REPORT

P-S SUSPENSION LOGGING
BOREHOLE B-11GEO

PORT ACCESS ROAD
NORTH CHARLESTON, SOUTH CAROLINA

Report 8456-01 Rev 1

December 22, 2008

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Report 8456-01 Rev 1
Prepared for:

S&ME, Inc.
620 Wando Park Boulevard
Mt. Pleasant SC 29464

Prepared by

GEOVision Geophysical Services
1124 Olympic Drive
Corona, California 92881
(951) 549-1234

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INTRODUCTION

OYO suspension velocity measurements were performed in a single borehole adjacent to I-26 off Austin Road, in North Charleston, South Carolina, as a component of the geotechnical investigation of the Port Access Road. Suspension logging data acquisition was performed on October 17 and December 11, 2008 by John Diehl of GEOVision. The analysis and report were prepared by John Diehl and all work was reviewed by Antony Martin, also of GEOVision. The work was performed under subcontract with S&ME of Charleston, with Aaron Goldberg as the point of contact for S&ME.

This report presents the results of suspension velocity measurements collected in the uncased boring designated B-11GEO, as detailed below. The purpose of this study was to acquire shear wave velocities and compressional wave velocities as a function of depth.

BORING DESIGNATION	DATES LOGGED	GENERAL LOCATION	GROUND SURFACE ELEVATION + (FT)	COORDINATES*	
				LAT (North)	LONG (West)
B-11GEO 60-500ft	10-17-08	Charleston, SC	8.5	32.833599	79.958476
B-11GEO 500-800ft	12-11-08	Charleston, SC	8.5	32.833599	79.958476

*coordinates are in NAD 83 latitudes and longitudes

+ vertical datum NAVD88, feet

Table 1 Boring locations and logging dates

The OYO Model 170 Suspension Logging Recorder and Suspension Logging Probe were used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.64 ft intervals. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

INSTRUMENTATION AND PROCEDURES

The **GEO***Vision* Procedure for Oyo P-S Suspension Seismic Velocity Logging (Appendix A) was followed during this investigation. This procedure was supplied and approved in advance of the field work. Following is a summary.

OYO P-S Suspension Instrumentation

Suspension soil velocity measurements were performed using the Model 170 P- and S_H-wave suspension logging system, manufactured by OYO Corporation. A 7-conductor version of this OYO system was used during the first logging run, and a 4-conductor version for the second run. Otherwise the probe for both tests was identical.

Calibration records for both recorders are presented in Appendix B. The suspension logging system directly determines the average velocity of a segment of the soil column surrounding the borehole 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 borehole 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 approximately 1 meter 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 total length of the probe as used in this survey is 5.8m with the center point of the receiver pair 3.7m above the bottom end of the probe. The probe receives control signals from, and sends the amplified receiver signals to, instrumentation on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured via encoder to provide probe depth data.

The entire probe is suspended by the cable and approximately centered in the borehole. Therefore, source motion is not coupled directly to the borehole walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the borehole 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 borehole wall. These waves propagate through the soil and rock surrounding the borehole, 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 achieved as follows:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, thereby maximizing the amplitude of the recorded SH-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 2.1m separation of source and first receiver permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In faster soils or rock, the isolation tube is extended to allow greater separation of the P- and S_H-wave signals.
4. 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.
5. 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 (meter versus centimeter scale), 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 gathered from each receiver during the source activation is recorded as a different channel on the recording system. The Model 170 digital recorder has six channels (two simultaneous recording channels), each with a 12 bit, 1024 sample record. The recorded data is displayed on a CRT display and transferred via GPIB interface to hard 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 CRT 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 Model 170 digital recorder is performed every twelve months using a NIST traceable frequency source and counter.

Field Measurement Procedures

10-17-08

The borehole probe was first positioned with the center of the receivers at ground surface. The electronic depth counters were set to 0m. The probe was then lowered below the surface to below the surface casing for the first measurement, at about 61ft. Subsequent measurements were made at 0.5m intervals as the probe was lowered down the borehole. At each measurement depth a measurement sequence of two opposite horizontal records and one vertical record was performed while the probe was stationary. Gains and record lengths were adjusted as required. The data record from each depth was checked, accepted or repeated, recorded on diskette, and printed before moving to the next depth. This continued until the last measurement at the bottom of the borehole.

12-11-08

The procedure for the second logging run was nearly identical, except that measurements began at approximately 480ft below the surface, providing a small overlap of data.

DATA ANALYSIS

The OYO Model 170 P-S Suspension Logger system can be used to measure ground velocity in two ways using the same data. The standard method is to measure the velocity from the travel time between the two receivers, as described under "Instrumentation" in the previous section. A second method is to use the travel time from the source to the first receiver. The difference between these methods is summarized as follows:

1. The receiver-to-receiver (R1-R2) method is normally more accurate, because the picks are made from the peak of the arrival waveform. The analyst picks the arrival waveform and software is used to find the peaks. Travel time is then from peak-to-peak.
2. R1-R2 data has higher resolution, because the travel time is averaged over the nominal 1m between receivers. The greater scatter in velocities is attributed to the changes in material from one measurement location to another. These measurements are very repeatable.
3. Averaging the "normal" and "reverse" travel times eliminates errors due to hysteresis of the source (difference in actuation pulses).
4. Source-to-receiver (S-R1) measurements are subject to a source delay, nominally 4 milliseconds for the 7-conductor system, and 3 milliseconds for the 4-conductor system. This source delay is independently verifiable, but subject at times to change due to degradation of source springs during the measurement program.
5. The S-R1 results are subject to larger errors as the analyst must select the first S_H-wave arrival (first motion) often in the presence of P-wave contamination rather that the first peak of the waveform. These errors are less significant, however, since the total travel path is twice as long.
6. The S-R1 results exhibit less scatter, since the velocity is averaged over the greater distance from the source to the first receiver, 2.1m compared to 1m.
7. The S-R1 results are less subject to possible effects of attenuation and dispersion, if present, because first arrivals are picked. However, if the horizontal waveforms exhibit significantly different frequency content at the near and far receivers then the R1-R2 data is interpreted using first arrival picks rather than peak to peak travel time.

8. The S-R1 data set extends about 1.5m deeper than the R1-R2 data set. The reason is that the depth reference location between the source and the first receiver is about 2.1m below the depth reference between R1 and R2.

For the above considerations, R1-R2 results are typically considered “primary” results, and S-R1 results are used only to check the validity of the R1-R2 results for quality assurance purposes.

P-Wave Analysis

The recorded digital records were analyzed to locate the first minima or first arrival 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 1m 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. P-wave arrival data was generally of excellent quality in the borehole.

The P-wave velocity calculated from the travel time over the 2.1m interval from source to receiver 1 (S-R1) was calculated and plotted for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 1.5m to correspond to the mid-point of the 2.1m S-R1 interval, as illustrated in Figure 1. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting the source delay; approximately 3 or 4 milliseconds (see above), the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

S_H-Wave Analysis

The recorded digital records were studied to establish 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 was used to remove the higher frequency P-wave signal from the S_H-wave signal. Different filter cutoffs were used to separate P- and S_H-waves at different depths.

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. This is caused by constant mechanical bias in the source or by borehole 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.

The S_H-wave velocity calculated from the travel time over the 2.1m interval from source to receiver 1 (S-R1) 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 1.5m to correspond to the mid-point of the 2.1m S-R1 interval, as illustrated in Figure 1. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting approximately 4 or 3 milliseconds (see above), the source delay.

RESULTS

Discussion of OYO P-S Suspension Velocity Log Results

Suspension R1-R2 P- and S_H-wave velocities for borehole B-11GEO is plotted in Figure 2. The suspension velocity data presented in Figure 2 are presented in Table 2.

P and S_H-wave velocity data from quality assurance analysis for borehole B-11GEO using S-R1 data is plotted together with R1-R2 analysis in Figure 3 to aid in visual comparison. It must be noted that R1-R2 data is an average velocity over a 1m segment of the soil column whereas S-R1 data is an average over 2.1m. S-R1 data are, therefore somewhat smoother. S-R1 data are presented in tabular format in Table 3.

The overall data quality in this borehole was excellent. Good correspondence between the shapes of the P- and S_H-wave velocity curves are observed for all data sets and velocities derived from S-R1 and R1-R2 data are generally in good agreement for the borehole, providing verification of the higher resolution R1-R2 data. The agreement is quite good, and the velocities are reasonable for these materials.

OYO P-S Suspension Data Reliability

P- and S_H-wave velocity measurement using the suspension method averages velocity over a 1m depth interval. This high resolution results in the scatter of velocity values shown in the plots. Individual measurements are very reliable with estimated precision of +/- 5%.

Standardized field procedures (Appendix A) and quality assurance checks add to the reliability of these data. P and S_H-wave data quality is generally excellent.

Quality Assurance

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

- Use of before and after NIST-traceable calibrations, where applicable, for field and laboratory instrumentation.
- Use of standard field data logs
- Use of independent verification of 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.

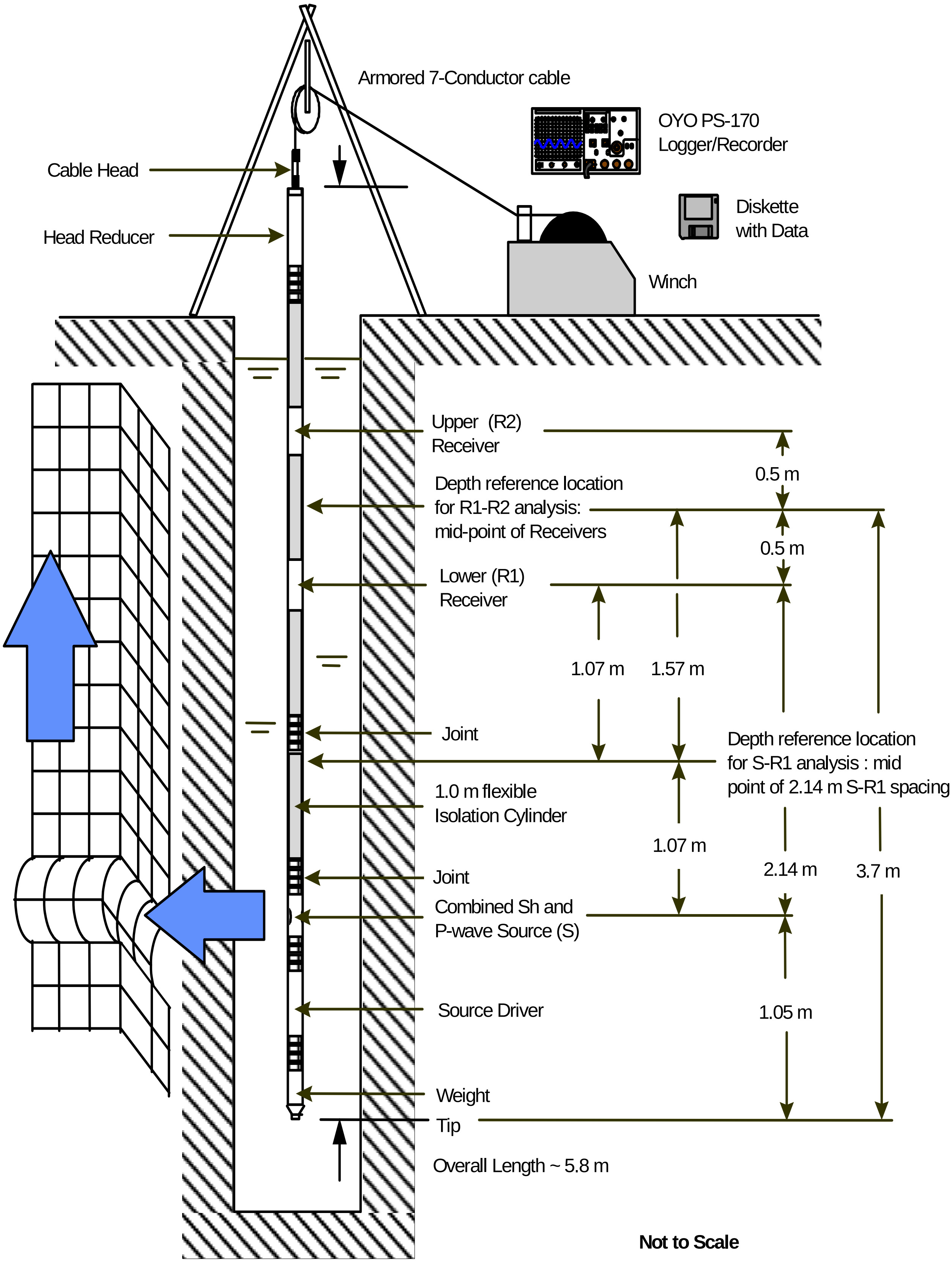


Figure 1: **Concept Illustration of P-S Logging System**

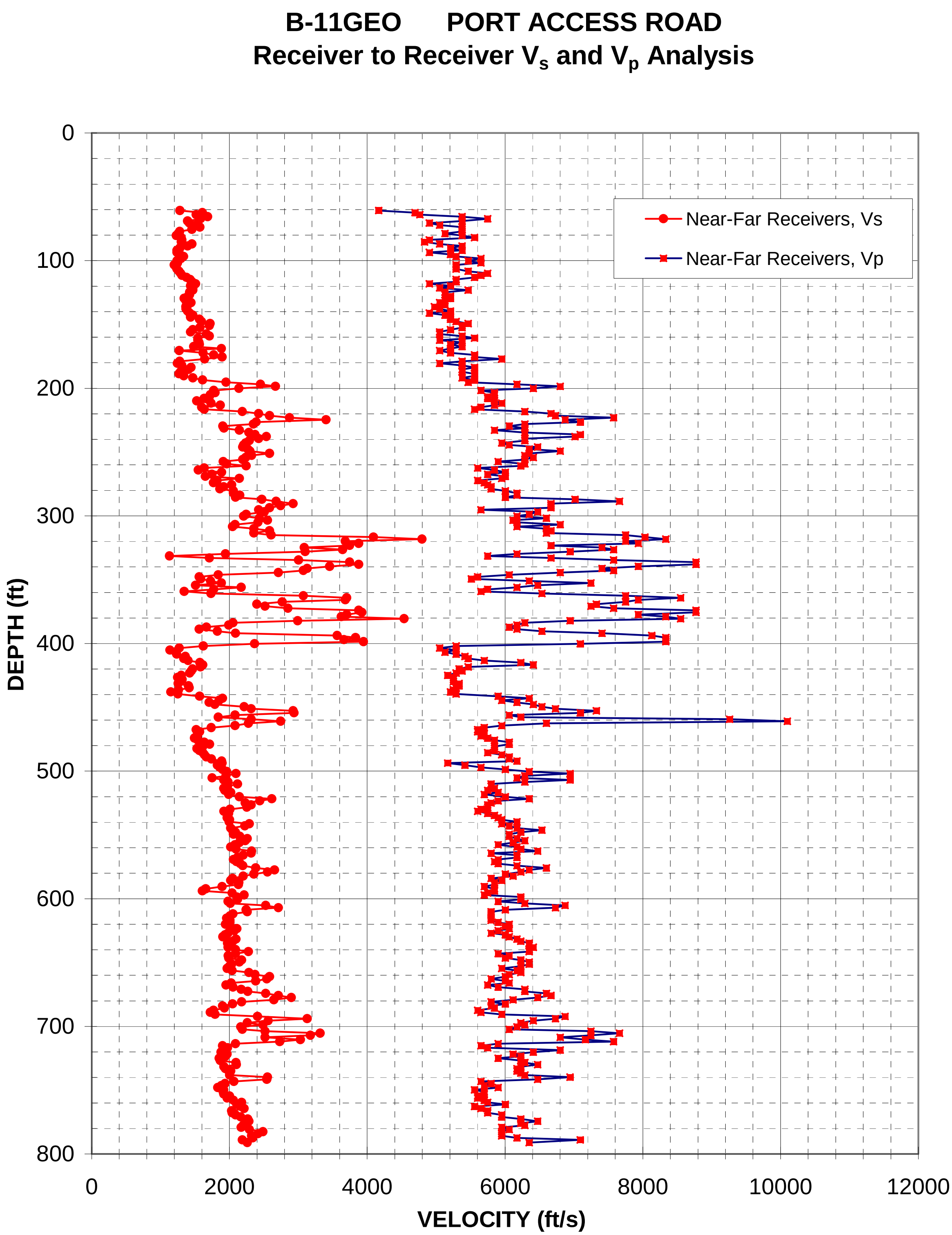


Figure 2: Borehole B-11GEO, Suspension Receiver to Receiver P- and S_H-wave Velocities

Table 2: Summary of Shear and Compressional Wave Velocity Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO, Port Access Road, North Charleston

