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TURKEY POINT COL PROJECT
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Appendix D – Geovision Downhole and P-S Logging Report

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MACTEC Project No. 6468-07-1950

Prepared For:

Bechtel Power Corporation
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MACTEC

DOCUMENTATION OF TECHNICAL REVIEW
SUBCONTRACTOR WORK PRODUCT

Project Name: Turkey Point COL

Project Number: 6468-07-1950

Project Manager: Scott Auger

Project Principals: Al Tice and Tom McDaniel

The report described below has been prepared by the named subcontractor retained in accordance with the MACTEC QAPD. The work and report have been reviewed by a MACTEC technically qualified person. Comments on the work or report, if any, have been satisfactorily addressed by the subcontractor. The attached report is approved in accordance with section QS-7 of MACTEC's QAPD

The information and date contained in the attached report are hereby released by MACTEC for project use.

REPORT : Report Boring Geophysical Logging. Report 8083-03 rev 0, July 24, 2008_

SUBCONTRACTOR: GeoVision

DATE OF ACCEPTANCE :_ 7-25-08

TECHNICAL REVIEWER: [signature]

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GEOVision
geophysical services

BORING GEOPHYSICAL LOGGING
BORINGS B-601 (DH), B-604 (DH), B-608 (DH), B-610 (DH), B-620 (DH), B-640 (DHT), B-701 (DH), B-704 G (DH), B-708 (DH), B-710 G (DH), B-720 G (DH) AND B-740 (DHT)

FPL TURKEY POINT COL

Report 8083-03 rev 0

July 24, 2008

DCN TUR 482

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FPL TURKEY POINT COL

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INTRODUCTION

Boring geophysical measurements were collected in ten uncased and two cased borings located at the Florida Power and Light (FPL) Turkey Point Combined Operating License (COL) Application Project, located near Florida City, Florida. Geophysical data acquisition was performed between March 8 and June 26, 2008 by Robert Steller, Charles Carter, Anthony Martin and Nathan Baldwin of **GEO***Vision*. Data analysis was performed by Robert Steller and Anthony Martin, and reviewed by John Diehl of GEOVision. Report preparation was performed by Robert Steller and reviewed by John Diehl of GEOVision. The work was performed under subcontract with MACTEC Engineering and Consulting, Inc., (MACTEC) with Stephen Criscenzo serving as the point of contact for MACTEC.

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

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between March 8 and June 26, in twelve borings, as detailed in Table 1. The purpose of these studies was to supplement stratigraphic information obtained during MACTEC's soil and rock sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth, as a component of the FPL Turkey Point COL Project.

The OYO/Robertson Suspension PS Logging System (Suspension System) was used to obtain in-situ horizontal shear (S_H) and compressional (P) wave velocity measurements in ten borings at 1.6 foot intervals. Measurements followed **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.31. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

The Robertson ELGX and 3ACS probes were used to collect long and short normal resistivity, single point resistance (SPR) Spontaneous Potential (SP), natural gamma and 3 arm mechanical caliper data at 0.05 foot intervals in the ten uncased borings to aid in identification of stratagraphic transitions. Measurement procedures followed these ASTM standards:

- ASTM D5753, "Planning and Conducting Borehole Geophysical Surveys
- ASTM D6167 "Conducting Borehole Geophysical Logging – Mechanical Caliper"
- ASTM D6274, "Conducting Borehole Geophysical Logging – Gamma"

The acquired data was combined and a profile of these parameters versus depth was produced.

The Robertson High Resolution Acoustic Televiewer (HiRAT) was used to collect deviation data at 0.04 foot intervals and acoustic televiewer images of the rock section of each boring at 0.008 foot intervals in the ten uncased borings. Measurements followed the **GEO***Vision* HiRAT Field Procedure, revision 1.0. The acquired data was analyzed and a profile of boring deviation versus depth was produced for each boring, and an image of the rock portions of the uncased borings, with 4 arm caliper dimensions superimposed, was produced.

The Downhole Seismic velocity logging system was used in the two PVC cased borings as a validation of the suspension velocity data collected at this site. In this method, the source remains stationary at the surface, while a single receiver travels down the cased boring at 5 foot intervals. Source energy is transmitted down the soil column from the surface and velocity is calculated from first arrival travel time and receiver depth. Measurements followed **GEO***Vision* Procedure for Downhole Seismic Velocity Logging, revision 1.1. The acquired data was analyzed and a profile of velocity versus depth was produced for both P- and S_H –waves.

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

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

INSTRUMENTATION

Suspension Velocity Instrumentation

Suspension velocity measurements were performed in ten uncased nominal 3.88 – 5.0 inch diameter borings using the suspension PS logging system, manufactured by OYO Corporation, and their subsidiary, Robertson Geologging. Components used for these measurements are listed in Table 2. This system directly determines the average velocity of a 3.3 foot high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 2. The separation of the two receivers is 3.3 feet, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the bottom end of the probe.

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

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

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 6.3 foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder 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 from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

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

Downhole Velocity Instrumentation

Downhole velocity measurements were performed in two 2 inch PVC cased borings using a Geostuff BHG-3, 3-component borehole geophone, serial number B-3079. This system orients the downhole geophones parallel to the axis of excitation at the surface, insuring that signals received at the downhole geophones are of maximum amplitude, and are not subject to errors in travel time caused by incorrect phase of first arrival picks, as found with non-orientable downhole probes. The downhole probe consists of horizontal and vertical geophones mounted on a rotatable structure with a fluxgate magnetometer compass sensor. The structure can be pre-set on the surface to match the azimuth of the horizontal geophone axis with the azimuth of the surface shear wave source whenever power is applied to the compass sensor and orientation servo mechanism. The probe receives control signals from, and sends the geophone signals to, instrumentation on the surface via cable. Cable travel is measured to provide probe depth data. The probe is locked into the boring using a motor driven clamp mechanism. The BHGC-4 controller directs the voltages to control the clamping mechanism and orientation mechanism. A meter monitors motor current to indicate the clamping action and force.

A triaxial geophone is placed on the surface adjacent to the boring collar, to record reference waveforms to validate the function of the hammer switch, as well as to monitor shifts in timing due to changes in source coupling to the soil.

The S_H -wave energy source consists of an 88-pound elastic band accelerated hammer striking horizontally against the ends of a steel capped traction plank. The traction plank is weighted by placing it beneath the rear end of a truck supported on an air suspension, as shown in Figure 2. The P-wave energy source utilizes the same energy source operating in a vertical orientation, striking an aluminum plate, as shown in Figure 3. A hammer switch mounted on the steel plank caps or aluminum plate is used to provide consistent triggering from each hammer blow. During logging operations, a repeatable pattern of impulses, similar to that produced by the suspension source, is generated at each measurement depth as follows:

1. The plank is struck with the hammer laterally in one direction, producing dominantly horizontal shear with some vertical compression, and the signals generated by the horizontal receivers are recorded. The signals are checked, and repeated (stacked) as needed.
2. The plank is struck in the opposite direction and the horizontal signals are recorded, and stacked as needed.
3. The plate is struck on top, and the signals generated by the vertical receivers are recorded. The repeated source pattern facilitates the picking of the P- and S_H-wave arrivals, since the reversal of the source direction changes the polarity of the S_H-wave pattern but not that of the P-wave pattern.

The signals from the BHG-3 geophone were recorded on a Geometrics Geode seismograph, controlled by a laptop computer. Geode S/N 3458 was used on both borings. The Geode is a 24-bit exploration seismograph with 113dB dynamic range. Triggered by the hammer switch (see procedure, Appendix G) the seismograph recorded the responses of the borehole and surface sensors. Data was reviewed on the computer screen, and stored internally on hard disk. Multiple hammer blows can be summed to improve the signal-to-noise ratio of the signals. Review of the displayed data on the screen allows the operator to set the gains, filters, sample rate, and summing number in order to optimize the quality of the data before recording to disk for later processing.

Caliper / Natural Gamma Instrumentation

Caliper and natural gamma data were collected using a Model 3ACS 3-leg caliper probe, serial number 5368, manufactured by Robertson Geologging, Ltd. With the short arm configuration used in these surveys, the probe permitted measurement of boring diameters between 1.6 and 16 inches. With this tool, caliper measurements were collected concurrent with measurement of natural gamma emission from the boring walls. The probe was 6.82 feet long, and 1.5 inches in diameter.

This probe is useful in the following studies:

- Measurement of boring diameter and volume
- Location of hard and soft formations
- Location of fissures, caving, pinching and casing damage
- Bed boundary identification
- Strata correlation between borings

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

The caliper consists of three arms, each with a toothed quadrant at their base, pivoted in the lower probe body. A toothed rack engages with each quadrant, thus constraining the arms to move together. Linear movement of the rack is converted to opening and closing of the arms. Springs hold the arms open in the operating position. A motor drive is provided to retract the arms, allowing the probe to be lowered into the boring. The rack is coupled to a potentiometer which converts movement into a voltage sensed by the probe's microprocessor.

Natural gamma measurements rely upon small quantities of radioactive material contained in all soil and rocks to emit gamma radiation as they decay. Trace amounts of Uranium and Thorium are present in a few minerals, where potassium-bearing minerals such as feldspar, mica and clays will include traces of a radioactive isotope of Potassium. These emit gamma radiation as they decay with an extremely long half-life. This radiation is detected by scintillation - the production of a tiny flash of light when gamma rays strike a crystal of sodium iodide. The light is converted into an electrical pulse by a photomultiplier tube. Pulses above a threshold value of 60 thousand electron Volts (KeV) are counted by the probe's microprocessor. The measurement is useful because the radioactive elements are concentrated in certain soil and rock types e.g. clay or shale, and depleted in others e.g. sandstone or coal.

Resistivity / Spontaneous Potential / Natural Gamma Instrumentation

Resistivity, spontaneous potential and natural gamma data were collected using a Model ELXG electric log probe, S/N 5490, manufactured by Robertson Geologging, Ltd. This probe measures Single Point Resistance (SPR), short normal (16 inch) resistivity, long normal (64 inch) resistivity, Spontaneous Potential (SP) and natural gamma. The probe is 8.20 feet long, and 1.73 inches in diameter.

This probe is useful in the following studies:

- Bed boundary identification
- Strata correlation between borings
- Strata geometry and type (shale indication)

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

The resistivity section of the probe operates by driving an alternating current into the formation from the central SPR/DRIVE electrode. The current returns via the logging cable armor. To ensure adequate penetration of the formation the logging cable is insulated for approximately 30 feet from the cablehead. Voltages are measured between the 16 inch and 64 inch electrodes and the remote earth connection at surface, as noted below:

- Single Point Resistance (SPR): The current flowing to the cable armor is measured along with the voltage at the SPR electrode. The voltage divided by current gives resistance.

- Spontaneous Potential (SP): This is the DC bias of the 16 inch electrode with respect to the voltage return at the surface (ground stake).

Data quality depends upon good grounding at the surface. This is achieved with a metal stake driven into the mud-pit.

Acoustic Televiewer / Boring Deviation Instrumentation

An acoustic image and boring deviation data were collected using a High Resolution Acoustic Televiewer probe (HiRAT), serial number 5174, manufactured by Robertson Geologging, Ltd. The probe is 7.58 feet long, and 1.9 inches in diameter, and is fitted with upper and lower four-band centralizers.

In this application, this probe is useful in the following studies:

- Measurement of boring inclination and deviation from vertical
- Determination of need to correct soil and geophysical log depths to true vertical depths
- Acoustic imaging of the boring wall to identify fractures, dikes, and weathered zones, and determine dip and azimuth of these features

The probe receives control signals from, and sends the digitized measurement values to, a Robertson Micrologger II on the surface via an armored 4 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder. The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop computer where it is displayed and stored on hard disk.

This system produces images of the boring wall based upon the amplitude and travel time of an ultrasonic beam reflected from the formation wall. The ultrasonic energy is generated by a piezoelectric transducer at a frequency of 1.4 MHz. A periodic acoustic energy wave is emitted by the transducer and travels through the acoustic head and boring fluid until it reaches the interface between the boring fluid and the boring wall. Here a portion of the energy is reflected back to the transducer, the remainder continuing on into the formation. By careful time sequencing, the piezoelectric transducer acts as both the transmitter of the ultrasonic pulse and receiver of the reflected wave. The travel time of the energy wave is the period between transmission of the source energy pulse and the return of the reflected wave measured at the point of maximum wave amplitude. The magnitude of the wave energy is measured in dB, a unit-less ratio of the detected echo wave amplitude divided by the amplitude of the transmitted wave. The strength of the reflected signal depends primarily upon the impedance contrast of the boring fluid and the boring wall formation. In the limestone sections of these borings, the contrast between the fluid filling the boring and the rock formation provides imaging of numerous small solution cavities, as well as areas where weathered limestone has been eroded by the drilling process.

The acoustic wave propagates along the axis of the probe and then is reflected perpendicular to this axis by a reflector that focuses the beam to a 0.1-inch diameter spot about 2 inches from the central axis of the probe. This reflector is mounted on the shaft of a stepper motor enabling the position of the measurement to be rotated through 360°. Sampling rates of 90, 180 and 360 measured points per revolution are available. During these surveys, data were collected at 360 samples per revolution for imaging the rock sections of the borings (above 120 feet and below 450 feet), and at 90 samples per revolution for deviation data in the rest of the depth range. It should be noted that during logging the probe is moving in the boring, so that the measured points describe a very fine pitch spiral.

The probe contains a fluxgate magnetometer to monitor magnetic north, and all raw televiewer data are referenced to magnetic north. Also, a three-axis accelerometer is enclosed in the probe, and boring deviation data are recorded during the logging runs, to permit correction of structure dip angle from apparent dip, (referenced to boring axis), to true dip (referenced to a vertical axis) in non-vertical borings.

The data are presented on a computer screen for operator review during the logging run, and stored on hard disk for later processing.

MEASUREMENT PROCEDURES

Suspension Velocity Measurement Procedures

Measurements followed the **GEO***Vision* Procedure for P-S Suspension Seismic Velocity Logging, revision 1.31, as presented in G. These procedures were supplied and approved in advance of the work. Ten borings were logged, filled with bentonite or polymer based drilling mud. 4 or 6 inch diameter steel surface casing was used to maintain an open hole through loose soils, necessitating multiple logging runs to access different portions of the borings. Permanent shallow surface casing was set to 16 – 25 feet in all of the borings, with B-701 (DH) being the only boring where it was removed and logs were collected to ground surface. Some borings had deeper temporary surface casing placed to below the limestone layer at approximately 110 feet, which was removed after logging the deeper section of the boring, as indicated in Table 3. Prior to each logging run, the probe was positioned with the top of the probe at the top of the surface casing, and the electronic depth counter was set to 8.2 feet, the distance between the mid-point of the receiver and the top of the probe, minus the height of the casing stick-up, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring, and then returned to the bottom of the surface casing, stopping at 1.6 foot intervals to collect data, as summarized in Table 3.

