RETURN to Jim Andersen

M-135[redacted]

(Full Repor[redacted]

WELL COMPLETION REPORT FOR FLORIDAN AQUIFER WELL RO-4

Prepared for Martin County Environmental Services

September, 2000

Stemle, Andersen and Associates, Inc.

ENVIRONMENTAL & HYDROLOGIC CONSULTANTS

FLORIDAN AQUIFER WELL COMPLETION REPORT FOR PRODUCTION WELL RO-4

MARTIN COUNTY ENVIRONMENTAL SERVICES

MARTIN COUNTY, FLORIDA

Prepared for

Hutcheon Engineers
A Division of
Kimley Horn and Associates, Inc.
4431 Embarcadero Drive
West Palm Beach, Florida 33407

September, 2000

Prepared by
Stemle, Andersen and Associates, Inc.
5307 Pennock Point Road
Jupiter, Florida 33458

James L. Andersen, P.G.
Principal Hydrogeologist
Licensed Professional Geologist #1103

Stemle, Andersen & Associates, Inc.

ENVIRONMENTAL AND HYDROLOGIC CONSULTANTS

7327 Catalina Club Circle
Lake Worth, Florida 33467
(561) 649-5369
(561) 649-2390 FAX

5307 Pennock Point Road
Jupiter, Florida 33458
(561) 745-9545
FAX (561) 745-9549

October 6, 2000

Ms. Dana Branscum, P.E.
Kimley-Horn and Associates
4431 Embarcadero Drive
West Palm Beach, FL 33407

Re: Martin County Environmental Services
RO-4 Well Completion Report

Dear Dana:

We are pleased to transmit the final well completion report for Martin County Environmental Services Floridan Aquifer Well RO-4. A complete set of geophysical logs is included with the report as Appendix B.

We appreciate the opportunity to provide our services for this project. Please do not hesitate to call if we can be of further assistance.

Sincerely,
Stemle, Andersen & Associates, Inc.

Amanda J. Krupa

Amanda Krupa, P.G.
Senior Hydrogeologist

Enclosures

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

This report documents the procedures, testing, as-built construction details and recommendations for Floridan Aquifer production well RO-4 for Martin County Environmental Services. The project site is located in Jensen Beach, Martin County, Florida, in Section 17, Township 37 South, Range 41 East, as indicated on Figure 1. Well RO-4 is located north of Jensen Beach Boulevard, on the east side of the future extension of Deer Oak Drive. The well is less than one mile east of Federal Highway, and approximately 2,300 feet northeast of the North Martin County Treatment Plant as shown on Figure 2.

The North Martin County Water Treatment Plant produces potable water for Martin County using reverse osmosis treatment under South Florida Water Management District Water Use Permit No. 43000102-W. Well RO-4 increases Martin County's Floridan Aquifer brackish raw water capacity to approximately nine million gallons per day (MGD).

2.0 WELL CONSTRUCTION AND TESTING

Hutcheon Engineers, a division of Kimley-Horn & Associates, Inc., and Stemle, Andersen and Associates, Inc. prepared technical specifications and conducted onsite observation during construction, well development, and aquifer performance testing.

2.1 Drilling Methods

Well RO-4 was constructed by Youngquist Brothers, Inc. of Fort Myers, Florida. Construction observation, development and testing were performed by Stemle, Andersen and Associates, Inc. (SAA) and Hutcheon Engineers. The methods and materials used by the drilling contractor were in accordance with 1) Technical specifications outlined in the contract document, 2) the standards of the American Water Works Association for Deep Wells (AWWA A100-90) and the National Water Well Association, and 3) South Florida Water Management District and Florida Department of Environmental Regulation rules and regulations. Well construction commenced on May 22, 2000 and was completed on August 25, 2000. The location of the well is shown in Figure 2. The drilling and casing depths are provided in Table 1. A schematic diagram of the well is provided as Figure 3. The drilling procedures used for the well are described below.

A nominal 36-inch diameter borehole was drilled to a depth of 203 feet below land surface (BLS) using the mud rotary method. The borehole was circulated to clear the cuttings from the mud and to prepare the hole for logging and setting of the surface casing. Geophysical logging (SP, resistivity, caliper, and gamma ray) was performed by Florida Geophysical Logging, Inc. as described in Section 2.7. The surface casing is 30-inch diameter, 0.375-inch thick steel pipe with factory-beveled ends. During installation, the ends were welded together, and centralizers were welded onto the casing at 40-foot intervals. Final depth of the casing installation was 199 feet below land surface (BLS). Upon completion of the casing installation, the annular space surrounding the casing was pressure grouted in a single stage-using API Class B Portland Cement, with 118 barrels of a 6% bentonite mixture followed by 65 barrels of neat cement. The cement was allowed to cure before drilling was resumed.

After drilling out the cement plug, a nominal 12-inch pilot hole was advanced from the base of the surface casing to a depth of 900 feet BLS. The pilot hole was drilled using the mud rotary method and a 12 ¼-inch bit. Lithologic samples were collected during drilling from the circulating mud. A field lithologic log was maintained by SAA. Pilot hole drilling continued until suitable competent limestone was encountered near the top of the Floridan aquifer. The maximum drilled depth of the 12-inch pilot hole was 900 feet BLS. After the pilot hole was completed, drilling fluid was circulated to clear the hole of cuttings, and to prepare the hole for logging. Geophysical logging (SP, resistivity, caliper, and gamma ray) of the pilot hole was performed by Florida Geophysical Logging, Inc. as described in Section 2.7.

Following logging, the pilot hole was reamed to 24-inches in diameter using the mud rotary method and a staged bit assembly consisting of a 12-inch diameter lead bit and a nominal 24-inch diameter reamer bit. To keep the reamed hole from deviating from the pilot hole, weight on the bit was kept to a minimum; with the drill string held plumb by the drill collars and bit assembly. After circulating the drilled cuttings and conditioning the drilling fluid, the drilling tools were removed and Florida Geophysical Logging, Inc. conducted caliper logging on the 24-inch reamed hole, as described in Section 2.7. Logged depth of the reamed hole was 895 feet BLS.

The 18-inch diameter intermediate casing string was installed into the 24-inch diameter borehole to a depth of 895 feet BLS. The intermediate casing consisted of 0.375-inch steel pipe, with factory-beveled ends, which were arc-welded together during installation. The top of the 18-inch casing string was completed at 176-feet BLS, and overlapped the 30-inch diameter surface casing by 23 feet. The intermediate casing was pressure-grouted using API Class B Portland cement. The initial grouting stage was neat cement for maximum strength near the base of the casing. Subsequent grouting stages included a 6% bentonite mixture. Grouting continued until the annular space between the 18-inch casing and the 24-inch borehole was completely filled with cement.

After the cement cured, drilling resumed using the reverse-air rotary method. Drilling was conducted using formation water with added clear water for drilling fluid. A nominal 17-inch diameter borehole was drilled from the bottom of the 18-inch casing to a total depth of 1,375 feet BLS. Lithologic samples were collected during drilling, and the field lithologic log was maintained by Stemle, Andersen and Associates, Inc. Flow testing was conducted during drilling of the 17-inch borehole. Upon reaching the total depth, the driller cleared the borehole of drill cuttings. Florida Geophysical Logging, Inc. conducted borehole logging (SP, resistivity, caliper, gamma ray, fluid conductivity, flow velocity, and temperature) as described in Section 2.7.

The final casing depth of 1,065 feet BLS was determined based on lithologic samples, water quality data, flow test results, geophysical logs, and flow and water quality logs. The primary objective was to select an interval within the Floridan aquifer with the best water quality and high permeability. The selected interval must have competent formation material to minimize erosion and the subsequent contribution of particulate matter to the raw water. The interval that was selected is a flow zone sequence within the Avon Park formation (described in more detail in Section 3.1). The final casing string consisted of 140 feet of 16-inch diameter PVC casing and 925 feet of 12-inch diameter PVC casing. The two casing strings were connected by a 16- by 12-inch reducer bushing. The PVC casing was Certainteed, Certa-Loc, SDR-17 lock coupling PVC casing. The annular space surrounding the PVC casing was grouted with neat cement to land surface. Cementing was conducted in stages to minimize grouting stress on the PVC casing.

2.2 Water Quality Testing During Drilling

During reverse-air drilling in the Floridan aquifer, temperature, specific conductance and chloride concentration of the formation water were measured at regular intervals. Water samples were collected from the reverse-air discharge after the bit drilled at the desired sampling depth. Lag time (time it takes for the fluid or cuttings to be brought to the surface) was monitored at the onset of drilling following each drill rod change to ensure that samples were being obtained from the desired depths. At approximately every ten feet during drilling, temperature and specific conductance of the formation water were recorded. Additionally, after every ten feet or significant change in specific conductance, a water sample was collected for chloride analysis. Temperature and specific conductance measurements were conducted using a YSI model 3000 SCT meter. Performance of the meter was checked on a regular basis against reference standards. Chloride analysis was performed using a Hach titrator and silver nitrate titrant. A summary of the water quality data collected during drilling is provided in Table 2.

2.3 Flow Testing During Drilling

During reverse air drilling through the Floridan aquifer, flow tests were performed to evaluate the specific capacity of the penetrated open interval. The tests were performed after every drill rod change (approximately every 30 feet). To perform the test, a construction header was fitted to the flanged 30-inch diameter surface casing and sealed to the drilling tools with a rotating head. The header and rotating head effectively sealed the wellhead so that the well could be drilled under "live" artesian conditions. The construction header was equipped with a valve, a 12-inch diameter flow port, a 2-inch diameter port for adding brine "kill" water, and a ¾-inch manometer fitting. A manometer tube was fitted to the construction header to measure the potentiometric (or static) water level which reached as high as 22 feet above land surface (39.75 ft NGVD).

During testing, the flow rate was measured using an in-line flow meter installed in the 12-inch diameter PVC line that discharged to a lined pond. Water levels in the well were measured during the pump test and compared to static, no-flow conditions measured at the beginning of each day and after each test. Measurement of flow rate (Q) and drawdown in the well (Δh) allowed calculation of specific capacity (C_s) of the well to be approximated using the formula $C_s = Q/\Delta h$ (Freeze and Cherry, 1979).

Table 2 includes a summary of the static and flowing water levels from flow tests conducted during the reverse air drilling phase.

2.4 Well Acidization

Well RO-4 was acid-treated on July 11, 2000 to increase specific capacity. The acidization procedure involved inserting 1,200 feet of drop tubing in the well, pumping 5,000 gallons of 32 percent hydrochloric acid into the open interval at a rate of 120 gallons per minute (gpm). Following the acid injection, approximately 2,500 gallons of potable chase water were pumped into the well at a rate of 47 gpm. During pumping, the wellhead was sealed and fitted with a pressure gauge to monitor pressure within the casing. A relief valve and gas discharge hose was in place on the wellhead to vent off excess pressure in the well if needed. Pressures were monitored continually during the process. Following the procedure, the well remained undisturbed until July 12 when well development was resumed.

Prior to acidization, the specific capacity was measured to be 56.6 gpm/ft at an artesian flow rate of 840 gpm. A pump was not yet installed in the well so the specific capacity could not be determined at a higher rate. To determine the percent improvement resulting from acid treatment, the first step of the step drawdown test is used for the comparison. At the 830 gpm pumping rate, the specific capacity was 104.4 gpm/ft. This represents an 84 percent increase in specific capacity resulting from the acid treatment.

2.5 Well Development Pumping

The well was developed using a diesel-powered, vertical turbine test pump equipped with a ten-inch diameter pump and column pipe. Formation water was discharged to a lined pond via an underground 12-inch diameter PVC raw water main. The pond was regularly discharged to a nearby creek via stormwater discharge piping along Jensen Beach Boulevard.

Initially, the well was pumped at a maximum steady rate until the discharge water was visibly free of solids and turbidity. The maximum flow rate attained was approximately 2,800 gpm. Following the steady flow period, the well was pumped intermittently with surge and rest periods. Development progress was measured by performing silt density index (SDI) testing of the raw water. Additionally, the specific capacity of the well was measured on a daily basis during development to evaluate progress of improvement in well performance. Development began on July 14, 2000 and continued until July 21, 2000. SDI test results at the end of development had dropped to a value of 3.7. It is recommended that the utility continue pumping the well after the permanent pump is installed, and monitor SDI values until they are reduced to a value less than one (1).

2.6 Drawdown Testing

After completion of acidification and well development, a step-drawdown test was performed on the well using the development pump and discharge setup. The completed well was pump-tested to assess well yield and anticipated drawdown, and to aid in final pump selection. The flow rates for the test were measured by SAA with an in-line flow meter that was calibrated just prior to the start of the project. Prior to starting the test, the static water level was measured with the use of an elevated manometer tube. The measured static water level was 24.10 feet above land surface (41.85 feet NGVD) on July 24, 2000. The step-drawdown test was conducted at 830, 1210, 1575, 2210 and 2980 gpm. These rates generally bracketed the proposed pumping rate of 1580 gpm for the well upon its completion. Water quality samples, including temperature, specific conductance, and chloride were collected at the end of each test step. SDI testing was also performed by SAA staff. . The results of the step drawdown test and water quality results are included in Table 3. SDI results ranged from 3.8 to 5.3 during the drawdown test. The results indicate that the well needs additional pumping to remove silt.

The drawdown data were used in conjunction with the pumping rates to obtain an estimated specific capacity value of 68 gpm/ft for the well at the proposed pumping rate of 1580 gpm. It is estimated that at a pumping rate of 1580 gpm, the water level will drop to approximately land surface, as seen during testing.

2.7 Geophysical Logging

Various borehole logs were conducted at each stage of well construction. The logs were used to aid in the decision-making and data-gathering process to determine hole dimensions, casing setting depths, geologic formation characteristics, water quality, and flow zone and aquifer characteristics.

An initial series of downhole logs was run on May 24, 2000, following the drilling of the 36-inch diameter hole to 199 feet BLS. The logs included spontaneous potential (SP), resistivity, caliper, and gamma ray.

A second series of logs was run on May 31, 2000, following the completion of the 12-inch pilot hole to 900 feet BLS. The second set included SP, gamma ray, resistivity, and caliper logs. On June 6, 2000, after the pilot hole was reamed to 24 inches in diameter, a caliper log was run on the reamed hole for installation of the intermediate casing.

On June 21, 2000, a final series was run after completion of the open interval from the bottom of the 18-inch casing to 1,375 feet BLS. These logs included SP, resistivity, caliper, gamma ray, fluid conductivity, flow velocity, and temperature.

The flow velocity log revealed the most productive zone from approximately 1190 to 1290 feet BLS. These results correlate well to the location of the production zone predicted from geophysical logging of nearby production wells.

All geophysical, flow, and video logs were recorded by Florida Geophysical Logging, Inc. Supervision was performed by an SAA hydrogeologist. Copies of the geophysical logs are included in Appendix B.

2.8 Video Log

A downhole television survey was run on the entire depth of the completed well on July 28, 2000. The video was performed by Florida Geophysical Logging, Inc. The video survey enabled inspection of the condition of the final casing string as well as the open-hole interval to the 1375-foot total depth of the well. The video showed that the PVC casing was in good condition, aside from some vertical scrape marks on the casing walls. The reduction from 16-inch to 12-inch diameter casing was apparent at 144 feet BLS, and the bottom of the 12-inch casing was noted at 1068 feet BLS. (These depths are slightly deeper than the actual depths verified by other methods.)

Just beneath the bottom of the casing, the open hole at 1074 feet BLS showed evidence of smooth cement that apparently invaded through the gravel during grouting of the casing. The borehole was clear to a depth of 1255 feet, with wide areas noted at 1093 and 1155 feet BLS. Smooth, uniform areas were noted at 1136-1137, 1160-1161, and 1188-1199 feet BLS. A large slab of rock was noted at 1202 feet, which sloughed off during video logging. At 1230 to 1232 feet, the color of the formation changed to dark gray. Below 1260 feet turbidity increased, in conjunction with a significant decrease in flow. The highly turbid, low-flow condition persisted throughout the remaining interval. At 1374.6 feet BLS, the video went black as the camera reached the bottom. A copy of the video log is included with this report.

3.0 HYDROGEOLOGY

Beneath northern Martin County, there are two major aquifer systems, the Surficial Aquifer System (SAS), and the deeper Floridan Aquifer System (FAS). They are separated by a thick confining unit. The drilling of RO-4 penetrated the full thickness of the SAS, and partially penetrated the FAS. Well RO-4 was drilled to a total depth of 1,375 feet BLS. A hydrogeologist from Stemle, Andersen & Associates, Inc. was present during key phases of the drilling to collect lithologic samples and log the geologic formation materials encountered. The resulting lithologic log is provided in Appendix A. A generalized hydrostratigraphic section showing the typical lithologies, aquifers and formations encountered during drilling is provided as Figure 4.

3.1 Surficial Aquifer System

In descending order from land surface, the SAS formations include the Pamlico Sand, Anastasia, Fort Thompson, and the Tamiami Formation (Lichtler, 1960).

The thin covering of sand present over most of South Florida is known as the Pamlico Sand. It consists of fine- to medium-grained loose quartz sand grains, loose detrital clay and shell, and may be cemented as cap rock near the top of the present or previous water table surface. At RO-4, sand extends to a depth of about 40 feet beneath the site where it becomes interbedded with sandstone and shell. Because the Pamlico Formation does not have a distinct lower boundary, the exact depth is not known. The Anastasia Formation underlies the Pamlico Formation and comprises the majority of the SAS in this region. The Anastasia Formation ranges in composition from coquina ("beach rock") to pure quartz sand, often with varying mixtures of shell, sandy limestone, and sandstone as well. In Martin County, the Anastasia Formation is composed of sand, shell beds, and thin, discontinuous layers of sandy limestone or sandstone (Lichtler, 1960). Here, vertical changes in lithology tend to follow a downward progression from unconsolidated sand and shell to calcareous sandstone and limestone. Sandstone and limestone units in the Anastasia make up the water-producing zone of the surficial aquifer in this area.

Underlying the Anastasia Formation in this area is the Tamiami Formation (Pliocene age), and/or the formations of the Hawthorn Group (Miocene age). Specific depths and even presence of these units are unclear in the available literature, as it is difficult to distinguish between the Tamiami and the Hawthorn Group. With depth, the sand, shell, sandy limestone and sandstone underlying this site undergo a downward fining trend and become the underlying confinement of the SAS. At this site, the basal confining unit of the SAS occurs at a depth of approximately 180 feet, where marl, clay and interbedded sandstone predominate.

3.2 Intermediate Confining Unit

The intermediate confining unit consists of the relatively impermeable calcareous clays and silts of the Hawthorn Group. The Miocene-aged Hawthorn sediments consist of dense, olive gray, clayey, unlithified lime mud, fine- to very-fine-grained quartz and phosphate sand and silt. Also present are beds of shell and sandy limestone within the upper and lower reaches of the unit. Here, the intermediate confining unit is approximately 560 feet thick, extending to a depth of 737 feet beneath the site. The predominately clayey upper section of the unit is known as the Peace River Formation.

The sandy-phosphatic limestones and phosphatic lime muds and that underlie the Peace River Formation are of the Arcadia Formation. These occur to a depth of 860 feet and although they are part of the Hawthorn Group, the permeable beds are considered to be part of the Floridan aquifer and may produce considerable amounts of water.

3.3 Floridan Aquifer System

The Floridan Aquifer System (FAS) is a confined aquifer that underlies the low-permeability beds of the intermediate confining unit. The brackish upper portion, referred to as the upper Floridan aquifer, has been classified by the Florida Department of Environmental Regulation as an underground source of drinking water (USDW) because it has a total dissolved solids (TDS) concentration of less than 10,000 mg/l.

The upper Floridan is composed predominantly of interbedded limestones and dolomites of late Miocene to middle Eocene age. Four primary rock units comprise the upper Floridan aquifer. From approximately 737 feet beneath the site, in descending order, these units are the Arcadia Formation limestones (Miocene age), Suwannee Limestone (Oligocene age), Ocala Group and the Avon Park Limestone (Eocene age). The uppermost rock unit (Arcadia) was cased off by the intermediate casing string because of poor consolidation.

The maximum depth penetrated during drilling was 1,375 feet. The lithology approaching the terminus of the well consists of interbedded, microcrystalline limestone, dolomitic limestone, and dolomite.

The producing zones within the Floridan aquifer can generally be referred to as "flow zones". A flow zone is typically a thin sequence of highly solutioned rock where water, flowing within the aquifer, is concentrated. Numerous thin flow zones may convey water to the open interval of a well and quite often, a high percentage of the water produced by the well comes from one or two thin flow zones.

Based on the lithologic logs, geophysical logs and wellhead flow data, the most productive flow zones occurred between approximately 1,190 feet and 1,290 feet BLS. These depths correspond to the same highly productive zones of the Avon Park limestone found in wells RO-1, RO-2, and RO-3. For the purposes of this report, this interval will be referred to as the mid-Floridan production zone.

Because the flow zones are typically separated from each other by continuous sequences of low permeability strata, water quality may very significantly with depth. As was found in similar wells drilled for Martin County water quality improves slightly with depth in the open interval of the well.

3.4 Floridan Aquifer Head Pressures

The aquifer artesian head was measured while drilling RO-4 to determine static head within the aquifer. Static head measurements were obtained using a manometer tube that was connected to the construction wellhead assembly and elevated by fastening the tube to the rig derrick. Static water levels were monitored during drilling; the measurements are summarized in Table 2. Upon completion of drilling and before commencement of the step-drawdown test, RO-4 had a static water level of 24.10 feet above land surface (approximately 41.85 feet NGVD). Results of the step-drawdown test are summarized in Table 3.

An increase in head was expected after penetrating the mid-Floridan production zone, as was the case in RO-3, where there was a significant change in head. However, that trend was not clearly evident during drilling of RO-4. It may be possible that there has been a decrease in head in the aquifer due to regional withdrawals.

4.0 PREDICATED DRAWDOWNS

Well RO-4 will experience two types of drawdown when it is pumped during the useful life of the well. The first type of drawdown is due pumping the well. The amount of drawdown in the well is a function of its specific capacity (pumping / drawdown rate). The second type of drawdown RO-4 will experience is the overall drawdown in the aquifer resulting from the withdrawals of surrounding existing and future wells completed in the same depth interval. This is known as wellfield drawdown or well interference effect. The amount of interference is dependent on the proximity of the surrounding wells. Based on the drawdown test results upon the completion of the well, RO-4 should maintain a pumping head approximately one foot above ground level at a pumping rate of 1580 GPM for now, although it may decrease as the aquifer yield decreases with the addition of more users.

5.0 CONCLUSIONS

The following conclusions are made based on results of the drilling and testing conducted during wellfield construction.

1. Floridan aquifer production well, RO-4, was constructed for Martin County Environmental Services between May 22, 2000 and August 25, 2000. The well was constructed in three casing strings, which enabled testing of the upper Floridan aquifer for productivity and water quality prior to installation of the final PVC casing string. Total depth of RO-4 is 1,375 feet.

2. At the design pumping rate of 1,580 gpm, the specific capacity value for well RO-4 is expected to be 68 gpm/ft, with a pumping water level of one foot above ground surface.

3. The chloride concentration in the groundwater sample collected from well RO-4 after pump testing was 775 mg/l. Average chloride concentration of all samples collected during pump testing was 756 mg/l.

4. The SDI test result at the end of development was 3.7. The SDI value can be expected to decrease to less than 1 with continued pumping using the permanent well pump before the well is placed into operation.

5. During testing, the static head in RO-4 was 24.1 feet above land surface, or approximately 41.85 feet above MSL (NGVD).

6. Most of the flow entering the well is produced from a 100-foot thick sequence of dolomite and limestone beds in the Avon Park Limestone. The best flow zones were encountered at an upper depth of 1,190 feet in the well. This interval correlates to the same zones found in wells RO-1, RO-2 and RO-3.

6.0 RECOMMENDATIONS

1. Before placement into operation, the well should be pumped to waste to reduce SDI values to less than one (1). The permanent well pump fitted to RO-4 will be satisfactory for this purpose and may be accomplished during the typical pre-startup testing of the well.

2. At the design flow rate of 1,580 gpm and without significant interference from other wells, the pumping water level in the well should be above land surface. The South Florida Water Management District (SFWMD) requires that Floridan aquifer wells in Martin County only be pumped at their land surface artesian flow rate. The operation of other nearby wells will lower the static water level in RO-4 and thereby lower the pumping level. A computer model impact analysis should be performed to evaluate the amount of drawdown this well will experience so that an appropriate pump setting depth can be determined.

3. In time, incrustation of the borehole may cause the specific capacity to degrade and pumping levels to decline. The incrustation is primarily composed of calcium carbonate, and hydrochloric acid treatment is typically an effective remedy for this condition. Acid treatment should be performed on the well if the specific capacity falls more than ten percent.