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity V_s	Velocity V_p	Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity V_s	Velocity V_p	Poisson's Ratio
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
60.7	1280	4170	0.45	18.5	390	1270	0.45
62.3	1610	4690	0.43	19.0	490	1430	0.43
64.0	1520	4760	0.44	19.5	460	1450	0.44
65.6	1680	5380	0.45	20.0	510	1640	0.45
67.3	1580	5750	0.46	20.5	480	1750	0.46
68.9	1390	5380	0.46	21.0	430	1640	0.46
70.5	1420	4900	0.45	21.5	430	1490	0.45
72.2	1520	5050	0.45	22.0	460	1540	0.45
73.8	1570	5380	0.45	22.5	480	1640	0.45
75.5	1460	5380	0.46	23.0	440	1640	0.46
77.1	1280	5380	0.47	23.5	390	1640	0.47
78.7	1260	5130	0.47	24.0	380	1560	0.47
80.4	1230	5380	0.47	24.5	370	1640	0.47
82.0	1300	5560	0.47	25.0	400	1690	0.47
83.7	1310	4900	0.46	25.5	400	1490	0.46
85.3	1300	4830	0.46	26.0	400	1470	0.46
86.9	1460	5050	0.45	26.5	440	1540	0.45
88.6	1390	5380	0.46	27.0	430	1640	0.46
90.2	1280	5210	0.47	27.5	390	1590	0.47
91.9	1240	5380	0.47	28.0	380	1640	0.47
93.5	1240	4900	0.47	28.5	380	1490	0.47
95.1	1280	5210	0.47	29.0	390	1590	0.47
96.8	1330	5290	0.47	29.5	410	1610	0.47
98.4	1300	5650	0.47	30.0	400	1720	0.47
100.1	1240	5460	0.47	30.5	380	1670	0.47
101.7	1250	5650	0.47	31.0	380	1720	0.47
103.4	1200	5290	0.47	31.5	370	1610	0.47
105.0	1230	5290	0.47	32.0	370	1610	0.47
106.6	1240	5290	0.47	32.5	380	1610	0.47
108.3	1270	5460	0.47	33.0	390	1670	0.47
109.9	1290	5750	0.47	33.5	390	1750	0.47
111.6	1310	5650	0.47	34.0	400	1720	0.47
113.2	1380	5560	0.47	34.5	420	1690	0.47
114.8	1430	5290	0.46	35.0	440	1610	0.46
116.5	1460	5290	0.46	35.5	440	1610	0.46
118.1	1510	4900	0.45	36.0	460	1490	0.45
119.8	1440	5210	0.46	36.5	440	1590	0.46
121.4	1470	5050	0.45	37.0	450	1540	0.45
123.0	1470	5460	0.46	37.5	450	1670	0.46
124.7	1420	5130	0.46	38.0	430	1560	0.46
126.6	1420	5130	0.46	38.6	430	1560	0.46

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
128.0	1400	5210	0.46	39.0	430	1590	0.46
129.6	1340	5210	0.46	39.5	410	1590	0.46
131.2	1370	5130	0.46	40.0	420	1560	0.46
132.9	1440	5050	0.46	40.5	440	1540	0.46
134.5	1400	5130	0.46	41.0	430	1560	0.46
136.2	1370	4980	0.46	41.5	420	1520	0.46
137.8	1370	5050	0.46	42.0	420	1540	0.46
139.4	1390	5210	0.46	42.5	430	1590	0.46
141.1	1420	4900	0.45	43.0	430	1490	0.45
142.7	1470	5130	0.46	43.5	450	1560	0.46
144.4	1440	5210	0.46	44.0	440	1590	0.46
146.0	1560	5210	0.45	44.5	480	1590	0.45
147.6	1590	5290	0.45	45.0	490	1610	0.45
149.3	1720	5460	0.45	45.5	520	1670	0.45
150.9	1710	5380	0.44	46.0	520	1640	0.44
152.6	1570	5380	0.45	46.5	480	1640	0.45
154.2	1470	5210	0.46	47.0	450	1590	0.46
155.8	1440	5050	0.46	47.5	440	1540	0.46
157.5	1670	5050	0.44	48.0	510	1540	0.44
159.1	1710	5380	0.44	48.5	520	1640	0.44
160.8	1540	5560	0.46	49.0	470	1690	0.46
162.4	1540	5050	0.45	49.5	470	1540	0.45
164.0	1560	5380	0.45	50.0	470	1640	0.45
165.7	1560	5210	0.45	50.5	480	1590	0.45
167.3	1480	5380	0.46	51.0	450	1640	0.46
169.0	1880	5210	0.42	51.5	570	1590	0.42
170.6	1270	5050	0.47	52.0	390	1540	0.47
172.2	1620	5210	0.45	52.5	490	1590	0.45
173.9	1770	5560	0.44	53.0	540	1690	0.44
175.5	1890	5560	0.43	53.5	580	1690	0.43
177.2	1640	5950	0.46	54.0	500	1810	0.46
178.8	1280	5380	0.47	54.5	390	1640	0.47
180.5	1240	5050	0.47	55.0	380	1540	0.47
182.1	1310	5380	0.47	55.5	400	1640	0.47
183.7	1440	5560	0.46	56.0	440	1690	0.46
185.4	1410	5380	0.46	56.5	430	1640	0.46
187.0	1290	5380	0.47	57.0	390	1640	0.47
188.7	1270	5560	0.47	57.5	390	1690	0.47
190.3	1340	5560	0.47	58.0	410	1690	0.47
191.9	1470	5380	0.46	58.5	450	1640	0.46
193.6	1610	5560	0.45	59.0	490	1690	0.45
195.2	1950	5460	0.43	59.5	590	1670	0.43
196.9	2450	6170	0.41	60.0	750	1880	0.41

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity V_s	Velocity V_p	Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity V_s	Velocity V_p	Poisson's Ratio
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
198.5	2670	6800	0.41	60.5	810	2070	0.41
200.1	2140	6410	0.44	61.0	650	1950	0.44
201.8	1770	5650	0.45	61.5	540	1720	0.45
203.4	1790	5850	0.45	62.0	550	1780	0.45
205.1	1720	5850	0.45	62.5	530	1780	0.45
206.7	1710	5750	0.45	63.0	520	1750	0.45
208.0	1630	5750	0.46	63.4	500	1750	0.46
210.0	1530	5850	0.46	64.0	460	1780	0.46
211.6	1730	5950	0.45	64.5	530	1810	0.45
213.3	1870	5850	0.44	65.0	570	1780	0.44
214.9	1600	5650	0.46	65.5	490	1720	0.46
216.5	1630	5560	0.45	66.0	500	1690	0.45
218.2	2190	6290	0.43	66.5	670	1920	0.43
219.8	2420	6670	0.42	67.0	740	2030	0.42
221.5	2580	6730	0.41	67.5	790	2050	0.41
223.1	2870	7580	0.42	68.0	880	2310	0.42
224.7	3400	6870	0.34	68.5	1040	2090	0.34
226.4	2390	7090	0.44	69.0	730	2160	0.44
228.0	2350	6290	0.42	69.5	720	1920	0.42
229.7	1900	6060	0.45	70.0	580	1850	0.45
231.3	1920	6290	0.45	70.5	590	1920	0.45
232.9	2140	5850	0.42	71.0	650	1780	0.42
234.6	2280	6290	0.42	71.5	700	1920	0.42
236.2	2370	7090	0.44	72.0	720	2160	0.44
237.9	2530	7020	0.42	72.5	770	2140	0.42
239.5	2420	6290	0.41	73.0	740	1920	0.41
241.1	2290	6290	0.42	73.5	700	1920	0.42
242.8	2240	5950	0.42	74.0	680	1810	0.42
244.4	2210	6060	0.42	74.5	670	1850	0.42
246.1	2190	6470	0.44	75.0	670	1970	0.44
247.7	2270	6350	0.43	75.5	690	1940	0.43
249.3	2300	6800	0.44	76.0	700	2070	0.44
251.0	2580	6350	0.40	76.5	790	1940	0.40
252.6	2320	6290	0.42	77.0	710	1920	0.42
254.3	2240	6410	0.43	77.5	680	1950	0.43
255.9	2190	6290	0.43	78.0	670	1920	0.43
257.6	1910	5900	0.44	78.5	580	1800	0.44
259.2	1960	6290	0.45	79.0	600	1920	0.45
260.8	2240	6230	0.43	79.5	680	1900	0.43
262.5	1630	5600	0.45	80.0	500	1710	0.45
264.1	1550	5850	0.46	80.5	470	1780	0.46
265.8	1890	6010	0.45	81.0	580	1830	0.45
267.4	1750	5750	0.45	81.5	530	1750	0.45

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
269.0	1650	6010	0.46	82.0	500	1830	0.46
270.7	2140	5950	0.43	82.5	650	1810	0.43
272.3	1820	5600	0.44	83.0	560	1710	0.44
274.0	1770	5700	0.45	83.5	540	1740	0.45
275.6	2030	5750	0.43	84.0	620	1750	0.43
277.2	1920	5800	0.44	84.5	580	1770	0.44
278.9	1860	5800	0.44	85.0	570	1770	0.44
280.5	2060	6010	0.43	85.5	630	1830	0.43
282.2	2060	6170	0.44	86.0	630	1880	0.44
283.8	2150	6170	0.43	86.5	660	1880	0.43
285.4	2090	6010	0.43	87.0	640	1830	0.43
287.1	2470	7020	0.43	87.5	750	2140	0.43
288.7	2680	7660	0.43	88.0	820	2340	0.43
290.4	2920	6670	0.38	88.5	890	2030	0.38
292.0	2740	6670	0.40	89.0	840	2030	0.40
293.6	2580	6670	0.41	89.5	790	2030	0.41
295.3	2420	5650	0.39	90.0	740	1720	0.39
296.9	2510	6470	0.41	90.5	760	1970	0.41
298.9	2240	6350	0.43	91.1	680	1940	0.43
300.2	2210	6170	0.43	91.5	670	1880	0.43
301.8	2430	6600	0.42	92.0	740	2010	0.42
303.5	2550	6120	0.39	92.5	780	1860	0.39
305.1	2420	6170	0.41	93.0	740	1880	0.41
306.8	2080	6800	0.45	93.5	640	2070	0.45
308.4	2040	6170	0.44	94.0	620	1880	0.44
310.0	2360	6600	0.43	94.5	720	2010	0.43
311.7	2580	6670	0.41	95.0	790	2030	0.41
313.3	2360	6600	0.43	95.5	720	2010	0.43
315.0	2600	7750	0.44	96.0	790	2360	0.44
316.6	4090	8030	0.32	96.5	1250	2450	0.32
318.2	4800	8330	0.25	97.0	1460	2540	0.25
319.9	3680	7750	0.35	97.5	1120	2360	0.35
321.5	3880	7940	0.34	98.0	1180	2420	0.34
323.2	3750	6670	0.27	98.5	1140	2030	0.27
324.8	3090	7410	0.39	99.0	940	2260	0.39
326.4	3640	7580	0.35	99.5	1110	2310	0.35
328.1	3100	6940	0.38	100.0	950	2120	0.38
329.7	1940	6170	0.44	100.5	590	1880	0.44
331.4	1130	5750	0.48	101.0	340	1750	0.48
333.0	1710	6670	0.46	101.5	520	2030	0.46
334.7	3000	7580	0.41	102.0	920	2310	0.41
336.3	3750	8770	0.39	102.5	1140	2670	0.39
337.9	3880	8770	0.38	103.0	1180	2670	0.38

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
339.6	3450	7940	0.38
341.2	3130	7410	0.39
342.9	3070	7580	0.40
344.5	2710	6800	0.41
346.1	1840	6060	0.45
347.8	1560	5600	0.46
349.4	1580	5510	0.45
351.1	1730	6350	0.46
352.7	1880	7250	0.46
354.3	1510	6470	0.47
356.0	2170	6170	0.43
357.6	1770	5750	0.45
359.3	1340	5650	0.47
360.9	1730	6540	0.46
362.5	3070	7750	0.41
364.2	3700	8550	0.38
365.8	3680	7940	0.36
367.5	2770	7750	0.43
369.1	2400	7330	0.44
370.7	2520	7250	0.43
372.4	2850	7580	0.42
374.0	3880	8770	0.38
375.7	3920	8770	0.38
377.3	3700	7940	0.36
378.9	3620	8330	0.38
380.6	4540	8550	0.30
382.2	2990	6940	0.39
383.9	2050	6290	0.44
385.5	1990	6170	0.44
387.1	1670	6060	0.46
388.8	1560	6170	0.47
390.4	1830	6540	0.46
392.1	2090	7410	0.46
393.7	3570	8130	0.38
395.3	3830	8330	0.37
397.0	3660	8330	0.38
398.6	3940	8330	0.36
400.3	2360	7090	0.44
401.9	1620	5290	0.45
403.5	1270	5050	0.47
405.2	1140	5290	0.48
406.8	1220	5130	0.47
408.5	1230	5290	0.47

Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
103.5	1050	2420	0.38
104.0	950	2260	0.39
104.5	940	2310	0.40
105.0	830	2070	0.41
105.5	560	1850	0.45
106.0	480	1710	0.46
106.5	480	1680	0.45
107.0	530	1940	0.46
107.5	570	2210	0.46
108.0	460	1970	0.47
108.5	660	1880	0.43
109.0	540	1750	0.45
109.5	410	1720	0.47
110.0	530	1990	0.46
110.5	940	2360	0.41
111.0	1130	2610	0.38
111.5	1120	2420	0.36
112.0	840	2360	0.43
112.5	730	2230	0.44
113.0	770	2210	0.43
113.5	870	2310	0.42
114.0	1180	2670	0.38
114.5	1200	2670	0.38
115.0	1130	2420	0.36
115.5	1100	2540	0.38
116.0	1380	2610	0.30
116.5	910	2120	0.39
117.0	630	1920	0.44
117.5	610	1880	0.44
118.0	510	1850	0.46
118.5	480	1880	0.47
119.0	560	1990	0.46
119.5	640	2260	0.46
120.0	1090	2480	0.38
120.5	1170	2540	0.37
121.0	1120	2540	0.38
121.5	1200	2540	0.36
122.0	720	2160	0.44
122.5	490	1610	0.45
123.0	390	1540	0.47
123.5	350	1610	0.48
124.0	370	1560	0.47
124.5	380	1610	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
410.1	1360	5420	0.47	125.0	410	1650	0.47
411.8	1340	5460	0.47	125.5	410	1670	0.47
413.4	1400	5700	0.47	126.0	430	1740	0.47
415.0	1570	6230	0.47	126.5	480	1900	0.47
416.7	1610	6410	0.47	127.0	490	1950	0.47
418.3	1580	5460	0.45	127.5	480	1670	0.45
420.0	1470	5330	0.46	128.0	450	1630	0.46
421.6	1450	5380	0.46	128.5	440	1640	0.46
423.2	1420	5290	0.46	129.0	430	1610	0.46
424.9	1300	5170	0.47	129.5	400	1580	0.47
426.5	1250	5250	0.47	130.0	380	1600	0.47
428.2	1310	5250	0.47	130.5	400	1600	0.47
429.8	1290	5250	0.47	131.0	390	1600	0.47
431.4	1260	5330	0.47	131.5	380	1630	0.47
433.1	1410	5330	0.46	132.0	430	1630	0.46
434.7	1420	5290	0.46	132.5	430	1610	0.46
436.4	1260	5250	0.47	133.0	380	1600	0.47
438.0	1150	5210	0.47	133.5	350	1590	0.47
439.6	1250	5290	0.47	134.0	380	1610	0.47
441.3	1570	5900	0.46	134.5	480	1800	0.46
442.9	1900	6350	0.45	135.0	580	1940	0.45
444.6	1850	5950	0.45	135.5	560	1810	0.45
446.2	1710	6170	0.46	136.0	520	1880	0.46
447.8	1790	6410	0.46	136.5	540	1950	0.46
449.5	2210	6540	0.44	137.0	680	1990	0.44
451.1	2310	6730	0.43	137.5	710	2050	0.43
452.8	2920	7330	0.41	138.0	890	2230	0.41
454.4	2940	7090	0.40	138.5	900	2160	0.40
456.0	2080	6060	0.43	139.0	640	1850	0.43
457.7	1840	6230	0.45	139.5	560	1900	0.45
459.3	2310	9260	0.47	140.0	710	2820	0.47
461.0	2740	10100	0.46	140.5	840	3080	0.46
462.6	2280	6600	0.43	141.0	690	2010	0.43
464.2	2080	5950	0.43	141.5	640	1810	0.43
465.9	1740	5700	0.45	142.0	530	1740	0.45
467.5	1520	5600	0.46	142.5	460	1710	0.46
469.2	1570	5600	0.46	143.0	480	1710	0.46
470.8	1540	5700	0.46	143.5	470	1740	0.46
472.4	1540	5650	0.46	144.0	470	1720	0.46
474.1	1490	5750	0.46	144.5	450	1750	0.46
475.7	1540	5850	0.46	145.0	470	1780	0.46
477.4	1630	6060	0.46	145.5	500	1850	0.46
479.0	1710	6060	0.46	146.0	520	1850	0.46

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
480.6	1610	5850	0.46	146.5	490	1780	0.46
482.3	1530	5850	0.46	147.0	470	1780	0.46
483.9	1560	5850	0.46	147.5	480	1780	0.46
485.6	1610	5750	0.46	148.0	490	1750	0.46
487.2	1640	5950	0.46	148.5	500	1810	0.46
488.9	1660	6060	0.46	149.0	510	1850	0.46
490.5	1740	6060	0.46	149.5	530	1850	0.46
492.1	1890	6170	0.45	150.0	580	1880	0.45
493.8	1890	5170	0.42	150.5	580	1580	0.42
495.4	1830	5420	0.44	151.0	560	1650	0.44
497.1	1860	5650	0.44	151.5	570	1720	0.44
498.7	1900	6010	0.44	152.0	580	1830	0.44
500.3	1960	6350	0.45	152.5	600	1940	0.45
502.0	2100	6940	0.45	153.0	640	2120	0.45
503.6	1950	6290	0.45	153.5	590	1920	0.45
505.3	1750	6170	0.46	154.0	530	1880	0.46
506.9	1920	6940	0.46	154.5	580	2120	0.46
508.5	1980	6290	0.45	155.0	600	1920	0.45
510.2	2120	5800	0.42	155.5	650	1770	0.42
511.8	1970	5800	0.43	156.0	600	1770	0.43
513.5	1920	5850	0.44	156.5	580	1780	0.44
515.1	1930	5750	0.44	157.0	590	1750	0.44
516.7	2020	5900	0.43	157.5	620	1800	0.43
518.4	1990	5700	0.43	158.0	610	1740	0.43
520.0	2140	6010	0.43	158.5	650	1830	0.43
521.7	2610	6350	0.40	159.0	800	1940	0.40
523.3	2440	5900	0.40	159.5	740	1800	0.40
524.9	2230	5800	0.41	160.0	680	1770	0.41
526.6	2310	5750	0.40	160.5	710	1750	0.40
528.2	2250	5750	0.41	161.0	690	1750	0.41
529.9	2010	5650	0.43	161.5	610	1720	0.43
531.5	1920	5600	0.43	162.0	590	1710	0.43
533.1	1990	5750	0.43	162.5	610	1750	0.43
534.8	1970	5850	0.44	163.0	600	1780	0.44
536.4	1970	5900	0.44	163.5	600	1800	0.44
538.1	2000	5950	0.44	164.0	610	1810	0.44
539.7	2000	6170	0.44	164.5	610	1880	0.44
541.3	2290	5950	0.41	165.0	700	1810	0.41
543.0	2220	6060	0.42	165.5	680	1850	0.42
544.6	2020	6170	0.44	166.0	620	1880	0.44
546.3	2040	6540	0.45	166.5	620	1990	0.45
547.9	2090	6230	0.44	167.0	640	1900	0.44
549.5	2060	6060	0.43	167.5	630	1850	0.43

