FOUNDATION REPORT

RETAINING WALLS
WILLOW ROAD/ROUTE 101 INTERCHANGE
COUNTY OF SAN LUIS OBISPO, CA
05-SLO-101 EA 474501
(100% PS&E)

For

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April 30, 2010

Job No. 203125.WIL

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Geotechnical ■
Environmental ■
Materials Testing ■
Construction Inspection ■

Rajappan & Meyer Consulting Engineers, Inc.
1038 Leigh Avenue, Suite 100
San Jose, CA 95126

April 30, 2010
Job No.: 203125.WIL

Attn.: Mr. Keith Meyer, P.E.

Sub: Foundation Report for Retaining Walls (100% PS&E)
Willow Road/Route 101 Interchange Improvements
San Luis Obispo County, CA 05-SLO-101 EA 4745013

Ref: Foundation Repot for Willow Road Undercrossing/Route 101 (Br. No. 49-0252 L/R)
San Luis Obispo County, CA 05-SLO-101 EA 474501 (Parikh, 7/14/2009)

Dear Mr. Meyer:

As requested, we are providing a foundation report for the proposed Retaining Walls at the Willow Road/Route 101 Interchange improvements project in San Luis Obispo County, CA. The location of the site and its vicinity are shown on the Location Map, Plate 1.

Proposed Construction

It is proposed to construct a new interchange at Willow Road and Route 101 near the City of Nipomo in San Luis Obispo County, CA. The new Route 101 undercrossing structure will require cut on the order of 25 feet below existing grade for the Willow Road extension. The planned undercrossing (UC) consists of left and right structures; each one is a single span CIP/PS concrete box girder structure.

In addition to the bridge structures, three retaining walls are proposed along the Route 101 northbound (NB) off- and on-ramps. The walls consist of Caltrans standard Type 1 walls and specially designed walls for higher portion of the walls (Type 1 modified) for Walls No. 2 & 3. Wall No. 1 consists of standard Type 5 wall (Wall No. 1A) and Type 7SW modified (Wall No. 1B).

Due to right-of-way and other civil design constraints, the design proposes to employ a Type 7SW modified wall in the southeast quadrant. Based on the designer's communication with Caltrans, the structural design may evaluate the standard Type 7SW design and modify it to suit project needs. Use of tiedowns is expected for the Type 7SW modified wall.

Geology and Subsurface Conditions

The subsurface conditions are based on the borings and CPTs performed in January and November, 2007, respectively. Borings A-07-001, A-07-002, A-07-009 and CPT07-00-1 & CPT-07-002 are referenced for the retaining walls.

The subsoils generally consist of an upper 10-15 feet thick layer of loose sand over approx. 30 feet of medium dense silty sand to about 40 feet depth below Route 101 grade. Underlay the sand layer is a layer of stiff to very stiff clay with approximate thickness of 25 feet. Medium to very dense silty sand was then encountered to the maximum depth of exploration (i.e. 90 feet below existing grade) beneath this clay layer in Borings A-07-001and A-07-002.

Groundwater was encountered during field exploration at approximately 30 feet depth (approx. Elev. 341 ft) in the borings. Groundwater level may vary with the passage of time due to seasonal rainfall, surface and subsurface flows, ground surface run-off and other factors that may not be present at the time of investigation.

General geologic features pertaining to the site were evaluated by reference to the geology map titled "Generalized Geology of the Arroyo Grande-Nipomo Mesa Area" by the Department of Water Resources, Southern District, 2002. The accompanied geologic section C-C' was also referenced in our evaluation. Based on the map and the section, the subject site is generally underlain by Older Dune Sands (Qos) of Pleistocene age. The geologic map and the geologic section C-C' are shown on Plates 2A and 2B, respectively.

Seismic Sources

The project site is located in a seismically active part of central coastal California. Many faults exist in the San Luis Obispo Area are capable of producing earthquakes that may cause strong ground shaking at the site. Maximum credible earthquake magnitudes for some of the major faults in the area as determined by Mualchin (1996) are summarized below. These maximum credible earthquake magnitudes represent the largest earthquakes that could occur on the given fault based on the current understanding of the regional tectonic structure.

EARTHQUAKE DATA

Fault	Type	Estimated Distance From Project Site (km)	Maximum Credible Earthquake	Anticipated Peak Bedrock Acceleration
SMF – Santa Maria River-Foxen Canyon	Reverse (including thrust)	< 1	6.5	0.7
OCO – Oceano	Reverse (including thrust)	4.3	6.0	0.4

Active faults in the vicinity include the Santa Maria River-Foxen Canyon Fault (reverse fault, Mw = 6.5) located within 1 km from the site, and the Oceano Fault (reverse fault, Mw = 6.0) located at approximately 4.3 km from the site. Based on the seismic hazard map prepared by Mualchin (1996) and attenuation relationship proposed by Sadigh, et al (1997), a Peak Bedrock Acceleration of 0.7g is anticipated at the site. The fault map for the project vicinity is shown on the Fault Map, Plate 3. The seismic design criteria for bridge structure design are presented in the separate foundation report for Willow Road Undercrossing (Br. No. 49-0252 L/R) and are not repeated in this report for retaining walls.

Liquefaction Potential Evaluation per SPT & CPT Data

Liquefaction potential evaluation of the subsoils was performed based on the drilled borings and CPT data. The design groundwater is recommended to be at Elev. 341 ft based on hollow stem auger borings.

Methodology. The liquefaction potential evaluation was performed in accordance with the methods proposed by Youd, et al. (2001) using the SPT and CPT procedures. The analysis results based on both SPT and CPT data are attached in Appendix C-1. In the attachments, the CPT Data Correlations showing soil strength, correlated SPT-N_{60}, soil behavior index (Ic) and generalized soil profile are presented along with liquefaction analysis results. Based on Youd, et al (2001), soils with $(N_1)_{60\text{-}cs}$ less than 30 (SPT procedures), or corrected Cone Tip Resistance $(q_{c1N})_{cs}$ less than 160 tsf (CPT procedures) are found to be potentially liquefiable or triggering of liquefaction. Soils with CPT data showing Soil Index (Ic) < 2.6 are most likely granular.

Analysis Results. Based on the analyses, Boring A-07-002 and CPT-2 indicated no to insignificant liquefaction potential. CPT-1, located in close proximity of Boring A-07-001, indicated that the submerged medium dense sandy soil at approximate depth of 36 to 39 feet (Elev. 331 to 334 ft) below existing ground level may be prone to triggering of liquefaction. This sand layer is the transition zone as it is just above the clay, which might have affected the cone tip resistance. Based on the geologic map, the site subsoil is the Older Dune Sands (Qos) and belongs to the Pleistocene age, which is older than Holocene age. From a geologic standpoint, Holocene age deposits are the ones most likely susceptible to liquefaction. The susceptibility decreases with age within the Holocene. Liquefaction of pre-Pleistocene deposits is rare. Based on the above discussion, it is our opinion that the liquefaction potential may be relatively insignificant. Even if we take conservative approach to assume liquefaction condition, the material is not anticipated to have "flow failure" since the material is dilative due to the medium dense to dense consistency. Seismic settlement on the order of half an inch may be anticipated even liquefaction does occur. Thus, relatively insignificant impact is anticipated even if we assume liquefaction case.

Retaining Walls

Due to right-of-way and other geometric constraints, the project requires construction of three retaining walls. Information of approximate wall locations, lengths and maximum wall heights provided by the designer are summarized in the table below. The subsurface soil conditions and design considerations are discussed below.

SUMMARY OF PROPOSED RETAINING WALLS

Wall No.	Approximate Wall Location	Max. Wall Height (ft)	Approx. Length (ft)	Proposed Wall Type
RW No. 1	Along Route 101 NB off-ramp, on the east side	23	1094	Std. Type 5 (Wall No. 1A) & Type 7SW modified (Wall No. 1B)
RW No. 2	Along Route 101 NB off-ramp, on the west side	16	492	Type 1 & modified
RW No. 3	Along Route 101 NB on-ramp, on the west side	16	328	Type 1 & modified

The walls are along Route 101 NB off- and on-ramps to provide grade separation. The wall heights vary from 6/8 ft to 22 to 23 ft near the bridge abutments/future Willow Road. The lowest elevation of the footing bottom is anticipated approximately at 336 to 337 ft.

Based on the exploration results, the subsurface material at the planned footing subgrade generally consists of medium sand. The sand grades to dense through approx. Elev. 330 ft overlying stiff to very stiff clay. Groundwater was encountered at approx. Elev. 341 ft in 2007.

Allowable & Ultimate Bearing Capacities. For foundation support of the proposed retaining walls, the recommended allowable bearing capacity is 4.5 ksf. The evaluation of bearing capacity is based on friction angle of 33 degrees and buoyant unit weight; the calculation is attached in Appendix C-2. Caltrans standard walls on shallow foundations may be used for foundation demand up to service capacity of 4.5 ksf per standard plans. Per our understanding, the structural designer will perform special design for higher wall height portion to use spread footing foundations. It is recommended to limit the allowable bearing capacity to 4.5 ksf.

A factor of safety (FS) of 3 was used in deriving the allowable bearing capacity. For the Type 7SW modified wall, the available ultimate bearing capacity is 13.5 ksf (FS=3) when checking the demand (ultimate foundation pressure) using LFD design. Based on the designer's communication with Caltrans, Caltrans has indicated that the structural design may evaluate the standard Type 7SW and modify it to suit the project needs.

Per Caltrans comment, settlement analyses were performed for the retaining walls. The analyses are attached in Appendix C-2 of the report. The analyses are based on elastic solutions since the subgrade soils consist of sands and very stiff clays. Based on the analyses, the anticipated total

and differential settlements are on the order of 0.5 inch and 0.25 inch, respectively, from a practical design standpoint.

Recommended Earth Pressures for Design of Modified Walls. Additional soil parameters for wall design are as follows:

Active Pressure (per Caltrans standard Structure Backfill, Sect. 19-3.06)
Equivalent Fluid Pressure = 36 pcf (level backfill)
45 pcf (4H:1V sloping backfill)
55 pcf (2H:1V sloping backfill)
Passive Resistance: 200 pcf (below water level); 350 pcf (above water level)
Friction Coefficient: 0.4

The active pressure is derived from the Coulomb's theory. The passive resistance is derived in accordance with Section 5, Bridge Design Specifications (BDS), using the log-spiral method. Per BDS Section 5.6.4.1, the sliding may be checked using maximum base friction and 50% of the available passive resistance. The above recommended passive resistance values represent the "50% of the available resistance". The derivations of the active and passive pressures are attached in Appendix C-3 of the report. If required, the friction angle (δ) between the backfill and back of wall may be assumed at 17 deg. (max. of ½ of the internal friction angle (ϕ = 34 deg.) of the structure backfill per BDS Section 5.

In addition to the earth pressure, BDS Section 5.5.5.10.5 should be verified to see if live load surcharge (traffic) will apply. Per the section, traffic surcharge applies if vehicular load is expected within the wall height behind the back face of the walls. A surcharge coefficient of 0.3 may be used for traffic load.

Tiedowns for Type 7SW Modified Walls. The Type 7SW modified wall uses tiedown as part of the retaining system in design. Caltrans standard performance specifications for tiedown anchors should be utilized for attaining the required design capacity. The contractor should develop their design and construction criteria.

A minimum unbonded length of 15 feet is recommended for the tiedown anchors. Per discussion with the structural design, the anticipated tiedown force is on the order of 150 kips. The recommended minimum tiedown spacing is 3 feet. The bond strength for design of tiedown bond length depends on factors such as installation and grouting technique, diameter of the holes, etc. For preliminary cost estimate, the estimated ultimate bond strength is 30 psi between the pressure grout and native material. A minimum FS of 2 is recommended for service design. The estimation of bond strength is based on pressure grouted anchors in native dense sand and very stiff clay per Post-Tensioning Institute (1996).

Note that tiedown is a design-build system, and the contractor should determine the bond length, drilling and grouting method, etc. The tiedowns should be constructed and tested as per Caltrans

standard performance specifications for tiedown anchors. All tiedowns should be either performance tested or proof tested. We recommend that at least 5% of the total number of tiedowns be performance tested. The remaining tiedowns should be proof tested. If the design capacity is not achieved during the initial test program, post-grouting technique, large diameter tiedown holes, etc. may be considered for the tiedown installation.

Because of the variability in the soil materials in nature and the limitations in the exploration program, it is recommended that several cost control measures be implemented in the specifications for the tiedown anchors. The contractor should be advised to verify the field conditions and verify the tiedown capacity through his own efforts. It would be advisable for the contractor to have capability to perform post-grouting for the tiedown installation. The contractor should also verify the drilling conditions into the existing soil materials. This is very important since groundwater and caving sand are expected for tiedown installation, which could present some drilling challenges and may require special drilling tools and equipment.

Footing Subgrade Treatment for Modified Walls. The footing construction for the Type 1 modified and Type 7SW modified walls is at the lower part of the excavation where groundwater is expected (Design Groundwater Level at Elev. 341 ft). To provide uniform foundation support and account for some uncertainties during construction, it is recommended that, for footing bottom at Elev. 343 ft or below, the footing subgrade consist of 2 ft of self-compacting material wrapped in geotextile fabric. The self-compacting material should consist of Caltrans standard Permeable Material (Class 1, Section 68-1.025 of standard specs), and the fabric should conform to Caltrans SSP for Subgrade Enhancement Geotextile (Class B2, Section 88-1.08 of June 2009).

Global Stability. Slope stability analysis was performed to evaluate the global stability of the walls. We have taken the conservative approach for post-liquefaction case assuming that there is a liquefiable layer at Elev. 331 to 334 ft with residual shear strength. Based on $(N_1)_{60\text{-}cs}$ value of approx. 22-25, a residual undrained shear strength value of 1200 psf was adopted. Groundwater was at Elev. 341 ft. The analysis was performed using SLPOE/W program. Based on the analysis, a minimum F.S. of 1.96 was obtained for the post-liquefaction case (conservative approach). The global stability of the walls is acceptable per the evaluation. The analysis result is attached in Appendix C-4.

Excavation & Shoring. Due to close proximity of the walls to existing Route 101 and private properties, temporary shoring is expected for wall construction when open cut is not feasible. For on-site sandy soils, the recommended maximum slope gradient is 1.5H:1V for temporary construction purposes. The selection and design of the shoring system should be the contractor's responsibility. The contractor should have the shoring system designed and signed by a California Registered Engineer. The shoring system should be designed to be relatively rigid and with as many supports as necessary to prevent excessive straining and deformation of the supported soils. This is important with regard to protection and movement within the existing Route 101 traffic and existing utilities. Temporary tiebacks may be expected for higher portion of the shoring.

Construction Dewatering. Groundwater is anticipated at lower portion of the footing excavation. Caltrans standard specifications (Section 19-3.04) for "Water Control and Foundation Treatment" should apply. Construction dewatering is expected during construction. Dewatering of excavations is normally the responsibility of the contractor and should be a design-build system. It appears that shallow sumps may be used when needed. The contractor should satisfy himself/herself with the prevailing conditions and obtain additional information if needed to design the required dewatering method. The native sand is anticipated to have relatively high permeability. The selected shoring system should be designed to assist the dewatering program.

Controlled dewatering should be performed to avoid possible piping/blowout at the base of excavation or to avoid excessive settlement problems in the surrounding areas. All dewatering systems should be properly designed to prevent pumping soil fines with the discharge water. This work should be closely monitored during construction. If soil fines are pumped, the contractor should revise the dewatering operations. Otherwise, failure of shoring wall, partial instability of excavation bottom resulting in intolerable settlement of the surrounding ground (affecting existing Route 101 and private properties), and unsafe working conditions may occur. The contractor should provide sampling locations for discharge of each pump for their monitoring purposes.

Corrosion

Per Caltrans guidelines and based on the corrosion test data, the subsurface soil at this site is not considered corrosive. Corrosion data is presented in the table below.

Boring	Location ("U" Line)		Depth (ft)	Minimum Resistivity (ohms-cm)	pH	Chloride (ppm)	Sulfate (ppm)
	Station	Offset (ft)					
A-07-001	350+19	0	9.5	11520	6.77	9.6	6.3
A-07-009	345+70	41	4.5	29210	7.26	8.4	1.1

Please be advised that we are performing a professional service and that our conclusions are professional opinions only. All work done and all recommendations made are in accordance

with generally accepted geotechnical engineering principles and practices. No warranty, expressed or implied, of merchantability or fitness, is made or intended in connection with our work.

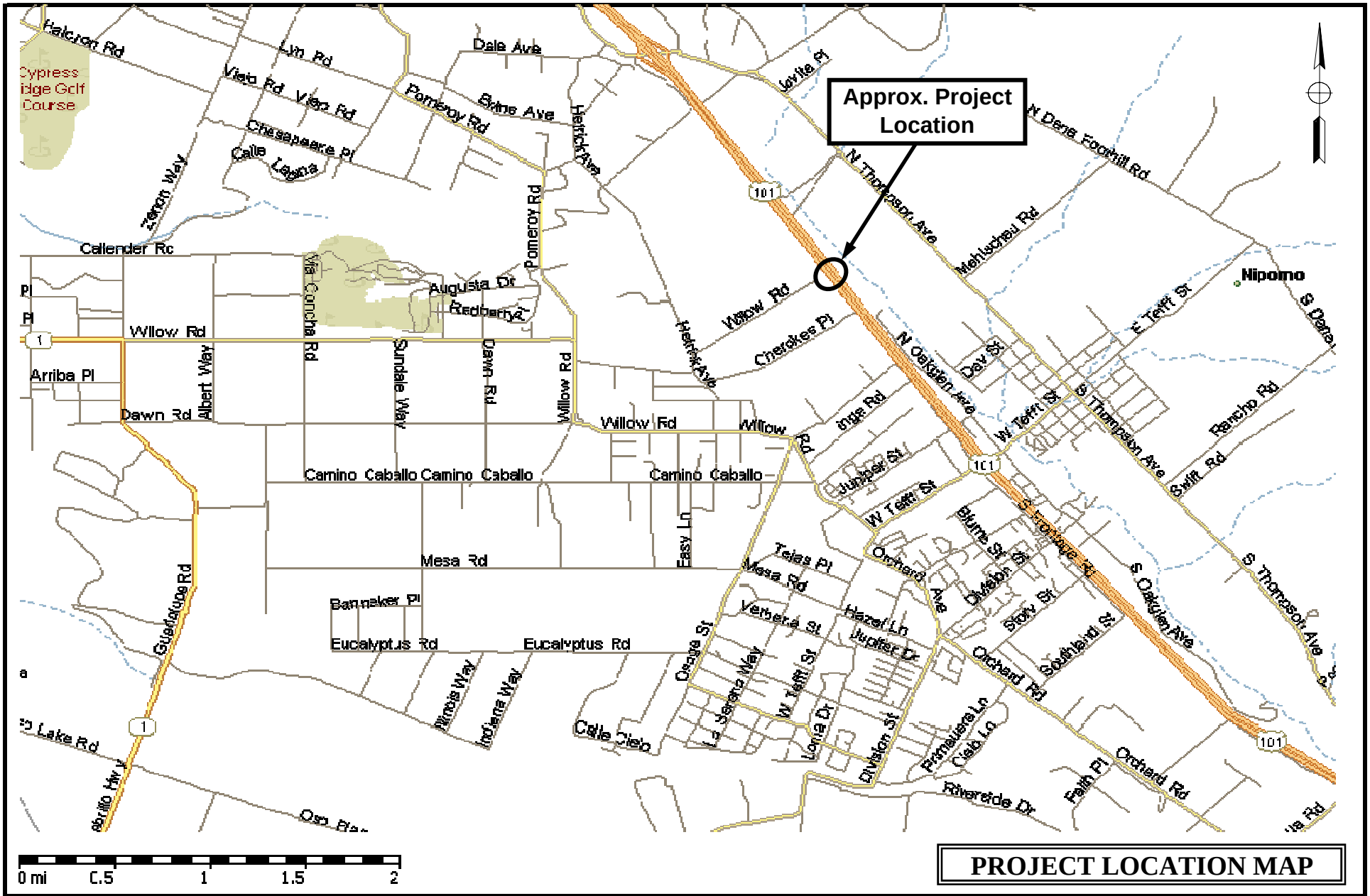
Very truly yours,
PARIKH CONSULTANTS, INC.

Y. David Wang, Ph.D., P.E., 52911
Senior Engineer

Gary Parikh, P.E., G.E., 666
Project Manager

REGISTERED PROFESSIONAL ENGINEER
GAURANG R. PARIKH
No. 666
EXP. 12-31-11
GEOTECHNICAL
STATE OF CALIFORNIA

Attachments: Plate 1 – Project Location Map
Plates 2A & 2B - Geologic Map
Plate 3 - Fault Map
Appendix A - Log of Test Borings (Parikh 2007)
Quality Control/Quality Assurance Documentation
CPT Site Investigation by Gregg In Situ (December 18,2007)
Appendix B - Laboratory Data
Appendix C – C-1: SPT Liquefaction Analyses, CPT Data Correlation & Liquefaction Analyses Results
C-2: Retaining Wall Bearing Capacity & Settlement Evaluation
C-3: Active & Passive Pressures For Design
C-4: Global Stability
Appendix D –Caltrans Comment/Response Form (10-5-2009)
Caltrans Comment/response Form (5-21-2009)
Caltrans Comment/response Form (2-23-2010)

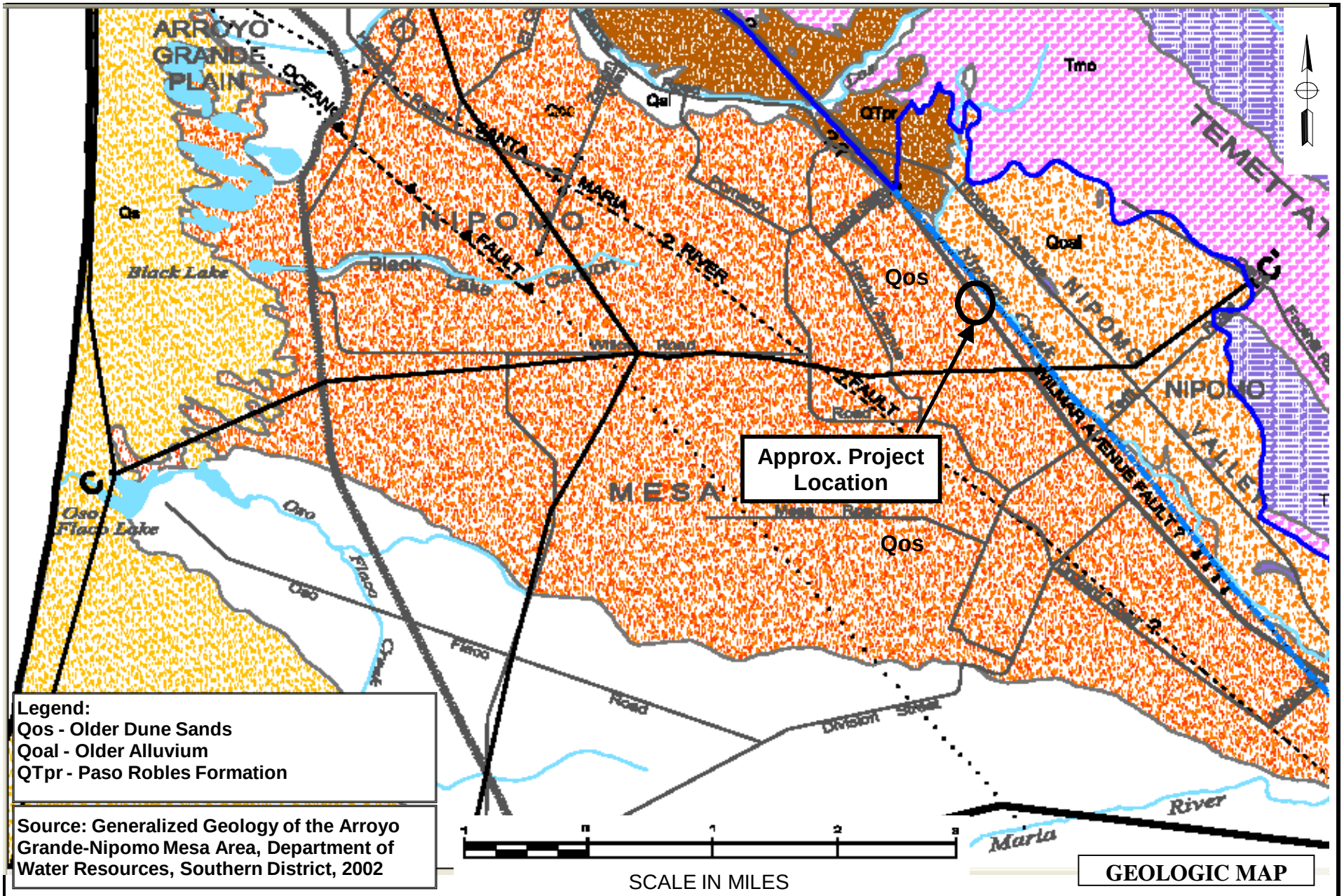


PROJECT LOCATION MAP

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS TESTING

WILLOW ROAD UNDERCROSSING AT ROUTE 101
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO.: 203125.WIL	PLATE NO.: 1

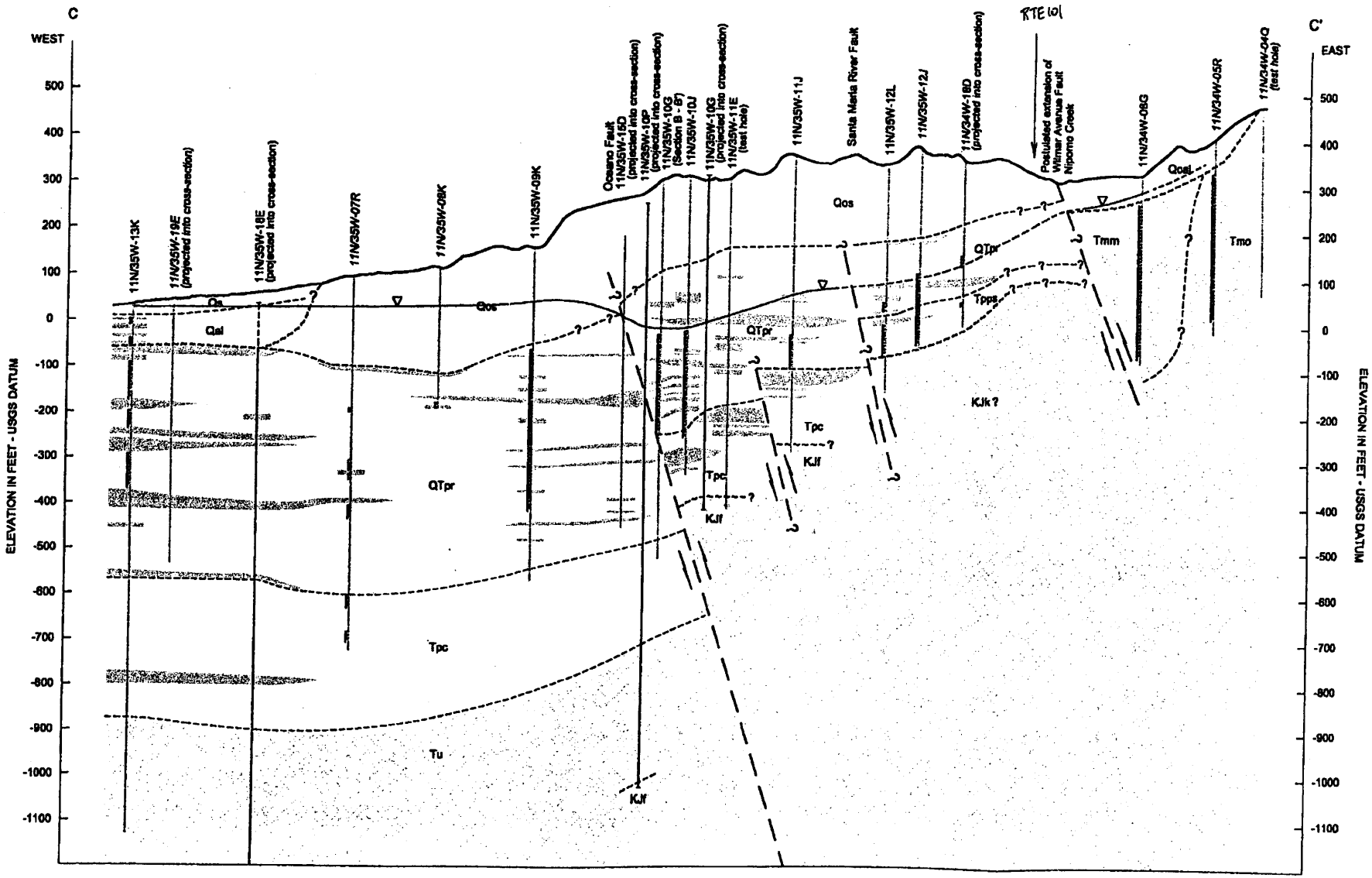


GEOLOGIC MAP

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS TESTING

WILLOW ROAD UNDERCROSSING AT ROUTE 101
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO.: 203125.WIL	PLATE NO.: 2A



EXPLANATION

Formation and Symbol

Qs	Dune Sand
Qal	Alluvial Deposits
Qos	Older Dune Sand
Qosl	Older Alluvial Deposits
QTpr	Paso Robles Formation
Tpc	Careaga Formation
Tpps	Squire Member, Pismo Formation
Tmm	Monterey Formation
Tmo	Obispo Formation
Tu	Undifferentiated Tertiary Deposits
KJk	Knoxville Formation
KJf	Franciscan Complex

12N/36W-36L — Water well with electric and geologic log

32S/12E-13L — Water well with geologic log

10N/36W-02G — Oil well with electric log, dashed above record

11N/35W-10P — Oil well with geologic log, dashed above record

Hydrogeologic Unit

Unconsolidated to weakly cemented clayey silt to silty clay with minor sand and gravel

Unconsolidated to weakly cemented sand, gravel, silt, sandstone with minor clay and silty clay

Bedrock

Perforated Interval

Fault, arrows indicate relative vertical movement

--- Unconformity

--- Contact

1995 Groundwater Elevation

Note: References include: Department of Water Resources, 1970; Buchanan-Banks et al., 1978; Hall, 1981; Nitchman, 1988; Hanson et al., 1994; Lettis et al., 1994.

Location of geologic section shown on Plate 2

Vertical scale 20 times horizontal scale

Horizontal scale in feet

4000 0 4000

WATER RESOURCES OF THE ARROYO GRANDE - NIPOMO MESA AREA

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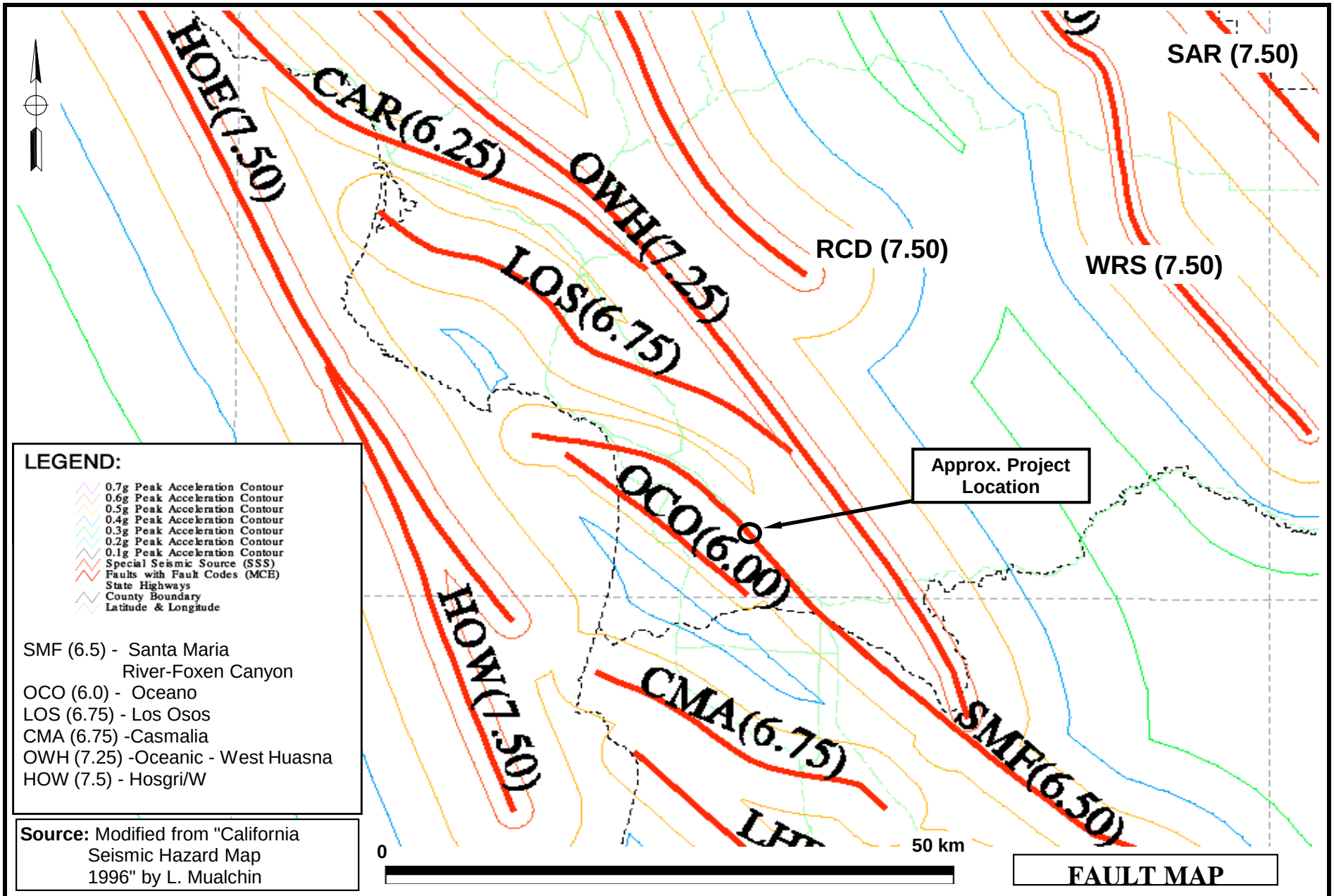
PLATE No. 2B

GEOLOGIC SECTION C - C'



FAULT MAP

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS TESTING

WILLOW ROAD UNDERCROSSING AT ROUTE 101
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO.: 203125.WIL	PLATE NO.: 3

APPENDIX A

REFERENCE: CALTRANS SOIL & ROCK LOGGING, CLASSIFICATION, AND PRESENTATION MANUAL (JUNE 2007)

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
05	SOL	101	–		

GEOTECHNICAL PROFESSIONAL DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER GARY PARIKH No. G.E. 666 Exp. 12/31/11 GEOTECHNICAL STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of scanned copies of this plan sheet.

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2360 QUME DRIVE, SUITE A
SAN JOSE, CA 95131

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names	Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND	CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND		
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND	CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND	ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)		
GM	SILTY GRAVEL SILTY GRAVEL with SAND	OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND		
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND	OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL		
SP	Poorly graded SAND Poorly graded SAND with GRAVEL	CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL		
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL		
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)	OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
SM	SILTY SAND SILTY SAND with GRAVEL		
SC	CLAYEY SAND CLAYEY SAND with GRAVEL	OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL		
PT	PEAT	OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND
	COBBLES COBBLES and BOULDERS BOULDERS		

FIELD AND LABORATORY TESTING

- (C) Consolidation (ASTM D 2435)
- (CL) Collapse Potential (ASTM D 5333)
- (CP) Compaction Curve (CTM 216)
- (CR) Corrosivity Testing (CTM 643, CTM 422, CTM 417)
- (CU) Consolidated Undrained Trioxial (ASTM D 4767)
- (DS) Direct Shear (ASTM D 3080)
- (EI) Expansion Index (ASTM D 4829)
- (M) Moisture Content (ASTM D 2216)
- (OC) Organic Content-% (ASTM D 2974)
- (P) Permeability (CTM 220)
- (PA) Particle Size Analysis (ASTM D 422)
- (PI) Plasticity Index (AASHTO T 90) Liquid Limit (AASHTO T 89)
- (PL) Point Load Index (ASTM D 5731)
- (PM) Pressure Meter
- (PP) Pocket Penetrometer
- (R) R-Value (CTM 301)
- (SE) Sand Equivalent (CTM 217)
- (SG) Specific Gravity (AASHTO T 100)
- (SL) Shrinkage Limit (ASTM D 427)
- (SW) Swell Potential (ASTM D 4546)
- (TV) Pocket Torvane
- (UC) Unconfined Compression-Soil (ASTM D 2166) Unconfined Compression-Rock (ASTM D 2938)
- (UU) Unconsolidated Undrained Triaxial (ASTM D 2850)
- (UW) Unit Weight (ASTM D 4767)
- (VS) Vane Shear (AASHTO T 223)

APPARENT DENSITY OF COHESIONLESS SOILS

Description	SPT N_{60} (Blows / 12 inches)
Very loose	0 – 4
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 – 50
Very Dense	> 50

MOISTURE

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS

Description	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

PARTICLE SIZE

Description		Size
Boulder		> 12"
Cobble		3" to 12"
Gravel	Coarse	3/4" to 3"
	Fine	No. 4 to 3/4"
Sand	Coarse	No. 10 to No. 4
	Medium	No. 40 to No. 10
	Fine	No. 200 to No. 40

CEMENTATION

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

CONSISTENCY OF COHESIVE SOILS

Description	Unconfined Compressive Strength (tsf)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)	Field Approximation
Very Soft	< 0.25	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	0.25 to 0.50	0.25 to 0.50	0.12 to 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 to 1.0	0.50 to 1.0	0.25 to 0.50	Penetrated several inches by thumb with moderate effort
Stiff	1 to 2	1 to 2	0.50 to 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2 to 4	2 to 4	1.0 to 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

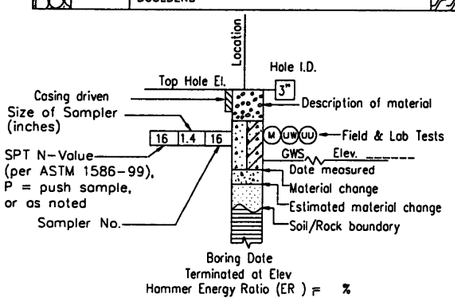
PLASTICITY OF FINE-GRAINED SOILS

Description	Criteria
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

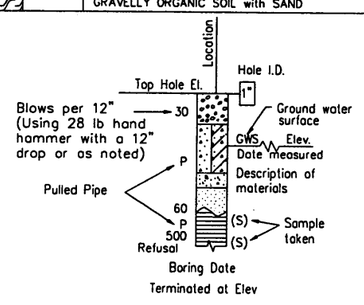
BOREHOLE IDENTIFICATION

Symbol	Hole Type	Description
Size	A	Auger Boring
Size	R P	Rotary drilled boring Rotary percussion boring (air)
Size	R	Rotary drilled diamond core
Size	HD HA	Hand driven (1-inch soil tube) Hand Auger
●	D	Dynamic Cone Penetration Boring
▲	CPT	Cone Penetration Test (ASTM D 5778-95)
□	O	Other

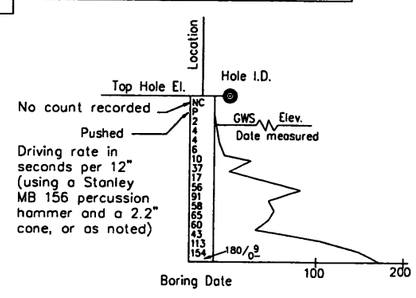
Note: Size in inches.



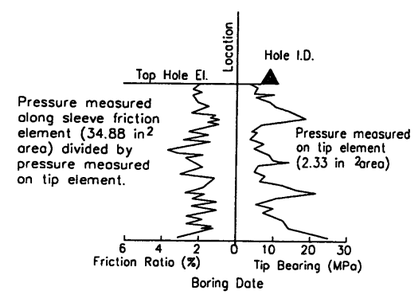
ROTARY BORING



HAND BORING



DYNAMIC CONE PENETRATION BORING



CONE PENETRATION TEST (CPT) SOUNDING

DESIGN OVERSIGHT	DRAWN BY	L. TRAN	L. BHANGOO FIELD INVESTIGATION BY: DATE: JANUARY 2007
SIGN OFF DATE	CHECKED BY	D. WANG	

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

D. WANG
PROJECT ENGINEER

BRIDGE NO. –
POST MILES –

SOIL LEGEND
LOG OF TEST BORINGS

DGS GEOTECHNICAL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU
EA 05-474503

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES 11/07/08 04/08/09 07/06/09 1/15/10

SHEET OF

FILE => $REQUEST

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
05	SLO	101	–		

GEOTECHNICAL PROFESSIONAL DATE

PLANS APPROVAL DATE

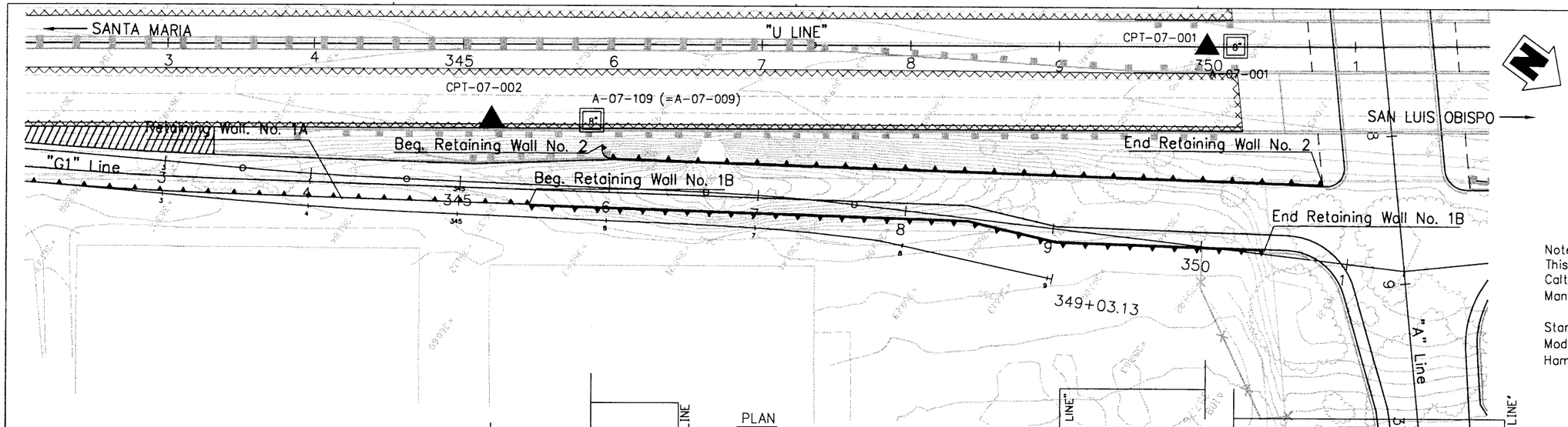
REGISTERED PROFESSIONAL ENGINEER GARY PARIKH No. G.E. 666 Exp. 12/31/11 GEOTECHNICAL STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of scanned copies of this plan sheet.

