April 12, 2012

Ms. Susan Bull
Maryland Department of the Environment - Oil Control Program
1800 Washington Boulevard, Suite 620
Baltimore, Maryland 21230-1719

Re: **Work Plan for Deep Well Discrete Groundwater Sampling**
Royal Farm Store #96
500 Mechanics Valley Road, North East, Maryland 21901
Case No. 2011-0729-CE
Facility I.D. No. 13326
AEC Project No. 05-056

Dear Ms. Bull:

Advantage Environmental Consultants, LLC (AEC) has completed this work plan for testing discrete intervals of the groundwater column in the three deep wells at Royal Farms Store #96.

Introduction and Background

In March 2012 AEC subcontracted Earth Data, Inc. to provide geophysical profiling services for the three deep wells installed in February 2012. The geophysical surveys included the following parameters and methods: single-point resistance (SPR); spontaneous potential (SP); natural gamma; caliper; fluid conductivity/resistivity; fluid temperature; acoustic borehole imaging (ABI); and heat-pulse flowmeter. The purpose of the investigation was to determine the orientation of structural features (e.g. fractures, bedding planes, and foliations) and locate possible water producing fracture zones over the length of the open borehole. A copy of the Earth Data report is provided as Attachment A.

Pursuant to the results of the geophysical profiling and lithologic logging during well advancement the following characteristics were identified.

Well ID	Geophysics Secondary Porosity Depth Intervals (ft)	Drillers Logs Fracture Zone Depth Intervals (ft)	Hydraulic Characteristics (Geophysics)	Hydraulic Characteristics (potentiometric surface analysis)	Well Depth (ft)
MW-10D (CE-10-0216)	75-80 80.5-85 85-90 174-177	95-96 130-131 190-191	No vertical flow	Downward vertical flow	201 feet
MW-12D (CE-10-0217)	63-75 84-97 127-154	110-111	No vertical flow	Downward vertical flow	160 feet
MW-13D (CE-10-0215)	56-66 119-131 140-142	65-66 125-130	Downward vertical flow	Downward vertical flow	180 feet

The secondary porosity findings were based on the correlation of fluid conductivity, fluid temperature, caliper, and acoustic televiewer logs. The fracture zone findings were based on drill stem penetration rate which is a more subjective approach to determining where these features are present. As a result, the geophysical logs provide more confidence concerning the actual locations of the features and will be used to place the discrete samplers. A cross section illustrating the locations of the secondary porosity zones is provided in Attachment B. Also shown on this figure are the selected discrete sample locations.

Sampling Means and Methods

The selected method for discrete sample collection is the HydraSleeve no-purge (passive) grab sampling device which is a proprietary sample collection technology. The HydraSleeve causes no drawdown in the well (until the sample is withdrawn from the water column) and only minimal disturbance of the water column, because it has a very thin cross section and it displaces very little water (<100 ml) during deployment in the well. The HydraSleeve collects a sample from within the borehole only, and it excludes water from any other part of the water column in the well through the use of a self-sealing check valve at the top of the sampler. A copy of the Hydrasleeve Standard Operating Procedures is provided as Attachment C.

The use of no-purge sampling as a means of collecting representative ground-water samples depends on the natural movement of ground water (under ambient hydraulic head) from the formation adjacent to the well screen through the screen. Robin and Gillham (1987) demonstrated the existence of a dynamic equilibrium between the water in a formation and the water in a well screen installed in that formation, which results in formation-quality water being available in the well screen for sampling at all times. No-purge sampling devices like the HydraSleeve collect this formation-quality water as the sample, under undisturbed (non-pumping) natural flow conditions. Samples collected in this manner generally provide more conservative (i.e., higher concentration) values than samples collected using well-volume purging, and values equivalent to samples collected using low-flow purging and sampling (Parsons, 2005). The above mentioned references are provided in Attachment D.

The cross section shows the discrete sample locations which were based on the following criteria: vertically profile all secondary porosity zones identified by the geophysical survey; collect samples from the three identified lithologic variations (i.e., sand and gravel unit, silty sandy clay unit and the top of the bedrock unit); and, collect samples from the associated shallow wells (MW-13, MW-10 and MW-12).

Prior to installation of the sample gear, groundwater levels within each well associated with testing effort will be measured using an electronic water level indicator accurate to 0.01 feet (Solinst Model 122 or equivalent). Sample bottles for VOCs will be filled so that there will be no headspace or air bubbles within the container and placed in a cooler on ice pending laboratory analysis. The analytical laboratory will provide pre-preserved sample containers where appropriate. Sample labels will be firmly attached to the container side, and the following information will be legibly and indelibly written on the labels: facility name; sample identification; sampling date and time; preservatives added; and, sample collector's initials. After the samples are sealed and labeled, they will be packaged for transport to the analytical laboratory.

The groundwater monitoring wells will be analyzed for VOCs including fuel oxygenates per EPA Analytical Method 8260, as well as total petroleum hydrocarbon (TPH) diesel range organics (DRO) and TPH gasoline range organics (GRO) per USEPA Analytical Method 8015B.

All well sampling and gauging equipment will be disassembled (if appropriate) and properly cleaned and calibrated (if required) prior to use in the field. All portions of the sampling and test equipment that contact the sample will be thoroughly cleaned with a Liquinox (phosphate-free laboratory-grade) bath and triple rinse of potable water before initial use and between each sampling point. In addition, a clean pair of new, disposable nitrile gloves will be worn each time a different well is gauged and sampled.

If you have any question regarding this information, or if we can be of further assistance, please contact AEC at (301) 766-0500.

Sincerely,

ADVANTAGE ENVIRONMENTAL CONSULTANTS, LLC

Jeffery S. Stein
Project Manager

Attachments

ATTACHMENT A

ROYAL FARMS NO. 96
500 MECHANICS VALLEY ROAD
NORTH EAST, MARYLAND

ANALYSIS OF
BOREHOLE GEOPHYSICAL
SURVEYS CONDUCTED
MARCH 7-8, 2012

Prepared For:

Advantage Environmental Consultants, LLC.
8610 Washington Blvd, Suite 217
Jessup, MD 20794

Prepared By:

Earth Data Incorporated
131 Comet Drive
Centreville, MD 21617
(410) 758-8160
www.earthdatainc.com

W.O. 4396

TABLE OF CONTENTS

Page No.

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Location

Earth Data Incorporated (EDI) of Centreville, Maryland, working as a subcontractor to Advantage Environmental Consultants, LLC. (AEC) of Jessup, Maryland, recently completed borehole geophysical surveys in three (3) monitoring wells at the Royal Farms Station No. 96 located at 500 Mechanics Valley Road, North East, Maryland 21901. Figure 1 is a map showing the project site and the location of the three wells.

The three monitoring wells were all constructed with 6-inch diameter steel casing set through overburden and into bedrock. Below the casing the wells were completed with open boreholes. The approximate construction features of the three wells, based on the geophysical surveys and reported information, are summarized as follows:

Well Name	Casing Diameter (in.)	Casing Material	Casing Depth (ft.)	Well Total Depth (ft.)
MW-10-D	6	Steel	61.0	198
MW-12-D	6	Steel	59.0	160
MW-13-D	6	Steel	59.0	180.5

1.2 Site Geology

The site is located in the vicinity of the contact between the Atlantic Coastal Plain and the Piedmont Plateau Physiographic Provinces. Surface materials are mapped by Higgins and Conant (1986) as the unconsolidated sediments of the Potomac Group. Higgins and Conant (1986) describe the bedrock underlying the Potomac Group in the vicinity of the site as either the Principio Furnace Member or the Frenchtown Member of the James Run Formation. Higgins and Conant (1990) describe these metamorphic rocks to consist of intermediate to felsic metavolcanics that are gray and light-gray to grayish-white in color. The Principio Furnace Member of the James Run Formation typically consists of light-gray granofels containing phenocrysts of plagioclase, green amphibole, and quartz, alternating with beds of gray biotite bearing gneiss.

1.3 Scope of Work

Earth Data Incorporated performed borehole geophysical surveys in the three (3) monitoring wells during March 7-8, 2012. The geophysical surveys included the following parameters and methods: single-point resistance (SPR); spontaneous potential (SP); natural gamma; caliper; fluid conductivity/resistivity; fluid temperature; acoustic borehole imaging (ABI); and heat-pulse flowmeter. The purpose of the investigation was to determine the orientation of structural features (e.g. fractures, bedding planes, and foliations) and locate possible water producing fracture zones over the length of the open borehole. This report presents the findings of the geophysical surveys.

2.0 GEOPHYSICAL PARAMETER DESCRIPTIONS

Vertical borehole geophysical surveys provide a measure of the physical properties of the borehole, the borehole fluid, and/or the formation(s) penetrated by the borehole during drilling. Geophysical logs, alone and together with other well information, can help determine geologic and hydrogeologic information pertaining to a borehole and the formation(s) penetrated.

Both individual and multi-parameter wireline geophysical logging tools are lowered into each well. For most geophysical techniques the specific data associated with each logging tool is typically collected continuously along the vertical depth of the borehole. For continuity all footages provided in this report are referenced from top of the steel well casings (feet btoc). Since the monitoring wells are all finished within flush mounted well vaults the top of casings are set slightly below ground surface.

2.1 Electric Log

Data for the electric log is collected using a multi-electrode tool that measures parameters relating to the flow of electrical currents within the borehole and surrounding material. Due to the nature of this tool only fluid filled (water or drilling-fluid) portions of the borehole can be logged. Parameters of the tool used include single-point resistance (SPR), and spontaneous potential (SP). A brief description of each electric log parameter is provided below.

2.1.1 Single-Point Resistance (SPR)

The single-point resistance (SPR) tool measures the apparent formation resistance in ohms. The logging equipment consists of two electrodes, one located in the borehole and one grounded at the surface. Current flow in some formations can be attributed to conductive mineral and the surface condition on clay particles. The amount of water present in the formation and the dissolved constituents in the water will also affect the electric current flow pattern. As a result the effective porosity of a formation and the interstitial fluid salinity has the greatest affect on the resistance. Typically, in sedimentary rocks a formation with high clay content will have a low resistance. However, in crystalline rocks more transmissive zones may display lower resistivity.

2.1.2 <u>Spontaneous-Potential (SP)</u>

The spontaneous-potential (SP) log reveals the electric potential or voltage differences that can develop at the contacts between dissimilar lithologic units, which are penetrated by the borehole, and occasionally at fractures in rock wells where groundwater is flowing. The measured unit of the SP log is millivolts (mv). Logging equipment is the same as for the SPR log. Spontaneous potential sources in a borehole include electrochemical, electro-kinetic/streaming, and oxidation-reduction potentials. Electrochemical effects are probably the most significant source factors, which can be subdivided into membrane and liquid-junction potentials. Both of these effects are the result of the migration of ions from a concentrated solution to a dilute solution. The migration of the ions and their detection is mostly affected by clay or shale, which decreases negative ion (anion) mobility.

2.2 Natural Gamma

Natural gamma logs are one of the most widely used geophysical logs in groundwater applications. The primary use of the gamma log is to identify changes in lithology and to determine the relative amounts of clay in various sedimentary lithologic units. The measured unit of the natural gamma log is counts per second (cps). The natural gamma photons detected by the gamma log survey will penetrate plastic and steel well casing and screens. As such natural gamma surveys can be completed inside wells or hollow stem augers. However, the casing and/or screen material may subdue the received signal. Upon exiting the screen/casing material the response of the log will typically show an increase in the natural gamma radiation that is detected.

2.3 Caliper (3-Arm)

The caliper log records average borehole diameter. The caliper log shows changes in borehole diameter that are related to well construction such as the depth of the well casing or the location of a screened interval. In addition, the caliper log is useful in determining the location of potential fracture zones in open bedrock wells. Three spring-loaded feeler arms act in conjunction with each other to calculate the average diameter of the borehole. The caliper logs are collected by first calibrating the tool at the surface using measuring templates. The caliper tool is then lowered into the borehole to the desired depth and the feeler arms are remotely opened. The borehole is then logged in an upward direction.

2.4 Fluid Conductivity/Resistivity

The fluid conductivity log records borehole fluid electrolytic measurements in micosiemens/centimeter (μs/cm). In general, water with a lower concentration of total dissolved solids (TDS) will result in a lower fluid conductivity value than water with higher amounts of total dissolved solids. Since water quality can influence the fluid conductivity, if enough information is known about the particular contaminants in a well some conclusions may be drawn from the fluid conductivity log. Fluid conductivity logs may also indicate changes in borehole fluid when water-producing fractures or formations are transmitting fluid of contrasting composition into or out of the borehole. Fluid conductivity is the reciprocal of fluid resistivity. The fluid conductivity log is generally the first parameter to be measured and is collected simultaneously with the temperature log.

2.5 Fluid Temperature

The fluid temperature (reported in degrees Celsius) log provides a measurement of the temperature of the surrounding air, water, or formation in the borehole. Abrupt changes in the slope of the temperature log may indicate where water of differing temperatures and/or quality is entering or exiting the borehole.

2.6 Acoustic Televiewer

The acoustic televiewer, also known as an acoustic borehole imager (ABI) is similar to a borehole television survey in that a 360° image of the borehole is produced. Instead of being dependent on light, the acoustic televiewer produces an image with a focused beam of ultrasound. The tool can only provide data in the fluid filled portion of a borehole. The tool registers both the amplitude and the delay in transit of the reflected signal (travel time). Borehole conditions such as reflectivity of the surrounding rock and borehole size can affect the quality of the final product. The acoustic televiewer provides some

The acoustic televiewer printout displays information obtained from the survey of the radius of the entire borehole. Starting on the left hand side of the page, the output graphic shows the borehole televiewer amplitude log as an "unwrapped core" shown North to North. The N 45° - N225° graphics show the apparent angle through the borehole as viewed from a position rotated clockwise 45 degrees. The tadpole plot shows the feature angle (0-90°) and direction of dip. A "tadpole" indicating features are placed at the dip angle of the feature with the tail will pointing in the direction of dip. The comments field lists the dip azimuth (trend) and dip (plunge) degree of the feature.

A continuously recording magnetometer is a component of the ABI tool and measures the orientation and inclination of features in the borehole. The received signals are presented as an unwrapped 360° image referenced to magnetic North. Under normal borehole conditions, using the magnetic declination of the site, dip azimuth (trend) and dip (plunge) of the borehole features (fractures, bedding planes, etc.) may be obtained. All data displayed on the geophysical logs presented in this report have been adjusted to True North from the 11.67° W magnetic declination in the vicinity of the North East, Maryland site. The data displayed has also been corrected from apparent dip to true dip based on ABI inclination data.

2.7 Heat-Pulse Flowmeter

The heat-pulse flowmeter is a stationary tool that is placed at pre-selected locations within the borehole to measure the vertical flow, if any, at the given location. The tool measures flow velocity and indicates direction (up or down). The depths to measure vertical flow in the borehole are usually based on the results of previously conducted caliper, fluid temperature and/or fluid conductivity surveys. Heat pulse flowmeter depths may also be chosen at fixed intervals to provide a flow profile of the entire borehole. The heat-pulse flow meter is designed for relatively low flow rates (between the ranges of 0.03 to 1.0 gallons per minute). Values less than 0.03 gpm are considered to be equivalent to non-detectable flow.

The heat-pulse flowmeter consists of a hollow cylinder containing a horizontal wire grid-heating element and thermistors located at a fixed distance above and below the grid. As the heat-pulse flow meter is "fired" an electrical current is sent through the high resistance wire grid. The heated borehole fluid migrates with the borehole flow upward or downward toward one of the thermistors. The tool is equipped with an auto-nulling facility to cancel any offset in thermistor characteristics and return the log trace to a fixed position prior to firing.

Heat-pulse flowmeter results are presented in graphical format along with fluid conductivity, fluid temperature, and caliper logs. During data collection a graph displays the temperature differential in counts per second (cps) between the two thermistors plotted against time (in seconds). Based on the interpretation point selected by the operator, the operating software calculates the fluid speed. The average of the tests conducted at each test depth is represented on the log print-out. Heat-pulse flow data represents vertical flow within the borehole; therefore, on the log print-out, a negative flow left of center represents downward movement of flow and the inverse response represents upward flow movement.

3.0 RESULTS OF BOREHOLE GEOPHYSICAL LOGGING

3.1 General Description

The findings of the geophysical surveys conducted in each individual well at the Royal Farms site are summarized below. Copies of the geophysical logs are provided in the appendices. The interpretation of the borehole geophysical data is focused primarily on determining zones of secondary porosity (i.e. open fractures) in each well. Secondary porosity analyses are based on fluid conductivity, fluid temperature, caliper, and acoustic televiewer logs, as well as heat-pulse flow meter data. Features identified with the acoustic televiewer are presented in table a format.

3.2 Specific Wells

3.2.1 Monitoring Well MW-10-D

Copies of the geophysical logs (caliper, fluid temperature, fluid conductivity, natural gamma, electric, acoustic televiewer, and heat-pulse flowmeter data) for monitoring well MW-10-D are found in Appendix A. The total depth (TD) of the well was observed to be approximately 198 feet below the top of casing (toc) during the surveys. The top of casing is set at approximately 0.85 feet below grade within a flush-mounted well-head completion. This well is constructed with 6-inch diameter steel casing set to a depth of approximately 61.0 feet btoc. The open borehole interval is from 61.0 feet to approximately 198 feet. At the time of the survey the depth-to-water level in the well was 13.47 feet btoc.

A decrease in natural gamma is noted at depth intervals between approximately 78 and 80 feet; 95 and 105 feet; and 169 and 186 feet. The normal resistivity log shows an area of increased resistivity from approximately 100 feet to 138 feet, and 175 to 198 feet. The log displays a decreased resistivity that correlates with an inflection in the caliper log at a depth of 76 feet and at 175 ft btoc.

The fluid temperature log displays a slight increasing water temperature from the static water level (SWL) at 13.5 feet to a depth of approximately 110 feet. There is a very slight increasing trend in fluid conductivity from 171 feet to approximately TD at 198 feet.

The acoustic televiewer log for MW-10-D was analyzed and 47 features were identified. More features may exist than were identified. The majority of the features identified are high-angle (greater than 45° from horizontal) fractures and foliation planes that dip toward the southeast. Table 1A lists the characteristics for each feature. Characterization of the features was aided by ALT WellCAD version 4.3 software provided by the tool manufacturer. The features for MW-10-D are summarized in the following table: (Strike azimuth is based on the "right hand rule").

Table 1A- Acoustic Televiewer Features For MW-10-D

Depth			**Feature**		
Average (feet)	**Upper (feet)**	**Lower (feet)**	**Strike Azimuth (0-360°)**	**Dip Azimuth (0-360°)**	**Dip Angle (° from hor.)**
63.5	63.3	63.7	96	186	37
66.0	65.7	66.2	97	187	42
68.0	67.7	68.3	101	191	51
75.3	74.9	75.8	23	113	63
77.0	76.6	77.3	32	122	51
78.8	78.3	79.3	51	141	64
80.0	79.7	80.3	164	254	49
81.7	80.9	82.4	43	133	72
84.2	80.3	88.1	67	157	86
88.7	88.3	89.2	126	216	59
90.0	89.8	90.2	132	222	43
91.4	91.0	91.7	134	224	54
93.6	93.1	94.0	128	218	63
94.4	94.2	94.5	340	70	36
95.9	95.5	96.4	205	295	62
97.6	97.4	97.8	147	237	44
100.4	100.1	100.8	27	117	55
101.3	100.9	101.6	57	147	57
103.2	102.9	103.4	198	288	46
108.1	105.7	110.6	4	94	84
112.1	111.6	112.5	25	115	63

Depth			Feature		
Average (feet)	Upper (feet)	Lower (feet)	Strike Azimuth (0-360°)	Dip Azimuth (0-360°)	Dip Angle (° from hor.)
114.5	114.1	115.0	45	135	61
124.9	124.5	125.3	62	152	56
129.1	128.6	129.5	121	211	61
132.0	131.5	132.5	141	231	65
135.6	135.2	135.9	134	224	54
138.8	138.3	139.2	64	154	61
140.7	139.8	141.7	132	222	75
144.4	144.2	144.6	158	248	38
146.9	146.4	147.4	125	215	63
149.6	149.3	149.8	135	225	41
150.9	150.5	151.2	97	187	55
151.8	151.4	152.2	62	152	57
156.1	155.6	156.6	29	119	62
157.2	156.4	157.9	21	111	71
159.2	158.0	160.4	23	113	78
163.4	162.9	163.8	34	124	62
166.7	165.0	168.4	32	122	82
174.8	174.4	175.2	2	92	58
180.8	180.4	181.3	115	205	61
185.6	185.2	186.0	9	99	56
187.2	187.1	187.3	21	111	29
188.8	188.5	189.1	34	124	48
189.5	189.1	189.8	44	134	54
191.0	190.6	191.5	12	102	62
192.2	191.8	192.6	38	128	58
193.0	192.6	193.5	57	147	62

Correlation of the fluid conductivity, fluid temperature, caliper, and acoustic televiewer logs indicates likely areas of secondary porosity at the following approximate depths: between 75 and 80 feet; 80.5 feet and 85 feet; 85 feet and 90 feet; 174 and 177 feet.

