GEOLOGY REPORT
DOCKUM WELL SR-1
CITY OF SEMINOLE
GAINES COUNTY, TEXAS

Prepared for:

Ken Rainwater, Ph.D., P.E., BCEE
Director, Water Resources Center
Texas Tech University
Lubbock, Texas

August 2011

Cirrus Associates, LLC™

Project No. 02-013600.01

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Date

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Executive Summary

The Dockum well SR-1 was drilled in the City of Seminole well field from June 21 through July 8, 2011. The Dockum Group of sediments underlies the Tertiary Ogallala and Cretaceous formations, which are the principal water bearing formations in Gaines County, i.e., the Ogallala and the Trinity-Edwards (High Plains) aquifers. Because water is mined at an unsustainable rate in the Ogallala and Trinity-Edwards (High Plains) aquifers, a deep well was installed to evaluate the water bearing zones in the Dockum sediments as potential sources of municipal water supply.

Cirrus Associates, LLC provided geologic services, including preparation of a geologic log based on examination of drill cuttings collected at 10 foot intervals during well placement, evaluation of geophysical logs, and provides this report of findings.

Findings

Based on evaluation of the geologic log developed from cuttings collected at 10 ft. intervals and on the two geophysical logs (gamma ray and compensated neutron density), the recommendation was made to perforate the well in three zones, from 540 ft. to 650 ft., from 890 ft. to 920 ft., and from 1,610 ft. to 1,770 ft.

The Dockum Group at this location consists of porous and permeable zones (including sandstones, siltstones, conglomerates, and gravels) that are interbedded with clays and mudstone/claystone. Thick sections of low permeability sediments, e.g., clay, claystone, mudstone, are the predominant lithology in the borehole.

During drilling, the driller observed that the best water bearing zone was the shallow zone at approximately 583 ft to 651 ft. bgs. Based on the driller's observations and subsequent evaluation of cuttings, the most prolific aquifer zone is anticipated to be in the upper portion of the Dockum sediments. This zone is comprised of sandstone and/or gravel that is interbedded with clay, claystone, and mudstone. This water bearing zone is interpreted as the lowermost section of the Cooper Canyon Formation. The Trujillo Formation consists of an upward fining sequence of silts and siltstones interbedded with clay that is overlain by clay, claystone and mudstone. A potential water bearing zone was observed in the interval from 890 ft. to 920 ft. The Tecovas Formation consists of a thick section of interbedded clay, claystone, mudstone and siltstone and is considered an aquiclude. The Santa Rosa Formation consists of alternating beds siltstone and sandstone (thin beds) with clay, claystone and mudstone. Permeability may be within the thin siltstone and sandstone beds or may be along the bedding planes, particularly in the interval from 1654 ft. to 1730 ft.

Recommendations

Drilling took twelve days and was interrupted by the Fourth of July holiday weekend and prolonged by equipment problems. The amount of hole that was drilled each day decreased as the hole was drilled deeper. The primary reason for this was because all drill pipe was tripped out of the hole at the end of each day so that the downhole equipment would not be lost due to potential overnight collapse of the hole. Each morning the drill pipe would have to be placed back in the hole. Tripping in and out of the hole each morning and evening took longer and longer each day, resulting in progressively lesser amounts of drilled hole each day. It is recommended that future deep Santa Rosa wells be drilled continuously from start to total depth of the hole, i.e., drill 24 hours per day, 7 days per week from start to finish.

It appeared that the major water bearing zone occurred in the upper Dockum. However, because there is potential for contribution of yield from other zones, hydraulic testing should be conducted to determine the contribution from each zone and discreet water samples should be collect to determine the quality of water in each zone.

Because of the paucity of geologic and geophysical data in the Dockum sediments that underlie the Southern High Plains, it is recommended that drilling data be captured to provide a better geologic and hydrogeologic understanding Dockum Group sediments during future placement of deep wells. This includes preparation of geologic logs, running appropriate suites of geophysical logs, collection of well yield and water quality data, and data analyses.

Section 1.0
Scope of Work and Limitations

1.1 Scope of Work

The scope of work for this project consisted of the following activities:

1. Provide field geological services during well placement, including preparation of a geologic log and collection of cuttings at 10 ft. intervals;

2. Evaluate the geophysical logs and provide recommendations for well completion; and

3. Prepare a summary report.

1.2 Limitations

This assessment is a limited evaluation of subsurface conditions based on compilation of data listed in Section 1.1. The work performed is considered to be a reasonable assessment in accordance with industry standards.

Section 2.0
Regional Geology and Hydrogeology

2.1 Regional Geology

The City of Seminole well SR-1 is located within the Southern High Plains physiographic province. The Southern High Plains province is characterized by broad, nearly flat topography with ephemeral streams, draws, and numerous playa lake basins. Surface sediments typically consist of sand, silt, clay, gravel, and caliche of Quaternary or Tertiary age, (Tertiary Miocene-Pliocene Ogallala and Quaternary Holocene Blackwater Draw formations). Underlying the Ogallala Formation are Cretaceous aged sediments (which pinch out in the southern part of Gaines County) and/or Triassic sediments. Triassic sediments were deposited in a basinal depositional environment that developed on the Paleozoic landscape as a result of the breakup of the super-continent Pangea. Gaines County is located near the center of the basin along the north-south trending axis of the basin. Due to its location near the center of the basin, Dockum sediments in Gaines County are thicker and deeper than the marginal areas of the basin, where thinning occurs.

Table 1 illustrates the stratigraphy on the Southern High Plains.

2.2 Regional Hydrogeology

The principal aquifers underlying the southern portion of the Southern High Plains are the Ogallala aquifer and the Edwards-Trinity (High Plains) aquifer. These aquifers are often grouped together and collectively referred to as the High Plains aquifer. One reason these aquifers are grouped together as a single unit, is because it is difficult to differentiate between the two units based on driller's logs, oftentimes the only source of stratigraphic information.

Underlying the High Plains aquifer in this part of Texas are sediments of Triassic age called the Dockum Group. The Dockum Group is broken down into four formations which are from youngest to oldest: the Cooper Canyon, Trujillo, Tecovas, and Santa Rosa formations. Typically, the best potential water bearing zone occurs in the Santa Rosa Formation; however, water may occur in the Trujillo Formation, and less frequently in the Cooper Canyon Formation. The Tecovas Formation is considered a non-water bearing zone or aquiclude.

The Ogallala aquifer is classified a major aquifer; whereas both the Edwards-Trinity (High Plains) and the Dockum aquifers are classified as minor aquifers in the State of Texas. Minor aquifers in Texas are water bearing zones that typically do not produce large quantities of water, are unable to sustain yield to wells, or produce water of poor quality.

Section 3.0
Well Placement of SR-1

3.1 Well Location

The location of well SR-1 is southwest of Seminole in Gaines County, Texas in a City of Seminole well field. The latitude and longitude is 32º 41' 06.415"N, 102º 40' 0.727"W; elevation is 3300' above mean sea level[1].

The well is located in the upper reaches of the Colorado River Basin between Wordswell and Seminole draws. Seminole Draw joins Monument Draw to the south in Andrews County and eventually becomes Mustang Creek. The well is situated on a pad on the southeast side of an irrigated circle which was planted with rye at the time of drilling. Figure 1 shows the location of SR-1.

3.2 Well Placement Chronology

Table 2 provides the chronology of drilling activities for advancement and installation of SR-1.

3.3 Stratigraphy Based on Soil Cuttings and Geophysical Logs

3.3.1 Quaternary. A red brown silty sand was observed in the mud pit from 0 to 6 ft. This silty sand was underlain by the Ogallala caprock caliche. Flower pot structures, a term used to describe the large bulbous protrusions of red brown sand incised into the top of the caliche, appear to be areas of eroded caprock that were subsequently infilled by Quaternary eolian sand and silt.

3.3.2 Tertiary Ogallala Formation. The Ogallala Formation was observed from 6 ft. to approximately 129 ft. bgs. As typical of the uppermost Ogallala Formation, caprock caliche was observed from 6 ft. to 39 ft. and underlain by sandstone and siltstone. Several thin beds of calcrete are interbedded in the sandstone/siltstone sediments.

3.3.3 Cretaceous. From 129 ft. to 174 ft. a section of siltstone and conglomerate was observed. Based on a change in color, the appearance of shale and limestone, and the thickness of the section, this strata represents either Cretaceous-aged sediments or eroded Cretaceous sediments that were redeposited at a later time.

[1] GPS location provided by West Texas Water Well Service

Based on field observations, the upper part of the section may be Duck Creek Formation sediments (limestone and yellow shale) and the lower part of the section may be Antlers Formation sediments (conglomerate).

It should be noted that most generalized subsurface maps of West Texas indicate that Cretaceous-aged sediments are present in the northern portion of Gaines County, but absent in the southern portion of the county. Observed cuttings from SR-1 suggest that approximately 45 ft. of Cretaceous-aged sediments occur at this location.

3.3.4 Dockum Group. Although the nomenclature for the formations in the Dockum Group has been variously designated by a number of different investigators through time, this report uses the stratigraphic nomenclature used by Lehman (1994a[2] and 1994b[3]) and currently used by the Texas Water Development Board[4]. The formations that comprise the Dockum Group in Texas are, from youngest to oldest, are the Cooper Canyon, Trujillo, Tecovas, and Santa Rosa.

Cooper Canyon Formation. The top of the Dockum was observed at 174 ft. below ground surface, consisting of interbedded clay, mudstone, claystone, siltstone, sandstone, and minor limestone. A zone of higher porosity and permeability was observed from approximately 600 ft. to 665 ft. In this interval, a claystone interbedded with sands and gravels, coarsened with depth until gravels predominated. The gamma ray log shows a distinct signature from 583 ft. to 651 ft. indicative of the sands and gravels. The neutron porosity log shows less porosity, but may be due to borehole washout in this zone.

Based on evaluation of both the cuttings and the geophysical logs, the Cooper Canyon Formation is interpreted as the zone from 174 ft. to 651 ft. bgs. This zone represents a fining upward sequence.

Trujillo Formation. From 651 ft. to 922 ft., clay, claystone, and mudstone predominated; however, coarsening was observed in the cuttings from 900 ft. to 950 ft. with silts and siltstones interbedded with clays.

The gamma ray log shows a distinct signature from approximately 890 ft. to 922 ft. indicative of the sandier zone. The neutron porosity log shows less porosity in

[2] Lehman, T.M. 1994a.
[2] Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.R., Gordon, K., Nicot, J., Scanlon, B., Ashworth, J.B., Beach, J., 2008.
[3] Lehman, T.M., 1994b.
[4] Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.R., Gordon, K., Nicot, J., Scanlon, B., Ashworth, J.B., Beach, J., 2008.

this zone, but similar to the 583 ft. to 651 ft. zone in the overlying section, this may be due to washout.

Based on evaluation of both the cuttings and the geophysical logs, the Trujillo Formation is interpreted as the zone from 651 ft. to 922 ft. bgs. This zone represents a fining upward sequence.

Tecovas Formation. From 922 ft. to approximately 1,540 ft. bgs, the section was dominated by red clays, claystone, mudstone, and siltstone. The gamma ray log indicated little variation, except for several shifts in the clay line and a zone with more silt from 930 ft. to 956 ft. (i.e., near the top of the section).

Based on evaluation of both the cuttings and the geophysical logs, the Tecovas Formation is interpreted as the zone from 922 ft. to approximately 1,540 ft.

Santa Rosa Formation. The section from 1,540 ft. to approximately 1,750 ft. is comprised of siltstone and sandstone interbedded with clay, claystone, and mudstone.

The gamma ray log indicated that sandier zones occur from 1,654 ft. to 1,726 ft. and then become more clayey to approximately 1762 ft. The neutron porosity log shows a low porosity zone through this section, but again, may be due to borehole washout.

Based on evaluation of both the cuttings and the geophysical logs, the Santa Rosa Formation is interpreted as the zone from 1,540 ft. to 1,762 ft., with the "best sandstone layer"[5] occurring from 1,654 ft. to 1,730 ft. The Santa Rosa represents a fining upward sequence.

3.3.5 Permian Dewey Lake Formation. From approximately 1,750 ft. to 1,800 ft. (i.e., the total depth of the well), the section was predominated by clay, claystone, and mudstone. A distinct change in the gamma ray signature occurs at approximately 1,760 ft. bgs and this is interpreted as the top of the Permian section.

3.4 Field Observations Regarding Potential Water Supply

During drilling, the driller observed that the best water bearing zone was the shallow zone at approximately 583 ft. to 651 ft. bgs. Based on observation of the cuttings, this was the only zone with significant sands and gravels.

[5] The "best sandstone layer" is a term commonly used (e.g., Bradley and Kalaswad, 2003) to describe the Santa Rosa Formation zone with the greatest potential for porosity and permeability.

3.5 Recommendation for Well Perforations

Based on evaluation of the geologic log developed from cuttings collected at 10 ft. intervals and on the two geophysical logs (gamma ray and compensated neutron density), the recommendation was made to perforate the well in three zones, from 540 ft. to 650 ft., from 890 ft. to 920 ft., and from 1,610 to 1,770 ft.

Section 4.0
Findings and Recommendations

4.1 Findings

Based on evaluation of the geologic log developed from cuttings collected at 10 ft. intervals and on the two geophysical logs (gamma ray and compensated neutron density), the recommendation was made to perforate the well in three zones, from 540 ft. to 650 ft., from 890 ft. to 920 ft., and from 1,610 ft. to 1,770 ft.

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4.2 Recommendations

Drilling took twelve days and was interrupted by the Fourth of July holiday weekend and was prolonged by equipment problems. The amount of hole that was drilled each day decreased as the hole was drilled deeper. The primary reason for this was because all drill pipe was tripped out of the hole at the end of each day so that the downhole equipment would not be lost due to potential overnight collapse of the hole. Each morning the drill pipe would have to be placed back in the hole. Tripping in and out of the hole each morning and evening took longer and longer each day, resulting in progressively lesser amounts of drilled hole each day. It is recommended that future deep

Santa Rosa wells be drilled continuously from start to total depth of the hole, i.e., drill 24 hours per day, 7 days per week from start to finish.