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
551.2	2150	6060	0.43	168.0	660	1850	0.43
552.8	2260	6170	0.42	168.5	690	1880	0.42
554.5	2230	6290	0.43	169.0	680	1920	0.43
556.1	2140	6120	0.43	169.5	650	1860	0.43
557.7	2080	5900	0.43	170.0	640	1800	0.43
559.4	2020	6170	0.44	170.5	620	1880	0.44
561.0	2100	6230	0.44	171.0	640	1900	0.44
562.7	2320	6470	0.43	171.5	710	1970	0.43
564.3	2310	5800	0.41	172.0	710	1770	0.41
565.9	2200	6170	0.43	172.5	670	1880	0.43
567.6	2120	6170	0.43	173.0	650	1880	0.43
569.2	2060	5900	0.43	173.5	630	1800	0.43
570.9	2100	5850	0.43	174.0	640	1780	0.43
572.5	2160	5900	0.42	174.5	660	1800	0.42
574.2	2190	6170	0.43	175.0	670	1880	0.43
575.8	2380	6600	0.43	175.5	730	2010	0.43
577.4	2660	6350	0.39	176.0	810	1940	0.39
579.1	2550	6230	0.40	176.5	780	1900	0.40
580.7	2360	6010	0.41	177.0	720	1830	0.41
582.4	2200	6120	0.43	177.5	670	1860	0.43
584.0	2040	5800	0.43	178.0	620	1770	0.43
585.6	2020	5950	0.43	178.5	620	1810	0.43
587.3	2140	5850	0.42	179.0	650	1780	0.42
588.9	2130	5850	0.42	179.5	650	1780	0.42
590.6	1890	5700	0.44	180.0	580	1740	0.44
592.2	1660	5850	0.46	180.5	510	1780	0.46
593.8	1610	5850	0.46	181.0	490	1780	0.46
595.5	2040	5750	0.43	181.5	620	1750	0.43
597.1	2210	5700	0.41	182.0	680	1740	0.41
598.8	2110	6230	0.44	182.5	640	1900	0.44
600.4	2120	6230	0.43	183.0	650	1900	0.43
602.0	1980	5900	0.44	183.5	600	1800	0.44
603.7	2010	6290	0.44	184.0	610	1920	0.44
605.3	2530	6870	0.42	184.5	770	2090	0.42
607.0	2710	6730	0.40	185.0	830	2050	0.40
608.6	2240	6010	0.42	185.5	680	1830	0.42
610.2	2260	5800	0.41	186.0	690	1770	0.41
611.9	2050	5800	0.43	186.5	630	1770	0.43
613.5	2010	5800	0.43	187.0	610	1770	0.43
615.2	1960	5800	0.44	187.5	600	1770	0.44
616.8	2010	5800	0.43	188.0	610	1770	0.43
618.4	2010	5900	0.43	188.5	610	1800	0.43
620.1	1940	6060	0.44	189.0	590	1850	0.44

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
621.7	2010	6010	0.44	189.5	610	1830	0.44
623.4	2110	6060	0.43	190.0	640	1850	0.43
625.0	2070	5900	0.43	190.5	630	1800	0.43
627.0	1980	5800	0.43	191.1	600	1770	0.43
628.3	1940	6010	0.44	191.5	590	1830	0.44
629.9	1900	6060	0.45	192.0	580	1850	0.45
631.6	2100	6170	0.43	192.5	640	1880	0.43
633.2	2050	6230	0.44	193.0	630	1900	0.44
634.8	1970	6350	0.45	193.5	600	1940	0.45
636.5	1990	6350	0.45	194.0	610	1940	0.45
638.1	1980	6410	0.45	194.5	600	1950	0.45
639.8	2090	6350	0.44	195.0	640	1940	0.44
641.4	2280	6350	0.43	195.5	690	1940	0.43
643.0	2090	5900	0.43	196.0	640	1800	0.43
644.7	1980	6060	0.44	196.5	600	1850	0.44
646.3	1990	6010	0.44	197.0	610	1830	0.44
648.0	2180	6230	0.43	197.5	660	1900	0.43
649.6	2140	6350	0.44	198.0	650	1940	0.44
651.3	2030	6350	0.44	198.5	620	1940	0.44
652.9	2000	6230	0.44	199.0	610	1900	0.44
654.5	1970	5950	0.44	199.5	600	1810	0.44
656.2	2040	6170	0.44	200.0	620	1880	0.44
657.8	2280	6230	0.42	200.5	700	1900	0.42
659.5	2370	6060	0.41	201.0	720	1850	0.41
661.1	2580	6010	0.39	201.5	790	1830	0.39
662.7	2540	5800	0.38	202.0	780	1770	0.38
664.4	2380	6010	0.41	202.5	730	1830	0.41
666.0	2030	6060	0.44	203.0	620	1850	0.44
667.7	1950	5750	0.44	203.5	590	1750	0.44
669.3	2050	5900	0.43	204.0	630	1800	0.43
670.9	2170	6290	0.43	204.5	660	1920	0.43
672.6	2270	6290	0.43	205.0	690	1920	0.43
674.2	2530	6600	0.41	205.5	770	2010	0.41
675.9	2710	6670	0.40	206.0	830	2030	0.40
677.5	2900	6470	0.37	206.5	880	1970	0.37
679.1	2650	6120	0.38	207.0	810	1860	0.38
680.8	2180	5800	0.42	207.5	660	1770	0.42
682.4	2040	6010	0.43	208.0	620	1830	0.43
684.1	1900	5800	0.44	208.5	580	1770	0.44
685.7	1930	5850	0.44	209.0	590	1780	0.44
687.3	1770	5600	0.44	209.5	540	1710	0.44
689.0	1720	5650	0.45	210.0	530	1720	0.45
690.6	1790	5950	0.45	210.5	550	1810	0.45

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
692.3	2410	6870	0.43	211.0	730	2090	0.43
693.9	3130	6730	0.36	211.5	950	2050	0.36
695.5	2560	6410	0.40	212.0	780	1950	0.40
697.2	2260	6230	0.42	212.5	690	1900	0.42
698.8	2490	6290	0.41	213.0	760	1920	0.41
700.5	2160	6170	0.43	213.5	660	1880	0.43
702.4	2190	6060	0.43	214.1	670	1850	0.43
703.7	2520	7250	0.43	214.5	770	2210	0.43
705.4	3320	7660	0.38	215.0	1010	2340	0.38
707.0	3170	7250	0.38	215.5	970	2210	0.38
708.7	2520	6800	0.42	216.0	770	2070	0.42
710.3	3030	7170	0.39	216.5	920	2180	0.39
711.9	2730	7580	0.43	217.0	830	2310	0.43
713.6	2090	5900	0.43	217.5	640	1800	0.43
715.2	1900	5650	0.44	218.0	580	1720	0.44
716.9	1970	5750	0.43	218.5	600	1750	0.43
718.5	1940	6800	0.46	219.0	590	2070	0.46
720.1	1880	6410	0.45	219.5	570	1950	0.45
721.8	1970	6120	0.44	220.0	600	1860	0.44
723.4	1940	6230	0.45	220.5	590	1900	0.45
725.1	1850	5900	0.45	221.0	560	1800	0.45
726.7	1870	6230	0.45	221.5	570	1900	0.45
728.4	2100	6290	0.44	222.0	640	1920	0.44
730.0	2100	6470	0.44	222.5	640	1970	0.44
731.6	1920	6230	0.45	223.0	590	1900	0.45
733.3	1940	6170	0.44	223.5	590	1880	0.44
734.9	2020	6170	0.44	224.0	620	1880	0.44
736.6	2000	6230	0.44	224.5	610	1900	0.44
738.2	2000	6290	0.44	225.0	610	1920	0.44
739.8	2550	6940	0.42	225.5	780	2120	0.42
741.5	2540	6470	0.41	226.0	780	1970	0.41
743.1	2060	5650	0.42	226.5	630	1720	0.42
744.8	1940	5800	0.44	227.0	590	1770	0.44
746.4	1880	5700	0.44	227.5	570	1740	0.44
748.0	1830	5900	0.45	228.0	560	1800	0.45
749.7	1920	5560	0.43	228.5	580	1690	0.43
751.3	1910	5700	0.44	229.0	580	1740	0.44
753.0	1920	5700	0.44	229.5	580	1740	0.44
754.6	2000	5600	0.43	230.0	610	1710	0.43
756.2	1970	5600	0.43	230.5	600	1710	0.43
757.9	2060	5700	0.43	231.0	630	1740	0.43
759.5	2180	5750	0.42	231.5	660	1750	0.42
761.2	2110	6010	0.43	232.0	640	1830	0.43

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Receiver-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint Between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
762.8	2160	5560	0.41	232.5	660	1690	0.41
764.4	2210	5650	0.41	233.0	680	1720	0.41
766.1	2030	5750	0.43	233.5	620	1750	0.43
767.7	2040	5750	0.43	234.0	620	1750	0.43
769.4	2090	5950	0.43	234.5	640	1810	0.43
771.0	2160	5950	0.42	235.0	660	1810	0.42
772.6	2270	6230	0.42	235.5	690	1900	0.42
774.3	2280	6470	0.43	236.0	700	1970	0.43
775.9	2240	6230	0.43	236.5	680	1900	0.43
777.6	2200	6290	0.43	237.0	670	1920	0.43
779.2	2170	5950	0.42	237.5	660	1810	0.42
780.8	2290	6060	0.42	238.0	700	1850	0.42
782.5	2490	5950	0.39	238.5	760	1810	0.39
784.1	2420	5950	0.40	239.0	740	1810	0.40
785.8	2320	5950	0.41	239.5	710	1810	0.41
787.4	2340	6170	0.42	240.0	710	1880	0.42
789.0	2190	7090	0.45	240.5	670	2160	0.45
791.0	2260	6350	0.43	241.1	690	1940	0.43

Notes: "-" means no data available at that particular interval of depth.

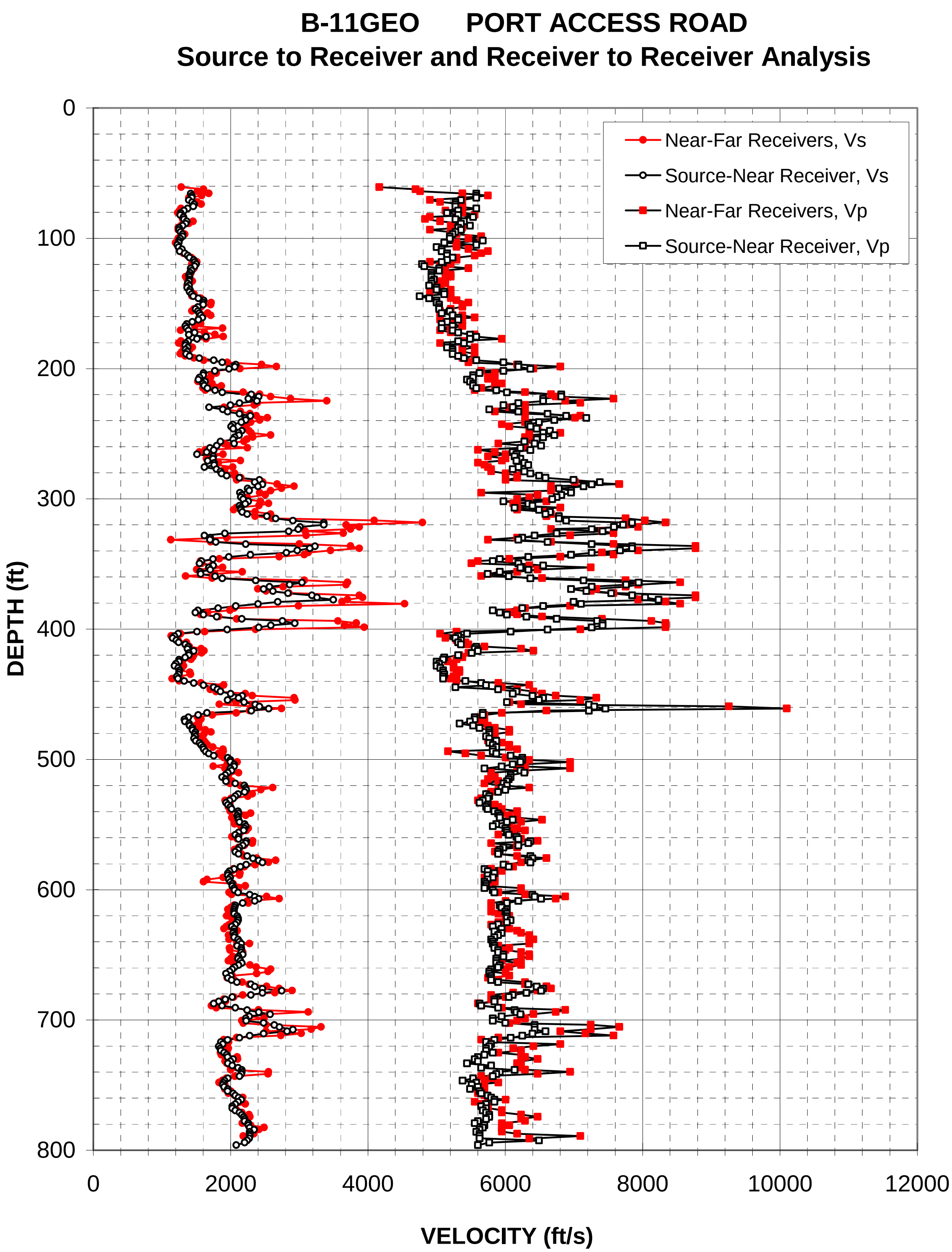


Figure 3: Borehole B-11GEO, Suspension Source to Receiver P- and S_H-wave Velocities

Table 3: Summary of Shear and Compressional Wave Velocity Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO, Port Access Road, North Charleston

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
65.7	1420	5580	0.47	20.0	430	1700	0.47
67.4	1440	5580	0.46	20.5	440	1700	0.46
69.0	1440	5580	0.46	21.0	440	1700	0.46
70.7	1390	5360	0.46	21.5	420	1630	0.46
72.3	1440	5270	0.46	22.0	440	1610	0.46
73.9	1470	5270	0.46	22.5	450	1610	0.46
75.6	1460	5270	0.46	23.0	440	1610	0.46
77.2	1370	5580	0.47	23.5	420	1700	0.47
78.9	1320	5310	0.47	24.0	400	1620	0.47
80.5	1280	5150	0.47	24.5	390	1570	0.47
82.1	1270	5310	0.47	25.0	390	1620	0.47
83.8	1320	5530	0.47	25.5	400	1690	0.47
85.4	1320	5270	0.47	26.0	400	1610	0.47
87.1	1360	5400	0.47	26.5	420	1650	0.47
88.7	1350	5360	0.47	27.0	410	1630	0.47
90.3	1300	5490	0.47	27.5	400	1670	0.47
92.0	1250	5310	0.47	28.0	380	1620	0.47
93.6	1250	5360	0.47	28.5	380	1630	0.47
95.3	1270	5270	0.47	29.0	390	1610	0.47
96.9	1300	5230	0.47	29.5	400	1590	0.47
98.5	1300	5190	0.47	30.0	400	1580	0.47
100.2	1270	5190	0.47	30.5	390	1580	0.47
101.8	1250	5670	0.47	31.0	380	1730	0.47
103.5	1250	5110	0.47	31.5	380	1560	0.47
105.1	1230	5580	0.47	32.0	370	1700	0.47
106.8	1240	5000	0.47	32.5	380	1520	0.47
108.4	1290	5080	0.47	33.0	390	1550	0.47
110.0	1260	5080	0.47	33.5	380	1550	0.47
111.7	1330	5150	0.46	34.0	410	1570	0.46
113.3	1370	5150	0.46	34.5	420	1570	0.46
115.0	1400	5230	0.46	35.0	430	1590	0.46
116.6	1460	5150	0.46	35.5	450	1570	0.46
118.2	1480	5080	0.45	36.0	450	1550	0.45
119.9	1500	4790	0.45	36.5	460	1460	0.45
121.5	1480	4820	0.45	37.0	450	1470	0.45
123.2	1420	5040	0.46	37.5	430	1540	0.46
124.8	1430	5040	0.46	38.0	440	1540	0.46
126.4	1410	4930	0.46	38.5	430	1500	0.46
128.1	1400	4930	0.46	39.0	430	1500	0.46
129.7	1400	4930	0.46	39.5	430	1500	0.46