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

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring, and the after survey depth error (ASDE) was calculated, as summarized in Table 4. Field data were backed up to CD-ROM each day upon completion of data acquisition.

Downhole Velocity Measurement Procedures

Measurements followed the GEOVision Procedure for Downhole Seismic Velocity Logging, revision 1.1. This procedure was supplied and approved in advance of the work, and is presented in Appendix G. B-640 (DHT) and B-740 (DHT) were logged as 2-inch PVC cased holes. The boring casings were pumped dry to a depth of approximately 120 feet. Prior to performing the downhole method surveys, the downhole probe compass azimuth was checked at the surface, and preset to the azimuth of the traction plank S_H -wave source. The probe cable was marked to provide depth reference. The probe was then lowered to the bottom of the boring at 5-foot intervals. At each desired depth, the probe was locked in place by driving the locking spring bail outward. The compass/geophone assembly was then rotated to match the azimuth of the surface S_H source.

At each sampling depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains adjusted as required. The waveform data from each depth was checked and recorded on disk before moving to the next depth. Field data were backed up to CD-ROM each day upon completion of data acquisition.

Caliper / Natural Gamma Measurement Procedures

Measurements followed ASTM D6167 Conducting Borehole Geophysical Logging – Mechanical Caliper. Ten borings were logged, filled with bentonite or polymer based drilling mud. 4 or 6 inch diameter steel surface casing was used to maintain an open hole through loose soils, necessitating multiple logging runs to access different portions of the borings. Permanent shallow surface casing was set to 16 – 25 feet in all of the borings, with B-701 (DH) being the only boring where it was removed and logs were collected to ground surface. Some borings had deeper temporary surface casing placed to below the limestone layer at approximately 110 feet, which was removed after logging the deeper section of the boring, as indicated in Table 3.

Prior to and following each logging run, the caliper tool was verified, using the manufacturer's supplied three point calibration jig, and a PVC coupling provided by MACTEC with an inside diameter traceable to NIST. The three point jig is a circular plate with a series of holes in the top surface into which the tips of the caliper arms fit. This has circles of diameters from 2 to 12 inches. The calibration jig is placed over a bucket with the probe standing upright with its nose section passing through the jig's central hole. The caliper probe arms are opened under program control, and a log is recorded as the tips of the arms are placed in the holes on the calibration jig and inside the PVC coupling. The measured dimensions, as displayed on the recording computer screen was recorded on the field log sheet, as well as in the digital files, and compared with the calibration jig dimensions. These files are presented in LAS 2.0 format in the boring specific sub-directories of the data directory on the data disk (DVD-R) labeled Report 8083-04 that accompanies this report. If the verification records did not fall within +/- 0.05 inches of the calibration jig values, the caliper tool was re-calibrated, using the three point calibration jig, and the log repeated. As with the verification, the tips of the caliper arms are placed in the holes marked with the required diameter. During calibration, the value of the current calibration point, as stamped on the jig, is entered via the control computer. The system counts for 15 seconds to make an average of the response. The procedure is repeated for the second and third required openings.

The computation and generation of the calibration coefficient file is entirely automatic. The calibration file is simply the set of coefficients of a quadratic curve which fits the three data points. Figure 4 shows the response of a caliper probe using data gathered during calibration.

Natural gamma was not calibrated in the field, as it is a qualitative measurement, not a quantitative value, and is used only to assist in picking transitions between stratigraphic units, as described in ASTM D6274, Conducting Borehole Geophysical Logging - Gamma.

In each boring, the probe was positioned with the top of the probe at the top of the surface casing, and the electronic depth counter was set to 6.82 feet, the specified length of the probe, minus the stick-up of the casing, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring, where the caliper legs were opened, and data collection begun. The probe was then returned to the bottom of the surface casing or ground surface at 10 feet/minute, collecting data continuously at 0.05 foot spacing, as summarized in Table 3.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring, and the after survey depth error (ASDE) was calculated, as summarized in Table 4. Field data were backed up to CD-ROM each day upon completion of data acquisition.

Resistivity / Spontaneous Potential / Natural Gamma Procedures

Ten borings were logged, filled with bentonite or polymer based drilling mud. 4 or 6 inch diameter steel surface casing was used to maintain an open hole through loose soils, necessitating multiple logging runs to access different portions of the borings. Permanent shallow surface casing was set to 16 – 25 feet in all of the borings, with B-701 (DH) being the only boring where it was removed, though resistivity logs were not collected to ground surface in B-701 (DH), as the yoke electrode would be above ground level, precluding the collection of electrical data. Some borings had deeper temporary surface casing placed to below the limestone layer at approximately 110 feet, which was removed after logging the deeper section of the boring, as indicated in Table 3. The probe was connected to the logging cable using a 32.8 foot long insulating cable section or "yoke". The probe head was insulated by wrapping all exposed metal of the cablehead and probe with self-amalgamating insulation tape. The 32.8 foot insulating yoke was checked for any damage, and repaired with self-amalgamating insulation tape as needed.

The reference ground stake was driven firmly into the mud pit, and connected to the ground socket on the winch switch box.

This sonde was not calibrated in the field, as it is used to provide qualitative measurements, not quantitative values, and is used only to assist in picking transitions between stratigraphic units, as described in ASTM D5753, Planning and Conducting Borehole Geophysical Surveys. A functional test is performed prior to each logging run by applying fixed resistance values across the probe electrodes, as well as a 100 millivolt signal across the SP electrodes, and recording the resultant output of the system. These functional checks are presented in LAS 2.0 format in the boring specific sub-directories of the data directory on the data disk (DVD-R) labeled Report 8083-04 that accompanies this report.

Natural gamma was not calibrated in the field, as it is a qualitative measurement, not a quantitative value, and is used only to assist in picking transitions between stratigraphic units, as described in ASTM D6274, Conducting Borehole Geophysical Logging - Gamma.

In each boring, the probe was positioned with the top of the probe at the top of the casing or mud box, and the electronic depth counter was set to 8.2 feet, the specified length of the probe, minus the height of the casing stick-up or mud box, as verified with a tape measure. When logging on smaller drill rigs, the depth was zeroed to the top of the yoke, and 32.8 feet was added to the zero depth, as recorded in the field logs. The probe was lowered to the bottom of the boring, where data collection was begun. The probe was then returned to the surface at 10 feet/minute, collecting data continuously at 0.05 foot spacing, as summarized in Table 3. The natural gamma data collected in these logs is redundant with the data collected in the caliper / natural gamma logs, and the caliper / natural data may be used to verify the natural gamma data collected in these logs.

Upon completion of the measurements, the probe zero depth indication at the depth reference point was verified prior to removal from the boring, and the after survey depth error (ASDE) was calculated, as summarized in Table 4. Field data were backed up to CD-ROM each day upon completion of data acquisition.

Acoustic Televiewer / Boring Deviation Measurement Procedures

All ten uncased borings were logged while filled with bentonite or polymer based drilling mud. 4 or 6 inch diameter steel surface casing was used to maintain an open hole through loose soils, necessitating multiple logging runs to access different portions of the borings. Permanent shallow surface casing was set to 16 - 25 feet in all of the borings, with B-701 (DH) being the only boring where it was removed and logs were collected to ground surface. Some borings had deeper temporary surface casing placed to below the limestone layer at approximately 110 feet, which was removed after logging the deeper section of the boring, as indicated in Table 3. Measurements followed the **GEO***Vision* standard field procedures, as presented in Appendix G.

Prior to use, the HiRAT probe tiltmeter and compass functions were checked by comparison with a Brunton surveyors' compass.

In each boring, the HiRAT probe was positioned with the top of the probe at the top of the casing, and the electronic depth counter was set to 4.71 feet, the specified length of the probe, minus the height of the casing stick-up, as verified with a tape measure, and recorded on the field logs. The probe was lowered to the bottom of the boring, and data collection begun. The probe was then returned to the surface at 3.0 feet/minute, collecting data continuously at 0.008 foot intervals, as summarized in Table 3.

Upon completion of the measurements, the probe zero depth indication at grade was verified prior to removal from the boring. The log was reviewed in the field, and all data were backed up to CD-ROM each day upon completion of data acquisition.

DATA ANALYSIS

Suspension Velocity Analysis

Using the proprietary OYO program PSLOG.EXE version 1.0, included in the data disk (DVD-R) labeled Report 8083-04 that accompanies this report, the recorded digital waveforms were analyzed to locate the most prominent first minima, first maxima, or first break on the vertical axis records, indicating the arrival of P-wave energy.

The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.3 foot segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data. The time picks were then transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based upon the arrival time picks made in PSLOG. The PSLOG pick files and the EXCEL analysis files are included in the boring specific directories on the data disk (DVD-R) labeled Report 8083-04 that accompanies this report.

The P-wave velocity over the 6.3 foot interval from source to receiver 1 (S-R1) was also picked using PSLOG, and calculated and plotted in EXCEL, for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 4.8 feet to correspond to the mid-point of the 6.3 foot S-R1 interval. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 0.3 milliseconds, 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.

As with the P-wave records, the recorded digital waveforms were analyzed to locate 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 Fast Fourier Transform – Inverse Fast Fourier Transform (FFT – IFFT) lowpass 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, ranging from 600 Hz in the slowest zones to 2000 Hz in the regions of highest velocity. At each depth, the filter frequency was selected to be at least twice the fundamental frequency of the S_H-wave signal being filtered.

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

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 6.3 foot interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 4.8 foot to correspond to the mid-point of the 6.3 foot S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 0.3 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

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

Figure 5 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 5, the time difference over the 3.3 foot interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H-wave velocity of 1745 feet/second. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 6 displays the same record before filtering of the S_H-waveform record with a 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

Downhole Velocity Analysis

The recorded digital records were studied using PICKWIN95, developed by OYO Corporation, to establish the arrival 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' hammer blows are very nearly inverted images of each other. The first arrival of the S_H-wave pulses was picked, as shown for B-640 (DHT), in Figure 7. Digital FFT-IFFT lowpass filtering was used to remove the higher frequency P-wave signal from the S_H-wave signal, as well as high frequency noise from the P-wave records.

The recorded digital records were also analyzed to locate the first arrival of P-wave energy. P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data.

Once the first arrival of P- and S_H-wave pulses was picked, the raw travel time picks were transferred into an EXCEL template (EXCEL version 2003 SP2) to complete the velocity calculations based upon the arrival time picks made in PICKWIN95. The EXCEL analysis files are included in the boring specific directories of the data DVD-R (Report 8083-04) that accompanies this report. The EXCEL template corrected for the actual travel distance using the measured separation between the surface source and the boring. These corrected travel times were plotted, and the slope of each interactively picked segment of the travel time curve was calculated, using the EXCEL "slope" function, providing the average velocity for that segment of the soil column.

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

Caliper / Natural Gamma Analysis

No analysis is required with the caliper or natural gamma data; however depths to identifiable boring features were compared to verify compatible depth readings on all logs. Using Robertson Geologging Winlogger software version 1.5, build 401J, these data were combined with the resistivity, ELOG based natural gamma and spontaneous potential (SP) logs, and converted to LAS 2.0 and PDF formats for transmittal to the client.

Resistivity / Spontaneous Potential / Natural Gamma Analysis

No analysis is required with the resistivity, natural gamma or spontaneous potential data; however depths to identifiable boring features were compared to verify compatible depth readings on all logs. Using Robertson Geologging Winlogger software version 1.5, build 401J, these data were combined with the caliper and caliper-based natural gamma logs, and converted to LAS 2.0 and PDF formats for transmittal to the client.

Acoustic Televiewer / Boring Deviation Analysis

The collected Acoustic Televiewer data was processed with Robertson Geologging's RGLDIP program, version 6.2, to identify boring features and to extract the deviation data and produce an ASCII file and plots of deviation data.

No significant planar structures are apparent in the televiewer images from this site, so no feature picking was performed. Instead, the televiewer amplitude images were processed to create an un-wrapped image of the wall of the borings. It should be considered that the un-wrapped image represents a core that would have the full 3.88 to 5.0 inch diameter of the boring, not the 2.5-inch diameter of the cores removed during drilling, so that direct comparison is not possible. Also, the unwrapped image is viewed from the perspective of an observer in the center of the boring looking outward. The cores are viewed from the "outside" of the boring looking inward, so there is a reversal of the position of east and west relative to north between the two. In addition, the acoustic travel time data was processed to produce a 4-arm caliper log of the boring. This caliper data is not NIST traceable, but is useful in conjunction with the image to evaluate the size of solution cavities and eroded zones of the boring.

RESULTS

Suspension Velocity Results

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 8, 13, 17, 21, 25, 29, 35, 39, 43 and 47. The suspension velocity data presented in these figures are presented in Tables 6 – 15. The PSLOG and EXCEL analysis files for each boring are included in the boring specific directories on the data disk (DVD-R) labeled Report 8083-04 that accompanies this report, along with the raw and filtered waveforms.

P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A-1 through A-10 to aid in visual comparison. It should be noted that R1-R2 data are an average velocity over a 3.3 foot segment of the soil column; S-R1 data are an average over 6.3 feet, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A-1 through A-10, and included in the EXCEL analysis files for each boring on the data disk (DVD-R) labeled Report 8083-04 that accompanies this report. The EXCEL analysis files include Poisson's Ratio calculations, tabulated data and plots. The data presented in these reports is marked as rev 1 or above, with rev 0 being the unprocessed data, as collected in the field.

Calibration procedures and records for the suspension PS measurement system are presented in Appendix E, and **GEO***Vision* standard field log sheets for all borings are reproduced in Appendix F.

The approved **GEO***Vision* standard field procedures, as included in the MACTEC Geotechnical Work Plan for Subsurface Investigation, are reproduced in Appendix G.

Downhole Velocity Results

P- and S_H -wave velocity measurements using the downhole method were collected in B-640 (DHT) and B-740 (DHT) to a maximum depth of 148 feet below grade, and are presented in Appendix B. These data were collected to provide validation of the higher resolution Suspension velocity data collected in these borings during these and previous surveys.

