# Hydrogeologic Investigation at Well OSF-64R for the Central Florida Water Initiative

Osceola County, Florida

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# EXECUTIVE SUMMARY

As part of the Central Florida Water Initiative (CFWI; www.cfwiwater.com), the Data Monitoring and Investigations Team (DMIT) identified several areas as lacking adequate monitoring and information on the hydraulic properties of the subsurface, particularly in the deeper portions of the Floridan aquifer system (FAS) known as the Lower Floridan aquifer (LFA). Consequently, DMIT developed a work plan to construct and test new data collection sites to meet future data needs within the CFWI Planning Area and increase understanding of the LFA as an alternative water supply source. This report documents one component of that work plan: the exploratory drilling and construction of monitor well OSF-64R, located along the C-34 Canal at the OSF64R site (28°04’21.4, -81°16’46.7) in Osceola County, Florida.

Exploratory drilling at this site extended the existing OSF-64 well from 610 feet below land surface (ft bls) to a maximum depth of 1,500 ft bls. The completed and redesigned well was named OSF-64R. A partial borehole collapse after the final reaming restricted maximum depth to 1,487 ft bls. Work included wire-line coring, geophysical logging, hydraulic testing, and water quality sampling. Data from these activities were used to identify hydrogeologic unit boundaries and evaluate variations in water quality and rock permeability with depth (**Table ES-1**).

Table ES-1. Major hydrogeologic findings at OSF-64R.

| Hydrogeologic Unit | | Unit Boundary | | Mean TDS (mg/L) | Transmissivity* (ft²/day) |
|---|---|---|---|---|---|
| | | Top (ft bls) | Bottom (ft bls) | | |
| Upper Floridan Aquifer | UFA-upper | 290 | 350 | 178 | 3,000 |
| | APPZ | 587 | 1,169 | 161 | 38,000 |
| Middle Confining Unit | MCU_I | 1,169 | 1,303 | 399 | -- |
| | MCU_II | Absent | | -- | -- |
| Lower Floridan Aquifer | LFA-upper | 1,303 | No Data | 949 | 41,000 |

APPZ = Avon Park permeable zone; bls = below land surface; ft = foot; LFA-upper = upper Lower Floridan aquifer; MCU = middle confining unit; mg/L = milligrams per liter; OCAPlpz = Ocala-Avon Park low-permeability zone; TDS = total dissolved solids; UFA-upper = upper permeable zone of the Upper Floridan aquifer.
* Estimated from sum of packer test results for that interval.

Major findings from the hydrogeologic testing are summarized as follows:

- The base of the underground source of drinking water – where total dissolved solids (TDS) concentrations of water samples exceed 10,000 milligrams per liter (mg/L) – was not reached.
- Hydrogeologic unit boundaries for the Avon Park permeable zone (APPZ) and middle confining units were not close to pre-project projections based on the most recent hydrostratigraphic interpretation. The top boundary of the LFA-upper was very close to pre-project projections.
- Three flow zones were identified within the APPZ: APhpz-1 (587 to 748 ft bls), APhpz-2 (849 to 931 ft bls), and APhpz-3 (1,050 to 1,169 ft bls).
- APhpz-1 and APhpz-2 had identical Frazee water types (Fresh Recharge Water Type II), but APhpz-3 was Fresh Formation Water Type IV. All three flow zones were separated by some degree of confinement.
- Evaporitic facies of the middle confining unit known as MCU_II was absent.
- Two significant productive zones were identified within the LFA above 1,500 ft bls: LF1 (1,303 to 1,376 ft bls) and LF2 (1,465 to 1,500 ft bls).
- LF1 was the zone of highest TDS concentrations (average of 1,343 mg/L) and was dominated by sulfate, bicarbonate, and calcium. LF2 had much lower TDS concentrations (average of 648 mg/L) and was dominated by sodium, chloride, and sulfate.

OSF-64R was completed with an open-hole interval from 1,303 to 1,500 ft bls. A partial borehole collapse occurred after drilling and before geophysical logging, which resulted in the final open-hole interval of 1,303 to 1,487 ft bls.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µS | microsiemen |
| APhpz | Avon Park high permeability zone |
| APPZ | Avon Park Permeable Zone |
| bls | below land surface |
| CFWI | Central Florida Water Initiative |
| cps | counts per second |
| CTD | conductivity, temperature, and depth |
| District | South Florida Water Management District |
| DMIT | Data Monitoring and Investigations Team |
| DTW | depth-to-water |
| ECFTX | East Central Florida Transient Expanded (model) |
| FAS | Floridan aquifer system |
| FGS | Florida Geological Survey |
| ft | foot |
| gpm | gallons per minute |
| IAP | ion activity product |
| K | solubility product constant |
| LFA | Lower Floridan aquifer |
| MCU | middle confining unit |
| mg/L | milligrams per liter |
| NTU | nephelometric turbidity units |
| OBI | optical borehole imaging |
| OCAPlpz | Ocala-Avon Park low-permeability zone |
| PVC | polyvinyl chloride |
| SAS | surficial aquifer system |
| SCADA | supervisory control and data acquisition |
| SFWMD | South Florida Water Management District |
| SI | saturation index |
| TDS | total dissolved solids |
| UFA | Upper Floridan aquifer |
| XRD | X-ray diffraction |

# INTRODUCTION

Over the last several years, the South Florida Water Management District (SFWMD or District) has been working cooperatively with the Southwest Florida and St. Johns River water management districts, Florida Department of Environmental Protection, Florida Department of Agriculture and Consumer Services, and local stakeholders to evaluate the status of traditional water supplies and plan for the future of water supply in Central Florida. As part of this Central Florida Water Initiative (CFWI; www.cfwiwater.com), the Data Monitoring and Investigations Team (DMIT) identified several areas lacking adequate monitoring and information on the hydraulic properties of the subsurface, particularly in the deeper portions of the Floridan aquifer system (FAS). Consequently, DMIT developed a work plan for the construction and testing of new data collection sites to meet future data needs within the CFWI Planning Area. This report documents one component of that work plan: the exploratory drilling and monitor well construction at the existing OSF64 site (28°04'21.4, -81°16'46.7).

Located in Osceola County, the OSF64 site is on the northern bank of the District's C-34 Canal right-of-way, west of Canoe Creed Road and south of Lake Cypress Road (**Figure 1**). Wells OSF-64, OSF-65, OSS-64S, and OSS-64D were previously constructed at this location. OSF-64 was completed in 1991 to monitor the Upper Floridan aquifer (UFA). The well was cased to 310 feet below land surface (ft bls), near the top of the FAS, with an open interval to the total drilled depth of 610 ft bls. OSF-65 is a shallow UFA well with an open borehole from 310 to 418 ft bls. OSS-64S (alternate name of OSF-64_GW1) and OSS-64D (alternate name of OSF-64_GW2) were adjacent 2-inch polyvinyl chloride (PVC) wells finished in the surficial aquifer system (SAS). The SAS wells were abandoned during the modification of OSF-64 to OSF-64R.

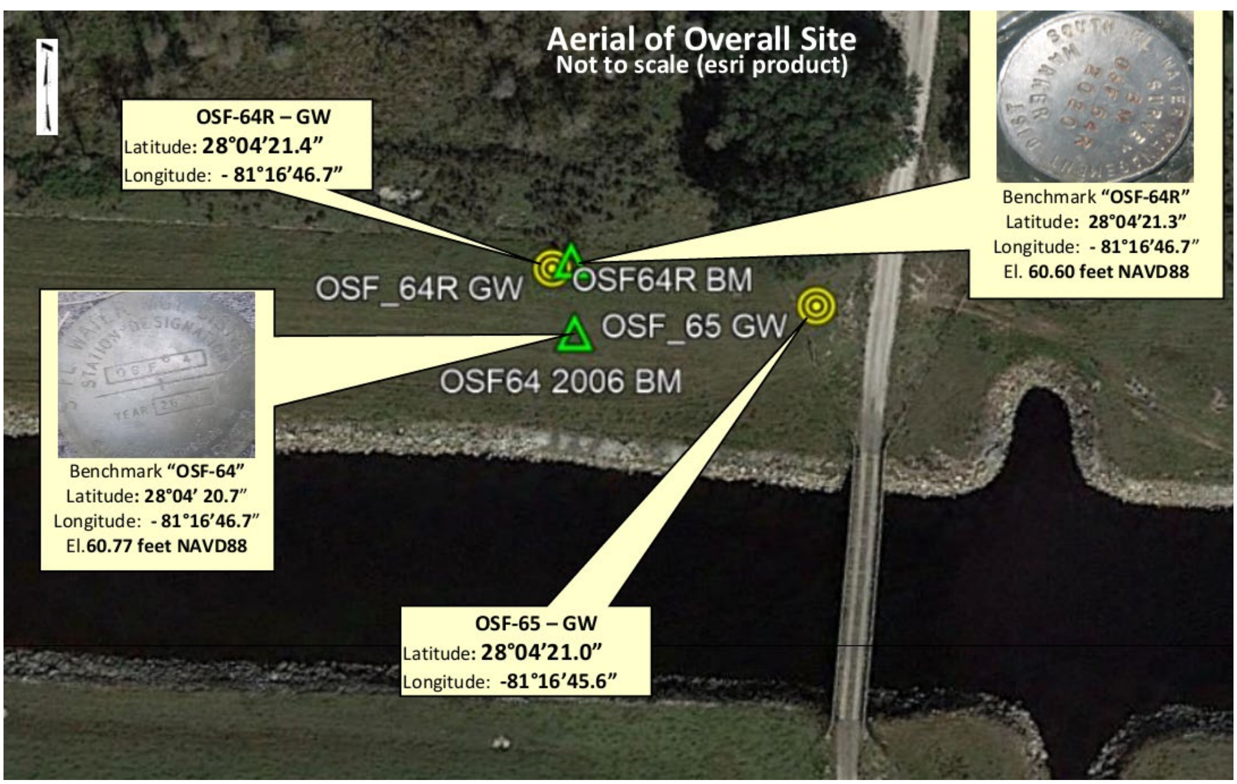


Figure 1. Location of monitor wells at the OSF64R site.

The similarity in site and well names warrants clarification on the nomenclature being used. The unhyphenated OSF64 is the name of the initial site where the well cluster is located. The hyphenated OSF-64 refers to the original well that was 610 ft deep. After the reconstruction detailed in the *Exploratory Coring and Well Construction* section of this report, well OSF-64 was renamed as OSF-64R. The new site, which now only includes wells OSF-64R and OSF-65, has been renamed from OSF64 to OSF64R.

## Project Objectives

Hydrogeologic data collection objectives include the following:

1. Evaluate the lithology, productivity, and water quality of the FAS from 610 to 1,500 ft bls.
2. Identify key hydrogeologic unit boundaries from the top of the Avon Park permeable zone (APPZ) to the top of the Lower Floridan aquifer (LFA).
3. Determine to what extent the evaporitic facies of the middle confining unit (MCU_II) is present at this site.

Monitoring objectives include the following:

1. Complete the new well (OSF-64R) to discretely monitor the upper permeable zone of the LFA (LFA-upper).
2. Install water level monitoring equipment at OSF-65 to complete it as a replacement monitor well in the upper permeable zone of the UFA (UFA-upper).
3. Reactivate the on-site supervisory control and data acquisition (SCADA) system to resume water level measurements.

# EXPLORATORY CORING AND WELL CONSTRUCTION

In November 2018, the SFWMD contracted Huss Drilling, Inc. for exploratory coring, packer testing, and monitor well construction services (CN#4600003906). Huss mobilized a Versa Drill 2000 drilling rig to the OSF64 site in August 2019 and commenced drilling of OSF-64R.

The existing OSF-64 well had a total depth of 610 ft bls and was cased to 310 ft bls with 8-inch PVC casing. Prior to drilling, 610 ft of 5-inch temporary steel casing was installed inside the PVC casing. From September 6 to October 24, a nominal 4-inch hole was advanced using wire-line core drilling in 10-ft increments from 610 to 1,500 ft bls. A Boart Longyear HQ series bit was used to produce 2.5-inch diameter rock cores. Thirty (off-bottom) packer tests were conducted during coring operations, at intervals ranging from 20 to 40 ft.

At 1,030 ft bls, coring was delayed due to rocks falling to the bottom of the borehole. After three airlifts, the borehole was reamed to 5 inches and a temporary 4-inch steel casing was installed to facilitate coring operations below 1,030 ft bls. As drilling continued, the temporary 4-inch casing was advanced to 1,100 ft bls. Upon achieving the final drilled depth of 1,500 ft bls, the borehole was reamed to 8 inches and developed to remove particulates from produced water.

Geophysical logs (caliper, gamma, normal resistivity, fluid resistivity, temperature, flow, sonic porosity, down-hole video, and optical borehole imaging [OBI]) were run in the reamed borehole. Geophysical logs reached a maximum depth of 1,487 ft bls due to a partial borehole collapse after reaming. The logs, cores, and packer tests were used to determine the top of the LFA-upper at 1,303 ft bls. A 4-inch diameter steel casing was set at 1,303 ft bls and tremie grouted in place, using cement baskets, to land surface. Gravel was used to fill in cavities and fractured intervals. An as-built construction diagram for OSF-64R is depicted in

**Figure 2**. On January 16, 2019, the well was completed, airlifted for 2 hours, then pumped at 78 gallons per minute (gpm) for 2 hours. Approximately five times the borehole volume was pumped out. Turbidity levels were less than 1 nephelometric turbidity unit (NTU), and pH and specific conductance were stable. A complete timeline of well construction operations is provided in **Appendix A**. A well completion report is provided in **Appendix B**.

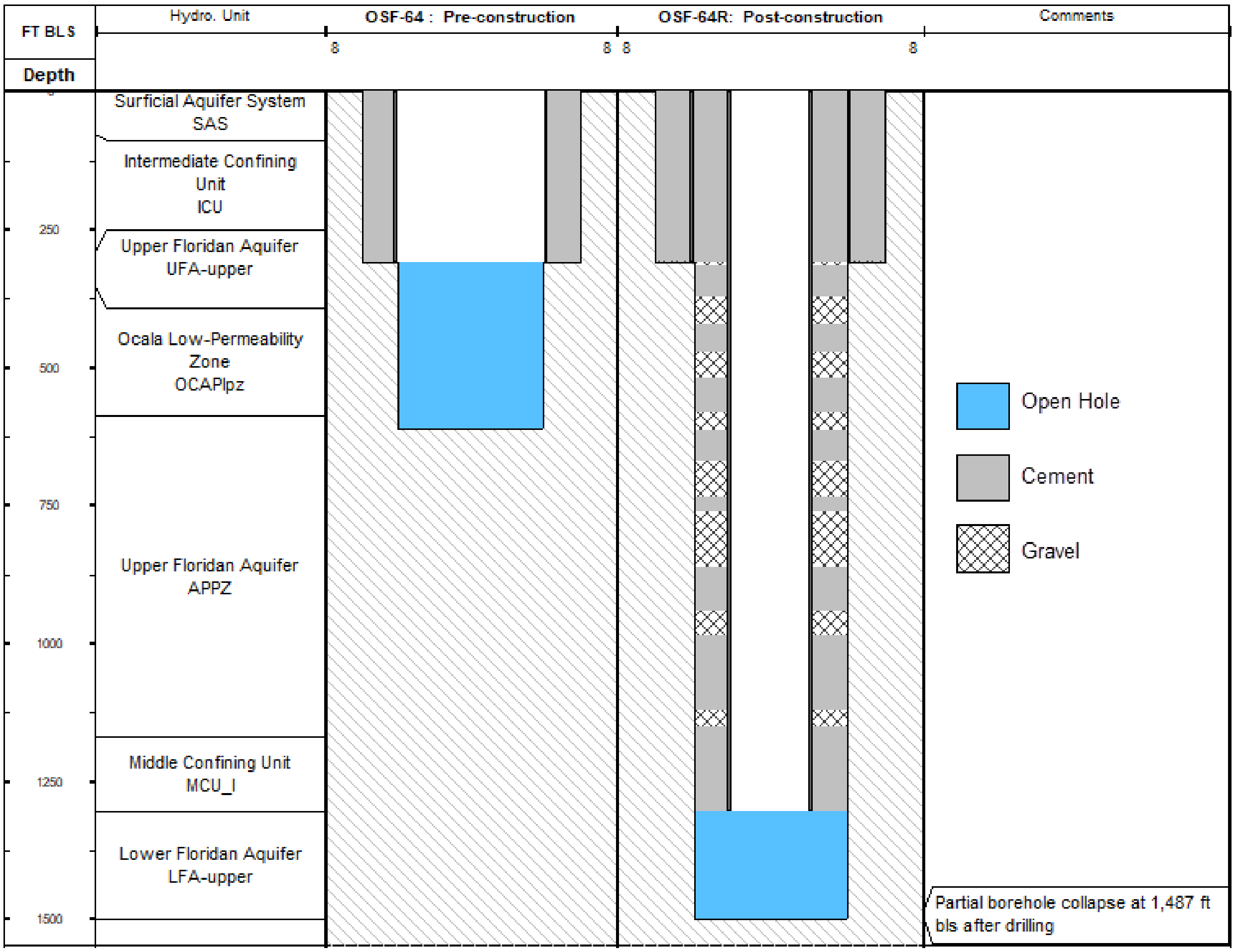


Figure 2. As-built construction diagram for the redesigned monitor well OSF-64R.

OSF-64R and OSF-65 were surveyed by SFWMD surveyors in February 2020 to provide precise locations and vertical references for depth-to-water (DTW) measuring points. **Figures 3** and **4** show the reference locations of surveyed measuring point elevations and wellheads of OSF-64R and OSF-65, respectively. **Figures 5** and **6** are close-ups of the brass tags. Metadata for the completed monitor wells are summarized in **Table 1**. In October 2020, both wells were incorporated into the District's SCADA network for real-time water level data collection. Well OSF-65 replaced OSF-64 as the UFA-upper monitor well, and OSF-64R is an LFA-upper monitor well.

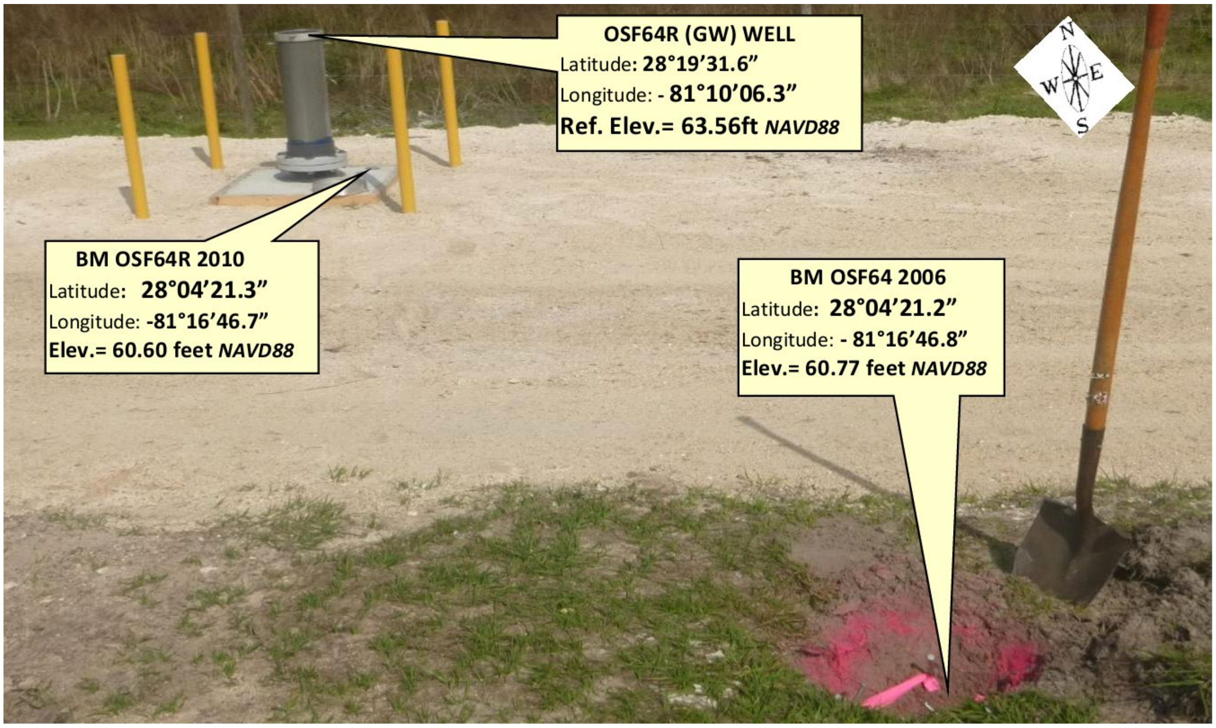


Figure 3. Completed wellhead, showing benchmark location and measuring point elevation for depth-to-water measurements for OSF-64R.


Figure 4. Completed wellhead, showing measuring point elevation for depth-to-water measurements for OSF-65.

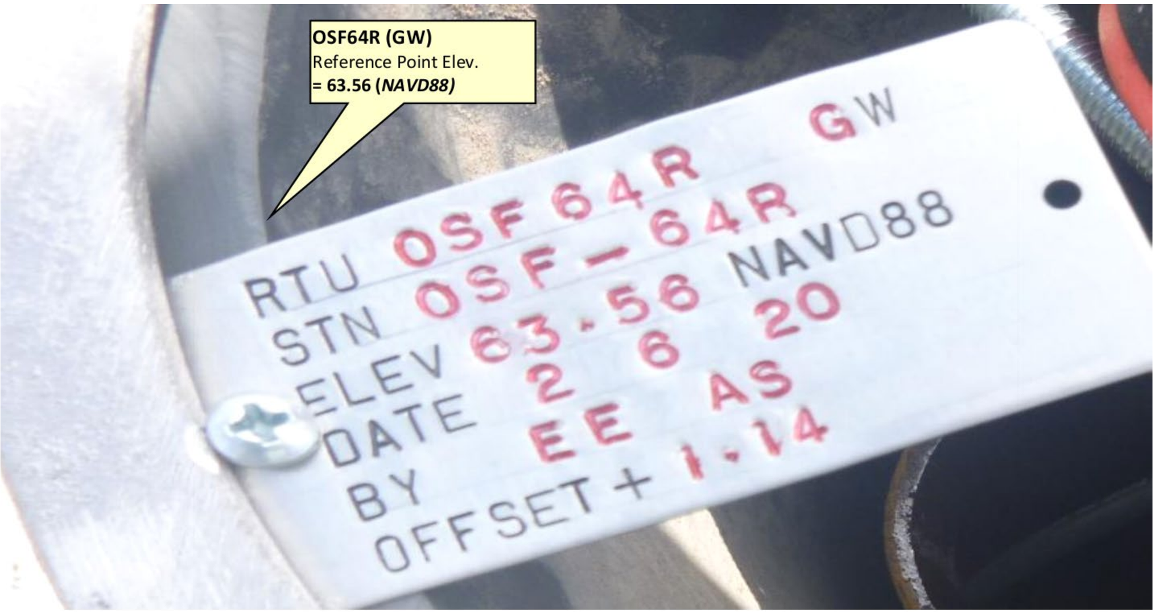


Figure 5. Close-up of brass tag and reference location for OSF-64R.


Figure 6. Close-up of brass tag and reference location for OSF-65.

Table 1. Metadata for the completed monitor wells at the OSF64R site.

| Well | Latitude | Longitude | Measuring Point Elevation (ft) | | Completed Depth | |
|---|---|---|---|---|---|---|
| | | | NAVD88 | NGVD29 | Cased Depth (ft bls) | Total Depth (ft bls) |
| OSF-65 | 28°04’21.0 | -81°16’45.6 | 62.11 | 63.25 | 310 | 418 |
| OSF-64R | 28°04’21.4 | -81°16’46.7 | 63.56 | 64.70 | 1,303 | 1,500 |

bls = below land surface; ft = foot; NAVD88 = North American Vertical Datum of 1988; NGVD29 = National Geodetic Vertical Datum of 1929.

## STRATIGRAPHIC FRAMEWORK

The SFWMD collected geologic formation samples (presented in **Appendix C**) from pilot holes during drilling of OSF-64R and described the samples based on the dominant lithologic, textural, and porosity characteristics using the expanded Dunham classification for carbonate rocks (Embry and Klovan 1971). Sampling methodology included wire-line core samples from 610 to 1,500 ft bls. Geophysical logs and OBI helped characterize the geologic features encountered during drilling. Examples of the features identified in the OBI are presented in **Figure 7**. **Appendix D** contains the complete OBI log. Lithology from ground surface to 610 ft bls comes from the Florida Geological Survey (FGS) lithology records, which are based on drill cuttings collected in 1991 during the construction of OSF-64. The FGS well number for OSF-64 is W-16953. In 2017, the formation picks were adjusted after reviewing the samples (Williams 2017). This technical publication follows the adjusted stratigraphy.

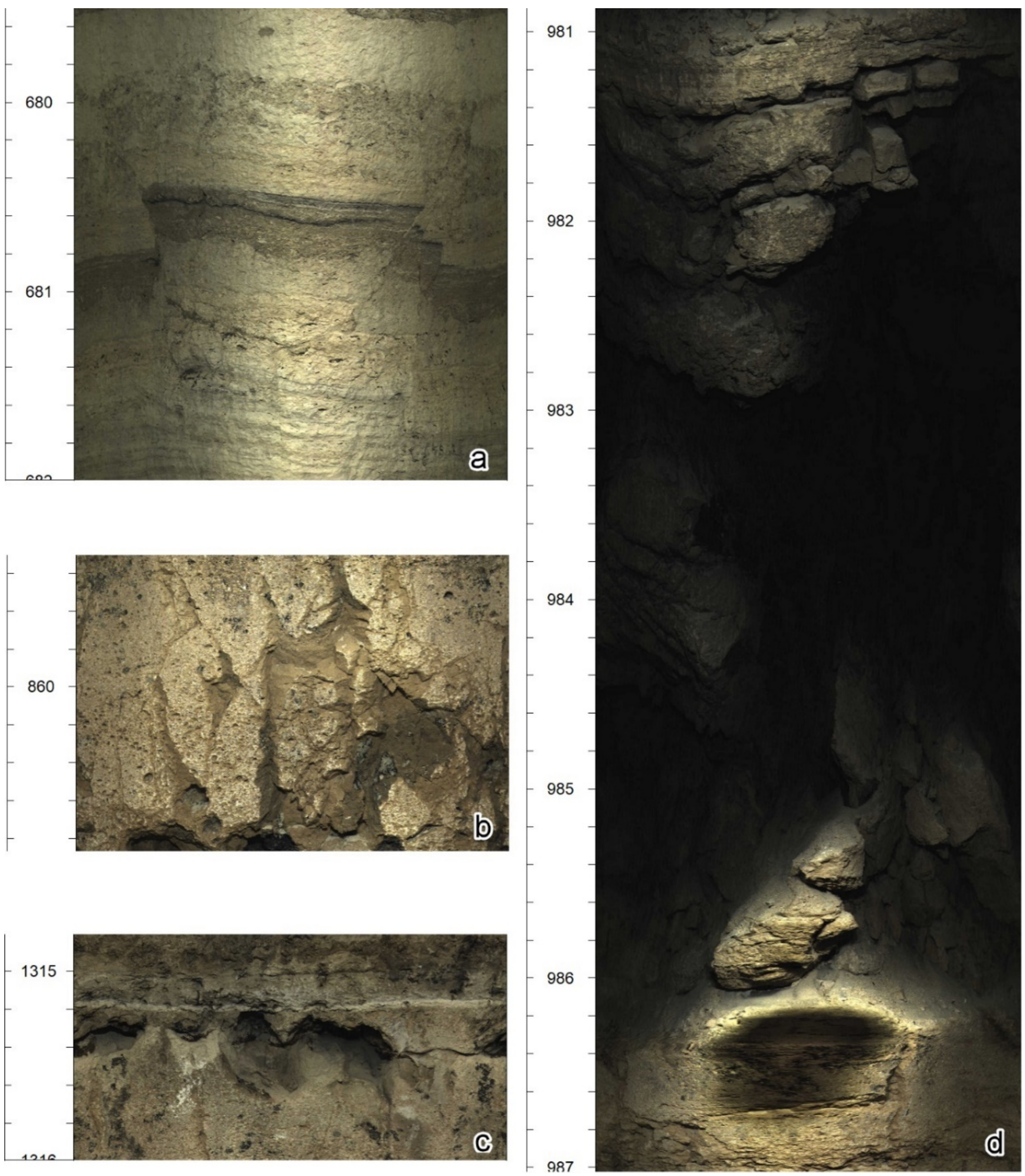


Figure 7. Geologic features present at OSF-64R: a) fault; b) fracture swarm; c) dissolution along horizontal fracture; and d) cavern.

## Holocene, Pleistocene, and Pliocene Series

Undifferentiated sediments of Quaternary age occurred from land surface to 70 ft bls in the samples. These undifferentiated sediments consisted of unconsolidated grayish orange to very light orange medium-grained quartz sand, poor to moderate indurated dark yellowish brown to yellowish brown sand cemented with clay and lime mud, with 1% to 2% phosphatic sand, organics, and fossil fragments.

Shell-bearing sediments occurred from 75 to 210 ft bls and consisted of light olive gray limestone with phosphate, quartz sand, silt, and clay. Fossils were abundant and included mollusks, fossil fragments, echinoid fossil molds, bryozoa, and barnacles. The sample had moderate to good induration. Shell fragments and medium quartz sand content increased with depth. There was moderate recrystallization of shell fragments and low to moderate intergranular porosity.

This interval (75 to 210 ft bls) was previously part of the Pliocene-Pleistocene unit, and the FGS lithologic log (Howell 1992) includes a comment that this unit will be named the Okeechobee Formation in the near future. Scott and Wingard (1995) proposed merging the Fort Thompson Formation, Bermont Formation, Caloosahatchee Formation, and Pinecrest Member of the Tamiami Formation into the Okeechobee Formation to solve the problem of these formations being determined through paleontology rather than lithology. When making new formation picks, the FGS characterized this interval as "shell-bearing sediments".

## Miocene Series

The Hawthorn Group is composed of clay, silt, calcareous clay, quartz sand, phosphatic sand, shell, limestone, and dolostone. The deposition of the Hawthorn Group occurred in shallow to moderately deep marine waters where deposition rates of clastic material were high. The prevalence of phosphate grains suggests these deep marine waters were colder than during the deposition of older units (Miller 1986). Scott (1988) brought the Hawthorn Formation to group status in Florida, and it consists of two formations: Peace River Formation and Arcadia Formation.

### *Peace River Formation*

Peace River Formation sediments occurred from 210 to 235 ft bls and consisted of light olive gray quartz sand, sandstone, dolomite, and dolosilt with phosphate pebbles and shell fragments. Induration was unconsolidated to poor, and porosity was moderate moldic and intergranular.

### *Arcadia Formation*

In the samples from 235 to 290 ft bls, the Arcadia Formation was composed of light olive gray dolosilt matrix with phosphate, calcarenite, quartz sand, and shell fragments. Phosphate, calcarenite, and quartz sand grains decreased in size and abundance with depth. Induration was poor, and porosity was moderate. Geophysical logs showed high gamma ray activity associated with this interval.

## Oligocene Series

### *Suwanee Limestone*

Suwanee Limestone was not present at this location.

## Eocene Series

### *Ocala Limestone*

The Upper Eocene Ocala Limestone occurred at a depth of 290 to 355 ft bls. Lithology consisted of poorly to moderately indurated, yellowish gray to very light orange grainstone to limestone with moderate porosity. The FGS lithology describes the occurrence of *Nummulites*, *Lepidocyclina*, mollusk fragments, and bryozoans (Howell 1992).

The Ocala Limestone was deposited on a warm, shallow, carbonate bank, similar to the modern day Bahamas (Miller 1986). This low-energy environment probably had low to moderate water circulation (Tucker and Wright 1990).

### *Avon Park Formation*

The top of the Middle Eocene Avon Park Formation was determined to be at 355 ft bls. An increase in gamma ray activity often is associated with the top of the Avon Park Formation but was not observed at this site (Bryan et al. 2011). Therefore, the appearance of *Fallotella cookei* (formerly *Dictyconus cookei*) was used as a diagnostic fossil for the Avon Park Formation. The depositional environment of the Avon Park Formation was a carbonate bank with shallow warm water (Miller 1986). The base of the Avon Park Formation was not observed.

From approximately 355 to 490 ft bls, lithology consisted of very pale orange packstone with poor induration and moderate porosity. This interval had abundant fossils on the top and graded to less abundant with depth. Fossils included *Nummulites*, *Lepidocyclina*, *Fallotella cookei*, and recrystallized echinoids. From 490 to 570 ft bls, lithology consisted of very light orange wackestone with poor induration and moderate porosity. This interval contained recrystallized shell fragments and fossils as well as slight dolomitization. From 570 to 580 ft bls, lithology changed to a very light orange packstone with poor induration and moderate porosity. Foraminifera and gastropods were found in the sample. From 580 to 610 ft bls, lithology consisted of a yellowish gray, moderately indurated, moderate-to-low porosity dolomite. The sample was moderately dolomitized and minimal biodebris was reported.

The interval described for installation of OSF-64R includes 610 through 1,500 ft bls. The interval from 610 to 702 ft bls was composed of very pale orange to pale yellowish brown, well indurated interbeds of foraminiferal wackestone and packstone with some minor mudstone and dolostone and predominantly low to moderate intergranular porosity. Bivalves and gastropod fossils were present with undifferentiated foraminifera. The interbeds averaged approximately 2 ft thick, with the thickest being 5.4 ft. Laminations were described in many of these interbeds.

Multiple features of secondary permeability were observed in the OBI log for the interval from 610 to 702 ft bls. From 634 to 647 ft bls, there were fracture swarms and up to 5 ft of solution-enhanced fractures. Brecciated zones were observed from 677 to 679 ft bls and from 687 to 693 ft bls. The OBI log recorded three faults (e.g., **Figure 7a**) and moderate fracturing from 693 to 702 ft bls.

From 702 to 1,500 ft bls, the lithology ranged from microcrystalline dolostone to microcrystalline calcareous dolostone, with changes in porosity, permeability, and other features.

From 702 to 770 ft bls, the lithology consisted of moderate yellowish brown dolostone with low to moderate porosity and good induration. Secondary permeability features were frequent and included brecciation, fracture swarms, bedding plane fractures, open fractures, and solution-enhanced fractures. An interval of no recovery (707.8 to 710 ft bls) represented a cavity, which could be the result of fracturing. Visible flow in the borehole was observed from 733 to 735 ft bls.

From 770 to 786 ft bls, the lithology was well indurated, grayish orange dolostone with little or no pinpoint porosity observed. Two fracture swarms were noted in the OBI log.

From approximately 786 to 849 ft bls, the lithology was grayish orange to pale yellowish brown microcrystalline dolostone with good induration and low to moderate porosity. The porosity type was primarily pinpoint, but some vugs and molds were present. A moderate number of fractures were found. Laminations were observed on the OBI log from 837 to 846 ft bls.

From approximately 849 to 926 ft bls, the lithology consisted of grayish orange to moderate yellowish brown, well indurated dolostone. Porosity increased from the previous interval to moderate or high pinpoint, vuggy and moldic porosity. The OBI log showed several bedding plane fractures, fracture swarms (e.g., **Figure 7b**), cavities, and brecciation. There was no recovery for the following intervals: 849.3 to 850 ft bls, 899.3 to 900 ft bls, 910.8 to 912 ft bls, and 919.4 to 920 ft bls, which correspond to cavities in the OBI log. One large cavity was recorded from 904.5 to 916 ft bls.

From approximately 926 to 1,169 ft bls, the lithology was grayish orange to moderate yellowish brown microcrystalline dolostone with moderate to good induration and low to moderate porosity. Laminations and organics were noted. Porosity was predominantly pinpoint, but vugular and moldic porosity was also often described. Fractures and sections of no recovery were frequent. Several large cavities were found in the borehole video and OBI log. **Figure 7d** shows the cavern from 982 to 987 ft bls, which was determined to be the result of borehole collapse. Brecciation, cavities, and borehole washouts were identified between 1,050 and 1,169 ft bls.

From 1,169 to 1,280 ft bls, the lithology changed with the inclusion of gastropod fossils, wormholes, and foraminifera in grayish orange to pale yellowish brown microcrystalline dolostone. Induration was moderate to good, and porosity was low to moderate. A large translucent mineral was found at 1,271.6 ft bls. X-ray diffraction (XRD) analysis determined it to be celestine. Pinpoint porosity was the dominant porosity type, though vugular and moldic porosity were more prevalent compared to the preceding interval. Fracturing was primarily from bedding plane fractures.

Lithology changed from dolostone to calcareous dolostone between 1,280 and 1,303 ft bls. The sample was grayish orange to pale yellowish brown and had moderate to good induration, a microcrystalline texture, and low to moderate pinpoint and vuggy porosity. Gastropod fossils and wormholes were identified. Calcite crystals were identified in vugs.

From 1,303 to 1,393 ft bls, the lithology changed to very pale orange to dark yellowish brown microcrystalline dolostone with low to moderate pinpoint, vuggy, and moldic porosity and moderate to good induration. Calcite crystals were found in vugs from 1,320 to 1,324 ft bls and 1,378 to 1,388 ft bls. Secondary permeability features were frequent, with most being dissolution along bedding planes (e.g., **Figure 7c**) and thin layers of organics. A brecciated zone approximately 5 ft thick with irregular boreholes was present at 1,308 ft bls.

From 1,393 to 1,403 ft bls, the lithology consisted of dark yellowish brown microcrystalline dolostone with moderate to low pinpoint and vuggy porosity and moderate induration. This interval was heavily laminated with organics. Geophysical logs showed a large spike in gamma ray activity correlated with these organics. Fractures mostly consisted of bedding plane fractures.

From 1,403 to 1,500 ft bls, the lithology was moderate to dark yellowish brown microcrystalline and sucrosic dolostone with moderate to good induration and moderate to high pinpoint, vuggy, and moldic porosity. The dolomite in this interval was more dolomitized and recrystallized than in shallower intervals. Few fractures were observed, except for solution-enhanced fractures from 1,459 to 1,460 ft bls and 1,474 to 1,476 ft bls. Several cavities were noted in the OBI log. The OBI ended at 1,481 ft and geophysical logs ended at 1,487 ft bls due to borehole collapse in a large, brecciated cavity from 1,483 to 1,487 ft bls.

# HYDROGEOLOGIC FRAMEWORK

The two aquifer systems intersected by OSF-64R are the SAS and FAS, with the FAS being the primary subject of this report. The FAS can be subdivided into aquifers of moderate to high permeability where dissolution features and fractures are common. These aquifers are separated by zones of low permeability that offer varying degrees of confinement. The nomenclature assigned to these aquifers and confining units varies in the literature. **Figure 8** depicts a comparison of these different nomenclatures.

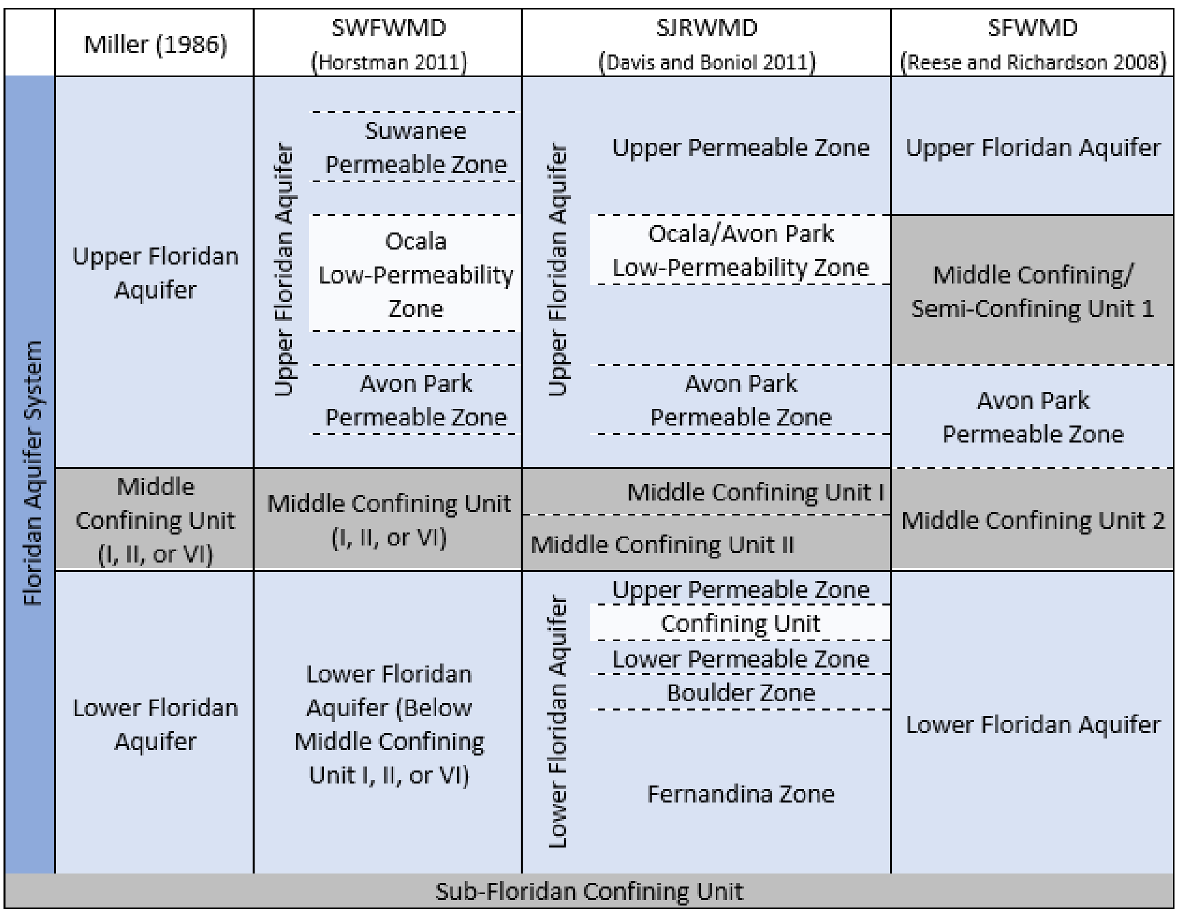

Figure 8. A nomenclature comparison of the hydrogeologic units of within the Floridan aquifer system.

To remain consistent within the CFWI Planning Area, the cooperating water management districts agreed on a slightly modified hydrogeologic conceptualization (**Figure 9**) as the basis for development of the East Central Florida Transient Expanded (ECFTX) groundwater model, which is being used to evaluate groundwater availability in the region. As a component of the CFWI, this report follows the same convention for the units intersected by the exploratory drilling at OSF-64R. A representative hydrogeologic section, with hydrogeologic units conforming most closely to the OSF64R site is presented in **Figure 10**.

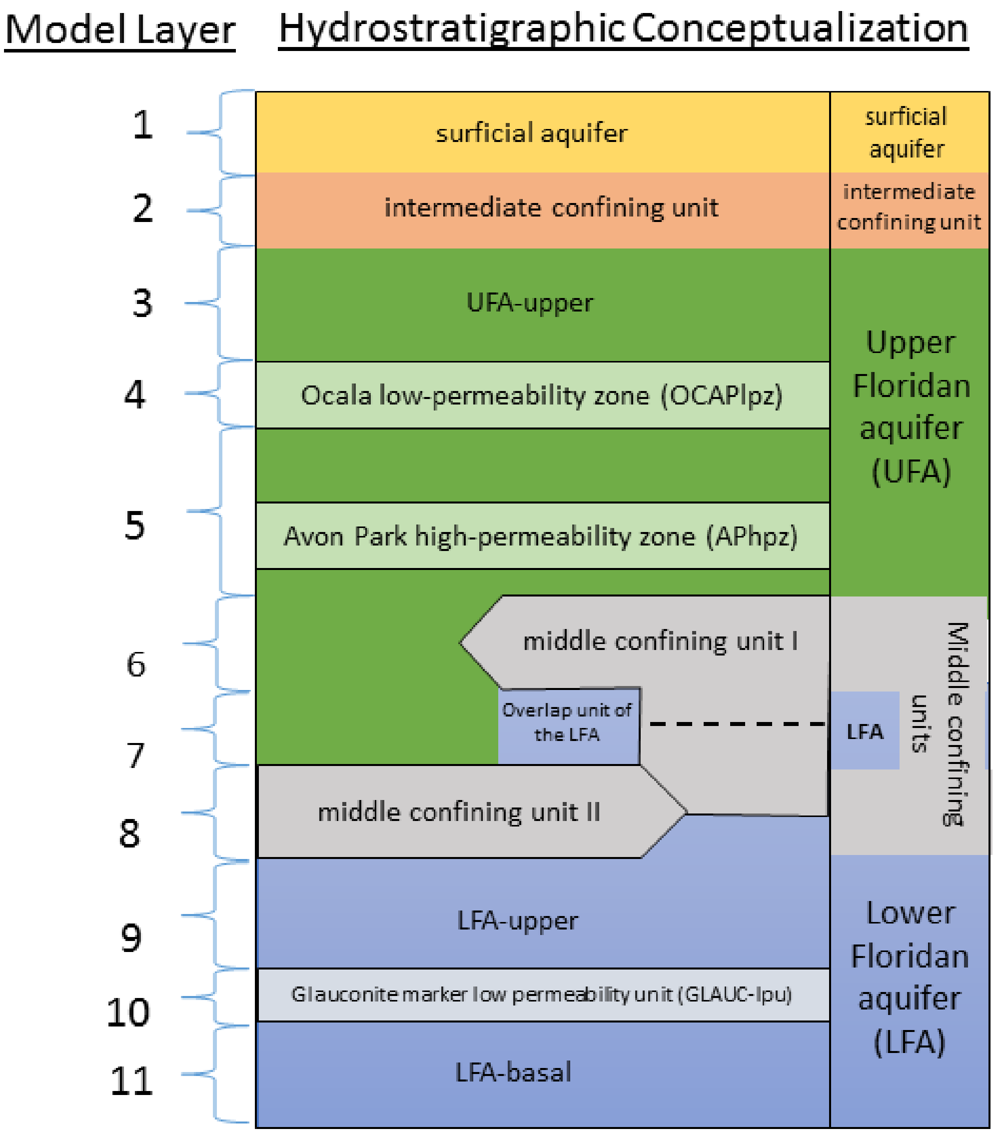


Figure 9. Hydrogeologic conceptualization and vertical discretization of the East Central Florida Transient Expanded (ECFTX) Model (From: Central Florida Water Initiative Hydrologic Assessment Team 2016).

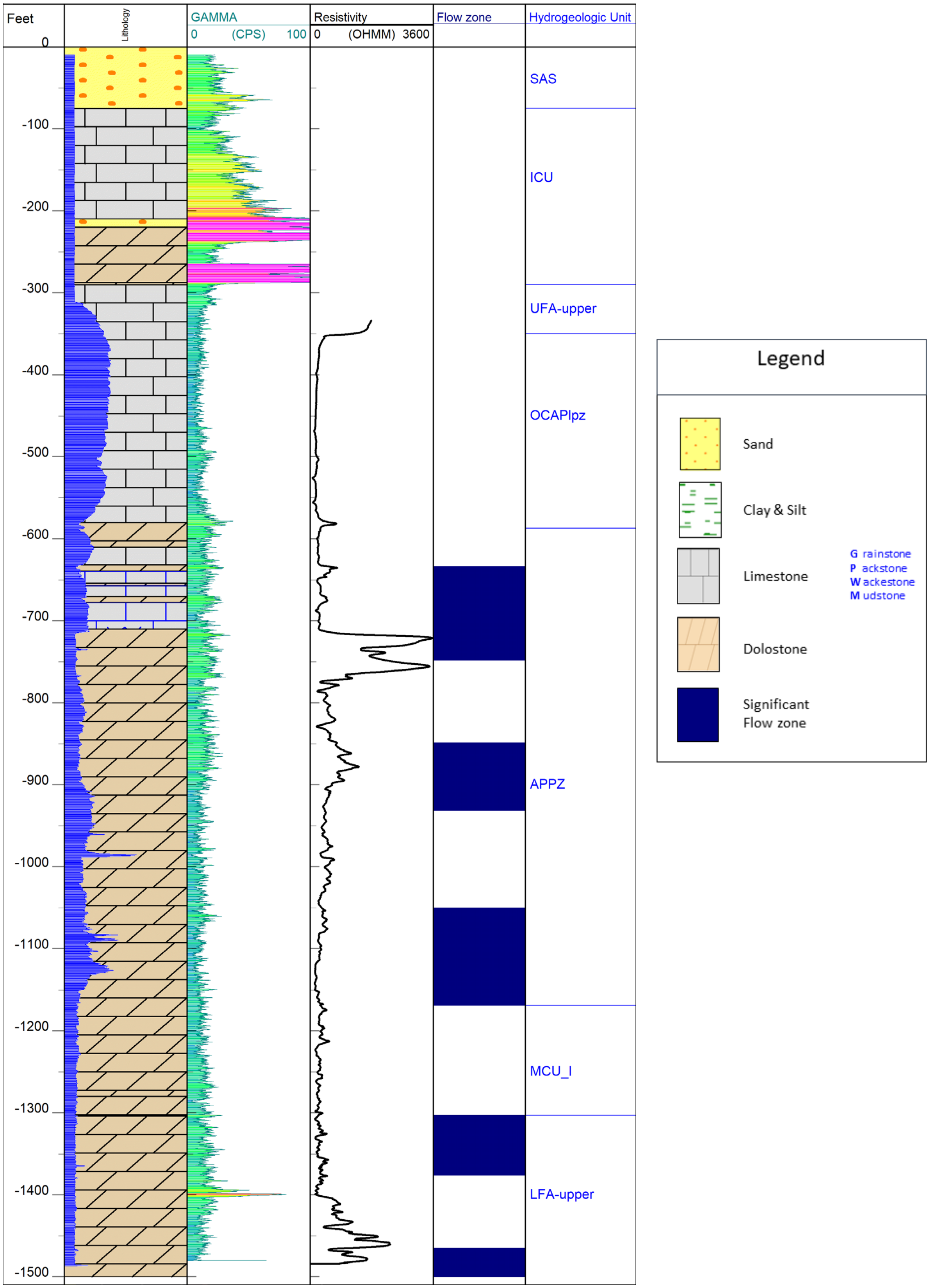


Figure 10. Representative hydrogeologic section for the OSF64R site. Caliper log deviation from nominal bit diameter is overlain on the lithologic column.

## Surficial Aquifer System

The SAS at the OSF64R site consists of quartz sand, organics, and shell. The top of the Hawthorn Group typically is selected as the base of the SAS, but lower-permeability sediments frequently are found at much shallower depths, so the base of this unit is gradational. The hydraulics of part of the SAS were tested during an aquifer performance test conducted in 2008. A transmissivity of 146 $ft^2$/day and hydraulic conductivity of 2.9 ft/day were determined for the tested interval (13 to 23 ft bls). With partial hydraulic information, lithology, and geophysical data, the top of the Hawthorn Group was selected as the base of the SAS, at 75 ft bls.

## Intermediate Confining Unit

The intermediate confining unit separates the SAS from the FAS. From 75 to 290 ft bls, the intermediate confining unit corresponds to the entire Hawthorn Group and is composed of light olive gray limestone and dolomite with fossils, phosphate, dolosilt, quartz sand, silt, and clay. This interval is part of the original OSF-64 well and was not tested during drilling of OSF-64R.

## Floridan Aquifer System

The FAS consists of a series of Tertiary-age limestones and dolostone units. At the OSF64R site, the FAS includes the Ocala Limestone and Avon Park Formation. The base of the FAS occurs in the Paleocene Cedar Keys Formation, not penetrated at the OSF64R site, which includes massive beds of gypsum and anhydrite (Miller 1986).

The hydrogeologic units within the FAS at the OSF64R site were delineated based on the exploratory coring, drilling, and geophysical logging of OSF-64R; hydraulic and water quality analyses from 30 off-bottom packer tests conducted during coring of OSF-64R; and previously gathered lithologic and geophysical log data from the existing well OSF-64. **Figure 11** summarizes some of the hydraulic and water quality analyses by showing the hydraulic conductivity, water level offset, specific conductance, and hydrogeologic units. Each packer test spans an interval of approximately 30 ft. The water level offset is the difference between the water level of a nearby well (OSF-112) and the water level of OSF-64R after a packer test that has been allowed to fully recover.