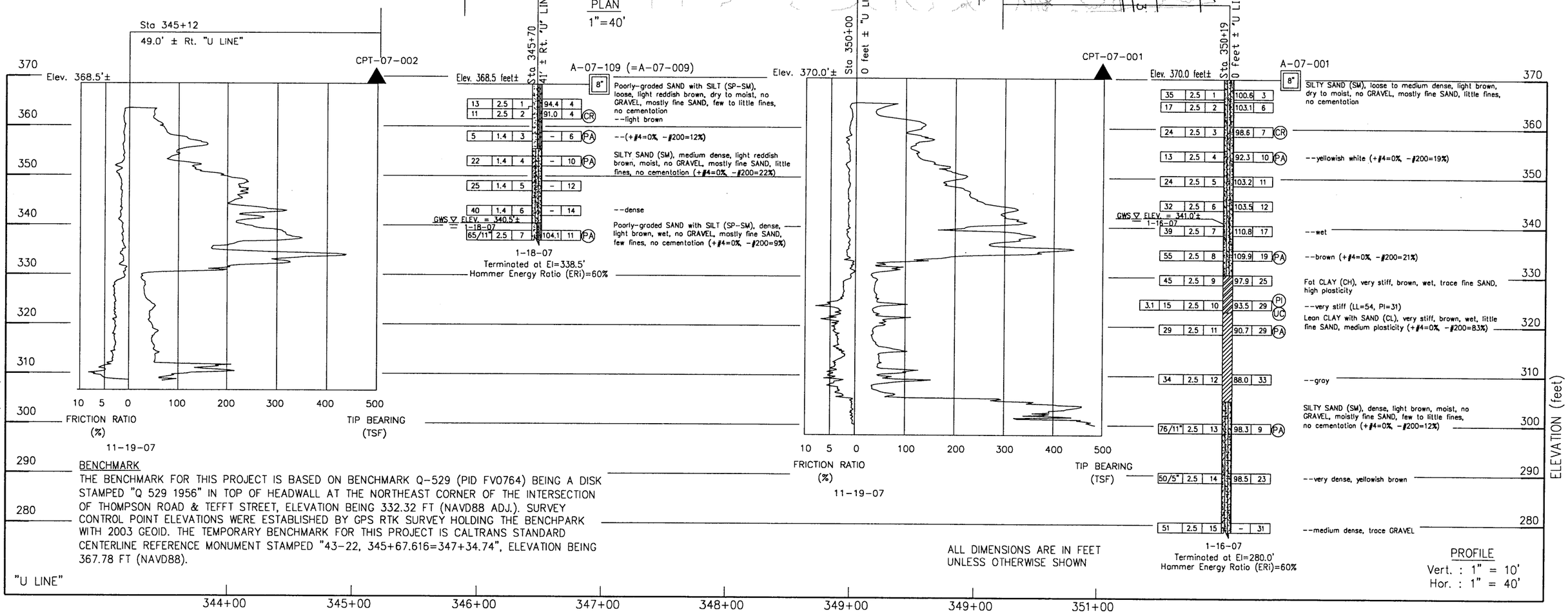
PARIKH CONSULTANTS, INC.
2360 QUME DRIVE, SUITE A
SAN JOSE, CA 95131

Notes:
This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging Classification, and Presentation Manual (June 2007)

Standard Penetration Test Sampler: I.D. = 1.4"; O.D. = 2"
Modified California Sampler: I.D. = 2.5"; O.D. = 3"
Hammer Assembly: A 140 lb hammer with a 30" drop



PLAN
1"=40'



BENCHMARK
THE BENCHMARK FOR THIS PROJECT IS BASED ON BENCHMARK Q-529 (PID FV0764) BEING A DISK STAMPED "Q 529 1956" IN TOP OF HEADWALL AT THE NORTHEAST CORNER OF THE INTERSECTION OF THOMPSON ROAD & TEFFT STREET, ELEVATION BEING 332.32 FT (NAVD88 ADJ.). SURVEY CONTROL POINT ELEVATIONS WERE ESTABLISHED BY GPS RTK SURVEY HOLDING THE BENCHPARK WITH 2003 GEOID. THE TEMPORARY BENCHMARK FOR THIS PROJECT IS CALTRANS STANDARD CENTERLINE REFERENCE MONUMENT STAMPED "43-22, 345+67.616=347+34.74", ELEVATION BEING 367.78 FT (NAVD88).

ALL DIMENSIONS ARE IN FEET UNLESS OTHERWISE SHOWN

PROFILE
Vert. : 1" = 10'
Hor. : 1" = 40'

DESIGN OVERSIGHT	DRAWN BY	L. TRAN	L. BHANGOO FIELD INVESTIGATION BY:	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	D. WANG PROJECT ENGINEER
SIGN OFF DATE	CHECKED BY	D. WANG	DATE: JANUARY AND NOVEMBER 2007		

BRIDGE NO. –
POST MILES –

WILLOW ROAD / ROUTE 101 INTERCHANGE
LOG OF TEST BORINGS

CU 05
EA 474501

DISREGARD PRINTS BEARING EARLIER REVISION DATES 11/20/08 4/30/09 7/30/09 1/15/10

REVISION DATES SHEET OF

OGS GEOTECHNICAL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

Mar 11, 2010 - 10:49am S:\ACAD\203123.dgn\LOTB (Rat Wall).dwg

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
05	SLO	101	5.9/6.9		

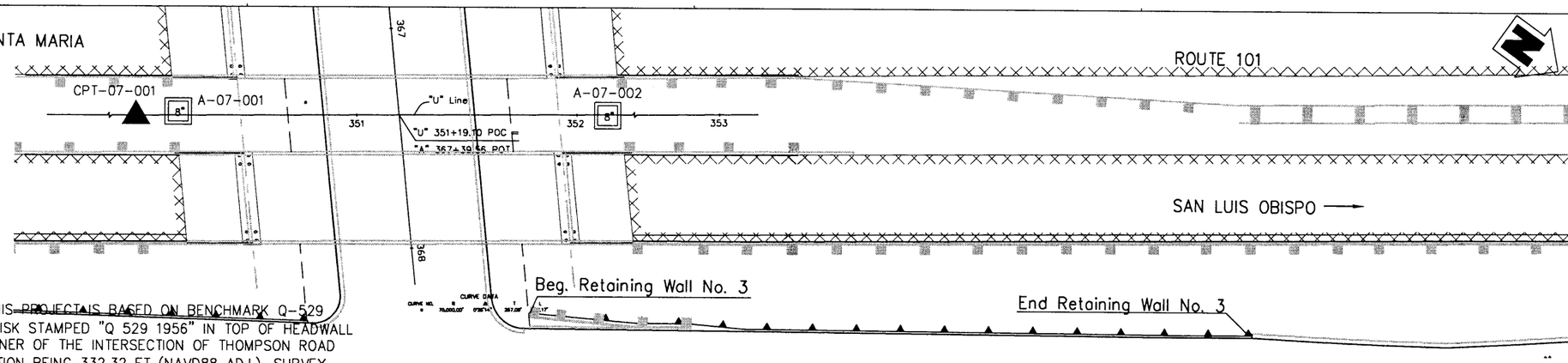
GEOTECHNICAL PROFESSIONAL — DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — GARY PARIKH — No. G.E. 666 — Exp. 12/31/11 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of scanned copies of this plan sheet.

PARIKH CONSULTANTS, INC.
2360 QUME DRIVE, SUITE A
SAN JOSE, CA 95131



PLAN
1"=30'

BENCHMARK
THE BENCHMARK FOR THIS PROJECT IS BASED ON BENCHMARK Q-529 (PID FV0764) BEING A DISK STAMPED "Q 529 1956" IN TOP OF HEADWALL AT THE NORTHEAST CORNER OF THE INTERSECTION OF THOMPSON ROAD & TEFFT STREET, ELEVATION BEING 332.32 FT (NAVD88 ADJ.). SURVEY CONTROL POINT ELEVATIONS WERE ESTABLISHED BY GPS RTK SURVEY HOLDING THE BENCHPARK WITH 2003 GEOID. THE TEMPORARY BENCHMARK FOR THIS PROJECT IS CALTRANS STANDARD CENTERLINE REFERENCE MONUMENT STAMPED "43-22, 345+67.616=347+34.74", ELEVATION BEING 367.78 FT (NAVD88).

Notes:
This LOTB sheet was prepared in accordance with the Caltrans Soil & Rock Logging Classification, and Presentation Manual (June 2007)

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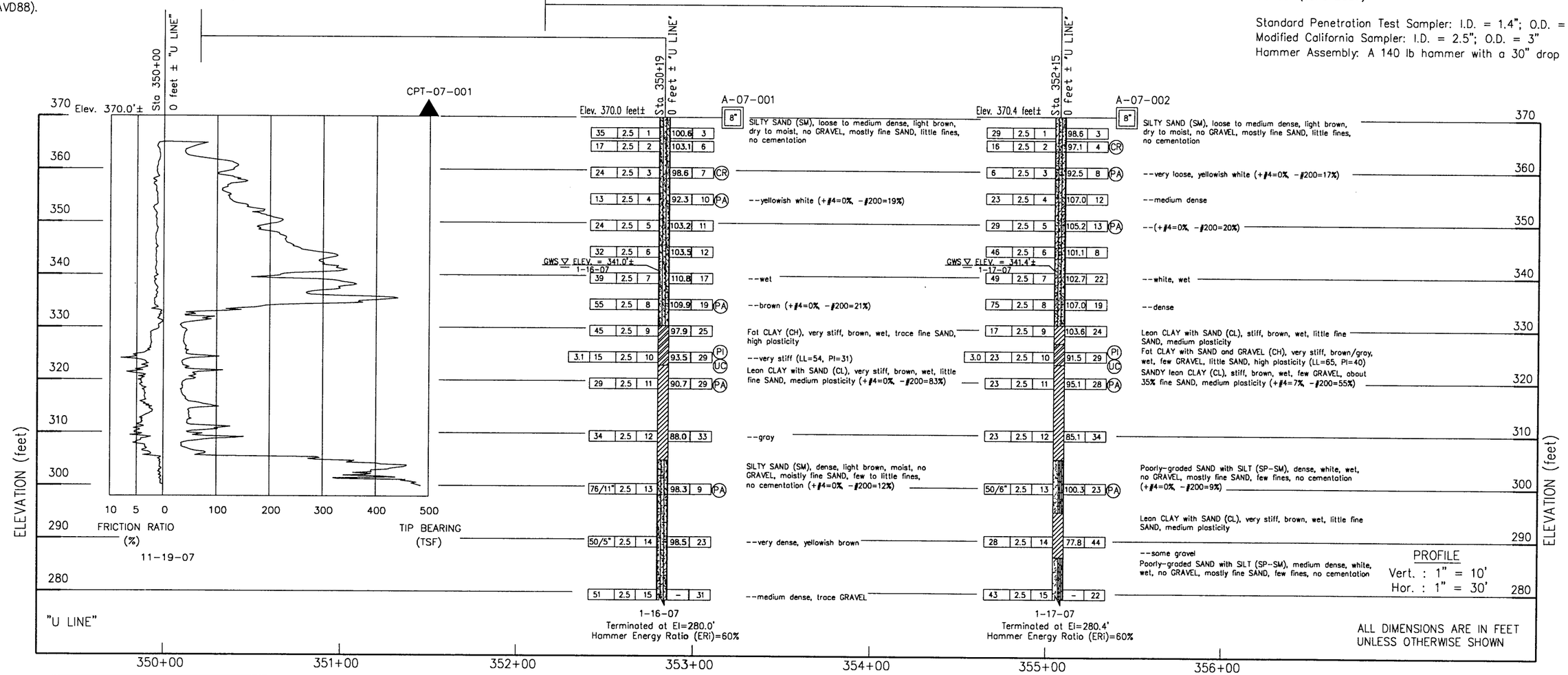
Modified California Sampler: I.D. = 2.5"; O.D. = 3"
Hammer Assembly: A 140 lb hammer with a 30" drop



DESIGN OVERSIGHT	DRAWN BY L. TRAN	L. BHANGOO	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	D. WANG	BRIDGE NO. –
SIGN OFF DATE	CHECKED BY D. WANG	FIELD INVESTIGATION BY: DATE: JANUARY AND NOVEMBER 2007		PROJECT ENGINEER	POST MILES –

WILLOW ROAD / ROUTE 101 INTERCHANGE
LOG OF TEST BORINGS

CU 05
EA 474501

DISREGARD PRINTS BEARING EARLIER REVISION DATES → REVISION DATES 11/24/08 04/30/09 07/08/09 1/15/10 — SHEET — OF

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

OGS GEOTECHNICAL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 06-01-09)

Mar 11, 2010 - 10:45am S:\ACAD\203125.gpl\LOTB (Bridge).dwg

Log of Test Boring (LOTB) Sheet Checklist

This checklist shall be used by the *checker* in his/her evaluation of a LOTB sheet's conformance with the Caltrans *Soil & Rock Logging, Classification, and Presentation Manual,* and other applicable standards. To facilitate a quality check, the checker shall be provided with the draft final LOTB sheets, pertinent laboratory test results, copies of approved *Request for Exceptions*, and the field logs. This checklist is not comprehensive and does not attempt to account for all logging and presentation standards. As such, the checker must be familiar with the entire manual in order to successfully perform a quality check. **One checklist shall be completed per LOTB plan sheet. One signature sheet may be used for each structure (Bridge No.).**

Project Information

Dist – EA: 47-4501 County: SLO Route: 5 PM: 6.45

Bridge No.: 49E0016

Sheet Title: Log of Test Borings 2 of 2

Revision Date: 7/10/09

Are there approved exceptions to the manual? ☐ Yes ☑ No (attach, if yes)

General

	Yes	No	N/A	
1.1	☑	☐	☐	Does the Plan View meet the requirements of Sec 5.2.3.3?
1.2	☑	☐		Does the Border meet the requirements of Sec 5.2.3.1 and Sec 5.2.3.2?
1.3	☑	☐	☐	Are the Notes clear and do they meet the requirements of Sec 5.2.2?
1.4	☐	☐	☑	If As-Built LOTB, does it meet the requirements of Sec 5.2.4?
1.5	☑	☐		Is the soil legend sheet attached and properly labeled?
1.6	☐	☐	☑	If rock is presented, is the rock legend attached and properly labeled?
1.7	☐	☐	☑	If approved "Exception to Policy" form is attached, does the LOTB meet the requirements of the approved exceptions?

Elevation View

2.1	☑	☐		Are the Hole Identifications correct? (Sec 2.3) (Sec. 5.2.3.4)
2.2	☑	☐		Are the location descriptions correct?
2.3	☑	☐		Are the holes located properly on the profile?
2.4	☑	☐		Is the elevation scale correct? (Sec 5.2.3.4)
2.5	☑	☐		Is the top of hole elevation presented and correct? (Sec 5.2.3.4)

Log of Test Boring (LOTB) Sheet Checklist

Bridge No.: 49E0016 Sheet Title: Log of Test Borings 2 of 2

	Yes	No	N/A	
2.6	☑	☐		Is the correct hole diameter presented in the correct Borehole Symbol? (Sec 5.2.5.6)
2.7	☑	☐		Does the stationing match the profile view?
2.8	☑	☐		Are the Boring Date and Termination Elevation presented at the bottom of each boring log? (Sec 5.2.3.4)
2.9	☑	☐	☐	If SPT tests were performed, is the correct hammer efficiency reported at the bottom of each borehole?
2.10	☑	☐	☐	Are lab tests reported at the correct elevations? (Sec 5.2.5.2)
2.11	☑	☐	☐	Are SPT blow counts reported at the correct elevations? (Sec 5.2.5.2)
2.12	☑	☐	☐	Is the groundwater presented at the correct elevation? (Sec 5.2.5.2)
2.13	☑	☐		Are the soil/rock layers and graphics presented correctly? (Sec 4, Sec 5.2.5.7)
2.14	☑	☐		Are the required descriptors presented and in the correct order? (Sec 2.4.1, Sec 2.5.1)
2.15	☑	☐		Are the descriptors presented consistent with those allowed in the manual?
2.16	☑	☐		Are the soil identifications consistent with the field observations? (Sec 2)
2.17	☑	☐		Are the soil classifications consistent with reported lab test results? (Sec 3)
2.18	☑	☐	☐	Are the consistency descriptors consistent with field observations and/or lab test results? (Sec 2.4.3, Sec 3.2.3)
2.19	☑	☐	☐	Are the apparent density descriptors consistent with the SPT results and hammer efficiency? (Sec 2.4.4)
2.20	☐	☐	☑	Are % recovery (REC) and rock quality designation (RQD) presented at the required elevations?
2.21	☐	☐	☑	Is rock strength presented where lab tests are reported? (Sec 3.3.1)
2.22	☑	☐	☐	Considering the field observations, are lab test results properly applied to the descriptors within a layer per Sec 4.3?
2.23	☑	☐		Are the presentations consistent with the rules presented in Sec 4?
2.24	☑	☐		Are the presentations consistent with the rules presented in Sec 5?

Log of Test Boring (LOTB) Sheet Checklist

List all variances identified during initial review of the LOTB sheet and steps needed to resolve the discrepancy (include item number). Also note any recommendations for revisions to the manual or procedures that might reduce or eliminate similar errors in the future.

Log of Test Boring QC/QA Signature Sheet

Dist – EA: 474501 Bridge No.: 49E0016

Sheet Titles:

Log of Test Borings 2 of 2

I, the undersigned on the date following my signature, hereby certify that I have performed a quality check of the referenced LOTB sheets and that the referenced LOTB sheets comply with the Caltrans *Soil and Rock Logging, Classification and Presentation Manual (June 2007)* and related policy and standards.

Lam Tran	Geotech Engineer
Checker (Print)	Title
	7/14/09
Checker (Signature)	Date

I, the undersigned on the date following my signature, hereby certify that the referenced LOTB sheets comply with Geotechnical Service's Quality Control/Quality Assurance procedures, as described in the memorandum, "Quality Control/Quality Assurance Documentation on LOTB Sheets", dated July 1, 2007.

Y. DAVID WANG	SENIOR ENGINEER
Functional Supervisor (Print)	Title
Y. David Wang	7/14/09
Functional Supervisor (Signature)	Date

(This original checklist and signature sheet shall be placed in the geotechnical project file, and a copy sent to the Geotechnical Services Corporate Unit (Mark Willian))

November 20, 2007

Parikh Consultants
Attn: Perry Chan
356 S. Milpitas Blvd.
Milpitas, California 95035

Subject: CPT Site Investigation
Willow Road Extension
Nipomo, California
GREGG Project Number: 07-179SH

Dear Mr. Chan:

The following report presents the results of GREGG Drilling & Testing's Cone Penetration Test investigation for the above referenced site. The following testing services were performed:

1	Cone Penetration Tests	(CPTU)	☒
2	Pore Pressure Dissipation Tests	(PPD)	☒
3	Seismic Cone Penetration Tests	(SCPTU)	☐
4	Resistivity Cone Penetration Tests	(RCPTU)	☐
5	UVIF Cone Penetration Tests	(UVIFCPTU)	☐
6	Groundwater Sampling	(GWS)	☐
7	Soil Sampling	(SS)	☐
8	Vapor Sampling	(VS)	☐
9	Vane Shear Testing	(VST)	☐
10	SPT Energy Calibration	(SPTE)	☐

A list of reference papers providing additional background on the specific tests conducted is provided in the bibliography following the text of the report. If you would like a copy of any of these publications or should you have any questions or comments regarding the contents of this report, please do not hesitate to contact our office at (562) 427-6899.

Sincerely,
GREGG Drilling & Testing, Inc.

Peter Robertson
Technical Operations

Cone Penetration Test Sounding Summary

-Table 1-

CPT Sounding Identification	Date	Termination Depth (Feet)	Depth of Groundwater Samples (Feet)	Depth of Soil Samples (Feet)	Depth of Pore Pressure Dissipation Tests (Feet)
CPT-01	11/19/07	70	-	-	64.5
CPT-02	11/19/07	60	-	-	60.0

Cone Penetration Testing Procedure (CPT)

Gregg In Situ, Inc. carries out all Cone Penetration Tests (CPT) using an integrated electronic cone system, *Figure CPT*. The soundings were conducted using a 20 ton capacity cone with a tip area of 10 cm^2 and a friction sleeve area of 150 cm^2. The cone is designed with an equal end area friction sleeve and a tip end area ratio of 0.80.

The cone takes measurements of cone bearing (q_c), sleeve friction (f_s) and penetration pore water pressure (u_2) at 5-cm intervals during penetration to provide a nearly continuous hydrogeologic log. CPT data reduction and interpretation is performed in real time facilitating on-site decision making. The above mentioned parameters are stored on disk for further analysis and reference. All CPT soundings are performed in accordance with revised (2002) ASTM standards (D 5778-95).

The cone also contains a porous filter element located directly behind the cone tip (u_2), *Figure CPT.* It consists of porous plastic and is 5.0mm thick. The filter element is used to obtain penetration pore pressure as the cone is advanced as well as Pore Pressure Dissipation Tests (PPDT's) during appropriate pauses in penetration. It should be noted that prior to penetration, the element is fully saturated with silicon oil under vacuum pressure to ensure accurate and fast dissipation.

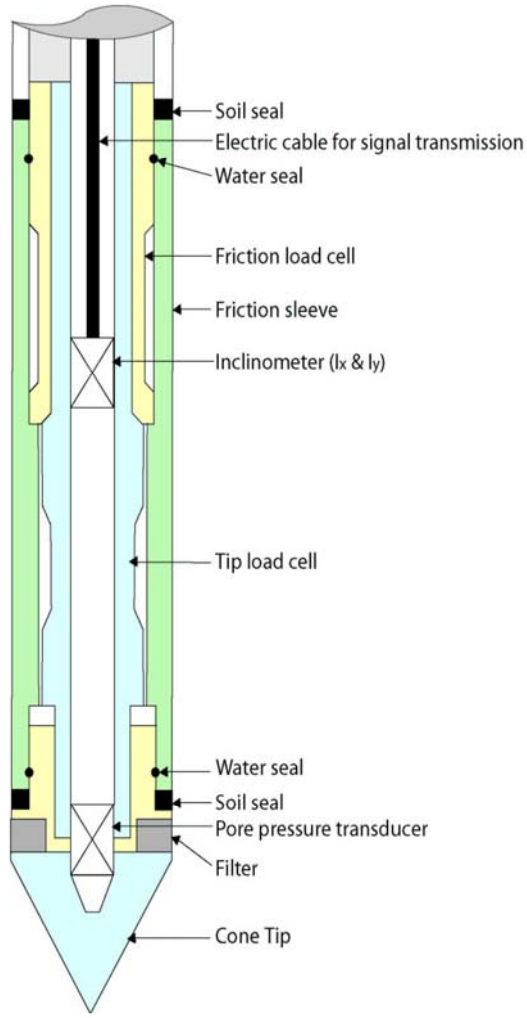


Figure CPT

When the soundings are complete, the test holes are grouted using a Gregg In Situ support rig. The grouting procedures generally consist of pushing a hollow CPT rod with a "knock out" plug to the termination depth of the test hole. Grout is then pumped under pressure as the tremie pipe is pulled from the hole. Disruption or further contamination to the site is therefore minimized.

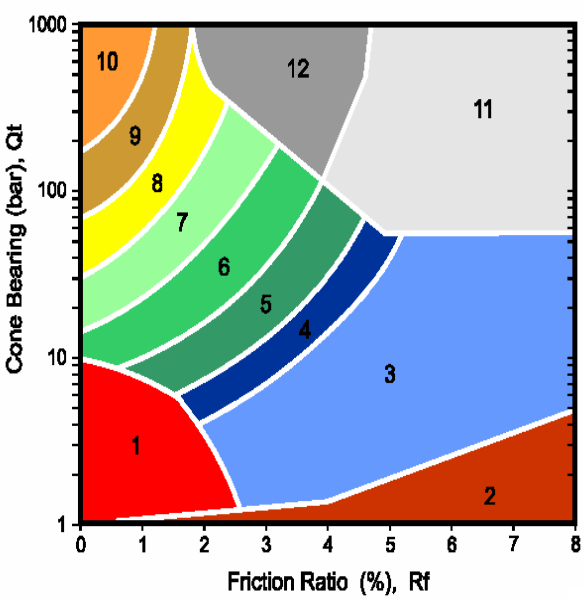
Cone Penetration Test Data & Interpretation

The Cone Penetration Test (CPT) data collected from your site are presented in graphical form in the attached report. The plots include interpreted Soil Behavior Type (SBT) based on the charts described by Robertson (1990). Typical plots display SBT based on the non-normalized charts of Robertson et al (1986). For CPT soundings extending greater than 50 feet, we recommend the use of the normalized charts of Robertson (1990) which can be displayed as SBTn, upon request. The report also includes spreadsheet output of computer calculations of basic interpretation in terms of SBT and SBTn and various geotechnical parameters using current published correlations based on the comprehensive review by Lunne, Robertson and Powell (1997), as well as recent updates by Professor Robertson. The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed. Gregg InSitu and Gregg Drilling & Testing Inc. do not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the software and do not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used in the software.

Some interpretation methods require input of the groundwater level to calculate vertical effective stress. An estimate of the in-situ groundwater level has been made based on field observations and/or CPT results, but should be verified by the user.

A summary of locations and depths is available in Table 1. Note that all penetration depths referenced in the data are with respect to the existing ground surface.

Note that it is not always possible to clearly identify a soil type based solely on q_t, f_s, and u_2. In these situations, experience, judgment, and an assessment of the pore pressure dissipation data should be used to infer the correct soil behavior type.



(After Robertson, et al., 1986)

ZONE		SBT
1		Sensitive, fine grained
2		Organic materials
3		Clay
4		Silty clay to clay
5		Clayey silt to silty clay
6		Sandy silt to clayey silt
7		Silty sand to sandy silt
8		Sand to silty sand
9		Sand
10		Gravely sand to sand
11		Very stiff fine grained*
12		Sand to clayey sand*

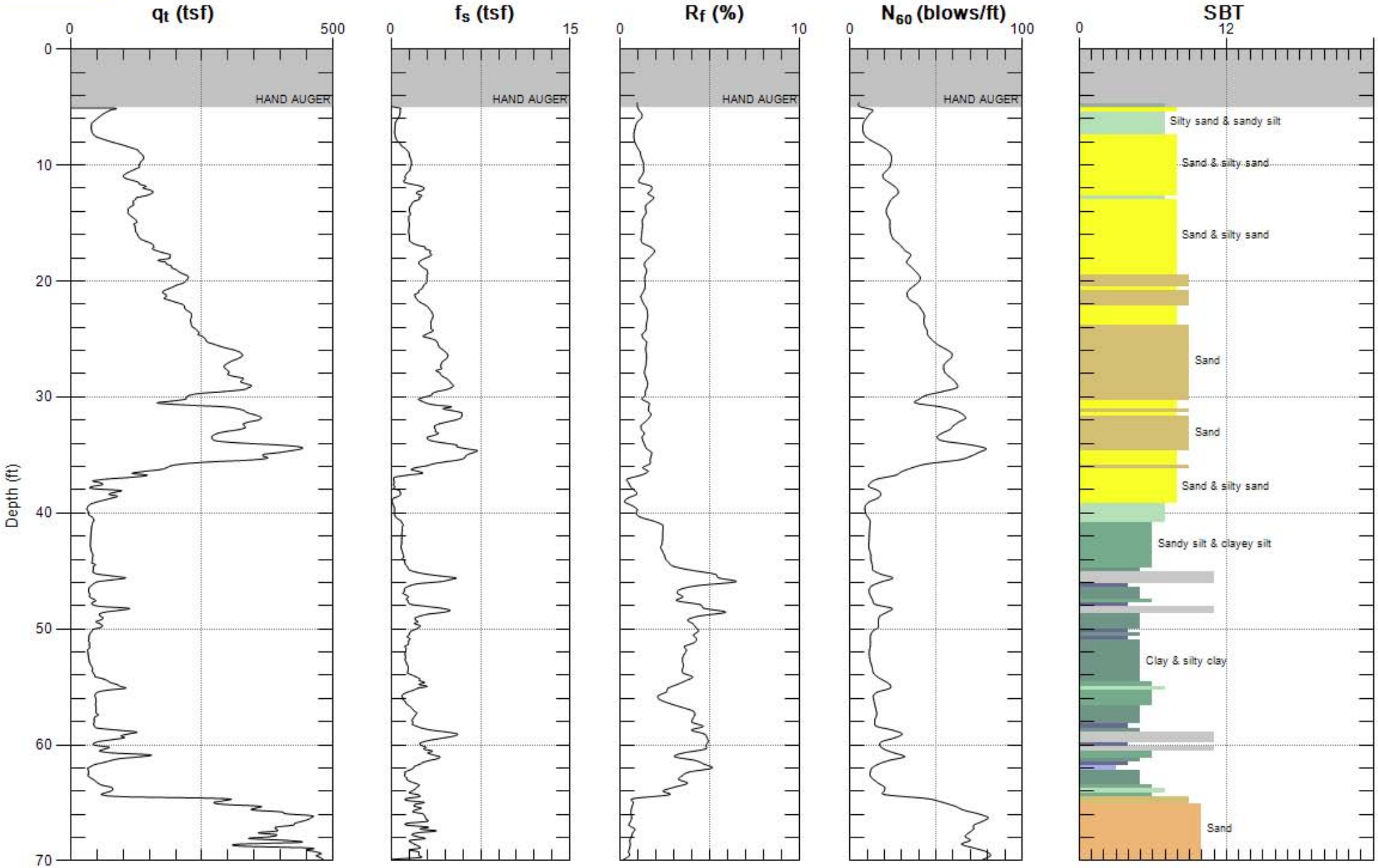
*over consolidated or cemented

Figure SBT

PARIKH CONSULTANTS

Site: WILLOW RD. EXT.
Sounding: CPT-01

Engineer: P.CHAN
Date: 11/19/2007 01:43



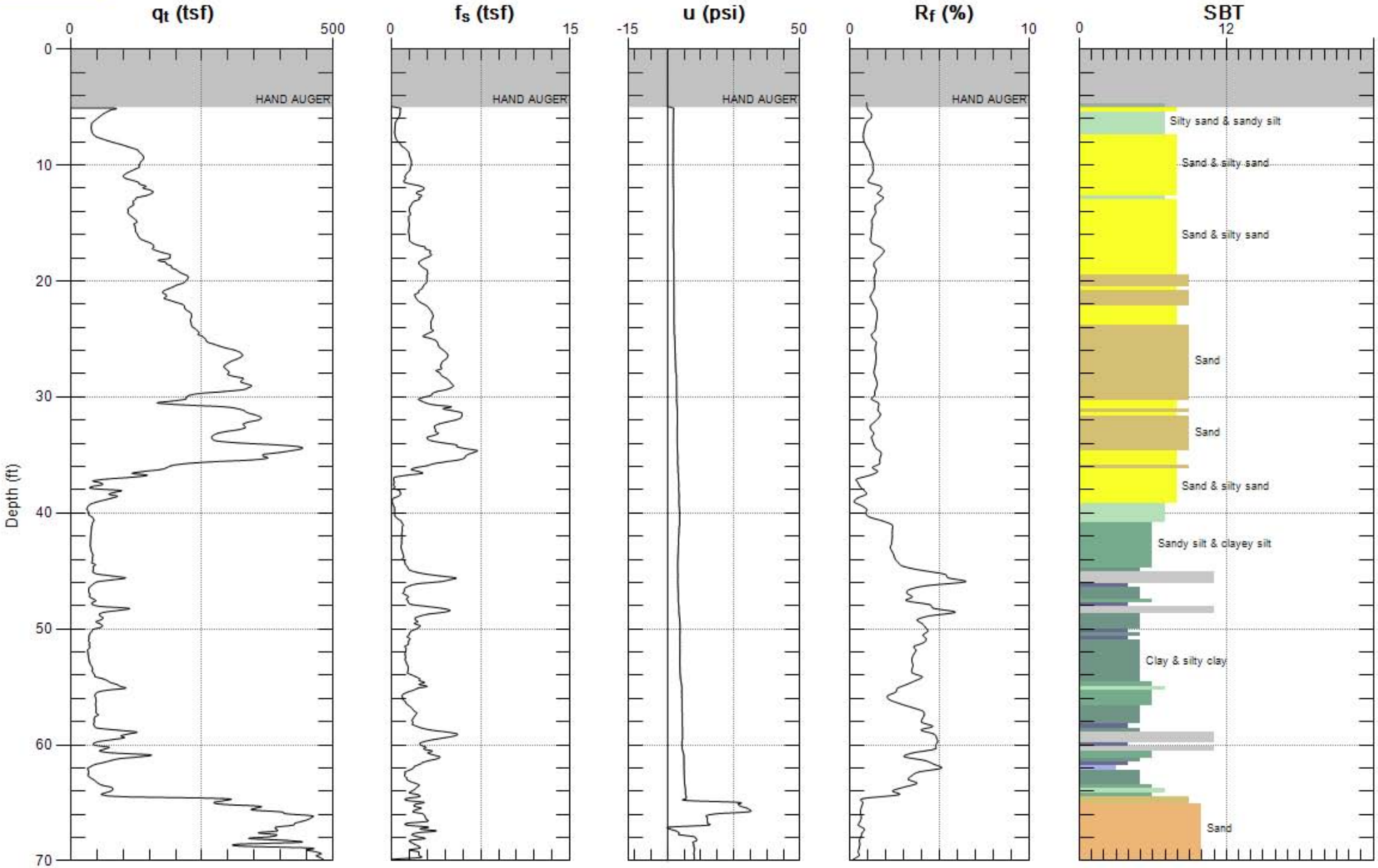
Max. Depth: 70.046 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

PARIKH CONSULTANTS

Site: WILLOW RD. EXT.
Sounding: CPT-01

Engineer: P.CHAN
Date: 11/19/2007 01:43



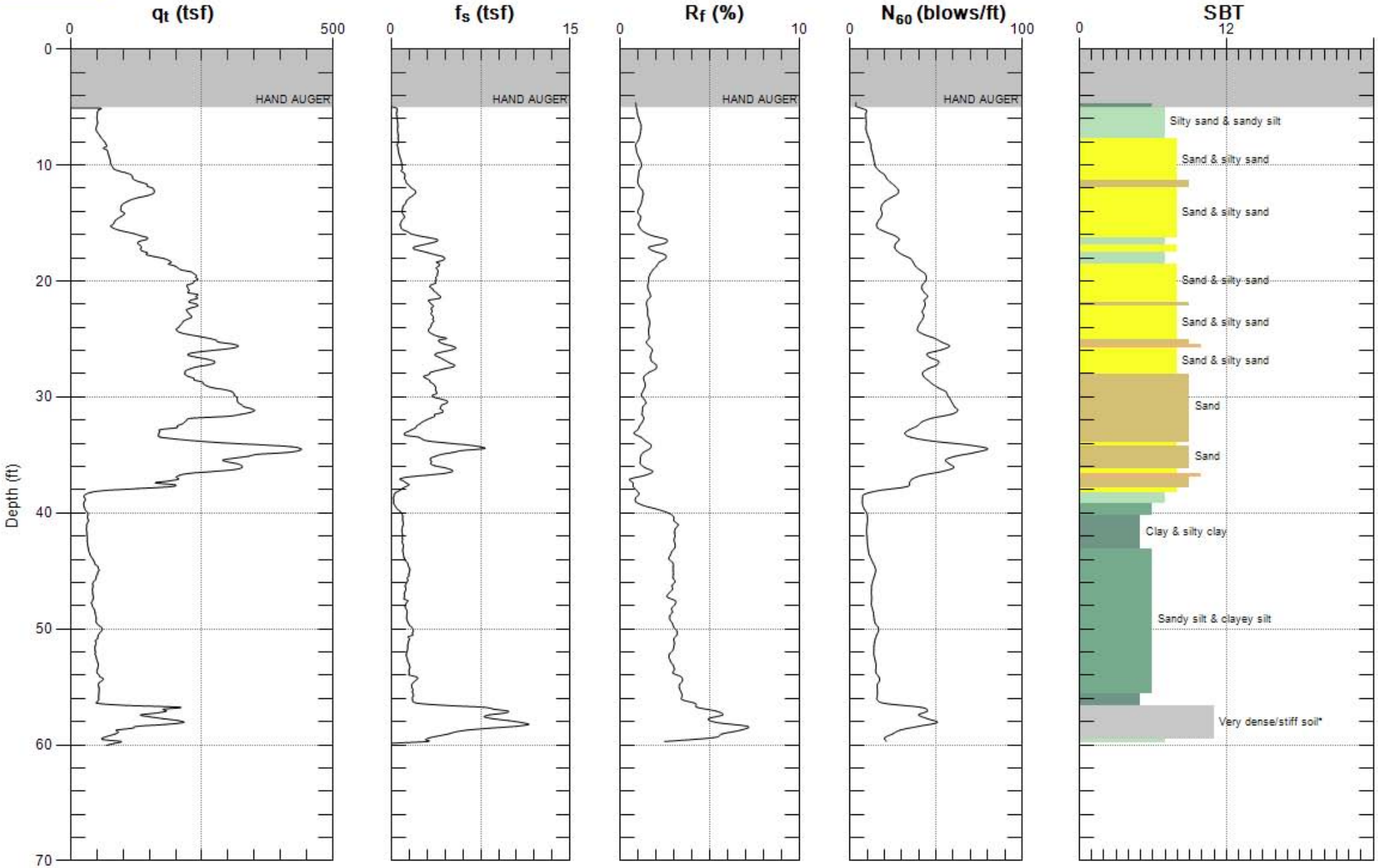
Max. Depth: 70.046 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

PARIKH CONSULTANTS

Site: WILLOW RD. EXT.
Sounding: CPT-02

Engineer: P.CHAN
Date: 11/19/2007 12:59



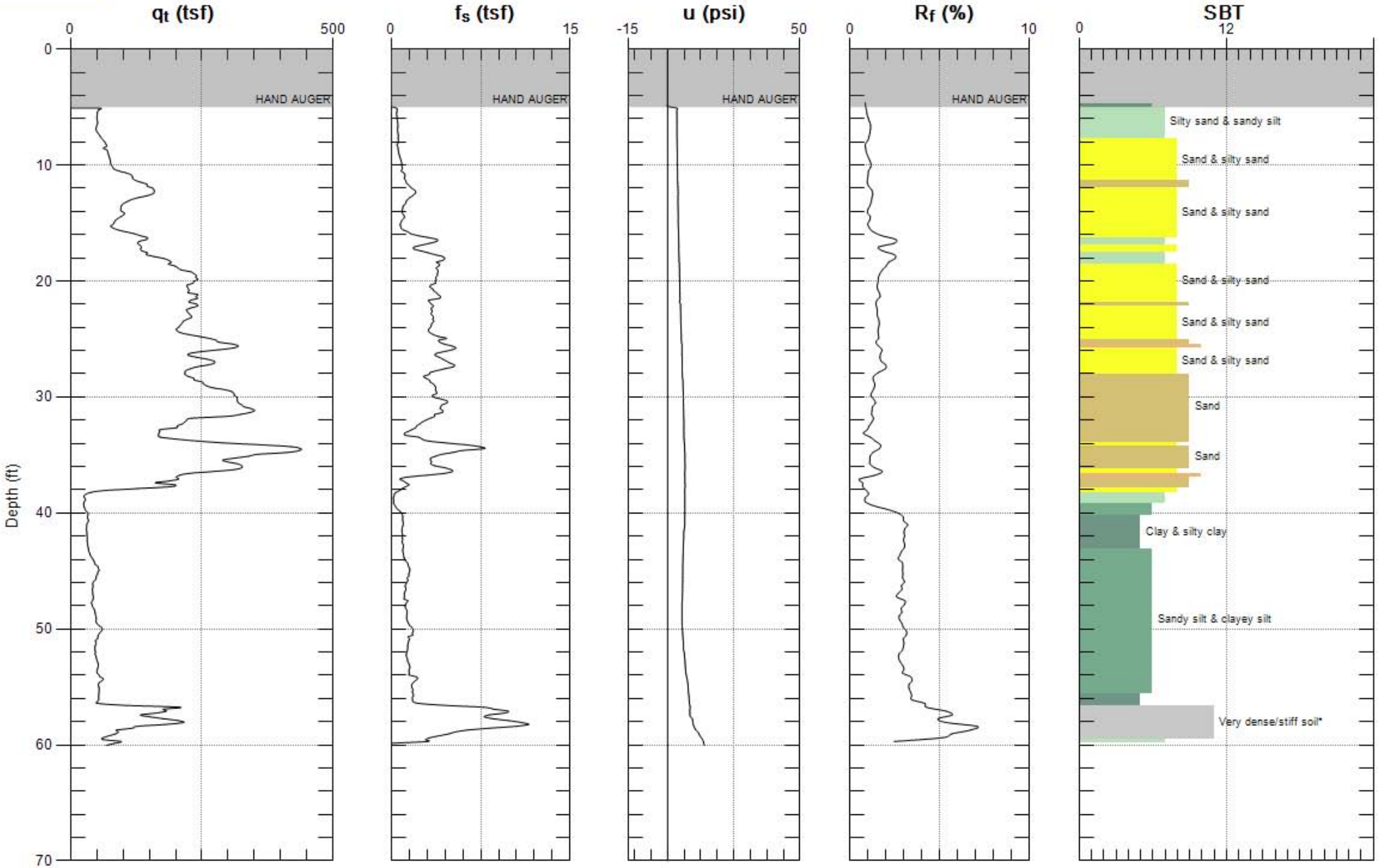
Max. Depth: 60.039 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

PARIKH CONSULTANTS

Site: WILLOW RD. EXT.
Sounding: CPT-02

Engineer: P.CHAN
Date: 11/19/2007 12:59



Max. Depth: 60.039 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG DRILLING & TESTING, INC.

