Leighton Consulting, Inc.
A LEIGHTON GROUP COMPANY

July 29, 2015

Project No. 603541-003

Sharp Healthcare
8695 Spectrum Center Boulevard
San Diego, California 92123

Attention: Mr. Matthew Teichner

Subject: Site-Specific Ground Motion Response Spectra
Sharp Chula Vista Medical Center Master Plan
Chula Vista, California

Reference: Leighton Consulting, Inc. 2013, Geotechnical Investigation, Sharp Chula Vista Medical Center Master Plan, California, Project No. 603541-002, dated July 18, 2013, Revised August 29, 2013.

Leighton Consulting, Inc. (Leighton) is pleased to submit this letter-report for the subject project. This letter-report presents site-specific ground motion response spectra for the subject project per your authorization of our supplemental scope on July 17, 2015.

Site-Specific Response Spectra

Site-specific response spectra were developed for the site based on a uniform-hazard approach using the computer program *EZ-FRISK* (Risk Engineering, 2015). The uniform-hazard approach assumes that the same level of hazard is uniformly applied to the entire response spectra. The spectral values were developed for a seismic event associated with the Maximum Considered Earthquake (MCE_G) with a return period of 2,475 years (2 percent chance of exceedance in 50 year). The response spectral values were calculated for 5 percent damping.

Attenuation relationships (Ground Motion Prediction Equations or GMPEs) describe the relation of ground motion levels with earthquake magnitude and distance (between the site and seismic source), site geology, and subsurface characterization. These relationships can be used to describe the variation of peak ground acceleration and response spectral acceleration with earthquake magnitude and distance, and to also incorporate the local geological conditions and near-source effects. An averaging of the following next-generation attenuation relationships (NGAs) was used with equal weights to calculate site-specific peak horizontal ground acceleration and spectra:

- Boore-Atkinson (2008),
- Campbell-Bozorgnia (2008), and
- Chiou-Youngs (2008)

We have used the Shahi and Baker (2014) $Sa_{RotD100}/Sa_{RotD50}$ factors to convert geometric mean values into maximum component values required to develop the MCE_R ground motions.

Suspension Logging

The survey was performed by GEOVision (attached). The primary purpose of performing suspension logging at Boring S-1 (referred to as B-1 in GEOVision report) was to develop subsurface compressional-wave (P) and shear-wave (S) velocity models down to a depth of approximately 100 feet below the bottom of excavation. See the attached Figure 2 for Boring S-1 location. Velocity measurements were performed using the PS logging system at 1.6 foot intervals, manufactured by OYO Corporation, and their subsidiary, Robertson Logging. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and shear waves.

The results of the geophysical testing indicated an average shear wave velocity of approximately 1,300 feet/second (396 m/s) for the upper 100 feet below the bottom of excavation.

Site Characterization (Site Class)

Utilizing the 2013 California Building Code (CBC) procedures, we have characterized the site soil profile to be Site Class C based on the measured shear wave velocity profile in the upper 30 meters (Vs_{30}) at Boring S-1.

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Methodology

The 2013 CBC requires the procedures of Chapter 21, Site-Specific Ground Motion Procedures for Seismic Design, of ASCE 7-10 be used to determine site-specific seismic response spectra and design parameters. We performed both deterministic and probabilistic seismic hazard analyses (DSHA and PSHA) and processed the results in accordance with the procedures in Chapter 21 of ASCE 7-10.

Conclusions

Results of the analysis are presented on Figure 1, which shows the probabilistic MCE_R spectrum, deterministic MCE spectrum, site-specific MCE_R spectrum, and design response spectrum. Digitized values of the design response spectrum are presented in Table A-1 (attached).

Seismic Design Parameters

To accommodate effects of ground shaking produced by regional seismic events, seismic design can, at the discretion of the designing Structural Engineer, be performed in accordance with the 2013 Edition of the California Building Code (CBC). Table 1, *Seismic Design Parameters* (below), lists code-based and site-specific seismic design parameters based on the 2013 CBC methodology:

Table 1. Seismic Design Parameters

Categorization/Coefficients	Code-Based	Site-Specific
Site Longitude (decimal degrees) West	-117.0227	
Site Latitude (decimal degrees) North	32.6191	
Site Class	C	
Mapped Spectral Response Acceleration at 0.2s Period, S_s	0.878	-
Mapped Spectral Response Acceleration at 1s Period, S_1	0.335	-
Short Period Site Coefficient at 0.2s Period, F_a	1.049	-
Long Period Site Coefficient at 1s Period, F_v	1.465	-
Adjusted Spectral Response Acceleration at 0.2s Period, S_{MS}	0.921	1.146
Adjusted Spectral Response Acceleration at 1s Period, S_{M1}	0.491	0.583
Design Spectral Response Acceleration at 0.2s Period, S_{DS}	0.614	0.764
Design Spectral Response Acceleration at 1s Period, S_{D1}	0.327	0.389

We appreciate the opportunity to work with you on this project. If you have any questions or if we can be of further service, please contact us at ***(866) LEIGHTON***.

Respectfully submitted,

LEIGHTON CONSULTING, INC.

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Project Engineer

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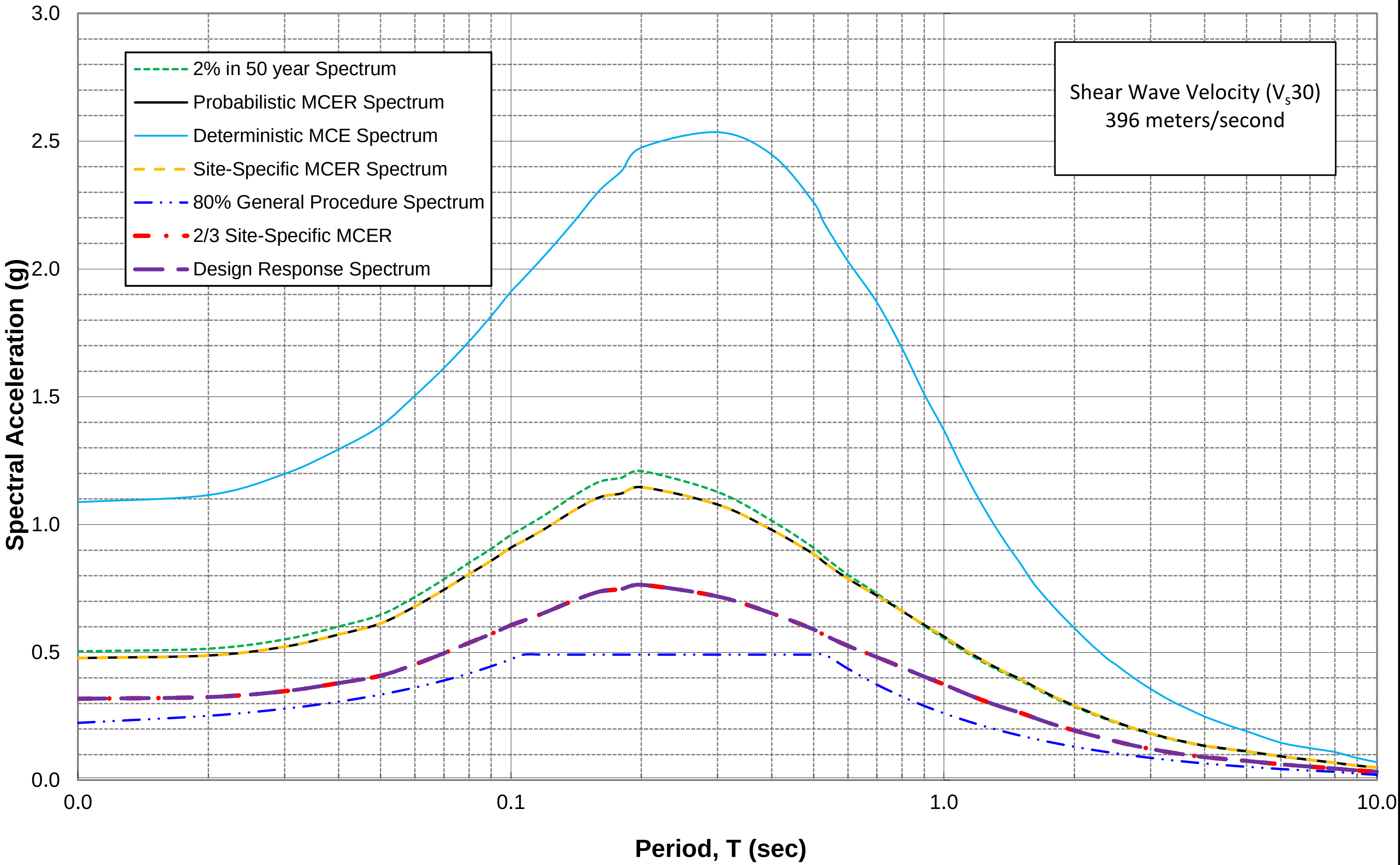
Senior Project Geologist

