of this report is not followed.
- This report is used for adjacent or other property.
- Changes of grade or groundwater occur between the issuance of this report and construction other than those anticipated in this report.
- Any other change that materially alters the project from that proposed at the time this report was prepared.

Findings and recommendations in this report are based on selected points of field exploration, geologic literature, laboratory testing, and our understanding of the proposed project. Our analysis of data and recommendations presented herein are based on the assumption that soil conditions do not vary significantly from those found at specific exploratory locations. Variations in soil conditions can exist between and beyond the exploration points or groundwater elevations may change. If detected, these conditions may require additional studies, consultation, and possible design revisions.

This report contains information that may be useful in the preparation of contract specifications. However, the report is not worded is such a manner that we recommend its use as a construction specification document without proper modification. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

This report was prepared according to the generally accepted *geotechnical engineering standards of practice* that existed in Imperial County at the time the report was prepared. No express or implied warranties are made in connection with our services. This report should be considered invalid for periods after two years from the report date without a review of the validity of the findings and recommendations by our firm, because of potential changes in the Geotechnical Engineering Standards of Practice.

APPENDIX A



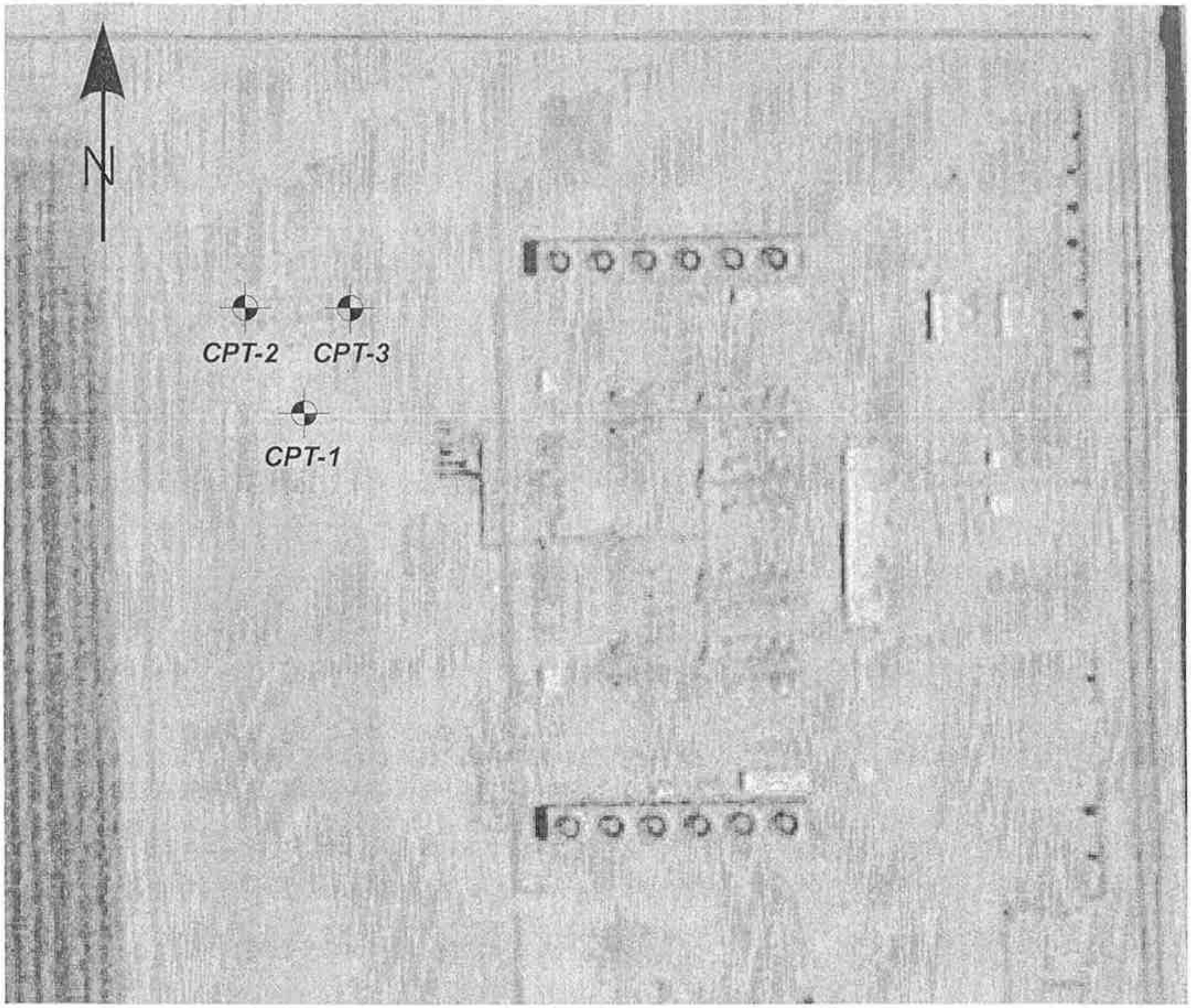
Project Site

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE04354

Vicinity Map

Plate A-1

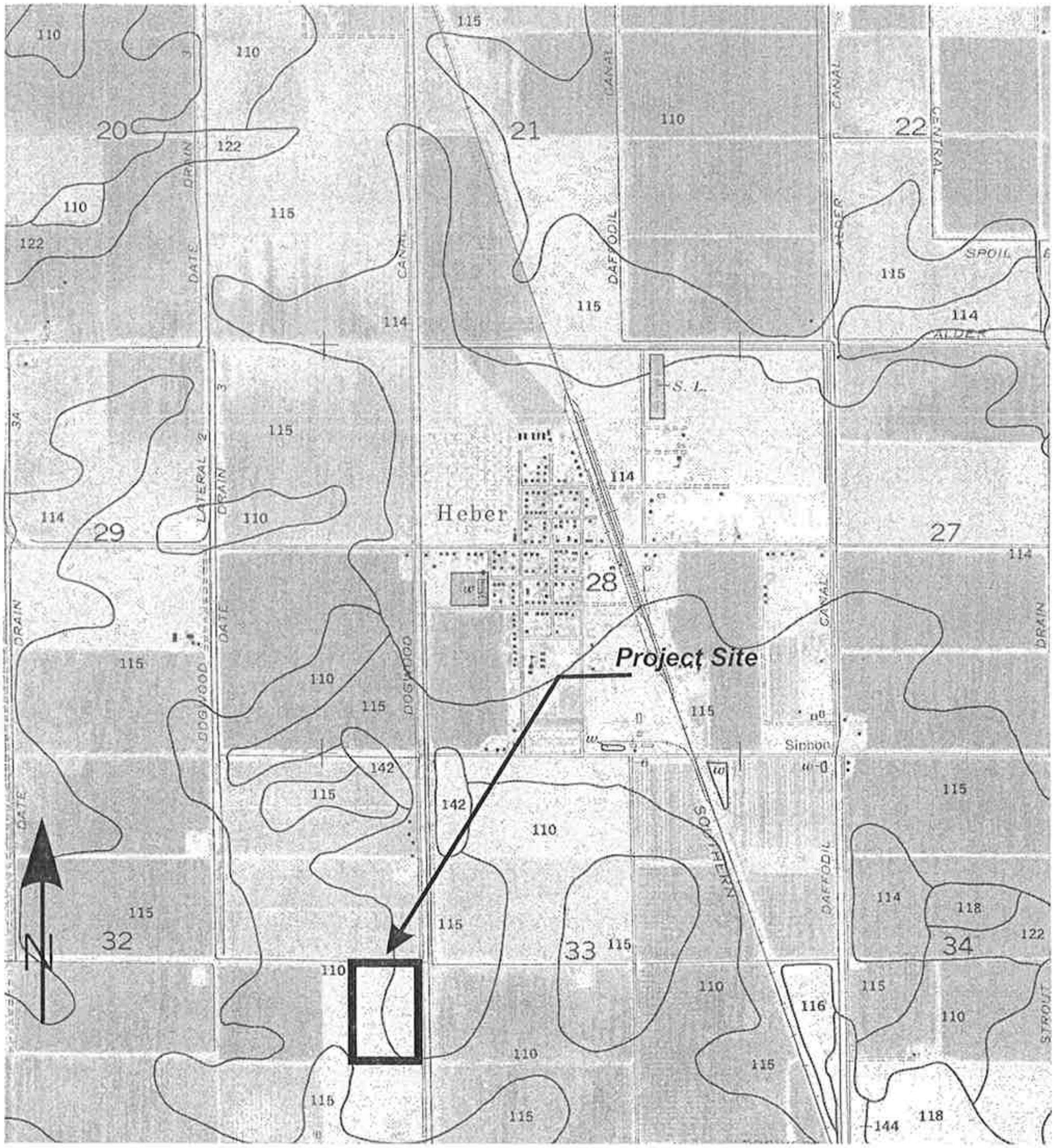


LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE04354

Site and Exploration Map

Plate A-2



LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

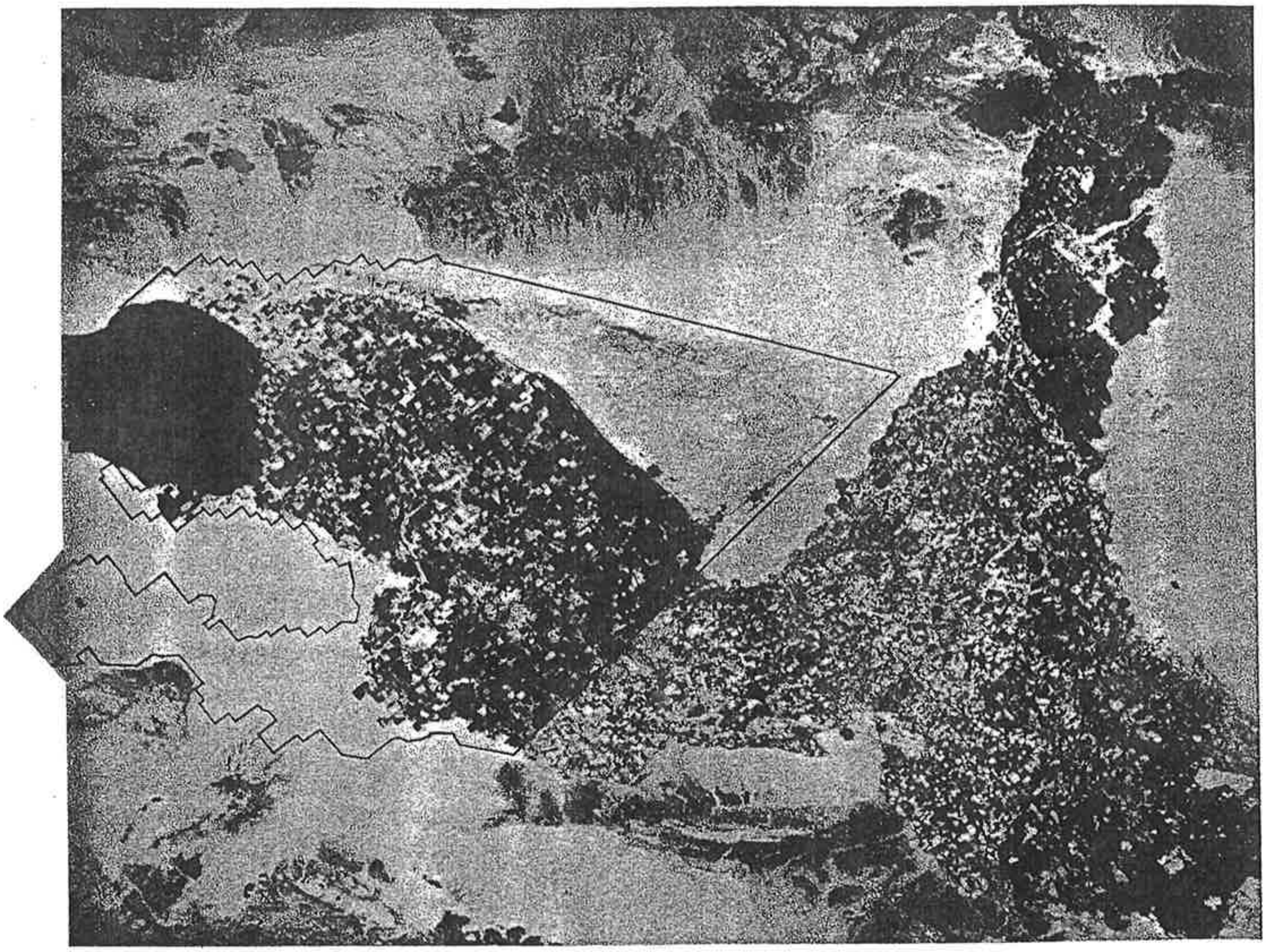
Project No.: LE04354

Soil Survey Map

Plate A-3

Soil Survey of

IMPERIAL COUNTY
CALIFORNIA
IMPERIAL VALLEY AREA



United States Department of Agriculture Soil Conservation Service
in cooperation with
University of California Agricultural Experiment Station
and
Imperial Irrigation District

TABLE 11.--ENGINEERING INDEX PROPERTIES

[The symbol > means more than. Absence of an entry indicates that data were not estimated]

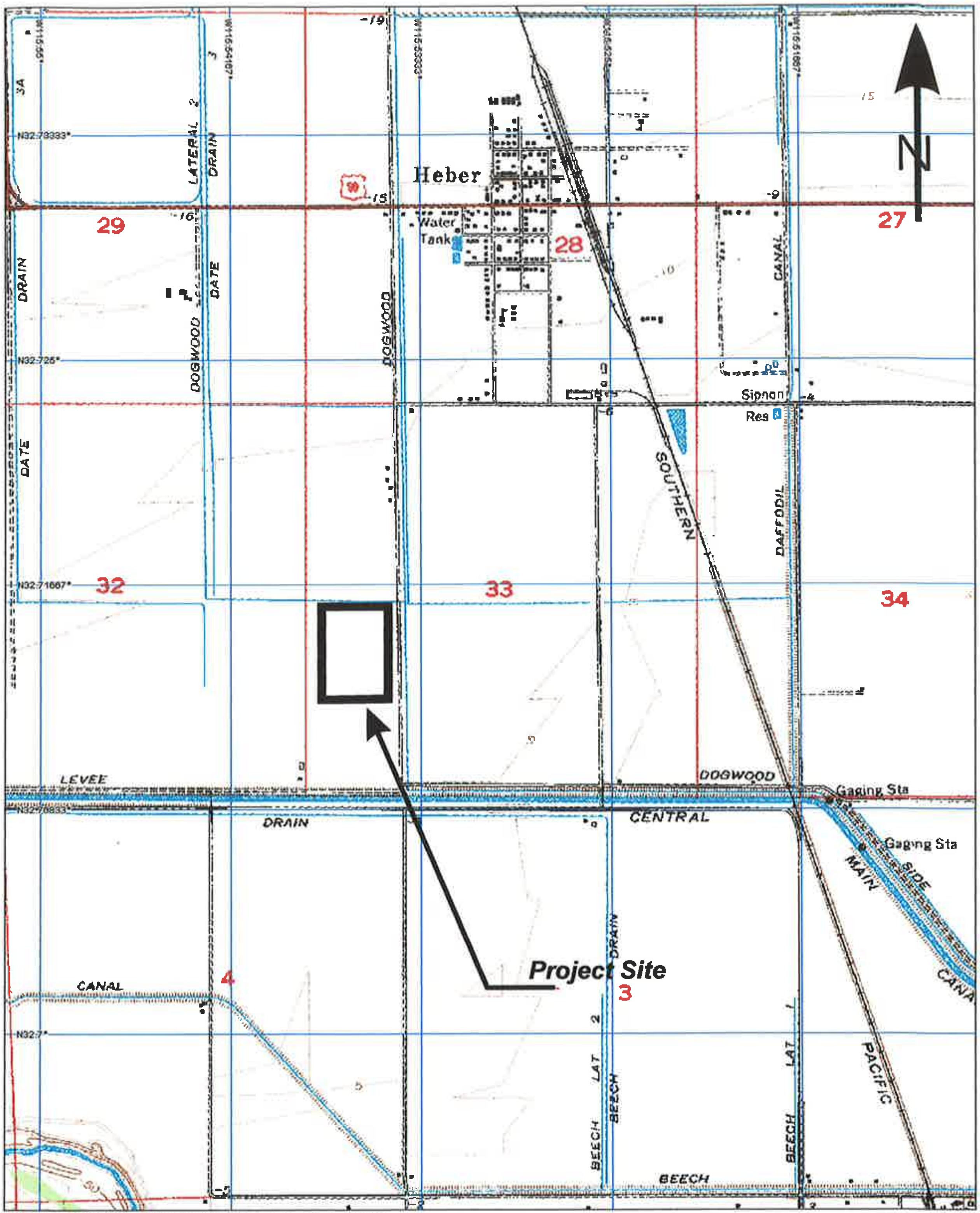
Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
100----------------- Antho	0-13	Loamy fine sand	SM	A-2	0	100	100	75-85	10-30	---	NP
	13-60	Sandy loam, fine sandy loam.	SM	A-2, A-4	0	90-100	75-95	50-60	15-40	---	NP
101*:											
Antho-------------	0-8	Loamy fine sand	SM	A-2	0	100	100	75-85	10-30	---	NP
	8-60	Sandy loam, fine sandy loam.	SM	A-2, A-4	0	90-100	75-95	50-60	15-40	---	NP
Superstition------	0-6	Fine sand-------	SM	A-2	0	100	95-100	70-85	15-25	---	NP
	6-60	Loamy fine sand, fine sand, sand.	SM	A-2	0	100	95-100	70-85	15-25	---	NP
102*. Badland											
103---------------- Carsitas	0-10	Gravelly sand---	SP, SP-SM	A-1, A-2	0-5	60-90	50-85	30-55	0-10	---	NP
	10-60	Gravelly sand, gravelly coarse sand, sand.	SP, SP-SM	A-1	0-5	60-90	50-85	25-50	0-10	---	NP
104* Fluvaquents											
105---------------- Glenbar	0-13	Clay loam-------	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
	13-60	Clay loam, silty clay loam.	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
106---------------- Glenbar	0-13	Clay loam-------	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
107*--------------- Glenbar	0-13	Loam------------	ML, CL-ML, CL	A-4	0	100	100	100	70-80	20-30	NP-10
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	95-100	75-95	35-45	15-30
108---------------- Holtville	0-14	Loam------------	ML	A-4	0	100	100	85-100	55-95	25-35	NP-10
	14-22	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	22-60	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
109---------------- Holtville	0-17	Silty clay------	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	17-24	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	24-35	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
	35-60	Loamy very fine sand, loamy fine sand.	SM, ML	A-2, A-4	0	100	100	75-100	20-55	---	NP
110---------------- Holtville	0-17	Silty clay------	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-35
	17-24	Clay, silty clay	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-35
	24-35	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	55-85	25-35	NP-10
	35-60	Loamy very fine sand, loamy fine sand.	SM, ML	A-2, A-4	0	100	100	75-100	20-55	---	NP

See footnote at end of table.

TABLE 11.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
111*:											
Holtville	0-10	Silty clay loam	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	10-22	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	22-60	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
Imperial	0-12	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
112 Imperial	0-12	Silty clay	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
113 Imperial	0-12	Silty clay	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay, clay, silty clay loam.	CH	A-7	0	100	100	100	85-95	50-70	25-45
114 Imperial	0-12	Silty clay	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
115*:											
Imperial	0-12	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
Glenbar	0-13	Silty clay loam	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
116*:											
Imperial	0-13	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	13-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
Glenbar	0-13	Silty clay loam	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
117, 118 Indio	0-12	Loam	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
	12-72	Stratified loamy very fine sand to silt loam.	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
119*:											
Indio	0-12	Loam	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
	12-72	Stratified loamy very fine sand to silt loam.	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
Vint	0-10	Loamy fine sand	SM	A-2	0	95-100	95-100	70-80	25-35	---	NP
	10-60	Loamy sand, loamy fine sand.	SM	A-2	0	95-100	95-100	70-80	20-30	---	NP
120* Laveen	0-12	Loam	ML, CL-ML	A-4	0	100	95-100	75-85	55-65	20-30	NP-10
	12-60	Loam, very fine sandy loam.	ML, CL-ML	A-4	0	95-100	85-95	70-80	55-65	15-25	NP-10

See footnote at end of table.



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

600 ft Scale: 1 : 20,000 Detail: 13-3 Datum: WGS84

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE04354

Topographic Map

Plate A-4

APPENDIX B

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: HOLGUIN, FAHAN & ASSC. Truck Mounted Electric Cone with 23 ton reaction weight
DATE: 12/20/04

LOG OF CONE SOUNDING DATA CPT-1

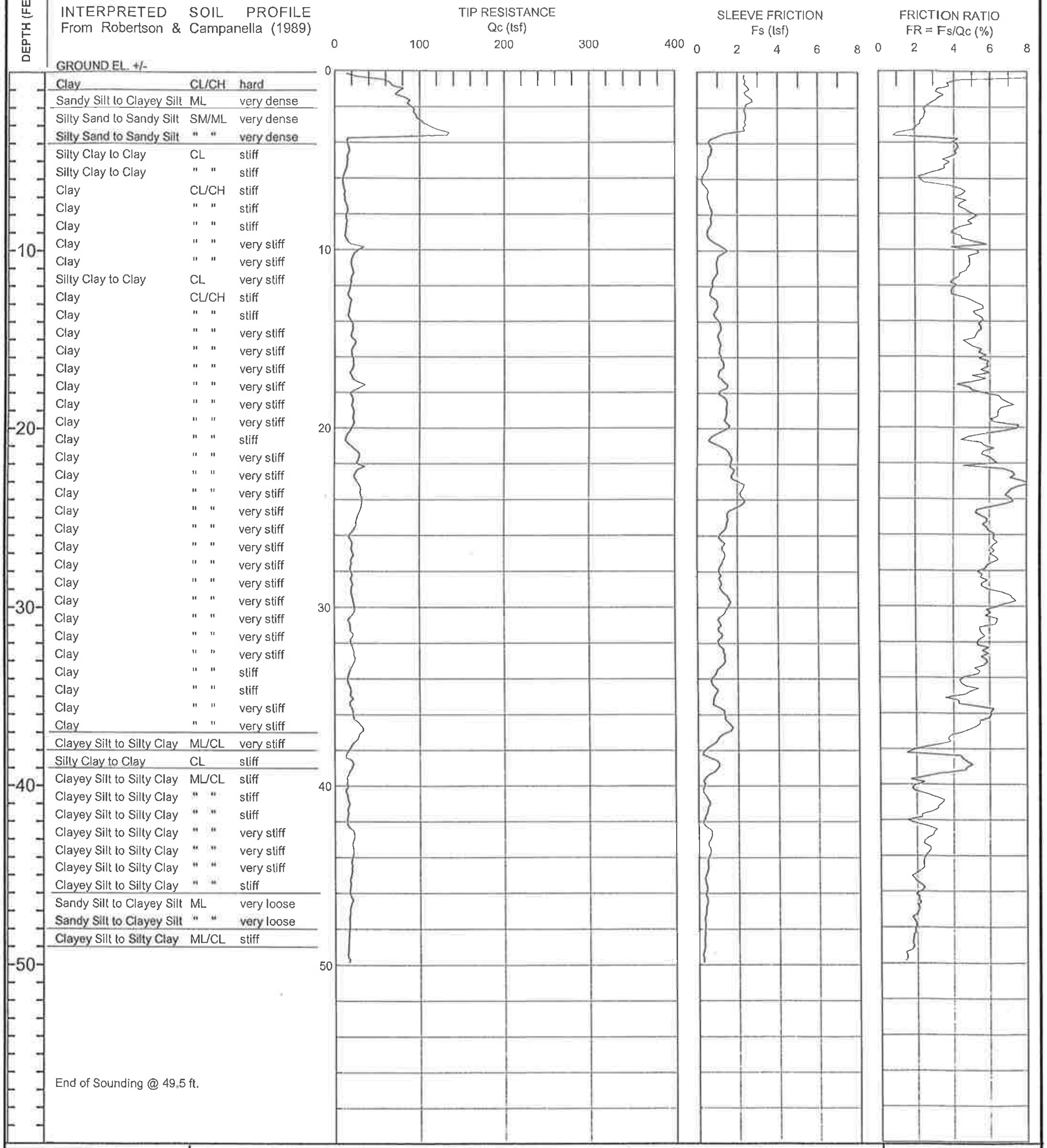
DEPTH (FEET)

INTERPRETED SOIL PROFILE
From Robertson & Campanella (1989)

GROUND EL. +/-

Clay	CL/CH	hard
Sandy Silt to Clayey Silt	ML	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Silty Clay to Clay	CL	stiff
Silty Clay to Clay	" "	stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Silty Clay to Clay	CL	stiff
Clayey Silt to Silty Clay	ML/CL	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff
Sandy Silt to Clayey Silt	ML	very loose
Sandy Silt to Clayey Silt	" "	very loose
Clayey Silt to Silty Clay	ML/CL	stiff

End of Sounding @ 49.5 ft.



Project No:
LE04354

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Plate
B-1

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA Project No: LE04354 Date: 12/20/04

CONE SOUNDING: CPT-1

Est. GWT (ft): 12.0 Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base	Base	Avg	Avg		1				Est.	Qc		Cn		Est.	Rel.	Nk:	17.0	
Depth	Depth	Tip	Friction		Soil	Soil		Density or	Density	to	SPT	or	Norm.	%	Dens.	Phi	Su	
meters	feet	Qc, tsf	Ratio, %		Type	Classification	USC	Consistency	(pcf)	N	N(60)	Cq	Qc1n	Fines	Dr (%)	(deg.)	(tsf)	OCR
0.15	0.5	31.82	10.13	3	3	Clay	CL/CH	very stiff	125	1.3	25	2.00		95			1.87	>10
0.30	1.0	71.19	3.50	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	20	2.00	134.6	45	107	43		
0.45	1.5	76.38	3.27	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	22	2.00	144.4	40	102	42		
0.60	2.0	88.21	2.88	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	25	2.00	166.8	35	101	42		
0.75	2.5	94.19	2.53	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	21	2.00	178.0	30	100	42		
0.93	3.0	101.94	2.35	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	23	2.00	192.7	30	99	42		
1.08	3.5	123.24	1.66	8	8	Sand to Silty Sand	SP/SM	very dense	115	5.5	22	2.00	233.0	20	102	42		
1.23	4.0	53.93	2.99	6	6	Sandy Silt to Clayey Silt	ML	dense	115	3.5	15	2.00	101.9	45	76	39		
1.38	4.5	16.43	4.19	3	3	Clay	CL/CH	stiff	125	1.3	13	2.00		85			0.95	>10
1.53	5.0	15.53	3.80	4	4	Silty Clay to Clay	CL	stiff	125	1.8	9	1.95		85			0.90	>10
1.68	5.5	13.99	3.48	4	4	Silty Clay to Clay	CL	stiff	125	1.8	8	1.85		85			0.80	>10
1.83	6.0	10.16	2.42	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	4	1.76		85			0.58	>10
1.98	6.5	10.41	3.55	4	4	Silty Clay to Clay	CL	stiff	125	1.8	6	1.69		95			0.59	>10
2.13	7.0	11.62	4.38	3	3	Clay	CL/CH	stiff	125	1.3	9	1.62		100			0.66	>10
2.28	7.5	13.29	4.44	3	3	Clay	CL/CH	stiff	125	1.3	11	1.56		95			0.76	>10
2.45	8.0	14.55	4.93	3	3	Clay	CL/CH	stiff	125	1.3	12	1.51		95			0.83	>10
2.60	8.5	13.90	4.96	3	3	Clay	CL/CH	stiff	125	1.3	11	1.46		100			0.79	>10
2.75	9.0	13.23	4.08	3	3	Clay	CL/CH	stiff	125	1.3	11	1.42		95			0.75	>10
2.90	9.5	13.66	4.68	3	3	Clay	CL/CH	stiff	125	1.3	11	1.38		100			0.77	>10
3.05	10.0	26.88	5.00	3	3	Clay	CL/CH	very stiff	125	1.3	22	1.34		80			1.55	>10
3.20	10.5	21.69	5.01	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.32		90			1.24	>10
3.35	11.0	19.84	4.85	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.30		95			1.13	>10
3.50	11.5	21.31	4.45	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	12	1.29		90			1.22	>10
3.65	12.0	18.97	4.00	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	1.27		90			1.08	>10
3.80	12.5	16.82	3.88	4	4	Silty Clay to Clay	CL	stiff	125	1.8	10	1.26		95			0.95	>10
3.95	13.0	18.18	4.91	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.24		100			1.03	>10
4.13	13.5	17.33	5.43	3	3	Clay	CL/CH	stiff	125	1.3	14	1.23		100			0.98	>10
4.28	14.0	17.04	5.46	3	3	Clay	CL/CH	stiff	125	1.3	14	1.22		100			0.96	>10
4.43	14.5	21.21	5.45	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.20		100			1.20	>10
4.58	15.0	19.96	5.21	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.19		100			1.13	>10
4.73	15.5	23.41	4.80	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.18		95			1.33	>10
4.88	16.0	20.50	5.51	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.17		100			1.16	>10
5.03	16.5	21.94	5.88	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.15		100			1.24	>10
5.18	17.0	19.22	5.48	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.14		100			1.08	>10
5.33	17.5	27.57	5.03	3	3	Clay	CL/CH	very stiff	125	1.3	22	1.13		95			1.57	>10
5.48	18.0	23.29	5.22	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.12		100			1.32	>10
5.65	18.5	20.85	6.67	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.11		100			1.18	>10
5.80	19.0	21.33	6.77	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.10		100			1.20	>10
5.95	19.5	21.97	6.29	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.09		100			1.24	>10
6.10	20.0	21.34	7.09	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.08		100			1.20	>10
6.25	20.5	15.48	5.72	3	3	Clay	CL/CH	stiff	125	1.3	12	1.07		100			0.86	5.53
6.40	21.0	15.87	5.20	3	3	Clay	CL/CH	stiff	125	1.3	13	1.06		100			0.88	5.65
6.55	21.5	26.53	5.79	3	3	Clay	CL/CH	very stiff	125	1.3	21	1.05		100			1.50	>10
6.70	22.0	27.19	6.21	3	3	Clay	CL/CH	very stiff	125	1.3	22	1.05		100			1.54	>10
6.85	22.5	29.12	6.18	3	3	Clay	CL/CH	very stiff	125	1.3	23	1.04		100			1.65	>10
7.00	23.0	24.40	7.41	3	3	Clay	CL/CH	very stiff	125	1.3	20	1.03		100			1.38	>10
7.18	23.5	29.74	7.65	3	3	Clay	CL/CH	very stiff	125	1.3	24	1.02		100			1.69	>10
7.33	24.0	31.24	7.01	3	3	Clay	CL/CH	very stiff	125	1.3	25	1.01		100			1.78	>10
7.48	24.5	31.71	6.74	3	3	Clay	CL/CH	very stiff	125	1.3	25	1.01		100			1.80	>10
7.63	25.0	28.38	5.36	3	3	Clay	CL/CH	very stiff	125	1.3	23	1.00		100			1.61	>10
7.78	25.5	25.50	5.79	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.99		100			1.44	>10
7.93	26.0	21.23	6.01	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.98		100			1.18	7.00
8.08	26.5	19.41	6.26	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.98		100			1.08	6.00
8.23	27.0	21.10	6.12	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.97		100			1.17	6.65
8.38	27.5	20.13	6.30	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.96		100			1.12	6.00
8.53	28.0	19.23	5.66	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.96		100			1.06	5.42
8.68	28.5	20.08	5.65	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.95		100			1.11	5.76
8.85	29.0	20.55	5.67	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.94		100			1.14	5.88
9.00	29.5	20.76	7.00	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.94		100			1.15	5.88
9.15	30.0	22.80	6.88	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.93		100			1.27	6.65

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA Project No: LE04354 Date: 12/20/04

