MACTEC

# APPENDIX F

**Report of SPT Energy Measurements**
**By GRL Engineers**

GRL Dynamic Measurements and Analyses
engineers, inc.

September 12, 2005

MACTEC Engineering and Consulting, Inc.
396 Plasters Avenue, N.E.
Atlanta, GA 30324

Attention: Mr. Allen Lancaster

Re: Summary Report for SPT Energy Measurements
Plant Vogtle
Augusta, GA

GRL Job No. 059063

Dear Mr. Lancaster:

This report summarizes the results from the Standard Penetration Test (SPT) energy measurements performed for two drilling rigs, at the above referenced project. Graphical and tabular summaries of the dynamic test results are included with this report. The field testing was performed during our site visit on September 6 and 7, 2005.

The purposes of the SPT energy measurements were to provide energy transfer measurements for the SPT N values obtained from two drill rigs and drillers. To meet this objective, a PAK Model Pile Driving Analyzer® (PDA) was used to acquire and process the dynamic test data. Additional information regarding the testing equipment and analytical procedures is included in Appendix A.

### *Soil Information*

The reported soil profile consisted mainly of silty or clayey sands underlain by silty sand or silty clay marl. The upper silty or clayey sands generally ranged from medium dense to loose and continued to depths ranging from 70 to 90 feet below existing grade. The silty sands or silty clays of the marl continued to the boring termination depths which range from approximately 100 to 125 feet below the existing ground surface. A detailed discussing of the subsurface conditions is beyond the scope of this report. The reader is referred to the proper geotechnical investigation report for further details.

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### *Test Sequence*

As directed by MACTEC, GRL was requested to obtain SPT energy measurements for two drill rigs at three general depth ranges. At least one energy measurement for each rig was to be obtained between the depths of 5 to 20 feet, 30 to 50 feet and below the depths of 75 to 100 feet. Therefore, GRL performed energy measurements between these depths with a total of three samples taken for each drill rig between these general depth locations. Specifically, measurements were provided at 6 to 7.5, 10.5 to 12, 13.5 to 15, 28.5 to 30, 33.5 to 35, 38.5 to 40, 98.5 to 100, 103.5 to 105 and 108.5 to 110 feet for drill rig number 1 (Truck No. 1344). For drill rig number 2 (Truck No. 1338) energy measurements were provided at 9 to 10.5, 10.5 to 12, 13.5 to 15, 38.5 to 40, 43.5 to 45, 48.5 to 50, 93.5 to 95, 98.5 to 100 and 103.5 to 105 feet. All SPT samples were driven for a total of 3 six-inch increments, or 1.5 feet.

## DYNAMIC TESTING ANALYSES AND RESULTS

### *Energy Transfer Measurements*

A PAK model Pile Driving Analyzer was used to take measurements of strain and acceleration. The strain and acceleration measurements were taken on the 2 ft long NW rod located directly below the CME automatic hammer. The strain and acceleration signal were conditioned and converted to force and velocities by the PDA. The PDA interprets the measured dynamic data according to the Case Method equation. The dynamic test data was evaluated for maximum force and velocity at the gage location. These quantities are presented in the summaries of the dynamic test results in Appendix B.

Force and velocity records from the PDA were also viewed graphically on a LCD screen to evaluate data quality. All force and velocity records were also digitally stored for subsequent laboratory analysis.

The maximum energy transferred to the gage location was calculated using two equations. The first equation, labeled EFV, calculated the maximum transferred energy by integrating both the force and velocity records over time as follows:

$$EFV = \int F(t)V(t)dt$$

Where: $F(t)$ = the force at time $t$

$V(t)$ = the velocity at time $t$

The integration begins at the time the hammer impacts the ram and continues until the maximum transferred energy is reached.

The second equation, EF2, calculates the transferred energy using the assumed proportionality between force and velocity to express the transferred energy in terms of one measured quantity, the force. By assuming that the force and velocity are proportional, the EF2 equation assumes that the drill rod is of constant cross-sectional area. This is seldom the case since the threaded connections between drill rod sections result in an increase in cross-sectional area at each connection. The EF2 equation can be expressed as:

$$EF2 = (c/EA)\int [F(t)]^2 dt$$

Where: $c$ = the stress wavespeed in the drill rod
$E$ = The modules of elasticity of the drill rod
$A$ = cross-sectional area of the drill rod at the gage location
$F(t)$ = the force at time $t$

The integration begins at the hammer impact time and continues to a cutoff time corresponding to the first occurrence of a zero force after impact. This is the method specified in ASTM D-46633-86, Standard Test Method for Stress Wave Energy Measurement for dynamic Penetrometer Systems. However, this ASTM standard has expired and a new standard has yet to be adopted. The new proposed standard specifies that the energy calculations be performed in accordance with the EFV method. The expired ASTM standard requires that the cutoff time fall within a time of 0.9(2$L/c$) and 1.2(2$L/c$) where $L$ is the length between the gage location and the bottom of the sampler. ASTM also requires that several correction factors be applied based upon the distance between the impact point and the measuring station, the overall rod length, and a velocity correction factor. For informational purposes, the energy calculated from this method is contained in the summary tables presented in Appendix B. However, none of the ASTM correction factors have been applied.

### *Discussion of Test Results*

Tables 1 and 2 contain a summary of the average energy transfer calculated using the EFV equation for each drilling rig and SPT sample with dynamic measurements. As noted earlier, the EF2 equation is based upon a uniform cross-sectional area. However, increases or decreases in the rod cross-sectional area typically occur at the rod connections. Therefore, the average energy transfer using the EF2 equation in Tables 1 and 2 should not be considered reliable or representative of the true energy transfer. Dynamic measurement of the energy transfer to the drill rods using the EFV equation ranged from 227 ft-lbs for sample B1013, SS-5 to 277 ft-lbs for sample B1008, SS-26, for drill rig number 1 (Truck No. 1344). This corresponds to a transfer efficiency ranging from 65 to 79% of the theoretical SPT hammer energy of 350 ft-lbs. Dynamic measurements of the energy transfer for drill rig number 2 (Truck No. 1338) ranged from 250 ft-lbs for sample B1006-SS-7 to 304 ft-lbs for sample B1006-SS-17. This corresponds to a transfer efficiency ranging from 71 to 87% of the theoretical SPT hammer energy of 350 ft-lbs. The average transferred energies for all nine samples collected for each drill rig were 252 ft-lbs and 282 ft-lbs, respectively for drill rig number 1 (Truck 1344) and drill rig number 2 (Truck No. 1338). These average transferred energies correspond to transfer efficiencies of 72 and 80%, respectively.

**Conclusions**

Based upon the dynamic test data obtained, the following conclusions are presented:

1 - Loose connections in the drill string were sometimes observed in the force and velocity records. Use of the EF2 equation (as specified in the expired ASTM Standard) would result in a lower calculated or inconsistent energy transfer to the drill rod in these cases and is therefore not considered representative of the true energy transfer. Energy transfer values calculated using the EFV equation are not adversely affected by the connectors and therefore are considered a better indication of transferred energy.

2 - Dynamic measurements of the transferred energy to the drill rods using the EFV equation ranged from 227 to 277 ft-lbs for drill rig number 1 (Truck No. 1344). This corresponds to a transfer efficiency ranging from 65 to 79% of the theoretical SPT hammer energy of 350 ft-lbs.

3 - Dynamic measurements of the transferred energy to the drill rods using the EFV equation ranged from 250 to 304 ft-lbs for drill rig number 2 (Truck No. 1338). This corresponds to a transfer efficiency ranging from 71 to 87% of the theoretical SPT hammer energy of 350 ft-lbs.

4 - The average energy for the nine SPT samples collected for each drill rig was 252 and 282 ft-lbs for drill rig number 1 (Truck 1344) and drill rig number 2 (Truck 1338), respectively. These average energy transfers correspond to transfer efficiencies of 72 and 80%, respectively.

We appreciate the opportunity to be of assistance on this project. Please do not hesitate to contact us if you have any questions regarding this report, or if we may be of further service.

Respectfully,
GRL Engineers, Inc.

Scott D. Webster dms

Scott D. Webster, P.E.

Karen Webster TJ

Karen Webster

SDW:KW:dms

## TABLE 1: Summary of STP Energy Measurements
## CME 55 Drill Rig - Truck 1344
## Plant Vogtle

| Borehole & Sample No. | Test Date | Reported Sample Depth (feet) | Reported Blow Count (blows/6") | SPT Field N Value | Avg. Energy Transferred FV Method (ft-lbs) | Energy Transfer Efficiency1 (%) | Avg. Energy Transferred F2 Method (ft-lbs) | Blow per Minute (bpm) |
|---|---|---|---|---|---|---|---|---|
| B1013-SS5 | 9/7/2005 | 6-7.5 | 5-6-6 | 12 | 227 | 65 | 128 | 48 |
| B1013-SS8 | 9/7/2005 | 10.5-12 | 16-17-10 | 17 | 246 | 70 | 151 | 47 |
| B1013-SS10 | 9/7/2005 | 13.5-15 | 4-4-18 | 22 | 238 | 68 | 142 | 47 |
| B1013-SS13 | 9/7/2005 | 28.5-30 | 10-8-8 | 16 | 247 | 71 | 147 | 47 |
| B1013-SS14 | 9/7/2005 | 33.5-35 | 12-14-20 | 34 | 251 | 72 | 151 | 46 |
| B1013-SS15 | 9/7/2005 | 38.5-40 | 7-10-12 | 22 | 256 | 73 | 145 | 47 |
| B1008-SS26 | 9/6/2005 | 98.5-100 | 18-24-41 | 65 | 277 | 79 | 161 | 45 |
| B1008-SS27 | 9/6/2005 | 103.5-105 | 18-23-30 | 53 | 262 | 75 | 152 | 45 |
| B1008-SS28 | 9/6/2005 | 108.5-110 | 17-21-50/3" | 71/9" | 263 | 75 | 152 | 46 |

Notes: All boring information and blow counts were reported to GRL by MACTEC.
1 - Energy transfer efficiency is the energy calculated by the FV method divided by the SPT hammer potential energy of 140 lbs times 2.5 foot drop height or 350 ft-lbs.

## TABLE 2: Summary of STP Energy Measurements
## CME 75 Drill Rig - Truck 1338
## Plant Vogtle

| Borehole & Sample No. | Test Date | Reported Sample Depth (feet) | Reported Blow Count (blows/6") | SPT Field N Value | Avg. Energy Transferred FV Method (ft-lbs) | Energy Transfer Efficiency1 (%) | Avg. Energy Transferred F2 Method (ft-lbs) | Blow per Minute (bpm) |
|---|---|---|---|---|---|---|---|---|
| B1006-SS7 | 9/6/2005 | 9-10.5 | 4-2-2 | 4 | 250 | 71 | 154 | 52 |
| B1006-SS8 | 9/6/2005 | 10.5-12 | 3-4-4 | 8 | 260 | 74 | 156 | 51 |
| B1006-SS10 | 9/6/2005 | 13.5-15 | 4-6-5 | 11 | 268 | 77 | 148 | 51 |
| B1006-SS15 | 9/6/2005 | 38.5-40 | 4-6-4 | 10 | 299 | 85 | 186 | 52 |
| B1006-SS16 | 9/6/2005 | 43.5-45 | 1-1-1 | 2 | 301 | 86 | 189 | 54 |
| B1006-SS17 | 9/6/2005 | 48.5-50 | 1-4-4 | 8 | 304 | 87 | 188 | 51 |
| B1006-SS26 | 9/7/2005 | 93.5-95 | 5-6-8 | 14 | 292 | 83 | 172 | 51 |
| B1006-SS27 | 9/7/2005 | 98.5-100 | 5-7-12 | 19 | 281 | 80 | 160 | 52 |
| B1006-SS28 | 9/7/2005 | 103.5-105 | 18-17-11 | 28 | 287 | 82 | 176 | 52 |

Notes: All boring information and blow counts were reported to GRL by MACTEC.
1 - Energy transfer efficiency is the energy calculated by the FV method divided by the SPT hammer potential energy of 140 lbs times 2.5 foot drop height or 350 ft-lbs.

# Appendix A

## *An Introduction into Dynamic Pile Testing Methods*

# APPENDIX A
# AN INTRODUCTION INTO DYNAMIC PILE TESTING METHODS

The following has been written by GRL Engineers, Inc. and may only be copied with its written permission.

## 1. BACKGROUND

Modern procedures of design and construction control require verification of bearing capacity and integrity of deep foundations during both preconstruction test programs and production installation. Dynamic pile testing methods meet this need economically and reliably, and therefore, form an important part of a quality assurance program when deep foundations are executed. Several dynamic pile testing methods exist; they have different benefits and limitations and different requirements for proper execution.

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (e.g. a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. The method is therefore also referred to as a "High Strain Method". The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then an evaluation of various quantities based on closed form solutions of the wave equation, a partial differential equation describing the motion of a rod under the effect of an impact. Conveniently, measurements and analyses are done by a single piece of equipment: the Pile Driving Analyzer® (PDA). However, for bearing capacity evaluations an important additional method is CAPWAP® which performs a much more rigorous analysis of the dynamic records than the simpler Case Method.

A related analysis method is the "Wave Equation Analysis" which calculates a relationship between bearing capacity and pile stress and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data.

The following description deals primarily with the "High Strain Test" Method of pile testing. However, for the sake of completeness, two types of "Low Strain Tests" are also mentioned: the Pile Integrity Test™ (PIT) and Cross Hole Sonic Logging conducted with the Cross Hole Analyzer (CHA).

## 2. RESULTS FROM PDA DYNAMIC TESTING

There are two main objectives of high strain dynamic pile testing:

- *Dynamic Pile Monitoring* and
- *Dynamic Load Testing.*

Dynamic pile monitoring is conducted during the installation of impact driven piles to achieve a safe and economical pile installation. Dynamic load testing, on the other hand, has as its primary goal the assessment of pile bearing capacity. It is applicable to both drilled shafts and impact driven piles during restrike.

### *2.1 DYNAMIC PILE MONITORING*

During pile installation, the sensors attached to the pile measure pile top force and velocity. A PDA conditions and processes these signals and calculates or evaluates:

- *Bearing capacity* at the time of testing, including an assessment of shaft resistance development and driving resistance. This information supports formulation of a driving criterion.

- *Dynamic pile stresses* axial and averaged over the pile cross section, both tensile and compressive, during pile driving to limit the potential of damage either near the pile top or along its length. Bending stresses can be evaluated at the point of sensor attachment.

- *Pile integrity* assessment by the PDA is based on the recognition of certain wave reflections from along the pile. If detected early enough, a pile may be saved from complete destruction. On the other hand, once damage is recognized measures can be taken to prevent reoccurrence.

- *Hammer performance* parameters including the energy transferred to the pile, the hammer speed in blows per minute and the stroke of open ended diesel hammers.

## 2.2 DYNAMIC PILE LOAD TESTING

Bearing capacity testing of either driven piles or drilled shafts employs the basic measurement approach of dynamic pile monitoring. However, the test is done independent of the pile installation process and therefore a pile driving hammer or other dynamic loading device may not be available. If a special ram has to be mobilized then its weight should be between 0.8 and 2% of the test load (e.g. between 4 and 10 tons for a 500 ton test load) to assure sufficient soil resistance activation.

For a successful test, it is most important that the test is conducted after a sufficient waiting time following pile installation for soil properties approaching their long term condition or concrete to properly set. During testing, PDA results of pile/shaft stresses and transferred energy are used to maintain safe stresses and assure sufficient resistance activation. For safe and sufficient testing of drilled shafts, ram energies are often increased from blow to blow until the test capacity has been activated. On the other hand, restrike tests on driven piles may require a warm hammer so that the very first blow produces a complete resistance activation. Data must be evaluated by CAPWAP for bearing capacity.

After the dynamic load test has been conducted with sufficient energy and safe stresses, the CAPWAP analysis provides the following results:

- *Bearing capacity i.e.* the mobilized capacity present at the time of testing
- *Resistance distribution* including shaft resistance and end bearing components
- *Stresses in pile or shaft* calculated for both the static load application and the dynamic test. These stresses are averages over the cross section and do not include bending effects or nonuniform contact stresses, e.g. when the pile toe is on uneven rock.
- *Shaft impedance vs. depth*; this is an estimate of the shaft shape if it differs substantially from the planned profile
- *Dynamic soil parameters* for shaft and toe, i.e. damping factors and quakes (related to the dynamic stiffness of the resistance at the pile/soil interface.)

# 3. MEASUREMENTS

The following is a general summary of dynamic measurements available to solve typical deep foundation problems.

## 3.1 PDA

The basis for the results calculated by the PDA are pile top strain and acceleration measurements which are converted to force and velocity records, respectively. The PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. Using closed form Case Method solutions, based on the one-dimensional linear wave equation, the PDA calculates the results described in the analytical solutions section below.

## 3.2 HPA

The ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. For this unit to be applicable, the ram must be visible. The impact velocity results can be automatically processed with a PC or recorded on a strip chart.

## 3.3 SAXIMETER™

For open end diesel hammers, the time between two impacts indicates the magnitude of the ram fall height or stroke. This information is not only measured and calculated by the PDA but also by the convenient, hand-held Saximeter.

## 3.4 PIT

The Pile Integrity Tester™ (PIT) helps in detecting major defects in concrete piles or shafts or assess the length of a variety of deep foundations, except steel piles. PIT performs the so-called "Pulse-Echo Method" which only requires the measurement of motion (e.g., acceleration) at the pile top caused by a light hammer impact. PIT also supports the so-called "Transient Response Method" which requires the additional measurement of the hammer force and an analysis in the frequency domain. PIT may also be used to evaluate the unknown length of deep foundations under existing structures.

### *3.5 CHA*

This test requires that at least two tubes (typically steel tubes of 50 mm diameter) are installed vertically in the shaft to be tested. A high frequency signal is generated in one of the water filled tubes and received in the other tube. The received signal strength and its First Time of Arrival (FAT) yield important information about the concrete quality between the two tubes. The transmitting and recording of the signal is repeated typically every 50 mm starting at the shaft bottom and all records together establish a log or profile of the concrete quality between the two tubes. The total number of tubes installed depends on the size of the drilled shaft. The more tubes are present the more profiles can be constructed.

## 4.ANALYTICAL SOLUTIONS

### 4.1 *BEARING CAPACITY*

### *4.1.1 WAVE EQUATION*

GRL has written the GRLWEAP™ program which calculates a relationship between bearing capacity, pile stress and blow count. This relationship is often called the "bearing graph." Once the blow count is known from pile installation logs, the bearing graph yields the bearing capacity. This approach requires no measurements other than blow count. Rather it requires an accurate knowledge of the various parameters describing hammer, driving system, pile and soil. The wave equation is also very useful during the design stage of a project for the selection of hammer, cushion and pile size.

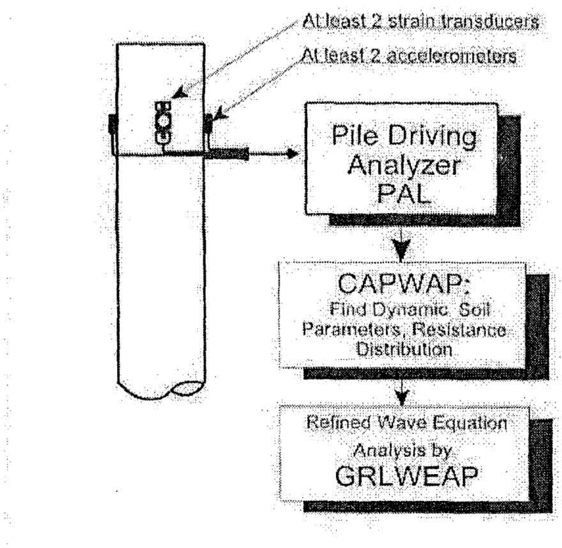



Figure 1. Block Diagram of Refined Wave Equation Analysis

After dynamic pile monitoring and/or dynamic load testing has been performed, the "Refined Wave Equation Analysis" or RWEA (Figure 1.) is often performed by inputting the PDA and CAPWAP calculated parameters. With many of the dynamic parameters verified by the dynamic tests, it is a more reliable basis for a safe and sufficient driving criterion.

### *4.1.2 CASE METHOD*

The Case Method is a closed form solution based on a few simplifying assumptions such as ideal plastic soil behavior and an ideally elastic and uniform pile. Given the measured pile top force, F(t), and pile top velocity, v(t), the total soil resistance is

$$R(t) = \tfrac{1}{2}\{[F(t) + F(t_2)] + Z[v(t) - v(t_2)]\} \qquad (1)$$

where

$t$ = a point in time after impact
$t_2$ = time t + 2L/c
$L$ = pile length below gages
$c$ = $(E/\rho)^{1/2}$ is the speed of the stress wave
$\rho$ = pile mass density
$Z$ = EA/c is the pile impedance
$E$ = elastic modulus of the pile ($\rho c^2$)
$A$ = pile cross sectional area

The total soil resistance consists of a dynamic ($R_d$) and a static ($R_s$) component. The static component is therefore

$$R_s(t) = R(t) - R_d(t) \qquad (2)$$

The dynamic component may be computed from a soil damping factor, J, and the pile velocity, $v_t(t)$ which is conveniently calculated for the pile toe. Using wave considerations, this approach leads immediately to the dynamic resistance

$$R_d(t) = J[F(t) + Zv(t) - R(t)] \qquad (3)$$

and finally to the static resistance by means of Equation 2.

There are a number of ways in which Eq. 1 through 3 could be evaluated. Most commonly, T is set to that time at which the static resistance becomes maximum. The result is the so-called **RMX** capacity. Damping factors for RMX typically range between 0.5 for coarse grained materials to 1.0 for clays. The **RSP** capacity (this method is most commonly referred to in the literature, yet it is not very frequently used) requires damping factors between 0.1 for sand and 1.0 for clay. Another capacity, **RA2**, determines the capacity at a time when the pile is essentially at rest and thus damping is small; RA2 therefore requires no damping parameter. In any event, the proper Case Method and its associated damping parameter is most conveniently found after a CAPWAP analysis has been performed for one record. The capacities for other hammer blows are then quickly calculated for the thus selected Case Method and its associated damping factor.

The static resistance calculated by either Case Method or CAPWAP is the mobilized resistance at the time of testing. Consideration therefore has to be given to soil setup or relaxation effects and whether or not a sufficient set has been achieved under the test loading that would correspond to a full activation of the ultimate soil resistance.

The PDA also calculates an estimate of shaft resistance as the difference between force and velocity times impedance at the time immediately prior to the return of the stress wave from the pile toe. This shaft resistance is not reduced by damping effects and is therefore called the total shaft resistance **SFT**. A correction for damping effects produces the static shaft resistance estimate, **SFR**.

The Case Method solution is simple enough to be evaluated "in real time," i.e. between hammer blows, using the PDA. It is therefore possible to calculate all relevant results for all hammer blows and plot these results as a function of depth or blow number. This is done in the PDI-PLOT program or formerly in the DOS based PDAPLOT program.

### *4.1.3 CAPWAP*

The CAse Pile Wave Analysis Program combines the wave equation pile and soil model with the Case Method measurements. Thus, the solution includes not only the total and static bearing capacity values but also the shaft resistance, end bearing, damping factors and soil stiffness values. The method iteratively calculates a number of unknowns by signal matching. While it is necessary to make hammer performance assumptions for a GRLWEAP analysis, the CAPWAP program works with the pile top measurements. Furthermore, while GRLWEAP and Case Method require certain assumptions regarding the soil behavior, CAPWAP calculates these soil parameters based on the dynamic measurements.

### *4.1.4 Capacity of damaged piles*

Occasionally piles are damaged during driving and such damage may be indicated in the PDA collected records, if it occurs below the sensor location. Damage on steel piles is often a broken splice, a collapsed pile bottom section, a ripped of flange on an H-pile or a sharp bend (a gradual dog leg is usually not recognized in the records). For concrete piles, among the problems encountered are cracks, perpendicular due to the pile axis, which deteriorate into a major damage, slabbing (loss of concrete cover) or a compressive failure at the bottom which in effect makes the pile shorter.

Damaged piles, with beta values less than 0.8 should never be evaluated for bearing capacity by the Case Method alone, because these are non-uniform piles which therefore violate the basic premise of the Case Method: a uniform, elastic pile.

Using the CAPWAP program, it is sometimes possible to obtain a reasonable match between computed and measured pile top quantities. In such an analysis the damaged section has to be modeled either by impedance reductions or by slacks. For piles with severe damage along their length it may be necessary to analyze a short pile. It should be born in mind, however, that such an analysis also violates the basic principles of the CAPWAP analysis, namely that the pile is elastic. Also, the nature of the damage is never be known with certainty. For example, a broken splice could be a cracked weld either with the neighboring sections lining up well or shifted laterally. In the former case the stresses would be similar to those in the undamaged pile; in the latter situation, high stress concentrations would develop. A sharp bend or toe damage present equally unpredictable situations under sustained loads which may cause further structural deterioration. If a short pile is analyzed then the lower section of the pile below the damage may offer unreliable end bearing and therefore should be discounted.

It is GRL's position that damaged piling should be replaced. Utilizing the CAPWAP calculated capacities should only be done after a very careful consideration of the effects of a loss of the foundation member while in service. Under no circumstances should the CAPWAP calculated capacity be utilized in the same manner in which the capacity of an undamaged pile be used. Under the best of circumstances the capacity should be used with an increased factor of safety and discounting all questionable capacity components. This evaluation cannot be made by GRL as it involves consideration of the type of structure, its seismic environment, the nature of the loads expected, the corrosiveness of the soil material, considerations of scour on the shortened pile, etc.

## 4.2 *STRESSES*

During pile monitoring, it is important that compressive stress maxima at pile top and toe and tensile stress maxima somewhere along the pile be calculated for each hammer blow.

At the pile top (location of sensors) both the maximum compression stress, **CSX**, and the maximum stress from individual strain transducers, **CSI**, are directly obtained from the measurements. Note that CSI is greater than or equal to CSX and the difference between CSI and CSX is a measure of bending in the plane of the strain transducers. Note also that all stresses calculated for locations below the sensors are averaged over the pile cross section and therefore do not include components from either bending or eccentric soil resistance effects.

The PDA calculates the compressive stress at the pile bottom, **CSB**, assuming (a) a uniform pile and (b) that the pile toe force is the maximum value of the total resistance, R(t), minus the total shaft resistance, SFT. Again, for this stress estimation uniform resistance force are assumed (e.g. not a sloping rock.)

For concrete piles, the maximum tension stress, **TSX**, is also of great importance. It occurs at some point below the pile top. The maximum tension stress, again averaged over the cross section and therefore not including bending stresses, can be computed from the pile top measurements by finding the maximum tension wave (either traveling upward, $W_U$, or downward, $W_d$) and reducing it by the minimum compressive wave traveling in opposite direction.

$$W_u = \tfrac{1}{2}[F(t) - Zv(t)] \quad (4)$$

$$W_d = \tfrac{1}{2}[F(t) + Zv(t)] \quad (5)$$

CAPWAP also calculates tensile and compressive stresses along the pile and, in general, more accurately than the PDA. In fact, for non-uniform piles or piles with joints, cracks or other discontinuities, the closed form solutions from the PDA may be in error.

## 4.3 *PILE INTEGRITY BY PDA*

Stress waves in a pile are reflected wherever the pile impedance, $Z = EA/c = \rho cA = A\sqrt{(E\,\rho)}$, changes. Therefore, the pile impedance is a measure of the quality of the pile material (E, ρ, c) and the size of its cross section (A). The reflected waves arrive at the pile top at a time which is greater the farther away from the pile top the reflection occurs. The magnitude of the change of the upward traveling wave (calculated from the measured force and velocity, Eq. 4) indicates the extent of the cross sectional change. Thus, with β (**BTA**) being a relative integrity factor which is unity for no impedance change and zero for the pile end, the following is calculated by the PDA.

$$\beta = (1 - \alpha)/(1 + \alpha) \quad (6)$$

with

$$\alpha = \tfrac{1}{2}(W_{UR} - W_{UD})/(W_{Di} - W_{UR}) \quad (7)$$

where

$W_{UR}$ is the upward traveling wave at the onset of the damage reflected wave. It is caused by resistance.

$W_{UD}$ is the upwards traveling reflection wave due to the damage.

$W_{Di}$ is the maximum downward traveling wave due to impact.

It can be shown that this formulation is quite accurate as long as individual reflections from different pile impedance changes have no overlapping effects on the stress wave reflections. Without rigorous derivation, it has been proposed to consider as slight damage when β is above 0.8 and a serious damage when β is less than 0.6.

### 4.4 *HAMMER PERFORMANCE BY PDA*

The PDA calculates the energy transferred to the pile top from:

$$E(t) = \int_0^t F(\tau)v(\tau)\, d\tau \qquad (8a)$$

The maximum of the E(t) curve is often called **ENTHRU**; it is the most important information for an overall evaluation of the performance of a hammer and driving system. **ENTHRU** or **EMX** allow for a classification of the hammer's performance when presented as, $e_T$, the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency.

$$e_T = EMX/E_R \qquad (8b)$$

where

$E_R$ is the hammer manufacturer's rated energy value.

Both Saximeter and PDA calculate the stroke (**STK**) of an open end diesel hammer using

$$STK = (g/8)\, T_B^2 - h_L \qquad (9)$$

where

*g* is the earth's gravitational acceleration,
$T_B$ is the time between two hammer blows,
$h_L$ is a stroke loss value due to gas compression and time losses during impact (usually 0.3 ft or 0.1 m).

### 4.5 *DETERMINATION OF WAVE SPEED*

An important facet of dynamic pile testing is an assessment of pile material properties. Since, n most cases general force is determined from strain by multiplication with elastic modulus, **E**, and cross sectional area, **A**, the dynamic elastic modulus has to be determined for pile materials other than steel. In general, the records measured by the PDA clearly indicate a pile toe reflection as long as pile penetration per blow is greater than 1 mm or .04 inches. The time between the onset of the force and velocity records at impact and the onset of the reflection from the toe (usually apparent by a local maximum of the wave up curve) is the so-called wave travel time, T. Dividing 2L (L is here the length of the pile below sensors) by T leads to the stress wave speed in the pile:

$$c = 2L/T \qquad (10)$$

The elastic modulus of the pile material is related to the wave speed according to the linear elastic wave equation theory by

$$E = c^2\rho \qquad (11)$$

Since the mass density of the pile material, ρ, is usually well known (an exception is timber for which samples should be weighed), the elastic modulus is easily found from the wave speed. Note, however, that this is a dynamic modulus which is generally higher than the static one and that the wave speed depends to some degree on the strain level of the stress wave. For example, experience shows that the wave speed from PIT is roughly 5% higher than the wave speed observed during a high strain test.

Other Notes:

- If the pile material is nonuniform then the wave speed c, according to Eq. 10, is an average wave speed and does not necessarily reflect the pile material properties of the location where the strain sensors are attached to the pile top. For example, pile driving often causes fine tension cracks some distance below the top of concrete piles. Then the average c of the whole pile is lower than the wave speed at the pile top. It is therefore recommended to determine E in the beginning of pile driving and not adjust it when the average c changes during the pile installation.

- If the pile has such a high resistance that there is no clear indication of a toe reflection then the wave speed of the pile material must be determined either by assumption or by taking a sample of the concrete and measuring its wave speed in a simple free column test. Another possibility is to use the proportionality relationship, discussed under "DATA QUALITY CHECKS" to find c as the ratio between the measured velocity and measured strain.

## 5. *DATA QUALITY CHECKS*

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing PDA or PIT tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to certain relationships.

### *5.1 PROPORTIONALITY*

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the pile, force and velocity measured at the pile top are proportional

$$F = v\,Z = v\,(EA/c) \qquad (12a)$$

This relationship can also be expressed in terms of stress

$$\sigma = v\,(E/c) \qquad (12b)$$

or strain

$$\epsilon = v\,/\,c \qquad (12c)$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements.

### 5.2 *NUMBER OF SENSORS*

Measurements are always taken at opposite sides of the pile so that the average force and velocity in the pile can be calculated. The velocity on the two sides of the pile is very similar even when high bending exists. Thus, an independent check of the velocity measurements is easy and simple.

Strain measurements may differ greatly between the two sides of the pile when bending exists. It is even possible that tension is measured on one side while very high compression exists on the other side of the pile. In extreme cases, bending might be so high that it leads to a nonlinear stress distribution. In that case the averaging of the two strain signals does not lead to the average pile force and proportionality will not be achieved.

When testing drilled shafts, measurements of strain may also be affected by local concrete quality variations. It is then often necessary to use four strain transducers spaced at 90 degrees around the pile for an improved strain data quality. The use of four transducers is also recommended for large pile diameters, particularly when it is difficult to mount the sensors at least two pile widths or diameters below the pile top.

## 6. LIMITATIONS, ADDITIONAL CONSIDERATIONS

### *6.1 MOBILIZATION OF CAPACITY*

Estimates of pile capacity from dynamic testing indicate the **mobilized pile capacity at the time of testing**. At very high blow counts (low set per blow), dynamic test methods tend to produce lower bound capacity estimates as not all resistance (particularly at and near the toe) is fully activated.

### *6.2 TIME DEPENDENT SOIL RESISTANCE EFFORTS*

Static pile capacity from dynamic method calculations provide an estimate of the axial pile capacity. Increases and decreases in the pile capacity with time typically occur as a result of soil setup and relaxation. Therefore, **restrike testing usually yields a better indication of long term pile capacity than a test at the end of pile driving**. Often a wait period of one or two days between end of driving and restrike is satisfactory for a realistic prediction of pile capacity but this waiting time depends, among other factors, on the permeability of the soil.

#### *6.2.1 SOIL SETUP*

Because excess positive pore pressures often develop during pile driving in fine grained soils (clays, silts or even fine sands), the capacity of a pile at the time of driving may often be less than the long term pile capacity. These pore pressures reduce the effective stress acting on the pile thereby reducing the soil resistance to pile penetration, and thus the pile capacity at the time of driving. As these pore pressures dissipate, the soil resistance acting on the pile increases as does the axial pile capacity. This phenomena is routinely called soil setup or soil freeze. There are numerous other reasons for soil setup such as realignment of clay particles, arching that reduces effective stresses during pile installation in ver dense sands, soil fatigue in over-consolidated clays etc.

### *6.2.2 RELAXATION*

Relaxation capacity reduction with time has been observed for piles driven into weathered shale, and may take several days to fully develop. Where relaxation occurs, pile capacity estimates based upon initial driving or short term restrike tests can significantly overpredict long term pile capacity. Therefore, piles driven into shale should be tested after a minimum one week wait either statically or dynamically with particular emphasis on the first few blows. Relaxation has also been observed for displacement piles driven into dense saturated silts or fine sands due to a negative pore pressure effect at the pile toe. In general, relaxation occurs at the pile toe and is therefore relevant for end bearing piles. Restrike tests should be performed and compared with the records from early restrike blows in order to avoid dangerous overpredictions

## *6.3 CAPACITY RESULTS FOR OPEN PILE PROFILES*

Open ended pipe piles or H-piles which do not bear on rock may behave differently under dynamic and static loading conditions. Under dynamic loads the soil inside the pile or between its flanges may slip and produce internal friction while under static loads the plug may move with the pile, thereby creating end bearing over the full pile cross section. As a result both friction and end bearing components may be different under static and dynamic conditions.

## *6.4 CAPWAP ANALYSIS RESULTS*

A portion of the soil resistance calculated on an individual soil segment in a CAPWAP analysis can usually be shifted up or down the shaft one soil segment without significantly altering the signal match quality. Therefore, use of the CAPWAP resistance distribution for uplift, downdrag, scour, or other geotechnical considerations should be made with an understanding of these analysis limitations.

## *6.5 STRESSES*

PDA and CAPWAP calculated stresses are average values over the cross section. Additional allowance has to be made for bending or non-uniform contact stresses. To prevent damage it is therefore important to maintain good hammer-pile alignment and to protect the pile toes using appropriate devices or an increased cross sectional area.

In the United States is has become generally acceptable to limit the dynamic installation stresses of driven piles to the following levels:

90% of yield strength for steel piles

85% of the concrete compressive strength - after subtraction of the effective prestress - for concrete piles in compression

100% of effective prestress plus ½ of the concrete's tension strength for prestressed piles in tension

70% of the reinforcement strength for regularly reinforced concrete piles in tension

300% of the static design allowable stress for timber

Note that the dynamic stresses may either be directly measured at the pile top by the PDA or calculated by the PDA for other locations along the pile based on the pile top measurements. The above allowable stresses also apply to those calculated by wave equation.