Carl C. Kim, PE, GE 2620
Senior Principal Engineer

SP/CCK/RCS/lr

Attachments: Figure 1 – Site Specific Response Spectra
Table A-1 – Site Specific Seismic Ground Motion Hazard Analysis per ASCE 7-10
Figure 2 – Existing Site Conditions and Exploration Map
GEOVision Report

Distribution: (1) Addressee



SITE-SPECIFIC RESPONSE SPECTRUM
SHARP CHULA VISTA MEDICAL CENTER
751 MEDICAL CENTER COURT
CHULA VISTA, CALIFORNIA

Project Name:	SHARP CV MC
Project No.:	603541.003
Designed/Checked by:	SP/CCK
Date:	July 2015

Figure 1

Table A-1: Site-Specific Seismic Ground Motion Hazard Analysis per ASCE 7-10

Project Name:		Sharp Chula Vista Medical Center			Date:	July 2015	Seismic Design Coefficients: Per ASCE 7-10/2013 CBC (USGS Seismic Design Maps)					
Project Number:		603541.003			Site Coordinates							
					Latitude	Longitude	S_s	0.878	S_{MS}	0.921	T_0	0.107
Site Class:		C	Chapter 20		32.61914	-117.02279	S_1	0.335	S_{M1}	0.491	T_s	0.533
Shear Wave Velocity:		396	m/sec				F_a	1.049	S_{DS}	0.614	T_L	8
Return Period:		2475	years (2 percent probability of exceedance in 50 years)				F_v	1.465	S_{D1}	0.327	**Design S_{DS}**	**0.764**
Percent Damping:		5	%				C_{RS}	0.948	C_{R1}	1.014	**Design S_{D1}**	**0.389**

	Sec. 21.2.1.1 Method 1 Probabilistic			**Sec. 21.2.2 Deterministic**			**Sec. 21.2.3 Site - Specific**	**Section 11.4.5 General Procedure**	**Sec. 21.3 Design Response Spectrum**			**Section 11.4.6 Risk-Targeted MCE_R**
Period (sec.)	Spectral Acceleration (g)	Siesmic Risk Coefficients from Figs. 22-17 and 22-18 (C_{RS} and C_{R1})	MCE_R Response Spectrum (g)	Spectral Acceleration at 84th-percentile (g)	Lower Limit on MCE_R Response Spectrum Figure 21.2-1	MCE_R Response Spectrum (g)	MCE_R S_{aM} (g)	Response Spectral Accelerations-Sa (g)	Lower Limit of General Procedure Spectrum-80% of Sa (g)	$(2/3)*S_{aM}$	Design Response Spectrum (g)	1.5* Final Design Response Spectrum (g)
0.01	0.504	0.948	0.478	1.088	0.629	1.088	0.478	0.280	0.224	0.319	0.319	0.478
0.02	0.514	0.948	0.488	1.115	0.722	1.115	0.488	0.315	0.252	0.325	0.325	0.488
0.03	0.551	0.948	0.522	1.198	0.815	1.198	0.522	0.349	0.279	0.348	0.348	0.522
0.04	0.601	0.948	0.570	1.295	0.908	1.295	0.570	0.384	0.307	0.380	0.380	0.570
0.05	0.647	0.948	0.613	1.386	1.001	1.386	0.613	0.418	0.335	0.409	0.409	0.613
0.06	0.717	0.948	0.680	1.504	1.093	1.504	0.680	0.453	0.362	0.453	0.453	0.680
0.07	0.786	0.948	0.745	1.612	1.186	1.612	0.745	0.488	0.390	0.497	0.497	0.745
0.08	0.850	0.948	0.806	1.716	1.279	1.716	0.806	0.522	0.418	0.537	0.537	0.806
0.09	0.905	0.948	0.858	1.816	1.372	1.816	0.858	0.557	0.445	0.572	0.572	0.858
0.10	0.960	0.948	0.910	1.911	1.465	1.911	0.910	0.591	0.473	0.606	0.606	0.910
0.11	0.988	0.948	0.936	1.964	1.574	1.964	0.936	0.614	0.491	0.624	0.624	0.936
0.12	1.038	0.948	0.984	2.055	1.574	2.055	0.984	0.614	0.491	0.656	0.656	0.984
0.14	1.113	0.948	1.055	2.186	1.574	2.186	1.055	0.614	0.491	0.704	0.704	1.055
0.16	1.167	0.948	1.107	2.306	1.574	2.306	1.107	0.614	0.491	0.738	0.738	1.107
0.18	1.183	0.948	1.122	2.383	1.574	2.383	1.122	0.614	0.491	0.748	0.748	1.122
0.2	1.209	0.948	1.147	2.474	1.574	2.474	1.147	0.614	0.491	0.764	0.764	1.147
0.3	1.128	0.956	1.078	2.535	1.574	2.535	1.078	0.614	0.491	0.719	0.719	1.078
0.4	1.015	0.965	0.979	2.448	1.574	2.448	0.979	0.614	0.491	0.653	0.653	0.979
0.5	0.909	0.973	0.885	2.261	1.574	2.261	0.885	0.614	0.491	0.590	0.590	0.885
0.53	0.873	0.975	0.851	2.177	1.500	2.177	0.851	0.614	0.491	0.568	0.568	0.851
0.6	0.804	0.981	0.788	2.031	1.465	2.031	0.788	0.545	0.436	0.526	0.526	0.788
0.7	0.730	0.989	0.722	1.870	1.256	1.870	0.722	0.467	0.374	0.482	0.482	0.722
0.8	0.663	0.998	0.662	1.690	1.099	1.690	0.662	0.409	0.327	0.441	0.441	0.662
0.9	0.604	1.006	0.608	1.512	0.977	1.512	0.608	0.364	0.291	0.405	0.405	0.608
1	0.554	1.014	0.562	1.369	0.879	1.369	0.562	0.327	0.262	0.375	0.375	0.562

Table A-1: Site-Specific Seismic Ground Motion Hazard Analysis per ASCE 7-10

Project Name:	Sharp Chula Vista Medical Center			Date:	July 2015
Project Number:	603541.003			Site Coordinates	
				Latitude	Longitude
Site Class:	C	Chapter 20		32.61914	-117.02279
Shear Wave Velocity:	396	m/sec			
Return Period:	2475	years (2 percent probability of exceedance in 50 years)			
Percent Damping:	5	%			

Seismic Design Coefficients: Per ASCE 7-10/2013 CBC (USGS Seismic Design Maps)					
S_s	0.878	S_{MS}	0.921	T_0	0.107
S_1	0.335	S_{M1}	0.491	T_s	0.533
F_a	1.049	S_{DS}	0.614	T_L	8
F_v	1.465	S_{D1}	0.327	**Design S_{DS}**	**0.764**
C_{RS}	0.948	C_{R1}	1.014	**Design S_{D1}**	**0.389**