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
131.7	1400	4960	0.46	40.1	430	1510	0.46
133.0	1400	4930	0.46	40.5	430	1500	0.46
134.6	1370	4930	0.46	41.0	420	1500	0.46
136.3	1400	4890	0.46	41.5	430	1490	0.46
137.9	1370	5000	0.46	42.0	420	1520	0.46
139.6	1410	5000	0.46	42.5	430	1520	0.46
141.2	1400	5110	0.46	43.0	430	1560	0.46
142.8	1430	5110	0.46	43.5	440	1560	0.46
144.5	1460	4750	0.45	44.0	440	1450	0.45
146.1	1530	4890	0.45	44.5	470	1490	0.45
147.8	1610	5000	0.44	45.0	490	1520	0.44
149.4	1600	5000	0.44	45.5	490	1520	0.44
151.0	1600	5040	0.44	46.0	490	1540	0.44
152.7	1520	5040	0.45	46.5	460	1540	0.45
154.3	1490	5040	0.45	47.0	450	1540	0.45
156.0	1520	5190	0.45	47.5	460	1580	0.45
157.6	1540	5080	0.45	48.0	470	1550	0.45
159.2	1570	5230	0.45	48.5	480	1590	0.45
160.9	1590	5310	0.45	49.0	480	1620	0.45
162.5	1530	5310	0.45	49.5	470	1620	0.45
164.2	1450	5150	0.46	50.0	440	1570	0.46
165.8	1360	5080	0.46	50.5	420	1550	0.46
167.4	1340	5230	0.46	51.0	410	1590	0.46
169.1	1360	5080	0.46	51.5	410	1550	0.46
170.7	1390	5230	0.46	52.0	420	1590	0.46
172.4	1480	5310	0.46	52.5	450	1620	0.46
174.0	1390	5490	0.47	53.0	420	1670	0.47
175.6	1640	5580	0.45	53.5	500	1700	0.45
177.3	1510	5490	0.46	54.0	460	1670	0.46
178.9	1390	5310	0.46	54.5	420	1620	0.46
180.6	1350	5400	0.47	55.0	410	1650	0.47
182.2	1340	5150	0.46	55.5	410	1570	0.46
183.9	1370	5150	0.46	56.0	420	1570	0.46
185.5	1350	5230	0.46	56.5	410	1590	0.46
187.1	1370	5230	0.46	57.0	420	1590	0.46
188.8	1350	5230	0.46	57.5	410	1590	0.46
190.4	1400	5310	0.46	58.0	430	1620	0.46
192.1	1540	5400	0.46	58.5	470	1650	0.46
193.7	1750	5580	0.45	59.0	530	1700	0.45
195.3	1880	5970	0.45	59.5	570	1820	0.45
197.0	2080	6190	0.44	60.0	630	1890	0.44
198.6	2060	6190	0.44	60.5	630	1890	0.44

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
200.3	1980	6370	0.45
201.9	1770	5970	0.45
203.5	1610	5630	0.46
205.2	1600	5530	0.45
206.8	1550	5530	0.46
208.5	1530	5440	0.46
210.1	1630	5490	0.45
211.7	1600	5530	0.45
213.1	1610	5530	0.45
215.0	1660	5580	0.45
216.7	1780	5870	0.45
218.3	1880	6030	0.45
219.9	2300	6820	0.44
221.6	2410	6820	0.43
223.2	2260	6550	0.43
224.9	2390	6550	0.42
226.5	2130	6190	0.43
228.1	2000	5970	0.44
229.8	1690	6110	0.46
231.4	1890	5770	0.44
233.1	1960	6190	0.44
234.7	2130	6620	0.44
236.3	2290	6890	0.44
238.0	2210	7180	0.45
239.6	2220	6720	0.44
241.3	2160	6490	0.44
242.9	2030	6340	0.44
244.5	2010	6370	0.44
246.2	2040	6460	0.44
247.8	2160	6650	0.44
249.5	2120	6550	0.44
251.1	2120	6720	0.44
252.7	2060	6550	0.45
254.4	2040	6460	0.44
256.0	1850	6280	0.45
257.7	2050	6430	0.44
259.3	1800	6520	0.46
261.0	1700	6220	0.46
262.6	1750	6370	0.46
264.2	1650	6110	0.46
265.9	1510	6160	0.47
267.5	1750	6140	0.46

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
61.0	600	1940	0.45
61.5	540	1820	0.45
62.0	490	1710	0.46
62.5	490	1690	0.45
63.0	470	1690	0.46
63.5	470	1660	0.46
64.0	500	1670	0.45
64.5	490	1690	0.45
64.9	490	1690	0.45
65.5	510	1700	0.45
66.0	540	1790	0.45
66.5	570	1840	0.45
67.0	700	2080	0.44
67.5	730	2080	0.43
68.0	690	2000	0.43
68.5	730	2000	0.42
69.0	650	1890	0.43
69.5	610	1820	0.44
70.0	510	1860	0.46
70.5	570	1760	0.44
71.0	600	1890	0.44
71.5	650	2020	0.44
72.0	700	2100	0.44
72.5	670	2190	0.45
73.0	680	2050	0.44
73.5	660	1980	0.44
74.0	620	1930	0.44
74.5	610	1940	0.44
75.0	620	1970	0.44
75.5	660	2030	0.44
76.0	640	2000	0.44
76.5	650	2050	0.44
77.0	630	2000	0.45
77.5	620	1970	0.44
78.0	570	1910	0.45
78.5	630	1960	0.44
79.0	550	1990	0.46
79.5	520	1900	0.46
80.0	530	1940	0.46
80.5	500	1860	0.46
81.0	460	1880	0.47
81.5	530	1870	0.46

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(ft)	(ft/s)	(ft/s)	
269.2	1740	6220	0.46
270.8	1670	6160	0.46
272.4	1760	6280	0.46
274.1	1760	6340	0.46
275.7	1620	6190	0.46
277.4	1800	6110	0.45
279.0	1850	6280	0.45
280.6	1870	6370	0.45
282.3	1950	6490	0.45
283.9	2130	6590	0.44
285.6	2420	6990	0.43
287.2	2350	7380	0.44
288.8	2460	7260	0.43
290.5	2400	7140	0.44
292.1	2250	6780	0.44
293.8	2270	6960	0.44
295.4	2140	6960	0.45
297.0	2160	6820	0.44
298.7	2150	6750	0.44
300.3	2180	6680	0.44
302.0	2260	5970	0.42
303.9	2210	6340	0.43
305.2	2130	6400	0.44
306.9	2150	6140	0.43
308.5	2150	6490	0.44
310.2	2170	6650	0.44
311.8	2240	6590	0.43
313.4	2530	6780	0.42
315.1	2660	6780	0.41
316.7	2910	6890	0.39
318.4	3360	7850	0.39
320.0	3360	7710	0.38
321.6	3010	7580	0.41
323.3	2990	7260	0.40
324.9	2850	7420	0.41
326.6	1920	6750	0.46
328.2	1620	6430	0.47
329.8	1700	6250	0.46
331.5	1700	6190	0.46
333.1	1790	6620	0.46
334.8	2220	7260	0.45
336.4	3230	7850	0.40

Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p	
(m)	(m/s)	(m/s)	
82.0	530	1900	0.46
82.5	510	1880	0.46
83.0	540	1910	0.46
83.5	540	1930	0.46
84.0	490	1890	0.46
84.5	550	1860	0.45
85.0	570	1910	0.45
85.5	570	1940	0.45
86.0	590	1980	0.45
86.5	650	2010	0.44
87.0	740	2130	0.43
87.5	720	2250	0.44
88.0	750	2210	0.43
88.5	730	2180	0.44
89.0	690	2070	0.44
89.5	690	2120	0.44
90.0	650	2120	0.45
90.5	660	2080	0.44
91.0	660	2060	0.44
91.5	670	2040	0.44
92.0	690	1820	0.42
92.6	670	1930	0.43
93.0	650	1950	0.44
93.5	660	1870	0.43
94.0	660	1980	0.44
94.5	660	2030	0.44
95.0	680	2010	0.43
95.5	770	2070	0.42
96.0	810	2070	0.41
96.5	890	2100	0.39
97.0	1020	2390	0.39
97.5	1020	2350	0.38
98.0	920	2310	0.41
98.5	910	2210	0.40
99.0	870	2260	0.41
99.5	580	2060	0.46
100.0	490	1960	0.47
100.5	520	1910	0.46
101.0	520	1890	0.46
101.5	540	2020	0.46
102.0	680	2210	0.45
102.5	980	2390	0.40

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
338.1	3150	7850	0.40	103.0	960	2390	0.40
339.7	2970	7670	0.41	103.5	910	2340	0.41
341.3	2810	7260	0.41	104.0	860	2210	0.41
343.0	2290	6960	0.44	104.5	700	2120	0.44
344.6	1970	6340	0.45	105.0	600	1930	0.45
346.3	1740	5920	0.45	105.5	530	1800	0.45
347.9	1580	5820	0.46	106.0	480	1770	0.46
349.5	1550	6190	0.47	106.5	470	1890	0.47
351.2	1750	6550	0.46	107.0	530	2000	0.46
352.8	1680	6220	0.46	107.5	510	1900	0.46
354.5	1700	6340	0.46	108.0	520	1930	0.46
356.1	1560	5920	0.46	108.5	480	1800	0.46
357.7	1570	5740	0.46	109.0	480	1750	0.46
359.4	1780	6050	0.45	109.5	540	1850	0.45
361.0	1880	6370	0.45	110.0	570	1940	0.45
362.7	2370	7140	0.44	110.5	720	2180	0.44
364.3	3040	7940	0.41	111.0	930	2420	0.41
365.9	2860	7760	0.42	111.5	870	2360	0.42
367.6	2570	7260	0.43	112.0	780	2210	0.43
369.2	2480	6960	0.43	112.5	760	2120	0.43
370.9	2620	7180	0.42	113.0	800	2190	0.42
372.5	2840	7540	0.42	113.5	860	2300	0.42
374.1	3180	7850	0.40	114.0	970	2390	0.40
375.8	3260	8040	0.40	114.5	990	2450	0.40
377.4	3500	8230	0.39	115.0	1070	2510	0.39
379.1	2690	6990	0.41	115.5	820	2130	0.41
380.7	2400	7110	0.44	116.0	730	2170	0.44
382.3	2080	6550	0.44	116.5	630	2000	0.44
384.0	1820	6250	0.45	117.0	550	1910	0.45
385.6	1520	5820	0.46	117.5	460	1770	0.46
387.3	1490	5920	0.47	118.0	450	1800	0.47
388.9	1610	6030	0.46	118.5	490	1840	0.46
390.5	1800	6310	0.46	119.0	550	1920	0.46
392.2	2160	6750	0.44	119.5	660	2060	0.44
393.8	2760	7340	0.42	120.0	840	2240	0.42
395.5	2930	7420	0.41	120.5	890	2260	0.41
397.1	2590	7420	0.43	121.0	790	2260	0.43
398.7	2410	7260	0.44	121.5	730	2210	0.44
400.4	1950	6620	0.45	122.0	590	2020	0.45
402.0	1510	6080	0.47	122.5	460	1850	0.47
403.7	1240	5440	0.47	123.0	380	1660	0.47
405.3	1180	5310	0.47	123.5	360	1620	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
406.9	1160	5270	0.47	124.0	350	1610	0.47
408.6	1210	5360	0.47	124.5	370	1630	0.47
410.2	1240	5310	0.47	125.0	380	1620	0.47
411.9	1340	5360	0.47	125.5	410	1630	0.47
413.5	1380	5580	0.47	126.0	420	1700	0.47
415.1	1370	5560	0.47	126.5	420	1690	0.47
416.8	1460	5600	0.46	127.0	450	1710	0.46
418.4	1390	5510	0.47	127.5	430	1680	0.47
420.1	1390	5310	0.46	128.0	430	1620	0.46
421.7	1340	5110	0.46	128.5	410	1560	0.46
423.4	1250	5090	0.47	129.0	380	1550	0.47
425.0	1250	5000	0.47	129.5	380	1520	0.47
426.6	1200	5040	0.47	130.0	370	1540	0.47
428.3	1180	5000	0.47	130.5	360	1520	0.47
429.9	1240	5060	0.47	131.0	380	1540	0.47
431.6	1260	5090	0.47	131.5	380	1550	0.47
433.2	1250	5090	0.47	132.0	380	1550	0.47
434.8	1240	5110	0.47	132.5	380	1560	0.47
436.5	1220	5090	0.47	133.0	370	1550	0.47
438.1	1230	5090	0.47	133.5	380	1550	0.47
439.8	1330	5420	0.47	134.0	400	1650	0.47
441.4	1460	5650	0.46	134.5	450	1720	0.46
443.0	1610	5720	0.46	135.0	490	1740	0.46
444.7	1750	5270	0.44	135.5	530	1610	0.44
446.3	1810	5900	0.45	136.0	550	1800	0.45
448.0	1850	6160	0.45	136.5	570	1880	0.45
449.6	2000	6110	0.44	137.0	610	1860	0.44
451.2	2170	6400	0.43	137.5	660	1950	0.43
452.9	2120	6550	0.44	138.0	640	2000	0.44
454.5	1960	6490	0.45	138.5	600	1980	0.45
456.2	2200	6030	0.42	139.0	670	1840	0.42
457.8	2360	7220	0.44	139.5	720	2200	0.44
459.4	2420	7300	0.44	140.0	740	2220	0.44
461.1	2560	7460	0.43	140.5	780	2270	0.43
462.7	2300	7220	0.44	141.0	700	2200	0.44
464.4	1660	5670	0.45	141.5	510	1730	0.45
466.0	1530	5670	0.46	142.0	470	1730	0.46
467.6	1390	5560	0.47	142.5	420	1690	0.47
469.3	1330	5560	0.47	143.0	410	1690	0.47
470.9	1340	5490	0.47	143.5	410	1670	0.47
472.6	1400	5340	0.46	144.0	430	1630	0.46
474.2	1400	5530	0.47	144.5	430	1690	0.47

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
475.8	1440	5630	0.46	145.0	440	1710	0.46
477.5	1450	5770	0.47	145.5	440	1760	0.47
479.1	1490	5770	0.46	146.0	450	1760	0.46
480.8	1480	5770	0.46	146.5	450	1760	0.46
482.4	1490	5720	0.46	147.0	450	1740	0.46
484.0	1470	5770	0.47	147.5	450	1760	0.47
485.7	1490	5870	0.47	148.0	460	1790	0.47
487.3	1550	5770	0.46	148.5	470	1760	0.46
489.0	1570	5820	0.46	149.0	480	1770	0.46
490.6	1600	5870	0.46	149.5	490	1790	0.46
492.2	1610	5820	0.46	150.0	490	1770	0.46
493.9	1640	5820	0.46	150.5	500	1770	0.46
495.5	1680	5870	0.46	151.0	510	1790	0.46
497.2	1750	6080	0.45	151.5	530	1850	0.45
498.8	1960	6250	0.45	152.0	600	1910	0.45
500.5	2000	6250	0.44	152.5	610	1910	0.44
502.1	2000	6220	0.44	153.0	610	1900	0.44
503.7	2050	6110	0.44	153.5	630	1860	0.44
505.4	2050	5950	0.43	154.0	630	1810	0.43
507.0	2000	5700	0.43	154.5	610	1740	0.43
508.7	2010	6220	0.44	155.0	610	1900	0.44
510.3	1960	6280	0.45	155.5	600	1910	0.45
511.9	1920	6080	0.44	156.0	590	1850	0.44
513.6	1880	6080	0.45	156.5	570	1850	0.45
515.2	1930	6050	0.44	157.0	590	1850	0.44
516.9	1930	6030	0.44	157.5	590	1840	0.44
518.5	2070	5970	0.43	158.0	630	1820	0.43
520.1	2200	6030	0.42	158.5	670	1840	0.42
521.8	2220	5950	0.42	159.0	680	1810	0.42
523.4	2230	6000	0.42	159.5	680	1830	0.42
525.1	2210	5900	0.42	160.0	670	1800	0.42
526.7	2110	5720	0.42	160.5	640	1740	0.42
528.3	2070	5770	0.43	161.0	630	1760	0.43
530.0	2040	5740	0.43	161.5	620	1750	0.43
531.6	1990	5670	0.43	162.0	610	1730	0.43
533.3	1930	5630	0.43	162.5	590	1710	0.43
534.9	1960	5740	0.43	163.0	600	1750	0.43
536.5	2000	5720	0.43	163.5	610	1740	0.43
538.2	2010	5740	0.43	164.0	610	1750	0.43
539.8	2110	5840	0.43	164.5	640	1780	0.43
541.5	2120	5900	0.43	165.0	640	1800	0.43
543.1	2100	5920	0.43	165.5	640	1800	0.43

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
544.7	2110	5920	0.43	166.0	640	1800	0.43
546.4	2120	6110	0.43	166.5	640	1860	0.43
548.0	2130	6030	0.43	167.0	650	1840	0.43
549.7	2210	5870	0.42	167.5	670	1790	0.42
551.3	2220	5820	0.41	168.0	680	1770	0.41
552.9	2200	6000	0.42	168.5	670	1830	0.42
554.6	2190	6030	0.42	169.0	670	1840	0.42
556.2	2120	6030	0.43	169.5	640	1840	0.43
557.9	2070	6050	0.43	170.0	630	1850	0.43
559.5	2120	6160	0.43	170.5	640	1880	0.43
561.1	2120	6190	0.43	171.0	640	1890	0.43
562.8	2230	6370	0.43	171.5	680	1940	0.43
564.4	2220	6340	0.43	172.0	680	1930	0.43
566.1	2180	6190	0.43	172.5	660	1890	0.43
567.7	2130	5970	0.43	173.0	650	1820	0.43
569.3	2110	5920	0.43	173.5	640	1800	0.43
571.0	2070	5900	0.43	174.0	630	1800	0.43
572.6	2120	5900	0.43	174.5	640	1800	0.43
574.3	2240	6370	0.43	175.0	680	1940	0.43
575.9	2330	6400	0.42	175.5	710	1950	0.42
577.6	2410	6340	0.42	176.0	730	1930	0.42
579.2	2460	6370	0.41	176.5	750	1940	0.41
580.8	2230	5970	0.42	177.0	680	1820	0.42
582.5	2140	6050	0.43	177.5	650	1850	0.43
584.1	2050	5700	0.43	178.0	630	1740	0.43
585.8	1990	5740	0.43	178.5	610	1750	0.43
587.4	1960	5840	0.44	179.0	600	1780	0.44
589.0	1960	5740	0.43	179.5	600	1750	0.43
590.7	1990	5820	0.43	180.0	610	1770	0.43
592.3	1970	5740	0.43	180.5	600	1750	0.43
594.0	2000	5700	0.43	181.0	610	1740	0.43
595.6	2030	5720	0.43	181.5	620	1740	0.43
597.2	2030	5720	0.43	182.0	620	1740	0.43
598.9	2050	5700	0.43	182.5	630	1740	0.43
600.5	2060	5820	0.43	183.0	630	1770	0.43
602.2	2110	5840	0.43	183.5	640	1780	0.43
603.8	2280	6400	0.43	184.0	700	1950	0.43
605.4	2350	6430	0.42	184.5	720	1960	0.42
607.1	2410	6520	0.42	185.0	730	1990	0.42
608.7	2350	6190	0.42	185.5	720	1890	0.42
610.4	2180	6030	0.42	186.0	660	1840	0.42
612.0	2070	5920	0.43	186.5	630	1800	0.43