CONE SOUNDING: CPT-1

Est. GWT (ft): 12.0

Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Nk: Phi (deg.)	17.0 Su (tsf)	OCR
9.30	30.5	21.60	5.89	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.93		100			1.20	6.00
9.45	31.0	17.19	6.36	3	3	Clay	CL/CH	stiff	125	1.3	14	0.92		100			0.94	4.00
9.60	31.5	20.05	5.47	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.92		100			1.10	5.10
9.75	32.0	19.47	5.50	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.91		100			1.07	4.68
9.90	32.5	21.74	5.63	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.90		100			1.20	5.53
10.05	33.0	23.37	5.76	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.90		100			1.30	6.10
10.20	33.5	20.39	5.56	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.89		100			1.12	4.78
10.38	34.0	15.97	5.12	3	3	Clay	CL/CH	stiff	125	1.3	13	0.89		100			0.86	3.28
10.53	34.5	16.45	4.48	3	3	Clay	CL/CH	stiff	125	1.3	13	0.88		100			0.89	3.35
10.68	35.0	18.50	4.96	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.88		100			1.01	3.91
10.83	35.5	19.11	4.05	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.87		100			1.04	5.21
10.98	36.0	20.64	5.86	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.87		100			1.13	4.47
11.13	36.5	25.44	5.72	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.86		100			1.41	6.21
11.28	37.0	31.72	4.84	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	18	0.86		100			1.78	>10
11.43	37.5	25.49	3.77	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.85		100			1.41	>10
11.58	38.0	17.68	2.48	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.85		100			0.95	5.65
11.73	38.5	15.25	3.47	4	4	Silty Clay to Clay	CL	stiff	125	1.8	9	0.85		100			0.81	3.35
11.88	39.0	20.64	4.84	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.84		100			1.13	4.00
12.05	39.5	15.50	3.51	4	4	Silty Clay to Clay	CL	stiff	125	1.8	9	0.84		100			0.82	3.28
12.20	40.0	14.77	2.00	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.83		100			0.78	3.91
12.35	40.5	13.50	2.07	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	5	0.83		100			0.70	3.43
12.50	41.0	15.96	3.29	4	4	Silty Clay to Clay	CL	stiff	125	1.8	9	0.82		100			0.85	3.28
12.65	41.5	15.32	3.05	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.82		100			0.81	4.00
12.80	42.0	14.74	2.01	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.82		100			0.77	3.66
12.95	42.5	17.48	2.54	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.81		100			0.93	4.78
13.10	43.0	22.47	2.80	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.81		100			1.23	7.13
13.25	43.5	20.78	2.49	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.13	6.21
13.40	44.0	21.29	2.62	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.80		100			1.16	6.43
13.58	44.5	19.71	2.35	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.80		100			1.06	5.53
13.73	45.0	19.60	2.17	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.80		100			1.05	5.42
13.88	45.5	18.05	1.84	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.79	13.5	100	13	30		
14.03	46.0	17.42	2.29	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.79		100			0.92	4.28
14.18	46.5	19.49	2.03	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.79	14.5	100	15	30		
14.33	47.0	17.99	2.10	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.78		100			0.96	4.37
14.48	47.5	16.62	1.85	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.78		100			0.88	3.83
14.63	48.0	16.66	1.91	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.78		100			0.88	3.83
14.78	48.5	15.96	1.83	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.77		100			0.83	3.58
14.93	49.0	15.56	1.78	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.77		100			0.81	3.35
15.10	49.5	14.89	1.48	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	4	0.77	10.8	100	7	29		

CLIENT: ORMAT

PROJECT: ORMAT Heber 2 Facilities, Heber, CA

LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: HOLGUIN, FAHAN & ASSC. Truck Mounted Electric Cone with 23 ton reaction weight

DATE: 12/20/04

LOG OF CONE SOUNDING DATA CPT-2

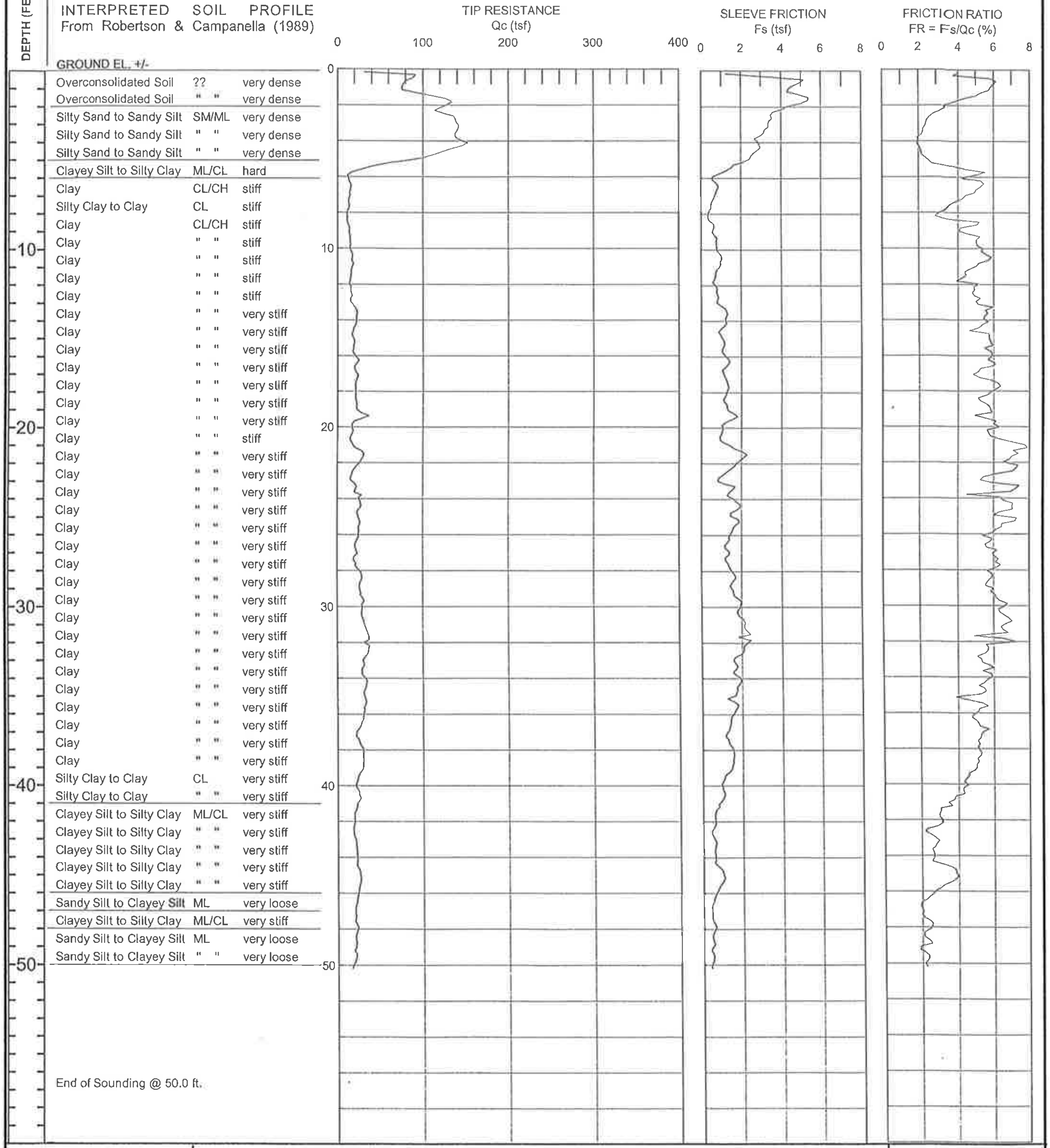
DEPTH (FEET)

INTERPRETED SOIL PROFILE
From Robertson & Campanella (1989)

GROUND EL. +/-

Overconsolidated Soil	??	very dense
Overconsolidated Soil	" "	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Silty Sand to Sandy Silt	" "	very dense
Clayey Silt to Silty Clay	ML/CL	hard
Clay	CL/CH	stiff
Silty Clay to Clay	CL	stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Silty Clay to Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Sandy Silt to Clayey Silt	ML	very loose
Clayey Silt to Silty Clay	ML/CL	very stiff
Sandy Silt to Clayey Silt	ML	very loose
Sandy Silt to Clayey Silt	" "	very loose

End of Sounding @ 50.0 ft.



Project No:
LE04354

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Plate
B-2

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA Project No: LE04354 Date: 12/20/04

CONE SOUNDING: CPT-2

Est. GWT (ft): 12.0 Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base	Base	Avg	Avg		1				Est.	Qc		Cn		Est.	Rel.	Nk:	17.0	
Depth	Depth	Tip	Friction		Soil	Soil		Density or	Density	to	SPT	or	Norm.	%	Dens.	Phi	Su	
meters	feet	Qc, tsf	Ratio, %		Type	Classification	USC	Consistency	(pcf)	N	N(60)	Cq	Qc1n	Fines	Dr (%)	(deg.)	(tsf)	OCR
0.15	0.5	70.28	4.52	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	28	2.00		50			4.13	>10
0.30	1.0	77.82	5.97	11	11	Overconsolidated Soil	??	very dense	120	1.0	78	2.00	147.1	55	110	43		
0.45	1.5	91.98	5.31	11	11	Overconsolidated Soil	??	very dense	120	1.0	92	2.00	173.9	50	107	43		
0.60	2.0	129.94	3.78	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	37	2.00	245.6	35	113	44		
0.75	2.5	119.62	3.11	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	34	2.00	226.1	30	107	43		
0.93	3.0	137.68	2.51	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	31	2.00	260.3	25	108	43		
1.08	3.5	140.87	2.30	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	31	2.00	266.3	25	106	43		
1.23	4.0	139.35	2.04	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	31	2.00	263.4	20	104	43		
1.38	4.5	144.85	2.01	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	32	2.00	273.8	20	103	42		
1.53	5.0	113.08	2.24	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	25	1.95	208.9	25	94	41		
1.68	5.5	52.70	3.38	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	21	1.86		50			3.08	>10
1.83	6.0	13.87	4.91	3	3	Clay	CL/CH	stiff	125	1.3	11	1.77		95			0.80	>10
1.98	6.5	15.08	5.36	3	3	Clay	CL/CH	stiff	125	1.3	12	1.70		95			0.87	>10
2.13	7.0	14.77	4.81	3	3	Clay	CL/CH	stiff	125	1.3	12	1.63		95			0.85	>10
2.28	7.5	13.38	3.90	3	3	Clay	CL/CH	stiff	125	1.3	11	1.57		90			0.76	>10
2.45	8.0	12.25	3.27	4	4	Silty Clay to Clay	CL	stiff	125	1.8	7	1.51		90			0.69	>10
2.60	8.5	11.34	3.86	3	3	Clay	CL/CH	stiff	125	1.3	9	1.46		100			0.64	9.79
2.75	9.0	13.62	4.43	3	3	Clay	CL/CH	stiff	125	1.3	11	1.42		95			0.77	>10
2.90	9.5	14.76	4.97	3	3	Clay	CL/CH	stiff	125	1.3	12	1.38		100			0.84	>10
3.05	10.0	15.04	5.19	3	3	Clay	CL/CH	stiff	125	1.3	12	1.34		100			0.85	>10
3.20	10.5	17.24	5.61	3	3	Clay	CL/CH	stiff	125	1.3	14	1.33		100			0.98	>10
3.35	11.0	17.82	5.31	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.31		100			1.01	>10
3.50	11.5	16.22	4.53	3	3	Clay	CL/CH	stiff	125	1.3	13	1.29		100			0.92	>10
3.65	12.0	14.59	4.45	3	3	Clay	CL/CH	stiff	125	1.3	12	1.28		100			0.82	9.19
3.80	12.5	15.95	4.89	3	3	Clay	CL/CH	stiff	125	1.3	13	1.26		100			0.90	>10
3.95	13.0	16.10	5.07	3	3	Clay	CL/CH	stiff	125	1.3	13	1.25		100			0.91	>10
4.13	13.5	20.52	5.55	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.23		100			1.17	>10
4.28	14.0	22.48	5.55	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.22		100			1.28	>10
4.43	14.5	20.89	5.42	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.21		100			1.19	>10
4.58	15.0	17.79	5.37	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.19		100			1.00	>10
4.73	15.5	19.47	5.86	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.18		100			1.10	>10
4.88	16.0	19.76	5.77	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.17		100			1.12	>10
5.03	16.5	22.53	5.91	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.16		100			1.28	>10
5.18	17.0	21.67	5.09	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.15		100			1.23	>10
5.33	17.5	22.15	5.77	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.13		100			1.25	>10
5.48	18.0	21.43	6.10	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.12		100			1.21	>10
5.65	18.5	21.56	5.34	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.11		100			1.22	>10
5.80	19.0	22.73	5.72	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.10		100			1.29	>10
5.95	19.5	30.63	5.48	3	3	Clay	CL/CH	very stiff	125	1.3	25	1.09		95			1.75	>10
6.10	20.0	17.95	6.14	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.08		100			1.00	7.41
6.25	20.5	17.30	5.70	3	3	Clay	CL/CH	stiff	125	1.3	14	1.07		100			0.96	6.65
6.40	21.0	16.60	6.99	3	3	Clay	CL/CH	stiff	125	1.3	13	1.07		100			0.92	6.10
6.55	21.5	26.75	7.44	3	3	Clay	CL/CH	very stiff	125	1.3	21	1.06		100			1.52	>10
6.70	22.0	28.17	6.81	3	3	Clay	CL/CH	very stiff	125	1.3	23	1.05		100			1.60	>10
6.85	22.5	20.17	7.24	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.04		100			1.13	7.85
7.00	23.0	16.15	5.62	3	3	Clay	CL/CH	stiff	125	1.3	13	1.03		100			0.89	5.21
7.18	23.5	21.37	6.84	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.02		100			1.20	8.27
7.33	24.0	24.23	5.98	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.02		100			1.36	>10
7.48	24.5	27.09	6.88	3	3	Clay	CL/CH	very stiff	125	1.3	22	1.01		100			1.53	>10
7.63	25.0	23.97	6.46	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.00		100			1.35	9.39
7.78	25.5	25.90	6.98	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.99		100			1.46	>10
7.93	26.0	24.80	6.17	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.99		100			1.39	9.59
8.08	26.5	22.94	5.66	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.98		100			1.28	8.00
8.23	27.0	22.28	5.92	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.97		100			1.24	7.27
8.38	27.5	20.15	6.14	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.97		100			1.12	6.10
8.53	28.0	24.13	6.05	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.96		100			1.35	8.14
8.68	28.5	28.28	5.86	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.95		100			1.59	>10
8.85	29.0	26.02	5.73	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.95		100			1.46	8.85
9.00	29.5	28.06	6.01	3	3	Clay	CL/CH	very stiff	125	1.3	22	0.94		100			1.58	>10
9.15	30.0	29.72	6.57	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.93		100			1.68	>10

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA　Project No: LE04354　Date: 12/20/04

CONE SOUNDING: CPT-2

Est. GWT (ft): 12.0

Phi Correlation: 0　0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Nk: Phi (deg.)	17.0 Su (tsf)	OCR
9.30	30.5	28.55	6.41	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.93		100			1.61	>10
9.45	31.0	31.07	6.84	3	3	Clay	CL/CH	very stiff	125	1.3	25	0.92		100			1.75	>10
9.60	31.5	34.71	6.59	3	3	Clay	CL/CH	very stiff	125	1.3	28	0.92		100			1.97	>10
9.75	32.0	35.27	6.25	3	3	Clay	CL/CH	very stiff	125	1.3	28	0.91		100			2.00	>10
9.90	32.5	37.01	5.65	3	3	Clay	CL/CH	hard	125	1.3	30	0.91		100			2.10	>10
10.05	33.0	32.37	5.31	3	3	Clay	CL/CH	very stiff	125	1.3	26	0.90		100			1.83	>10
10.20	33.5	30.28	5.70	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.89		100			1.70	9.59
10.38	34.0	29.97	5.71	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.89		100			1.68	9.19
10.53	34.5	34.16	5.42	3	3	Clay	CL/CH	very stiff	125	1.3	27	0.88		100			1.93	>10
10.68	35.0	31.53	5.44	3	3	Clay	CL/CH	very stiff	125	1.3	25	0.88		100			1.77	9.79
10.83	35.5	33.18	4.62	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	19	0.87		100			1.87	>10
10.98	36.0	31.41	5.32	3	3	Clay	CL/CH	very stiff	125	1.3	25	0.87		100			1.77	9.19
11.13	36.5	28.95	4.94	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.86		100			1.62	7.70
11.28	37.0	23.74	5.43	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.86		100			1.31	5.42
11.43	37.5	24.03	5.19	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.85		100			1.33	5.42
11.58	38.0	28.73	5.16	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.85		100			1.60	7.13
11.73	38.5	29.89	5.19	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.85		100			1.67	7.56
11.88	39.0	29.55	5.05	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.84		100			1.65	7.27
12.05	39.5	25.32	4.72	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.84		100			1.40	5.53
12.20	40.0	22.19	4.46	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.83		100			1.22	4.37
12.35	40.5	24.43	4.30	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	14	0.83		100			1.35	6.54
12.50	41.0	24.85	3.66	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.82		100			1.37	9.39
12.65	41.5	21.29	3.25	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.82		100			1.16	6.88
12.80	42.0	19.81	3.04	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.82		100			1.07	6.00
12.95	42.5	18.87	2.79	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.02	5.42
13.10	43.0	19.60	2.48	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.06	5.76
13.25	43.5	21.70	2.84	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.81		100			1.18	6.65
13.40	44.0	22.24	2.62	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.80		100			1.21	6.88
13.58	44.5	22.52	2.78	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.80		100			1.23	6.88
13.73	45.0	25.15	3.77	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.80		100			1.38	8.27
13.88	45.5	26.20	3.80	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.79		100			1.44	8.85
14.03	46.0	24.44	3.02	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.79		100			1.34	7.70
14.18	46.5	22.65	2.43	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.79		100			1.23	6.54
14.33	47.0	20.81	1.98	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.78	15.4	100	17	30		
14.48	47.5	20.51	2.12	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.78	15.1	100	17	30		
14.63	48.0	22.61	2.50	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.78		100			1.23	6.32
14.78	48.5	20.83	2.13	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.77	15.2	100	17	30		
14.93	49.0	20.93	2.27	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.77		100			1.13	5.42
15.10	49.5	20.67	2.11	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.77	15.0	100	16	30		
15.25	50.0	19.06	2.25	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.76		100			1.01	4.47

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: HOLGUIN, FAHAN & ASSC. Truck Mounted Electric Cone with 23 ton reaction weight
DATE: 12/20/04

LOG OF CONE SOUNDING DATA CPT-3

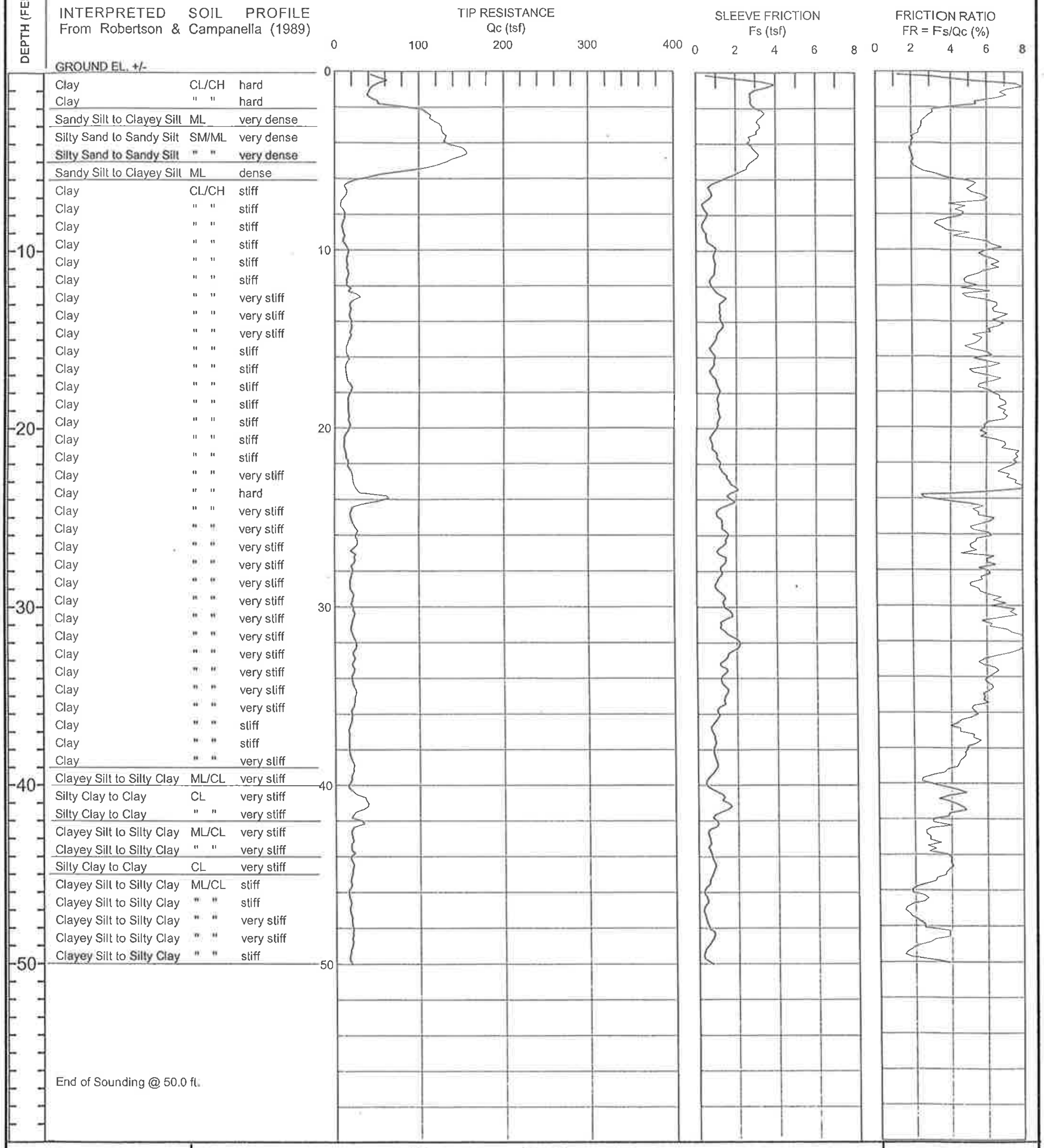
DEPTH (FEET)

INTERPRETED SOIL PROFILE
From Robertson & Campanella (1989)

GROUND EL. +/-

Clay	CL/CH	hard
Clay	" "	hard
Sandy Silt to Clayey Silt	ML	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Sandy Silt to Clayey Silt	ML	dense
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	hard
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Silty Clay to Clay	CL	very stiff
Silty Clay to Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clayey Silt to Silty Clay	ML/CL	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff

End of Sounding @ 50.0 ft.



Project No:
LE04354

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Plate
B-3

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA   Project No: LE04354   Date: 12/20/04

CONE SOUNDING: CPT-3

Est. GWT (ft): 12.0   Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Nk: 17.0

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Phi (deg.)	Su (tsf)	OCR
0.15	0.5	51.76	3.36	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	21	2.00		50			3.04	>10
0.30	1.0	46.42	7.56	3	3	Clay	CL/CH	hard	125	1.3	37	2.00		75			2.73	>10
0.45	1.5	40.35	6.79	3	3	Clay	CL/CH	hard	125	1.3	32	2.00		75			2.37	>10
0.60	2.0	61.72	4.80	4	4	Silty Clay to Clay	CL	hard	125	1.8	35	2.00		55			3.62	>10
0.75	2.5	109.67	3.07	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	31	2.00	207.3	35	104	43		
0.93	3.0	118.60	2.64	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	26	2.00	224.2	30	103	42		
1.08	3.5	127.70	2.43	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	28	2.00	241.4	25	103	42		
1.23	4.0	131.15	2.02	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	29	2.00	247.9	25	102	42		
1.38	4.5	147.55	1.96	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	33	2.00	278.9	20	103	42		
1.53	5.0	148.38	2.05	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	33	1.94	271.7	20	102	42		
1.68	5.5	111.44	2.28	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	25	1.85	194.4	25	92	41		
1.83	6.0	40.17	4.02	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	16	1.76		60			2.34	>10
1.98	6.5	13.36	5.18	3	3	Clay	CL/CH	stiff	125	1.3	11	1.69		100			0.76	>10
2.13	7.0	13.22	5.65	3	3	Clay	CL/CH	stiff	125	1.3	11	1.62		100			0.75	>10
2.28	7.5	7.68	4.85	3	3	Clay	CL/CH	firm	125	1.3	6	1.56		100			0.43	6.10
2.45	8.0	11.50	4.55	3	3	Clay	CL/CH	stiff	125	1.3	9	1.51		100			0.65	>10
2.60	8.5	10.61	3.49	4	4	Silty Clay to Clay	CL	stiff	125	1.8	6	1.46		95			0.60	>10
2.75	9.0	9.81	4.10	3	3	Clay	CL/CH	stiff	125	1.3	8	1.42		100			0.55	6.54
2.90	9.5	10.85	5.09	3	3	Clay	CL/CH	stiff	125	1.3	9	1.38		100			0.61	7.00
3.05	10.0	14.61	6.36	3	3	Clay	CL/CH	stiff	125	1.3	12	1.34		100			0.82	>10
3.20	10.5	14.97	5.91	3	3	Clay	CL/CH	stiff	125	1.3	12	1.32		100			0.85	>10
3.35	11.0	14.49	6.53	3	3	Clay	CL/CH	stiff	125	1.3	12	1.31		100			0.82	>10
3.50	11.5	15.94	5.42	3	3	Clay	CL/CH	stiff	125	1.3	13	1.29		100			0.90	>10
3.65	12.0	14.15	5.01	3	3	Clay	CL/CH	stiff	125	1.3	11	1.27		100			0.79	8.56
3.80	12.5	20.31	5.15	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.26		95			1.16	>10
3.95	13.0	23.81	5.79	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.24		95			1.36	>10
4.13	13.5	18.35	6.42	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.23		100			1.04	>10
4.28	14.0	18.13	6.73	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.22		100			1.02	>10
4.43	14.5	19.70	6.56	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.20		100			1.12	>10
4.58	15.0	18.07	5.71	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.19		100			1.02	>10
4.73	15.5	14.86	5.24	3	3	Clay	CL/CH	stiff	125	1.3	12	1.18		100			0.83	7.00
4.88	16.0	14.60	5.69	3	3	Clay	CL/CH	stiff	125	1.3	12	1.17		100			0.81	6.65
5.03	16.5	13.49	6.25	3	3	Clay	CL/CH	stiff	125	1.3	11	1.16		100			0.75	5.65
5.18	17.0	13.31	5.44	3	3	Clay	CL/CH	stiff	125	1.3	11	1.14		100			0.74	5.31
5.33	17.5	16.20	6.21	3	3	Clay	CL/CH	stiff	125	1.3	13	1.13		100			0.90	7.13
5.48	18.0	19.16	5.98	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.12		100			1.08	9.59
5.65	18.5	15.49	6.80	3	3	Clay	CL/CH	stiff	125	1.3	12	1.11		100			0.86	6.32
5.80	19.0	15.81	6.89	3	3	Clay	CL/CH	stiff	125	1.3	13	1.10		100			0.88	6.32
5.95	19.5	16.32	7.00	3	3	Clay	CL/CH	stiff	125	1.3	13	1.09		100			0.91	6.43
6.10	20.0	17.26	5.95	3	3	Clay	CL/CH	stiff	125	1.3	14	1.08		100			0.96	6.88
6.25	20.5	13.28	5.76	3	3	Clay	CL/CH	stiff	125	1.3	11	1.07		100			0.73	4.37
6.40	21.0	11.14	6.84	3	3	Clay	CL/CH	stiff	125	1.3	9	1.06		100			0.60	3.28
6.55	21.5	12.48	7.40	3	3	Clay	CL/CH	stiff	125	1.3	10	1.06		100			0.68	3.74
6.70	22.0	14.92	7.62	3	3	Clay	CL/CH	stiff	125	1.3	12	1.05		100			0.82	4.89
6.85	22.5	17.77	6.98	3	3	Clay	CL/CH	stiff	125	1.3	14	1.04		100			0.99	6.32
7.00	23.0	21.45	7.34	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.03		100			1.20	8.41
7.18	23.5	24.58	7.84	3	3	Clay	CL/CH	very stiff	125	1.3	20	1.02		100			1.39	>10
7.33	24.0	51.65	3.68	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	21	1.02		70			2.98	>10
7.48	24.5	34.37	4.91	3	3	Clay	CL/CH	very stiff	125	1.3	27	1.01		95			1.96	>10
7.63	25.0	18.84	5.44	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.00		100			1.05	6.10
7.78	25.5	21.09	6.11	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.99		100			1.18	7.13
7.93	26.0	26.12	5.49	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.99		100			1.47	>10
8.08	26.5	26.28	5.55	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.98		100			1.48	>10
8.23	27.0	21.92	5.06	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.97		100			1.22	7.13
8.38	27.5	23.63	6.15	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.97		100			1.32	8.00
8.53	28.0	20.49	6.07	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.96		100			1.14	6.10
8.68	28.5	19.11	5.87	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.95		100			1.06	5.31
8.85	29.0	18.15	5.24	3	3	Clay	CL/CH	stiff	125	1.3	15	0.95		100			1.00	4.78
9.00	29.5	21.72	6.18	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.94		100			1.21	6.32
9.15	30.0	20.63	6.55	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.93		100			1.14	5.65

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA Project No: LE04354 Date: 12/20/04

CONE SOUNDING: CPT-3

Est. GWT (ft): 12.0 Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base	Base	Avg	Avg		1				Est.	Qc		Cn		Est.	Rel.	Nk:	17.0	
Depth	Depth	Tip	Friction		Soil	Soil		Density or	Density	to	SPT	or	Norm.	%	Dens.	Phi	Su	
meters	feet	Qc, tsf	Ratio, %		Type	Classification	USC	Consistency	(pcf)	N	N(60)	Cq	Qc1n	Fines	Dr (%)	(deg.)	(tsf)	OCR
9.30	30.5	22.90	7.51	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.93		100			1.27	6.54
9.45	31.0	20.57	6.23	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.92		100			1.14	5.42
9.60	31.5	19.55	6.90	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.92		100			1.08	4.89
9.75	32.0	23.76	8.37	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.91		100			1.32	6.54
9.90	32.5	24.30	8.05	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.90		100			1.35	6.65
10.05	33.0	22.78	6.54	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.90		100			1.26	5.88
10.20	33.5	21.56	5.91	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.89		100			1.19	5.31
10.38	34.0	20.82	6.40	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.89		100			1.15	4.89
10.53	34.5	21.17	6.04	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.88		100			1.17	4.89
10.68	35.0	24.71	6.05	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.88		100			1.37	6.21
10.83	35.5	23.14	5.91	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.87		100			1.28	5.53
10.98	36.0	19.96	5.21	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.87		100			1.09	4.28
11.13	36.5	19.03	4.88	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.86		100			1.04	3.91
11.28	37.0	16.19	4.33	3	3	Clay	CL/CH	stiff	125	1.3	13	0.86		100			0.87	3.07
11.43	37.5	16.02	5.36	3	3	Clay	CL/CH	stiff	125	1.3	13	0.85		100			0.86	3.00
11.58	38.0	16.15	5.06	3	3	Clay	CL/CH	stiff	125	1.3	13	0.85		100			0.86	3.00
11.73	38.5	17.81	4.75	3	3	Clay	CL/CH	stiff	125	1.3	14	0.85		100			0.96	3.35
11.88	39.0	21.66	4.41	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	12	0.84		100			1.19	5.65
12.05	39.5	20.18	3.42	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.84		100			1.10	6.65
12.20	40.0	17.00	2.62	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.83		100			0.91	5.00
12.35	40.5	20.64	4.32	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	12	0.83		100			1.12	5.00
12.50	41.0	36.57	3.70	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	15	0.82		95			2.06	>10
12.65	41.5	31.64	4.64	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	18	0.82		100			1.77	>10
12.80	42.0	23.58	3.56	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.82		100			1.29	8.14
12.95	42.5	24.97	3.28	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.81		100			1.37	8.85
13.10	43.0	19.07	2.71	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.03	5.42
13.25	43.5	18.86	2.98	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.01	5.31
13.40	44.0	19.54	3.20	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.80		100			1.05	5.53
13.58	44.5	19.29	3.97	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.80		100			1.04	3.91
13.73	45.0	19.79	3.86	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.80		100			1.07	4.00
13.88	45.5	17.66	3.31	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.79		100			0.94	4.47
14.03	46.0	16.42	2.18	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.79		100			0.87	3.91
14.18	46.5	15.61	2.35	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.78		100			0.82	3.58
14.33	47.0	16.68	1.80	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.78	12.3	100	11	29		
14.48	47.5	18.25	1.80	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.78	13.4	100	13	30		
14.63	48.0	19.39	2.43	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.78		100			1.04	4.89
14.78	48.5	19.39	3.87	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.77		100			1.04	3.58
14.93	49.0	19.13	2.69	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.77		100			1.02	4.57
15.10	49.5	16.46	1.59	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.77	11.9	100	10	29		
15.25	50.0	16.91	2.83	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.76		100			0.89	3.74

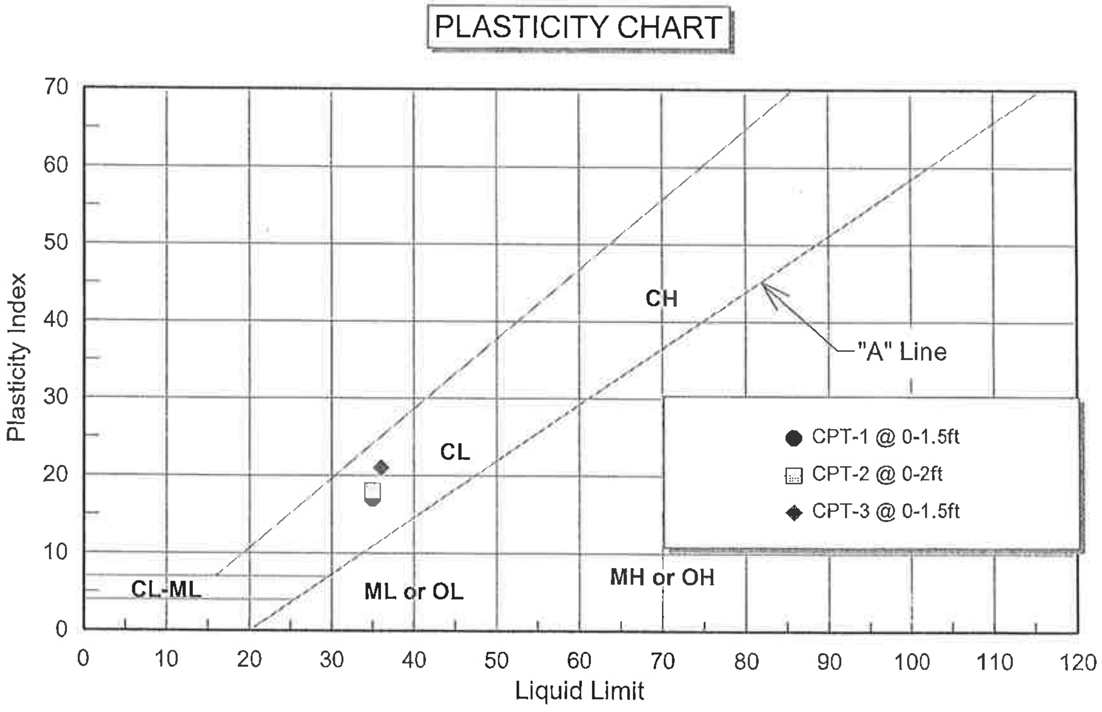
APPENDIX C

LANDMARK CONSULTANTS, INC.

