APPENDIX H

1991 GEEX STUDIES

APPENDIX H.1	REPORT ON GEOPHYSICAL LOGGING STUDY
APPENDIX H.2	MAGNOMETER SURVEY STUDY

APPENDIX H.1

REPORT ON GEOPHYSICAL LOGGING STUDY

GeEx

Exploration Geophysics for the Groundwater Industry

REPORT ON THE GEOPHYSICAL WELL LOGGING STUDY AT THE FORMER LAGOON SITE FOR NEPERA, INC., HAMPTONBURG, NEW YORK

Submitted To:
Conestoga-Rovers & Associates Ltd.

January, 1992

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INTRODUCTION

In October of 1991, GeEx was contracted by Conestoga-Rovers and Associates, Ltd. (CRA) to perform a geophysical logging study at the Former Lagoon Site of Nepera, Inc. in Hamptonburg, New York. The purpose of the study was to identify any significant subsurface hydrogeologic parameters on the site. The field investigation was performed between October 16th and October 18, 1991. This report presents the results of the study.

DESCRIPTION OF METHODS

Geophysical well logs are tools, commonly used to determine the physical properties of in-situ geologic materials penetrated by a borehole. The geophysical logs used for this study were Caliper, Self-Potential(SP), Natural Gamma-Ray, Electrical Resistance, and Temperature.

CALIPER LOG

The Caliper Log measures variations in borehole diameter. This is accomplished by pulling a device that has three spring-loaded arms up the borehole while recording the movement of these arms. Where the arms extend outward beyond the diameter of the original drill bit that was used, the log curve moves to the right, indicating that this particular portion of the borehole has become enlarged. Contraction of the caliper arms inward, moves the log curve towards the left, indicating that the borehole may be partially blocked.

Caliper Logs are useful in two ways. First, they measure and record borehole integrity. Areas of increased borehole diameter, which indicate a washout or fracture zone, show up quite clearly on the log record. Second, the use of the Caliper Log is also a check on data from other logs, such as SP and Electrical Resistance. An increase in borehole diameter as indicated by the Caliper Log record, is an indication that the data measured by other logs may be inaccurate.

SP LOG

Self-Potential or SP Logs measure the natural electrical potential that develops between the formation and the borehole fluids. The response of the SP Log in a shale is generally flat along a line arbitrarily selected as the shale base line (arbitrary relative zero line), which is a function of the instrument reference level (arbitrarily set). Deflections to the right (positive) indicates formation water fresher than the borehole. Deflections to the left (negative) indicate more saline formation water.

If the resistivities of the borehole fluid and the formation water are about equal, the SP deflection will be small and rather featureless. Since these wells are fairly shallow, and it has been a period of months to years between the completion of the wells and the logging study, considerable mixing within the borehole has occurred and the water in the borehole has probably reached equilibrium with the formation water. Therefore, there is probably very little salinity contrast between borehole fluid and formation water, reducing the intensity of any SP anomalies that might have existed at the time of drilling.

NATURAL GAMMA-RAY LOG

Natural Gamma-Ray Logs measure the natural gamma rays emitted by a formation as the logging tool passes up the borehole. The tool detects natural gamma rays that are emitted by radioactive isotopes within rock units, such as potassium 40, uranium 238 decay series, and thorium 232 decay series.

All rocks contain some minerals with radioactive isotopes, by far the most common is potassium 40 which is found in all potassium bearing minerals. Since potassium is common in clay minerals, rocks that contain clay minerals tend to emit gamma rays at relatively high rates. Thus, a Natural Gamma-Ray Log will show highest response opposite sedimentary beds that contain potassium-rich shale, clay, or phosphate rich materials. Since phosphate minerals are not common in this area, Natural Gamma-Ray Logs indicate the relative abundance of clay minerals which are highest in shale deposits or clay rich soils. Under certain conditions, uranium salts can accumulate along flowing fracture planes causing sharp natural gamma ray spikes which indicate flowing fracture zones.

ELECTRICAL RESISTANCE LOG

The Electrical Resistance, or Single Point Resistance Log used in this study consists of a single electrode that is lowered in the borehole, and a second electrode at the ground surface. As the electrode is lifted up the borehole, the change in resistance of the earth between the two electrodes is measured.

A majority of the variation in resistance is due to changes in the conductivity of the borehole fluid and to the small volume of rock in the borehole surrounding the electrode. When the borehole fluid is largely homogeneous, as is the case at this site, the variation in resistance will be due to lithologic variations near the borehole.

The Electrical Resistance Log measures the resistance of the circuit formed between the two electrodes. As such, the log does not measure the actual resistivity of any interval of the borehole. The primary use of the resistance tool is to detect horizontal bedding planes. The tool can also be useful in detecting fluid-filled fracture zones.

TEMPERATURE LOG

A Temperature Log provides a continuous vertical measurement of borehole temperatures as a temperature probe is lowered through a fluid-filled borehole. If a well has been left undisturbed long enough to reach thermal equilibrium, the temperature log can reveal zones of differing temperature in the well. Superimposed on the system will be the effects from variations in surface temperature and the effect from the geothermal gradient. Zones of flowing groundwater may create temperature anomalies which are sharper. The anomalies can either be increases or decreases in temperature, depending on the temperature of the water source. The magnitude of the temperature anomaly is a function of the flow volume and the temperature contrast of the injected water relative to the borehole fluid. These zones may represent areas in the borehole where fracture zones are present or area of increased permeability where natural flow into or out of the borehole is occurring.

GENERAL CONSIDERATIONS

The interpretation of the various well logs depends heavily on the borehole conditions and drilling history of each monitoring well. Boreholes which have been left open for a long period of time can be expected to have formation and borehole fluids which have become mixed. Logs which depend on a contrast between the fluids will have a minimal response.

In addition, a point should be made that although each logging tool provides valuable information about rock properties and borehole fluids, reliable interpretations are usually based on comparisons between log curves from several tools. Correlations based on different logging tools from the same borehole eliminate mistakes in interpretation that would result from single tool correlation.

DESCRIPTION OF FIELD PROCEDURES

Six bedrock monitoring wells were logged at the Former lagoon site. These wells are DW-1, DW-2, MW-1D-91, MW-2D-91, MW-3D-91, and MW-4D-91. Monitoring wells DW-1 and DW-2 are deep monitoring wells, whereas MW-1D-91 thru MW-4D-91 are shallow monitoring wells.

The equipment used for this study was Century Geophysical Corporation's Compu-Log Portable Logging System with a combination SP, Natural Gamma-Ray, Single Point Resistance, and Temperature tool, and a separate 3-arm Caliper tool. At each monitoring well, a temperature log was run on the initial downward pass, so the temperature readings were taken when the water column was least disturbed. The rest of the logs were run from the bottom of the well to the surface so that a constant logging speed could be maintained. The SP, Natural Gamma-Ray, Single Point Resistance, and a second Temperature Log were all collected simultaneously on a single pass. The Caliper Log was collected on a second pass with a different tool. The logging tools and cables were thoroughly rinsed with distilled water between boreholes to prevent cross contamination.

The log curves from the various tools for each monitoring well were analyzed. Significant features from each monitoring well were determined such as depth of casing, approximate static water level, borehole diameter, changes in borehole diameter, and any other relevant features. The sensors used by the different logs are located in various parts of the logging tool. As a result, the logs start at different depths depending on the separation of the sensor from the bottom of the tool. The logs are all corrected for the location of the sensor. All depths are referenced to ground surface. All of the well logs from the various monitoring wells are in Appendix A.

RESULTS

DW-1:

The total depth of DW-1 is 152 feet. Casing extends down to 24.8 feet. The static water level in the well at the time of the logging study was at approximately 18 feet below ground surface.

The Caliper Log for DW-1 indicates that the borehole diameter is not constant. The borehole diameter is as follows: 10.1 inch casing from ground surface to 24.8 feet; approximately 10 inches from 24.8 to 53.7 feet; 6.1 inches from 53.7 to 66 feet; 6.05 inches from approximately 66 to 113.6 feet; 6 inches from 113.6 to 139.5 feet; 5.95 inches from 139.5 to 143.5 feet; and 5.8 inches from 143.5 to 152 feet. These variations in borehole size are generally smooth and consistent, suggesting that they are a result of the drilling procedure. The log also indicates several zones where the diameter of the borehole has been enlarged. Zones where the borehole has been enlarged 2 or more inches from the assumed normal diameter are at depths of 25 feet, 32 to 34 feet, 36 to 54 feet, 58 to 61 feet, and 64 to 66 feet. These irregular zones are due to either washouts from drilling or zones of caving in the borehole or fracture zones.

The electrical resistance increases slightly at 54 feet in response to a reduction in the borehole diameter. The resistance decreases slightly at 36 to 38 feet, 58 to 61 feet, and 64 to 66 feet in response to enlargements in the borehole diameter. These enlargements could indicate fracture zones or zones of caving of the borehole.

The Natural Gamma-Ray Log curve indicates that the lithology changes slightly with depth. It is difficult to determine the contact between the Normanskill Formation, which is predominantly shale, from the overburden due to the "shielding effect" of the steel casing and bentonite seal. The casing and low potassium bentonite inhibit the transmission of gamma rays and causes a reduction in log response of approximately 20 percent. Split spoon sample descriptions from nearby monitoring wells indicate that the overburden in this area is composed of layers of silty sand and gravel, which is expected to have a lower gamma response than the shale bedrock.

The high natural gamma response for the bedrock indicates that it is predominantly composed of shale. There are some zones where the gamma response decreases, indicating lower clay mineral content which could indicate higher amounts of silica. Based on the description of the Normanskill Formation, these zones are probably siltstone, argillite or quartz-filled veins or fractures.

The SP Log curve of DW1 has a fairly smooth response. The large decrease in voltage that occurs between 25 and 35 feet is due to the presence of the steel casing at 25 feet. However, below the casing there are two zones with slight deflections in the SP response. There is a decrease of about 5 millivolts between 35 and 38 feet. This decrease in voltage corresponds to a decrease in electrical resistance on the electrical resistance log and a washout zone on the caliper log. This voltage decrease is probably not significant, but may be due to more saline formation water, possibly in a fracture zone. Between 55 and 105 feet, there is also a decrease in voltage of 5 to 15 millivolts. This decrease in voltage indicates that the formation fluid is more conductive than the borehole fluid. This zone is not distinctive on any other log. Therefore, the significance of this feature is unknown.

The Temperature Log curve response for monitoring well DW1 is minimal. The air temperature in the borehole decreases with depth to the static water level at about 18 feet. At the static water level, the temperature of the water in the borehole is approximately 56 degrees fahrenheit. Below the static water level the temperature decreases until a depth of 38 feet. This temperature drop is due to the seasonal thermal wave from the previous winter that has propagated down from the surface. From 38 to 60 feet, the borehole temperature is fairly constant, approximately 50.4 degrees fahrenheit. This represents the year round, average, ambient soil temperature, which is relatively unaffected by surface effects. Below 60 feet, the temperature begins to increase, which is a result of the influence of the geothermal gradient.

The minor aberrations that appear on certain parts of the temperature log curve, such as between 89 and 108 feet are small in magnitude and are not readily correlated to the other logs. These minor fluctuations appear to be insignificant, but could indicate zones of minor inflows of water from thin fractures.

DW-2:

The total depth of DW-2 is 178.5 feet. The casing extends down to approximately 15 feet. The static water level in the well at the time of the logging study was at approximately 9 feet below ground surface.

The Caliper Log for DW-2 indicates that the borehole diameter fluctuates. The borehole diameter is as follows: 10.1 inch diameter casing extends from ground surface to 15 feet; 10.1 inches from 15 to 42.7 feet; approximately 10 inches from 42.7 to 63.7 feet; 6.15 inches from 63.7 to 120.3 feet; 6.05 inches from 120.3 to 151 feet; 6 inches from 151 to 163.8 feet; and 5.95 inches from 163.8 to 174 feet. These variations in borehole size, which generally are smooth and consistent, suggest that they are a result of the drilling procedure. There are several zones where the borehole diameter has been enlarged. Zones where the borehole has been enlarged 2 or more inches from the assumed normal diameter are 15.4 to 18.3 feet, 20.5 to 25 feet, 35.4 to 39 feet, 41.8 to 42.7 feet, 50.5 feet, 71.5 to 74 feet, 95.4 to 111 feet, and 131 feet. These irregular zones are due to either washouts or zones of caving in the borehole, or fracture zones.

The electrical resistance decreases slightly between 19 and 25 feet, 41 and 43 feet, 70 and 74 feet, 94 and 120 feet, and 128 and 132 feet, due to an enlargement of the borehole. The electrical resistance increases slightly between 63.5 and 69 feet, due to a decrease in borehole diameter which starts at approximately 64 feet.

The high natural gamma response for the bedrock indicates that it is predominantly composed of shale. Zones where the gamma response decreases, are between 137 and 139 feet, 141.5 to 143 feet, and 163 and 164 feet, which suggests elevated amounts of silica. The lithology in these zones is probably siltstone, argillite or quartz-filled veins or fractures.

The SP Log curve for DW-2 has a fairly smooth pattern. There is one distinct zone, between the bottom of the borehole and 137 feet, where there is an increase in SP voltage. The increase in SP voltage may indicate that the borehole fluid is more conductive than the formation fluid suggesting that the formation fluid is less saline than the borehole fluid. This zone does not correlate with any distinctive feature on the other logs. The significance of this feature is unknown.

The Temperature Log curve is generally non-remarkable. At static water level, approximately 9 feet, the temperature of the water in the borehole is 57.8 degrees fahrenheit. Below the static water level, the temperature decreases until a depth of 90 feet. This temperature drop is due to the seasonal thermal wave from the previous winter that has propagated down from the surface. From 90 to approximately 120 feet, the borehole fluid temperature is fairly constant, approximately 51.6 degrees fahrenheit. This temperature represents the year round, average, ambient soil temperature. Below 120 feet, the temperature begins to increase, which is a result of the influence of the geothermal gradient.

The aberrations that appear on the temperature curve are similar in magnitude to those observed on the Temperature Log curve for DW-1. As was previously stated, these fluctuations appear to be insignificant, but could indicate zones of minor inflows of water from thin fracture zones.

A comparison between the Temperature Log curves between DW1 and DW2 indicates that there is a large difference in the vertical extent of the seasonal thermal wave for each well. For DW1 the borehole temperature decreases down to a depth of 38 feet, whereas for DW2 the borehole temperature decreases down to a depth of 90 feet. This large variation between the two wells is not completely understood. One possible explanation is that there are vertical fractures in the vicinity of DW2, which would provide a conduit for increased recharge of colder surface water from the spring recharge event. This could cause the decrease in borehole temperature down to 90 feet for DW2.

MW-1D-91:

The total depth of MW-1D-91 is 32 feet. Casing extends down to 13 feet. The contact between overburden and bedrock, based on the stratigraphic log, is at 8 feet. The static water level at the time of the logging study was at approximately 10.5 feet.

The Caliper Log curve for MW-1D-91 indicates that the borehole diameter is not constant. The borehole diameter is as follows: 4.28 inches from ground surface to 10.8 feet; 4.08 inches from 10.8 to 14 feet; 4 inches from 14 to 25.9 feet; and 3.9 inches from 25.9 feet to the bottom of the borehole.. These variations in borehole diameter are generally smooth and consistent, suggesting that they are a result of the drilling procedure. The Caliper Log indicates a minor enlargement at 10.8 feet. The reason for this enlargement, which is 2.2 feet above the bottom of casing, is unknown.

The Caliper Log does not indicate any washout or fracture zones. The stratigraphic log for MW-1D-91 indicates that fractures are present in the borehole, at depths of 13.5 to 14.3 feet, 18.3 to 19 feet, 20.5 to 22 feet, and 24 feet. The log description indicates that most of these fractures are filled with quartz. The fact that no enlargements are seen at these depths suggests that these fractures are filled.

The Electrical Resistance Log curve for MW-1D-91 shows more significant response than DW1 or DW2. Most notable is an increase in resistance between 21 and 26 feet. The cause of the increase in electrical resistance between 21 and 26 feet is not obvious. The two points where the resistance increase is the largest are 21 and 22.6 feet, which correspond to decreases in the natural gamma-ray response. The stratigraphic log indicates that quartz-filled veins and fractures are present in this interval. Thus, the increase in resistance response is possibly due to the presence of the quartz-filled veins and fractures. The decrease in resistance above and below the elevated resistance zone, is probably due to the contrast in water content between the low moisture, quartz-filled voids and the higher moisture, fractured shale. The increase in resistance response from 9 to 15.5 feet, is due to the influence of the casing at 13 feet, and the static water level at approximately 10.5 feet.

The Natural Gamma-Ray Log curve for MW-1D-91 shows very little variation. The natural gamma-ray response indicates that the lithology of the bedrock is shale. Decreases in natural gamma-ray response occur at 21 and 22.6 feet. The decrease in gamma-ray response may be due to increased silica content in those particular intervals as a result of the presence of quartz-filled veins and fractures.

The SP Log curve also shows very little variation. The sharp increase at 15 feet is probably due to the influence of the casing at 13 feet. There is a slight, but consistent trend of increasing SP response from bottom to top of the borehole. The elevated SP response below 15 feet does not readily correlate with any other feature on the other well logs, and is probably insignificant.

The temperature log curve for MW-1D-91 is generally non-remarkable. From the static water level at 9 feet to 10.5 feet the temperature of the borehole fluid is constant at approximately 58.9 degrees fahrenheit. From 10.5 feet to approximately 23 feet, there is a steady decrease in temperature. The temperature remains constant, approximately 55.1 degrees fahrenheit, from 23 to 26.3 feet. This zone of constant temperature overlaps the zone of elevated resistance on the electrical resistance log for MW-1D-91. The constant temperature may be caused by inter-flow between two fractures at 23 and 26.3 feet. No evidence for the existence of these fractures was found on the other logs. Not enough information is present to explain this zone of constant temperature, and thus its significance is unknown. Below 26.3 feet to the bottom of the borehole, the temperature of the borehole fluid again starts to decline.

MW-2D-91:

The total depth of MW-2D-91 is 52 feet. Casing extends down to 24 feet. According to the stratigraphic log for MW-2D-91, the contact between overburden and bedrock is approximately 19 feet. The static water level at the time of the logging study was at approximately 10.8 feet.

The Caliper Log curve for MW-2D-91 indicates changes in the borehole diameter. Accurate caliper readings begin at 49.2 feet. The borehole diameter is as follows: from the top of the log to 13 feet the borehole diameter is 4.28 inches; 4.3 inches from 13 to 23 feet; 4 inches from 23 to 34 feet; and 4.08 inches from 34 to 49.2 feet. These variations in borehole diameter are generally smooth and consistent, suggesting that they are a result of the drilling procedure. The caliper response from 49 to 50 feet suggests a washout at the bottom of the borehole. However, it is possible that the tool was resting on sediment in the bottom of the borehole causing the tool not to be centered in the borehole. Under these conditions, the caliper arms would not be evenly deployed and erroneous readings could result.

The Caliper Log curve indicates no borehole enlargements that may be due to washout or fracture zones. The Stratigraphic Log for MW-2D-91 indicates numerous fracture zones. The Caliper Log curve response suggests that the fractures are small or filled with quartz or geologic material.

The response from the Electrical Resistance Log curve for MW-2D-91 is rather featureless. There are some zones where minor decreases in resistance are observed, such as 31 to 32.5 feet, 34 to 36 feet, and 43 to 46 feet. These zones do not correlate with any significant features on the other logs for this well, thus these features are probably insignificant. The large decrease in resistance at 24 feet is due to the casing.

The natural gamma-ray response for MW-2D-91 is similar to the Natural Gamma-Ray Log response for MW-1D-91. The natural gamma-ray response for MW-2D-91 indicates that the dominant bedrock lithology is shale. There are some zones, such as 25.5, 35, and 42 feet, where there is a slight reduction in natural gamma-ray response. This response could indicate a higher silica content and may correspond to quartz-filled fractures or veins.