CONE PENETRATION TEST DATA

Client:	PARIKH CONSULTANTS		
Site:	WILLOW RD. EXT.		
Engineer:	P.CHAN		
Sounding:	CPT-01		
Date:	11/19/2007		
Time:	1:43 PM		

Units:	Imperial	
Data averaging interval:	0.100	meters
Assumed depth of water:	50.013	feet
Net area ratio of cone:	0.80	
Unit weight of water:	62.4	lb/ft3
Relative density constant, CDR:	350	
Young's modulus for sands, a:	4	
Small strain shear modulus number, SG (s	180	
Small strain shear modulus number, CG (c	50	
Nkt for clays:	15	
OCR number, kocr:	0.3	

Interpretation based on Lunne, Robertson and Powell, 1997

Col 1i	Col 2i	Col 3i	Col 4i	Col 5i	Col 6i	Col 7i	Col 8i	Col 9i	Col 10i	Col 11i	Col 12i	Col 13i	Col 14i	Col 15i	Col 16i	Col 17i	Col 18i	Col 19i	Col 20i	Col 21i	Col 22i	Col 23i	Col 24i	Col 25i	Col 26i	Col 27i	Col 28i	Col 29i
Depth	Depth	qc	fs	u	Other	qt	Rf	SBT	Unit Weight, γ	Total Overburden Stress, σv	Insitu pore pressure, uo	Effective overburden stress, σ'v	Normalized cone resistance, Qtl	Normalized Friction raio, Fr	Normalized pore pressure ratio, Bq	Soil Behavior Type (normalized) SBTn	SBTn Index, Ic	Normalized Cone resistance, Qtn	Estimated permeability, kSBT	SPT N60	SPT (N1)60	Relative Density, Dr	Friction Angle, φ'	Young's modulus, Es	Small strain shear modulus, Go	Undrained shear strength, su	Undrained strength ratio, su/σ'v	Over consolidation ratio, OCR
(m)	(ft)	(tsf)	(tsf)	(psi)		(tsf)	(%)		(pcf)	(tsf)	(tsf)	(tsf)							(ft/sec)	(blows/ft)	(blows/ft)	(%)	(degrees)	(tsf)	(tsf)	(tsf)		
0.100	0.328	0.000	0.000	0.000							0.000																	
0.200	0.656	0.000	0.000	0.000							0.000																	
0.300	0.984	0.000	0.000	0.000							0.000																	
0.400	1.312	0.000	0.000	0.000							0.000																	
0.500	1.640	0.000	0.000	0.000							0.000																	
0.600	1.969	0.000	0.000	0.000							0.000																	
0.700	2.297	0.000	0.000	0.000							0.000																	
0.800	2.625	0.000	0.000	0.000							0.000																	
0.900	2.953	0.000	0.000	0.000							0.000																	
1.000	3.281	0.000	0.000	0.000							0.000																	
1.100	3.609	0.000	0.000	0.000							0.000																	
1.200	3.937	0.000	0.000	0.000							0.000																	
1.300	4.265	0.000	0.000	0.000							0.000																	
1.400	4.593	0.000	0.000	0.000							0.000																	
1.500	4.921	27.664	0.260	0.741		27.67	0.94	7	118	0.290	0.000	0.290	94.50	0.95	0.00	6	1.92	55.04	3.00E-4	5.3	10.1	40	40	111	367			
1.600	5.249	76.043	0.778	2.222		76.07	1.02	8	121	0.310	0.000	0.310	244.70	1.03	0.00	6	1.64	132.37	3.00E-4	13.1	24.3	61	45	304	526			
1.700	5.577	63.036	0.749	2.210		63.07	1.19	7	118	0.329	0.000	0.329	190.73	1.19	0.00	6	1.76	110.90	3.00E-4	11.4	20.4	56	44	252	504			
1.800	5.906	53.072	0.624	2.186		53.10	1.18	7	118	0.348	0.000	0.348	151.48	1.18	0.00	6	1.83	92.47	3.00E-4	9.8	17.1	51	43	212	485			
1.900	6.234	44.388	0.427	2.151		44.42	0.96	7	118	0.368	0.000	0.368	119.84	0.97	0.00	6	1.84	75.29	3.00E-4	8.2	14.0	46	42	178	465			
2.000	6.562	40.027	0.341	2.121		40.06	0.85	7	118	0.387	0.000	0.387	102.53	0.86	0.00	6	1.86	66.27	3.00E-4	7.5	12.4	44	41	160	457			
2.100	6.890	39.875	0.320	2.115		39.91	0.80	7	118	0.406	0.000	0.406	97.23	0.81	0.00	6	1.86	64.23	3.00E-4	7.5	12.0	43	40	160	464			
2.200	7.218	42.141	0.315	2.104		42.17	0.75	7	118	0.426	0.000	0.426	98.10	0.76	0.00	6	1.84	65.74	3.00E-4	7.8	12.3	43	40	169	480			
2.300	7.546	50.559	0.375	2.098		50.59	0.74	8	121	0.445	0.000	0.445	112.59	0.75	0.00	6	1.79	75.97	3.00E-4	9.2	14.2	47	41	202	518			
2.400	7.874	69.843	0.537	2.098		69.87	0.77	8	121	0.465	0.000	0.465	149.19	0.77	0.00	6	1.71	100.54	3.00E-4	12.3	18.6	54	43	279	585			
2.500	8.202	94.331	0.798	2.104		94.36	0.85	8	121	0.485	0.000	0.485	193.53	0.85	0.00	6	1.65	131.33	3.00E-4	16.4	24.2	61	44	377	656			
2.600	8.530	117.445	1.125	2.098		117.47	0.96	8	121	0.505	0.000	0.505	231.67	0.96	0.00	6	1.63	160.03	3.00E-4	20.3	29.3	68	45	470	715			
2.700	8.858	131.059	1.433	2.092		131.09	1.09	8	121	0.525	0.000	0.525	248.81	1.10	0.00	6	1.66	175.81	3.00E-4	22.8	32.3	71	45	524	752			
2.800	9.186	137.477	1.558	2.080		137.51	1.13	8	121	0.545	0.000	0.545	251.50	1.14	0.00	6	1.66	181.33	3.00E-4	24.0	33.4	72	45	550	773			
2.900	9.514	137.363	1.660	2.080		137.39	1.21	8	121	0.564	0.000	0.564	242.42	1.21	0.00	6	1.70	178.95	3.00E-4	24.2	33.1	72	45	550	782			
3.000	9.843	132.310	1.713	2.074		132.34	1.29	8	121	0.584	0.000	0.584	225.50	1.30	0.00	6	1.74	170.58	3.00E-4	23.7	31.8	70	45	529	781			
3.100	10.171	128.243	1.647	2.080		128.27	1.28	8	121	0.604	0.000	0.604	211.33	1.29	0.00	6	1.76	162.81	3.00E-4	23.1	30.5	68	44	513	782			
3.200	10.499	115.710	1.505	2.074		115.74	1.30	8	121	0.624	0.000	0.624	184.49	1.31	0.00	6	1.80	145.29	3.00E-4	21.1	27.5	64	44	463	764			
3.300	10.827	103.594	1.260	2.080		103.62	1.22	8	121	0.644	0.000	0.644	159.96	1.22	0.00	6	1.82	128.17	3.00E-4	19.1	24.4	61	43	414	744			
3.400	11.155	108.249	1.160	2.074		108.28	1.07	8	121	0.664	0.000	0.664	162.16	1.08	0.00	6	1.78	130.91	3.00E-4	19.6	24.8	61	43	433	763			
3.500	11.483	126.593	1.325	2.092		126.62	1.05	8	121	0.683	0.000	0.683	184.26	1.05	0.00	6	1.73	149.86	3.00E-4	22.6	28.1	65	44	506	811			
3.600	11.811	137.657	2.335	2.139		137.69	1.70	8	121	0.703	0.000	0.703	194.77	1.70	0.00	6	1.87	163.35	3.00E-4	25.8	31.6	68	44	551	842			
3.700	12.139	148.721	2.551	2.198		148.75	1.72	8	121	0.723	0.000	0.723	204.70	1.72	0.00	6	1.86	173.56	3.00E-4	27.8	33.6	70	44	595	872			
3.800	12.467	151.451	2.316	2.204		151.48	1.53	8	121	0.743	0.000	0.743	202.88	1.54	0.00	6	1.82	173.38	3.00E-4	27.9	33.3	70	44	606	886			
3.900	12.795	131.315	2.439	2.228		131.35	1.86	7	118	0.762	0.000	0.762	171.30	1.87	0.00	6	1.94	149.71	3.00E-4	25.2	29.7	65	43	525	852			
4.000	13.123	120.990	2.019	2.240		121.02	1.67	8	121	0.782	0.000	0.782	153.73	1.68	0.00	6	1.93	135.72	3.00E-4	23.2	27.0	62	43	484	836			
4.100	13.451	117.795	1.677	2.234		117.83	1.42	8	121	0.802	0.000	0.802	145.92	1.43	0.00	6	1.90	129.78	3.00E-4	22.3	25.6	61	43	471	835			
4.200	13.780	110.960	1.549	2.228		110.99	1.40	8	121	0.822	0.000	0.822	134.05	1.41	0.00	6	1.92	120.65	3.00E-4	21.2	24.0	59	42	444	826			
4.300	14.108	110.268	1.578	2.210		110.30	1.43	8	121	0.842	0.000	0.842	130.05	1.44	0.00	6	1.93	118.35	3.00E-4	21.2	23.7	58	42	441	831			
4.400	14.436	116.411	1.529	2.216		116.44	1.31	8	121	0.862	0.000	0.862	134.16	1.32	0.00	6	1.90	123.00	3.00E-4	22.0	24.4	59	42	466	852			
4.500	14.764	124.090	1.500	2.222		124.12	1.21	8	121	0.881	0.000	0.881	139.83	1.22	0.00	6	1.86	129.16	3.00E-4	23.2	25.4	61	42	496	877			
4.600	15.092	123.266	1.522	2.198		123.30	1.23	8	121	0.901	0.000	0.901	135.81	1.24	0.00	6	1.88	126.77	3.00E-4	23.1	25.1	60	42	493	882			
4.700	15.420	123.218	1.502	2.175		123.25	1.22	8	121	0.921	0.000	0.921	132.81	1.23	0.00	6	1.88	125.15	3.00E-4	23.2	24.8	60	42	493	888			
4.800	15.748	124.981	1.487	2.169		125.01	1.19	8	121	0.941	0.000	0.941	131.87	1.20	0.00	6	1.87	125.37	3.00E-4	23.4	24.9	60	42	500	899			
4.900	16.076	128.802	1.523	2.169		128.83	1.18	8	121	0.961	0.000	0.961	133.10	1.19	0.00	6	1.87	127.67	3.00E-4	24.1	25.3	60	42	515	914			
5.000	16.404	136.444	1.559	2.175		136.48	1.14	8	121	0.981	0.000	0.981	138.18	1.15	0.00	6	1.85	133.65	3.00E-4	25.3	26.3	62	42	546	938			
5.100	16.732	151.461	1.878	2.186		151.49	1.24	8	121	1.000	0.000	1.000	150.43	1.25	0.00	6	1.84	146.78	3.00E-4	28.1	28.9	65	43	606	978			
5.200	17.060	157.367	2.646	2.198		157.40	1.68	8	121	1.020	0.000	1.020	153.27	1.69	0.00	6	1.94	151.00	3.00E-4	30.2	30.8	66	43	630	997			
5.300	17.388	165.558	3.143	2.275		165.59	1.90	8	121	1.040	0.000	1.040	158.21	1.91	0.00	6	1.97	157.12	3.00E-4	32.2	32.4	67	43	662	1021			
5.400	17.717	184.823	3.279	2.341		184.86	1.77	8	121	1.060	0.000	1.060	173.40	1.78	0.00	6	1.92	173.53	3.00E-4	35.3	35.2	70	43	739	1065			
5.500	18.045	181.059	2.848	2.370		181.09	1.57	8	121	1.080	0.000	1.080	166.71	1.58	0.00	6	1.89	168.16	3.00E-4	34.2	33.8	69	43	724	1065			
5.600	18.373	176.746	2.406	2.376		176.78	1.36	8	121	1.100	0.000	1.100	159.76	1.37	0.00	6	1.86	162.46	3.00E-4	32.9	32.3	68	43	707	1063			
5.700	18.701	189.203	2.534	2.376		189.24	1.34	8	121	1.119	0.000	1.119	168.04	1.35	0.00	6	1.84	172.28	3.00E-4	35.0	34.0	70	43	757	1093			
5.800	19.029	200.191	2.923	2.388		200.23	1.46	8	121	1.139	0.000	1.139	174.74	1.47	0.00	6	1.85	180.47	3.00E-4	37.3	35.9	72	43	801	1121			
5.900	19.357	213.653	3.042	2.394		213.69	1.42	8	121	1.159	0.000	1.159	183.35	1.43	0.00	6	1.83	190.91	3.00E-4	39.4	37.7	74	44	855	1152			
6.000	19.685	222.783	3.006	2.412		222.82	1.35	9	124	1.180	0.000	1.180	187.91	1.36	0.00	6	1.81	197.33	3.00E-4	40.8	38.6	75	44	891	1175			
6.100	20.013	218.394	2.981	2.418		218.43	1.36	9	124	1.200	0.000	1.200	181.04	1.37	0.00	6	1.82	191.49	3.00E-4	40.2	37.7	74	44	874	1174			
6.200	20.341	203.708	2.784	2.418		203.74	1.37	9	124	1.220	0.000	1.220	165.97	1.37	0.00	6	1.85	176.67	3.00E-4	37.8	35.2	71	43	815	1153			
6.300	20.669	186.245	2.524	2.406		186.28	1.35	8	121	1.240	0.000	1.240	149.22	1.36	0.00	6	1.88	159.74	3.00E-4	35.0	32.3	68	43	745	1125			
6.400	20.997	178.063	2.207	2.412		178.10	1.24	9	124	1.260	0.000	1.260	140.30	1.25	0.00	6	1.87	151.32	3.00E-4	33.3	30.5	66	42	712	1115			
6.500	21.325	180.585	2.039	2.424		180.62	1.13	9	124	1.281	0.000	1.281	140.02	1.14	0.00	6	1.84	152.31	3.00E-4	33.4	30.4	66	42	722	1126			
6.600	21.654	188.814	2.257	2.435		188.85	1.20	9	124	1.301	0.000	1.301	144.14	1.20	0.00	6	1.85	157.80	3.00E-4	35.1	31.6	67	42	755	1149			
6.700	21.982	209.397	2.713	2.435		209.43	1.30	9	124	1.322	0.000	1.322	157.48	1.30	0.00	6	1.84	173.61	3.00E-4	38.9	34.8	70	43	838	1195			
6.800	22.310	217.891	3.138	2.429		217.93	1.44	8	121	1.341	0.000	1.341	161.47	1.45	0.00	6	1.87	178.84	3.00E-4	40.8	36.3	71	43	872	1217			
6.900	22.638	225.001	3.375	2.435		225.04	1.50	8	121	1.361	0.000	1.361	164.32	1.51	0.00	6	1.88	183.04	3.00E-4	42.3	37.3	72	43	900	1236			
7.000	22.966	230.140	3.502	2.441		230.18	1.52	8	121	1.381	0.000	1.381	165.67	1.53	0.00	6	1.88	185.66	3.00E-4	43.3	37.9	73	43	921	1252			
7.100	23.294	229.012	3.427	2.441		229.05	1.50	8	121	1.401	0.000	1.401	162.50	1.51	0.00	6	1.88	183.22	3.00E-4	43.1	37.4	72	43	916	1256			
7.200	23.622	229.353	3.336	2.447		229.39	1.45	8	121	1.421	0.000	1.421	160.46	1.46	0.00	6	1.88	182.10	3.00E-4	43.1	37.2	72	43	918	1262			

Col 1i	Col 2i	Col 3i	Col 4i	Col 5i	Col 6i	Col 7i	Col 8i	Col 9i	Col 10i	Col 11i	Col 12i	Col 13i	Col 14i	Col 15i	Col 16i	Col 17i	Col 18i	Col 19i	Col 20i	Col 21i	Col 22i	Col 23i	Col 24i	Col 25i	Col 26i	Col 27i	Col 28i	Col 29i
Depth	Depth	qc	fs	u	Other	qt	Rf	SBT	Unit Weight, γ	Total Overburden Stress, σv	Insitu pore pressure, uo	Effective overburden stress, σ'v	Normalized cone resistance, Qtl	Normalized Friction raio, Fr	Normalized pore pressure ratio, Bq	Soil Behavior Type (normalized) SBTn	SBTn Index, Ic	Normalized Cone resistance, Qtn	Estimated permeability, kSBT	SPT N60	SPT (N1)60	Relative Density, Dr	Friction Angle, φ'	Young's modulus, Es	Small strain shear modulus, Go	Undrained shear strength, su	Undrained strength ratio, su/σ'v	Over consolidation ratio, OCR
(m)	(ft)	(tsf)	(tsf)	(psi)		(tsf)	(%)		(pcf)	(tsf)	(tsf)	(tsf)							(ft/sec)	(blows/ft)	(blows/ft)	(%)	(degrees)	(tsf)	(tsf)	(tsf)		
7.300	23.950	233.278	3.344	2.465		233.31	1.43	9	124	1.441	0.000	1.441	160.90	1.44	0.00	6	1.87	183.81	3.00E-4	43.7	37.5	72	43	933	1275			
7.400	24.278	241.175	3.383	2.489		241.21	1.40	9	124	1.461	0.000	1.461	164.05	1.41	0.00	6	1.86	188.77	3.00E-4	45.0	38.3	73	43	965	1296			
7.500	24.606	246.228	2.951	2.559		246.27	1.20	9	124	1.482	0.000	1.482	165.19	1.21	0.00	6	1.81	192.24	3.00E-4	45.1	38.1	74	43	985	1311			
7.600	24.934	254.874	3.227	2.672		254.91	1.27	9	124	1.502	0.000	1.502	168.69	1.27	0.00	6	1.82	197.30	3.00E-4	46.8	39.3	75	43	1020	1332			
7.700	25.262	263.397	3.833	2.702		263.44	1.46	9	124	1.523	0.000	1.523	172.02	1.46	0.00	6	1.86	201.55	3.00E-4	49.1	40.9	76	43	1054	1353			
7.800	25.591	282.851	4.008	2.738		282.89	1.42	9	124	1.543	0.000	1.543	182.35	1.42	0.00	6	1.83	215.51	3.00E-4	52.2	43.2	78	44	1132	1391			
7.900	25.919	307.947	4.322	2.773		307.99	1.40	9	124	1.563	0.000	1.563	196.01	1.41	0.00	6	1.81	233.66	3.00E-4	56.4	46.4	82	44	1232	1438			
8.000	26.247	324.215	4.661	2.821		324.26	1.44	9	124	1.584	0.000	1.584	203.75	1.44	0.00	6	1.80	244.40	3.00E-4	59.3	48.5	84	44	1297	1469			
8.100	26.575	322.243	4.697	2.874		322.28	1.46	9	124	1.604	0.000	1.604	199.92	1.46	0.00	6	1.81	240.89	3.00E-4	59.1	48.0	83	44	1289	1472			
8.200	26.903	307.245	4.386	2.927		307.29	1.43	9	124	1.624	0.000	1.624	188.17	1.43	0.00	6	1.82	227.72	3.00E-4	56.6	45.7	81	44	1229	1455			
8.300	27.231	295.176	4.192	2.975		295.22	1.42	9	124	1.645	0.000	1.645	178.49	1.43	0.00	6	1.84	216.81	3.00E-4	54.6	43.8	79	44	1181	1442			
8.400	27.559	295.508	4.055	3.022		295.55	1.37	9	124	1.665	0.000	1.665	176.50	1.38	0.00	6	1.83	215.79	3.00E-4	54.5	43.5	79	43	1182	1448			
8.500	27.887	300.059	3.995	3.129		300.10	1.33	9	124	1.685	0.000	1.685	177.05	1.34	0.00	6	1.82	217.96	3.00E-4	55.2	43.7	79	43	1200	1461			
8.600	28.215	312.459	4.362	3.307		312.51	1.40	9	124	1.706	0.000	1.706	182.20	1.40	0.00	6	1.83	225.28	3.00E-4	57.6	45.4	80	44	1250	1487			
8.700	28.543	326.254	4.794	3.330		326.30	1.47	9	124	1.726	0.000	1.726	188.03	1.48	0.00	6	1.83	233.45	3.00E-4	60.3	47.2	82	44	1305	1515			
8.800	28.871	334.653	5.090	3.360		334.70	1.52	9	124	1.747	0.000	1.747	190.64	1.53	0.00	6	1.84	237.65	3.00E-4	62.0	48.3	82	44	1339	1534			
8.900	29.199	337.033	4.951	3.384		337.08	1.47	9	124	1.767	0.000	1.767	189.77	1.48	0.00	6	1.83	238.16	3.00E-4	62.2	48.2	82	44	1348	1543			
9.000	29.528	288.502	3.970	3.389		288.55	1.38	9	124	1.787	0.000	1.787	160.45	1.38	0.00	6	1.86	201.50	3.00E-4	53.8	41.4	76	43	1154	1471			
9.100	29.856	230.566	3.193	3.395		230.62	1.38	9	124	1.808	0.000	1.808	126.58	1.40	0.00	6	1.93	157.86	3.00E-4	44.2	33.8	67	42	922	1370			
9.200	30.184	211.036	2.540	3.395		211.09	1.20	9	124	1.828	0.000	1.828	114.47	1.21	0.00	6	1.92	143.67	3.00E-4	40.3	30.7	64	41	844	1335			
9.300	30.512	191.327	3.039	3.437		191.38	1.59	8	121	1.848	0.000	1.848	102.57	1.60	0.00	6	2.04	126.78	3.00E-4	38.2	28.9	60	41	766	1297			
9.400	30.840	274.186	4.340	3.561		274.24	1.58	8	121	1.868	0.000	1.868	145.83	1.59	0.00	6	1.93	184.37	3.00E-4	52.5	39.5	73	43	1097	1468			
9.500	31.168	327.543	5.102	3.633		327.59	1.56	9	124	1.888	0.000	1.888	172.51	1.57	0.00	6	1.88	221.15	3.00E-4	61.5	46.1	79	43	1310	1563			
9.600	31.496	347.101	5.902	3.662		347.15	1.70	8	121	1.908	0.000	1.908	180.96	1.71	0.00	6	1.89	232.39	3.00E-4	65.6	48.8	81	44	1389	1599			
9.700	31.824	359.625	5.694	3.644		359.68	1.58	9	124	1.928	0.000	1.928	185.53	1.59	0.00	6	1.86	240.66	3.00E-4	67.2	49.8	83	44	1439	1624			
9.800	32.152	341.745	4.686	3.644		341.80	1.37	9	124	1.949	0.000	1.949	174.40	1.38	0.00	6	1.83	228.48	3.00E-4	63.2	46.5	81	43	1367	1602			
9.900	32.480	330.577	3.779	3.638		330.63	1.14	9	124	1.969	0.000	1.969	166.92	1.15	0.00	6	1.79	221.52	3.00E-4	60.1	44.1	80	43	1323	1590			
10.000	32.808	316.166	3.695	3.626		316.22	1.17	9	124	1.989	0.000	1.989	157.96	1.18	0.00	6	1.81	209.66	3.00E-4	58.0	42.3	77	43	1265	1572			
10.100	33.136	282.434	3.761	3.626		282.49	1.33	9	124	2.010	0.000	2.010	139.56	1.34	0.00	6	1.89	183.31	3.00E-4	53.3	38.7	72	42	1130	1519			
10.200	33.465	270.100	3.240	3.626		270.15	1.20	9	124	2.030	0.000	2.030	132.08	1.21	0.00	6	1.88	174.72	3.00E-4	50.7	36.6	71	42	1081	1501			
10.300	33.793	289.668	3.639	3.626		289.72	1.26	9	124	2.050	0.000	2.050	140.30	1.26	0.00	6	1.87	186.58	3.00E-4	54.3	39.0	73	42	1159	1542			
10.400	34.121	381.572	5.124	3.644		381.62	1.34	9	124	2.071	0.000	2.071	183.29	1.35	0.00	6	1.81	247.73	3.00E-4	70.0	50.0	84	44	1526	1696			
10.500	34.449	432.388	6.317	3.692		432.44	1.46	9	124	2.091	0.000	2.091	205.79	1.47	0.00	6	1.81	279.68	3.00E-4	79.1	56.3	89	44	1730	1774			
10.600	34.777	396.514	6.867	3.757		396.57	1.73	8	121	2.111	0.000	2.111	186.86	1.74	0.00	6	1.89	250.63	3.00E-4	74.8	53.0	85	44	1586	1729			
10.700	35.105	370.025	6.275	3.798		370.08	1.70	8	121	2.131	0.000	2.131	172.68	1.71	0.00	6	1.90	231.80	3.00E-4	70.2	49.5	81	43	1480	1695			
10.800	35.433	327.780	5.419	3.798		327.83	1.65	8	121	2.151	0.000	2.151	151.43	1.66	0.00	6	1.93	202.80	3.00E-4	62.9	44.1	76	43	1311	1633			
10.900	35.761	224.394	3.688	3.798		224.45	1.64	8	121	2.171	0.000	2.171	102.41	1.66	0.00	5	2.05	134.26	3.00E-6	45.0	31.4	62	41	898	1443			
11.000	36.089	182.064	2.274	3.881		182.12	1.25	9	124	2.191	0.000	2.191	82.13	1.26	0.00	6	2.04	108.26	3.00E-4	36.4	25.3	56	40	728	1350			
11.100	36.417	142.872	2.207	3.935		142.93	1.54	8	121	2.211	0.000	2.211	63.65	1.57	0.00	5	2.19	81.54	3.00E-6	30.3	20.9	48	38	572	1249			
11.200	36.745	127.504	1.424	4.065		127.56	1.12	8	121	2.231	0.000	2.231	56.19	1.14	0.00	5	2.14	72.92	3.00E-6	26.5	18.3	46	37	510	1206			
11.300	37.073	76.916	0.285	4.124		76.98	0.37	8	121	2.250	0.000	2.250	33.20	0.38	0.00	5	2.11	43.57	3.00E-6	15.8	10.8	35	34	308	1022			
11.400	37.402	53.527	0.247	4.183		53.59	0.46	8	121	2.270	0.000	2.270	22.60	0.48	0.01	5	2.30	28.47	3.00E-6	11.9	8.1	29	32	214	909			
11.500	37.730	47.593	0.267	4.189		47.65	0.56	8	121	2.290	0.000	2.290	19.81	0.59	0.01	5	2.39	24.51	3.00E-6	11.0	7.5	26	31	191	877			
11.600	38.058	73.939	0.584	4.219		74.00	0.79	8	121	2.310	0.000	2.310	31.04	0.82	0.00	5	2.28	39.48	3.00E-6	16.3	11.0	34	34	296	1018			
11.700	38.386	82.168	0.743	4.290		82.23	0.90	8	121	2.330	0.000	2.330	34.29	0.93	0.00	5	2.27	43.83	3.00E-6	18.0	12.2	35	34	329	1057			
11.800	38.714	77.740	0.330	4.308		77.80	0.42	8	121	2.350	0.000	2.350	32.11	0.44	0.00	5	2.14	42.42	3.00E-6	16.2	10.9	35	34	311	1041			
11.900	39.042	51.716	0.119	4.302		51.78	0.23	8	121	2.369	0.000	2.369	20.85	0.24	0.01	5	2.23	27.03	3.00E-6	11.2	7.5	28	31	207	911			
12.000	39.370	35.343	0.230	4.349		35.41	0.65	7	118	2.389	0.000	2.389	13.82	0.70	0.01	5	2.56	16.59	3.00E-6	8.9	5.9	22	29	142	805			
12.100	39.698	32.405	0.304	4.432		32.47	0.94	7	118	2.408	0.000	2.408	12.48	1.01	0.01	4	2.67	14.60	3.00E-8	8.6	5.7				1623	2.00	0.83	3.7
12.200	40.026	34.557	0.302	4.491		34.62	0.87	7	118	2.427	0.000	2.427	13.26	0.94	0.01	4	2.63	15.69	3.00E-8	9.0	5.9				1731	2.15	0.88	4.0
12.300	40.354	40.216	0.438	4.503		40.28	1.09	7	118	2.447	0.000	2.447	15.46	1.16	0.01	4	2.62	18.39	3.00E-8	10.4	6.8				2014	2.52	1.03	4.6
12.400	40.682	43.420	0.784	4.521		43.49	1.80	7	118	2.466	0.000	2.466	16.63	1.91	0.01	4	2.70	19.38	3.00E-8	11.7	7.7				2174	2.73	1.11	5.0
12.500	41.011	41.155	0.962	4.462		41.22	2.33	6	115	2.485	0.000	2.485	15.59	2.48	0.01	4	2.79	17.79	3.00E-8	11.6	7.6				2061	2.58	1.04	4.7
12.600	41.339	39.913	0.948	4.338		39.98	2.37	6	115	2.504	0.000	2.504	14.97	2.53	0.01	4	2.81	17.01	3.00E-8	11.4	7.4				1999	2.50	1.00	4.5
12.700	41.667	39.287	0.924	4.278		39.35	2.35	6	115	2.522	0.000	2.522	14.60	2.51	0.01	4	2.82	16.58	3.00E-8	11.3	7.3				1967	2.46	0.97	4.4
12.800	41.995	38.633	0.911	4.213		38.69	2.36	6	115	2.541	0.000	2.541	14.23	2.52	0.01	4	2.83	16.13	3.00E-8	11.2	7.2				1935	2.41	0.95	4.3
12.900	42.323	38.178	0.896	4.142		38.24	2.34	6	115	2.560	0.000	2.560	13.94	2.51	0.01	4	2.83	15.79	3.00E-8	11.1	7.1				1912	2.38	0.93	4.2
13.000	42.651	37.780	0.878	4.077		37.84	2.32	6	115	2.579	0.000	2.579	13.67	2.49	0.01	4	2.84	15.49	3.00E-8	11.0	7.0				1892	2.35	0.91	4.1
13.100	42.979	38.282	0.859	4.023		38.34	2.24	6	115	2.598	0.000	2.598	13.76	2.40	0.01	4	2.83	15.65	3.00E-8	11.0	7.1				1917	2.38	0.92	4.1
13.200	43.307	40.017	0.938	3.976		40.07	2.34	6	115	2.616	0.000	2.616	14.32	2.51	0.01	4	2.82	16.32	3.00E-8	11.5	7.3				2004	2.50	0.95	4.3
13.300	43.635	42.171	1.035	3.917		42.23	2.45	6	115	2.635	0.000	2.635	15.02	2.61	0.01	4	2.82	17.18	3.00E-8	12.1	7.7				2111	2.64	1.00	4.5
13.400	43.963	41.982	1.055	3.881		42.04	2.51	6	115	2.654	0.000	2.654	14.84	2.68	0.01	4	2.83	16.93	3.00E-8	12.1	7.7				2102	2.63	0.99	4.5
13.500	44.291	43.373	1.173	3.822		43.43	2.70	6	115	2.673	0.000	2.673	15.25	2.88	0.01	4	2.84	17.37	3.00E-8	12.6	7.9				2171	2.72	1.02	4.6
13.600	44.619	44.852	1.342	3.822		44.91	2.99	6	115	2.692	0.000	2.692	15.68	3.18	0.01	3	2.85	17.81	1.00E-9	13.1	8.2				2245	2.81	1.05	4.7
13.700	44.948	43.231	1.723	3.834		43.29	3.98	5	115	2.710	0.000	2.710	14.97	4.25	0.01	3	2.95	16.57	1.00E-9	13.4	8.4				2164	2.71	1.00	4.5
13.800	45.276	58.618	3.087	3.881		58.67	5.26	11	131	2.732	0.000	2.732	20.48	5.52	0.00	3	2.92	22.88	1.00E-9	17.8	11.1				2934	3.73	1.37	6.1
13.900	45.604	87.979	4.826	3.899		88.04	5.48	11	131	2.753	0.000	2.753	30.98	5.66	0.00	3	2.79	35.88	1.00E-9	24.9	15.4				4402	5.69	2.07	9.3
14.000	45.932	58.362	3.757	3.840		58.42	6.43	11	131	2.775	0.000	2.775	20.05	6.75	0.00	3	2.98	22.02	1.00E-9	18.5	11.4				2921	3.71	1.34	6.0
14.100	46.260	40.083	1.732	3.870		40.14	4.32	4	115	2.793	0.000	2.793	13.37	4.64	0.01	3	3.01	14.58	1.00E-9	12.9	7.9				2007	2.49	0.89	4.0
14.200	46.588	35.116	1.171	3.946		35.17	3.33	5	115	2.812	0.000	2.812	11.51	3.62	0.01	3	2.99	12.61	1.00E-9	11.2	6.9				1759	2.16	0.77	3.5
14.300	46.916	35.713	1.133	3.982		35.77	3.17	5	115	2.831	0.000	2.831	11.64	3.44	0.01	3	2.98	12.82	1.00E-9	11.3	6.9				1789	2.20	0.78	3.5
14.400	47.244	38.709	1.346	4.006		38.77	3.47	5	115	2.850	0.000	2.850	12.60	3.75	0.01	3	2.97	13.92	1.00E-9	12.2	7.4				1938	2.39	0.84	3.8
14.500	47.572	44.208	1.391	4.041		44.27	3.14	6	115	2.869	0.000	2.869	14.43	3.36	0.01	3	2.90	16.32	1.00E-9	13.3	8.1				2213	2.76	0.96	4.3
14.600	47.900	47.184	2.088	4.136		47.24	4.42	4	115	2.887	0.000	2.887	15.36	4.71	0.01	3	2.97	17.02	1.00E-9	14.8	8.9				2362	2.96	1.02	4.6
14.700	48.228	87.581	4.089	4.243		87.64	4.67	11	131	2.909	0.000	2.909	29.13	4.83	0.00	3	2.77	34.33	1.00E-9	24.4	14.7				4382	5.65	1.94	8.7
14.800	48.556	71.189	4.177	4.284		71.25	5.86	11	131	2.930	0.000	2.930	23.32	6.11	0.00	3	2.91	26.35	1.00E-9	21.5	12.9				3563	4.55	1.55	7.0
14.900	48.885	57.945	2.545	4.415		58.01	4.39	5	115	2.949	0.000	2.949	18.67	4.62	0.01	3	2.90	21.18	1.00E-9	17.4	10.4				2900	3.67	1.24	5.6
15.000	49.213	56.210	2.108	4.551		56.28	3.75	5	115	2.968	0.000	2.968	17.96	3.95	0.01	3	2.87	20.59	1.00E-9	16.6	9.9				2814	3.55	1.20	5.4
15.100	49.541	54.882	2.210	4.639		54.95	4.02	5	115	2.987	0.000	2.987	17.40	4.25	0.01	3	2.90	19.77	1.00E-9	16.5	9.8				2747	3.46	1.16	5.2
15.200	49.869	53.963	2.267	4.681		54.03	4.20	5	115	3.005	0.000	3.005	16.98	4.44	0.01	3	2.92	19.18	1.00E-9	16.4	9.7				2702	3.40	1.13	5.1
15.300	50.197	40.501	1.760	4.669		40.57	4.34	4	115	3.024	0.006	3.018	12.44	4.69	0.01	3	3.04	13.54	1.00E-9	13.2	7.8				2028	2.50	0.83	3.7
15.400	50.525	36.130	1.475	4.663		36.20	4.07	5	115	3.043	0.016	3.027	10.95	4.45	0.01	3	3.07	11.82	1.00E-9	12.0	7.1				1810	2.21	0.73	3.3
15.500	50.853	34.935	1.483	4.663		35.00	4.24	4	115	3.062	0.026	3.036	10.52	4.64	0.01	3	3.09	11.27	1.00E-9	11.8	7.0				1750	2.13	0.70	3.2
15.600	51.181	35.504	1.463	4.646		35.57	4.11	5	115	3.081	0.036	3.044	10.67	4.50	0.01	3	3.08	11.48	1.00E-9	11.9	7.0				1779	2.17	0.71	3.2
15.700	51.509	36.017	1.288	4.640		36.08	3.57	5	115	3.099	0.047	3.053	10.80	3.91	0.01	3	3.04	11.77	1.00E-9	11.8	6.9				1804	2.20	0.72	3.2
15.800	51.837	33.826	1.249	4.640		33.89	3.68	5	115	3.118	0.057	3.061	10.05	4.06	0.01	3	3.07	10.84	1.00E-9	11.3	6.7				1695	2.05	0.67	3.0
15.900	52.165	33.713	1.204	4.640		33.78	3.56	5	115	3.137	0.067	3.070	9.98	3.93	0.01	3	3.07	10.78	1.00E-9	11.2	6.6				1689	2.04	0.67	3.0
16.000	52.493	34.595	1.201	4.634		34.66	3.46	5	115	3.156	0.077	3.078	10.23	3.81	0.01	3	3.05	11.12	1.00E-9	11.4	6.7				1733	2.10	0.68	3.1
16.100	52.822	36.083	1.246	4.640		36.15	3.45	5	115	3.175	0.088	3.087	10.68	3.78	0.01	3	3.03	11.67	1.00E-9	11.8	6.9				1807	2.20	0.71	3.2

Col 1i	Col 2i	Col 3i	Col 4i	Col 5i	Col 6i	Col 7i	Col 8i	Col 9i	Col 10i	Col 11i	Col 12i	Col 13i	Col 14i	Col 15i	Col 16i	Col 17i	Col 18i	Col 19i	Col 20i	Col 21i	Col 22i	Col 23i	Col 24i	Col 25i	Col 26i	Col 27i	Col 28i	Col 29i
Depth	Depth	qc	fs	u	Other	qt	Rf	SBT	Unit Weight, γ	Total Overburden Stress, σv	Insitu pore pressure, uo	Effective overburden stress, σ'v	Normalized cone resistance, Qtl	Normalized Friction raio, Fr	Normalized pore pressure ratio, Bq	Soil Behavior Type (normalized) SBTn	SBTn Index, Ic	Normalized Cone resistance, Qtn	Estimated permeability, kSBT	SPT N60	SPT (N1)60	Relative Density, Dr	Friction Angle, φ'	Young's modulus, Es	Small strain shear modulus, Go	Undrained shear strength, su	Undrained strength ratio, su/σ'v	Over consolidation ratio, OCR
(m)	(ft)	(tsf)	(tsf)	(psi)		(tsf)	(%)		(pcf)	(tsf)	(tsf)	(tsf)							(ft/sec)	(blows/ft)	(blows/ft)	(%)	(degrees)	(tsf)	(tsf)	(tsf)		
16.200	53.150	39.240	1.384	4.646		39.31	3.52	5	115	3.193	0.098	3.096	11.67	3.83	0.01	3	3.00	12.86	1.00E-9	12.6	7.4				1965	2.41	0.78	3.5
16.300	53.478	41.620	1.437	4.675		41.69	3.45	5	115	3.212	0.108	3.104	12.39	3.73	0.01	3	2.98	13.79	1.00E-9	13.1	7.7				2084	2.56	0.83	3.7
16.400	53.806	43.544	1.521	4.711		43.61	3.49	5	115	3.231	0.118	3.113	12.97	3.77	0.01	3	2.96	14.50	1.00E-9	13.6	7.9				2181	2.69	0.86	3.9
16.500	54.134	51.631	2.080	4.788		51.70	4.02	5	115	3.250	0.129	3.121	15.52	4.29	0.00	3	2.94	17.50	1.00E-9	15.9	9.2				2585	3.23	1.03	4.7
16.600	54.462	69.236	2.530	4.972		69.31	3.65	5	115	3.269	0.139	3.130	21.10	3.83	0.00	4	2.80	24.86	3.00E-8	19.7	11.5				3465	4.40	1.41	6.3
16.700	54.790	86.349	2.730	5.220		86.42	3.16	6	115	3.287	0.149	3.138	26.49	3.28	0.00	4	2.68	32.45	3.00E-8	23.1	13.4				4321	5.54	1.77	7.9
16.800	55.118	89.762	2.383	5.339		89.84	2.65	7	118	3.307	0.159	3.147	27.49	2.75	0.00	4	2.62	34.38	3.00E-8	23.2	13.5				4492	5.77	1.83	8.2
16.900	55.446	56.732	1.447	5.339		56.81	2.55	6	115	3.325	0.170	3.156	16.95	2.71	0.00	4	2.78	20.11	3.00E-8	16.0	9.3				2840	3.57	1.13	5.1
17.000	55.774	47.317	0.990	5.369		47.39	2.09	6	115	3.344	0.180	3.165	13.92	2.25	0.00	4	2.81	16.40	3.00E-8	13.5	7.8				2370	2.94	0.93	4.2
17.100	56.102	48.427	1.066	5.404		48.50	2.20	6	115	3.363	0.190	3.173	14.23	2.36	0.00	4	2.81	16.75	3.00E-8	13.9	8.0				2425	3.01	0.95	4.3
17.200	56.430	48.057	1.315	5.422		48.13	2.73	6	115	3.382	0.200	3.182	14.07	2.94	0.00	3	2.87	16.24	1.00E-9	14.2	8.2				2407	2.98	0.94	4.2
17.300	56.759	48.436	1.653	5.440		48.51	3.41	5	115	3.401	0.210	3.190	14.14	3.66	0.00	3	2.93	16.04	1.00E-9	14.8	8.5				2426	3.01	0.94	4.2
17.400	57.087	48.711	1.978	5.469		48.79	4.05	5	115	3.419	0.221	3.199	14.18	4.36	0.00	3	2.97	15.85	1.00E-9	15.3	8.8				2439	3.02	0.95	4.3
17.500	57.415	49.621	2.057	5.499		49.70	4.14	5	115	3.438	0.231	3.207	14.42	4.45	0.00	3	2.97	16.12	1.00E-9	15.6	9.0				2485	3.08	0.96	4.3
17.600	57.743	45.743	1.845	5.499		45.82	4.03	5	115	3.457	0.241	3.216	13.17	4.36	0.00	3	3.00	14.61	1.00E-9	14.6	8.4				2291	2.82	0.88	4.0
17.700	58.071	44.805	1.802	5.528		44.88	4.01	5	115	3.476	0.251	3.224	12.84	4.35	0.00	3	3.01	14.20	1.00E-9	14.4	8.2				2244	2.76	0.86	3.9
17.800	58.399	47.422	2.189	5.546		47.50	4.61	4	115	3.495	0.262	3.233	13.61	4.97	0.00	3	3.02	14.98	1.00E-9	15.4	8.8				2375	2.93	0.91	4.1
17.900	58.727	89.070	3.535	5.617		89.15	3.96	5	115	3.513	0.272	3.242	26.42	4.13	0.00	4	2.75	31.85	3.00E-8	24.6	14.1				4458	5.71	1.76	7.9
18.000	59.055	110.998	5.173	5.629		111.08	4.66	11	131	3.535	0.282	3.253	33.06	4.81	0.00	4	2.72	40.23	3.00E-8	30.3	17.3				5554	7.17	2.20	9.9
18.100	59.383	92.795	4.473	5.623		92.88	4.82	11	131	3.556	0.292	3.264	27.37	5.01	0.00	3	2.80	32.52	1.00E-9	26.3	15.0				4644	5.95	1.82	8.2
18.200	59.711	59.547	2.916	5.457		59.63	4.89	11	131	3.578	0.303	3.275	17.11	5.20	0.00	3	2.96	19.26	1.00E-9	18.6	10.5				2981	3.74	1.14	5.1
18.300	60.039	54.902	2.616	5.410		54.98	4.76	4	115	3.596	0.313	3.284	15.65	5.09	0.00	3	2.98	17.47	1.00E-9	17.4	9.9				2749	3.43	1.04	4.7
18.400	60.367	64.553	3.043	5.570		64.63	4.71	11	131	3.618	0.323	3.295	18.52	4.99	0.00	3	2.92	21.12	1.00E-9	19.7	11.1				3232	4.07	1.23	5.6
18.500	60.696	95.630	3.350	5.920		95.71	3.50	6	115	3.637	0.333	3.303	27.87	3.64	0.00	4	2.70	34.33	3.00E-8	25.7	14.5				4786	6.14	1.86	8.4
18.600	61.024	126.527	3.831	6.121		126.62	3.03	6	115	3.655	0.344	3.312	37.13	3.12	0.00	4	2.56	47.96	3.00E-8	31.7	17.9				6331	8.20	2.48	11.1
18.700	61.352	78.205	3.262	6.145		78.29	4.17	5	115	3.674	0.354	3.321	22.47	4.37	0.00	3	2.82	26.56	1.00E-9	22.5	12.7				3915	4.97	1.50	6.7
18.800	61.680	50.209	2.354	6.186		50.30	4.68	4	115	3.693	0.364	3.329	14.00	5.05	0.00	3	3.02	15.47	1.00E-9	16.2	9.1				2515	3.11	0.93	4.2
18.900	62.008	35.419	1.809	6.198		35.51	5.09	3	111	3.711	0.374	3.337	9.53	5.69	0.00	3	3.18	9.96	1.00E-9	12.7	7.2				1775	2.12	0.64	2.9
19.000	62.336	34.082	1.315	6.234		34.17	3.85	5	115	3.730	0.384	3.346	9.10	4.32	0.00	3	3.12	9.70	1.00E-9	11.8	6.6				1709	2.03	0.61	2.7
19.100	62.664	35.059	1.206	6.263		35.15	3.43	5	115	3.749	0.395	3.354	9.36	3.84	0.00	3	3.08	10.12	1.00E-9	11.8	6.6				1757	2.09	0.62	2.8
19.200	62.992	43.155	1.410	6.317		43.25	3.26	5	115	3.768	0.405	3.363	11.74	3.57	0.00	3	2.98	13.13	1.00E-9	13.7	7.7				2162	2.63	0.78	3.5
19.300	63.320	53.735	2.010	6.411		53.83	3.73	5	115	3.787	0.415	3.371	14.84	4.02	0.00	3	2.93	16.90	1.00E-9	16.5	9.2				2691	3.34	0.99	4.5
19.400	63.648	72.649	2.190	6.601		72.74	3.01	6	115	3.805	0.425	3.380	20.40	3.18	0.00	4	2.76	24.65	3.00E-8	20.2	11.3				3637	4.60	1.36	6.1
19.500	63.976	74.915	1.775	6.702		75.01	2.37	7	118	3.825	0.436	3.389	21.01	2.49	0.00	4	2.69	26.07	3.00E-8	20.0	11.2				3751	4.75	1.40	6.3
19.600	64.304	76.062	2.067	6.838		76.16	2.71	6	115	3.843	0.446	3.398	21.29	2.86	0.00	4	2.72	26.14	3.00E-8	20.7	11.5				3808	4.82	1.42	6.4
19.700	64.633	228.538	1.672	7.010		228.64	0.73	9	124	3.864	0.456	3.408	65.96	0.74	0.00	6	1.98	105.10	3.00E-4	44.6	24.9	55	38	915	1688			
19.800	64.961	284.909	2.054	20.046		285.20	0.72	9	124	3.884	0.466	3.418	82.31	0.73	0.00	6	1.89	135.24	3.00E-4	53.9	30.0	62	40	1141	1819			
19.900	65.289	333.364	2.175	28.045		333.77	0.65	10	127	3.905	0.477	3.428	96.21	0.66	0.00	6	1.81	162.89	3.00E-4	61.2	34.0	68	40	1335	1919			
20.000	65.617	366.081	2.145	30.469		366.52	0.59	10	127	3.926	0.487	3.439	105.43	0.59	0.00	6	1.75	182.54	3.00E-4	65.8	36.5	72	41	1466	1981			
20.100	65.945	422.746	2.433	21.207		423.05	0.58	10	127	3.947	0.497	3.450	121.49	0.58	0.00	6	1.70	214.81	3.00E-4	74.5	41.3	78	42	1692	2081			
20.200	66.273	456.070	2.893	14.873		456.28	0.63	10	127	3.968	0.507	3.460	130.71	0.64	0.00	6	1.70	231.52	3.00E-4	80.4	44.5	81	42	1825	2136			
20.300	66.601	439.451	2.454	15.021		439.67	0.56	10	127	3.989	0.518	3.471	125.52	0.56	0.00	6	1.68	224.11	3.00E-4	77.0	42.5	80	42	1759	2112			
20.400	66.929	413.683	1.948	10.310		413.83	0.47	10	127	4.009	0.528	3.482	117.71	0.48	0.00	6	1.66	211.84	3.00E-4	72.0	39.7	78	41	1655	2072			
20.500	67.257	391.698	3.121	1.612		391.72	0.80	10	127	4.030	0.538	3.492	111.01	0.81	0.00	6	1.82	189.37	3.00E-4	72.0	39.6	74	41	1567	2036			
20.600	67.585	380.492	2.590	3.958		380.55	0.68	10	127	4.051	0.548	3.503	107.48	0.69	0.00	6	1.79	185.60	3.00E-4	69.1	38.0	73	41	1522	2019			
20.700	67.913	370.651	2.265	8.278		370.77	0.61	10	127	4.072	0.558	3.514	104.36	0.62	0.00	6	1.77	181.57	3.00E-4	67.0	36.7	72	41	1483	2003			
20.800	68.241	395.518	2.044	10.387		395.67	0.52	10	127	4.093	0.569	3.524	111.11	0.52	0.00	6	1.71	198.06	3.00E-4	69.9	38.3	75	41	1583	2049			
20.900	68.570	360.962	1.981	9.730		361.10	0.55	10	127	4.114	0.579	3.535	100.99	0.56	0.00	6	1.75	177.09	3.00E-4	64.9	35.5	71	41	1444	1990			
21.000	68.898	410.156	2.110	10.026		410.30	0.51	10	127	4.135	0.589	3.546	114.55	0.52	0.00	6	1.69	205.70	3.00E-4	72.2	39.4	77	41	1641	2078			
21.100	69.226	464.034	2.075	9.978		464.18	0.45	10	127	4.156	0.599	3.556	129.36	0.45	0.00	6	1.62	237.15	3.00E-4	79.5	43.4	82	42	1857	2168			
21.200	69.554	473.041	2.382	9.973		473.18	0.50	10	127	4.177	0.610	3.567	131.49	0.51	0.00	6	1.64	241.42	3.00E-4	81.7	44.5	83	42	1893	2184			
21.300	69.882	480.179	0.826	10.061		480.32	0.17	10	127	4.197	0.620	3.578	133.09	0.17	0.00	6	1.42	244.72	3.00E-4	77.3	42.0	84	42	1921	2197			

GREGG DRILLING & TESTING, INC.