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
JOB NO: LE04354
DATE: 12/28/04

ATTERBERG LIMITS (ASTM D4318)

Sample Location	Sample Depth (ft)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	USCS Classif-ation
CPT-1	0-1.5	35	18	17	CL
CPT-2	0-2	35	17	18	CL
CPT-3	0-1.5	36	15	21	CL



LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No: LE04354

Atterberg Limits
Test Results

Plate
C-1

LANDMARK CONSULTANTS, INC.

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
JOB NO: LE04354
DATE: 12/28/04

CHEMICAL ANALYSES

Boring:	CPT-1	CPT-1	CPT-2	CPT-2	**CalTrans**
Sample Depth, ft:	0-1.5	1.5-3	0-2	2-3	**Method**
pH:	7.9	7.9	7.8	7.9	**643**
Electrical Conductivity (mmhos):	2.5	1.7	1.8	0.9	**424**
Resistivity (ohm-cm):	260	1000	300	1000	**643**
Chloride (Cl), ppm:	3,040	230	1,490	220	**422**
Sulfate (SO4), ppm:	2,812	3,006	1,500	1,106	**417**

General Guidelines for Soil Corrosivity

Material Affected	Chemical Agent	Amount in Soil (ppm)	Degree of Corrosivity
Concrete	Soluble Sulfates	0 -1000	Low
		1000 - 2000	Moderate
		2000 - 20,000	Severe
		> 20,000	Very Severe
Normal Grade Steel	Soluble Chlorides	0 - 200	Low
		200 - 700	Moderate
		700 - 1500	Severe
		> 1500	Very Severe
Normal Grade Steel	Resistivity	1-1000	Very Severe
		1000-2000	Severe
		2000-10,000	Moderate
		10,000+	Low

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No: **LE04354**

Selected Chemical Analyses Results

Plate C-2

LANDMARK CONSULTANTS, INC.

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
JOB NO: LE04354
DATE: 12/28/04

CHEMICAL ANALYSES

Boring:	CPT-3	CPT-3	**CalTrans**
Sample Depth, ft:	0-1.5	1.5-3	**Method**
pH:	7.9	7.8	**643**
Electrical Conductivity (mmhos):	1.5	1.3	**424**
Resistivity (ohm-cm):	450	1000	**643**
Chloride (Cl), ppm:	570	210	**422**
Sulfate (SO4), ppm:	1,785	1,052	**417**

General Guidelines for Soil Corrosivity

Material Affected	Chemical Agent	Amount in Soil (ppm)	Degree of Corrosivity
Concrete	Soluble Sulfates	0 -1000	Low
		1000 - 2000	Moderate
		2000 - 20,000	Severe
		> 20,000	Very Severe
Normal Grade Steel	Soluble Chlorides	0 - 200	Low
		200 - 700	Moderate
		700 - 1500	Severe
		> 1500	Very Severe
Normal Grade Steel	Resistivity	1-1000	Very Severe
		1000-2000	Severe
		2000-10,000	Moderate
		10,000+	Low

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No: **LE04354**

Selected Chemical Analyses Results

Plate C-3

APPENDIX D

REFERENCES

Arango I., 1996, Magnitude Scaling Factors for Soil Liquefaction Evaluations: ASCE Geotechnical Journal, Vol. 122, No. 11.

Bartlett, Steven F. and Youd, T. Leslie, 1995, Empirical Prediction of Liquefaction-Induced Lateral Spread: ASCE Geotechnical Journal, Vol. 121, No. 4.

Blake, T. F., 2000, FRISKSP - A computer program for the probabilistic estimation of seismic hazard using faults as earthquake sources.

Boore, D. M., Joyner, W. B., and Fumal, T. E., 1997, Empirical Near-Source Attenuation Relationships for Horizontal and Vertical Components of Peak Ground Acceleration, Peak Ground Velocity, and Pseudo-Absolute Acceleration Response Spectra: Seismological Research Letters, Vol. 68, No. 1, p. 154-179.

Building Seismic Safety Council (BSSC), 1991, NEHRP recommended provisions for the development of seismic regulations of new buildings, Parts 1, 2 and Maps: FEMA 222, January 1992

California Division of Mines and Geology (CDMG), 1996, California Fault Parameters: available at http://www.consrv.ca.gov/dmg/shezp/fltindex.html.

California Division of Mines and Geology (CDMG), 1962, Geologic Map of California – San Diego-El Centro Sheet: California Division of Mines and Geology, Scale 1:250,000.

Ellsworth, W. L., 1990, Earthquake History, 1769-1989 in: The San Andreas Fault System, California: U.S. Geological Survey Professional Paper 1515, 283 p.

International Conference of Building Officials (ICBO), 1997, Uniform Building Code, 1997 Edition.

Ishihara, K. (1985), Stability of natural deposits during earthquakes, Proc. 11th Int. Conf. On Soil Mech. And Found. Engrg., Vol. 1, A. A. Balkema, Rotterdam, The Netherlands, 321-376.

Jennings, C. W., 1994, Fault activity map of California and Adjacent Areas: California Division of Mines and Geology, DMG Geologic Map No. 6.

Jones, L. and Hauksson, E., 1994, Review of potential earthquake sources in Southern California: Applied Technology Council, Proceedings of ATC 35-1.

Maley, R. P. and Etheredge, E. C., 1981, Strong motion data from the Westmorland, California earthquake of April 26, 1981: U.S. Geological Survey Open File Report 81-1149, 18 p.

Morton, P. K., 1977, Geology and mineral resources of Imperial County, California: California Division of Mines and Geology, County Report No. 7, 104 p.

Mualchin, L. and Jones, A. L., 1992, Peak acceleration from maximum credible earthquakes in California (Rock and Stiff Soil Sites): California Division of Mines and Geology, DMG Open File Report 92-01.

Naeim, F. and Anderson, J. C., 1993, Classification and evaluation of earthquake records for design: Earthquake Engineering Research Institute, NEHRP Report.

National Research Council, Committee of Earthquake Engineering, 1985, Liquefaction of Soils during Earthquakes: National Academy Press, Washington, D.C.

Porcella, R., Etheredge, E., Maley, R., and Switzer, J., 1987, Strong motion data from the Superstition Hills earthquake of November 24, 1987: U.S. Geological Survey Open File Report 87-672, 56 p.

Robertson, P. K. and Wride, C. E., 1996, Cyclic Liquefaction and its Evaluation based on the SPT and CPT, Proceeding of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils, NCEER Technical Report 97-0022, p. 41-88.

Seed, Harry B., Idriss, I. M., and Arango I., 1983, Evaluation of liquefaction potential using field performance data: ASCE Geotechnical Journal, Vol. 109, No. 3.

Seed, Harry B., et al, 1985, Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations: ASCE Geotechnical Journal, Vol. 113, No. 8.

Sharp, R. V., 1982, Tectonic setting of the Imperial Valley region: U.S. Geological Survey Professional Paper 1254, p. 5-14.

Sylvester, A. G., 1979, Earthquake damage in Imperial Valley, California May 18, 1940, as reported by T. A. Clark: Bulletin of the Seismological Society of America, v. 69, no. 2, p. 547-568.

Tokimatsu, K. and Seed H. B., 1987, Evaluation of settlements in sands due to earthquake shaking: ASCE Geotechnical Journal, v. 113, no. 8.

U.S. Geological Survey (USGS), 1982, The Imperial Valley California Earthquake of October 15, 1979: Professional Paper 1254, 451 p.

U.S. Geological Survey (USGS), 1990, The San Andreas Fault System, California, Professional Paper 1515.

U.S. Geological Survey (USGS), 1996, National Seismic Hazard Maps: available at http://gldage.cr.usgs.gov

Working Group on California Earthquake Probabilities (WGCEP), 1992, Future seismic hazards in southern California, Phase I Report: California Division of Mines and Geology.

Working Group on California Earthquake Probabilities (WGCEP), 1995, Seismic hazards in southern California, Probable Earthquakes, 1994-2014, Phase II Report: Southern California Earthquake Center.

Youd, T. Leslie and Garris, C. T., 1995, Liquefaction induced ground surface disruption: ASCE Geotechnical Journal, Vol. 121, No. 11.

Youd, T. L. et. al., 2001, Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils: Journal of Geotechnical and Geoenvironmental Engineering, Vol. 127, No. 10, p. 817-833.

Zimmerman, R. P., 1981, Soil survey of Imperial County, California, Imperial Valley Area: U.S. Dept. of Agriculture Soil Conservation Service, 112 p.

APPENDIX E

LANDMARK
Geo-Engineers and Geologists

780 N. 4th Street
El Centro, CA 92243
(760) 370-3000
(760) 337-8900 fax

77-948 Wildcat Drive
Palm Desert, CA 92211
(760) 360-0665
(760) 360-0521 fax

May 9, 2007

Mr. Yuri Gal
ORMAT Nevada, Inc.
947 Dogwood Road
Heber, CA 92249

Geotechnical Investigation
Proposed Heber South Geothermal Plant
Dogwood Road
Heber, California
LCI Project No. L07178

Dear Mr. Gal:

Landmark Consultants, Inc. is pleased to present this geotechnical report update for design and construction of the Heber South Geothermal Plant facility located on Dogwood Road south of Heber, California. The project site is located in the southwest corner of the existing Heber geothermal plant site. The proposed plant will consist of one OEC unit, one cooling tower, and various ancillary structures including pumps, filters, and shelter.

This update report presents selected elements of our findings and recommendations only. For the proper application of our findings and recommendations, reading of the full geotechnical report (LCI Report No. LE04354, dated January 5, 2005) is required, and are best evaluated with the active participation of the engineer of record who developed them.

The scope of work consisted of conducting two (2) electronic CPT soundings within the OEC and cooling tower footprints and review of the existing geotechnical report for the Heber 2 plant expansion (Landmark, 2005) to determine suitability of the prior geotechnical report for use with the design and construction of the proposed Heber South plant.

Small structures are planned for electrical control panels, consisting of masonry or panelized concrete construction. Expected footing loads are estimated at 1 to 2 kips per lineal foot for the small structures. Expected plant components, cooling tower and turbine/generator columns loads range from 5 to 400 kips. If structural loads exceed those stated above, we should be notified so we may evaluate their impact on foundation settlement and bearing capacity. Site development will include foundation support pad preparation and underground utility installation.

Subsurface Exploration

Subsurface exploration was performed on May 2, 2007 using Holguin, Fahan, & Associates, Inc. of Cypress, California to advance three (3) electric cone penetrometer (CPT) soundings to an approximate depth of 50 feet below existing ground surface. The soundings were made at the locations shown on the Site and Exploration Plan (Plate A-2). The approximate sounding locations were established in the field and plotted on the site map by sighting to discernable site features.

Interpretive logs of the CPT soundings were produced and presented in final form after review of field and laboratory data and are presented on Plates B-1 and B-2 in Appendix B. A key to the interpretation of CPT soundings is presented on Plate B-3. The stratification lines shown on the subsurface logs represent the approximate boundaries between the various strata. However, the transition from one stratum to another may be gradual over some range of depth.

Subsurface soils encountered during the field exploration conducted on May 2, 2007 consist of medium dense to dense silty sands extend to a depth of 4 to 5 feet below ground surface. Stiff to very stiff clays extend from 4 feet to a depth of 50 feet, the maximum depth of exploration. The subsurface logs (Plates B-1 and B-2) depict the stratigraphic relationships of the various soil types.

Groundwater Elevation

Groundwater was not noted in the CPT soundings at the time of exploration, but is typically encountered at approximately 10 to 15 feet below ground surface in the vicinity of the site. There is uncertainty in the accuracy of short-term water level measurements, particularly in fine-grained soil. Groundwater levels may fluctuate with precipitation, irrigation of adjacent properties, drainage, and site grading. The referenced groundwater level should not be interpreted to represent an accurate or permanent condition.

Seismic Parameters

The project site is located in the seismically active Imperial Valley in Southern California, and is considered likely to be subjected to moderate to strong ground shaking from earthquakes in the region. The project site lies approximately 11.3 km southwest of the Imperial Fault. Strong ground shaking can be expected for magnitudes of 6.0 to 7.2 events on the Imperial Fault with a recurrence interval for 6.0 magnitude events at about 29 years. We have used the computer program FRISKSP (Blake, 2000) to provide a probabilistic estimate of the site Peak Ground Acceleration (PGA) using the attenuation relationship of Boore, Joyner, and Fumal (1997) NEHRP D (250). The PGA estimate for the project site having a 10% probability of being exceeded in 50 years (return period of 475 years) is **0.60g**.

CBC Seismic Coefficients: The California Building Code (CBC) seismic response coefficients are calculated from the near-source factors for Seismic Zone 4. The near-source factors are based on the distance from the fault and the seismic source type. The following table lists seismic and site coefficients (near source factors) determined by Chapter 16 of the 2001 CBC. ***This site lies within 11.3 km of a Type A fault overlying S_D (stiff) soil.***

CBC Seismic Coefficients for Chapter 16 Seismic Provisions

CBC Code Edition	Soil Profile Type	Seismic Source Type	Distance to Critical Source	Near Source Factors		Seismic Coefficients	
				Na	Nv	Ca	Cv
2001	S_D (stiff soil)	A	< 11.3 km	1.00	1.15	0.44	0.74
Ref. Table	16-J	16-U	---	16-S	16-T	16-Q	16-R

Liquefaction Potential

Evaluation of liquefaction potential at the site indicates that it is unlikely that the subsurface soil will liquefy under seismically induced groundshaking due to the predominance of cohesive clay (non-liquefiable) subsurface soil below the groundwater depth. No mitigation is required for liquefaction effects at this site.

Lateral Earth Pressures

Earth retaining structures, such as retaining walls, should be designed to resist the soil pressure imposed by the retained soil mass. Walls with granular drained backfill may be designed for an assumed static earth pressure equivalent to that exerted by a fluid weighing 55 pcf for unrestrained (active) conditions (able to rotate 0.1% of wall height), and 70 pcf for restrained (at-rest) conditions.

Surcharge loads should be considered if loads are applied within a zone between the face of the wall and a plane projected behind the wall 45 degrees upward from the base of the wall. The increase in lateral earth pressure acting uniformly against the back of the wall should be taken as 50% of the surcharge load within this zone. Areas of the retaining wall subjected to traffic loads should be designed for a uniform surcharge load equivalent to two feet of native soil.

Walls should be provided with backdrains to reduce the potential for the buildup of hydrostatic pressure. The drainage system should consist of a composite HDPE drainage panel or a 2-foot wide zone of free draining crushed rock placed adjacent to the wall and extending 2/3 the height of the wall. The gravel should be completely enclosed in an approved filter fabric to separate the gravel and backfill soil. A perforated pipe should be placed perforations down at the base of the permeable material at least six inches below finished floor elevations. The pipe should be sloped to drain to an appropriate outlet that is protected against erosion. Walls should be properly waterproofed. The project geotechnical engineer should approve any alternative drain system.

Structure Support Pads/Foundation

The subsurface exploration conducted in May 2007 identified engineering properties of the soil nearly identical to the Landmark, 2005 geotechnical report. The findings and recommendations within the 2005 geotechnical report may be used for the Heber South project. A copy of the Landmark 2005 geotechnical report is provide in Appendix C.

Closure

We appreciate the opportunity to provide our findings and professional opinions regarding geotechnical conditions at the site. If you have any questions or comments regarding our findings, please call our office at (760) 370-3000.

Respectfully Submitted,
Landmark Consultants, Inc.

PROFESSIONAL GEOLOGIST
STEVEN K. WILLIAMS
CERTIFIED ENGINEERING GEOLOGIST
CEG 2261
STATE OF CALIFORNIA

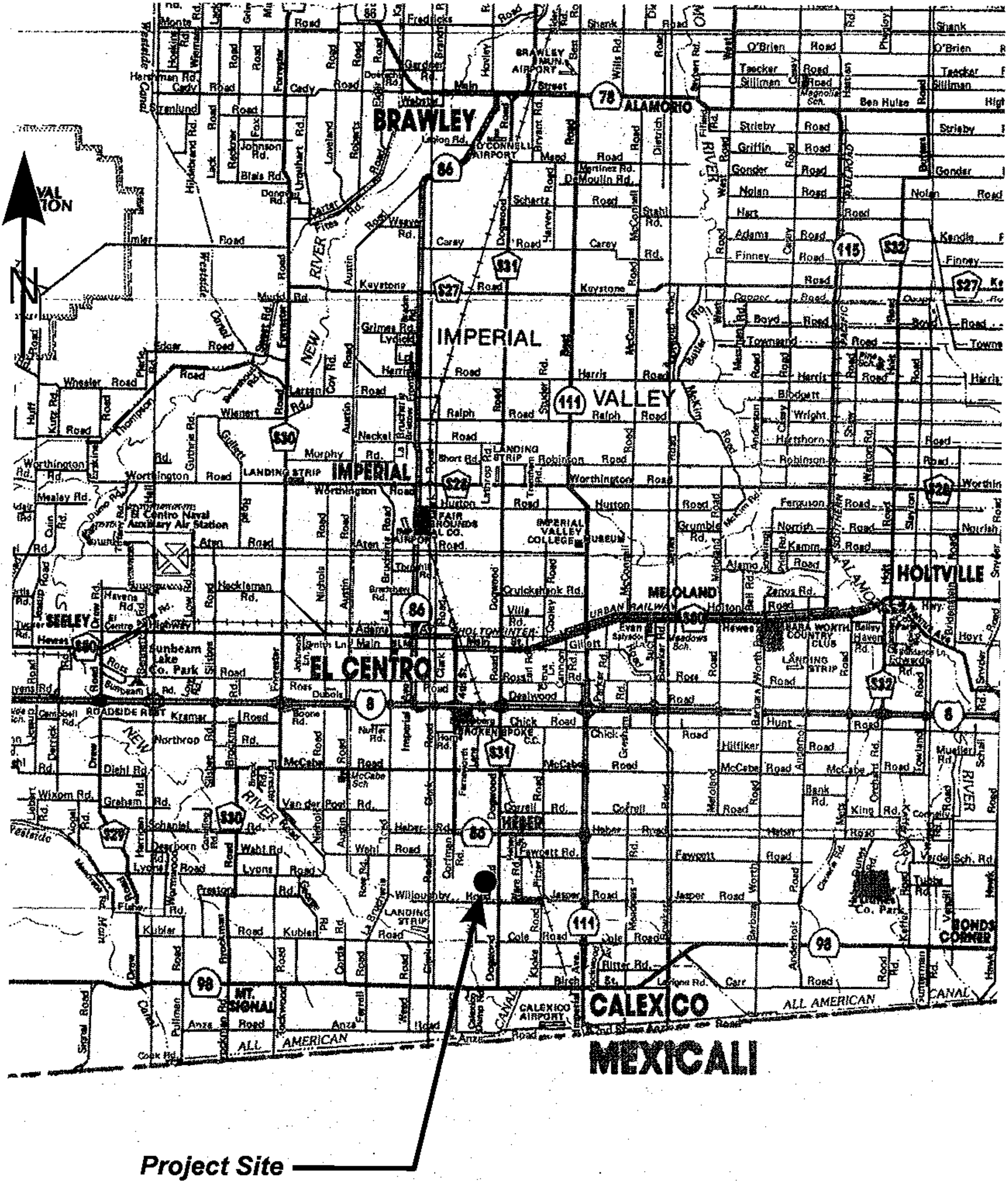
Steven K. Williams, CEG
Senior Engineering Geologist

Julian R. Avalos, EIT
Staff Engineer

REGISTERED PROFESSIONAL ENGINEER
JEFFREY O. LYON
No. 31921
EXPIRES 12-31-08
CIVIL
STATE OF CALIFORNIA

Jeffrey O. Lyon, PE
President

APPENDIX A



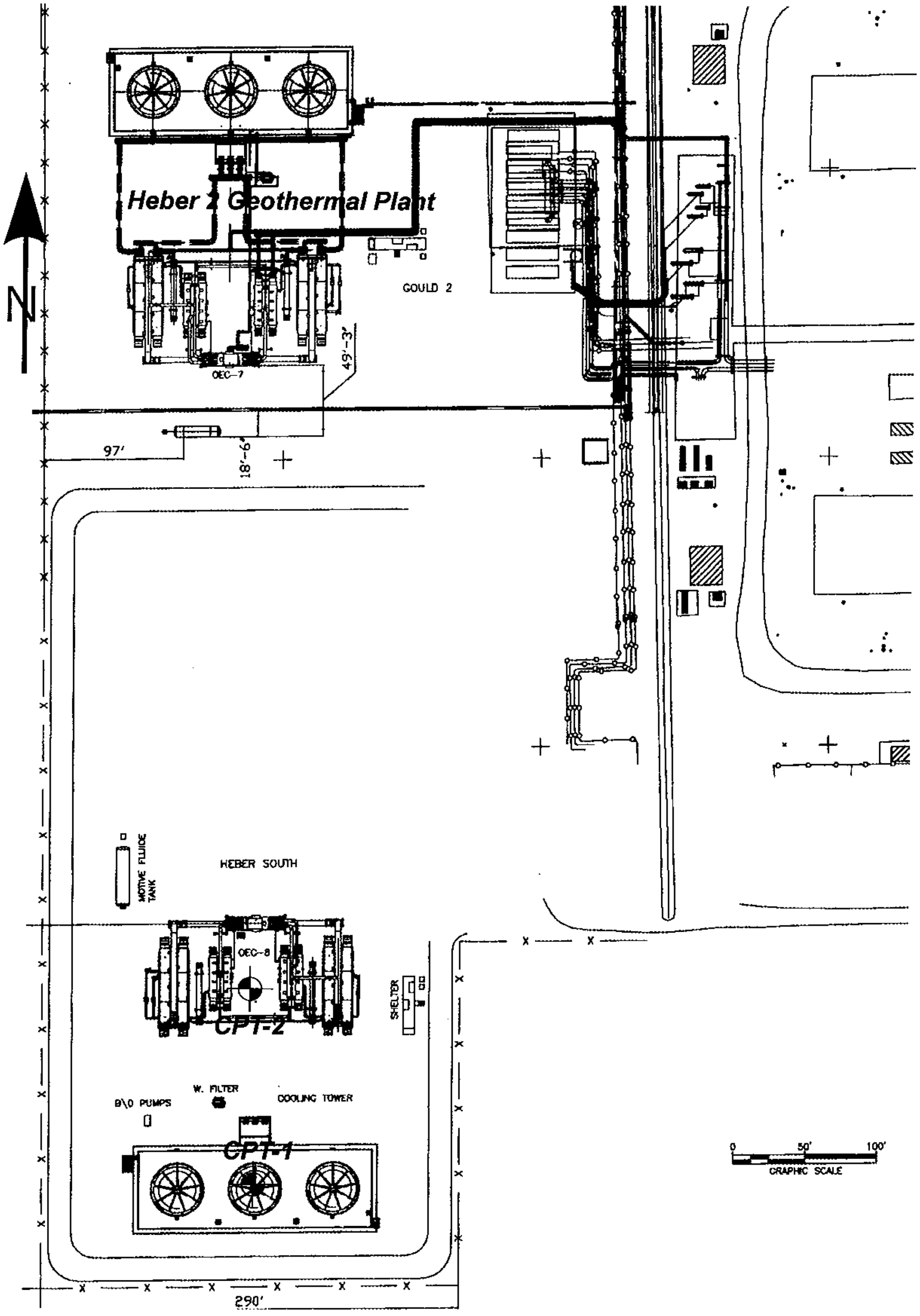
LANDMARK

Geo-Engineers and Geologists

Project No.: LE07178

Vicinity Map

Plate A-1



LANDMARK

Geo-Engineers and Geologists

Project No.: LE07178

Site and Exploration Map

Plate A-2

APPENDIX B

CLIENT: Ormat Nevada
PROJECT: Heber South Geothermal Plant -- Heber, CA
LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: HOLGUIN, FAHAN & ASSC. Truck Mounted Electric Cone with 23 ton reaction weight
DATE: 05/02/07

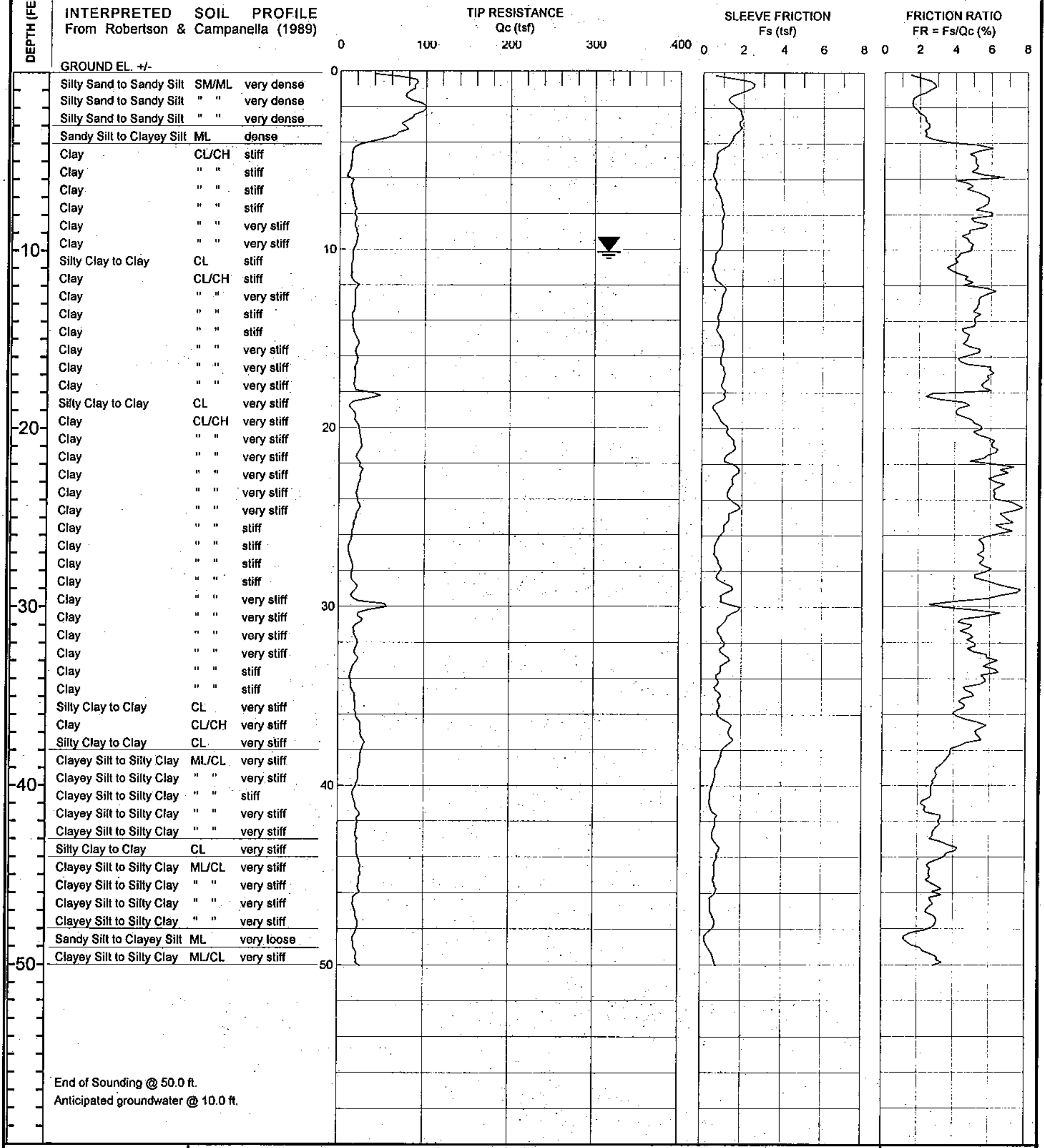
LOG OF CONE SOUNDING DATA CPT-1

INTERPRETED SOIL PROFILE
From Robertson & Campanella (1989)

GROUND EL. +/-

Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Silty Sand to Sandy Silt	" "	very dense
Sandy Silt to Clayey Silt	ML	dense
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	stiff
Clay	CL/CH	stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clay	CL/CH	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Silty Clay to Clay	CL	very stiff
Clay	CL/CH	very stiff
Silty Clay to Clay	CL	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Sandy Silt to Clayey Silt	ML	very loose
Clayey Silt to Silty Clay	ML/CL	very stiff

End of Sounding @ 50.0 ft.
Anticipated groundwater @ 10.0 ft.