### *6.6 ADDITIONAL DESIGN CONSIDERATIONS*

Numerous factors have to be considered in pile foundation design. Some of these considerations include

- additional pile loading from downdrag or negative skin friction,
- lateral and uplift loading requirements
- effective stress changes (due to changes in water table, excavations, fills or other changes in overburden),
- long term settlements in general and settlement from underlying weaker layers and/or pile group effects,
- loss of shaft resistance due to scour or other effects,
- loss of structural pile strength due to additional bending loads, buckling (the dynamic loads general due not cause buckling even though they may exceed the buckling strength of the pile section), corrosion etc.

These factors have not been evaluated by GRL and have not been considered in the interpretation of the dynamic testing results. The foundation designer should determine if these or any other considerations are applicable to this project and the foundation design.

### *6.7 WAVE EQUATION ANALYSIS RESULTS*

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input parameters. Although attempts have been made to base the analysis on the best available information, actual field conditions may vary and therefore stresses and blow counts may differ from the predictions reported. Capacity predictions derived from wave equation analyses should use restrike information. However, because of the uncertainties associated with restrike blow counts and restrike hammer energies, correlations of such results with static test capacities with have often displayed considerable scatter.

As for PDA and CAPWAP, the theory on which GRLWEAP is based is the one-dimensional wave equation. For that reason, stress predictions by the wave equation analysis can only be averages over the pile cross section. Thus, bending stresses or stress concentrations due to non-uniform impact or uneven soil or rock resistance are not considered in these results. Stress maxima calculated by the wave equation are usually subjected to the same limits as those measured directly or calculated from measurements by the PDA.

## 7. FACTORS OF SAFETY

Run to failure, static or dynamic load tests yield an ultimate pile bearing capacity, $R_{ult}$. If this failure load were applied to the pile, then excessive settlements would occur. Therefore, it is absolutely necessary that the actually applied load, also called the design load, $R_d$ (or working load or safe load), is less than $R_{ult}$. In most soils, to limit settlements, it is necessary that $R_{ult}$, is at least 50% higher than $R_d$. This means that

$$R_{ult} \geq 1.5\ R_d,$$

or the Factor of Safety has to be at least 1.5.

Unfortunately, neither applied loads nor $R_{ult}$ are exactly known. One static load test may be performed at a site, but that would not guarantee that all other piles have the same capacity and it is to be expected that a certain percentage of the production piles have lower capacities, either due to soil variability or due to pile damage. If, for example, dynamic pile tests are performed on piles in shale only a short time after pile installation, then the test capacity may be higher than the long term capacity of the pile. On the other hand, due to soil setup, piles generally gain capacity after installation and since tests are only done a short time after installation, a lower capacity value is ascertained than the capacity that eventually develops.

Not only bearing capacity values of all piles are unknown, even loads vary considerably and occasional overloads must be expected. We would not want a structure to become unserviceable or useless because of either an occasional overload or a few piles with low capacity. For this reason, and to avoid being overly conservative which would mean excessive cost, modern safety concepts suggest that the overall factor of safety should reflect both the uncertainty in loads and resistance. Thus, if all piles were tested statically and if we carefully controlled the loads, we probably could live with F.S. = 1.5. However, in general, depending on the building type or load combinations and as a function of quality assurance of pile foundations, a variety of Factors of Safety have been proposed.

For example, for highway related loads and based on AASHTO specifications, the Federal Highway Administration proposes the following:

F.S.= 2.00 for static load test with wave equation.

F.S.=2.25 for dynamic testing with wave equation analysis.

F.S.=2.50 for indicator piles with wave equation analysis.

F.S.=2.75 for wave equation analysis.

F.S.=3.00 for Gates or other dynamic formula.

It should be mentioned that all of these methods should always be combined with soil exploration and static pile analysis. Also, specifications of what are occasionally updated and therefore the latest version should be various consulted for the appropriate factors of safety.

Codes, among them PDCA, ASCE, or specifications issued by State Departments of Transportation specify different factors of safety. However, the range of recommended overall factors of safety in the United States varies between 1.9 and 6.

It is the designer's responsibility to identify design loads together with the adopted safety factor concept and associated construction control procedure. The required factors of safety should be included in design drawings or specifications together with the required testing. Only contractors bid for the work and develop the most economical solution. This should include a program of increased testing for lower required pile capacities. This will also help to reduce the confusion that often exists on construction sites as to design loads and require capacities. In any event, it cannot expected that the test engineer is aware of and responsible for the variety of considerations that must be met to find the appropriate factor of safety.

App-A-PDA-9-01

# Appendix B:

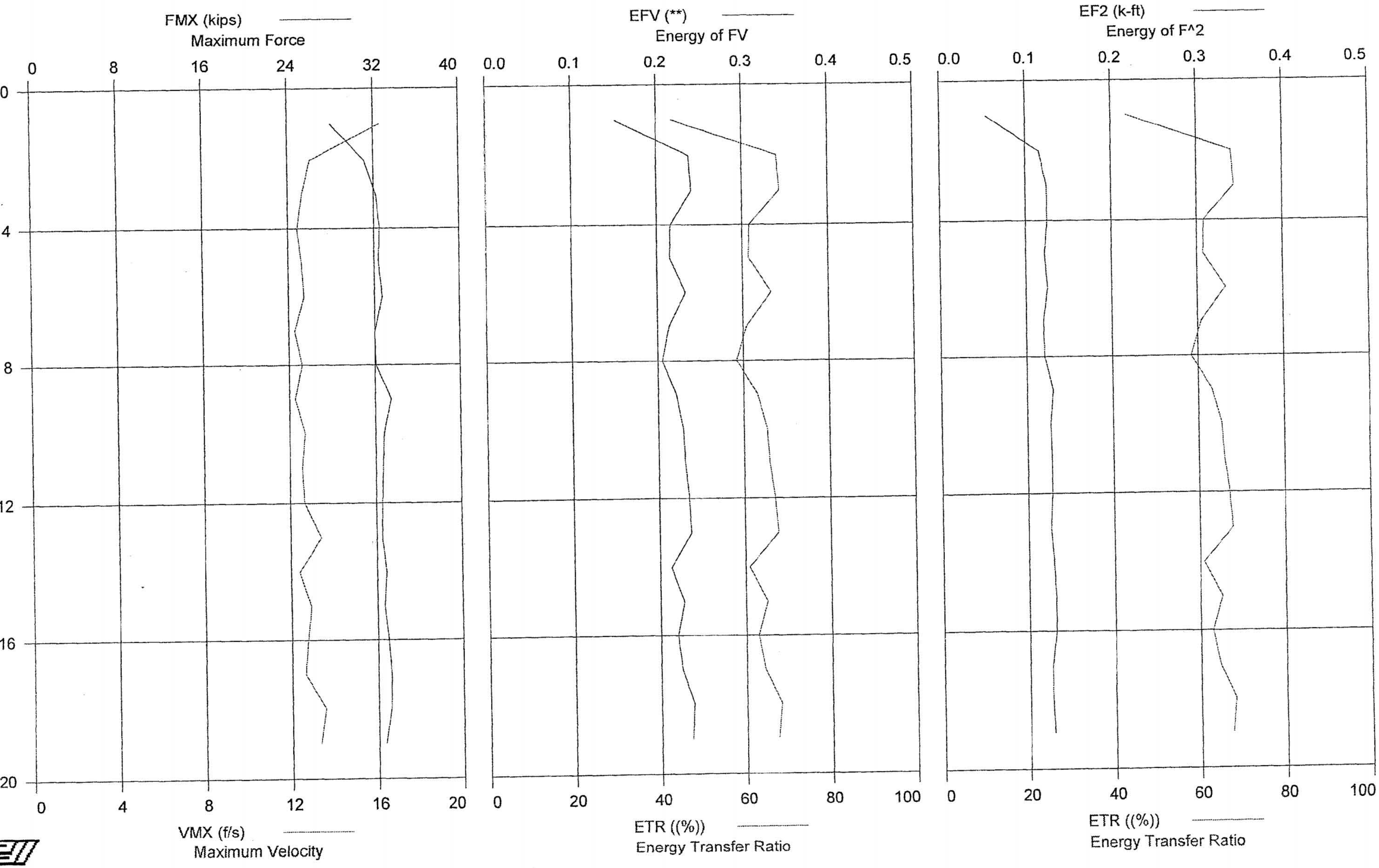
# SPT Energy Measurement

GRL Engineers, Inc. - Case Method Results

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-5

Test date: 7-Sep-2005



GRL Engineers, Inc. Page 1 of 1
Case Method Results PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-5 SPT
OP: SDW Test date: 7-Sep-2005

AR: 2.30 in^2 SP: 0.492 k/ft3
LE: 11.00 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.70

FMX: Maximum Force BPM: Blows per Minute
VMX: Maximum Velocity EF2: Energy of F^2
EFV: Energy of FV ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 28 | 16.3 | 0.152 | ** | 0.054 | 43.5 |
| 2 | 0.00 | AV1 | 31 | 13.0 | 0.238 | ** | 0.116 | 68.1 |
| 3 | 0.00 | AV1 | 32 | 12.7 | 0.241 | 50.9 | 0.125 | 68.7 |
| 4 | 0.00 | AV1 | 33 | 12.4 | 0.216 | 47.8 | 0.125 | 61.6 |
| 5 | 0.00 | AV1 | 32 | 12.6 | 0.215 | 48.0 | 0.122 | 61.4 |
| 6 | 0.00 | AV1 | 33 | 12.7 | 0.233 | 47.7 | 0.125 | 66.6 |
| 7 | 0.00 | AV1 | 32 | 12.3 | 0.213 | 47.8 | 0.120 | 60.8 |
| 8 | 0.00 | AV1 | 32 | 12.6 | 0.205 | 48.0 | 0.121 | 58.4 |
| 9 | 0.00 | AV1 | 33 | 12.3 | 0.221 | 47.5 | 0.130 | 63.2 |
| 10 | 0.00 | AV1 | 33 | 12.7 | 0.229 | 47.5 | 0.127 | 65.4 |
| 11 | 0.00 | AV1 | 33 | 12.6 | 0.231 | 48.0 | 0.128 | 65.9 |
| 12 | 0.00 | AV1 | 33 | 12.7 | 0.235 | 47.2 | 0.128 | 67.1 |
| 13 | 0.00 | AV1 | 33 | 13.4 | 0.237 | 47.7 | 0.126 | 67.7 |
| 14 | 0.00 | AV1 | 33 | 12.4 | 0.213 | 47.7 | 0.129 | 60.9 |
| 15 | 0.00 | AV1 | 33 | 12.9 | 0.228 | 47.6 | 0.131 | 65.1 |
| 16 | 0.00 | AV1 | 33 | 12.7 | 0.220 | 47.3 | 0.131 | 62.8 |
| 17 | 0.00 | AV1 | 33 | 12.6 | 0.225 | 47.6 | 0.126 | 64.4 |
| 18 | 0.00 | AV1 | 33 | 13.5 | 0.238 | 47.6 | 0.126 | 68.0 |
| 19 | 0.00 | AV1 | 33 | 13.3 | 0.236 | 47.2 | 0.128 | 67.3 |

Time Summary

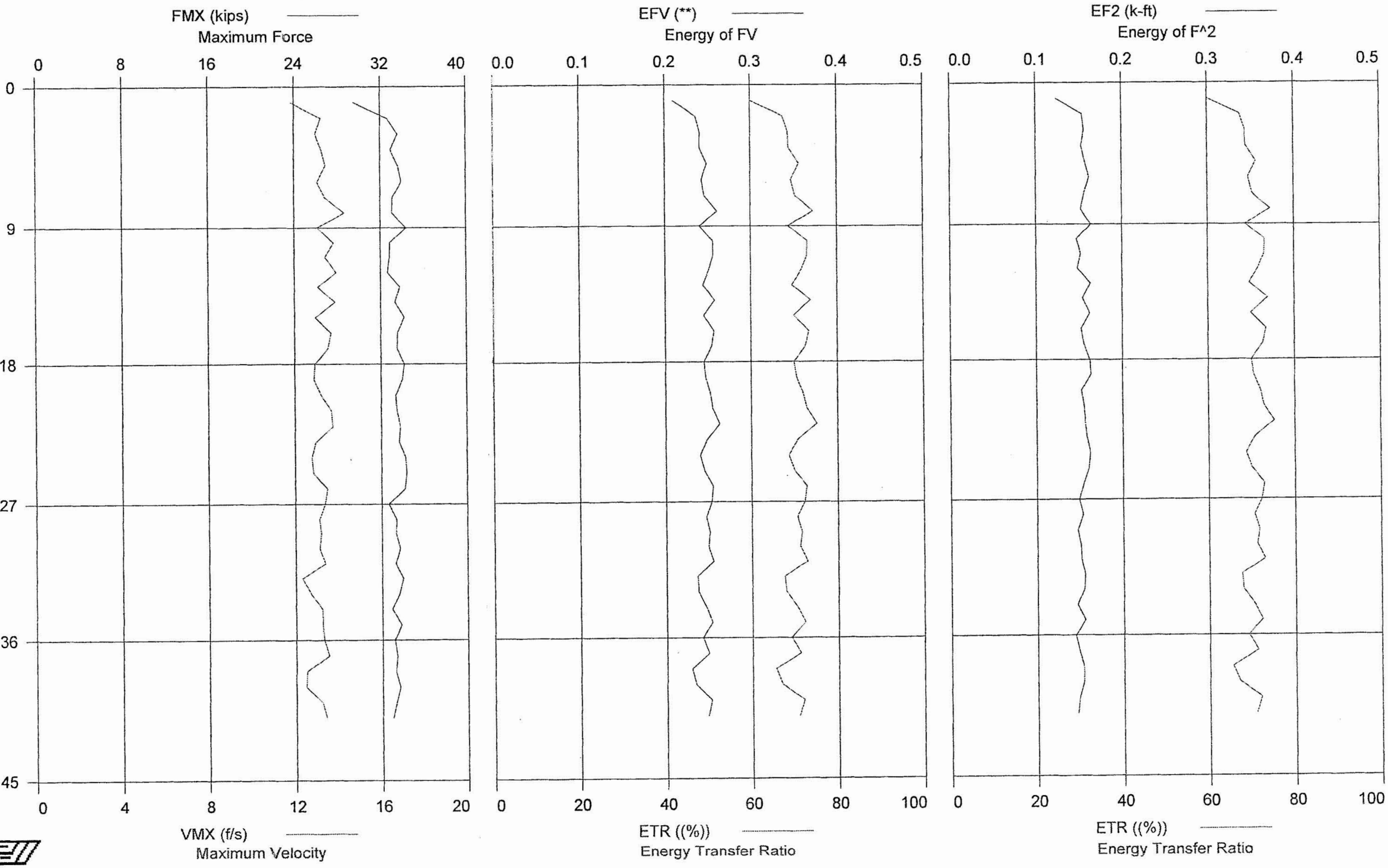
Drive 5 minutes 25 seconds 11:43:14 AM - 11:48:39 AM (9/7/2005)

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

GRL Engineers, Inc. - Case Method Results

Test date: 7-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-8



GRL Engineers, Inc.
Case Method Results

Page 1 of 1
PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-8 SPT
OP: SDW Test date: 7-Sep-2005

AR: 2.30 in^2
LE: 16.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 30 | 11.9 | 0.210 | 133.3 | 0.124 | 60.0 |
| 2 | 0.00 | AV1 | 33 | 13.2 | 0.236 | 46.3 | 0.154 | 67.6 |
| 3 | 0.00 | AV1 | 34 | 13.0 | 0.241 | 43.6 | 0.156 | 68.7 |
| 4 | 0.00 | AV1 | 33 | 13.3 | 0.241 | 39.3 | 0.153 | 68.9 |
| 5 | 0.00 | AV1 | 34 | 13.5 | 0.249 | 47.4 | 0.157 | 71.3 |
| 6 | 0.00 | AV1 | 34 | 13.1 | 0.243 | 47.2 | 0.162 | 69.5 |
| 7 | 0.00 | AV1 | 33 | 13.4 | 0.246 | 47.4 | 0.156 | 70.3 |
| 8 | 0.00 | AV1 | 33 | 14.3 | 0.261 | 47.2 | 0.152 | 74.5 |
| 9 | 0.00 | AV1 | 34 | 13.1 | 0.240 | 47.1 | 0.164 | 68.7 |
| 10 | 0.00 | AV1 | 33 | 13.8 | 0.256 | 47.2 | 0.147 | 73.1 |
| 11 | 0.00 | AV1 | 33 | 13.4 | 0.256 | 46.9 | 0.152 | 73.1 |
| 12 | 0.00 | AV1 | 33 | 13.9 | 0.251 | 47.4 | 0.148 | 71.7 |
| 13 | 0.00 | AV1 | 34 | 13.1 | 0.244 | 47.1 | 0.163 | 69.6 |
| 14 | 0.00 | AV1 | 33 | 13.9 | 0.258 | 47.1 | 0.154 | 73.8 |
| 15 | 0.00 | AV1 | 34 | 13.0 | 0.245 | 47.1 | 0.162 | 69.9 |
| 16 | 0.00 | AV1 | 34 | 13.7 | 0.257 | 47.1 | 0.152 | 73.4 |
| 17 | 0.00 | AV1 | 34 | 13.5 | 0.254 | 46.7 | 0.155 | 72.7 |
| 18 | 0.00 | AV1 | 34 | 12.9 | 0.245 | 47.3 | 0.162 | 70.0 |
| 19 | 0.00 | AV1 | 34 | 12.9 | 0.247 | 46.8 | 0.163 | 70.5 |
| 20 | 0.00 | AV1 | 33 | 13.2 | 0.252 | 47.2 | 0.152 | 72.0 |
| 21 | 0.00 | AV1 | 33 | 13.7 | 0.255 | 47.2 | 0.155 | 72.9 |
| 22 | 0.00 | AV1 | 34 | 13.7 | 0.263 | 46.9 | 0.156 | 75.2 |
| 23 | 0.00 | AV1 | 34 | 12.9 | 0.248 | 47.0 | 0.158 | 70.7 |
| 24 | 0.00 | AV1 | 34 | 12.8 | 0.240 | 46.9 | 0.162 | 68.7 |
| 25 | 0.00 | AV1 | 34 | 12.8 | 0.245 | 46.9 | 0.160 | 70.0 |
| 26 | 0.00 | AV1 | 34 | 13.5 | 0.255 | 46.9 | 0.154 | 72.8 |
| 27 | 0.00 | AV1 | 33 | 13.4 | 0.253 | 47.0 | 0.149 | 72.3 |
| 28 | 0.00 | AV1 | 33 | 13.1 | 0.247 | 46.6 | 0.153 | 70.6 |
| 29 | 0.00 | AV1 | 33 | 13.2 | 0.251 | 46.9 | 0.147 | 71.6 |
| 30 | 0.00 | AV1 | 34 | 13.1 | 0.249 | 46.9 | 0.150 | 71.1 |
| 31 | 0.00 | AV1 | 33 | 13.4 | 0.255 | 46.8 | 0.151 | 72.9 |
| 32 | 0.00 | AV1 | 34 | 12.3 | 0.236 | 47.0 | 0.155 | 67.5 |
| 33 | 0.00 | AV1 | 34 | 12.7 | 0.237 | 47.0 | 0.154 | 67.8 |
| 34 | 0.00 | AV1 | 33 | 13.2 | 0.246 | 47.0 | 0.146 | 70.4 |
| 35 | 0.00 | AV1 | 34 | 13.2 | 0.253 | 47.0 | 0.155 | 72.3 |
| 36 | 0.00 | AV1 | 33 | 13.3 | 0.242 | 46.7 | 0.144 | 69.1 |
| 37 | 0.00 | AV1 | 33 | 13.5 | 0.249 | 46.8 | 0.148 | 71.2 |
| 38 | 0.00 | AV1 | 33 | 12.5 | 0.229 | 46.5 | 0.153 | 65.4 |
| 39 | 0.00 | AV1 | 34 | 12.5 | 0.234 | 46.7 | 0.153 | 66.9 |
| 40 | 0.00 | AV1 | 33 | 13.2 | 0.252 | 46.5 | 0.148 | 72.0 |
| 41 | 0.00 | AV1 | 33 | 13.4 | 0.248 | 46.8 | 0.146 | 70.8 |

Time Summary

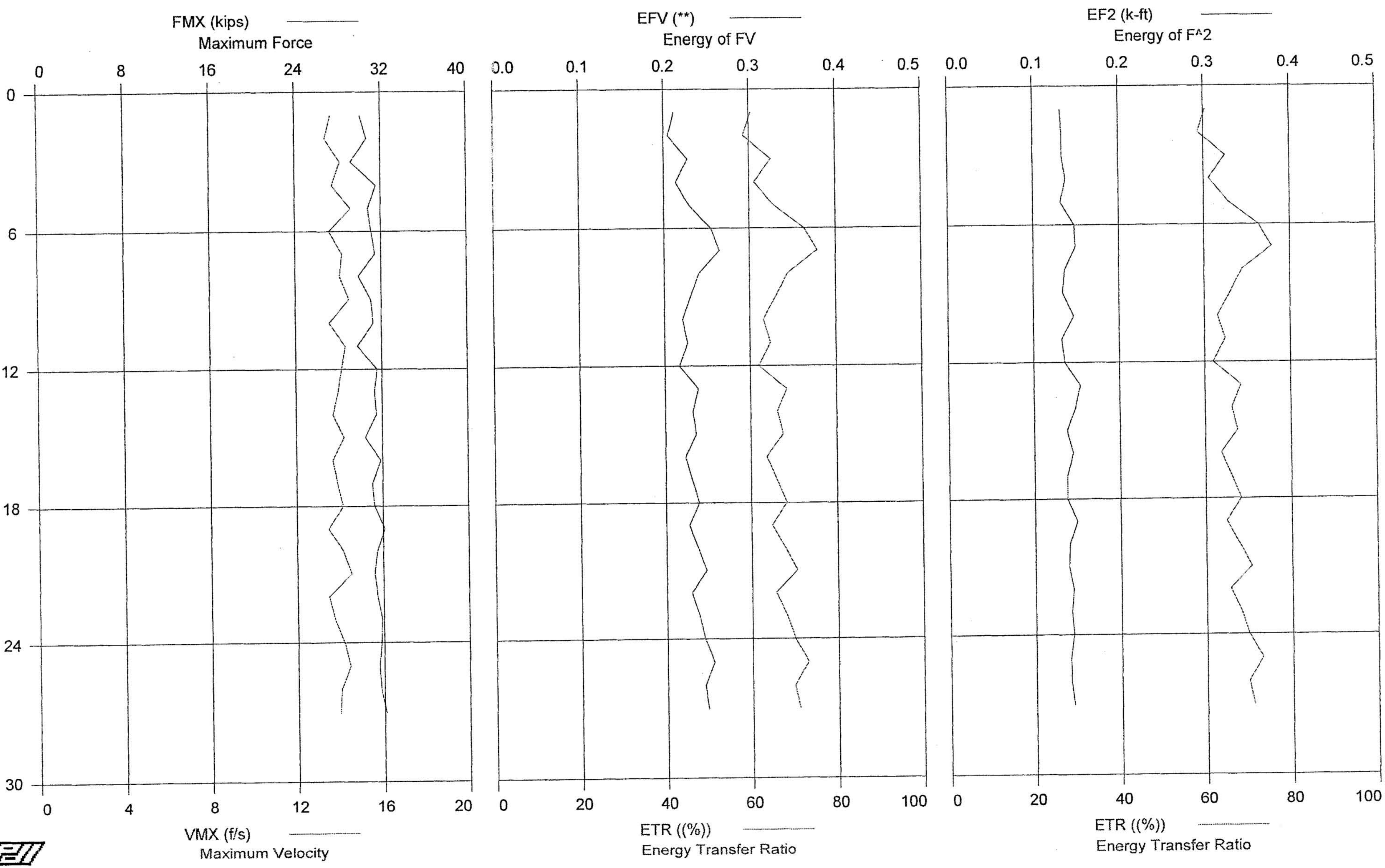
Drive 55 seconds 12:07:37 PM - 12:08:32 PM (9/7/2005)

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

GRL Engineers, Inc. - Case Method Results

Test date: 7-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-10



GRL Engineers, Inc. Page 1 of 1
Case Method Results PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-10 SPT
OP: SDW Test date: 7-Sep-2005

AR: 2.30 in^2 SP: 0.492 k/ft3
LE: 19.00 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.70

FMX: Maximum Force BPM: Blows per Minute
VMX: Maximum Velocity EF2: Energy of F^2
EFV: Energy of FV ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 30 | 13.7 | 0.212 | ** | 0.132 | 60.5 |
| 2 | 0.00 | AV1 | 31 | 13.4 | 0.205 | 47.5 | 0.134 | 58.7 |
| 3 | 0.00 | AV1 | 29 | 14.1 | 0.228 | 116.3 | 0.134 | 65.0 |
| 4 | 0.00 | AV1 | 32 | 13.7 | 0.214 | 72.6 | 0.138 | 61.2 |
| 5 | 0.00 | AV1 | 31 | 14.6 | 0.230 | 47.0 | 0.132 | 65.7 |
| 6 | 0.00 | AV1 | 31 | 13.6 | 0.255 | 113.6 | 0.148 | 72.7 |
| 7 | 0.00 | AV1 | 31 | 14.2 | 0.265 | 47.3 | 0.149 | 75.7 |
| 8 | 0.00 | AV1 | 30 | 14.1 | 0.241 | 47.4 | 0.137 | 68.9 |
| 9 | 0.00 | AV1 | 31 | 14.5 | 0.231 | 47.4 | 0.134 | 66.1 |
| 10 | 0.00 | AV1 | 31 | 13.6 | 0.221 | 47.0 | 0.147 | 63.1 |
| 11 | 0.00 | AV1 | 30 | 14.3 | 0.227 | 47.3 | 0.133 | 64.8 |
| 12 | 0.00 | AV1 | 32 | 14.1 | 0.217 | 104.3 | 0.136 | 61.9 |
| 13 | 0.00 | AV1 | 31 | 13.9 | 0.239 | 116.3 | 0.154 | 68.4 |
| 14 | 0.00 | AV1 | 31 | 13.7 | 0.232 | 103.8 | 0.148 | 66.2 |
| 15 | 0.00 | AV1 | 30 | 14.2 | 0.236 | 81.6 | 0.138 | 67.5 |
| 16 | 0.00 | AV1 | 32 | 13.7 | 0.223 | 47.1 | 0.145 | 63.7 |
| 17 | 0.00 | AV1 | 31 | 13.9 | 0.231 | 35.0 | 0.138 | 66.0 |
| 18 | 0.00 | AV1 | 31 | 14.1 | 0.239 | 46.7 | 0.138 | 68.3 |
| 19 | 0.00 | AV1 | 32 | 13.5 | 0.227 | 47.0 | 0.149 | 64.8 |
| 20 | 0.00 | AV1 | 31 | 14.1 | 0.237 | 47.0 | 0.140 | 67.7 |
| 21 | 0.00 | AV1 | 31 | 14.5 | 0.247 | 46.9 | 0.139 | 70.6 |
| 22 | 0.00 | AV1 | 31 | 13.5 | 0.229 | 47.0 | 0.144 | 65.5 |
| 23 | 0.00 | AV1 | 32 | 13.7 | 0.238 | 46.9 | 0.142 | 68.1 |
| 24 | 0.00 | AV1 | 32 | 14.1 | 0.244 | 46.9 | 0.144 | 69.8 |
| 25 | 0.00 | AV1 | 32 | 14.4 | 0.255 | 46.9 | 0.140 | 72.9 |
| 26 | 0.00 | AV1 | 32 | 14.0 | 0.244 | 47.0 | 0.141 | 69.7 |
| 27 | 0.00 | AV1 | 32 | 13.9 | 0.248 | 46.8 | 0.144 | 70.9 |

Time Summary

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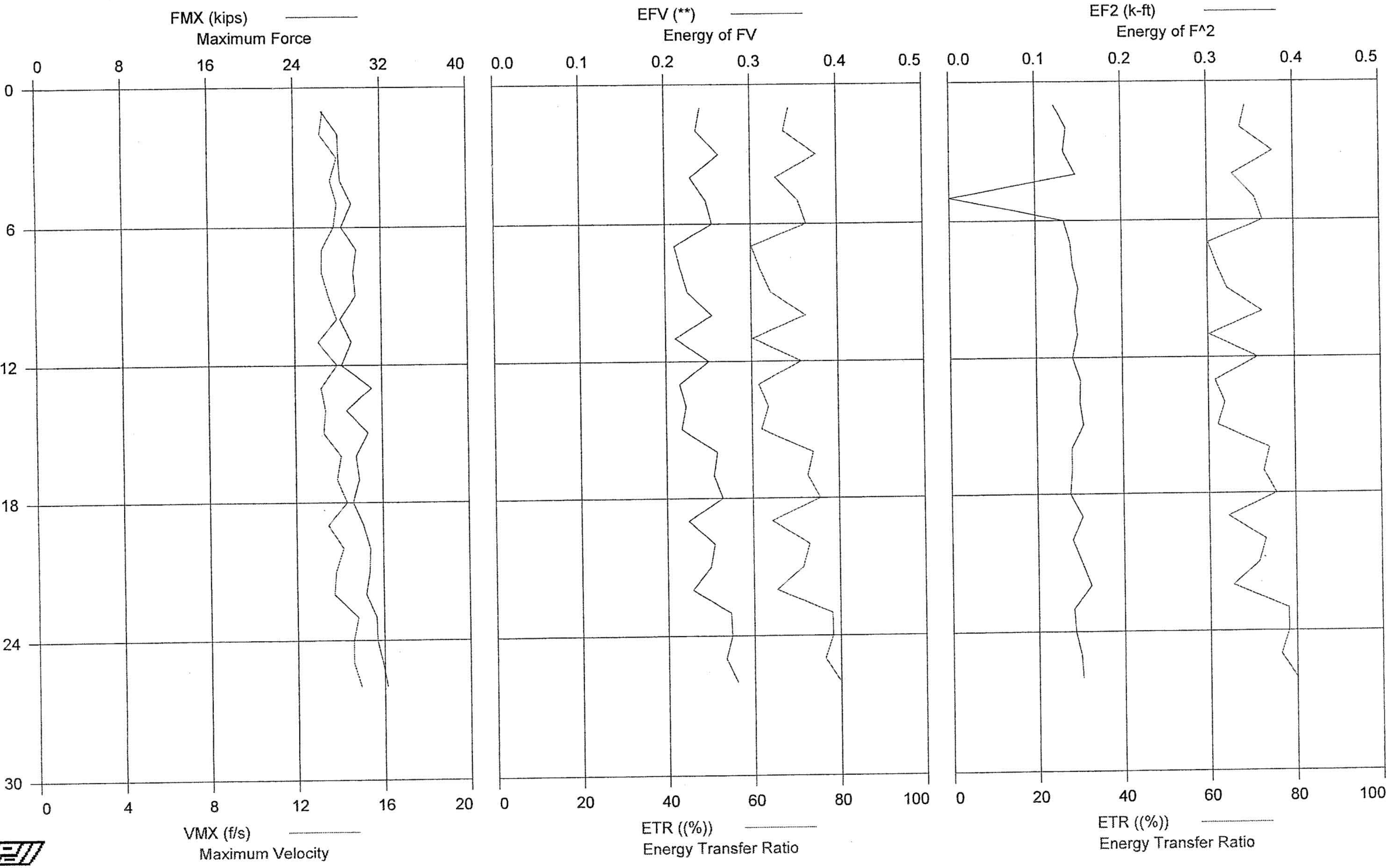
GRL Engineers, Inc. - Case Method Results

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

Test date: 7-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-13



GRL Engineers, Inc.
Case Method Results

Page 1 of 1
PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-13
OP: SDW

SPT
Test date: 7-Sep-2005

AR: 2.30 in^2
LE: 34.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 27 | 13.4 | 0.242 | 57.4 | 0.122 | 69.0 |
| 2 | 0.00 | AV1 | 28 | 13.2 | 0.237 | 47.6 | 0.136 | 67.7 |
| 3 | 0.00 | AV1 | 28 | 14.0 | 0.263 | 46.7 | 0.133 | 75.3 |
| 4 | 0.00 | AV1 | 28 | 13.7 | 0.230 | 47.2 | 0.147 | 65.8 |
| 5 | 0.00 | AV1 | 29 | 14.0 | 0.248 | 47.1 | 0.000 | 71.0 |
| 6 | 0.00 | AV1 | 28 | 13.8 | 0.255 | 47.4 | 0.133 | 72.8 |
| 7 | 0.00 | AV1 | 30 | 13.3 | 0.211 | 47.0 | 0.140 | 60.2 |
| 8 | 0.00 | AV1 | 29 | 13.3 | 0.218 | 47.4 | 0.143 | 62.2 |
| 9 | 0.00 | AV1 | 30 | 13.6 | 0.226 | 46.9 | 0.149 | 64.5 |
| 10 | 0.00 | AV1 | 28 | 13.9 | 0.254 | 46.9 | 0.145 | 72.6 |
| 11 | 0.00 | AV1 | 29 | 13.1 | 0.211 | 47.2 | 0.148 | 60.3 |
| 12 | 0.00 | AV1 | 28 | 13.9 | 0.250 | 46.4 | 0.142 | 71.5 |
| 13 | 0.00 | AV1 | 31 | 13.2 | 0.216 | 46.6 | 0.151 | 61.6 |
| 14 | 0.00 | AV1 | 29 | 13.4 | 0.223 | 46.8 | 0.150 | 63.8 |
| 15 | 0.00 | AV1 | 31 | 13.3 | 0.218 | 46.8 | 0.154 | 62.2 |
| 16 | 0.00 | AV1 | 30 | 14.1 | 0.259 | 47.0 | 0.140 | 74.0 |
| 17 | 0.00 | AV1 | 30 | 13.9 | 0.255 | 46.9 | 0.140 | 72.7 |
| 18 | 0.00 | AV1 | 29 | 14.4 | 0.265 | 46.7 | 0.138 | 75.6 |
| 19 | 0.00 | AV1 | 30 | 13.5 | 0.225 | 47.0 | 0.152 | 64.4 |
| 20 | 0.00 | AV1 | 31 | 14.2 | 0.255 | 47.1 | 0.140 | 73.0 |
| 21 | 0.00 | AV1 | 31 | 13.8 | 0.250 | 47.1 | 0.151 | 71.4 |
| 22 | 0.00 | AV1 | 30 | 13.7 | 0.229 | 46.9 | 0.161 | 65.4 |
| 23 | 0.00 | AV1 | 31 | 14.8 | 0.273 | 47.1 | 0.141 | 78.1 |
| 24 | 0.00 | AV1 | 31 | 14.6 | 0.274 | 46.8 | 0.143 | 78.2 |
| 25 | 0.00 | AV1 | 32 | 14.6 | 0.267 | 46.7 | 0.149 | 76.4 |
| 26 | 0.00 | AV1 | 32 | 14.9 | 0.280 | 46.8 | 0.151 | 79.9 |