Downhole waveforms and arrival picks for B-640 (DHT) are presented in Figures B-1 and B-2. B-740 (DHT) waveforms are presented in Figures B-6 through B-9. The downhole travel time curves are presented with suspension derived travel time curves in Figures B-3 and B-10 respectively. Comparisons of the downhole layered models with suspension R1-R2 data are presented in Figures B-4 and B-11. Comparisons of the downhole layered models with suspension layered models are presented in Figures B-5 and B-12. Tables B-1 and B-2 present the downhole layer depths and velocities, as well as Poisson's Ratio for each layer. All tables and figures are included in the EXCEL analysis files for each boring in the boring specific directories of the data DVD-R (Report 8083-04) that accompanies this report. The data presented in these reports is marked as rev 1 or above, with rev 0 being the unprocessed data, as collected in the field.

Calibration procedures and records for the downhole measurement system are presented in Appendix E.

The **GEO***Vision* standard field log sheets for all borings are reproduced in Appendix F.

The approved **GEO***Vision* standard field procedures, as included in the MACTEC Down-hole Seismic Velocity (Shear Wave) Testing Work Plan, are reproduced in Appendix G.

Caliper/ Natural Gamma Results

Caliper and natural gamma data are presented in combined log plots with resistivity and spontaneous potential as single page logs in Figures 9, 10, 11, 14, 15, 18, 19, 22, 23, 26, 27, 30, 31, 32, 33, 36, 37, 40, 41, 44, 45, 48 and 49, as well as multi-page logs in Appendix C. On these plots, the following acronyms are used:

- NGAM: Natural gamma data collected with the ELOG probe.
- SP: Spontaneous (self) potential.
- CGAM: Natural gamma data collected with the caliper probe.
- CALP: Caliper (borehole diameter)
- SHN: Short normal resistivity (16 inch resistivity)
- LON: Long normal resistivity (64 inch resistivity)
- SPR: Single point resistance

LAS 2.0 data and Acrobat files of the plots for each boring are included in the boring specific sub-directories in the data directory on the data disk (DVD-R) labeled Report 8083-04 that accompanies this report. The data presented in these reports is marked as rev 1 or above, with rev 0 being the unprocessed data, as collected in the field.

Resistivity / Spontaneous Potential / Natural Gamma Results

Resistivity and spontaneous potential data are presented in combined log plots with caliper and natural gamma data as single page logs in Figures 9, 10, 11, 14, 15, 18, 19, 22, 23, 26, 27, 30, 31, 32, 33, 36, 37, 40, 41, 44, 45, 48 and 49, as well as multi-page logs in Appendix C. LAS 2.0 data and Acrobat files for each boring are included in the boring specific sub-directories in the data directory on the data disk (DVD-R) labeled Report 8083-04 that accompanies this report. The data presented in these reports is marked as rev 1 or above, with rev 0 being the unprocessed data, as collected in the field.

Acoustic Televiewer / Boring Deviation Results

Acoustic televiewer amplitude images and acoustic travel-time derived boring radii are presented in Appendix C. The same logs are presented in .pdf format in the boring specific sub-directories of the data disk (DVD-R) labeled Report 8083-04 that accompanies this report. No planar features were identified in these data sets, so no depth, dip angle or azimuth data are provided.

Boring deviation data is presented graphically in Figures 12, 16, 20, 24, 28, 34, 38, 42, 46 and 50, and summarized in Table 5. Deviation data plots in Acrobat format and deviation data at 1.0 foot stations are presented in text format in the boring specific sub-directories of the data disk (DVD-R) labeled Report 8083-04 that accompanies this report. The data presented in these reports is marked as rev 1 or above, with rev 0 being the unprocessed data, as collected in the field.

SUMMARY

Discussion of Suspension Velocity Results

Suspension PS velocity data are ideally collected in an uncased fluid filled boring, drilled with rotary mud (rotary wash) methods. The borings at this site were well suited for collection of suspension PS velocity data, though there were some regions prone to squeezing and washouts, particularly just below the upper limestone layer, between 115 and 120 feet.

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

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

All of these data show excellent correlation between R1 - R2 and S - R1 data, as well as excellent correlation between P-wave and S_H-wave velocities. P-wave and S_H-wave onsets are very clear, and later oscillations are well damped. There is variation between the profiles from all these borings above 115 feet, due to different degrees of degradation of the limestone, but the general velocity trends are similar. Below 115 feet, the profiles are very similar, with slight variation of the harder layers between 120 - 150 feet and 210 - 260 feet.

Discussion of Downhole Velocity Results

P- and S_H-wave velocity measurements using the Downhole method were collected in B-640 (DHT) and B-740 (DHT). Both borings were cased with 2 inch PVC to 150 feet below grade, but bends in the casing of B-640 (DHT) prevented the downhole probe from passing below 125 feet. The P-wave data are excellent, and the S-wave data are generally of medium quality, as discussed below.

Downhole velocity data quality is judged based upon 5 criteria:

1. Good signal to noise ratio.
2. Clarity of P-wave and S_H-wave onset, as well as damping of later oscillations
3. Consistent waveforms between adjacent depth stations.
4. Consistent relationship between P-wave and S_H -wave (excluding transition to saturated soils)
5. Consistency of profile between adjacent borings, if available.

P- and S_H-wave velocity measurements using the Downhole method measure average velocities based on changes in travel time over a 5.0 foot interval of depth. If data quality is good, individual S_H-wave measurements (combining picking errors of adjacent measurements) in soft soil can have a precision of +/- 5%. However, poor data quality can quickly decrease reliability to as much as +/-20%. Also, as P- and S_H-wave velocities increase, changes in travel time are difficult to pick over small intervals due to the low frequencies of source energy, hence the decrease in measurement resolution at higher velocities.

It should be noted that the original analyst's arrival picks were used in most cases for this analysis. Since these picks were made blind, without reference to the Suspension velocity results, we can conclude that the validation provided here is acceptable. Additional comments for each borehole follow:

B-640(DHT). P-wave data in this borehole are excellent, and arrivals were picked without filtering. The S_H-wave velocity data for this boring are acceptable, but adversely affected by 30 Hz noise at the site. First arrivals are in-phase making it difficult to pick, likely due to a combination of the 30 Hz noise and path effects. Shear waves measured with the Downhole method are most often and best recognized by "butterfly" polarity reversals, but these were not observed at this site in either borehole. Therefore these S-wave data fail the first two criteria of the quality standard above. On the other hand, we do find consistent waveforms between adjacent depth stations, good consistency in the relationship between P- and S-waves, and good consistency between profiles of adjacent borings.

The first-arrival picks were confirmed by subtracting the waveforms, and picking a later arrival where we do have good polarity reversals, partially removing the concern about the clarity of onset, criteria 2. However, these later arrival picks were not used here because the documented and validated analysis spreadsheet we use for Downhole analysis does not correctly adjust for non-first arrival picks, giving lower velocities in the upper 40ft. Furthermore, later arrival waveforms have already lost high frequency content, and therefore do not capture well the high velocities in the layer from 25 to 55ft below ground surface.

Comparison with Suspension velocities is within 10% for the fast layer from 25 to 55ft, and within 20% for the remaining layers, except where there is insufficient data for comparison. There is a slow layer between 55 and 60ft that is not well modeled by the Downhole Method, so it has been isolated.

P-wave velocities in the fast layer are still slower than measured by the Suspension method. In order to properly image this fast layer we need higher frequency waves from the source, and unfortunately these are getting filtered out by the slow fill layer at the top of the borehole, despite our efforts to remove it.

It should be noted that these results were compared to the Suspension results from B-610, which is 120ft away. There is enough variability at this site to account for some of the differences observed here.

B-740 (DHT). P-wave data in this borehole are excellent, and arrivals were picked with minimal filtering. The S_H-wave velocity data for this boring are acceptable, but adversely affected by noise at the site, even more so than for B-640. In fact, in this borehole, first arrivals could not reliably be picked, as illustrated in Appendix B, Figures B-6 and B-7. Instead, S-wave picks were made on a later part of the waveform. Picks were made using only one polarity of the data.

However, the documented and validated analysis spreadsheet we use for Downhole analysis does not correctly adjust for non-first arrival picks, giving lower velocities in the upper 40ft. Furthermore, later arrival waveforms have already lost high frequency content, and therefore do not capture well the high velocities in the layer from 30 to 65ft below ground surface. As a result, the measured velocities in this fast layer are significantly lower than the PS Suspension. Further analysis, using the simple artifice of subtracting 25ms from all picks thereby creating an artificial "first arrival pick", increases the velocity of this fast layer from 4770fps to 5410fps, within 15% of the PS Suspension results. The 25ms is approximately correct based on comparison of first arrival and late arrival picks for B-640.

Despite the data quality issues, Figure B-8 illustrates that we do find consistent waveforms between adjacent depth stations, and good consistency in the relationship between P- and S-waves. Also we have good consistency between profiles of adjacent borings.

As with B-640, P-wave velocities in the fast layer are slower than measured by the PS Suspension method. In order to properly image this fast layer we need higher frequency waves from the source, and unfortunately these are getting filtered out by the slow fill layer at the top of the borehole, despite our efforts to remove it.

Except for the layers near the surface, comparison with Suspension velocities is within 10% for the remaining layers.

Discussion of Caliper / Natural Gamma Results

Caliper and natural gamma data were collected for the entire depth of each boring. The caliper logs for these borings generally show diameter of less than 6 inches below 30 feet, with the exception of a soft layer between 10 and 120 feet, which was often eroded out to more than 12 inches. Natural gamma data were collected with this tool in all the borings, as well as with the ELOG probe, and the comparison between the two data sets provides an almost exact match, verifying the performance of the natural gamma measuring systems. There may be differences in the boring diameters at the same depth from different logging runs due to reaming of the boring, or erosion by the drilling fluid between logging runs.

Discussion of Resistivity / Spontaneous Potential / Natural Gamma Results

These electrical methods provide poor demarcation of different lithologic units at this site, due to the influence of salt water intrusion. Several of the borings exhibited artesian flow, and the composition of the boring fluid changed significantly during the collection of field data, with the drilling mud being displaced by clear water. The electrical data are not valid above 40 feet below grade, as the upper yoke electrode moves out of the boring fluid at this depth. There may also be differences in the electrical data at the same depth from different logging runs due to changes in the salinity of the boring fluid. In addition, the upper 40 feet of many of the deeper logs are affected by the movement of the yoke electrode into the steel surface casing.

This natural gamma data agrees well with the natural gamma data collected with the caliper probe. The comparison between the two data sets provides an almost exact match, verifying the performance of the natural gamma measuring systems.

Discussion of Acoustic Televiewer / Boring Deviation Results

The acoustic televiewer data quality in all ten borings is very good, providing clear images of a number of small solution cavities and eroded zones. Many of the borings exhibit diagonal banding (zebra striping) caused by rapid reaming down the boring with new core bits that are slightly larger than the gauge of the original boring. This creates a spiral wear pattern in the boring that alters the characteristic smooth surface of diamond cored borings. This wear pattern can have a significant impact on acoustic televiewer image quality, and in these borings may conceal smaller dikes. It will not conceal fractures, however.

Location of cavities and weathered zones on the televiewer logs correspond precisely with increases in caliper log diameter and suspension PS velocity drops.

All ten uncased borings were inclined at 3.0 degrees, or less, from vertical, and the maximum error in depth value was 0.3 feet in 160 ft, or less than 0.2 percent, as presented in Table 5. This error is less than depth errors from other causes, and no adjustment of log depths is indicated.

Quality Assurance

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

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

Suspension Velocity Data Reliability

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

BORING DESIGNATION	DATES LOGGED	COORDINATES (FEET) [1]		ELEVATION [1] (FEET)
		NORTHING	EASTING	
B-601 (DH)	3/10, 26/2008	396967.9	876642.9	-1.4
B-604 (DH)	3/21, 22, 24/2008	396915.9	876591.6	-1.5
B-608 (DH)	4/3/2008	396829.5	876735.9	-1.5
B-610 (DH)	4/2/2008	397084.2	876644.4	-1.4
B-620 (DH)	3/21, 23/2008	397394.9	876648.3	-1.5
B-640 (DHT)	6/5, 6/2008 6/26/2008	397116.6	876528.3	-0.3
B-701 (DH)	3/17, 18, 20, 21/2008 5/3, 5, 6, 7/2008	396976.1	875792.3	-1.1
B-704 G (DH)	3/8, 9/2008	396938.6	875749.0	-1.3
B-708 (DH)	3/9, 10, 13/2008	396829.7	875885.7	-1.4
B-710 G (DH)	3/11, 18/2008	397075.1	875792.2	-1.4
B-720 G (DH)	3/20/2008	397385.2	875794.0	-1.1
B-740 (DHT)	6/24, 25/2008	397137.2	875841.7	-0.8

[1] Survey data and elevation provided by MACTEC dated 7/1/08

State Plane Coordinates, NAD 1983/ Adjustment of 1990, Florida East, Zone 0901; Elevations NADV 1988

Table 1. Boring locations and logging dates

Winch GEOVision 4-conductor
Sheave - Measuring wheel GEOVision S/N 102
Robertson Suspension PS telemetry unit M/N 3403 S/N 160023, 160024
Robertson Micrologger II S/N 5772
OYO Suspension PS Logger Borehole Probe, includes:
Receiver/Sensor S/N 30086, S/N 12008, S/N 20042
Isolation tube, 1m M/N 3387B S/N 24053, S/N 28072, S/N 28068, S/N 300083
Source M/N 3304 S/N 19043, S/N 21050
Driver M/N 3386A S/N 27073, S/N 490157
Weight M/N 3302W S/N 12007, S/N 470150