	Sec. 21.2.1.1 Method 1 Probabilistic			**Sec. 21.2.2 Deterministic**			**Sec. 21.2.3 Site - Specific**	**Section 11.4.5 General Procedure**	**Sec. 21.3 Design Response Spectrum**			**Section 11.4.6 Risk-Targeted MCE_R**
Period (sec.)	Spectral Acceleration (g)	Siesmic Risk Coefficients from Figs. 22-17 and 22-18 (C_{RS} and C_{R1})	MCE_R Response Spectrum (g)	Spectral Acceleration at 84th-percentile (g)	Lower Limit on MCE_R Response Spectrum Figure 21.2-1	MCE_R Response Spectrum (g)	MCE_R S_{aM} (g)	Response Spectral Accelerations-Sa (g)	Lower Limit of General Procedure Spectrum-80% of Sa (g)	$(2/3)*S_{aM}$	Design Response Spectrum (g)	1.5* Final Design Response Spectrum (g)
1.1	0.510	1.014	0.517	1.224	0.799	1.224	0.517	0.297	0.238	0.345	0.345	0.517
1.2	0.472	1.014	0.479	1.104	0.733	1.104	0.479	0.273	0.218	0.319	0.319	0.479
1.3	0.440	1.014	0.446	1.005	0.676	1.005	0.446	0.252	0.201	0.297	0.297	0.446
1.4	0.413	1.014	0.419	0.920	0.628	0.920	0.419	0.234	0.187	0.279	0.279	0.419
1.5	0.390	1.014	0.396	0.849	0.586	0.849	0.396	0.218	0.174	0.264	0.264	0.396
1.6	0.365	1.014	0.370	0.777	0.549	0.777	0.370	0.204	0.164	0.247	0.247	0.370
1.7	0.341	1.014	0.346	0.722	0.517	0.722	0.346	0.192	0.154	0.231	0.231	0.346
1.8	0.321	1.014	0.326	0.675	0.488	0.675	0.326	0.182	0.145	0.217	0.217	0.326
1.9	0.304	1.014	0.308	0.633	0.463	0.633	0.308	0.172	0.138	0.205	0.205	0.308
2	0.288	1.014	0.292	0.596	0.440	0.596	0.292	0.164	0.131	0.195	0.195	0.292
2.1	0.273	1.014	0.276	0.560	0.419	0.560	0.276	0.156	0.125	0.184	0.184	0.276
2.2	0.259	1.014	0.263	0.527	0.400	0.527	0.263	0.149	0.119	0.175	0.175	0.263
2.3	0.247	1.014	0.250	0.498	0.382	0.498	0.250	0.142	0.114	0.167	0.167	0.250
2.4	0.234	1.014	0.237	0.472	0.366	0.472	0.237	0.136	0.109	0.158	0.158	0.237
2.5	0.224	1.014	0.227	0.451	0.352	0.451	0.227	0.131	0.105	0.152	0.152	0.227
2.6	0.214	1.014	0.217	0.429	0.338	0.429	0.217	0.126	0.101	0.144	0.144	0.217
2.7	0.204	1.014	0.207	0.409	0.326	0.409	0.207	0.121	0.097	0.138	0.138	0.207
2.8	0.196	1.014	0.199	0.390	0.314	0.390	0.199	0.117	0.093	0.132	0.132	0.199
2.9	0.188	1.014	0.191	0.373	0.303	0.373	0.191	0.113	0.090	0.127	0.127	0.191
3	0.181	1.014	0.184	0.357	0.293	0.357	0.184	0.109	0.087	0.122	0.122	0.184
3.2	0.168	1.014	0.170	0.329	0.275	0.329	0.170	0.102	0.082	0.114	0.114	0.170
3.4	0.157	1.014	0.159	0.304	0.259	0.304	0.159	0.096	0.077	0.106	0.106	0.159
3.6	0.149	1.014	0.151	0.285	0.244	0.285	0.151	0.091	0.073	0.100	0.100	0.151
3.8	0.140	1.014	0.142	0.266	0.231	0.266	0.142	0.086	0.069	0.095	0.095	0.142
4	0.133	1.014	0.135	0.249	0.220	0.249	0.135	0.082	0.065	0.090	0.090	0.135

Table A-1: Site-Specific Seismic Ground Motion Hazard Analysis per ASCE 7-10

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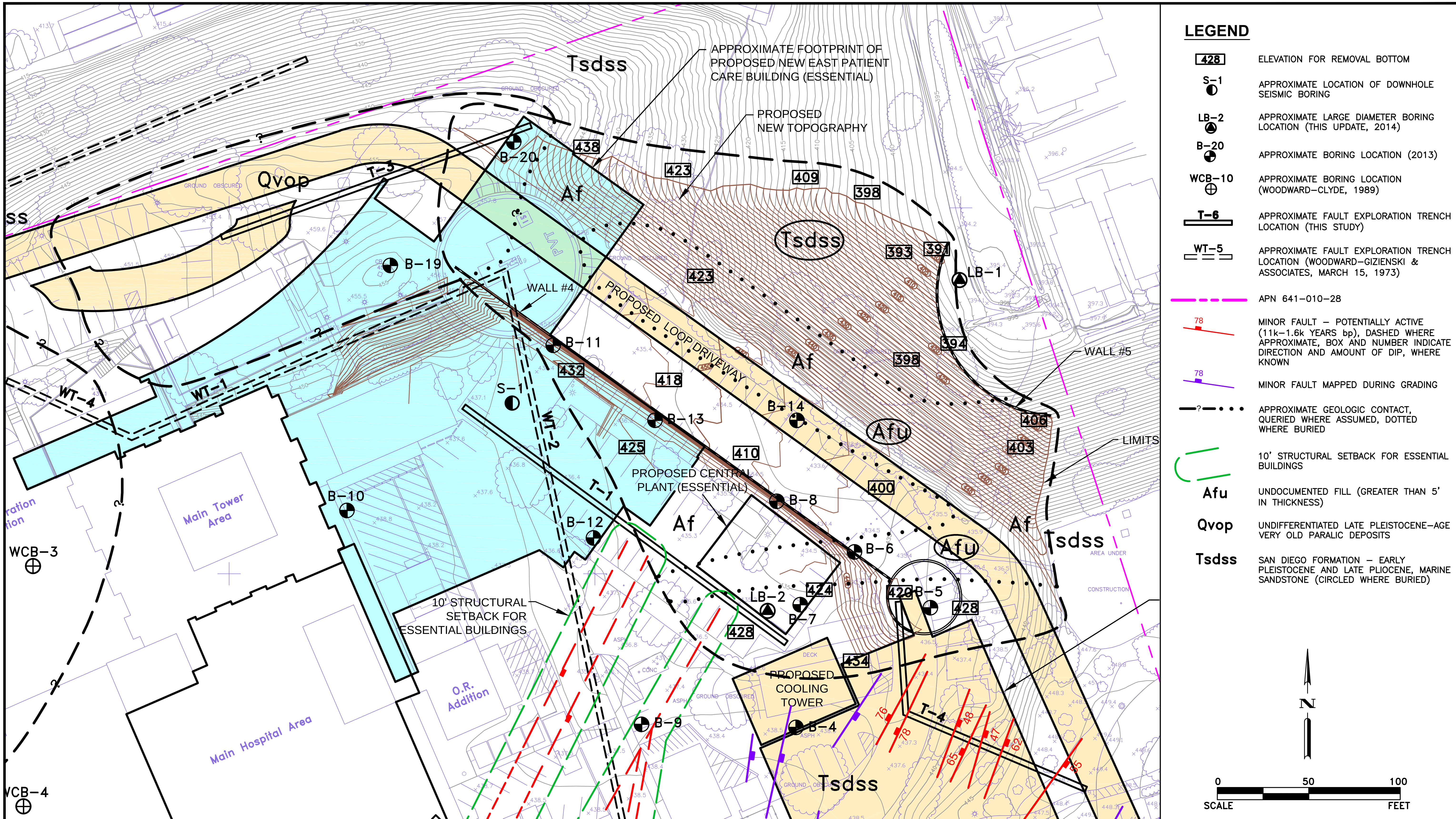
Return Period:		2475	years (2 percent probability of exceedance in 50 years)				F_v	1.465	S_{D1}	0.327	**Design S_{DS}**	**0.764**
Percent Damping:		5	%				C_{RS}	0.948	C_{R1}	1.014	**Design S_{D1}**	**0.389**
	Sec. 21.2.1.1 Method 1 Probabilistic			**Sec. 21.2.2 Deterministic**			**Sec. 21.2.3 Site - Specific**	**Section 11.4.5 General Procedure**	**Sec. 21.3 Design Response Spectrum**			**Section 11.4.6 Risk-Targeted MCE_R**
Period (sec.)	Spectral Acceleration (g)	Siesmic Risk Coefficients from Figs. 22-17 and 22-18 (C_{RS} and C_{R1})	MCE_R Response Spectrum (g)	Spectral Acceleration at 84th-percentile (g)	Lower Limit on MCE_R Response Spectrum Figure 21.2-1	MCE_R Response Spectrum (g)	MCE_R S_{aM} (g)	Response Spectral Accelerations-Sa (g)	Lower Limit of General Procedure Spectrum-80% of Sa (g)	(2/3)*S_{aM}	Design Response Spectrum (g)	1.5* Final Design Response Spectrum (g)
4.2	0.128	1.014	0.130	0.235	0.209	0.235	0.130	0.078	0.062	0.087	0.087	0.130
4.4	0.123	1.014	0.125	0.223	0.200	0.223	0.125	0.074	0.059	0.083	0.083	0.125
4.6	0.119	1.014	0.121	0.211	0.191	0.211	0.121	0.071	0.057	0.080	0.080	0.121
4.8	0.115	1.014	0.117	0.201	0.183	0.201	0.117	0.068	0.055	0.078	0.078	0.117
5	0.112	1.014	0.113	0.192	0.176	0.192	0.113	0.065	0.052	0.075	0.075	0.113
6	0.092	1.014	0.093	0.144	0.147	0.147	0.093	0.055	0.044	0.062	0.062	0.093
7	0.079	1.014	0.080	0.114	0.126	0.126	0.080	0.047	0.037	0.053	0.053	0.080
8	0.067	1.014	0.068	0.089	0.110	0.110	0.068	0.041	0.033	0.045	0.045	0.068
9	0.056	1.014	0.057	0.071	0.087	0.087	0.057	0.032	0.026	0.038	0.038	0.057
10	0.049	1.014	0.049	0.060	0.070	0.070	0.049	0.026	0.021	0.033	0.033	0.049