Time Summary

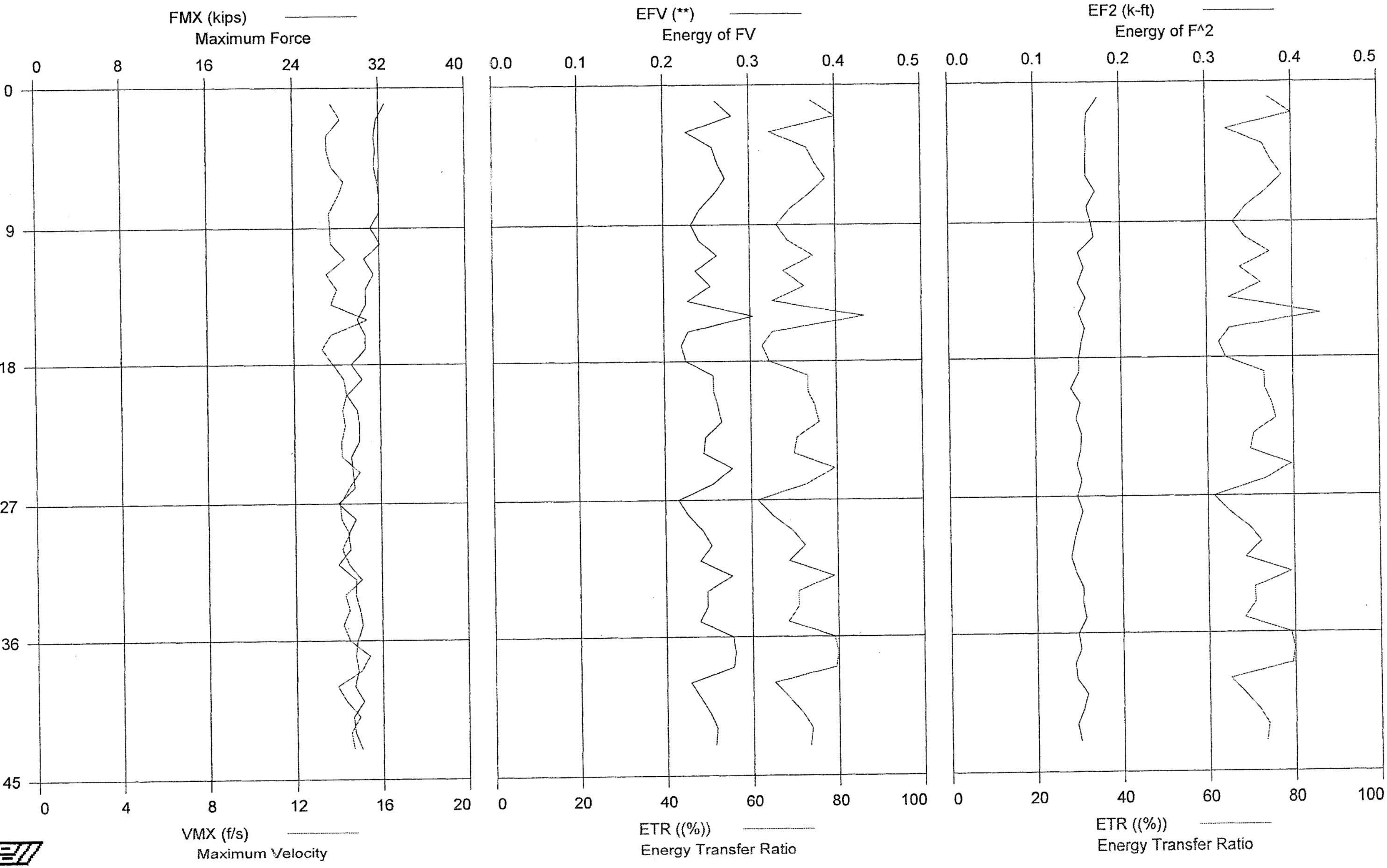
Drive 32 seconds 1:42:54 PM - 1:43:26 PM (9/7/2005)

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

GRL Engineers, Inc. - Case Method Results

Test date: 7-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-14



PLANT VOGTLE - RIG 1 - B-1013-SS-14 SPT
OP: SDW Test date: 7-Sep-2005

AR: 2.30 in^2 SP: 0.492 k/ft3
LE: 39.00 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.70

FMX: Maximum Force BPM: Blows per Minute
VMX: Maximum Velocity EF2: Energy of F^2
EFV: Energy of FV ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 92.00 | AV1 | 33 | 13.8 | 0.261 | 19.1 | 0.175 | 74.5 |
| 2 | 0.00 | AV1 | 32 | 14.2 | 0.280 | 37.2 | 0.162 | 80.1 |
| 3 | 0.00 | AV1 | 32 | 13.6 | 0.227 | 47.2 | 0.160 | 64.8 |
| 4 | 0.00 | AV1 | 32 | 13.6 | 0.257 | 41.6 | 0.161 | 73.3 |
| 5 | 0.00 | AV1 | 32 | 13.8 | 0.263 | 47.4 | 0.160 | 75.2 |
| 6 | 0.00 | AV1 | 32 | 14.3 | 0.272 | 69.0 | 0.160 | 77.7 |
| 7 | 0.00 | AV1 | 32 | 14.1 | 0.259 | 47.3 | 0.171 | 73.9 |
| 8 | 0.00 | AV1 | 32 | 13.7 | 0.242 | 47.2 | 0.161 | 69.2 |
| 9 | 0.00 | AV1 | 31 | 13.7 | 0.232 | 46.9 | 0.166 | 66.3 |
| 10 | 0.00 | AV1 | 32 | 13.7 | 0.241 | 46.9 | 0.169 | 68.8 |
| 11 | 0.00 | AV1 | 31 | 14.4 | 0.262 | 47.1 | 0.151 | 74.8 |
| 12 | 0.00 | AV1 | 31 | 13.5 | 0.237 | 46.9 | 0.157 | 67.8 |
| 13 | 0.00 | AV1 | 31 | 14.0 | 0.254 | 46.7 | 0.150 | 72.6 |
| 14 | 0.00 | AV1 | 31 | 13.7 | 0.228 | 46.9 | 0.159 | 65.2 |
| 15 | 0.00 | AV1 | 30 | 15.4 | 0.303 | 46.5 | 0.151 | 86.5 |
| 16 | 0.00 | AV1 | 31 | 13.7 | 0.228 | 46.5 | 0.158 | 65.2 |
| 17 | 0.00 | AV1 | 31 | 13.3 | 0.220 | 46.8 | 0.154 | 62.8 |
| 18 | 0.00 | AV1 | 29 | 13.8 | 0.225 | 46.2 | 0.151 | 64.4 |
| 19 | 0.00 | AV1 | 30 | 14.3 | 0.257 | 46.7 | 0.151 | 73.3 |
| 20 | 0.00 | AV1 | 29 | 14.4 | 0.257 | 46.1 | 0.141 | 73.4 |
| 21 | 0.00 | AV1 | 30 | 14.2 | 0.262 | 46.6 | 0.152 | 74.9 |
| 22 | 0.00 | AV1 | 30 | 14.4 | 0.266 | 46.4 | 0.147 | 75.9 |
| 23 | 0.00 | AV1 | 30 | 14.2 | 0.247 | 46.3 | 0.153 | 70.7 |
| 24 | 0.00 | AV1 | 29 | 14.2 | 0.245 | 45.8 | 0.152 | 70.0 |
| 25 | 0.00 | AV1 | 29 | 15.0 | 0.278 | 46.3 | 0.148 | 79.4 |
| 26 | 0.00 | AV1 | 30 | 14.5 | 0.255 | 46.1 | 0.153 | 72.9 |
| 27 | 0.00 | AV1 | 28 | 14.1 | 0.215 | 45.5 | 0.148 | 61.4 |
| 28 | 0.00 | AV1 | 30 | 14.1 | 0.227 | 46.3 | 0.154 | 64.9 |
| 29 | 0.00 | AV1 | 29 | 14.5 | 0.243 | 46.3 | 0.148 | 69.5 |
| 30 | 0.00 | AV1 | 29 | 14.2 | 0.253 | 45.9 | 0.144 | 72.4 |
| 31 | 0.00 | AV1 | 28 | 14.5 | 0.240 | 45.6 | 0.140 | 68.6 |
| 32 | 0.00 | AV1 | 30 | 15.1 | 0.277 | 46.1 | 0.146 | 79.1 |
| 33 | 0.00 | AV1 | 30 | 14.3 | 0.248 | 46.0 | 0.154 | 70.7 |
| 34 | 0.00 | AV1 | 30 | 14.5 | 0.248 | 45.9 | 0.154 | 70.8 |
| 35 | 0.00 | AV1 | 30 | 14.2 | 0.239 | 45.8 | 0.157 | 68.3 |
| 36 | 0.00 | AV1 | 30 | 14.5 | 0.277 | 45.3 | 0.148 | 79.1 |
| 37 | 0.00 | AV1 | 30 | 15.4 | 0.280 | 45.5 | 0.151 | 79.9 |
| 38 | 0.00 | AV1 | 30 | 15.0 | 0.278 | 45.7 | 0.144 | 79.4 |
| 39 | 0.00 | AV1 | 29 | 13.9 | 0.228 | 45.8 | 0.146 | 65.0 |
| 40 | 0.00 | AV1 | 30 | 14.3 | 0.239 | 45.8 | 0.158 | 68.3 |
| 41 | 0.00 | AV1 | 29 | 14.9 | 0.250 | 45.7 | 0.153 | 71.6 |
| 42 | 0.00 | AV1 | 29 | 14.5 | 0.258 | 45.9 | 0.146 | 73.7 |
| 43 | 848.00 | AV1 | 30 | 14.6 | 0.256 | 45.6 | 0.150 | 73.2 |

Time Summary

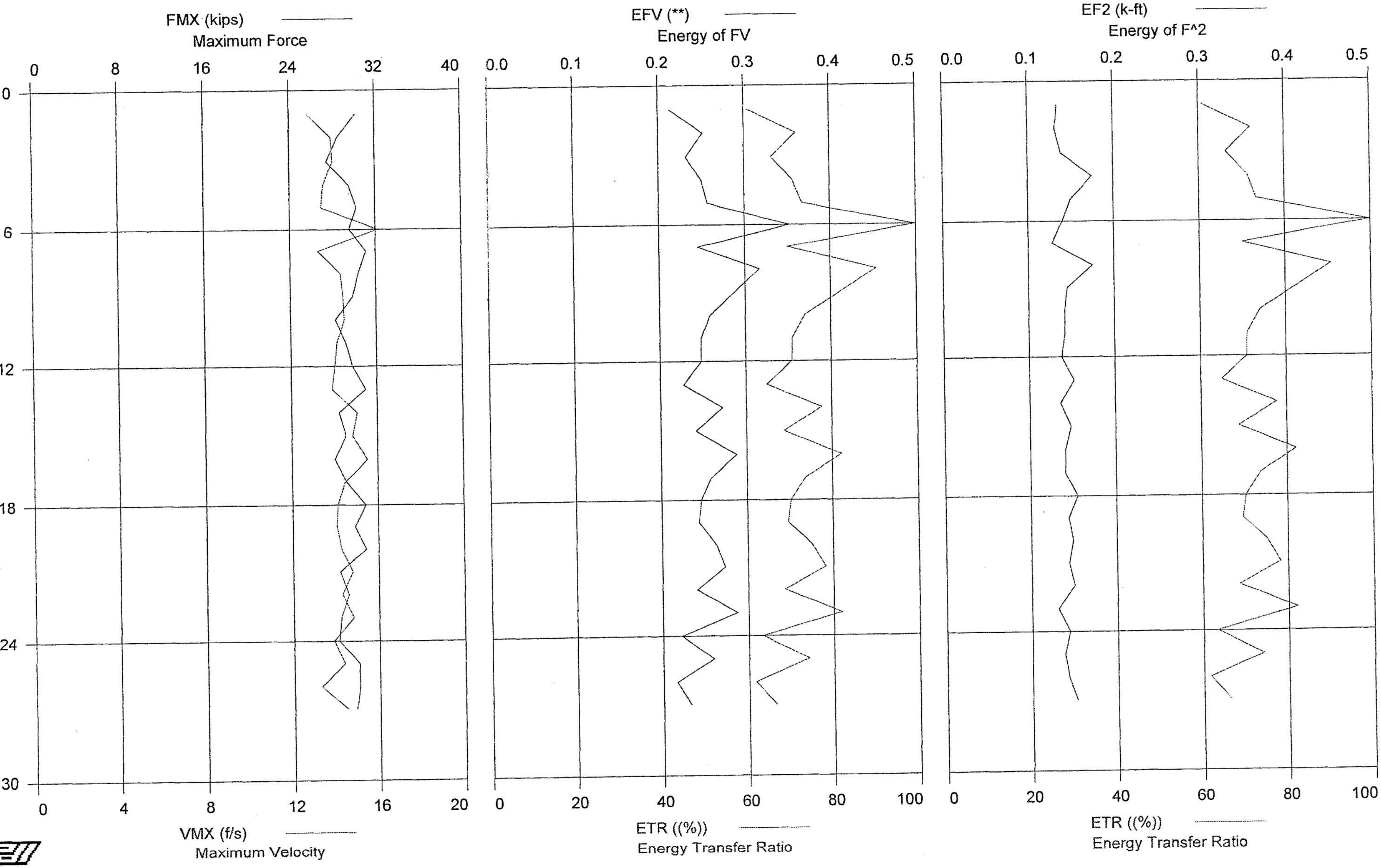
Drive 1 minute 1:57:14 PM - 1:58:14 PM (9/7/2005)

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

GRL Engineers, Inc. - Case Method Results

PLANT VOGTLE - RIG 1 - B-1013-SS-15

Test date: 7-Sep-2005



GRL Engineers, Inc.
Case Method Results

PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 1 - B-1013-SS-15
OP: SDW

SPT
Test date: 7-Sep-2005

AR: 2.30 in^2
LE: 44.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 30 | 12.8 | 0.213 | 105.8 | 0.135 | 60.8 |
| 2 | 0.00 | AV1 | 29 | 14.0 | 0.252 | 46.8 | 0.132 | 72.1 |
| 3 | 0.00 | AV1 | 27 | 14.0 | 0.232 | 46.7 | 0.139 | 66.3 |
| 4 | 0.00 | AV1 | 30 | 13.6 | 0.250 | 98.7 | 0.175 | 71.4 |
| 5 | 0.00 | AV1 | 30 | 13.5 | 0.257 | 81.5 | 0.150 | 73.5 |
| 6 | 0.00 | AV1 | 30 | 16.1 | 0.353 | 127.9 | 0.140 | 100.8 |
| 7 | 0.00 | AV1 | 31 | 13.3 | 0.245 | 47.0 | 0.128 | 70.0 |
| 8 | 0.00 | AV1 | 30 | 14.4 | 0.317 | 80.9 | 0.175 | 90.7 |
| 9 | 0.00 | AV1 | 30 | 14.5 | 0.288 | 38.3 | 0.145 | 82.4 |
| 10 | 0.00 | AV1 | 28 | 14.5 | 0.259 | 46.4 | 0.142 | 74.0 |
| 11 | 0.00 | AV1 | 29 | 14.2 | 0.248 | 46.2 | 0.142 | 71.0 |
| 12 | 0.00 | AV1 | 30 | 14.0 | 0.248 | 46.2 | 0.138 | 70.8 |
| 13 | 0.00 | AV1 | 31 | 13.9 | 0.227 | 46.3 | 0.152 | 64.9 |
| 14 | 0.00 | AV1 | 28 | 15.1 | 0.272 | 46.6 | 0.136 | 77.7 |
| 15 | 0.00 | AV1 | 29 | 14.8 | 0.241 | 46.4 | 0.148 | 68.8 |
| 16 | 0.00 | AV1 | 28 | 15.5 | 0.288 | 45.9 | 0.141 | 82.1 |
| 17 | 0.00 | AV1 | 29 | 14.5 | 0.258 | 46.4 | 0.141 | 73.7 |
| 18 | 0.00 | AV1 | 31 | 14.1 | 0.246 | 45.8 | 0.155 | 70.3 |
| 19 | 0.00 | AV1 | 30 | 14.1 | 0.243 | 46.0 | 0.144 | 69.5 |
| 20 | 0.00 | AV1 | 31 | 14.3 | 0.263 | 45.9 | 0.149 | 75.1 |
| 21 | 0.00 | AV1 | 28 | 14.8 | 0.273 | 46.2 | 0.144 | 78.1 |
| 22 | 0.00 | AV1 | 29 | 14.3 | 0.240 | 45.5 | 0.150 | 68.5 |
| 23 | 0.00 | AV1 | 28 | 14.8 | 0.287 | 45.9 | 0.131 | 82.0 |
| 24 | 0.00 | AV1 | 28 | 13.9 | 0.222 | 45.9 | 0.144 | 63.3 |
| 25 | 0.00 | AV1 | 30 | 14.4 | 0.259 | 45.5 | 0.138 | 74.1 |
| 26 | 0.00 | AV1 | 30 | 13.3 | 0.216 | 46.3 | 0.143 | 61.6 |
| 27 | 0.00 | AV1 | 30 | 14.5 | 0.232 | 45.1 | 0.152 | 66.3 |

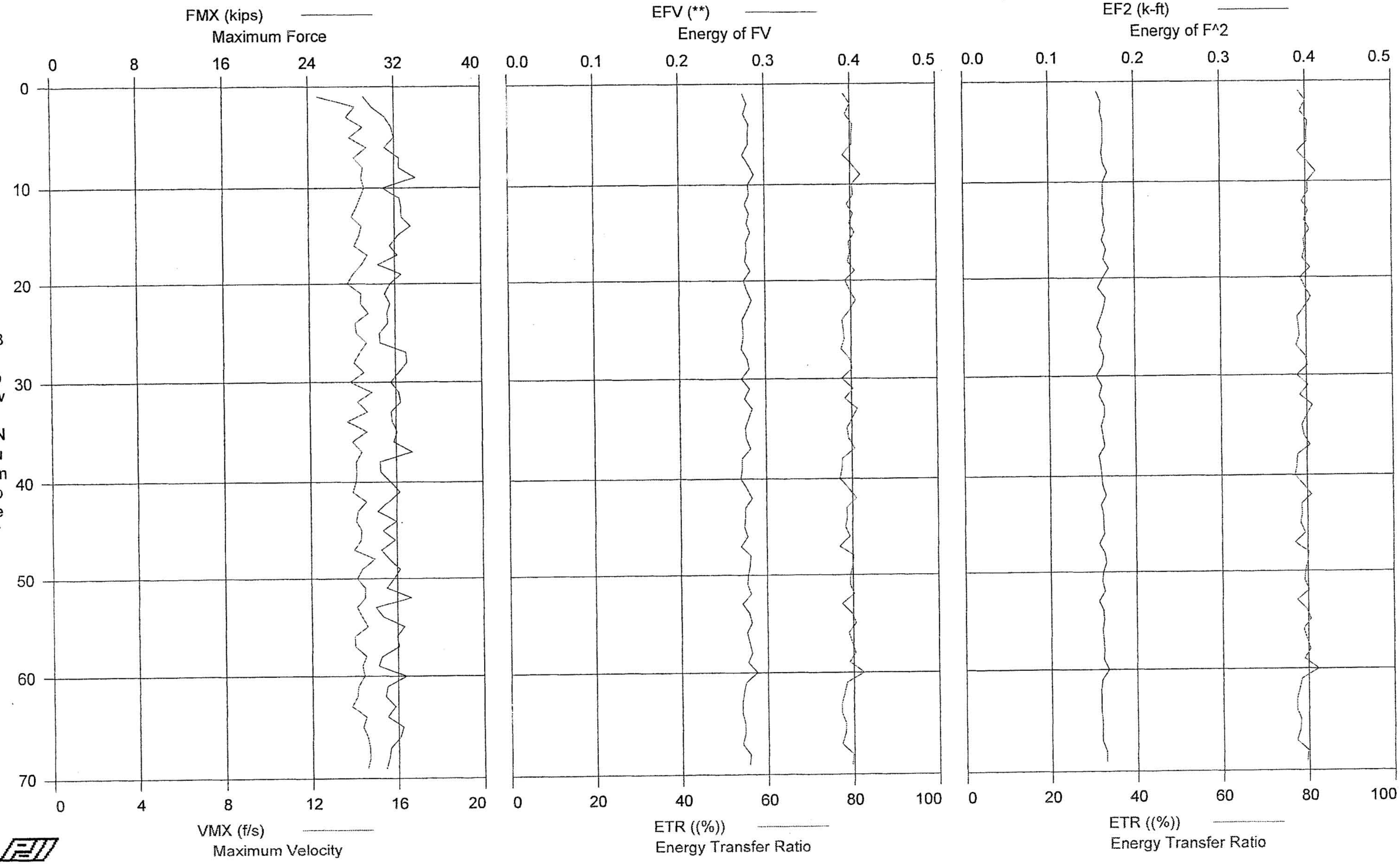
Time Summary

Drive 37 seconds 2:07:11 PM - 2:07:48 PM (9/7/2005)

GRL Engineers, Inc. - Case Method Results

PLANT VOGTLE - RIG 1 - B-1008-SS-26

Test date: 6-Sep-2005



GRL Engineers, Inc.
Case Method Results

PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 1 - B-1008-SS-26
OP: SDW

SPT
Test date: 6-Sep-2005

AR: 2.30 in^2
LE: 104.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 29 | 12.4 | 0.275 | ** | 0.157 | 78.5 |
| 2 | 0.00 | AV1 | 30 | 14.2 | 0.280 | 51.1 | 0.162 | 80.0 |
| 3 | 0.00 | AV1 | 31 | 13.8 | 0.276 | 46.7 | 0.161 | 78.8 |
| 4 | 0.00 | AV1 | 32 | 14.5 | 0.282 | 46.2 | 0.164 | 80.6 |
| 5 | 0.00 | AV1 | 32 | 13.9 | 0.281 | 46.6 | 0.164 | 80.3 |
| 6 | 0.00 | AV1 | 31 | 14.7 | 0.281 | 46.4 | 0.164 | 80.4 |
| 7 | 0.00 | AV1 | 32 | 14.1 | 0.274 | 46.4 | 0.162 | 78.2 |
| 8 | 0.00 | AV1 | 32 | 14.5 | 0.282 | 46.6 | 0.164 | 80.4 |
| 9 | 0.00 | AV1 | 34 | 14.5 | 0.288 | 46.6 | 0.169 | 82.3 |
| 10 | 0.00 | AV1 | 31 | 14.6 | 0.281 | 46.5 | 0.164 | 80.4 |
| 11 | 0.00 | AV1 | 32 | 14.4 | 0.282 | 46.0 | 0.164 | 80.6 |
| 12 | 0.00 | AV1 | 33 | 14.2 | 0.277 | 46.3 | 0.163 | 79.2 |
| 13 | 0.00 | AV1 | 33 | 14.0 | 0.282 | 46.2 | 0.165 | 80.6 |
| 14 | 0.00 | AV1 | 33 | 14.4 | 0.279 | 46.3 | 0.163 | 79.7 |
| 15 | 0.00 | AV1 | 32 | 14.3 | 0.283 | 46.0 | 0.166 | 80.9 |
| 16 | 0.00 | AV1 | 32 | 14.1 | 0.278 | 46.2 | 0.162 | 79.5 |
| 17 | 0.00 | AV1 | 32 | 14.7 | 0.279 | 45.9 | 0.167 | 79.8 |
| 18 | 0.00 | AV1 | 30 | 14.5 | 0.277 | 45.8 | 0.164 | 79.3 |
| 19 | 0.00 | AV1 | 33 | 14.0 | 0.283 | 46.1 | 0.170 | 81.0 |
| 20 | 0.00 | AV1 | 32 | 13.8 | 0.275 | 45.7 | 0.163 | 78.7 |
| 21 | 0.00 | AV1 | 31 | 14.4 | 0.279 | 45.9 | 0.157 | 79.7 |
| 22 | 0.00 | AV1 | 32 | 14.4 | 0.284 | 45.7 | 0.166 | 81.1 |
| 23 | 0.00 | AV1 | 31 | 14.7 | 0.279 | 45.6 | 0.164 | 79.7 |
| 24 | 0.00 | AV1 | 31 | 14.1 | 0.273 | 45.5 | 0.160 | 77.9 |
| 25 | 0.00 | AV1 | 31 | 14.2 | 0.274 | 45.6 | 0.156 | 78.2 |
| 26 | 0.00 | AV1 | 31 | 14.6 | 0.274 | 45.6 | 0.161 | 78.4 |
| 27 | 0.00 | AV1 | 33 | 14.4 | 0.272 | 45.2 | 0.159 | 77.6 |
| 28 | 0.00 | AV1 | 33 | 14.1 | 0.279 | 45.8 | 0.164 | 79.7 |
| 29 | 0.00 | AV1 | 32 | 14.5 | 0.281 | 45.1 | 0.162 | 80.3 |
| 30 | 0.00 | AV1 | 32 | 13.9 | 0.272 | 45.4 | 0.155 | 77.8 |
| 31 | 0.00 | AV1 | 32 | 14.9 | 0.281 | 45.2 | 0.161 | 80.3 |
| 32 | 0.00 | AV1 | 32 | 14.2 | 0.275 | 45.5 | 0.158 | 78.4 |
| 33 | 0.00 | AV1 | 32 | 14.7 | 0.284 | 45.4 | 0.164 | 81.3 |
| 34 | 0.00 | AV1 | 32 | 13.7 | 0.280 | 45.2 | 0.164 | 80.1 |
| 35 | 0.00 | AV1 | 32 | 14.6 | 0.276 | 45.6 | 0.160 | 78.8 |
| 36 | 0.00 | AV1 | 32 | 14.0 | 0.277 | 45.5 | 0.162 | 79.2 |
| 37 | 0.00 | AV1 | 33 | 14.4 | 0.282 | 45.7 | 0.164 | 80.6 |
| 38 | 0.00 | AV1 | 30 | 14.1 | 0.272 | 45.1 | 0.157 | 77.7 |
| 39 | 0.00 | AV1 | 31 | 14.2 | 0.272 | 45.7 | 0.159 | 77.6 |
| 40 | 0.00 | AV1 | 31 | 14.1 | 0.270 | 45.5 | 0.160 | 77.1 |
| 41 | 0.00 | AV1 | 32 | 14.0 | 0.277 | 45.0 | 0.161 | 79.1 |
| 42 | 0.00 | AV1 | 31 | 14.6 | 0.283 | 45.6 | 0.165 | 80.9 |
| 43 | 0.00 | AV1 | 30 | 14.2 | 0.275 | 44.6 | 0.159 | 78.6 |
| 44 | 0.00 | AV1 | 32 | 14.1 | 0.275 | 45.4 | 0.162 | 78.7 |
| 45 | 0.00 | AV1 | 31 | 14.4 | 0.274 | 44.8 | 0.162 | 78.3 |
| 46 | 0.00 | AV1 | 32 | 14.3 | 0.278 | 45.2 | 0.163 | 79.4 |
| 47 | 0.00 | AV1 | 31 | 14.0 | 0.270 | 45.3 | 0.157 | 77.0 |
| 48 | 0.00 | AV1 | 31 | 15.0 | 0.281 | 45.1 | 0.163 | 80.2 |
| 49 | 0.00 | AV1 | 32 | 14.4 | 0.280 | 44.8 | 0.165 | 79.9 |
| 50 | 0.00 | AV1 | 32 | 14.1 | 0.278 | 44.3 | 0.161 | 79.4 |
| 51 | 0.00 | AV1 | 31 | 14.5 | 0.277 | 44.8 | 0.160 | 79.3 |
| 52 | 0.00 | AV1 | 33 | 14.5 | 0.281 | 45.1 | 0.163 | 80.2 |
| 53 | 0.00 | AV1 | 30 | 14.1 | 0.271 | 44.4 | 0.156 | 77.4 |
| 54 | 0.00 | AV1 | 31 | 14.3 | 0.279 | 45.0 | 0.161 | 79.6 |
| 55 | 0.00 | AV1 | 33 | 14.6 | 0.282 | 45.0 | 0.162 | 80.6 |
| 56 | 0.00 | AV1 | 32 | 14.0 | 0.276 | 44.5 | 0.160 | 78.9 |
| 57 | 0.00 | AV1 | 32 | 14.0 | 0.279 | 44.7 | 0.161 | 79.7 |
| 58 | 0.00 | AV1 | 31 | 14.5 | 0.282 | 44.9 | 0.162 | 80.5 |
| 59 | 0.00 | AV1 | 30 | 14.3 | 0.277 | 44.7 | 0.161 | 79.1 |
| 60 | 0.00 | AV1 | 33 | 14.4 | 0.288 | 44.8 | 0.167 | 82.4 |
| 61 | 0.00 | AV1 | 31 | 14.1 | 0.274 | 44.6 | 0.159 | 78.4 |
| 62 | 0.00 | AV1 | 31 | 14.1 | 0.272 | 44.7 | 0.158 | 77.9 |

PLANT VOGTLE - RIG 1 - B-1008-SS-26 SPT
OP: SDW Test date: 6-Sep-2005

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 64 | 0.00 | AV1 | 31 | 14.5 | 0.270 | 44.7 | 0.158 | 77.2 |
| 65 | 0.00 | AV1 | 32 | 14.4 | 0.273 | 44.6 | 0.159 | 78.1 |
| 66 | 0.00 | AV1 | 32 | 14.6 | 0.273 | 45.0 | 0.159 | 78.0 |
| 67 | 0.00 | AV1 | 31 | 14.7 | 0.270 | 44.6 | 0.159 | 77.2 |
| 68 | 0.00 | AV1 | 31 | 14.7 | 0.279 | 44.7 | 0.164 | 79.8 |
| 69 | 0.00 | AV1 | 31 | 14.6 | 0.278 | 44.4 | 0.164 | 79.5 |

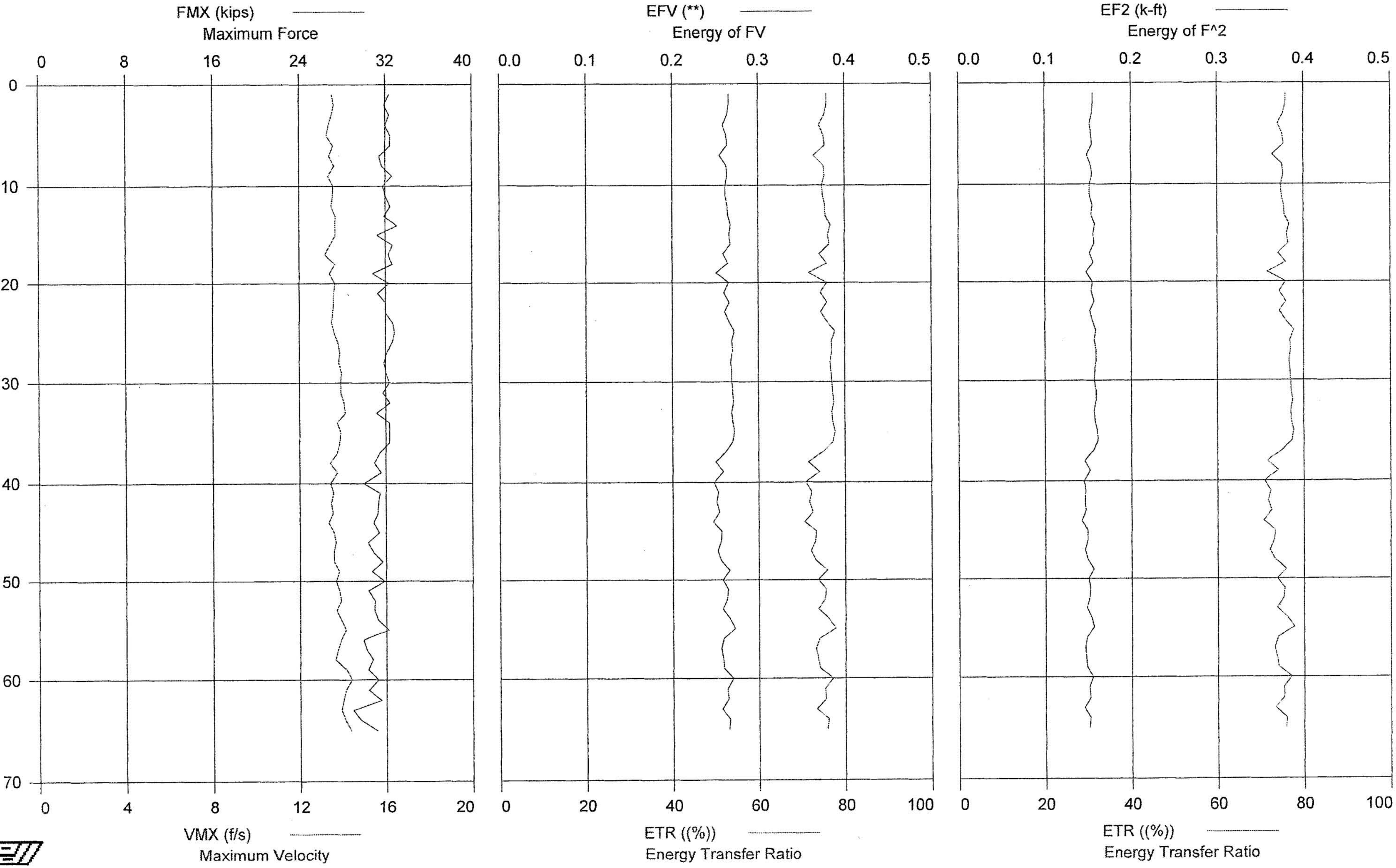
Time Summary

Drive 1 minute 30 seconds 3:22:58 PM - 3:24:28 PM (9/6/2005)