Two zones were selected for the heat-pulse flowmeter survey at depths where the tool's flow diverter petals would make a good seal along the borehole wall. Based on other logs the heat-pulse flowmeter survey was conducted at depths of 74.5 feet; 91.25 feet; 172 feet; and 178 feet in this well. The results indicate no vertical flow or flow was below the operating limits of the tool. Table 1B presents a summary of the averaged results.

Table 1B- Well MW-10-D Heat-Pulse Flowmeter Summary Table

Depth Feet btoc	Flow Rate Gal./min.	Flow Direction
74.5	0.01	n/a
91.25	0.02	n/a
172	0.01	n/a
178	0.01	n/a

3.2.2 Monitoring Well MW-12-D

Copies of the geophysical logs for monitoring well MW-12-D are found in Appendix B. The total depth (TD) of the well was observed to be approximately 160 feet btoc during the surveys. This well is constructed with 6-inch diameter steel well casing set to a depth of approximately 59 feet btoc. The top of the casing is set at approximately 0.5 feet below grade within a flush-mount installation. The open borehole interval is from 59.0 feet to approximately 160 feet. At the time of the survey the depth-to-water level in the well was 26.47 feet btoc.

A decrease in natural gamma is noted at a depth of 93 feet and 150 feet. The SPR log displays a decreased resistivity that correlates with an inflection in the caliper log at a depth of 70 feet; 83 feet; and 143 feet. The SPR log shows an area of increased resistivity at a depth of approximately 93 feet and 150 feet, which correlates with an inflection on the gamma log.

The fluid temperature log displays a decreasing trend from 60 feet to 132 feet. An inflection in the fluid conductivity is observed at 64 feet; 84 feet; 96 feet; 126 feet, and 145 feet correlating with inflections on the caliper and temperature logs. A slight increasing trend is observed from 132 feet to approximately 152 feet.

The acoustic televiewer log produced for MW-12-D was analyzed and 27 features were identified. There may be features that exist than were not identified. The majority of the features appear to be high-angle (greater than 45° from horizontal) fractures and foliation planes that dip toward the southeast. The features for MW-12-D are summarized in the following table: (Strike azimuth is based on the "right hand rule").

Table 2A- Acoustic Televiewer Features For MW-12-D

Depth			Feature		
Average (feet)	**Upper (feet)**	**Lower (feet)**	**Strike Azimuth (0-360°)**	**Dip Azimuth (0-360°)**	**Dip Angle (° from hor.)**
64.2	63.9	64.6	109	199	55
70.5	70.2	70.9	21	111	53
73.5	73.0	73.9	46	136	63
75.5	75.0	75.9	185	275	61
76.5	76.2	76.7	201	291	48
77.4	76.7	78.1	185	275	70
81.7	81.6	81.8	134	224	25
84.9	84.6	85.1	29	119	43
90.0	89.4	90.6	47	137	67
92.1	91.6	92.6	348	78	62
94.4	94.1	94.7	3	93	48
98.7	98.3	99.0	157	247	55
104.2	104.0	104.3	132	222	32
109.0	108.6	109.4	53	143	56
112.5	112.1	112.9	182	272	55
116.7	116.5	116.9	14	104	42
120.6	120.2	120.9	168	258	54
122.1	121.7	122.5	72	162	58
123.5	123.1	123.9	45	135	58
125.6	125.3	125.9	36	126	50
126.6	126.4	126.9	31	121	44
133.5	133.1	133.9	246	336	59
136.6	136.3	136.9	36	126	53
143.0	142.8	143.2	45	135	41
146.8	146.8	146.9	44	134	16
150.9	150.7	151.2	46	136	45
156.2	155.6	156.7	145	235	64

Correlation of the fluid conductivity, fluid temperature, caliper, and acoustic televiewer logs indicates likely zones of secondary porosity at the following approximate depths: between 63 and 75 feet; 84 feet and 97 feet; 127 and 154 feet.

Three zones were identified for heat-pulse flowmeter investigation. The depths were selected in the field based on the fluid temperature, fluid conductivity, and caliper logs. The heat pulse tool was set at locations slightly above and below each zone where the tool's flow diverter petals would make a good seal along the borehole wall. The heat-pulse flowmeter survey was conducted at depths of 60 feet; 76 feet; 83 feet; 96 feet; 126 feet; and 155 feet in this well. The results indicate no vertical flow or flow below the operating limits of the tool. Table 2B presents a summary of the averaged results.

Table 2B- Well MW-12-D Heat-Pulse Flowmeter Summary Table

Depth feet btoc	Flow Rate Gal./min.	Flow Direction
60.00	0.01	n/a
76.00	0.01	n/a
83.00	0.01	n/a
96.00	0.01	n/a
126.00	0.01	n/a
155.00	0.01	n/a

3.2.3 Monitoring Well MW-13-D

Copies of the geophysical logs for monitoring well MW-13-D are found in Appendix C. The total depth (TD) of the well was observed to be approximately 180.5 feet btoc. This well is constructed with 6-inch diameter steel well casing set to a depth of approximately 59 feet btoc and completed with flush mount installation. The top of the well casing is 0.35 feet below grade. The borehole is open from 59.0 feet to approximately 180.5 feet. At the time of the survey the depth-to-water level in the well was 19.18 feet btoc.

Small inflections in the natural gamma log are noted at depth intervals between approximately 62 to 68 feet; as well as 118 to 124 feet, which correlate with inflections in the caliper log. A large decreased inflection in the gamma log is noted at a depth interval between 154 and 168 feet. The SPR log shows an area of decreased resistivity from approximately 112 feet to 124 feet and 154 to 168 feet.

The fluid temperature log displays slightly decreasing water temperature from the static water level (SWL) at 19 feet to a depth of approximately 180 feet. The fluid conductivity log displays a slight decreasing trend from 60 feet to a depth of 150 feet. A sharp increase in the fluid conductivity is observed at 154 feet, correlating with an inflection in the gamma and SPR logs.

The acoustic televiewer survey in MW-13-D was analyzed and 27 features were identified. More features may exist than were identified. The majority of the features identified are high-angle (greater than 45° from horizontal) fractures and foliation planes that dip toward the southeast. A fracture zone identified on the caliper log at 121 feet and at 126 feet is seen by dark areas on the acoustic log. However, planar features within this zone were not discernable for azimuth and dip analysis. The features for MW-13-D are summarized in the following table: (Strike azimuth is based on the "right hand rule").

Table 3A- Acoustic Televiewer Features For MW-13-D

Depth			Feature		
Average (feet)	**Upper (feet)**	**Lower (feet)**	**Strike Azimuth (0-360°)**	**Dip Azimuth (0-360°)**	**Dip Angle (° from hor.)**
61.6	61.4	61.8	206	296	41
62.8	62.6	63.1	246	336	45
69.0	68.8	69.2	335	65	42
72.4	72.2	72.6	15	105	33
74.0	73.7	74.2	12	102	44
78.4	78.2	78.6	55	145	34
80.0	79.7	80.3	45	135	52
89.1	88.8	89.4	49	139	51
93.1	92.7	93.4	59	149	56
97.0	96.5	97.5	18	108	64
99.9	99.5	100.3	38	128	58

Depth			Feature		
Average (feet)	Upper (feet)	Lower (feet)	Strike Azimuth (0-360°)	Dip Azimuth (0-360°)	Dip Angle (° from hor.)
100.9	100.5	101.2	36	126	52
101.7	101.2	102.2	37	127	64
104.9	104.5	105.3	39	129	58
106.1	105.7	106.5	42	132	59
107.7	107.3	108.1	37	127	59
131.5	131.2	131.8	48	138	49
133.4	133.0	133.8	104	194	59
134.3	133.9	134.7	107	197	61
140.9	140.6	141.2	359	89	51
148.0	147.4	148.7	132	222	69
152.9	152.4	153.4	2	92	65
154.3	154.1	154.5	10	100	43
155.2	155.0	155.5	10	100	46
166.5	166.2	166.8	15	105	54
167.5	167.2	167.8	3	93	52
174.8	174.4	175.1	38	128	57

Correlation of the fluid conductivity, fluid temperature, caliper, and acoustic televiewer logs indicates likely areas of secondary porosity at the following approximate depths: between 56 and 66 feet; 119 and 131 feet; and 140 feet and 142 feet.

Three zones were selected for the heat pulse flowmeter survey. The heat pulse tool was set at locations slightly above and below each zone as described previously. The heat-pulse flowmeter survey was set at depths of 55 feet; 59 feet; 67 feet; 118 feet; 132 feet; 139 feet; and 143 feet in this well. Down-flow was detected at depths of 59 feet and 67 feet with flow rates ranging -0.45 to -0.62 gpm. Down-flow was also detected at the top of the second zone at 118 feet with an average flow rate of -0.50 gpm. At the depths of 132, 139.5 and 143 feet, no flow was detected or the flow was below the operating limits of the tool. Table 2B presents a summary of the averaged results.

Table 3B- Well MW-13-D Heat-Pulse Flowmeter Summary Table

Depth feet btoc	Flow Rate Gal./min.	Flow Direction
55.0	0.01	n/a
59.0	-0.45	Down
67.0	-0.62	Down
118.0	-0.50	Down
132.0	0.01	n/a
139.5	0.01	n/a
143.0	0.01	n/a

4.0 LIMITATIONS

The findings and conclusions presented in this report are the result of fieldwork, data analysis, and interpretations completed by Earth Data Incorporated as of this date. This report was prepared in response to a request from Advantage Environmental Consultants, LLC., and was prepared using generally accepted borehole geophysical practices for the exclusive use of AEC. No other warranty, expressed or implied, is made.

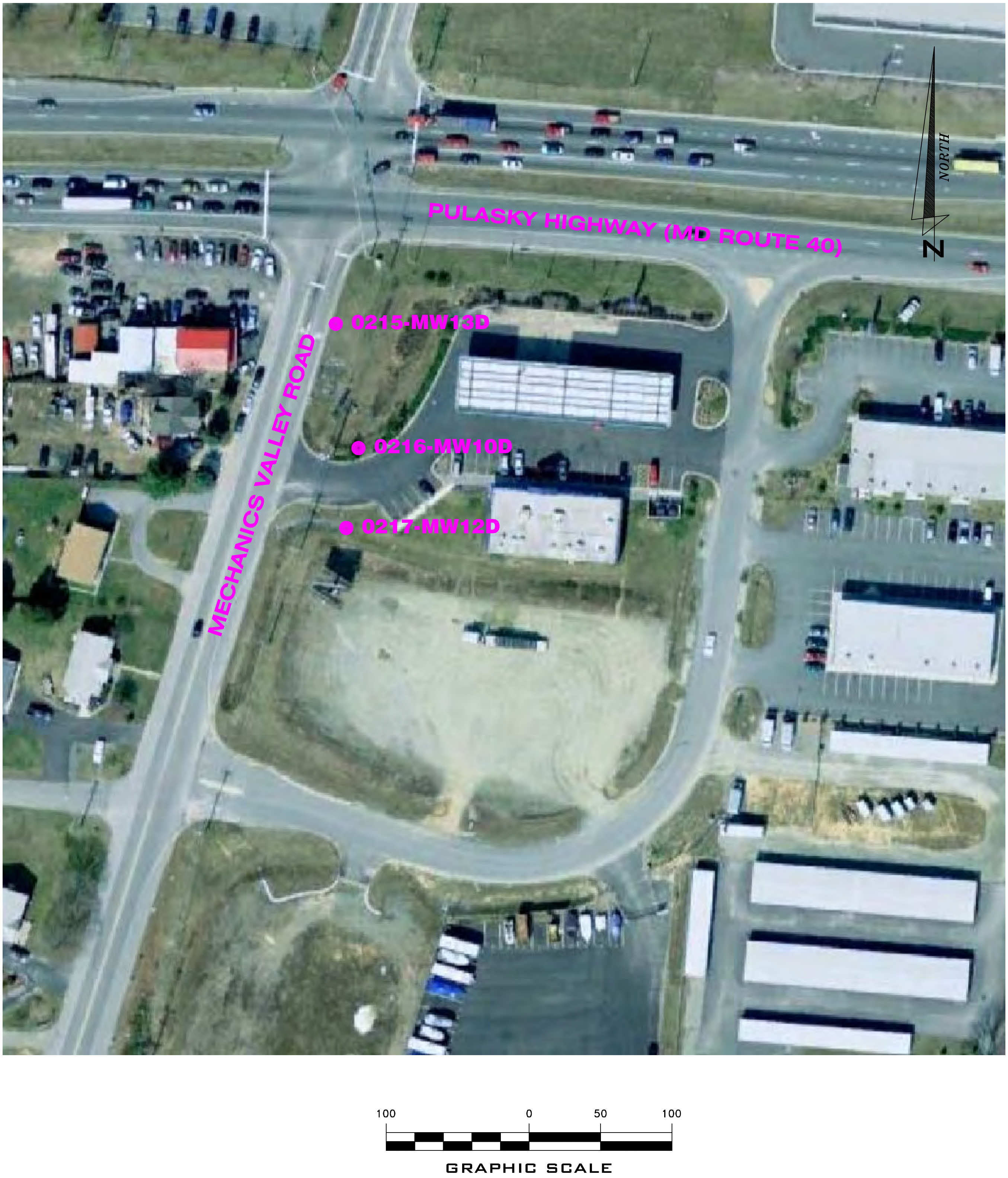
5.0 REFERENCES CITED

Cleaves, E. T., Edwards, J. Jr., and Glaser, J. D., 1968, Geologic Map of Maryland: Baltimore, Maryland, Maryland Geological Survey, scale 1:250,000.

Higgins, M. W., and Conant L. B., 1986, Geologic Map of Cecil County: Maryland Geological Survey Map, scale 1:62,500

Higgins, M. W., and Conant L.B., 1990, The geology of Cecil County, Maryland: Maryland Geological Survey Bulletin 37, 183 P.

FIGURES



J:_Job_Directories\current\4396_royal farms_northeast, md\CADD\FIGURES 4396.dwg

Earth Data INCORPORATED

GROUNDWATER & ENVIRONMENTAL CONSULTANTS

131 COMET DRIVE
CENTREVILLE, MARYLAND 21617
TEL. 410.758.8160 / FAX 410.758.8168
www.earthdatainc.com

FIGURE 1

SITE MAP
FOR
ROYAL FARMS STORE #96
NORTH EAST, CECIL COUNTY, MARYLAND

PROJ. MGR.:	T.MOORSHEAD
DATE:	03/22/2012
SCALE:	AS SHOWN
EDI #:	4396
DRAWN BY:	T.COCHRUN

Figure 1 – Map showing location of monitoring wells at Royal Farms store #96. Image from Google Earth, US Geological Survey dated 1/31/2008.

APPENDICES

APPENDIX A

MW-10-D
Geophysical Logs

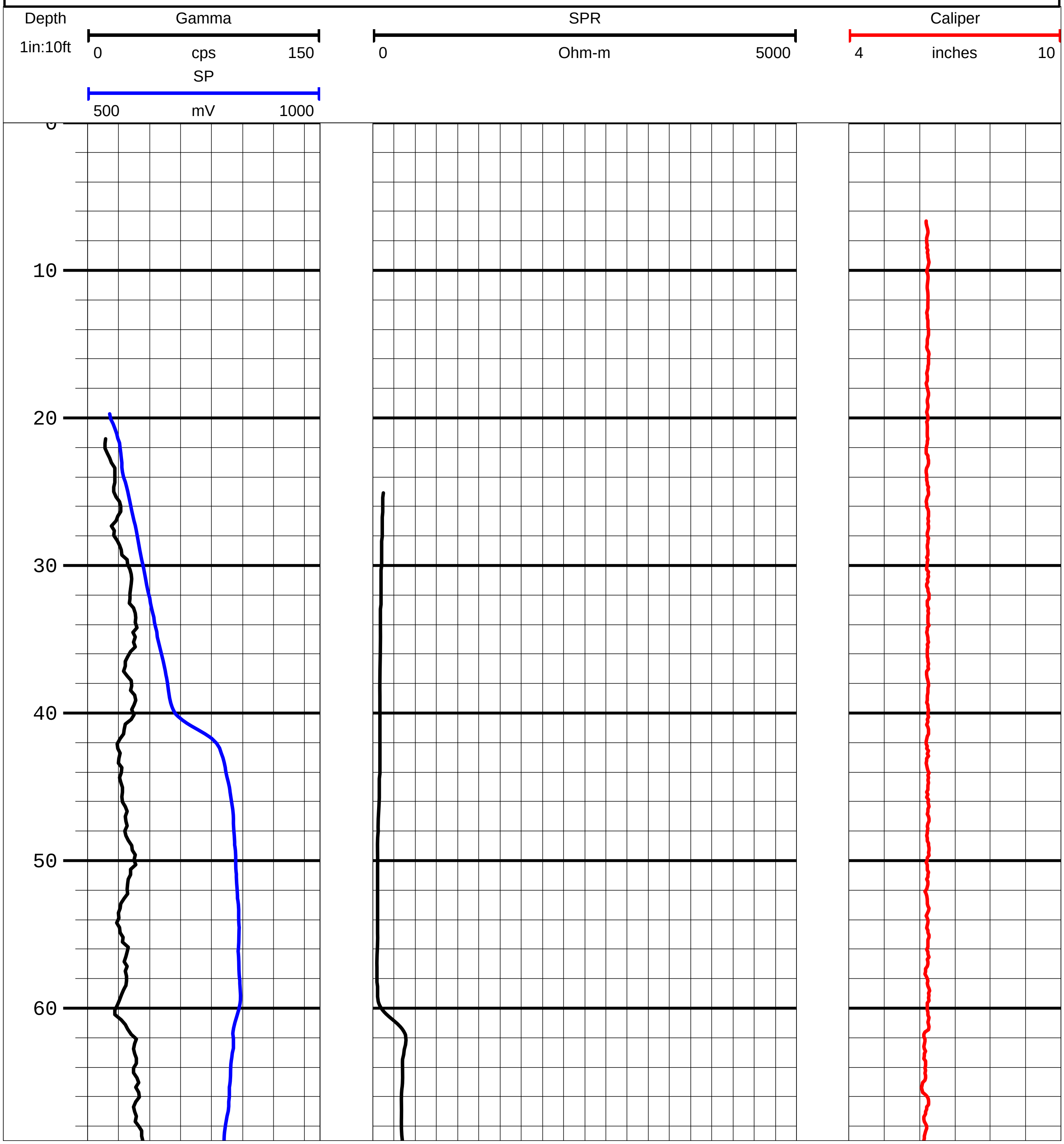
Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