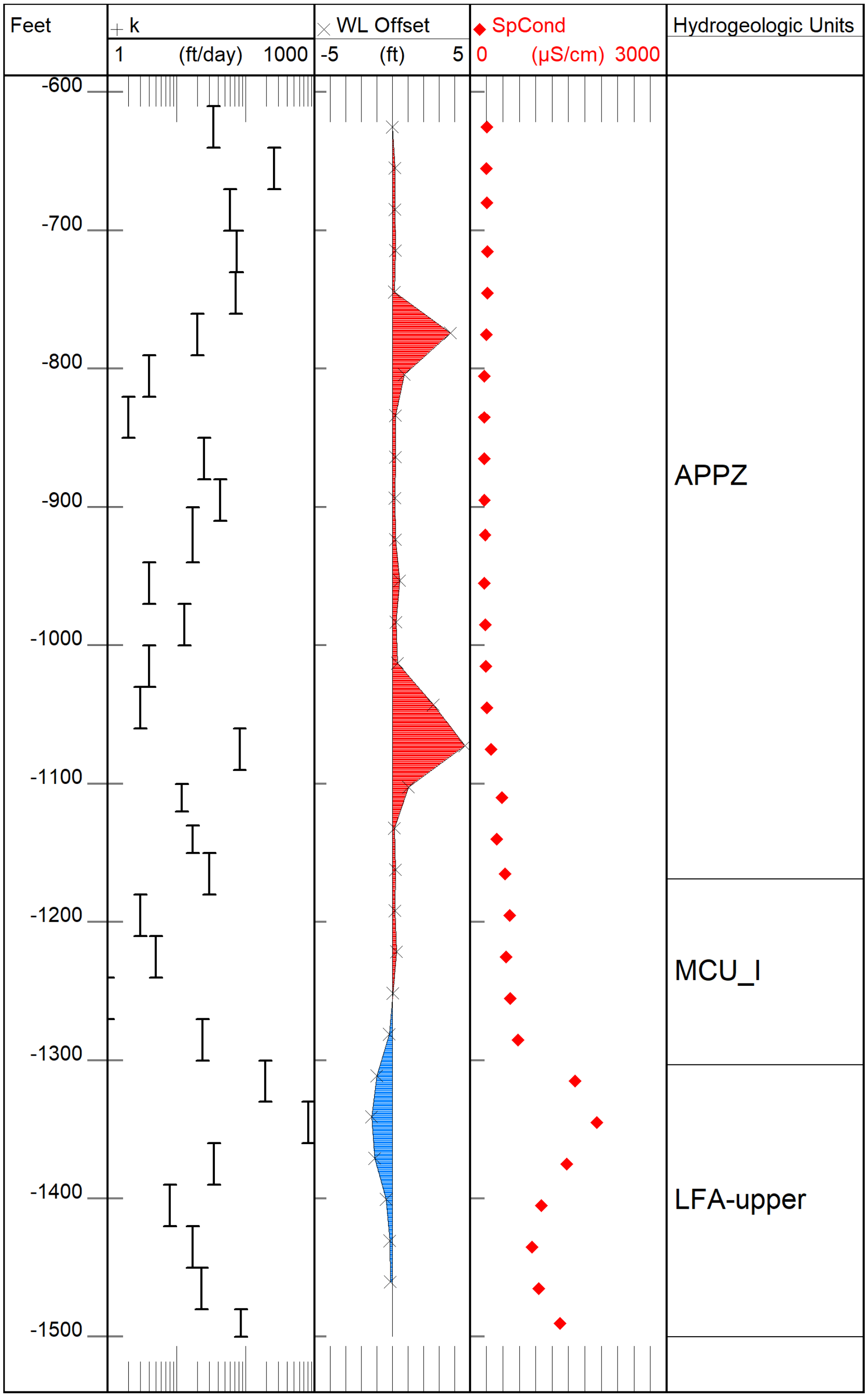


Figure 11. Specific conductance (SpCond), water level offset (WL Offset), and hydraulic conductivity (k) with depth, from off-bottom packer testing in OSF-64R. The vertical bars in the k column represent the interval tested. Water level offset equals packer test water level minus water level of the reference well (OSF-112). Red is positive offset and blue is negative offset.

### *Upper Floridan Aquifer*

The UFA generally occurs at the base of the Hawthorn Group, though it may include permeable units within the lower Arcadia Formation. It includes the Suwanee Limestone, where present; the Ocala Limestone; and portions of the Avon Park Formation. The UFA generally consists of several thin, highly permeably water-bearing zones interbedded with thicker zones of lower permeability. The CFWI Hydrologic Assessment Team (2016) used three regionally mappable units to represent the vertical heterogeneity of the UFA: UFA-upper, Ocala-Avon Park low-permeability zone (OCAPlpz), and Avon Park high-permeability zone (APhpz).

#### UFA-upper (290 to 350 ft bls)

The UFA-upper is the uppermost permeable zone of the FAS. It is predominantly limestone and characterized by intergranular, vuggy or moldic porosity and well-developed secondary porosity (Davis and Boniol 2011). This flow zone often is observed at the contact between the Hawthorn Group and Ocala Limestone. At the OSF64 site, the UFA-upper was identified at 290 ft bls, at the first occurrence of consolidated limestone below the clayey sands and dolosilt of the Hawthorn Group. With a lack of packer testing for this interval, the base of the UFA-upper was determined to be 350 ft bls based on increased flow in borehole flowmeter data and vuggy appearance in the borehole video and the OBI logs.

The UFA-upper is highly productive in the northern portion of the CFWI Planning Area, but productivity tends to decline to the south. Reported transmissivity of the UFA-upper ranges from less than 10,000 to more than 100,000 $ft^2$/day in the greater Central Florida area (CFWI Hydrologic Assessment Team 2016). An aquifer performance test conducted after construction of OSF-65 provided a transmissivity of 2,684 $ft^2$/day for the interval between 310 and 610 ft bls, which partially overlaps the UFA-upper (Butler 1992).

#### OCAPlpz (350 to 587 ft bls)

The OCAPlpz is distinguished from the UFA-upper by a reduction in secondary permeability, which provides most of the productive capacity of the UFA-upper. At the OSF64 site, the OCAPlpz is composed of packstone and wackestone. It tends to be less consolidated than the overlying UFA-upper, as indicated by the large washout on the caliper log throughout the interval. No packer tests were performed in this interval. The OCAPlpz depths were determined through flowmeter data, borehole video, and OBI logs. Flow through the interval had relatively little fluctuation and came from the UFA-upper flowing down borehole to an aquifer of lower head. Borehole video and OBI logs showed a reduction in vugs and abundant laminations and bedding boundaries.

#### APhpz (587 to 748, 849 to 931, and 1050 to 1,169 ft bls)/APPZ (587 to 1,169 ft bls)

Reese and Richardson (2008) described the APPZ as a regionally mappable, high-permeability zone within the Avon Park Formation, characterized by dolostone or interbedded dolostone and dolomitic limestone with a high degree of secondary permeability. The permeability primarily is associated with fracturing, but cavernous or karstic, intergranular, and intercrystalline permeability also can be present. As mapped by Reese and Richardson (2008), the APPZ included all materials from the base of the OCAPlpz to the top of the middle confining unit (MCU). The CFWI Hydrologic Assessment Team (2016) used the term APhpz to distinguish the most productive fractured intervals. In **Figure 9**, the APPZ is equivalent to ECFTX model layer 5, while the APhpz is a subset of that unit.

The top 123 ft of the APPZ at the OSF64 site is composed of interbedded wackestone and packstone, with minor layers of mudstone and dolostone. The lower 459 ft is dolostone and calcareous dolostone. Flow is centered around regions of abundant fractures and dissolution along bedding planes, with the first fracture swarm found at 587 ft bls. The geophysical logs showed high formation resistivity and large variability in sonic porosity.

The APhpz is represented by three flow zones at heavily fractured intervals from 587 to 748 ft bls (APhpz-1), 849 to 931 ft bls (APhpz-2), and 1,050 to 1,169 ft bls (APhpz-3). Hydraulic conductivity (k) ranged from 58 to 436 ft/day in APhpz-1 (packer tests 1 to 5), 28 to 73 ft/day in APhpz-2 (packer tests 9 to 11), and 21 to 138 ft/day in APhpz-3 (packer tests 16 to 19). Using the mean hydraulic conductivity for the fractured intervals, the transmissivity for each flow zone is shown in **Table 2**. In the remainder of the APPZ, the tested hydraulic conductivity ranged from 3 to 21 ft/day. Packer test 13 (970 to 1,000 ft bls), which had a hydraulic conductivity of 21 ft/day, is described in the lithology has having low to moderate vuggy and pinpoint porosity. Within this packer test interval is a cavern from borehole collapse between 982 and 987 ft bls. The cavern had increased flow based on the flowmeter data, which likely skewed the packer test. The packer test results represent horizontal hydraulic conductivity over 30-ft intervals, which can easily be skewed by a single fracture or solution feature. The hydraulic conductivity is likely influenced by the flow from this cavern and is not representative of the entire tested interval.

Table 2. Hydraulic details on the individual flow zones within the Avon Park permeable zone at OSF-64R.

| Flow Zone | Interval (ft bls) | | Packer Tests | Mean Hydraulic Conductivity (ft/day) | Transmissivity[a] ($ft^2$/day) |
|---|---|---|---|---|---|
| | From Depth | To Depth | | | |
| APPZ bulk[b] | 587 | 1,169 | 1 to 18 | 69.40 | 38,000 |
| APhpz-1 | 587 | 748 | 1 to 5 | 166.89 | 26,000 |
| APhpz-2 | 849 | 931 | 9 to 11 | 47.31 | 5,000 |
| APhpz-3 | 1,050 | 1,169 | 16 to 19 | 59.65 | 7,000 |

APPZ = Avon Park permeable zone; APhpz = Avon Park high-permeability zone; ft = foot; bls = below land surface.
[a] Transmissivity is rounded to the nearest thousand due to the homogeneity of transmissivity and its order of magnitude being more descriptive of an aquifer than the exact calculated value.
[b] APPZ values were calculated starting at 610 ft bls due to a lack of hydraulic data for 587 to 610 ft bls.

The degree of hydraulic connection between fracture sets in the APPZ is a subject of some interest and debate within the CFWI Planning Area. Some exploratory sites within the SFWMD have shown strong evidence for hydraulic connection between fracture sets, while other data have been more ambiguous. At OSF-64R, there are two distinct water types in the APPZ. From 610 to 1,060 ft bls, the water is Fresh Recharge Water Type II and from 1,060 to 1,180 ft bls, the water is Fresh Formation Water Type IV, based on Frazee (1982). Water levels measured during packer testing indicated three packer test intervals with large changes in water level occurred within the APPZ, suggesting intervals of lower-permeability material between flow zones. Packer test 6 (760 to 790 ft bls) had a 4.6-ft head difference and marked a separation between APhpz-1 and APhpz-2. Packer tests 15 (1,030 to 1,060 ft bls) and 16 (1,060 to 1,090 ft bls) reflected a change in head between APhpz-2 and APhpz-3 of 3.6 and 5.6 ft, respectively, suggesting each layer is hydraulically separated by lower-permeability materials. APhpz-1 and APhpz-2 have the same ionic profile, so it is possible they are regionally connected or have water with similar flow paths and histories. APhpz-3 is ionically similar to MCU_I. When considering the lower-permeability rock between it and the upper two flow zones, local hydraulic separation can be concluded. There is not enough information to determine a regional level of hydraulic separation between APhpz-3 and APhpz-2.

### *Middle Confining Unit*

The MCU divides the UFA and LFA. Miller (1986) defined the MCU and subdivided it into eight regional units designated by roman numerals I to VIII. The CFWI Hydrologic Assessment Team (2016) recognized two of these units (MCU_I and MCU_II) as composing the MCU within the ECFTX model domain. MCU_I, which ranges in lithology from dolostone to micritic limestone, is the leakier of the two units. The dolomitic limestone of MCU_II is characterized by the occurrence of evaporites as beds or pore in-fillings, which greatly reduces permeability. MCU_I, the shallower unit, is absent from the western portion of the ECFTX model domain, while MCU_II is absent from the eastern portion. Along the western reaches of the Kissimmee River valley and Lake Wales Ridge, the two units overlap each other, greatly increasing the thickness of the MCU in the region. MCU_II was not encountered at the OSF64R site.

#### MCU_I (1,169 to 1,303 ft bls)

Compared to the APPZ, the MCU_I formation rock is similar to the APhpz-3, with moderate to well indurated dolostone and calcareous dolostone. Porosity is low to moderate, and secondary permeability is from dissolution along bedding planes, which tend to be less permeable than other types of secondary permeability. At 1,271.6 ft bls, a large celestine crystal was identified, and from 1,280 to 1,303 ft bls, brown calcite crystals were found growing inside the vugs.

Four packer tests (20 through 23) were completed entirely within MCU_I. These yielded hydraulic conductivity estimates from 2.2 to 40.63 ft/day and an average of 14 ft/day. Packer test 23 had the highest permeability and is an interval of transition into the LFA-upper. The static flow station at 1,280 ft bls recorded -256 revolutions per minute in the borehole flowmeter log. At 1,295 ft bls, downward flow strengthened to -349 revolutions per minute. This marks a region of increased flow at the base of packer test 23, but water levels and water quality were consistent with the rest of MCU_I.

Matrix permeability was very low. Three rock core samples from the lower portion of the interval (1,274 to 1,297 ft bls) had an average porosity of 27%, but all yielded permeabilities of less than 0.1 ft/day. There was a gradual increase in total dissolved solids (TDS) concentrations (277 to 492 milligrams per liter [mg/L]) with depth, but these values are low, and the groundwater is considered fresh. Strontium concentrations also increased (32.1 to 54.7 mg/L) across MCU_I and were the highest measured concentrations for OSF-64R. The base of MCU_I in OSF-64R is marked by an abrupt increase in TDS concentrations and abrupt decrease in strontium concentrations.

### *Lower Floridan Aquifer*

The LFA consists of a sequence of permeable zones separated by lower-permeability units. One or two of these permeable zones, such as the Boulder Zone of south and east-central Florida, are regionally mapped units. In most cases, however, the availability and distribution of deep well data are not sufficient to establish continuity of permeable zones between wells. Literature values show the LFA to be more than 1,000 ft thick within the CFWI Planning Area. This thickness includes highly productive zones and inter-aquifer confining units as well as salinities ranging from fresh to seawater.

For the ECFTX model, the LFA was subdivided into upper (LFA-upper) and basal (LFA-basal) permeable zones, separated by the regionally mappable glauconite marker low-permeability unit (CFWI Hydrologic Assessment Team 2016). The exploratory corehole at the OSF64 site was terminated within the LFA-upper.

## LFA-upper (1,303 ft bls to Total Depth)

The top of the LFA was identified at 1,303 ft bls, in conjunction with an increase in secondary permeability and notable changes in water chemistry and water levels. TDS concentrations increased significantly from 492 mg/L in the last MCU_I packer test to 1,259 mg/L. Strontium concentrations decreased from 54.7 to 23.7 mg/L. Productivity in the LFA-upper at OSF-64R was characterized by fractures, cavities, and dissolution features within lower-permeability dolostone. Recovery water levels in comparison to nearby OSF-112 changed from a negative value in packer test 22 to a positive value in packer test 23, showing a downward gradient of flow and a breach of confinement. From 1,303 ft bls to the total depth of 1,500 ft bls, fractures and dissolution features were common. Two depth intervals had more abundant secondary permeability features and higher flow during packer testing. To facilitate discussion, these zones are numbered sequentially from shallow to deep: LF1 (1,303 to 1,376 ft bls) and LF2 (1,465 to 1,500 ft bls).

Following ECFTX model mapping protocol (CFWI Hydrologic Assessment Team 2016), the base of the LFA-upper should coincide with the base of the last productive zone above the natural gamma log marker for the glauconite marker low-permeability unit. In OSF-64R, the glauconitic horizon was below the depth of investigation. Therefore, the base of the LFA-upper was not defined.

Estimated permeability from packer tests within the LFA-upper (tests 24 to 30) ranged from 13.3 to 323 ft/day. Packer test 25 had turbulent flow, which caused a negative hydraulic conductivity value after correcting for friction headloss. It can only be concluded that hydraulic conductivity and transmissivity are "very high". For hydraulic calculations such as those presented in **Table 3**, the absolute value of the hydraulic conductivity value was used. Using the mean hydraulic conductivity for the fractured intervals, the transmissivity for the bulk LFA-upper and for each flow zone was calculated (**Table 3**).

Table 3. Hydraulic details on the individual flow zones within the LFA-upper at OSF-64R.

| Flow Zone | Interval (ft bls) | | Packer Tests | Mean Hydraulic Conductivity (ft/day) | Transmissivity* ($ft^2$/day) |
|---|---|---|---|---|---|
| | From Depth | To Depth | | | |
| LFA-upper bulk | 1,303 | 1,500 | 24 to 30 | 204.64 | 41,000 |
| LF1 | 1,303 | 1,376 | 24 to 26 | 398.74 | 36,000 |
| LF2 | 1,465 | 1,500 | 29 to 30 | 97.08 | 4,000 |

bls = below land surface; ft = foot; LFA = Lower Floridan aquifer.

* Transmissivity is rounded to the nearest thousand due to the homogeneity of transmissivity and its order of magnitude being more descriptive of an aquifer than the exact calculated value.

Water quality varies significantly in the LFA-upper at OSF-64R. LF1 is brackish and has TDS and sulfate concentrations high enough to exceed secondary drinking water standards. The Frazee (1982) water type of FW-IV indicates limited circulation and a long residence time. From 1,390 to 1,500 ft bls, sulfate, bicarbonate, magnesium, calcium, and strontium concentrations decrease, while chloride, sodium, and potassium concentrations gradually increase until LF2 is sodium-chloride-dominant water. Frazee (1982) water types of TCW and TWI indicate transitional waters that are mixing with seawater and connate water.

# DISCUSSION

Exploratory drilling and coring at OSF-64R reached a maximum depth of 1,500 ft bls, but a borehole collapse after reaming resulted in a final well depth of 1,487 ft bls. Work at the OSF-64R site was completed in January 2020 and included the following activities:

- Exploratory wire-line coring, geophysical logging, hydraulic testing, and water quality sampling to identify hydrogeologic unit boundaries and evaluate variations in water quality and rock permeability with depth.
- Modification of a previously existing UFA monitor well (OSF-64) to a permanent LFA-upper monitor well (OSF-64R).
- Instrumentation of OSF-64R and OSF-65 (UFA-upper) for incorporation into the SFWMD regional water-level monitoring network.

As a component of the CFWI DMIT project, the results from the OSF64 site must be reviewed based on their potential impact to the hydrogeologic framework used in the ECFTX groundwater model. Differences between interpreted hydrogeologic unit boundaries pre- and post-project are summarized in **Table 4.**

Table 4. Hydrostratigraphic comparison at the OSF64 site, current report versus ECFTX model layering (From: Central Florida Water Initiative Hydrologic Assessment Team 2016).

| Hydrogeologic Unit | Current Report | | | ECFTX Model | | |
|---|---|---|---|---|---|---|
| | Top (ft bls) | Base (ft bls) | Thickness (ft) | Top (ft bls) | Base (ft bls) | Thickness (ft) |
| UFA-upper | 290 | 350 | 60 | 257 | 349 | 92 |
| OCAPlpz | 350 | 587 | 237 | 349 | 643 | 294 |
| APPZ | 587 | 1,169 | 582 | 643 | 1,061 | 418 |
| MCU_I | 1,169 | 1,303 | 134 | 1,061 | 1,307 | 246 |
| MCU_II | Absent | | | Absent | | |
| LFA-upper | 1,303 | No Data | No Data | 1,307 | 1,569 | 262 |

APPZ = Avon Park permeable zone; bls = below land surface; ECFTX = East Central Floridan Transient Expanded; ft = foot; LFA = Lower Floridan aquifer; MCU = middle confining unit; OCAPlpz = Ocala-Avon Park low-permeability zone; UFA = Upper Floridan aquifer.

The hydrogeologic unit boundaries identified at OSF-64R are similar to most predicted values for the ECFTX model. However, for the APPZ, there is a 59-ft difference for the top and a 108-ft difference for the base. The APPZ was slightly shallower and much thicker than expected. The thicker APPZ does not affect the deeper layers because the MCU_I was much thinner than expected (134 ft rather than 246 ft), and the base of MCU_I was close to the predicted depth.

Drilling was completed to 1,500 ft bls but due to a borehole collapse at 1,487 ft bls, geophysical logs, OBI, and video could not be collected from the last 13 ft. Water quality samples and cores were collected for this collapsed interval, however, so all objectives for this site were met.

The very low-permeability evaporitic facies of MCU_II was not encountered at OSF-64R. When the area was mapped for the ECFTX model in 2016, MCU_II was expected to be absent based on exploratory well data from the planned Cypress Lakes LFA-upper wellfield. Well OSF-106, 1.7 miles north of OSF-64R, and DCBR-TPW1, 5.4 miles southeast of OSF-64R, represent the northern and southern ends of that wellfield, and neither reported encountering MCU_II. However, continuous core well OSF-112 was installed in 2017, 6 miles northwest of OSF-64R, and encountered more than 200 ft of MCU_II. A lesser amount of MCU_II might be present in the northern end of the Cypress Lakes wellfield but may have been overlooked during the reverse-air drilling process. MCU_II is one or more orders of magnitude less permeable than MCU_I, so erroneously omitting it would result in the ECFTX model greatly overpredicting drawdown effects from the wellfield. Consequently, verifying the absence or presence of MCU_II in the vicinity of the wellfield was one reason for the selection of the OSF64R site.

High concentrations of strontium (18 to 55 mg/L) were measured in packer tests 16 to 23, with concentrations gradually increasing with depth. Strontium is mobilized in groundwater through the dissolution of aragonite as part of the carbonate recrystallization process or through dissolution of evaporites such as gypsum (West 1973, Taberner et al. 2002, Swart 2014). The strontium ion can replace calcium during recrystallization; however, it is preferentially rejected and builds up in groundwater. The most common strontium minerals found in South Florida carbonate rocks are celestine ($SrSO_4$) and strontianite ($SrCO_3$) (McCartan et al. 1988). Celestine was identified at 1,271.6 ft bls in a large crystal growing in the core. Previously, celestine has been identified growing as small grains within the host rock matrix, but in OSF-64R, celestine grew as a large subhedral crystal. Multiple studies suggest celestine deposition occurs through the replacement of gypsum and anhydrite due to the higher solubility of these calcium sulfate minerals and the reduction of sulfate by bacteria (West 1973, Schultze-Lam and Beveridge 1994, Taberner et al. 2002, Hanor 2004). If the large celestine crystal was previously gypsum that had been replaced by celestine, then there was possibly more gypsum and anhydrite infilling pore space, and MCU_II could have existed in the past and since been dissolved and/or replaced. This is one possible explanation for the abrupt disappearance of MCU_II rock between OSF-112 and the Cypress Lakes wells just a few miles to the southeast. Further investigations on the occurrence of celestine and MCU_II are needed to confirm this theory.

# SITE DATA

Various data collection methods were used to determine the hydrogeologic framework at the OSF64 site. Packer tests were used to collect water quality samples and measure water levels, while wire-line coring yielded rock cores used to describe lithology.

## Packer Testing

Packer tests provide hydraulic data for a discrete section of rock and formation water quality. Thirty (off-bottom) packer tests were conducted during drilling of OSF-64R.

### *Methods*

Packer tests were planned for 30-ft intervals. After three 10-ft coring runs, the core casing was pulled up from the maximum cored depth to the base of the previous packer test interval. If borehole features prevented the packer from being set, the test interval could deviate from 30 ft. Due to cavities and borehole washouts preventing packer placement, the intervals from 1,090 to 1,100 ft bls and 1,120 to 1,130 ft bls were not included in any packer tests and packer test 17 was a 20-ft interval.

**Figure 12** depicts the packer test setup for OSF-64R. The test interval was air-developed for a minimum of 1 hour prior to lowering the packer assembly. A submersible pump was set in the space above it, and then the packers were inflated. The packer test interval was pumped for at least three borehole volumes at a maximum sustainable rate (17 to 34 gpm), while water level measurements were taken manually with an electric DTW tape. A conductivity, temperature, and depth (CTD) probe installed below the pump intake continuously collected conductivity, temperature, and pressure data during packer tests. Once three borehole volumes had been pumped, a water quality sample was collected and the pump was shut down. DTW measurements continued to be collected during drawdown and recovery at 1-minute intervals for the first 5 minutes, and at 5-minute intervals thereafter. Configuration specifics for each test are summarized in **Table 5**.

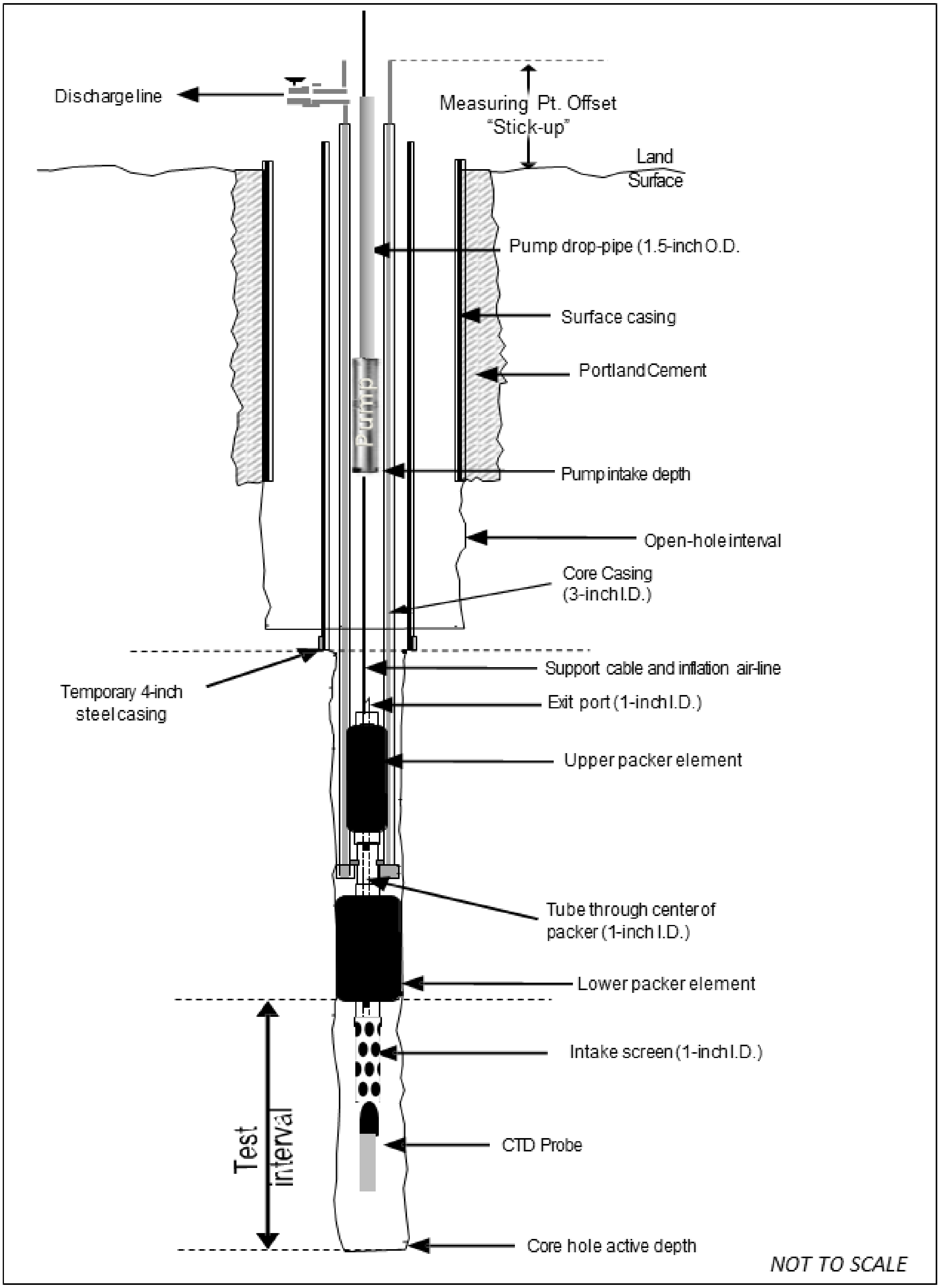


Figure 12. Generalized components of the packer test setup used in OSF-64R.

Table 5. Packer test configuration summary at OSF-64R.

| Test # | Date | Water Quality Sample ID | Test Interval (ft bls) | | Q (gpm) | Pumping Duration (hh:mm) | Stick-up* (ft) |
|---|---|---|---|---|---|---|---|
| | | | From Depth | To Depth | | | |
| 1 | 09-Sep-19 | P109007-3 | 610 | 640 | 30.0 | 1:06 | 4.55 |
| 2 | 10-Sep-19 | P109008-3 | 640 | 670 | 34.7 | 0:49 | 4.72 |
| 3 | 10-Sep-19 | P109008-4 | 660 | 700 | 30.4 | 0:45 | 4.70 |
| 4 | 11-Sep-19 | P109009-3 | 700 | 730 | 30.0 | 0:55 | 4.69 |
| 5 | 12-Sep-19 | P109010-3 | 730 | 760 | 29.0 | 1:00 | 4.48 |
| 6 | 13-Sep-19 | P109011-3 | 760 | 790 | 30.0 | 1:00 | 4.60 |
| 7 | 16-Sep-19 | P109012-3 | 790 | 820 | 27.0 | 1:08 | 4.46 |
| 8 | 17-Sep-19 | P109013-3 | 820 | 850 | 25.0 | 1:15 | 4.60 |
| 9 | 18-Sep-19 | P109014-3 | 850 | 880 | 28.0 | 1:11 | 4.62 |
| 10 | 19-Sep-19 | P109014-4 | 880 | 910 | 27.0 | 1:15 | 4.74 |
| 11 | 19-Sep-19 | P109015-3 | 900 | 940 | 27.0 | 1:15 | 4.55 |
| 12 | 23-Sep-19 | P109016-3 | 940 | 970 | 27.3 | 1:16 | 4.56 |
| 13 | 24-Sep-19 | P109017-3 | 970 | 1,000 | 28.0 | 1:15 | 4.48 |
| 14 | 24-Sep-19 | P109017-4 | 1,000 | 1,030 | 27.3 | 1:25 | 4.53 |
| 15 | 02-Oct-19 | P109018-3 | 1,030 | 1,060 | 28.4 | 1:05 | 4.41 |
| 16 | 03-Oct-19 | P109019-3 | 1,060 | 1,090 | 29.4 | 1:15 | 4.41 |
| 17 | 08-Oct-19 | P109020-3 | 1,100 | 1,120 | 28.5 | 1:20 | 4.55 |
| 18 | 09-Oct-19 | P109020-4 | 1,130 | 1,150 | 31.0 | 1:20 | 4.60 |
| 19 | 10-Oct-19 | P109021-3 | 1,150 | 1,180 | 30.5 | 1:25 | 4.58 |
| 20 | 11-Oct-19 | P109021-4 | 1,180 | 1,210 | 30.0 | 1:45 | 4.55 |
| 21 | 14-Oct-19 | P109023-3 | 1,210 | 1,240 | 30.0 | 1:25 | 4.57 |
| 22 | 15-Oct-19 | P109024-3 | 1,240 | 1,270 | 17.0 | 2:26 | 4.58 |
| 23 | 16-Oct-19 | P109025-3 | 1,270 | 1,300 | 30.0 | 1:30 | 4.51 |
| 24 | 17-Oct-19 | P109026-3 | 1,300 | 1,330 | 30.0 | 1:35 | 4.64 |
| 25 | 18-Oct-19 | P109022-3 | 1,330 | 1,360 | 30.0 | 1:30 | 4.62 |
| 26 | 21-Oct-19 | P110757-5 | 1,360 | 1,390 | 32.0 | 1:30 | 4.67 |
| 27 | 22-Oct-19 | P110758-5 | 1,390 | 1,420 | 30.0 | 1:34 | 4.69 |
| 28 | 22-Oct-19 | P110758-4 | 1,420 | 1,450 | 31.0 | 1:33 | 4.39 |
| 29 | 23-Oct-19 | P110759-5 | 1,450 | 1,480 | 29.0 | 1:41 | 4.72 |
| 30 | 24-Oct-19 | P110760-5 | 1,480 | 1,500 | 30.0 | 1:39 | 4.43 |

bls = below land surface; ft = foot; gpm = gallons per minute; hh:mm = hours:minutes; Q = rate of discharge.
* Stick-up is the offset distance (in feet) of the depth-to-water measuring point from land surface.

### *Hydraulic Analysis*

To estimate the hydraulic properties of the geologic formation from the packer tests, well loss components of the measured drawdown need to be eliminated, such as those caused by turbulent flow into the packer intake screen or friction losses in the packer pipe (1-inch diameter) and core casing (3-inch diameter). The Hazen-Williams equation (Finnemore and Franzini 2002) was used to calculate the pressure lose due to friction in the pipes (**Table 6**). A conversion factor of 2.31 ft of water per pound per square inch of pressure was used to convert to consistent drawdown units.

$$P_d = L\frac{4.52Q^{1.85}}{C^{1.85}d^{4.865}}$$

Where:

$P_d$ = pressure drop due to friction loss over the length of pipe (pounds per square inch)
L = length of pipe (ft)
Q = discharge rate (gpm)
C = pipe roughness coefficient
d = inside pipe diameter (inches)

Table 6. Pipe information for well loss calculations using the Hazen-Williams equation.

| Pipe Section | Inner Diameter (inches) | Length (feet) | Roughness Coefficient* |
|---|---|---|---|
| Core Casing | 3.00 | Top of Test Interval – DTW | 140 |
| Packer Assembly | 1.00 | 9.0 | 150 |

DTW = depth to water.
* Hazen-Williams coefficients for unlined steel 140-150 sourced from Engineering Toolbox (2004).

The intake screen below the packer assembly was fabricated by the driller to facilitate use of the CTD probe. The resulting head losses due to the addition of this custom-designed device were estimated empirically. An equation to estimate head losses due to the intake screen as a function of pumping rate was developed during the initial deployment of the component (Richardson et al. 2020).

$$\text{Screen Head Loss (ft of } H_2O) = -0003\text{rate}^3 + 0.0147\text{rate}^2 - 0.0993\text{rate} + 0.0532$$

Total well losses were estimated as the sum of the friction losses across the packer assembly, core casing, and intake screen.

The screen and CTD probe were deployed on multiple packer tests, but the temperature sensor did not work or gave unreasonable values. The pressure and conductivity sensors collected reliable data; however, those sensors must be temperature compensated to correct for density, so the CTD results were judged insufficiently reliable for use in this report.

Calculated total well losses for the 30 packer tests ranged from 4.07 to 10.74 ft, depending on the pumping rate and depth of the tested interval. After head loss corrections were made, hydraulic properties were estimated from the drawdown data using an empirical formula by Driscoll (1986). This formula estimates transmissivity in a confined aquifer based on specific capacity as:

$$T = \frac{Q}{s} * 2000$$

Where:

T = transmissivity (gallons/day/ft)
Q = pumping rate (gpm)
s = drawdown (ft)

After converting transmissivity (T) from gallons/day/ft to $ft^2$/day, the hydraulic conductivity was calculated as:

$$k = \left(\frac{T}{b}\right)$$

Where:

k = hydraulic conductivity (ft/day)
b = thickness of the tested interval (ft)

### *Hydraulic Analysis Results and Discussion*

Results from the hydraulic analysis are summarized in **Table 7**. The measured DTW, corrected DTW, and hydraulic conductivity using the Driscoll (1986) solution method are summarized for each packer test interval. Hydraulic conductivity varied by two orders of magnitude in OSF-64R, from 2.19 ft/day in the MCU_I to 323.33 ft/day in the fractured dolostone of the LFA-upper. Packer test 25 had an anomalous value of -813.4 ft/day, which is discussed later in this section.

Driscoll (1986) listed numerous factors that result in well losses, including pipe wall roughness, pipe diameter, flow velocity, water density and viscosity , directional changes in the flow path, obstructions in the flow path, and any changes in the cross-sectional area or slope of the flow path. The Hazen-Williams analysis accounts for losses due to the diameter and roughness of the pipe, which generally are the largest percentage of the loss in piping systems (Driscoll 1986). The other factors can be difficult to quantify. Driscoll's (1986) equation assumes that flow will be laminar and the Hazen-Williams equation (Finnemore and Franzini 2002) works to correct the changes in drawdown that occur in actuality as flow is never ideal. Other possible errors that are not included in the equations are potential errors in DTW measurements.

With actual pipe loss difficult to determine, the degree of error between calculated and actual pipe loss is also difficult to determine. However, certain aspects of the error can be inferred. Errors during testing have greater influence when drawdown is small (e.g., in high-permeability zones) due to a flat error in head being proportionally small in large drawdown tests. To further explain this, the equation for percent error is as follows:

$$\%\ Error = \left|\frac{Actual\ value - Experimental\ value}{Experimental\ value}\right| \times 100\%$$

For example, where the measured drawdown (experimental value) is 20 ft, and the absolute error in that measurement is 0.1 ft, then the percent error is

$$\left|\frac{19.9 - 20}{20}\right| \times 100\% = 0.5\%$$

If the measured drawdown changes to 2 ft, and the error in that measurement remains 0.1 ft, then the percent error is

$$\left|\frac{1.9 - 2}{2}\right| \times 100\% = 5\%$$

If the measured drawdown is even smaller, at 0.2 ft, and the error in that measurement remains 0.1 ft, then the percent error is

$$\left|\frac{0.1 - 0.2}{0.2}\right| \times 100\% = 50\%$$

Therefore, packer tests with lower drawdown can be expected to have a larger percent error in the hydraulic conductivity estimates.

Packer test 25 within the LFA-upper had a negative corrected drawdown and negative hydraulic conductivity because the estimated pipe loss was greater than the raw drawdown. Packer test 25 also had a small drawdown and probably turbulent flow. The percent error could not be calculated, but it can be concluded that packer test 25 is a very productive interval. When calculating aquifer characteristics, the absolute value of the hydraulic conductivity was used.

Table 7. Summary of results from the hydraulic analysis of OSF-64R

| Packer Test # | Hydrogeologic Unit | Test Interval (ft bls) | | Drawdown (ft) | | Hydraulic Conductivity (ft/day) |
|---|---|---|---|---|---|---|
| | | From Depth | To Depth | Raw | Corrected | |
| 1 | APPZ | 610 | 640 | 25.37 | 4.62 | 57.82 |
| 2 | APPZ | 640 | 670 | 11.44 | 0.71 | 436.04 |
| 3 | APPZ | 660 | 700 | 12.85 | 2.12 | 95.79 |
| 4 | APPZ | 700 | 730 | 11.18 | 2.16 | 123.85 |
| 5 | APPZ | 730 | 760 | 10.84 | 2.14 | 120.97 |
| 6 | APPZ | 760 | 790 | 16.8 | 7.60 | 35.18 |
| 7 | APPZ | 790 | 820 | 47.12 | 39.11 | 6.15 |
| 8 | APPZ | 820 | 850 | 82.51 | 75.33 | 2.96 |
| 9 | APPZ | 850 | 880 | 14.57 | 5.98 | 41.76 |
| 10 | APPZ | 880 | 910 | 11.64 | 3.31 | 72.61 |
| 11 | APPZ | 900 | 940 | 13.63 | 6.55 | 27.56 |
| 12 | APPZ | 940 | 970 | 45.25 | 36.76 | 6.61 |
| 13 | APPZ | 970 | 1,000 | 20.68 | 11.78 | 21.18 |
| 14 | APPZ | 1,000 | 1,030 | 49.73 | 41.08 | 5.92 |
| 15 | APPZ | 1,030 | 1,060 | 53.68 | 44.44 | 5.70 |
| 16 | APPZ | 1,060 | 1,090 | 11.69 | 1.90 | 137.59 |
| 17 | APPZ | 1,100 | 1,120 | 27.6 | 18.13 | 21.01 |
| 18 | APPZ | 1,130 | 1,150 | 24.36 | 13.63 | 30.40 |
| 19 | APPZ | 1,150 | 1,180 | 16.04 | 5.48 | 49.59 |
| 20 | MCU_I | 1,180 | 1,210 | 73.66 | 63.25 | 4.23 |
| 21 | MCU_I | 1,210 | 1,240 | 40.33 | 29.83 | 8.96 |
| 22 | MCU_I | 1,240 | 1,270 | 73.35 | 69.28 | 2.19 |
| 23 | MCU_I | 1,270 | 1,300 | 17.25 | 6.58 | 40.63 |
| 24 | LFA-upper | 1,300 | 1,330 | 11.58 | 0.83 | 323.33 |
| 25 | LFA-upper | 1,330 | 1,360 | 10.51 | -0.33 | -813.46 |
| 26 | LFA-upper | 1,360 | 1,390 | 14.63 | 4.80 | 59.42 |
| 27 | LFA-upper | 1,390 | 1,420 | 27.11 | 20.09 | 13.31 |
| 28 | LFA-upper | 1,420 | 1,450 | 16.87 | 9.59 | 28.81 |
| 29 | LFA-upper | 1,450 | 1,480 | 13.29 | 6.55 | 39.46 |
| 30 | LFA-upper | 1,480 | 1,500 | 9.61 | 2.59 | 154.70 |

APPZ = Avon Park permeable zone; bls = below land surface; ft = foot; LFA = lower Florida aquifer; MCU = middle confining unit.

## Water Levels

Measuring and tracking water levels during drilling can help determine when there is a breach of confinement. DTW recorded at the end of recovery during packer testing operations most accurately reflects static water level within the geologic formation. Referenced water levels calculated from DTW at the end of recovery during packer testing are presented in **Figure 13**. Blue points show the water level elevations at the end of recovery from OSF-64R packer testing. Because these measurements were recorded over approximately 2 months (September 9 to October 24, 2019), it is necessary to differentiate between regional changes in water level over time and those related to changes in depth. To this end, orange points represent the background water level from the nearest off-site FAS monitor well, OSF-112, for the same date and time of each packer test reading. The difference between the two water levels (black squares) best reflects depth-related change.

OSF-112, located 6.4 miles northwest of OSF-64R, is open to the APPZ. The APPZ at OSF-112 is thinner (141 ft) than at the OSF64R site (582 ft). While drilling through the APPZ, static water levels at OSF-64R were approximately 1 ft higher than at OSF-112, with three exceptions. Packer tests 6, 15, and 16 had water levels 3.5 to 5.5 ft higher than OSF-112. These packer tests align with the regions of lower permeability between the individual flow zones of the APPZ. This suggests the flow zones are hydraulically independent of each other. Water levels gradually decline through the MCU_I, with an abrupt change in water level when the LFA-upper is breached at 1,303 ft bls. The first flow zone of the LFA-upper is marked by water levels that are approximately 0.5 ft lower than at OSF-112. Below LF1, water levels recover to approximately 0.5 ft above those at OSF-112.

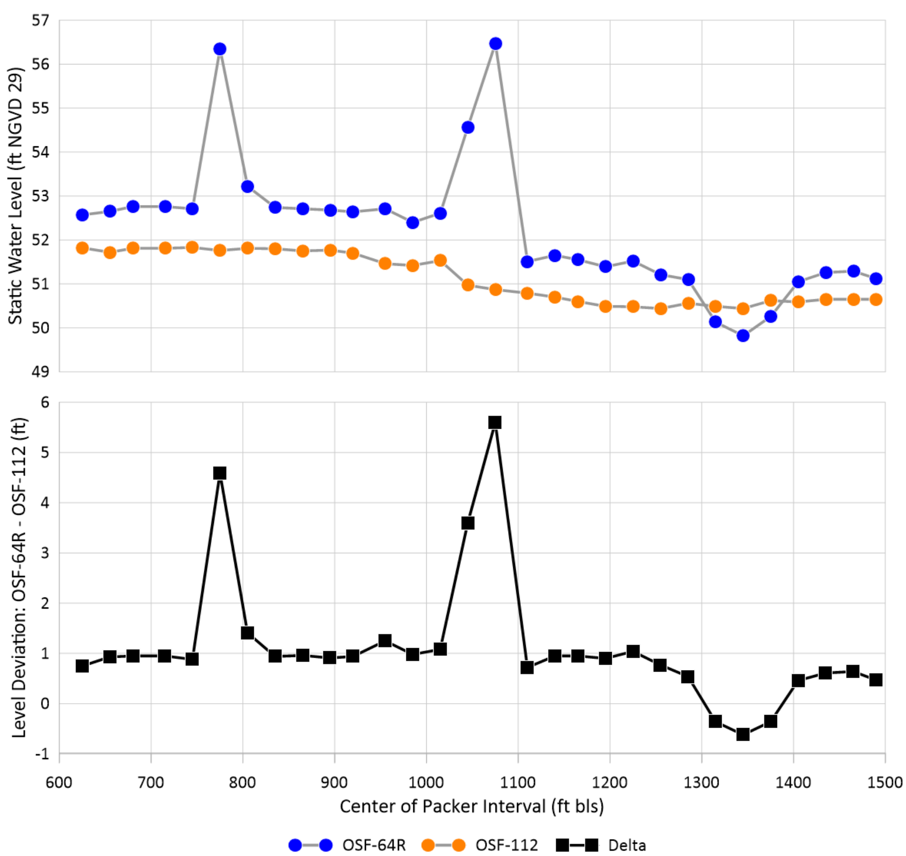


Figure 13. Recovered water levels from packer testing in OSF-64R, relative to time-variant changes in water level from off-site monitor well OSF-112.

After construction, OSF-64R and OSF-65 were instrumented for water level monitoring. Water levels are collected at 15-minute intervals and incorporated into the District's SCADA system. **Figure 14** shows the water levels of both wells up to November 16, 2020. Provisional data were not included. Data collection began in April 2019 at OSF-65 and in February 2020 at OSF-64R. The head in OSF-65 is consistently higher than in OSF-64R. This is consistent with packer test results, as there was a drop in head when the LFA-upper was breached during drilling.

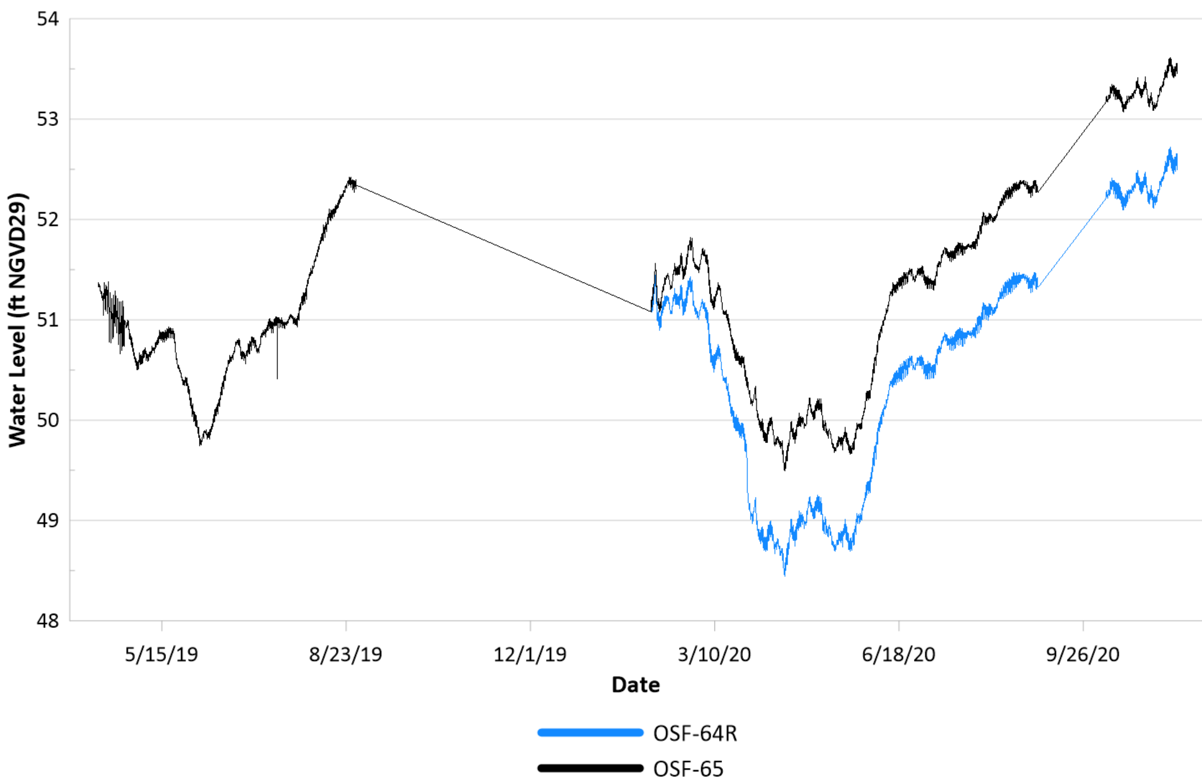


Figure 14. Water levels of OSF-64R and OSF-65 after construction of OSF-64R.

## Water Quality and Inorganic Chemistry

Thirty water samples were collected during packer testing at OSF-64R to characterize the water chemistry variation in the FAS. Field parameters (temperature, pH, and specific conductance) were recorded with a YSI EXO multiparameter sonde, and each sample was collected and submitted for laboratory analysis in accordance with the project's Water Quality Monitoring Plan (SFWMD 2017). Major cations and anions, strontium, and stable isotopes of oxygen and hydrogen ($^{18}O$ and $^{2}H$) were analyzed in each packer test sample. Complete water quality results are available for download from the District's DBHYDRO database (www.sfwmd.gov/dbhydro). Field parameters and quality assurance data are provided in **Table 8**, and major ion chemistry is provided in **Table 9**. The profile of water quality with depth is depicted in **Figure 15**.

Table 8. Field parameters and quality assurance of samples at OSF-64R. (Note: Bolded values exceed the secondary drinking water standard.)

| Packer Test # | Field Parameters | | | Sample Ion Balance | | | TDS (mg/L) | TDS to Specific Conductance Ratio |
|---|---|---|---|---|---|---|---|---|
| | pH | Temp. (°C) | Specific Cond. (µS/cm) | Sum of Anions (meq/L) | Sum of Cations (meq/L) | Balance % | | |
| 1 | 7.3 | 25.3 | 253 | 2.48 | 2.97 | 9.00% | 145 | 0.57 |
| 2 | 8.1 | 25.2 | 247 | 2.34 | 2.72 | 7.59% | 145 | 0.59 |
| 3 | 8.1 | 25.4 | 256 | 2.51 | 2.61 | 1.89% | 144 | 0.56 |
| 4 | 7.8 | 25.6 | 264 | 2.59 | 2.75 | 3.00% | 154 | 0.58 |
| 5 | 8.4 | 25.6 | 262 | 2.59 | 2.54 | 1.06% | 157 | 0.60 |
| 6 | 7.5 | 25.5 | 248 | 2.50 | 2.49 | 0.30% | 151 | 0.61 |
| 7 | 8 | 25.7 | 219 | 2.10 | 2.25 | 3.51% | 141 | 0.64 |
| 8 | 7.8 | 25.7 | 217 | 2.17 | 2.28 | 2.51% | 130 | 0.60 |
| 9 | 7.8 | 25.6 | 219 | 2.13 | 2.10 | 0.74% | 126 | 0.58 |
| 10 | 7.8 | 25.7 | 220 | 2.17 | 2.14 | 0.53% | 130 | 0.59 |
| 11 | 8.1 | 25.7 | 228 | 2.27 | 2.28 | 0.18% | 136 | 0.60 |
| 12 | 8 | 25.7 | 219 | 2.17 | 2.31 | 3.12% | 135 | 0.62 |
| 13 | 8.2 | 25.8 | 232 | 2.07 | 2.35 | 6.54% | 144 | 0.62 |
| 14 | 8 | 26 | 238 | 2.37 | 2.39 | 0.59% | 146 | 0.61 |
| 15 | 8 | 26.1 | 252 | 2.50 | 3.58 | 17.85%* | 166 | 0.66 |
| 16 | 8 | 26.8 | 318 | 3.22 | 2.80 | 6.87% | 218 | 0.69 |
| 17 | 7.8 | 25.9 | 482 | 3.81 | 8.07 | 35.83%* | 261 | 0.54 |
| 18 | 7.9 | 26 | 409 | 3.98 | 3.73 | 3.32% | 266 | 0.65 |
| 19 | 8 | 26.1 | 535 | 4.14 | 3.71 | 5.47% | 277 | 0.52 |
| 20 | 7.6 | 26.2 | 604 | 5.17 | 4.71 | 4.71% | 341 | 0.56 |
| 21 | 7.5 | 26.2 | 549 | 5.49 | 5.01 | 4.59% | 362 | 0.66 |
| 22 | 7.4 | 26.3 | 609 | 6.27 | 5.40 | 7.50% | 400 | 0.66 |
| 23 | 7.2 | 26.3 | 728 | 7.04 | 6.59 | 3.30% | 492 | 0.68 |
| 24 | 6.9 | 26.4 | 1,598 | 17.89 | 19.55 | 4.44% | **1,259** | 0.79 |
| 25 | 6.8 | 26.3 | 1,928 | 22.10 | 24.75 | 5.66% | **1,613** | 0.84 |
| 26 | 7.1 | 26.5 | 1,470 | 17.83 | 18.36 | 1.46% | **1,159** | 0.79 |
| 27 | 7.4 | 26.4 | 1,089 | 11.55 | 9.96 | 7.39% | **736** | 0.68 |
| 28 | 7.7 | 26.7 | 943 | 9.56 | 12.00 | 11.29%* | **583** | 0.62 |
| 29 | 8 | 26.6 | 1,046 | 9.57 | 9.99 | 2.12% | **570** | 0.54 |
| 30 | 7.8 | 26.8 | 1,370 | 12.55 | 12.54 | 0.04% | **725** | 0.53 |

°C = degrees Celsius; µS/cm = microsiemens per centimeter; meq/L = milliequivalents per liter; mg/L = milligrams per liter; TDS = total dissolved solids.
* Potentially unreliable; ion-balance error is above the threshold for acceptance.