Project: 603541-003	Eng/Geol: DBN/RCS
Scale: 1"=50'	Date: July 2015
Reference:	
Author: MAM	

EXISTING SITE CONDITIONS AND EXPLORATION

Sharp Chula Vista Tower Project
Foundation Recommendations
Chula Vista, California

Figure 2

Leighton

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SUSPENSION P & S VELOCITIES

AND Vs30

CHULA VISTA HOSPITAL

BORING B-1

Report 14242-01 rev 0

September 16, 2014

SUSPENSION P & S VELOCITIES
AND Vs30
CHULA VISTA HOSPITAL
BORING B-1

Report 14242-01 rev 0

September 16, 2014

Prepared for:

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APPENDICES

INTRODUCTION

Boring geophysical measurements were collected in one 4 inch diameter uncased boring at the Chula Vista Hospital in Chula Vista, California. Geophysical data acquisition was performed on August 29, 2014 by Victor Gonzalez of **GEO***Vision*. Data analysis and report preparation was performed by Emily Feldman and reviewed by John Diehl of **GEO***Vision*. The work was performed under subcontract with Leighton Consulting, Inc. (Leighton), with Bob Stroh serving as the point of contact.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of suspension velocity measurements in one uncased boring, as detailed in Table 1. The purpose of the study was to supplement stratigraphic information obtained during Leighton's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth, as well as to determine Vs30 for the site.

BORING DESIGNATION	DATES LOGGED	BORING DEPTH (FEET)	LOCATION* (ESTIMATED ON GOOGLE EARTH)
B-1	8/29/2014	140	32^{o} 37.168' N, 117^{o} 1.364' W

Table 1: Boring locations and logging dates

*Location data not available at time of report issuance

The OYO Suspension Logging System was used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.6-foot intervals. The acquired data were analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

Suspension soil velocity measurements were performed using the PS suspension logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. This system directly determines the average velocity of a 3.3-foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The typical total length of the probe is 21 feet, with the center point of the receiver pair 12.5 feet above the bottom end of the probe.

The probe receives control signals from, and sends the receiver signals to, instrumentation on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28-foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 6.3-foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H-wave signal, permitting additional separation of the two signals by low pass filtering.
4. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe, preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed at least every twelve months using a NIST traceable frequency source and counter, as presented in Appendix B.

MEASUREMENT PROCEDURES

The boring was logged uncased, filled with bentonite based drilling mud. Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.5. Prior to each logging run, the suspension probe was positioned with the mid-point of the receiver spacing at grade, and the mechanical and electronic depth counters were set to zero. The probe was lowered to the bottom of the boring or until probe descent was inhibited, stopping at 1.6-foot intervals to collect data, as summarized in Table 2.

At each measurement depth, the measurement sequence of two opposite horizontal records and one vertical record was performed and the gains were adjusted as required. The data from each depth were viewed on the computer display, checked, and recorded on disk before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at the stationary reference point was verified and recorded on the field logs prior to removal from the boring. Field data were backed up to USB flash drive upon completion of data acquisition.

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	DEPTH TO BOTTOM OF BORING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
B-1	SUSPENSION PS 1	4.92 – 125.0	140	1.6	8/29/2014

Table 2: Logging dates and depth ranges

DATA ANALYSIS

Using the proprietary OYO program PSLOG.EXE version 1.0, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3-foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into a Microsoft Excel® template (version 2003 SP2) to complete the velocity calculations based on the arrival time picks made in PSLOG.

The P-wave velocity over the 6.3-foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in Microsoft Excel®, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 5.15 feet to correspond to the mid-point of the 6.3-foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact, typically 4 milliseconds. This delay corresponds to the duration of acceleration of the solenoid before impact.

As with the P-wave records, using PSLOG, the recorded digital waveforms were analyzed to locate the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT low-pass filtering can be used to remove the higher frequency P-wave signal from the S_H-wave signal.

Generally, the first maxima were picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.33-foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 5.15 feet to correspond to the mid-point of the 6.3-foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact, typically 4 milliseconds.

These data and analysis were reviewed by John Diehl as a component of **GEO***Vision*'s in-house QA-QC program.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.3-foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1,745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital low-pass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

Vs30 was calculated by summing the calculated travel times over each 1.64 ft interval from 0 ft (0 m) to a depth of 98.4 ft (30.0 m).

RESULTS

Suspension P- and S_H-wave velocities for boring B-1 are plotted with the calculated Vs30 of 396 m/sec (1300 ft/sec) in Figure 4. The calculated suspension travel time curves for boring B-1 are presented with the calculated Vs30 in Figure 5. Tabulated measurement depths, pick times and velocities are presented in Table 3. These plots and data are included in the Microsoft Excel® analysis files accompanying this report.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figure A-1 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3-foot segment of the soil column; S-R1 data are an average over 6.3 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Table A-1, and included in the Microsoft Excel® analysis files.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods, as this boring was.

Suspension PS velocity data quality is judged based upon 5 criteria:

1. Consistent data between receiver to receiver (R1 – R2) and source to receiver (S – R1) data.
2. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
3. Consistency between data from adjacent depth intervals.
4. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations.
5. Consistency of profile between adjacent borings, if available.

These data show excellent correlation between R1 – R2 and S – R1 data, as well as good correlation between P-wave and S_H-wave velocities. P-wave and S_H-wave onsets are generally clear, and later oscillations are well damped. These are excellent quality velocity data. Both borings provide velocity profiles indicative of soft rock transitioning into hard rock, overlain by a layer of weathered rock or soil.

Discussion of Vs30

Vs30 for B-1 from 6.6 to 105 ft (2.0 – 32.0 m) was calculated at 1300 ft/sec (396 m/sec), classifying it as a NEHRP site class C.

Quality Assurance

These boring geophysical measurements were performed using industry-standard or better methods for measurements and analyses. All work was performed under **GEO***Vision* quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of velocity data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Suspension Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.3-foot interval of depth. This high resolution results in the scatter of values shown in the graphs. In uncased borings, individual measurements are very reliable, with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks contribute to the reliability of the data.