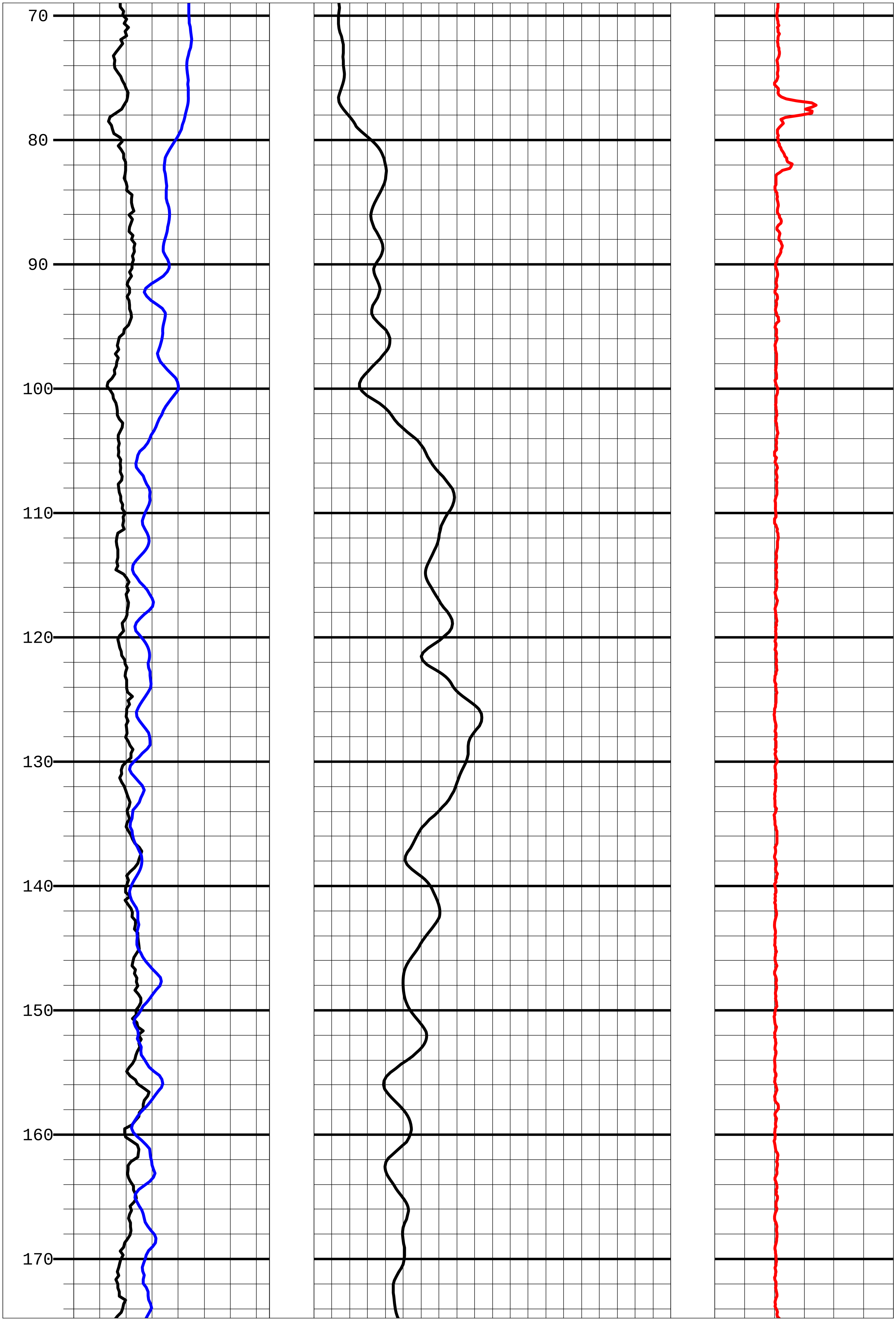
WELL I.D. MW-10-D

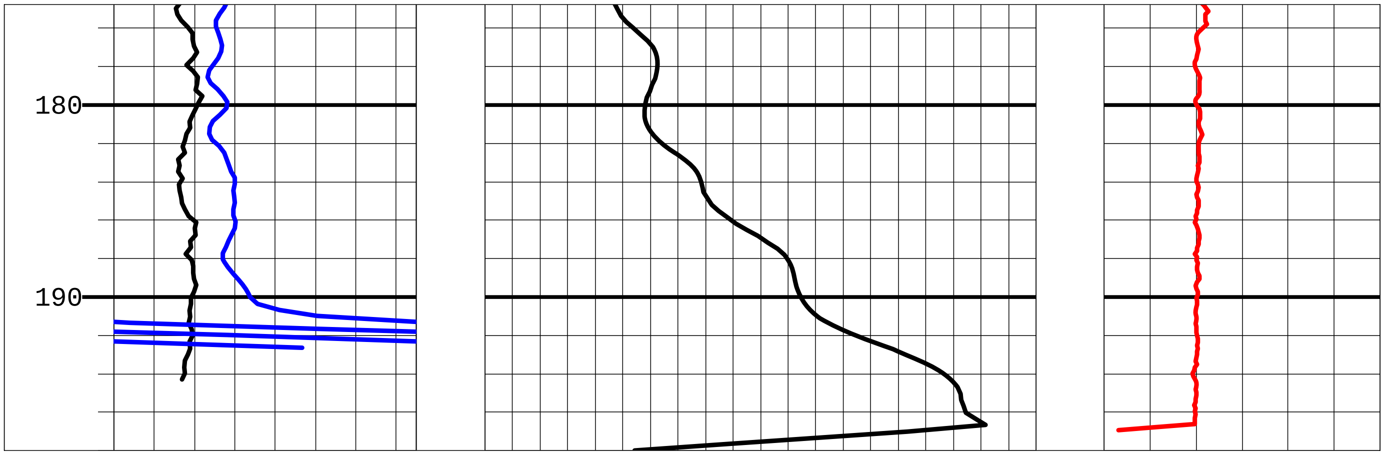
Logging Date: 3-7-2012
Logging Speed: 17 ft/min x Up Down
BOC: 61 ft btoc TD: 198 ft btoc

Project:	Royal Farms 96	Bit Size:		EDI Job No.:	4396
Client:	Advantage Environmental Consultants, LLC.	Fluid Type:	Ground Water	Technician:	M. Williams
		LAT:	39.61162° N		
Location:	North East, Cecil Co., MD	LONG:	075.93212° W	Witness:	J. Sheidy
		Casing Material:	Steel		

Notes: Depth referenced from top of casing at 0.85 ft below grade.
Static water level measured at 13.47 ft btoc.




70
80
90
100
110
120
130
140
150
160
170


180
190

Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

WELL I.D.
MW-10-D

Logging Date: *3-7-2012*
Logging Speed: *17 ft/min* x Up x Down
BOC: *61 ft btoc* TD: *198 ft btoc*

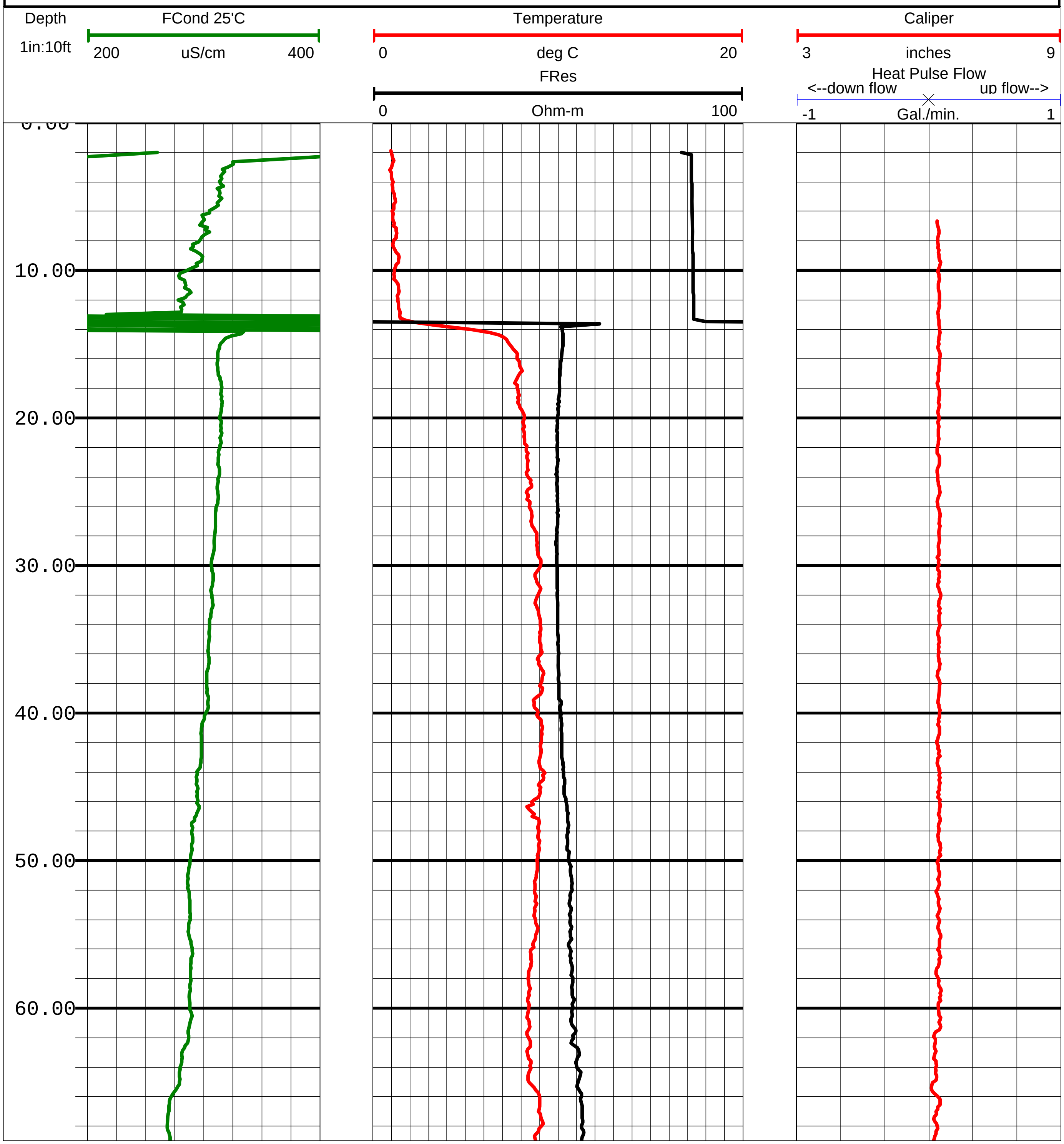
Project: *Royal Farms 96*
Bit Size:
EDI Job No.: *4396*

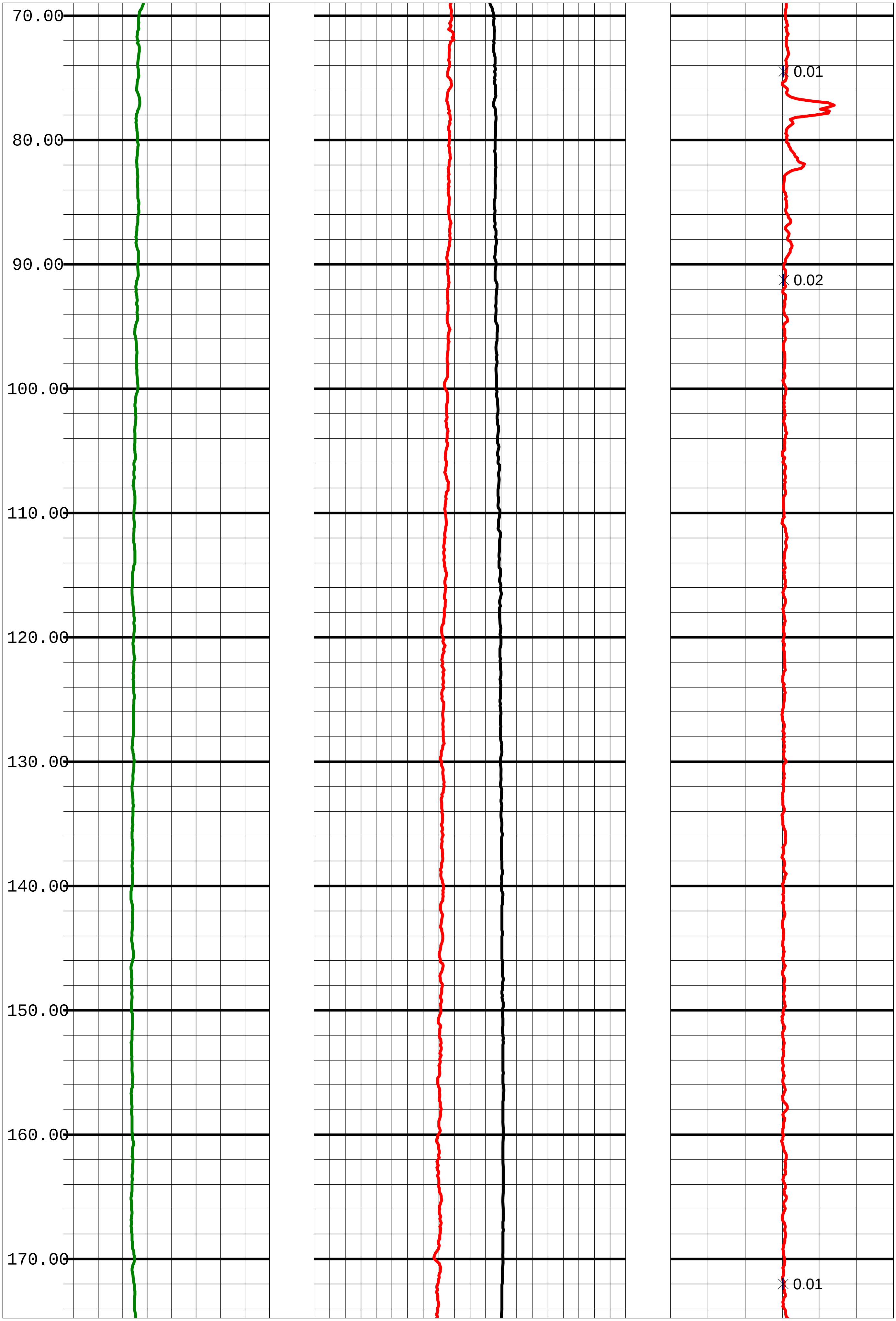
Client: *Advantage Environmental Consultants, LLC.*
Fluid Type: *ground water*
Technician: *M. Williams*

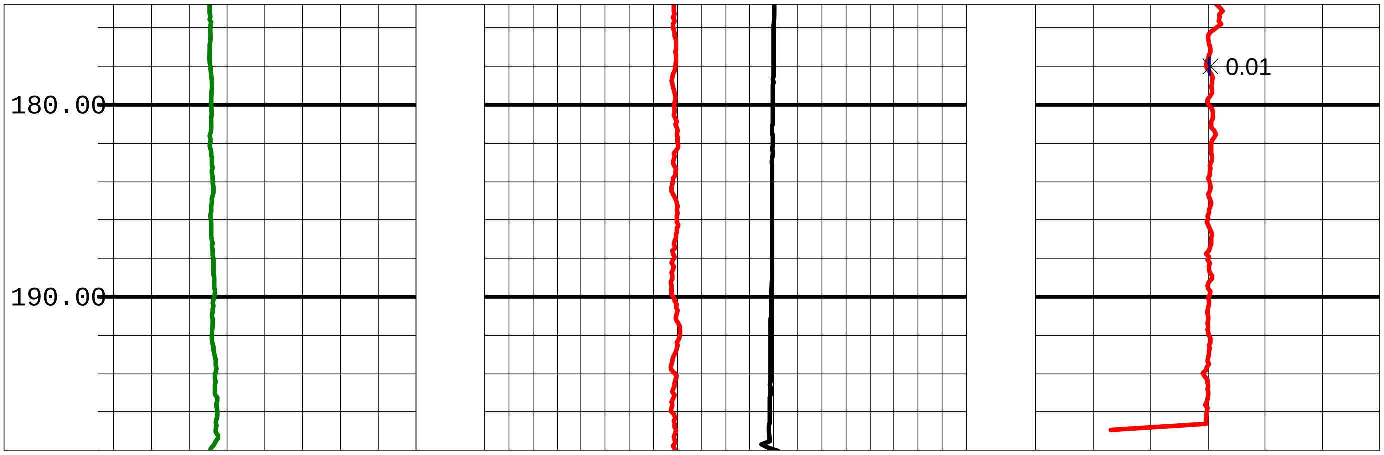
LAT: *39.61162° N*

Location: *North East, Cecil Co., MD*
LONG: *075.93212° W*
Casing Material: *Steel*
Witness: *J.Sheidy*

Notes: *Depth referenced from top of casing at 0.85 ft below grade.*
Static water level measured at 13.47 ft btoc.




70.00
0.01
80.00
90.00
0.02
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
0.01


180.00
190.00
0.01

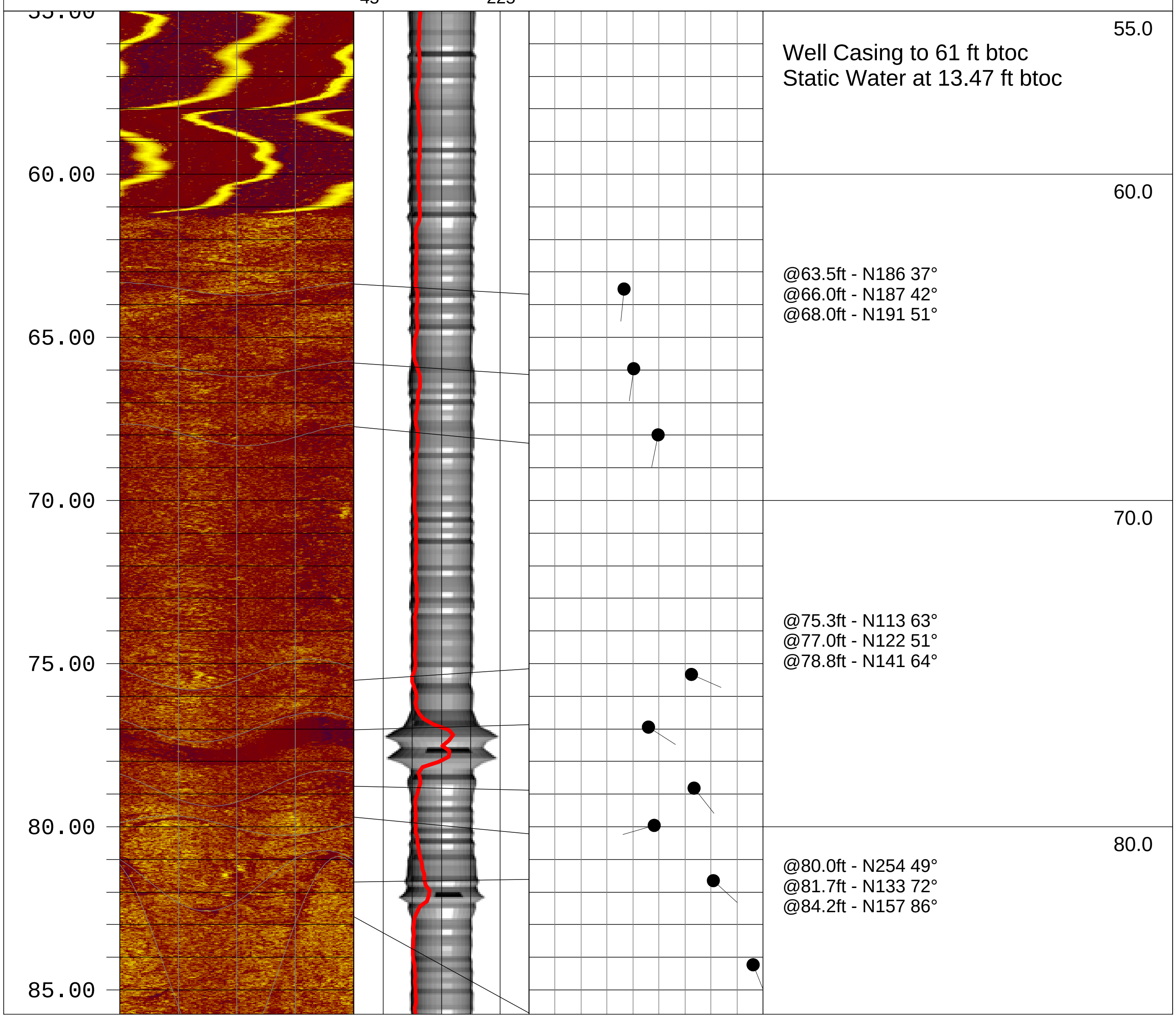
Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