The SP Log curve response for MW-2D-91 is rather smooth and non-distinctive. The SP response that occurs above 27 feet is due to the influence of the casing, which occurs at 24 feet. From 27 to 49 feet, the SP curve is fairly smooth.

The Temperature Log for MW-2D-91 is also non-remarkable. From the static water level, which is approximately 10.8 feet, to 12 feet the temperature of the borehole fluid is greater than 60 degrees fahrenheit. Below 12 feet the temperature of the borehole fluid decreases at a relatively constant rate down to approximately 40 feet. From 40 feet to the bottom of the borehole, the temperature is fairly constant, averaging 53 degrees fahrenheit. This zone may be the yearly average ambient soil temperature, and the zone above 40 feet is influenced by the previous seasonal thermal wave. However, the relatively shallow temperature record makes it difficult to verify this interpretation.

MW-3D-91:

The total depth of MW-3D-91 is 53 feet. Casing extends down to 27.9 feet. The Stratigraphic Log for MW-3D-91 indicates that the contact between overburden and bedrock is 23 feet. The static water level at the time of the logging study was approximately 23 feet.

The Caliper Log for MW-3D-91 indicates changes in the borehole diameter. The borehole diameters are as follows: 4.29 inches from the top of the log to 17 feet; 4.22 inches from 17 to 27.9 feet;

and 3.9 inches from the bottom of the casing at 27.9 feet, to the bottom of the log. The decrease in borehole diameter at 7 and 17 feet appears to be related to joints in the casing. The variations in borehole diameter are fairly smooth and consistent, suggesting they are related to the drilling procedure. The Caliper Log indicates that there is a increase in borehole diameter at the bottom of the casing at 27.9 feet. This enlargement may be due to a washout or fracture zone below the casing or an erroneous caliper reading due to a jostling of the tool upon entering the casing. There is also minor variations in borehole diameter near the bottom of the borehole from 48 to 52 feet. These variations are slight and the decreases in diameter may be due to sediment at the bottom of the borehole, the enlargement may be due to a small washout or fracture zone.

The Electrical Resistance Log curve for MW-3D-91 indicates there are distinct variations in the resistance response for certain borehole intervals. Above 32 feet the resistance response is influenced by the casing at 27.9 feet. The resistance increases from 32 to 36 feet. From 36 to 37 feet there is a sharp decrease in resistance. From 37 to 43 feet the resistance response again increases.

The apparent cause of the variation in resistance between 32 and 51 feet is unknown. The increase in resistance between 37 and 43 feet indicates that the lithology in this zone is most likely associated with lower bulk water content of the formation. The Natural Gamma-Ray Log for this interval does not indicate any apparent lithology change. A possible explanation is that this interval contains more of a cement matrix, possibly quartz, than the intervals above and below, which would result in lower moisture content for the high resistance interval.

The Natural Gamma-Ray Log curve for MW-3D-91 is rather non-distinctive. The natural gamma-ray response indicates that the bedrock is predominantly composed of shale. The slight reductions in the gamma-ray response in some intervals most likely correspond to higher silica content due to the presence of siltstone, argillite or quartz-filled veins or fractures.

The SP Log curve for MW-3D-91 is also rather non-distinct. The log curve indicates a slight decrease in SP voltage between 35 and 41.5 feet. This zone overlaps the high resistance interval from the electrical resistance log curve. However, the decrease in SP voltage is so small that it is probably insignificant.

The Temperature Log for MW-3D-91 indicates no significant trends. From the top of the log at 15 feet down to approximately 23, there is a slight decline in air temperature in the borehole. From 23 feet to approximately 32 feet, there is a sharp decrease in the borehole temperature. This temperature drop is due to the temperature probe coming into contact with the static water level. Below 32 feet, the temperature remains fairly constant, approximately 50.1 degrees fahrenheit, down to the bottom of the log.

MW-4D-91:

The total depth of MW-4D-91 is 26 feet. Casing extends down to approximately 21 feet. The Stratigraphic Log indicates that the contact between overburden and bedrock is at approximately 14.5 feet.

The Caliper Log curve for MW-4D-91 is fairly smooth. From the top of the log to 19.4 feet, the borehole diameter in the casing is fairly constant, approximately 4.28 inches. There is a small decrease in borehole diameter at 10.4 feet, which is probably due to the presence of a joint in the casing. The log indicates that the borehole is enlarged between 21 and 22 feet. This enlargement is either due to a washout, a fracture zone or from the tool being jostled entering the casing, forcing an erroneous caliper reading.

The Electrical Resistance Log for MW-4D-91 has been heavily influenced by the presence of casing down to 21 feet, which leaves only 5 feet of open borehole. The flat resistance response above 20 feet is most likely due to the presence of the casing. The log curve does show a resistance increase at the bottom of the log, approximately 20 to 22 feet. The resistance increase could also be due to interference from the casing.

The results from the Natural Gamma-Ray, and SP Logs also are hampered by the presence of casing down to 21 feet. The log curve from the SP and Natural Gamma-Ray will provide very little information. The SP Log curve is a flat response due to the influence of the casing. Due to the location of the scintillation counter in the Natural Gamma-Ray Tool,the first reading from the Natural Gamma-Ray Log curve is at 18 feet, which is already in the casing. Thus, the results from the Natural Gamma-Ray Log will be influenced by the casing.

The Temperature Log curve for MW-4D-91 is fairly non-distinctive. The Log curve indicates that from 8.8 feet down to 14 feet, the air temperature in the borehole decreases slightly. Below 14 feet to the bottom of the log, there is a sharp drop in borehole temperature. The location of the static water level is approximately 14 feet, and the drop in temperature below that is a result of the previous seasonal thermal wave.

CONCLUSION:

A geophysical well logging study was performed on six monitoring wells at the Former Lagoon Site of Nepera, Inc., in Hamptonburg, NY. The logs used for this study were Caliper, Self-Potential (SP), Electrical Resistance, Natural Gamma-Ray, and Temperature. The Caliper Log was useful for identifying washout or fracture zones. The Electrical Resistance Log indicated intervals in certain boreholes that had a low bulk formation water content.

Correlating these intervals with Stratigraphic Logs indicated that these zones may contain fractures that were filled with quartz. The Natural Gamma-Ray Log was of limited use for this study because the lithology was predominantly shale. However, the log did indicate decreases in natural gamma-ray response in certain intervals in some of the wells. This decrease in gamma-ray response was attributed to high silica content in these intervals which may be due to the presence of argillite, siltstone, or quartz-filled fractures. The SP Log was also of limited use for this study due to the slight resistivity contrast between formation and borehole fluids due to long time periods between the drilling and logging of the boreholes. This caused a state of chemical equilibrium between borehole and formation fluids. The Temperature Log curves for the boreholes showed minor aberrations on the log curve. These aberrations may be due to inflows of ground water in thin fractures.

The condition of these boreholes was not ideal for the logging suite performed. Due to the long period of mixing that has occurred, the SP and Electrical Resistance Logs were of limited use. The results of these logs could have been improved by pumping the wells before logging. The Natural Gamma-Ray Log confirmed that the wells are completed in shale bedrock and that no significant lithologic changes occurred. The Temperature Logs indicated that surface thermal effects appear to be penetrating to greater depths at DW2 than DW1, possibly due to higher rates of ground water recharge down vertical fractures. A minor flat spot was detected in the thermal profile of MW-1D-91, possibly indicating a zone of inter-flow within the borehole. No other significant signs of fracture flow were observed in the Temperature Logs.

Respectfully submitted:

Patrick Jurcek
Staff Geophysicist

John Jansen
President

DISCLAIMER

Although the results presented in this report represent the best interpretation available to GeEx based on the existing information referenced in the report text at the time of the survey, they remain an interpretation. Geophysical exploration is a difficult field with many unknowns, subject to many interpretations. GeEx endeavors to be as precise as possible, but the nature of our work makes it impossible for us to guarantee our results. We strongly recommend to our clients that they verify our findings with borings or some other type of quantitative investigation before basing design decisions on our results. As we cannot directly verify our findings, we cannot assume any liability as to their application.

APPENDIX A
GEOPHYSICAL WELL LOGS

MONITORING WELL: DW-1

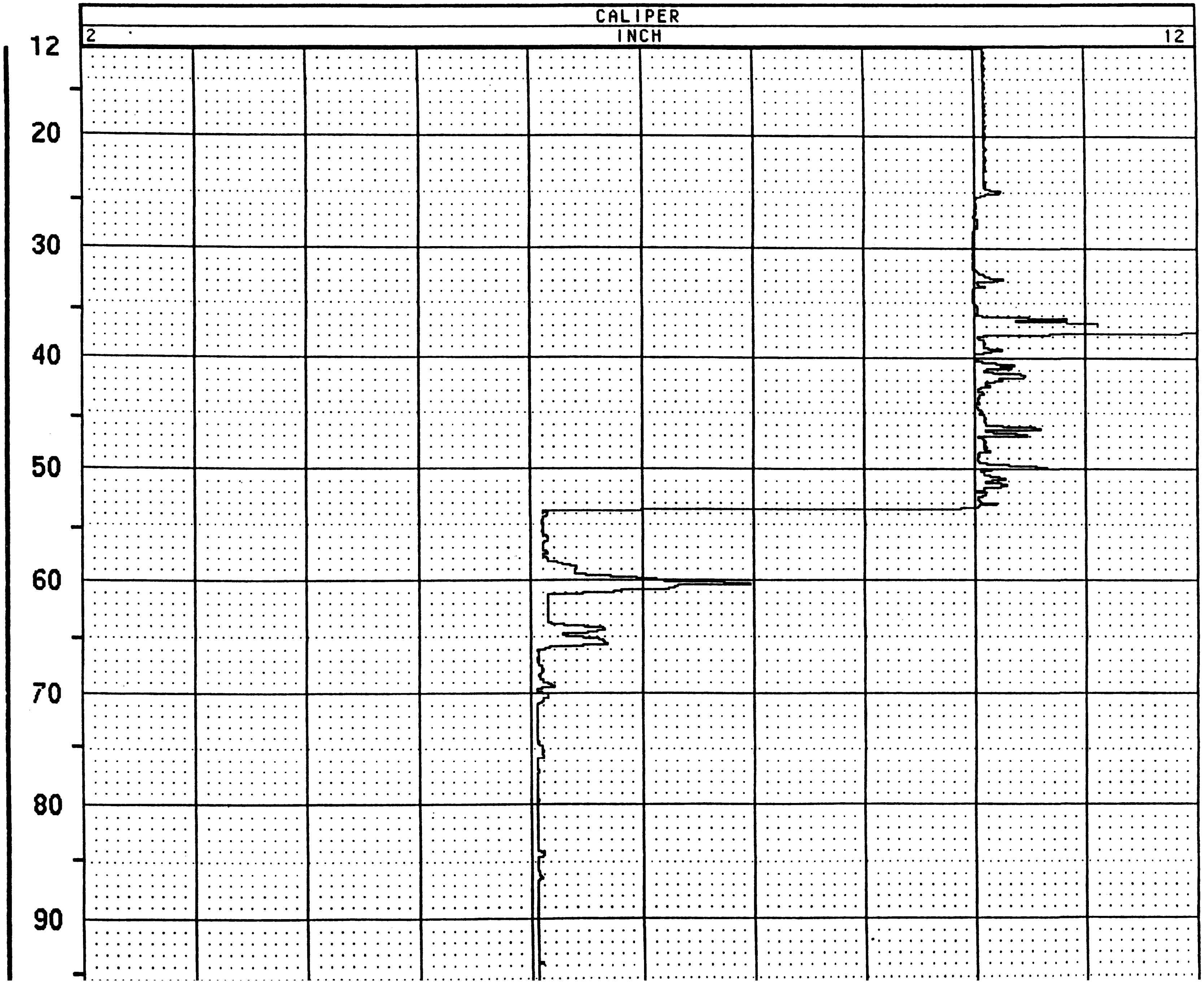
CGC

Century GEOPHYSICAL CORP.

DW1

COMPANY	: GeEx			OTHER SERVICES:	
WELL	: DW1				
LOCATION/FIELD	: NEPERA LAGOON				
COUNTY	: ORANGE				
STATE	: NY				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 10/18/91	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 152	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 154.60	LOG MEASURED FROM	: GL	DF	:
LOG TOP	: 12.20	DRL MEASURED FROM	:	GL	:
CASING DRILLER	:	LOGGING UNIT	:		
CASING TYPE	:	FIELD OFFICE	:		
CASING THICKNESS	:	RECORDED BY	:		
BIT SIZE	:	BOREHOLE FLUID	:	FILE	: ORIGINAL
MAGNETIC DECL.	:	RM	:	TYPE	: 9065A
MATRIX DENSITY	:	RM TEMPERATURE	:	LOG	: 2
FLUID DENSITY	:	MATRIX DELTA T	:	PLOT	: 9065A 0
NEUTRON MATRIX	:	FLUID DELTA T	:	THRESH	:
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



CALIPER
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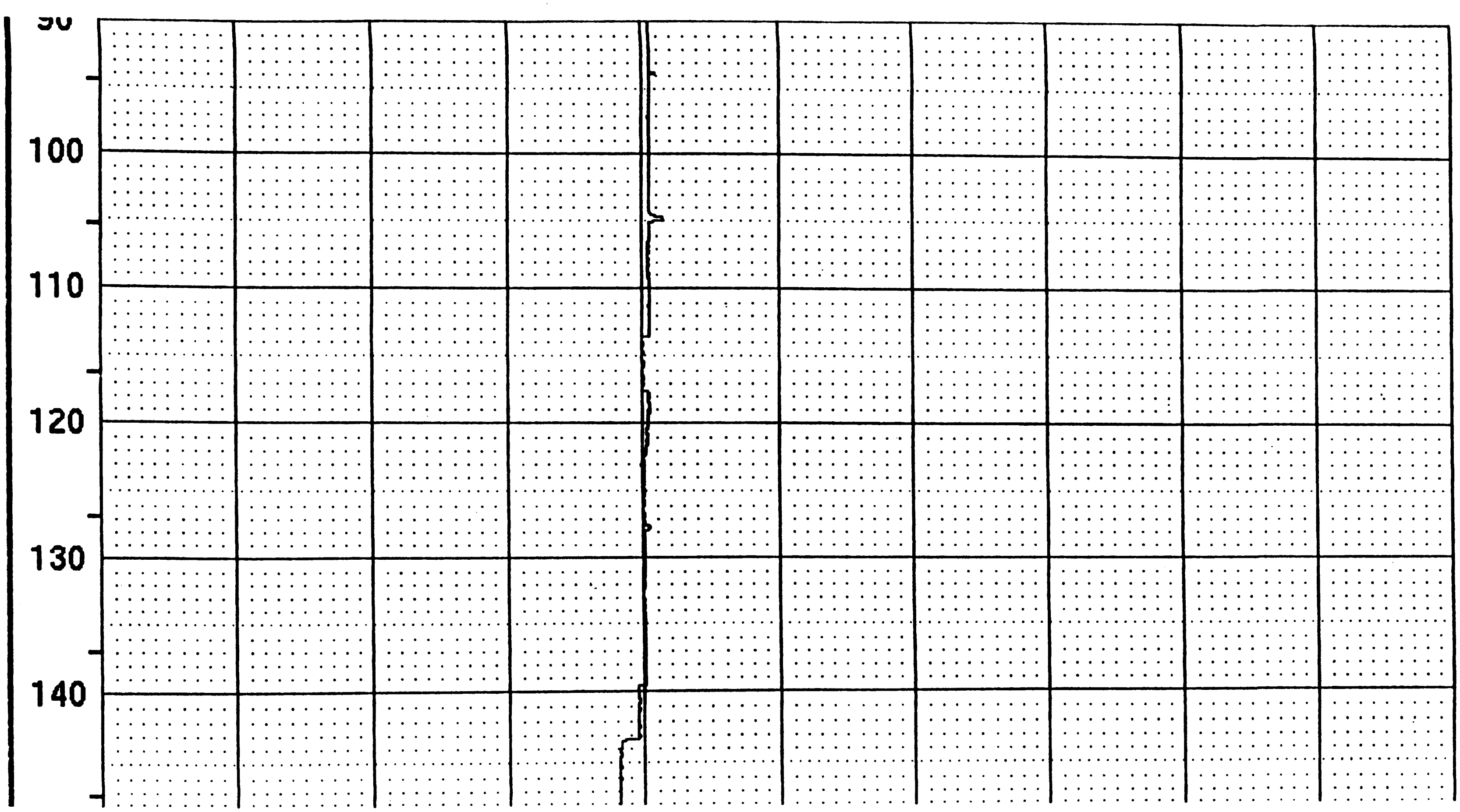
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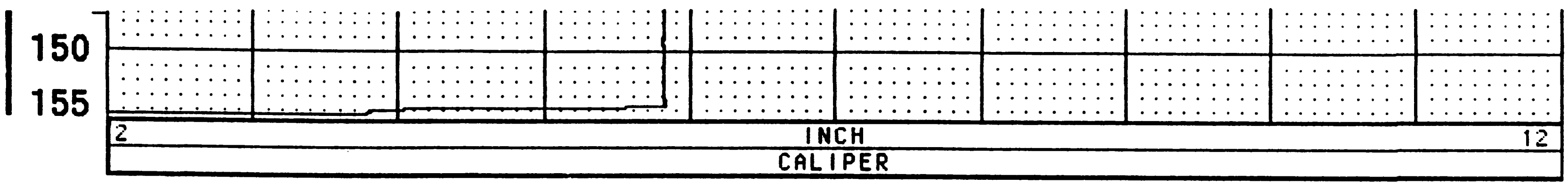

TOOL CALIBRATION   TOOL = 9065A   SERIAL NUMBER = 715

	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
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1	OCT16.91	14:57:01	0	CALIPER	4170.000 CPS	12.000	INCH
2	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH
3	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH

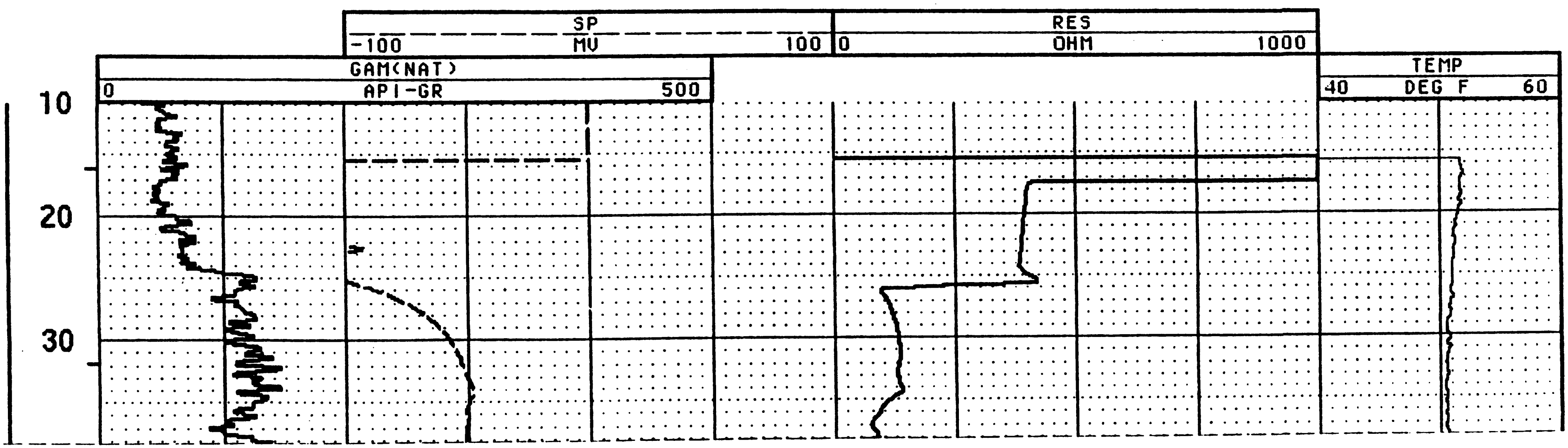
CGC

Century Geophysical Corp.