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Because of the paucity of geologic and geophysical data in the Dockum sediments that underlie the Southern High Plains, it is recommended that drilling data be captured to provide a better geologic and hydrogeologic understanding Dockum Group sediments during future placement of deep wells. This includes preparation of geologic logs, running appropriate suites of geophysical logs, collection of well yield and water quality data, and data analyses. .

Section 5.0

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FIGURES

DOQQ from ESRI ArcGIS

N
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0 0.25 0.5 1 Miles

City of Seminole
Dockum Well

Project No. 02-013600.01	July 2011

Figure 1
SR-1 Well Location

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TABLES

Table 1
Stratigraphy on the Southern High Plains

Era	*System*	*Series*	*Group*	*Formation*	*General Description*	*Aquifer*
Cenozoic	Quaternary			Blackwater Draw	Fine grained sand, silt, clay	
	Tertiary			Ogallala	Sand, silt, clay, gravel, caliche	Ogallala
Mesozoic	Cretaceous		Washita	Duck Creek	Clay/shale with limestone	Edwards-Trinity (High Plains)
			Fredericksburg	Kiamichi	Massive shale	
				Edwards	Limestone	
				Comanche Peak	Argillaceous limestone	
				Walnut		
			Trinity	Antlers	Sand, sandstone	
	Jurassic					
	Triassic		Dockum	Cooper Canyon	Mudstone with siltstone, sandstone, and conglomerate	Dockum
				Trujillo	Massive crossbedded sandstones and conglomerates	
				Tecovas	Mudstone and siltstone	
				Santa Rosa	Sandstone and conglomerate	
Paleozoic	Permian	Ochoa		Dewey Lake		
		Guadalupe		Rustler	Anhydrite marker bed at top	

Table 2
Activity Log for Placement of SR-1

			Driller: Rory Roach (West Texas Water Well Drillers)
			Rig type: Ingersoll Rand/Sargent 3000
Date	***Interval Drilled***	***Daily Total Drilled***	***Notes***
6/21/2011	0-38'	38'	Started drilling at 2:00 pm; End drilling at 7:00 pm @ 38 ft.
			Drilled 12 1/4" pilot hole; reamed to 14 ¾ in., then 17 ½ in.
6/22/2011	38-275'	237'	End drilling at 2:30 pm.
			Set 12 ¾ in. steel casing to 100 ft. below top of the Dockum Formation. Pressure cemented well annulus (Basic Energy Services).
6/25/2011	275-585'	310'	Drilled 9:00 am to 6:30 pm. Drilled through approximately 20 ft. of cement inside surface casing to a depth of 585'. Bit size is 11 in.
6/26/2011	585-930'	345'	Drilled 9:00 am to 5:00 pm.
6/27/2011	930-1182'	252'	Drilled 10:30 am to 6:00 pm.
6/28/2011	1182-1369'	187'	Drilled 10:15 am to 5:45 pm.
6/29/2011	1369-1570'	201'	Drilled 10:15 am to 6:00 pm.
6/30/2011	1570-1680'	110'	Drilled 12:00 pm to 6:45 pm.
7/1/2011	1680-1740'	60'	Drilled 8:45 am to 12:00 pm.
7/5/2011		0'	Drilling started at ~ 11:00 am (part needed to be welded on the track). Driller determined that the hole had collapsed (probably due to water zone in the upper Dockum that caused the clays to swell). The entire hole needed to be reamed prior to further drilling. At 12:15 pm a valve blew on the circulation system and the rig shut down for the rest of the day for repairs.
7/6/2011		0'	Driller on site at 7:00 am with parts to fix the valve. Repairs took ~ 1 hour. Started back down hole. At ~1500 ft., the bit plugged up and had to come out of the hole. One jet was plugged with a hard clay nodule and not jet was plugged with a bolt.
7/7/2011	1740-1800'	60'	Drilling started at 12:15 pm; TD'd the hole at 5:00 pm.
7/8/2011			Drill crew installed 7 in. casing to 1800 ft. Well annulus pressure cemented.
7/21/2011			Geophysical logs(gamma ray, compensated neutron, and casing collar) run by Schlumberger (from approximately 10 ft. to 1792 ft. bgs)
7/22/2011			Well perforated by Basic Energy. Intervals perforated: 540 - 650' 890 - 920' 1610 - 1770'

ATTACHMENT A

Geologic Log

CLIENT Dr. Ken Rainwater WELL No. SR-1 SHEET: 1 OF: 19

SITE: City of Seminole well field DATE: START: June 21, 2011 FINISH: July 7, 2011

GEOLOGIST: Judy A Reeves, Ph.D., P.G.

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT.)	LITHOLOGIC DESCRIPTION
0				
	Q		0-6'	**Silty sand**, red brown. Flower pot structure observed in the side of the mud pit (silt/sand zone incised into top of caliche to a depth of approximately 6 ft.)
10	T_o		6 - 33.5'	**Caliche (caprock)**, with subrounded pebbles (including chert and jasper) and thin very fine grained sand lenses. Becomes sandier with depth (very fine grained, weakly cemented).
20				
30				
			33.5-39'	**Calcrete**, hard, silicified caliche, light tan.
40				
50				
60				
			39 -99'	**Sandstone**, 5YR6/6 (reddish yellow), weakly cemented. Sand grains: subrounded, mostly quartz, 0.1 - 0.25 mm dia.
70				
80				
90				
100			99-101'	**Calcrete** (hard, silicified sandy caliche)

STATE OF TEXAS
Judy A. Reeves, Ph.D.
GEOLOGY
426
LICENSED
PROFESSIONAL GEOSCIENTIST

Geologic Log

CLIENT: Dr. Ken Rainwater | WELL No: SR-1 | SHEET: 2 | OF: 19

SITE: City of Seminole well field | DATE: START: June 21, 2011 | FINISH: July 7, 2011

GEOLOGIST: Judy A Reeves, Ph.D., P.G.

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT.)	LITHOLOGIC DESCRIPTION
100				
			99-101'	**Calcrete** (continued)
			101-105'	**Sandstone**, weakly cemented, tan.
			105-110'	**Calcrete**
110				
			110-120'	**Siltstone**, 5YR7/1 (light grey), well cemented (v. hard!), mottled with 7.5YR8/3 (pink) with 7.5YR6/8 (reddish yellow)
	T_o			
120				
			120-129'	**Sandstone**, 2.5YR6/4 (light reddish brown), very fine grained sand, medium hard occasional stringers of clear, quartz (silica) cement.
130				
140				
			129-157'	**Siltstone**, 10R5/1 (reddish grey), medium cemented, argillaceous interbedded with sandstone and grey shale, drilled soft light shale per driller with small pebble sized rock fragments (up to 5mm, subangular limestone and jasper), black carbonacious material, and subrounded quartzite
150	K			at 140': silty clay, 7.5YR5/8 to 7.5YR6/8 (strong brown to reddish yellow) (Kdc?) layered with well cemented sandstone and siltstone (10YR7/6, reddish yellow) and angular to subrounded rock fragments up to 15 mm, including limestone (10YR4/1, dark grey), quartzite (2.5YR5/8, red, translucent)
160				
			157-174'	**Conglomerate** (weakly cemented), grey sand, taking water per driller, gravels (angular, up to ~ 20 mm, quartzite (subrounded, including flint, light colored sandstone rock fragments (vfg), grey siltstone rock fragment
170				
180				
	TR_C		174-193'	**Silty clay**, 10R4/4 (weak red), mottled with reduced clayey silt zones (grey).
190				
			193-215'	**Sandstone** with clay, 2.5YR5/3 (reddish brown) mottled with grey; weakly-to-well cemented, quartz sand grains.
200				

Geologic Log

CLIENT: Dr. Ken Rainwater | WELL No: SR-1 | SHEET: 3 | OF: 19

SITE: City of Seminole well field | DATE: START: June 21, 2011 | FINISH: July 7, 2011

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT.)	LITHOLOGIC DESCRIPTION
200				
			193-215' (cont)	
210				
220			215-235'	**Silty clay**, dense, 2.5YR3/3 (dark reddish brown), some mottling with grey clay (2.5YR6/0) and greenish grey clay (5GY5/1). at 225': intebedded (?) with with well consolidated sandstone and siltstone, very fine grained, reddish brown.
230				
			235-240'	**Clay**, dense, 2.5YR3/4 (dark reddish brown) with thinly bedded layers of light grey clay (7.5YR7/0). Minor grey sandy stringers (sand poorly sorted, subrounded to subangular, 5YR7/1).
240				
			240-245'	**Clayey silt**, grey (5YR6/1)
250				
	TR_C		245-255'	**Silty clay and sand**, becomes more clayey with depth, dark brown (7.5YR3/4) to grey (2.5Y5/0)
260				
			255-275'	**Siltstone**, blue grey with clay and sand, weakly consolidated @ 269': Dark grey siltstone transitions to well consolidated and interbedded with blue grey clay lenses (thin layers that are harder to drill)
270				
				Set 12 3/4" surface casing to a depth of 275'.
		N.S.		
280			275-280'	No sample (cement only)
			280-290'	**Limestone** with pebbles and quartz stringers, variegated pinkish white (5YR8/2) with reddish yellow (5YR7/8) interbedded (?) with clay (unconsolidated, greenish grey (5G6/1)) and siltstone (dark grey (2.5Y4/0), very fine grained, subrounded, some rock clasts (up to 5mm, including pink sandstone, quartzite, red shale).
290				
			290-310'	**Siltstone and sandstone (interbedded)**, siltstone: reddish (2.5YR4/3), well consolidated with concoidal fracture; sandstone: well consolidated, angular grains, poorly sorted, up to 1mm; with minor greenish gray clay (5BG6/1). Per driller: hard layers (siltstone?) are a couple of inches thick.
300				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL	LITHOLOGIC DESCRIPTION
300				
			290-310' (cont.)	
310				
			310-320'	**Clay**, dark greenish gray (5G4/1), with argillaceous sand lenses (dark reddish brown (5YR3/3))
320				
330				
			320-360'	**Clayey silt**, blue (5G5/4) and dark reddish brown (5YR3/4), with some sand and very dark grey (10YR3/1) silt
340				
350	TR_C			at 349': hard layer: light reddish brown sandstone (5YR6/4), vfg sand grains: multicolored, subangular at 350': clayey silt becomes dark greenish grey (5G4/1) at 352': hard layer: light reddish brown sandstone (5YR6/4), vfg sand grains: multicolored, subangular at 353': hard layer: light reddish brown sandstone (5YR6/4), vfg sand grains: multicolored, subangular
360				
			360-370'	**Clayey silt**, blue (5GB5/1), weakly consolidated, with clayey zones. Hard layers at 362'-363'
370				
			370-400'	**Sandy clay**, reddish brown (5YR4/3), with silt.
380				at 380': becomes dark reddish brown (5YR3/4)
390				at 390': mottled with greenish grey sandy clay(5BG6/1)
400				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
400				
			400-410'	**Clay**, dark grey (10YR4/1) with sand and silt, also with some angular sandstone clasts.
410				
			410-420'	**Silty clay**, reddish brown (5YR4/3) and blue grey (5BG6/1), with minor stringers of clear mineral (gypsum?) and nodules of $CaCO_3$.
420				
				Clay, greenish grey (5BG6/1) with very fine grained sand and silt.
430				at 430': clay becomes red (2.5YR4/6) with some thin beds of silt (interbedded?)
			420-450'	
440				at 440': clay becomes greenish grey (5BG6/1) with large clasts of siltstone, dark greyish brown (2.5Y4/2), up to ~50mm, well cemented, vesicular (small sand sized holes in layers).
450	TR_C			
			450-460'	**Mudstone**, silty, reddish brown (2.5YR4/4), weakly consolidated, mottled with blue clay.
460				
				Clay, yellowish red (5YR4/6), with silt and sand.
470				
			460-490'	at 470': clay becomes greenish grey (5BG5/1); with some sandstone (weakly consolidated, vfg, <0.1mm, with gypsum(?) sand grains); lacustrine varves?
480				
490				
			490-512'	**Mudstone**, silty, reddish brown (2.5YR4/4), weakly consolidated, easy drilling.
500				

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DEPTH (FEET)	STRATIGRAPHY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
500			
		500-512'	**Mudstone (continued)**
510			
520		512-530'	**Clay**, greenish grey (5G6/1), very silty with very fine grained sands (<0.1mm).
			at 520: with thin beds (?) of weakly consolidated reddish brown silty shale and gypsum (secondary?)
530			
		530-540'	**Silty clay** with sand, greenish grey (5GY5/1), some zones weakly consolidated.
540			
		540-550'	**Silt and sand**, greenish grey (5GY5/1), becomes more sandy and more consolidated with depth, some clay.
550			
	TR_C		**Siltstone**, grey (5YR6/1), weakly consolidated, iron oxide stringers (secondary), with minor sandy carbonaceous nodules.
560		550-570'	at 560': becomes more clayey with depth
570			
		570-580'	**Clayey silt**, grey (5Y5/1)
580			
		580-600'	**Clay**, dark reddish brown (5YR3/3), weakly consolidated, with silt and sand.
590			at 590': clay becomes very dark grey (10YR3/1)
600			at 599': thin hard layer (carbonate or caliche?)