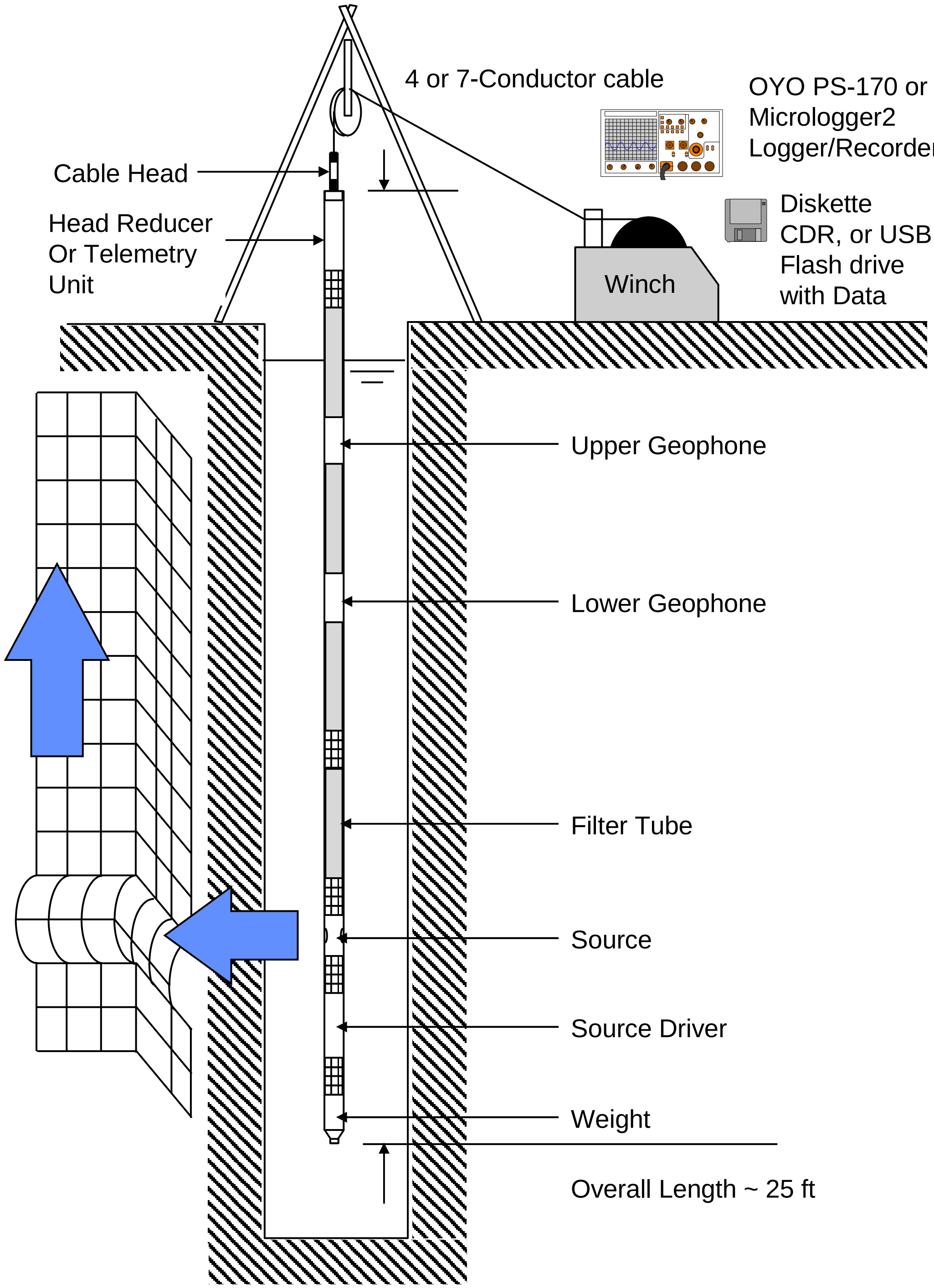

Figure 1: Concept illustration of P-S logging system

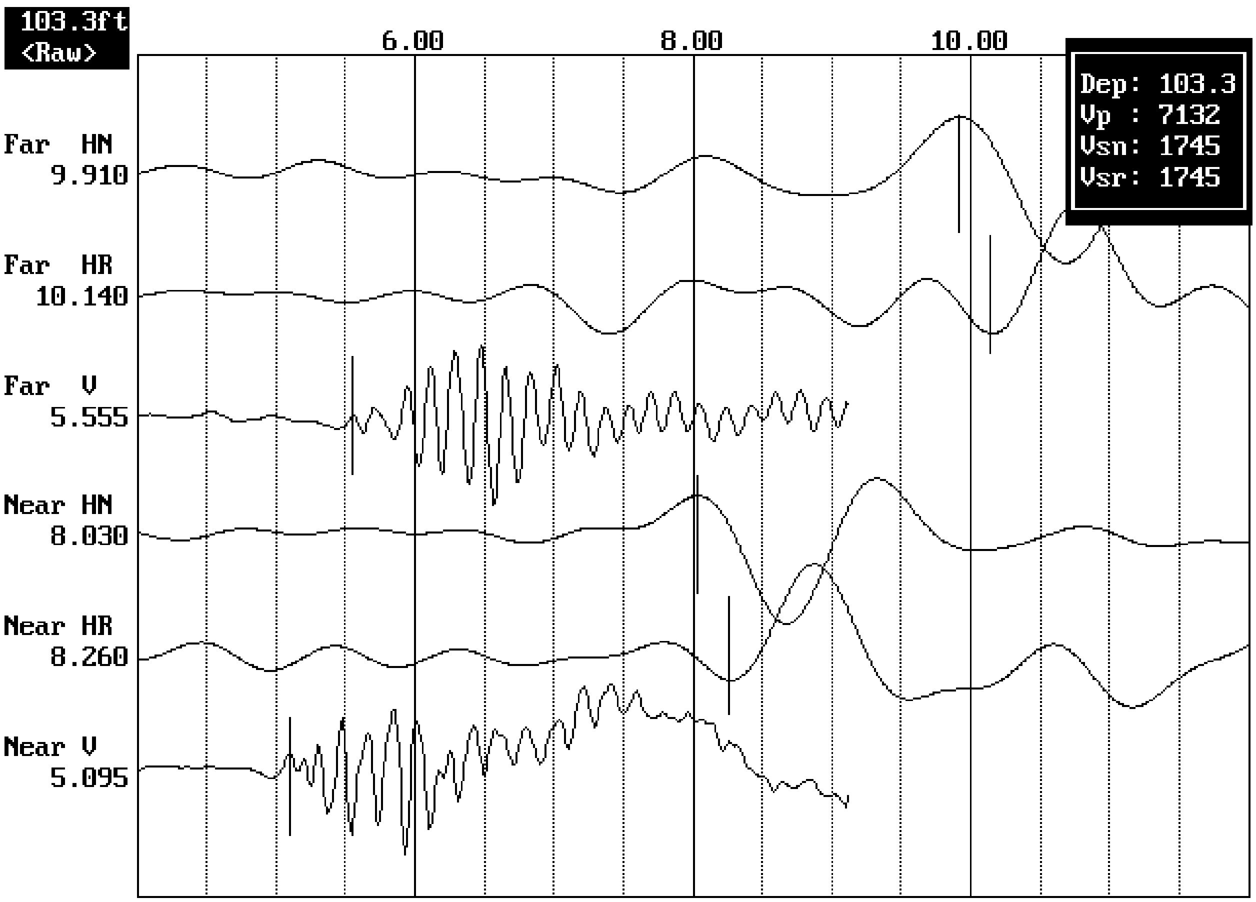

Figure 2: Example of filtered (1400 Hz lowpass) record

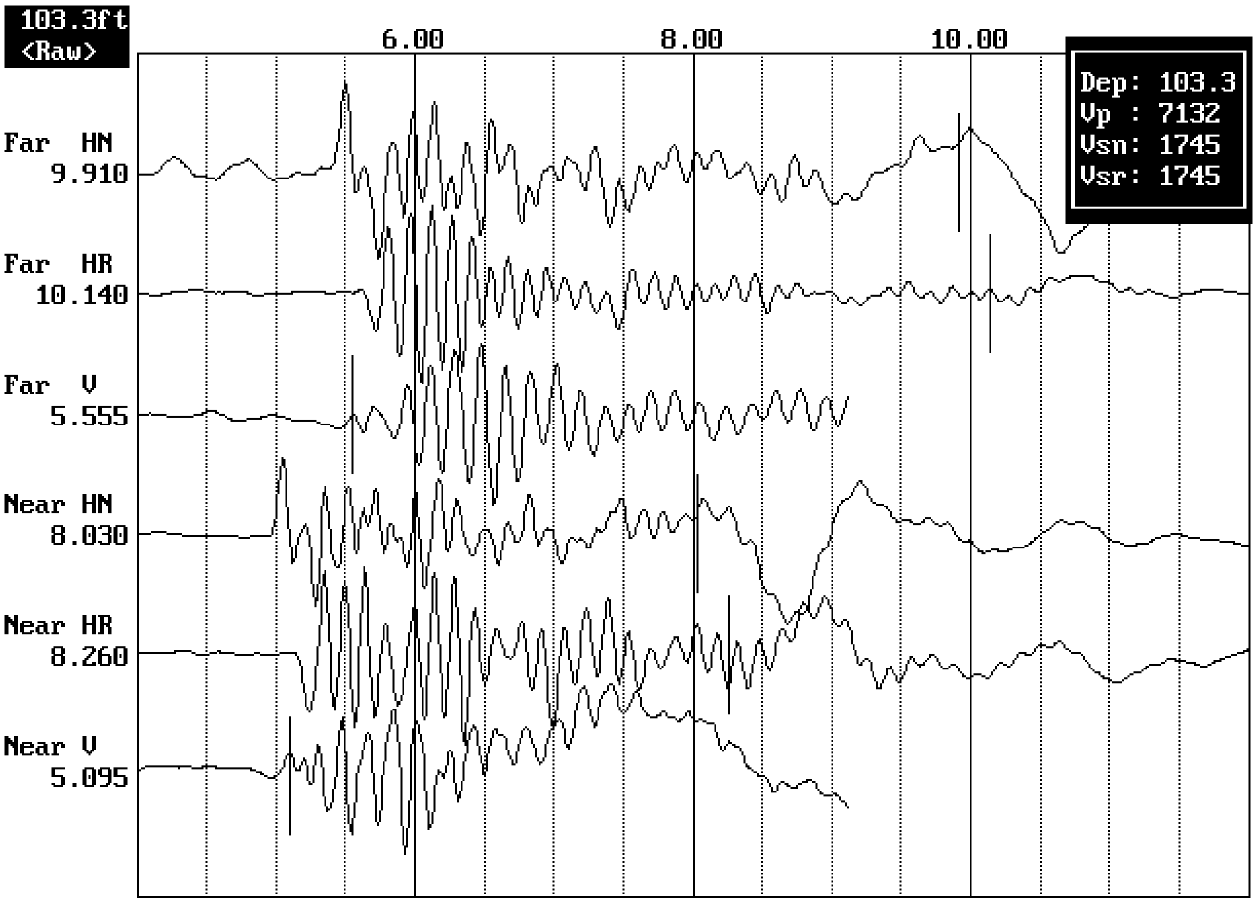

Figure 3: Example of unfiltered record

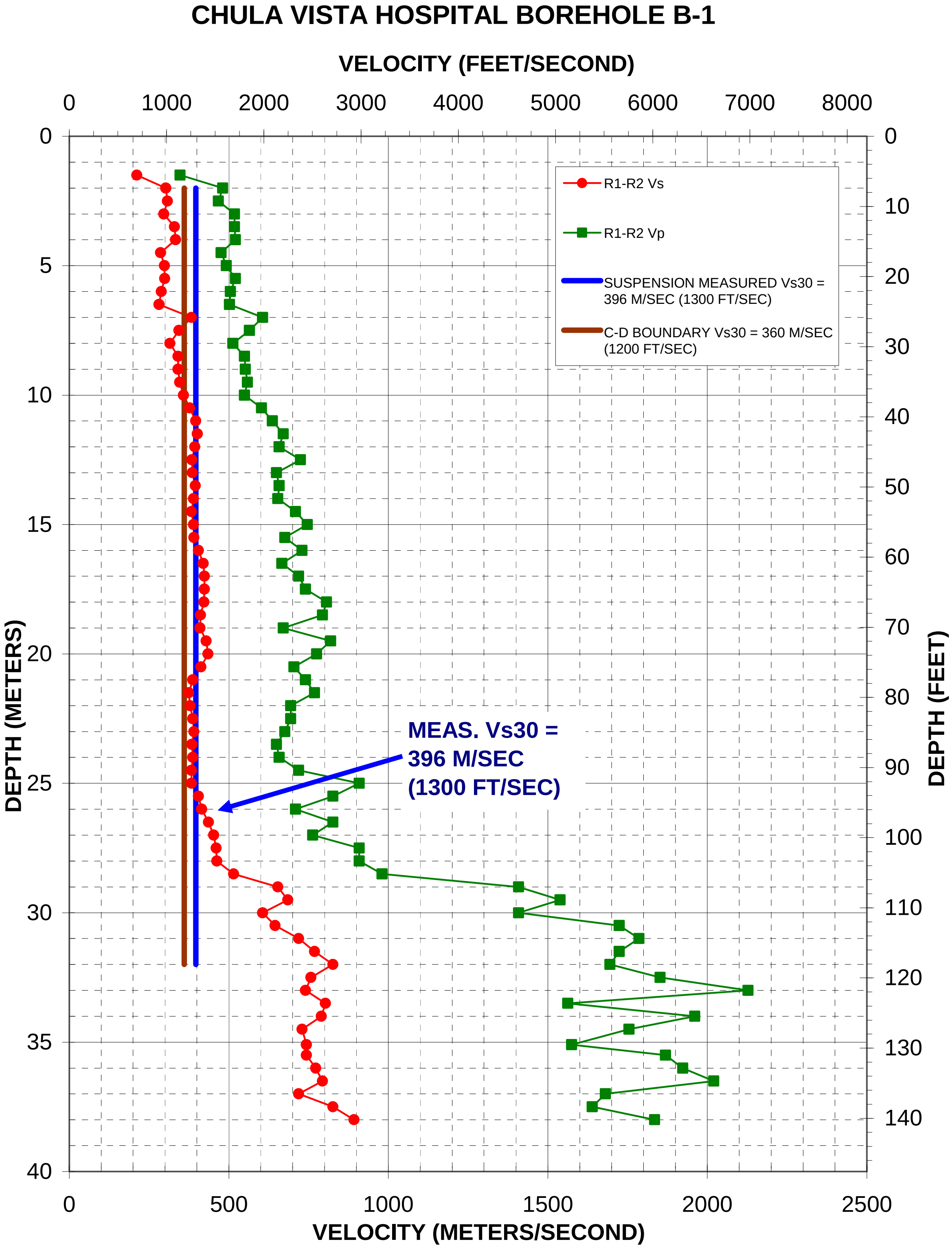

Figure 4: Boring B-1, Suspension R1-R2 P- and S_H-wave velocities with Vs30 values

Table 3: Boring B-1, Suspension R1-R2 depths and P- and S_H-wave velocities

RECEIVER 1 - RECEIVER 2 VELOCITY DATA					
	METRIC			ENGLISH	
DEPTH	Vs	Vp	DEPTH	Vs	Vp
(M)	(M/SEC)	(M/SEC)	(FT)	(FT/SEC)	(FT/SEC)
1.5	212	347	4.92	694	1139
2.0	303	481	6.56	994	1577
2.5	308	467	8.20	1009	1533
3.0	296	518	9.84	972	1700
3.5	330	518	11.48	1083	1700
4.0	333	521	13.12	1094	1709
4.5	287	476	14.76	940	1562
5.0	299	493	16.40	979	1616
5.5	299	521	18.04	982	1709
6.0	288	505	19.69	945	1657
6.5	282	503	21.33	924	1649
7.0	383	606	22.97	1257	1988
7.5	344	565	24.61	1127	1854
8.0	315	513	26.25	1035	1682
8.5	341	549	27.89	1120	1803
9.0	341	552	29.53	1120	1813
9.5	346	559	31.17	1135	1833
10.0	358	549	32.81	1176	1803
10.5	377	602	34.45	1238	1976
11.0	397	637	36.09	1302	2090
11.5	402	671	37.73	1318	2202
12.0	394	658	39.37	1292	2158
12.5	385	725	41.01	1262	2377
13.0	386	649	42.65	1267	2130
13.5	395	658	44.29	1297	2158
14.0	389	654	45.93	1277	2144
14.5	383	709	47.57	1257	2327
15.0	389	746	49.21	1277	2448
15.5	391	676	50.85	1282	2217
16.0	405	730	52.49	1328	2395