CONE PENETRATION TEST DATA

Client:	PARIKH CONSULTANTS		
Site:	WILLOW RD. EXT.		
Engineer:	P.CHAN		
Sounding:	CPT-02		
Date:	11/19/2007		
Time:	12:59 PM		

Units:	Imperial	
Data averaging interval:	0.100	meters
Assumed depth of water:	50.013	feet
Net area ratio of cone:	0.80	
Unit weight of water:	62.4	lb/ft3
Relative density constant, CDR:	350	
Young's modulus for sands, a:	4	
Small strain shear modulus number, SG (sa	180	
Small strain shear modulus number, CG (cla	50	
Nkt for clays:	15	
OCR number, kocr:	0.3	

Interpretation based on Lunne, Robertson and Powell, 1997

Col 1i	Col 2i	Col 3i	Col 4i	Col 5i	Col 6i	Col 7i	Col 8i	Col 9i	Col 10i	Col 11i	Col 12i	Col 13i	Col 14i	Col 15i	Col 16i	Col 17i	Col 18i	Col 19i	Col 20i	Col 21i	Col 22i	Col 23i	Col 24i	Col 25i	Col 26i	Col 27i	Col 28i	Col 29i
Depth	Depth	qc	fs	u	Other	qt	Rf	SBT	Unit Weight, γ	Total Overburden Stress, σv	Insitu pore pressure, uo	Effective overburden stress, σ'v	Normalized cone resistance, Qtl	Normalized Friction raio, Fr	Normalized pore pressure ratio, Bq	Soil Behavior Type (normalized) SBTn	SBTn Index, Ic	Normalized Cone resistance, Qtn	Estimated permeability, kSBT	SPT N60	SPT (N1)60	Relative Density, Dr	Friction Angle, φ'	Young's modulus, Es	Small strain shear modulus, Go	Undrained shear strength, su	Undrained strength ratio, su/σ'v	Over consolidation ratio, OCR
(m)	(ft)	(tsf)	(tsf)	(psi)		(tsf)	(%)		(pcf)	(tsf)	(tsf)	(tsf)							(ft/sec)	(blows/ft)	(blows/ft)	(%)	(degrees)	(tsf)	(tsf)	(tsf)		
0.100	0.328	0.000	0.000	0.000							0.000																	
0.200	0.656	0.000	0.000	0.000							0.000																	
0.300	0.984	0.000	0.000	0.000							0.000																	
0.400	1.312	0.000	0.000	0.000							0.000																	
0.500	1.640	0.000	0.000	0.000							0.000																	
0.600	1.969	0.000	0.000	0.000							0.000																	
0.700	2.297	0.000	0.000	0.000							0.000																	
0.800	2.625	0.000	0.000	0.000							0.000																	
0.900	2.953	0.000	0.000	0.000							0.000																	
1.000	3.281	0.000	0.000	0.000							0.000																	
1.100	3.609	0.000	0.000	0.000							0.000																	
1.200	3.937	0.000	0.000	0.000							0.000																	
1.300	4.265	0.000	0.000	0.000							0.000																	
1.400	4.593	0.000	0.000	0.000							0.000																	
1.500	4.921	18.497	0.159	1.179		18.51	0.86	6	115	0.282	0.000	0.282	64.66	0.87	0.00	6	2.02	38.88	3.00E-4	3.7	7.1	33	38	74	318			
1.600	5.249	53.328	0.490	3.519		53.38	0.92	7	118	0.301	0.000	0.301	176.18	0.92	0.00	6	1.70	96.29	3.00E-4	9.4	17.6	52	43	214	463			
1.700	5.577	51.015	0.480	3.484		51.07	0.94	7	118	0.321	0.000	0.321	158.28	0.95	0.00	6	1.74	90.45	3.00E-4	9.1	16.6	51	43	204	466			
1.800	5.906	50.541	0.512	3.490		50.59	1.01	7	118	0.340	0.000	0.340	147.84	1.02	0.01	6	1.79	88.13	3.00E-4	9.2	16.2	50	43	202	473			
1.900	6.234	51.300	0.553	3.502		51.35	1.08	7	118	0.359	0.000	0.359	141.94	1.08	0.00	6	1.82	87.67	3.00E-4	9.4	16.2	50	42	205	485			
2.000	6.562	50.219	0.578	3.502		50.27	1.15	7	118	0.379	0.000	0.379	131.79	1.16	0.01	6	1.86	84.44	3.00E-4	9.4	15.7	49	42	201	490			
2.100	6.890	49.024	0.560	3.514		49.07	1.14	7	118	0.398	0.000	0.398	122.34	1.15	0.01	6	1.88	80.60	3.00E-4	9.2	15.1	48	42	196	494			
2.200	7.218	52.096	0.581	3.526		52.15	1.11	7	118	0.417	0.000	0.417	124.00	1.12	0.00	6	1.87	83.10	3.00E-4	9.8	15.6	49	42	209	512			
2.300	7.546	57.016	0.604	3.543		57.07	1.06	7	118	0.437	0.000	0.437	129.74	1.07	0.00	6	1.84	87.96	3.00E-4	10.6	16.5	50	42	228	536			
2.400	7.874	62.771	0.625	3.555		62.82	0.99	8	121	0.456	0.000	0.456	136.66	1.00	0.00	6	1.81	93.65	3.00E-4	11.5	17.5	52	42	251	561			
2.500	8.202	67.539	0.572	3.561		67.59	0.85	8	121	0.476	0.000	0.476	140.94	0.85	0.00	6	1.75	97.12	3.00E-4	12.1	18.1	53	42	270	583			
2.600	8.530	67.075	0.586	3.591		67.13	0.87	8	121	0.496	0.000	0.496	134.33	0.88	0.00	6	1.78	94.87	3.00E-4	12.2	17.7	52	42	269	590			
2.700	8.858	70.753	0.639	3.614		70.81	0.90	8	121	0.516	0.000	0.516	136.25	0.91	0.00	6	1.78	98.08	3.00E-4	12.8	18.4	53	42	283	609			
2.800	9.186	73.019	0.714	3.626		73.07	0.98	8	121	0.536	0.000	0.536	135.40	0.98	0.00	6	1.81	99.67	3.00E-4	13.4	18.8	53	42	292	623			
2.900	9.514	75.105	0.813	3.638		75.16	1.08	8	121	0.556	0.000	0.556	134.28	1.09	0.00	6	1.84	101.12	3.00E-4	13.9	19.2	54	42	301	636			
3.000	9.843	76.622	0.893	3.656		76.67	1.16	8	121	0.575	0.000	0.575	132.25	1.17	0.00	6	1.87	101.64	3.00E-4	14.3	19.4	54	42	307	648			
3.100	10.171	80.357	0.933	3.668		80.41	1.16	8	121	0.595	0.000	0.595	134.09	1.17	0.00	6	1.86	104.47	3.00E-4	15.0	20.0	55	42	322	666			
3.200	10.499	93.345	0.964	3.697		93.40	1.03	8	121	0.615	0.000	0.615	150.85	1.04	0.00	6	1.79	117.81	3.00E-4	17.0	22.3	58	43	374	708			
3.300	10.827	112.942	1.142	3.727		113.00	1.01	8	121	0.635	0.000	0.635	176.97	1.02	0.00	6	1.73	139.03	3.00E-4	20.1	26.0	63	43	452	762			
3.400	11.155	120.043	1.174	3.745		120.10	0.98	8	121	0.655	0.000	0.655	182.42	0.98	0.00	6	1.71	145.00	3.00E-4	21.3	27.0	64	44	480	786			
3.500	11.483	134.662	1.297	3.769		134.72	0.96	9	124	0.675	0.000	0.675	198.54	0.97	0.00	6	1.68	159.48	3.00E-4	23.6	29.5	68	44	539	825			
3.600	11.811	149.309	1.559	3.857		149.36	1.04	9	124	0.695	0.000	0.695	213.76	1.05	0.00	6	1.68	174.29	3.00E-4	26.2	32.3	71	44	597	862			
3.700	12.139	158.183	1.917	3.911		158.24	1.21	8	121	0.715	0.000	0.715	220.21	1.22	0.00	6	1.72	182.87	3.00E-4	28.1	34.2	72	45	633	887			
3.800	12.467	154.059	1.964	3.917		154.12	1.27	8	121	0.735	0.000	0.735	208.63	1.28	0.00	6	1.76	176.14	3.00E-4	27.7	33.2	71	44	616	888			
3.900	12.795	130.784	1.595	3.899		130.84	1.22	8	121	0.755	0.000	0.755	172.30	1.23	0.00	6	1.80	147.90	3.00E-4	23.9	28.3	65	43	523	848			
4.000	13.123	108.922	1.302	3.905		108.98	1.19	8	121	0.775	0.000	0.775	139.64	1.20	0.00	6	1.86	121.94	3.00E-4	20.3	23.7	59	42	436	805			
4.100	13.451	98.418	1.104	3.911		98.47	1.12	8	121	0.795	0.000	0.795	122.91	1.13	0.00	6	1.88	108.72	3.00E-4	18.5	21.3	56	42	394	785			
4.200	13.780	95.820	0.971	3.923		95.88	1.01	8	121	0.815	0.000	0.815	116.71	1.02	0.00	6	1.87	104.22	3.00E-4	17.9	20.4	55	41	384	784			
4.300	14.108	99.877	0.972	3.946		99.93	0.97	8	121	0.834	0.000	0.834	118.77	0.98	0.00	6	1.85	107.04	3.00E-4	18.6	20.9	55	41	400	801			
4.400	14.436	95.839	1.080	3.964		95.90	1.13	8	121	0.854	0.000	0.854	111.26	1.14	0.00	6	1.91	101.73	3.00E-4	18.2	20.3	54	41	384	797			
4.500	14.764	86.282	0.938	3.964		86.34	1.09	8	121	0.874	0.000	0.874	97.78	1.10	0.00	6	1.94	90.43	3.00E-4	16.6	18.3	51	40	345	775			
4.600	15.092	80.376	0.800	3.994		80.43	0.99	8	121	0.894	0.000	0.894	88.98	1.01	0.00	6	1.95	83.08	3.00E-4	15.5	16.9	49	40	322	763			
4.700	15.420	82.689	0.893	4.065		82.75	1.08	8	121	0.914	0.000	0.914	89.56	1.09	0.00	6	1.97	84.45	3.00E-4	16.1	17.3	49	40	331	776			
4.800	15.748	105.765	1.369	4.106		105.82	1.29	8	121	0.934	0.000	0.934	112.35	1.31	0.00	6	1.95	106.77	3.00E-4	20.4	21.7	55	41	423	848			
4.900	16.076	133.107	2.333	4.148		133.17	1.75	8	121	0.953	0.000	0.953	138.67	1.76	0.00	6	1.98	133.03	3.00E-4	26.0	27.4	62	42	533	922			
5.000	16.404	140.701	3.589	4.171		140.76	2.55	7	118	0.973	0.000	0.973	143.71	2.57	0.00	5	2.09	139.37	3.00E-6	28.7	29.9	63	42	563	945			
5.100	16.732	130.225	3.220	4.195		130.29	2.47	7	118	0.992	0.000	0.992	130.33	2.49	0.00	5	2.11	127.34	3.00E-6	26.7	27.6	60	42	521	927			
5.200	17.060	133.363	2.141	4.225		133.42	1.60	8	121	1.012	0.000	1.012	130.85	1.62	0.00	6	1.97	128.53	3.00E-4	25.9	26.5	61	42	534	941			
5.300	17.388	138.368	2.492	4.243		138.43	1.80	8	121	1.032	0.000	1.032	133.17	1.81	0.00	6	2.00	131.86	3.00E-4	27.2	27.6	61	42	554	959			
5.400	17.717	149.679	3.694	4.261		149.74	2.47	7	118	1.051	0.000	1.051	141.47	2.48	0.00	5	2.09	141.12	3.00E-6	30.4	30.5	63	42	599	990			
5.500	18.045	174.309	4.380	4.302		174.37	2.51	7	118	1.070	0.000	1.070	161.91	2.53	0.00	5	2.05	162.61	3.00E-6	35.0	34.8	68	43	697	1048			
5.600	18.373	188.265	4.064	4.361		188.33	2.16	7	118	1.090	0.000	1.090	171.82	2.17	0.00	6	1.99	173.84	3.00E-4	36.8	36.3	70	43	753	1082			
5.700	18.701	196.522	3.946	4.450		196.59	2.01	8	121	1.110	0.000	1.110	176.18	2.02	0.00	6	1.96	179.60	3.00E-4	38.0	37.1	72	43	786	1104			
5.800	19.029	214.355	3.877	4.480		214.42	1.81	8	121	1.129	0.000	1.129	188.86	1.82	0.00	6	1.90	194.12	3.00E-4	40.6	39.3	74	44	858	1143			
5.900	19.357	234.312	3.897	4.509		234.38	1.66	8	121	1.149	0.000	1.149	202.94	1.67	0.00	6	1.85	210.39	3.00E-4	43.6	41.9	78	44	938	1185			
6.000	19.685	240.104	3.802	4.527		240.17	1.58	8	121	1.169	0.000	1.169	204.44	1.59	0.00	6	1.83	213.64	3.00E-4	44.4	42.2	78	44	961	1201			
6.100	20.013	236.909	3.740	4.539		236.97	1.58	8	121	1.189	0.000	1.189	198.32	1.59	0.00	6	1.84	208.74	3.00E-4	43.9	41.4	77	44	948	1202			
6.200	20.341	225.826	3.439	4.562		225.89	1.52	8	121	1.209	0.000	1.209	185.88	1.53	0.00	6	1.85	197.03	3.00E-4	42.0	39.3	75	44	904	1190			
6.300	20.669	224.139	3.434	4.586		224.20	1.53	8	121	1.229	0.000	1.229	181.49	1.54	0.00	6	1.86	193.67	3.00E-4	41.8	38.8	74	44	897	1193			
6.400	20.997	230.567	3.762	4.622		230.63	1.63	8	121	1.248	0.000	1.248	183.74	1.64	0.00	6	1.87	197.27	3.00E-4	43.3	39.8	75	44	923	1211			
6.500	21.325	240.692	4.039	4.657		240.76	1.68	8	121	1.268	0.000	1.268	188.83	1.69	0.00	6	1.88	204.10	3.00E-4	45.2	41.3	76	44	963	1235			
6.600	21.654	231.985	3.482	4.592		232.05	1.50	8	121	1.288	0.000	1.288	179.15	1.51	0.00	6	1.85	195.18	3.00E-4	43.2	39.2	75	44	928	1226			
6.700	21.982	235.710	3.393	4.729		235.78	1.44	9	124	1.308	0.000	1.308	179.19	1.45	0.00	6	1.84	196.75	3.00E-4	43.7	39.3	75	44	943	1239			
6.800	22.310	230.519	3.449	4.882		230.59	1.50	8	121	1.328	0.000	1.328	172.60	1.50	0.00	6	1.86	190.46	3.00E-4	43.1	38.5	74	43	922	1236			
6.900	22.638	222.812	3.395	4.906		222.88	1.52	8	121	1.348	0.000	1.348	164.32	1.53	0.00	6	1.88	182.23	3.00E-4	42.0	37.2	72	43	892	1229			
7.000	22.966	228.073	3.458	4.942		228.14	1.52	8	121	1.368	0.000	1.368	165.77	1.52	0.00	6	1.88	185.04	3.00E-4	42.9	37.7	73	43	913	1244			
7.100	23.294	222.157	3.547	4.966		222.23	1.60	8	121	1.388	0.000	1.388	159.13	1.61	0.00	6	1.91	178.31	3.00E-4	42.2	36.9	71	43	889	1239			

Col 1i	Col 2i	Col 3i	Col 4i	Col 5i	Col 6i	Col 7i	Col 8i	Col 9i	Col 10i	Col 11i	Col 12i	Col 13i	Col 14i	Col 15i	Col 16i	Col 17i	Col 18i	Col 19i	Col 20i	Col 21i	Col 22i	Col 23i	Col 24i	Col 25i	Col 26i	Col 27i	Col 28i	Col 29i
Depth	Depth	qc	fs	u	Other	qt	Rf	SBT	Unit Weight, γ	Total Overburden Stress, σv	Insitu pore pressure, uo	Effective overburden stress, σ'v	Normalized cone resistance, Qtl	Normalized Friction raio, Fr	Normalized pore pressure ratio, Bq	Soil Behavior Type (normalized) SBTn	SBTn Index, Ic	Normalized Cone resistance, Qtn	Estimated permeability, kSBT	SPT N60	SPT (N1)60	Relative Density, Dr	Friction Angle, φ'	Young's modulus, Es	Small strain shear modulus, Go	Undrained shear strength, su	Undrained strength ratio, su/σ'v	Over consolidation ratio, OCR
(m)	(ft)	(tsf)	(tsf)	(psi)		(tsf)	(%)		(pcf)	(tsf)	(tsf)	(tsf)							(ft/sec)	(blows/ft)	(blows/ft)	(%)	(degrees)	(tsf)	(tsf)	(tsf)		
7.200	23.622	212.212	3.464	4.983		212.28	1.63	8	121	1.408	0.000	1.408	149.80	1.64	0.00	6	1.93	168.51	3.00E-4	40.7	35.3	69	43	849	1226			
7.300	23.950	205.889	3.290	5.013		205.96	1.60	8	121	1.428	0.000	1.428	143.28	1.61	0.00	6	1.94	162.01	3.00E-4	39.6	34.1	68	42	824	1220			
7.400	24.278	204.343	3.188	5.043		204.42	1.56	8	121	1.447	0.000	1.447	140.23	1.57	0.00	6	1.94	159.48	3.00E-4	39.3	33.6	68	42	818	1222			
7.500	24.606	225.874	3.566	5.102		225.95	1.58	8	121	1.467	0.000	1.467	153.00	1.59	0.00	6	1.92	175.35	3.00E-4	43.0	36.6	71	43	904	1269			
7.600	24.934	261.833	4.192	5.161		261.91	1.60	8	121	1.487	0.000	1.487	175.13	1.61	0.00	6	1.88	202.55	3.00E-4	49.3	41.6	76	43	1048	1339			
7.700	25.262	288.730	4.167	5.256		288.81	1.44	9	124	1.507	0.000	1.507	190.59	1.45	0.00	6	1.82	223.10	3.00E-4	53.2	44.6	80	44	1155	1390			
7.800	25.591	312.716	4.979	5.398		312.79	1.59	10	127	1.528	0.000	1.528	203.67	1.60	0.00	6	1.84	239.50	3.00E-4	57.9	48.2	83	44	1251	1434			
7.900	25.919	281.003	4.995	5.398		281.08	1.78	8	121	1.548	0.000	1.548	180.56	1.79	0.00	6	1.91	211.83	3.00E-4	53.4	44.1	78	44	1124	1390			
8.000	26.247	233.117	3.966	5.392		233.19	1.70	8	121	1.568	0.000	1.568	147.72	1.71	0.00	6	1.95	173.36	3.00E-4	45.0	37.0	70	43	933	1312			
8.100	26.575	241.801	4.030	5.428		241.88	1.67	8	121	1.588	0.000	1.588	151.33	1.68	0.00	6	1.94	178.80	3.00E-4	46.4	37.9	71	43	968	1333			
8.200	26.903	268.991	4.642	5.475		269.07	1.73	8	121	1.608	0.000	1.608	166.37	1.74	0.00	6	1.92	197.97	3.00E-4	51.4	41.7	75	43	1076	1387			
8.300	27.231	258.420	5.145	5.493		258.50	1.99	8	121	1.628	0.000	1.628	157.83	2.00	0.00	6	1.98	187.26	3.00E-4	50.5	40.7	73	43	1034	1374			
8.400	27.559	229.126	4.517	5.499		229.20	1.97	8	121	1.647	0.000	1.647	138.14	1.98	0.00	6	2.02	163.92	3.00E-4	45.4	36.4	68	42	917	1326			
8.500	27.887	218.157	3.443	5.528		218.24	1.58	8	121	1.667	0.000	1.667	129.90	1.59	0.00	6	1.96	155.99	3.00E-4	42.3	33.7	67	42	873	1309			
8.600	28.215	225.229	2.949	5.564		225.31	1.31	9	124	1.688	0.000	1.688	132.51	1.32	0.00	6	1.90	161.35	3.00E-4	42.7	33.8	68	42	901	1329			
8.700	28.543	240.379	3.145	5.712		240.46	1.31	9	124	1.708	0.000	1.708	139.79	1.32	0.00	6	1.88	171.49	3.00E-4	45.3	35.6	70	42	962	1363			
8.800	28.871	254.353	3.505	5.801		254.44	1.38	9	124	1.728	0.000	1.728	146.22	1.39	0.00	6	1.89	180.22	3.00E-4	47.9	37.5	72	43	1018	1395			
8.900	29.199	274.471	3.714	5.831		274.55	1.35	9	124	1.749	0.000	1.749	156.01	1.36	0.00	6	1.86	193.99	3.00E-4	51.3	39.9	74	43	1098	1436			
9.000	29.528	303.756	3.778	5.878		303.84	1.24	9	124	1.769	0.000	1.769	170.76	1.25	0.00	6	1.81	215.17	3.00E-4	55.6	43.0	78	43	1215	1491			
9.100	29.856	313.028	3.631	5.914		313.11	1.16	9	124	1.789	0.000	1.789	173.99	1.17	0.00	6	1.78	221.33	3.00E-4	56.8	43.7	80	43	1252	1512			
9.200	30.184	317.020	4.182	5.937		317.11	1.32	9	124	1.810	0.000	1.810	174.22	1.33	0.00	6	1.82	221.34	3.00E-4	58.3	44.6	80	43	1268	1524			
9.300	30.512	320.926	4.546	5.967		321.01	1.42	9	124	1.830	0.000	1.830	174.41	1.42	0.00	6	1.84	221.85	3.00E-4	59.5	45.3	80	43	1284	1536			
9.400	30.840	333.288	4.177	5.979		333.37	1.25	9	124	1.850	0.000	1.850	179.16	1.26	0.00	6	1.80	230.83	3.00E-4	60.8	46.0	81	44	1333	1561			
9.500	31.168	345.205	4.242	6.032		345.29	1.23	9	124	1.871	0.000	1.871	183.57	1.24	0.00	6	1.78	238.23	3.00E-4	62.7	47.1	83	44	1381	1586			
9.600	31.496	321.456	3.869	6.038		321.54	1.20	9	124	1.891	0.000	1.891	169.02	1.21	0.00	6	1.80	219.75	3.00E-4	58.7	43.9	79	43	1286	1554			
9.700	31.824	250.751	3.290	6.097		250.84	1.31	9	124	1.912	0.000	1.912	130.22	1.32	0.00	6	1.91	166.94	3.00E-4	47.6	35.4	69	42	1003	1436			
9.800	32.152	217.237	2.648	6.145		217.33	1.22	9	124	1.932	0.000	1.932	111.49	1.23	0.00	6	1.93	142.87	3.00E-4	41.7	30.8	64	41	869	1373			
9.900	32.480	205.917	2.210	6.151		206.01	1.07	9	124	1.952	0.000	1.952	104.52	1.08	0.00	6	1.92	134.90	3.00E-4	39.3	28.9	62	41	824	1354			
10.000	32.808	180.680	1.753	6.145		180.77	0.97	9	124	1.973	0.000	1.973	90.64	0.98	0.00	6	1.94	117.06	3.00E-4	34.7	25.4	58	40	723	1301			
10.100	33.136	168.431	1.270	6.133		168.52	0.75	9	124	1.993	0.000	1.993	83.56	0.76	0.00	6	1.90	109.14	3.00E-4	31.9	23.3	56	40	674	1275			
10.200	33.465	179.912	2.051	6.145		180.00	1.14	9	124	2.013	0.000	2.013	88.40	1.15	0.00	6	1.99	113.96	3.00E-4	35.3	25.6	57	40	720	1308			
10.300	33.793	244.702	3.427	6.228		244.79	1.40	9	124	2.034	0.000	2.034	119.37	1.41	0.00	6	1.95	155.62	3.00E-4	47.3	34.1	67	41	979	1454			
10.400	34.121	358.269	6.100	6.364		358.36	1.70	8	121	2.054	0.000	2.054	173.51	1.71	0.00	6	1.90	229.33	3.00E-4	68.0	48.8	81	43	1433	1656			
10.500	34.449	431.260	7.070	6.435		431.35	1.64	9	124	2.074	0.000	2.074	206.99	1.65	0.00	6	1.84	278.16	3.00E-4	80.0	57.1	89	44	1725	1767			
10.600	34.777	401.605	5.133	6.488		401.70	1.28	9	124	2.094	0.000	2.094	190.81	1.28	0.00	6	1.78	260.67	3.00E-4	72.9	51.8	86	44	1607	1732			
10.700	35.105	335.535	3.762	6.542		335.63	1.12	9	124	2.115	0.000	2.115	157.72	1.13	0.00	6	1.80	215.71	3.00E-4	61.3	43.3	79	43	1343	1636			
10.800	35.433	300.220	3.343	6.524		300.31	1.11	9	124	2.135	0.000	2.135	139.66	1.12	0.00	6	1.84	190.40	3.00E-4	55.5	39.1	74	42	1201	1582			
10.900	35.761	314.185	3.451	6.559		314.28	1.10	9	124	2.155	0.000	2.155	144.81	1.11	0.00	6	1.82	198.91	3.00E-4	57.8	40.5	75	42	1257	1611			
11.000	36.089	321.333	4.368	6.577		321.43	1.36	9	124	2.176	0.000	2.176	146.73	1.37	0.00	6	1.88	199.72	3.00E-4	60.4	42.2	76	43	1286	1628			
11.100	36.417	270.404	4.880	6.542		270.50	1.80	8	121	2.196	0.000	2.196	122.20	1.82	0.00	6	2.03	161.78	3.00E-4	53.7	37.3	68	42	1082	1542			
11.200	36.745	211.615	2.933	6.518		211.71	1.39	10	127	2.216	0.000	2.216	94.52	1.40	0.00	6	2.02	125.60	3.00E-4	42.0	29.0	60	40	847	1425			
11.300	37.073	198.305	1.046	6.536		198.40	0.53	9	124	2.237	0.000	2.237	87.70	0.53	0.00	6	1.80	123.09	3.00E-4	36.2	24.9	59	40	794	1399			
11.400	37.402	182.557	1.282	6.542		182.65	0.70	9	124	2.257	0.000	2.257	79.92	0.71	0.00	6	1.90	110.06	3.00E-4	34.6	23.7	56	39	731	1365			
11.500	37.730	172.262	1.224	6.553		172.36	0.71	9	124	2.278	0.000	2.278	74.68	0.72	0.00	6	1.93	102.58	3.00E-4	33.0	22.5	54	39	689	1343			
11.600	38.058	77.655	0.705	6.482		77.75	0.91	8	121	2.297	0.000	2.297	32.84	0.93	0.01	5	2.29	41.63	3.00E-6	17.2	11.7	34	34	311	1033			
11.700	38.386	31.248	0.321	6.506		31.34	1.03	7	118	2.317	0.000	2.317	12.53	1.11	0.02	4	2.69	14.49	3.00E-8	8.4	5.6				1567	1.93	0.84	3.8
11.800	38.714	26.963	0.227	6.524		27.06	0.84	7	118	2.336	0.000	2.336	10.58	0.92	0.02	4	2.72	12.18	3.00E-8	7.3	4.9				1353	1.65	0.71	3.2
11.900	39.042	26.527	0.228	6.524		26.62	0.86	7	118	2.355	0.000	2.355	10.30	0.94	0.02	4	2.73	11.83	3.00E-8	7.3	4.9				1331	1.62	0.69	3.1
12.000	39.370	25.617	0.334	6.518		25.71	1.30	6	115	2.374	0.000	2.374	9.83	1.43	0.02	4	2.83	11.02	3.00E-8	7.4	5.0				1286	1.56	0.66	2.9
12.100	39.698	28.214	0.595	6.518		28.31	2.10	6	115	2.393	0.000	2.393	10.83	2.30	0.02	4	2.90	11.95	3.00E-8	8.5	5.7				1415	1.73	0.72	3.2
12.200	40.026	32.281	0.878	6.500		32.37	2.71	6	115	2.412	0.000	2.412	12.42	2.93	0.02	3	2.91	13.69	1.00E-9	9.8	6.5				1619	2.00	0.83	3.7
12.300	40.354	32.860	0.979	6.482		32.95	2.97	5	115	2.431	0.000	2.431	12.56	3.21	0.02	3	2.93	13.79	1.00E-9	10.1	6.7				1648	2.03	0.84	3.8
12.400	40.682	33.315	0.997	6.459		33.41	2.98	5	115	2.449	0.000	2.449	12.64	3.22	0.02	3	2.93	13.89	1.00E-9	10.2	6.7				1670	2.06	0.84	3.8
12.500	41.011	31.343	1.012	6.423		31.44	3.22	5	115	2.468	0.000	2.468	11.74	3.49	0.02	3	2.98	12.76	1.00E-9	9.9	6.5				1572	1.93	0.78	3.5
12.600	41.339	30.623	0.941	6.305		30.71	3.06	5	115	2.487	0.000	2.487	11.35	3.33	0.02	3	2.98	12.35	1.00E-9	9.7	6.3				1536	1.88	0.76	3.4
12.700	41.667	31.011	0.937	6.121		31.10	3.01	5	115	2.506	0.000	2.506	11.41	3.28	0.02	3	2.97	12.44	1.00E-9	9.7	6.3				1555	1.91	0.76	3.4
12.800	41.995	31.580	0.963	6.073		31.67	3.04	5	115	2.525	0.000	2.525	11.54	3.30	0.02	3	2.97	12.60	1.00E-9	9.9	6.4				1583	1.94	0.77	3.5
12.900	42.323	31.855	0.951	6.014		31.94	2.98	5	115	2.543	0.000	2.543	11.56	3.24	0.01	3	2.96	12.65	1.00E-9	10.0	6.4				1597	1.96	0.77	3.5
13.000	42.651	32.443	0.988	5.961		32.53	3.04	5	115	2.562	0.000	2.562	11.70	3.30	0.01	3	2.96	12.81	1.00E-9	10.1	6.5				1626	2.00	0.78	3.5
13.100	42.979	33.485	1.022	5.914		33.57	3.04	5	115	2.581	0.000	2.581	12.01	3.30	0.01	3	2.96	13.19	1.00E-9	10.4	6.7				1679	2.07	0.80	3.6
13.200	43.307	35.031	1.006	5.860		35.12	2.87	6	115	2.600	0.000	2.600	12.51	3.09	0.01	3	2.93	13.86	1.00E-9	10.7	6.8				1756	2.17	0.83	3.8
13.300	43.635	37.951	1.057	5.813		38.03	2.78	6	115	2.619	0.000	2.619	13.53	2.98	0.01	3	2.89	15.15	1.00E-9	11.3	7.2				1902	2.36	0.90	4.1
13.400	43.963	42.236	1.140	5.777		42.32	2.69	6	115	2.637	0.000	2.637	15.05	2.87	0.01	4	2.84	17.09	3.00E-8	12.3	7.8				2116	2.65	1.00	4.5
13.500	44.291	45.886	1.341	5.754		45.97	2.92	6	115	2.656	0.000	2.656	16.31	3.10	0.01	4	2.83	18.59	3.00E-8	13.3	8.4				2298	2.89	1.09	4.9
13.600	44.619	50.768	1.494	5.724		50.85	2.94	6	115	2.675	0.000	2.675	18.01	3.10	0.01	4	2.80	20.74	3.00E-8	14.4	9.1				2543	3.21	1.20	5.4
13.700	44.948	53.072	1.563	5.706		53.15	2.94	6	115	2.694	0.000	2.694	18.73	3.10	0.01	4	2.79	21.68	3.00E-8	15.0	9.4				2658	3.36	1.25	5.6
13.800	45.276	50.882	1.506	5.718		50.96	2.95	6	115	2.713	0.000	2.713	17.79	3.12	0.01	4	2.80	20.50	3.00E-8	14.5	9.1				2548	3.22	1.19	5.3
13.900	45.604	48.427	1.420	5.718		48.51	2.93	6	115	2.731	0.000	2.731	16.76	3.10	0.01	4	2.82	19.23	3.00E-8	13.9	8.7				2425	3.05	1.12	5.0
14.000	45.932	44.312	1.350	5.694		44.39	3.04	6	115	2.750	0.000	2.750	15.14	3.24	0.01	3	2.87	17.16	1.00E-9	13.1	8.1				2220	2.78	1.01	4.5
14.100	46.260	42.511	1.222	5.665		42.59	2.87	6	115	2.769	0.000	2.769	14.38	3.07	0.01	3	2.87	16.30	1.00E-9	12.6	7.8				2130	2.65	0.96	4.3
14.200	46.588	42.103	1.222	5.629		42.18	2.90	6	115	2.788	0.000	2.788	14.13	3.10	0.01	3	2.88	15.98	1.00E-9	12.5	7.7				2109	2.63	0.94	4.2
14.300	46.916	42.303	1.145	5.582		42.38	2.70	6	115	2.806	0.000	2.806	14.10	2.89	0.01	3	2.87	16.04	1.00E-9	12.5	7.7				2119	2.64	0.94	4.2
14.400	47.244	43.051	1.120	5.558		43.13	2.60	6	115	2.825	0.000	2.825	14.27	2.78	0.01	4	2.85	16.31	3.00E-8	12.6	7.7				2157	2.69	0.95	4.3
14.500	47.572	41.487	1.274	5.499		41.57	3.06	6	115	2.844	0.000	2.844	13.62	3.29	0.01	3	2.91	15.31	1.00E-9	12.6	7.7				2078	2.58	0.91	4.1
14.600	47.900	40.757	1.237	5.404		40.84	3.03	6	115	2.863	0.000	2.863	13.26	3.26	0.01	3	2.92	14.90	1.00E-9	12.4	7.5				2042	2.53	0.88	4.0
14.700	48.228	43.886	1.253	5.386		43.96	2.85	6	115	2.882	0.000	2.882	14.26	3.05	0.01	3	2.88	16.23	1.00E-9	13.0	7.9				2198	2.74	0.95	4.3
14.800	48.556	46.408	1.343	5.386		46.49	2.89	6	115	2.900	0.000	2.900	15.03	3.08	0.01	3	2.86	17.20	1.00E-9	13.6	8.2				2324	2.91	1.00	4.5
14.900	48.885	48.038	1.319	5.398		48.12	2.74	6	115	2.919	0.000	2.919	15.48	2.92	0.01	4	2.84	17.87	3.00E-8	13.9	8.4				2406	3.01	1.03	4.6
15.000	49.213	48.720	1.346	5.404		48.80	2.76	6	115	2.938	0.000	2.938	15.61	2.94	0.01	4	2.83	18.04	3.00E-8	14.1	8.5				2440	3.06	1.04	4.7
15.100	49.541	50.873	1.475	5.428		50.95	2.90	6	115	2.957	0.000	2.957	16.23	3.07	0.01	4	2.83	18.79	3.00E-8	14.7	8.8				2548	3.20	1.08	4.9
15.200	49.869	57.926	1.724	5.505		58.01	2.97	6	115	2.976	0.000	2.976	18.49	3.13	0.01	4	2.79	21.69	3.00E-8	16.4	9.8				2900	3.67	1.23	5.5
15.300	50.197	58.116	1.835	5.599		58.20	3.15	6	115	2.994	0.006	2.989	18.47	3.32	0.01	4	2.81	21.57	3.00E-8	16.6	9.9				2910	3.68	1.23	5.5
15.400	50.525	53.414	1.679	5.682		53.50	3.14	6	115	3.013	0.016	2.997	16.84	3.33	0.01	3	2.84	19.48	1.00E-9	15.5	9.2				2675	3.37	1.12	5.1
15.500	50.853	50.276	1.494	5.795		50.36	2.97	6	115	3.032	0.026	3.006	15.75	3.16	0.01	4	2.85	18.17	3.00E-8	14.7	8.7				2518	3.16	1.05	4.7
15.600	51.181	48.067	1.449	5.926		48.15	3.01	6	115	3.051	0.036	3.014	14.96	3.21	0.01	3	2.87	17.15	1.00E-9	14.2	8.4				2408	3.01	1.00	4.5
15.700	51.509	47.043	1.403	5.979		47.13	2.98	6	115	3.070	0.047	3.023	14.57	3.18	0.01	3	2.88	16.68	1.00E-9	14.0	8.3				2356	2.94	0.97	4.4
15.800	51.837	46.881	1.371	6.091		46.97	2.92	6	115	3.088	0.057	3.032	14.47	3.12	0.01	3	2.88	16.58	1.00E-9	13.9	8.2				2348	2.93	0.96	4.3
15.900	52.165	47.536	1.300	6.305		47.63	2.73	6	115	3.107	0.067	3.040	14.64	2.92	0.01	4	2.85	16.90	3.00E-8	13.9	8.2				2381	2.97	0.98	4.4
16.000	52.493	49.119	1.333	6.441		49.21	2.71	6	115	3.126	0.077	3.049	15.12	2.89	0.01	4	2.84	17.52	3.00E-8	14.3	8.4				2461	3.07	1.01	4.5

Col 1i	Col 2i	Col 3i	Col 4i	Col 5i	Col 6i	Col 7i	Col 8i	Col 9i	Col 10i	Col 11i	Col 12i	Col 13i	Col 14i	Col 15i	Col 16i	Col 17i	Col 18i	Col 19i	Col 20i	Col 21i	Col 22i	Col 23i	Col 24i	Col 25i	Col 26i	Col 27i	Col 28i	Col 29i
Depth	Depth	qc	fs	u	Other	qt	Rf	SBT	Unit Weight, γ	Total Overburden Stress, σv	Insitu pore pressure, uo	Effective overburden stress, σ'v	Normalized cone resistance, Qtl	Normalized Friction raio, Fr	Normalized pore pressure ratio, Bq	Soil Behavior Type (normalized) SBTn	SBTn Index, Ic	Normalized Cone resistance, Qtn	Estimated permeability, kSBT	SPT N60	SPT (N1)60	Relative Density, Dr	Friction Angle, φ'	Young's modulus, Es	Small strain shear modulus, Go	Undrained shear strength, su	Undrained strength ratio, su/σ'v	Over consolidation ratio, OCR
(m)	(ft)	(tsf)	(tsf)	(psi)		(tsf)	(%)		(pcf)	(tsf)	(tsf)	(tsf)							(ft/sec)	(blows/ft)	(blows/ft)	(%)	(degrees)	(tsf)	(tsf)	(tsf)		
16.100	52.822	51.271	1.431	6.542		51.37	2.79	6	115	3.145	0.088	3.057	15.77	2.97	0.01	4	2.83	18.34	3.00E-8	14.8	8.7				2568	3.21	1.05	4.7
16.200	53.150	52.513	1.544	6.630		52.61	2.94	6	115	3.164	0.098	3.066	16.13	3.12	0.01	4	2.84	18.73	3.00E-8	15.2	9.0				2630	3.30	1.08	4.8
16.300	53.478	51.138	1.540	6.713		51.23	3.01	6	115	3.182	0.108	3.074	15.63	3.21	0.01	3	2.86	18.05	1.00E-9	15.0	8.8				2562	3.20	1.04	4.7
16.400	53.806	51.660	1.516	6.897		51.76	2.93	6	115	3.201	0.118	3.083	15.75	3.12	0.01	4	2.85	18.25	3.00E-8	15.1	8.8				2588	3.24	1.05	4.7
16.500	54.134	57.585	1.950	7.164		57.69	3.38	6	115	3.220	0.129	3.091	17.62	3.58	0.01	3	2.84	20.44	1.00E-9	16.8	9.8				2884	3.63	1.17	5.3
16.600	54.462	59.007	2.043	7.448		59.11	3.46	6	115	3.239	0.139	3.100	18.02	3.66	0.01	3	2.84	20.93	1.00E-9	17.2	10.0				2956	3.73	1.20	5.4
16.700	54.790	53.793	1.776	7.632		53.90	3.29	6	115	3.258	0.149	3.109	16.29	3.51	0.01	3	2.87	18.79	1.00E-9	15.9	9.3				2695	3.38	1.09	4.9
16.800	55.118	54.030	1.783	7.745		54.14	3.29	6	115	3.276	0.159	3.117	16.32	3.51	0.01	3	2.87	18.83	1.00E-9	15.9	9.3				2707	3.39	1.09	4.9
16.900	55.446	54.068	1.834	7.845		54.18	3.38	6	115	3.295	0.170	3.126	16.28	3.60	0.01	3	2.87	18.74	1.00E-9	16.0	9.3				2709	3.39	1.09	4.9
17.000	55.774	53.565	1.844	7.993		53.68	3.44	5	115	3.314	0.180	3.134	16.07	3.66	0.01	3	2.88	18.45	1.00E-9	15.9	9.3				2684	3.36	1.07	4.8
17.100	56.102	52.835	1.815	8.088		52.95	3.43	5	115	3.333	0.190	3.143	15.79	3.66	0.01	3	2.89	18.10	1.00E-9	15.8	9.2				2648	3.31	1.05	4.7
17.200	56.430	69.834	2.916	8.231		69.95	4.17	5	115	3.352	0.200	3.151	21.13	4.38	0.01	3	2.84	24.62	1.00E-9	20.3	11.8				3498	4.44	1.41	6.3
17.300	56.759	163.463	6.972	8.420		163.58	4.26	11	131	3.373	0.210	3.163	50.66	4.35	0.00	4	2.56	64.67	3.00E-8	41.1	23.7				8179	10.68	3.38	15.2
17.400	57.087	174.480	9.312	8.396		174.60	5.33	11	131	3.394	0.221	3.174	53.95	5.44	0.00	4	2.62	67.73	3.00E-8	45.0	26.0				8730	11.41	3.60	16.2
17.500	57.415	149.290	8.519	8.438		149.41	5.70	11	131	3.416	0.231	3.185	45.84	5.84	0.00	3	2.69	56.28	1.00E-9	39.9	23.0				7471	9.73	3.06	13.8
17.600	57.743	177.334	8.709	9.131		177.47	4.91	11	131	3.437	0.241	3.196	54.45	5.00	0.00	4	2.59	69.14	3.00E-8	45.0	25.9				8873	11.60	3.63	16.3
17.700	58.071	200.532	10.737	9.575		200.67	5.35	11	131	3.459	0.251	3.207	61.49	5.44	0.00	4	2.58	78.33	3.00E-8	50.8	29.2				10034	13.15	4.10	18.4
17.800	58.399	141.943	10.059	9.949		142.09	7.08	11	131	3.480	0.262	3.218	43.07	7.26	0.00	3	2.77	51.43	1.00E-9	39.8	22.8				7104	9.24	2.87	12.9
17.900	58.727	99.053	6.658	10.796		99.21	6.71	11	131	3.501	0.272	3.230	29.63	6.96	0.01	3	2.87	34.28	1.00E-9	29.3	16.8				4960	6.38	1.98	8.9
18.000	59.055	83.381	4.737	11.815		83.55	5.67	11	131	3.523	0.282	3.241	24.69	5.92	0.01	3	2.88	28.51	1.00E-9	24.8	14.2				4178	5.34	1.65	7.4
18.100	59.383	65.700	3.396	12.663		65.88	5.16	11	131	3.544	0.292	3.252	19.17	5.45	0.01	3	2.93	21.73	1.00E-9	20.2	11.5				3294	4.16	1.28	5.8
18.200	59.711	80.537	1.990	13.445		80.73	2.46	7	118	3.564	0.303	3.261	23.66	2.58	0.01	4	2.66	29.48	3.00E-8	21.2	12.1				4037	5.14	1.58	7.1

Cone Penetration Test (CPT) Interpretation

Gregg have recently updated their CPT interpretation and plotting software (2007). The software takes the CPT data and performs basic interpretation in terms of soil behavior type (SBT) and various geotechnical parameters using current published empirical correlations based on the comprehensive review by Lunne, Robertson and Powell (1997). The interpretation is presented in tabular format using MS Excel. The interpretations are presented only as a guide for geotechnical use and should be carefully reviewed. Gregg does not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the software and does not assume any liability for any use of the results in any design or review. The user should be fully aware of the techniques and limitations of any method used in the software.