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
600				
			600-612'	**Claystone**, grey (10YR5/1), weakly consolidated, with occasional rock fragments including milky colored quartzite (?) - jasper, rounded to subrounded; up to 7mm.
610				
			600-635'	at 612' to 620': claystone becomes black (10YR2/1), gravels (thin layer?) include rounded to subangular rock fragments including quartzite and charcoal.
620				
			620-635'	at 620' to 630': with gravels (broken rock fragments (up to ~10mm) including milky colored quartzite) ~25% dark reddish brown (2.5YR3/4) mudstone nodules.
630	TR_C			
640				**Gravel,** rock fragments are well rounded to subangular, mostly quartzite (milky), sandstone nodules with calcite and/or gypsum(?), up to 10mm.
				at 645'to 656' - with sand and pebbles up to 15mm, rock fragments include grey sandstone, black aphanitic rock, chert with concoidal fracture, obsidian, milky quartz, and quartzite.
650			635-665'	Per driller: zone of soft drilling.
660				
			665-670'	**Clay**, greyish green (5G5/2)
670				
680				
	TR_j		670-680'	**Claystone**, dark reddish brown (2.5YR3/4), weakly consolidated.
690				
				at 690': claystone become red (2.5YR4/6)
700				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
700				
			690-710' (cont)	**Claystone** (continued)
710				
720				**Clayey silt**, reddish brown (2.5YR5/4).
			710-740'	at 720': alternating layers of clayey silt and silty clay; occasional light grey (2.5YR6/0) mottling of the siltier zones.
730				
				at 730': becomes weak red (2.5YR4/2) and more sandy (sand grains - vfg, clear quartz), with $CaCO_3$ nodules.
740				
750	TR_j			**Claystone**, reddish brown (2.5YR4/3), weakly consolidated, occasional light grey shale (2.5YR6/0) in thin layers.
			740-770'	at 750': minor mottling with greenish grey (5G6/1).
760				
770				
			770-780'	**Clay**, weak red (10R4/4), with silty clay stringers (greenish grey (5G6/1)).
780				
			780-790'	**Claystone**, dark reddish brown (5YR3/2), competent with minor greenish grey sandy, silty clay stringers (unconsolidated).
790				
			790-800'	**Clay**, reddish brown (2.5YR5/3), very silty with light grey, clayey silt stringers (5YR7/1).
800				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
800				
			800-810'	**Silty clay**, red (2.5YR4/6), mottled with grey clayey silt (some mineralization around margins of mottled zones).
810				
			810-820'	**Claystone**, dark reddish brown (2.5YR3/3), weakly consolidated with very dark grey competent shale (thin layers); ~3% sandstone with $CaCO_3$ matrix (or caliche?).
820				
			820-838'	**Silty Clay**, greenish grey (5GY6/1), with 1% caliche(?) fragments.
830				at 850': but becomes less silty with depth and more competent.
840				
				Mudstone, dark reddish brown (2.5YR3/3), weakly consolidated.
850	TR_j		838-900'	at 850': ~10% reduced to light grey (2.5Y7/1).
860				at 860' to 870': with thin layer(s?) of competent red (10R5/6) siltstone.
870				at 870' to 880': reddish brown (2.5YR4/3), competent.
880				at ~885': becomes greenish grey (5BG5/1).
890				at 890": becomes dark brown (7.5YR4/2), well consolidated.
900				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
900				
	TR_j		900-910'	**Siltstone**, grey (2.5YR5/0), argillaceous.
910				
			910-920'	**Silty Clay**, greenish grey (5G5/1), interbedded (?) with slightly consolidated layers (thin). Per driller - softer drilling between 910-920'.
920				
			920-940'	**Clayey Silt**, greenish grey (5G5/1), very sandy with vfg sand (up to 0.5mm).
930				
940				
			940-945'	**Clay**, reddish brown (2.5YR4/3), with grey mottling.
			945-950'	**Siltstone**, weak red (10R4/2), competent.
950				
	TR_V		950-1010'	**Clay**, reddish brown (2.5YR4/3), minor grey mottling.
960				at 960': weak red (10R4/3), weakly consolidated, with silty/sandy stringers.
970				at 970': weak red (10R4/2) with some blue mottling.
980				at 980': weak red (10R5/4) with increased blue grey mottling in siltier zones.
990				at 990': weak red (10R4/4) with small (<2mm) white soft clasts of $CaCO_3$ (?) (could crush clasts to a powder).
1000				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
1000				
			950-1010' (cont.)	**Clay** (continued): red (10R4/6) with greenish grey (5G6/1) clay stringers.
1010				
			1010-1020'	**Mudstone**, reddish brown (2.5YR4/3), weakly consolidated.
1020				
				Clay, weak red (10R5/3), with thin layers that are slightly consolidated.
1030				
				at 1030': mottled with light greenish grey (5GY7/1) clayey silt.
1040			1020-1060'	
1050	TR_V			
1060				
			1060-1070'	**Claystone**, weak red (10R4/3) very weakly consolidated.
1070				
				Clay, weak red (10R4/4), unconsolidated to weakly consolidated.
1080				
			1070-1120'	at 1080': becomes light greenish grey (5BG7/1).
				at 1085' - weak red (10R4/4) clay mottled with brownish yellow clay (10YR6/8).
1090				
				at 1090 - 1100': with thin siltstone beds (?) that are reddish brown (2.5YR4/4) to grey (2.5Y6/0).
1100				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
1100				
				Clay (continued) with small silty clasts (grey) that crumble easily; mottled with light grey clay (minor). at 1100': hard layer thin layer (thin carbonate layer interbedded with weakly consolidated shale?
1110			1070-1120' (cont.)	at 1110': reddish brown (2.5YR4/4).
1120				
			1120-1130'	**Claystone**, dusky red (10R3/3), weakly consolidated, mottled with dark reddish grey (10R4/1), with gypsum(?) and/or calcite (?) stringers (secondary mineralization).
1130				
				Clay, yellowish red (5YR4/6), interbedded with weakly consolidated claystone. at 1137': thin hard layer
1140			1130-1150'	at 1140': becomes red (2.5YR4/6), silty, unconsolidated to weakly consolidated.
1150	TR_V			
			1150-1160'	**Claystone**, weak red (10R4/3), weakly consolidated, with hard chert with cocoidal fracture, very hard, thin layer?
1160				
				Clay, red (2.5YR4/8), with some silt, unconsolidated to weakly consolidated.
1170			1160-1180'	at 1170': becomes weak red (10R5/4) with minor mottling with clayey silts (greenish grey (5G6/1).
1180				
			1180-1190'	**Claystone**, red (2.5YR4/6), weakly consolidated with thin layers of light grey (5YR7/1) hard siltstone(?); layers a couple of inches thick with concoidal-like fracture.
1190				
			1190-1218'	**Siltstone**, weak red (10R4/4).
1200				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
1200				**Siltstone (continued)**
				at 1200 - 1210": well consolidated, thinly laminated.
			1190-	
1210			1218'	
			(cont.)	at 1210': interbedded with mudstone (~50-50).
				mudstone: reddish brown (2.5YR4/3) with rock fragments (well rounded, up to 2mm).
1220				
			1218-	**Mudstone**, dark reddish brown (2.5YR3/3), occasional small rounded rock pebbles imbedded in the mudstone.
			1230'	~3% clasts of light sandstone, light red (2.5YR6/6) with CaCO3 cement(?) - medium-to-coarse grained sands.
1230				
				Siltstone, dark reddish brown (2.5YR3/4).
1240				at 1240': with mudstone (minor mottling ; light grey, yellow, and red)
			1230-	
			1260'	
1250	TR_V			at 1250': dark red (10R3/6) siltstone and weak red (10R5/3) mudstone (~50-50); both weakly consolidated.
1260				
			1260-	**Claystone**, red (2.5YR4/6) to dusky red (2.5YR3/3), large black shard-liked rock fragment
			1270'	with coarse soft sandstone, weak red (10R4/3).
1270				
			1270-	**Clay**, dark grey (10YR4/1)
1280			1285'	
1290				
			1285-	**Claystone**, greenish grey (5G5/1), weakly consolidated and weak red (10R4/1) clay.
			1320'	
1300				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
1300				
				Claystone (continued), weak red (10R4/2), competent.
				at 1305': minor sand
1310			1285-	at 1310': with thin lenses of weak red siltstone (well-cemented).
			1320'	
1320				
				Siltstone, reddish brown (2.5YR4/3), with some laminations, laminated zones are more coarse, grey, may be reduced zones.
1330			1320-	
			1340'	at 1330': occasional well cemented vfg sandstone clast (pink (5YR7/3)) (thin layer ~1/8" thick?).
1340				
			1340-	**Mudstone**, weak red (2.5YR3/2), interbedded with greenish grey (5G5/1) and dusky red (2.5YR3/2)
1350	TR_V		1350'	siltstone layers.
			1350-	**Clay**, dark grey (10YR4/1).
1360			1360'	at 1356' : hard layer serveral inches thick, grey, siliceous siltstone (?)
				Siltstone, dusky red (10R3/3), well cemented.
1370				
				at 1370': dark reddish brown (2.5YR3/4), and mudstone/shale, very dark grey (2.5YR3/0).
1380			1360-	
			1410'	
1390				
				at 1390' to 1400': interbedded (?) with sandstone, reddish grey (10R5/1), well consolidated.
1400				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
1400				
			1400-1410'	**Siltstone**, weak red (10R4/2), occasional thinly laminated with grey sandy zone (~1/8" thick) and thin layers(?) of very dark grey shale (crumbles).
1410				
			1410-1420'	**Claystone**, weak red (2.5YR4/2).
1420				
			1420-1430'	**Siltstone**, weak red (10R4/3), weakly cemented, mottled with greenish grey (5BG6/1) clay.
1430				
				Clay, reddish brown (5YR4/3), with sand and silt, and light grey, thin sandy lenses.
1440				
				at 1440': clay becomes greenish grey (5GY5/1), mottled with brownish yellow (10YR6/6) and weak red (10R5/4); minor sand and silt.
1450	TR_V		1430-1470'	at 1450': greenish grey (5G5/1) clay is interbedded with weak red (10R5/4) siltstone.
1460				at 1460': clay becomes greenish grey (5BG5/1) and weak red (10R4/4).
1470				
			1470-1480'	**Mudstone** and siltstone (~50-50), mudstone is weak red (10R5/4) to dark reddish grey (10R4/1); siltstone is N4 (dark grey).
1480				
				Clay, weak red (10R4/3), very dense.
1490			1480-1520'	at 1490': becomes sandier.
				at 1493' - thin hard layer of silicified siltstone(?), weak red (2.5YR5/2) with secondary mineralization (gypsum?) in fractures and blue green reduction halo around margins of rocks. Rock fragments up to ~ 40mm x 20mm.
1500				

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DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
1500				
				Clay (continued).
				at 1500': clay is weak red (10R4/3) with reddish brown mudstone (2.5YR4/3) with ~7% angular to subrounded rock fragments (including $CaCO_3$).
1510			1480-1520' (cont.)	
1520				
				Mudstone, dense weak red (10R5/4), mottled throughout, red/yellow/grey; with well cemented gravel sized rocks (~50mm), rounded, very silty, fractured.
1530			1520-1540'	at 1530': reddish brown mudstone (2.5YR4/3) with weak red clay (10R4/3) and ~7% angular to subrounded rock fragments (including CaCO3).
1540				
			1540-1550'	**Siltstone**, reddish brown (2.5YR4/4) and mudstone, weak red (2.5YR4/2), competent (better consolidated). Softer drilling at 1548' per driller.
1550				
			1550-1560'	**Sandstone**, weak red (10R4/2), very fine grained.
1560				
				Clay, red (2.5YR4/6), silty.
1570	TR_S		1560-1580'	at 1570' to 1580': with ~2% clasts of greenish grey (5GY5/1) claystone and ~1% carbonate fragments (~1mm).
1580				
				Claystone, dusky red (10R3/2) and dark reddish grey (10R4/1), silty, interbedded(?) with thin layers of greenish grey (5G5/1) soft claystone.
1590			1580-1610'	at 1590': dark reddish brown (2.5YR3/3); with occasional thin layer(?) of very fine grained sandstone; and ~10% greenish grey (5G5/1) mudstone.
1600				

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DEPTH (FEET)	STRATIGRAPH	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
1600				
			1580-1610' (cont.)	**Claystone (continued)**. at 1600': as above but no sandstone lenses.
1610				
			1610-1620'	**Siltstone**, weak red (10R4/3), well consolidated with mudstone (~50-50). Mudstone is poorly consolidated with occasional black subrounded rock fragments (pebble sized) and some yellow mottling.
1620				
			1620-1650'	**Claystone**, weak red (10R4/3), weakly consolidated, with thin lenses(?) of grey mudstone (5Y5/1). at 1625': drill bit started to drop a couple of times (?) claystone becomes weak red (2.5YR4/4) with mudstone with occasional blue grey mottling with some very fine grained sand (minor).
1630				at 1630': claystone is weak red (2.5YR4/2).
1640				at 1640': claystone becomes dark reddish grey (10R3/1) and mudstone, dark reddish grey (10R4/1) (~50/50) with some clasts of weakly consolidated siltstone (dark greenish grey (5GY4/1) and weak red (2.5YR4/2)).
1650	TR_S			
1660			1650-1670'	**Clay**, red (2.5YR4/6) at 1668' - hard layer of claystone (very dark grey (2.5YR3/0), well consolidated).
1670				
1680			1670-1690'	**Sandstone**, pale red (10R6/2), very fine to medium grained, well consolidated to weakly consolidated, with silt and clay. Sand grains: black and red rock fragments (subrounded, ~0.1mm), quartz (0.25mm, subangular) Per driller: drills faster. at 1680': hard layer ~6" thick (claystone and/or mudstone). **Sandstone**, fine to medium grained, weakly consolidated, subangular quartz grains with silt and clay (back in clay before 1690' per driller).
1690				
1700			1690-1700'	**Mudstone** and **Siltstone**, weakly consolidated, laminated with thin very fine grained sandstone zones. Mudstone mottled dusky red (10R3/2) and weak red (10R4/4); siltstone dusky red (10R3/2) at 1697' : hard layer several inches thick.

Geologic Log

CLIENT Dr. Ken Rainwater | WELL No: SB-1 | SHEET: 18 OF: 19

SITE: City of Seminole well field | DATE: START: June 21, 2011 | FINISH: July 7, 2011

GEOLOGIST: Judy A Reeves, Ph.D., P.G.