16.5	420	667	54.13	1379	2187
17.0	424	719	55.77	1390	2360
17.5	424	741	57.41	1390	2430
18.0	422	806	59.06	1384	2646
18.5	412	794	60.70	1350	2604
19.0	410	671	62.34	1345	2202

RECEIVER 1 - RECEIVER 2 VELOCITY DATA					
	METRIC			ENGLISH	
DEPTH	Vs	Vp	DEPTH	Vs	Vp
(M)	(M/SEC)	(M/SEC)	(FT)	(FT/SEC)	(FT/SEC)
19.5	429	820	63.98	1408	2689
20.0	435	775	65.62	1426	2543
20.5	413	704	67.26	1356	2310
21.0	388	741	68.90	1272	2430
21.5	375	769	70.54	1229	2524
22.0	379	694	72.18	1243	2278
22.5	388	694	73.82	1272	2278
23.0	391	676	75.46	1282	2217
23.5	385	649	77.10	1262	2130
24.0	388	658	78.74	1272	2158
24.5	383	719	80.38	1257	2360
25.0	383	909	82.02	1257	2983
25.5	405	826	83.66	1328	2711
26.0	415	709	85.30	1361	2327
26.5	437	826	86.94	1433	2711
27.0	452	763	88.58	1485	2504
27.5	461	909	90.22	1512	2983
28.0	463	909	91.86	1519	2983
28.5	515	980	93.50	1691	3217
29.0	654	1408	95.14	2144	4621
29.5	685	1538	96.78	2247	5047
30.0	606	1408	98.43	1988	4621
30.5	645	1724	100.07	2117	5657
31.0	719	1786	101.71	2360	5859
31.5	769	1724	103.35	2524	5657
32.0	826	1695	104.99	2711	5561
32.5	758	1852	106.63	2485	6076
33.0	741	2128	108.27	2430	6981
33.5	803	1563	109.91	2635	5126
34.0	791	1961	111.55	2594	6433
34.5	730	1754	113.19	2395	5756
35.1	743	1575	115.16	2439	5167
35.5	743	1869	116.47	2439	6132
36.0	772	1923	118.11	2533	6309
36.5	794	2020	119.75	2604	6628
37.0	719	1681	121.39	2360	5514
37.5	826	1639	123.03	2711	5378
38.0	893	1835	124.67	2929	6020