The following provides a summary of the methods used for the interpretation. Many of the empirical correlations to estimate geotechnical parameters have constants that have a range of values depending on soil type, geologic origin and other factors. The software uses 'default' values that have been selected to provide, in general, conservatively low estimates of the various geotechnical parameters.

Input:

1. Units for display (Imperial or metric) (atm. pressure, pa = 0.96 tsf or 0.1 MPa)
2. Depth interval to average results,(ft or m). Data are collected at either 0.02 or 0.05m and can be averaged every 1, 3 or 5 intervals.
3. Elevation of ground surface (ft or m)
4. Depth to water table, z_w (ft or m) – input required
5. Net area ratio for cone, a (default to 0.80)
6. Relative Density constant, C_{Dr} (default to 350)
7. Young's modulus number for sands, α (default to 5)
8. Small strain shear modulus number
   a. for sands, S_G (default to 180 for SBT_n 5, 6, 7)
   b. for clays, C_G (default to 50 for SBT_n 1, 2, 3 & 4)
9. Undrained shear strength cone factor for clays, N_{kt} (default to 15)
10. Over Consolidation ratio number, k_{ocr} (default to 0.3)
11. Unit weight of water, (default to γ_w = 62.4 lb/ft^3 or 9.81 kN/m^3)

Column

1. Depth, z, (m) – CPT data is collected in meters
2. Depth (ft)
3. Cone resistance, q_c (tsf or MPa)
4. Sleeve friction, f_s (tsf or MPa)
5. Penetration pore pressure, u (psi or MPa), measured behind the cone (i.e. u_2)
6. Other – any additional data, if collected, e.g. electrical resistivity or UVIF
7. Total cone resistance, q_t (tsf or MPa) $q_t = q_c + u\,(1-a)$

8	Friction Ratio, R_f (%)	$R_f = (f_s/q_t) \times 100\%$
9	Soil Behavior Type (non-normalized), SBT	see note
10	Unit weight, γ (pcf or kN/m^3)	based on SBT, see note
11	Total overburden stress, σ_v (tsf)	$\sigma_{vo} = \gamma z$
12	Insitu pore pressure, u_o (tsf)	$u_o = \gamma_w (z - z_w)$
13	Effective overburden stress, σ'_{vo} (tsf)	$\sigma'_{vo} = \sigma_{vo} - u_o$
14	Normalized cone resistance, Q_{t1}	$Q_{t1} = (q_t - \sigma_{vo}) / \sigma'_{vo}$
15	Normalized friction ratio, F_r (%)	$F_r = f_s / (q_t - \sigma_{vo}) \times 100\%$
16	Normalized Pore Pressure ratio, B_q	$B_q = u - u_o / (q_t - \sigma_{vo})$
17	Soil Behavior Type (normalized), SBT_n	see note
18	SBT_n Index, I_c	see note
19	Normalized Cone resistance, Q_{tn} (n varies with Ic)	see note
20	Estimated permeability, k_{SBT} (cm/sec or ft/sec)	see note
21	Equivalent SPT N_{60}, blows/ft	see note
22	Equivalent SPT $(N_1)_{60}$ blows/ft	see note
23	Estimated Relative Density, D_r, (%)	see note
24	Estimated Friction Angle, ϕ', (degrees)	see note
25	Estimated Young's modulus, E_s (tsf)	see note
26	Estimated small strain Shear modulus, Go (tsf)	see note
27	Estimated Undrained shear strength, s_u (tsf)	see note
28	Estimated Undrained strength ratio	s_u/σ_v'
29	Estimated Over Consolidation ratio, OCR	see note

Notes:

1 Soil Behavior Type (non-normalized), SBT — Lunne et al. (1997)
listed below

2 Unit weight, γ either constant at 119 pcf or based on Non-normalized SBT
(Lunne et al., 1997 and table below)

3 Soil Behavior Type (Normalized), SBT_n — Lunne et al. (1997)

4 SBT_n Index, I_c — $I_c = ((3.47 - \log Q_{t1})^2 + (\log F_r + 1.22)^2)^{0.5}$

5 Normalized Cone resistance, Q_{tn} (n varies with Ic)

$Q_{tn} = ((q_t - \sigma_{vo})/pa)\ (pa/(\sigma'_{vo})^n$ and recalculate I_c, then iterate:

When $I_c < 1.64$, $n = 0.5$ (clean sand)
When $I_c > 3.30$, $n = 1.0$ (clays)
When $1.64 < I_c < 3.30$, $n = (I_c - 1.64)0.3 + 0.5$
Iterate until the change in n, $\Delta n < 0.01$

6 Estimated permeability, k_{SBT} (based on Normalized SBT_n)
(Lunne et al., 1997 and table below)

7 Equivalent SPT N_{60}, blows/ft Lunne et al. (1997)

$$\frac{(q_t/p_a)}{N_{60}} = 8.5\left(1 - \frac{I_c}{4.6}\right)$$

8 Equivalent SPT $(N_1)_{60}$ blows/ft $(N_1)_{60} = N_{60}\, C_N$,
where $C_N = (pa/\sigma'_{vo})^{0.5}$

9 Relative Density, D_r, (%) $D_r^2 = Q_{tn} / C_{Dr}$
Only SBT_n 5, 6, 7 & 8 *Show 'N/A' in zones 1, 2, 3, 4 & 9*

10 Friction Angle, ϕ', (degrees) $\tan\phi' = \frac{1}{2.68}\left[\log\left(\frac{q_c}{\sigma'_{vo}}\right) + 0.29\right]$
Only SBT_n 5, 6, 7 & 8 *Show'N/A' in zones 1, 2, 3, 4 & 9*

11 Young's modulus, E_s $E_s = \alpha\, q_t$
Only SBT_n 5, 6, 7 & 8 *Show 'N/A' in zones 1, 2, 3, 4 & 9*

12 Small strain shear modulus, Go
a. $G_o = S_G\,(q_t\ \sigma'_{vo}\ pa)^{1/3}$ *For SBT_n 5, 6, 7*
b. $G_o = C_G\, q_t$ *For SBT_n 1, 2, 3& 4*
Show 'N/A' in zones 8 & 9

13 Undrained shear strength, s_u $s_u = (q_t - \sigma_{vo}) / N_{kt}$
Only SBT_n 1, 2, 3, 4 & 9 *Show 'N/A' in zones 5, 6, 7 & 8*

14 Over Consolidation ratio, OCR $OCR = k_{ocr}\, Q_{t1}$
Only SBT_n 1, 2, 3, 4 & 9 *Show 'N/A' in zones 5, 6, 7 & 8*

SBT Zones **SBT_n Zones**

The following updated and simplified SBT descriptions have been used in the software:

1	sensitive fine grained	1	sensitive fine grained
2	organic soil	2	organic soil
3	clay	3	clay
4	clay & silty clay	4	clay & silty clay
5	clay & silty clay		
6	sandy silt & clayey silt		
7	silty sand & sandy silt	5	silty sand & sandy silt
8	sand & silty sand	6	sand & silty sand
9	sand		
10	sand	7	sand
11	very dense/stiff soil*	8	very dense/stiff soil*
12	very dense/stiff soil*	9	very dense/stiff soil*

* heavily overconsolidated and/or cemented

Track when soils fall with zones of same description and print that description (i.e. if soils fall only within SBT zones 4 & 5, print 'clays & silty clays')

Estimated Permeability (see Lunne et al., 1997)

SBT_n	Permeability (ft/sec)	(m/sec)
1	$3x\ 10^{-8}$	$1x\ 10^{-8}$
2	$3x\ 10^{-7}$	$1x\ 10^{-7}$
3	$1x\ 10^{-9}$	$3x\ 10^{-10}$
4	$3x\ 10^{-8}$	$1x\ 10^{-8}$
5	$3x\ 10^{-6}$	$1x\ 10^{-6}$
6	$3x\ 10^{-4}$	$1x\ 10^{-4}$
7	$3x\ 10^{-2}$	$1x\ 10^{-2}$
8	$3x\ 10^{-6}$	$1x\ 10^{-6}$
9	$1x\ 10^{-8}$	$3x\ 10^{-9}$

Estimated Unit Weight (see Lunne et al., 1997)

SBT	Approximate Unit Weight (lb/ft^3)	(kN/m^3)
1	111.4	17.5
2	79.6	12.5
3	111.4	17.5
4	114.6	18.0
5	114.6	18.0
6	114.6	18.0
7	117.8	18.5
8	120.9	19.0
9	124.1	19.5
10	127.3	20.0
11	130.5	20.5
12	120.9	19.0

Pore Pressure Dissipation Tests (PPDT)

Pore Pressure Dissipation Tests (PPDT's) conducted at various intervals measured hydrostatic water pressures and determined the approximate depth of the ground water table. A PPDT is conducted when the cone is halted at specific intervals determined by the field representative. The variation of the penetration pore pressure (u) with time is measured behind the tip of the cone and recorded by a computer system.

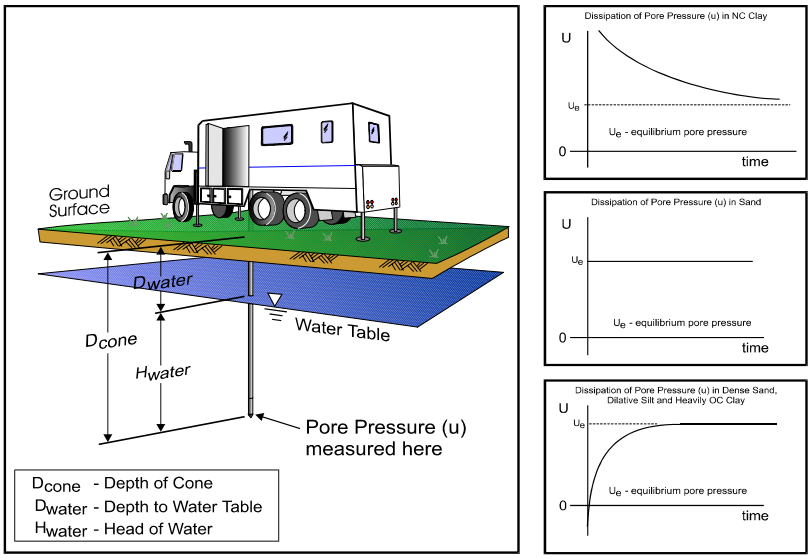
Pore pressure dissipation data can be interpreted to provide estimates of:

- Equilibrium piezometric pressure
- Phreatic Surface
- In situ horizontal coefficient of consolidation (c_h)
- In situ horizontal coefficient of permeability (k_h)

In order to correctly interpret the equilibrium piezometric pressure and/or the phreatic surface, the pore pressure must be monitored until such time as there is no variation in pore pressure with time, *Figure PPDT*. This time is commonly referred to as t_{100}, the point at which 100% of the excess pore pressure has dissipated.

A complete reference on pore pressure dissipation tests is presented by Robertson et al. 1992.

A summary of the pore pressure dissipation tests is summarized in Table 1. Pore pressure dissipation data is presented in graphical form in Appendix PPDT.



Water Table Calculation

$$D_{water} = D_{cone} - H_{water}$$

where $H_{water} = U_e$ (depth units)

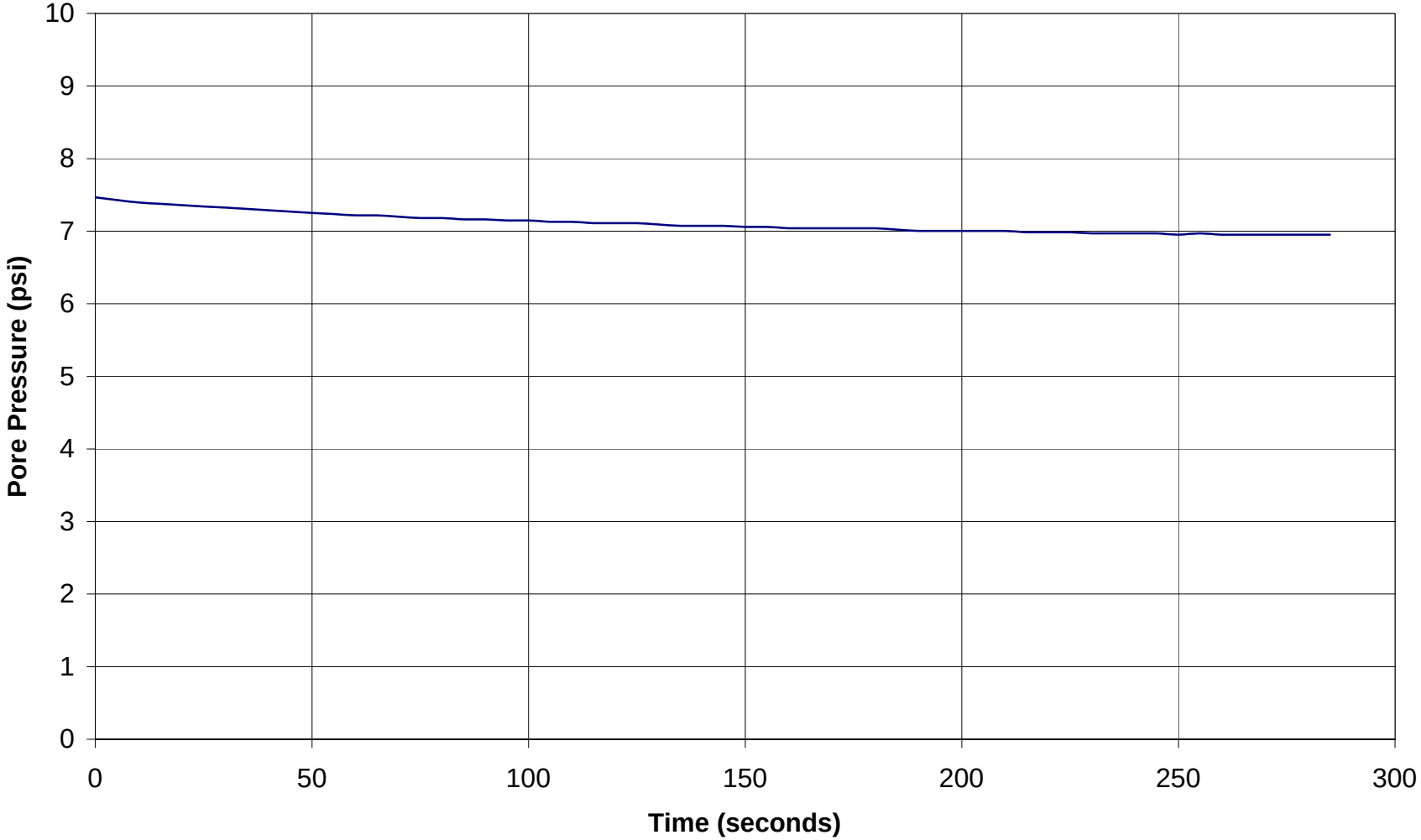
Useful Conversion Factors: 1psi = 0.704m = 2.31 feet (water)
1tsf = 0.958 bar = 13.9 psi
1m = 3.28 feet

Figure PPDT

GREGG DRILLING & TESTING

Pore Pressure Dissipation Test

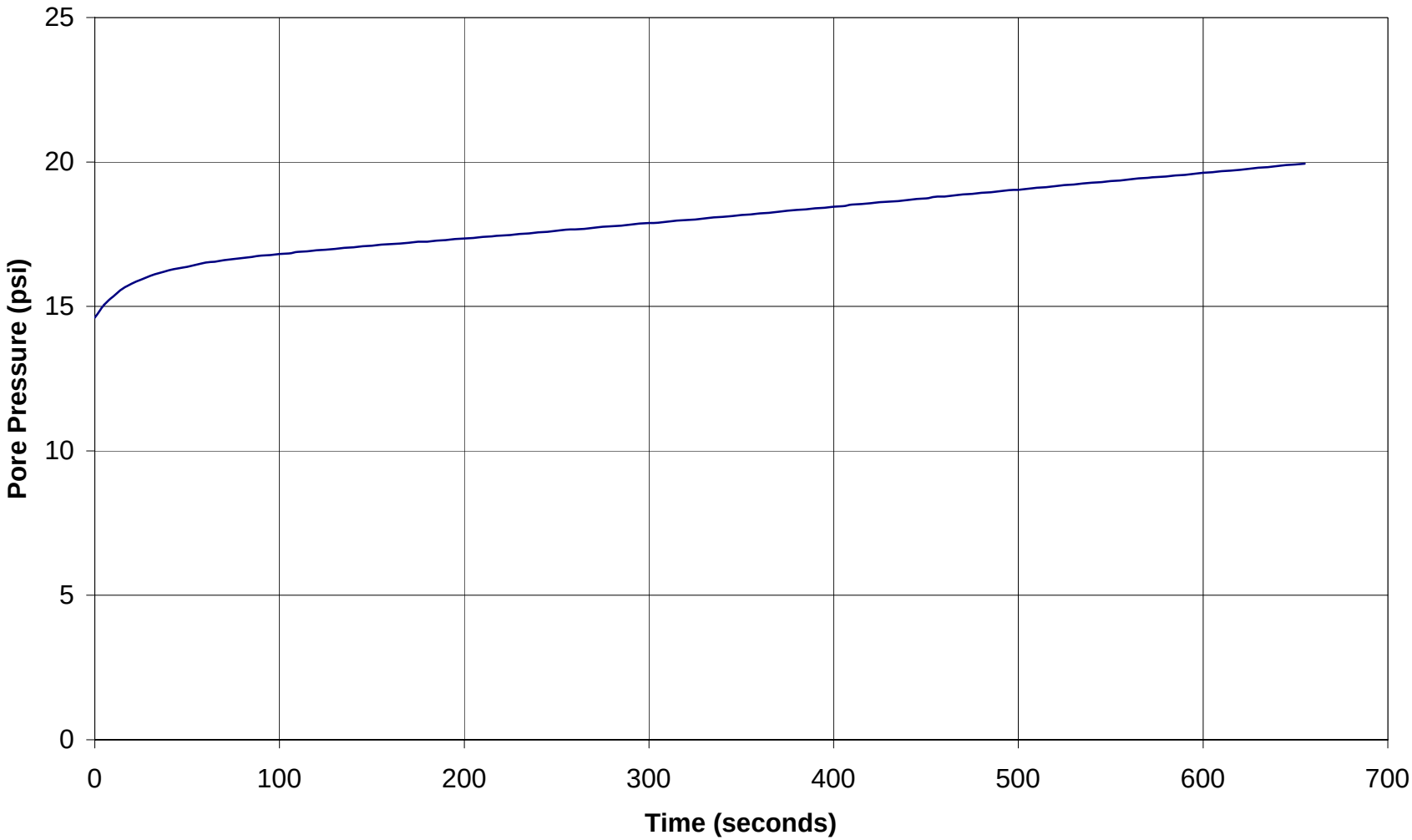
Sounding: CPT-01
Depth: 64.468
Site: WILLOW RD.
Engineer: P.CHAN



GREGG DRILLING & TESTING

Pore Pressure Dissipation Test

Sounding: CPT-02
Depth: 60.039
Site: WILLOW RD.
Engineer: P.CHAN



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Copies of ASTM Standards are available through www.astm.org

APPENDIX B

APPENDIX B

LABORATORY TESTS

Classification Tests
The field classification of the samples was visually verified in the laboratory according to the Unified Soil Classification System. The results are presented in “Log of Test Borings”, Appendix A.

Moisture-Density
The natural moisture contents and dry unit weights were determined for selected undisturbed samples of the soils in general accordance with ASTM Test Method D 2216-92. This information was used to classify and correlate the soils. The results are presented at the appropriate depths on the "Log of Test Borings", Appendix A.

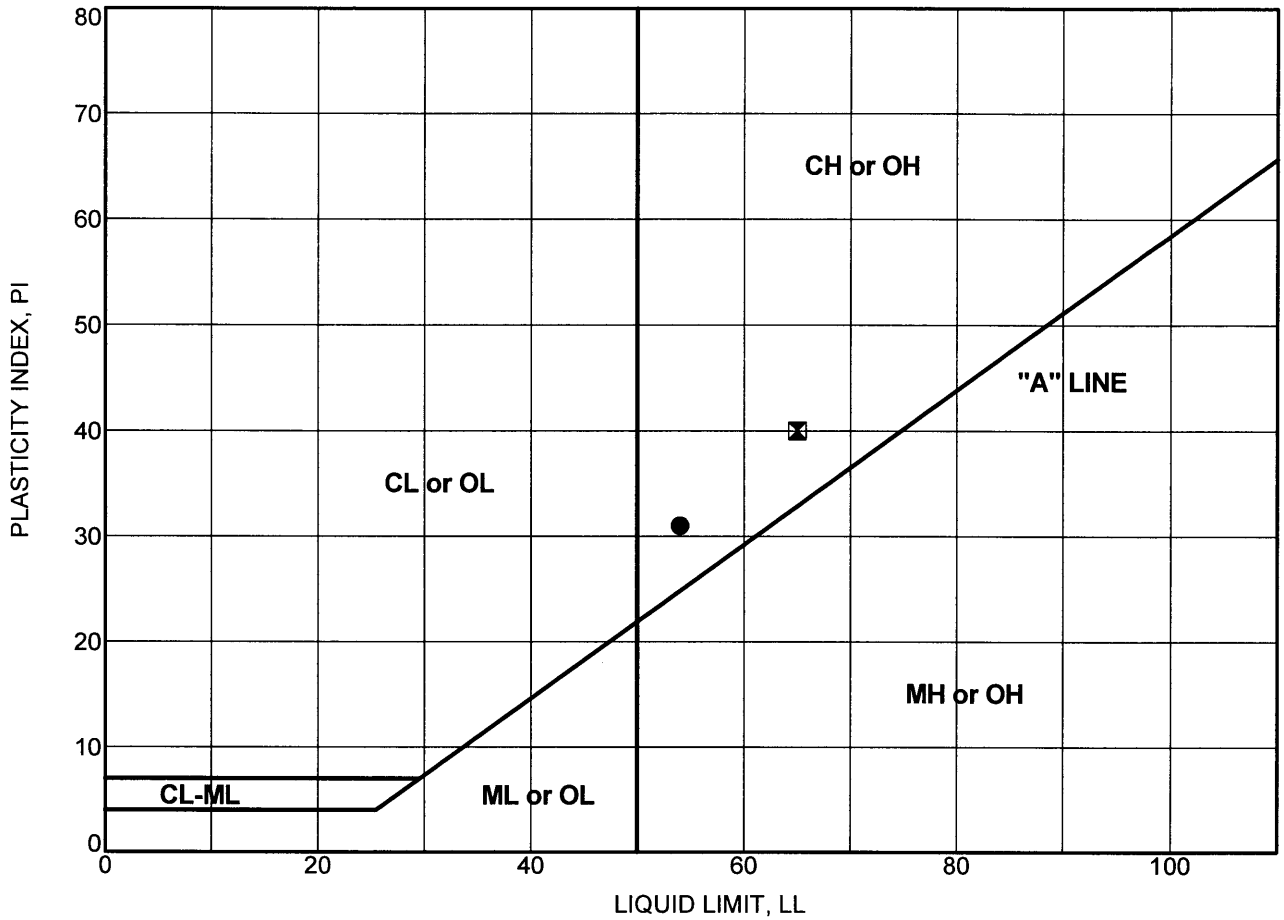
Atterberg Limits
The Atterberg Limits were determined for selected samples of the fine-grained materials. These results were used to classify the soils, as well as to obtain an indication of the effective strength characteristics and expansion potential with variations in moisture content. The Atterberg Limits were determined in general accordance with ASTM Test Method D 4318-93. The results of these tests are presented on Plate B-2, “Plasticity Chart”.

Grain Size Classification
Grain size classification tests (ASTM Test Method D422-63) were performed on selected samples of granular soil to aid in the classification. The results are presented on Plates B-3, “Grain Size Distribution Curves”.

Unconfined Compression Tests
Strength tests were performed on selected undisturbed samples using unconfined compression machine. Unconfined compression tests were performed in general accordance with ASTM Test Method D 2166-91. The results are presented on “Log of Test Borings”, Appendix A.

Corrosion Tests
Corrosion tests were performed on selected samples to determine the corrosion potential of the soils. The pH and minimum resistively tests were performed according to California Test Method 643. The tests were performed by Sunland Analytical. The test results are presented on Plates B-4A and B-4B.

Boring No. as Drilled in 2007 (in Caltrans Right-of-Way)	Boring Designation as per Caltrans 2007 Soil and Rock Logging, Classification, and Presentation Manual
CPT-1	CPT-07-001
CPT-2	CPT-07-002
BR-1	A-07-001
BR-2	A-07-002
RW-9	A-07-009



PLASTICITY CHART

Boring Number	Sample Number	Depth (feet)	Test Symbol	Moisture Content (%)	LL	PL	PI	Description
BR-1	MC-8	34.5	●	19	54	23	31	FAT CLAY (CH)
BR-2	MC-10	44.5	⊠	29	65	25	40	FAT CLAY (CH)

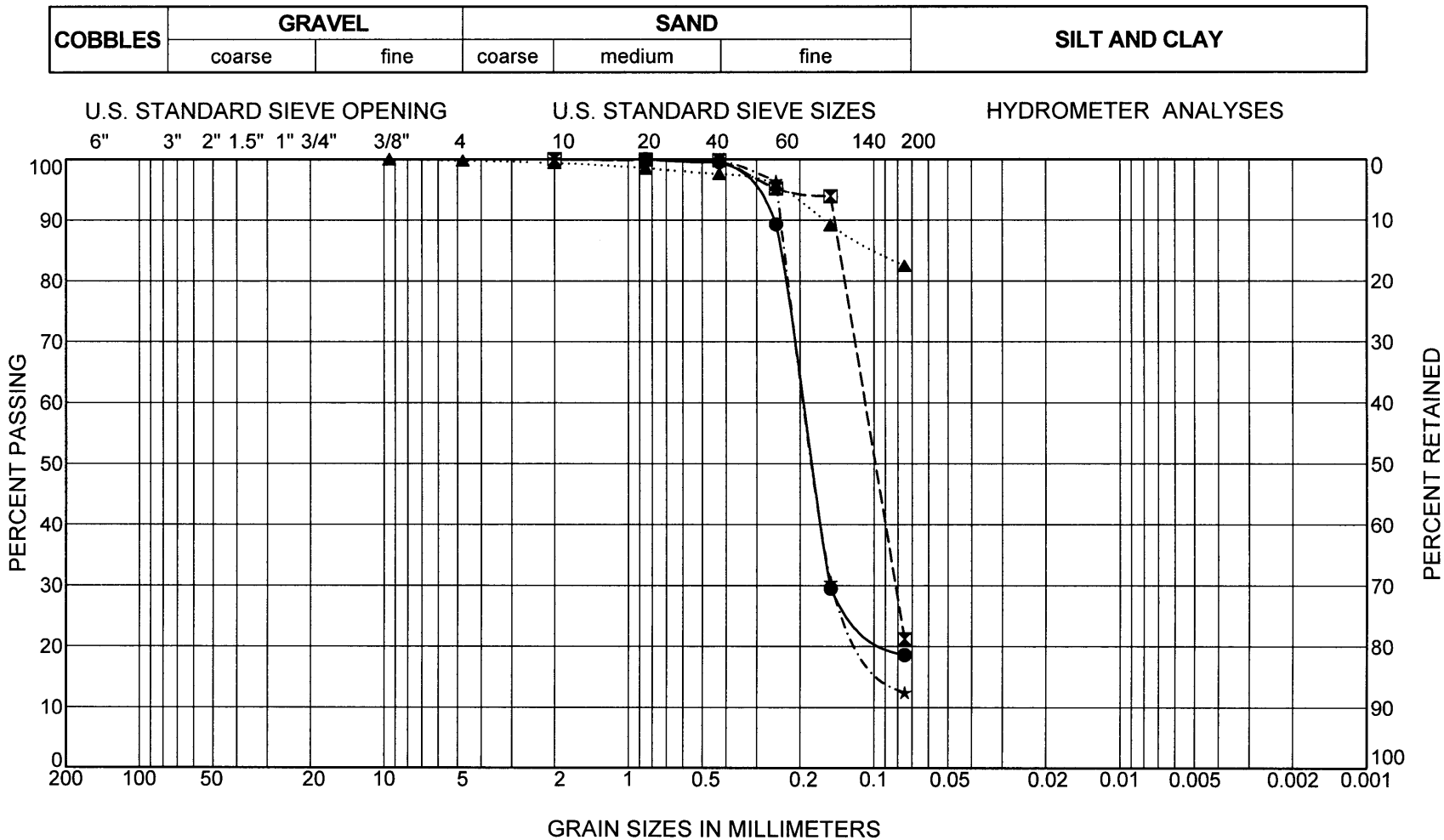
PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS ENGINEERING

WILLOW ROAD AT ROUTE 101 INTERCHANGE
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO: 203125.WIL

PLATE NO: B-2

GRAIN SIZE DISTRIBUTION CURVES



Boring Number	Sample Number	Depth (feet)	Symbol	LL	PI	Description
BR-1	MC-4	14.5	●			SILTY SAND (SM)
BR-1	MC-8	34.5	⊠	54	31	FAT CLAY (CH)
BR-1	MC-11	49.5	▲			LEAN CLAY WITH SAND (CL)
BR-1	MC-13	69.5	★			SILTY SAND (SM)

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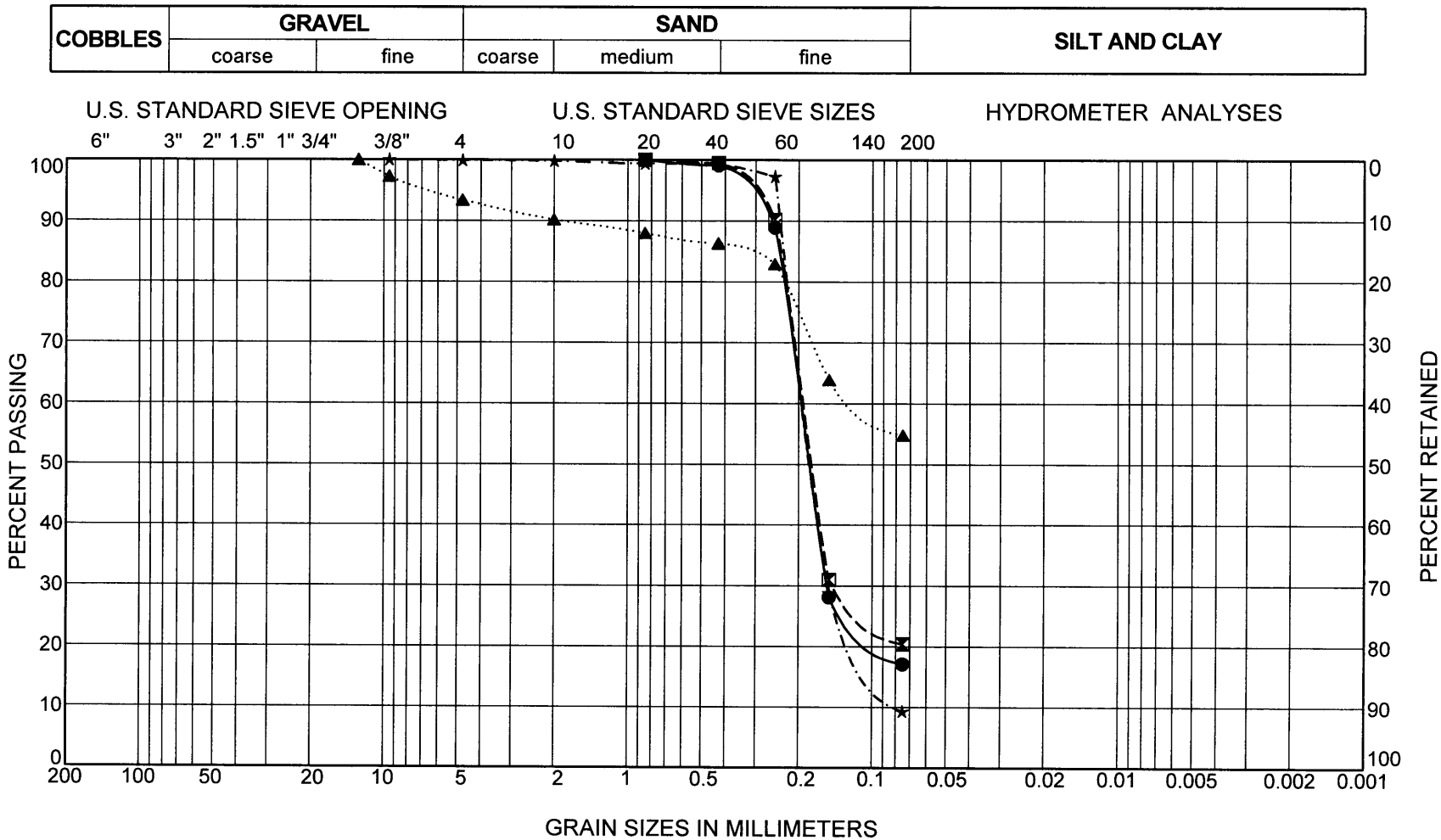
MATERIALS ENGINEERING

WILLOW ROAD AT ROUTE 101 INTERCHANGE
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO: 203125.WIL

PLATE NO: B-3A

GRAIN SIZE DISTRIBUTION CURVES



Boring Number	Sample Number	Depth (feet)	Symbol	LL	PI	Description
BR-2	MC-3	9.5	●			SILTY SAND (SM)
BR-2	MC-5	19.5	⊠			SILTY SAND (SM)
BR-2	MC-11	49.5	▲			SANDY LEAN CLAY (CL)
BR-2	MC-13	69.5	★			POORY-GRADED SAND WITH SILT (SP-SM)

PARIKH CONSULTANTS, INC.
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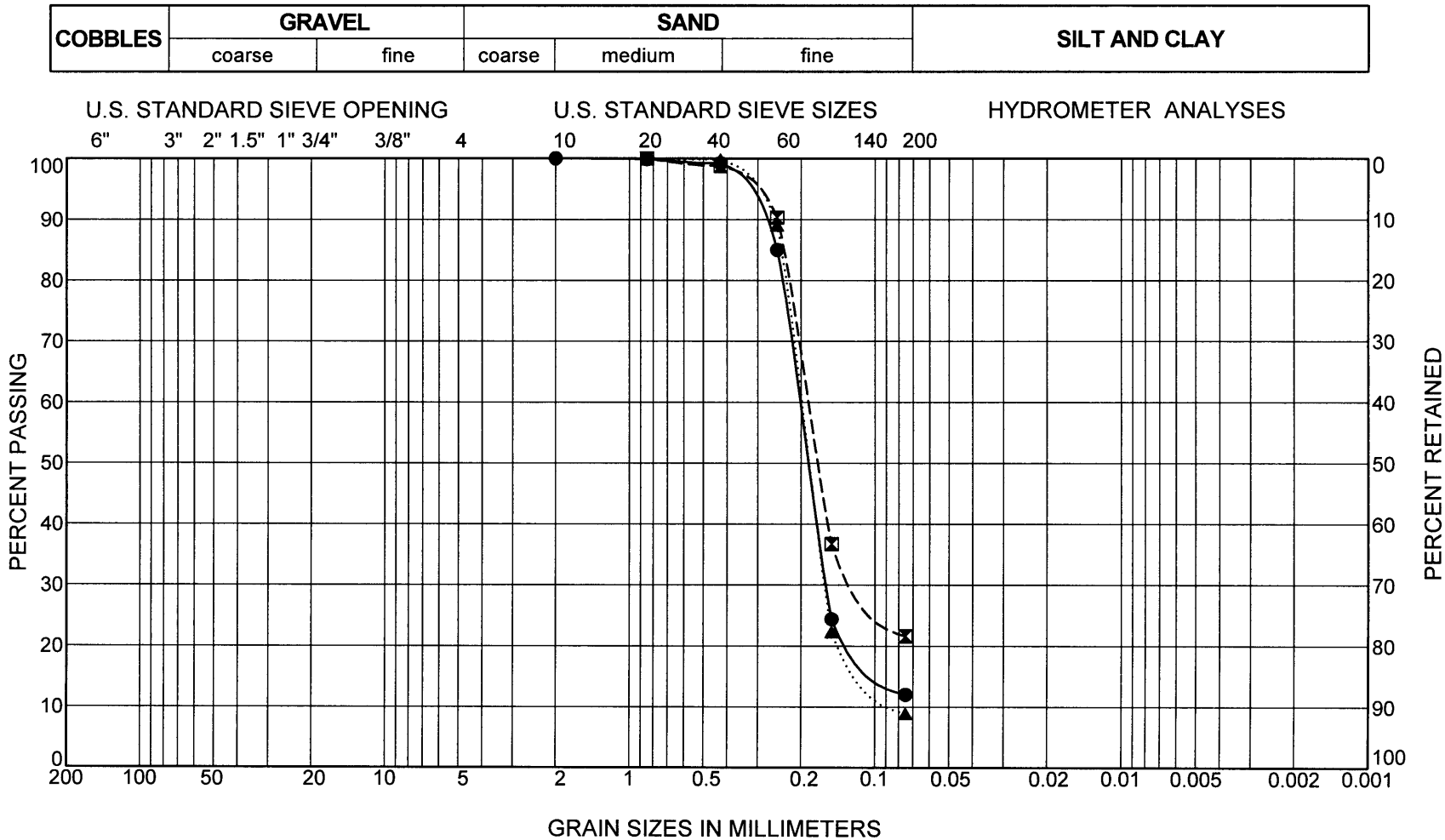
MATERIALS ENGINEERING

WILLOW ROAD AT ROUTE 101 INTERCHANGE
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO: 203125.WIL

PLATE NO: B-3B

GRAIN SIZE DISTRIBUTION CURVES



Boring Number	Sample Number	Depth (feet)	Symbol	LL	PI	Description
RW-9	SPT-3	9.5	●			POORLY-GRADED SAND WITH SILT (SP-SM)
RW-9	SPT-4	14.5	⊠			SILTY SAND (SM)
RW-9	MC-7	29.5	▲			POORLY-GRADED SAND WITH SILT (SP-SM)

PARIKH CONSULTANTS, INC.
GEOTECHNICAL CONSULTANTS
MATERIALS ENGINEERING

WILLOW ROAD AT ROUTE 101 INTERCHANGE
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO: 203125.WIL

PLATE NO: B-3C

Sunland Analytical
11353 Pyrites Way, Suite 4
Rancho Cordova, CA 95670
(916) 852-8557

Date Reported 03/15/2007
Date Submitted 03/13/2007

To: Prav Dayah
Parikh Consultants, Inc.
356 S. Milpitas Blvd.
Milpitas, Ca 95035

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following location:
Location : 203125.WIL/RTE 101 Site ID : BR1 #3 @ 9.5'.
Thank you for your business.