Cirrus Associates, LLC

Dallas Office:
600 S. Sherman Street
Suite 102
Richardson, TX 75081
(972) 680-8555

Houston Office:
11757 Katy Freeway
Suite 1300
Houston, TX 77079
(281) 854-2383

DEPTH (FEET)	STRATIGRAPHY	LITHOLOGY	INTERVAL (FT)	LITHOLOGIC DESCRIPTION
1700				
				Sandstone, Claystone, and Mudstone (interbedded) with silt and clay.
				Sandstone is mostly reddish brown (2.5YR4/4) and weakly cemented.
				(quartz grains 0.25mm, subrounded to subangular) Claystone is dusky red (10R3/4);
				mudstone is reddish brown (2.5YR4/3) and competent.
1710				at 1704': hard layer (mudstone?).
				at 1710": more clayey with minor greenish grey silty sandstone (5G6/1).
			1700-	
			1730'	
1720				
				at 1720': ~ 25% clasts of black, siliceous,angular, carbonaceous material (~2mm).
1730	TR_S			
				Siltstone, red (10R4/6), and **Mudstone**, dark reddish grey (10R4/1), (thin, interbedded layers?).
1740			1730-	at 1740': mudstone and siltstone become weak red, with claystone and thin sandstone beds (very fine
			1750'	to medium grained) and ~1-2% greenish grey (5BG5/1) very fine grained sandstone.
1750				
			1750-	**Claystone** reddish brown (2.5YR4/4), with siltstone layers, dark reddish brown (2.5YR3/3).
			1760'	Both weakly consolidated; minor blue mottling, some zones of silicified stringers in claystone.
1760				
				Mudstone, weak red (10R4/4)mottled with red (10R5/6) and greenish grey (5G5/1), weakly cemented.
			1760-	With greenish grey (5GY7/1) clasts of laminated silty sandstone (weakly cemented, sands: vfg, black rock,
			1770'	quartz, pink feldspar?),and minor red (10R4/6) claystone clasts; ~1% pebble sized limestone nodules.
1770				
			1770-	**Claystone**, weakly cemented, reddish brown (2.5YR4/4), silty, rock fragment that "sparkles,"
			1780'	with 25% greenish grey (5GY5/1) sandy siltstone, weakly cemented, sand grains very fine grained.
1780	P_{DL}			
				Siltstone, clayey, very dense, dark reddish brown (5YR3/3) and **claystone**, dusky red (2.5YR3/2) to
			1780-	very dark grey - (2.5YR3/). Some mudstone**,** weak red (10R4/4) mottled with greenish grey (5G5/1);
			1790'	all weakly-to-medium consolidated.
1790				
				Silty Clay, greenish grey (5GY5/1) interbedded with weak red (10R4/3) claystone mottled with
				greenish grey (5GY6/1).
			1790-	at 1795': hard layer of dark reddish brown (5YR3/4) claystone, dense, well consolidated, mottled with
			1800'	greenish grey (5GY5/1), layer ~10mm thick.
1800				**Clay**, dark reddish brown (5YR3/3), dense to slightly consolidated; TD - 1800 ft.

Geologic Log

CLIENT Dr. Ken Rainwater WELL No: SB-1 SHEET: 19 OF: 19

SITE: City of Seminole well field DATE: START: June 21, 2011 FINISH: July 7, 2011

GEOLOGIST: Judy A Reeves, Ph.D., P.G.

Cirrus Associates, LLC

Dallas Office:
600 S. Sherman Street
Suite 102
Richardson, TX 75081
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Houston Office:
11757 Katy Freeway
Suite 1300
Houston, TX 77079
(281) 854-2383

LEGEND

Q	Quarternary, Blackwater Draw Formation
T_O	Tertiary Ogallala
K	Cretaceous
TR_C	Triassic, Dockum - Cooper Canyon
TR_j	Triassic, Dockum Trujillo
TR_V	Triassic, Dockum Tecovas
TR_S	Triassic, Dockum Santa Rosa
P_{DL}	Permian Dewey Lake

Note: The stratigraphic units have been picked based on analyses of both cuttings and geophysical logs.

ATTACHMENT B

STATE OF TEXAS WELL REPORT for Tracking #259331

Owner:	**City of Seminole**	Owner Well #:	**NewMuni.Well**
Address:	**302 S. Main** **Seminole , TX 79360**	Grid #:	**27-19-5**
Well Location:	**CR 306** **Seminole , TX 79360**	Latitude:	**32° 41' 06" N**
Well County:	**Gaines**	Longitude:	**102° 40' 01" W**
Elevation:	**3300 ft.**	GPS Brand Used:	**Garmin**
Type of Work:	**New Well**	Proposed Use:	**Test Well**

Drilling Date: Started: **6/21/2011**
Completed: **7/7/2011**

Diameter of Hole: Diameter: **17-1/2 in From Surface To 275 ft**
Diameter: 11 In **From 275 ft To 1808 ft**

Drilling Method: **Mud Rotary**

Borehole Completion: **Straight Wall**

Annular Seal Data: 1st Interval: **From 0 ft to 275 ft with 350 Class C Cem (#sacks and** material)
2nd Interval: **From 0 ft to 1800 ft with 800 Class C Cem (#sacks and** material)
3rd Interval: **No Data**
Method Used: **Pressure Cement**
Cemented By: **Basic Energy**
Distance to Septic Field or other Concentrated Contamination: **N/A ft**
Distance to Property Line: **65 ft**
Method of Verification: **Measured**
Approved by Variance: **No Data**

Surface Completion: **Surface Sleeve Installed**

Water Level: Static level: **No Data**
Artesian flow: **No Data**

Packers: **No Data**

Plugging Info: Casing or Cement/Bentonite left in well: **No Data**

Type Of Pump: **No Data**

Well Tests: **No Data**

Water Quality: Type of Water: **Fresh**
Depth of Strata: **640 - 1800 ft.**
Chemical Analysis Made: **No**
Did the driller knowingly penetrate any strata which contained undesirable constituents: **No**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.

Company **West Texas Water Well Service**

Information:	**3410 Mankins Odessa , TX 79764**
Driller License Number:	**54815**
Licensed Well Driller Signature:	**Rory Roach**
Registered Driller Apprentice Signature:	**No Data**
Apprentice Registration Number:	**No Data**
Comments:	**No Data**

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking number (Tracking **#259331**) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL

From (ft) To (ft) Description
0 3 Top soil
3 31 Caliche
31 33 Red sand
33 39 Calcrete
39 98 Brown sandstone
98 101 Calcrete
101 109 Brown sandstone
109 120 Calcrete
120 129 Brown & tan sandstone
129 173 Small sand & gravel, some gray shale
173 240 Red clay
240 275 Red clay, brown sandstone
275 350 Brown clay, gray shale
350 360 Gray shale
360 470 Brown clay, gray shale
470 480 Gray shale
480 510 Brown clay
510 520 Gray shale
520 645 Brown clay, gray shale
645 656 Small sand & gravel
656 770 Brown clay
770 790 Brown clay w/small gravel
790 880 Brown & red clay
880 920 Brown clay, gray shale
920 930 Small gray shale, silt

CASING, BLANK PIPE & WELL SCREEN DATA

Dia. New/Used Type Setting From/To
12-3/4 New Steel 0 - 274 Blank
7 New Steel 0 - 1800 Blank

930 1030 Brown clay, gray shale
1030 1260 Brown clay
1260 1550 Brown clay, gray shale
1550 1670 Brown clay
1670 1808 Brown clay, gray shale

ATTACHMENT C

Schlumberger

Company: **City of Seminole**

Well: **Seminole Santa Rosa Well**

Field:

County: **Gaines** State: **Texas**

County: Gaines
Field:
Location:
Well: Seminole Santa Rosa Well
Company: City of Seminole

Compensated Neutron Log
Gamma Ray
Casing Collar Log

LOCATION

Elev.: K.B.
G.L.
D.F.

Permanent Datum: GROUND LEVEL Elev.: 0.00 ft
Log Measured From: GROUND LEVEL 0.00 ft above Perm. Datum
Drilling Measured From: GROUND LEVEL

API Serial No.	Section	Township	Range

		Run 1	Run 2	Run
PVT DATA	Oil Density			
	Water Salinity			
	Gas Gravity			
	Bo			
	Bw			
	1/Bg			
	Bubble Point Pressure			
	Bubble Point Temperature			
	Solution GOR			
	Maximum Deviation			
	CEMENTING DATA			
	Primary/Squeeze	Primary		
	Casing String No			
	Lead Cement Type			
	Volume			
	Density			
	Water Loss			
	Additives			
	Tail Cement Type			
	Volume			
	Density			
	Water Loss			
	Additives			
	Expected Cement Top			

Logging Date		21−Jul−2011						
Run Number		1						
Depth Driller		1800 ft						
Schlumberger Depth		1791 ft						
Bottom Log Interval		1789 ft						
Top Log Interval		0 ft						
Casing Fluid Type								
Salinity								
Density		8.4 lbm/gal						
Fluid Level								
BIT/CASING/TUBING STRING								
Bit Size		11.000 in						
From		200 ft						
To		1800 ft						
Casing/Tubing Size		7.000 in						
Weight		26 lbm/ft						
Grade								
From		0 ft						
To		1800 ft						
Maximum Recorded Temperatures								
Logger On Bottom	Time	21−Jul−2011	10:24					
Unit Number	Location	378	Hobbs, NM					
Recorded By		Anthony Charleston						
Witnessed By		Gil Gillespie						

Logging Date								
Run Number								
Depth Driller								
Schlumberger Depth								
Bottom Log Interval								
Top Log Interval								
Casing Fluid Type								
Salinity								
Density								
Fluid Level								
BIT/CASING/TUBING STRING								
Bit Size								
From								
To								
Casing/Tubing Size								
Weight								
Grade								
From								
To								
Maximum Recorded Temperatures								
Logger On Bottom	Time							
Unit Number	Location							
Recorded By								
Witnessed By								

Run 3

Run 4

DISCLAIMER

THE USE OF AND RELIANCE UPON THIS RECORDED−DATA BY THE HEREIN NAMED COMPANY (AND ANY OF ITS AFFILIATES, PARTNERS, REPRESENTATIVES, AGENTS, CONSULTANTS AND EMPLOYEES) IS SUBJECT TO THE TERMS AND CONDITIONS AGREED UPON BETWEEN SCHLUMBERGER AND THE COMPANY, INCLUDING: (a) RESTRICTIONS ON USE OF THE RECORDED−DATA; (b) DISCLAIMERS AND WAIVERS OF WARRANTIES AND REPRESENTATIONS REGARDING COMPANY'S USE OF AND RELIANCE UPON THE RECORDED−DATA; AND (c) CUSTOMER'S FULL AND SOLE RESPONSIBILITY FOR ANY INFERENCE DRAWN OR DECISION MADE IN CONNECTION WITH THE USE OF THIS RECORDED−DATA.

OTHER SERVICES1	OTHER SERVICES2
OS1: none	OS1:
OS2:	OS2:
OS3:	OS3:
OS4:	OS4:
OS5:	OS5:

REMARKS: RUN NUMBER 1	REMARKS: RUN NUMBER 2
No correlation log provided	
Neutron porosity logged on a Sandstone Matrix	
Porosity logged from 1791' to surface	
Gamma Ray/ CCL logged from 1791' to surface	
PBTD at 1791'	
Crew: Eddie, Terry, Dan	
Thank you for using Schlumberger!	

RUN 1

SERVICE ORDER #:
PROGRAM VERSION: 18C0−147
FLUID LEVEL:

LOGGED INTERVAL	START	STOP

RUN 2

SERVICE ORDER #:
PROGRAM VERSION:
FLUID LEVEL:

LOGGED INTERVAL	START	STOP

EQUIPMENT DESCRIPTION

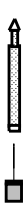
RUN 1 RUN 2

SURFACE EQUIPMENT

WITM−A
PSC_16MHZ

DOWNHOLE EQUIPMENT

MH−22 21.4
MH−22



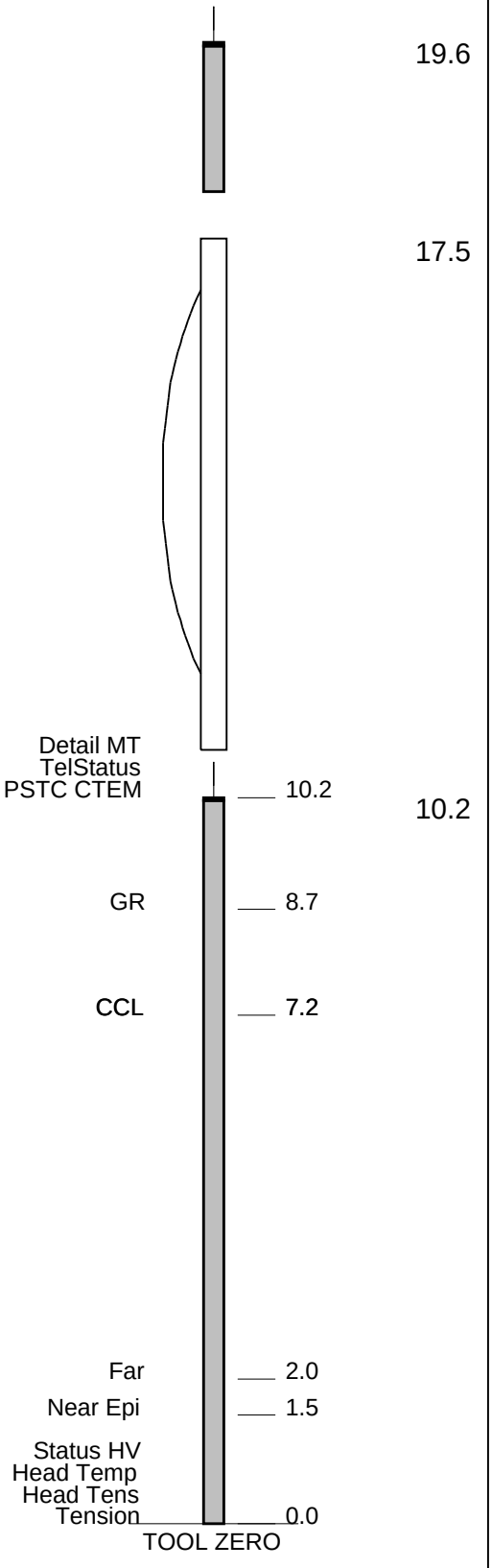
AH−38 19.8

SAH−Q
SAH−Q

19.6

ILE−I
ILE−I

17.5



ITGN−B
PSC−ATS
PSTC−A
ITNH−B 36
ITNS−B 36
NNLS−C 6003

10.2

MAXIMUM STRING DIAMETER 2.25 IN
MEASUREMENTS RELATIVE TO TOOL ZERO
ALL LENGTHS IN FEET

Schlumberger

Compensated Neutron Log
Mainpass

MAXIS Field Log

Company: City of Seminole **Well: Seminole Santa Rosa Well**

Input DLIS Files

DEFAULT	CNL_007LUP	FN:6	PRODUCER	21−Jul−2011 09:43	1800.0 FT	0.1 FT

Output DLIS Files

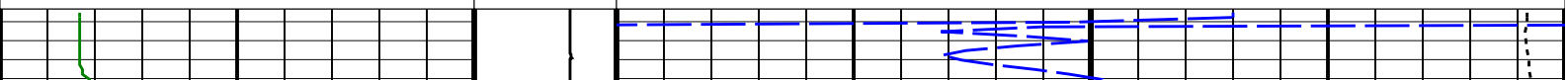
DEFAULT	CNL_009PUP	FN:8	PRODUCER	21−Jul−2011 10:19	1800.0 FT	0.5 FT