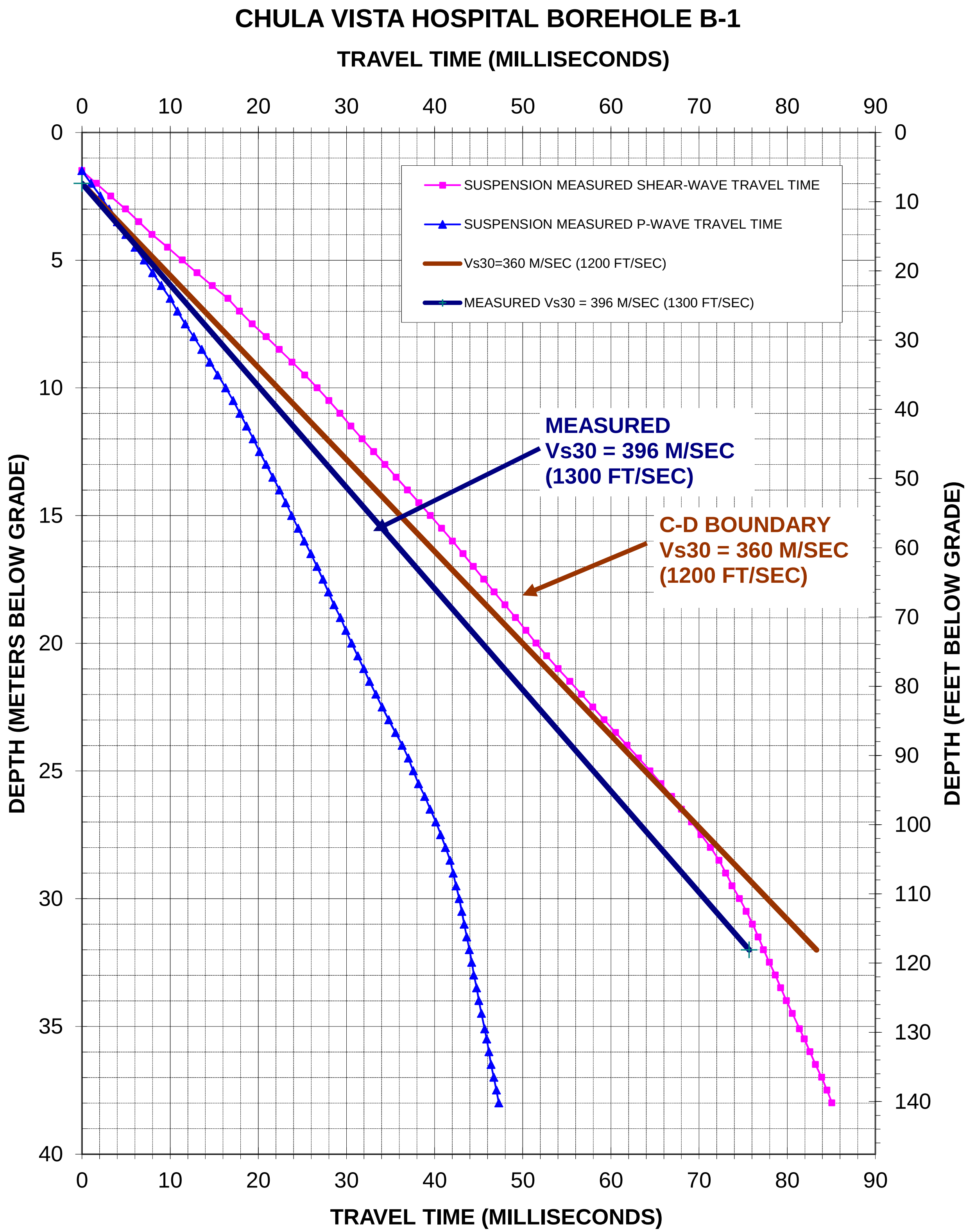

Figure 5: Boring B-1, Suspension P- and S_H-wave travel times with Vs30 values

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

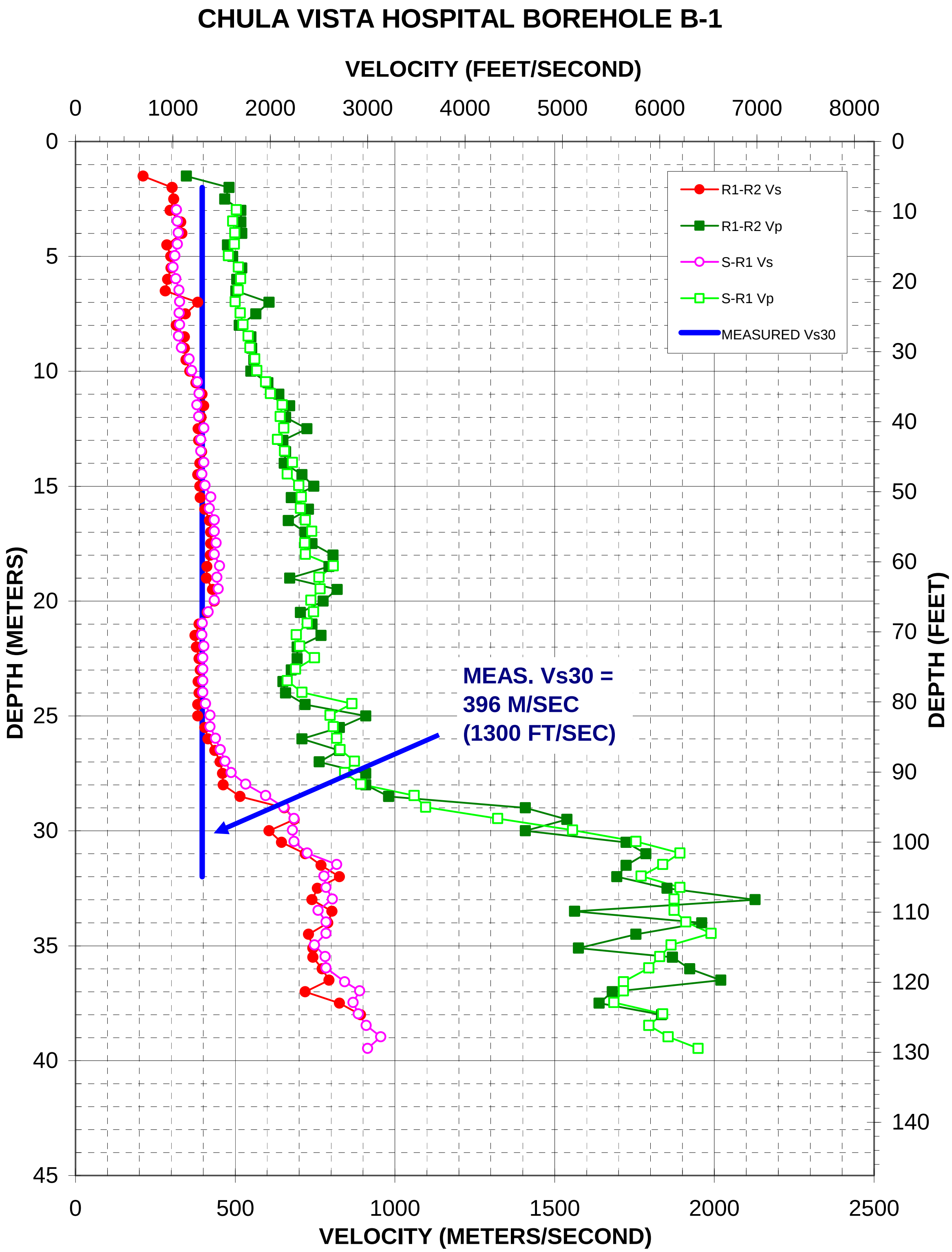

Figure A-1. Boring B-1, R1 - R2 high resolution analysis and S - R1 quality assurance analysis P- and S_H-wave data