Table 9. Major ion composition with depth at OSF-64R. (Note: Bolded values exceed the secondary drinking water standard.)

| Packer Test # | Anions (mg/L) | | | Cations (mg/L) | | | | |
|---|---|---|---|---|---|---|---|---|
| | Chloride | Bicarbonate | Sulfate | Sodium | Magnesium | Calcium | Potassium | Strontium* |
| 1 | 13.5 | 112.2 | 12.6 | 7.6 | 10.2 | 35.6 | <1.0 | 1.8 |
| 2 | 12.5 | 106.1 | 11.8 | 7.3 | 9.0 | 32.8 | <1.0 | 1.8 |
| 3 | 12.9 | 114.6 | 12.8 | 7.3 | 9.0 | 30.5 | <1.0 | 1.7 |
| 4 | 13.3 | 119.5 | 12.5 | 7.6 | 10.1 | 31.4 | <1.0 | 1.8 |
| 5 | 13.8 | 117.0 | 13.5 | 7.7 | 9.2 | 28.4 | <1.0 | 1.9 |
| 6 | 10.8 | 118.3 | 12.5 | 6.2 | 8.7 | 29.6 | <1.0 | 3.1 |
| 7 | 6.7 | 103.6 | 10.1 | 4.5 | 7.5 | 28.3 | <1.0 | 1.7 |
| 8 | 6.7 | 108.5 | 9.6 | 4.4 | 7.9 | 28.3 | <1.0 | 1.3 |
| 9 | 6.8 | 106.1 | 9.8 | 4.3 | 7.0 | 26.4 | <1.0 | 1.3 |
| 10 | 6.6 | 108.5 | 9.6 | 4.2 | 7.4 | 26.6 | <1.0 | 1.3 |
| 11 | 7.3 | 113.4 | 9.8 | 4.6 | 8.1 | 27.8 | <1.0 | 1.2 |
| 12 | 6.2 | 108.5 | 10.2 | 4.3 | 8.0 | 28.8 | <1.0 | 1.3 |
| 13 | 6.7 | 100.0 | 11.4 | 4.5 | 8.0 | 29.6 | <1.0 | 1.7 |
| 14 | 7.1 | 115.8 | 12.8 | 4.8 | 7.8 | 30.4 | <1.0 | 2.3 |
| 15 | 7.6 | 117.0 | 17.4 | 5.0 | 14.3 | 43.2 | 1.0 | 3.7 |
| 16 | 7.8 | 124.4 | 46.0 | 4.9 | 9.2 | 36.2 | <1.0 | 18.3 |
| 17 | 8.1 | 131.7 | 68.5 | 5.4 | 39.4 | 91.4 | 1.0 | 30.6 |
| 18 | 8.1 | 141.4 | 69.0 | 5.2 | 13.2 | 47.8 | 1.0 | 31.1 |
| 19 | 9.2 | 146.3 | 71.2 | 6.2 | 11.8 | 48.8 | 1.2 | 29.9 |
| 20 | 11.3 | 184.1 | 88.2 | 7.4 | 14.6 | 63.0 | 1.4 | 32.1 |
| 21 | 12.5 | 198.7 | 90.3 | 8.8 | 15.5 | 66.2 | 1.6 | 39.2 |
| 22 | 15.1 | 236.5 | 95.0 | 10.9 | 16.2 | 70.9 | 1.8 | 45.6 |
| 23 | 20.0 | 247.5 | 116.0 | 14.7 | 19.6 | 85.6 | 2.2 | 54.7 |
| 24 | 24.9 | 274.3 | **609.0** | 19.5 | 66.3 | 263.6 | 2.5 | 23.7 |
| 25 | 27.2 | 273.1 | **809.0** | 21.4 | 87.0 | 331.9 | 2.6 | 17.0 |
| 26 | 41.0 | 228.0 | **621.0** | 23.7 | 64.5 | 239.3 | 2.2 | 12.9 |
| 27 | 76.8 | 170.7 | **316.0** | 51.1 | 33.3 | 98.6 | 2.6 | 10.0 |
| 28 | 91.7 | 153.6 | 214.0 | 44.6 | 41.4 | 131.7 | 2.6 | 6.6 |
| 29 | 182.0 | 121.9 | 117.0 | 100.8 | 27.8 | 64.2 | 4.1 | 4.5 |
| 30 | **296.0** | 108.5 | 116.0 | 159.8 | 30.1 | 59.2 | 5.9 | 4.5 |

mg/L = milligrams per liter.

* Values shaded in blue indicate the analyte is not currently regulated but exceeds the United States Environmental Protection Agency's proposed health reference level for strontium of 1.5 mg/L.

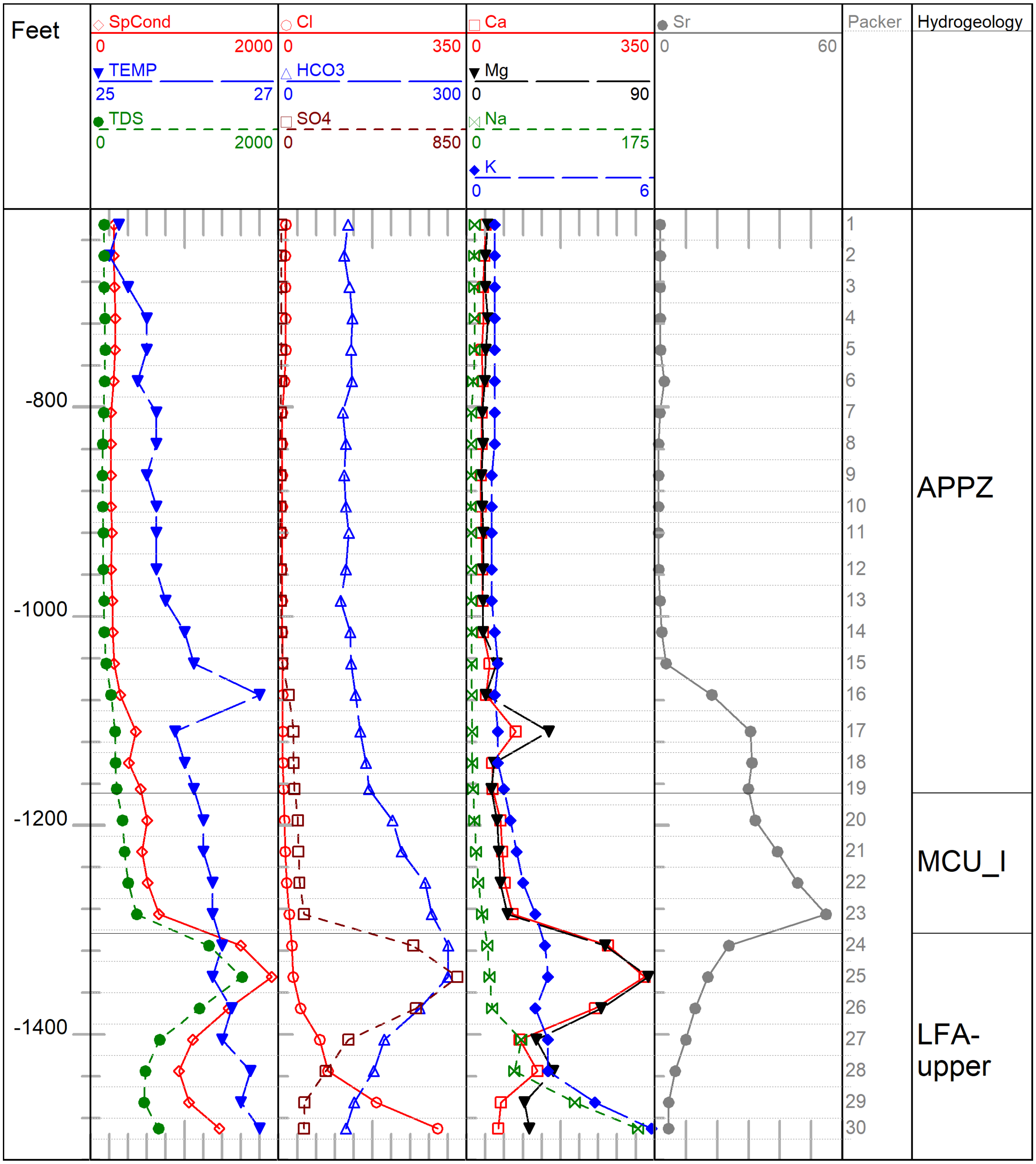


Figure 15. Depth profile of water quality data from OSF-64R packer testing. Units are consistent with **Table 9**.

From 610 to 1,000 ft bls, the formation yielded fresh water with a very similar ionic profile. Bicarbonate was the dominant anion and calcium was the dominant cation. TDS concentrations were between 126 and 157 mg/L. From 820 to 970 ft bls, strontium concentrations were below the United States Environmental Protection Agency's proposed health reference level of 1.5 mg/L.

Overall, the interval from 1,000 to 1,300 ft bls showed an increasing trend in ionic concentrations. Strontium stands out among the ions from 1,180 to 1,300 ft bls because concentrations increased steeply from 31.1 to 54.7 mg/L. TDS concentrations increased from 146 to 492 mg/L.

Packer test 17 was in a region of soft rock with cavities and borehole washouts, so only a 20-ft interval (1,100 to 1,120 ft bls) was tested. This packer test showed greater calcium and magnesium concentrations than the adjacent tests. Without a corresponding increase in anions to pair with this increase in cations, the charge balance error is 35.84%. Different sources of error were present for the anions and cations because the analytes were collected in different bottles and processed separately at the lab. The bottle for cations was preserved with acid, while the bottle for anions was not.

When considering the anions, the charge balance error could be the result of carbon dioxide degassing. As the groundwater sample changes pressure and temperature as it is brought to the surface for sampling, carbon dioxide degassing can occur. During this degassing, pH will increase and ions that were in an aqueous state will precipitate in response. This leads to a lower measured alkalinity concentration than was present in the formation.

The bottle for sampling cations was preserved with acid to a pH of less than 2. This lower pH prevents precipitation and may dissolve particles of host rock suspended in the solution. The charge balance error could be due to these rock particles in the water quality sample. The turbidity prior to sampling was measured at 21.5 NTU, which is higher than the Florida Department of Environmental Protection groundwater sampling protocol of 20 NTU. Because the last three turbidity measurements were within 5 NTU of each other, turbidity was considered stable. The elevated but stable turbidity could have been the result of fine rock particles in the water quality sample.

The anions in packer test 17 showed a smooth gradient with the adjacent tests. The magnesium and calcium concentrations were much higher than the other tests, and the turbidity was also higher than reasonable. Given these considerations, the charge balance error appears to be the result of the dissolution of host rock particles in the cation sample. The magnesium and calcium results should be considered suspect and overestimated.

From 1,300 to 1,360 ft bls, water quality changed dramatically. Strontium concentrations decreased, while bicarbonate, sodium, and chloride concentrations continued to slowly increase with depth. Sulfate, magnesium, calcium, and TDS concentrations as well as specific conductance and temperature increased sharply, with the highest values recorded from packer test 25.

TDS concentrations decreased from 1,360 to 1,500 mg/L, but there were mixed trends in individual ion concentrations. Bicarbonate, sulfate, and strontium concentrations decreased. Overall, calcium and magnesium concentrations also decreased, but there was a small increase in packer test 28. Sodium and chloride concentrations increased, resulting in sodium-chloride-dominant water for the last two packer tests.

Samples were further examined using the geochemical pattern analysis method developed for the FAS by Frazee (1982) to relate the chemical signature to recharge source, residence time, and saltwater intrusion. The Frazee (1982) water types are defined in **Table 10**. **Figure 16** shows how the packer test samples conformed to the water types.

Formation water from 610 to 1,060 ft bls (including APhpz-1 and APhpz-2) matched Fresh Recharge Water Type II (Frazee 1982). This is fresh and young limestone water, with calcium bicarbonate dominance. Two clusters are in Fresh Formation Water Type IV. The first cluster is from 1,060 to 1,300 ft bls, which includes the APhpz-3 and MCU_I. The second cluster is from 1,300 to 1,390 ft bls, which is LF1 in the LFA-upper. Fresh Formation Water Type IV waters are older than Fresh Recharge Water Types II and III and have become further enriched in calcium, magnesium, and sulfate due to limited circulation and longer residence time. Each packer test from 1,390 to 1,500 ft bls had a slightly different water quality profile. Starting with Fresh Formation Water Type IV, the water type transitions to Transitional Connate Water, then to Transitional Water Type I, with increasing depth. This transition points towards increasing sodium and chloride dominance of formation water with depth and mixing with seawater and connate water.

A sample from OSF-65 was taken on March 27, 2020, from the open interval of 310 to 418 ft bls. This sample is included to represent the UFA-upper because packer testing could not be completed through this zone in OSF-64R to collect water quality data. The UFA-upper is Fresh Recharge Water Type II and is plotted near the samples for APhpz-1 and APhpz-2. These waters have the same water type, but the water in the UFA-upper has slightly lower sulfate and magnesium concentrations and bicarbonate and sodium concentrations.

The sample in **Figure 16** labeled OSF-64 is the average of multiple water quality samples from the original OSF-64 well. These samples were collected between 1993 and 2008 and had a charge balance error of less than 8%. The pre-construction OSF-64 water type is Fresh Recharge Water Type II and is located between the OSF-65 sample and the cluster of samples from the APhpz-2 and APPZ. These three points being in line on the Piper plot suggests the water from pre-construction OSF-64 was a transition or mixture of water of the shallower UFA-upper and the deeper APPZ. This is consistent with the open-hole borehole of OSF-64 overlapping both aquifers.

Table 10. Description of Frazee (1982) water types.

| Abbreviation | Description | Characteristics |
|---|---|---|
| FW-I | Fresh Recharge Water Type I | Rapid infiltration through sands, high calcium bicarbonate ($CaHCO_3$). |
| FW-II | Fresh Recharge Water Type II | Infiltration through sands and clay lenses, $CaHCO_3$ with sodium (Na), sulfate ($SO_4$), and chloride (Cl).<br>Marginal type II waters are beginning to transition toward FW-IV. |
| FW-III | Fresh Recharge Water Type III | Infiltration through clay-silt estuarine depositional environment, high sodium bicarbonate ($NaHCO_3$). |
| FW-IV | Fresh Formation Water Type IV | Fresh water, low calcium (Ca), magnesium (Mg), $SO_4$, and Cl. Vertical infiltration insignificant. Older form of FW-II or FW-III. |
| TW-I | Transitional Water Type I | Seawater begins to dominate source water; Cl begins to dominate bicarbonate ($HCO_3$) with increasing sodium chloride (NaCl) percentage. |
| TW-II | Transitional Water Type II | Transitional water with source water still dominant, $HCO_3$ – $SO_4$ mixing zone with increasing Cl. |
| TCW | Transitional Connate Water | Connate water dominates source water, $SO_4$ begins to dominate $HCO_3$ with increasing Cl. |
| TRSW | Transitional Seawater | Transitional water with seawater dominating source water. |
| CW | Connate Water | Highly mineralized fresh water with high total dissolved solids and calcium sulfate ($CaSO_4$) dominance. Presence of highly soluble minerals; hydrogen sulfide ($H_2S$) gas prevalent. |
| RSW* | Relict Seawater | Unflushed seawater with NaCl. |

* Strongly NaCl-dominant waters may plot in this category even if the overall salinity is substantially less than seawater.

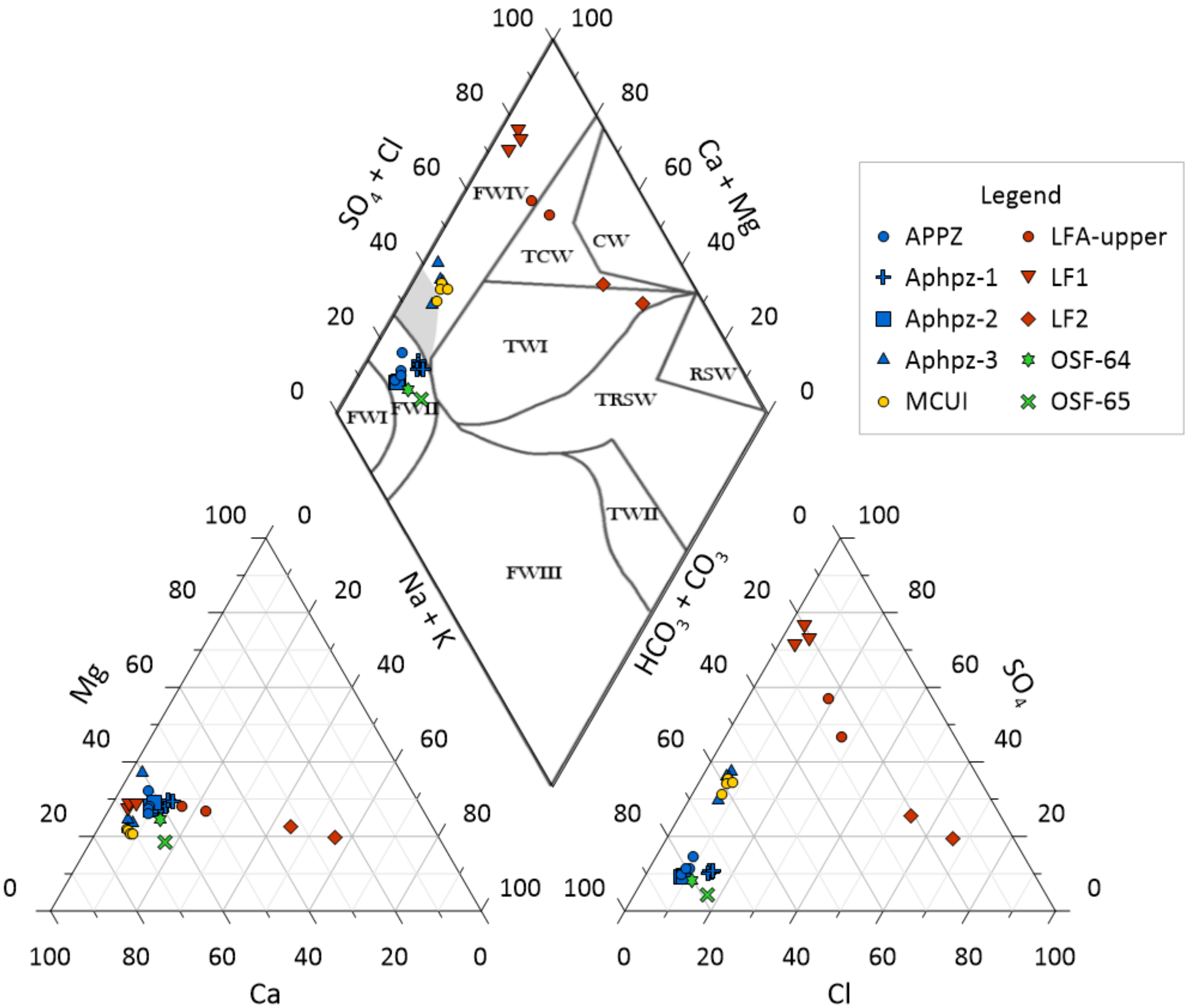


Figure 16. Water type classification of packer test sample data from OSF-64R, the adjacent OSF-65, and OSF-64 prior to well modification, illustrating distinctions between hydrogeologic units and flow zones (Modified from: Frazee 1982).

Stable isotopes of oxygen and hydrogen ($^{18}O$ and $^{2}H$) were analyzed by the Environmental Isotope Laboratory at the University of Arizona to identify distinctions between source waters in the hydrogeologic units penetrated during coring and packer testing operations (**Figure 17**). No isotope sample was collected for packer test 12 (940 to 970 ft bls).

Craig (1961) first noted a linear relationship between $^{18}O$ and $^{2}H$ isotope values measured in precipitation from all over the world. This relationship $^{2}H = 8\ ^{18}O + 10‰$ has become known as the global meteoric water line. All OSF-64R water quality samples plotted slightly below the global meteoric water line, implying none of the source waters experienced a prolonged period of evaporation prior to recharge. The samples taken from the APPZ and its flow zones are clustered in the bottom left of the graph. Conversely, samples from the MCU_I and LFA-upper flow zones have a wider range. Even with this wider range, they plotted parallel to the slope of the global meteoric water line.

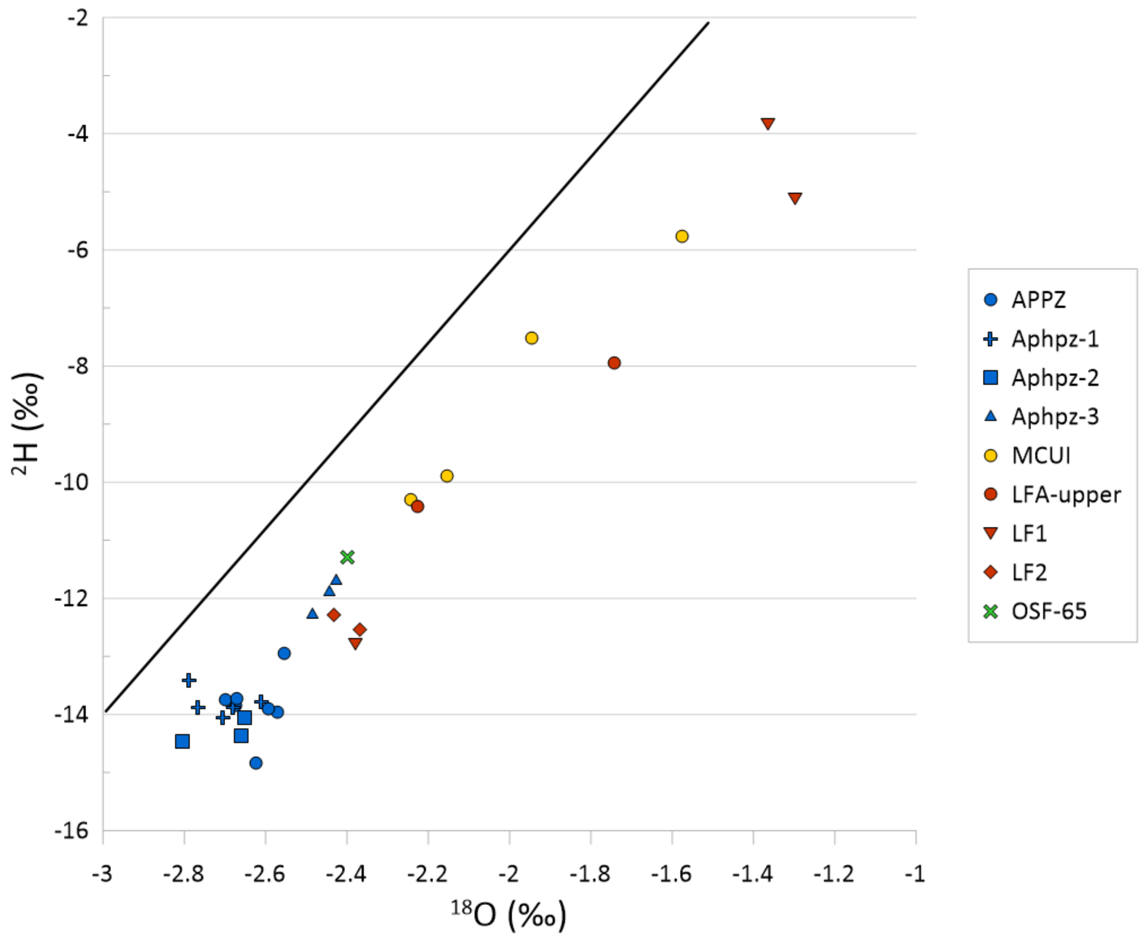


Figure 17. Stable isotopic ratios of $^{2}H$ and $^{18}O$ from OSF-64R packer test water quality samples, shown relative to the global meteoric water line.

The saturation indices for eight minerals were calculated using the PHREEQC program and thermodynamic database as part of the AquaChem software (Schlumberger Water Services 2014). The saturation index (SI) is the log of the ratio of ion activity product (IAP) and the solubility product constant corrected for temperature ($K_T$):

$$SI = \log\left(\frac{IAP}{K_T}\right)$$

Where:

SI = saturation index (unitless)
IAP = ion activity product (unitless)
$K_T$ = solubility product constant corrected for temperature (unitless)

The IAP is calculated using the sampled ionic concentrations, with corrections applied based on field temperature and ionic strength of the solution (Parkhurst and Appelo 1999). The solubility product constant ($K_{sp}$) is based on thermodynamics for the dissolved mineral at equilibrium. However, $K_{sp}$ assumes a temperature of 25°C, so a correction was applied to account for the field temperature to give $K_T$. **Appendix E** provides further detail on the calculations of the IAP and the corrections applied to both the IAP and $K_T$.

The IAP is based on the sample collected during packer testing, while $K_T$ is calculated based on chemical equilibrium. By comparing these two values using the SI equation, it can quantitatively be determined if a solution is saturated, undersaturated, or supersaturated with respect to a certain mineral. If the IAP equals the $K_T$, then the sample is in equilibrium and the SI is 0. A negative SI means the sample is undersaturated with respect to the mineral and more can be dissolved into solution. A positive SI means the sample is supersaturated, and the mineral could precipitate out of solution. PHREEQC did not model minerals precipitating out of solution or include adjustments for pressure at depth. While supersaturation suggests that formation of the mineral is expected, it may not always be found.

**Table 11** shows the log of the $K_{sp}$ of each mineral at 25°C and 1 atmosphere of pressure, sorted from least soluble to most soluble. **Figure 18** shows the SI for these minerals in each packer test, also sorted from least soluble to most soluble. The blue regions are undersaturated, and the red regions are supersaturated.

The SIs for aragonite, calcite, and dolomite had similar profiles, fluctuating between unsaturated and supersaturated but staying relatively close to equilibrium. This is to be expected, as the majority of the core was limestone and dolostone. Aragonite has the same chemical formula as calcite, but it is more soluble. In a solution where calcium and bicarbonate are dissolved, calcite will precipitate out first and aragonite will form under either very high pressure or by mollusks and corals.

Anhydrite and gypsum were undersaturated in packer tests 1 to 15, which have very low sulfate values. Once sulfate begins increasing in packer test 16, the SI also increases but never reaches equilibrium. No gypsum or anhydrite were found in the lithology.

The SI for celestine, which is a sulfate mineral, increased after packer test 16. It became supersaturated in packer test 24 (1,300 to 1,330 ft bls), with an SI of 0.0723. Celestine was observed at 1,271.6 ft bls. No samples from the region of celestine supersaturation were sent for laboratory analysis. In packer test 23, where the celestine was found, the SI was -0.0099, which is nearly equilibrium.

Strontianite has an interval of supersaturation from packer tests 16 to 24. No strontianite was found in the few samples sent for laboratory core analysis, but the groundwater chemistry is conducive for strontianite precipitation at the base of the APPZ and in the MCU_I. The bicarbonate in solution may have been utilized for calcite and dolomite dissolution, so the remaining aqueous strontium only reached saturation with sulfate to form celestine.

Table 11. Solubility product constants for select minerals at 25°C (From: Parkhurt and Appelo 1999).

| Mineral | Formula | $\log(K_{sp})$ |
|---|---|---|
| Dolomite | $CaMg(CO_3)_2$ | -17.09 |
| Strontianite | $SrCO_3$ | -9.27 |
| Calcite | $CaCO_3$ | -8.48 |
| Aragonite | $CaCO_3$ | -8.34 |
| Celestine | $SrSO_4$ | -6.63 |
| Gypsum | $CaSO_4 \cdot 2H_2O$ | -4.58 |
| Anhydrite | $CaSO_4$ | -4.36 |

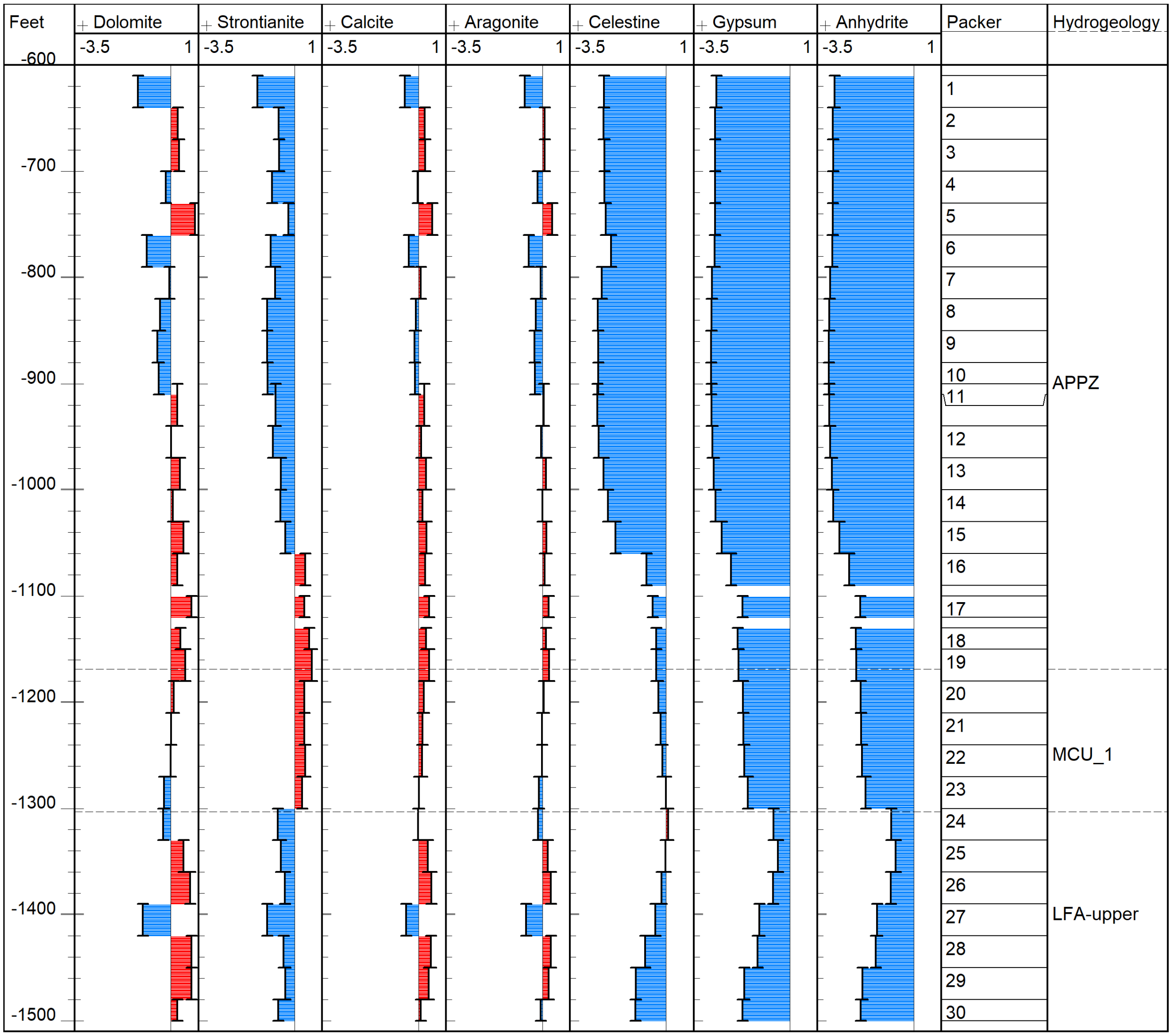

Figure 18. Saturation indices for OSF-64R packer tests.

## Geophysical Logging

Borehole geophysical logs collected during the construction of OSF-64R and the initial construction of OSF-64 are listed in **Table 12**. The logging of OSF-64R was conducted after borehole reaming and before casing installation. Geophysical logs collected during construction of OSF-64R are provided in **Appendix F**.

Natural gamma and dual-induction are the only geophysical logs available for the 0 to 310 ft bls interval for the December 13, 2019 logging run due to the 8-inch PVC casing from the original OSF-64 well. The other logging techniques are inhibited by the casing and require an open borehole to collect accurate information. The natural gamma was very high from 210 to 290 ft bls, ranging from approximately 65 to 320 counts per second (cps). This is consistent with the high phosphate concentration in the interval that corresponds to the Hawthorn Group sediments.

Table 12. Geophysical log inventory for the OSF64 site.

| | OSF-64 | | OSF-64R | |
|---|---|---|---|---|
| Date | 1-May-91 | 26-Mar-18 | 11-Dec-19 | 13-Dec-19 |
| Logging Company | | Baker | USGS | Baker |
| Logged Interval (ft bls) | 0-610 | 0-610 | 310-1,500 | 0-1,500 |
| Caliper | ✓ | ✓ | | ✓ |
| Natural Gamma | ✓ | ✓ | | ✓ |
| Normal Resistivity | ✓ | ✓ | | ✓ |
| Dual Induction/Spontaneous Potential | ✓ | | | ✓ |
| Neutron Porosity | ✓ | | | |
| Sonic Porosity | | ✓ | | ✓ |
| Flow Meter | | ✓ | | ✓ |
| Temperature | ✓ | ✓ | | ✓ |
| Fluid Resistivity | ✓ | | | ✓ |
| Downhole Video | | ✓ | | ✓ |
| Optical Borehole Imaging | | | ✓ | |

Baker = RMBaker LLC; ft bls = feet below land surface; SFWMD = South Florida Water Management District; USGS = United States Geological Survey.
✓ Collected under static flow conditions.

The interval from 310 to 610 ft bls is the original open-hole interval for OSF-64 and has been open since its construction in 1991. From 290 to 570 ft bls, the natural gamma is greatly reduced, ranging from 5 to 35 cps. The caliper log showed an enlarged and rounded borehole more than 15 inches in diameter. The sonic log was primarily more than 120 microsiemens per foot (µS/ft) and likely affected by the very large borehole diameter. Resistivity was low and flat. These features correspond to the low induration, granular limestone that compose the Ocala Limestone and the upper limestone section of the Avon Park Formation.

At 570 ft bls, near the top of the APPZ, the limestone became more consolidated and dolomitized. This can be seen in the logs through a rounded but smaller borehole diameter than the above section. Sonic porosity fluctuated around 120 µS/ft, and downward flow increased approximately 25%. Natural gamma response was slightly higher, ranging from approximately 15 to 50 cps. This increase likely was the result of the laminations of organics found throughout the interval from 570 to 710 ft bls.

From 710 to 770 ft bls, resistivity was very high, reaching a maximum of approximately 6,520 ohms for the normal 64-inch and approximately 3,575 ohms for the normal 16-inch. The sonic log was reduced by approximately half, while natural gamma response followed the same profile as the above section. Downward flow noticeably increased in the video and flowmeter logs. These coincide with the well indurated dolostone that has frequent fractures and brecciation and moderately low porosity.

In the next interval, from 770 to 900 ft bls, resistivity was reduced to one-third of the 710 to 770 ft bls interval and was approximately twice that of the 310 to 710 ft bls interval. Natural gamma was marginally reduced, ranging from 10 to 35 cps. The caliper profile was jagged, with a low diameter averaging approximately 2 inches wider than the nominal diameter of 8 inches. Sonic porosity log values remained low. These traits point towards high induration, moderately fractured, low porosity rock.

A large borehole and multiple cavities were found in the caliper and video logs between 900 to 1,150 ft bls. Some of these were larger than the caliper tool's diameter of 20 inches and negatively influenced other logs. The sonic porosity logs showed large spikes in porosity that aligned with these cavities. Natural gamma ranged from 5 to 30 cps, with drops corresponding to where the caliper tool was not large enough to measure the space. Resistivity gradually decreased through this interval, from approximately 200 to 890 ohms in the 64-inch normal. Flow was slightly reduced from the suprajacent interval. The geophysical data reflect the lithology being moderate induration, moderate porosity, with large cavities, washouts, and frequent intervals of no recovery.

From 1,150 to 1,315 ft bls, resistivity and caliper log values were low. Borehole diameter was within 2 inches of gauge. Natural gamma had a similar profile as the 900 to 1,150 ft bls interval. Sonic porosity was low. This interval encompassed MCU_I, where there was low permeability and few fractures.

The LFA-upper corresponds with the interval from 1,315 to 1,403 ft bls. Resistivity was the same as the above section, but downward flow increased and there were larger amplitude fluctuations in sonic porosity. A large spike in gamma counts from 1,393 to 1,403 ft bls coincided with a section of organics found in the lithology.

From 1,403 ft bls to the maximum depth of 1,487 ft bls, resistivity was the only log that showed a significant change, with a sharp increase to approximately 3,000 ohms for the 64-inch resistivity. The total drilled depth of 1,500 ft bls could not be logged due to a borehole collapse at 1,487 ft bls. The logs reflect the moderate to well indurated dolostone of the interval.

## Laboratory Core Analysis

Eleven core samples were shipped to Core Laboratories in Houston, Texas, for analysis. The objectives of the analysis were to evaluate the presence of celestine and assess the heterogeneity and anisotropy of permeability of the cores. Samples were studied using thin-section petrography, XRD, and conventional plug analysis. The conventional plug analysis determined horizontal and vertical permeability, porosity, and bulk density. Core Laboratories reported the permeability in milli-Darcy, but for the purpose of this report, it has been converted to ft/day, the same units as the packer test data. The core sample inventory and tests are summarized in **Table 13**. The permeability data are summarized in **Table 14**, and the XRD data are summarized in **Table 15. Appendix G** contains the complete laboratory and petrographic reports.

Table 13. Inventory of core samples and tests performed at OSF-64R.

| Packer Test # | Approximate Sample Depth (ft bls) | Horizontal Permeability | Vertical Permeability and Porosity | Thin-Section Petrography | XRD | Apparent Permeability (Visual) | Comments |
|---|---|---|---|---|---|---|---|
| 12 | 955.3 | | | | | Low | Plug not possible |
| 13 | 977.7 | X | X | | | Moderate | |
| 17 | 1,115.2 | X | X | X | | None | |
| 23 | 1,271.6 | | | | X | Moderate | |
| 23 | 1,274.9 | X | X | | X | None | |
| 23 | 1,279.0 | X | X | | X | Low | |
| 23 | 1,297.4 | X | X | X | | High | |
| 25 | 1,334.4 | | | X | | Low | |
| 25 | 1,340.4 | | | X | | Moderate | |
| 27 | 1,417.7 | X | X | | X | Low | |
| 30 | 1,481.8 | X | X | | | Moderate | |

ft bls = feet below land surface; XRD = X-ray diffraction.

Table 14. Results of permeability tests and thin section petrography at OSF-64R.

| Packer Test # | Approximate Sample Depth (ft bls) | Grain Density ($g/cm^3$) | Dunham Classification | Horizontal Plug Orientation | | | Vertical Plug Orientation | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Permeability (ft/day) | | Porosity (%) | Permeability (ft/day) | | Porosity (%) |
| | | | | Klinkenberg | Kair | | Klinkenberg | Kair | |
| 13 | 977.7 | 2.84 | -- | 0.23 | 0.26 | 26.69 | 0.04 | 0.04 | 29.25 |
| 17 | 1,115.2 | 2.85 | Peloidal Dolopackstone | 0.29 | 0.33 | 44.30 | 0.30 | 0.34 | 43.70 |
| 23 | 1,274.9 | 2.84 | -- | 0.01 | 0.01 | 26.96 | 0.01 | 0.02 | 29.13 |
| 23 | 1,279.0 | 2.85 | -- | 0.01 | 0.02 | 35.41 | 0.04 | 0.06 | 39.73 |
| 23 | 1,297.4 | 2.85 | Bioclastic Dolopackstone | 0.001 | 0.002 | 17.73 | 0.0002 | 0.001 | 19.56 |
| 25 | 1,334.4 | -- | Bioclastic Dolowackestone | -- | -- | -- | -- | -- | -- |
| 25 | 1,340.4 | -- | Bioclastic Dolopackstone | -- | -- | -- | -- | -- | -- |
| 27 | 1,417.7 | 2.79 | -- | 5.59 | 5.67 | 35.20 | 11.19 | 11.56 | 38.24 |
| 30 | 1,481.8 | 2.80 | -- | 1.89 | 1.94 | 23.77 | 11.52 | 12.65 | 23.75 |

bls = below land surface; ft = foot; $g/cm^3$ = grams per cubic centimeter.

Table 15. Results of X-ray diffraction analysis at OSF-64R.

| Packer Test # | Approximate Sample Depth (ft bls) | Quartz (%) | Calcite (%) | Dolomite and Iron-Dolomite (%) | Celestine (%) | Pyrite (%) | Total Clay (%) |
|---|---|---|---|---|---|---|---|
| 23 | 1,271.6 | 1.0 | 0.0 | 99.0 | 0.0 | 0.0 | 0.0 |
| 23 | 1,271.6 Crystal | 0.0 | 0.0 | 19.4 | 80.6 | 0.0 | 0.0 |
| 23 | 1,274.9 | 0.5 | 0.0 | 99.5 | 0.0 | 0.0 | 0.0 |
| 23 | 1,279.0 | 0.4 | 1.9 | 99.6 | 0.0 | 0.0 | 0.0 |
| 27 | 1,417.7 | 0.8 | 0.0 | 97.3 | 0.0 | 0.0 | 0.0 |

ft bls = feet below land surface.

Multiple samples from 1,270 to 1,300 ft bls (packer test 23) were tested with XRD because the interval had the highest strontium concentrations, suggesting the presence of celestine or other strontium mineral in the host rock. Celestine was located in OSF-64R as a large subhedral crystal at a depth of 1,271.6 ft bls. In a test of the host rock at the same interval, no celestine was detected during XRD analysis. In Florida wells, celestine has been found as fine sand-sized grains, rather than as large whole crystals (McCartan et al. 1988). During CFWI drilling, celestine was encountered at OSF-133 at 1,030 ft bls (SFWMD 2020). **Figure 19** shows the crystal under visible and shortwave ultraviolet light.

Figure 19. Photos of celestine found at 1,271.6 feet below land surface under visible light (left) and under shortwave ultraviolet light (right).

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# APPENDICES

# APPENDIX A:
# WELL CONSTRUCTION SUMMARY

Table A-1. Well construction summary of OSF-64R.

| Date From | Date To | Activity | Site Geologist |
|---|---|---|---|
| 19-Aug-19 | 5-Sep-19 | Huss mobilized to site. 610 ft of 5-inch temporary steel casing installed. | - |
| 6-Sep-19 | 6-Sep-19 | Coring from 610 to 640 ft bls | E. Richardson |
| 9-Sep-19 | 13-Sep-19 | Coring and packer testing from 640 to 790 ft bls | L. Lindstrom |
| 16-Sep-19 | 20-Sep-19 | Coring and packer testing from 790 to 970 ft bls | S. Krupa |
| 23-Sep-19 | 25-Sep-19 | Coring and packer testing from 970 to 1,030 ft bls. Drilling stopped to fix issue of rocks restricting piping movement. | S. Coonts |
| 26-Sep-19 | 1-Oct-19 | Casing removed, borehole reamed to 5 inches, and 4-inch temporary casing advanced to 1,030 ft bls when replaced | - |
| 2-Oct-19 | 4-Oct-19 | Coring and packer testing from 1,030 to 1,116 ft bls | E. Richardson |
| 7-Oct-19 | 11-Oct-19 | Coring and packer testing from 1,116 to 1,220 ft bls | K. Smith |
| 14-Oct-19 | 18-Oct-19 | Coring and packer testing from 1,220 to 1,380 ft bls | E. Geddes |
| 21-Oct-19 | 24-Oct-19 | Coring and packer testing from 1,380 to 1,500 ft bls | J. Janzen |
| 25-Oct-19 | 10-Dec-19 | Huss removed casing and reamed borehole to 8 inches from 610 to 1,500 ft bls | - |
| 11-Dec-19 | 13-Dec-19 | USGS logged OBI; RMBaker LLC logged geophysics | S. Coonts |
| 16-Dec-19 | 18-Dec-19 | Casing installation and cementing from 1,300 to 1,273 ft bls | E. Geddes |
| 19-Dec-19 | 20-Dec-19 | Cementing from 1,273 to 1,058 ft bls | K. Smith |
| 23-Dec-19 | 3-Jan-20 | Christmas and New Year’s holidays – no work | - |
| 6-Jan-20 | 10-Jan-20 | Cementing from 1,058 to 735 ft bls | E. Geddes |
| 13-Jan-20 | 17-Jan-20 | Cementing from 735 to 30 ft bls. Well development by airlifting 6.5 borehole volumes then pumping 5 borehole volumes | E. Richardson |

bls = below land surface; ft = foot; OBI = optical borehole imaging; USGS = United States Geological Survey.

# APPENDIX B:
# WELL COMPLETION REPORT

**STATE OF FLORIDA PERMIT APPLICATION TO CONSTRUCT, REPAIR, MODIFY, OR ABANDON A WELL**

☐ Southwest
☐ Northwest
☐ St. Johns River
☐ South Florida
☐ Suwannee River
☐ DEP
☒ Delegated Authority (if Applicable) Osceola

PLEASE FILL OUT ALL APPLICABLE FIELDS
(*Denotes Required Fields Where Applicable)

*The water well contractor is responsible for completing this form and forwarding the permit application to the appropriate delegated authority where applicable.*

Permit No. 49-WP-1977955
Florida Unique ID
Permit Stipulations Required (See Attached)
62-524 Quad No. ______ Delineation No. ______
CUP/WUP Application No. ______
DELINEATION - FOR OFFICIAL USE ONLY

1. Bronsons PO Box 420879 Kissimmee, Fl. 34742
*Owner, Legal Name if Corporation *Address *City *State *ZIP Telephone Number

2. Lake Cypress Rd. Kenansville, Fl. 34739
*Well Location - Address/Road Name or Number, City

3. 0126300000010000
*Parcel ID No. ☒ (PIN) or ☐ Alternate Key Lot Block Unit

4. Check if 62-524: ☐ Yes ☐ No
*Section or Land Grant *Township *Range *County Subdivision

5. Stephanie Stallsmith 9342 352-567-9500 stephanie@bessdrilling.com
*Water Well Contractor *License Number *Telephone Number E-mail Address

6. 35920 State Road 52 Dade City Fl. 33525
*Water Well Contractor's Address City State ZIP

7. *Type of Work: ☐ Construction ☐ Repair ☒ Modification ☐ Abandonment ______
*Reason for Repair, Modification, or Abandonment

8. *Number of Proposed Wells ______

9. *Specify Intended Use(s) of Well(s):
☐ Domestic ☐ Landscape Irrigation ☐ Agricultural Irrigation ☐ Site Investigations
☐ Bottled Water Supply ☐ Recreation Area Irrigation ☐ Livestock ☐ Monitoring
☐ Public Water Supply (Limited Use/DOH) ☐ Nursery Irrigation ☒ Test
☐ Public Water Supply (Community or Non-Community/DEP) ☐ Commercial/Industrial ☐ Earth-Coupled Geothermal
☐ Class I Injection ☐ Golf Course Irrigation ☐ HVAC Supply
☐ HVAC Return

Class V Injection: ☐ Recharge ☐ Commercial/Industrial Disposal ☐ Aquifer Storage and Recovery ☐ Drainage
Remediation: ☐ Recovery ☐ Air Sparge ☐ Other (Describe) ______
☐ Other (Describe) ______

Date Stamp

Official Use Only

10. *Distance from Septic System if ≤ 200 ft. ______ 11. Facility Description pastureland 12. Estimated Start Date 8/1/19

13. *Estimated Well Depth 500 ft. *Estimated Casing Depth 300 ft. Primary Casing Diameter 4 in. Open Hole: From 300 To 500 ft.

14. Estimated Screen Interval: From ______ To ______ ft.

15. *Primary Casing Material: ☒ Black Steel ☐ Galvanized ☐ PVC ☐ Stainless Steel
☐ Not Cased ☐ Other ______

16. Secondary Casing: ☐ Telescope Casing ☐ Liner ☐ Surface Casing Diameter ______ in.

17. Secondary Casing Material: ☐ Black Steel ☐ Galvanized ☐ PVC ☐ Stainless Steel ☐ Other ______

18. *Method of Construction, Repair, or Abandonment: ☐ Auger ☐ Cable Tool Jetted ☒ Rotary ☐ Sonic
☐ Combination (Two or More Methods) ☐ Hand Driven (Well Point, Sand Point) ☐ Hydraulic Point (Direct Push)
☐ Horizontal Drilling ☐ Plugged by Approved Method ☐ Other (Describe) ______

19. Proposed Grouting Interval for the Primary, Secondary, and Additional Casing:
From 0 To 300 Seal Material (☐ Bentonite ☒ Neat Cement ☐ Other ______)
From ______ To ______ Seal Material (☐ Bentonite ☐ Neat Cement ☐ Other ______)
From ______ To ______ Seal Material (☐ Bentonite ☐ Neat Cement ☐ Other ______)
From ______ To ______ Seal Material (☐ Bentonite ☐ Neat Cement ☐ Other ______)

20. Indicate total number of existing wells on site 0 List number of existing unused wells on site 0

21. *Is this well or any existing well or water withdrawal on the owner's contiguous property covered under a Consumptive/Water Use Permit (CUP/WUP) or CUP/WUP Application? Yes (No) If yes, complete the following: CUP/WUP No. ______ District Well ID No. ______

22. Latitude ______ Longitude ______

23. Data Obtained From: ☐ GPS ☐ Map ☐ Survey Datum: ______ NAD 27 ______ NAD 83 ______ WGS 84

I hereby certify that I will comply with the applicable rules of Title 40, Florida Administrative Code, and that a water use permit or artificial recharge permit, if needed, has been or will be obtained prior to commencement of well construction. I further certify that all information provided on this application is accurate and that I will obtain necessary approval from other federal, state, or local governments, if applicable. I agree to provide a well completion report to the District within 30 days after completion of the construction, repair, modification, or abandonment authorized by this permit, or the permit expiration, whichever occurs first.

I certify that I am the owner of the property, that the information provided is accurate, and that I am aware of my responsibilities under Chapter 373, Florida Statutes, to maintain or properly abandon this well, or, I certify that I am the agent for the owner, that the information provided is accurate, and that I have informed the owner of their responsibilities as stated above. Owner consents to allow personnel of the WMD or Delegated Authority access to the well site during the construction, repair, modification, or abandonment authorized by this permit.

[signature] 9342 [signature] 7/26/19
*Signature of Contractor *License No. *Signature of Owner or Agent *Date

Approval Granted By [signature] Issue Date 7-26-19 Expiration Date 1-26-20 Hydrologist Approval ______ (if req'd)
Fee Received $ ______ Receipt No. 49-BID-1968495 Check No. ______

THIS PERMIT IS NOT VALID UNTIL PROPERLY SIGNED BY AN AUTHORIZED OFFICER OR REPRESENTATIVE OF THE WMD OR DELEGATED AUTHORITY. THE PERMIT SHALL BE AVAILABLE AT THE WELL SITE DURING ALL CONSTRUCTION, REPAIR, MODIFICATION, OR ABANDONMENT ACTIVITIES.

# STATE OF FLORIDA WELL COMPLETION REPORT

☐ Southwest
☐ Northwest
☐ St. Johns River
☐ South Florida
☐ Suwannee River
☐ DEP
☐ Delegated Authority (If Applicable) Osceola

PLEASE, FILL OUT ALL APPLICABLE FIELDS
(*Denotes Required Fields Where Applicable)

Date Stamp

Official Use Only

1.*Permit Number 49-WP-197-7955 *CUP/WUP Number ____ *DID Number ____ 62-524 Delineation No. ____

2.*Number of permitted wells constructed, repaired, or abandoned 1 *Number of permitted wells not constructed, repaired, or abandoned Ø

3.*Owner's Name Bronsons 4.*Completion Date 1/17/20 5. Florida Unique ID ____

6. Lake Cypress Rd Kenansville, Fl. 34739
*Well Location - Address, Road Name or Number, City, ZIP

7. *County Osceola *Section ____ Land Grant ____ *Township ____ *Range ____

8. Latitude 28 072402 Longitude 81 279614

9. Data Obtained From: ____ GPS ____ Map ____ Survey Datum: ____ NAD 27 ____ NAD 83 ____ WGS 84

10.*Type of Work: ____ Construction ____ Repair X Modification ____ Abandonment

11.*Specify Intended Use(s) of Well(s):
____ Domestic ____ Landscape Irrigation ____ Agricultural Irrigation ____ Site Investigation
____ Bottled Water Supply ____ Recreation Area Irrigation ____ Livestock ____ Monitoring
____ Public Water Supply (Limited Use/DOH) ____ Nursery Irrigation X Test
____ Public Water Supply (Community or Non-Community/DEP) ____ Commercial/Industrial ____ Earth-Coupled Geothermal
____ Golf Course Irrigation ____ HVAC Supply
____ Class I Injection ____ HVAC Return
Class V Injection: ____ Recharge ____ Commercial/Industrial Disposal ____ Aquifer Storage and Recovery ____ Drainage
Remediation: ____ Recovery ____ Air Sparge ____ Other (Describe) ____
____ Other (Describe) ____

12.*Drill Method: ____ Auger ____ Cable Tool X Rotary ____ Combination (Two or More Methods) ____ Jetted ____ Sonic
____ Horizontal Drilling ____ Hydraulic Point (Direct Push) ____ Other ____

13.*Measured Static Water Level ____ ft. Measured Pumping Water Level ____ ft. After ____ Hours at ____ GPM

14.*Measuring Point (Describe) ____ Which is ____ ft. ____ Above ____ Below Land Surface *Flowing: ____ Yes ____ No

15.*Casing Material: X Black Steel ____ Galvanized ____ PVC ____ Stainless Steel ____ Not Cased ____ Other ____

16.*Total Well Depth 1500 ft. Cased Depth 300 ft. *Open Hole: From 300 To 1500 ft. *Screen: From ____ To ____ ft. Slot Size ____

17.*Abandonment: ____ Other (Explain) ____

| From | To | No. of Bags | Seal Material (Check One) |
|---|---|---|---|
| ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |

18.*Surface Casing Diameter and Depth:

| Dia | From | To | No. of Bags | Seal Material (Check One) |
|---|---|---|---|---|
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |

19.*Primary Casing Diameter and Depth:

| Dia | From | To | No. of Bags | Seal Material (Check One) |
|---|---|---|---|---|
| 4 in. | 0 ft. | 300 ft. | 503 | X Neat Cement ____ Bentonite ____ Other ____ |
| ____ in. | ____ ft. | ____ ft. | 17.7 | ____ Neat Cement ____ Bentonite X Other Gravel |
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |

20.*Liner Casing Diameter and Depth:

| Dia | From | To | No. of Bags | Seal Material (Check One) |
|---|---|---|---|---|
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |

21.*Telescope Casing Diameter and Depth:

| Dia | From | To | No. of Bags | Seal Material (Check One) |
|---|---|---|---|---|
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |
| ____ in. | ____ ft. | ____ ft. | ____ | ____ Neat Cement ____ Bentonite ____ Other ____ |

22. Pump Type (If Known):
____ Centrifugal ____ Jet ____ Submersible ____ Turbine
Horsepower ____ Pump Capacity (GPM) ____
Pump Depth ____ ft. Intake Depth ____ ft.