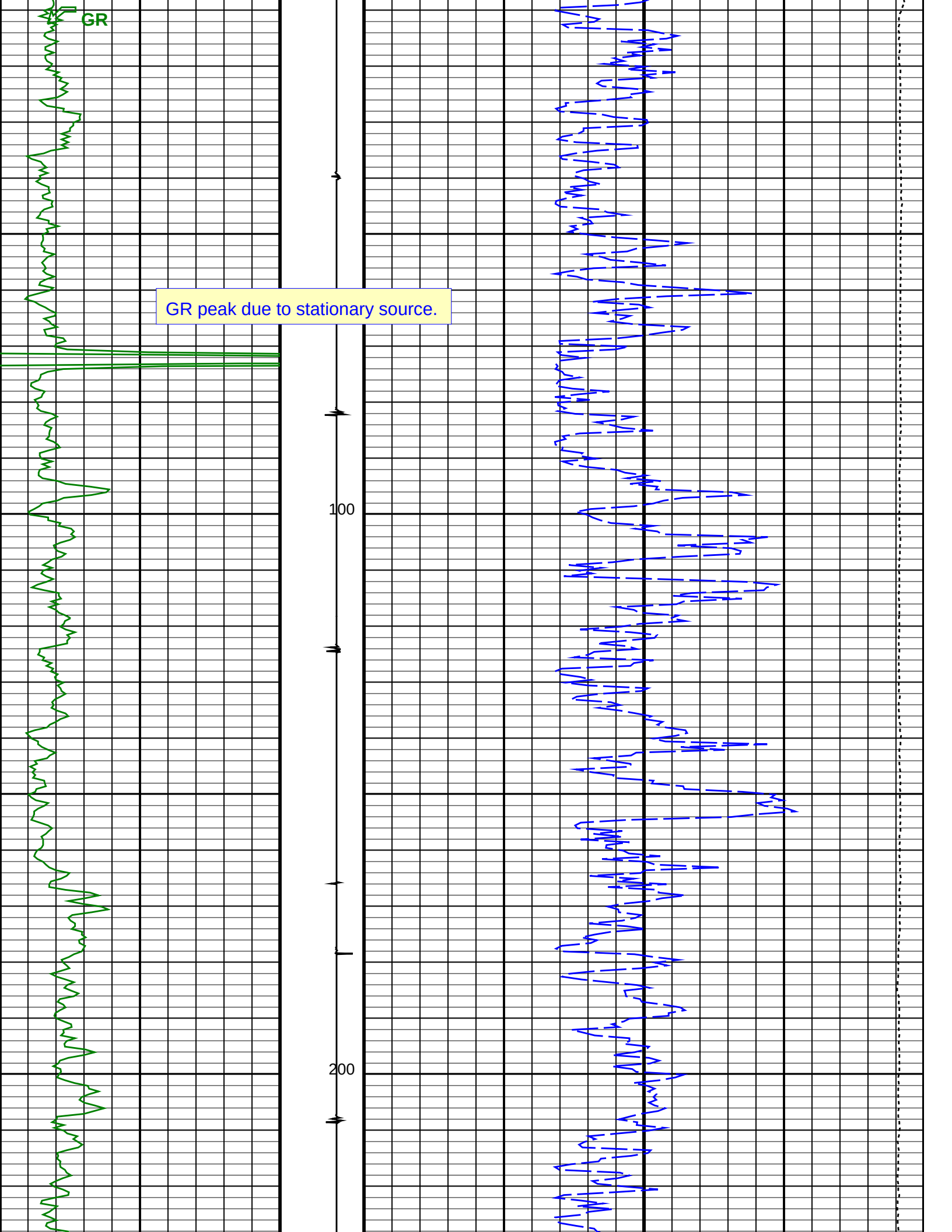
OP System Version: 18C0−147

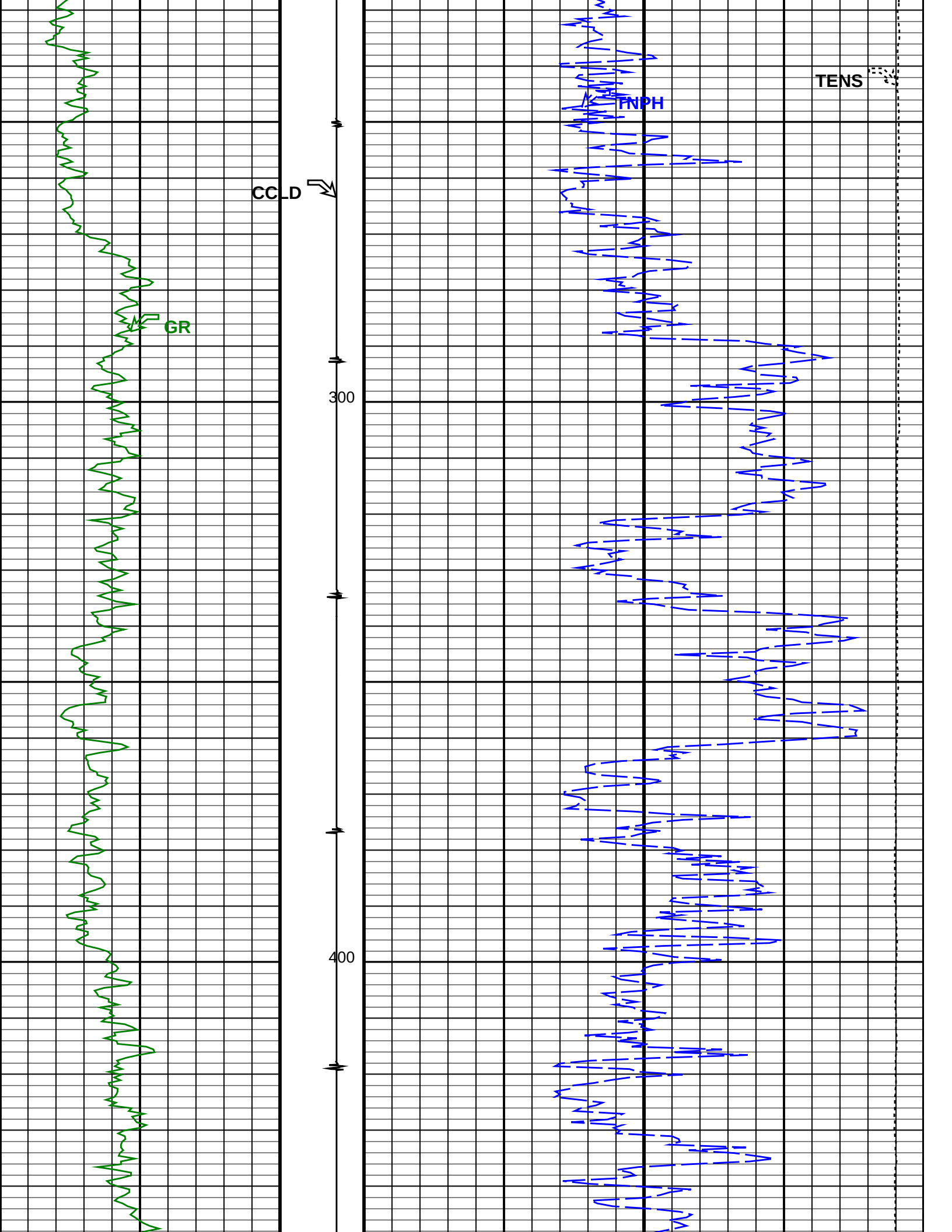
ITGN−B SPC−5020−IFLEX

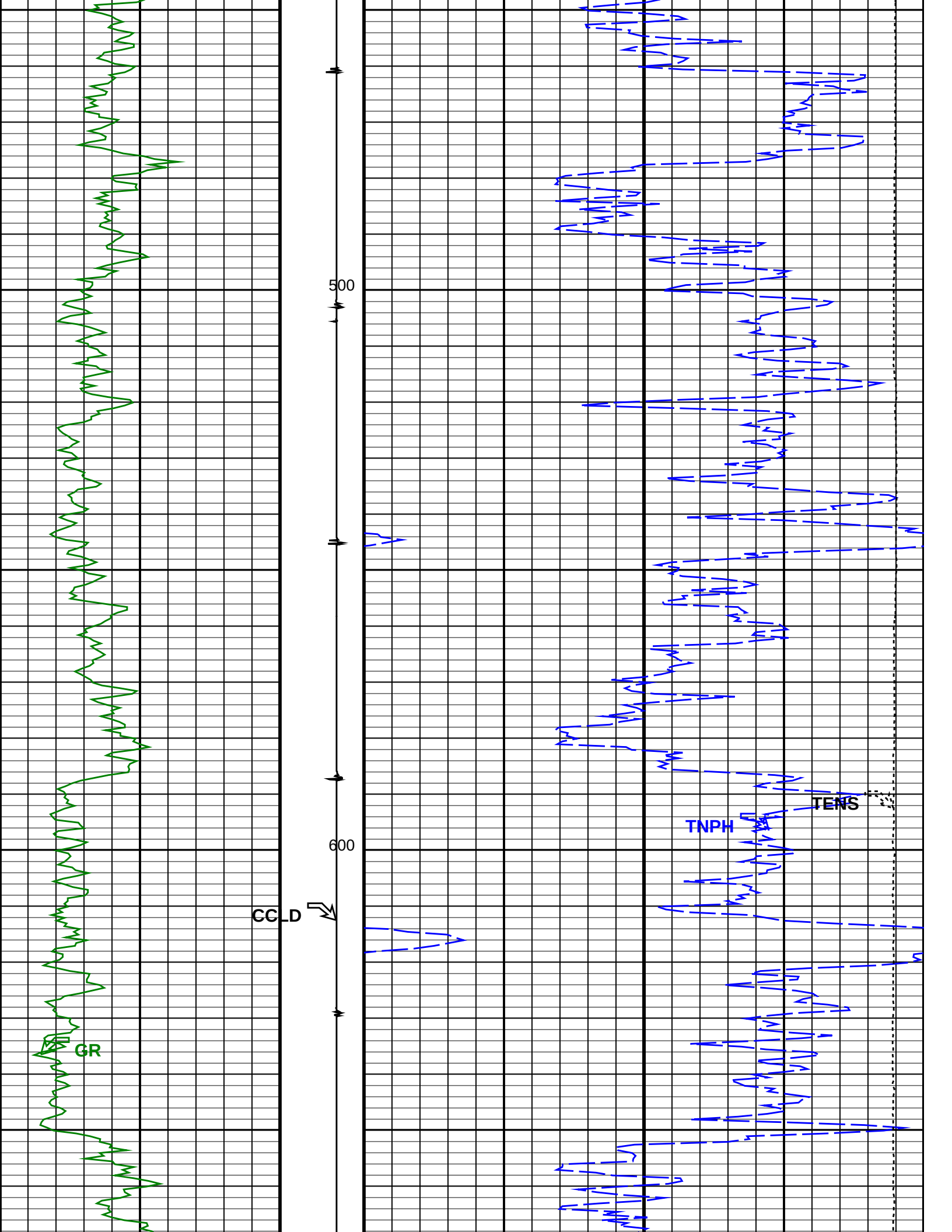
Tension (TENS)
2000 (LBF) 0

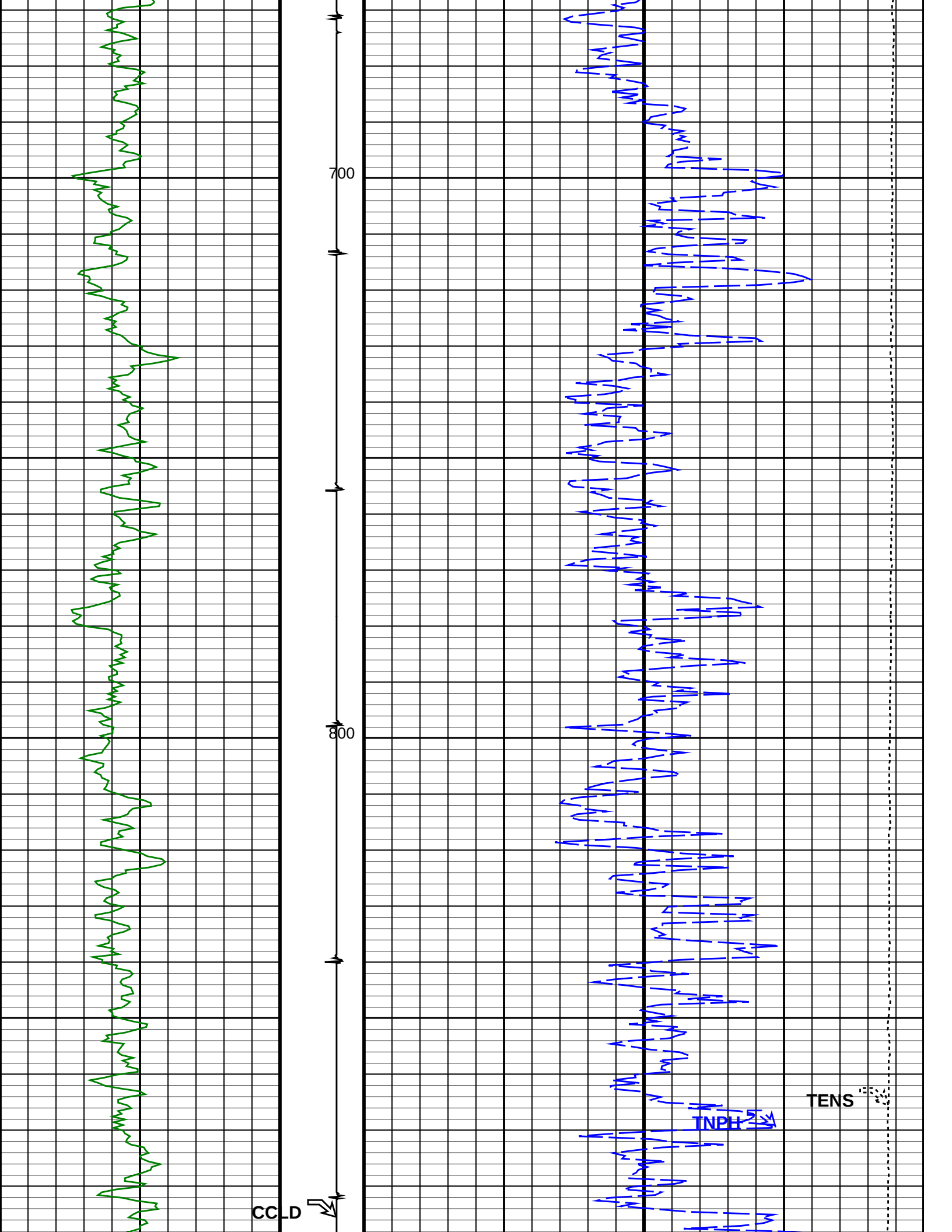
Gamma Ray (GR)	Discriminated Casing Collar Locator Amplitude (CCLD)	Thermal Neutron Porosity (TNPH)
0 (GAPI) 150	−10(−−−−) 5	0.3 (V/V) −0.1