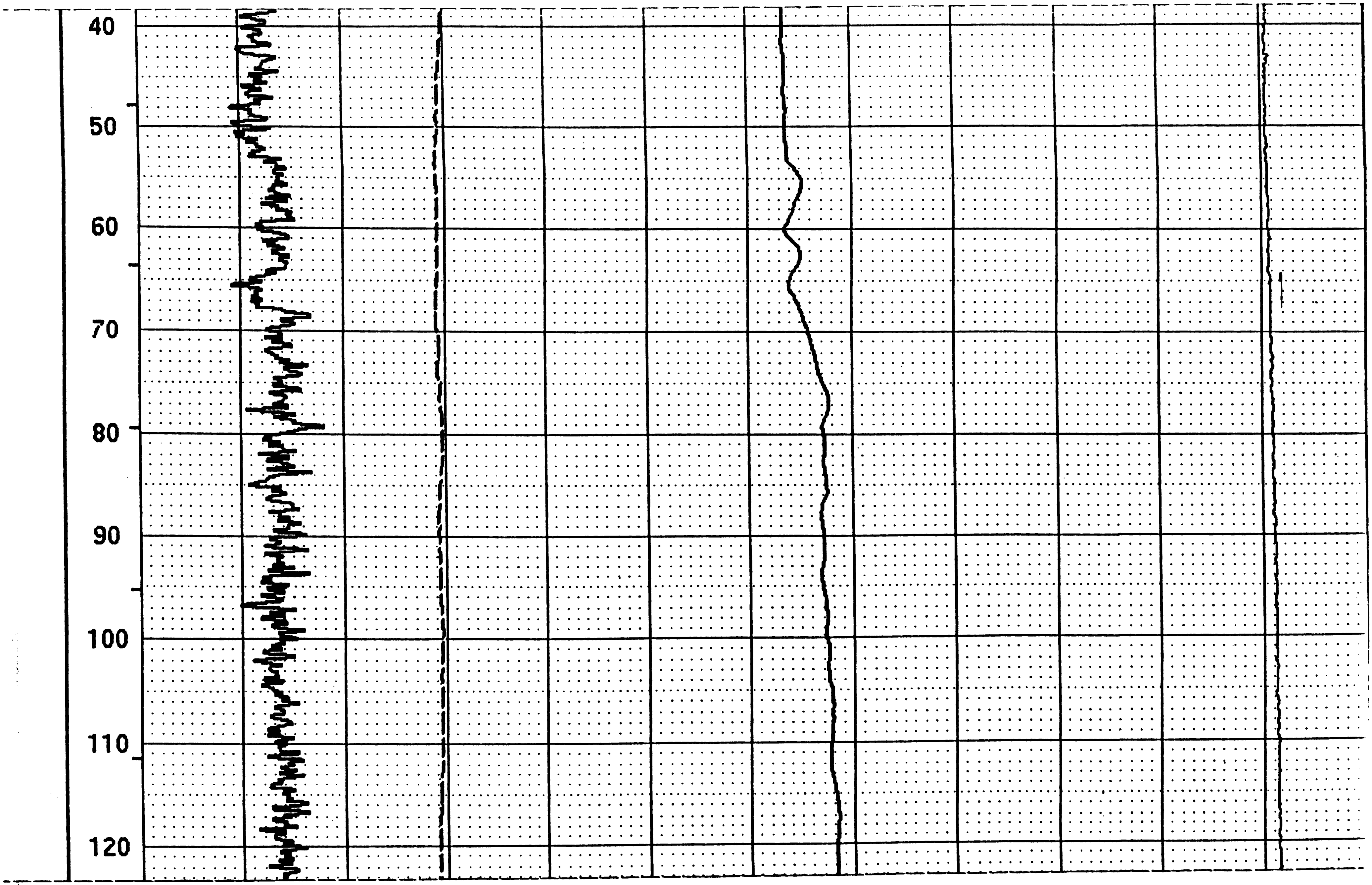
DW1

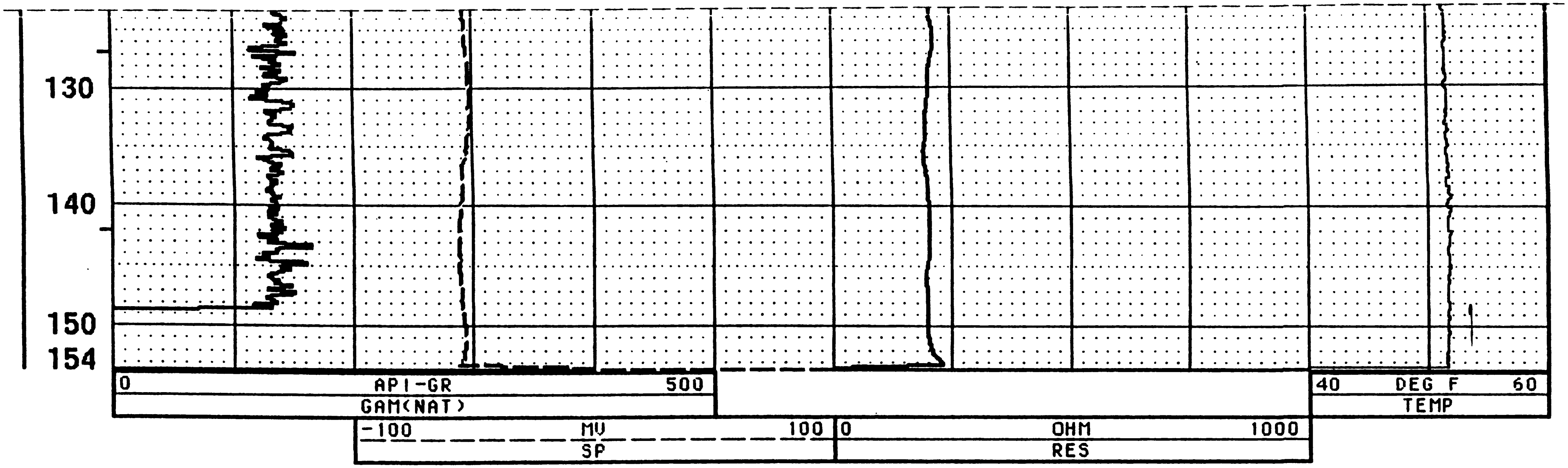
COMPANY	GeEx			OTHER SERVICES:	
WELL	DW1				
LOCATION/FIELD	NEPERA LAGOON				
COUNTY	ORANGE				
STATE	NY				
SECTION		TOWNSHIP		RANGE	
DATE	10/18/91	PERMANENT DATUM		ELEVATIONS	
DEPTH DRILLER	152	ELEV. PERM. DATUM		KB	
LOG BOTTOM	153.80	LOG MEASURED FROM	GL	DF	
LOG TOP	10.90	DRL MEASURED FROM		GL	
CASING DRILLER		LOGGING UNIT			
CASING TYPE		FIELD OFFICE			
CASING THICKNESS		RECORDED BY			
BIT SIZE		BOREHOLE FLUID		FILE	ORIGINAL
MAGNETIC DECL.		RM		TYPE	9055A
MATRIX DENSITY		RM TEMPERATURE		LOG	1
FLUID DENSITY		MATRIX DELTA T		PLOT	9055A 0
NEUTRON MATRIX		FLUID DELTA T		THRESH	
REMARKS					

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



SP
-100
MV
100
RES
0
OHM
1000
GAM(NAT)
0
API-GR
500
TEMP
40
DEG F
60
10
20
30


40
50
60
70
80
90
100
110
120



TOOL CALIBRATION   TOOL = 9055A   SERIAL NUMBER = 252

	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
0	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
1	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
2	OCT10.91	10:47:34	0	POROSITY	0.000 CPS	0.000	CPS
3	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
4	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
5	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
6	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
7	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N
8	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N

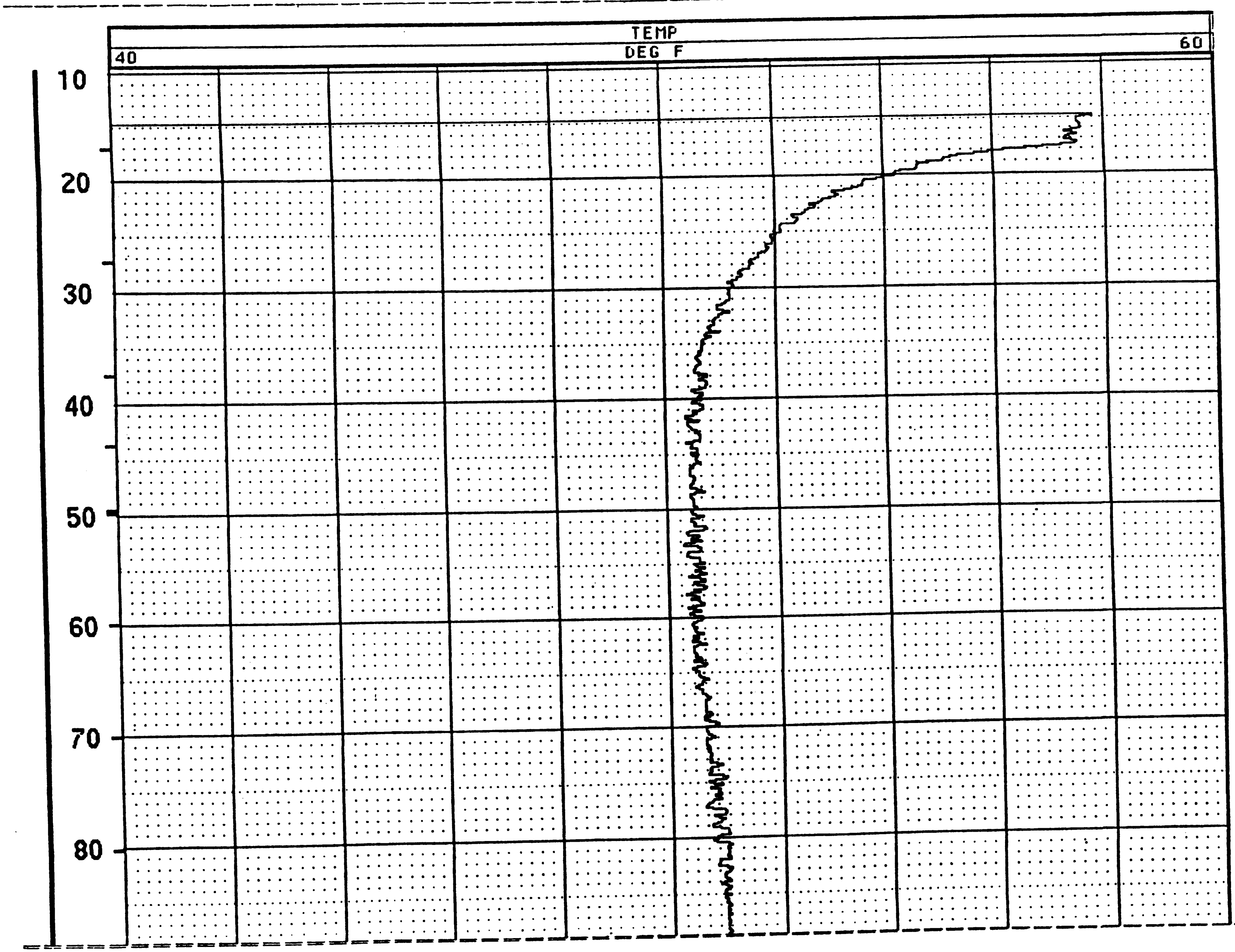
CGC

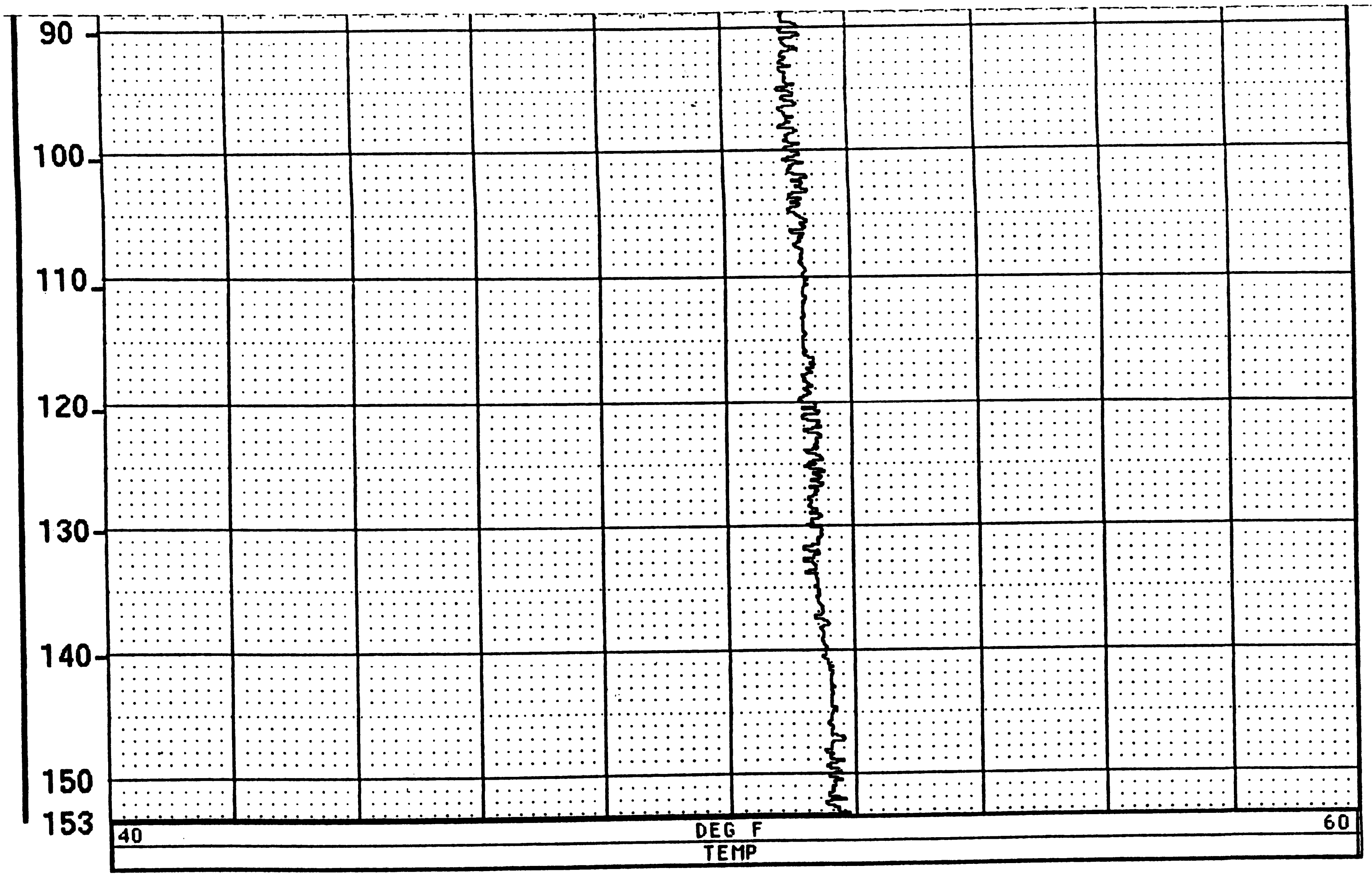
Century Geophysical Corp.

DW1

COMPANY	GeEx			OTHER SERVICES:	
WELL	DW1				
LOCATION/FIELD	NEPERA LAGOON				
COUNTY	ORANGE				
STATE	NY				
SECTION		TOWNSHIP		RANGE	
DATE	10/18/91	PERMANENT DATUM		ELEVATIONS	
DEPTH DRILLER	152	ELEV. PERM. DATUM		KB	
LOG BOTTOM	153.50	LOG MEASURED FROM	GL	DF	
LOG TOP	9.80	DRL MEASURED FROM		GL	
CASING DRILLER		LOGGING UNIT			
CASING TYPE		FIELD OFFICE			
CASING THICKNESS		RECORDED BY			
BIT SIZE		BOREHOLE FLUID		FILE	ORIGINAL
MAGNETIC DECL.		RM		TYPE	9055A
MATRIX DENSITY		RM TEMPERATURE		LOG	0
FLUID DENSITY		MATRIX DELTA T		PLOT	9055B 0
NEUTRON MATRIX		FLUID DELTA T		THRESH:	
REMARKS					

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS


TEMP
DEG F
40
60
10
20
30
40
50
60
70
80



TOOL CALIBRATION TOOL = 9055A SERIAL NUMBER = 252

CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD

0	OCT10.91	10:47:34	0	GAM(NAT)	0.000	CPS	0.000	API-GR
1	OCT10.91	10:47:34	0	GAM(NAT)	0.000	CPS	0.000	API-GR
2	OCT10.91	10:47:34	0	POROSITY	0.000	CPS	0.000	CPS
3	OCT10.91	10:47:34	0	RES	0.000	CPS	0.000	OHM
4	OCT10.91	10:47:34	0	RES	0.000	CPS	0.000	OHM
5	OCT10.91	10:47:34	0	SP	0.000	CPS	0.000	MV
6	OCT10.91	10:47:34	0	SP	0.000	CPS	0.000	MV
7	OCT10.91	10:47:34	0	NEUTRON	0.000	CPS	0.000	API-N
8	OCT10.91	10:47:34	0	NEUTRON	0.000	CPS	0.000	API-N

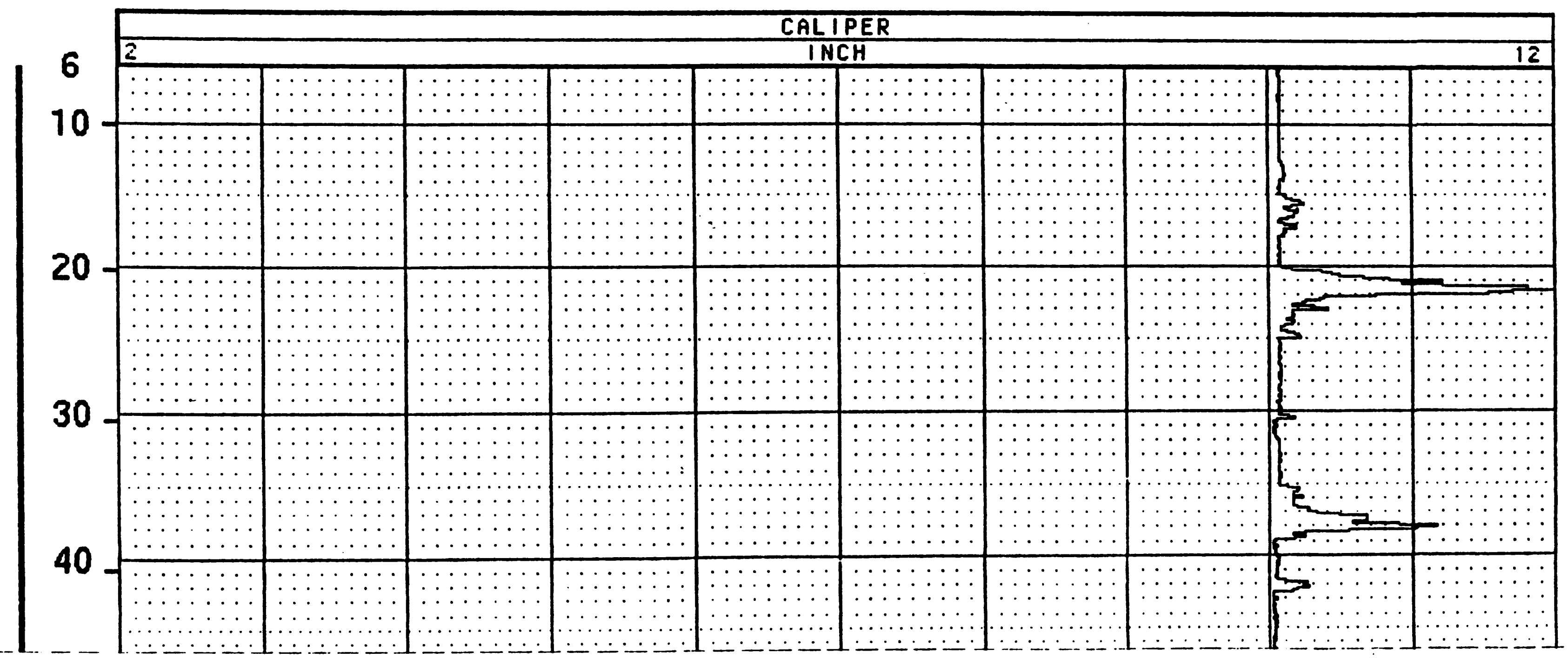
MONITORING WELL: DW-2

Century Geophysical Corp.