* For future reference to this analysis please use SUN # 50037-99701.

EVALUATION FOR SOIL CORROSION

Soil pH	6.77		
Minimum Resistivity	11.52	ohm-cm (x1000)	
Chloride	9.6 ppm	00.00096	%
Sulfate	6.3 ppm	00.00063	%

METHODS
pH and Min.Resistivity CA DOT Test #643 Mod.(Sm.Cell)
Sulfate CA DOT Test #417, Chloride CA DOT Test #422

Plate B-4A

Sunland Analytical

11353 Pyrites Way, Suite 4
Rancho Cordova, CA 95670
(916) 852-8557

Date Reported 02/16/2007
Date Submitted 02/12/2007

To: Prav Dayah
Parikh Consultants, Inc.
356 S. Milpitas Blvd.
Milpitas, Ca 95035

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The reported analysis was requested for the following location:
Location : 203125.GR1\WILLOWS R Site ID : RW9#2 @ 4.5'.
Thank you for your business.

* For future reference to this analysis please use SUN # 49870-99413.

EVALUATION FOR SOIL CORROSION

Soil pH	7.26		
Minimum Resistivity	29.21	ohm-cm (x1000)	
Chloride	8.4 ppm	00.00084	%
Sulfate	1.1 ppm	00.00011	%

METHODS
pH and Min.Resistivity CA DOT Test #643
Sulfate CA DOT Test #417, Chloride CA DOT Test #422

APPENDIX C

APPENDIX C-1

SPT LIQUEFACTION ANALYSES, CPT DATA CORRELATION & LIQUEFACTION ANALYSES

LIQUEFACTION POTENTIAL ANALYSIS

PROJECT NAME **Willow Road/route 101 Interchange**
PROJECT NO. **203125.GD1**
BORING NO. **A-07-001 (Parikh 2007)**

BOREHOLE DIA (in)= 6
GW DEPTH (ft)= 28

SOIL GROUPS
1. GRAVELS, SANDS AND NONPLASTIC SILTS
2. CLAYS AND PLASTIC SILTS

HAMMER ENERGY = *60%* *(Pithcer Freste Rig-auto hammer = 75%)*
(Pithcer Failing Rig-auto hammer = 68%-80%; verify)
(Pithcer Failing Rig-rope & pulley = 60%)

FAULT INFO
Santa MariaRiver -Foxen Canyon
(Design Basis EQ) a_{max} *(g)=* 0.7
FAULT M_w = 6.5
MSF = 1.44

					CYCLIC STRESS RATIO (CSR)				*LIQUEFACTION RESISTANCE* ($CRR_{7.5}$)											*F.S.=*($CRR_{7.5}$/CSR)*MSF*Kσ*Kα		
Sample No	Depth (ft)	Soil Type	Blow Count	Sampler Type	σ_v (psf)	σ_v' (psf)	γ_d	CSR	SPT-$N_{eq.}$	C_E	C_R	C_S	C_B	N_{60}	C_N	$(N_1)_{60}$	F.C.	$(N_1)_{60,CS}$	$CRR_{7.5}$	Kσ	Kα	F.S.
1	2	1	23	SPT	250	250	1.00	0.45	23.0	1.0	0.75	1.2	1.05	21.7	1.66	36.1		36.1		1.00	1	
2	5	1	11	SPT	625	625	0.99	0.45	11.0	1.0	0.75	1.2	1.05	10.4	1.45	15.1	20%	19.9	0.21	1.00	1	
3	10	1	16	SPT	1250	1250	0.98	0.45	16.0	1.0	0.80	1.2	1.05	16.1	1.21	19.4	20%	24.6	0.28	1.00	1	
4	15	1	8	SPT	1875	1875	0.97	0.44	8.0	1.0	0.85	1.2	1.05	8.6	1.03	8.8	20%	13.1	0.14	1.00	1	
5	20	1	16	SPT	2500	2500	0.96	0.44	16.0	1.0	0.95	1.2	1.05	19.2	0.90	17.2	20%	22.2	0.24	0.93	1	
6	25	1	21	SPT	3125	3125	0.94	0.43	21.0	1.0	0.95	1.2	1.05	25.1	0.80	20.0	20%	25.2	0.30	0.85	1	
7	29	1	25	SPT	3625	3563	0.93	0.43	25.4	1.0	0.95	1.2	1.05	30.4	0.74	22.4	20%	27.8	0.36	0.80	1	0.98
8	35	1	36	SPT	4375	3938	0.89	0.45	36.0	1.0	1.00	1.2	1.05	45.4	0.69	31.5	20%	37.6		0.51	1	

1. The correction factors C_E (Energy Ratio), C_B (Borehole Diameter), C_R (Rod Length) and C_S (Sampling Method-liner) are per Youd et al. (2001).
2. For correction of overburden, $C_N = 2.2/(1.2 + \sigma_v'/P_a)$ with a maximum value of 1.7 per Kayen et al. (1992) as cited in Youd et al. (2001).
3. The influence of Fines Contents are expressed by the following correction: $(N_1)_{60cs} = \alpha + \beta\,(N_1)_{60}$
   where α and β = coefficients determined from the following relationships
   for FC $\leq$ 5% $\alpha = 0$, $\beta = 1.0$
   for 5% < FC < 35% $\alpha = \exp(1.76-(190/FC^2))$, $\beta = (0.99+(FC^{1.5}/1000))$
   for FC $\geq$ 35% $\alpha = 5.0$, $\beta = 1.2$

Reference: Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER Workshops on Evaluation of Liquefaction Resistance of Soils, Youd, et al., ASCE Journal of Geotechnical and Geoenvironmental Engineering, October 2001, Vol. 127 No. 10

LIQUEFACTION POTENTIAL ANALYSIS

PROJECT NAME **Willow Road/route 101 Interchange**
PROJECT NO. **203125.GD1**
BORING NO. **A-07-002 (Parikh 2007)**

BOREHOLE DIA (in)= 6
GW DEPTH (ft)= 28

SOIL GROUPS
1. GRAVELS, SANDS AND NONPLASTIC SILTS
2. CLAYS AND PLASTIC SILTS

(Design Basis EQ)

HAMMER ENERGY = 60% *(Pithcer Freste Rig-auto hammer = 75%)*
(Pithcer Failing Rig-auto hammer = 68%-80%; verify)
(Pithcer Failing Rig-rope & pulley = 60%)

FAULT INFO
Santa MariaRiver -Foxen Canyon
a_{max} *(g)=* 0.7
FAULT M_w = 6.5

MSF = 1.44

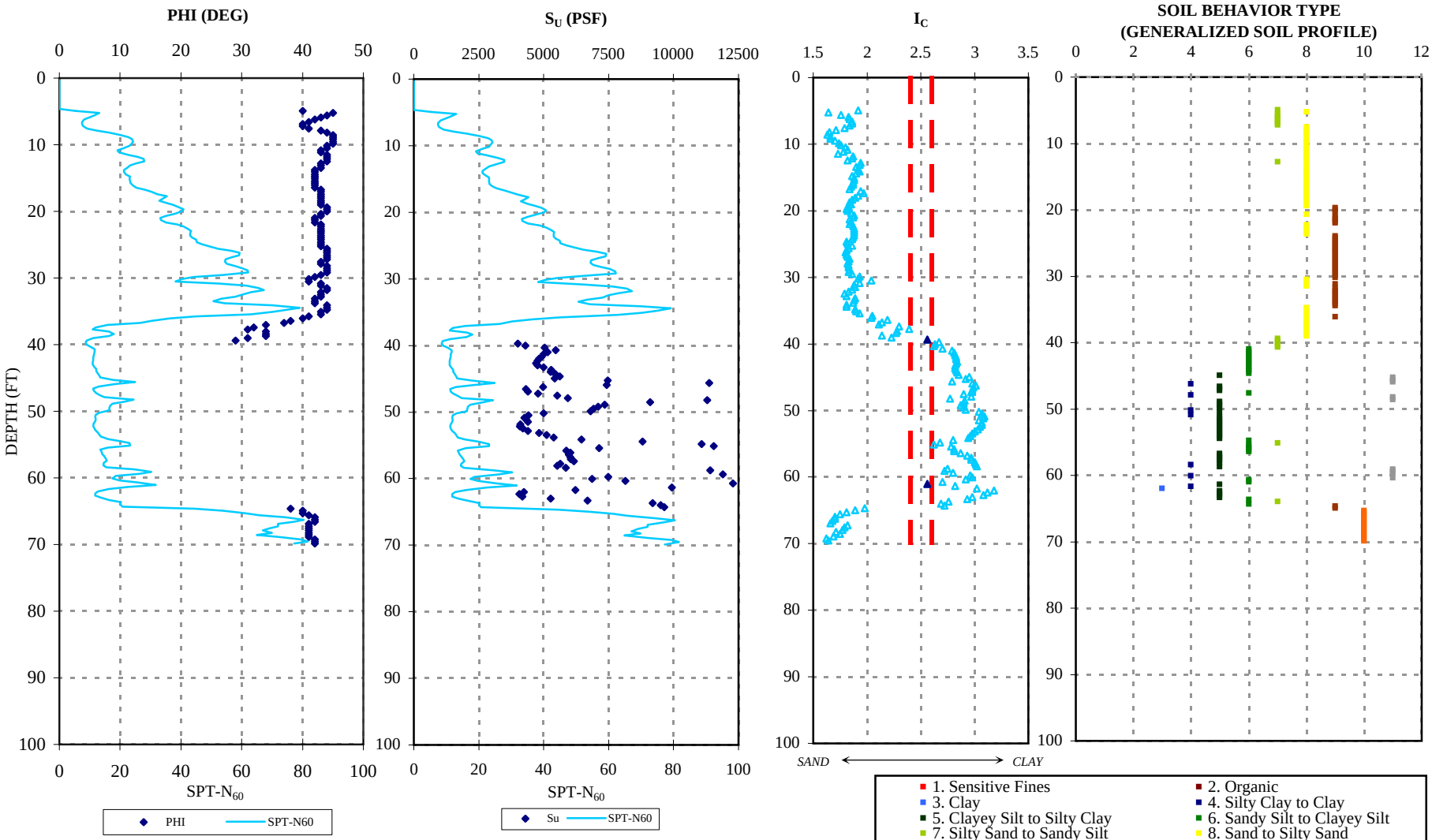
					CYCLIC STRESS RATIO (CSR)				*LIQUEFACTION RESISTANCE* ($CRR_{7.5}$)											*F.S.=(CRR$_{7.5}$/CSR)*MSF*Kσ*Kα*		
Sample No	Depth (ft)	Soil Type	Blow Count	Sampler Type	σ_v (psf)	σ_v' (psf)	γ_d	CSR	SPT-$N_{eq.}$	C_E	C_R	C_S	C_B	N_{60}	C_N	$(N_1)_{60}$	F.C.	$(N_1)_{60,CS}$	$CRR_{7.5}$	Kσ	Kα	F.S.
1	2	1	19	SPT	250	250	1.00	0.45	19.0	1.0	0.75	1.2	1.05	18.0	1.66	29.8		29.8	0.46	1.00	1	
2	5	1	10	SPT	625	625	0.99	0.45	10.0	1.0	0.75	1.2	1.05	9.5	1.45	13.7	20%	18.5	0.20	1.00	1	
3	10	1	4	SPT	1250	1250	0.98	0.45	4.0	1.0	0.80	1.2	1.05	4.0	1.21	4.9	20%	8.9	0.10	1.00	1	
4	15	1	15	SPT	1875	1875	0.97	0.44	15.0	1.0	0.85	1.2	1.05	16.1	1.03	16.5	20%	21.5	0.23	1.00	1	
5	20	1	19	SPT	2500	2500	0.96	0.44	19.0	1.0	0.95	1.2	1.05	22.7	0.90	20.4	20%	25.7	0.31	0.92	1	
6	25	1	30	SPT	3125	3125	0.94	0.43	30.0	1.0	0.95	1.2	1.05	35.9	0.80	28.6	20%	34.5		0.84	1	
7	29	1	32	SPT	3625	3563	0.93	0.43	32.0	1.0	0.95	1.2	1.05	38.3	0.74	28.3	20%	34.1		0.79	1	
8	35	1	48	SPT	4375	3938	0.89	0.45	48.0	1.0	1.00	1.2	1.05	60.5	0.69	42.0	20%	48.9		0.51	1	

1. The correction factors C_E (Energy Ratio), C_B (Borehole Diameter), C_R (Rod Length) and C_S (Sampling Method-liner) are per Youd et al. (2001).
2. For correction of overburden, $C_N = 2.2/(1.2 + \sigma_v'/P_a)$ with a maximum value of 1.7 per Kayen et al. (1992) as cited in Youd et al. (2001).
3. The influence of Fines Contents are expressed by the following correction: $(N_1)_{60cs} = \alpha + \beta\,(N_1)_{60}$
   where α and β = coefficients determined from the following relationships
   for $FC \leq 5\%$ $\alpha = 0$, $\beta = 1.0$
   for $5\% < FC < 35\%$ $\alpha = \exp(1.76-(190/FC^2))$, $\beta = (0.99+(FC^{1.5}/1000))$
   for $FC \geq 35\%$ $\alpha = 5.0$, $\beta = 1.2$

Reference: Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER Workshops on Evaluation of Liquefaction Resistance of Soils, Youd, et al., ASCE Journal of Geotechnical and Geoenvironmental Engineering, October 2001, Vol. 127 No. 10

CPT DATA CORRELATION

CPT-1



Reference: CPT data and correlation provided by Gregg Drilling and Testing, Inc.

PARIKH

Practicing in the Geosciences

WILLOW ROAD EXTENSION AT ROUTE 101
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO.: 203125.EXT

PLATE NO.:

LIQUEFACTION POTENTIAL ANALYSIS (per Youd & Idriss, 2001)

PROJECT NAME	***WILLOW ROAD EXTENSION AT ROUTE 101***	*FAULT INFO*		*FAULT M_w =* 6.5
PROJECT NO.	***203125.EXT***	*SANTA MARIA RIVER - FOXEN CANYON FAULT*		*MSF =* 1.44
CPT NO.	***CPT-1***	*a_{max} (g)=*	0.7	
				DESIGN GW DEPTH= 30

		CPT RESULT INPUT							*CSR*		*$CRR_{7.5}$*						*F.S.=($CRR_{7.5}$/CSR)*MSF*K_σ*K_α*		
Depth (ft)	Soil Behavior Type	qc (tsf)	fs (tsf)	σ_v (tsf)	u (tsf)	σ_v' (tsf)	Ic*	C_N*	γ_d	CSR	Ic	C_Q	q_{c1N}	K_C	$(q_{c1N})_{cs}$	$CRR_{7.5}$	$K\sigma$	$K\alpha$	F.S.
0.328																			
0.656																			
0.984																			
1.312																			
1.64																			
1.969																			
2.297																			
2.625								1.7	1.00									1	
2.953								1.7	1.00									1	
3.281								1.7	0.99									1	
3.609								1.7	0.99									1	
3.937								1.7	0.99									1	
4.265								1.7	0.99									1	
4.593								1.7	0.99									1	
4.921	7 Silty Sand to Sandy Silt	27.664	0.26	0.29		0.29	1.92	1.47651	0.99	0.451	1.920	1.48	40.85	1.208	49.353	0.09	1.00	1	
5.249	8 Sand to Silty Sand	76.043	0.778	0.31		0.31	1.64	1.45695	0.99	0.450	1.640	1.46	110.79	1.000	110.791	0.21	1.00	1	
5.577	7 Silty Sand to Sandy Silt	63.036	0.749	0.329		0.329	1.76	1.43885	0.99	0.450	1.760	1.44	90.70	1.078	97.814	0.17	1.00	1	
5.906	7 Silty Sand to Sandy Silt	53.072	0.624	0.348		0.348	1.83	1.42119	0.99	0.450	1.830	1.42	75.43	1.129	85.169	0.14	1.00	1	
6.234	7 Silty Sand to Sandy Silt	44.388	0.427	0.368		0.368	1.84	1.40306	0.99	0.449	1.840	1.40	62.28	1.137	70.813	0.11	1.00	1	
6.562	7 Silty Sand to Sandy Silt	40.027	0.341	0.387		0.387	1.86	1.38626	0.99	0.449	1.860	1.39	55.49	1.153	63.997	0.10	1.00	1	
6.89	7 Silty Sand to Sandy Silt	39.875	0.32	0.406		0.406	1.86	1.36986	0.99	0.449	1.860	1.37	54.62	1.153	62.999	0.10	1.00	1	
7.218	7 Silty Sand to Sandy Silt	42.141	0.315	0.426		0.426	1.84	1.35301	0.99	0.448	1.840	1.35	57.02	1.137	64.831	0.11	1.00	1	
7.546	8 Sand to Silty Sand	50.559	0.375	0.445		0.445	1.79	1.33739	0.98	0.448	1.790	1.34	67.62	1.099	74.341	0.12	1.00	1	
7.874	8 Sand to Silty Sand	69.843	0.537	0.465		0.465	1.71	1.32132	0.98	0.448	1.710	1.32	92.29	1.045	96.401	0.16	1.00	1	
8.202	8 Sand to Silty Sand	94.331	0.798	0.485		0.485	1.65	1.30564	0.98	0.447	1.650	1.31	123.16	1.003	123.573	0.26	1.00	1	
8.53	8 Sand to Silty Sand	117.445	1.125	0.505		0.505	1.63	1.29032	0.98	0.447	1.630	1.29	151.54	1.000	151.542	0.40	1.00	1	
8.858	8 Sand to Silty Sand	131.059	1.433	0.525		0.525	1.66	1.27536	0.98	0.447	1.660	1.28	167.15	1.010	168.887		1.00	1	
9.186	8 Sand to Silty Sand	137.477	1.558	0.545		0.545	1.66	1.26074	0.98	0.446	1.660	1.26	173.32	1.010	175.127		1.00	1	
9.514	8 Sand to Silty Sand	137.363	1.66	0.564		0.564	1.7	1.24717	0.98	0.446	1.700	1.25	171.31	1.038	177.800		1.00	1	
9.843	8 Sand to Silty Sand	132.31	1.713	0.584		0.584	1.74	1.23318	0.98	0.446	1.740	1.23	163.16	1.065	173.737		1.00	1	
10.171	8 Sand to Silty Sand	128.243	1.647	0.604		0.604	1.76	1.21951	0.98	0.445	1.760	1.22	156.39	1.078	168.661		1.00	1	
10.499	8 Sand to Silty Sand	115.71	1.505	0.624		0.624	1.8	1.20614	0.98	0.445	1.800	1.21	139.56	1.107	154.448	0.42	1.00	1	
10.827	8 Sand to Silty Sand	103.594	1.26	0.644		0.644	1.82	1.19306	0.98	0.445	1.820	1.19	123.59	1.122	138.612	0.33	1.00	1	
11.155	8 Sand to Silty Sand	108.249	1.16	0.664		0.664	1.78	1.18026	0.98	0.444	1.780	1.18	127.76	1.092	139.560	0.33	1.00	1	
11.483	8 Sand to Silty Sand	126.593	1.325	0.683		0.683	1.73	1.16835	0.98	0.444	1.730	1.17	147.90	1.058	156.492	0.44	1.00	1	
11.811	8 Sand to Silty Sand	137.657	2.335	0.703		0.703	1.87	1.15607	0.98	0.444	1.870	1.16	159.14	1.162	184.896		1.00	1	
12.139	8 Sand to Silty Sand	148.721	2.551	0.723		0.723	1.86	1.14405	0.97	0.443	1.860	1.14	170.14	1.153	196.234		1.00	1	
12.467	8 Sand to Silty Sand	151.451	2.316	0.743		0.743	1.82	1.13227	0.97	0.443	1.820	1.13	171.48	1.122	192.321		1.00	1	
12.795	7 Silty Sand to Sandy Silt	131.315	2.439	0.762		0.762	1.94	1.1213	0.97	0.443	1.940	1.12	147.24	1.229	180.961		1.00	1	
13.123	8 Sand to Silty Sand	120.99	2.019	0.782		0.782	1.93	1.10999	0.97	0.443	1.930	1.11	134.30	1.218	163.637		1.00	1	
13.451	8 Sand to Silty Sand	117.795	1.677	0.802		0.802	1.9	1.0989	0.97	0.442	1.900	1.10	129.45	1.189	153.890	0.42	1.00	1	
13.78	8 Sand to Silty Sand	110.96	1.549	0.822		0.822	1.92	1.08803	0.97	0.442	1.920	1.09	120.73	1.208	145.873	0.37	1.00	1	
14.108	8 Sand to Silty Sand	110.268	1.578	0.842		0.842	1.93	1.07738	0.97	0.442	1.930	1.08	118.80	1.218	144.753	0.36	1.00	1	
14.436	8 Sand to Silty Sand	116.411	1.529	0.862		0.862	1.9	1.06693	0.97	0.441	1.900	1.07	124.20	1.189	147.656	0.38	1.00	1	
14.764	8 Sand to Silty Sand	124.09	1.5	0.881		0.881	1.86	1.05718	0.97	0.441	1.860	1.06	131.19	1.153	151.303	0.40	1.00	1	
15.092	8 Sand to Silty Sand	123.266	1.522	0.901		0.901	1.88	1.04712	0.97	0.441	1.880	1.05	129.07	1.171	151.091	0.40	1.00	1	
15.42	8 Sand to Silty Sand	123.218	1.502	0.921		0.921	1.88	1.03725	0.97	0.440	1.880	1.04	127.81	1.171	149.608	0.39	1.00	1	
15.748	8 Sand to Silty Sand	124.981	1.487	0.941		0.941	1.87	1.02756	0.97	0.440	1.870	1.03	128.43	1.162	149.209	0.39	1.00	1	
16.076	8 Sand to Silty Sand	128.802	1.523	0.961		0.961	1.87	1.01805	0.97	0.440	1.870	1.02	131.13	1.162	152.348	0.41	1.00	1	
16.404	8 Sand to Silty Sand	136.444	1.559	0.981		0.981	1.85	1.00871	0.97	0.439	1.850	1.01	137.63	1.145	157.601	0.44	1.00	1	
16.732	8 Sand to Silty Sand	151.461	1.878	1		1	1.84	1	0.96	0.439	1.840	1.00	151.46	1.137	172.216		1.00	1	
17.06	8 Sand to Silty Sand	157.367	2.646	1.02		1.02	1.94	0.99099	0.96	0.439	1.940	0.99	155.95	1.229	191.660		0.99	1	
17.388	8 Sand to Silty Sand	165.558	3.143	1.04		1.04	1.97	0.98214	0.96	0.438	1.970	0.98	162.60	1.263	205.321		0.99	1	
17.717	8 Sand to Silty Sand	184.823	3.279	1.06		1.06	1.92	0.97345	0.96	0.438	1.920	0.97	179.92	1.208	217.388		0.98	1	
18.045	8 Sand to Silty Sand	181.059	2.848	1.08		1.08	1.89	0.96491	0.96	0.438	1.890	0.96	174.71	1.180	206.078		0.97	1	
18.373	8 Sand to Silty Sand	176.746	2.406	1.1		1.1	1.86	0.95652	0.96	0.437	1.860	0.96	169.06	1.153	194.986		0.97	1	
18.701	8 Sand to Silty Sand	189.203	2.534	1.119		1.119	1.84	0.94868	0.96	0.437	1.840	0.95	179.49	1.137	204.090		0.96	1	
19.029	8 Sand to Silty Sand	200.191	2.923	1.139		1.139	1.85	0.94057	0.96	0.437	1.850	0.94	188.29	1.145	215.612		0.95	1	
19.357	8 Sand to Silty Sand	213.653	3.042	1.159		1.159	1.83	0.9326	0.96	0.436	1.830	0.93	199.25	1.129	224.992		0.95	1	
19.685	9 Sand	222.783	3.006	1.18		1.18	1.81	0.92437	0.96	0.436	1.810	0.92	205.93	1.114	229.412		0.94	1	
20.013	9 Sand	218.394	2.981	1.2		1.2	1.82	0.91667	0.96	0.435	1.820	0.92	200.19	1.122	224.521		0.93	1	
20.341	9 Sand	203.708	2.784	1.22		1.22	1.85	0.90909	0.96	0.435	1.850	0.91	185.19	1.145	212.057		0.93	1	
20.669	8 Sand to Silty Sand	186.245	2.524	1.24		1.24	1.88	0.90164	0.96	0.435	1.880	0.90	167.93	1.171	196.569		0.93	1	
20.997	9 Sand	178.063	2.207	1.26		1.26	1.87	0.89431	0.95	0.434	1.870	0.89	159.24	1.162	185.015		0.93	1	
21.325	9 Sand	180.585	2.039	1.281		1.281	1.84	0.88674	0.95	0.434	1.840	0.89	160.13	1.137	182.075		0.92	1	
21.654	9 Sand	188.814	2.257	1.301		1.301	1.85	0.87965	0.95	0.433	1.850	0.88	166.09	1.145	190.186		0.92	1	
21.982	9 Sand	209.397	2.713	1.322		1.322	1.84	0.87232	0.95	0.433	1.840	0.87	182.66	1.137	207.692		0.91	1	
22.31	8 Sand to Silty Sand	217.891	3.138	1.341		1.341	1.87	0.8658	0.95	0.432	1.870	0.87	188.65	1.162	219.181		0.90	1	
22.638	8 Sand to Silty Sand	225.001	3.375	1.361		1.361	1.88	0.85904	0.95	0.432	1.880	0.86	193.28	1.171	226.254		0.89	1	
22.966	8 Sand to Silty Sand	230.14	3.502	1.381		1.381	1.88	0.85238	0.95	0.432	1.880	0.85	196.17	1.171	229.628		0.89	1	
23.294	8 Sand to Silty Sand	229.012	3.427	1.401		1.401	1.88	0.84583	0.95	0.431	1.880	0.85	193.70	1.171	226.746		0.89	1	
23.622	8 Sand to Silty Sand	229.353	3.336	1.421		1.421	1.88	0.83937	0.95	0.431	1.880	0.84	192.51	1.171	225.351		0.88	1	
23.95	9 Sand	233.278	3.344	1.441		1.441	1.87	0.83302	0.95	0.430	1.870	0.83	194.32	1.162	225.773		0.88	1	
24.278	9 Sand	241.175	3.383	1.461		1.461	1.86	0.82676	0.94	0.430	1.860	0.83	199.39	1.153	229.969		0.87	1	
24.606	9 Sand	246.228	2.951	1.482		1.482	1.81	0.82028	0.94	0.429	1.810	0.82	201.98	1.114	225.004		0.86	1	
24.934	9 Sand	254.874	3.227	1.502		1.502	1.82	0.81421	0.94	0.429	1.820	0.81	207.52	1.122	232.738		0.86	1	
25.262	9 Sand	263.397	3.833	1.523		1.523	1.86	0.80793	0.94	0.428	1.860	0.81	212.81	1.153	245.440		0.85	1	
25.591	9 Sand	282.851	4.008	1.543		1.543	1.83	0.80204	0.94	0.428	1.830	0.80	226.86	1.129	256.164		0.84	1	
25.919	9 Sand	307.947	4.322	1.563		1.563	1.81	0.79624	0.94	0.427	1.810	0.80	245.20	1.114	273.154		0.84	1	
26.247	9 Sand	324.215	4.661	1.584		1.584	1.8	0.79023	0.94	0.426	1.800	0.79	256.20	1.107	283.531		0.83	1	
26.575	9 Sand	322.243	4.697	1.604		1.604	1.81	0.78459	0.94	0.426	1.810	0.78	252.83	1.114	281.655		0.83	1	
26.903	9 Sand	307.245	4.386	1.624		1.624	1.82	0.77904	0.93	0.425	1.820	0.78	239.36	1.122	268.440		0.82	1	
27.231	9 Sand	295.176	4.192	1.645		1.645	1.84	0.77329	0.93	0.425	1.840	0.77	228.26	1.137	259.534		0.82	1	
27.559	9 Sand	295.508	4.055	1.665		1.665	1.83	0.76789	0.93	0.424	1.830	0.77	226.92	1.129	256.231		0.82	1	
27.887	9 Sand	300.059	3.995	1.685		1.685	1.82	0.76256	0.93	0.423	1.820	0.76	228.81	1.122	256.618		0.81	1	
28.215	9 Sand	312.459	4.362	1.706		1.706	1.83	0.75705	0.93	0.423	1.830	0.76	236.55	1.129	267.106		0.81	1	
28.543	9 Sand	326.254	4.794	1.726		1.726	1.83	0.75188	0.93	0.422	1.830	0.75	245.30	1.129	276.992		0.80	1	
28.871	9 Sand	334.653	5.09	1.747		1.747	1.84	0.74652	0.93	0.421	1.840	0.75	249.83	1.137	284.060		0.80	1	
29.199	9 Sand	337.033	4.951	1.767		1.767	1.83	0.74149	0.92	0.421	1.830	0.74	249.91	1.129	282.190		0.80	1	
29.528	9 Sand	288.502	3.97	1.787		1.787	1.86	0.73652	0.92	0.420	1.860	0.74	212.49	1.153	245.073		0.80	1	
29.856	9 Sand	230.566	3.193	1.808		1.808	1.93	0.73138	0.92	0.419	1.930	0.73	168.63	1.218	205.472		0.82	1	
30.184	9 Sand	211.036	2.54	1.828		1.828	1.92	0.72655	0.92	0.418	1.920	0.73	153.33	1.208	185.263		0.82	1	
30.512	8 Sand to Silty Sand	191.327	3.039	1.848		1.848	2.04	0.72178	0.92	0.418	2.040	0.72	138.10	1.356	187.243		0.83	1	
30.84	8 Sand to Silty Sand	274.186	4.34	1.868		1.868	1.93	0.71708	0.92	0.417	1.930	0.72	196.61	1.218	239.566		0.80	1	
31.168	9 Sand	327.543	5.102	1.888		1.888	1.88	0.71244	0.91	0.416	1.880	0.71	233.35	1.171	273.157		0.78	1	
31.496	8 Sand to Silty Sand	347.101	5.902	1.908		1.908	1.89	0.70785	0.91	0.415	1.890	0.71	245.70	1.180	289.815		0.77	1	

LIQUEFACTION POTENTIAL ANALYSIS (per Youd & Idriss, 2001)

PROJECT NAME	***WILLOW ROAD EXTENSION AT ROUTE 101***	*FAULT INFO*		*FAULT M_w =*	6.5
PROJECT NO.	***203125.EXT***	*SANTA MARIA RIVER - FOXEN CANYON FAULT*		*MSF =*	1.44
CPT NO.	***CPT-1***	*a_{max} (g)=*	0.7		
				DESIGN GW DEPTH=	30

			CPT RESULT INPUT							*CSR*		*CRR 7.5*						*F.S.=(CRR 7.5/CSR)*MSF*K σ*K α*		
Depth (ft)		Soil Behavior Type	qc (tsf)	fs (tsf)	σ_v (tsf)	u (tsf)	σ_v' (tsf)	Ic*	C_N*	γ_d	CSR	Ic	C_Q	q_{c1N}	K_C	$(q_{c1N})_{cs}$	$CRR_{7.5}$	Kσ	Kα	F.S.
31.824	9	Sand	359.625	5.694	1.928		1.928	1.86	0.70332	0.91	0.414	1.860	0.70	252.93	1.153	291.719		0.77	1	
32.152	9	Sand	341.745	4.686	1.949		1.949	1.83	0.69863	0.91	0.414	1.830	0.70	238.75	1.129	269.597		0.77	1	
32.48	9	Sand	330.577	3.779	1.969		1.969	1.79	0.69423	0.91	0.413	1.790	0.69	229.49	1.099	252.316		0.76	1	
32.808	9	Sand	316.166	3.695	1.989		1.989	1.81	0.68987	0.90	0.412	1.810	0.69	218.11	1.114	242.981		0.77	1	
33.136	9	Sand	282.434	3.761	2.01		2.01	1.89	0.68536	0.90	0.411	1.890	0.69	193.57	1.180	228.328		0.78	1	
33.465	9	Sand	270.1	3.24	2.03		2.03	1.88	0.68111	0.90	0.410	1.880	0.68	183.97	1.171	215.349		0.78	1	
33.793	9	Sand	289.668	3.639	2.05		2.05	1.87	0.67692	0.90	0.409	1.870	0.68	196.08	1.162	227.816		0.77	1	
34.121	9	Sand	381.572	5.124	2.071		2.071	1.81	0.67258	0.90	0.408	1.810	0.67	256.64	1.114	285.896		0.75	1	
34.449	9	Sand	432.388	6.317	2.091		2.091	1.81	0.66849	0.89	0.407	1.810	0.67	289.05	1.114	322.001		0.74	1	
34.777	8	Sand to Silty Sand	396.514	6.867	2.111		2.111	1.89	0.66445	0.89	0.406	1.890	0.66	263.46	1.180	310.775		0.74	1	
35.105	8	Sand to Silty Sand	370.025	6.275	2.131		2.131	1.9	0.66046	0.89	0.405	1.900	0.66	244.39	1.189	290.538		0.74	1	
35.433	8	Sand to Silty Sand	327.78	5.419	2.151		2.151	1.93	0.65652	0.89	0.404	1.930	0.66	215.19	1.218	262.206		0.75	1	
35.761	8	Sand to Silty Sand	224.394	3.688	2.171		2.171	2.05	0.65263	0.89	0.403	2.050	0.65	146.45	1.371	200.784		0.79	1	
36.089	9	Sand	182.064	2.274	2.191		2.191	2.04	0.64878	0.88	0.402	2.040	0.65	118.12	1.356	160.155		0.80	1	
36.417	8	Sand to Silty Sand	142.872	2.207	2.211		2.211	2.19	0.64497	0.88	0.401	2.190	0.64	92.15	1.643	151.365	0.40	0.83	1	1.00
36.745	8	Sand to Silty Sand	127.504	1.424	2.231		2.231	2.14	0.64121	0.88	0.399	2.140	0.64	81.76	1.532	125.249	0.26	0.83	1	0.66
37.073	8	Sand to Silty Sand	76.916	0.285	2.25		2.25	2.11	0.63768	0.88	0.398	2.110	0.64	49.05	1.473	72.256	0.12	0.85	1	0.29
37.402	8	Sand to Silty Sand	53.527	0.247	2.27		2.27	2.3	0.63401	0.87	0.397	2.300	0.63	33.94	1.949	66.133	0.11	0.85	1	0.27
37.73	8	Sand to Silty Sand	47.593	0.267	2.29		2.29	2.39	0.63037	0.87	0.396	2.390	0.63	30.00	2.272	68.164	0.11	0.85	1	0.28
38.058	8	Sand to Silty Sand	73.939	0.584	2.31		2.31	2.28	0.62678	0.87	0.395	2.280	0.63	46.34	1.886	87.412	0.14	0.85	1	0.36
38.386	8	Sand to Silty Sand	82.168	0.743	2.33		2.33	2.27	0.62323	0.86	0.393	2.270	0.62	51.21	1.856	95.049	0.16	0.84	1	0.41
38.714	8	Sand to Silty Sand	77.74	0.33	2.35		2.35	2.14	0.61972	0.86	0.392	2.140	0.62	48.18	1.532	73.805	0.12	0.84	1	0.30
39.042	8	Sand to Silty Sand	51.716	0.119	2.369		2.369	2.23	0.61642	0.86	0.391	2.230	0.62	31.88	1.743	55.579	0.10	0.84	1	0.25
39.37	7	Silty Sand to Sandy Silt	35.343	0.23	2.389		2.389	2.56	0.61298	0.86	0.390	2.560	0.61	21.66	3.091	66.956	0.11	0.84	1	0.28
39.698	7	Silty Sand to Sandy Silt	32.405	0.304	2.408		2.408	2.67	0.60976	0.85	0.388							0.84	1	
40.026	7	Silty Sand to Sandy Silt	34.557	0.302	2.427		2.427	2.63	0.60656	0.85	0.387							0.84	1	
40.354	7	Silty Sand to Sandy Silt	40.216	0.438	2.447		2.447	2.62	0.60324	0.85	0.386							0.84	1	
40.682	7	Silty Sand to Sandy Silt	43.42	0.784	2.466		2.466	2.7	0.60011	0.84	0.384							0.83	1	
41.011	6	Sandy Silt to Clayey Silt	41.155	0.962	2.485		2.485	2.79	0.59701	0.84	0.383							0.83	1	
41.339	6	Sandy Silt to Clayey Silt	39.913	0.948	2.504		2.504	2.81	0.59395	0.84	0.382							0.83	1	
41.667	6	Sandy Silt to Clayey Silt	39.287	0.924	2.522		2.522	2.82	0.59108	0.84	0.380							0.83	1	
41.995	6	Sandy Silt to Clayey Silt	38.633	0.911	2.541		2.541	2.83	0.58808	0.83	0.379							0.83	1	
42.323	6	Sandy Silt to Clayey Silt	38.178	0.896	2.56		2.56	2.83	0.58511	0.83	0.378							0.83	1	
42.651	6	Sandy Silt to Clayey Silt	37.78	0.878	2.579		2.579	2.84	0.58216	0.83	0.376							0.83	1	
42.979	6	Sandy Silt to Clayey Silt	38.282	0.859	2.598		2.598	2.83	0.57925	0.82	0.375							0.83	1	
43.307	6	Sandy Silt to Clayey Silt	40.017	0.938	2.616		2.616	2.82	0.57652	0.82	0.373							0.83	1	
43.635	6	Sandy Silt to Clayey Silt	42.171	1.035	2.635		2.635	2.82	0.57366	0.82	0.372							0.82	1	
43.963	6	Sandy Silt to Clayey Silt	41.982	1.055	2.654		2.654	2.83	0.57084	0.81	0.370							0.82	1	
44.291	6	Sandy Silt to Clayey Silt	43.373	1.173	2.673		2.673	2.84	0.56804	0.81	0.369							0.82	1	
44.619	6	Sandy Silt to Clayey Silt	44.852	1.342	2.692		2.692	2.85	0.56526	0.81	0.367							0.82	1	
44.948	5	Clayey Silt to Silty Clay	43.231	1.723	2.71		2.71	2.95	0.56266	0.80	0.366							0.82	1	
45.276	11	Sitff Fine-Grained	58.618	3.087	2.732		2.732	2.92	0.55951	0.80	0.364							0.82	1	
45.604	11	Sitff Fine-Grained	87.979	4.826	2.753		2.753	2.79	0.55654	0.80	0.363							0.82	1	
45.932	11	Sitff Fine-Grained	58.362	3.757	2.775		2.775	2.98	0.55346	0.79	0.361							0.82	1	
46.26	4	Silty Clay to Clay	40.083	1.732	2.793		2.793	3.01	0.55096	0.79	0.360							0.81	1	
46.588	5	Clayey Silt to Silty Clay	35.116	1.171	2.812		2.812	2.99	0.54835	0.79	0.358							0.81	1	
46.916	5	Clayey Silt to Silty Clay	35.713	1.133	2.831		2.831	2.98	0.54577	0.78	0.357							0.81	1	
47.244	5	Clayey Silt to Silty Clay	38.709	1.346	2.85		2.85	2.97	0.54321	0.78	0.355							0.81	1	
47.572	6	Sandy Silt to Clayey Silt	44.208	1.391	2.869		2.869	2.9	0.54067	0.78	0.354							0.81	1	
47.9	4	Silty Clay to Clay	47.184	2.088	2.887		2.887	2.97	0.53829	0.77	0.352							0.81	1	
48.228	11	Sitff Fine-Grained	87.581	4.089	2.909		2.909	2.77	0.53541	0.77	0.351							0.81	1	
48.556	11	Sitff Fine-Grained	71.189	4.177	2.93		2.93	2.91	0.53269	0.77	0.349							0.81	1	
48.885	5	Clayey Silt to Silty Clay	57.945	2.545	2.949		2.949	2.9	0.53025	0.76	0.348							0.81	1	
49.213	5	Clayey Silt to Silty Clay	56.21	2.108	2.968		2.968	2.87	0.52783	0.76	0.346							0.80	1	
49.541	5	Clayey Silt to Silty Clay	54.882	2.21	2.987		2.987	2.9	0.52544	0.76	0.345							0.80	1	
49.869	5	Clayey Silt to Silty Clay	53.963	2.267	3.005		3.005	2.92	0.52319	0.75	0.343							0.80	1	
50.197	4	Silty Clay to Clay	40.501	1.76	3.024	0.006	3.018	3.04	0.52157	0.75	0.342							0.80	1	
50.525	5	Clayey Silt to Silty Clay	36.13	1.475	3.043	0.016	3.027	3.07	0.52046	0.75	0.342							0.80	1	
50.853	4	Silty Clay to Clay	34.935	1.483	3.062	0.026	3.036	3.09	0.51936	0.74	0.341							0.80	1	
51.181	5	Clayey Silt to Silty Clay	35.504	1.463	3.081	0.036	3.044	3.08	0.51838	0.74	0.341							0.80	1	
51.509	5	Clayey Silt to Silty Clay	36.017	1.288	3.099	0.047	3.053	3.04	0.51728	0.74	0.341							0.80	1	
51.837	5	Clayey Silt to Silty Clay	33.826	1.249	3.118	0.057	3.061	3.07	0.51631	0.73	0.340							0.80	1	
52.165	5	Clayey Silt to Silty Clay	33.713	1.204	3.137	0.067	3.07	3.07	0.51522	0.73	0.340							0.80	1	
52.493	5	Clayey Silt to Silty Clay	34.595	1.201	3.156	0.077	3.078	3.05	0.51426	0.73	0.339							0.80	1	
52.822	5	Clayey Silt to Silty Clay	36.083	1.246	3.175	0.088	3.087	3.03	0.51318	0.72	0.339							0.80	1	
53.15	5	Clayey Silt to Silty Clay	39.24	1.384	3.193	0.098	3.096	3	0.5121	0.72	0.338							0.80	1	
53.478	5	Clayey Silt to Silty Clay	41.62	1.437	3.212	0.108	3.104	2.98	0.51115	0.72	0.338							0.80	1	
53.806	5	Clayey Silt to Silty Clay	43.544	1.521	3.231	0.118	3.113	2.96	0.51009	0.71	0.338							0.80	1	
54.134	5	Clayey Silt to Silty Clay	51.631	2.08	3.25	0.129	3.121	2.94	0.50914	0.71	0.337							0.80	1	
54.462	5	Clayey Silt to Silty Clay	69.236	2.53	3.269	0.139	3.13	2.8	0.50808	0.71	0.337							0.80	1	
54.79	6	Sandy Silt to Clayey Silt	86.349	2.73	3.287	0.149	3.138	2.68	0.50715	0.71	0.336							0.80	1	
55.118	7	Silty Sand to Sandy Silt	89.762	2.383	3.307	0.159	3.147	2.62	0.5061	0.70	0.336							0.80	1	
55.446	6	Sandy Silt to Clayey Silt	56.732	1.447	3.325	0.17	3.156	2.78	0.50505	0.70	0.335							0.79	1	
55.774	6	Sandy Silt to Clayey Silt	47.317	0.99	3.344	0.18	3.165	2.81	0.50401	0.70	0.335							0.79	1	
56.102	6	Sandy Silt to Clayey Silt	48.427	1.066	3.363	0.19	3.173	2.81	0.50309	0.69	0.334							0.79	1	
56.43	6	Sandy Silt to Clayey Silt	48.057	1.315	3.382	0.2	3.182	2.87	0.50205	0.69	0.334							0.79	1	
56.759	5	Clayey Silt to Silty Clay	48.436	1.653	3.401	0.21	3.19	2.93	0.50114	0.69	0.333							0.79	1	
57.087	5	Clayey Silt to Silty Clay	48.711	1.978	3.419	0.221	3.199	2.97	0.50011	0.68	0.333							0.79	1	
57.415	5	Clayey Silt to Silty Clay	49.621	2.057	3.438	0.231	3.207	2.97	0.49921	0.68	0.332							0.79	1	
57.743	5	Clayey Silt to Silty Clay	45.743	1.845	3.457	0.241	3.216	3	0.49819	0.68	0.332							0.79	1	
58.071	5	Clayey Silt to Silty Clay	44.805	1.802	3.476	0.251	3.224	3.01	0.49729	0.68	0.331							0.79	1	
58.399	4	Silty Clay to Clay	47.422	2.189	3.495	0.262	3.233	3.02	0.49628	0.67	0.331							0.79	1	
58.727	5	Clayey Silt to Silty Clay	89.07	3.535	3.513	0.272	3.242	2.75	0.49527	0.67	0.330							0.79	1	
59.055	11	Sitff Fine-Grained	110.998	5.173	3.535	0.282	3.253	2.72	0.49405	0.67	0.330							0.79	1	
59.383	11	Sitff Fine-Grained	92.795	4.473	3.556	0.292	3.264	2.8	0.49283	0.66	0.329							0.79	1	
59.711	11	Sitff Fine-Grained	59.547	2.916	3.578	0.303	3.275	2.96	0.49162	0.66	0.329							0.79	1	
60.039	4	Silty Clay to Clay	54.902	2.616	3.596	0.313	3.284	2.98	0.49063	0.66	0.328							0.79	1	
60.367	11	Sitff Fine-Grained	64.553	3.043	3.618	0.323	3.295	2.92	0.48943	0.66	0.328							0.79	1	
60.696	6	Sandy Silt to Clayey Silt	95.63	3.35	3.637	0.333	3.303	2.7	0.48856	0.65	0.327							0.79	1	
61.024	6	Sandy Silt to Clayey Silt	126.527	3.831	3.655	0.344	3.312	2.56	0.48759	0.65	0.327	2.560	0.49	61.69	3.091	190.666		0.79	1	
61.352	5	Clayey Silt to Silty Clay	78.205	3.262	3.674	0.354	3.321	2.82	0.48662	0.65	0.326							0.79	1	
61.68	4	Silty Clay to Clay	50.209	2.354	3.693	0.364	3.329	3.02	0.48576	0.65	0.326							0.79	1	
62.008	3	Clay	35.419	1.809	3.711	0.374	3.337	3.18	0.4849	0.64	0.326							0.79	1	
62.336	5	Clayey Silt to Silty Clay	34.082	1.315	3.73	0.384	3.346	3.12	0.48394	0.64	0.325							0.79	1	
62.664	5	Clayey Silt to Silty Clay	35.059	1.206	3.749	0.395	3.354	3.08	0.48309	0.64	0.325							0.79	1	
62.992	5	Clayey Silt to Silty Clay	43.155	1.41	3.768	0.405	3.363	2.98	0.48214	0.64	0.324							0.78	1	
63.32	5	Clayey Silt to Silty Clay	53.735	2.01	3.787	0.415	3.371	2.93	0.4813	0.63	0.324							0.78	1	
63.648	6	Sandy Silt to Clayey Silt	72.649	2.19	3.805	0.425	3.38	2.76	0.48035	0.63	0.323							0.78	1	
63.976	7	Silty Sand to Sandy Silt	74.915	1.775	3.825	0.436	3.389	2.69	0.47941	0.63	0.323							0.78	1	
64.304	6	Sandy Silt to Clayey Silt	76.062	2.067	3.843	0.446	3.398	2.72	0.47847	0.63	0.323							0.78	1	