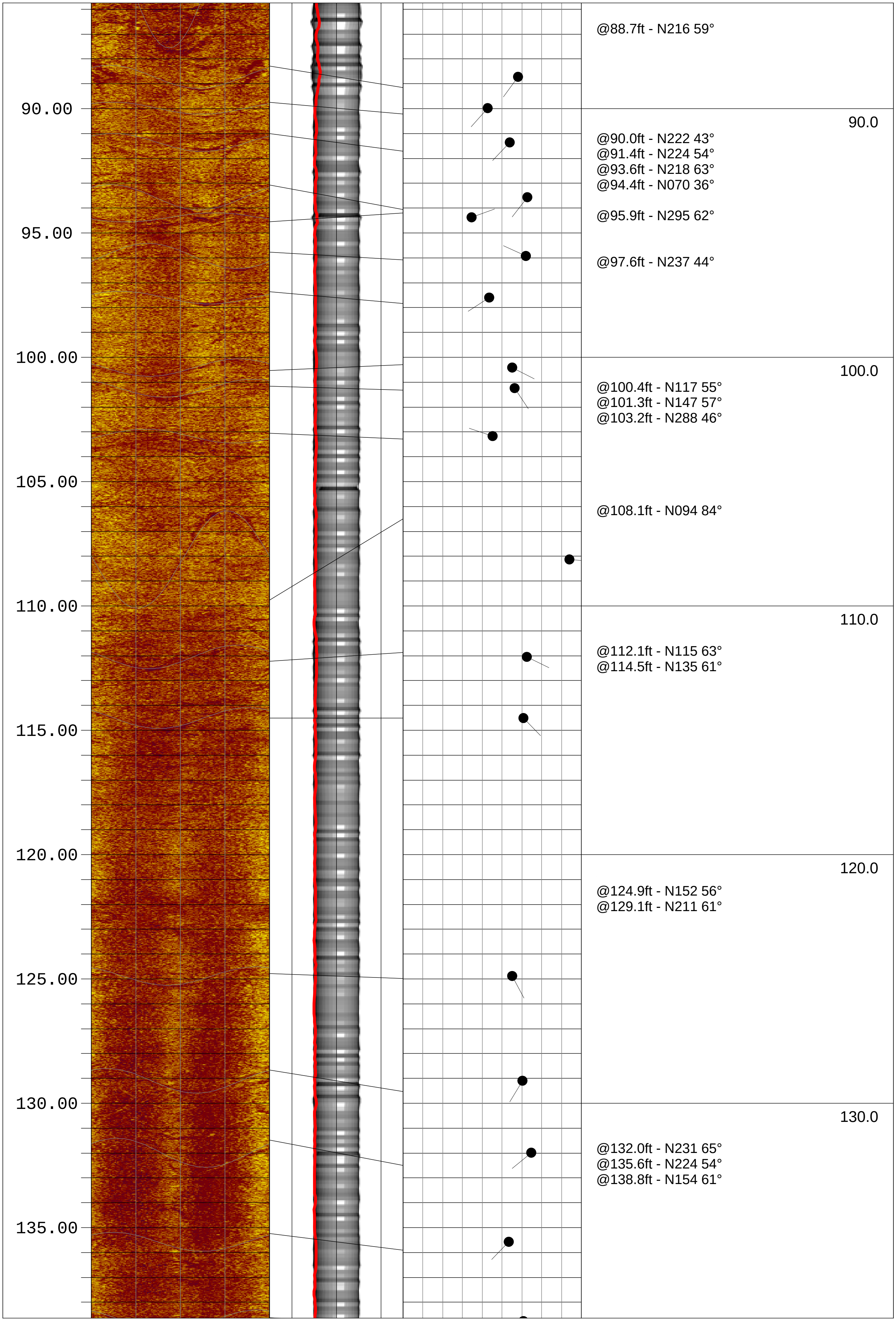
WELL I.D.	Logging Date:	3-7-2012		
MW-10-D	Logging Speed:	5 ft/min.	x Up	Down
	BOC:	61 ft btoc	TD:	198 ft btoc

Project:	Royal Farms 96	Borehole Diameter:	6 inch	EDI Job No.:	4396
Client:	Advantage Environmental Consultants, LLC.	Fluid Type:	ground water	Technician:	M. Williams
Location:	North East, Cecil Co., MD	Casing Material:	Steel	Witness:	J. Sheidy
Dip Azimuth:	True North	Dip Angle:	Corrected For Deviation	GPS:	

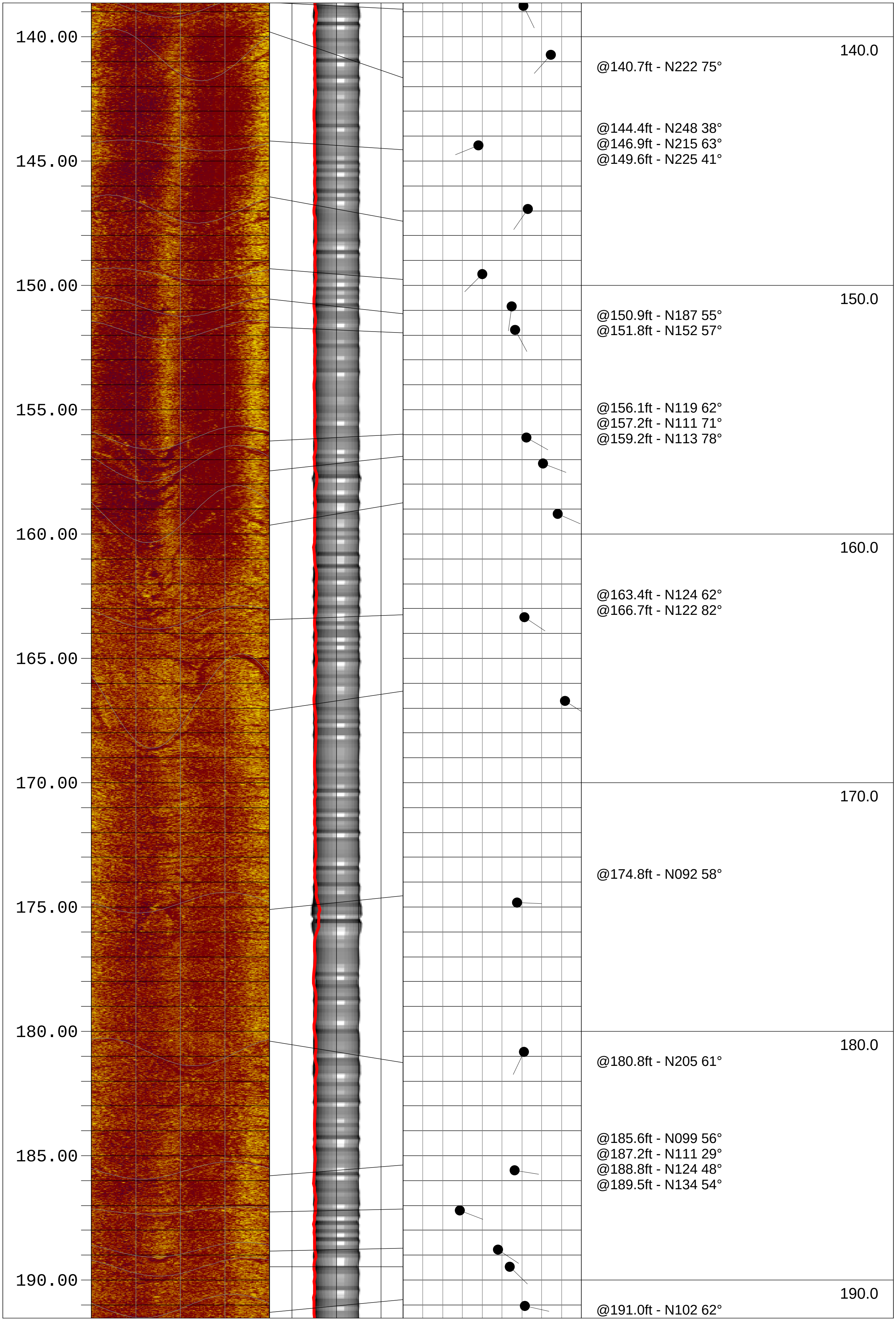
Notes: *Depth referenced from top of casing at 0.85 ft below grade.*
Static water level measured at 13.47 ft btoc.

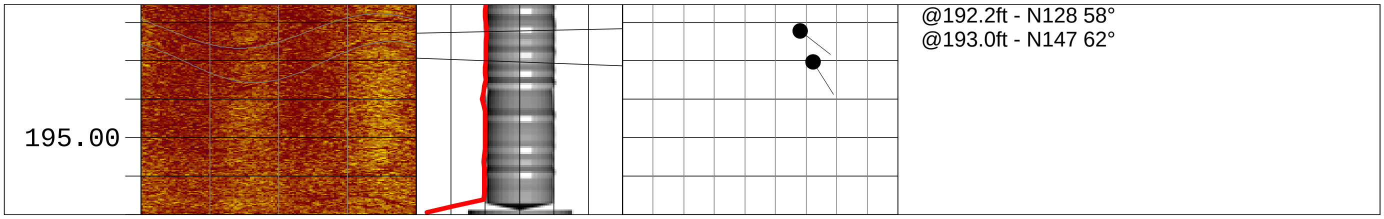
Depth	Amplitude1-NM	Caliper	Tadpole Plot	Comments
1in:5ft	0° 90° 180° 270° 0°	4 inches 10	0 90	
	Structure Trace	3D-Caliper		
	0° 90° 180° 270° 0°	0°		
		Core Trace Projection		
		45° 225°		





90.00
95.00
100.00
105.00
110.00
115.00
120.00
125.00
130.00
135.00
@88.7ft - N216 59°
90.0
@90.0ft - N222 43°
@91.4ft - N224 54°
@93.6ft - N218 63°
@94.4ft - N070 36°
@95.9ft - N295 62°
@97.6ft - N237 44°
100.0
@100.4ft - N117 55°
@101.3ft - N147 57°
@103.2ft - N288 46°
@108.1ft - N094 84°
110.0
@112.1ft - N115 63°
@114.5ft - N135 61°
120.0
@124.9ft - N152 56°
@129.1ft - N211 61°
130.0
@132.0ft - N231 65°
@135.6ft - N224 54°
@138.8ft - N154 61°


140.00
145.00
150.00
155.00
160.00
165.00
170.00
175.00
180.00
185.00
190.00
140.0
@140.7ft - N222 75°
@144.4ft - N248 38°
@146.9ft - N215 63°
@149.6ft - N225 41°
150.0
@150.9ft - N187 55°
@151.8ft - N152 57°
@156.1ft - N119 62°
@157.2ft - N111 71°
@159.2ft - N113 78°
160.0
@163.4ft - N124 62°
@166.7ft - N122 82°
170.0
@174.8ft - N092 58°
180.0
@180.8ft - N205 61°
@185.6ft - N099 56°
@187.2ft - N111 29°
@188.8ft - N124 48°
@189.5ft - N134 54°
190.0
@191.0ft - N102 62°


195.00
@192.2ft - N128 58°
@193.0ft - N147 62°

APPENDIX B

MW-12-D
Geophysical Logs

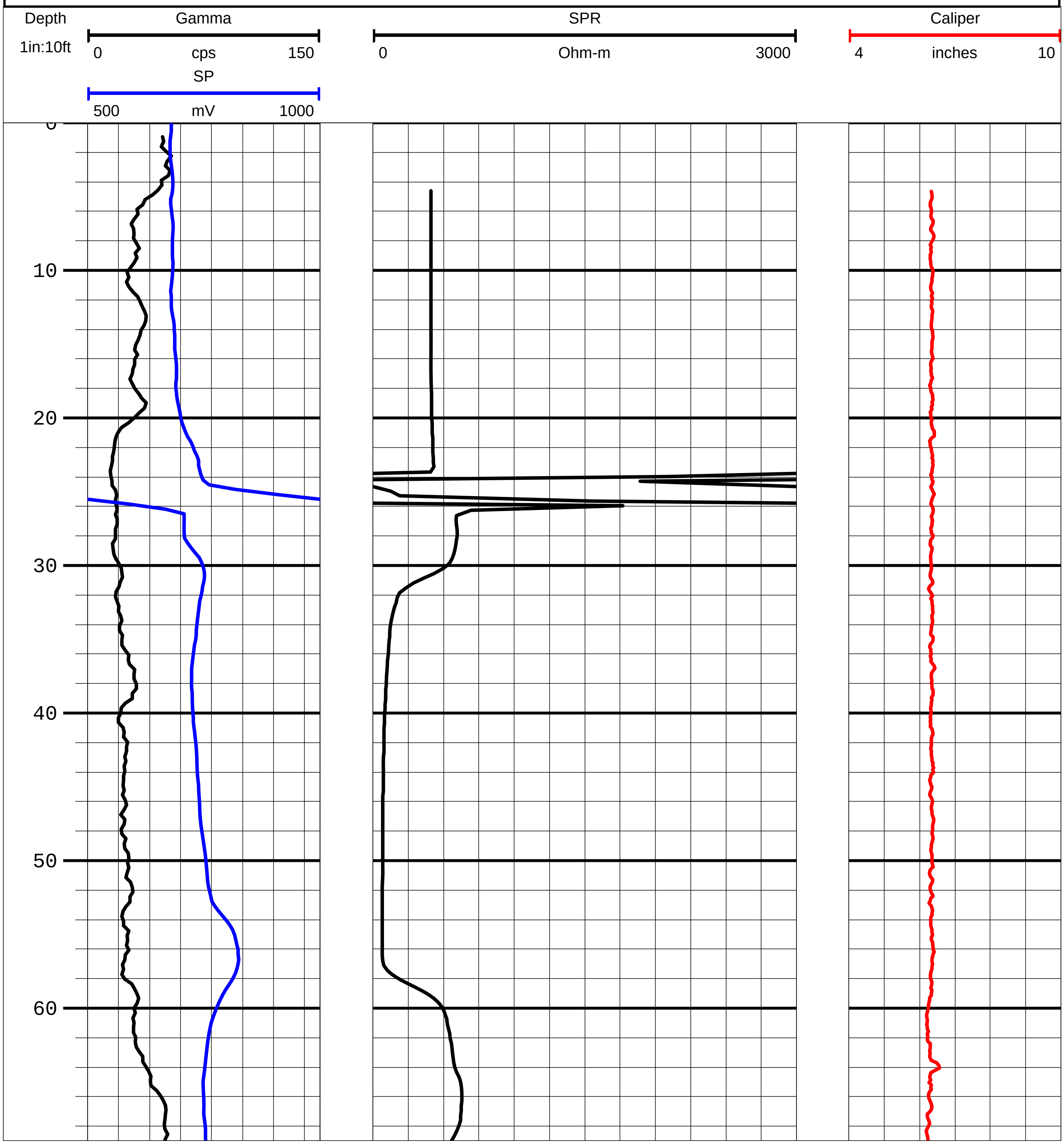
Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

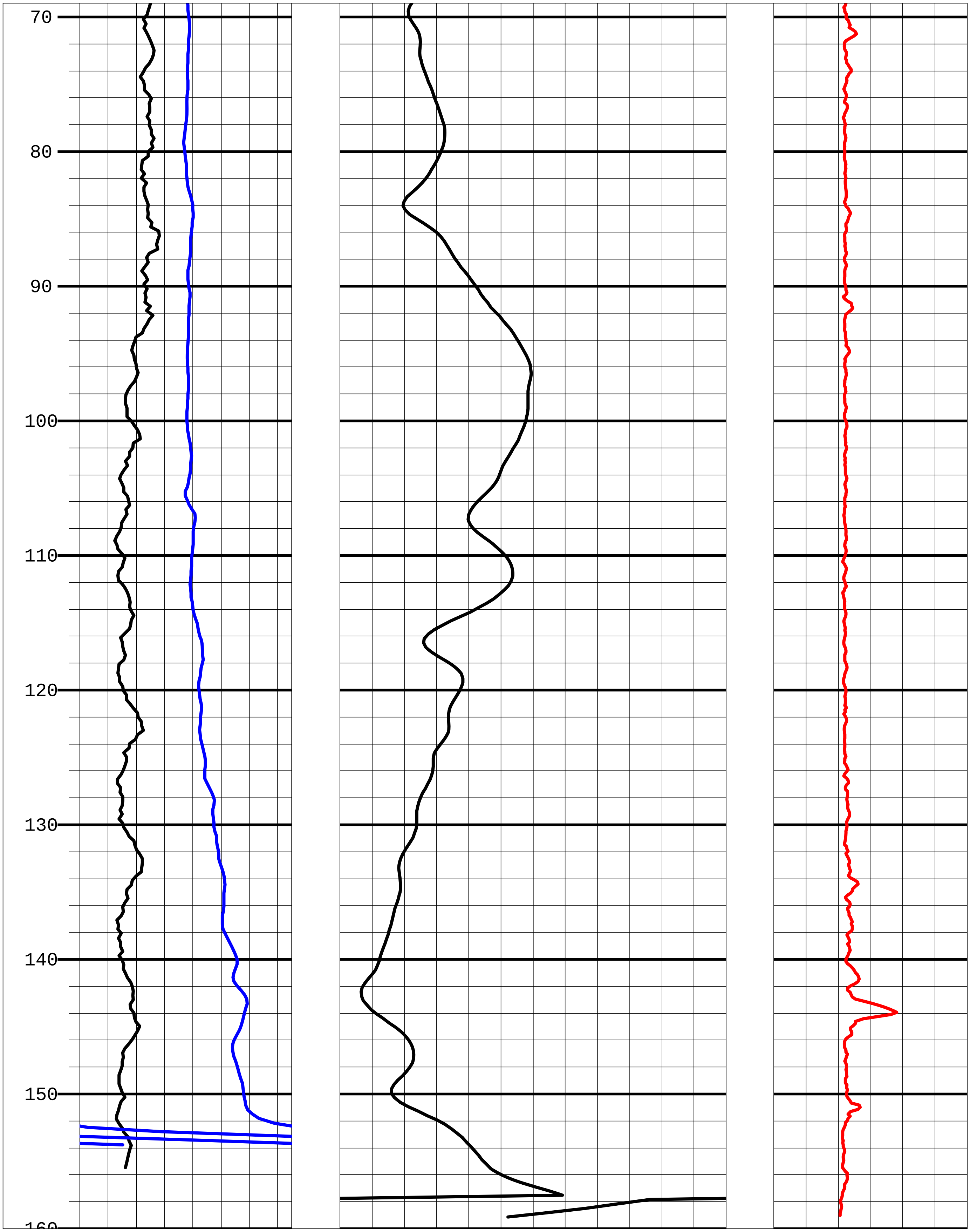
WELL I.D. *MW-12-D*

Logging Date:	*3-7-2012*
Logging Speed:	*17 ft/min* x Up Down
BOC:	*59 ft btoc*
TD:	*160 ft btoc*

Project:	*Royal Farms 96*	Bit Size:		EDI Job No.:	*4396*
Client:	*Advantage Environmental Consultants, LLC.*	Fluid Type:	*ground water*	Technician:	*M. Williams*
		LAT:	*39.61145° N*		
Location:	*North East, Cecil Co., MD*	LONG:	*075.93215° W*	Casing Material: *Steel*	Witness: *J. Sheidy*

Notes: *Depth referenced from top of casing at 0.5 ft below grade.*
Static water level at 26.47 ft btoc.