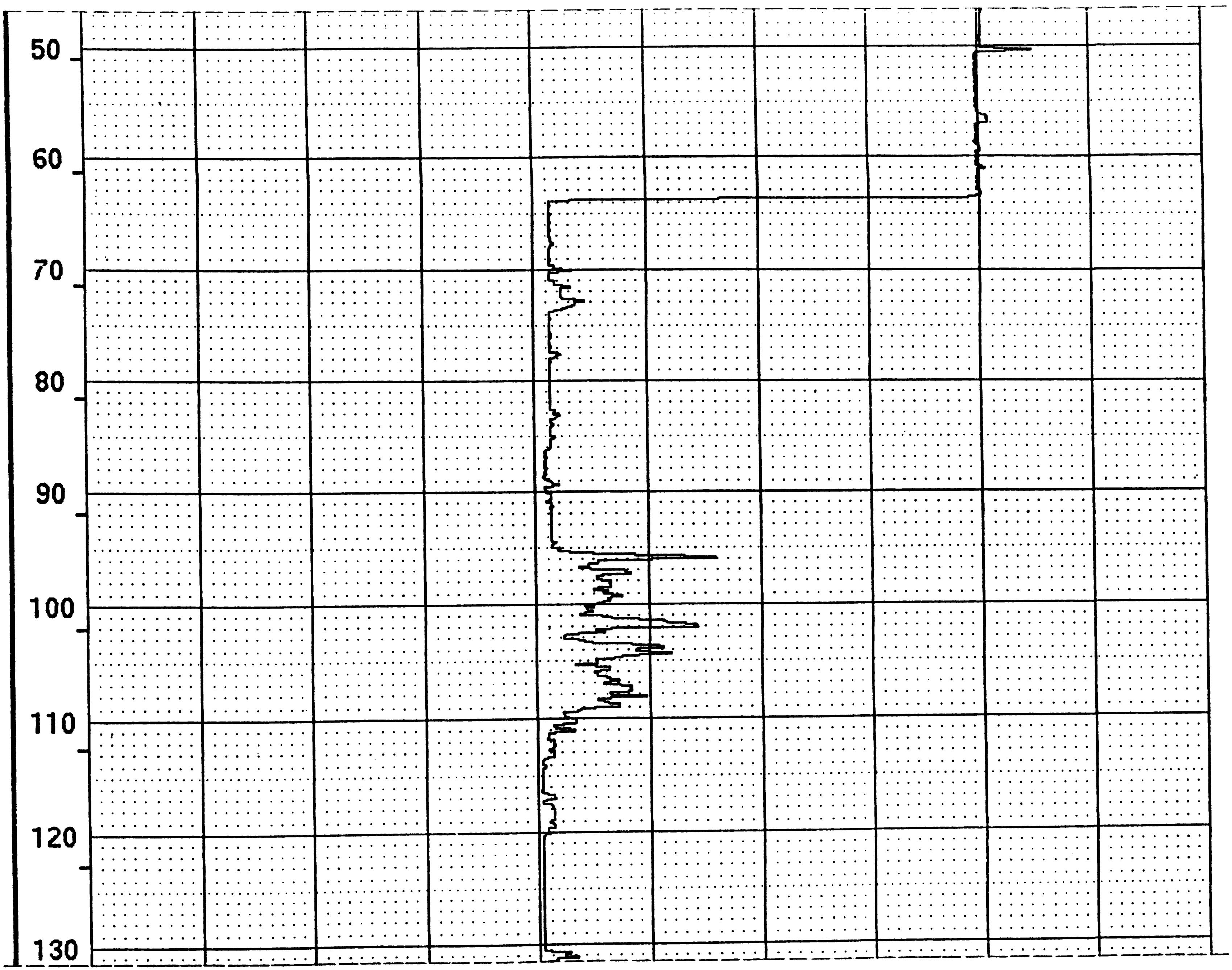
DW2

COMPANY	: GeEx			OTHER SERVICES:	
WELL	: DW2				
LOCATION/FIELD	: NEPERA LAGOON				
COUNTY	: ORANGE				
STATE	: NY				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 10/16/91	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 178.5	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 179.50	LOG MEASURED FROM	: GL	DF	:
LOG TOP	: 6.20	DRL MEASURED FROM	:	GL	:
CASING DRILLER	:	LOGGING UNIT	:		
CASING TYPE	:	FIELD OFFICE	:		
CASING THICKNESS	:	RECORDED BY	: JRJ		
BIT SIZE	:	BOREHOLE FLUID	:	FILE	: ORIGINAL
MAGNETIC DECL.	:	RM	:	TYPE	: 9065A
MATRIX DENSITY	:	RM TEMPERATURE	:	LOG	: 6
FLUID DENSITY	:	MATRIX DELTA T	:	PLOT	: 9065A 0
NEUTRON MATRIX	:	FLUID DELTA T	:	THRESH	: 100000
REMARKS	:				

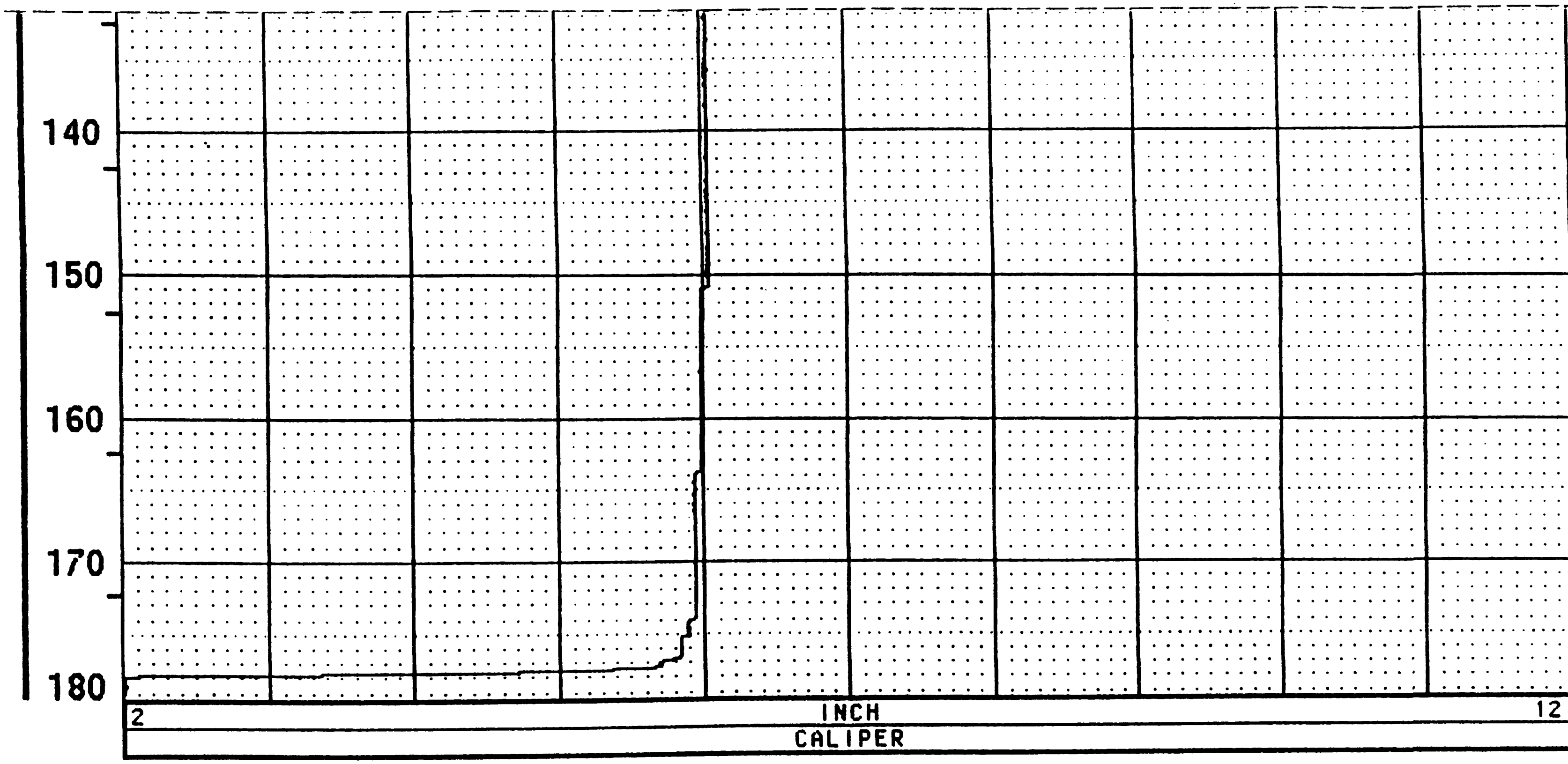
ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



CALIPER
2
INCH
12
6
10
20
30
40



50
60
70
80
90
100
110
120
130



TOOL CALIBRATION TOOL = 9065A SERIAL NUMBER = 715

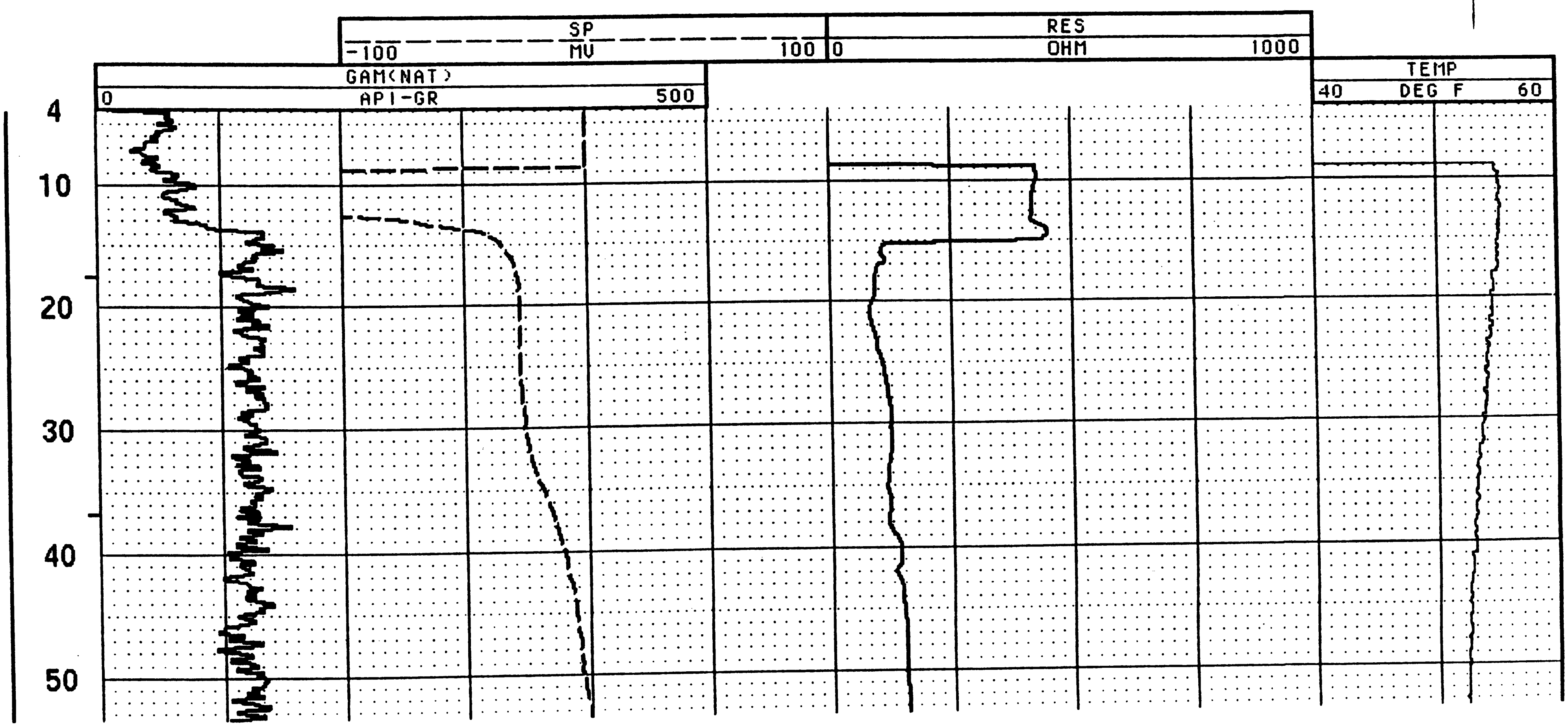
	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
0	OCT16.91	14:57:01	0	CALIPER	1415.000 CPS	2.950	INCH
1	OCT16.91	14:57:01	0	CALIPER	4170.000 CPS	12.000	INCH
2	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH
3	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH

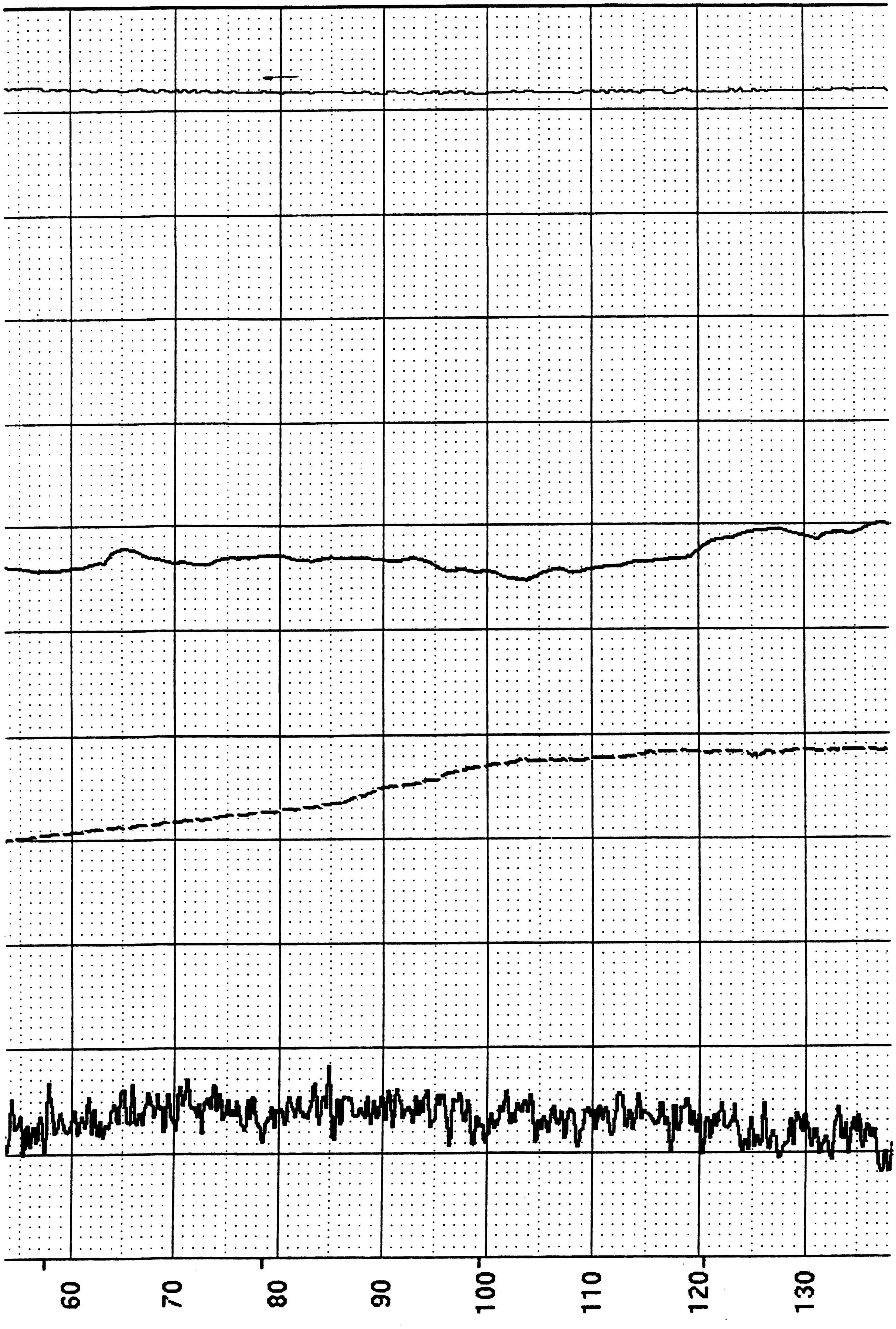
Century GEOPHYSICAL CORP.

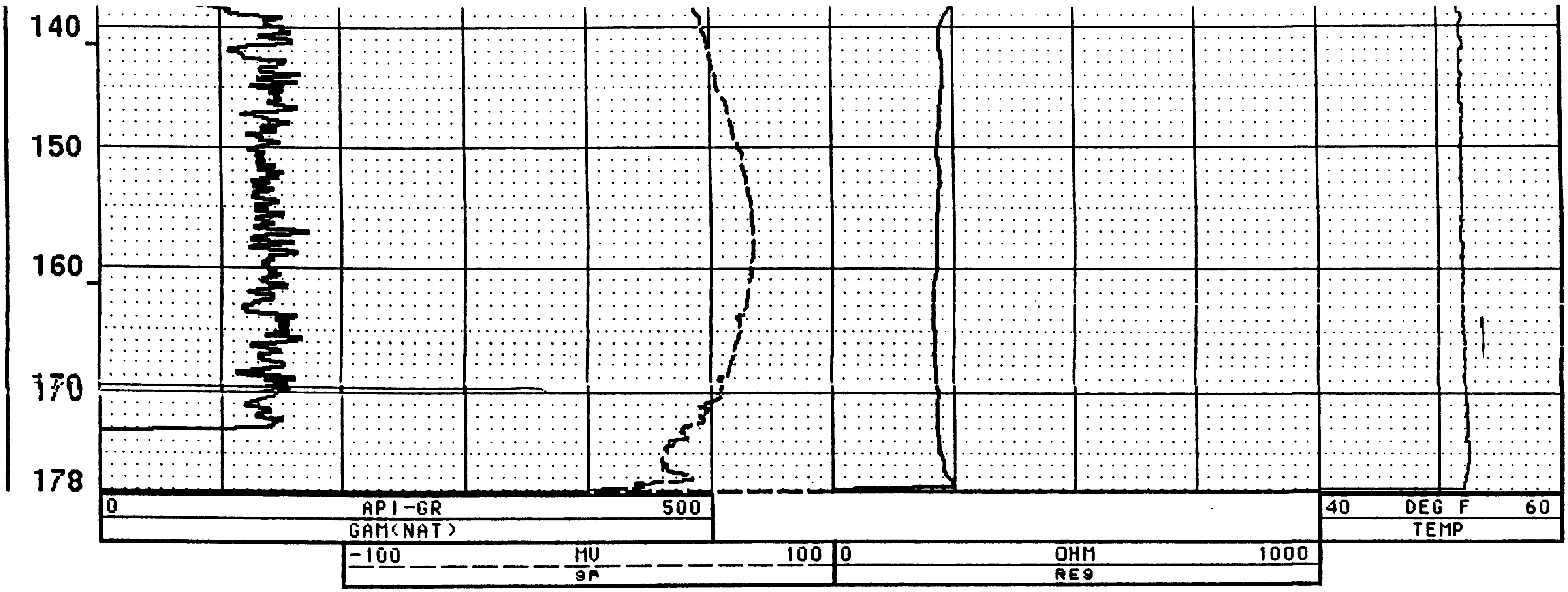
DW2

COMPANY	GeEx	OTHER SERVICES:			
WELL	DW2				
LOCATION/FIELD	NEPERA LAGOON				
COUNTY	ORANGE				
STATE	NY				
SECTION		TOWNSHIP		RANGE	
DATE	10/16/91	PERMANENT DATUM		ELEVATIONS	
DEPTH DRILLER	178.5	ELEV. PERM. DATUM		KB	
LOG BOTTOM	178.40	LOG MEASURED FROM	GL	DF	
LOG TOP	4.20	DRL MEASURED FROM		GL	
CASING DRILLER		LOGGING UNIT			
CASING TYPE		FIELD OFFICE			
CASING THICKNESS		RECORDED BY	JRJ		
BIT SIZE		BOREHOLE FLUID		FILE	ORIGINAL
MAGNETIC DECL.		RM		TYPE	9055A
MATRIX DENSITY		RM TEMPERATURE		LOG	5
FLUID DENSITY		MATRIX DELTA T		PLOT	9055A 0
NEUTRON MATRIX		FLUID DELTA T		THRESH	100000
REMARKS					