23. Chemical Analysis (When Required):
Iron ____ ppm Sulfate ____ ppm Chloride ____ ppm
____ Laboratory Test ____ Field Test Kit

24. Water Well Contractor:
*Contractor Name Stephanie Stallsworth *License Number 9342 E-mail Address Stephanie@hussdrilling.com
*Contractor's Signature [signature] *Driller's Name (Print or Type) Eddie Palmer
(I certify that the information provided in this report is accurate and true.)

**SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT**
2379 BROAD STREET, BROOKSVILLE, FL 34604-6899
PHONE: (352) 796-7211 or (800) 423-1476
WWW.SWFWMD.STATE.FL.US

**ST. JOHNS RIVER WATER MANAGEMENT DISTRICT**
4049 REID STREET, PALATKA, FL 32178-1429
PHONE: (386) 329-4500
WWW.SJRWMD.COM

**NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT**
152 WATER MANAGEMENT DR., HAVANA, FL 32333-4712
(U.S. Highway 90, 10 miles west of Tallahassee)
PHONE: (850) 539-5999
WWW.NWFWMD.STATE.FL.US

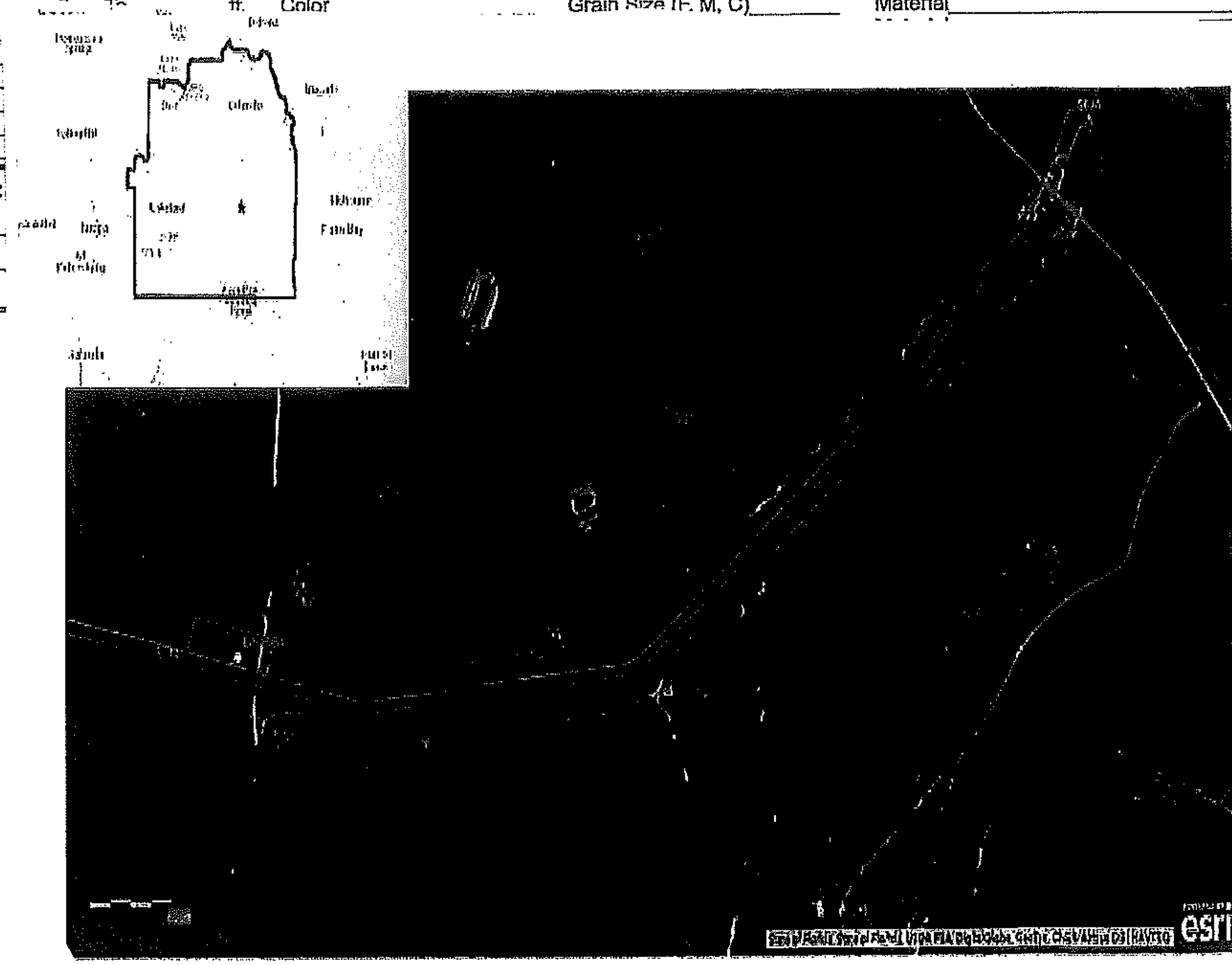
**SOUTH FLORIDA WATER MANAGEMENT DISTRICT**
P.O. BOX 24680
3301 GUN CLUB ROAD
WEST PALM BEACH, FL 33416-4680
PHONE: (561) 686-8800
WWW.SFWMD.GOV

**SUWANNEE RIVER WATER MANAGEMENT DISTRICT**
9225 CR 49
LIVE OAK, FL 32060
PHONE: (386) 362-1001 or (800) 226-1066 (Florida only)
WWW.MYSUWANNEERIVER.COM

***DRILL CUTTINGS LOG** (Examine cuttings every 20 ft. or at formation changes. Note cavities and depth to producing zone. Grain Size: F=Fine, M=Medium, and C=Coarse)

| | | | | |
|---|---|---|---|---|
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ft. | To____ft. | Color____ | Grain Size (F, M, C)____ | Material____ |
| From____ | ____ | ft. Color | Grain Size (F, M, C)____ | Material____ |
| From____ | | | | |
| From____ | | | | |
| From____ | | | | |
| From____ | | | | |
| From____ | | | | |
| From____ | | | | |

Comments:



OSF-64R Drill-Site Location

Give ... n roads and landmarks. Give distances from all reference points or structures...

# APPENDIX C:
# LITHOLOGIC DESCRIPTION

Table C-1. Lithology of OSF-64R.

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 610.0 | 614.0 | Limestone (wackestone); very pale orange (10yr 8/2); good intergranular and moldic porosity; good induration; bivalves, gastropods |
| 614.0 | 614.7 | Limestone (packstone); grayish orange (10yr 7/4); good intergranular and vuggy porosity; moderate induration; bivalves, gastropods |
| 614.7 | 618.6 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; bivalves, gastropods |
| 618.6 | 620.0 | Limestone (packstone); pale yellowish brown (10yr 6/2); good intergranular and moldic porosity; moderate induration; intraclasts; bivalves, gastropods |
| 620.0 | 622.8 | Limestone (packstone); grayish orange (10yr 7/4); good intergranular, vuggy, and moldic porosity; moderate induration; undifferentiated foraminifera, miliolids, bivalves, gastropods |
| 622.8 | 626.0 | Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; good induration; bivalves, gastropods |
| 626.0 | 631.4 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; lamination; bivalves, gastropods |
| 631.4 | 635.2 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint and moldic porosity; good induration; undifferentiated foraminifera, bivalves |
| 635.2 | 636.2 | Dolostone; yellowish gray (10yr 8/2); no observable porosity; good induration |
| 636.2 | 637.8 | Limestone (wackestone); pale yellowish brown (10yr 6/2); low intergranular porosity; good induration; undifferentiated foraminifera |
| 637.8 | 639.3 | Dolostone; dark yellow orange (10yr 6/6); microcrystalline; moderate pinpoint and moldic porosity; good induration |
| 639.3 | 640.0 | Limestone (wackestone); pale yellowish brown (10yr 6/2); low intergranular porosity; good induration; undifferentiated foraminifera |
| 640.0 | 643.3 | Limestone (packstone to wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; good induration; undifferentiated foraminifera |
| 643.3 | 645.7 | Limestone (wackestone); pale yellowish brown (10yr 6/2); low intergranular porosity; good induration; bivalves |
| 645.7 | 646.0 | Limestone (mudstone); white (10yr 8/2); no observable porosity; poor induration; laminated |
| 646.0 | 648.0 | Limestone (packstone to wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; undifferentiated foraminifera |
| 648.0 | 649.5 | Dolomitic limestone; pale yellowish brown (10yr 6/2); low intergranular porosity; good induration; undifferentiated foraminifera |
| 649.5 | 650.0 | Limestone (packstone); dark yellow orange (10yr 6/6); moderate intergranular porosity; good induration |
| 650.0 | 652.0 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; pellets, undifferentiated foraminifera |
| 652.0 | 653.3 | Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; moderate induration; pellets, gastropods, undifferentiated foraminifera |
| 653.3 | 654.0 | Limestone (grainstone); very pale orange (10yr 8/2); good intergranular porosity; moderate induration; pellets, gastropods, undifferentiated foraminifera |
| 654.0 | 657.2 | Limestone (packstone); very pale orange (10yr 8/2); moderate to low intergranular porosity; moderate induration; pellets, gastropods, undifferentiated foraminifera |
| 657.2 | 660.0 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; pellets, undifferentiated foraminifera |
| 660.0 | 660.8 | Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; good induration; brecciated |
| 660.8 | 664.0 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; pellets, undifferentiated foraminifera |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 664.0 | 666.0 | Limestone (packstone); grayish orange (10yr 7/4); moderate intergranular porosity; good induration; laminated; pellets, bivalves |
| 666.0 | 668.4 | Limestone (packstone); grayish orange (10yr 7/4); fractured; moderate intergranular porosity; good induration; laminated |
| 668.4 | 670.0 | No recovery |
| 670.0 | 673.8 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; fractured; good induration |
| 673.8 | 676.2 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; good vuggy, moldic, and pinpoint porosity; fractured; good induration |
| 676.2 | 677.5 | Dolomitic limestone; pale yellowish brown (10yr 6/2); low intergranular porosity; good induration |
| 677.5 | 679.3 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; intraclasts, pellets |
| 679.3 | 680.0 | No recovery |
| 680.0 | 680.5 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; pellets |
| 680.5 | 682.1 | Limestone (packstone to wackestone); very pale orange (10yr 8/2); good intergranular porosity; good induration; pellets |
| 682.1 | 685.5 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; pellets |
| 685.5 | 687.2 | Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; good induration; pellets, bivalves, foraminifera |
| 687.2 | 690.0 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; pellets; foraminifera |
| 690.0 | 692.0 | Limestone (wackestone); grayish orange (10yr 7/4); low intergranular porosity; fractured; good induration |
| 692.0 | 694.0 | Limestone (wackestone); grayish orange (10yr 7/4); low intergranular porosity; good induration |
| 694.0 | 696.2 | Limestone (wackestone); grayish orange (10yr 7/4); low intergranular porosity; fractured; good induration |
| 696.2 | 698.6 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; pellets |
| 698.6 | 700.0 | Limestone (grainstone); grayish orange (10yr 7/4); good intergranular porosity; good induration; pellets, undifferentiated foraminifera |
| 700.0 | 702.0 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; fractured; good induration; pellets |
| 702.0 | 703.2 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; pellets; laminated |
| 703.2 | 704.5 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; fractured; good induration; pellets |
| 704.5 | 706.0 | Limestone (packstone); grayish orange (10yr 7/4); moderate intergranular porosity; good induration; pellets |
| 706.0 | 706.8 | Limestone (packstone); grayish orange (10yr 7/4); moderate intergranular porosity; fractured; good induration; pellets |
| 706.8 | 707.8 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; fractured; good induration; pellets |
| 707.8 | 710.0 | No recovery |
| 710.0 | 715.2 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration |
| 715.2 | 718.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate to low pinpoint and vuggy porosity; fractured; good induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 718.0 | 719.5 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 719.5 | 720.0 | Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration |
| 720.0 | 728.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint and vuggy porosity; good induration |
| 728.0 | 729.3 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 729.3 | 731.6 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration |
| 731.6 | 732.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; fractured; good induration |
| 732.0 | 733.6 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration |
| 733.6 | 734.6 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; fractured; good induration |
| 734.6 | 740.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration |
| 740.0 | 742.5 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 742.5 | 743.5 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint and vuggy porosity; good induration |
| 743.5 | 744.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; good induration |
| 744.0 | 746.6 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; good induration |
| 746.6 | 750.0 | Dolostone: grayish orange (10yr 7/4); no visible porosity; good induration |
| 750.0 | 751.2 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; good induration |
| 751.2 | 752.2 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; fractured; good induration |
| 752.2 | 760.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration; some lamination |
| 760.0 | 762.4 | Dolostone: grayish orange (10yr 7/4); no visible porosity; good induration |
| 762.4 | 763.6 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; good pinpoint and vuggy porosity; good induration |
| 763.6 | 766.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; fractured; good induration |
| 766.0 | 770.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration |
| 770.0 | 770.4 | Dolostone: grayish orange (10yr 7/4); low pinpoint porosity; fractured; good induration |
| 770.4 | 771.6 | Dolostone: grayish orange (10yr 7/4); low pinpoint porosity; good induration |
| 771.6 | 773.6 | Dolostone: grayish orange (10yr 7/4); low pinpoint porosity; fractured; good induration |
| 773.6 | 780.0 | Dolostone: grayish orange (10yr 7/4); no visible porosity; good induration |
| 780.0 | 780.3 | Dolostone: grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; good induration |
| 780.3 | 781.6 | Dolostone: grayish orange (10yr 7/4); no visible porosity; good induration; some lamination |
| 781.6 | 783.0 | Dolostone: grayish orange (10yr 7/4); low pinpoint porosity; fractured; good induration |
| 783.0 | 786.0 | Dolostone: grayish orange (10yr 7/4); low pinpoint porosity; good induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 786.0 | 787.4 | Dolostone: grayish orange (10yr 7/4); microcrystalline to sucrosic; moderate to low pinpoint porosity; fractured; good induration |
| 787.4 | 788.5 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; good pinpoint and vuggy porosity; good induration |
| 788.5 | 790.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration |
| 790.0 | 790.3 | Dolostone: grayish orange (10yr 7/4); low pinpoint porosity; fractured; good induration |
| 790.3 | 791.7 | Dolostone: grayish orange (10yr 7/4); microcrystalline; moderate to low pinpoint porosity; fractured; good induration |
| 791.7 | 792.6 | Dolostone: grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 792.6 | 793.7 | Dolostone: grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 793.7 | 798.0 | Dolostone: grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; some fractures; good induration |
| 798.0 | 798.5 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; good pinpoint and vuggy porosity; fractured; good induration |
| 798.5 | 801.5 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low to moderate pinpoint porosity; few fractures; good induration |
| 801.5 | 804.4 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate to low pinpoint, vuggy, and moldic porosity; good induration |
| 804.4 | 808.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low to moderate pinpoint porosity; good induration |
| 808.0 | 810.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; good induration |
| 810.0 | 814.8 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; highly fractured; good induration |
| 814.8 | 817.6 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; good pinpoint, vuggy, and moldic porosity; some fractures; good induration |
| 817.6 | 822.7 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate to low pinpoint, vuggy, and moldic porosity; fractured; good induration |
| 822.7 | 825.1 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; few fractures; good induration |
| 825.1 | 827.2 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; fractured; good induration |
| 827.2 | 828.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; high pinpoint, vuggy, and moldic porosity; fractured; good induration |
| 828.0 | 830.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; fractured; good induration; some organics |
| 830.0 | 834.0 | Dolostone: grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; good induration; some organics |
| 834.0 | 835.4 | Dolostone; very pale orange (10yr 8/2); microcrystalline; no observable porosity; some fractures; good induration |
| 835.4 | 837.5 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 837.5 | 848.7 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low to moderate pinpoint and vuggy porosity; good induration; some lamination |
| 848.7 | 849.3 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 849.3 | 850.0 | No recovery |
| 850.0 | 852.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 852.0 | 853.1 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; good pinpoint and vuggy porosity; good induration |
| 853.1 | 855.3 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 855.3 | 856.9 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; fractured; good induration |
| 856.9 | 859.6 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 859.6 | 863.2 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; some fractures; good induration |
| 863.2 | 864.9 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; some fractures; good induration |
| 864.9 | 865.6 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; no observable porosity; good induration |
| 865.6 | 867.6 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 867.6 | 870.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 870.0 | 880.0 | Dolostone; dark yellowish orange (10yr 6/6); microcrystalline; low pinpoint and vuggy porosity; highly fractured; good induration; some lamination |
| 880.0 | 884.9 | Dolostone: grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 884.9 | 886.3 | Dolostone: grayish orange (10yr 7/4); microcrystalline; moderate pinpoint porosity; good induration |
| 886.3 | 887.5 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 887.5 | 890.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration; some lamination |
| 890.0 | 892.0 | Dolostone: grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moderate porosity; few fractures; good induration |
| 892.0 | 895.0 | Dolostone: grayish orange (10yr 7/4); microcrystalline; low to moderate pinpoint and vuggy porosity; good induration; some lamination |
| 895.0 | 897.4 | Dolostone: grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; good induration |
| 897.4 | 899.3 | Dolostone: grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moderate porosity; fractured; good induration |
| 899.3 | 900.0 | No recovery |
| 900.0 | 907.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate to low pinpoint and vuggy porosity; fractured; good induration |
| 907.0 | 910.8 | Dolostone: grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moderate porosity; fractured; good induration |
| 910.8 | 912.0 | No recovery |
| 912.0 | 919.4 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good to moderate pinpoint, vuggy, and moderate porosity; fractured; good induration |
| 919.4 | 920.0 | No recovery |
| 920.0 | 925.9 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good to moderate pinpoint, vuggy, and moderate porosity; fractured; good induration |
| 925.9 | 926.9 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint and vuggy porosity; good induration |
| 926.9 | 929.5 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint and vuggy porosity; fractured; good induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 929.5 | 935.3 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good to moderate pinpoint, vuggy, and moderate porosity; fractured; poor to good induration |
| 935.3 | 939.2 | Dolostone; dark yellow orange (10yr 6/6); microcrystalline; moderate to low pinpoint and vuggy porosity; good to moderate induration |
| 939.2 | 943.8 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate to low pinpoint porosity; highly fractured; moderate to good induration |
| 943.8 | 946.7 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good to moderate pinpoint, vuggy, and moderate porosity; fractured; moderate to good induration |
| 946.7 | 950.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; fractured; moderate to good induration |
| 950.0 | 954.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low to moderate pinpoint and vuggy porosity; fractured; moderate induration |
| 954.0 | 958.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; moderate induration; some lamination |
| 958.0 | 959.0 | No recovery |
| 959.0 | 960.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; moderate induration |
| 960.0 | 960.6 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; fractured; moderate induration |
| 960.6 | 965.4 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; moderate to good induration; some lamination |
| 965.4 | 977.9 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; fractured; good induration; some lamination |
| 977.9 | 980.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low to moderate pinpoint porosity; moderate to good induration; some lamination |
| 980.0 | 980.6 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; fractured; good induration |
| 980.6 | 983.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 983.0 | 987.4 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low to moderate pinpoint and vuggy porosity; fractured; good induration |
| 987.4 | 990.0 | No recovery |
| 990.0 | 991.8 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; good induration |
| 991.8 | 995.2 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; highly fractured; good induration |
| 995.2 | 997.9 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate to low pinpoint porosity; good induration; some lamination |
| 997.9 | 1,002.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate to good pinpoint, vuggy, and moldic porosity; fractured; moderate to good induration |
| 1,002.0 | 1,005.2 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 1,005.2 | 1,006.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 1,006.0 | 1,010.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; highly fractured; good induration |
| 1,010.0 | 1,011.5 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; good induration |
| 1,011.5 | 1,013.7 | Dolostone; very pale orange (10yr 8/2); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 1,013.7 | 1,016.6 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low to moderate pinpoint and vuggy porosity; good induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,016.6 | 1,019.3 | Dolostone; very pale orange (10yr 8/2); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 1,019.3 | 1,020.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; good induration |
| 1,020.0 | 1,021.3 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; fractured; good induration |
| 1,021.3 | 1,022.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; good pinpoint, vuggy, and moldic porosity; fractured; good induration |
| 1,022.0 | 1,025.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; fractured; good induration |
| 1,025.0 | 1,025.8 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration |
| 1,025.8 | 1,026.6 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; good induration |
| 1,026.6 | 1,030.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration |
| 1,030.0 | 1,034.6 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; moderate to good induration |
| 1,034.6 | 1,035.4 | Dolostone; grayish orange (10yr 7/4); microcrystalline; no observable porosity; fractured; poor induration |
| 1,035.4 | 1,040.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; moderate to good induration |
| 1,040.0 | 1,048.3 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate to low pinpoint and vuggy porosity; moderate induration |
| 1,048.3 | 1,050.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; moderate induration |
| 1,050.0 | 1,053.8 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate to low pinpoint porosity; fractured; good induration |
| 1,053.8 | 1,055.1 | Dolostone; very pale orange (10yr 8/2); microcrystalline; no observable porosity; fractured; poor induration |
| 1,055.1 | 1,061.1 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; moderate to good induration |
| 1,061.1 | 1,062.8 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint and vuggy porosity; good induration |
| 1,062.8 | 1,063.8 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 1,063.8 | 1,069.4 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration |
| 1,069.4 | 1,073.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; partially fractured; good induration; undifferentiated foraminifera, bivalves |
| 1,073.0 | 1,078.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint, vuggy, and moldic porosity; fractured; good induration |
| 1,078.0 | 1,080.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 1,080.0 | 1,084.0 | No recovery |
| 1,084.0 | 1,086.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; fractured; moderate induration |
| 1,086.0 | 1,090.0 | No recovery |
| 1,090.0 | 1,090.6 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint porosity; fractured; moderate induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,090.6 | 1,092.8 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 1,092.8 | 1,093.5 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; fractured; good induration |
| 1,093.5 | 1,094.6 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration; some lamination |
| 1,094.6 | 1,100.0 | Dolostone: grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; good induration; some lamination |
| 1,100.0 | 1,100.8 | No recovery |
| 1,100.8 | 1,113.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint and vuggy porosity; fractured; moderate induration |
| 1,113.0 | 1,114.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; no observable porosity; moderate induration |
| 1,114.0 | 1,115.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; good induration; some lamination |
| 1,115.0 | 1,116.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; no observable porosity; moderate induration |
| 1,116.0 | 1,130.0 | No recovery |
| 1,130.0 | 1,130.4 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; good induration; some lamination |
| 1,130.4 | 1,136.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 1,136.0 | 1,137.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; no observable porosity; moderate induration |
| 1,137.0 | 1,142.1 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; moderate induration; some lamination |
| 1,142.1 | 1,143.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; moderate induration; some lamination |
| 1,143.0 | 1,146.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; good induration |
| 1,146.0 | 1,148.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; moderate to poor induration; organics |
| 1,148.0 | 1,150.0 | No recovery |
| 1,150.0 | 1,153.8 | Dolostone; very pale orange (10yr 8/2); microcrystalline; no observable porosity; fractured; poor induration |
| 1,153.8 | 1,154.7 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; fractured; good to poor induration |
| 1,154.7 | 1,155.6 | Dolostone; grayish orange (10yr 7/4); microcrystalline; no observable porosity; fractured; poor induration |
| 1,155.6 | 1,157.7 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint and vuggy porosity; fractured; moderate induration |
| 1,157.7 | 1,159.3 | Dolostone; grayish orange (10yr 7/4); microcrystalline; no observable porosity; fractured; poor induration |
| 1,159.3 | 1,160.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; moderate induration |
| 1,160.0 | 1,161.5 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration |
| 1,161.5 | 1,166.8 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration |
| 1,166.8 | 1,168.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; moderate induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,168.0 | 1,168.8 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration; some lamination |
| 1,168.8 | 1,170.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; fractured; good induration |
| 1,170.0 | 1,171.4 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration |
| 1,171.4 | 1,173.2 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; fractured; moderate induration; gastropods |
| 1,173.2 | 1,174.7 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; good induration |
| 1,174.7 | 1,176.7 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; fractured; moderate induration; undifferentiated foraminifera |
| 1,176.7 | 1,182.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration; gastropods, undifferentiated foraminifera |
| 1,182.0 | 1,184.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; moderate induration; gastropods, undifferentiated foraminifera |
| 1,184.0 | 1,190.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; gastropods, undifferentiated foraminifera |
| 1,190.0 | 1,192.2 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; gastropods, undifferentiated foraminifera |
| 1,192.2 | 1,194.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; good induration |
| 1,194.0 | 1,194.9 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; fractured; good induration |
| 1,194.9 | 1,197.8 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,197.8 | 1,199.1 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; gastropods |
| 1,199.1 | 1,200.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; fractured; moderate induration; gastropods |
| 1,200.0 | 1,209.2 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate to low pinpoint and vuggy porosity; moderate induration |
| 1,209.2 | 1,210.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; moderate induration; gastropods |
| 1,210.0 | 1,211.3 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration; gastropods |
| 1,211.3 | 1,212.9 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; fractured; moderate induration |
| 1,212.9 | 1,214.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,214.0 | 1,216.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; moderate induration |
| 1,216.0 | 1,217.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,217.0 | 1,218.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; moderate induration |
| 1,218.0 | 1,220.0 | No recovery |
| 1,220.0 | 1,220.8 | Dolostone; very pale orange (10yr 8/2); microcrystalline; high pinpoint and vuggy porosity; moderate induration; wormholes |
| 1,220.8 | 1,225.5 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low to moderate pinpoint and vuggy porosity; moderate induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,225.5 | 1,228.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint and vuggy porosity; moderate induration; wormholes |
| 1,228.0 | 1,230.5 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate to low pinpoint and vuggy porosity; moderate induration |
| 1,230.5 | 1,233.4 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint and vuggy porosity; moderate induration; wormholes, gastropods |
| 1,233.4 | 1,235.7 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration; wormholes, gastropods |
| 1,235.7 | 1,236.6 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,236.6 | 1,237.8 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; fractured; moderate induration; wormholes |
| 1,237.8 | 1,239.3 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration; wormholes |
| 1,239.3 | 1,240.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration |
| 1,240.0 | 1,242.4 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration; wormholes, gastropods |
| 1,242.4 | 1,243.5 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,243.5 | 1,244.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; high pinpoint, vuggy, and moldic porosity; moderate induration; wormholes, gastropods |
| 1,244.0 | 1,246.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,246.0 | 1,247.4 | Dolostone; very pale orange (10yr 8/2); microcrystalline; high pinpoint, vuggy, and moldic porosity; moderate induration; wormholes, gastropods |
| 1,247.4 | 1,257.5 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low to moderate pinpoint porosity; moderate induration |
| 1,257.5 | 1,260.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; no observable porosity; moderate induration |
| 1,260.0 | 1,264.3 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate to low pinpoint porosity; moderate induration |
| 1,264.3 | 1,265.5 | Dolostone; grayish orange (10yr 7/4); microcrystalline; good pinpoint and vuggy porosity; moderate induration |
| 1,265.5 | 1,268.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; moderate to low induration |
| 1,268.0 | 1,269.0 | Dolostone; grayish orange (10yr 7/4); microcrystalline; low to moderate pinpoint porosity; fractured; moderate induration |
| 1,269.0 | 1,272.2 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate to low pinpoint porosity; moderate induration; wormholes, celestine |
| 1,272.2 | 1,273.0 | Dolostone; yellow gray (10yr 8/2); microcrystalline; high pinpoint and vuggy porosity; moderate induration; wormholes |
| 1,273.0 | 1,274.3 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint; moderate induration |
| 1,274.3 | 1,276.2 | Dolostone; very pale orange (10yr 8/2); microcrystalline; no observable porosity; moderate induration |
| 1,276.2 | 1,280.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate to low pinpoint porosity; moderate induration; wormholes |
| 1,280.0 | 1,281.4 | Calcareous dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; wormholes |
| 1,281.4 | 1,284.2 | Calcareous dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,284.2 | 1,287.6 | Calcareous dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; wormholes |
| 1,287.6 | 1,288.4 | Calcareous dolostone; very pale orange (10yr 8/2); microcrystalline; high pinpoint and vuggy porosity; moderate induration; wormholes |
| 1,288.4 | 1,290.5 | Calcareous dolostone; very pale orange (10yr 8/2); microcrystalline; moderate to low pinpoint and vuggy porosity; moderate to low induration; wormholes |
| 1,290.5 | 1,292.0 | Calcareous dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration; gastropods, wormholes |
| 1,292.0 | 1,292.8 | Calcareous dolostone; grayish orange (10yr 7/4); microcrystalline; high pinpoint, vuggy, and moderate porosity; moderate induration; gastropods, wormholes |
| 1,292.8 | 1,294.0 | Calcareous dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,294.0 | 1,296.7 | Calcareous dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; wormholes, gastropods |
| 1,296.7 | 1,298.3 | Calcareous dolostone; grayish orange (10yr 7/4); microcrystalline; high pinpoint, vuggy, and moderate porosity; moderate induration; gastropods, wormholes; crystalline calcite in vugs |
| 1,298.3 | 1,300.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration; gastropods, wormholes |
| 1,300.0 | 1,304.0 | Calcareous dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint and vuggy porosity; moderate induration; some crystalline calcite in vugs |
| 1,304.0 | 1,308.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,308.0 | 1,310.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; fractured; moderate induration |
| 1,310.0 | 1,311.6 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration; some crystalline calcite in vugs |
| 1,311.6 | 1,317.0 | Dolostone: grayish orange (10yr 7/4); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration; bivalves; some crystalline calcite in vugs |
| 1,317.0 | 1,320.0 | Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; fractured; good induration; some crystalline calcite in vugs |
| 1,320.0 | 1,320.4 | Dolostone; light greenish gray (5g 8/1); microcrystalline; moderate pinpoint porosity; good induration; calcite crystals |
| 1,320.4 | 1,324.5 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint and vuggy porosity; good induration; calcite crystals |
| 1,324.5 | 1,327.2 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint porosity; good induration |
| 1,327.2 | 1,331.1 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration; chalky |
| 1,331.1 | 1,335.2 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; good induration |
| 1,335.2 | 1,337.5 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,337.5 | 1,338.2 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate vuggy and moldic porosity; good induration; fractured |
| 1,338.2 | 1,340.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 1,340.0 | 1,341.9 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate vuggy porosity; moderate induration |
| 1,341.9 | 1,343.8 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration; some laminations |
| 1,343.8 | 1,345.8 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,345.8 | 1,347.8 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,347.8 | 1,350.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,350.0 | 1,351.0 | Dolostone; very pale orange (10yr 8/2); microcrystalline; moderate pinpoint and moldic porosity; good induration |
| 1,351.0 | 1,352.3 | Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; moderate induration |
| 1,352.3 | 1,353.7 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint and moldic porosity; moderate induration |
| 1,353.7 | 1,354.8 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint porosity; good induration |
| 1,354.8 | 1,356.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint and moldic porosity; good induration |
| 1,356.0 | 1,358.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint, moldic, and vuggy porosity; good induration; some organics |
| 1,358.0 | 1,360.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic, and vuggy porosity; good induration |
| 1,360.0 | 1,361.2 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration |
| 1,361.2 | 1,362.3 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; low pinpoint porosity; moderate induration |
| 1,362.3 | 1,367.5 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; fractured |
| 1,367.5 | 1,370.0 | Dolostone; brownish gray (5yr 4/1); microcrystalline; high pinpoint and vuggy porosity; good induration; fractured; organics in vugs |
| 1,370.0 | 1,371.4 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; moderate induration; fractured |
| 1,371.4 | 1,373.2 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint and vuggy porosity; moderate induration; fractured; shell fragments |
| 1,373.2 | 1,378.1 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint and vuggy porosity; good induration; fractured; shell fragments |
| 1,378.1 | 1,382.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint, moldic, and vuggy porosity; good induration; calcite crystals |
| 1,382.0 | 1,383.6 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; moderate induration |
| 1,383.6 | 1,387.6 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint, moldic, and vuggy porosity; good induration; fractured; some laminations; calcite crystals |
| 1,387.6 | 1,389.7 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration |
| 1,389.7 | 1,390.0 | No recovery |
| 1,390.0 | 1,390.6 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration |
| 1,390.6 | 1,392.4 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint and vuggy porosity; moderate induration |
| 1,392.4 | 1,392.9 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint and vuggy porosity; moderate induration |
| 1,392.9 | 1,396.2 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; laminations |
| 1,396.2 | 1,397.7 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; low pinpoint porosity; moderate induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,397.7 | 1,400.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; poor induration; laminations |
| 1,400.0 | 1,403.3 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration; laminations |
| 1,403.3 | 1,404.8 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration |
| 1,404.8 | 1,405.5 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint and vuggy porosity; moderate induration |
| 1,405.5 | 1,407.5 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; moderate induration |
| 1,407.5 | 1,408.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low intergranular porosity; poor induration |
| 1,408.0 | 1,409.7 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,409.7 | 1,410.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate vuggy porosity; moderate induration |
| 1,410.0 | 1,411.7 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,411.7 | 1,412.6 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; poor induration |
| 1,412.6 | 1,415.2 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,415.2 | 1,416.9 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; moderate induration |
| 1,416.9 | 1,418.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration; fractured |
| 1,418.0 | 1,420.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint and vuggy porosity; high induration; fractured |
| 1,420.0 | 1,421.5 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint, vuggy, and moldic porosity; moderate induration; fractured |
| 1,421.5 | 1,422.7 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; low pinpoint porosity; poor induration; laminations |
| 1,422.7 | 1,423.5 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint, vuggy, and moldic porosity; good induration |
| 1,423.5 | 1,424.4 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; poor induration |
| 1,424.4 | 1,425.4 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; good induration; fractured |
| 1,425.4 | 1,427.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; moderate induration; fractured |
| 1,427.0 | 1,428.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint, vuggy, and moldic porosity; good induration; fractured |
| 1,428.0 | 1,431.1 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 1,431.1 | 1,432.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint, vuggy, and moldic porosity; good induration |
| 1,432.0 | 1,435.2 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint, vuggy, and moldic porosity; good induration; fractured |
| 1,435.2 | 1,436.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration |
| 1,436.0 | 1,439.2 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint porosity; moderate induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,439.2 | 1,440.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint and moldic porosity; moderate induration |
| 1,440.0 | 1,442.0 | Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration |
| 1,442.0 | 1,443.2 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,443.2 | 1,444.8 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint porosity; good induration |
| 1,444.8 | 1,446.3 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint, vuggy, and moldic porosity; moderate induration; fractured |
| 1,446.3 | 1,446.9 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; high pinpoint porosity; good induration |
| 1,446.9 | 1,452.2 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 1,452.2 | 1,453.1 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,453.1 | 1,454.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,454.0 | 1,454.8 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration |
| 1,454.8 | 1,464.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 1,464.0 | 1,465.0 | No recovery |
| 1,465.0 | 1,470.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 1,470.0 | 1,471.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; moderate induration |
| 1,471.0 | 1,473.0 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint porosity; moderate induration |
| 1,473.0 | 1,476.1 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 1,476.1 | 1,476.9 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; moderate induration |
| 1,476.9 | 1,480.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration |
| 1,480.0 | 1,480.6 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration |
| 1,480.6 | 1,482.1 | Dolostone; moderate yellowish brown (10yr 5/4); microcrystalline; high pinpoint and moldic porosity; moderate induration |
| 1,482.1 | 1,483.7 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint porosity; good induration; fractured |
| 1,483.7 | 1,488.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration; fractured |
| 1,488.0 | 1,490.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint, vuggy, and moldic porosity; good induration; fractured |
| 1,490.0 | 1,491.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration |
| 1,491.0 | 1,492.4 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration; fractured |
| 1,492.4 | 1,493.5 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint and vuggy porosity; good induration |

| From Depth (ft bls) | To Depth (ft bls) | Lithologic Description |
|---|---|---|
| 1,493.5 | 1,496.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint and moldic porosity; good induration |
| 1,496.0 | 1,498.0 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint, vuggy, and moldic porosity; good induration; fractured |
| 1,498.0 | 1,498.2 | Dolostone; dark yellowish brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration |
| 1,498.2 | 1,500.0 | No recovery |

# APPENDIX D:
# OPTICAL BOREHOLE IMAGING LOG

# USGS Caribbean-Florida Water Science Center

| | | | | | |
|---|---|---|---|---|---|
| WELL | OSF-64 | PROJECT | SFWMD OBI Logging | DATE OF COMPLETION | December 2019 |
| LOCATION | 28-04-21.23 N (GPS, NAD 83) | ELEVATION | GL 60.40 Feet (Survey, NAVD88) | WELL DEPTH | 1,500 Feet TD |
| | 080-16-46.89 W | DATE OF OBI/ABI LOGGING | 11 December 2019 | | |

Depth 1ft:4ft

**Optical Borehole Image (QL40-OBI-2G)**

0° 90° 180° 270° 0°

310

315

320

325

330
335
340
345


350
355
360
365


370
375
380
385

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425
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650
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675
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685
690


695
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705
710


715
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730


735
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745
750


755
760
765
770


775
780
785
790


795
800
805

810
815
820
825


830
835
840
845


850
855
860
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870
875
880
885


890
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900
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910
915
920
925

930
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940


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985
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1000


1005
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1080
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1100
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# APPENDIX E:
# SUPPORTING INFORMATION FOR SATURATION INDICES

The saturation index (SI) is the log of the ratio of ion activity product (IAP) and the solubility product constant corrected for temperature ($K_T$):

$$SI = \log\left(\frac{IAP}{K_T}\right)$$

Where:

SI = saturation index (unitless)
IAP = ion activity product (unitless)
$K_T$ = solubility product constant corrected for temperature (unitless)

Calculation of the IAP starts with the mass action equation. For a mineral $A_aB_b$ that has an equilibrium constant $K_{sp}$, it dissolves and precipitates according to formula:

$$XxYy = xX + yY$$

This is defined by the mass action equation as:

$$K_{sp} = \frac{\{X\}^x\{Y\}^y}{\{X_xY_y\}} = \{X\}^x\{Y\}^y$$

The curly brackets indicate ionic activities. Activities (*a*) are calculated using the ion activity coefficient (γ) and molality (*m*):

$$a = \gamma m$$

Where:

*a* = activity (unitless)
γ = ion activity coefficient (unitless)
*m* = molality (mol/kg)

The ion activity coefficient can be calculated in several ways. PHREEQC uses the Davies equation and the extended Debye-Hückel equation to calculate individual ion activity coefficients for the solute species. The extended Debye-Hückel equation was only used when $a^o$ and *b* were provided in the thermodynamic database.

The Davies equation:

$$\log\gamma = -Az^2\left(\frac{\sqrt{\mu}}{1 + \sqrt{\mu}} - 0.3\mu\right)$$

The extended Debye-Hückel equation:

$$\log\gamma = -\left(\frac{Az^2\sqrt{\mu}}{1 + Ba^o\sqrt{\mu}} - b\mu\right)$$

Where:

$\gamma$ = ion activity coefficient (unitless)
A and B = constants dependent only on temperature (unitless)
z = ionic charge of aqueous species (unitless)
$\mu$ = ionic strength (mol/kg)
$a^o$ and $b$ = ion-specific parameters fitted from mean salt activity coefficient data (unitless)

The ion activity coefficients are multiplied by the ion concentrations from the water quality results to get ion activities. These activities are then input into the mass action equation to solve for the IAP.

The solubility product constant $K_{sp}$ is a constant based on thermodynamics calculations for the dissolved mineral at equilibrium. Because the constant assumes a temperature of 25°C, a correction is applied to account for the field temperature. A polynomial temperature correction function is used when the $A_1$ to $A_6$ parameters are included in the database for the ion species being solved for:

$$\log K_T = A_1 + A_2 T + \frac{A_3}{T} + A_4 \log T + \frac{A_5}{T^2} + A_6 T^2$$

Where:

$K_T$ = solubility product constant corrected for temperature (unitless)
$A_1$ to $A_6$ = species-specific correction coefficients (unitless)
T = field temperature (Kelvin)

If the correction coefficients are not available, the enthalpy of reaction ($\Delta_r H$) is used to calculate the corrected K value. The reference temperature ($T_r$) is 25°C or 298.15 Kelvin.

$$\log K_T = \log K_{sp} + \frac{\Delta_r H^0}{2.303R}\left(\frac{1}{T_r} - \frac{1}{T}\right)$$

Where:

$K_T$ = solubility product constant corrected for temperature (unitless)
$K_{sp}$ = solubility product constant (unitless)
$\Delta_r H$ = enthalpy of reaction (kcal)
$T_r$ = reference temperature (Kelvin)
T = field temperature (Kelvin)

Now that $K_T$ is calculated, it can be used with the IAP that was calculated using the mass action equation to solve for the SI. The SI can be used to determine if a solution is undersaturated, saturated, or supersaturated with respect to a certain mineral. An SI value of 0 means the solution is at equilibrium. A supersaturated solution has a positive SI value, and an undersaturated solution has a negative SI value.

# APPENDIX F:
# GEOPHYSICAL LOGS

RMBAKER LLC

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SFWMD OSF-64

PROVISIONAL FIELD LOG

COMPANY SFWMD
WELL OSF-64
FIELD CANOE CREEK
COUNTRY USA
STATE FL
COUNTY OSCEOLA
LAT.:
LONG.:

OTHER SERVICES

CAL
GAMM
ELOG
HRFM
TCDS

Perm. Da.. Elev
Log. Datum GS
Drill Datum

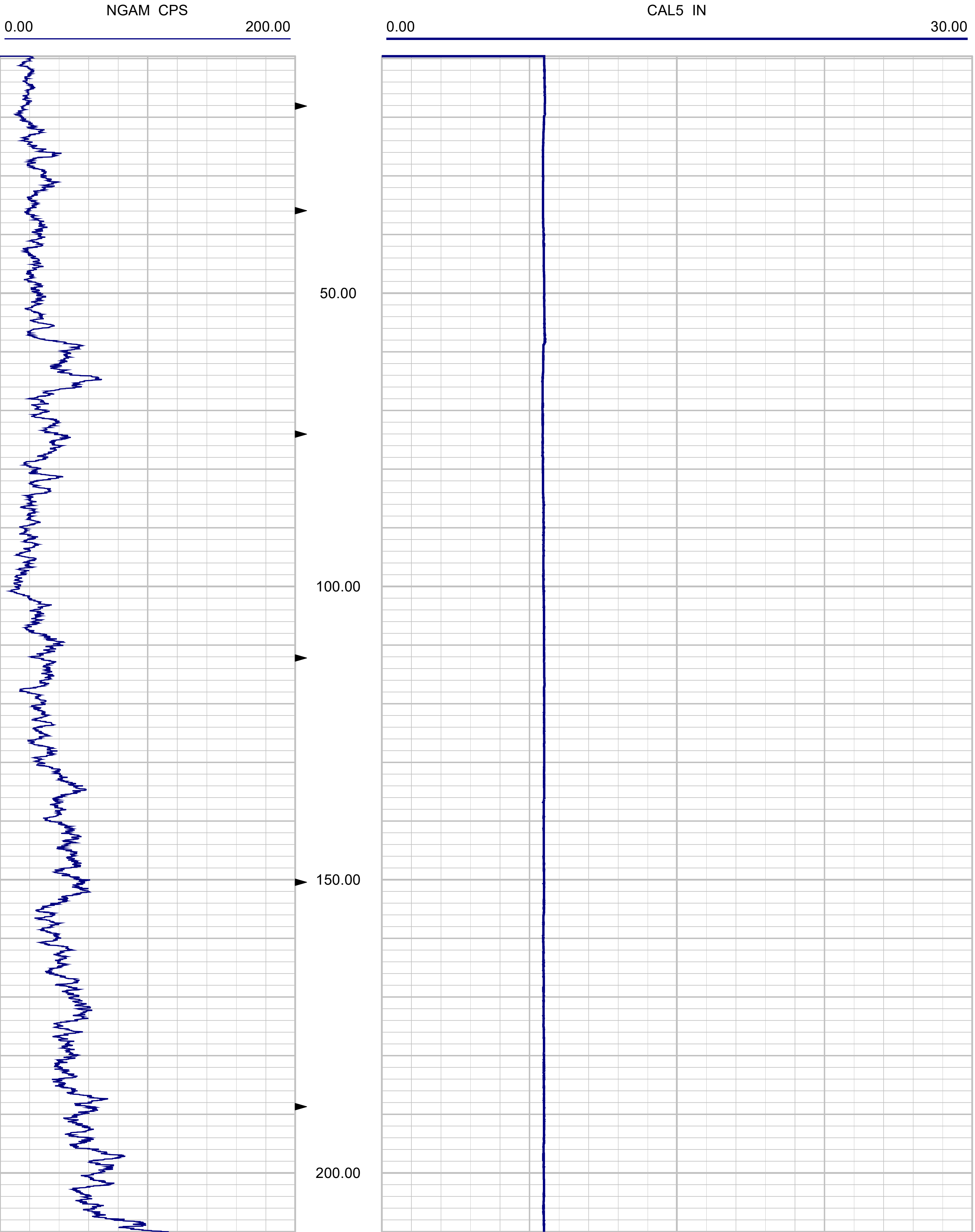
KB 0.00
DF 0.00
GL 0.00

| | | | |
|---|---|---|---|
| DATE | 12 Dec 1 | 18 Nov 1 | 18 Nov 1 |
| RUN# | 0 | 0 | 0 |
| TYPE OF LOG | CAL | | |
| DEPTH DRILLER | 1500.00 | 0.00 | 0.00 |
| DEPTH LOGGER | 1486.90 | 0.00 | 0.00 |
| LOG DEEPEST | 0.00 | 0.00 | 0.00 |
| LOG SHALLOW | 0.00 | 0.00 | 0.00 |
| FLUID IN HOLE | WATER | | |
| SALINITY | | | |
| DENSITY | | | |
| LEVEL | | | |
| MAX TEMP °C | 0.00 | 0.00 | 0.00 |
| RIG TIME | | | |
| RECORDED BY | RMB | | |
| WITNESSED BY | SFWMD | | |

| RUN# | BIT RECORD | | | CASING RECORD | | | |
|---|---|---|---|---|---|---|---|
| | SIZE | FROM | TO | SIZE | WEIGHT | FROM | TO |
| 0 | 7.50 | 311.00 | 1500.00 | 8.00 | 0.00 | 0.00 | 311.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