Project No:
LE07178

LANDMARK
Geo-Engineers and Geologists

Plate
B-1

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber South Plant -- Heber, CA Project No: LE07178 Date: 05/02/07

CONE SOUNDING: CPT-1

Est. GWT (ft): 10.0

Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Nk: 17.0

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Phi (deg.)	Su (tsf)	OCR
0.15	0.5	66.25	2.04	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	15	2.00	125.2	35	122	45		
0.30	1.0	88.18	2.75	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	25	2.00	166.7	35	114	44		
0.45	1.5	77.73	1.95	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	17	2.00	146.9	30	103	42		
0.60	2.0	92.53	1.60	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	21	2.00	174.9	25	103	42		
0.75	2.5	93.95	2.02	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	21	2.00	177.6	25	100	42		
0.93	3.0	77.68	2.40	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	17	2.00	146.8	35	91	41		
1.08	3.5	74.47	2.39	6	6	Sandy Silt to Clayey Silt	ML	dense	115	3.5	21	2.00	140.8	35	88	40		
1.23	4.0	52.73	2.83	6	6	Sandy Silt to Clayey Silt	ML	dense	115	3.5	15	2.00	99.7	45	75	39		
1.38	4.5	18.49	5.55	3	3	Clay	CL/CH	very stiff	125	1.3	15	2.00		90			1.07	>10
1.53	5.0	13.75	5.02	3	3	Clay	CL/CH	stiff	125	1.3	11	1.95		100			0.79	>10
1.68	5.5	12.39	5.11	3	3	Clay	CL/CH	stiff	125	1.3	10	1.85		100			0.71	>10
1.83	6.0	10.98	5.45	3	3	Clay	CL/CH	stiff	125	1.3	9	1.77		100			0.63	>10
1.98	6.5	13.51	4.77	3	3	Clay	CL/CH	stiff	125	1.3	11	1.69		95			0.77	>10
2.13	7.0	14.72	5.56	3	3	Clay	CL/CH	stiff	125	1.3	12	1.62		100			0.84	>10
2.28	7.5	16.58	5.71	3	3	Clay	CL/CH	stiff	125	1.3	13	1.56		95			0.95	>10
2.45	8.0	17.99	5.72	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.51		95			1.03	>10
2.60	8.5	18.67	5.21	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.46		90			1.07	>10
2.75	9.0	19.02	5.07	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.42		90			1.09	>10
2.90	9.5	20.58	4.59	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.38		85			1.18	>10
3.05	10.0	17.46	4.91	3	3	Clay	CL/CH	stiff	125	1.3	14	1.34		95			0.99	>10
3.20	10.5	15.45	4.14	3	3	Clay	CL/CH	stiff	125	1.3	12	1.32		95			0.87	>10
3.35	11.0	13.93	3.83	4	4	Silty Clay to Clay	CL	stiff	125	1.8	8	1.31		100			0.78	>10
3.50	11.5	13.83	4.23	3	3	Clay	CL/CH	stiff	125	1.3	11	1.29		100			0.78	8.56
3.65	12.0	18.01	4.65	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.27		95			1.02	>10
3.80	12.5	18.70	5.93	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.26		100			1.06	>10
3.95	13.0	18.01	5.35	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.24		100			1.02	>10
4.13	13.5	17.39	5.15	3	3	Clay	CL/CH	stiff	125	1.3	14	1.23		100			0.98	>10
4.28	14.0	14.93	5.20	3	3	Clay	CL/CH	stiff	125	1.3	12	1.22		100			0.84	8.00
4.43	14.5	15.49	4.86	3	3	Clay	CL/CH	stiff	125	1.3	12	1.20		100			0.87	8.27
4.58	15.0	18.22	4.65	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.19		100			1.03	>10
4.73	15.5	22.11	4.64	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.18		95			1.26	>10
4.88	16.0	19.85	4.92	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.17		100			1.12	>10
5.03	16.5	19.77	4.96	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.16		100			1.12	>10
5.18	17.0	18.38	5.96	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.14		100			1.03	9.39
5.33	17.5	17.64	5.69	3	3	Clay	CL/CH	stiff	125	1.3	14	1.13		100			0.99	8.41
5.48	18.0	25.50	4.80	3	3	Clay	CL/CH	very stiff	125	1.3	20	1.12		95			1.45	>10
5.65	18.5	32.47	3.36	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	13	1.11		75			1.86	>10
5.80	19.0	13.48	4.36	3	3	Clay	CL/CH	stiff	125	1.3	11	1.10		100			0.74	4.89
5.95	19.5	18.41	4.55	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.09		100			1.03	8.00
6.10	20.0	22.07	5.36	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.08		100			1.25	>10
6.25	20.5	24.57	5.40	3	3	Clay	CL/CH	very stiff	125	1.3	20	1.07		100			1.39	>10
6.40	21.0	26.18	6.13	3	3	Clay	CL/CH	very stiff	125	1.3	21	1.07		100			1.49	>10
6.55	21.5	23.24	6.19	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.06		100			1.31	>10
6.70	22.0	22.66	5.55	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.05		100			1.28	>10
6.85	22.5	26.25	6.97	3	3	Clay	CL/CH	very stiff	125	1.3	21	1.04		100			1.49	>10
7.00	23.0	25.11	6.17	3	3	Clay	CL/CH	very stiff	125	1.3	20	1.03		100			1.42	>10
7.18	23.5	22.18	6.48	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.02		100			1.25	8.70
7.33	24.0	21.09	6.24	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.02		100			1.18	7.85
7.48	24.5	23.54	7.51	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.01		100			1.32	9.39
7.63	25.0	21.31	6.90	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.00		100			1.19	7.56
7.78	25.5	18.21	6.87	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.99		100			1.01	5.65
7.93	26.0	15.91	6.78	3	3	Clay	CL/CH	stiff	125	1.3	13	0.99		100			0.87	4.37
8.08	26.5	13.54	5.59	3	3	Clay	CL/CH	stiff	125	1.3	11	0.98		100			0.73	3.43
8.23	27.0	11.78	5.53	3	3	Clay	CL/CH	stiff	125	1.3	9	0.97		100			0.63	2.73
8.38	27.5	14.49	5.56	3	3	Clay	CL/CH	stiff	125	1.3	12	0.97		100			0.79	3.58
8.53	28.0	16.02	5.84	3	3	Clay	CL/CH	stiff	125	1.3	13	0.96		100			0.87	4.09
8.68	28.5	15.04	5.37	3	3	Clay	CL/CH	stiff	125	1.3	12	0.95		100			0.82	3.66
8.85	29.0	20.59	6.98	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.95		100			1.14	5.88
9.00	29.5	16.05	6.66	3	3	Clay	CL/CH	stiff	125	1.3	13	0.94		100			0.87	3.83
9.15	30.0	44.48	3.37	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	18	0.93		80			2.54	>10
9.30	30.5	27.03	5.86	3	3	Clay	CL/CH	very stiff	125	1.3	22	0.93		100			1.52	8.85

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber South Plant – Heber, CA Project No: LE07178 Date: 05/02/07

CONE SOUNDING: CPT-1

Est. GWT (ft): 10.0

Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base	Base	Avg	Avg		1				Est.	Qc		Cn		Est.	Rel.	Nk:	17.0	
Depth	Depth	Tip	Friction		Soil	Soil		Density or	Density	to	SPT	or	Norm.	%	Dens.	Phi	Su	
meters	feet	Qc, tsf	Ratio, %		Type	Classification	USC	Consistency	(pcf)	N	N(60)	Cq	Qc1n	Fines	Dr (%)	(deg.)	(tsf)	OCR
9.45	31.0	24.88	4.56	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.92		100			1.39	7.41
9.60	31.5	17.85	4.68	3	3	Clay	CL/CH	stiff	125	1.3	14	0.92		100			0.98	4.18
9.75	32.0	21.43	4.98	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.91		100			1.19	5.53
9.90	32.5	19.94	5.01	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.91		100			1.10	4.78
10.05	33.0	21.67	6.03	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.90		100			1.20	5.42
10.20	33.5	17.09	5.96	3	3	Clay	CL/CH	stiff	125	1.3	14	0.89		100			0.93	3.66
10.38	34.0	13.75	5.92	3	3	Clay	CL/CH	stiff	125	1.3	11	0.89		100			0.73	2.65
10.53	34.5	14.75	5.27	3	3	Clay	CL/CH	stiff	125	1.3	12	0.88		100			0.79	2.91
10.68	35.0	17.80	4.91	3	3	Clay	CL/CH	stiff	125	1.3	14	0.88		100			0.97	3.66
10.83	35.5	19.50	4.45	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.87		100			1.07	4.18
10.98	36.0	20.06	4.23	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.87		100			1.10	5.53
11.13	36.5	23.73	5.01	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.86		100			1.31	5.53
11.28	37.0	26.37	5.33	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.86		100			1.47	6.43
11.43	37.5	29.22	5.23	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.85		100			1.63	7.56
11.58	38.0	28.26	4.00	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	16	0.85		100			1.58	9.39
11.73	38.5	26.29	3.66	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	11	0.85		100			1.46	>10
11.88	39.0	24.98	3.19	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.84		100			1.38	>10
12.05	39.5	23.62	3.00	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.84		100			1.30	9.00
12.20	40.0	21.78	2.80	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.83		100			1.19	7.56
12.35	40.5	17.57	2.75	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.83		100			0.94	5.21
12.50	41.0	19.10	2.36	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.83		100			1.03	5.88
12.65	41.5	22.54	2.42	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.82		100			1.23	7.70
12.80	42.0	23.41	3.23	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.82		100			1.28	8.14
12.95	42.5	22.05	3.08	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.81		100			1.20	7.13
13.10	43.0	21.46	2.78	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.81		100			1.17	6.65
13.25	43.5	22.21	3.76	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	13	0.81		100			1.21	5.10
13.40	44.0	22.69	3.76	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	13	0.80		100			1.24	5.21
13.58	44.5	25.69	2.81	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.80		100			1.41	8.85
13.73	45.0	26.50	2.66	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	11	0.80		100			1.46	9.19
13.88	45.5	25.22	2.66	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.79		100			1.38	8.27
14.03	46.0	24.83	3.10	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.79		100			1.36	7.85
14.18	46.5	18.88	2.93	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.79		100			1.01	4.89
14.33	47.0	19.43	2.84	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.78		100			1.04	5.00
14.48	47.5	22.40	3.03	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.78		100			1.22	6.32
14.63	48.0	23.12	2.75	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.78		100			1.26	6.54
14.78	48.5	18.94	1.38	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.77	13.8	100	14	30		
14.93	49.0	18.77	1.78	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.77	13.7	100	14	30		
15.09	49.5	21.59	2.73	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.77		100			1.16	5.65
15.25	50.0	23.82	3.12	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.76		100			1.29	6.54

CLIENT: Ormat Nevada
PROJECT: Heber South Plant -- Heber, CA
LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: HOLGUIN, FAHAN & ASSC. Truck Mounted Electric Cone with 23 ton reaction weight
DATE: 05/02/07

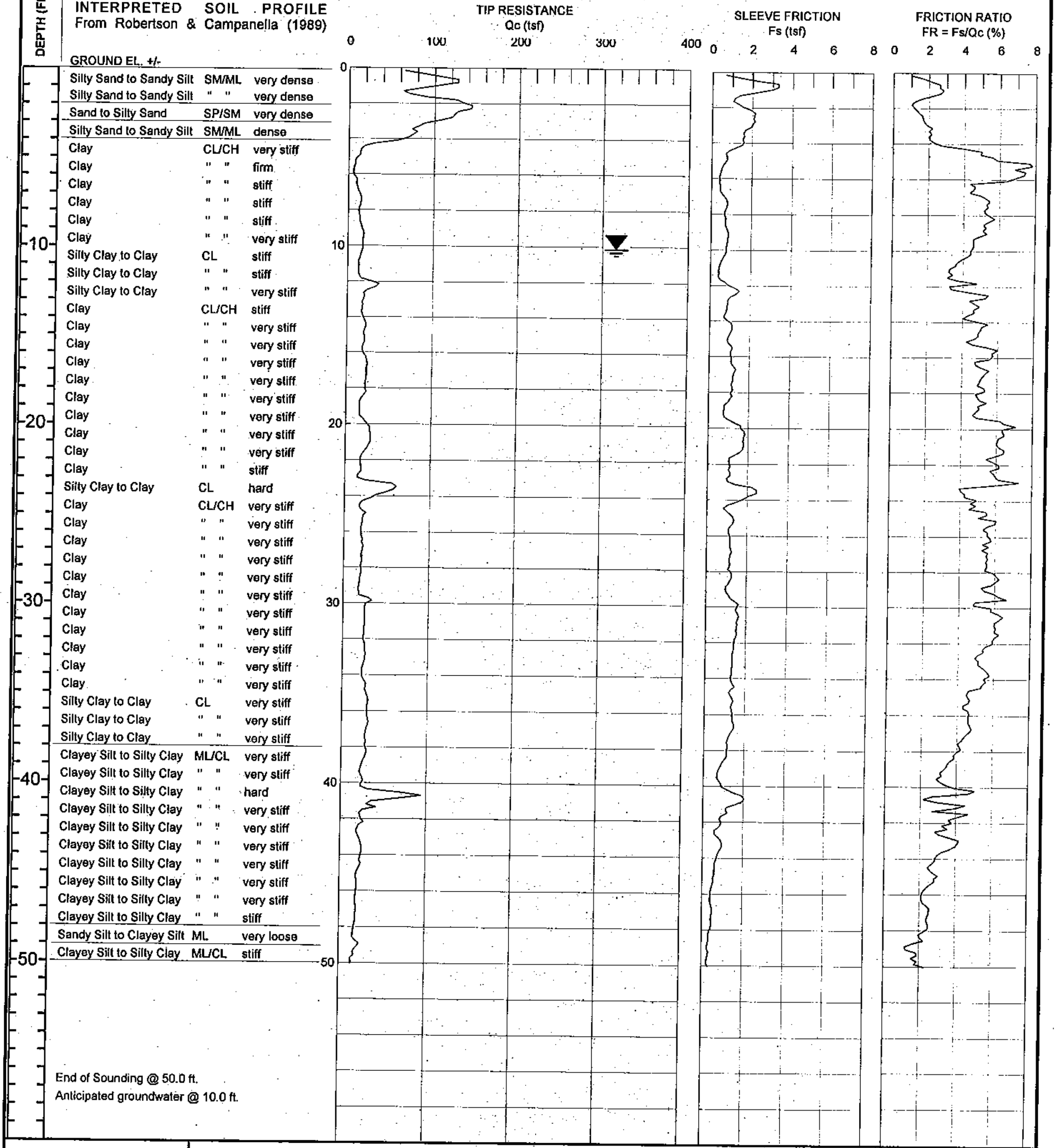
LOG OF CONE SOUNDING DATA CPT-2

DEPTH (FEET)

INTERPRETED SOIL PROFILE
From Robertson & Campanella (1989)

GROUND EL. +/-

Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Sand to Silty Sand	SP/SM	very dense
Silty Sand to Sandy Silt	SM/ML	dense
Clay	CL/CH	very stiff
Clay	" "	firm
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	stiff
Silty Clay to Clay	" "	stiff
Silty Clay to Clay	" "	very stiff
Clay	CL/CH	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Silty Clay to Clay	CL	hard
Clay	CL/CH	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Silty Clay to Clay	" "	very stiff
Silty Clay to Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	hard
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff
Sandy Silt to Clayey Silt	ML	very loose
Clayey Silt to Silty Clay	ML/CL	stiff



End of Sounding @ 50.0 ft.
Anticipated groundwater @ 10.0 ft.

Project No:
LE07178

LANDMARK
Geo-Engineers and Geologists

Plate
B-2

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber South Plant -- Heber, CA   Project No: LE07178   Date: 05/02/07

CONE SOUNDING: CPT-2

Est. GWT (ft): 10.0   Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base	Base	Avg	Avg		1				Est.	Qc		Cn		Est.	Rel.	Nk:	17.0	
Depth	Depth	Tip	Friction		Soil	Soil		Density or	Density	to	SPT	or	Norm.	%	Dens.	Phi	Su	
meters	feet	Qc, tsf	Ratio, %		Type	Classification	USC	Consistency	(pcf)	N	N(60)	Cq	Qc1n	Fines	Dr (%)	(deg.)	(tsf)	OCR
0.15	0.5	85.14	1.61	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	19	2.00	161.0	25	130	46		
0.30	1.0	120.36	2.66	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	27	2.00	227.5	30	124	45		
0.45	1.5	72.28	2.13	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	16	2.00	136.6	30	101	42		
0.60	2.0	116.67	1.12	8	8	Sand to Silty Sand	SP/SM	very dense	115	5.5	21	2.00	220.6	15	110	43		
0.75	2.5	138.05	1.48	8	8	Sand to Silty Sand	SP/SM	very dense	115	5.5	25	2.00	261.0	15	111	44		
0.93	3.0	117.13	1.76	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	26	2.00	221.4	20	104	42		
1.08	3.5	81.23	2.12	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	18	2.00	153.5	30	90	41		
1.23	4.0	74.63	2.12	7	7	Silty Sand to Sandy Silt	SM/ML	dense	115	4.5	17	2.00	141.1	30	86	40		
1.38	4.5	34.90	3.90	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	14	2.00		60			2.04	>10
1.53	5.0	13.76	5.45	3	3	Clay	CL/CH	stiff	125	1.3	11	1.96		100			0.79	>10
1.68	5.5	7.57	7.44	3	3	Clay	CL/CH	firm	125	1.3	6	1.86		100			0.43	>10
1.83	6.0	5.99	6.88	3	3	Clay	CL/CH	firm	125	1.3	5	1.77		100			0.33	6.10
1.98	6.5	9.47	4.51	3	3	Clay	CL/CH	stiff	125	1.3	8	1.69		100			0.54	>10
2.13	7.0	11.69	4.84	3	3	Clay	CL/CH	stiff	125	1.3	9	1.63		100			0.66	>10
2.28	7.5	14.81	5.37	3	3	Clay	CL/CH	stiff	125	1.3	12	1.57		95			0.85	>10
2.45	8.0	13.05	5.28	3	3	Clay	CL/CH	stiff	125	1.3	10	1.51		100			0.74	>10
2.60	8.5	13.41	5.40	3	3	Clay	CL/CH	stiff	125	1.3	11	1.46		100			0.76	>10
2.75	9.0	15.40	5.21	3	3	Clay	CL/CH	stiff	125	1.3	12	1.42		100			0.88	>10
2.90	9.5	18.24	4.66	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.38		90			1.04	>10
3.05	10.0	17.49	4.50	3	3	Clay	CL/CH	stiff	125	1.3	14	1.34		95			0.99	>10
3.20	10.5	16.07	4.15	3	3	Clay	CL/CH	stiff	125	1.3	13	1.32		95			0.91	>10
3.35	11.0	13.34	3.48	4	4	Silty Clay to Clay	CL	stiff	125	1.8	8	1.31		95			0.75	>10
3.50	11.5	12.52	3.24	4	4	Silty Clay to Clay	CL	stiff	125	1.8	7	1.29		100			0.70	9.79
3.65	12.0	18.93	3.91	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	1.28		90			1.08	>10
3.80	12.5	31.15	4.38	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	18	1.26		75			1.79	>10
3.95	13.0	19.46	4.78	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.25		95			1.10	>10
4.13	13.5	17.74	4.74	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.23		100			1.00	>10
4.28	14.0	17.58	4.34	3	3	Clay	CL/CH	stiff	125	1.3	14	1.22		100			0.99	>10
4.43	14.5	21.21	5.18	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.20		100			1.20	>10
4.58	15.0	20.43	4.83	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.19		100			1.16	>10
4.73	15.5	20.79	4.75	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.18		100			1.18	>10
4.88	16.0	18.89	5.75	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.17		100			1.07	>10
5.03	16.5	23.41	4.88	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.16		95			1.33	>10
5.18	17.0	23.59	5.34	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.14		100			1.34	>10
5.33	17.5	23.27	4.98	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.13		100			1.32	>10
5.48	18.0	22.19	5.13	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.12		100			1.26	>10
5.65	18.5	20.81	5.10	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.11		100			1.17	>10
5.80	19.0	15.78	4.92	3	3	Clay	CL/CH	stiff	125	1.3	13	1.10		100			0.88	6.32
5.95	19.5	16.06	5.23	3	3	Clay	CL/CH	stiff	125	1.3	13	1.09		100			0.89	6.32
6.10	20.0	22.81	6.58	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.08		100			1.29	>10
6.25	20.5	28.53	6.30	3	3	Clay	CL/CH	very stiff	125	1.3	23	1.07		100			1.62	>10
6.40	21.0	28.99	6.06	3	3	Clay	CL/CH	very stiff	125	1.3	23	1.07		100			1.65	>10
6.55	21.5	24.82	6.26	3	3	Clay	CL/CH	very stiff	125	1.3	20	1.06		100			1.40	>10
6.70	22.0	18.48	5.79	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.05		100			1.03	6.88
6.85	22.5	18.41	5.89	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.04		100			1.03	6.65
7.00	23.0	15.96	6.46	3	3	Clay	CL/CH	stiff	125	1.3	13	1.03		100			0.88	5.10
7.18	23.5	46.63	4.62	4	4	Silty Clay to Clay	CL	hard	125	1.8	27	1.02		80			2.68	>10
7.33	24.0	47.09	4.48	4	4	Silty Clay to Clay	CL	hard	125	1.8	27	1.02		80			2.71	>10
7.48	24.5	23.27	4.67	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.01		100			1.31	9.00
7.63	25.0	21.09	5.34	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.00		100			1.18	7.41
7.78	25.5	21.71	5.85	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.99		100			1.21	7.56
7.93	26.0	19.90	5.47	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.99		100			1.11	6.32
8.08	26.5	20.78	5.59	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.98		100			1.16	6.65
8.23	27.0	21.98	5.44	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.97		100			1.23	7.13
8.38	27.5	20.73	5.53	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.97		100			1.15	6.32
8.53	28.0	20.36	5.62	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.96		100			1.13	6.00
8.68	28.5	19.99	6.11	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.95		100			1.11	5.76
8.85	29.0	18.33	5.49	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.95		100			1.01	4.89
9.00	29.5	17.78	6.27	3	3	Clay	CL/CH	stiff	125	1.3	14	0.94		100			0.98	4.47
9.15	30.0	29.76	5.16	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.93		100			1.68	>10
9.30	30.5	25.36	6.14	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.93		100			1.42	7.85

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: Heber South Plant – Heber, CA Project No: LE07178 Date: 05/02/07

CONE SOUNDING: CPT-2

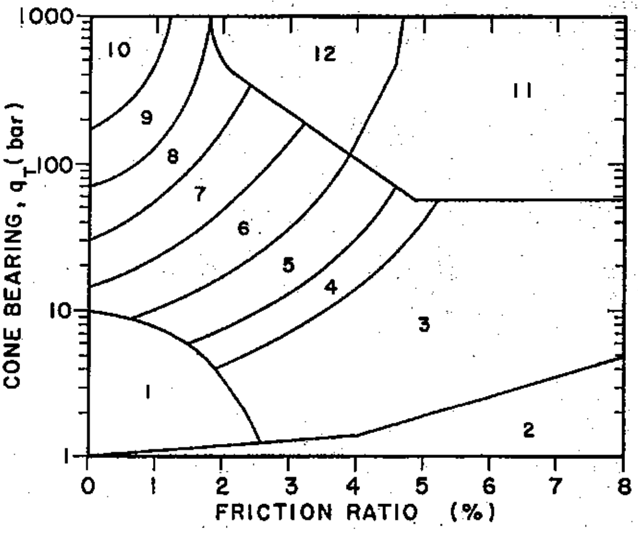
Est. GWT (ft): 10.0

Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Nk: Phi (deg.)	17.0 Su (tsf)	OCR
9.45	31.0	25.65	6.08	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.92		100			1.44	7.85
9.60	31.5	24.99	6.11	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.92		100			1.40	7.27
9.75	32.0	24.42	5.93	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.91		100			1.36	6.88
9.90	32.5	25.69	5.42	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.90		100			1.43	7.27
10.05	33.0	26.43	5.06	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.90		100			1.48	7.56
10.20	33.5	24.95	5.31	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.89		100			1.39	6.65
10.38	34.0	22.88	5.62	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.89		100			1.27	5.65
10.53	34.5	25.51	5.40	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.88		100			1.42	6.65
10.68	35.0	27.31	4.56	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	16	0.88		100			1.53	>10
10.83	35.5	30.04	4.55	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	17	0.87		100			1.69	>10
10.98	36.0	29.52	4.52	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	17	0.87		100			1.65	>10
11.13	36.5	30.25	4.64	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	17	0.86		100			1.70	>10
11.28	37.0	29.39	4.68	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	17	0.86		100			1.64	>10
11.43	37.5	27.60	4.22	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	16	0.85		100			1.54	9.00
11.58	38.0	27.92	4.11	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	16	0.85		100			1.56	9.00
11.73	38.5	28.57	3.77	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	11	0.85		100			1.59	>10
11.88	39.0	24.62	3.37	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.84		100			1.36	>10
12.05	39.5	22.28	3.04	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.84		100			1.22	8.00
12.20	40.0	24.64	3.45	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.83		100			1.36	9.59
12.35	40.5	41.78	4.14	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	17	0.83		95			2.37	>10
12.50	41.0	64.96	3.22	6	6	Sandy Silt to Clayey Silt	ML	medium dense	115	3.5	19	0.83	50.7	70	52	35		
12.65	41.5	32.37	3.75	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	13	0.82		100			1.81	>10
12.80	42.0	22.75	3.82	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	13	0.82		100			1.25	5.53
12.95	42.5	22.78	3.20	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.81		100			1.25	7.56
13.10	43.0	19.79	3.62	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.81		100			1.07	4.28
13.25	43.5	23.86	3.91	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	14	0.81		100			1.31	5.76
13.40	44.0	24.93	3.00	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.80		100			1.37	8.41
13.58	44.5	23.46	2.65	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.80		100			1.28	7.41
13.73	45.0	21.13	2.78	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.80		100			1.14	6.10
13.88	45.5	19.10	2.73	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.79		100			1.02	5.10
14.03	46.0	19.63	2.23	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.79		100			1.06	5.31
14.18	46.5	18.74	2.12	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	7	0.79		100			1.00	4.78
14.33	47.0	18.93	2.49	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.78		100			1.01	4.78
14.48	47.5	18.85	2.42	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.78		100			1.01	4.68
14.63	48.0	17.53	2.38	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.78		100			0.93	4.09
14.78	48.5	16.01	2.08	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.77		100			0.84	3.58
14.93	49.0	20.91	1.36	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.77	15.2	100	17	30		
15.09	49.5	17.29	1.76	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.77	12.5	100	11	30		
15.25	50.0	13.85	1.98	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.76		100			0.71	2.82

Simplified Soil Classification Chart

After Robertson & Campanella (1989)



Geotechnical Parameters from CPT Data:

Equivalent SPT N(60) blow count = Qc/(Qc/N Ratio)

N1(60) = Cn*N(60) Normalized SPT blow count

Cn = 1/(p'o)^0.5 < 1.6 max. from Liao & Whitman (1986)

p'o = effective overburden pressure (tsf) using unit densities
given below and estimated groundwater table.

Dr = Relative density (%) from Jamiolkowski et. al. (1986) relationship
= -98 +68*log(Qc/p'o^0.5) where Qc, p'o in tonne/sqm

Note: 1 tonne/sqm = 0.1024 tsf, 1 bar =1.0443 tsf

Phi = Friction Angle estimated from either:

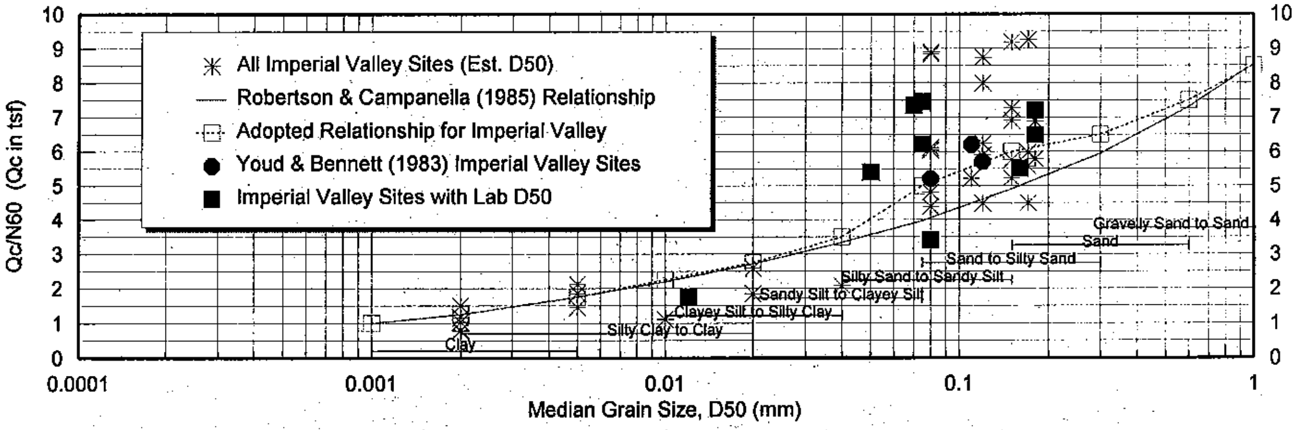
1. Roberton & Campanella (1983) chart:
   Phi = 5.3 + 24*(log(Qc/p'o))+3(log(Qc/p'o))^2
2. Peck, Hansen & Thornburn (1974) N-Phi Correlation
3. Schmertman (1978) chart [Phi = 28+0.14*Dr for fine uniform sands]

Su = undrained shear strength (tsf)

= (Qc-p'o)/Nk where Nk varies from 10 to 22, 17 for OC clays

OCR = Overconsolidation Ratio estimated from Schmertman (1978)
chart using Su/p'o ratio and estimated normal consolidated Su/p'o

Variation of Qc/N Ratio with Grain Size



Note: Assumed Properties and Adopted Qc/N Ratio based on correlations from Imperial Valley, California soils

Table of Soil Types and Assumed Properties

Zone	Soil Classification	UCS	Density (pcf)	R&C Qc/N	Adopted Qc/N	Est. PI	Fines (%)	D50 (mm)	Su (tsf)	Consistency
1	Sensitive fine grained	ML	120	2	2	NP-15	65-100	0.020	0-0.13	very soft
2	Organic Material	OL/OH	120	1	1	--	--	--	0.13-.25	soft
3	Clay	CL/CH	125	1	1.25	25-40+	90-100	0.002	0.25-0.5	firm
4	Silty Clay to Clay	CL	125	1.5	2	15-40	90-100	0.010	0.5-1.0	stiff
5	Clayey Silt to Silty Clay	ML/CL	120	2	2.75	5-25	90-100	0.020	1.0-2.0	very stiff
6	Sandy Silt to Clayey Silt	ML	115	2.5	3.5	NP-10	65-100	0.040	>2.0	hard
7	Silty Sand to Sandy Silt	SM/ML	115	3	5	NP	35-75	0.075	Dr (%)	Relative Density
8	Sand to Silty Sand	SP/SM	115	4	6	NP	5-35	0.150	0-15	very loose
9	Sand	SP	110	5	6.5	NP	0-5	0.300	15-35	loose
10	Gravelly Sand to Sand	SW	115	6	7.5	NP	0-5	0.600	35-65	medium dense
11	Overconsolidated Soil	--	120	1	1	NP	90-100	0.010	65-85	dense
12	Sand to Clayey Sand	SP/SC	115	2	2	NP-5	--	---	>85	very dense

LANDMARK
Geo-Engineers and Geologists

Project No: LE07178

Key to CPT Interpretation of Logs

Plate B-3

APPENDIX C

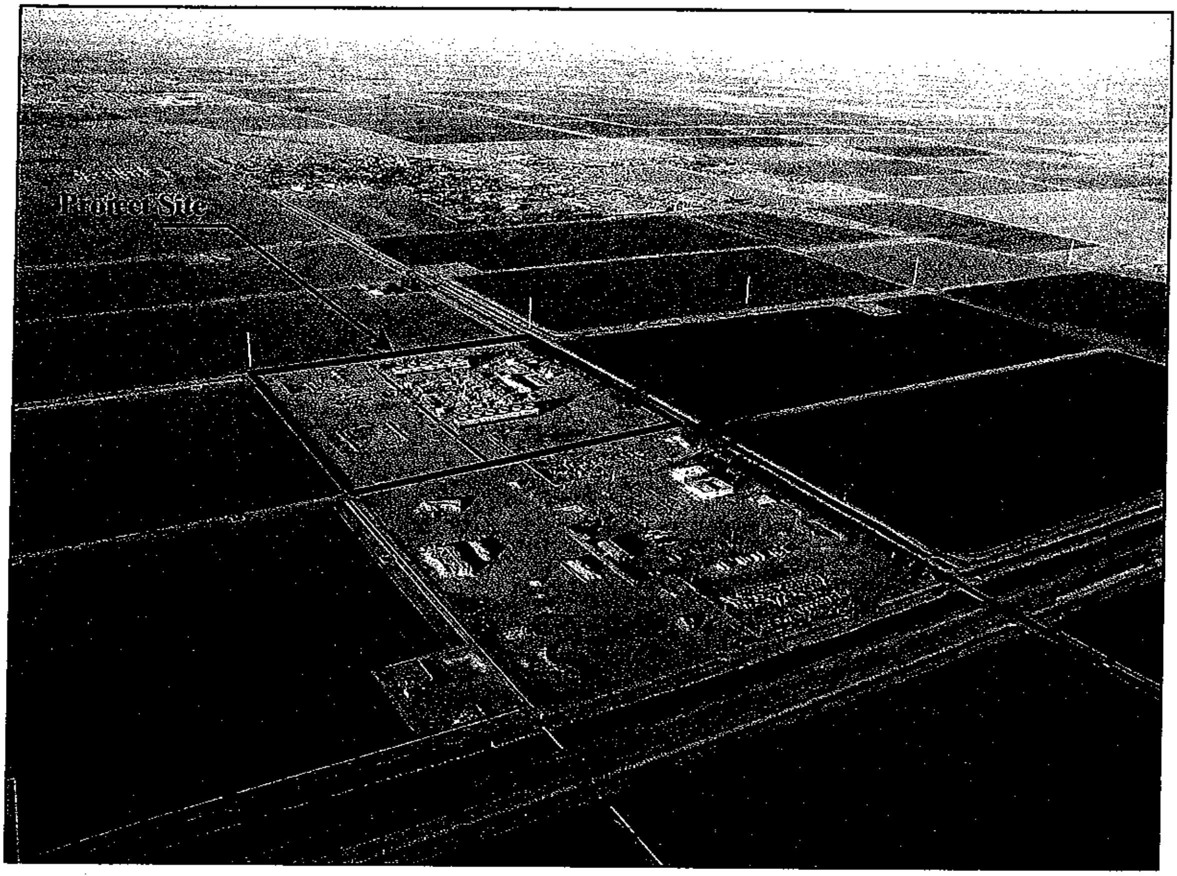
Geotechnical Report

New Turbine Generator and Cooling Tower
Heber 2 Geothermal Plant

Heber, CA

Prepared for:

ORMAT
947 Dogwood Road
Heber, CA 92249



LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Prepared by:

Landmark Consultants, Inc.
780 N. 4th Street
El Centro, CA 92243
(760) 370-3000

January 2005

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

780 N. 4th Street
El Centro, CA 92243
(760) 370-3000
(760) 337-8900 fax

77-948 Wildcat Drive
Palm Desert, CA 92211
(760) 360-0665
(760) 360-0521 fax

January 10, 2005

Mr. Mike Collins
ORMAT
947 Dogwood Road
Heber, CA 92249

Geotechnical Investigation
New Turbine Generator and Cooling Tower
Heber 2 Geothermal Plant
Dogwood Road
Heber, California
LCI Report No. LE04354 (2)

Dear Mr. Collins:

This geotechnical report is provided for design and construction of the new turbine generator and cooling tower additions to the Ormat Heber 2 geothermal power plant located on Dogwood Road southwest of Heber, California. Our geotechnical investigation was conducted in response to your request for our services. The enclosed report describes our soil engineering investigation and presents our professional opinions regarding geotechnical conditions at the site to be considered in the design and construction of the project.

This executive summary presents ***selected*** elements of our findings and recommendations only. It ***does not*** present crucial details needed for the proper application of our findings and recommendations. Our findings, recommendations, and application options are related ***only through reading the full report***, and are best evaluated with the active participation of the engineer of record who developed them.

The findings of this study indicate that the site is predominantly underlain by clays of moderate expansion.

The soil are highly corrosive to metals and contain sufficient sulfates and chlorides to require special concrete mixes (4,500 psi with a 0.45 maximum water cement ratio) and protection of embedded steel building components when concrete is placed in contact with native soil. If the native soils are replaced with imported granular soils with low sulfate and chloride content, no special concrete mixes are required.

Evaluation of liquefaction potential at the site indicates that it is unlikely that the subsurface soil will liquefy under seismically induced groundshaking due to the nature of the soil (clays soils predominate). No mitigation is required for liquefaction effects at this site.

Foundation settlements are indicated on figures 2 thru 5. Differential settlement is estimated to be about of two-thirds of total settlement.

We did not encounter soil conditions that would preclude development of the site for its intended use provided the recommendations contained in this report are implemented in the design and construction of this project.

We appreciate the opportunity to provide our findings and professional opinions regarding geotechnical conditions at the site. If you have any questions or comments regarding our findings, please call our office at (760) 370-3000.

Respectfully Submitted,
Landmark Consultants, Inc.