4. Water levels should be monitored in RO-4 and existing wells RO-1, RO-2 and RO-3. Water levels should be collected weekly on pumping wells and at least monthly on non-pumping wells. Not only will this confirm that pumping equipment is operating within design criteria, but it will allow tracking of well performance and forecasting of well problems.

5. A monitoring program will also provide background Floridan aquifer water levels, as competition for the resource escalates over time.

6. Water quality samples should be collected monthly from pumping wells and at a minimum, analyzed for chloride and specific conductance. Well pumping should be rotated so that all wells are used and monitored. Any time a water sample is collected, a minimum of three casing volumes of water should be purged from the well prior to sample collection. The Floridan aquifer is a leaky aquifer with varying water quality both vertically and horizontally. Additionally, water quality within the open interval of the well varies with depth and ranges from 725 mg/l to 1810 mg/l chloride. Given this, water quality at RO-4 is expected to vary. We anticipate that the chloride concentration will be at the low end of this range, but monitoring will better establish the actual range. Rotation of well usage minimizes the stress on the aquifer in any one area and will help to limit degradation of water quality.

7. The well construction method specified for this project has proven to be reliable, with fewer construction problems encountered than with alternate techniques on similar wells. This method allows testing of the aquifer at depth for collection of reliable data on aquifer properties and water quality. This method is recommended for future wells constructed for Martin County Environmental Services.

7.0 REFERENCES

Freeze, R.A. and Cherry, J.A., 1979. Groundwater. Prentice-Hall, Inc. Englewood, N.J., 604 pp.

Lichtler, W.F., 1960, Geology and Groundwater Resources of Martin County, Florida. U.S. Geological Survey Report of Investigations No. 23.

Lukasiewicz, J. and Smith, K., 1996. Hydrogeologic Data and Information Collected from the Surficial and Floridan Aquifer Systems, Upper East Coast Planning Area. South Florida Water Management District Technical Publication 96-02, West Palm Beach, Florida. 224 pp.

Miller, W.L. 1980. Geologic Aspects of the Surficial Aquifer in the Upper East Coast Planning Area, Southeast Florida. U.S. Geological Survey Open File Report 80-586. 2 sheets.

Nealon, D., Shih, D., Trost, S., and others, 1987. Martin County Water Resource Assessment, Martin, Florida. South Florida Water Management District, Resource Planning Department.

Parker, G.G., Ferguson, G.E., Love, S.K., 1955. Water Resources of Southeastern Florida. Water Supply Paper 1255. United States Geological Survey. Washington D.C. 965p.

Stemle, Andersen & Associates, Inc., 1998. Floridan Aquifer Wellfield Expansion, Results Of Existing Water Use Inventory And Aquifer Drawdown Modeling For The North Martin County Reverse Osmosis Plant, Jensen Beach, Florida.

Stemle, Andersen & Associates, Inc., 1999. Well Completion Report for Floridan Aquifer Well RO-3. Prepared for Martin County Utilities and Hutcheon Engineers. 20 pp.

TABLES

TABLE 1

WELL CONSTRUCTION DETAILS

MARTIN COUNTY ENVIRONMENTAL SERVICES
PRODUCTION WELL RO-4

	CASING DETAILS										
TOTAL DEPTH (FEET)	**OUTER CASING**			**INTERMEDIATE CASING**			**INNER CASING**			**OPEN HOLE COMPLETION**	
	TYPE	DIAM. (in.)	DEPTH (ft.)	TYPE	DIAM. (in.)	DEPTH INTERVAL (ft.)	TYPE	DIAM. (in.)	DEPTH (ft.)	DIAM. (in.)	DEPTH INT. (ft.)
1375	STEEL	30	199	STEEL	18	176 - 893	SCH 80 PVC	16/12	140/1065	17	1065-1375

Abbreviations:
Ft. - feet
DIAM. - Diameter
INT. - Interval
in. – inches
PVC - Polyvinyl chloride
SCH 80 - Schedule 80

Depths are feet below land surface.
PVC casings used in RO-4 were Certa-Lok (TM) type, manufactured by CertainTeed Corporation, Social Circle, Georgia.

TABLE 2

WATER QUALITY AND WELL FLOW CAPACITY SUMMARY

MARTIN COUNTY ENVIRONMENTAL SERVICES
PRODUCTION WELL RO-4
DRILLING DATA (FROM 930 TO 1375 FEET BLS)
Reference elevation: +17.75 feet NGVD

Sample Depth (feet)	Chloride Conc. (mg/l)	Specific Conductance (µmos/cm)	Temp (°C)	Static water level (ft above land surface	*Static water level (ft NGVD)*	Flowing water level (ft. above land surface)	*Flowing water level (ft NGVD)*	Wellhead Flow (gpm)
930		3902	28.0			8.45	*25.9*	70 (vm)
940		5150	28.8					
950		3872	28.6					
955		4870	28.8					
Wellhead (955)		4880	29.2	22.22	*39.65*	8.45	*25.9*	87 (vm)
960		4910	29.0					
970		4760	29.1					
980		4700	29.0					
Wellhead (985)		4500	29.2	21.07	*38.52*	8.50	*25.95*	140 (vm)
990		4208	29.1					
1000		4400	29.2					
1010		4340	29.2					
Wellhead (1015)		4500	29.5	20.90	*38.35*	9.00	*26.45*	228 (vm)
1020		4365	29.8					
1030		4195	29.4					
1040		4230	29.4					
Wellhead (1045)		4365	29.6	21.65	*39.1*	10.45	*27.9*	360 (orf)
1045		5330	28.5					
1070		4240	29.3					
1075				20.66	*38.11*	9.3	*26.75*	403 (orf)
Wellhead (1075)		4330	28.7					
Flowed well to remove current water quality from casing, displacing with ambient water.								
Wellhead (1075)		5660	26.8			22.37	*39.82*	
1080	1780	6400	25.7					
1100		6470	25.2					

TABLE 2

WATER QUALITY AND WELL FLOW CAPACITY SUMMARY

MARTIN COUNTY ENVIRONMENTAL SERVICES
PRODUCTION WELL RO-4
DRILLING DATA (FROM 930 TO 1375 FEET BLS)
Reference elevation: +17.75 feet NGVD

Sample Depth (feet)	Chloride Conc. (mg/l)	Specific Conduct-ance (µmos/cm)	Temp (°C)	Static water level (ft above land surface	*Static water level (ft NGVD)*	Flowing water level (ft. above land surface)	*Flowing water level (ft NGVD)*	Wellhead Flow (gpm)
Wellhead (1105)		6010	26.5	19.73	*37.18*	9.78	*27.23*	483 (orf) 490 (vm)
1110	1950	6670	25.3					
1120		6450	25.3					
1130		6430	25.1					
Wellhead (1135)		5600	25.5	19.18	*36.63*	9.85	*27.3*	483 (orf) 525 (vm)
1140	1825	6450	25.3					
1150		6350	25.2					
1160		6320	25.6					
Wellhead (1165)		5610	25.5	18.85	*36.3*	9.95	*27.4*	483 (orf) 525 (vm)
1170	1810	6300	25.6					
1180		6000	25.2					
1190		5990	25.0					
1195		5420	25.4	19.12	*26.57*	10.32 to 10.40	*27.77 to 27.85*	588 (orf) 630 (vm)
1198 (well flowing) (well not flowing)		5320 5880	25 25					
1200	1685	5780	25					
1210		5490	25.1					
Wellhead (1225)	1870	6240	25.2	18.90	*36.35*	11.44	*28.89*	744 (orf) 735 (vm)
1230	775	3039	25.2					
1240		4840	25.5					
1250		4750	24.9					

TABLE 2

WATER QUALITY AND WELL FLOW CAPACITY SUMMARY

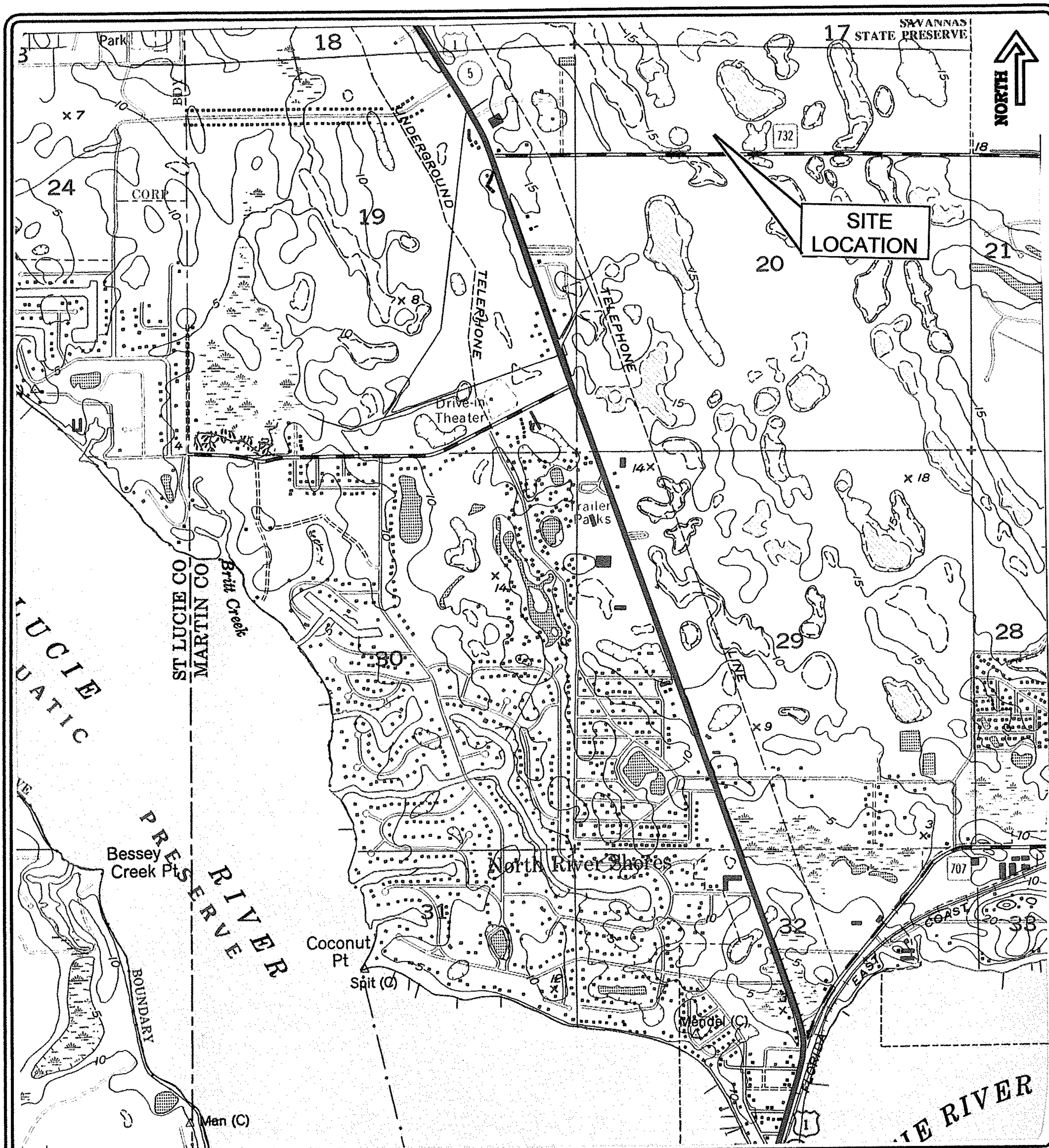
MARTIN COUNTY ENVIRONMENTAL SERVICES
PRODUCTION WELL RO-4
DRILLING DATA (FROM 930 TO 1375 FEET BLS)
Reference elevation: +17.75 feet NGVD

Sample Depth (feet)	Chloride Conc. (mg/l)	Specific Conduct-ance (µmos/cm)	Temp (°C)	Static water level (ft above land surface	*Static water level (ft NGVD)*	Flowing water level (ft. above land surface)	*Flowing water level (ft NGVD)*	Wellhead Flow (gpm)
1255		5890	25.1	19.25	*36.7*	12.33	*29.78*	858 (orf) 893 (vm)
1260	985	3802	24.9					
1270		4498	24.8					
1285		4880	25.1	21.80	*39.25*	13.65	*31.1*	1002(orf) 980 (vm)
1290		4490	25.0					
1300		4510	25.0					
1310		4470	24.9					
Wellhead (1315)		5750	24.9	20.95	*38.4*	13.55	*31*	1002(orf) 980 (vm)
1320		3360	25.0					
1340		4268	24.8					
1345		5510	25.1	21.63	*39.08*	11.03	*28.48*	1244(orf) 1225(vm)
1350	725	2990	25.0					
1360		3845	24.9					
1370		4414	24.9					
1375		4454	24.9					
1375		4680	24.9	19.70	*37.15*	10.70	*28.15*	1157(orf)
Wellhead (1375)		3520	24.6			12.73	*30.18*	

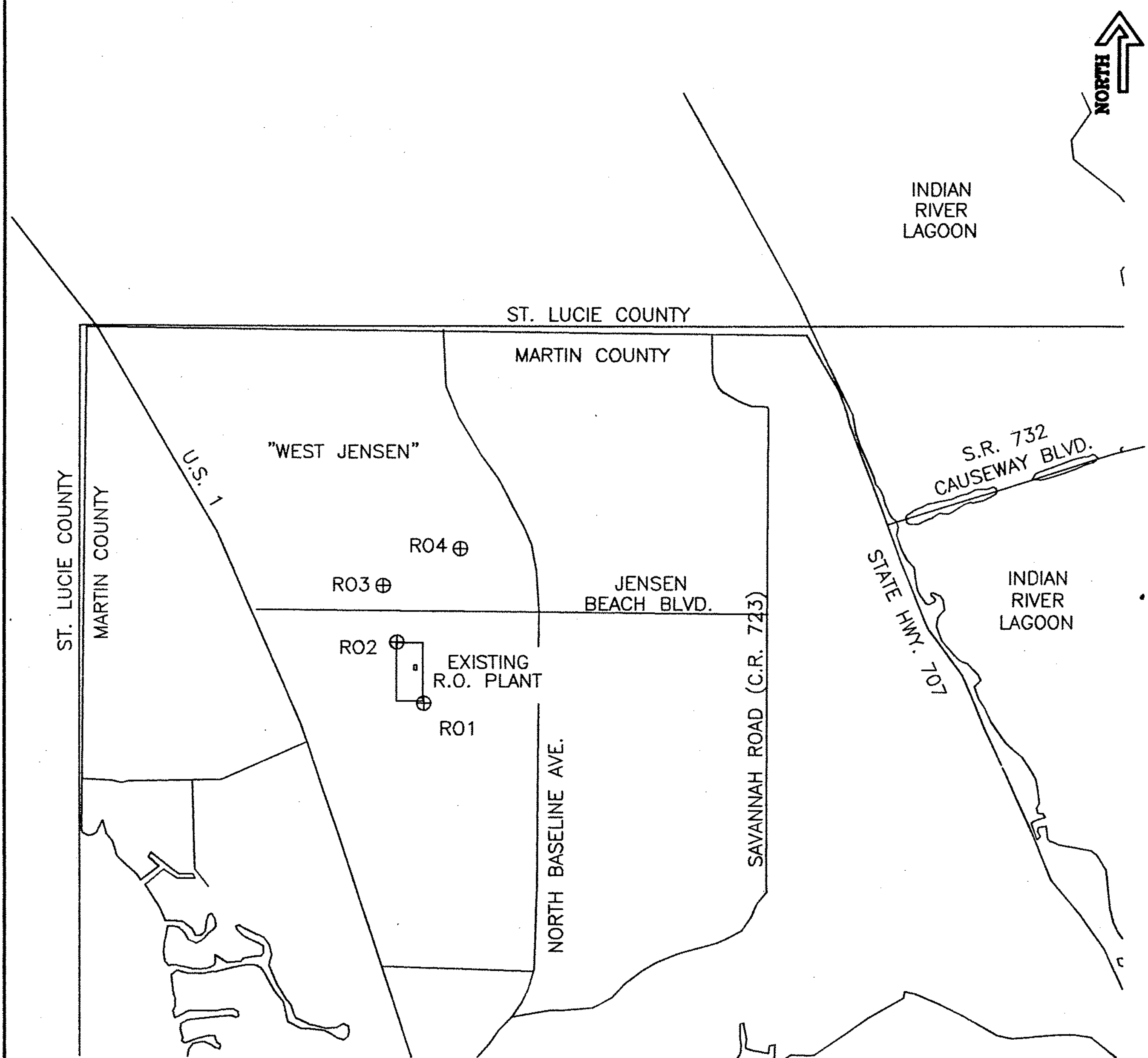
Notes:

mg/l - milligrams per liter, chloride concentration determined by the silver nitrate titration method.
µmos/cm - micromhos per cubic centimeter
°C - degrees Celsius
gpm - gallons per minute
orf - orifice weir flow measurement method
vm - timed volume flow measurement method

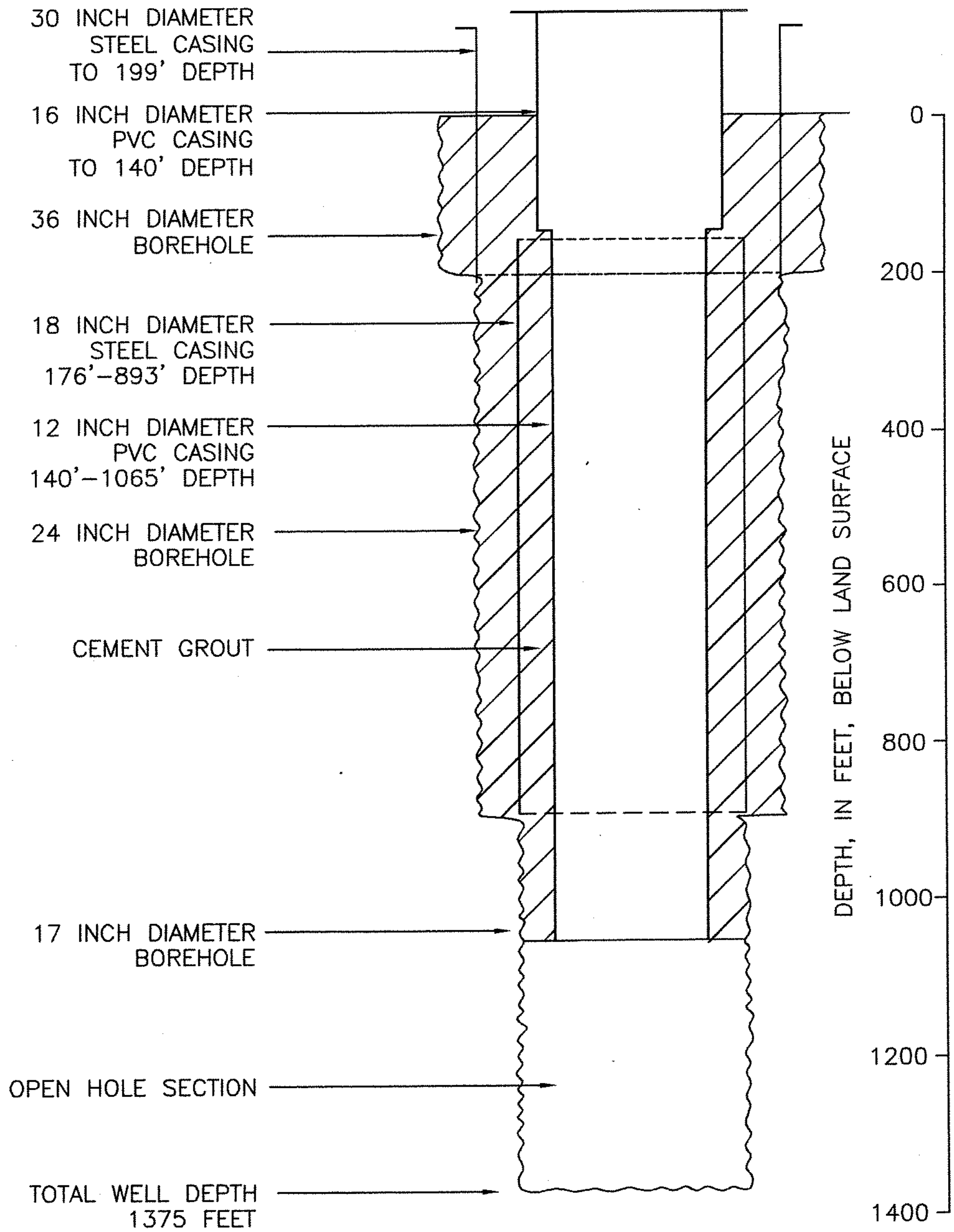
FIGURES



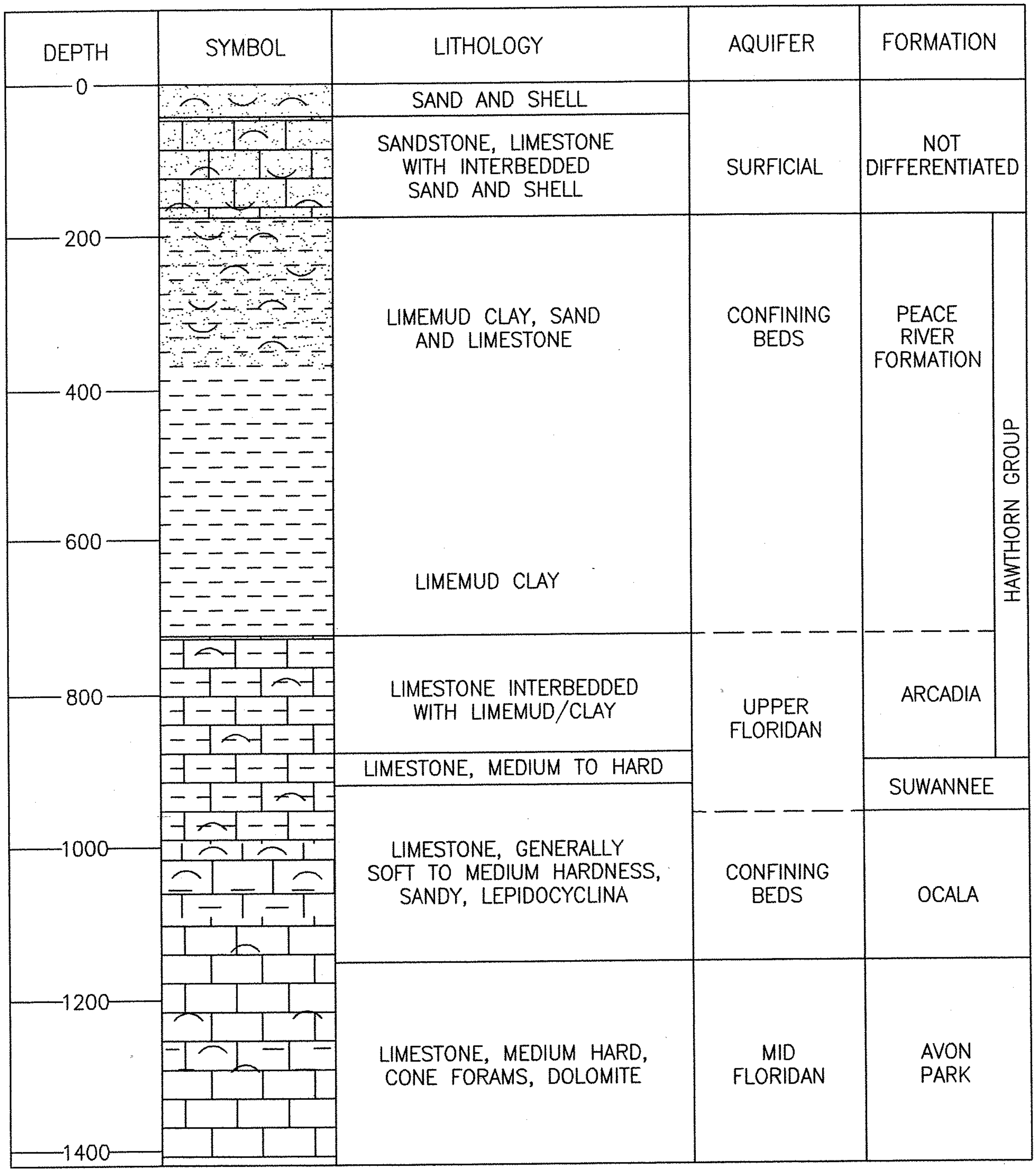
SOURCE: USGS TOPOGRAPHIC MAP PALM CITY, FLA QUADRANGLE PHOTOREVISED 1983	SCALE 1:24,000	**Stemle, Andersen & Associates**
PREPARED FOR: MARTIN COUNTY ENVIRONMENTAL SERVICES		DRAWN BY: JM DATE: 09/12/00 DWG #: 000904F2
FIGURE TITLE: RO-4 SITE LOCATION MAP	PROJECT NUMBER:	FIGURE NUMBER: 1