ROBERTSON GEOLOGGING TECHNOLOGY

REMARKS ( G:\RobMB\Documents\LOGGING DATA\OSF-64\O..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CAL5 IN
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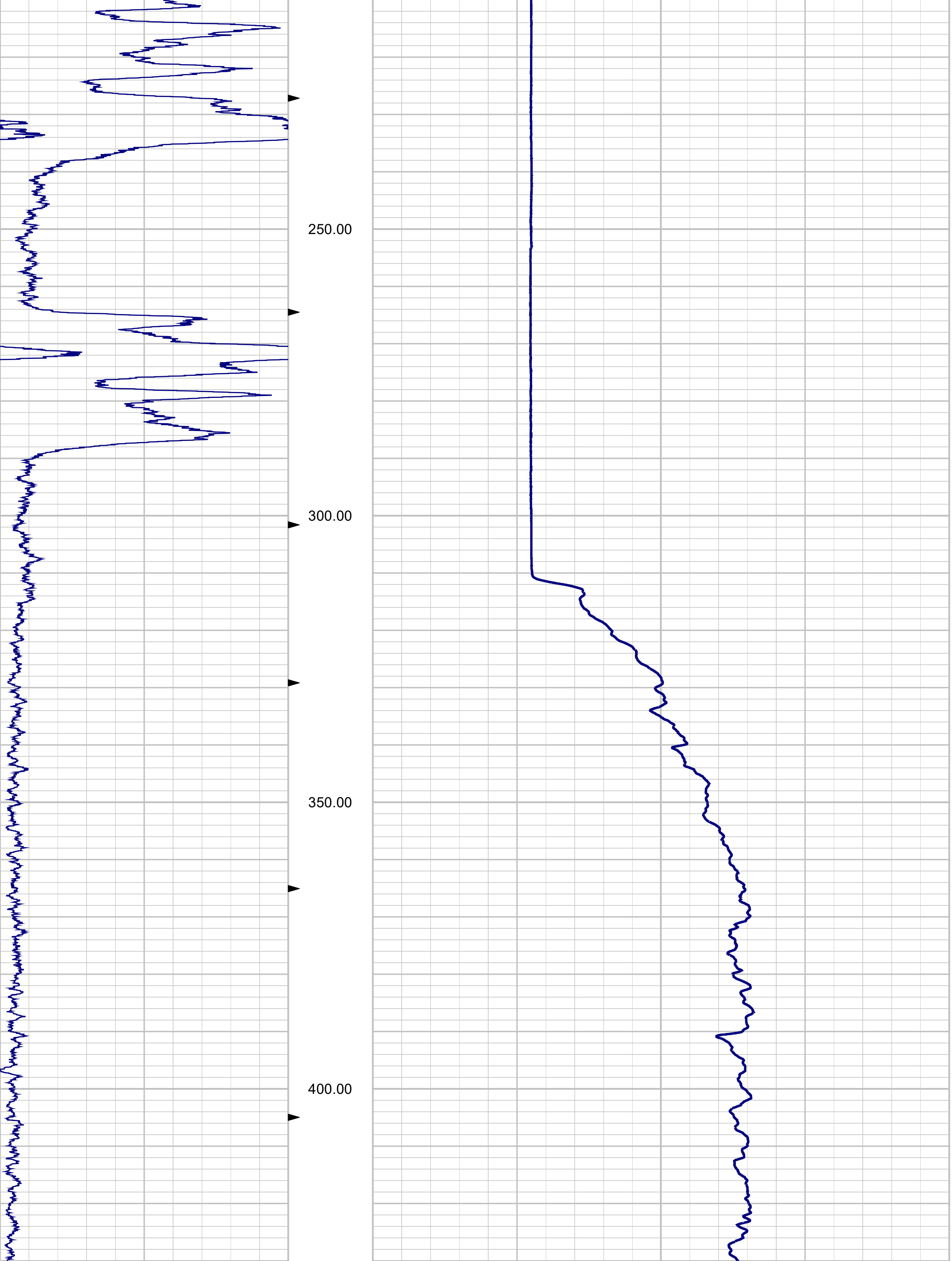
30.00
50.00
100.00
150.00
200.00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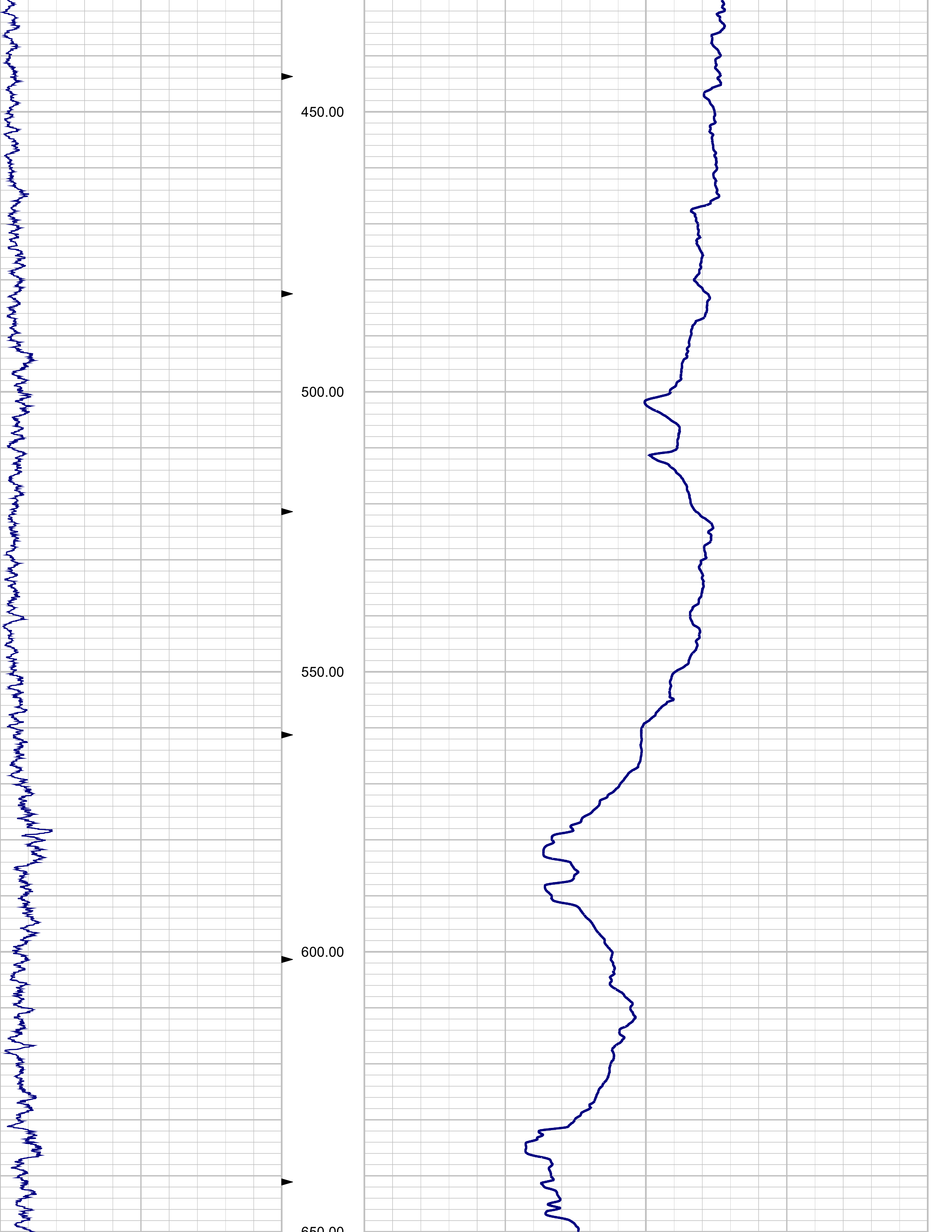
300.00
350.00
400.00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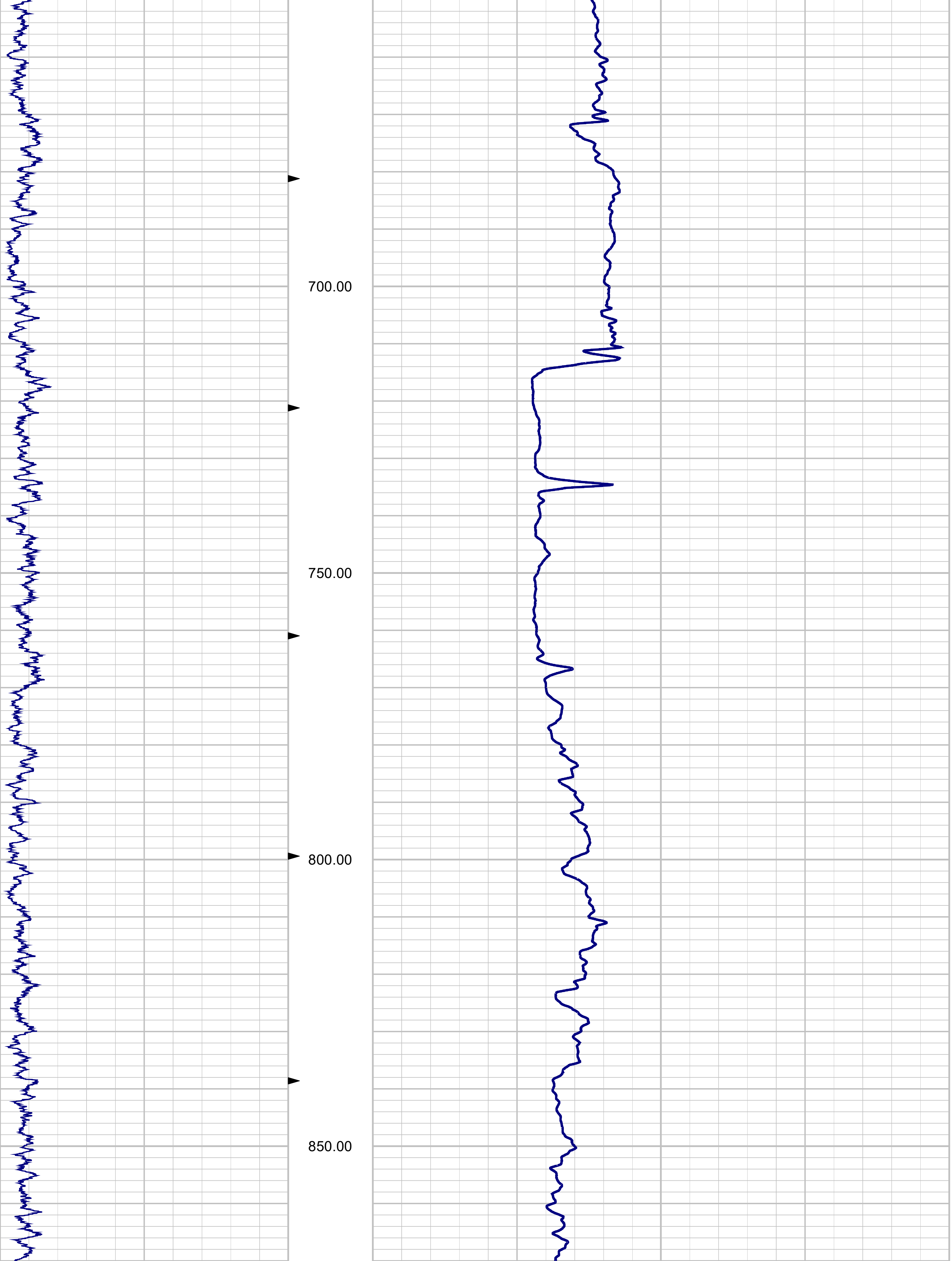
650.00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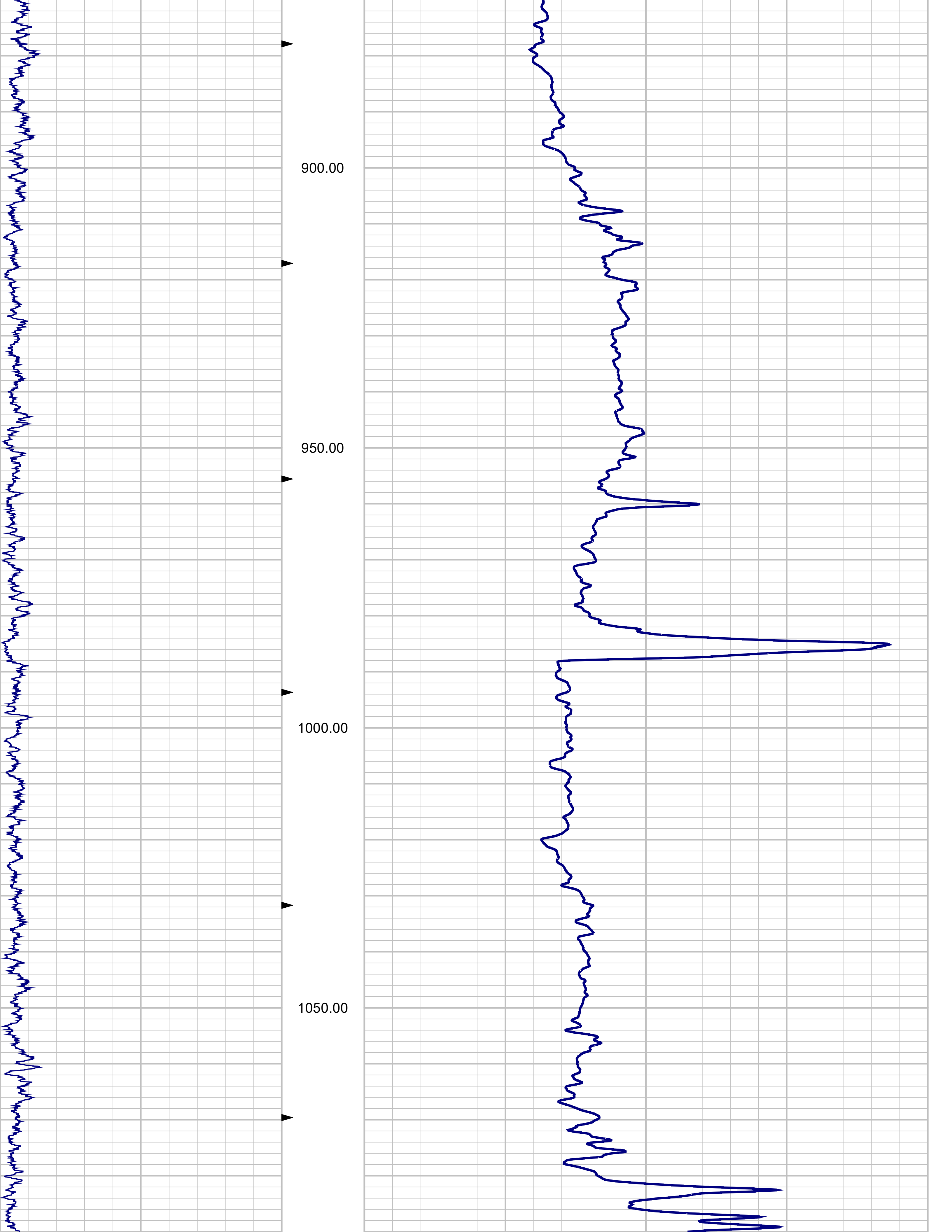
750.00
800.00
850.00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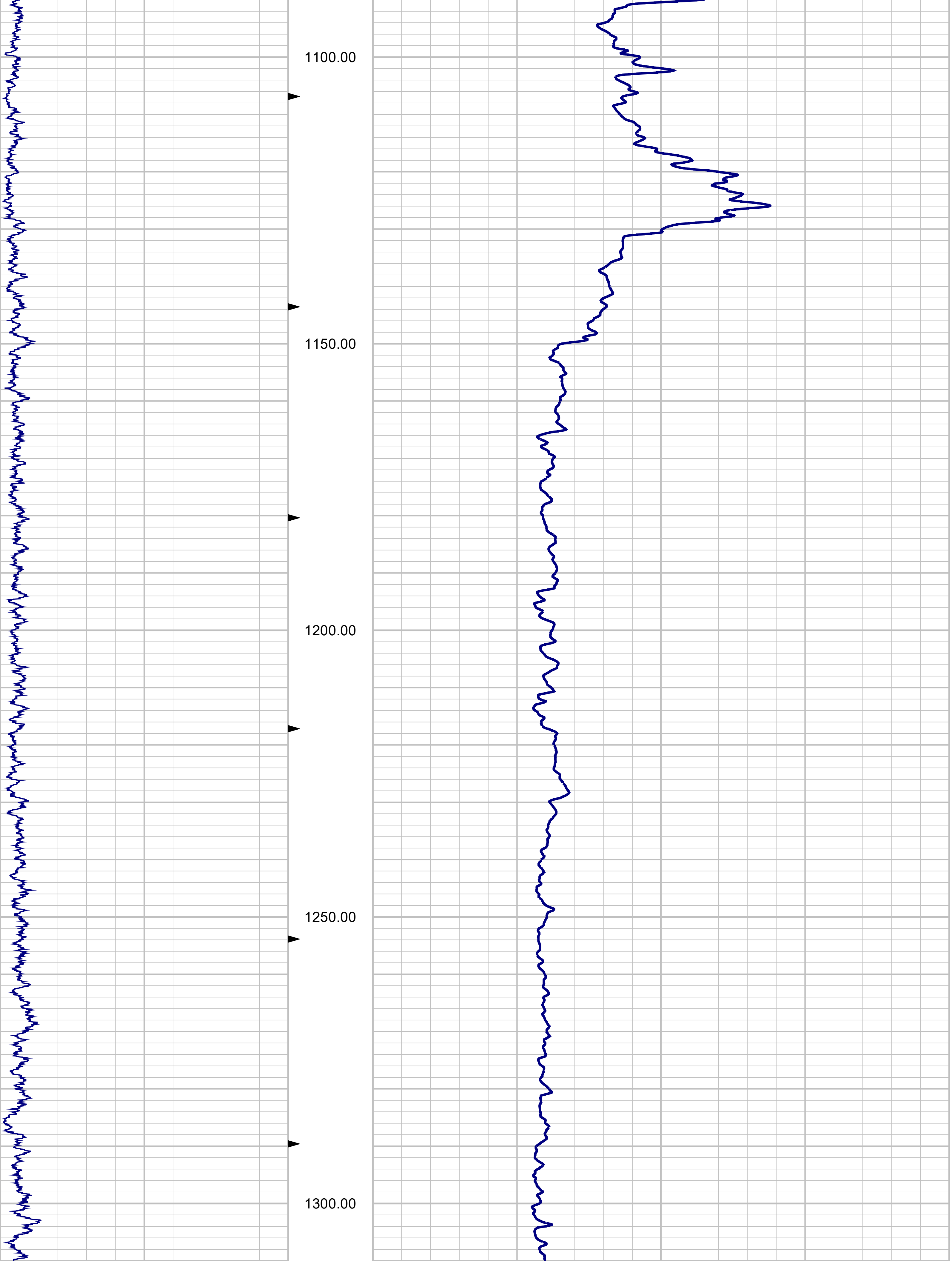
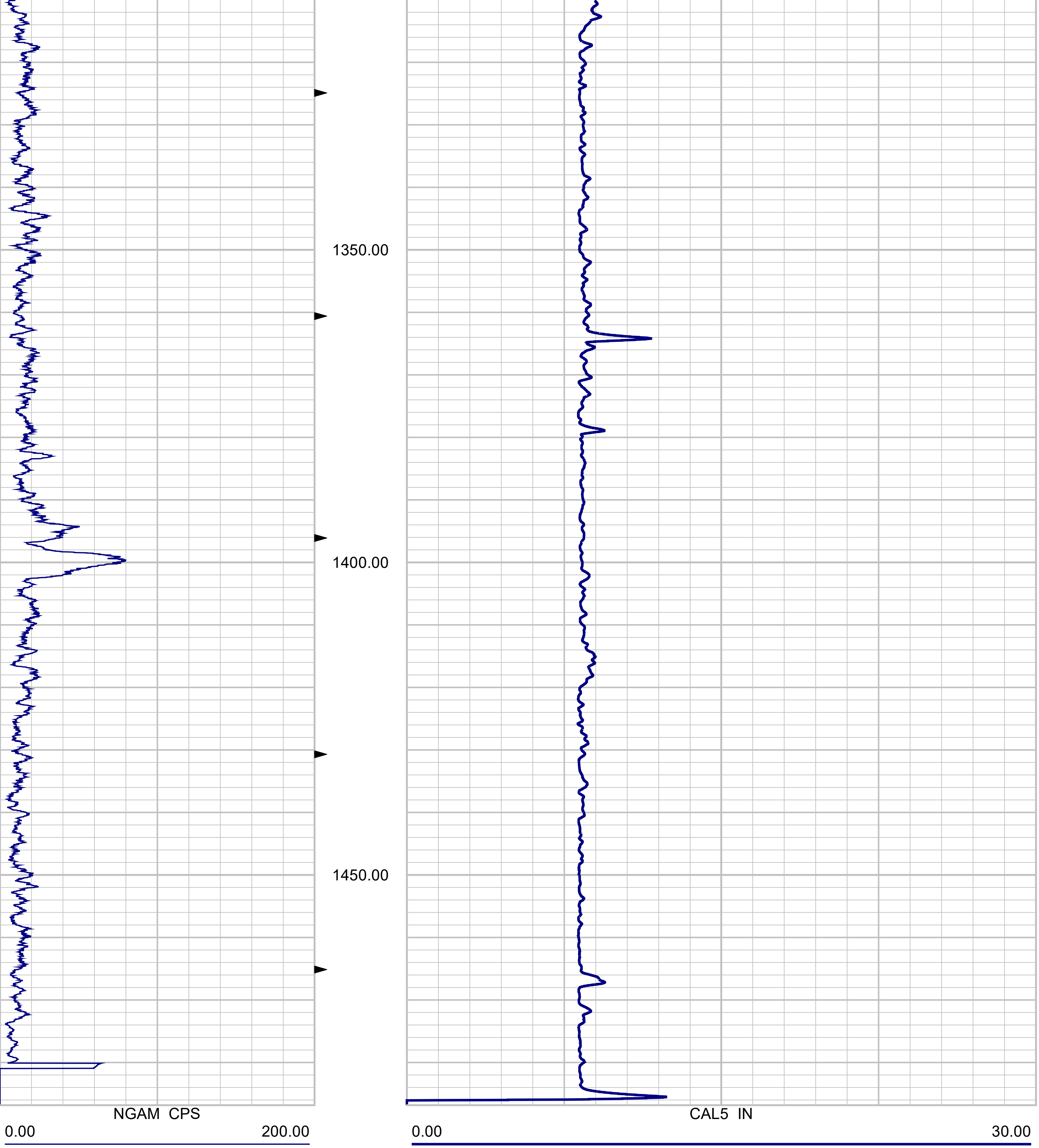
1000.00
1050.00


1100.00
1150.00
1200.00
1250.00
1300.00




Depth: 9.00 ft Date: 12 Dec 2019 Time: 16:33:37 File: "G:\RobMB\Documents\LOGGING DATA\OSF-64\OSF64 12-12 CAL GAM.LOG"

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SFWMD OSF-64

PROVISIONAL FIELD LOG

| | | |
|---|---|---|
| COMPANY | SFWMD | OTHER SERVICES |
| WELL | OSF-64 | |
| FIELD | CANOE CREEK | CAL |
| COUNTRY | USA | GAMM |
| STATE | FL | ELOG |
| COUNTY | OSCEOLA | HRFM |
| LAT.: | | TCDS |
| LONG.: | | |

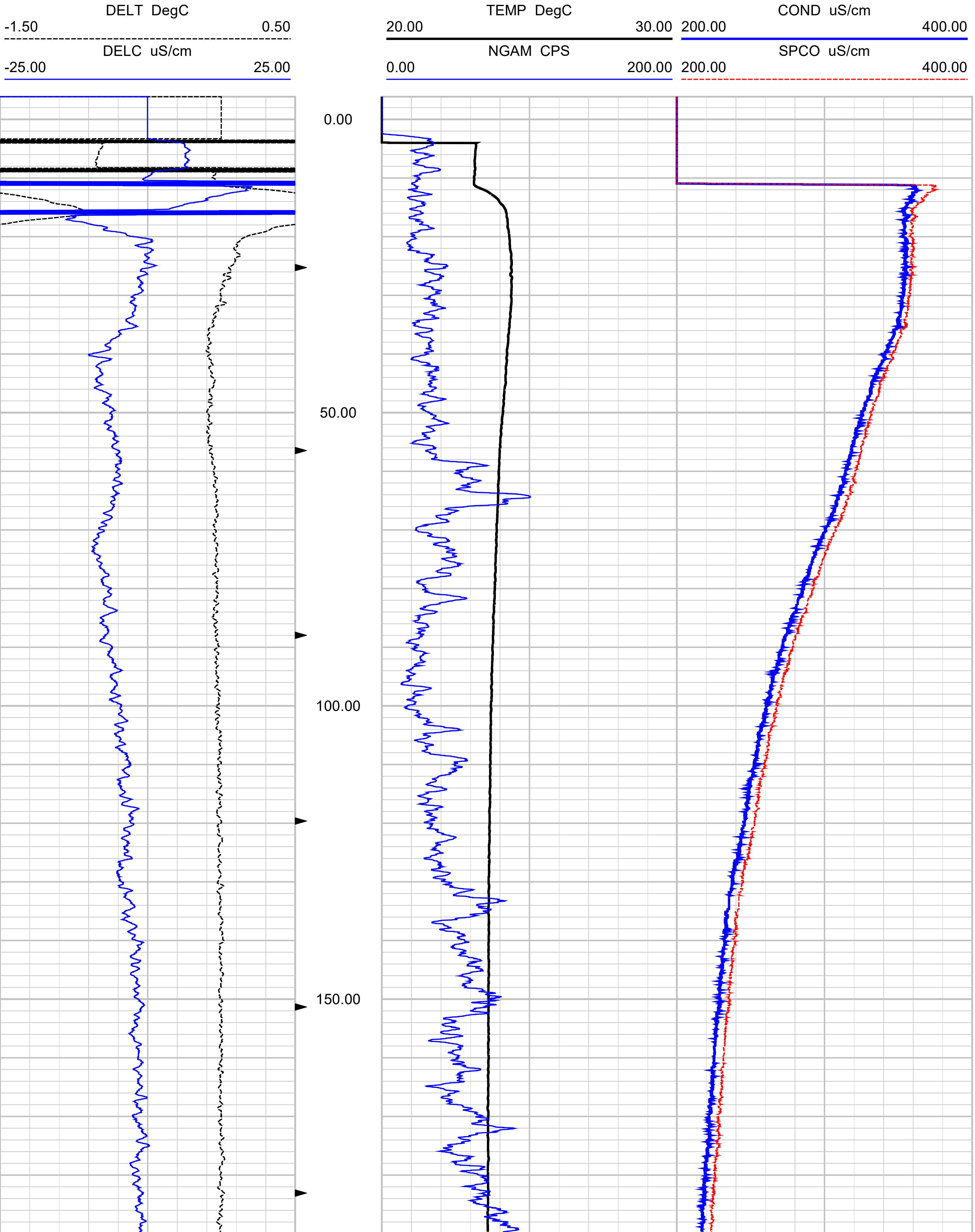
| | | | | |
|---|---|---|---|---|
| Perm. Da.. | | Elev | KB | 0.00 |
| Log. Datum | GS | | DF | 0.00 |
| Drill Datum | | | GL | 0.00 |

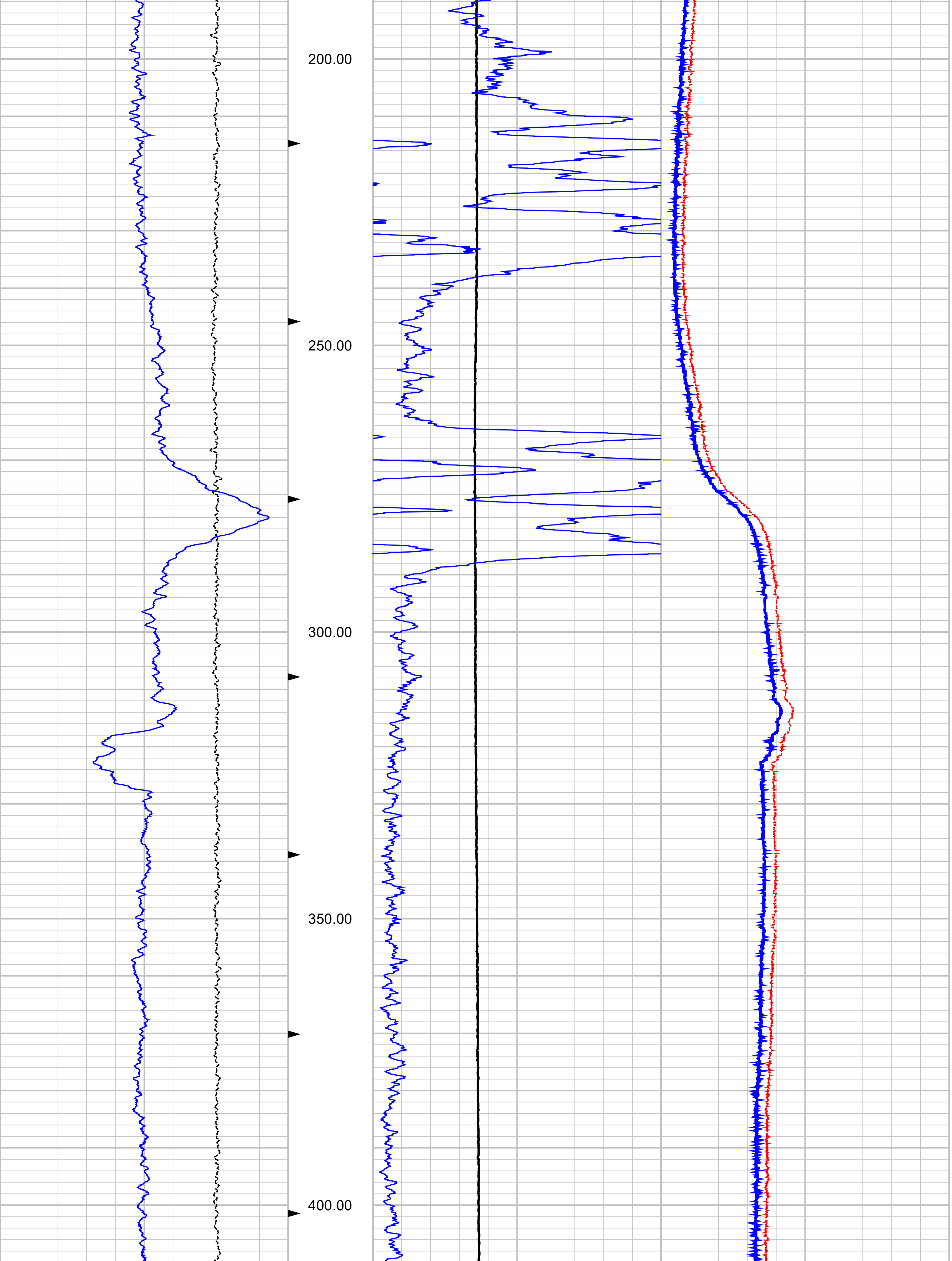
| | | | |
|---|---|---|---|
| DATE | 12 Dec 1 | 18 Nov 1 | 18 Nov 1 |
| RUN# | 0 | 0 | 0 |
| TYPE OF LOG | TCDS DS | | |
| DEPTH DRILLER | 1500.00 | 0.00 | 0.00 |
| DEPTH LOGGER | 1487.00 | 0.00 | 0.00 |
| LOG DEEPEST | 0.00 | 0.00 | 0.00 |
| LOG SHALLOW | 0.00 | 0.00 | 0.00 |
| FLUID IN HOLE | WATER | | |
| SALINITY | | | |
| DENSITY | | | |
| LEVEL | | | |
| MAX TEMP °C | 0.00 | 0.00 | 0.00 |
| RIG TIME | | | |
| RECORDED BY | RMB | | |
| WITNESSED BY | SFWMD | | |

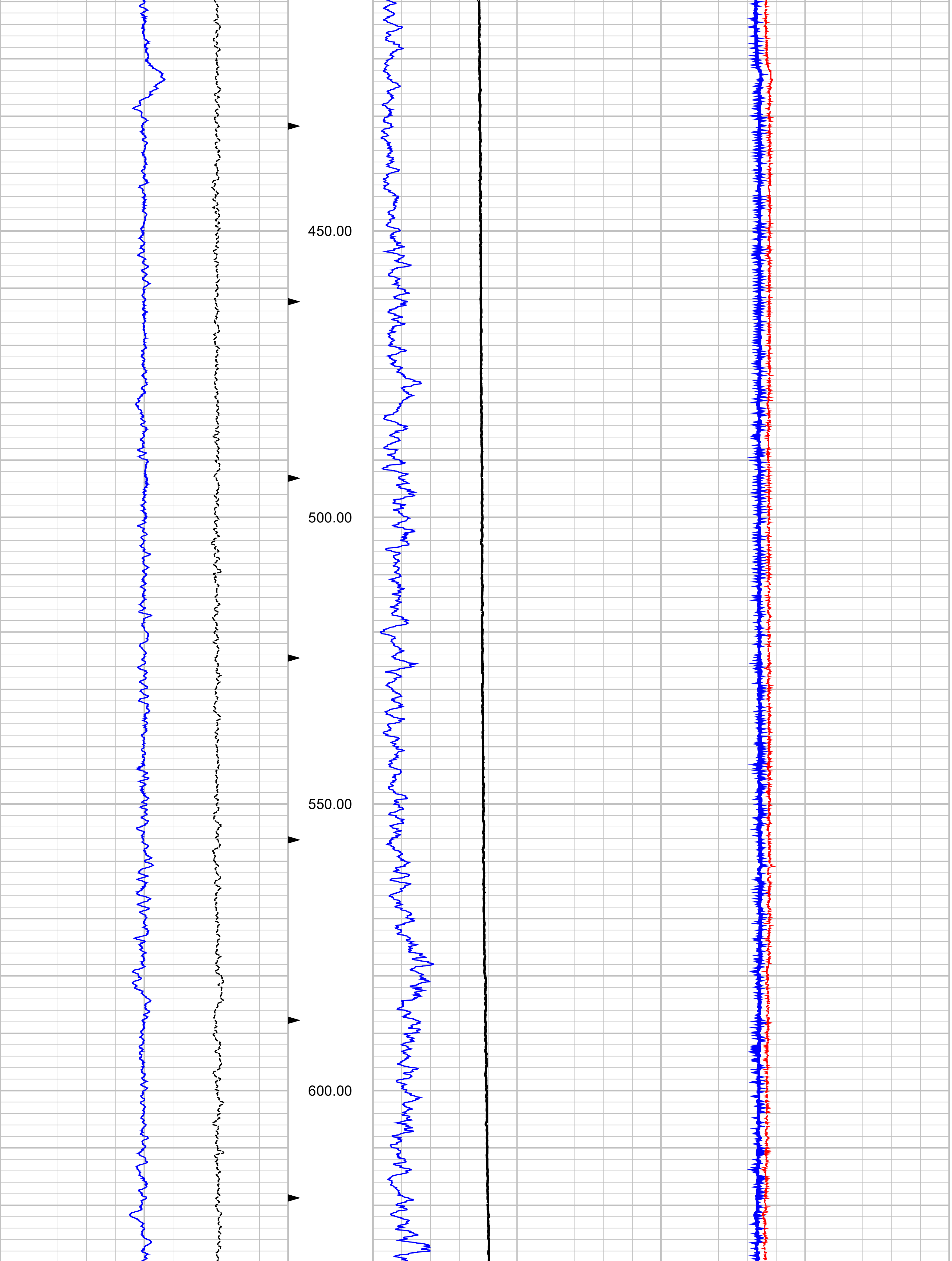
| RUN# | BIT RECORD | | | CASING RECORD | | | |
|---|---|---|---|---|---|---|---|
| | SIZE | FROM | TO | SIZE | WEIGHT | FROM | TO |
| 0 | 7.50 | 311.00 | 1500.00 | 8.00 | 0.00 | 0.00 | 311.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

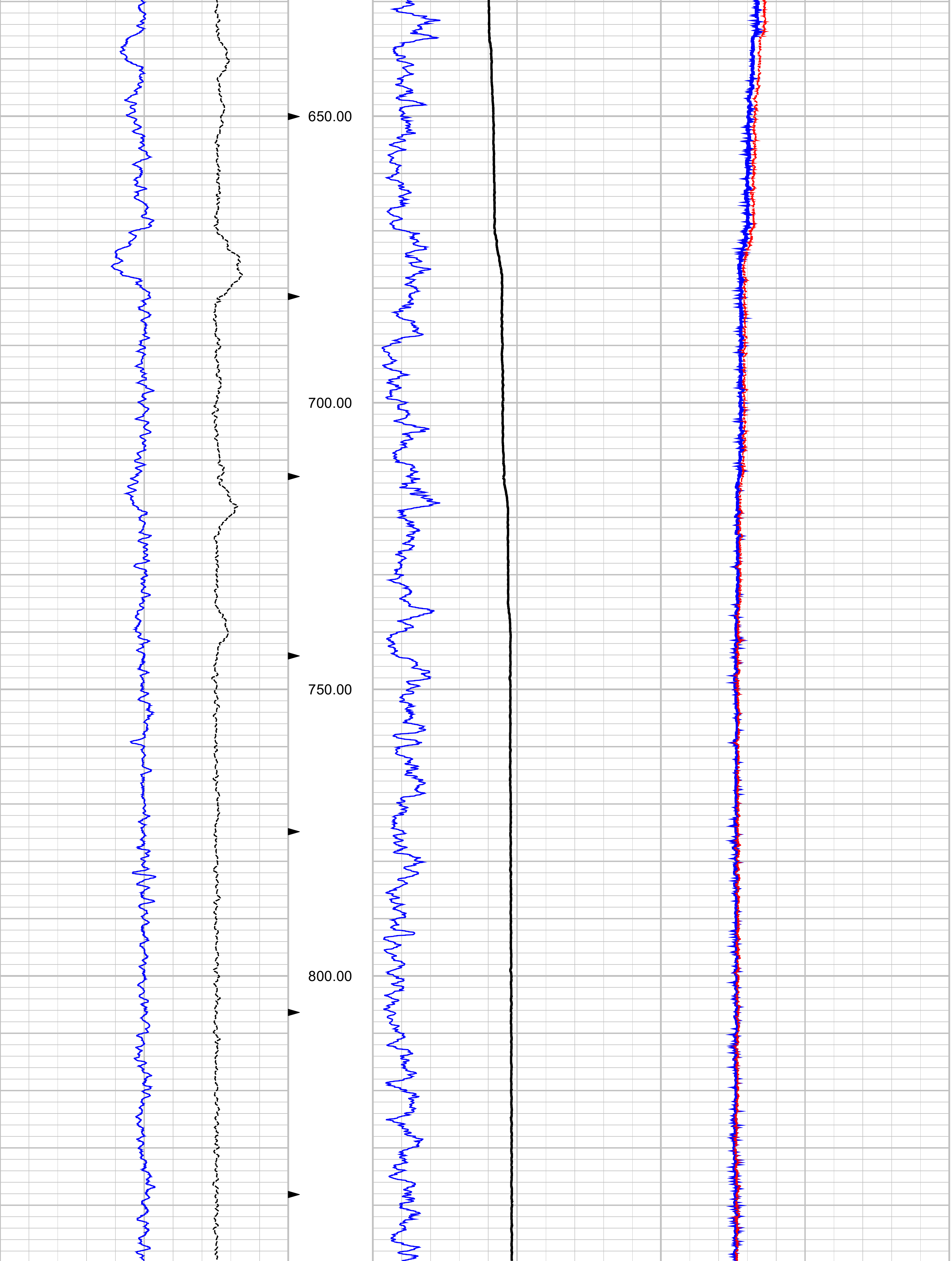
ROBERTSON GEOLOGGING TECHNOLOGY

REMARKS ( G:\RobMB\Documents\LOGGING DATA\OSF-64\O..

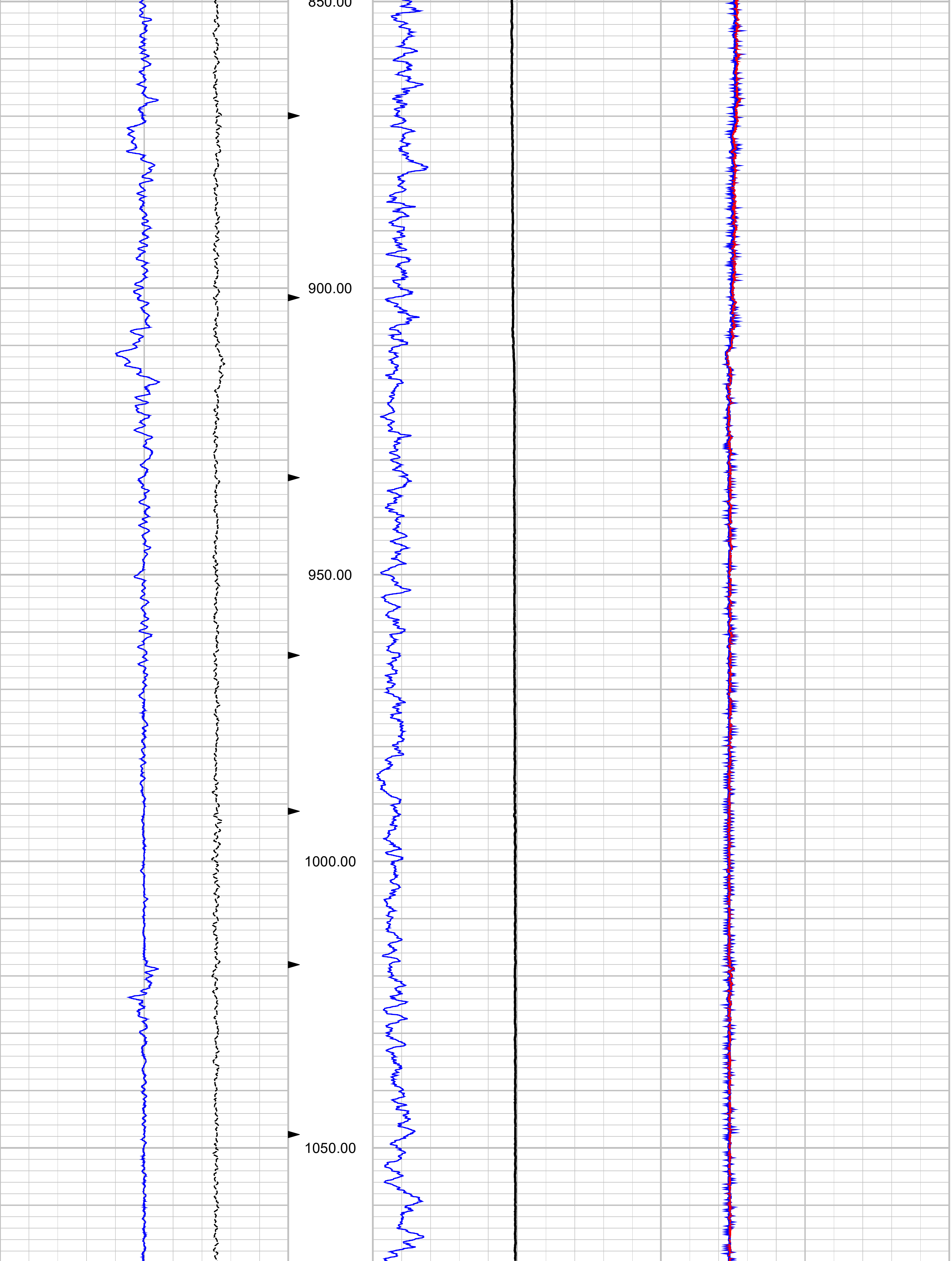

DELT DegC
-1.50
0.50
DELC uS/cm
-25.00
25.00
TEMP DegC
20.00
30.00
NGAM CPS
0.00
200.00
COND uS/cm
200.00
400.00
SPCO uS/cm
200.00
400.00
0.00
50.00
100.00
150.00

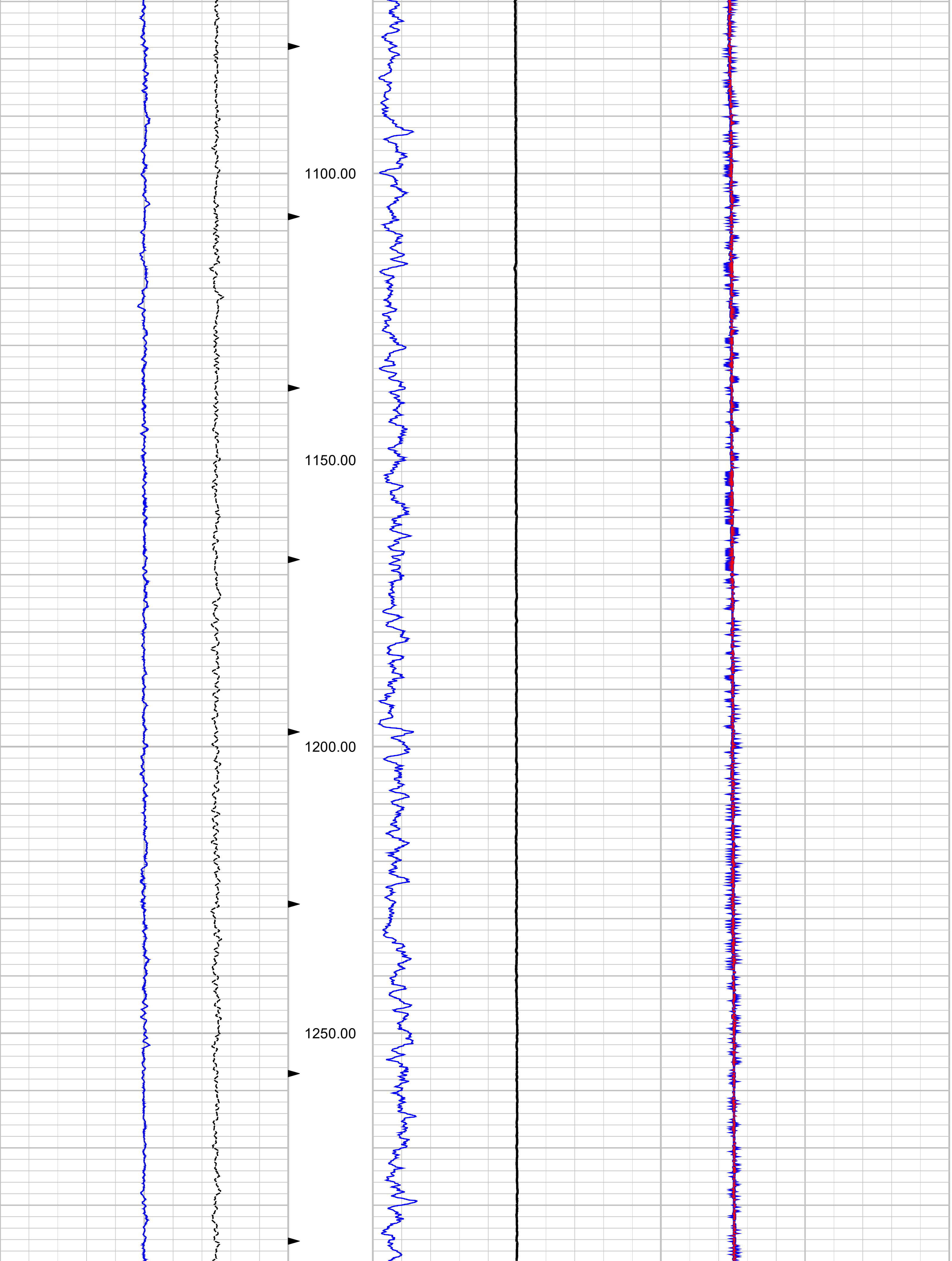

200.00
250.00
300.00
350.00
400.00

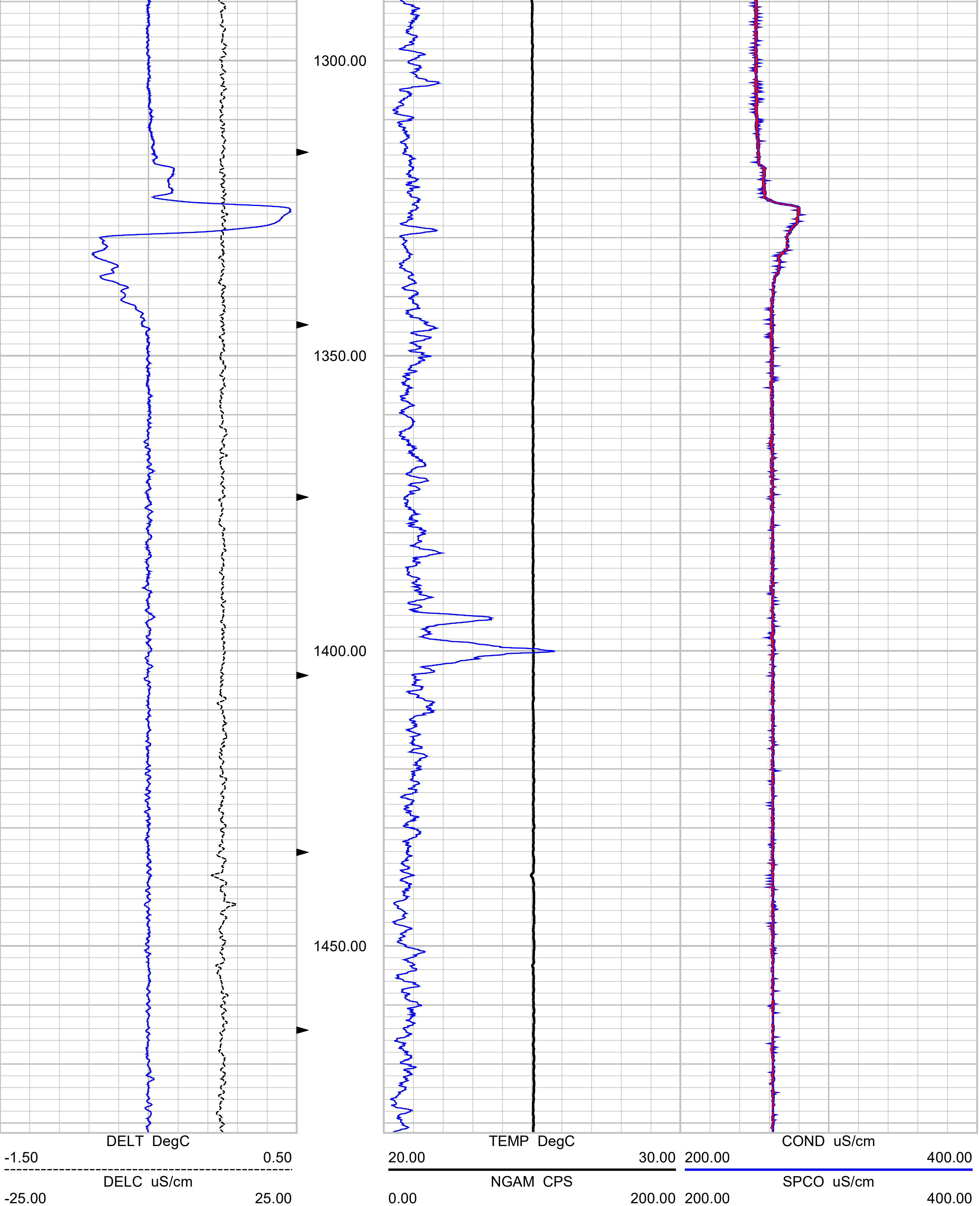

450.00
500.00
550.00
600.00



650.00
700.00
750.00
800.00


850.00
900.00
950.00
1000.00
1050.00


1100.00
1150.00
1200.00
1250.00




Depth: 1481.00 ft Date: 12 Dec 2019 Time: 14:28:10 File: "G:\RobMB\Documents\LOGGING DATA\OSF-64\OSF64 12-12 TCDS GAM DS.LOG"

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www.rmbaker.com

SFWMD OSF-64

PROVISIONAL FIELD LOG

| | | | |
|---|---|---|---|
| COMPANY | SFWMD | OTHER SERVICES | |
| WELL | OSF-64 | | |
| FIELD | CANOE CREEK | CAL | |
| COUNTRY | USA | GAMM | |
| STATE | FL | ELOG | |
| COUNTY | OSCEOLA | HRFM | |
| LAT.: | | TCDS | |
| LONG.: | | | |

| | | | | |
|---|---|---|---|---|
| Perm. Da.. | | Elev | KB | 0.00 |
| Log. Datum | GS | | DF | 0.00 |
| Drill Datum | | | GL | 0.00 |

| | | | |
|---|---|---|---|
| DATE | 13 Dec 1 | 18 Nov 1 | 18 Nov 1 |
| RUN# | 0 | 0 | 0 |
| TYPE OF LOG | SONIC | | |
| DEPTH DRILLER | 1500.00 | 0.00 | 0.00 |
| DEPTH LOGGER | 1486.90 | 0.00 | 0.00 |
| LOG DEEPEST | 0.00 | 0.00 | 0.00 |
| LOG SHALLOW | 0.00 | 0.00 | 0.00 |
| FLUID IN HOLE | WATER | | |
| SALINITY | | | |
| DENSITY | | | |
| LEVEL | | | |
| MAX TEMP °C | 0.00 | 0.00 | 0.00 |
| RIG TIME | | | |
| RECORDED BY | RMB | | |
| WITNESSED BY | SFWMD | | |

| RUN# | BIT RECORD | | | CASING RECORD | | | |
|---|---|---|---|---|---|---|---|
| | SIZE | FROM | TO | SIZE | WEIGHT | FROM | TO |
| 0 | 7.50 | 311.00 | 1500.00 | 8.00 | 0.00 | 0.00 | 311.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

ROBERTSON GEOLOGGING TECHNOLOGY

REMARKS ( G:\RobMB\Documents\LOGGING DATA\OSF-64\O..

| TA µs | |
|---|---|
| 0.00 | 3000.00 |

| TB µs | |
|---|---|
| 0.00 | 3000.00 |

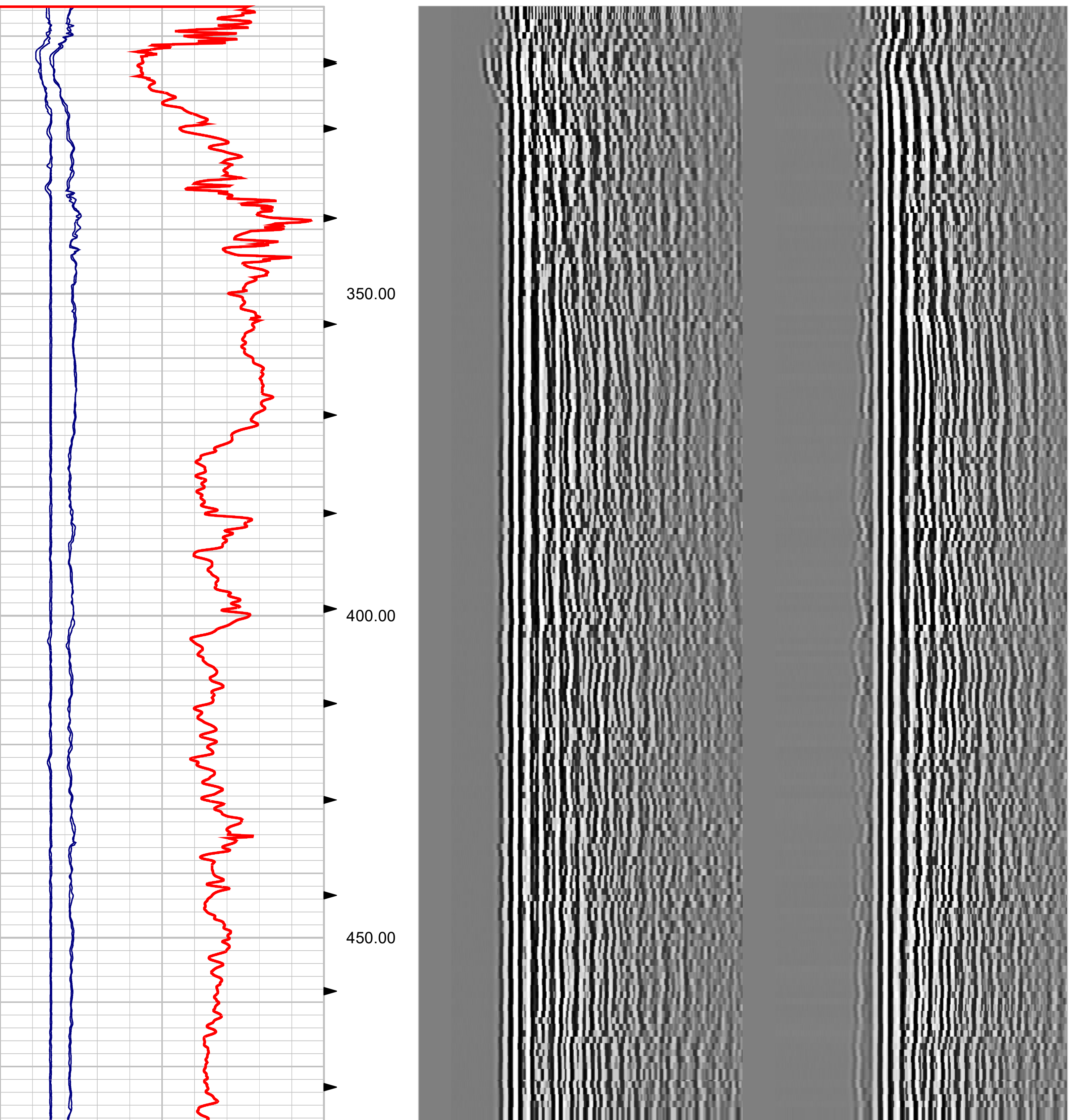
| TC µs | |
|---|---|
| 0.00 | 3000.00 |