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS


SP
-100
MV
100
RES
0
OHM
1000
GAM(NAT)
0
API-GR
500
TEMP
40
DEG F
60
4
10
20
30
40
50


60
70
80
90
100
110
120
130



TOOL CALIBRATION TOOL = 9055A SERIAL NUMBER = 252

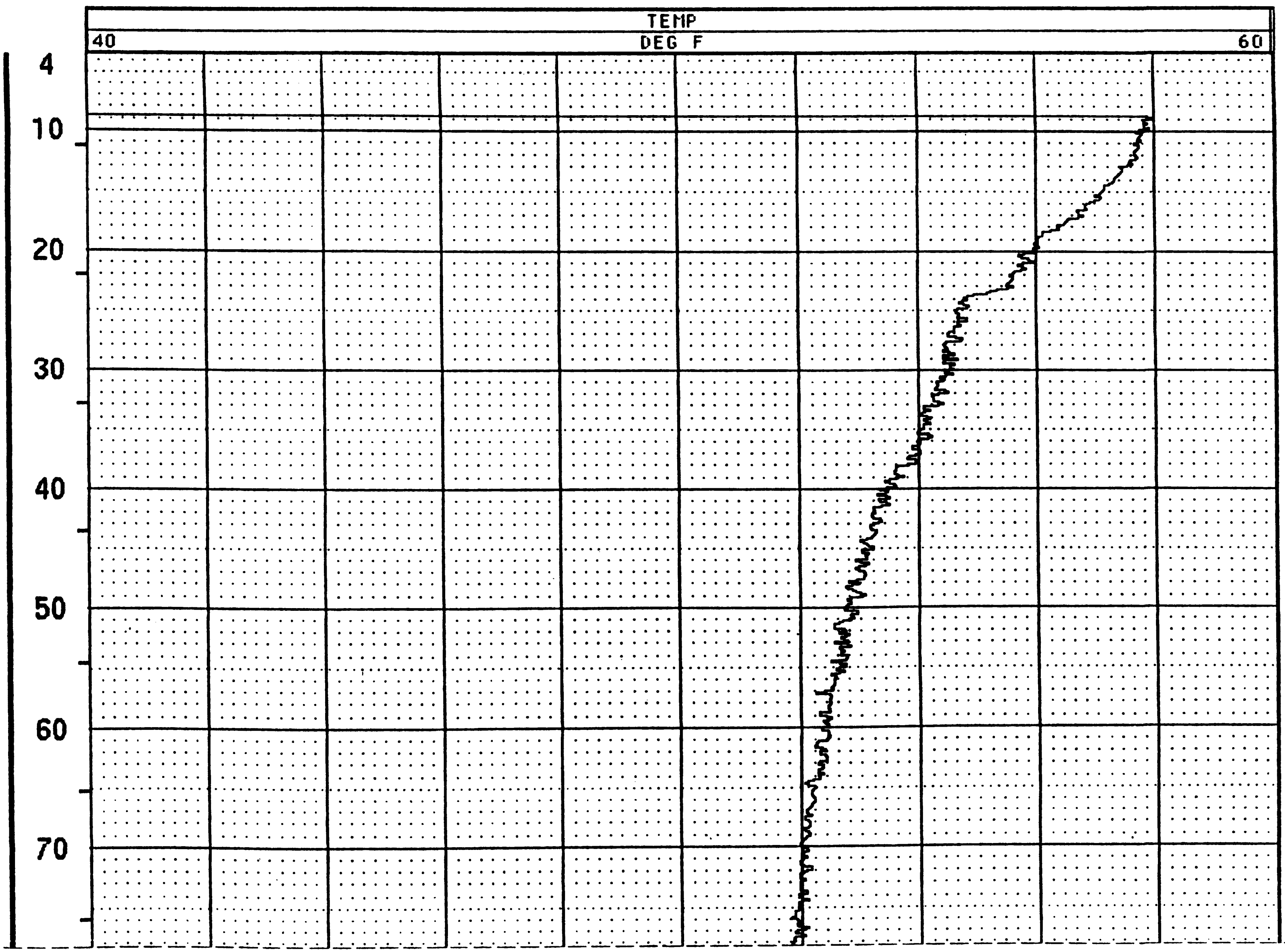
	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
0	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
1	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
2	OCT10.91	10:47:34	0	POROSITY	0.000 CPS	0.000	CPS
3	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
4	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
5	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
6	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
7	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N
8	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N

Century Geophysical Corp.

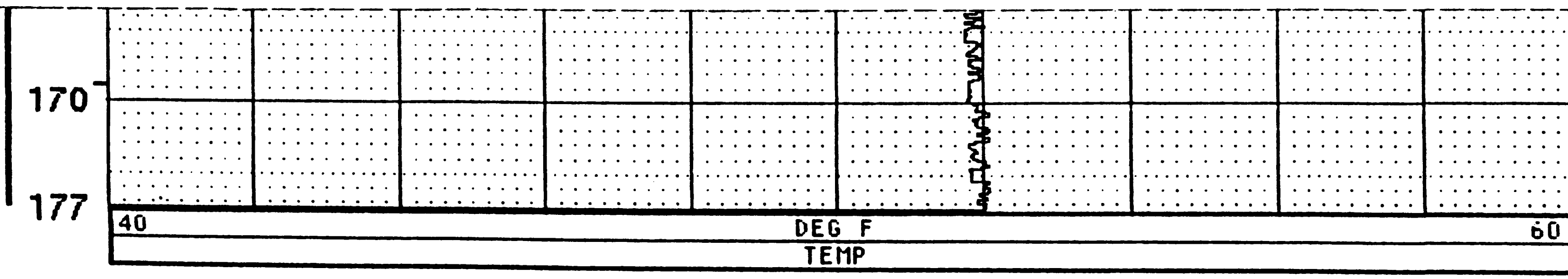
DW2

COMPANY	: GeEx			OTHER SERVICES:	
WELL	: DW2				
LOCATION/FIELD	: NEPERA LAGOON				
COUNTY	: ORANGE				
STATE	: NY				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 10/16/91	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 178.5	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 177.60	LOG MEASURED FROM	: GL	DF	:
LOG TOP	: 3.80	DRL MEASURED FROM	:	GL	:
CASING DRILLER	:	LOGGING UNIT	:		
CASING TYPE	:	FIELD OFFICE	:		
CASING THICKNESS	:	RECORDED BY	: JRJ		
BIT SIZE	:	BOREHOLE FLUID	:	FILE	: ORIGINAL
MAGNETIC DECL.	:	RM	:	TYPE	: 9055A
MATRIX DENSITY	:	RM TEMPERATURE	:	LOG	: 3
FLUID DENSITY	:	MATRIX DELTA T	:	PLOT	: 9055B 0
NEUTRON MATRIX	:	FLUID DELTA T	:	THRESH	: 2900
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



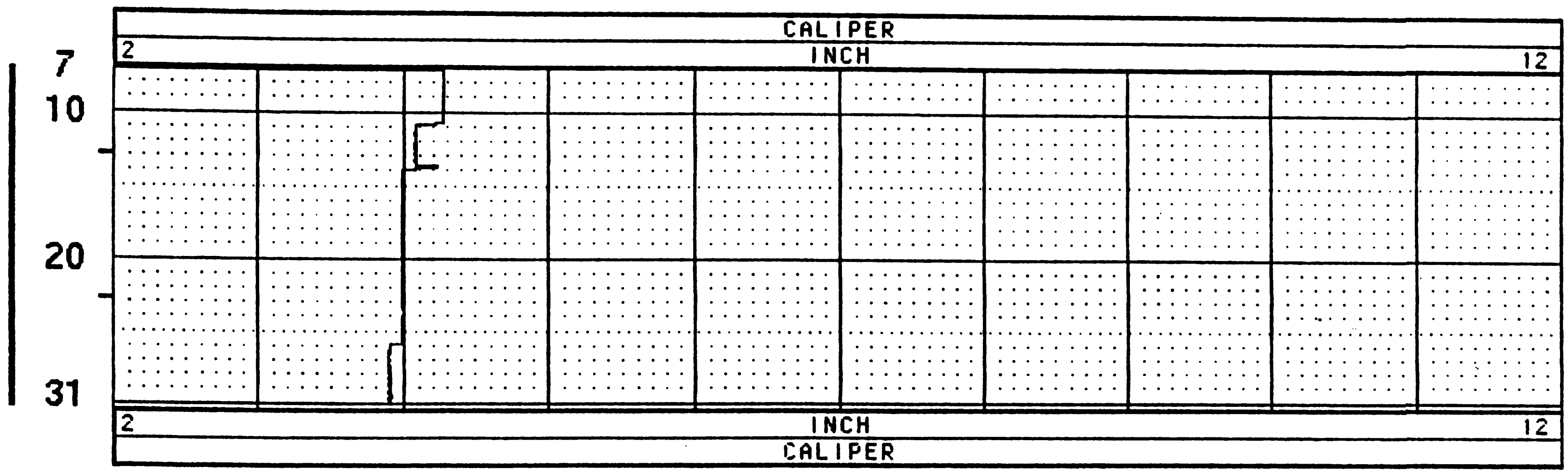
TEMP
DEG F
40
60
4
10
20
30
40
50
60
70



TOOL CALIBRATION TOOL = 9055A SERIAL NUMBER = 252

	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
0	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
1	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
2	OCT10.91	10:47:34	0	POROSITY	0.000 CPS	0.000	CPS
3	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
4	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
5	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
6	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
7	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N
8	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N

MONITORING WELL: MW-1D-91



TOOL CALIBRATION TOOL = 9065A SERIAL NUMBER = 715

	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
0	OCT16.91	14:57:01	0	CALIPER	1415.000 CPS	2.950	INCH
1	OCT16.91	14:57:01	0	CALIPER	4170.000 CPS	12.000	INCH
2	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH
3	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH

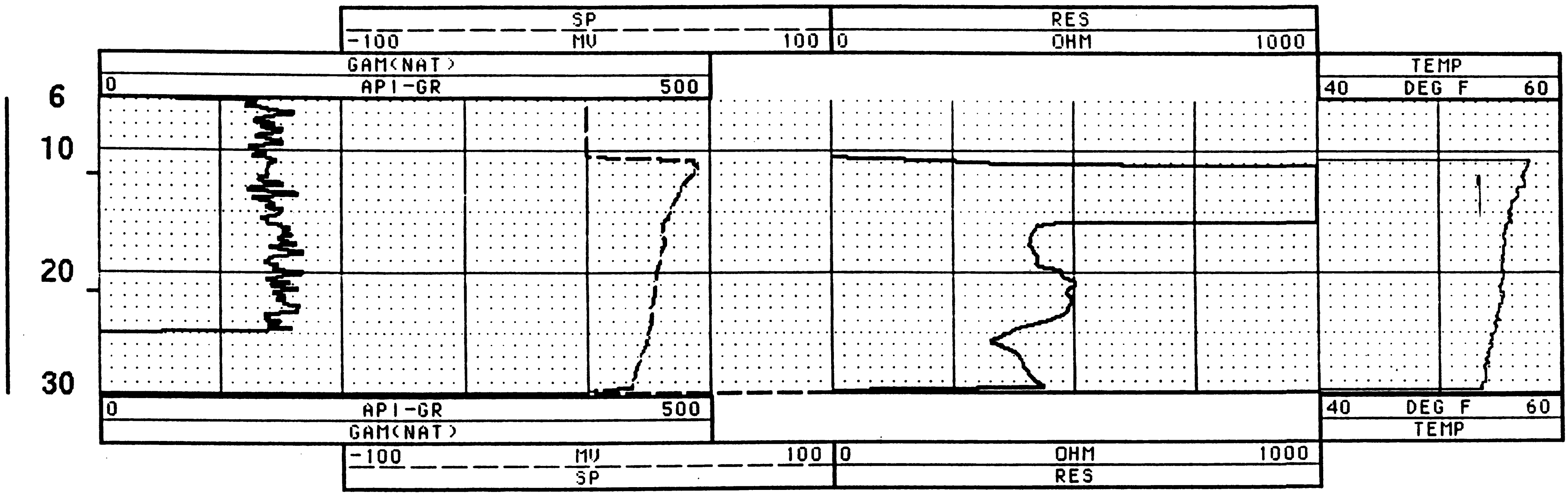
Century GEOPHYSICAL CORP.

MW-1D-91

OTHER SERVICES:

COMPANY	GeEx				
WELL	MW-1D-91				
LOCATION/FIELD	NEPERA LAGOON				
COUNTY	ORANGE				
STATE	NY				
SECTION		TOWNSHIP		RANGE	
DATE	10/18/91	PERMANENT DATUM		ELEVATIONS	
DEPTH DRILLER	152	ELEV. PERM. DATUM		KB	
LOG BOTTOM	30.20	LOG MEASURED FROM	GL	DF	
LOG TOP	6.10	DRL MEASURED FROM		GL	
CASING DRILLER		LOGGING UNIT			
CASING TYPE		FIELD OFFICE			
CASING THICKNESS		RECORDED BY			
BIT SIZE		BOREHOLE FLUID		FILE	ORIGINAL
MAGNETIC DECL.		RM		TYPE	9055A
MATRIX DENSITY		RM TEMPERATURE		LOG	8
FLUID DENSITY		MATRIX DELTA T		PLOT	9055A 0
NEUTRON MATRIX		FLUID DELTA T		THRESH	
REMARKS					

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



TOOL CALIBRATION   TOOL = 9055A   SERIAL NUMBER = 252

	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
0	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
1	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
2	OCT10.91	10:47:34	0	POROSITY	0.000 CPS	0.000	CPS
3	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
4	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
5	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
6	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
7	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N
8	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N

CGC

Century GEOPHYSICAL CORP.

MW-1D-91

COMPANY : GeEx
WELL : MW-1D-91
LOCATION/FIELD : NEPERA LAGOON
COUNTY : ORANGE
STATE : NY

OTHER SERVICES:

SECTION :
TOWNSHIP :
RANGE :

DATE : 10/18/91
DEPTH DRILLER : 152
LOG BOTTOM : 29.90
LOG TOP : 3.80

PERMANENT DATUM :
ELEV. PERM. DATUM:
LOG MEASURED FROM: GL
DRL MEASURED FROM:

ELEVATIONS
KB :
DF :
GL :

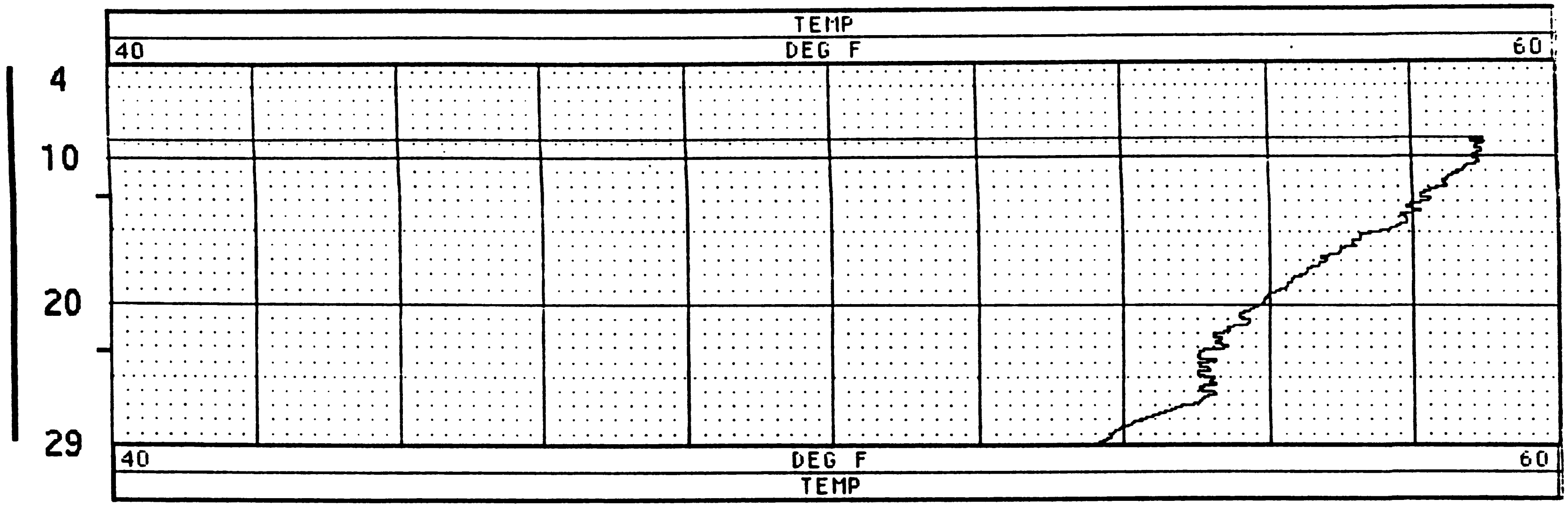
CASING DRILLER :
CASING TYPE :
CASING THICKNESS:

LOGGING UNIT :
FIELD OFFICE :
RECORDED BY :

BIT SIZE :
MAGNETIC DECL. :
MATRIX DENSITY :
FLUID DENSITY :
NEUTRON MATRIX :
REMARKS :

BOREHOLE FLUID :
RM :
RM TEMPERATURE :
MATRIX DELTA T :
FLUID DELTA T :

FILE : ORIGINAL
TYPE : 9055A
LOG : 7
PLOT : 9055B 0
THRESH:



TOOL CALIBRATION   TOOL = 9055A   SERIAL NUMBER = 252

	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
0	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
1	OCT10.91	10:47:34	0	GAM(NAT)	0.000 CPS	0.000	API-GR
2	OCT10.91	10:47:34	0	POROSITY	0.000 CPS	0.000	CPS
3	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
4	OCT10.91	10:47:34	0	RES	0.000 CPS	0.000	OHM
5	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
6	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
7	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N
8	OCT10.91	10:47:34	0	NEUTRON	0.000 CPS	0.000	API-N

MONITORING WELL: MW-2D-91

CGC

Century Geophysical Corp.