GRL Engineers, Inc. - Case Method Results

Test date: 6-Sep-2005

PLANT VOGTLE - RIG 1 - B-1008-SS-27



GRL Engineers, Inc.
Case Method Results

PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 1 - B-1008-SS-27
OP: SDW

SPT
Test date: 6-Sep-2005

AR: 2.30 in^2
LE: 109.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 32 | 13.5 | 0.266 | ** | 0.156 | 75.9 |
| 2 | 0.00 | AV1 | 32 | 13.6 | 0.266 | 47.0 | 0.156 | 75.9 |
| 3 | 0.00 | AV1 | 32 | 13.5 | 0.264 | 47.0 | 0.155 | 75.4 |
| 4 | 0.00 | AV1 | 32 | 13.4 | 0.259 | 47.0 | 0.152 | 74.1 |
| 5 | 0.00 | AV1 | 32 | 13.3 | 0.263 | 46.8 | 0.154 | 75.1 |
| 6 | 0.00 | AV1 | 32 | 13.6 | 0.264 | 46.8 | 0.155 | 75.5 |
| 7 | 0.00 | AV1 | 31 | 13.4 | 0.255 | 46.9 | 0.149 | 72.9 |
| 8 | 0.00 | AV1 | 32 | 13.6 | 0.263 | 46.6 | 0.153 | 75.1 |
| 9 | 0.00 | AV1 | 33 | 13.3 | 0.264 | 46.7 | 0.155 | 75.4 |
| 10 | 0.00 | AV1 | 32 | 13.6 | 0.262 | 46.7 | 0.152 | 74.8 |
| 11 | 0.00 | AV1 | 32 | 13.6 | 0.262 | 46.7 | 0.152 | 75.0 |
| 12 | 0.00 | AV1 | 32 | 13.5 | 0.264 | 46.3 | 0.155 | 75.4 |
| 13 | 0.00 | AV1 | 32 | 13.7 | 0.265 | 46.3 | 0.154 | 75.6 |
| 14 | 0.00 | AV1 | 33 | 13.7 | 0.268 | 46.2 | 0.158 | 76.7 |
| 15 | 0.00 | AV1 | 31 | 13.7 | 0.266 | 45.7 | 0.156 | 76.1 |
| 16 | 0.00 | AV1 | 33 | 13.4 | 0.268 | 46.4 | 0.157 | 76.5 |
| 17 | 0.00 | AV1 | 32 | 13.2 | 0.259 | 46.3 | 0.152 | 74.1 |
| 18 | 0.00 | AV1 | 33 | 13.7 | 0.265 | 45.9 | 0.156 | 75.8 |
| 19 | 0.00 | AV1 | 31 | 13.4 | 0.251 | 45.7 | 0.148 | 71.7 |
| 20 | 0.00 | AV1 | 32 | 13.7 | 0.266 | 45.9 | 0.155 | 75.9 |
| 21 | 0.00 | AV1 | 31 | 13.6 | 0.260 | 45.8 | 0.154 | 74.4 |
| 22 | 0.00 | AV1 | 32 | 13.6 | 0.266 | 46.0 | 0.157 | 75.9 |
| 23 | 0.00 | AV1 | 32 | 13.6 | 0.261 | 45.9 | 0.152 | 74.5 |
| 24 | 0.00 | AV1 | 33 | 13.5 | 0.266 | 45.6 | 0.155 | 75.9 |
| 25 | 0.00 | AV1 | 33 | 13.6 | 0.272 | 46.1 | 0.159 | 77.7 |
| 26 | 0.00 | AV1 | 33 | 13.8 | 0.269 | 45.3 | 0.157 | 76.9 |
| 27 | 0.00 | AV1 | 32 | 13.9 | 0.270 | 45.9 | 0.159 | 77.0 |
| 28 | 0.00 | AV1 | 32 | 13.8 | 0.268 | 45.0 | 0.159 | 76.6 |
| 29 | 0.00 | AV1 | 32 | 14.0 | 0.269 | 45.6 | 0.158 | 76.8 |
| 30 | 0.00 | AV1 | 32 | 13.9 | 0.269 | 45.3 | 0.157 | 77.0 |
| 31 | 0.00 | AV1 | 32 | 13.9 | 0.270 | 45.6 | 0.159 | 77.1 |
| 32 | 0.00 | AV1 | 32 | 14.1 | 0.271 | 44.9 | 0.159 | 77.5 |
| 33 | 0.00 | AV1 | 31 | 14.1 | 0.269 | 45.1 | 0.157 | 77.0 |
| 34 | 0.00 | AV1 | 32 | 13.7 | 0.270 | 45.0 | 0.158 | 77.2 |
| 35 | 0.00 | AV1 | 32 | 13.9 | 0.272 | 44.7 | 0.160 | 77.7 |
| 36 | 0.00 | AV1 | 32 | 13.9 | 0.270 | 45.3 | 0.161 | 77.2 |
| 37 | 0.00 | AV1 | 31 | 13.8 | 0.262 | 45.3 | 0.156 | 75.0 |
| 38 | 0.00 | AV1 | 31 | 13.4 | 0.250 | 44.8 | 0.146 | 71.5 |
| 39 | 0.00 | AV1 | 32 | 13.7 | 0.259 | 45.6 | 0.152 | 74.0 |
| 40 | 0.00 | AV1 | 30 | 13.4 | 0.248 | 45.1 | 0.145 | 70.9 |
| 41 | 0.00 | AV1 | 31 | 13.6 | 0.253 | 45.2 | 0.147 | 72.3 |
| 42 | 0.00 | AV1 | 31 | 13.5 | 0.251 | 45.0 | 0.146 | 71.7 |
| 43 | 0.00 | AV1 | 31 | 13.5 | 0.254 | 45.1 | 0.147 | 72.5 |
| 44 | 0.00 | AV1 | 31 | 13.3 | 0.247 | 45.1 | 0.142 | 70.6 |
| 45 | 0.00 | AV1 | 31 | 13.6 | 0.257 | 45.4 | 0.149 | 73.3 |
| 46 | 0.00 | AV1 | 30 | 13.7 | 0.256 | 45.2 | 0.149 | 73.1 |
| 47 | 0.00 | AV1 | 31 | 13.6 | 0.252 | 45.2 | 0.146 | 72.1 |
| 48 | 0.00 | AV1 | 32 | 13.6 | 0.256 | 45.7 | 0.149 | 73.2 |
| 49 | 0.00 | AV1 | 31 | 13.8 | 0.266 | 45.0 | 0.156 | 75.9 |
| 50 | 0.00 | AV1 | 32 | 13.7 | 0.258 | 44.9 | 0.150 | 73.7 |
| 51 | 0.00 | AV1 | 30 | 13.8 | 0.264 | 44.7 | 0.152 | 75.5 |
| 52 | 0.00 | AV1 | 31 | 13.9 | 0.263 | 45.1 | 0.151 | 75.2 |
| 53 | 0.00 | AV1 | 31 | 13.7 | 0.258 | 44.6 | 0.148 | 73.8 |
| 54 | 0.00 | AV1 | 31 | 13.9 | 0.266 | 45.6 | 0.153 | 76.1 |
| 55 | 0.00 | AV1 | 32 | 14.1 | 0.272 | 45.0 | 0.156 | 77.7 |
| 56 | 0.00 | AV1 | 30 | 13.9 | 0.259 | 45.1 | 0.148 | 74.0 |
| 57 | 0.00 | AV1 | 30 | 13.8 | 0.256 | 45.4 | 0.146 | 73.1 |
| 58 | 0.00 | AV1 | 31 | 13.6 | 0.258 | 45.5 | 0.147 | 73.6 |
| 59 | 0.00 | AV1 | 30 | 14.1 | 0.259 | 45.2 | 0.148 | 74.1 |
| 60 | 0.00 | AV1 | 31 | 14.4 | 0.270 | 44.7 | 0.155 | 77.1 |
| 61 | 0.00 | AV1 | 30 | 14.1 | 0.263 | 46.0 | 0.151 | 75.3 |
| 62 | 0.00 | AV1 | 32 | 14.0 | 0.264 | 45.6 | 0.152 | 75.4 |
| [illegible] | [illegible] | AV1 | [illegible] | [illegible] | 0.257 | 45.2 | 0.145 | 73.3 |

PLANT VOGTLE - RIG 1 - B-1008-SS-27 SPT
OP: SDW Test date: 6-Sep-2005

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 64 | 0.00 | AV1 | 30 | 14.1 | 0.266 | 45.8 | 0.152 | 76.0 |
| 65 | 0.00 | AV1 | 31 | 14.4 | 0.265 | 44.5 | 0.151 | 75.8 |

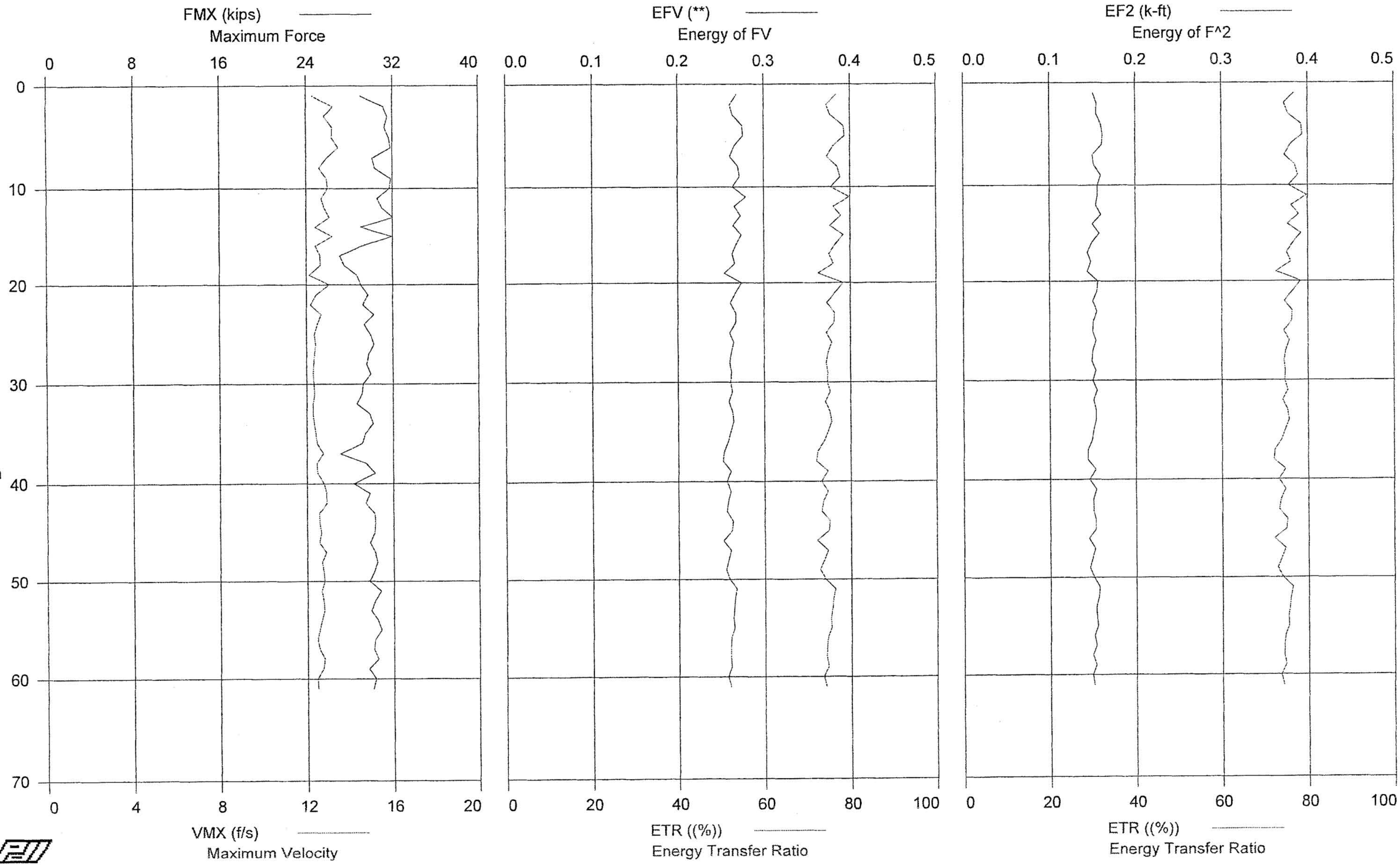
Time Summary

Drive 1 minute 24 seconds 3:45:17 PM - 3:46:41 PM (9/6/2005)

GRL Engineers, Inc. - Case Method Results

Test date: 6-Sep-2005

PLANT VOGTLE - RIG 1 - B-1008-SS-28



PLANT VOGTLE - RIG 1 - B-1008-SS-28 SPT
OP: SDW Test date: 6-Sep-2005

AR: 2.30 in^2 SP: 0.492 k/ft3
LE: 114.00 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.70

FMX: Maximum Force BPM: Blows per Minute
VMX: Maximum Velocity EF2: Energy of F^2
EFV: Energy of FV ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 29 | 12.3 | 0.269 | ** | 0.151 | 76.8 |
| 2 | 0.00 | AV1 | 31 | 13.2 | 0.261 | 47.3 | 0.155 | 74.5 |
| 3 | 0.00 | AV1 | 32 | 12.8 | 0.264 | 47.3 | 0.155 | 75.5 |
| 4 | 0.00 | AV1 | 31 | 13.2 | 0.275 | 23.5 | 0.160 | 78.5 |
| 5 | 0.00 | AV1 | 32 | 13.2 | 0.276 | 46.2 | 0.162 | 78.8 |
| 6 | 0.00 | AV1 | 32 | 13.5 | 0.266 | 47.3 | 0.161 | 76.0 |
| 7 | 0.00 | AV1 | 30 | 12.9 | 0.261 | 23.4 | 0.150 | 74.6 |
| 8 | 0.00 | AV1 | 30 | 12.6 | 0.270 | 47.1 | 0.152 | 77.1 |
| 9 | 0.00 | AV1 | 32 | 12.9 | 0.272 | 23.3 | 0.160 | 77.7 |
| 10 | 0.00 | AV1 | 32 | 13.0 | 0.264 | 46.4 | 0.156 | 75.6 |
| 11 | 0.00 | AV1 | 31 | 12.7 | 0.279 | ** | 0.156 | 79.8 |
| 12 | 0.00 | AV1 | 31 | 12.8 | 0.266 | 46.2 | 0.154 | 76.1 |
| 13 | 0.00 | AV1 | 32 | 13.1 | 0.273 | ** | 0.160 | 77.9 |
| 14 | 0.00 | AV1 | 29 | 12.4 | 0.264 | 45.8 | 0.150 | 75.3 |
| 15 | 0.00 | AV1 | 32 | 13.2 | 0.274 | ** | 0.158 | 78.4 |
| 16 | 0.00 | AV1 | 29 | 12.4 | 0.268 | 45.6 | 0.149 | 76.5 |
| 17 | 0.00 | AV1 | 27 | 12.6 | 0.263 | 45.4 | 0.144 | 75.1 |
| 18 | 0.00 | AV1 | 27 | 12.6 | 0.266 | ** | 0.148 | 76.0 |
| 19 | 0.00 | AV1 | 29 | 12.1 | 0.254 | 22.7 | 0.144 | 72.6 |
| 20 | 0.00 | AV1 | 29 | 13.1 | 0.274 | 45.1 | 0.156 | 78.3 |
| 21 | 0.00 | AV1 | 30 | 12.4 | 0.267 | 45.2 | 0.155 | 76.4 |
| 22 | 0.00 | AV1 | 29 | 12.2 | 0.261 | ** | 0.150 | 74.5 |
| 23 | 0.00 | AV1 | 30 | 12.7 | 0.267 | 22.6 | 0.155 | 76.3 |
| 24 | 0.00 | AV1 | 29 | 12.5 | 0.267 | 45.0 | 0.151 | 76.2 |
| 25 | 0.00 | AV1 | 30 | 12.4 | 0.260 | 22.6 | 0.150 | 74.4 |
| 26 | 0.00 | AV1 | 30 | 12.4 | 0.265 | 44.8 | 0.154 | 75.6 |
| 27 | 0.00 | AV1 | 30 | 12.4 | 0.262 | 45.1 | 0.150 | 74.8 |
| 28 | 0.00 | AV1 | 30 | 12.3 | 0.260 | 22.7 | 0.149 | 74.4 |
| 29 | 0.00 | AV1 | 30 | 12.3 | 0.262 | 22.7 | 0.154 | 74.7 |
| 30 | 0.00 | AV1 | 29 | 12.3 | 0.261 | 45.4 | 0.150 | 74.5 |
| 31 | 0.00 | AV1 | 29 | 12.4 | 0.263 | 22.6 | 0.155 | 75.3 |
| 32 | 0.00 | AV1 | 29 | 12.3 | 0.259 | 45.2 | 0.151 | 74.1 |
| 33 | 0.00 | AV1 | 30 | 12.3 | 0.263 | 45.7 | 0.154 | 75.2 |
| 34 | 0.00 | AV1 | 30 | 12.3 | 0.264 | 45.6 | 0.154 | 75.6 |
| 35 | 0.00 | AV1 | 29 | 12.4 | 0.261 | 22.7 | 0.151 | 74.7 |
| 36 | 0.00 | AV1 | 29 | 12.5 | 0.258 | 22.8 | 0.149 | 73.8 |
| 37 | 0.00 | AV1 | 27 | 12.7 | 0.253 | ** | 0.144 | 72.3 |
| 38 | 0.00 | AV1 | 29 | 12.5 | 0.252 | 45.6 | 0.144 | 72.0 |
| 39 | 0.00 | AV1 | 30 | 12.5 | 0.261 | 45.6 | 0.153 | 74.7 |
| 40 | 0.00 | AV1 | 28 | 12.8 | 0.256 | 45.1 | 0.146 | 73.2 |
| 41 | 0.00 | AV1 | 30 | 12.9 | 0.261 | 45.8 | 0.154 | 74.7 |
| 42 | 0.00 | AV1 | 29 | 12.9 | 0.258 | 45.7 | 0.150 | 73.6 |
| 43 | 0.00 | AV1 | 30 | 12.6 | 0.256 | 45.5 | 0.150 | 73.1 |
| 44 | 0.00 | AV1 | 30 | 12.6 | 0.263 | 46.1 | 0.153 | 75.1 |
| 45 | 0.00 | AV1 | 30 | 12.6 | 0.262 | 45.6 | 0.153 | 74.9 |
| 46 | 0.00 | AV1 | 30 | 12.5 | 0.252 | 45.6 | 0.145 | 72.1 |
| 47 | 0.00 | AV1 | 30 | 12.9 | 0.261 | 45.4 | 0.152 | 74.6 |
| 48 | 0.00 | AV1 | 30 | 12.7 | 0.258 | 45.6 | 0.149 | 73.8 |
| 49 | 0.00 | AV1 | 30 | 12.7 | 0.255 | 45.7 | 0.146 | 72.8 |
| 50 | 0.00 | AV1 | 30 | 12.8 | 0.259 | 46.0 | 0.151 | 74.0 |
| 51 | 0.00 | AV1 | 31 | 12.6 | 0.267 | 46.0 | 0.157 | 76.2 |
| 52 | 0.00 | AV1 | 30 | 12.7 | 0.265 | 45.3 | 0.156 | 75.8 |
| 53 | 0.00 | AV1 | 30 | 12.8 | 0.264 | 46.0 | 0.153 | 75.6 |
| 54 | 0.00 | AV1 | 31 | 12.6 | 0.263 | 45.3 | 0.154 | 75.3 |
| 55 | 0.00 | AV1 | 31 | 12.5 | 0.264 | 46.0 | 0.155 | 75.3 |
| 56 | 0.00 | AV1 | 30 | 12.4 | 0.261 | 45.8 | 0.151 | 74.5 |
| 57 | 0.00 | AV1 | 30 | 12.6 | 0.260 | 45.8 | 0.153 | 74.3 |
| 58 | 0.00 | AV1 | 31 | 12.8 | 0.260 | 45.9 | 0.149 | 74.2 |
| 59 | 0.00 | AV1 | 30 | 12.7 | 0.261 | 45.9 | 0.153 | 74.6 |
| 60 | 0.00 | AV1 | 30 | 12.4 | 0.257 | 45.9 | 0.149 | 73.6 |
| 61 | 0.00 | AV1 | 30 | 12.5 | 0.260 | 45.9 | 0.151 | 74.2 |

PLANT VOGTLE - RIG 1 - B-1008-SS-28 SPT
OP: SDW Test date: 6-Sep-2005

| | FMX | VMX | EFV | BPM | EF2 | ETR |
|---|---|---|---|---|---|---|
| | kips | f/s | ** | ** | k-ft | (%) |
| Average | 30 | 12.6 | 0.263 | 41.1 | 0.152 | 75.2 |

Total number of blows analyzed: 61

Time Summary

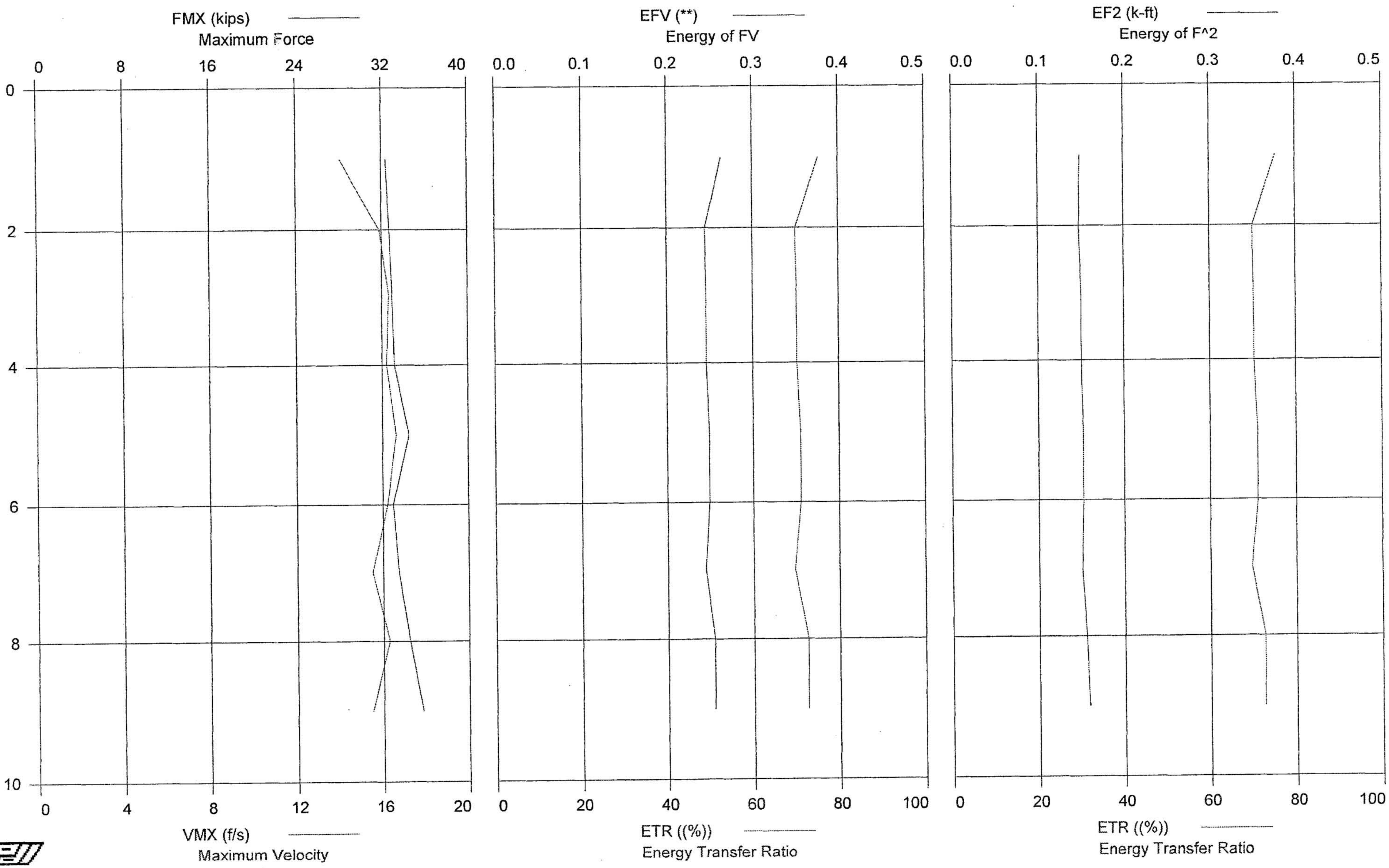
Drive 1 minute 58 seconds 4:09:03 PM - 4:11:01 PM (9/6/2005)

GRL Engineers, Inc. - Case Method Results

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

Test date: 6-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-7



GRL Engineers, Inc.
Case Method Results


PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-7
OP: SDW

SPT
Test date: 6-Sep-2005

AR: 2.30 in^2
LE: 14.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 32 | 14.1 | 0.264 | ** | 0.149 | 75.4 |
| 2 | 0.00 | AV1 | 33 | 15.9 | 0.245 | 53.0 | 0.148 | 70.0 |
| 3 | 0.00 | AV1 | 33 | 16.3 | 0.246 | 52.4 | 0.150 | 70.2 |
| 4 | 0.00 | AV1 | 33 | 16.2 | 0.246 | 52.3 | 0.150 | 70.3 |
| 5 | 0.00 | AV1 | 34 | 16.6 | 0.249 | 52.3 | 0.152 | 71.1 |
| 6 | 0.00 | AV1 | 33 | 16.2 | 0.249 | 52.2 | 0.152 | 71.0 |
| 7 | 0.00 | AV1 | 33 | 15.5 | 0.244 | 52.5 | 0.150 | 69.6 |
| 8 | 0.00 | AV1 | 34 | 16.3 | 0.254 | 52.3 | 0.155 | 72.6 |
| 9 | 0.00 | AV1 | 36 | 15.5 | 0.254 | 52.1 | 0.158 | 72.6 |

Time Summary

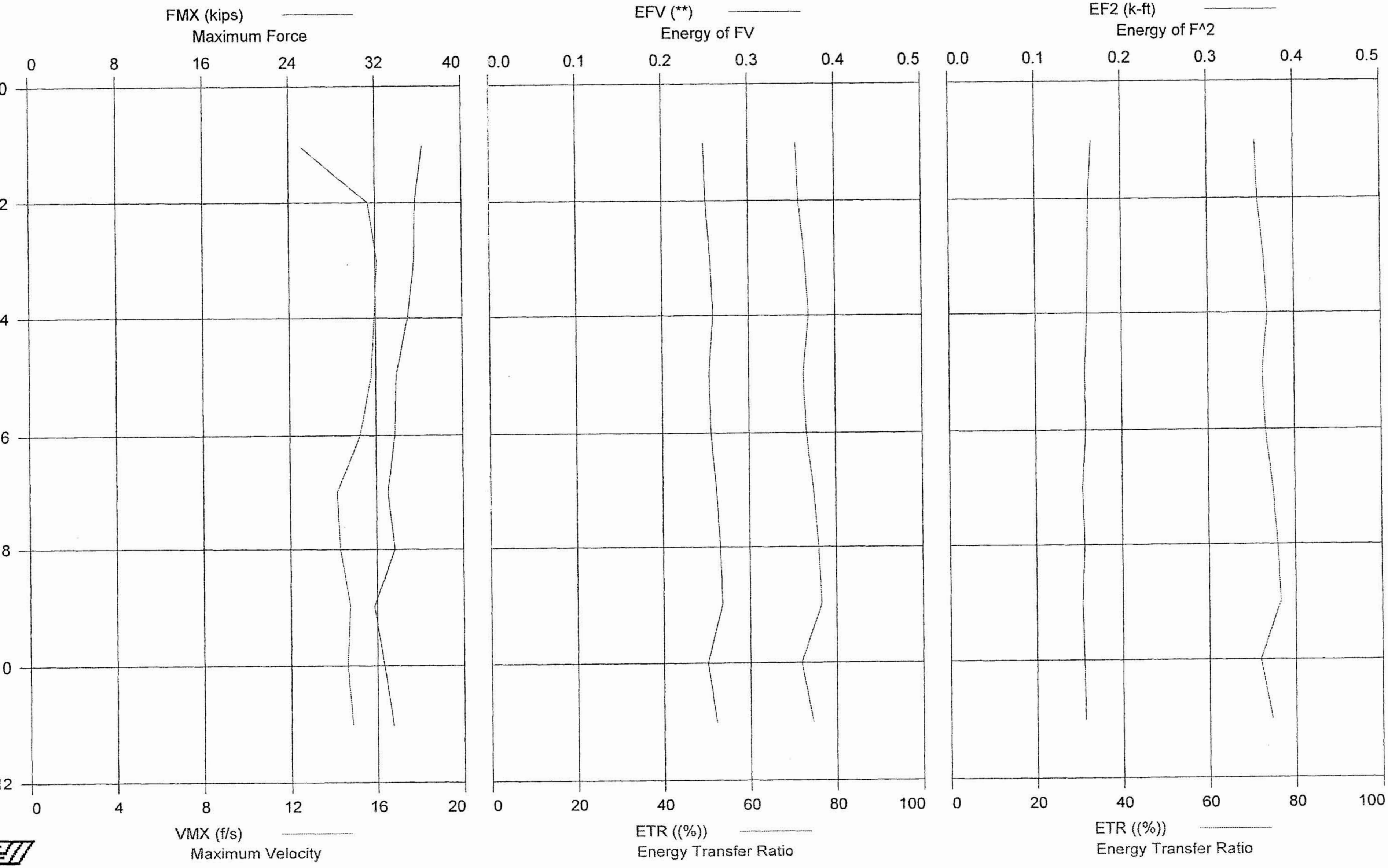
Drive 9 seconds 2:35:08 PM - 2:35:17 PM (9/6/2005)

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

GRL Engineers, Inc. - Case Method Results

PLANT VOGTLE - RIG 2 - B-1006-SS-8

Test date: 6-Sep-2005



GRL Engineers, Inc.
Case Method Results


PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-8
OP: SDW

SPT
Test date: 6-Sep-2005

AR: 2.30 in^2
LE: 14.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 36 | 12.5 | 0.249 | ** | 0.166 | 71.1 |
| 2 | 0.00 | AV1 | 36 | 15.7 | 0.251 | 51.8 | 0.162 | 71.7 |
| 3 | 0.00 | AV1 | 36 | 16.1 | 0.256 | 51.6 | 0.161 | 73.1 |
| 4 | 0.00 | AV1 | 35 | 15.9 | 0.259 | 51.3 | 0.160 | 73.9 |
| 5 | 0.00 | AV1 | 34 | 15.8 | 0.254 | 51.5 | 0.157 | 72.6 |
| 6 | 0.00 | AV1 | 34 | 15.3 | 0.256 | 51.3 | 0.158 | 73.3 |
| 7 | 0.00 | AV1 | 33 | 14.2 | 0.262 | 51.5 | 0.154 | 74.9 |
| 8 | 0.00 | AV1 | 34 | 14.3 | 0.266 | 51.3 | 0.156 | 76.0 |
| 9 | 0.00 | AV1 | 32 | 14.8 | 0.268 | 51.5 | 0.153 | 76.5 |
| 10 | 0.00 | AV1 | 33 | 14.6 | 0.251 | 51.5 | 0.155 | 71.8 |
| 11 | 0.00 | AV1 | 33 | 14.9 | 0.261 | 51.4 | 0.156 | 74.5 |

Time Summary

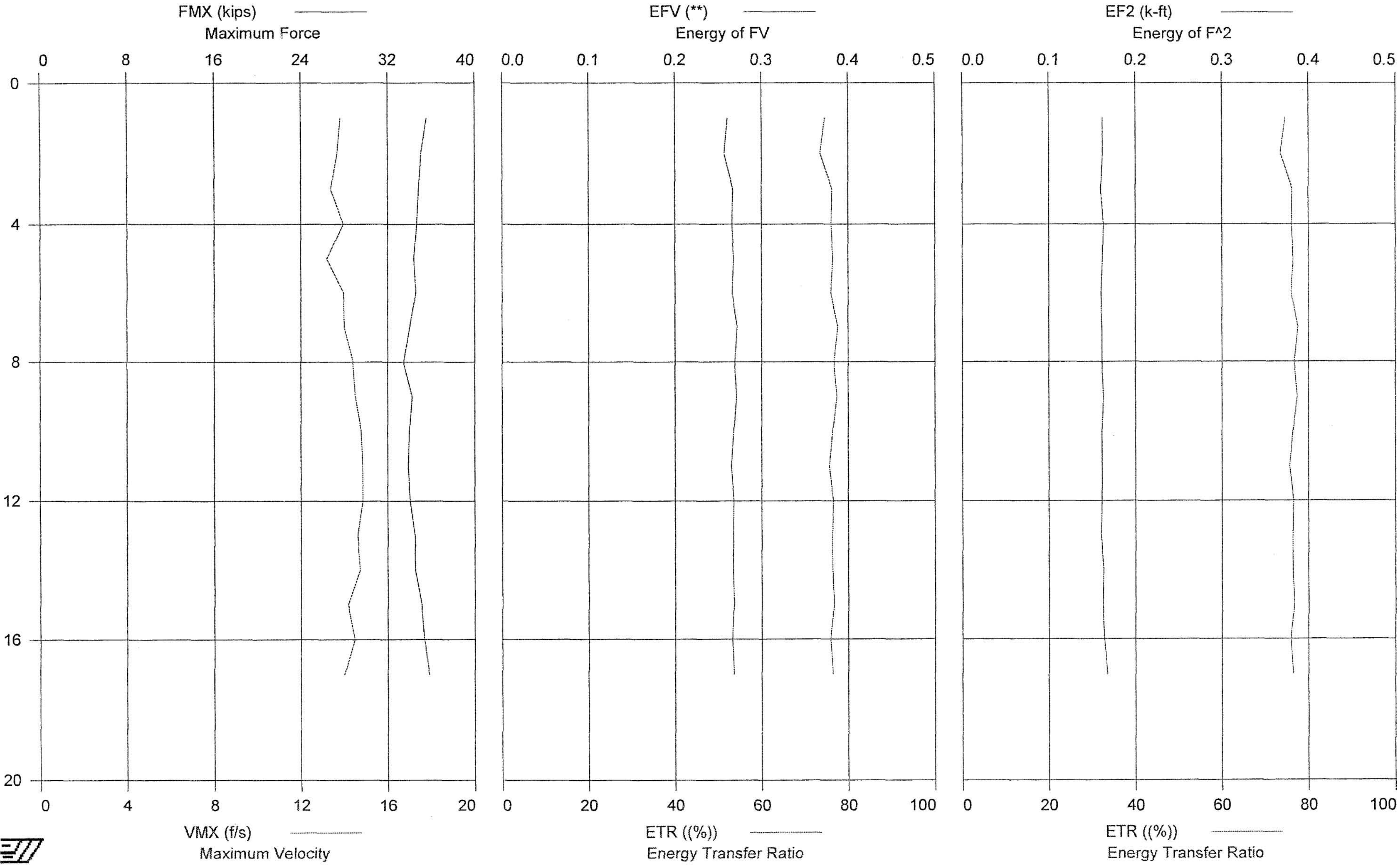
Drive 11 seconds 2:45:19 PM - 2:45:30 PM (9/6/2005)

GRL Engineers, Inc. - Case Method Results

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

Test date: 6-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-10



PLANT VOGTLE - RIG 2 - B-1006-SS-10 SPT
OP: SDW Test date: 6-Sep-2005

AR: 2.30 in^2
LE: 19.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 36 | 13.8 | 0.261 | ** | 0.162 | 74.7 |
| 2 | 0.00 | AV1 | 35 | 13.7 | 0.257 | 51.5 | 0.162 | 73.5 |
| 3 | 0.00 | AV1 | 35 | 13.4 | 0.267 | 51.2 | 0.160 | 76.3 |
| 4 | 0.00 | AV1 | 35 | 14.0 | 0.266 | 51.3 | 0.163 | 76.1 |
| 5 | 0.00 | AV1 | 34 | 13.2 | 0.268 | 51.4 | 0.162 | 76.5 |
| 6 | 0.00 | AV1 | 35 | 14.0 | 0.266 | 51.3 | 0.160 | 76.0 |
| 7 | 0.00 | AV1 | 34 | 14.0 | 0.272 | 51.2 | 0.161 | 77.6 |
| 8 | 0.00 | AV1 | 33 | 14.4 | 0.269 | 51.4 | 0.161 | 76.7 |
| 9 | 0.00 | AV1 | 34 | 14.5 | 0.271 | 51.2 | 0.163 | 77.4 |
| 10 | 0.00 | AV1 | 34 | 14.8 | 0.268 | 51.4 | 0.161 | 76.5 |
| 11 | 0.00 | AV1 | 34 | 14.8 | 0.265 | 51.3 | 0.161 | 75.6 |
| 12 | 0.00 | AV1 | 34 | 14.9 | 0.268 | 51.3 | 0.161 | 76.5 |
| 13 | 0.00 | AV1 | 34 | 14.6 | 0.267 | 51.4 | 0.160 | 76.4 |
| 14 | 0.00 | AV1 | 35 | 14.7 | 0.267 | 51.2 | 0.163 | 76.4 |
| 15 | 0.00 | AV1 | 35 | 14.2 | 0.268 | 51.4 | 0.162 | 76.7 |
| 16 | 0.00 | AV1 | 35 | 14.5 | 0.266 | 51.2 | 0.164 | 75.9 |
| 17 | 0.00 | AV1 | 36 | 14.0 | 0.268 | 51.5 | 0.167 | 76.4 |

Time Summary

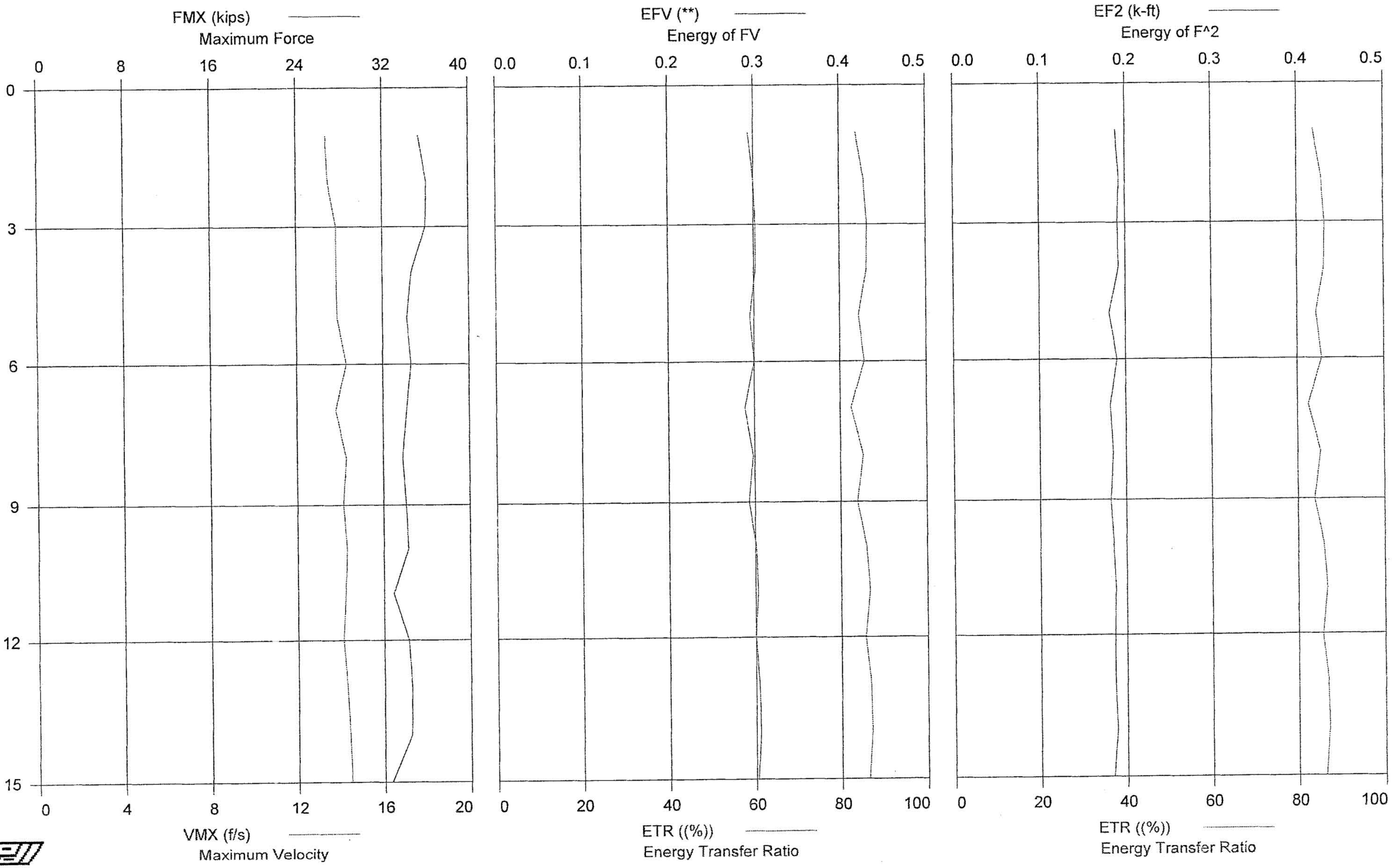
Drive 19 seconds 2:55:19 PM - 2:55:38 PM (9/6/2005)