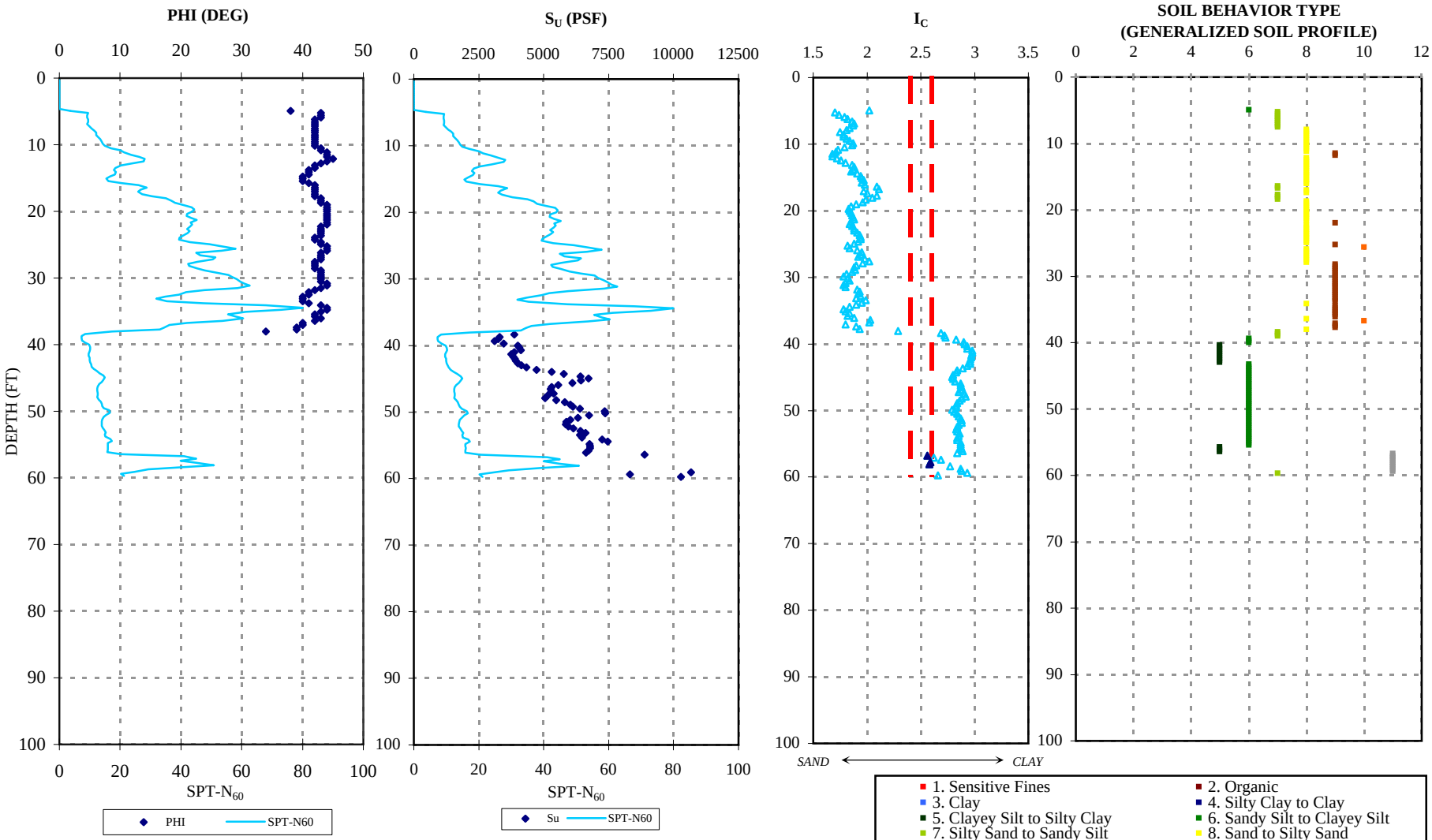
LIQUEFACTION POTENTIAL ANALYSIS (per Youd & Idriss, 2001)

PROJECT NAME	***WILLOW ROAD EXTENSION AT ROUTE 101***	*FAULT INFO*		*FAULT M_w =* 6.5
PROJECT NO.	***203125.EXT***	*SANTA MARIA RIVER - FOXEN CANYON FAULT*		*MSF =* 1.44
CPT NO.	***CPT-1***	*a_{max} (g)=*	0.7	
				DESIGN GW DEPTH= 30

		CPT RESULT INPUT							*CSR*		*CRR 7.5*						*F.S.=(CRR 7.5/CSR)*MSF*Kσ*Kα*		
Depth (ft)		Soil Behavior Type	qc (tsf)	fs (tsf)	σ_v (tsf)	u (tsf)	σ_v' (tsf)	Ic*	C_N*	γ_d	CSR	Ic	C_Q	q_{c1N}	K_C	$(q_{c1N})_{cs}$	$CRR_{7.5}$	Kσ	Kα	F.S.
64.633	9	Sand	228.538	1.672	3.864	0.456	3.408	1.98	0.47743	0.62	0.322	1.980	0.48	109.11	1.275	139.088	0.33	0.71	1	1.02
64.961	9	Sand	284.909	2.054	3.884	0.466	3.418	1.89	0.4764	0.62	0.322	1.890	0.48	135.73	1.180	160.103		0.68	1	
65.289	10	Gravelly Sand to Sand	333.364	2.175	3.905	0.477	3.428	1.81	0.47537	0.62	0.321	1.810	0.48	158.47	1.114	176.538		0.66	1	
65.617	10	Gravelly Sand to Sand	366.081	2.145	3.926	0.487	3.439	1.75	0.47424	0.62	0.321	1.750	0.47	173.61	1.072	186.040		0.64	1	
65.945	10	Gravelly Sand to Sand	422.746	2.433	3.947	0.497	3.45	1.7	0.47312	0.62	0.321	1.700	0.47	200.01	1.038	207.581		0.62	1	
66.273	10	Gravelly Sand to Sand	456.07	2.893	3.968	0.507	3.46	1.7	0.4721	0.61	0.320	1.700	0.47	215.31	1.038	223.463		0.61	1	
66.601	10	Gravelly Sand to Sand	439.451	2.454	3.989	0.518	3.471	1.68	0.47099	0.61	0.320	1.680	0.47	206.98	1.024	211.999		0.61	1	
66.929	10	Gravelly Sand to Sand	413.683	1.948	4.009	0.528	3.482	1.66	0.46988	0.61	0.319	1.660	0.47	194.38	1.010	196.406		0.61	1	
67.257	10	Gravelly Sand to Sand	391.698	3.121	4.03	0.538	3.492	1.82	0.46888	0.61	0.319	1.820	0.47	183.66	1.122	205.978		0.63	1	
67.585	10	Gravelly Sand to Sand	380.492	2.59	4.051	0.548	3.503	1.79	0.46779	0.61	0.319	1.790	0.47	177.99	1.099	195.689		0.63	1	
67.913	10	Gravelly Sand to Sand	370.651	2.265	4.072	0.558	3.514	1.77	0.46669	0.60	0.318	1.770	0.47	172.98	1.085	187.745		0.64	1	
68.241	10	Gravelly Sand to Sand	395.518	2.044	4.093	0.569	3.524	1.71	0.46571	0.60	0.318	1.710	0.47	184.20	1.045	192.410		0.62	1	
68.57	10	Gravelly Sand to Sand	360.962	1.981	4.114	0.579	3.535	1.75	0.46463	0.60	0.318	1.750	0.46	167.71	1.072	179.720		0.64	1	
68.898	10	Gravelly Sand to Sand	410.156	2.11	4.135	0.589	3.546	1.69	0.46355	0.60	0.317	1.690	0.46	190.13	1.031	196.037		0.61	1	
69.226	10	Gravelly Sand to Sand	464.034	2.075	4.156	0.599	3.556	1.62	0.46257	0.60	0.317	1.620	0.46	214.65	1.000	214.650		0.60	1	
69.554	10	Gravelly Sand to Sand	473.041	2.382	4.177	0.61	3.567	1.64	0.46151	0.59	0.317	1.640	0.46	218.31	1.000	218.311		0.60	1	
69.882	10	Gravelly Sand to Sand	480.179	0.826	4.197	0.62	3.578	1.42	0.46044	0.59	0.316	1.420	0.46	221.10	1.000	221.095		0.60	1	

CPT DATA CORRELATION

CPT-2



Reference: CPT data and correlation provided by Gregg Drilling and Testing, Inc.

PARIKH

Practicing in the Geosciences

WILLOW ROAD EXTENSION AT ROUTE 101
COUNTY OF SAN LUIS OBISPO, CALIFORNIA

JOB NO.: 203125.EXT

PLATE NO.:

LIQUEFACTION POTENTIAL ANALYSIS (per Youd & Idriss, 2001)

PROJECT NAME	***WILLOW ROAD EXTENSION AT ROUTE 101***	*FAULT INFO*		*FAULT M_w =*	6.5
PROJECT NO.	***203125.EXT***	*SANTA MARIA RIVER - FOXEN CANYON FAULT*		*MSF =*	1.44
CPT NO.	***CPT-2***	*a_{max} (g)=*	0.7		
				DESIGN GW DEPTH=	18

		CPT RESULT INPUT							*CSR*		*CRR 7.5*						*F.S.=(CRR 7.5/CSR)*MSF*Kσ*Kα*		
Depth (ft)		Soil Behavior Type	qc (tsf)	fs (tsf)	σ_v (tsf)	u (tsf)	σ_v' (tsf)	Ic*	C_N*	γ_d	CSR	Ic	C_Q	q_{c1N}	K_C	$(q_{c1N})_{cs}$	$CRR_{7.5}$	Kσ	Kα	F.S.
0.328																				
0.656																				
0.984																				
1.312																				
1.64																				
1.969																				
2.297																				
2.625																				
2.953																				
3.281																				
3.609																				
3.937																				
4.265																				
4.593																				
4.921	6	Sandy Silt to Clayey Silt	18.497	0.159	0.282		0.282	2.02	1.48448	0.99	0.451	2.020	1.48	27.46	1.327	36.438	0.08	1.00	1
5.249	7	Silty Sand to Sandy Silt	53.328	0.49	0.301		0.301	1.7	1.46569	0.99	0.450	1.700	1.47	78.16	1.038	81.121	0.13	1.00	1
5.577	7	Silty Sand to Sandy Silt	51.015	0.48	0.321		0.321	1.74	1.44642	0.99	0.450	1.740	1.45	73.79	1.065	78.571	0.13	1.00	1
5.906	7	Silty Sand to Sandy Silt	50.541	0.512	0.34		0.34	1.79	1.42857	0.99	0.450	1.790	1.43	72.20	1.099	79.381	0.13	1.00	1
6.234	7	Silty Sand to Sandy Silt	51.3	0.553	0.359		0.359	1.82	1.41116	0.99	0.449	1.820	1.41	72.39	1.122	81.189	0.13	1.00	1
6.562	7	Silty Sand to Sandy Silt	50.219	0.578	0.379		0.379	1.86	1.39329	0.99	0.449	1.860	1.39	69.97	1.153	80.699	0.13	1.00	1
6.89	7	Silty Sand to Sandy Silt	49.024	0.56	0.398		0.398	1.88	1.37672	0.99	0.449	1.880	1.38	67.49	1.171	79.005	0.13	1.00	1
7.218	7	Silty Sand to Sandy Silt	52.096	0.581	0.417		0.417	1.87	1.36054	0.99	0.448	1.870	1.36	70.88	1.162	82.350	0.13	1.00	1
7.546	7	Silty Sand to Sandy Silt	57.016	0.604	0.437		0.437	1.84	1.34392	0.98	0.448	1.840	1.34	76.63	1.137	87.125	0.14	1.00	1
7.874	8	Sand to Silty Sand	62.771	0.625	0.456		0.456	1.81	1.3285	0.98	0.448	1.810	1.33	83.39	1.114	92.899	0.15	1.00	1
8.202	8	Sand to Silty Sand	67.539	0.572	0.476		0.476	1.75	1.31265	0.98	0.447	1.750	1.31	88.66	1.072	95.003	0.16	1.00	1
8.53	8	Sand to Silty Sand	67.075	0.586	0.496		0.496	1.78	1.29717	0.98	0.447	1.780	1.30	87.01	1.092	95.042	0.16	1.00	1
8.858	8	Sand to Silty Sand	70.753	0.639	0.516		0.516	1.78	1.28205	0.98	0.447	1.780	1.28	90.71	1.092	99.085	0.17	1.00	1
9.186	8	Sand to Silty Sand	73.019	0.714	0.536		0.536	1.81	1.26728	0.98	0.446	1.810	1.27	92.54	1.114	103.086	0.18	1.00	1
9.514	8	Sand to Silty Sand	75.105	0.813	0.556		0.556	1.84	1.25285	0.98	0.446	1.840	1.25	94.10	1.137	106.989	0.19	1.00	1
9.843	8	Sand to Silty Sand	76.622	0.893	0.575		0.575	1.87	1.23944	0.98	0.446	1.870	1.24	94.97	1.162	110.337	0.20	1.00	1
10.171	8	Sand to Silty Sand	80.357	0.933	0.595		0.595	1.86	1.22563	0.98	0.445	1.860	1.23	98.49	1.153	113.590	0.22	1.00	1
10.499	8	Sand to Silty Sand	93.345	0.964	0.615		0.615	1.79	1.21212	0.98	0.445	1.790	1.21	113.15	1.099	124.397	0.26	1.00	1
10.827	8	Sand to Silty Sand	112.942	1.142	0.635		0.635	1.73	1.19891	0.98	0.445	1.730	1.20	135.41	1.058	143.269	0.35	1.00	1
11.155	8	Sand to Silty Sand	120.043	1.174	0.655		0.655	1.71	1.18598	0.98	0.444	1.710	1.19	142.37	1.045	148.719	0.39	1.00	1
11.483	9	Sand	134.662	1.297	0.675		0.675	1.68	1.17333	0.98	0.444	1.680	1.17	158.00	1.024	161.837		1.00	1
11.811	9	Sand	149.309	1.559	0.695		0.695	1.68	1.16095	0.98	0.444	1.680	1.16	173.34	1.024	177.546		1.00	1
12.139	8	Sand to Silty Sand	158.183	1.917	0.715		0.715	1.72	1.14883	0.97	0.443	1.720	1.15	181.72	1.051	191.052		1.00	1
12.467	8	Sand to Silty Sand	154.059	1.964	0.735		0.735	1.76	1.13695	0.97	0.443	1.760	1.14	175.16	1.078	188.897		1.00	1
12.795	8	Sand to Silty Sand	130.784	1.595	0.755		0.755	1.8	1.12532	0.97	0.443	1.800	1.13	147.17	1.107	162.871		1.00	1
13.123	8	Sand to Silty Sand	108.922	1.302	0.775		0.775	1.86	1.11392	0.97	0.443	1.860	1.11	121.33	1.153	139.936	0.33	1.00	1
13.451	8	Sand to Silty Sand	98.418	1.104	0.795		0.795	1.88	1.10276	0.97	0.442	1.880	1.10	108.53	1.171	127.044	0.27	1.00	1
13.78	8	Sand to Silty Sand	95.82	0.971	0.815		0.815	1.87	1.09181	0.97	0.442	1.870	1.09	104.62	1.162	121.548	0.25	1.00	1
14.108	8	Sand to Silty Sand	99.877	0.972	0.834		0.834	1.85	1.08161	0.97	0.442	1.850	1.08	108.03	1.145	123.701	0.26	1.00	1
14.436	8	Sand to Silty Sand	95.839	1.08	0.854		0.854	1.91	1.07108	0.97	0.441	1.910	1.07	102.65	1.198	123.018	0.25	1.00	1
14.764	8	Sand to Silty Sand	86.282	0.938	0.874		0.874	1.94	1.06075	0.97	0.441	1.940	1.06	91.52	1.229	112.482	0.21	1.00	1
15.092	8	Sand to Silty Sand	80.376	0.8	0.894		0.894	1.95	1.05062	0.97	0.441	1.950	1.05	84.44	1.240	104.700	0.19	1.00	1
15.42	8	Sand to Silty Sand	82.689	0.893	0.914		0.914	1.97	1.04068	0.97	0.440	1.970	1.04	86.05	1.263	108.661	0.20	1.00	1
15.748	8	Sand to Silty Sand	105.765	1.369	0.934		0.934	1.95	1.03093	0.97	0.440	1.950	1.03	109.04	1.240	135.190	0.31	1.00	1
16.076	8	Sand to Silty Sand	133.107	2.333	0.953		0.953	1.98	1.02183	0.97	0.440	1.980	1.02	136.01	1.275	173.380		1.00	1
16.404	7	Silty Sand to Sandy Silt	140.701	3.589	0.973		0.973	2.09	1.01243	0.97	0.439	2.090	1.01	142.45	1.437	204.688		1.00	1
16.732	7	Silty Sand to Sandy Silt	130.225	3.22	0.992		0.992	2.11	1.00365	0.96	0.439	2.110	1.00	130.70	1.473	192.543		1.00	1
17.06	8	Sand to Silty Sand	133.363	2.141	1.012		1.012	1.97	0.99458	0.96	0.439	1.970	0.99	132.64	1.263	167.487		1.00	1
17.388	8	Sand to Silty Sand	138.368	2.492	1.032		1.032	2	0.98566	0.96	0.438	2.000	0.99	136.38	1.300	177.299		0.99	1
17.717	7	Silty Sand to Sandy Silt	149.679	3.694	1.051		1.051	2.09	0.97734	0.96	0.438	2.090	0.98	146.29	1.437	210.204		0.98	1
18.045	7	Silty Sand to Sandy Silt	174.309	4.38	1.07		1.07	2.05	0.96916	0.96	0.438	2.050	0.97	168.93	1.371	231.617		0.98	1
18.373	7	Silty Sand to Sandy Silt	188.265	4.064	1.09		1.09	1.99	0.9607	0.96	0.437	1.990	0.96	180.87	1.287	232.803		0.97	1
18.701	8	Sand to Silty Sand	196.522	3.946	1.11		1.11	1.96	0.95238	0.96	0.437	1.960	0.95	187.16	1.251	234.161		0.96	1
19.029	8	Sand to Silty Sand	214.355	3.877	1.129		1.129	1.9	0.94461	0.96	0.437	1.900	0.94	202.48	1.189	240.719		0.96	1
19.357	8	Sand to Silty Sand	234.312	3.897	1.149		1.149	1.85	0.93657	0.96	0.436	1.850	0.94	219.45	1.145	251.287		0.95	1
19.685	8	Sand to Silty Sand	240.104	3.802	1.169		1.169	1.83	0.92866	0.96	0.436	1.830	0.93	222.98	1.129	251.780		0.94	1
20.013	8	Sand to Silty Sand	236.909	3.74	1.189		1.189	1.84	0.92089	0.96	0.435	1.840	0.92	218.17	1.137	248.062		0.94	1
20.341	8	Sand to Silty Sand	225.826	3.439	1.209		1.209	1.85	0.91324	0.96	0.435	1.850	0.91	206.23	1.145	236.154		0.93	1
20.669	8	Sand to Silty Sand	224.139	3.434	1.229		1.229	1.86	0.90572	0.96	0.435	1.860	0.91	203.01	1.153	234.138		0.93	1
20.997	8	Sand to Silty Sand	230.567	3.762	1.248		1.248	1.87	0.89869	0.95	0.434	1.870	0.90	207.21	1.162	240.743		0.92	1
21.325	8	Sand to Silty Sand	240.692	4.039	1.268		1.268	1.88	0.89141	0.95	0.434	1.880	0.89	214.56	1.171	251.153		0.91	1
21.654	8	Sand to Silty Sand	231.985	3.482	1.288		1.288	1.85	0.88424	0.95	0.433	1.850	0.88	205.13	1.145	234.892		0.91	1
21.982	9	Sand	235.71	3.393	1.308		1.308	1.84	0.87719	0.95	0.433	1.840	0.88	206.76	1.137	235.096		0.90	1
22.31	8	Sand to Silty Sand	230.519	3.449	1.328		1.328	1.86	0.87025	0.95	0.432	1.860	0.87	200.61	1.153	231.372		0.90	1
22.638	8	Sand to Silty Sand	222.812	3.395	1.348		1.348	1.88	0.86342	0.95	0.432	1.880	0.86	192.38	1.171	225.196		0.90	1
22.966	8	Sand to Silty Sand	228.073	3.458	1.368		1.368	1.88	0.8567	0.95	0.432	1.880	0.86	195.39	1.171	228.718		0.89	1
23.294	8	Sand to Silty Sand	222.157	3.547	1.388		1.388	1.91	0.85008	0.95	0.431	1.910	0.85	188.85	1.198	226.320		0.89	1
23.622	8	Sand to Silty Sand	212.212	3.464	1.408		1.408	1.93	0.84356	0.95	0.431	1.930	0.84	179.01	1.218	218.121		0.89	1
23.95	8	Sand to Silty Sand	205.889	3.29	1.428		1.428	1.94	0.83714	0.95	0.430	1.940	0.84	172.36	1.229	211.825		0.89	1
24.278	8	Sand to Silty Sand	204.343	3.188	1.447		1.447	1.94	0.83113	0.94	0.430	1.940	0.83	169.84	1.229	208.726		0.88	1
24.606	8	Sand to Silty Sand	225.874	3.566	1.467		1.467	1.92	0.8249	0.94	0.429	1.920	0.82	186.32	1.208	225.129		0.87	1
24.934	8	Sand to Silty Sand	261.833	4.192	1.487		1.487	1.88	0.81876	0.94	0.429	1.880	0.82	214.38	1.171	250.945		0.86	1
25.262	9	Sand	288.73	4.167	1.507		1.507	1.82	0.81271	0.94	0.428	1.820	0.81	234.65	1.122	263.166		0.85	1
25.591	10	Gravelly Sand to Sand	312.716	4.979	1.528		1.528	1.84	0.80645	0.94	0.428	1.840	0.81	252.19	1.137	286.748		0.84	1
25.919	8	Sand to Silty Sand	281.003	4.995	1.548		1.548	1.91	0.80058	0.94	0.427	1.910	0.80	224.97	1.198	269.601		0.84	1
26.247	8	Sand to Silty Sand	233.117	3.966	1.568		1.568	1.95	0.7948	0.94	0.426	1.950	0.79	185.28	1.240	229.723		0.85	1
26.575	8	Sand to Silty Sand	241.801	4.03	1.588		1.588	1.94	0.7891	0.94	0.426	1.940	0.79	190.80	1.229	234.496		0.85	1
26.903	8	Sand to Silty Sand	268.991	4.642	1.608		1.608	1.92	0.78348	0.93	0.425	1.920	0.78	210.75	1.208	254.641		0.84	1
27.231	8	Sand to Silty Sand	258.42	5.145	1.628		1.628	1.98	0.77793	0.93	0.425	1.980	0.78	201.03	1.275	256.265		0.84	1
27.559	8	Sand to Silty Sand	229.126	4.517	1.647		1.647	2.02	0.77274	0.93	0.424	2.020	0.77	177.06	1.327	234.955		0.84	1
27.887	8	Sand to Silty Sand	218.157	3.443	1.667		1.667	1.96	0.76735	0.93	0.423	1.960	0.77	167.40	1.251	209.439		0.84	1
28.215	9	Sand	225.229	2.949	1.688		1.688	1.9	0.76177	0.93	0.423	1.900	0.76	171.57	1.189	203.974		0.84	1
28.543	9	Sand	240.379	3.145	1.708		1.708	1.88	0.75653	0.93	0.422	1.880	0.76	181.85	1.171	212.874		0.83	1
28.871	9	Sand	254.353	3.505	1.728		1.728	1.89	0.75137	0.93	0.421	1.890	0.75	191.11	1.180	225.430		0.82	1
29.199	9	Sand	274.471	3.714	1.749		1.749	1.86	0.74602	0.92	0.421	1.860	0.75	204.76	1.153	236.158		0.81	1
29.528	9	Sand	303.756	3.778	1.769		1.769	1.81	0.74099	0.92	0.420	1.810	0.74	225.08	1.114	250.742		0.80	1
29.856	9	Sand	313.028	3.631	1.789		1.789	1.78	0.73603	0.92	0.419	1.780	0.74	230.40	1.092	251.675		0.79	1
30.184	9	Sand	317.02	4.182	1.81		1.81	1.82	0.7309	0.92	0.418	1.820	0.73	231.71	1.122	259.865		0.79	1
30.512	9	Sand	320.926	4.546	1.83		1.83	1.84	0.72607	0.92	0.418	1.840	0.73	233.02	1.137	264.946		0.79	1
30.84	9	Sand	333.288	4.177	1.85		1.85	1.8	0.72131	0.92	0.417	1.800	0.72	240.40	1.107	266.046		0.78	1
31.168	9	Sand	345.205	4.242	1.871		1.871	1.78	0.71638	0.91	0.416	1.780	0.72	247.30	1.092	270.134		0.78	1
31.496	9	Sand	321.456	3.869	1.891		1.891	1.8	0.71174	0.91	0.415	1.800	0.71	228.79	1.107	253.197		0.78	1

LIQUEFACTION POTENTIAL ANALYSIS (per Youd & Idriss, 2001)

PROJECT NAME	***WILLOW ROAD EXTENSION AT ROUTE 101***	*FAULT INFO*		*FAULT M_w =* 6.5
PROJECT NO.	***203125.EXT***	*SANTA MARIA RIVER - FOXEN CANYON FAULT*		*MSF =* 1.44
CPT NO.	***CPT-2***	*a_{max} (g)=*	0.7	
				DESIGN GW DEPTH= 18

			CPT RESULT INPUT							*CSR*		*CRR 7.5*						*F.S.=(CRR 7.5/CSR)*MSF*Kσ*Kα*		
Depth (ft)		Soil Behavior Type	qc (tsf)	fs (tsf)	σ_v (tsf)	u (tsf)	σ_v' (tsf)	Ic*	C_N*	γ_d	CSR	Ic	C_Q	q_{c1N}	K_C	$(q_{c1N})_{cs}$	$CRR_{7.5}$	Kσ	Kα	F.S.
31.824	9	Sand	250.751	3.29	1.912		1.912	1.91	0.70694	0.91	0.414	1.910	0.71	177.27	1.198	212.437		0.80	1	
32.152	9	Sand	217.237	2.648	1.932		1.932	1.93	0.70243	0.91	0.414	1.930	0.70	152.59	1.218	185.929		0.81	1	
32.48	9	Sand	205.917	2.21	1.952		1.952	1.92	0.69797	0.91	0.413	1.920	0.70	143.72	1.208	173.658		0.81	1	
32.808	9	Sand	180.68	1.753	1.973		1.973	1.94	0.69335	0.90	0.412	1.940	0.69	125.27	1.229	153.961	0.42	0.82	1	1.02
33.136	9	Sand	168.431	1.27	1.993		1.993	1.9	0.68901	0.90	0.411	1.900	0.69	116.05	1.189	137.965	0.32	0.82	1	0.79
33.465	9	Sand	179.912	2.051	2.013		2.013	1.99	0.68472	0.90	0.410	1.990	0.68	123.19	1.287	158.564	0.45	0.82	1	1.10
33.793	9	Sand	244.702	3.427	2.034		2.034	1.95	0.68027	0.90	0.409	1.950	0.68	166.46	1.240	206.392		0.79	1	
34.121	8	Sand to Silty Sand	358.269	6.1	2.054		2.054	1.9	0.67609	0.90	0.408	1.900	0.68	242.22	1.189	287.964		0.75	1	
34.449	9	Sand	431.26	7.07	2.074		2.074	1.84	0.67196	0.89	0.407	1.840	0.67	289.79	1.137	329.500		0.75	1	
34.777	9	Sand	401.605	5.133	2.094		2.094	1.78	0.66788	0.89	0.406	1.780	0.67	268.22	1.092	292.993		0.74	1	
35.105	9	Sand	335.535	3.762	2.115		2.115	1.8	0.66365	0.89	0.405	1.800	0.66	222.68	1.107	246.428		0.74	1	
35.433	9	Sand	300.22	3.343	2.135		2.135	1.84	0.65967	0.89	0.404	1.840	0.66	198.05	1.137	225.185		0.76	1	
35.761	9	Sand	314.185	3.451	2.155		2.155	1.82	0.65574	0.89	0.403	1.820	0.66	206.02	1.122	231.057		0.75	1	
36.089	9	Sand	321.333	4.368	2.176		2.176	1.88	0.65166	0.88	0.402	1.880	0.65	209.40	1.171	245.117		0.74	1	
36.417	8	Sand to Silty Sand	270.404	4.88	2.196		2.196	2.03	0.64782	0.88	0.401	2.030	0.65	175.17	1.341	234.944		0.77	1	
36.745	10	Gravelly Sand to Sand	211.615	2.933	2.216		2.216	2.02	0.64403	0.88	0.399	2.020	0.64	136.29	1.327	180.853		0.79	1	
37.073	9	Sand	198.305	1.046	2.237		2.237	1.8	0.64009	0.88	0.398	1.800	0.64	126.93	1.107	140.472	0.34	0.79	1	0.85
37.402	9	Sand	182.557	1.282	2.257		2.257	1.9	0.63639	0.87	0.397	1.900	0.64	116.18	1.189	138.117	0.33	0.80	1	0.82
37.73	9	Sand	172.262	1.224	2.278		2.278	1.93	0.63255	0.87	0.396	1.930	0.63	108.96	1.218	132.769	0.30	0.80	1	0.75
38.058	8	Sand to Silty Sand	77.655	0.705	2.297		2.297	2.29	0.62911	0.87	0.395	2.290	0.63	48.85	1.917	93.655	0.16	0.85	1	0.40
38.386	7	Silty Sand to Sandy Silt	31.248	0.321	2.317		2.317	2.69	0.62553	0.86	0.393							0.85	1	
38.714	7	Silty Sand to Sandy Silt	26.963	0.227	2.336		2.336	2.72	0.62217	0.86	0.392							0.84	1	
39.042	7	Silty Sand to Sandy Silt	26.527	0.228	2.355		2.355	2.73	0.61885	0.86	0.391							0.84	1	
39.37	6	Sandy Silt to Clayey Silt	25.617	0.334	2.374		2.374	2.83	0.61556	0.86	0.390							0.84	1	
39.698	6	Sandy Silt to Clayey Silt	28.214	0.595	2.393		2.393	2.9	0.6123	0.85	0.388							0.84	1	
40.026	6	Sandy Silt to Clayey Silt	32.281	0.878	2.412		2.412	2.91	0.60908	0.85	0.387							0.84	1	
40.354	5	Clayey Silt to Silty Clay	32.86	0.979	2.431		2.431	2.93	0.60589	0.85	0.386							0.84	1	
40.682	5	Clayey Silt to Silty Clay	33.315	0.997	2.449		2.449	2.93	0.6029	0.84	0.384							0.84	1	
41.011	5	Clayey Silt to Silty Clay	31.343	1.012	2.468		2.468	2.98	0.59978	0.84	0.383							0.83	1	
41.339	5	Clayey Silt to Silty Clay	30.623	0.941	2.487		2.487	2.98	0.59669	0.84	0.382							0.83	1	
41.667	5	Clayey Silt to Silty Clay	31.011	0.937	2.506		2.506	2.97	0.59363	0.84	0.380							0.83	1	
41.995	5	Clayey Silt to Silty Clay	31.58	0.963	2.525		2.525	2.97	0.5906	0.83	0.379							0.83	1	
42.323	5	Clayey Silt to Silty Clay	31.855	0.951	2.543		2.543	2.96	0.58776	0.83	0.378							0.83	1	
42.651	5	Clayey Silt to Silty Clay	32.443	0.988	2.562		2.562	2.96	0.5848	0.83	0.376							0.83	1	
42.979	5	Clayey Silt to Silty Clay	33.485	1.022	2.581		2.581	2.96	0.58186	0.82	0.375							0.83	1	
43.307	6	Sandy Silt to Clayey Silt	35.031	1.006	2.6		2.6	2.93	0.57895	0.82	0.373							0.83	1	
43.635	6	Sandy Silt to Clayey Silt	37.951	1.057	2.619		2.619	2.89	0.57607	0.82	0.372							0.82	1	
43.963	6	Sandy Silt to Clayey Silt	42.236	1.14	2.637		2.637	2.84	0.57336	0.81	0.370							0.82	1	
44.291	6	Sandy Silt to Clayey Silt	45.886	1.341	2.656		2.656	2.83	0.57054	0.81	0.369							0.82	1	
44.619	6	Sandy Silt to Clayey Silt	50.768	1.494	2.675		2.675	2.8	0.56774	0.81	0.367							0.82	1	
44.948	6	Sandy Silt to Clayey Silt	53.072	1.563	2.694		2.694	2.79	0.56497	0.80	0.366							0.82	1	
45.276	6	Sandy Silt to Clayey Silt	50.882	1.506	2.713		2.713	2.8	0.56223	0.80	0.364							0.82	1	
45.604	6	Sandy Silt to Clayey Silt	48.427	1.42	2.731		2.731	2.82	0.55965	0.80	0.363							0.82	1	
45.932	6	Sandy Silt to Clayey Silt	44.312	1.35	2.75		2.75	2.87	0.55696	0.79	0.361							0.82	1	
46.26	6	Sandy Silt to Clayey Silt	42.511	1.222	2.769		2.769	2.87	0.5543	0.79	0.360							0.82	1	
46.588	6	Sandy Silt to Clayey Silt	42.103	1.222	2.788		2.788	2.88	0.55165	0.79	0.358							0.81	1	
46.916	6	Sandy Silt to Clayey Silt	42.303	1.145	2.806		2.806	2.87	0.54918	0.78	0.357							0.81	1	
47.244	6	Sandy Silt to Clayey Silt	43.051	1.12	2.825		2.825	2.85	0.54658	0.78	0.355							0.81	1	
47.572	6	Sandy Silt to Clayey Silt	41.487	1.274	2.844		2.844	2.91	0.54402	0.78	0.354							0.81	1	
47.9	6	Sandy Silt to Clayey Silt	40.757	1.237	2.863		2.863	2.92	0.54147	0.77	0.352							0.81	1	
48.228	6	Sandy Silt to Clayey Silt	43.886	1.253	2.882		2.882	2.88	0.53895	0.77	0.351							0.81	1	
48.556	6	Sandy Silt to Clayey Silt	46.408	1.343	2.9		2.9	2.86	0.53659	0.77	0.349							0.81	1	
48.885	6	Sandy Silt to Clayey Silt	48.038	1.319	2.919		2.919	2.84	0.53411	0.76	0.348							0.81	1	
49.213	6	Sandy Silt to Clayey Silt	48.72	1.346	2.938		2.938	2.83	0.53166	0.76	0.346							0.81	1	
49.541	6	Sandy Silt to Clayey Silt	50.873	1.475	2.957		2.957	2.83	0.52923	0.76	0.345							0.81	1	
49.869	6	Sandy Silt to Clayey Silt	57.926	1.724	2.976		2.976	2.79	0.52682	0.75	0.343							0.80	1	
50.197	6	Sandy Silt to Clayey Silt	58.116	1.835	2.994	0.006	2.989	2.81	0.52519	0.75	0.342							0.80	1	
50.525	6	Sandy Silt to Clayey Silt	53.414	1.679	3.013	0.016	2.997	2.84	0.52418	0.75	0.342							0.80	1	
50.853	6	Sandy Silt to Clayey Silt	50.276	1.494	3.032	0.026	3.006	2.85	0.52306	0.74	0.341							0.80	1	
51.181	6	Sandy Silt to Clayey Silt	48.067	1.449	3.051	0.036	3.014	2.87	0.52207	0.74	0.341							0.80	1	
51.509	6	Sandy Silt to Clayey Silt	47.043	1.403	3.07	0.047	3.023	2.88	0.52096	0.74	0.341							0.80	1	
51.837	6	Sandy Silt to Clayey Silt	46.881	1.371	3.088	0.057	3.032	2.88	0.51985	0.73	0.340							0.80	1	
52.165	6	Sandy Silt to Clayey Silt	47.536	1.3	3.107	0.067	3.04	2.85	0.51887	0.73	0.340							0.80	1	
52.493	6	Sandy Silt to Clayey Silt	49.119	1.333	3.126	0.077	3.049	2.84	0.51777	0.73	0.339							0.80	1	
52.822	6	Sandy Silt to Clayey Silt	51.271	1.431	3.145	0.088	3.057	2.83	0.5168	0.72	0.339							0.80	1	
53.15	6	Sandy Silt to Clayey Silt	52.513	1.544	3.164	0.098	3.066	2.84	0.51571	0.72	0.339							0.80	1	
53.478	6	Sandy Silt to Clayey Silt	51.138	1.54	3.182	0.108	3.074	2.86	0.51474	0.72	0.338							0.80	1	
53.806	6	Sandy Silt to Clayey Silt	51.66	1.516	3.201	0.118	3.083	2.85	0.51366	0.71	0.338							0.80	1	
54.134	6	Sandy Silt to Clayey Silt	57.585	1.95	3.22	0.129	3.091	2.84	0.5127	0.71	0.337							0.80	1	
54.462	6	Sandy Silt to Clayey Silt	59.007	2.043	3.239	0.139	3.1	2.84	0.51163	0.71	0.337							0.80	1	
54.79	6	Sandy Silt to Clayey Silt	53.793	1.776	3.258	0.149	3.109	2.87	0.51056	0.71	0.336							0.80	1	
55.118	6	Sandy Silt to Clayey Silt	54.03	1.783	3.276	0.159	3.117	2.87	0.50961	0.70	0.336							0.80	1	
55.446	6	Sandy Silt to Clayey Silt	54.068	1.834	3.295	0.17	3.126	2.87	0.50855	0.70	0.335							0.80	1	
55.774	5	Clayey Silt to Silty Clay	53.565	1.844	3.314	0.18	3.134	2.88	0.50761	0.70	0.335							0.80	1	
56.102	5	Clayey Silt to Silty Clay	52.835	1.815	3.333	0.19	3.143	2.89	0.50656	0.69	0.334							0.80	1	
56.43	5	Clayey Silt to Silty Clay	69.834	2.916	3.352	0.2	3.151	2.84	0.50563	0.69	0.334							0.79	1	
56.759	11	Sitff Fine-Grained	163.463	6.972	3.373	0.21	3.163	2.56	0.50424	0.69	0.333	2.560	0.50	82.42	3.091	254.738		0.79	1	
57.087	11	Sitff Fine-Grained	174.48	9.312	3.394	0.221	3.174	2.62	0.50297	0.68	0.333							0.79	1	
57.415	11	Sitff Fine-Grained	149.29	8.519	3.416	0.231	3.185	2.69	0.50171	0.68	0.332							0.79	1	
57.743	11	Sitff Fine-Grained	177.334	8.709	3.437	0.241	3.196	2.59	0.50045	0.68	0.332	2.590	0.50	88.75	3.266	289.853		0.79	1	
58.071	11	Sitff Fine-Grained	200.532	10.737	3.459	0.251	3.207	2.58	0.49921	0.68	0.331	2.580	0.50	100.11	3.206	320.987		0.79	1	
58.399	11	Sitff Fine-Grained	141.943	10.059	3.48	0.262	3.218	2.77	0.49796	0.67	0.331							0.79	1	
58.727	11	Sitff Fine-Grained	99.053	6.658	3.501	0.272	3.23	2.87	0.49661	0.67	0.330							0.79	1	
59.055	11	Sitff Fine-Grained	83.381	4.737	3.523	0.282	3.241	2.88	0.49538	0.67	0.330							0.79	1	
59.383	11	Sitff Fine-Grained	65.7	3.396	3.544	0.292	3.252	2.93	0.49416	0.66	0.329							0.79	1	
59.711	7	Silty Sand to Sandy Silt	80.537	1.99	3.564	0.303	3.261	2.66	0.49316	0.66	0.329							0.79	1	

APPENDIX C-2

RETAINING WALL BEARING CAPACITY & SETTLEMENT EVALUATION

WILLOW ROAD / ROUTE 101 INTERCHANGE

BEARING CAPACITY EVALUATION FOR RETAINING WALLS NO. 1, 2 & 3

FOOTING SUBGRADE IN MEDIUM DENSE SAND
ASSUME SATURATED CONDITION, $\gamma' = 63$ pcf, USE $\phi = 33°$ (CONSERVATIVE)

FOR BEARING EVALUATION, LIMIT THE EFFECTIVE FOOTING WIDTH, B, TO 7'

$\phi = 33°$, $N_q = 26$, $N_\gamma = 35$, FOOTING EMBEDMENT = 3.5'

$$q_{ult} = \gamma' D N_q + \tfrac{1}{2}\gamma B N_\gamma$$
$$= (63)(3.5')(26) + \tfrac{1}{2}(63)(7')(35)$$
$$= 5.7 + 7.7 = 13.4 \text{ ksf}$$

$$q_{allow} = q_{ult} / \underset{\nwarrow 3}{FS} = 4.5 \text{ ksf (SERVICE)}$$

FOR THE PLANNED STANDARD TYPE I WALLS, RECOMMEND ALLOWABLE BEARING = 4.5 ksf. FOR FOUNDATION LOADS HIGHER THAN 4.5 ksf, STANDARD WALLS MAY BE LIMITED.