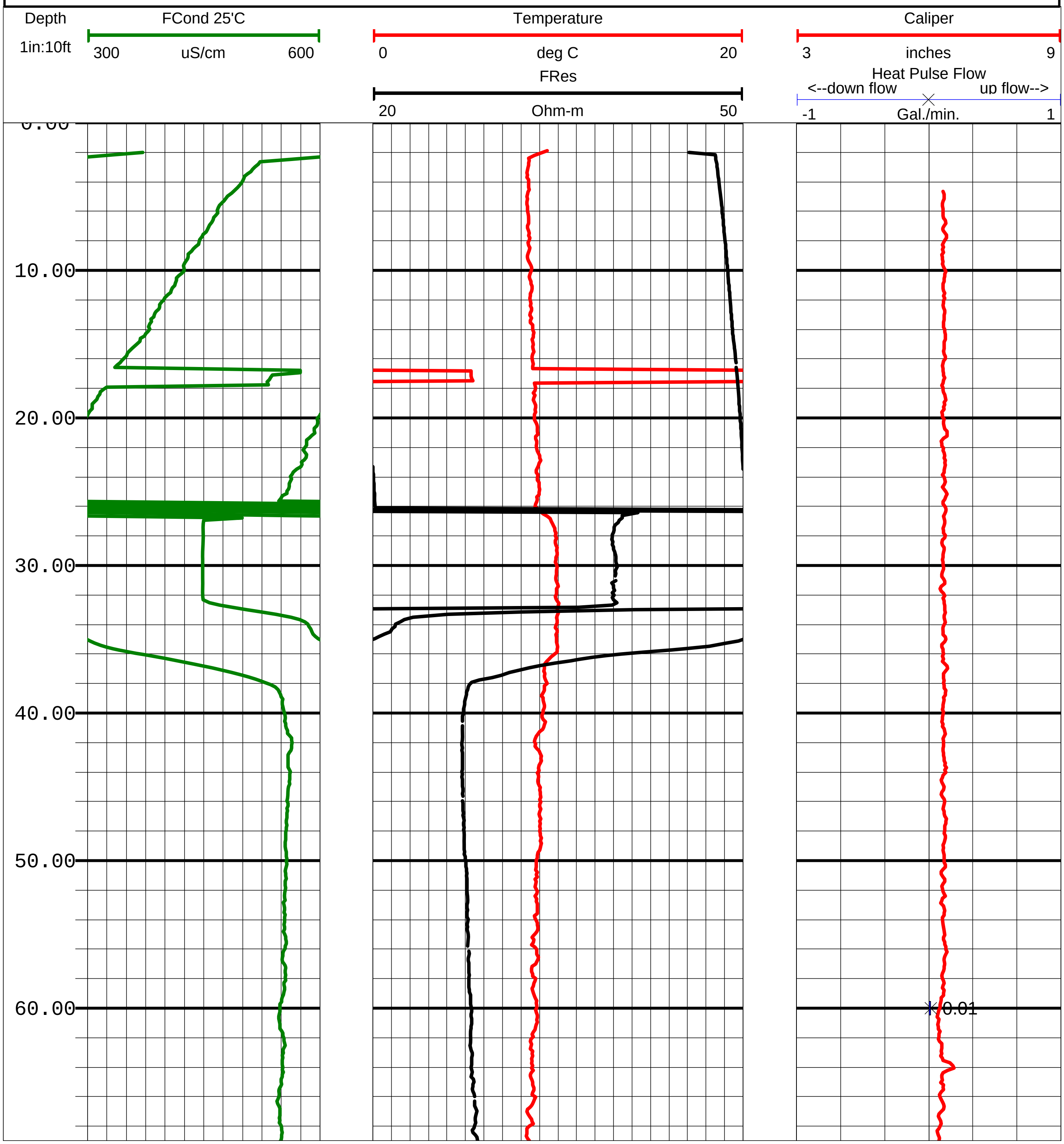

70
80
90
100
110
120
130
140
150
160

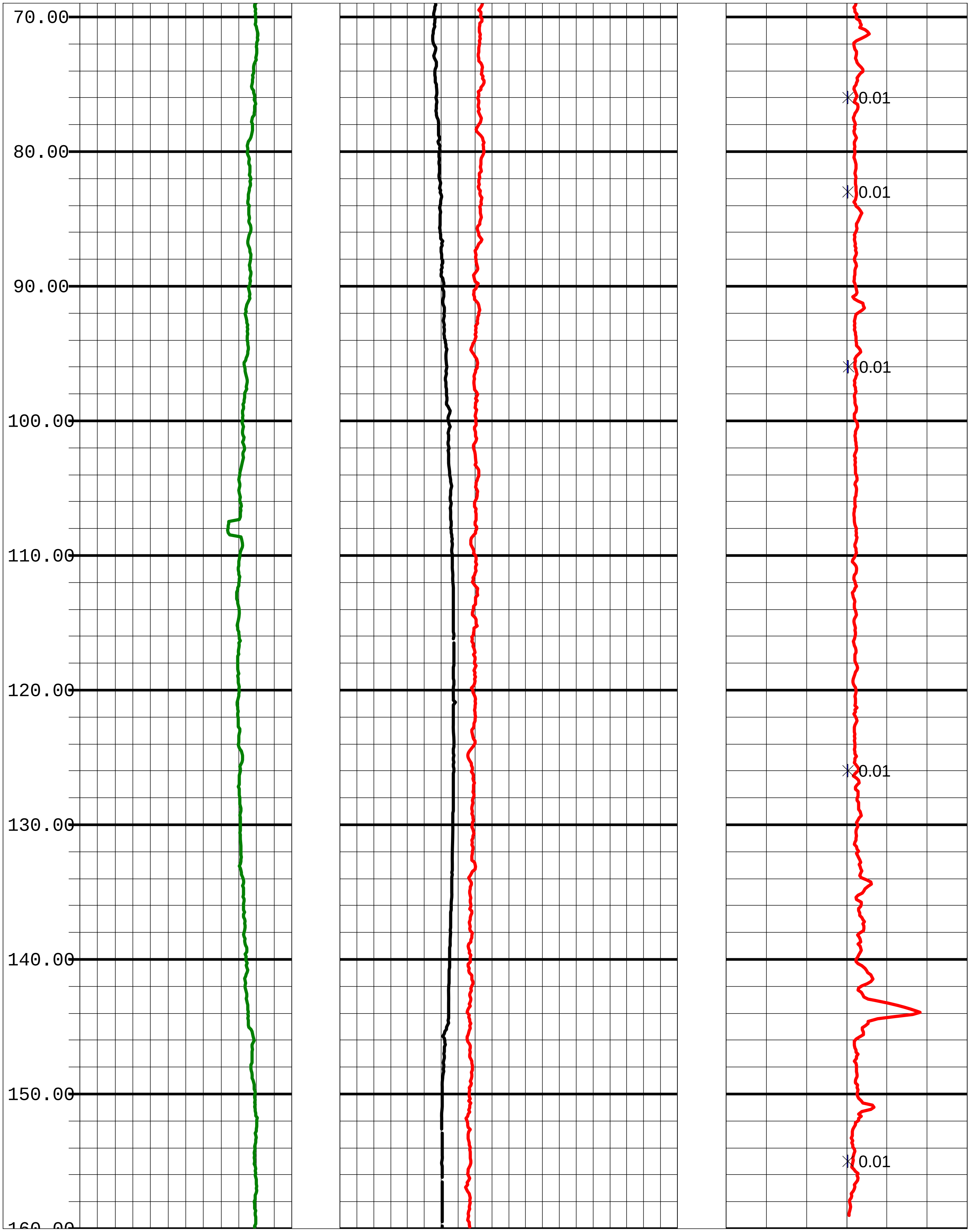
Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

WELL I.D.	Logging Date:	3-7-2012	
MW-12-D	Logging Speed:	17 ft/min	x Up x Down
	BOC:	59 ft btoc	TD: 160 ft btoc

Project:	Royal Farms 96	Bit Size:		EDI Job No.:	4396
Client:	Advantage Environmental Consultants, LLC	Fluid Type:	Ground Water	Technician:	M. Williams
		LAT:	39.61145° N		
Location:	North East, Cecil Co., MD	LONG:	075.93215° W	Casing Material: Steel	Witness: J. Sheidy

Notes: Depth referenced from top of casing at 0.5 ft below grade.
Water level measured at 26.47 ft btoc.




70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
0.01
0.01
0.01
0.01
0.01

Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

WELL I.D.

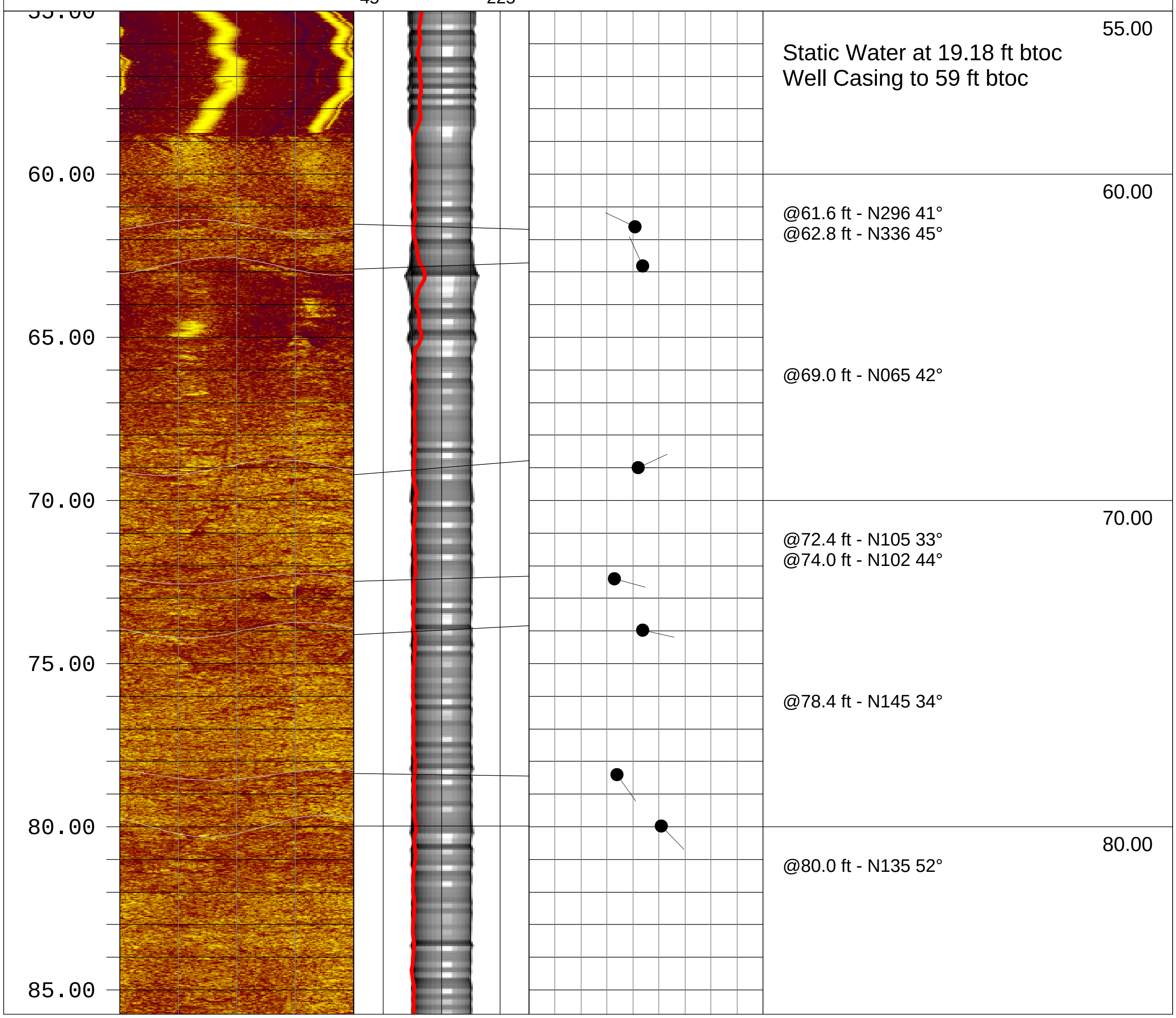
MW-13-D

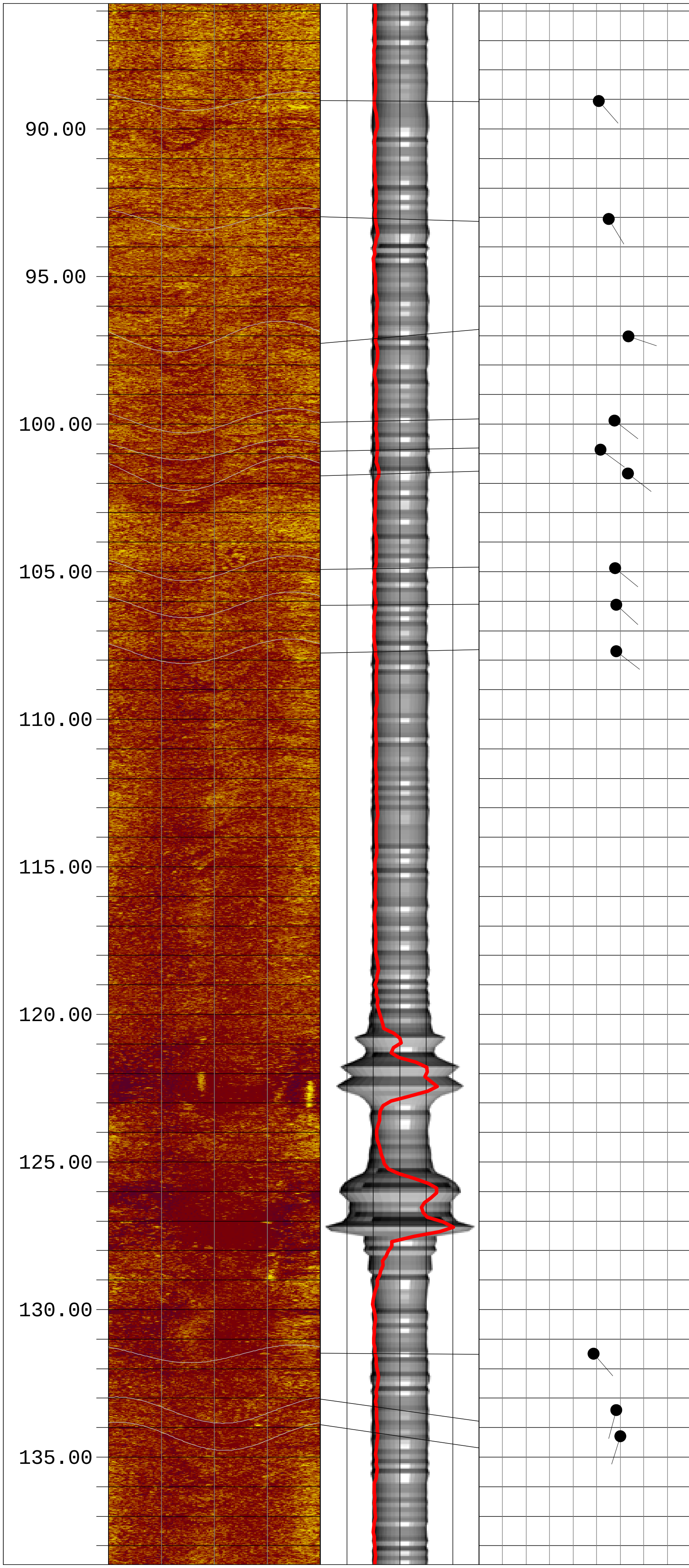
Logging Date:	*3-7-2012*		
Logging Speed:	*5 ft/min*	x Up	Down
BOC:	*59 ft btoc*	TD:	*180.5 ft btoc*

Project:	*Royal Farms 96*	Borehole Diameter:		EDI Job No.:	*4396*
Client:	*Advantage Envrironmental Consultants, LLC.*	Fluid Type:	*ground water*	Technician:	*M. Williams*
Location:	*North East, Cecil Co., MD*	Casing Material:	*Steel*	Witness:	*J. Sheidy*
Dip Azimuth:	*True North*	Dip Angle:	*Corrected For Deviation*	GPS:	

Notes: *Depth referenced from top of casing at 0.35 ft below grade.*
Static water level measured at 19.18 ft btoc.

Depth	Amplitude1-NM	Caliper	Tadpole Plot	Comments
1in:5ft	0° 90° 180° 270° 0°	4 inches 10	0 90	
	Structure Trace	3D-Caliper		
	0° 90° 180° 270° 0°	0°		
		Core Trace Projection		
		45° 225°		





@89.1 ft - N139 51°

90.00

@93.1 ft - N149 56°

@97.0 ft - N108 64°
@99.9 ft - N128 58°

100.00

@100.9 ft - N126 52°
@101.7 ft - N127 64°

@14.9 ft - N129 58°
@106.1 ft - N132 59°
@107.7 ft - N127 59°

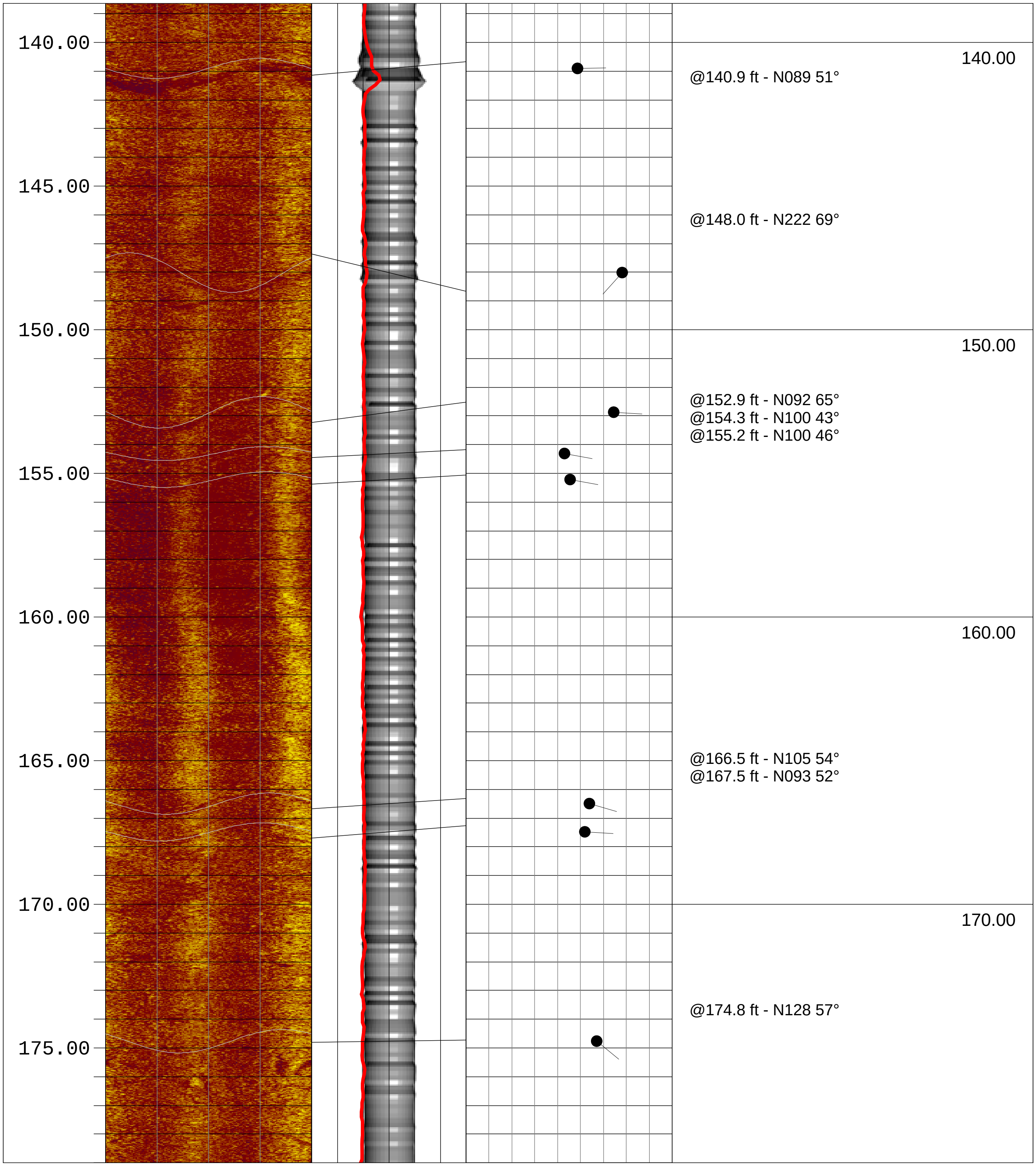
110.00

120.00

@120 to 128 ft - highly fractured
broken zone
No discernable planar features

130.00

@131.5 ft - N138 49°
@133.4 ft - N194 59°
@134.3 ft - N197 61°


140.00
145.00
150.00
155.00
160.00
165.00
170.00
175.00
140.00
@140.9 ft - N089 51°
@148.0 ft - N222 69°
150.00
@152.9 ft - N092 65°
@154.3 ft - N100 43°
@155.2 ft - N100 46°
160.00
@166.5 ft - N105 54°
@167.5 ft - N093 52°
170.00
@174.8 ft - N128 57°