Table 2. Suspension PS Logging Equipment

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	OPEN HOLE (FEET)	DEPTH TO BOTTOM OF CASING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
B-601 (DH)	ELOG/GAMMA 1	137.7 – 37.9	137.7	25	0.05	3/10/08
B-601 (DH)	SUSPENSION PS 1	27.9 – 123.0	-	25	1.6	3/10/08
B-601 (DH)	ACOUSTIC TV 1	27.9 – 123.0	-	25	.008	3/10/08
B-601 (DH)	CALIPER/GAMMA 1	131.9 – 14.9	-	25	0.05	3/10/08
B-601 (DH)	ELOG/GAMMA 2	416.3 – 140.4	416.3	153	0.05	3/26/08
B-601 (DH)	SUSPENSION PS 2	150.9 – 400.3	-	153	1.6	3/26/08
B-601 (DH)	ACOUSTIC TV 2	401.4 – 117.4	-	153	.008	3/26/08
B-601 (DH)	CALIPER/GAMMA 2	411.2 – 148.0	-	153	0.05	3/26/08
B-601 (DH)	ELOG/GAMMA 3	169.4 – 110.8	-	117	0.05	3/26/08
B-601 (DH)	SUSPENSION PS 3	118.1 – 157.5	-	117	1.6	3/26/08
B-601 (DH)	CALIPER/GAMMA 3	157.2 – 110.5	-	117	0.05	3/26/08
B-604 (DH)	ELOG/GAMMA 1	112.7 – 66.5	112.7	24	0.05	3/21/08
B-604 (DH)	ELOG/GAMMA 2	112.7 – 39.3	-	24	0.05	3/21/08
B-604 (DH)	SUSPENSION PS 1	26.2 – 98.4	-	24	1.6	3/21/08
B-604 (DH)	ACOUSTIC TV 1	91.8 – 30.0	-	24	.008	3/22/08
B-604 (DH)	ACOUSTIC TV 2	35.2 – 22.9	-	24	.008	3/22/08
B-604 (DH)	CALIPER/GAMMA 1	103.7 – 19.8	-	24	0.05	3/22/08
B-604 (DH)	ELOG/GAMMA 3	163.3 – 39.1	163.3	30	0.05	3/24/08
B-604 (DH)	SUSPENSION PS 2	91.9 – 150.9	-	30	1.6	3/24/08
B-604 (DH)	CALIPER/GAMMA 2	160.6 – 36.9	-	30	0.05	3/24/08
B-604 (DH)	ACOUSTIC TV 3	160.4 – 4.0	-	30	.04	3/24/08
B-604 (DH)	ACOUSTIC TV 4	121.1 – 77.5	-	30	.008	3/24/08
B-608 (DH)	ELOG/GAMMA 1	262.4 – 112.8	262.4	117	0.05	4/3/08
B-608 (DH)	SUSPENSION PS 1	119.8 – 249.4	-	117	1.6	4/3/08
B-608 (DH)	ACOUSTIC TV 1	253.3 – 105.7	-	117	0.04	4/3/08
B-608 (DH)	CALIPER/GAMMA 1	254.4 – 109.7	-	117	0.05	4/3/08
B-608 (DH)	ELOG/GAMMA 2	139.0 – 37.4	-	20	0.05	4/3/08
B-608 (DH)	SUSPENSION PS 2	23.0 – 128.0	-	20	1.6	4/3/08
B-608 (DH)	ACOUSTIC TV 2	120.3 – 19.8	-	20	0.008	4/3/08
B-608 (DH)	CALIPER/GAMMA 2	123.0 – 15.1	-	20	0.05	4/3/08
B-610 (DH)	ELOG/GAMMA 1	266.5 – 102.7	266.5	105	0.05	4/3/08
B-610 (DH)	SUSPENSION PS 1	106.6 – 251.0	-	105	1.6	4/3/08
B-610 (DH)	ACOUSTIC TV 1	252.2 – 102.3	-	105	0.04	4/3/08
B-610 (DH)	CALIPER/GAMMA 1	256.2 – 98.7	-	105	0.05	4/3/08
B-610 (DH)	ELOG/GAMMA 2	124.2 39.4	-	20	0.05	4/3/08
B-610 (DH)	SUSPENSION PS 2	23.0 – 113.2	-	20	1.6	4/3/08
B-610 (DH)	ACOUSTIC TV 2	120.9 – 19.0	-	20	0.008	4/3/08
B-610 (DH)	CALIPER/GAMMA 2	111.5 – 14.7	-	20	0.05	4/3/08

- PROBE DID NOT TOUCH BOTTOM OF BORING

Table 3. Logging dates and depth ranges

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	OPEN HOLE (FEET)	DEPTH TO BOTTOM OF CASING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
B-620 (DH)	ELOG/GAMMA 1	122.1 – 38.3	122.1	25.5	0.05	3/21/08
B-620 (DH)	SUSPENSION PS 1	26.3 – 109.9	-	25.5	1.6	3/21/08
B-620 (DH)	ACOUSTIC TV 1	119.1 – 24.0	-	25.5	0.008	3/21/08
B-620 (DH)	CALIPER/GAMMA 1	120.2 – 13.6	-	25.5	0.05	3/21/08
B-620 (DH)	ELOG/GAMMA 2	214.7 – 101.6	214.7	105	0.05	3/23/08
B-620 (DH)	SUSPENSION PS 2	106.6 – 129.6	-	105	1.6	3/23/08
B-620 (DH)	SUSPENSION PS 3	121.4 – 200.1	-	105	1.6	3/23/08
B-620 (DH)	ACOUSTIC TV 2	201.5 – 102.0	-	105	0.04	3/23/08
B-620 (DH)	CALIPER/GAMMA 2	206.0 - 97.5	-	105	0.05	3/23/08
B-640 (DHT)	DOWNHOLE PS 1	5.0 – 124.7	124.7	150	5.0	6/5-6/08
B-640 (DHT)	DOWNHOLE PS 2	5.0 – 122.0	-	150	5.0	6/26/08
B-701 (DH)	ELOG/GAMMA 1	419.5 – 114.7	419.5	116	0.05	4/17/08
B-701 (DH)	SUSPENSION PS 1	118.1 – 403.5	-	116	1.6	4/17/08
B-701 (DH)	CALIPER/GAMMA 1	407.1 – 110.7	-	116	0.05	4/18/08
B-701 (DH)	ACOUSTIC TV 1	411.7 – 110.7	-	116	0.04	4/18/08
B-701 (DH)	ELOG/GAMMA 2	456.9 – 369.2	456.9	116	0.05	4/20/08
B-701 (DH)	CALIPER/GAMMA 2	455.9 – 389.7	-	116	0.05	4/21/08
B-701 (DH)	SUSPENSION PS 2	397.0 – 434.7	-	116	1.6	4/21/08
B-701 (DH)	ELOG/GAMMA 3	555.0 – 457.0	555.0	457	0.05	5/3/08
B-701 (DH)	CALIPER/GAMMA 3	553.0 – 451.0	-	457	0.05	5/3/08
B-701 (DH)	SUSPENSION PS 3	459.3 – 493.8	-	457	1.6	5/3/08
B-701 (DH)	SUSPENSION PS 4	457.7 – 541.3	-	457	1.6	5/3/08
B-701 (DH)	ELOG/GAMMA 4	615.3 – 450.0	615.3	457	0.05	5/5/08
B-701 (DH)	CALIPER/GAMMA 4	612.0 – 450.0	-	457	0.05	5/5/08
B-701 (DH)	SUSPENSION PS 5	459.3 – 602.0	-	457	1.6	5/5/08
B-701 (DH)	ACOUSTIC TV 2	610.0 – 400.0	-	457	0.008	5/5/08
B-701 (DH)	ELOG/GAMMA 5	485.0 – 425.0	-	427	0.05	5/6/08
B-701 (DH)	ELOG/GAMMA 6	155.0 – 20.0	-	16	0.05	5/7/08
B-701 (DH)	CALIPER/GAMMA 5	155.0 – 0.0	-	16	0.05	5/7/08
B-701 (DH)	SUSPENSION PS 7	16.4 – 134.5	-	16	1.6	5/7/08
B-701 (DH)	ACOUSTIC TV 3	125.0 – 15.0	-	16	0.008	5/7/08
B-701 (DH)	ACOUSTIC TV 4	25.0 – 0.0	-	NONE	0.008	5/7/08
B-701 (DH)	SUSPENSION PS 8	1.6 – 23.0	-	NONE	1.6	5/7/08
B-701 (DH)	CALIPER/GAMMA 6	155.0 – 0.0	-	NONE	0.05	5/7/08

- PROBE DID NOT TOUCH BOTTOM OF BORING

Table 3, continued. Logging dates and depth ranges

BORING NUMBER	TOOL AND RUN NUMBER	DEPTH RANGE (FEET)	OPEN HOLE (FEET)	DEPTH TO BOTTOM OF CASING (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
B-704 G (DH)	ELOG/GAMMA 1	129.0 – 39.5	-	24	0.05	3/8/08
B-704 G (DH)	ELOG/GAMMA 2	129.5 – 37.5	129.5	24	0.05	3/8/08
B-704 G (DH)	SUSPENSION PS 1	26.3 – 116.5	-	24	1.6	3/8/08
B-704 G (DH)	ACOUSTIC TV 1	119.4 – 5.5	-	24	0.008	3/8/08
B-704 G (DH)	CALIPER/GAMMA 1	121.0 – 8.6	-	24	0.05	3/8/08
B-704 G (DH)	ELOG/GAMMA 3	163.1 – 103.8	163.1	114	0.05	3/9/08
B-704 G (DH)	SUSPENSION PS 2	116.5 – 149.3	-	114	1.6	3/9/08
B-704 G (DH)	ACOUSTIC TV 2	157.2 – 108.5	-	114	0.04	3/9/08
B-704 G (DH)	CALIPER/GAMMA 2	155.4 – 105.1	-	114	0.05	3/9/08
B-708 (DH)	ELOG/GAMMA 1	125.4 – 36.0	125.4	25	0.05	3/9/08
B-708 (DH)	SUSPENSION PS 1	27.9 – 72.2	-	25	1.6	3/9/08
B-708 (DH)	SUSPENSION PS 2	68.9 – 105.0	-	25	1.6	3/10/08
B-708 (DH)	ACOUSTIC TV 1	100.9 – 19.9	-	25	0.008	3/10/08
B-708 (DH)	CALIPER/GAMMA 1	116.7 – 15.4	-	25	0.05	3/10/08
B-708 (DH)	ELOG/GAMMA 2	260.7 – 102.3	260.7	106	0.05	3/13/08
B-708 (DH)	SUSPENSION PS 3	108.3 247.7	-	106	1.6	3/13/08
B-708 (DH)	CALIPER/GAMMA 2	252.3 – 94.4	-	106	0.05	3/13/08
B-708 (DH)	ACOUSTIC TV 2	251.3 – 94.9		106	0.04	3/13/08
B-708 (DH)	ACOUSTIC TV 3	118.4 – 97.4		106	0.008	3/13/08
B-710 G (DH)	ELOG/GAMMA 1	140.6 – 38.5	140.6	19.5	0.05	3/11/08
B-710 G (DH)	SUSPENSION PS 1	21.3 – 128.0	-	19.5	1.6	3/11/08
B-710 G (DH)	ACOUSTIC TV 1	120.5 – 17.1	-	19.5	0.008	3/11/08
B-710 G (DH)	CALIPER/GAMMA 1	132.4 – 13.4	-	19.5	0.05	3/11/08
B-710 G (DH)	ELOG/GAMMA 2	270.6 – 94.8	270.6	115	0.05	3/18/08
B-710 G (DH)	SUSPENSION PS 2	121.4 – 252.6	-	115	1.6	3/18/08
B-710 G (DH)	ACOUSTIC TV 2	253.7 – 102.2	-	115	0.04	3/18/08
B-710 G (DH)	CALIPER/GAMMA 2	258.0 – 108.6	-	115	0.05	3/18/08
B-720 G (DH)	ELOG/GAMMA 1	219.4 – 69.7	219.4	73	0.05	3/20/08
B-720 G (DH)	SUSPENSION PS 1	75.5 – 200.1		73	1.6	3/20/08
B-720 G (DH)	ACOUSTIC TV 1	200.4 – 0.0		73	0.04	3/20/08
B-720 G (DH)	CALIPER/GAMMA 1	202.5 – 59.6		73	0.05	3/20/08
B-720 G (DH)	ELOG/GAMMA 2	131.2 – 31.0		20.5	0.05	3/20/08
B-720 G (DH)	SUSPENSION PS 2	26.2 – 121.4		20.5	1.6	3/20/08
B-720 G (DH)	ACOUSTIC TV 2	120.4 – 19.7		20.5	0.008	3/20/08
B-720 G (DH)	CALIPER/GAMMA 2	82.1 – 16.3		20.5	0.05	3/20/08
B-740 (DHT)	DOWNHOLE PS 1	5.0 – 148.0	150.0	150	5.0	6/24-25/08

- PROBE DID NOT TOUCH BOTTOM OF BORING

Table 3, continued. Logging dates and depth ranges

BORING NUMBER	TOOL AND RUN NUMBER	TOOL HIT BOTTOM DEPTH (FEET)	DRILLER DEPTH (FEET)	STARTING DEPTH REF. (FEET)	ENDING DEPTH REF. (FEET)	ASDE (FEET)
B-601 (DH)	ELOG/GAMMA 1	137.7	139	39.4	39.4	0
B-601 (DH)	SUSPENSION PS 1	-	-	6.6	6.6	0
B-601 (DH)	ACOUSTIC TV 1	-	-	3.1	3.1	0
B-601 (DH)	CALIPER/GAMMA 1	-	-	5.2	5.2	0
B-601 (DH)	ELOG/GAMMA 2	416.3	420	39.1	39.1	0
B-601 (DH)	SUSPENSION PS 2	-	-	6.3	6.2	-0.1
B-601 (DH)	ACOUSTIC TV 2	-	-	2.8	2.8	0
B-601 (DH)	CALIPER/GAMMA 2	-	-	4.9	4.9	0
B-601 (DH)	ELOG/GAMMA 3	-	-	38.3	38.3	0
B-601 (DH)	SUSPENSION PS 3	-	-	5.4	5.4	0
B-601 (DH)	CALIPER/GAMMA 3	-	-	4.1	4.0	-0.1
B-604 (DH)	ELOG/GAMMA 1	112.7	118	40.0	40.1	0.1
B-604 (DH)	ELOG/GAMMA 2	-	-	40.0	40.1	0.1
B-604 (DH)	SUSPENSION PS 1	-	-	7.2	7.2	0
B-604 (DH)	ACOUSTIC TV 1	-	-	3.7	3.3	-0.4
B-604 (DH)	ACOUSTIC TV 2	-	-	3.7	3.3	-0.4
B-604 (DH)	CALIPER/GAMMA 1	-	-	5.8	5.8	0
B-604 (DH)	ELOG/GAMMA 3	163.3	165	40.0	40.0	0
B-604 (DH)	SUSPENSION PS 2	-	-	6.8	6.7	-0.1
B-604 (DH)	CALIPER/GAMMA 2	-	-	5.4	5.5	0.1
B-604 (DH)	ACOUSTIC TV 3	-	-	3.3	3.3	0
B-604 (DH)	ACOUSTIC TV 4	-	-	3.3	3.3	0
B-608 (DH)	ELOG/GAMMA 1	262.4	263	39.3	39.3	0
B-608 (DH)	SUSPENSION PS 1	-	-	6.5	6.5	0
B-608 (DH)	ACOUSTIC TV 1	-	-	3.1	3.0	-0.1
B-608 (DH)	CALIPER/GAMMA 1	-	-	5.2	5.1	-0.1
B-608 (DH)	ELOG/GAMMA 2	-	-	39.3	39.3	0
B-608 (DH)	SUSPENSION PS 2	-	-	6.5	6.6	0.1
B-608 (DH)	ACOUSTIC TV 2	-	-	3.1	3.0	-0.1
B-608 (DH)	CALIPER/GAMMA 2	-	-	5.2	5.2	0
B-610 (DH)	ELOG/GAMMA 1	266.5	269	39.9	40.0	0.1
B-610 (DH)	SUSPENSION PS 1	-	-	7.1	7.1	0
B-610 (DH)	ACOUSTIC TV 1	-	-	3.6	3.6	0
B-610 (DH)	CALIPER/GAMMA 1	-	-	5.7	5.7	0
B-610 (DH)	ELOG/GAMMA 2	-	-	39.5	39.6	0.1
B-610 (DH)	SUSPENSION PS 2	-	-	6.7	6.7	0
B-610 (DH)	ACOUSTIC TV 2	-	-	3.2	3.2	0
B-610 (DH)	CALIPER/GAMMA 2	-	-	5.3	5.3	0