Steven K. Williams, CEG
Senior Engineering Geologist

REGISTERED GEOLOGIST
STEVEN K. WILLIAMS
CERTIFIED ENGINEERING GEOLOGIST
CEG 2261
STATE OF CALIFORNIA

Julian R. Avalos
Staff Engineer

Jeffrey O. Lyon, PE
President

REGISTERED PROFESSIONAL ENGINEER
JEFFREY O. LYON
No. 31921
EXPIRES 12-31-~~04~~ 06
CIVIL
STATE OF CALIFORNIA

Distribution:
Client (4)

TABLE OF CONTENTS

Section 1
INTRODUCTION

1.1 Project Description

This report presents the findings of our geotechnical investigation for the proposed additions to the Ormat Heber 2 geothermal power plant located on Dogwood Road southwest of Heber, California (See Vicinity Map, Plate A-1). The proposed development will consist of the addition of one (1) turbine/generator set and one (1) cooling tower. A site plan for the proposed power plant improvements was not made available to us at the time that this report was prepared.

Small structures may be are planned for electrical control panels, consisting of masonry or panelized concrete construction. Expected footing loads are estimated at 1 to 2 kips per lineal foot for the small structures. Expected plant components, cooling tower and turbine/generator columns loads range from 5 to 400 kips. If structural loads exceed those stated above, we should be notified so we may evaluate their impact on foundation settlement and bearing capacity. Site development will include foundation support pad preparation and underground utility installation.

1.2 Purpose and Scope of Work

The purpose of this geotechnical study was to investigate the upper 50 feet of subsurface soil at selected locations within the site for physical/engineering properties. From the subsequent field and laboratory data, professional opinions were developed and are provided in this report regarding geotechnical conditions at this site and the effect on design and construction. The scope of our services consisted of the following:

- Field exploration and in-situ testing of the site soils at selected locations and depths.
- Laboratory testing for physical properties of selected samples.
- A review of the available literature and publications pertaining to local geology, faulting, and seismicity.
- Engineering analysis and evaluation of the data collected.
- Preparation of this report presenting our findings, professional opinions, and recommendations for the geotechnical aspects of project design and construction.

This report addresses the following geotechnical issues:

- Subsurface soil and groundwater conditions
- Site geology, regional faulting and seismicity, near source factors, and site seismic accelerations
- Liquefaction potential and its mitigation
- Expansive soil and methods of mitigation
- Aggressive soil conditions to metals and concrete

Professional opinions with regard to the above issues are presented for the following:

- Site grading and earthwork
- Foundation subgrade preparation
- Allowable soil bearing pressures and expected settlements
- Concrete slabs-on-grade
- Mitigation of the potential effects of salt concentrations in native soil to concrete mixes and steel reinforcement
- Seismic design parameters

Our scope of work for this report did not include an evaluation of the site for the presence of environmentally hazardous materials or conditions.

1.3 Authorization

Mr. Mike Collins, Project Manager of Ormat for Power Generation Construction provided authorization by written agreement to proceed with our work on December 14, 2004. We conducted our work according to our written proposal dated December 13, 2004.

Section 2
METHODS OF INVESTIGATION

2.1 Field Exploration

Subsurface exploration was performed on December 20, 2004 using Holguin, Fahan, & Associates, Inc. of Cypress, California to advance three (3) electric cone penetrometer (CPT) soundings to an approximate depth of 50 feet below existing ground surface. The soundings were made at the locations shown on the Site and Exploration Plan (Plate A-2). The approximate sounding locations were established in the field and plotted on the site map by sighting to discernable site features.

CPT soundings provide a continuous profile of the soil stratigraphy with readings every 2.5cm (1 inch) in depth. Direct sampling for visual and physical confirmation of soil properties has been used by our firm to establish direct correlations with CPT exploration in this geographical region.

The CPT exploration was conducted by hydraulically advancing an instrumented Hogentogler 10cm^2 conical probe into the ground at a rate of 2cm per second using a 23-ton truck as a reaction mass. An electronic data acquisition system recorded a nearly continuous log of the resistance of the soil against the cone tip (Qc) and soil friction against the cone sleeve (Fs) as the probe was advanced. Empirical relationships (Robertson and Campanella, 1989) were then applied to the data to give a continuous profile of the soil stratigraphy. Interpretation of CPT data provides correlations for SPT blow count, phi (ϕ) angle (soil friction angle), undrained shear strength (S_u) of clays and over-consolidation ratio (OCR). These correlations may then be used to evaluate vertical and lateral soil bearing capacities and consolidation characteristics of the subsurface soil.

Interpretive logs of the CPT soundings were produced and presented in final form after review of field and laboratory data and are presented on Plates B-1 through B-3 in Appendix B. A key to the interpretation of CPT soundings is presented on Plate B-4. The stratification lines shown on the subsurface logs represent the approximate boundaries between the various strata. However, the transition from one stratum to another may be gradual over some range of depth.

2.2 Laboratory Testing

Laboratory tests were conducted on selected bulk soil samples obtained from hand auger borings made adjacent to the CPT locations to aid in classification and evaluation of selected engineering properties of the near surface soils. The tests were conducted in general conformance to the procedures of the American Society for Testing and Materials (ASTM) or other standardized methods as referenced below. The laboratory testing program consisted of the following tests:

- Plasticity Index (ASTM D4318) – used for soil classification and expansive soil design criteria.
- Chemical Analyses (soluble sulfates & chlorides, pH, and resistivity) (Caltrans Methods) – used for concrete mix evaluations and corrosion protection requirements.

The laboratory test results are presented on the subsurface logs (Appendix B) and on Plates C-1, C-2 and C-3 in Appendix C.

Engineering parameters of soil strength, compressibility and relative density utilized for developing design criteria provided within this report were either extrapolated from correlations with the subsurface CPT data or from data obtained from the field and laboratory testing program.

Section 3
DISCUSSION

3.1 Site Conditions

The plant additions are located in the northwest corner of the Heber 2 geothermal plant on the west side of the existing turbine generators and cooling tower. The area is relatively vacant and approximately has the same elevation as the existing plant facilities. An overhead pipe rack is located to the south side of the proposed location.

Adjacent properties outside of the fenced operations yard consist of agricultural land to the north and west. The site is bounded on the east by Dogwood Road and headquarters facilities of a general engineering construction company lie to the south side. Dogwood Road is slated to be a 6-lane north-south arterial from Calexico to Brawley in Imperial County. Adjacent properties are flat-lying and are approximately at the same elevation with this site.

The project site lies at an elevation of approximately 15 feet below mean sea level (MSL) (El. 985 local datum) in the Imperial Valley region of the California low desert. The surrounding properties lie on terrain which is flat (planar), part of a large agricultural valley, which was previously an ancient lake bed covered with fresh water to an elevation of 43± feet above MSL. Annual rainfall in this arid region is less than 4 inches per year with four months of average summertime temperatures above 100 °F. Winter temperatures are mild, seldom reaching freezing.

3.2 Geologic Setting

The project site is located in the Imperial Valley portion of the Salton Trough physiographic province. The Salton Trough is a geologic structural depression resulting from large scale regional faulting. The trough is bounded on the northeast by the San Andreas Fault and Chocolate Mountains and the southwest by the Peninsular Range and faults of the San Jacinto Fault Zone. The Salton Trough represents the northward extension of the Gulf of California, containing both marine and non-marine sediments since the Miocene Epoch. Tectonic activity that formed the trough continues at a high rate as evidenced by deformed young sedimentary deposits and high levels of seismicity. Figure 1 shows the location of the site in relation to regional faults and physiographic features.

The Imperial Valley is directly underlain by lacustrine deposits, which consist of interbedded lenticular and tabular silt, sand, and clay. The Late Pleistocene to Holocene lake deposits are probably less than 100 feet thick and derived from periodic flooding of the Colorado River which intermittently formed a fresh water lake (Lake Cahuilla). Older deposits consist of Miocene to Pleistocene non-marine and marine sediments deposited during intrusions of the Gulf of California. Basement rock consisting of Mesozoic granite and Paleozoic metamorphic rocks are estimated to exist at depths between 15,000 - 20,000 feet.

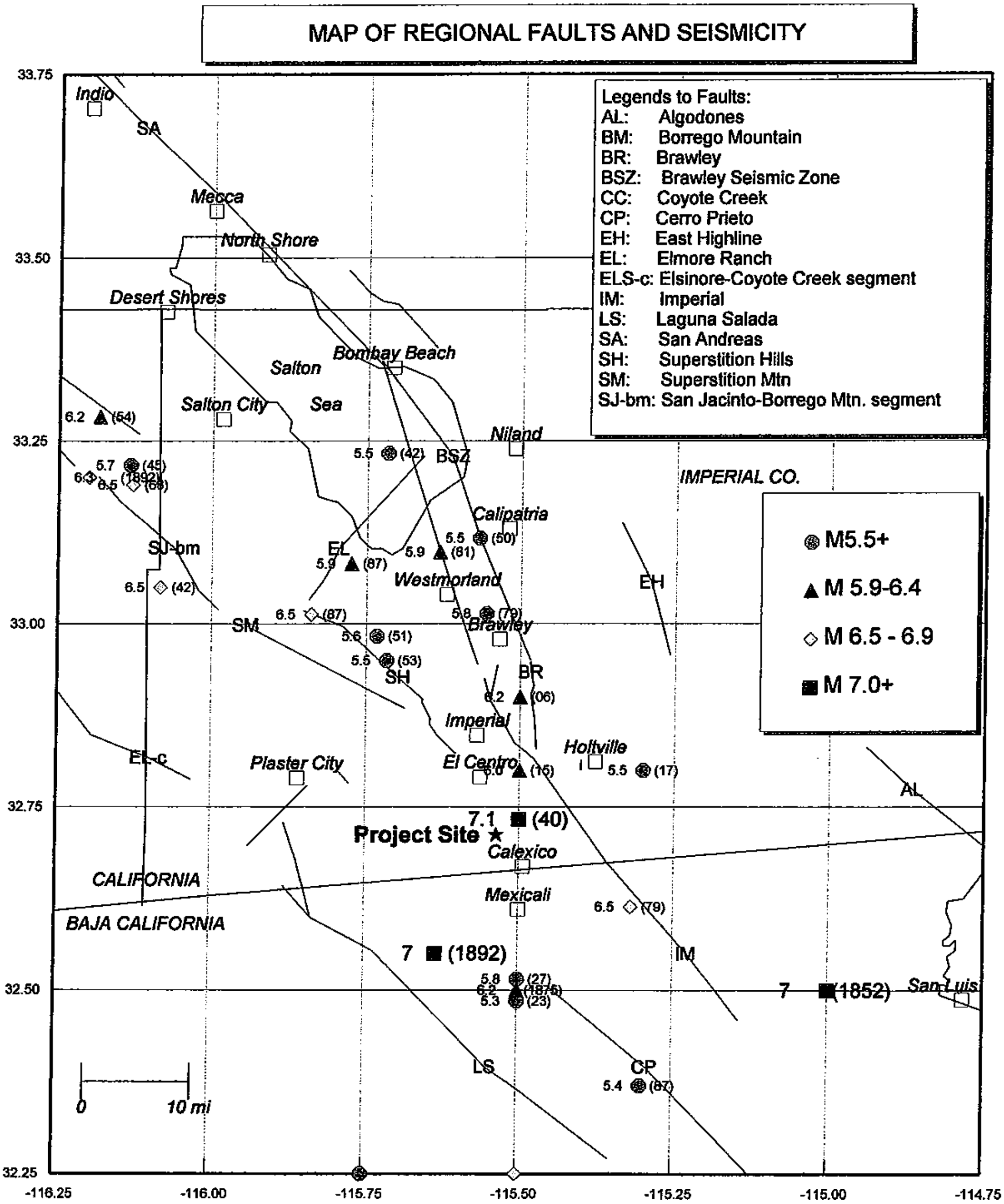
3.3 Seismicity and Faulting

Faulting and Seismic Sources: We have performed a computer-aided search of known faults or seismic zones that lie within a 62 mile (100 kilometers) radius of the project site as shown on Figure 1 and Table 1. The search identifies known faults within this distance and computes deterministic ground accelerations at the site based on the maximum credible earthquake expected on each of the faults and the distance from the fault to the site. The Maximum Magnitude Earthquake (Mmax) listed was taken from published geologic information available for each fault (CDMG OFR 96-08 and Jennings, 1994).

Seismic Risk: The project site is located in the seismically active Imperial Valley of southern California and is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. The proposed site structures should be designed in accordance with the California Building Code (CBC) for near source factors derived from a "Design Basis Earthquake" (DBE). The DBE is defined as the motion having a 10 percent probability of being exceeded in 50 years. The DBE generally corresponds to the Mmax magnitude discussed here.

Seismic Hazards.

- **Groundshaking.** The primary seismic hazard at the project site is the potential for strong groundshaking during earthquakes along the Imperial, Brawley, and Superstition Hills Faults. A further discussion of groundshaking follows in Section 3.4.
- **Surface Rupture.** The project site does not lie within a State of California, Alquist-Priolo Earthquake Fault Zone. Surface fault rupture is considered to be unlikely at the project site because of the well-delineated fault lines through the Imperial Valley as shown on USGS and CGS maps. However, because of the high tectonic activity and deep alluvium of the region, we cannot preclude the potential for surface rupture on undiscovered or new faults that may underlie the site.



Copyright 1997 by Shelton L, Stringer, GE

Faults and Seismic Zones from Jennings (1994), Earthquakes modified from Ellsworth (1990) catalog.

Figure 1. Map of Regional Faults and Seismicity

Table 1
FAULT PARAMETERS & DETERMINISTIC ESTIMATES OF PEAK GROUND ACCELERATION (PGA)

Fault Name or Seismic Zone	**Distance (mi) & Direction from Site**	**Fault Type**		**Fault Length (km)**	**Maximum Magnitude Mmax (Mw)**	**Avg Slip Rate (mm/yr)**	**Avg Return Period (yrs)**	**Date of Last Rupture (year)**	**Largest Historic Event >5.5M**	**(year)**	**Est. Site PGA (g)**
Reference Notes: (1)		(2)	(3)	(2)	(4)	(3)	(3)	(3)	(5)		(6)
Imperial Valley Faults											
Imperial	7.0 NE	A	B	62	**7.0**	20	79	1979	7.0	1940	**0.33**
Brawley	8.8 NNE	B	B	14	**7.0**	20	—	1979	5.8	1979	**0.28**
Cerro Prieto	15 SSE	A	B	116	**7.2**	34	50	1980	7.1	1934	**0.21**
Brawley Seismic Zone	16 N	B	B	42	**6.4**	25	24		5.9	1981	**0.13**
East Highline Canal	23 NE	C	C	22	**6.3**	1	774				**0.09**
San Jacinto Fault System											
- Superstition Hills	8.5 NNW	B	A	22	**6.6**	4	250	1987	6.5	1987	**0.23**
- Superstition Mtn.	15 NW	B	A	23	**6.6**	5	500	1440 +/-			**0.16**
- Elmore Ranch	28 NW	B	A	29	**6.6**	1	225	1987	5.9	1987	**0.10**
- Borrego Mtn	34 NW	B	A	29	**6.6**	4	175		6.5	1942	**0.08**
- Anza Segment	51 NW	A	A	90	**7.2**	12	250	1918	6.8	1918	**0.08**
- Coyote Creek	53 NW	B	A	40	**6.8**	4	175	1968	6.5	1968	**0.07**
- Whole Zone	15 NW	A	A	245	**7.5**	—	—				**0.25**
Elsinore Fault System											
- Laguna Salada	16 SW	B	B	67	**7.0**	3.5	336		7.0	1891	**0.18**
- Coyote Segment	29 W	B	A	38	**6.8**	4	625				**0.11**
- Julian Segment	55 WNW	A	A	75	**7.1**	5	340				**0.08**
- Earthquake Valley	57 WNW	B	A	20	**6.5**	2	351				**0.05**
- Whole Zone	29 W	A	A	250	**7.5**	—	—				**0.15**
San Andreas Fault System											
- Coachella Valley	45 NNW	A	A	95	**7.4**	25	220	1690+/-	6.5	1948	**0.10**
- Whole S. Calif. Zone	45 NNW	A	A	458	**7.9**	—	—	1857	7.8	1857	**0.13**
Algodones	36 E	C	C	74	**7.0**	0.1	20,000				**0.10**

Notes:

1. Jennings (1994) and CDMG (1996)
2. CDMG (1996), where Type A faults -- slip rate >5 mm/yr and well constrained paleoseismic data
   Type B faults -- all other faults.
3. WGCEP (1995)
4. CDMG (1996) based on Wells & Coppersmith (1994)
5. Ellsworth Catalog in USGS PP 1515 (1990) and USBR (1976), Mw = moment magnitude,
6. The deterministic estimates of the Site PGA are based on the attenuation relationship of:
   Boore, Joyner, Fumal (1997)

▸ **Liquefaction.** Liquefaction is unlikely to be a potential hazard at the site due to the lack of saturated granular soil (clay soils predominate).

Other Secondary Hazards.

▸ **Landsliding.** The hazard of landsliding is unlikely due to the regional planar topography. No ancient landslides are shown on geologic maps of the region and no indications of landslides were observed during our site investigation.

▸ **Volcanic hazards.** The site is not located in proximity to any known volcanically active area and the risk of volcanic hazards is considered very low.

▸ **Tsunamis, sieches, and flooding.** The site does not lie near any large bodies of water, so the threat of tsunami, sieches, or other seismically-induced flooding is unlikely.

▸ **Expansive soil.** In general, much of the near surface soils in the Imperial Valley consist of silty clays and clays which are moderate to highly expansive. The expansive soil conditions are discussed in more detail in Section 3.5.

3.4 Site Acceleration and UBC Seismic Coefficients

Deterministic horizontal peak ground accelerations (PGA) from maximum probable earthquakes on regional faults have been estimated and are included in Table 1. Ground motions are dependent primarily on the earthquake magnitude and distance to the seismogenic (rupture) zone. Accelerations also are dependent upon attenuation by rock and soil deposits, direction of rupture and type of fault; therefore, ground motions may vary considerably in the same general area.

We have used the computer program FRISKSP (Blake, 2000) to provide a probabilistic estimate of the site PGA using the attenuation relationship of Boore, Joyner, and Fumal (1997) Soil (250). The PGA estimate for the project site having a 10% probability of being exceeded in 50 years (return period of 475 years) is **0.60g**.

CBC Seismic Coefficients: The CBC seismic coefficients are roughly based on an earthquake ground motion that has a 10% probability of being exceeded in 50 years. The following table lists seismic and site coefficients (near source factors) determined by Chapter 16 of the 2001 CBC. ***This site lies within 11.3 km of a Type A fault overlying S_D (stiff) soil.***

CBC Seismic Coefficients for Chapter 16 Seismic Provisions

CBC Code Edition	Soil Profile Type	Seismic Source Type	Distance to Critical Source	Near Source Factors		Seismic Coefficients	
				Na	Nv	Ca	Cv
2001	S_D (stiff soil)	A	< 11.3 km	1.00	1.15	0.44	0.74
Ref. Table	16-J	16-U	---	16-S	16-T	16-Q	16-R

3.5 Subsurface Soil

Subsurface soils encountered during the field exploration conducted on December 20, 2004 indicates that 1.0 to 1.5 feet of stiff clay are at ground surface. Dense to very dense silty sands lie below the clays and extend to a depth of 4 to 5 feet. Stiff to very stiff clays extend a depth of 50 feet, the maximum depth of exploration. The subsurface logs (Plates B-1 through B-3) depict the stratigraphic relationships of the various soil types.

The native surface clays exhibit moderate swell potential (Expansion Index, EI = 51 - 90) when correlated to Plasticity index tests (ASTM D4318) performed on the native clays. The clay is expansive when wetted and can shrink with moisture loss (drying). Development of building foundations, concrete flatwork, and asphaltic concrete pavements should include provisions for mitigating potential swelling forces and reduction in soil strength, which can occur from saturation of the soil. Causes for soil saturation include landscape irrigation, broken utility lines, or capillary rise in moisture upon sealing the ground surface to evaporation. Moisture losses can occur with lack of landscape watering, close proximity of structures to downslopes and root system moisture extraction from deep rooted shrubs and trees placed near the foundations. Typical measures used for industrial projects to remediate expansive soil include:

- replacement of silt/clay with non-expansive granular fill,
- moisture conditioning subgrade soils to a minimum of 5% above optimum moisture (ASTM D1557) for the full range in depth of surface soils.
- design of foundations that are resistant to shrink/swell forces of silt/clay soil.

3.6 Groundwater

Groundwater was not noted on the CPT sounding at the time of exploration, but is typically encountered at approximately 10 to 15 feet below ground surface in the vicinity of the site. There is uncertainty in the accuracy of short-term water level measurements, particularly in fine-grained soil. Groundwater levels may fluctuate with precipitation, irrigation of adjacent properties, drainage, and site grading. The referenced groundwater level should not be interpreted to represent an accurate or permanent condition.

3.7 Liquefaction

Liquefaction occurs when granular soil below the water table is subjected to vibratory motions, such as produced by earthquakes. With strong ground shaking, an increase in pore water pressure develops as the soil tends to reduce in volume. If the increase in pore water pressure is sufficient to reduce the vertical effective stress (suspending the soil particles in water), the soil strength decreases and the soil behaves as a liquid (similar to quicksand). Liquefaction can produce excessive settlement, ground rupture, lateral spreading, or failure of shallow bearing foundations.

Four conditions are generally required for liquefaction to occur:

(1) the soil must be saturated (relatively shallow groundwater);
(2) the soil must be loosely packed (low to medium relative density);
(3) the soil must be relatively cohesionless (not clayey); and
(4) groundshaking of sufficient intensity must occur to function as a trigger mechanism.

All of these conditions exist to some degree at this site.

Methods of Analysis: Liquefaction potential at the project site was evaluated using the 1997 NCEER Liquefaction Workshop methods that are based on the Seed, et. al. 1985 and Robertson and Campanella (1985) methods. The 1997 NCEER methods utilize direct SPT blow counts or CPT cone readings from site exploration and earthquake magnitude/PGA estimates from the seismic hazard analysis. The resistance to liquefaction is plotted on a chart of cyclic shear stress ratio (CSR) versus a corrected blow count $N_{1(60)}$ or Qc_{IN}. A ground acceleration of 0.60g was used in the analysis with a 12 foot groundwater depth.

Liquefaction induced settlements have been estimated using the 1987 Tokimatsu and Seed method. Fines content of liquefiable sands and silt increase the liquefaction resistance in that more cycles of ground motions are required to fully develop pore pressures. The SPT blow counts were adjusted to an equivalent clean sand blow count, $N_{1(60)}$ prior to calculating settlements using Robertson and Wride (1997) adjustments. A computed factor of safety less than 1.0 indicates a liquefiable condition.

Liquefaction Effects: Based on empirical relationships, liquefaction is not expected to occur at the project site.

Section 4
RECOMMENDATIONS

4.1 Site Preparation

Clearing and Grubbing: All surface improvements, debris or vegetation including grass and weeds on the site at the time of construction should be removed from the construction area. Organic strippings should be hauled from the site and not used as fill. Any trash, construction debris, concrete slabs, old pavement, landfill, and buried obstructions such as old foundations and utility lines exposed during rough grading should be traced to the limits of the foreign material by the grading contractor and removed under our supervision. Any excavations resulting from site clearing should be dish-shaped to the lowest depth of disturbance and backfilled under observation by the geotechnical engineer's representative with compacted fill as described below.

Structure Subgrade Preparation: The exposed surface soil within the foundation areas should be removed to 12 inches below the foundation elevation or existing grade (whichever is lower). Exposed subgrade should be scarified to a depth of 8 inches, uniformly moisture conditioned to 3 to 8% above optimum moisture content (clays) or 0 to 4% above optimum (silts), and recompacted to at least 90% of the maximum density determined in accordance with ASTM D1557 methods.

The native soil is suitable for use as engineered fill provided it is free from concentrations of organic matter or other deleterious material. The fill soil should be uniformly moisture conditioned by discing and watering to the limits specified above, placed in maximum 8-inch lifts (loose), and compacted to the limits specified above.

Imported fill soil (if required) should have a Plasticity Index less than 15 and sulfates (SO_4) less than 1,000 ppm or non-expansive, granular soil meeting the USCS classifications of SM, SP-SM, or SW-SM with a maximum rock size of 3 inches and 5 to 35% passing the No. 200 sieve. The geotechnical engineer should approve imported fill soil sources before hauling material to the site. Imported granular fill should be placed in lifts no greater than 8 inches in loose thickness and compacted to at least 90% of ASTM D1557 maximum dry density at optimum moisture ±2%.

In areas other than the structures pad which are to receive area concrete slabs, the ground surface should be presaturated to a minimum depth of 18 inches and then scarified to 6 inches, moisture conditioned to a minimum of 5% over optimum, and recompacted to 83-87% of ASTM D1557 maximum density just prior to concrete placement.

Trench Backfill: On-site soil free of debris, vegetation, and other deleterious matter may be suitable for use as utility trench backfill, but may be difficult to uniformly maintain at specified moistures and compact to the specified densities. Granular material is often more cost effective for backfill of utility trenches.

Backfill soil within roadways or traffic areas should be placed in layers not more that 6 inches in thickness and mechanically compacted to a minimum of 87% of the ASTM D1557 maximum dry density except for the top 12 inches of the trench which shall be compacted to at least 90%. Native backfill should only be placed and compacted after encapsulating buried pipes with suitable bedding and pipe envelope material. Pipe envelope/bedding should either be clean sand (Sand Equivalent SE>30) or crushed rock when encountering groundwater. A geotextile filter fabric (Mirafi 140N or equivalent) should be used to encapsulate the crushed rock when placed below groundwater to reduce the potential for in-washing of fines into the gravel void space. Precautions should be taken in the compaction of the backfill to avoid damage to the pipes and structures.

Observation and Density Testing: All site preparation and fill placement should be continuously observed and tested by a representative of a qualified geotechnical engineering firm. Full-time observation services during the excavation and scarification process is necessary to detect undesirable materials or conditions and soft areas that may be encountered in the construction area. The geotechnical firm that provides observation and testing during construction shall assume the responsibility of "*geotechnical engineer of record*" and, as such, shall perform additional tests and investigation as necessary to satisfy themselves as to the site conditions and the recommendations for site development.

Auxiliary Structures Foundation Preparation: Auxiliary structures such as free standing or retaining walls should have the existing soil beneath the structure foundation prepared in the manner recommended for the building pad except the preparation needed only to extend 12 inches below and beyond the footing.

4.2 Foundations and Settlements

Shallow spread footings and continuous wall footings are suitable to support the structures associated with the turbine generator and cooling tower. Footings shall be founded on a layer of properly prepared and compacted soil as described in Section 4.1. The foundations may be designed using an allowable soil bearing pressure of 1,500 psf for compacted native clay soil and 2,000 psf when foundations are supported on imported sands (extending a minimum of 1.0 feet below footings). The allowable soil pressure may be increased by 20% for each foot of embedment depth in excess of 18 inches and by one-third for short term loads induced by winds or seismic events. The maximum allowable soil pressure at increased embedment depths shall not exceed 3,000 psf (clays). Settlements associated with variable loadings and structure/footing sizes are shown on figures 2 thru 5. As an alternative to shallow spread foundations, flat plate structural mats or grade-beam reinforced foundations may be used to mitigate expansive soil heave.

Flat Plate Structural Mats: Structural mats may be designed for a modulus of subgrade reaction (Ks) of 100 pci when placed on compacted clay or a subgrade modulus of 250 pci when placed on 2.5 feet of granular fill. Mats shall overlay 2 inches of sand and a 10-mil polyethylene vapor retarder. The structure support pad shall be moisture conditioned and recompacted as specified in Section 4.1 of this report.

All exterior and interior foundations should be embedded a minimum of 18 inches below the structure support pad or lowest adjacent final grade, whichever is deeper. Continuous wall footings should have a minimum width of 12 inches. Spread footings should have a minimum width of 24 inches. Recommended concrete reinforcement and sizing for all footings should be provided by the structural engineer.

Resistance to horizontal loads will be developed by passive earth pressure on the sides of footings or grade beams and frictional resistance developed along the bases of footings or grade beams and concrete slabs. Passive resistance to lateral earth pressure may be calculated using an equivalent fluid pressure of 250 pcf (300 pcf for sands) to resist lateral loadings. The top one foot of embedment should not be considered in computing passive resistance unless the adjacent area is confined by a slab or pavement. An allowable friction coefficient of 0.25 (0.35 for sands) may also be used at the base of the footings or grade beams to resist lateral loading.

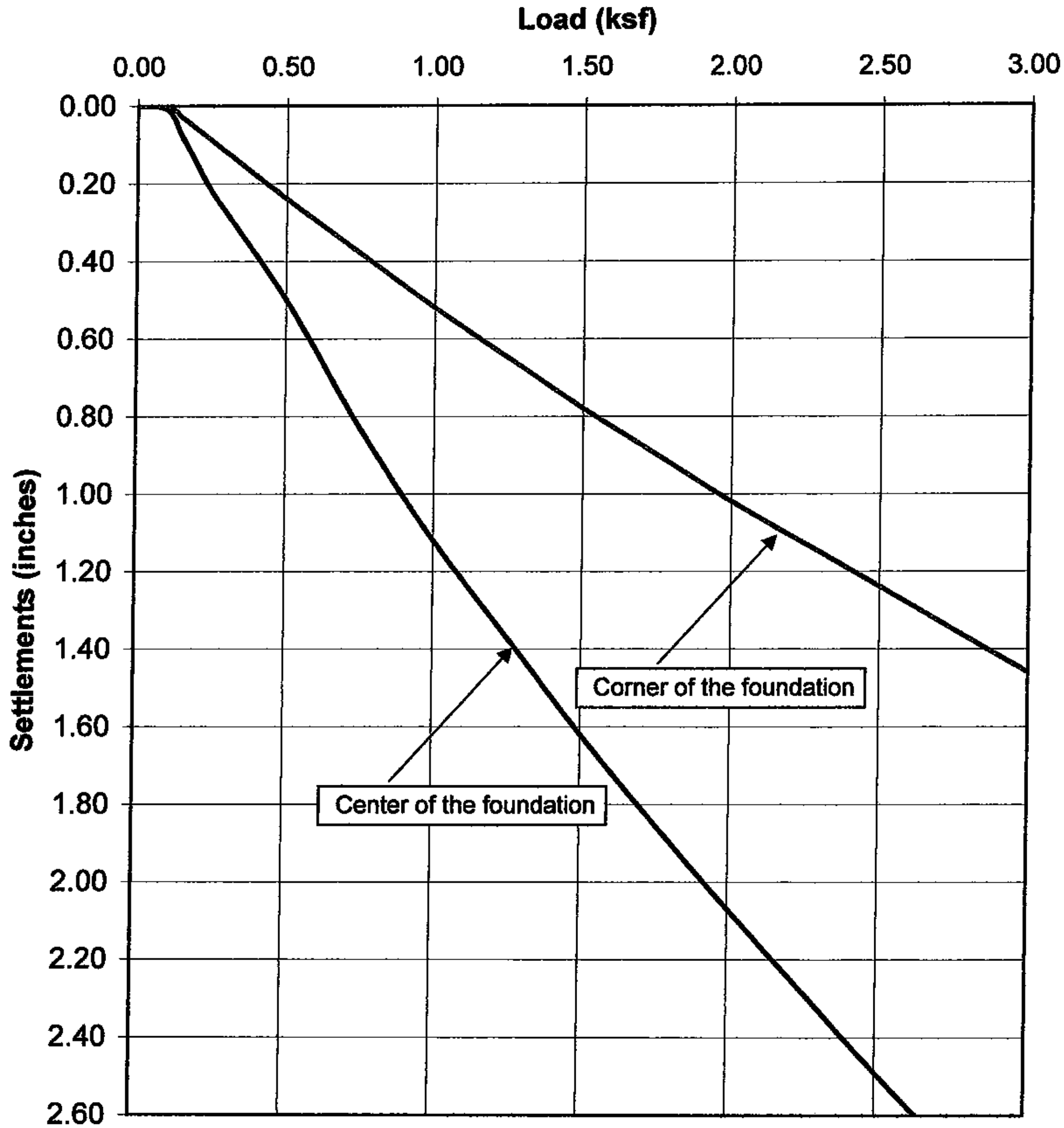
Total foundation movements under estimated loadings are shown on the load/settlement curves (Figures 2 thru 5). Differential movement is estimated to be about two-thirds of total movement

4.3 Slabs-On-Grade

Thin concrete slabs and flatwork (6 inches or less in thickness) placed over native clay soil should be designed in accordance with Chapter 18, Division III of the 2001 CBC (using an Effective Plasticity Index of 17) and shall be a minimum of 5 inches thick due to expansive soil conditions. Concrete floor slabs shall be monolithically placed with the foundations unless placed on 2.5 feet of granular fill or lime treated soil.

The concrete slabs should be underlain by a minimum of 4 inches of clean sand (Sand Equivalent SE>30) or aggregate base or may be placed directly on a 2.5-foot thick granular fill pad (if used) that has been moistened to approximately optimum moisture just before the concrete placement. A 10-mil visqueen vapor retarder, properly lapped and sealed with a 2-inch sand cover and extended a minimum of 12 inches into the footing, should be placed as a capillary break to prevent moisture migration into the slab section. Concrete slabs may be placed directly over a 15-mil vapor retarder if desired (Stego-Wrap or equivalent).

Concrete slab and flatwork reinforcement should consist of chaired rebar slab reinforcement (minimum of No. 4 bars at 18-inch centers, both horizontal directions) placed at slab mid-height to resist potential swell forces and cracking. Slab thickness and steel reinforcement are minimums only and should be verified by the structural engineer/designer knowing the actual project loadings. All steel components of the foundation system should be protected from corrosion by maintaining a 4-inch minimum concrete cover of densely consolidated concrete at footings (by use of a vibrator). The construction joint between the foundation and any mowstrips/sidewalks placed adjacent to foundations should be sealed with a polyurethane based non-hardening sealant to prevent moisture migration between the joint. Epoxy coated embedded steel components or permanent waterproofing membranes placed at the exterior footing sidewall may also be used to mitigate the corrosion potential of concrete placed in contact with native soil.