APPENDIX C

MW-13-D
Geophysical Logs

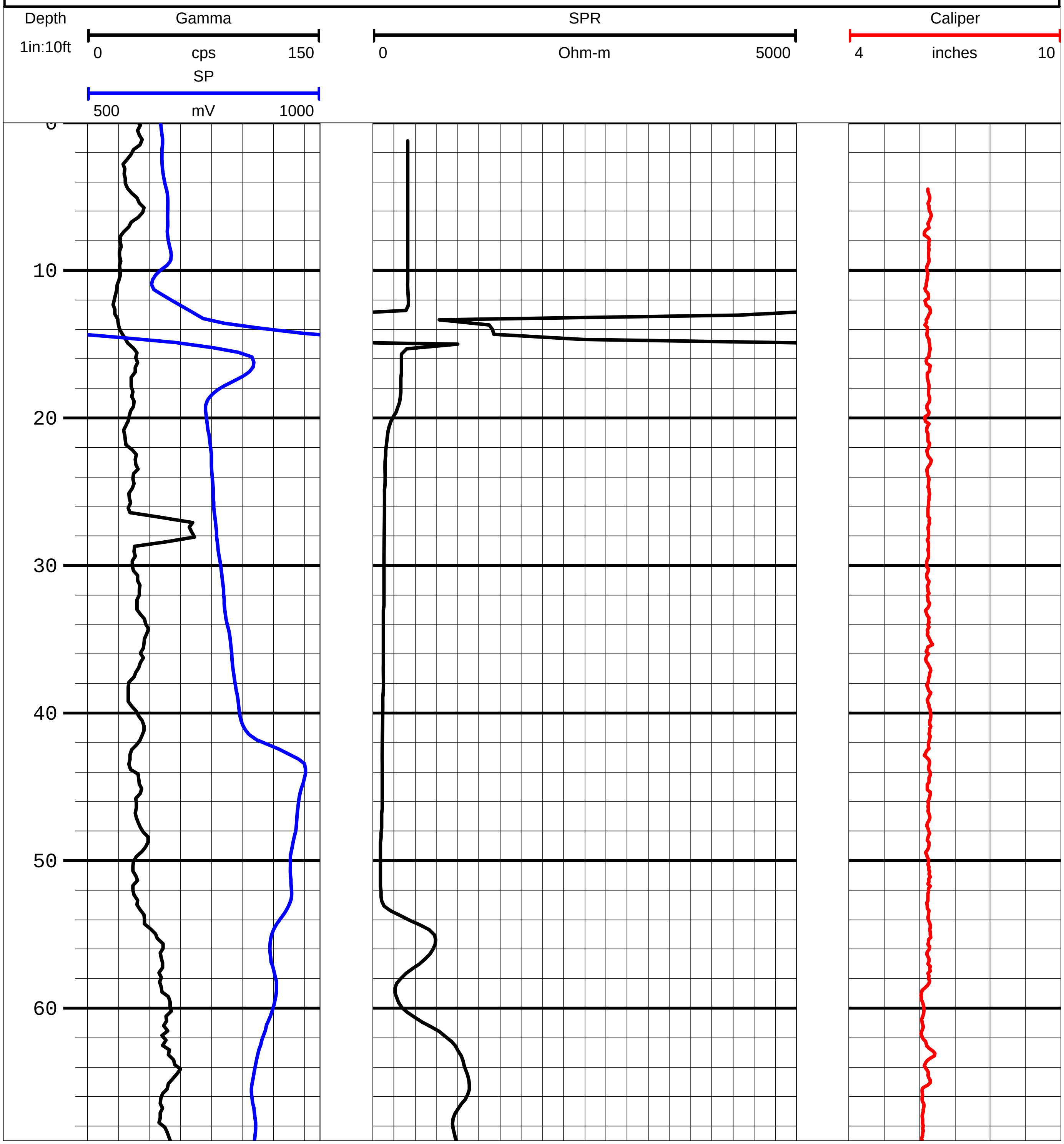
Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

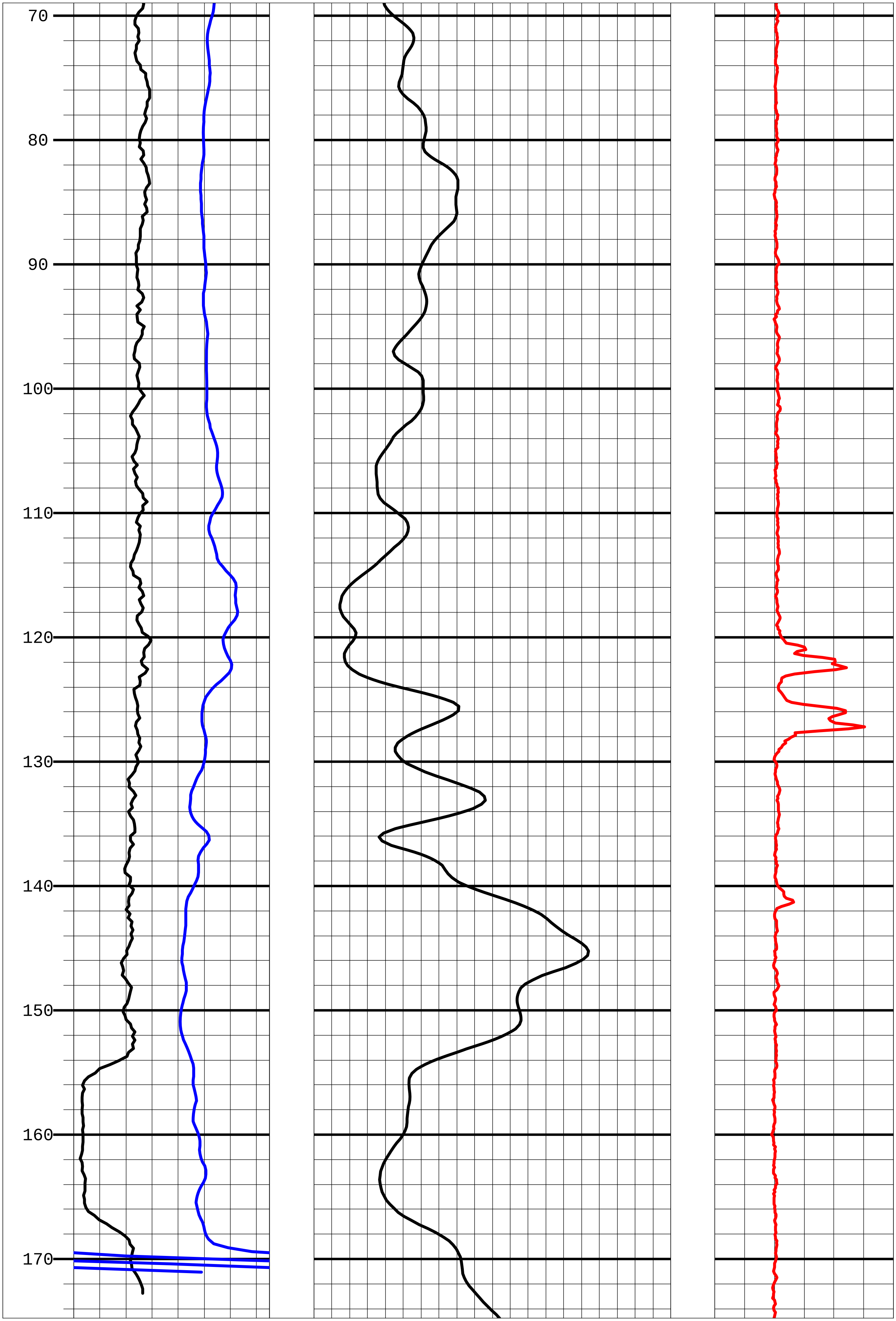
WELL I.D. MW-13-D

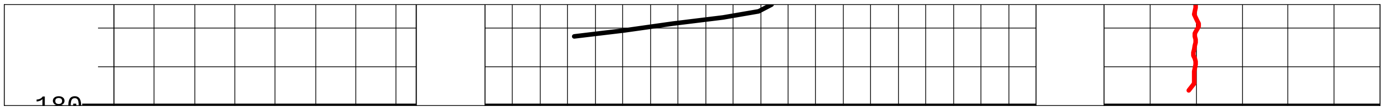
Logging Date: 3-7-2012
Logging Speed: 17 ft/min x Up Down
BOC: 59 ft btoc TD: 180.5 ft btoc

Project:	Royal Farms 96	Bit Size:		EDI Job No.:	4396
Client:	Advantage Environmental Consultants, LLC.	Fluid Type:	Ground Water	Technician:	M. Williams
		LAT:	39.61188° N		
Location:	North East, Cecil Co., MD	LONG:	075.93218° W	Casing Material: Steel	Witness: J. Sheidy

Notes: *Depth referenced from top of casing at 0.35 ft below grade.*
Static water level measured at 19.18 ft btoc.




70
80
90
100
110
120
130
140
150
160
170

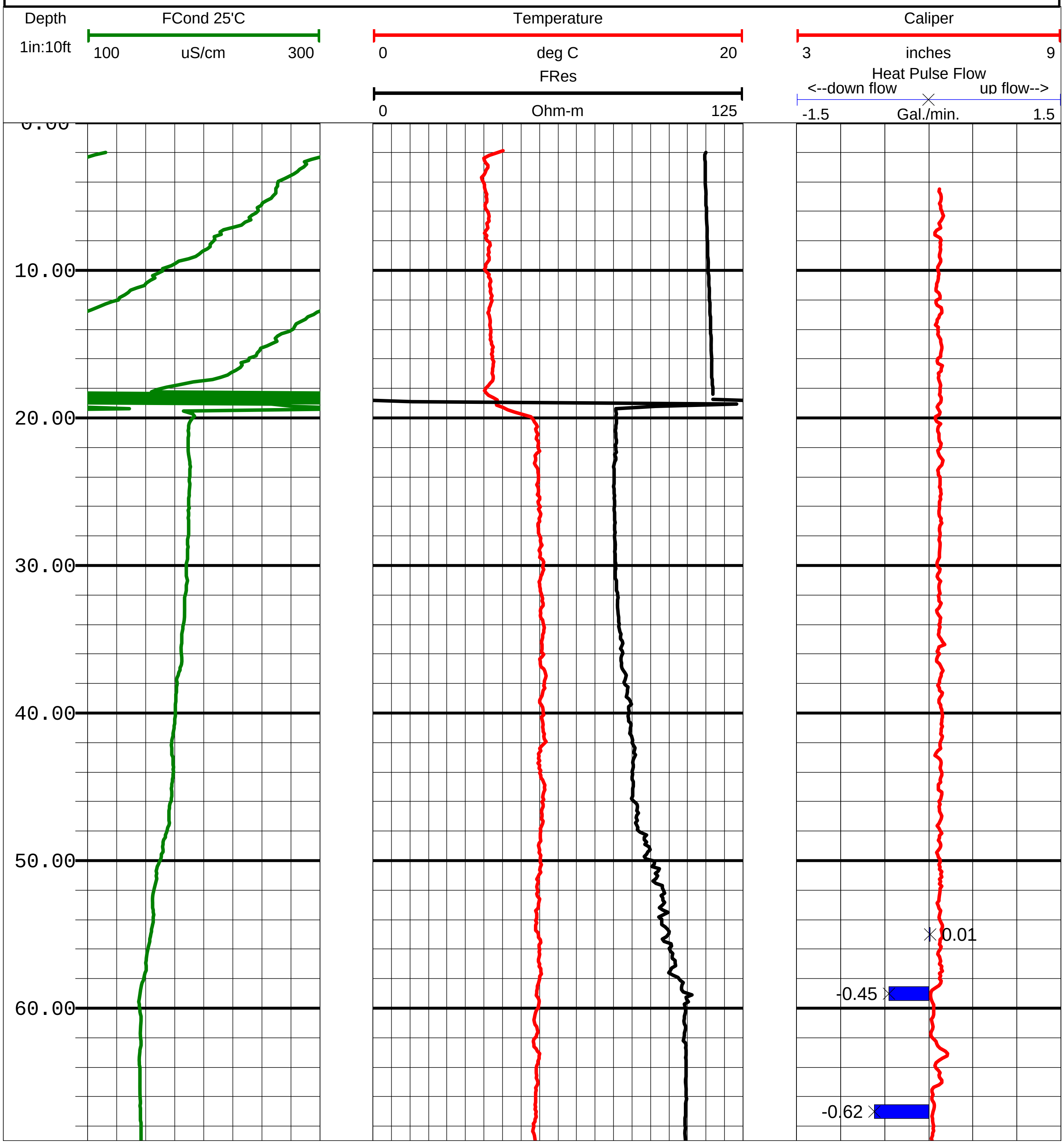


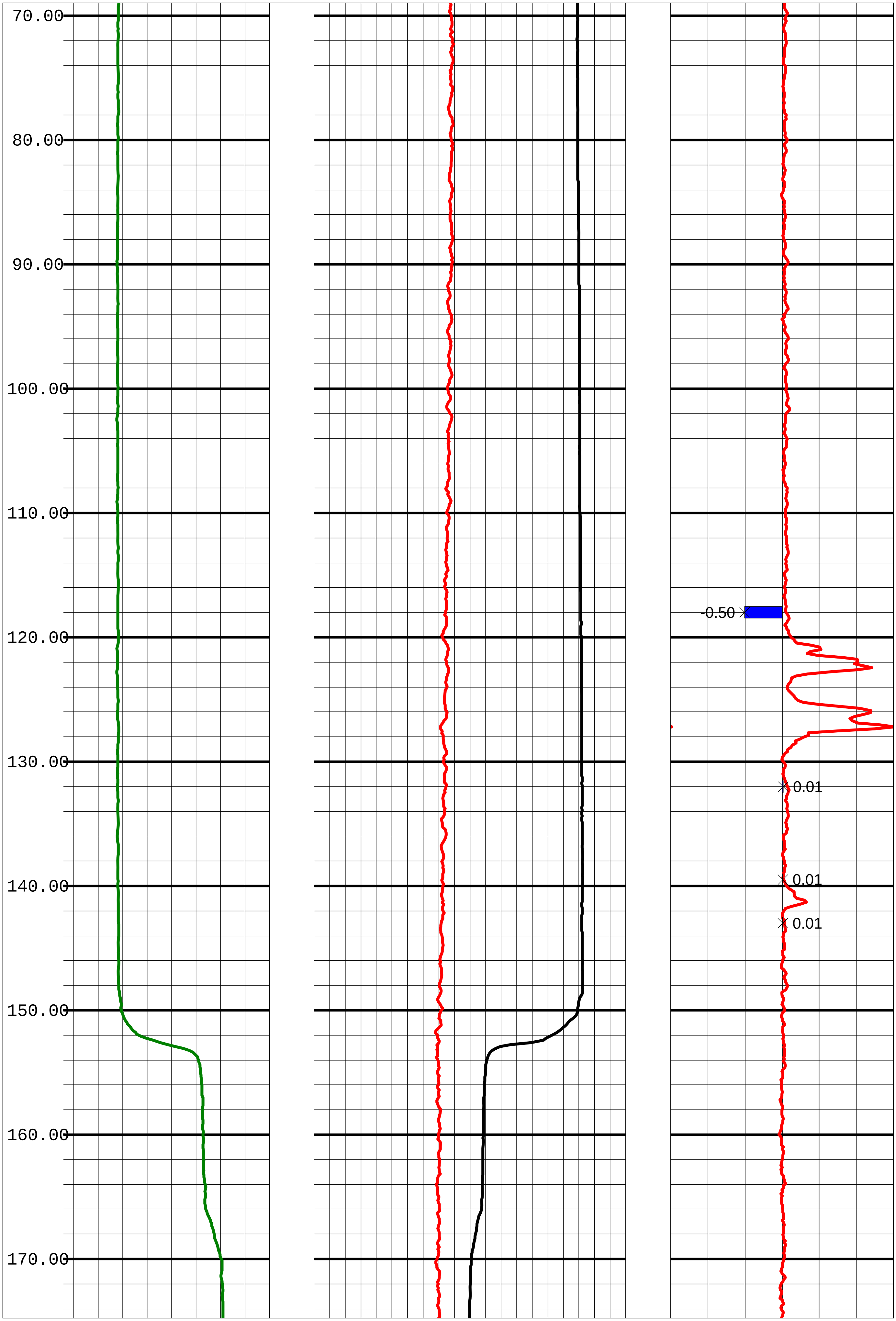
Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

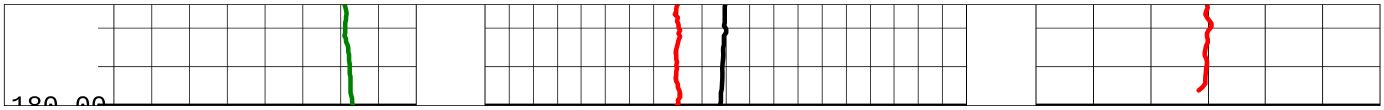
WELL I.D.	MW-13-D
Logging Date:	3-7-2012
Logging Speed:	17 ft/min x Up x Down
BOC:	59 ft btoc
TD:	180.5 ft btoc

Project:	Royal Farms 96	Bit Size:		EDI Job No.:	4396
Client:	Advantage Environmental Consultants, LLC.	Fluid Type:	ground water	Technician:	M. Williams
		LAT:	39.61188° N		
Location:	North East, Cecil Co., MD	LONG:	075.93218° W	Witness:	J. Sheidy
		Casing Material:	Steel		

Notes: Depth Referenced from top of casing at 0.35 ft below grade.
Static water level measured at 19.18 ft btoc.