MW-2-91

COMPANY : GeEx
WELL : MW-2-91
LOCATION/FIELD : NEPERA LAGOON
COUNTY : ORANGE
STATE : NY
SECTION :

TOWNSHIP :

RANGE :

OTHER SERVICES:

DATE : 10/18/91
DEPTH DRILLER : 152
LOG BOTTOM : 50.50
LOG TOP : 7.20

PERMANENT DATUM :
ELEV. PERM. DATUM:
LOG MEASURED FROM: GL
DRL MEASURED FROM:

ELEVATIONS
KB :
DF :
GL :

CASING DRILLER :
CASING TYPE :
CASING THICKNESS:

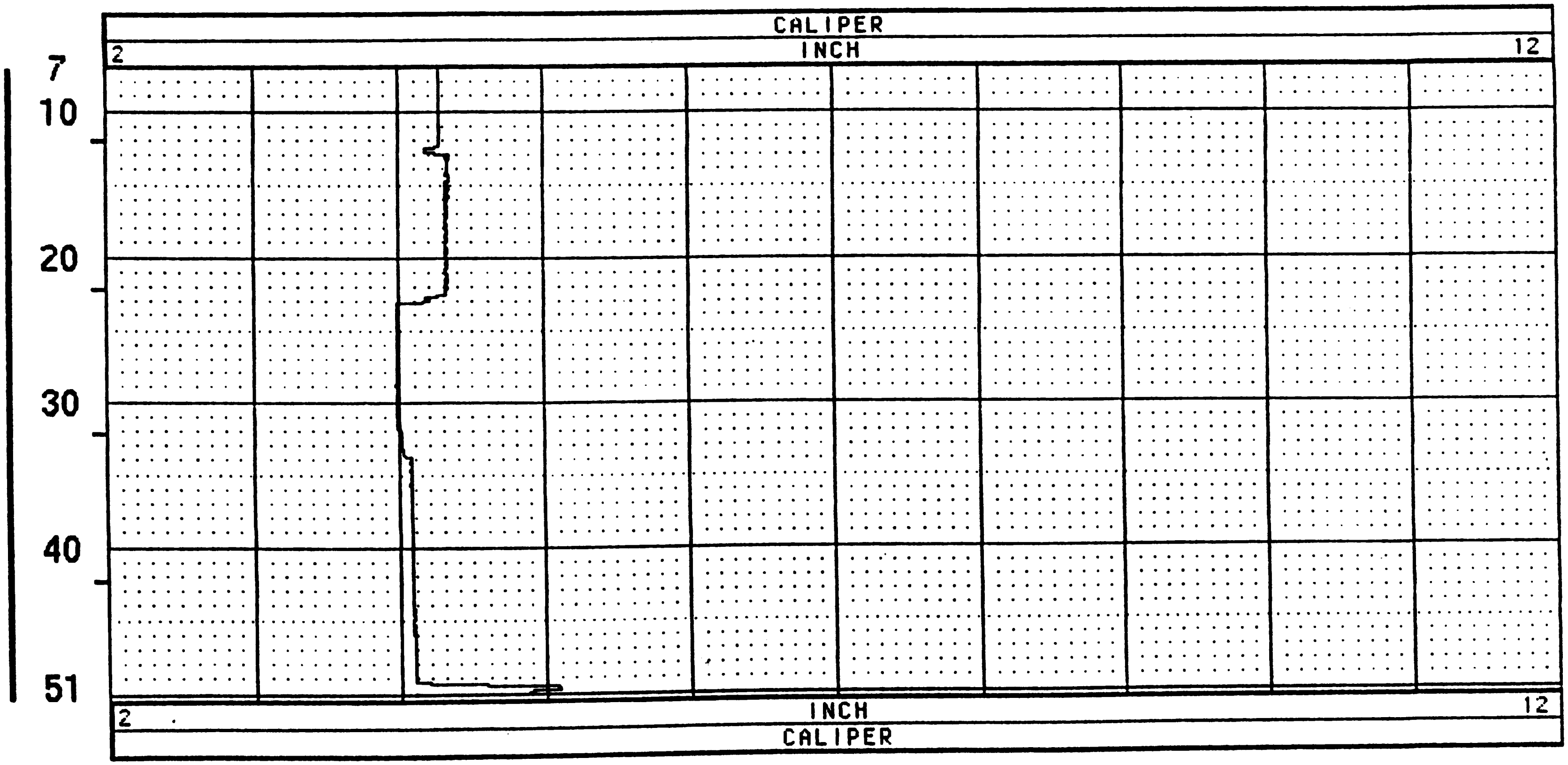
LOGGING UNIT :
FIELD OFFICE :
RECORDED BY :

BIT SIZE :
MAGNETIC DECL. :
MATRIX DENSITY :
FLUID DENSITY :
NEUTRON MATRIX :
REMARKS :

BOREHOLE FLUID :
RM :
RM TEMPERATURE :
MATRIX DELTA T :
FLUID DELTA T :

FILE : ORIGINAL
TYPE : 9065A
LOG : 2
PLOT : 9065A 0
THRESH:

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



TOOL CALIBRATION TOOL = 9065A SERIAL NUMBER = 715

	CAL-DATE	CAL-TIME	SRCE	SENSOR	RESPONSE	STANDARD	
0	OCT16.91	14:57:01	0	CALIPER	1415.000 CPS	2.950	INCH
1	OCT16.91	14:57:01	0	CALIPER	4170.000 CPS	12.000	INCH
2	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH
3	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH

CGC

Century Geophysical Corp.

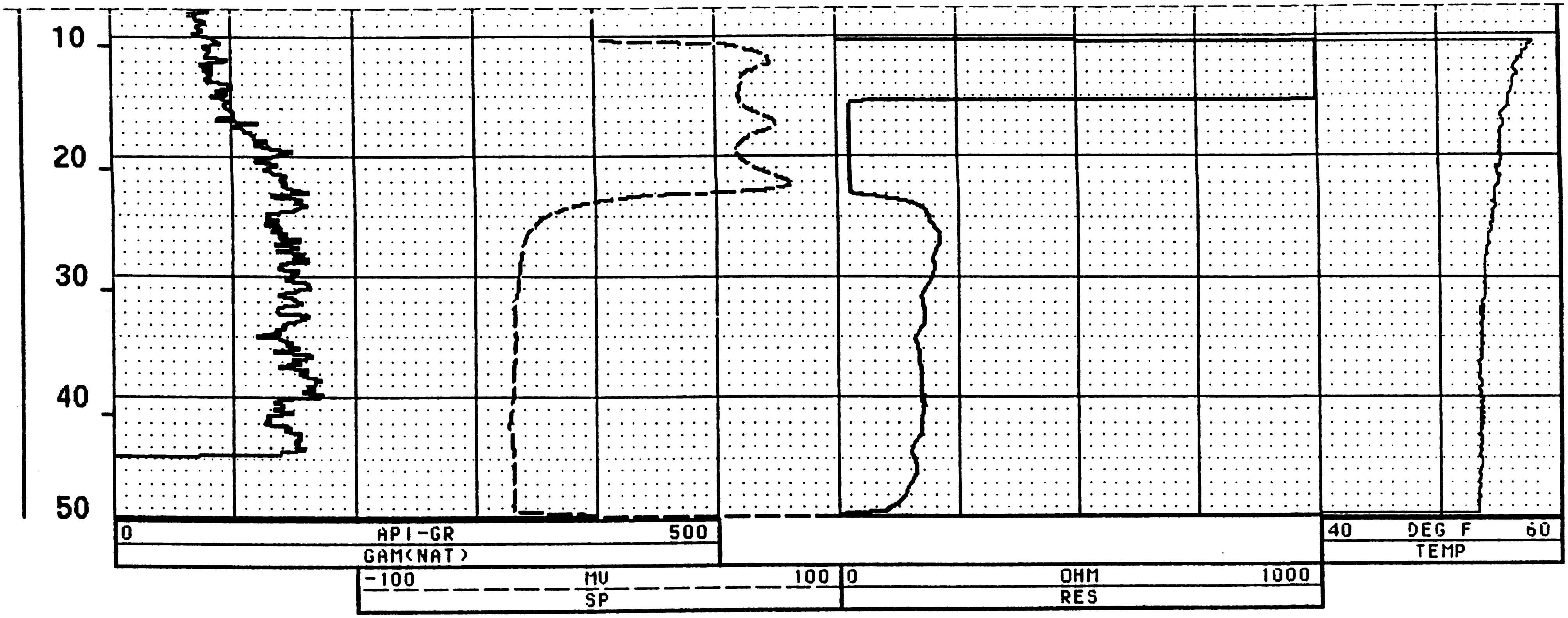
MW-2-91

COMPANY	: GeEx			OTHER SERVICES:	
WELL	: MW-2-91				
LOCATION/FIELD	: NEPERA LAGOON				
COUNTY	: ORANGE				
STATE	: NY				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 10/18/91	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 152	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 50.00	LOG MEASURED FROM	: GL	DF	:
LOG TOP	: 5.90	DRL MEASURED FROM	:	GL	:
CASING DRILLER	:	LOGGING UNIT	:		
CASING TYPE	:	FIELD OFFICE	:		
CASING THICKNESS	:	RECORDED BY	:		
BIT SIZE	:	BOREHOLE FLUID	:	FILE	: ORIGINAL
MAGNETIC DECL.	:	RM	:	TYPE	: 9055A
MATRIX DENSITY	:	RM TEMPERATURE	:	LOG	: 1
FLUID DENSITY	:	MATRIX DELTA T	:	PLOT	: 9055A 0
NEUTRON MATRIX	:	FLUID DELTA T	:	THRESH	:
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS

GAM(NAT) API-GR	SP MV	RES OHM	TEMP DEG F
0 – 500	-100 – 100	0 – 1000	40 – 60

5



TOOL CALIBRATION   TOOL = 9055A   SERIAL NUMBER = 252

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CGC

Century Geophysical Corp.

MW-2-91

COMPANY	GeEx			OTHER SERVICES:	
WELL	MW-2-91				
LOCATION/FIELD	NEPERA LAGOON				
COUNTY	ORANGE				
STATE	NY				
SECTION		TOWNSHIP		RANGE	
DATE	10/18/91	PERMANENT DATUM		ELEVATIONS	
DEPTH DRILLER	152	ELEV. PERM. DATUM		KB	
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LOG TOP	3.80	DRL MEASURED FROM		GL	
CASING DRILLER		LOGGING UNIT			
CASING TYPE		FIELD OFFICE			
CASING THICKNESS		RECORDED BY			
BIT SIZE		BOREHOLE FLUID		FILE	ORIGINAL
MAGNETIC DECL.		RM		TYPE	9055A
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FLUID DENSITY		MATRIX DELTA T		PLOT	9055B 0
NEUTRON MATRIX		FLUID DELTA T		THRESH:	
REMARKS					

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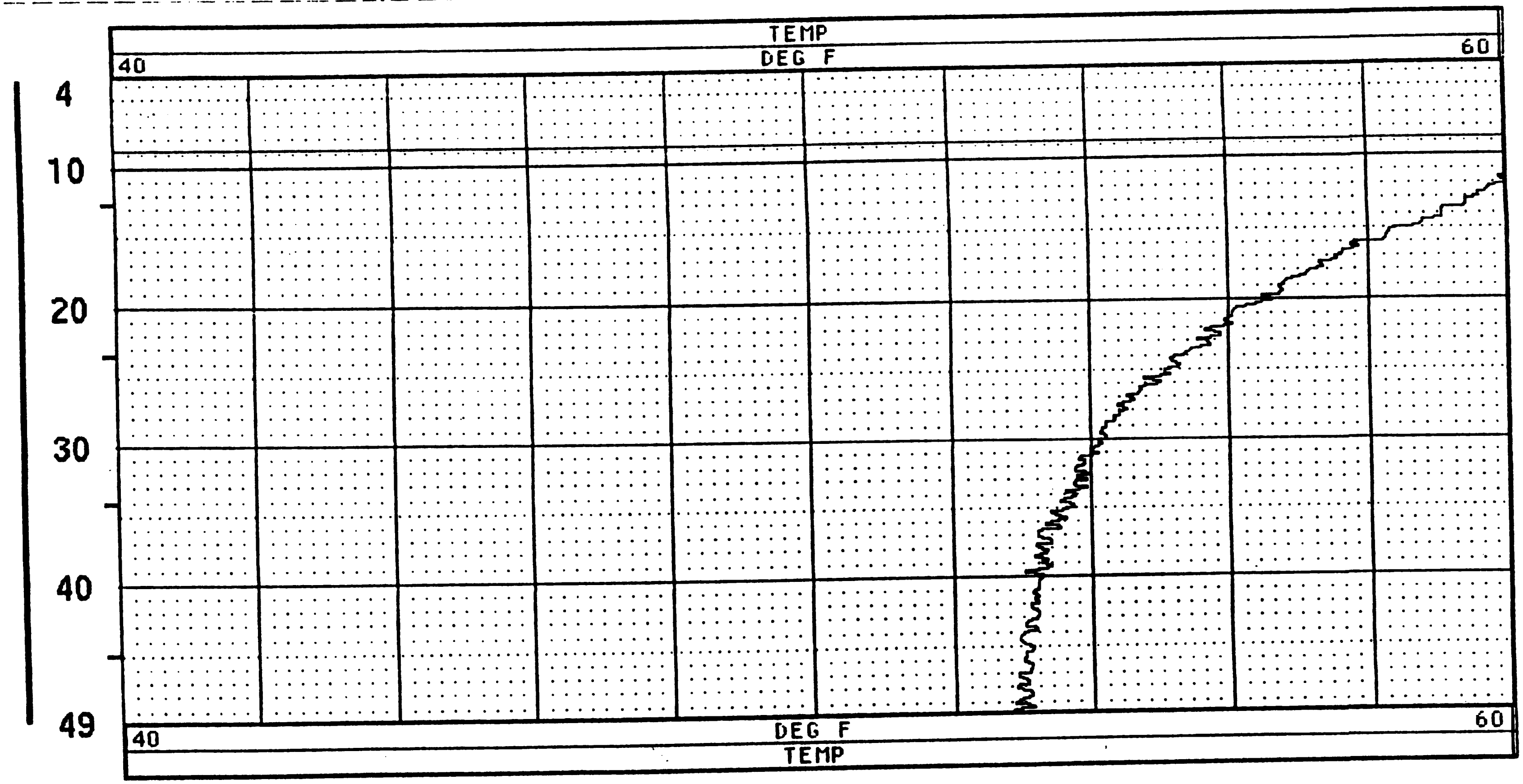

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MONITORING WELL: MW-3D-91

GeEx

CGC

Century Geophysical Corp.

MW-3D-91

OTHER SERVICES:

COMPANY	: GeEx				
WELL	: MW-3D-91				
LOCATION/FIELD	: NEPERA LAGOON				
COUNTY	: ORANGE				
STATE	: NY				
SECTION	:	TOWNSHIP	:	RANGE	:
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REMARKS	:				

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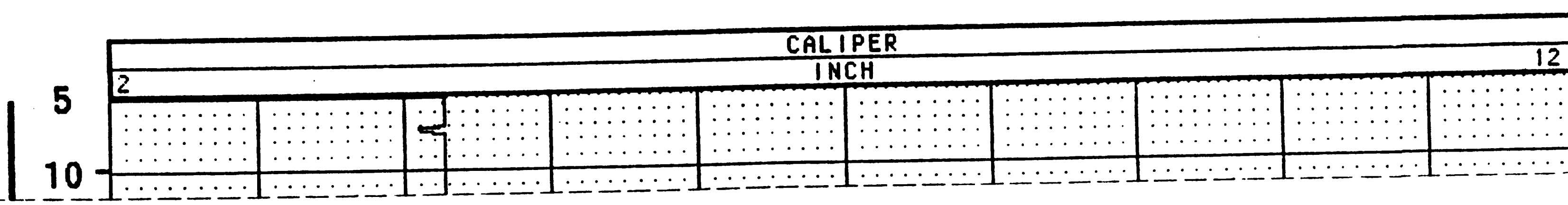
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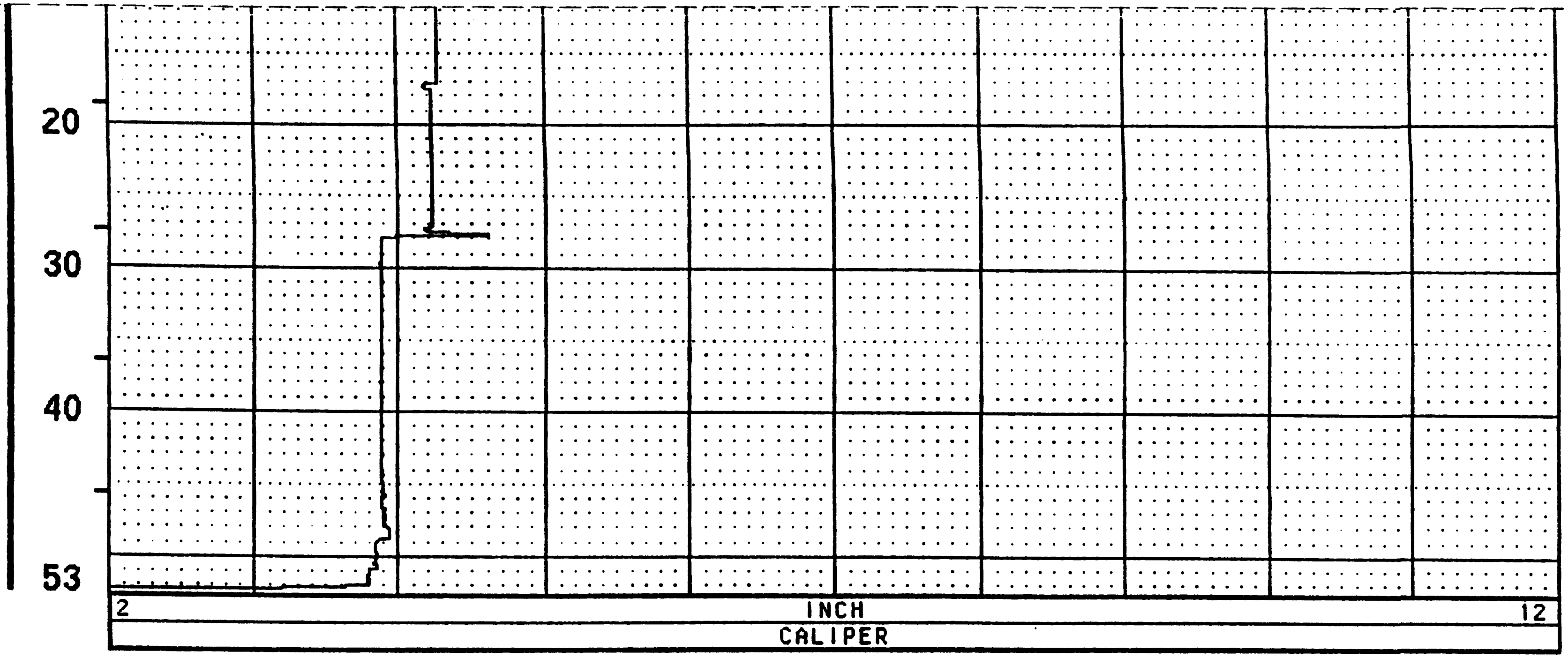

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CGC

Century GEOPHYSICAL CORP.