GRL Engineers, Inc. - Case Method Results

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

Test date: 6-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-15



GRL Engineers, Inc.
Case Method Results


PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-15
OP: SDW

SPT
Test date: 6-Sep-2005

AR: 2.30 in^2
LE: 44.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

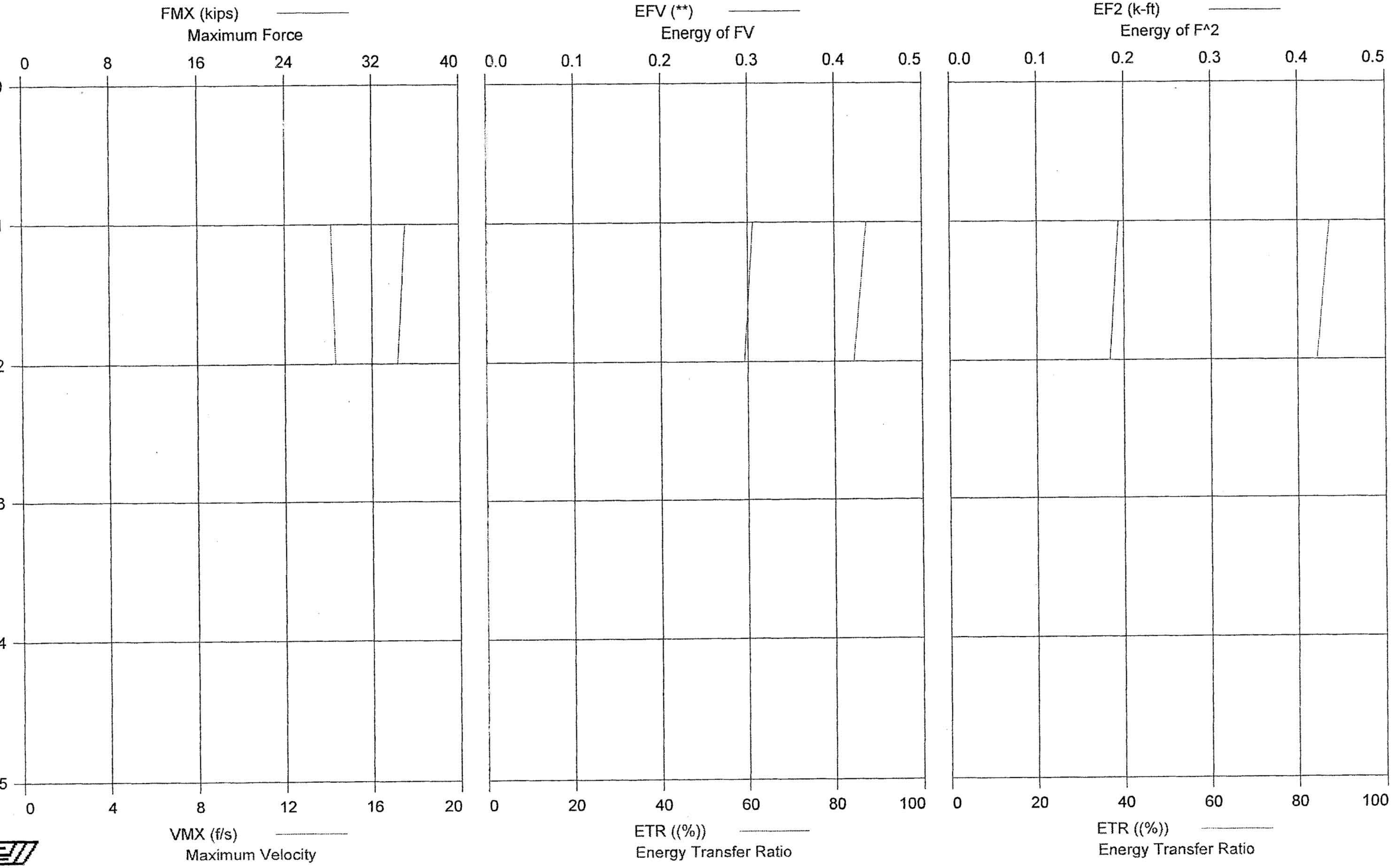
BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 35 | 13.4 | 0.294 | ** | 0.189 | 83.9 |
| 2 | 0.00 | AV1 | 36 | 13.5 | 0.300 | 52.7 | 0.193 | 85.7 |
| 3 | 0.00 | AV1 | 36 | 13.9 | 0.302 | 51.8 | 0.191 | 86.4 |
| 4 | 0.00 | AV1 | 35 | 13.9 | 0.302 | 51.8 | 0.192 | 86.2 |
| 5 | 0.00 | AV1 | 34 | 13.9 | 0.295 | 51.6 | 0.181 | 84.4 |
| 6 | 0.00 | AV1 | 35 | 14.3 | 0.300 | 52.0 | 0.190 | 85.6 |
| 7 | 0.00 | AV1 | 34 | 13.8 | 0.289 | 51.7 | 0.182 | 82.5 |
| 8 | 0.00 | AV1 | 34 | 14.3 | 0.298 | 51.7 | 0.185 | 85.3 |
| 9 | 0.00 | AV1 | 34 | 14.1 | 0.293 | 51.9 | 0.182 | 83.8 |
| 10 | 0.00 | AV1 | 34 | 14.3 | 0.301 | 51.8 | 0.185 | 85.9 |
| 11 | 0.00 | AV1 | 33 | 14.2 | 0.303 | 51.7 | 0.187 | 86.7 |
| 12 | 0.00 | AV1 | 34 | 14.1 | 0.300 | 51.8 | 0.186 | 85.6 |
| 13 | 0.00 | AV1 | 35 | 14.3 | 0.304 | 51.8 | 0.186 | 86.8 |
| 14 | 0.00 | AV1 | 34 | 14.4 | 0.305 | 51.8 | 0.188 | 87.0 |
| 15 | 0.00 | AV1 | 33 | 14.5 | 0.302 | 51.8 | 0.184 | 86.3 |

Time Summary

Drive 17 seconds 4:32:23 PM - 4:32:40 PM (9/6/2005)

PLANT VOGTLE - RIG 2 - B-1006-SS-16



GRL Engineers, Inc.
Case Method Results

PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-16 SPT
OP: SDW Test date: 6-Sep-2005

AR: 2.30 in^2 SP: 0.492 k/ft3
LE: 49.00 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV
BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 35 | 14.1 | 0.306 | ** | 0.194 | 87.3 |
| 2 | 0.00 | AV1 | 34 | 14.3 | 0.296 | 54.3 | 0.184 | 84.4 |

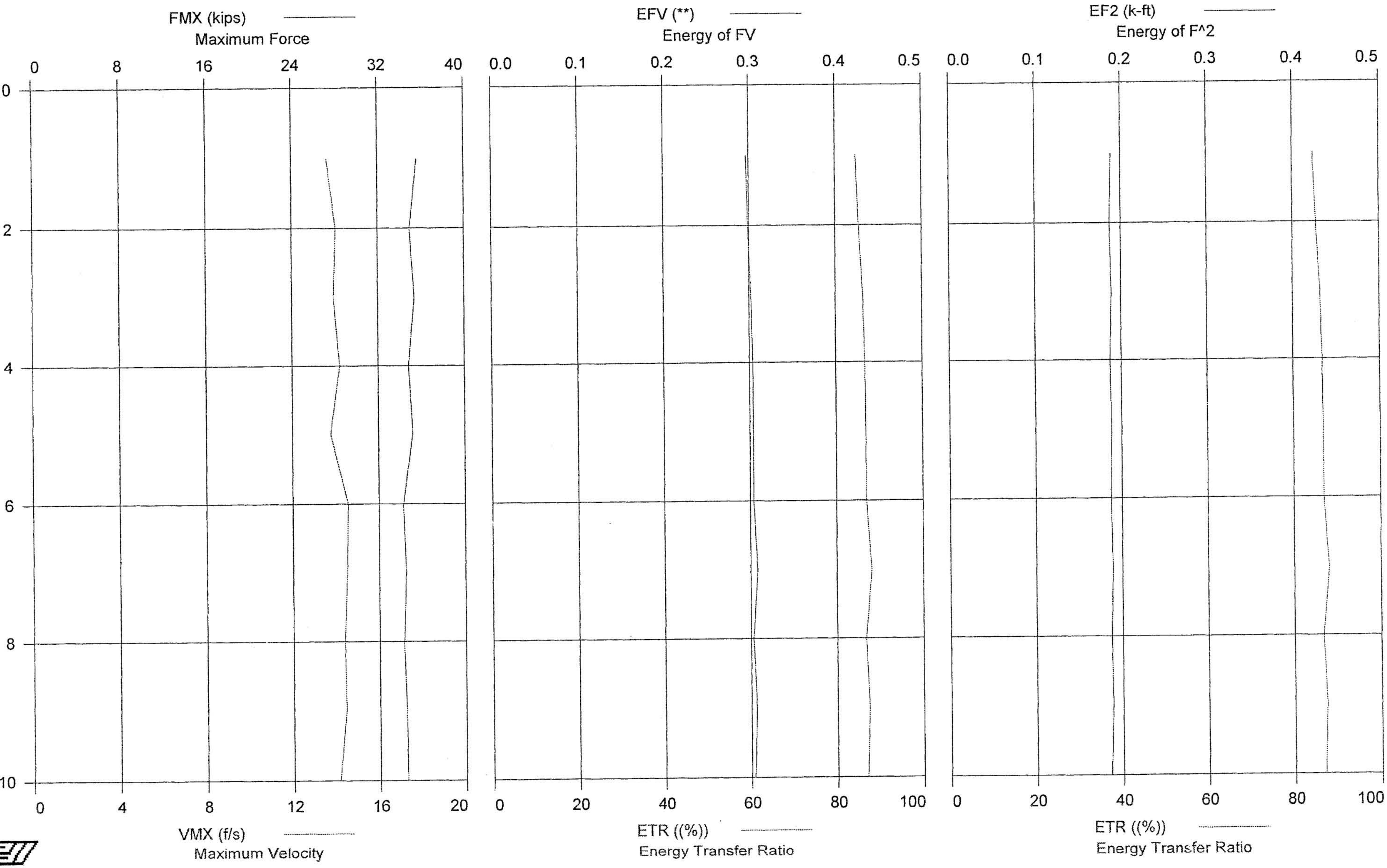
Time Summary
Drive 1 second 4:44:31 PM - 4:44:32 PM (9/6/2005)

GRL Engineers, Inc. - Case Method Results

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

Test date: 6-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-17



PLANT VOGTLE - RIG 2 - B-1006-SS-17 SPT
OP: SDW Test date: 6-Sep-2005

AR: 2.30 in^2 SP: 0.492 k/ft3
LE: 54.00 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.70

FMX: Maximum Force BPM: Blows per Minute
VMX: Maximum Velocity EF2: Energy of F^2
EFV: Energy of FV ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 36 | 13.6 | 0.297 | ** | 0.189 | 84.8 |
| 2 | 0.00 | AV1 | 35 | 14.1 | 0.299 | 50.8 | 0.187 | 85.4 |
| 3 | 0.00 | AV1 | 35 | 13.9 | 0.302 | 50.6 | 0.189 | 86.3 |
| 4 | 0.00 | AV1 | 35 | 14.2 | 0.304 | 50.4 | 0.187 | 86.8 |
| 5 | 0.00 | AV1 | 35 | 13.8 | 0.304 | 50.5 | 0.188 | 86.8 |
| 6 | 0.00 | AV1 | 34 | 14.6 | 0.304 | 50.3 | 0.187 | 86.9 |
| 7 | 0.00 | AV1 | 34 | 14.5 | 0.308 | 51.7 | 0.189 | 88.0 |
| 8 | 0.00 | AV1 | 34 | 14.4 | 0.303 | 51.8 | 0.187 | 86.6 |
| 9 | 0.00 | AV1 | 34 | 14.4 | 0.306 | 51.8 | 0.188 | 87.4 |
| 10 | 0.00 | AV1 | 35 | 14.1 | 0.304 | 52.0 | 0.186 | 86.9 |

Time Summary

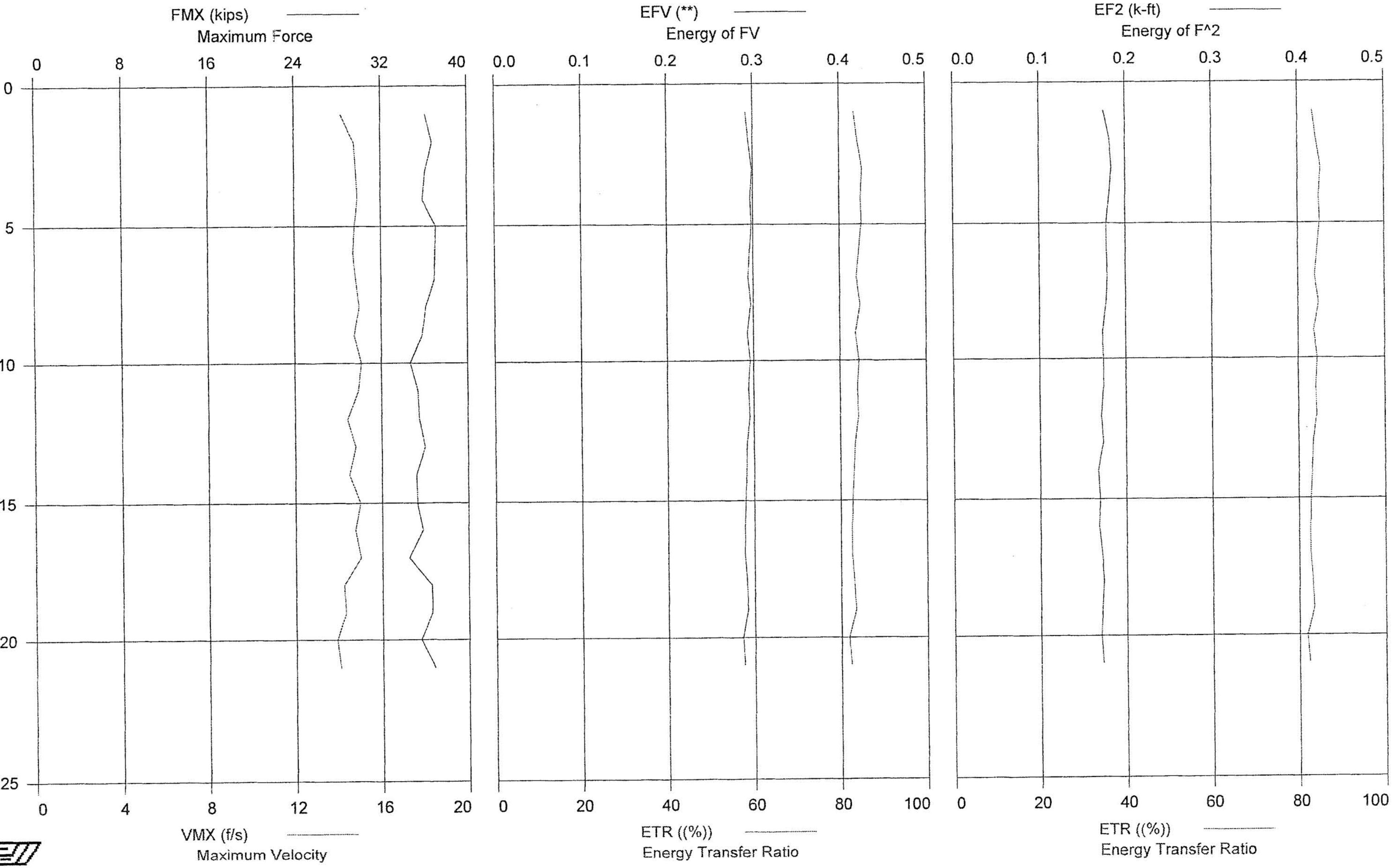
Drive 11 seconds 4:58:48 PM - 4:58:59 PM (9/6/2005)

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

GRL Engineers, Inc. - Case Method Results

Test date: 7-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-26



GRL Engineers, Inc.
Case Method Results

Page 1 of 1
PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-26
OP: SDW

SPT
Test date: 7-Sep-2005

AR: 2.30 in^2
LE: 99.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 36 | 14.2 | 0.292 | ** | 0.175 | 83.5 |
| 2 | 0.00 | AV1 | 37 | 14.8 | 0.295 | 51.3 | 0.182 | 84.3 |
| 3 | 0.00 | AV1 | 36 | 14.9 | 0.299 | 51.2 | 0.184 | 85.3 |
| 4 | 0.00 | AV1 | 36 | 14.9 | 0.297 | 51.2 | 0.181 | 84.9 |
| 5 | 0.00 | AV1 | 37 | 14.8 | 0.298 | 51.3 | 0.178 | 85.1 |
| 6 | 0.00 | AV1 | 37 | 14.7 | 0.296 | 51.5 | 0.178 | 84.5 |
| 7 | 0.00 | AV1 | 37 | 14.8 | 0.294 | 51.1 | 0.179 | 83.9 |
| 8 | 0.00 | AV1 | 36 | 15.0 | 0.297 | 51.4 | 0.177 | 84.7 |
| 9 | 0.00 | AV1 | 36 | 14.8 | 0.293 | 51.3 | 0.173 | 83.6 |
| 10 | 0.00 | AV1 | 35 | 15.1 | 0.296 | 51.2 | 0.174 | 84.4 |
| 11 | 0.00 | AV1 | 35 | 14.9 | 0.294 | 51.5 | 0.174 | 84.0 |
| 12 | 0.00 | AV1 | 35 | 14.4 | 0.295 | 51.4 | 0.171 | 84.2 |
| 13 | 0.00 | AV1 | 36 | 14.8 | 0.292 | 51.3 | 0.173 | 83.3 |
| 14 | 0.00 | AV1 | 35 | 14.5 | 0.291 | 51.3 | 0.167 | 83.1 |
| 15 | 0.00 | AV1 | 35 | 15.0 | 0.290 | 51.4 | 0.169 | 82.7 |
| 16 | 0.00 | AV1 | 36 | 14.7 | 0.289 | 51.4 | 0.168 | 82.6 |
| 17 | 0.00 | AV1 | 34 | 15.0 | 0.289 | 51.2 | 0.171 | 82.6 |
| 18 | 0.00 | AV1 | 37 | 14.2 | 0.291 | 51.4 | 0.173 | 83.1 |
| 19 | 0.00 | AV1 | 37 | 14.3 | 0.292 | 51.2 | 0.171 | 83.4 |
| 20 | 0.00 | AV1 | 36 | 13.9 | 0.286 | 51.4 | 0.170 | 81.8 |
| 21 | 0.00 | AV1 | 37 | 14.0 | 0.288 | 51.2 | 0.172 | 82.3 |

Time Summary

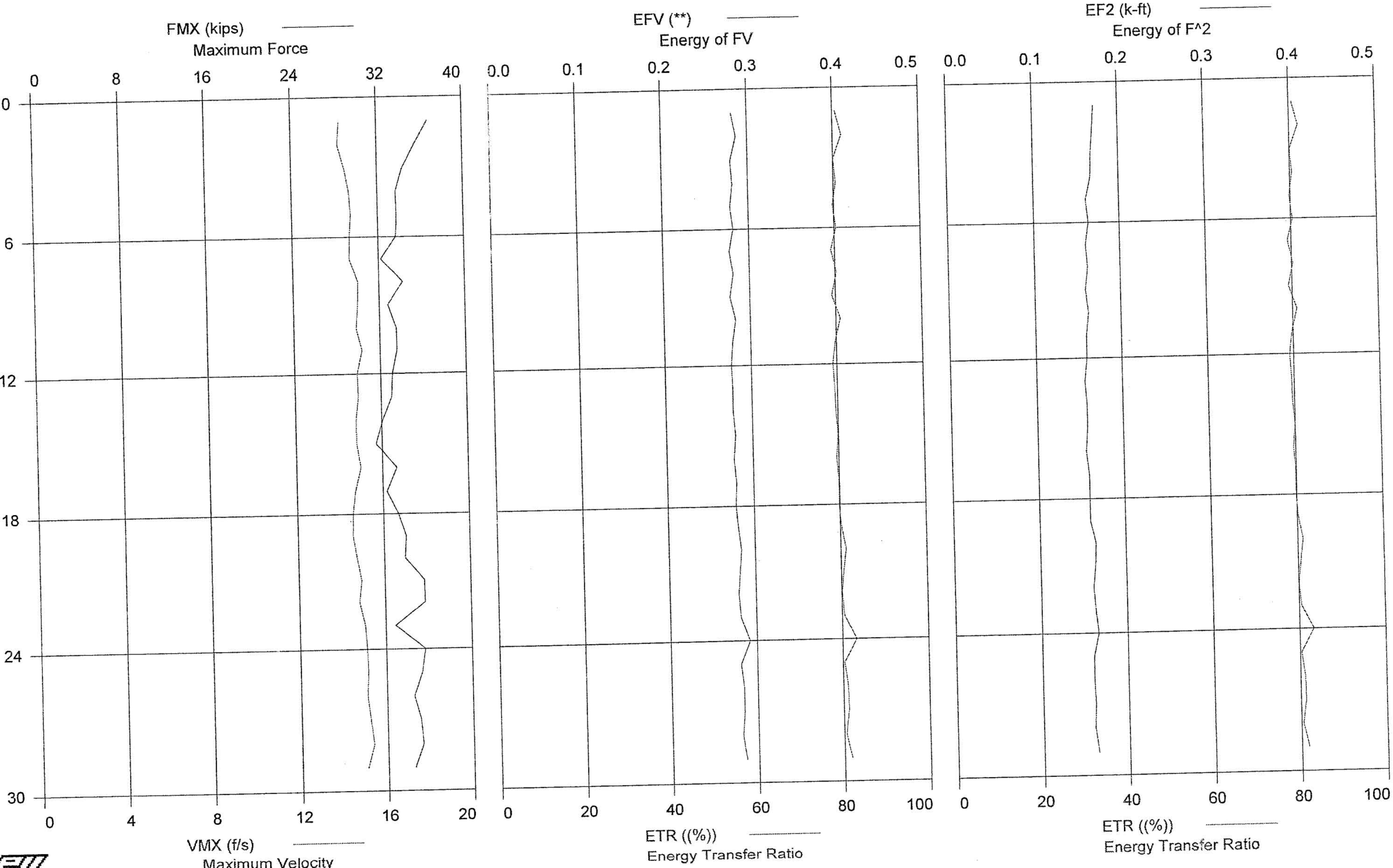
Drive 24 seconds 2:35:27 PM - 2:35:51 PM (9/7/2005)

PLOT Ver. 2005.1 - Printed: 8-Sep-2005

GRL Engineers, Inc. - Case Method Results

PLANT VOGTLE - RIG 2 - B-1006-SS-27

Test date: 7-Sep-2005



GRL Engineers, Inc.
Case Method Results

Page 1 of 1
PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-27
OP: SDW

SPT
Test date: 7-Sep-2005

AR: 2.30 in^2
LE: 104.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 37 | 14.3 | 0.282 | ** | 0.172 | 80.6 |
| 2 | 0.00 | AV1 | 36 | 14.2 | 0.287 | 51.6 | 0.170 | 82.0 |
| 3 | 0.00 | AV1 | 34 | 14.5 | 0.280 | 51.8 | 0.168 | 80.0 |
| 4 | 0.00 | AV1 | 34 | 14.7 | 0.282 | 51.7 | 0.167 | 80.6 |
| 5 | 0.00 | AV1 | 34 | 14.7 | 0.279 | 52.0 | 0.161 | 79.7 |
| 6 | 0.00 | AV1 | 34 | 14.7 | 0.282 | 51.9 | 0.164 | 80.4 |
| 7 | 0.00 | AV1 | 32 | 14.6 | 0.277 | 52.3 | 0.160 | 79.1 |
| 8 | 0.00 | AV1 | 34 | 15.0 | 0.281 | 52.0 | 0.162 | 80.3 |
| 9 | 0.00 | AV1 | 33 | 15.0 | 0.277 | 52.0 | 0.159 | 79.1 |
| 10 | 0.00 | AV1 | 34 | 14.9 | 0.283 | 52.1 | 0.162 | 81.0 |
| 11 | 0.00 | AV1 | 34 | 15.1 | 0.279 | 52.1 | 0.159 | 79.7 |
| 12 | 0.00 | AV1 | 33 | 14.9 | 0.277 | 52.3 | 0.159 | 79.1 |
| 13 | 0.00 | AV1 | 33 | 14.9 | 0.278 | 52.1 | 0.156 | 79.4 |
| 14 | 0.00 | AV1 | 32 | 14.8 | 0.278 | 52.1 | 0.158 | 79.5 |
| 15 | 0.00 | AV1 | 31 | 14.8 | 0.280 | 52.2 | 0.158 | 79.9 |
| 16 | 0.00 | AV1 | 33 | 15.0 | 0.278 | 52.1 | 0.156 | 79.5 |
| 17 | 0.00 | AV1 | 32 | 14.7 | 0.280 | 52.2 | 0.159 | 79.9 |
| 18 | 0.00 | AV1 | 33 | 14.6 | 0.279 | 52.2 | 0.159 | 79.8 |
| 19 | 0.00 | AV1 | 34 | 14.6 | 0.281 | 52.0 | 0.159 | 80.3 |
| 20 | 0.00 | AV1 | 34 | 14.7 | 0.284 | 52.3 | 0.165 | 81.2 |
| 21 | 0.00 | AV1 | 36 | 14.9 | 0.282 | 52.0 | 0.164 | 80.6 |
| 22 | 0.00 | AV1 | 36 | 14.8 | 0.280 | 52.3 | 0.161 | 80.1 |
| 23 | 0.00 | AV1 | 33 | 15.0 | 0.282 | 51.9 | 0.163 | 80.5 |
| 24 | 0.00 | AV1 | 36 | 15.1 | 0.292 | 52.1 | 0.166 | 83.3 |
| 25 | 0.00 | AV1 | 35 | 15.1 | 0.281 | 52.2 | 0.160 | 80.4 |
| 26 | 0.00 | AV1 | 35 | 15.1 | 0.284 | 52.0 | 0.160 | 81.1 |
| 27 | 0.00 | AV1 | 35 | 15.2 | 0.284 | 52.1 | 0.161 | 81.2 |
| 28 | 0.00 | AV1 | 35 | 15.3 | 0.282 | 52.2 | 0.160 | 80.5 |
| 29 | 0.00 | AV1 | 35 | 15.0 | 0.286 | 52.0 | 0.164 | 81.7 |

Time Summary

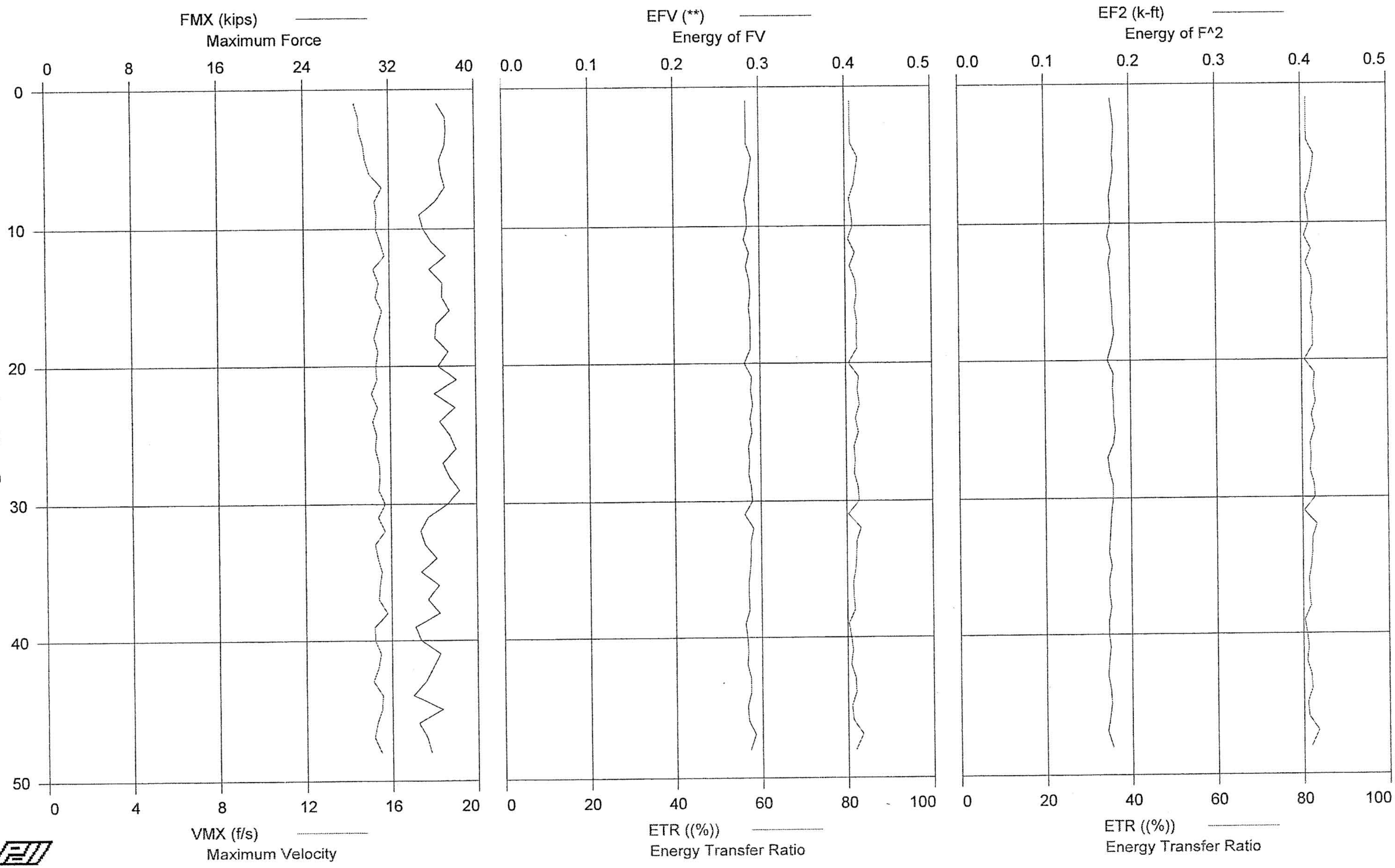
Drive 32 seconds 3:02:56 PM - 3:03:28 PM (9/7/2005)

DIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

GRL Engineers, Inc. - Case Method Results

Test date: 7-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-28



GRL Engineers, Inc.
Case Method Results



PDIPLOT Ver. 2005.1 - Printed: 8-Sep-2005

PLANT VOGTLE - RIG 2 - B-1006-SS-28 SPT
OP: SDW Test date: 7-Sep-2005

AR: 2.30 in^2
LE: 109.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.70

FMX: Maximum Force
VMX: Maximum Velocity
EFV: Energy of FV

BPM: Blows per Minute
EF2: Energy of F^2
ETR: Energy Transfer Ratio

| BL# end | depth ft | TYPE | FMX kips | VMX f/s | EFV ** | BPM ** | EF2 k-ft | ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | AV1 | 37 | 14.4 | 0.285 | ** | 0.178 | 81.3 |
| 2 | 0.00 | AV1 | 37 | 14.6 | 0.285 | 50.7 | 0.180 | 81.3 |
| 3 | 0.00 | AV1 | 37 | 14.6 | 0.285 | 50.5 | 0.182 | 81.3 |
| 4 | 0.00 | AV1 | 37 | 14.8 | 0.285 | 50.7 | 0.181 | 81.4 |
| 5 | 0.00 | AV1 | 37 | 14.9 | 0.291 | 50.9 | 0.180 | 83.0 |
| 6 | 0.00 | AV1 | 37 | 15.1 | 0.289 | 51.9 | 0.181 | 82.6 |
| 7 | 0.00 | AV1 | 37 | 15.7 | 0.287 | 51.8 | 0.179 | 82.1 |
| 8 | 0.00 | AV1 | 36 | 15.3 | 0.283 | 51.7 | 0.176 | 81.0 |
| 9 | 0.00 | AV1 | 35 | 15.4 | 0.285 | 51.7 | 0.177 | 81.5 |
| 10 | 0.00 | AV1 | 35 | 15.4 | 0.286 | 51.9 | 0.177 | 81.8 |
| 11 | 0.00 | AV1 | 36 | 15.6 | 0.282 | 51.7 | 0.174 | 80.7 |
| 12 | 0.00 | AV1 | 37 | 15.8 | 0.288 | 51.8 | 0.178 | 82.3 |
| 13 | 0.00 | AV1 | 36 | 15.2 | 0.284 | 51.7 | 0.175 | 81.0 |
| 14 | 0.00 | AV1 | 37 | 15.5 | 0.288 | 51.8 | 0.177 | 82.3 |
| 15 | 0.00 | AV1 | 37 | 15.3 | 0.289 | 51.9 | 0.177 | 82.6 |
| 16 | 0.00 | AV1 | 38 | 15.6 | 0.287 | 51.5 | 0.179 | 82.1 |
| 17 | 0.00 | AV1 | 36 | 15.4 | 0.289 | 51.8 | 0.179 | 82.6 |
| 18 | 0.00 | AV1 | 36 | 15.3 | 0.289 | 51.6 | 0.181 | 82.5 |
| 19 | 0.00 | AV1 | 37 | 15.4 | 0.289 | 51.7 | 0.178 | 82.7 |
| 20 | 0.00 | AV1 | 37 | 15.3 | 0.282 | 51.9 | 0.173 | 80.6 |
| 21 | 0.00 | AV1 | 38 | 15.4 | 0.290 | 51.6 | 0.180 | 83.0 |
| 22 | 0.00 | AV1 | 36 | 15.1 | 0.289 | 51.6 | 0.179 | 82.7 |
| 23 | 0.00 | AV1 | 38 | 15.4 | 0.291 | 51.6 | 0.180 | 83.1 |
| 24 | 0.00 | AV1 | 37 | 15.2 | 0.288 | 51.9 | 0.180 | 82.2 |
| 25 | 0.00 | AV1 | 38 | 15.4 | 0.290 | 51.5 | 0.182 | 82.8 |
| 26 | 0.00 | AV1 | 38 | 15.3 | 0.286 | 51.8 | 0.180 | 81.8 |
| 27 | 0.00 | AV1 | 37 | 15.5 | 0.287 | 51.6 | 0.173 | 82.1 |
| 28 | 0.00 | AV1 | 37 | 15.5 | 0.286 | 51.8 | 0.175 | 81.8 |
| 29 | 0.00 | AV1 | 38 | 15.4 | 0.289 | 51.8 | 0.179 | 82.7 |
| 30 | 0.00 | AV1 | 37 | 15.7 | 0.290 | 51.8 | 0.179 | 82.9 |
| 31 | 0.00 | AV1 | 35 | 15.4 | 0.281 | 51.9 | 0.177 | 80.4 |
| 32 | 0.00 | AV1 | 35 | 15.7 | 0.291 | 51.6 | 0.176 | 83.3 |
| 33 | 0.00 | AV1 | 35 | 15.2 | 0.288 | 51.9 | 0.175 | 82.3 |
| 34 | 0.00 | AV1 | 36 | 15.4 | 0.288 | 51.7 | 0.174 | 82.2 |
| 35 | 0.00 | AV1 | 35 | 15.6 | 0.287 | 51.7 | 0.177 | 82.0 |
| 36 | 0.00 | AV1 | 36 | 15.5 | 0.285 | 51.8 | 0.174 | 81.4 |
| 37 | 0.00 | AV1 | 35 | 15.4 | 0.285 | 51.9 | 0.174 | 81.5 |
| 38 | 0.00 | AV1 | 37 | 15.8 | 0.286 | 51.5 | 0.176 | 81.8 |
| 39 | 0.00 | AV1 | 34 | 15.2 | 0.281 | 51.9 | 0.173 | 80.3 |
| 40 | 0.00 | AV1 | 35 | 15.2 | 0.283 | 51.7 | 0.173 | 80.8 |
| 41 | 0.00 | AV1 | 37 | 15.5 | 0.284 | 51.5 | 0.175 | 81.2 |
| 42 | 0.00 | AV1 | 36 | 15.4 | 0.283 | 51.9 | 0.173 | 80.8 |
| 43 | 0.00 | AV1 | 35 | 15.1 | 0.287 | 51.6 | 0.172 | 81.9 |
| 44 | 0.00 | AV1 | 34 | 15.6 | 0.287 | 51.7 | 0.175 | 82.0 |
| 45 | 0.00 | AV1 | 37 | 15.5 | 0.283 | 51.8 | 0.176 | 80.9 |
| 46 | 0.00 | AV1 | 34 | 15.3 | 0.284 | 51.6 | 0.174 | 81.3 |
| 47 | 0.00 | AV1 | 35 | 15.2 | 0.292 | 51.5 | 0.171 | 83.5 |
| 48 | 0.00 | AV1 | 36 | 15.5 | 0.286 | 51.5 | 0.177 | 81.8 |