GR
GR peak due to stationary source.
100
200


TENS
FNPH
CCL_D
GR
300
400


500
600
CCL_D
GR
TNPH
TENS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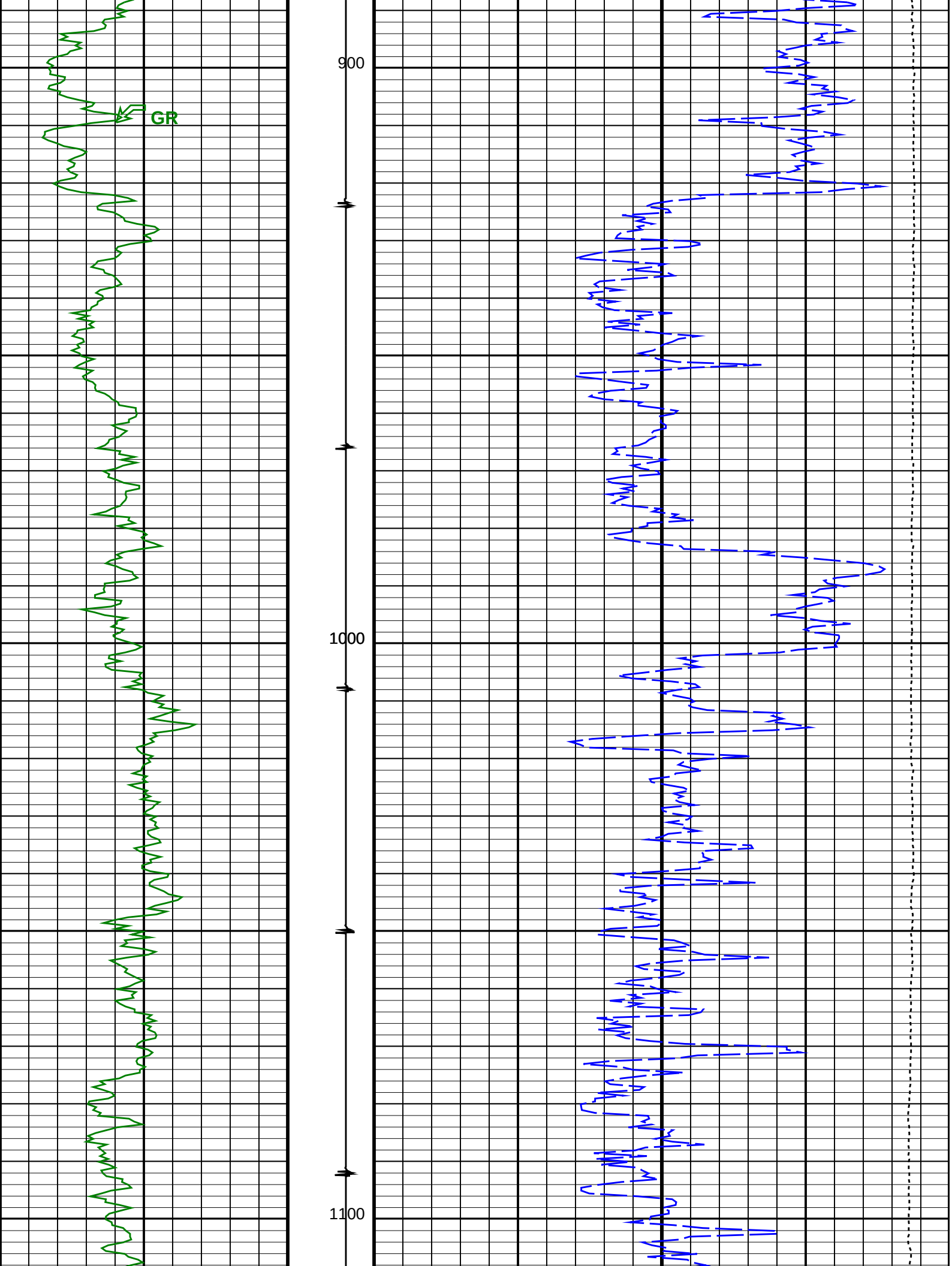
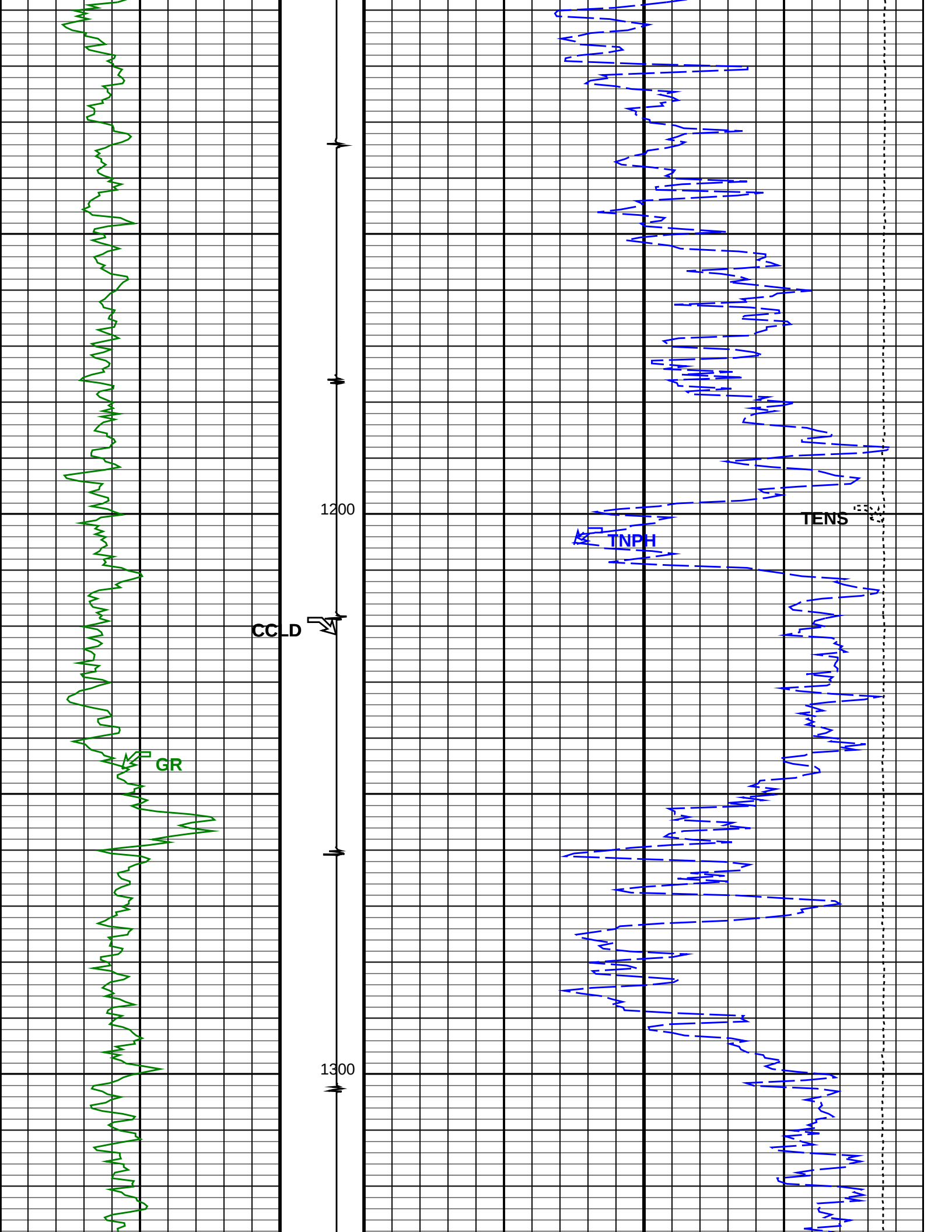
800
CC_D
TNPH
TENS