MW-3D-91

OTHER SERVICES:

COMPANY	: GeEx				
WELL	: MW-3D-91				
LOCATION/FIELD	: NEPERA LAGOON				
COUNTY	: ORANGE				
STATE	: NY				
SECTION	:	TOWNSHIP	:	RANGE	:
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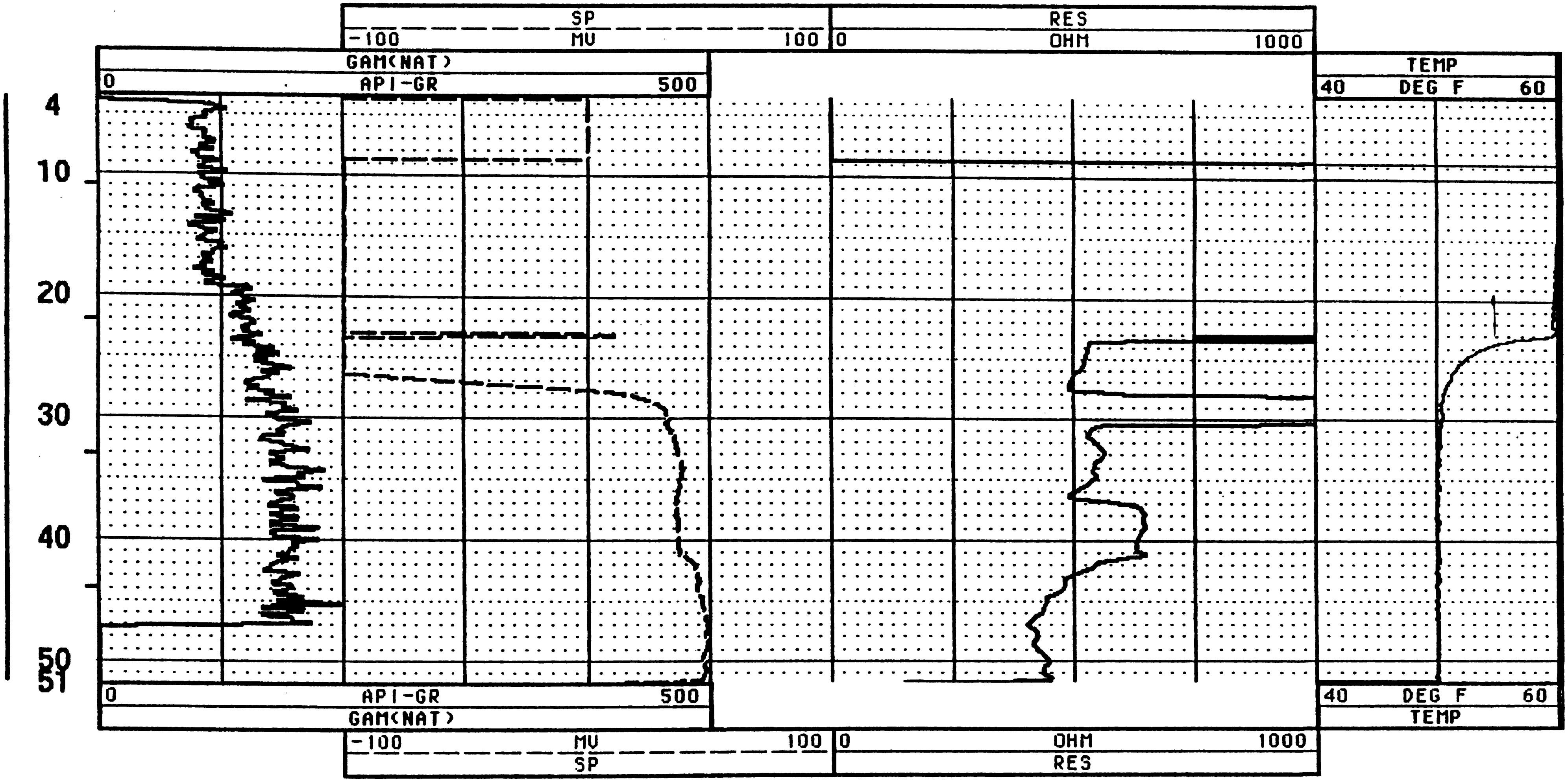
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



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Century Geophysical Corp.

MW-3D-91

OTHER SERVICES:

COMPANY	GeEx				
WELL	MW-3D-91				
LOCATION/FIELD	NEPERA LAGOON				
COUNTY	ORANGE				
STATE	NY				
SECTION		TOWNSHIP		RANGE	
DATE	10/16/91	PERMANENT DATUM		ELEVATIONS	
DEPTH DRILLER	53	ELEV. PERM. DATUM		KB	
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LOG TOP	3.80	DRL MEASURED FROM		GL	
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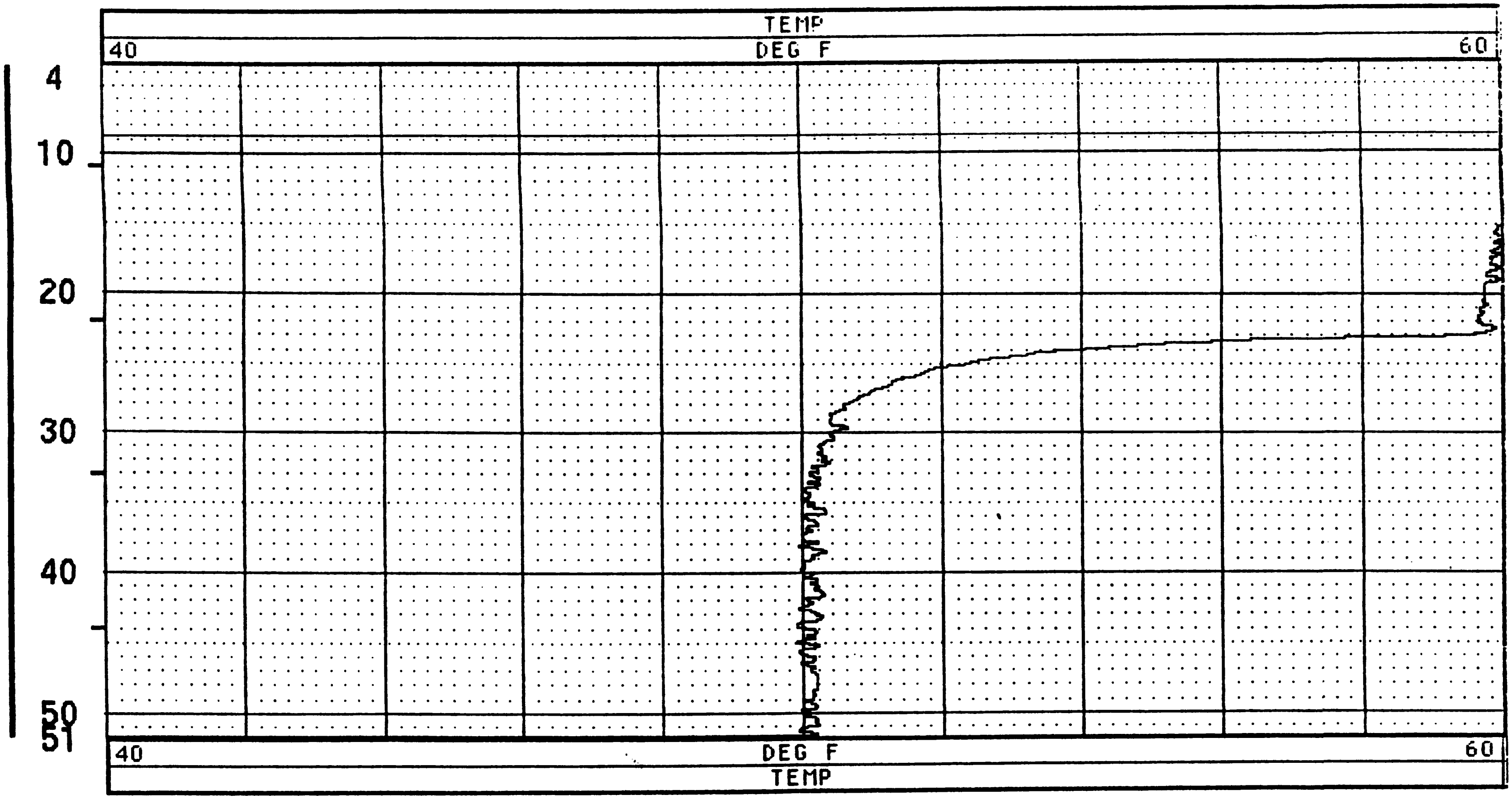
CASING TYPE		FIELD OFFICE			
CASING THICKNESS		RECORDED BY			
BIT SIZE		BOREHOLE FLUID		FILE	ORIGINAL
MAGNETIC DECL.		RM		TYPE	9055A
MATRIX DENSITY		RM TEMPERATURE		LOG	3
FLUID DENSITY		MATRIX DELTA T		PLOT	9055B 0
NEUTRON MATRIX		FLUID DELTA T		THRESH	
REMARKS					

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



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MONITORING WELL: MW-4D-91

CGC

Century GEOPHYSICAL CORP.

MW-4-91

OTHER SERVICES:

COMPANY	: GeEx				
WELL	: MW-4-91				
LOCATION/FIELD	: NEPERA LAGOON				
COUNTY	: ORANGE				
STATE	: NY				
SECTION	:	TOWNSHIP	:	RANGE	:
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CASING TYPE	:	FIELD OFFICE	:		
CASING THICKNESS	:	RECORDED BY	:		
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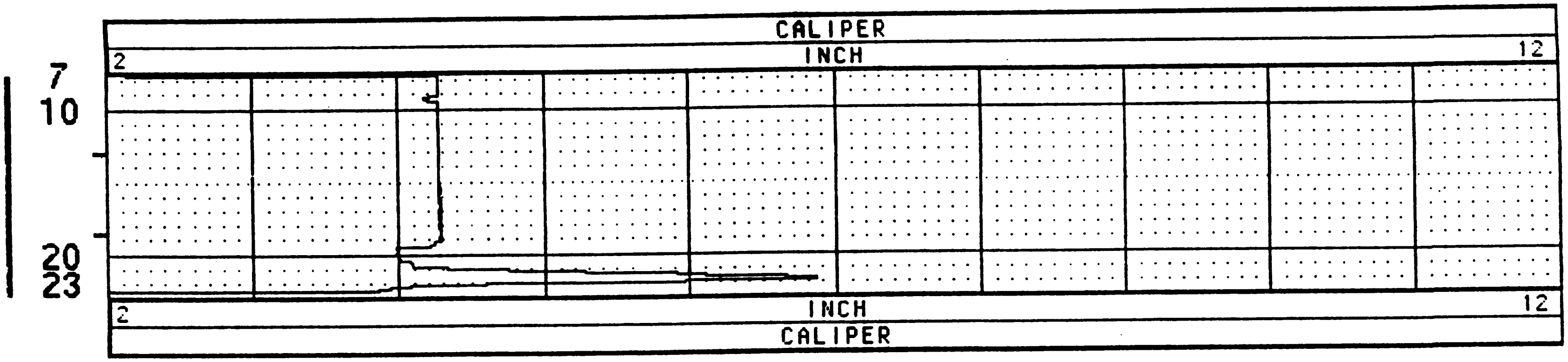
REMARKS	:				



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2	OCT16.91	14:57:01	0	CALIPERL	0.000 CPS	0.000	INCH
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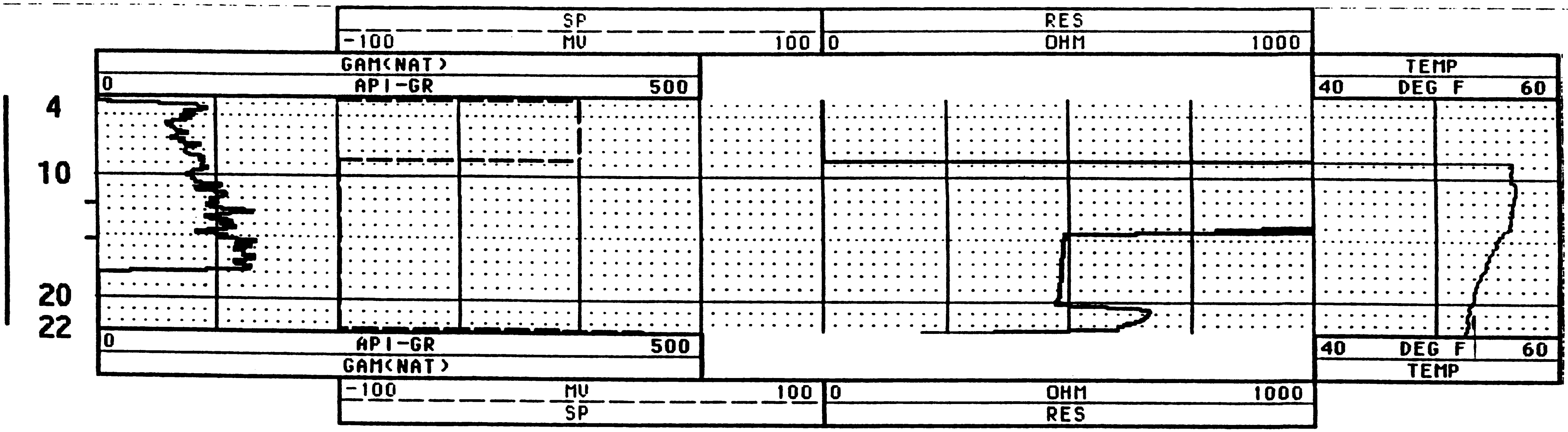

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5	OCT10.91	10:47:34	0	SP	0.000 CPS	0.000	MV
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CGC

Century Geophysical Corp.

MW-4-91

OTHER SERVICES:

COMPANY	GeEx				
WELL	MW-4-91				
LOCATION/FIELD	NEPERA LAGOON				
COUNTY	ORANGE				
STATE	NY				
SECTION		TOWNSHIP		RANGE	
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FLUID DENSITY		MATRIX DELTA T		PLOT	9055B 0
NEUTRON MATRIX		FLUID DELTA T		THRESH	
REMARKS					

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APPENDIX H.2

MAGNOMETER SURVEY STUDY

GeEx

Exploration Geophysics for the Groundwater Industry

REPORT ON THE MAGNETOMETER SURVEY AT THE FORMER LAGOON SITE

FOR NEPERA, INC. IN HAMPTONBURG, NEW YORK

Submitted To:
Conestoga Rovers & Associates Ltd.

November, 1991

128 N. Main St., West Bend, Wisconsin 53095-0541 • (414) 335-0301

INTRODUCTION

In October of 1991, GeEx was contracted by Conestoga Rovers & Associates, Ltd. (CRA) to perform a magnetometer survey at the Former Lagoon Site of Nepera, Inc. in Hamptonburg, New York. The purpose of the survey was to find buried metallic objects, such as steel drums. The field investigations were performed between October 14th and October 19th, 1991.

DISCUSSION OF THE MAGNETOMETRY METHOD

Convective cells within the outer core of the Earth create a dipolar magnetic field which surrounds the planet. The field is generally smooth but the intensity, inclination, and declination of the field vary depending on the latitude and longitude of the observation point. Accumulations of ferrous metal objects cause localized distortions of the natural magnetic field which can be used to detect the presence of anomalous ferrous bodies. The magnetometry method involves making precise measurements of the intensity of the Earth's magnetic field at distinct stations on a grid to detect magnetic anomalies caused by local accumulations of ferrous metal.

The shape and intensity of the magnetic anomalies will vary depending on the size, shape, and depth of the metal target. Single metal targets with simple shapes produce distinctive anomaly patterns which can be analyzed to estimate the depth, shape, and ferrous metal content of the body. This is particularly useful when looking for a steel storage tank or steel drums. Accumulations of multiple targets create complex anomaly patterns which cannot be analyzed to determine the position and shape of the individual targets. In these cases, the location of the magnetic anomaly indicates the area over which the multiple targets are distributed, but the area must be excavated to identify the individual targets. The areal extent and the relative intensity of the anomaly can be used to qualitatively estimate the significance of an anomaly.

When making magnetic field readings, the maximum absolute intensity of the field can be measured without regard to the inclination or declination of the field. This type of measurement is known as a total field measurement. Proton Precession instruments, such as the GEMS system used for this survey, are total field instruments. Close to the sides of ferrous targets, strong horizontal magnetic fields are created. Over the top of ferrous targets, the magnetic field is nearly vertical with essentially no horizontal component. When making total field measurements, the horizontal fields encountered to the side of the target are not distinguished from the vertical field encountered over the top of the target. As a result, total field measurements tend to show anomalies from local targets as relatively broad features. This has an advantage in screening a site for targets between measurement points, but it has the disadvantage of not sharply delineating the limits of the target body and tends to blend separate anomalies from multiple targets into a single anomaly.

Magnetometers exist, called flux gate magnetometers, which only measure the vertical component of the magnetic field. Since flux gate magnetometers measure only the vertical magnetic field above a target, they are not affected by the horizontal fields present to the sides of a body and produce sharper anomalies which more precisely define the limits of the target. Flux gate systems are also less sensitive to artificial sources of interference, such as from large metallic surface bodies or power lines, and can be used in areas in which a proton precession instrument will not function. Due to the higher lateral resolution of the flux gate system, closer station spacings are required to screen an area, thereby increasing the required number of stations. Flux gate systems are also slower in the field, further increasing field time and survey costs.

While proton precession instruments can only measure the total field intensity, the vertical gradient of the total field can be measured by making measurements at two sensors at different elevations. These type of measurements are known as gradiometer measurements and are a physical analog of a first derivative of the total field. Gradiometer measurements reduce the sensitivity of the proton precession instrument to horizontal fields and therefore make the anomalies sharper. Gradiometer measurements can often separate out individual anomalies from the broader anomalies seen in the total field data. Since gradiometer measurements can be made simultaneously with total field measurements, a site can be surveyed with advantages of the screening ability of the total field measurements while still being able to improve the delineation of individual anomalies. Gradiometer measurements are intended to improve the resolution of the proton precession instrument, but they cannot fully reproduce the resolution or insensitivity to interference of the flux gate systems.

PRE-SURVEY MODELS

Limited pre-survey models were performed to determine the expected response from buried drums at the site. The models indicated that using the typical sensor height of 8 feet produces a magnetic anomaly of approximately 150 nano Teslas (nT) over a single vertical steel drum buried at 2 feet. The expected intensity of the anomaly decreases to 60 nT for a drum at 6 feet. The model also indicated that the intensity of the anomaly is significantly increased by reducing the sensor height. The response from a vertical drum at 2 feet increases to approximately 300 nT by lowering the sensor height to 4 feet. Lowering the sensor height brings it closer to the operator and potential sources of interference from metal carried by the operator. To increase the survey sensitivity, the operator removed potential sources of interference, such as keys, knives, metal clip boards and the survey was conducted with a sensor height of 4 feet.

DISCUSSION OF FIELD PROCEDURES

The Former Lagoon Site was gridded on 20 foot centers using a tape and compass. Heavy brush and rolling topography created some difficulties in establishing the grid. The final field grid was compared to a site map provided by CRA. In several areas the location of key landmarks shown on the site map, such as test pits and monitoring wells, did not agree with the grid coordinates. This suggests that the topographic relief and areas of dense vegetation caused errors in the grid measurements. Upon closer examination, it was not clear if the discrepancies were caused solely to errors in gridding, or if some landmarks might have been misplaced on the base map. The spacing between the grid nodes were checked and found to be consistent over most of the site. Some variations in spacing due to topography were detected and corrected. The resulting grid appeared to provide generally uniform coverage over the site although some of the discrepancies with the base map could not be resolved.

Due to the difficulties in surveying with a tape and compass in irregular terrain, a decision was made to use the existing field grid for the magnetometer survey and to have significant features properly surveyed to position them on the site map. For the purposes of this report, all locations will described relative to our grid coordinates. Grid positions were flagged every 20 feet with the coordinates labeled every 100 feet. We recommend that excavations be directed relative to the grid flags in the field and that significant features be surveyed to determine their location relative to the site map coordinates.

After the grid was completed with pin flags on 20 foot centers, the site was surveyed using a GEMS GSM-19G Proton Precession Gradiometer Memory Magnetometer with a spacing between stations and survey lines of 10 feet. A total of 2,235 stations were measured in an area which is roughly triangular in shape and is shown by Figure 1. The monitoring wells shown on Figure 1, and on all subsequent figures, are positioned relative to the grid coordinates and may not correspond to the positions shown on the site map provided by CRA. The survey area extends past the test pit sites and includes the full extent of the lagoon sites as determined by CRA. Total field and vertical gradient measurements were made at all stations.

A base station was established along the abandoned railroad bed approximately at grid location -20 North, 250 East. Readings were taken at the base station approximately every 30 minutes to 1 hour during the surveying periods. The base station measurements were used to determine the degree of diurnal drift of the magnetic field. A maximum drift of approximately 120 nT was detected. While this amount of drift is probably not significant, the data was corrected for the drift, thereby eliminating any effects from natural variations in the magnetic field intensity from the field data.

DISCUSSION OF RESULTS

Figure 2 is a plot of the corrected total magnetic field data from the survey area. Several anomalies are obvious, many of which appeared to be caused by metal objects on the surface. The most significant feature detected by the total field survey is a large anomaly extending from stations 20 to 140 North, 30 to 170 East which is noted as "Anomaly A". The magnitude of Anomaly A is approximately 3,000 nT above the average field value of approximately 55,200 nT observed on site. The magnitude of this anomaly is significantly higher than any other anomaly observed on site. Many of the other features seen on Figure 2 are reductions in the magnetic field intensity (negative anomalies) caused by surface targets, primarily portions of a metal fence.