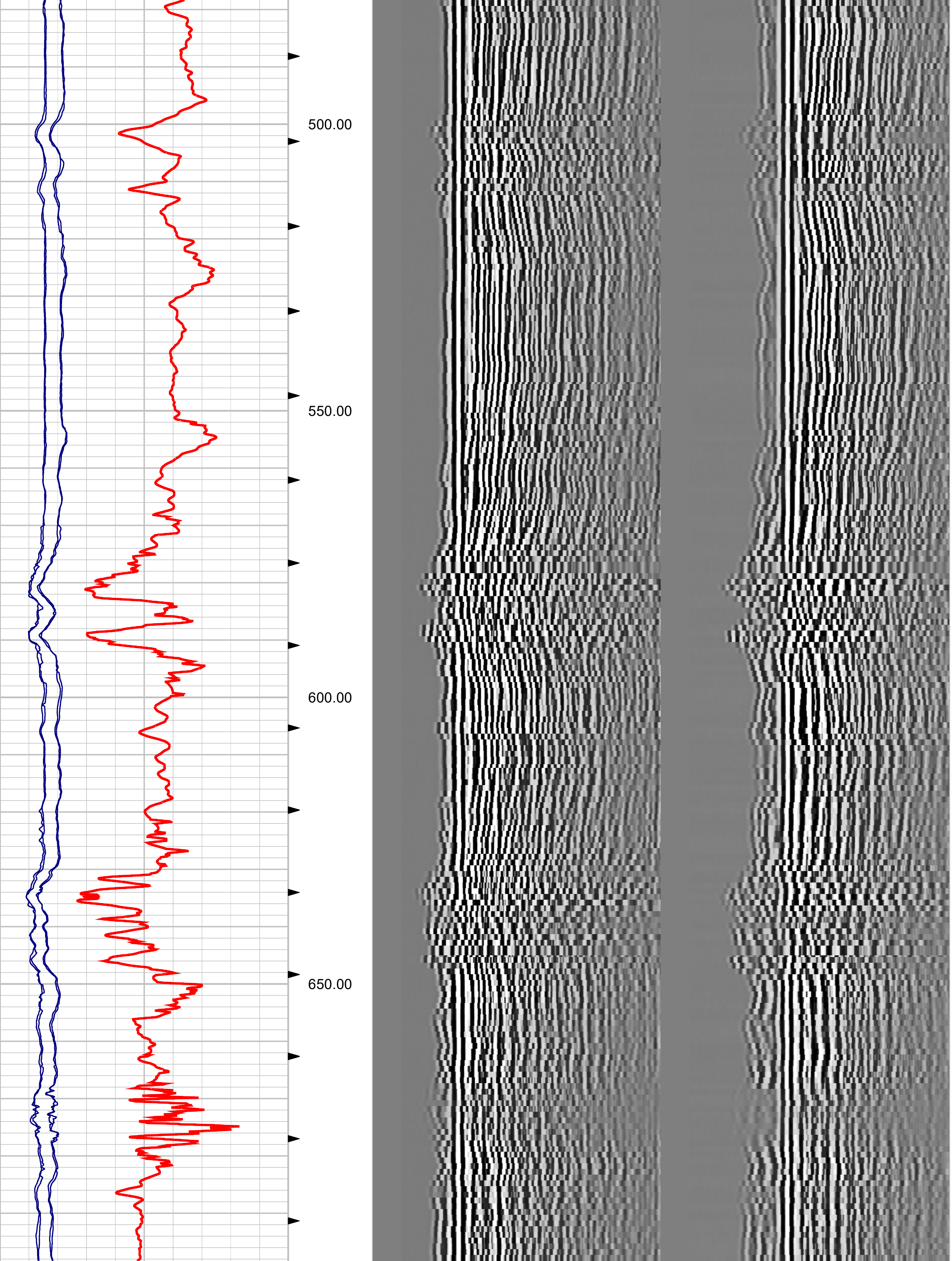
| TD µs | |
|---|---|
| 0.00 | 3000.00 |

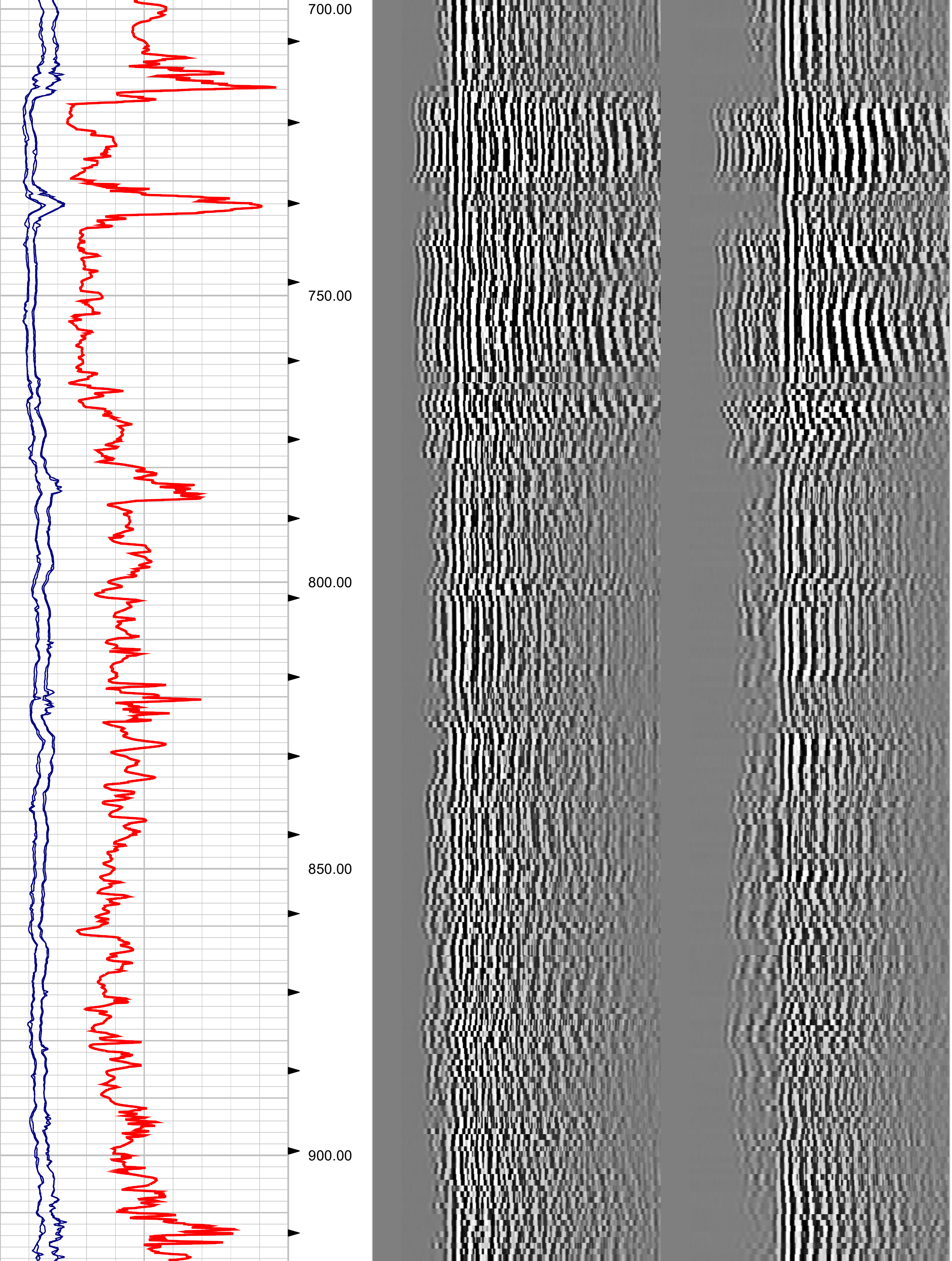
| SVEL µs/ft | |
|---|---|
| 0.00 | 200.00 |

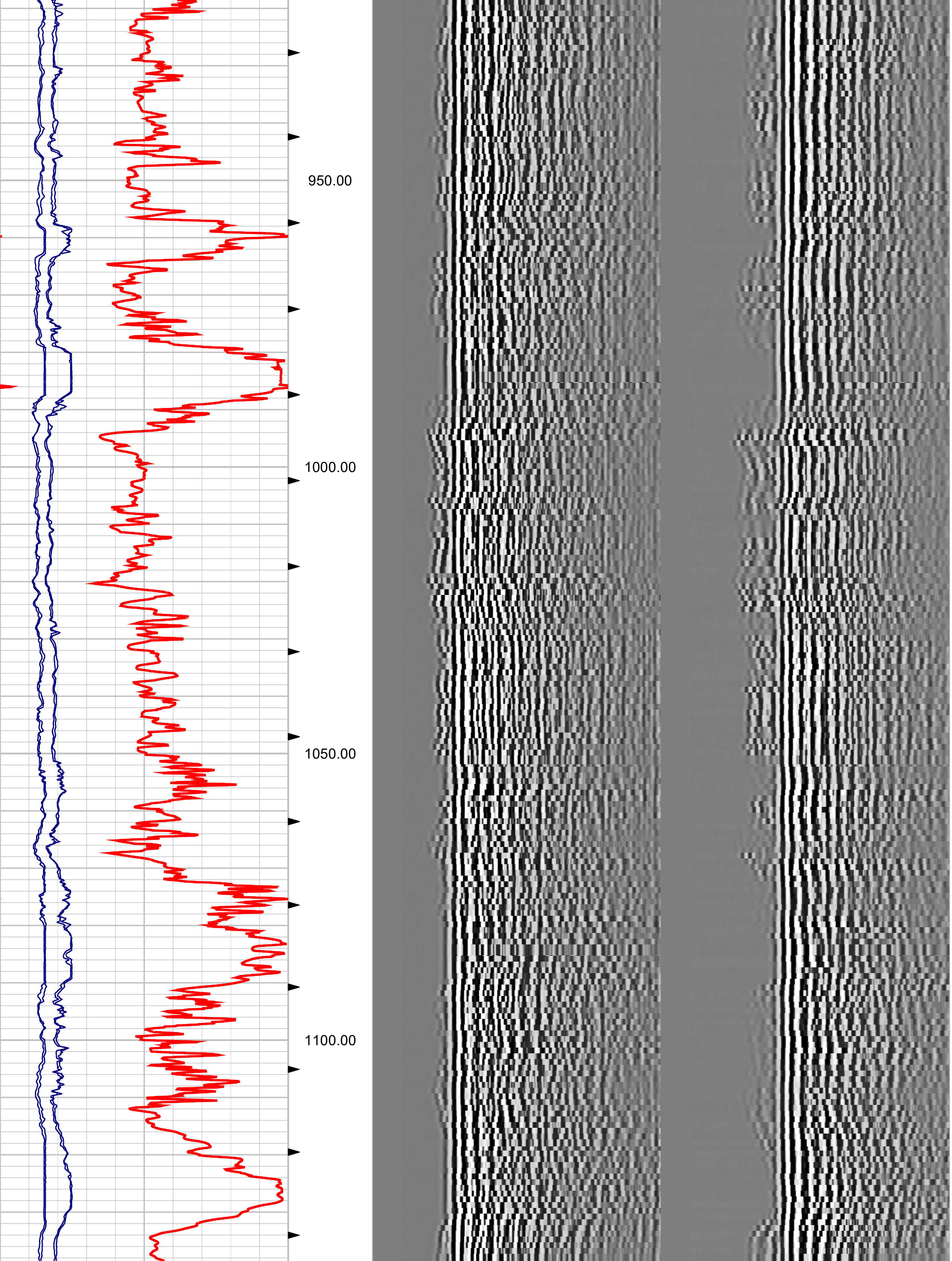
| NEAR µs | |
|---|---|
| 0.00 | 960.00 |

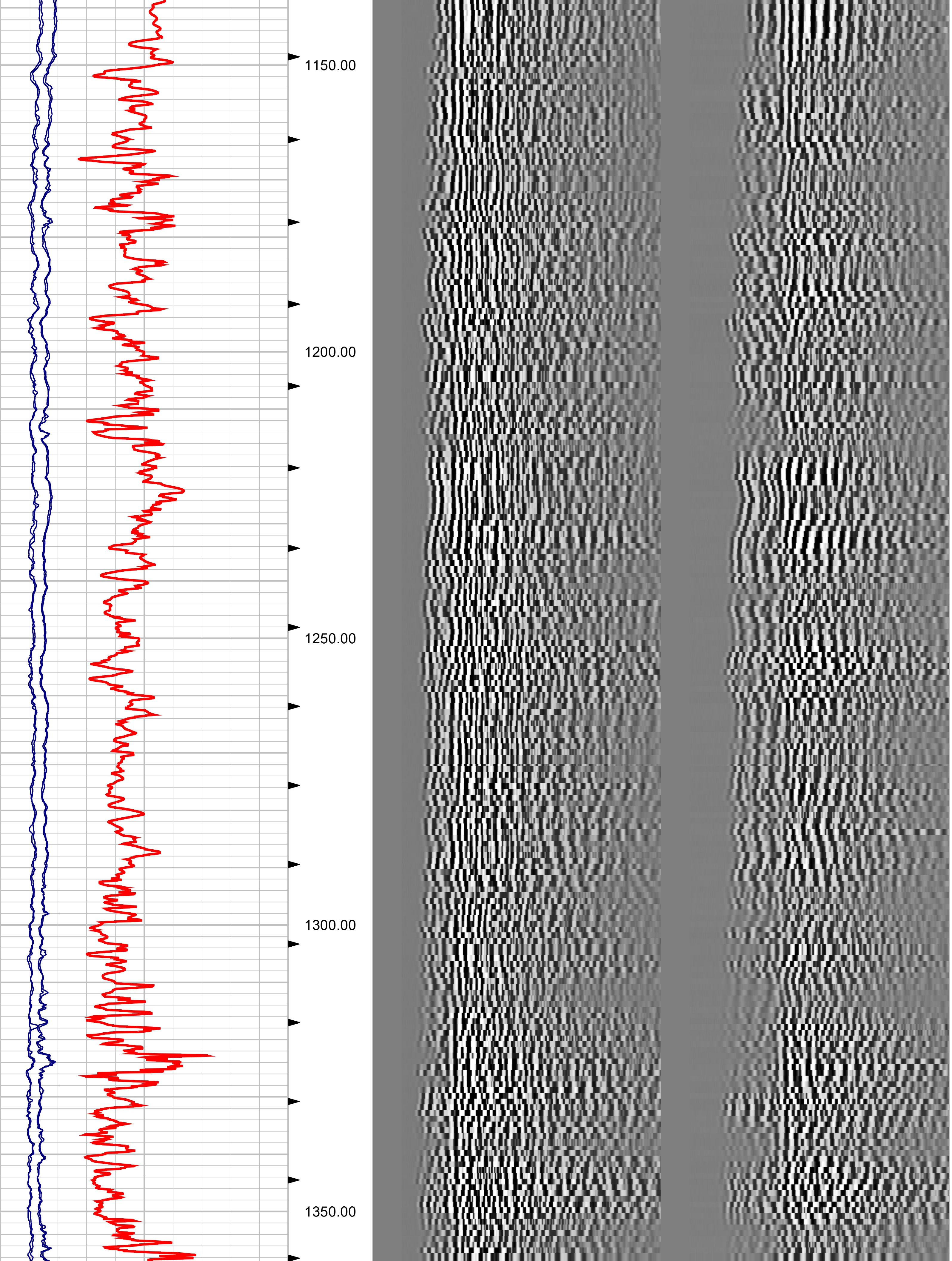
| FAR µs | |
|---|---|
| 0.00 | 960.00 |

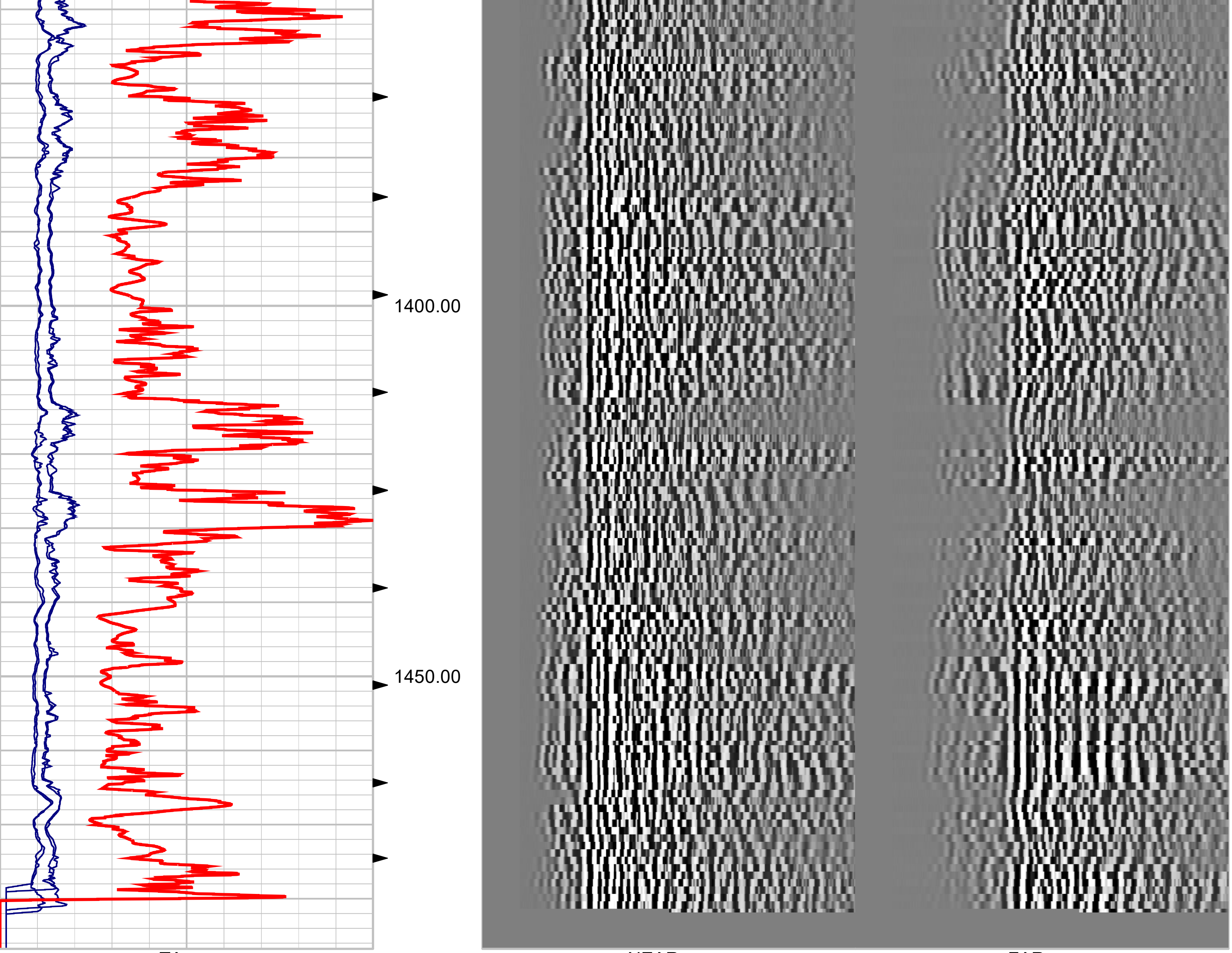



500.00
550.00
600.00
650.00


700.00
750.00
800.00
850.00
900.00


950.00
1000.00
1050.00
1100.00






| NEAR μs | | FAR μs | |
|---|---|---|---|
| 0.00 | 960.00 | 0.00 | 960.00 |

TA μs

0.00 3000.00

TB μs

0.00 3000.00

TC μs

0.00 3000.00

TD μs

0.00 3000.00

SVEL μs/ft

0.00 200.00

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SFWMD OSF-64

PROVISIONAL FIELD LOG

| | |
|---|---|
| COMPANY | SFWMD |
| WELL | OSF-64 |
| FIELD | CANOE CREEK |
| COUNTRY | USA |
| STATE | FL |
| COUNTY | OSCEOLA |
| LAT.: | |
| LONG.: | |

OTHER SERVICES

CAL
GAMM
ELOG
HRFM
TCDS

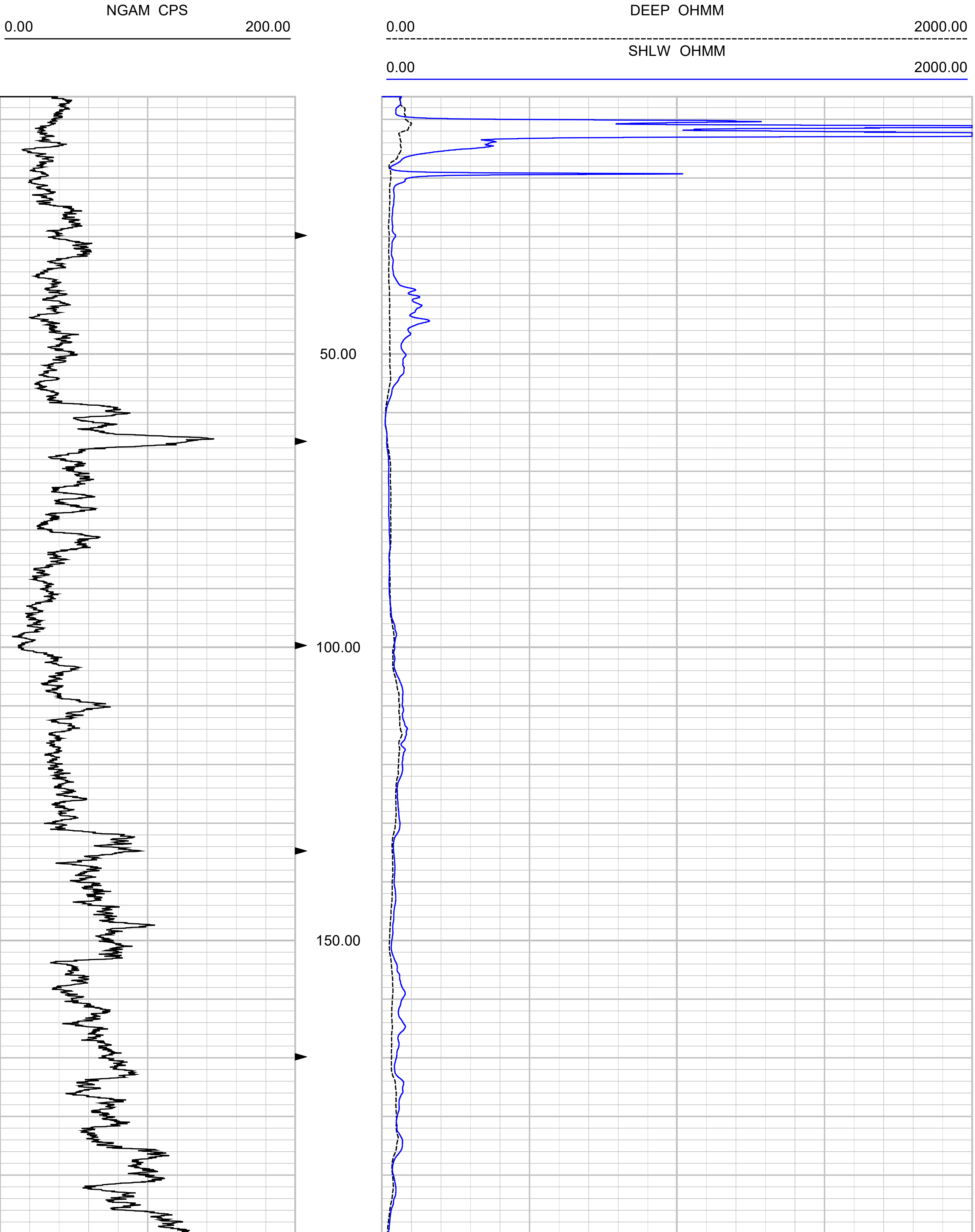
| | | | | |
|---|---|---|---|---|
| Perm. Da.. | | Elev | KB | 0.00 |
| Log. Datum | GS | | DF | 0.00 |
| Drill Datum | | | GL | 0.00 |

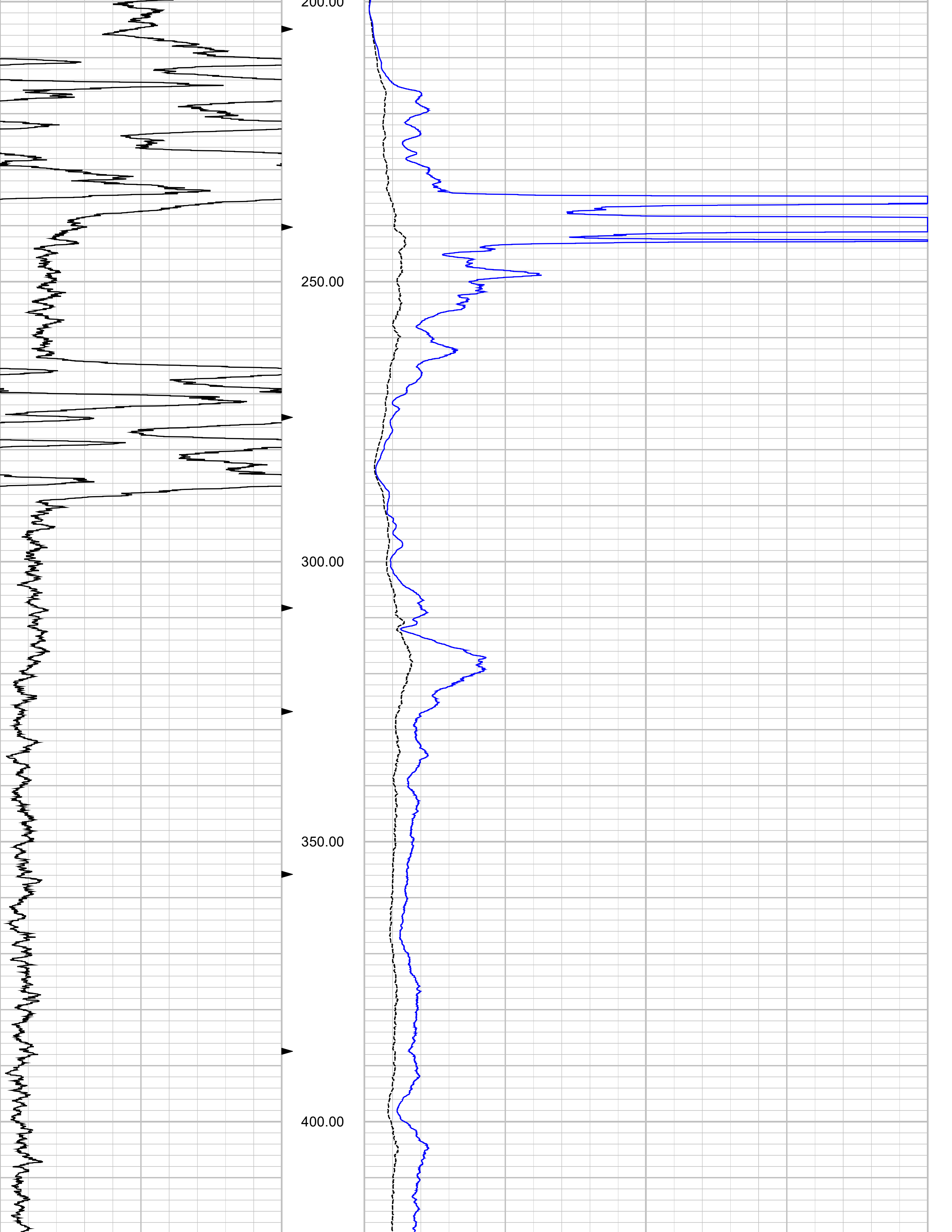
| | | | |
|---|---|---|---|
| DATE | 13 Dec 1 | 18 Nov 1 | 18 Nov 1 |
| RUN# | 0 | 0 | 0 |
| TYPE OF LOG | DUIN | | |
| DEPTH DRILLER | 1500.00 | 0.00 | 0.00 |
| DEPTH LOGGER | 1486.90 | 0.00 | 0.00 |
| LOG DEEPEST | 0.00 | 0.00 | 0.00 |
| LOG SHALLOW | 0.00 | 0.00 | 0.00 |
| FLUID IN HOLE | WATER | | |
| SALINITY | | | |
| DENSITY | | | |
| LEVEL | | | |
| MAX TEMP °C | 0.00 | 0.00 | 0.00 |
| RIG TIME | | | |
| RECORDED BY | RMB | | |
| WITNESSED BY | SFWMD | | |

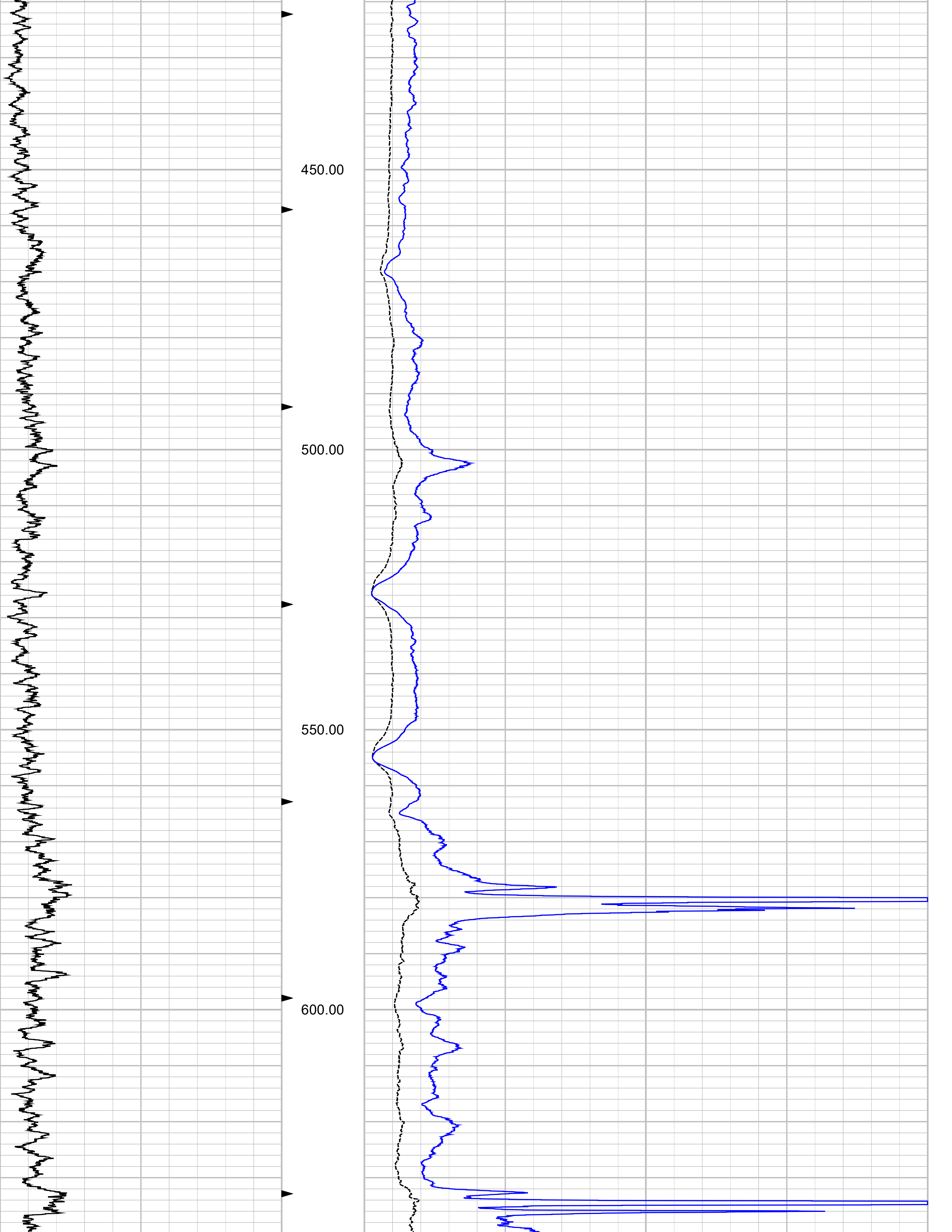
| RUN# | BIT RECORD | | | CASING RECORD | | | |
|---|---|---|---|---|---|---|---|
| | SIZE | FROM | TO | SIZE | WEIGHT | FROM | TO |
| 0 | 7.50 | 311.00 | 1500.00 | 8.00 | 0.00 | 0.00 | 311.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

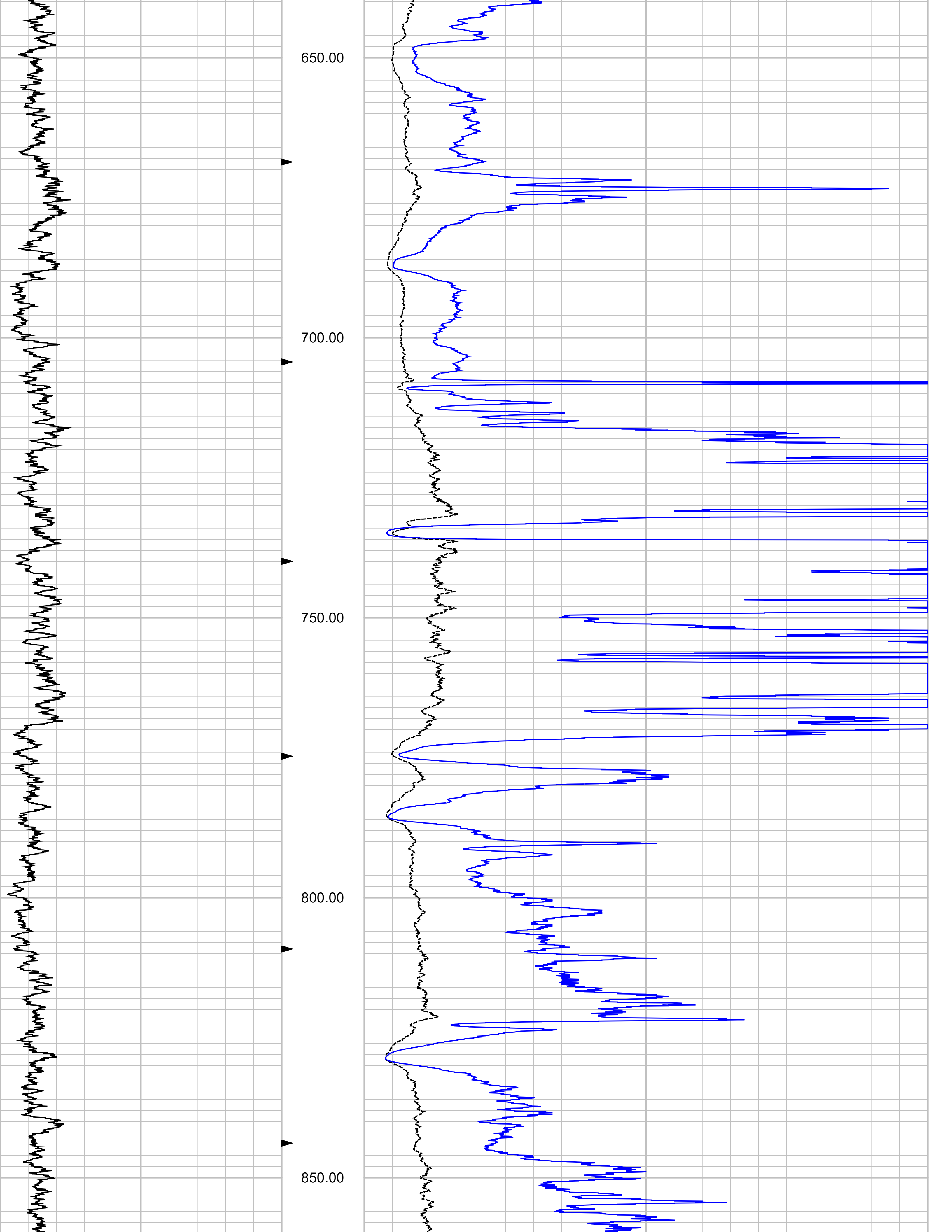
ROBERTSON GEOLOGGING TECHNOLOGY

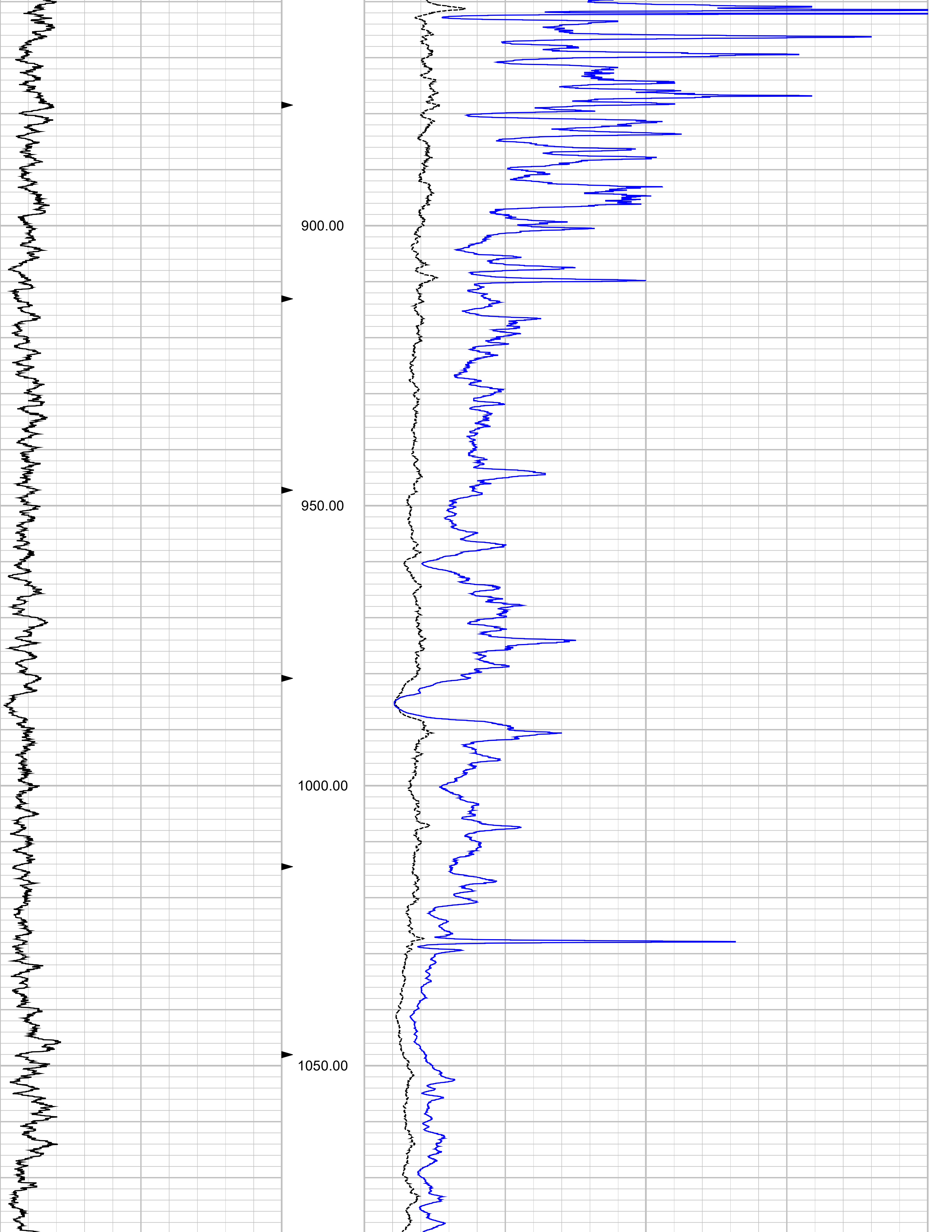
REMARKS ( G:\RobMB\Documents\LOGGING DATA\OSF-64\O..

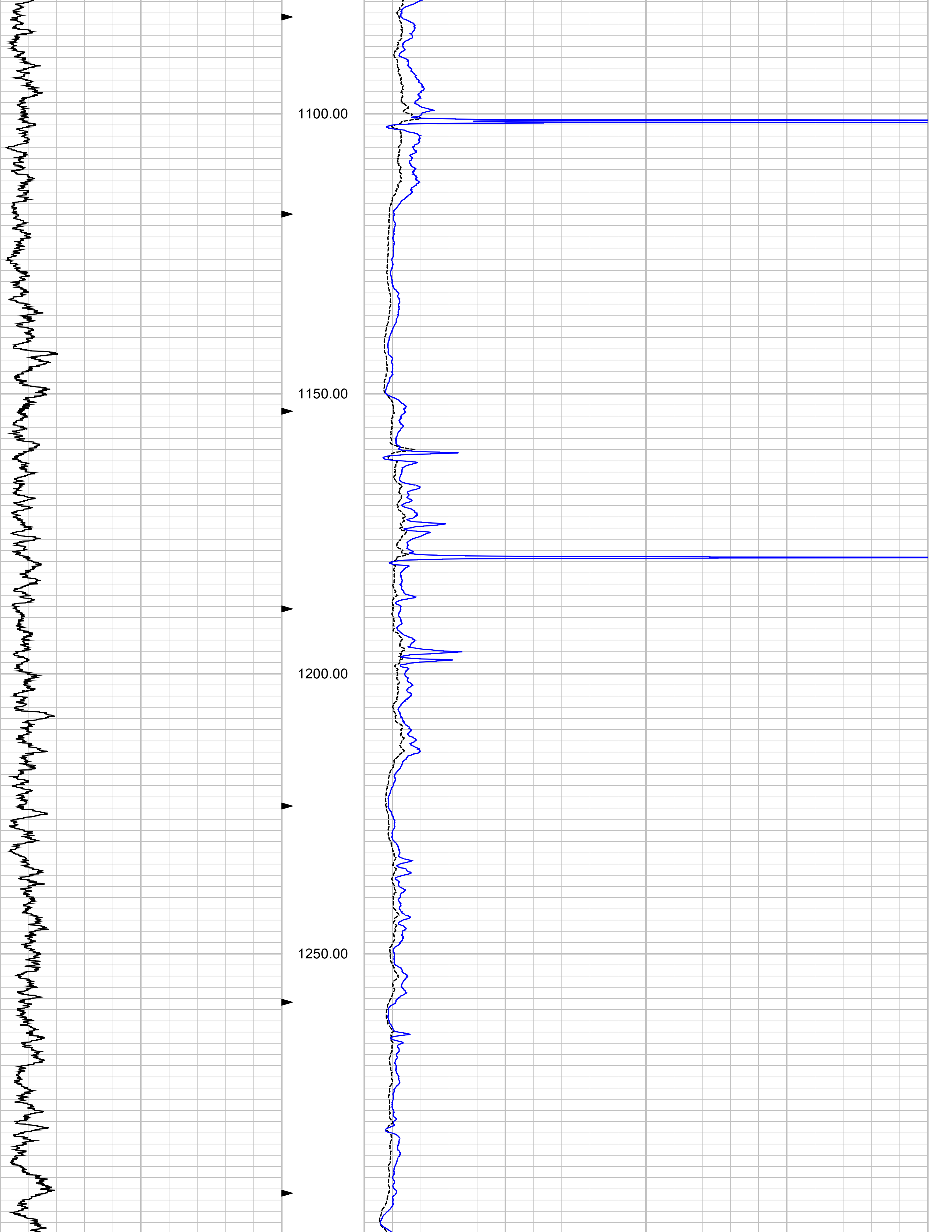

NGAM CPS
0.00
200.00
DEEP OHMM
0.00
2000.00
SHLW OHMM
0.00
2000.00
50.00
100.00
150.00

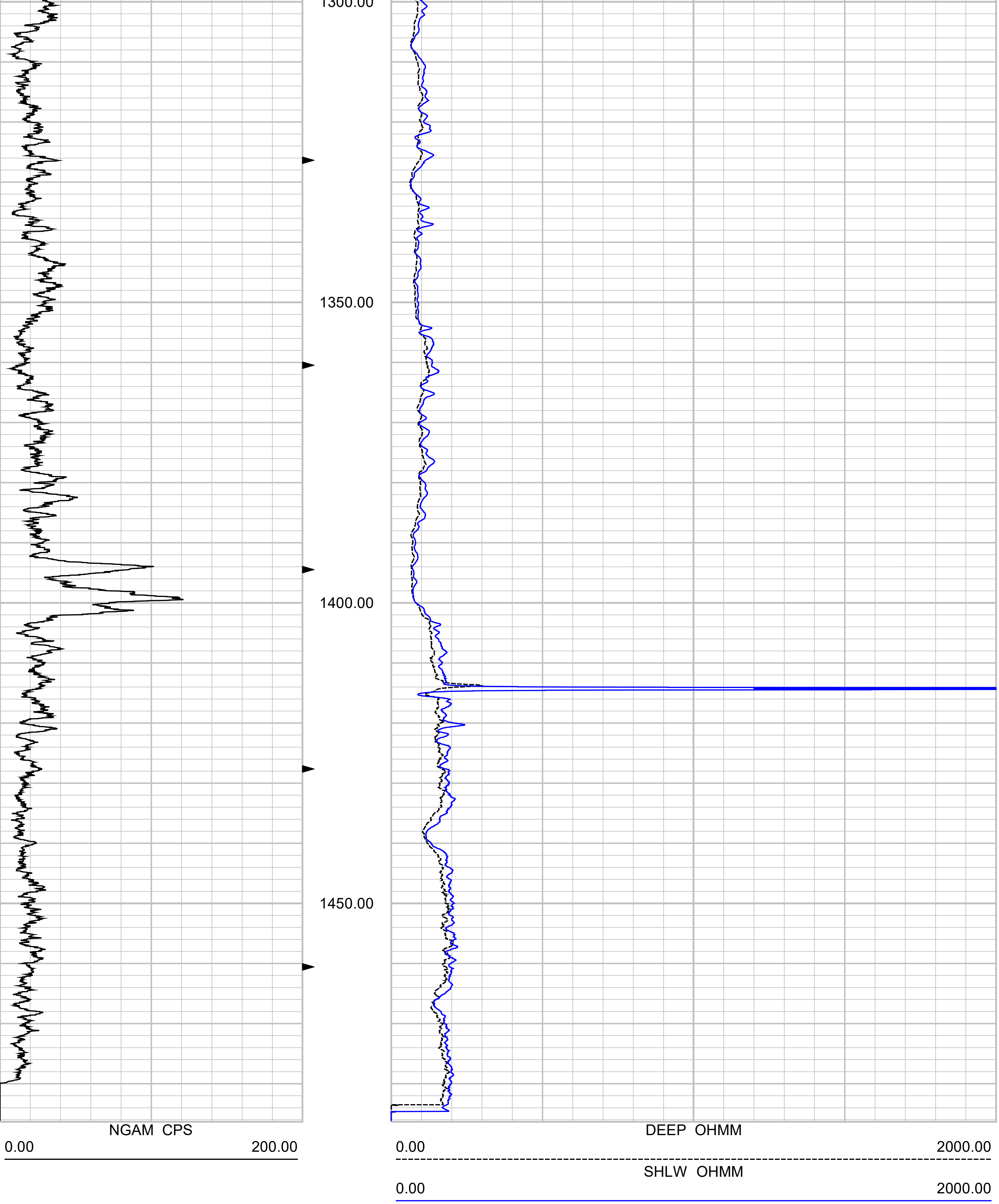

200.00
250.00
300.00
350.00
400.00


450.00
500.00
550.00
600.00


650.00
700.00
750.00
800.00
850.00


900.00
950.00
1000.00
1050.00


1100.00
1150.00
1200.00
1250.00




Depth: 6.00 ft   Date: 13 Dec 2019   Time: 13:14:14   File: "G:\RobMB\Documents\LOGGING DATA\OSF-64\OSF64 12-13 DUIN GAM.LOG"

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www.rmbaker.com

SFWMD OSF-64

PROVISIONAL FIELD LOG

| | |
|---|---|
| COMPANY | SFWMD |
| WELL | OSF-64 |
| FIELD | CANOE CREEK |
| COUNTRY | USA |
| STATE | FL |
| COUNTY | OSCEOLA |
| LAT.: | |
| LONG.: | |

OTHER SERVICES

CAL
GAMM
ELOG
HRFM
TCDS

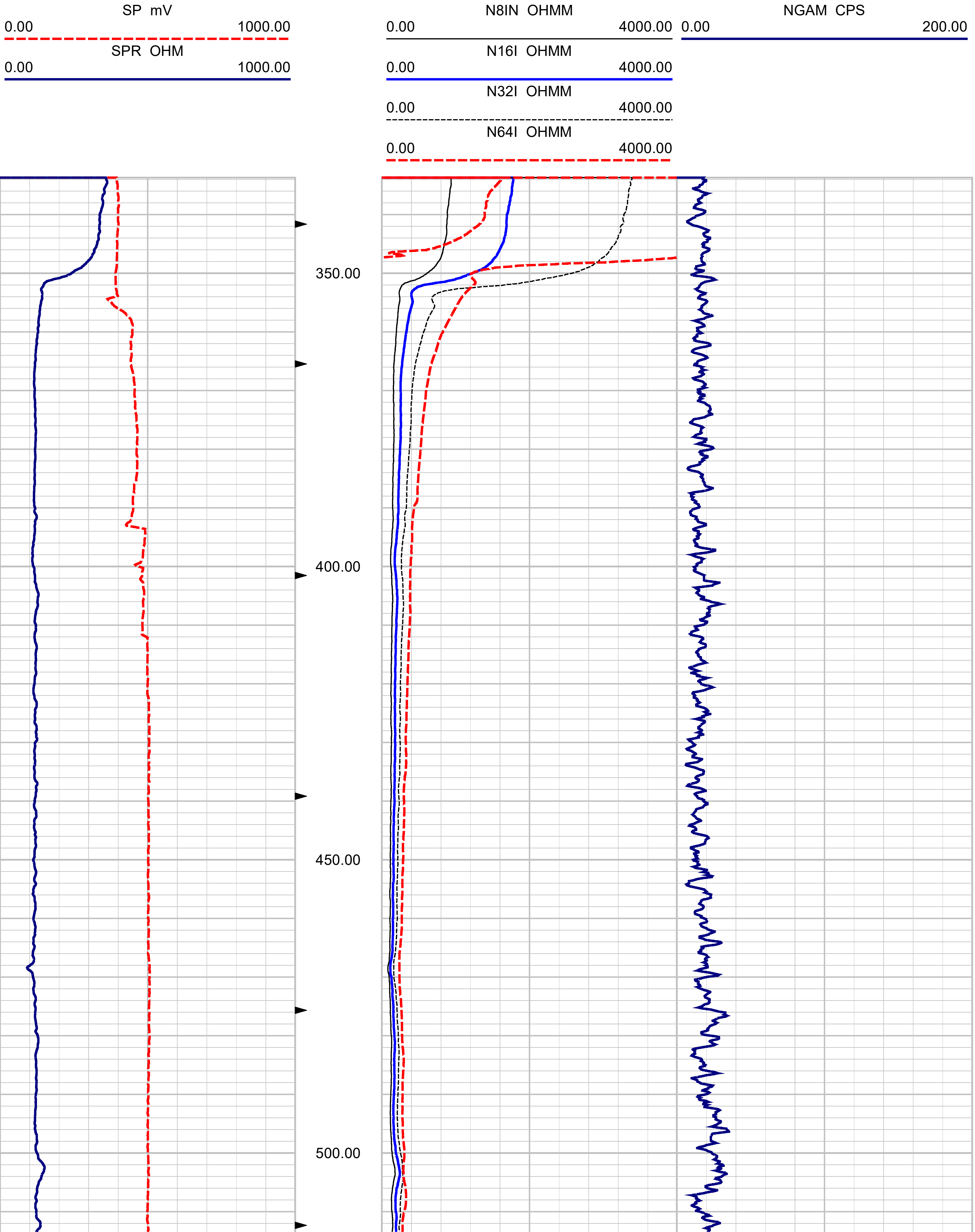
| | | | | |
|---|---|---|---|---|
| Perm. Da.. | | Elev | KB | 0.00 |
| Log. Datum | GS | | DF | 0.00 |
| Drill Datum | | | GL | 0.00 |

| | | | |
|---|---|---|---|
| DATE | 13 Dec 1 | 18 Nov 1 | 18 Nov 1 |
| RUN# | 0 | 0 | 0 |
| TYPE OF LOG | ELOG | | |
| DEPTH DRILLER | 1500.00 | 0.00 | 0.00 |
| DEPTH LOGGER | 1486.90 | 0.00 | 0.00 |
| LOG DEEPEST | 0.00 | 0.00 | 0.00 |
| LOG SHALLOW | 0.00 | 0.00 | 0.00 |
| FLUID IN HOLE | WATER | | |
| SALINITY | | | |
| DENSITY | | | |
| LEVEL | | | |
| MAX TEMP °C | 0.00 | 0.00 | 0.00 |
| RIG TIME | | | |
| RECORDED BY | RMB | | |
| WITNESSED BY | SFWMD | | |