70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
-0.50
0.01
0.01
0.01

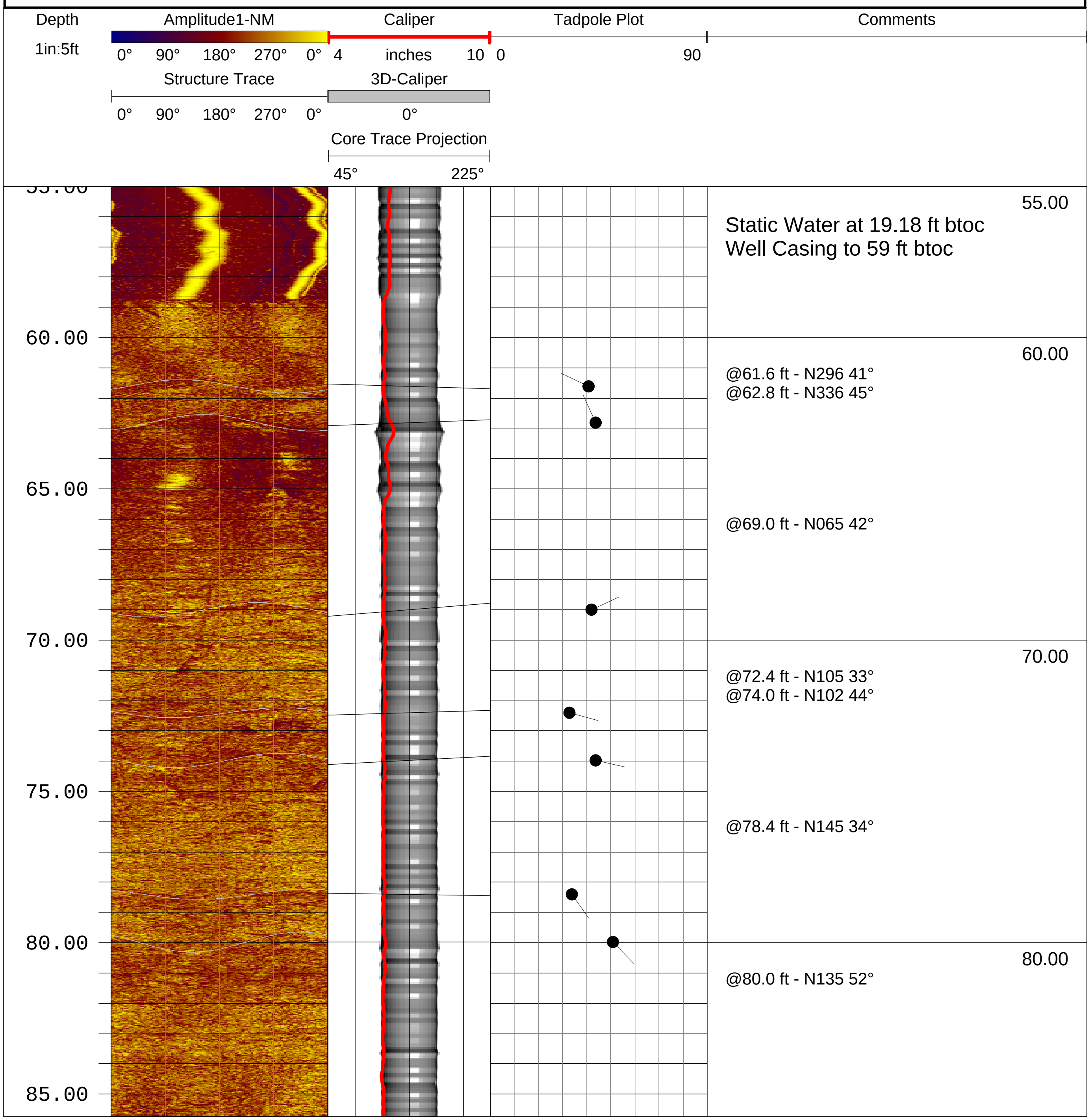

180.00

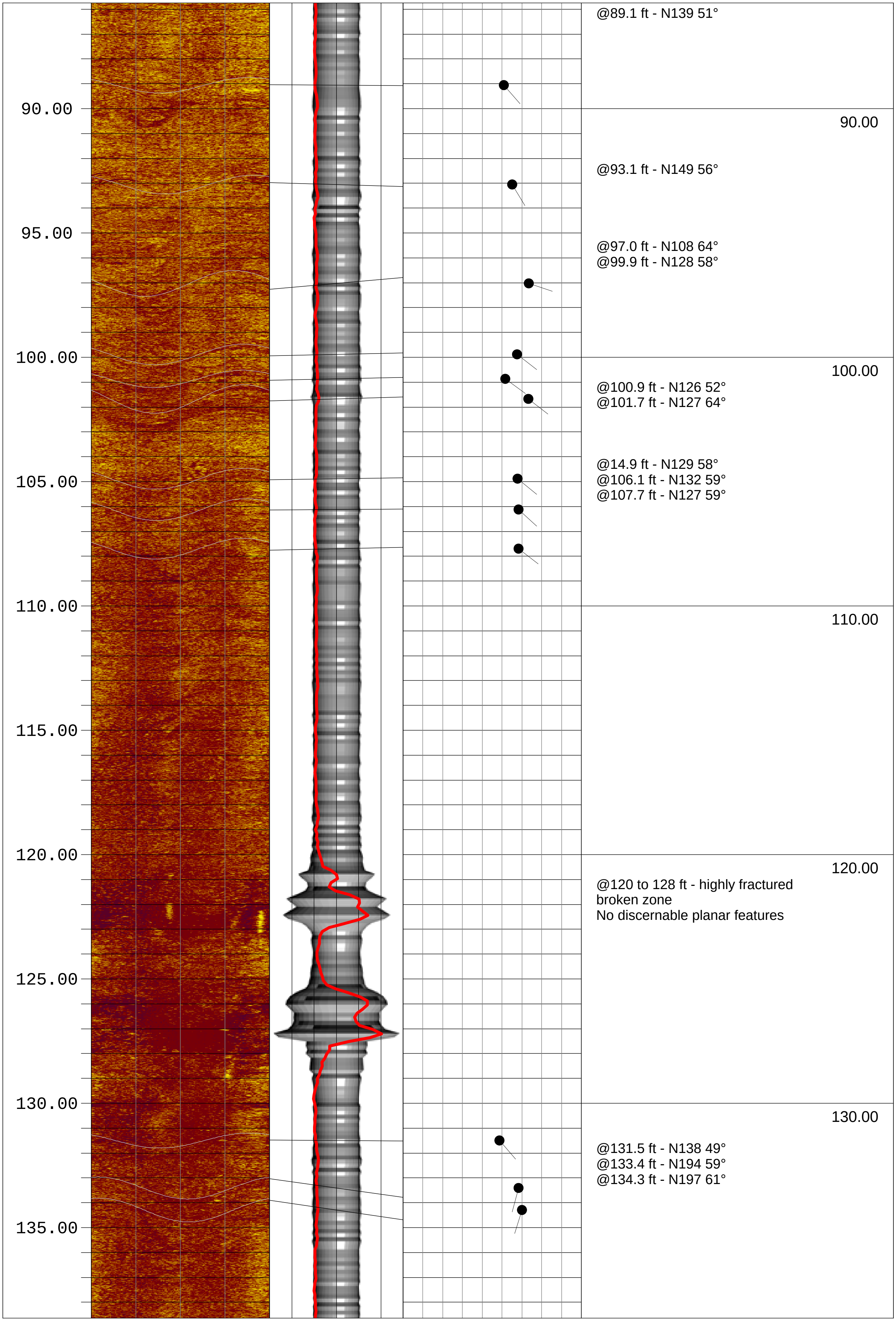
Earth Data Incorporated
131 Comet Drive, Centreville, MD 21617
Phone: (410) 758-8160 / Facsimile (410) 758-8168
www.earthdatainc.com

WELL I.D.	*MW-13-D*
Logging Date:	*3-7-2012*
Logging Speed:	*5 ft/min* x Up Down
BOC:	*59 ft btoc*
TD:	*180.5 ft btoc*

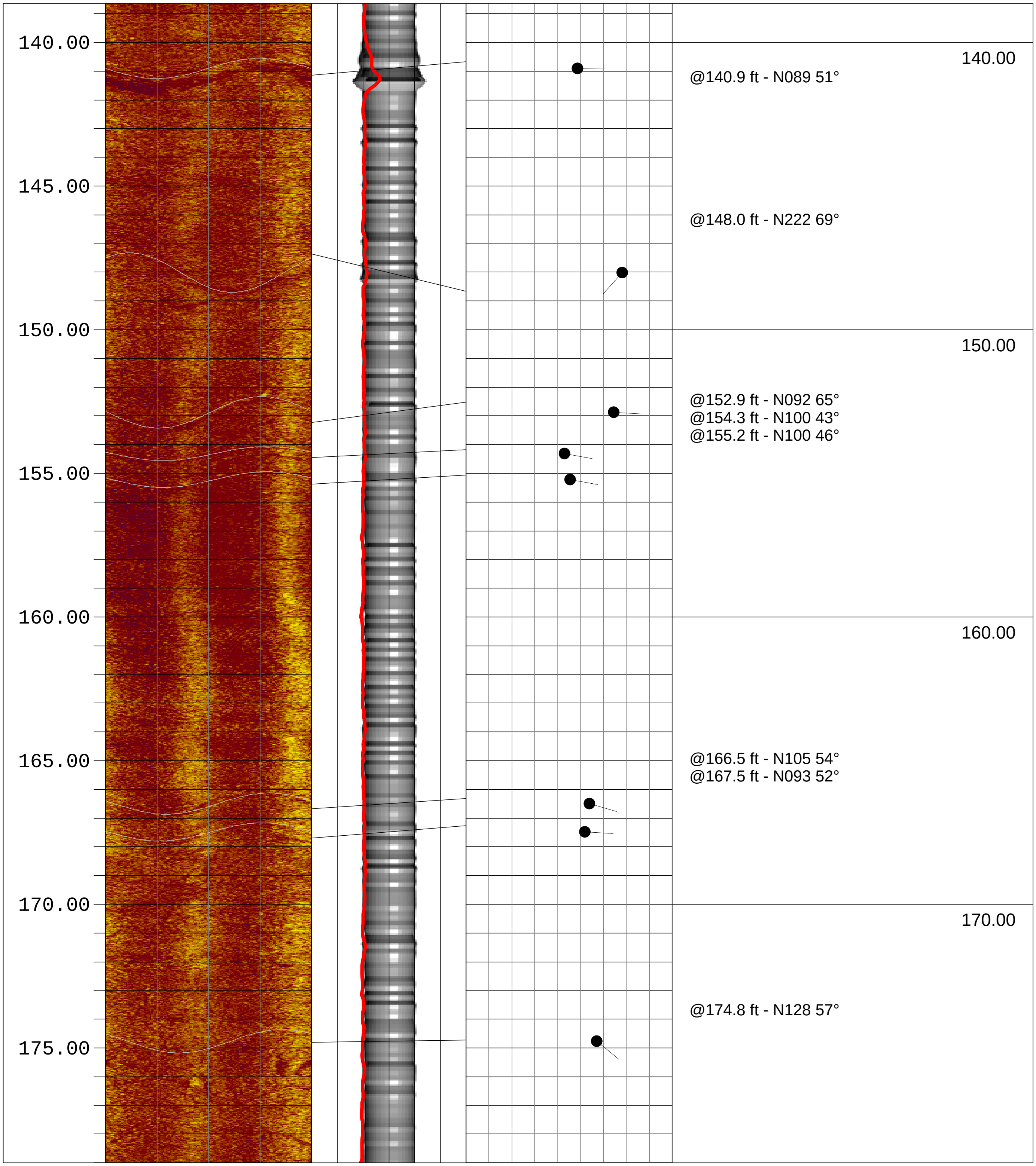
Project:	*Royal Farms 96*	Borehole Diameter:		EDI Job No.:	*4396*
Client:	*Advantage Envrironmental Consultants, LLC.*	Fluid Type:	*ground water*	Technician:	*M. Williams*
Location:	*North East, Cecil Co., MD*	Casing Material:	*Steel*	Witness:	*J. Sheidy*
Dip Azimuth:	*True North*	Dip Angle:	*Corrected For Deviation*	GPS:	

Notes: *Depth referenced from top of casing at 0.35 ft below grade.*
Static water level measured at 19.18 ft btoc.

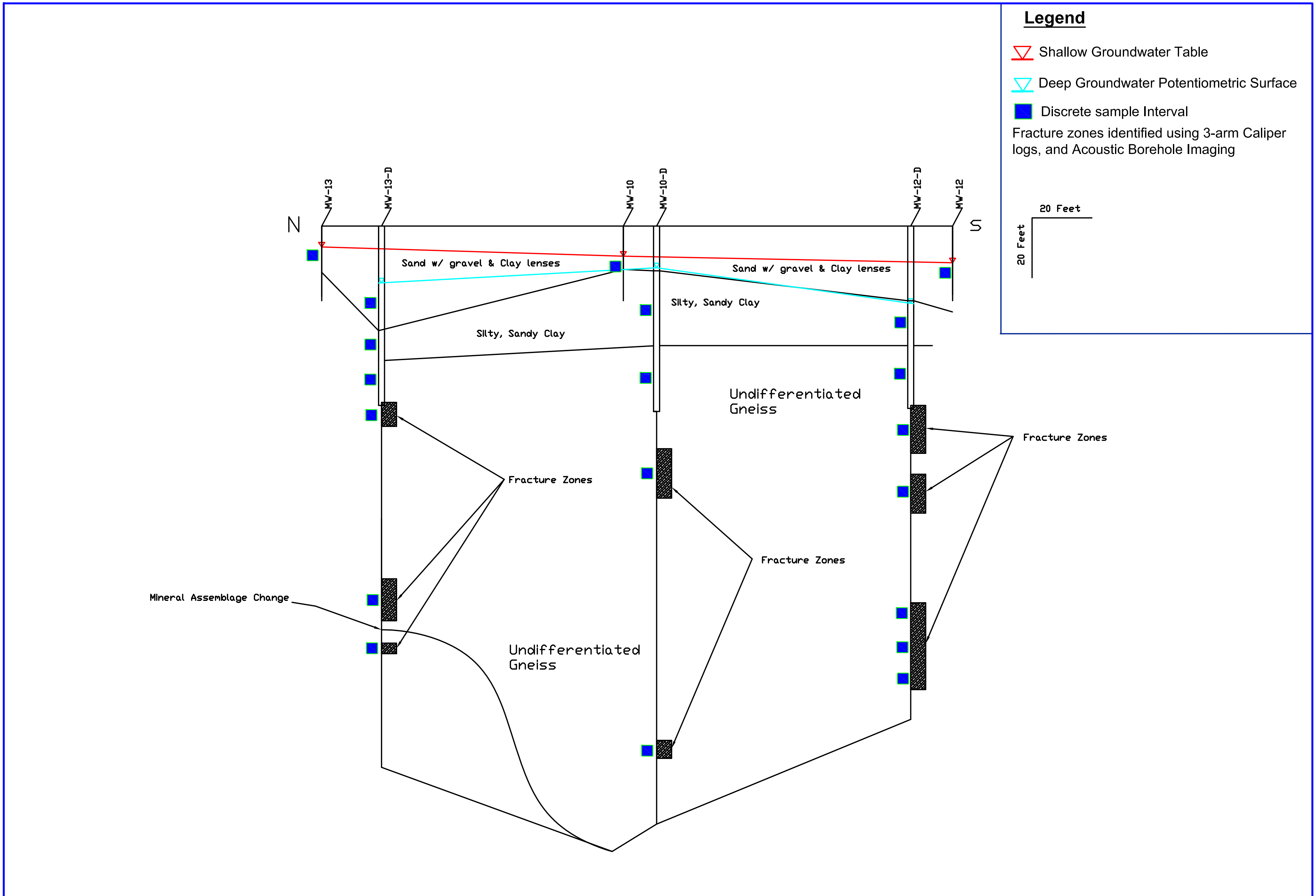




90.00
95.00
100.00
105.00
110.00
115.00
120.00
125.00
130.00
135.00
@89.1 ft - N139 51°
90.00
@93.1 ft - N149 56°
@97.0 ft - N108 64°
@99.9 ft - N128 58°
100.00
@100.9 ft - N126 52°
@101.7 ft - N127 64°
@14.9 ft - N129 58°
@106.1 ft - N132 59°
@107.7 ft - N127 59°
110.00
120.00
@120 to 128 ft - highly fractured
broken zone
No discernable planar features
130.00
@131.5 ft - N138 49°
@133.4 ft - N194 59°
@134.3 ft - N197 61°


140.00
145.00
150.00
155.00
160.00
165.00
170.00
175.00
140.00
@140.9 ft - N089 51°
@148.0 ft - N222 69°
150.00
@152.9 ft - N092 65°
@154.3 ft - N100 43°
@155.2 ft - N100 46°
160.00
@166.5 ft - N105 54°
@167.5 ft - N093 52°
170.00
@174.8 ft - N128 57°

ATTACHMENT B



Advantage Environmental Consultants, LLC

8610 Washington Blvd. Suite 217
Jessup, MD 20794
Phone 301-776-0500 Fax 301-776-1123

Drawn by: JSS	Cross Section Royal Farms No. 96 500 Mechanics Valley Road North East, MD 21901
Project No. 05-056-RF96	
Date: 3-15-2012	

ATTACHMENT C

HYDRASleeve™

Simple by Design US Patent No. 6,481,300; No. 6,837,120 others pending

Standard Operating Procedure: Sampling Ground Water with a HydraSleeve

This Guide should be used in addition to field manuals appropriate to sampling device (i.e., HydraSleeve or Super Sleeve).

Find the appropriate field manual on the HydraSleeve website at http://www.hydrasleeve.com.

For more information about the HydraSleeve, or if you have questions, contact:
GeoInsight, 2007 Glass Road, Las Cruces, NM 88005, 1-800-996-2225, info@hydrasleeve.com.

Table of Contents

Introduction

The HydraSleeve is classified as a no-purge (passive) grab sampling device, meaning that it is used to collect ground-water samples directly from the screened interval of a well without having to purge the well prior to sample collection. When it is used as described in this Standard Operating Procedure (SOP), the HydraSleeve causes no drawdown in the well (until the sample is withdrawn from the water column) and only minimal disturbance of the water column, because it has a very thin cross section and it displaces very little water (<100 ml) during deployment in the well. The HydraSleeve collects a sample from within the screen only, and it excludes water from any other part of the water column in the well through the use of a self-sealing check valve at the top of the sampler. It is a single-use (disposable) sampler that is not intended for reuse, so there are no decontamination requirements for the sampler itself.

The use of no-purge sampling as a means of collecting representative ground-water samples depends on the natural movement of ground water (under ambient hydraulic head) from the formation adjacent to the well screen through the screen. Robin and Gillham (1987) demonstrated the existence of a dynamic equilibrium between the water in a formation and the water in a well screen installed in that formation, which results in formation-quality water being available in the well screen for sampling at all times. No-purge sampling devices like the HydraSleeve collect this formation-quality water as the sample, under undisturbed (non-pumping) natural flow conditions. Samples collected in this manner generally provide more conservative (i.e., higher concentration) values than samples collected using well-volume purging, and values equivalent to samples collected using low-flow purging and sampling (Parsons, 2005).

Applications of the HydraSleeve

The HydraSleeve can be used to collect representative samples of ground water for all analytes (volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], common metals, trace metals, major cations and anions, dissolved gases, total dissolved solids, radionuclides, pesticides, PCBs, explosive compounds, and all other analytical parameters). Designs are available to collect samples from wells from 1” inside diameter and larger. The HydraSleeve can collect samples from wells of any yield, but it is especially well-suited to collecting samples from low-yield wells, where other sampling methods can’t be used reliably because their use results in dewatering of the well screen and alteration of sample chemistry (McAlary and Barker, 1987).

The HydraSleeve can collect samples from wells of any depth, and it can be used for single-event sampling or long-term ground-water monitoring programs. Because of its thin cross section and flexible construction, it can be used in narrow, constricted or damaged wells where rigid sampling devices may not fit. Using multiple HydraSleeves deployed in series along a single suspension line or tether, it is also possible to conduct in-well vertical profiling in wells in which contaminant concentrations are thought to be stratified.

As with all groundwater sampling devices, HydraSleeves should not be used to collect ground-water samples from wells in which separate (non-aqueous) phase hydrocarbons (i.e., gasoline, diesel fuel or jet fuel) are present because of the possibility of incorporating some of the separate-phase hydrocarbon into the sample.

Description of the HydraSleeve

The HydraSleeve (Figure 1) consists of the following basic components:

- A suspension line or tether (A.), attached to the spring clip or directly to the top of the sleeve to deploy the device into and recover the device from the well. Tethers with depth indicators marked in 1-foot intervals are available from the manufacturer.
- A long, flexible, 4-mil thick lay-flat polyethylene sample sleeve (C.) sealed at the bottom (this is the sample chamber), which comes in different sizes, as discussed below with a self-sealing reed-type flexible polyethylene check valve built into the top of the sleeve (B.) to prevent water from entering or exiting the sampler except during sample acquisition.
- A reusable stainless-steel weight with clip (D.), which is attached to the bottom of the sleeve to carry it down the well to its intended depth in the water column. Bottom weights available from the manufacturer are 0.75” OD and are available in three sizes: 5 oz. (2.5” long); 8 oz. (4” long); and 16 oz. (8” long). In lieu of a bottom weight, an optional top weight may be attached to the top of the HydraSleeve to carry it to depth and to compress it at the bottom of the well (not shown in Figure 1);
- A discharge tube that is used to puncture the HydraSleeve after it is recovered from the well so the sample can be decanted into sample bottles (not shown).
- Just above the self-sealing check valve at the top of the sleeve are two holes which provide attachment points for the spring clip and/or suspension line or tether. At the bottom of the sample sleeve are two holes which provide attachment points for the weight clip and weight.

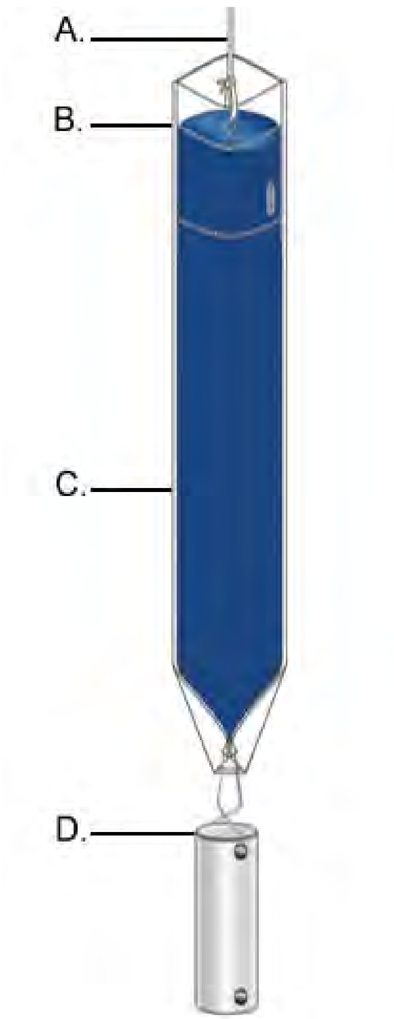


Figure 1. HydraSleeve components.