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
613.6	2060	5950	0.43	187.0	630	1810	0.43
615.3	2050	6030	0.43	187.5	630	1840	0.43
616.9	2050	6000	0.43	188.0	630	1830	0.43
618.6	2050	6030	0.43	188.5	630	1840	0.43
620.2	2100	6030	0.43	189.0	640	1840	0.43
621.8	2110	6030	0.43	189.5	640	1840	0.43
623.5	2110	6080	0.43	190.0	640	1850	0.43
625.1	2100	6030	0.43	190.5	640	1840	0.43
626.8	2070	5900	0.43	191.0	630	1800	0.43
628.4	2020	5820	0.43	191.5	620	1770	0.43
630.0	2050	5950	0.43	192.0	630	1810	0.43
632.0	2050	5840	0.43	192.6	630	1780	0.43
633.3	2040	5950	0.43	193.0	620	1810	0.43
635.0	2060	5900	0.43	193.5	630	1800	0.43
636.6	2050	5840	0.43	194.0	630	1780	0.43
638.2	2110	5790	0.42	194.5	640	1770	0.42
639.9	2130	5820	0.42	195.0	650	1770	0.42
641.5	2160	5820	0.42	195.5	660	1770	0.42
643.2	2100	5840	0.43	196.0	640	1780	0.43
644.8	2160	5840	0.42	196.5	660	1780	0.42
646.4	2160	5900	0.42	197.0	660	1800	0.42
648.1	2160	5900	0.42	197.5	660	1800	0.42
649.7	2180	5970	0.42	198.0	660	1820	0.42
651.4	2120	5970	0.43	198.5	640	1820	0.43
653.0	2110	5870	0.43	199.0	640	1790	0.43
654.7	2140	5870	0.42	199.5	650	1790	0.42
656.3	2160	5870	0.42	200.0	660	1790	0.42
657.9	2120	5920	0.43	200.5	640	1800	0.43
659.6	2060	5900	0.43	201.0	630	1800	0.43
661.2	2030	5790	0.43	201.5	620	1770	0.43
662.9	1990	5770	0.43	202.0	610	1760	0.43
664.5	1930	5770	0.44	202.5	590	1760	0.44
666.1	2010	5790	0.43	203.0	610	1770	0.43
667.8	1960	5790	0.44	203.5	600	1770	0.44
669.4	2010	5790	0.43	204.0	610	1770	0.43
671.1	2090	5900	0.43	204.5	640	1800	0.43
672.7	2300	6340	0.42	205.0	700	1930	0.42
674.3	2350	6460	0.42	205.5	720	1970	0.42
676.0	2460	6550	0.42	206.0	750	2000	0.42
677.6	2740	6520	0.39	206.5	840	1990	0.39
679.3	2460	6310	0.41	207.0	750	1920	0.41
680.9	2300	6110	0.42	207.5	700	1860	0.42

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
682.5	2030	6050	0.44	208.0	620	1850	0.44
684.2	1920	5840	0.44	208.5	590	1780	0.44
685.8	1830	5840	0.45	209.0	560	1780	0.45
687.5	1750	5630	0.45	209.5	530	1710	0.45
689.1	1880	5650	0.44	210.0	570	1720	0.44
690.7	2070	5900	0.43	210.5	630	1800	0.43
692.4	2240	6140	0.42	211.0	680	1870	0.42
694.0	2410	6160	0.41	211.5	730	1880	0.41
695.7	2580	6220	0.40	212.0	790	1900	0.40
697.3	2270	5950	0.41	212.5	690	1810	0.41
698.9	2220	5820	0.41	213.0	680	1770	0.41
700.6	2230	5820	0.41	213.5	680	1770	0.41
702.2	2480	6000	0.40	214.0	760	1830	0.40
703.9	2640	6430	0.40	214.5	800	1960	0.40
705.5	2710	6430	0.39	215.0	830	1960	0.39
707.5	2910	6430	0.37	215.6	890	1960	0.37
708.8	2820	6590	0.39	216.0	860	2010	0.39
710.4	2480	6400	0.41	216.5	760	1950	0.41
712.1	2280	6250	0.42	217.0	700	1910	0.42
713.7	2130	6080	0.43	217.5	650	1850	0.43
715.3	1960	5840	0.44	218.0	600	1780	0.44
717.0	1860	5720	0.44	218.5	570	1740	0.44
718.6	1890	5790	0.44	219.0	570	1770	0.44
720.3	1830	5770	0.44	219.5	560	1760	0.44
721.9	1850	5720	0.44	220.0	560	1740	0.44
723.5	1860	5720	0.44	220.5	570	1740	0.44
725.2	1910	5820	0.44	221.0	580	1770	0.44
726.8	1950	5700	0.43	221.5	590	1740	0.43
728.5	1960	5600	0.43	222.0	600	1710	0.43
730.1	2040	5560	0.42	222.5	620	1690	0.42
731.8	2000	5600	0.43	223.0	610	1710	0.43
733.4	1960	5440	0.43	223.5	600	1660	0.43
735.0	2030	5790	0.43	224.0	620	1770	0.43
736.7	2110	5650	0.42	224.5	640	1720	0.42
738.3	2160	6140	0.43	225.0	660	1870	0.43
740.0	2160	5920	0.42	225.5	660	1800	0.42
741.6	2160	5870	0.42	226.0	660	1790	0.42
743.2	2130	5820	0.42	226.5	650	1770	0.42
744.9	1960	5530	0.43	227.0	600	1690	0.43
746.5	1910	5380	0.43	227.5	580	1640	0.43
748.2	1900	5580	0.43	228.0	580	1700	0.43
749.8	1890	5510	0.43	228.5	570	1680	0.43

Summary of Compressional Wave Velocity, Shear Wave Velocity, and Poisson's Ratio
Based on Source-to-Receiver Travel Time Data - Borehole B-11GEO

American Units				Metric Units			
Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio	Depth at Midpoint Between Source and Near Receiver	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft)	(ft/s)	(ft/s)		(m)	(m/s)	(m/s)	
751.4	1910	5600	0.43	229.0	580	1710	0.43
753.1	1960	5490	0.43	229.5	600	1670	0.43
754.7	1960	5630	0.43	230.0	600	1710	0.43
756.4	2040	5650	0.43	230.5	620	1720	0.43
758.0	2070	5740	0.43	231.0	630	1750	0.43
759.6	2120	5790	0.42	231.5	640	1770	0.42
761.3	2160	5840	0.42	232.0	660	1780	0.42
762.9	2110	5840	0.43	232.5	640	1780	0.43
764.6	2070	5720	0.42	233.0	630	1740	0.42
766.2	2030	5650	0.43	233.5	620	1720	0.43
767.8	2030	5720	0.43	234.0	620	1740	0.43
769.5	2070	5670	0.42	234.5	630	1730	0.42
771.1	2130	5720	0.42	235.0	650	1740	0.42
772.8	2160	5770	0.42	235.5	660	1760	0.42
774.4	2190	5770	0.42	236.0	670	1760	0.42
776.0	2210	5720	0.41	236.5	670	1740	0.41
777.7	2210	5600	0.41	237.0	670	1710	0.41
779.3	2260	5560	0.40	237.5	690	1690	0.40
781.0	2260	5700	0.41	238.0	690	1740	0.41
782.6	2280	5670	0.40	238.5	700	1730	0.40
784.2	2340	5630	0.39	239.0	710	1710	0.39
785.9	2280	5580	0.40	239.5	700	1700	0.40
787.5	2280	5630	0.40	240.0	700	1710	0.40
789.2	2280	5630	0.40	240.5	700	1710	0.40
790.8	2270	5630	0.40	241.0	690	1710	0.40
792.4	2240	6490	0.43	241.5	680	1980	0.43
794.1	2210	5770	0.41	242.0	670	1760	0.41
796.1	2080	5600	0.42	242.6	640	1710	0.42

Notes: "-" means no data available at that particular interval of depth.

APPENDIX A

PROCEDURE FOR
OYO P-S SUSPENSION SEISMIC
VELOCITY LOGGING

PROCEDURE FOR

OYO P-S SUSPENSION SEISMIC VELOCITY LOGGING

Background

This procedure describes a method for measuring shear and compressional wave velocities in soil and rock. The OYO P-S Suspension Method is applied by generating shear and compressional waves in a borehole using the OYO P-S Suspension Logger borehole tool and measuring the travel time between two receiver geophones or hydrophones located in the same tool.

Objective

The outcome of this procedure is a plot and table of P and S_H wave velocity versus depth for each borehole. Standard analysis is performed on receiver to receiver data. Data is presented in report format, with digital data files transmitted in Excel, Word or ASCII format.

Instrumentation

1. OYO Model 170 Digital Logging Recorder or equivalent

2. OYO P-S Suspension Logger probe or equivalent, including two sets horizontal and vertical geophones, seismic source, and power supply for the source and receivers

3. Winch and winch controller, with logging cable

4. Batteries to operate P-S Logger and winch

The Suspension P-S Logger system, manufactured by OYO Corporation, or the Robertson Digital P-S Suspension Probe with the Robertson Micrologger2 are currently the only commercially available suspension logging systems. As shown in Figure 1, these systems consists of a borehole probe suspended by a cable and a recording/control electronics package on the surface.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave generator (S_H) and compressional-wave generator (P), joined to two biaxial geophones by a flexible isolation cylinder. The separation of the two geophones is one meter, allowing average wave velocity in the region between the geophones to be determined by inversion of the wave travel time between the two geophones. The total length of the probe is approximately 7 meters; the center point of the geophones is approximately 4 meters above the bottom end of the probe.

The probe receives control signals from, and sends the amplified geophone signals to, the instrumentation package on the surface via an armored 4 or 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured by a rotary encoder to provide probe depth data.

The entire probe is suspended by the cable and may be centered in the borehole by nylon "whiskers." Therefore, source motion is not coupled directly to the borehole walls; rather, the source motion creates a horizontally propagating pressure wave in the fluid filling the borehole and surrounding the source. This pressure wave produces a horizontal displacement of the soil forming the wall of the borehole. This displacement propagates up and down the borehole wall, in turn causing a pressure wave to be generated in the fluid surrounding the geophones as the soil displacement wave passes their location.

Environmental Conditions

The OYO P-S Suspension Logging Method can be used in either cased or uncased boreholes. For best results, the uncased borehole must be between 10 and 20 cm in diameter, or 4 to 8 inches. A cased borehole may be as small as 3 inches, if properly grouted (see below) and the grout annulus does not exceed 1 inch.

Uncased boreholes are preferred because the effects of the casing and grouting are removed. It is recommended that the borehole be drilled using the rotary mud method. This method does little damage to the borehole wall, and the drilling fluid coats and seals the borehole wall reducing fluid loss and wall collapse. The borehole fluid is required for the logging, and must be well circulated prior to logging.

If the borehole must be cased, the casing must be PVC and properly installed and grouted. Any voids in the grout will cause problems with the data. Likewise, large grout bulbs used to fill cavities will also cause problems. The grout must be set before testing. This means the grouting must take place at least 48 hours before testing.

For borehole casing, applicable preparation procedures are presented in ASTM Standard D4428/D4428M-91 Section 4.1 (see ASTM website for copy).

Calibration

Calibration of the digital recorder is required. Calibration is limited to the timing accuracy of the recorder. GEOVision's Seismograph Calibration Procedure or equivalent should be used. Calibration must be performed on an annual basis.

Measurement Procedure

The entire probe is lowered into the borehole to a specific measurement depth by the winch. A measurement sequence is then initiated by the operator from the instrumentation package control panel. No further operator intervention is then needed to complete the measurement sequence described below.

The system electronics activates the SH-wave source in one direction and records the output of the two horizontally oriented geophone axes which are situated parallel to the axis of motion of the source. The source is then activated in the opposite direction, and the horizontal output signals are again recorded, producing a SH-wave record of polarity opposite to the previous record. The source is finally actuated in the first direction again, and the responses of the vertical geophone axes to the resultant P-wave are recorded during this sampling.

The data from each geophone during each source activation is recorded as a different channel on the recording system. The seismograph has at least six channels (two simultaneous recording channels), each with at least a 12 bit 1024 sample record. Newer seismographs may have longer record lengths. The recorded data is displayed on a CRT or LCD display and possibly on paper tape output as six channels with a common time scale. Data is stored on digital media for further processing. Up to 8 sampling sequences can be stacked (averaged) to improve the signal to noise ratio of the signals.

Review of the data on the display or paper tape allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and stacking number in order to optimize the quality of the data before recording. In the case of the Model 170, printed data is verified by the operator prior to moving the probe. In the case of the Robertson Micrologger2, storage on the hard disk should be verified from time-to-time, certainly before exiting the borehole.

Typical depth spacing for measurements is 1.0 meters, or 3.3 feet. Alternative spacing is 0.5 meter, or 1.6 feet.

Required Field Records

1) Field log for each borehole showing

    a) Borehole identification

    b) Date of test

    c) Tester or data recorder

d) Description of measurement

e) Any deviations from test plan and action taken as a result

f) QA Review

2) Paper output records are no longer required, since the Micrologger2 cannot generate them. However, data must be stored in at least 2 places prior to leaving the site

3) List of record ID numbers (for data on digital media) and corresponding depth

4) Diskettes, CDRom, or USB flash drives with backup copies of data on hard disk, labeled with borehole designation, record ID numbers, date, and tester name.

An example Field Log is attached to this procedure.

Analysis

Following completion of field work, the recorded digital records are processed by computer using the OYO Corporation software program PSLOG and interactively analyzed by an experienced geophysicist to produce plots and tables of P and S_H wave velocity versus depth.

The digital time series records from each depth are transferred to a personal computer for analysis. Figure 2 shows a sample of the data from a single depth. These digital records are analyzed to locate the first minima on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between these arrivals is used to calculate the P-wave velocity for that 1-meter interval. When observable, P-wave arrivals on the horizontal axis records are used to verify the velocities determined from the vertical axis data. In addition, the soil velocity calculated from the travel time from source to first receiver is compared to the velocity derived from the travel time between receivers.

The digital records are studied to establish the presence of clear SH-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the SH-wave signals from the ‘normal’ and ‘reverse’ source pulses are very nearly inverted images of each other. Digital FFT – IFFT lowpass filtering are used to remove the higher frequency P-wave signal from the SH-wave signal.

The first maxima are picked for the ‘normal’ signals and the first minima are picked for the 'reverse' signals. The absolute arrival time of the ‘normal’ and ‘reverse’ signals may vary by +/- 0.2 milliseconds, due to differences in actuation time of the solenoid source caused by constant mechanical bias in the source or by borehole inclination. This variation does not affect the 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.

In Figure 2, the time difference over the 1-meter interval of 1.70 millisecond is equivalent to a SH-wave velocity of 588 m/sec. Whenever possible, time differences are determined from several phase points on the S_H -wave pulse trains to verify the data obtained from the first arrival of the S_H -wave pulse. In addition, the soil velocity calculated from the travel time from source to first receiver is compared to the velocity derived from the travel time between receivers.

Figure 3 is a sample composite plot of the far normal horizontal geophone records for a range of depths. This plot shows the waveforms at each depth, clearly showing the S-wave arrivals. This display format is used during analysis to observe trends in velocity with changing depth.

Once the proper picks are entered in PSLOG, the picks are transferred to an Excel spreadsheet where Vs and Vp are calculated. The spreadsheet allows output for presentation in charts and tables.

Standard analysis is performed on receiver 1 to receiver 2 data, with separate analysis performed on source to receiver data as a quality assurance procedure.

Registered Geophysicist Antony J Martin Date 9/11/06

QA Review __________ Date 9/11/06

References:

1. “In Situ P and S Wave Velocity Measurement”, Ohya, S. 1986. Proceedings of In-Situ ’86, *Use of In-Situ Tests In Geotechnical Engineering*, an ASCE Specialty Conference sponsored by the Geotechnical Engineering Division of ASCE and co-sponsored by the Civil Engineering Dept of Virginia Tech.