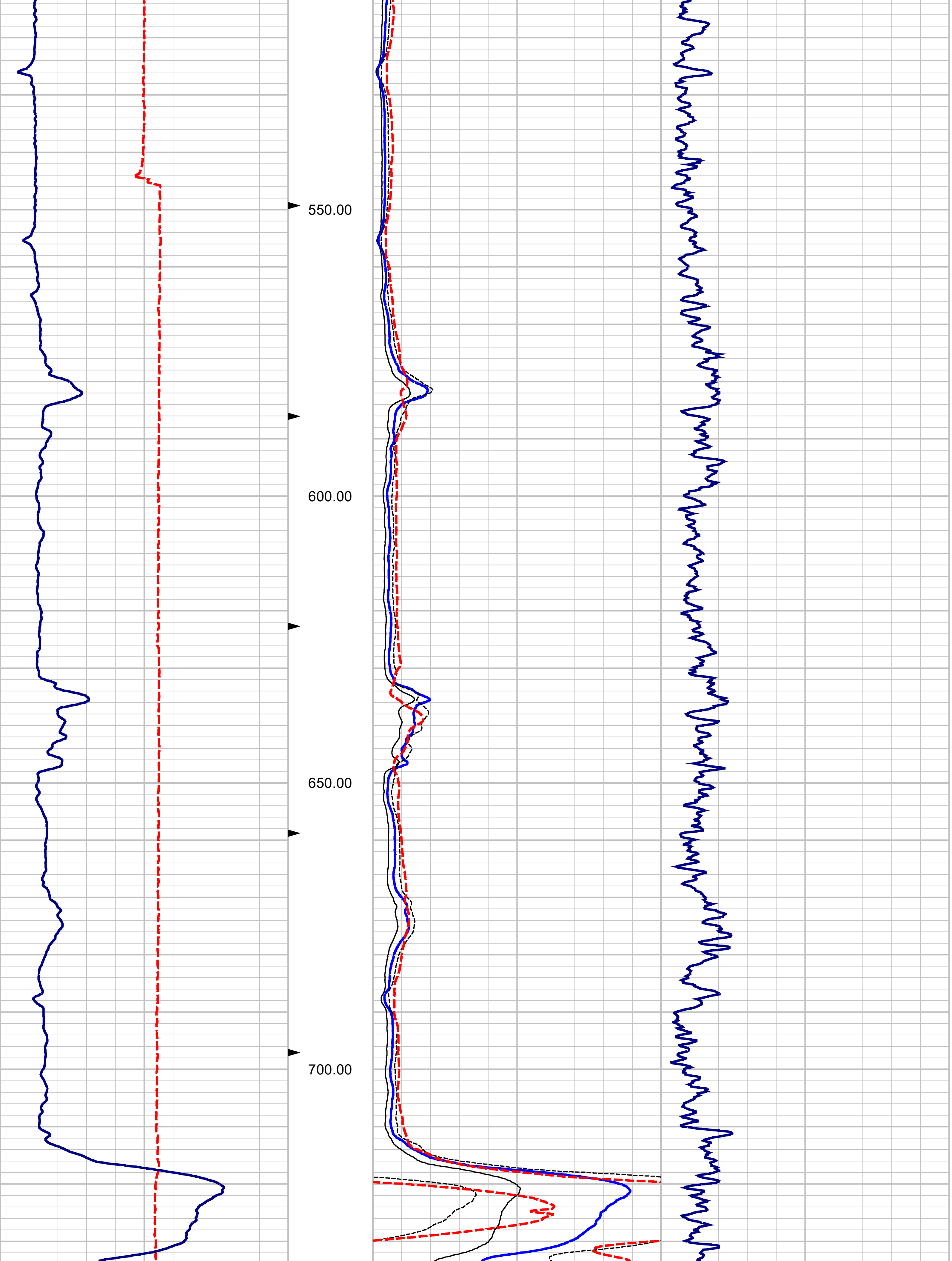
| RUN# | BIT RECORD | | | CASING RECORD | | | |
|---|---|---|---|---|---|---|---|
| | SIZE | FROM | TO | SIZE | WEIGHT | FROM | TO |
| 0 | 7.50 | 311.00 | 1500.00 | 8.00 | 0.00 | 0.00 | 311.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

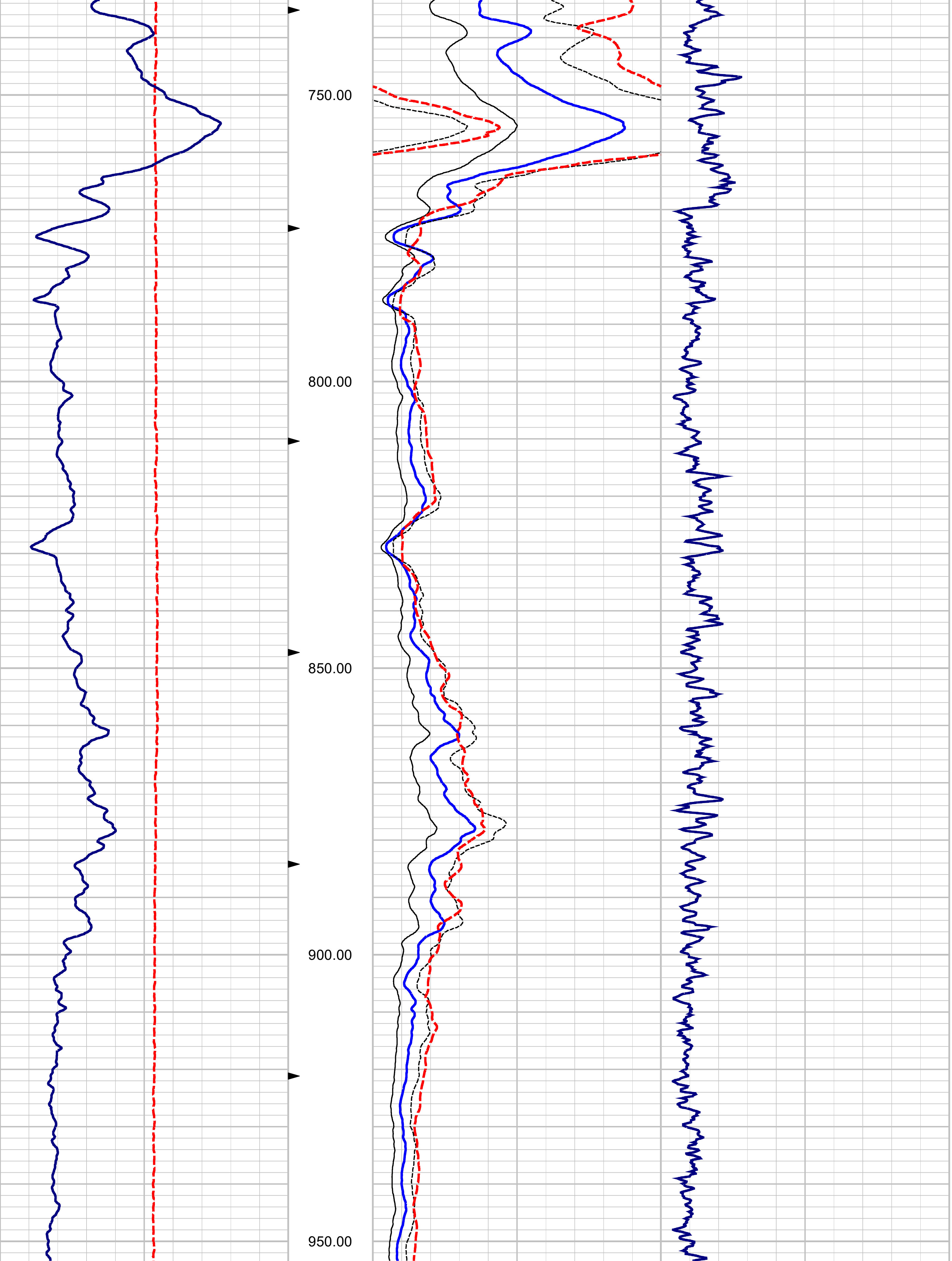
ROBERTSON GEOLOGGING TECHNOLOGY

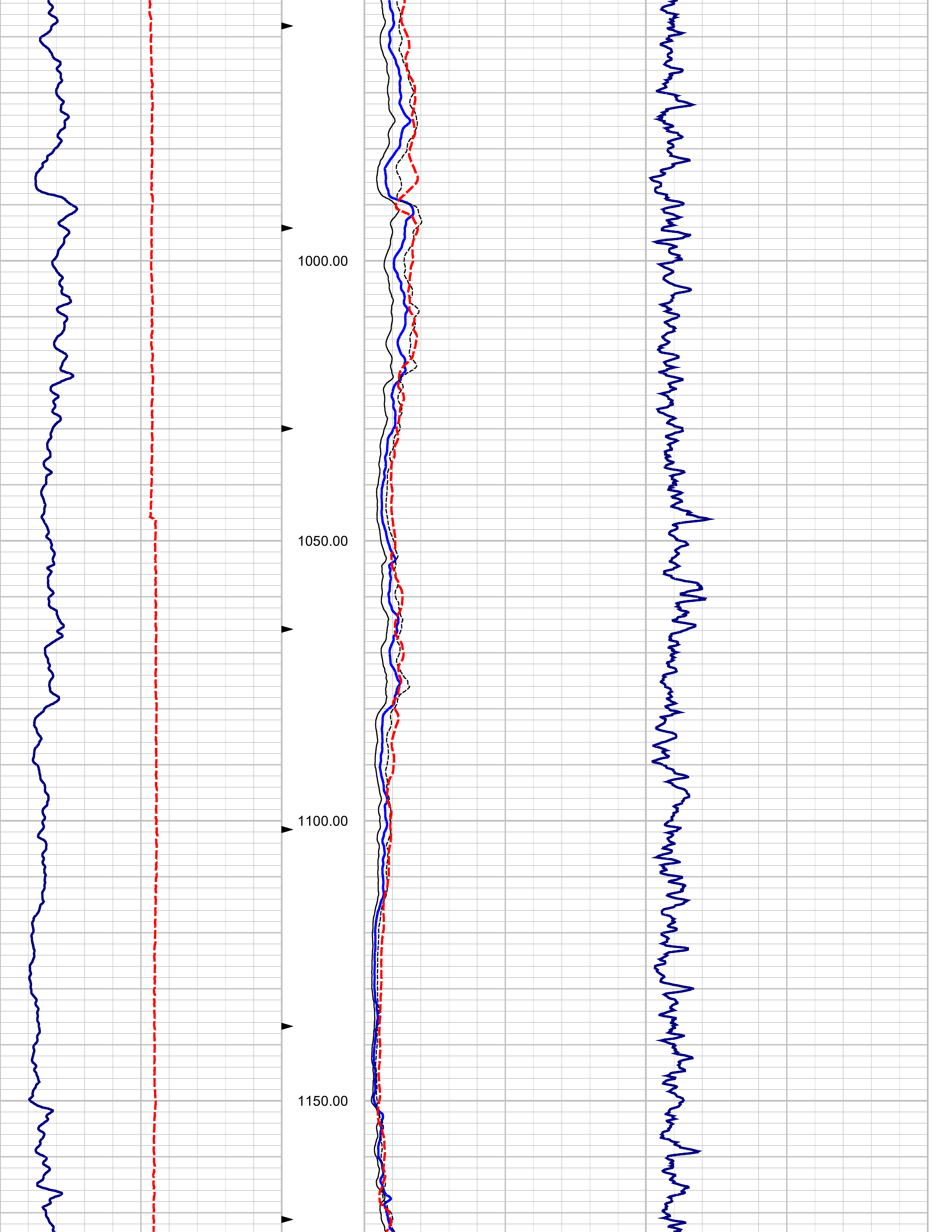
REMARKS ( G:\RobMB\Documents\LOGGING DATA\OSF-64\O..

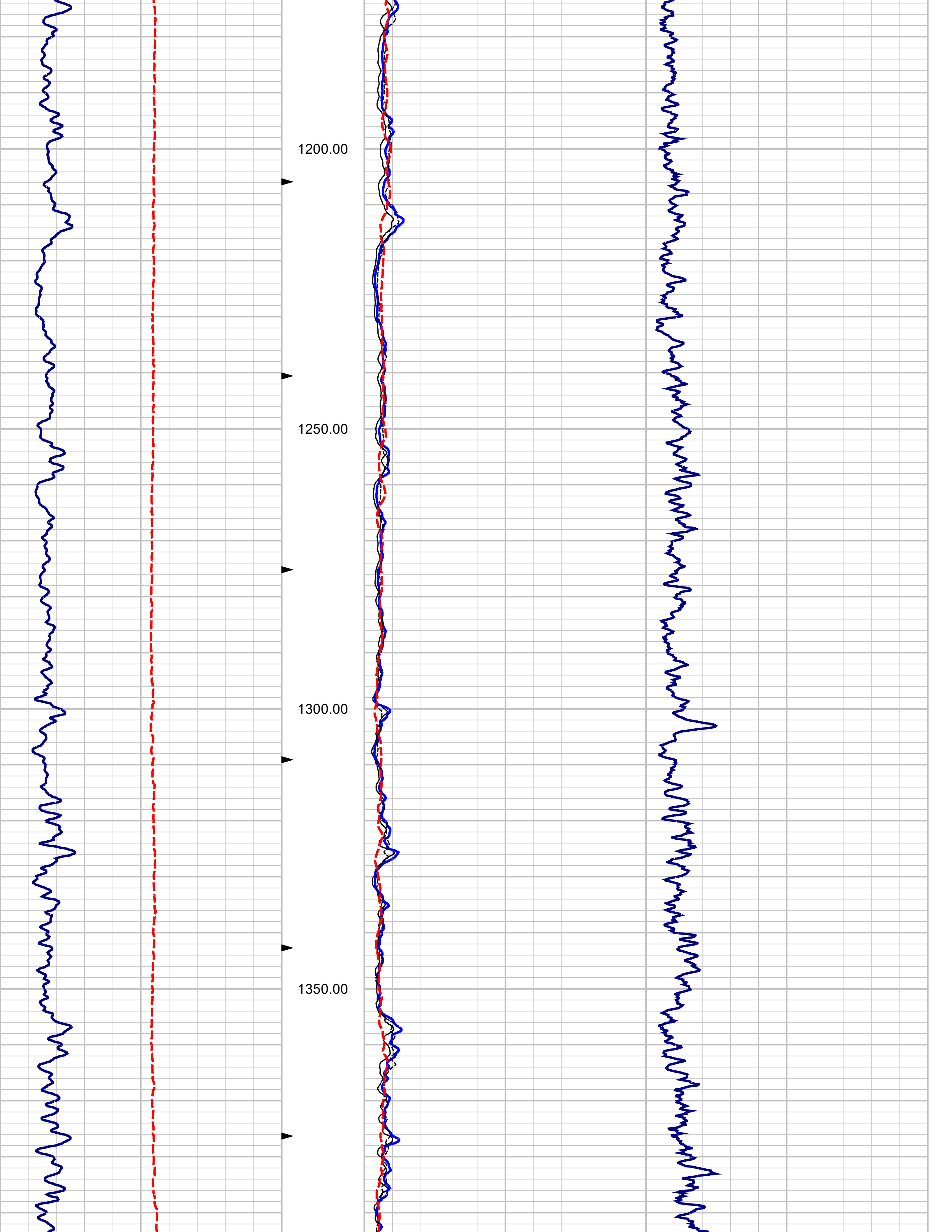


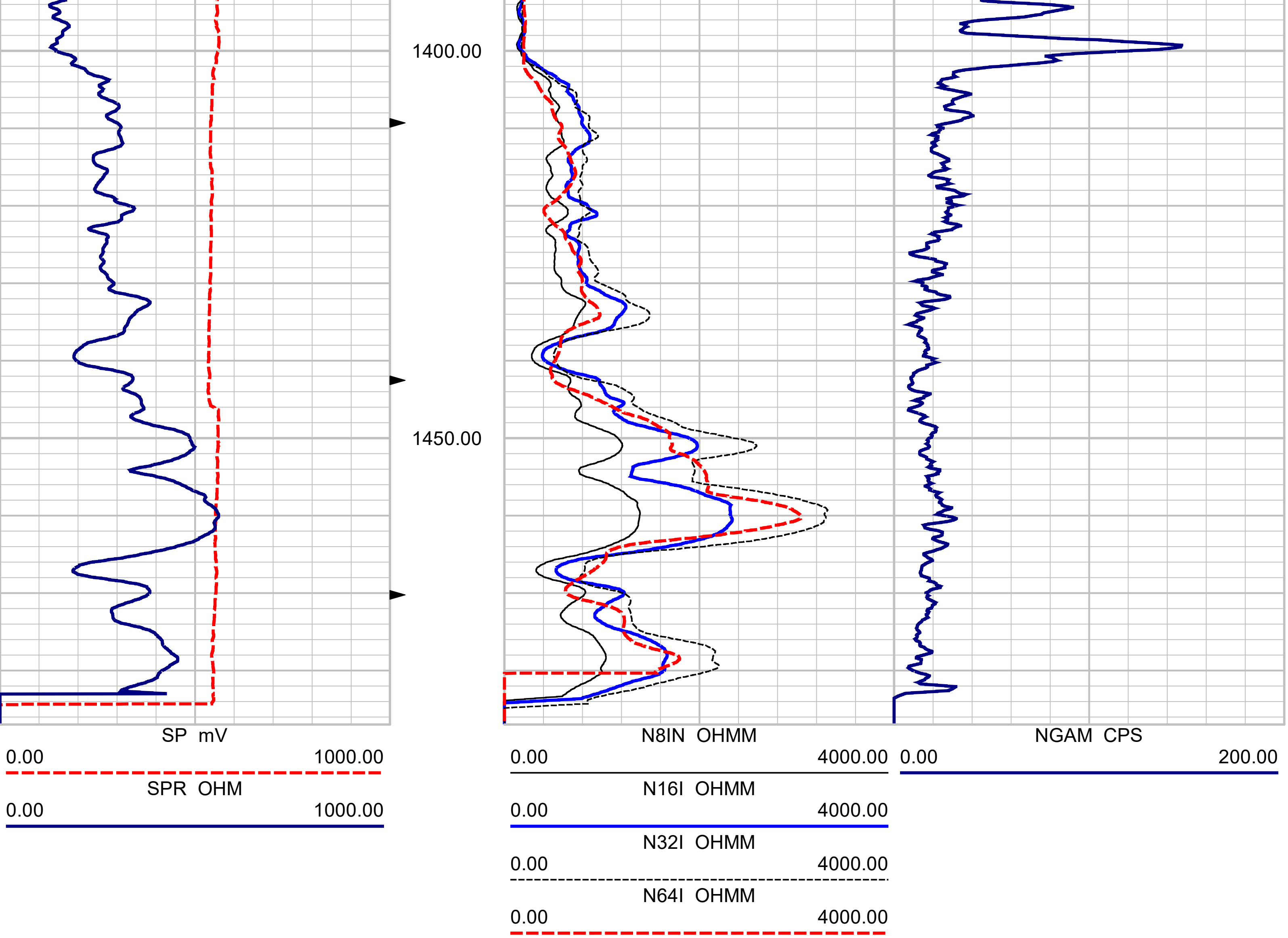
SP mV
0.00
1000.00
SPR OHM
0.00
1000.00
N8IN OHMM
0.00
4000.00
N16I OHMM
0.00
4000.00
N32I OHMM
0.00
4000.00
N64I OHMM
0.00
4000.00
NGAM CPS
0.00
200.00
350.00
400.00
450.00
500.00


550.00
600.00
650.00
700.00


750.00
800.00
850.00
900.00
950.00


1000.00
1050.00
1100.00
1150.00


1200.00
1250.00
1300.00
1350.00




Depth: 333.00 ft Date: 13 Dec 2019 Time: 14:28:17 File: "G:\RobMB\Documents\LOGGING DATA\OSF-64\OSF64 12-13 ELOG GAM.LGX"

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rob@rmbaker.com
**www.rmbaker.com**

SFWMD OSF-64

PROVISIONAL FIELD LOG

| | |
|---|---|
| COMPANY | SFWMD |
| WELL | OSF-64 |
| FIELD | CANOE CREEK |
| COUNTRY | USA |
| STATE | FL |
| COUNTY | OSCEOLA |
| LAT.: | |
| LONG.: | |

OTHER SERVICES

CAL
GAMM
ELOG
HRFM
TCDS

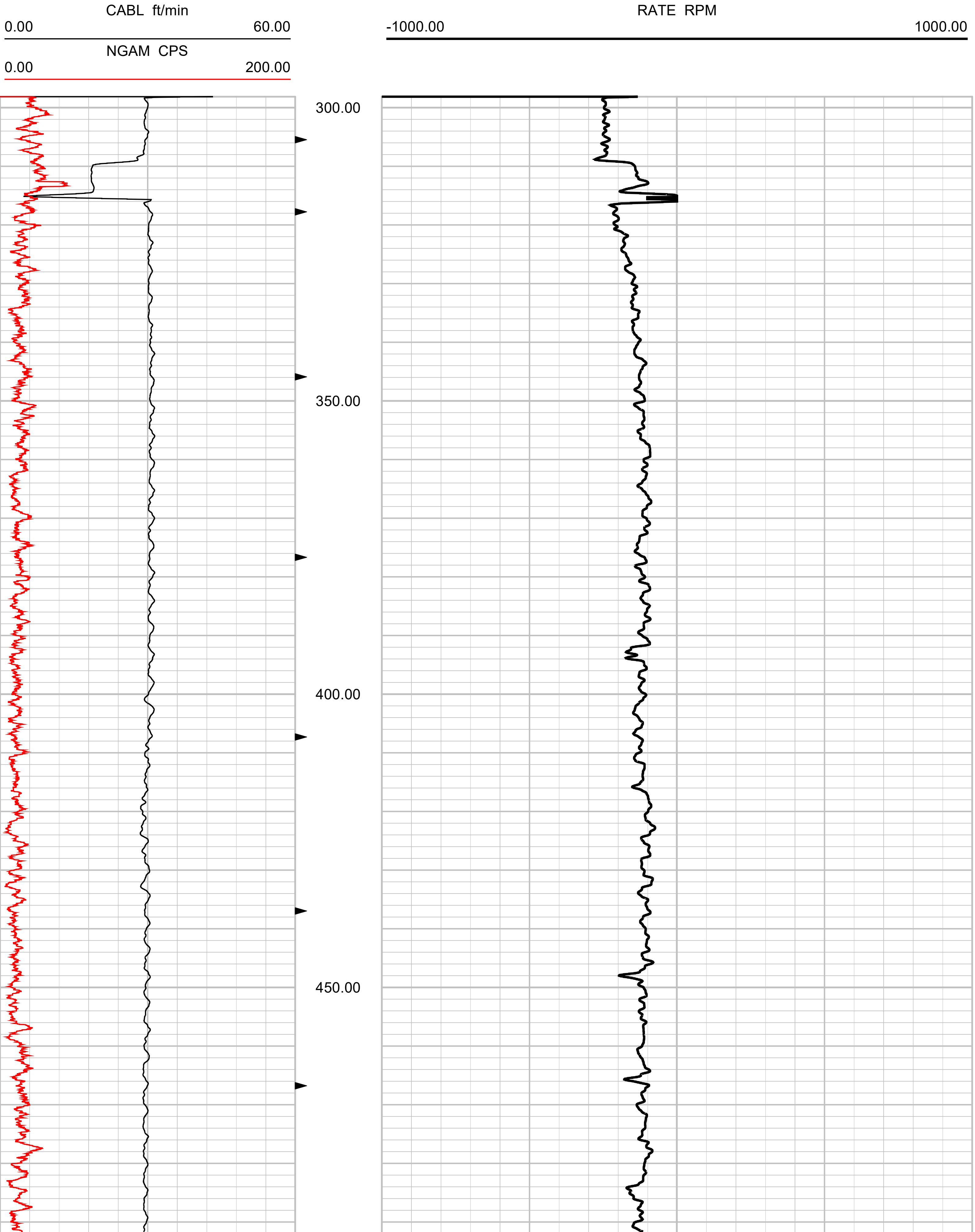
| | | | | |
|---|---|---|---|---|
| Perm. Da.. | | Elev | KB | 0.00 |
| Log. Datum | GS | | DF | 0.00 |
| Drill Datum | | | GL | 0.00 |

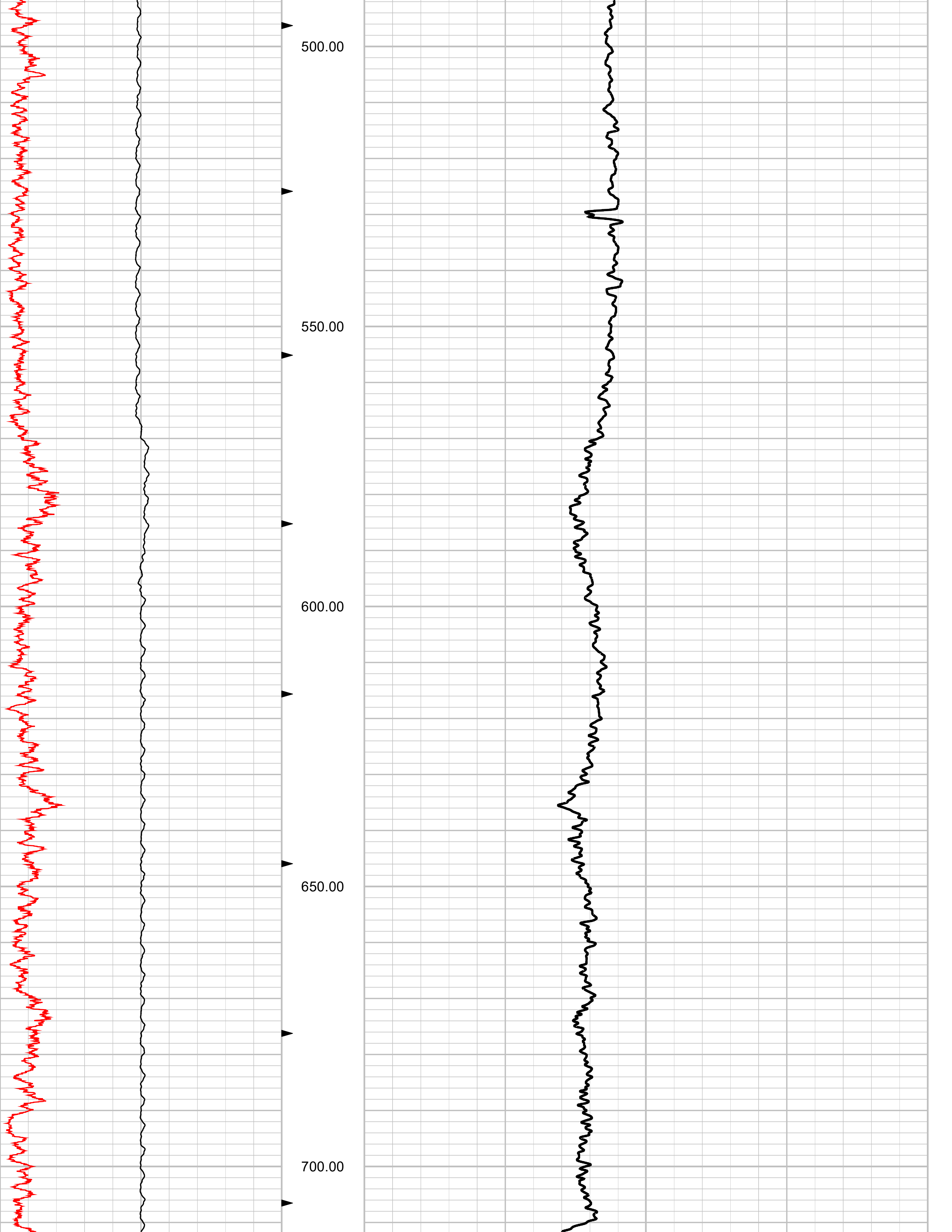
| | | | |
|---|---|---|---|
| DATE | 13 Dec 1 | 18 Nov 1 | 18 Nov 1 |
| RUN# | 0 | 0 | 0 |
| TYPE OF LOG | HRFM US | | |
| DEPTH DRILLER | 1500.00 | 0.00 | 0.00 |
| DEPTH LOGGER | 1486.90 | 0.00 | 0.00 |
| LOG DEEPEST | 0.00 | 0.00 | 0.00 |
| LOG SHALLOW | 0.00 | 0.00 | 0.00 |
| FLUID IN HOLE | WATER | | |
| SALINITY | | | |
| DENSITY | | | |
| LEVEL | | | |
| MAX TEMP °C | 0.00 | 0.00 | 0.00 |
| RIG TIME | | | |
| RECORDED BY | RMB | | |
| WITNESSED BY | SFWMD | | |

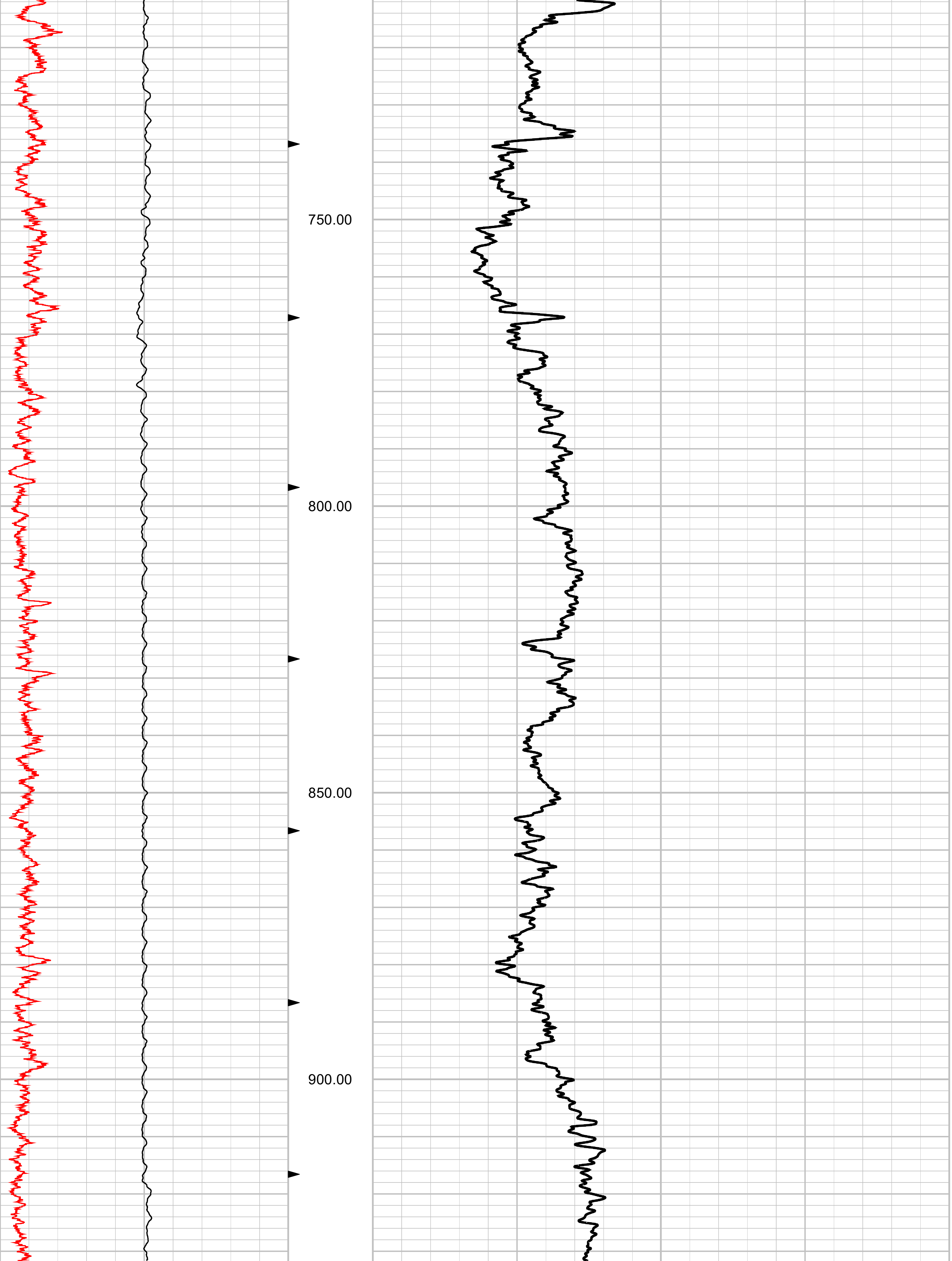
| RUN# | BIT RECORD | | | CASING RECORD | | | |
|---|---|---|---|---|---|---|---|
| | SIZE | FROM | TO | SIZE | WEIGHT | FROM | TO |
| 0 | 7.50 | 311.00 | 1500.00 | 8.00 | 0.00 | 0.00 | 311.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

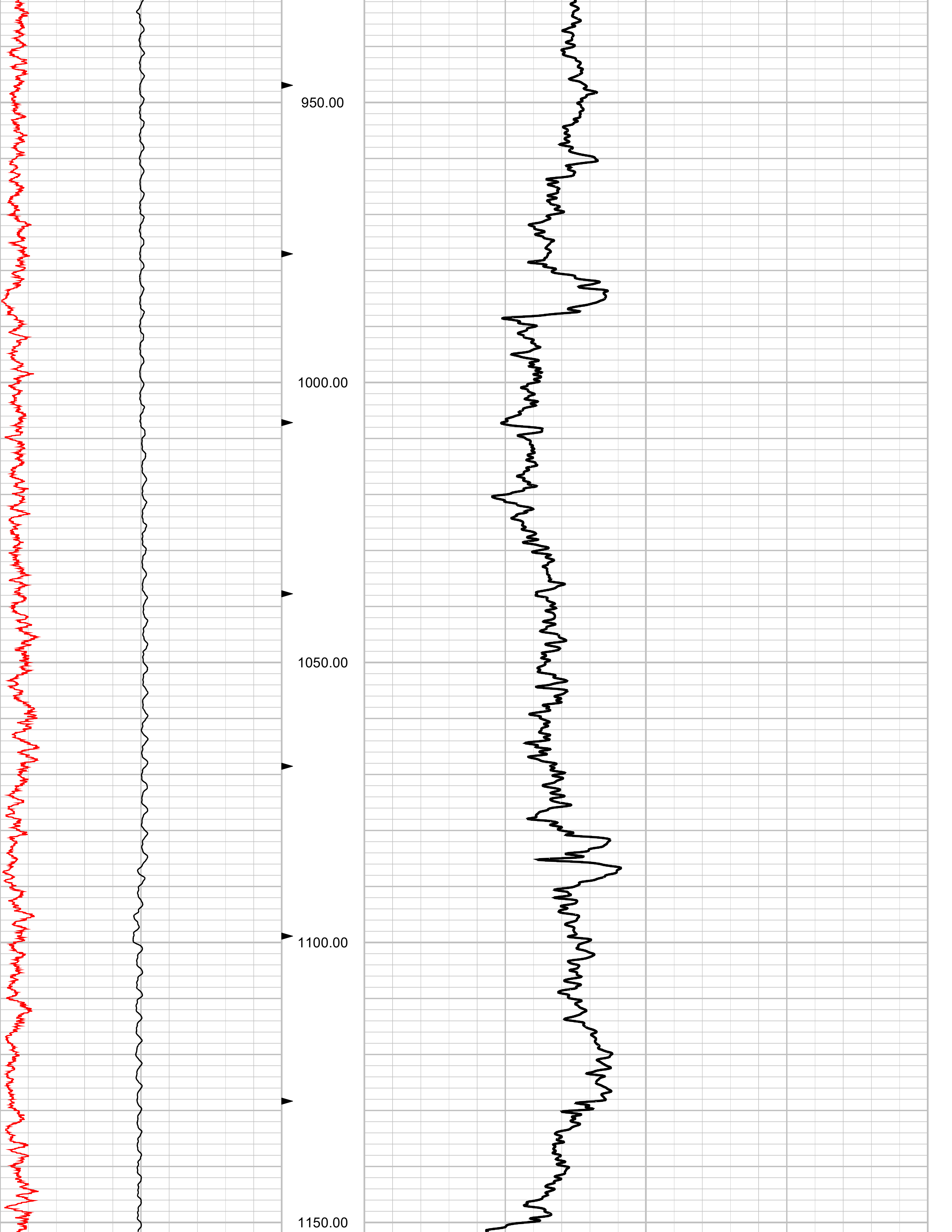
ROBERTSON GEOLOGGING TECHNOLOGY

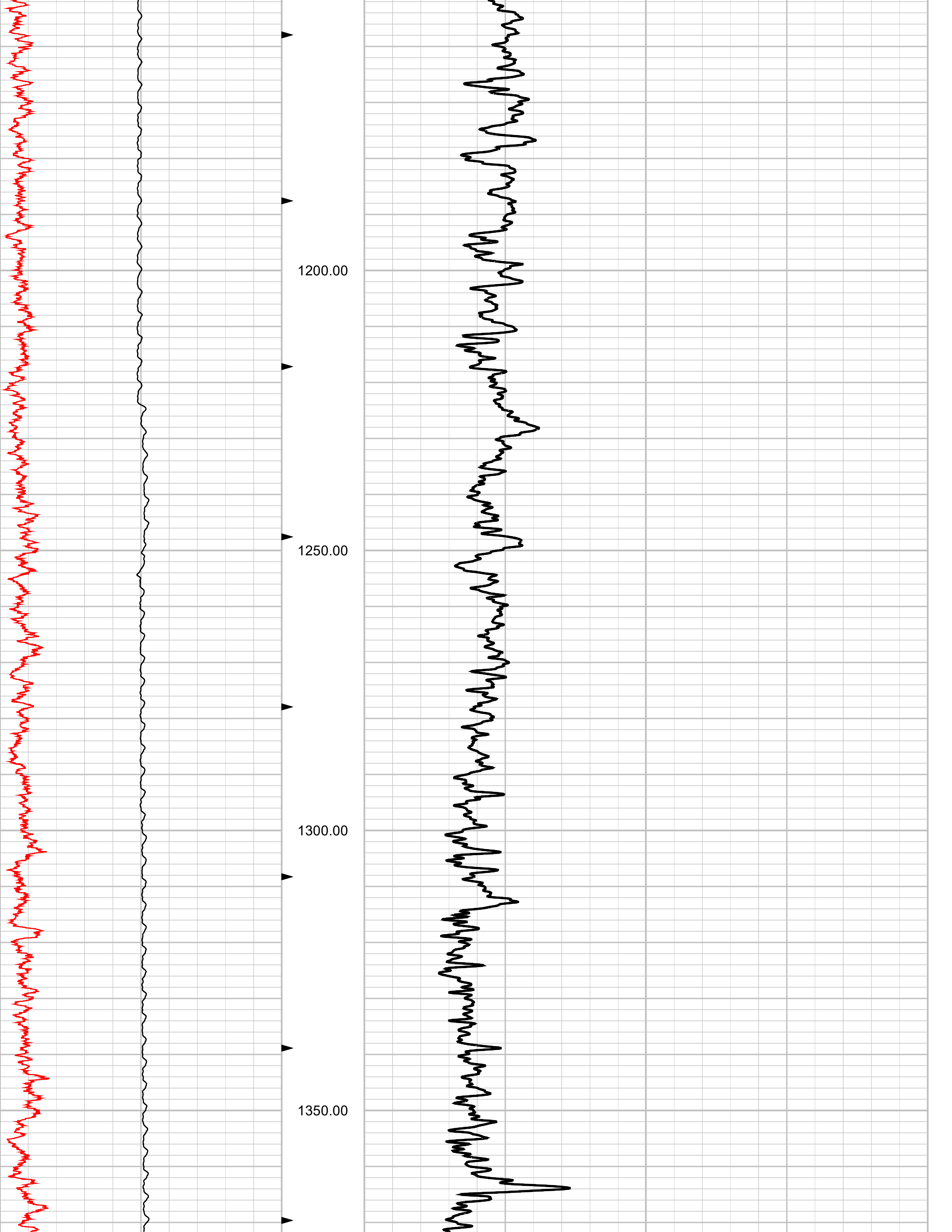
REMARKS ( G:\RobMB\Documents\LOGGING DATA\OSF-64\O..

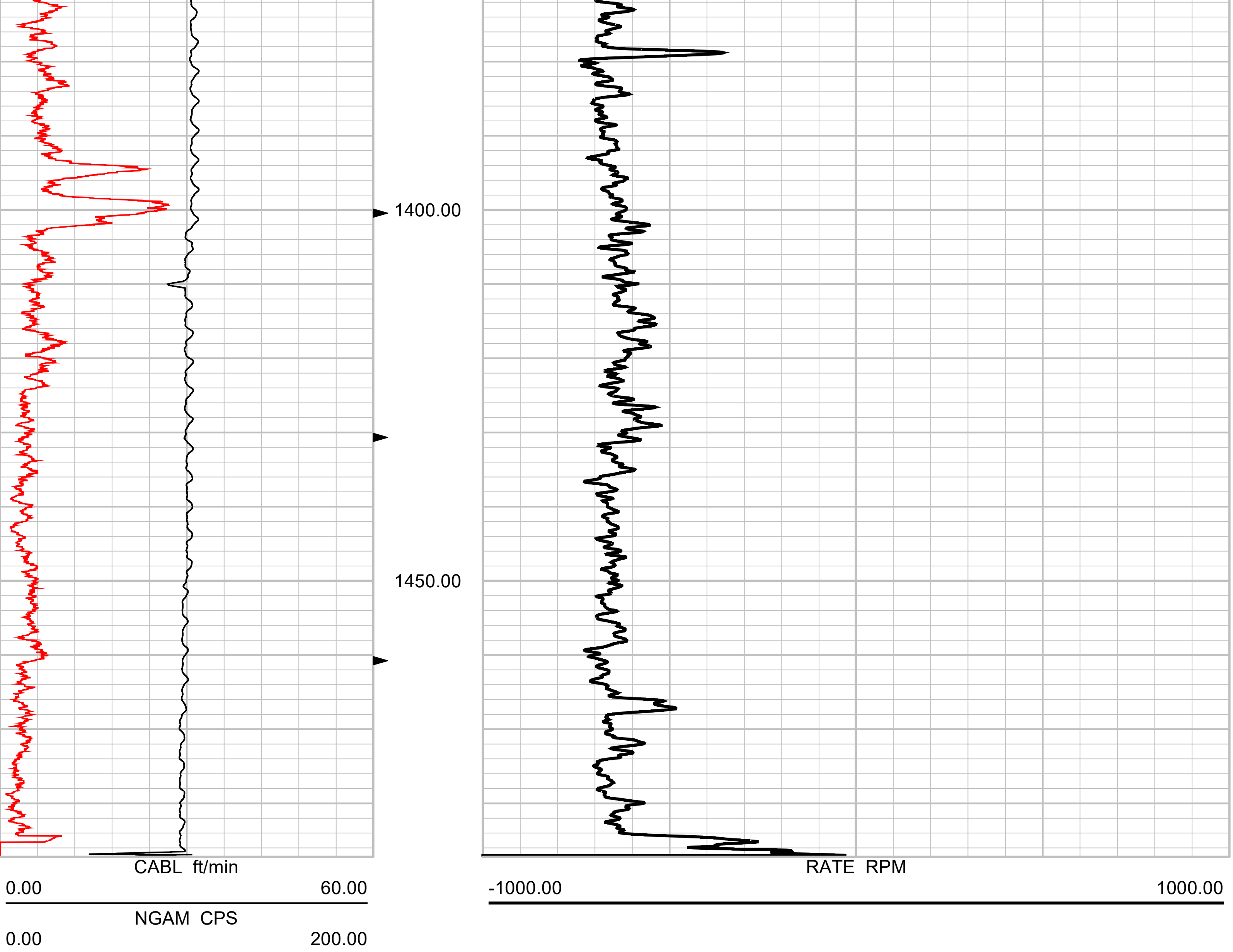

CABL ft/min
0.00
60.00
NGAM CPS
0.00
200.00
RATE RPM
-1000.00
1000.00
300.00
350.00
400.00
450.00


500.00
550.00
600.00
650.00
700.00


750.00
800.00
850.00
900.00


950.00
1000.00
1050.00
1100.00
1150.00


1200.00
1250.00
1300.00
1350.00




Depth: 298.00 ft Date: 13 Dec 2019 Time: 10:02:43 File: "G:\RobMB\Documents\LOGGING DATA\OSF-64\OSF64 12-13 HRFM GAM US.LOG"

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fax 407-370-4129
rob@rmbaker.com
**www.rmbaker.com**

SFWMD OSF-64

PROVISIONAL FIELD LOG

| | |
|---|---|
| COMPANY | SFWMD |
| WELL | OSF-64 |
| FIELD | CANOE CREEK |
| COUNTRY | USA |
| STATE | FL |
| COUNTY | OSCEOLA |
| LAT.: | |
| LONG.: | |

OTHER SERVICES

CAL
GAMM
ELOG
HRFM
TCDS

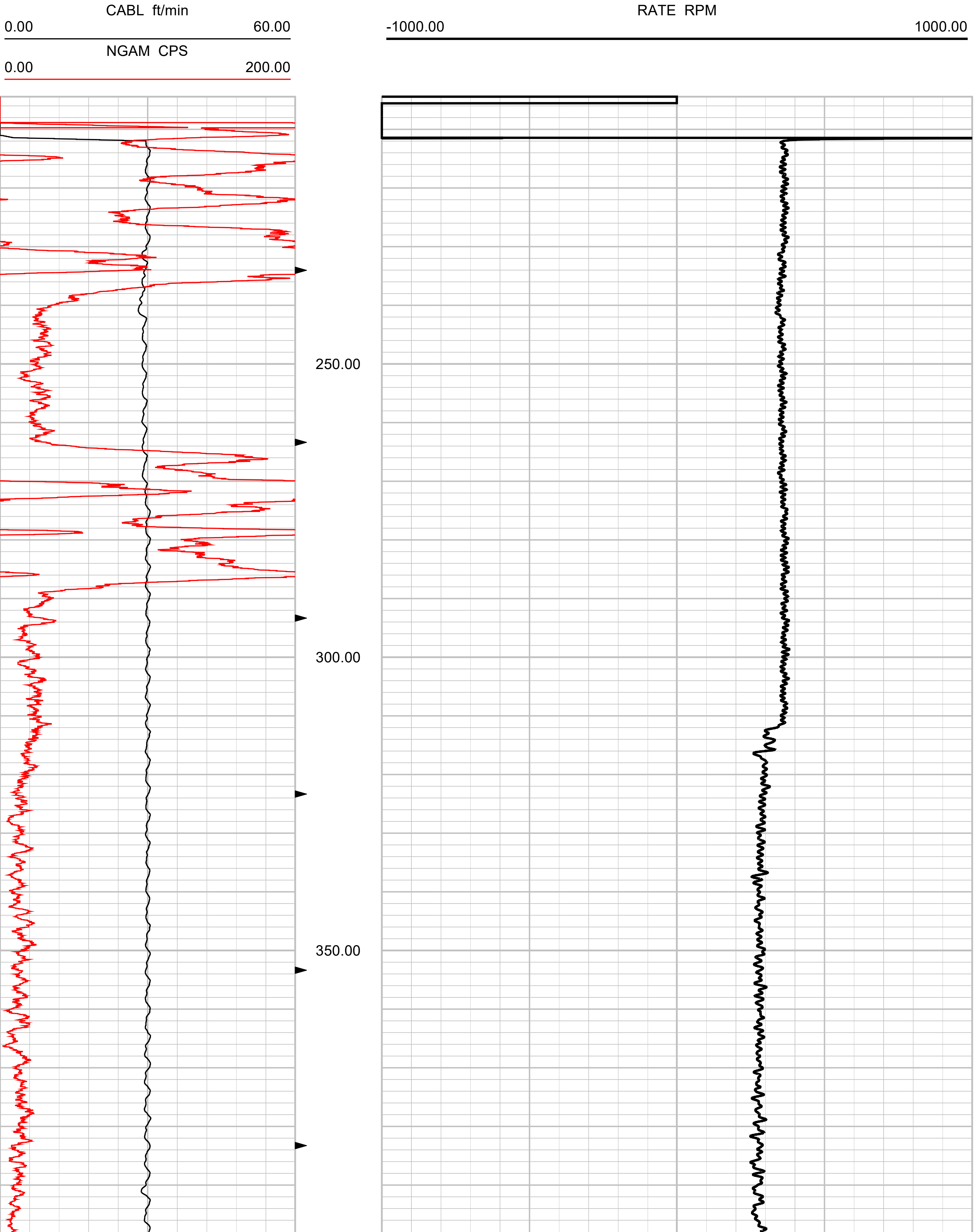
| | | | | |
|---|---|---|---|---|
| Perm. Da.. | | Elev | KB | 0.00 |
| Log. Datum | GS | | DF | 0.00 |
| Drill Datum | | | GL | 0.00 |

| | | | |
|---|---|---|---|
| DATE | 13 Dec 1 | 18 Nov 1 | 18 Nov 1 |
| RUN# | 0 | 0 | 0 |
| TYPE OF LOG | HRFM DS | | |
| DEPTH DRILLER | 1500.00 | 0.00 | 0.00 |
| DEPTH LOGGER | 1486.90 | 0.00 | 0.00 |
| LOG DEEPEST | 0.00 | 0.00 | 0.00 |
| LOG SHALLOW | 0.00 | 0.00 | 0.00 |
| FLUID IN HOLE | WATER | | |
| SALINITY | | | |
| DENSITY | | | |
| LEVEL | | | |
| MAX TEMP °C | 0.00 | 0.00 | 0.00 |
| RIG TIME | | | |
| RECORDED BY | RMB | | |
| WITNESSED BY | SFWMD | | |

| RUN# | BIT RECORD | | | CASING RECORD | | | |
|---|---|---|---|---|---|---|---|
| | SIZE | FROM | TO | SIZE | WEIGHT | FROM | TO |
| 0 | 7.50 | 311.00 | 1500.00 | 8.00 | 0.00 | 0.00 | 311.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

ROBERTSON GEOLOGGING TECHNOLOGY

REMARKS ( G:\RobMB\Documents\LOGGING DATA\OSF-64\O..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NGAM CPS
0.00
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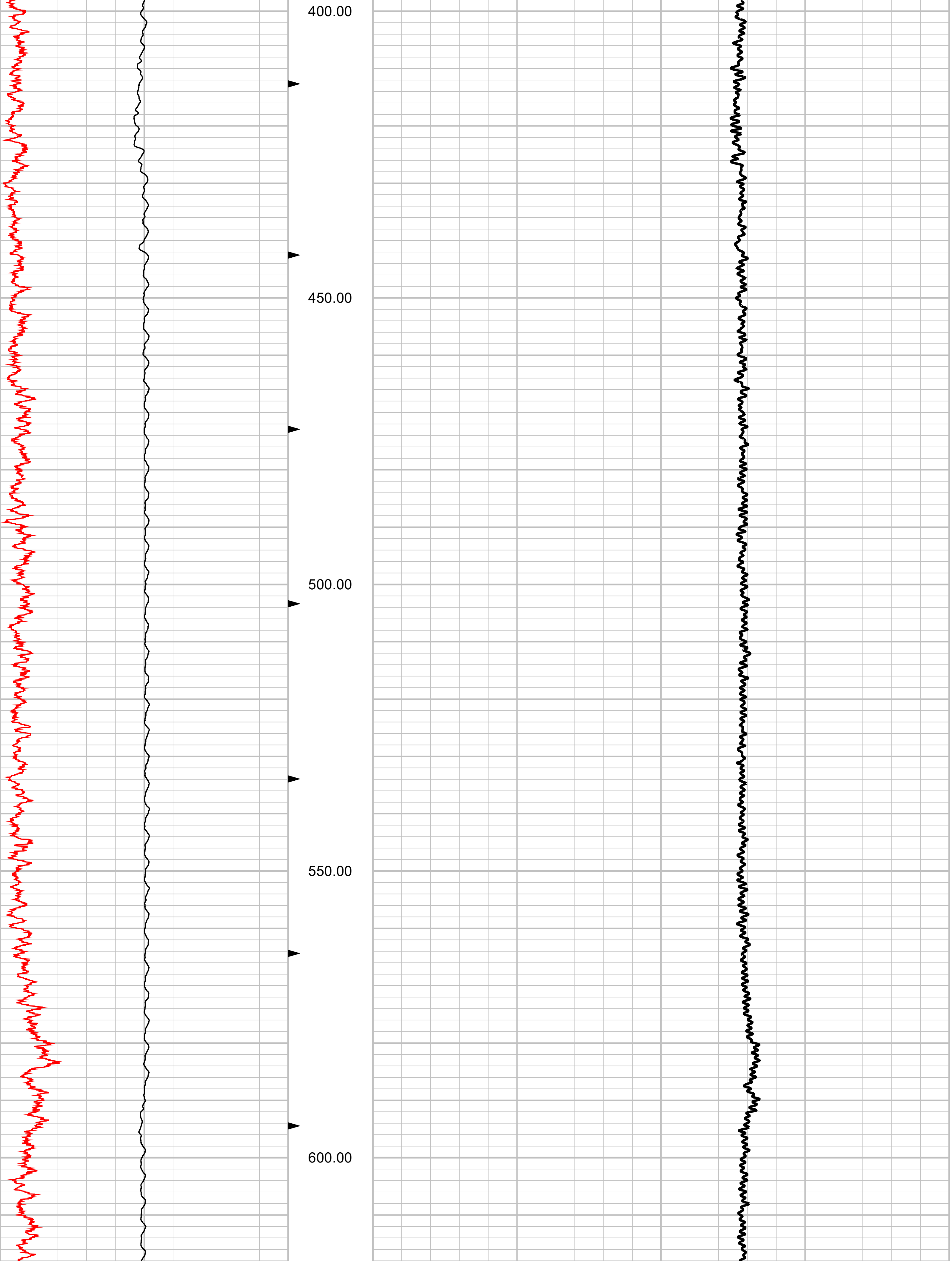
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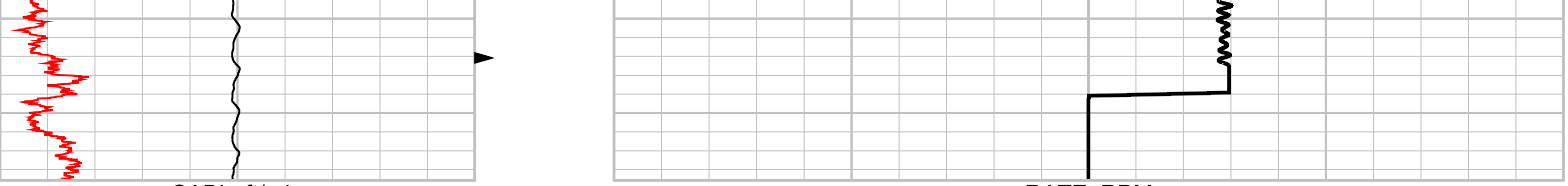