LEGEND: ⊕ RO-# FLORIDAN WELL LOCATION	SCALE 1" = 3,600'	**Stemle, Andersen & Associates**
PREPARED FOR: MARTIN COUNTY ENVIRONMENTAL SERVICES		DRAWN BY: JM DATE: 09/12/00 DWG #: 000904F3
FIGURE TITLE: SITE AND WELL LOCATIONS	PROJECT NUMBER:	FIGURE NUMBER: 2



LEGEND: ▨ CEMENT GROUT	SCALE AS SHOWN	**Stemle, Andersen & Associates**
PREPARED FOR: MARTIN COUNTY ENVIRONMENTAL SERVICES		DRAWN BY: JM DATE: 09/11/00 DWG #: 000904F1
FIGURE TITLE: FLORIDAN AQUIFER PRODUCTION WELL RO-4 AS-BUILT CONSTRUCTION DETAILS	PROJECT NUMBER:	FIGURE NUMBER: 3



LEGEND: DETAILS SHOWN

SCALE: AS SHOWN

Stemle, Andersen & Associates

PREPARED FOR: MARTIN COUNTY ENVIRONMENTAL SERVICES

DRAWN BY: JM
DATE: 09/12/00
DRAWING #: 000904F4

FIGURE TITLE: TYPICAL HYDROSTRATRIGRAPHIC SECTION IN THE VICINITY OF THE NO. MARTIN COUNTY TREATMENT PLANT

PROJECT NUMBER:

FIGURE NUMBER: 4

APPENDICES

APPENDIX A

RO-4 LITHOLOGIC LOG

LITHOLOGIC LOG

MARTIN COUNTY ENVIRONMENTAL SERVICES REVERSE OSMOSIS WELL NO. RO-4	
Depth in Feet Below Land Surface	**Description**
0 – 5	SAND, dark yellowish brown (10R3/2); unconsolidated; quartz grains, fine to medium grain size; ORGANIC MATTER.
5 - 10	SAND, pale yellowish brown (10YR 6/2) as above, decreasing organic content with depth.
10 - 20	SAND, 90%, light olive gray (5Y 5/2), unconsolidated, fine to coarse quartz grains and trace white shell fragments (sand size); CLAY 10%, light olive gray in sand matrix.
20 – 25	SAND, as above; somewhat less clay.
25 – 40	SAND, as above, 100%, minor dark grains.
40 – 45	SAND, 60% as above; SHELL 30%, medium to dark gray (N5-N3), and very pale orange (10YR 8/2), unconsolidated to poorly lithified small fragments mostly less than 1 mm size; SANDSTONE 10%, light olive gray (5Y 5/2), poorly lithified to hard, cemented quartz grains.
45 - 50	SHELL 50%, as above, common larger fragments; SAND 30%, as above; and SANDSTONE 20% as above.
50 - 55	SHELL 60% as above, fragments sand size to 5 mm, unconsolidated; LIMESTONE 20%, medium dark gray (N-4), hard to medium, cemented shell and quartz sand; and SAND 20%, as above, unconsolidated and fine to very fine quartz and phosphate sand.
55 - 60	SHELL, 60%, as above, unconsolidated; LIMESTONE 30%, medium dark gray (N3), sandy, fine quartz and phosphate grains, hard, rounded pebbles, some common uncemented; and SAND, fine to very fine quartz and phosphate, unconsolidated.
60 - 70	SHELL, 60%, as above, LIMESTONE 20% as above; and SAND 20% as above.
70 - 75	SHELL 50%; LIMESTONE 30%; SAND 20%.
75 - 85	SANDY LIMESTONE / SANDSTONE 50%, medium gray (N5), medium hardness, sandy fine quartz and phosphate grains, becoming light olive gray with depth (5Y5/2); SHELL 30%, as above; and SAND 20%, as above. Production zone. Good secondary porosity, molds and casts.
85 - 90	SANDY LIMESTONE / SANDSTONE as above, light in color to yellowish gray (5Y 7/2), soft to medium hardness, more granular texture.
90 – 110	SANDY LIMESTONE / SANDSTONE as above.
110 - 115	LIMESTONE 80%, medium light gray (N6), medium hardness, sandy, good moldic porosity; and SHELL 20%, minor SAND, unlithified.
115 - 125	SANDY LIMESTONE 40%; SHELL 40%, and SAND 20%.
125 - 130	SHELL 60%; SANDY LIMESTONE 20%, soft, friable, as above; and SAND 20%.
130 - 140	SANDY LIMESTONE / SANDSTONE 60%, light olive gray (5Y 5/2) to yellowish gray (5Y 7/2), medium hardness, fine quartz and phosphate grains and cemented shell; SHELL 20%, same color; and SAND, 20%, very fine quartz and phosphate grains.
140 - 150	SAND, 50%, medium dark gray (N4), unconsolidated, fine to coarse quartz, shell and lithic grains; LIMESTONE / SANDSTONE, 30%, as above, soft to friable; and SHELL, small fragments, loose.
150 - 165	SANDSTONE, 70%, light olive gray (5Y 6/1) lighter than above, calcareous cement, soft, poorly lithified, granular texture; and SHELL & SAND 30%, unlithified as above.
165 - 170	SANDSTONE as above, minor marly with lime mud, light yellowish gray.

MARTIN COUNTY ENVIRONMENTAL SERVICES REVERSE OSMOSIS WELL NO. RO-4	
Depth in Feet Below Land Surface	**Description**
170 - 175	SANDSTONE as above, lime mud marl 30% of sandstone percentage.
175 - 180·	MARL, lime mud marl, 70%, pale olive (10Y 6/2), unlithified, clayey texture; SAND, fine quartz and phosphate grains, unconsolidated; SHELL and SANDSTONE as above, 30%.
190 - 200	MARL as above, greenish gray (5 GY 6/1) and interbedded; chert.
200 – 215	MARL: LIMESTONE 40%, greenish gray (5GY 6/1), soft, sandy granular texture, friable; LIME MUD, same, unlithified, clayey; FINE SHELL & SAND, 20%, quartz and phosphate, fine to very fine size, small sand sized shell fragments; unlithified.
215 – 225	As above, LIMESTONE 70%, soft to medium, sandy, fine quartz & phosphate grains; LIME MUD 10%; SHELL & SAND 20%.
235 – 250	CLAY / LIME MUD, 100%, as above, becoming more silty and sandy with depth, sand is very fine, probably quartz or carbonates, apparent phosphate.
250 – 305	CLAY / LIME MUD, as above, 100%, dark greenish gray (5Y 4/1), dense clayey, silty to fine sandy. Becoming grayish olive (10Y 5/2) with depth.
305 - 315	CLAY / LIME MUD, as above, dark greenish gray (5GY 4/1), silty, fine sandy, quartz and phosphate grains.
315 – 355	CLAY / LIME MUD, 100%, dark greenish gray (5GY 4/1), dense clayey texture, "greasy", fine silt, phosphate.
355 – 380	CLAY / LIME MUD, as above, and dryer dense grayish olive clay (10Y 4/2)
380 – 410	CLAY / LIME MUD, as above, grayish olive green (5GY 3/2) fine clayey greasy texture, fine silty.
410 – 485	CLAY / LIME MUD, as above, becoming dusky yellow green (5GY 4/2) with depth.
485 – 505	CLAY / LIME MUD, as above, olive gray (5Y 3/2), increased silt percentage and size to very fine sandy, phosphatic sand.
505 - 515	CLAY / LIME MUD, as above, interbedded, clayey, greasy textured clay and sandy/ silty clay phosphate.
515 – 555	CLAY / LIME MUD, as above, predominantly greasy/clayey, slightly sandy; interbedded, poorly lithified layers of the same, soft.
555 – 575	CLAY / LIME MUD, as above, dark greenish gray, very dense, silty, fine sandy and phosphatic.
575 – 584	CLAY / LIME MUD, as above, very dense dolosilt.
584 – 590	CLAY / LIME MUD, as above (90%) and phosphatic sand, coarse grains (minor) to gravel size; and minor interbedded SILTSTONE, black (N1) from 584'; and LIMESTONE, light olive gray (5Y 5/1), hard, crystalline, and LIME MUD, same, clayey; trace brown bone fragments.
590 – 600	CLAY / LIME MUD / DOLOSILT 90% (5y 3/2), dense, clayey, unlithified; LIME MUD 10%, light olive gray (5Y 6/2), clayey, unlithified; and LIMESTONE, same, hard microcrystalline; phosphatic sand and gravel (minor).
610 – 605	LIME MUD 70%, light olive brown (5Y 5/4), unlithified, clayey, granular /sandy texture, carbonate, quartz and phosphate sand grains; LIME MUD, olive gray as above 30%, and CHERT as above (minor) possibly DOLOMITE, hard, microcrystalline.
605 – 630	LIME MUD 100%, light olive (10Y 5/2), unlithified, dense clayey texture, silty.
630 – 640	LIME MUD, as above 80%, and SAND 20%, medium dark gray (N4), unlithified, clayey matrix, very fine quartz and phosphate grains.

LITHOLOGIC LOG

MARTIN COUNTY ENVIRONMENTAL SERVICES REVERSE OSMOSIS WELL NO. RO-4	
Depth in Feet Below Land Surface	**Description**
640 – 655	LIME MUD 100%, light olive, as above, dense clayey; minor sandy clay, olive gray (5Y 3/2), loose, sandy, phosphate and quartz, fine to medium sand, sharks tooth.
655 – 660	LIME MUD, as above, 50%; and LIMESTONE, 50%, light olive brown (5Y5/4), soft, friable, sandy granular texture, minor quartz and phosphatic sand; minor shell, white, and lime mud, light yellowish gray (5Y 7/2), minor, unlithified.
660 – 670	LIME MUD 70%, light yellowish gray (5Y 7/2), unlithified, clayey, sandy with quartz and phosphate grains; and LIMESTONE as above ,30%, decreasing to 10% with depth (90% lime mud).
670 – 680	LIME MUD 90%, yellowish gray, as above; and SAND 10%, quartz and phosphate, unconsolidated to fine gravel size, sharks teeth; minor chert, as above, hard microcrystalline.
680 – 694	LIME MUD, as above, 50%; and LIMESTONE / SANDSTONE, medium gray (N5) to light olive gray (5Y 6/1), hard, sandy quartz and phosphate grains, fine to very fine size, limestone becoming softer and unlithified with depth.
694 – 700	LIMESTONE, 100%, light yellowish gray (5Y 8/1), medium hardness, sandy, fine quartz and phosphate grains, moldic porosity.
700 – 710	LIMESTONE, as above, 50% marly same; LIME MUD, sandy, phosphatic.
710 – 737	LIME MUD, 80%, olive gray (5Y 4/2), unlithified and yellowish gray (5& 7/1), sandy to clayey, sand fine quartz and phosphate.
737 – 750	LIMESTONE, 90%, very pale orange (10YR 8/2), soft, friable, granular texture, calcarenite, microfossiliferous, Lepidocyclina ocalina, large fossil shell fragments; and LIME MUD, 10%, as above.
750 – 770	LIMESTONE, as above and yellowish gray (5Y 7/2), soft to medium hardness, fine granular texture, minor moldic porosity; absence of Lepidocyclina, low to medium permeability; minor LIME MUD, very light yellowish gray (5Y 8/1), clayey, unconsolidated.
770 – 805	LIMESTONE 100%, light yellowish gray, medium to hard, moldic, microcrystalline to fine granular texture; becoming soft and granular with depth, friable.
815 – 825	LIMESTONE 100%, as above, predominantly soft, friable calcarenite.
825 – 830	LIMESTONE 90%, as above; and LIME MUD 10%, clayey, harder at 830'.
830 – 835	LIMESTONE, 100%, very light yellowish gray (5Y 8/2) to very pale orange (10YR 8/2), very soft to unconsolidated, friable, granular texture, fossiliferous / microfossiliferous, low permeability.
835 – 845	LIMESTONE, 100% as above. Clay contamination in sample (from above)
845 – 850	LIMESTONE, 100% as above. Lepidocyclina ocalina.
850 – 855	LIMESTONE, 70%, light yellowish gray to very pale orange, soft, friable, granular texture; and LIME MUD 30%, yellowish gray (5y 7/2), unlithified, clayey, low permeability.
855 – 860	LIMESTONE, 90%, as above, soft, friable, LIME MUD 10%, as above.
860 –875	LIMESTONE, 100%, yellowish gray (5Y 7/2), soft, common friable; and limestone fragments, light gray (N6), sand size fragments, granular texture, Lepidocyclina ocalina.
875 – 891	LIMESTONE, 100% as above.
891 – 899	LIMESTONE, 100%, yellowish gray (5Y 7/2) to pale orange (10YR 8/2), medium hardness, granular texture, microfossiliferous, Lepidocyclina ocalina, echinoids; light gray granules, calcareous (N6) as above. Low to medium permeability.

MARTIN COUNTY ENVIRONMENTAL SERVICES REVERSE OSMOSIS WELL NO. RO-4	
Depth in Feet Below Land Surface	**Description**
899 – 900	LIMESTONE, 100%, soft as above, loose granular texture, friable, calcarenite.
900-930	No data
930-935	LIMESTONE, 100%, very pale orange (10YR 8/2), soft, friable, calcarenite, granular texture, low permeability.
935-940	LIMESTONE, 100% as above. Very soft.
940-945	LIMESTONE, 100%, very pale orange (10Y 8/2) and medium gray (N5), medium hardness, granular texture sand-size gray clasts, minor moldic and vuggy porosity, microfossil, Lepidocyclina ocalina, Low to medium permeability.
945-952	LIMESTONE, 100%, as above, medium to hard from 947 f t; yellowish brown (10YR 6/4), hard, microcrystalline texture, low to medium permeability.
952-955	LIMESTONE, 100%, very pale orange (10YR /2), soft to medium, calcarenite, granular to microcrystalline, low permeability, Intergranular porosity.
955-960	LIMESTONE 100%, very pale orange (10YR 7/2), as above, minor moldic porosity.
960-965	LIMESTONE 100% as above, becoming very soft and poorly consolidated "cemented carbonate sand", calcarenite, microfossiliferous, discs, spheres.
965-970	LIMESTONE 100% as above, better consolidation.
970-975	LIMESTONE 100% as above, very pale orange (10YR 7/2) to pale yellowish brown, soft, calcarenite, microfossiliferous, discs, spheres abundant.
975-992	LIMESTONE 100% as above, predominantly pale orange.
992-995	LIMESTONE, 100%, light yellowish gray (5Y8/1), medium hardness, microcrystalline, fine aphanitic to micritic- microcrystalline texture, fine vugged porosity, low to medium permeability.
995-1000	LIMESTONE, 100%, as above, becoming light gray (N7) medium hardness, low to medium permeability.
1000-1005	LIMESTONE 100%, very pale orange (10YR8/2), soft, fine granular texture, becoming yellowish brown with depth (10YR 6/4), microcrystalline and microfossiliferous. Low permeability.
1005-1010	LIMESTONE, 100%, pale orange (10YR7/2), soft and light gray (N6), granular texture, calcarenite. Low permeability.
1010-1015	LIMESTONE, 40%, very pale orange (10YR8/2), soft, fine granular texture, very vine vugged porosity; DOLOMITIC LIMESTONE 30%, olive gray (5y 5/1), hard, microcrystalline; LIMESTONE 30%, grayish orange (10YR 7/4), granular calcarenite, very soft, overall low permeability; Minor LIME MUD, dense, clayey.
1015-1020	LIMESTONE 100%, very pale orange (10YR8/2), and light gray (N7), medium hardness, fine granular to microcrystalline texture, common gastropod casts, minor moldic porosity and vugged. Low to medium permeability.
1020-1025	LIMESTONE 100%, as above. Predominantly very pale orange (10YR8/2); Minor LIME MUD, white, dense, clayey.
1025-1030	LIMESTONE 50%, as above and gray granular. More coarsely textured calcarenite; and LIMESTONE, 50%, medium light gray (N6) to light olive gray (57 6/1), hard, microcrystalline, vugged porosity, becoming granular calcarenite with depth.
1030-1035	LIMESTONE 100%, pale orange (10YR 7/2), soft granular, calcarenite, microfossiliferous, friable, low permeability.

LITHOLOGIC LOG

MARTIN COUNTY ENVIRONMENTAL SERVICES REVERSE OSMOSIS WELL NO. RO-4	
Depth in Feet Below Land Surface	**Description**
1035-1040	Interbedded LIME MUD 60%, dark gray (N2), and light gray (N7) dense clayey texture; and LIMESTONE 40%, very pale orange (10YR8/2), to very light gray (n8), medium fine granular texture, low permeability.
1040-1045	LIMESTONE 100%, as above, medium hardness, fine granular to microcrystalline texture, fine vugged porosity. Low permeability.
1045-1050	LIMESTONE 100% as above, very pale orange (10YR8/2) to very light gray, soft to medium hardness, fine granular texture to microcrystalline, fine vugged porosity, low permeability.
1050-1055	LIMESTONE 100% as above, very pale orange (10YR8/2) to white.
1055-1058	LIME MUD 100%, light gray (N7) to pale orange (10YR 7/2), clayey, interbedded, low permeability.
1058-1060	LIMESTONE 100%, light gray (N2) pale orange (10YR7/2). Soft to medium hardness, microcrystalline to fine granular, low to medium permeability.
1060-1065	LIMESTONE 100%, as above, very pale orange (10YR8/2).
1065-1075	No data
1075-1080	LIMESTONE, 100%, light gray (N7), medium hardness, fine granular texture, minor pale orange limestone as above. Low permeability.
1080-1085	LIMESTONE 100%, very pale orange (10YR8/2), soft to medium hardness, fine granular texture, low permeability.
1085-1090	LIMESTONE 100%, medium gray (N5), very light gray with depth (N8), then pale orange, softer with depth. Medium hardness, very fine granular texture, microcrystalline or micritic moderately well vugged porosity, medium permeability.
1090-1095	LIMESTONE 80%, very pale orange (10YR 8/2) and very light gray (N8), soft. minor unlithified; and LIME MUD 20%, very pale orange (10YR 8/2) and very light gray (N8) low permeability, granular texture.
1095-1100	LIMESTONE 100%, very pale orange (10YR 8/2) and very light gray (N8), soft. minor unlithified; soft and pale orange (10YR 7/2), soft, friable, granular, microfossiliferous, cones and discs, flat echinoids.
1100-1105	LIMESTONE 30% as above, and LIMESTONE 70%, medium gray (N5) to light gray (N7), medium hardness to soft and unlithified (minor lime mud, same), low to medium permeability.
1105-1110	LIMESTONE, as above, black string of vugs becoming very light gray and granular with depth, soft; Trace LIME MUD / DOLOSILT at top of interval, grayish blue green.
1110-1115	LIMESTONE 50%, pale orange (10YR 7/2), soft, calcarenite, granular, microfossiliferous, cones, discs, echinoids. LIMESTONE 40%, very light gray, granular, soft; minor hard interbedded; LIME MUD 10%, very light gray, unlithified, overall low permeability;
1115-1120	LIMESTONE as above, to dark gray, and soft to medium hardness. Granular to very fine grained, low to medium permeability.
1120-1125	LIMESTONE as above, highly interbedded.
1125-1130	LIMESTONE, as above, very light gray (N7) to pale orange(10YR 7/2), medium-soft, fine to coarse granular calcarenite, minor fine vugged porosity to intergranular porosity, low permeability.
1130-1135	LIMESTONE as above, predominantly pale orange (10Y/R 7/2), abundant fossil discs and echinoids.

MARTIN COUNTY ENVIRONMENTAL SERVICES REVERSE OSMOSIS WELL NO. RO-4	
Depth in Feet Below Land Surface	**Description**
1135-1144	LIMESTONE, as above, interbedded, pale orange to light gray, soft to medium, granular to fine-grained, low permeability.
1144-1150	DOLOMITIC LIMESTONE, pale yellowish brown (10YR6/2), hard, microcrystalline; then LIMESTONE, very pale orange (10YR8/2), fine granular to very fine microcrystalline texture, soft to medium, overall low permeability.
1150-1155	LIME MUD 80%, interbedded, pale yellowish brown (10YR6/2), pale orange (10YR 8/2), grayish black (N2), clayey, low permeability; and interbedded LIMESTONE, same, soft.
1155-1160	LIMESTONE 100%, very pale orange (10YR8/2), yellowish brown (10YR 6/2) to light olive gray (5Y 6/1), interbedded, soft to medium hardness; minor unlithified LIME MUD, same; and SILTSTONE, thin laminar beds, dusky brown (5Y 2/2) to black (N1).
1160-1165	DOLOMITIC LIMESTONE, mod. yellowish brown (10YR 6/4) and light olive gray (5Y 6/1), hard, sparry, microcrystalline, low to medium permeability; some SILTSTONE, laminar bedding as above, olive gray color.
1165-1175	DOLOMITIC LIMESTONE as above, interbedded, low to medium permeability; and LIMESTONE, pale orange, granular, soft.
1175-1180	LIMESTONE, 100%, highly interbedded, black to dark olive gray, pale orange, light olive gray, medium to hard, unconsolidated, vugged, medium permeability, laminar beds.
1180-1185	LIMESTONE, 100%, as above, highly interbedded, predominantly light gray, fossiliferous calcarenite, yellowish brown, granular with depth and dark gray, soft, friable.
1185-1195	LIMESTONE, 80%, pale yellowish brown (10YR 6/2); and 20% pale orange (10YR 8/2), hard, microcrystalline to soft calcarenite, fossiliferous, discs and cones common with pale orange limestone, well vugged porosity, medium permeability.
1195-1200	LIMESTONE 90%, very pale orange (10YR 7/2) to pale yellowish brown (10YR 6/2), hard to soft microcrystalline to fine granular texture, low permeability and interbedded 10%; LAMINAR BEDDED SILTSTONE, olive gray, black, dark yellowish brown; thin beds of black organic material, clayey liths, low permeability.
1200-1205	DOLOMITIC LIMESTONE, pale yellowish brown (10YR 6/2), hard, microcrystalline, vugged with black zonation around vugs. high permeability.
1205-1215	LIMESTONE, pale orange, soft, granular texture, cones common, increasing with depth, microfossiliferous, low permeability.
1215-1225	LIMESTONE, very pale orange, soft to medium hardness, fine granular texture, minor microfossils, fine vugged porosity, low permeability.
1225-1230	LIMESTONE, as above, becoming gray (N5) with depth, high permeability, minor interbedded laminar beds as above; SILTSTONE, clayey.
1230-1235	LIMESTONE, pale orange to medium gray, soft, friable calcarenite with micrite matrix, granular interbedded (possible high permeability interbedded), over low-medium permeability.
1235-1240	LIMESTONE, medium to very light gray (N6-N8), fine granular texture, becoming lighter and granular with depth, low to medium permeability.
1240-1245	DOLOSILT, medium bluish gray (5B 5/1), clayey unlithified, then LIMESTONE, medium gray and pale orange; minor LIME MUD then calcarenite, pale orange, soft.
1245-1250	DOLOMITIC LIMESTONE, highly interbedded, medium dark gray (N4) to pale orange, mottled appearance, thin laminar beds, soft friable to clayey, microfossiliferous, arenitic layers, yellowish

MARTIN COUNTY ENVIRONMENTAL SERVICES REVERSE OSMOSIS WELL NO. RO-4	
Depth in Feet Below Land Surface	**Description**
	brown color, discs and cones common. Low to medium permeability.
1250-1255	DOLOMITIC LIMESTONE, as above, predominantly pale orange and more granular, minor very vugged porosity, possible high permeability.
1255-1260	LIMESTONE, 100%, very pale orange (10YR 7/2), soft, granular calcarenite, microfossiliferous, cones and disc forams common. Low permeability.
1260-1265	DOLOMITIC LIMESTONE, dark gray (N3) to pale yellowish brown (10YR 6/2) mottled color, hard, microfossiliferous, well vugged, medium to high permeability, light gray with depth, softer.
1265-1270	LIMESTONE, 100%, medium dark gray (N4) to grayish black (N2), mottled appearance, microcrystalline or micritic matrix, hard, vugged, medium permeability, becoming as above with depth medium hardness.
1270-1275	LIMESTONE, pale orange (10YR 8/2) to moderate yellowish brown (10YR 5/4), soft to hard, granular to microcrystalline, darker colors dolomitic, mottled color, low permeability overall.
1285-1290	LIMESTONE, 100%, medium light gray (N6/7) to yellowish gray (5Y 7/1), medium hard, microcrystalline to micritic matrix, minor softer and granular texture, minor gray LIME MUD, black in-filling / staining of voids.
1290-1295	LIMESTONE 80%, very pale orange (10YR 8/2), soft, calcarenite, granular to unlithified lime mud, becoming darker to moderate yellowish brown (10YR 6/4) and common unlithified clayey same, fossils common, discs, cone forams from 1294', gray color, hard as prior interval.
1295-1300	LIMESTONE, as above, gray, becoming pale orange, soft to medium, minor microfossils, fine granular texture, low permeability.
1310-1315	LIMESTONE, as above, interbedded, dense LIME MUD, same to darker yellowish brown, low permeability.
1315-1325	LIMESTONE 100%, very pale orange(10YR 8/2) to pale yellow brown (10YR 6/2), soft/ friable, and hard layers, microfossiliferous, cones and discs common, hard layer fair vugged porosity. Low permeability.
1325-1330	LIMESTONE, as above, some laminar bedding, same, and dark brownish black, low permeability.
1330-1335	LIMESTONE, 90%, very pale orange (10YR 8/2), soft to medium hardness, fine granular texture; and LIMESTONE, 10%, dark to light gray, interbedded hard to medium, crystalline, fair porosity, vugged, low to medium permeability.
1335-1340	LIMESTONE, as above, gray absent, and pale orange (10YR 7/2).
1335-1345	LIMESTONE, as above, 50%, and light olive gray (5Y 7/2), hard, black infilling/staining of voids, vugged, low to medium permeability; from 1343' LIME MUD, same (pale orange to light olive gray), dense, unlithified, clayey, low permeability.
1345-1365	LIMESTONE, as above, minor light gray to gray , hard, low permeability overall.
1365-1375	LIMESTONE, as above, yellowish brown siltstone, LIME MUD with depth, interbedded, minor laminar bedding, overall low permeability.