Notes:

1. A 15' x 15' foundation was used for settlement analysis

LANDMARK

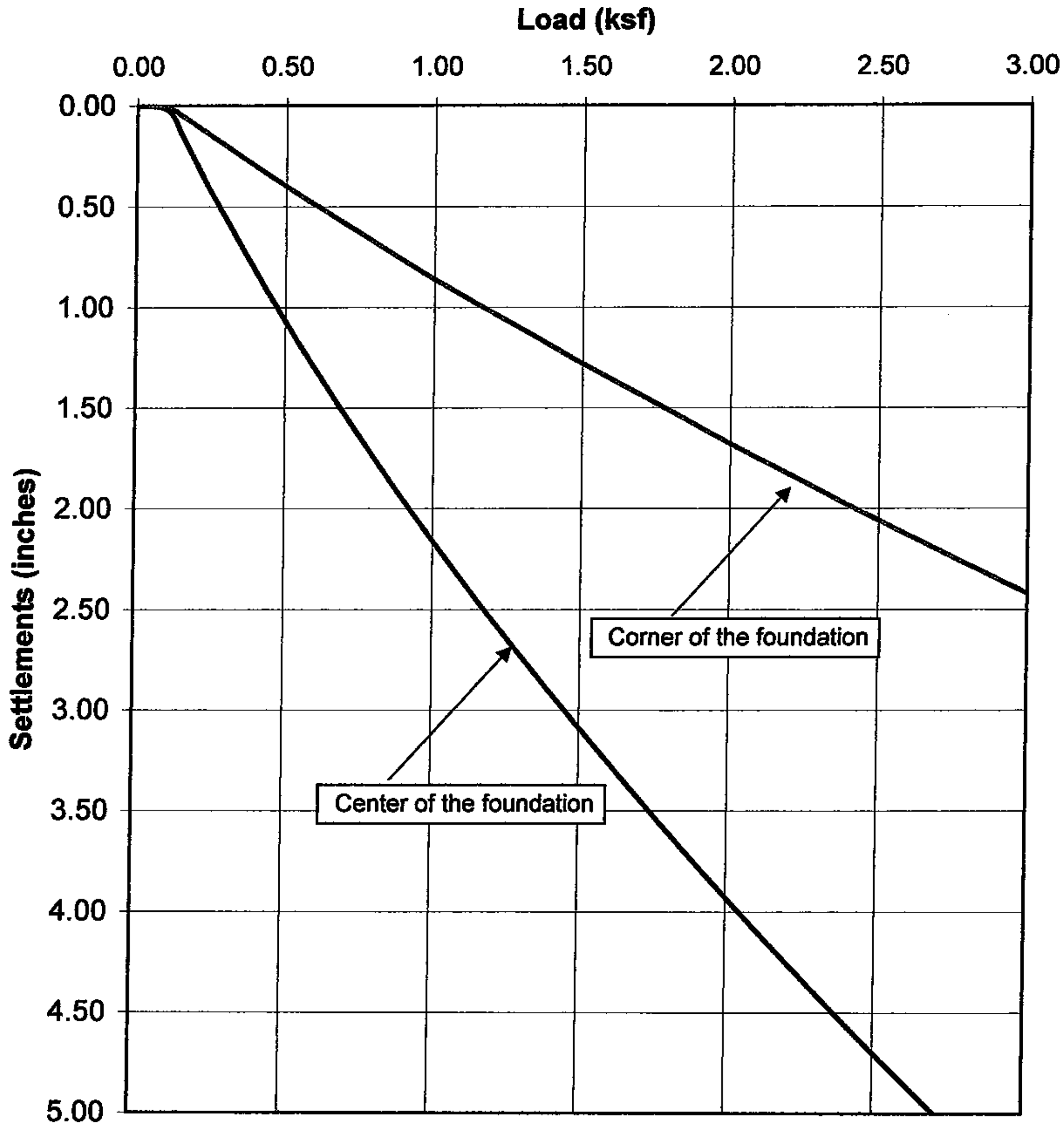
Geo-Engineers and Geologists

a DBE/MBE/SBE Company

Project No.: LE04354

Total Settlements for a Turbine Generator Foundation at Heber 2 Geothermal Plant

Figure 2



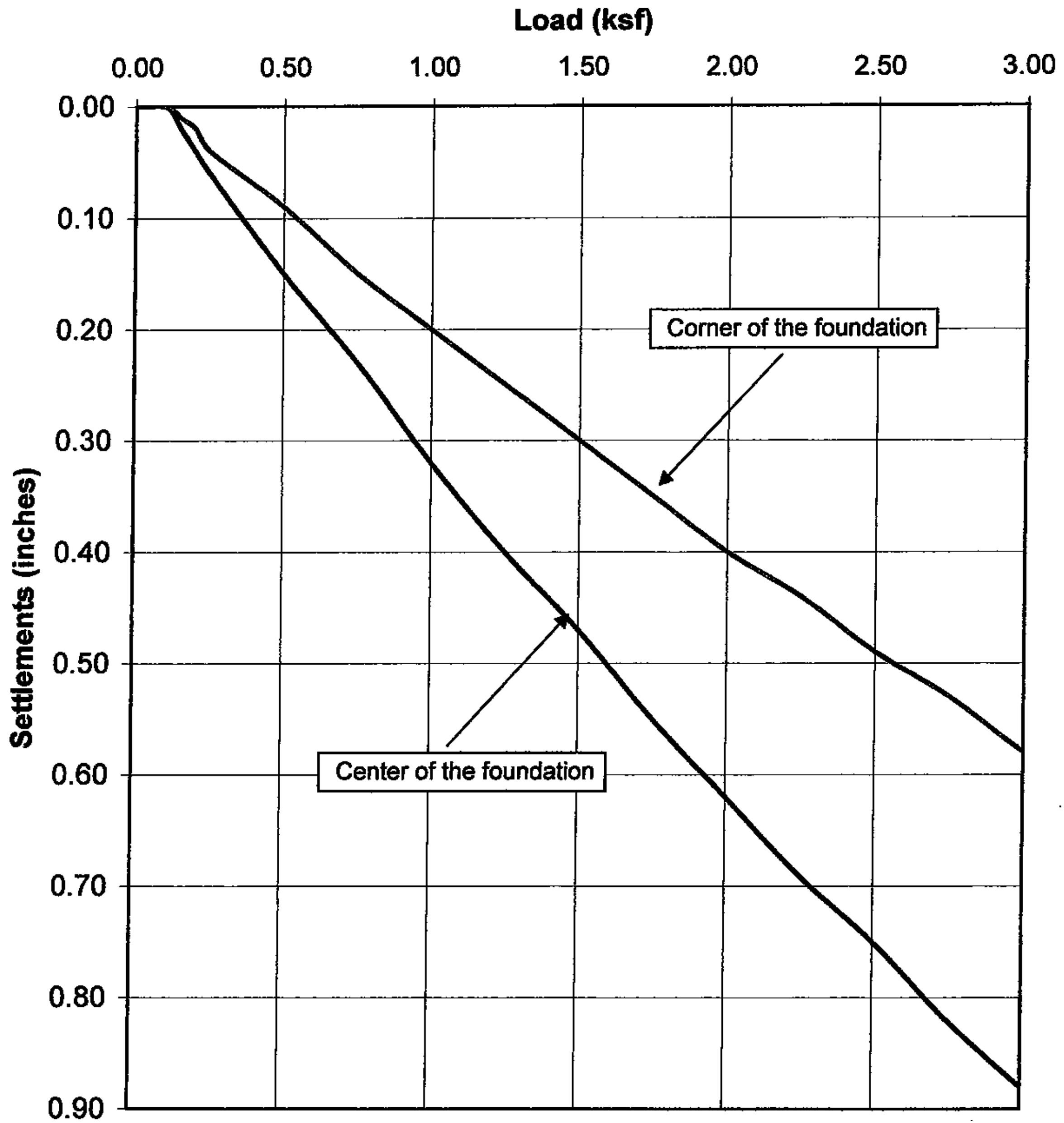
Notes:

1. A 30' x 60' foundation was used for settlement analysis

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company
Project No.: LE04354

Total Settlements for a Turbine Generator Foundation at Heber 2 Geothermal Plant

Figure 3



Notes:

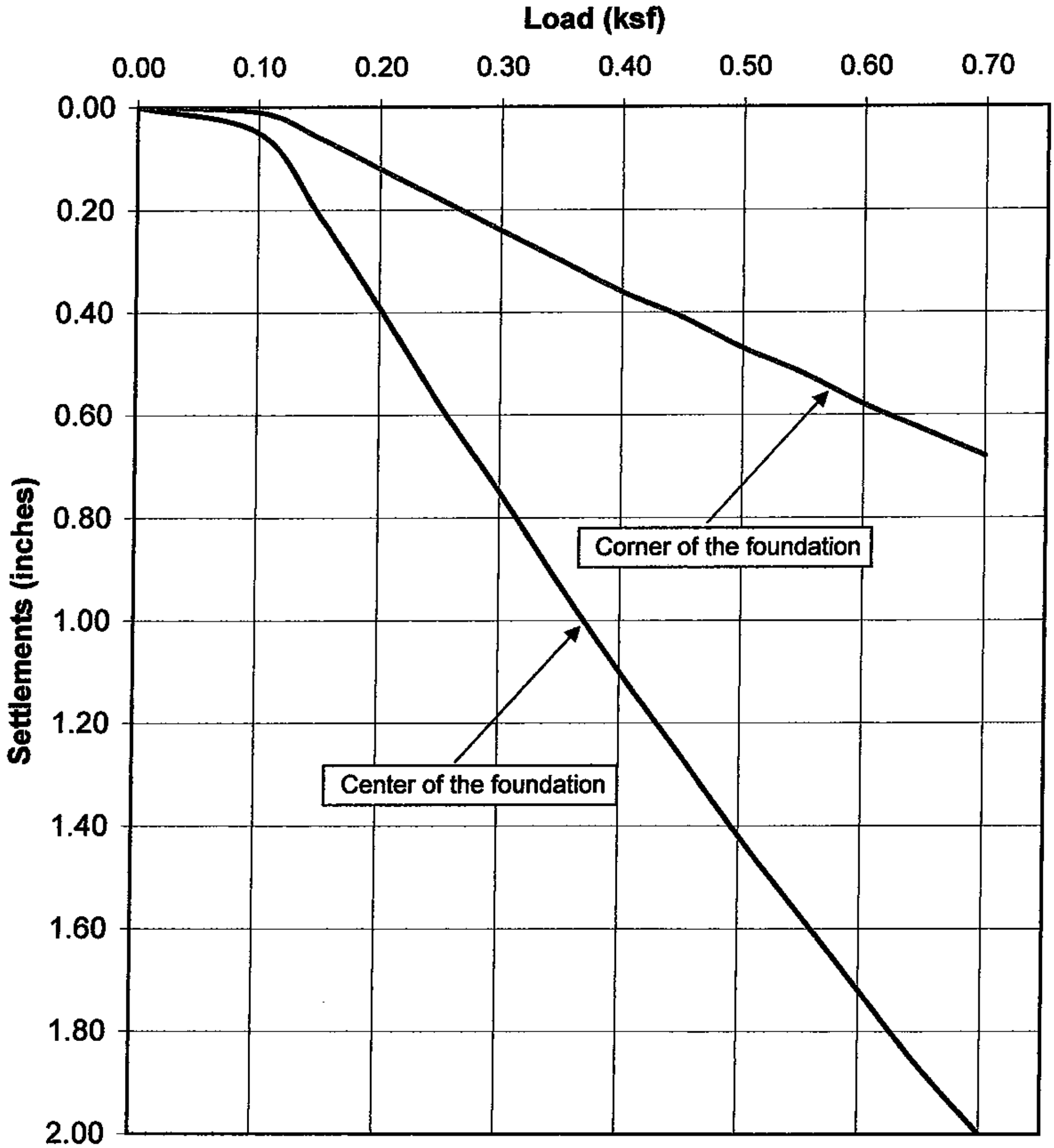
1. A 5' x 5' foundation was used for settlement analysis

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE04354

Total Settlements for a Cooling Tower Foundation at Heber 2 Geothermal Plant

Figure 4



Notes:

1. A 60' x 180' foundation was used for settlement analysis

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company
Project No.: LE04354

Total Settlements for a Cooling Tower Foundation at Heber 2 Geothermal Plant

Figure 5

Control joints should be provided in all concrete slabs-on-grade at a maximum spacing (in feet) of 2 to 3 times the slab thickness (in inches) as recommended by American Concrete Institute (ACI) guidelines. All joints should form approximately square patterns to reduce randomly oriented contraction cracks. Contraction joints in the slabs should be tooled at the time of the pour or sawcut (¼ of slab depth) within 6 to 8 hours of concrete placement. Construction (cold) joints in foundations and area flatwork should either be thickened butt-joints with dowels or a thickened keyed-joint designed to resist vertical deflection at the joint. All joints in flatwork should be sealed to prevent moisture, vermin, or foreign material intrusion. Precautions should be taken to prevent curling of slabs in this arid desert region (refer to ACI guidelines).

All independent flatwork (sidewalks, housekeeping slabs) should be placed on a minimum of 2 inches of concrete sand or aggregate base, dowelled to the perimeter foundations where adjacent to the structures and sloped 1% or more away from the structure. A minimum of 18 inches of moisture conditioned (3% minimum above optimum) and 8 inches of compacted subgrade (83 to 87%) and a 10-mil (minimum) polyethylene separation sheet should underlie the flatwork. All flatwork should be jointed in square patterns and at irregularities in shape at a maximum spacing of 10 feet or the least width of the sidewalk.

4.4 Concrete Mixes and Corrosivity

Selected chemical analyses for corrosivity were conducted on bulk samples of the near surface soil from the project site (Plates C-2 and C-3). The native soils were found to have moderate to severe levels of sulfate ion concentration (1,052 to 3,006 ppm). Sulfate ions in high concentrations can attack the cementitious material in concrete, causing weakening of the cement matrix and eventual deterioration by raveling. The California Building Code recommends that increased quantities of Type II Portland Cement be used at a low water/cement ratio when concrete is subjected to moderate sulfate concentrations. Type V Portland Cement and/or Type II/V cement with 25% flyash replacement is recommended when the concrete is subjected to soil with severe sulfate concentration.

A minimum of 6.25 sacks per cubic yard of concrete (4,500 psi) of Type V Portland Cement with a maximum water/cement ratio of 0.45 (by weight) should be used for concrete placed in contact with native soil on this project. Admixtures may be required to allow placement of this low water/cement ratio concrete.

There are no special requirements for concrete mixes when foundations are placed on 2.5 feet of low sulfate content granular fill.

The native soil has moderate to very severe level of chloride ion concentration (210 to 3,040 ppm). Chloride ions can cause corrosion of reinforcing steel, anchor bolts and other buried metallic conduits. Resistivity determinations on the soil indicate very severe potential for metal loss because of electrochemical corrosion processes. Mitigation of the corrosion of steel can be achieved by using steel pipes coated with epoxy corrosion inhibitors, asphaltic and epoxy coatings, cathodic protection or by encapsulating the portion of the pipe lying above groundwater with a minimum of 4 inches of densely consolidated concrete. ***No metallic pipes or conduits should be placed below foundations.***

Foundation designs shall provide a minimum concrete cover of four (4 inches around steel reinforcing or embedded components (anchor bolts, hold-downs, etc.) exposed to native soil or landscape water (to 18 inches above grade). If the 4-inch concrete edge distance cannot be achieved, all embedded steel components (anchor bolts, hold-downs, etc.) shall be epoxy dipped for corrosion protection or a corrosion inhibitor and a permanent waterproofing membrane shall be placed along the exterior face of the exterior footings. Additionally, the concrete should be thoroughly vibrated at footings during placement to decrease the permeability of the concrete.

4.5 Excavations

All site excavations should conform to CalOSHA requirements for Type B soil. The contractor is solely responsible for the safety of workers entering trenches. Temporary excavations with depths of 4 feet or less may be cut nearly vertical for short duration. Excavations deeper than 4 feet will require shoring or slope inclinations in conformance to CAL/OSHA regulations for Type B soil. Surcharge loads of stockpiled soil or construction materials should be set back from the top of the slope a minimum distance equal to the height of the slope. All permanent slopes should not be steeper than 3:1 to reduce wind and rain erosion. Protected slopes with ground cover may be as steep as 2:1. However, maintenance with motorized equipment may not be possible at this inclination.

4.6 Seismic Design

This site is located in the seismically active southern California area and the site structures are subject to strong ground shaking due to potential fault movements along the Brawley, Superstition Hills, and Imperial Faults. Engineered design and earthquake-resistant construction are the common solutions to increase safety and development of seismic areas. Designs should comply with the latest edition of the CBC for Seismic Zone 4 using the seismic coefficients given in Section 3.4 of this report. ***This site lies within 11.3 km of a Type A fault overlying S_D (stiff) soil.***

Section 5
LIMITATIONS AND ADDITIONAL SERVICES

5.1 Limitations

The recommendations and conclusions within this report are based on current information regarding the proposed additions to the Ormat Heber 2 geothermal power plant located on Dogwood Road southwest of Heber, California. The conclusions and recommendations of this report are invalid if:

- Structural loads change from those stated or the structures are relocated.
- The Additional Services section of this report is not followed.
- This report is used for adjacent or other property.
- Changes of grade or groundwater occur between the issuance of this report and construction other than those anticipated in this report.
- Any other change that materially alters the project from that proposed at the time this report was prepared.

Findings and recommendations in this report are based on selected points of field exploration, geologic literature, laboratory testing, and our understanding of the proposed project. Our analysis of data and recommendations presented herein are based on the assumption that soil conditions do not vary significantly from those found at specific exploratory locations. Variations in soil conditions can exist between and beyond the exploration points or groundwater elevations may change. If detected, these conditions may require additional studies, consultation, and possible design revisions.

This report contains information that may be useful in the preparation of contract specifications. However, the report is not worded is such a manner that we recommend its use as a construction specification document without proper modification. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

This report was prepared according to the generally accepted *geotechnical engineering standards of practice* that existed in Imperial County at the time the report was prepared. No express or implied warranties are made in connection with our services. This report should be considered invalid for periods after two years from the report date without a review of the validity of the findings and recommendations by our firm, because of potential changes in the Geotechnical Engineering Standards of Practice.

The client has responsibility to see that all parties to the project including, designer, contractor, and subcontractor are made aware of this entire report. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

5.2 Additional Services

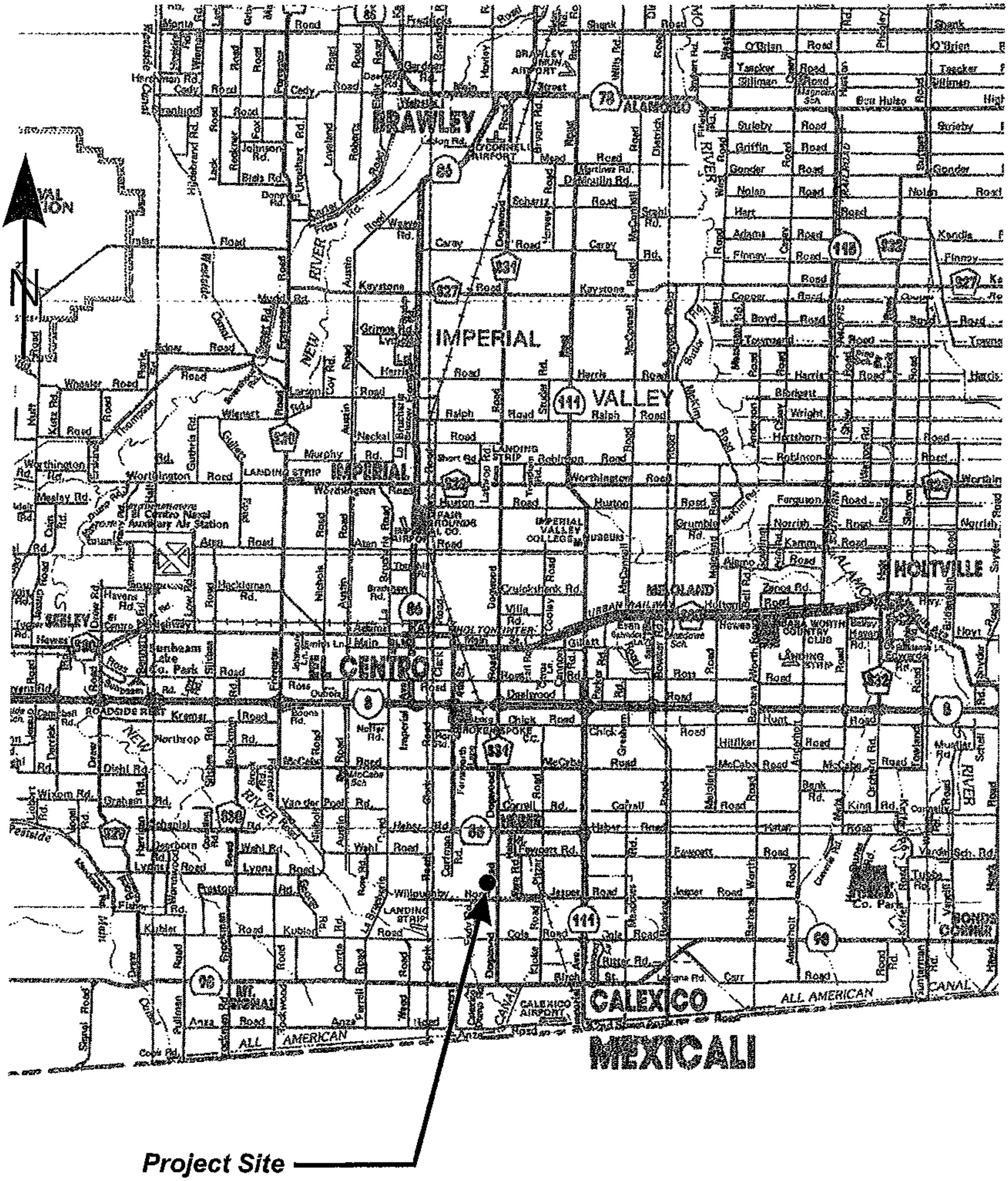
We recommend that Landmark Consultants, Inc. be retained as the geotechnical consultant to provide the tests and observations services during construction. If Landmark Consultants does not provide such services then *the geotechnical engineering firm providing such tests and observations shall become the geotechnical engineer of record and assume responsibility for the project.*

The recommendations presented in this report are based on the assumption that:

- Consultation during development of design and construction documents to check that the geotechnical recommendations are appropriate for the proposed project and that the geotechnical recommendations are properly interpreted and incorporated into the documents.
- Landmark Consultants will have the opportunity to review and comment on the plans and specifications for the project prior to the issuance of such for bidding.
- Continuous observation, inspection, and testing by the geotechnical consultant of record during site clearing, grading, excavation, placement of fills, building pad and subgrade preparation, and backfilling of utility trenches.
- Observation of foundation excavations and reinforcing steel before concrete placement.
- Other consultation as necessary during design and construction.

We emphasize our review of the project plans and specifications to check for compatibility with our recommendations and conclusions. Additional information concerning the scope and cost of these services can be obtained from our office.

APPENDIX A



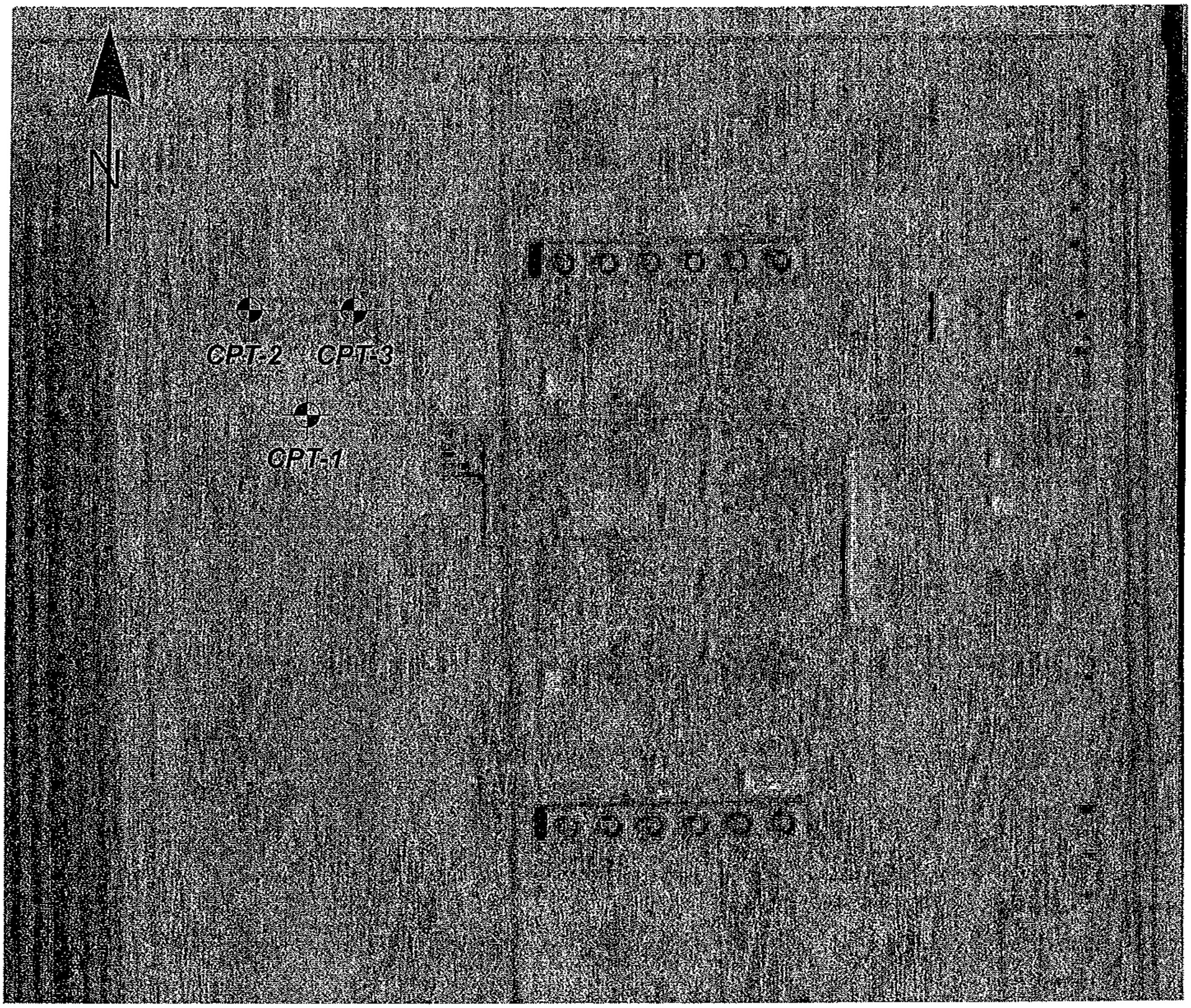
Project Site

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE04354

Vicinity Map

Plate A-1

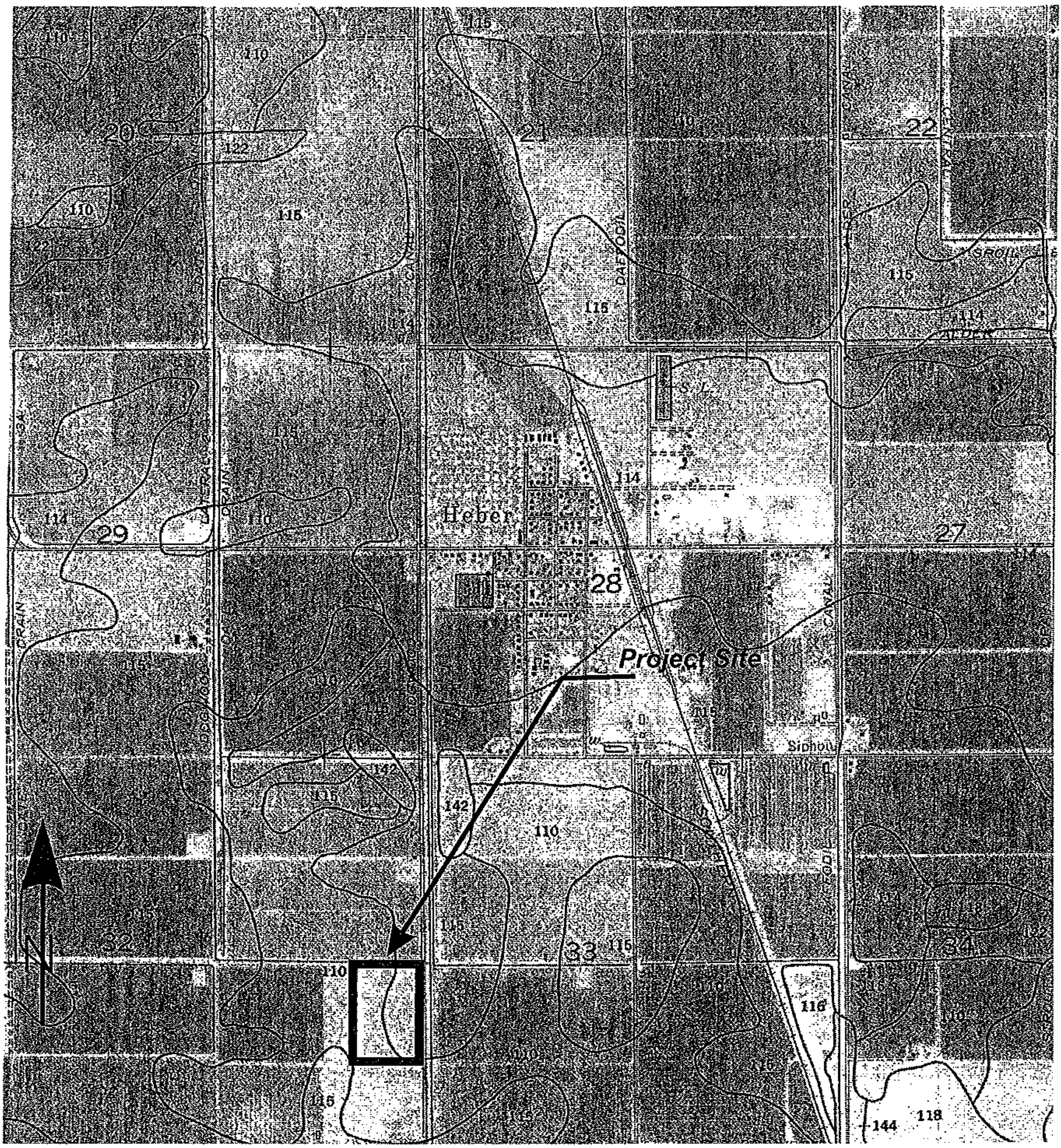


LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE04354

Site and Exploration Map

Plate A-2



LANDMARK

Geo-Engineers and Geologists

a DBE/MBE/SBE Company

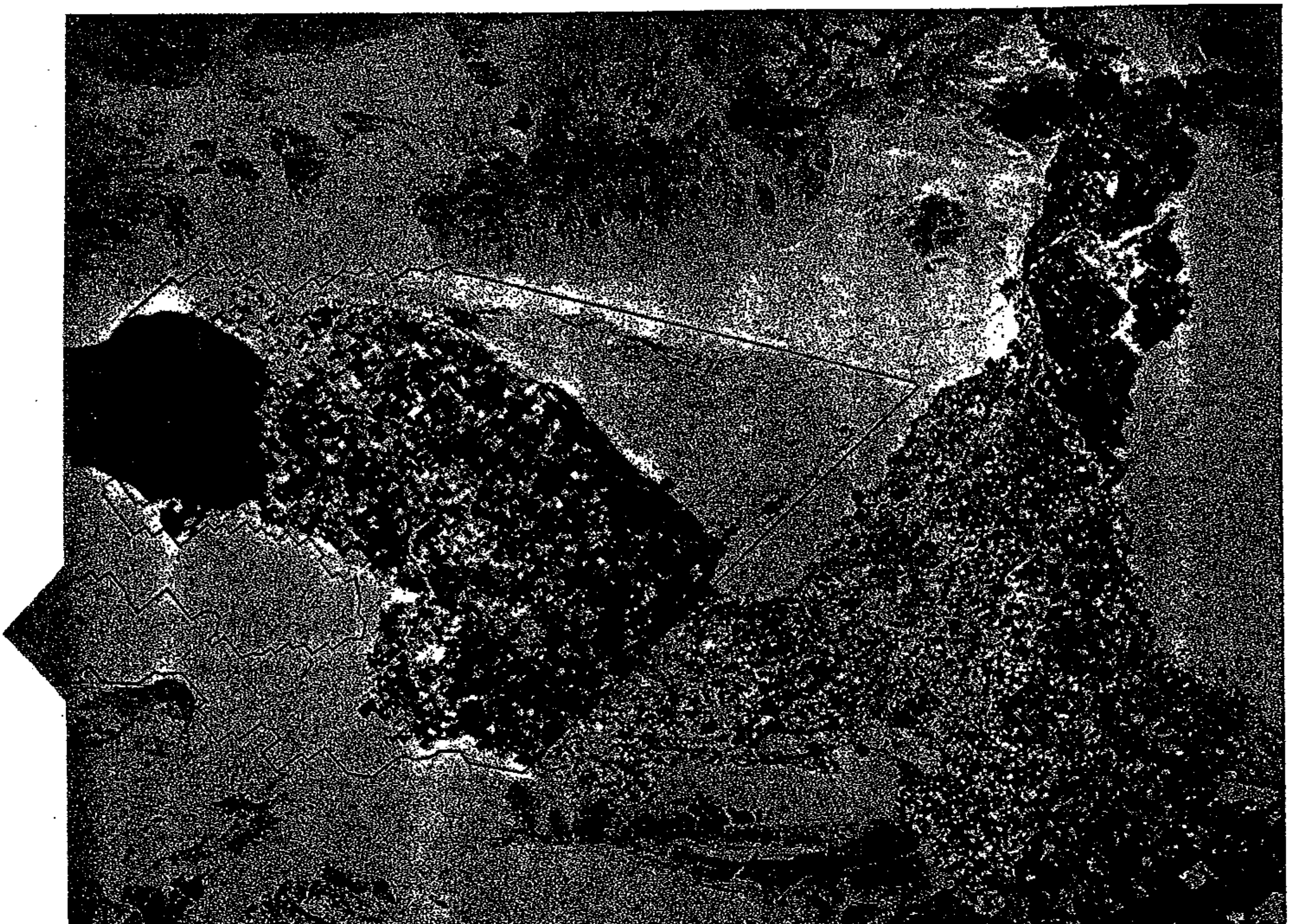
Project No.: LE04354

Soil Survey Map

Plate A-3

Soil Survey of

IMPERIAL COUNTY
CALIFORNIA
IMPERIAL VALLEY AREA



United States Department of Agriculture Soil Conservation Service
in cooperation with
University of California Agricultural Experiment Station
and
Imperial Irrigation District