- PROBE DID NOT TOUCH BOTTOM OF BORING

Table 4. Boring Bottom Depths and After Survey Depth Error (ASDE)

BORING NUMBER	TOOL AND RUN NUMBER	TOOL HIT BOTTOM DEPTH (FEET)	DRILLER DEPTH (FEET)	STARTING DEPTH REF. (FEET)	ENDING DEPTH REF. (FEET)	ASDE (FEET)
B-620 (DH)	ELOG/GAMMA 1	122.1	130	39.7	39.7	0
B-620 (DH)	SUSPENSION PS 1	-	-	6.9	6.9	0
B-620 (DH)	ACOUSTIC TV 1	-	-	3.4	3.3	-0.1
B-620 (DH)	CALIPER/GAMMA 1	-	-	5.5	5.5	0
B-620 (DH)	ELOG/GAMMA 2	214.7	215	39.5	39.5	0
B-620 (DH)	SUSPENSION PS 2	-	-	6.7	6.7	0
B-620 (DH)	SUSPENSION PS 3	-	-	6.0	6.0	0
B-620 (DH)	ACOUSTIC TV 2	-	-	3.2	3.1	-0.1
B-620 (DH)	CALIPER/GAMMA 2	-	-	5.3	5.3	0
B-640 (DHT)	DOWNHOLE PS 1	124.7	150.0	NA	NA	NA
B-640 (DHT)	DOWNHOLE PS 2	-	150.0	NA	NA	NA
B-701 (DH)	ELOG/GAMMA 1	419.5	420	38.8	38.8	0
B-701 (DH)	SUSPENSION PS 1	-	-	5.9	5.9	0
B-701 (DH)	CALIPER/GAMMA 1	-	-	4.6	4.3	-0.3
B-701 (DH)	ACOUSTIC TV 1	-	-	2.5	2.4	-0.1
B-701 (DH)	ELOG/GAMMA 2	456.9	457.5	38.8	38.6	-0.2
B-701 (DH)	CALIPER/GAMMA 2	-	-	4.3	4.1	-0.2
B-701 (DH)	SUSPENSION PS 2	-	-	5.7	5.6	-0.1
B-701 (DH)	ELOG/GAMMA 3	555.0	555.5	37.7	37.6	-0.1
B-701 (DH)	CALIPER/GAMMA 3	-	-	3.5	3.5	0
B-701 (DH)	SUSPENSION PS 3	-	-	4.9	4.9	0
B-701 (DH)	SUSPENSION PS 4	-	-	4.9	4.9	0
B-701 (DH)	ELOG/GAMMA 4	615.3	615.5	37.7	37.6	-0.1
B-701 (DH)	CALIPER/GAMMA 4	-	-	3.5	3.5	0
B-701 (DH)	SUSPENSION PS 5	-	-	4.9	4.9	0
B-701 (DH)	ACOUSTIC TV 2	-	-	2.3	2.2	-0.1
B-701 (DH)	ELOG/GAMMA 5	-	-	37.7	37.8	0.1
B-701 (DH)	ELOG/GAMMA 6	-	-	40.0	40.0	0
B-701 (DH)	CALIPER/GAMMA 5	-	-	5.8	5.8	0
B-701 (DH)	SUSPENSION PS 7	-	-	7.2	7.2	0
B-701 (DH)	ACOUSTIC TV 3	-	-	3.7	3.7	0
B-701 (DH)	ACOUSTIC TV 4	-	-	4.2	4.2	0
B-701 (DH)	SUSPENSION PS 8	-	-	7.9	NA	NA
B-701 (DH)	CALIPER/GAMMA 6	-	-	6.3	6.3	0

- PROBE DID NOT TOUCH BOTTOM OF BORING

Table 4, continued. Boring Bottom Depths and After Survey Depth Error (ASDE)

BORING NUMBER	TOOL AND RUN NUMBER	TOOL HIT BOTTOM DEPTH (FEET)	DRILLER DEPTH (FEET)	STARTING DEPTH REF. (FEET)	ENDING DEPTH REF. (FEET)	ASDE (FEET)
B-704 G (DH)	ELOG/GAMMA 1	-	-	40.0	40.0	0
B-704 G (DH)	ELOG/GAMMA 2	129.5	133	40.0	40.0	0
B-704 G (DH)	SUSPENSION PS 1	-	-	7.2	7.1	-0.1
B-704 G (DH)	ACOUSTIC TV 1	-	-	3.7	3.7	0
B-704 G (DH)	CALIPER/GAMMA 1	-	-	5.8	5.7	-0.1
B-704 G (DH)	ELOG/GAMMA 3	163.1	163	39.0	38.9	-0.1
B-704 G (DH)	SUSPENSION PS 2	-	-	6.2	6.2	0
B-704 G (DH)	ACOUSTIC TV 2	-	-	4.8	4.7	-0.1
B-704 G (DH)	CALIPER/GAMMA 2	-	-	2.7	2.7	0
B-708 (DH)	ELOG/GAMMA 1	125.4	130	39.7	39.4	-0.3
B-708 (DH)	SUSPENSION PS 1	-	-	6.9	6.8	-0.1
B-708 (DH)	SUSPENSION PS 2	-	-	6.9	6.9	0
B-708 (DH)	ACOUSTIC TV 1	-	-	3.4	3.1	-0.3
B-708 (DH)	CALIPER/GAMMA 1	-	-	5.5	5.3	-0.2
B-708 (DH)	ELOG/GAMMA 2	260.7	265	39.8	39.6	-0.2
B-708 (DH)	SUSPENSION PS 3	-	-	7.0	6.9	-0.1
B-708 (DH)	CALIPER/GAMMA 2	-	-	5.6	5.7	0.1
B-708 (DH)	ACOUSTIC TV 2			3.5	3.4	-0.1
B-708 (DH)	ACOUSTIC TV 3			1.2	1.1	-0.1
B-710 G (DH)	ELOG/GAMMA 1	140.6	143	40.1	40.0	-0.1
B-710 G (DH)	SUSPENSION PS 1	-	-	7.3	7.3	0
B-710 G (DH)	ACOUSTIC TV 1	-	-	3.8	3.7	-0.1
B-710 G (DH)	CALIPER/GAMMA 1	-	-	5.9	5.9	0
B-710 G (DH)	ELOG/GAMMA 2	270.6	273	3.9	3.9	0
B-710 G (DH)	SUSPENSION PS 2	-	-	7.1	7.0	-0.1
B-710 G (DH)	ACOUSTIC TV 2	-	-	3.6	3.6	0
B-710 G (DH)	CALIPER/GAMMA 2	-	-	5.7	5.6	-0.1
B-720 G (DH)	ELOG/GAMMA 1	219.4	220	32.9	32.6	-0.3
B-720 G (DH)	SUSPENSION PS 1			0.1	0.9	0.8
B-720 G (DH)	ACOUSTIC TV 1			3.4	3.4	0
B-720 G (DH)	CALIPER/GAMMA 1			1.2	1.2	0
B-720 G (DH)	ELOG/GAMMA 2			30.9	30.9	0
B-720 G (DH)	SUSPENSION PS 2			1.9	1.9	0
B-720 G (DH)	ACOUSTIC TV 2			5.4	5.3	-0.1
B-720 G (DH)	CALIPER/GAMMA 2			3.3	3.2	-0.1
B-740 (DHT)	DOWNHOLE PS 1	150.0	150.0	NA	NA	NA

- PROBE DID NOT TOUCH BOTTOM OF BORING

Table 4, continued. Boring Bottom Depths and After Survey Depth Error (ASDE)

BORING NUMBER	MEAN DEVIATION AND AZIMUTH (DEGREES TN)	SURVEY DEPTH (FEET)	VERTICAL DEPTH (FEET)	DEPTH ERROR (FEET)	HORIZONTAL OFFSET (FEET)
B-601 (DH)	0.0 – N296.6	401.4	401.3	0.1	0.2
B-604 (DH)	3.0 – N104.6	160.2	159.9	0.3	8.4
B-608 (DH)	0.6 – N 6.3	253.4	253.4	0.0	2.6
B-610 (DH)	0.5 – N288	252.2	252.2	0.0	2.4
B-620 (DH)	1.1 – N39.1	201.5	201.5	0.0	3.7
B-701 (DH)	0.1 – N0.6	610.0	609.9	0.1	1.3
B-704 G (DH)	0.2 – N71.0	157.2	157.1	0.1	0.6
B-708 (DH)	1.1 – N37.9	251.3	251.2	0.1	5.0
B-710 G (DH)	2.3 – N104.7	253.6	253.4	0.2	10.2
B-720 G (DH)	2.0 – N65.2	200.4	200.2	0.2	6.8

Table 5. Boring Deviation Data Summary

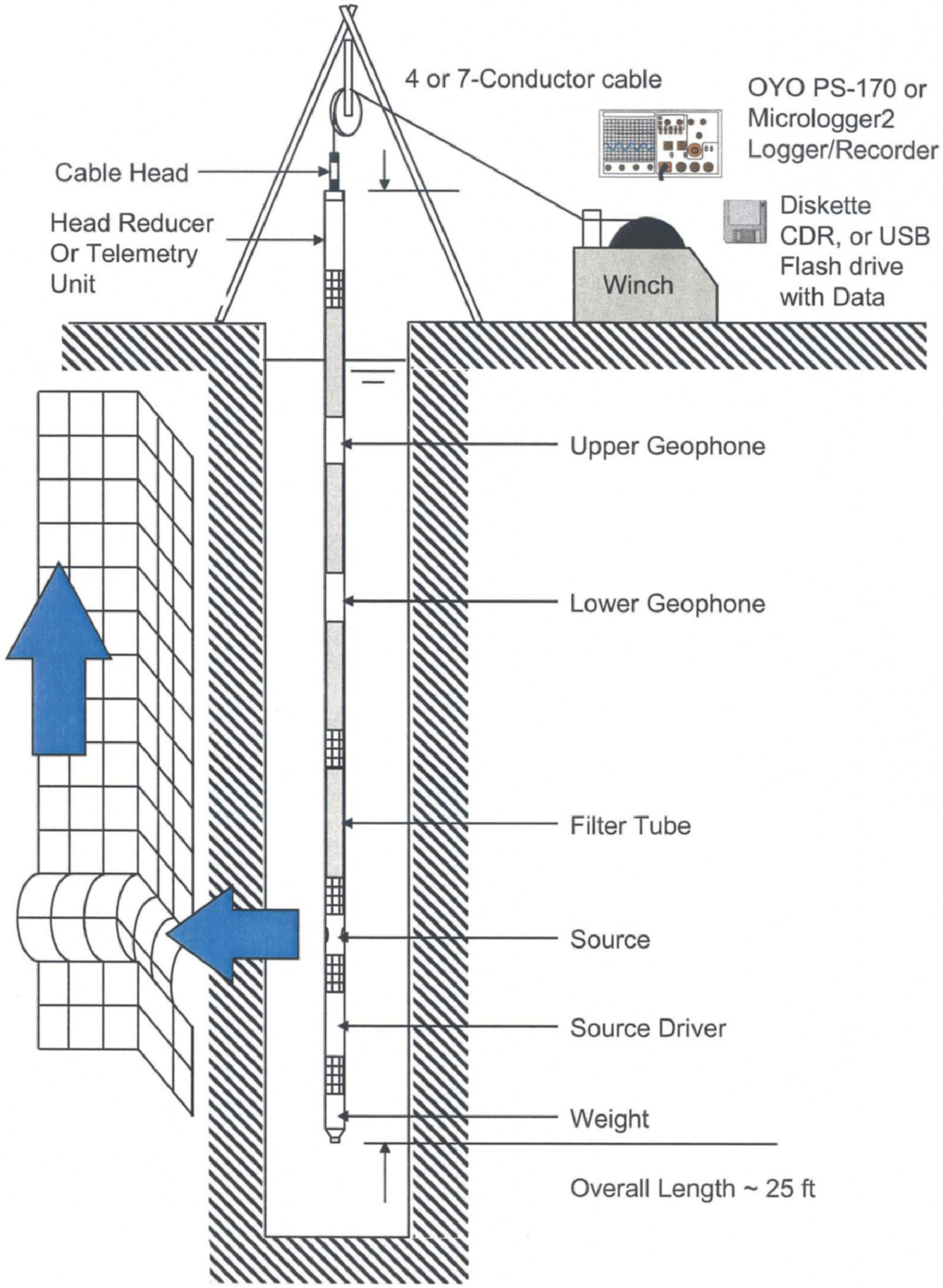


Figure 1: Concept illustration of P-S logging system

Figure 2: Downhole P– and S_H-wave energy source (Triple Whammy)