APPENDIX B

GEOPHYSICAL LOGS

FLORIDA GEOPHYSICAL LOGGING, INC.

X-Y CALIIPER GAMMA RAY LOG

Company	MARTIN CO. ENVIRO. SVCS.
Well	RO-4
Field	JENSEN BEACH
Country	MARTIN
State/Prv	FL

Company MARTIN CO. ENVIRO. SVCS.
Well RO-4
Field JENSEN BEACH
Country MARTIN State/Prv FLORIDA
Location
Other Services DIL/LL3/SP

Permanent Datum	PAD	Elevation		Elevation KB
Log Measured From	PAD			D.F.
Drilling Measured From	PAD			G.L.

Date	5/24/00
Run Number	ONE
Depth Driller	203'
Depth Logger	202'
Bottom Logged Interval	202'
Top Log Interval	SURFACE
Open Hole Size	36.5"
Type Fluid	MUD
Density / Viscosity	NA
Max. Recorded Temp.	NA
Estimated Cement Top	NA
Time Well Ready	ON ARRIVAL
Time Logger on Bottom	0830
Equipment Number	103
Location	FT MYERS
Recorded By	DENISON
Witnessed By	JIM ANDERSEN

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	36.5"	SURFACE	203'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String				
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and we cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to our general terms and conditions set out in our current Price Schedule.

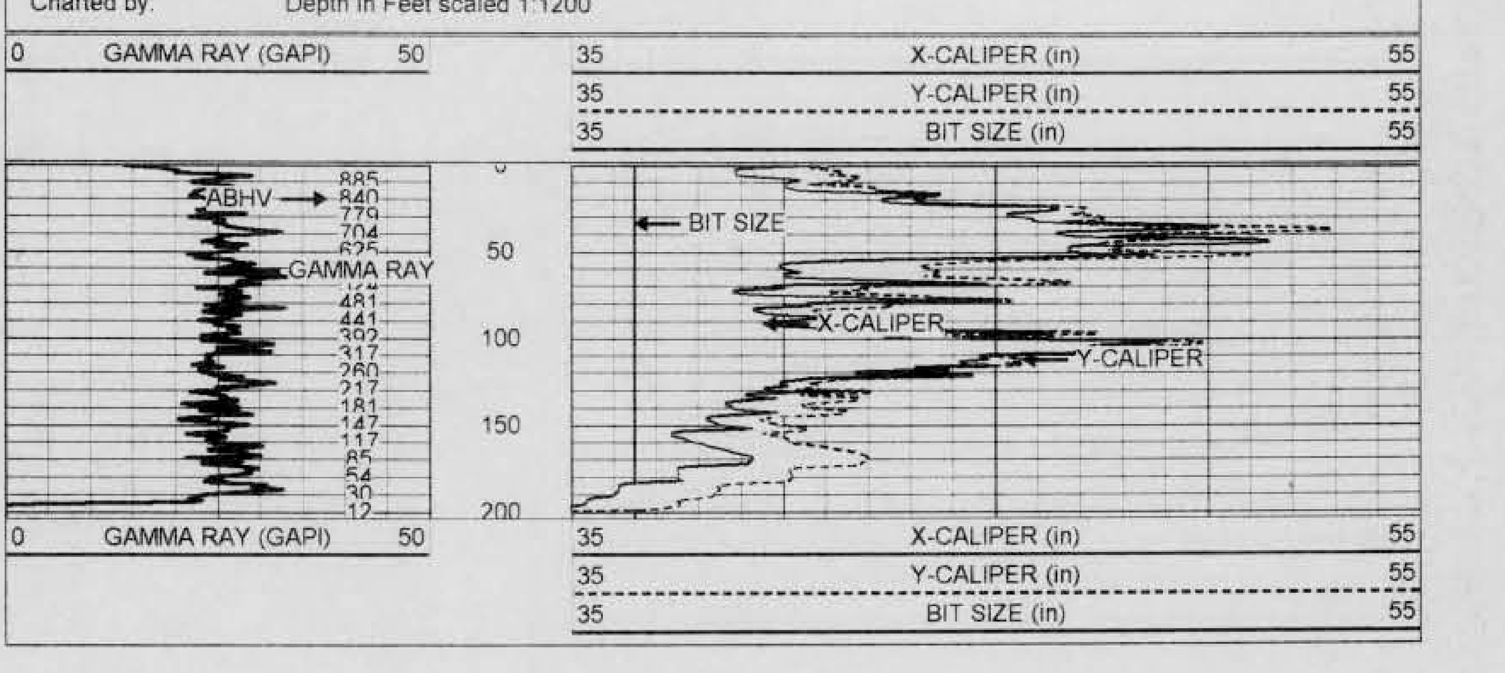
Comments

ANNULAR HOLE VOLUME CALCULATED FOR
30" CASING

FLORIDA GEOPHYSICAL LOGGING, INC.

MAIN PASS

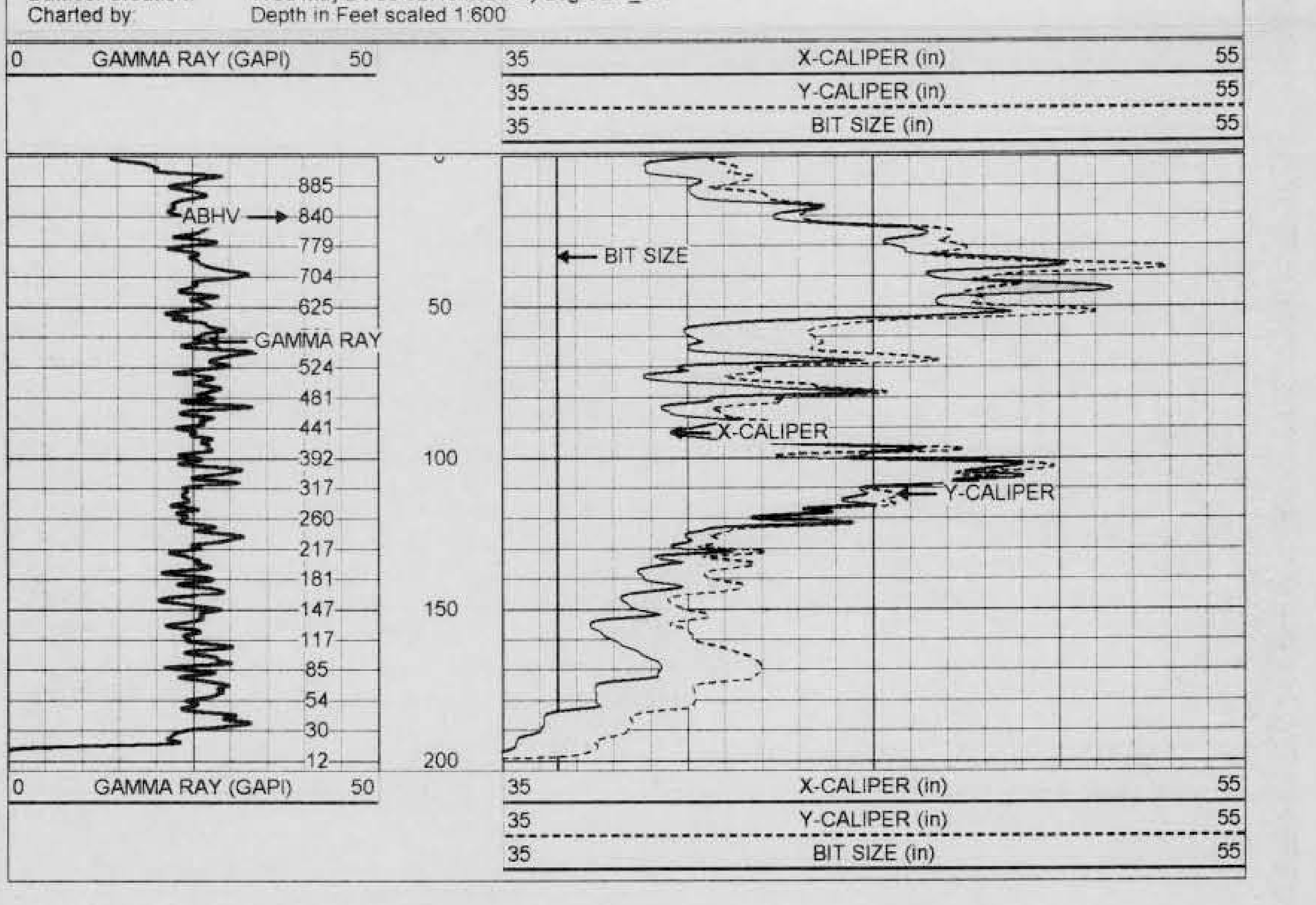
Database File: jensbro4.db
Dataset Pathname: pass2
Presentation Format: grxyc.prs
Dataset Creation: Wed May 24 08:32:40 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:1200



FLORIDA GEOPHYSICAL LOGGING, INC.

MAIN PASS

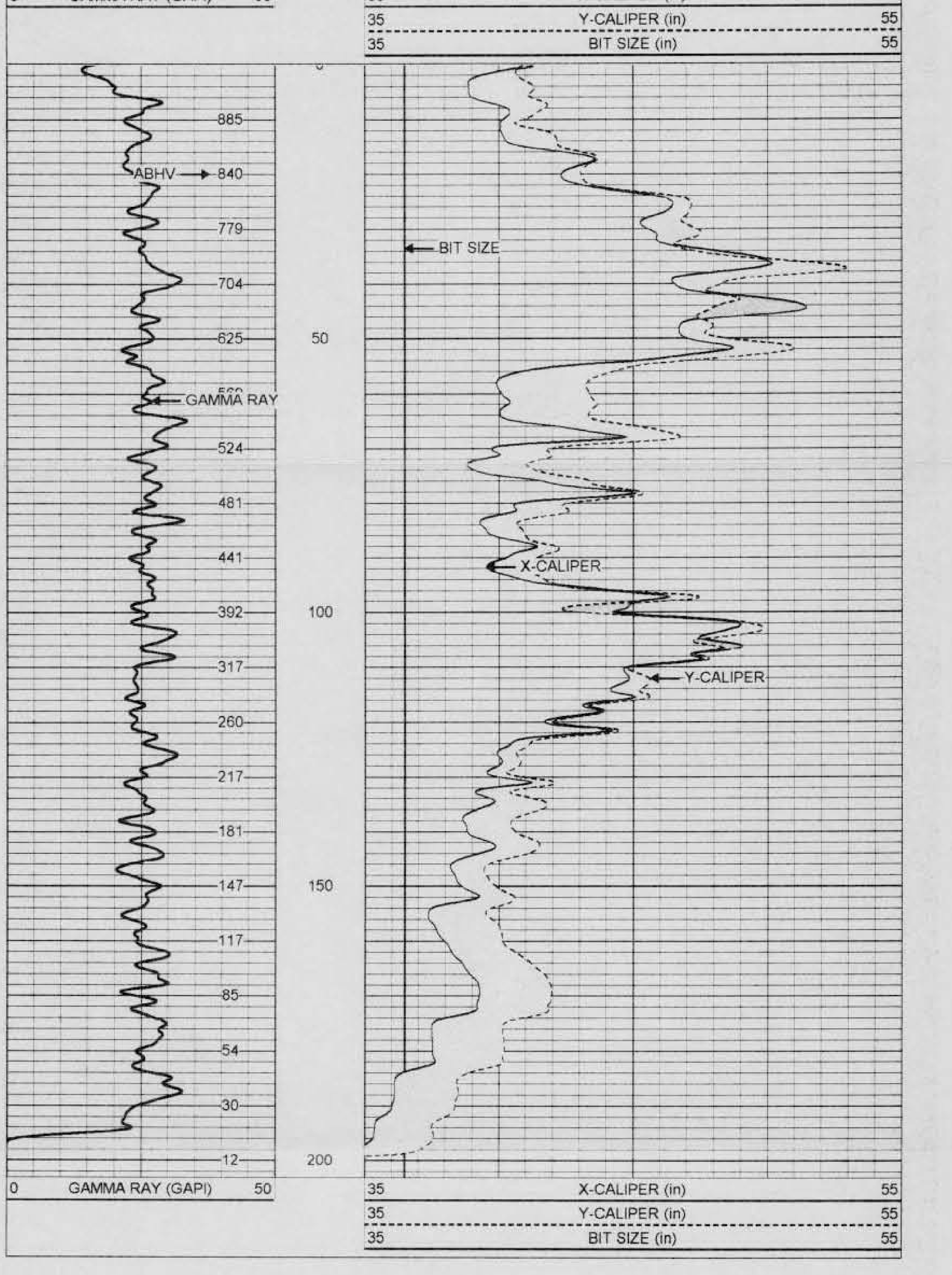
Database File: jensbro4.db
Dataset Pathname: pass2
Presentation Format: grxyc.prs
Dataset Creation: Wed May 24 08:32:40 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:600



FLORIDA GEOPHYSICAL LOGGING, INC.

MAIN PASS

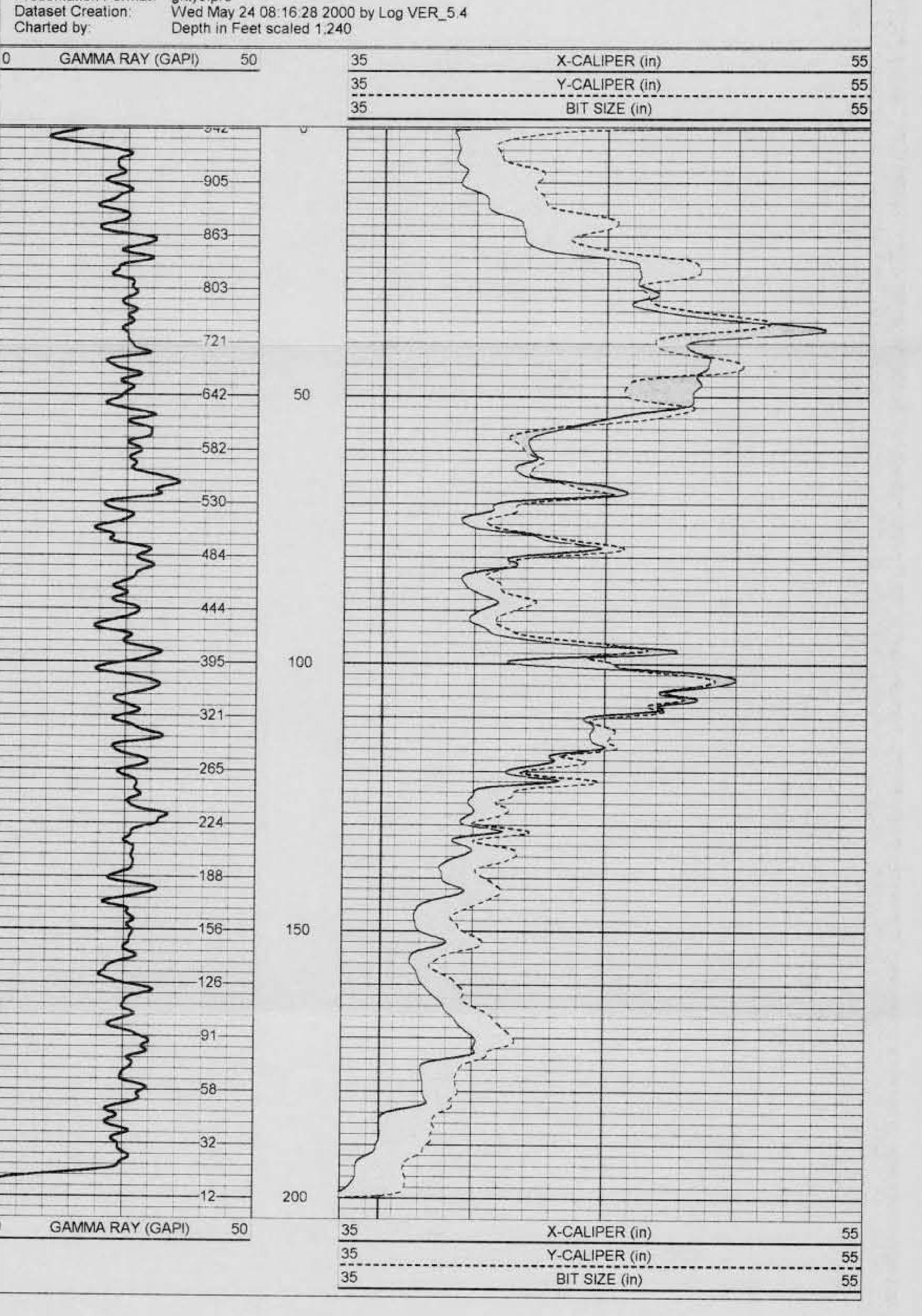
Database File: jensbro4.db
Dataset Pathname: pass2
Presentation Format: grxyc.prs
Dataset Creation: Wed May 24 08:32:40 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:240

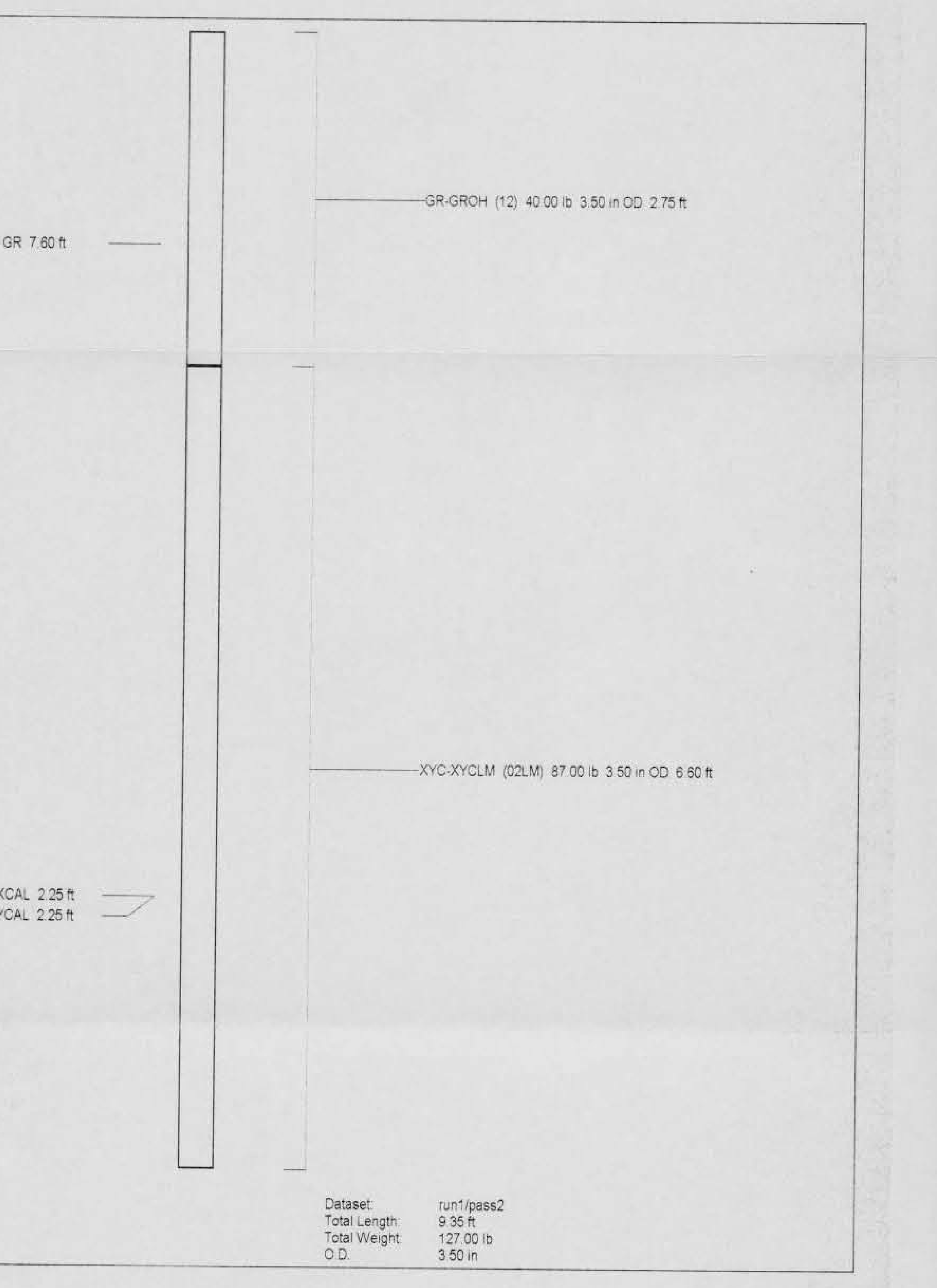


FLORIDA GEOPHYSICAL LOGGING, INC.

REPEAT PASS

Database File: jensbro4.db
Dataset Pathname: pass1
Presentation Format: grxyc.prs
Dataset Creation: Wed May 24 08:16:28 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:240





Dataset: run1/pass2
Total Length: 9.35 ft
Total Weight: 127.00 lb
O.D. 3.50 in

XY Caliper Calibration Report

Serial Number/Model: 02LM-XYCLM
Performed: Sat May 06 08:10:17 2000

Ring			X Caliper		Y Caliper	
1:	10	in	740.941	cps	814.915	cps
2:	20	in	872.973	cps	912.913	cps
3:	30	in	1003.9	cps	1027.83	cps
4:	40	in	1158.78	cps	1154.59	cps
5:	56.5	in	1398.2	cps	1382.98	cps
6:		in		cps		cps

Gamma Ray Calibration Report

Serial Number:	12	
Tool Model:	GROH	
Performed:	Wed Dec 29 15:27:58 1999	
Calibrator Value:	120	GAPI
Background Reading:	57.4716	cps
Calibrator Reading:	157.872	cps
Sensitivity:	1.19522	GAPI/cps

FLORIDA GEOPHYSICAL LOGGING, INC.

X-Y CALIPER GAMMA RAY LOG

Company MARTIN CO. ENVIRONMENTAL SVCS.
Well RO-4
Field JENSEN BEACH
Country MARTIN
State/Prv FLORIDA
Location
Other Services NONE

Company MARTIN CO.
Well RO-4
Field JENSEN BEACH
Country MARTIN
State/Prv FL

		Elevation	
Permanent Datum	PAD		K.B.
Log Measured From	PAD		D.F.
Drilling Measured From	PAD		G.L.