GR
900
1000
1100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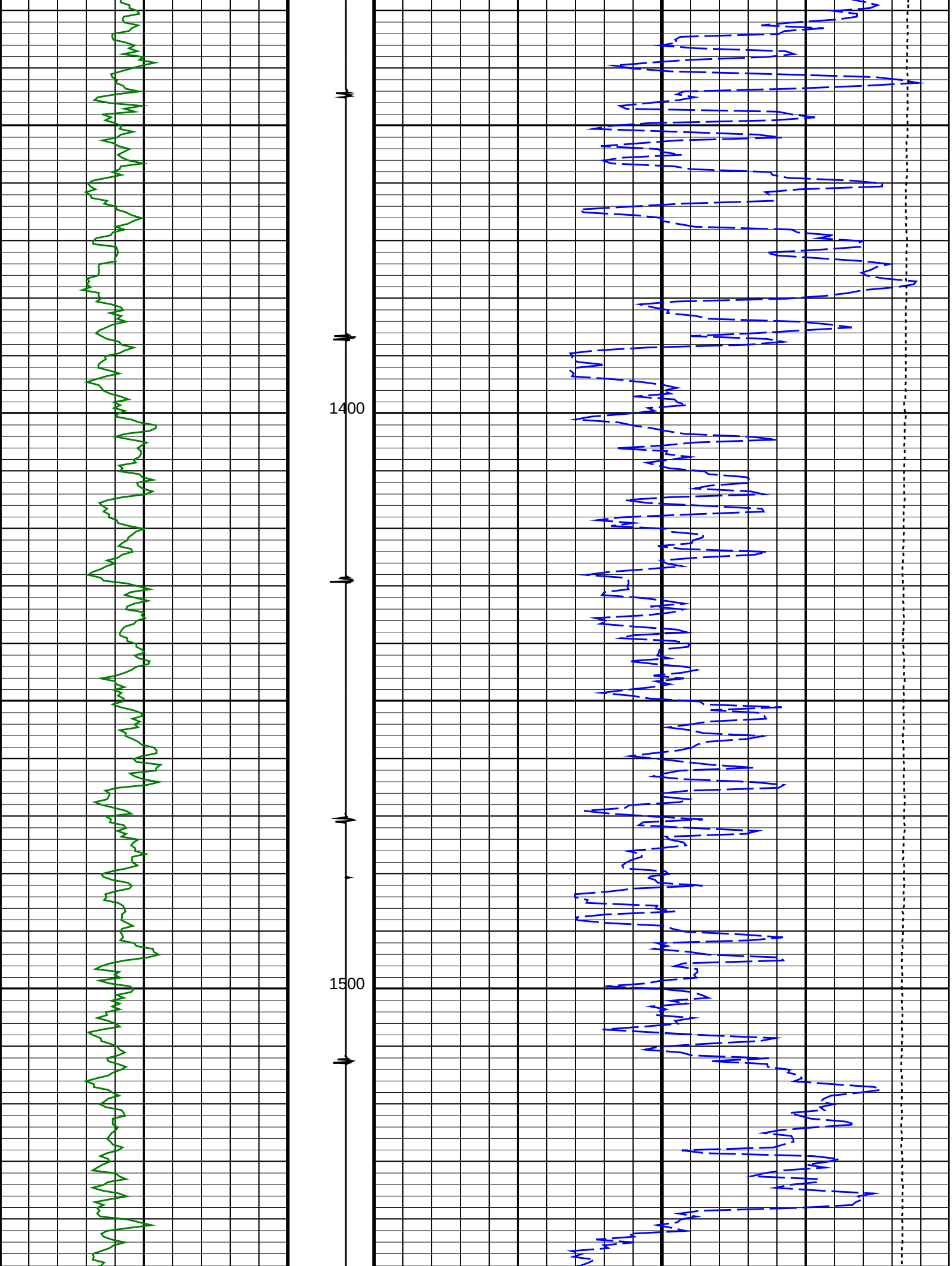
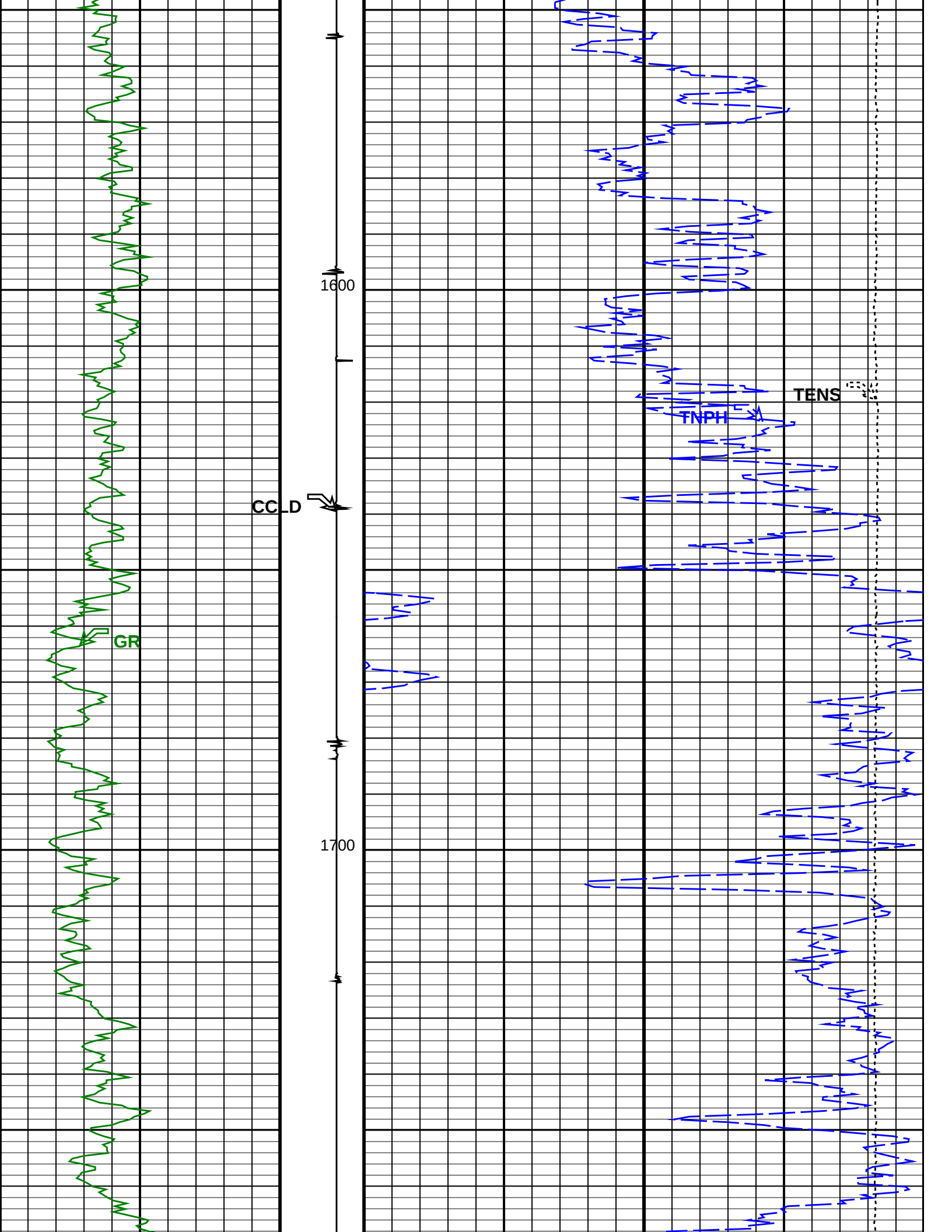
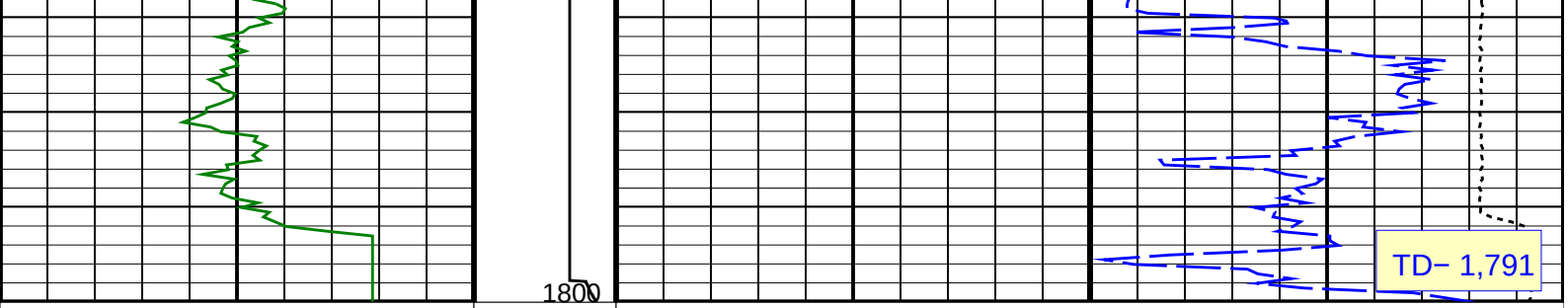
CCL_D
GR
TNPH
TENS


1400
1500


1600
1700
CCL_D
GR
TENS
TNPH



Gamma Ray (GR)
0 (GAPI) 150

Discriminated Casing Collar Locator Amplitude (CCLD)
−10(−−−−) 5

Thermal Neutron Porosity (TNPH)
0.3 (V/V) −0.1

Tension (TENS)
2000 (LBF) 0

Parameters

DLIS Name	Description	Value	
	ITGN−B: iFlex Telemetry Gamma Neutron Tool		
BARI_ITGN	Barite Mud Presence Flag	NO	
BHS	Borehole Status	CASED	
BSCO	Borehole Salinity Correction Option	NO	
CCCO	Casing & Cement Thickness Correction Option	YES	
DFT_IFLEX	Drilling Fluid Type	WATER	
FSAL	Formation Salinity	−50000	PPM
FSCO	Formation Salinity Correction Option	NO	
GCSE	Generalized Caliper Selection	BS	
HSCO	Hole Size Correction Option	YES	
MATR	Rock Matrix for Neutron Porosity Corrections	SANDSTONE	
MCCO	Mud Cake Correction Option	NO	
MWCO	Mud Weight Correction Option	NO	
NICO	Neutron Interference Correction Option	YES	
PTCO	Pressure Temperature Correction Option	NO	
PVN_ITGN	ITGN Computation Version	1.005	
SDAT	Standoff Data Source	SOCN	
SOCN	Standoff Distance	2	IN
SOCO	Standoff Correction Option	YES	
TBHDS	Tool Borehole Diameter Source	CALI	
TBHTS	Tool Borehole Temperature Source	GTSE	
	System and Miscellaneous		
BS	Bit Size	11.000	IN
BSAL	Borehole Salinity	−50000.00	PPM
CSIZ	Current Casing Size	0.000	IN
CWEI	Casing Weight	26.00	LB/F
DFD	Drilling Fluid Density	8.40	LB/G
DO	Depth Offset for Playback	0.0	FT
DORL	Depth Offset for Repeat Analysis	0.0	FT
PP	Playback Processing	NORMAL	

Format: NUC_5 Vertical Scale: 5" per 100' Graphics File Created: 21−Jul−2011 10:19

OP System Version: 18C0−147

ITGN−B SPC−5020−IFLEX

Input DLIS Files

DEFAULT	CNL_007LUP	FN:6	PRODUCER	21−Jul−2011 09:43	1800.0 FT	0.1 FT

Output DLIS Files

DEFAULT	CNL_009PUP	FN:8	PRODUCER	21−Jul−2011 10:19

Schlumberger

Compensated Neutron Log

Schlumberger

Repeat Analysis (1650−1740)

MAXIS Field Log

Company: City of Seminole | **Well: Seminole Santa Rosa Well**

Input DLIS Files

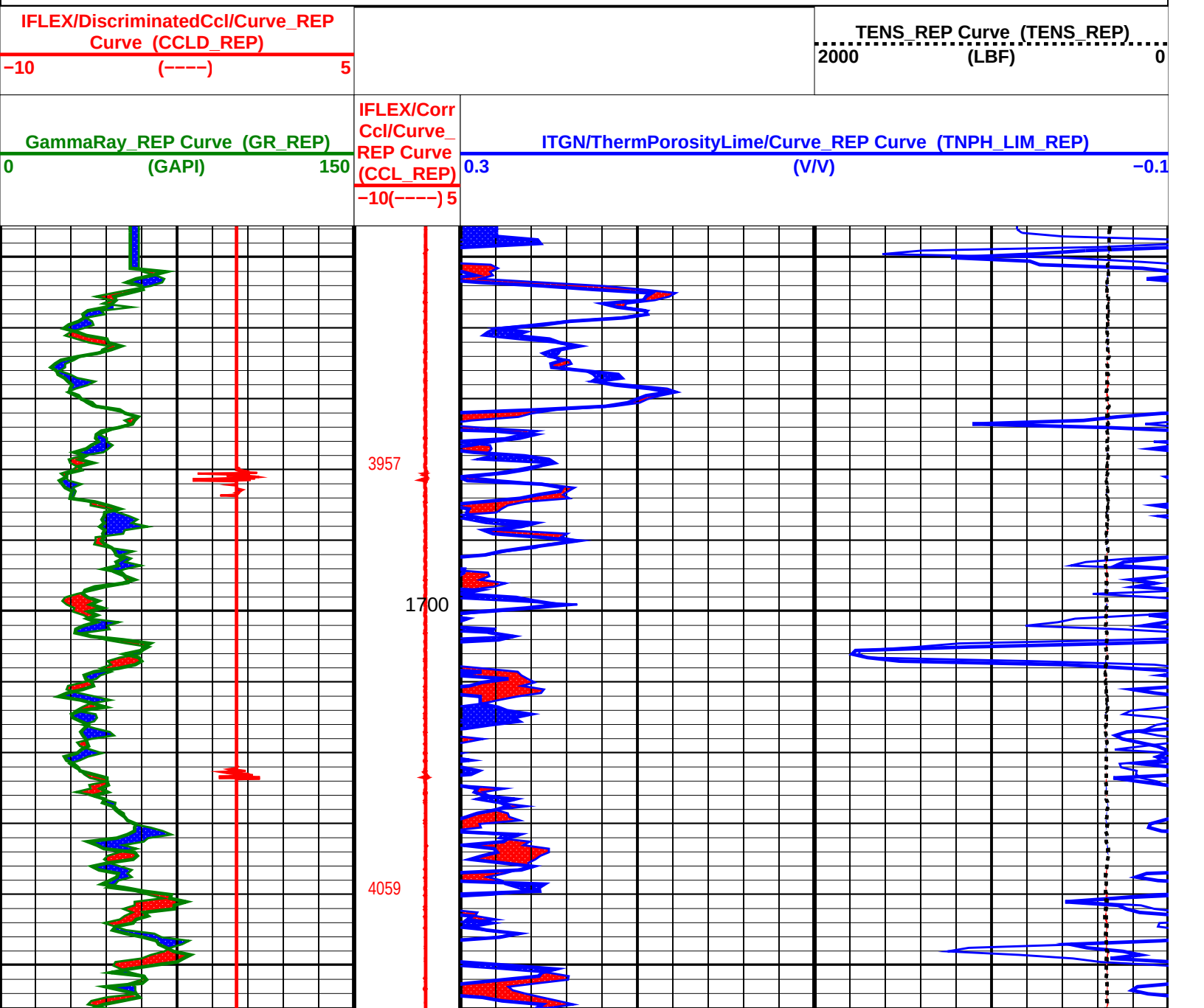
DEFAULT	CNL_007LUP	FN:6	PRODUCER	21−Jul−2011 09:43	1800.0 FT	0.1 FT
DEFAULT	CNL_006LUP	FN:5	PRODUCER	21−Jul−2011 09:39	1805.0 FT	1645.5 FT

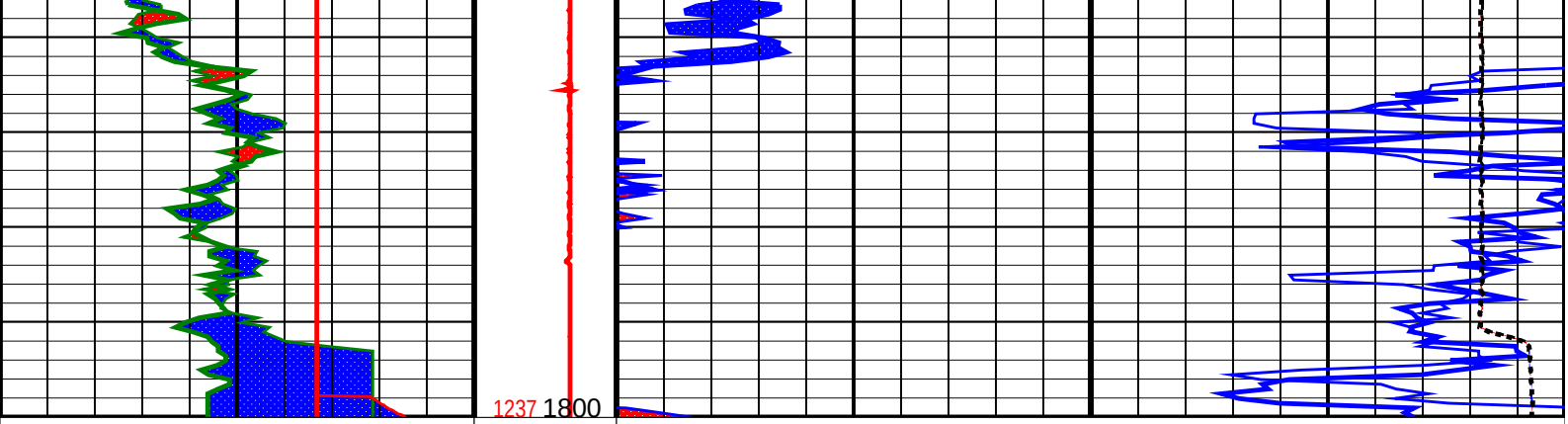
Output DLIS Files

DEFAULT	CNL_009PUP	FN:8	PRODUCER	21−Jul−2011 10:19

OP System Version: 18C0−147

ITGN−B SPC−5020−IFLEX





Parameters

DLIS Name	Description	Value	
	ITGN−B: iFlex Telemetry Gamma Neutron Tool		
BARI_ITGN	Barite Mud Presence Flag	NO	
BHS	Borehole Status	CASED	
BSCO	Borehole Salinity Correction Option	NO	
CCCO	Casing & Cement Thickness Correction Option	YES	
CCLD	CCL reset delay	12	IN
CCLT	CCL Detection Level	0.3	V
DFT_IFLEX	Drilling Fluid Type	WATER	
FSAL	Formation Salinity	−50000	PPM
FSCO	Formation Salinity Correction Option	NO	
GCSE	Generalized Caliper Selection	BS	
HSCO	Hole Size Correction Option	YES	
MATR	Rock Matrix for Neutron Porosity Corrections	SANDSTONE	
MCCO	Mud Cake Correction Option	NO	
MWCO	Mud Weight Correction Option	NO	
NICO	Neutron Interference Correction Option	YES	
PTCO	Pressure Temperature Correction Option	NO	
PVN_ITGN	ITGN Computation Version	1.005	
SDAT	Standoff Data Source	SOCN	
SOCN	Standoff Distance	2	IN
SOCO	Standoff Correction Option	YES	
TBHDS	Tool Borehole Diameter Source	CALI	
TBHTS	Tool Borehole Temperature Source	GTSE	
	System and Miscellaneous		
BS	Bit Size	11.000	IN
BSAL	Borehole Salinity	−50000.00	PPM
CSIZ	Current Casing Size	0.000	IN
CWEI	Casing Weight	26.00	LB/F
DFD	Drilling Fluid Density	8.40	LB/G
DO	Depth Offset for Playback	0.0	FT
DORL	Depth Offset for Repeat Analysis	0.0	FT
PP	Playback Processing	NORMAL	