Table A-1. Boring B-1, S - R1 quality assurance analysis P- and S_H-wave data

SOURCE - RECEIVER 1 VELOCITY DATA					
	METRIC			ENGLISH	
DEPTH	Vs	Vp	DEPTH	Vs	Vp
(M)	(M/SEC)	(M/SEC)	(FT)	(FT/SEC)	(FT/SEC)
3.0	316	504	9.73	1038	1653
3.5	319	492	11.37	1047	1615
4.0	322	499	13.01	1055	1636
4.5	319	497	14.65	1047	1632
5.0	311	479	16.29	1021	1571
5.5	305	511	17.93	1002	1675
6.0	314	517	19.57	1031	1698
6.5	324	509	21.21	1062	1671
7.0	326	500	22.85	1070	1640
7.5	325	516	24.49	1066	1693
8.0	326	524	26.13	1070	1721
8.5	323	541	27.77	1059	1774
9.0	332	547	29.41	1088	1794
9.5	356	561	31.05	1168	1841
10.0	364	568	32.69	1195	1862
10.5	381	596	34.33	1251	1954
11.0	388	611	35.97	1271	2004
11.5	380	648	37.61	1246	2125
12.0	386	641	39.26	1266	2104
12.5	402	652	40.90	1319	2139
13.0	392	633	42.54	1287	2076
13.5	392	654	44.18	1287	2146
14.0	402	680	45.82	1319	2230
14.5	395	663	47.46	1298	2176
15.0	405	699	49.10	1330	2294
15.5	423	707	50.74	1389	2319
16.0	420	704	52.38	1377	2311
16.5	435	720	54.02	1426	2363
17.0	435	739	55.66	1426	2426
17.5	441	717	57.30	1446	2354
18.0	435	720	58.94	1426	2363
18.5	451	808	60.58	1479	2649
19.0	443	763	62.22	1452	2503
19.5	447	766	63.86	1466	2513
20.0	435	737	65.50	1426	2417
20.5	416	745	67.14	1365	2445
21.0	397	726	68.78	1303	2380

SOURCE - RECEIVER 1 VELOCITY DATA					
	METRIC			ENGLISH	
DEPTH	Vs	Vp	DEPTH	Vs	Vp
(M)	(M/SEC)	(M/SEC)	(FT)	(FT/SEC)	(FT/SEC)
21.5	395	692	70.42	1298	2270
22.0	402	702	72.06	1319	2303
22.5	399	748	73.70	1308	2454
23.0	399	689	75.34	1308	2261
23.5	399	663	76.98	1308	2176
24.0	399	710	78.63	1308	2328
24.5	407	865	80.27	1336	2839
25.0	421	798	81.91	1383	2617
25.5	421	808	83.55	1383	2649
26.0	439	818	85.19	1439	2683
26.5	453	828	86.83	1486	2718
27.0	468	873	88.47	1537	2865
27.5	487	843	90.11	1599	2765
28.0	533	894	91.75	1749	2931
28.5	596	1060	93.39	1954	3479
29.0	652	1097	95.03	2139	3598
29.5	684	1322	96.67	2245	4337
30.0	680	1556	98.31	2230	5106
30.5	684	1755	99.95	2245	5756
31.0	726	1892	101.59	2380	6208
31.5	818	1838	103.23	2683	6030
32.0	778	1771	104.87	2553	5809
32.5	785	1892	106.51	2574	6208
33.0	804	1874	108.15	2638	6148
33.5	760	1874	109.79	2493	6148
34.0	785	1911	111.43	2574	6269
34.5	785	1990	113.07	2574	6528
35.0	748	1865	114.71	2454	6118
35.5	781	1829	116.35	2564	6002
36.0	785	1795	118.00	2574	5890
36.6	843	1716	119.96	2765	5628
37.0	889	1716	121.28	2918	5628
37.5	869	1686	122.92	2852	5530
38.0	885	1838	124.56	2905	6030
38.5	910	1795	126.20	2987	5890
39.0	955	1856	127.84	3135	6088
39.5	915	1949	129.48	3001	6396

APPENDIX B

BORING GEOPHYSICAL LOGGING SYSTEMS - NIST TRACEABLE CALIBRATION RECORDS

MICRO PRECISION CALIBRATION, INC
12686 HOOVER ST
GARDEN GROVE CA 92841
714-901-5659

Calibration CERT #
935.11

Certificate of Calibration

Date: Aug 27, 2014 **Cert No. 222008122227166**

Customer:
GEOVISION
1124 OLYMPIC DRIVE
CORONA CA 92881

Work Order #: LA-90014973

MPC Control #:	AM6768	Serial Number:	160024
Asset ID:	160024	Department:	N/A
Gage Type:	LOGGER	Performed By:	STEVE BORING
Manufacturer:	OYO	Received Condition:	IN TOLERANCE
Model Number:	3403	Returned Condition:	IN TOLERANCE
Size:	N/A	Cal. Date:	August 26, 2014
Temp/RH:	71°F / 52 %	Cal. Interval:	12 MONTHS
		Cal. Due Date:	August 26, 2015

Calibration Notes:

See attached data sheet for calculations.
Calibrated IAW customer supplied data form Rev 2.1
Frequency measurement uncertainty = 0.0005 Hz
Unit calibrated with Laptop Panasonic s/n: 5KKSA84231
Calibrated to 4:1 accuracy ratio.

Standards Used to Calibrate Equipment

I.D.	Description.	Model	Serial	Manufacturer	Cal. Due Date	Traceability #
BD7715	UNIVERSAL COUNTER	53131A	3416A05377	HEWLETT PACKARD	Aug 1, 2015	222008122225973
CC8416	MULTIFUNCTION CALIBRATOR	5700A	5860909	FLUKE	Dec 3, 2014	220081202213692

Procedures Used in this Event

Procedure Name	Description
GEOVISION SEISMIC	Suspension PS Seismic Logger/Recorder Calibration Procedure

Calibrating Technician: STEVE BORING

QC Approval: Jim Williams

GEOVision geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3403
Serial no.:	160024	Calibration date:	8/26/2014
By:	Charles Carter	Due date:	8/26/2015
Counter mfg.:	Hewlett-Packard	Model no.:	53131A
Serial no.:	3146A05377	Calibration date:	8/1/2014
By:	Microprecision	Due date:	8/1/2015
Signal generator mfg.:	Fluke	Model no.:	5700A
Serial no.:	5860909	Calibration date:	12/3/2014
By:	Microprecision	Due date:	12/3/2015
Laptop controller mfg.:	Panasonic	Model no.:	Toughbook CF-29
Serial no.:	5KKSA84231	Calibration date:	N/A

SYSTEM SETTINGS:

Gain:	2
Filter	10KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	8/26/2014 10:55

PROCEDURE:

Set sine wave frequency to target frequency with amplitude of approximately 0.25 volt peak
Note actual frequency on data form.
Set sample period and record data file to disk. Note file name on data form.
Pick duration of 9 cycles using PSLOG.EXE program, note duration on data form, and save as .sps file. Calculate average frequency for each channel pair and note on data form.

Average frequency must be within +/- 1% of actual frequency at all data points.

Maximum error ((AVG-ACT)/ACT*100)% As found + 0.12% As left + 0.12%

Target Frequency (Hz)	Actual Frequency (Hz)	Sample Period (microS)	File Name	Time for 9 cycles Hn (msec)	Average Frequency Hn (Hz)	Time for 9 cycles Hr (msec)	Average Frequency Hr (Hz)	Time for 9 cycles V (msec)	Average Frequency V (Hz)
50.00	50.00	200	019	180.0	50.00	180.0	50.00	180.2	49.94
100.0	100.0	100	020	90.00	100.0	90.10	99.9	90.10	99.9
200.0	200.0	50	021	45.05	199.8	45.00	200.0	45.00	200.0
500.0	500.0	20	022	18.00	500.0	18.02	499.4	18.00	500.0
1000	999.97	10	023	9.000	1000	9.000	1000.0	8.990	1001.1
2000	1999.92	5	024	4.500	2000	4.495	2002	4.495	2002

Calibrated by: Steve Boring — Name; 8/26/2014 — Date; Steve Boring — Signature

Witnessed by: Charles Carter — Name; 8/26/2014 — Date; Charles Carter — Signature

Suspension PS Seismic Recorder/Logger Calibration Data Form Rev 2.1 February 7, 2012