TABLE 11.--ENGINEERING INDEX PROPERTIES

[The symbol > means more than. Absence of an entry indicates that data were not estimated]

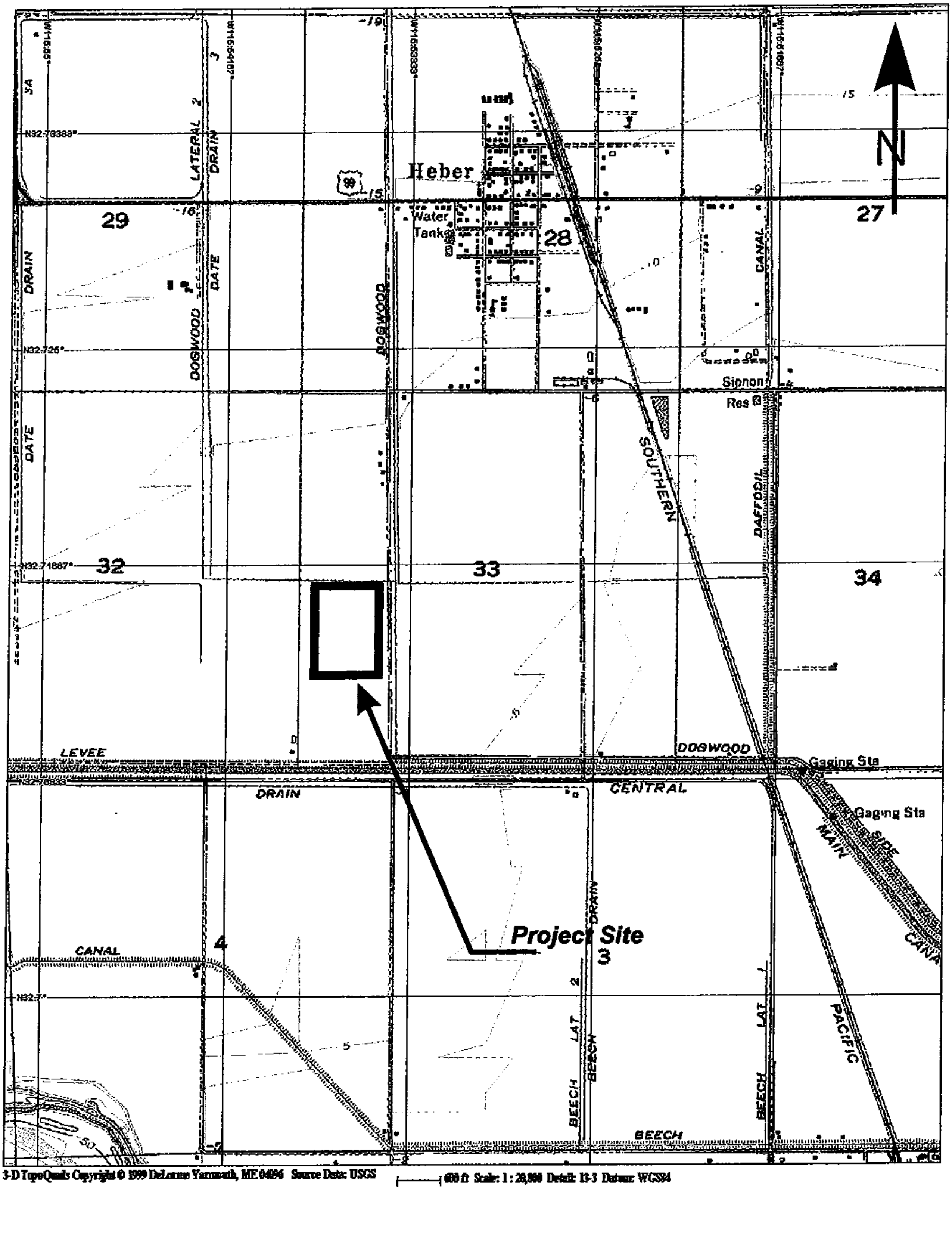
Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
100----------------- Antho	0-13	Loamy fine sand	SM	A-2	0	100	100	75-85	10-30	---	NP
	13-60	Sandy loam, fine sandy loam.	SM	A-2, A-4	0	90-100	75-95	50-60	15-40	---	NP
101*:											
Antho--------------	0-8	Loamy fine sand	SM	A-2	0	100	100	75-85	10-30	---	NP
	8-60	Sandy loam, fine sandy loam.	SM	A-2, A-4	0	90-100	75-95	50-60	15-40	---	NP
Superstition-------	0-6	Fine sand--------	SM	A-2	0	100	95-100	70-85	15-25	---	NP
	6-60	Loamy fine sand, fine sand, sand.	SM	A-2	0	100	95-100	70-85	15-25	---	NP
102*. Badland											
103----------------- Carsitas	0-10	Gravelly sand---	SP, SP-SM	A-1, A-2	0-5	60-90	50-85	30-55	0-10	---	NP
	10-60	Gravelly sand, gravelly coarse sand, sand.	SP, SP-SM	A-1	0-5	60-90	50-85	25-50	0-10	---	NP
104* Fluvaquents											
105----------------- Glenbar	0-13	Clay loam--------	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
	13-60	Clay loam, silty clay loam.	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
106----------------- Glenbar	0-13	Clay loam--------	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
107*---------------- Glenbar	0-13	Loam-------------	ML, CL-ML, CL	A-4	0	100	100	100	70-80	20-30	NP-10
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	95-100	75-95	35-45	15-30
108----------------- Holtville	0-14	Loam-------------	ML	A-4	0	100	100	85-100	55-95	25-35	NP-10
	14-22	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	22-60	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
109----------------- Holtville	0-17	Silty clay-------	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	17-24	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	24-35	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
	35-60	Loamy very fine sand, loamy fine sand.	SM, ML	A-2, A-4	0	100	100	75-100	20-55	---	NP
110----------------- Holtville	0-17	Silty clay-------	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-35
	17-24	Clay, silty clay	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-35
	24-35	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	55-85	25-35	NP-10
	35-60	Loamy very fine sand, loamy fine sand.	SM, ML	A-2, A-4	0	100	100	75-100	20-55	---	NP

See footnote at end of table.

TABLE 11.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
111*:											
Holtville	0-10	Silty clay loam	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	10-22	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	22-60	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
Imperial	0-12	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
112 Imperial	0-12	Silty clay	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
113 Imperial	0-12	Silty clay	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay, clay, silty clay loam.	CH	A-7	0	100	100	100	85-95	50-70	25-45
114 Imperial	0-12	Silty clay	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
115*:											
Imperial	0-12	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
Glenbar	0-13	Silty clay loam	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
116*:											
Imperial	0-13	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	13-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
Glenbar	0-13	Silty clay loam	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
117, 118 Indio	0-12	Loam	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
	12-72	Stratified loamy very fine sand to silt loam.	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
119*:											
Indio	0-12	Loam	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
	12-72	Stratified loamy very fine sand to silt loam.	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
Vint	0-10	Loamy fine sand	SM	A-2	0	95-100	95-100	70-80	25-35	---	NP
	10-60	Loamy sand, loamy fine sand.	SM	A-2	0	95-100	95-100	70-80	20-30	---	NP
120* Laveen	0-12	Loam	ML, CL-ML	A-4	0	100	95-100	75-85	55-65	20-30	NP-10
	12-60	Loam, very fine sandy loam.	ML, CL-ML	A-4	0	95-100	85-95	70-80	55-65	15-25	NP-10

See footnote at end of table.



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

600 ft Scale: 1 : 20,000 Detail: 13-3 Datum: WGS84

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No.: LE04354

Topographic Map

Plate A-4

APPENDIX B

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: HOLGUIN, FAHAN & ASSC. Truck Mounted Electric Cone with 23 ton reaction weight
DATE: 12/20/04

LOG OF CONE SOUNDING DATA CPT-1

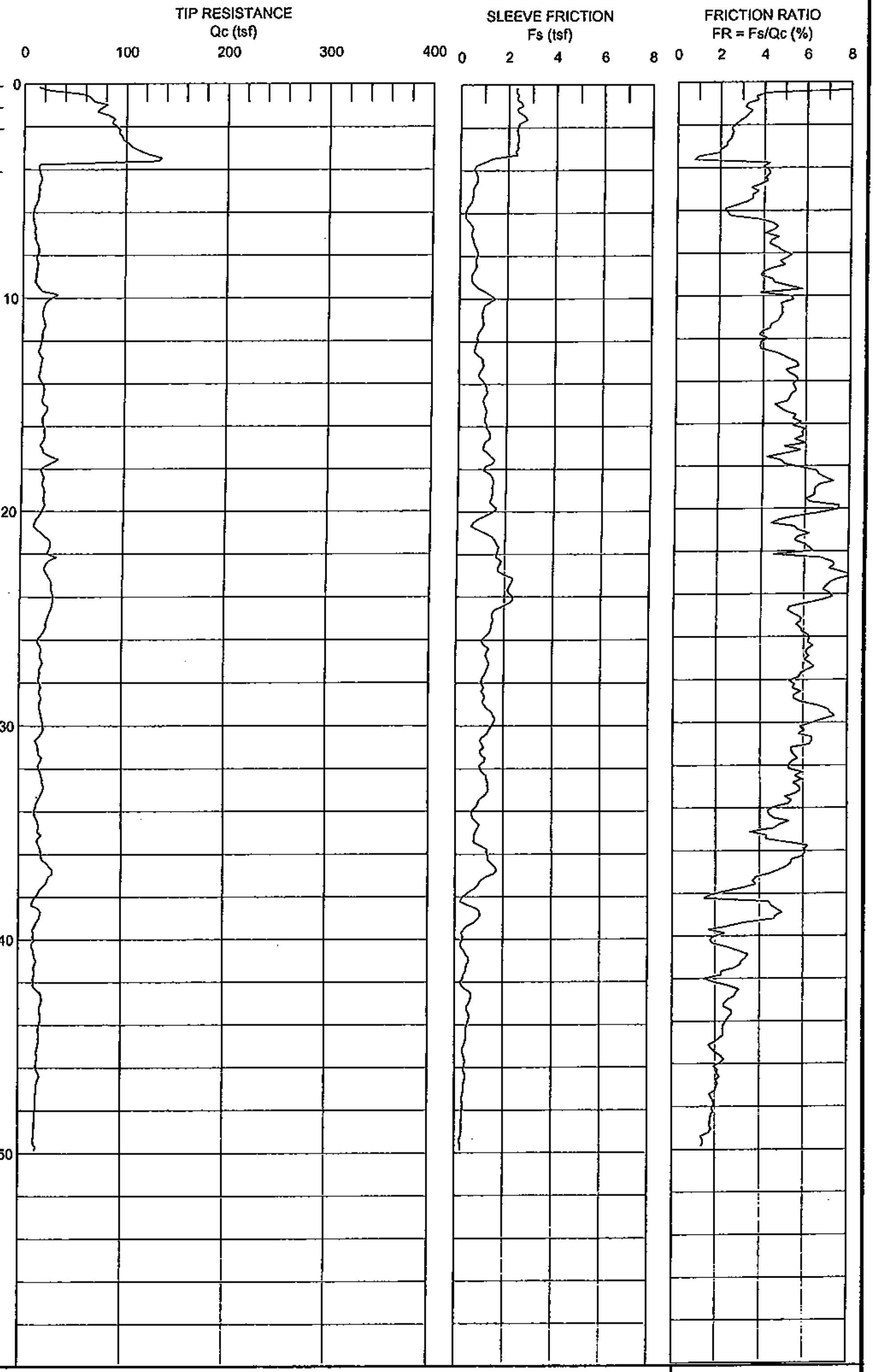
DEPTH (FEET)

INTERPRETED SOIL PROFILE
From Robertson & Campanella (1989)

GROUND EL. +/-

Clay	CL/CH	hard
Sandy Silt to Clayey Silt	ML	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Silty Clay to Clay	CL	stiff
Silty Clay to Clay	" "	stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Silty Clay to Clay	CL	stiff
Clayey Silt to Silty Clay	ML/CL	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff
Sandy Silt to Clayey Silt	ML	very loose
Sandy Silt to Clayey Silt	" "	very loose
Clayey Silt to Silty Clay	ML/CL	stiff

End of Sounding @ 49.5 ft.



Project No:
LE04354

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Plate
B-1

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA Project No: LE04354 Date: 12/20/04

CONE SOUNDING: CPT-1

Est. GWT (ft): 12.0

Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Nk: Phi (deg.)	17.0 Su (tsf)	OCR
0.15	0.5	31.82	10.13	3	3	Clay	CL/CH	very stiff	125	1.3	25	2.00		95			1.87	>10
0.30	1.0	71.19	3.50	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	20	2.00	134.6	45	107	43		
0.45	1.5	76.38	3.27	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	22	2.00	144.4	40	102	42		
0.60	2.0	88.21	2.88	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	25	2.00	166.8	35	101	42		
0.75	2.5	94.19	2.53	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	21	2.00	178.0	30	100	42		
0.93	3.0	101.94	2.35	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	23	2.00	192.7	30	99	42		
1.08	3.5	123.24	1.66	8	8	Sand to Silty Sand	SP/SM	very dense	115	5.5	22	2.00	233.0	20	102	42		
1.23	4.0	53.93	2.99	6	6	Sandy Silt to Clayey Silt	ML	dense	115	3.5	15	2.00	101.9	45	76	39		
1.38	4.5	16.43	4.19	3	3	Clay	CL/CH	stiff	125	1.3	13	2.00		85			0.95	>10
1.53	5.0	15.53	3.80	4	4	Silty Clay to Clay	CL	stiff	125	1.8	9	1.95		85			0.90	>10
1.68	5.5	13.99	3.48	4	4	Silty Clay to Clay	CL	stiff	125	1.8	8	1.85		85			0.80	>10
1.83	6.0	10.16	2.42	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	4	1.76		85			0.58	>10
1.98	6.5	10.41	3.55	4	4	Silty Clay to Clay	CL	stiff	125	1.8	6	1.69		95			0.59	>10
2.13	7.0	11.62	4.38	3	3	Clay	CL/CH	stiff	125	1.3	9	1.62		100			0.66	>10
2.28	7.5	13.29	4.44	3	3	Clay	CL/CH	stiff	125	1.3	11	1.56		95			0.76	>10
2.45	8.0	14.55	4.93	3	3	Clay	CL/CH	stiff	125	1.3	12	1.51		95			0.83	>10
2.60	8.5	13.90	4.96	3	3	Clay	CL/CH	stiff	125	1.3	11	1.46		100			0.79	>10
2.75	9.0	13.23	4.08	3	3	Clay	CL/CH	stiff	125	1.3	11	1.42		95			0.75	>10
2.90	9.5	13.66	4.68	3	3	Clay	CL/CH	stiff	125	1.3	11	1.38		100			0.77	>10
3.05	10.0	26.88	5.00	3	3	Clay	CL/CH	very stiff	125	1.3	22	1.34		80			1.55	>10
3.20	10.5	21.69	5.01	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.32		90			1.24	>10
3.35	11.0	19.84	4.85	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.30		95			1.13	>10
3.50	11.5	21.31	4.45	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	12	1.29		90			1.22	>10
3.65	12.0	18.97	4.00	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	1.27		90			1.08	>10
3.80	12.5	16.82	3.88	4	4	Silty Clay to Clay	CL	stiff	125	1.8	10	1.26		95			0.95	>10
3.95	13.0	18.18	4.91	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.24		100			1.03	>10
4.13	13.5	17.33	5.43	3	3	Clay	CL/CH	stiff	125	1.3	14	1.23		100			0.98	>10
4.28	14.0	17.04	5.46	3	3	Clay	CL/CH	stiff	125	1.3	14	1.22		100			0.96	>10
4.43	14.5	21.21	5.45	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.20		100			1.20	>10
4.58	15.0	19.96	5.21	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.19		100			1.13	>10
4.73	15.5	23.41	4.80	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.18		95			1.33	>10
4.88	16.0	20.50	5.51	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.17		100			1.16	>10
5.03	16.5	21.94	5.88	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.15		100			1.24	>10
5.18	17.0	19.22	5.48	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.14		100			1.08	>10
5.33	17.5	27.57	5.03	3	3	Clay	CL/CH	very stiff	125	1.3	22	1.13		95			1.57	>10
5.48	18.0	23.29	5.22	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.12		100			1.32	>10
5.65	18.5	20.85	6.67	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.11		100			1.18	>10
5.80	19.0	21.33	6.77	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.10		100			1.20	>10
5.95	19.5	21.97	6.29	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.09		100			1.24	>10
6.10	20.0	21.34	7.09	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.08		100			1.20	>10
6.25	20.5	15.48	5.72	3	3	Clay	CL/CH	stiff	125	1.3	12	1.07		100			0.86	5.53
6.40	21.0	15.87	5.20	3	3	Clay	CL/CH	stiff	125	1.3	13	1.06		100			0.88	5.65
6.55	21.5	26.53	5.79	3	3	Clay	CL/CH	very stiff	125	1.3	21	1.05		100			1.50	>10
6.70	22.0	27.19	6.21	3	3	Clay	CL/CH	very stiff	125	1.3	22	1.05		100			1.54	>10
6.85	22.5	29.12	6.18	3	3	Clay	CL/CH	very stiff	125	1.3	23	1.04		100			1.65	>10
7.00	23.0	24.40	7.41	3	3	Clay	CL/CH	very stiff	125	1.3	20	1.03		100			1.38	>10
7.18	23.5	29.74	7.65	3	3	Clay	CL/CH	very stiff	125	1.3	24	1.02		100			1.69	>10
7.33	24.0	31.24	7.01	3	3	Clay	CL/CH	very stiff	125	1.3	25	1.01		100			1.78	>10
7.48	24.5	31.71	6.74	3	3	Clay	CL/CH	very stiff	125	1.3	25	1.01		100			1.80	>10
7.63	25.0	28.38	5.36	3	3	Clay	CL/CH	very stiff	125	1.3	23	1.00		100			1.61	>10
7.78	25.5	25.50	5.79	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.99		100			1.44	>10
7.93	26.0	21.23	6.01	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.98		100			1.18	7.00
8.08	26.5	19.41	6.26	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.98		100			1.08	6.00
8.23	27.0	21.10	6.12	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.97		100			1.17	6.65
8.38	27.5	20.13	6.30	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.96		100			1.12	6.00
8.53	28.0	19.23	5.66	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.96		100			1.06	5.42
8.68	28.5	20.08	5.65	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.95		100			1.11	5.76
8.85	29.0	20.55	5.67	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.94		100			1.14	5.88
9.00	29.5	20.76	7.00	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.94		100			1.15	5.88
9.15	30.0	22.80	6.88	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.93		100			1.27	6.65

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA Project No: LE04354 Date: 12/20/04

CONE SOUNDING: CPT-1

Est. GWT (ft): 12.0

Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Nk: Phi (deg.)	17.0 Su (tsf)	OCR
9.30	30.5	21.60	5.89	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.93		100			1.20	6.00
9.45	31.0	17.19	6.36	3	3	Clay	CL/CH	stiff	125	1.3	14	0.92		100			0.94	4.00
9.60	31.5	20.05	5.47	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.92		100			1.10	5.10
9.75	32.0	19.47	5.50	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.91		100			1.07	4.68
9.90	32.5	21.74	5.63	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.90		100			1.20	5.53
10.05	33.0	23.37	5.76	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.90		100			1.30	6.10
10.20	33.5	20.39	5.56	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.89		100			1.12	4.78
10.38	34.0	15.97	5.12	3	3	Clay	CL/CH	stiff	125	1.3	13	0.89		100			0.86	3.28
10.53	34.5	16.45	4.48	3	3	Clay	CL/CH	stiff	125	1.3	13	0.88		100			0.89	3.35
10.68	35.0	18.50	4.96	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.88		100			1.01	3.91
10.83	35.5	19.11	4.05	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.87		100			1.04	5.21
10.98	36.0	20.64	5.86	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.87		100			1.13	4.47
11.13	36.5	25.44	5.72	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.86		100			1.41	6.21
11.28	37.0	31.72	4.84	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	18	0.86		100			1.78	>10
11.43	37.5	25.49	3.77	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.85		100			1.41	>10
11.58	38.0	17.68	2.48	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.85		100			0.95	5.65
11.73	38.5	15.25	3.47	4	4	Silty Clay to Clay	CL	stiff	125	1.8	9	0.85		100			0.81	3.35
11.88	39.0	20.64	4.84	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.84		100			1.13	4.00
12.05	39.5	15.50	3.51	4	4	Silty Clay to Clay	CL	stiff	125	1.8	9	0.84		100			0.82	3.28
12.20	40.0	14.77	2.00	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.83		100			0.78	3.91
12.35	40.5	13.50	2.07	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	5	0.83		100			0.70	3.43
12.50	41.0	15.96	3.29	4	4	Silty Clay to Clay	CL	stiff	125	1.8	9	0.82		100			0.85	3.28
12.65	41.5	15.32	3.05	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.82		100			0.81	4.00
12.80	42.0	14.74	2.01	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.82		100			0.77	3.66
12.95	42.5	17.48	2.54	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.81		100			0.93	4.78
13.10	43.0	22.47	2.80	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.81		100			1.23	7.13
13.25	43.5	20.78	2.49	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.13	6.21
13.40	44.0	21.29	2.62	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.80		100			1.16	6.43
13.58	44.5	19.71	2.35	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.80		100			1.06	5.53
13.73	45.0	19.60	2.17	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.80		100			1.05	5.42
13.88	45.5	18.05	1.84	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.79	13.5	100	13	30		
14.03	46.0	17.42	2.29	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.79		100			0.92	4.28
14.18	46.5	19.49	2.03	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.79	14.5	100	15	30		
14.33	47.0	17.99	2.10	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.78		100			0.96	4.37
14.48	47.5	16.62	1.85	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.78		100			0.88	3.83
14.63	48.0	16.66	1.91	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.78		100			0.88	3.83
14.78	48.5	15.96	1.83	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.77		100			0.83	3.58
14.93	49.0	15.56	1.78	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.77		100			0.81	3.35
15.10	49.5	14.89	1.48	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	4	0.77	10.8	100	7	29		

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: HOLGUIN, FAHAN & ASSC. Truck Mounted Electric Cone with 23 ton reaction weight
DATE: 12/20/04

LOG OF CONE SOUNDING DATA CPT-2

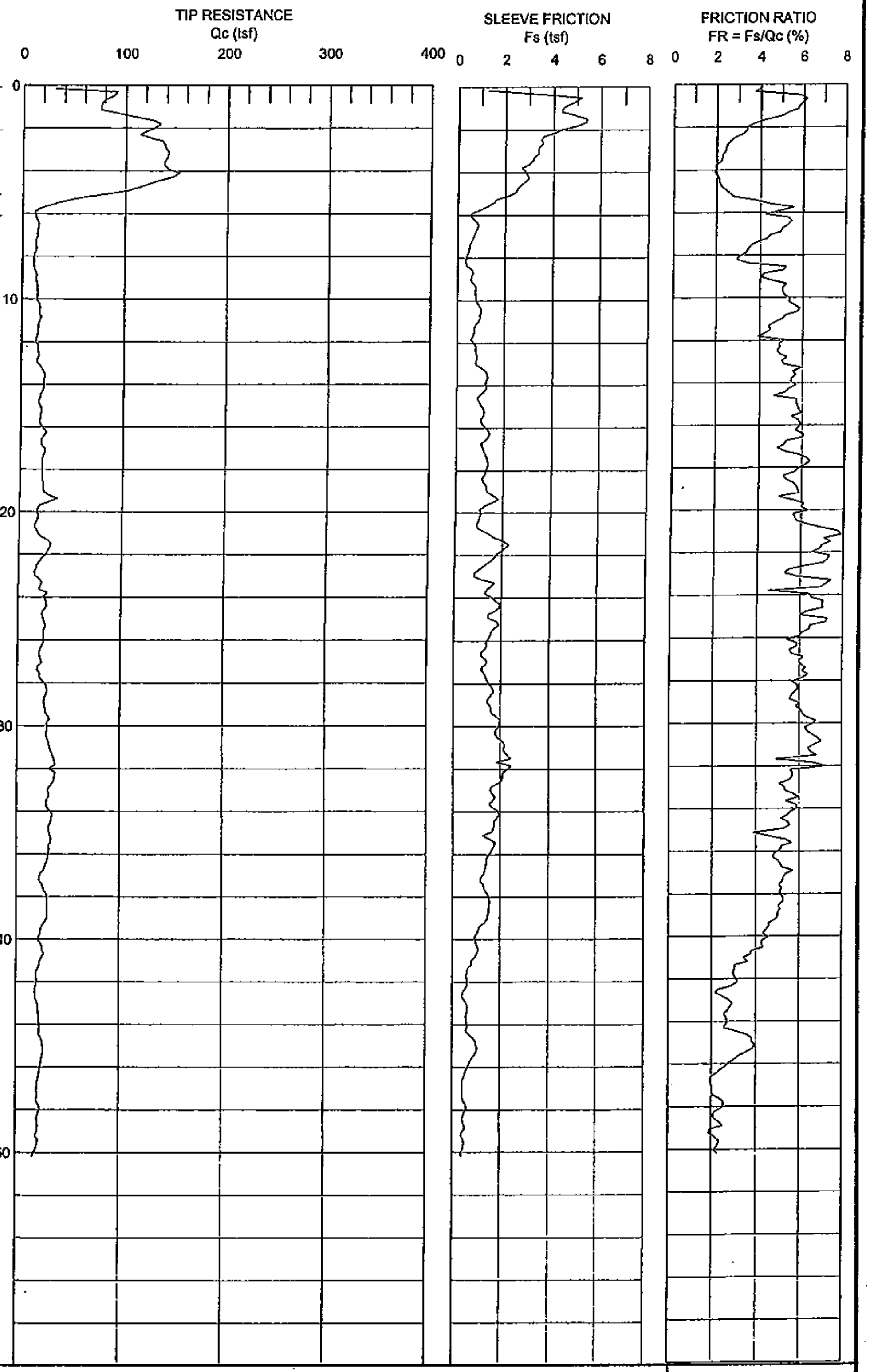
DEPTH (FEET)

INTERPRETED SOIL PROFILE
From Robertson & Campanella (1989)

GROUND EL. +/-

Overconsolidated Soil	??	very dense
Overconsolidated Soil	" "	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Silty Sand to Sandy Silt	" "	very dense
Clayey Silt to Silty Clay	ML/CL	hard
Clay	CL/CH	stiff
Silty Clay to Clay	CL	stiff
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Silty Clay to Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Sandy Silt to Clayey Silt	ML	very loose
Clayey Silt to Silty Clay	ML/CL	very stiff
Sandy Silt to Clayey Silt	ML	very loose
Sandy Silt to Clayey Silt	" "	very loose

End of Sounding @ 50.0 ft.



Project No:
LE04354

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Plate
B-2

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA   Project No: LE04354   Date: 12/20/04

CONE SOUNDING: CPT-2

Est. GWT (ft): 12.0   Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Nk: **17.0**

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Phi (deg.)	Su (tsf)	OCR
0.15	0.5	70.28	4.52	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	28	2.00		50			4.13	>10
0.30	1.0	77.82	5.97	11	11	Overconsolidated Soil	??	very dense	120	1.0	78	2.00	147.1	55	110	43		
0.45	1.5	91.98	5.31	11	11	Overconsolidated Soil	??	very dense	120	1.0	92	2.00	173.9	50	107	43		
0.60	2.0	129.94	3.78	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	37	2.00	245.6	35	113	44		
0.75	2.5	119.62	3.11	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	34	2.00	226.1	30	107	43		
0.93	3.0	137.68	2.51	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	31	2.00	260.3	25	108	43		
1.08	3.5	140.87	2.30	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	31	2.00	266.3	25	106	43		
1.23	4.0	139.35	2.04	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	31	2.00	263.4	20	104	43		
1.38	4.5	144.85	2.01	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	32	2.00	273.8	20	103	42		
1.53	5.0	113.08	2.24	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	25	1.95	208.9	25	94	41		
1.68	5.5	52.70	3.38	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	21	1.86		50			3.08	>10
1.83	6.0	13.87	4.91	3	3	Clay	CL/CH	stiff	125	1.3	11	1.77		95			0.80	>10
1.98	6.5	15.08	5.36	3	3	Clay	CL/CH	stiff	125	1.3	12	1.70		95			0.87	>10
2.13	7.0	14.77	4,81	3	3	Clay	CL/CH	stiff	125	1.3	12	1.63		95			0.85	>10
2.28	7.5	13.38	3.90	3	3	Clay	CL/CH	stiff	125	1.3	11	1.57		90			0.76	>10
2.45	8.0	12.25	3.27	4	4	Silty Clay to Clay	CL	stiff	125	1.8	7	1.51		90			0.69	>10
2.60	8.5	11.34	3.86	3	3	Clay	CL/CH	stiff	125	1.3	9	1.46		100			0.64	9.79
2.75	9.0	13.62	4.43	3	3	Clay	CL/CH	stiff	125	1.3	11	1.42		95			0.77	>10
2.90	9.5	14.76	4.97	3	3	Clay	CL/CH	stiff	125	1.3	12	1.38		100			0.84	>10
3.05	10.0	15.04	5.19	3	3	Clay	CL/CH	stiff	125	1.3	12	1.34		100			0.85	>10
3.20	10.5	17.24	5.61	3	3	Clay	CL/CH	stiff	125	1.3	14	1.33		100			0.98	>10
3.35	11.0	17.82	5.31	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.31		100			1.01	>10
3.50	11.5	16.22	4.53	3	3	Clay	CL/CH	stiff	125	1.3	13	1.29		100			0.92	>10
3.65	12.0	14.59	4.45	3	3	Clay	CL/CH	stiff	125	1.3	12	1.28		100			0.82	9.19
3.80	12.5	15.95	4.89	3	3	Clay	CL/CH	stiff	125	1.3	13	1.26		100			0.90	>10
3.95	13.0	16.10	5.07	3	3	Clay	CL/CH	stiff	125	1.3	13	1.25		100			0.91	>10
4.13	13.5	20.52	5.55	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.23		100			1.17	>10
4.28	14.0	22.48	5.55	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.22		100			1.28	>10
4.43	14.5	20.89	5.42	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.21		100			1.19	>10
4.58	15.0	17.79	5.37	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.19		100			1.00	>10
4.73	15.5	19.47	5.86	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.18		100			1.10	>10
4.88	16.0	19.76	5.77	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.17		100			1.12	>10
5.03	16.5	22.53	5.91	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.16		100			1.28	>10
5.18	17.0	21.67	5.09	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.15		100			1.23	>10
5.33	17.5	22.15	5.77	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.13		100			1.25	>10
5.48	18.0	21.43	6.10	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.12		100			1.21	>10
5.65	18.5	21.56	5.34	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.11		100			1.22	>10
5.80	19.0	22.73	5.72	3	3	Clay	CL/CH	very stiff	125	1.3	18	1.10		100			1.29	>10
5.95	19.5	30.63	5.48	3	3	Clay	CL/CH	very stiff	125	1.3	25	1.09		95			1.75	>10
6.10	20.0	17.95	6.14	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.08		100			1.00	7.41
6.25	20.5	17.30	5.70	3	3	Clay	CL/CH	stiff	125	1.3	14	1.07		100			0.96	6.65
6.40	21.0	16.60	6.99	3	3	Clay	CL/CH	stiff	125	1.3	13	1.07		100			0.92	6.10
6.55	21.5	26.75	7.44	3	3	Clay	CL/CH	very stiff	125	1.3	21	1.06		100			1.52	>10
6.70	22.0	28.17	6.81	3	3	Clay	CL/CH	very stiff	125	1.3	23	1.05		100			1.60	>10
6.85	22.5	20.17	7.24	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.04		100			1.13	7.85
7.00	23.0	16.15	5.62	3	3	Clay	CL/CH	stiff	125	1.3	13	1.03		100			0.89	5.21
7.18	23.5	21.37	6.84	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.02		100			1.20	8.27
7.33	24.0	24.23	5.98	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.02		100			1.36	>10
7.48	24.5	27.09	6.88	3	3	Clay	CL/CH	very stiff	125	1.3	22	1.01		100			1.53	>10
7.63	25.0	23.97	6.46	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.00		100			1.35	9.39
7.78	25.5	25.90	6.98	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.99		100			1.46	>10
7.93	26.0	24.80	6.17	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.99		100			1.39	9.59
8.08	26.5	22.94	5.66	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.98		100			1.28	8.00
8.23	27.0	22.28	5.92	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.97		100			1.24	7.27
8.38	27.5	20.15	6.14	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.97		100			1.12	6.10
8.53	28.0	24.13	6.05	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.96		100			1.35	8.14
8.68	28.5	28.28	5.86	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.95		100			1.59	>10
8.85	29.0	26.02	5.73	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.95		100			1.46	8.85
9.00	29.5	28.06	6.01	3	3	Clay	CL/CH	very stiff	125	1.3	22	0.94		100			1.58	>10
9.15	30.0	29.72	6.57	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.93		100			1.68	>10