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

3. “Standard test Methods for Crosshole Seismic Testing”, ASTM Standard D4428/D4428M-91, July 1991, Philadelphia, PA

OYO SUSPENSION P-S VELOCITY LOGGING SETUP

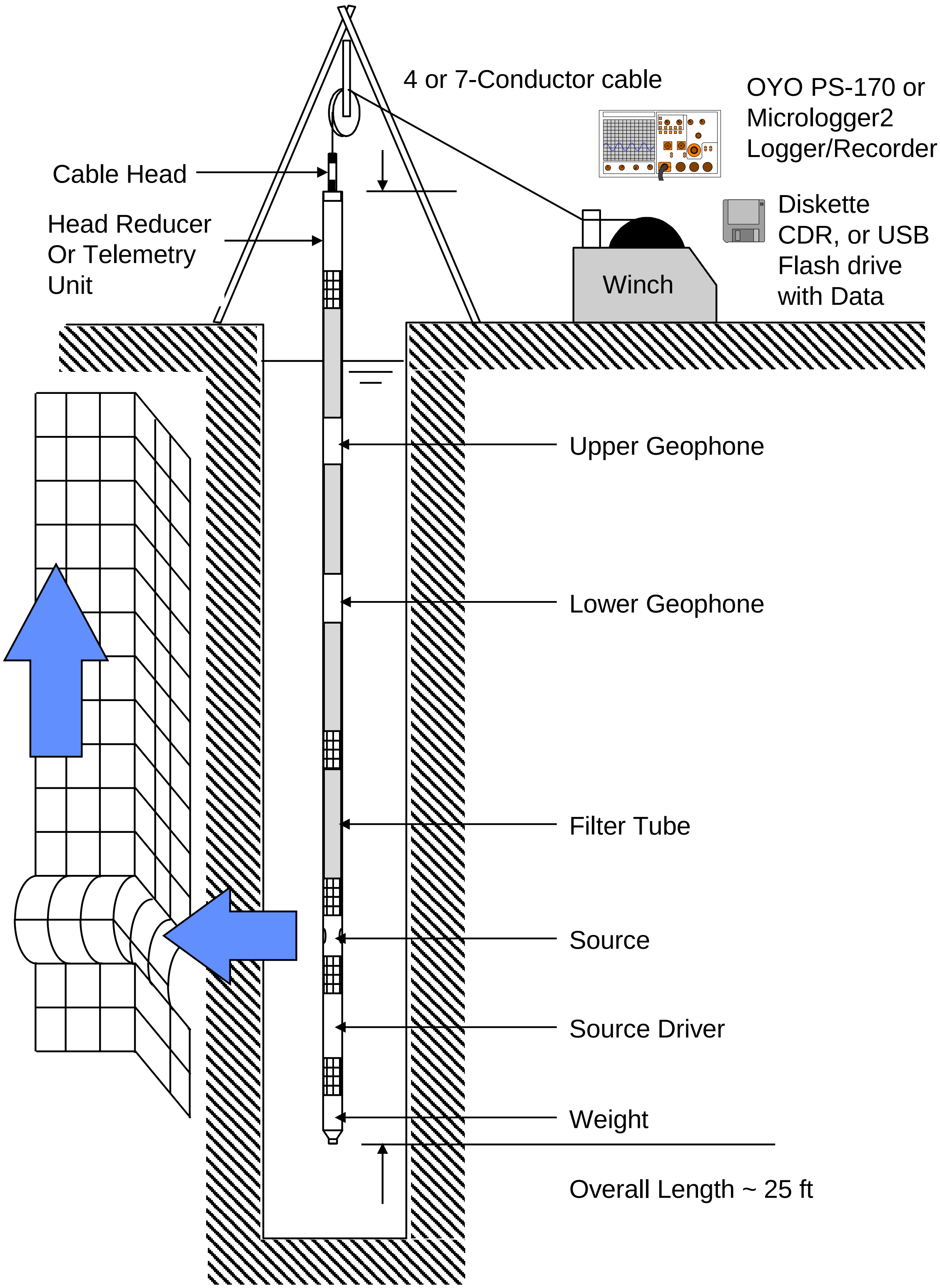


Figure 1. Suspension PS logging method setup

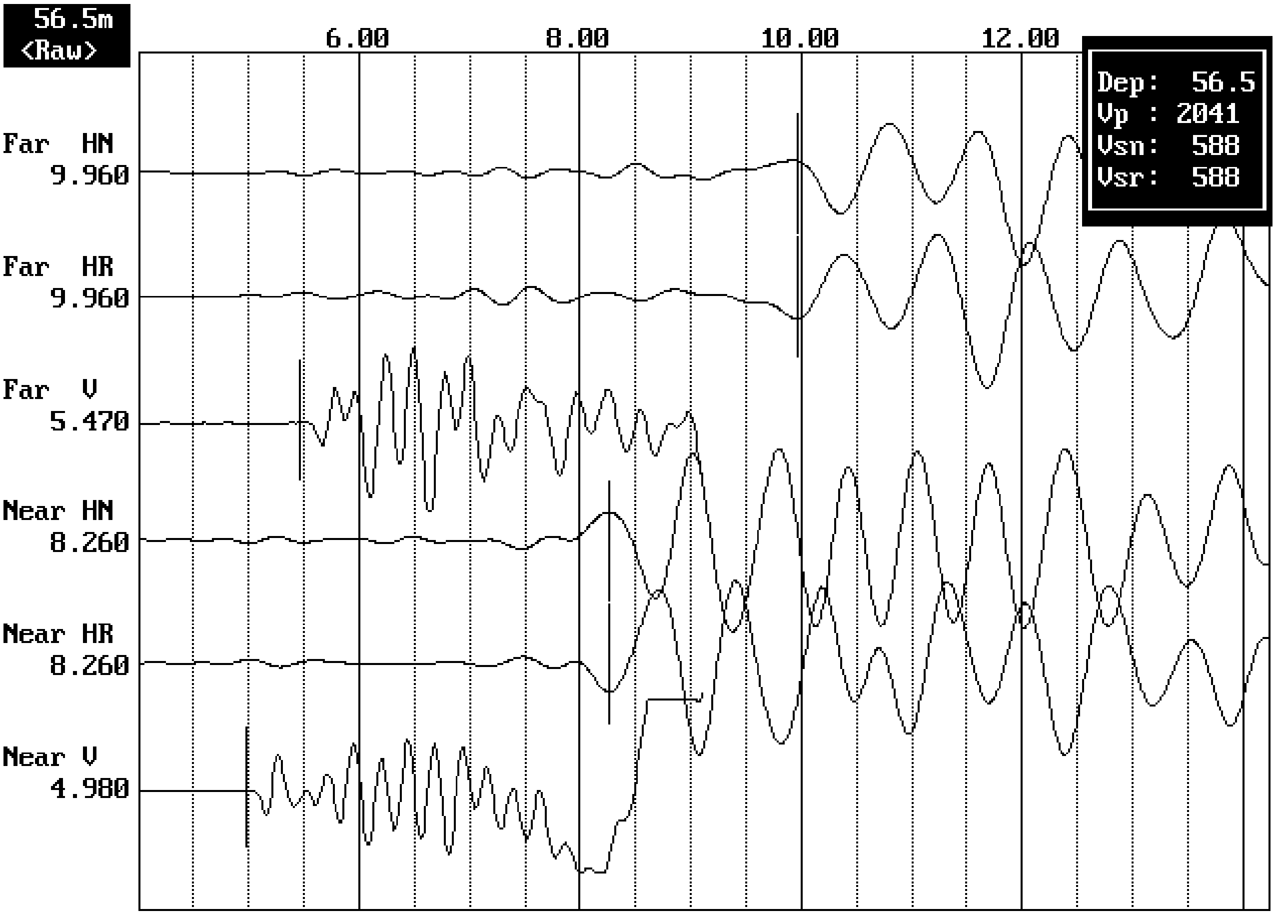


Figure 2. Sample suspension method waveform data showing horizontal normal and reversed (HR and HN), and vertical (V) waveforms received at the near (bottom 3 channels) and far (top 3 channels) geophones. The arrivals in milliseconds for each pick are shown on the left. The box in the upper right corner shows the depth in the borehole and the velocities calculated based on the picks.

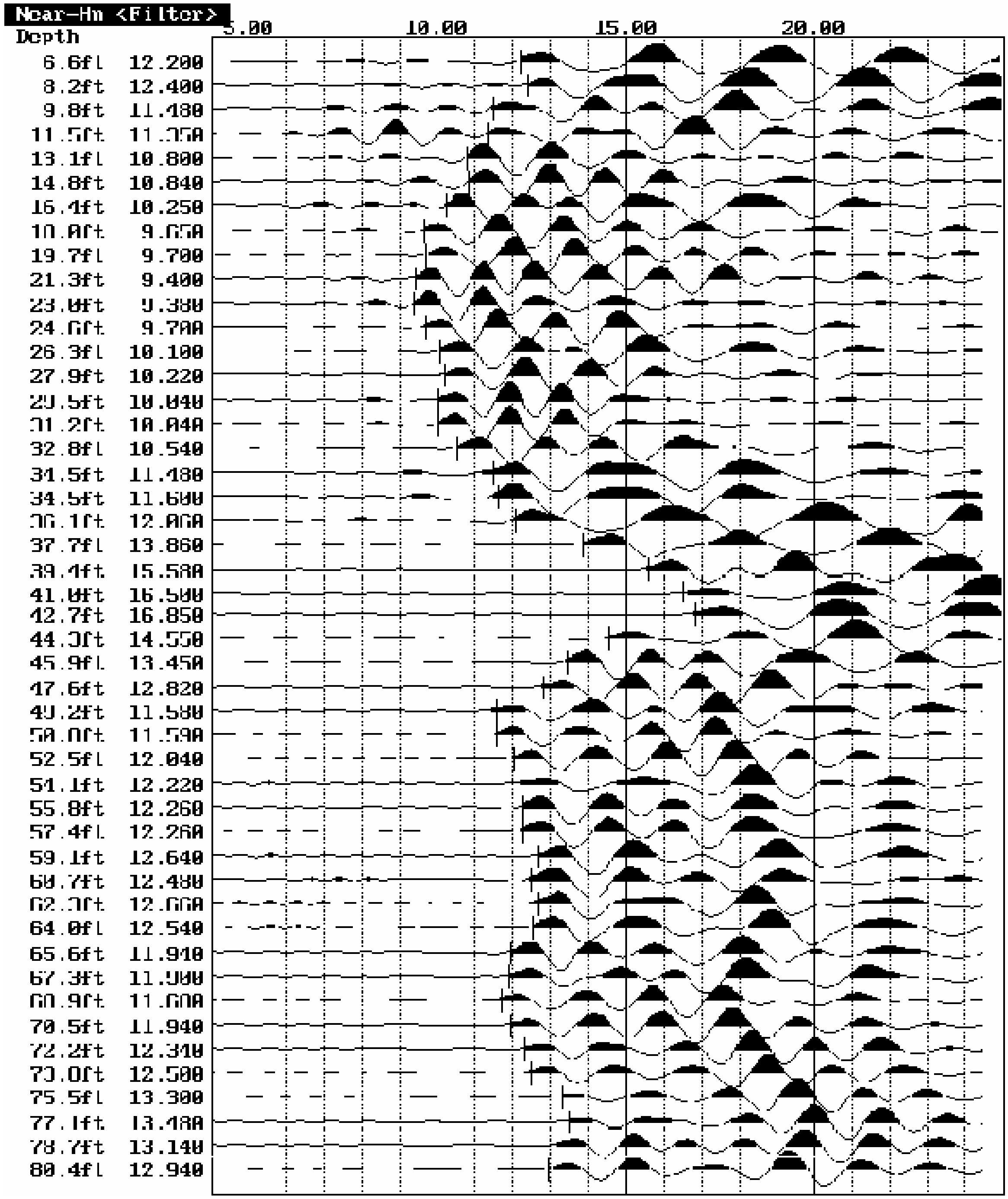


Figure 3. Sample composite waveform plot for normal shear waves received at the near geophone in a single borehole

APPENDIX B

OYO 170 VELOCITY LOGGING SYSTEM

NIST TRACEABLE CALIBRATION PROCEDURE AND CALIBRATION RECORDS

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Phone: 866-723-2257

Calibration Report

NVLAP Accredited Calibration

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

TEST NUMBER
558547

NVLAP
Lab Code:105014-0

Manufacturer:	Oyo	**Condition As Found:**	In Tolerance
Model Number:	03331-0000	**Condition As Left:**	In Tolerance
Description:	Seismograph,	**Calibration Date:**	07/31/2008
Asset Number:	15014	**Calibration Due Date:**	07/31/2009
Serial Number:	15014	**Calibration Interval:**	12 Months
PO Number:	8200-080122-01		

Remarks:

This unit was calibrated with the customer's old procedure and specifications which have been reviewed by Metrology Engineering and documented in SCE Document M013684. The data can be found on page 2 of this report with the original observation data on pages 3,4,5. The unit was then calibrated with the customer's new procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 6 and 7 of this report with the original observation data on page 8 of this report.

Standards Utilized

I.D. No.	Mfg.	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal,	07/17/2008	01/17/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	04/24/2008	10/24/2008
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/22/2008	01/22/2009

Procedure: Customer
Temperature: 23° C
Humidity: 52% RH
Test No.: 558547

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A CAB	Metrologist	714-895-0714	[signature]	8-2-08
Name	Title	Phone	Name	Date

Custom Specification Report

Oyo 03331-0000 Seismograph

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Square Wave	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	Sine Wave	100.0 Hz	100.1	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	CH HR Frequency Square Wave	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	Sine Wave	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	99.8	Same		99.0 to 101.0 Hz [EMU 0.000500]
	CH V Frequency Square Wave	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	Sine Wave	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]

Remarks:

3.58

GEOVision geophysical services

SEISMOGRAPH CALIBRATION DATA SHEET REV 4/6/06

INSTRUMENT DATA

SYSTEM MFR:	OYO	MODEL NO.:	03331-0000
SERIAL NO.:	15014	CALIBRATION DATE:	7/31/2008
BY:	CRAIG BRANSON	DUE DATE:	7/31/2009
COUNTER MFR:	HEWLETT PACKARD	MODEL NO.:	5335A
SERIAL NO.:	2626A09881	CALIBRATION DATE:	7/17/2008
BY:	SCE #S1-01252	DUE DATE:	1/17/2009
FCTN GEN MFR:	HEWLETT PACKARD	MODEL NO.:	3325A
SERIAL NO.:	2652A25647	CALIBRATION DATE:	4/24/2008
BY:	SCE #S1-01347	DUE DATE:	10/24/2008

SYSTEM SETTINGS:

GAIN:	10
FILTER:	20 KHZ
RANGE:	100 MILLISEC
DELAY:	0
STACK: 1 (STD)	1
PULSE:	1.6
DISPLAY:	NA
SYSTEM: DATE = CORRECT DATE & TIME	7/31/2008 1729

PROCEDURE:

SET FREQUENCY TO 100.0HZ SQUAREWAVE WITH AMPLITUDE APPROXIMATELY 0.25 VOLT PEAK. RECORD BOTH ON DISK AND PAPER TAPE, IF AVAILABLE. ANALYZE AND PRINT WAVEFORMS FROM ANALYSIS UTILITY. ATTACH PAPER COPIES OF PRINTOUT AND PAPER TAPES, IF AVAILABLE, TO THIS FORM. AVERAGE FREQUENCY MUST BE BETWEEN 99.0 AND 101.0 HZ.

AS FOUND 99.9 HZ AS LEFT 99.9 HZ

WAVEFORM	FILE NO	FREQUENCY	TIME FOR 9 CYCLES Hn	TIME FOR 9 CYCLES Hr	TIME FOR 9 CYCLES V	AVERAGE FREQ.
SQUARE	201	100.0	90.00 ms	90.00 ms	90.00 ms	100.0 Hz
SQUARE	202	100.0	90.00 ms	90.00 ms	90.00 ms	100.0 Hz
SINE	203	100.0	89.90 ms	90.00 ms	90.00 ms	100.0 Hz
SINE	204	100.0	90.00 ms	90.20 ms	90.00 ms	99.9 Hz

CALIBRATED BY: CRAIG BRANSON 7/31/2008 Craig Branson

NAME DATE SIGNATURE

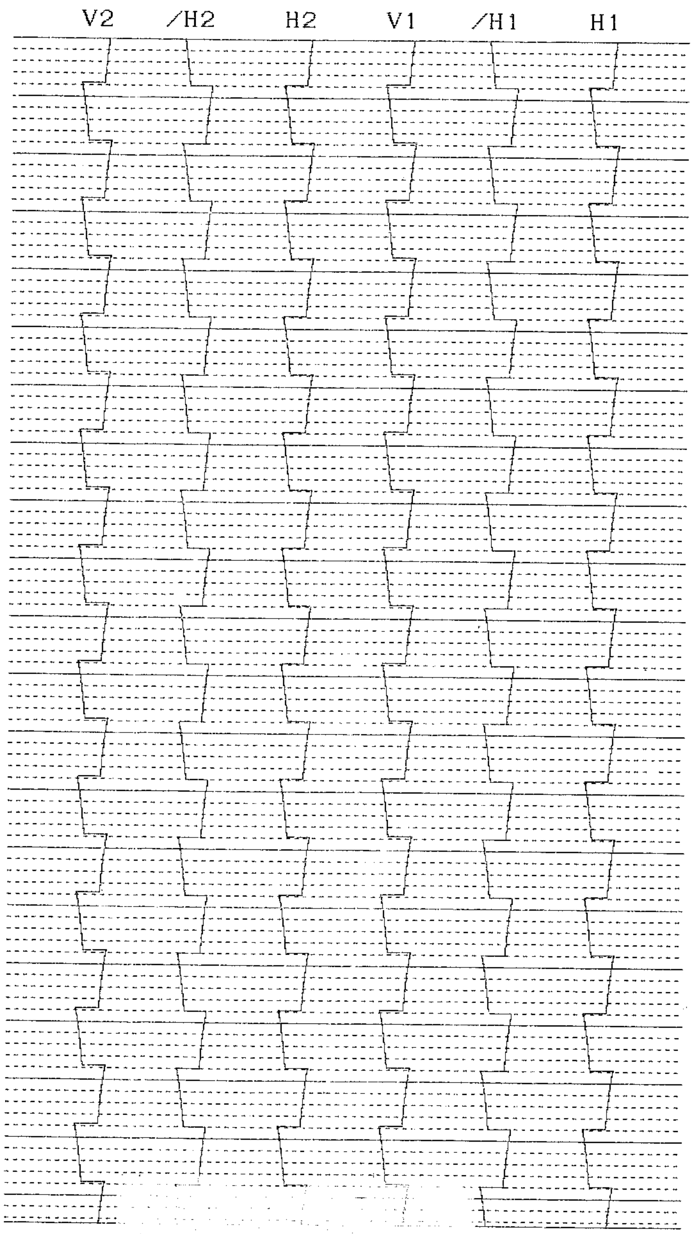
OYO   S/N 15014

Suspension 170 1.42

ID_NO.	: 201					
HOLE NO.	: 0					
DEPTH	: 0.0 [m]					
DATE	: 31/07/08 05:28:48 PM					
H-SAMPLE RATE	: 100 [μSEC]					
V-SAMPLE RATE	: 100 [μSEC]					
PULSE WIDTH	: 1.6 [mSEC]					
DELAY TIME	: 0 [mSEC]					