Figure 3: Downhole P-wave striking plate with hammer switch

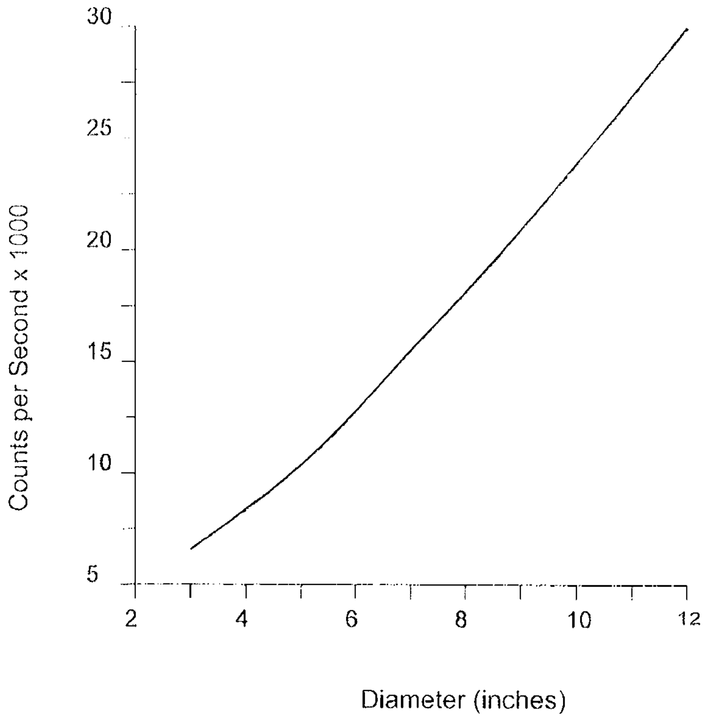


Figure 4. Example Calibration Curve for Caliper Probe

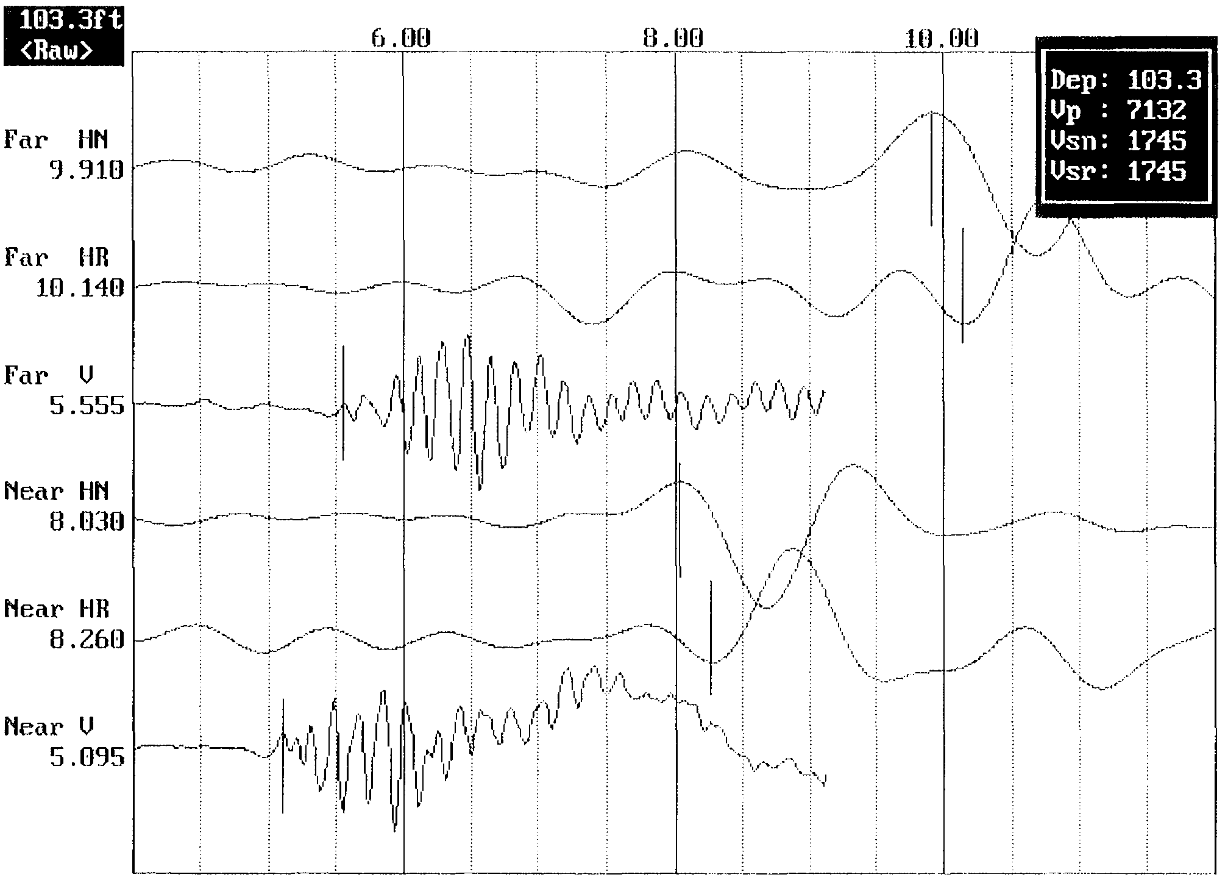


Figure 5: Example of filtered (1400 Hz lowpass) record

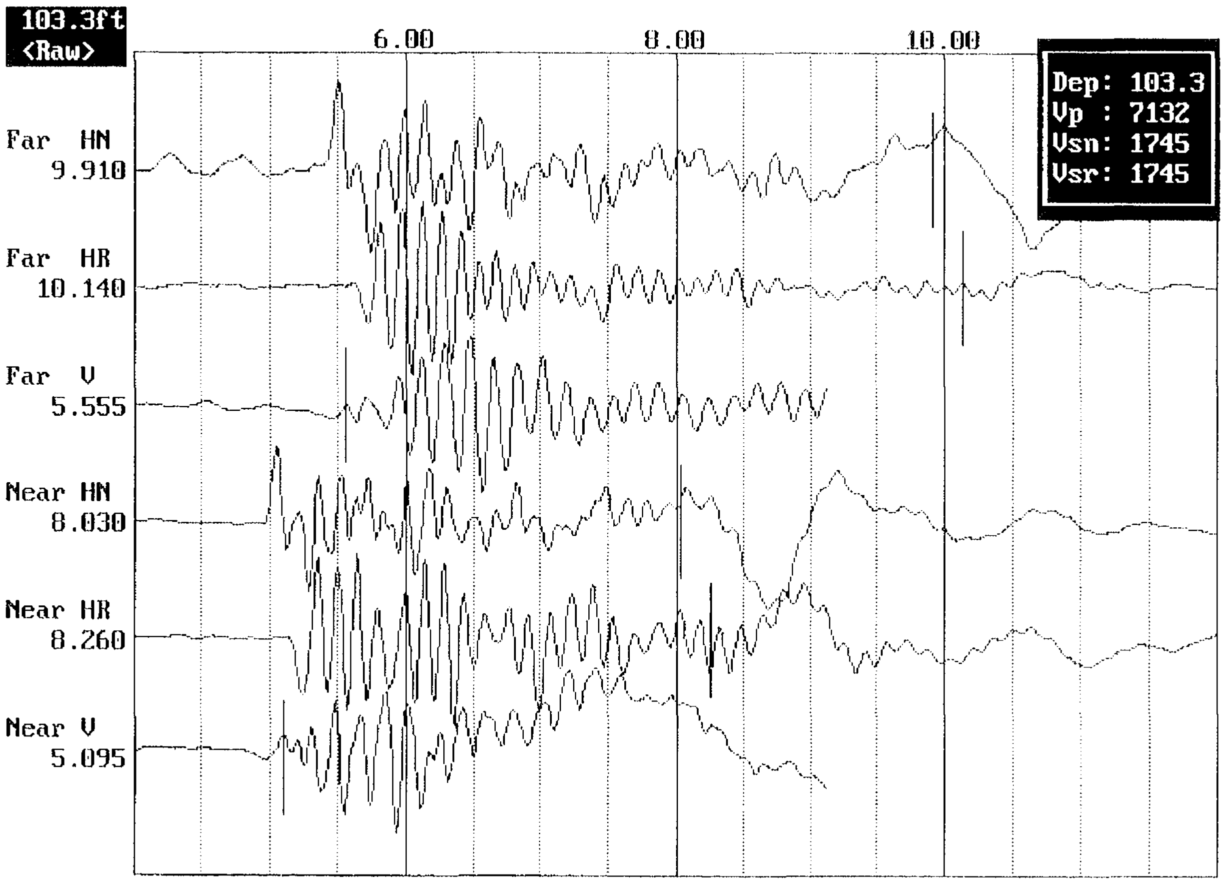
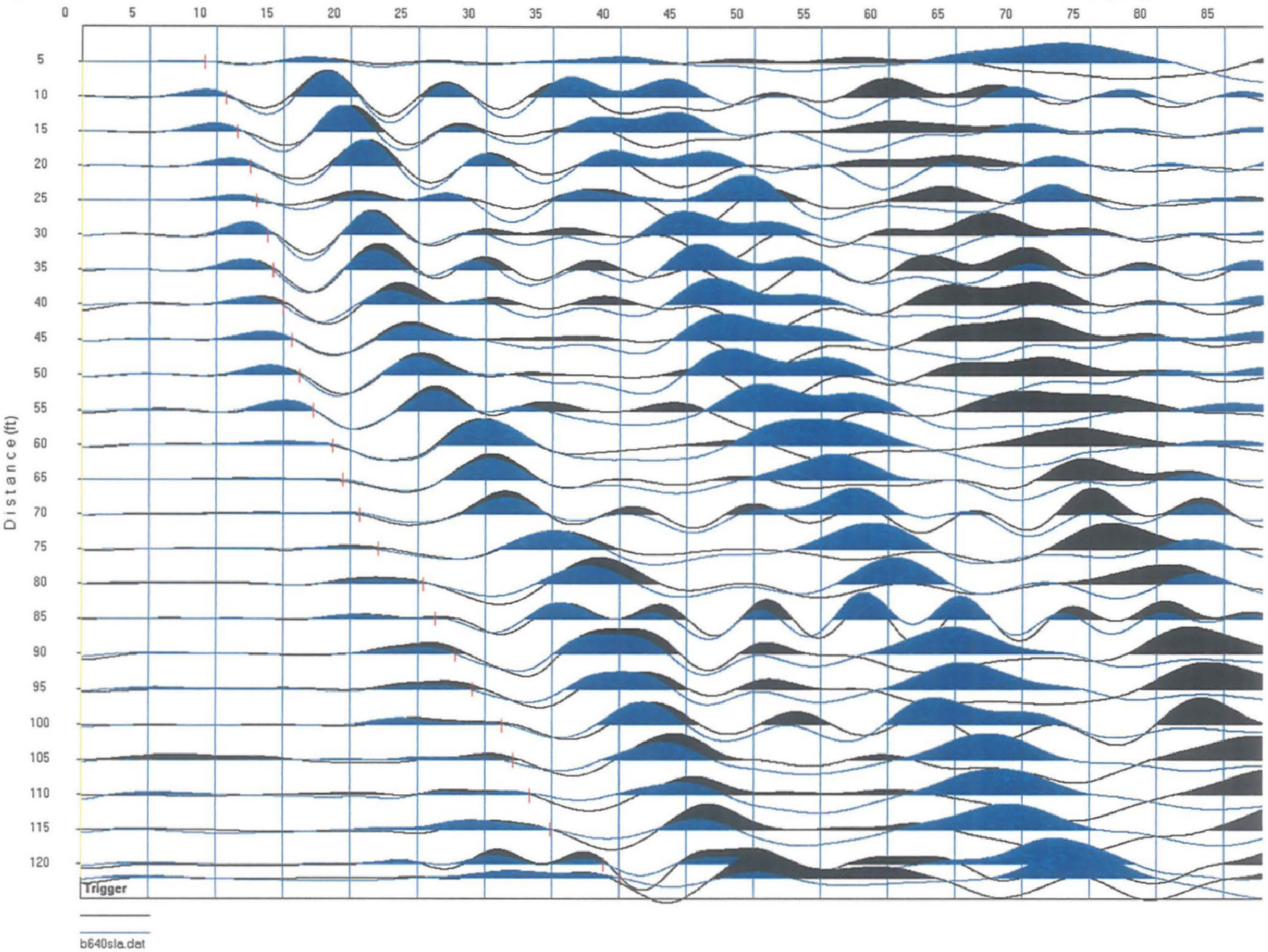


Figure 6. Example of unfiltered record



NOTE: Shear wave arrivals are in-phase – see report for discussion

Figure 7. Boring B-640 (DHT), Downhole Vs 100 Hz filtered waveforms and first arrival picks