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NGAM CPS
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RATE RPM
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Depth: 637.00 ft   Date: 13 Dec 2019   Time: 08:49:16   File: "G:\RobMB\Documents\LOGGING DATA\OSF-64\OSF64 12-13 HRFM GAM DS.LOG"

CABL ft/min
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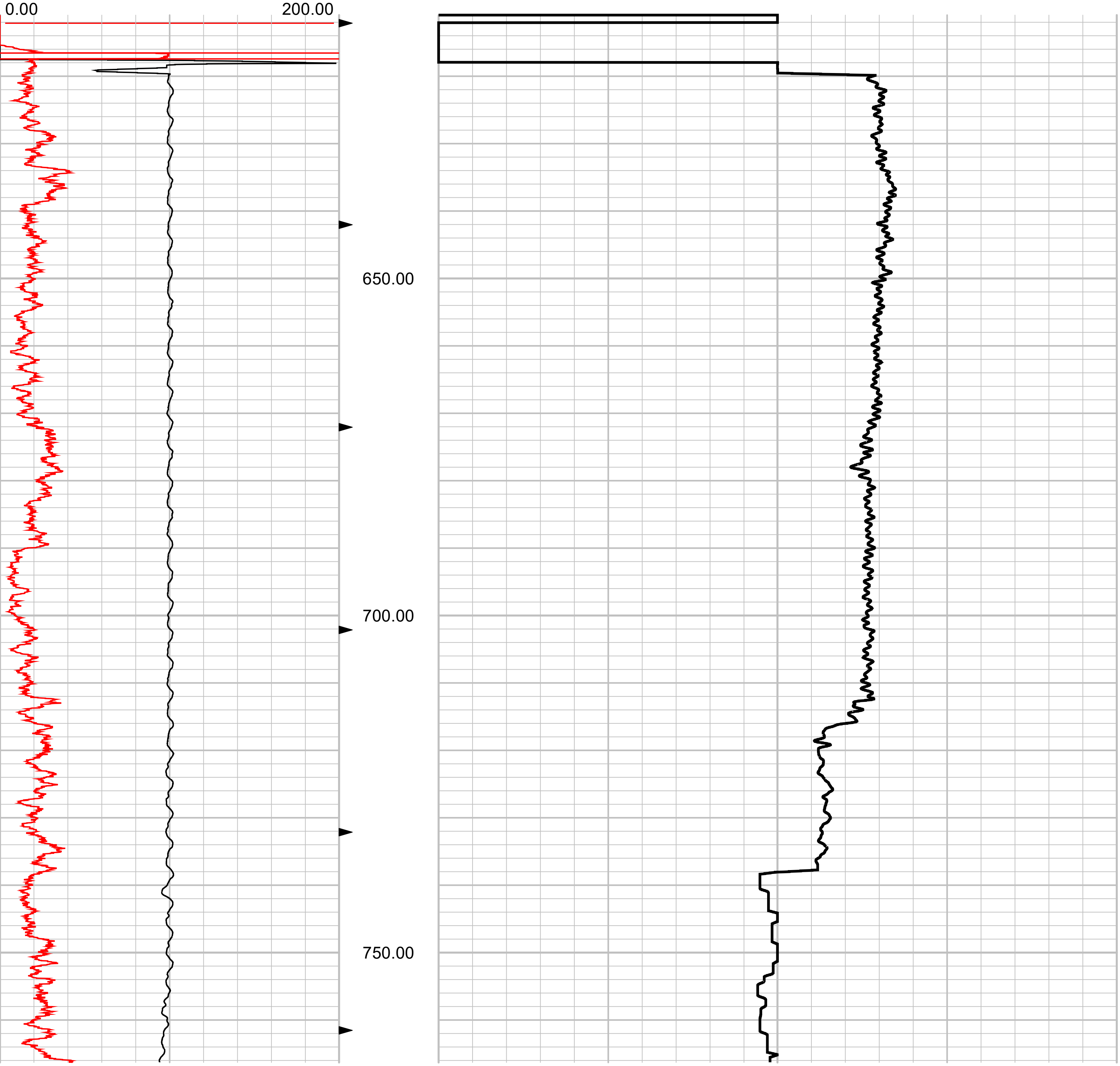
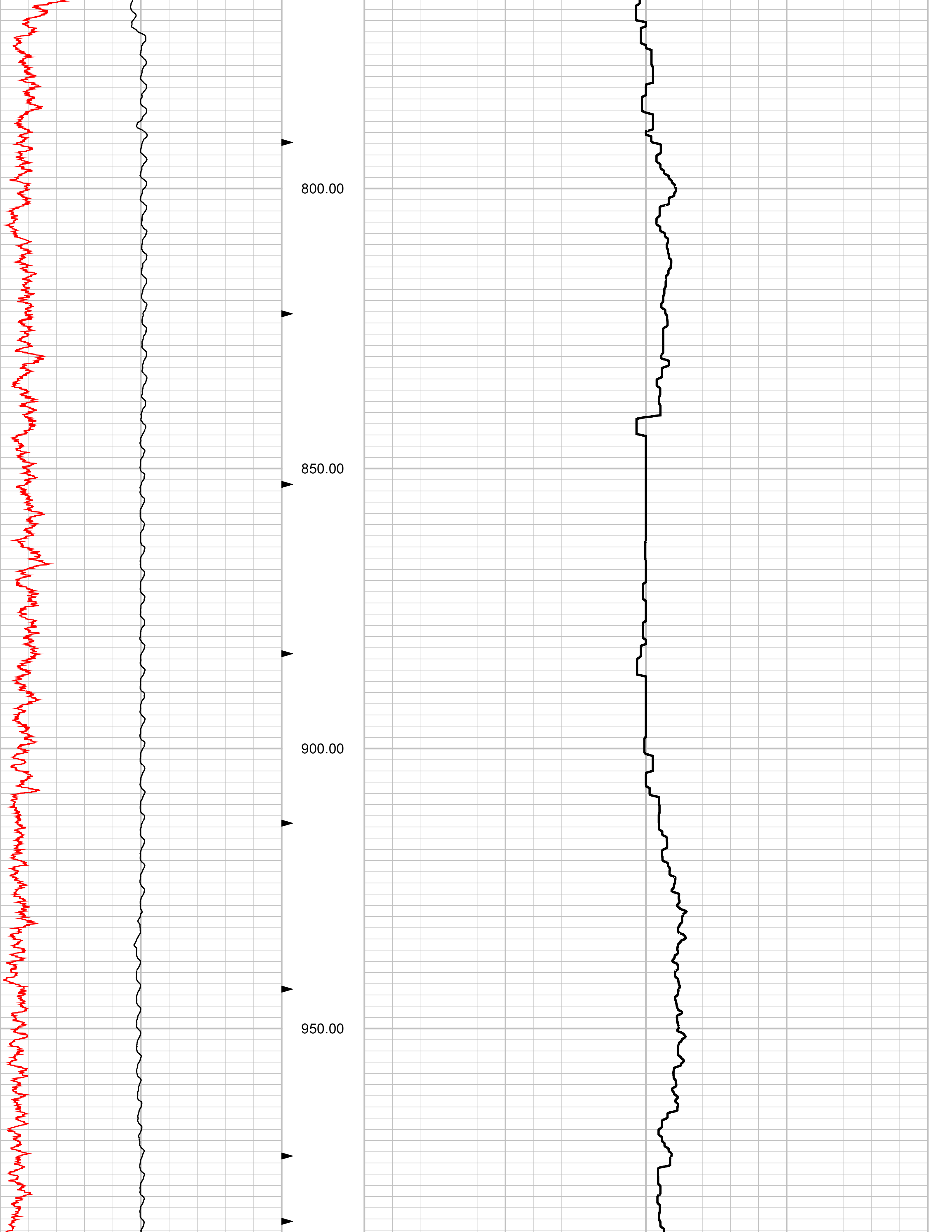
NGAM CPS
0.00 200.00

RATE RPM
-1000.00 1000.00

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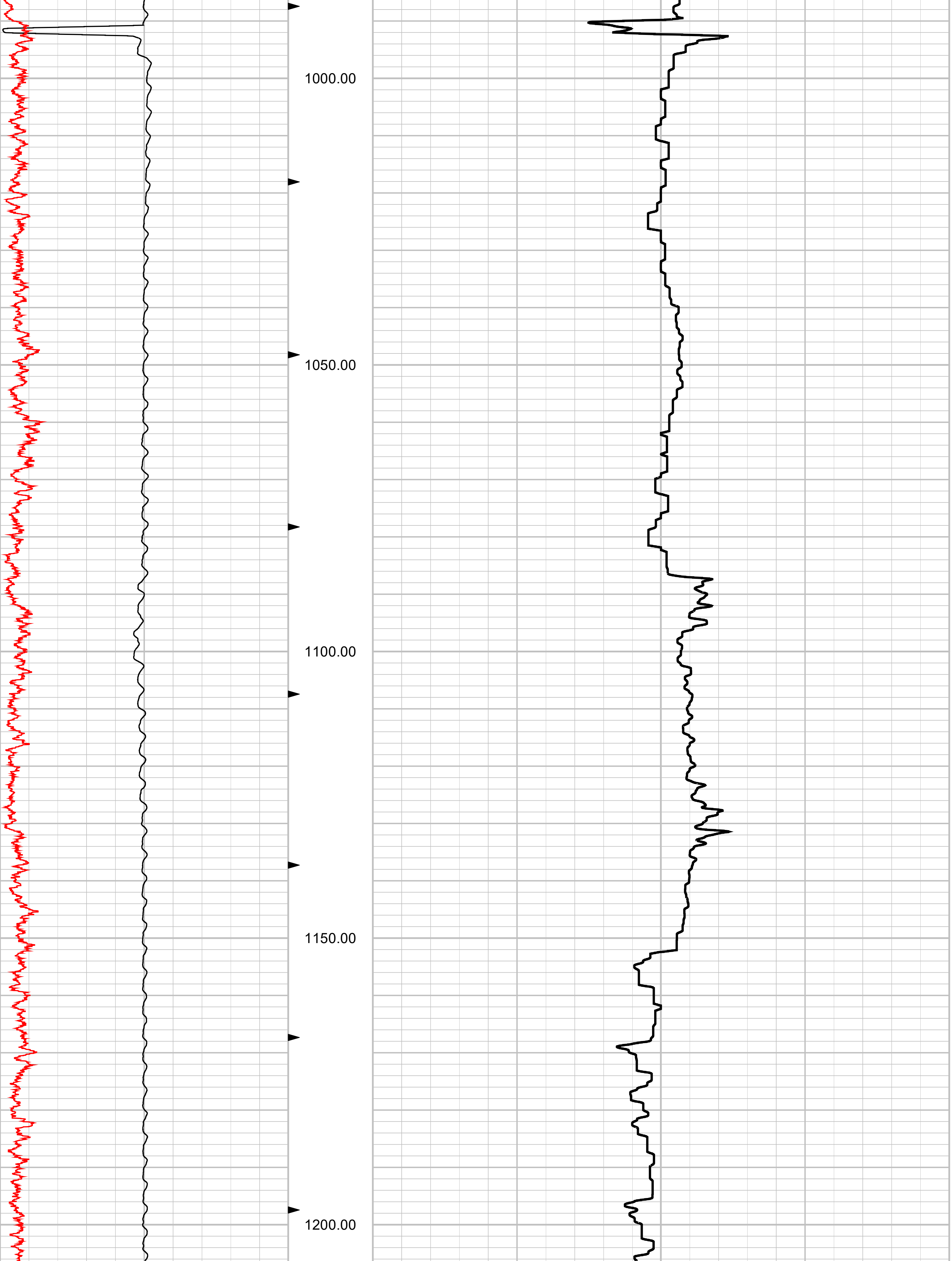
900.00
950.00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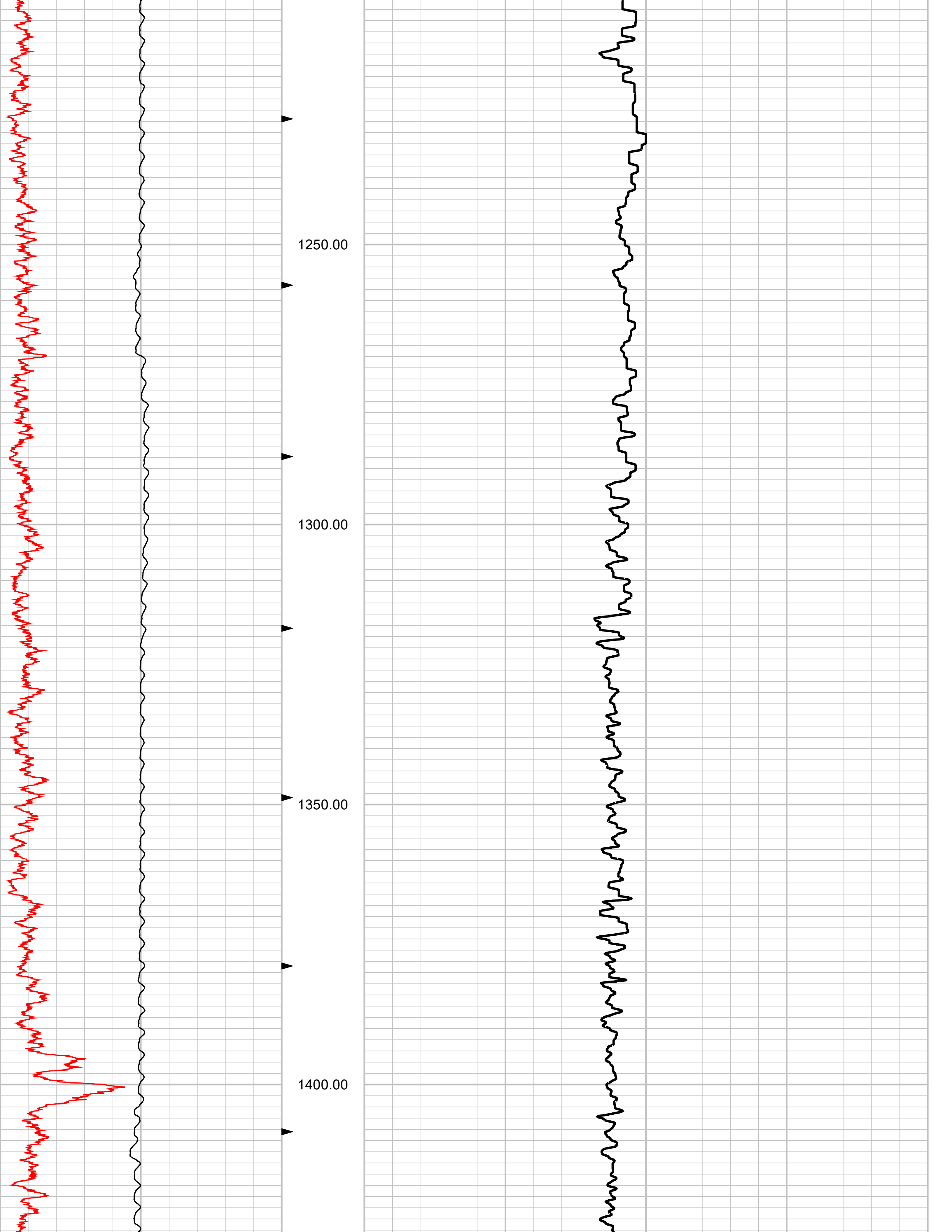
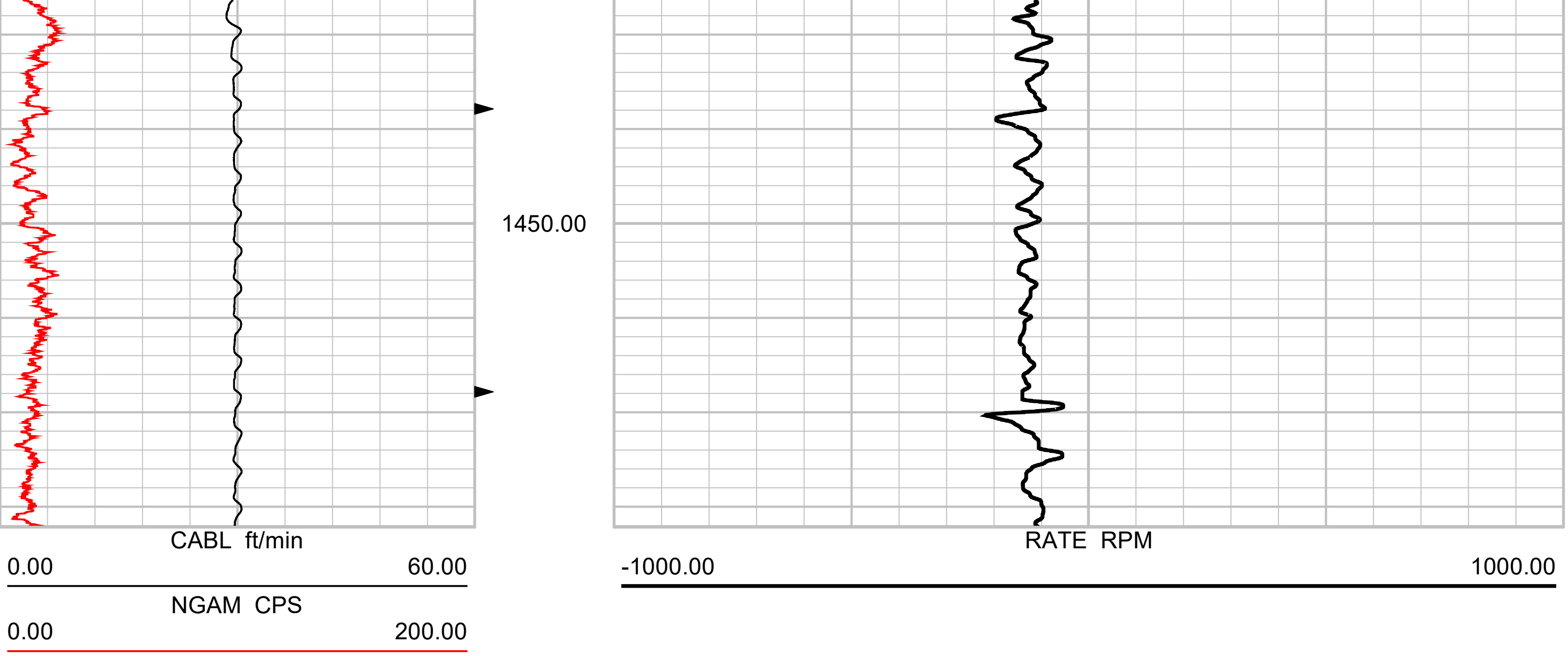
1200.00


1250.00
1300.00
1350.00
1400.00




Depth: 1482.00 ft Date: 13 Dec 2019 Time: 09:20:47 File: "G:\RobMB\Documents\LOGGING DATA\OSF-64\OSF64 12-13 HRFM GAM DS1.LOG"

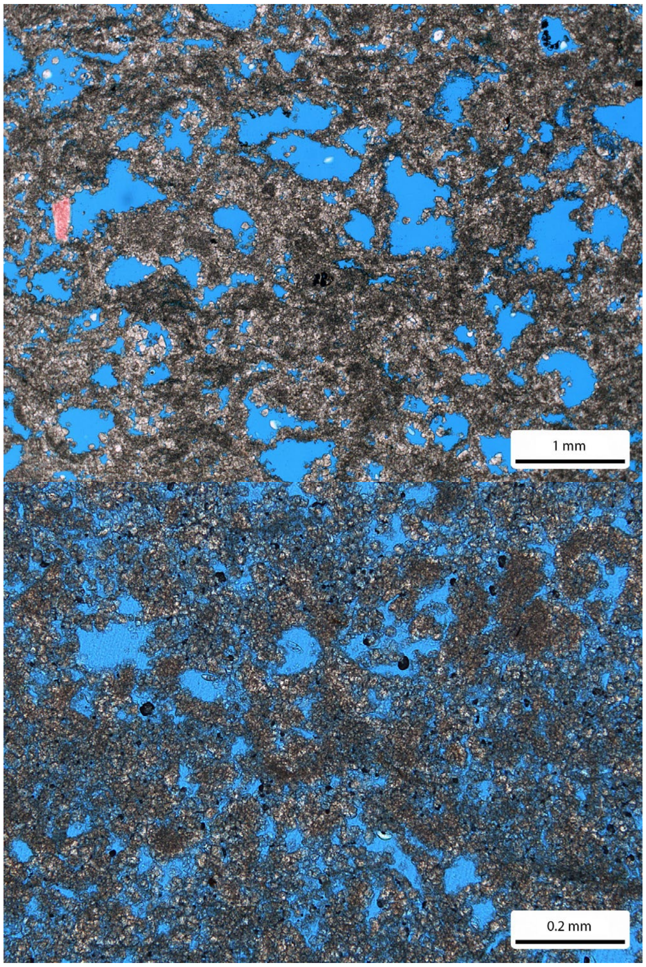
# APPENDIX G:
# CORE LABORATORY REPORTS

**PETROLEUM SERVICES**

# Core Analysis of OSF-64 BAR

## For

## South Florida Water Management District




**August 2020**

**Core Laboratories, Inc.**
**Houston Advanced Technology Center**
**6316 Windfern Road**
**Houston, Texas 77040**

**Houston ATC Job File No.: 2003255G**

**Core Laboratories**
6316 Windfern Road
Houston, Texas 77040
Tel: 713-328-2673
Fax: 713-328-2170
www.corelab.com

August 27th, 2020

Stacey Coonts, G.I.T.
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

**RE: Core Analysis of OSF-64 BAR**
**Houston Job #: 2003255G**

Dear Stacey Coonts,

This report presents the results of detailed thin section petrographic analysis performed on four (4) samples from the OSF-64 BAR Well. In Plates 1-4, the thin sections are described in detail and illustrated by representative photomicrographs. A 300-point modal analysis was also made of each thin section. In addition, XRD analysis and porosity & permeability measurements were conducted at seven (7) intervals (including the four analyzed samples - Tables 1 & 2). The objectives of this study are to determine the mineralogy, framework grain composition, authigenic mineralogy, pore types, textures, and reservoir quality of the cored intervals.

The samples examined in this study are all dolostones with a moderate to high porosity. XRD analysis indicates the cores consist of 97.3 wt.% to 99.0 wt.% dolomite, with very minor calcite and quartz. This result is consistent with the petrographic analysis. The thin section petrographic examination identifies one bioclastic dolowackestone (sample 1334.40 feet), one peloidal dolo-packstone (sample 1115.10 feet), and two bioclastic dolopackstones (samples 1297.40 feet & 1340.40 feet). Depositional textures and allochems are obscured to varying degrees by dolomite replacement and dissolution. The depositional textures of two samples (i.e. 1115.10 feet & 1340.40 feet) have been severely altered, and the abundance of allochems and matrix cannot be determined. The textures of two matrix-rich samples (i.e. 1297.40 feet & 1334.40 feet) are relatively well-preserved, although allochems have been commonly dissolved. Preserved allochems are minor and include silt- to pebble-sized, elongate to rounded peloids (Plates 1B & 3B), intraclasts, coral fragments, benthic foraminifers, pelecypods, gastropods, and undifferentiated skeletal grains (Plates 1A & 3A). Detrital quartz, organic matter, and clay are rare. The depositional environment of the cored interval is tentatively interpreted as a moderate energy, shallow marine environment (e.g. peritidal carbonate platform) based on very limited core data.

Authigenic minerals predominantly comprise anhedral to subhedral, very finely crystalline to finely crystalline dolomite. Aphanocrystalline dolomite is present in the matrix of samples 1297.40 feet and 1334.40 feet (Plates 2A & 3A), while relatively coarser, finely crystalline dolomite occurs as a late-stage, pore-filling cement (Plates 2B & 3B). Sample 1340.40 feet consists mostly of relatively coarser, finely crystalline dolomite, with two generations recognized; an early, inclusion-rich dolomite and a later, clear dolomite cement (Plate 4B). Authigenic calcite and pyrite are rare.

These dolostone samples show moderate to very high porosity and low to very high permeability. Core porosity ranges from 17.73% to 44.30%, while permeability (Kair) ranges from 0.194 md to 4235 md. The horizontal and vertical plugs from the same depth generally show similar porosity and permeability, while a rough positive correlation exists between porosity and permeability. The porosity of two samples from the point-count suite is somewhat lower compared to the measurements from plugs (possibly due to micropores). From thin section observations, the dolopackstone samples show higher porosities than the dolowackestone. Pore types include intercrystal, moldic, and vuggy. Sample 1115.10 feet features abundant intercrystal pores, with lesser amounts of moldic pores (Plate 1A & B). The other three samples contain common moldic pores with lesser amounts of vuggy and intercrystal pores (Plate 2A & 4B). Intraparticle pores are very minor. Partially filled, microfractures are observed in sample 1334.40 feet.

Thank you for choosing Core Laboratories to perform this study. Please feel free to contact us if you have any questions or comments concerning this report.

Sincerely,

Dr. Jie Zhou
Geologist, Petroleum Services
Core Laboratories
713-328-2665
jie.zhou@corelab.com

## ANALYTICAL PROCEDURES

### Thin Sections

Thin sections were prepared by first impregnating the samples with epoxy to augment cohesion and prevent loss of material during grinding. Blue dye was added to the epoxy to highlight the pore spaces. Each thinly sliced sample was mounted on a frosted glass slide and then cut and ground in oil to an approximate thickness of 30 microns and wedged. Selected thin sections were partially stained with alizarin red-S to differentiate calcite (stains red) from clear dolomite (does not stain) and potassium ferricyanide to identify ferroan dolomite (stains medium blue) and ferroan calcite (stains purple). In an effort to avoid sample damage, samples containing large amounts of clay minerals were not stained. Thin sections were analyzed using standard petrographic techniques. Photomicrographs are calibrated for on-screen viewing, and the high magnification views are within the low magnification images, unless otherwise noted.

# THIN SECTION PETROGRAPHY

**Company:** South Florida Water Management
**Well:** OSF-64 BAR
**Location:** Osceola County, Florida
**Job Number:** 2003255G

| | |
|---|---|
| **Depth (ft)** | 1115.10 |
| **Porosity (%)** | 44.30 |
| **Kair (md)** | 120.0 |
| **Klinkenberg (md)** | 105.0 |
| **Grain density (g/cc)** | 2.84 |

**Plate 1A**

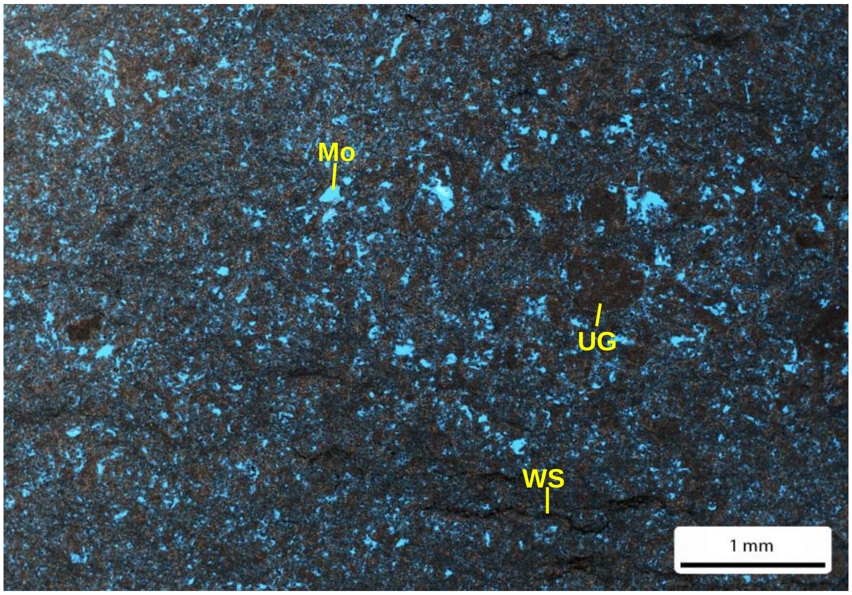
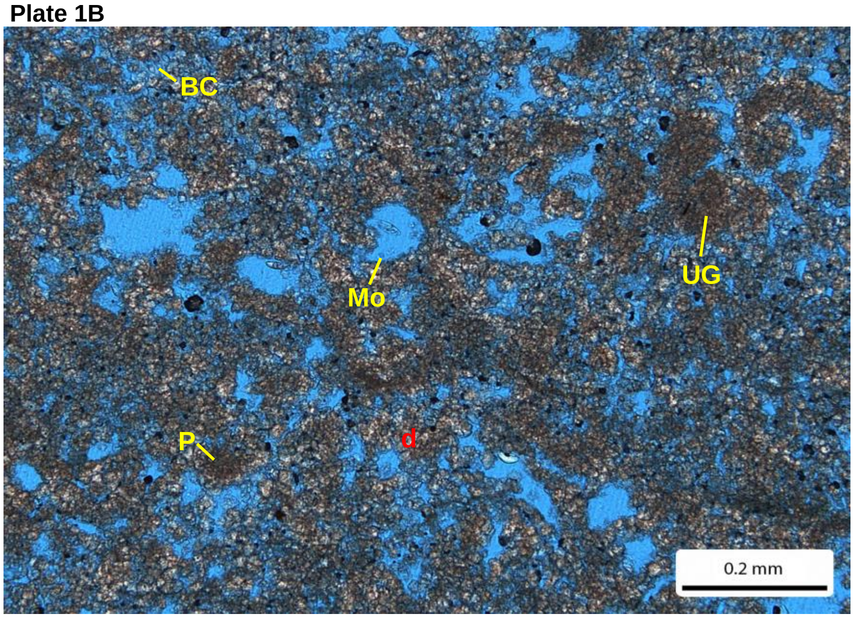



**Plate 1B**




| | |
|---|---|
| **Depositional texture** | |
| Lithology | Dolostone |
| Classification (Dunham) | Peloidal Dolopackstone |
| Average grain size (µm) | 150 |
| Average crystal size (µm) | 15 |
| **Framework grains** | Abundance (%) |
| Red Algae | |
| Benthic foraminifera | |
| Bryozoans | |
| Echinoderms | |
| Glauconite | |
| Intraclasts | |
| Mollusks | |
| Ooids / coated grains | |
| Ostracods | |
| Peloids | 5.2 |
| Phosphatic fragments | 2.4 |
| Planktonic foraminifera | |
| Undiff. skeletal fragments | |
| Organic matter | |
| **Authigenic minerals** | |
| Calcite | |
| Dolomite | 64.4 |
| Gypsum/Anhydrite | |
| Pyrite | |
| Silica | |
| Celestine | |
| **Matrix** | |
| Micrite/microspar | |
| Dolomicrite | |
| Clay | |
| **Pore types** | |
| Primary Interparticle | |
| Primary intraparticle | |
| Secondary Intraparticle | 0.4 |
| Intercrystal pores | 20.8 |
| Moldic | 6.4 |
| Vugs | |
| Fractures | |

**Petrographic description**

This sample has been extensively replaced by anhedral to subhedral, very finely crystalline, dolomite (d) with a significant amount of open pores. The depositional texture is obscured by dolomite replacement and dissolution. Preserved allochems include peloids (p) and undifferentiated skeletal grains (UG). Trace amounts of detrital quartz, clay, organic matter, and pyrite are present. Pore types include intercrystal (BC) and moldic (Mo). Intraparticle pores are very minor. Discontinuous wispy seams (WS) and induced microfractures are observed.

Core Lab
RESERVOIR OPTIMIZATION

**Trace/Rare (<1%)**
**Minor (1-5%)**
**Moderate (5-10%)**
**Common (10-20%)**
**Abundant (>20%)**

# THIN SECTION PETROGRAPHY

**Company:** South Florida Water Management
**Well:** OSF-64 BAR
**Location:** Osceola County, Florida
**Job Number:** 2003255G

| | |
|---|---|
| **Depth (ft)** | 1297.40 |
| **Porosity (%)** | 17.73 |
| **Kair (md)** | 0.63 |
| **Klinkenberg (md)** | 0.51 |
| **Grain density (g/cc)** | 2.85 |

**Plate 2A**

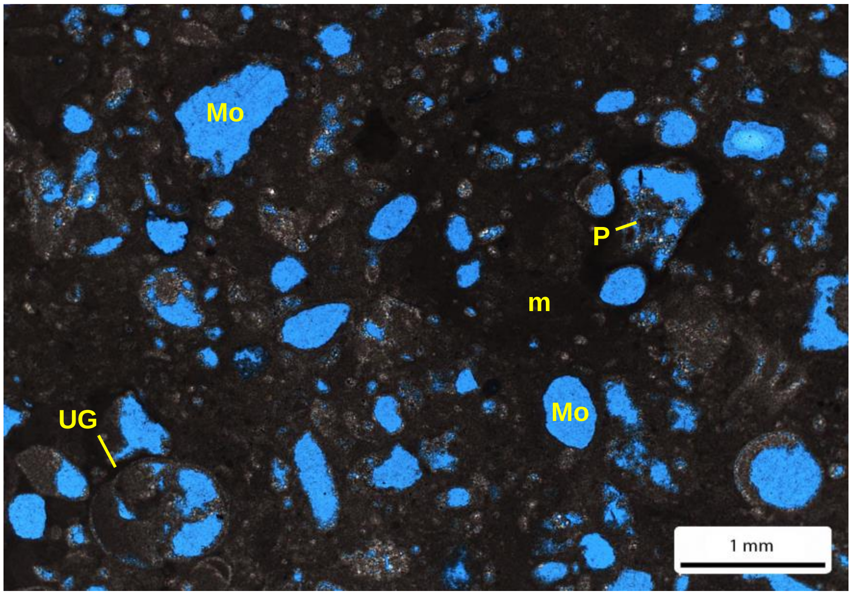
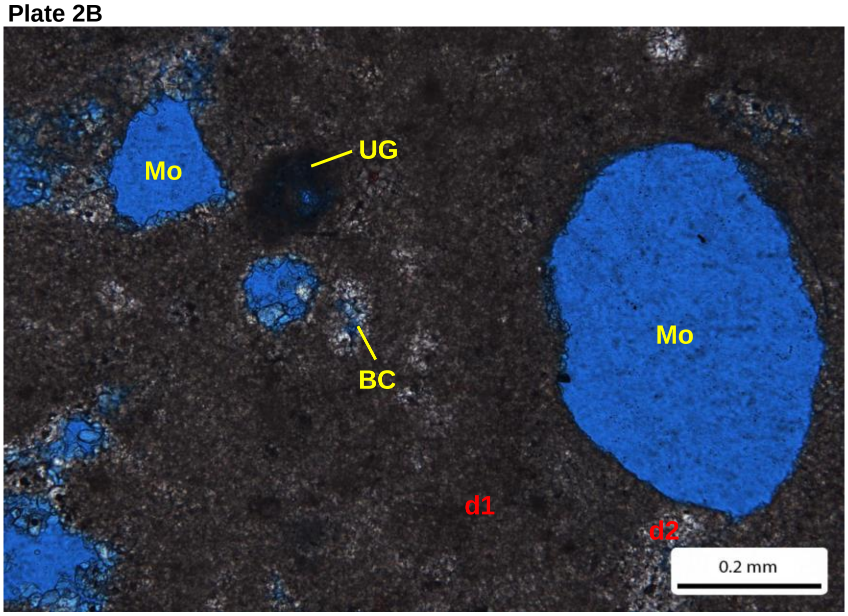



**Plate 2B**




| | |
|---|---|
| **Depositional texture** | |
| Lithology | Dolostone |
| Classification (Dunham) | Bioclastic Dolopackstone |
| Average grain size (µm) | 700 |
| Average crystal size (µm) | 12 |
| **Framework grains** | Abundance (%) |
| Red Algae | |
| Benthic foraminifera | |
| Bryozoans | |
| Echinoderms | |
| Glauconite | |
| Intraclasts | 1.6 |
| Mollusks | |
| Ooids / coated grains | |
| Ostracods | |
| Peloids | 0.8 |
| Phosphatic fragments | |
| Planktonic foraminifera | |
| Undiff. skeletal fragments | 7.2 |
| Organic matter | |
| **Authigenic minerals** | |
| Calcite | |
| Dolomite | 74.0 |
| Gypsum/Anhydrite | |
| Pyrite | |
| Silica | |
| Celestine | |
| **Matrix** | |
| Micrite/microspar | |
| Dolomicrite | |
| Clay | |
| **Pore types** | |
| Primary Interparticle | |
| Primary intraparticle | |
| Secondary Intraparticle | |
| Intercrystal pores | 2.0 |
| Moldic | 14.0 |
| Vugs | |
| Fractures | |

**Petrographic description**

This sample has been extensively replaced by anhedral to subhedral, very finely crystalline dolomite, with common open pores. The depositional texture is relatively well-preserved, although allochems have mostly been dissolved during dolomite replacement. Preserved allochems include silt- to pebble-sized, subangular to rounded intraclasts, benthic foraminifers, coral fragments, peloids (p), and undifferentiated skeletal grains (UG). The common matrix (m) consists of aphanocrystalline to very finely crystalline dolomite (d1). Relatively coarser, finely crystalline dolomite (d2) occurs as a late stage, pore-filling cement. Trace calcite is present. Pore types are predominantly moldic (Mo), with minor intercrystal pores (BC). Intraparticle and vuggy pores also exist.

Core Lab
RESERVOIR OPTIMIZATION

**Trace/Rare (<1%)**
**Minor (1-5%)**
**Moderate (5-10%)**
**Common (10-20%)**
**Abundant (>20%)**

# THIN SECTION PETROGRAPHY

| | |
|---|---|
| **Company:** | **South Florida Water Management** |
| **Well:** | **OSF-64 BAR** |
| **Location:** | **Osceola County, Florida** |
| **Job Number:** | **2003255G** |

| | |
|---|---|
| **Depth (ft)** | 1334.40 |
| **Porosity (%)** | N/A |
| **Vertical Kair (md)** | N/A |
| **Maximum Kair (md)** | N/A |
| **Grain density (g/cc)** | N/A |

**Plate 3A**

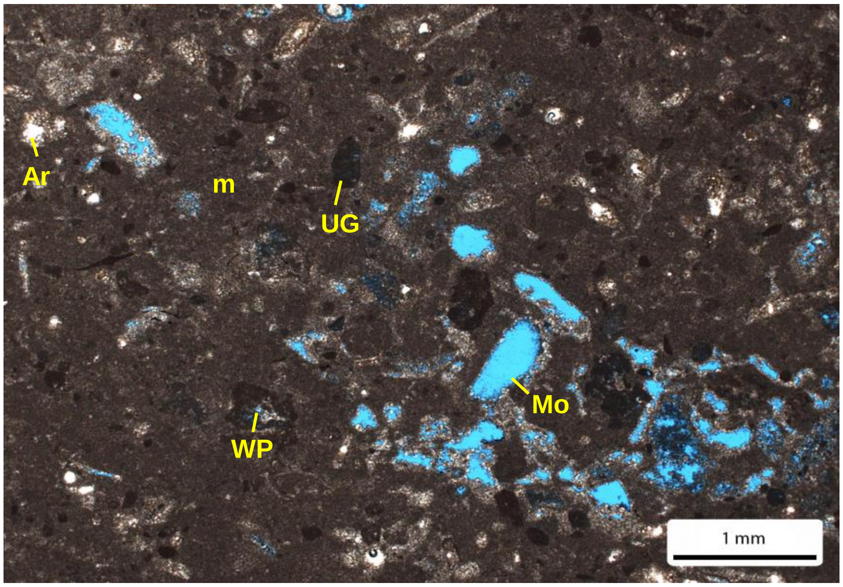
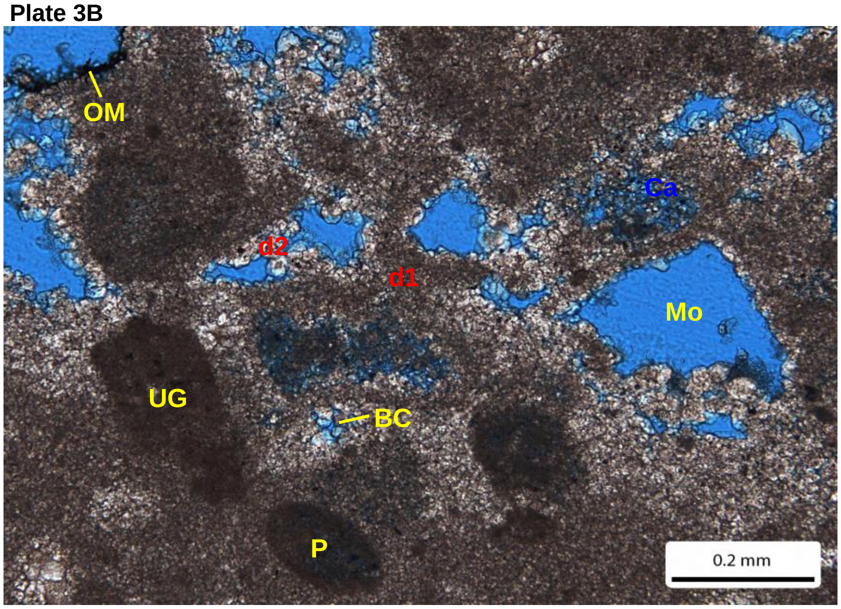



**Plate 3B**




| | |
|---|---|
| **Depositional texture** | |
| Lithology | Dolostone |
| Classification (Dunham) | Bioclastic dolowackestone |
| Average grain size (µm) | 400 |
| Average crystal size (µm) | 12 |
| **Framework grains** | Abundance (%) |
| Algae | |
| Benthic foraminifera | |
| Bryozoans | |
| Echinoderms | |
| Glauconite | |
| Intraclasts | |
| Mollusks | |
| Ooids / coated grains | |
| Ostracods | |
| Peloids | 3.2 |
| Phosphatic fragments | |
| Planktonic foraminifera | |
| Undiff. skeletal fragments | 2.0 |
| Organic matter | |
| **Authigenic minerals** | |
| Calcite | |
| Dolomite | 83.2 |
| Gypsum/Anhydrite | |
| Pyrite | |
| Silica | |
| Celestine | |
| **Matrix** | |
| Micrite/microspar | |
| Dolomicrite | |
| Clay | |
| **Pore types** | |
| Primary Interparticle | |
| Primary intraparticle | |
| Secondary Intraparticle | |
| Intercrystal pores | 2.8 |
| Moldic | 4.8 |
| Vugs | 4.0 |
| Fractures | |

**Petrographic description**

This sample has been extensively replaced by anhedral to subhedral, very finely crystalline dolomite, with relatively common open pores. The depositional texture is relatively well-preserved, although allochems have commonly been dissolved during dolomite replacement. Preserved allochems include pelecypods, benthic foraminifers, gastropods, peloids (p), and undifferentiated skeletal grains (UG). The matrix (m) is abundant and consists of aphanocrystalline to very finely crystalline dolomite (d1). Relatively coarser, finely crystalline dolomite (d2) occurs as a late stage, pore-filling cement. Trace pyrite, organic matter (OM), and calcite are present. Pore types include moldic (Mo), vuggy, and intercrystal (BC). Microfractures and artifacts (Ar - trapped air bubbles) are noted.

Core Lab
RESERVOIR OPTIMIZATION

**Trace/Rare (<1%)**
**Minor (1-5%)**
**Moderate (5-10%)**
**Common (10-20%)**
**Abundant (>20%)**

# THIN SECTION PETROGRAPHY

| | |
|---|---|
| **Company:** | **South Florida Water Management** |
| **Well:** | **OSF-64 BAR** |
| **Location:** | **Osceola County, Florida** |
| **Job Number:** | **2003255G** |

| | |
|---|---|
| **Depth (ft)** | 1340.40 |
| **Porosity (%)** | N/A |
| **Vertical Kair (md)** | N/A |
| **Maximum Kair (md)** | N/A |
| **Grain density (g/cc)** | N/A |

**Plate 4A**

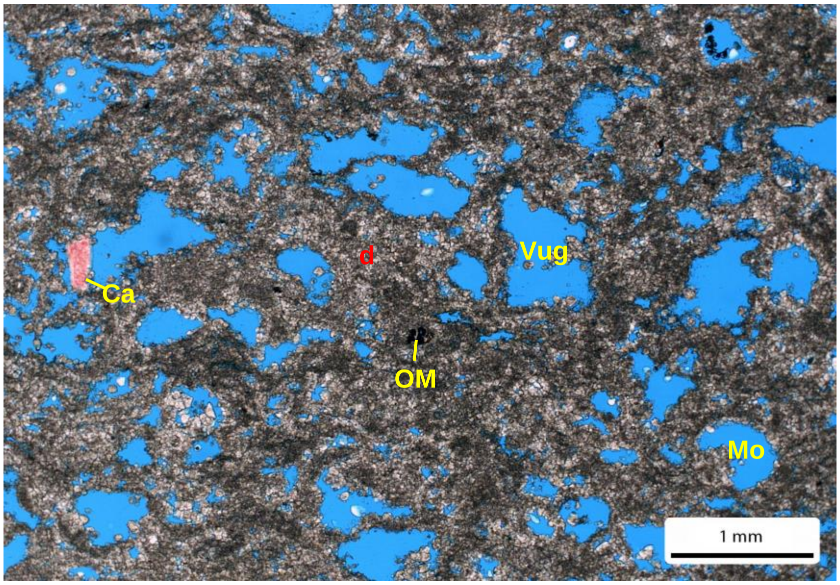
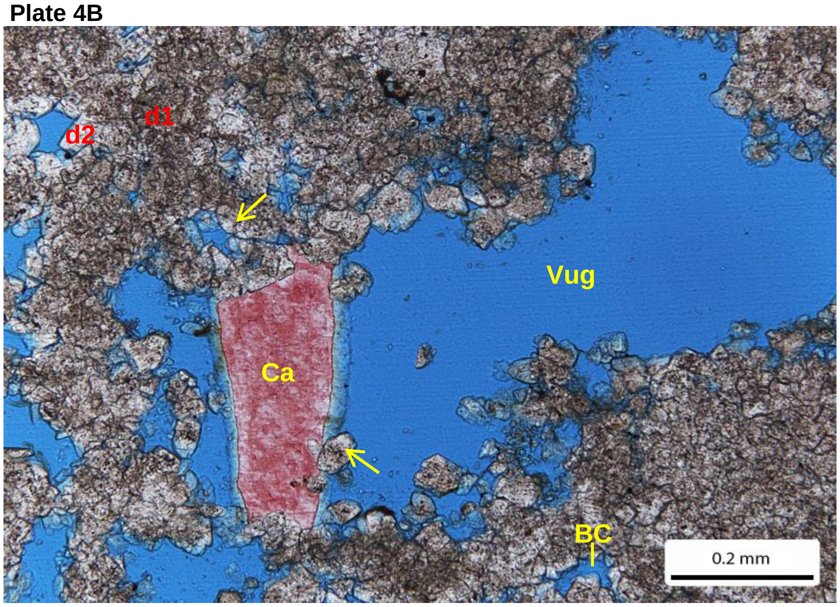



**Plate 4B**




| | |
|---|---|
| **Depositional texture** | |
| Lithology | Dolostone |
| Classification (Dunham) | Bioclastic Dolopackstone |
| Average grain size (µm) | 900 |
| Average crystal size (µm) | 30 |
| **Framework grains** | Abundance (%) |
| Red Algae | |
| Benthic foraminifera | |
| Bryozoans | |
| Echinoderms | |
| Glauconite | |
| Intraclasts | |
| Mollusks | |
| Ooids / coated grains | |
| Ostracods | |
| Peloids | 0.4 |
| Phosphatic fragments | |
| Planktonic foraminifera | |
| Undiff. skeletal fragments | 0.8 |
| Organic matter | |
| **Authigenic minerals** | |
| Calcite | |
| Dolomite | 64.8 |
| Gypsum/Anhydrite | |
| Pyrite | |
| Silica | |
| Celestine | |
| **Matrix** | |
| Micrite/microspar | |
| Dolomicrite | |
| Clay | |
| **Pore types** | |
| Primary Interparticle | |
| Primary intraparticle | |
| Secondary Intraparticle | |
| Intercrystal pores | 7.2 |
| Moldic | 14.8 |
| Vugs | 12 |
| Fractures | |

**Petrographic description**

This sample has been extensively replaced by anhedral to subhedral, finely crystalline dolomite, with a significant amount of open pores. The depositional texture is obscured by dolomite replacement and dissolution. Very minor allochems including peloids (p) and undifferentiated ghost grains are observed locally. Rare organic matter (OM) and pyrite are noted. Two generations of dolomite are recognized, including an early, inclusion-rich dolomite (d1), and a relatively late, clear dolomite (d2). Some dolomite crystals show cloudy cores and clear over-growths (yellow arrows). Trace calcite (Ca) occurs as a very late-stage, pore-occluding cement. Pore types include moldic (Mo), vuggy (Vug), and intercrystal (BC).

Core Lab
RESERVOIR OPTIMIZATION

**Trace/Rare (<1%)**
**Minor (1-5%)**
**Moderate (5-10%)**
**Common (10-20%)**
**Abundant (>20%)**

## Mineralogy Determined by X-ray Diffraction



| | Whole Rock Mineralogy (Weight %) | | | | | |
|---|---|---|---|---|---|---|
| Depth | Quartz | Calcite | Dolomite & Fe-Dolomite | Celestine | Pyrite | Total Clay |
| 1271.60 | 1.0 | 0.0 | 99.0 | 0.0 | 0.0 | 0.0 |
| 1275.00 | 0.5 | 0.0 | 99.5 | 0.0 | 0.0 | 0.0 |
| 1279.00 | 0.4 | 0.0 | 99.6 | 0.0 | 0.0 | 0.0 |
| 1417.70 | 0.8 | 1.9 | 97.3 | 0.0 | 0.0 | 0.0 |
| 1271.60 Crystal | 0 | 0 | 19.4 | 80.6 | 0.0 | 0.0 |

**South Florida Water Management**
OSF-64 BAR
Osceola County, Florida

CL File No: 202003255
Date: 11-Aug-2020

## Table 2 CMS-300 CONVENTIONAL PLUG ANALYSIS

| H & V Plug Pairs | Sample Number | Depth (ft) | Net Confining Stress (psig) | Porosity (%) | Permeability (md) Klinkenberg | Permeability (md) Kair | b(air) psi | Beta ft(-1) | Alpha (microns) | Grain Density (g/cm3) | Footnote |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2H | 977.70 | 800 | 26.69 | 85.0 | 96.4 | 2.29 | 4.21E+08 | 1.16E+02 | 2.835 | (6) |
| | 2V | 977.70 - 978.00 | 800 | 29.25 | 13.4 | 15.7 | 3.27 | 3.93E+09 | 1.68E+02 | 2.840 | (6) |
| 2 | 3H | 1115.10 | 800 | 44.30 | 105 | 120 | 2.34 | 6.46E+06 | 2.19E+00 | 2.841 | (1) |
| | 3V | 1115.10 - 1115.25 | 800 | 43.70 | 109 | 125 | 2.47 | 4.50E+06 | 1.58E+00 | 2.846 | (1) |
| 3 | 5H | 1274.90 | 800 | 26.96 | 3.10 | 4.45 | 8.96 | 1.57E+08 | 1.55E+00 | 2.836 | (1),(3) |
| | 4V | 1274.90 - 1275.20 | 800 | 29.13 | 4.93 | 6.91 | 7.95 | 3.30E+08 | 5.20E+00 | 2.840 | (1) |
| 4 | 6H | 1279.00 | 800 | 35.41 | 5.15 | 7.46 | 8.91 | 1.51E+09 | 2.50E+01 | 2.823 | (1),(6) |
| | 5V | 1279.00 - 1279.30 | 800 | 39.73 | 15.8 | 21.0 | 6.10 | 2.53E+08 | 1.29E+01 | 2.846 | (1),(3),(6) |
| 5 | 7H | 1297.40 | 800 | 17.73 | .510 | .630 | 5.38 | 2.47E+11 | 4.05E+02 | 2.848 | (6) |
| | 6V | 1297.40 - 1297.70 | 800 | 19.56 | .088 | .194 | 30.69 | 8.06E+11 | 2.32E+02 | 2.845 | (6) |
| 6 | 10H | 1417.70 | 800 | 35.20 | 2048 | 2079 | 0.23 | 1.29E+06 | 8.54E+00 | 2.796 | (6) |
| | 7V | 1417.70 - 1418.00 | 800 | 38.24 | 4101 | 4235 | 0.48 | 4.84E+05 | 6.44E+00 | 2.788 | (6) |
| 7 | 8V | 1481.25 - 1481.85 | 800 | 23.77 | 691 | 712 | 0.47 | 2.03E+07 | 4.54E+01 | 2.802 | (6) |
| | 11H | 1481.80 | 800 | 23.75 | 4223 | 4650 | 1.51 | 4.67E+06 | 6.38E+01 | 2.802 | (6) |

Footnotes :

(1) : Denotes fractured or chipped sample. Permeability and/or porosity may be optimistic.

(3) : Denotes very short sample, porosity may be optimistic due to lack of conformation of boot material to plug surface.

(6) : Denotes sample contains vugs.

Permeability greater than 0.1 mD measured using helium gas. Permeability less than 0.1 mD measured using nitrogen gas. All b values converted to b (air)