Time Summary

Drive 54 seconds 3:31:41 PM - 3:32:35 PM (9/7/2005)

MACTEC

# APPENDIX G

**Boring B-1003 Core Photos**

**Photos not included, available upon request**

MACTEC

# APPENDIX H (NOT PREVIOUSLY SUBMITTED)

November 16, 2007

Carbonate Content Test Results
Additional Index Test Results

MACTEC

# Determination of Carbonate Content of Soils

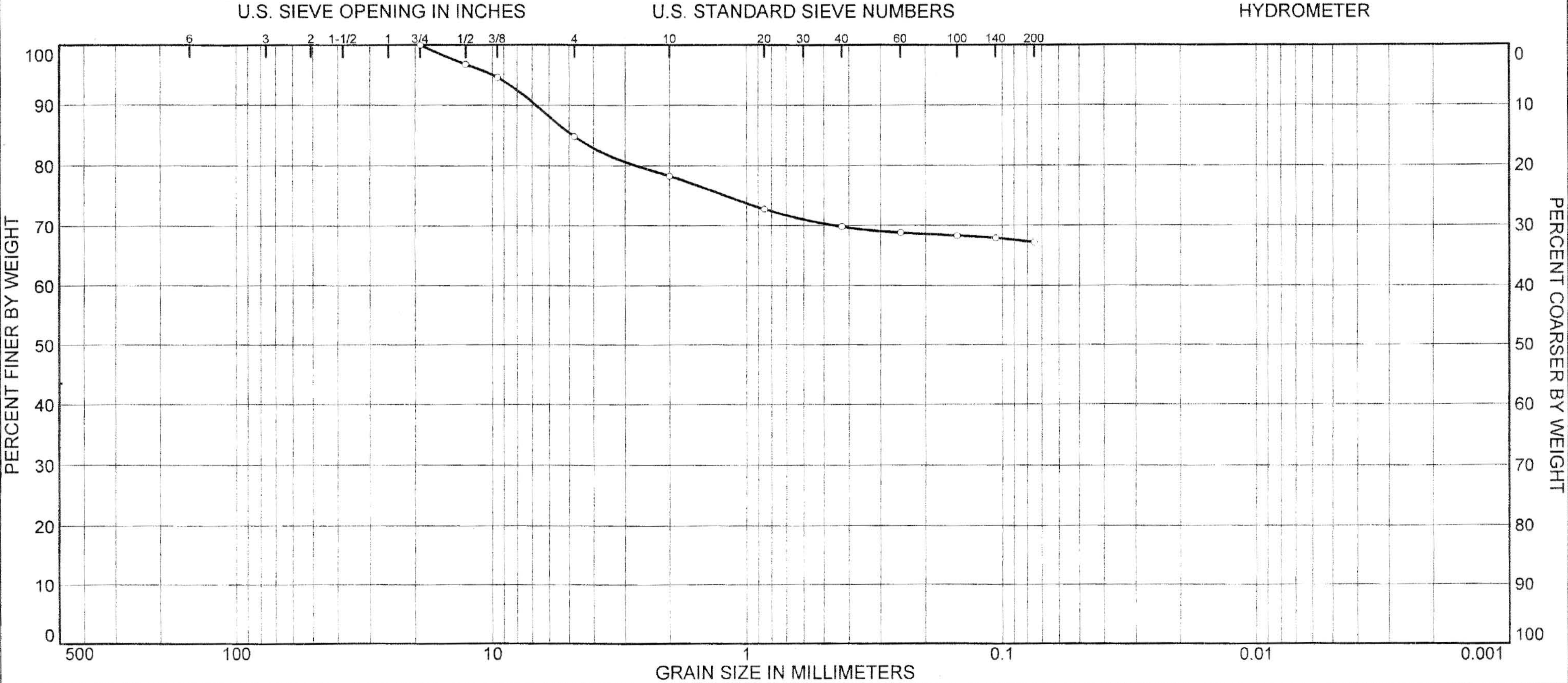
Project No.: 6141-05-0277  Tested By: BM  Reviewed By: JW

Project Name: Vogtle ESP  Test Date: 10/18/2007-10/30/07  Review Date: 11/1/2007

| Sample Information | | | | ASTM D 4373-02 | | ASTM D 3042-03 |
|---|---|---|---|---|---|---|
| Boring No. | Sample No. | Depth (ft.) | Lab ID No. | Pre-washed Calcite Equivalent (%) | Post-washed Calcite Equivalent (%) | Soluble Material (%) |
| B-1002 | UD-1 | 92.0 | 4390 | 21 | 17 | NA* |
| B-1002 | UD-5 | 133.5 | 4394 | 81 | NA* | 97 |
| B-1003 | DCS-18 | 96.0 | 8064 | 60 | 72 | NA* |
| B-1003 | DCS-27 | 123.7 | 8065 | NA* | NA* | 98 |
| B-1003 | DCS-31 | 145.7 | 8066 | 83 | 79 | NA* |
| B-1004 | UD-3 | 163.5 | 4450 | 52 | 76 | NA* |
| B-1004 | SPT-34&35 | 134-140 | 8068 & 8069 | 24 | NA* | NA* |
| B-1005 | SPT-44 | 213.5 | 8074 | 47 | 23 | NA* |
| B-1004 | UD-5 | 188.5 | 4452 | 80 | 91 | NA* |
| B-1010 | SPT-27 | 98.5 | 8076 | 18 | 15 | NA* |
| | | | | | | |
| | | | | | | |
| | | | | | | |

*NA: Not Assigned.

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 15.2 | 6.5 | 8.5 | 2.6 | 67.2 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1002 | UD-1 | 92.0/130.0 | 10/18/07 | MH | Sandy Elastic silt (MH) | | 83 | 50 |

Client Southern Nuclear Operating Company

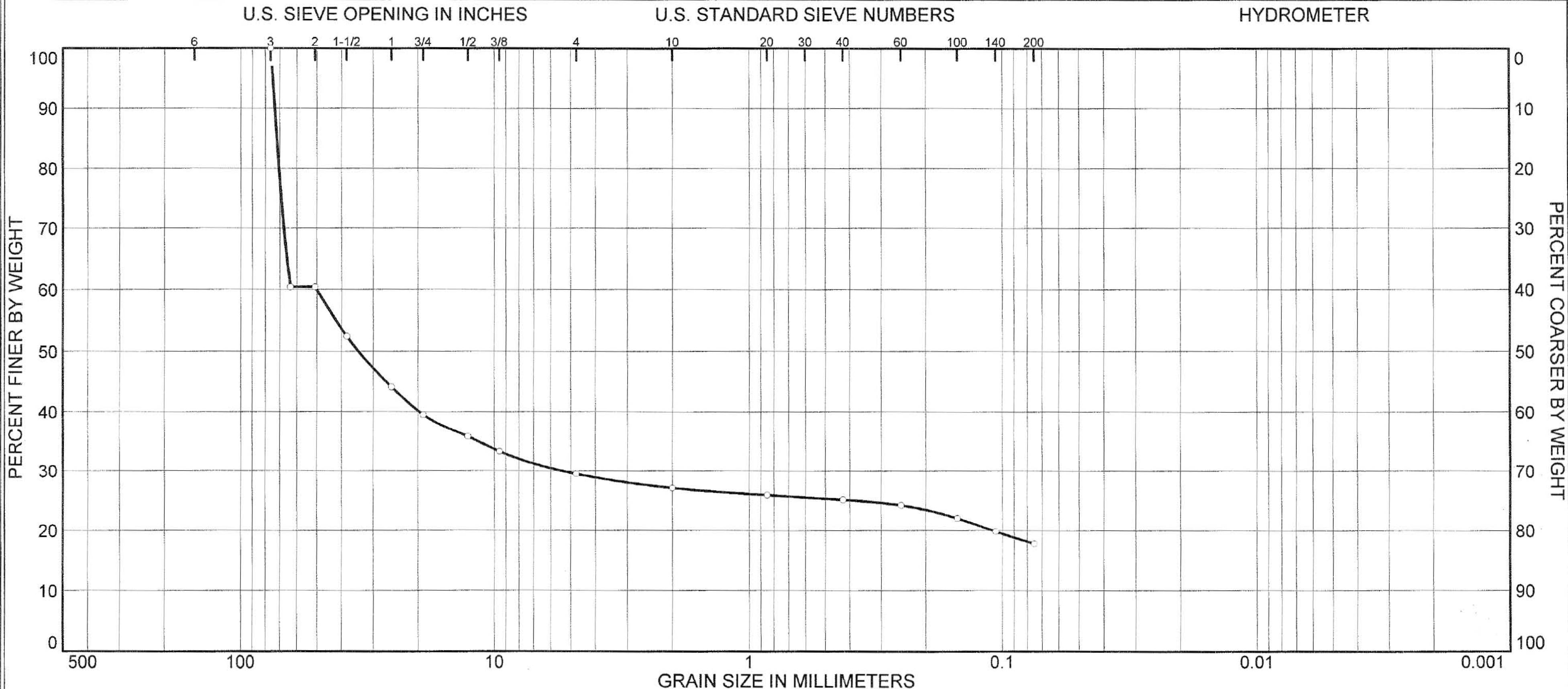
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 4390

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 60.5 | 10.0 | 2.4 | 2.0 | 7.3 | 17.8 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1002 | UD-5 | 133.5/88.5 | 10/16/07 | | Not Applicable | | 40 | 26 |
| | Before Acid | | | | | | | |

Client Southern Nuclear Operating Company

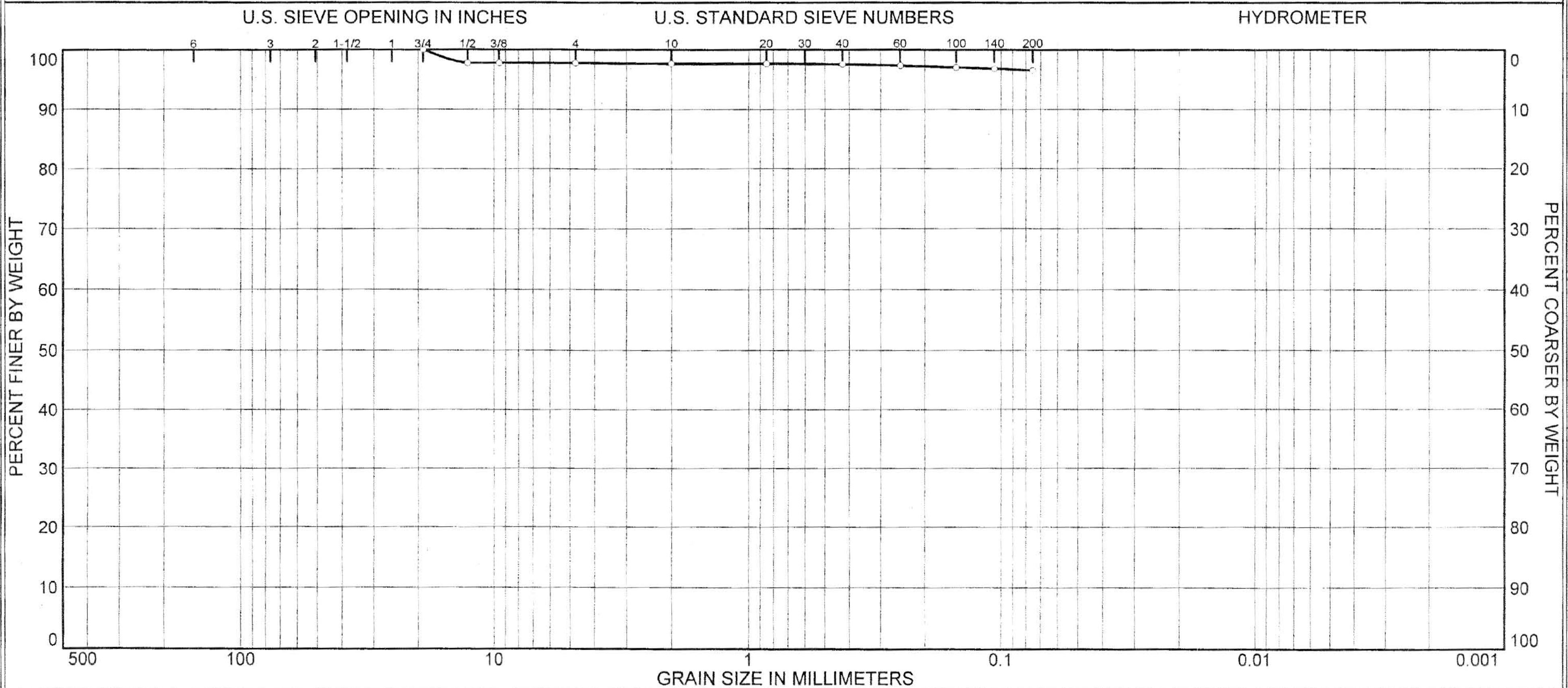
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 4394

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 2.2 | 0.1 | 0.1 | 1.0 | 96.6 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1002 | UD-5 After Acid | 133.5/88.5 | 10/30/07 | | Not Applicable | | | |

Client Southern Nuclear Operating Company

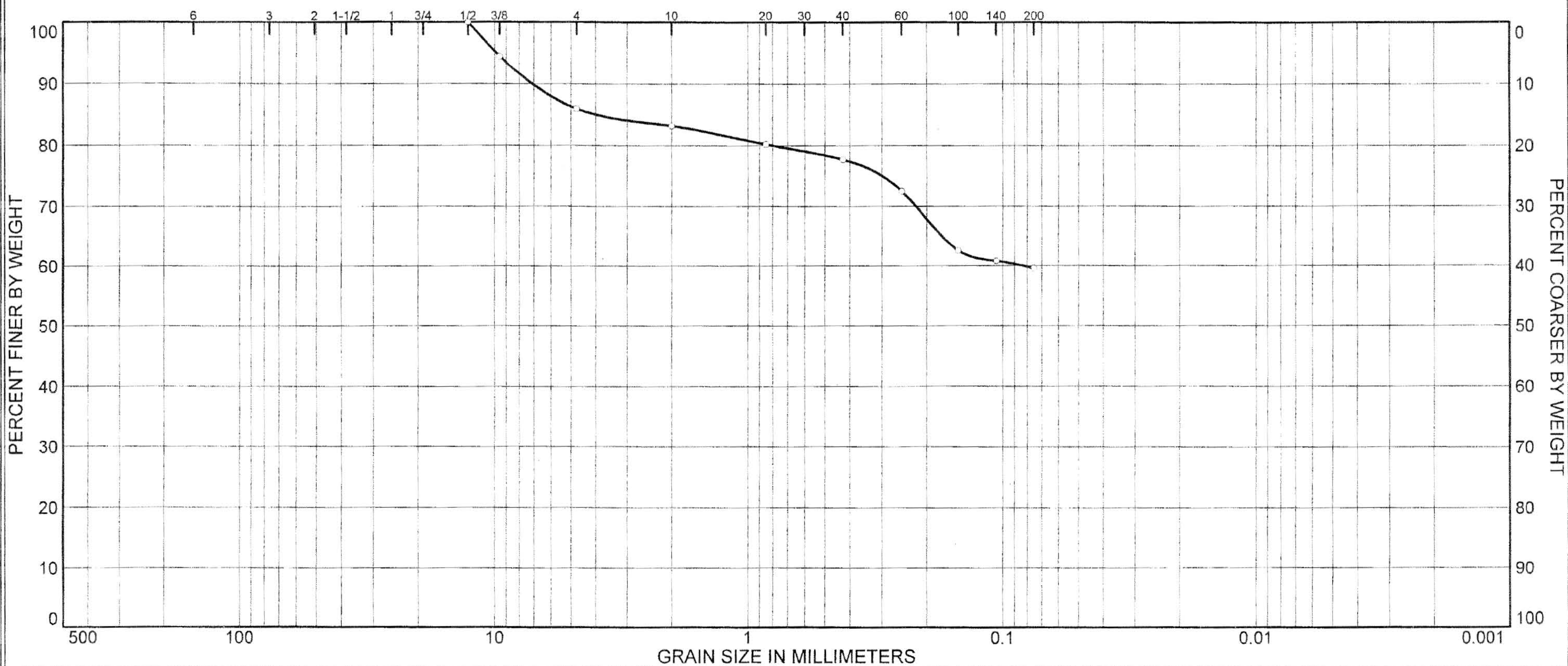
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 4394

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by; EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 14.0 | 2.8 | 5.5 | 18.1 | 59.6 | |

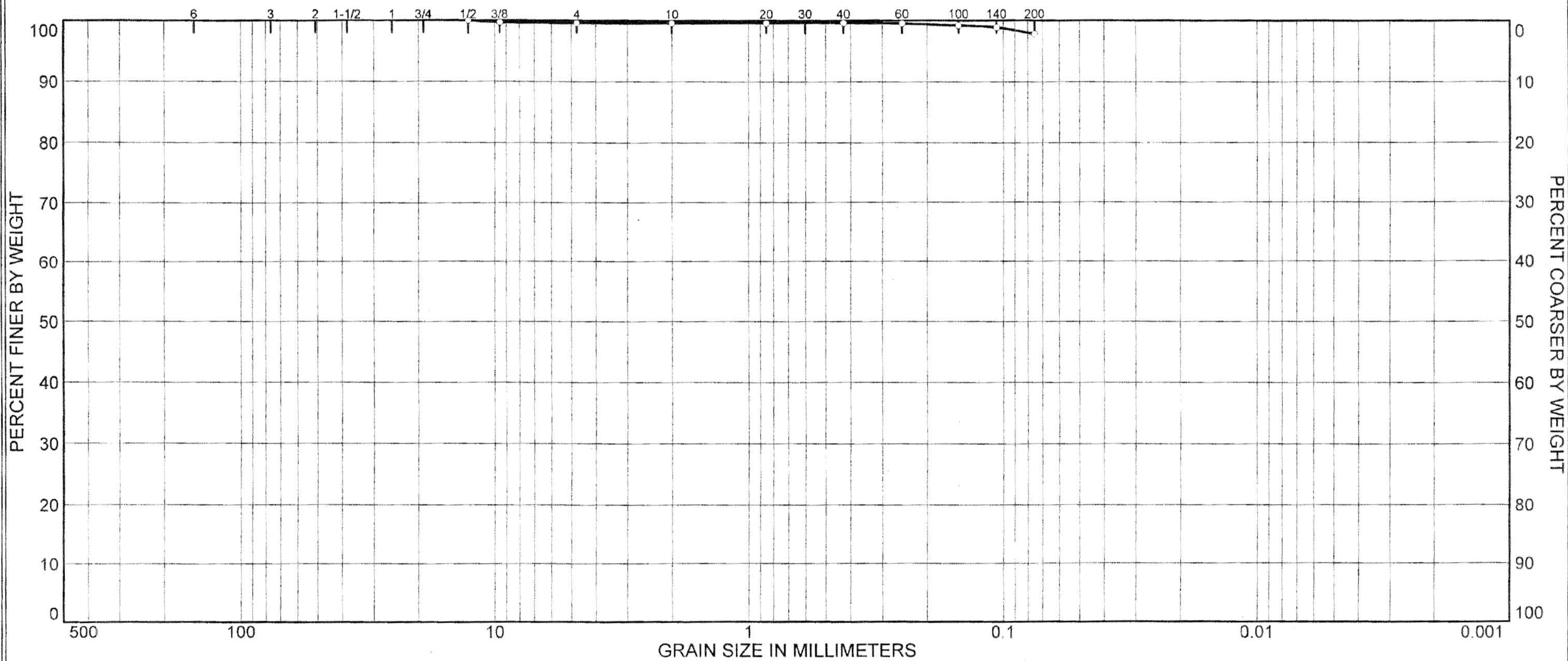
| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1003 | DCS-18 | 96.0/127.2 | 10/18/07 | | Sandy Silt (ML) | | | |

Client Southern Nuclear Operating Company
Project Vogtle ESP
Project No. 6141-05-0227 Lab no. 8064

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 1.8 | 97.8 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1003 | DCS-27 After Acid Wash | 123.7/99.5 | 11/1/07 | | Not Applicable | | | |

Client Southern Nuclear Operating Company

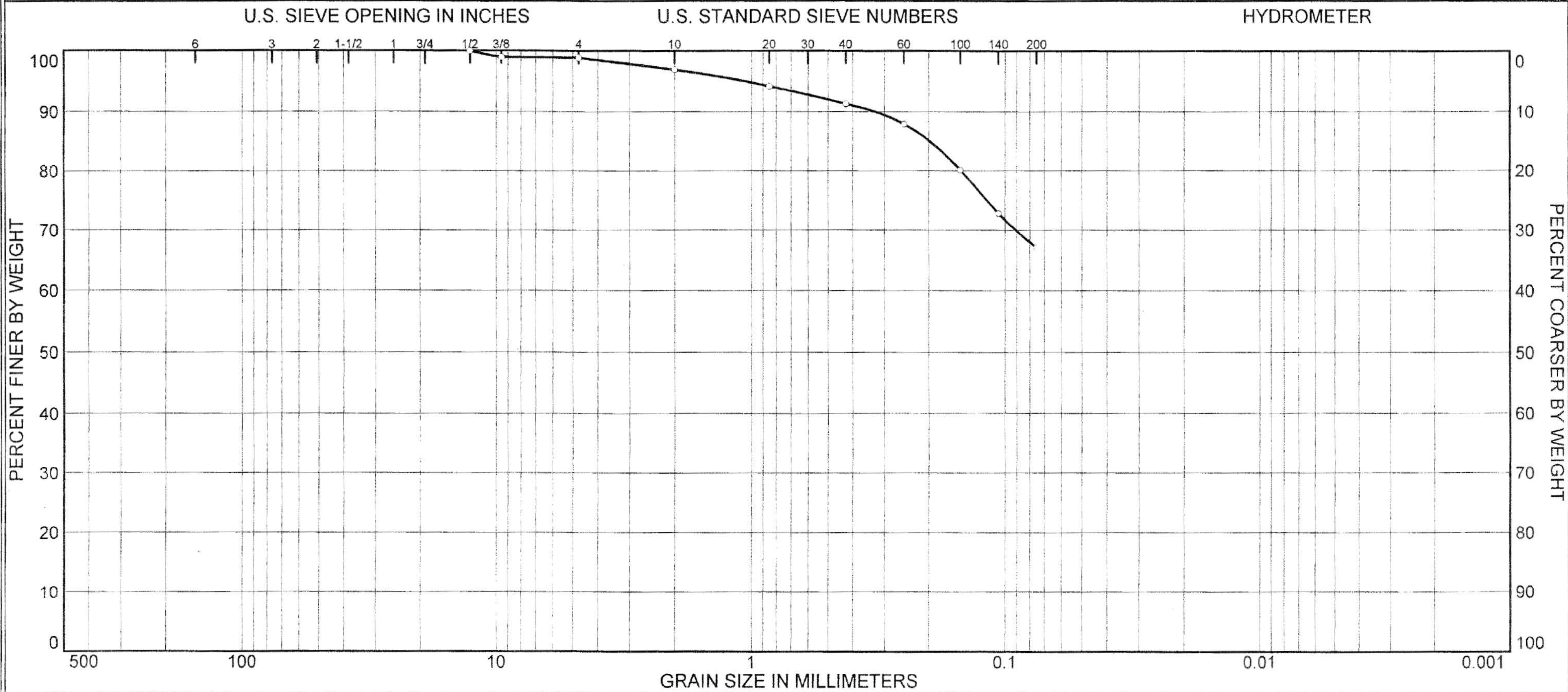
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 8065

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 1.1 | 1.9 | 5.7 | 24.3 | 67.0 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1003 | DCS-31 | 145.7/77.5 | 10/18/07 | CL | Sandy lean clay (CL) | | 45 | 23 |

Client Southern Nuclear Operating Company

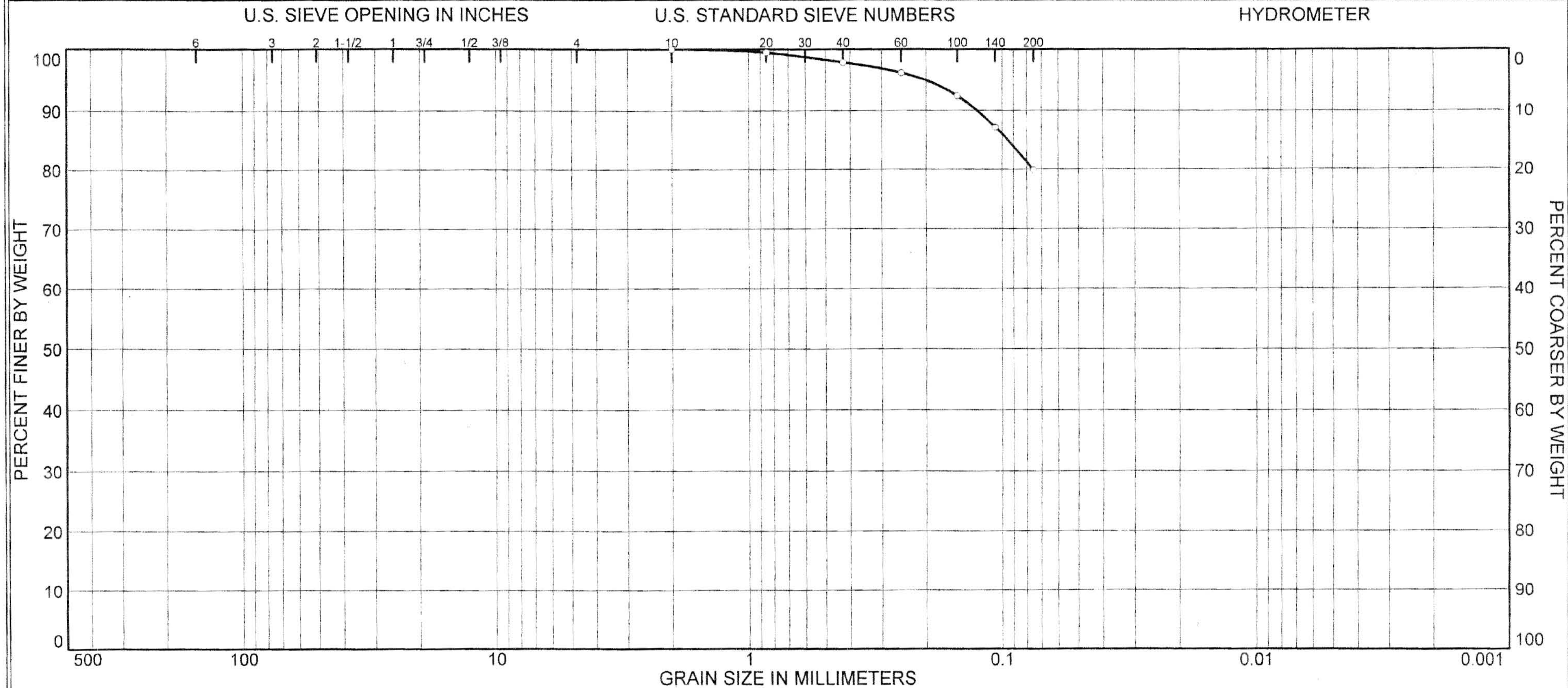
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 8066

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 18.1 | 79.8 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1003 | DCS-66 | 315.7/92.5 ft | 10/29/07 | CL | CLAY, with sand (CL) | | 43 | 24 |

Client Southern Nuclear Operating Company

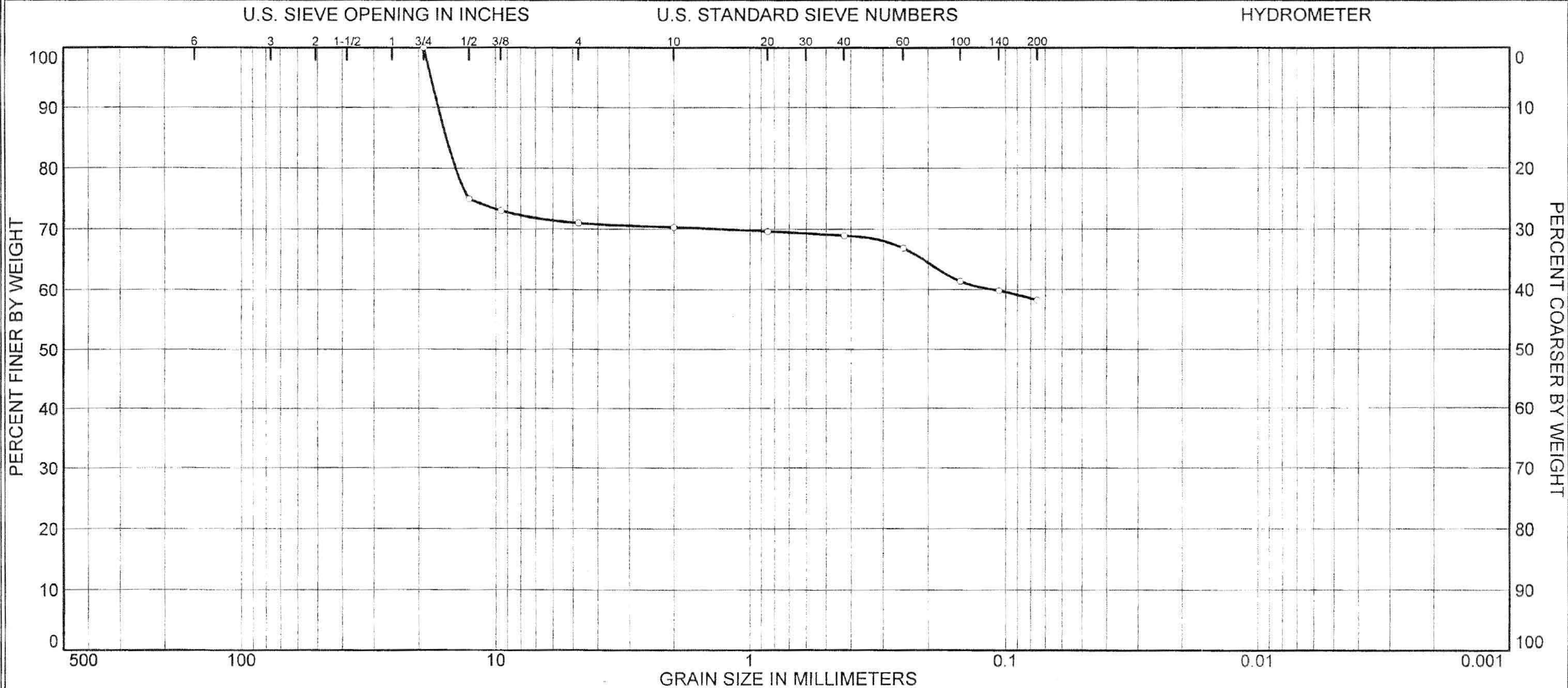
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 4445

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 29.0 | 0.7 | 1.4 | 10.6 | 58.3 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1004 | UD-3 (Top) | 163.5/86.3 | 10/18/07 | MH | Elastic Silt (MH) | | 55 | 37 |

Client Southern Nuclear Operating Company

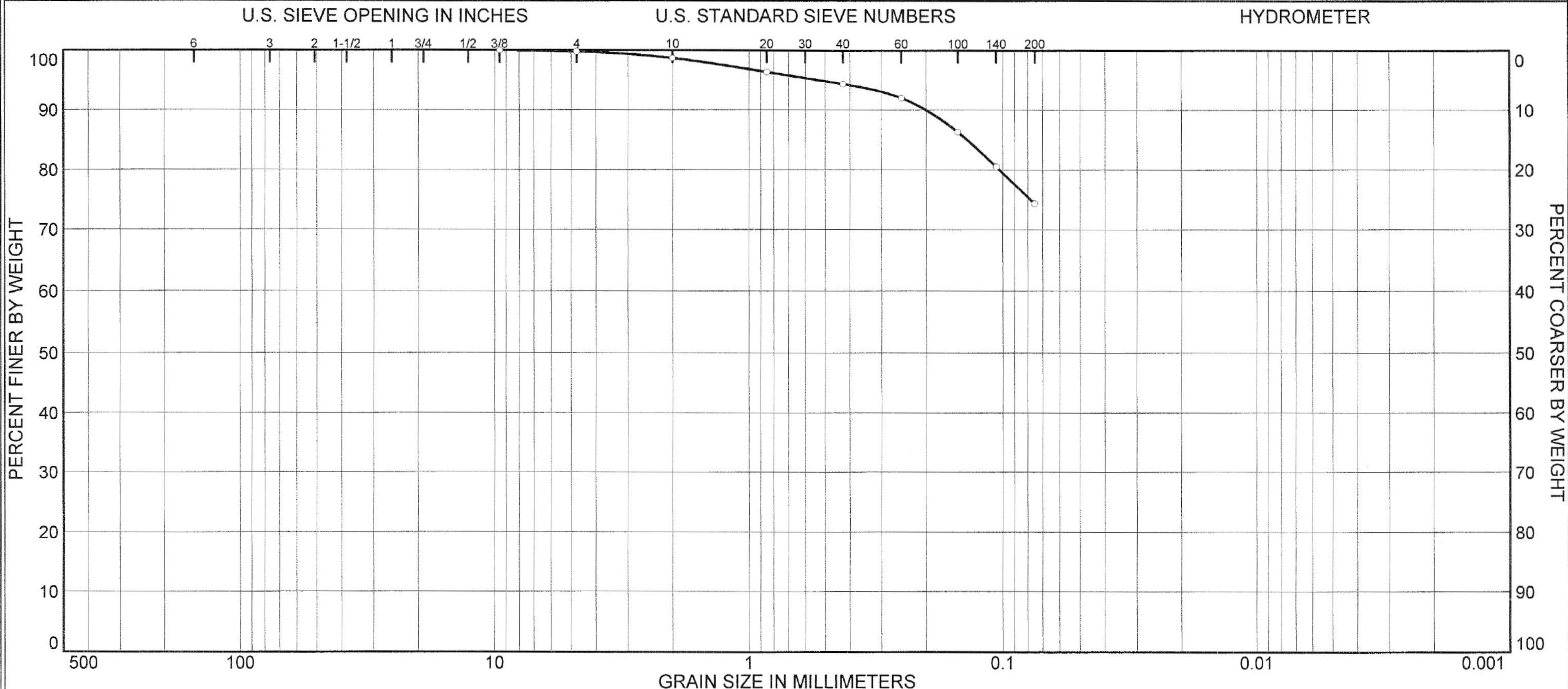
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 4450