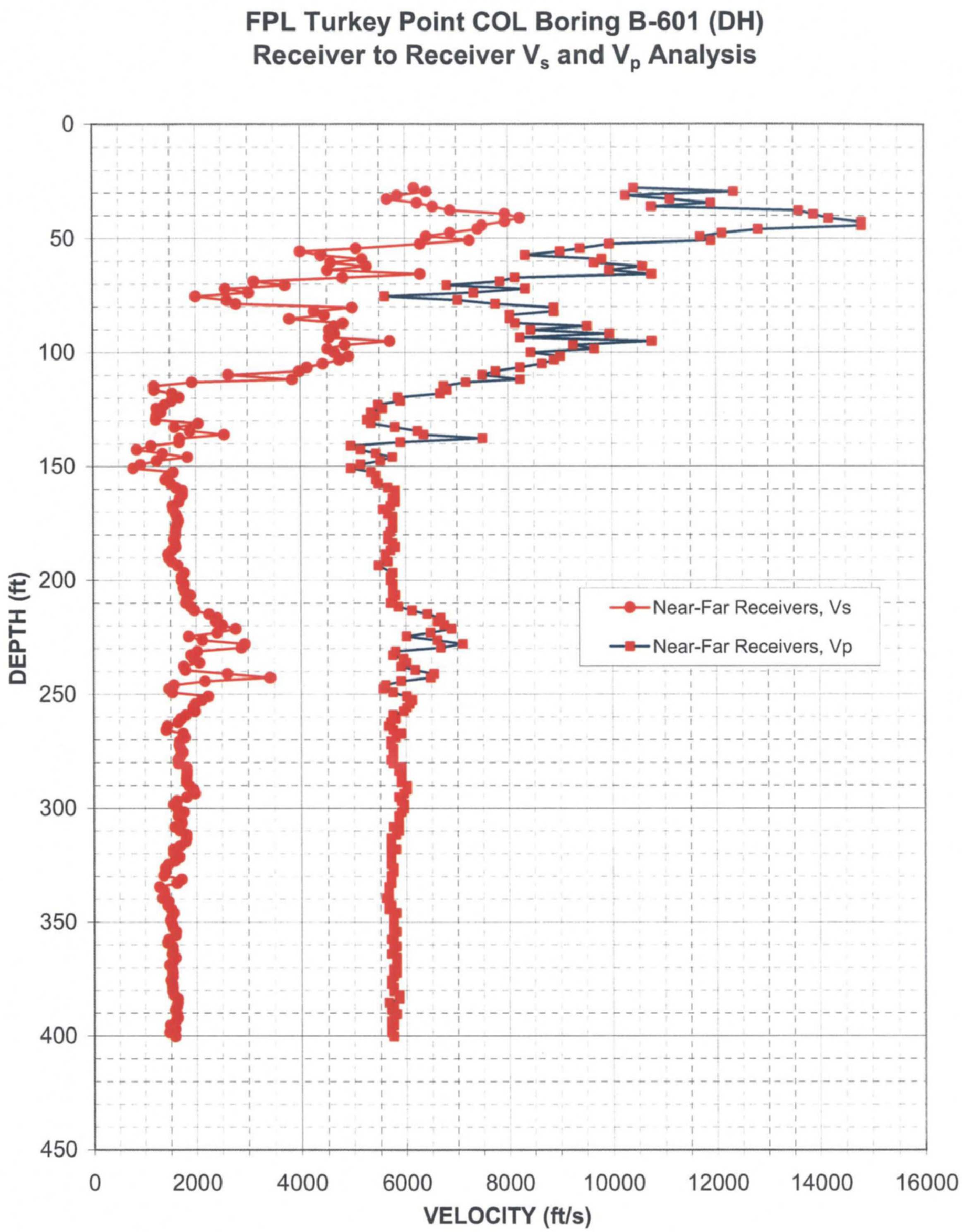


Figure 8: Boring B-601 (DH), Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
27.9	6170	10420
29.5	6410	12350
31.2	5850	10260
32.8	5650	11110
34.5	6230	11900
36.1	6540	10750
37.7	6870	13610
39.4	7940	13890
41.0	8230	14180
42.7	7940	14810
44.3	7490	14810
45.9	7410	12820
47.6	6870	12120
49.2	6410	11700
50.9	7250	11900
52.5	6290	9950
54.5	5050	9390
55.8	3990	9010
57.4	4390	8330
59.1	5170	9800
60.7	4570	9660
62.3	5250	10580
64.0	4500	9950
65.6	6290	10750
67.3	4800	8130
68.9	3120	7840
70.5	3700	6800
72.2	2570	8330
73.8	3020	7330
75.5	2000	5600
77.1	2600	7020
78.7	2780	7750
80.4	4980	8890
82.0	4250	8890
83.7	4440	8030
85.3	3790	8030
87.3	4800	8130
88.6	4630	9520
90.2	4540	8440
91.9	4630	9950
93.5	4540	8230
95.1	5700	10750
96.8	4830	9260
98.4	4500	9660
100.1	4630	8440
101.7	4900	9010
103.4	4730	8890
105.0	4420	8660
106.6	4120	8230
108.3	3970	7750
109.9	2620	7490
111.9	3830	8230
113.2	1930	7170
114.8	1190	6730
116.5	1190	6800
118.1	1540	6670
119.8	1680	5850
121.4	1520	5900
123.0	1390	5460
124.7	1230	5560
126.3	1320	5330
128.0	1230	5420
129.6	1220	5250
131.2	2040	5330
132.9	1590	5800
134.5	1880	6230
136.2	2540	6350
137.8	1680	7490
139.4	1680	5900
141.1	1130	4940
142.7	850	5130
144.4	1360	5420
146.0	1830	5750
147.6	1230	5510
149.3	920	5130
150.9	780	4940
152.6	1560	5330
154.2	1460	5420
155.8	1400	5420
157.5	1510	5460
159.5	1610	5650
160.8	1740	5800
162.4	1740	5800
164.0	1680	5750
165.7	1660	5800
167.3	1540	5700
169.0	1560	5560
170.9	1600	5650
172.2	1630	5750
173.9	1650	5750
175.5	1630	5750
177.2	1600	5750
178.8	1590	5700
180.5	1590	5650
182.1	1570	5650
183.7	1590	5750
185.4	1600	5800
187.0	1530	5700
188.7	1450	5600
190.3	1470	5600
191.9	1530	5650
193.6	1640	5460
196.9	1760	5750
198.5	1710	5700
200.1	1710	5700
201.8	1760	5750
203.4	1750	5750
205.1	1780	5750
206.7	1880	5800
208.3	1810	5750
210.0	1790	5700
211.6	1890	5850
213.3	1960	6120
214.9	2240	6410
216.5	2400	6670
218.2	2370	6600
219.8	2500	6730
221.5	2750	6870
223.1	2400	6470
224.7	1850	6010
226.4	2120	6600
228.0	2920	7090
229.7	2860	6670
231.3	2010	5800
232.9	1890	5750
234.6	1950	5950
236.2	2060	6010
237.9	1750	5900
239.5	1780	6170
241.1	2590	6540
242.8	3400	6470
244.4	2160	5900
246.1	1560	5600
247.7	1460	5560
249.3	1530	5750
251.0	2220	6010
252.6	2100	6120
254.3	1970	6060
255.9	1930	6010
257.6	1970	5950
259.2	1790	5750
260.8	1700	5800
262.5	1640	5700
264.1	1430	5650
265.8	1400	5750
267.4	1740	5900
269.0	1770	5800
270.7	1670	5700
272.3	1660	5700
274.0	1680	5750

Table 6. Boring B-601 (DH), Suspension R1-R2 depths and P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
275.6	1730	5750
277.2	1680	5750
278.9	1630	5700
280.5	1650	5750
282.2	1800	5900
283.8	1810	5850
285.4	1800	5900
287.1	1800	5900
288.7	1800	5900
290.4	1850	6010
292.0	1940	6010
293.6	1960	5950
295.3	1800	5850
296.9	1610	5900
298.6	1550	5950
300.2	1620	5950
301.8	1750	5900
303.5	1630	5850
305.1	1700	5850
306.8	1710	5850
308.4	1570	5750
310.0	1680	5850
311.7	1790	5800
313.3	1790	5700
315.0	1780	5700
316.6	1680	5700
318.2	1550	5800
319.9	1550	5700
321.5	1660	5700
323.2	1570	5700
324.8	1440	5700
326.4	1380	5750
328.1	1380	5750
329.7	1360	5700
331.4	1700	5700
333.0	1610	5700
334.7	1270	5650
336.3	1360	5650
337.9	1370	5650
339.6	1330	5600
341.2	1450	5650
342.9	1430	5700
344.5	1500	5650
346.1	1540	5800
347.8	1510	5750
349.4	1480	5750
351.1	1520	5750
352.7	1540	5750
354.3	1590	5800
356.0	1580	5750
357.6	1450	5700
359.3	1420	5750
360.9	1520	5800
362.5	1530	5750
364.2	1520	5700
365.8	1580	5800
367.5	1530	5800
369.1	1460	5800
370.7	1520	5750
372.4	1520	5800
374.0	1520	5750
375.7	1490	5700
377.3	1520	5700
378.9	1520	5750
380.6	1520	5750
382.2	1550	5850
383.9	1620	5850
385.5	1620	5650
387.1	1600	5750
388.8	1570	5700
390.4	1600	5800
392.1	1620	5750
393.7	1580	5700
395.3	1470	5750
397.0	1570	5700
398.6	1460	5700
400.3	1570	5750

Table 6, continued. Boring B-601 (DH), Suspension R1-R2 depths and P- and S_H-wave velocities

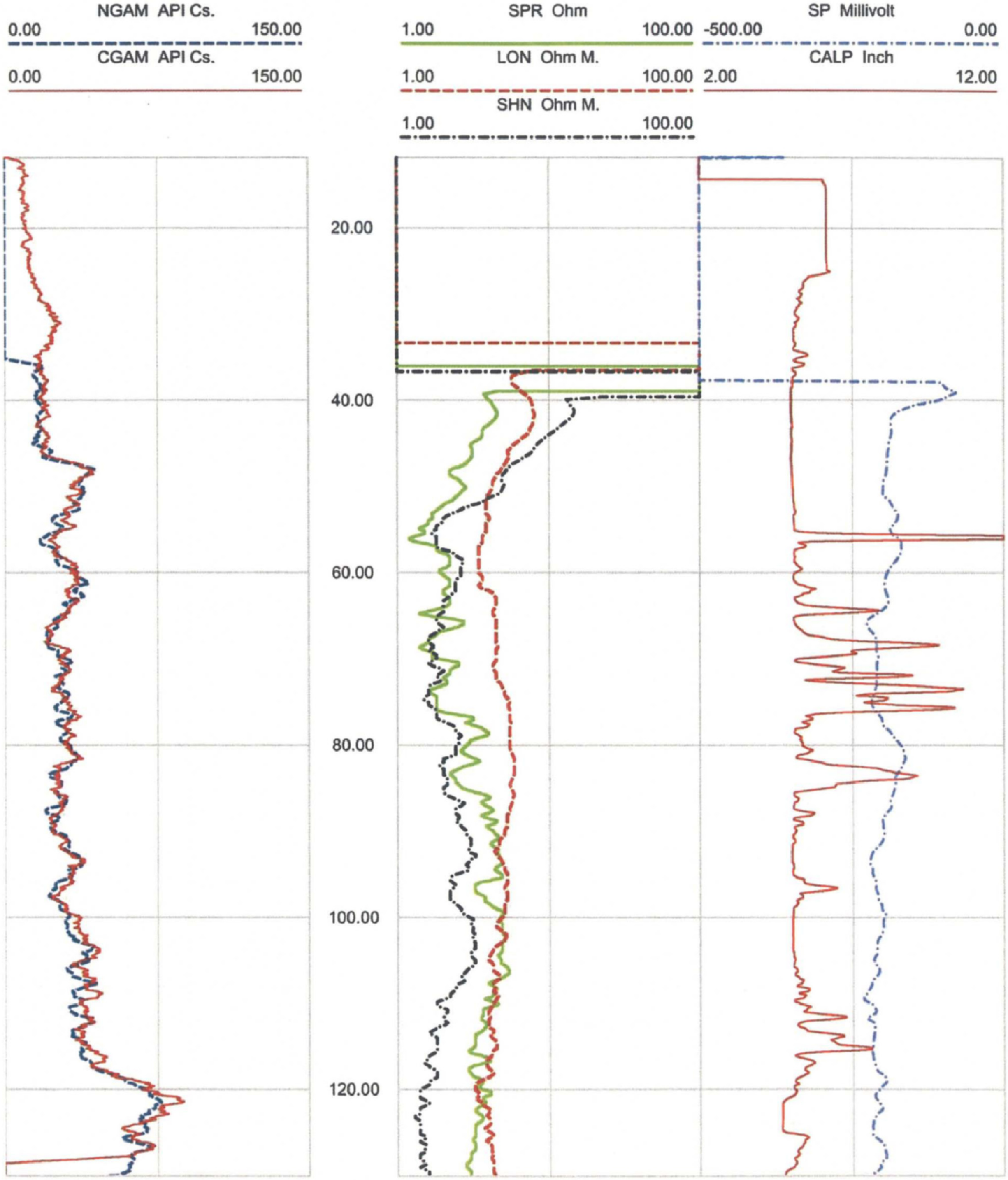


Figure 9. Boring B-601 (DH) upper section, Caliper, Natural gamma, Resistivity and SP logs

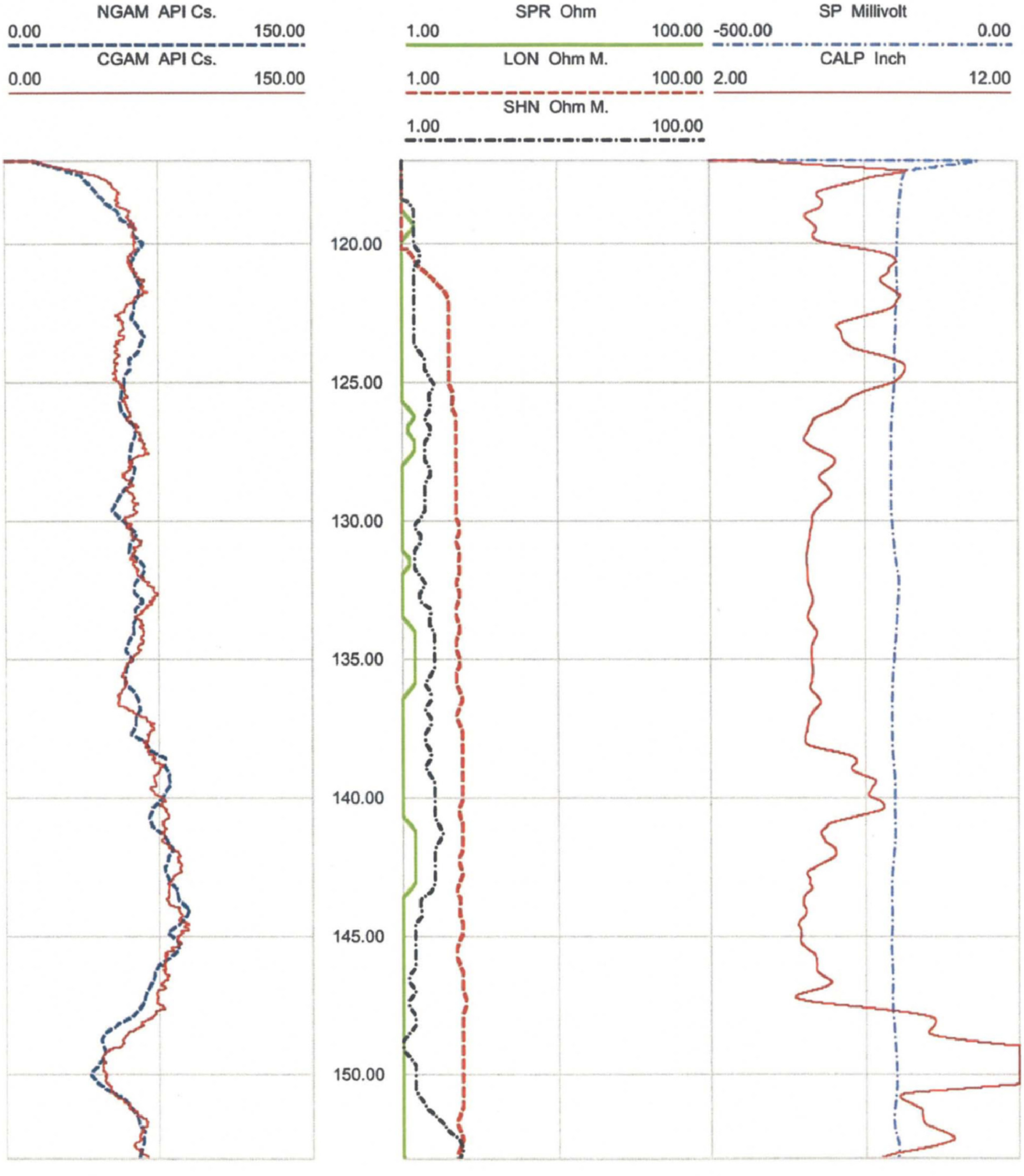


Figure 10. Boring B-601 (DH) middle section, Caliper, Natural gamma, Resistivity and SP logs