Date	06-JUNE-2000
Run Number	THREE
Depth Driller	895'
Depth Logger	895'
Bottom Logged Interval	895'
Top Log Interval	SURFACE
Open Hole Size	26"
Type Fluid	MUD
Density / Viscosity	NA
Max. Recorded Temp.	NA
Estimated Cement Top	NA
Time Well Ready	ON ARRIVAL
Time Logger on Bottom	0900
Equipment Number	103
Location	FT. MYERS
Recorded By	LEE
Witnessed By	JIM ANDERSEN

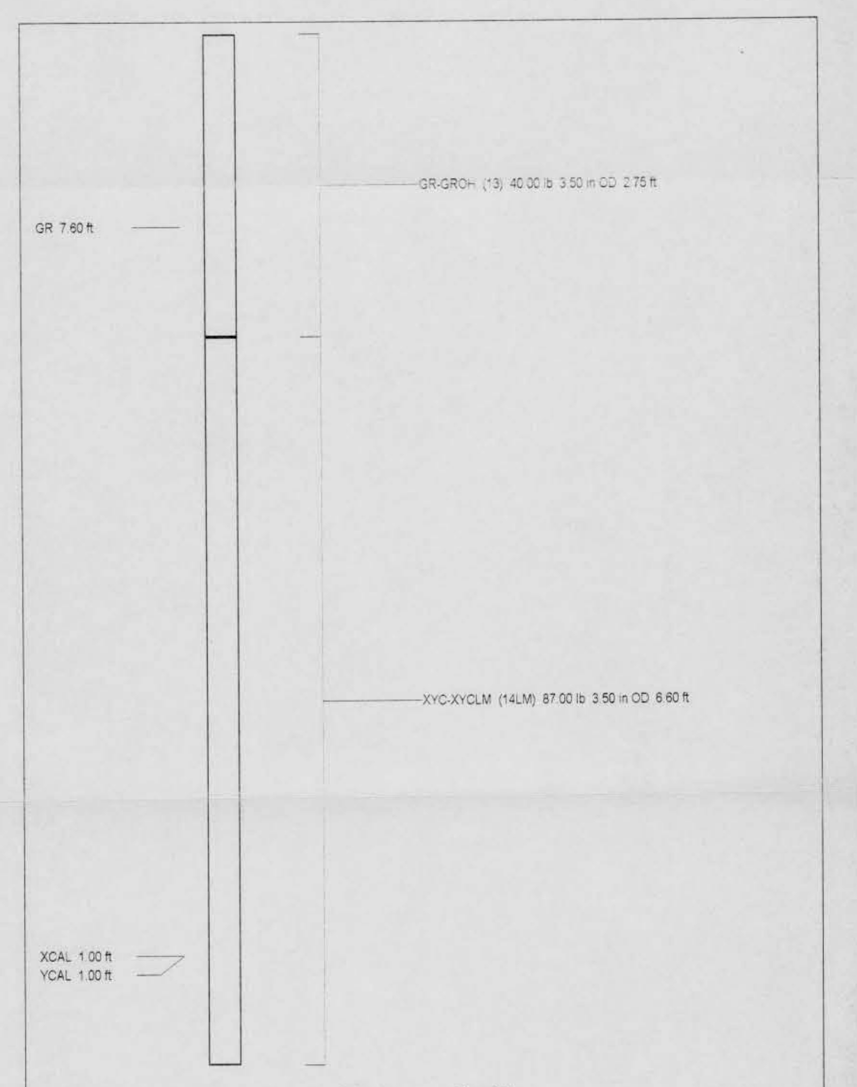
Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	36.5"	SURFACE	203				
THREE	26"	CASING	895				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	30"	.375 W.T.	SURFACE	199'
Prot. String				
Production String				
Liner				

<<< Fold Here >>>

Comments

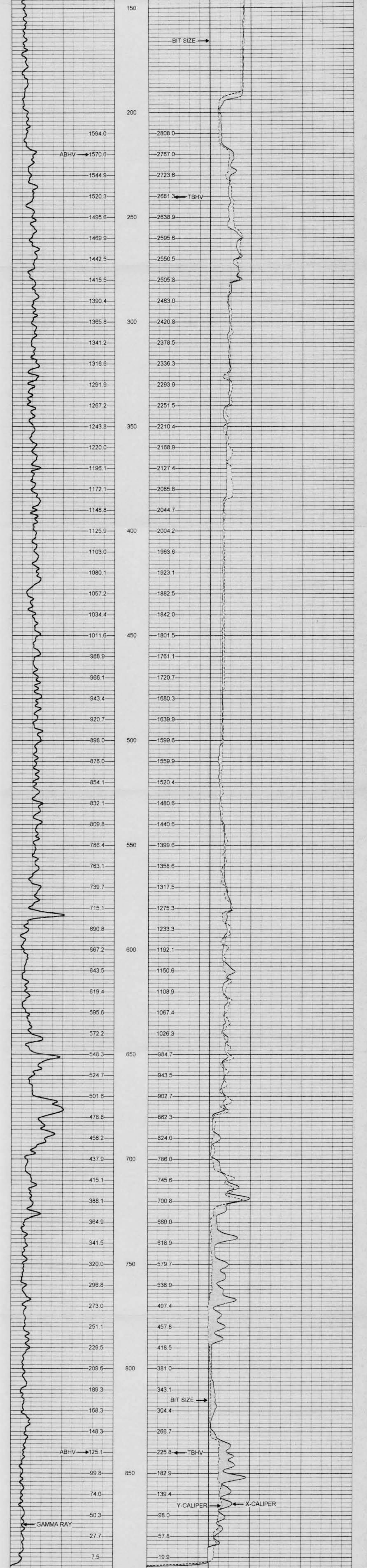
ABHV COMPUTED WITH 18" CASING



Dataset: run3/pass2.1
Total Length: 9.35 ft
Total Weight: 127.00 lb
O.D. 3.50 in

Database File: jensbro4.db
Dataset Pathname: run3/pass2.1
Presentation Format: grxyc.prs
Dataset Creation: Tue Jun 06 18:12:16 2000 by Calc VER_5.4
Charted by: Depth in Feet scaled 1:240

0 GAMMA RAY (GAPI) 100		20 X-CALIPER (in) 40
		20 Y-CALIPER (in) 40
		20 BIT SIZE (in) 40



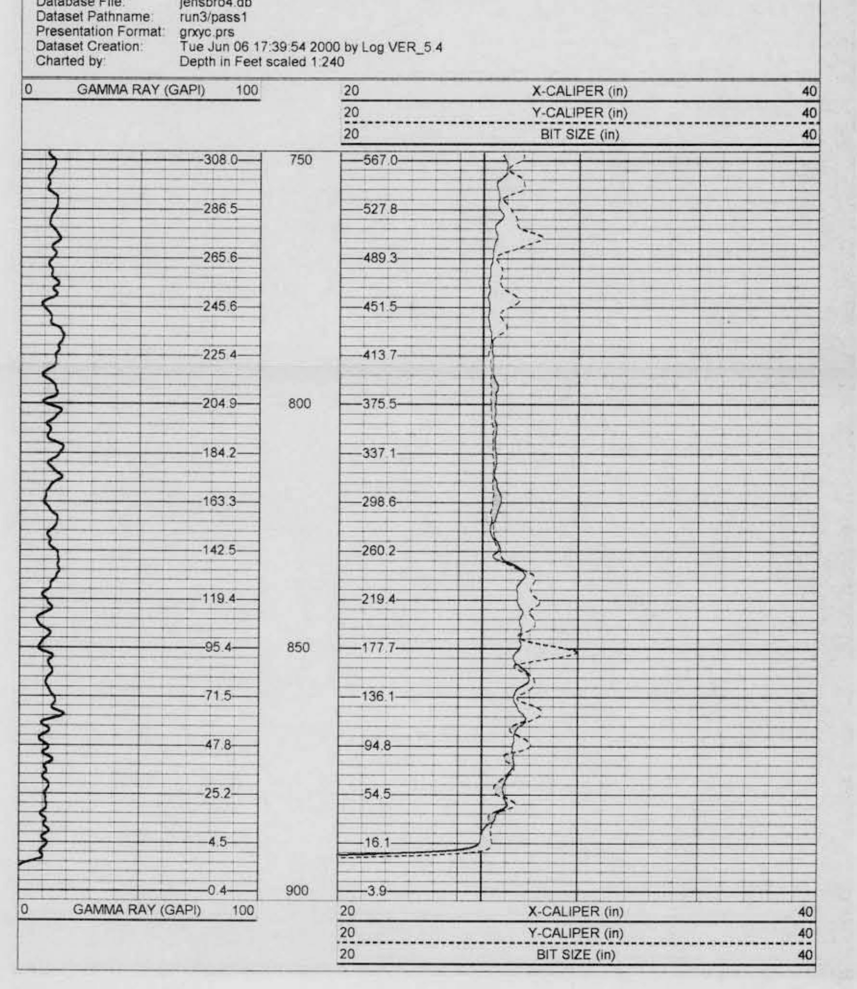
0 GAMMA RAY (GAPI) 100		20 X-CALIPER (in) 40
		20 Y-CALIPER (in) 40
		20 BIT SIZE (in) 40

FLORIDA GEOPHYSICAL LOGGING, INC.

REPEAT PASS

Database File: jensbro4.db
Dataset Pathname: run3/pass1
Presentation Format: grxyc.prs
Dataset Creation: Tue Jun 06 17:39:54 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:240

0 GAMMA RAY (GAPI) 100		20 X-CALIPER (in) 40
		20 Y-CALIPER (in) 40
		20 BIT SIZE (in) 40



0 GAMMA RAY (GAPI) 100		20 X-CALIPER (in) 40
		20 Y-CALIPER (in) 40
		20 BIT SIZE (in) 40

XY Caliper Calibration Report

Serial Number/Model: 14LM-XYCLM
Performed: Tue Jun 06 17:30:16 2000

Ring			X Caliper		Y Caliper	
1:	20	in	484.885	cps	488.589	cps
2:	30	in	607.608	cps	609.71	cps
3:	40	in	738.539	cps	739.84	cps
4:		in		cps		cps
5:		in		cps		cps
6:		in		cps		cps

Gamma Ray Calibration Report

Serial Number: 13
Tool Model: GROH
Performed: Fri Jan 30 03:34:53 1998

Calibrator Value: 120 GAPI

Background Reading: 18.1565 cps
Calibrator Reading: 149.8 cps

Sensitivity: 0.911554 GAPI/cps

FLORIDA GEOPHYSICAL LOGGING, INC.

FLOWMETER LOG

Company	MARTIN CO.
Well	RO-4
Field	JENSEN BEACH
Country	MARTIN
State/Prv	FL

Company MARTIN CO. ENVIRONMENTAL SVCS
Well RO-4
Field JENSEN BEACH
Country MARTIN State/Prv FLORIDA
Location

Other Services: FCT, X-Y / GR, DIL/LL3/SP

		Elevation		Elevation
Permanent Datum	PAD		K.B.	
Log Measured From	PAD		D.F.	
Drilling Measured From	PAD		G.L.	PAD

Date	21-JUNE-2000
Run Number	FOUR
Depth Driller	1375'
Depth Logger	1375'
Bottom Logged Interval	1365'
Top Log Interval	SURFACE
Open Hole Size	17"
Type Fluid	WATER
Density / Viscosity	NA
Max. Recorded Temp.	NA
Estimated Cement Top	NA
Time Well Ready	ON ARRIVAL
Time Logger on Bottom	0900
Equipment Number	103
Location	FT. MYERS
Recorded By	LEE
Witnessed By	JIM ANDERSEN

Borehole Record

Run Number	Bit	From	To
ONE	36.5"	SURFACE	203'
THREE	26"	CASING	895'
FOUR	17"	CASING	1375'

Tubing Record

Size	Weight	From	To

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	30"	375 W.T.	SURFACE	199'
Prot. String	18"	375 W.T.	176'	893'
Production String				
Liner				

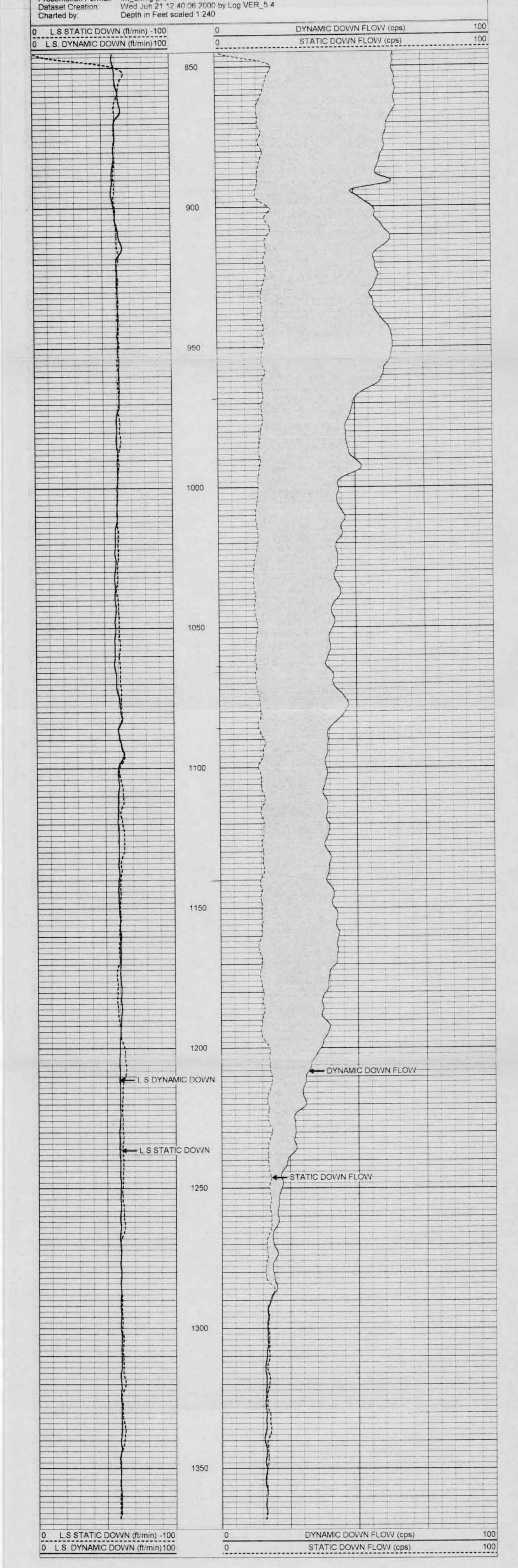
<<< Fold Here >>>

Comments

FLOWRATE=1,250 GPM

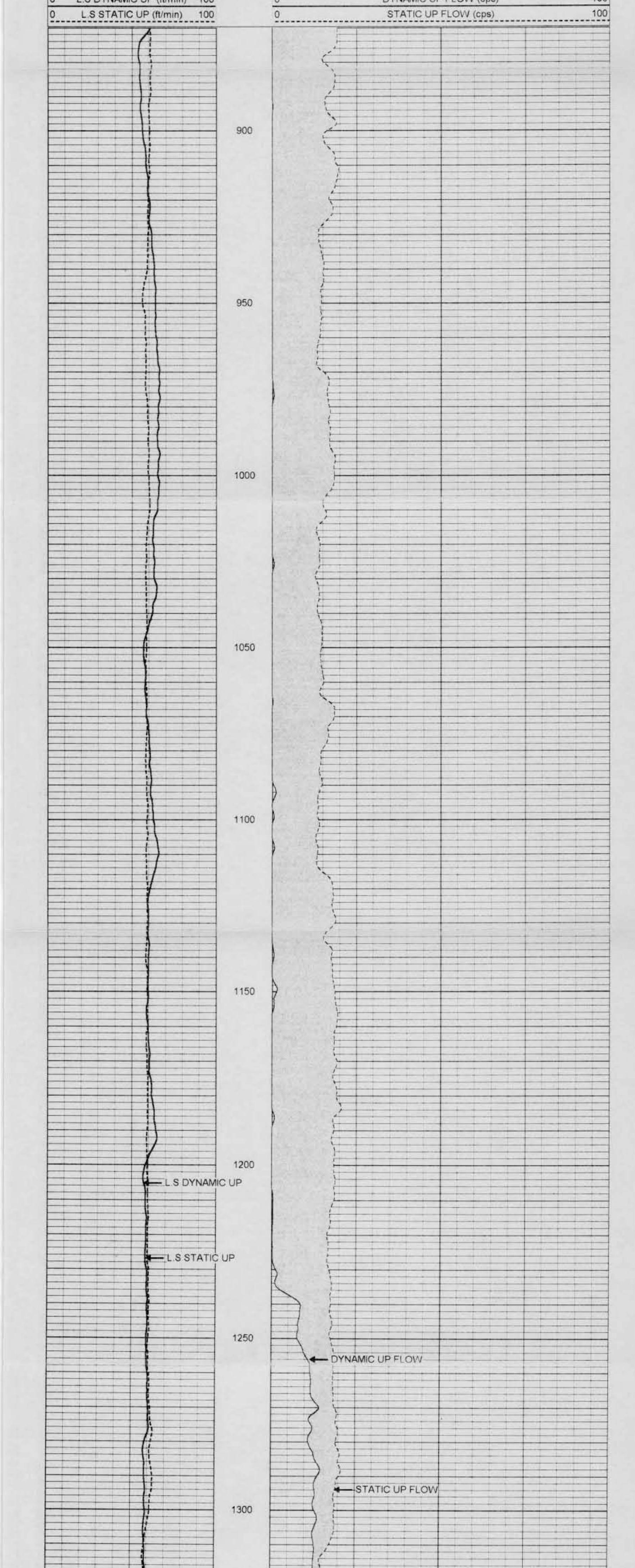
FLORIDA GEOPHYSICAL LOGGING, INC. — MERGED DOWN PASSES

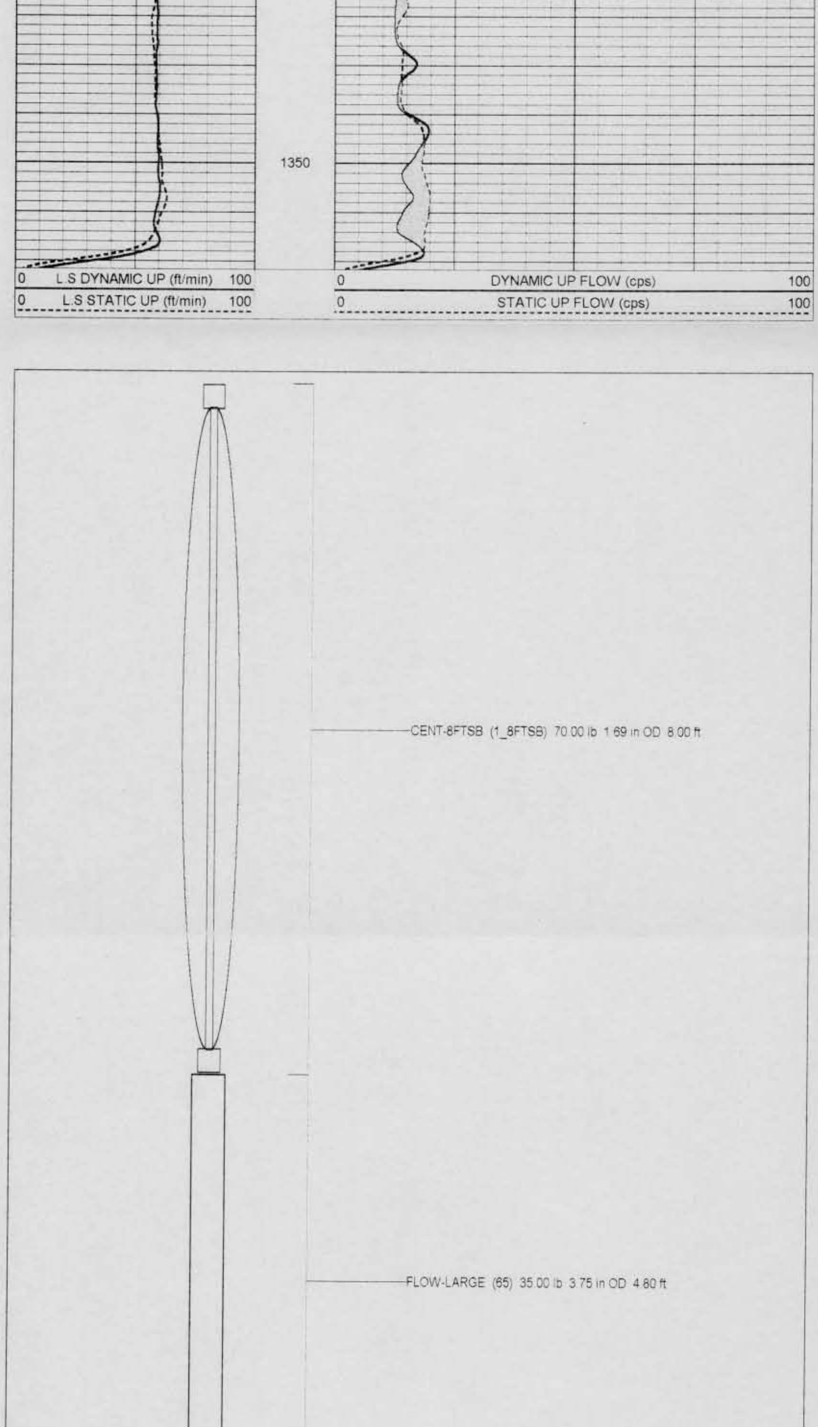
Database File: jensbro4.db
Dataset Pathname: run4/pass14
Presentation Format: fm_dnmg.prs
Dataset Creation: Wed Jun 21 12:40:06 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:240



FLORIDA GEOPHYSICAL LOGGING, INC. — MERGED UP PASSES

Database File: jensbro4.db
Dataset Pathname: run4/pass15
Presentation Format: fm_upmg.prs
Dataset Creation: Wed Jun 21 12:49:12 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:240





Dataset: run4/pass15
Total Length: 12.80 ft
Total Weight: 105.00 lb
O.D.: 3.75 in

FLORIDA GEOPHYSICAL LOGGING, INC.

DUAL INDUCTION LL3/SP LOG

Company MARTIN CO.
Well RO-4
Field JENSEN BEACH
Country MARTIN
State/Prv FL

Company	MARTIN CO. ENVIRONMENTAL SVCS
Well	RO-4
Field	JENSEN BEACH
Country	MARTIN
State/Prv	FLORIDA
Location	
Other Services	FCT X-Y / GR FLOWMETER

		Elevation	
Permanent Datum	PAD		K.B.
Log Measured From	PAD		D.F.
Drilling Measured From	PAD		G.L.

Date	21-JUNE-2000	
Run Number	FOUR	
Depth Driller	1375'	
Depth Logger	1375'	
Bottom Logged Interval	1325'	
Top Log Interval	SURFACE	
Open Hole Size	17"	
Type Fluid	WATER	
Density / Viscosity	NA	
Max. Recorded Temp.	NA	
Estimated Cement Top	NA	
Time Well Ready	ON ARRIVAL	
Time Logger on Bottom	0900	
Equipment Number	103	
Location	FT MYERS	
Recorded By	LEE	DENISON
Witnessed By	JIM ANDERSEN	

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	36.5"	SURFACE	203'				
THREE	26"	CASING	895'				
FOUR	17"	CASING	1375'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	30"	.375 W.T.	SURFACE	199'
Prot. String	18"	.375 W.T.	176'	893'
Production String				
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and we cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to our general terms and conditions set out in our current Price Schedule.

Comments

FLORIDA GEOPHYSICAL LOGGING, INC.

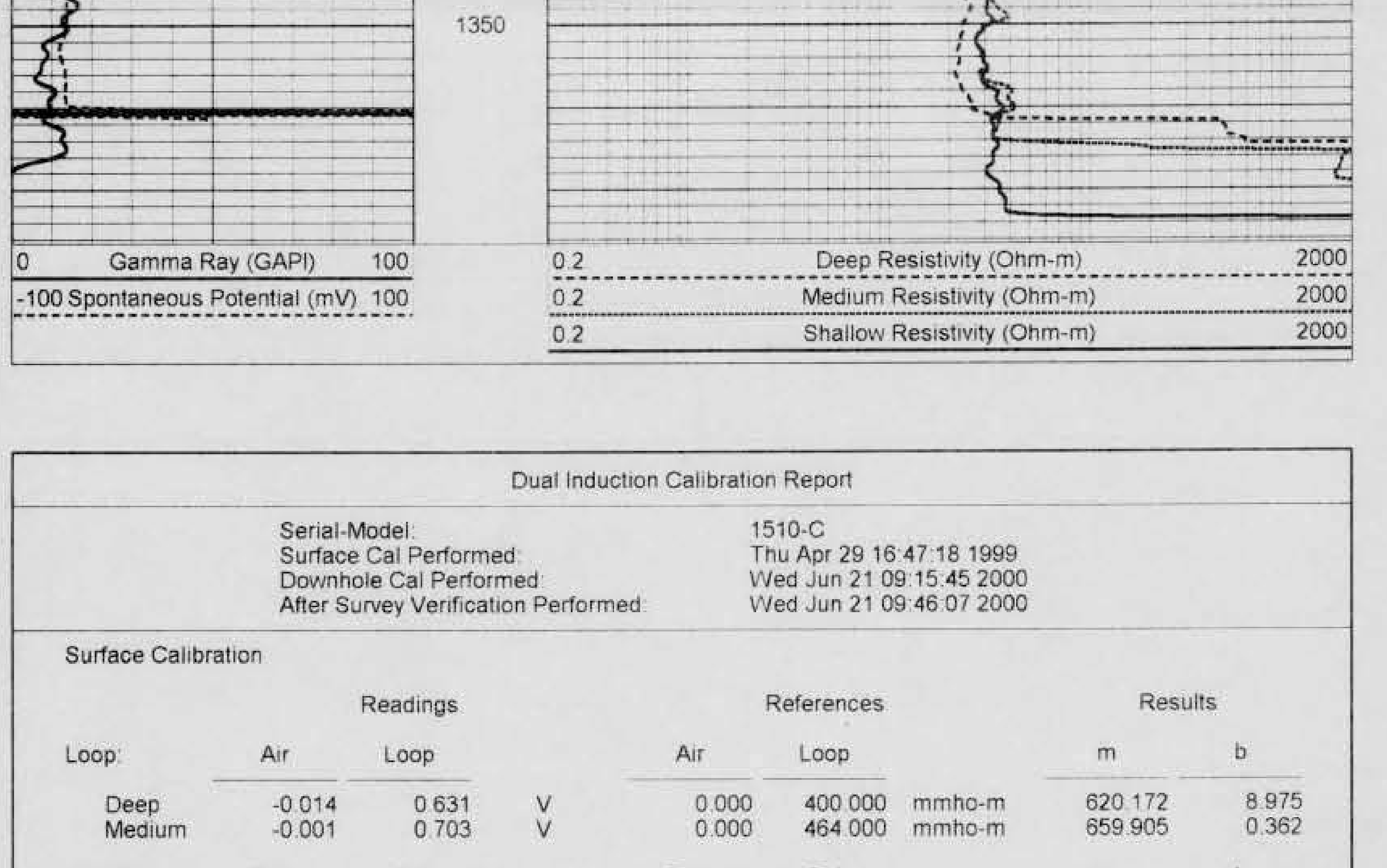
MAIN PASS

Database File: jensbro4.db
Dataset Pathname: run4/pass7
Presentation Format: dil.prs
Dataset Creation: Wed Jun 21 09:48:07 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:240

FLORIDA GEOPHYSICAL LOGGING, INC.