	H1	/H1	V1	H2	/H2	V2
GAIN	:X 10	X 10	X 10	X 10	X 10	X 10
LCF[Hz]	: 5	5	5	5	5	5
HCF[Hz]	: 20K	20K	20K	20K	20K	20K
STACK	: 1	1	1	1	1	1

TRACE SIZE : 1
H-TIME SCALE: 1.00 [mSEC/LINE]
V-TIME SCALE: 1.00 [mSEC/LINE]



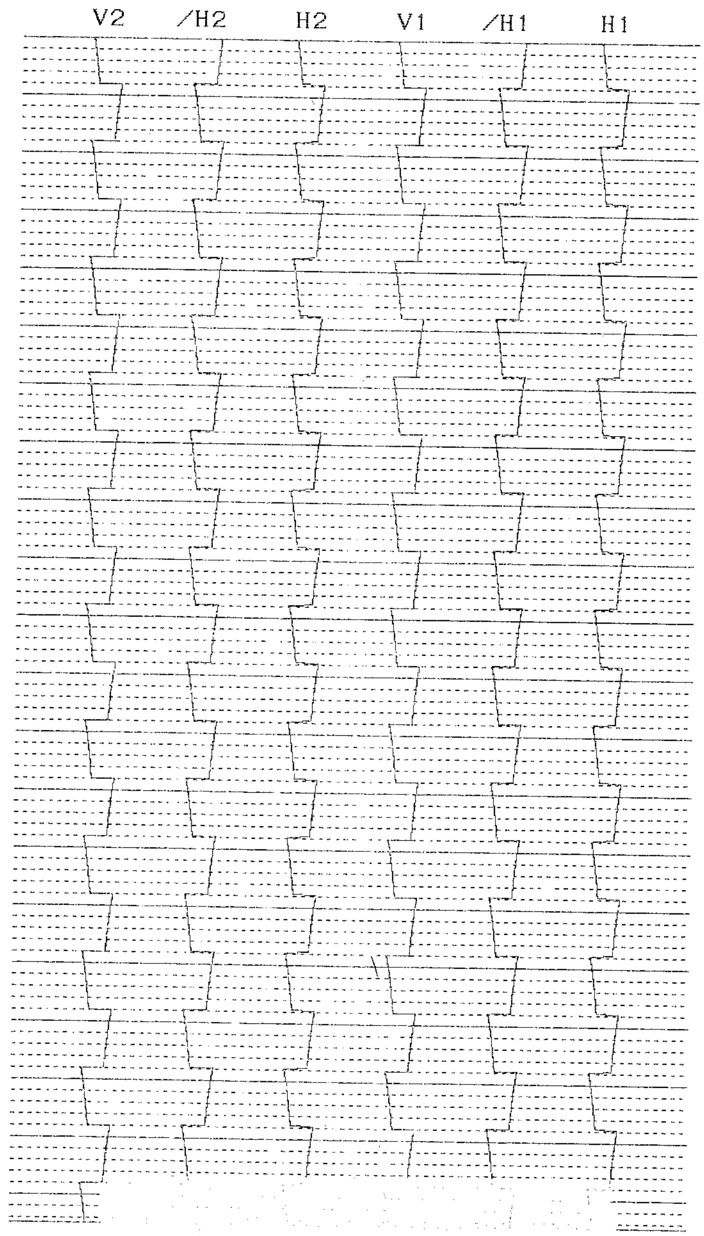
OYO   S/N 15014

Suspension 170 1.42

ID_NO.	: 202					
HOLE NO.	: 0					
DEPTH	: 0.0 [m]					
DATE	: 31/07/08 05:30:17 PM					
H-SAMPLE RATE	: 100 [μSEC]					
V-SAMPLE RATE	: 100 [μSEC]					
PULSE WIDTH	: 1.6 [mSEC]					
DELAY TIME	: 0 [mSEC]					

	H1	/H1	V1	H2	/H2	V2
GAIN	:X 10	X 10	X 10	X 10	X 10	X 10
LCF[Hz]	: 5	5	5	5	5	5
HCF[Hz]	: 20K	20K	20K	20K	20K	20K
STACK	: 1	1	1	1	1	1

TRACE SIZE : 1
H-TIME SCALE: 1.00 [mSEC/LINE]
V-TIME SCALE: 1.00 [mSEC/LINE]



5.28

OYO

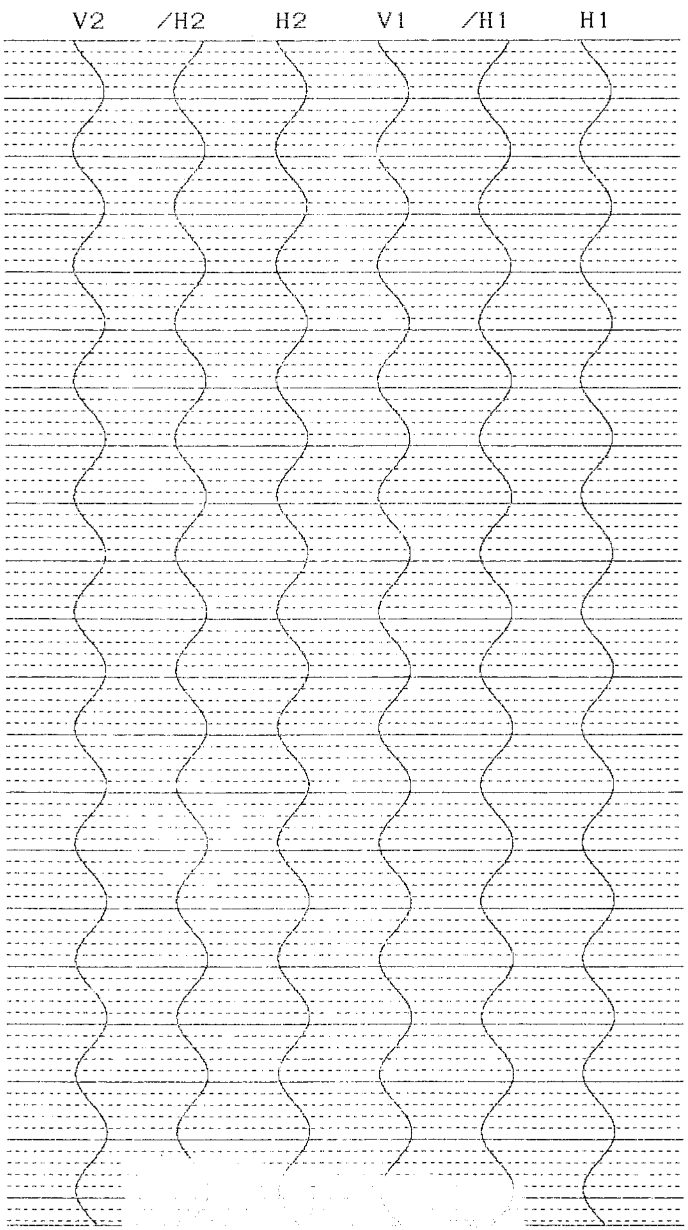
S/N 15014

Suspension 170 1.42

ID_NO. : 203
HOLE NO. : 0
DEPTH : 0.0 [m]
DATE : 31/07/08 05:31:28 PM
H-SAMPLE RATE: 100 [μSEC]
V-SAMPLE RATE: 100 [μSEC]
PULSE WIDTH : 1.6 [mSEC]
DELAY TIME : 0 [mSEC]

	H1	/H1	V1	H2	/H2	V2
GAIN	:X 10	X 10	X 10	X 10	X 10	X 10
LCF[Hz]	: 5	5	5	5	5	5
HCF[Hz]	: 20K	20K	20K	20K	20K	20K
STACK	: 1	1	1	1	1	1

TRACE SIZE : 1
H-TIME SCALE: 1.00 [mSEC/LINE]
V-TIME SCALE: 1.00 [mSEC/LINE]



OYO

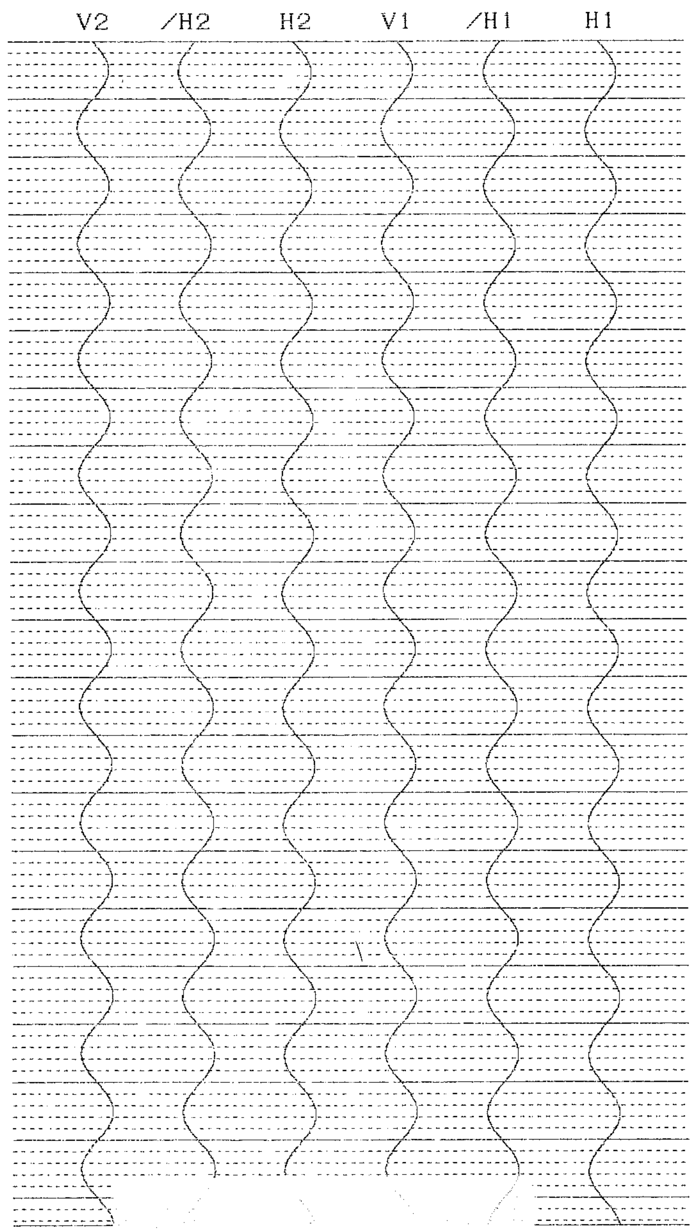
S/N 15014

Suspension 170 1.42

ID_NO. : 204
HOLE NO. : 0
DEPTH : 0.0 [m]
DATE : 31/07/08 05:32:32 PM
H-SAMPLE RATE: 100 [μSEC]
V-SAMPLE RATE: 100 [μSEC]
PULSE WIDTH : 1.6 [mSEC]
DELAY TIME : 0 [mSEC]

	H1	/H1	V1	H2	/H2	V2
GAIN	:X 10	X 10	X 10	X 10	X 10	X 10
LCF[Hz]	: 5	5	5	5	5	5
HCF[Hz]	: 20K	20K	20K	20K	20K	20K
STACK	: 1	1	1	1	1	1

TRACE SIZE : 1
H-TIME SCALE: 1.00 [mSEC/LINE]
V-TIME SCALE: 1.00 [mSEC/LINE]



Custom Specification Report

Oyo 03331-0000 Logger/Recorder, Seismic, PS Suspension

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	199.8	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	499.4	Same		495.0 to 505.0 Hz [EMU 0.002500]
	|	1000 Hz	1000	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2002	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	50.00	Same		49.50 to 50.50 Hz [EMU 0.000250]
	|	100.0 Hz	100.1	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	199.8	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	499.4	Same		495.0 to 505.0 Hz [EMU 0.002500]
	|	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	50.06	Same		49.50 to 50.50 Hz [EMU 0.000250]
	|	100.0 Hz	99.9	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	500.6	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Oyo 03331-0000 Logger/Recorder, Seismic, PS Suspension

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	1998	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

GEOVision
geophysical services

SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	03331-0000
Serial no.:	15014	Calibration date:	7/31/2008
By:	Craig Branson	Due date:	7/31/2009
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	7/17/2008
By:	SCE #S1-01252	Due date:	1/17/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	4/24/2008
By:	SCE #S1-01347	Due date:	10/24/2008

SYSTEM SETTINGS:

Gain:	10
Filter	20KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/31/2008 1734

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	205	180.0	50.00	180.0	50.00	179.8	50.06
100.0	100.0	100	206	90.00	100.0	89.90	100.1	90.10	99.9
200.0	200.0	50	207	45.05	199.8	45.05	199.8	45.00	200.0
500.0	500.0	20	208	18.02	499.4	18.02	499.4	17.98	500.6
1000	1000	10	209	9.000	1000	8.990	1001	8.990	1001
2000	2000	5	210	4.495	2002	4.500	2000	4.505	1998

Calibrated by:	Craig Branson Name	7/31/2008 Date	Craig Branson Signature
Witnessed by:	Robert Steller Name	7/31/2008 Date	Signature

EDISON ESI℠

A SOUTHERN CALIFORNIA EDISON® Company

Metrology
7300 Fenwick Lane
Westminster, CA 92683
Phone: 866-723-2257

Calibration Report

NVLAP Accredited Calibration

GEOVision Geophysical Services
1124 Olympic Drive
Corona, CA 92881-3390

TEST NUMBER
558548

NVLAP
Lab Code:105014-0

Manufacturer: Oyo Corporation
Model Number: 3331-A
Description: Logger, Suspension,
Asset Number: 19029
Serial Number: 19029
PO Number: 8200-080122-01

Condition As Found: In Tolerance
Condition As Left: In Tolerance
Calibration Date: 07/31/2008
Calibration Due Date: 07/31/2009
Calibration Interval: 12 Months

Remarks:

This unit was calibrated with the customer's old procedure and specifications which have been reviewed by Metrology Engineering and documented in SCE Document M013684. The data can be found on page 2 of this report with the original observation data on pages 3,4,5. The unit was then calibrated with the customer's new procedure and specification's which have been reviewed by Metrology Engineering and documented in SCE Document M013987. The data can be found on pages 6 and 7 of this report with the original observation data on page 8 of this report.

Standards Utilized

I.D. No.	Mfg.	Model No.	Description	Cal. Date	Due Date
S1-01252	Hewlett Packard	5335A OPT 010,203040	Counter, Universal,	07/17/2008	01/17/2009
S1-01347	Hewlett Packard	3325A	Generator, Function, Synthesizer	04/24/2008	10/24/2008
S1-03686	Fluke	910	Standard, Frequency, Controlled, Gps	01/22/2008	01/22/2009

Procedure: Customer
Temperature: 23° C
Humidity: 52% RH
Test No.: 558548

Calibration Performed By:			Quality Reviewer:	
Branson, Craig A	Metrologist	714-895-0714		8-2-08
Name	Title	Phone	Name	Date

Custom Specification Report

Oyo 3331-A Seismograph

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Square Wave	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	Sine Wave	100.0 Hz	99.9	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	99.8	Same		99.0 to 101.0 Hz [EMU 0.000500]
	CH HR Frequency Square Wave	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	Sine Wave	100.0 Hz	99.9	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	99.8	Same		99.0 to 101.0 Hz [EMU 0.000500]
	CH V Frequency Square Wave	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]
	Sine Wave	100.0 Hz	99.8	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	100.0 Hz	100.0	Same		99.0 to 101.0 Hz [EMU 0.000500]

Remarks:

3-48

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SEISMOGRAPH CALIBRATION DATA SHEET REV 4/6/06

INSTRUMENT DATA

SYSTEM MFR:	OYO	MODEL NO.:	3331-A
SERIAL NO.:	19029	CALIBRATION DATE:	7/31/2008
BY:	CRAIG BRANSON	DUE DATE:	7/31/2009
COUNTER MFR:	HEWLETT PACKARD	MODEL NO.:	5335A
SERIAL NO.:	2626A09881	CALIBRATION DATE:	7/17/2008
BY:	SCE #S1-01252	DUE DATE:	1/17/2009
FCTN GEN MFR:	HEWLETT PACKARD	MODEL NO.:	3325A
SERIAL NO.:	2652A25647	CALIBRATION DATE:	4/24/2008
BY:	SCE #S1-01347	DUE DATE:	10/24/2008

SYSTEM SETTINGS:

GAIN:	10
FILTER:	20 KHZ
RANGE:	100 MILLISEC
DELAY:	0
STACK: 1 (STD)	1
PULSE:	1.6
DISPLAY:	NA
SYSTEM: DATE = CORRECT DATE & TIME	7/31/2008 1810

PROCEDURE:

SET FREQUENCY TO 100.0HZ SQUAREWAVE WITH AMPLITUDE APPROXIMATELY 0.25 VOLT PEAK. RECORD BOTH ON DISK AND PAPER TAPE, IF AVAILABLE. ANALYZE AND PRINT WAVEFORMS FROM ANALYSIS UTILITY. ATTACH PAPER COPIES OF PRINTOUT AND PAPER TAPES, IF AVAILABLE, TO THIS FORM. AVERAGE FREQUENCY MUST BE BETWEEN 99.0 AND 101.0 HZ.