Figure 3 is a plot of the vertical gradient data. The gradient data shows that Anomaly A is actually composed of at least two, and possibly three, distinct bodies. One body appears to be located between stations 50 to 100 North, 30 to 70 East. The second body may consist of two nearby targets. One target appears to be located between stations 80 to 110 North, 90 to 110 East, and the other body appears to be located between stations 100 to 140 North, 130 to 150 east. These anomalies do not appear to be created by individual targets, but are more likely to be caused by multiple ferrous bodied in close proximity within the limits of the area of the anomalies. Several other features are present on Figure 3, many of which can be related to surface objects.

Figure 4 is an interpreted base map showing the expected limits of the ferrous targets for the significant magnetic anomalies and the positions of the surface features which appear to be interfering with the data. Two distinct target areas are shown in the area of Anomaly A which are designated as Primary Magnetic Anomalies. These areas probably represent accumulations of buried ferrous metal targets in close proximity and within the limits of the shaded areas. Five Minor magnetic Anomalies are shown. Four of these features, centered at 200 North 300 East, 280 North 350 East, 280 North 410 East, and 280 North 460 East, are small negative anomalies of approximately 100 nT or less. These features may be a result of small, shallow ferrous targets located a few feet south of the stations or they may be caused by minor diurnal variations in the field intensity which were not adequately corrected by the diurnal corrections, or by variations in site geology, such as soil type. The feature at 200 North, 370 to 400 East is a minor increase in field intensity of approximately 150 nT which could indicate an accumulation of small, shallow ferrous targets. It is also possible that this anomaly is also due to uncorrected diurnal variations or changes in soil type.

The composition of the buried ferrous targets in the Primary Magnetic Anomalies and the Minor Magnetic Anomalies cannot be directly determined from the existing data. The anomaly patterns are complex, suggesting the presence of multiple small targets. The amplitude of the negative Minor Magnetic Anomalies suggests that they may not be significant. The amplitude of the positive Minor Magnetic Anomaly between station 200 North, 370 to 400 East suggests that this feature may represent small buried ferrous objects, probably smaller than the size of a steel drum or highly corroded. The two Primary Magnetic Anomalies probably represent significant accumulations of buried ferrous metal objects. The size of the individual targets cannot be determined, but the amplitude of the anomaly suggests that the bodies could be an accumulation of several drum sized objects or numerous smaller objects.

Figure 4 shows the position of surface features, such as the remnants of a metal fence and the monitoring wells. Many of these features have created significant magnetic anomalies, most of which are reductions in the magnetic field intensity. The negative anomalies are probably due to upward vertical components created by the elevated ferrous metal in the fence posts and other features. Since the sensor height was lowered to 4 feet to increase the sensitivity to buried targets, the effects of the elevated bodies was probably increased. Three highly corroded drums were partially exposed along the remnants of a fence at station 160 North, 480 East. The negative anomaly from the fence completely obscured the response of the drums, suggesting that other buried targets may be present which could not be detected due to interference from surface objects.

RECOMMENDATIONS

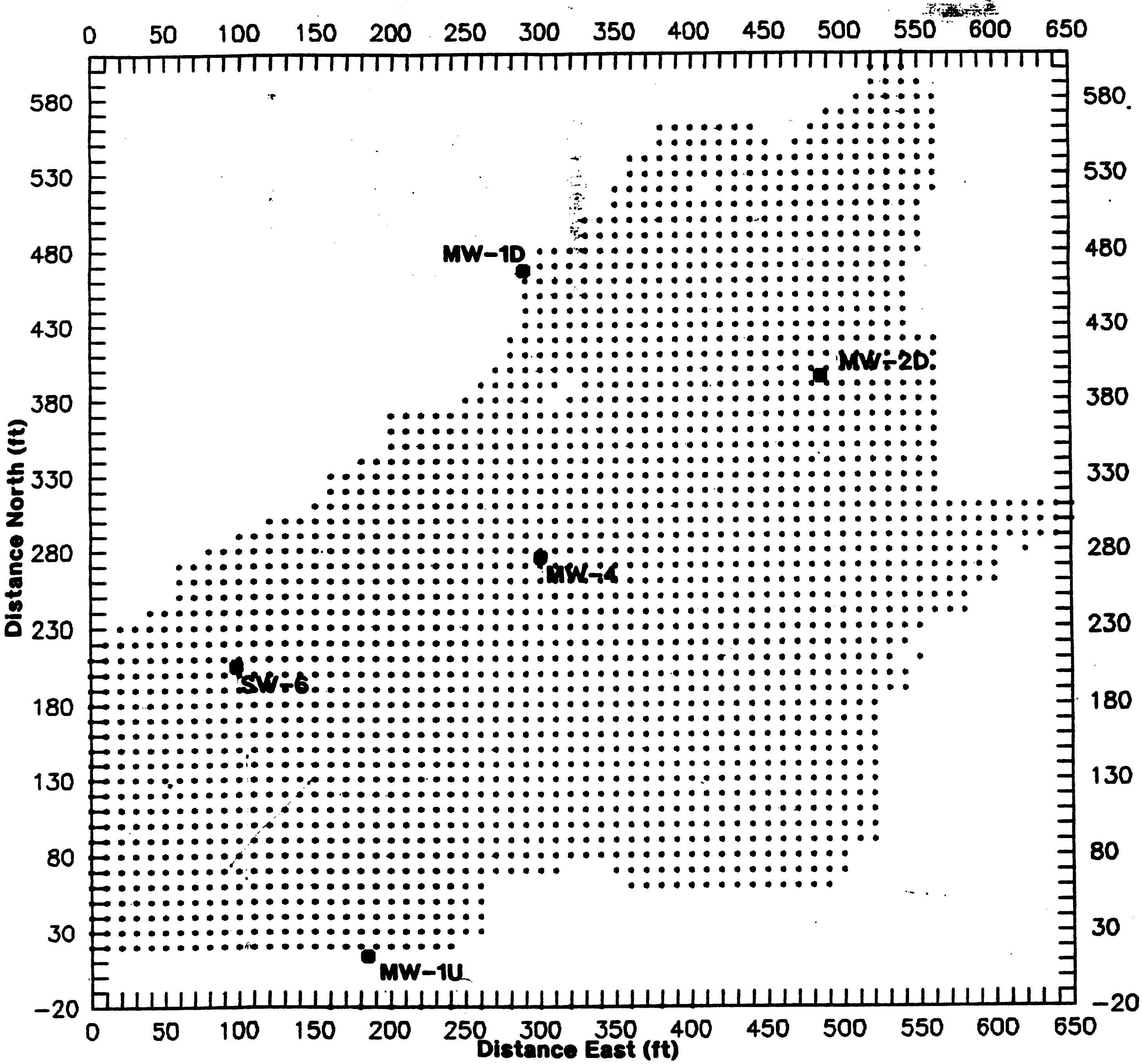
GeEx recommends that CRA conduct test pits to verify the results of our survey. The initial test pitting should concentrate on the two parts of Anomaly A shown on Figure 4. The excavations should concentrate on the center of the assumed target locations (at stations 80 North 50 East, 100 North 100 East, and 130 North 140 East) and continue outward until the edge of the accumulation of targets is found or to the edge of the anomalous area. The minor anomalies are less likely to indicate significant targets, but they should be excavated if confirmation is desired. No indications of other significant buried ferrous targets was found over the remaining portion of the site. While the remaining portion of the site appears to be free of buried ferrous targets, it is possible that highly corroded targets are present which will not produce strong anomalies or ferrous bodies may be located in areas of interference from surface features.

Respectfully submitted,

Pat Jurcek
Staff Geophysicist

John Jansen
President

FORMER LAGOON SITE SURVEY AREA



SCALE 1:100

Figure 1

0 50 100 200 300ft

North

Contour Interval = 50 nT

• **Magnetometer Station**

● **Monitoring Well**

GeEx November, 1991

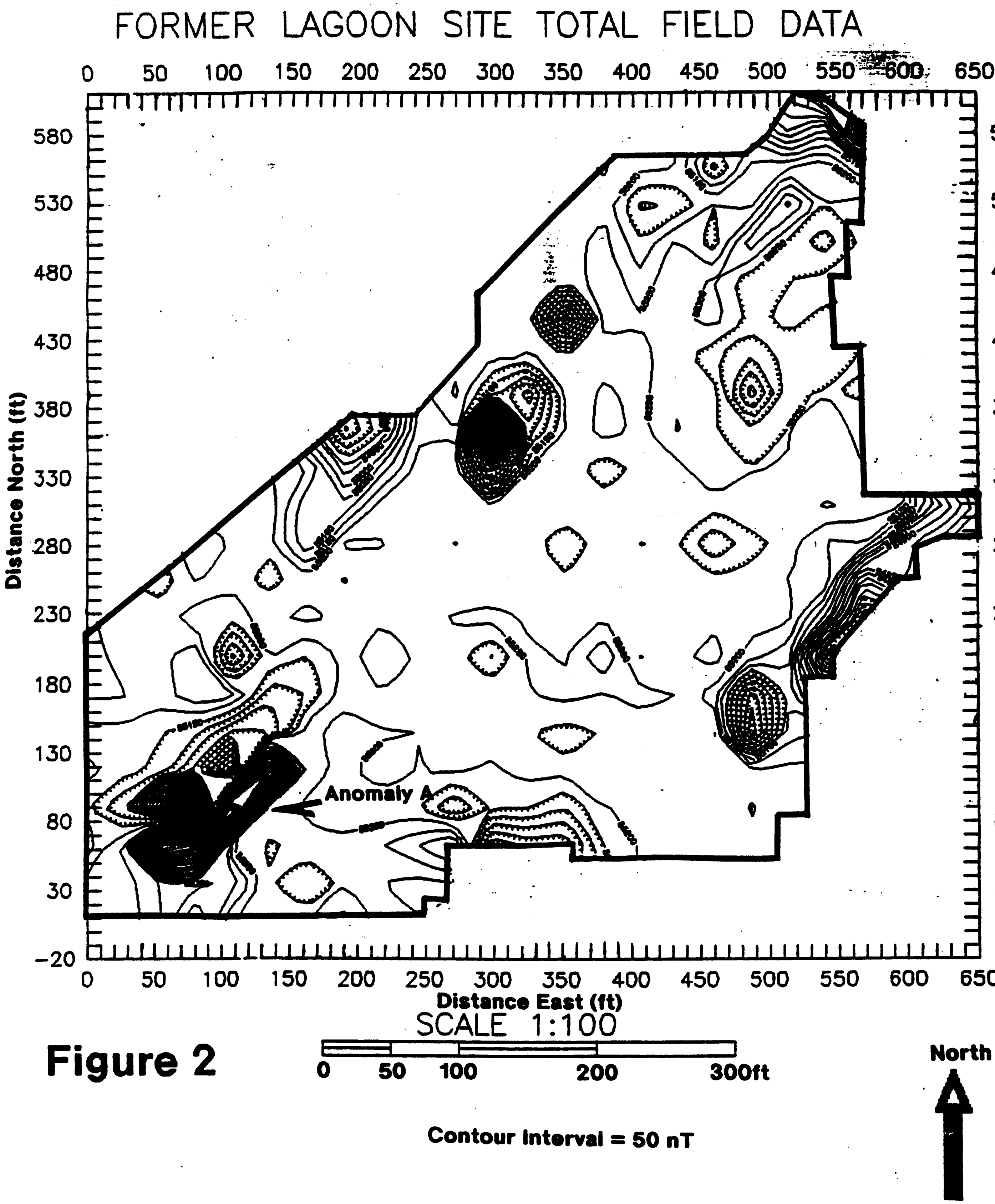


Figure 2

Contour Interval = 50 nT

GeEx November, 1991

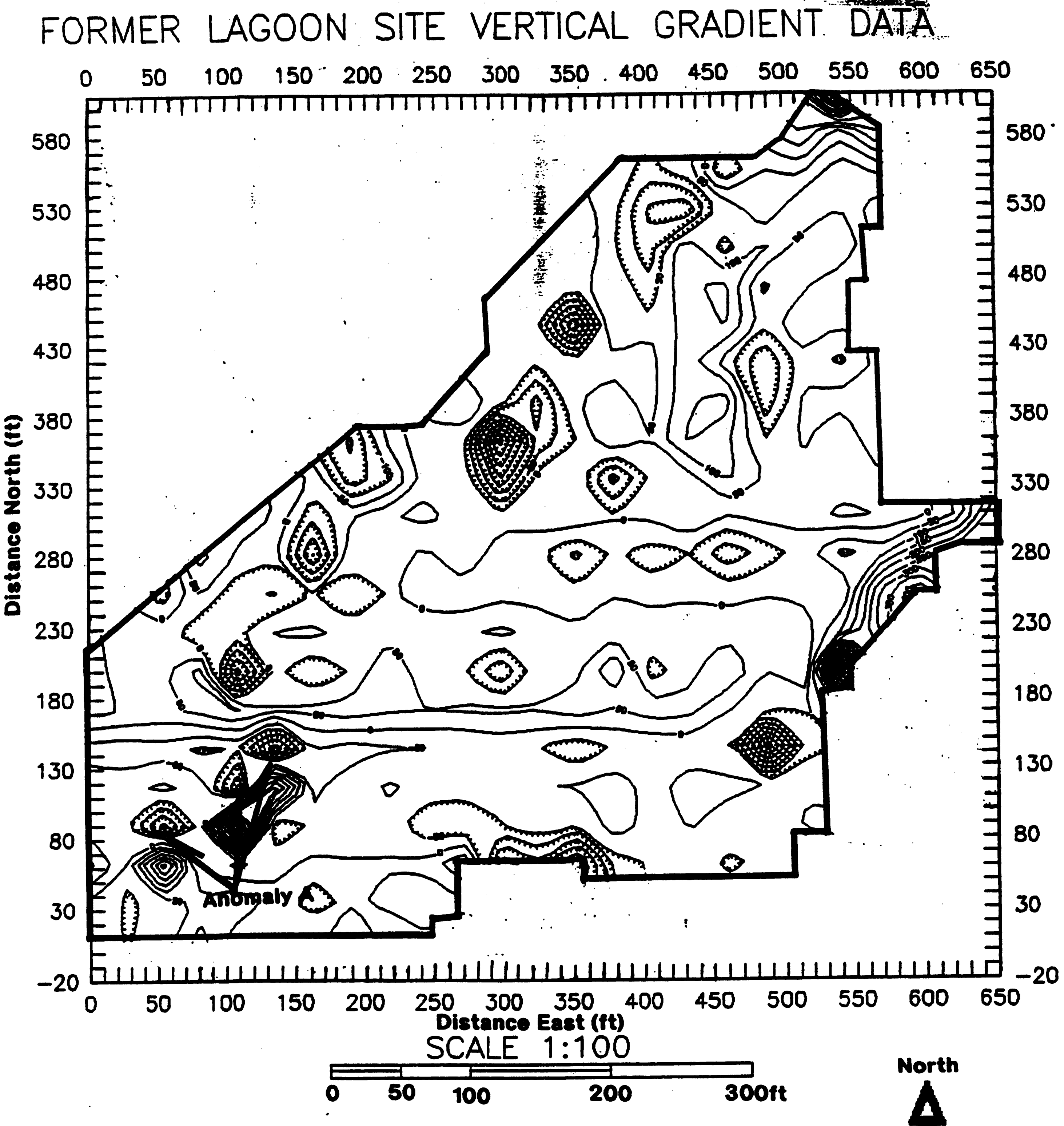


Figure 3

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FORMER LAGOON SITE INTERPRETED BASE MAP

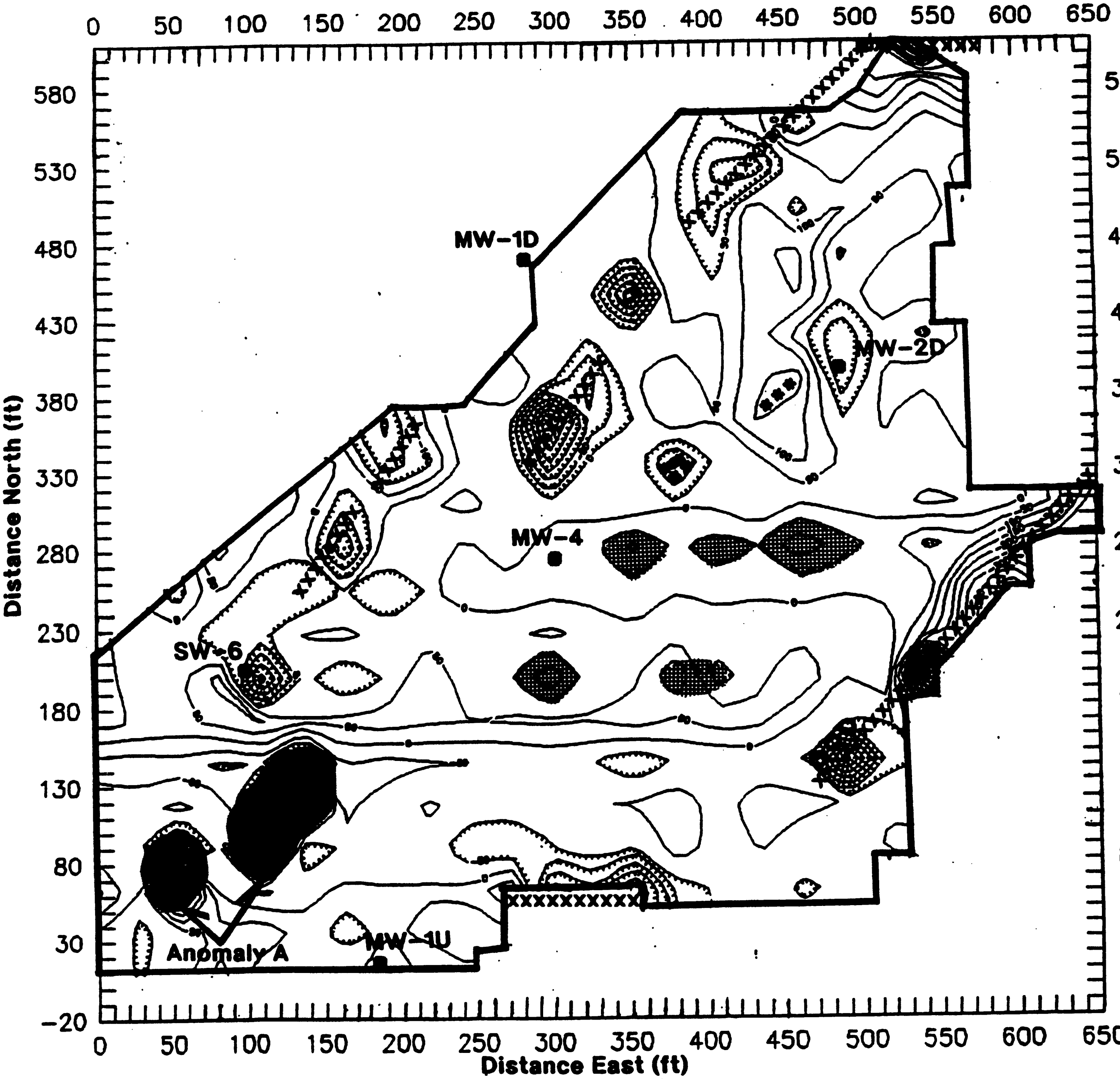

Figure 4

SCALE 1:100

0 50 100 200 300ft

■ Monitoring Well

xxx Metal Fence

O Exposed Drum

** Metal Debris on Surface

Primary Magnetic Anomaly

Minor Magnetic Anomaly

North

GeEx November, 1991

DISCLAIMER

Although the results presented in this report represent the best interpretation available to GeEx based on the existing information referenced in the report text at the time of the survey, they remain an interpretation. Geophysical exploration is a difficult field with many unknowns, subject to many interpretations. GeEx endeavors to be as precise as possible, but the nature of our work makes it impossible for us to guarantee our results. We strongly recommend to our clients that they verify our findings with borings or some other type of quantitative investigation before basing design decisions on our results. As we cannot directly verify our findings, we cannot assume any liability as to their application.