REPEAT PASS

Database File: jensbro4.db
Dataset Pathname: run4/pass6
Presentation Format: dil.prs
Dataset Creation: Wed Jun 21 09:40:37 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:240



Dual Induction Calibration Report

Serial-Model: 1510-C
Surface Cal Performed: Thu Apr 29 16:47:18 1999
Downhole Cal Performed: Wed Jun 21 09:15:45 2000
After Survey Verification Performed: Wed Jun 21 09:46:07 2000

Surface Calibration

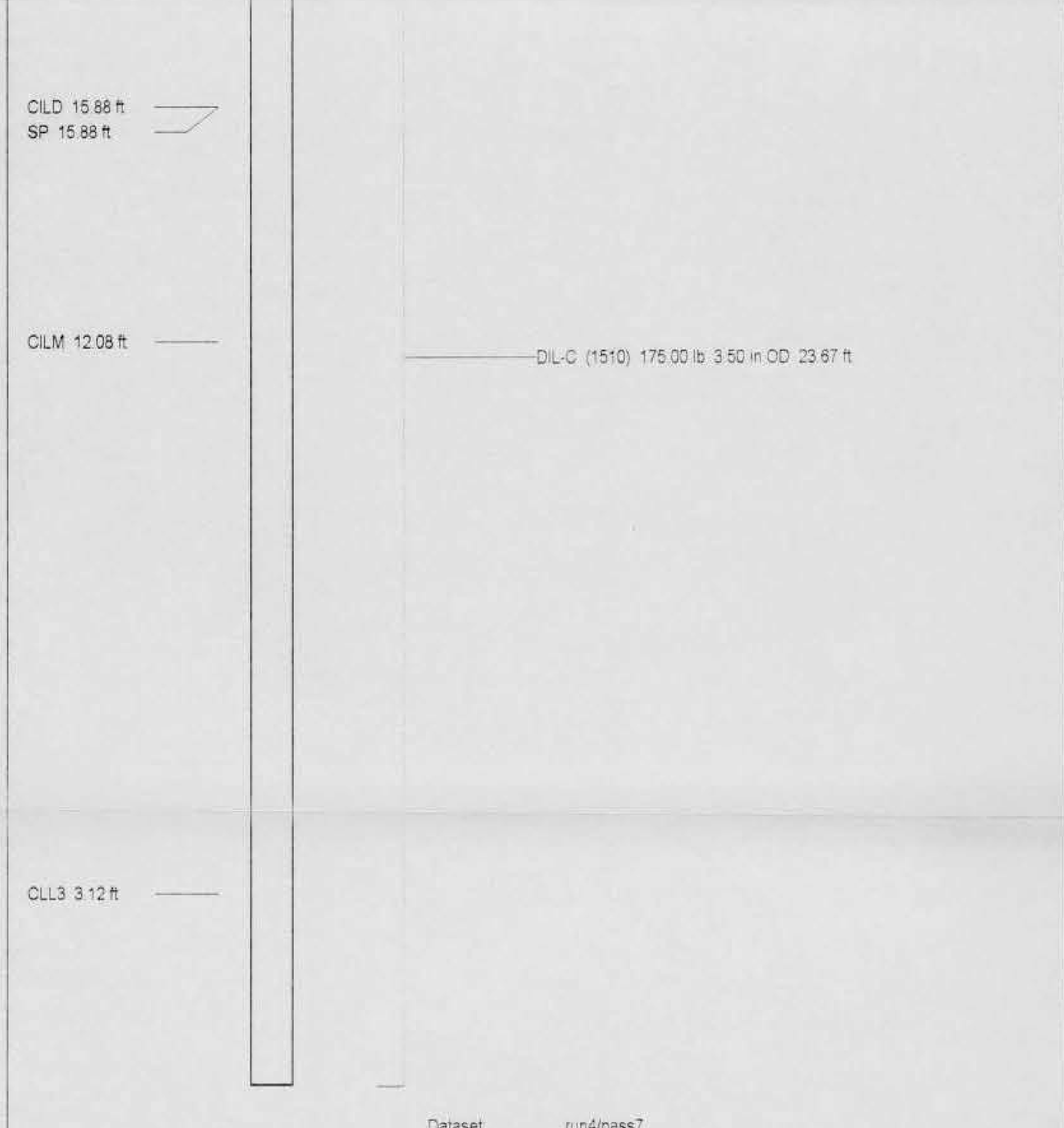
	Readings			References			Results	
Loop:	Air	Loop		Air	Loop		m	b
Deep	-0.014	0.631	V	0.000	400.000	mmho-m	620.172	8.975
Medium	-0.001	0.703	V	0.000	464.000	mmho-m	659.905	0.362
Internal:	Zero	Cal		Zero	Cal		m	b
Deep	0.012	0.641	V	17.680	407.650	mmho-m	620.191	10.098
Medium	0.009	0.728	V	6.060	482.670	mmho-m	662.558	0.111

Downhole Calibration

	Readings			References			Results	
Internal:	Zero	Cal		Zero	Cal		m	b
Deep	12.802	408.475	mmho-m	16.557	406.514	mmho-m	0.986	3.940
Medium	8.325	489.487	mmho-m	6.287	480.989	mmho-m	0.987	-1.926
Shallow	0.028	0.417		3.000	88.900	mmho-m	220.676	-3.084

After Survey Verification

	Readings			Targets			Results	
Internal:	Zero	Cal		Zero	Cal		m'	b'
Deep	12.450	393.350	mmho-m	12.802	408.475	mmho-m	0.986	3.940
Medium	7.834	470.714	mmho-m	8.325	489.487	mmho-m	0.987	-1.926
Shallow	3.059	85.957	mmho-m	3.000	88.900	mmho-m	1.036	-0.170



Dataset: run4/pass7
Total Length: 23.67 ft
Total Weight: 175.00 lb
O.D. 3.50 in

FLORIDA
GEOPHYSICAL LOGGING, INC.

DUAL INDUCTION LL3/SP LOG

Company	MARTIN CO. ENVIRO. SVCS.
Well	RO-4
Field	JENSEN BEACH
Country	MARTIN
State/Prv	FL

Company	MARTIN CO. ENVIRO. SVCS.		
Well	RO-4		
Field	JENSEN BEACH		
Country	MARTIN	State/Prv	FLORIDA
Location		Other Services	XY/C/GR
Permanent Datum	PAD	Elevation	K.B.
Log Measured From	PAD		D.F.
Drilling Measured From	PAD	Elevation	G.L.

Date	5/24/00
Run Number	ONE
Depth Driller	203'
Depth Logger	202'
Bottom Logged Interval	202'
Top Log Interval	SURFACE
Open Hole Size	36.5"
Type Fluid	MUD
Density / Viscosity	NA
Max. Recorded Temp	NA
Estimated Cement Top	NA
Time Well Ready	ON ARRIVAL
Time Logger on Bottom	0900
Equipment Number	103
Location	FT. MYERS
Recorded By	DENISON
Witnessed By	JIM ANDERSEN

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	36.5"	SURFACE	203'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String				
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and we cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to our general terms and conditions set out in our current Price Schedule.

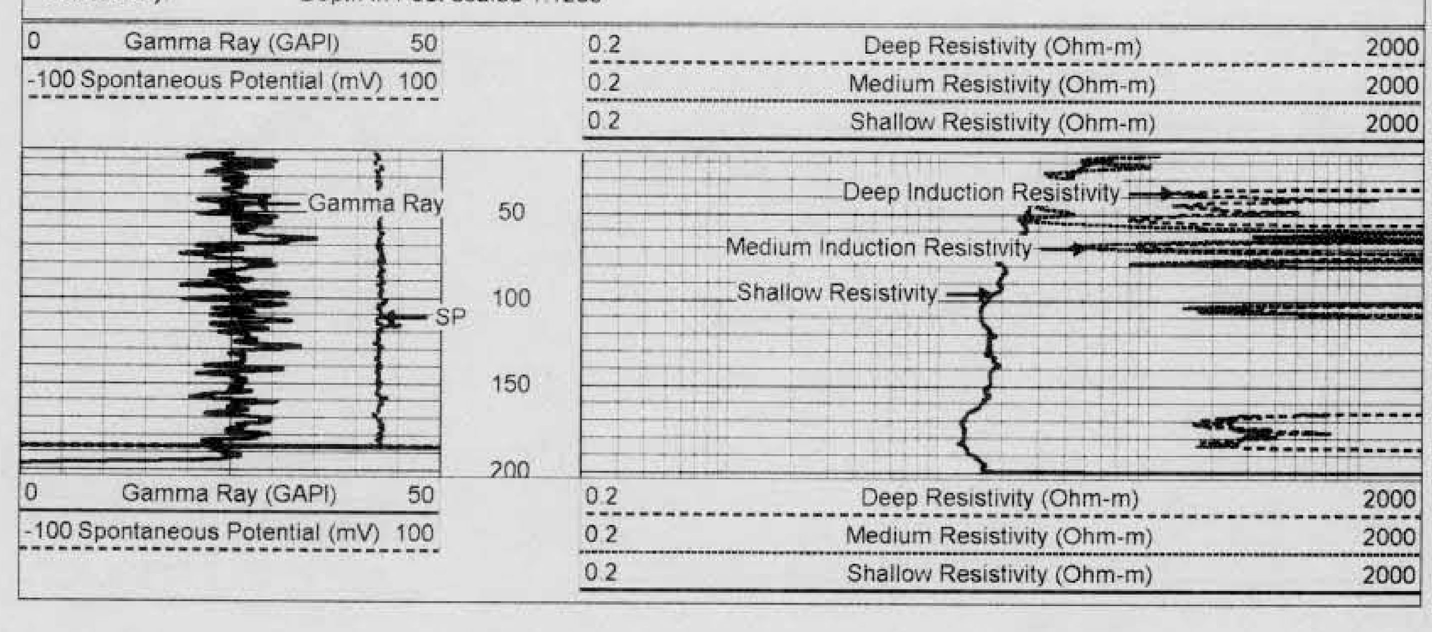
Comments

FLORIDA
GEOPHYSICAL LOGGING, INC.

MAIN PASS

Database File: jensbro4.db
Dataset Pathname: pass7
Presentation Format: dil.prs
Dataset Creation: Wed May 24 09:21:44 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:1200

0 Gamma Ray (GAPI) 50
-100 Spontaneous Potential (mV) 100
0.2 Deep Resistivity (Ohm-m) 2000
0.2 Medium Resistivity (Ohm-m) 2000
0.2 Shallow Resistivity (Ohm-m) 2000



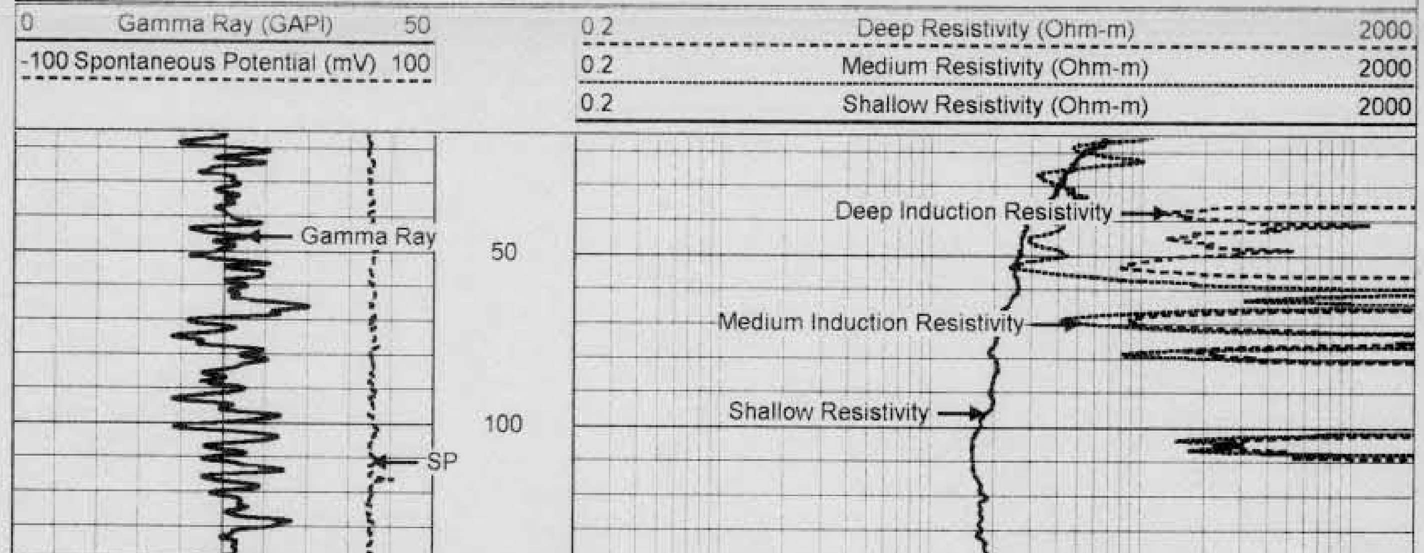
0 Gamma Ray (GAPI) 50
-100 Spontaneous Potential (mV) 100
0.2 Deep Resistivity (Ohm-m) 2000
0.2 Medium Resistivity (Ohm-m) 2000
0.2 Shallow Resistivity (Ohm-m) 2000

FLORIDA
GEOPHYSICAL LOGGING, INC.

MAIN PASS

Database File: jensbro4.db
Dataset Pathname: pass7
Presentation Format: dil.prs
Dataset Creation: Wed May 24 09:21:44 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:600

0 Gamma Ray (GAPI) 50
-100 Spontaneous Potential (mV) 100
0.2 Deep Resistivity (Ohm-m) 2000
0.2 Medium Resistivity (Ohm-m) 2000
0.2 Shallow Resistivity (Ohm-m) 2000



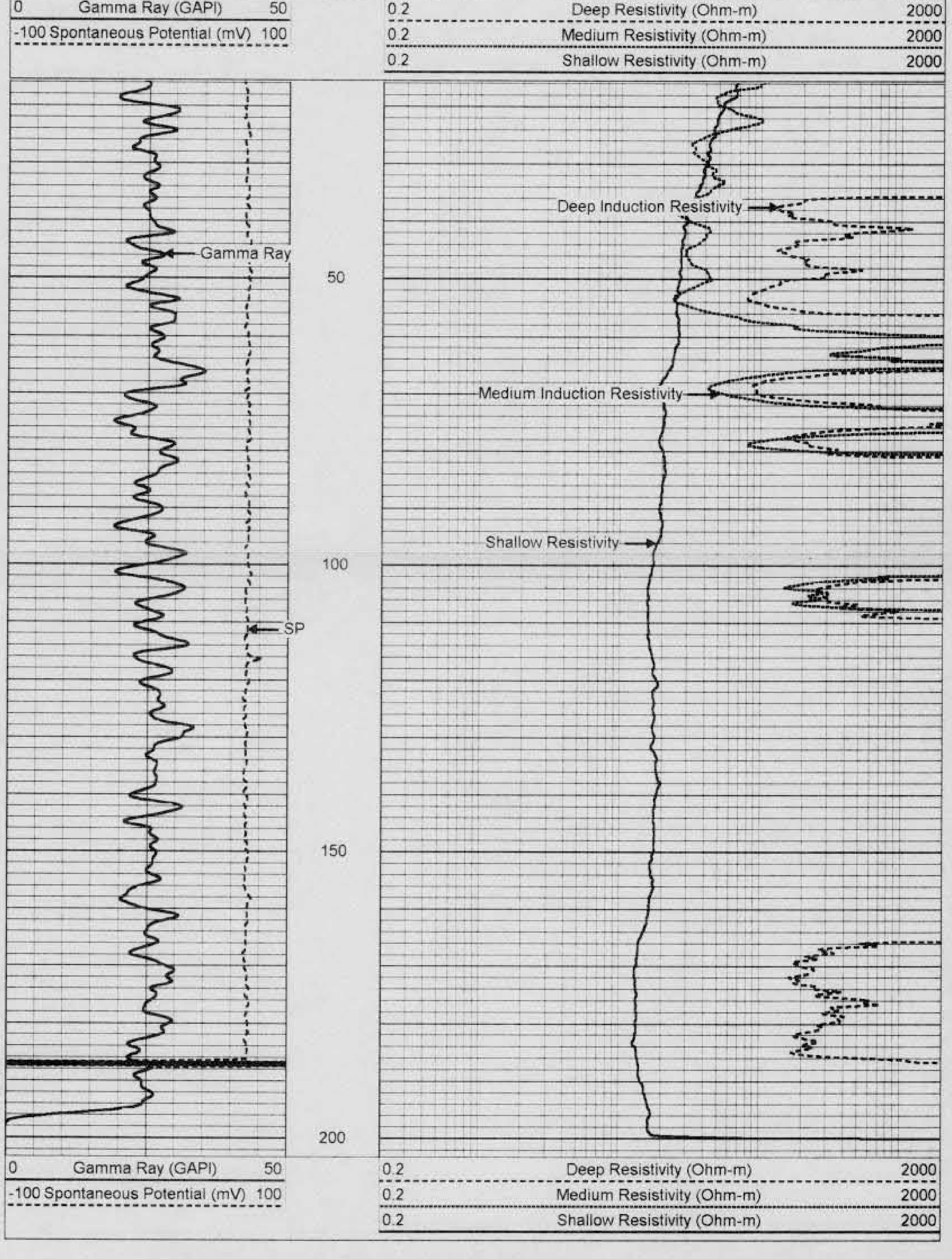
0 Gamma Ray (GAPI) 50
-100 Spontaneous Potential (mV) 100
0.2 Deep Resistivity (Ohm-m) 2000
0.2 Medium Resistivity (Ohm-m) 2000
0.2 Shallow Resistivity (Ohm-m) 2000

FLORIDA
GEOPHYSICAL LOGGING, INC.

MAIN PASS

Database File: jensbro4.db
Dataset Pathname: pass7
Presentation Format: dil.prs
Dataset Creation: Wed May 24 09:21:44 2000 by Log VER_5.4
Charted by: Depth in Feet scaled 1:240

0 Gamma Ray (GAPI) 50
-100 Spontaneous Potential (mV) 100
0.2 Deep Resistivity (Ohm-m) 2000
0.2 Medium Resistivity (Ohm-m) 2000
0.2 Shallow Resistivity (Ohm-m) 2000



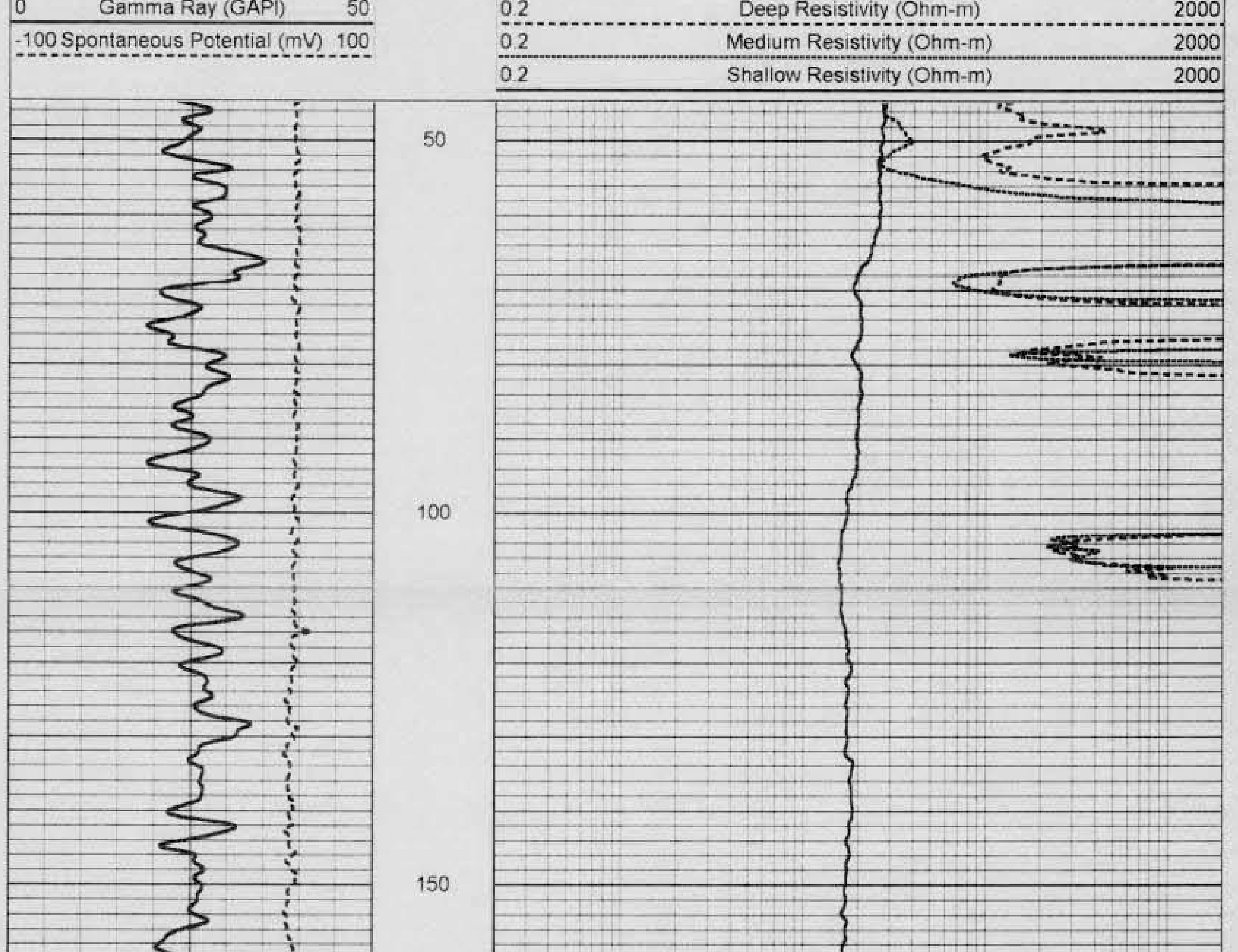
0 Gamma Ray (GAPI) 50
-100 Spontaneous Potential (mV) 100
0.2 Deep Resistivity (Ohm-m) 2000
0.2 Medium Resistivity (Ohm-m) 2000
0.2 Shallow Resistivity (Ohm-m) 2000

FLORIDA
GEOPHYSICAL LOGGING, INC.