AS FOUND 99.8 HZ AS LEFT 99.8 HZ

WAVEFORM	FILE NO	FREQUENCY	TIME FOR 9 CYCLES Hn	TIME FOR 9 CYCLES Hr	TIME FOR 9 CYCLES V	AVERAGE FREQ.
SQUARE	301	100.0	90.00 ms	90.00 ms	90.00 ms	100.0 HZ
SQUARE	302	100.0	90.00 ms	90.00 ms	90.00 ms	100.0 HZ
SINE	303	100.0	90.10 ms	90.10 ms	90.20 ms	99.85 HZ
SINE	304	100.0	90.20 ms	90.20 ms	90.00 ms	99.85 HZ

CALIBRATED BY: CRAIG BRANSON 7/31/2008 Craig Branson

NAME DATE SIGNATURE

OYO   s/n 19029

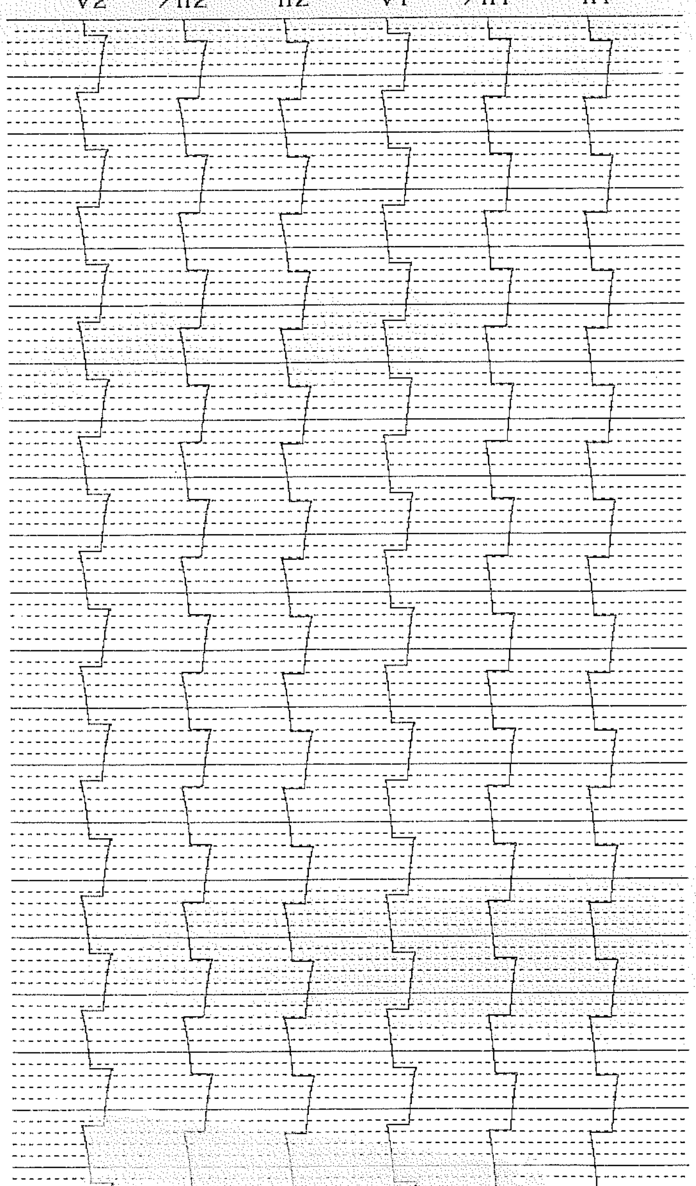
Suspension 170 4.25

ID_NO. : 301
HOLE NO. : 2
DEPTH : 0.0 [m]
DATE : 31/07/08 06:08:54 PM
H-SAMPLE RATE: 100 [μSEC]
V-SAMPLE RATE: 100 [μSEC]
PULSE WIDTH : 1.6 [mSEC]
DELAY TIME : 0 [mSEC]

	H1	/H1	V1	H2	/H2	V2
GAIN :	X 10	X 10	X 10	X 10	X 10	X 10
LCF[Hz] :	5	5	5	5	5	5
HCF[Hz] :	20K	20K	20K	20K	20K	20K
STACK :	1	1	1	1	1	1

TRACE SIZE : 1
H-TIME SCALE: 1.00 [mSEC/LINE]
V-TIME SCALE: 1.00 [mSEC/LINE]

V2 /H2 H2 V1 /H1 H1



OYO   s/n 19029

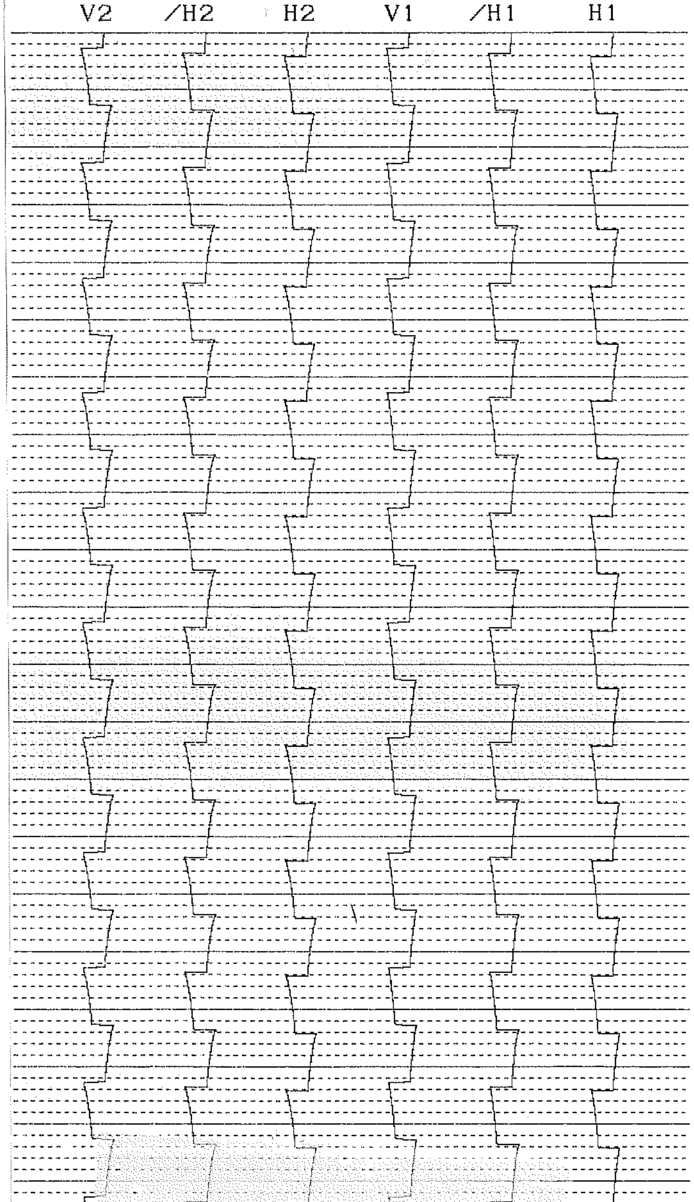
Suspension 170 4.25

ID_NO. : 302
HOLE NO. : 2
DEPTH : 0.0 [m]
DATE : 31/07/08 06:11:54 PM
H-SAMPLE RATE: 100 [μSEC]
V-SAMPLE RATE: 100 [μSEC]
PULSE WIDTH : 1.6 [mSEC]
DELAY TIME : 0 [mSEC]

	H1	/H1	V1	H2	/H2	V2
GAIN :	X 10	X 10	X 10	X 10	X 10	X 10
LCF[Hz] :	5	5	5	5	5	5
HCF[Hz] :	20K	20K	20K	20K	20K	20K
STACK :	1	1	1	1	1	1

TRACE SIZE : 1
H-TIME SCALE: 1.00 [mSEC/LINE]
V-TIME SCALE: 1.00 [mSEC/LINE]

V2 /H2 H2 V1 /H1 H1



5.58.

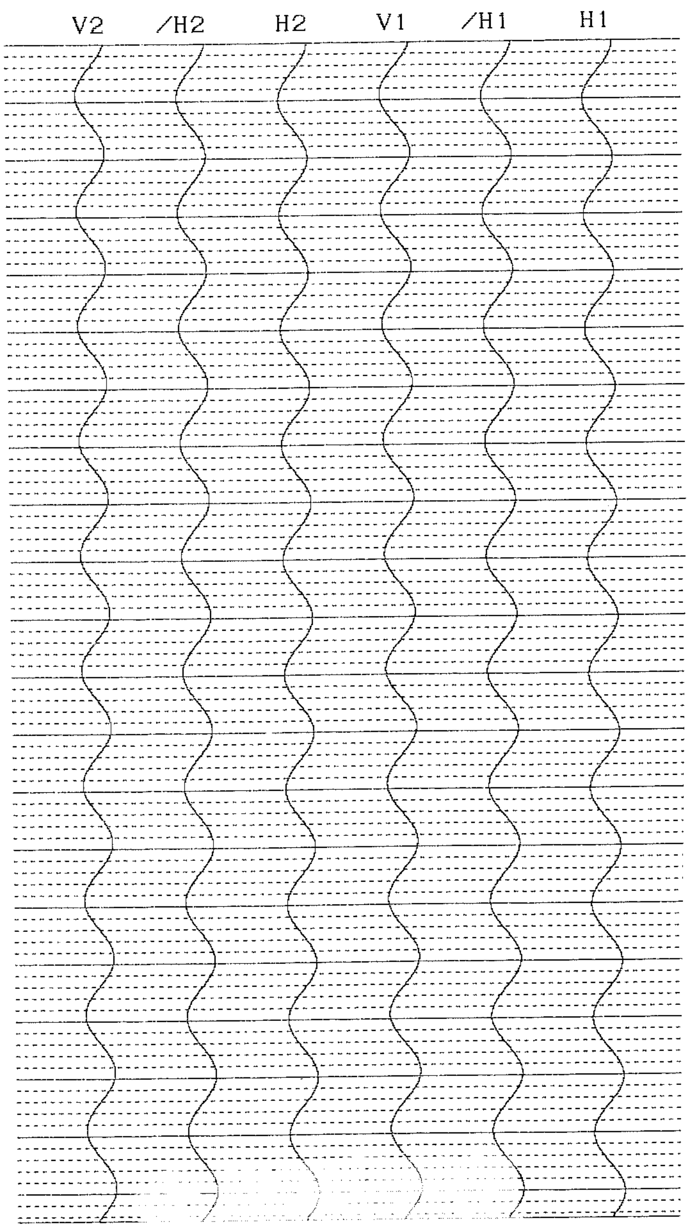
OYO S/N 19029

Suspension 170 4.25

ID_NO. : 303
HOLE NO. : 2
DEPTH : 0.0 [m]
DATE : 31/07/08 06:13:02 PM
H-SAMPLE RATE: 100 [μSEC]
V-SAMPLE RATE: 100 [μSEC]
PULSE WIDTH : 1.6 [mSEC]
DELAY TIME : 0 [mSEC]

	H1	/H1	V1	H2	/H2	V2
GAIN	:X 10	X 10	X 10	X 10	X 10	X 10
LCF[Hz]	: 5	5	5	5	5	5
HCF[Hz]	: 20K	20K	20K	20K	20K	20K
STACK	: 1	1	1	1	1	1

TRACE SIZE : 1
H-TIME SCALE: 1.00 [mSEC/LINE]
V-TIME SCALE: 1.00 [mSEC/LINE]



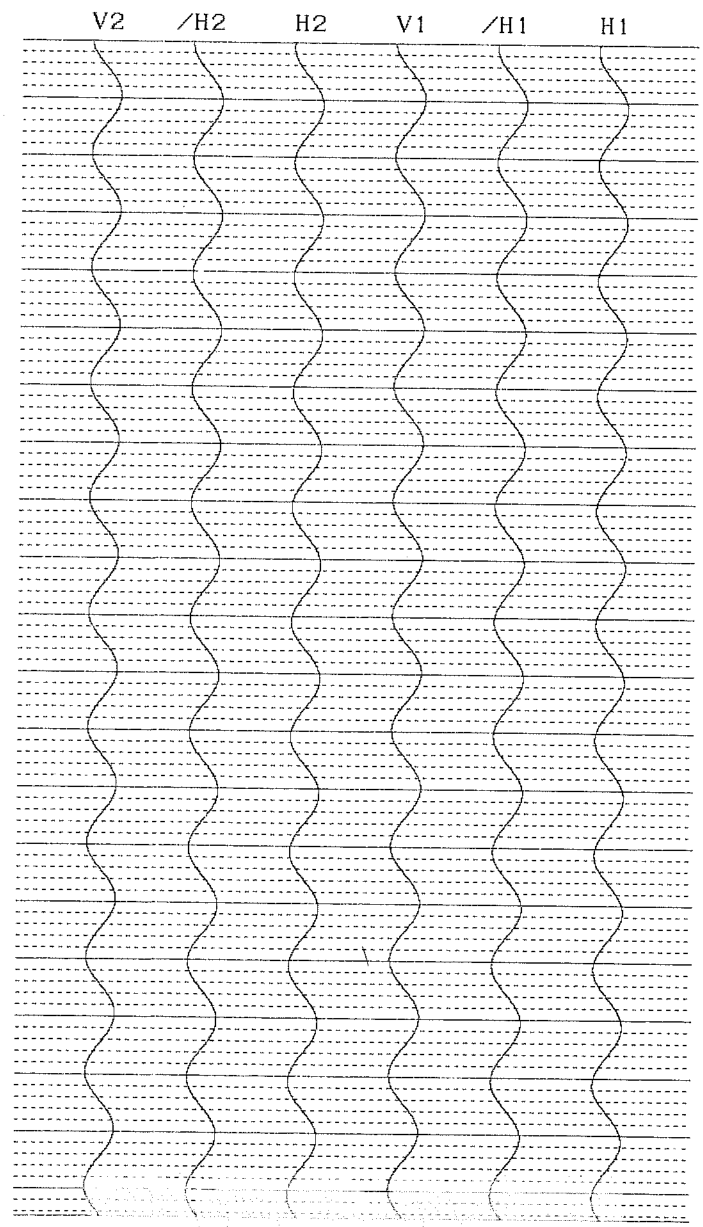
OYO S/N 19029

Suspension 170 4.25

ID_NO. : 304
HOLE NO. : 2
DEPTH : 0.0 [m]
DATE : 31/07/08 06:13:50 PM
H-SAMPLE RATE: 100 [μSEC]
V-SAMPLE RATE: 100 [μSEC]
PULSE WIDTH : 1.6 [mSEC]
DELAY TIME : 0 [mSEC]

	H1	/H1	V1	H2	/H2	V2
GAIN	:X 10	X 10	X 10	X 10	X 10	X 10
LCF[Hz]	: 5	5	5	5	5	5
HCF[Hz]	: 20K	20K	20K	20K	20K	20K
STACK	: 1	1	1	1	1	1

TRACE SIZE : 1
H-TIME SCALE: 1.00 [mSEC/LINE]
V-TIME SCALE: 1.00 [mSEC/LINE]



Custom Specification Report

Oyo Corporation 3331-A Logger, Suspension,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH HN Frequency Sine Wave	50.00 Hz	49.95	Same		49.50 to 50.50 Hz [EMU 0.000250]
	|	100.0 Hz	100.1	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	199.8	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	500.0	Same		495.0 to 505.0 Hz [EMU 0.002500]
	|	1000 Hz	1001	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	1998	Same		1980 to 2020 Hz [EMU 0.010000]
	CH HR Frequency Sine Wave	50.00 Hz	49.89	Same		49.50 to 50.50 Hz [EMU 0.000500]
	|	100.0 Hz	99.9	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	200.0	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	499.4	Same		495.0 to 505.0 Hz [EMU 0.002500]
	|	1000 Hz	997.8	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	2000	Same		1980 to 2020 Hz [EMU 0.010000]
	CH V Frequency Sine Wave	50.00 Hz	49.95	Same		49.50 to 50.50 Hz [EMU 0.000500]
	|	100.0 Hz	99.78	Same		99.0 to 101.0 Hz [EMU 0.000500]
	|	200.0 Hz	199.8	Same		198.0 to 202.0 Hz [EMU 0.001000]
	|	500.0 Hz	499.4	Same		495.0 to 505.0 Hz [EMU 0.002500]

Remarks:

Custom Specification Report

Oyo Corporation 3331-A Logger, Suspension,

STEP NUM	FUNCTION TESTED	NOMINAL VALUE	AS FOUND	AS LEFT	Out of Tol	CALIBRATION TOLERANCE
	CH V Frequency Sine Wave	1000 Hz	997.8	Same		990 to 1010 Hz [EMU 0.005000]
	|	2000 Hz	1998	Same		1980 to 2020 Hz [EMU 0.010000]

Remarks:

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SUSPENSION PS SEISMIC LOGGER/RECORDER CALIBRATION DATA FORM

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INSTRUMENT DATA

System mfg.:	Oyo	Model no.:	3331-A
Serial no.:	19029	Calibration date:	7/31/2008
By:	Craig Branson	Due date:	7/31/2009
Counter mfg.:	Hewlett-Packard	Model no.:	5335A
Serial no.:	2626A09881	Calibration date:	7/17/2008
By:	SCE #S1-01252	Due date:	1/17/2009
Signal generator mfg.:	Hewlett-Packard	Model no.:	3325A
Serial no.:	2652A25647	Calibration date:	4/24/2008
By:	SCE #S1-01347	Due date:	10/24/2008

SYSTEM SETTINGS:

Gain:	10
Filter	20KHz
Range:	See sample period in table below
Delay:	0
Stack (1 std)	1
System date = correct date and time	7/31/2008 1816

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 -0.22 As left -0.22

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	305	180.2	49.95	180.4	49.89	180.2	49.95
100.0	100.0	100	306	89.9	100.1	90.1	99.9	90.2	99.78
200.0	200.0	50	307	45.05	199.8	45.00	200.0	45.05	199.8
500.0	500.0	20	308	18.00	500.0	18.02	499.4	18.02	499.4
1000	1000	10	309	8.990	1001	9.020	997.8	9.020	997.8
2000	2000	5	310	4.505	1998	4.500	2000	4.505	1998

Calibrated by:	Craig Branson	7/31/2008	Craig Branson
	Name	Date	Signature
Witnessed by:	Robert Steller	7/31/2008	[signature]
	Name	Date	Signature