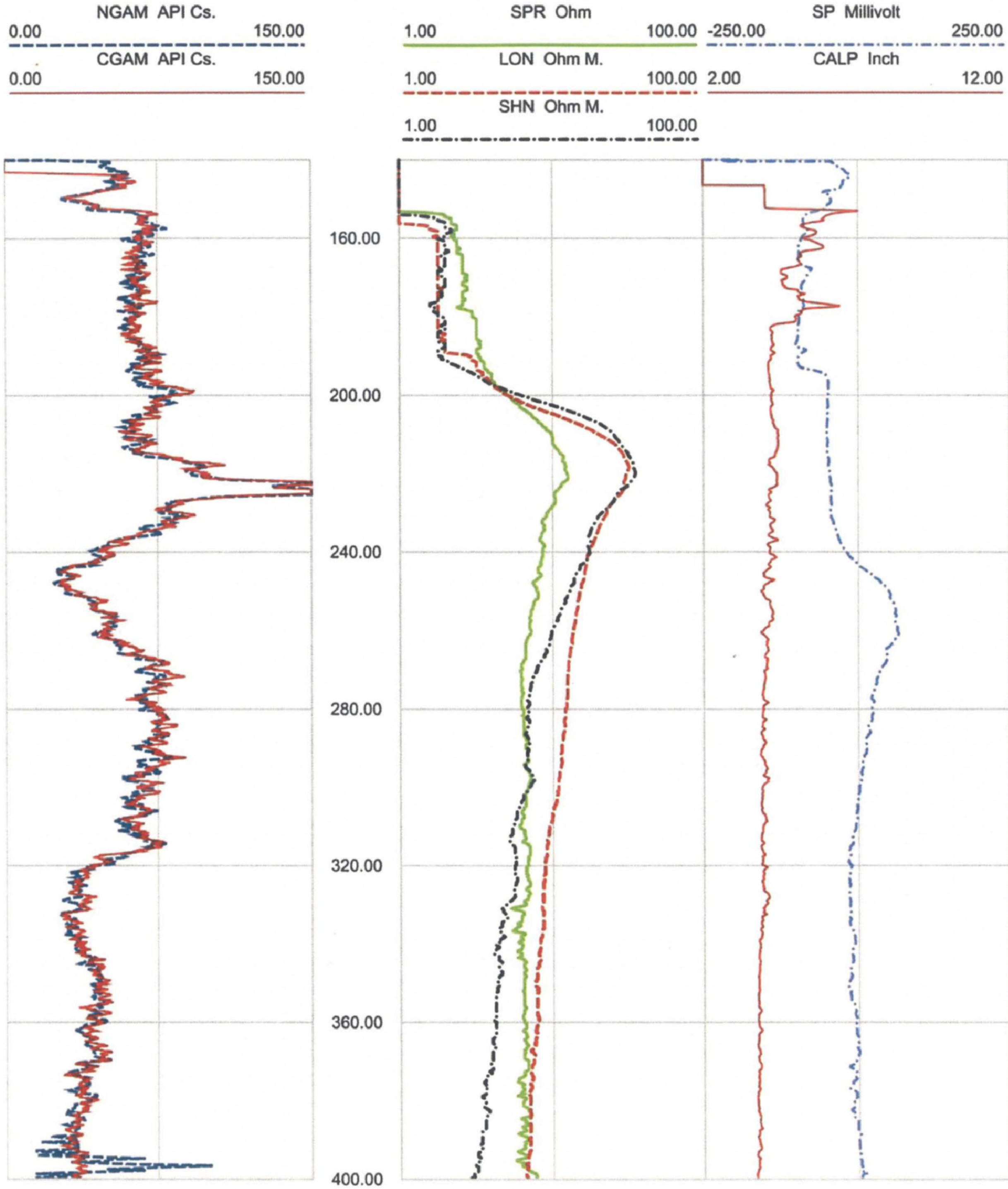
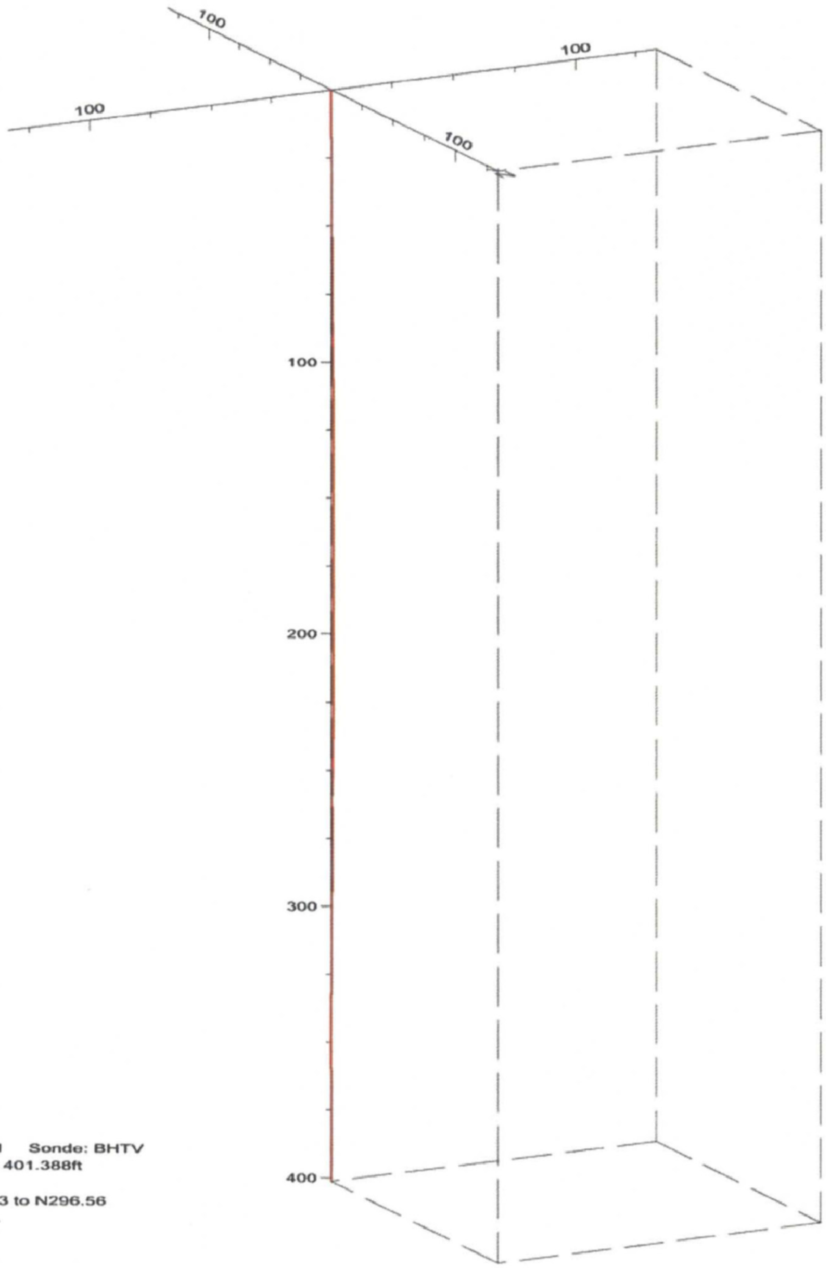


Figure 11. Boring B-601 (DH) lower section, Caliper, Natural gamma, Resistivity and SP logs

Deviated borehole in orthographic projection, viewed from N27



Borehole: B-601 DH Sonde: BHTV
Zone from: 0.000 to 401.388ft
North ref is true
Mean deviation: 0.03 to N296.56
End coordinates .....
North: 0.105
East : -0.210
Down : 401.296
Azimuth of end: N296.59
Distance start-end: 0.234ft
Viewpoint: N27
Data extrapolated to the surface from 21.972ft

Figure 12. Boring B-601 (DH), Deviation Projection (dimensions in feet)

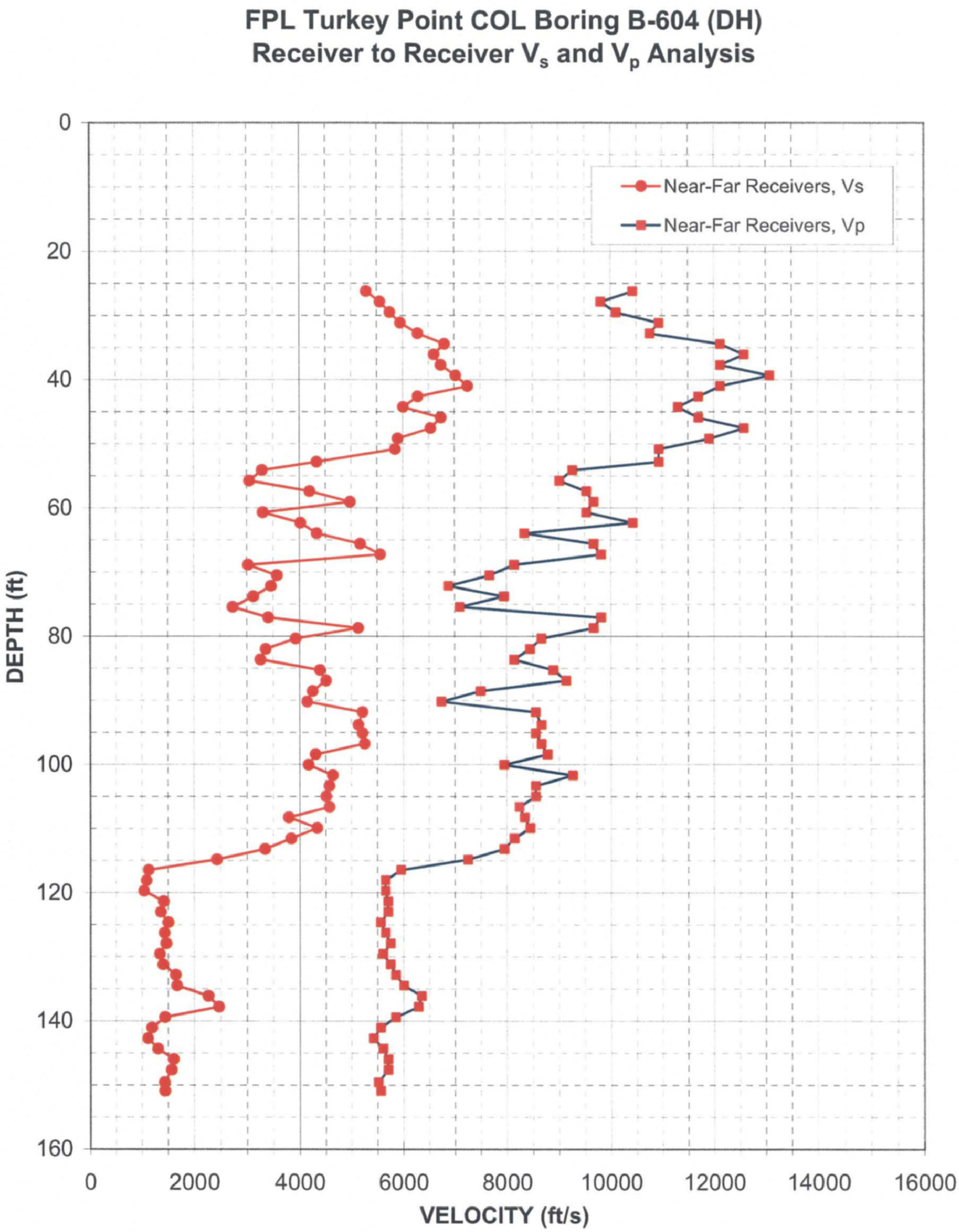


Figure 13: Boring B-604 (DH), Suspension R1-R2 P- and S_H-wave velocities

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
26.3	5290	10420
27.9	5560	9800
29.5	5750	10100
31.2	5950	10930
32.8	6290	10750
34.5	6800	12120
36.1	6600	12580
37.7	6730	12120
39.4	7020	13070
41.0	7250	12120
42.7	6290	11700
44.3	6010	11300
45.9	6730	11700
47.6	6540	12580
49.2	5900	11900
50.9	5850	10930
52.8	4330	10930
54.1	3280	9260
55.8	3040	9010
57.4	4190	9520
59.1	4980	9660
60.7	3300	9520
62.3	4020	10420
64.0	4330	8330
65.6	5170	9660
67.3	5560	9800
68.9	3020	8130
70.5	3570	7660
72.2	3450	6870
73.8	3120	7940
75.5	2720	7090
77.1	3400	9800
78.7	5130	9660
80.4	3920	8660
82.0	3350	8440
83.7	3250	8130
85.3	4390	8890
86.9	4500	9130
88.6	4250	7490
90.2	4140	6730
91.9	5210	8550
93.8	5130	8660
95.1	5210	8550
96.8	5250	8660
98.4	4300	8770
100.1	4170	7940
101.7	4630	9260
103.4	4570	8550
105.0	4500	8550
106.6	4570	8230

Depth (feet)	V_s (feet/sec)	V_p (feet/sec)
108.3	3790	8330
109.9	4330	8440
111.6	3830	8130
113.2	3330	7940
114.8	2420	7250
116.5	1120	5950
118.1	1080	5650
119.8	1030	5650
121.4	1410	5700
123.0	1360	5700
124.7	1490	5560
126.3	1420	5650
128.0	1460	5750
129.6	1330	5600
131.2	1390	5750
132.9	1630	5850
134.5	1660	6010
136.2	2250	6350
137.8	2450	6290
139.4	1430	5850
141.1	1180	5560
142.7	1100	5420
144.4	1300	5600
146.0	1590	5700
147.6	1560	5700
149.6	1420	5510
150.9	1430	5560

Table 7. Boring B-604 (DH), Suspension R1-R2 depths and P- and S_H-wave velocities