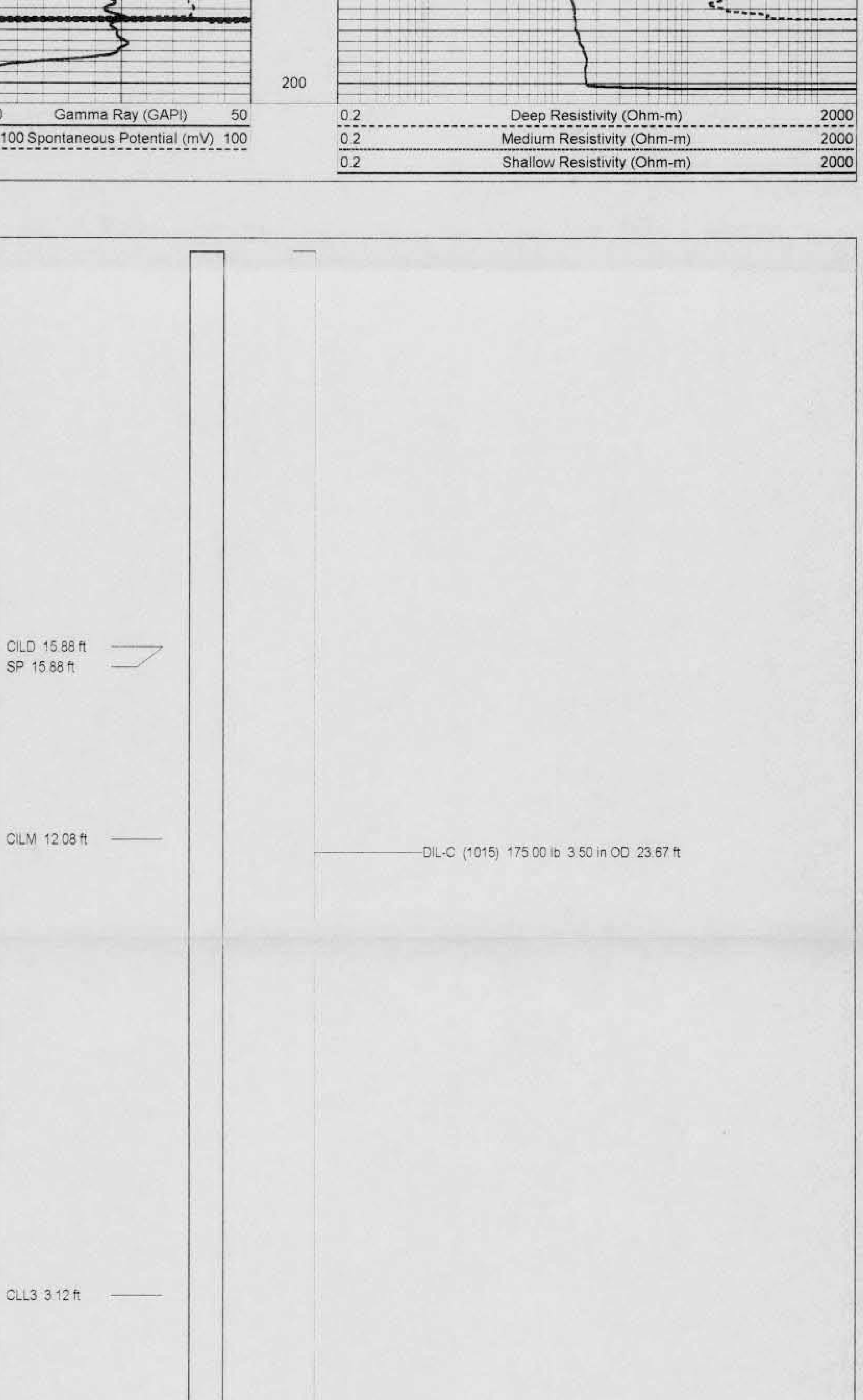
REPEAT PASS

Database File: jensbro4.db
Dataset Pathname: pass6.1
Presentation Format: dil.prs
Dataset Creation: Wed May 24 10:20:16 2000 by Calc VER_5.4
Charted by: Depth in Feet scaled 1:240

0 Gamma Ray (GAPI) 50
-100 Spontaneous Potential (mV) 100
0.2 Deep Resistivity (Ohm-m) 2000
0.2 Medium Resistivity (Ohm-m) 2000
0.2 Shallow Resistivity (Ohm-m) 2000



0 Gamma Ray (GAPI) 50
-100 Spontaneous Potential (mV) 100
0.2 Deep Resistivity (Ohm-m) 2000
0.2 Medium Resistivity (Ohm-m) 2000
0.2 Shallow Resistivity (Ohm-m) 2000



Dataset: run1/pass7
Total Length: 23.67 ft
Total Weight: 175.00 lb
O.D.: 3.50 in

Dual Induction Calibration Report

Serial-Model: 1015-C
Surface Cal Performed: Thu Apr 29 13:06:56 1999
Downhole Cal Performed: Wed May 24 08:50:52 2000
After Survey Verification Performed: Wed May 24 09:12:53 2000

Surface Calibration

	Readings			References			Results	
Loop:	Air	Loop		Air	Loop		m	b
Deep	-0.007	0.685	V	0.000	400.000	mmho-m	577.909	4.014
Medium	0.008	0.735	V	0.000	464.000	mmho-m	638.543	-5.261
Internal:	Zero	Cal		Zero	Cal		m	b
Deep	0.004	0.672	V	5.410	390.940	mmho-m	577.627	3.027
Medium	0.004	0.775	V	0.630	489.010	mmho-m	632.969	-1.831

Downhole Calibration

	Readings			References			Results	
Internal:	Zero	Cal		Zero	Cal		m	b
Deep	13.552	388.572	mmho-m	6.398	392.117	mmho-m	1.029	-7.540
Medium	2.518	476.584	mmho-m	-2.779	489.902	mmho-m	1.039	-5.395
Shallow	0.034	0.416		5.400	182.730	mmho-m	463.895	-10.263

After Survey Verification

	Readings			Targets			Results	
Internal:	Zero	Cal		Zero	Cal		m'	b'
Deep	13.192	381.701	mmho-m	13.552	388.572	mmho-m	1.029	-7.540
Medium	2.475	480.264	mmho-m	2.518	476.584	mmho-m	1.039	-5.395
Shallow	6.269	181.912	mmho-m	5.400	182.730	mmho-m	1.010	-0.929

FLORIDA GEOPHYSICAL LOGGING, INC.

X-Y CALIPER GAMMA RAY LOG

Company	MARTIN CO. ENVIRONMENTAL SVCS
Well	RO-4
Field	JENSEN BEACH
Country	MARTIN
State/Prv	FLORIDA
Location	

Other Services: FCT, DIL/LL3/SP, FLOWMETER

Permanent Datum	PAD	Elevation	Elevation: K.B. / D.F. / G.L.
Log Measured From	PAD		
Drilling Measured From	PAD		

Company MARTIN CO.
Well RO-4
Field JENSEN BEACH
Country MARTIN
State/Prv FL

Date	21-JUNE-2000
Run Number	FOUR
Depth Driller	1375'
Depth Logger	1375'
Bottom Logged Interval	1325'
Top Log Interval	875'
Open Hole Size	17"
Type Fluid	WATER
Density / Viscosity	NA
Max. Recorded Temp.	NA
Estimated Cement Top	NA
Time Well Ready	ON ARRIVAL
Time Logger on Bottom	0900
Equipment Number	103
Location	FT MYERS
Recorded By	LEE
Witnessed By	JIM ANDERSEN / DENISON

Run Number	Borehole Record: Bit	From	To	Tubing Record: Size	Weight	From	To
ONE	36.5"	SURFACE	203'				
THREE	26"	CASING	895'				
FOUR	17"	CASING	1375'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	30"	375 W.T	SURFACE	199'
Prot. String	18"	375 W.T	187'	892'
Production String				
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and we cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to our general terms and conditions set out in our current Price Schedule.

Comments

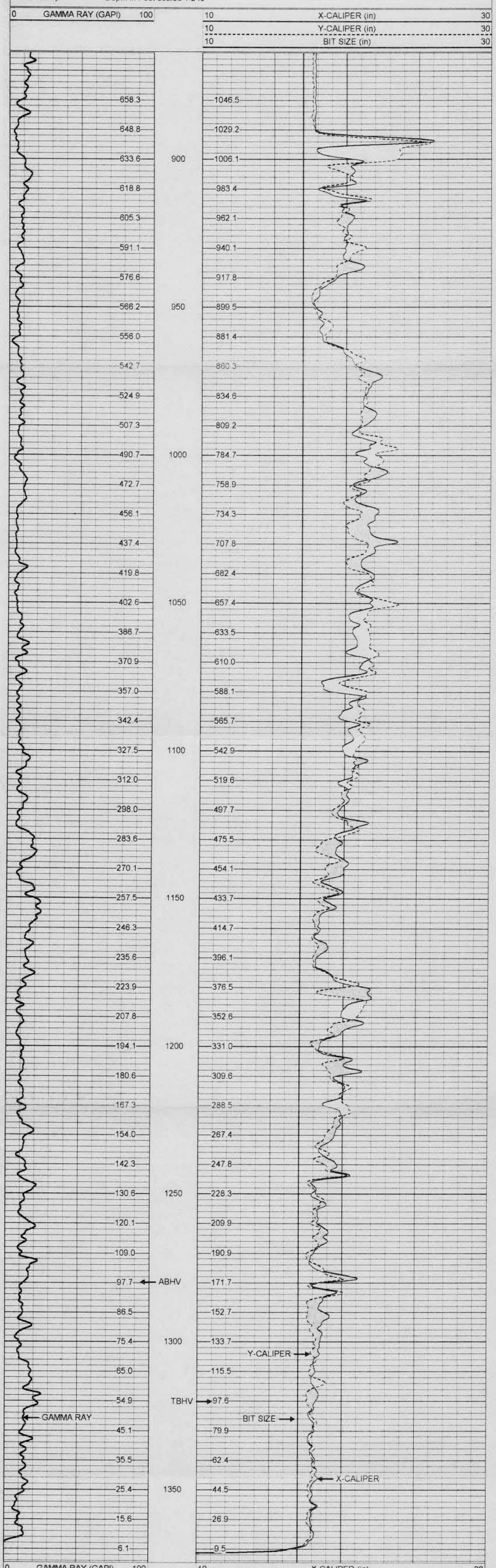
ABHV COMPUTED WITH 12" CASING

FLORIDA GEOPHYSICAL LOGGING, INC.

MAIN PASS

Database File:	jensbro4.db
Dataset Pathname:	run4/pass3.1
Presentation Format:	grxyc.prs
Dataset Creation:	Wed Jun 21 09:08:54 2000 by Calc VER_5.4
Charted by:	Depth in Feet scaled 1:240

0 GAMMA RAY (GAPI) 100
10 X-CALIPER (in) 30
10 Y-CALIPER (in) 30
10 BIT SIZE (in) 30



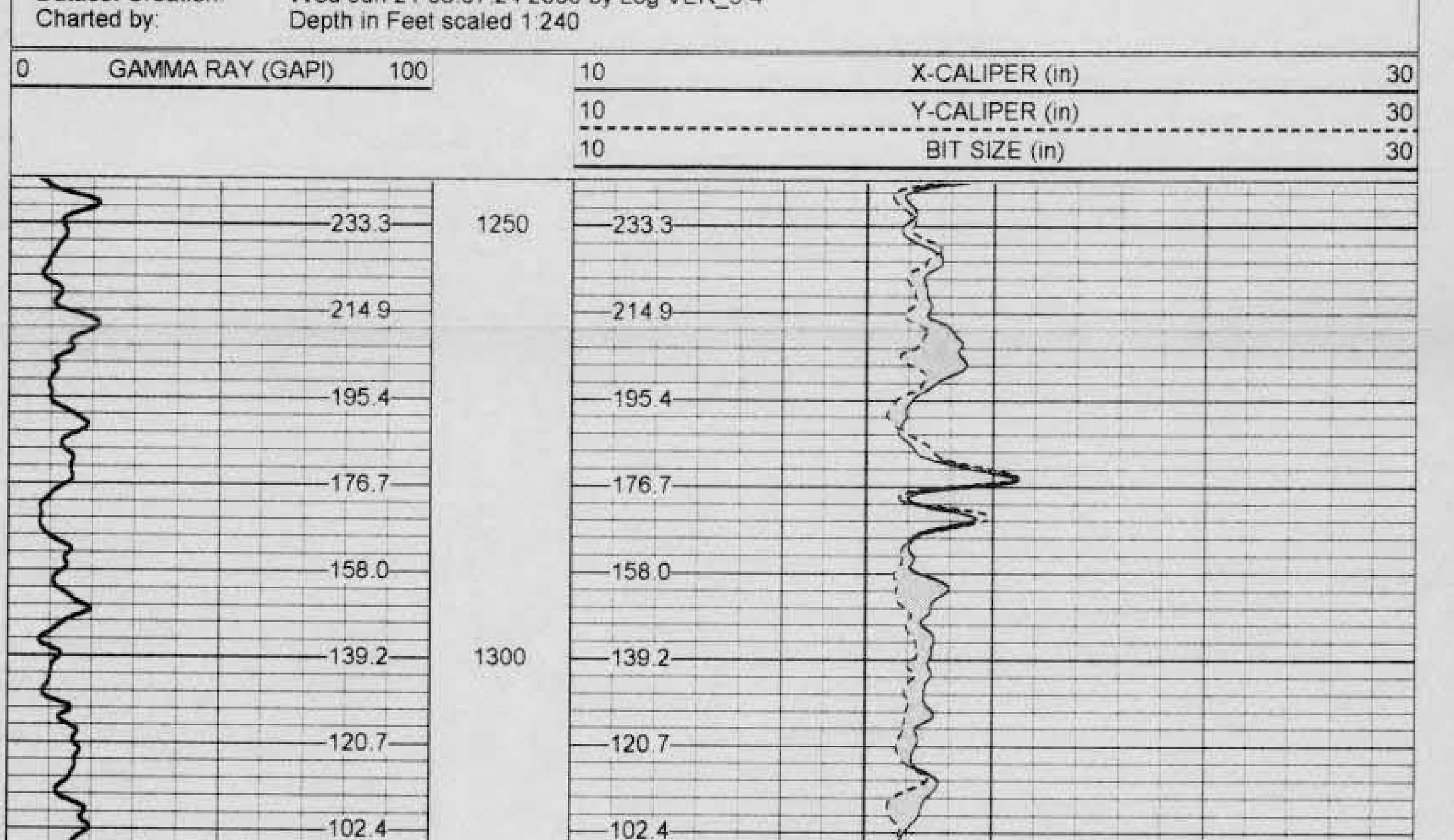
0 GAMMA RAY (GAPI) 100
10 X-CALIPER (in) 30
10 Y-CALIPER (in) 30
10 BIT SIZE (in) 30

FLORIDA GEOPHYSICAL LOGGING, INC.

REPEAT PASS

Database File:	jensbro4.db
Dataset Pathname:	run4/pass2
Presentation Format:	grxyc.prs
Dataset Creation:	Wed Jun 21 08:07:24 2000 by Log VER_5.4
Charted by:	Depth in Feet scaled 1:240

0 GAMMA RAY (GAPI) 100
10 X-CALIPER (in) 30
10 Y-CALIPER (in) 30
10 BIT SIZE (in) 30



0 GAMMA RAY (GAPI) 100
10 X-CALIPER (in) 30
10 Y-CALIPER (in) 30
10 BIT SIZE (in) 30

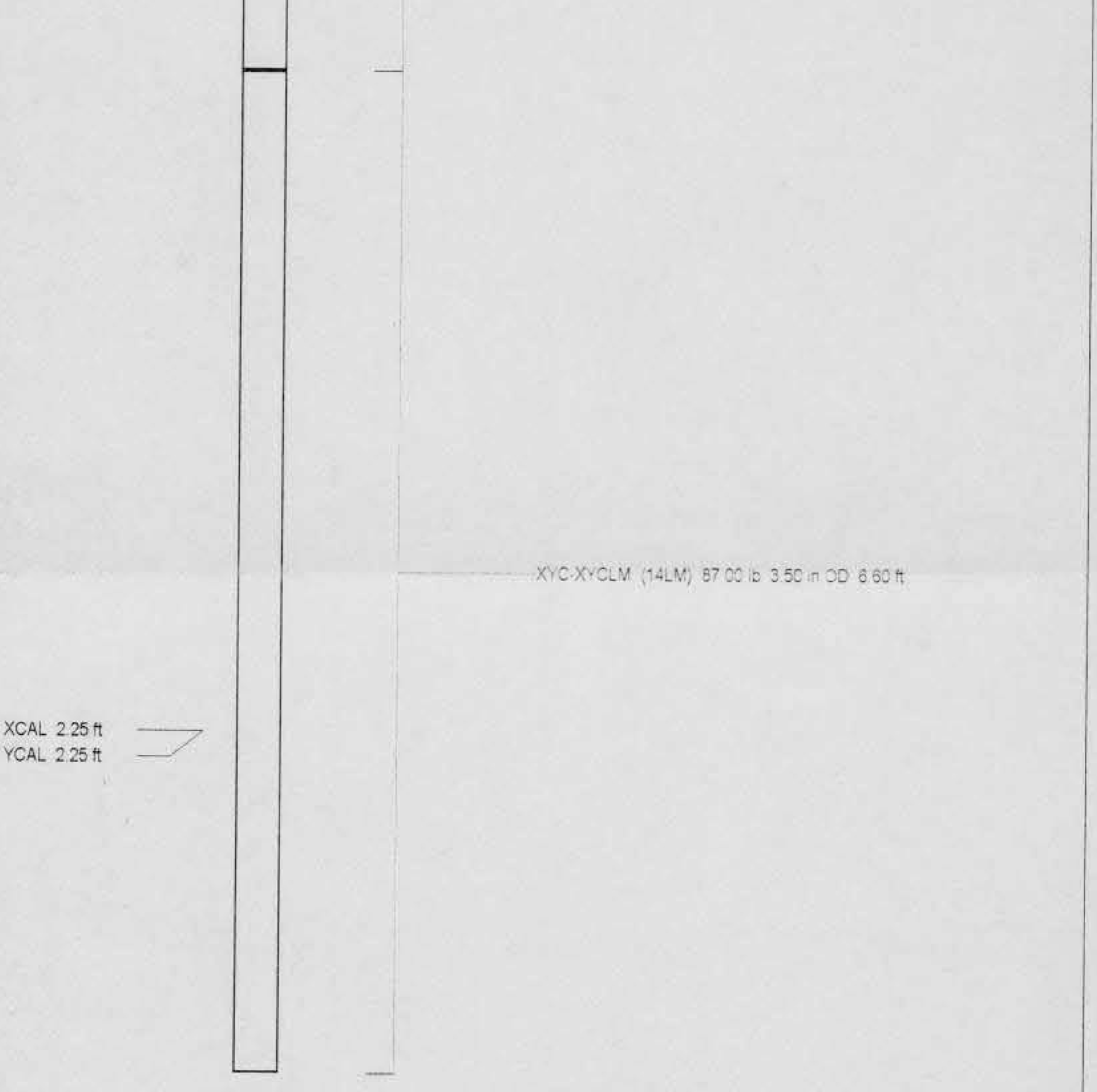
XY Caliper Calibration Report

Serial Number/Model: 14LM-XYCLM
Performed: Wed Jun 21 07:27:08 2000

Ring			X Caliper		Y Caliper	
1:	10	in	380.681	cps	390.891	cps
2:	20	in	487.487	cps	492.092	cps
3:	30	in	608.508	cps	611.912	cps
4:		in		cps		cps
5:		in		cps		cps
6:		in		cps		cps

Gamma Ray Calibration Report

Serial Number:	15	
Tool Model:	GROH	
Performed:	Tue Feb 01 08:17:08 2000	
Calibrator Value:	120	GAPI
Background Reading:	26.6066	cps
Calibrator Reading:	140.807	cps
Sensitivity:	1.05078	GAPI/cps



Dataset:	run4/pass3
Total Length:	9.35 ft
Total Weight:	127.00 lb
O.D.:	3.50 in

FLORIDA GEOPHYSICAL LOGGING, INC.

DUAL INDUCTION LL3/SP LOG

Company	MARTIN CO. ENVIRO. SVCS.
Well	RO-4
Field	JENSEN BEACH
Country	MARTIN
State/Prv	FL

Company	MARTIN CO. ENVIRO. SVCS.		
Well	RO-4		
Field	JENSEN BEACH		
Country	MARTIN	State/Prv	FLORIDA
Location		Other Services	XYC-GR
Permanent Datum	PAD	Elevation	K.B.
Log Measured From	PAD		D.F.
Drilling Measured From	PAD		G.L.

Date	5/31/00
Run Number	TWO
Depth Driller	900'
Depth Logger	900'
Bottom Logged Interval	900'
Top Log Interval	CASING
Open Hole Size	12.25"
Type Fluid	MUD
Density / Viscosity	NA
Max. Recorded Temp	NA
Estimated Cement Top	NA
Time Well Ready	ON ARRIVAL
Time Logger on Bottom	1030
Equipment Number	103
Location	FT. MYERS
Recorded By	DENISON
Witnessed By	JIM ANDERSEN

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	36.5"	SURFACE	203'				
TWO	12.25"	CASING	900'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	30"	375	SURFACE	199'
Prot. String				
Production String				
Liner				

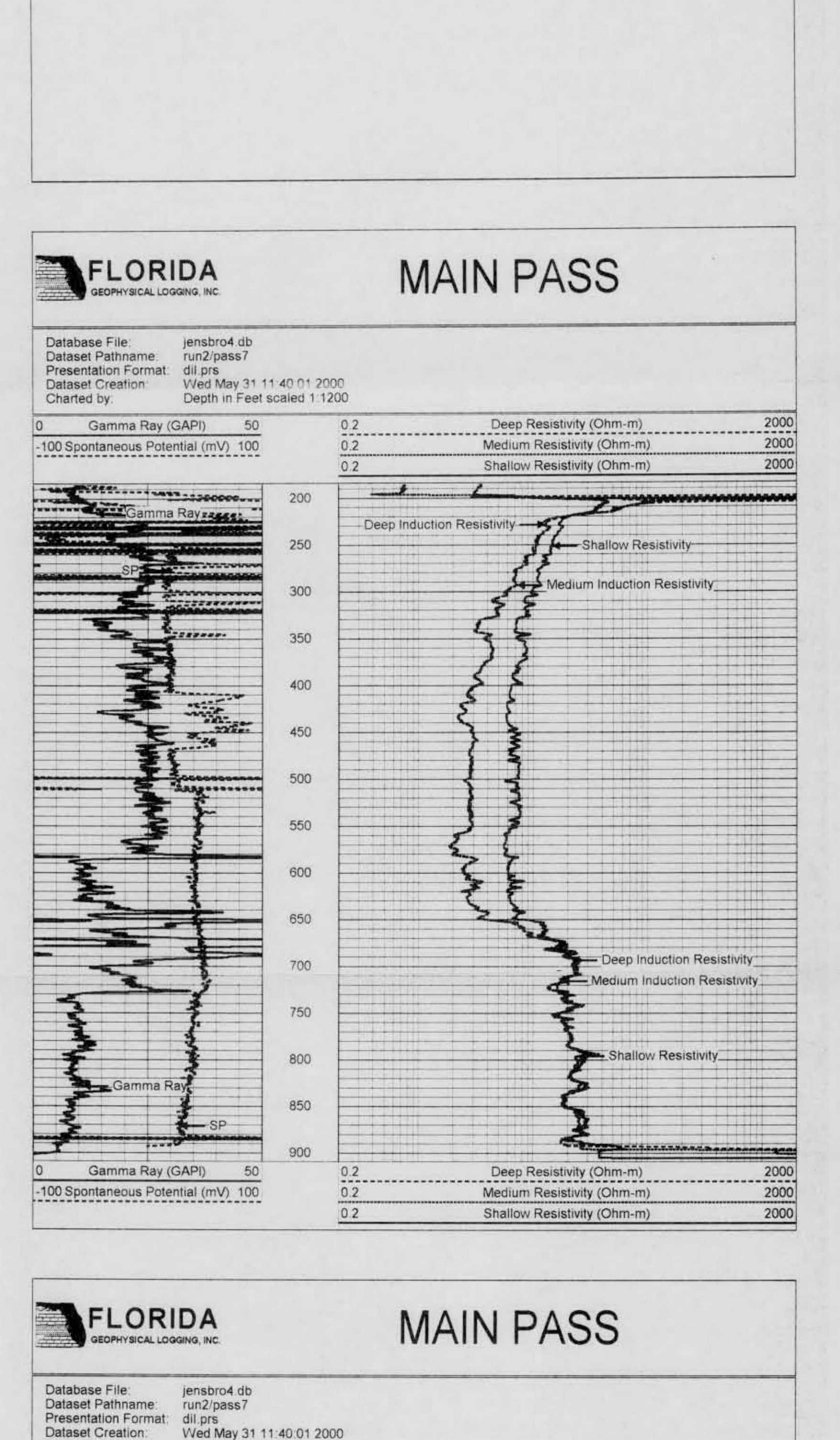
<<< Fold Here >>>

Comments

FLORIDA GEOPHYSICAL LOGGING, INC. — MAIN PASS

Database File: jensbro4.db
Dataset Pathname: run2/pass7
Presentation Format: dil.prs
Dataset Creation: Wed May 31 11:40:01 2000
Charted by: Depth in Feet scaled 1:1200

0 Gamma Ray (GAPI) 50		0.2 Deep Resistivity (Ohm-m) 2000
-100 Spontaneous Potential (mV) 100		0.2 Medium Resistivity (Ohm-m) 2000
		0.2 Shallow Resistivity (Ohm-m) 2000