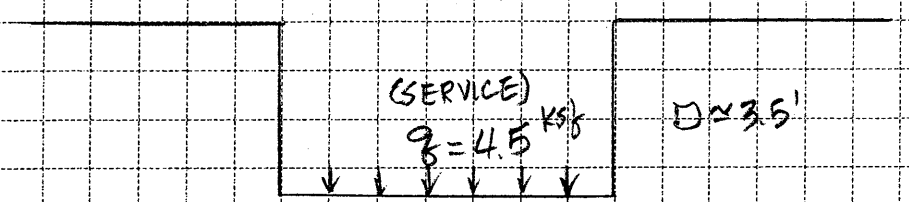
PER OUR UNDERSTANDING, THE STRUCTURAL ENGINEER WILL PERFORM SPECIAL DESIGN FOR HIGH WALL.

WILLOW ROAD / ROUTE 101 INTERCHANGE

SETTLEMENT EVALUATION FOR RETAINING WALLS

FOR THE MAX WALL HEIGHT, THE FOOTING IS AT APPROX. ELEV. 324.0', AND THE FOOTING SUBGRADE CONSISTS OF MEDIUM TO DENSE SAND (~10') OVER STIFF TO VERY STIFF CLAY ($q_u \simeq 6$ ksf) PER BORINGS 001 & 002.

RECOMMENDED ALLOWABLE BEARING CAPACITY = 4.5 ksf (FS = 3)



$L \simeq \infty$, CONSIDER $H \simeq 30'$
$\therefore L/B \simeq \infty$, $H/B \simeq 4$, $D/B \simeq .5$
$\therefore I_1 = 1.1$, $I_0 \simeq .98$
$\nu = .3$

USE B = 7' (MAX. PRESSURE INTENSITY PART OF FOOTING)

- FOR THE MEDIUM TO DENSE SAND (AVG SPT-N ≃ 30±), ADOPT E ≃ 500 Pa PER KULHAWY & MAYNE (1990) - MANUAL OF ESTIMATING SOIL PROPERTIEY FOR FOUNDATION DESIGN. Pa = 2000 psf (ATMOSPHERIC PRESSURE); E ≃ 500 Pa = 1000 ksf.
- FOR THE STIFF TO VERY STIFF CLAY, C ≃ 3 ksf ($q_u \simeq 6$ ksf). USE E ≃ 350·C = 1050 ksf (DUNCAN & BUCHIGNANI, 1976).

$\therefore$ IT IS REASONABLE TO USE E ≃ 1000 ksf FOR ANALYSIS.

USE ELASTIC SOLUTION PER JANBU, BJERRUM & KJAERNSLI, 1956

$$\rho = I_0 \cdot I_1 \cdot \frac{q B}{E}(1-\nu^2)$$

ASSUME WALL LENGTH, $L \simeq \infty$
CONSIDER $H \simeq 30'$ BELOW FOOTING

$$\rho = (0.98)(1.1)\frac{q \times 7' \times 12''/ft}{1000\ ksf}(1-.3^2)$$

$$= 0.082\,q'' \quad (q \text{ in ksf})$$

(I) q = 4.5 ksf (SERVICE DEMAND, FOR MOD. TYPE I WALL), SETTLEMENT ≃ 0.4" ← δ_{TOTAL}

(II) q = 7.5 ksf (ULTIMATE DEMAND, FOR MOD. TYPE 7B WALL), SETTLEMENT ≃ 0.6"

DIFFERENTIAL SETTLEMENT MAY BE ASSUMED AT 50% OF THE δ_{TOTAL}

Ref: Manual on Estimating Soil Properties for Foundation Design
EPRI EL-6800, Aug. 1990, Kulhawy & Mayne

Table 5-7

VALUES OF RIGIDITY INDEX FOR SELECTED COHESIONLESS SOILS

Soil	Relative Density D_r (%)	Normalized Mean Normal Stress, $\bar{\sigma}_o/p_a$	Rigidity Index, I_r
Chattahoochee sand	80	0.1	200
	80	1	118
	80	10	52
	80	100	12
	20	0.1	140
	20	1	85
Ottawa sand	82	0.05	265
	21	0.05	89
Piedmont silt	-	0.70	10 to 30

Source: Vesic (20), p. 68.

$$I_{rr} = I_r/(1 + I_r\,\epsilon_v) \qquad (5\text{-}24)$$

Vesic (20) noted that ϵ_v would be zero for dense soils and range from 0 to 0.05 for loose soils in the stress range from 1 to 10 atmospheres. For convenience in computer code implementation, Trautmann and Kulhawy (1) approximated ϵ_v as follows:

$$\epsilon_v = 0.005(\bar{\sigma}_v/p_a)(1 - \phi_{rel}) \qquad (5\text{-}25)$$

in which ϵ_v = vertical effective stress (up to 10 atmospheres), and ϕ_{rel} is defined in Equation 5-8.

Correlations with SPT N Value

Young's Modulus. Early correlations in the literature related E_{ds} of sands directly to the standard penetration test (SPT) N value. Several of these correlations are shown in Figure 5-13. Others within the same ranges are given by Mitchell and Gardner (23). Later correlations attempted to relate the constrained modulus (M) and N as a function of overburden stress (e.g., 24).

However, all attempts to date that correlate a modulus with N show considerable

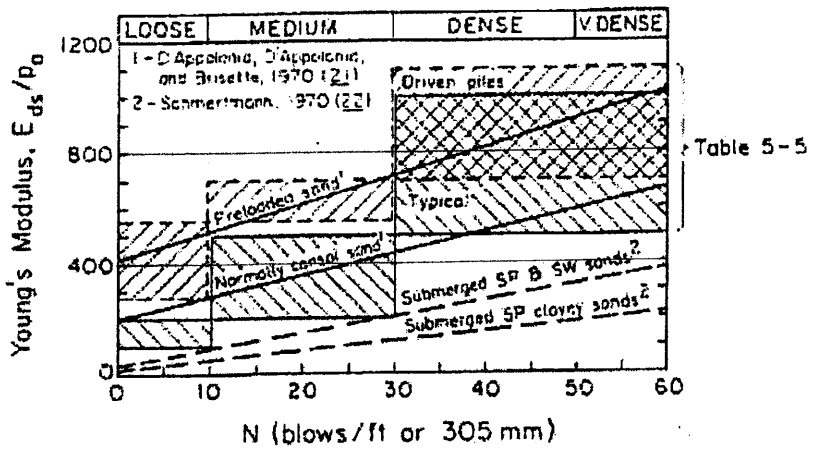


Figure 5-13. Comparative Plot of Drained Modulus Correlations for Sand

Source: Callanan and Kulhawy (13), p. 3-16.

scatter. This lack of correlation is to be expected because the SPT N value varies with many factors, as described in Section 2, and these factors have yet to be incorporated in these correlations. Therefore, as a first order estimator, the following may be used:

$$E/p_a \approx 5\ N_{60} \quad \text{(sands with fines)} \tag{5-26a}$$

$$\approx 10\ N_{60} \quad \text{(clean NC sands)} \tag{5-26b}$$

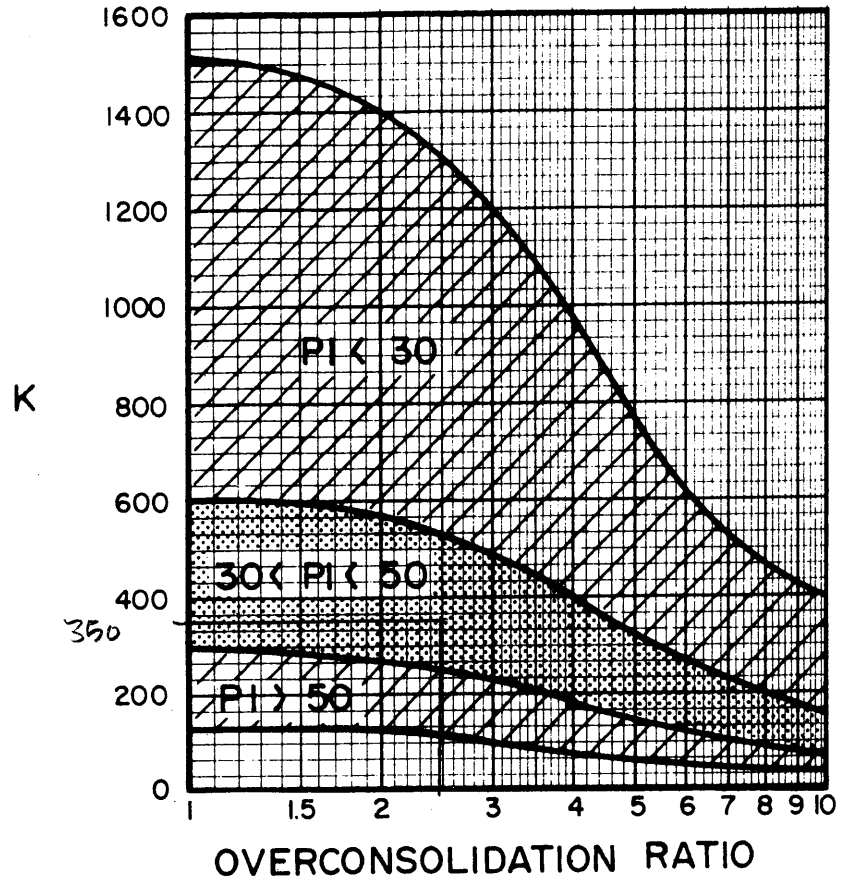
$$\approx 15\ N_{60} \quad \text{(clean OC sands)} \tag{5-26c}$$

in which N_{60} is the N value corrected for field procedures to an average energy ratio of 60 percent. Equation 2-11 gives the appropriate correction factors.

Pressuremeter Modulus. The pressuremeter test (PMT) provides a direct measurement of the horizontal modulus of cohesionless soils. This modulus (E_{PMT}) often is presumed to be roughly equivalent to Young's modulus (E). Correlations between the N value and E_{PMT} have been developed, as shown in Figure 5-14. The scatter shown is typical of other N correlations because of the reasons noted above.

Dilatometer Modulus. The dilatometer test (DMT) also provides a direct modulus measurement for cohesionless soils. The dilatometer modulus (E_D) is related to Young's modulus as follows:

REF: AN ENGINEERING MANUAL FOR SETTLEMENT STUDIES
J.M. DUNCAN & A.L. BUCHIGNANI (1976)



$E_u = KS_u$

E_u = UNDRAINED MODULUS OF CLAY

K = FACTOR FROM CHART ABOVE

S_u = UNDRAINED SHEAR STRENGTH OF CLAY

TYPICAL SAMPLE IN BORINGS 001 & 002 @ ELEV. 320'±
$\sigma_v' \approx 118 pcf \times 30' + 63 pcf \times 20' \approx 4.8$ ksf
$q_u \approx 3$ tsf. $S_u \approx 3$ ksf. USE $S_u/p_p \approx .25$, $P_p \approx 12$ ksf.
$OCR \approx P_p/\sigma_v' = 12/4.8 = 2.5 \longrightarrow$ USE $E \approx 350 S_u$.

Fig. 5 CHART FOR ESTIMATING UNDRAINED MODULUS OF CLAY

APPENDIX C-3

ACTIVE & PASSIVE PRESSURES FOR DESIGN

WILLOW ROAD / ROUTE 101 INTERCHANGE

SOIL PARAMETARS FOR RETAINING WALL SPECIAL DESIGN WHEN STANDARD WALL IS LIMITED BY BEARING CAPACITY

(I) ACTIVE EARTH PRESSURE - CALTRANS STANDARD STRUCTURE BACKFILL, USE $\phi = 34°$, $\gamma = 130$ pcf.

COULOMB'S EARTH PRESSURE COEFFICIENT

$$K_a = \frac{\sin^2(\beta+\phi)}{\sin^2\beta \cdot \sin(\beta-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\cdot\sin(\phi-\alpha)}{\sin(\beta-\delta)\cdot\sin(\alpha+\beta)}}\right]^2}$$

$\beta = 90°$ (VERTICAL WALL STEM)
$\alpha =$ 0 (LEVEL BACK FILL)
14° (4H:1V SLOPE FILL)
26° (2H:1V SLOPE FILL)
$\phi = 34°$, $\delta = \frac{1}{2}\phi$ (PER BDS SECTION 5)

- LEVEL BCKFILL CASE ($\alpha = 0$)

$$K_a = \frac{0.6873}{1 \cdot 1 \cdot \left[1+\sqrt{\frac{0.5592 \times 0.5592}{1 \cdot 1}}\right]^2} = 0.28$$

EQUIVALENT FLUID PRESSURE = 130 × 0.28 ≈ 36 pcf

- 4H:1V SLOPE FILL CASE ($\alpha = 14°$)

$$K_a = \frac{0.6873}{1 \cdot 1 \cdot \left[1+\sqrt{\frac{\sin 34° \cdot \sin(34-14)}{1 \cdot \sin(14+90)}}\right]^2} = 0.33$$

EQUIVALENT FLUID PRESSURE = 130 × 0.33 ≈ 45 pcf.

- 2H:1V SLOPE FILL CASE ($\alpha = 26°$)

$$K_a = \frac{0.6873}{1 \cdot 1 \cdot \left[1+\sqrt{\frac{\sin 34 \cdot \sin(34-26)}{1 \cdot \sin(26+90)}}\right]^2} = 0.41$$

EQUIVALENT FLUID PRESSURE = 130 × 0.41 ≈ 55 pcf

(II) PASSIVE RESISTANCE

THE WALL FOOTINGS ARE ANTICIPATED TO BE AT ABOUT ELEV 340'±, WHICH IS THE GROUNDWATER LEVEL. PER BORING DATA, THE SAND AT ELEV. 340'± APPEARS TO BE DENSER (HIGHER BLOW COUNTS) THAN UPPER MATERIAL.

- AT ELEV 340'±, $N_{MC} \approx 39 \sim 49 \approx 45$ avg
  $\sigma_v' = 118\ pcf \times 30' = 3540\ psf = 1.77\ tsf$
  $C_N = 1/\sqrt{\sigma_v'} = 0.75$
  $\therefore$ N-SPT $\approx 45 \times .65 \times .75 = 22$
  $\rightarrow$ USE $\phi \approx 35°$
- ABOVE ELEV 340'±, $N_{MC} \approx 25$ avg
  $\sigma_v' = 118 \times 20' = 2360\ psf = 1.18\ tsf$
  $C_N = 1/\sqrt{\sigma_v'} = 0.92$
  $\therefore$ N-SPT $\approx 25 \times .65 \times .92 = 15$
  $\rightarrow$ USE $\phi \approx 33°$

PER BDS SECTION 5, USE LOG-SPIRAL TO DETERMINE K_p W/ $\delta \leq 1/2\ \phi$. ALSO, USE 50% AVAILABLE PASSIVE FOR DESIGN

- WITH WATER, $\phi = 35°$, $K_p = 10.5 \times .67 = 7$
  50% $K_p = 3.5$ (SECT. 5.6.4.1)
  EQUIVALENT FLUID PRESSURE $= 58\ pcf \times 3.5 =$ <u>200 pcf</u>
- ABOVE WATER, $\phi = 33°$, $K_p = 8.5 \times .7 \approx 5.9$
  50% $K_p = 3$ (SECT. 5.6.4.1)
  EQUIVALENT FLUID PRESSURE $= 118 \times 3 =$ <u>350 pcf</u>

FRICTION COEFFICIENT = <u>0.4</u> (CONCRETE OVER FINE SAND, NAVFAC DM 7.2)

- PER BDS SECTION (5.6.4.1), THE SLIDING MAY BE CHECKED USING MAX. BASE FRICTION AND 50% OF THE AVAILABLE PASSIVE RESISTANCE.
- ADD LIVE (TRAFFIC) SURCHARGE IF TRAFFIC IS EXPECTED TO BE WITHIN WALL Ht BEHIND WALL FACE (SECT. 5.5.5.1.1.5).

Ref: Terzaghi, Peck & Mesari (1996)

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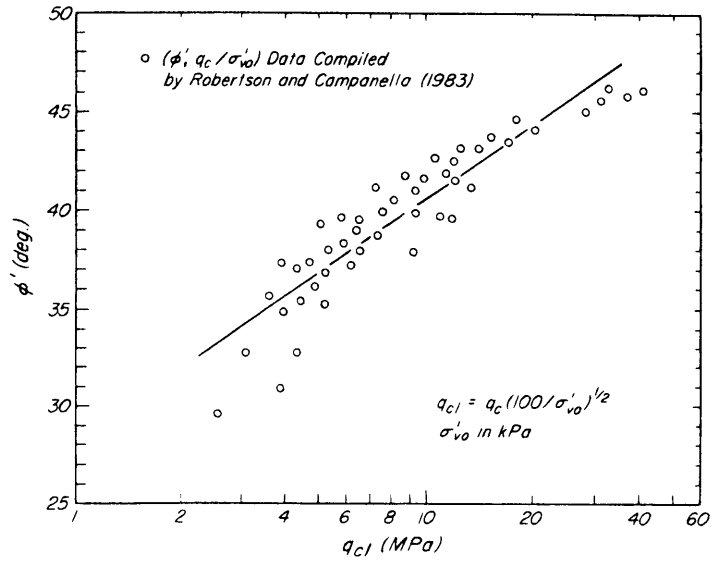


Figure 19.5 Empirical correlation between friction angle ϕ' of sands and normalized push cone tip penetration resistance.

ory (de Beer 1948, Meyerhof 1961, Janbu and Senneset 1974, Durgunoglu and Mitchell 1975, Mitchell and Keaveny 1986). Data compiled by Robertson and Campanella (1983) are plotted in terms of q_{cl} in Fig. 19.5. The correlation is mainly applicable to normally consolidated young sand deposits composed of quartz and feldspars. It underestimates by several degrees the friction angle of compressible carbonate sands with crushable particles, and it overestimates by several degrees the friction angle of overconsolidated or aged sands with values of σ'_{ho} higher than those in normally consolidated young deposits (Schmertmann 1975).

The correlation between ϕ' and $(N_1)_{60}$ in Fig. 19.6 is based on various proposals for the relationship between ϕ' and standard penetration blow count N (Peck et al. 1953, De Mello 1971, Schmertmann 1975, Stroud 1988). It underestimates ϕ' for calcareous sands with crushable particles and overestimates ϕ' for overconsolidated sands (Stroud 1988). Figure 19.6 also includes relations between ϕ' and $(N_1)_{60}$ determined from the empirical correlation in Fig. 19.6 together with q_c/N_{60} values of 400 and 500 kPa for sand deposits. The two different empirical correlations between ϕ' and q_c and between ϕ' and N_{60}, which have originated from separate databases, lead to comparable values of ϕ' for sands.

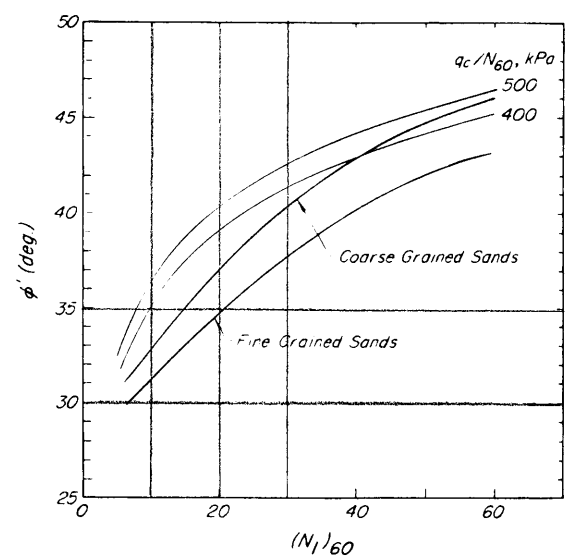


Figure 19.6 Empirical correlation between friction angle ϕ' of sands and normalized standard penetration blowcount.

19.2 Drained Shear Strength of Cohesive Soils

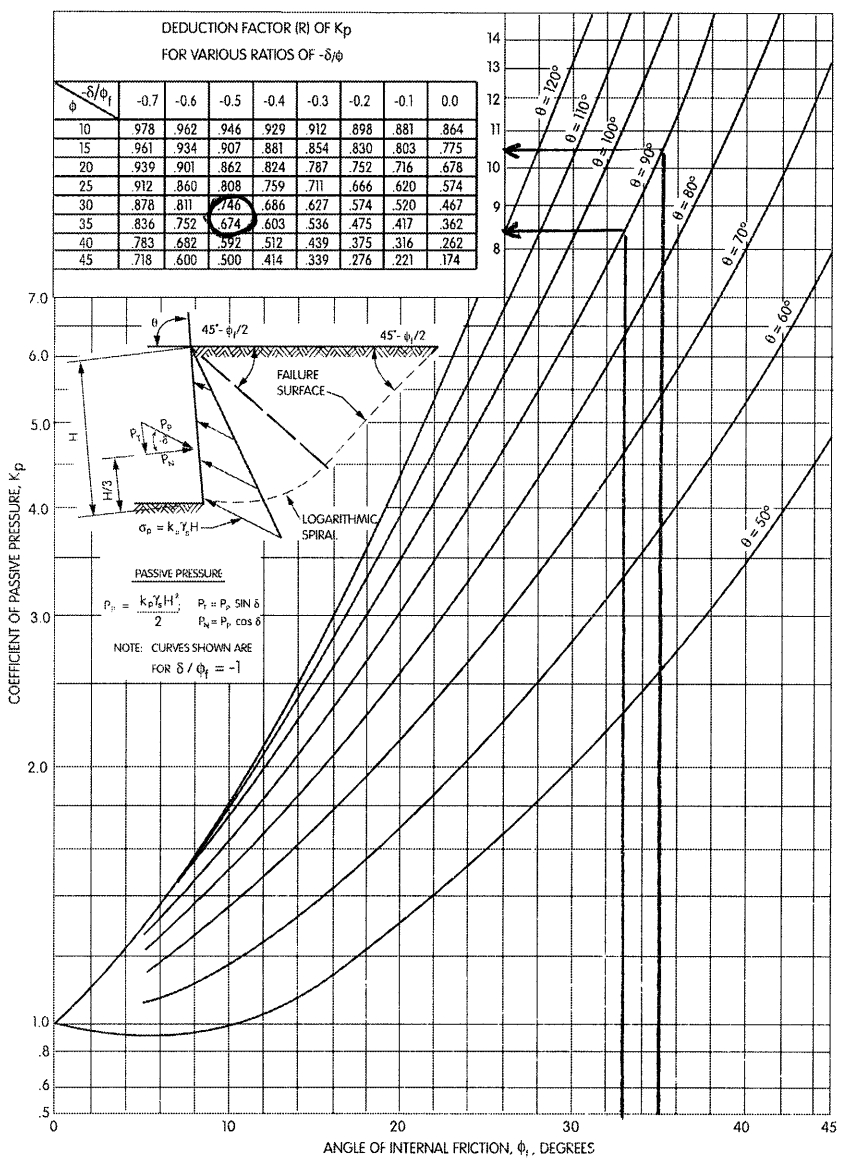
The drained shear strength of normally consolidated cohesive soils is defined by the friction angle ϕ', as follows:

$$s = \sigma' \tan \phi' \tag{19.6}$$

The effective normal stress σ' on the plane of shear is determined by the total normal stress and the equilibrium hydrostatic or steady porewater pressure condition. The friction angle ϕ', which corresponds to a more or less random arrangement of particles, is mainly a function of the clay mineral content and clay mineralogy of the composition. Values of ϕ' for the full range of clay compositions are shown in Fig. 19.7. Among the pure clay minerals, sodium montmorillonite (consisting of filmy particles) has the lowest value of ϕ', whereas attapulgite (with interlocking fibers) exhibits the highest value. Typical values of ϕ' for soft clay, stiff clay, and shale constituents are in the range of 25° to 35°, 20° to 35°, and 15° to 35°, respectively. The water-filled and rough surface-

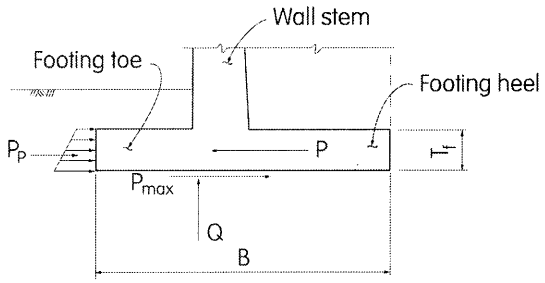
5.5.5.4 Passive Lateral Earth Pressure Coefficient, k_p

For non-cohesive soils, values of the passive lateral earth pressure may be taken from Figure 5.5.5.4-1 for the case of a sloping or vertical wall with a horizontal backfill or from Figure 5.5.5.4-2 for the case of a vertical wall and sloping backfill. For conditions that deviate from those described in Figures 5.5.5.4-1 and 5.5.5.4-2, the passive pressure may be calculated by using a trial procedure based on wedge theory or a logarithmic spiral method. When wedge theory or logarithmic spiral method are used, the limiting value of the wall friction angle should not be taken larger than one-half the effective angle of internal friction, ϕ'_f.



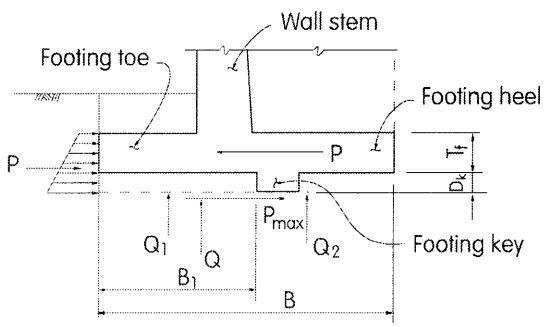
ϕ \ $-\delta/\phi_f$	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.0
10	.978	.962	.946	.929	.912	.898	.881	.864
15	.961	.934	.907	.881	.854	.830	.803	.775
20	.939	.901	.862	.824	.787	.752	.716	.678
25	.912	.860	.808	.759	.711	.666	.620	.574
30	.878	.811	.746	.686	.627	.574	.520	.467
35	.836	.752	.674	.603	.536	.475	.417	.362
40	.783	.682	.592	.512	.439	.375	.316	.262
45	.718	.600	.500	.414	.339	.276	.221	.174

Figure 5.5.5.4-1 Coefficient of Passive Lateral Earth Pressure for Vertical and Sloping Walls with Horizontal Backfill (Caquot and Kerisel Analysis), Modified after U.S. Department of Navy (1971)



$$FS_{SL} = \frac{P_{max} + P_p}{p}$$

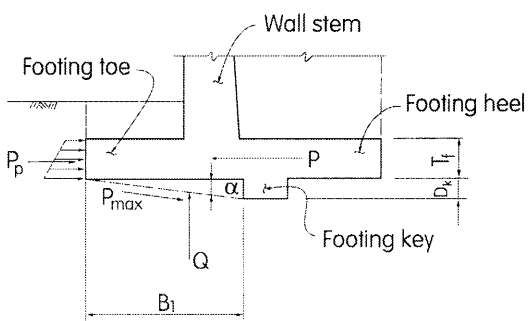
a. Wall footing without footing key



$$Q = Q_1 + Q_2$$

$$FS_{SL} = \frac{P_{max} + P_p}{P}$$

b. Wall footing with footing key and horizontal sliding plane



$$\alpha = \arctan \frac{D_k}{B_1}$$

$$P_{max} = (Q\cos\alpha - P_p \sin\alpha)\tan\phi'_f + \frac{B_1}{\cos\alpha}c$$

$$FS_{SL} = \frac{(P_{max} + P_p\cos\alpha - Q\sin\alpha)}{P\cos\alpha}$$

c. Wall footing with footing key and inclined sliding plane

where:

P = tangential component of force on wall footing (KIP)

$Pmax$ = maximum resisting force between wall footing base and foundation soil or rock against sliding failure (KIP)

P_p = passive lateral earth pressure, not to exceed 50 percent of the available passive lateral earth pressure (KIP)

Q = normal component of force on wall footing (KIP)

Q_1 = normal component of force on wall footing within distance B_1 (KIP)

Q_2 = normal component of force on wall footing within distance $(B - B_1)$ (KIP)

B = width of wall footing (FT)

B_1 = distance from toe of footing to front face of footing key (FT)

B' = width of wall footing actually in compression $(B' = B - 2e)$ (FT)

T_f = wall footing thickness (FT)

D_k = depth of wall footing key (FT)

ϕ'_f = effective angle of internal friction of foundation soil (DEG)

δ = angle of friction between wall footing and foundation soil, or rock (for footings on soil, δ, may be taken as, $\frac{2}{3}\phi'_f$) (DEG)

c = cohesion of foundation soil (KSF)

c_a = adhesion between wall footing and foundation soil or rock (KSF)

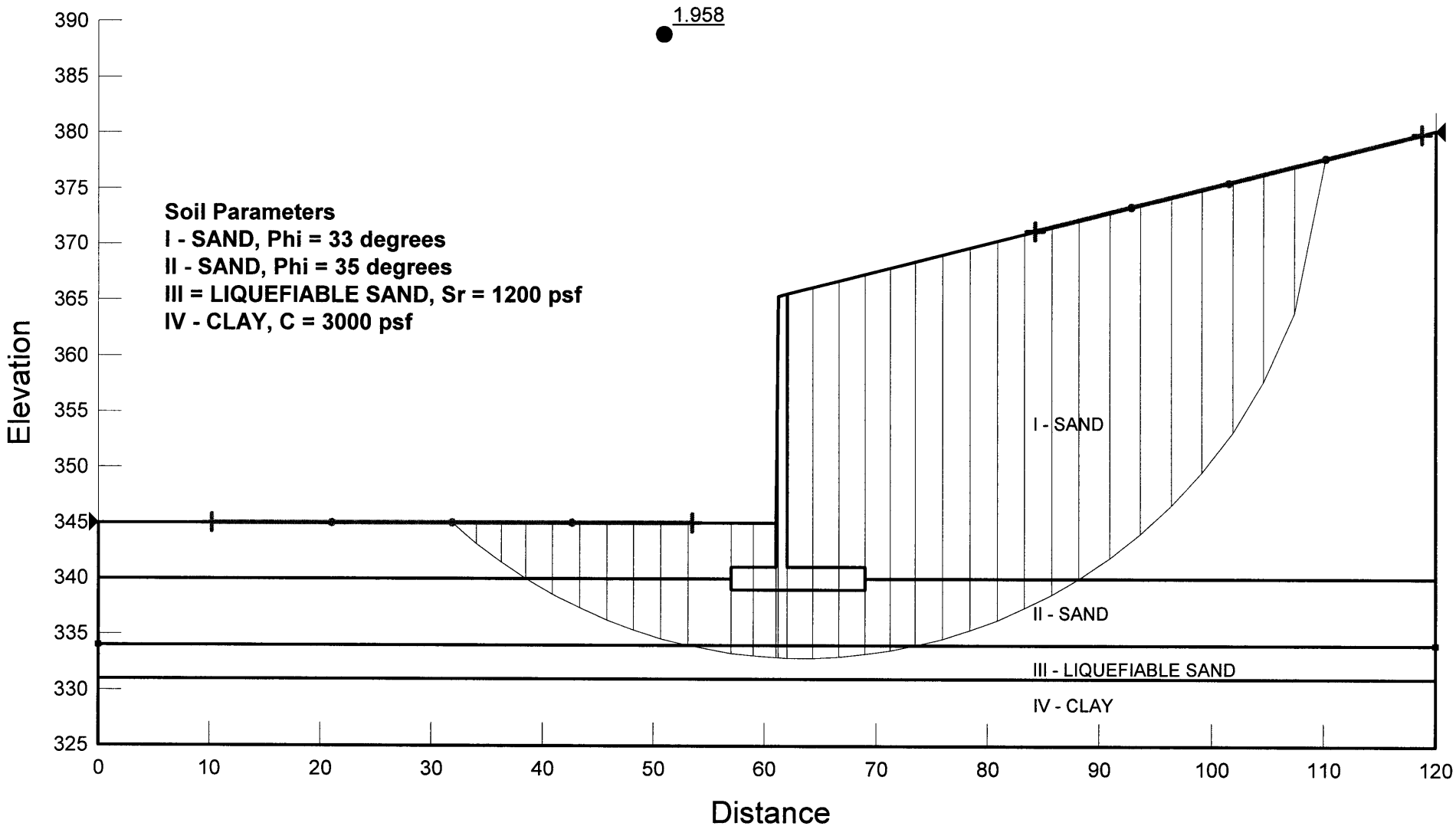
α = angle between bottom of wall footing and a plane passing through lower front corner of the footing and the lower front corner of the footing key (DEG)

Figure 5.6.4.1-1 Procedures to Determine the Factor of Safety Against Sliding

APPENDIX C-4

GLOBAL STABILITY

WILLOW ROAD / ROUTE 101 INTERCHANGE - RETAINING WALLS (TYPICAL)



APPENDIX D

Office of Special Funded Projects
Comment & Response Form

General Project Information	Review Phase	Reviewer Information
Dist: 05 EA: 474501 Project Name: Willow Rd UC + 1 OSFP Liaison: B. Massey Phone: 916-227-8868 e-mail:_____	☐ PSR/PDS (Review No.) ☐ APS/PSR (Review No.) ☐ APS/PR (Review No.) ☐ Type Selection ☐ 65% PS&E Unchecked Details ☒ PS&E (Review No.) ☐ Construction Support ☐ Other:_____ **Structure Information** (Use when necessary to document comments by individual structure) Structure Name:_____ Br No: _____	Reviewer Name: Mike Finegan Functional Unit: Geotechncial Design Cost Center: 59-323 Phone Number: 805-549-3194 e-mail: _____ Date of Review: 2-23-10

Consultant Information (to be filled in by Consultant)

Consultant Structure Lead (First and Last Name)	Structure Consultant Firm	Phone Number	e-mail	Response Date
_____	_____	_____	_____	_____

#	Doc. (See Note 1)	Page, Section, or SSP	Review Comments	Consultant Responses	✓
1	P		The detail for drain rock wrapped in fabric below the retaining wall footing is not shown in the Elevation views as indicated on the Typical Sections.	The designer has updated the plans.	
2	FR		Total and differential settlement of the Type 1 walls needs to be determined.	Settlement analyses were performed and attached in Appendix C-2. The analyses were based on elastic solution. The total and differential settlements of the retaining walls are on the order of 0.5 inch and 0.25 inch, respectively, from a practical design standpoint.	
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Note 1: Abbreviations for Typical Documents (if Abbr. is not below, type in the document type)					
P=Structure Plans	SP=Special Provisions	FR=Foundation Rpt	DC=Design Calcs	TS=Type Sel. Report	QCC=Quant. Check Calcs
RP=Road Plans	E=Estimate	H=Hydraulics Rpt	CC=Check Calcs	QC=Quant. Calcs	

✓= Comment Resolved (for Reviewer's use)

Office of Special Funded Projects
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General Project Information	Review Phase	Reviewer Information
Dist: 05 EA: 454701 Project Name: Willow Rd UC + 1 OSFP Liaison: B. Massey Phone: 916-227-8868 e-mail:_____	☐ PSR/PDS (Review No.) ☐ APS/PSR (Review No.) ☐ APS/PR (Review No.) ☐ Type Selection ☐ 65% PS&E Unchecked Details ☒ PS&E (Review No.) ☐ Construction Support ☐ Other:_____ **Structure Information** (Use when necessary to document comments by individual structure) Structure Name:_____ Br No: _____	Reviewer Name: Mike Finegan Functional Unit: Geotechncial Design Cost Center: 59-323 Phone Number: 805-549-3194 e-mail: _____ Date of Review: 10-5-09

Consultant Information (to be filled in by Consultant)

Consultant Structure Lead (First and Last Name)	Structure Consultant Firm	Phone Number	e-mail	Response Date
_____	_____	_____	_____	_____

#	Doc. (See Note 1)	Page, Section, or SSP	Review Comments	Consultant Responses	✓
1	FR	4	Portions of the soldier piles are expected to extend below the ground water table. Why are soldier piles that are to be placed in a drilled hole specified below the ground water elevation?	Not applicable. Due to alignment change, wall type has been revised from Solider Pile Wall to Standard Type 1 Wall.	
2	FR	5	The FR states that it is anticipated that ground water will be encountered during installation of the soldier piles and that the contractor has the option to use slurry to stabilize the hole during construction. The use of slurry is not allowed on page 283 of the Special Provisions. Slurry displacement methods are also not feasible for the construction of the soldier pile wall as shown. With a steel h-pile used as the soldier pile the required inspection tubes used for gamma-gamma testing cannot be placed and a 6 inch tremie for placing concrete would not fit in the drilled hole with the h-pile. Even if the tremie could be made to fit, the ability of the concrete to flow around the h-pile and displace the slurry is doubtful. A cast in drilled hole pile with a minimum 24 inch diameter and a rebar cage is an option for use as a soldier pile or driven piles may used as soldier piles The use of h-piles placed in a drilled hole below the water table as shown on the plans and specified in the Foundation Report is not recommended.	Not applicable. Due to alignment change, wall type has been revised from Solider Pile Wall to Standard Type 1 Wall.	

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✓ = Comment Resolved (for Reviewer's use)

Office of Special Funded Projects
Comment & Response Form

General Project Information	Review Phase		Reviewer Information
Dist: 05 EA: 454701 **Project Name: Willow Rd UC + 1** **OSFP Liaison: B. Massey** **Phone: 916-227-8868** **e-mail:_____**	☐ PSR/PDS (Review No. _) ☐ APS/PSR (Review No. _) ☐ APS/PR (Review No. _) ☐ Type Selection	☒ 65% PS&E Unchecked Details ☐ PS&E (Review No. _) ☐ Construction Support ☐ Other:_____	**Reviewer Name: Mike Finegan** **Functional Unit: Geotechncial Design** **Cost Center: 59-323** **Phone Number: 805-549-3194** **e-mail: _____** **Date of Review: 5-21-09**
	Structure Information (Use when necessary to document comments by individual structure) **Structure Name:_____** **Br No: _____**		

Consultant Information (to be filled in by Consultant)

Consultant Structure Lead (First and Last Name)	Structure Consultant Firm	Phone Number	e-mail	Response Date
_____	_____	_____	_____	_____

#	Doc. (See Note 1)	Page, Section, or SSP	Review Comments	Consultant Responses	✓
1	P		Need Quality Control / Quality Assurance Documentation for the LOTB sheets for both the Willow Rd UC and the Retaining Wall. A Memorandum with the subject Quality Control / Quality Assurance Documentation on LOTB Sheets was prepared by James Davis, Deputy Division Chief, Geotechnical Services, dated July 1, 2007. The memo states that effective August 1, 2007, all Geotechnical Services staff and consultants shall use the procedures in this memorandum when preparing LOTB sheets.	Quality Control/Quality Assurance documentation for the LOTB sheets are attached in Appendix A for both the Willow Road UC and retaining wall foundation reports.	
2	P		The soil description and identification on the LOTBs does not follow the identification and description sequence in the June 2007 Soil and Rock Logging, Classification, and Presentation Manual.	The soil description and identification has been revised in accordance with the June 2007 Soil and Rock Logging, Classification, and Presentation Manual.	
3	P	20, 30	Bench Mark information is not on the LOTB sheets.	Benchmark information has been added.	
4	P		The borehole naming convention does not follow the June 2007 Soil and Rock Logging, Classification, and Presentation Manual	The borehole naming convention has been revised.	

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✓= Comment Resolved
(for Reviewer's use)

5	P, FR	2, 8	For the Willow Rd UC the Pile Data Table in the FR shows 0 tension on the piles and the Pile Data Table on the Plans shows 140k of tension on the piles. A tension pile tip elevation is required on the Pile Data Table if there is tension on the piles.	We have double-checked with the structural designer. The nominal tension demand is 0 for the piles. The Pile Data Table on the plans will be revised accordingly.	
6	P, FR	23, 5	At the soldier pile wall pile tip elevations are shown to be as much as16 feet below the ground water table. Temporary casing is recommended in the FR to be used to control caving and dewatering / pumping (?) is recommended to control ground water. In our experience it is not possible to withdraw the casing while placing concrete in the drilled hole and be able to hold the steel soldier pile in place. Pumping and dewatering are likely not feasible at this site as water cannot adequately be pumped out of a cased hole prior to concrete placement and a dewatering scheme would need to be elaborate for a wall 288 feet long. A retaining wall founded on driven piles or a soil nail wall would be better retaining wall alternatives from a constructability standpoint.	The wall layout line is next to the right-of-way, and there is an existing building (nursery) in close proximity. Therefore a soldier pile lagging wall was selected at the location, and these items were discussed in the Type Selection Meeting on 9/17/2007. To facilitate construction, the contractor has the option to use slurry construction to stabilize the hole with partial casing for the upper portion. It does not have to be full depth casing for construction. We have revised the language in the report.	
7	FR	8	The undercrossing requires an excavation of approximately 25 feet from existing grade. This excavation will be approximately 4 feet above the ground water elevation. Ground water fluctuation or additional excavation for the roadway structural section may result in ground water being encountered or pumping sub-grade below the structural section. Provisions should be made in the roadway plans for this possibility.	To facilitate construction and compaction operation, it is recommended that, at deeper part of the cut, a layer of geotextile fabric (Caltrans Standard Specification Section 88-1.04 Type B) with a foot of Aggregate Base be used below the pavement subgrade. This applies to location where the subgrade is below Elev. 343 feet. (The design groundwater level is at Elev. 341 ft). The intention is to mitigate potential pumping subgrade by creating a "working platform". The provision has been provided to the roadway designer.	
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Note 1: Abbreviations for Typical Documents (if Abbr. is not below, type in the document type)					
P=Structure Plans	SP=Special Provisions	FR=Foundation Rpt	DC=Design Calcs	TS=Type Sel. Report	QCC=Quant. Check Calcs
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✓= Comment Resolved
(for Reviewer's use)