> **Note:** The sample sleeve and the discharge tube are designed for one-time use and are disposable. The spring clip, weight and weight clip may be reused after thorough cleaning. Suspension cord is generally disposed after one use although, if it is dedicated to the well, it may be reused at the discretion of the sampling personnel.

Selecting the HydraSleeve Size to Meet Site-Specific Sampling Objectives

It is important to understand that each HydraSleeve is able to collect a finite volume of sample because, after the HydraSleeve is deployed, you only get one chance to collect an undisturbed sample. Thus, the volume of sample required to meet your site-specific sampling and analytical requirements will dictate the size of HydraSleeve you need to meet these requirements.

The volume of sample collected by the HydraSleeve varies with the diameter and length of the HydraSleeve. Dimensions and volumes of available HydraSleeve models are detailed in Table 1.

Table 1. Dimensions and volumes of HydraSleeve models.

Diameter	Volume	Length	Lay-Flat Width	Filled Dia.
2-Inch HydraSleeves				
Standard 625-ml HydraSleeve	625 ml	< 30”	2.5”	1.4”
Standard 1-Liter HydraSleeve	1 Liter	38”	3”	1.9”
1-Liter HydraSleeve SS	1 Liter	36”	3”	1.9”
2-Liter HydraSleeve SS	2 Liters	60”	3”	1.9”
4-Inch HydraSleeves				
Standard 1.6-Liter HydraSleeve	1.6 Liters	30”	3.8”	2.3”
Custom 2-Liter HydraSleeve	2 Liters	36”	4”	2.7”

HydraSleeves can be custom-fabricated by the manufacturer in varying diameters and lengths to meet specific volume requirements. HydraSleeves can also be deployed in series (i.e., multiple HydraSleeves attached to one tether) to collect additional sample to meet specific volume requirements, as described below.

If you have questions regarding the availability of sufficient volume of sample to satisfy laboratory requirements for analysis, it is recommended that you contact the laboratory to discuss the minimum volumes needed for each suite of analytes. Laboratories often require only 10% to 25% of the volume they specify to complete analysis for specific suites of analytes, so they can often work with much smaller sample volumes that can easily be supplied by a HydraSleeve.

HydraSleeve Deployment

Information Required Before Deploying a HydraSleeve

Before installing a HydraSleeve in any well, you will need to know the following:

- The inside diameter of the well
- The length of the well screen
- The water level in the well
- The position of the well screen in the well
- The total depth of the well

The inside diameter of the well is used to determine the appropriate HydraSleeve diameter for use in the well. The other information is used to determine the proper placement of the HydraSleeve in the well to collect a representative sample from the screen (see HydraSleeve Placement, below), and to determine the appropriate length of tether to attach to the HydraSleeve to deploy it at the appropriate position in the well.

Most of this information (with the exception of the water level) should be available from the well log; if not, it will have to be collected by some other means. The inside diameter of the well can be measured at the top of the well casing, and the total depth of the well can be measured by sounding the bottom of the well with a weighted tape. The position and length of the well screen may have to be determined using a down-hole camera if a well log is not available. The water level in the well can be measured using any commonly available water-level gauge.

HydraSleeve Placement

The HydraSleeve is designed to collect a sample directly from the well screen, and it fills by pulling it up through the screen a distance equivalent to 1 to 1.5 times its length. This upward motion causes the top check valve to open, which allows the device to fill. To optimize sample recovery, it is recommended that the HydraSleeve be placed in the well so that the bottom weight rests on the bottom of the well and the top of the HydraSleeve is as close to the bottom of the well screen as possible. This should allow the sampler to fill before the top of the device reaches the top of the screen as it is pulled up through the water column, and ensure that only water from the screen is collected as the sample. In short-screen wells, or wells with a short water column, it may be necessary to use a top-weight on the HydraSleeve to compress it in the bottom of the well so that, when it is recovered, it has room to fill before it reaches the top of the screen.

Example

2" ID PVC well, 50' total depth, 10' screen at the bottom of the well, with water level above the screen (the entire screen contains water).

Correct Placement (figure 2): Using a standard HydraSleeve for a 2" well (2.6" flat width/1.5" filled OD x 30" long, 650 ml volume), deploy the sampler so the weight (an 8 oz., 4"-long weight with a 2"-long clip) rests at the bottom of the well. The top of the sleeve is thus set at about 36" above the bottom of the well. When the sampler is recovered, it will be pulled upward approximately 30" to 45" before it is filled; therefore, it is full (and the top check valve closes) at approximately 66" (5 ½ feet) to 81" (6 ¾ feet) above the bottom of the well, which is well before the sampler reaches the top of the screen. In this example, only water from the screen is collected as a sample.

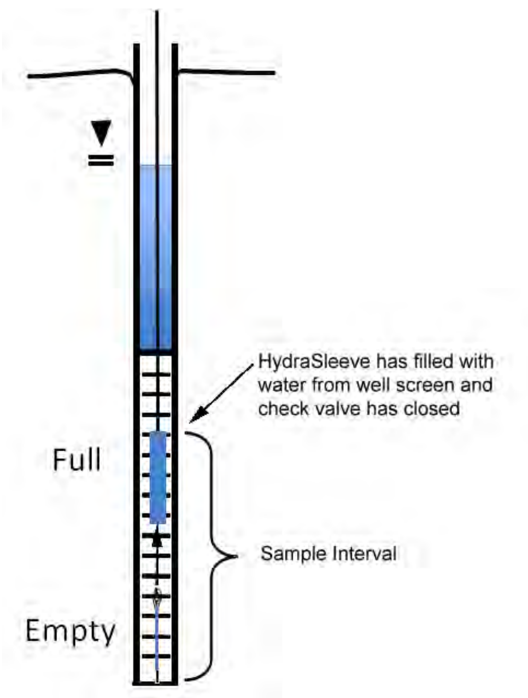


Figure 2. Correct placement of HydraSleeve.

Incorrect Placement (figure 3): If the well screen in this example was only 5' long, and the HydraSleeve was placed as above, it would not fill before the top of the device reached the top of the well screen, so the sample would include water from above the screen, which may not have the same chemistry.

The solution? Deploy the HydraSleeve with a top weight, so that it is collapsed to within 6" to 9" of the bottom of the well. When the HydraSleeve is recovered, it will fill within 39" (3 ¼ feet) to 54" (4 ½ feet) above the bottom of the well, or just before the sampler reaches the top of the screen, so it collects only water from the screen as the sample.

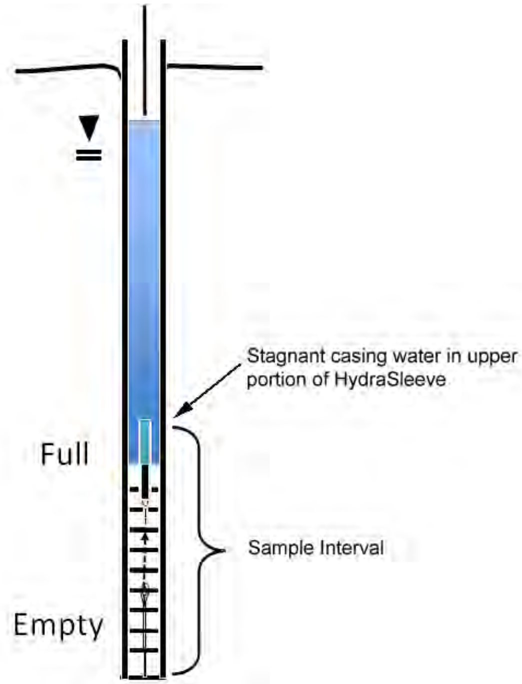


Figure 3. Incorrect placement of HydraSleeve.

This example illustrates one of many types of HydraSleeve placements. More complex placements are discussed in a later section.

Procedures for Sampling with the HydraSleeve

Collecting a ground-water sample with a HydraSleeve is a simple one-person operation.

Note: Before deploying the HydraSleeve in the well, collect the depth-to-water measurement that you will use to determine the preferred position of the HydraSleeve in the well. This measurement may also be used with measurements from other wells to create a ground-water contour map. If necessary, also measure the depth to the bottom of the well to verify actual well depth to confirm your decision on placement of the HydraSleeve in the water column.

Measure the correct amount of tether needed to suspend the HydraSleeve in the well so that the weight will rest on the bottom of the well (or at your preferred position in the well). Make sure to account for the need to leave a few feet of tether at the top of the well to allow recovery of the sleeve

Note: Always wear sterile gloves when handling and discharging the HydraSleeve.

I. Assembling the HydraSleeve

1. Remove the HydraSleeve from its packaging, unfold it, and hold it by its top.
2. Crimp the top of the HydraSleeve by folding the hard polyethylene reinforcing strips at the holes.
3. Attach the spring clip to the holes to ensure that the top will remain open until the sampler is retrieved.
4. Attach the tether to the spring clip by tying a knot in the tether.

Note: Alternatively, attach the tether to one (NOT both) of the holes at the top of the Hydrasleeve by tying a knot in the tether.

5. Fold the flaps with the two holes at the bottom of the HydraSleeve together and slide the weight clip through the holes.
6. Attach a weight to the bottom of the weight clip to ensure that the HydraSleeve will descend to the bottom of the well.

II. Deploying the HydraSleeve

1. Using the tether, carefully lower the HydraSleeve to the bottom of the well, or to your preferred depth in the water column

   During installation, hydrostatic pressure in the water column will keep the self-sealing check valve at the top of the HydraSleeve closed, and ensure that it retains its flat, empty profile for an indefinite period prior to recovery.

Note: Make sure that it is not pulled upward at any time during its descent. If the HydraSleeve is pulled upward at a rate greater than 0.5'/second at any time prior to recovery, the top check valve will open and water will enter the HydraSleeve prematurely.

2. Secure the tether at the top of the well by placing the well cap on the top of the well casing and over the tether.

Note: Alternatively, you can tie the tether to a hook on the bottom of the well cap (you will need to leave a few inches of slack in the line to avoid pulling the sampler up as the cap is removed at the next sampling event).

III. Equilibrating the Well

The equilibration time is the time it takes for conditions in the water column (primarily flow dynamics and contaminant distribution) to restabilize after vertical mixing occurs (caused by installation of a sampling device in the well).

- Situation: The HydraSleeve is deployed for the first time or for only one time in a well

  The HydraSleeve is very thin in cross section and displaces very little water (<100 ml) during deployment so, unlike most other sampling devices, it does not disturb the water column to the point at which long equilibration times are necessary to ensure recovery of a representative sample.

  In most cases, the HydraSleeve can be recovered immediately (with no equilibration time) or within a few hours. In regulatory jurisdictions that impose specific requirements for equilibration times prior to recovery of no-purge sampling devices, these requirements should be followed.

- Situation: The HydraSleeve is being deployed for recovery during a future sampling event

  In periodic (i.e., quarterly or semi-annual) sampling programs, the sampler for the current sampling event can be recovered and a new sampler (for the next sampling event) deployed immediately thereafter, so the new sampler remains in the well until the next sampling event.

Thus, a long equilibration time is ensured and, at the next sampling event, the sampler can be recovered immediately. This means that separate mobilizations, to deploy and then to recover the sampler, are not required. HydraSleeves can be left in a well for an indefinite period of time without concern.

IV. HydraSleeve Recovery and Sample Collection

1. Hold on to the tether while removing the well cap.

2. Secure the tether at the top of the well while maintaining tension on the tether (but without pulling the tether upwards)

3. Measure the water level in the well.

4. In one smooth motion, pull the tether up between 30” to 45” (36” to 54” for the longer HydraSleeve) at a rate of about 1’ per second (or faster).

   The motion will open the top check valve and allow the HydraSleeve to fill (it should fill in about 1 to 1.5 times the length of the HydraSleeve). This is analogous to coring the water column in the well from the bottom up.

   When the HydraSleeve is full, the top check valve will close. You should begin to feel the weight of the HydraSleeve on the tether and it will begin to displace water. The closed check valve prevents loss of sample and entry of water from zones above the well screen as the HydraSleeve is recovered.

5. Continue pulling the tether upward until the HydraSleeve is at the top of the well.

6. Decant and discard the small volume of water trapped in the Hydrasleeve above the check valve by turning the sleeve over.

V. Sample Collection

Note: Sample collection should be done immediately after the HydraSleeve has been brought to the surface to preserve sample integrity.

1. Remove the discharge tube from its sleeve.

2. Hold the HydraSleeve at the check valve.

3. Puncture the HydraSleeve just below the check valve with the pointed end of the discharge tube

4. Discharge water from the HydraSleeve into your sample containers.

Control the discharge from the HydraSleeve by either raising the bottom of the sleeve, by squeezing it like a tube of toothpaste, or both.

5. Continue filling sample containers until all are full.

Measurement of Field Indicator Parameters

Field indicator parameter measurement is generally done during well purging and sampling to confirm when parameters are stable and sampling can begin. Because no-purge sampling does not require purging, field indicator parameter measurement is not necessary for the purpose of confirming when purging is complete.

If field indicator parameter measurement is required to meet a specific non-purging regulatory requirement, it can be done by taking measurements from water within a HydraSleeve that is not used for collecting a sample to submit for laboratory analysis (i.e., a second HydraSleeve installed in conjunction with the primary sample collection HydraSleeve [see Multiple Sampler Deployment below]).

Alternate Deployment Strategies

Deployment in Wells with Limited Water Columns

For wells in which only a limited water column exists to be sampled, the HydraSleeve can be deployed with an optional top weight instead of a bottom weight, which collapses the HydraSleeve to a very short (approximately 6” to 9”) length, and allows the HydraSleeve to fill in a water column only 36” to 45” in height.

Multiple Sampler Deployment

Multiple sampler deployment in a single well screen can accomplish two purposes:

- It can collect additional sample volume to satisfy site or laboratory-specific sample volume requirements.
- It can accommodate the need for collecting field indicator parameter measurements.
- It can be used to collect samples from multiple intervals in the screen to allow identification of possible contaminant stratification.

It is possible to use up to 3 standard 30" HydraSleeves deployed in series along a single tether to collect samples from a 10' long well screen without collecting water from the interval above the screen.

The samplers must be attached to the tether at both the top and bottom of the sleeve. Attach the tether at the top with a stainless-steel clip (available from the manufacturer). Attach the tether at the bottom using a cable tie. The samplers must be attached as follows (figure 4):

- The first (attached to the tether as described above, with the weight at the bottom) at the bottom of the screen
- The second attached immediately above the first
- The third (attached the same as the second) immediately above the second

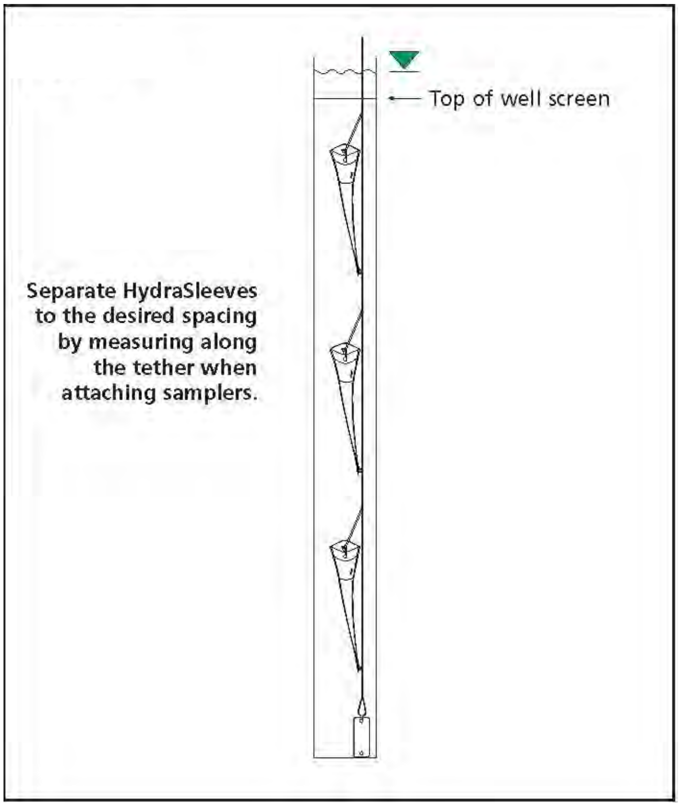


Figure 4. Multiple HydraSleeve deployment.

Alternately, the first sampler can be attached to the tether as described above, a second attached to the bottom of the first using a short length of tether (in place of the weight), and the third attached to the bottom of the second in the same manner, with the weight attached to the bottom of the third sampler (figure 5).

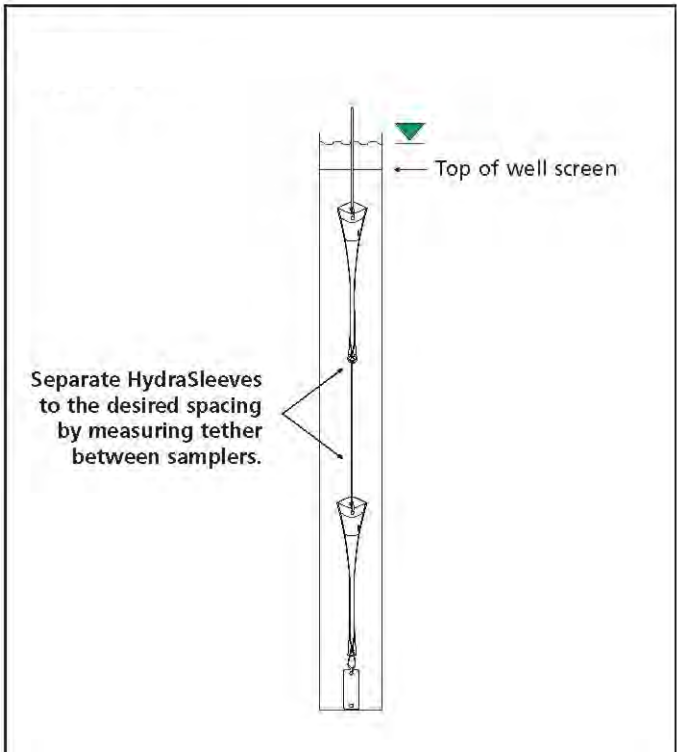


Figure 5. Alternative method for deploying multiple HydraSleeves.

In either case, when attaching multiple HydraSleeves in series, more weight may be required to hold the samplers in place in the well than would be required with a single sampler. Recovery of multiple samplers and collection of samples is done in the same manner as for single sampler deployments.

Post-Sampling Activities

The recovered HydraSleeve and the sample discharge tubing should be disposed as per the solid waste management plan for the site. To prepare for the next sampling event, a new HydraSleeve can be deployed in the well (as described previously) and left in the well until the next sampling event, at which time it can be recovered.

The weight and weight clip can be reused on this sampler after they have been thoroughly cleaned as per the site equipment decontamination plan. The tether may be dedicated to the well and reused or discarded at the discretion of sampling personnel.

References

McAlary, T. A. and J. F. Barker, 1987, Volatilization Losses of Organics During Ground-Water Sampling From Low-Permeability Materials, Ground-Water Monitoring Review, Vol. 7, No. 4, pp. 63-68

Parsons, 2005, Results Report for the Demonstration of No-Purge Ground-Water Sampling Devices at Former McClellan Air Force Base, California; Contract F44650-99-D-0005, Delivery Order DKO1, U.S. Army Corps of Engineers (Omaha District), U.S. Air Force Center for Environmental Excellence, and U.S. Air Force Real Property Agency

Robin, M. J. L. and R. W. Gillham, 1987, Field Evaluation of Well Purging Procedures, Ground-Water Monitoring Review, Vol. 7, No. 4, pp. 85-93

ATTACHMENT D

References

Parsons, 2005, Results Report for the Demonstration of No-Purge Ground-Water Sampling Devices at Former McClellan Air Force Base, California; Contract F44650-99-D-0005, Delivery Order DKO1, U.S. Army Corps of Engineers (Omaha District), U.S. Air Force Center for Environmental Excellence, and U.S. Air Force Real Property Agency

Robin, M. J. L. and R. W. Gillham, 1987, Field Evaluation of Well Purging Procedures, Ground-Water Monitoring Review, Vol. 7, No. 4, pp. 85-93