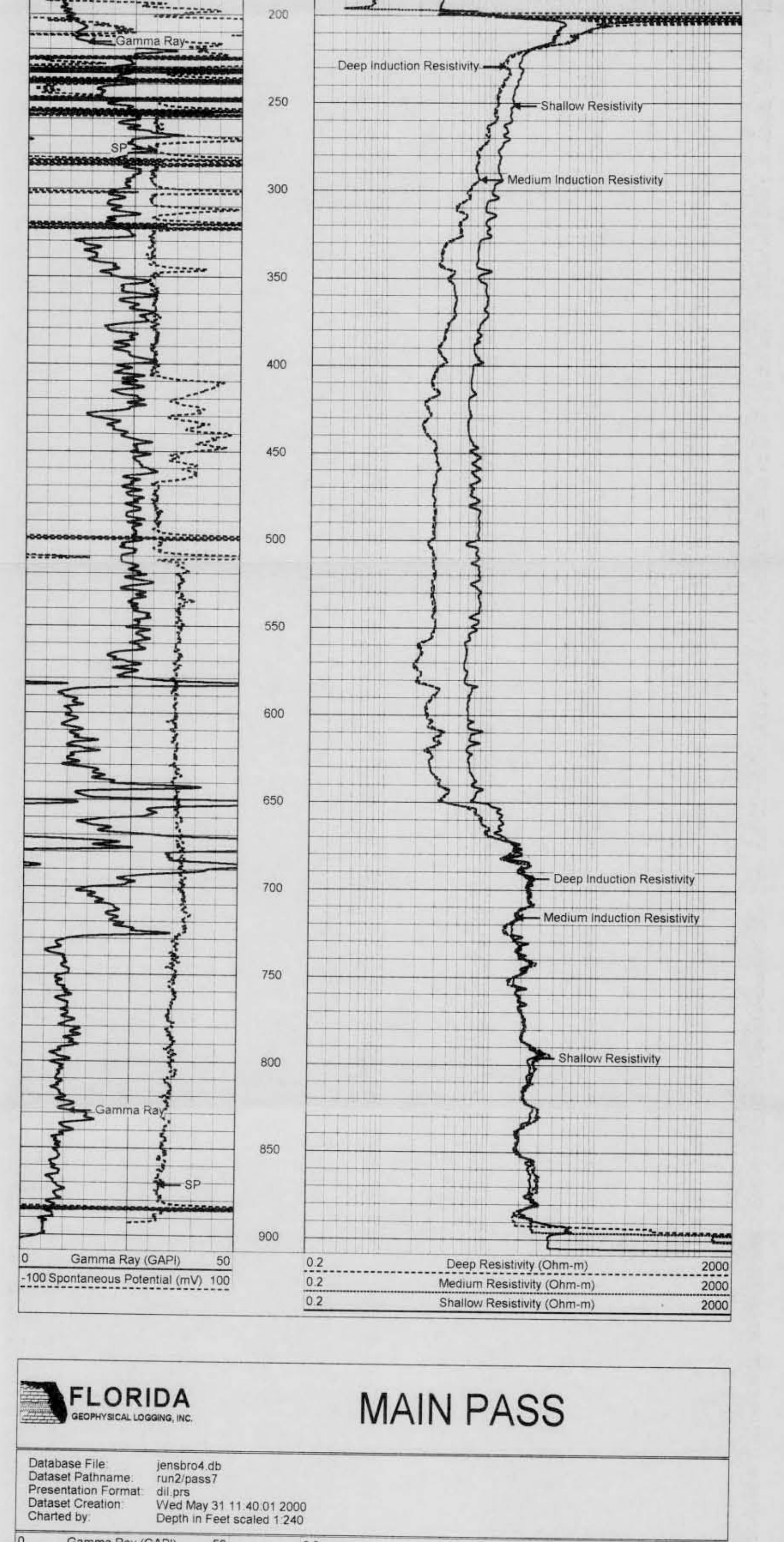


0 Gamma Ray (GAPI) 50		0.2 Deep Resistivity (Ohm-m) 2000
-100 Spontaneous Potential (mV) 100		0.2 Medium Resistivity (Ohm-m) 2000
		0.2 Shallow Resistivity (Ohm-m) 2000

FLORIDA GEOPHYSICAL LOGGING, INC. — MAIN PASS

Database File: jensbro4.db
Dataset Pathname: run2/pass7
Presentation Format: dil.prs
Dataset Creation: Wed May 31 11:40:01 2000
Charted by: Depth in Feet scaled 1:600

0 Gamma Ray (GAPI) 50		0.2 Deep Resistivity (Ohm-m) 2000
-100 Spontaneous Potential (mV) 100		0.2 Medium Resistivity (Ohm-m) 2000
		0.2 Shallow Resistivity (Ohm-m) 2000

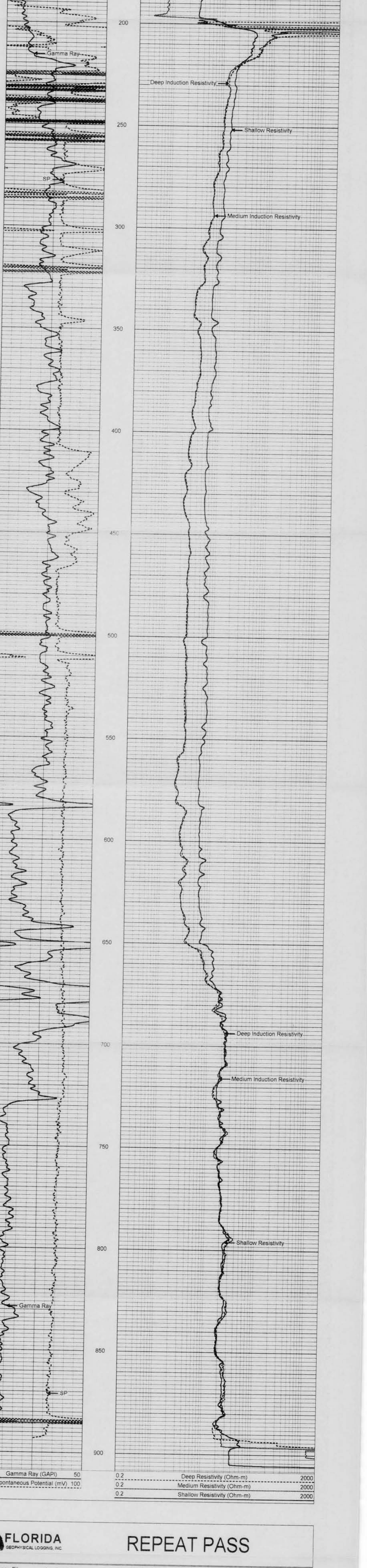


0 Gamma Ray (GAPI) 50		0.2 Deep Resistivity (Ohm-m) 2000
-100 Spontaneous Potential (mV) 100		0.2 Medium Resistivity (Ohm-m) 2000
		0.2 Shallow Resistivity (Ohm-m) 2000

FLORIDA GEOPHYSICAL LOGGING, INC. — MAIN PASS

Database File: jensbro4.db
Dataset Pathname: run2/pass7
Presentation Format: dil.prs
Dataset Creation: Wed May 31 11:40:01 2000
Charted by: Depth in Feet scaled 1:240

0 Gamma Ray (GAPI) 50		0.2 Deep Resistivity (Ohm-m) 2000
-100 Spontaneous Potential (mV) 100		0.2 Medium Resistivity (Ohm-m) 2000
		0.2 Shallow Resistivity (Ohm-m) 2000

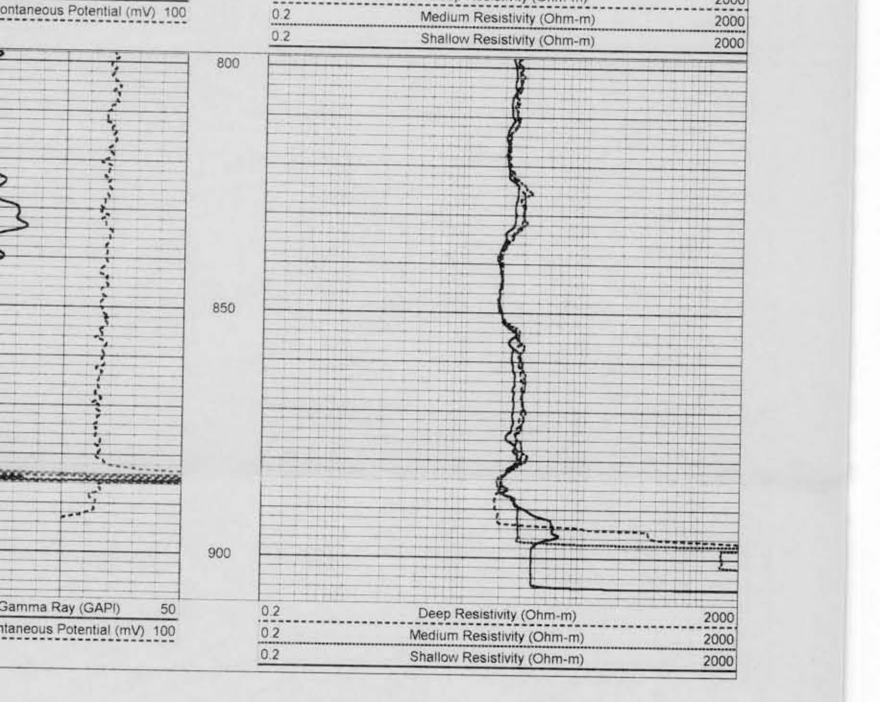


0 Gamma Ray (GAPI) 50		0.2 Deep Resistivity (Ohm-m) 2000
-100 Spontaneous Potential (mV) 100		0.2 Medium Resistivity (Ohm-m) 2000
		0.2 Shallow Resistivity (Ohm-m) 2000

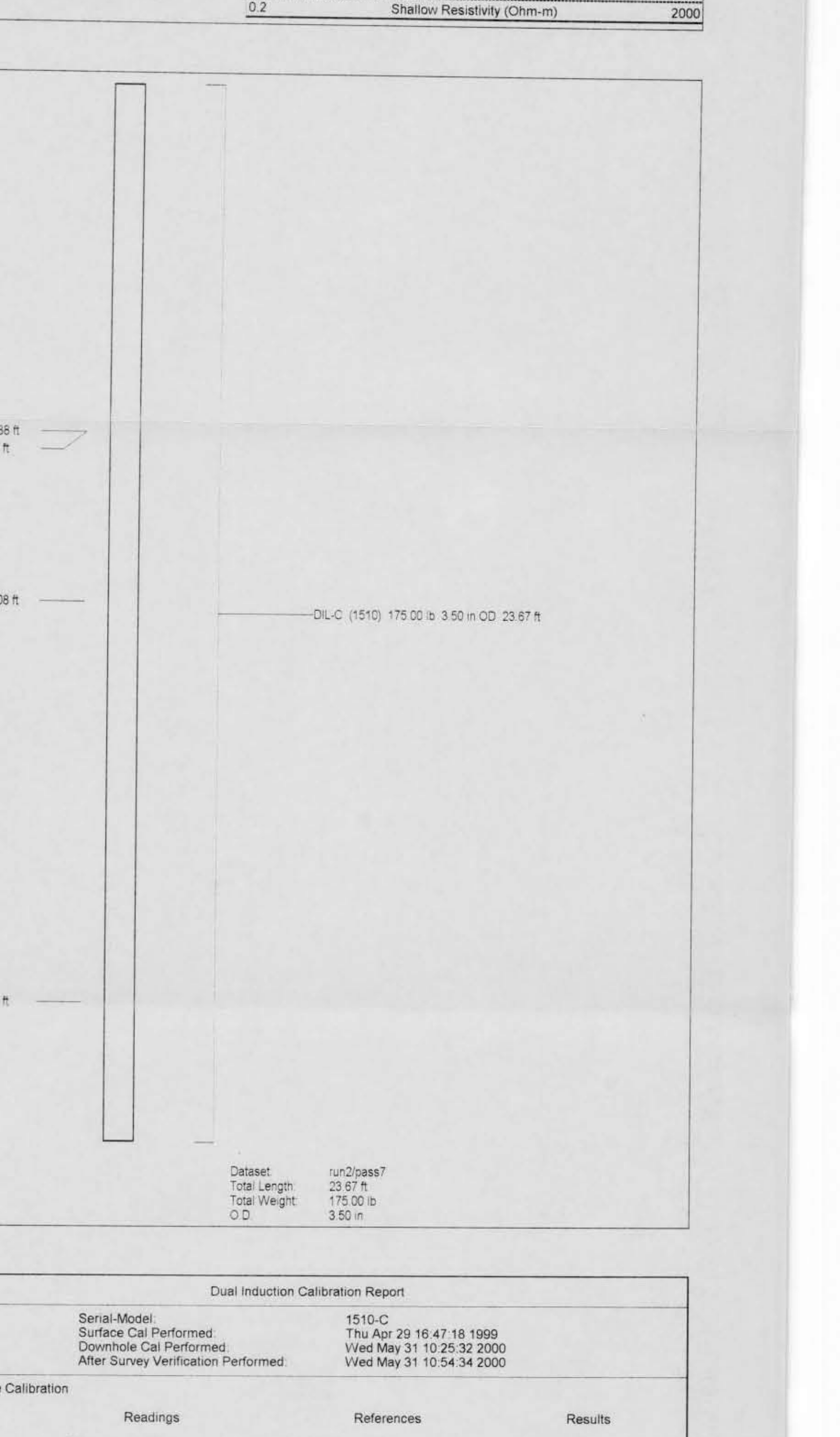
FLORIDA GEOPHYSICAL LOGGING, INC. — REPEAT PASS

Database File: jensbro4.db
Dataset Pathname: run2/pass5
Presentation Format: dil.prs
Dataset Creation: Wed May 31 11:40:01 2000
Charted by: Depth in Feet scaled 1:240

0 Gamma Ray (GAPI) 50		0.2 Deep Resistivity (Ohm-m) 2000
-100 Spontaneous Potential (mV) 100		0.2 Medium Resistivity (Ohm-m) 2000
		0.2 Shallow Resistivity (Ohm-m) 2000



0 Gamma Ray (GAPI) 50		0.2 Deep Resistivity (Ohm-m) 2000
-100 Spontaneous Potential (mV) 100		0.2 Medium Resistivity (Ohm-m) 2000
		0.2 Shallow Resistivity (Ohm-m) 2000



Dataset: run2/pass7
Total Length: 23.67 ft
Total Weight: 175.00 lb
O.D.: 3.50 in

Dual Induction Calibration Report

Serial-Model: 1510-C
Surface Cal Performed: Thu Apr 29 16:47:18 1999
Downhole Cal Performed: Wed May 31 10:25:32 2000
After Survey Verification Performed: Wed May 31 10:54:34 2000

Surface Calibration

Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	-0.014	0.631	V	0.000	400.000	mmho-m	620.172	8.975
Medium	-0.001	0.703	V	0.000	464.000	mmho-m	659.905	0.362

Internal:	Zero	Cal		Zero	Cal		m	b
Deep	0.012	0.641	V	17.680	407.650	mmho-m	620.191	10.098
Medium	0.009	0.728	V	6.060	482.670	mmho-m	662.558	0.111

Downhole Calibration

Internal:	Readings Zero	Readings Cal		References Zero	References Cal		Results m	Results b
Deep	18.934	420.615	mmho-m	16.557	406.514	mmho-m	0.971	-1.825
Medium	8.712	497.204	mmho-m	6.287	480.989	mmho-m	0.972	-2.179
Shallow	0.035	0.422		3.000	88.900	mmho-m	221.730	-4.733

After Survey Verification

Internal:	Readings Zero	Readings Cal		Targets Zero	Targets Cal		Results m'	Results b'
Deep	18.642	411.420	mmho-m	18.934	420.615	mmho-m	0.971	-1.825
Medium	8.394	485.737	mmho-m	8.712	497.204	mmho-m	0.972	-2.179
Shallow	3.183	88.644	mmho-m	3.000	88.900	mmho-m	1.005	-0.199

FLORIDA
GEOPHYSICAL LOGGING, INC.

FLUID CONDUCTIVITY TEMPERATURE LOG

Company MARTIN CO.
Well RO-4
Field JENSEN BEACH
Country MARTIN
State/Prv FL

Company	MARTIN CO. ENVIRONMENTAL SVCS.
Well	RO-4
Field	JENSEN BEACH
Country	MARTIN
State/Prv	FLORIDA
Location	

Other Services: FLOWMETER, X-Y / GR, DIL/LL3/SP

		Elevation	Elevation
Permanent Datum	PAD		K.B.
Log Measured From	PAD		D.F.
Drilling Measured From	PAD		G.L.

Date	21-JUNE-2000
Run Number	FOUR
Depth Driller	1375'
Depth Logger	1375'
Bottom Logged Interval	1325'
Top Log Interval	850'
Open Hole Size	17"
Type Fluid	WATER
Density / Viscosity	NA
Max. Recorded Temp.	NA
Estimated Cement Top	NA
Time Well Ready	ON ARRIVAL
Time Logger on Bottom	0900
Equipment Number	103
Location	FT MYERS
Recorded By	LEE
Witnessed By	JIM ANDERSEN, DENISON

Borehole Record / Tubing Record

Run Number	Bit	From	To	Size	Weight	From	To
ONE	36.5"	SURFACE	203'				
THREE	26"	CASING	895'				
FOUR	17"	CASING	1375'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	30"	375 W.T.	SURFACE	199'
Prot. String	18"	375 W.T.	176'	893'
Production String				
Liner				

<<< Fold Here >>>

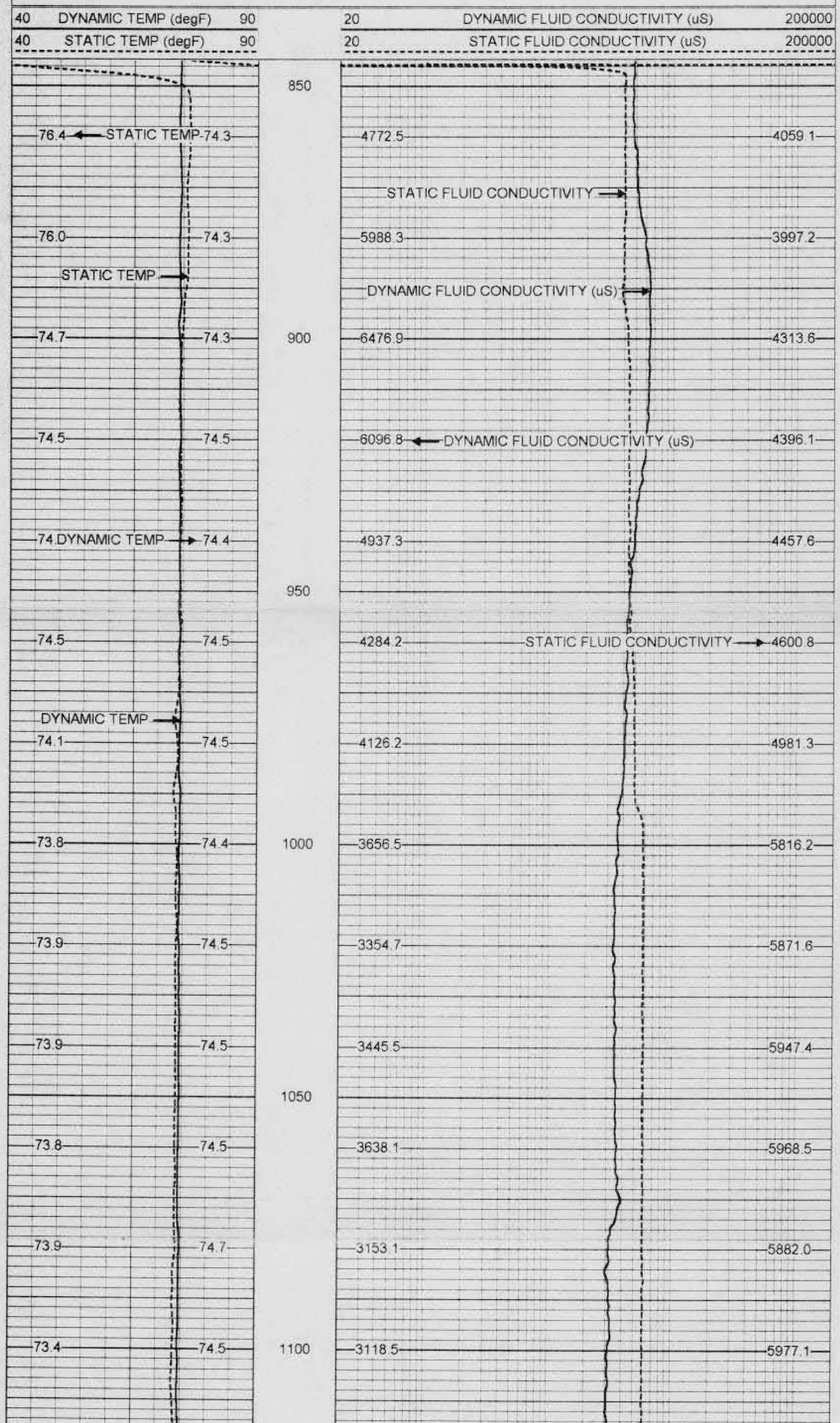
Comments

FLOWRATE=1,250 GPM

FLORIDA
GEOPHYSICAL LOGGING, INC.

MERGED PASSES

Database File:	jensbro4.db
Dataset Pathname:	run4/pass16
Presentation Format:	frt_mg.prs
Dataset Creation:	Wed Jun 21 13:32:47 2000 by Log VER_5.4
Charted by:	Depth in Feet scaled 1:240



FRT Calibration Report

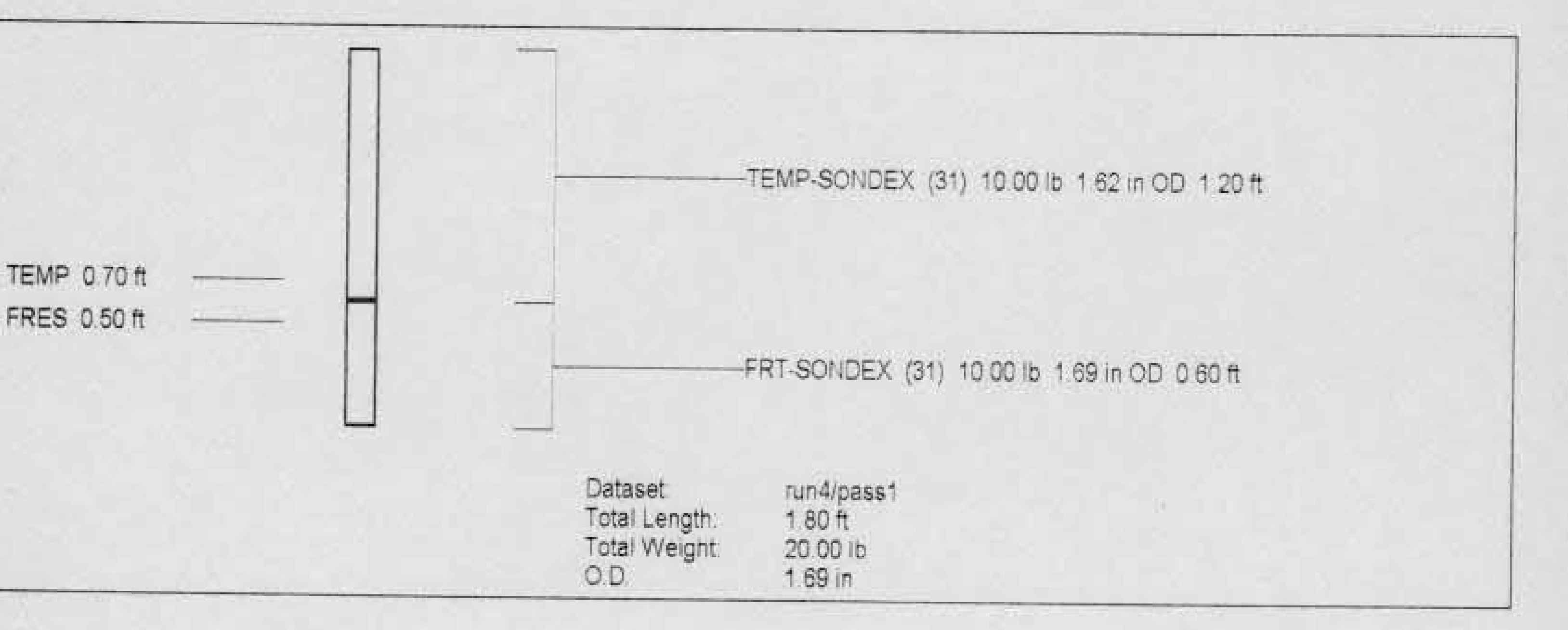
Serial Number: 31
Tool Model: SONDEX
Performed: Thu Sep 02 16:23:55 1999

Point #	Reading		Reference
1	25.985	cps	500.000
2	32.773	cps	1000.000
3	220.093	cps	10000.000
4	1235.570	cps	50000.000
5	3336.770	cps	100000.000
6		cps	

Temperature Calibration Report

Serial Number: 31
Tool Model: SONDEX
Performed: Wed Sep 01 14:44:38 1999

Point #	Reading		Reference	
1	128.676	cps	36	degF
2	400.758	cps	93	degF
3	625.501	cps	139	degF



Dataset:	run4/pass1
Total Length:	1.80 ft
Total Weight:	20.00 lb
O.D.	1.69 in