Format: NUC_5_REP Vertical Scale: 5" per 100' Graphics File Created: 21−Jul−2011 10:19

OP System Version: 18C0−147

ITGN−B SPC−5020−IFLEX

Input DLIS Files

DEFAULT	CNL_007LUP	FN:6	PRODUCER	21−Jul−2011 09:43	1800.0 FT	0.1 FT
DEFAULT	CNL_006LUP	FN:5	PRODUCER	21−Jul−2011 09:39	1805.0 FT	1645.5 FT

Output DLIS Files

DEFAULT	CNL_009PUP	FN:8	PRODUCER	21−Jul−2011 10:19		

DEFAULT CNL_009PUP FN:8 PRODUCER 21-Jul-2011 10:19

Schlumberger

Compensated Neutron Log
Repeat Analysis (600-670)

MAXIS Field Log

Company: City of Seminole **Well: Seminole Santa Rosa Well**

Input DLIS Files

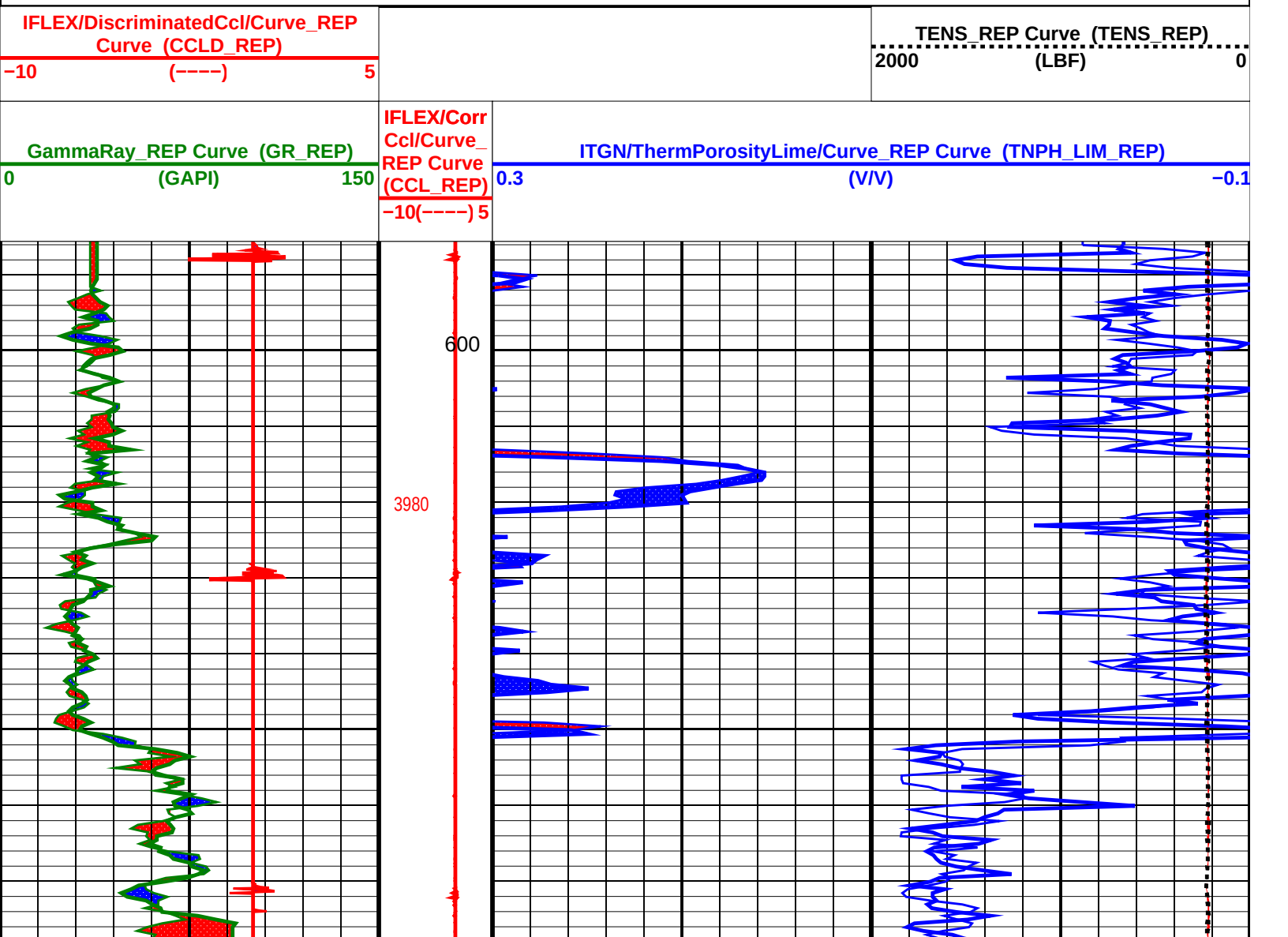
DEFAULT	CNL_007LUP	FN:6	PRODUCER	21-Jul-2011 09:43	1800.0 FT	0.1 FT
DEFAULT	CNL_004LUP	FN:3	PRODUCER	21-Jul-2011 09:29	683.0 FT	585.0 FT

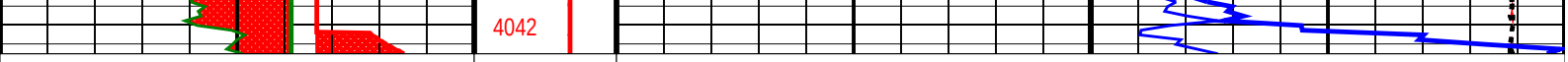
Output DLIS Files

DEFAULT	CNL_010PUP	FN:9	PRODUCER	21-Jul-2011 10:21

OP System Version: 18C0-147

ITGN-B SPC-5020-IFLEX





GammaRay_REP Curve (GR_REP)
0 (GAPI) 150

IFLEX/Corr Ccl/Curve_ REP Curve (CCL_REP)
−10(−−−−) 5

ITGN/ThermPorosityLime/Curve_REP Curve (TNPH_LIM_REP)
0.3 (V/V) −0.1

IFLEX/DiscriminatedCcl/Curve_REP Curve (CCLD_REP)
−10 (−−−−) 5

TENS_REP Curve (TENS_REP)
2000 (LBF) 0

Parameters

DLIS Name	Description	Value	
	ITGN−B: iFlex Telemetry Gamma Neutron Tool		
BARI_ITGN	Barite Mud Presence Flag	NO	
BHS	Borehole Status	CASED	
BSCO	Borehole Salinity Correction Option	NO	
CCCO	Casing & Cement Thickness Correction Option	YES	
CCLD	CCL reset delay	12	IN
CCLT	CCL Detection Level	0.3	V
DFT_IFLEX	Drilling Fluid Type	WATER	
FSAL	Formation Salinity	−50000	PPM
FSCO	Formation Salinity Correction Option	NO	
GCSE	Generalized Caliper Selection	BS	
HSCO	Hole Size Correction Option	YES	
MATR	Rock Matrix for Neutron Porosity Corrections	SANDSTONE	
MCCO	Mud Cake Correction Option	NO	
MWCO	Mud Weight Correction Option	NO	
NICO	Neutron Interference Correction Option	YES	
PTCO	Pressure Temperature Correction Option	NO	
PVN_ITGN	ITGN Computation Version	1.005	
SDAT	Standoff Data Source	SOCN	
SOCN	Standoff Distance	2	IN
SOCO	Standoff Correction Option	YES	
TBHDS	Tool Borehole Diameter Source	CALI	
TBHTS	Tool Borehole Temperature Source	GTSE	
	System and Miscellaneous		
BS	Bit Size	11.000	IN
BSAL	Borehole Salinity	−50000.00	PPM
CSIZ	Current Casing Size	0.000	IN
CWEI	Casing Weight	26.00	LB/F
DFD	Drilling Fluid Density	8.40	LB/G
DO	Depth Offset for Playback	0.0	FT
DORL	Depth Offset for Repeat Analysis	0.0	FT
PP	Playback Processing	NORMAL	

Format: NUC_5_REP Vertical Scale: 5" per 100' Graphics File Created: 21−Jul−2011 10:21

OP System Version: 18C0−147

ITGN−B SPC−5020−IFLEX

Input DLIS Files

DEFAULT	CNL_007LUP	FN:6	PRODUCER	21−Jul−2011 09:43	1800.0 FT	0.1 FT
DEFAULT	CNL_004LUP	FN:3	PRODUCER	21−Jul−2011 09:29	683.0 FT	585.0 FT

Output DLIS Files

DEFAULT	CNL_010PUP	FN:9	PRODUCER	21−Jul−2011 10:21

Company: **City of Seminole**

Well: **Seminole Santa Rosa Well**

Field:

County: **Gaines**

State: **Texas**

Schlumberger

Compensated Neutron Log
Gamma Ray
Casing Collar Log

ATTACHMENT D

PHOTO NO. 1 **DESCRIPTION:**	"Flower pot" structures in the side of the mud pit. Reddish brown silty sand of the Blackwater Draw formation overlies the Ogallala caprock caliche. The flower pot structures are the silty sands incised into the top of the caliche zone.

PHOTO NO. 2 **DESCRIPTION:**	Basic Energy cementing the surface casing.

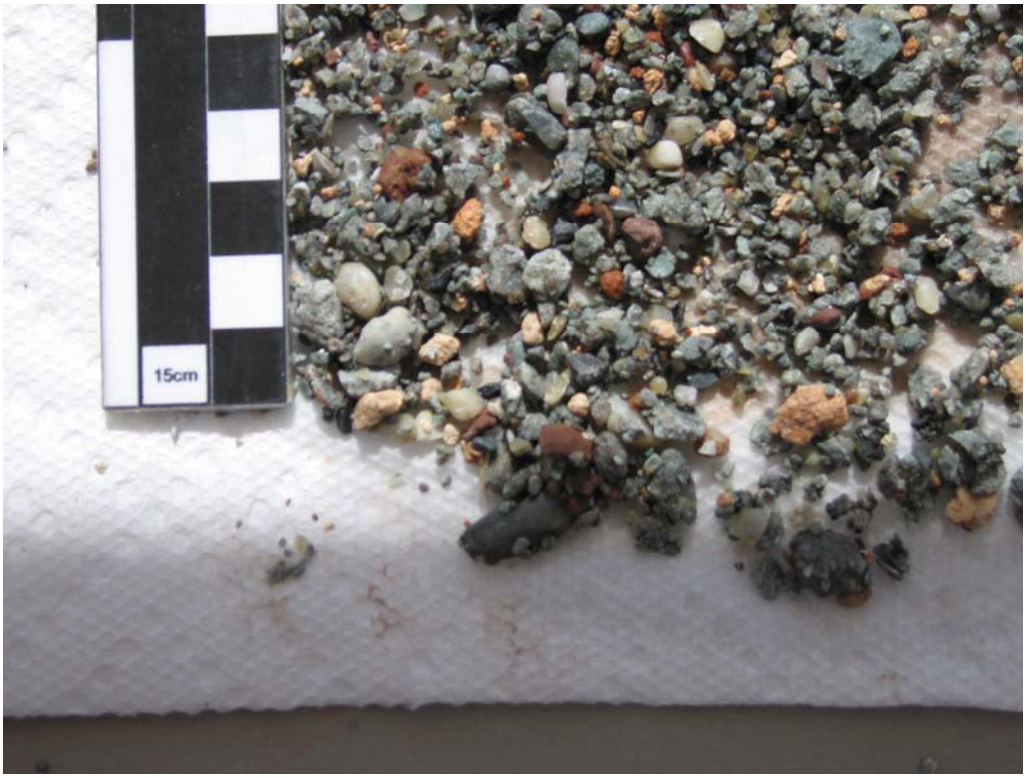


PHOTO NO. 3 DESCRIPTION:	Gravel section at a depth of 640' bgs. Each unit on the right side of the scale is equal to 1cm.

PHOTO NO. 4 DESCRIPTION:	The driller laid out soil samples collected at 10' intervals from the shaker and prepared the driller's log based on these cuttings.

PHOTO NO. 5 DESCRIPTION:	Cuttings collected from the “shaker” were used for preparation of the geologic log. The “fines” are separated out by the shaker, thereby biasing the soil samples. Sandy zones (i.e., fines) were noted based on the volume of sand from the sand separator.

PHOTO NO. 6 DESCRIPTION:	Near the bottom of the hole, approximately 60 drill stems (shown in the rack) were tripped in and out of the hole each day. The drill stems are approximately 30 feet in length.

PHOTO NO. 7 **DESCRIPTION:**	Steel casing being delivered to the site. Seven inch casing was used to complete the well.