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA Project No: LE04354 Date: 12/20/04

CONE SOUNDING: CPT-2

Est. GWT (ft): 12.0 Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base	Base	Avg	Avg		1				Est.	Qc		Cn		Est.	Rel.	Nk:	17.0	
Depth	Depth	Tip	Friction		Soil	Soil		Density or	Density	to	SPT	or	Norm.	%	Dens.	Phi	Su	
meters	feet	Qc, tsf	Ratio, %		Type	Classification	USC	Consistency	(pcf)	N	N(60)	Cq	Qc1n	Fines	Dr (%)	(deg.)	(tsf)	OCR
9.30	30.5	28.55	6.41	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.93		100			1.61	>10
9.45	31.0	31.07	6.84	3	3	Clay	CL/CH	very stiff	125	1.3	25	0.92		100			1.75	>10
9.60	31.5	34.71	6.59	3	3	Clay	CL/CH	very stiff	125	1.3	28	0.92		100			1.97	>10
9.75	32.0	35.27	6.25	3	3	Clay	CL/CH	very stiff	125	1.3	28	0.91		100			2.00	>10
9.90	32.5	37.01	5.65	3	3	Clay	CL/CH	hard	125	1.3	30	0.91		100			2.10	>10
10.05	33.0	32.37	5.31	3	3	Clay	CL/CH	very stiff	125	1.3	26	0.90		100			1.83	>10
10.20	33.5	30.28	5.70	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.89		100			1.70	9.59
10.38	34.0	29.97	5.71	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.89		100			1.68	9.19
10.53	34.5	34.16	5.42	3	3	Clay	CL/CH	very stiff	125	1.3	27	0.88		100			1.93	>10
10.68	35.0	31.53	5.44	3	3	Clay	CL/CH	very stiff	125	1.3	25	0.88		100			1.77	9.79
10.83	35.5	33.18	4.62	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	19	0.87		100			1.87	>10
10.98	36.0	31.41	5.32	3	3	Clay	CL/CH	very stiff	125	1.3	25	0.87		100			1.77	9.19
11.13	36.5	28.95	4.94	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.86		100			1.62	7.70
11.28	37.0	23.74	5.43	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.86		100			1.31	5.42
11.43	37.5	24.03	5.19	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.85		100			1.33	5.42
11.58	38.0	28.73	5.16	3	3	Clay	CL/CH	very stiff	125	1.3	23	0.85		100			1.60	7.13
11.73	38.5	29.89	5.19	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.85		100			1.67	7.56
11.88	39.0	29.55	5.05	3	3	Clay	CL/CH	very stiff	125	1.3	24	0.84		100			1.65	7.27
12.05	39.5	25.32	4.72	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.84		100			1.40	5.53
12.20	40.0	22.19	4.46	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.83		100			1.22	4.37
12.35	40.5	24.43	4.30	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	14	0.83		100			1.35	6.54
12.50	41.0	24.85	3.66	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.82		100			1.37	9.39
12.65	41.5	21.29	3.25	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.82		100			1.16	6.88
12.80	42.0	19.81	3.04	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.82		100			1.07	6.00
12.95	42.5	18.87	2.79	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.02	5.42
13.10	43.0	19.60	2.48	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.06	5.76
13.25	43.5	21.70	2.84	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.81		100			1.18	6.65
13.40	44.0	22.24	2.62	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.80		100			1.21	6.88
13.58	44.5	22.52	2.78	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.80		100			1.23	6.88
13.73	45.0	25.15	3.77	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.80		100			1.38	8.27
13.88	45.5	26.20	3.80	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.79		100			1.44	8.85
14.03	46.0	24.44	3.02	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.79		100			1.34	7.70
14.18	46.5	22.65	2.43	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.79		100			1.23	6.54
14.33	47.0	20.81	1.98	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.78	15.4	100	17	30		
14.48	47.5	20.51	2.12	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.78	15.1	100	17	30		
14.63	48.0	22.61	2.50	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.78		100			1.23	6.32
14.78	48.5	20.83	2.13	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.77	15.2	100	17	30		
14.93	49.0	20.93	2.27	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.77		100			1.13	5.42
15.10	49.5	20.67	2.11	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	6	0.77	15.0	100	16	30		
15.25	50.0	19.06	2.25	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.76		100			1.01	4.47

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
LOCATION: See Site and Boring Location Plan

CONE PENETROMETER: HOLGUIN, FAHAN & ASSC. Truck Mounted Electric Cone with 23 ton reaction weight
DATE: 12/20/04

LOG OF CONE SOUNDING DATA CPT-3

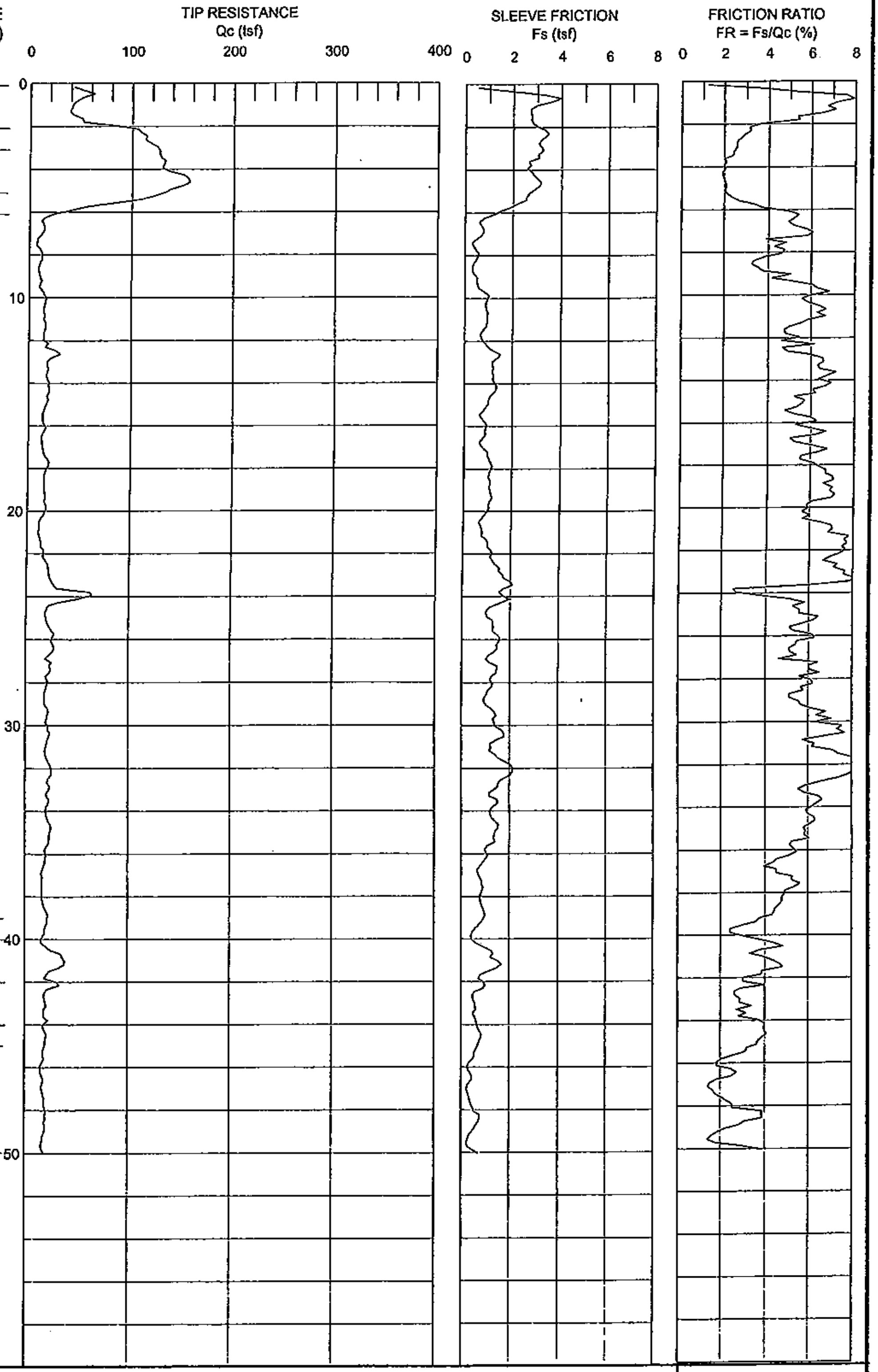
DEPTH (FEET)

INTERPRETED SOIL PROFILE
From Robertson & Campanella (1989)

GROUND EL. +/-

Clay	CL/CH	hard
Clay	" "	hard
Sandy Silt to Clayey Silt	ML	very dense
Silty Sand to Sandy Silt	SM/ML	very dense
Silty Sand to Sandy Silt	" "	very dense
Sandy Silt to Clayey Silt	ML	dense
Clay	CL/CH	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clay	" "	hard
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	very stiff
Clay	" "	stiff
Clay	" "	stiff
Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Silty Clay to Clay	CL	very stiff
Silty Clay to Clay	" "	very stiff
Clayey Silt to Silty Clay	ML/CL	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Silty Clay to Clay	CL	very stiff
Clayey Silt to Silty Clay	ML/CL	stiff
Clayey Silt to Silty Clay	" "	stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	very stiff
Clayey Silt to Silty Clay	" "	stiff

End of Sounding @ 50.0 ft.



-10-
-20-
-30-
-40-
-50-

Project No:
LE04354

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Plate
B-3

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA Project No: LE04354 Date: 12/20/04

CONE SOUNDING: CPT-3

Est. GWT (ft): 12.0

Phi Correlation: 0 0-Schm(78),1-R&C(83),2-PHT(74)

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Nk: Phi (deg.)	17.0 Su (tsf)	OCR
0.15	0.5	51.76	3.36	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	21	2.00		50			3.04	>10
0.30	1.0	46.42	7.56	3	3	Clay	CL/CH	hard	125	1.3	37	2.00		75			2.73	>10
0.45	1.5	40.35	6.79	3	3	Clay	CL/CH	hard	125	1.3	32	2.00		75			2.37	>10
0.60	2.0	61.72	4.80	4	4	Silty Clay to Clay	CL	hard	125	1.8	35	2.00		55			3.62	>10
0.75	2.5	109.67	3.07	6	6	Sandy Silt to Clayey Silt	ML	very dense	115	3.5	31	2.00	207.3	35	104	43		
0.93	3.0	118.60	2.64	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	26	2.00	224.2	30	103	42		
1.08	3.5	127.70	2.43	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	28	2.00	241.4	25	103	42		
1.23	4.0	131.15	2.02	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	29	2.00	247.9	25	102	42		
1.38	4.5	147.55	1.96	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	33	2.00	278.9	20	103	42		
1.53	5.0	148.38	2.05	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	33	1.94	271.7	20	102	42		
1.68	5.5	111.44	2.28	7	7	Silty Sand to Sandy Silt	SM/ML	very dense	115	4.5	25	1.85	194.4	25	92	41		
1.83	6.0	40.17	4.02	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	16	1.76		60			2.34	>10
1.98	6.5	13.36	5.18	3	3	Clay	CL/CH	stiff	125	1.3	11	1.69		100			0.76	>10
2.13	7.0	13.22	5.65	3	3	Clay	CL/CH	stiff	125	1.3	11	1.62		100			0.75	>10
2.28	7.5	7.68	4.85	3	3	Clay	CL/CH	firm	125	1.3	6	1.56		100			0.43	6.10
2.45	8.0	11.50	4.55	3	3	Clay	CL/CH	stiff	125	1.3	9	1.51		100			0.65	>10
2.60	8.5	10.61	3.49	4	4	Silty Clay to Clay	CL	stiff	125	1.8	6	1.46		95			0.60	>10
2.75	9.0	9.81	4.10	3	3	Clay	CL/CH	stiff	125	1.3	8	1.42		100			0.55	6.54
2.90	9.5	10.85	5.09	3	3	Clay	CL/CH	stiff	125	1.3	9	1.38		100			0.61	7.00
3.05	10.0	14.61	6.36	3	3	Clay	CL/CH	stiff	125	1.3	12	1.34		100			0.82	>10
3.20	10.5	14.97	5.91	3	3	Clay	CL/CH	stiff	125	1.3	12	1.32		100			0.85	>10
3.35	11.0	14.49	6.53	3	3	Clay	CL/CH	stiff	125	1.3	12	1.31		100			0.82	>10
3.50	11.5	15.94	5.42	3	3	Clay	CL/CH	stiff	125	1.3	13	1.29		100			0.90	>10
3.65	12.0	14.15	5.01	3	3	Clay	CL/CH	stiff	125	1.3	11	1.27		100			0.79	8.56
3.80	12.5	20.31	5.15	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.26		95			1.16	>10
3.95	13.0	23.81	5.79	3	3	Clay	CL/CH	very stiff	125	1.3	19	1.24		95			1.36	>10
4.13	13.5	18.35	6.42	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.23		100			1.04	>10
4.28	14.0	18.13	6.73	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.22		100			1.02	>10
4.43	14.5	19.70	6.56	3	3	Clay	CL/CH	very stiff	125	1.3	16	1.20		100			1.12	>10
4.58	15.0	18.07	5.71	3	3	Clay	CL/CH	very stiff	125	1.3	14	1.19		100			1.02	>10
4.73	15.5	14.86	5.24	3	3	Clay	CL/CH	stiff	125	1.3	12	1.18		100			0.83	7.00
4.88	16.0	14.60	5.69	3	3	Clay	CL/CH	stiff	125	1.3	12	1.17		100			0.81	6.65
5.03	16.5	13.49	6.25	3	3	Clay	CL/CH	stiff	125	1.3	11	1.16		100			0.75	5.65
5.18	17.0	13.31	5.44	3	3	Clay	CL/CH	stiff	125	1.3	11	1.14		100			0.74	5.31
5.33	17.5	16.20	6.21	3	3	Clay	CL/CH	stiff	125	1.3	13	1.13		100			0.90	7.13
5.48	18.0	19.16	5.98	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.12		100			1.08	9.59
5.65	18.5	15.49	6.80	3	3	Clay	CL/CH	stiff	125	1.3	12	1.11		100			0.86	6.32
5.80	19.0	15.81	6.89	3	3	Clay	CL/CH	stiff	125	1.3	13	1.10		100			0.88	6.32
5.95	19.5	16.32	7.00	3	3	Clay	CL/CH	stiff	125	1.3	13	1.09		100			0.91	6.43
6.10	20.0	17.26	5.95	3	3	Clay	CL/CH	stiff	125	1.3	14	1.08		100			0.96	6.88
6.25	20.5	13.28	5.76	3	3	Clay	CL/CH	stiff	125	1.3	11	1.07		100			0.73	4.37
6.40	21.0	11.14	6.84	3	3	Clay	CL/CH	stiff	125	1.3	9	1.06		100			0.60	3.28
6.55	21.5	12.48	7.40	3	3	Clay	CL/CH	stiff	125	1.3	10	1.06		100			0.68	3.74
6.70	22.0	14.92	7.62	3	3	Clay	CL/CH	stiff	125	1.3	12	1.05		100			0.82	4.89
6.85	22.5	17.77	6.98	3	3	Clay	CL/CH	stiff	125	1.3	14	1.04		100			0.99	6.32
7.00	23.0	21.45	7.34	3	3	Clay	CL/CH	very stiff	125	1.3	17	1.03		100			1.20	8.41
7.18	23.5	24.58	7.84	3	3	Clay	CL/CH	very stiff	125	1.3	20	1.02		100			1.39	>10
7.33	24.0	51.65	3.68	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	21	1.02		70			2.98	>10
7.48	24.5	34.37	4.91	3	3	Clay	CL/CH	very stiff	125	1.3	27	1.01		95			1.96	>10
7.63	25.0	18.84	5.44	3	3	Clay	CL/CH	very stiff	125	1.3	15	1.00		100			1.05	6.10
7.78	25.5	21.09	6.11	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.99		100			1.18	7.13
7.93	26.0	26.12	5.49	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.99		100			1.47	>10
8.08	26.5	26.28	5.55	3	3	Clay	CL/CH	very stiff	125	1.3	21	0.98		100			1.48	>10
8.23	27.0	21.92	5.06	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.97		100			1.22	7.13
8.38	27.5	23.63	6.15	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.97		100			1.32	8.00
8.53	28.0	20.49	6.07	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.96		100			1.14	6.10
8.68	28.5	19.11	5.87	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.95		100			1.06	5.31
8.85	29.0	18.15	5.24	3	3	Clay	CL/CH	stiff	125	1.3	15	0.95		100			1.00	4.78
9.00	29.5	21.72	6.18	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.94		100			1.21	6.32
9.15	30.0	20.63	6.55	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.93		100			1.14	5.65

LANDMARK CONSULTANTS, INC.

CONE PENETROMETER INTERPRETATION (based on Robertson & Campanella, 1989, refer to Key to CPT logs)

Project: ORMAT Heber 2 Facilities, Heber, CA   Project No: LE04354   Date: 12/20/04

CONE SOUNDING: CPT-3

Est. GWT (ft): 12.0

Phi Correlation: **0** 0-Schm(78),1-R&C(83),2-PHT(74)

Nk: **17.0**

Base Depth meters	Base Depth feet	Avg Tip Qc, tsf	Avg Friction Ratio, %		1 Soil Type	Soil Classification	USC	Density or Consistency	Est. Density (pcf)	Qc to N	SPT N(60)	Cn or Cq	Norm. Qc1n	Est. % Fines	Rel. Dens. Dr (%)	Phi (deg.)	Su (tsf)	OCR
9.30	30.5	22.90	7.51	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.93		100			1.27	6.54
9.45	31.0	20.57	6.23	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.92		100			1.14	5.42
9.60	31.5	19.55	6.90	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.92		100			1.08	4.89
9.75	32.0	23.76	8.37	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.91		100			1.32	6.54
9.90	32.5	24.30	8.05	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.90		100			1.35	6.65
10.05	33.0	22.78	6.54	3	3	Clay	CL/CH	very stiff	125	1.3	18	0.90		100			1.26	5.88
10.20	33.5	21.56	5.91	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.89		100			1.19	5.31
10.38	34.0	20.82	6.40	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.89		100			1.15	4.89
10.53	34.5	21.17	6.04	3	3	Clay	CL/CH	very stiff	125	1.3	17	0.88		100			1.17	4.89
10.68	35.0	24.71	6.05	3	3	Clay	CL/CH	very stiff	125	1.3	20	0.88		100			1.37	6.21
10.83	35.5	23.14	5.91	3	3	Clay	CL/CH	very stiff	125	1.3	19	0.87		100			1.28	5.53
10.98	36.0	19.96	5.21	3	3	Clay	CL/CH	very stiff	125	1.3	16	0.87		100			1.09	4.28
11.13	36.5	19.03	4.88	3	3	Clay	CL/CH	very stiff	125	1.3	15	0.86		100			1.04	3.91
11.28	37.0	16.19	4.33	3	3	Clay	CL/CH	stiff	125	1.3	13	0.86		100			0.87	3.07
11.43	37.5	16.02	5.36	3	3	Clay	CL/CH	stiff	125	1.3	13	0.85		100			0.86	3.00
11.58	38.0	16.15	5.06	3	3	Clay	CL/CH	stiff	125	1.3	13	0.85		100			0.86	3.00
11.73	38.5	17.81	4.75	3	3	Clay	CL/CH	stiff	125	1.3	14	0.85		100			0.96	3.35
11.88	39.0	21.66	4.41	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	12	0.84		100			1.19	5.65
12.05	39.5	20.18	3.42	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.84		100			1.10	6.65
12.20	40.0	17.00	2.62	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.83		100			0.91	5.00
12.35	40.5	20.64	4.32	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	12	0.83		100			1.12	5.00
12.50	41.0	36.57	3.70	5	5	Clayey Silt to Silty Clay	ML/CL	hard	120	2.5	15	0.82		95			2.06	>10
12.65	41.5	31.64	4.64	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	18	0.82		100			1.77	>10
12.80	42.0	23.58	3.56	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	9	0.82		100			1.29	8.14
12.95	42.5	24.97	3.28	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	10	0.81		100			1.37	8.85
13.10	43.0	19.07	2.71	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.03	5.42
13.25	43.5	18.86	2.98	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.81		100			1.01	5.31
13.40	44.0	19.54	3.20	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.80		100			1.05	5.53
13.58	44.5	19.29	3.97	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.80		100			1.04	3.91
13.73	45.0	19.79	3.86	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.80		100			1.07	4.00
13.88	45.5	17.66	3.31	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.79		100			0.94	4.47
14.03	46.0	16.42	2.18	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.79		100			0.87	3.91
14.18	46.5	15.61	2.35	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	6	0.78		100			0.82	3.58
14.33	47.0	16.68	1.80	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.78	12.3	100	11	29		
14.48	47.5	18.25	1.80	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.78	13.4	100	13	30		
14.63	48.0	19.39	2.43	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.78		100			1.04	4.89
14.78	48.5	19.39	3.87	4	4	Silty Clay to Clay	CL	very stiff	125	1.8	11	0.77		100			1.04	3.58
14.93	49.0	19.13	2.69	5	5	Clayey Silt to Silty Clay	ML/CL	very stiff	120	2.5	8	0.77		100			1.02	4.57
15.10	49.5	16.46	1.59	6	6	Sandy Silt to Clayey Silt	ML	very loose	115	3.5	5	0.77	11.9	100	10	29		
15.25	50.0	16.91	2.83	5	5	Clayey Silt to Silty Clay	ML/CL	stiff	120	2.5	7	0.76		100			0.89	3.74

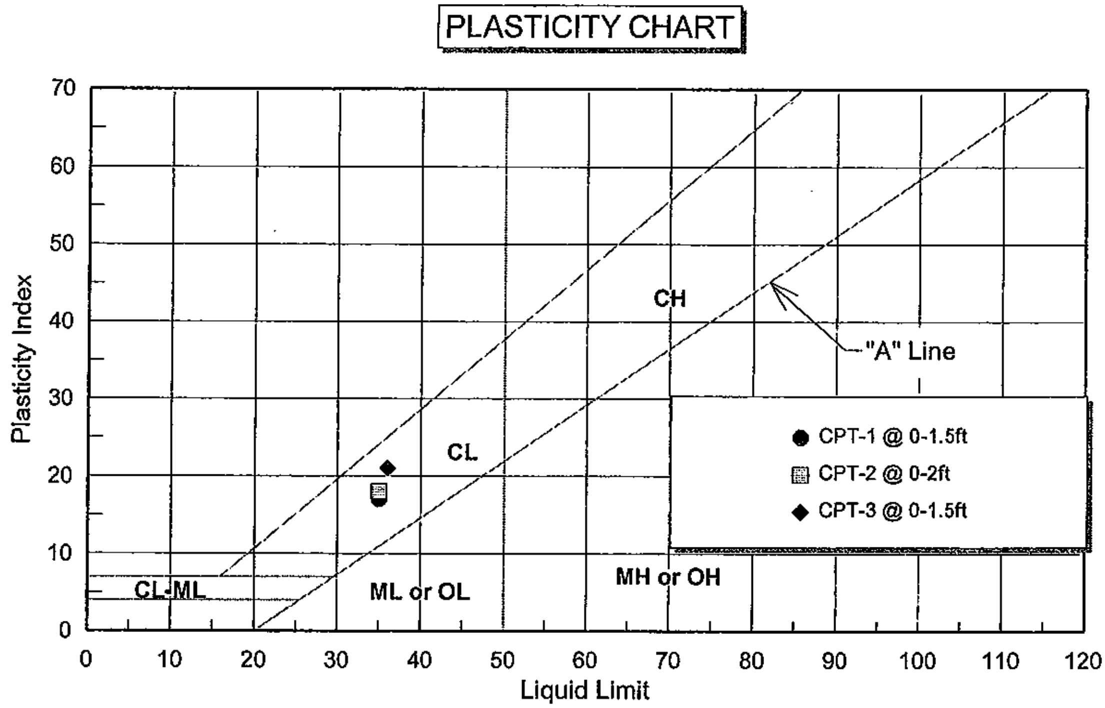
APPENDIX C

LANDMARK CONSULTANTS, INC.

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
JOB NO: LE04354
DATE: 12/28/04

ATTERBERG LIMITS (ASTM D4318)

Sample Location	Sample Depth (ft)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	USCS Classif-ation
CPT-1	0-1.5	35	18	17	CL
CPT-2	0-2	35	17	18	CL
CPT-3	0-1.5	36	15	21	CL



LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No: LE04354

**Atterberg Limits
Test Results**

**Plate
C-1**

LANDMARK CONSULTANTS, INC.

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
JOB NO: LE04354
DATE: 12/28/04

CHEMICAL ANALYSES

Boring:	CPT-1	CPT-1	CPT-2	CPT-2	**CalTrans**
Sample Depth, ft:	0-1.5	1.5-3	0-2	2-3	**Method**
pH:	7.9	7.9	7.8	7.9	**643**
Electrical Conductivity (mmhos):	2.5	1.7	1.8	0.9	**424**
Resistivity (ohm-cm):	260	1000	300	1000	**643**
Chloride (Cl), ppm:	3,040	230	1,490	220	**422**
Sulfate (SO4), ppm:	2,812	3,006	1,500	1,106	**417**

General Guidelines for Soil Corrosivity

Material Affected	Chemical Agent	Amount in Soil (ppm)	Degree of Corrosivity
Concrete	Soluble	0 -1000	Low
	Sulfates	1000 - 2000	Moderate
		2000 - 20,000	Severe
		> 20,000	Very Severe
Normal	Soluble	0 - 200	Low
Grade	Chlorides	200 - 700	Moderate
Steel		700 - 1500	Severe
		> 1500	Very Severe
Normal	Resistivity	1-1000	Very Severe
Grade		1000-2000	Severe
Steel		2000-10,000	Moderate
		10,000+	Low

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No: **LE04354**

Selected Chemical Analyses Results

Plate C-2

LANDMARK CONSULTANTS, INC.

CLIENT: ORMAT
PROJECT: ORMAT Heber 2 Facilities, Heber, CA
JOB NO: LE04354
DATE: 12/28/04

CHEMICAL ANALYSES

Boring:	CPT-3	CPT-3	**CalTrans**
Sample Depth, ft:	0-1.5	1.5-3	**Method**
pH:	7.9	7.8	**643**
Electrical Conductivity (mmhos):	1.5	1.3	**424**
Resistivity (ohm-cm):	450	1000	**643**
Chloride (Cl), ppm:	570	210	**422**
Sulfate (SO4), ppm:	1,785	1,052	**417**

General Guidelines for Soil Corrosivity

Material Affected	Chemical Agent	Amount in Soil (ppm)	Degree of Corrosivity
Concrete	Soluble	0 -1000	Low
	Sulfates	1000 - 2000	Moderate
		2000 - 20,000	Severe
		> 20,000	Very Severe
Normal	Soluble	0 - 200	Low
Grade	Chlorides	200 - 700	Moderate
Steel		700 - 1500	Severe
		> 1500	Very Severe
Normal	Resistivity	1-1000	Very Severe
Grade		1000-2000	Severe
Steel		2000-10,000	Moderate
		10,000+	Low

LANDMARK
Geo-Engineers and Geologists
a DBE/MBE/SBE Company

Project No: **LE04354**

Selected Chemical Analyses Results

Plate C-3

APPENDIX D

REFERENCES

Arango I., 1996, Magnitude Scaling Factors for Soil Liquefaction Evaluations: ASCE Geotechnical Journal, Vol. 122, No. 11.

Bartlett, Steven F. and Youd, T. Leslie, 1995, Empirical Prediction of Liquefaction-Induced Lateral Spread: ASCE Geotechnical Journal, Vol. 121, No. 4.

Blake, T. F., 2000, FRISKSP - A computer program for the probabilistic estimation of seismic hazard using faults as earthquake sources.

Boore, D. M., Joyner, W. B., and Fumal, T. E., 1997, Empirical Near-Source Attenuation Relationships for Horizontal and Vertical Components of Peak Ground Acceleration, Peak Ground Velocity, and Pseudo-Absolute Acceleration Response Spectra: Seismological Research Letters, Vol. 68, No. 1, p. 154-179.

Building Seismic Safety Council (BSSC), 1991, NEHRP recommended provisions for the development of seismic regulations of new buildings, Parts 1, 2 and Maps: FEMA 222, January 1992

California Division of Mines and Geology (CDMG), 1996, California Fault Parameters: available at http://www.consrv.ca.gov/dmg/shezp/fltindex.html.

California Division of Mines and Geology (CDMG), 1962, Geologic Map of California – San Diego-El Centro Sheet: California Division of Mines and Geology, Scale 1:250,000.

Ellsworth, W. L., 1990, Earthquake History, 1769-1989 in: The San Andreas Fault System, California: U.S. Geological Survey Professional Paper 1515, 283 p.

International Conference of Building Officials (ICBO), 1997, Uniform Building Code, 1997 Edition.

Ishihara, K. (1985), Stability of natural deposits during earthquakes, Proc. 11th Int. Conf. On Soil Mech. And Found. Engrg., Vol. 1, A. A. Balkema, Rotterdam, The Netherlands, 321-376.

Jennings, C. W., 1994, Fault activity map of California and Adjacent Areas: California Division of Mines and Geology, DMG Geologic Map No. 6.

Jones, L. and Hauksson, E., 1994, Review of potential earthquake sources in Southern California: Applied Technology Council, Proceedings of ATC 35-1.

Maley, R. P. and Etheredge, E. C., 1981, Strong motion data from the Westmorland, California earthquake of April 26, 1981: U.S. Geological Survey Open File Report 81-1149, 18 p.

Morton, P. K., 1977, Geology and mineral resources of Imperial County, California: California Division of Mines and Geology, County Report No. 7, 104 p.

Mualchin, L. and Jones, A. L., 1992, Peak acceleration from maximum credible earthquakes in California (Rock and Stiff Soil Sites): California Division of Mines and Geology, DMG Open File Report 92-01.

Naeim, F. and Anderson, J. C., 1993, Classification and evaluation of earthquake records for design: Earthquake Engineering Research Institute, NEHRP Report.

National Research Council, Committee of Earthquake Engineering, 1985, Liquefaction of Soils during Earthquakes: National Academy Press, Washington, D.C.

Porcella, R., Etheredge, E., Maley, R., and Switzer, J., 1987, Strong motion data from the Superstition Hills earthquake of November 24, 1987: U.S. Geological Survey Open File Report 87-672, 56 p.

Robertson, P. K. and Wride, C. E., 1996, Cyclic Liquefaction and its Evaluation based on the SPT and CPT, Proceeding of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils, NCEER Technical Report 97-0022, p. 41-88.

Seed, Harry B., Idriss, I. M., and Arango I., 1983, Evaluation of liquefaction potential using field performance data: ASCE Geotechnical Journal, Vol. 109, No. 3.

Seed, Harry B., et al, 1985, Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations: ASCE Geotechnical Journal, Vol. 113, No. 8.

Sharp, R. V., 1982, Tectonic setting of the Imperial Valley region: U.S. Geological Survey Professional Paper 1254, p. 5-14.

Sylvester, A. G., 1979, Earthquake damage in Imperial Valley, California May 18, 1940, as reported by T. A. Clark: Bulletin of the Seismological Society of America, v. 69, no. 2, p. 547-568.

Tokimatsu, K. and Seed H. B., 1987, Evaluation of settlements in sands due to earthquake shaking: ASCE Geotechnical Journal, v. 113, no. 8.

U.S. Geological Survey (USGS), 1982, The Imperial Valley California Earthquake of October 15, 1979: Professional Paper 1254, 451 p.

U.S. Geological Survey (USGS), 1990, The San Andreas Fault System, California, Professional Paper 1515.

U.S. Geological Survey (USGS), 1996, National Seismic Hazard Maps: available at http://gldage.cr.usgs.gov

Working Group on California Earthquake Probabilities (WGCEP), 1992, Future seismic hazards in southern California, Phase I Report: California Division of Mines and Geology.

Working Group on California Earthquake Probabilities (WGCEP), 1995, Seismic hazards in southern California, Probable Earthquakes, 1994-2014, Phase II Report: Southern California Earthquake Center.

Youd, T. Leslie and Garris, C. T., 1995, Liquefaction induced ground surface disruption: ASCE Geotechnical Journal, Vol. 121, No. 11.

Youd, T. L. et. al., 2001, Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils: Journal of Geotechnical and Geoenvironmental Engineering, Vol. 127, No. 10, p. 817-833.

Zimmerman, R. P., 1981, Soil survey of Imperial County, California, Imperial Valley Area: U.S. Dept. of Agriculture Soil Conservation Service, 112 p.