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| | % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|---|
| | | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| ○ | 0.0 | 0.0 | 0.2 | 1.1 | 4.3 | 20.0 | 74.4 | |

| | SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|---|
| ○ | B-1004 | SPT-34 & 35 | 134-140/ 115.8-109.8 | 10/31/07 | MH | Elastic Silt with sand (MH) | | 96 | 47 |

Client Southern Nuclear Operating Company

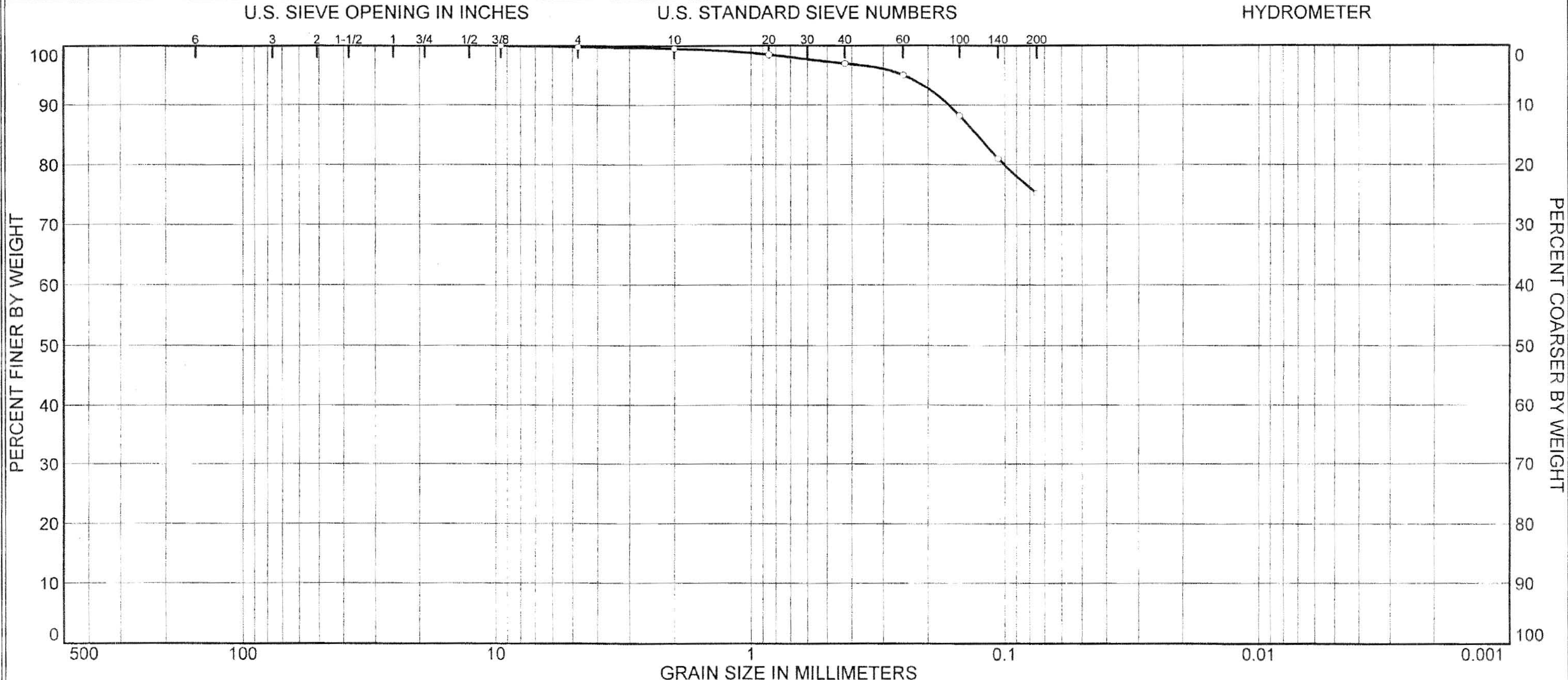
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 8068-9

**MACTEC ENGINEERING AND CONSULTING, INC.**

○ Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 0.2 | 0.3 | 2.5 | 21.8 | 75.2 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1004 | UD-5 (Top) | 188.5/61.2 | 10/18/07 | CL | Lean Clay with sand (CL) | | 41 | 24 |

Client Southern Nuclear Operating Company

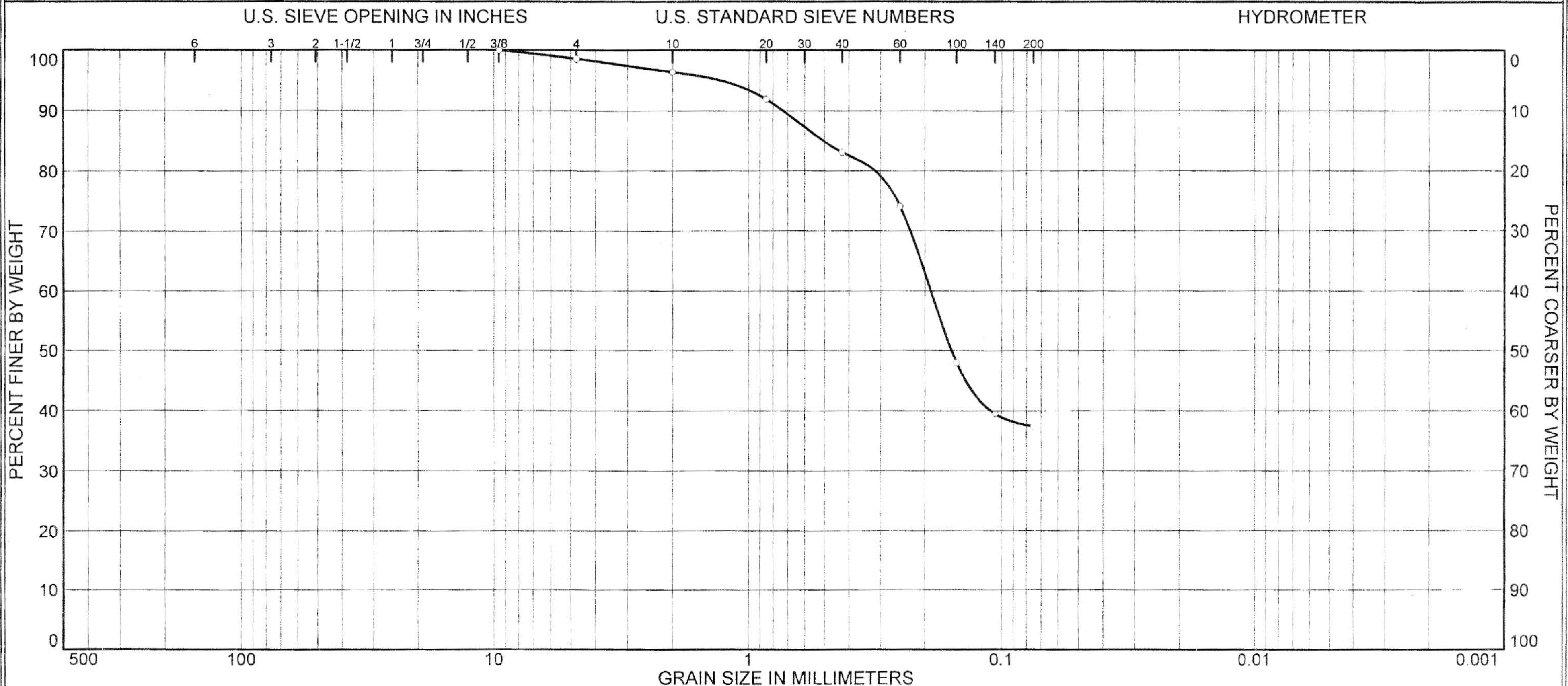
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 4452

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 1.4 | 2.2 | 13.3 | 45.7 | 37.4 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1004 | SPT-44 | 213.5/36.3 | 10/15/07 | SC | Clayey Sand (SC) | | 41 | 20 |

Client Southern Nuclear Operating Company

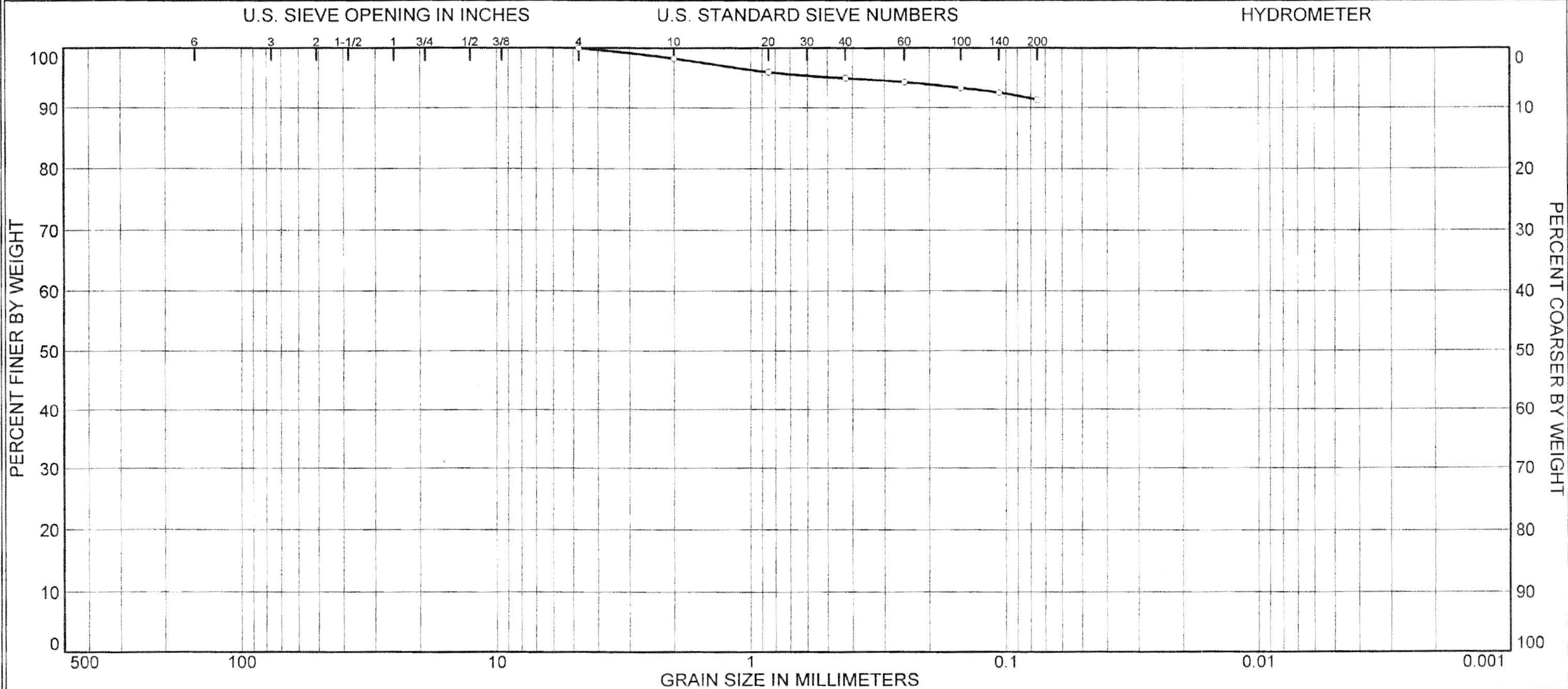
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 8074

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Particle Size Distribution Report




| % COBBLES | % GRAVEL | | % SAND | | | % FINES | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT | CLAY |
| 0.0 | 0.0 | 0.0 | 1.7 | 3.3 | 3.7 | 91.3 | |

| SOURCE | SAMPLE # | DEPTH/ELEV. | DATE SAMPLED | USCS | MATERIAL DESCRIPTION | NM % | LL | PL |
|---|---|---|---|---|---|---|---|---|
| B-1010 | SPT-27 | 98.5/120.1 | 10/18/07 | MH | Elastic silt (MH) | | 94 | 47 |

Client Southern Nuclear Operating Company
Project Vogtle ESP

Project No. 6141-05-0227 Lab no. 8076

**MACTEC ENGINEERING AND CONSULTING, INC.**

Tested by: EH Reviewed by: HJ

# Appendix 2.5B—High Resolution Compressional Seismic Survey Field Report

(Excluding Appendices)

Prepared by
Bay Geophysical, Inc.

February 8, 2006

Bay Geophysical, Inc.

# FIELD REPORT

## High Resolution Compressional Seismic Survey Vogtle Electric Generating Plant Burke County, Georgia

*Prepared for:*

**Southern Nuclear Operating Company**
**Work Order SN050193**

*Birmingham, AL*

**February 8, 2006**
Bay Project Number: **6011SNC**

*Prepared By:*

**BAY GEOPHYSICAL, INC.**
868 Robinwood Court
Traverse City, Michigan 49686
*(231)-941-7660 • Fax (231)-941-7412*

# Bay Geophysical

March 16, 2006

Donald Moore
Southern Nuclear
Building 42
Inverness Center Parkway
Birmingham, AL 35242
(205) 992-6672

Re: Final Deliverables, Seismic Surveys Vogtle Electric Generating Plant

Don,

Please find enclosed the final deliverables for the Vogtle Electric Generating Plant. This package includes:

1. Corrected text as per Randy Cumbest's request in the final field report. This replaces all text of the report that you already have.
2. I copy of the CDROM for Appendix E, .SEGY files for the reflection data. Final static information is supplied in the .a_db files. This CDROM replaces the existing CDROM in Appendix E.
3. Appendix E plots of the extended processing of the reflection Lines 1 through 4. The extended versions have FX Decon, FX Decon (fx) with Spectral Whitening (whtfx) and FX Decon, Spectral Whitening and Migration (whtfx-migr) applied. These versions can be appended to the existing seismic reflection plots (stack 1) in this appendix.
4. I copy of the CDROM for Appendix F, .SEGY files for the depth migration sections, .PDF files of the refraction inversions and .PDF files of the depth migration sections. Paper plots of the depth migration sections can be appended to the existing refraction plots in this appendix. The CDROM can replace the existing CDROM in this appendix. Also, a brief report from Optim regarding processing information can be put into Appendix F as well.

This should conclude the deliverable part of this project. These deliverables have also been sent to Scott Lindvall of Lettis & Associates, Inc. and Randy Cumbest. If you have any questions, please call.

Best Regards,

Phil Van Hollebeke
Bay Geophysical, Inc.



868 Robinwood Ct.
Traverse City, MI 49686

Ph: (231) 941-7660
Fax: (231) 941-7412

Bay Geophysical, Inc.

# FIELD REPORT

## High Resolution Compressional Seismic Survey Vogtle Electric Generating Plant Burke County, Georgia

*Prepared for:*

**Southern Nuclear Operating Company**
**Work Order SN050193**

*Birmingham, AL*

**February 8, 2006**
Bay Project Number: **6011SNC**

*Prepared By:*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868 Robinwood Court
Traverse City, Michigan 49686
*(231)-941-7660 • Fax (231)-941-7412*

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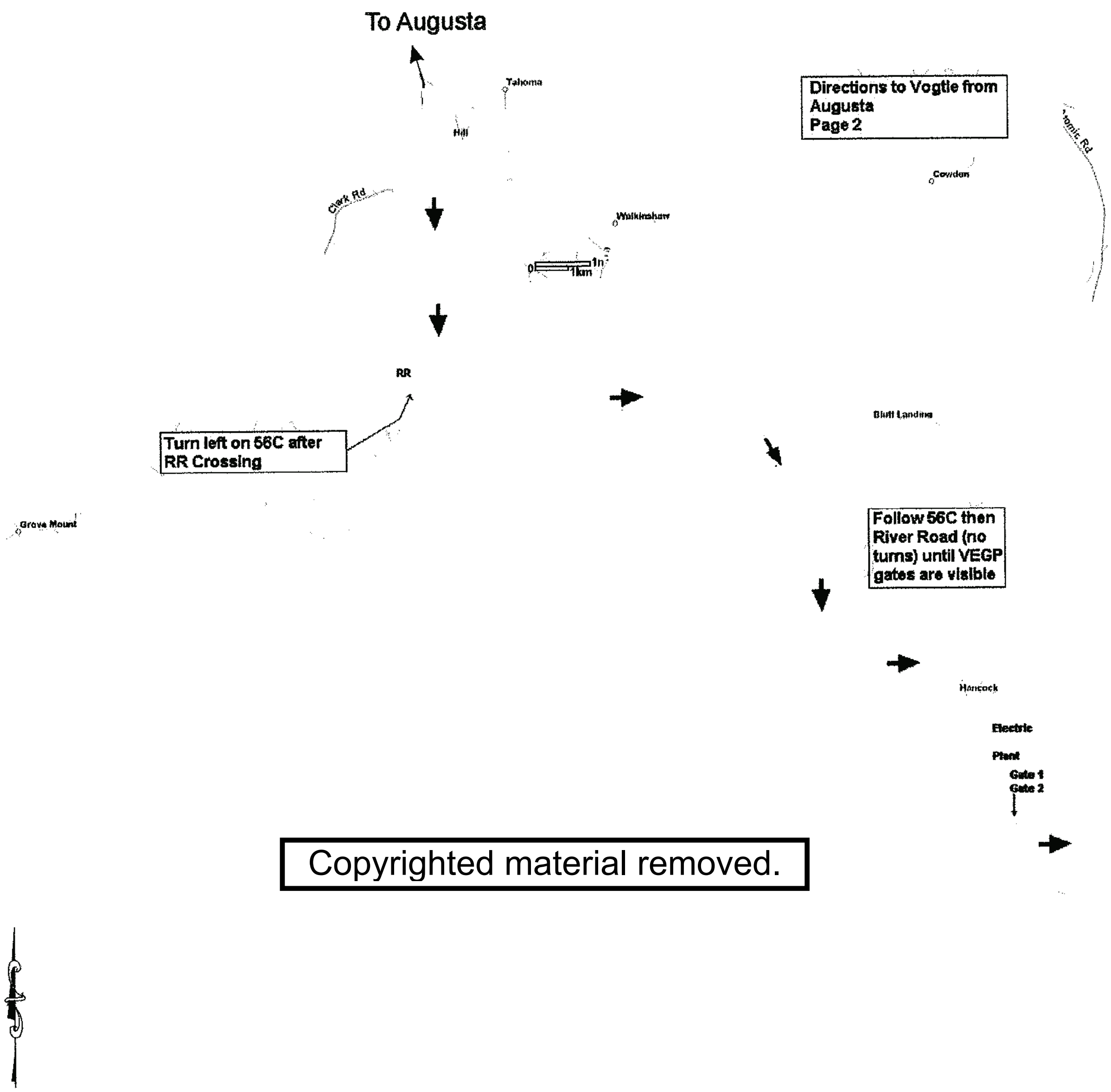




Approved By: NAS Date:

Not scale

Figure 1-1
General Location of
Vogtle Electrical Generation Plant
Burke County, GA
Work Order SN050193

# 1.0 INTRODUCTION

Bay Geophysical, Inc. (Bay) performed high resolution seismic compressional (P-) wave surveys in eastern Georgia within the Vogtle Electric Generating Plant (VEGP) south of Augusta, GA in Burke County for Southern Nuclear Operating Company (SNOC). This report details the daily field activities performed in January and February 2006.

The general location of the VEGP is illustrated in Figure 1-1. The work performed by Bay consisted of the acquisition of high resolution compressional (P- Wave) seismic reflection and refraction data and final field report generation. The land survey was performed by Georgia Power and contracted under SNOC. Bay sub-contracted Sterling Seismic Services to process the seismic reflection data and Optim Software (Optim) to process the seismic refraction data. The results of these surveys will be interpreted by others as directed by SNOC.

Deliverables by Bay will include all daily logs, observer's logs, various system and acquisition tests, raw seismic refraction and reflection data, processed seismic refraction and reflection data and a final field report summarizing all deliverables.

## 1.1 Purpose of the Survey

The objective of the geophysical survey was to image the Pen Branch Fault that is thought to intersect beneath VEGP in a northeast to southwest trend. The objective of the seismic reflection data is to image the subsurface formations and any offsets as a result of faulting. The objective of the seismic refraction data is to perform a depth migration to image the dip of the fault.

The total field effort consisted of acquiring reflection and refraction seismic data acquisition. The four seismic reflection profiles totaled 3140 records and 3 seismic refraction profiles totaling 434 records. As seen from the line location map in Figure 1-1, all of the seismic lines were acquired within the VEGP property, except for Line VEGP3. The end of this line, after crossing Hancock Road, traverses onto private property.

The initial P- Wave parameter testing began on January 24, 2006 on Line 1. Data acquisition began immediately after parameter testing and was completed on February 9, 2006. All data were submitted to Sterling and Optim after the completion of each line. The results, without interpretation, of the final processing are included in this report in SEG standard SEGY formatted files.

# 2.0 SITE DESCRIPTION

## 2.1 Line Locations and Site Conditions

### *2.1.1 Line Locations*

The seismic reflection lines were located within VEGP along existing roads, power lines and cross country. The general locations of these lines are displayed in Figure 1-2, while the shotpoint maps for the reflection and refraction surveys are displayed in Figures 1-2A and 1-2B respectively.

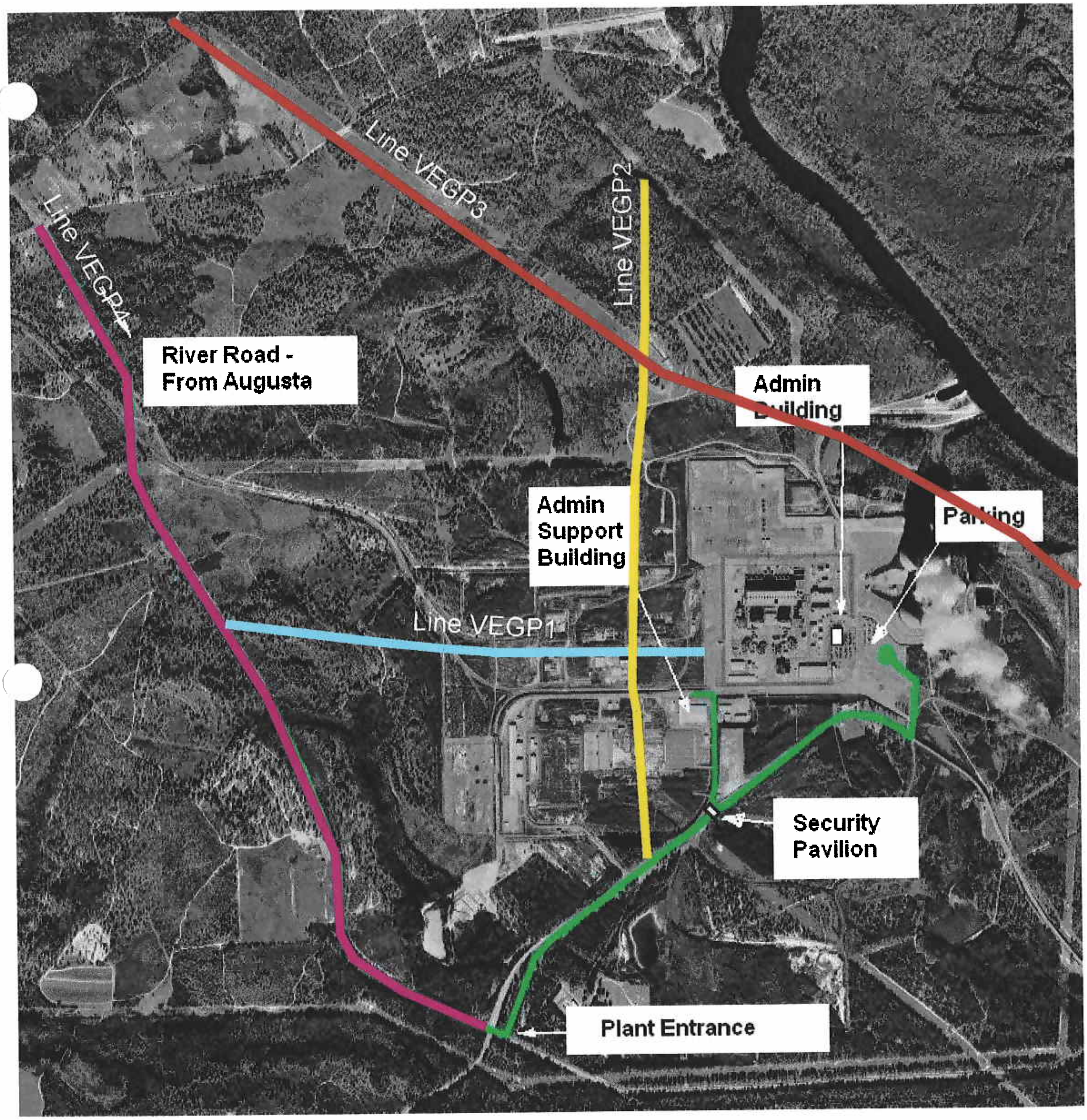
Lines 1, 2 and 3 reflection were acquired with 10 foot receiver and 10 foot source intervals and Line 4 reflection was acquired with 20 foot receivers and 20 foot source intervals as requested by SNOC. Refraction Lines 1, 3 and 4 were acquired with 50 foot receivers and 100 foot source intervals. Table 2.1.1.1 below summarizes the length of each line and a brief description of their location.

Table 2.1.1.1
Survey Line Lengths and Locations

| Line | Length | Type | Location |
|---|---|---|---|
| 1 | 5,970 | Reflection and Refraction | Starts at River Road and runs east toward generating plant |
| 2 | 6,400 | Reflection Only | Runs south to north along the west end of the generating plant and crosses Lines 1 and 2 |
| 3 | 13,000 | Reflection and Refraction | Runs southeast to northwest beneath power line along the south edge of Savannah River |
| 4 | 11,980 | Reflection and Refraction | Starts at the plant access road along River Road to the northwest |

### *2.1.2 Site Conditions*

Geophones and cables were placed off roadways as road ditches provided better coupling of geophones and reduced the obstruction of normal vehicular traffic on VEGP property. The vibrator operated adjacent to the road right of way, moving with traffic. The vibrator was not authorized to work on the road surface. When larger or heavier traffic existed, data acquisition halted briefly until the traffic passed.




Approved By: NMS Date: 05/10/06

Not to scale

Figure 1-2
Site Map With Line Locations
Vogtle Electrical Generation Plant
Burke County, GA
Work Order SN050193

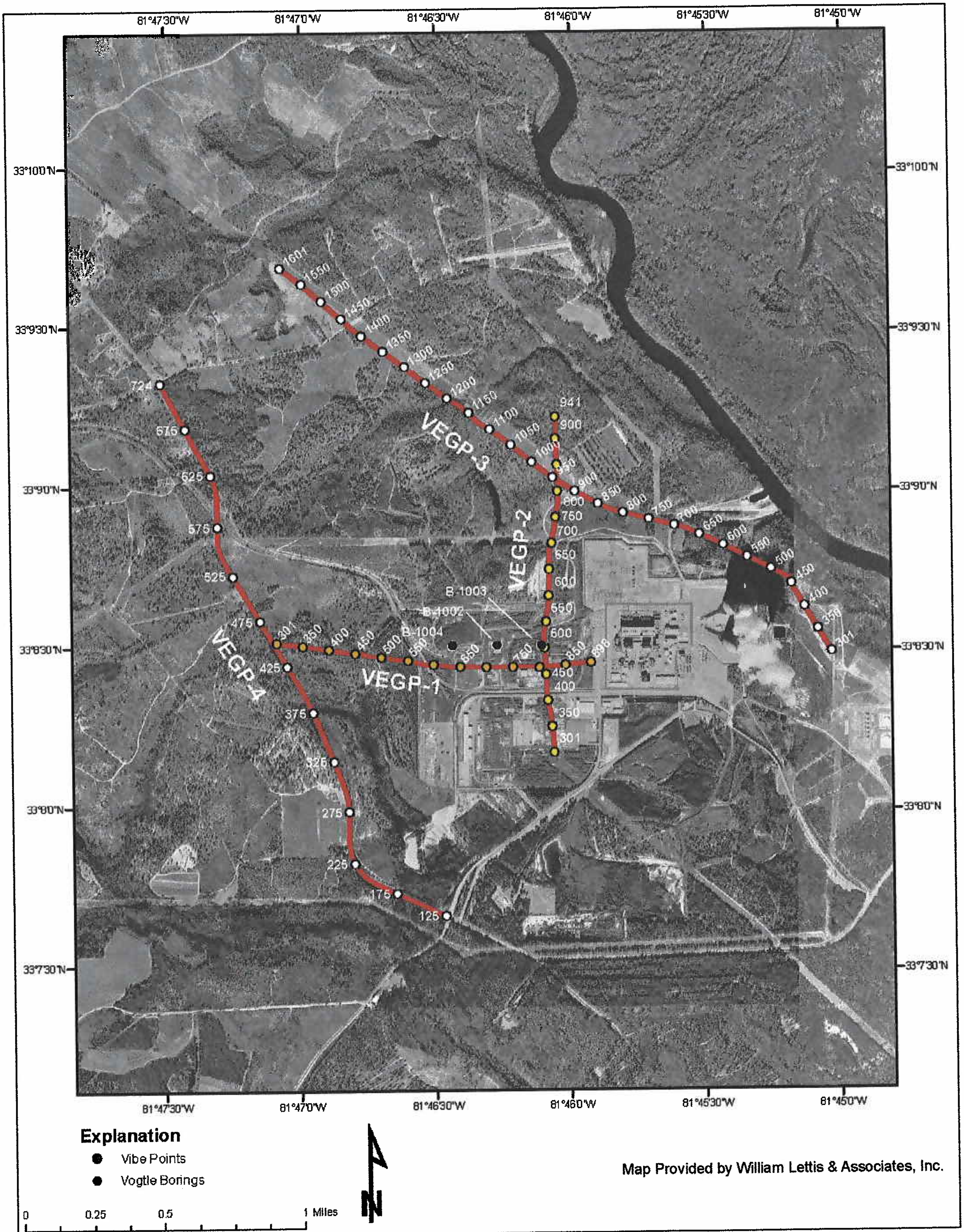



Figure 1-2A
Reflection Shotpoint Map
Vogtle Electrical Generation Plant
Burke County, GA
Work Order SN050193

Approved By: NMS

Date: 03/10/06

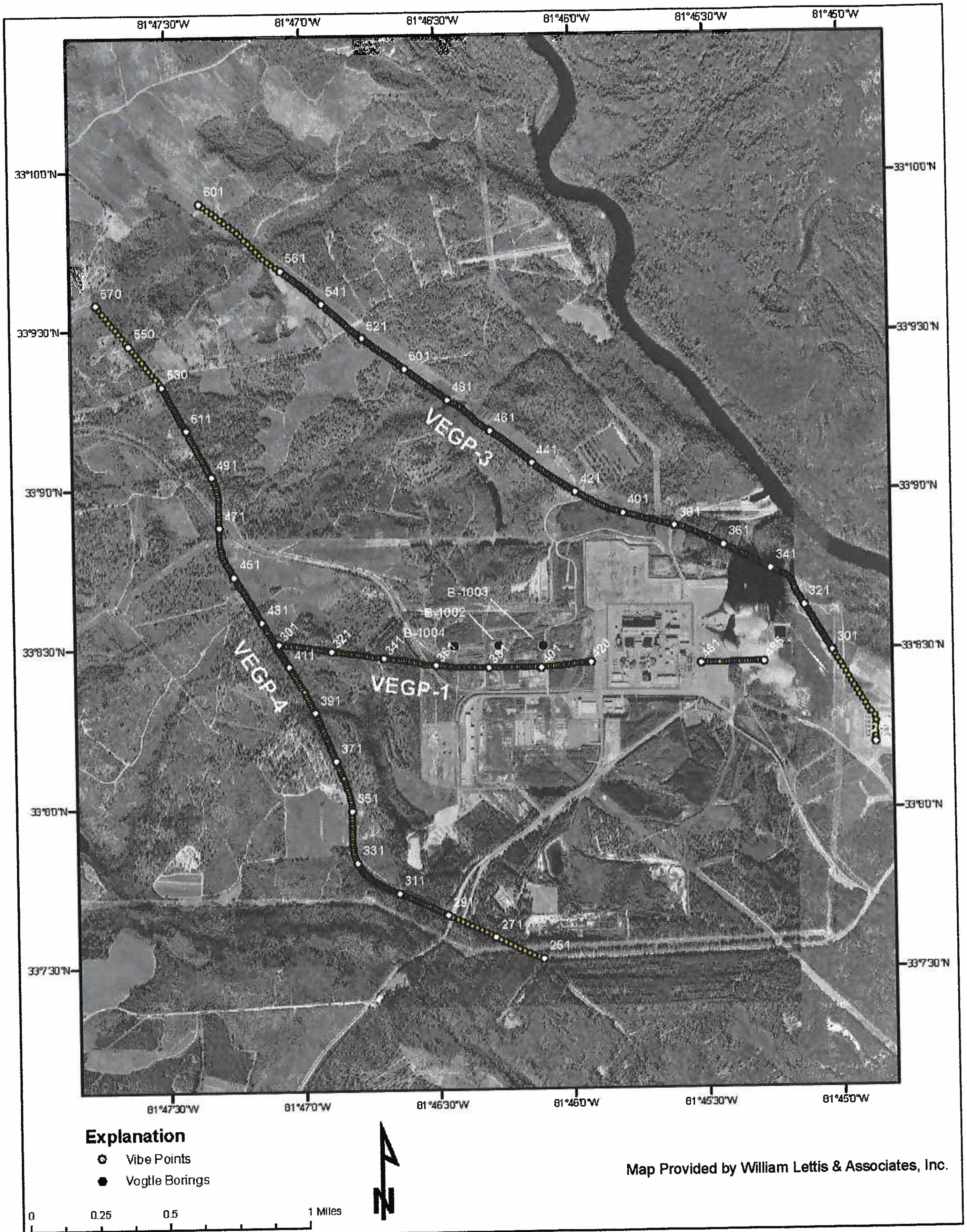



Figure 1-2B
Refraction Shotpoint Map
Vogtle Electrical Generation Plant
Burke County, GA
Work Order SN050193

Approved By: NAS

Date: 03/10/06

Some site noise was observed along Lines 1, 2 and 3. The majority of the noise was determined to originate from the plant. Specifically, the second half of Line 1 and the center portion of Line 2 experienced turbine noise. Line 3 experienced similar noise but its location being further from the plant than Lines 1 and 2; the noise may be attributed to geology. During seismic data acquisition, 6 sweeps was the nominal stack used. In noisy areas, the number of sweeps was increased to help improve the signal in an attempt to overcome some of the noise emanating from the plant. In some cases, for instance Line 1 and 2, this did improve the data; however this did not improve the data on Line 3. Since the increase in number of sweeps on Line 3 did not improve the data, it is possible that the noisier records could be attributed to localized geology.

# 3.0 GEOPHYSICAL SURVEY METHODS

## 3.1 Seismic Reflection

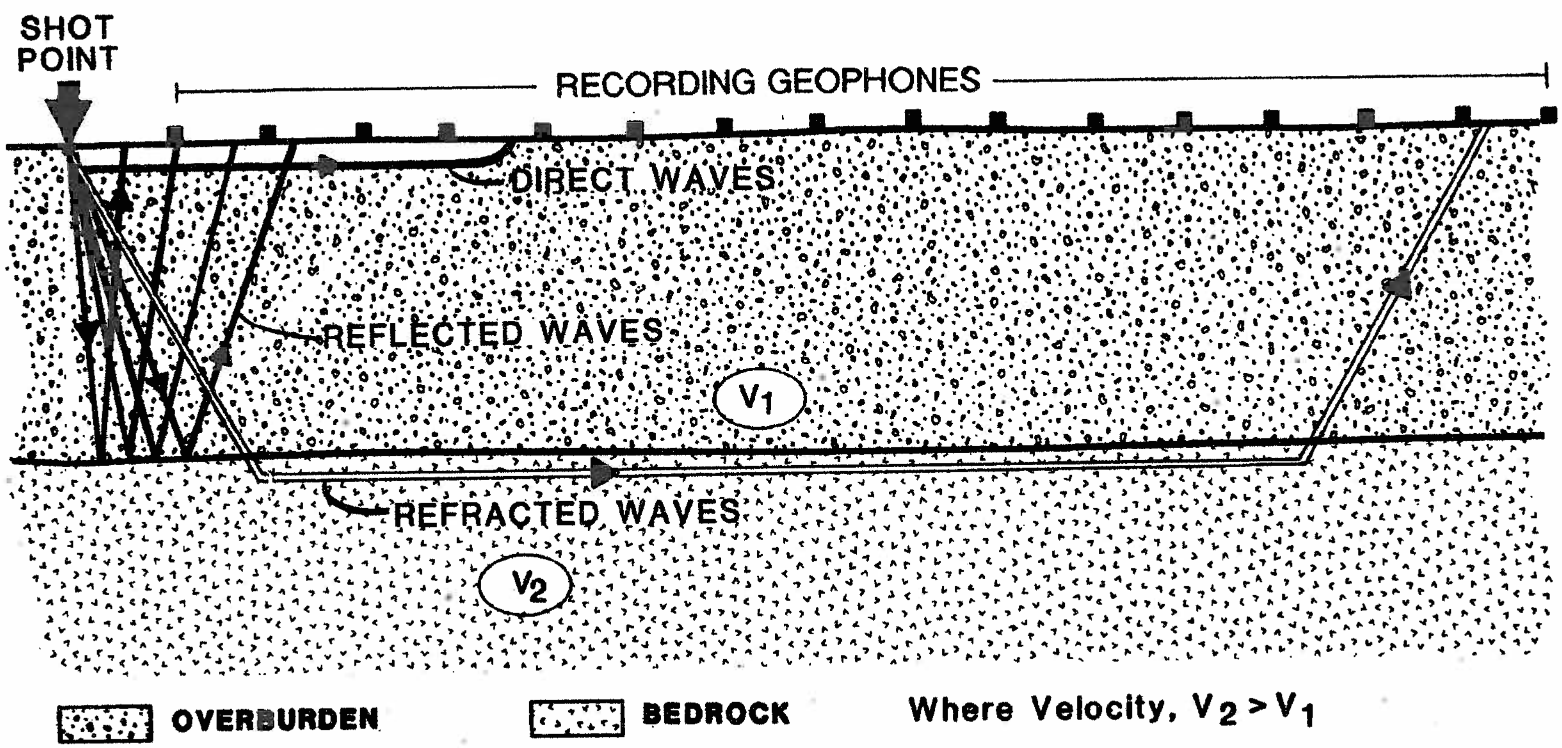
### *3.1.1 Introduction*

Seismic reflection profiling is a geophysical method that has been used extensively since the 1950's. It is the most widely used geophysical technique today, primarily in the search for hydrocarbon resources in depth ranging from 1,000 to 20,000 feet. This report will not go into detail on the method as extensive references exist (Dobrin, 1988).

Several seismic methods have been extensively used in environmental and engineering investigations over the past two decades. The most commonly used are seismic refraction and reflection. Both methods rely on the ability to record seismic signals and determine the time it takes for seismic energy to travel from a seismic source through the subsurface to a receiver (geophone). What differentiates the two methods is the path that the seismic energy travels. Ray paths for both reflected and refracted signals are shown in Figure 3-1, which illustrates the common case where competent bedrock is overlain by overburden.

The refracted wave travels down through the overburden and is critically refracted at the overburden/bedrock interface and is displayed in Figure 3-1. (Note: While the figure shows refraction at the bedrock-overburden interface, refraction will occur at any interface where the densities and seismic wave velocities of the underlying units are significantly higher). The wave travels along the surface of the bedrock and then upward to the geophones. The wave travels at overburden velocities on the up and down path to the bedrock surface and at bedrock velocities when traveling along the bedrock surface.

The basic principles of the reflection technique are also illustrated in Figure 3-1. The seismic reflection method involves projecting a wave down from the surface, and then recording the returning wave back at the surface as it reflects off formations at depth. Seismic energy will also be reflected, refracted and diffracted at boundaries in the subsurface, in accordance with Snell's Law. The main design consideration for a successful seismic reflection survey is the ability to separate the reflected energy from other arrivals in processing.

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# SEISMIC RAYPATH GEOMETRY

Approved By: NB

Date: 03/10/06

Figure 3-1

Project: 6011SNC
SNC: SN050193

Burke County, GA

A seismic reflection occurs when an acoustic wave front encounters an impedance boundary in the subsurface. Seismic impedance depends on both the velocity and density of a rock, and impedance boundaries occur where these rock properties change abruptly, usually due to changes in lithology. The reflection coefficient, R, across an interface, is expressed by a function relating the acoustic impedance of adjacent layers. R determines the relative amplitude of the reflected wavelet.

$$\mathbf{R} = \frac{\sigma_2 \mathbf{V}_2 - \sigma_1 \mathbf{V}_1}{\sigma_2 \mathbf{V}_2 + \sigma_1 \mathbf{V}_1}$$

Where, R = reflection coefficient,

$\sigma_1$, $\sigma_2$ = mass density of the material on each side of the interface, and

$V_1$, $V_2$ = seismic wave velocity on each side of the interface.

The sign of the reflection coefficient determines the polarity of the reflected wave. The magnitude of the reflection coefficient is critical to obtaining usable data. The seismic reflection technique will not work if the acoustic contrast is not sufficient to produce a clear reflection, regardless of the survey parameters or processing techniques employed. The ability of the seismic reflection method to detect an individual sedimentary bed is not only a function of the acoustic impedance at the top and bottom of the bed, but also depends on the layer thickness. The minimum resolvable bed thickness is often quoted as 1/4 to 1/8 of the wavelength at the target depth. Wavelength is inversely proportional to frequency.

When a reflecting boundary exists, it is important to optimize the field procedure and acquisition parameters to maximize the quality of the final processed data. Choosing the best field parameters involves determining the relative importance of several competing objectives, such as site constraints, equipment capabilities and processing needs.

In all geophysical surveys, the objective is to extract the usable data (i.e., in this case, reflections from various lithologic boundaries) from the unwanted background information (source generated and ambient noise). In reflection seismology, it is desirable to record high frequency, high signal-to-noise ratio reflection events from the boundary of interest. The frequency of a reflection event is largely determined by the source input frequency and the filtering effect of the ground. Often, the target reflector frequency is similar to that commonly recorded for coherent noise (in particular, the noise from ground roll), making it difficult or impossible to selectively filter out the noise. Isolation of the reflection events requires careful design of field acquisition parameters, such as the source/receiver geometry, choice of source and receiver types, as well as recording parameters, such as sampling rate and filter settings. The choice of these parameters is discussed in Sections 3.1.2.1.

A seismic source generates a number of seismic events every time it is used. These include the refraction, reflection events and ground roll. Once a certain source-receiver offset is reached (critical distance) the refracted event arrives first. The reflection events occur after the refraction and before the ground roll event.

The application of seismic reflection surveys to environmental investigations began in the 1980's and requires several adaptations to the method. These include the following:

- Ability to generate and use high frequency signals.
- Higher density shot and receiver locations.
- Record at higher sampling rates.

In addition, the processing of the data differs from oil and gas processing because coherent noise events, such as ground roll and refraction events are closer in time and velocity to the seismic. Further information on high-resolution seismic reflection surveys can be found in Steeples (1986, 1997).

## *3.1.2 Seismic Reflection Data Acquisition*

Key elements of seismic reflection acquisition are the seismic source, acquisition geometry and the recording system. Optimal selection and "tuning" of these elements is critical to acquiring high-resolution seismic data. Key requirements for this survey include the ability of the source to accomplish the following:

- Generate a broadband signal, so adequate resolution could be obtained at the target horizons.
- Operate with minimum impact on the environment and ongoing site activities.
- Generate sufficient energy to image targets to depths 1000 feet.
- To record useful seismic signals at the geophones with as high a frequency content as possible.
- To start the low end of the sweep such that the appropriate depth of penetration is achieved without generating intolerable ground roll.

The key parameters in determining the acquisition geometry are the selection of the minimum and maximum offsets (i.e., distances between) of the geophones from the source. The key requirement is that the spacing must produce the ability to image geologic horizons from the surface to 800 feet below surface grade (bsg). The recording system parameters include the selection of geophones and seismograph that must be capable of sensing and recording seismic signals that have an adequate bandwidth and dynamic range to image the targets of interest. The parameters that were selected, as well as the rationale behind their selection, are discussed in the sections that follow.

### 3.1.2.1 Seismic Source

The seismic source selected for these surveys is Industrial Vehicles International (IVI) Minibuggy II for the seismic survey. The Minibuggy vibratory source is capable of generating seismic energy between 6 Hz and 350 Hz with a maximum energy force of 12,000 lbs. This vibratory source creates a frequency-modulated signal by oscillating a mass through a user-defined range of frequencies, which are transmitted into the ground. The use of vibratory sources for seismic exploration was developed in the 1970's and is used extensively for land seismic surveys. The use of a vibratory source instead of an impulse source is for several reasons including the following:

- Ability to generate the high frequencies necessary to image shallow geologic horizons, as well as attenuate low frequencies, which are the main component of coherent noise events, such as ground roll.
- Better signal to noise ratio.
- Lower sensitivity to ambient noise such as traffic.
- Low environmental impact (no discernable noise, shock or penetrations).

A vibratory source functions by holding a plate on the ground and vibrating the plate through a user-defined range of frequencies. This is known as a "sweep." The length of the sweep, peak force and frequency range can be changed during testing. The selection of these parameters is discussed in the next section.

The primary advantage of a vibratory source is that it spreads out the generation of seismic energy over a period of time. Therefore, more energy can be generated by vibratory sources than by other types of seismic sources, such as impact or explosive sources. However, the vibroseis method requires an additional processing step before the data becomes useful. This step is referred to as cross-correlation and is diagrammed in Figure 3-2.

The signal received at the geophones (Trace 2 in Figure 3-2) is actually a sum of a series of source signals from the vibrator (Trace 1) that have been shifted in time. The amount of the shift depends on the depth of the reflecting horizons and the velocities in the subsurface. To obtain the output trace (bottom trace in Figure 3-2), a mathematical algorithm called cross-correlation is used. Using knowledge of the input signal, this algorithm compresses each of the source signals summed in Trace 2 into a simple wavelet. Cross-correlation also produces the added benefit of reducing the effects of ambient noise. Once the cross-correlation is performed, the record is similar to a seismic trace that would be obtained using an impact or explosive source.

Obtaining the input signal from the Minibuggy is critical to performing the cross-correlation. This was done in real time by using a radio link that sends the signal generated by the signal generator to the seismograph. The seismograph uses this signal to correlate with the recorded data received from the geophones. The cross-correlation was performed in real time using GEO-X Aries software through a local area network.

#### *3.1.2.1.1 Vibrator Sweep Testing*

In order to optimize the results from the Vibrator, several tests were run to select or adjust the following parameters:

- Sweep starting and ending frequencies.
- Sweep length.
- Number of sweeps.

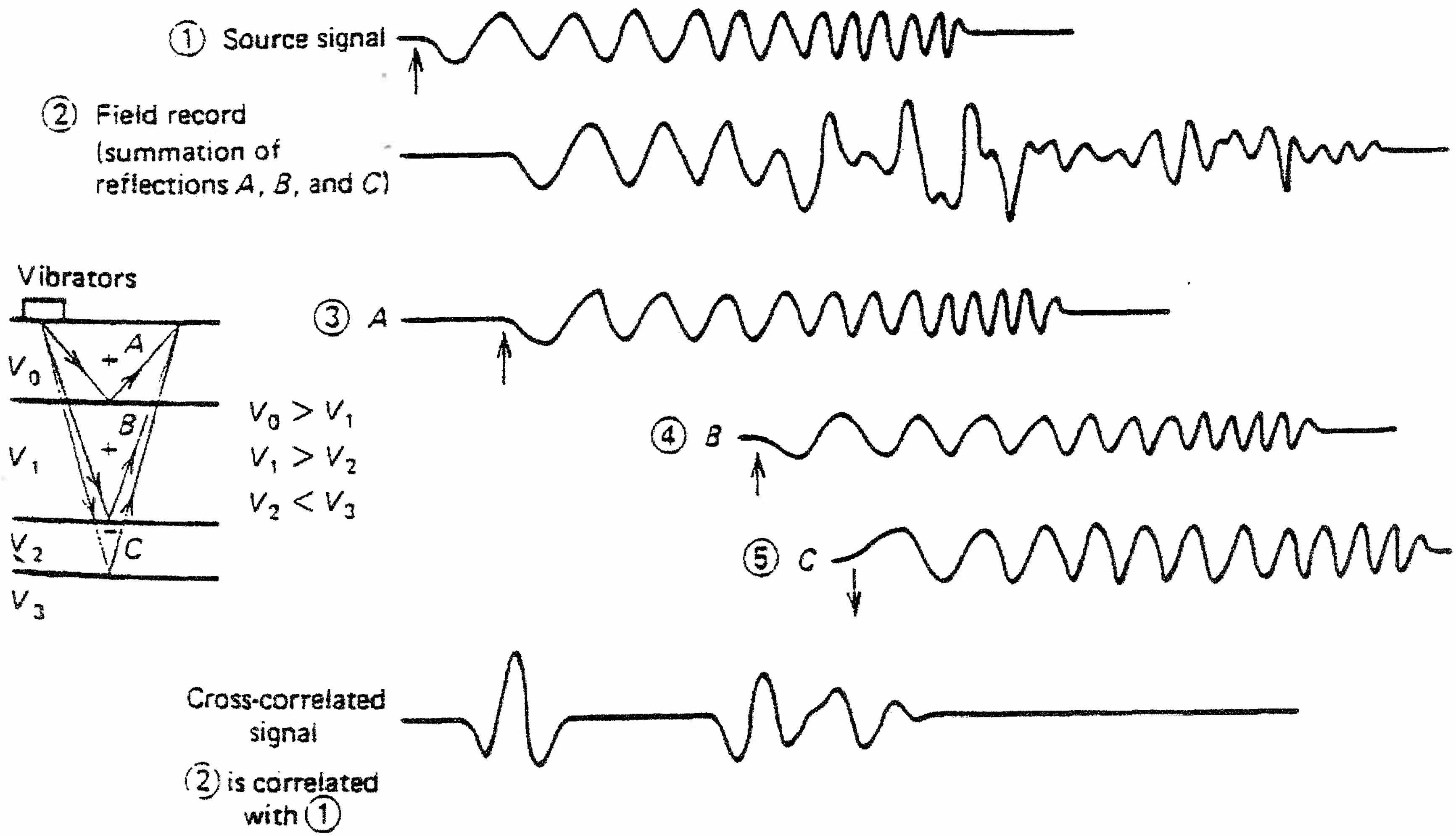


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Diagram of Vibroseis Cross-Correlation Operation

Approved By: NHS

Date: 03/10/06

2.5B - 18

Figure 3-2

Project: 6011SNC
SNC: SN050193

Burke County, GA

### *3.1.2.1.2 Parameter Testing*

The testing was performed along Line 1. The following parameters were tested:

- Sweep frequencies from 20 to 250 Hz.
- Sweep lengths of 6, 8 and 10 seconds.
- 4, 6 and 8 sweeps per station.

High-resolution reflection data may be recorded when geophones acquire a wide range of frequencies with a good signal-to-noise ratio. This is because the wider the range of frequencies in which there is good signal to noise, the better resolution there is to image the subsurface. The frequency content of the recorded signal is a function of several factors including the following:

- Frequencies generated by the seismic source. In the case of the vibrator source, the starting and ending frequencies in the sweep control the range of generated frequencies.
- Attenuation of the subsurface. The Earth tends to attenuate higher frequencies more rapidly than low frequency signals. This means that the Earth acts as a low-pass filter. The result of this is that even though high frequencies may be generated by the source, they may not be received at the geophones, because they have been attenuated by travel through the subsurface.

Another important objective in high-resolution seismic reflection is the minimization of ground roll energy. Ground roll energy is generated by the seismic source itself. Ground roll travels along the ground surface and is akin to the ripples observed on a pond when a pebble is dropped into the water. These surface waves interfere with the measurement of reflected energy from depth because they create vertical motion in the seismic transducers. In surveys for deeper objectives, typically ground roll energy is attenuated by the use of geophone arrays that can extend over 100 feet in length. This is not possible for high-resolution reflection, because these geophone arrays would result in an unacceptable degradation of the near-surface reflections. Therefore, a source that minimizes the amount of ground roll energy is important. The primary method of reducing ground roll is to reduce the amount of energy that is generated in the lower frequency bands, typically 60 Hz or less.

After initial seismic data analysis of field records on Line 1, it was determined that the useable frequency range was 25 to 220 Hz. This frequency range was used for the remainder of acquisition.

## 3.1.2.2 Recording System

### *3.1.2.2.1 Seismograph*

The recording system selected for this survey was the ARAM Aries manufactured by GEO-X Systems, LTD. The ARAM system is a modern engineering seismograph with the following features:

- 1000 plus channel recording
- A/D converter with 24 bit sigma-delta processor (high dynamic range)

- 1 millisecond sample interval
- Analog signal/noise ratio: Less than minus 100 dB, 96 channel
- Maximum samples per channel: 32,000
- Plotter: 6 inch 600 dpi thermal

#### *3.1.2.2.2 Geophones*

The geophones selected for this survey were Oyo Geospace 10 Hz geophones vertical 6 per station. The geophones were connected to Aries RAM boxes using specific seismic cable network (distributive) designed by GEO-X.

## *3.1.3 Data Acquisition*

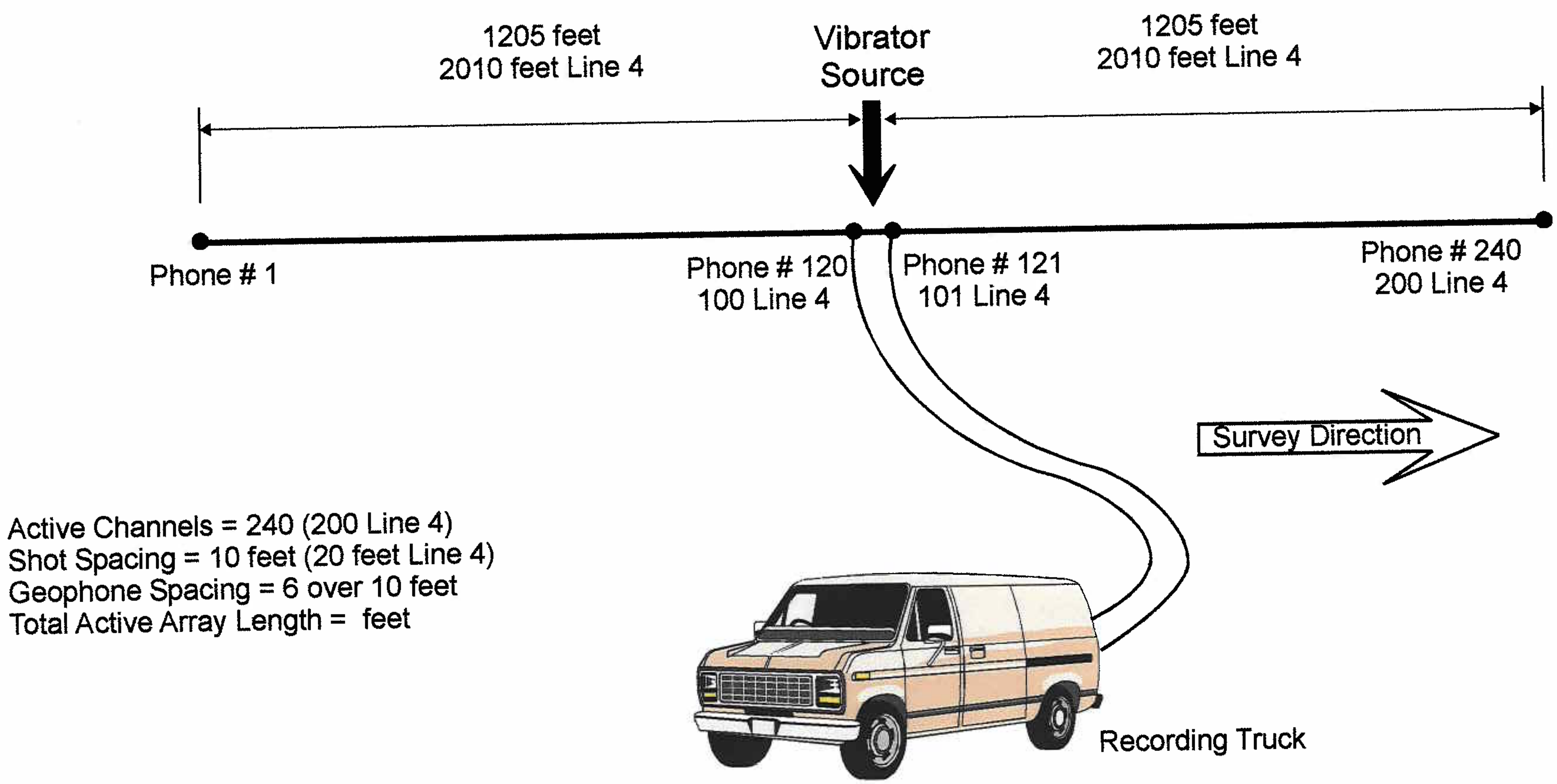
### 3.1.3.1 Data Acquisition Parameters

The seismic lines were acquired with the nominal acquisition parameters shown in Table 3.1.3.1. A diagram of the acquisition geometry is shown in Figure 3-3.

**Table 3.1.3.1**

**Nominal Reflection Acquisition Parameters**

| | |
|---|---|
| Source Interval | 10 feet (20 feet optional Line 4) |
| Receiver Interval | 10 feet (20 feet optional Line 4) |
| Number of Channels | 240, Lines 1, 2 and 3, Auxiliary Trace and Vibrator Signal Input<br>200, Line 4 |
| Nominal CDP Fold | 120, 100 Line 4 |
| Maximum Offset | 1205 feet, 2010 feet Line 4 |
| Minimum Offset | 5 feet, 10 feet Line 4 |
| Spread Geometry | Split Spread |
| Seismograph | GEO-X ARAM 24 |
| Record Length | 6 seconds, 2 second listen |
| Sample Interval | 1.0 ms |
| Seismic Source | Minibuggy<br>25-220 Hz, 6 second sweep, 6 sweeps/station |
| Vibrator Controller | Pelton Advanced System II |
| Geophones | 6 x 10 Hz Oyo |

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# Diagram of Nominal Acquisition Geometry

Approved By: ____________ Date: 03/10/06

2.5B - 21

Figure 3-3

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### 3.1.3.2 Data Quality

The observed frequency content of the seismic data was around 30 to 120 Hz. Depth to target, approximately 1000+ feet bsg, was achieved. The delineation of events below and above target depth was also achieved. The quality of the data is considered good, although there existed some site noise mentioned above and portions of the noisy areas may be attributed to localized geology.

#### *3.1.3.2.1 Coherent Noise*

Coherent noise was observed on the field records as ground roll but was minimal.

#### *3.1.3.2.2 Ambient Noise*

Minimal ambient noise was encountered due to road traffic along the county roads during acquisition. During heavier traffic on all roads, acquisition ceased until after the vehicles had passed. This could be achieved by watching the noise monitoring equipment during data acquisition and communication with the line crew.

### 3.1.3.3 Data Acquisition and Quality Control Procedures

Typical field operations were as follows:

1. At the beginning of each day, a printout was made of a record for an uncorrelated vibrator sweep to ensure that seismograph triggering and vibrator operation was normal. System tests were run at the beginning of each day. These tests include:

    - Channel Test: this is to ensure that each RAM box is working within a specified window and that the gain, harmonic distortion, dynamic range and other parameters are relatively equal for all channels. Channels are flagged individually if any parameter is out of range. If so, the RAM box is immediately replaced. If either of these parameters is out of range during acquisition, the system flags the RAM box as an error so that that particular box can be checked or replaced. An example of this test is provided in Appendix B. The remainder of the tests is on the CDROM labeled TESTS.
    - Internal Automatic Test: This test is to observe the recorder (ARAM) is operating within specific tolerances and basically tests the communications between the recorder and the RAM boxes. An example of this test is provided in Appendix B. The remainder of the tests is on the CDROM labeled Daily Tests.
    - Vibrator Controller Test: This test is to ensure the encoder of the vibrator controller (located in the vibrator) is functioning properly. These tests could not be written to CDROM, therefore copies are provided in Appendix B.
    - Vibrator Controller Observer's Screen: This is not a test. Primarily, this display is viewed during acquisition with specific settings to observe the function of the vibrator. This display shows Total Distortion, Vibrator Output Force (in pounds) and Reference verses Vibrator signal. The later makes sure the vibrator is in phase with the controller. Preset values are entered into this system to alarm the observer of errors in either of these categories. One screen capture per day is provided in Appendix B

2. The noise levels were monitored for the live geophone spread to ensure that the levels were acceptable and that the number of dead channels was at a minimum (zero).
3. Prior to beginning the acquisition of each field record, a check was made of the vibrator position, file number on the seismograph, and status of the seismograph. Any anomalies were noted on the observer's notes. The vibrator operator at every vibrator point checked the vibrator position. Skips, re-acquisitions and offsets were noted on the observer notes.
4. The vibrator was triggered from the recording doghouse, and a sweep is initiated. The record can be correlated using ARAM software, displayed on the screen (every shot location) and printed out at a predetermined interval. The uncorrelated record was stored to hard disk and 8mm DAT tape drive in real time. The first and last file on the tape was played back after move-ups and at the end of the line to ensure no tape errors. The correlated record was also analyzed on screen and checked for proper equipment operation and number of, if any, dead channels.
5. A cable and geophone continuity check to the geophone was performed before the beginning of and during acquisition each day.

#### 3.1.3.4 Processing

The processing flow for the data is based on a standard common depth point reflection processing flow with several enhancements due to the high resolution required for the survey and specific conditions at the site. The processed shot records (or CDP gathers) from each location along the survey line were then stacked to form the trace record. A sample processing flow is provided in Appendix E.

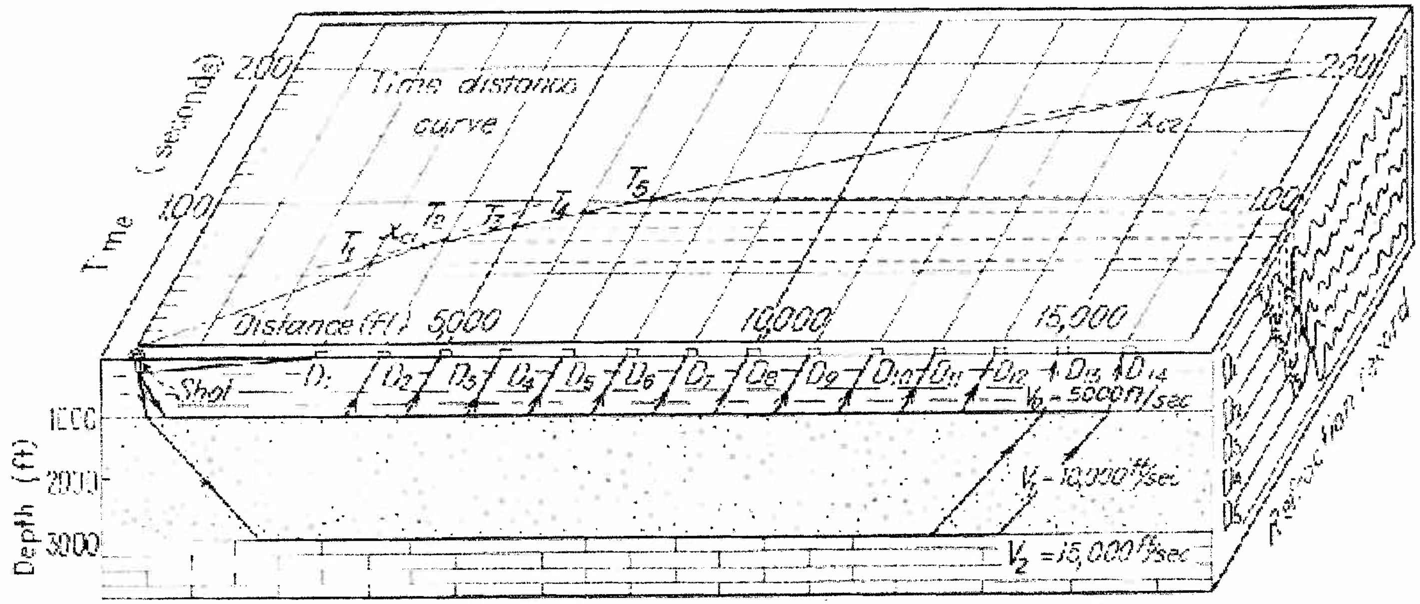
The noise from the Vogtle Plant made it difficult for refraction analysis. This noise overrides refraction, or first break picks, especially near the plant. Therefore, refraction statics were not applied to Lines 1, 2 and 3 for the reflection lines. Only elevation statics were applied to the final stack data. Line 4 had no noise issues and therefore refraction statics and elevation statics were applied to this line.

## 3.2 Seismic Refraction

### *3.2.1 Introduction*

The refraction technique is based on Snell's law: a propagating wave impinging upon an interface between two materials of differing propagation velocities will, at the correct angle of incidence, travel along the interface at the higher of the two propagation velocities. Huygen's principle states that every point along this interface will act as an independent source of acoustic energy as the wave passes. Typically, this method has been used to map depths to interfaces where the propagation velocity of the surface to be mapped is appreciably higher than that of the materials above. Only the onset of the acoustic energy (the time of arrival) is used in a typical refraction mapping application.

Figure 3-4 (Dobrin, 1976) illustrates the wave paths, travel times and a seismic record for a typical application of the refraction seismic method. In the typical refraction seismic method, the slope of arrivals at adjacent receivers is utilized to determine the

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# Refraction Schematic, 3 Layer Case

**(Dobrin, 1976)**

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Figure 3-4

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propagation velocity of that material. The typical application of the seismic refraction method implicitly assumes that the propagation velocity of layered materials in the sub-surface increases with depth.

Seismic refraction techniques are typically employed to determine the thickness and depth of subsurface stratigraphic layers and the velocities of seismic waves within these layers. Simplified, the seismic waves generated at the surface travel at different velocities in various types of soil and rock and are refracted at the interfaces between these layers. The density and elastic properties of the subsurface layers determine the speed or velocity that the seismic wave (in this case, the compressional or P-wave) will travel through the layer. The greater the difference in density and elastic properties between layers the better and more accurate mapping. To successfully map the near-subsurface layer using refraction techniques, preceding concepts then are based on the fundamental assumptions onsite:

1. Seismic velocities of the geologic layers must increase with depth.
2. The geologic layers must be of sufficient thickness to allow detection as defined by the geophone station interval.
3. The seismic velocities of the geologic layers must be sufficiently different to allow the resolution of the individual layers.

### *3.2.2 Seismic Refraction Data Acquisition*

The seismic survey parameter testing was initiated on January 27th on Line 1. Basically, the acquisition of the seismic refraction data was the same as the reflection acquisition including the following:

- The geophone group was changed to 50 feet to allow longer offsets, source to geophone. The source interval was also increased to 100 feet.
- Offend source locations are required to build target depth redundancy at the ends of the seismic lines.
- The entire line(s) were live during acquisition. That is, every geophone at 50 feet was recorded regardless of the position of the vibrator source.

Geophones and related equipment were laid out at 50 foot receiver intervals along Line 1 and energy source testing began on station 301. The sweep parameters remained the same. Source interval progressed down Line 1 at 100 foot intervals, including twenty 100 foot intervals off each end to increase redundancy at the beginning and ends of the line. Off-end stacks could not be acquired beyond the ends of Line 1 due to private property to the west and the plant on the east. Lines 3 and 4 had adequate space for offend acquisition.

Since refraction information was compromised due to plant generated noise observed during seismic reflection acquisition, it was decided by an SNOC representative that refraction acquisition not be conducted along Line 2 that runs close to the west end of the generating plant.

## 4.0 DELIVERABLES

All deliverables are provided in the Appendix portion of this field report. The deliverables, as stated in the proposal, are of the following and a brief description of the deliverable is described separately below.

### 4.1 Appendix A Observer's Logs

Observer's logs are a means by which the observer can identify which channels are live on the ground, the source position, the file number that is being recorded, the time in which the file was recorded, all parameters pertaining to the specific line that is being acquired and any comments that relate to acquisition, field conditions, etc. These items are necessary to assist the seismic data processor during front end input of the data called geometries. The files are in Excel ® spreadsheet format.

### 4.2 Appendix B Daily Tests

Daily tests, as mentioned before, were run to ensure proper function of the recording system. Included are:

- Channel Tests: individual channel testing
- Auto Tests: seismic recorder testing, communications with the seismic line
- Vibrator Status: checking the encoder of the seismic controller
- Vibrator Functionality: observe the vibrator sweep is during acquisition

The channel tests and auto tests could be written to disc and are therefore provided on CDROM in this appendix. They are ASCII files and can be read with any word processing program.

### 4.3 Appendix C Survey Data

The survey data was acquired by Georgia Power. After completion of the surveys, the data was provided in ASCII format of eastings, northings, elevations and station numbers to be sent to the seismic processors.

The 10-ft and 20-ft prefixed *.txt files are the seismic reflection line coordinates. The 50-ft and 100-ft prefixed *.txt files are the seismic refraction coordinates.

## 4.4 Appendix D Field Data for Reflection and Refraction

The raw field records are provided in SEG standard SEGY format for both the reflection and refraction data are provided on DVD. The reflection data are raw uncorrelated field files and the refraction data are both correlated and uncorrelated.

## 4.5 Appendix E Paper Plots and SEGYs of Reflection Data

All four seismic reflection lines are plotted in trace amplitude. Only the first version, Stack 1 is plotted but all subsequent process is provided on CDROM. The processes are:

- Stack 1: Normal stack of the seismic reflection data
- Stack 1 FX: FX decon applied to the stack
- Stack 1 WHTFX: FX decon and spectral whitening applied to the stack
- Stack 1 WHTFX MIGR: FX decon, spectral whitening and migration applied to the stack
- VEL RMS: These are the stacking velocities used to process the data. Instead of time amplitude pairs, these data are time velocity pairs.
- The final static for each reflection line CDP is provided in ASCII format. These files are Line number totstat.a_db.

A data input loading form and example processing side label is also included in this section. This loading form tells where the easting and northing information is located in the trace headers.

## 4.6 Appendix F Paper Plots and Refraction Data and Depth Migration Data

The three refraction and depth migration profiles for Lines 1, 3 and 4 are plotted and included in this appendix. The plots are also provided in Adobe® .PDF format on the CDROM in this appendix. Also included in this appendix are:

- A text or ASCII file that provides all the output X, Z and Vp values used to render the 2-D Vp models in a graphic format. This is a .txt file and .vel file.
- A file containing or otherwise documenting the first-arrival picks used in the velocity inversions. This is a *.brk file.
- Pre Stack Depth Migration seismic profiles in .PDF and SEGY format.
- Report on the seismic refraction and depth migration technique and procedures.

A letter report describing the specific processing flow used to produce the depth-migrated images was not available at the time of this report. This report will be provided once the depth migration portion of this analysis is complete.

## 4.7 Appendix G Miscellaneous Information

This appendix exhibits other pertinent information used to justify checking of the geophones prior to mobilization, daily logs, variance logs and crew sign in sheets. Specifically they are:

- Daily logs showing day to day activities during acquisition.
- Variance logs show that tests were run during acquisition to improve data quality. These logs primarily describe the issue at hand, what change was made to improve the issue (variance) and that a field representative has concurred.
- Geophone check sheet by Cadillac Geophysical Services. These checks include measuring the resistance of the geophone string and making sure they fall in within a specified tolerance in ohms. This is to ensure that all geophones are hooked up in the string. An impulse check is to make sure that all geophones have the same response as the reference string. This includes amplitude and phase of the response.
- Crew sign in sheets are to discuss field activities each morning prior to going to the field. These meetings are similar to tailgate safety meetings to discuss any activities prior to the morning that my pose as a safety issue so that all hazards are addressed and to promote safety. No occurrence of injuries was discovered during seismic data acquisition activities at the Vogtle facility.

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